MODEL SIMULATION REPORT FOR THE FOLLOWING SCENARIOS:

SCENARIO 4: PVP REVISED OPERATIONS, compared with

BASELINE OPERATIONS: CURRENT OPERATIONS ON EEL RIVER AND CURRENT OPERATIONS ON RUSSIAN RIVER

Table SC4-1. Summary of modeling scenarios evaluated by the Water Supply Work Group. Modeling for scenarios bounded in red are summarized in this document.

Modeling Scenarios Updated 4/16/19		**Russian River & Lake Mendocino Alternatives**		
		Current Operations	Lake Mendocino FIRO (Hybrid) with Fish Flow EIR Operations	Raise Coyote Valley Dam
Potter Valley Project Alternatives	Current Operations	Baseline: Existing Climate (n=1)		
		Baseline FC: Future Climate (n=4)		
	PVP Revised Operations	Scenario 4: Existing Climate (n=1)		
	Run-of-the-River		Scenario 2: Existing Climate (n=1)	
			Scenario 2FC: Future Climate (n=4)	
	PVP Decommission	Scenario 1: Existing Climate (n=1)	Scenario 3: Existing Climate (n=1)	Scenario 5: Preliminary analysis with Existing Climate (includes two sub-scenarios)

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1. SUMMARY OF ASSUMPTIONS

Primary model assumptions for each scenario are summarized in Table SC4-2 and highlight key assumptions that differ. These assumptions are summarized in more detail below.

Table SC4-2. Summary of modeled scenarios and assumptions.

Model	Assumptions	Baseline Operations	Scenario 4 PVP Revised Operations
PVP ResSim	Plot Legend	PVP Current Operations	PVP Modified RPA
	Operations	RPA/Current Operations	PVP Modified RPA
	Year Storage Capacity	2016	2016
	Max Tunnel Capacity	170	170
	Hydrology	Historical-Cardno	Historical-Cardno
Russian River ResSim	Plot Legend	Current Operations	PVP Modified RPA
	Minimum Flows	BO TUC/D1610	BO TUC/D1610
	Hydrologic Index	D1610	D1610
	LM Year Storage Capacity	2001	2001
	Calpella Reach Loss	~8,600 acre-ft	~8,600 acre-ft
	Calpella Reach Source	Natural flows/Tunnel Div	Natural Flows
	Upper River Losses	Fish Flow EIR	Fish Flow EIR
	Hydrology	Historical-USGS BCM	Historical-USGS BCM
Both	Simulation Period	WY 1911-2017	WY 1911-2017

Baseline Operations Model Assumptions

<u>Eel River:</u>

- Current minimum flow released based on 2002 Biological Opinion RPA flows .
- Historical Cardno hydrology for Lake Pillsubry inflow (no climate change).
- Cardno 2018 estimates of daily unimpaired tributary accretion between E-2 and E-11.
- 2017 Block Water hydrograph used for all years, triggered when E-11 flows drop below 250 cfs after April 1.
- Maximum PVP diversion capacity = 170 cfs to best represent historical→simulated volumetric mass balance for discretionary power generation diversions.
- Regression equation used for the timing of Scott Dam gate closure.
- Drought, Maintenance, and Testing flow variances excluded.
- Storage based on Lake Pillsbury 2016 bathymetric survey (water supply storage capacity is 76,876 ac-ft).
- Based on the model verification, the PVP model may exhibit some bias in accretions between Scott Dam and Cape Horn dam in the spring of some years due to downstream gage error. This translates into over/under estimate of flows below Van Arsdale (E-11) that is consistently applied to all scenarios.
- Van Arsdale Reservoir storage used to meet RPA flows when possible.

<u>Baseline Conditions</u>

- *Current Operations on the Russian River remain in place.*
- *Current Operations on the Eel River remain in place.*

- Buffers for mininum instream flows range from 5 cfs to 20 cfs below E-11 (Van Arsdale), depending on magnitude of the minimum instream flow. Flow buffer for meeting minimum instream flows on the East Fork Russian River at the E-16 PVP diversion are always 5 cfs. These flow buffers are for all scenarios where applicable.
- Calpella reach demands, which includes PVID demands, are approximately 8,600 acre-feet annually.

<u>Russian River:</u>

- Flow source to Lake Mendocino = Unimpaired Flows + modeled PVP diversions–Calpella reach loss.
- Historic unimpaired flows computed using USGS Basin Characterization Model.
- Storage based on Lake Mendocino 2001 bathymetric survey (water supply storage capacity is 111,000 ac-ft).
- Minimum flow releases to the East Branch Russian River below Potter Valley Powerhouse and below Lake Mendocino based on the 2008 Biological Opinon RPA and 1986 Decision 1610.
- Minimum flood control releases based on existing ACOE rule curve, no Forecast Information Reservoir Operations (FIRO).
- Hydrologic index used for minimum flow releases based on 1986 Decision 1610 (inflow to Lake Pillsbury rather than Lake Mendocino).
- Assumptions for losses in the East Branch Russian River include 8,600 ac-ft loss from E-16 to Calpella and none from Calpella to Lake Mendocino.
- Buffer for minimum instream flows below Lake Mendocino range from 5 cfs to 20 cfs, depending on the time of year and river reach, and are consistently used for all scenarios.
- Hydrologic index used for minimum flow releases based on 1986 Decision 1610 (inflow to Lake Pillsbury).
- Assumed annual flow losses from Calpella to Lake Mendocino=8,600 ac-ft, losses below Lake Mendocino based on Fish Flow EIR based on depletion analysis for the period

Differences between Model Assumptions for Baseline and Scenario 4

<u>Eel River</u>, same as Baseline, except:

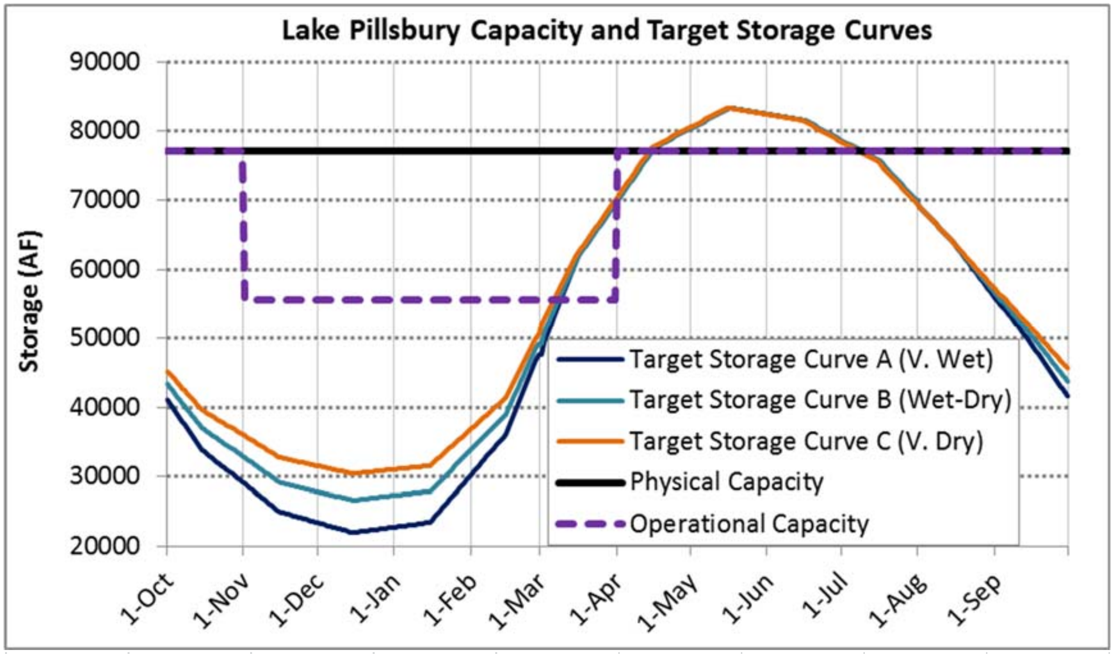
- Additional PVP diversions are allowed to occur when the Lake Pillsbury water level is spilling, even when storage is below the Target Storage Curve. Under the current RPA (baseline operations), discretionary diversions from the Eel River to the Russian River cannot be made when Lake Pillsbury storage is below the Target Storage Curve (TSC) for the given water year type (Figure SC4-1a). Only the required minimum flow for the East Branch Russian River and PVID’s allotment can be diverted under those circumstances. In Scenario 4, there would be an exception to this rule when Lake Pillsbury is spilling: discretionary diversions would be allowed during the spill even if the reservoir’s storage is under the TSC. This would likely allow additional diversion in the spring of wetter water years,

<u>Scenario 4:</u>
<u>PVP Modified Operations</u>

- *PVP remains in place with modified minimum flow requirements and diversion rules*
- *Scott Dam releases and PVP diversions are updated to reflect 1) more discretionary diversions when Scott Dam is spilling, 2) lower E-11 floor in winter, and 3) lower instream flow requirements in the East Branch Russian River year round*

with limited impact to Eel River flows while delivering cold water to Lake Mendocino. (Figure SC4-1b).

- The Eel River below Cape Horn Dam minimum instream flow floor is lowered by up to 50 cfs in the spring and winter to better match natural flow patterns during drier years. Under baseline operations, aside from set summer flows, the required minimum Eel River flows below Van Arsdale (E-11) vary daily between a floor and a cap (Figure SC4-2a) and are indexed to the calculated unimpaired flow at Van Arsdale. The winter/spring floor (Dec 1- May 15) on minimum Eel River flows below Van Arsdale (E-11) is 100 cfs in all water year types (Figure SC4-2a). In dry years, this can exceed inflows to Lake Pillsbury and deplete storage in the reservoir. Additionally, it does not mimic natural hydrology, setting an artificially high flow rate when unimpaired flows in the Eel River would be lower. In Scenario 4, the E-11 winter/spring floor would be reduced from 100 cfs to 50 cfs (Figure SC4-2b). The E-11 cap on required minimum flows would remain the same. While the E-11 floor spring recession would be modified slightly to account for the lower starting point, the summer flows would remain the same.



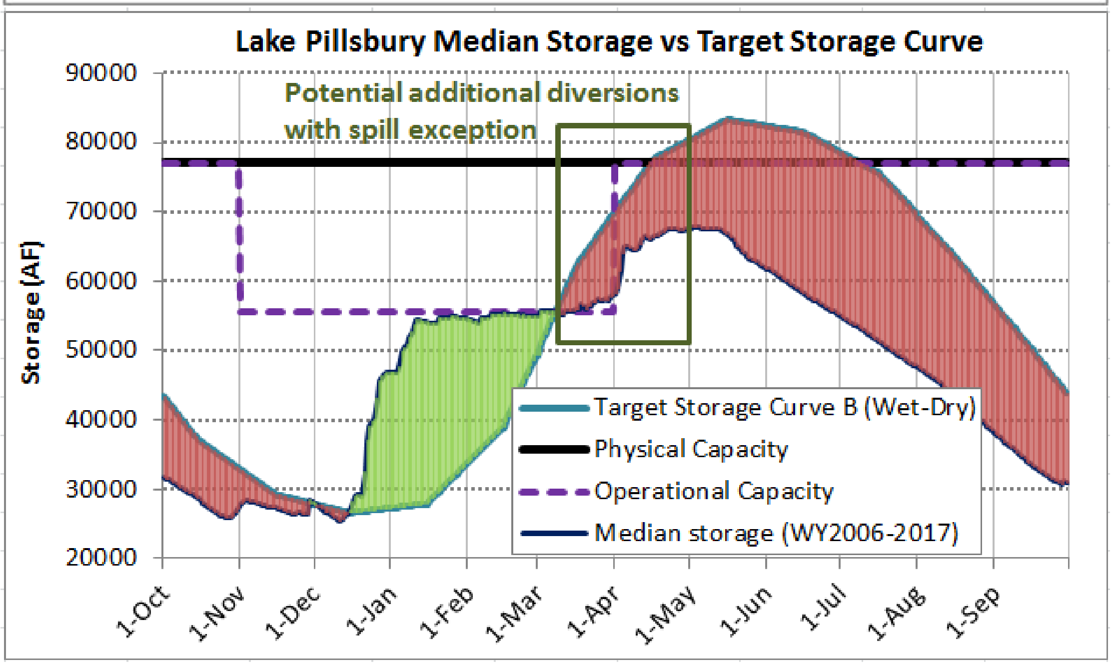


Figure SC4-1. a) Comparison of RPA-designated Target Storage Curves to reservoir physical and operational capacities, and b) Comparison of recent median daily storage to most common classification of the Target Storage Curves (green and red bars indicate when median storage is above or below TSC B, allowing or prohibiting discretionary diversions). The green box highlights the period of potential additional diversions the spill exception would allow.

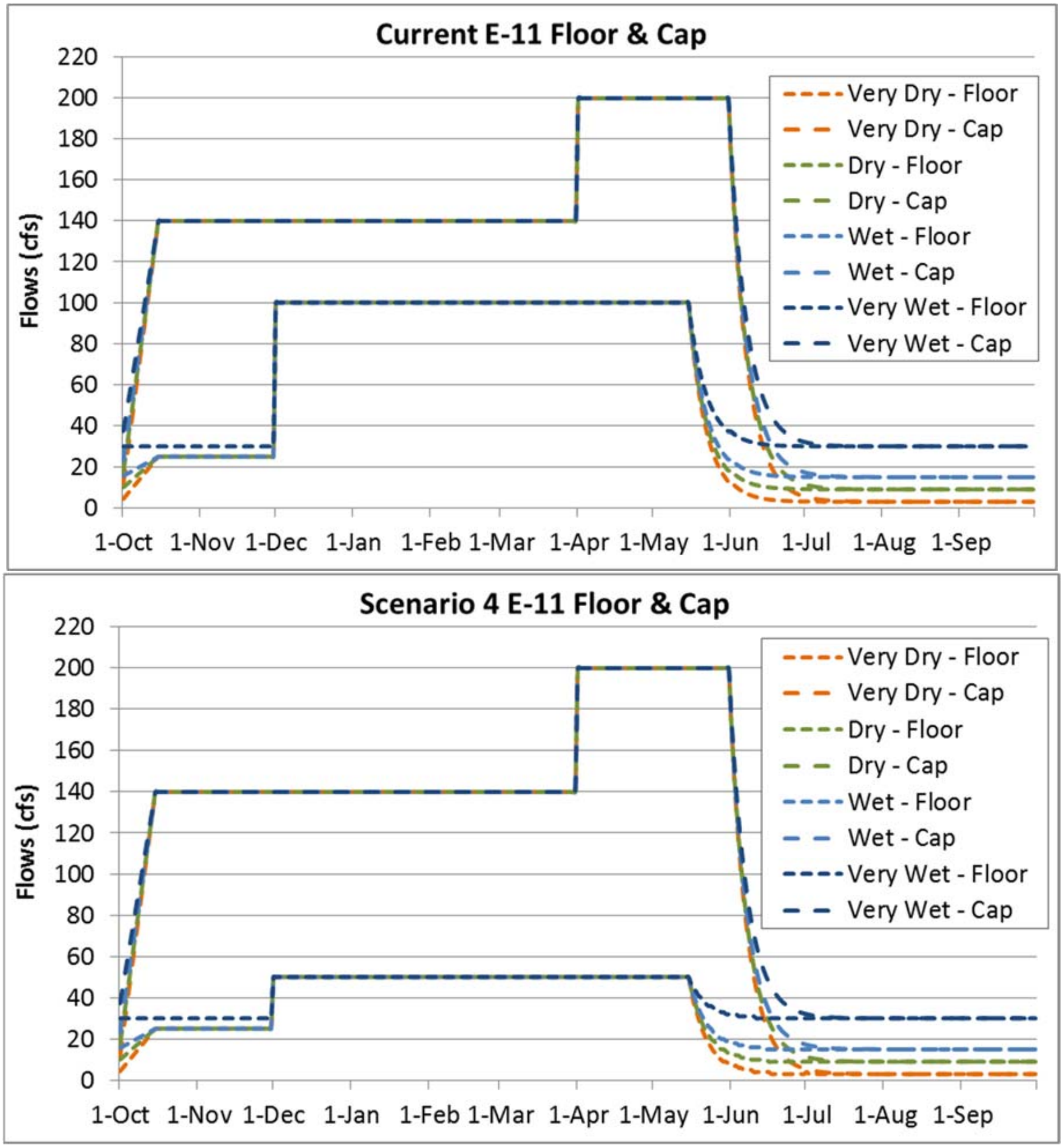


Figure SC4-2. a) Current E-11 floor and cap on required minimum flow by water year type, and b) Scenario 4 lowered E-11 floor (cap remains the same). For simplification, the serial cases (years that follow Very Wet years) are not shown. When the Very Wet classification is triggered, the following summer has an increased flow requirement as follows: Very Dry – 3 cfs increases to 5 cfs, Dry – 9 cfs increases to 20 cfs, Wet – 15 cfs increases to 25 cfs, and Very Wet – 30 cfs increases to 35 cfs.

Russian River, same as Baseline, except:

- Required releases to East Branch Russian River are lowered to support higher storage in Lake Pillsbury[1]. (The additional diversions allowed by the spill exception discussed earlier are expected to make up for some of the reduction, while not impacting storage.) The required summer flows are reduced from 75 cfs (Figure SC4-3a) to 35 cfs (Figure SC4-3b) for the Normal year type and remain at 25 cfs for the Dry year type. In both Normal and Dry year types, the winter/spring required flows are reduced from 35 cfs (Figure SC4-3a) to 20 cfs (Figure SC4-3b). The rarely triggered Critical water year type remains 5 cfs.

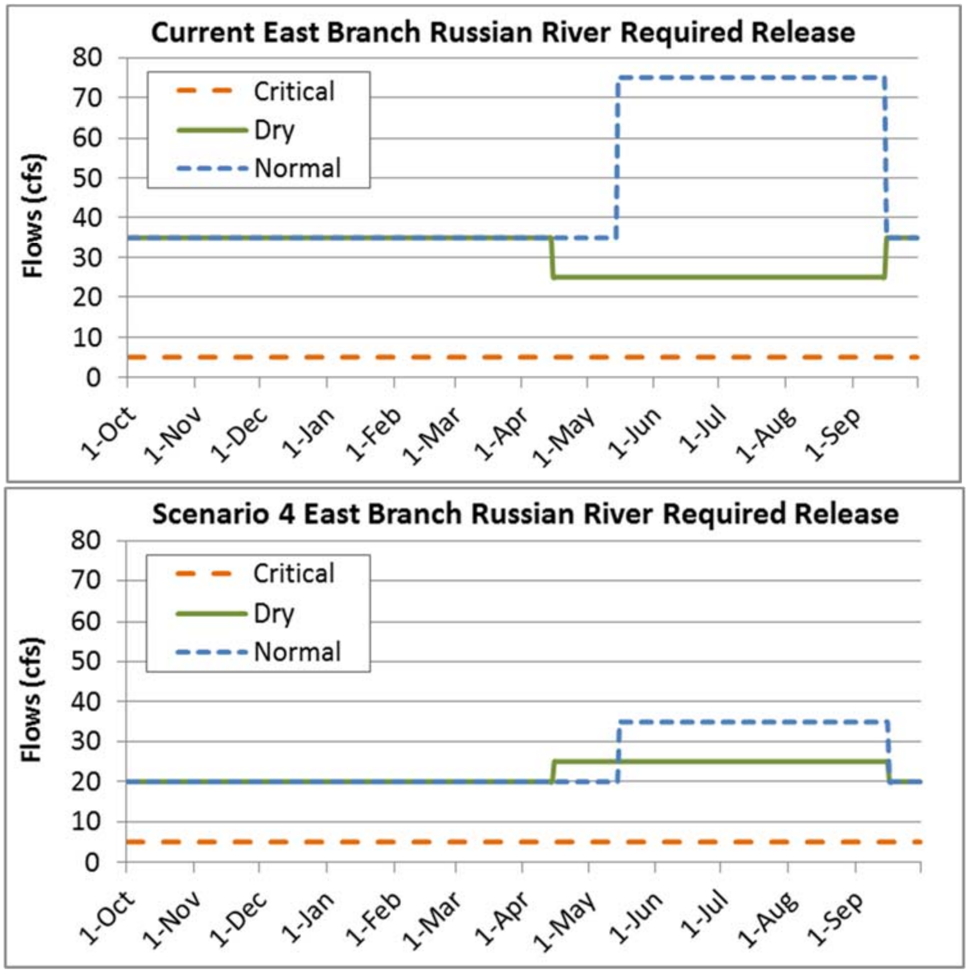


Figure SC4-3. a) Current East Branch Russian River required release by water year type, and b) Scenario 4 lowered required releases (with no change to the rarely triggered Critical water year type). To simplify, Normal WY type with Dry Spring Exception not shown. In that special case, the summer flow requirement for the East Branch Russian River drops to 40 cfs under the baseline operations. In Scenario 4, there is no Dry Spring Exception, as the required summer flow for Normal WY type has been reduced to 35 cfs.

[1] Under baseline operations, the summertime (May 15 – Sept 14) required flow for the East Branch Russian River under the Normal water year type is 75 cfs (Figure SC4-3a). This requirement, combined with a 50 cfs growing season delivery to PVID plus a 5 cfs buffer, results in a steep drawdown of Lake Pillsbury. This can result in a depleted reservoir in years when Lake Pillsbury did not fill, as well as years with a dry fall and early winter.

Example Hydrographs Comparing Flow Management Results

Example hydrographs have been provided for a recent dry year (Water Year [WY] 2015) and a recent dry year (WY 2017), as examples of how flows are predicted to change under Scenario 4, compared to baseline operations for Lake Pillsbury (Figure SC4-4 and Figure SC4-5), Cape Horn Dam (E-11, Figure SC4-6 and Figure SC4-7), Potter Valley Diversion (E-16, Figure SC4-8 and Figure SC4-9), Lake Mendocino storage (Figure SC4-10 and Figure SC4-11), and the Russian River at Cloverdale (Figure SC4-12 and Figure SC4-13).

Lake Pillsbury Storage. Storage in Lake Pillsbury increases in both dry and wet water years, primarily as a result of decreased minimum flow requirements in the East Branch Russian River (Figure SC4-4 and Figure SC4-5). Summer drawdown is notably less steep than baseline, and the reservoir enters the fall with significantly more storage and presumably a more substantial cold water pool. Reservoir storage across the winter period changes only slightly between baseline operations and Scenario 4.

Cape Horn Dam (E-11). The Eel River hydrograph for Scenario 4 in a dry water year is nearly identical to baseline operations, except for lower flow periods during the wet season. Differences are apparent only when the instream flow floor is lowered by up to 50 cfs in the spring and winter to better match natural flow patterns during drier years (e.g., April and May in Figure SC4-6). Scenario 4 flows are also largely identical to baseline conditions in wetter water years, with changes attributable to the spill exception allowing additional (discretionary) diversions during spring and winter (Figure SC4-7).

PVP Diversion (E-16). During both dry and wet water years, the PVP diversion decreases by 15 cfs or 40 cfs, depending on timing, below baseline operations diversion levels outside winter months when diversions are otherwise maximized at 170 cfs (Figure SC4-8 and Figure SC4-9). During wetter water years, the period of diversion is longer. Diversions also increase by 125 cfs in November and March through May due to adjustments in the Lake Pillsbury Target Storage Curve (Figure SC4-9).

Lake Mendocino. In Lake Mendocino during dry conditions, the model predicts Scenario 4 storage to be predominantly lower than baseline operations (Figure SC4-10). During wetter years, Scenario 4 storage is lower than baseline operations for most of the year, with the exception of spring when storage from runoff is maximized above the existing storage rule curve and during winter flood peak events (Figure SC4-11).

Russian River at Cloverdale. During dry water years, Scenario 4 flows are identical to current operations, with the exception of an approximate 85 cfs flow decrease in late November when Lake Mendocino was depleted (<2,100 ac-ft) and unable to meet minimum flow releases for a short duration, limiting flows to tributary accretion only (Figure SC4-12). In wetter water years, flows are identical to baseline operations (Figure SC4-13).

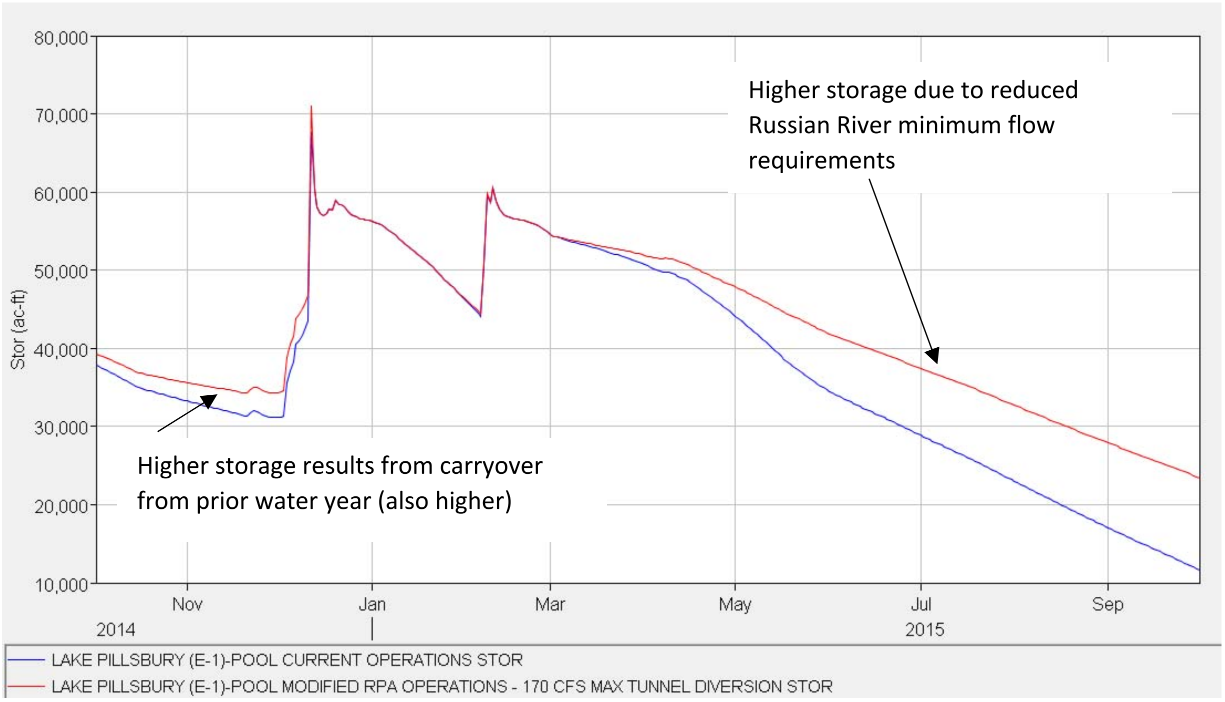


Figure SC4-4. Model results for Lake Pillsbury storage comparing baseline operations and Scenario 4. Water Year 2015 is shown as an example of a drier water year type.

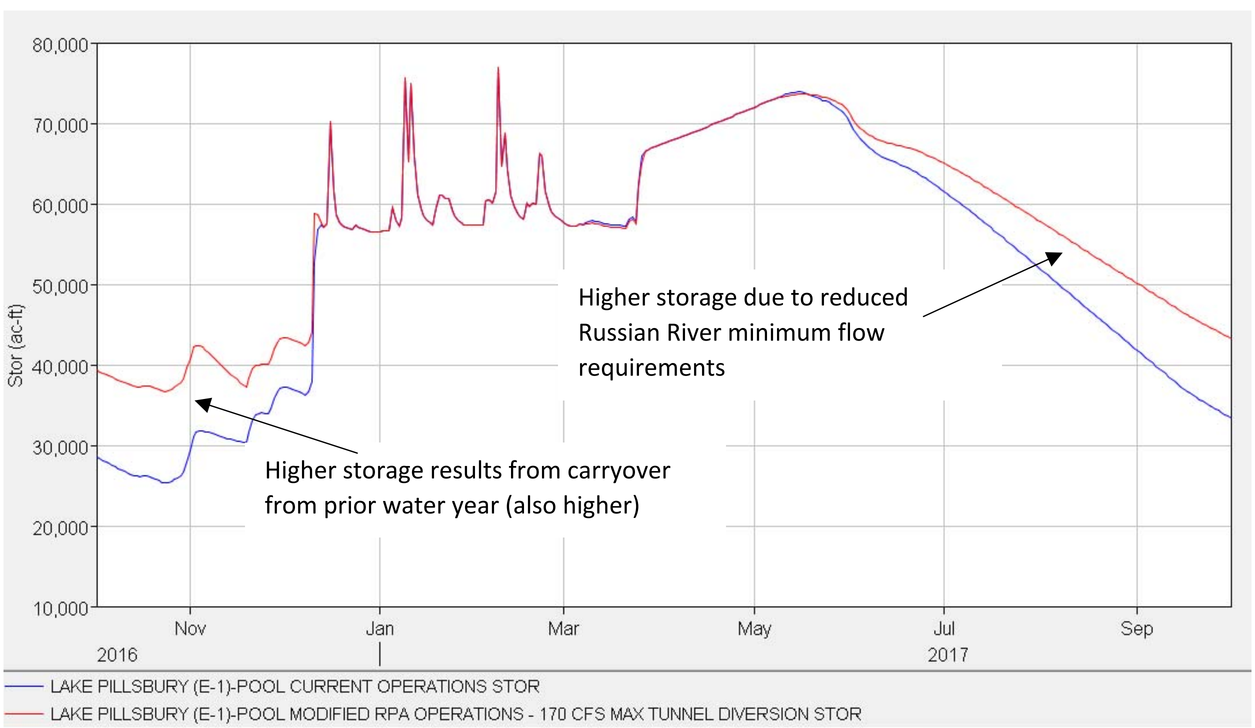


Figure SC4-5. Model results for Lake Pillsbury storage comparing baseline operations and Scenario 4. Water Year 2017 is shown as an example of a wetter water year type.

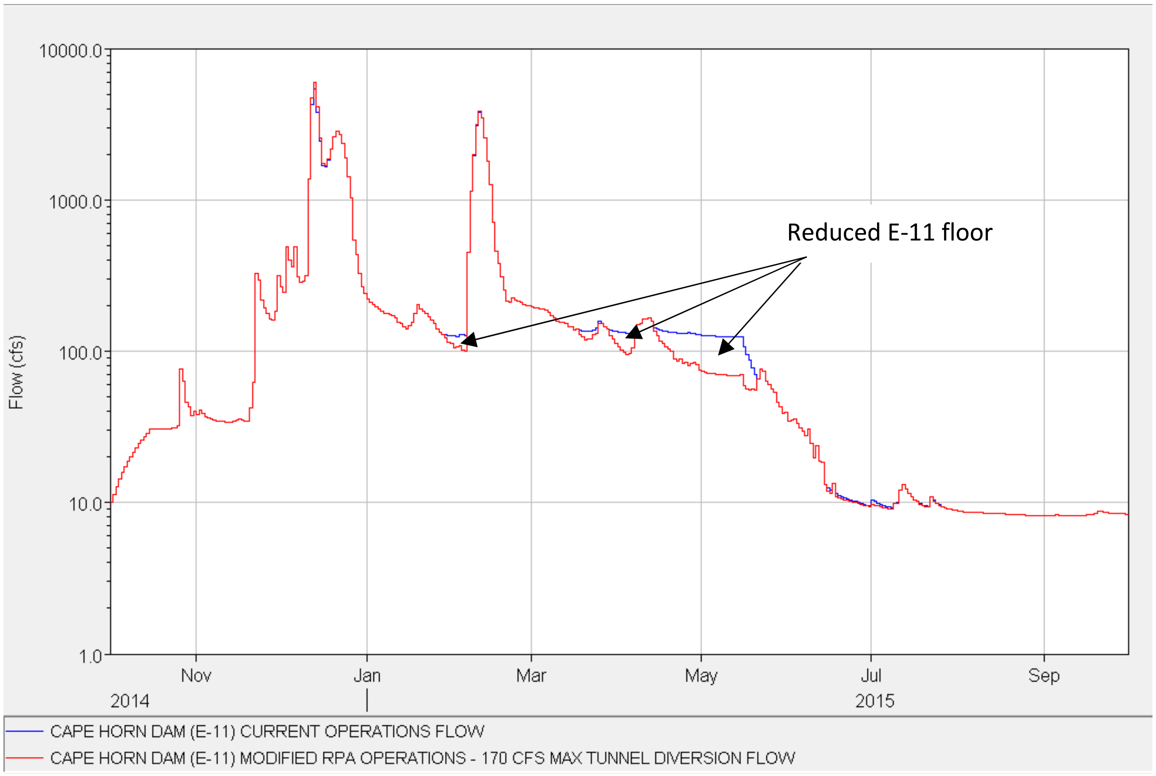


Figure SC4-6. Model results for Eel River flow below Cape Horn Dam (E-11) comparing baseline operations and Scenario 4. Water Year 2015 is shown as an example of a drier water year type.

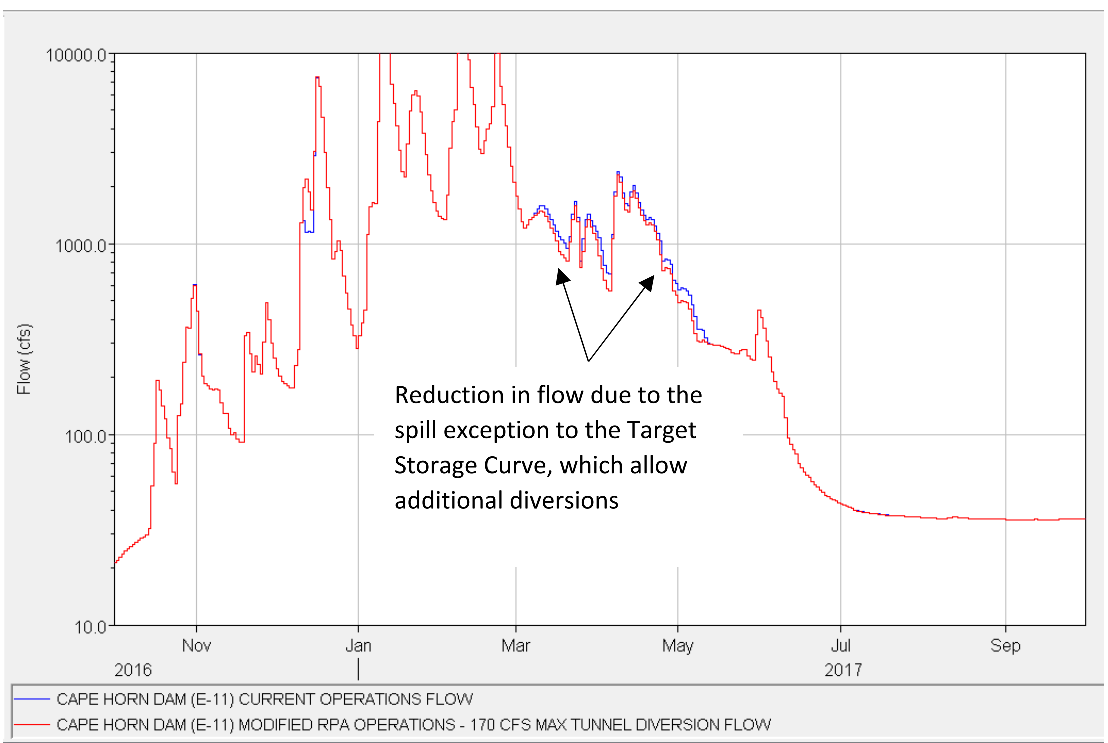


Figure SC4-7. Model results for Eel River flow below Cape Horn Dam (E-11) comparing baseline operations and Scenario 4. Water Year 2017 is shown as an example of a wetter water year type.

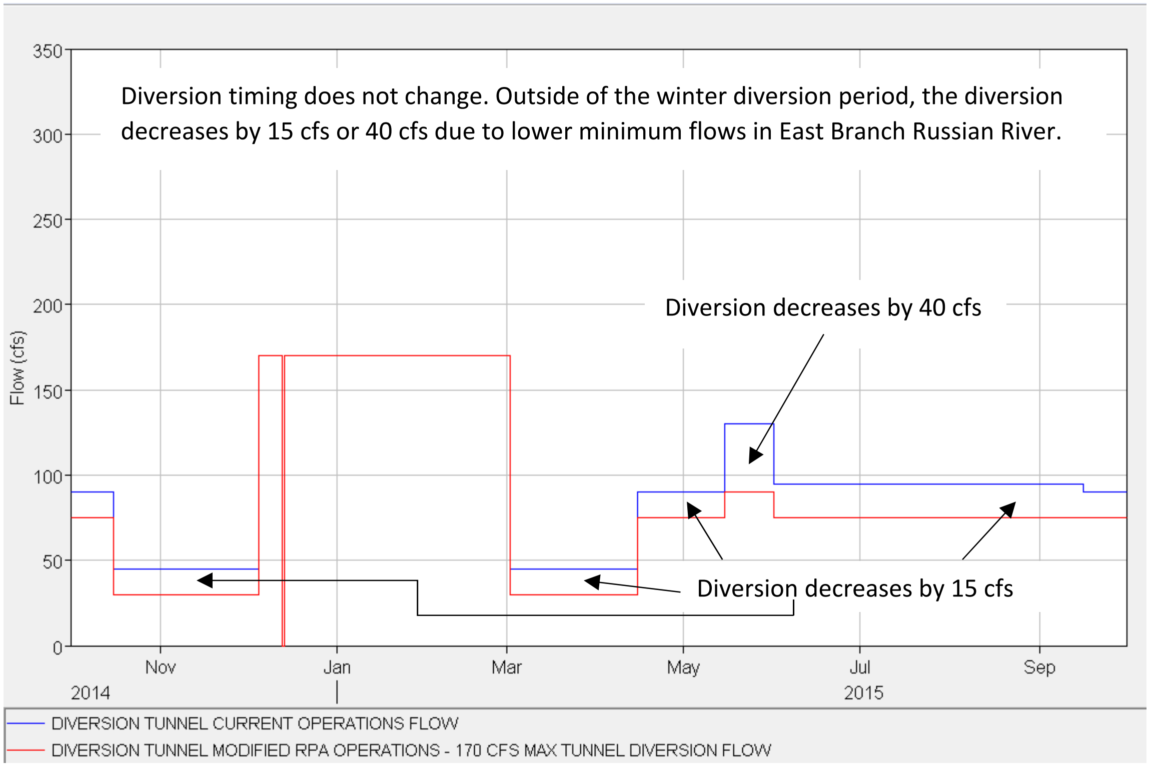


Figure SC4-8. Model results for the Potter Valley diversion (E-16) comparing baseline operations and Scenario 4. Water Year 2015 is shown as an example of a drier water year type.

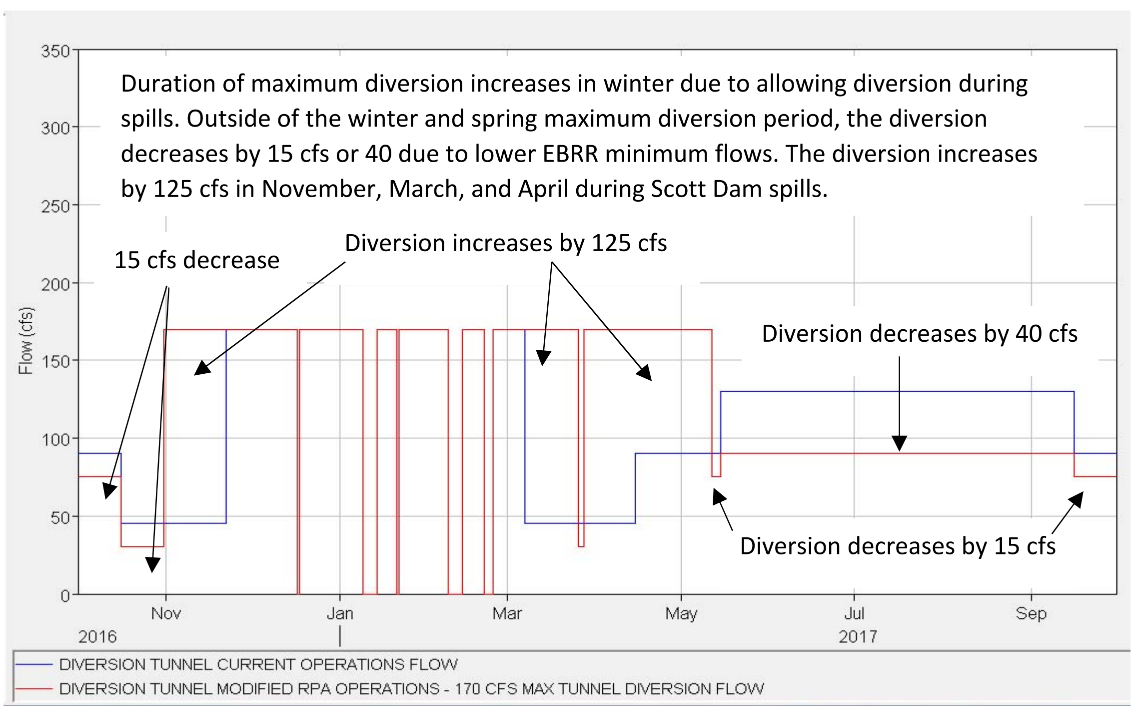


Figure SC4-9. Model results for the Potter Valley diversion (E-16) comparing baseline operations and Scenario 4. Water Year 2017 is shown as an example of a wetter water year type.

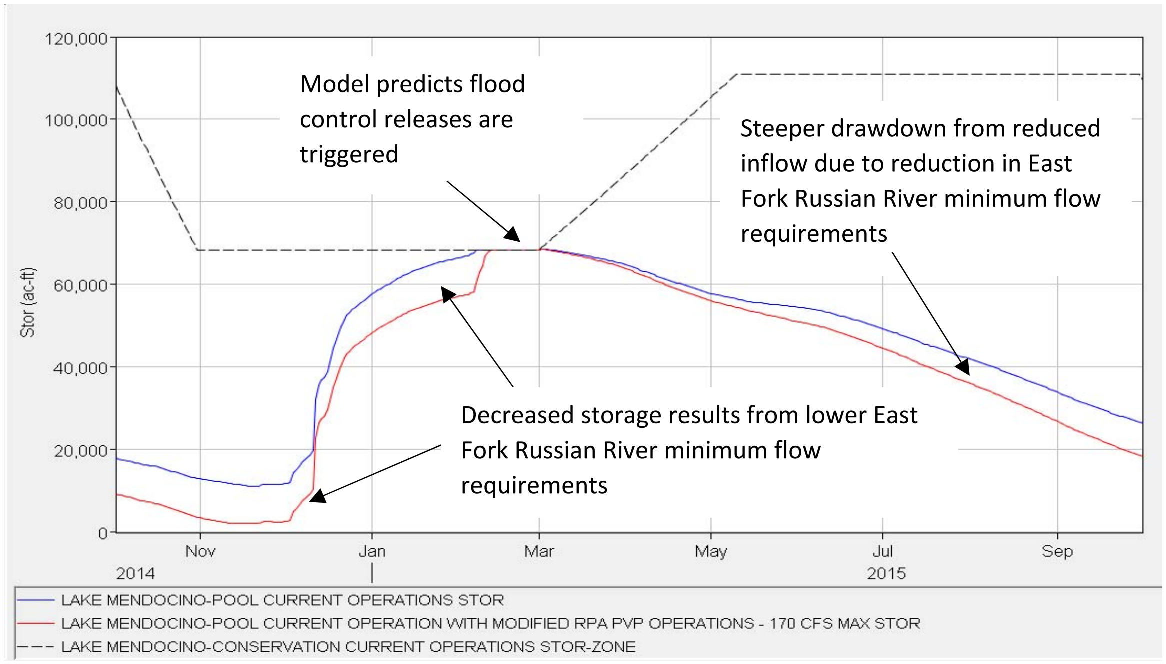


Figure SC4-10. Model results for Lake Mendocino storage comparing baseline operations and Scenario 4. Water Year 2015 is shown as an example of a drier water year type.

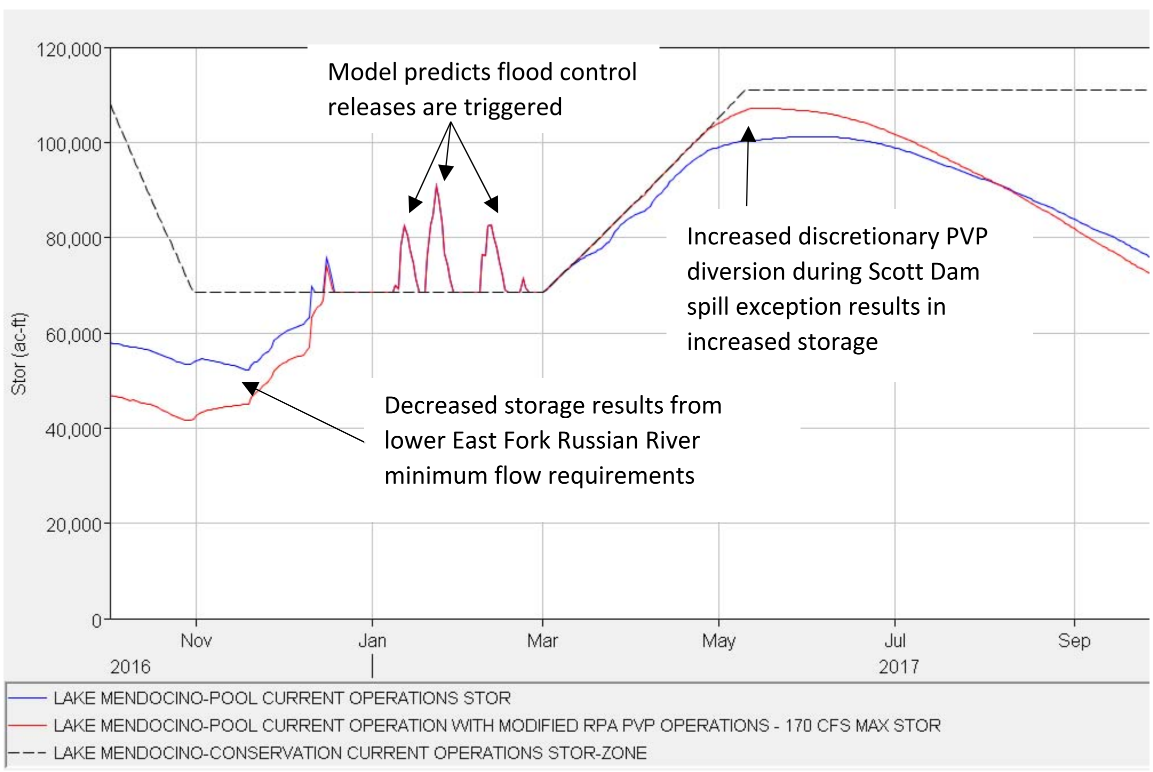


Figure SC4-11. Model results for Lake Mendocino storage comparing baseline operations and Scenario 4. Water Year 2017 is shown as an example of a wetter water year type.

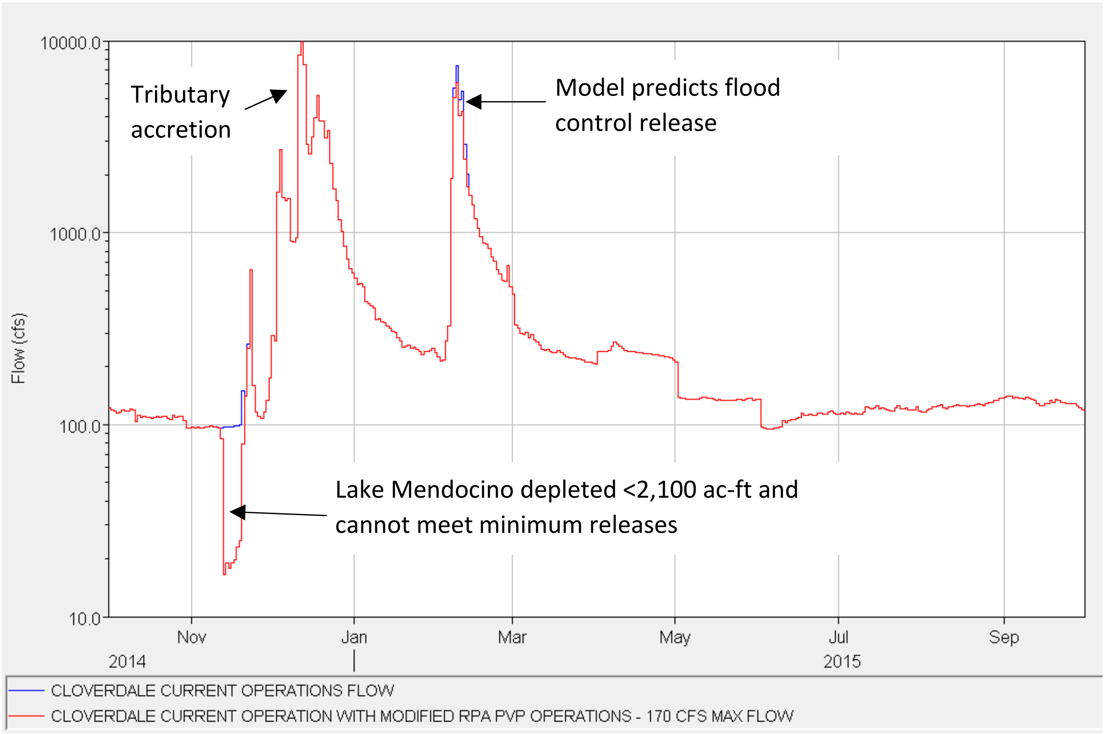


Figure SC4-12. Model results for Russian River flow at Cloverdale comparing baseline operations and Scenario 4. Water Year 2015 is shown as an example of a drier water year type.

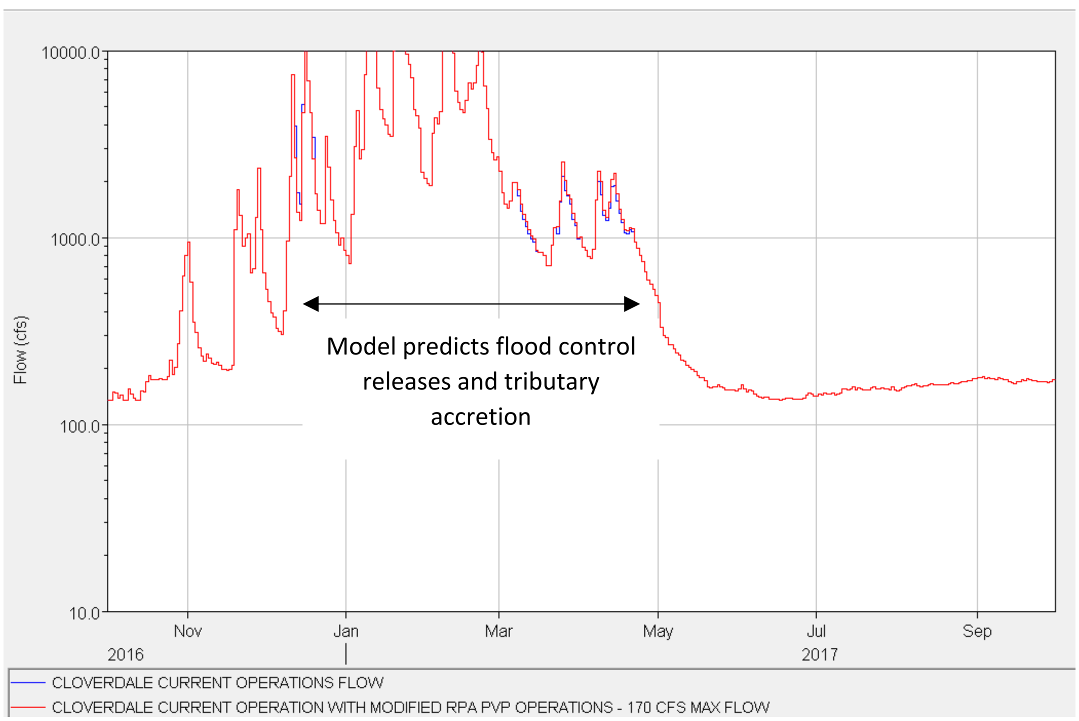


Figure SC4-13. Model results for Russian River flow at Cloverdale comparing baseline operations and Scenario 4. Water Year 2017 is shown as an example of a wetter water year type.

2. KEY METRICS

Table SC4-3. Summary of Eel River performance metrics for the WY 1911-2017 period of record (107 years).

Model Junction	Evaluation Metric	Baseline Operations	Scenario 4: PVP Revised ops and modified East Branch Russian River flows	Scenario 4 Percent Change from Baseline Operations Scenario
Lake Pillsbury	Average Annual Inflow (ac-ft)	411,870	411,870	0%
	Standard Deviation of Average Annual Inflow (ac-ft)	234,731	234,731	0%
	Relative Standard Deviation (%)	57%	57%	0%
	Minimum Average Annual Inflow (ac-ft)	30,447	30,447	0%
	Average Overall Storage (ac-ft)	50,858	53,760	6%
	Average Low Point of Annual Storage (March -February) (ac-ft)	24,829	28,883	16%
	Relative Standard Deviation (%)	8,005	6,694	-16%
	Standard Deviation of Low Point of Annual Storage (ac-ft)	32%	23%	-28%
	Number of Years Below 35,000 ac-ft Storage from August-October[1]	65	17	-74%
	Number of Years Below 9,700 ac-ft Storage from August-October	6	0	-100%
	Number of Years Below 5,000 ac-ft Storage at Any Time During the Year	5	0	-100%
Below Scott Dam (E-2)	Average June-September flows (cfs)	153	130	-15%
	Minimum Weekly June-September flows (cfs)	0	0	-
	Standard Deviation of Minimum Weekly June-September flows (cfs)	61	64	5%
	Relative Standard Deviation (%)	239%	226%	-5%
	Average October-December flows (cfs)	397	423	7%
	Minimum Weekly October-December flows (cfs)	0	0	-
	Standard Deviation of Minimum Weekly October-December flows (cfs)	950	958	1%
	Relative Standard Deviation (%)	619%	735%	19%
	Average Water Year Volumes (ac-ft)	404,161	403,926	0%
	Standard Deviation of Average water year volumes (ac-ft)	230,136	230,808	0%
	Relative Standard Deviation (%)	57%	57%	0%
Below Cape Horn Dam (E-11)	Average June-September flows (cfs)	43	42	-2%
	Minimum Weekly June-September flows (cfs)	0[2]	0[2]	0[2]
	Standard Deviation of Minimum Weekly June-September flows (cfs)	67	64	-4%
	Relative Standard Deviation (%)	18%	17%	-5%
	Average October-December flows (cfs)	373	377	1%
	Minimum Weekly October-December flows (cfs)	0[2]	0[2]	0[2]
	Standard Deviation of Minimum Weekly October-December flows (cfs)	1,091	1,107	1%
	Relative Standard Deviation (%)	2525%	2605%	3%
	Average Water Year Volumes (ac-ft)	413,281	407,296	-1%
	Standard Deviation of Average water year volumes (ac-ft)	274,001	271,867	-1%
	Relative Standard Deviation (%)	66%	67%	1%

1 Metric can be triggered by one day (e.g. October 30), although the reservoir does not typically refill once it is dry.

2 In 1924, the local flows reach 0 cfs from mid-July through mid-October in both baseline operations (reservoir depleted to meet baseline operations flows) and unimpaired conditions. Additionally, Lake Pillsbury was depleted from late August to late October in 1924.

Table SC4-4. Summary of Russian River performance metrics for the WY 1911-2017 period of record (107 years).

Model Junction	Evaluation Metric	Baseline Operations	Scenario 3: PVP Decommissioning and Modified Russian River	Scenario 3 Percent Change from Baseline Operations Scenario
Lake Mendocino	Average Annual Inflow (ac-ft)	173,380	180,921	4%
	Standard Deviation of Average Annual Inflow (ac-ft)	67,567	70,790	5%
	Relative Standard Deviation (%)	39%	39%	0%
	Minimum Average Annual Inflow (ac-ft)	21,099	18,538	-12%
	Average Overall Storage (ac-ft)	66,659	67,660	2%
	Average Low Point of Annual Storage (March-February) (ac-ft)	45,034	45,936	2%
	Standard Deviation of Low Point of Annual Storage (ac-ft)	16,508	18,190	10%
	Relative Standard Deviation (%)	37%	40%	8%
	Number of Years Below Minimum Storage at Any Time During the Year (reservoir depletion)	1	2	100%
Russian River at Cloverdale	Average June-September flows (cfs)	147	148	1%
	Minimum Weekly June-September flows (cfs)	0	0	-
	Standard Deviation of Minimum Weekly June-September flows (cfs)	25	29	14%
	Relative Standard Deviation (%)	0%	0%	13%
Russian River at Healdsburg	Average October-December flows (cfs)	1,075	1,086	1%
	Minimum Weekly October-December flows (cfs)	0	0	-
	Standard Deviation of Minimum Weekly October-December flows (cfs)	2,396	2,407	0%
	Relative Standard Deviation (%)	0%	0%	0%
	Average water year volumes (ac-ft)	906,151	911,994	1%
	Standard Deviation of Average water year volumes (ac-ft)	507,077	508,654	0%
	Relative Standard Deviation (%)	56%	56%	0%

Table SC4-5. Summary of PVID performance metrics for the WY 1911-2017 period of record (107 years).

Model Junction	Evaluation Metric	Baseline Operations	Scenario 3: PVP Decommissioning and Modified Russian River	Scenario 3 Percent Change from Baseline Operations Scenario
Diverted to Potter Valley via Tunnel (E-16)	Average Water Year Volumes (ac-ft)	78,077	0	-100%
	Standard Deviation of Average water year volumes (ac-ft)	14,615	0	-100%
	Relative Standard Deviation (%)	19%	0%	-99%
	Minimum Water Year Volume (ac-ft)	24,377	0	-100%
PVID pumpback from Lake Mendocino (May-Oct)	Average Water Year Volumes (ac-ft)	N/A[1]	14,109	N/A[1]
	Standard Deviation of Average water year volumes (ac-ft)	N/A[1]	2,601	N/A[1]
	Relative Standard Deviation (%)	N/A[1]	18%	N/A[1]
	Minimum Water Year Volume (ac-ft)	N/A[1]	0	N/A[1]
PVID water supply deficiencies (<15,140[2] ac-ft)	90th Percentile Deficiency Volumes (ac-ft)	0	5,161	-
	Maximum May -Oct Deficiency Volume (ac-ft)	5,996	15,140	152%
	Number of years May-Oct PVID delivery less than 15,140 ac-ft	2	22	1000%

1 N/A because PVID pumpback does not occur.

2 Reported 2016 water use

3. OVERVIEW OF RESULTS

This summary of results compares Scenario 4 (Modified PVP Operations) to baseline operations, highlighting differences in flow and water storage availability at key locations in both the Eel River and Russian River basin.

Eel River Results (Below Scott Dam and Below Cape Horn Dam)

- Flows below Scott Dam are similar to baseline operations in all water years types from January through May, with changes attributable to reductions in required flows for both E-11 and East ranch Russian River. From May through December, Scott Dam releases decrease below baseline operations by up to 40 cfs.
- Flows below Cape Horn are also similar to baseline operations in the winter and spring months during all water years types, with reductions attributable to the spill exception and lowered winter and spring E-11 floor on required flows.

Potter Valley Diversion Results

- The magnitude and duration of diversion increases during late fall through May (exact timing dependent on exceedence type) from 45 cfs (mostly commonly) or 90 cfs (less commonly) up to 170 cfs.
- During summer months, the diversion decreases from 130 cfs to 90 cfs under normal and wetter (50% and 75% exceedence conditions) and remains the same under a dry (90% exceedence condition).

Russian River Results

- Calpella flows remain similar to baseline except when the increased PVP diversion is occurring. During these periods, flows increase commensurate with the increased PVP diversion as water is conveyed downstream to Lake Mendocino for storage.
- Lake Mendocino inflow is very similar in January through February, up to 100 cfs higher in March through May due to an increase in the PVP diversion, and lower during the summer months when the PVP diversion decreases (< 75 cfs). Changes in fall inflow varies based on exceedence condition from identical to 150 cfs above baseline operations, depending on the month.
- Lake Mendocino storage is higher in the winter and spring due to increased PVP diversions and lower in the summer and fall.
- Releases from Lake Mendocino remain nearly identical to baseline operations in January and February. Releases are up to 25 cfs higher in March during wetter conditions only, and up to 15 cfs higher in April during 55%-85% exceedence conditions. From May through December, Scenario 4 releases remain nearly identical to baseline operations, except in extremely dry conditions when Lake Mendocino reaches its floor during the fall and releases are not possible for short durations (e.g. WY 2015).
- Along the Russian River downstream of Lake Mendocino (Forks, Hopland, Cloverdale, and Healdsburg), Scenario 4 flows are nearly identical to baseline operations. As an exception, during very dry conditions when Lake Mendocino releases are not possible in the fall, flows downstream of Lake Mendocino are reduced to tributary accretion only (e.g., WY 2015).

APPENDIX OF DETAILED RESULTS COMPARING BASELINE OPERATIONS AND SCENARIO 4 WITH 170 CFS MAXIMUM TUNNEL CAPACITY