The Lower American River

Modified Flow Management Standard

A Drought Buffer for the Environment and Local Water Supplies

WATER FORUM

By The Sacramento Water Forum

October 2015

Sacramento Water Forum
2831 G St., Ste. 100
Sacramento, CA 95816

The Lower American River MODIFIED FLOW MANAGEMENT STANDARD

A Drought Buffer for the Environment and Local Water Supplies

TABLE OF CONTENTS

List of Tables and Figures

EXECUTIVE SUMMARY

The Sacramento Water Forum has developed a Modified Flow Management Standard (*Modified FMS*) for the lower American River, with the goals of protecting anadromous salmonids and avoiding catastrophic water shortages in the basin. After 20 years of study and refinement, the Water Forum strongly believes that this standard represents the best path forward for protecting these local resources without re-directing negative impacts to other regions. This document describes the development and performance of the *Modified FMS*.

EXECUTIVE SUMMARY

"The current drought in California has demonstrated in real-world terms the limits of current flow requirements that apply to the lower American River.[1] The State Water Resources Control Board (State Water Board) and local stakeholders agree that the existing operations do not sufficiently protect the fish in the lower American River."

The lower American River is a spectacular regional and statewide resource. It is the second-largest tributary to the Sacramento River, which is a critical component of the San Francisco Bay and Sacramento–San Joaquin Delta. Folsom Dam and Reservoir, located at the confluence of the North Fork and South Fork American rivers, provide flood control and drinking water to nearly 1 million residents of the Sacramento region. The river is home to 43 fish species, including federally threatened Central Valley steelhead and struggling fall-run Chinook salmon.

The current drought in California has demonstrated in real-world terms the limits of current flow requirements that apply to the lower American River.[1] The State Water Resources Control Board (State Water Board) and local stakeholders agree that the existing operations do not sufficiently protect the fish in the lower American River. Conditions are often unhealthy for fall-run Chinook salmon and steelhead, due to high water temperatures.

Existing operations are also problematic for water supply reliability. As Folsom Reservoir storage levels drop below 200,000 AF, water deliveries become significantly constrained. At storage levels below 90,000 AF, the water level falls below the water supply intakes at Folsom Dam and El Dorado Hills, thereby preventing local water agencies from making critical water deliveries. Modeling by the California Department of Water Resources shows that, with current operations and projected climate change, Folsom Reservoir would drop below 90,000 AF in about 1 out of every 10 years in the future.[2]

The lower American River has been the focus of a successful stakeholder effort, known as the Sacramento Water Forum (Water Forum), to improve conditions for fish and for water supply. A central element of the 2000 Water Forum Agreement calls for developing and implementing a flow management standard on the lower American River.

Beginning in 2000, the Water Forum worked jointly with state and federal agencies for 5 years to develop a rigorous, science-based flow management standard. Key to this work was an improved understanding of the definition of healthy conditions for fish. Many experts said that water temperature is equally, if not more important, than flows for improving conditions for lower American River fish. This work resulted in a 2006 proposed standard that specified minimum releases from Folsom and Nimbus Dams and a new approach to managing water temperatures. The proposal was given the accurate, though not particularly catchy, name of the Lower American River Flow Management Standard (*2006 FMS*). Reclamation has consistently operated to the *2006 FMS* since that time.

The *2006 FMS* is a set of measures that includes minimum release requirements and water temperature objectives, oversight by an interagency workgroup (the American River Group), and monitoring and evaluation. Unlike other flow standards, the *2006 FMS* uses a sliding scale for minimum flow releases, and water temperature targets that balance available water supplies with achievable biological objectives.

1. For the purposes of this report, "current flow requirements" or "existing operations" refer to the system-wide rules for operating the State Water Project (SWP) and Central Valley Project (CVP), including Decision 893 (D 893) on the lower American River, the Biological Opinions written in 2008 and 2009 by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service, the Operations Criteria and Plan (OCAP), and the 2006 Lower American River Flow Management Standard (*2006 FMS*), all of which are discussed in this report.
2. California Department of Water Resources, DWR 2013 Delivery Reliability Report, CALSIM II Output from the Future with Climate Change Scenario, Late Long-Term Planning Horizon and the 5th Climate Change Region, June, 2013.

Although the *2006 FMS* was an improvement over the historical American River operations, that flow prescription still potentially allows water storage to drop to levels that would preclude purveyor diversions and cause lethal water temperatures for salmonids. Indeed, in 2009, the National Marine Fisheries Service (NMFS) issued a Jeopardy Biological Opinion related to the federal Central Valley Project (CVP) that called for improvements in the temperature management aspects of the *2006 FMS*.

The 2009 Biological Opinion and recent drought impacts led to development of a better approach: the *Modified FMS*, which in many ways builds upon and improves the *2006 FMS*. Similar elements between the two standards include:

- minimum release requirements and adjustments
- water temperature management
- collaboration with stakeholders through the American River Group
- monitoring and adaptive management

However, the *Modified FMS* differs from the *2006 FMS* in a few key ways. In particular, the *Modified FMS* includes a Seasonal Release Allocation which banks water in the event of dry conditions, and relies upon more representative indices of water availability than the *2006 FMS*.

The Water Forum modeled the performance of the *Modified FMS* and compared it to the *2006 FMS*, which is also the existing condition. These approaches were also compared to a third approach – High Spring Flows – under consideration by the State Water Board that mimics parts of a natural unregulated hydrograph. Each flow regime was modeled using an 82-year simulation based on historical hydrologic conditions and 2030-level water demand.

"The lower American River has been the focus of a successful stakeholder effort, known as the Sacramento Water Forum (Water Forum), to improve conditions for fish and for water supply. A central element of the 2000 Water Forum Agreement calls for developing and implementing a flow management standard on the lower American River."

As shown by Table 1 on the following page, the *Modified FMS* performs exceedingly well compared with other approaches. Specifically, the *Modified FMS* would:

- Significantly **lower water temperatures** in the lower American River during the crucial rearing season for juvenile steelhead.
- Provide **more spawning habitat** for fall-run Chinook salmon.
- Provide **better overall habitat conditions**, particularly in the driest years. Under the *Modified FMS*, flows never drop below 500 cubic feet per second (cfs) and only rarely drop to 800 cfs, under conditions modeled in the simulation.
- Significantly **improve water supply reliability** in the American River basin by avoiding low reservoir levels.
- **Avoid redirected impacts** to Sacramento River fisheries.

Table 1. Summary of benefits and harm of lower American River flow regimes

	Metric		Affected Feature	Benefit / Harm: Compared to Existing Condition (2006 FMS)	
				High Spring Flows	Modified FMS
American River	Water supply	Urban deliveries			
	Steelhead spawning and rearing	Temperature			
		Habitat			
	Fall-run Chinook spawning and rearing	Temperature			
		Habitat			
		Mortality			---
	Flows under 800 cfs				
	Flows under 500 cfs				
Sacramento River	Water supply	Ag & urban delivery		---	---
	Winter-run Chinook	Temperature			---
		Mortality		---	---
	Spring-run Chinook	Temperature			---
		Mortality			---
	Fall-run Chinook	Temperature			
	Late fall-run Chinook	Temperature			
	Steelhead	Temperature		---	---
Delta	Water supply	CVP ag supply			---
		CVP urban supply			
		SWP ag supply		---	---
		SWP urban supply		---	---
	Outflow			---	---
	Water quality			---	---

- Legend -

Water temperature effects (on salmonids)

Water supply reliability

Flow and habitat for fish

Harm			No change	Benefit		
Large	Medium	Small		Small	Medium	Large

Table 1 also shows that, although the High Spring Flows approach would modestly improve flow and habitat conditions in the lower American River (compared to existing conditions), it would significantly degrade the reliability of water temperature and water supply in the river.

The Water Forum believes that the *Modified FMS* is the best approach that has been identified for protecting and restoring steelhead and fall-run Chinook salmon in the lower American River while also improving the reliability of local water supplies. The *Modified FMS* has been developed to avoid redirected impacts and to operate within the current regulatory schema. Future study might lead to new approaches and even greater improvements, and the Water Forum is committed to continued engagement in these efforts.

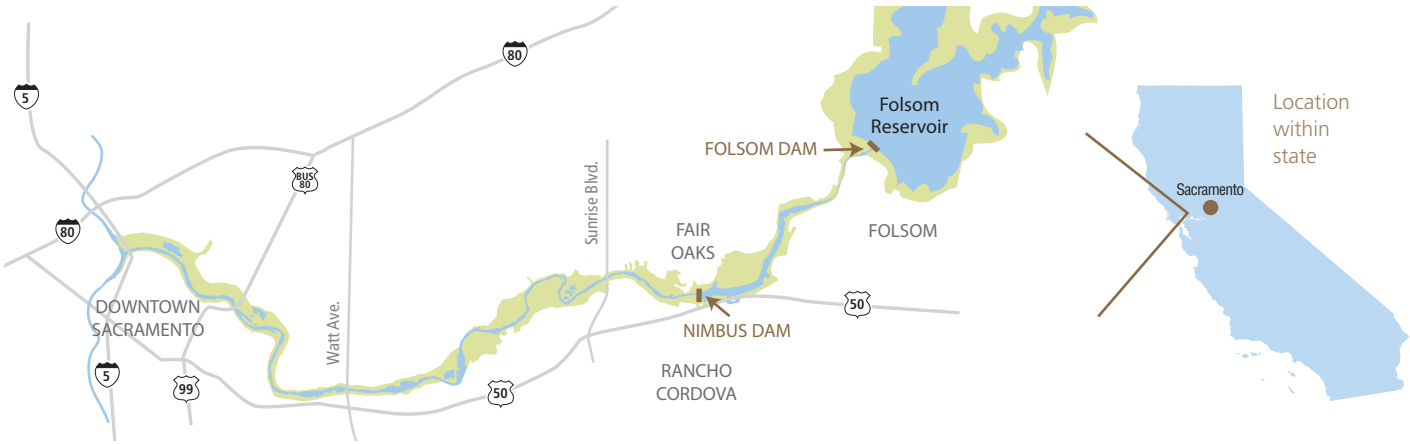
PART I: BACKGROUND

Introduction

The Sacramento Water Forum has developed a Modified Flow Management Standard (*Modified FMS*) for the lower American River. Designed to protect anadromous salmonids and avoid catastrophic water shortages in the basin, the *Modified FMS* represents the best path forward for protecting local resources without re-directing negative impacts to other regions.

The lower American River is the only urban waterway in the United States to be designated a "Wild and Scenic River" (Figure 1) by state and federal governments.[1] The river is home to 43 fish species, including federally threatened steelhead and struggling fall-run Chinook salmon. Folsom Dam and Reservoir, located at the confluence of the North and South Fork American rivers, provide flood control and drinking water to nearly 1 million residents of the Sacramento region. In particular, about 500,000 people in the cities of Folsom and Roseville and in the San Juan and El Dorado Water Districts depend on diversions directly from Folsom Reservoir as their primary water supply.

Figure 1. Location of lower American River and surrounding area



1. 46 Federal Register 7484 (January 23, 1981) (federal designation); Public Resources Code Section 5093.54(3) (state designation).

Like most rivers in California, the lower American River has been the subject of rancorous battles in recent decades, including whether to build additional dams and whether to allow additional water diversions. Also similar to most other rivers in California, the lower American River is facing increased stress from the ongoing drought in California and will face future stress as the result of climate change. Yet the lower American River has also been the focus of a successful united stakeholder effort, known as the Water Forum, to improve conditions for fish and for water supply. Building on this past success, the Water Forum is proposing a revised flow regime that would benefit all stakeholders.

Background on the Lower American River

The lower American River is the second-largest tributary to the Sacramento River, and a critical component of the San Francisco Bay and Sacramento–San Joaquin Delta system (Bay-Delta). The Bay-Delta provides a portion of the drinking water supply to two-thirds of the state as well as a portion of the irrigation water supply for half of California's agricultural industry.

A valuable regional and state asset, the lower American River provides fish and wildlife habitat, a high-quality water source for the Sacramento Valley, a critical floodway, and a spectacular regional recreational parkway (Figure 2). The American River Parkway is considered the crown jewel of the Sacramento region and is recognized and protected in the Urban American River Parkway Preservation Act of 2008 (California Public Resources Code Section 5840-5843).

Figure 2. Images of the lower American River and the American River Parkway

"Both water supplies and fish populations are at risk under the current operating regime. Establishing more-stable storage levels is critical to protect against the catastrophic effects of a severe or prolonged drought on both the environment and the region's economy."

Low water storage in Folsom Reservoir threatens both water supply and the environment. A half-million people in the Sacramento region depend on water supply that is diverted directly from the reservoir. If water storage in Folsom Reservoir drops below 90,000 acre-feet (AF), water levels fall below urban water supply intakes, preventing local water agencies from making critical water deliveries.

Folsom Reservoir is relatively small, so the year-to-year variability that is an inherent part of California's hydrology hits Folsom harder than other reservoirs. This extreme variability causes management challenges because of the tension between flood-control operations and water supply. Climate change will exacerbate these challenges. Modeling by the California Department of Water Resources shows that, with current operations and projected climate change, Folsom Reservoir would drop to a level precluding direct deliveries in about 1 out every 10 years in the future.[2]

The lower American River is home to two anadromous salmonid species – Central Valley steelhead and fall-run Chinook salmon. Only a few hundred steelhead spawn annually in the lower American River, and in 1998, the federal government listed steelhead as a threatened species. Fall-run Chinook salmon populations have been at historical lows in the past decade.[3] Conditions in the lower American River are often unhealthy for these anadromous fish due to high water temperatures.

Both water supplies and fish populations are at risk under the current operating regime. Establishing more-stable storage levels is critical to protect against the catastrophic effects of a severe or prolonged drought on both the environment and the region's economy.

Historical Water Operations and Decisions

The U.S. Army Corps of Engineers constructed Folsom and Nimbus dams as part of the federal Central Valley Project (CVP) for flood control, water supply, and other authorized project purposes. Completion of these dams in 1955 blocked access to 70% of the historical Chinook salmon spawning habitat and all of the historical steelhead spawning habitat in the American River basin.[4] Anadromous salmonids are presently restricted to the lower 23 miles of the American River from Nimbus Dam to the confluence of the American and Sacramento rivers.

The U.S. Bureau of Reclamation (Reclamation) operates Folsom Dam under State Water Rights permits and fish protection requirements that were adopted by the State Water Board in 1958 in the Order resulting from Decision 893. For the purposes of this document, the Order resulting from Decision 893 will be referred to as D-893.

D-893 allows flows at the confluence as low as 250 cubic feet per second (cfs) from January through mid-September and a minimum of 500 cfs between September 15 and December 31 for the protection, propagation, and preservation of fish life, with exceptions for critically dry years. Notably, the issuance of D-893 was the first time that the State Water Board set instream flow requirements for fish.[5]

2. California Department of Water Resources, DWR 2013 Delivery Reliability Report, CALSIM II Output from the Future with Climate Change Scenario, Late Long-Term Planning Horizon and the 5th Climate Change Region, June, 2013.
3. California Department of Fish and Wildlife, *California Central Valley Chinook Population Database Report* (April 2015), https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=84381&inline=1
4. http://www.safca.org/protection/NR_Documents/RCMP_5_Appendix.A.Chapter3.pdf
5. Karragan S. Bork, et al., "The Rebirth of California Fish and Game Code 5937: Water for Fish," *UC Davis Law Review*, Vol. 45, 809–913 (2012). "In 1958 the Board affirmatively recognized for the first time that flows for fish protection were not available for appropriation. In determining water availability in the American River, the Water Board found that [u]nappropriated water may be deemed to exist in the American River at such times as flows passing Fair Oaks exceed requirements below that point … for fish conservation."

Reclamation, the State Water Board, and various stakeholders agree that D-893 does not sufficiently protect the fishery resources in the lower American River.[6] Also, D-893 does not account for more recent developments and regulatory requirements, such as the Central Valley Project Improvement Act and Biological Opinions issued by the National Marine Fisheries Service (NMFS). Although flows in the lower American River frequently exceed the minimums specified in D-893, more protective requirements have not yet been incorporated into Reclamation's Water Rights permits. Including the FMS in Reclamation's American River water rights permits is a principal objective of the Water Forum to ensure that the *Modified FMS* is durable and enforceable.

Sacramento Water Forum

In 1993, after decades of contentious battles over the lower American River,[7] including a 17-year legal battle over whether the East Bay Municipal Utility District (EBMUD) could divert additional water from the river and whether Reclamation would construct Auburn Dam, diverse regional interests came together to create the Water Forum. The Water Forum is a group of over 40 stakeholder organizations including environmental advocacy groups, citizen groups, water purveyors, local governments, agricultural interests, and business and trade organizations that have agreed to pursue a series of seven elements as a means to achieve the dual objectives of protecting the fishery, recreation, and aesthetic values of the lower American River, as well as providing a safe and reliable water supply for the region to the year 2030. The seven elements of the Water Forum Agreement are:

1) Increased surface water diversions
2) Dry-year diversion reductions
3) Lower American River flow management standard
4) Lower American River habitat management
5) Water conservation
6) Groundwater management
7) The Water Forum Successor Effort

In addition to its efforts toward developing a durable flow standard for the lower American River, the Water Forum and its member organizations have been active on the other elements of the agreement. These initiatives have included side-channel enhancement and gravel replenishment projects to improve spawning and rearing habitat for salmonids, removal of invasive plants, groundwater management, and implementation of water efficiency programs, including installation of water meters.[8]

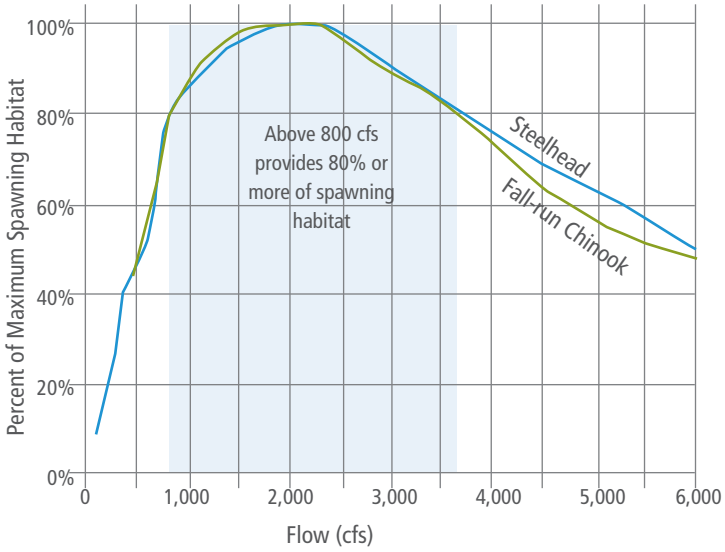
2006 Flow Management Standard – Addressing Water Temperature

A central element of the Water Forum Agreement calls for developing and implementing a flow management standard on the lower American River.[9] Prior to this, there had already been many attempts to improve the flow requirements in D-893. These efforts included those undertaken by the U.S. Fish and Wildlife Service (USFWS) pursuant to the Anadromous Fish Restoration Program.[10] These previous efforts were unsuccessful because they relied so heavily on high spring flows that inadequate water remained in summer and fall for either water supply or fishery purposes. In essence, these approaches did not create winners and losers, only losers. The Water Forum decided to try a different approach.

Starting in 2000, the Water Forum worked jointly with Reclamation, USFWS, the California Department of Fish and Wildlife (CDFW, formerly the California Department of Fish and Game), and NMFS for 5 years to develop a rigorous, science-based flow management standard. Key to this work was an improved understanding of what fish need. Many experts said that water temperature is equally, if not more important, than flows in improving conditions for fish.[11] Also, as illustrated in Figure 3, while optimal flows for anadromous salmonid spawning are in the range of 2,000 cfs, 80% of the spawning habitat benefits are achieved by flows of 800 cfs or greater. Below 800 cfs, spawning habitat rapidly begins to diminish. [12]

6. In 1984, the Alameda County Superior Court appointed the State Water Board as a referee in a lawsuit over water rights in the American River (Environmental Defense Fund v. East Bay Municipal Utility District) and directed the Board to prepare a Report of Referee. After an extensive investigation, the Board adopted the Report of Referee in 1988. In that report, the Board concluded that the existing flow requirements do not provide an adequate level of protection to the uses in the lower American River.
7. These battles included the proposed construction of Auburn Dam, *EDF v. EBMUD,* etc. (http://waterforum.org/wp-content/uploads/2015/09/WF_DEIR_Appendix_res7.pdf). The "Hodge Decision" which resulted from *EDF v. EBMUD*, allowed EBMUD to take water from the lower American River, but only when specified flows remain in the river.
8. See, for example, *The Water Forum: Ten Years of Implementation—2000 to 2010* (Sacramento Water Forum, October 2010).
9. Sacramento Water Forum, Water Forum Agreement: Support for Improved Pattern of Fishery Flow Releases from Folsom Reservoir (2000), p. 73
10. The Central Valley Project Improvement Act of 1992 (Public Law 102-575) directed the U.S. Fish and Wildlife Service to "make all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis."
11. http://www.cwemf.org/Pubs/TempReview.pdf
12. U.S. Fish and Wildlife Service, Energy Planning and Instream Flow Branch, *Comparison of PHABSIM and 2 D Modeling of Habitat for Steelhead and Fall-Run Chinook Salmon Spawning in the Lower American River* (2003)

Figure 3. Flow and habitat relationships for lower American River salmonids



Culminating in 2006, these efforts yielded a new approach for specifying minimum flow releases from Folsom Dam and for managing water temperatures in the lower American River.[13] The approach was given the accurate, though not particularly catchy name of the Lower American River Flow Management Standard (*2006 FMS*). The *2006 FMS* is a set of measures that includes:

1) Minimum release requirements;
2) Water temperature objectives;
3) Oversight by the American River Group, an interagency workgroup comprised of representatives from Reclamation, USFWS, NMFS, and CDFW; and
4) Monitoring and evaluation

Although the *2006 FMS* is a prescriptive standard, it is also adaptive. In other words, flow releases are adjusted based on current conditions. For this reason, the American River Group plays a key ongoing role in reviewing information, developing recommendations, and coordinating operational requirements for the river.

The foundation of the *2006 FMS* is its adaptive Minimum Release Requirement and water temperature objectives. The Minimum Release Requirement uses a sliding scale for minimum flows and establishes water temperature targets that balance available water supplies with achievable biological objectives. The flow progression has been developed to provide more water when anadromous salmonids are expected to be spawning and rearing.

The water temperature objectives strive to provide optimal summer water temperatures of 63 degrees Fahrenheit (°F) (17 degrees Celsius [°C]) and fall temperatures of 56°F (13°C) to support salmonid spawning and rearing. The adaptive approach of the *2006 FMS* allows higher water temperatures during drier years when cold-water supplies are not available to support the optimal temperatures.

As a general rule, under the *2006 FMS*, the minimum flow releases must equal or exceed 800 cfs year-round,[14] with narrowly defined exceptions when dry or critically dry conditions are forecasted to occur. Thus, in most years, flows would exceed those specified by D-893.

The exceptions fall into two categories: (1) an off-ramp; and (2) a conference year.

- An off-ramp occurs when Folsom Reservoir storage is forecasted to fall below 200,000 acre-feet (AF) at any time during the next 12-month period.
- A conference year occurs when the projected unimpaired inflow to Folsom Reservoir from March through November is computed to be less than 400,000 AF.

When either of these conditions occurs, flow requirements under the *2006 FMS* revert back to those specified in D-893 and allow releases to the river to drop below 800 cfs.

Reclamation began implementing the *2006 FMS* on a voluntary basis in 2006, with the intention of asking the State Water Board to modify Reclamation's permits to reflect this approach.[15] However, due to a protracted period of regulatory uncertainty associated with the 2004 and 2009 NMFS Biological Opinions, both of which were extensively litigated, Reclamation determined that substantive work on the *2006 FMS* would have to wait until completion of a final Operating Criteria and Plan (OCAP)[16], and Reclamation's request to the State Water Board was deferred.

13. Although the *2006 FMS* addresses temperature using flow management, there are other elements of temperature management, including hardware-based approaches such as the Folsom Dam Temperature Control Device. Although the *2006 FMS* addresses temperature using flow management, there are other elements of temperature management, including hardware-based approaches such as the Folsom Dam Temperature Control Device.
14. October 1 through December 31 minimum release requirements range between 800 and 2,000 cfs, January 1 through Labor Day minimum release requirements range between 800 and 1,750 cfs, and post–Labor Day through September minimum release requirements range between 800 and 1,500 cfs.
15. U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, and Sacramento Water Forum, "Memorandum of Understanding on Lower American River Flow Management Standard" (2004)
16. Letter from Donald Glaser, U.S. Bureau of Reclamation Regional Director, to Tom Gohring, Sacramento Water Forum Executive Director (October 2008)

PART II: PROPOSED APPROACH

Modified Flow Management Standard

Although the *2006 FMS* was an improvement over the historical operations of Folsom Dam, that regime – together with Bay-Delta outflow and other requirements – could still allow water storage in Folsom Reservoir to drop to levels that would cause lethal temperatures for anadromous salmonids and would preclude (or limit) diversions to municipal and industrial water users. Several additional factors led the Water Forum to revisit this standard.

First, the ground shifted in 2008 and 2009 when NMFS and USFWS issued Biological Opinions that found that CVP operations, including those at Folsom Dam, were placing the federally threatened steelhead in jeopardy.[17] NMFS issued many "reasonable and prudent alternatives" for avoiding jeopardy, including the *2006 FMS*.[18]

Second, recent history, including the current drought, has demonstrated that the water resources of the America River basin under the current operating regime are not as reliable as previously believed, and therefore must be managed to account for this increased risk. This unreliability became abundantly clear in 2014, when Folsom Reservoir storage dropped to its lowest level in more than three decades. The continuation of the severe drought into 2015 further emphasized the lessons learned in 2014 when projections indicated that Folsom Reservoir would be drawn down to 120,000 AF by the end 2015.

With these developments, the Water Forum restarted its modeling efforts, which led to the development of a better approach that can operate within the current regulatory schema and improve conditions for fish and protect water supply without transferring impacts to other water users or to the Bay-Delta.

Coincidentally, passage of the Sacramento–San Joaquin Delta Reform Act in 2009 required the State Water Board to develop flow criteria for priority streams in the Bay-Delta watershed by 2012 and for all major rivers and streams tributary to the Sacramento River by 2018. The State Water Board is currently finalizing its methodology for determining these flows. Draft versions of the methodology indicate that the State Water Board will use an analysis of "idealized flows" as part of its study. The new Water Forum proposal builds on the State Water Board's approach and has supplemented the Board's efforts with more site-specific work and analysis.

17. National Marine Fisheries Service, Southwest Region, "Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project" (June 2009)
18. The Biological Opinions also required that Reclamation take additional actions to address high river water temperatures that were adversely affecting fish.

To retain consistency in terminology, we refer to the Water Forum's proposed method as the Lower American River Modified Flow Management Standard, or *Modified FMS*. Functionally, the *Modified FMS* is intended to provide a drought buffer for the lower American River.

Methodology

In many ways, the *Modified FMS* builds and improves upon the *2006 FMS*. Similar elements include Minimum Release Requirements and adjustments, temperature management, and oversight by the American River Group as well as monitoring and adaptive management.

However, the *Modified FMS* differs from the *2006 FMS* in a few key ways. In particular, the *Modified FMS* includes a Seasonal Release Allocation which banks cold water in the event of dry conditions, and relies on more representative indices of water availability than does the *2006 FMS*. The *Modified FMS* also includes a pulse flow component of about a 1 week duration (with a 2 day peak) during March in dry and below-normal conditions. Relative to the *2006 FMS*, the *Modified FMS* also simplifies the types of adjustments that can be made to the Minimum Release Requirements and differs in what is required in off-ramp and conference years. These differences are explained below.

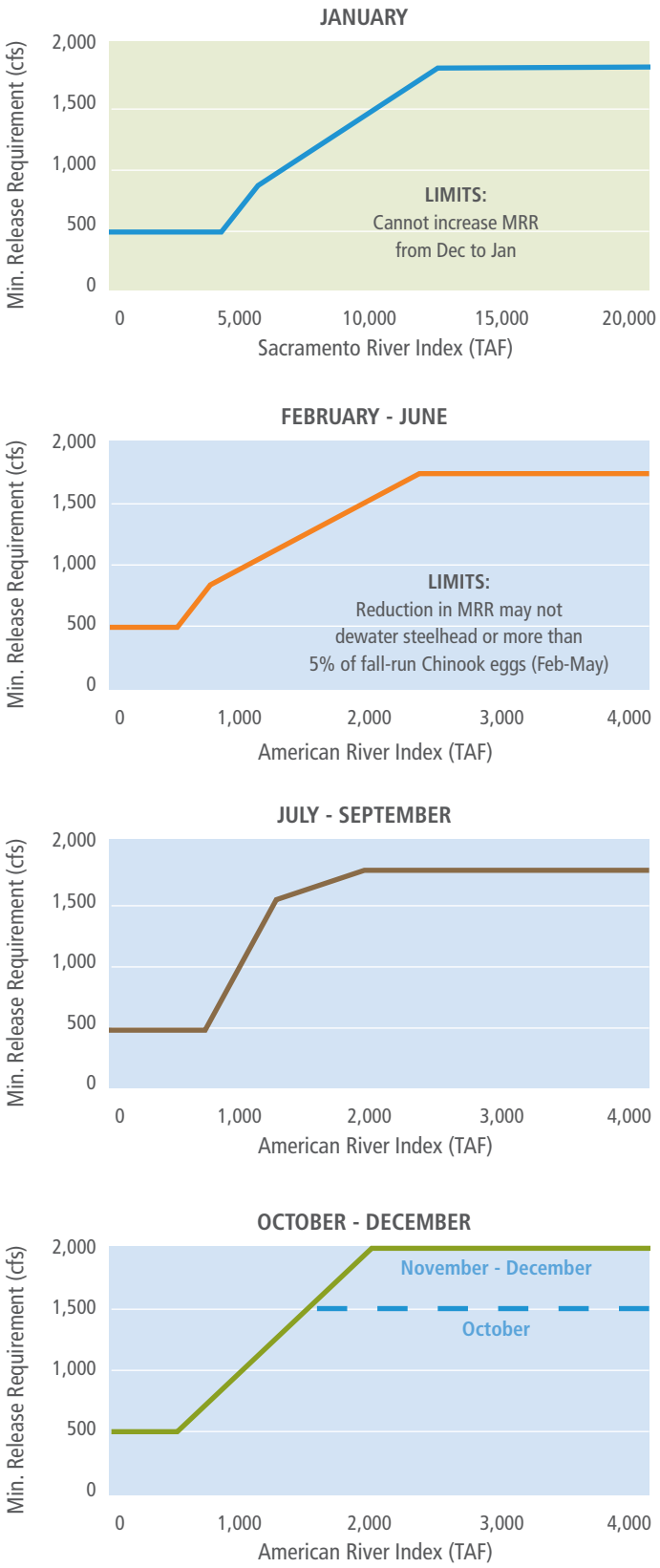
Seasonal Release Allocation/End-of-December Storage Target

Both the *2006 FMS* and the *Modified FMS* are based on Minimum Release Requirements from Folsom and Nimbus Dams. The *Modified FMS* adds an end-of-December storage target, which puts a modest limit on the amount of water that can be released from storage between June and December, and provides a reserve that improves water supply reliability and helps manage water temperatures in the river. In essence, the Minimum Release Requirements set the minimum amount of water to be released during each month, and the end-of-December storage target effectively sets the maximum amount of water that can be released over the entire season. Within these two "bookends," the seasonal and monthly allocations are computed each month starting in May.

Minimum Release Requirement

As with the *2006 FMS*, the *Modified FMS* relies on Minimum Release Requirements (from Nimbus Dam) that are based on indices of water availability. Implementation curves that are based on the indices (Figure 4) specify higher releases during wet years and lower releases during dry conditions in order to ensure adequate flows later in the season.

Figure 4. Minimum release requirements vs. hydrologic indices



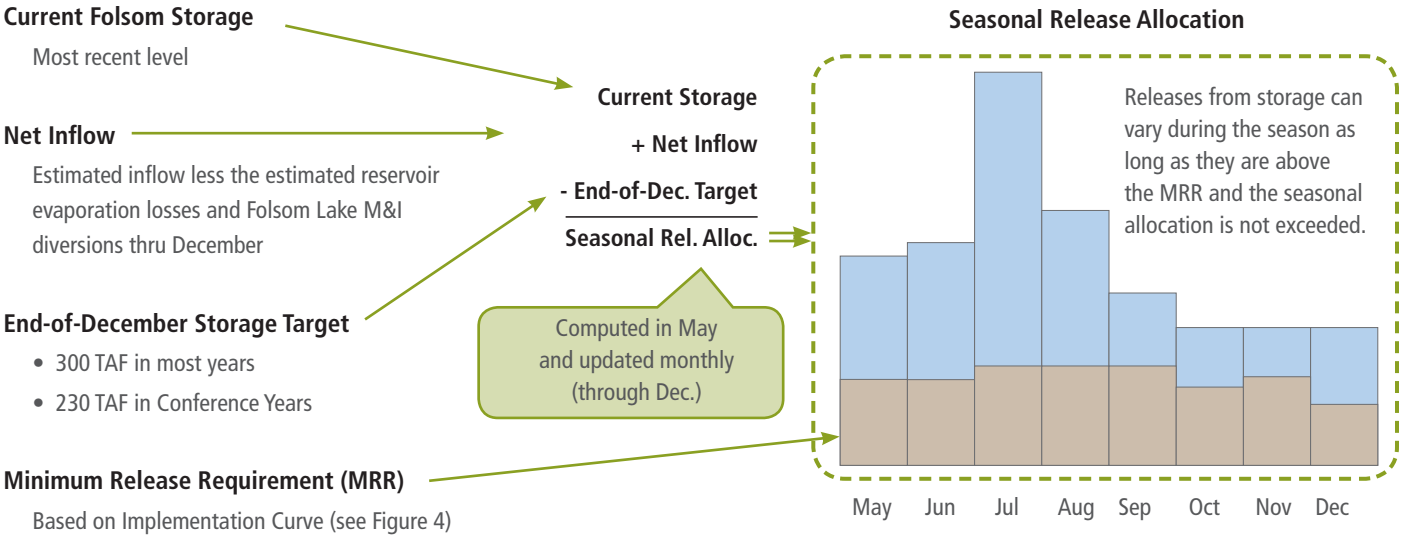
To implement the *Modified FMS*, Reclamation would compute the Minimum Release Requirements each month as new hydrology data become available and would compute the Seasonal Release Allocation each month (in May through December) based on the latest hydrologic data and water storage level in Folsom Reservoir (Figure 5). At no time, however, would the Minimum Release Requirement result in flows less than those ordered by the State Water Board in D-893.

The parameters used in the methodology reflect the California hydrologic cycle of wet winters and dry summers as well as the lifecycles of anadromous salmonids in the lower American River.

The modeling used to evaluate the *Modified FMS* assumed that Reclamation would release water for diversion by the City of Sacramento and Carmichael Water District in accordance with existing water rights and operating contract obligations. Accordingly, under the CALSIM II[19] model logic used to describe operation of the *Modified FMS*, the minimum release by Reclamation at Nimbus Dam was computed as the higher of:

- The minimum release requirement from the "implementation curves" shown in Figure 4, or
- The minimum release required under D-893 (that is, either 500 cfs or 250 cfs, depending on the date), plus diversions from Sacramento's Fairbairn Water Treatment Plant and Carmichael Water District's Bajamont Way Filtration Plant plus net river losses.

Figure 5. Method for computing seasonal release allocation



19. CALSIMII is a hydrologic-based planning model developed by DWR and Reclamation. It simulates SWP and CVP operations against a specified level of development and infrastructure with 82-years of historical hydrology and provides comparative output on potential impacts of changing California water regulations or SWP/CVP operations.

Hydrologic Indices

The system for developing the Minimum Release Requirements is based on hydrologic indices that reflect how much water is projected to be available in the lower American River system in the given year. Runoff projections are not available in January, so the best available indicator of water availability in that month is the Sacramento River Index (SRI), which estimates water conditions for a broader area (the Sacramento Valley) and a broader time scale. Both the *2006 FMS* and the *Modified FMS* use this index for January. The American River Index (ARI), as defined for use in the *Modified FMS*, is the best indicator of water availability in the American River basin for the rest of the year because it is based on the most recent projection of in-basin runoff.[20,21]

Adjustments

While the *2006 FMS* allowed for five prescriptive and two voluntary adjustments to the Minimum Release Requirements, the *Modified FMS* has only two adjustments, both designed to avoid dewatering eggs of anadromous salmonids in their spawning nests ("redds"). Specifically:

- During January, the Minimum Release Requirement cannot be increased relative to the December Minimum Release Requirements; it can only be held constant or decreased. This is because of the inherent uncertainty of the SRI, upon which the January Minimum Release Requirement is based. If the SRI proves to be overly optimistic (that is, indicates a wetter year), then the flows in the river would likely have to be reduced later in the season, resulting in increased risk of steelhead redd dewatering.
- During January through May, if the Minimum Release Requirement is reduced (based on hydrologic indices), then it will be adjusted as necessary in order to not dewater any steelhead redds or more than 5% of fall-run Chinook salmon redds.

Conference Year and Off-Ramp Conditions

As discussed above, a conference year occurs when the projected unimpaired inflow into Folsom Reservoir from March through November is computed to be less than 400,000 AF. Under the *2006 FMS*, that condition was used to suspend the Minimum Release Requirements and revert to D-893. Under the *Modified FMS*, the Minimum Release Requirements remain in effect in conference years. However, the end-of-December storage target in conference years is reduced to 230,000 AF to provide a storage reserve even in the driest years.

During off-ramp years (when Folsom Reservoir storage is forecasted to fall below 200,000 AF) the *2006 FMS* suspends the Minimum Release Requirements and reverts to D-893 to conserve reservoir storage. The *Modified FMS* does not have an off-ramp provision because it incorporates storage conservation into its primary elements.

20. The ARI is the net seasonal volume of water retained in storage (unimpaired inflow minus spill). The ARI is computed based on DWR Bulletin 120, which is published in early February and updated in March, April and May. Bulletin 120 provides a forecast of monthly unimpaired flows on rivers throughout California, and the probability of exceedance.
21. The *2006 FMS* uses the SRI in January and February, the Impaired Folsom Inflow Index (IFII) for March through September, and the Four Reservoir Index (FRI) for October through December. These other indices are now considered less representative of in-basin runoff.

PART III: RESULTS

The goals of the *Modified FMS* are to protect anadromous salmonids in the lower American River and avoid catastrophic water shortages in the basin without redirecting negative environmental impacts to other areas. As discussed previously, the lower American River is home to both steelhead and fall-run Chinook salmon. Life stages – as well as the most stressful periods – for steelhead and fall-run Chinook salmon are presented in Figure 6.

Figure 6. Life stages for steelhead and fall-run Chinook salmon

Some biologists consider March through May to be stressful for lower American River salmonids because flows deviate from the natural hydrograph, since much of the runoff from the spring snowmelt is captured to fill Folsom Reservoir.[22] June through October can be stressful due to excessively warm water temperatures.

The Water Forum modeled the performance of the *Modified FMS* and compared it to the existing *2006 FMS* as well as to a third approach – High Spring Flows – under consideration by the State Water Board that more closely mimics elements of the natural hydrograph (A description of the High Spring Flows approach is contained in Appendix A). Each flow regime was modeled using an 82-year simulation based on the hydrologic conditions from 1922 through 2003, current regulations, and projected water demand in 2030. This approach provides a comprehensive range of hydrologic conditions from critically dry to extremely wet years.

The goal of the modeling was to compare the performance of the three flow regimes on a variety of parameters, including water temperature, spawning habitat, water quality, and water supply. The performances of the *Modified FMS* and the High Spring Flows approaches relative to the *2006 FMS* (existing condition) are summarized in Table 1. A comparable table with more-detailed explanation of its evaluation metrics is provided in Appendix B.

Table 1. Summary of benefits and harm of lower American River flow regimes

	Metric		Affected Feature	Benefit / Harm: Compared to Existing Condition (2006 FMS)	
				High Spring Flows	Modified FMS
American River	Water supply	Urban deliveries	💧	↘↘	↗↗
	Steelhead spawning and rearing	Temperature	🌡	↘↘	↗↗
		Habitat	🐟	↗	↗
	Fall-run Chinook spawning and rearing	Temperature	🌡	↗	↗
		Habitat	🐟	↗	↗
		Mortality	🌡	↘	---
	Flows under 800 cfs		🐟	↗↗	↗↗
	Flows under 500 cfs		🐟	↗↗↗	↗↗↗
Sacramento River	Water supply	Ag & urban delivery	💧	---	---
	Winter-run Chinook	Temperature	🌡	↘	---
		Mortality	🌡	---	---
	Spring-run Chinook	Temperature	🌡	↘	---
		Mortality	🌡	↘	---
	Fall-run Chinook	Temperature	🌡	↘	↗
	Late fall-run Chinook	Temperature	🌡	↗	↗
	Steelhead	Temperature	🌡	---	---
Delta	Water supply	CVP ag supply	💧	↘	---
		CVP urban supply	💧	↘	↘
		SWP ag supply	💧	---	---
		SWP urban supply	💧	---	---
	Outflow		🐟	---	---
	Water quality		💧🐟	---	---

- Legend -

🌡 Water temperature effects (on salmonids)

💧 Water supply reliability

🐟 Flow and habitat for fish

Harm			No change	Benefit		
Large	Medium	Small		Small	Medium	Large
↘↘	↘	↘	---	↗	↗↗	↗↗↗

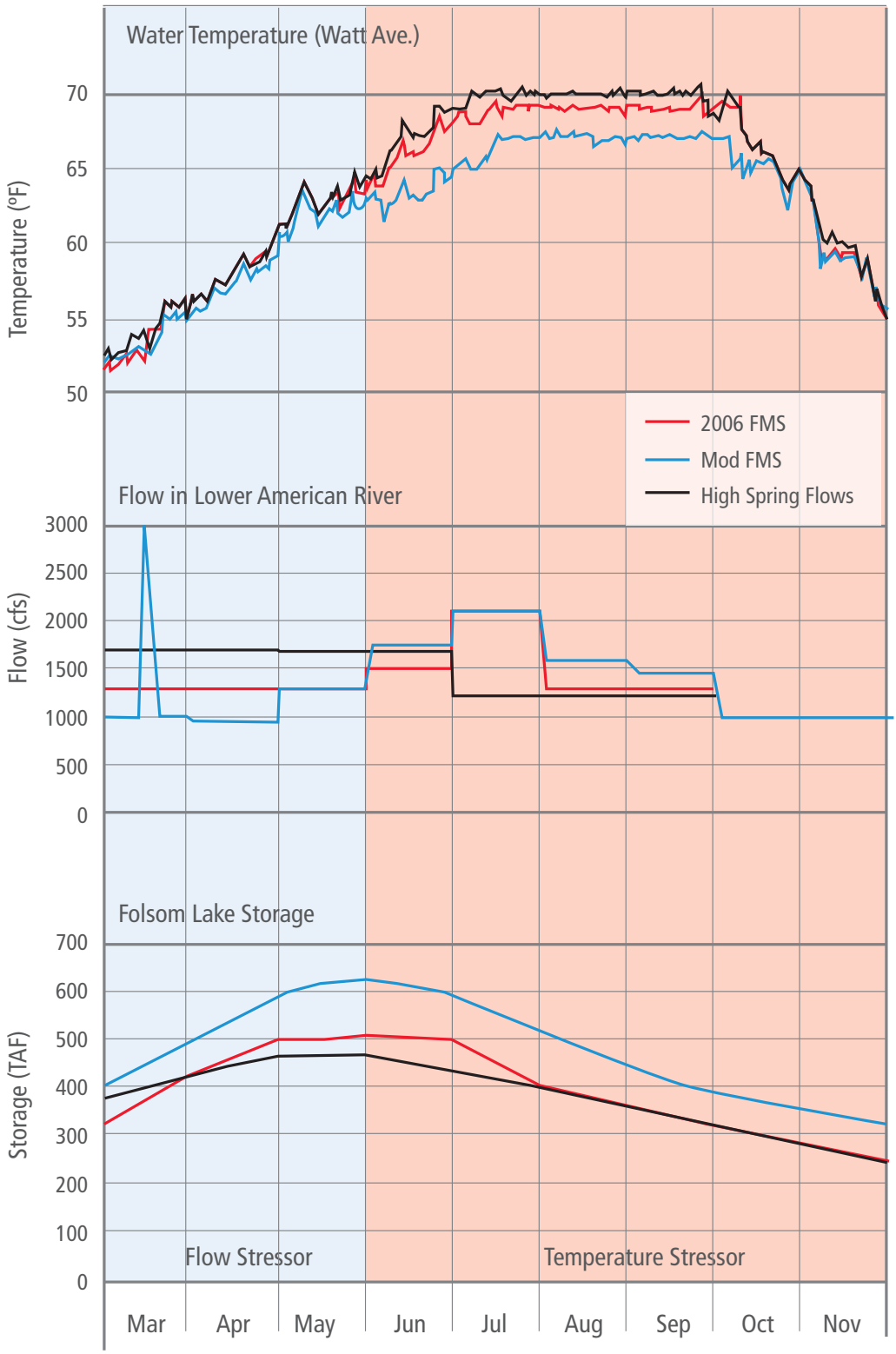
22. The elevated flows of the spring snowmelt have been identified as an important factor that shapes both physical and biological components of river systems including, but not limited to, providing rearing habitat along the channel margins and floodplains and aiding the outmigration for juvenile salmonids. Sarah M. Yarnell, et al., "Ecology and Management of the Spring Snowmelt Recession," BioScience 60:114–127 (February 2010).

As shown by Table 1, the *Modified FMS* performs exceedingly well compared with both other approaches. The modeling results show that the *Modified FMS* would:

- Significantly **lower water temperatures** in the lower American River during the crucial rearing season for juvenile steelhead. This would greatly reduce the June-October temperature stressor.
- Provide **more spawning habitat** for fall-run Chinook salmon.
- Provide **better overall habitat conditions**, particularly in the driest years. Under the *Modified FMS*, flows never drop below 500 cfs under conditions modeled in the simulation, and only rarely drop below 800 cfs.
- Significantly **improve water supply reliability** in the American River basin by avoiding low reservoir levels.
- **Avoid redirected impacts** to Sacramento River fisheries.

Figure 7 presents the performance of the three approaches over the course of a single dry year with regard to lower American River water temperature, flow, and storage (a more-detailed depiction of water temperature is provided in Appendix C). While these graphs are not representative of all water year types, they present an important snapshot of the type of water year that the *Modified FMS* is intended to address because it is most likely to create serious challenges for both water supply and salmonids. Each of the key parameters is further discussed on the following page.

Figure 7. Performance of flow regimes for a single dry year



Water Temperature

Fall-run Chinook salmon and steelhead need cool water. The optimum water temperature depends on the species and the life stage. For example, if the water temperature is higher than 65°F (18°C), juvenile steelhead can begin to experience adverse physiologic effects and greater susceptibility to disease and predators. The effects of water temperature are associated with the duration of exposure. Water temperatures at or above 72°F (22°F) for an extended period (that is, 1 or more months) can be lethal to rearing juvenile steelhead, though short-duration exposure to higher water temperatures might not result in sustained adverse effects if temperatures quickly decrease to suitable levels.

Steelhead spawn during winter, and juvenile steelhead generally rear over summer before emigrating to the ocean following winter or spring. Therefore, their biggest stressor is high water temperature during the summer, when the air temperature is hot. Fall-run Chinook salmon spawn during the fall, and the juveniles emigrate from the river before summer. Their biggest stressor is warm water temperatures and inadequate spawning flows during October and November. If the water temperature is too high during this period, the fish will not spawn, or, if they do, the eggs will not survive.

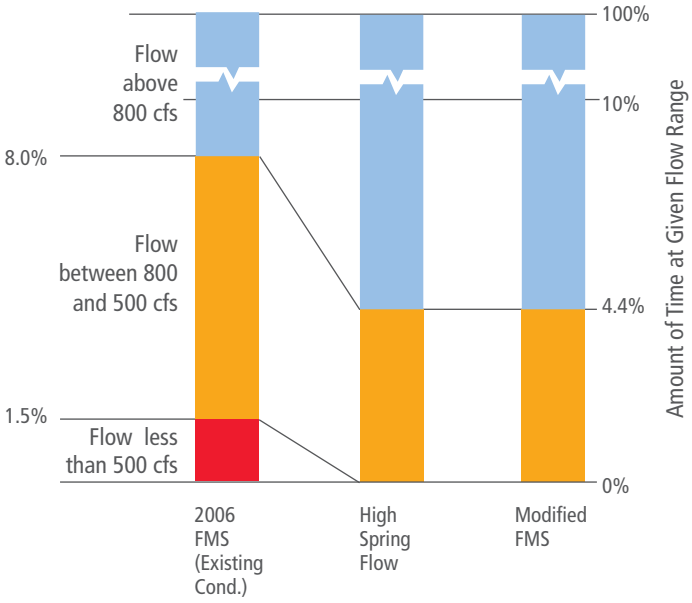
As illustrated in Figure 7, during a dry year, the *Modified FMS* results in significantly lower water temperature than the other two approaches during the key months of June through October. In contrast, the High Spring Flows approach results in higher and less healthy temperatures during the same critical period. A more comprehensive view of lower American River water temperature is provided in Appendix C.

Habitat and Flow

As described earlier, flows in the lower American River of 800 cfs provide 80% of the available spawning habitat. The maximum amount of habitat is provided at 2,000 cfs, and the amount of spawning habitat decreases at flows higher than 2,000 cfs. The Water Forum estimates that flows of 500 cfs provide about 40% of the maximum amount of spawning habitat. Accordingly, increasing flows from 500 to 800 cfs doubles the amount of spawning habitat, and flows below 500 cfs create adverse conditions for spawning and rearing.

As illustrated in Figure 8, the *2006 FMS* allows flows to drop below 800 cfs for about 7% of the simulation period and allows flows below 500 cfs for about 1.5% of the simulation. These conditions are adverse for spawning and rearing. A more detailed graphical representation of flows and habitat is provided in Appendix D.

Figure 8. Percent of time flows are below 800 cfs and 500 cfs



The *Modified FMS* and High Spring Flows approaches never allow flows below 500 cfs and allow flows to drop below 800 cfs only about 4% of the time.

Figure 7 illustrates that the High Spring Flows approach addresses the flow stressor period (March through May) with higher flows. The purpose of these higher flows is to stimulate ecological processes, including out-migration of salmonids. While the *2006 FMS* has no such spring flow functions, the *Modified FMS* addresses these ecological needs with a 2 day, 3,030-cfs pulse flow (Figure 7).

Water Supply

Water Forum modeling shows that the *Modified FMS* retains a higher level of storage in Folsom Reservoir than both other approaches and in particular avoids the dangerously low late-November storage that occurs in both of the other approaches, thereby protecting water supply reliability. Figure 7 shows that, even in a dry year, water storage is maintained at a higher level with the *Modified FMS*.

As mentioned previously, if water storage in Folsom Reservoir drops below 90,000 AF, the water level will fall below the water supply intakes at Folsom Dam and El Dorado Hills, thereby preventing local water agencies from making critical water deliveries. Even levels above 90,000 AF can impact water supply reliability. As Folsom Reservoir storage levels drop below 200,000 AF, water deliveries become significantly constrained.[23]

Figure 9 shows that over the 82-year simulation, the *Modified FMS* never draws Folsom Reservoir below 200,000 AF, while the *2006 FMS* draws the reservoir below 200,000 AF about 6% of the time and the High Spring Flows approach draws the reservoir below 200,000 AF about 14% of the time. In addition, the High Spring Flows approach draws the reservoir below 90,000 AF about 6% of the time.

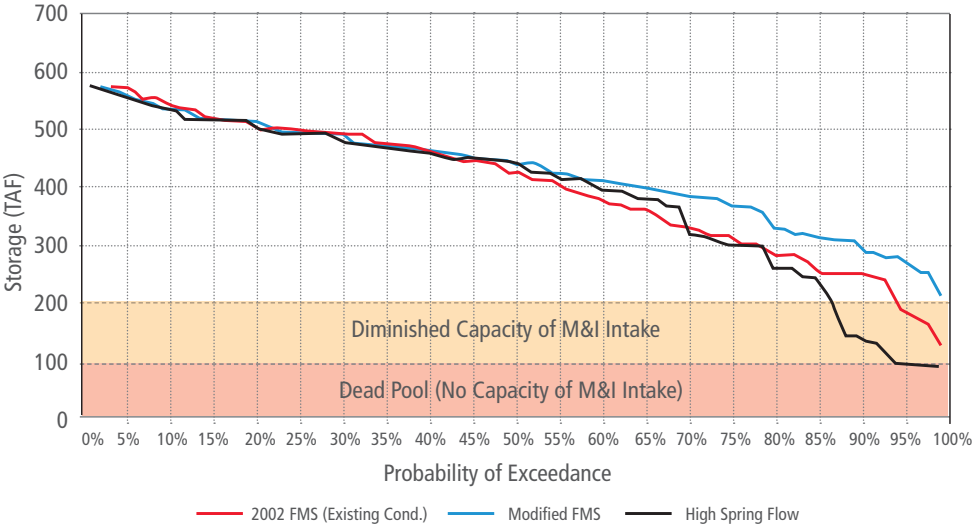
As shown earlier in Table 1, the simulation indicated that the *Modified FMS* has no impact on the Sacramento River resources and has the potential to cause only slight reductions in municipal and industrial CVP contract deliveries south of the Delta.

Fine-Tuning

Even after the Water Forum identified the *Modified FMS* as the most promising approach, it continued to fine-tune the End-of-December Storage Target for Folsom Reservoir in order to maximize benefits and avoid or minimize negative impacts.

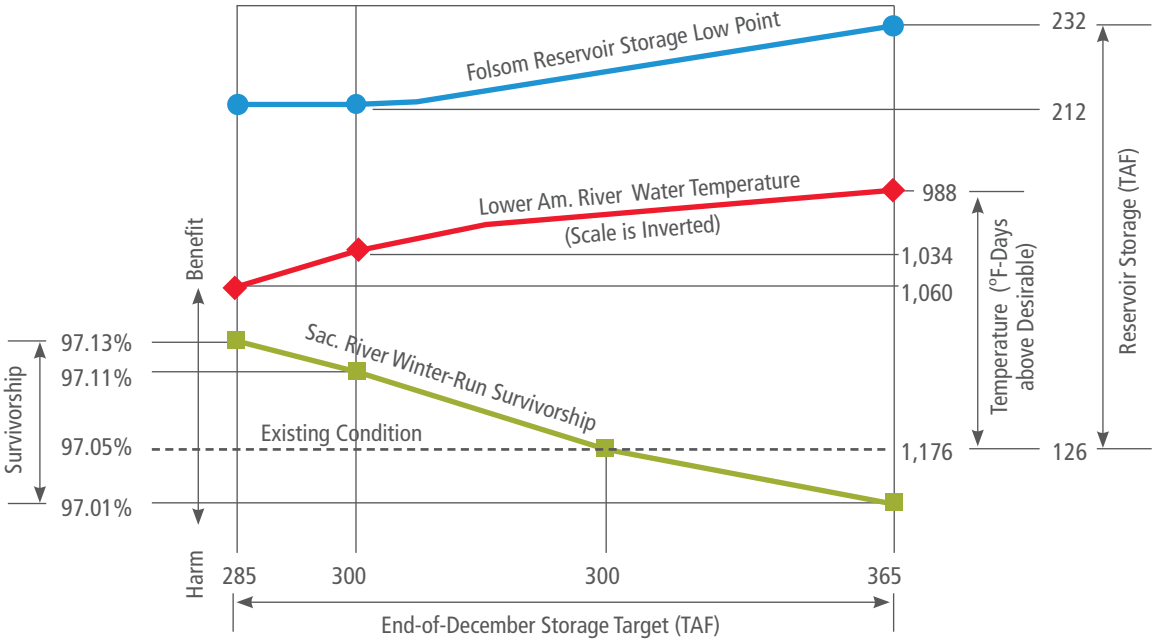
The Water Forum modeled and evaluated storage target values ranging from 285 to 365 thousand acre-feet (TAF). As illustrated in Figure 10, a storage target of 300 TAF appears to be the "sweet spot" where significant American Basin benefits are realized but Sacramento River harm is avoided. At a higher storage target value, 365 TAF, we gain marginal benefit to lower American River temperature and water supply reliability, but survivorship of Sacramento River winter-run Chinook salmon decreases below the existing condition – this is considered to be an unacceptable re-directed impact.

Figure 9. Probability of exceedance of end-of-November storage in Folsom Reservoir



23. Modeling performed by the California Department of Water Resources, which extends to 2065 level of demand and accounts for climate change. This modeling shows that, with current operations, Folsom Reservoir storage would drop below 90,000 AF, thereby disabling the water supply intake, in about 1 out of every 10 years in the future. Due to time and resource constraints, the Water Forum's modeling only extends to the 2030 level of demand and does not account for the effects of climate change. Therefore, the Water Forum's modeling does not show water storage under the *2006 FMS* dropping to 90,000 AF, but does show water storages causing significant reductions in municipal water deliveries.

Figure 10. Results of tuning the *Modified FMS* to avoid impacts to Sacramento River fisheries



PART IV: CONCLUSION

The Water Forum has expended significant effort over many years studying flow management approaches for the lower American River. During this time, there has been both a shifting of priorities – from salmon to steelhead – and an evolution of understanding that water temperature, perhaps even more than flow, plays a key role in restoring and protecting threatened species in the system. There is also a widespread acknowledgment that this drought will not be the last one, and that the lower American River system, along with the rest of the Bay-Delta system and the entire state, is likely to face increasing stress in the future as a result of the changing climate. Thus, it is imperative that we improve the management of the river to protect fish and wildlife while also ensuring a reliable water supply for the communities that depend on the river.

We believe that the *Modified FMS* is the best approach that has been identified for protecting and restoring anadromous salmonids in the lower American River, while also improving water supply reliability. The *Modified FMS* has been developed to avoid redirected impacts and to operate within the current regulatory schema. Future study might lead to new approaches and even greater improvements. The Water Forum is committed to working with the state and federal agencies on the *Modified FMS*, to learn from the adaptive management that is part of this approach, and to continue our efforts to protect all uses of the lower American River.

APPENDIX A. Assumptions for High Spring Flows Approach

High Spring Flows Approach

The High Spring Flows approach (HSFA) was developed to be consistent with the approach described by State Water Board and staff in the following documents and communications:

- Public Workshop, Method to Develop Flow Criteria for Priority Tributaries to the Bay-Delta, State Water Board, March 2014
- Recommendations for Determining Regional Instream Flow Criteria for Priority Tributaries to the Sacramento-San Joaquin Delta, Delta Science Panel, 2014
- Personal Communication on idealized tributary flows, Daniel Shultz and William Anderson, May 18, 2015

The HSFA was developed to represent some components of the natural hydrograph, specifically elevated flows during the spring to emulate snowmelt runoff, in order to activate a variety ecological processes including, but not limited to:

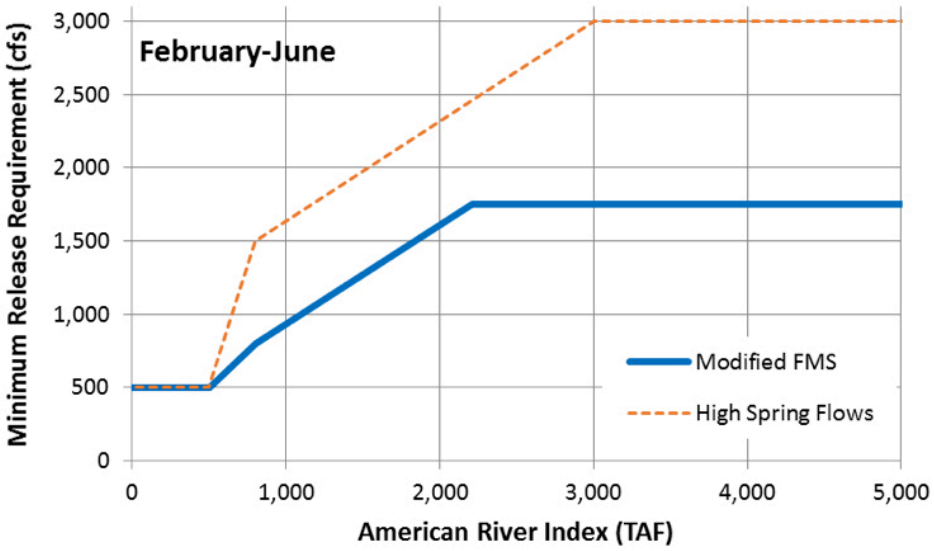
- Inundate off-channel areas (e.g., high flow secondary channels, channel margins, and bar features) to provide habitat for rearing salmonids and to flush allocthonous material (i.e., organic matter not derived from the main channel) into the main channel.
- Provide a cue and additional habitat availability for spring spawning native fishes.
- Assist outmigration and/or redistribution of juvenile native fishes, both by assisting downstream travel due to higher downstream velocities, but also by increased turbidity and habitat availability along the channel margins.

The HSFA was developed as a variation on the Modified FMS so as to create a reasonable comparison to our proposed alternative. It includes all of the elements of the Modified FMS with the exception of the March Pulse Flow, but with a different relationship between the American River Index (ARI) and the Minimum Release Requirement (MRR) for February through June. The HSFA includes higher MRR values relative to the Modified FMS for February and June. This was the primary function used to create the higher spring flows.

The values of the MRR were developed to create a reasonable increase in spring flows. If the spring flows were too high, they would unreasonably deplete Folsom Reservoir storage and cold-water pool, thereby unreasonably disadvantaging the HSFA. If the MRR were too low, then the HFSA would not provide the intended higher spring flow benefits.

Figure A.1 shows the relationship between the hydrologic index and MRR for the HSFA and the Modified FMS.

Figure A.1. Minimum Release Requirements for High Spring Flows approach and Modified FMS.



Detailed Summary of Impacts and Benefits of Lower American River Flow Regimes										
Indicator				Existing: 2006 FMS	High Spring Flows			Modified FMS		
Metric	Affected Feature	Units	Beneficial Change	Baseline Value	Value	Change from Baseline	Benefit	Value	Change from Baseline	Benefit
American River										
Water supply: days of reduced deliveries		Days of simulation	↓ (-)	150	200	33%		100	-33%	
Steelhead spawning and rearing										
Juvenile: temp. above desirable (65°F) during critical years		°F-days	↓ (-)	1027	1243	21%		871	-15%	
Habitat: weighted useable area during critical years		% of Maximum of weighted useable area	(+) ↑	79	91	15%		83	5%	
Fall-run Chinook spawning and rearing										
Temperature above desirable (65°F) during critical years		°F-days	↓ (-)	200	183	-9%		198	-1%	
Habitat: weighted useable area during critical years		% of Maximum	(+) ↑	78	80	3%		81	5%	
Mortality (temperature-related)		% Mortality	↓ (-)	7	8	10%		7	0%	---
Flows under 800 cfs		% of Simulation	↓ (-)	8.0	4.4	-45%		4.4	-45%	
Flows under 500 cfs		% of Simulation	↓ (-)	1.5	0.0	-100%		0.0	-100%	

(Continued…)

Detailed Summary of Impacts and Benefits of Lower American River Flow Regimes											
Indicator				Existing: 2006 FMS	High Spring Flows			Modified FMS			
Metric	Affected Feature	Units	Beneficial Change	Baseline Value	Value	Change from Baseline	Benefit	Value	Change from Baseline	Benefit	
Sacramento River											
Total CVP & SWP deliveries north of the delta	💧	TAF/Year	🡻 (-)	3,322	3,318	0%	---	3,322	0%	---	
Winter-run Chinook											
Temperature above desirable (56°F) during critical years	🌡	°F-days	🡻 (-)	406	412	1%	↘	404	0%	---	
Mortality (temperature-related)	🌡	% Mortality	🡻 (-)	2.9	2.9	0%	---	2.9	0%	---	
Spring-run Chinook											
Temperature above desirable (56°F) during critical years	🌡	°F-days	🡻 (-)	47	50	6%	↘	47	0%	---	
Mortality (temperature-related)	🌡	% Mortality	🡻 (-)	10.9	11.4	5%	↘	10.9	0%	---	
Fall-run Chinook											
Temperature above desirable (56°F) during critical years	🌡	°F-days	🡻 (-)	50	53	6%	↘	49	-2%	↗	
Late fall-run Chinook											
Temperature above desirable (56°F) during critical years	🌡	°F-days	🡻 (-)	55	54	-2%	↗	52	-5%	↗	
Steelhead temperature above desirable (65°f) critical years	🌡	°F-days	🡻 (-)	4	5	25%	---	5	25%	---	

(Continued...)

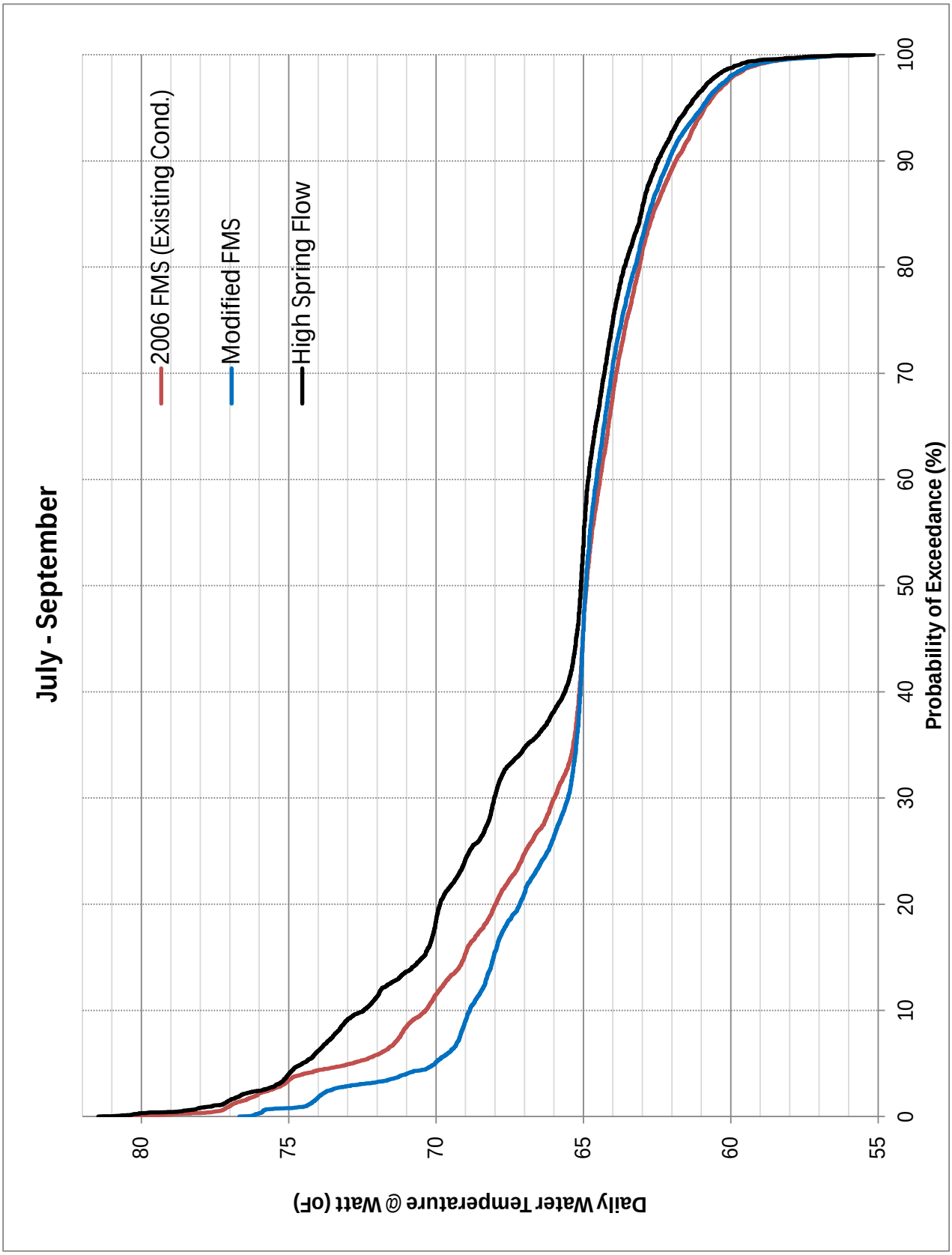
Detailed Summary of Impacts and Benefits of Lower American River Flow Regimes											
Indicator				Existing: 2006 FMS	High Spring Flows			Modified FMS			
Metric	Affected Feature	Units	Beneficial Change	Baseline Value	Value	Change from Baseline	Benefit	Value	Change from Baseline	Benefit	
Delta											
Water Supply Reliability (South of Delta Deliveries)											
CVP ag deliveries	💧	TAF/Year	(+) ↑	929	920	-1%	↘	931	0%	---	
CVP urban deliveries	💧	TAF/Year	(+) ↑	118	117	-1%	↘	117	-1%	↘	
SWP ag deliveries	💧	TAF/Year	(+) ↑	634	637	0%	---	634	0%	---	
SWP urban deliveries	💧	TAF/Year	(+) ↑	1,835	1,841	0%	---	1,838	0%	---	
Average monthly surplus delta outflow	🐟	cfs	(+) ↑	13,652	13,689	0%	---	13,653	0%	---	
Water quality: location of X2	💧 🐟	km	↓ (-)	74	74	0%	---	74	0%	---	

Legend:

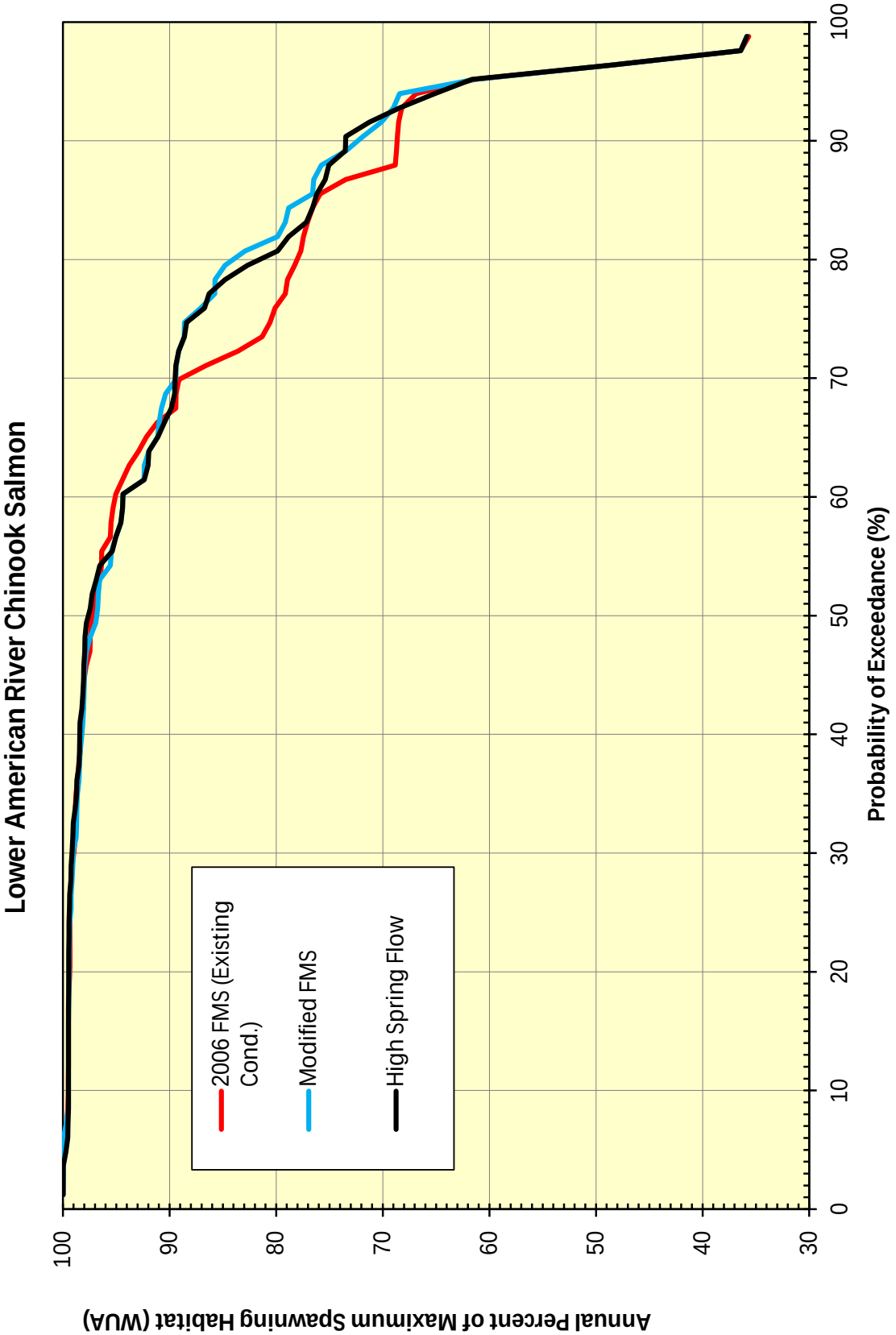
- Water temperature effects (on salmonids)
- Water supply reliability
- Flow and habitat for fish

Harm			No change	Benefit		
Large	Medium	Small		Small	Medium	Large
↘	↘	↘	---	↗	↗	↗

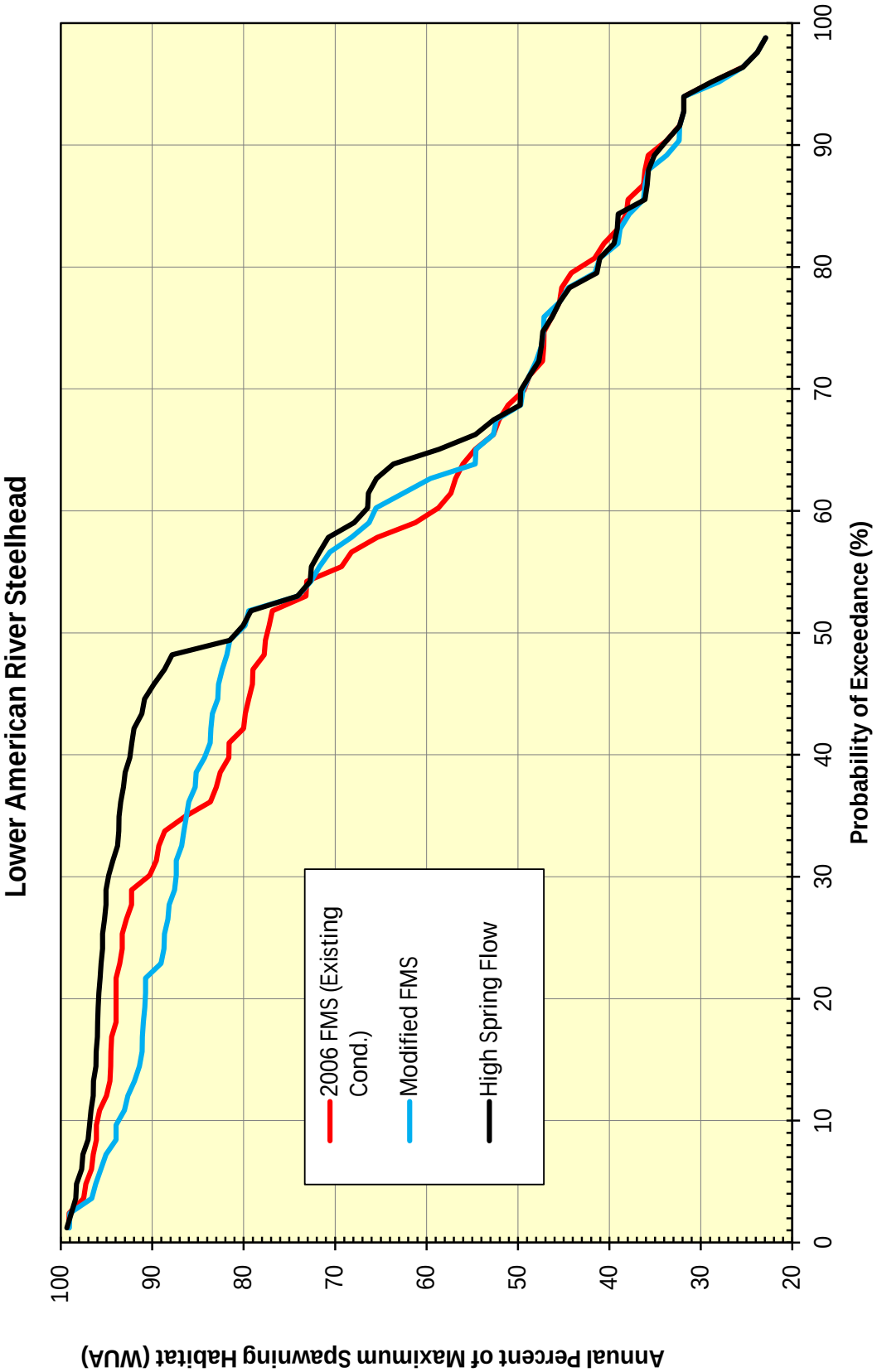
APPENDIX C. Exceedance Graph of Water Temperature



APPENDIX D. Exceedance Graphs of Salmonid Spawning Habitat



APPENDIX D. Exceedance Graphs of Salmonid Spawning Habitat



Sacramento Water Forum
2831 G St., Ste. 100
Sacramento, CA 95816

waterforum.org