APPENDIX A: SURFACE WATER HYDROLOGY

SANTA ANA RIVER WATER RIGHT APPLICATIONS FOR SUPPLEMENTAL WATER SUPPLY DRAFT ENVIRONMENTAL IMPACT REPORT

October 2004

SAN BERNARDINO VALLEY MUNICIPAL WATER DISTRICT • 1954 •

WESTERN MUNICIPAL WATER DISTRICT

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1.0 INTRODUCTION

This Surface Water Hydrology appendix contains background information that supports the impact analyses in the Environmental Impact Report (EIR). The effects identified through these analyses also influence groundwater characteristics such as depth to groundwater, interaction with contaminant plumes, and water quality. Such potential interactions are addressed in *Appendix B - Groundwater Hydrology.*

Chapter 2, Santa Ana River System, presents a description of existing and future conditions in the upper SAR basin. The conditions described include the following:

- Hydrologic characteristics of the SAR and its tributaries;
- Effects on the flow regime of the SAR attributable to construction and operation of Seven Oaks Dam;
- Major structures on the mainstem of the SAR such as dams and water diversion structures;
- Water rights and water diversions; and
- Water quality conditions and objectives.

Chapter 3, Hydrologic Base Period Determination, describes the selection of the base period used in the surface water and groundwater hydrologic modeling for the Project.

Chapter 4, Operations Model (OPMODEL), describes the model developed to estimate the quantity of unappropriated SAR water available for diversion by Muni/Western. This model simulates monthly releases that could be made from Seven Oaks Dam under a set of variable conditions. These conditions are determined by a number of parameters including the following:

- Diversions by senior water rights claimants;
- Diversions by the San Bernardino Valley Water Conservation District (Conservation District);
- Releases designed to accomplish habitat restoration as prescribed by the terms of the Biological Opinion (BO) of the U.S. Fish and Wildlife Service for operation of Seven Oaks Dam; and
- Operation of Seven Oaks Dam for either flood control or a combination of flood control and seasonal storage.

Chapter 5, Allocation Model, describes the approach taken to simulate the manner in which water diverted by Muni/Western would be put to beneficial use. The Allocation Model is a mechanism designed to distribute the diverted water through a set of existing and proposed conveyance facilities to a set of water uses. These uses are:

- Direct use in the Muni/Western service areas;
- Groundwater recharge of the San Bernardino Basin Area (SBBA);

- Groundwater recharge outside the SBBA but within the Muni/Western service areas; and
- Water Exchange.

Chapter 6, River Analysis, is a collection of analytical techniques designed to assess the changes that potential diversions by Muni/Western could have on the flow regime of the SAR. Analyses are conducted for two sets of conditions:

- Non-storm flow conditions where attention is focused on changes in instream channel flow; and
- Storm flow conditions where attention is focused on overbank flooding.

The interrelationship between these models and analytical techniques is illustrated in Figure 1-1.

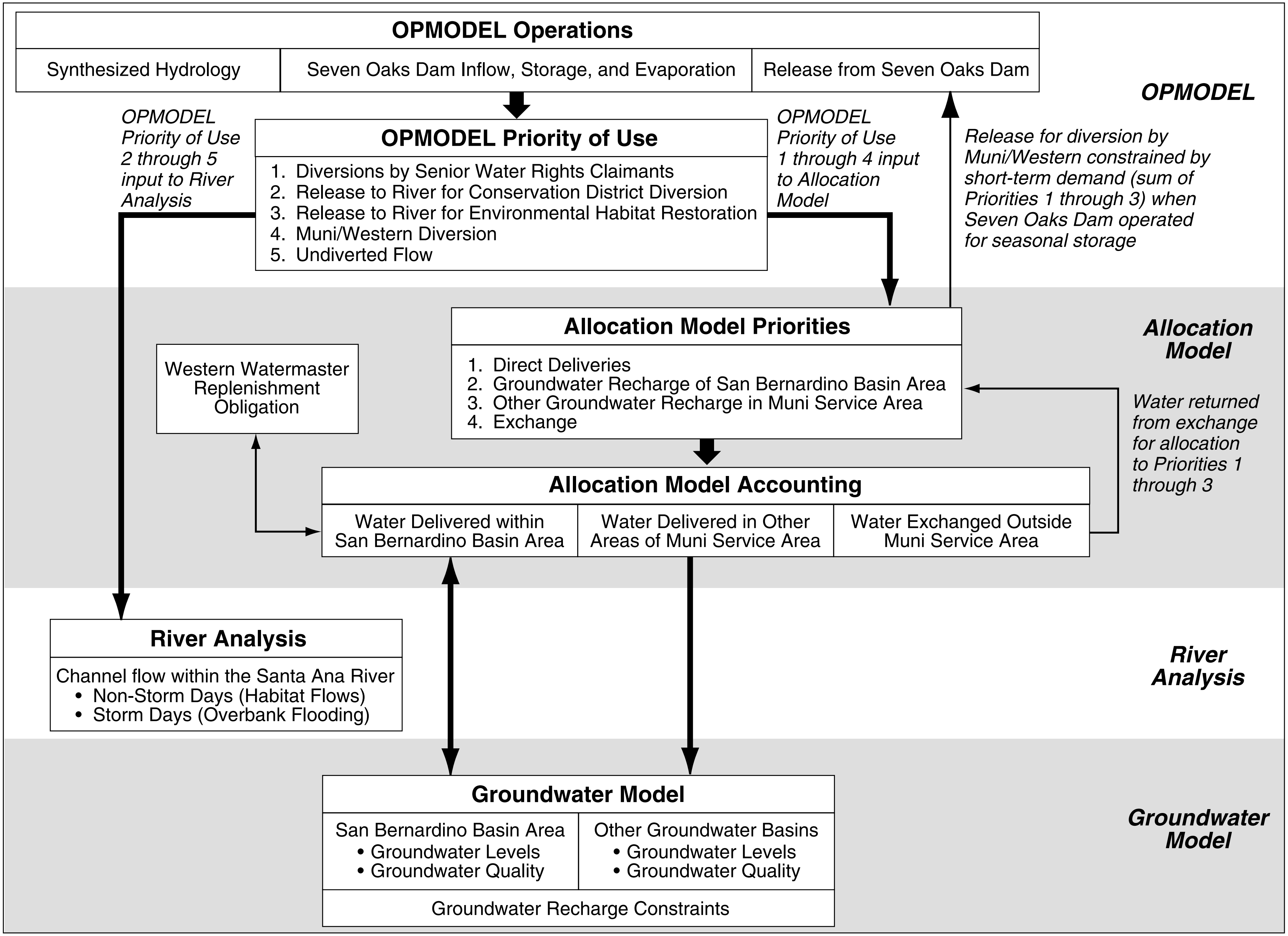

Figure 1-1. Modeling Tools Used in Hydrologic Analyses

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2.0 SANTA ANA RIVER SYSTEM

2.1 SANTA ANA RIVER WATERSHED

The Santa Ana River (SAR) is the largest stream system in southern California. It begins high in the San Bernardino Mountains and flows over 100 miles southwesterly where it discharges to the Pacific Ocean between Newport Beach and Huntington Beach. The SAR watershed covers over 2,650 square miles of widely varying urban, rural, and forested terrain and covers the more populated urban areas of San Bernardino, Riverside, and Orange counties, as well as a small portion of Los Angeles County. The SAR watershed and its relationship to the Muni/Western service areas is illustrated in Figure 2.1-1.

The Santa Ana River flows from the San Bernardino Mountains are constrained by Seven Oaks Dam. About 1 mile downstream from Seven Oaks Dam, the SAR emerges from the upper SAR canyon and flows through the San Bernardino Valley. The mainstem is joined, along this segment, by several tributaries of which the largest are Mill Creek and Lytle Creek. The SAR then flows through the Prado Basin and a narrow canyon in the Santa Ana Mountains.

Climate in the Project area is characterized by relatively hot, dry summers and cool winters with intermittent precipitation. Precipitation is nearly always in the form of rain in the lower elevations and mostly in the form of snow above about 6,000 feet mean sea level (msl) in the San Bernardino Mountains. Mean annual precipitation ranges from about 12 inches in the vicinity of Riverside, to about 20 inches at the base of the San Bernardino Mountains, to more than 35 inches along the crest of the mountains. The long-term (water years [WY] 1883-84 through 2001-02)[1] mean annual precipitation recorded at the San Bernardino County Hospital Gage is 16.4 inches. The historical record indicates that a period of above-average or below-average precipitation can last more than 30 years, such as the recent dry period that extended from 1947 to 1977.

Three types of storms produce precipitation in the SAR basin: general winter storms, local storms, and general summer storms. General winter storms usually occur from December through March. They originate over the Pacific Ocean as a result of the interaction between polar Pacific and tropical Pacific air masses and move eastward over the basin. These storms, which often last for several days, reflect orographic (i.e., land elevation) influences and are accompanied by widespread precipitation in the form of rain and, at higher elevations, snow.

Local storms cover small areas, but can result in high intensity precipitation for durations of approximately 6 hours. These storms can occur any time of the year, either as isolated events or as part of a general storm, and those occurring during the winter are generally associated with frontal systems (a "front" is the interface between air masses of different temperatures or densities). Summer storms can occur in the late summer and early fall months in the San Bernardino area, although they are infrequent. The large portion (73 percent) of average annual precipitation occurs during December through March and rainless periods of several months are common in the summer.

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1 A water year runs from October through September of the following year. For example, wy 2000- 2001 begins on October 1, 2000 and ends on September 30, 2001.

2.2 CHARACTERISTICS OF THE SANTA ANA RIVER AND ITS TRIBUTARIES

2.2.1 Measurement of Stream Flow and Stream Flow Variability

Runoff[2] records provide information on the characteristics of the SAR and its tributaries. Runoff records are available for a number of stream gaging stations located on the mainstem of the SAR and throughout the SAR watershed, as shown in Figure 2.1-1. The runoff records demonstrate the highly variable nature of river flow, with large floods and long periods of extremely low flow. As shown in Figure 2.2-1, three U.S. Geological Survey (USGS) gaging stations are located within the upper SAR canyon:

1) the Southern California Edison (SCE) Canal Gage (USGS Gage 11049500) records flow that is diverted into the SCE Canal above Seven Oaks Dam;

2) the Auxiliary Canal Gage (USGS Gage 11051502) records flow diverted from the SAR into the Auxiliary Diversion above Cuttle Weir which ultimately enters the Division Box; and

3) the Mentone Gage (USGS Gage 11051499) located on the SAR at River Mile (RM)[3] 69.96, just upstream of Cuttle Weir, accounts for water flowing in the main channel of the SAR just below Seven Oaks Dam.

The combination of all three gages (referred to as the "Combined Flow" Mentone Gage [USGS record 11051501]) represents the sum of stream flow recorded in the river at the Mentone Gage, in addition to flow that would have been in the river at this location had it not been diverted upstream by the SCE hydroelectric system and other water diversions. The "River Only" Mentone Gage (USGS record 11051500) is the sum of the Mentone Gage and Auxiliary Canal Gage and is representative of SAR flow near Seven Oaks Dam.

Additionally, there are two other USGS gaging stations located downstream of Seven Oaks Dam, but within the upper SAR basin: the "E" Street Gage (USGS Gage 11059300) located in the City of San Bernardino at RM 57.69; and the MWD Crossing Gage (USGS Gage 11066460) located at RM 45.7 (in a geographic area called the Riverside Narrows). Table 2.2-1 provides the annual median[4], maximum, and minimum stream flow recorded at the River Only Mentone, "E" Street, and MWD Crossing gages.

Annual flows at the River Only Mentone, "E" Street, and MWD Crossing gages are provided on Figure 2.2-2. As shown on this figure, flow in the SAR is highly variable from year to year. Additionally, flow in the SAR increases as one progresses downstream due to inflows from tributaries, rising water[5], and inflow from wastewater treatment plants (WWTPs). SAR flows at

2 Runoff is that portion of precipitation that flows off the land surface to creeks, streams, and other water bodies.

3 In this report, river miles are counted from the mouth of the SAR at the Pacific Ocean, with miles increasing upstream. The SAR mouth is RM 0, Prado Dam is RM 30.5, and Seven Oaks Dam is RM 70.93.

4 Median is a measure of central tendency, as is the mean (average). The median represents the 50th percentile, i.e., if data is sorted from highest value to lowest value, the median value is the value in the exact center of the distribution. The median is a more appropriate measure of central tendency than the mean when data is highly skewed.

5 Rising water is applied to noticeable increases in streamflow in reaches where a subsurface restriction forces groundwater to the surface.

the "E" Street Gage include flows from Mill Creek and San Timoteo Creek but not from Lytle and Warm creeks, which enter the SAR below the "E" Street Gage. SAR flows at the MWD Crossing include inflows from Lytle and Warm creeks, two large public WWTPs, and rising water.

Table 2.2-1. Upper Santa Ana River Median, Maximum, and Minimum Annual Flow

	Median Annual Flow (af)	*Maximum Annual Flow (af)*	*Minimum Annual Flow (af)*
River Only Mentone [a]	7,991	204,812	9
"E" Street [b]	25,525	319,976	0
MWD Crossing [c]	75,934	301,004	9,979

Source: USGS gage data.
[a] USGS Gage 11051500. Period of record is WY 1911-12 through WY 1999-2000.
[b] USGS Gage 11059300. Period of record is WY 1938-39 through WY 1953-54, WY 1966-67 through WY 2000-01.
[c] USGS Gage 11066460. Period of record is WY 1969-70 through WY 2000-01.

Figure 2.2-3 illustrates probability of exceedance[6] curves based on gage records for the River Only Mentone, "E" Street, and MWD Crossing locations. As shown in this figure, large annual flows in the upstream areas can be expected quite infrequently, but the probability of the same flow occurring downstream is greater. For example, flows in excess of about 70,000 acre-feet per year (afy) have a frequency of occurrence of only 10 percent at the River Only Mentone Gage, whereas this same flow has a frequency of occurrence of over 60 percent at the MWD Crossing Gage. Additionally, in the upstream areas, minimum annual stream flows are generally much smaller than minimum annual flows in the downstream areas.

Figure 2.2-4 shows the median flow of each month and total monthly flow for different types of water years (e.g., dry, average, and wet years). Figures 2.2-5 through 2.2-8 show the probability of a given flow being exceeded within a given month at the River Only Mentone Gage. These figures demonstrate the variability in flow between different types of water years and variability between months, but also illustrate some consistent trends, such as the largest monthly flows typically occur in February and March, and the lowest monthly flows typically occur August through October. Although stream flow increases downstream, the timing of flows (i.e., when the monthly maximums and minimums occur) is similar to the timing of flows observed at the River Only Mentone Gage.

2.2.2 Tributaries

There are numerous tributaries that contribute flow to the mainstem of the SAR in the Project area including Mill Creek, City Creek, Plunge Creek (a tributary of City Creek), Mission Zanja Creek (located just upstream of the San Timoteo Creek), San Timoteo Creek, East Twin Creek, Lytle Creek, and Warm Creek (a tributary to Lytle Creek); see Figure 2.1-1. The flow (under 100-

6 A probability of exceedance curve illustrates the cumulative frequency (probability) that a flow of a specific quantity has occurred historically. The graph portrays the probability of stream flow being greater than or equal to specific quantities. For example, Figure 2.2-3 shows that in about 40 percent of the years, stream flow at the River Only Mentone gage would be expected to equal or exceed 10,000 af; and in about 20 percent of the years, stream flow would be expected to equal or exceed 30,000 af.

year flood conditions[7]) contributed by each of the tributary creeks to the SAR is shown in Table 2.2-2. As a reference, during a 100-year flood event, Seven Oaks Dam releases would be up to 5,000 cfs (USACE 1988).

Table 2.2-2. Tributary Flow Contribution to the Santa Ana River
(100-year flood event discharge in cfs)

Tributary	*River Mile* [a]	*Inflow (cfs)*
Mill Creek	68.67	19,500
City Creek & Plunge Creek (Combined)	62.87	5,000
Mission Zanja Creek	59.08	3,500
San Timoteo Creek	58.44	15,500
East Twin Creek	58.14	18,000
Lytle Creek & Warm Creek (Combined)	56.74	70,000

Source: USACE 2000a.
a. Miles from the mouth of the SAR at the Pacific Ocean.

2.2.2.1 *Mill Creek*

Mill Creek is one of the largest tributaries to the SAR in the Project area, with a drainage basin of approximately 49 square miles (USGS 1999). Flow in Mill Creek depends largely on storm precipitation, with a general reduction in stream flow during the dry summer and fall months.

The USGS maintained several stream gages on Mill Creek to measure stream flow that have provided flow measurements for the period 1948-1986. Average discharge for this 39-year period is 37.6 cubic feet per second (cfs) and the maximum 1-day discharge during the period of record was 5,310 cfs (occurring on January 25, 1969). The highest estimated flows on record occurred on March 26, 1938, producing an instantaneous discharge of 18,100 cfs. In general, flows in Mill Creek tend toward the extreme, with either excessive, or minimal, amounts of water present.

These extremes are attributable to the absence of reservoirs and very steep terrain in the Mill Creek watershed. The only existing flood control structure on Mill Creek is a levee system comprised of embankments and masonry and concrete walls. The USACE completed the Mill Creek Levee modifications portion of the Santa Ana River Mainstem Project in 1998. These modifications consisted of construction of a floodwall on top of the existing levees and extension of the riprap toe of the existing levees. The flood control structure on Mill Creek now consists of a vertical reinforced concrete floodwall, beginning 2 miles upstream of the SAR and Mill Creek confluence, 2.4 miles long and approximately 6 feet high, on the waterside edge of the levee berm (USACE 1988). These modifications restored the original standard project flood level of protection to adjacent communities, i.e., 33,000 cfs contained within the banks.

7 A flood as defined under the Standard Flood Insurance Policy is a general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters or from the unusual and rapid accumulation of runoff of surface waters from any source. A 100-year flood refers to a flood level with a 1 in 100 percent change of being equaled or exceeded in any given year.

2.2.2.2 *Lytle Creek*

Lytle Creek runs along the eastern end of the San Gabriel Mountains in a southeasterly direction and is joined by Cajon Creek before finally reaching its confluence with the SAR near Colton. The Lytle Creek drainage basin is approximately 186 square miles (USGS 1999). Combined annual flows average 43.8 cfs (as measured at USGS Gage No. 11062001, the Lytle Creek Gaging Station). The maximum peak flow measured over the period 1899-2000 was 25,200 cfs and mean annual runoff during this period was 31,720 af.

2.2.3 Recent and Anticipated Changes in the Santa Ana River Flow Regime

2.2.3.1 *Wastewater Treatment Plant (WWTP) Discharges*

There are 14 publicly owned WWTPs located above Prado Dam or in the Upper SAR watershed (Santa Ana River Watermaster 2003). Nine of these plants contribute to surface flow of the SAR. Between 1970 and 2000, the total volume of wastewater contributions to SAR flows increased from 44,000 afy to 169,000 afy (Santa Ana River Watermaster 2003).

Three wastewater treatment plants (Redlands, Beaumont, and Yucaipa) discharge to the SAR and its tributaries upstream of the City of San Bernardino, but these discharges generally do not flow continuously to the SAR at "E" Street (Santa Ana River Watermaster 2003). Two plants - the Rapid Infiltration/Extraction (RIX)[8] facility in the City of Colton, and the Rialto WWTP in the City of Rialto - discharge directly to the SAR via a discharge channel at RM 53.46 (approximately 4 miles below "E" Street and more than 7 miles upstream of Riverside Narrows). Wastewater discharges from these plants have hydraulic continuity to the SAR above Riverside Narrows. As can be seen in Figure 2.2-9, combined wastewater discharge from these two facilities has risen from around 22,000 afy in WY 1970-71 to 57,750 afy in WY 2000-01 (Santa Ana River Watermaster 2003). The combined wastewater discharge is expected to increase to about 59,000 afy with both facilities operating at their respective design capacities. See Table 2.2-3.

Seven plants (Riverside, Corona, Inland Empire Utilities Agency [IEUA] Regional Plan 1, IEUA Regional Plant 2, IEUA Regional Plant 4, Carbon Canyon, and Western Riverside County) contribute wastewater discharges to the SAR between Riverside Narrows and Prado Dam. In WY 2000-01, these discharges totaled 110,852 af (Santa Ana River Watermaster 2003).

Despite the likelihood that WWTP discharges will increase in the future, not all of the treated water may enter the SAR. Several cities and utilities are in the process of developing plans to recycle WWTP effluent, which could decrease discharges to the river. For example (and as described in detail in Chapter 6), the City of San Bernardino is currently evaluating a program to sell approximately 18,000 afy of tertiary effluent (relative to the approximately 44,800 afy of potential discharge) from the RIX facility. Muni is currently working with the City of San Bernardino to ensure that the RIX facility continues to release at least 16 million gallons a day of treated effluent to the SAR to fulfill downstream water obligations (see section 2.4.1, *Orange County* Judgment).

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8 The RIX facility went into operation in 1996 and receives all effluent from the San Bernardino and Colton water reclamation plants. Prior to 1996, effluent from these plants entered the SAR just above and just below "E" Street, respectively.

2.2.3.2 *Increased Urbanization*

Urbanization taking place in the valley areas of the SAR Basin has resulted in increased responsiveness of the basin to rainfall. The increase in impervious surfaces (such as roofs, roads, parking lots, etc.) and constructed drainages to remove surface water from urban areas has resulted in decreased groundwater infiltration and increased runoff from urban areas, and has reduced the lag time between peak rainfall and peak runoff (i.e., constructed drainage systems move water from the urban areas to the river faster than if the land was not developed).

Table 2.2-3. Treated Wastewater Discharged Directly to the Santa Ana River above Riverside Narrows

Facility	*Current Discharge (afy)*	*Potential Future Discharge [a] (afy)*
RIX	49,407[b]	44,800
Rialto	8,346[b]	14,200
Total Discharges	57,753	59,000

Notes:
a. Potential future discharge based on design flow.
b. Based on 2000-2001 water year data reported in Thirty-Second Annual Report of the Santa Ana River Watermaster (Santa Ana River Watermaster 2003).

Compared to a basin without the influence of urbanization, the same rainfall occurring over an urbanized segment of the basin will result in higher peak discharges, a shorter lag time to the peak discharge, and an overall larger volume of water entering the local drainage areas. Because the SAR Basin is experiencing rapid growth, increased urbanization of the basin is expected to continue, and therefore, this trend in increased discharge and decreased lag times between peak rainfall and peak stream flow is expected to continue in the future.

2.2.3.3 *Seven Oaks Dam*

Seven Oaks Dam and reservoir was completed in 1999. The dam provides flood protection for communities downstream of the dam as a component of the ongoing Santa Ana River-Mainstem Project of the U.S. Army Corps of Engineers (USACE). The dam is located 1 mile upstream of the mouth of the SAR canyon in the upper reaches of the river. Approximately 177 square miles of the SAR watershed are located upstream of the dam (USACE 2000a). Seven Oaks Dam is a 550-foot high earth/rock-fill dam with a gross storage capacity of 145,600 af at spillway crest (elevation 2,580 feet National Geodetic Vertical Datum [NGVD]). The dam, the various reservoir levels, and associated storage for different reservoir elevations is depicted in Figure 2.2-10.

From June through October of each year the dam operates in “pass through” mode, i.e., all water arriving at the reservoir is released downstream. From the beginning of November to the end of May all flows except 3 cfs are stored until target debris pool storage is met at 2,200 NGVD. Once target debris pool storage is obtained, the reservoir is operated so that outflow equals inflow. In the event of a flood, Seven Oaks Dam is operated in conjunction with Prado Dam. Releases at

Seven Oaks Dam are held at 500 cfs or less until peak water surface elevation has passed at Prado Dam. Following a flood, water is released from Seven Oaks Dam at up to 7,000 cfs[9] until target storage is again reached. However, the outlet works are sized to pass a slightly larger discharge to provide flexibility and a factor of safety, and releases as great as 8,000 cfs are possible through the outlet works under emergency operating conditions (USACE 1988). Releases greater than 8,000 cfs can only be done using the dam spillway. Beginning in June and continuing through September, the debris pool is emptied.

Seven Oaks Dam has substantially altered the hydrology of the SAR, with the largest changes occurring during and after periods of high stream flow (i.e., flood flows). Seven Oaks Dam has altered the discharge rate, depth, velocity, and volume of flow in the SAR and, hence, has affected flood magnitude, and the extent of overbank flooding, along with the erosional and depositional characteristics in the overbank area. These changes are discussed immediately below.

2.2.4 Past and Future Flooding, Sediment Transport, and Overbank Flows of the Santa Ana River

2.2.4.1 Flooding

Flood events are the predominant factor in shaping the overbank or floodplain areas through erosion and deposition of sediment. The largest recorded flood is that of 1862, which had an estimated discharge rate of 317,000 cfs at Riverside Narrows (USACE 2000a). It is believed that the 1862 flood had a major effect on the SAR channel. Prior to the flood, the river upstream from what is now the City of Redlands was a narrow, meandering stream lined with alder, willow, sycamore, and cottonwood trees (USACE 2000a). The flood of 1862 washed out trees and deposited sand, gravel, and boulders on the riverbed and on the adjacent floodplain (USACE 2000a). After the flood, the river no longer followed a well-defined course, but instead ran in several channels in the section below the mouth of the canyon (USACE 2000a).

Historic records point to other large floods in 1867, 1869, 1891, 1916, 1927, 1938, 1967, and 1969. Estimated discharge for most floods that have occurred since 1862 (with the exception of those in 1867 and 1869, due to lack of data for these floods) are provided in Table 2.2-4. Information presented in Table 2.2-4 also shows how operation of Seven Oaks Dam will alter the flood discharges if similar floods occur in the future. Of the 15 historic events for which flows were estimated, six produced overbank flooding (plus the historic events of 1867 and 1869). Based on hydraulic modeling conducted by the USACE, overbank flows were estimated to be greater than 30,000 cfs in the 1862 flood event (USACE 2000a). In the 1938 flood, the next largest flood event, overbank flows were estimated to be about 9,000 cfs (USACE 2000a). The third largest flood event in 1891 was similar to the 1938 event in magnitude and overbank flows. The remaining three flood events caused overbank flows of a much smaller extent (estimated at between 600 cfs and 1,300 cfs; USACE 2000a). Field investigations by the USACE point to the fact that the 1938 and 1969 floods occupied pre-existing overbank channels that were likely formed by the large floods of 1862 and 1869 (USACE 2000a).

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9 The maximum rate at which water can be released from the dam varies depending on the surface water elevation (i.e., stage) of the reservoir.

USACE projections of instantaneous peak flows at various locations along the mainstem of the SAR downstream from Seven Oaks Dam for pre- and post-dam conditions are provided in Table 2.2-5. The effect of Seven Oaks Dam on flow regulation in the SAR becomes attenuated the further downstream from the dam, with the largest changes in peak discharge for a given frequency seen nearest the dam and the smallest changes seen in inflow to Prado Dam. Under 100-year flood conditions and under present conditions, SAR flow downstream of the confluence with Mill Creek is reduced by about 67 percent from 75,000 cfs prior to the construction of Seven Oaks Dam to 25,000 after the dam's construction (USACE 1988). Under 100-year flood conditions, inflow to Prado Dam under present conditions is reduced by about 15 percent from 230,000 to 195,000 cfs (USACE 1988). This downstream attenuation in the effect of Seven Oaks Dam is attributable to tributary and other storm water inflows to the river.

Table 2.2-4. Estimated Historic Flows on the Santa Ana River Downstream of the Santa Ana River – Mill Creek Confluence

Event Date	*Pre- Seven Oaks Dam Flow (cfs)*	*Pre-Dam Overbank Flooding*	*Post- Seven Oaks Dam Flow (cfs)*
1862	96,700	Yes	18,500
1891	58,100	Yes	14,700
1916	31,500	Yes	8,700
1927	25,700	Yes	5,000
1938	58,600	Yes	18,600
1966	12,900	No	10,500
1967	18,500	No	10,100
January 1969	25,700	Yes	20,100
February 1969	12,000	No	8,000
January 1980	8,200	No	6,000
February 17, 1980	5,500	No	2,500
February 21, 1980	6,500	No	3,000
1983	3,300	No	600
1993	7,600	No	2,800
1995	9,700	No	3,400

Source: Based on discharge-frequency analysis of USGS stream gage data and Hydrologic Engineering Center's Flood Frequency Analysis computer program, USACE 2000a and 2000b.

In the future, the magnitude of the peak discharge for a given frequency is expected to increase due to greater levels of urbanization in the drainage area (i.e., the flow associated with the 100-year flood is expected to be greater in the future). Therefore, the ability of Seven Oaks Dam to reduce peak discharge for a given frequency in the future is expected to decline slightly over time (i.e., the flood control benefits of the dam will be slightly less in the future as runoff increases).

2.2.4.2 Fluvial Processes

Changes in flood flows below Seven Oaks Dam result in changes to the area subject to overbank flooding, as well as changes to sediment transport within the SAR wash. Water velocity and depth, both in the channel and in overbank areas, under pre- and post-dam conditions, are provided in Table 2.2-6.

Table 2.2-5. Santa Ana River Mainstem Discharge-Frequency Values under Pre- and Post-Seven Oaks Dam

LOCATION	PRE- OR POST-SEVEN OAKS DAM	DRAINAGE AREA SIZE (sq. mi.)	FREQUENCY OF PEAK DISCHARGE (CFS)						
			200-Year	*100-Year*	*50-Year*	*25-Year*	*10-Year*	*5-Year*	*2-Year*
Outflow from Seven Oaks Dam	Pre	177	88,000	58,000	34,000	20,500	8,800	4,300	1,100
	Post		6,400	5,000	3,800	2,900	500	500	400
Downstream of Mill Creek	Pre	242	120,000	75,000	45,000	26,000	11,700	5,600	1,400
	Post		37,000	25,000	15,500	9,300	4,300	2,050	760
Downstream of City Creek	Pre	290	125,000	80,000	48,000	28,000	12,500	5,800	1,400
	Post		49,000	32,000	20,000	12,000	5,400	2,600	800
At E Street	Pre	500	165,000	105,000	60,000	33,000	13,500	6,000	1,400
	Post		100,000	67,000	39,000	22,000	9,000	4,000	920
At Riverside Narrows	Pre	824	265,000	175,000	102,000	57,000	23,000	9,500	1,600
	Post		205,000	130,000	80,000	45,000	18,000	7,600	1,400
Inflow to Prado Dam	Pre	2,255	360,000	230,000	132,000	72,000	28,000	11,500	2,800
	Post		300,000	195,000	110,000	60,000	23,000	9,500	2,300

Source: USACE 1988.

Sediment Transport

As shown in Table 2.2-6, the operation of Seven Oaks Dam will modify the historic flow pattern of the upper SAR by lowering the hydrologic energy regime and reducing the discharge and velocity of flows below the dam.

Operation of Seven Oaks Dam will store and release flows to the upper SAR according to the fill and release criteria specified for Prado Dam. Generally, during a flood event, flows less than or equal to 500 cfs are passed through Seven Oaks Dam, and flows in excess of 500 cfs are stored behind Seven Oaks Dam until Prado Basin can accommodate the additional water. Longer periods of flow in the SAR in the 1,000 to 4,000 cfs range, than would have occurred historically, result from this flood water storage and later releases from Seven Oaks Dam. Data indicate that, with operation of the dam, there is consistently an approximately 15 percent increase in the frequency of flows in the SAR downstream of Seven Oaks Dam in the 500 to 4,000 cfs range, and a decrease of approximately 25 percent in frequency of flows over 4,000 cfs (EIP 2004). According to recent sediment transport analysis, it is flows over 4,000 cfs which mobilize gravel and cobbles in the SAR, whereas flows in the 500 to 4,000 cfs range transport sand (EIP 2004).

The operation of Seven Oaks Dam effectively eliminated downstream transport of sediment larger than sand from the upper SAR watershed (EIP 2004, USACE 2000a). The primary sediment sources to the river are tributaries such as Mill Creek, City Creek and Plunge Creek, Lytle Creek and Warm Creek (see Table 2.2-7).

Gravel and Cobble Transport. Sediment transport analysis indicates that even with a 25 percent reduction in the frequency of flows over 4,000 cfs attributable to dam operation, the SAR will transport gravel from the primary sediment sources (listed in Table 2.2-7). Nearly 90 percent of the gravel and cobble that would have moved downstream prior to the construction of Seven Oaks Dam will continue to move downstream. Modeling indicates that sediment deposition begins upstream of where the SAR water velocity slows at the energy dissipation structure near Interstate 10 (RM 60.5 to RM 57.5) (EIP 2004). Gravel-sized sediment moving past the energy dissipation structures downstream of Interstate 10 will be deposited over the next 10 miles (EIP 2004).

Table 2.2-6. Discharge, Depth and Velocity for Pre- and Post-Seven Oaks Dam Conditions, 50- and 100-Year Flood Events

	Pre – Seven Oaks Dam		Post – Seven Oaks Dam	
	50-Year Flood	*100-Year Flood*	*50-Year Flood*	*100-Year Flood*
SAR Channel below Mill Creek Confluence				
Discharge	45,000 cfs	75,00 cfs	15,500 cfs	25,000 cfs
Velocity up to	12 ft/s	13 ft/s	10 ft/s	11 ft/s
Average flow depth up to	9 ft	11 ft	8 ft	9 ft
Overbank[a]				
Overbank Flood Area Acreage	1,379 acres	1,653 acres	1,031 acres	1,202 acres
Discharge	4,200 cfs	17,300 cfs	80 cfs	600 cfs
Velocity up to	2.5-4.5 ft/s	3.5-7.0 ft/s	1.0-2.0 ft/s	2.0-3.0 ft/s
Average flood depth up to	2.0-3.5 ft	2.5-5.0 ft	0.5-1.0 ft	1.0-2.5 ft

Source: HEC-RAS modeling, USACE 2000a.

[a] Overbank flooding is generally limited to three areas between the SAR confluence with Mill Creek downstream to RM 59.17 where the river is in an alluvial floodplain. Downstream of RM 59.17 the river is channelized and overbank flooding is unlikely.

Sand Transport. Sediment transport modeling shows that sediment reaching Prado Dam was 44,000 tons per year for both pre-and post-dam conditions. However, with the dam in operation, more of the sediment (about 30,000 tons) will be composed of sand coming from degradation of the river downstream of the energy dissipaters at Interstate 10. With increased urbanization, it is likely that more flows of a magnitude to transport sand-sized material will occur – causing further scour below the energy dissipaters in the SAR (EIP 2004). Because there will be more flows of a magnitude adequate for moving sand, but not gravel, gravel downstream of the energy dissipaters will tend to remain in the area where deposited and will be relatively exposed and free of sand (EIP 2004).

Table 2.2-7. Tributaries Contributing Sediment to the SAR

River Mile	*Location*	*Significant Sediment Source*	*Area Yielding Sediment (sq. mi.)*
70.9	Santa Ana River Below Seven Oaks Dam	No	
69.7	Mill Creek at USGS Gage	Yes	43
62.87	City Creek and Plunge Creek (combined)	Yes	37
59.09	Mission Zanja Creek	No	
58.44	San Timoteo Creek	No	
58.14	East Twin Creek	No	
56.74	Lytle Creek and Warm Creek	Yes	155
55.50	Reche Canyon Channel	Yes	14
46.50	Sunnyslope Creek	No	
39.5	San Sevaine/Etiwanda Channel	No	
38.50	Day Creek	No	
Source: EIP 2004.			

Overbank Flooding

Information presented in Table 2.2-6 also demonstrates that Seven Oaks Dam will decrease the extent of the areas likely to experience overbank flooding. Based on results of modeling (HEC-2 and HEC-RAS[10]) performed as part of the Biological Assessment (BA) for Seven Oaks Dam, the USACE determined that there are three major areas where 100-year floods could result in overbank flooding under post-Seven Oaks Dam conditions:

1. The north bank between the Mill Creek confluence and RM 65.41 where the 100-year flood could overtop the existing low flow channel banks and create continuous, separate, and parallel overbank flood flows within this approximately 4-mile stretch;

2. Between RM 64.90 and RM 63.78 flood flows could break out into the north overbank area and inundate a large active sand and gravel mining operation; and

3. Just upstream of the BNSF Railroad Bridge between RM 59.12 and RM 59.17, approximately 1,200 cfs of the post-dam 100-year flood flows (of 33,000 cfs) could break out into the north overbank (USACE 2000a). Model results indicate that the flooding in this area would amount to less than 6 inches of shallow sheet flow (USACE 2000a).

USACE estimates that, with Seven Oaks Dam in place, the acreage of overbank flood areas will decrease by between 25 to 27 percent, relative to pre-dam conditions (though other estimates put the reduction in overbank flood acreages as high as 39 percent) (USACE 2000a). Not only will overbank flood areas be smaller but the velocity and flood depth will be altered and this, in turn, will alter the sediment transport and scour experienced in these areas. Water velocity in the overbank flood areas would be reduced (under 100-year flood conditions) from between 3.5 and 7.0 feet per second (ft/s) to between 2.0 and 3.0 ft/s while average flood depth would be

10 HEC-2 and HEC-RAS are software models used to compute water surface profiles, developed by the Hydrologic Engineering Center of the Army Corps of Engineers.

decreased from 2.5 to 5.0 feet to 1.0 to 2.5 feet (see Table 2.2-6). Generally, it is estimated that in the overbank flood areas sands become mobilized at about 2 to 3 ft/s, gravels at about 6 ft/s, and boulders at 10 ft/s (USACE 2000a). Vegetation can resist short-duration velocities up to 6 to 8 ft/s, but will be uprooted at higher velocities and/or longer duration flows (USACE 2000a).

As discussed earlier, under post-dam conditions, velocities within the river channel are sufficient to transport sand- to boulder-sized material, and sand deposition would be expected in overbank flood areas adjacent to the river. However, the 50-year overbank flows would have a lower velocity, be shallow, and would mobilize and ultimately deposit substantially lower quantities of sand in the overbank areas than 100-year flood flows. Deposition of sands would be possible with the shallow overbank flows associated with a 100-year flood event size, but scour and exposure of new surfaces outside of historic channels and rivulets on the floodplain is unlikely with Seven Oaks Dam in operation.

2.3 WATER QUALITY

The State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control-Boards (RWQCBs) located throughout the state are responsible for the protection and, where possible, enhancement of the quality of California's waters. The SWRCB sets statewide policies and, together with the RWQCBs, implements state and federal laws and regulations. Each of the nine RWQCBs adopts a Water Quality Control Plan or Basin Plan, which recognizes and reflects regional differences in existing water quality, the beneficial uses of the region's ground and surface waters, and local water quality conditions and concerns. The SAR Basin is within the boundaries of the Santa Ana Regional Water Quality Control Board (SARWQCB). The current Basin Plan for the SAR Basin was adopted in 1995, and amendments to this plan are being evaluated (SARWQCB 2002).

The SARWQCB has divided the mainstem of the SAR into six reaches, Reaches 1 through 6, with reach numbers beginning at the Pacific Ocean and increasing upstream. Reaches 3 through 6 are located in the upper SAR basin (see Figure 2.3-1 for the location of these reaches). These 4 reaches are described in more detail below from upstream to downstream.

Reach 6 (RM 70.93 and above) includes the river upstream of Seven Oaks Dam where flows consist largely of snowmelt and storm runoff and where water tends to be of excellent quality (SARWQCB 1995).

Reach 5 (RM 70.93 to RM 57.68) extends from Seven Oaks Dam to the Bunker Hill Dike (San Jacinto Fault), which marks the downstream edge of the Bunker Hill groundwater basin. This reach tends to be dry except for storm flows. The lower end of this reach has rising groundwater and San Timoteo Creek flows on an intermittent basis (SARWQCB 1995).

Reach 4 (RM 57.68 to RM 49.00) includes the SAR from the Bunker Hill Dike downstream to Mission Boulevard Bridge in Riverside. The bridge is the upstream limit of rising groundwater resulting from the constriction at Riverside Narrows. Up to about 1985, most water in the reach percolated to the local groundwater, leaving the lower part of the reach dry. However, flows are now perennial because of discharge from the RIX and Rialto WWTPs (USACE 2000a). Much of the reach is operated for flood control (SARWQCB 1995).

Reach 3 (RM 49.00 to RM 30.50) includes the SAR from Mission Boulevard Bridge in Riverside to Prado Dam. At the Riverside Narrows, rising groundwater feeds several small tributaries including Sunnyslope Channel, Tequesquite Arroyo, and Anza Park Drain (SARWQCB 1995).

2.3.1 Beneficial Use

Beneficial use refers to the manner in which water is used for the benefit of one or more activities or purposes. Beneficial uses are determined by the SARWQCB, and specified in the Basin Plan. The beneficial uses are classed as an existing or potential use or as an intermittent use. The beneficial uses for each reach are provided in Table 2.3-1. Table 2.3-1 displays the beneficial uses as adopted in the 1995 Basin Plan, however, the proposed amendments to the Basin Plan do not include changes to the designated beneficial uses of these reaches of the SAR (SARWQCB 2004).

2.3.2 Components of Water Quality and Water Quality Characteristics

The SARWQCB states that the quality of the SAR is a function of the quantity and quality of the various components of the flows (SARWQCB 1995). Three components make up the flow of the water in the SAR: (1) storm flows; (2) baseflow; and (3) non-tributary flow and the relative proportion of these components varies throughout the year.

The first component, "storm flows," results directly from rainfall, usually occurring between the months of December and April. Much of the rainfall and surface water runoff from the storms is captured and percolates into the groundwater basins. The quality of storm flow water is highly variable and programs to control its quality have not yet been developed.

"Baseflow" makes up the second component of flow of water in the SAR, a large portion coming from the discharge of treated wastewater into the river, in addition to rising groundwater. This baseflow includes the non-point source discharges, as well as the uncontrolled and unregulated agricultural and urban runoff. Water quality objectives are set based on the amount of baseflow in the river, rather than on the total flow in the river. The water quality objectives relevant to the Project are provided in Table 2.3-2. Proposed amendments to the Basin Plan do not include changes to the surface water quality objectives in these reaches of the SAR (SARWQCB 2004). The intent of these objectives is to protect the river's groundwater recharge beneficial use. Compliance with these objectives is verified by annual measurement of the baseflow quality.

The quantity and quality of baseflow is most consistent during the month of August. At that time of year the influence of storm flows and non-tributary flows is at a minimum and the volumes of rising water and non-point source discharges tend to be low. The major component of baseflow in August, therefore, is municipal wastewater. For these reasons, this period has been selected by the SARWQCB as the time when baseflow will be measured and its quality determined.

To determine whether the water quality and quantity objectives for baseflow in Reach 3 of the SAR are being met, the SARWQCB collects a series of grab and composite samples during August of each year. The results are compared with the continuous monitoring data collected by USGS and data from other sources.

The SARWQCB sets discharge requirements on wastewater discharges, the major source of baseflow in the SAR. Waste water discharge requirements are developed on the basis of the limited assimilative capacity of the river. Non-point source discharges, generally from urban runoff and agricultural tail-water, are regulated by requiring compliance with Best Management Practices (BMPs), where appropriate.

The third component of flow in the SAR that influences water quality is characterized by the SARWQCB as "non-tributary flow." Non-tributary flow is generally imported water released in the upper basin for recharge in the lower basin.

Table 2.3-1. Beneficial Uses of Santa Ana River Water

	BENEFICIAL USE*										
Inland Surface Streams in the Upper Santa Ana River Basin	*Municipal and Domestic Supply*	*Agricultural Supply*	*Groundwater Recharge*	*Hydropower Generation*	*Water Contact Recreation*	*Non-Contact Water Recreation*	*Warm Freshwater Habitat*	*Cold Freshwater Habitat*	*Wildlife Habitat*	*Rare, Threatened or Endangered Species*	*Spawning, Reproduction, and Development*
Reach 2 – 17th Street in Santa Ana to Prado Dam	+	X	X		X	X	X		X	X	
Reach 3 - Prado Dam to Mission Blvd. (Segment F, G**)	+	X	X		X	X	X		X	X	
Reach 4 - Mission Blvd. in Riverside to San Jacinto Fault (Segment E, F)	+		X		X[c]	X	X		X		
Reach 5 - San Jacinto Fault in San Bernardino to Seven Oaks Dam[a, c] (Segment B, C, D, E)	X[b]	X	X		X	X	X		X	X	
Reach 6 - Seven Oaks Dam to Headwaters (Segment A)	X[b]	X	X	X	X	X		X	X		X

Source: SARWQCB 1995.

Notes:

"X" indicates that the waterbody has an existing or potential use.

"+" in the Municipal and Domestic Supply column indicates that the waterbody has been specifically excepted from the Municipal and Domestic Supply designation in accordance with the criteria specified in the "Sources of Drinking Water Policy."

a. Reach 5 uses are intermittent upstream of Waterman Avenue.

b. Municipal beneficial use designation applies upstream of Orange Street (Redlands); downstream of Orange Street, water is excepted from Municipal beneficial use designation.

c. Access prohibited in some portions by San Bernardino County Flood Control District (SBCFCD) and USACE.

* Proposed amendments to the Basin Plan do not include changes to the designated beneficial uses of these reaches of the SAR (SARWQCB 2004).

** Segment refers to a stretch of the SAR delineated for use in this document. See section 2.5.

Table 2.3-2. Santa Ana River Basin Surface Water Quality Objectives

Inland Surface Streams in the Upper Santa Ana River Basin	WATER QUALITY OBJECTIVES (mg/L)*						
	Total Dissolved Solids (TDS)	*Hardness ($CaCO_3$)*	*Sodium (Na)*	*Chloride (Cl)*	*Total Inorganic Nitrogen (TIN)* [a]	*Sulfate (SO_4)*	*Chemical Oxygen Demand (COD)*
Reach 2 – 17th Street in Santa Ana to Prado Dam	650 [b]	---	---	---	---	---	---
Reach 3 - Prado Dam to Mission Blvd. (Segment F, G**)	700	350	110	140	10[a]	150	30
Reach 4 - Mission Blvd. in Riverside to San Jacinto Fault (Segment E, F**)	550	---	---	---	10	---	30
Reach 5 - San Jacinto Fault in San Bernardino to Seven Oaks Dam (Segment B, C, D, E**)	300	190	30	20	5	60	25
Reach 6 - Seven Oaks Dam to Headwaters (Segment A**)	200	100	30	10	1	20	5

Source: SARWQCB 1995

a. Total nitrogen, filtered sample.

b. 5-year moving average.

* Proposed amendments to the Basin Plan do not include changes to the water quality objectives of these reaches of the SAR (SARWQCB 2004).

** Segment refers to a stretch of the SAR delineated for used in this analysis and the associated EIR. See section 2.5.

2.3.3 Water Quality Measurement Activities

Prado Dam has a subsurface groundwater barrier and, as a result, all ground and surface waters from the upper basin are forced to pass through the dam (or over the spillway). For this reason, it is an ideal place to measure flows and monitor water quality.

The USGS operates a permanent continuous stream flow gaging station immediately below Prado Dam. Orange County Water District (OCWD) also takes water quality samples at the USGS gage every month. Compliance with the objectives for Reaches 2 and 3 is monitored by the SARWQCB, using the data and information available from the USGS gage, plus the data from its own specific sampling programs.

A recent USGS study conducted by the National Water Quality Assessment Program entitled *Concentrations of Dissolved Solids and Nutrients in Water Sources and Selected Streams of the Santa Ana Basin, California, October 1998-September 2001* examined concentrations of total dissolved solids (TDS) and nutrients in selected Santa Ana Basin streams as a function of water source. The principal water sources considered in the study were mountain runoff, wastewater, urban runoff, and storm flow. The USGS study of water quality conditions in the SAR and tributaries focused on TDS and nutrients conditions representative of baseflow water of mountain sites, baseflow of the valley floor, and storm flow.

The USGS report notes that streams on the Santa Ana Basin valley floor, including the SAR, generally have increasing dissolved minerals as one goes downstream. This effect is because water is used, recycled, and used again. The level of TDS rises with each use of water, as solids are added, or increase due to the reduction in water volume from evaporation. All uses of water (residential, commercial, industrial, and agricultural) contribute to this problem as the water in the region is used, treated, recharged into the groundwater basins, extracted, and used again. The USGS report notes that rising groundwater also enters basin streams in some reaches and their sampling indicated some of the highest TDS (and in some cases nitrates) may occur at sites on the valley floor that are dominated by rising groundwater. Nitrate concentrations are higher in Santa Ana Basin streams receiving treated wastewater than in streams without treated wastewater. The principal source of nitrate is fertilizer from historic agricultural operations. Since nitrate is in the groundwater, it is also in groundwater reaching the surface.

2.3.4 Existing Water Quality

While there are basin plan objectives for multiple constituents, water quality monitoring has focused on two constituents: TDS and nitrogen. These constituents both have been reported at or near regulatory standards and have, thus, been the focal point of regulatory activities.

Table 2.3-3 provides a summary of the available historical surface water quality data for TDS and nitrogen at points along the SAR. Water quality at the Mentone Gage, because of its location in the immediate vicinity of where Project diversions would occur, is representative of the water that would be diverted by the Project.

Table 2.3-3. Average Historic Surface Water Quality for Locations on the Santa Ana River (1990-2001)

Water Quality Constituent	MWD Crossing Gage (Reach 3*)	RIX and Rialto Effluent Outfall (Reach 4*)	Mentone Gage (Reach 5*)
Total Dissolved Solids (TDS) mg/L	560 [a]	520 [b]	230 [a]
TDS Basin Plan Objective by Reach mg/L	700	550	300
Total Inorganic Nitrogen (TIN)	7.3 [a]	8.5 [b]	0.3 [a]
TIN Basin Plan Objective by Reach	10 [c]	10	5

Source: USGS Gage data. Data for Mentone River Only Gage begins in October 1998. Data for Riverside Narrows Gage begins in August 1997.

a. USGS 2004.

b. The TDS and TIN values assigned for RIX and Rialto are the maximum values that occurred during 2001-2002 as reported in Table 4.4-9 of the City of San Bernardino Municipal Water Department RIX Facility Recycled Water Sales Program Preliminary PEIR, March 2003.

c. Total nitrogen, filtered sample.

* Proposed amendments to the Basin Plan do not include changes to the water quality objectives in these reaches of the SAR (SARWQCB 2004).

2.3.5 Imported Water Quality

Water is imported to the SAR basin from the Colorado River via the CRA, owned and operated by The Metropolitan Water District of Southern California (Metropolitan), and via SWP facilities. The TDS level in CRA water averages approximately 700 mg/L and, during drought years, can increase to above 900 mg/L (Metropolitan and USBR 1999). Salinity projections for wet year conditions show TDS values between 650 and 800 mg/L (Metropolitan and USBR 1999). SWP water is suitable for most beneficial uses due to its low TDS levels of between 200 and 300 mg/L (DWR 2003). However, TDS levels of SWP water can vary due to drought conditions, flood events, reservoir management practices, and salt input from local streams.

2.4 REGULATORY AND INSTITUTIONAL SETTING

Both water rights and water use on the SAR have been the subject of a number of court judgments and SWRCB orders. Two court judgments, referred to as the *Orange County* Judgment and the *Western* Judgment, provide the overall framework for the division of rights and responsibilities for water users in the SAR basin.

2.4.1 The Orange County Judgment

In 1963, the Orange County Water District (OCWD) filed suit against substantially all water users in the area tributary to Prado Dam seeking adjudication of water rights on the SAR. The litigation ultimately involved over 4,000 served water users and water agencies, the four largest of which were OCWD, Muni, Western, and the Chino Basin Municipal Water District (now the Inland Empire Utilities Agency). Given the magnitude of the potential litigation, these four districts and other parties developed a settlement that was approved by the Orange County Superior Court in a stipulated judgment entered on April 17, 1969. *Orange County Water District v. City of Chino et al.*, Case No. 117628 (*Orange County* Judgment). The *Orange County* Judgment imposes a physical solution that requires parties in the upper SAR watershed to deliver a minimum quantity and quality of water to points downstream including Riverside Narrows and Prado Dam. A provision of the *Orange County* Judgment related to conservation establishes that, once the flow requirements are met, the Upper Area parties "may engage in unlimited water conservation activities, including spreading, impounding, and other methods, in the area above Prado reservoir." The *Orange County* Judgment is administered by the five-member SAR Watermaster that reports annually to the court and the four representative agencies. Muni, the Inland Empire-Utilities Agency, and Western nominate one member each to the Watermaster, OCWD nominates two members, and members are appointed by the court.

2.4.2 The Western Judgment

The *Western* Judgment, entered simultaneously with the *Orange County* Judgment, settled rights within the upper SAR watershed in part to ensure that those resources upstream of Riverside Narrows would be sufficient to meet the flow obligations of the *Orange County* Judgment at Riverside Narrows. *Western Municipal Water District of Riverside County v. East San Bernardino County Water District*, Superior Court of Riverside County, Case No. 78426 (April 17, 1969). Toward this end, the *Western* Judgment generally provides for:

- A determination of safe yield of the San Bernardino Basin Area (SBBA);
- Establishment of specific amounts that can be extracted from the SBBA by plaintiff parties equal in aggregate to 27.95 percent of safe yield;
- An obligation of Muni to replenish any extractions from SBBA by non-plaintiffs in aggregate in excess of 72.05 percent of safe yield;
- An obligation of Western to replenish the Colton and Riverside basins if extractions for use in Riverside County in aggregate exceed certain specific amounts; and
- An obligation of Muni to replenish the Colton and Riverside basins if water levels are lower than certain specific water level elevations in specified wells.

Like the *Orange County* Judgment, the *Western* Judgment identifies regional representative agencies to be responsible, on behalf of the numerous parties bound thereby, for implementing the replenishment obligations and other requirements of the Judgment. The representative entities for the *Western* Judgment are Muni and Western. Muni and Western are principally responsible for providing replenishment of the groundwater basins if extractions exceed amounts specified in the Judgment or as determined by the Watermaster. For the purposes of this replenishment obligation, Muni acts on behalf of all defendants (Non-Plaintiffs) dismissed from the *Western* Judgment and, similarly, Western acts on behalf of the Plaintiffs and other dismissed parties within Western. Plaintiff parties with specific rights to produce 27.95 percent of the safe yield from the SBBA are the City of Riverside, Riverside Highland Water Company, Meeks & Daley Water Company, and the Regents of the University of California. The *Western* Judgment is administered by the two-person Western-San Bernardino Watermaster, one person nominated each by Muni and Western, and both appointed by the court.

Like the *Orange County* Judgment, the *Western* Judgment contemplates that the parties will undertake "new conservation" which is defined as any increase in replenishment from natural precipitation which results from operation of works and facilities that did not exist in 1969. The *Western* Judgment specifies that the parties to the Judgment have the right to participate in any new conservation projects and, provided their appropriate shares of costs are paid, rights under the Judgment are increased by the respective shares in new conservation (72.05 percent by Muni and 27.95 by Western).

2.4.3 State Water Resources Control Board Orders

In 1989 (WR 89-25) and again in 1998 (WR 98-08), the State Water Resources Control Board (SWRCB) included the SAR in its Declaration of Fully Appropriated Streams (Declaration). Per this Declaration, the SAR was considered fully appropriated year-round. In 1989, the state Water Code prevented the SWRCB from accepting any new applications to appropriate water from watercourses listed in the Declaration.

In 1991, Muni submitted an application on behalf of itself and Western to appropriate up to 100,000 af annually from the SAR. At that time, the SAR was categorized as "fully appropriated" by the SWRCB. However, in May 1995, the SWRCB adopted procedures for reviewing the fully appropriated stream status and Muni/Western subsequently submitted a petition to revise the

Declaration of Fully Appropriated Stream Status for the Santa Ana River, together with the 1991 application.

The petition to revise the Declaration of Fully Appropriated Stream Status for the Santa Ana River submitted in 1995 by Muni and Western was followed in 1999 by a similar petition by OCWD. The SWRCB held hearings on the petitions in December 1999. Muni/Western provided evidence which demonstrated that flows in the SAR watershed had increased due to urbanization and the attendant increased runoff and increased releases of treated wastewater. Additionally, completion and subsequent operation of Seven Oaks Dam would increase availability of water for diversion during wet years. Based on evidence in the hearing record, the SWRCB amended the Declaration in Order WR 2000–12, to allow for the processing of the water right applications submitted by Muni/Western and OCWD (SWRCB 2000). Order WR 2000-12 did not determine the specific amount of water available for appropriation by petitioners.

In May 2001 Muni and Western jointly submitted a second application to appropriate 100,000 af of water annually ("Second Application") in addition to the 100,000 afy previously requested under the First Application, along with a second petition to revise the Fully Appropriated Streams Declaration for the SAR ("Second Petition"). The Second Petition and Second Application were based on updated hydrologic analyses submitted during the 1999 hearings which indicated that, in certain years, there is in excess of 200,000 af of water available for appropriation in the SAR. Based on the hydrologic evidence, in Order WR 2002-06 the SWRCB revised the Declaration pursuant to Muni/Western's Second Petition (and similar petitions by other parties) and accepted the following applications for processing:

- Muni/Western application requesting a right to collect a maximum of 100,000 af annually in surface and underground storage (the "Second Application");
- Chino Basin Watermaster application requesting a right to divert 97,000 af per year to groundwater storage;
- San Bernardino Valley Water Conservation District (Conservation District) application proposing groundwater and surface storage of 174,545 af annually;
- City of Riverside application proposing direct diversion of 75 cfs throughout the year for a total maximum direct diversion of 41,400 af per year; and
- Four minor applications for diversion of up to 102 af annually throughout the year from the West and East Forks of Cable Creek within the SAR watershed.

Order WR 2002-06 did not determine the specific amount of water available for appropriation or whether the amount of water available for appropriation is sufficient to approve the applications. As in Order WR 2000-12, prior to any potential approval of the applications, the SWRCB requires that applications meet all necessary obligations under CEQA.

2.4.4 Senior Water Rights Claimants and Seven Oaks Accord

The senior water rights claimants are a group of purveyors who claim pre-1914 rights on the SAR. They are Bear Valley Mutual Water Company, Lugonia Water Company (and shareholders including City of Redlands), North Fork Water Company (and shareholders including East Valley

Water District), and Redlands Water Company. The senior water rights claimants receive all of their SAR water via diversions made from the SAR at the Redlands Tunnel, the SCE Canal, and at the smaller Auxiliary Diversion (see Figure 2.2-1).

On July 21, 2004, Muni, Western, the City of Redlands, East Valley Water District, Bear Valley Mutual Water Company, Lugonia Water Company, North Fork Water Company, and Redlands Water Company, signed a settlement agreement known as the Seven Oaks Accord. The Seven Oaks Accord calls for Muni/Western to recognize the prior rights of the water users up to 88 cfs from the natural flow of the SAR. In exchange, the water users agree to withdraw their protests to the Muni/Western water right applications. All the parties to the Seven Oak Accord have agreed to support the grant of other necessary permits to allow Muni/Western to divert water from the SAR. By means of the Seven Oaks Accord, Muni/Western agreed to modify their water right applications to the SWRCB to incorporate implementation of the Accord. Consequently, the analysis conducted in this EIR assumes implementation of the Accord.

2.4.5 San Bernardino Valley Water Conservation District

The San Bernardino Valley Water Conservation District (Conservation District) holds two licenses issued by the SWRCB to divert water from the SAR (Licenses 2831 and 2832). License 2831 grants the Conservation District the right to divert and spread 8,300 af of water annually during the period January 1 to May 31. License 2832 grants the Conservation District the right to divert and spread 2,100 af annually from October 1 to December 31. The total of the two licenses is 10,400 afy. The Conservation District diverts water directly from the SAR, just upstream of the Cuttle Weir, a low dam in the river channel (shown schematically in Figure 2.2-1). The current capacity of the Conservation District's diversion canal is estimated at 300 cfs. The Conservation District also claims pre-1914 water rights.

Conservation District diversions are measured below the North Fork Box and include the total of diversions made at the Cuttle Weir and waters from the North Fork Box. A histogram showing historical Conservation District diversions of SAR water for the period 1914-15 through 1998-99 is presented in Figure 2.4-1. Diversions by the Conservation District have averaged 9,870 af annually over the period of record, with median annual diversions being 6,145 af. For the period WY 1915-16 to WY 1968-69 Conservation District diversions averaged 7,337 afy; from WY 1970-71 to 1999-2000 diversions averaged 14,896 afy.

2.4.6 Santa Ana River-Mill Creek Cooperative Water Project Agreement

The Santa Ana River-Mill Creek Cooperative Water Project Agreement (informally known as the Exchange Plan), is an agreement among 10 agencies and water companies in eastern San Bernardino Valley, executed in May 1976. The 10 parties to the Exchange Plan fall into three groups:

- SAR Water Users (Redlands Water Company, Bear Valley Mutual Water Company, Crafton Water Company, North Fork Water Company [East Valley Water District], Lugonia Water Company, City of Redlands, and the Conservation District);
- Mill Creek Water Users (City of Redlands, Crafton Water Company, and the Conservation District);

- Exchange Water Users (Yucaipa Valley Water District); and
- State Water Project Contractor (Muni).

The parties have agreed to the exchange of water from the SAR, Mill Creek, and the SWP. The agreement is described as a "bucket for bucket exchange," whereby a party to the agreement provides a "bucket" of their water to a second, higher elevation, party, and the second party provides a "bucket" of water from an alternate, lower elevation, source back to the original party. To facilitate exchanges, parties to the agreement share their existing facilities. However, specific facilities (called Cooperative Water Project facilities) were built and are operated by Muni, in part, to accommodate Exchange Plan deliveries. Given the three water sources and the available facilities, there are multiple delivery possibilities. Examples of exchanges that occur under the Exchange Plan include two level exchanges, three level exchanges, and water banking with the California Department of Water Resources. In a two level exchange, two water sources are used, for example SAR water is delivered to Mill Creek water users and, in return, an equal amount of SWP water is delivered to SAR water users. In a three level exchange, three sources are used. For example, Mill Creek water is delivered to the Yucaipa area, an equal amount of SAR water is then delivered to Mill Creek water users, and finally SWP water is delivered to SAR water users. To bank water within the SWP, a party entitled to local water exchanges their water when the local water is available and then takes SWP water at a later date.

2.4.7 Big Bear Lake Operations

Bear Valley Dam, which forms Big Bear Lake, is the only major dam that affects runoff into Seven Oaks Dam. Big Bear Lake is a water conservation reservoir, presently owned by the Big Bear Municipal Water District. Big Bear Lake is located on Bear Creek, a tributary to the SAR. The lake has a drainage area of about 38 square miles.

Bear Valley Mutual Water Company and its predecessors constructed, owned and operated Big Bear Lake as a supplemental water supply reservoir to meet the irrigation water supply demand within the Bear Valley Mutual Water Company service area in the easterly end of the San Bernardino Valley. Historical irrigation releases during dry periods sometimes caused low water levels in Big Bear Lake.

As recreation uses of Big Bear Lake became more important, Big Bear Municipal Water District sought to control the water levels in Big Bear Lake. On February 4, 1977, a stipulated judgment was entered in San Bernardino County Superior Court for Case No. 165493 *Big Bear Municipal Water District vs. North Fork Water Co. et al.* Big Bear Municipal Water District obtained the opportunity to furnish "in-lieu" water from several other named sources other than Big Bear Lake, to meet the water supply demands of Bear Valley Mutual Water Company. Big Bear Municipal Water District was allowed to retain an amount of water in Big Bear Lake equal to the amount of water furnished "in-lieu" to Bear Valley Mutual Water Company. Big Bear Municipal Water District explored and implemented the alternate sources. Providing water from these alternate "in-lieu" sources resulted in water being retained in Big Bear Lake to stabilize the water levels in the lake.

On May 1, 1987, Big Bear Municipal Water District adopted operating criteria for Big Bear Lake that contain conditions regarding when Big Bear Municipal Water District will release water from

Big Bear Lake and when Big Bear Municipal Water District will acquire "in-lieu" water, for Bear Valley Mutual Water Company.

On February 16, 1995, the SARWQCB adopted Order No. 95-4 which requires that Big Bear Municipal Water District make releases from Big Bear Lake through Bear Valley Dam to provide water for preservation of fish in Bear Creek.

On February 1, 1996, Big Bear Municipal Water District and Muni entered into an agreement which provides for Muni to furnish all "in-lieu" water that Big Bear Municipal Water District needs to meet the water supply demands of Bear Valley Mutual Water Company.

Big Bear Lake is now maintained at higher levels for recreation uses; the lake will spill (i.e., need to release water because the reservoir is full) more often than occurred under the historic irrigation supply operation. However, inflow to the SAR during irrigation months may be less than historic irrigation releases. Inflow to the SAR during winter months may be greater than under the historic operation of Bear Valley Dam. The changes in the operation of Big Bear Lake, from an irrigation water supply reservoir to a recreation reservoir, result in changes in the timing and amounts of water Big Bear Lake and Bear Creek contribute to the SAR.

2.5 SANTA ANA RIVER SEGMENTS

For the purposes of this Project, conditions in the SAR are evaluated for seven river segments. Each specific segment of the river is delineated using criteria that have important implications for the analysis of Project-related impacts.

Segment A – Upstream of Seven Oaks Dam (above RM 70.93);

Segment B – Seven Oaks Dam to just above Cuttle Weir (RM 70.93 to RM 69.9);

Segment C – Cuttle Weir to just above the confluence with Mill Creek (RM 69.9 to RM 67.89);

Segment D – Mill Creek confluence to just above "E" Street (RM 67.89 to RM 57.69);

Segment E – "E" Street to just above RIX and Rialto Effluent Outfall (RM 57.69 to RM 53.46);

Segment F – RIX and Rialto Effluent Outfall to just above Riverside Narrows (RM 53.46 to RM 45.7);

Segment G – Riverside Narrows to Prado Dam (RM 45.7 to RM 30.5)

The river segments have been chosen for particular purposes, e.g., locations at which USGS gage data are available, locations at which river flow changes due to large inflow or large diversion, and locations specific to water rights agreements and judgments. However, other reports and other agencies have used other designations to describe various segments of the SAR. For example, the SARWQCB has divided the mainstem of the SAR into six reaches, Reaches 1 through 6, with reach numbers beginning at the Pacific Ocean and increasing upstream. The USACE treats the SAR between Seven Oaks Dam and Prado Dam as two sub-areas. Sub-Area 2 of the SAR, as defined by the USACE, extends from Seven Oaks Dam downstream to just below the confluence of City Creek (RM 70.93 to RM 61.5); and Sub-Area 3 continues downstream to the upstream limit of the 100-year pool elevation for Prado Dam (RM 61.5 to RM 35.5). Figure 2.3-1 illustrates these segment schemes.

2.5.1 Segment A, Upstream of Seven Oaks Dam

Segment A of the Santa Ana River is above RM 70.93, in SARWQCB Reach 6 and in USACE Sub-Area 1.

2.5.1.1 Major Features

This segment of Santa Ana River has two major structures, Bear Valley Dam and the SCE hydroelectric system. Bear Valley Dam and operations of Big Bear Lake are described above in section 2.4.5.

2.5.1.1.1 Southern California Edison Diversion and Conveyance Structures

SCE operates the Santa Ana River Powerhouse 1 (SAR 1), and Santa Ana River Powerhouse 2/3 (SAR 2/3)[11] hydroelectric projects (SAR 1 powerhouse is upstream of Seven Oaks Dam, SAR 2/3 is downstream of the dam), consisting of water conveyance and power generation systems on the river. Six diversions upstream of Seven Oaks Dam are in place to convey water into the SCE Canal for power generation and for use by senior water rights claimants (see section 2.4.4).

The SAR system diverts water at concrete diversion dams on the SAR and its tributaries of Bear Creek, Breakneck Creek, Keller Creek, and Alder Creek. The SAR diversion dams and SCE conduit are capable of withdrawing and conveying water at a maximum rate of 93.3 cfs, which is conveyed, via the SCE conduit, along the canyon walls to a forebay where the water enters the SAR 1 Powerhouse. From the SAR 1 Powerhouse the SCE conduit continues, collecting more water along the SAR and tributaries. The SCE conduit bypasses Seven Oaks Dam and Reservoir and delivers water to the SAR 2/3 Powerhouse. Historic flows recorded at the USGS Gage 11049500 on the SCE Canal are shown on Figure 2.5-1. Median annual diversions into the SCE Canal for WY 1914-15 through 1998-99 are 31,824 af.

2.5.1.2 SAR Characteristics

The watershed above Seven Oaks Dam drains approximately 177 square miles (USACE 2000a). The average gradient of the river above Seven Oaks Dam is 300 feet per mile, but tributaries have gradients ranging from 600 feet per mile to 1,900 feet per mile, which illustrate the steep topography of this area.

2.5.2 Segment B, Seven Oaks Dam to Just Above Cuttle Weir

Segment B of the SAR extends between RM 70.93 and RM 69.9, in SARWQCB Reach 5 and is in USACE Sub-Area 2.

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11 A portion of SCE conduit was replaced, Santa Ana River Powerhouse 2 was abandoned, and Santa Ana River Powerhouse 3 was replaced with Santa Ana River Powerhouse 2/3 to accommodate Seven Oaks Dam. Diversion points, uses of water and flow paths are essentially the same as before construction of Seven Oaks Dam.

2.5.2.1 *Major Features*

Major features in this river segment include Seven Oaks Dam (section 2.2.3.3), the Auxiliary Diversion, and the Francis Cuttle Weir.

2.5.2.1.1 Auxiliary Diversion/Auxiliary River Pickup

Small amounts of water are diverted from the SAR into the Division Box via the Auxiliary Diversion (also called the "Auxiliary River Pickup") for use by the senior water rights claimants. This diversion takes water from the SAR upstream of the Mentone Gage, but downstream of Seven Oaks Dam (see Figure 2.2-1). The USGS maintains a gaging station on the Auxiliary Diversion to measure flows. Flows diverted via the Auxiliary Diversion are then conveyed via the Division Box and distributed via the Redlands Aqueduct or the River Crossing Pipeline.

2.5.2.1.2 Francis Cuttle Weir

The Francis Cuttle Weir was built in 1932 by what is now known as the Conservation District to divert flow in the SAR for groundwater spreading. The weir is located approximately 1 mile downstream from Seven Oaks Dam. Diverted SAR water is conveyed via the Conservation District Canal to the Santa Ana River Spreading Grounds.

2.5.2.2 *Santa Ana River Characteristics*

Releases from Seven Oaks Dam control the flow in this segment of the river. Up to 3 cfs is continuously released from Seven Oaks Dam into the plunge pool and becomes surface flow diverted via the Auxiliary Diversion or by infiltration into the Redlands Tunnel. Stream flow in this segment is now perennial due to this constant release. The other major water diversions in this segment are those made by the Conservation District through the intake structure adjacent to Cuttle Weir.

Figure 2.5-2 shows probability of exceedance curves for flow above Cuttle Weir; these curves are estimated based on nearby gage data with adjustments made for diversions. It is evident from this figure that prior to the construction of Seven Oak Dam, more than 30 percent of the time there was no flow in this segment, flows above 10 cfs occurred approximately 35 percent of days, and flows above 100 cfs were rare, occurring only about 10 percent of the time. With the dam in operation, mean daily discharge is at least 3 cfs, and about 60 percent of the time discharge is greater than 3 cfs. For this segment of the SAR, with the dam in operation a mean daily discharge of 10 cfs is equaled or exceeded approximately 45 percent of the time, while for flows of 100 cfs and higher, the frequency drops to less than 10 percent (Figure 2.5-2).

In this segment, the SAR slope is fairly steep, bed material is generally coarse, and the SAR is confined by the canyon walls and in a constructed channel throughout.

2.5.3 Segment C, Cuttle Weir to just above the Confluence of Mill Creek

Segment C of the SAR is between RM 69.9 and RM 67.89, in SARWQCB Reach 5, and is in USACE Sub-Area 2. There are no major tributaries or water control features in this segment of the SAR[12]. Like its upstream segment, the SAR slope is fairly steep and bed material is generally coarse throughout. However, just downstream of the Cuttle Weir, the SAR exits the upper SAR canyon and enters the upper end of the Santa Ana Wash. At the Greenspot Road bridge the SAR channel is approximately 250 feet wide. Throughout this segment, the river floodplain is wider and is no longer confined by the upper SAR canyon walls. Stream flows in this reach are ephemeral.

Figure 2.5-3 shows probability of exceedances curves for flow downstream of Cuttle Weir; these curves are estimated based on nearby gage data and adjustments are made for diversions. Prior to the construction of Seven Oak Dam, more than 65 percent of the time there was no flow in this segment, flows above 10 cfs occurred only about 20 percent of days, and flows above 100 cfs occurred less than 10 percent of the time. With the dam in operation, approximately 75 percent of the time there is no discharge in this river segment. With the dam in operation a mean daily discharge of 10 cfs is equaled or exceeded approximately 22 percent of the time, while for flows of 100 cfs and higher, the frequency drops to less than 10 percent (Figure 2.5-3).

2.5.4 Segment D, Mill Creek Confluence to just above "E" Street

Segment D of the SAR is between RM 67.89 and RM 57.69, in SARWQCB Reach 5, and is in both USACE Sub-Areas 2 and 3. This river segment receives a substantial amount of tributary inflow from Mill Creek, City Creek and Plunge Creek, Mission Zanja Creek, San Timoteo Creek, and East Twin Creek. Table 2.2-2 above, provides data on the relative contributions of each of these tributaries to SAR flow.

At the upper end of this river segment, river bed material is generally coarse, whereas the downstream portion of this river segment consists of a soft-bottom channel with uncompacted earthen berms on both banks. In the upper end of this river segment the channel is about 1,800 feet wide (USACE 2000a). In this downstream portion, the river is part of a broad wash up to 5,000 feet wide, which includes part of the floodplain for City Creek and Plunge Creek.

Figure 2.5-4 shows probability of exceedances curves for flow below the confluence of Mill Creek; these curves are estimated based on nearby gage data with adjustments made for diversions and other losses as well as inflow. This figure shows that prior to the construction of Seven Oak Dam, about 55 percent of the time there was no flow in this segment, flows above 10 cfs occurred approximately 35 percent of days, and flows above 100 cfs occurred approximately 15 percent of the time. With the dam in operation flows are similar to those of pre-dam conditions, demonstrating that the inflow from Mill Creek lessens the influence of flows from the Project area in this segment. With the dam in operation approximately 48 percent of the time there is no discharge in this river segment, flow above 10 cfs is equaled or exceeded approximately

12 A river diversion at Greenspot Road bridge, "the Hole in the Wall" was a historic diversion into the Redlands Aqueduct. This diversion was last used in 1969. It is no longer usable as the river channel is well below the intake (personal communication C. Vann 2004).

40 percent of the time, while for flows of 100 cfs and higher, the frequency drops to about 17 percent (Figure 2.5-4).

Segment D includes multiple areas that could be subject to overbank flooding (based on results of HEC–2 and HEC-RAS modeling performed as part of the BA for Seven Oaks Dam, USACE 2000a). At the upstream portion of this river segment, between the Mill Creek confluence and RM 65.41, a 100-year flood could overtop the existing low flow channel banks and create continuous, separate, and parallel overbank flood flows. A second area that could experience overbank flooding is between RM 64.90 and RM 63.78. Here, 100-year flood flows could break out onto the north bank area and inundate a large active sand and gravel mining operation. A third area subject to overbank flooding is near the BNSF Railroad Bridge between RM 59.12 and RM 59.17. Modeling suggests that approximately 1,200 cfs of the post-dam 100-year flood flows could break out into the north overbank areas (USACE 2000a). Model results indicate that the flooding in this area would amount to less than 6 inches of shallow sheet flow (USACE 2000a).

2.5.5 Segment E, "E" Street to just above the RIX and Rialto Effluent Outfall

Segment E of the SAR is between RM 57.69 and RM 53.46. The majority of this river segment is in SARWQCB Reach 4 though a small portion (about 0.02 miles) at the upstream end is in Reach 5. This river segment is entirely within USACE Sub-Area 3. River Segment E receives a substantial amount of tributary inflow from Lytle Creek and Warm Creek. Table 2.2-2, above, provides data on the relative contribution of these tributaries to SAR flow. From November to April, this segment generally has baseflow along its entire length, however, from May to October the streambed typically dries out at approximately RM 54.5 and downstream until the RIX and Rialto Effluent Outfall (USACE 2000a). Throughout Segment E, the river has been largely channelized to confine flows and protect bridges and other structures. The average invert slope in this river reach is 0.005 (USACE 2000a).

Figure 2.5-5 presents probability of exceedance curves for flow downstream of "E" Street. Prior to the construction of Seven Oak Dam, about 5 percent of the time there was no flow in this segment, flows above 10 cfs occurred approximately 90 percent of days, and flows above 100 cfs occurred approximately 13 percent of the time. Since December 1999 (with the dam in operation) flows are consistently lower than pre-dam conditions, but this effect is due largely to the loss of WWTP effluent that, prior to 1996, was discharged in this river reach but has since been discharged in Segment F. Currently, approximately 42 percent of the time there is no discharge in this river segment, flows above 10 cfs are equaled or exceeded approximately 48 percent of the time, while for flows of 100 cfs and higher, the frequency drops to about 12 percent (Figure 2.5-5).

2.5.6 Segment F, RIX and Rialto Effluent Outfall to just above Riverside Narrows

Segment F of the SAR is between RM 53.46 and RM 45.7 and is evenly divided, with about half the segment in SARWQCB Reach 4 and half in Reach 3. This river segment is entirely within USACE Sub-Area 3. The river in Segment F receives significant inflow from wastewater discharges from the RIX and Rialto WWTPs. As described in section 2.2.3.1, these wastewater treatment plants discharged 57,750 af in WY 2000-01 and in the future could discharge as much as 59,000 afy. Generally, this river segment and downstream have flow year round, attributable to the effluent discharge, rising water, and urban and agricultural runoff (USACE 2000a).

Figure 2.5-6 presents probability of exceedance curves downstream at the RIX and Rialto Effluent Outfall, these curves are synthesized from gage data and effluent discharges of the WWTPs. This varies from the curves shown for the upstream segments (Figures 2.5-2 through 2.5-5) and illustrates the presence of higher and more sustained flows below the RIX and Rialto Effluent Outfall. This figure shows that prior to the construction of Seven Oak Dam, flows equaled or exceed 10 cfs at all times. Since December 1999 (with the dam in operation) flows are consistently higher than pre-dam conditions, but this effect is due largely to the addition of WWTP effluent that, prior to 1996, was discharged in Segment E. Since 1999, discharge in this river segment has equaled or exceed 60 cfs at all times.

2.5.7 Segment G, Riverside Narrows to Prado Dam

Segment G extends from Riverside Narrows at RM 45.7 to Prado Dam at RM 30.5. This river segment falls entirely within SARWQCB Reach 3 and is within USACE Sub-Area 3. Stream flow is perennial throughout Segment G due to inflow from WWTPs and groundwater influences. This river segment is the furthest downstream in which project-related impacts can be anticipated.

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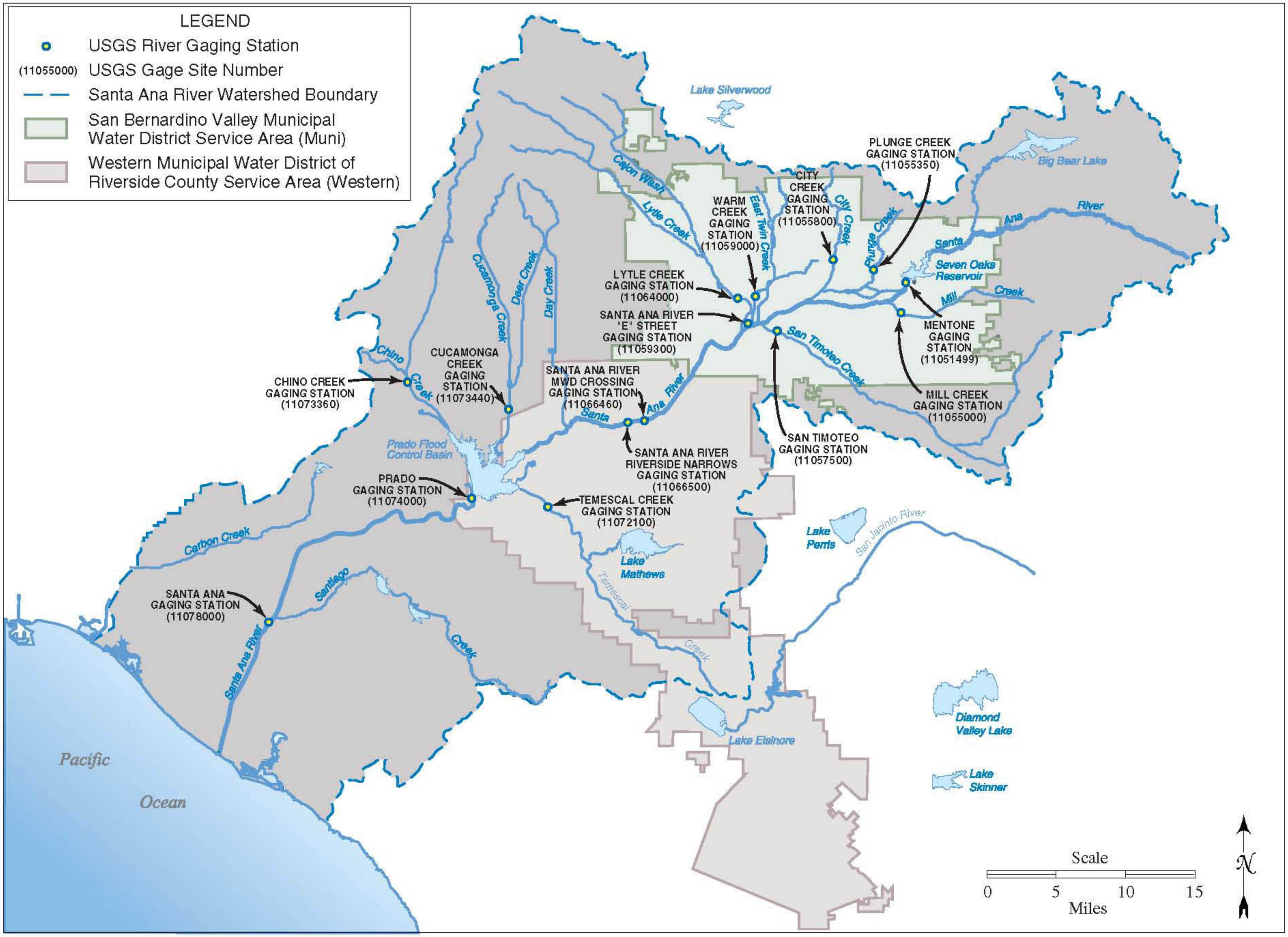

Figure 2.1-1. Santa Ana River Watershed, Gaging Stations, and Muni/Western Service Areas

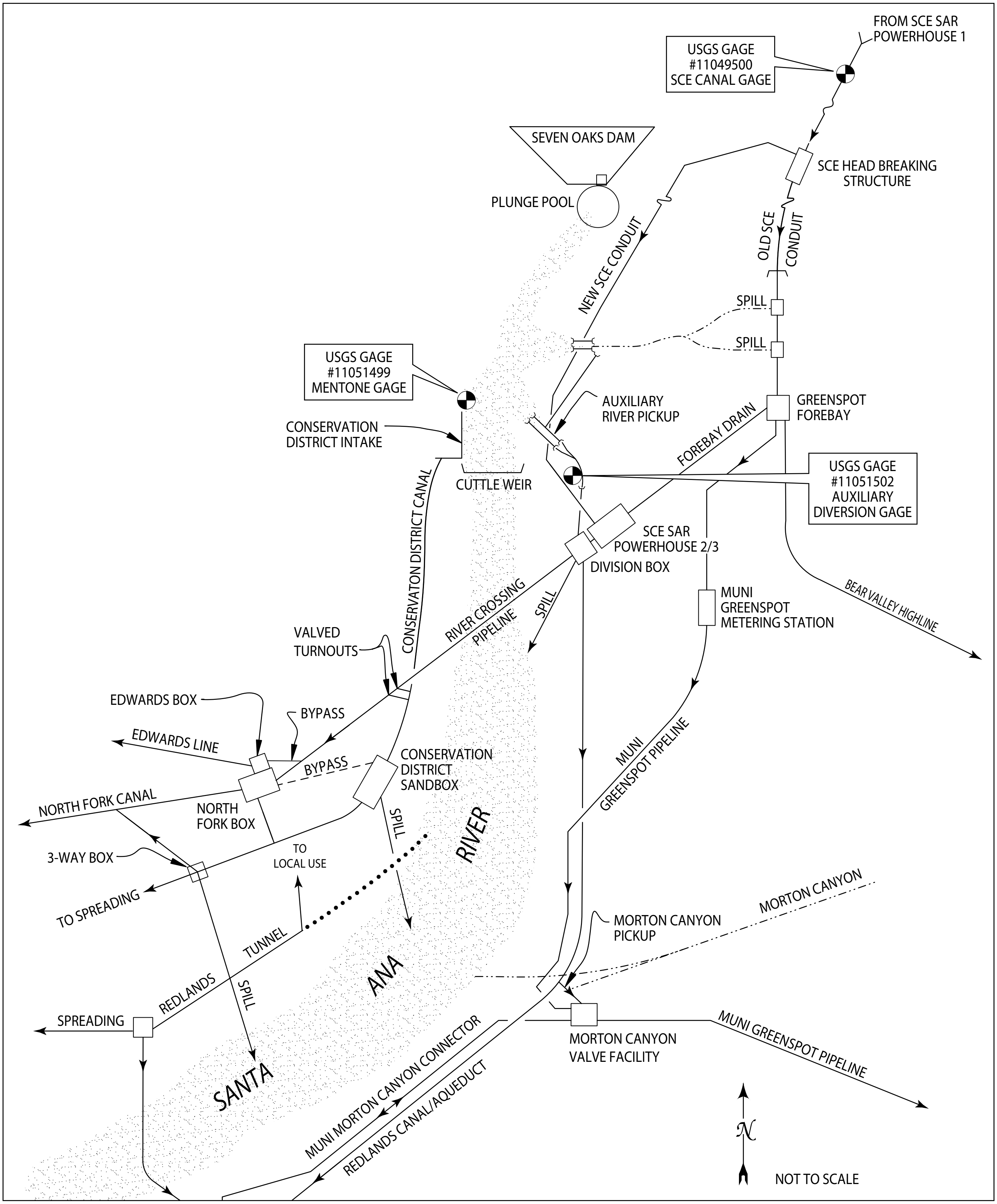

Figure 2.2-1. Schematic of Water Control Features and Gages in the Santa Ana River Canyon

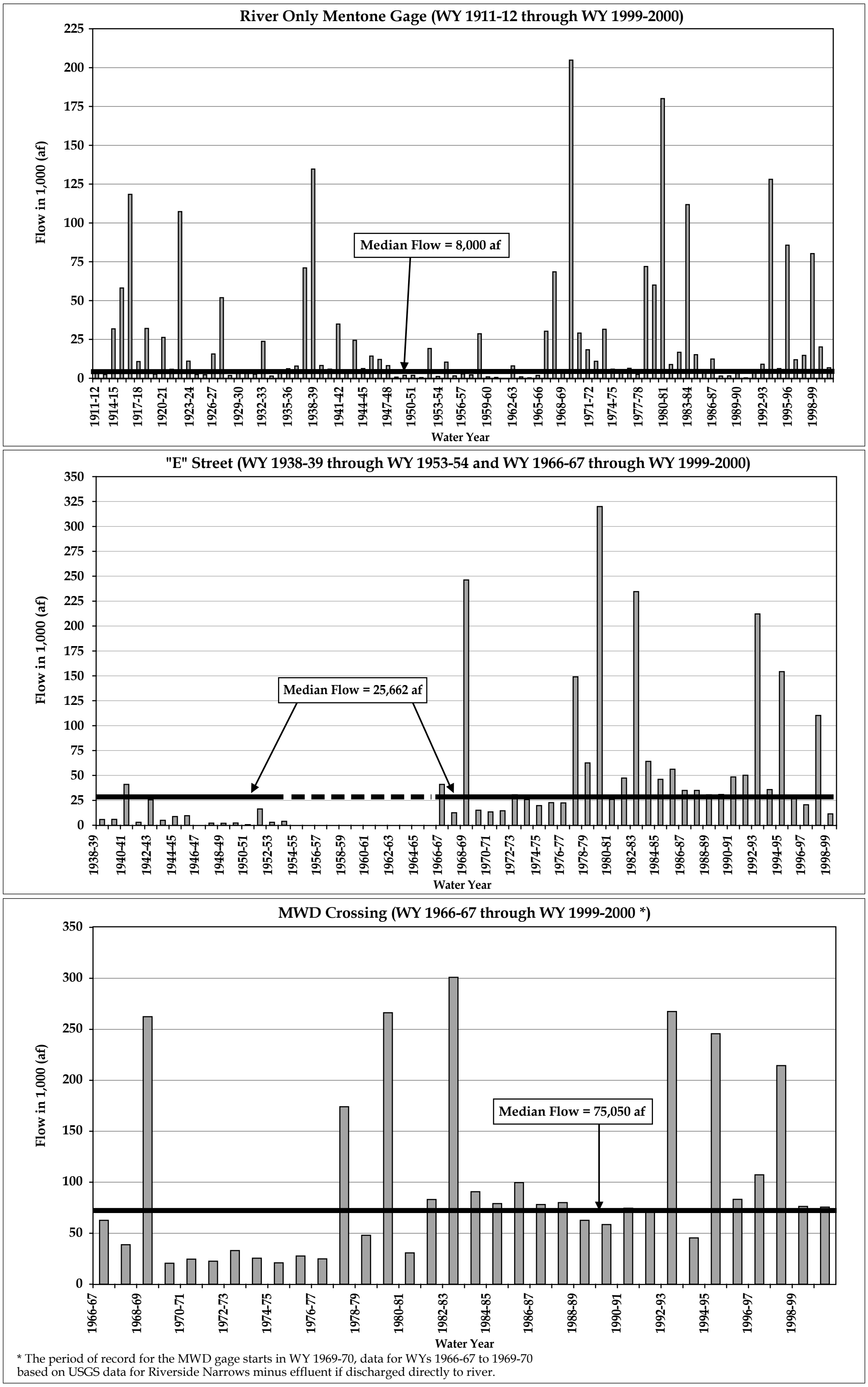

Figure 2.2-2. Annual Flows at the River Only Mentone, "E" Street, and MWD Crossing Gages

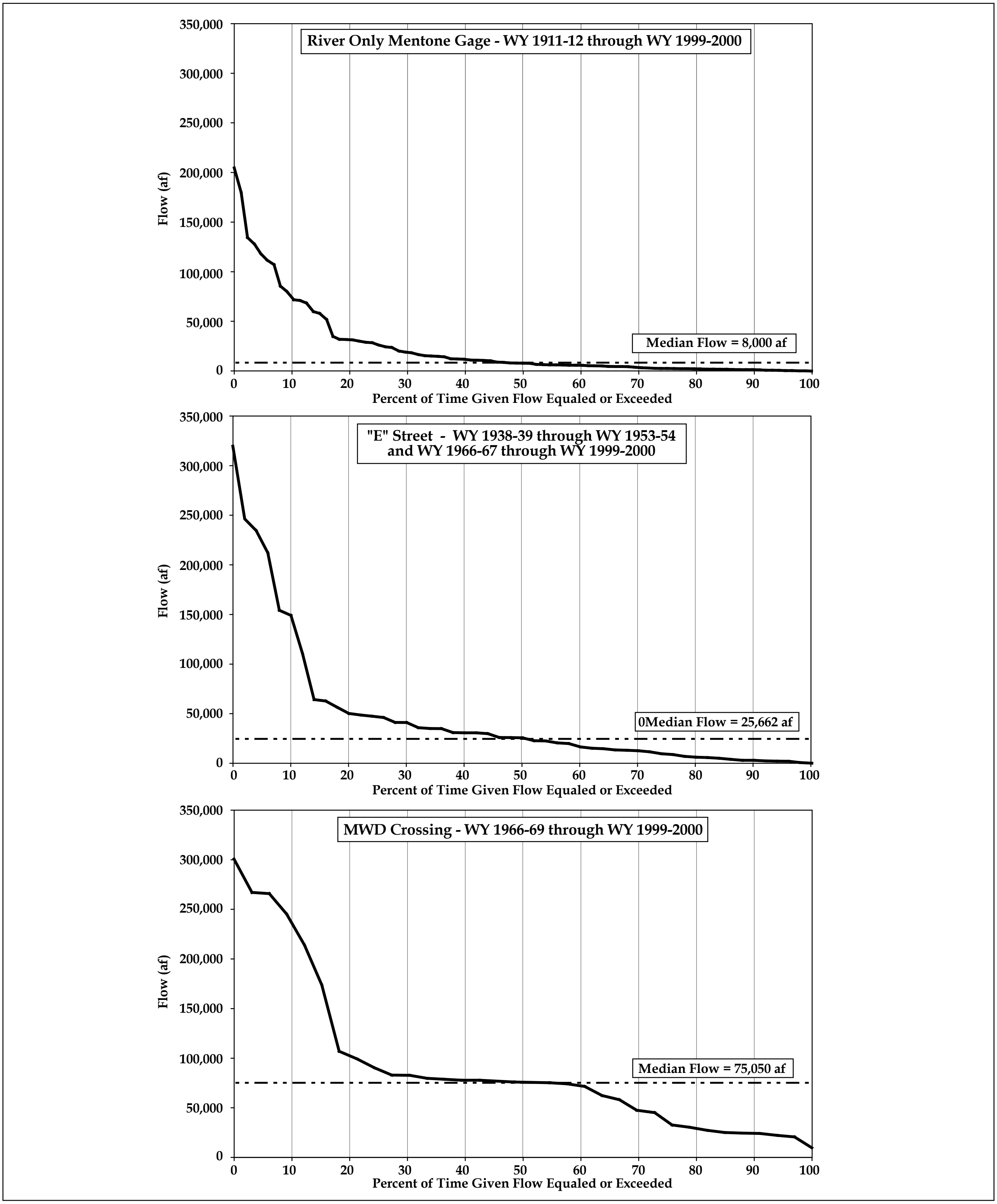

Figure 2.2-3. Probability of Annual Flow at the River Only Mentone, "E" Street, and MWD Crossing Gages

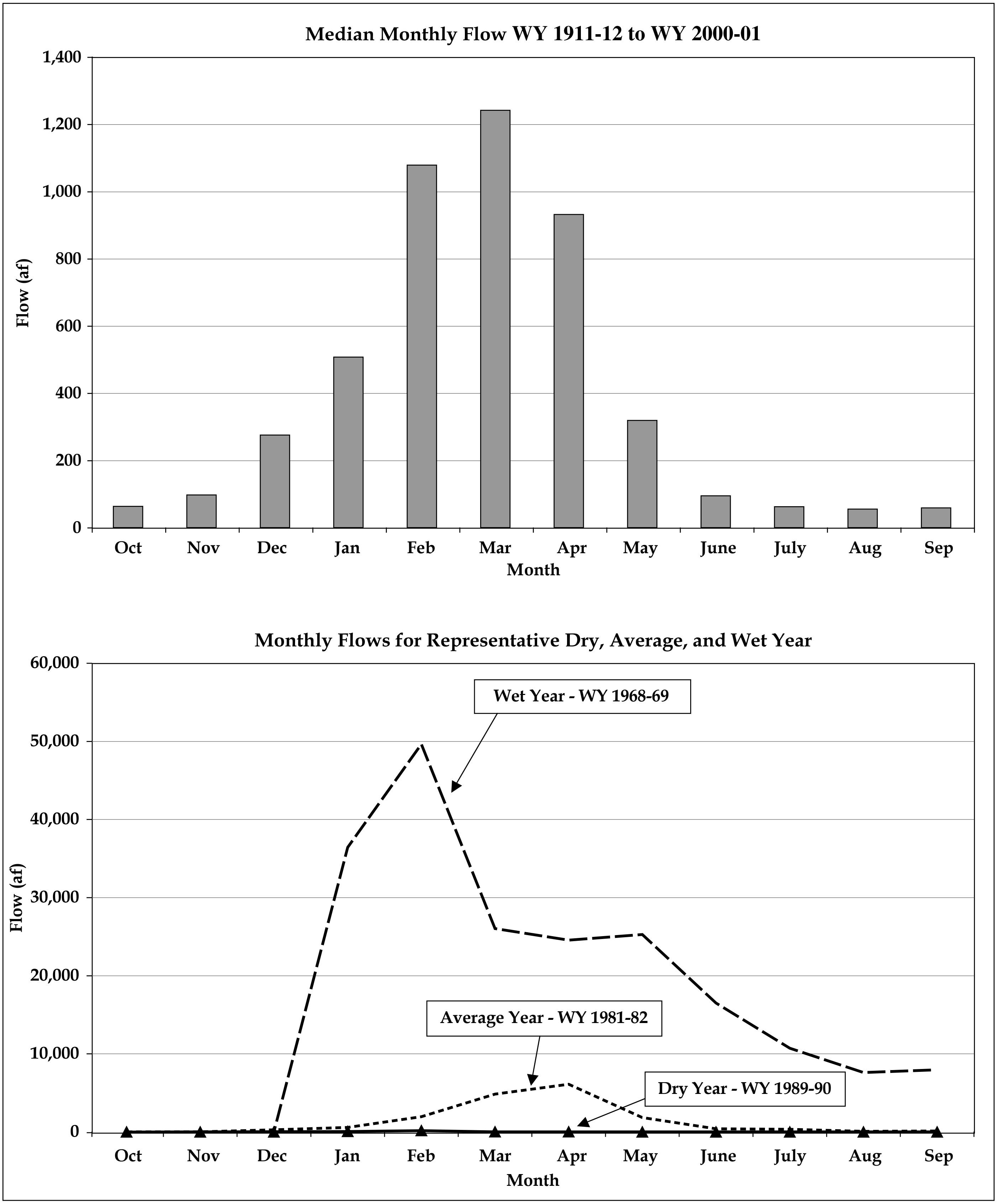

Figure 2.2-4. Variability in Monthly Flow, Santa Ana River at River Only Mentone Gage

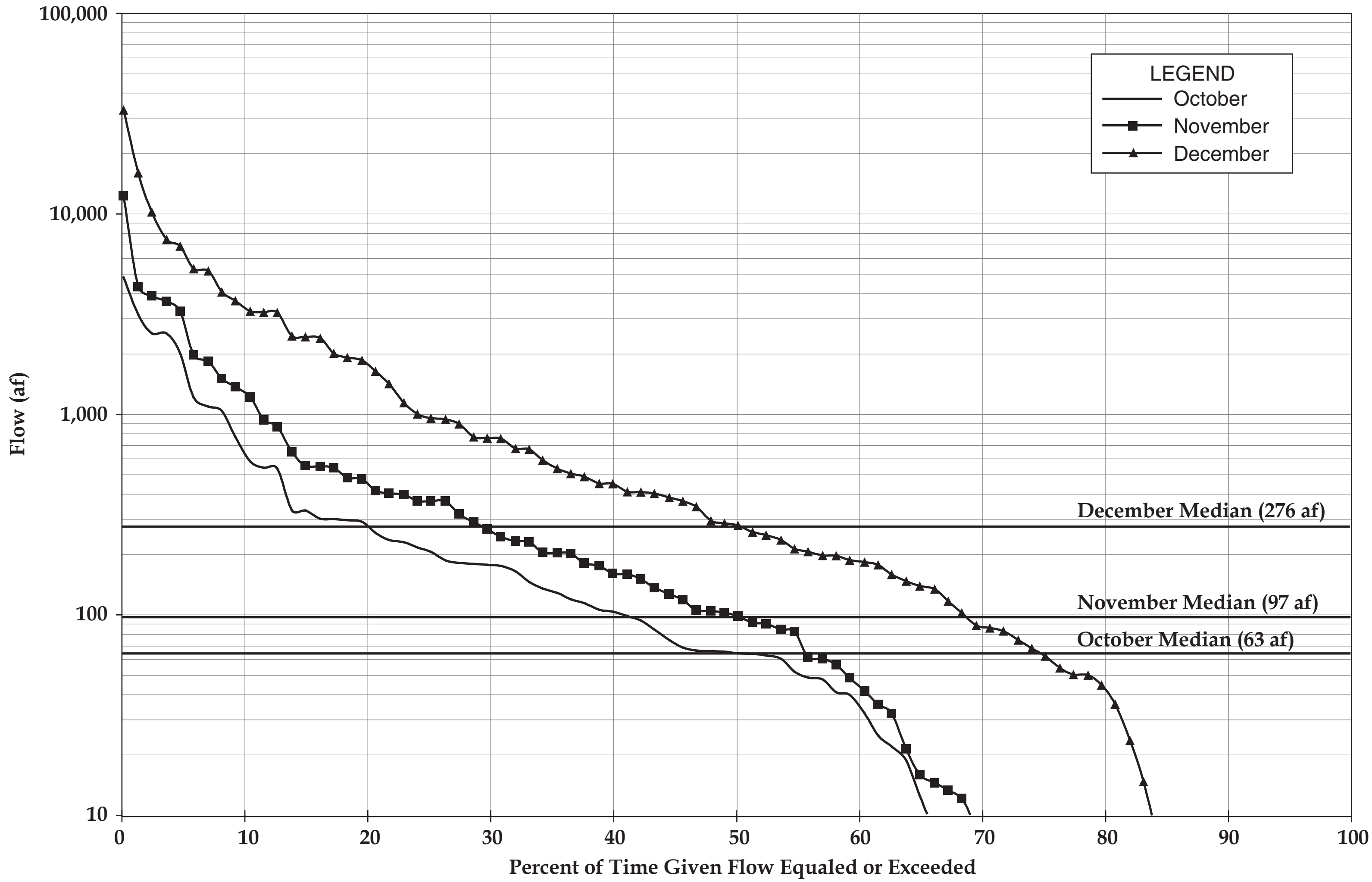

Figure 2.2-5. Probability of Monthly Flow at River Only Mentone Gage, Months of October, November, and December (WY 1911-12 to WY 1999-2000)

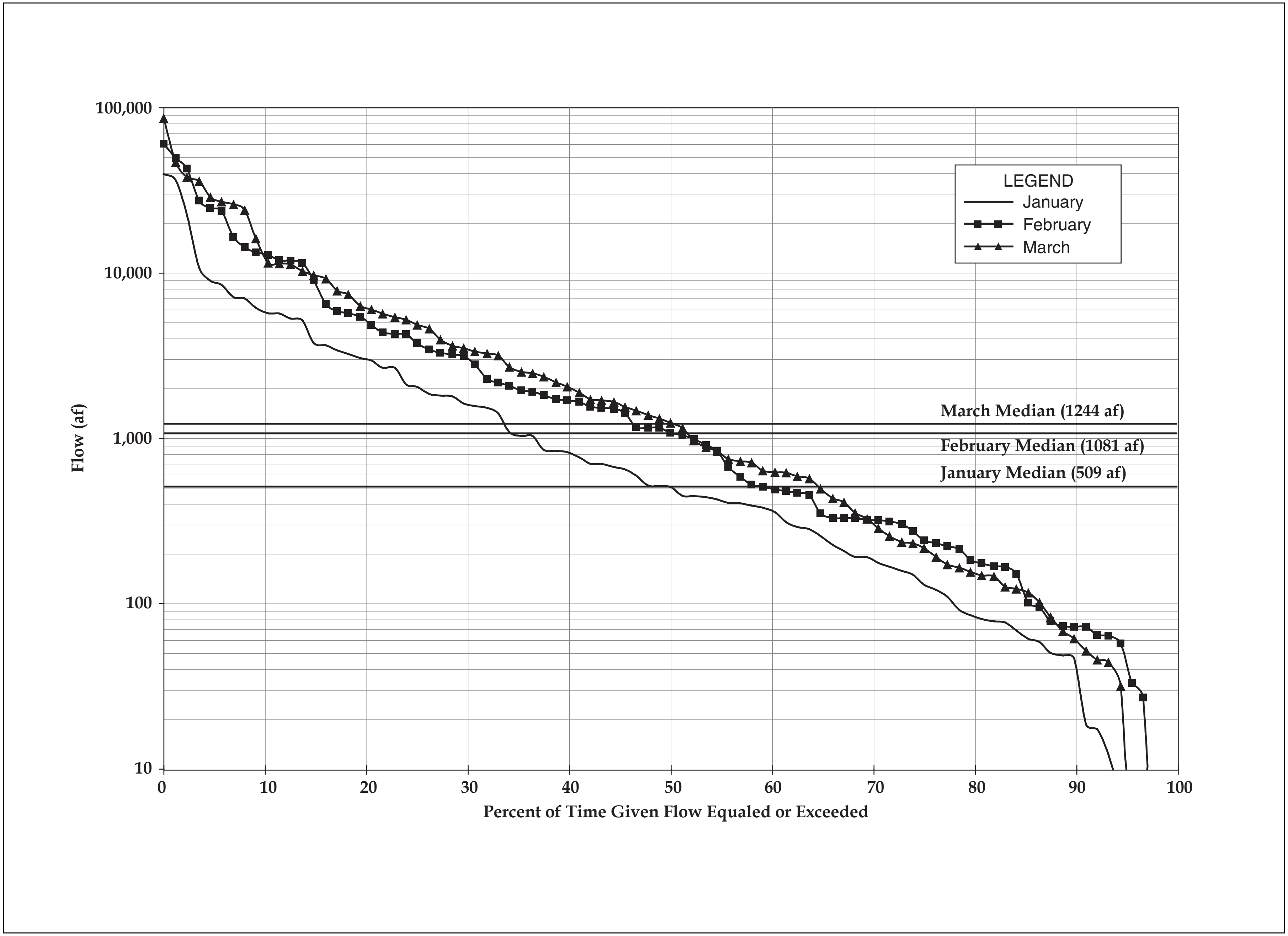

Figure 2.2-6. Probability of Monthly Flow at River Only Mentone Gage, Months of January, February, and March (WY 1911-12 to WY 1999-2000)

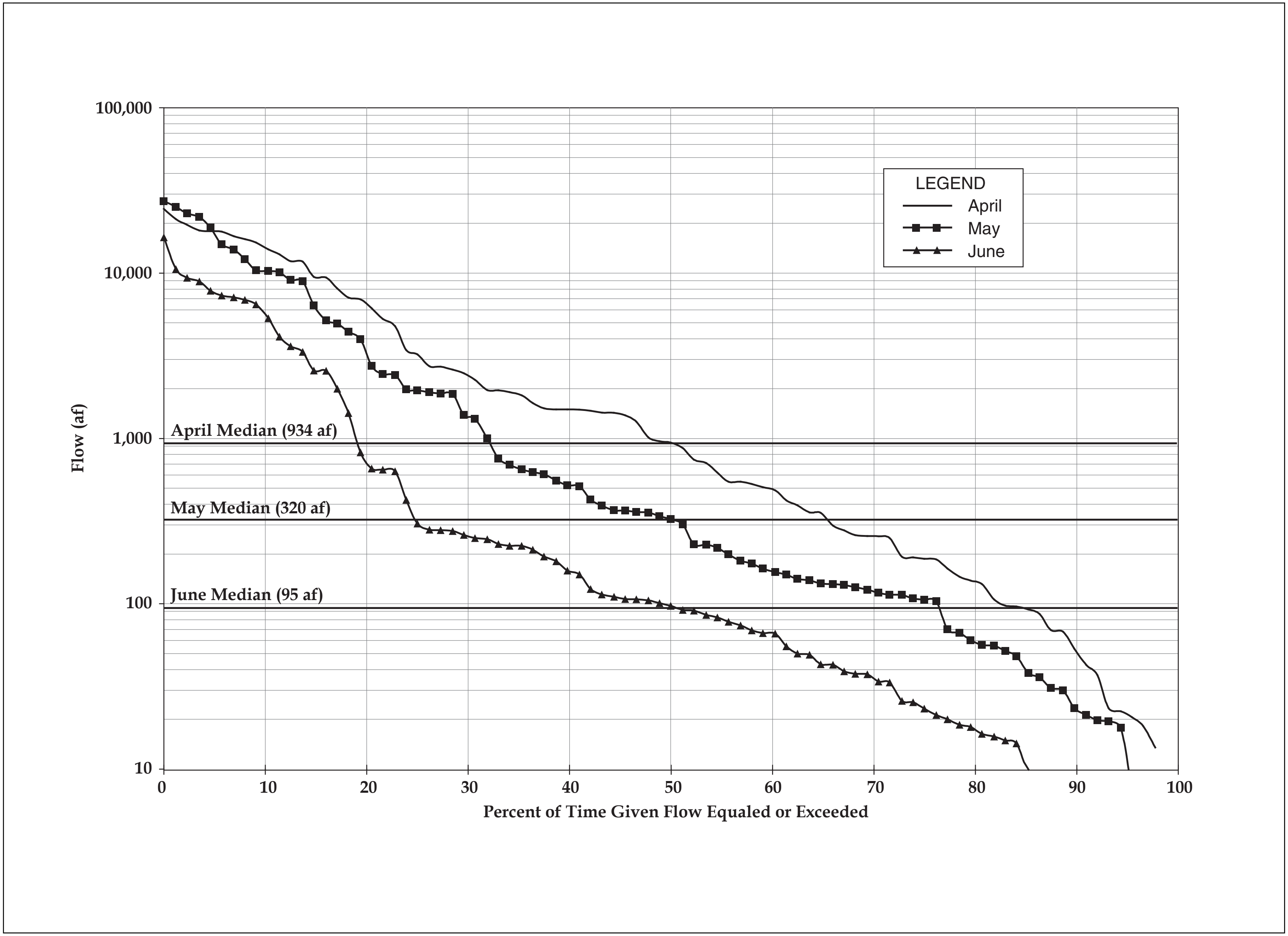

Figure 2.2-7. Probability of Monthly Flow at River Only Mentone Gage, Months of April, May, and June (WY 1911-12 to WY 1999-2000)

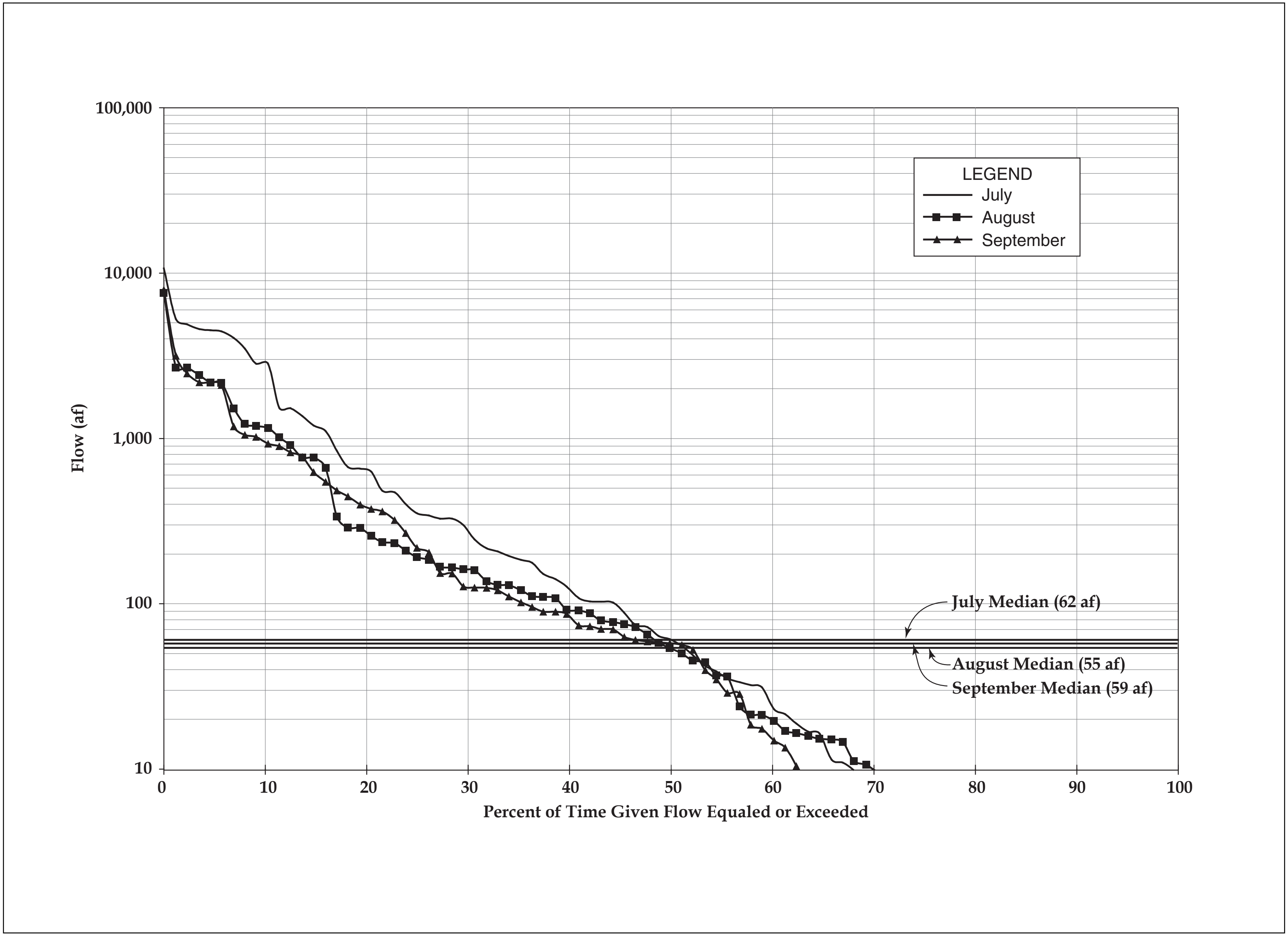

Figure 2.2-8. Probability of Monthly Flow at River Only Mentone Gage, Months of July, August, and September (WY 1911-12 to WY 1999-2000)

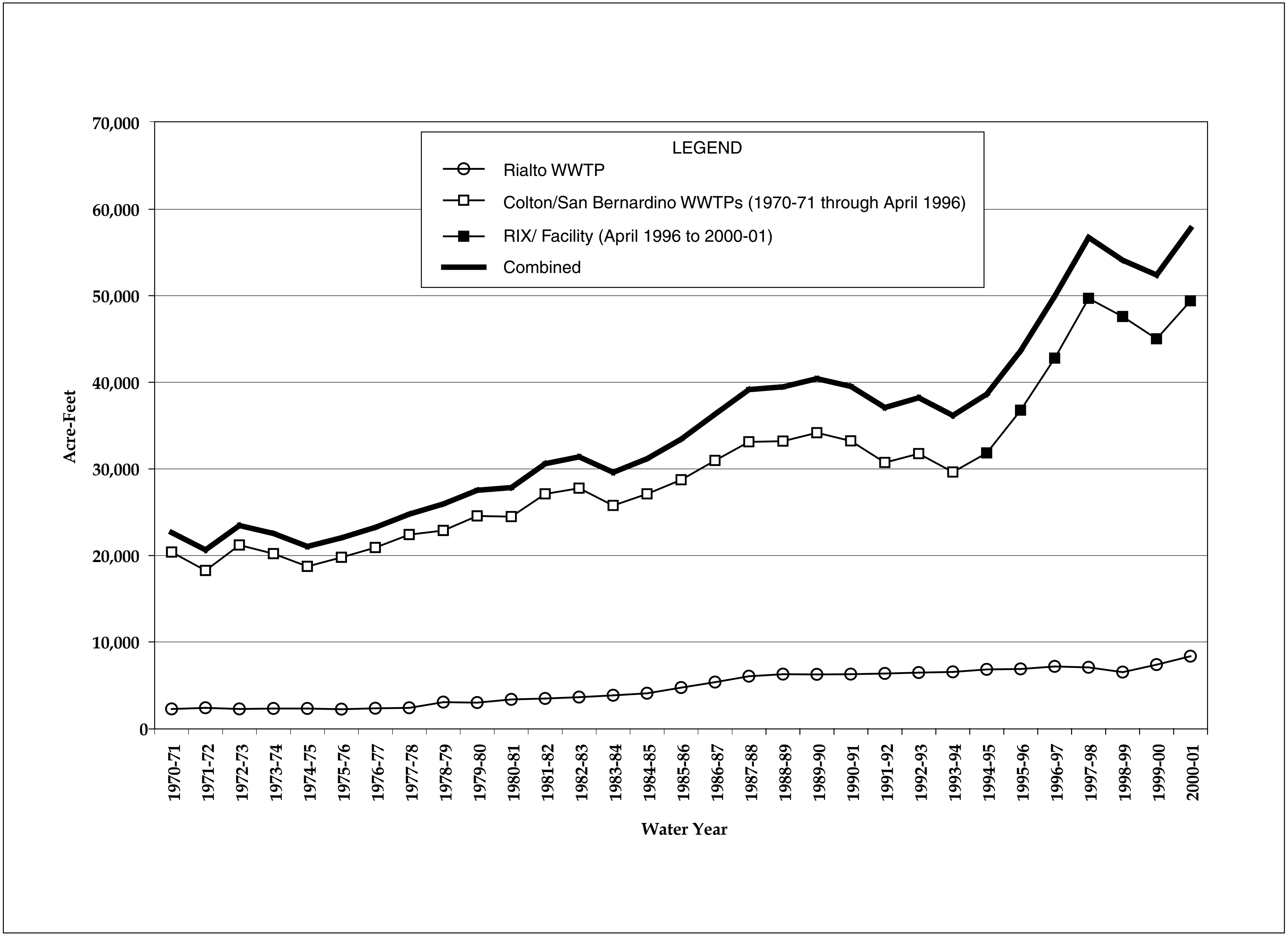

Figure 2.2-9. Wastewater Discharges to Santa Ana River above Riverside Narrows, WY 1970-71 through WY 2000-01

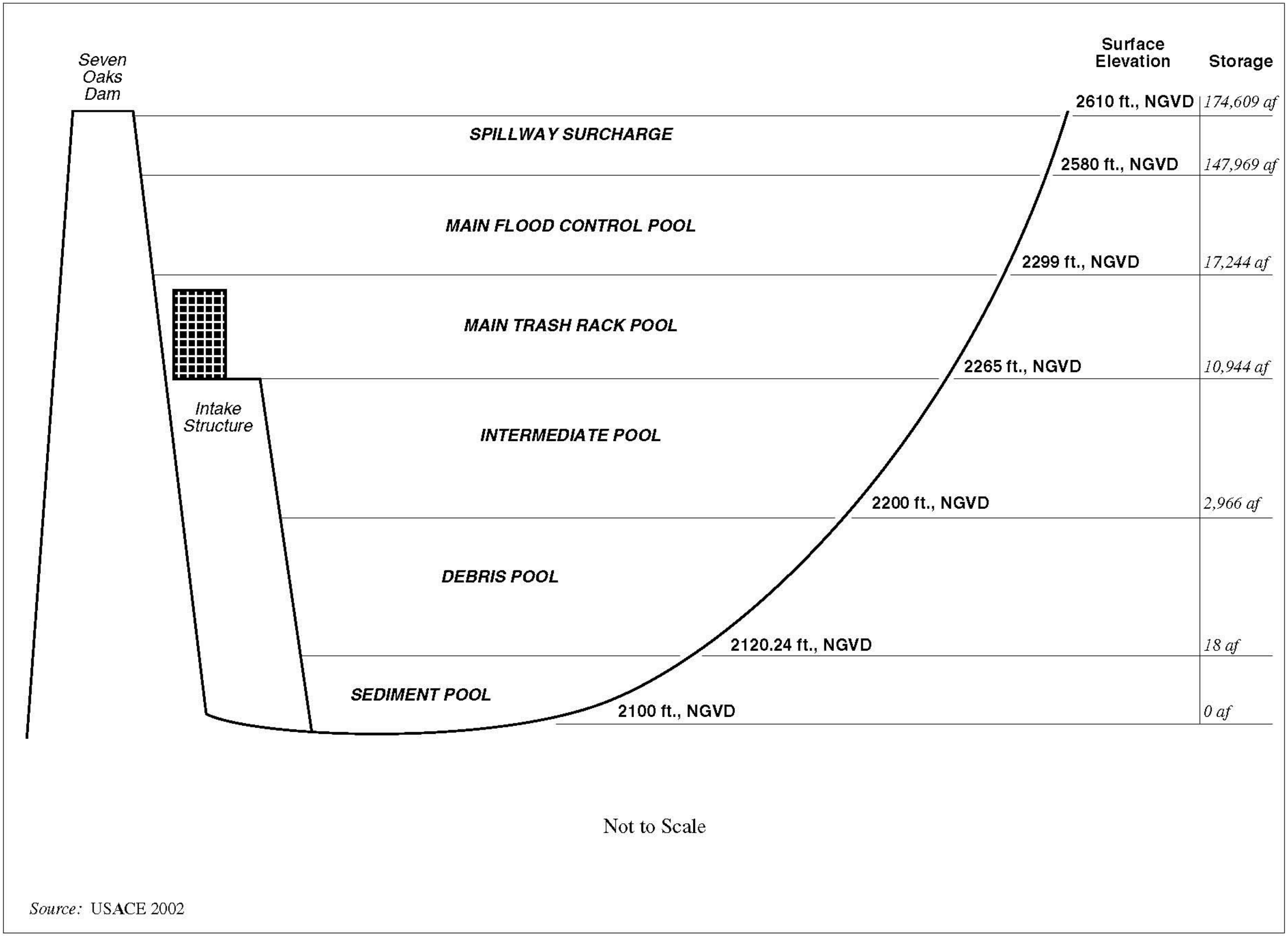

Figure 2.2-10. Seven Oaks Reservoir Levels

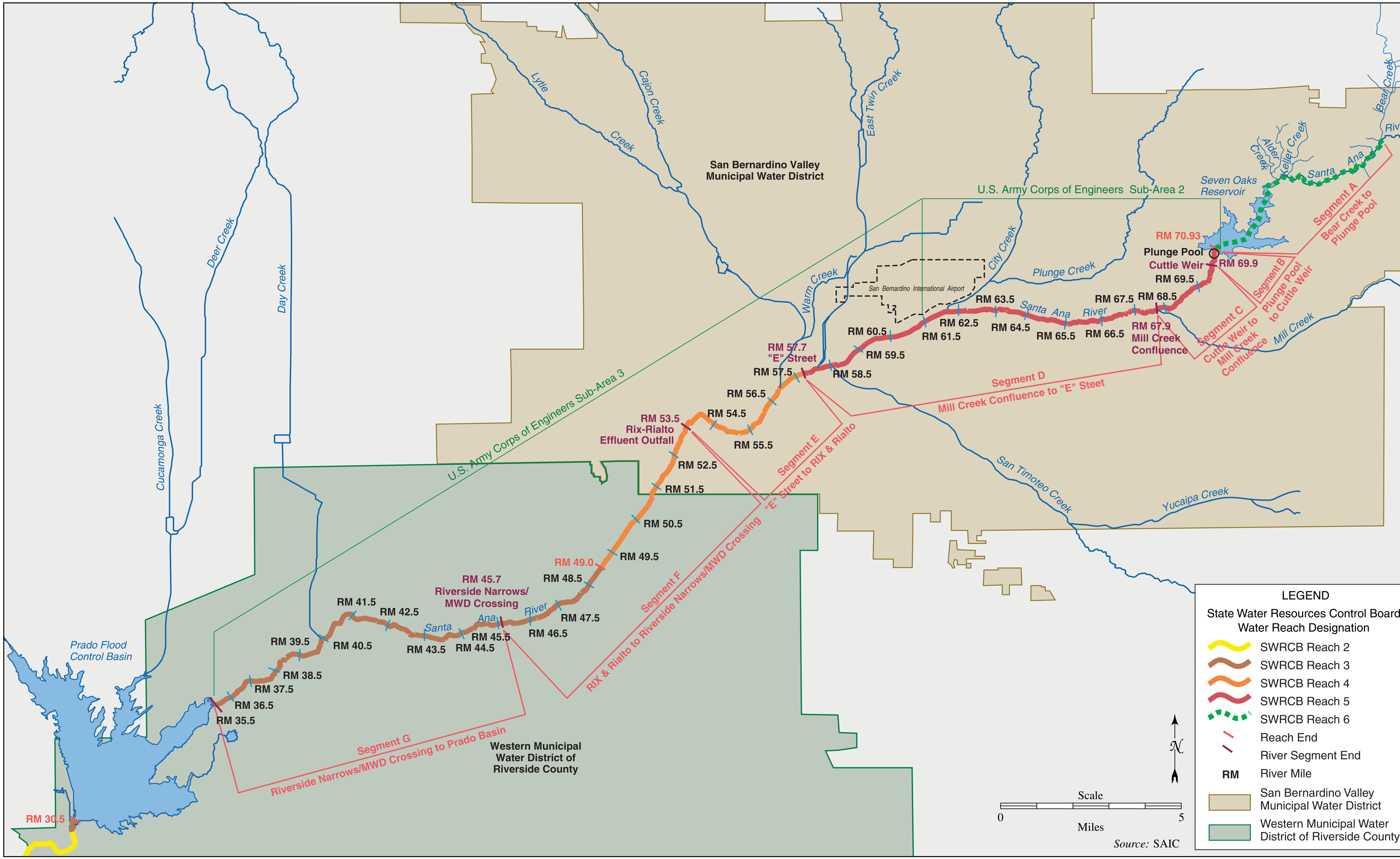

Figure 2.3-1. Santa Ana River, Tributaries, and Segment Indicators

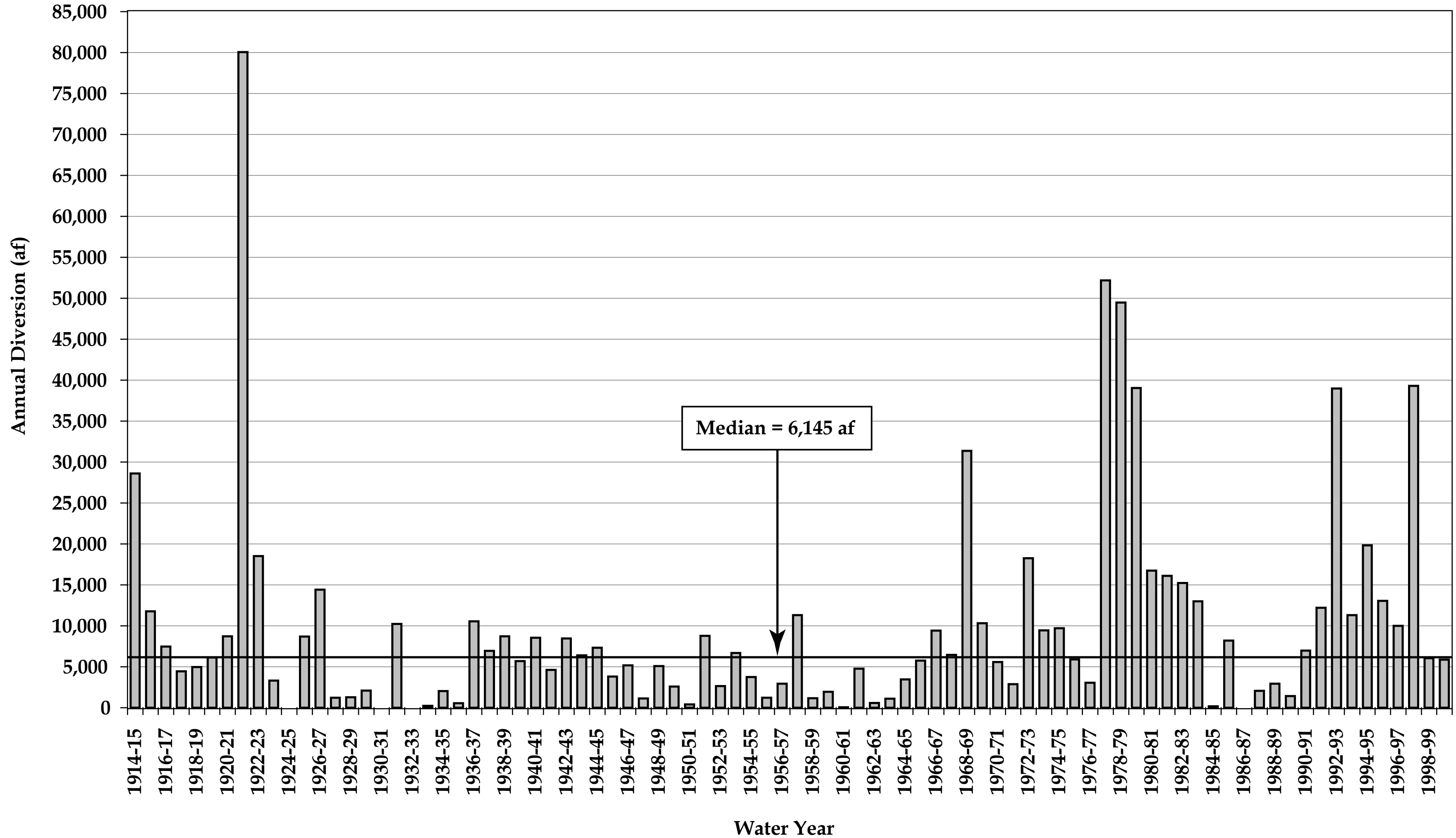

Figure 2.4-1. San Bernardino Valley Water Conservation District Annual Santa Ana River Diversions, WY 1914-15 through 1998-99

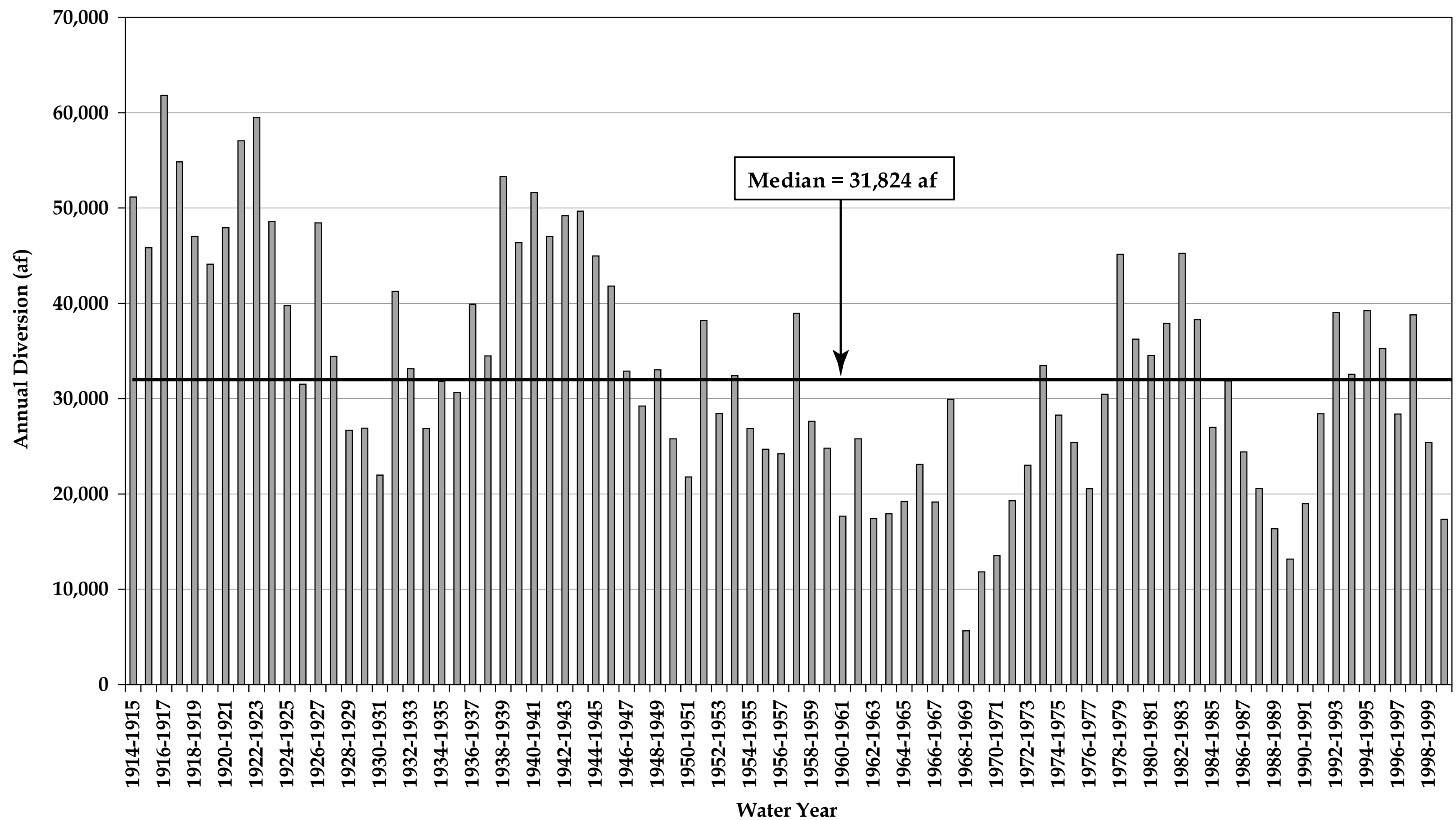

Figure 2.5-1. Southern California Edison Company Canal USGS Gaging Station 11049500, WY 1914-15 through 1998-99

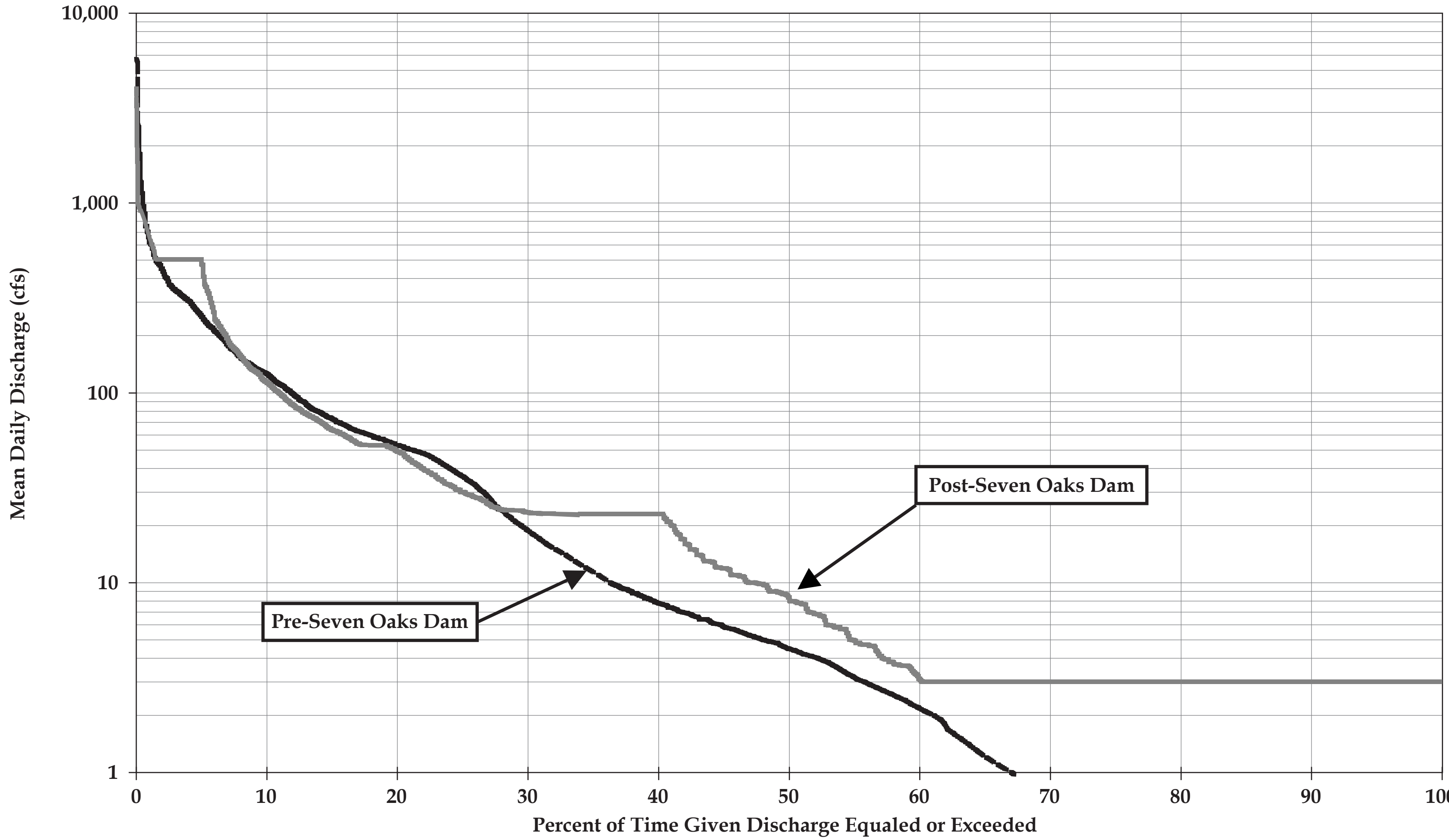

Figure 2.5-2. Probability of Daily Discharge for SAR Segment B, above Cuttle Weir, WY 1966-67 through WY 1999-2000

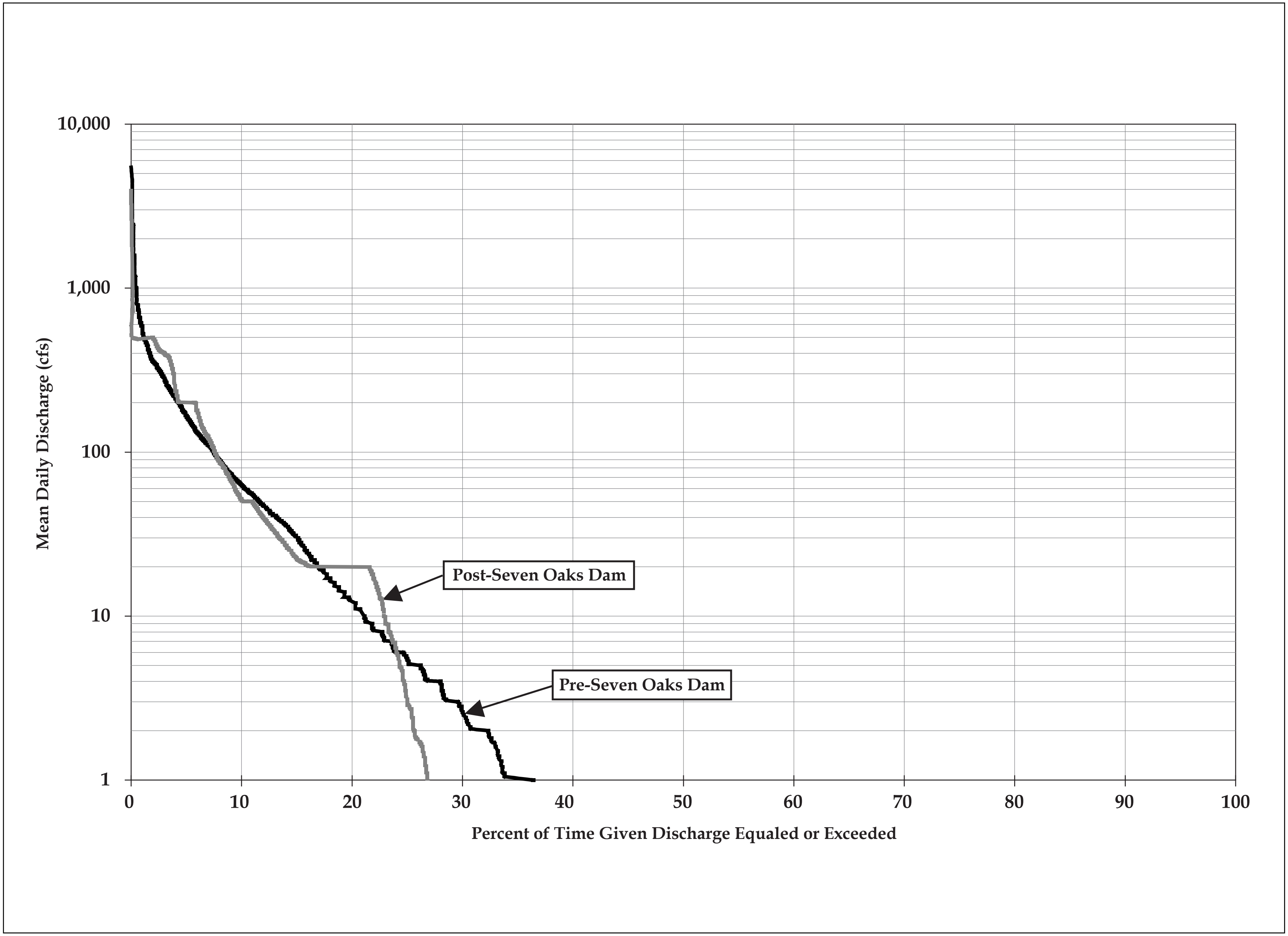

Figure 2.5-3. Probability of Daily Discharge for SAR Segment C, below Cuttle Weir, WY 1966-67 through WY 1999-2000

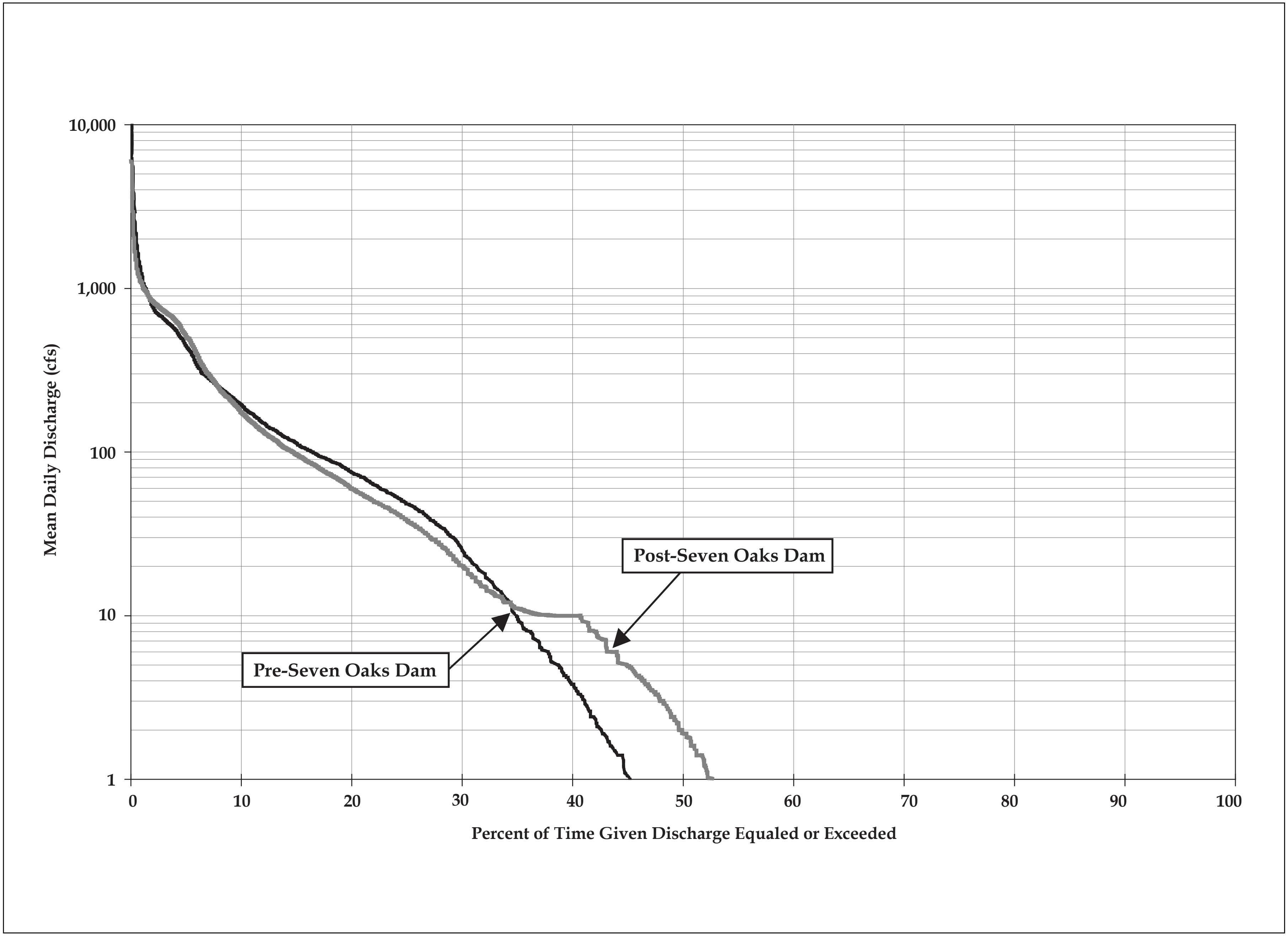

Figure 2.5-4. Probability of Daily Discharge for SAR Segment D, below Mill Creek, WY 1966-67 through WY 1999-2000

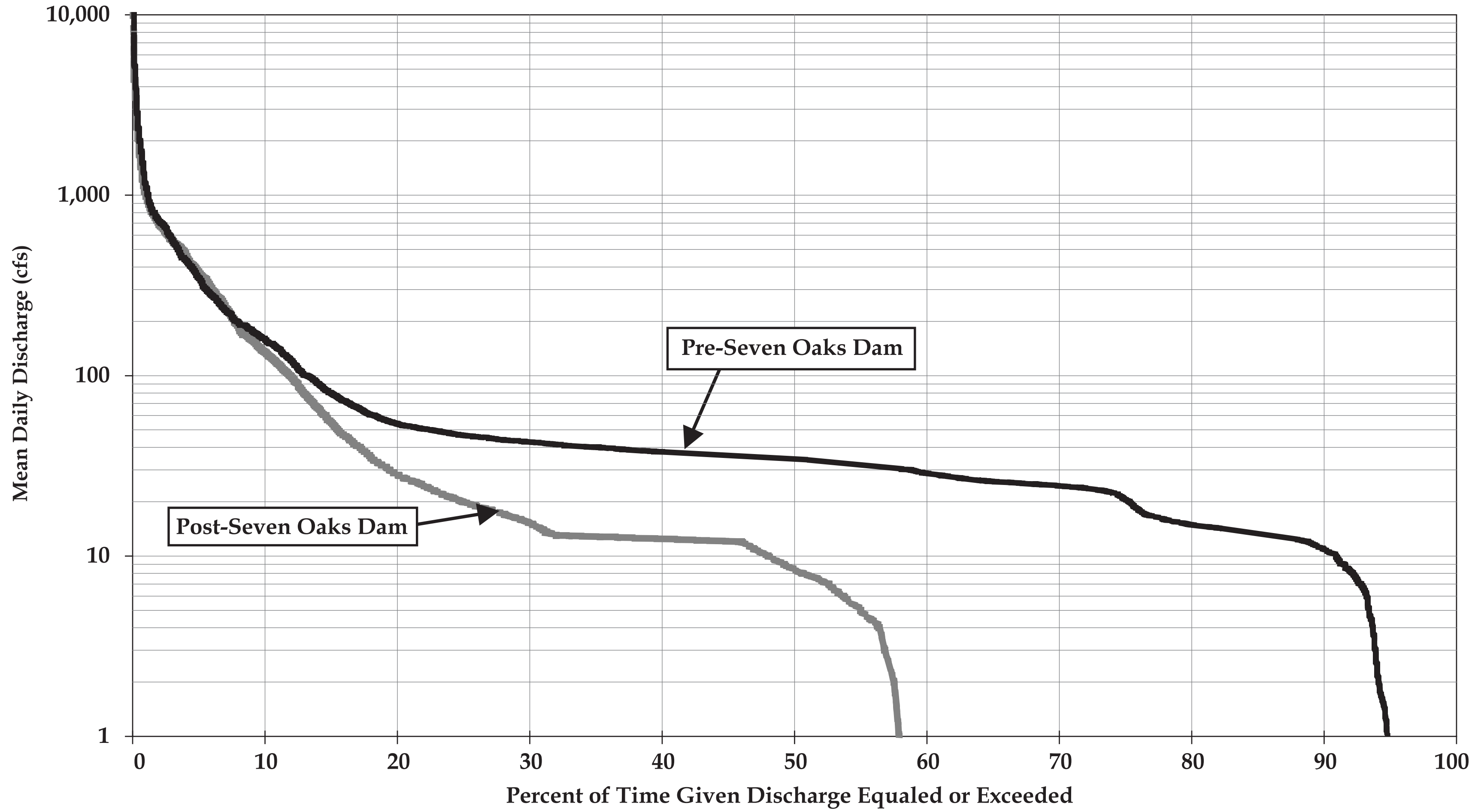

Figure 2.5-5. Probability of Daily Discharge for SAR Segment E, below "E" Street Gage, WY 1966-67 through WY 1999-2000

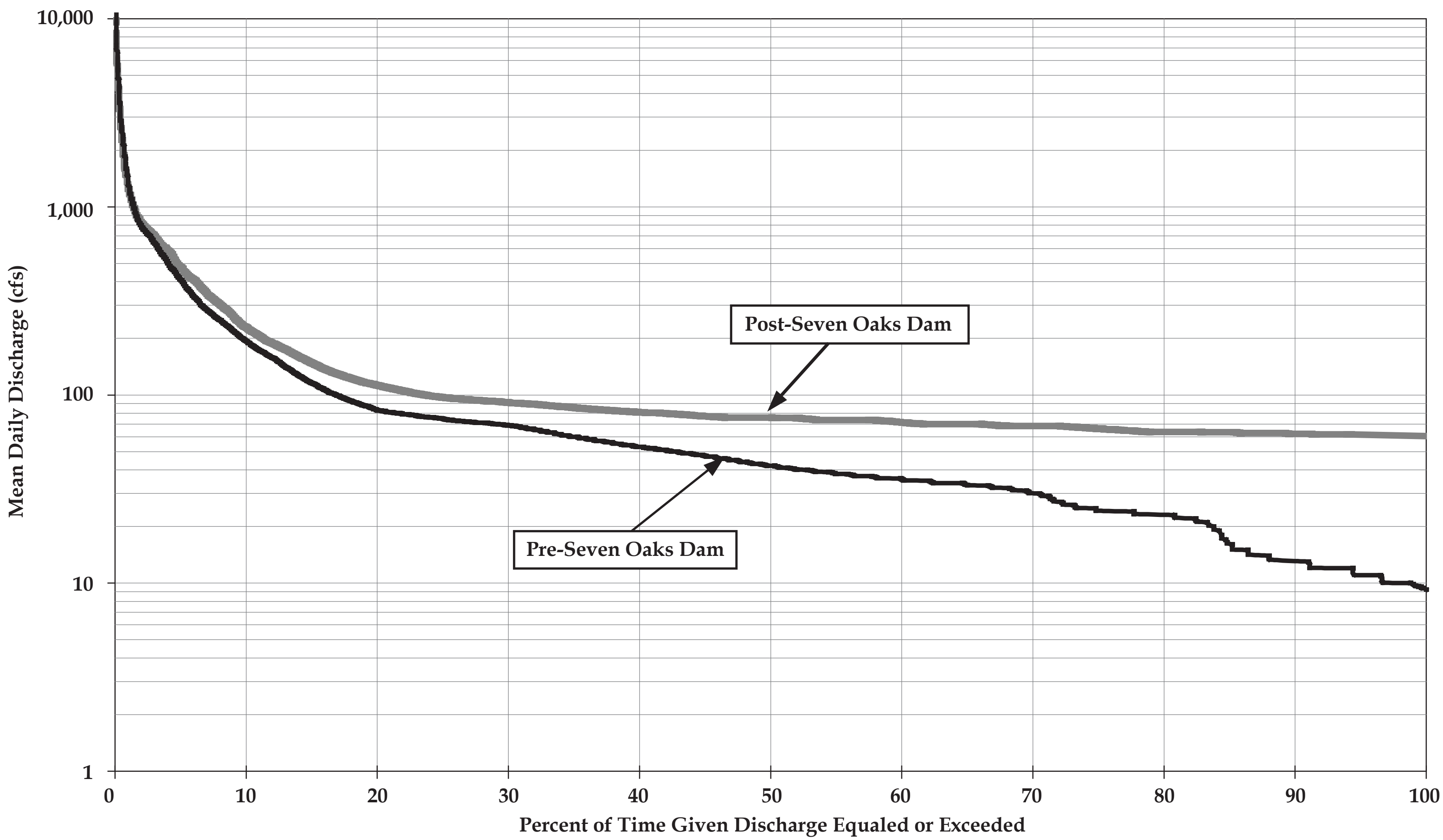

Figure 2.5-6. Probability of Daily Discharge for SAR Segment F, below RIX and Rialto Effluent Outfall, WY 1966-67 through WY 1999-2000

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3.0 HYDROLOGIC BASE PERIOD DETERMINATION

3.1 INTRODUCTION

A hydrologic base period is the period of time over which a water balance (hydrologic budget) is evaluated. Selection of a base period that represents long-term hydrologic conditions is necessary prior to conducting surface water and groundwater modeling of the SAR and San Bernardino Basin Area (SBBA), respectively. The time period selected as the base period should have the following characteristics:

- Average precipitation of the base period is approximately equal to the average precipitation of the entire period of record;
- Average runoff of the base period is approximately equal to the average runoff of the entire period of record;
- Contain periods of wet, dry, and average hydrologic conditions;
- Be sufficiently long to contain data representative of the averages, deviations from the averages, and extreme values of the entire historical period (typically a 20- to 30-year period, suggested by Mann [1968]);
- Contain a dry trend at both the beginning and end of the period in order to minimize the difference between the amount of water in transit in the soil at either end of the base period (Nevada Division of Water Resources 2000); and
- Be representative of recent environmental and cultural conditions (e.g., land use, extent of urbanization, urban runoff) for the purpose of using the base period in forecasting models.

For OPMODEL, Allocation Model, and the groundwater model, the base period selected to represent average hydrologic conditions was WY 1961-62 through 1999-2000 (a 39-year period). Due to data limitations, the base period selected for the non-storm flow portion of River Analysis is shorter, i.e., WY 1966-67 to WY 1999-2000 (a 34-year period).

3.2 DETERMINING THE APPROPRIATE BASE PERIOD USING RAINFALL DATA

For purposes of assessing potential base periods relative to historic rainfall conditions, data describing average annual precipitation at the San Bernardino County Hospital recording station for WYs 1883-84 to 2001-02 was used.

A useful way of illustrating trends and possible cycles in time series data is to plot the annual cumulative departure from the long-term average (mean). Figure 3.2-1 illustrates the cumulative departure from the long-term average annual rainfall over the period WY 1883-34 to WY 2001-02 at the San Bernardino County Hospital recording station. The cumulative departure can be viewed as a running total: in a succession wet years the curve trends upward; in a succession of dry years the curve trends downwards. Examples of periods with above average rainfall are WY 1933-34 through WY 1943-44 and WY 1976-77 through WY 1981-82. Conversely, a declining segment of the curve represents years of below-average rainfall, e.g., WY 1889-90 through

WY 1902-03, WY 1957-58 through WY 1963-64, WY 1981-82 through WY 1988-89, and WY 1997-98 through WY 2001-02. For example, in Figure 3.2-1, the value for WY 1945 indicates that the cumulative average annual departure from the mean from the beginning of the record was more than 300 percent, i.e., over three times the long-term average annual rainfall.

Points where the graphed line crosses zero percent on the vertical axis represent a point in time where the cumulative departure from the mean has "balanced out", i.e., above-average and below-average precipitation years equal each other. As can be seen in Figure 3.2-1, over the period WY 1963-64 through WY 2001-02, the graphed line deviates relatively little from zero percent, and crosses zero percent on five different occasions.

3.3 DETERMINING THE APPROPRIATE BASE PERIOD USING RUNOFF DATA

For purposes of base period determination, runoff is assumed to be represented by historic measurement of flows in the SAR near Seven Oaks Dam. The runoff is based on data from the USGS Combined Flow Mentone River Gage (USGS Gage Number 11051501) for the period WY 1913-14 to 2000-01. As described in Chapter 2.0, this record includes data from three gages near the Seven Oaks Dam site that, additively, best describe flows in the SAR near Seven Oaks Dam.

Using data from the Combined Flow Mentone River Gage for the period WY 1913-14 to WY 2000-01, Figure 3.2-2 illustrates the cumulative departure from the long-term average. As shown, the cumulative departure from the average annual runoff in WY 1926-27 and again in WY 1942-43 is more than 700 percent. This indicates that the years leading up to both these peaks had higher than average stream flow. Over the period WY 1962-63 to WY 2000-01, the graph oscillates above and below zero percent. The beginning and ending points of the base period are slightly above zero percent and the cumulative departure from the average of the beginning and end points of the base period differ by 6 percent. This indicates an approximately equal number of above-average and below-average periods of runoff.

3.4 SELECTION OF A BASE PERIOD

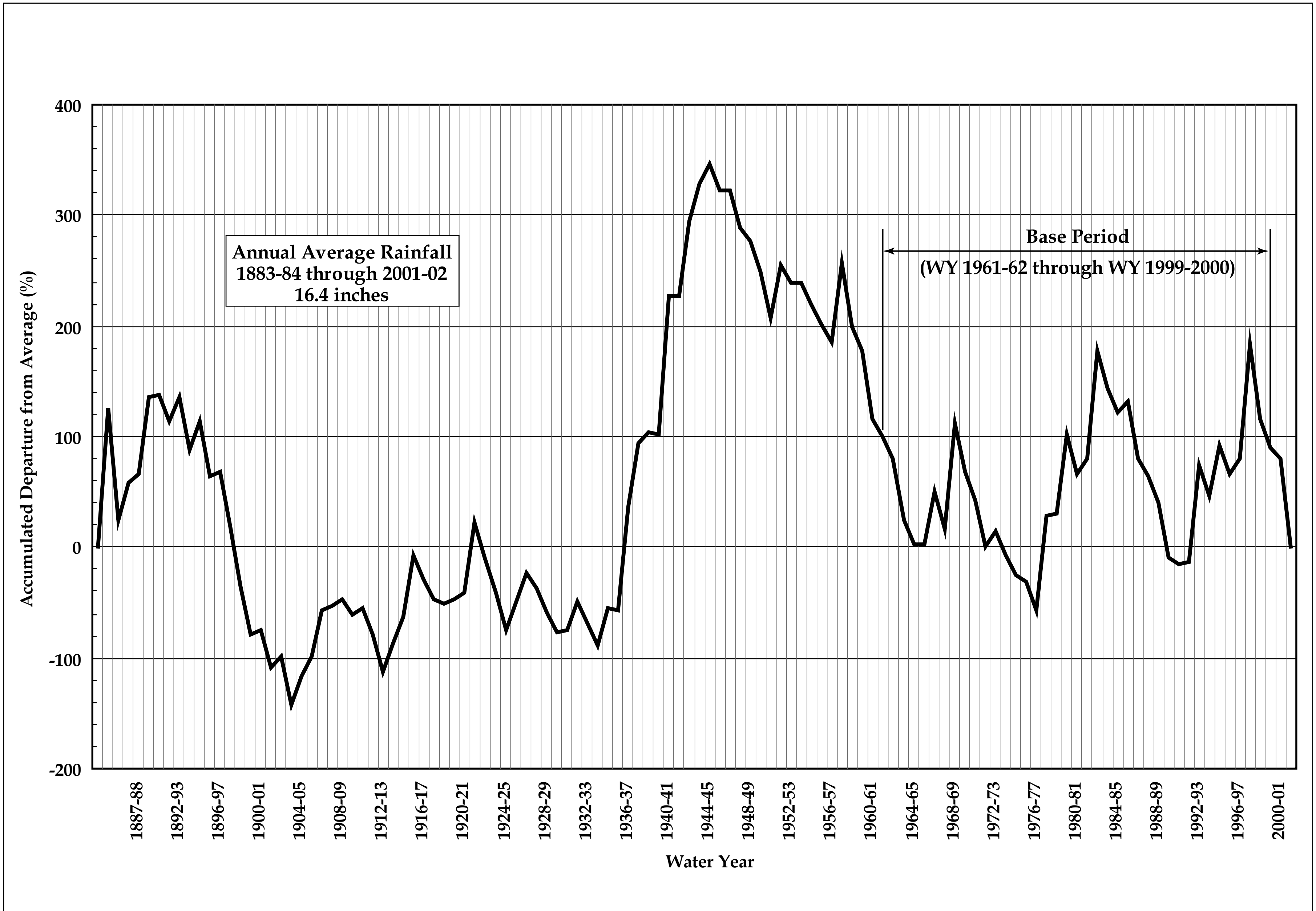
Based on the analyses of precipitation and runoff, a series of potential base periods were examined, all of which ended in WY 1999-2000 so as to reflect recent environmental and cultural conditions (WY 1999-2000 is the latest year for which verified groundwater pumping data was available) (see Table 3.4-1). The potential base periods selected ranged from WY 1959-60 through WY 1999-2000 to WY 1967-68 through WY 1999-2000. Because of limitations in verified pumping data (data needed for the groundwater analysis), the base period could not extend past WY 1999-2000. As shown in Table 3.4-1, of the potential base periods assessed, WY 1961-62 to WY 1999-2000 had the best fit for both consistency with long-term average precipitation and consistency with long-term average runoff. The cumulative deviation from the mean precipitation for the base period WY 1961-62 to WY 1999-2000 varies by only 10 percent from the long-term average at the San Bernardino County Hospital recording station. Values for other potential base periods vary between +88 and -88 percent. The same base period (WY 1961-62 to WY 1999-2000) has the lowest cumulative departure from the long-term average runoff (6 percent). This period, WY 1961-62 to WY 1999-2000, is long enough to contain data representative of wet, dry, and average hydrologic conditions. This period also begins and ends at the conclusion of a dry trend, meaning the difference between the amount of water in transit in soil at either end of the base period is minimal. Weighing the results of the analyses of both precipitation and runoff patterns, the base period WY 1961-62 to WY 1999-2000 was selected for OPMODEL, Allocation Model, and the groundwater model. Due to limitations in available data, the base period used within the non-storm portion of River Analysis was WY 1966-67 to WY 1999-2000.

Table 3.4-1. Potential Base Periods

Potential Base Period [a]	Number of Years	Percent Deviation from Long-Term Average Precipitation *San Bernardino County Hospital Recording Station*	Percent Deviation from Long-Term Average Runoff *USGS Combined Record at Mentone Gage*
WY 1959-60 to 1999-2000	41	-88	-122
WY 1960-61 to 1999-2000	40	-25	65
WY 1961-62 to 1999-2000	39	-10	6
WY 1962-63 to 1999-2000	38	11	48
WY 1963-64 to 1999-2000	37	66	118
WY 1964-65 to 1999-2000	36	88	187
WY 1965-66 to 1999-2000	35	88	252
WY 1966-67 to 1999-2000	34	41	261

Notes:

a. There was no verified pumping data for WY 2000-01 at the time of base period selection (February 2003). This information is required for groundwater modeling.



Source: San Bernardino County Flood Control District

Figure 3.2-1. Accumulated Departure from Average Annual Precipitation at San Bernardino County Hospital Recording Station, WY 1883-84 through WY 2001-02

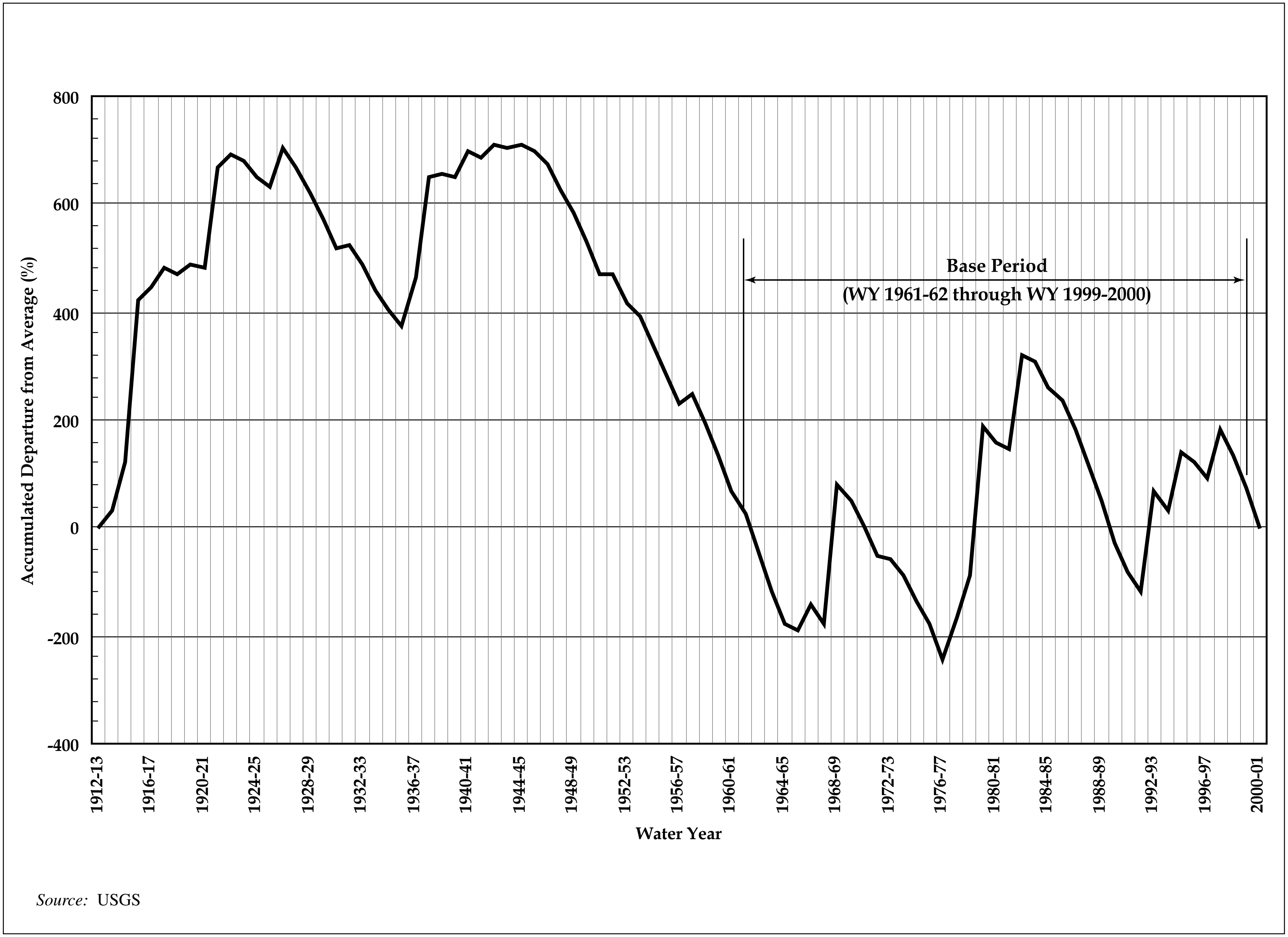


Figure 3.2-2. Accumulated Departure from Average Annual Runoff at Combined Flow Mentone Gage for WY 1913-14 through WY 2000-01

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4.0 OPERATIONS MODEL (OPMODEL)

4.1 OVERVIEW OF OPMODEL

OPMODEL was developed to estimate the quantity of unappropriated SAR water available for diversion by Muni/Western after accounting for diversions by prior water rights holders. This model, simulates monthly releases that could be made from Seven Oaks Dam under a variable set of conditions. Estimates of the quantities of unappropriated water are influenced by a number of factors, the most critical of which are:

- Quantity of diversions by senior water rights claimants;
- Diversions by the Conservation District;
- Releases designed to accomplish habitat restoration as prescribed by the USFWS BO for flood control operations of Seven Oaks Dam; and
- Operation of Seven Oaks Dam for either flood control or flood control with seasonal storage.

4.2 GENERAL DESCRIPTION AND PURPOSE OF OPMODEL

Muni/Western have two applications pending before the SWRCB to divert up to 200,000 afy of SAR surface water. The quantities requested in these applications rest on a determination of the potential amount of water available for appropriation once all prior rights have been fulfilled. Muni/Western developed a water accounting model to estimate the quantity of unappropriated water that is available for diversion. This model is referred to as OPMODEL and is implemented through a set of linked spreadsheets.

OPMODEL provides monthly estimates of the amount of water Muni/Western could divert from the SAR based on a number of assumptions regarding existing water rights, operation of Seven Oaks Dam, and other factors. The initial input to OPMODEL is an estimate of SAR surface water inflow to Seven Oaks Reservoir. There is no gage to measure this quantity, and, thus, it is necessary to develop an estimate. This SAR surface water inflow is referred to as the synthesized hydrology of the SAR and is based primarily on USGS historical data recorded at the Mentone Gage modified to reflect current operating conditions of Bear Valley Dam located upstream of Seven Oaks Dam.

Another basic assumption underpinning OPMODEL is that, once all pre-existing water rights claims are satisfied, the remaining water, i.e., unappropriated water, is available for diversion by Muni/Western. First, water is distributed to senior water rights claimants (Bear Valley Mutual-Water Company, Lugonia Water Company, North Fork Water Company, and Redlands Water Company), and the Conservation District. After this, water is allotted for releases from Seven Oaks Dam as called for under the terms of the BO issued in December 2002 by the USFWS for downstream habitat restoration. The amount of SAR surface water remaining is available for potential diversion by Muni/Western.

A monthly time-step was chosen for OPMODEL because of data availability and because a volumetric estimate of the amount of water available for Muni/Western diversion is needed. Synthesized flow for the SAR based on the re-operation of Big Bear Lake and diversions by the Conservation District are available on a monthly basis. Output from OPMODEL is used in the Allocation Model, which also uses a monthly time-step.

The results of OPMODEL that are most pertinent to the EIR are estimates of: (i) unappropriated water available to Muni/Western for diversion; and (ii) water remaining un-diverted and contributing to flow in the SAR. As described earlier, this information is used as input to two models employed in analyses designed to address issues in the EIR: the Allocation Model and the groundwater model (see Figure 1-1).

OPMODEL contains four main parameters or conditions, the values of which influence model results. Depending on the combination of parameter values, a range of unappropriated SAR surface water is potentially available for diversion by Muni/Western. These main parameters (which are described in more detail in subsequent sections) that affect the quantity of water available for diversion by Muni/Western are:

1. Diversions by senior water rights claimants (ranging between their historical diversions and up to 88 cfs);
2. Diversions by the Conservation District (historical or licensed);
3. Releases of SAR surface water from Seven Oaks Dam to accommodate habitat restoration (up to 1,000 cfs for 2 days when water is available); and
4. Operation of Seven Oaks Dam for flood control or seasonal storage.

The amounts of unappropriated SAR surface water in any given year depend on the values of these parameters. A number of OPMODEL simulations reflecting combinations of these parameters were made in order to determine the extreme (high and low) quantities of potential unappropriated SAR surface water.

After the first three uses of SAR surface water are met, any water that is released from Seven Oaks Dam is available for diversion by Muni/Western, up to their specified diversion rate. Muni/Western diversions would not exceed 200,000 af in any water year. After all diversions are made, including those of Muni/Western, any SAR surface water not diverted is assumed to flow down the river.

The following sections provide a detailed description of the logic used in OPMODEL and provide the reader with details regarding: (i) model structure; (ii) model input, parameters, and assumptions; (iii) model application; and (iv) model results.

4.2.1 Model Structure

Figure 4.2-1, presents a flowchart illustrating the structure of OPMODEL. Estimates of inflow to, and storage within, Seven Oaks Reservoir is based upon USGS gage data which has been modified to reflect current operations of Big Bear Lake pursuant to the 1977 Judgment and diversions by senior water rights claimants. The senior water rights claimants take water above

Seven Oaks Dam via the SCE Canal and via the Auxiliary Diversion below the dam. Storage of surface water inflow is augmented by up-welling groundwater that is intercepted by the grout curtain underlying Seven Oaks Dam and is reduced by evaporation from the reservoir surface. Releases from Seven Oaks Dam depend on the resulting reservoir storage and whether the dam is operated for flood control purposes or for a combination of flood control and seasonal storage. The major parameters of OPMODEL are outlined in Table 4.2-1.

Table 4.2-1. Water Uses in OPMODEL

Parameter	*Parameter Type*	*Value in Model*
Diversions by senior water rights claimants	Variable	Range between historical diversions and up to 88 cfs
Interception and Release of Groundwater Underflow at Seven Oaks Dam (credited to senior water rights claimants)	Constant	3 cfs
Reservoir Evaporation	Variable	Average reservoir surface area multiplied by an evaporation rate for a given month (see Table 4.2-2)
Seasonal Storage within Seven Oaks Reservoir	Variable	Dam operated for flood control *or* Dam operated for flood control and seasonal storage
Conservation District Diversion (assuming a maximum diversion rate of 300 cfs)	Variable	Historical *or* Licensed right
Environmental Habitat Releases	Variable	1,000 cfs for 2 days at 6-month minimum interval when water is available *or* Other Habitat Treatment
Muni/Western Diversion		
Maximum Annual Diversion	Constant	200,000 af
Diversion Capacity	Variable	500 cfs to 1,500 cfs
Monthly Demand for Short-Term Beneficial Use	Variable	Iterative, derived from output of Allocation Model for Seasonal Storage

4.2.2 Model Inputs, Parameters, and Assumptions

Both Figure 4.2-1 and Table 4.2-1 provide a general outline of the various inputs to, and parameters within, OPMODEL. This section provides detailed descriptions of the data used as input to OPMODEL, the computation processes employed within the model, and the assumptions made as part of model development.

4.2.2.1 Seven Oaks Dam Inflow and Storage

U.S. Geological Survey Gage Data

Monthly inflow to Seven Oaks reservoir is derived from USGS gage records of historical SAR flow near Mentone (USGS Gage No. 11051499), at the Auxiliary Canal Gage (USGS Gage No. 11051502), and in the SCE Canal (USGS Gage No. 11049500) (see Figure 2.2-1). By using a combination of these gage records it is possible to estimate flow in the SAR both upstream and downstream of the points of diversion used by the senior water rights claimants and conveyed via the SCE Canal. As described earlier, the combination of three gages (flow near Mentone, Auxiliary Diversion, and SCE Canal), known as the "Combined Flow" Mentone Gage record, reflects historical SAR flow in the main stem upstream of senior water rights claimants points of diversion. The combination of just the Mentone Gage and Auxiliary Canal Gage is called the "River Only" Mentone record, denoted as USGS Gage No. 11051500. Within OPMODEL the simplifying assumption is made that the senior water rights claimants take all their diversions from the SCE Canal, even though they have the operational flexibility to take water that passes by Seven Oaks Dam via the Auxiliary Diversion. However, the demand at the destination of the Auxiliary Diversion can also be satisfied by conveyance through the SCE Canal.

Big Bear Lake Operations and Synthesized Santa Ana River Hydrology

Tributary flow to the SAR includes releases and spills from Big Bear Lake located at the headwaters of Bear Creek. Historically, irrigation releases were made from Big Bear Lake to meet the demand of Bear Valley Mutual Water Company and the lake spilled only during extremely wet years. Although most of the irrigation releases were diverted into the SCE Canal, at times some water remained in the SAR and contributed to historical SAR flow.

Irrigation releases made from Big Bear Lake during dry periods sometimes resulted in low water levels in the reservoir, to the detriment of recreational uses of the lake. As recreational uses increased, a revised reservoir operating policy was enacted in 1987. Per the revised reservoir operations policy, Bear Valley Mutual Water Company receives SWP water from time to time (from Muni) in lieu of water from Big Bear Lake. The resulting decrease in releases from Big Bear Lake has helped stabilize lake elevations but has, at the same time, generally reduced the amount of water that Big Bear Lake contributes to flow in the SAR and the SCE Canal. OPMODEL accounts for these changes in the operation of Bear Valley Dam and SAR hydrology through the use of a "synthesized hydrology." The synthesized hydrology estimates what Seven Oaks Dam inflow would have been over the base period had current Big Bear Lake operations been in effect during this time.

Diversions by Senior Water Rights Claimants

OPMODEL estimates historical inflow to Seven Oaks Dam under two different assumptions regarding diversions by senior water rights claimants. The diversions are based on either *historical* diversions or on a *user-specified diversion rate*. When the model is configured for historical diversions, estimates of the SAR flow entering Seven Oaks reservoir are based on historical records derived from flows measured by the "River Only" Mentone Gage.

When the model is configured to use an assumed diversion rate of up to 88 cfs, monthly inflow to Seven Oaks Reservoir is calculated as the monthly historical SAR flow as measured at the "Combined Flow" Mentone Gage minus the assumed 88 cfs allotted to senior water rights claimants. The senior water rights claimants diversion rate of 88 cfs is derived from senior water rights claimants information presented in Exhibits A and B of the Santa Ana River – Mill Creek Cooperative Water Project Agreement (Muni and Conservation District 2001). This document specifies that 9 cfs of SAR shall go to the Bear Valley Mutual Water Company and 79 cfs shall go to the North Fork Water Company, Lugonia Water Company, and Bear Valley Mutual Water Company. Of this total of 88 cfs allotted to the senior water rights claimants, 3 cfs is comprised of sub-surface flow that is intercepted by Seven Oaks Dam and subsequently released for pick up by the Redlands Tunnel. The sub-surface flow that is forced to the surface because of the grout curtain beneath the dam is released at a rate of 3 cfs to coincide with criteria stated in the USACE *Seven Oaks Dam Water Conservation Feasibility Report* (1997). Thus, 85 cfs of the senior water rights claimants diversions is delivered via the SCE Canal and, hence, diverted from the SAR upstream of the Seven Oaks Dam.

A comparison of the cumulative diversions by senior water rights claimants under the two different assumptions, historical or 88 cfs diversion rate, is presented in Figure 4.2-2.

Seven Oaks Reservoir Evaporation

Water losses from the surface of the reservoir due to evaporation are accounted for in OPMODEL. The estimated reservoir surface area each month is multiplied by an evaporation rate (see Table 4.2-2) to estimate the net average monthly volume of water lost through evaporation. Evaporation rates are taken from monthly pan evaporation rates observed at the San Bernardino County Flood Control District facility (USACE 1997 and 2000c).

Table 4.2-2. Average Net Evaporation Rates (inches per month)

OCT	*NOV*	*DEC*	*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*TOTAL*
3.64	1.58	0.01	0.17	0.21	1.11	3.07	4.88	5.70	7.93	7.34	5.22	40.86

4.2.2.2 *Operations at Seven Oaks Dam*

Seven Oaks Dam, a component of the Santa Ana River Mainstem Project, was designed to assist in providing flood protection for downstream communities. At this time, operating policies concerning monthly target storage volumes for the dam have not been finalized by USACE and, thus, the USACE is using an "Interim Operational Control Plan." Also, conservation storage is not accommodated by these policies. For this reason, OPMODEL has been designed with the flexibility to address a wide range of potential dam operations. Parameters related to dam operations have been set so as to be consistent with operating criteria specified in the *Seven Oaks Dam Water Conservation Feasibility Report* (1997), the *Interim Water Control Plan Prior to and During Section 7 Consultation Period* (January 2000), and *Initial Reservoir Filling Plan* (July 2002).

As noted in the *Seven Oaks Dam Water Conservation Feasibility Report* by USACE (1997), after the flood season has ended in any given water year, reservoir storage space, up to a specified target pool level elevation, could be used to allow controlled releases for downstream uses while providing conservation storage of SAR flows. Therefore, OPMODEL has been designed to simulate Seven Oaks Dam operations under two different assumptions – operations *with* seasonal storage and operations *without* seasonal storage. These assumptions affect dam operations, including target storage and Seven Oaks Dam releases. It is important to note that Muni/Western intend to operate Seven Oaks Dam to provide both regulatory and seasonal storage. Regulatory storage, as that term is used by the SWRCB and in this Appendix, refers to the temporary storage (i.e., less than 30 days) of water due to the fact that inflows into Seven Oaks Reservoir will, during the rainy season, exceed outflows. Seasonal storage refers to the storage of water for later delivery that begins on March 1 of each water year and continues into the summer. Muni/Western's applications for water currently pending before the SWRCB include the use of both regulatory storage (due to the presence of Seven Oaks Dam) and seasonal storage outside the flood season.

Seven Oaks Reservoir Target Storage Capacities

OPMODEL calculates inflow to Seven Oaks Dam, estimates reservoir storage behind the dam, and computes outflow based on USACE operating criteria. The model calculates dam releases, in part, by setting an end-of-month target reservoir storage volume for each month. OPMODEL uses two different sets of monthly reservoir storage targets depending on whether or not seasonal storage is specified. When inflow to the dam exceeds the monthly storage target, OPMODEL logic assumes excess water is released from the reservoir.

When the model is configured for operations *without* seasonal storage, OPMODEL uses flood control storage targets specified by the USACE (2000c). When the model is configured for operations *with* seasonal storage, OPMODEL uses storage targets identified as Alternative 3 in the *Seven Oaks Dam Water Conservation Feasibility Report* (USACE 1997). Alternative 3 is used in OPMODEL because it is based upon a 50,000 af reservoir pool, which is consistent with seasonal storage proposed under the Project. End-of-month target storage capacities, both with and without seasonal storage, are summarized in Table 4.2-3.

Table 4.2-3. Seven Oaks Dam End-of-Month Target Storage (in af)

OCT	*NOV*	*DEC*	*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*
WITHOUT SEASONAL STORAGE											
73	2,966	2,966	2,966	2,966	2,966	2,966	2,966	2,966	1,166	73	73
WITH SEASONAL STORAGE											
73	2,966	2,966	2,966	2,966	50,000	50,000	50,000	37,500	25,000	12,500	73

As is the case with the USACE (2000c) criteria, under the assumption of operations without seasonal storage, OPMODEL assumes the creation and maintenance of a year-round sediment pool of 73 af. Under operations without seasonal storage, a debris pool is formed beginning in November and held at 2,966 af until the end of June. All inflows to the dam in excess of those required to maintain the debris pool are released after the debris pool is filled. Under operations without seasonal storage, starting in July, the debris pool is drained, and the reservoir level is returned to the sediment pool elevation by the end of August.

With seasonal storage, beginning in March, up to 50,000 af of water can be stored in the reservoir. This water is released from the dam from June through September when the reservoir elevation is reduced to the sediment pool level in preparation for the next flood season. With or without seasonal storage, there is no water stored above the sediment pool in September and October.

The initial sediment pool of 73 af is used in OPMODEL to allow for reservoir sediment. The USACE estimated that approximately 16,000 af of sediment would accumulate over 50 years (or approximately 320 afy).

4.2.2.3 Releases from Seven Oaks Dam

OPMODEL uses the difference between average monthly storage and the end-of-month target storage quantities to calculate the release of water from Seven Oaks Dam. The end-of-month target depends on whether or not the dam is to be operated with or without seasonal storage. As can be seen in Table 4.2-3, target-storages and hence, releases are identical for the months September through February. From March through August, without seasonal storage, all water in excess of that contained in the debris pool is released from the dam. With seasonal storage, target storages are much higher from March through August.

Conservation District Diversion of Santa Ana River Flow

OPMODEL has the capability to account for Conservation District diversions from the SAR under two different assumptions: reported *historical* diversions or *licensed* diversions. A comparison of the cumulative diversions by the Conservation District for the two different assumptions is presented in Figure 4.2-3.

HISTORICAL CONSERVATION DISTRICT DIVERSIONS OF SAR WATER

The Conservation District maintains records of its historical monthly spreading activities. However, these records include not only spreading of SAR water, but also spreading of Mill Creek water, and spreading for other entities (including water delivered to the Conservation District Canal after being used for power generation). Occasionally the monthly volume of water recorded in the Conservation District spreading record for the SAR spreading grounds exceeds the estimated flow in the SAR. OPMODEL simulates the historical diversions of the Conservation District as the minimum of (1) recorded historical monthly Conservation District spreading, or (2) simulated monthly release from Seven Oaks Dam. This method approximates water available for diversion by Muni/Western because some of the water listed in the historical Conservation District spreading records is water that had been historically diverted from sources other than the SAR. The data are inadequate for a more refined analysis.

This logic prevents the model from diverting water that is unavailable and results in the model not matching exactly historical Conservation District spreading. The model is configured to track and attempt to fill any differences between simulated diversions and historical spreading. OPMODEL attempts to balance any deficit by allowing excess water in a later month to be shown as a delivery to the Conservation District. The model, when configured for historical

Conservation District diversions, ensures that historical Conservation District diversions are met to the extent possible over the period of analysis.

LICENSED CONSERVATION DISTRICT DIVERSIONS OF SANTA ANA RIVER FLOW

OPMODEL is also configured to use releases from Seven Oaks Dam to attempt to meet the licensed diversions of the Conservation District. The licensed diversions are variables that can be specified by the user to coincide with the current two SWRCB licenses (Nos. 2831 and 2832) held by the Conservation District for diversion of SAR water. The licenses give the Conservation District the right to divert and spread 8,300 af of SAR water from January 1 through May 31 and 2,100 af from October 1 through December 31, respectively, for a total annual diversion limit of 10,400 af. No licensed diversions are permitted from June 1 through September 30. Once the seasonal limit of the licensed diversions are met, the model assumes no additional water is diverted by the Conservation District.

The timing of licensed diversions (October through May) by the Conservation District's is important when considered in conjunction with the Seven Oaks Dam target storages shown in Table 4.2-3. With or without seasonal storage, the dam begins storing water in November to fill the debris pool to 2,966 af and holds that storage through at least June. With seasonal storage, water in the debris pool is held until August. The debris pool is filled during the Conservation District's licensed seasonal diversion period and released outside of that period. When OPMODEL is configured to assume licensed Conservation District diversions, the model assumes that due to the timing of filling and draining of the debris pool, water from the debris pool is not available to the Conservation District.

DIVERSION CAPACITY

OPMODEL allows the model user to specify a rate (in cfs) for Conservation District diversions which can, depending on the value, act as a constraint on total potential diversions. For the purposes of modeling the Project, the Conservation District diversion rate is assumed to be 300 cfs. This capacity is based on the capacity of the Conservation District Canal. The assumed capacity of 300 cfs allows all historical diversions to be delivered.

Environmental Habitat Releases from Seven Oaks Dam

OPMODEL includes a parameter that accounts for releases that are used for environmental habitat restoration. Environmental restoration activities designed to mitigate impacts from flood control operations of Seven Oaks Dam are proposed in the USACE 2000 BA and USFWS 2002 BO. One of the methods suggested to accomplish habitat restoration is through periodic release of water from the dam. This water would be directed to specific habitat areas through the use of temporary dikes constructed across the main channel of the SAR, downstream of the confluence with Mill Creek. Other mitigation methods proposed in the BA and BO do not use water releases from Seven Oaks Dam.

Assuming operations with habitat releases, once all prior rights and diversions have been met, OPMODEL then determines if there is enough reservoir storage remaining to allow a release of sufficient magnitude to implement effective habitat restoration.

Related model variables that can be specified by the user include a release rate, duration, and interval for the environmental habitat releases. The BA suggests (in Table 38 of the document) a magnitude for the habitat release of between 1,000 cfs and 2,000 cfs for a few days occurring every 5 to 10 years for 10-acre parcels. The BA also states that construction of the necessary SAR dikes and a dike to protect the Woolly Star Preserve area would take 3 to 5 months to prepare with additional time needed for habitat surveys prior to construction (USACE 2000a). This implies that habitat releases must be made at least 6 months apart. OPMODEL was run under various assumptions to determine the appropriate duration (in days) of environmental habitat releases. Based on this analysis, it was determined that to have an environmental habitat release every 5 to 10 years, the volume of water associated with the release would have to be 1,000 cfs for 2 days (4,000 af) or less, and Seven Oaks Dam would have to be operated to allow for temporary or seasonal storage. Based on these results, OPMODEL assumes environmental habitat releases are 1,000 cfs for a duration of 2 days, with at least 6 months elapsed time between releases. OPMODEL assumes a habitat release is made only when: (1) there is a sufficient volume of water available above that needed for Conservation District diversions; (2) when reservoir elevation is great enough to sustain the specified release rate (1,000 cfs); and (3) when there has not been a release within the specified interval, i.e., the past 6 months.

4.2.2.4 Unappropriated Santa Ana River Water and Muni/Western Diversions

Muni/Western diversions of SAR flow are taken from unappropriated SAR water. Unappropriated water is that which is released (if any) from Seven Oaks Dam after accounting for: (1) discharge of intercepted groundwater; (2) Conservation District diversions; and (3) environmental habitat releases. Muni/Western diversions would be withdrawn from the river through two proposed pipelines: the Plunge Pool Pipeline and the Low Flow Connector Pipeline. Muni/Western diversions are calculated as the minimum of either the available unappropriated water or the combined capacity of the proposed diversion pipelines (e.g., 500 cfs to 1,500 cfs).

There is an additional constraint placed on Muni/Western diversions when seasonal storage is assumed. In months when Seven Oaks Dam operations would allow seasonal storage (March through August), Muni/Western diversions are limited to the volume which Muni/Western can beneficially use in the short-term. Water in excess of short-term beneficial use is left in seasonal storage in Seven Oaks reservoir for release at a later time. An estimate of the amount of water to be released for short-term beneficial use in the Muni/Western service areas is derived, on a monthly basis, from Allocation Model.

4.2.3 Model Application (Methodology)

Assuming the range of values for the four most critical parameters, OPMODEL estimates the amount of water available for Muni/Western appropriation.

As shown in Table 4.2-4, there are 16 different "scenarios" created by the different combinations of these four assumptions.

Table 4.2-4. Scenarios for Analysis

Assumption/ Variable	***Combinations of Assumptions***															
Senior Water Rights Claimants Diversion	Diversions Up to of 88 CFS								Historical Diversions							
Conservation District Diversions	*Historical*				*Licensed Right (10,400 afy)*				*Historical*				*Licensed Right (10,400 afy)*			
Environmental Habitat Releases	1,000 cfs/ 2 days		Other Habitat Treatment		1,000 cfs/ 2 days		Other Habitat Treatment		1,000 cfs/ 2 days		Other Habitat Treatment		1,000 cfs/ 2 days		Other Habitat Treatment	
Seasonal Storage	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Scenario Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Each of the 16 scenarios is further defined by a diversion rate. In Phase I of the Plunge Pool Pipeline (the primary diversion pipeline proposed for Muni/Western capture), 500 cfs of diversion capacity would be available. In later phases of the Plunge Pool Pipeline, up to 1,500 cfs of diversion capacity would be available. Of all the possible scenarios, five have been carried forward for detailed analyses. They represent the following: maximum quantity of SAR water appropriated by Muni/Western with a 1,500 cfs diversion rate; maximum quantity of SAR water appropriated by Muni/Western with a 500 cfs diversion rate; minimum quantity of SAR water appropriated by Muni/Western with a diversion rate of 1,500 cfs; minimum quantity of SAR water appropriated by Muni/Western with a diversion rate of 500 cfs; and the scenario representative of No Project conditions. Assumptions underlying each of these five scenarios are as follows:

- Scenario A. Scenario 15 in Tables 4.2-4, 4.2-5, and 4.2-6 represents the maximum potential appropriation by Muni/Western at a diversion rate of 1,500 cfs and is the result of assuming (i) historical diversions by senior water rights claimants, (ii) licensed diversions by the Conservation District, (iii) environmental restoration without releases from the dam, and (iv) seasonal storage at Seven Oaks Dam.
- Scenario B. Scenario B results from the same assumptions as Scenario A, except the proposed Muni/Western diversion rate is set at 500 cfs instead of 1,500 cfs.
- Scenario C. Scenario 2 in Tables 4.2-4, 4.2-5, and 4.2-6 represents the minimum potential appropriation by Muni/Western at a diversion rate of 1,500 cfs and is the result of assuming (i) 88 cfs diversions by senior water rights claimants, (ii) historical diversions by the Conservation District, (iii) releases for environmental restoration, and (iv) no seasonal storage at Seven Oaks Dam.
- Scenario D. Scenario D results from the same assumptions as Scenario C, except the proposed Muni/Western diversion rate is set at 500 cfs instead of 1,500 cfs.
- No Project Scenario. Scenario 10 in Table 4.2-4 was chosen as representative of No Project conditions and is the result of assuming (i) historical diversions by senior water rights claimants, (ii) historical diversions by the Conservation District, (iii) releases for environmental restoration, and (iv) no seasonal storage at Seven Oaks Dam.

Table 4.2-5. Estimates of Unappropriated SAR Water Available for Capture by Muni/Western for Base Period WY 1961-62 through WY 1999-2000
Project Diversion Capacity of 1,500 cfs
(Values in Acre-Feet)

	1	Scenario C 2	3	4	5	6	7	8	9	10	11	12	13	14	Scenario A 15	16
Senior Claimants Diversions	**88 cfs**								**Historical**							
Conservation District Diversions	**Historical**				**10,400 AFY**				**Historical**				**10,400 AFY**			
Environmental Habitat Release	**1,000 cfs / 2 days**		**Other Habitat Treatment**		**1,000 cfs / 2 days**		**Other Habitat Treatment**		**1,000 cfs / 2 days**		**Other Habitat Treatment**		**1,000 cfs / 2 days**		**Other Habitat Treatment**	
Seasonal Storage	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Cumulative Total																
Senior Claimants Diversions	1,416,607	1,416,607	1,416,607	1,416,607	1,416,607	1,416,607	1,416,607	1,416,607	1,038,135	1,038,135	1,038,135	1,038,135	1,038,135	1,038,135	1,038,135	1,038,135
Reservoir Evaporation	3,196	3,196	3,196	3,196	3,196	3,196	3,196	3,196	5,608	5,608	5,608	5,608	5,608	5,608	5,608	5,608
Conservation District Diversions	398,466	398,466	398,466	398,466	107,060	107,060	107,060	107,060	404,980	404,980	404,980	404,980	193,483	193,483	193,483	193,483
Environmental Habitat Release	27,769	27,769	-	-	35,703	35,703	-	-	35,703	35,703	-	-	35,703	35,703	-	-
Total Potential Capture	445,836	445,836	473,605	473,605	729,308	729,308	765,011	765,011	807,448	807,448	843,151	843,151	1,018,945	1,018,945	1,054,648	1,054,648
Undiverted from SAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874
Average Annual																
Senior Claimants Diversions	36,323	36,323	36,323	36,323	36,323	36,323	36,323	36,323	26,619	26,619	26,619	26,619	26,619	26,619	26,619	26,619
Reservoir Evaporation	82	82	82	82	82	82	82	82	144	144	144	144	144	144	144	144
Conservation District Diversions	10,217	10,217	10,217	10,217	2,745	2,745	2,745	2,745	10,384	10,384	10,384	10,384	4,961	4,961	4,961	4,961
Environmental Habitat Release	712	712	-	-	915	915	-	-	915	915	-	-	915	915	-	-
Total Potential Capture	11,432	11,432	12,144	12,144	18,700	18,700	19,616	19,616	20,704	20,704	21,619	21,619	26,127	26,127	27,042	27,042
Undiverted from SAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maximum Annual																
Senior Claimants Diversions	58,528	58,528	58,528	58,528	58,528	58,528	58,528	58,528	45,245	45,245	45,245	45,245	45,245	45,245	45,245	45,245
Reservoir Evaporation	273	273	273	273	273	273	273	273	368	368	368	368	368	368	368	368
Conservation District Diversions	56,953	56,953	56,953	56,953	10,400	10,400	10,400	10,400	48,152	48,152	48,152	48,152	10,400	10,400	10,400	10,400
Environmental Habitat Release	3,967	3,967	-	-	3,967	3,967	-	-	3,967	3,967	-	-	3,967	3,967	-	-
Total Potential Capture	121,026	121,026	124,933	124,993	147,468	147,468	151,435	151,435	171,389	171,389	175,356	175,356	194,350	194,350	198,317	198,317
Undiverted from SAR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Model input variables that are common to all scenarios include the following (variables described in OPMODEL documentation):
1) Values shown in table for Total Potential Capture and Undiverted from SAR are estimated using OPMODEL and Allocation Model
2) Synthesized hydrology based on re-operated Bear Valley Dam
3) Release of continual 3 cfs from dam to account for groundwater interruption by the dam foundation
4) USGS gage differences and rounding accounted for in senior water claimant diversions
5) Conservation District diversion capacity = 300 cfs
6) For scenarios with environmental habitat releases, release frequency is no more than once every 6 months
7) Maximum number of environmental habitat releases = 100% of potential releases for scenarios with environmental habitat releases
8) Maximum annual diversion by Muni/Western = 200,000 afy
9) Percent of available dam release un-diverted through Plunge Pool Pipeline = 0%
10) Flood/Conservation target storages from USACE Feasibility Report and Interim Water Control Plan
11) Evaporation rates from USACE Feasibility Report

Table 4.2-6. Estimates of Unappropriated SAR Water Available for Capture by Muni/Western for Base Period WY 1961-62 through WY 1999-2000
Project Diversion Capacity of 500 cfs
(Values in Acre-Feet)

	1	Scenario D 2	3	4	5	6	7	8	9	10	11	12	13	14	Scenario B 15	16
Senior Claimants Diversions	88 cfs								Historical							
Conservation District Diversions	Historical				10,400 AFY				Historical				10,400 AFY			
Environmental Habitat Release	1,000 cfs / 2 days		Other Habitat Treatment		1,000 cfs / 2 days		Other Habitat Treatment		1,000 cfs / 2 days		Other Habitat Treatment		1,000 cfs / 2 days		Other Habitat Treatment	
Seasonal Storage	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Cumulative Total	(39-Year Base Period)															
Senior Claimants Diversions	1,416,606	1,416,607	1,416,607	1,416,608	1,416,605	1,416,608	1,416,610	1,416,610	1,038,137	1,038,139	1,038,139	1,038,138	1,038,128	######	1,038,131	1,038,134
Reservoir Evaporation	3,218	3,196	3,234	3,196	3,328	3,196	3,380	3,196	5,734	5,608	5,783	5,608	6,029	5,608	6,081	5,608
Conservation District Diversions	398,466	398,466	398,466	398,466	107,060	107,060	107,060	107,060	404,980	404,980	404,980	404,980	193,483	193,483	193,483	193,483
Environmental Habitat Release	27,769	27,769	-	-	35,703	35,703	-	-	35,703	35,703	-	-	39,670	35,703	-	-
Total Potential Capture	407,312	400,599	431,097	420,165	680,406	663,260	712,085	688,520	748,045	727,788	768,762	740,623	954,556	916,718	981,931	936,212
Undiverted from SAR	38,503	45,237	42,470	53,439	48,772	66,047	52,739	76,488	59,275	79,656	74,210	102,525	60,008	102,230	72,248	118,437
Total	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	2,291,874	######	2,291,874	2,291,874
Average Annual																
Senior Claimants Diversions	36,323	36,323	36,323	36,323	36,323	36,323	36,323	36,323	26,619	26,619	26,619	26,619	26,619	26,619	26,619	26,619
Reservoir Evaporation	83	82	83	82	85	82	87	82	147	144	148	144	155	144	156	144
Conservation District Diversions	10,217	10,217	10,217	10,217	2,745	2,745	2,745	2,745	10,384	10,384	10,384	10,384	4,961	4,961	4,961	4,961
Environmental Habitat Release	712	712	-	-	915	915	-	-	915	915	-	-	1,017	915	-	-
Total Potential Capture	10,444	10,272	11,054	10,773	17,446	17,007	18,259	17,654	19,181	18,661	19,712	18,990	24,476	23,506	25,178	24,005
Undiverted from SAR	987	1,160	1,089	1,370	1,251	1,694	1,352	1,961	1,520	2,042	1,903	2,629	1,539	2,621	1,853	3,037
Maximum Annual																
Senior Claimants Diversions	58,528	58,528	58,528	58,528	58,528	58,528	58,528	58,528	45,245	45,245	45,245	45,245	45,245	45,245	45,245	45,245
Reservoir Evaporation	278	273	278	273	343	273	343	273	410	368	410	368	551	368	573	368
Conservation District Diversions	56,953	56,953	56,953	56,953	10,400	10,400	10,400	10,400	48,152	48,152	48,152	48,152	10,400	10,400	10,400	10,400
Environmental Habitat Release	3,967	3,967	-	-	3,967	3,967	-	-	3,967	3,967	-	-	7,934	3,967	-	-
Total Potential Capture	104,294	104,294	108,261	108,261	128,351	126,721	132,318	130,688	145,880	144,520	145,880	144,520	166,402	158,831	173,580	162,064
Undiverted from SAR	22,101	28,505	26,068	32,472	30,024	41,347	33,991	45,314	34,538	41,841	40,703	47,971	34,745	56,408	38,382	61,109

Model input variables that are common to all scenarios include the following (variables described in OPMODEL documentation):
1) Values shown in table for Total Potential Capture and Undiverted from SAR are estimated using OPMODEL and Allocation Model
2) Synthesized hydrology based on re-operated Bear Valley Dam
3) Release of continual 3 cfs from dam to account for groundwater interruption by the dam foundation
4) USGS gage differences and rounding accounted for in senior water claimant diversions
5) Conservation District diversion capacity = 300 cfs
6) For scenarios with environmental habitat releases, release frequency is no more than once every 6 months
7) Maximum number of environmental habitat releases = 100% of potential releases for scenarios with environmental habitat releases
8) Maximum annual diversion by Muni/Western = 200,000 afy
9) Percent of available dam release un-diverted through Plunge Pool Pipeline = 0%
10) Flood/Conservation target storages from USACE Feasibility Report and Interim Water Control Plan
11) Evaporation rates from USACE Feasibility Report

Scenarios A through D span the range of possible operations of Seven Oaks Dam, the range of possible releases from Seven Oaks Dam, and the range of potential Muni/Western appropriation. Evaluating Scenarios A through D encompasses all possible scenarios and negates the need to analyze each of the 16 scenarios individually.

4.2.4 Model Results

For each of the 16 potential scenarios outlined in Table 4.2-4 a quantity of unappropriated SAR water is available for capture by Muni/Western. For the purposes of the EIR, it is important to identify the extreme values resulting from this range of potential combinations of conditions (scenarios) that can affect the quantity of unappropriated water. This range is identified for the two potential diversion rates that might be utilized by Muni/Western: 500 cfs and 1,500 cfs.

Table 4.2-7 illustrates OPMODEL results assuming that Phase I of the Plunge Pool Pipeline, with a conveyance capacity limited to 500 cfs, is implemented. Table 4.2-8 provides corresponding results with implementation of Phase II or later phases of the Plunge Pool Pipeline when a conveyance capacity of 1,500 cfs is available. Results under the No Project conditions are also shown. The cumulative amount of SAR water available for capture by Muni/Western over the 39-year period could vary from a low of about 400,600 af (Scenario D) to a high of about 1,054,648 af (Scenario A). Diversion by Muni/Western at 500 cfs (as per Scenarios B and D) would still result in unappropriated water remaining in the channel, but under a 1,500 cfs diversion (as per Scenarios A and C) no unappropriated water would remain in the channel. The median annual quantity of water captured by Muni/Western could range from about 0 af to 3,265 af.

Table 4.2-7. Estimated Muni/Western Diversions (in acre feet) for No Project and Scenarios B and D

	No Project	*Scenario B*	*Scenario D*
Median Annual			
Senior Water Rights Claimants Diversions	25,772	25,772	35,454,
Reservoir Evaporation	133	133	65
Conservation District Diversions	5,587	4,674	1,319
Environmental Habitat Releases	0	0	0
Total Potential Muni/Western Capture	0	3,265	0
Undiverted Water	2,581	0	0
Average Annual			
Senior Water Rights Claimants Diversions	26,619	26,619	36,323
Reservoir Evaporation	144	156	82
Conservation District Diversions	10,384	4,961	10,217
Environmental Habitat Releases	915	0	712
Total Potential Muni/Western Capture	0	25,178	10,272
Undiverted Water	20,704	1,853	1,160
Maximum Annual			
Senior Water Rights Claimants Diversions	45,245	45,245	58,528
Reservoir Evaporation	368	573	273
Conservation District Diversions	48,152	10,400	56,953
Environmental Habitat Releases	3,967	0	3,967
Total Potential Muni/Western Capture	0	173,580	104,294
Undiverted Water	171,389	38,382	28,505
Cumulative Total (39-Year Base Period)			
Senior Water Rights Claimants Diversions	1,038,135	1,038,131	1,416,607
Reservoir Evaporation	5,608	6,081	3,196
Conservation District Diversions	404,980	193,483	398,466
Environmental Habitat Releases	35,703	0	27,769
Total Potential Muni/Western Capture	0	981,931	400,599
Undiverted Water	807,448	72,248	45,237

Table 4.2-8. Estimated Muni/Western Diversions (in acre feet) for No Project, and Scenarios A and C

	No Project	*Scenario A*	*Scenario C*
Median Annual			
Senior Water Rights Claimants Diversions	25,772	25,772	35,454
Reservoir Evaporation	133	133	65
Conservation District Diversions	5,587	4,674	1,319
Environmental Habitat Releases	0	0	0
Total Potential Muni/Western Capture	0	3,265	0
Undiverted Water	2,581	0	0
Average Annual			
Senior Water Rights Claimants Diversions	26,619	26,619	36,323
Reservoir Evaporation	144	144	82
Conservation District Diversions	10,384	4,961	10,217
Environmental Habitat Releases	915	0	712
Total Potential Muni/Western Capture	0	27,042	11,432
Undiverted Water	20,704	0	0
Maximum Annual			
Senior Water Rights Claimants Diversions	45,245	45,245	58,528
Reservoir Evaporation	368	368	273
Conservation District Diversions	48,152	10,400	56,953
Environmental Habitat Releases	3,967	0	3,967
Total Potential Muni/Western Capture	0	198,317	121,026
Undiverted Water	171,389	0	0
Cumulative Total			
Senior Water Rights Claimants Diversions	1,038,135	1,038,135	1,416,607
Reservoir Evaporation	5,608	5,608	3,196
Conservation District Diversions	404,980	193,483	398,466
Environmental Habitat Releases	35,703	0	27,769
Total Potential Muni/Western Capture	0	1,054,648	445,836
Undiverted Water	807,448	0	0

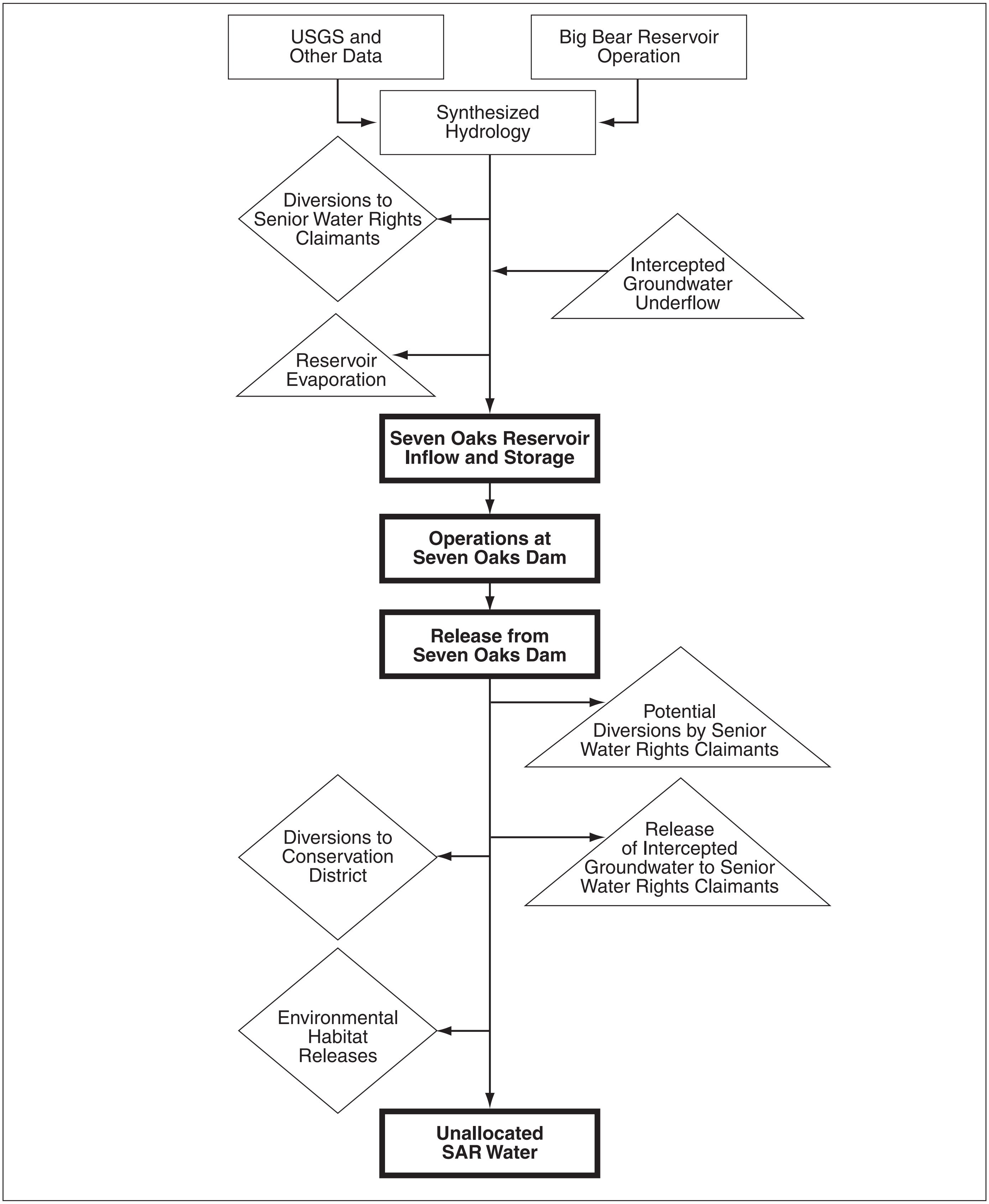

Figure 4.2-1. OPMODEL Structure

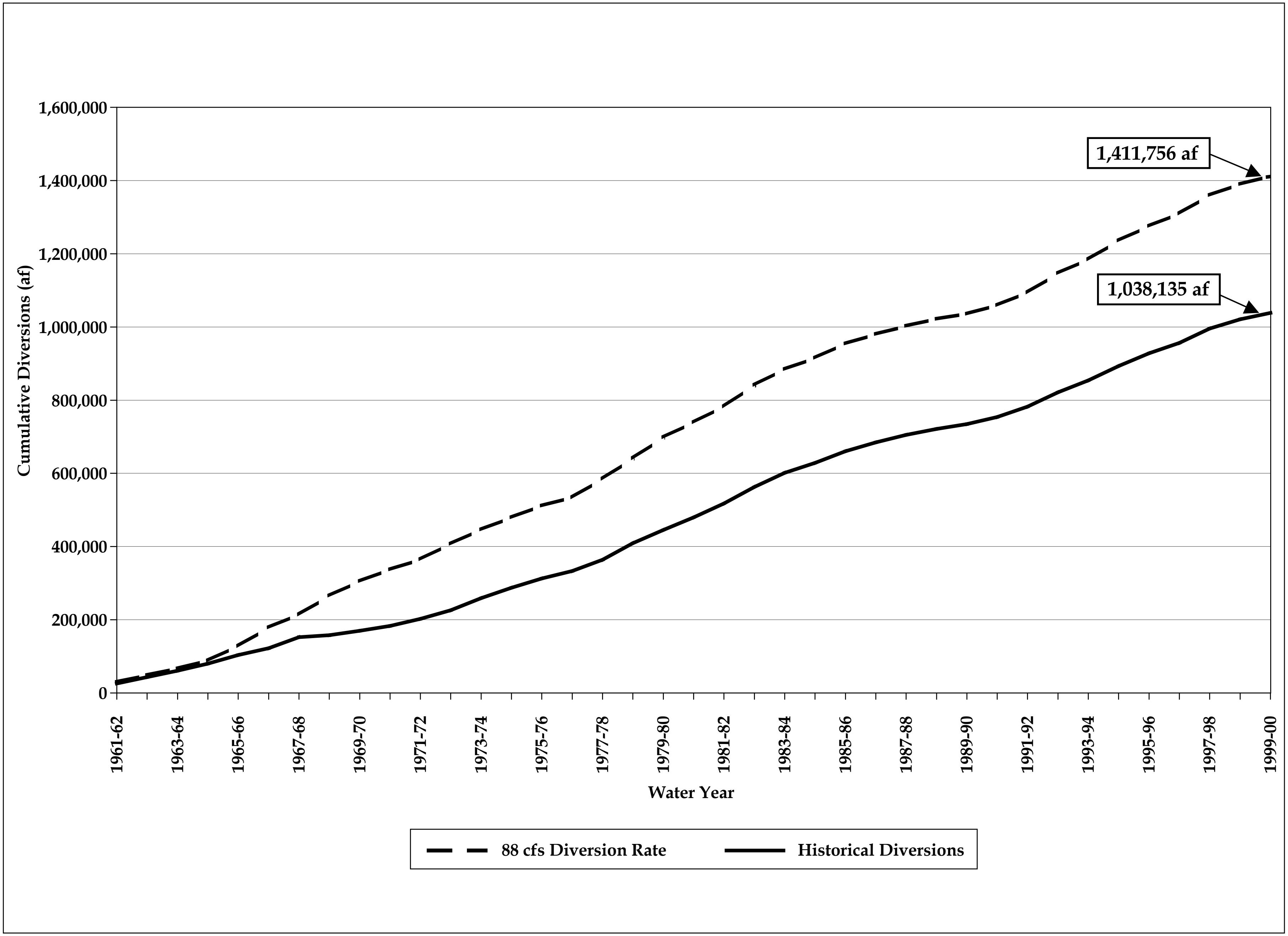

Figure 4.2-2. Cumulative Diversions by Senior Water Rights Claimants from the Santa Ana River, WY 1961-62 through WY 1999-2000

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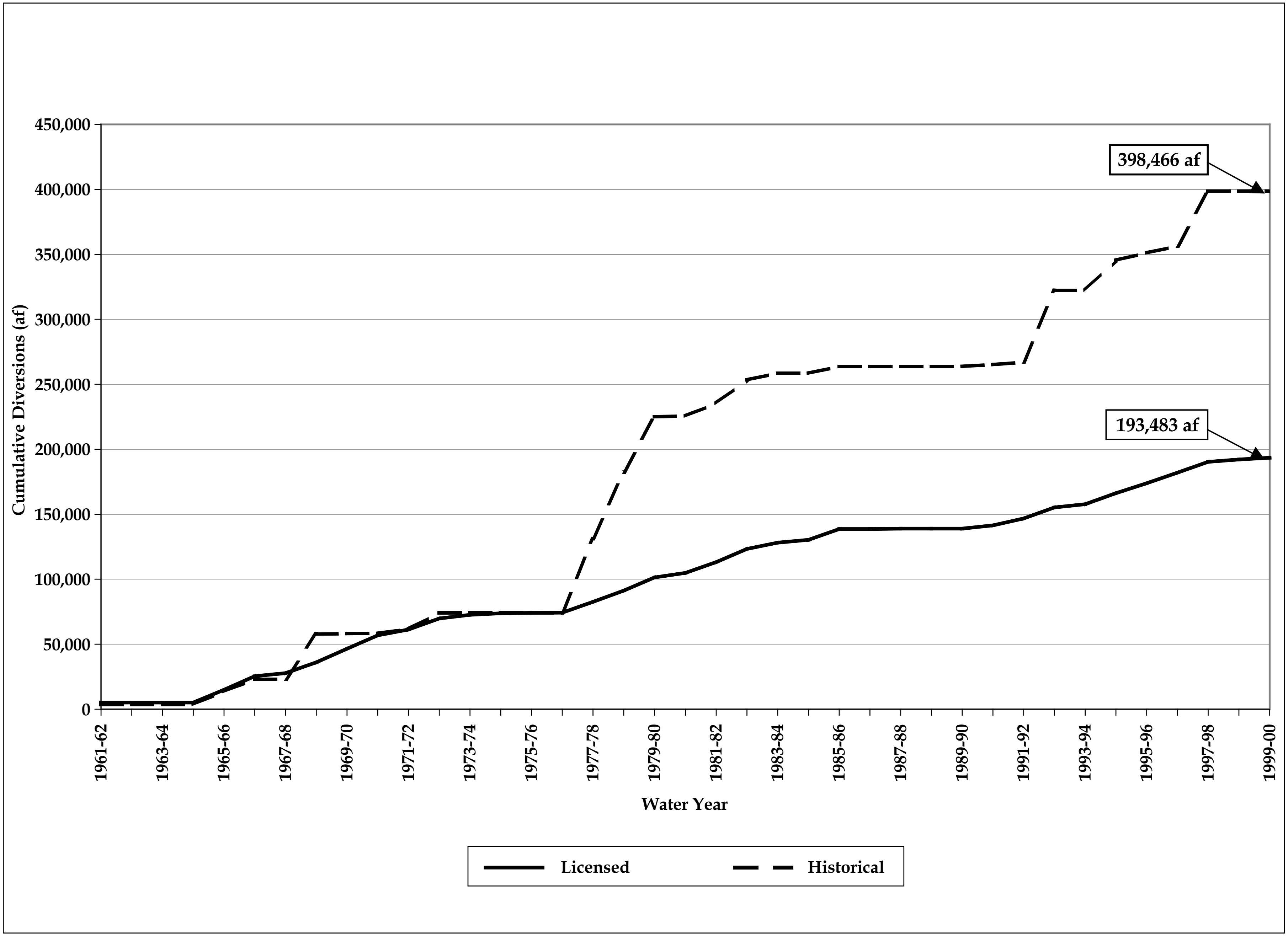

Figure 4.2-3. Cumulative Diversions by the Conservation District from the Santa Ana River, WY 1961-62 through 1999-2000

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5.0 ALLOCATION MODEL

The Allocation Model is designed to account for how diversions from the SAR by Muni/Western would be put to a variety of beneficial uses. The priorities assigned to Muni/Western diversions of SAR water are: (1) direct use in the Muni/Western service areas; (2) groundwater recharge of the San Bernardino Basin Area (SBBA); (3) groundwater recharge outside the SBBA but within the Muni/Western service areas; and (4) exchange programs (described in detail in section 5.3.1). These priorities reflect the desirability of minimizing energy costs (direct delivery is less expensive than groundwater pumping) and the desirability of utilizing high quality SAR water locally.

5.1 GENERAL DESCRIPTION AND PURPOSE OF ALLOCATION MODEL

The Allocation Model provides a tool for estimating the quantities of captured water delivered to different beneficial uses under No Project and Project (Scenarios A through D) conditions. To make forecasts, OPMODEL and Allocation Model assume a repeat of historical hydrologic conditions of the period WY 1961-62 through WY 1999-2000.

Similar to OPMODEL, Allocation Model operates on a monthly time-step. To take account of future conditions with and without the Project, it is necessary that Allocation Model use assumptions concerning future water demand, future groundwater pumping, future capacity of conveyance and treatment facilities, and future water management actions. Allocation Model accounts for: (1) the absorptive capacity of each beneficial use (i.e., the quantity of water that can be effectively utilized) and (2) the conveyance capacity of the delivery system.

Allocation Model is designed to distribute captured SAR water to the above stated beneficial uses while, at the same time, meeting a number of external objectives. The objectives include: (1) meeting Muni's replenishment obligations of the SBBA under the *Western* Judgment; (2) avoiding high groundwater conditions; and (3) not adversely affecting groundwater contamination plumes. To meet these various objectives, Allocation Model tracks deliveries of SAR water diverted as part of the Project, deliveries of SAR and imported water to meet the requirements of the *Western* Judgment, and deliveries of SWP water returned from exchange programs. These deliveries are tracked to locations within Muni's service area that are inside and outside the SBBA. Allocation Model also tracks the amount *Western* Judgment Plaintiff pumping can increase due to the "new conservation" portion of Muni/Western diversions. It is assumed that direct deliveries would not be made to Western's service area, rather, increased groundwater spreading in the Muni service area would support increased groundwater pumping for export to users in the Western service area.

Allocation Model is integrated with other models developed to support the SAR water rights applications and EIR. Allocation Model accepts as input the results derived from OPMODEL for the No Project scenario and Project (Scenarios A through D). These inputs include: (1) monthly amounts of SAR water that could be diverted by Muni/Western; (2) monthly amounts of SAR water that would be diverted by the Conservation District and delivered to the Santa Ana River Spreading Grounds for recharge; and (3) annual amounts of environmental habitat releases that contribute to deep percolation in the river channel. Allocation Model and the groundwater model are interpolated and work "iteratively" in estimating reasonable deliveries to spreading grounds.

The iterative process is necessary since deliveries of water to spreading grounds are not only limited by delivery constraints (e.g., available conveyance route capacities and absorptive capacities of spreading facilities) but also by groundwater levels and the location of groundwater contamination plumes in the SBBA. Initial results from the groundwater model are used to set recharge targets that limit recharge of Muni/Western SAR diversions to meet groundwater management goals. By coordinating Allocation Model and the groundwater model, it is possible to approximate water deliveries (of both SAR and imported water) to spreading grounds while simultaneously achieving the external objectives referred to above. The results of the Allocation Model are summarized annually for use in the groundwater model.

5.2 MODEL STRUCTURE

Figure 5.2-1, illustrates the logic upon which Allocation Model is structured. Allocation to each beneficial use is limited by: (1) the amount of water remaining after deliveries to a higher priority use; (2) available conveyance capacity; (3) available absorptive capacity of a given beneficial use; and (4) consideration of groundwater levels using groundwater targets (more detail on groundwater targets is provided in section 5.3.5). Allocation Model assumes that, if it is not possible to use SAR water for direct uses or groundwater spreading in the SBBA or other locations in the Muni/Western service areas, as a last priority, SAR water would be exchanged with other agencies and an equal amount of water would be returned at a later date. As shown in Figure 5.2-1, water returned as part of an exchange would be put to beneficial use, again with the first priority being direct use, second to groundwater spreading in the SBBA, and lastly to groundwater spreading in other areas of the Muni/Western service areas. Allocation Model assumes that water returned as part of an exchange would be from the SWP, not the same SAR water that was diverted.

After determining the monthly quantity of captured SAR water allocated to each beneficial use for a given water year, Allocation Model calculates the annual quantity of water needed to fulfill Muni's groundwater replenishment obligations for the SBBA under the *Western* Judgment.

5.3 MODEL INPUT, PARAMETERS, AND ASSUMPTIONS

5.3.1 Priorities for Water Allocation

Allocation Model operates under a set of priorities that define the order in which deliveries of SAR water and returns from exchange are made to beneficial uses. These priorities are described in detail below.

5.3.1.1 Direct Use – Priority 1

Table 5.3-1 lists the six direct uses proposed to receive SAR water under the Project. In total, direct uses represent 155 cfs of absorptive capacity. However, constraints assigned within Allocation Model lower the available absorptive capacity to below 155 cfs during some months. The demand for SAR water delivered by Muni/Western to West Valley, City Creek, Hinckley, and Tate WTPs is set to zero from September through May to reflect the fact that in these months other local water supplies are delivered to these plants. In Allocation Model demand by the Yucaipa WTP increases over the 39-year base period to reflect increasing use of the new facility and fluctuates to reflect the seasonality of demands.

Table 5.3-1. Characteristics of Deliveries to Beneficial Uses

Delivery Point for Beneficial Use	*Available Absorptive Capacity Assigned in Allocation Model (cfs)*	*Conveyance Routes Used*	*Within SBBA*	*Potential Delivery Season*
Priority 1: Direct Uses				
Yucaipa WTP	54	Santa Ana Low and Greenspot Route	No	Year-round
Yucaipa Irrigation	5	Santa Ana Low and Greenspot Route	No	Year-round
West Valley WTP	13	Foothill Reverse Flow & Lytle Creek Routes	Yes	June through August
City Creek WTP	12	Foothill Reverse Flow Route	Yes	June through August
Hinckley WTP	40	Santa Ana Low and Greenspot Route	Yes	June through August
Tate WTP	31	Santa Ana Low and Greenspot Route	Yes	June through August
Priority 2: Groundwater Recharge in San Bernardino Basin Area				
Santa Ana River SG	50	Santa Ana Low Route	Yes	Year-round
Sweetwater SG	23	Foothill Reverse Flow Route	Yes	Year-round
Lytle Basins SG	30	Foothill Reverse Flow Route and Lytle Creek Route	Yes	Year-round
City Creek SG	57	Foothill Reverse Flow Route	Yes	March through August
Patton SG	1	Foothill Reverse Flow Route	Yes	March through August
Waterman SG	30	Foothill Reverse Flow Route	Yes	March through August
East Twin Creek SG	24	Foothill Reverse Flow Route	Yes	March through August

Table 5.3-1. Characteristics of Beneficial Uses (continued)

Delivery Point for Beneficial Use	Available Absorptive Capacity Assigned in Allocation Model (cfs)	Conveyance Routes Used	Within SBBA	Potential Delivery Season
Badger SG	4	Foothill Reverse Flow Route	Yes	March through August
Mill Creek SG	20	Santa Ana Low and Greenspot Route	Yes	March through August
Priority 3: Other Groundwater Recharge in Muni Service Area				
Cactus SG	35	Foothill Reverse Flow & Lytle Creek Routes	No	Year-round
Wilson SG	6	Santa Ana Low and Greenspot Route	No	Year-round
Garden Air Creek	16	Santa Ana Low and Greenspot Route	No	Year-round
Priority 4: Exchange				
Metropolitan Exchange	1,000	Inland Feeder South Route	No	Year-round
SGVMWD Exchange	55	Foothill Reverse Flow & Lytle Creek Routes	No	Year-round
SGPWA Exchange	16	Santa Ana Low and Greenspot Route	No	Year-round
DWR	300	Inland Feeder North Route	No	Year-round

Available Absorptive Capacity – assigned in the Allocation Model; based on consideration of turnout capacity, historical use, shared facility use, and design capacities.
DWR – California Department of Water Resources
SG – Spreading Grounds
SGPWA – San Gorgonio Pass Water Agency
SGVMWD – San Gabriel Valley Municipal Water District
WTP – Water Treatment Plant

5.3.1.2 Groundwater Recharge in the San Bernardino Basin Area – Priority 2

It is proposed that nine existing spreading grounds that overlie the SBBA would receive captured SAR water under the Project (see Table 5.3-1). Details regarding each of the nine spreading basins are provided in Appendix B, Groundwater Hydrology Technical Appendix. In total, these spreading grounds have 239 cfs of available absorptive capacity as assigned in the Allocation Model. However, due to recharge targets, Allocation Model delivers less captured SAR water than the available absorptive capacity.

5.3.1.3 Other Groundwater Recharge in Muni Service Area - Priority 3

Groundwater recharge outside the SBBA but within Muni's service area is the third priority use for captured SAR water. As shown in Table 5.3-1, three spreading grounds outside of the SBBA are proposed to receive SAR water. Details about each of the three spreading basins are provided in Appendix B, Groundwater Hydrology Technical Appendix. In total, these spreading grounds have 57 cfs of available absorptive capacity based on reasonable monthly recharge rates assigned considering year-round use. On average, the Allocation Model delivers less SAR water than the assigned available absorptive capacity of these groundwater spreading basins because SAR water is not available in all months of all years evaluated.

5.3.1.4 Exchange - Priority 4

Exchange is the lowest priority use for captured SAR water. As shown in Table 5.3-1, four potential exchange partners have been identified: The Metropolitan Water District of Southern California (Metropolitan); San Gabriel Valley Municipal Water District (SGVMWD); San Gorgonio Pass Water Agency (SGPWA); and the California Department of Water Resources (DWR). These agencies have access to SWP water and are agencies to which Muni can physically deliver water.

Within Allocation Model, potential deliveries to exchange partners are only limited by the conveyance capacity available. It is assumed that there is adequate demand and/or reservoir storage capacity on the part of the exchange partners to accept captured SAR water in the amounts proposed in Table 5.3-1. For conveyance to exchange partners, the total absorptive capacity is 1,371 cfs.

Return of Imported Water from Exchanges

The amount of imported water delivered in exchange for prior deliveries of SAR water is estimated in Allocation Model. Allocation Model accounts for deliveries to, and returns from, exchange partners, and the corresponding "account" balance with each partner. The Allocation Model returns water to Muni/Western as soon as possible, subject to the following constraints:

- No water is returned to Muni/Western in months that Muni/Western takes delivery of SAR water; and

- The total water returned from exchange in a month is estimated based on the absorptive capacities of the beneficial uses and the conveyance capacities. The conveyance capacity limitations used in the analysis are the same as those used to evaluate deliveries of diverted SAR water.

- The total capacity for return from exchange was assigned a limit of 288 cfs within the Allocation Model. This limit corresponds to the maximum conveyance capacity of the Foothill Pipeline. Based on this set conveyance limit the Allocation Model indicates return of exchange water can be made within about 10 years or less for Scenarios A and B and about 5 years or less for Scenarios C and D, and it is all brought back within the 39-year period.

Within Allocation Model, water that is returned to the Muni service area is distributed using the same priority scheme used for the distribution of captured SAR water. First priority is given to direct use, second priority is for groundwater recharge within the SBBA area, and third priority is for groundwater spreading outside of the SBBA but within the Muni service area. An additional timing constraint is placed on return of exchange water. Returns are not programmed for spreading grounds early in the water year. This constraint ensures that the monthly delivery of captured SAR water is made ahead of the monthly delivery of water returned from exchanges within the same water year.

5.3.2 Future Conditions in Muni/Western Service Areas

In the future, as demand for water increases, additional supplies will be required. Potential additional supplies include increased extractions of groundwater, more use of local surface water, and imported water. It is likely that a continuation of current water use practices in the future, given increasing supply and demand conditions, would require groundwater management actions to avoid adverse groundwater conditions such as high groundwater in the Pressure Zone area of the SBBA. Therefore, it is reasonably foreseeable that, with or without the Project, actions designed to integrate groundwater, local surface water, and imported water resources would occur. These actions could include integrating various sources of supply of recharge water, and the location, timing, and quantity of groundwater recharge in order to maximize in-basin storage, minimize high groundwater conditions, and minimize the potential to adversely affect groundwater contamination plumes.

5.3.3 Future Demands in the Muni Service Area Including Exports

Estimates are made of future water demands and sources of water supply for purveyors within Muni's service area and purveyors exporting from the Muni service area. Estimates of water demand are derived on a production basis, i.e., the amount that needs to be pumped, including an allowance for return flows. These estimates are necessary in determining replenishment requirements for the SBBA, an integral part of the Allocation Model analysis, and to estimate amounts of groundwater pumping for the groundwater model. The analysis of demands focuses on production in the Muni service area since this is where captured SAR water would be first put to beneficial use. It is assumed that direct deliveries would not be made to Western's service area, rather, increased groundwater spreading in the Muni service area would support increased groundwater pumping for export to users in the Western service area.

Within the Muni service area, there are purveyors who extract and use the water within the service area ("Non-Exporters") and other purveyors who extract water from the service area and export it for use in a different geographical area ("Exporters"). Non-Exporters and Exporters include cities, water districts, local water companies and numerous individuals. The analysis of future local groundwater and surface water use in the Muni service area concentrates on larger purveyors and does not include all individual water users. Non-Exporters included in the analysis are comprised of:

- City of San Bernardino
- City of Redlands
- West Valley Water District
- East Valley Water District
- City of Rialto
- City of Colton
- Yucaipa Valley Water District, including Western Heights Water Company
- City of Loma Linda
- Marygold Mutual Water Company
- Terrace Water Company
- Former Norton Air Force Base
- Muscoy Mutual Water Company

Exporters included in the analysis are comprised of:

- City of Riverside, including Gage Canal
- Riverside-Highland Water Company
- Regents of the University of California
- Fontana Union/ Water Company
- Other/Agricultural/Private exporters (e.g., Bear Valley Mutual Water Company, Crafton Water Company, Marigold Farms Company, and Meeks and Daley Water Company)

The analysis evaluates existing production by using year 2000 Urban Water Management Plans (UWMPs) for each purveyor, where available, or Muni's Regional Water Facilities Masterplan (when an UWMP is not available). As shown in Table 5.3-2, a water supply source was assigned to each purveyor using the data contained within the UWMPs and/or production records. The following water source categories are used:

- Groundwater, Bunker Hill
- Groundwater, Lytle Basin
- Groundwater, Chino
- Groundwater, Riverside North
- Groundwater, Rialto
- Groundwater, Yucaipa
- Surface Water, Lytle Creek
- Surface Water, Mill Creek
- Surface Water, Santa Ana River
- Imported SWP Water
- Reclaimed Water

Table 5.3-2. Existing and Future Water Demands and Water Supplies for Purveyors in the Muni Service Area

Purveyors	*Annual Water to meet Demand[1] in 2000 (af)*	*Sources to Meet Demands in 2000*	*Annual Water to meet Demand[1] in 2020 (af)*	*Sources to Meet Demands in 2020*	*Percent Change in Demands (2000 to 2020)*
City of Riverside[2] including Gage Canal (Exporter)	57,703	Groundwater, Bunker Hill	57,703	Groundwater, Bunker Hill	0%
Fontana Union / W.C. (Exporter)	20,522	Groundwater, Bunker Hill Surface Water, Lytle Creek	20,522	Groundwater, Bunker Hill Surface Water, Lytle Creek	0%
Riverside-Highland W.C.(Exporter)	4,075	Groundwater, Bunker Hill Groundwater, Lytle Basin Groundwater, North Riverside	4,075	Groundwater, Bunker Hill Groundwater, Lytle Basin Groundwater, North Riverside	0%
City of San Bernardino	51,772	Groundwater, Bunker Hill	70,000	Groundwater, Bunker Hill	35%
City of Redlands	30,130	Groundwater, Bunker Hill Surface Water, Mill Creek Surface Water, Santa Ana River	65,100	Groundwater, Bunker Hill Surface Water, Mill Creek Surface Water, Santa Ana River	116%
West Valley W.D.	20,500	Groundwater, Bunker Hill Groundwater, Rialto Groundwater, North Riverside Groundwater, Lytle Basin Surface Water, Lytle Creek Imported Water, SWP	31,100	Groundwater, Bunker Hill Groundwater, Rialto Groundwater, North Riverside Groundwater, Lytle Basin Surface Water, Lytle Creek Imported Water, SWP	52%
East Valley W.D.	22,019	Groundwater, Bunker Hill Surface Water, Santa Ana River Import Water, SWP	24,375	Groundwater, Bunker Hill Surface Water, Santa Ana River Import Water, SWP	11%
City of Rialto	16,300	Groundwater, Bunker Hill Groundwater, Lytle Basin Groundwater, Rialto Surface Water, Lytle Creek	19,200	Groundwater, Bunker Hill Groundwater, Lytle Basin Groundwater, Rialto Surface Water, Lytle Creek	18%
City of Colton	14,350	Groundwater, Bunker Hill Groundwater, Rialto	18,260	Groundwater, Bunker Hill Groundwater, Rialto	27%
Yucaipa Valley W.D. including Western Heights W.C.	13,850	Imported Water, SWP Groundwater, Yucaipa	27,880	Imported Water, SWP Groundwater, Yucaipa	101%
City of Loma Linda	5,040	Groundwater, Bunker Hill	6,370	Groundwater, Bunker Hill	26%
Former Norton Air Force Base	2,755	Groundwater, Bunker Hill	2,755	Groundwater, Bunker Hill	0%
Muscoy Mutual W.C.	2,368	Groundwater, Bunker Hill	2,370	Groundwater, Bunker Hill	0%

Table 5.3-2. Existing and Future Water Demands and Water Supplies for Purveyors in Muni Service Area (continued)

Purveyors	*Annual Water to meet Demand[1] in 2000 (af)*	*Sources to meet Demands in 2000*	*Annual Water to meet Demand[1] in 2020 (af)*	*Sources to meet Demands in 2020*	*Percent Change in Demands (2000 to 2020)*
Marygold Mutual W.C.	1,780	Groundwater, Bunker Hill Groundwater, Lytle Basin	2,400	Groundwater, Bunker Hill Groundwater, Lytle Basin	35%
Terrace W. C.	944	Groundwater, Bunker Hill	944	Groundwater, Bunker Hill	0%
Regents of the Univ. of CA	536	Groundwater, Bunker Hill	536	Groundwater, Bunker Hill	0%
Municipal Subtotal	*264,644*		*353,590*		34%
Other/Agricultural/Private[3]	*44,784*		*23,378*		-48%
Total Demand (Rounded to nearest 1,000 af)	**309,000**		**377,000**		22%

Notes:

1 Deliveries to meet annual and ultimate Water Demands from Table 7-1 of the Regional Water Facilities Master Plan, prepared by Albert A Webb Associates, 2000 for Muni and presented in Appendix A and B of SAWPA's Integrated Watershed Management Plan, June 2002. Some values were updated based on purveyor's YR2000 Urban Water Management Plans.

2 Assigned demand as part of Muni service area since it is extracted from Bunker Hill Basin.

3 Agriculture demands come from Bear Valley Mutual W. C., Crafton W. C., Marigold Farms Company, Meeks and Daley W. C., Riverside-Highland W. C., and Other/Private

SWP – State Water Project

W.C. – Water Company

W.D. – Water District

n.a. – Not Applicable

In Allocation Model, Yucaipa WTP is assumed to accept SAR water year-round. For this reason a monthly demand pattern was developed for this WTP. Other WTPs are available only over one season and for these WTPs demand was set at a constant rate for the season. Spreading grounds are assigned long-term absorptive capacities for the potential delivery of captured SAR water and are not varied seasonally since recharge can follow a different pattern than the ultimate monthly or seasonal demand for water.

The analysis of future water demand in the Muni service area assumes that Non-Exporters may increase groundwater pumping as their demands increase. Though water demand of Exporters are anticipated to increase, Exporter supplies from the SBBA are limited by the terms of the *Western* Judgment. Allocation Model assumes Exporter extractions from the SBBA are constant unless new conservation occurs (see Table 5.3-2). Further, no increase in production of local water supplies from the SBBA was assumed for former Norton Air Force Base, Muscoy Mutual Water Company, and Terrace Water Company, since the areas served by these purveyors are assumed to be built out.

Projected year 2020 annual water demands for municipal Non-Exporters were obtained from the UWMPs for each purveyor where available, or from Muni's Regional Water Facilities Master Plan if UWMPs were not available. Projected water demand through year 2039, which is the end of the Allocation Model base period, was estimated by applying anticipated water demand increases obtained from (i) the Santa Ana Integrated Wastershed Plan (2002) or (ii) by extrapolation using the year 2020 estimates. Projected changes in agricultural water demand in the Muni service area through year 2015 were obtained from the Regional Water Facilities Master Plan. The Master Plan estimated a 15 percent decrease in agricultural demands every five years. This same trend was applied to estimate agricultural demands as part of the projected water demands for the Allocation Model. It is anticipated that some of the existing agricultural supply will transfer to urban uses as development occurs.

For those purveyors who indicated that existing supply sources would be used to meet future demands, the proportion of each supply source used was assumed to be the same in year 2020 as in year 2000. For those purveyors who indicated a change in existing supplies would be necessary to meet future demands, examples for nearby purveyors were used to assign supply sources and percent of demand met by each source. Monthly demand patterns in year 2020 were assumed to be the same as for year 2000.

As shown in Table 5.3-2, municipal and industrial production demands are estimated to increase by about 34 percent (including consideration of water conservation and recycling), whereas agricultural demand is expected to decrease by about 48 percent between the years 2000 and 2020. The resulting annual net increase in production demand of 3,380 afy for 2000 to 2020 was assigned for the first 20 years and used for the projected replenishment calculations. Lower annual growth rates of 740 afy were assigned for the final 19 years of the 39-year base period based on information continued in SAWPA planning reports indicating build-out of the Muni service area and allowing for no additional extractions to meet growth in demand by Exporters (SAWPA 2002).

5.3.4 Constraints to Allocation of Santa Ana River Water

Allocation Model distributes captured SAR water and imported water to twenty-two specific beneficial uses within four general categories as illustrated in Table 5.3-1. The Allocation Model considers the following constraints when delivering water to each of the 22 beneficial uses: (1) the conveyance capacity of the delivery route (including the turnout capacity); (2) the monthly available absorptive capacity of the receiving beneficial use; and (3) annual recharge targets set (applicable only to spreading grounds). Descriptions of constraining factors are provided in the sections that follow.

5.3.4.1 Conveyance Routes Used for Captured SAR Water

Under the Project, the majority of water captured from the SAR would be conveyed through the proposed Plunge Pool Pipeline. From the terminus of the completed Plunge Pool Pipeline, at the inter-tie between the Foothill Pipeline and the Inland Feeder Pipeline, five potential conveyance routes could be used to distribute water to locations both within and outside the Muni/Western service areas. These routes are shown in Figure 5.3-1. They are:

- Foothill Pipeline Route (Reverse Flow);
- Foothill Pipeline Route (Normal Flow)
  - Santa Ana Low Route;
  - Greenspot Route;
- Inland Feeder (South) Route; and
- Inland Feeder (North) Route.

These conveyance routes include either existing pipes, pipes currently under construction, or pipelines included as part of the Project. In the future, other conveyance routes may become available, such as pipelines proposed as part of the East Branch Extension (EBX) – Phase II.

Foothill Pipeline Route (Reverse Flow)

This route includes the following combination of pipelines from east to west: Foothill Pipeline (existing Muni pipeline); Devil Canyon By-Pass Pipeline (proposed Muni pipeline); and Lytle Pipeline (existing pipeline owned by San Gabriel Valley Municipal Water District, in which Muni has capacity rights).

This route would convey water to the west from the terminus of the proposed Plunge Pool Pipeline, through the Foothill Pipeline, in reverse direction of the normal flow. As shown in Figure 5.3-1 and Table 5.3-1, this route could deliver water to a number of spreading facilities along the base of the San Bernardino Mountains and to a number of purveyors in the Muni service area. Water could also be conveyed west of Devil Canyon via the Lytle Pipeline.

The capacity of the Foothill Pipeline, in reverse flow, is 200 cfs between the inter-tie of the Inland Feeder and the Devil Canyon By-Pass Pipeline. Currently, conveyance from the Foothill Pipeline to the Lytle Pipeline has a capacity of 55 cfs. However, once the Devil Canyon By-Pass Pipeline is completed and agreements are in place with San Gabriel Valley Municipal Water District, the capacity of this route could increase to 120 cfs for points west of the Devil Canyon By-Pass Pipeline.

Foothill Pipeline Route (Normal Flow)

Between the inter-tie with the Inland Feeder and SARC, it would be possible to operate the Foothill Pipeline in normal flow (288 cfs), even when the remainder of the Foothill Pipeline (inter-tie to Devil Canyon By-Pass Pipeline) is operating in reverse flow. Using the Foothill Pipeline in normal flow would make it possible to access the Santa Ana Low Route (see below) and the Greenspot Route (see below) for delivery of Muni/Western SAR water.

Santa Ana Low Route

The Santa Ana Low turnout is located along the Foothill Pipeline west of the SARC. This turnout provides an opportunity to deliver up to an estimated 288 cfs of SAR water to the Conservation District spreading grounds located just west of the borrow pit in the SAR channel. Within the allocation analysis, this route is assigned a limit of 50 cfs based on shared use of this spreading facility. Deliveries would take place from the Foothill Pipeline operating in its conventional manner (flow from west to east).

Greenspot Route

The Greenspot Route could be used to convey captured SAR water or SWP water to the eastern portion of Muni's service area. SAR water from Seven Oaks could use this pipeline system in two different ways. First, large SAR flows could be delivered to the Greenspot Pump Station through use of the Plunge Pool Pipeline connecting to the Foothill Pipeline and then to the SARC. Second, low SAR flows could be delivered to the Greenspot Pump Station through use of the proposed Low Flow Connector to the existing Greenspot Pipeline and the proposed Morton Canyon Connector II. Regardless of the route taken, once the water reaches the Greenspot Pump Station, it would be lifted through the existing Morton Canyon Connector to the Greenspot Pipeline and ultimately to the Crafton Hills Pump Station. From the Crafton Hills Pump Station the water would be lifted to the eastern portion of the Muni service area. This route capacity is limited to the 70 cfs capacity of the SARC and Morton Canyon Connector.

Inland Feeder (South) Route

The portion of the Inland Feeder, south of the inter-tie with the Foothill Pipeline, which became operational in December of 2002, is a 12-foot diameter pipeline with a conveyance capacity of 1,000 cfs. It is owned and operated by Metropolitan and ultimately designed to deliver SWP water from the Devil Canyon Second Afterbay to Diamond Valley Lake (a reservoir with 450,000 af active surface storage capacity of its 800,000 af total capacity). The water, once at Diamond Valley Lake, could be conveyed to other storage facilities and then be used to meet demands of Metropolitan member district Western, as well as other member districts.

Inland Feeder (North) Route

Currently under construction, with an estimated completion date of 2010, the northern portion of the Inland Feeder could be used in reverse direction. Such operation could provide a conveyance route for captured SAR water to be transmitted from the Plunge Pool Pipeline to Lake Perris (via the California Aqueduct) for delivery to Western or for exchange. This route has an estimated conveyance capacity of 300 cfs.

5.3.4.2 Total Conveyance Capacity for Distributing Captured SAR Water

During Phase I of the Plunge Pool Pipeline, capacity for distributing captured SAR water is more limited than in later phases. During Phase I, the pipeline would divert up to 500 cfs and terminate at the junction of the Foothill Pipeline and the SARC, meaning the only conveyance routes available would be the Foothill Pipeline (Reverse Flow) Route and Greenspot Route. It is assumed in the model that the Foothill Pipeline (Reverse Flow) from the SARC westward to the Inland Feeder could carry as much as 300 cfs. Therefore, combined, these two routes would convey up to 370 cfs, and the remaining diversion (130 cfs) would be conveyed in the Conservation District Canal to the Santa Ana River Spreading Grounds.

During Phase II and later Phases of the Plunge Pool Pipeline, diversion capacity is 1,500 cfs and all conveyance routes are available. In total, the conveyance capacity representing the combined use of all routes identified is 1,788 cfs at build-out, exceeding the 1,500 cfs combined design capacity of the completed Plunge Pool Pipeline and Low Flow Connector Pipeline. This total capacity is the sum of the maximum system conveyance capacities of the following components: (1) Foothill Pipeline Route in reverse flow (existing 55 cfs and up to 200 cfs at build-out); (2) Inland Feeder (South) Route (existing 1,000 cfs capacity); (3) the Inland Feeder (North) Route (up to 300 cfs of capacity in reverse flow upon completion); and (4) Foothill Pipeline in normal flow (up to 288 cfs capacity). Since both the Santa Ana Low and the Greenspot Routes are reached via the Foothill Pipeline, their capacities are not included in calculating overall capacity. Allocation Model assumes 1,500 cfs as the maximum SAR water diversion rate via the Plunge Pool Pipeline, and that other uses of conveyance facilities would not interfere with the use of available capacity to deliver SAR water. If necessary, the full capacity of the conveyance routes could be available to deliver captured SAR water.

5.3.4.3 Conveyance Routes Used for Return of Exchange Water

It is assumed that as part of an exchange, Muni/Western would deliver SAR water to a number of exchange partners and in return would receive a like volume of SWP water at a later date. The water returned to Muni/Western would be delivered to the SWP Devil Canyon Afterbays, and from this location would then be distributed according to Priorities 1 through 3. Figure 5.3-2 illustrates the routes available for distributing this returned SWP water. Three routes are identified:

- Foothill Pipeline Route;
- Lytle Creek Route; and
- Greenspot Route.

Foothill Pipeline Route

This route uses the Foothill Pipeline to convey water eastward from the Devil Canyon Afterbays. As shown in Figure 5.3-2, this route could deliver water to a number of spreading facilities along the base of the San Bernardino Mountains and to a number of purveyors in the Muni service area. The capacity of the Foothill Pipeline Route is 288 cfs.

Lytle Pipeline Route

This route uses the Lytle Pipeline to convey water westward from the Devil Canyon Afterbays. As shown in Figure 5.3-2, this route could deliver water to a number of spreading facilities and the West Valley Water District water treatment plant. The capacity of the Lytle Route is assigned 120 cfs within the Allocation Model, which assumes the Devil Canyon By-Pass Pipeline is operational.

Greenspot Pipeline Route

This route is the same as described earlier for delivery of captured SAR water. The route is essentially an eastward extension of the Foothill Pipeline Route. Water conveyed by the Foothill Pipeline from the Devil Canyon Afterbays could enter the SARC Pipeline and the Greenspot Route. This route capacity is limited to the 70 cfs capacity of the SARC, Greenspot Pump Station, and the Morton Canyon Connector.

Total Capacity Available for Distributing Returned Exchange Water

In total, the maximum possible conveyance capacity for water returned as part of an exchange is 408 cfs. This total capacity is the sum of the maximum system conveyance capacities of the following components: (1) Foothill Pipeline Route (288 cfs); and (2) Lytle Route (120 cfs). The Greenspot Route shares capacity with the Foothill Pipeline Route; therefore, it is does not add to the total conveyance capacity.

The Allocation Model assigns the maximum quantity of return from exchange in any month as 288 cfs. This represents the capacity of the Foothill Pipeline when operated from west to east. The actual potential capacity for exchange would be greater than this, as water could also be conveyed in the Lytle Pipeline. However, Allocation Model applies the 288 cfs as a reasonable conveyance capacity limit to reflect possible operational limitations in the return of exchange water.

5.3.4.4 Available Absorptive Capacity and Demand Factors of Beneficial Uses

As shown in Table 5.3-1, within Allocation Model each beneficial use is assigned an available absorptive capacity (e.g., capacity at buildout), representing a reasonable rate at which water can be absorbed, or used, over a specific period. There are, however, seasonal variations in the absorptive capacity of the beneficial uses. This is accommodated in Allocation Model by assigning a "demand factor" to each beneficial use. The "demand factor" can assume a value between zero and one for each month of the analysis. A value of zero reflects that, in a given month, a particular beneficial use cannot take any delivery of captured SAR water. A value of 1 signifies that in that month the full absorptive capacity of the beneficial use is available for SAR water delivery. A value of 0.5 signifies that in that month half of the assigned absorptive capacity of a beneficial use is available to take Project water. For example, in the months of September through February many of the spreading grounds are assigned demand factors of zero, since during these months it is assumed that the absorptive capacity of the spreading grounds is dedicated to local runoff and no additional space is available for SAR water. Likewise, demand factors for water treatment plants (with the exception of the Yucaipa Water Treatment Plant) are set to zero from September through May, reflecting the fact that in those months other local or imported water supplies meet demands and these WTPs have no available capacity to take captured SAR water.

5.3.5 Constraints to Allocation of Water for Groundwater Recharge

Allocation Model directs water to a given beneficial use based on its priority, the available conveyance capacity, and the available absorptive capacity of the beneficial use. However, an additional constraint applies to deliveries to each of the groundwater spreading facilities in the SBBA. Based on the results of groundwater modeling, each spreading ground in the SBBA was assigned a "recharge target" for each year of the analysis. The recharge target is an estimated volume of spreading, which balances the sometimes conflicting objectives of meeting Muni's recharge obligations under the *Western* Judgment and undertaking the greatest possible recharge for local beneficial use, while simultaneously avoiding groundwater mounding[13], high groundwater levels in the Pressure Zone, and adverse movement of existing groundwater contamination plumes. Recharge targets for the spreading grounds differ from year to year, depending on antecedent conditions. They do not represent optimum groundwater management; but provide a guideline on how much, and in what manner, water could be spread to avoid the adverse affects mentioned above.

5.3.5.1 Defining Recharge Targets

The iterative process between the Allocation Model and the groundwater model starts with an initial estimate of annual deliveries to each spreading ground (provided as output from Allocation Model) as input to the groundwater model. The effect of these initial delivery estimates on groundwater levels are evaluated, and then manual adjustments are made to the recharge targets used in the Allocation Model. The iterative process is repeated until an acceptable recharge target is identified that meets the groundwater management objectives.

In developing recharge targets, consideration is given to:

- Groundwater level hydrographs from the previous groundwater model iteration. Emphasis is placed on spreading water away from those groundwater basins that adversely influence groundwater levels in the Pressure Zone;.

- Muni's replenishment obligation. Under the terms of the *Western* Judgment, Muni is responsible for providing imported water for replenishment of the SBBA at least equal to the amount by which extractions exceed the sum of San Bernardino County water user's share of the 72.05 percent of safe yield and any new conservation to which

13 Mounding is an upward and outward expansion of the groundwater table (Nevada Division of Water Planning 2000).

San Bernardino County water users are entitled. Muni can accumulate credit for use in meeting such replenishment obligation and any new export obligation as follows:

- Water users extract less than 72.05 percent of the safe yield in any year;
- Muni replenishes the SBBA with imported water; and
- Return flow recharged to the SBBA from imported water and excess extractions.

- Increasing recharge in years when recharge can be accomplished using Muni's Table A[14] amount or captured SAR water rather than years when it would be necessary to purchase more expensive "market water."

- The volume of water spread in the Santa Ana River Spreading Grounds by the Conservation District. Quantities of SAR water diverted by the Conservation District to the Santa Ana Spreading Grounds are estimated in OPMODEL and become input to Allocation Model. The Model assumes the Conservation District will always spread all of the water it has diverted. The volume of water spread in the Santa Ana River Spreading Grounds by the Conservation District is not adjusted within Allocation Model, even if the recharge target for the spreading grounds is exceeded. Deliveries to the Santa Ana River Spreading Grounds by the Conservation District reduce the absorptive capacity available to Muni/Western.

5.3.6 Replenishment Obligations

5.3.6.1 Background

The *Western* Judgment contains the settlement of a complaint filed by certain parties (Plaintiffs) exporting water from the area defined as the SBBA for use in the Western service area. The Plaintiffs in the *Western* Judgment sought a general adjudication of water rights in the SBBA. The Plaintiffs are represented by Western and include the City of Riverside, Riverside Highland Water Company, Meeks & Daley Water Company, and the Regents of the University of California. The result of the Plaintiffs' action, the *Western* Judgment, aims to preserve the natural safe yield of the SBBA by establishing specific rights to groundwater extraction by plaintiff parties and by requiring replenishment of the basin when verified surface water diversions plus groundwater extractions by non-plaintiffs exceed a specified share of safe yield. The *Western* Judgment provides for implementation of the replenishment obligations and other requirements of the Judgment. Western acts on behalf of the Plaintiffs; Muni acts on behalf of all defendants dismissed from the *Western* Judgment (referred to as Non-Plaintiffs). The Non-Plaintiffs represented by Muni include entities that extract from the SBBA (either surface water diversions or groundwater pumping), and include individual well owners, ranches, dairies, sand and gravel operations, cities such as Colton, Redlands, Rialto, and San Bernardino, as well as other water agencies including Bear Valley Mutual Water Company, Crafton Water Company, North Fork Water Company, East Valley Water District, and West Valley Water District. Muni and Western

14 Table A is a schedule of annual water amounts as set forth in long-term SWP delivery contracts. Table A defines the annual volume of water that could be delivered to a SWP contractor in a given year under regular contract provisions without consideration of surplus SWP water deliveries or other supplies available to a SWP contractor.

nominate representatives who are appointed by the court, who, as Watermaster, prepare an annual report which includes groundwater extractions and surface water diversions made within the San Bernardino, Colton, and Riverside Basin Areas by Plaintiffs and Non-Plaintiffs.

Muni must provide replenishment water to the extent that non-plaintiff extractions in the SBBA exceed the defined share of natural safe yield[15]. Likewise, when extractions are less than the defined natural safe yield, then no replenishment water is needed and within the Watermaster accounting, credits are awarded to Muni against future replenishment obligations. Credits are also awarded when replenishment water in excess of the replenishment obligations is recharged in the SBBA. Muni can meet replenishment obligations by delivering "newly conserved" SAR water, importing SWP water, purchasing water that can be imported through the SWP, or by using existing credits.

5.3.6.2 Parameters Used in Calculating Replenishment Obligation

Muni's replenishment obligations are estimated within Allocation Model. The replenishment obligation is based on the provisions of the *Western* Judgment as described above, in addition to forecasted supplies and demands within the SBBA. Parameters used to determine the annual replenishment obligation include:

- Natural safe yield;
- Water demand by Non-Plaintiffs (production to meet demand includes SBBA groundwater extractions, SBBA surface water diversions, plus imported water delivered as direct delivery within the SBBA);
- SAR water diverted as part of the Project and delivered within Muni's Service area; and
- SBBA groundwater extractions by Plaintiffs.

Natural Safe Yield

The Watermaster has determined the natural safe yield of the water supply accruing to the SBBA at 232,100 afy (Chapter IV of the 2001 Annual Report of the Watermaster). Of the 232,100 afy natural safe yield, 72.05 percent, or 167,238 afy, is the defined portion of natural safe yield available to the Non-Plaintiffs. The Plaintiffs' portion of the defined natural safe yield (27.95 percent) is 64,862 afy, of which 63,435 afy may be exported for use outside the SBBA and 1,427 afy is for use within the SBBA.

The natural safe yield of 232,100 afy was based on recharge practices during WY 1934-35 through WY 1959-60 (the period used by the Watermaster to define the natural safe yield); during that time the average annual recharge by the Conservation District was 4,941 afy. One of the adjustments made in the replenishment calculation represents the difference between the average annual diversions made by the Conservation District (based on diversion records) and their average annual diversion based on the conditions set for each project scenario. The first value is

15 As stated in the Western Judgment, natural safe yield is "That portion of the safe yield of the San Bernardino Basin Area which could be derived solely from natural precipitation in the absence of imported water and the return flows there from, and without contributions from new conservation."

the 4,941 afy, based on the Watermaster 26-year base period of WY 1934-35 to WY 1959-60, and the second value is determined using OPMODEL for the 39-year base period of the proposed Project.

Water Demand by Non-Plaintiffs

As discussed in section 5.3.3, Allocation Model uses a projected increase in water demand by the Non-Plaintiffs over the base period, which recognizes some water conservation and recycling to meet future demands. Within the Allocation Model there are three sources of water available to meet Non-Plaintiff demands: imported water (SWP); local surface water diversions; and groundwater pumping. The estimated amount of water used from each of these sources affects the replenishment obligation estimated by the Allocation Model.

SWP deliveries to Non-Plaintiffs are estimated within Allocation Model based on SWP deliveries reported by the Watermaster for year 2000, but with yearly increases to account for increasing demand (see section 5.3.3). Based on OPMODEL output, Allocation Model estimates Non-Plaintiff local surface water diversions assuming historical diversions by senior water rights claimants (applicable to analyzing the No Project and Scenarios A and B) up to a diversion capacity of 88 cfs (applicable to analyzing Scenarios C and D). The amount of surface water available to the Non-Plaintiffs is dependent upon the forecasted hydrology. Estimates of available surface water, in turn, affect projected groundwater pumping.

Allocation Model assumes that any water demands that are not met by SWP water or local surface water supplies will be met by groundwater pumping. These estimates of groundwater pumping from Allocation Model become input to the groundwater model. The Allocation Model applies the assumptions used in the USGS groundwater modeling that all water pumped from groundwater or used for direct delivery in the basin has a 30 percent return flow. Since the natural safe yield quantities established by the Watermaster accounted for return flows, only the 30 percent return from extractions above the natural safe yield reduce the replenishment obligation as calculated within the Allocation Model.

SAR Water Diverted by the Project

The net increase in SAR water diverted and made available for beneficial use by the Project is considered "new conservation" and, per the terms of the *Western* Judgment, 27.95 percent of this newly conserved water is available to the Plaintiffs. Accordingly, Allocation Model assumes that the Plaintiffs can increase groundwater extractions within the SBBA to use their share (27.95 percent) of any new conservation. The increased pumping by the Plaintiffs and its effect on the replenishment obligation is discussed later.

SAR water that is diverted and subsequently delivered to spreading grounds overlying the SBBA acts to recharge the basin. Similarly, when exchange water is "returned" to the SBBA, this also recharges the basin. However, since the Plaintiffs are expected to export[16] their portion of the new conservation (27.95 percent), Allocation Model uses the assumption that only 72.05 percent of the

16 Only a small portion of the service areas of the various Exporters overlie the SBBA, thus typically Exporters move water from the SBBA to areas outside the SBBA.

SAR water or exchange water delivered to the SBBA will reduce the replenishment obligation. Thus, in the calculation of the replenishment target, Allocation Model counts only 72.05 percent of diverted SAR water and exchange water delivered to the SBBA toward the replenishment obligation. The remaining 27.95 percent is passed through the SBBA and allows the Plaintiffs to increase extractions. Thus, the 27.95 percent Plaintiffs' share of the diverted SAR water delivered to the SBBA neither increases nor decreases the replenishment obligations.

The groundwater modeling indicates that Project diversions of SAR water could cause a decrease in natural deep percolation in the river reach between Cuttle Weir and "E" Street. Thus, an adjustment is made within the replenishment calculation to account for the difference in groundwater recharge by reducing a portion of the SAR water diversions that can be counted as "new conservation."

SBBA Water Extractions by Plaintiffs

As discussed in section 5.3.3, Allocation Model assumes that direct deliveries would not be made to Western's service area, rather increased groundwater spreading in Muni's service area would support increased groundwater pumping for export to users in Western's service area. Allocation Model uses the assumption that, at a minimum, Plaintiffs will pump and export their adjudicated safe yield, and will increase pumping to appropriate their share of any new conservation (27.95 percent). Further, Allocation Model assumes that Plaintiffs will increase pumping to export their share of new conservation within five years from the year in which new water is captured by the Project. When SAR water is captured and exchanged, water is returned to the Muni service area within a reasonable period.

5.3.6.3 Calculating Replenishment Obligation

The annual replenishment obligation under the *Western* Judgment is initially estimated in the Allocation Model as the difference between the Watermaster determined natural safe yield of the SBBA and extractions from the SBBA by Plaintiffs and Non-Plaintiffs. Allocation Model calculation of the annual replenishment obligation considers eight adjustments to the initial estimate.

1) Return flow credit for groundwater extractions greater than SBBA natural safe yield.

2) Return flow credit for SWP Direct Deliveries to SBBA.

3) Combined replenishment adjustment (Non-Plaintiffs' portion [72.05%] of each item 3a, 3b, and 3c).

    (3a) Conservation District Replenishment Adjustment.

    (3b) Newly conserved SAR water delivered to SBBA.

    (3c) Estimated change in natural river recharge from SAR water diversions under each Project scenario in comparison to the No Project condition.

4) Estimated percolation from environmental releases.

5) Recharge from additional senior water rights claimants diversions.

6) Estimated percolation from senior water rights claimants diversions that are returned to the SAR channel downstream.

7) Plaintiffs' portion (27.95%) of the newly conserved SAR water delivered outside the SBBA (but not exchanged).

8) Use of groundwater credits.

Four items that affect the Plaintiffs' annual groundwater pumping from the SBBA resulting from diverted SAR water delivered as new conservation are listed below.

1) Plaintiffs' portion of the diverted SAR water delivered outside the SBBA (but not exchanged).

2) Plaintiffs' portion of the Conservation District replenishment adjustment.

3) Plaintiffs' portion of the diverted SAR water delivered to the SBBA.

4) Plaintiffs' portion of the estimated change in natural river recharge based on SAR water diversions under each Project scenario in comparison to the No Project condition.

The Plaintiffs' adjusted pumping is input to the groundwater model.

5.3.6.4 Availability of SWP Water

A projection of the amount of SWP deliveries available to Muni in any given year is made and used as an input to Allocation Model. A portion of Muni's SWP water is committed to direct deliveries and for use in areas outside of the SBBA but within Muni's service area. Allocation Model assumes that the remaining SWP water is available for replenishment. The projections of the available SWP water for delivery to Muni were derived from results of CALSIM II modeling DWR (2002).

5.3.6.5 Relationship Between Replenishment Obligation and Recharge Target

As described earlier, Muni can meet replenishment obligations by delivering captured SAR water, importing SWP water, purchasing water that can be imported through the SWP, or by using existing credits. In years when recharging water to meet the replenishment obligation would be inconsistent with the groundwater recharge target, Muni can use credits instead of undertaking groundwater recharge. In 2001, the Western-San Bernardino Watermaster reported Muni credits of approximately 270,000 af. Per the direction of the Watermaster, Allocation Model uses the following criteria to balance recharge targets and replenishment obligation annually:

- When Muni's accumulated credit is greater than 270,000 af, then credit is used in lieu of undertaking groundwater replenishment.
- When Muni's accumulated credit is more than 100,000 af and less than 270,000 af, and the recharge target is less than the replenishment obligation, then credit is used to meet the portion of the replenishment obligation that is greater than the recharge target, thus using existing credit and lowering the credit balance.

- When Muni's accumulated credit is more than 100,000 af and less than 270,000 af and the recharge target is more than the replenishment obligation, then Muni's available Table A water supplies are used to try and meet the recharge target, thus restoring used credit and adding to the credit balance.
- Credit cannot be used when Muni's accumulated credit is less than 100,000 af.
- No more credit can be used in any given year than the lesser of 25,000 af or the amount of Muni's accumulated credit in excess of the 100,000 af reserve limit.
- If the combination of Muni's SWP supply and use of accumulated credits is insufficient to meet the Replenishment Obligation in a given year, it is assumed that Muni will purchase water as necessary to replenish the SBBA.

5.3.6.6 Allocation of Replenishment Water

Within Allocation Model, replenishment water is distributed on an annual basis to the spreading grounds that overlay the SBBA. This water is allocated subject to remaining absorptive capacity of each of the spreading grounds (after consideration of spreading of captured SAR water) and subject to recharge targets established in the groundwater model. Possible limitations in conveyance capacity are not considered when allocating replenishment water. It is assumed that replenishment water deliveries could be scheduled throughout the year to avoid periods when conveyance capacity could be inadequate.

5.4 MODEL OUTPUT

Consistent with the other hydrology models, Allocation Model analyzes five scenarios: A, B, C, and D, and the No Project condition.

Allocation Model provides results for the following project-related characteristics:

- Quantity of captured SAR water delivered monthly and annually to each of the 22 specific beneficial uses;
- Monthly and annual quantity of captured SAR water to be returned as SWP water in an exchange;
- Quantity of SWP water returned as part of an exchange with other SWP contractors and delivered to each of the 22 beneficial uses;
- Quantity of SWP water imported by Muni to meet replenishment obligations; and
- Annual quantity of additional imported water purchased by Muni on an "as needed" basis to meet replenishment obligations.

5.5 MODEL RESULTS

This section presents model results describing the quantities of captured SAR water allocated to each of the beneficial uses under different Project scenarios. Attention is given first to initial deliveries to the four general beneficial users (direct, recharge of the SBBA, groundwater recharge outside the SBBA, and exchange) followed by initial deliveries to the specific beneficial uses. This is followed by an examination of ultimate deliveries to the same beneficial uses, i.e., the deliveries once all exchange water has been returned.

5.5.1 Deliveries of SAR Water to Beneficial Uses

5.5.1.1 Initial Deliveries to Beneficial Uses

Projected initial median annual deliveries to the four priorities under different project scenarios are illustrated in Figure 5.5-1. Initial deliveries refer to those deliveries of water made to beneficial uses directly after their diversion from the SAR. They do not account for water ultimately allocated in later years when exchange water is returned to the Muni/Western service area. As can be seen from the information presented in Figure 5.5-1, in the majority of years deliveries would be small, ranging from no water under Scenario C or D to approximately 3,265 af under Scenario A or B. With median annual capture, all water would be devoted to Direct Uses (Priority 1). Because the amount of median annual diversions is small, no water would go to Priorities 2 through 4. However, water would go to these priorities during large flow years, as can be seen in the information presented in Figures 5.5-2 and 5.5-3. As demonstrated by these figures, under any of the four Project scenarios, in the maximum year and cumulatively over the base period, the largest share of captured water would be allocated to exchange (Priority 4). In a maximum year, between 56,270 af and 88,438 af would be allocated to combined Priorities 1 through 3 and thereby remain in the Muni/Western service area and between 69,289 af and 147,254 af would go to exchange. Cumulatively over the 39-year base period, between 213,224 af and 661,559 af would be allocated to combined Priorities 1 through 3 and thereby remain in the Muni/Western service area and between 157,452 af and 427,510 af would go to exchange.

As indicated in Figures 5.5-2 and 5.5-3, with other assumptions being the same, changing the diversion rate from 500 cfs to 1,500 cfs (i.e., Scenario A vs. Scenario B or Scenario C vs. Scenario D) increases the quantity of water delivered to exchange, but does not substantially change deliveries to direct uses or groundwater spreading. When diversion capacity is limited to 500 cfs conveyance is limited and it is necessary to spread water in the SAR spreading grounds, regardless of whether the recharge targets set in the Allocation Model indicate high water table elevations may result from these deliveries. While this is undesirable, for the purposes of preventing high groundwater in the pressure zone, spreading water in the SAR spreading grounds (which will, after a lag, reach the pressure zone) is preferable to leaving water in the SAR because of the immediate influence on groundwater levels. Thus, initial deliveries of captured SAR water to spreading in the SBBA (Priority 2) are greater under the 500 cfs diversion rate than the 1,500 cfs diversion rate for each Project scenario (Scenario B rather than Scenario A, Scenario D rather than Scenario C).

A comparison of median annual Muni/Western deliveries (Figure 5.5-1) to maximum annual deliveries (Figure 5.5-2) demonstrates that, in those infrequent high flow years, large quantities of water are available, even under the constraints of Scenarios C and D. Direct deliveries (Priority 1) under Scenarios C and D have a median value of zero, but in the maximum year almost 18,000 af would be allocated to direct delivery.

The deliveries that would be made to specific beneficial uses under Scenario A are shown in Figure 5.5-4. The first priority for delivery is direct uses, and within this category the Yucaipa

WTP would receive the largest delivery relative to the other WTPs. This large quantity is based on the assumption that the Yucaipa WTP can accept SAR water throughout the year, whereas other WTP can accept SAR water only during the period June through August. Under Scenario A, spreading grounds in the SBBA would receive Project deliveries (Priority 2); however, water would also be allocated to spreading grounds outside of the SBBA (Priority 3). This demonstrates the influence that recharge targets have on the amount of SAR water delivered to spreading basins in the SBBA. Consistent with Figures 5.5-2 through 5.5–3, the greatest amount of SAR Project water is allocated to exchange (Priority 4).

An inspection of the information contained in Figure 5.5-4 indicates that no exchanges are made with San Gorgonio Pass Water Agency (SGPWA), or the Department of Water Resources (DWR). Typically, under most hydrologic conditions, all exchange water would be delivered to Metropolitan. This result, however, is an outcome of using a monthly time step for analysis in OPMODEL and Allocation Model. An analysis with a finer time-step (daily) for selected storm events would account for the potential daily peak diversions of up to 1,500 cfs. During these infrequent but high flow events, it would be necessary to use all the conveyance routes and their attendant capacities. This would result in deliveries to SGVMWD, SGPWA, and DWR. A demonstration of water allocation during high flow events is provided in section 5.7.

The deliveries that would be made to specific beneficial uses under Scenario B are shown in Figure 5.5-5. This figure shows that Scenario B would have very similar deliveries to Scenario A, albeit with less water going to each beneficial use, the exceptions being increased deliveries to the Santa Ana River Spreading Grounds and increased exchanges with San Gorgonio Pass Water Agency.

Under Scenarios C and D, deliveries to specific beneficial uses are as illustrated in Figures 5.5-6 and 5.5-7. The majority of time there is no water diverted by the Project under Scenario C or D (see Figure 5.5-1), but in years when water is diverted the first priority for delivery is direct use. Quantities allocated to direct uses (Priority 1) are similar to those observed under Scenarios A and B with the Yucaipa WTP receiving the largest water delivery relative to the other WTPs. Spreading grounds in the SBBA would receive Project deliveries, but diverted water is also allocated to spreading grounds outside of the SBBA. Most deliveries are to exchange (Priority 4).

Initial Deliveries by Year

With a repeat of base period hydrologic conditions, projected initial deliveries to each of the four groups of beneficial uses under Scenario A or B would be as shown in Figure 5.5-8 and 5.5-9. Under Scenario A or B, water would be diverted in all but 2 of the 39 years shown.

A comparison of initial deliveries under Scenario A or B (Figures 5.5-8 and 5.5-9) and Scenario C or D (Figures 5.5-10 and 5.5-11) for each year in the future base period demonstrates that not only is more water delivered under the Scenario A and B, but that water is delivered more frequently. Since water is available more frequently under the Scenarios A and B, it is possible to allocate more water to direct use (Priority 1), spreading in the SBBA (Priority 2), and other groundwater spreading in the Muni service area (Priority 3) than under Scenarios C and D. This condition is evident from the information presented in Figure 5.5-10 and 5.5-11, where capture of SAR water under Scenarios C or D would occur in only 8 of the 39 years with intervening periods between diversions lasting as long as 10 years.

5.5.1.2 Ultimate Deliveries to Beneficial Uses

As described earlier, Allocation Model accounts for deliveries to, and returns from, exchange partners. Within Allocation Model, water that is returned to the Muni service area is distributed using the same priority scheme used for the initial distribution of captured SAR water. First priority is given to direct use, second priority is for groundwater recharge within the SBBA area, and third priority is for groundwater spreading outside of the SBBA but within the Muni service area. Allocation after exchange water has been returned is referred to in this analysis as ultimate delivery.

Projected ultimate median annual deliveries to direct use, spreading in the SBBA, and other spreading in the Muni service area for the Project scenarios are illustrated in Figure 5.5-12. With return of exchange water, the median annual amount of water allocated under Scenario A would be 24,483 af and under Scenario B 17,792 af, with the majority allocated to direct use (Priority 1). Even with the return of exchange water, the median annual amount of water allocated under Scenarios C and D would be zero. On an annual median basis, Allocation Model projects that between 0 to 11,484 af would be allocated to direct uses, between 0 and 9,607 af to groundwater spreading in the SBBA, and the smallest amount to other groundwater spreading in the Muni service area (between 0 and 3,392 af).

The deliveries that would be made to specific beneficial uses under all Project scenarios, following return of exchange water are shown in Figures 5.5-13 through 5.5-16. Again, within Priority 1, Yucaipa WTP would receive the largest delivery relative to other WTPs. For Project Scenarios A and B, return of exchange water increases the amount of water delivered to direct uses (Priority 1) and spread in the SBBA (Priority 2) (compare median initial deliveries in Figures 5.5-4 and 5.5-5 to median ultimate deliveries in Figures 5.5-13 and 5.5-14).

5.5.1.3 Ultimate Deliveries by Year

The yearly projected ultimate deliveries under the Scenarios A and B are illustrated in Figures 5.5-17 and 5.5-18. The information presented in Figures 5.5-17 and 5.5-18 show how under Scenarios A and B water is delivered in all but two of the 39 years. A comparison of annual initial and ultimate deliveries for these scenarios (as shown in Figures 5.5-19 and 5.5-20) demonstrates that water initially allocated to exchange, returns to the Muni service area in succeeding years. The large initial diversion in WY 2005-06, results in large quantities of exchange water, which returns in succeeding years. Initial deliveries in WY 2006-07 are projected to be less than 3,100 af, but with return of exchange water, ultimate deliveries that year would be close to or more than 23,000 af.

Projected ultimate deliveries by year under Scenarios C and D are illustrated in Figure 5.5-21 and 5.5-22. Ultimate deliveries to beneficial uses occur in 12 to 15 of 39 years. This compares to initial deliveries that occur in only eight of 39 years. The comparison between initial and ultimate deliveries by year can be seen in Figures 5.5-23 and 5.5-24. As can be seen from the information portrayed in these figures, there is a large initial delivery under Scenarios C and D in WY 2007-08, but no other initial diversions or deliveries until WY 2018-19. By comparing this initial delivery to ultimate delivery it can be seen that water initially delivered to exchange is returned in the succeeding WYs of 2009-10 and 2010-11. The majority of water returned from exchange would go to direct uses and to groundwater spreading in the SBBA.

The comparison of cumulative total initial to ultimate deliveries (as shown in Figures 5.5-3 and 5.5-25) demonstrates that the majority of water returned from exchange, under all Project scenarios, would be allocated to direct use (Priority 1) and groundwater spreading in the SBBA (Priority 2) and some additional allocated to other spreading (Priority 3).

5.5.2 Replenishment Obligations

As discussed in section 5.3.6, Allocation Model estimates the replenishment obligations of Muni under the terms of the *Western* Judgment. Muni can meet replenishment obligations by: (i) delivering captured SAR water; (ii) importing SWP water; (iii) importing purchased market water through the SWP; (iv) importing other contractor's SWP water as part of an exchange for delivery of captured SAR water; and (v) using existing SBBA groundwater credits (as shown in Figure 5.5-26). Under all Project scenarios a combination of these five sources is used. Under the No Project, the only sources available to meet replenishment obligations are Muni's SWP supply (Table A), credits, and purchase of market water. Allocation Model was designed so all Project scenarios and the No Project are subject to the same rules for calculating the replenishment obligation. Allocation Model was also designed so that all Project scenarios would match the change in annual groundwater storage as the No Project, by allowing some shifting of spreading and use of credits between years. These design features are to ensure that comparisons of the scenarios are not skewed by use of credits and groundwater storage.

With the Project, the total volume of replenishment water is greater than under the No Project (as shown in Figure 5.5-26). This phenomenon is because, with the Project (any scenario), Plaintiffs (Western) are allowed to increase their pumping by 27.95 percent of the "newly conserved" water, regardless of whether water diverted under the Project is delivered within or outside the SBBA.

Allocation Model predicts that Muni will use less SWP water with the Project than under No Project conditions (as shown in Figure 5.5-27); approximately 195,016 af to 303,111 af less within the Muni service area over the 39 year period. It is estimated that under Scenarios C and D, cumulatively over the 39 years of the future base period, Muni would have 1,177,532 af to 1,228,218 af of unused SWP Table A water. Under Scenarios A and B, unused Table A water would range between 1,264,593 af and 1,285,327 af. Under the No Project scenario, Muni's unused SWP Table A water is estimated at 982,516 af. Though overall less of Muni's Table A SWP water would be delivered to the service area, a greater portion Muni's Table A would be delivered to the SBBA under Project scenarios.

5.6 SENSITIVITY ANALYSIS: SEASONAL WATER CONSERVATION STORAGE

Seasonal water conservation storage is defined by the USACE as increased allowable reservoir storage during the months of March through August. Seasonal water conservation storage allows more SAR water to be stored at Seven Oaks and adds flexibility to delivery of water to maximize direct and recharge beneficial uses within Muni's service area, thus potentially reducing the use of regional exchanges.

Based on OPMODEL results, when the Muni/Western diversion rate is 1,500 cfs (as per Scenario A or C), all of the SAR water available for diversion is shown to be diverted by the Plunge Pool Pipeline with or without seasonal water conservation storage. With a 1,500 cfs diversion rate seasonal water conservation storage does not increase capture but does facilitate releasing water after capture in a manner that allows more water to be delivered to direct uses and recharge within Muni's service area boundary and minimizes the use of regional storage.

When the Muni/Western diversion rate is 500 cfs (as per Scenarios B or D), the diversion pipeline is unable to capture all of the SAR water available. Based on these conditions, seasonal water conservation storage helps capture more of the SAR water available for diversion in addition to helping with lagging the delivery so that more of the captured SAR water could be delivered to direct uses and recharge within Muni's service area boundary. Seasonal storage, (given the assumptions of Scenario A), adds about 45,700 af (over the 39-year base period) to total capture by Muni/Western. The maximum annual quantity of water added by seasonal storage in any given year, again given the assumptions of Scenario A, would be 11,500 af. There is only minimal benefit of seasonal storage given the assumptions of Scenario D (see also Tables 4.2-5 and 4.2-6).

The sensitivity of seasonal water conservation was also examined at a daily time step. Based on a daily analysis of captured SAR flows simulated with the Daily Operations Model (DOP) (more detail on DOP is provided in section 6.2), some of the SAR water available for diversion during large storm events would exceed even 1,500 cfs (maximum capacity of the Plunge Pool Pipeline) and be left undiverted. Seasonal water conservation storage was shown to help Muni/Western capture more of this undiverted SAR water. The amount that seasonal water conservation storage helps to capture the undiverted SAR water is dependent on factors such as reservoir conditions behind Prado Dam and the timing of storm runoff events.

In order to evaluate the effects of seasonal water conservation storage on Muni/Western SAR water capture, the two largest storm runoff events in the base period were analyzed with and without seasonal water conservation storage. This evaluation indicated seasonal water conservation storage increased the amount of the available SAR diversions that Muni/Western was able to divert by 23,102 af during the storm runoff event occurring in WY 1979-80 (storm runoff event from February 13, 1980 to April 6, 1980) and a total of 16,182 af during the storm runoff event occurring in WY 1968-69 (storm runoff event from January 19, 1969 to March 31, 1969).

5.7 ANALYSIS OF MAXIMUM DAILY FLOW EVENTS

DOP results were used to identify the possible timing and number of days that a flow of 1,500 cfs (the maximum Muni/Western diversion rate) or greater would occur. An evaluation was also conducted, based on the delivery constraints within the Allocation Model, to identify how a peak diversion of 1,500 cfs would be allocated. This evaluation approximates the daily maximum delivery rate and the total amount of captured water that would not be diverted or delivered to beneficial uses during periods of peak diversions.

Based on DOP results, peak unappropriated flows of 1,500 cfs are available within the months of December, January, February, and March. Since seasonal water conservation storage begins in March, all available SAR water can be captured and delivered in this month. An evaluation of the likely available absorptive capacity for each of the priorities during the months December, January, and February indicates the following limits:

– Direct Delivery (Priority 1)	5 to 10 cfs
– Recharge within SBBA (Priority 2)	0 cfs
– Recharge Outside SBBA (Priority 3)	21 cfs
– Exchanges (Priority 4)	1,371 cfs

The likely maximum absorptive capacity during December, January, and February therefore would be roughly 1,400 cfs.

Based on the DOP results, during the months of December, January, and February, over the 39-year base period, there would be 14 days with a peak unappropriated flow of 1,500 cfs given the assumptions of Scenario A or B, and 8 days where a peak unappropriated flow of 1,500 cfs would be occur given the assumptions of Scenario C or D. With a maximum absorptive capacity of 1,400 cfs available during these 3 months, 100 cfs (approximately 200 af per day) would not be diverted or delivered to beneficial uses during these days, or approximately 1,600 af and 2,800 af, over the base period. Thus the potential loss of Muni/Western diversion, based on the above conditions, ranges from 1,600 af to 2,800 af over the 39-year base period (or 41 to 72 afy). In both cases, at least half of the potential loss occurred in the month of February.

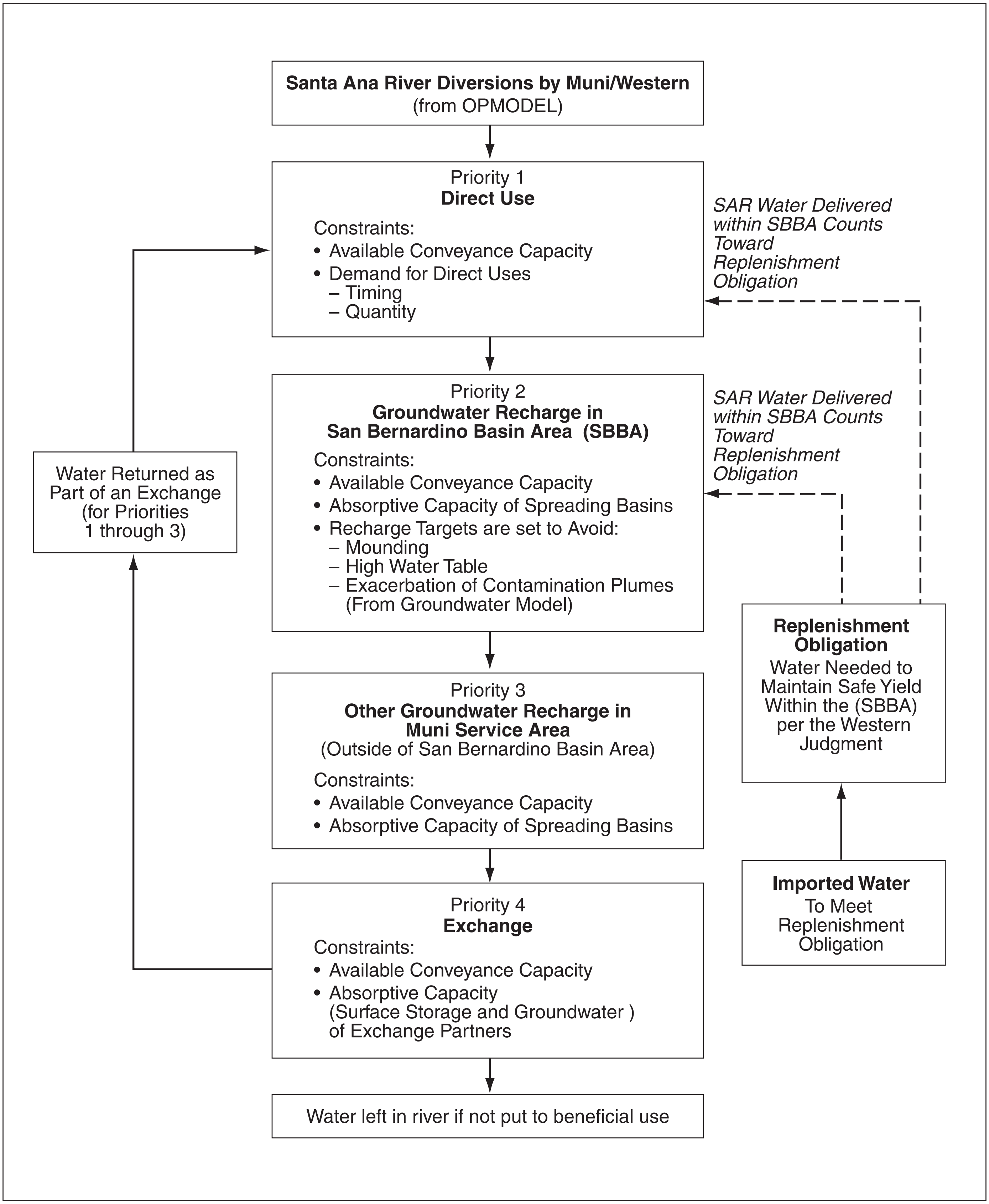


Figure 5.2-1. Allocation Model Structure

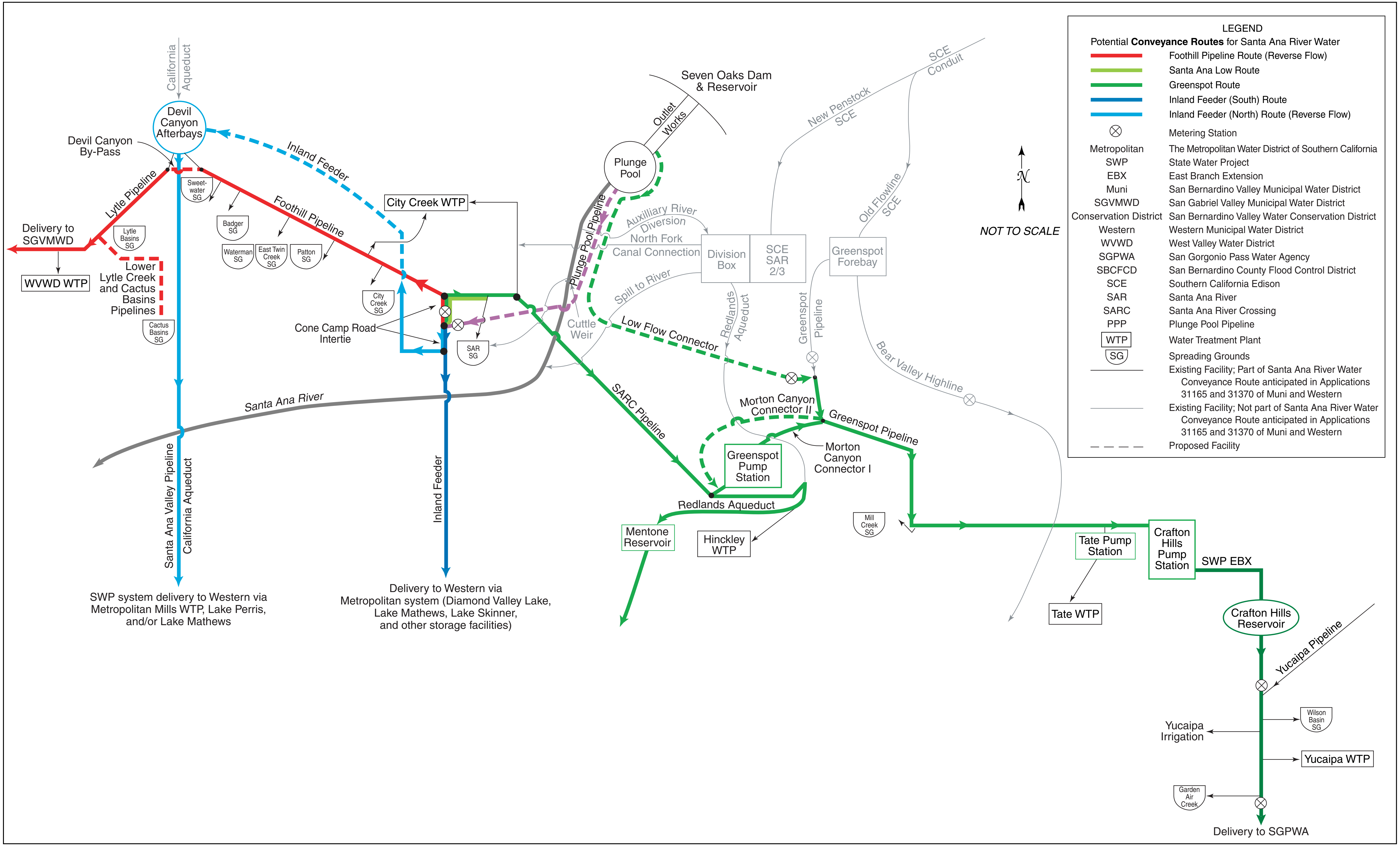


Figure 5.3-1. Potential Conveyance Routes for Santa Ana River Water

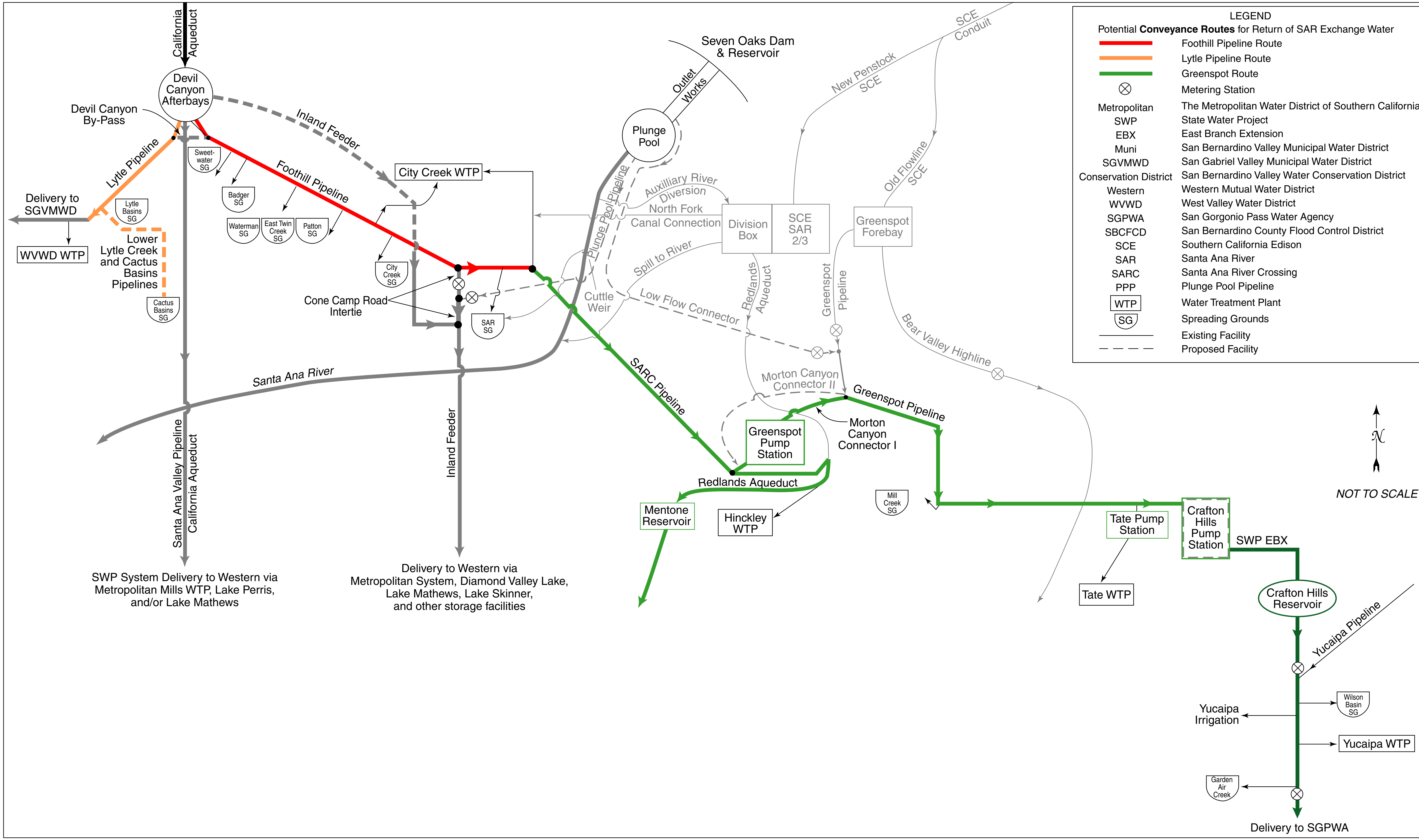
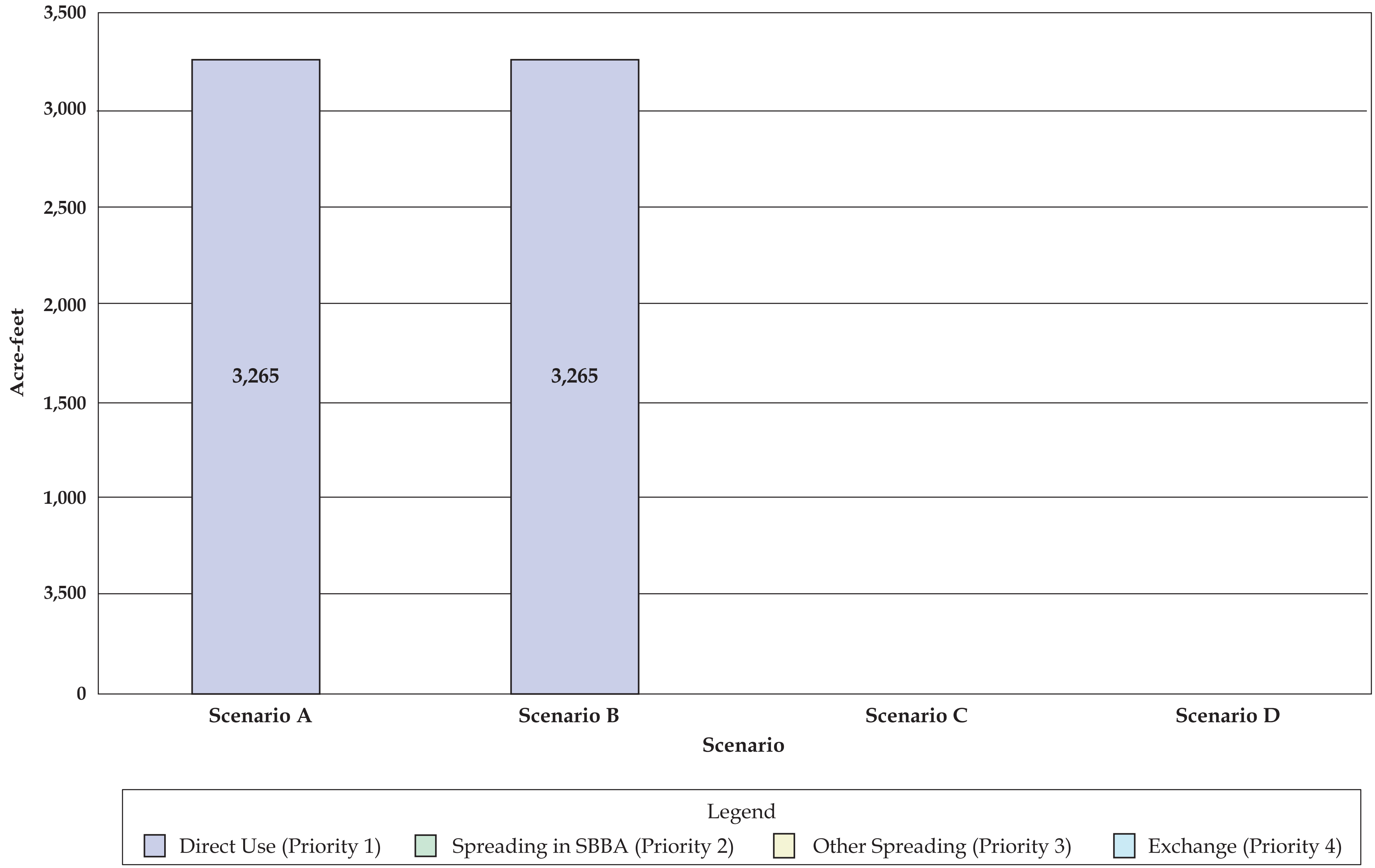
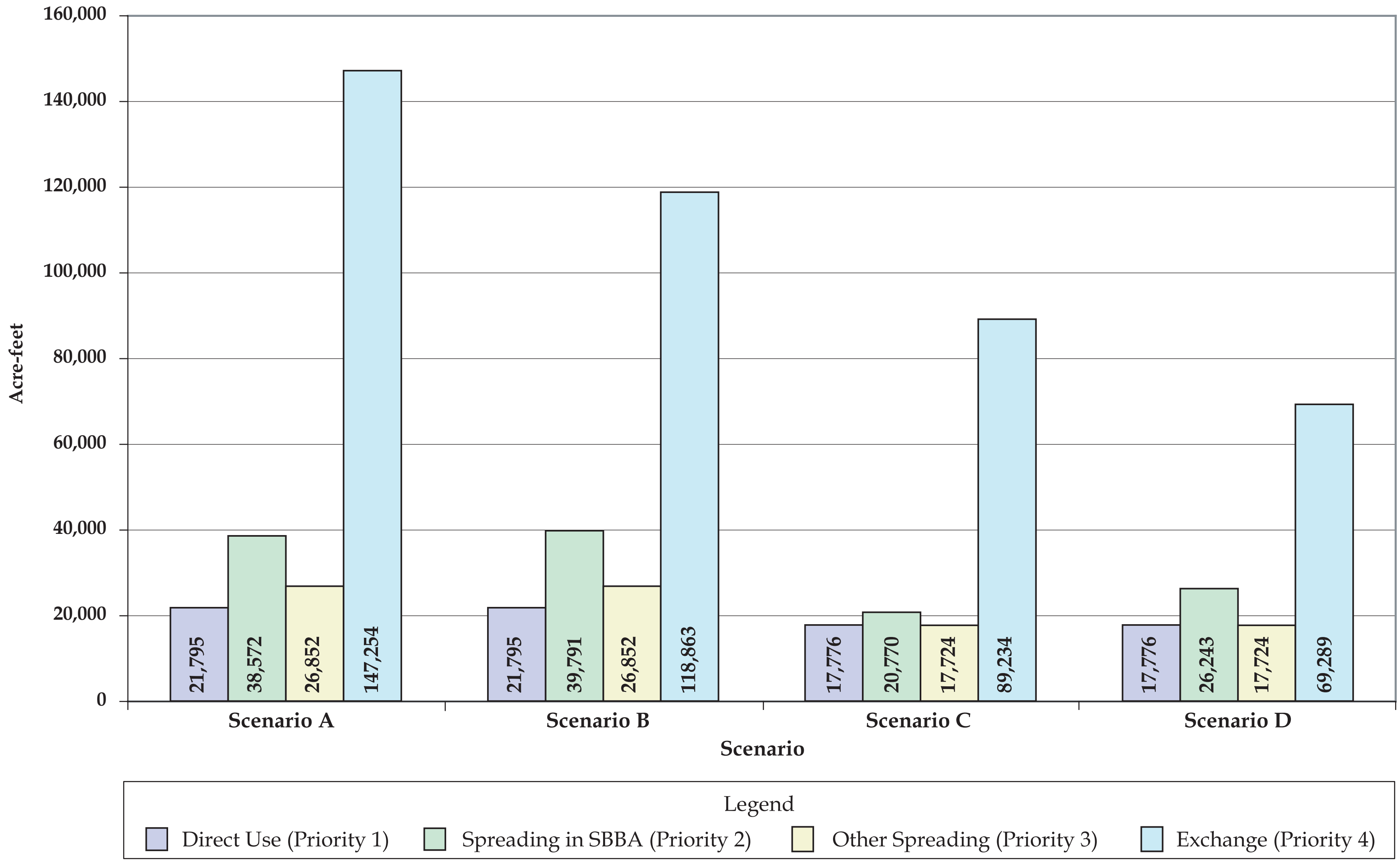


Figure 5.3-2. Potential Conveyance Routes for Return of SAR Exchange Water



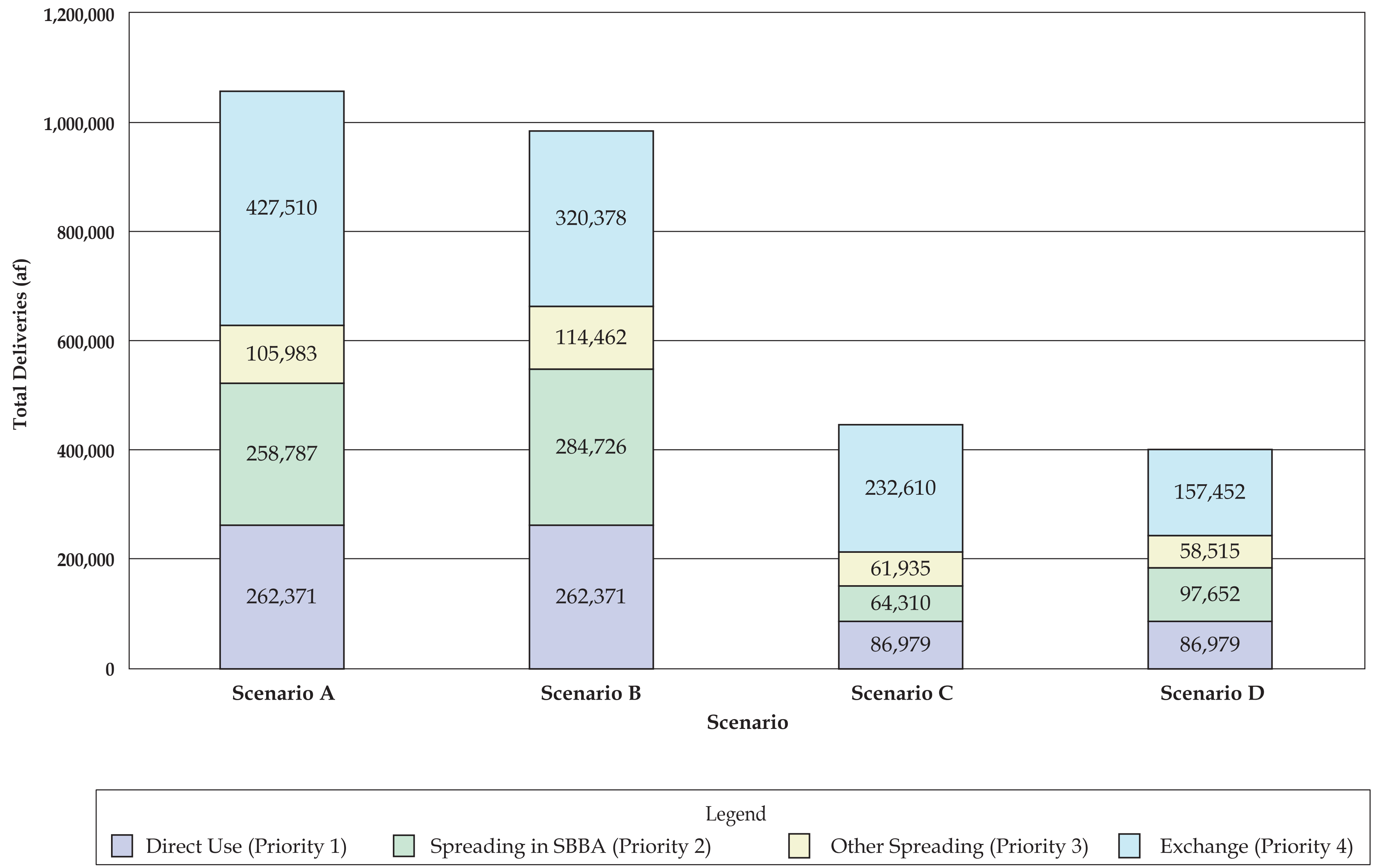
Note: Median values for Scenarios C and D are zero.

Figure 5.5-1. Projected Median Annual Initial Delivery of Captured SAR Water by Priority



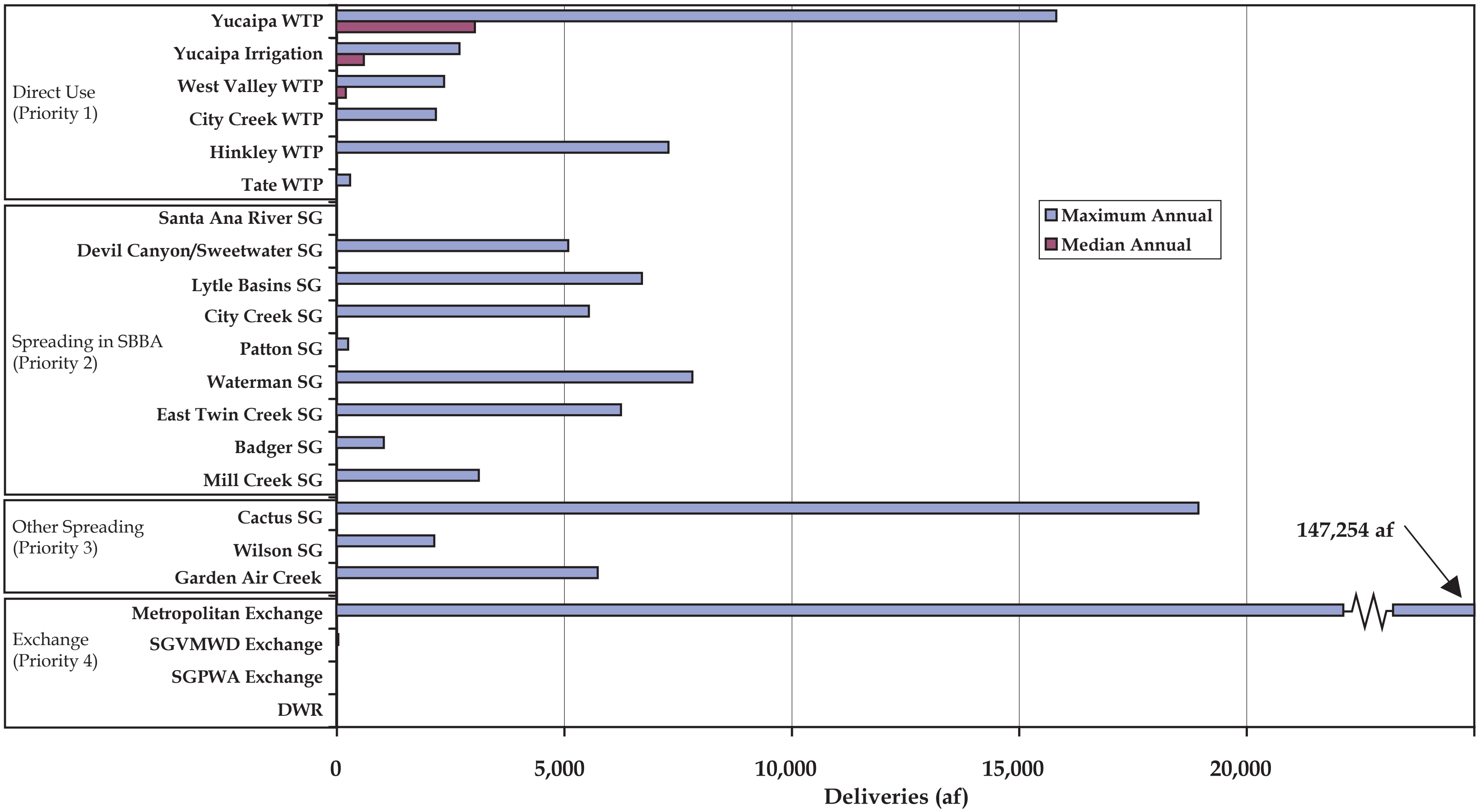
Note: For a given scenario, maximum annual deliveries to Priority 1, Priority 2, Priority 3, and Priority 4 may occur in different years.

Figure 5.5-2. Projected Maximum Annual Initial Delivery of Captured SAR Water by Priority



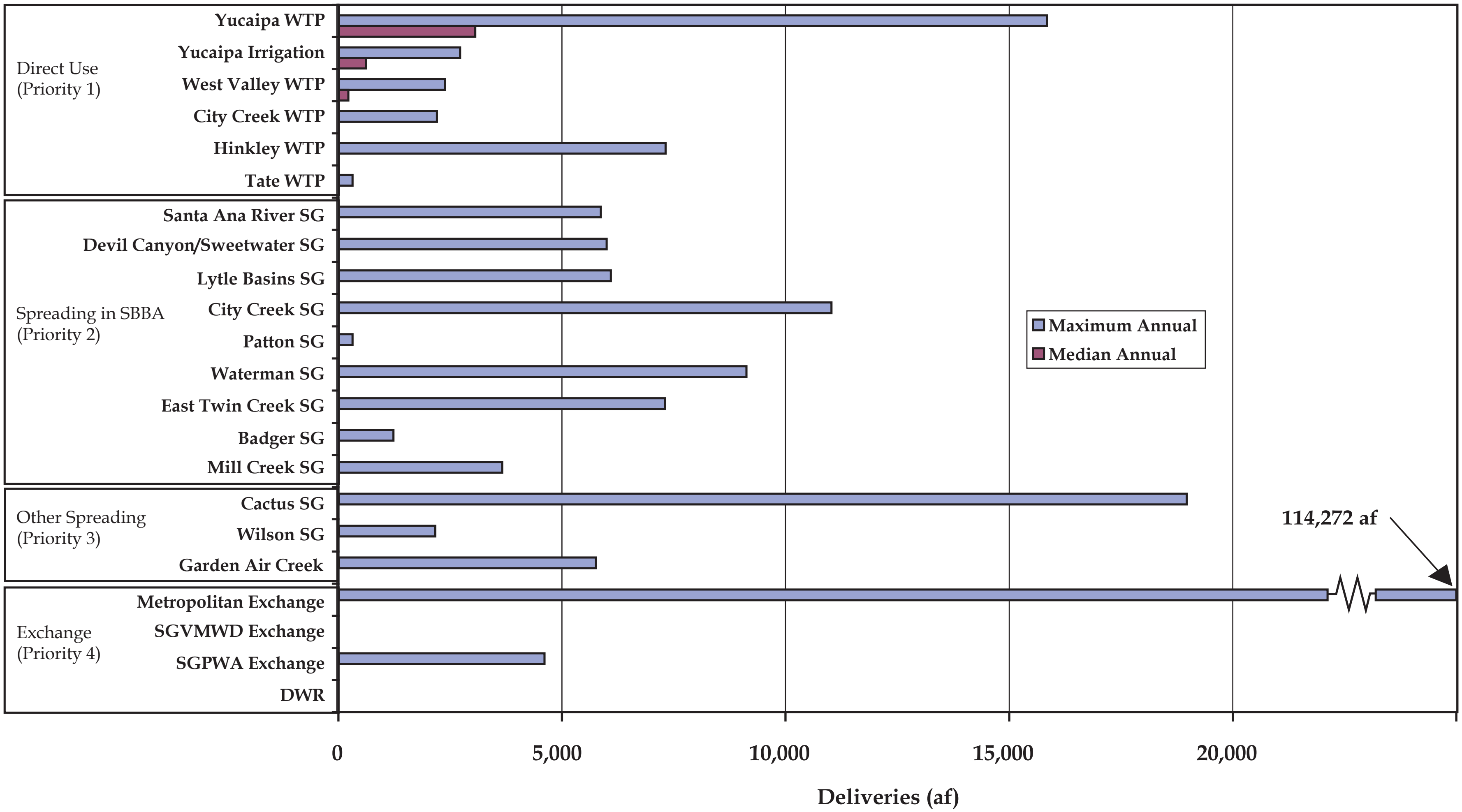
Note: For Water Years 2000-2001 through 2038-2039.

Figure 5.5-3. Projected Cumulative Total Initial Delivery of Captured SAR Water by Priority



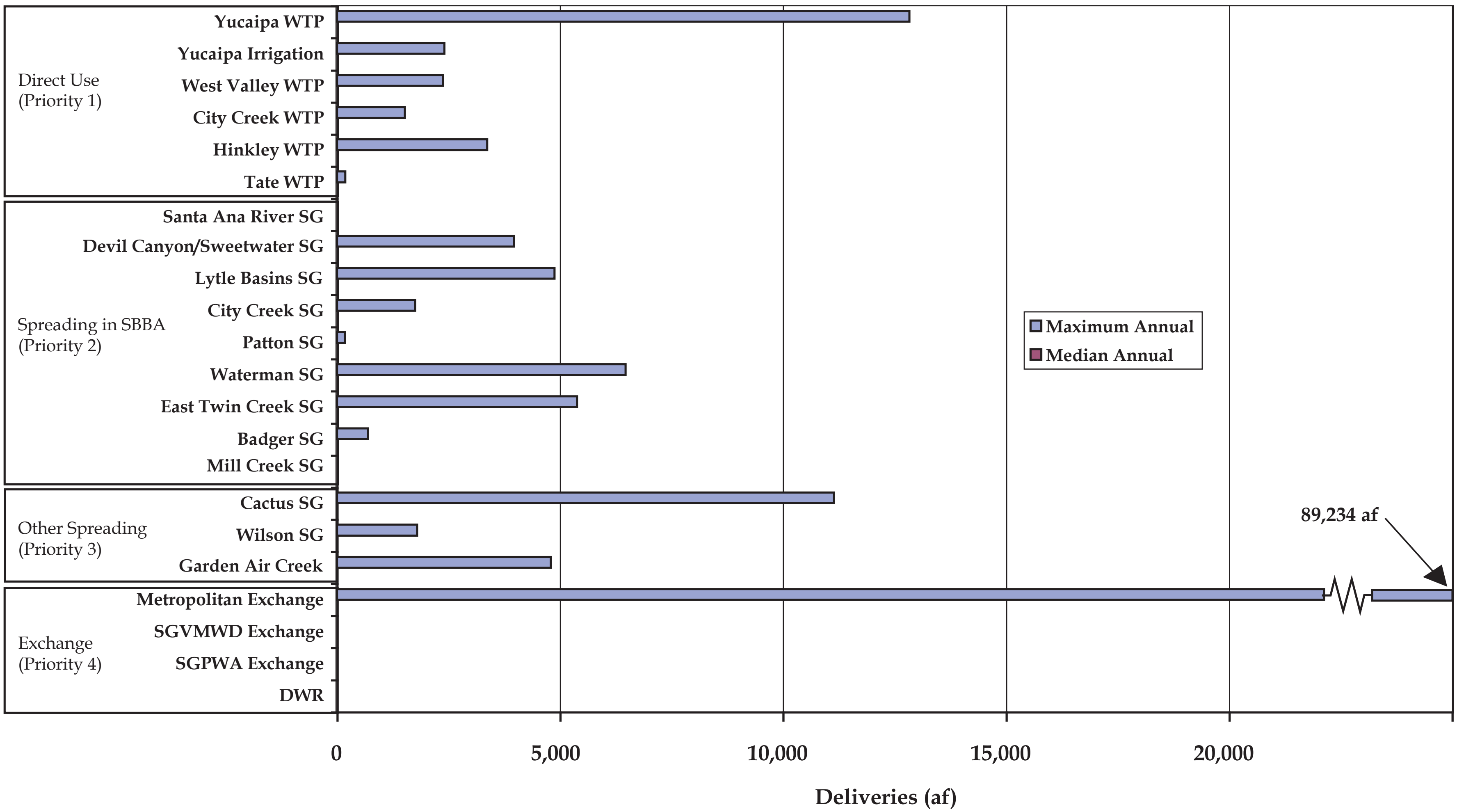
Note: WTP: Water Treatment Plant, SG: Spreading Grounds, SGVMWD: San Gabrial Valley Municipal Water District, SGPWA: San Gorgonio Pass Water Agency, DWR: Department of Water Resources

Figure 5.5-4. Projected Annual Initial Deliveries of Captured SAR Water to Specific Beneficial Uses, Scenario A



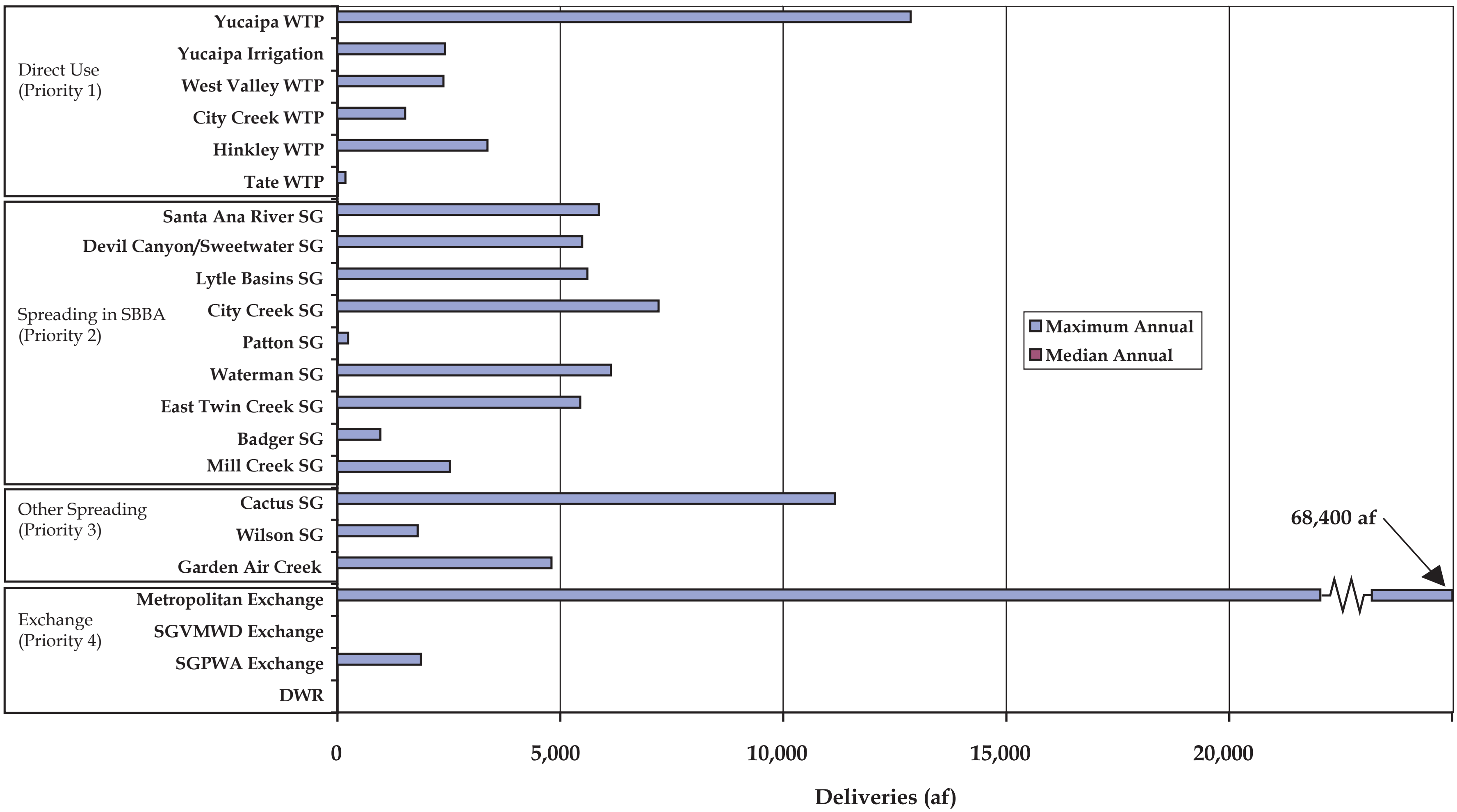
Note: WTP: Water Treatment Plant, SG: Spreading Grounds, SGVMWD: San Gabrial Valley Municipal Water District, SGPWA: San Gorgonio Pass Water Agency, DWR: Department of Water Resources

Figure 5.5-5. Projected Annual Initial Deliveries of Captured SAR Water to Specific Beneficial Uses, Scenario B



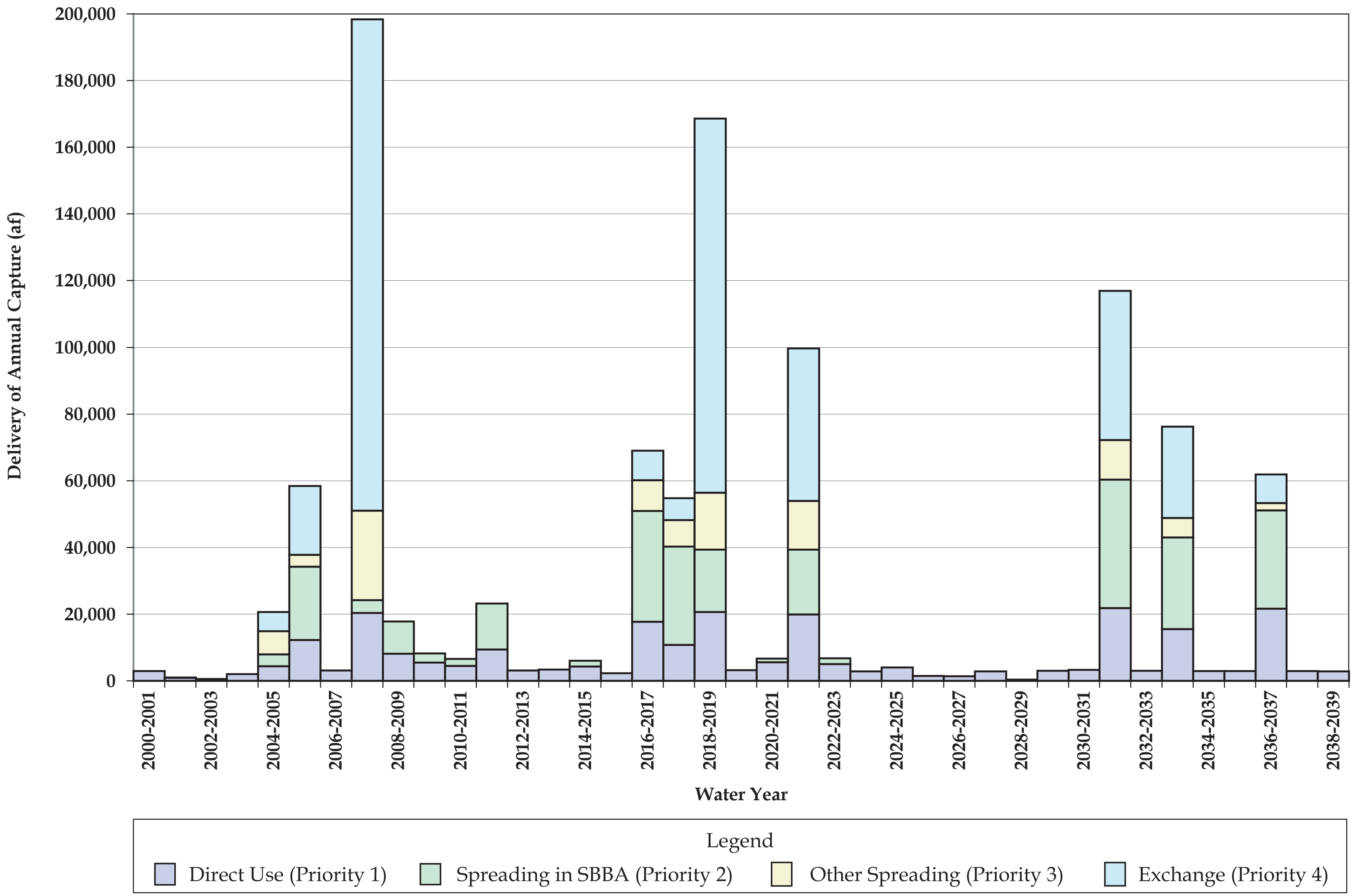
Note: WTP: Water Treatment Plant, SG: Spreading Grounds, SGVMWD: San Gabrial Valley Municipal Water District, SGPWA: San Gorgonio Pass Water Agency, DWR: Department of Water Resources

Figure 5.5-6. Projected Annual Initial Deliveries of Captured SAR Water to Specific Beneficial Uses, Scenario C



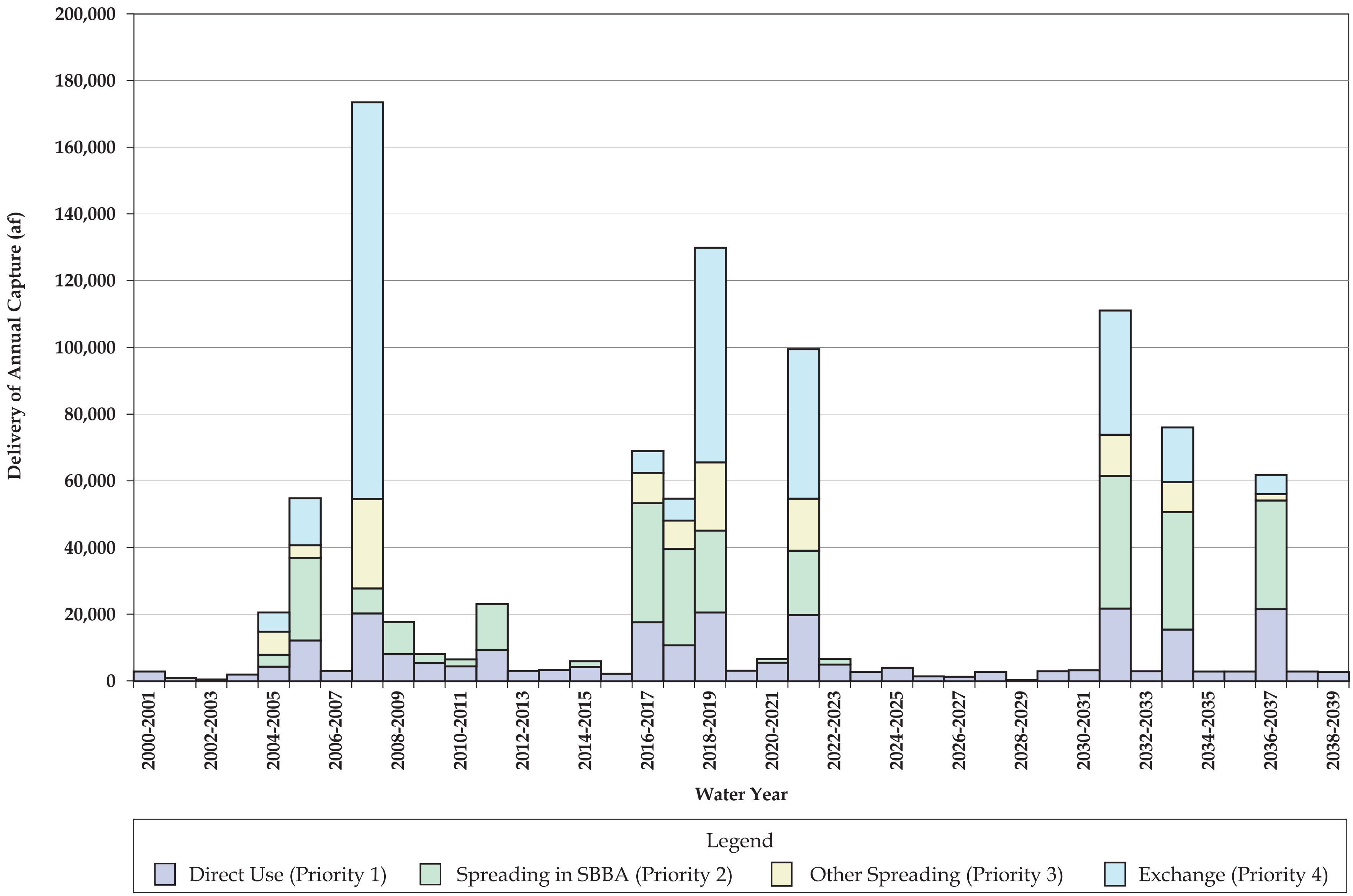
Note: WTP: Water Treatment Plant, SG: Spreading Grounds, SGVMWD: San Gabrial Valley Municipal Water District, SGPWA: San Gorgonio Pass Water Agency, DWR: Department of Water Resources

Figure 5.5-7. Projected Annual Initial Deliveries of Captured SAR Water to Specific Beneficial Uses, Scenario D



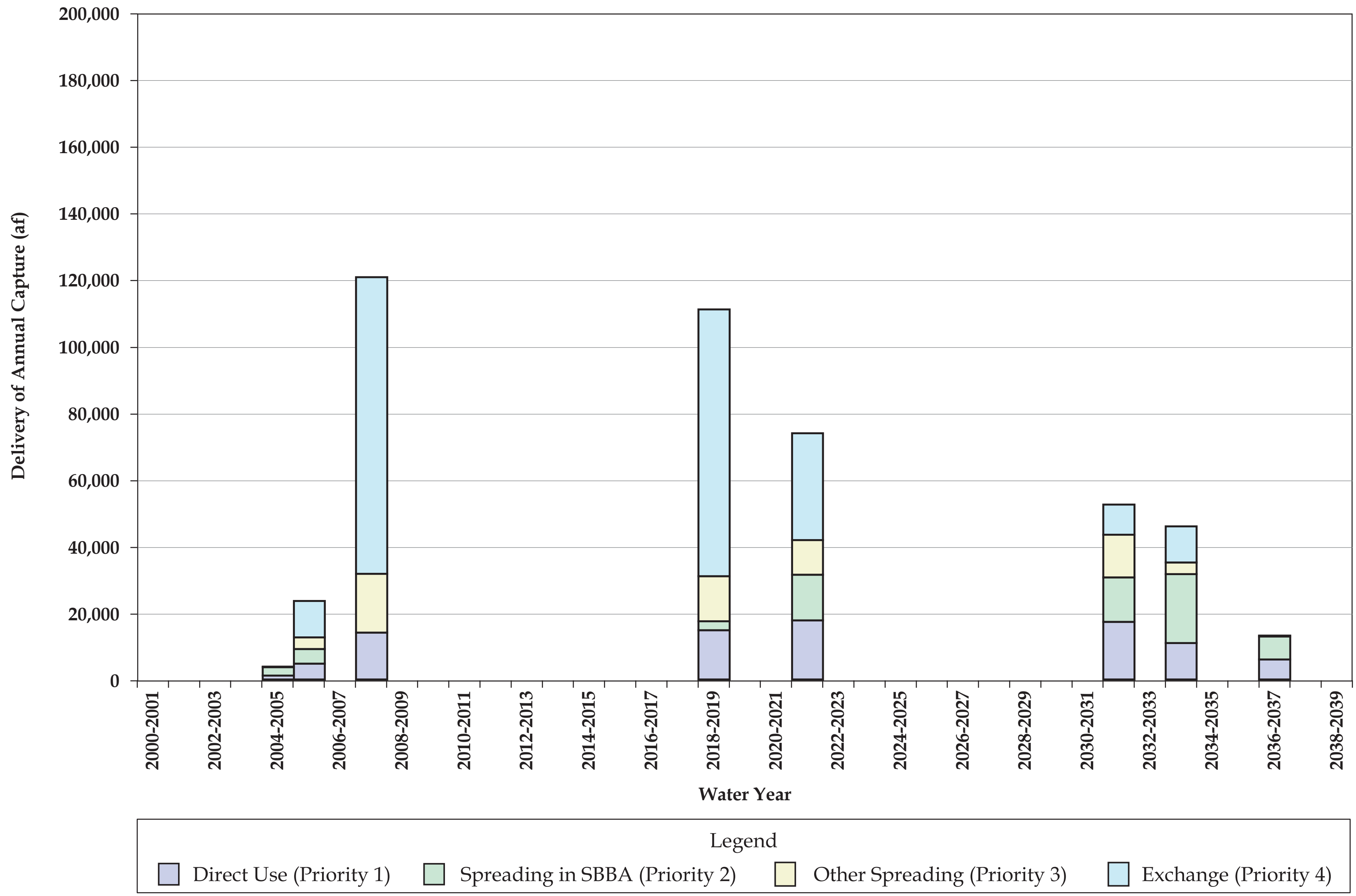
Note: For Water Years 2000-2001 through 2038-2039. Includes only initial delivery of appropriated SAR for exchange. Return from exchange not shown.

Figure 5.5-8. Projected Initial Annual Delivery of Captured SAR Water by Priority, Scenario A



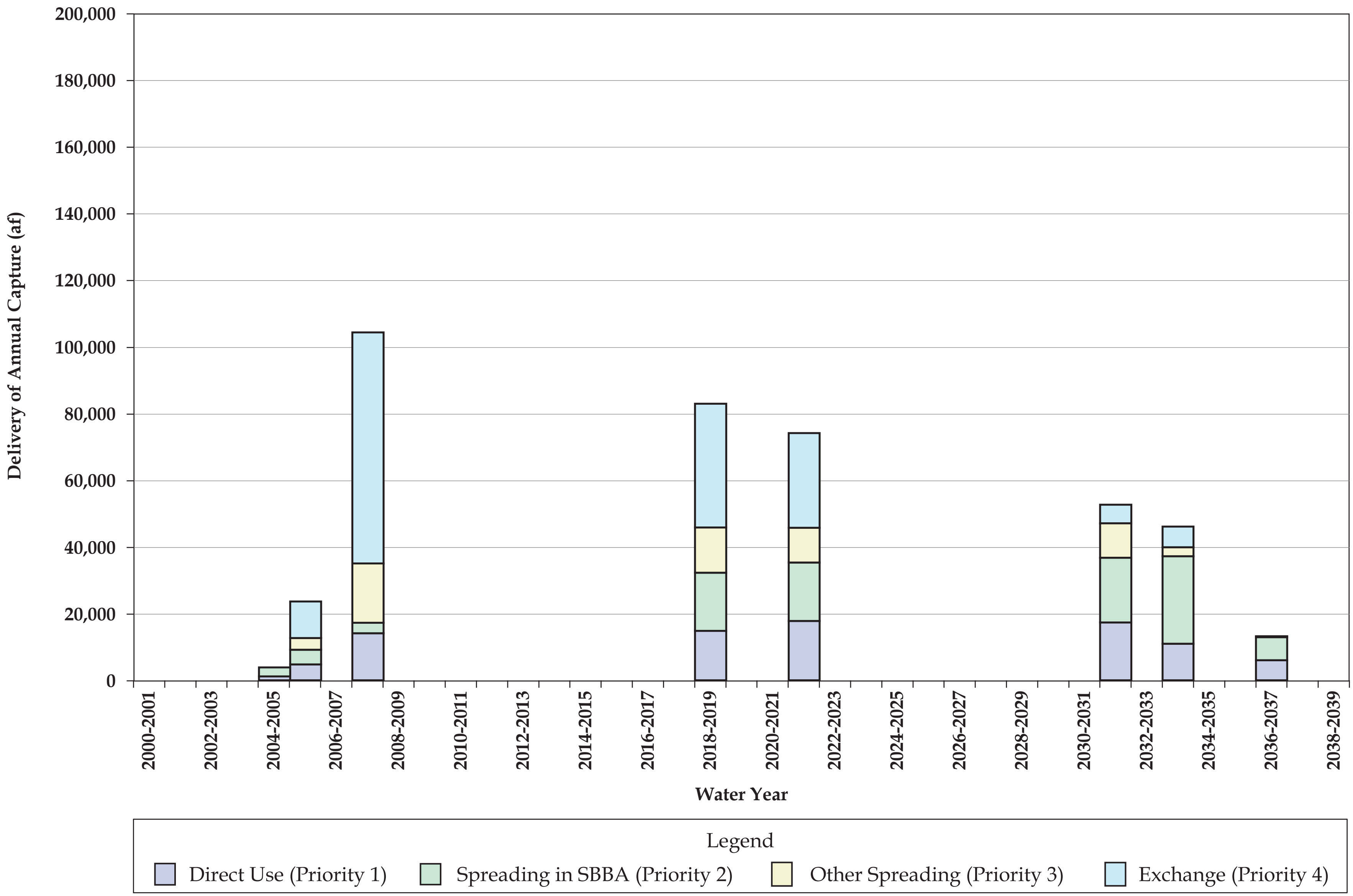
Note: For Water Years 2000-2001 through 2038-2039. Includes only initial delivery of appropriated SAR for exchange. Return from exchange not shown.

Figure 5.5-9. Projected Initial Annual Delivery of Captured SAR Water by Priority, Scenario B



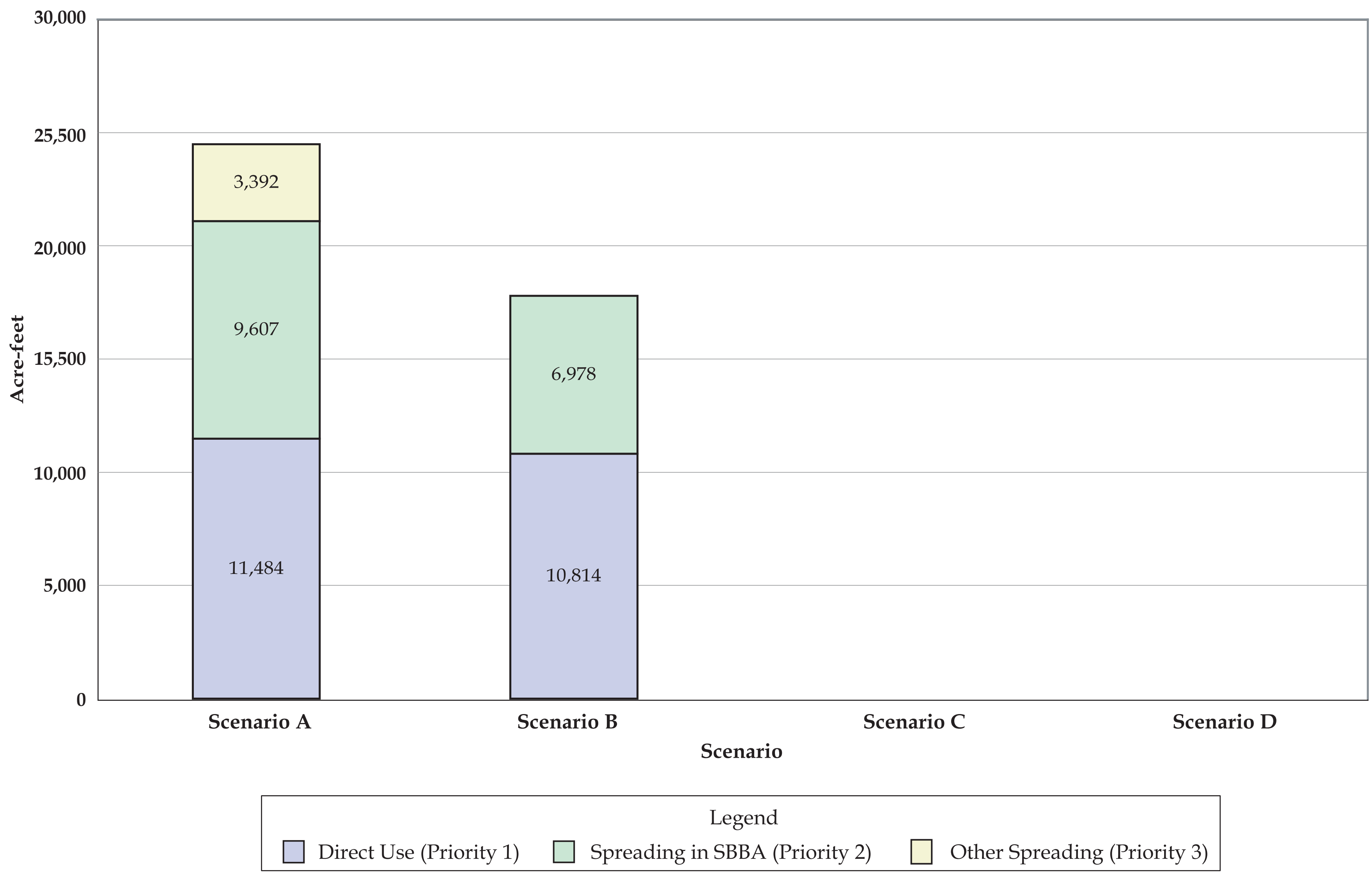
Note: For Water Years 2000-2001 through 2038-2039. Includes only initial delivery of appropriated SAR for exchange. Return from exchange not shown.

Figure 5.5-10. Projected Initial Annual Delivery of Captured SAR Water by Priority, Scenario C



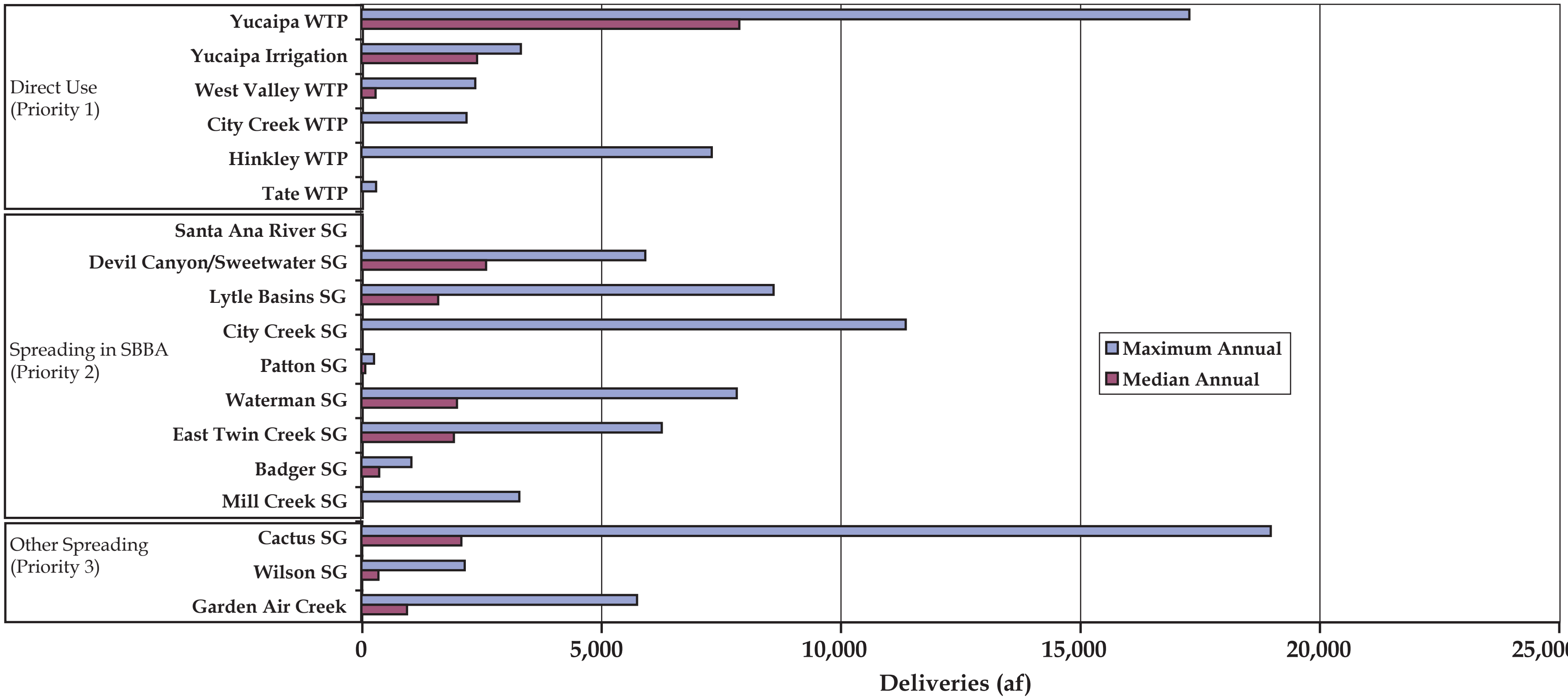
Note: For Water Years 2000-2001 through 2038-2039. Includes only initial delivery of appropriated SAR for exchange. Return from exchange not shown.

Figure 5.5-11. Projected Initial Annual Delivery of Captured SAR Water by Priority, Scenario D



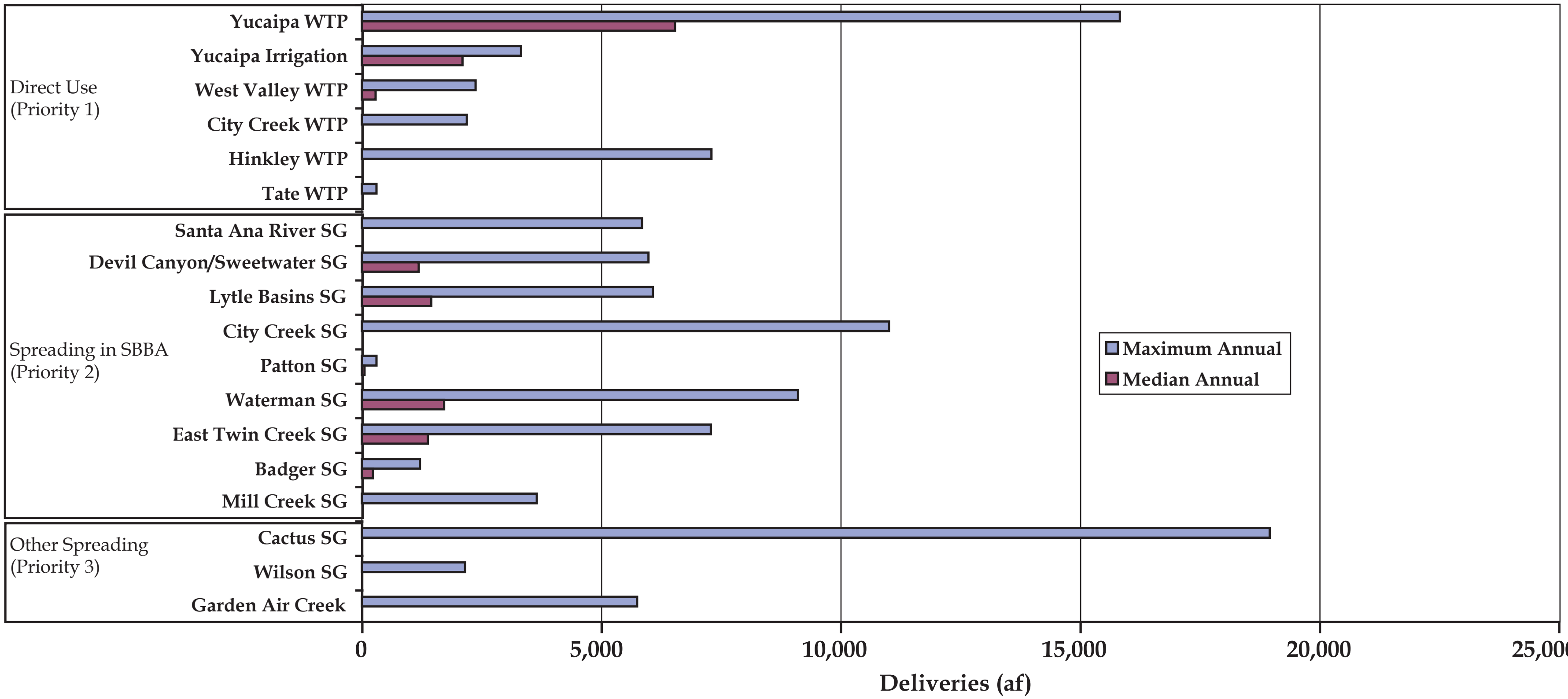
Note: Median values for Scenarios C and D are zero.

Figure 5.5-12. Projected Median Annual Ultimate Delivery of Captured SAR Water by Priority



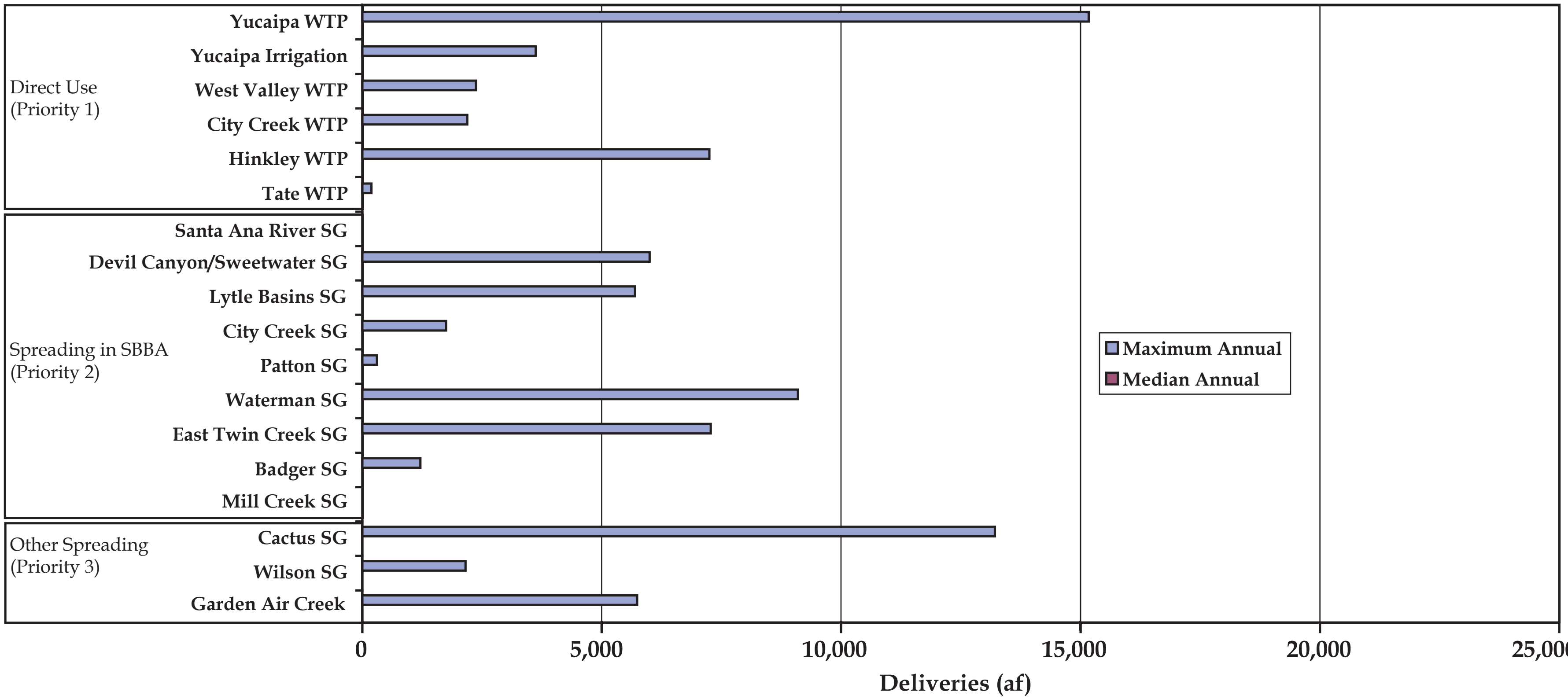
Note: WTP: Water Treatment Plant, SG: Spreading Grounds.

Figure 5.5-13. Projected Ultimate Delivery of Captured SAR Water to Specific Beneficial Uses, Scenario A



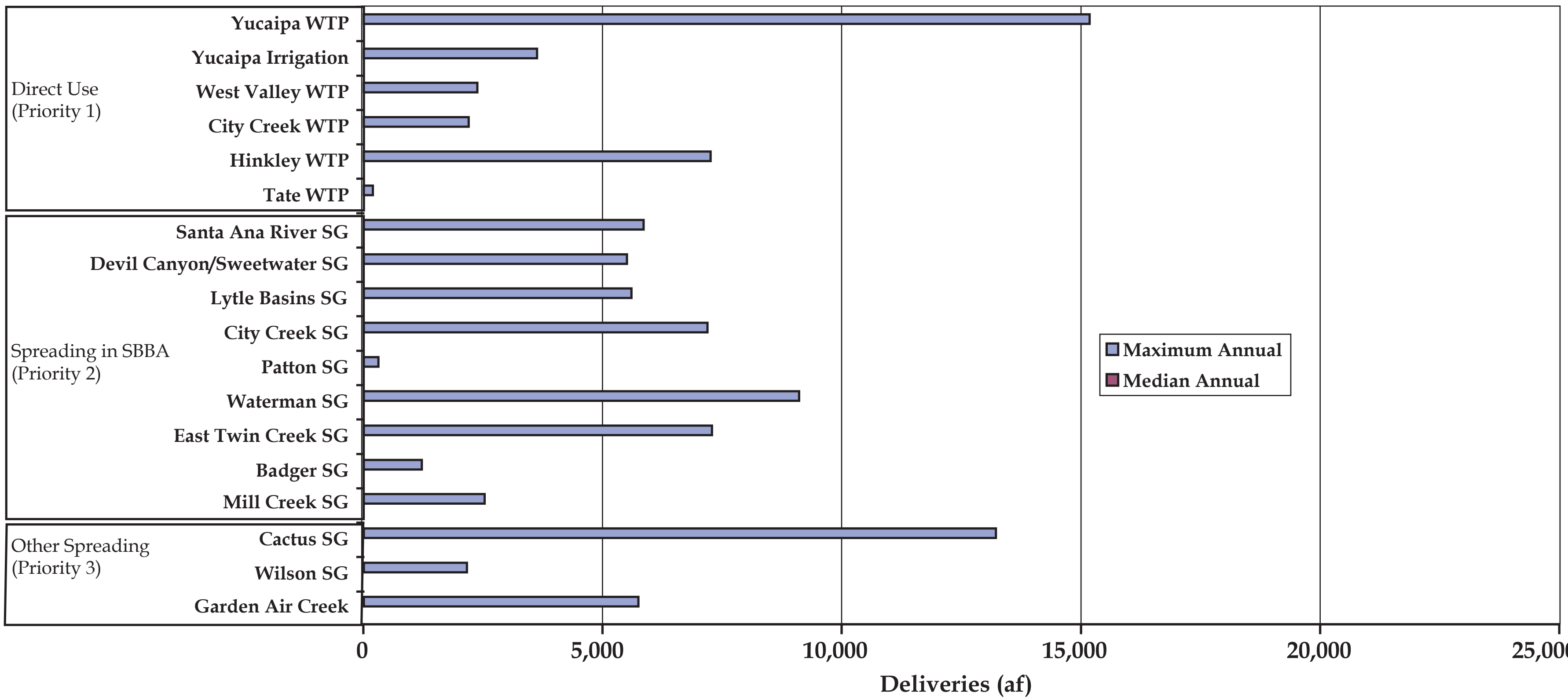
Note: WTP: Water Treatment Plant, SG: Spreading Grounds.

Figure 5.5-14. Projected Ultimate Delivery of Captured SAR Water to Specific Beneficial Uses, Scenario B



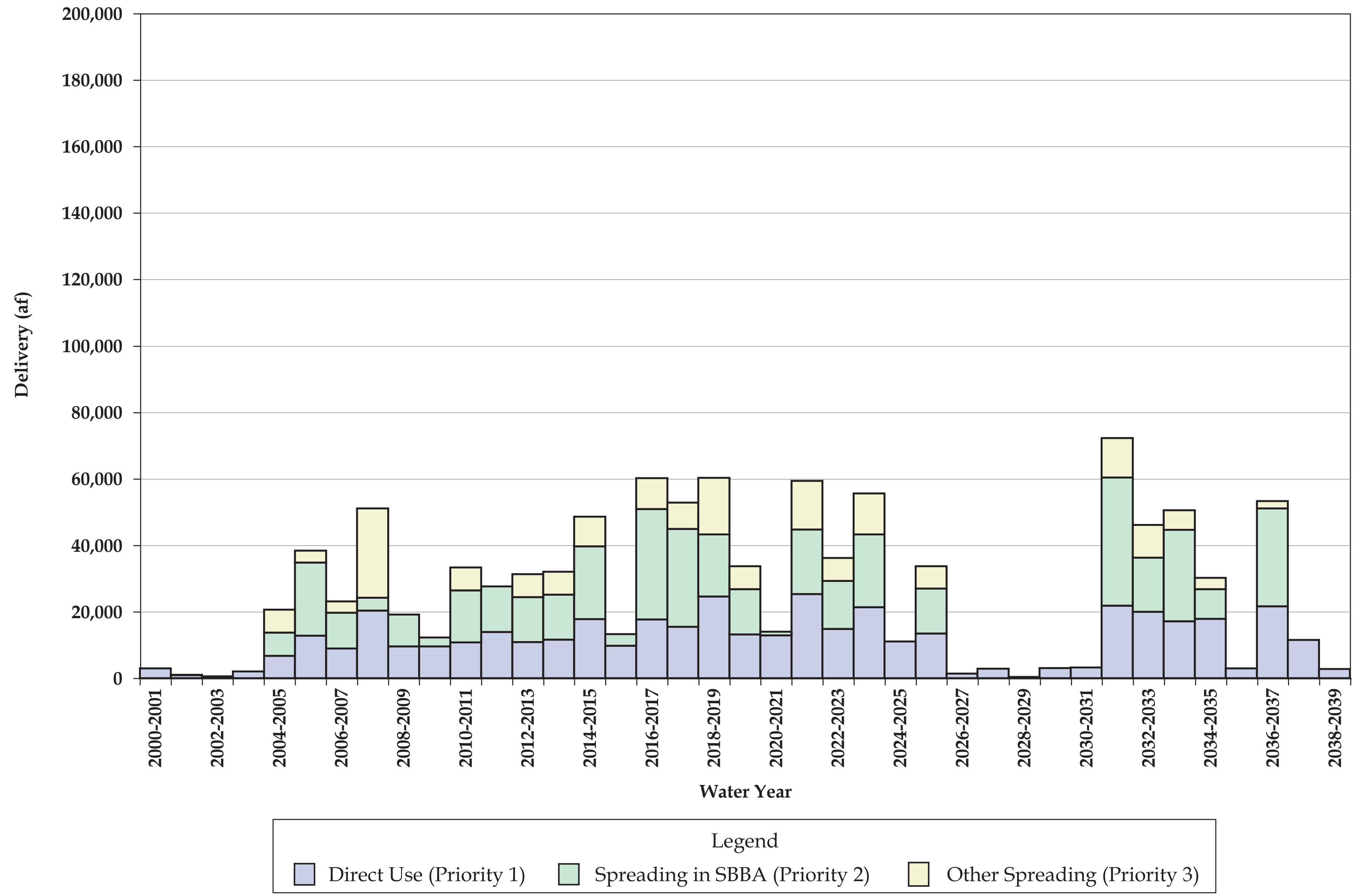
Note: WTP: Water Treatment Plant, SG: Spreading Grounds.

Figure 5.5-15. Projected Ultimate Delivery of Captured SAR Water to Specific Beneficial Uses, Scenario C



Note: WTP: Water Treatment Plant, SG: Spreading Grounds.

Figure 5.5-16. Projected Ultimate Delivery of Captured SAR Water to Specific Beneficial Uses, Scenario D



Note: For Water Years 2000-2001 through 2038-2039. Ultimate Delivery accounts for delivery after return and allocation of exchange water

Figure 5.5-17. Projected Ultimate Delivery of Captured SAR Water by Priority, Scenario A

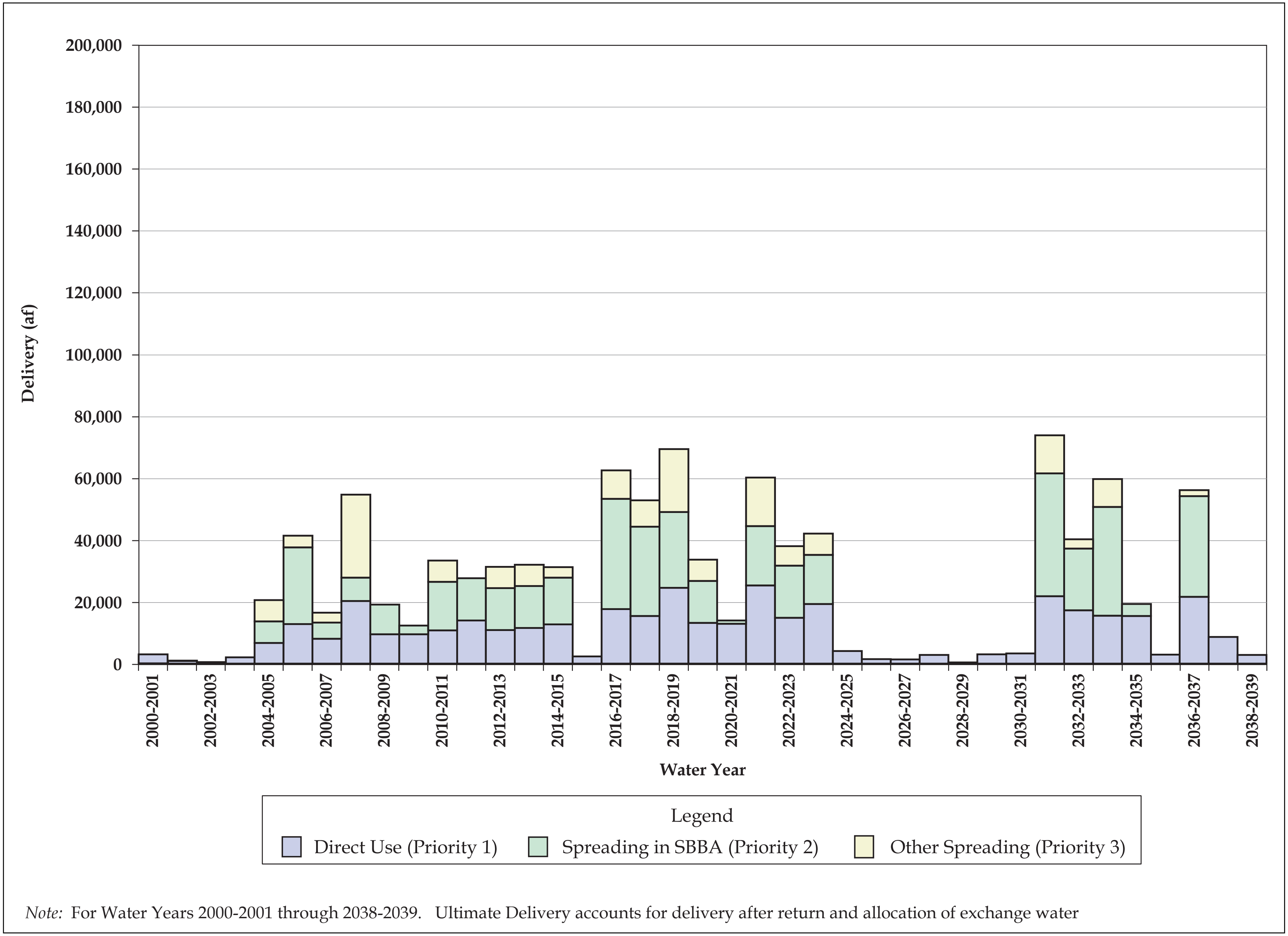


Figure 5.5-18. Projected Ultimate Delivery of Captured SAR Water by Priority, Scenario B

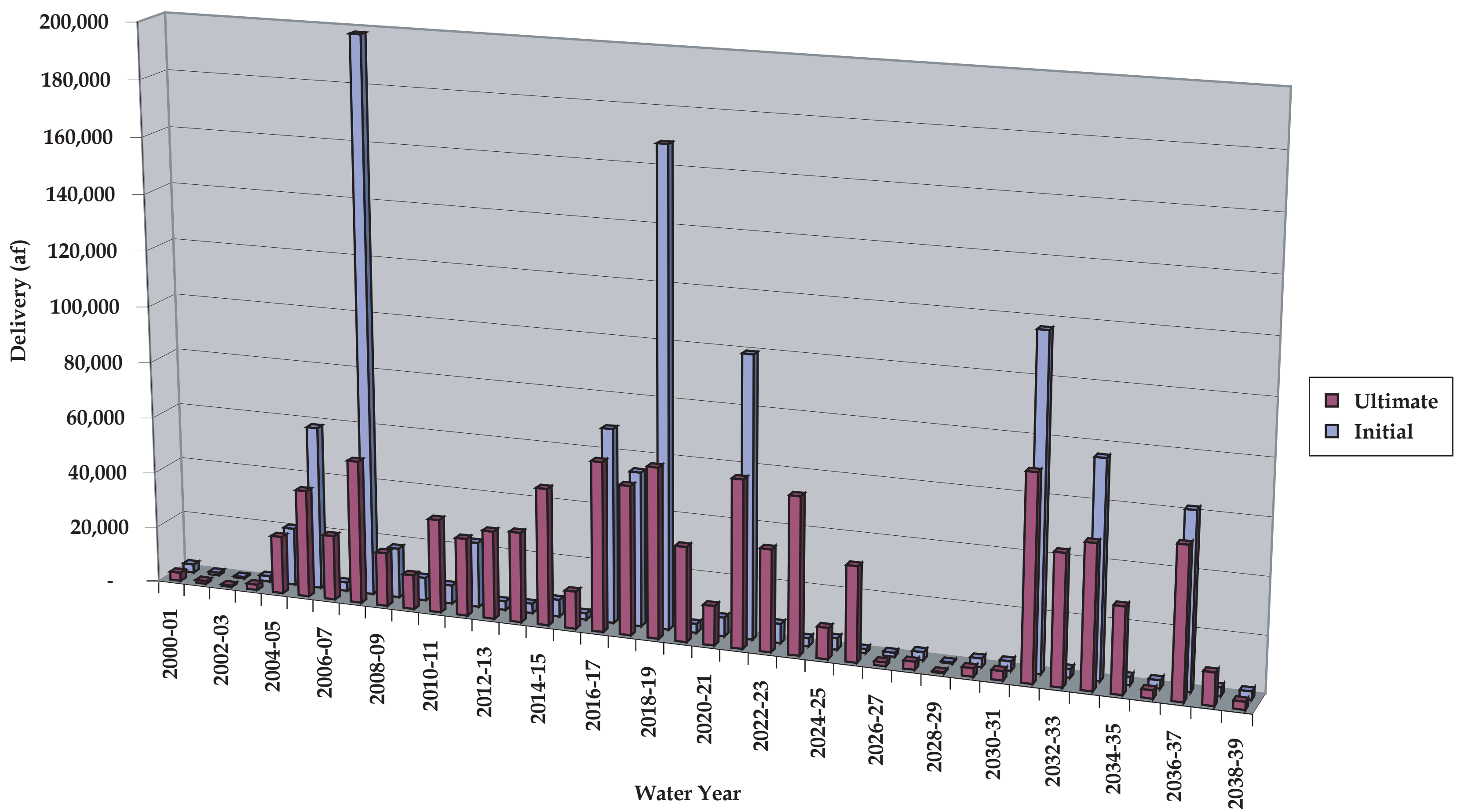


Figure 5.5-19. Comparison of Initial and Ultimate Annual Deliveries, Scenario A

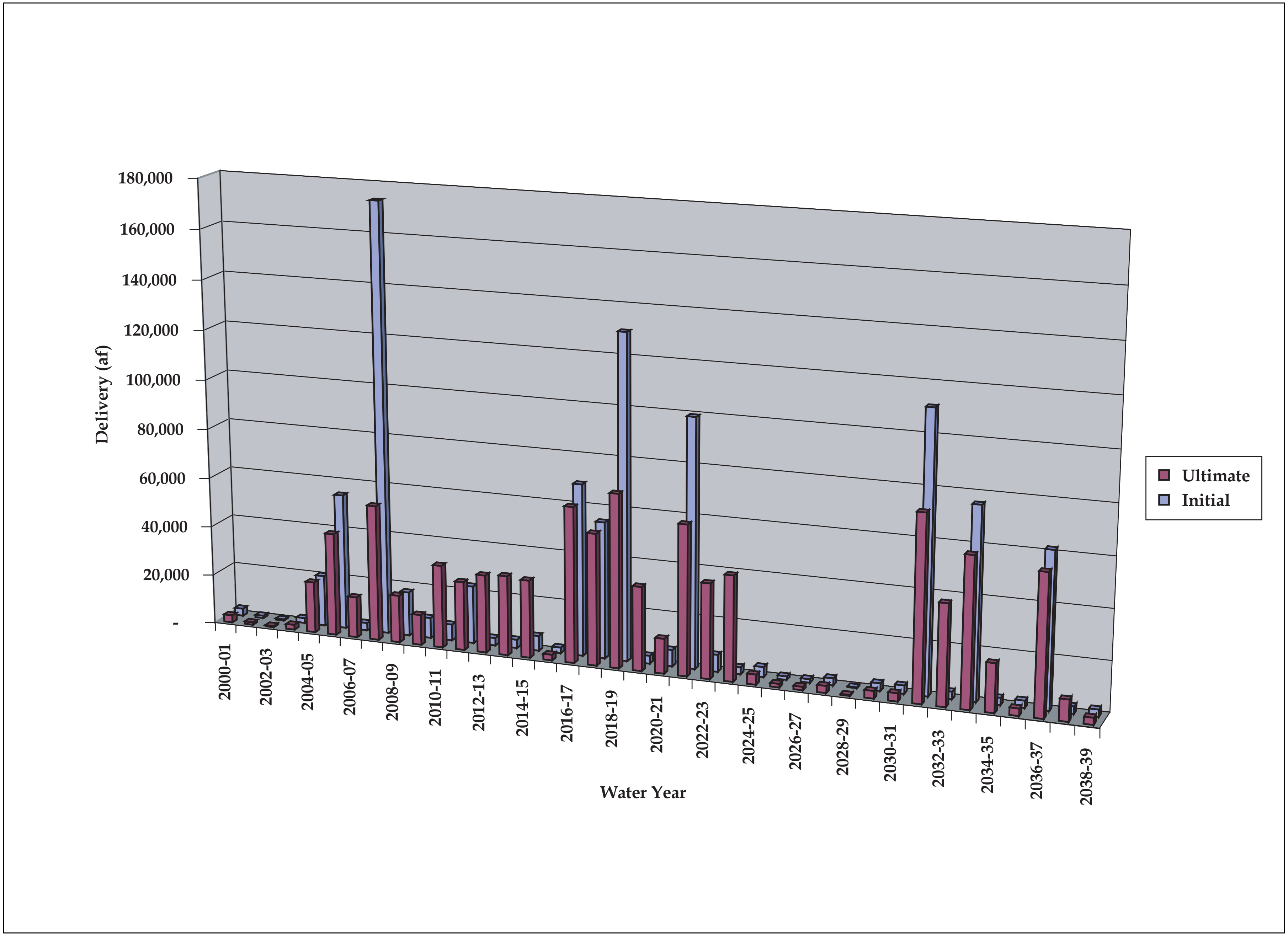
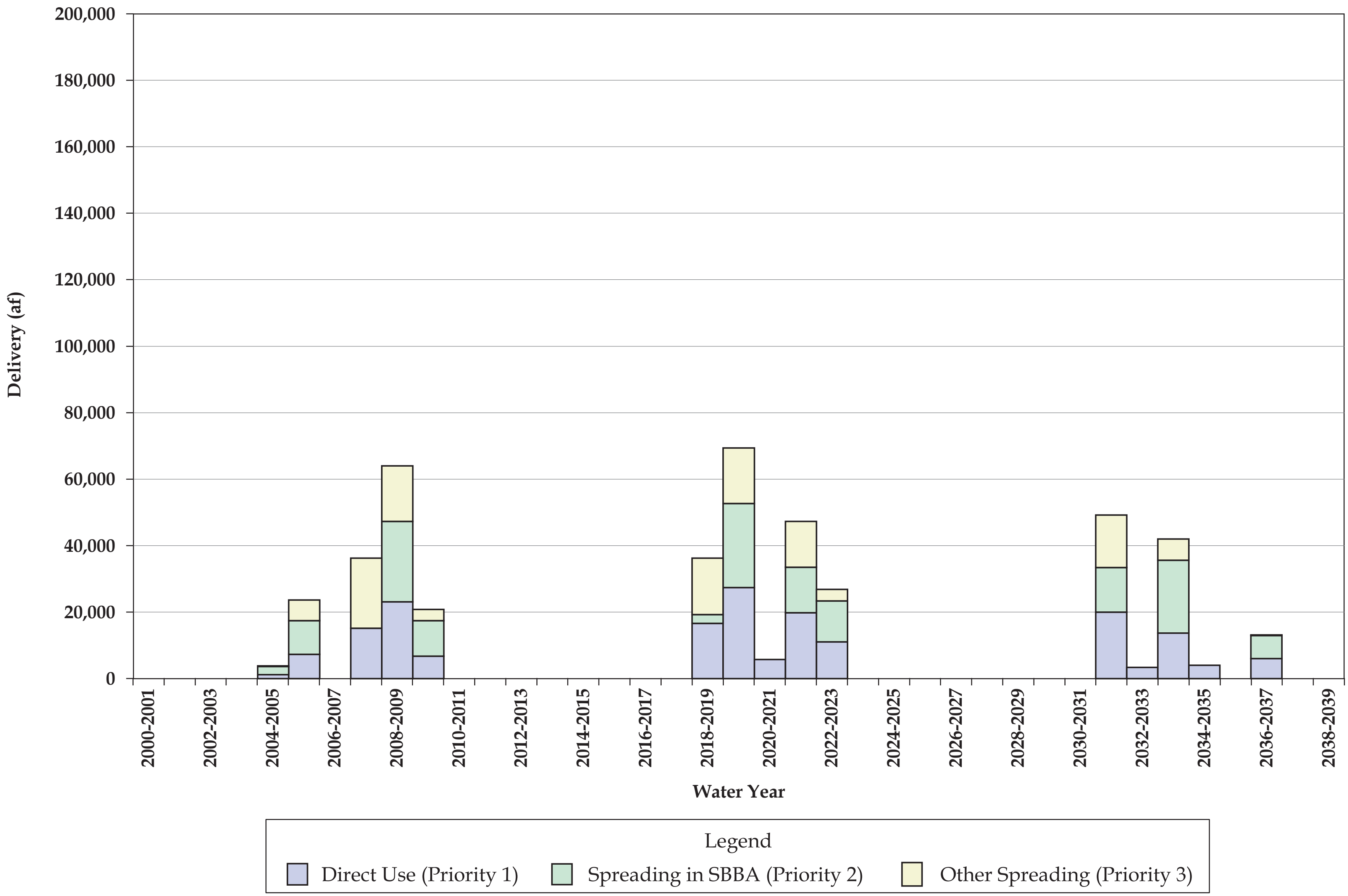
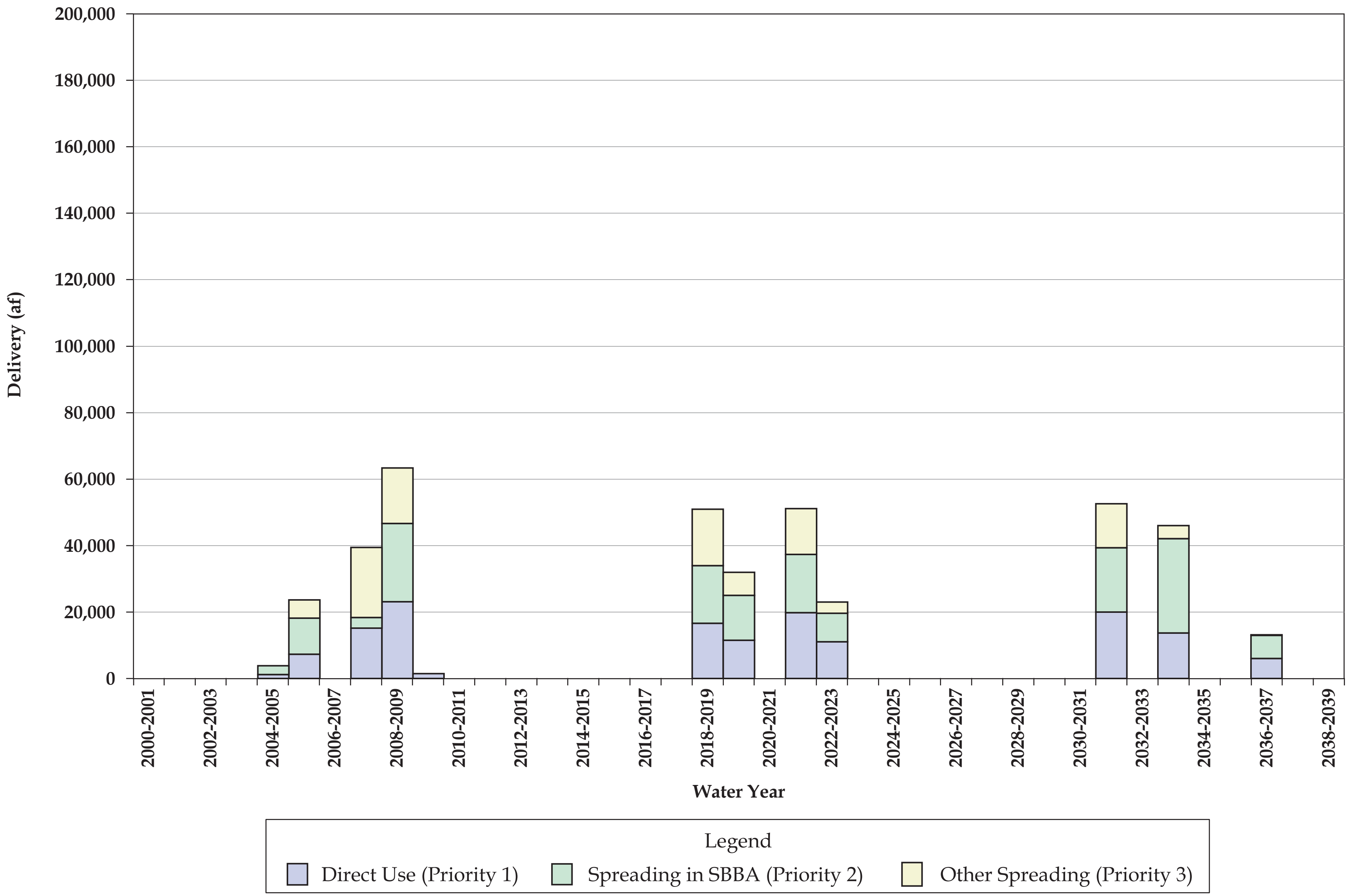


Figure 5.5-20. Comparison of Initial and Ultimate Annual Deliveries, Scenario B



Note: For Water Years 2000-2001 through 2038-2039. Ultimate Delivery accounts for delivery after return and allocation of exchange water.

Figure 5.5-21. Projected Ultimate Delivery of Captured SAR Water by Priority, Scenario C



Note: For Water Years 2000-2001 through 2038-2039. Ultimate Delivery accounts for delivery after return and allocation of exchange water.

Figure 5.5-22. Projected Ultimate Delivery of Captured SAR Water by Priority, Scenario D

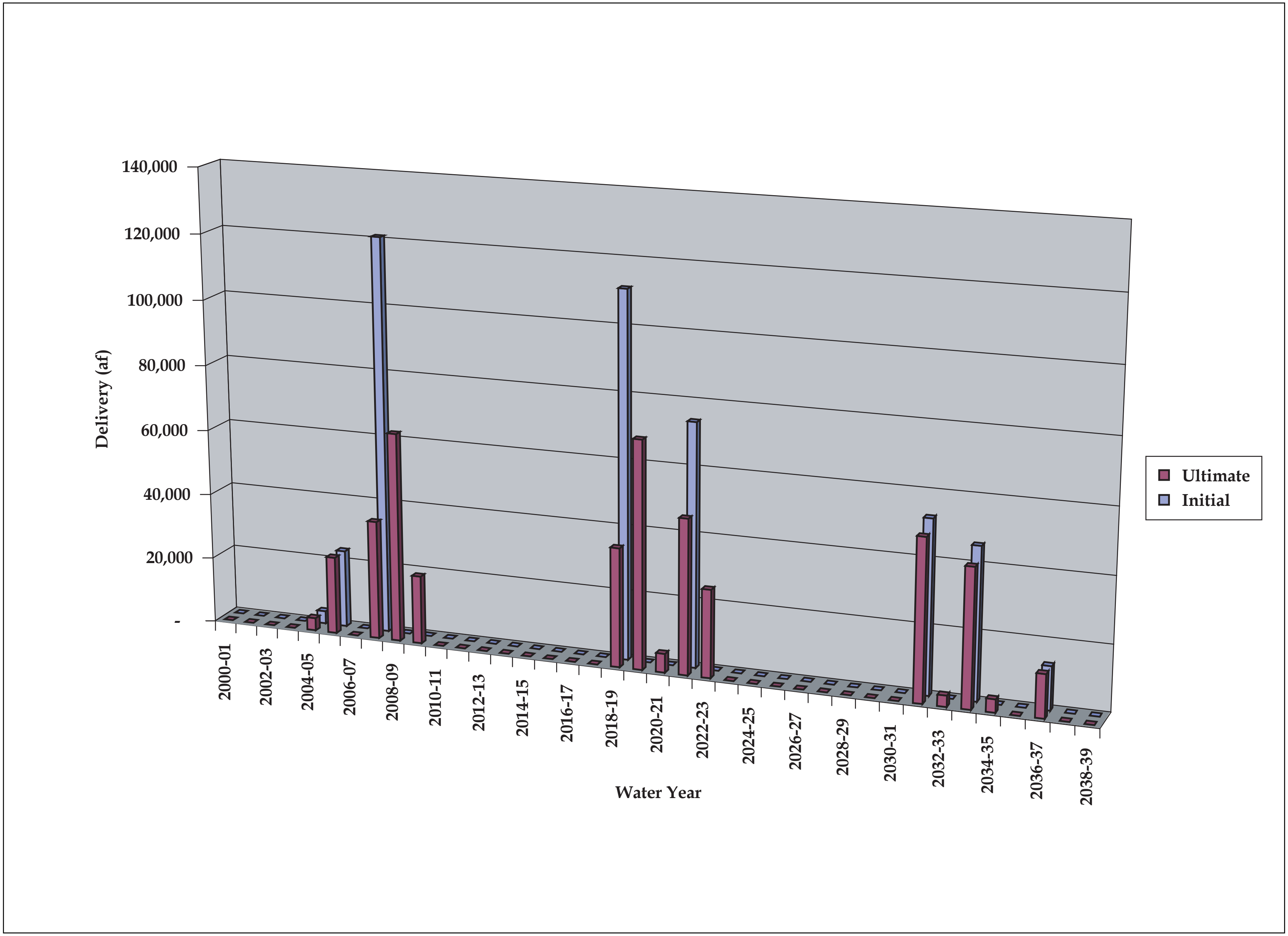


Figure 5.5-23. Comparison of Initial and Ultimate Annual Deliveries, Scenario C

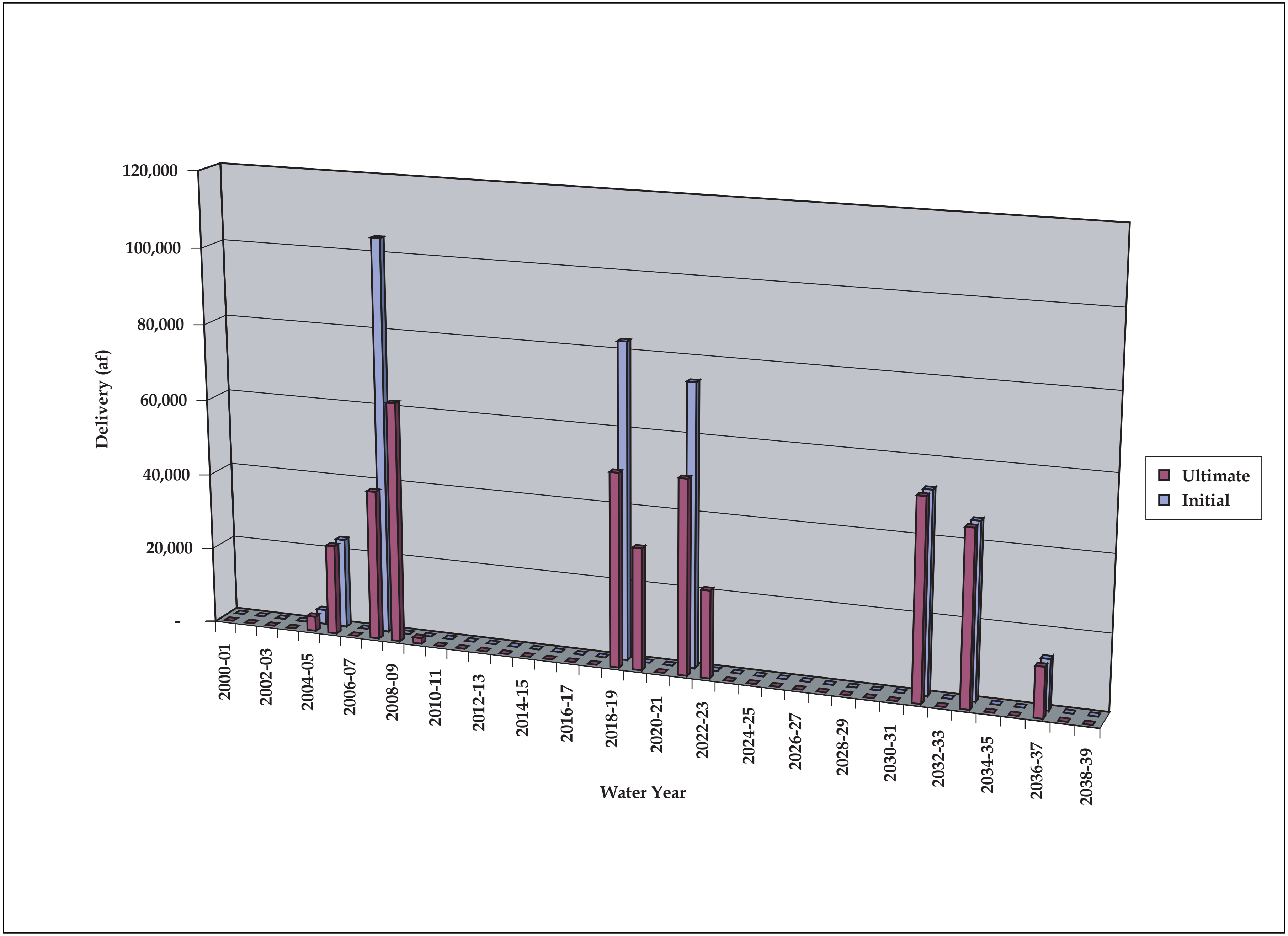
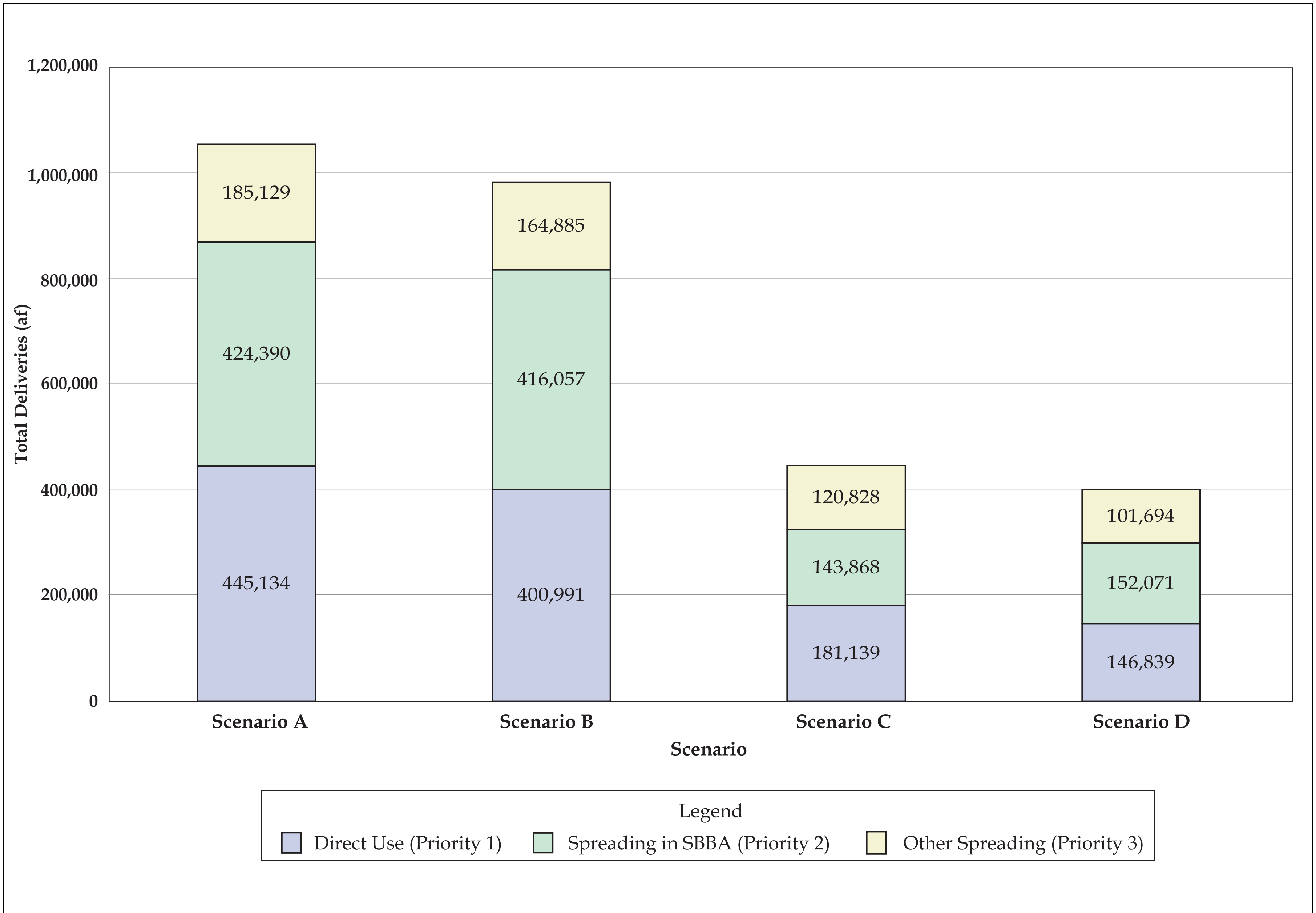
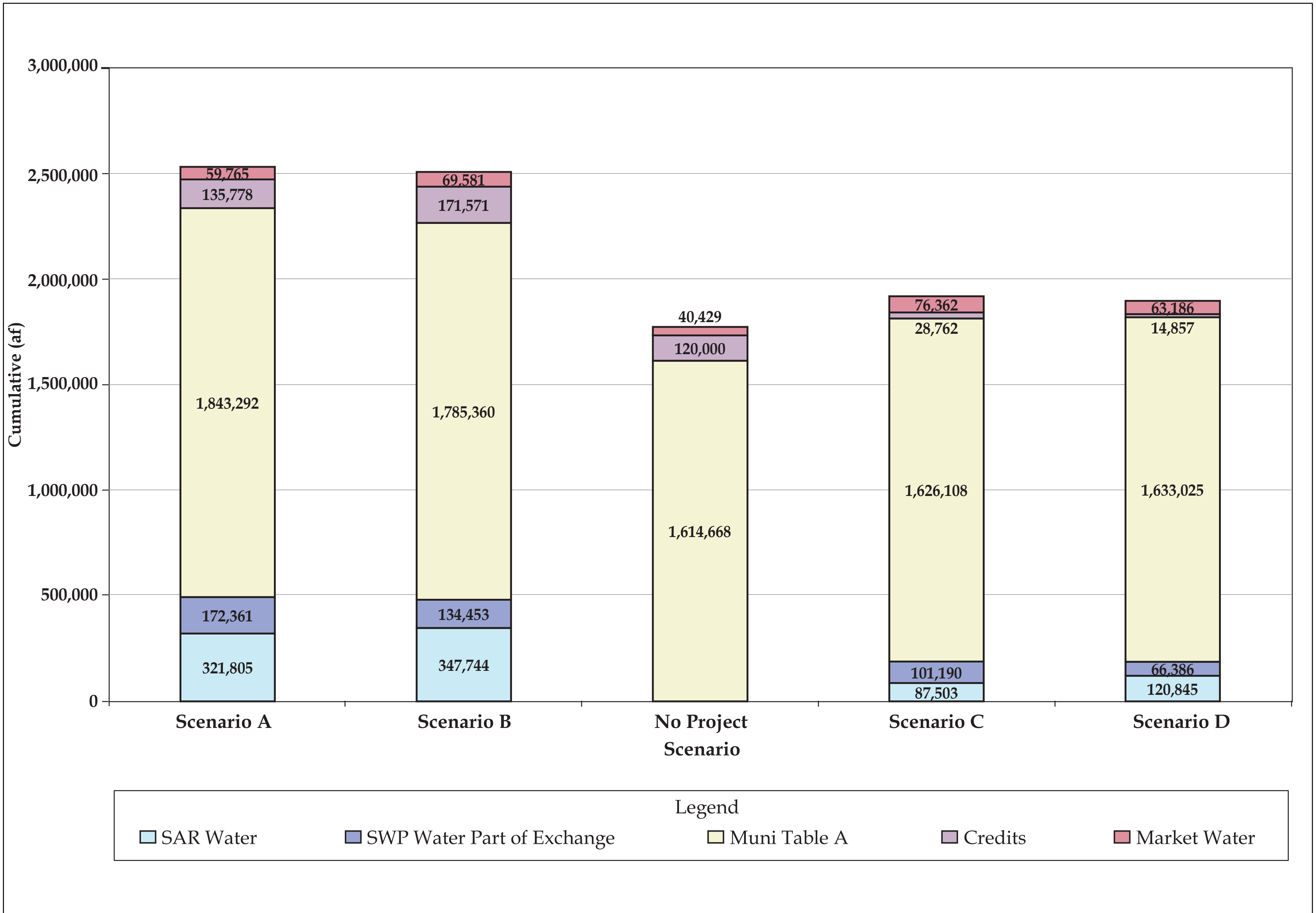


Figure 5.5-24. Comparison of Initial and Ultimate Annual Deliveries, Scenario D



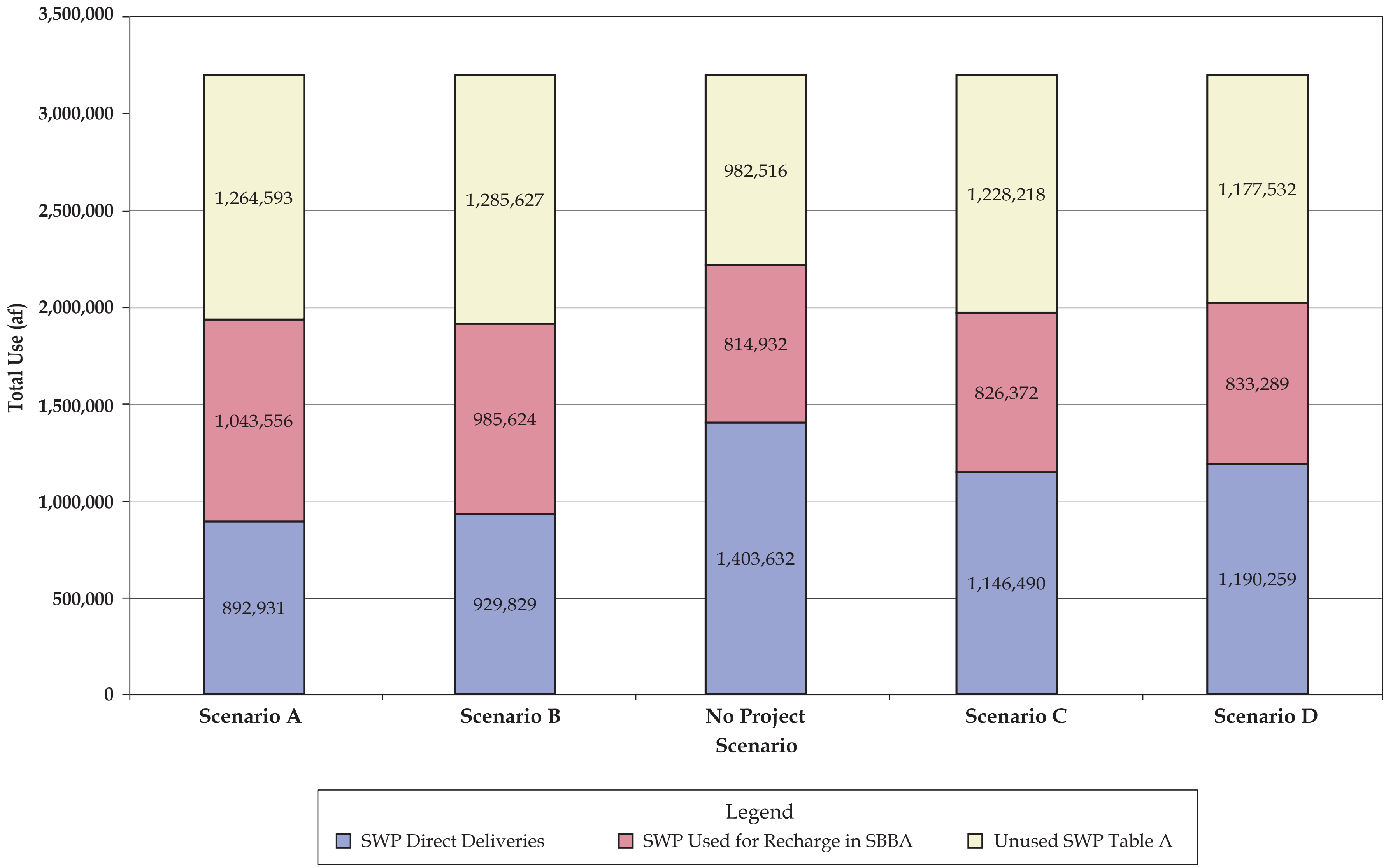
Note: For Water Years 2000-2001 through 2038-2039.

Figure 5.5-25. Projected Ultimate Delivery of Captured SAR Water by Priority (Cumulative Total)



Note: For Water Years 2000-2001 through 2038-2039.

Figure 5.5-26. Projected Sources of Water Used to Meet Replenishment Obligation of SBBA (Cumulative Total)



Note: For Water Years 2000-2001 through 2038-2039.

Figure 5.5-27. Projected Use of Muni's Available SWP Table A Water within Muni's Service Area

6.0 RIVER ANALYSIS

River Analysis is a collection of analytical techniques designed to assess the effects that potential diversions by Muni/Western could have on the flow regime of the SAR. Results from OPMODEL provide estimates of the amounts of water currently and potentially diverted from the SAR and the amount remaining in the river.

River Analysis was conducted for two sets of conditions:

- Storm flow conditions where attention is focused on overbank flooding; and
- Non-storm flow conditions where attention is focused on changes in channel flow.

As discussed in Chapter 2, storm flow is directly attributable to runoff events and is highly variable. Overbank flooding is flow that overtops the banks of the active stream channel onto the adjacent floodplain. Storm and non-storm days are defined by the Santa Ana River Watermaster each year based on rainfall and flow in the SAR channel at Riverside Narrows.

River Analysis is applied to a number of segments of the river, the end-points of which are determined by: availability of USGS gage data; locations at which flow characteristics of the river change due to a inflow or diversions; and locations specific to water rights agreements and judgments. Flow characteristics at locations other than USGS gage locations must be interpolated using USGS gage data, WWTP discharge data, and assumptions related to water losses due to channel percolation and evaporation. Due to the length of the data record for the "E" Street Gage, the river analysis base period of WY 1966-67 to WY 1999-2000 is shorter than the base period used in the other models (WY 1961-62 to WY 1999-2000).

In River Analysis, "historical flow" refers to flow in each segment of the SAR (recorded and interpolated) and includes natural river flow unimpaired by Seven Oaks Dam from the beginning of the period of analysis through December 1999 and after December 1999 river flow with the dam in operation. "Estimated flows under No Project conditions" refer to historical flows modified to include operation of the Seven Oaks Dam and are also referred to as "Post-Seven Oaks Dam Flows". "Estimated flows under Project scenarios" refer to No Project flows modified to include potential Muni/Western diversions. Project conditions cover the range of potential diversions represented by Scenarios A, B, C, and D. In this analysis, potential Project effects are assessed for six specific segments of the SAR:

1. Segment B, Seven Oaks Dam to Cuttle Weir (RM 70.93 to RM 69.9);
2. Segment C, Cuttle Weir to the confluence of Mill Creek (RM 69.9 to RM 67.89);
3. Segment D, Mill Creek Confluence to "E" Street (RM 67.89 to RM 57.69);
4. Segment E, "E" Street to the RIX and Rialto Effluent Outfall (RM 57.69 to RM 53.46);
5. Segment F, RIX and Rialto Effluent Outfall to Riverside Narrows (RM 53.46 to RM 45.7); and
6. Segment G, Riverside Narrows to Prado Dam (RM 45.7 to RM 30.5).

Flows in Segment A, Upstream of Seven Oaks Dam, are not analyzed because potential Project diversions only affects flows downstream of the dam.

6.1 STORM FLOW ANALYSIS

Devastating floods have occurred historically on the SAR and investigating storm flow is an important part of River Analysis. As mentioned previously in Chapter 2, there are general winter and summer storms and local storms, the latter of which can include high intensity precipitation. The highest rates of runoff occur when a spring storm combines with snow melt.

As described earlier, operation of Seven Oaks Dam will decrease the extent of the areas likely to experience overbank flooding. With Seven Oaks Dam, overbank flooding is generally limited to three areas between the SAR confluence with Mill Creek to RM 59.17 where the river is in an alluvial floodplain. Downstream of RM 59.17 the river is channelized and overbank flooding is unlikely. Table 6.1-1 provides information concerning overbank flooding downstream of the SAR-Mill Creek confluence and estimated historic peak flows. During a 100-year event, it is estimated that historical peak discharge rates will be reduced by 67 percent and that the flooded area will be reduced by 27 percent (451 acres) due to construction of Seven Oaks Dam.

Table 6.1-1. Pre-Dam and Post-Dam Peak Discharges and Areas Flooded Downstream of the SAR and Mill Creek Confluence

	Flood Recurrence Interval						
	2-year	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*	*200-year*
Total Area Flooded (acres)							
Pre-Seven Oaks Dam	-	-	-	-	1,379	1,653	-
Post- Seven Oaks Dam	-	-	-	-	1,031	1,202	-
Reduction (acres)					348	451	
Reduction (%)					25%	27%	
Peak Discharge (cfs)							
Pre-Seven Oaks Dam	1,400	5,600	11,700	22,000	45,000	75,000	120,000
Post- Seven Oaks Dam	760	2,050	4,300	8,000	15,500	25,000	38,000
Percent reduction	46 %	63 %	63 %	64 %	66 %	67 %	68 %
Source: USACE 2000a, Table 21 and 22							

6.1.1 General Description and Purpose of Storm Flow Analysis

This section presents estimates of the potential effects that Muni/Western diversions could have on flood flow and channel characteristics for segments of the SAR between the plunge pool and Prado Reservoir. The characteristics are:

1. Areas subject to overbank flooding during storm flows (peak flows), particularly in the area of the alluvial fan;
2. Sedimentation and scour;

3. Flow depth, velocity, and other hydraulic properties; and
4. Groundwater recharge.

Hydrologic and hydraulic effects associated with the operation of Seven Oaks Dam are described in the BA (USACE 2000a) and Chapter 2 of this document. Estimates of these potential effects were derived using the public domain water surface profile-model HEC-RAS Version 3.1.1 (May 2003). The potential effects of the diversions by Muni/Western on the area subject to overbank flooding were also estimated using the HEC-RAS model. A description of the software model used in the analysis here is from documentation contained on the USACE HEC website, http://www.hec.usace.army.mil/ software/.

6.1.2 HEC-RAS Model Structure

HEC-RAS calculates water surface profiles assuming steady, gradually varied flow in a river reach or a full network of channels. For comparison purposes, the analysis here was completed for the two Sub-areas originally modeled by the USACE. These sub-areas are defined as follows:

- Sub-area 2 (RM 70.93 to RM 61.5), the main channel of the SAR from Seven Oaks Dam downstream to just below the confluence with City Creek; and
- Sub-area 3 (RM 61.5 to RM 35.5) continuation of Sub-area 2 downstream to the upstream limit of the 100-year pool elevation for Prado Reservoir. See Figure 2.3-1.

6.1.3 Model Assumptions

A number of assumptions are made during the process of estimating the effects of the Muni\Western diversions on peak flows:

1. The Project does not affect environmental habitat releases as anticipated in the BA and BO. Habitat releases are assumed to have a higher priority than Muni/Western diversions.
2. The effects of the environmental habitat releases on the river are not analyzed because they are a mitigation measure for a previously implemented project and they are not planned to occur during peak flows that are analyzed in this section. Environmental habitat releases, and subsequent diversion to portions of the overbank channel, are planned after a peak has passed and diversion levees have been constructed.
3. USACE estimates of peak flow from Mill Creek, Plunge Creek, and other tributaries are included for each respective flood event frequency.
4. Historical locations of contributing stream confluence points along the main stem of the SAR used by USACE were adopted for the analysis undertaken here.
5. Estimates of changes in flow depths and velocities are consistent with modeling performed for the BA (USACE 2000a).
6. Estimates of the scour and sediment transport contained in the BA were adopted.
7. For the flow profiles, it was assumed that the channel is saturated during the peak flow and that infiltration is minimal.

6.1.4 HEC-RAS Model Input

The USACE provided data for cross sections, instantaneous flow rates for various return periods (e.g., 50-year flood, 100-year flood, etc.) and other channel data. USACE hydrologists used a previous version of HEC-RAS for their analysis of the SAR in support of the BA (USACE 2000a) and the BO (USFWS 2002) for the Seven Oaks Dam. Diversion rates projected for Muni/Western were developed from OPMODEL.

HEC-RAS (version 3.1.1) was used[17], along with data sets provided by USACE, to replicate the results in the BA (USACE 2000a). HEC-RAS was run with the channel geometry parameters (cross sections, Manning's "n" for channel roughness, overbank areas, and tributary inflow provided by the USACE [2003]) and flow data used in the BA for the area defined as Sub-Area 2 (RM 70.93 to RM 61.5). Over 380 cross sections of the SAR were modeled based on 1998 digital topography and workmap detailed at 2-foot contour intervals. USACE provided additional data files for reaches in the area defined as Sub-Area 3 (RM 61.5 to RM 35.5). For purposes of comparison with results report in the BA, HEC-RAS was used to calculate flow rates, depth, and areas inundated for Sub-Area 2 for the 50-year and 100-year floods. For Sub-Area 3, only the 100-year flood data was available for comparison.

For Sub-Area 2, from near Seven Oaks Dam to approximately 13 miles downstream, data were provided for three sub-reaches:

1. *Upper:* from the Greenspot Road bridge downstream of Seven Oaks Dam to the Mill Creek confluence;
2. *Middle:* from the Mill Creek confluence to the historical confluence with City Creek;
3. *Lower*: downstream from the historical confluence of City Creek to RM 61.5.

There were some minor differences in distance measurements between the river mile indicators contained in the BA and the HEC-RAS model river stations. The source of the differences is due to rounding of distance measurements, and the way that distances between confluences were calculated. New flood control channels have changed the historical confluence locations that were used for the HEC-RAS data set. City Creek is included in Sub-Area 2 in the BA and HEC-RAS data, but now discharges downstream in Sub-Area 3. Table 6.1-2 compares the BA river miles with the HEC-RAS river stations.

Inflow from tributaries is included in the analysis but cross-sections and flow within tributaries were not modeled. Several wastewater treatment plants contribute to the flow in the river, however, these flows are assumed to be included in the increasing quantities of flow as one proceeds downstream.

The USACE also provided a HEC-2 (HEC-2 is the forerunner to HEC-RAS) dataset for Sub-Area 3. The BA describes the Sub-Area 3 analysis as "less detailed" than the HEC-RAS analysis of Sub-Area 2, e.g., no overbank area was delineated. The Sub-Area 3 dataset did not include detailed

17 HEC-RAS version 3.1.1 was used because, being the most recent version of the model, this version provides the most accurate results and the best estimate of changes due to the Project.

Table 6.1-2. Description of Reaches of SAR by River Mile Stationing

Description	*EIR River Miles*	*BA River Miles*	*BA Reach Name*	*USACE HEC-RAS Mile*	*USACE HEC-RAS Reach Name*
Seven Oaks Dam to confluence with Mill Creek	70.93 to 67.9	40.3 to 38.17	Sub-Area 2	12.938 to 11.7	Upper*
Confluence with Mill Creek to confluence with City Creek	67.9 to 62.3	38.17 to 32.37	Sub-Area 2	11.7 to 5.5	Middle
Confluence with City Creek to end of Sub-Area 2	62.3 to 61.5	32.37 to 31.0	Sub-Area 2	5.5 to 5.0	Lower **
Beginning of Sub-Area 3 to Prado Reservoir 100-year elevation	61.5 to 35.5	31.0 to 3.90	Sub-Area 3	HEC-2 dataset	HEC-2 dataset

Notes:
Mile stationing increases as one moves upstream.
* The HEC-RAS model of the SAR started at the Greenspot Road bridge downstream of Seven Oaks Dam.
** Only a portion of the Lower reach is within Sub-Area 2.

modeling of the tributaries, but simply made a flow adjustment at each confluence, and only 100-year flows were provided. The Sub-Area 3 dataset was based on 1986 and 1987 topography mapped at a 5-foot contour interval.

6.1.5 HEC-RAS Model Results

It was verified that the HEC-RAS data provided by the USACE could be used to replicate results contained in the BA (USACE 2000a, USACEb). The verified model was then used to illustrate the potential effects on such variables as water velocity, water depth, and area of inundation in the overbank (floodplain) areas that could result from implementation of the Project, i.e., Muni/Western diversions of up to 1,500 cfs.

Project-related effects under high flows (such as 50-year and 100-year events) and lower flows (more frequent 5- and 10-year events) in Sub-Area 2 are contained in Table 6.1-3. As shown in Table 6.1-3, there is no overbank flooding in the Upper Reach portion of Sub-Area 2 and the effects of the Project would be limited to changes in flow in the main channel. In the Middle Reach portion of Sub-Area 2, the change in overbank velocity and depth is minor. Overall, in Sub-Area 2 inundation would be reduced by 3.8 percent and 2.4 percent, for the 50-year and 100-year flood events, respectively. Mill Creek, Plunge Creek, City Creek, and other tributaries would

Table 6.1-3. Effects of Muni/Western Diversion of up to 1,500 cfs in Sub-Area 2

	Peak Flow Below Cuttle Weir (cfs)	*Peak Flow near Mill Creek Confluence (cfs)*	*Sub-Area 2 Main Channel Velocity [a] (ft/s)*	*Sub-Area 2 Main Channel Depth [b] (ft)*	*Upper Reach Overbank Velocity [c, g] (ft/s)*	*Upper Reach Overbank Hydraulic Flood Depth [d] (ft)*	*Middle Reach Overbank Velocity [c, g] (ft/s)*	*Middle Reach Overbank Hydraulic Flood Depth [d,g] (ft)*	*Sub-Area 2 Area of Inundation Santa Ana River only [e] (acres)*
5-YEAR FLOOD									
No Project	500	2,000	3.6	5.2	0.0	0.0	1.6	0.8	361
Project [f]	0	1,500	3.1	4.8	0.0	0.0	1.3	0.5	296
Effect of Project [h, i, j]	-500	-500	-0.5	-0.4	0.0	0.0	-0.3	-0.3	-65
Percent Change	-100.0%	-25.0%							-18.1%
10-YEAR FLOOD									
No Project	500	4,200	4.1	6.3	0.0	0.0	2.3	1.1	496
Project [f]	0	3,700	3.6	6.1	0.0	0.0	2.3	1.0	461
Effect of Project [h, i, j]	-500	-500	-0.5	-0.2	0.0	0.0	0	-0.1	-35
Percent Change	-100.0%	-11.9%							-6.9%
20-YEAR FLOOD									
No Project	2,500	8,000	4.8	7.7	0.0	0.0	2.7	2.0	623
Project [f]	1,000	6,500	4.5	7.1	0.0	0.0	2.5	1.6	579
Effect of Project [h, i, j]	-1,500	-1,500	-0.3	-0.6	0.0	0.0	-0.2	-0.4	-44
Percent Change	-60.0%	-18.8%							-7.1%
50-YEAR FLOOD									
No Project	3,800	15,500	5.8	9.0	0.0	0.0	1.0	0.4	764
Project [f]	2,300	14,000	5.5	8.8	0.0	0.0	0.5	0.2	735
Effect of Project [h, i, j]	-1,500	-1,500	-0.3	-0.2	0.0	0.0	-0.5	-0.2	-29
Percent Change	-39.5%	-9.7%							-3.8%

Table 6.1-3. Effects of Muni/Western Diversion of up to 1,500 cfs in Sub-Area 2 (continued)

	Peak Flow Below Cuttle Weir (cfs)	*Peak Flow near Mill Creek Confluence (cfs)*	*Sub-Area 2 Main Channel Velocity [a] (ft/s)*	*Sub-Area 2 Main Channel Depth [b] (ft)*	*Upper Reach Overbank Velocity [c, g] (ft/s)*	*Upper Reach Overbank Hydraulic Flood Depth [d] (ft)*	*Middle Reach Overbank Velocity [c, g] (ft/s)*	*Middle Reach Overbank Hydraulic Flood Depth [d,g] (ft)*	*Sub-Area 2 Area of Inundation Santa Ana River only [e] (acres)*
100-YEAR FLOOD									
No Project	5,000	25,000	6.5	10.3	0.0	0.0	1.3	0.5	862
Project [f]	3,500	23,500	6.3	10.1	0.0	0.0	1.3	0.5	841
Effect of Project [h, i, j]	-1,500	-1,500	-0.2	-0.2	0.0	0.0	0.0	0.0	-21
Percent Change	-30.0%	-6.0%							-2.4%

Notes:

[a] Main channel velocity is median value of cross section average velocities.

[b] Main channel depth is median value of the maximum depths of the cross section.

[c] Overbank velocity is average velocity of the cross section velocities.

[d] Overbank hydraulic flood depth is the median value of the hydraulic flood depths for each cross section. The hydraulic flood depth is the cross section area of the flow divided by the top width of the flow.

[e] Inundation Area is only approximate and includes only the Santa Ana River. Mill Creek, City Creek and Plunge Creek inundation areas would be unaffected.

[f] Project is diversion of up to 1,500 cfs by Muni/Western.

[g] Average for main overbank area (right side as one looks downstream) in the vicinity of the Wooly Star Preserve.

[h] Small positive effects of Project due to calculation methods (including tolerance levels) and do not reflect significant differences.

[i] Effects of Project may not appear to be the difference between baseline and Project because of displayed rounding.

[j] Under 5- and 10-year floods, water available for Muni/Western diversion is estimated to be no more than 500 cfs.

Table 6.1-4. Effects of Muni/Western Diversion of up to 1,500 cfs in Sub-Area 3

Location	*No Project or Project*	*Channel Depth (ft)*	*Velocity (ft/s)*	*Top Width of Channel*
RM 56	No Project	19.1	13.2	1,569
	Project	19.1	13.1	1,572
RM 54.5	No Project	22.3	14.3	1,024
	Project	22.2	14.2	1,021
RM 51.5	No Project	12.8	10.9	1,678
	Project	12.8	10.8	1,678
RM 45.5	No Project	35.3	16.8	1,143
	Project	35.1	16.7	1,141
RM 40.5	No Project	15.6	13.5	2,281
	Project	15.5	13.4	2,280
RM 35.5	No Project	16.4	11.3	3,342
	Project	16.3	11.4	3,341

not be affected by the diversion. This is the worst-case reduction in flood flows; with a 500 cfs diversion rate, changes to flood flows would be less pronounced.

In Sub-Area 3, the effects of Muni/Western diversions were analyzed for the 100-year flood scenario for key cross sections as shown in Table 6.1-4. No flow data for the 50-year event or other frequency events in Sub-Area 3 were available from the USACE dataset. Model results reveal an overall decrease of inundated area for Sub-Area 3 of about 11 acres (0.2 percent of total area inundated) for the 100-year flood scenario associated with the Project.

6.1.5.1 Verification of HEC-RAS Model Results

Table 6.1-5 presents a comparison of results from the BA for the 50-year and 100-year flood with the estimates made herein for Sub-Area 2. Table 6.1-6 shows a corresponding comparison for Sub-Area 3. This shows that the HEC-RAS data provided by the USACE and the current version of HEC-RAS 3.1.1 could be used to replicate the results of analysis presented in the BA. Results show that the runs were within an accuracy that is acceptable for comparing scenarios. The only exception is at RM 56.0 in Sub-Area 3 where it appears there is a typographical or other unexplained discrepancy in the BA.

6.2 NON-STORM FLOW ANALYSIS

In addition to the storm flow analysis described above, a non-storm, low flow analysis of the SAR was undertaken. The non-storm flow analysis was conducted through the use of a daily version of the monthly OPMODEL, DOP, and a river analysis model, referred to as the Daily River Analysis Model (DRAM). The goal of the non-storm flow analysis, under both No Project and Project scenarios, is to simulate, or interpolate, hydrological flows at specific locations along the river channel for each river segment. HEC-RAS could have been used to perform an analysis of non-storm flows, to provide information on water level and channel velocities. However, the desired data for impact analyses in the EIR related to flows (cfs) and the number of wet- versus dry-days in different segments of the SAR. This information could not be derived from HEC-RAS modeling.

Table 6.1-5. Verification of HEC-RAS 3.1.1 Model for Sub-Area 2

	Flow at Mill Creek Confluence (cfs)	*Main Channel Max. Velocity (ft/s)*	*Main Channel Max. Depth (ft)*	*Overbank Velocity [b] (ft/s)*	*Overbank Flood Depths[b] (ft)*	*Area of Inundation[c] Sub-Area 2 (acres)*
50-YEAR FLOOD EVENT [a]						
HEC-RAS (BA)	15,500	10	8	1 to 2	0.5 to 1.0	1,031
HEC-RAS 3.1.1	15,500	9.9	8.2	0.2 to 3.7	0 to 3.2	1,038
Difference	0	-.01 or 1%	+.2 or 2%	less than ± 3.7	less than ± 3.2	+7 or 1%
100-YEAR FLOOD EVENT [a]						
HEC-RAS (BA)	25,000	11	9	2 to 3	1.0 to 2.5	1,202
HEC-RAS 3.1.1	25,000	11.2	10.0	0.1 to 4.1	0 to 3.4	1,213
Difference	0	+0.2 or 2%	+1 or 1%	less than ± 3.1	less than ± 3.4	+11 or 1%

Notes:
[a] Estimates for flood events are from the BA (USACE 2000a) and the verified HEC-RAS 3.1.1 model.
[b] BA only used USGS section 12, a portion of the main overbank area used in this analysis.
[c] Area of inundation includes flooded area of Mill Creek, City Creek and Plunge Creek.

Table 6.1-6. Verification of HEC-RAS 3.1.1 Model for Sub-Area 3

100-Year Flood Event at Key Cross Section	*Instantaneous Peak Flow (cfs)*	*Velocity (ft/s)*	*Depth (ft)*	*Top Width (ft)*
RM 56.0				
HEC-RAS [a]	140,000	13.2	19.1	1,057
HEC-RAS 3.1.1	140,000	13.2	19.1	1,569
Difference	0	Within Rounding	Within Rounding	Typographical or other discrepancy in BA. (extra 0) -511.9 or 48%
RM 54.8				
HEC-RAS [a]	140,000	10.0	24.7	639
HEC-RAS 3.1.1	140,000	10.0	24.8	639
Difference	0	0	+0.14 or 0.6%	Within Rounding
RM 45.5				
HEC-RAS [a]	144,000	15.6	35.3	1,143
HEC-RAS 3.1.1	144,000	16.8	35.33	1,142.9
Difference	0	+1.2 or 8%	Within Rounding	Within Rounding
RM 40.5				
HEC-RAS [a]	153,000	13.4	15.5	2,280
HEC-RAS 3.1.1	153,000	13.5	15.58	2,281.4
Difference	0	+0.1 or 0.7%	+0.8 or 0.5%	Within Rounding

Notes:
[a] BA values are from USACE 2000a, Table 24, page 179

A daily time-step is used for the following reasons: (1) historical storm and non-storm categorization does not fit a monthly pattern; (2) the Santa Ana River Watermaster categorizes storm and non-storm periods on a daily basis; and (3) flow data is available from the USGS on a daily basis at various sites along the SAR. Assumptions are made in both DOP and DRAM to account for some data limitations as described for each model in detail below.

6.2.1 DOP Input Parameters and Assumptions

DOP is a spreadsheet model used to simulate the release of water from Seven Oaks Dam on a daily time step. The model is based on similar input parameters and computational criteria to those used in the monthly OPMODEL for dam operations and releases of SAR water to senior water rights claimants, the Conservation District, environmental habitat releases, and Muni/Western diversions. OPMODEL is discussed in detail in Chapter 3. Although DOP and OPMODEL are both based on similar logic, parameters, and criteria, they do possess differences as described below.

1. Daily average flow rate (cfs) is used as the basis for DOP computations whenever possible as opposed to the volumetric method (af/month) used in the monthly OPMODEL. In calculations involving storage and Conservation District diversions, the daily average flow rate (cfs) was converted to a volume (af) for computational purposes.
2. To compute the release rate from Seven Oaks Dam, DOP incorporates rising and falling conditions of Prado Reservoir into the operational criteria for Seven Oaks Dam. This logic simulates the tandem operations of both dams to control storm flows.
3. Hydrologic records of flow at the USGS Combined Flow Mentone Gage are not adjusted to reflect re-operation of Big Bear Lake. Big Bear Lake operations have little effect on non-storm flow days because non-storm day releases from Big Bear Lake would be diverted before reaching Seven Oaks Dam.
4. Seasonal storage is post-processed by limiting Seven Oaks Dam releases during the seasonal storage period to ensure all releases are diverted by either the Conservation District or Muni/Western.

Selected results from DOP become input data to DRAM and include: (1) historical and up to 88 cfs diversions by senior water rights claimants; (2) historical or licensed diversions by the Conservation District; (3) environmental habitat releases; (4) diversions by Muni/Western as represented by Scenarios A, B, C, and D; and (5) undiverted SAR flow. These outputs are combined with estimated SAR inflows (tributary and WWTP) and outflows (evaporation and infiltration losses) to provide the hydrologic basis for flow downstream from Seven Oaks Dam under various operational scenarios.

6.2.1.1 Assumptions

The following discussion provides descriptions of the major assumptions contained in the DOP model.

Inflow to Seven Oaks Dam

Daily data from the USGS Combined Flow Mentone Gage is used as the basis for inflow into Seven Oaks Dam. Releases made from Big Bear Lake on non-storm days would be diverted by senior water rights claimants and would not affect the amount of SAR water flowing into Seven Oaks Dam.

Operation of Seven Oaks Dam

As outlined in the Seven Oaks Dam Interim Water Control Plan (USACE 2000c), the release rate at Seven Oaks Dam is a function of both the storage level behind the dam, and storm conditions at Prado Reservoir. If storm conditions exist at Prado Reservoir, the release rate at Seven Oaks Dam is limited for specific storage levels to allow greater overall flood control for the SAR. Logic for a time lag between Seven Oaks Dam and Prado Dam conditions was built into DOP to account for the delay in storm conditions subsiding at Prado Reservoir.

Diversions by Senior Water Rights Claimants

The model has the ability to simulate various diversions by senior water rights claimants using either historical or user-specified flow rates. The SCE Canal Gage, the USGS Auxiliary Canal Gage and senior water rights claimants flow records are used to represent historical diversions from the SAR by these entities. For scenarios where historical data is not used, the minimum of 88 cfs or the historical flow rate in the SAR at Mentone is used to estimate the total diversions made from the river by the senior water rights claimants. For scenarios using historical diversions, the daily historical diversions by the senior water rights claimants equal the minimum of either: the sum of the flow at the SCE Canal, the Auxiliary Canal Gage and pumping at Bear Valley Mutual Water Company Well #2; or the flow at the Mentone Gage . Senior water rights claimants also use 3 cfs that the USACE assumed was subsurface flow that historically passed through the cross section of the SAR at the Seven Oaks Dam site.

End-of-Day Storage in Seven Oaks Dam

The end-of-day storage is the previous day's storage plus inflow less: (a) losses due to evaporation and (b) the release from the dam (including the 3 cfs released for groundwater recharge). The inflow to Seven Oaks reservoir is estimated as the historical surface flow in the river, the Combined Flow Mentone Gage flow less the senior water rights claimants diversion. This SAR surface water flow rate, plus 3 cfs of groundwater flow intercepted by the dam, is converted to acre-feet and added to the previous day's end-of-day storage to compute the beginning-of-day storage in the reservoir. Water loss through evaporation from the dam surface area is calculated using standard pan evaporation rates less average precipitation.

The daily release rate to the plunge pool is based on the release rating curve with consideration of a number of inter-related factors such as whether it is flood season, reservoir condition at Prado (storm or non-storm), water in excess of target storage, and whether or not the debris pool is being filled or drained. It is assumed that in the months of July and August when the debris pool behind the dam is drained, releases are limited to a rate equal to inflow plus an additional 20 cfs.

Diversions by the Conservation District

After the diversions by senior water rights claimants, the Conservation District has the next highest priority to water released from Seven Oaks Dam. Two scenarios are used in the model to simulate the daily contribution to Conservation District diversions: (1) historical diversions; or (2) licensed right of 10,400 afy.

Under their licensed right, the Conservation District can divert from the SAR up to 8,300 af from January through May, no water during the summer months (June through September) and 2,100 af from October through December. The DOP assumes the Conservation District can divert all flows released from the dam up to the 300 cfs capacity of the diversion canal on a daily basis. The daily Conservation District diversions are converted to acre-feet and cumulated to track the remaining unused licensed right to be applied during the spring and winter months. The Conservation District diverts all flows until the licensed right is met for the spring and winter months. In DOP, after the licensed right is met, the Conservation District does not divert any flows released from the dam.

Historical Conservation District diversions used in the model are based on daily data where available and any data gaps are in-filled using interpolated monthly data. Daily Conservation District diversion data (measured as cfs) is available for WY 1966-67 through WY 1977-78 and was, therefore, used in DOP for that time period (Vann 1994). The remainder of the record (from October 1961 through September 1966, and from October 1977 through September 2000) was in-filled using monthly diversion records provided by the Conservation District. The model assumes that the Conservation District diverts all flows released from the dam (up to the 300 cfs capacity) on a daily basis until monthly historical volumes are met. The daily diversions are converted to acre-feet and cumulated to compare to the monthly records. Once the historical monthly volume is met it is assumed that the Conservation District does not divert any more flows for the remainder of the month. Any shortfalls in meeting the historical monthly diversions are carried over to be met the next month, if possible. When the daily record is available, the minimum of the Conservation District daily record or the flow released from the dam is assumed to represent the Conservation District daily diversion.

No data is available to account for the occurrences when water in the SCE Canal and the Auxiliary Diversion contributed to the Conservation District spreading volumes the division box near the SAR 2/3. Logic in DOP is based on the assumption that the Conservation District diversion originates solely from water released from the dam. This is the best possible approach identified for the analysis, given limited data, and this method ensures that all Conservation District demands are met, prior to unappropriated SAR water being made available for Muni/Western diversion.

Environmental Habitat Releases

Water in excess of the senior water rights claimants and Conservation District diversions is available for potential environmental habitat releases. Per conditions in the BA, DOP modeling assumes a release is made only if it would be possible to release water for at least two days at the desired rate and sufficient time (6 months) has passed since the last environmental habitat release. The model is limited to a release duration of 2 days.

Muni/Western Capture

Any unappropriated water released from the dam after diversion by senior water rights claimants and the Conservation District and environmental releases is potentially available for Muni/Western capture. Muni/Western can only divert up to the capacity of the Plunge Pool Pipeline which can be either 500 (Phase I) or 1,500 cfs (Phase II or later), and cannot divert more than the amount stated in their applications (200,000 afy).

Undiverted Water

Undiverted SAR water represents unappropriated water released from the dam that continues to flow in the SAR toward Prado Dam and which recharges groundwater.

6.2.2 Daily River Analysis Model (DRAM)

DRAM is designed to estimate daily river flow rates for non-storm days at six specific locations along the mainstem of the SAR between Seven Oaks Dam and Riverside Narrows under three different sets of conditions. The locations are: (1) upstream of Cuttle Weir; (2) immediately downstream of Cuttle Weir; (3) immediately downstream of the Mill Creek confluence; (4) at "E" Street in the City of San Bernardino; (5) immediately downstream of the outfall of the RIX and Rialto WWTPs; and (6) at the MWD Crossing Gage at Riverside Narrows. The three sets of conditions represented are: (1) prior to the construction and operation of Seven Oaks Dam; (2) under No Project conditions (i.e., with the operation of Seven Oaks Dam); and (3) Project implementation (i.e., with Muni/Western diversions taking place). The methodology used to simulate the SAR flow rates at these six locations is described below.

DRAM is a spreadsheet model that uses data from a number of sources to compute flows at specific locations on the SAR. The sources of data are: (1) output describing upper SAR hydrology and river diversions from DOP; (2) SAR inflows from tributaries and WWTPs; and (3) losses attributable to evaporation and infiltration.

The generic structure of DRAM presented in Figure 6.2-1 helps illustrate the components of the estimated flows and data sources. Rectangular shapes represent input data sources, e.g., USGS gages or treatment plant outflow records, while hexagonal shapes represent major model products, i.e., interpolated hydrology at specific locations. Losses from the main channel vary and are shown as triangles in the illustration. Losses occur in the channel through percolation and through evaporation. Diversions are shown with diamond shapes.

6.2.2.1 Input and Methodology

Flow above Cuttle Weir

Pre-Seven Oaks Dam flows in this segment are represented by the historical daily average flow rate recorded at the Combined Flow Mentone Gage, minus diversions by senior water rights claimants. Under No Project conditions, estimated flows in this reach are represented by

Seven Oaks Dam releases and flows include diversions made by the Conservation District. Only after Phase III of the Plunge Pool Pipeline has been built (the primary diversion pipeline for the Project) would Project diversions affect flows in this reach. Phase III of the Plunge Pool Pipeline would enable Muni/Western diversions of 1,500 cfs at the plunge pool. Under Phase III of the Plunge Pool Pipeline, estimated flows in this reach are represented by Seven Oaks Dam releases minus Project diversions.

Flow below Cuttle Weir

Pre-Seven Oaks Dam flows in this segment are represented by the daily average flow rate recorded at the USGS Combined Flow Mentone Gage minus diversions by senior water rights claimants and the Conservation District. To estimate flows under No Project conditions and flows with the Project, output derived from DOP is successively used as input to DRAM.

Estimated average daily SAR flow rates just below Cuttle Weir are derived from DOP. Estimated flows under No Project conditions account for: (1) senior water rights claimants diversions; (2) releases from Seven Oaks Dam; (3) Conservation District diversions; and (4) releases for habitat restoration. Estimated flows under Project scenarios account for all of the above plus proposed Muni/Western diversions. User-specified parameters in DOP simulate various alternatives for senior water rights claimants diversions (historical up to 88 cfs) and Conservation District diversions (historical or licensed), as well as Project diversion capacities for Muni/Western (500 cfs and 1,500 cfs).

Flow at Mill Creek Confluence

Pre-Seven Oaks Dam flows in this segment are represented by the historical daily average flow rate recorded by the USGS Combined Flow Mentone Gage, minus diversions made by senior water rights claimants and the Conservation District, plus historical flow recorded by the Mill Creek Gage at Yucaipa. Estimated flows under the No Project account for Seven Oaks Dam operations and estimated flows under Project scenarios are No Project flows less the Muni/Western diversions.

Flow at "E" Street

Prior to April 1996, the San Bernardino Water Reclamation Plant discharged to the SAR above "E" Street. Since April 1996, effluent from the San Bernardino Water Reclamation Plant has been sent to the RIX facility and is ultimately discharged downstream of "E" Street (Santa Ana River Watermaster 2003). The Pre-Seven Oaks Dam flow at "E" Street is the average daily flow recorded by the "E" Street Gage and includes effluent once discharged by the San Bernardino Water Reclamation Plant. Estimated flows under No Project conditions at "E" Street are calculated as the historical "E" Street Gage data, less inflows attributable to the San Bernardino Water Reclamation Plant which no longer discharges effluent upstream of this location, plus the effect that Seven Oaks Dam has on flows at "E" Street. Under Project scenarios, flow at "E" Street is estimated using DOP output for flows at Cuttle Weir reduced by 40 percent to account for losses through percolation in the stream channel and evaporation. The methods used to estimate flow losses from Cuttle Weir to "E" Street are discussed below.

Flow at RIX and Rialto Effluent Outfalls

The Pre-Seven Oaks Dam flow at the RIX and Rialto Effluent Outfall is comprised of the gaged flow at "E" Street minus the losses to the channel that this flow incurs between "E" Street and the RIX and Rialto effluent discharge channel. To this is added the historical Warm Creek and Lytle Creek inflows, and effluent discharges from the RIX and Rialto facilities. Because the RIX facility began operation in April 1996, historical flows only include 4 years with RIX effluent flows. Under No Project conditions and for Project scenarios, estimated flows assume RIX effluent (at plant capacity) for all years in the base period. With regard to tributary inflow from Warm and Lytle creeks, it was assumed that these tributaries incurred channel losses from the gaging station to the confluence with the SAR of approximately 9 cfs prior to 1974 and only 4 cfs after 1974 when portions of these tributaries were concrete-lined.

Flow at Riverside Narrows

The Pre-Seven Oaks Dam flow at Riverside Narrows is the average daily flow recorded by the MWD Crossing Gage. This gage record begins in WY 1969-70, so the period of record for this segment is limited to WY 1969-70 through WY 1999-2000. Flows in this segment include effluent from the Riverside Water Quality Control Plant. Based on the analysis undertaken, changes in flow at this point are not detectable when comparing No Project conditions to Project Scenarios C or D.

Flow Losses to the Stream Channel

The method for calculating losses is discussed in more detail in this section for the segments between Cuttle Weir and "E" Street and between "E" Street and RIX and Rialto Effluent Outfall. In total, three different approaches were used: water balance; statistical regression; and infiltration analysis.

SANTA ANA RIVER SEGMENT C AND SEGMENT D (CUTTLE WEIR TO "E" STREET)

A water balance approach and a statistical regression approach were both employed to estimate SAR losses between Cuttle Weir and "E" Street.

<u>Water Balance Approach</u>. A water balance of historical surface water inflows and outflows was used to estimate the total amount of loss of SAR mainstem and tributary inflow to the SAR channel segment between Cuttle Weir and "E" Street. The period of analysis included WY 1966-67 through WY 1980–81, the period of record for which all system inflow and outflow data are available. The historical system inflows are subtracted from the corresponding historical system outflows to estimate historical losses (i.e., infiltration and evaporation) of the entire system. Total inflows to the system included the sum of gaged flow of the mainstem SAR at Mentone (adjacent to Cuttle Weir) and the gauged tributary inflow to the SAR between Cuttle Weir and "E" Street including Mill Creek, Plunge Creek, City Creek, San Timoteo Creek, Warm Creek, and San Bernardino Wastewater Treatment Plant effluent. Total outflows from the system included the sum of gaged flow of the mainstem SAR at "E" Street and historical Conservation District diversions.

The estimated total system loss described above is then pro-rated according to Mentone flow volume and flow length contribution to total system inflow regime between Mentone and "E" Street to estimate the SAR mainstem-only flow loss between Mentone and "E" Street.

Statistical Regression Approach. Statistical regression analyses between monthly SAR flow at Mentone and "E" Street was performed for WY 1966–67 through WY 1999–00 (34 years, the available record). This method of analysis was performed to quantify the relationship between historical flow at Mentone and "E" Street using the coefficient of determination (R^2) as an indicator of the amount of variation in the flow data between the two gages. In turn, the estimated coefficient of determination can be used loosely to reflect how much an incremental change in flow at Mentone (e.g., Project diversions) could impact SAR flow at "E" Street. This method of analysis can also be compared to results obtained from the water balance approach.

Estimated Flow Losses. From WY 1966–67 through WY 1980–81, when the tributary gage records were most complete, an average of approximately 40 percent of SAR Mentone flow is estimated to be lost through infiltration and evaporation before reaching "E" Street. Therefore, an average of approximately 60 percent of SAR Mentone flow is estimated to reach "E" Street over the period of analysis, a general indication of how upstream Project diversions could affect SAR flow at "E" Street. While the average was 60 percent, the range of historical SAR flow at Mentone reaching "E" Street was between 25 percent and 92 percent on an annual basis.

SANTA ANA RIVER SEGMENTS C AND E (CUTTLE WEIR TO MILL CREEK CONFLUENCE AND "E" STREET TO RIX AND RIALTO EFFLUENT OUTFALL)

Infiltration Analysis Approach. Infiltration analysis was performed for multiple SAR flow rates in each channel segment to estimate ranges of losses of SAR flow rate due to infiltration. This analysis was performed by multiplying the total wetted area of a specific SAR segment (assuming a continuous flow rate) by an assumed river bed infiltration rate to compute the instantaneous flow rate that is lost to infiltration. The wetted area of a given channel segment was computed by multiplying the wetted perimeter of river cross-sections times the lengths between the cross-sections. The wetted perimeter of a given river cross-section was computed utilizing the HEC-RAS program. This analysis was performed for seven SAR flow rates (5, 10, 20, 60, 100, 1,000, 2,000 cfs) for each of the two SAR channel segments. Loss of instantaneous SAR flow due to infiltration ranges between 8 and 12 cfs for low flows between the USGS "E" Street Gage and the RIX and Rialto Effluent Outfall point. Based on this data, a representative flow loss of 11 cfs is assumed for non-storm flows in the SAR channel segment between "E" Street and RIX and Rialto Effluent Outfall.

6.2.3 Non-Storm Flow Analysis Results

Monthly flow summaries for non-storm days are presented for each of the six locations: (1) above Cuttle Weir (Table 6.2-1); (2) below Cuttle Weir (Table 6.2-2); (3) at the Mill Creek confluence (Table 6.2-3); (4) at "E" Street (Table 6.2-4); (5) at the RIX and Rialto Effluent Outfall (Table 6.2-5); and (6) at Riverside Narrows (Table 6.2-6). Each of these tables show, on a monthly basis, the number of zero-flow and flow days and daily flows under each of the following conditions: Pre-Seven Oaks Dam (historical); No Project; and Project scenarios. A summary of the results is presented in Table 6.2-7.

The daily analysis of Seven Oaks Dam operations shows that releases from the dam rarely exceed 500 cfs on non-storm days. Therefore, the effect of Project diversions on SAR flows during non-storm periods is essentially identical for both the 500 cfs and 1,500 cfs Muni/Western diversion rates - resulting in Scenario A having the same effect on non-storm day river flow as Scenario B – and Scenario C having similar effects as Scenario D.

Zero-Flow Days

Zero-flow days are defined as days in which the channel is dry. Non-storm days are based on a determination of the Santa Ana River Watermaster and comprised 8,375 (67 percent) of the total 12,419 days contained in the period of record used in this analysis.

Above Cuttle Weir

Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 4,012 days (or approximately 32 percent of the time) in which there was no flow in the channel, i.e. zero-flow days. Under No Project and Project conditions (with both the dam in place and Project diversions) there are no zero-flow days in this segment. This is attributable to a constant 3 cfs release from the dam (see Table 6.2-1).

Below Cuttle Weir

Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 5,966 days (or approximately 48 percent of the time) without flow in this segment of the river. Under No Project conditions with the Seven Oaks Dam in place, the number of zero-flow days increases to 6,183 (50 percent of the total days). With implementation of the Project diversion (regardless of capture scenario), the number of zero-flow days increases to 8,374, or 67 percent of total days in the period (see Table 6.2-2).

Mill Creek Confluence

Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 5,499 zero-flow days (approximately 46% of the time) at the Mill Creek confluence. With Seven Oaks Dam in place, the number of zero-flow days is 4,661, about 40 percent of the total days for the period. With the Project diversion in place, the number of days with no flow increases to 5,504 days, about 46 percent of the total days (see Table 6.2-3).

"E" Street Gage

Over the base period, prior to the construction of Seven Oaks Dam, it is estimated that there were 521 zero-flow days, about 4 percent of the total days in the period at "E" Street. Under No Project conditions, the number of zero-flow days increases to 4,371 (35 percent of the total days). The increase in zero-flow days with Seven Oaks Dam in place is due, in large part, to the filling of the debris pool in the early winter months and maintenance target storage. With implementation of Scenario C or D, the number of zero-flow days increases to 5,289 (43 percent of total days). This increase is attributable to all dam releases being diverted by Muni/Western instead of flowing downstream. With implementation of Scenario A or B, there is a greater frequency and volume of

Table 6.2-1. Project Effect on Non-Storm Days Above Cuttle Weir (River Segment B) - Monthly Summary for WY 1966-67 through WY 1999-00

	Base Period		January		February		March		April		May		June		July		August		September		October		November		December	
	Days	*% of Total Days*	*Days*	*% of Jan Days*	*Days*	*% of Feb Days*	*Days*	*% of Mar Days*	*Days*	*% of Apr Days*	*Days*	*% of May Days*	*Days*	*% of Jun Days*	*Days*	*% of Jul Days*	*Days*	*% of Aug Days*	*Days*	*% of Sep Days*	*Days*	*% of Oct Days*	*Days*	*% of Nov Days*	*Days*	*% of Dec Days*
HISTORICAL CONDITIONS																										
Total Days	12,419		1,054		961		1,054		1,020		1,054		1,020		1,054		1,054		1,020		1,054		1,020		1,054	
Storm Days	4,044	33%	577	55%	565	59%	698	66%	588	58%	341	32%	224	22%	122	12%	79	7%	126	12%	146	14%	203	20%	375	36%
Non-Storm Days	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Zero Flow Days	4,012	32%	172	16%	79	8%	45	4%	88	9%	223	21%	422	41%	553	52%	606	57%	542	53%	524	50%	455	45%	303	29%
Minimum Flow for Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow for Non-Storm Day (cfs)	1		4		5		6		5		2		0		0		0		0		0		0		2	
Maximum Flow for Non-Storm Days (cfs)	520		223		520		155		115		184		92		257		180		167		171		68		99	
NO PROJECT																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Minimum Flow on Non-Storm Days (cfs)	3		3		3		3		3		3		3		3		3		3		3		3		3	
Median Flow on Non-Storm Days (cfs)	5		3		5		7		8		4		3		23		23		23		3		3		3	
Maximum Flow on Non-Storm Days (cfs)	4,003		503		4,003		158		118		187		1,003		280		203		190		134		1,503		503	
PROJECT SCENARIO A OR B[1,2]																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Non-Storm Days with Project Diversion	3,268	26%	6	1%	38	4%	25	2%	68	7%	159	15%	361	35%	854	81%	939	89%	571	56%	33	3%	110	11%	104	10%
Median Flow for Non-Storm Day (cfs)	3		3		3		6		5		3		3		3		3		3		3		3		3	
Maximum Flow for Non-Storm Days (cfs)	3,503		303		3,503		103		52		23		3		3		3		3		134		278		102	
PROJECT SCENARIO C OR D[1,2]																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Non-Storm Days with Project Diversion	821	7%	6	1%	10	1%	1	0%	4	0%	31	3%	24	2%	210	20%	295	28%	110	11%	107	10%	22	2%	1	0%
Median Flow for Non-Storm Day (cfs)	3		3		3		3		3		3		3		3		17		3		3		3		3	
Maximum Flow for Non-Storm Days (cfs)	3,503		142		3,503		107		65		164		303		111		89		84		68		303		46	
NO PROJECT versus SCENARIO A OR B																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	-2	-40%	0	0%	-2	-45%	-1	-14%	-3	-37%	-1	-30%	0	0%	-20	-87%	-20	-87%	-20	-87%	0	0%	0	0%	0	0%
NO PROJECT versus SCENARIO C OR D																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	-2	-40%	0	0%	-2	-45%	-4	-57%	-5	-60%	-1	-30%	0	0%	-20	-87%	-6	-26%	-20	-87%	0	0%	0	0%	0	0%

Notes:

[1] Results for 500 cfs and 1,500 cfs diversion rate differ by less than 1%

[2] Only Phase III of the Plunge Pool Pipeline, a 1,500 cfs Muni/Western diversion pipeline at the plunge pool, affects this river segment.

Table 6.2-2. Project Effect on Non-Storm Days Downstream from Cuttle Weir (River Segment C) - Monthly Summary for WY 1966-67 through WY 1999-00

	Base Period		January		February		March		April		May		June		July		August		September		October		November		December	
	Days	*% of Total Days*	*Days*	*% of Jan Days*	*Days*	*% of Feb Days*	*Days*	*% of Mar Days*	*Days*	*% of Apr Days*	*Days*	*% of May Days*	*Days*	*% of Jun Days*	*Days*	*% of Jul Days*	*Days*	*% of Aug Days*	*Days*	*% of Sep Days*	*Days*	*% of Oct Days*	*Days*	*% of Nov Days*	*Days*	*% of Dec Days*
HISTORICAL CONDITIONS																										
Total Days	12,419		1,054		961		1,054		1,020		1,054		1,020		1,054		1,054		1,020		1,054		1,020		1,054	
Storm Days	4,044	33%	577	55%	565	59%	698	66%	588	58%	341	32%	224	22%	122	12%	79	7%	126	12%	146	14%	203	20%	375	36%
Non-Storm Days	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Zero Flow Days	5,966	48%	291	28%	199	21%	220	21%	281	28%	451	43%	608	60%	798	76%	823	78%	711	70%	726	69%	471	46%	387	37%
Minimum Flow for Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow for Non-Storm Day (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	441		103		441		110		65		176		92		191		140		167		171		59		66	
NO PROJECT																										
Non-Storm Days with Zero Flow	6,183	50%	426	40%	309	32%	271	26%	302	30%	493	47%	659	65%	521	49%	540	51%	603	59%	712	68%	717	70%	630	60%
Non-Storm Days with Flow	2,192	18%	51	5%	87	9%	85	8%	130	13%	220	21%	137	13%	411	39%	435	41%	291	29%	196	19%	100	10%	49	5%
Minimum Flow on Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow on Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Maximum Flow on Non-Storm Days (cfs)	3,921		482		3,921		110		65		176		1,000		211		160		187		90		1,200		457	
PROJECT SCENARIO A OR B[1]																										
Non-Storm Days with Zero Flow	8,374	67%	477	45%	395	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Non-Storm Days with Flow	1	0%	0	0%	1	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Project Diversion	3,268	26%	6	1%	38	4%	25	2%	68	7%	159	15%	361	35%	854	81%	939	89%	571	56%	33	3%	110	11%	104	10%
Median Flow for Non-Storm Day (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	3,500		0		3,500		0		0		0		0		0		0		0		0		0		0	
PROJECT SCENARIO C OR D[1]																										
Non-Storm Days with Zero Flow	8,374	67%	477	45%	395	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Non-Storm Days with Flow	1	0%	0	0%	1	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Project Diversion	821	7%	6	1%	10	1%	1	0%	4	0%	31	3%	24	2%	210	20%	295	28%	110	11%	107	10%	22	2%	1	0%
Median Flow for Non-Storm Day (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	3,421		0		3,421		0		0		0		0		0		0		0		0		0		0	
NO PROJECT versus SCENARIO A OR B																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
NO PROJECT versus SCENARIO C OR D																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

Notes:

[1] Results for 500 cfs and 1,500 cfs diversion rate differ by less than 1%

Table 6.2-3. Project Effect on Non-Storm Days below Mill Creek Confluence (River Segment D) - Monthly Summary for WY 1966-67 through WY 1998-99

	Base Period		January		February		March		April		May		June		July		August		September		October		November		December	
	Days	*% of Total Days*	*Days*	*% of Jan Days*	*Days*	*% of Feb Days*	*Days*	*% of Mar Days*	*Days*	*% of Apr Days*	*Days*	*% of May Days*	*Days*	*% of Jun Days*	*Days*	*% of Jul Days*	*Days*	*% of Aug Days*	*Days*	*% of Sep Days*	*Days*	*% of Oct Days*	*Days*	*% of Nov Days*	*Days*	*% of Dec Days*
HISTORICAL CONDITIONS																										
Total Days	12,053		1,023		932		1,023		990		1,023		990		1,023		1,023		990		1,023		990		1,023	
Storm Days	3,989	33%	568	56%	544	58%	690	67%	574	58%	341	33%	224	23%	122	12%	79	8%	126	13%	146	14%	201	20%	374	37%
Non-Storm Days	8,064	67%	455	44%	388	42%	333	33%	416	42%	682	67%	766	77%	901	88%	944	92%	864	87%	877	86%	789	80%	649	63%
Zero Flow Days	5,499	46%	236	23%	177	19%	147	14%	206	21%	481	47%	607	61%	682	67%	724	71%	600	61%	676	66%	572	58%	391	38%
Minimum Flow for Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow for Non-Storm Day (cfs)	0		0		1		2		1		0		0		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	951		217		951		248		167		342		174		438		310		327		332		112		155	
NO PROJECT																										
Non-Storm Days with Zero Flow	4,661	39%	237	23%	180	19%	147	14%	206	21%	481	47%	607	61%	365	36%	397	39%	468	47%	611	60%	571	58%	391	38%
Non-Storm Days with Flow	3,403	28%	218	21%	208	22%	186	18%	210	21%	201	20%	159	16%	536	52%	547	53%	396	40%	266	26%	218	22%	258	25%
Minimum Flow on Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow on Non-Storm Days (cfs)	0		0		1		2		1		0		0		10		10		0		0		0		0	
Maximum Flow on Non-Storm Days (cfs)	4,431		527		4,431		248		167		342		1,082		458		330		347		168		1,214		544	
PROJECT SCENARIO A OR B[1]																										
Non-Storm Days with Zero Flow	5,504	46%	237	23%	180	19%	147	14%	207	21%	481	47%	607	61%	682	67%	724	71%	600	61%	676	66%	572	58%	391	38%
Non-Storm Days with Flow	2,560	21%	218	21%	208	22%	186	18%	209	21%	201	20%	159	16%	219	21%	220	22%	264	27%	201	20%	217	22%	258	25%
Non-Storm Days with Project Diversion	3,195	27%	6	1%	38	4%	25	2%	68	7%	159	16%	361	36%	823	80%	908	89%	560	57%	33	3%	110	11%	104	10%
Median Flow for Non-Storm Day (cfs)	0		0		1		2		1		0		0		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	4,010		217		4,010		150		110		179		87		252		175		165		166		71		94	
PROJECT SCENARIO C OR D[1]																										
Non-Storm Days with Zero Flow	5,504	46%	237	23%	180	19%	147	14%	207	21%	481	47%	607	61%	682	67%	724	71%	600	61%	676	66%	572	58%	391	38%
Non-Storm Days with Flow	2,560	21%	218	21%	208	22%	186	18%	209	21%	201	20%	159	16%	219	21%	220	22%	264	27%	201	20%	217	22%	258	25%
Non-Storm Days with Project Diversion	821	7%	6	1%	10	1%	1	0%	4	0%	31	3%	24	2%	210	21%	295	29%	110	11%	107	10%	22	2%	1	0%
Median Flow for Non-Storm Day (cfs)	0		0		1		2		1		0		0		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	3,931		217		3,931		150		110		179		87		252		175		165		166		71		94	
NO PROJECT versus SCENARIO A OR B																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	-10	-100%	-10	-100%	0	0%	0	0%	0	0%	0	0%
NO PROJECT versus SCENARIO C OR D																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	-10	-100%	-10	-100%	0	0%	0	0%	0	0%	0	0%

Notes:

[1] Results for 500 cfs and 1,500 cfs diversion rate differ by less than 1%

Table 6.2-4. Project Effect on Non-Storm Days below "E" Street (River Segment E) - Monthly Summary for WY 1966-67 through WY 1999-00

	Base Period		January		February		March		April		May		June		July		August		September		October		November		December	
	Days	*% of Total Days*	*Days*	*% of Jan Days*	*Days*	*% of Feb Days*	*Days*	*% of Mar Days*	*Days*	*% of Apr Days*	*Days*	*% of May Days*	*Days*	*% of Jun Days*	*Days*	*% of Jul Days*	*Days*	*% of Aug Days*	*Days*	*% of Sep Days*	*Days*	*% of Oct Days*	*Days*	*% of Nov Days*	*Days*	*% of Dec Days*
HISTORICAL CONDITIONS																										
Total Days	12,419		1,054		961		1,054		1,020		1,054		1,020		1,054		1,054		1,020		1,054		1,020		1,054	
Storm Days	4,044	33%	577	55%	565	59%	698	66%	588	58%	341	32%	224	22%	122	12%	79	7%	126	12%	146	14%	203	20%	375	36%
Non-Storm Days	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Zero Flow Days	521	4%	5	0%	0	0%	29	3%	42	4%	66	6%	59	6%	70	7%	66	6%	66	6%	50	5%	49	5%	19	2%
Minimum Flow for Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow for Non-Storm Day (cfs)	27		26		25		23		24		25		30		30		31		32		28		27		28	
Maximum Flow for Non-Storm Days (cfs)	400		170		400		61		57		87		70		188		250		190		182		79		95	
NO PROJECT																										
Non-Storm Days with Zero Flow	4,371	35%	331	31%	265	28%	220	21%	313	31%	495	47%	528	52%	62	6%	33	3%	355	35%	552	52%	658	65%	559	53%
Non-Storm Days with Flow	4,004	32%	146	14%	131	14%	136	13%	119	12%	218	21%	268	26%	870	83%	942	89%	539	53%	356	34%	159	16%	120	11%
Minimum Flow on Non-Storm Days (cfs)	0		0		0		0		0		0		0		0		0		0		0		0		0	
Median Flow on Non-Storm Days (cfs)	4		1		0		0		0		0		6		16		17		12		0		0		0	
Maximum Flow on Non-Storm Days (cfs)	2,184		267		2,184		28		41		63		556		176		219		176		150		896		242	
PROJECT SCENARIO A OR B[1]																										
Non-Storm Days with Zero Flow	6,212	50%	331	31%	271	28%	222	21%	317	31%	515	49%	553	54%	715	68%	801	76%	668	65%	584	55%	674	66%	561	53%
Non-Storm Days with Flow	2,163	17%	146	14%	125	13%	134	13%	115	11%	198	19%	243	24%	217	21%	174	17%	226	22%	324	31%	143	14%	118	11%
Non-Storm Days with Project Diversion	3,268	26%	6	1%	38	4%	25	2%	68	7%	159	15%	361	35%	854	81%	939	89%	571	56%	33	3%	110	11%	104	10%
Median Flow for Non-Storm Day (cfs)	0		1		0		0		0		0		3		0		0		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	1,884		147		1,884		28		41		42		21		68		219		64		150		178		59	
PROJECT SCENARIO C OR D[1]																										
Non-Storm Days with Zero Flow	5,289	43%	322	31%	268	28%	212	20%	313	31%	495	47%	528	52%	414	39%	403	38%	500	49%	626	59%	651	64%	557	53%
Non-Storm Days with Flow	3,086	25%	155	15%	128	13%	144	14%	119	12%	218	21%	268	26%	518	49%	572	54%	394	39%	282	27%	166	16%	122	12%
Non-Storm Days with Project Diversion	821	7%	6	1%	10	1%	1	0%	4	0%	31	3%	24	2%	210	20%	295	28%	110	11%	107	10%	22	2%	1	0%
Median Flow for Non-Storm Day (cfs)	0		4		0		0		0		0		6		12		12		0		0		0		0	
Maximum Flow for Non-Storm Days (cfs)	1,937		144		1,937		40		41		63		141		147		220		115		150		180		59	
NO PROJECT versus SCENARIO A OR B																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	-4	-100%	0	0%	0	0%	0	0%	0	0%	0	0%	-3	-50%	-16	-100%	-17	-100%	-12	-100%	0	0%	0	0%	0	0%
NO PROJECT versus SCENARIO C OR D																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	-4	-100%	3	300%	0	0%	0	0%	0	0%	0	0%	0	0%	-4	-25%	-5	-29%	-12	-100%	0	0%	0	0%	0	0%

Notes:

[1] Results for 500 cfs and 1,500 cfs diversion rate differ by less than 1%

Table 6.2-5. Project Effect on Non-Storm Days below RIX and Rialto Effluent Outfall (River Segment F) - Monthly Summary for WY 1966-67 through WY 19

	Base Period		January		February		March		April		May		June		July		August		September		October		November		December	
	Days	*% of Total Days*	*Days*	*% of Jan Days*	*Days*	*% of Feb Days*	*Days*	*% of Mar Days*	*Days*	*% of Apr Days*	*Days*	*% of May Days*	*Days*	*% of Jun Days*	*Days*	*% of Jul Days*	*Days*	*% of Aug Days*	*Days*	*% of Sep Days*	*Days*	*% of Oct Days*	*Days*	*% of Nov Days*	*Days*	*% of Dec Days*
HISTORICAL CONDITIONS																										
Total Days	12,419		1,054		961		1,054		1,020		1,054		1,020		1,054		1,054		1,020		1,054		1,020		1,054	
Storm Days	4,044	33%	577	55%	565	59%	698	66%	588	58%	341	32%	224	22%	122	12%	79	7%	126	12%	146	14%	203	20%	375	36%
Non-Storm Days	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Zero Flow Days	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Minimum Flow for Non-Storm Days (cfs)	9		10		10		10		10		10		10		9		9		10		10		10		10	
Median Flow for Non-Storm Day (cfs)	34		35		31		32		27		35		33		36		36		36		33		34		33	
Maximum Flow for Non-Storm Days (cfs)	1,320		365		1,320		245		140		169		112		187		704		224		181		269		281	
NO PROJECT																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	713	70%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Minimum Flow on Non-Storm Days (cfs)	61		62		62		62		61		62		63		64		62		63		68		70		64	
Median Flow on Non-Storm Days (cfs)	74		67		67		63		61		63		71		83		81		75		68		70		64	
Maximum Flow on Non-Storm Days (cfs)	2,271		393		2,271		269		134		203		619		240		747		268		218		976		311	
PROJECT SCENARIO A OR B[1]																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Non-Storm Days with Project Diversion	3,268	26%	6	1%	38	4%	25	2%	68	7%	159	15%	361	35%	854	81%	939	89%	571	56%	33	3%	110	11%	104	10%
Median Flow for Non-Storm Day (cfs)	68		67		67		62		61		62		69		70		67		63		68		70		64	
Maximum Flow for Non-Storm Days (cfs)	1,971		393		1,971		269		134		203		115		184		735		268		218		312		311	
PROJECT SCENARIO C OR D[1]																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	8,375	67%	477	45%	396	41%	356	34%	432	42%	713	68%	796	78%	932	88%	975	93%	894	88%	908	86%	817	80%	679	64%
Non-Storm Days with Project Diversion	821	7%	6	1%	10	1%	1	0%	4	0%	31	3%	24	2%	210	20%	295	28%	110	11%	107	10%	22	2%	1	0%
Median Flow for Non-Storm Day (cfs)	70		68		67		63		61		63		71		76		74		63		68		70		64	
Maximum Flow for Non-Storm Days (cfs)	2,023		393		2,023		269		134		203		204		211		747		268		218		312		310	
NO PROJECT versus SCENARIO A OR B																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	-5	-7%	0	0%	0	-1%	0	0%	0	0%	0	0%	-2	-3%	-12	-15%	-15	-18%	-12	-16%	0	0%	0	0%	0	0%
NO PROJECT versus SCENARIO C OR D																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	-4	-5%	1	2%	-1	-1%	0	0%	0	0%	0	0%	0	0%	-7	-8%	-8	-10%	-12	-16%	0	0%	0	0%	0	0%

Notes:

[1] Results for 500 cfs and 1,500 cfs diversion rate differ by less than 1%

Table 6.2-6. Project Effect on Non-Storm Days at Riverside Narrows (River Segment G) - Monthly Summary for WY 1969-70 through WY 1999-00

	Base Period		January		February		March		April		May		June		July		August		September		October		November		December	
	Days	*% of Total Days*	*Days*	*% of Jan Days*	*Days*	*% of Feb Days*	*Days*	*% of Mar Days*	*Days*	*% of Apr Days*	*Days*	*% of May Days*	*Days*	*% of Jun Days*	*Days*	*% of Jul Days*	*Days*	*% of Aug Days*	*Days*	*% of Sep Days*	*Days*	*% of Oct Days*	*Days*	*% of Nov Days*	*Days*	*% of Dec Days*
HISTORICAL CONDITIONS																										
Total Days	11,164		930		848		953		930		961		930		961		961		930		930		900		930	
Storm Days	3,683	33%	516	55%	519	61%	632	66%	526	57%	310	32%	194	21%	119	12%	79	8%	126	14%	140	15%	181	20%	341	37%
Non-Storm Days	7,481	67%	414	45%	329	39%	321	34%	404	43%	651	68%	736	79%	842	88%	882	92%	804	86%	790	85%	719	80%	589	63%
Zero Flow Days	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Minimum Flow for Non-Storm Days (cfs)	38		40		44		43		41		42		43		41		38		42		40		43		46	
Median Flow for Non-Storm Day (cfs)	86		73		75		89		96		103		96		87		81		82		84		89		87	
Maximum Flow for Non-Storm Days (cfs)	336		182		166		172		212		190		166		155		336		156		217		179		157	
NO PROJECT																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	7,481	67%	414	45%	329	39%	321	34%	404	43%	651	68%	736	79%	842	88%	882	92%	804	86%	790	85%	719	80%	589	63%
Minimum Flow on Non-Storm Days (cfs)	38		40		44		43		41		42		43		41		38		42		40		43		46	
Median Flow on Non-Storm Days (cfs)	86		73		77		89		96		103		96		87		81		82		84		91		87	
Maximum Flow on Non-Storm Days (cfs)	710		182		589		172		212		190		576		155		336		156		217		710		157	
PROJECT SCENARIO A OR B[1]																										
Non-Storm Days with Zero Flow	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
Non-Storm Days with Flow	7,481	67%	414	45%	329	39%	321	34%	404	43%	651	68%	736	79%	842	88%	882	92%	804	86%	790	85%	719	80%	589	63%
Non-Storm Days with Project Diversion	2,836	25%	3	0%	9	1%	19	2%	67	7%	128	13%	328	35%	764	80%	848	88%	501	54%	12	1%	85	9%	72	8%
Median Flow for Non-Storm Day (cfs)	86		73		75		89		96		103		96		87		81		82		84		89		87	
Maximum Flow on Non-Storm Days (cfs)	336		182		166		172		212		190		166		155		336		156		217		179		157	
PROJECT SCENARIO C OR D[1]																										
No difference between the No Project and Scenario C and D was detectable and thus data for Scenarios C and D are not presented.																										
NO PROJECT versus SCENARIO A OR B[2]																										
		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change		% Change
Median Flow for Non-Storm Day (cfs)	0	0%	0	0%	-2	-3%	0	0%	0	0%	0	0%	0	0%	-1	-1%	0	0%	0	0%	0	0%	-2	-2%	0	0%
NO PROJECT versus SCENARIO C OR D[1]																										
No difference between the No Project and Scenario C and D was detectable.																										

Notes:

[1] Results for 500 cfs and 1,500 cfs diversion rate differ by less than 1%

Muni/Western diversions and the number of zero-flow days increases to 6,212 (50 percent of total days).

Table 6.2-7 Summary Results of Zero-Flow Day Analysis (WY 1966-67 to WY 1999-2000)

	Above Cuttle Weir	*Below Cuttle Weir*	*Mill Creek Confluence*	*"E" Street*	*RIX & Rialto*	*Riverside Narrows*
PRE-SEVEN OAKS DAM						
Number of Zero-Flow Days	4,012	5,966	5,499	521 (2)	0	0
Percent of Total Days (1)	32 %	48 %	46 %	4 %	0 %	0 %
NO PROJECT (POST-SEVEN OAKS DAM)						
Number of Zero-Flow Days	0	6,183	4,661	4,371	0	0
Percent of Total Days (1)	0 %	50 %	39 %	35 %	0 %	0 %
PROJECT SCENARIO A OR B						
Number of Zero-Flow Days	0	8,374	5,504	6,212	0	0
Percent of Total Days (1)	0 %	67 %	46 %	50%	0 %	0 %
PROJECT SCENARIO C OR D						
Number of Zero-Flow Days	0	8,374	5,504	5,289	0	0
Percent of Total Days (1)	0 %	67 %	46 %	43%	0 %	0 %
PERCENT CHANGE FROM NO PROJECT						
Scenario A or B minus No Project	0 %	+17 %	+7 %	+15 %	0 %	0 %
Scenario C or D minus No Project	0 %	+17 %	+7 %	+8 %	0 %	0 %

Notes:

1. For all locations except Mill Creek Confluence and Riverside Narrows, gage records are available for WY 1966-67 through WY 1999-2000, with 12,419 total days in the base period record and 8,375 non-storm days in the base period record. At Mill Creek Confluence the gage record is WY 1966-67 through WY 1998-99 and total days in the base period are 12,053 and total non-storm days in the base period are 8,064. At Riverside Narrows the available gage record is 1969-70 to WY 1999-2000 and total days in the base period are 11,164 and total non-storm days in the base period are 7,481.
2. The small number of zero-flow days is attributable to effluent inflow from City of San Bernardino WWTP.

RIX and Rialto Effluent Outfall

There are no zero-flow days in the river channel under either historical, No Project, or Project conditions. This is attributable to the effluent discharged by the RIX and Rialto WWTPs, and tributary inflow along the SAR. (See Table 6.2-5)

Riverside Narrows

There are also no zero-flow days in the river channel under either historical, No Project, or Project conditions at Riverside Narrows (see Table 6.2-6). This is attributable to effluent being discharged upstream from the RIX and Rialto WWTPs and the Riverside Water Quality Control Plant effluent discharged immediately above this gaging point.

Median Monthly Flows for Non-Storm Days

As can be seen from the information presented in Table 6.2-7, the river segment most affected by the Project is downstream of Cuttle Weir, while segments further downstream are progressively less affected. This is because the downstream segments have other flows contributing to the river. Thus Project diversions from the river represent progressively smaller and smaller proportions of total flows. In upstream segments of the SAR the largest change in flows occurs in the late summer months when comparing No Project flows to Project flows because of the draining of the debris pool to meet operational requirements for Seven Oaks Dam.

Above Cuttle Weir

Flows in this segment have a median annual value of 5 cfs for the period of record under the No Project condition (see Table 6.2-1 and Figure 6.2-2). Median flows in the spring months, up to 8 cfs in the month of April, are due to rainfall in these months. In the late summer months a median flow of 23 cfs occurs in the months of July, August, and September. This is due to the draining of the debris pool, which is limited to a rate of 20 cfs plus inflow to the dam. Generally median flows are small under the Project Scenarios A, B, C, and D, generally about 3 cfs attributable to the 3 cfs release of captured groundwater. The greatest difference between median flows in this segment between the No Project and Project Scenarios A, B, C, and D occurs in the summer months of July through September; under the No Project in these months this reach would receive water drained from the debris pool, but with the Project (assuming Phase III of the Plunge Pool Pipeline is completed and diversions occur upstream at the plunge pool) this water would be diverted.

Below Cuttle Weir

Under No Project conditions, median flows in this segment are zero cfs for all months. Under No Project conditions, all dam releases are diverted by senior water rights claimants or the Conservation District at Cuttle Weir. Median flow is also zero in this river segment under all Project scenarios. See Table 6.2-2 and Figure 6.2-3.

Mill Creek Confluence

Under No Project conditions, the median flow for this segment is 0 cfs over the base period, a median flow of 10 cfs occurs in the months of July and August due to the draining of the debris pool, and minimal median flows of 1 cfs to 2 cfs occur in February, March, and April (these flows relate to Mill Creek adding flow to this river segment during spring months). A reduction of flows to zero cfs due to the Project occurs in the late summer months of July and August. See Table 6.2-3 and Figure 6.2-4.

"E" Street Gage

Change in daily median flow is less marked at "E" Street than at upstream locations as can be seen from the information presented in Table 6.2-4. The difference in monthly median flows between the No Project and Scenarios A or B is greatest in the month of August with a reduction from 17 cfs under the No Project to zero cfs for Scenarios A or B, a 100 percent reduction. The greatest difference between median flows under No Project and Scenarios C or D is in September with 12 cfs under No Project and 0 cfs under Scenarios C or D. This also represents a reduction of 100 percent. See Table 6.2-4 and Figure 6.2-5.

RIX and Rialto Effluent Outfall

Change in median daily flow at the RIX and Rialto Effluent Outfall is still more attenuated as can be seen from the information presented in Table 6.2-5 and Figure 6.2-6. The difference in median daily flows between No Project and Scenarios A or B is the greatest in the month of August with a reduction of 18 percent from 81 cfs under No Project to 67 cfs for Scenarios A or B. There is a reduction of 16 percent in the month of September from 75 cfs under No Project to 63 cfs under Scenario C or D.

Riverside Narrows

A slight reduction in flows at this location occurs in the months of February, July, and November when comparing No Project conditions to Scenario A or B. The maximum change in flows for these months is a drop from 77 cfs in February under No Project conditions to 75 cfs under Scenario A or B, a reduction of 3 percent. No change from the No Project was detected with Scenarios C or D. See Table 6.1-6 and Figure 6.2-7.

6.2.4 Hydrologic Effects

Probability of exceedance curves aid in the presentation and interpretation of Project-related effects on flows under all conditions (Scenarios A through D). The information presented in Figures 6.2-8 through 6.2-13 compare Project scenarios with No Project and Pre-Seven Oaks Dam flow for non-storm days.

Figure 6.2-8 shows characteristics of flow above Cuttle Weir. Prior to Seven Oaks Dam, flow occurred in this segment only 50 percent of the time. Under both Project and No Project conditions, a constant flow of 3 cfs occurs. This is attributable to the release from Seven Oaks Dam that is diverted by the senior water rights claimants. Under the No Project and Scenarios C and D, a sustained flow at 23 cfs is noticeable. This is due to the draining of the debris pool which causes a sustained release of 20 cfs in the late summer months plus the 3 cfs for diversion by the senior water rights claimants. Under Scenarios A or B, the flows attributable to the draining of the debris pool are captured by the Project diversion.

Figure 6.2-9 shows the probability of daily discharge below Cuttle Weir. Prior to Seven Oaks Dam, flow only occurred in this segment about 25 percent of the time. Similarly, under No Project conditions flows only occur in this segment about 25 percent of the time. A sustained flow at 20 cfs under No Project conditions is due to the draining of the debris pool. Under both Project scenarios, flows do not occur in this segment. Any flows released by Seven Oaks Dam in excess of senior water rights claimants and Conservation District requirements are captured by the Project diversion.

Figure 6.2-10 shows the probability of daily discharge at the Mill Creek confluence. Prior to Seven Oaks Dam, flow occurred in this segment about 30 percent of the time. Under No Project conditions, flows exists about 40 percent of the time. A sustained flow of 10 cfs occurs due to the annual draining of the debris pool in the late summer months. On non-storm days, under all

Project conditions (Scenarios A through D), SAR flows do exists and resemble the Pre-Seven Oaks Dam flow regime.

Figure 6.2-11 shows the probability of daily discharge the "E" Street Gage. Prior to Seven Oaks Dam flow occurred in this segment about 93 percent of the time. This is attributable to the San Bernardino Water Reclamation Plant which historically discharged effluent upstream of the gage. Currently, the San Bernardino Water Reclamation Plant effluent is conveyed to the RIX facility and this has substantially decreased flows in this segment. Under the No Project condition, flows occurs in this segment only about 50 percent of the time. When comparing No Project and Project conditions, a noticeable difference in flows only occurs for flow less than 30 cfs. Scenarios A or B would create lower flows at all times compared to the Scenarios C or D and No Project conditions.

Figure 6.2-12 shows the probability of daily discharge at the RIX and Rialto Effluent Outfall. Under all Project scenarios (Scenarios A through D), flows occur in this segment 100 percent of the time. The estimated Project flows are higher than the historical flows because they include effluent from both the RIX and Rialto facilities operating at plant capacity. A difference of less than 1 percent is noticeable when comparing No Project, and Scenarios A, B, C, and D. For flows less than 70 cfs, the No Project, and Project curves converge.

Figure 6.2-13 shows the probability of daily discharge at Riverside Narrows. No difference is seen when comparing Pre-Seven Oaks Dam, No Project and Project scenarios. Because a difference is not discernable between the No Project and Project scenarios below Riverside Narrows, this location was the furthest downstream location studied in the analysis.

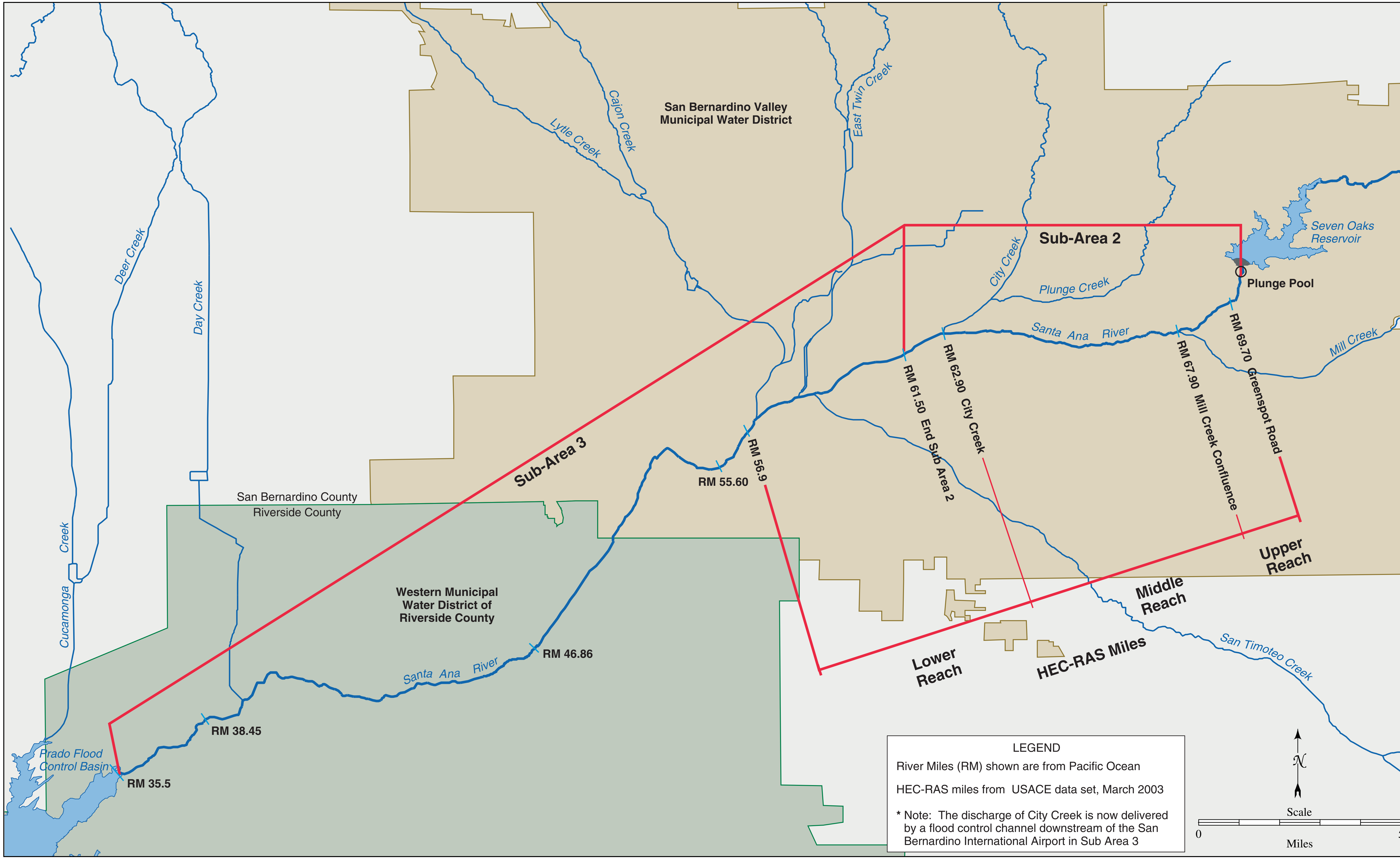


Figure 6.1-1. River Analysis (Peak Flow, Channel Velocity, Depth, and Overbank Flow)

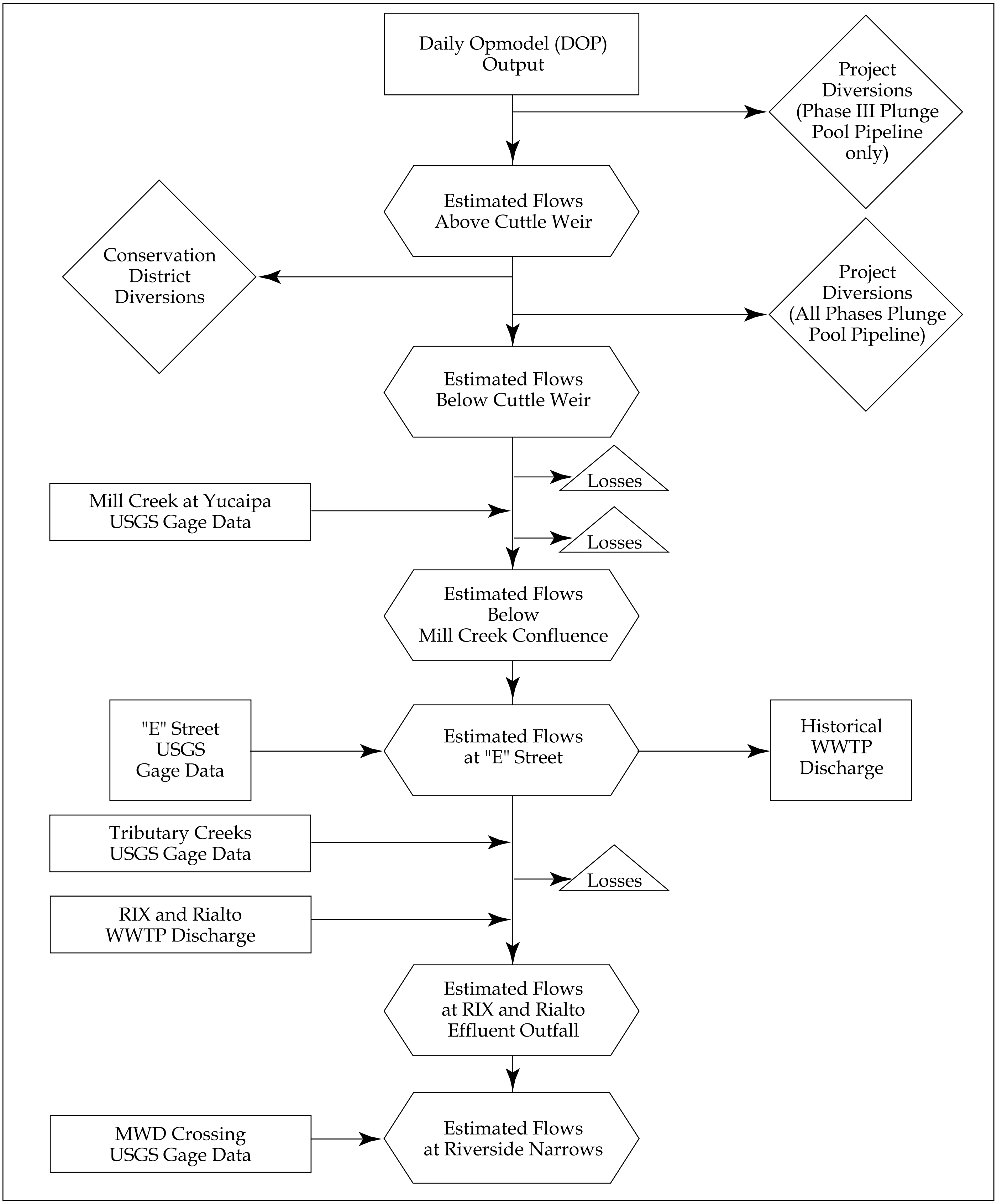


Figure 6.2-1. Daily River Analysis Model (DRAM) Structure

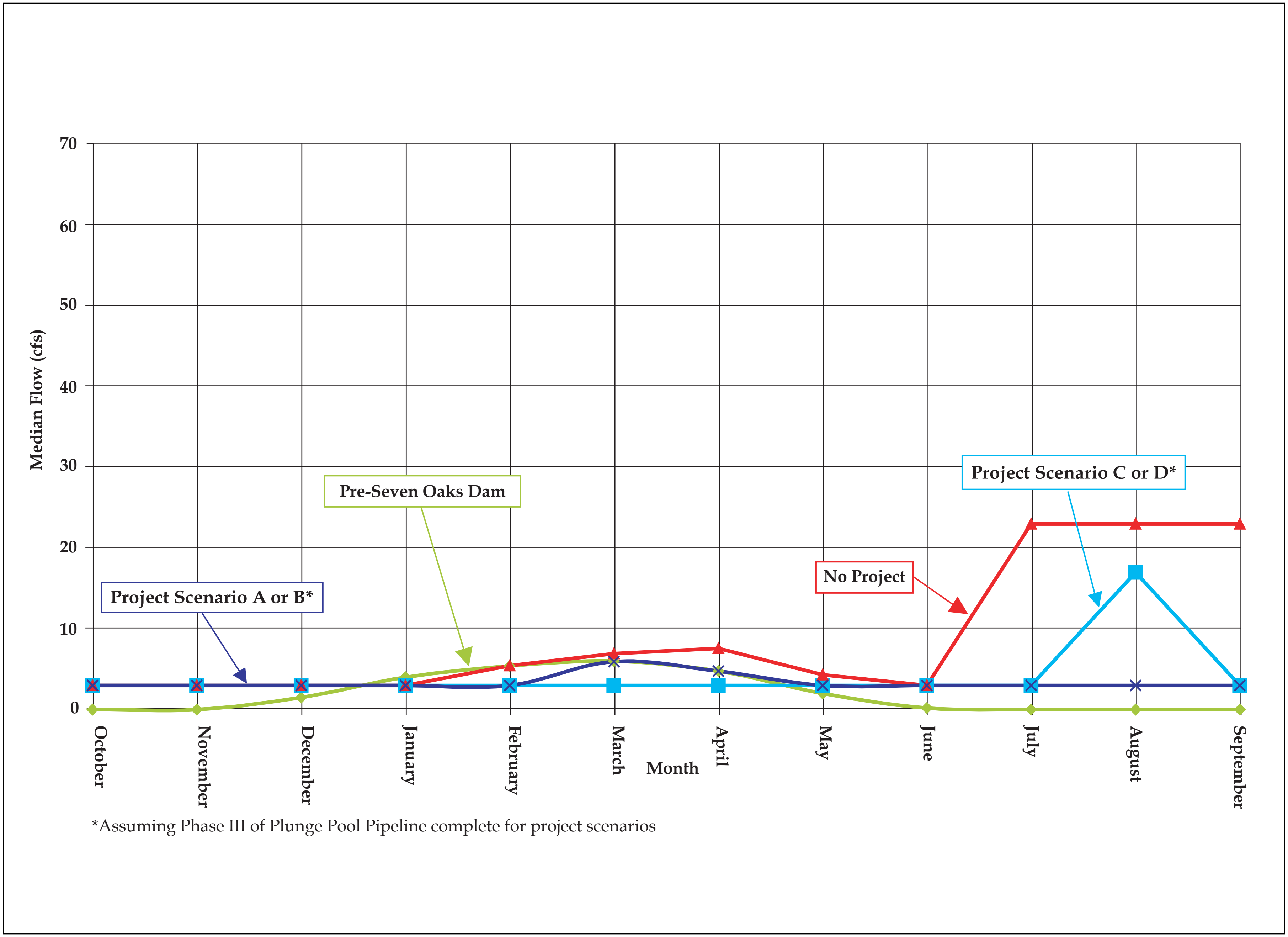


Figure 6.2-2. Median Monthly Flows (Non-Storm Days) for SAR Segment B, just above Cutter Wier, WY 1966-67 through WY 1999-2000

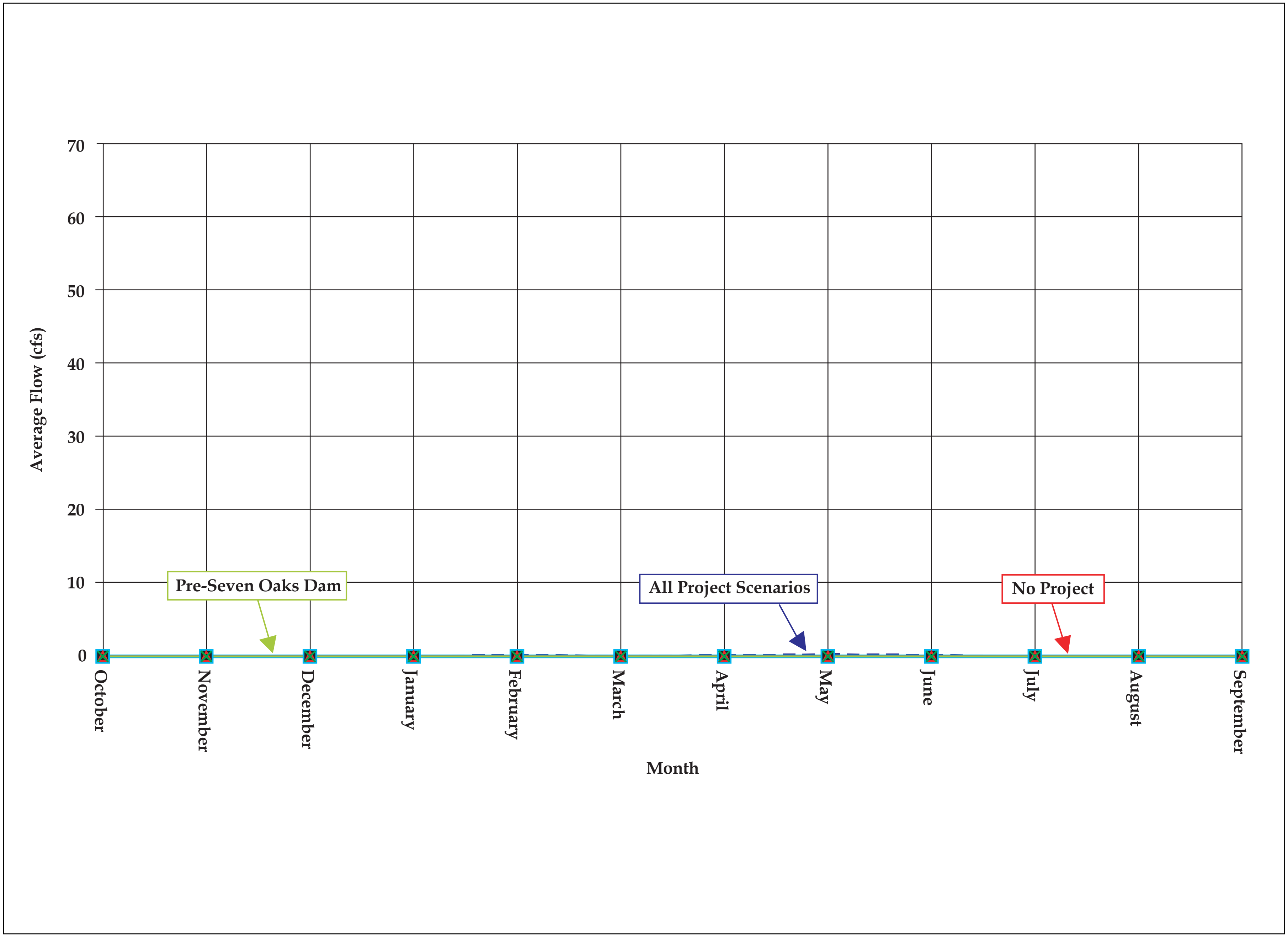


Figure 6.2-3. Median Monthly Flows (Non-Storm Days) for SAR Segment B, below Cuttle Wier, WY 1966-67 through WY 1999-2000

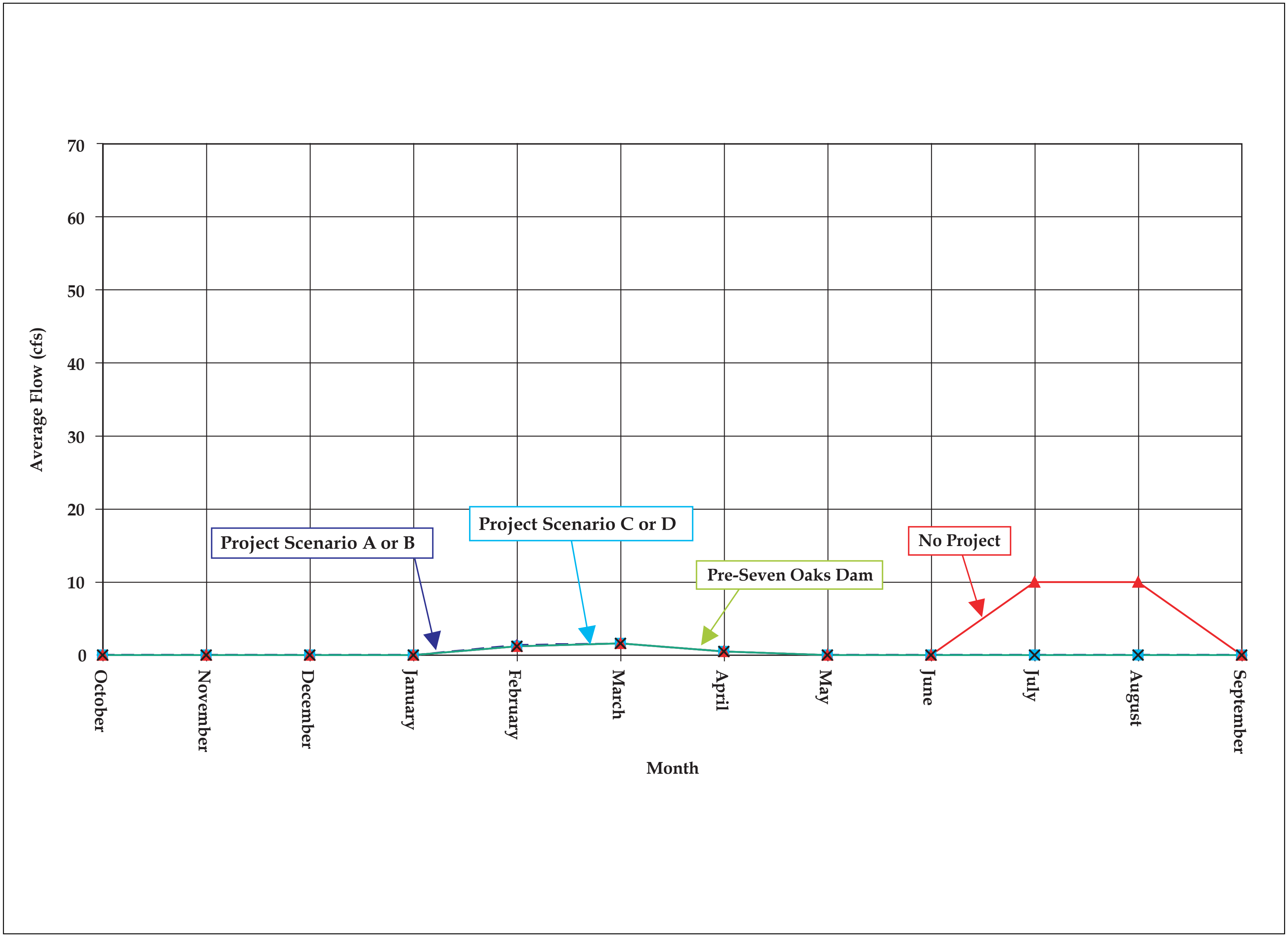


Figure 6.2-4. Median Monthly Flows (Non-Storm Days) for SAR Segment D, below Mill Creek Confluence, WY 1966-67 through WY 1999-2000

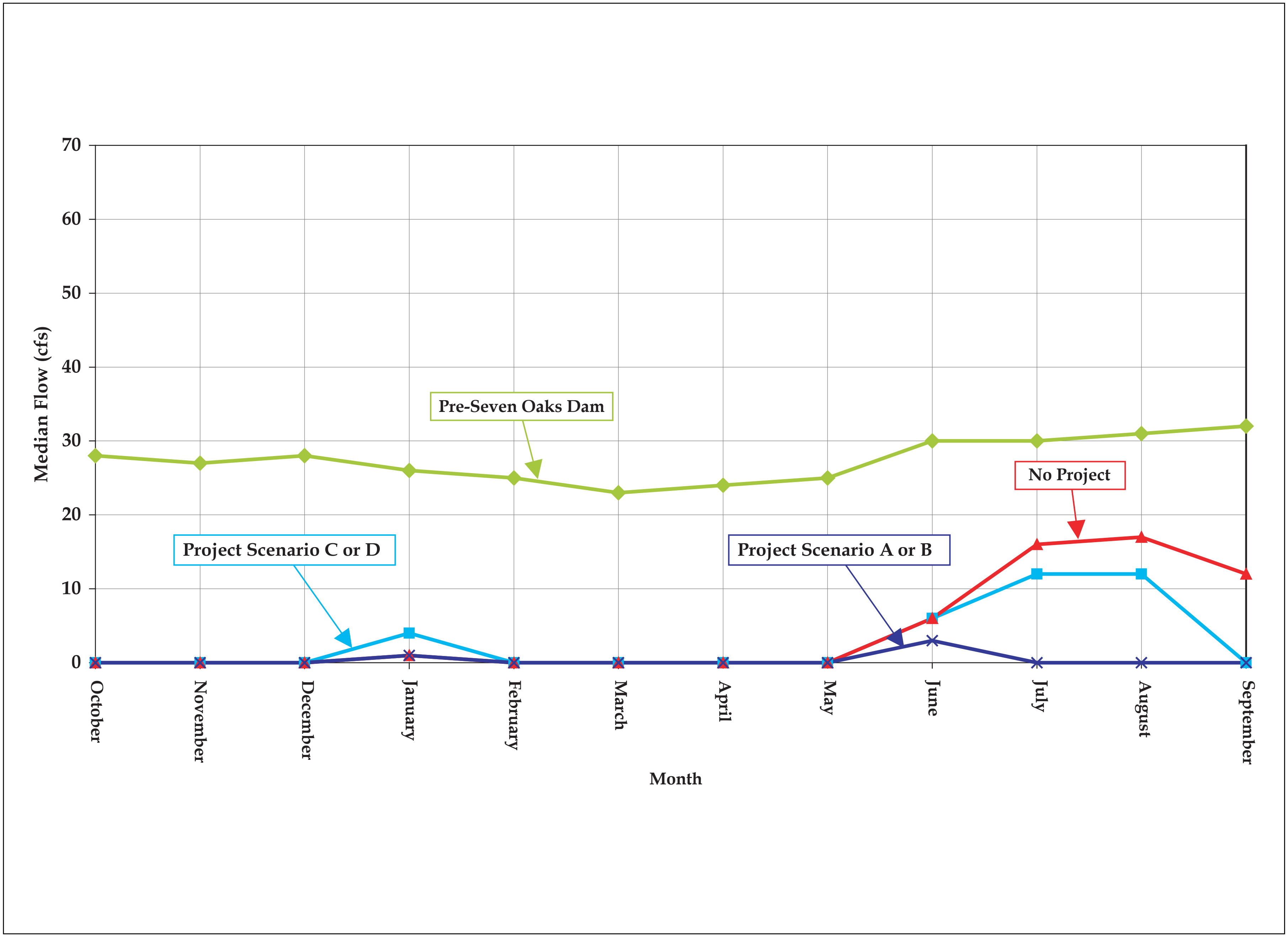


Figure 6.2-5. Median Monthly Flows (Non-Storm Days) for SAR Segment E, below "E" Street, WY 1966-67 through WY 1999-2000

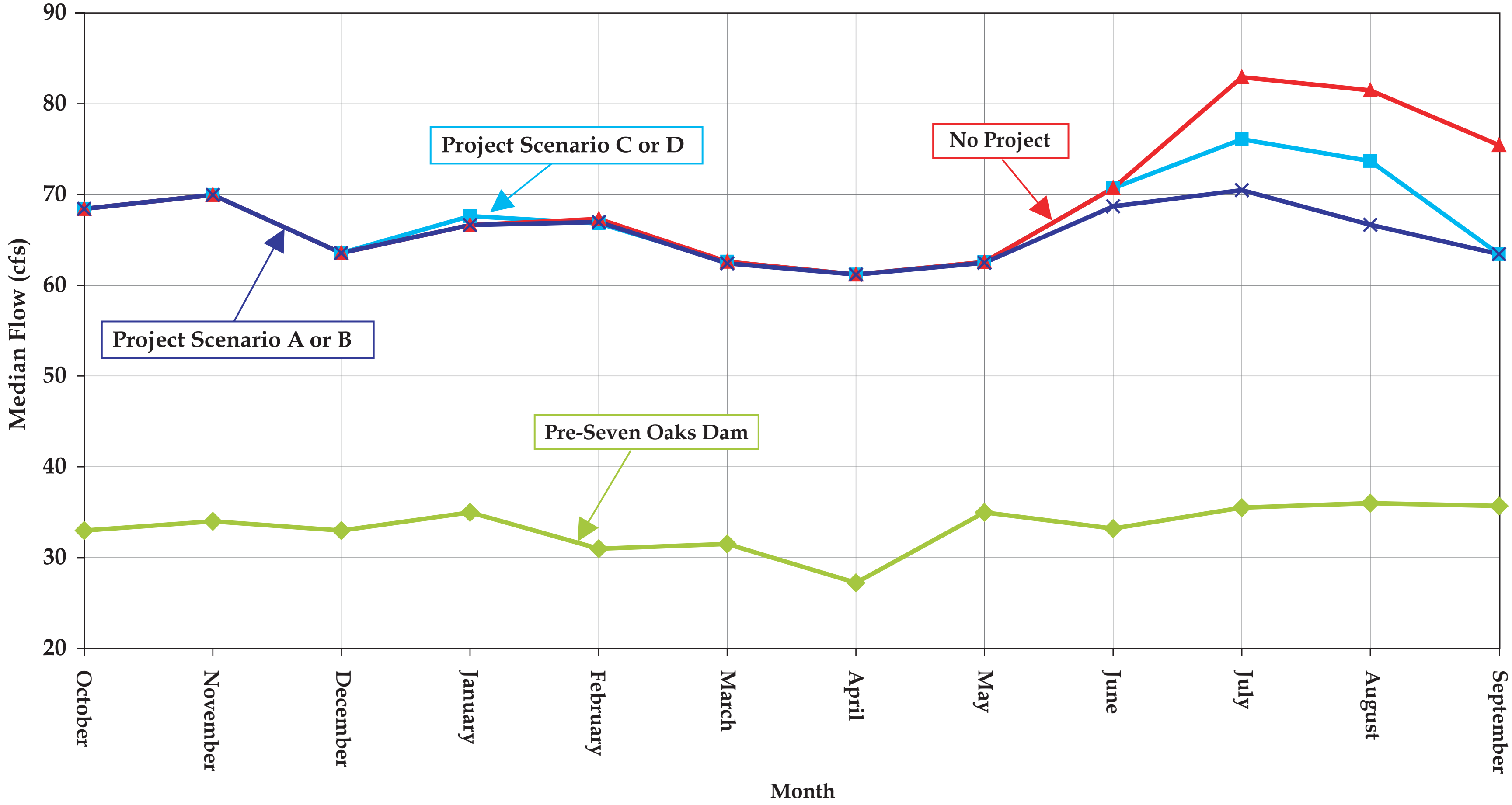


Figure 6.2-6. Median Monthly Flows (Non-Storm Days) for SAR Segment F, below RIX and Rialto Effluent Outfall, WY 1966-67 through WY 1999-2000

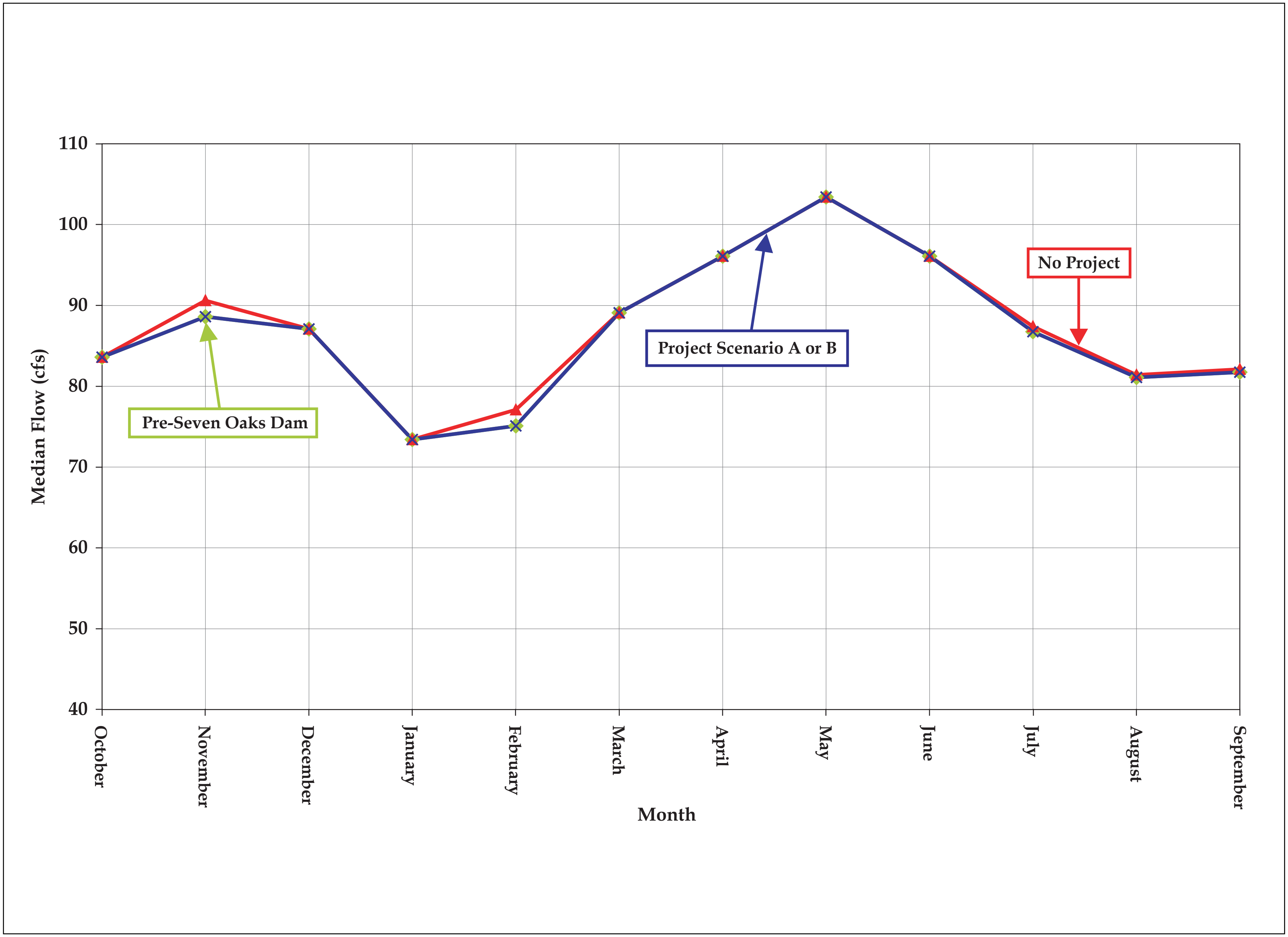
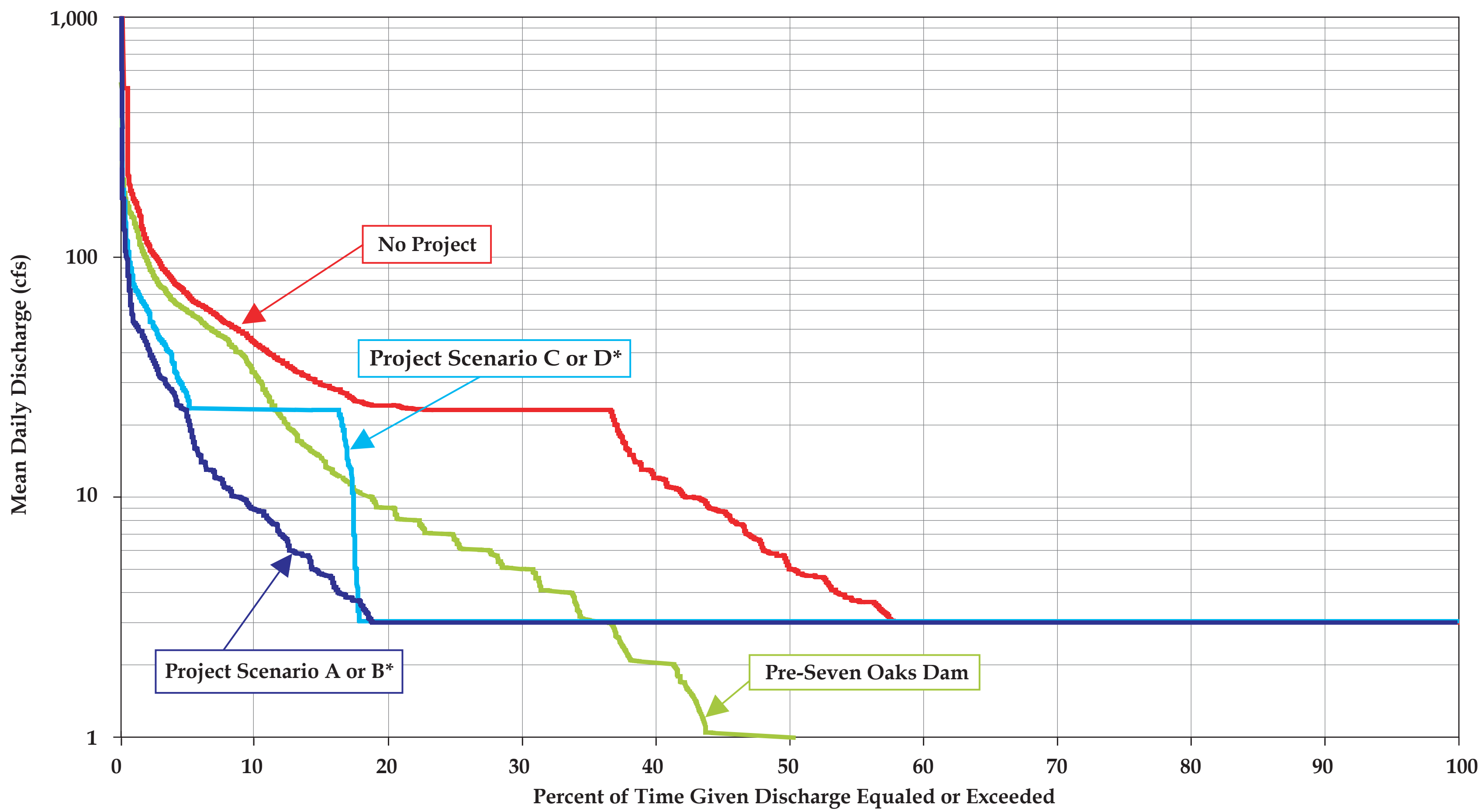
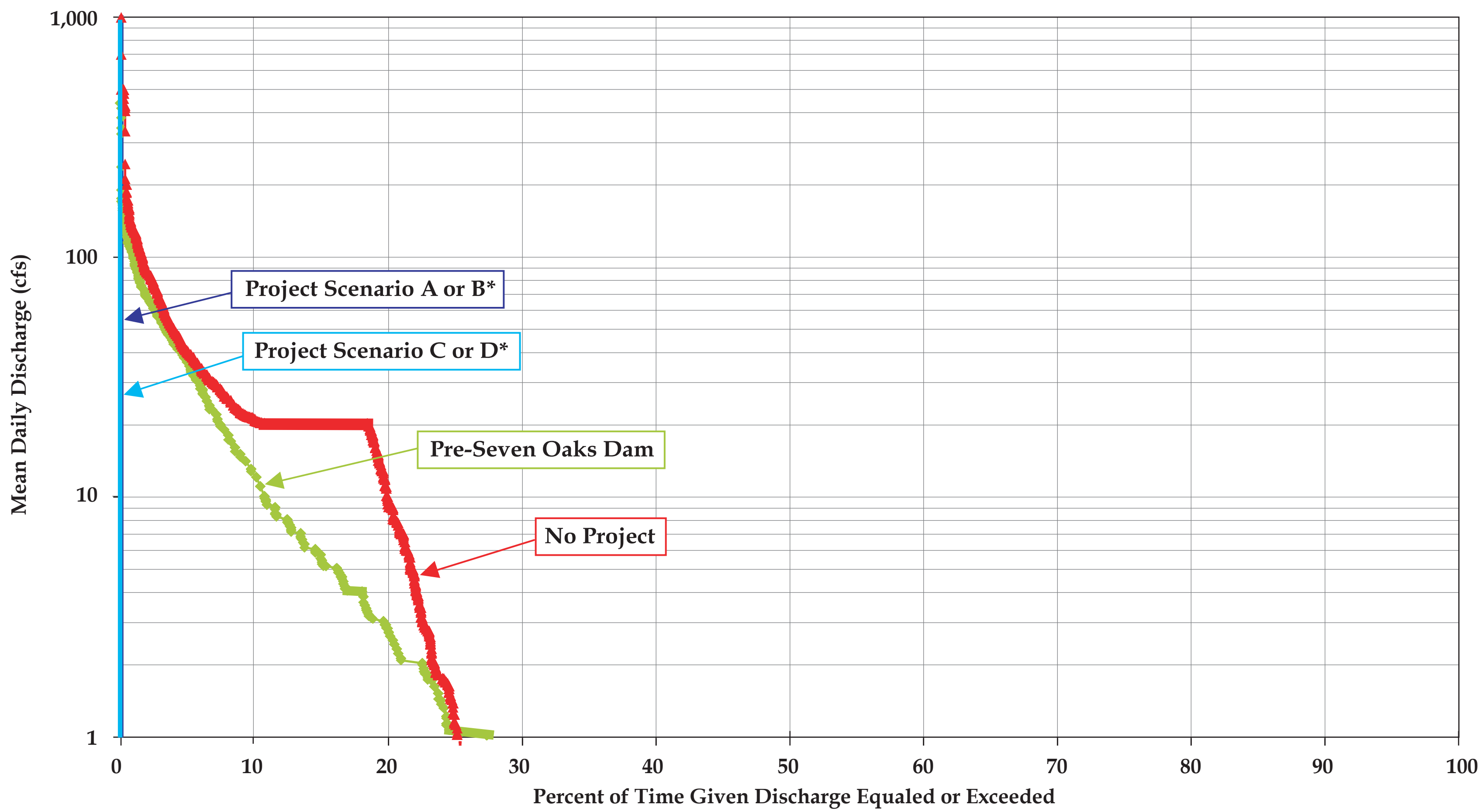


Figure 6.2-7. Median Monthly Flows (Non-Storm Days) for SAR Segment G, at Riverside Narrows, WY 1966-67 through WY 1999-2000



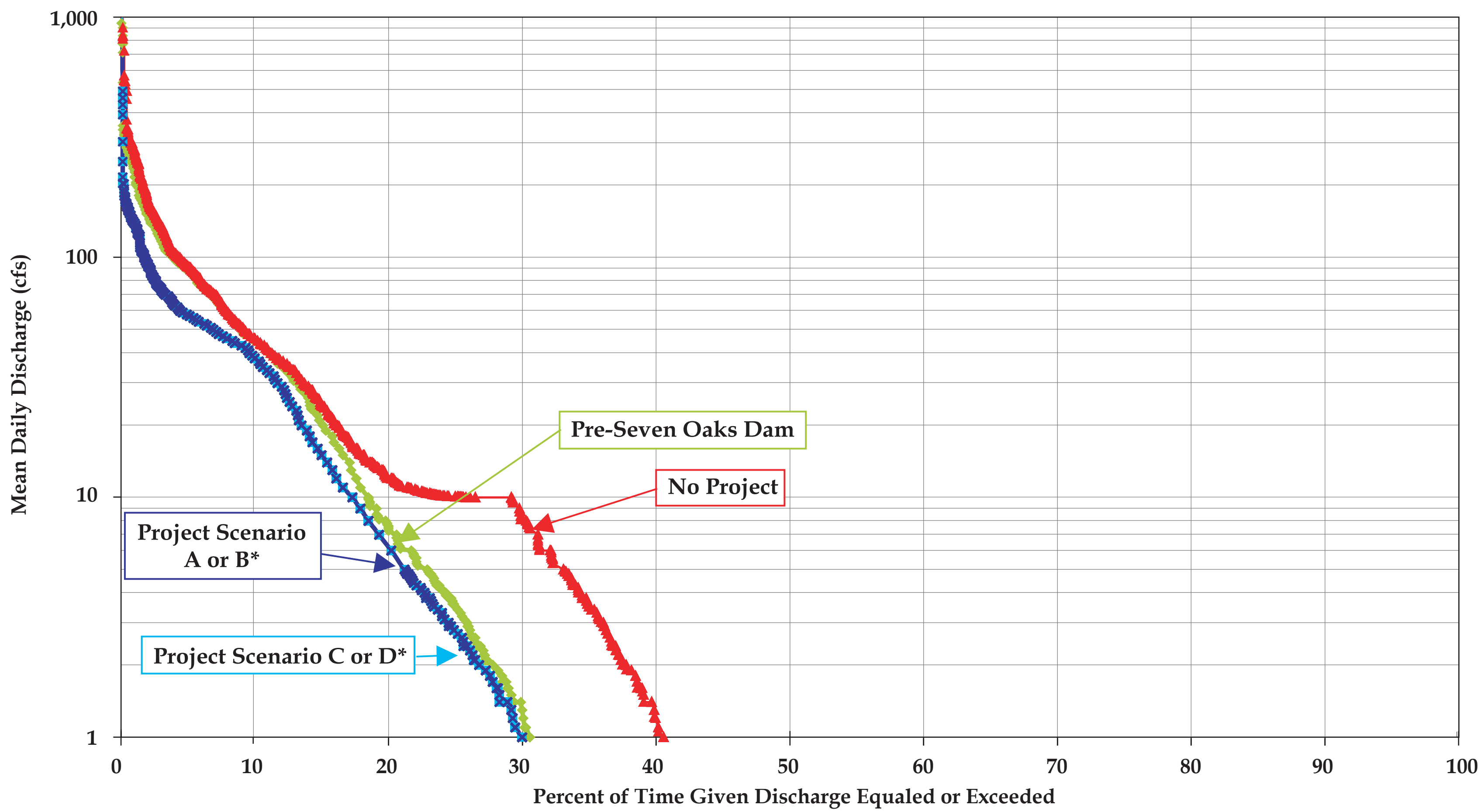
*Assuming Phase III of Plunge Pool Pipeline complete for project scenarios

Figure 6.2-8. Probability of Daily Discharge (Non-Storm Days) for SAR Segment B, just above Cuttle Weir* WY 1966-67 through YW 1999-2000



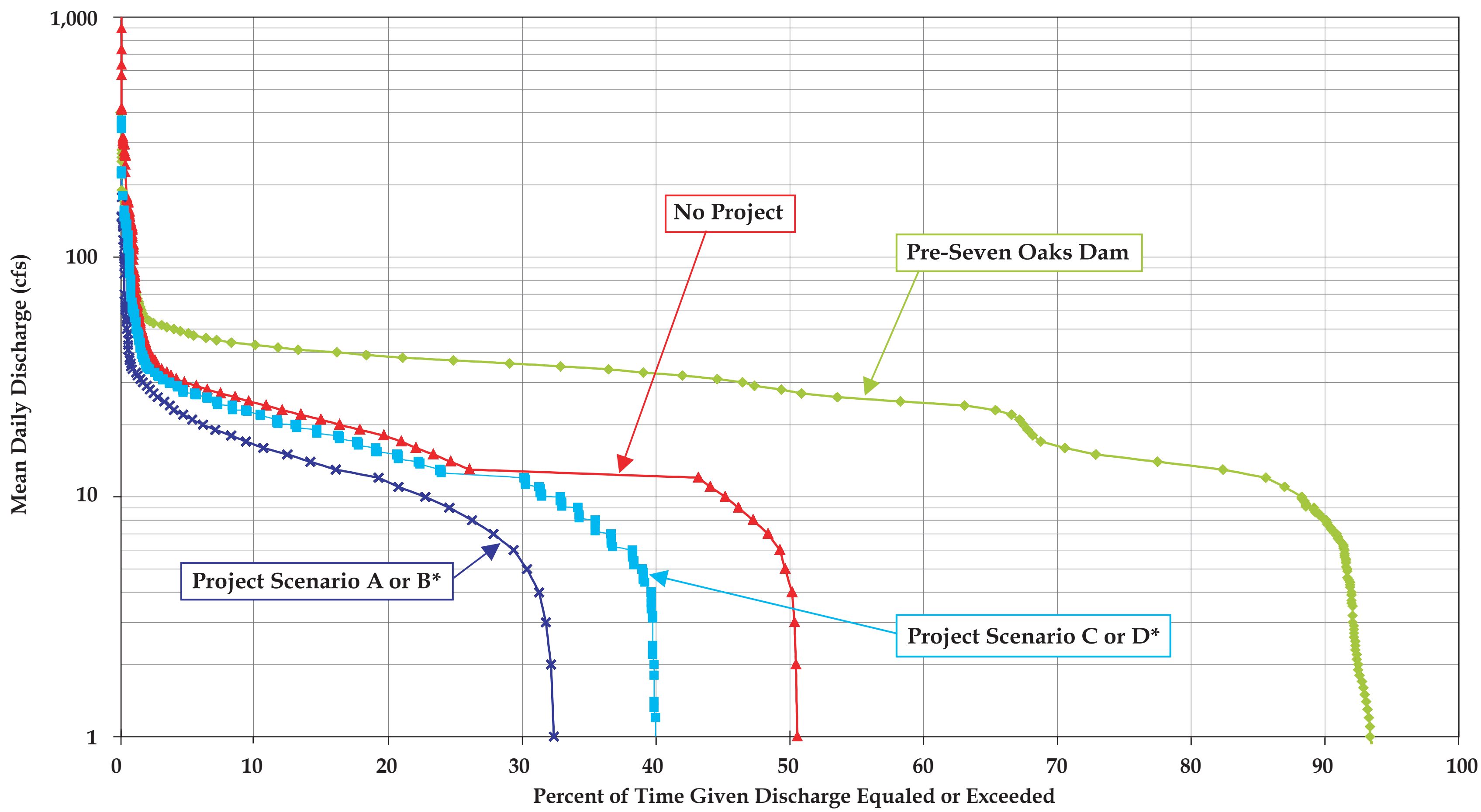
* Results for 500 cfs and 1,500 cfs diversion rates differ by less than 1% for flows higher than 500 cfs.

Figure 6.2-9. Probability of Daily Discharge (Non-Storm Days) for SAR Segment C, below Cuttle Weir* WY 1966-67 through YW 1999-2000



* Results for 500 cfs and 1,500 cfs diversion rates differ by less than 1% for flows higher than 500 cfs.

Figure 6.2-10. Probability of Daily Discharge (Non-Storm Days) for SAR Segment D, below Mill Creek Confluence, WY 1966-67 through YW 1999-2000



* Results for 500 cfs and 1,500 cfs diversion rates differ by less than 1% for flows higher than 500 cfs.

Figure 6.2-11. Probability of Daily Discharge (Non-Storm Days) for SAR Segment E, below "E" Street, WY 1966-67 through YW 1999-2000

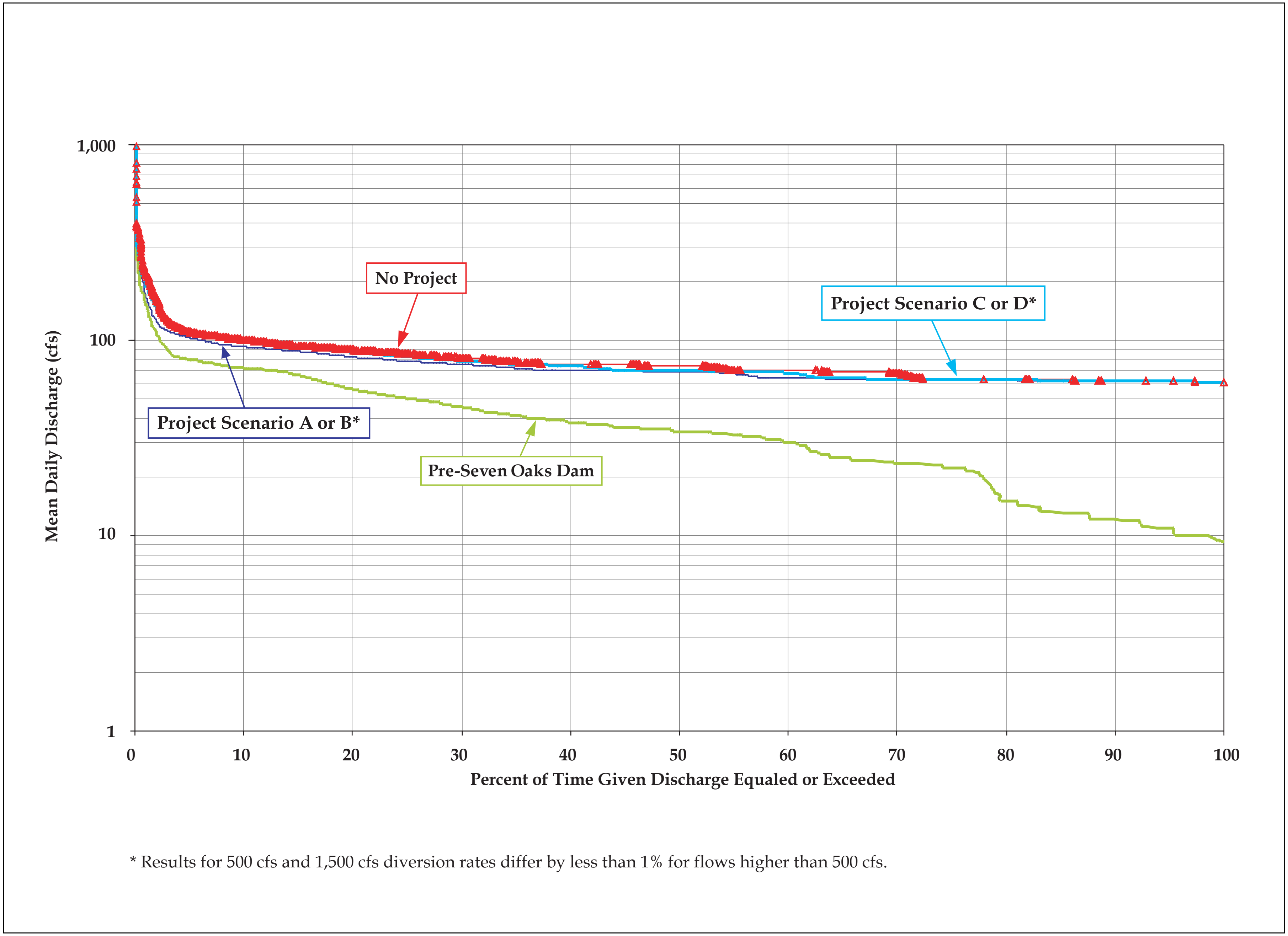
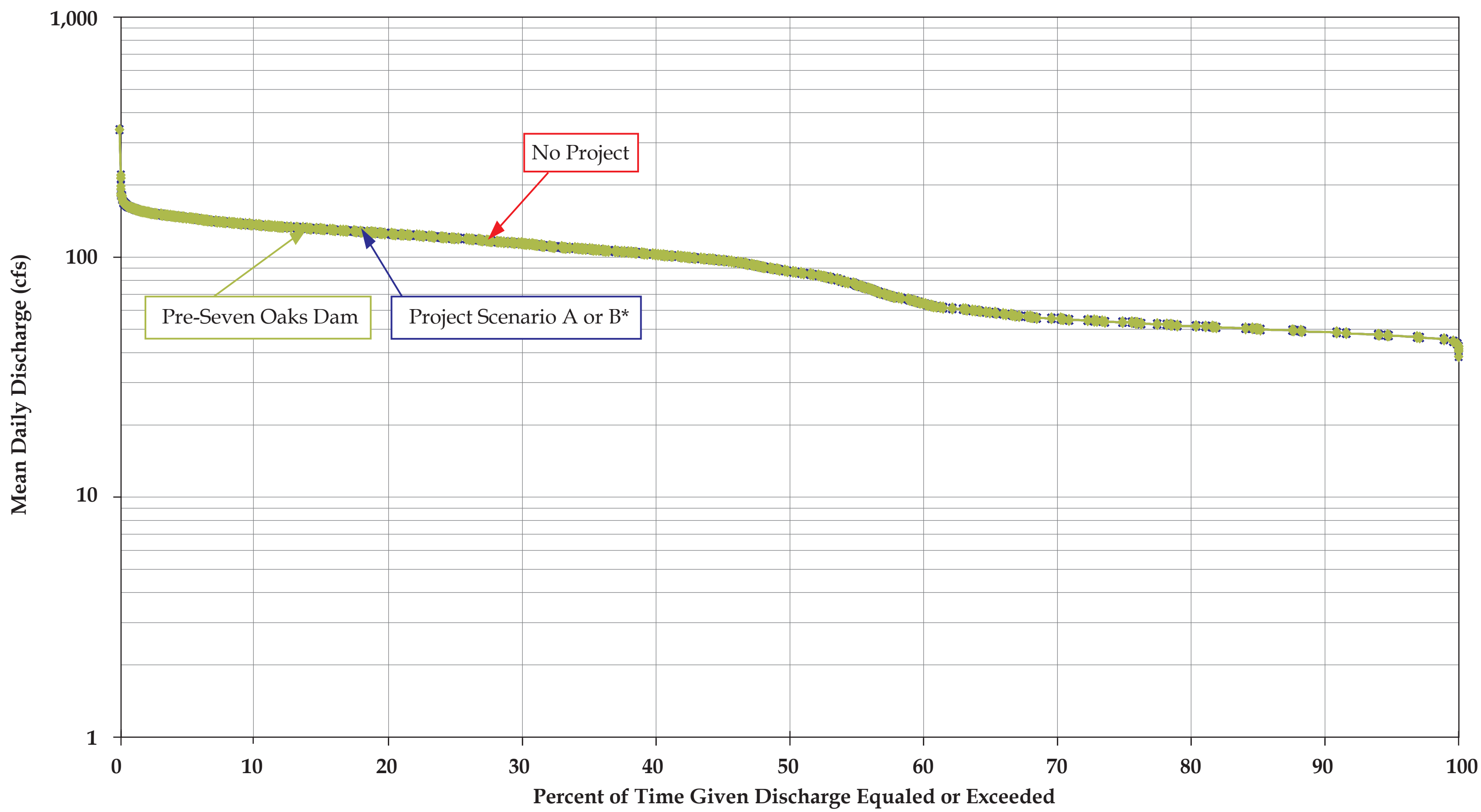


Figure 6.2-12. Probability of Daily Discharge (Non-Storm Days) for SAR Segment F, below RIX and Rialto Effluent Outfall, WY 1966-67 through YW 1999-2000



* Results for 500 cfs and 1,500 cfs diversion rates differ by less than 1% for flows higher than 500 cfs.
Only Scenarios A and B portrayed because effects of Scenarios C and D undetectable.

Figure 6.2-13. Probability of Daily Discharge (Non-Storm Days) for SAR Segment G, below Riverside Narrows, WY 1966-67 through YW 1999-2000

7.0 REFERENCES

California Code of Regulations, Title 22, Chapter 15, Article 5.5. Primary Standards – organic Chemicals. Primary MCL revisions regulation – Effective June 12, 2003.

City of San Bernardino. 2003. RIX Facility Recycled Water Sales Program, Program Environmental Impact Report. Municipal Water Department. March.

______. 2002. Urban Water Management Plan Update for the Planning Period 2000-2020. January.

City of Redlands. 2000. 2000 Urban Management Plan. December.

DWR (California Department of Water Resources). 2003. DWR ES Conference, State Water Project Water Monitoring Presentation. September.

______. 2002. The State Water Project Delivery Reliability Report, 2002, Final. Bay-Delta Office.

______. 1999. *California State Water Project Atlas*.

East Valley Water District. 2000. Year 2000 Urban Water Management Plan. December.

EIP 2004. Evaluation of the Final Rule to Designate Critical Habitat for the Santa Ana Sucker. April. Prepared for Best Best & Krieger LLP.

Mann, J.F., 1968. University of California, Berkley. Lecture Notes.

Metropolitan (Metropolitan Water District of Southern California). 2002. *Report on Metropolitan's Water Supplies*. Dated February 11, 2002.

Metropolitan & USBR (Metropolitan Water District of Southern California & United States Bureau of Reclamation). 1999. Salinity Management Study Final Report. Long-term Strategy and Recommended Action Plan. June.

Muni (San Bernardino Valley Municipal Water District). 2000a. Engineering Investigation of the Bunker Hill Basin 1999-2000.

_____. 2000b. *Regional Water Facilities Master Plan.*

Muni and Conservation District 2001. Bucket for Bucket. A Layperson's guide to the Santa Ana River – Mill Creek Cooperative Water Project Agreement. March.

Nevada Division of Water Planning. 2000. Dictionary of Technical Water, Water Quality, Environmental, and Water-Related Terms.

OCWD (Orange County Water District). 1999. Petition to the State Water Resources For an Order Revising the Declaration of Full Appropriation of the Santa Ana River. Written testimony of William R. Mills Jr.

Santa Ana River Watermaster. 2003. Thirty-Second Annual Report of the Santa Ana Watermaster for October 2001 to September 2002. April

______. 2002. Thirty-First Annual Report of the Santa Ana Watermaster for October 2000 to September 2001. April.

______. 2001. Thirtieth Annual Report of the Santa Ana Watermaster for October 1999 to September 2000.

______. 2000. Twenty Ninth Annual Report of the Santa Ana Watermaster for October 1998 to September 1999.

______. 1999. Twenty Eighth Annual Report of the Santa Ana Watermaster for October 1997 to September 1998.

SARWQCB (Santa Ana Regional Water Quality Control Board). Resolution No. R8-2004-0001. Resolution Amending the Water Quality Control Plan for the Santa Ana River Basin to Incorporate an Updated Total Dissolved Solids (TDS) and Nitrogen Management Plan for the Santa Ana Region Including Revised Groundwater Subbasin Boundaries, Revised TDS and Nitrate-Nitrogen Quality Objectives for Groundwater, Revised TDS and Nitrogen Wasteload Allocations and Revised Reach Designations, TDS and Nitrogen Objectives and Beneficial Uses for Specific Surface Waters.

______.2003. Wastewater Treatment Plants in the Santa Ana Region. Unpublished data.

______. 2002. Triennial Review of the Water Quality Control Plan – Santa Ana River Basin. website: www.swrcb.ca.gov/rwqcb8/html/basin_plan_review.html. Updated July 25, 2002. Accessed April 2004.

______. 1995. Water Quality Control Plan Santa Ana River Basin.

SAWPA (Santa Ana Watershed Project Authority). 2002. Santa Ana Integrated Watershed Plan. 2002 Integrated Water Resources Plan. June 2002.

SWRCB (State Water Resources Control Board). 2000. Order WR 2000-12. In the Matter of the Petitions To Revise Declaration of Fully Appropriated Streams to Allow Processing Specified Applications to Appropriate Water From the Santa Ana River. September 21.

USACE (U.S. Army Corps of Engineers). 2003. HEC-RAS Version 3.1.1. Computer software.

______. 2002. Seven Oaks Dam Initial Reservoir Filling Plan. San Bernardino County, California.

______. 2000a. Final Biological Assessment Seven Oaks Dam, Santa Ana River Mainstem Project, San Bernardino County, California. August .

______. 2000b. Technical Report for the Biological Assessment of Seven Oaks Dam. San Bernardino Kangaroo Rat (SBKR) Hydraulic Design Components. March.

______. 2000c. Seven Oaks Dam Interim Water Control Plan. January.

______. 1997. Seven Oaks Dam Water Conservation Feasibility Report.

______. 1988. Santa Ana River Design Memorandum No. 1. Phase II GDM on the Santa Ana River Mainstem including Santiago Creek.

US EPA (United States Environmental Protection Agency). 2003. Permit Compliance System query results for water discharge permits in San Bernardino and Riverside County. Website: www.epa.gov/enviro/html/pcs/pcs_query.html. Website accessed November 5, 2003.

USFWS (U.S. Fish and Wildlife Service). 2002. Section Seven Consultation for Operations of Seven Oaks Dam, San Bernardino County, California (1-6-02-F-1000.10) (Biological Opinion). December.

USGS (U.S. Geological Survey). 2004. Concentrations of Dissolved Solids and Nutrients in Water Sources and Selected Streams of the Santa Ana Basin, California, October 1998-September 2001. May.

______. NWISWeb Data for California. http://waterdata.usgs.gov/ca/nwis. Website accessed October 2003.

______. 1999. 1998 California Hydrologic Data Report Index for Lytle Creek at Colton, CA.

Vann, L. Curtis. 1994. Santa Ana River Unappropriated Water Study for San Bernardino Valley Municipal Water District

West San Bernardino County Water District. 2001. Urban Water Management Plan. February.

Western Municipal Water District of Riverside County (Western). 2001. *2000 Urban Water Management Plan*.

______. 1995. *Urban Water Management Plan for 1995 to 2000*.

Western – San Bernardino Watermaster. 2002. Annual Report of the Western – San Bernardino Watermaster for Calendar Year 2001.

______. 1997. Annual Report of the Western – San Bernardino Watermaster for Calendar Year 1996.

YVWD (Yucaipa Valley Water District). 2000. Urban Water Management Plan and Water Shortage Contingency Plan. As cited in DWR (California Department of Water Resources. 2003. California's Groundwater. Bulletin 118 – Update 2003.

PERSONS AND AGENCIES CONTACTED

Nicklen, Robert. Santa Ana Regional Water Quality Control Board. Telephone conversation November 12, 2003.

Vann, Curtis. Consulting Civil Engineer. Telephone Conversation. September 2002.

______. Written notes. May 2004.

8.0 ACRONYMS

af	acre-feet
afy	acre-feet per year
BA	Biological Assessment
BO	Biological Opinion
cfs	cubic feet per second
Conservation District	San Bernardino Valley Water Conservation District
CRA	Colorado River Aqueduct
DOP	Daily Operations Model
DRAM	Daily River Analysis Model
ft/s	feet per second
Metropolitan	The Metropolitan Water District of Southern California
Muni	San Bernardino Valley Municipal Water District
Mutual	Bear Valley Mutual Water Company
OPMODEL	Operations Model
RIX	Rapid Infiltration and Extraction wastewater treatment facility
RWQCB	Regional Water Quality Control Board
SAR	Santa Ana River
SARC	Santa Ana River Crossing pipeline
SARWQCB	Santa Ana Regional Water Quality Control Board
SBBA	San Bernardino Basin Area
SCE	Southern California Edison
Senior	senior water rights claimants
SWP	California State Water Project
SWRCB	State Water Resources Control Board

USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
Western	Western Municipal Water District or Riverside County
WTP	water treatment plant
WWTP	wastewater treatment plant
WY	Water Year