MATILIJA DAM REMOVAL, SEDIMENT TRANSPORT, AND ROBLES DIVERSION MITIGATION PROJECT

HYDROLOGIC ASSESSMENT FOR WATER SUPPLY
SEPTEMBER 10, 2014

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1.0 PURPOSE & INTRODUCTION

The purpose of this memorandum is to evaluate hydrologic conditions of the Ventura River watershed for water supply, and to summarize our understanding of water supply and demand associated with Casitas Municipal Water District (CMWD), Lake Casitas, and the Robles diversion. The discussion is divided into two primary sections:

- A summary of our understanding of water supply and demand based on historical diversion and stream gage data
- An evaluation of alternative supply scenarios in an attempt to clarify the relative significance of the Robles diversion (compared to other sources to Lake Casitas Reservoir). Subsequently, an assessment of the impacts associated with scenarios that would limit the ability to divert at Robles Diversion Dam.

2.0 HISTORICAL WATER SUPPLY TO LAKE CASITAS

2.1 BACKGROUND

The CMWD supplies water to approximately 70,000 customers in Western Ventura County and to approximately 5,200 acres of agriculture land that are primarily composed of tree crops (citrus and avocado). The CMWD boundaries encompass the city of Ojai, Upper Ojai, the Ventura River Valley area, the city of Ventura to Mills Road, and the Rincon and beach area to the ocean and Santa Barbara County line (the Casitas Service District).

The CMWD was formed in 1952, and the Ventura River project was authorized by Congress in 1956. The project included the Robles diversion facility on the Ventura River, the Robles Canal, and Casitas Dam. Construction of Casitas Dam was completed in November 1958, and the reservoir spilled for the first time in 1978. Lake Casitas Reservoir has a capacity of approximately 254,000 acre-feet.

Robles Diversion Dam is located on the Ventura River near Ventura, California at approximately river mile (RM) 14.2, and supplies water to Lake Casitas via a canal (Figure 1). The normal maximum diversion is approximately 500 cubic feet per second (cfs). The existing diversion dam is a low rock weir with a gated spillway (Figure 2), canal diversion headworks and a fish passage facility located on the right abutment. The diversion weir has a hydraulic height of 13 feet.

The fish passage facility was adapted to the existing Robles Diversion Dam structures to provide the dual purposes of water diversions to Lake Casitas and to provide a migration corridor for steelhead trout (CMWD 2005).

Since water year 1960, Robles Diversion Dam has diverted water via the Robles-Casitas Canal to Lake Casitas. The canal enters Lake Casitas south of Highway 150 near where Santa Ana Creek enters the reservoir. The canal is concrete lined (typically 3 inches unreinforced). The canal prism is 7 feet wide at the bottom, approximately 27.5 feet wide at the top, has a design water depth of 5.6 feet and a freeboard of 15 inches. The canal is approximately 27,500 feet long with an additional boxed inverted siphon that is approximately 5,400 feet long. The capacity of the canal is 600 cfs. For the majority of its length, an access road parallels the canal and several small bridges provide locations for vehicles to cross over the canal.

Stored water in Lake Casitas is piped via the intake structure and tunnel through Casitas Dam directly into the water treatment facility located just downstream of the dam. The outlet works at the end of the tunnel divert up to 100 cfs to the water treatment plant and allow for emergency drawdown of the reservoir at a rate up to 570 cfs.

Inflows to Lake Casitas are from three sources: 1) diverted water from the Ventura River at Robles diversion, 2) direct capture of water from Coyote Creek, Santa Ana Creek, and other

tributary streams, and 3) direct rainfall on the surface of the lake. Therefore, total inflow to the reservoir consists of direct runoff + precipitation + diversion.

Water leaves Lake Casitas through three pathways: 1) delivery of water through the conveyance system to meet local demand, 2) evaporation of water from the lake, and 3) water that goes over the spillway.[1] Therefore, total outflow from the reservoir includes demand + flow over the spillway + evaporation.

Annual water deliveries by the CMWD can vary considerably from year to year, primarily due to the large number of agricultural customers whose water needs can change significantly due to variations in weather and rainfall. Water deliveries can range from less than 15,000 acre-feet per year to greater than 23,000 acre-feet in a given year (CMWD 2014). Over the period from 1976 to 2002, residential water supply sales were relatively steady with a gradual increase from about 800 acre-feet per year to about 1,600 acre-feet per year over the period (CMWD 2004). During the same period, agricultural water sales varied significantly from year to year, inverse to the amount of precipitation, and ranged from about 4,000 acre-feet per year to about 10,600 acre-feet per year (CMWD 2004).

[1] Note that discharges to Coyote Creek downstream of the Casitas Dam were recorded for January 1993 through April 1996 and were on the order of 6 acre-feet per month during that period. Thereafter, no discharge to the creek was recorded. Due to the minimal amount of data, this component of water leaving Lake Casitas was ignored for this analysis.

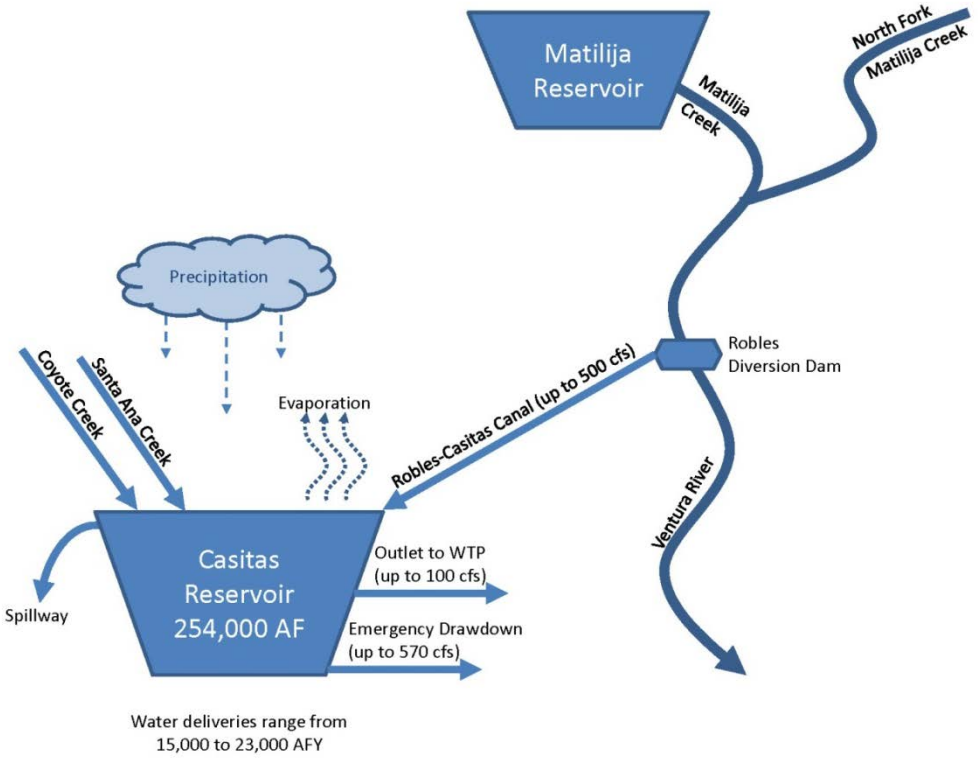


Figure 1: Lake Casitas and Robles Diversion (Location Map and Water Cycle Schematic)

Figure 2: Robles Diversion Dam

2.2 HISTORICAL WATER BALANCE DATA FOR LAKE CASITAS

CMWD provided mass balance spreadsheets that included the following data on a daily and monthly basis from 1993 to 2013:

- Water Elevation in Lake Casitas (feet)
- Storage in Casitas Reservoir (acre-feet)
- Inflow from tributaries entering into the Casitas Reservoir (acre-feet)
- Precipitation at Casitas Reservoir (acre-feet)
- Inflow from diversion at Robles-Casitas Canal (acre-feet)
- Outflow from Casitas Reservoir to Main Distribution System (acre-feet)
- Outflow from Casitas Reservoir through spillway (acre-feet)
- Outflow from Casitas Reservoir to the downstream Coyote Creek channel (acre-feet)
- Evaporation from Casitas Reservoir (acre-feet)

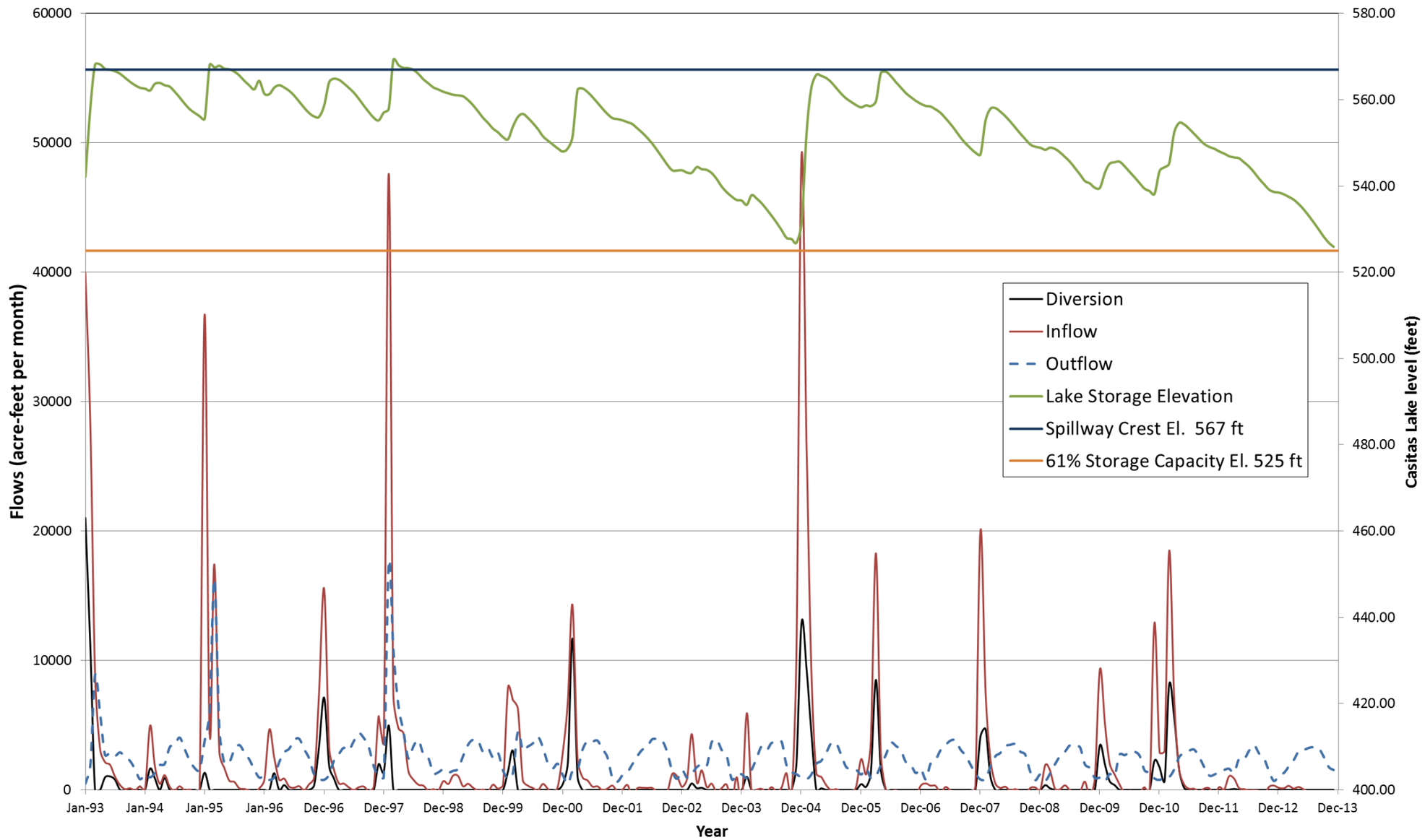
Figure 3 shows the variation of total inflow, total outflow, Robles diversion and reservoir elevation for the period of record from 1993 to 2013, which indicates that demand and inflow are offset in time (demand peaks in the summer and inflow peaks in the winter). Figure 4 shows the demand and evaporation from the Lake Casitas, which shows that demand and evaporation have consistent timing.

As shown in Figure 3, diversions occur during the precipitation season and, during the period of record, have ranged from zero (Water Years[2] 1999, 2002, 2007, and 2013) to greater than 20,000 acre-feet per month (Water Year 1993). The average monthly diversion (when they occur) was about 2,800 acre-feet per month from 1993 to 2013. The minimum reservoir level in the past 20 years was approximately El. 525 feet, which represents approximately 61% of the reservoir capacity. The maximum monthly total demand (releases to the Main Distribution System) is typically between 2,000 and 3,000 acre-feet.

The volume of water available in Lake Casitas to meet the water supply demand is managed under a safe annual yield concept. It is defined as the amount of water that the reservoir can yield for deliveries (consumption) without resulting in unacceptable negative impacts on the long-term water supply within the boundaries of the Casitas Service District. This is to ensure that that the water supply in the reservoir, when full, would extend through a period characterized by the most severe drought on record. The safe annual yield for Lake Casitas is 20,840 acre-ft with the operating criteria in the Robles Diversion Fish Passage Facility Project

[2] Water Years start on October 1 of the previous year and end on September 30 of the cited year.

Biological Opinion and without Matilija Dam (CMWD 2004). The stage-storage and reservoir capacity levels in the lake are provided in Table 1.



Notes: Inflow = Diversion + Surface Runoff + Precipitation; Outflow = Demand + Evaporation + Spill

Figure 3: Historical Diversion Monthly Data (1993-2013)

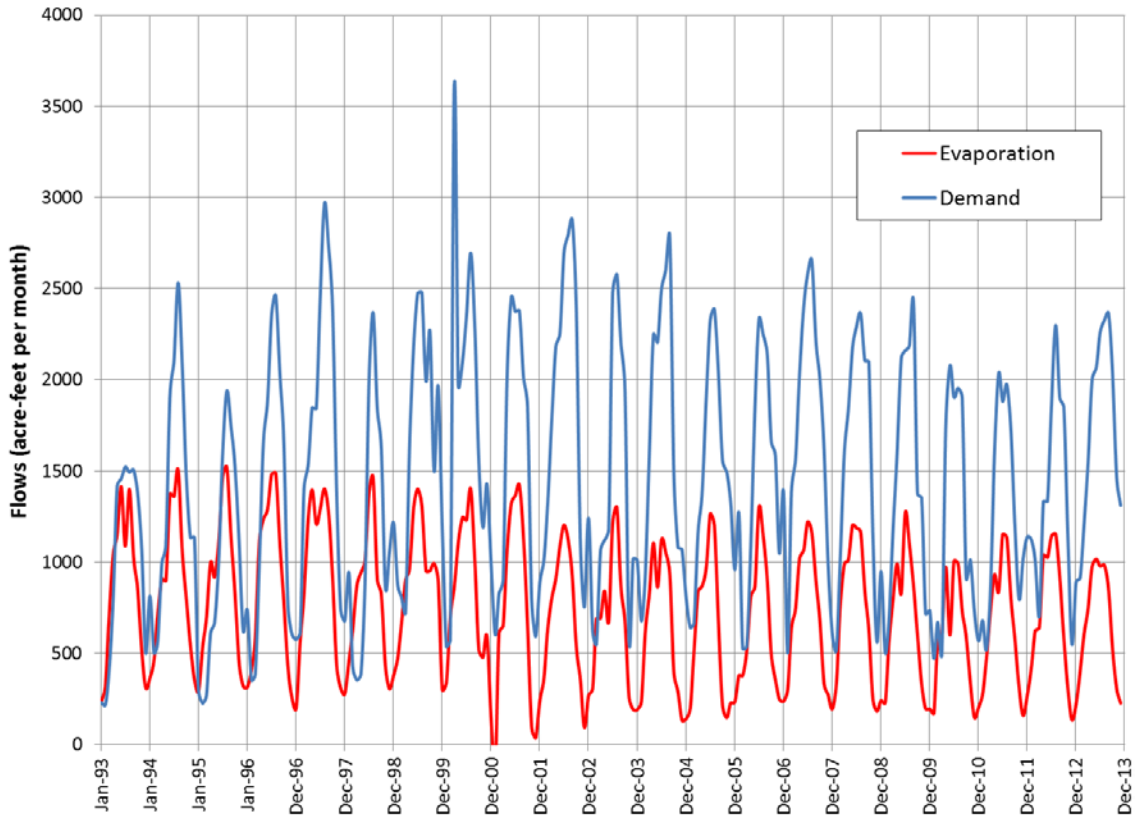


Figure 4: Monthly Variation of Demand and Evaporation from 1993 to 2013

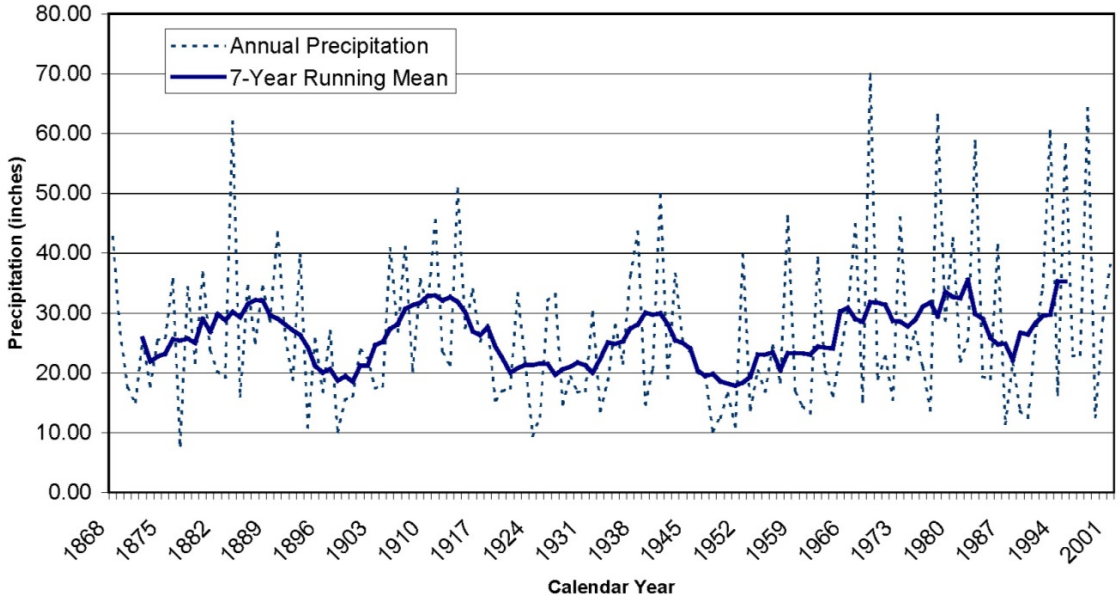
Table 1: Lake Elevation and Storage in Lake Casitas

Lake Elevation (feet)	Storage (acre-feet)	Storage Capacity (percent)	Lake Elevation (feet)	Storage (acre-feet)	Storage Capacity (percent)
380	9,560	3.8	**490**	94,878	37.4
390	13,082	5.2	**500**	109,916	43.3
400	17,250	6.8	**510**	126,649	49.9
410	22,101	8.7	**520**	144,906	57.1
420	27,669	10.9	**530**	165,020	65.0
430	34,084	13.4	**540**	186,804	73.5
440	41,402	16.3	**550**	210,262	82.8
450	46,690	19.6	**560**	235,411	92.1
460	59,025	23.2	**567**	254,002	100.0
470	69,496	27.4	**570**	262,208	103.2
480	81,444	32.1	**580**	290,693	114.4

Note – Spillway crest is at El. 567 feet.

2.3 HISTORICAL STREAM GAGE DATA

The long-term precipitation pattern for the Ventura River watershed, based on the Matilija Dam precipitation gage, exhibits a wet-dry year cycle (Figure 5; Entrix and CMWD 2002). The precipitation has fluctuated from wet year periods to dry year periods over approximately a 20-year cycle when viewed as a seven-year running mean (Entrix and CMWD 2002).



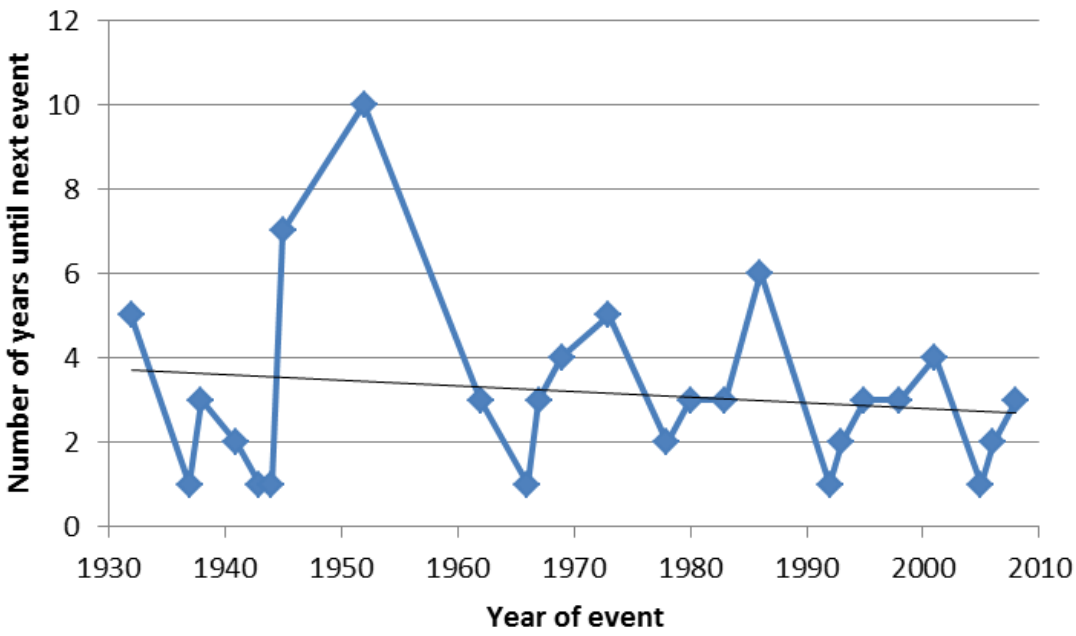
Source: Entrix and CMWD 2002.

Figure 5: Long-term precipitation pattern as recorded at the Matilija Gage 1868-2001

The Ventura River experiences large annual variations in peak flow magnitudes (BOR 2006):

- 1930s to 1940s: frequent flows
- 1940s to 1960s: less frequent and small magnitude flows except for 1969 flood
- Since 1970s: relatively frequent flows

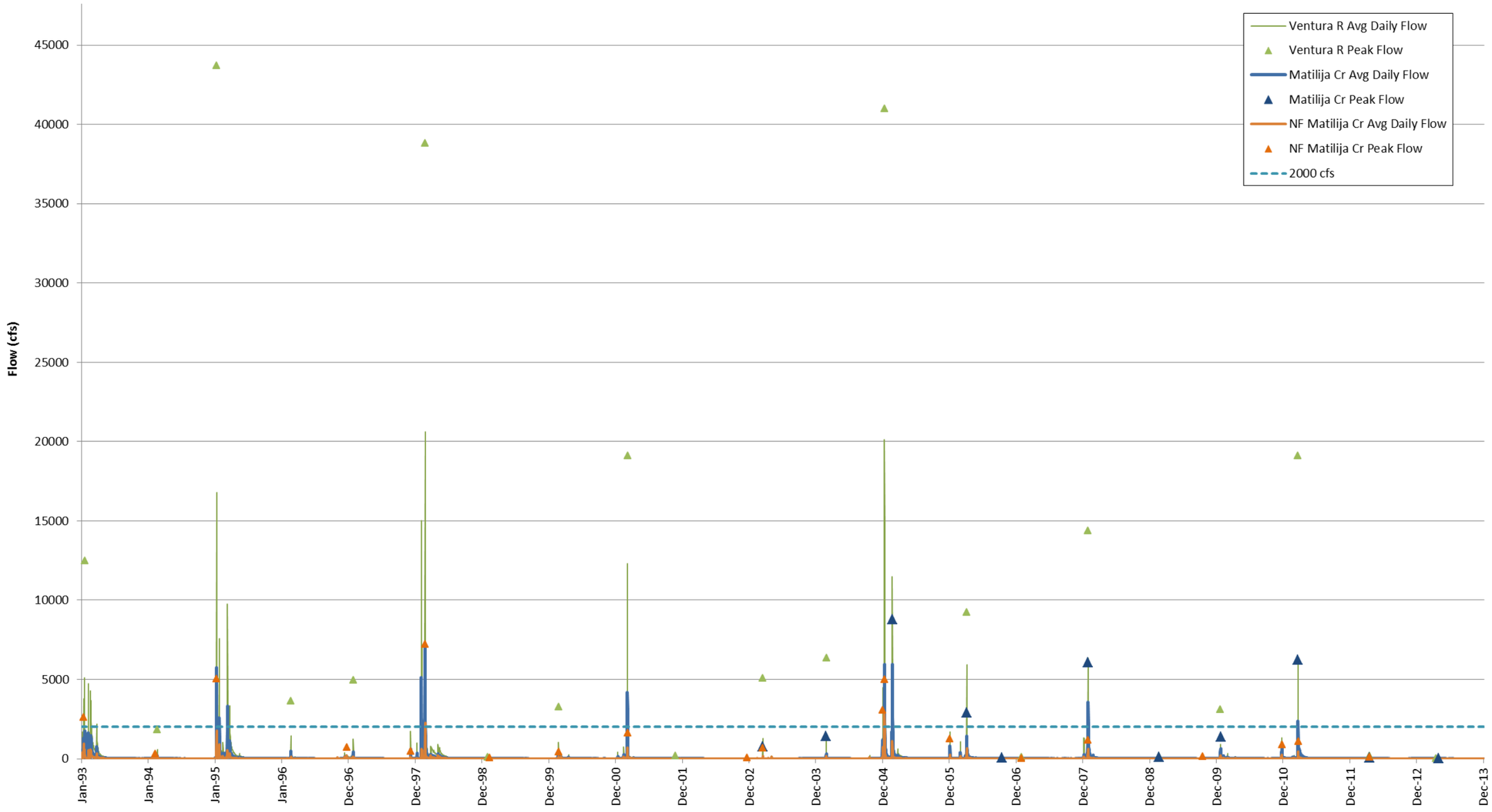
BOR 2006 notes that it is difficult to extrapolate the peak flow variation into the future and predict if a relatively wet period will continue or will enter into a relatively dry period. However, analysis of long-term trends in the flow record shows there is a typical pattern of oscillation between wet and dry periods suggesting a general 10- to 15-year cycle over the past 50 years (see Figure 6).



Source: Stillwater Sciences 2014.

Figure 6: Time series of "events" (average daily flow of ≥5,000 cfs at Ventura River gage (11118500) and/or ≥1,667 cfs in Matilija Creek) plotted on the y-axis as the number of years until the next year with at least one such event. Multiple events within the same water year are ignored. The black line suggests a linear trend of slightly decreasing duration between successive water years with one or more events, but this pattern is strongly influenced by the dry period of the late 1940's and 1950's and is not evident over the last 50 years.

Figure 7 shows the flows in the Ventura River, Matilija Creek, and North Fork Matilija Creek for the same period (1993 to 2013) as is available for the Lake Casitas water balance. Figure 7 shows that flows in these three reaches are intermittent, highly variable, and typically only occur for a few months in years when precipitation occurs. This figure also shows that peak flows are several times larger than the highest average daily flows, which indicates that the hydrology has a very flashy response to precipitation.



Source: Ventura River data from USGS gage 11118500. Matilija Creek data for Feb 15, 2002 through Dec 31, 2013 from USGS gage 11114495. Matilija Creek data for Jan 1, 1993 through Feb 14, 2002 calculated based on Ventura River data and a ratio of average daily flows of 0.3409:1 (Matilija Creek:Ventura River) (ratio based on Stillwater 2014). North Fork Matilija Creek data from Ventura County Watershed Protection District gage 604.

Figure 7: Matilija Creek, North Fork Matilija Creek, and Ventura River flows 1993 to 2013.

2.4 ROBLES DIVERSION

CMWD operates the Robles diversion facility to provide water supply to Lake Casitas. The operation is also managed to minimize the spill at Lake Casitas by stopping diversions at Robles diversion when the water elevation in Lake Casitas is within two feet of the spillway crest (elevation 565.0 feet) (Entrix and CMWD 2002). The reservoir has spilled in eight separate years since operations commenced. The first time it spilled was when it first filled in 1978. It subsequently spilled while the reservoir was full in 1979, 1980, 1983, 1986, 1993, 1995, and 1998. There were substantial flows in the Ventura River during many of these years. The likelihood of Lake Casitas spilling is low during years when reservoir volume is less than 200,000 acre-ft (79 percent full) at the start of the precipitation season (BOR 2000).

Figure 8 shows the cumulative runoff, precipitation and diversion into Lake Casitas for the 21-year period between 1993 and 2013. Table 2 provides the percentage of the respective cumulative contributions over the 21-year period and shows that the Robles diversion contributed a total of approximately 30.8 percent of the total cumulative inflows over that period. However, reservoir spills occurred in 1993, 1995 and 1998 during this period, for a total of approximately 75,800 acre-feet spilled compared to a total of at least[3] 41,560 acre-feet of Robles diversion inflow leading up to these spills. If management of the Robles diversion had avoided these spills by shutting down the Robles diversion as was done in 2005, the Robles diversion contribution to Lake Casitas would have been approximately 22.9 percent of total inflows (Table 3).

[3] Prior to the 1993 spill that occurred from February to May, Robles diversions were made in both January and February that year. Additional Robles diversions that contributed to the 1993 spill may have occurred prior to January 1993, but data was not provided for the preceding years.

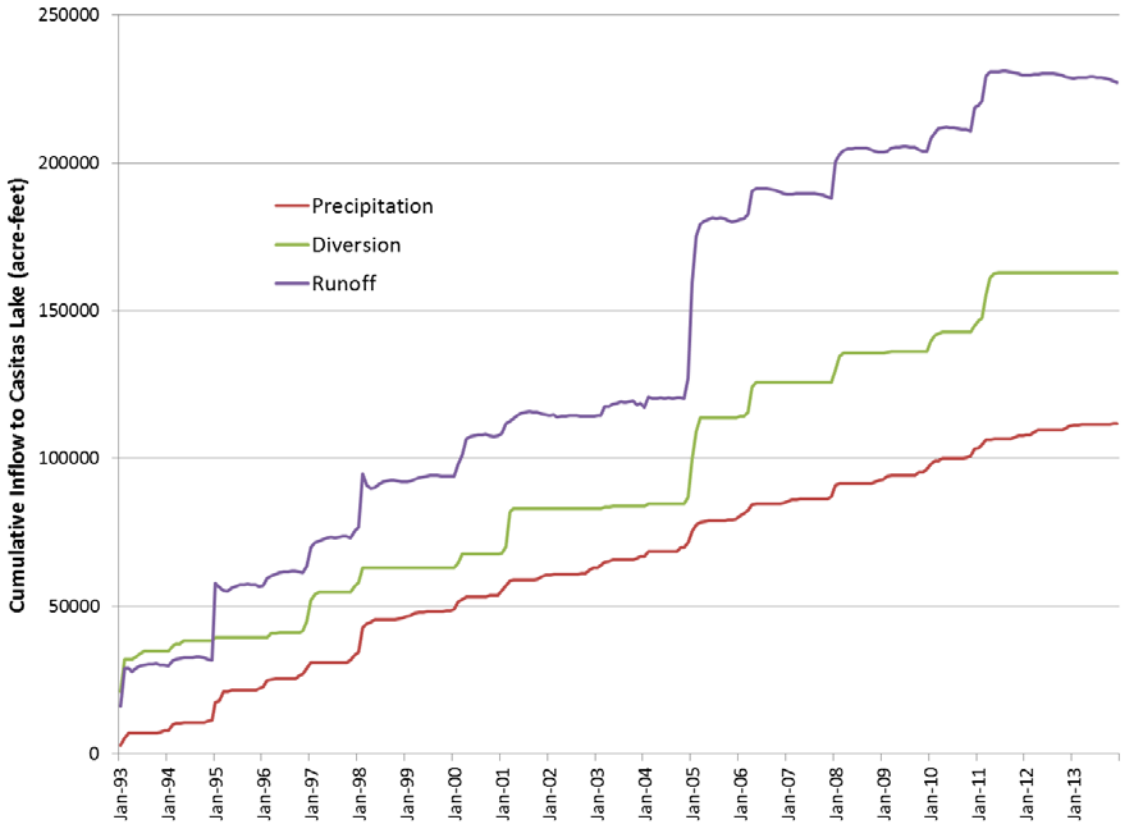


Figure 8: Cumulative precipitation, diversion and runoff to Lake Casitas (1993-2013)

Table 2: Cumulative Inflows into Lake Casitas (1993-2013).

Source	acre-feet	percent of total
Runoff from reservoir watershed[a]	253,717	48.0
Robles diversion	162,824	30.8
Direct precipitation	111,867	21.2

[a] Reservoir spills were subtracted from the cumulative runoff to create a more accurate understanding of the contribution of runoff to water supply.

Table 3: Cumulative Inflows into Lake Casitas (1993-2013) without diversions prior to spills.

Source	acre-feet	percent of total
Runoff from reservoir watershed [a]	295,278	55.9
Robles diversion	121,263	22.9
Direct precipitation	111,867	21.2

[a] Reservoir spills were subtracted from the cumulative runoff to create a more accurate understanding of the contribution of runoff to water supply.

2.4.1 ENVIRONMENTAL WATER REQUIREMENTS AT ROBLES

After the West Coast steelhead trout (*Oncorhynchus mykiss*) was listed as an endangered species, and in order to avoid potential liability under Section 9 of the Endangered Species Act, the Bureau of Reclamation consulted with the National Marine Fisheries Service and issued a biological opinion associated with diversion at Robles. The biological opinion describes diversion operations rules to provide flow through the fish ladder including base flows and a ramp down schedule following storm peaks.

2.4.2 SEDIMENTATION CONDITIONS AT ROBLES

Large amounts of sediment deposition occur at the Robles diversion during floods. In the Ventura River, the suspended material is mostly clays, silts, and sands, while the bed load is composed of gravels, cobbles, and boulders (BOR 2006). The diversion structure is not large enough to trap the suspended material transported by the river, but does trap a significant portion of the bed load. Based on sediment removal operations between 1966 and 1998, an average of 8 acre-feet per year of sediment (about 13,000 cubic yards) has been removed (BOR 2006).

3.0 DIVERSION DISRUPTION SCENARIOS

Diversions at Robles are an important source of water for Lake Casitas. It is anticipated that during the removal of Matilija Dam there will be some periods when the diversion may need to be shut down due to higher than normal suspended sediment loads or high organic carbon concentrations. To better understand the impacts to Lake Casitas during dam removal, three scenarios were modeled based on the 21-year historical record between 1993 and 2013:

- Scenario 1 – Lake Casitas levels without Robles diversion
- Scenario 2 – Lake Casitas levels without Robles diversion during one major storm
- Scenario 3 – Lake Casitas levels without Robles diversion during three consecutive major storms

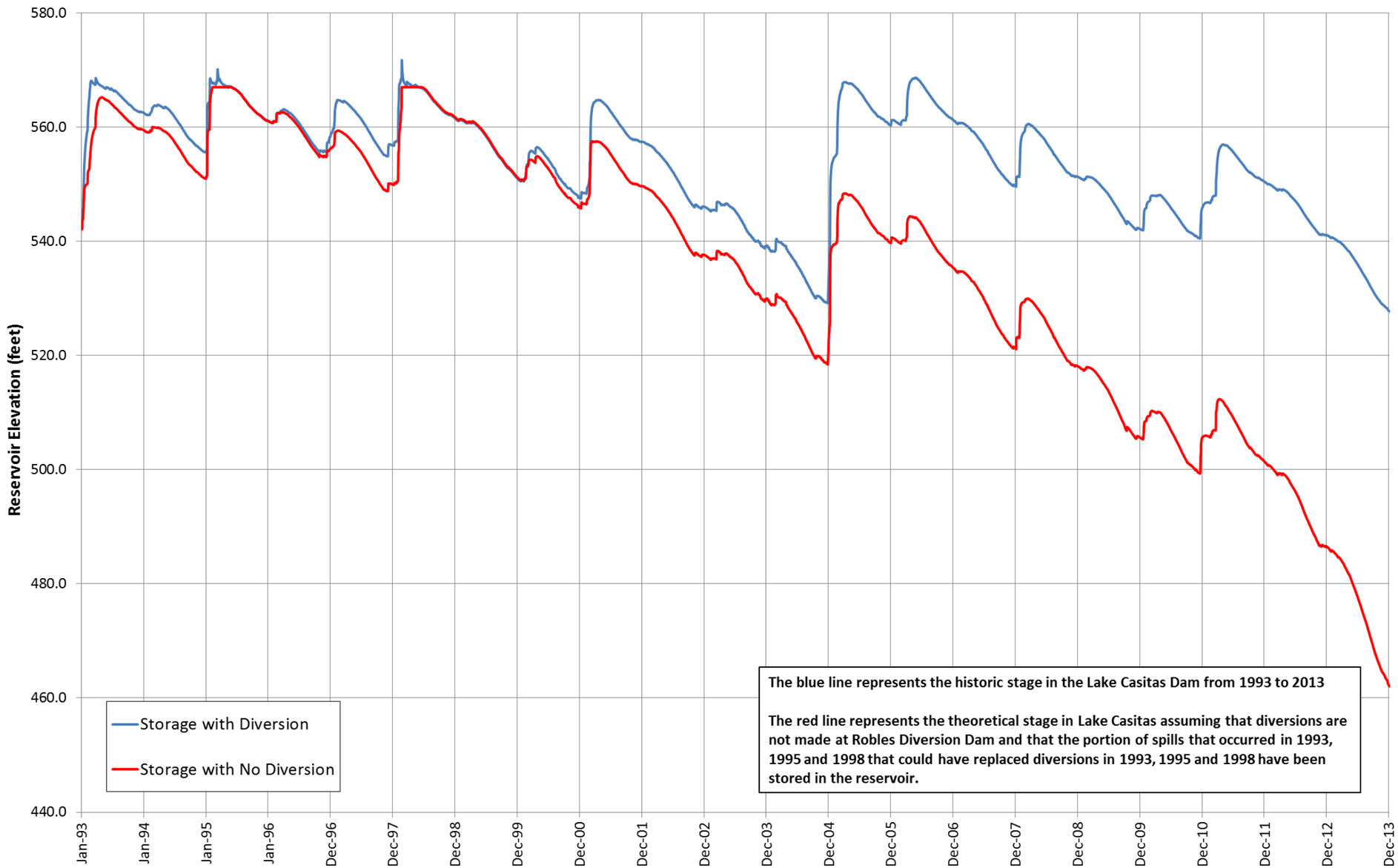
3.1 SCENARIO 1: LAKE CASITAS LEVELS WITHOUT ROBLES DIVERSION

Scenario 1 assumes diversions to Lake Casitas do not occur from 1993 through 2013 while all other conditions remain the same. Scenario 1 was developed to better understand the impact of Robles diversion on the storage in Lake Casitas. Using the daily data provided by CMWD, all diversions were ignored when calculating inflows to the reservoir. Periods when spilling had

historically occurred were adjusted to avoid losing volume to the spill if the reservoir level was lower than the spillway crest elevation of 567.0 feet. Figure 9 shows historical Lake Casitas levels in blue and lake levels for Scenario 1 in red. Historical lake levels show spills occurring during 1993, 1995, and 1998. Subsequently, CMWD decided to limit the Robles diversion when the reservoir level was within 2 feet of the spillway crest. This decision resulted in the district avoiding spilling in 2005 and 2006 when precipitation was great enough to refill the reservoir after several dry years without the additional contribution from Robles diversion.

In general, the historical data can be broken into two broad periods: a relatively wet period between 1993 and 1998 followed by a generally dry period through 2013, although the outlying wet year of 2005 occurs during this overall generally dry period. During the wetter period, Scenario 1 indicates that diversions from Robles were not needed as inflows from the Lake Casitas watershed were still sufficient on their own to cause spilling. Without diversions from Robles during the entire period, Lake Casitas would only be 24 percent full compared to 63 percent full with diversions.

Based on this information, it is apparent that implementation of a Matilija dam removal option that releases large amounts of fine sediment (restricting or preventing Robles diversions) during a wet period similar to the early 1990's could occur without having any significant effect on Lake Casitas storage. Whereas, implementation of a similar Matilija dam removal option during drier periods could have a significant, but likely temporary, impact on Lake Casitas storage volume as demonstrated in Scenarios 2 and 3 below.



Note: For the "Storage with No Diversion" plot, the spills recorded in water years 1993, 1995, and 1998 were added back into reservoir storage. The reservoir tops out in 1995 and 1998 due to this additional volume.

Figure 9: Comparison of Lake Casitas levels 1993-2013 (a) with Diversion (i.e., actual) and (b) with No Diversion

3.2 SCENARIO 2: LAKE CASITAS LEVELS WITHOUT ROBLES DIVERSION DURING ONE MAJOR STORM

Scenario 2 assumes that one large storm (average daily flow >2,000 cfs in Matilija Creek) will be used to transport the majority of fine sediment out of Matilija reservoir, during which diversions would not be made at Robles.

Table 4 lists events in Matilija Creek where average daily flows were greater than 2,000 cfs for the period between 1993 and 2013, along with the Lake Casitas initial stage and capacity, and the Robles diversion associated with each storm event. Where gage data was not directly available for Matilija Creek, a ratio of 0.35 (Stillwater 2014) was used to convert average daily flows in Ventura River (gage 11118500) to average daily flows in Matilija Creek.

Table 4: Events with average daily flow >2000 cfs in Matilija Creek

Date (Event Start)	Date (Event Peak)	Matilija Cr Avg Daily Flow >2000 (Event Peak) (cfs)	Lake Casitas Elevation (Event Start) (ft)	Lake Casitas Capacity (Event Start) (percent)	Robles Diversion (Event Total) (acre-feet)
1/9/1995	1/10/1995	5,727 [a]	557.7	90%	1,175
3/2/1995	3/11/1995	3,324 [a]	567.6	101%	0
2/2/1998	2/3/1998	5,114 [a]	560.5	93%	4,859
2/14/1998	2/23/1998	7,023 [a]	568.2	101%	0
2/24/2001	3/5/2001	4,193 [a]	550.6	83%	10,008
12/28/2004	1/9/2005	5,950 [b]	528.4	64%	15,435
2/11/2005	2/21/2005	5,940 [b]	552.9	86%	13,180
1/23/2008	1/27/2008	3,560 [b]	549.2	82%	9,212
3/20/2011	3/20/2011	2,350 [b]	546.0	79%	13,536

[a] Average daily flow calculated as 0.3409 x Ventura River average daily flow.

[b] Data from gage 11114495.

Grey rows indicate storms with the greatest potential impact on Lake Casitas storage levels if diversions had been suspended.

The worst case scenario event (i.e., where Lake Casitas storage is most impacted) would occur when the lake storage was at a minimum and diversion of flow into Lake Casitas was at a maximum. For the analysis, the storms that peaked on 3/5/2001, 1/9/2005, and 3/20/2011 were selected (grey rows in Table 4). The storms during the 1990s (wet period) were not selected because Scenario 1 demonstrated that diversions during wet periods are not necessary for maintaining storage in Lake Casitas.

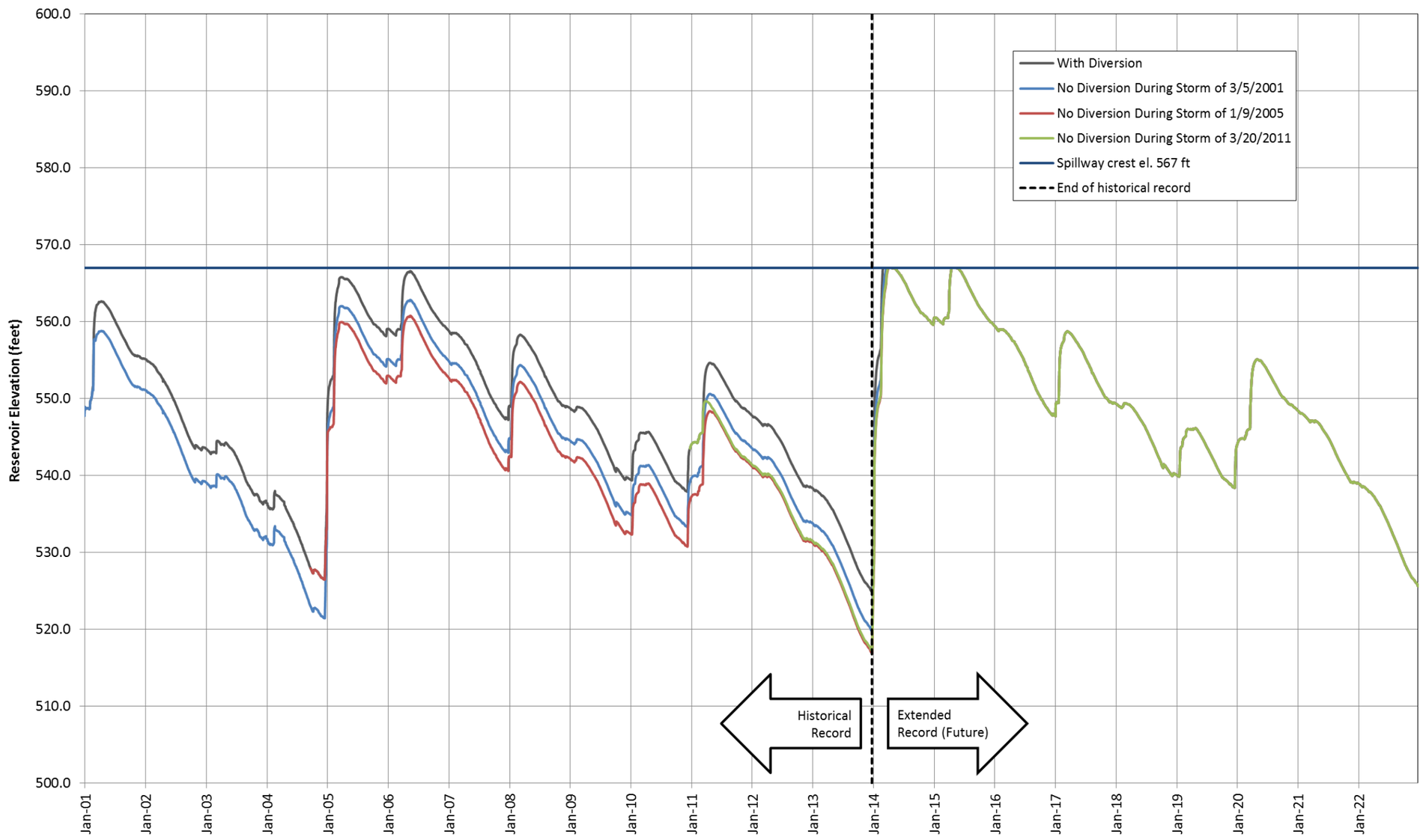
A “gap analysis” was performed to show the impact on the water storage, assuming diversions are not made during the storm when flows in Matilija Creek exceed 50 cfs (Figure 10). The duration without the diversion is conservative, since the diversion could potentially resume

after the sediment has been removed by the peak of the major storm allowing a greater portion of the tail of the storm to be diverted. As shown in Figure 10, by the end of the historical record (12/31/2013), the Lake Casitas storage capacity would drop approximately 4 percent, 6 percent, and 6 percent, respectively for the 3/5/2001, 1/9/2005, and 3/20/2011 storm events, compared to storage levels with diversion.

However, as shown in Figures 5 and 6, the Ventura River watershed experiences cycles of wet and dry periods. To understand the effect of the next wet cycle on the analysis, the record period from 12/26/2004 to 12/25/2013 was repeated at the end of the historical record, representing plausible future conditions from 2014 through 2022. This extended record includes a repeat of the historical 2005 storms in analysis year 2014, historical 2006 storms in analysis year 2015, etc.

The extended record also recognizes additional flows that could have been diverted at Robles during the 2005 storms but were not diverted due to the level in Lake Casitas approaching spilling. Total diversions during the 1/9/2005 and 2/21/2005 storms were approximately 15,435 and 13,180 acre-feet, respectively. Assuming flows at Robles are similar to the sum of Matilija Creek and North Fork Matilija Creek flows, the total potential diversions for the two storms could have been approximately 26,670 and 25,930 acre-feet. The calculated potential diversions account for the base flow and ramp down schedule from the Robles fish passage facility Biological Opinion.

In the extended record, potential diversions are assumed during the analysis year 2014 storms (historical 2005 storms) and historical diversions are assumed for the remainder of the extended record. As shown in Figure 10, all scenarios are able to capture sufficient water in analysis year 2014 to cause spilling at Lake Casitas. This means that diversions that are lost during a single storm event for dam removal will result in a temporary 4 to 6 percent drop in Lake Casitas storage that would be fully recovered during the next wet cycle.



Notes: Available historical record is 1/1/1993 to 12/31/2013. Extended record repeats the record from 12/26/2004 to 12/25/2013 at the end of the historical record to simulate the next wet period. Analysis year 2014 storms assume all potential diversions are captured. All the scenario plots are coincident after March 2014.

Figure 10: Comparison of storage (a) with regular diversion, (b) no diversion for the storm of 3/5/2001, (c) no diversion for the storm of 1/9/2005, and (d) no diversion for the storm of 3/20/2011

3.3 SCENARIO 3: LAKE CASITAS LEVELS WITHOUT ROBLES DIVERSION DURING THREE CONSECUTIVE MAJOR STORMS

Scenario 3 assumes that three large storms (each with average daily flow >2,000 cfs in Matilija Creek) will be used to transport the majority of fine sediment out of Matilija reservoir during which diversions would not be made at Robles. This scenario assumes that diversions would resume in between the three events during smaller storms (e.g., if gated orifices are used to control the release of fine sediment from Matilija reservoir or if smaller flows are able to pass through the reservoir area without eroding significant quantities of remaining fine sediment). This scenario may occur if one major storm (Scenario 2) is unable to clear all the fine sediment from Matilija reservoir.

Table 5 lists events in Matilija Creek where average daily flows were greater than 2,000 cfs for the period between 1993 and 2013 along with the Lake Casitas initial stage and capacity, the volume of diversion associated with each event, and the volume of diversion associated with the two consecutive prior events. Where gage data was not directly available for Matilija Creek, a ratio of 0.35 (Stillwater 2014) was used to convert average daily flows in Ventura River (gage 11118500) to average daily flows in Matilija Creek.

Table 5: Events with average daily flow >2000 cfs in Matilija Creek and three storm totals

Date (Event Start)	Date (Event Peak)	Matilija Cr Avg Daily Flow >2000 (Event Peak) (cfs)	Lake Casitas Elevation (Event Start) (ft)	Lake Casitas Capacity (Event Start) (percent)	Robles Diversion (Event Total) (acre-feet)	Robles Diversion (Three-Event Total) (acre-feet) [c]
1/9/1995	1/10/1995	5,727 [a]	557.7	90%	1,175	-
3/2/1995	3/11/1995	3,324 [a]	567.6	101%	0	-
2/2/1998	2/3/1998	5,114 [a]	560.5	93%	4,859	6,034
2/14/1998	2/23/1998	7,023 [a]	568.2	101%	0	4,859
2/24/2001	3/5/2001	4,193 [a]	550.6	83%	10,008	14,867
12/28/2004	1/9/2005	5,950 [b]	528.4	64%	15,435	25,443
2/11/2005	2/21/2005	5,940 [b]	552.9	86%	13,180	38,623
1/23/2008	1/27/2008	3,560 [b]	549.2	82%	9,212	37,827
3/20/2011	3/20/2011	2,350 [b]	546.0	79%	13,536	35,928

[a] Average daily flow calculated as 0.3409 x Ventura River average daily flow.

[b] Data from gage 11114495.

[c] The sum of diversions for this event plus the two prior events listed in the table.

Grey rows indicate the series of storms with the greatest potential impact on Lake Casitas storage levels if diversions had been suspended.

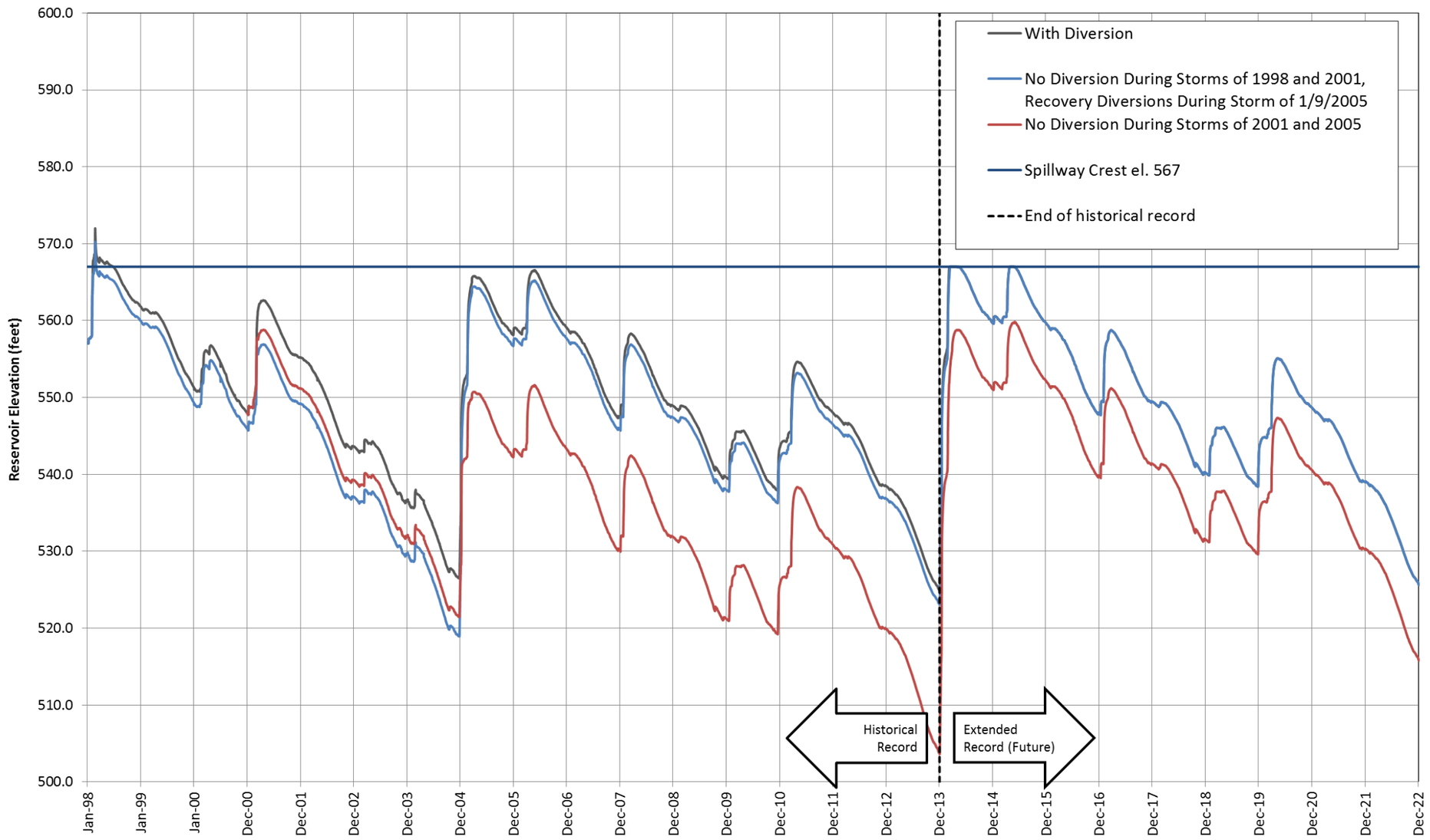
Rows outlined by the red box indicate the series of storms with an intermediate impact on Lake Casitas storage levels if diversions had been suspended.

The worst case scenario event (i.e., where Lake Casitas is most impacted) would be when the diversion of flow into Lake Casitas was at a maximum for the three consecutive events. For this analysis, the three storms that occurred in 2001 and 2005 were selected to show the worst case (grey rows in Table 5). The average storage capacity of the reservoir was 78 percent and the cumulative diversion was 38,623 acre-feet. The storms during the 1990s (wet period) represent a best case scenario and were not selected because Scenario 1 demonstrated that diversions during wet periods are not necessary for maintaining storage in Lake Casitas.

A "gap analysis" was performed to show the impact on the water storage, assuming diversions are not made during the three storms that occurred on 3/5/2001, 1/9/2005, and 2/21/2005 (Figure 11). The duration without diversion is conservative, since diversion could potentially resume after sediment has been removed by the peak of each major storm allowing a greater portion of the tail of each storm to be diverted. As shown in Figure 11, by the end of the historical record (12/31/2013), the Lake Casitas storage level would drop approximately 15 percent compared to storage levels with diversion.

A second set of three storms, judged to be intermediate between the best and worst case scenarios was also evaluated (red box in Table 5). The second set of storms (2/3/1998, 2/23/1998, and 3/5/2001) was assumed to have no diversions, and the 1/9/2005 storm was assumed to have the maximum potential diversion as discussed previously in Section 3.2. For this case, by the end of the historical record (12/31/2013), Lake Casitas returns to levels almost identical to the conditions with the continuous diversion.

Similar to Scenario 2, an extended record was added to the end of the historical record to represent a future wet period, and during the analysis year 2014 storms (historical 2005 storms), and the full potential diversions are taken rather than the historical diversions in all scenarios. For the remainder of the extended record, the historical diversions were used. As shown in blue in Figure 11, the intermediate case scenario (no diversions during the 1998 and 2001 storms followed by recovery diversions in the first 2005 event) is able to capture sufficient water in analysis year 2014 to cause spilling at Lake Casitas. This means that the next wet cycle would likely result in a full recovery at Lake Casitas. For the worst case scenario (i.e., no diversion during the 2001 and 2005 storms) shown in red, the next wet cycle as modeled would result in recovery of Lake Casitas to 91 percent of total storage capacity.



Notes: Available historical record is 1/1/1993 to 12/31/2013. Extended record repeats the record from 12/26/2004 to 12/25/2013 at the end of the historical record to simulate the next wet period. Analysis year 2014 storms assume all potential diversions are captured. The black and blue lines are coincident after March 2014.

Figure 11: Comparison of storage (a) with regular diversion, (b) No diversion for storms of 2/3/1998, 2/23/1998, and 3/5/2001 and storage recovery in 1/9/2005 storm, and (c) No diversion for storms of 3/5/2001, 1/9/2005, and 2/21/2005

4.0 CONCLUSIONS

The following are conclusions from the analyses summarized above, for consideration during refinement of Matilija dam removal options and discussions concerning associated mitigation for lost Robles diversions:

1. During the period of record available for this analysis, the Robles diversion provided approximately 31 percent of the inflow into Lake Casitas. This percentage would have been lower if diversions had been managed in some instances to prevent reservoir spilling.
2. There is a typical pattern of oscillation between wet and dry periods in the Ventura River watershed that has been on a roughly 10- to 15-year cycle for the past 50 years. Wet periods in the analyzed record are sufficient to refill Lake Casitas without any diversion at all.
3. Implementation of a dam removal project during a typical wet cycle as experienced in the 1993-1998 period that restricts diversions (allows diversion of a portion of storm or allows diversion between storms) or prevents diversions (no diversions throughout the period) would have little to no effect on water levels in Lake Casitas.
4. Implementation of a dam removal project during one of the typical dry cycles that suspends Robles diversions would significantly reduce water levels in Lake Casitas. If the suspension were limited to a few storms or less, it is probable that loss of storage capacity could be limited to between 4 and 15 percent and would persist only until the next wet cycle when those losses would be restored.

5.0 REFERENCES

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