Authority Land Management Committee Meeting Agenda

Date: July 9, 2021 **Location:** Maxwell / Virtual

Time: 3:00pm – 5:00pm

Leader:	Supervisor Gary Evans	**Recorder:**	Conner McDonald

Purpose: Update on activities associated with the project mitigation cost estimate, Section 106 permitting, geotechnichal investigations, and real estate activites

Attendees:

Supervisor Gary Evans (Colusa)
Supervisor Ken Hahn (Glenn)
Jeff Sutton (TCCA)
Logan Dennis (GCID)

Mike Azevedo (Colusa)
Thad Bettner (GCID)
Jerry Brown (Sites)
Kevin Spesert (Sites)
Ali Forsythe (Sites)

Conner McDonald (HDR)
Henry Luu (HDR)
Jeriann Alexander (Fugro)
Pete Rude (Jacobs)
Jeff Smith (Jacobs)
Mark Twede (Jacobs)
Derek Morley (Geosyntec)
Brian Martinez (Geosyntec)
Larry Fishman (Vanderweil)
Jeff Herrin (AECOM)
Howard Michael (AECOM)
Michael Smith (AECOM)
Michael Forrest (AECOM)

Agenda:

Discussion Topic	**Topic Leader**	**Time Allotted**
• Introductory Remarks	Evans	3 minutes
• Meeting Minutes & Action Item Follow Up	Evans	2 minutes
• Review updated project mitigation cost estimate • **Requested Action:** Feedback/Direction	Forsythe	30 minutes
• Discussion on Section 106 activites • **Requested Action:** Feedback/Direction	Forsythe	20 minutes
• Review of proposed Amendment 3 workplan geotechnical investigations locations • **Requested Action:** Feedback/Direction	Luu	40 minutes
• Amendment 3 Real Estate approach/considerations • **Requested Action:** Feedback/Direction	Spesert	20 minutes

• Action Items and Closing Comments	Evans	5 minutes

Agenda Item #1 – Introductory Remarks – Supervisor Gary Evans

Meeting called to order at 3:00pm by Supervisor Gary Evans.

Kevin Spesert confirmed Attendees.

Attendees introduced themselves.

Agenda Item #2 – Meeting Minutes & Action Item Follow-Up – Supervisor Gary Evans

Meeting Minutes from prior meeting have been reviewed.

Agenda Item #3 – Review of Updated Project Mitigation Cost Estimate – Ali Forsythe

Ali Forsythe presented on the Mitigation Cost Estimate, providing background on how the cost was arrived at. The mitigation activities will have an effect on land activities, and the estimate will be refined over time, with the current estimate providing a good anticipated cost.

The current mitigation estimate is based upon the 2016 Technical Memo that was part of the USBR process. This memo looked at specific resources and all impacts; added greenhouse gas emissions; and considered broad categories, monitored over time.

In developing the current estimate, the Project Team worked with the EIR / EIS Team, and looked at all mitigation measures – upfront versus long-term monitoring versus construction. These costs were placed where they most logically fit, and the 2016 Memo was used as the basis.

There were changes to the Terrestrial and Land Cover sections, based on outreach to Westervelt, RES, Wildlands, to determine current cost with regard to mitigation bank credits in today's market. ASFMRA was also used as a resource to confirm land value numbers. The mitigation ratio is determined by negotiations with agencies during the permit process.

Ali Forsythe presented a table identifying the resources, and planning-level cost estimates, totaling $562,477,300, and compared this cost estimate to the 2020 Value Planning Estiamte of $540,000,000, identifying the line-item changes between the two.

USBR undertakes mitigation in a different manner than others would – USBR mitigation costs are based upon land acquisition costs. Sites' process will differ from the USBR process. Sites will have lifecycle costs for mitigation; and the estimate assumes a suite of mitigation options, including both on-site and use of a mitigation bank.

At this time, there is not land access to conduct surveys – land has been mapped by aerial desktop surveys, and information is coarse. When land access is possible, there will be much work to ground truth what has been identified, and refine the mitigation needs.

The Committee asked how the removal of the Delevan Pipeline from the proposed project features affects the Project's mitigation needs.

Ali Forsythe advised that much of the costs for the Delevan Pipeline were assumed as temporary impacts (construction-related) for Giant Garter Snake, and not accounted for in the 2016 costs.

The Committee asked if the cost estimate could be refined via obsersations of the land made from the public right-of-way.

Ali Forsythe advised that the agencies will want surveys that occur on the actual ground being affected.

With regard to Terrestrial Wildlife Resourses / Wildlife Habitat, credit stacking is applied where applicable. With regard to Vernal Pool Brachiopods, the cost assumes presence, with the modeled habitat to be verified, and confirmed for presence/absence.

With regard to Agricultural Lands, the variation from the Value Planning Estimate is currently estimated at +$15M.

With regard to next steps, the Project Team will continue to refine effects, refine assumptions, minimize impacts through design refinements, work with agencies to solidify ratios, and conduct surveys as access becomes available.

Agenda Item #4 – Review of Proposed Amendment 3 Workplan Geotechnical Investigation Locations – Henry Luu

H Luu introduced the topic, and advised that the Project Team has been working to refine the geotech needs since the last discussion of this matter, and hopes to have a good idea of the anticipated geotech needs by the end of July, with the primary focus being on the geotech work required for permitting and water right certainty.

Jeriann Alexander presented on the geotech effort, and advised that there has been geotechnical data collected to support the engineering feasibility studies, allowing for concept assessments, preliminary alternatives evaluations, development of preliminary cost estimates, and identification of scope for future design-level data collection. These efforts have not been sufficient to complete engineering analysis and design, gain regulatory acceptance, or refine construction cost estimating.

The design-level field data collection is envisioned to support the engineering design of all project elements, support refined construction cost estimates, facilitate development of construction drawings, answer jurisdictional versus non-jurisdictional questions, and garner jurisdictional acceptance.

Jeriann Alexander presented on the anticipated investigation areas of the GCID Headworks, Sites Reservoir Dams and associated facilities, and the Dunnigan Pipeleline; with the anticipated types of investigations including geologic mapping, utility locating, geophysics, CPTs, borings, piezometers, well tests, test pits, trenching, and test-fill.

The proposed Amendment 3 work has been categorized into Phase I and Phase II, with Phase I focusing on limited data collection for specific features, and Phase II focusing on data collection for overall 30% design.

Agenda Item #5 – Discussion of Section 106 Activites – Ali Forsythe

Ali Forsythe advised that the Section 106 activities have land implications. NHPA requires agencies to consult regarding the potential effects on cultural resources. USBR has agreed to be the lead federal agency responsible for Section 106 compliance for the project.

The basic steps in the Section 106 process include initiation, identification of historic properties, assessment of the Project on the identified resources, and resolution of adverse effects to the identified properties.

Project effects are difficult to determine as there is a large project footprint, land without access permission, and multiple alternatives. Under this scenario, a Programmatic Agreement is the right mechanism to address the 106 needs. The Agreement will outline the procedures for identifying and considering historic properties that could be affected by the Project, and will include any proposed plans, inventories, evaluations, mitigation measures, and reporting that is agreed to.

USBR has sent correspondence to the appropriate parties, and is revising a draft agreement provided by the Authority. Biweekly coordination calls are being conducted to advance this effort. Based on the anticipated schedule, the parties hope to develop a general consensus by early 2022, and have the agreement prepared for signature at that time.

The plan will require engagement with Landowners, and there will be a need to talk with Landowners prior to the rule coming out.

Cemetery Relocation has been considered as part of this process.

Agenda Item #6 – Amendment 3 Real Estate Approach / Considerations – Kevin Spesert

Kevin Spesert presented on the real estate approach and considerations for Amendment 3, and advised that the real estate process builds upon the field work from prior years, and the Real Estate Policy that was approved by the Committee and the Board.

For the upcoming Amendment 3, it is anticipated that there will be field work occurring on both public lands and private lands. Private Landowners are all unique individuals, and process the negotiations for access permission in their own ways. Negotiations with Landowners can be very complex, and require long lead times. The Project can move only as fast as the Landowners are comfortable to do so, and the Team must respect their timeframe and involvement. Some Landowners will not allow access to field work locations.

The right-of-entry program from Amendment 3 will be similar to that of the past. Compensation will be a component of access to private lands. Depending on the number of activities proposed, some levels of compensation may be much more than in the past. Compensation is an important component in the negotiation process, and has resulted in collaborative discussions with Landowners.

In addition to the geotechnical work considerations, Landowners will have logistical requirements, and activities that are not workable for them. Access routes, timing, seasonality, project work schedule, wildfire risk, tenants, agricultural operations, harvest, livestock, and go / no-go areas are all considerations and terms of the negotiations. Landowners set these terms and the negotiation schedule. The Project Team wants to ensure that all discussions with Landowners are done collaboratively, and with respect to the Landowner's time, terms, and conditions.

Kevin Spesert advised that option agreements may be useful in offering additional options to the Project and Landowners, and may help provide some certainty in land delivery.

Conner McDonald presented on the use of option agreements in land acquisition-negotiation, and advised that such agreements allow the opportunity, with a willing Landowner, to agree to terms regarding purchase rights for necessary lands. Such agreements have a focused and specific use, but could also be used as a vehicle for field access, if amenable to the Landowner.

Kevin Spesert advised that the next steps for the Real Estate Team involve planning for the upcoming field activities, developing a plan and approach for the right-of-entry program, and considering a plan and approach with regard to option agreements. This planning will be based upon the successes of the 2019 and 2020 field work campaigns. The Team has built collaborative relationships with the Landowners and the Community from Day 1, and this gives an enhanced opportunity to discuss field access.

Agenda Item #7 – Action Items and Closing Comments – Supervisor Gary Evans

The meeting was adjourned at 5:16pm.

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Agenda Item #7 – Action Items and Closing Comments – Supervisor Gary Evans

The meeting was adjourned at 5:16pm.

From: Eric Leitterman [ELeitterman@valleywater.org]
Sent: 10/1/2021 12:55:35 PM
To: Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Andrew Garcia [AndrewGarcia@valleywater.org]
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin,

I would like to request results from the CALSIM runs for Alternative 1B with Historic hydrology and for Alternative 1B with 2030 WSIP Hydrology. Specifically, what I am looking for are the monthly time step results for SOD exports of Sites Water for SOD of Delta PWAs only (No Refuge Water, No transfers from NOD PWAs).

I would also like to request the end of month storage levels in the SOD PWA bucket from the same two runs.

I know these requests may take some post processing to accomplish. Please let me know if staff have the bandwidth to accommodate my request and if so when I can expect to have my requests to be fulfilled.

ERIC LEITTERMAN
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Valley Water

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www.valleywater.org

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Friday, June 11, 2021 9:52 AM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

Apologies for the delay on this and thanks for the reminder. I thought I had sent this out but looked back and could not find it. Here is the table, where an X indicates model runs that have been performed and are available.

	Project Size/Level of Federal Investment	Historic hydrology	2035 Central Tendency Climate Change	2030 WSIP Climate Change	2070 WSIP Climate Change
No Action	No project	X	X	X	X
Alternative 1A	1.5 MAF	X	X		

	No federal funding				
Alternative 1B	1.5 MAF 7% federal funding	X	X	X	X
Alternative 2	1.3 MAF No federal funding	X	X		
Alternative 3	1.5 MAF 25% federal funding	X	X		

I will also send this out to the full workgroup after next week's meeting.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Wednesday, May 26, 2021 1:51 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin

Did you ever send out the table of alternatives you mentioned your email below? I can't find it in my records and may have missed it.

ERIC LEITTERMAN
ASSOCIATE ENGINEER - CIVIL
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Tel. (408) 630-2669 / Cell. (408) 784-4966
eleitterman@valleywater.org

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, April 19, 2021 10:08 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; Dwayne Chisam

<DChisam@avek.org>; 'Robert Cheng' <RCheng@cvwd.org>; pvasileva@cvwd.org; Mark Krause <MKrause@dwa.org>; Paul Weghorst <weghorst@irwd.com>; Kellie Welch <welch@irwd.com>; 'Randall Neudeck' <rneudeck@mwdh2o.com>; 'CWang (cwang@mwdh2o.com)' <cwang@mwdh2o.com>; Bradshaw,Dee <VBradshaw@mwdh2o.com>; Sheehan,Rebecca D <RSheehan@mwdh2o.com>; Dan Bartel <dbartel@rrbwsd.com>; 'Bob Tincher' <bobt@sbvmwd.com>; Heather Dyer <heatherd@sbvmwd.com>; Jeff Davis <jdavis@sgpwa.com>; Eric Leitterman <ELeitterman@valleywater.org>; 'Dirk Marks' <dmarks@scvwa.org>; 'AFlores (AFlores@zone7water.com)' <AFlores@zone7water.com>; Xie, Lillian <lxie@zone7water.com>; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde <rkunde@wrmwsd.com>
Cc: Jerry Brown <jbrown@sitesproject.org>; JP Robinette <JRobinette@BrwnCald.com>; Alicia Forsythe <aforsythe@sitesproject.org>; steve.micko@jacobs.com; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites South of Delta/SWP Modeling

Good morning,

Thank you for your participation in last week's modeling meeting. Attached is the PowerPoint presentation. I will also be following up with a table describing the alternatives that have been modeled and the associated hydrology. Please reach out if you would like any of the data or available results we discussed. For those of you who have already requested information, I will be getting back to you shortly.

Best,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9756

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-----Original Appointment-----
From: Heydinger, Erin
Sent: Wednesday, March 31, 2021 5:13 PM
To: Heydinger, Erin; fhernandez@cityofamericancanyon.org; Dwayne Chisam; Robert Cheng; pvasileva@cvwd.org; Mark Krause; Paul Weghorst ; Kellie Welch; Randall Neudeck; CWang (cwang@mwdh2o.com); Bradshaw,Dee; Sheehan,Rebecca D; Dan Bartel; Bob Tincher; Heather Dyer; Jeff Davis; ELeitterman@valleywater.org; Dirk Marks; AFlores (AFlores@zone7water.com); Xie, Lillian; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde
Cc: Jerry Brown; JP Robinette (JRobinette@BrwnCald.com); Alicia Forsythe; steve.micko@jacobs.com; Thayer, Reed/SAC; Leaf, Rob/SAC
Subject: Sites South of Delta/SWP Modeling
When: Tuesday, April 13, 2021 2:00 PM-4:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Good afternoon – the meeting agenda is attached. Thanks!

Thanks for your responses to the Doodle poll. This invite is to discuss Sites modeling assumptions for Delta and South of Delta participants. **Please RSVP** so we can ensure we do not exceed the quorum limit. Agenda coming soon.

Microsoft Teams meeting

Join on your computer or mobile app
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(833) 255-2803,,895164312#   United States (Toll-free)

Phone Conference ID: 895 164 312#

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From: Eric Leitterman [ELeitterman@valleywater.org]
Sent: 10/1/2021 2:19:30 PM
To: Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Andrew Garcia [AndrewGarcia@valleywater.org]
Subject: RE: Sites South of Delta/SWP Modeling

I am looking for Exports at Banks.

Next week should be just fine for me.

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Friday, October 1, 2021 1:54 PM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

This information should be pretty easy to pull together. I should be able to send you something next week. Are you looking for exports at Banks or reservoir releases (no losses accounted for).

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Friday, October 1, 2021 12:56 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

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	No federal funding				
Alternative 3	1.5 MAF 25% federal funding	X	X		

I will also send this out to the full workgroup after next week's meeting.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Wednesday, May 26, 2021 1:51 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin

Did you ever send out the table of alternatives you mentioned your email below? I can't find it in my records and may have missed it.

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ASSOCIATE ENGINEER - CIVIL
Imported Water Unit
Water Supply Division
Tel. (408) 630-2669 / Cell. (408) 784-4966
eleitterman@valleywater.org

SANTA CLARA VALLEY WATER DISTRICT
5750 Almaden Expressway, San Jose CA 95118
www.valleywater.org

Clean Water · Healthy Environment · Flood Protection

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, April 19, 2021 10:08 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; Dwayne Chisam <DChisam@avek.org>; 'Robert Cheng' <RCheng@cvwd.org>; pvasileva@cvwd.org; Mark Krause <MKrause@dwa.org>; Paul Weghorst <weghorst@irwd.com>; Kellie Welch <welch@irwd.com>; 'Randall Neudeck' <rneudeck@mwdh2o.com>; 'CWang (cwang@mwdh2o.com)' <cwang@mwdh2o.com>; Bradshaw,Dee <VBradshaw@mwdh2o.com>; Sheehan,Rebecca D <RSheehan@mwdh2o.com>; Dan Bartel <dbartel@rrbwsd.com>; 'Bob Tincher'

<bobt@sbvmwd.com>; Heather Dyer <heatherd@sbvmwd.com>; Jeff Davis <jdavis@sgpwa.com>; Eric Leitterman <ELeitterman@valleywater.org>; 'Dirk Marks' <dmarks@scvwa.org>; 'AFlores (AFlores@zone7water.com)' <AFlores@zone7water.com>; Xie, Lillian <lxie@zone7water.com>; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde <rkunde@wrmwsd.com>
Cc: Jerry Brown <jbrown@sitesproject.org>; JP Robinette <JRobinette@BrwnCald.com>; Alicia Forsythe <aforsythe@sitesproject.org>; steve.micko@jacobs.com; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites South of Delta/SWP Modeling

Good morning,

Thank you for your participation in last week's modeling meeting. Attached is the PowerPoint presentation. I will also be following up with a table describing the alternatives that have been modeled and the associated hydrology. Please reach out if you would like any of the data or available results we discussed. For those of you who have already requested information, I will be getting back to you shortly.

Best,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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-----Original Appointment-----
From: Heydinger, Erin
Sent: Wednesday, March 31, 2021 5:13 PM
To: Heydinger, Erin; fhernandez@cityofamericancanyon.org; Dwayne Chisam; Robert Cheng; pvasileva@cvwd.org; Mark Krause; Paul Weghorst ; Kellie Welch; Randall Neudeck; CWang (cwang@mwdh2o.com); Bradshaw,Dee; Sheehan,Rebecca D; Dan Bartel; Bob Tincher; Heather Dyer; Jeff Davis; ELeitterman@valleywater.org; Dirk Marks; AFlores (AFlores@zone7water.com); Xie, Lillian; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde
Cc: Jerry Brown; JP Robinette (JRobinette@BrwnCald.com); Alicia Forsythe; steve.micko@jacobs.com; Thayer, Reed/SAC; Leaf, Rob/SAC
Subject: Sites South of Delta/SWP Modeling
When: Tuesday, April 13, 2021 2:00 PM-4:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Good afternoon – the meeting agenda is attached. Thanks!

Thanks for your responses to the Doodle poll. This invite is to discuss Sites modeling assumptions for Delta and South of Delta participants. **Please RSVP** so we can ensure we do not exceed the quorum limit. Agenda coming soon.

Microsoft Teams meeting

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Preliminary Flow Capacity of Funks Creek and Stone Corral Creek Draft Technical Memorandum

To:	Sites Project Authority
CC:	Henry Luu, P.E. (HDR)
Date:	September 28, 2021
From:	Frans Lambrechtsen/Jacobs Joey Sinclair/Jacobs
Quality Review:	Duane McClelland/Jacobs Peter Rude, P.E./Jacobs
Authority Agent Review:	Reviewer
Subject:	Preliminary Flow Capacity of Funks Creek and Stone Corral Creek for Sites Reservoir Channel-Forming Flow Releases

1.0 Introduction

The proposed Sites Reservoir Project entails, in part, constructing a reservoir that can store 1.5 million acre-feet (ac-ft) near Maxwell, California. Dam construction will have significant hydrologic impacts on dammed streams. Two streams that will be affected are Funks Creek and Stone Corral Creek.

The California Department of Fish and Wildlife (CDFW) would like to periodically release channel-forming flow rates from Sites Reservoir to mimic and preserve historical geomorphic processes in Funks Creek and Stone Corral Creek. HDR provided Jacobs with historical flow data from a United States Geological Survey (USGS) stream gauge that was once located on Stone Corral Creek. The gauge obtained data from 1958 to 1985. The maximum mean daily flow during this period was roughly 2,000 cubic feet per second (cfs). No comparable gage data was available for Funks Creek, but CDFW judged that Funks Creek might have experienced similar flow rates. CDFW asked Sites Authority to assess the ability of Stone Corral Creek and Funks Creek to each pass 2,000 cfs as a "channel-forming flow" that remains within the creek banks.

Sites Authority requested that Jacobs perform hydraulic modeling to assess the capability of Funks Creek and Stone Corral Creek to contain 2,000 cfs and alternative flow rates within their banks. Recognizing that informal and formal levees line the creeks in many reaches, Jacobs selected a standard 3-ft freeboard criteria as the minimum acceptable freeboard between channel flows and top of levee or top of bank. This would provide adequate freeboard to avoid flooding private property if levees are properly designed, constructed, and maintained.

Jacobs performed two-dimensional (2D) modeling in Hydrologic Engineering Center River Analysis System (HEC-RAS) using steady flow rates to evaluate the available freeboard at selected locations. Details of the modeling and model results are provided in the following sections.

2.0 Data Collection

2.1 USGS Stream Gauge Data

As provided by HDR, stream-flow data from USGS Gauge No. 11390672 for the period 1958 to 1985 was used in this assessment. The location of the USGS gauge is shown on Figure 2-1, indicated by the red arrow, and is downstream of the proposed Sites Dam. Gage flow statistics are summarized in Table 2-1. The data set includes mean daily flows segregated by month over the period of record. The maximum mean daily flow rates recorded for December, January, February, and March are close to 2,000 cfs, and greatly exceed the minimum daily flows of zero and the monthly averages of 11 to 39 cfs based on all mean daily flows that occurred during those months over the period of record. The disparity between single-day maximums and multiyear monthly averages indicates that the high flows were infrequent and short-lived.[1]

Table 2-1. Stone Corral Creek Daily and Monthly Flow Statistics for USGS Gage 11390672 Based on Mean Daily Averages

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Min and Max Mean Daily Flows and Monthly Average Mean Daily Flows (cfs)												
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	0	74	2,230	1,910	2,150	1,980	619	45	9	1	0	0
Avg	0	1	11	32	39	21	8	1	0	0	0	0
Monthly Flows (ac-ft) for Period of Record												
Min	0	0	0	0	0	0	0	0	0	0	0	0
Max	0	427	11,432	8,825	11,137	15,227	4,451	740	146	19	0	0
Avg	0	37	660	1,946	2,190	1,300	484	83	13	1	0	0

2.2 Digital Elevation Model

The Digital Elevation Model (DEM) used for prior Sites emergency release inundation modeling was also used to define the stream channels for this modeling effort. The DEM has 1-meter-resolution, Light Detection and Ranging (LiDAR) data downloaded from the USGS' National Map Viewer between October 16, 2020, and April 15, 2021. The data are a collection of tiles of the standard 1-meter resolution DEM produced through the 3D Elevation Program (3DEP). The elevations in this DEM represent the topographic bare-earth surface collected between July 7, 2018, and February 2, 2019. Using ArcMap version 10.7.1, the DEM tiles were combined into a single Geo Tag Image File Format (GeoTIFF).

[1] Note that the mean monthly flows span the period of record, and therefore encompass many more years than the single-day maximum and minimum daily flows. If the mean monthly flow only encompassed the year of the maximum daily flow, the mean monthly flow would necessarily be higher. For example, the maximum mean daily flow of 2,230 cfs occurred on December 24, 1983. If flow was zero every other day that month, the mean December flow would have been 2,230/31 = 72 cfs. Because the average mean daily flow rate in December over the period of record was only 11 cfs, it demonstrates that flow rates were overwhelming less than 11 cfs in December periods.

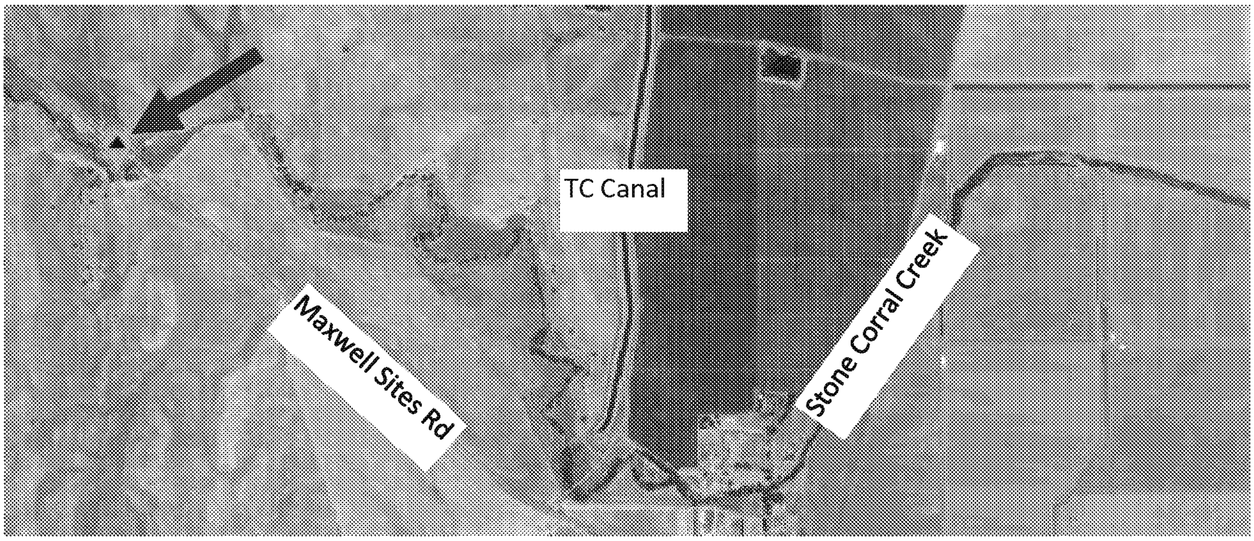

Figure 2-1. USGS Flow Measurement Gage Location on Stone Corral Creek

The following was observed in the USGS DEM:

- Along major roads, large bridges were "removed" from the DEM displaying values for the ground, road, or river topography beneath the bridge.
- Like all LiDAR, the sensors used were unable to penetrate water; therefore, the bottom of each creek channel reflects any water surface that may have existed when the LiDAR was flown. Reviewing the LiDAR in the creek beds, it appears that there was little water present in the reaches modeled because the creek beds appear irregular, consistent with bare ground.

2.3 Datums

The spatial reference used for tiles of the 1-meter DEM is Universal Transverse Mercator (UTM) Zone 10 North in units of meters, and in conformance with the North American Datum of 1983 (NAD83). All bare-earth elevation values were in meters and are referenced to the North American Vertical Datum of 1988 (NAVD88). Using ArcMap version 10.7.1, the combined GeoTIFF DEM was converted from UTM Zone 10N to California State Plane NAD83 Zone II. The elevation values were converted from meters to ft, dividing elevation values by 0.3048.

3.0 Methodology

3.1 HEC-RAS Model

Jacobs used HEC-RAS v6.0 hydraulic modeling software developed by the U.S. Army Corps of Engineers to assess the capacity of the creeks. A model was built for Funks Creek and another for Stone Corral Creek. Both models were 2D to capture the influence of variable channel geometry, the serpentine nature of the channels, and identify points along the levee crest and channel bank where flow might leave the channels.

The average mesh element for Funks Creek was 20 ft by 20 ft and the mesh for Stone Corral Creek was 12 ft by 12 ft. HEC-RAS algorithms capture the underlying topography within each mesh element, so the level of detail exceeded the cell size. A breakline was drawn along the thalweg of the channels to align the mesh cells perpendicular to the flow. This should increase the stability and accuracy of the models.

The upstream boundary was placed where reservoir releases would occur into each creek: where Sites Dam will be on Stone Corral Creek and at the Funks Reservoir outlet gates on Funks Creek. A flow hydrograph was used as the upstream boundary condition to release a steady flow into the channel. The downstream boundary for each model was normal depth where each creek crosses over the Glenn Colusa Irrigation District Main Canal siphon under the creeks. Normal depth neglects any potential downstream backwater effects that might raise the creek water surface.

The Funks Creek simulations were run for a model time of 2 hours at a 0.5-second time-step. The Stone Corral Creek simulations were run for 5 hours in model time at a 0.3-second time-step. For each model, the total model time was sufficient to allow flow to run through the entire channel reach. Time-steps were first estimated and then changed if needed to create a stable model.

An important parameter to add to the model was Manning's "n" roughness values to capture channel friction and other sources of energy loss. Jacobs selected a Manning's Roughness value of 0.05 for Funks Creek to represent its densely vegetated channel. Jacobs selected a Manning's "n" value of 0.045 for Stone Corral Creek because it has less vegetation than Funks Creek.

Jacobs selected several cross-sections along the Funks Creek channel to plot the modeled water surface within the channel geometry. The cross-sections were distributed throughout the reach and finalized after examining preliminary 2D results. Most channel cross-sections in Funks Creek have an irregular, trapezoidal shape with raised levee-like banks where farmers have placed earth along the edges of the channel. Geometric data for the Funks Creek cross-sections is presented in Table 3-1.

Over the 3.7 mi reach of Funks Creek that was modeled, five cross-sections were evaluated. The channel geometry tended to shrink moving from the upstream end (west) to the downstream end (east). Figure 3-1 presents the reach of Funks Creek that was modeled and the approximate locations of each cross-section.

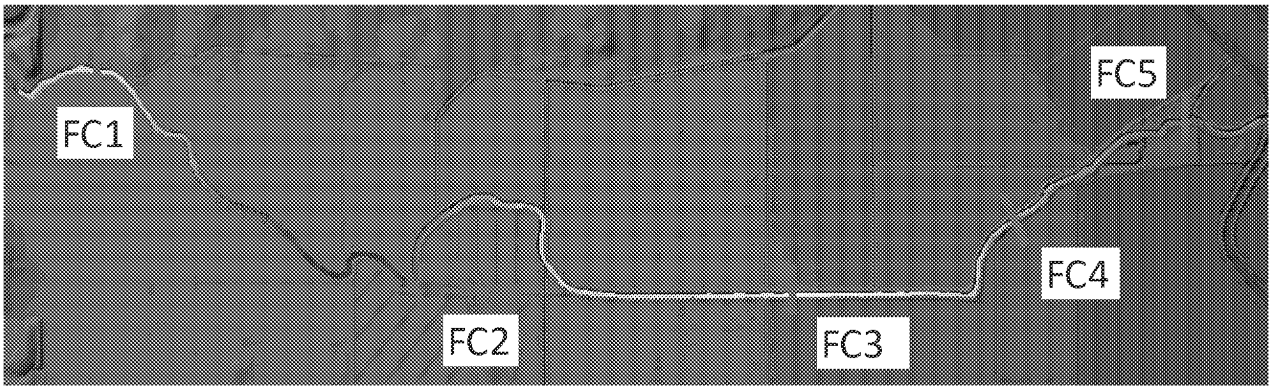

Figure 3-1. Funks Creek Modeled Channel Reach and Cross-Section Locations

Table 3-1. Cross-Section Geometry For Funks Creek

Cross-Section Number	Top Width (ft)	Depth (ft)	Slide Slopes (H:V)	Bed Slope (%)
FC1	98	11	1.5:1	0.33%
FC2	150	9	2:1	0.36%
FC3	75	14	1.6:1	0.85%
FC4	81	15	1.6:1	0.21%
FC5	48	12	1.6:1	0.83%

Notes:

% = percent

H:V = horizontal:vertical (slope)

Cross sections were similarly selected for Stone Corral Creek. Stone Corral Creek was geometrically similar to Funks Creek, with most irregular geometry in the upstream portion of the channel and trapezoidal geometries toward the downstream end. Geometric data for Stone Corral Creek is presented in Table 3-2.

There were seven cross-sections analyzed over a 6.5 mile reach. Figure 3-2 presents the reach of Stone Corral Creek that was modeled and the approximate location of each cross-section. As with Funks Creek, the channel geometry in Stone Corral Creek shrinks as it moves downstream.

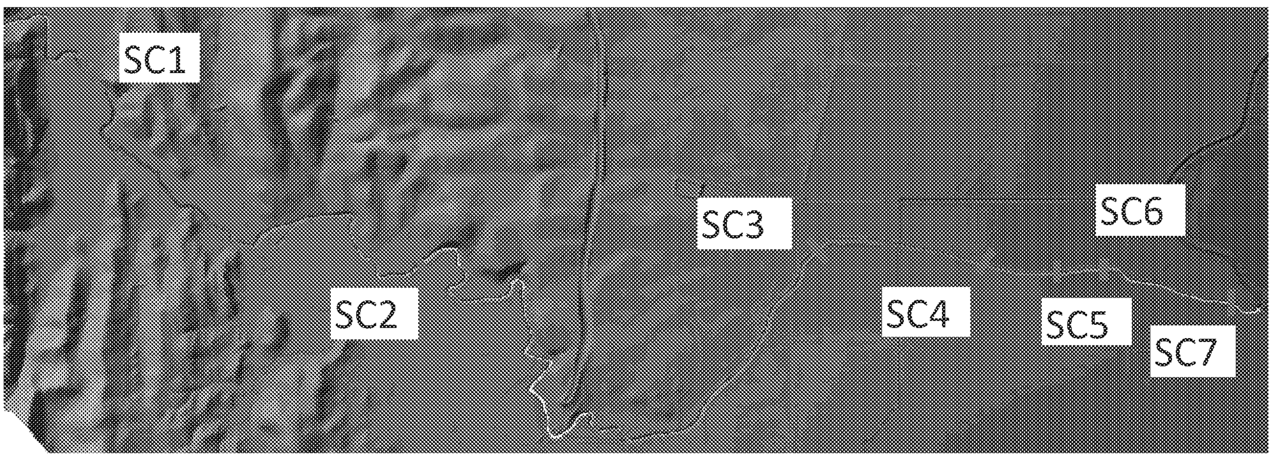

Figure 3-2. Stone Corral Creek Modeled Channel Reach and Cross-section Locations

Table 3-2. Cross-section Geometry for Stone Corral Creek

Cross-Section Number	Top Width (ft)	Depth (ft)	Slide Slopes (H:V)	Bed Slope (%)
SC1	95	17	1.7:1	0.72%
SC2	49	14	0.8:1	0.16%
SC3	83	8	1.9:1	0.05%
SC4	71	9	2:1	0.18%
SC5	60	8	2.3:1	0.04%
SC6	81	7	2.6:1	0.21%
SC7	69	12	1.6:1	0.04%

3.2 Evaluated Flow Rates

For Funks Creek, four flow rates were simulated, shown in Table 3-3.

Table 3-3. Flow Rates Simulated for Funks Creek

Simulation	Flow Rate (cfs)
FC2000	2,000
FC1750	1,750
FC1500	1,500
FC1000	1,000

Stone Corral Creek was modeled with six different flow rates, shown in Table 3-4.

Table 3-4. Flow Rates Simulated for Stone Corral Creek

Simulation	Flow Rate (cfs)
SC2000	2,000
SC1000	1,000
SC750	750
SC500	500
SC300	300
SC250	250

3.3 Freeboard Evaluation

Several cross-sections along the channel reaches were analyzed to evaluate freeboard using the water surface elevation compared against the channel geometry and the lower of the two bank elevations. The cross-sections were evenly distributed throughout the reach, with additional cross-sections at areas with critical capacity. The limiting cross-section was found after examining preliminary 2D results, examining channel geometries and by identifying where flow left the channel. The limiting cross-section had the smallest conveyance capacity due to geometry, roughness, and slope conditions. Without channel modification, flow discharges must meet conveyance criteria through the limiting cross-section.

If the freeboard criteria was not met at the limiting cross-section, the flow rate was decreased and iterated until a flow rate that provided at least 3 ft of freeboard at each cross-section location was found. The same cross-sections were analyzed to calculate the freeboard. Flow was first decreased to 1,000 cfs, with further adjustments up or down to target 3 ft of freeboard.

4.0 Modeling Results

4.1 Funks Creek Model Results

With 2,000 cfs in Funks Creek, the modeled flow did not overtop the leveed channel banks; however, at Cross-Sections FC1 and FC5 there was less than 3 ft of freeboard. After iterating, it was found that a lower flow rate of 1,500 cfs was required to meet the 3 ft freeboard criteria at the limiting cross-section.

Table 4-1 shows the freeboard modeled for each cross section. The limiting cross-section with the smallest conveyance capacity was FC5. This cross-section also had a high relative velocity compared to the other cross-sections.

Table 4-1. Freeboard Calculations for Funks Creek

Cross Section Number	Parameter	1,000 cfs Measurement (ft)	1,500 cfs Measurement (ft)	1,750 cfs Measurement (ft)	2,000 cfs Measurement (ft)
FC1	Lower Bank Elevation	178.14	178.14	178.14	178.14
	Water Surface Elevation	173.12	174.43	174.86	175.33
	Freeboard Calculation	5.02	3.71	3.28	2.81
FC2	Lower Bank Elevation	161.85	161.85	161.85	161.85
	Water Surface Elevation	157.37	158.61	159.15	159.64
	Freeboard Calculation	4.48	4.63	4.09	3.60
FC3	Lower Bank Elevation	145.22	145.22	145.22	145.22
	Water Surface Elevation	138.86	140.60	141.31	141.96
	Freeboard Calculation	6.36	4.62	3.91	3.27

Table 4-1. Freeboard Calculations for Funks Creek

Cross Section Number	Parameter	1,000 cfs Measurement (ft)	1,500 cfs Measurement (ft)	1,750 cfs Measurement (ft)	2,000 cfs Measurement (ft)
FC4	Lower Bank Elevation	137.96	137.96	137.96	137.96
	Water Surface Elevation	131.22	132.93	133.62	134.24
	Freeboard Calculation	6.74	5.03	4.34	3.72
FC5	Lower Bank Elevation	130.21	130.21	130.21	130.21
	Water Surface Elevation	126.04	127.29	127.80	128.25
	Freeboard Calculation	4.17	2.92	2.41	1.96

While 2,000 cfs can flow through Funks Creek without overtopping the leveed banks, it is recommended that a selected channel-forming flow not exceed 1,500 cfs.

4.2 Stone Corral Creek Model Results

At flows above 750 cfs in Stone Corral Creek, modeled flow was bankfull at Cross-Sections SC3 through SC6. The limiting cross-section with the smallest conveyance capacity was SC6. At 250 cfs there is 2.92 ft of freeboard at the limiting cross-section.

Table 4-2 shows the freeboard modeled for each cross-section. It should be noted that for the 2,000 cfs base case, flows at SC5 through SC7 have less than 2,000 cfs due to permanent out-of-bank flood losses onto the recessed floodplain along upstream channel reaches. Therefore, should 2,000 cfs be run strictly through these cross-sections, the water surface elevation would increase.

Given the model results, discharging more than 250 cfs to Stone Corral Creek would likely violate minimum freeboard criteria. Flow rates above 1,000 cfs may lead to local flooding, even without bank/levee failures. Therefore it is recommended that a selected channel-forming flow not exceed 250 cfs.

4.3 Model Results Versus Gage Results

The potential 250 cfs capacity of Stone Corral Creek at Cross Section 6 is less than the maximum mean daily flows recorded in Table 2-1 for the upstream gage. The difference in channel capacity can be explained by differences in the cross sections and reaches. The gage is in an upstream reach where the channel slope and geometry can accommodate higher flows. Although the two sections have similar depth, the upstream channel area is approximately 20 percent larger. The upstream bed slope is also steeper. In addition, there could have been local flooding in flows greater than 250 cfs.

5.0 Next Steps

The model results presented herein are considered preliminary. If additional refinement is desired, the following may be considered for next steps:

1. Discuss with Sites Project Authority the risks of local flooding by the Project, if channel forming flows are in excess of the preliminary results provided in this TM (Funks Creek flows greater than 1,500 cfs and Stone Corral Creek flows greater than 250 cfs).
2. Confirm the model DEM with surveyed cross sections or supplemental surveys of the channel thalweg, breaklines, and top of bank.
3. Obtain and incorporate surveyed data for each hydraulic crossing at roads, culverts, siphons, and similar features.
4. Inspect the levee-like channel banks for likely resistance to failure during elevated creek flows, especially where leveed banks are more than 2.5 ft above the adjacent fields.
5. Evaluate the channels for stability against modeled velocities. Stability risks should be weighed against CDFW channel-forming objectives that may require some channel scour or instability.
6. Establish clear CDFW channel-forming objectives to inform stability evaluations and freeboard adequacy.
7. Update modeling evaluations accordingly.

Table 4-2. Freeboard Calculations for Stone Corral Creek

Cross Section Number	Parameter	2,000 cfs Measurement (ft)	1,000 cfs Measurement (ft)	750 cfs Measurement (ft)	500 cfs Measurement (ft)	300 cfs Measurement (ft)	250 cfs Measurement (ft)
SC1	Lower Bank Elevation	216.69	216.69	216.69	216.69	216.69	216.69
	Water Surface Elevation	209.04	206.67	205.90	205.63	204.61	204.31
	Freeboard Calculation	7.65	10.02	10.79	11.06	12.08	12.38
SC2	Lower Bank Elevation	180.30	180.30	180.30	180.30	180.30	180.30
	Water Surface Elevation	178.44	174.49	174.52	174.15	172.82	172.42
	Freeboard Calculation	1.86	4.81	5.78	6.15	7.48	7.88
SC3	Lower Bank Elevation	140.45	140.45	140.45	140.45	140.45	140.45
	Water Surface Elevation	140.37	138.36	137.62	137.35	136.31	136.00
	Freeboard Calculation	0.08	2.09	2.83	3.1	4.14	4.45
SC4	Lower Bank Elevation	134.03	134.03	134.03	134.03	134.03	134.03
	Water Surface Elevation	133.90	132.38	131.48	131.12	129.82	129.42
	Freeboard Calculation	0.13	1.65	2.55	2.91	4.21	4.61

Table 4-2. Freeboard Calculations for Stone Corral Creek

Cross Section Number	Parameter	2,000 cfs Measurement (ft)	1,000 cfs Measurement (ft)	750 cfs Measurement (ft)	500 cfs Measurement (ft)	300 cfs Measurement (ft)	250 cfs Measurement (ft)
SC5	Lower Bank Elevation	131.30	131.30	131.30	131.30	131.30	131.30
	Water Surface Elevation	131.12	130.49	129.73	129.39	128.26	127.90
	Freeboard Calculation	0.18	0.81	1.57	1.91	3.04	3.4
SC6	Lower Bank Elevation	130.25	130.25	130.25	130.25	130.25	130.25
	Water Surface Elevation	129.90	129.43	129.40	128.52	127.57	127.28
	Freeboard Calculation	0.35	0.81	0.85	1.73	2.68	2.97
SC7	Lower Bank Elevation	125.52	125.52	125.52	125.52	125.52	125.52
	Water Surface Elevation	120.99	120.50	120.48	119.83	118.58	118.29
	Freeboard Calculation	4.53	5.02	5.04	5.69	6.94	7.23

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/4/2021 11:14:13 AM
To: DOrth@newcurrentwater.com; Dick Moss [DMoss@newcurrentwater.com]
CC: Marcia Kivett [MKivett@sitesproject.org]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Sites Discussion Follow-up
Attachments: Potential Investor FAQs 091231.docx; Sites_Overview 2021 Update DO-DM 100421.pptx; 20210720 Sites Project Cost Draft Tables (2)[2][1][1].pdf

Hi Dave and Dick –

Please find attached background information about the Sites project following up on our 9/23 discussion. We've found in speaking with other potentially interested parties that these were the most helpful and informative materials in their consideration of potential interest in the project. Please feel free to pass these along to your clients as you see fit. We also promised a kmz file of the current place of use map being developed as part of our water rights application. We're very close to producing an update to this map so we decided it would be best to hold off a little longer to get you the most up to date information. Ali will be sending this to you in a separate email very soon.

Two updates since we talked -

1. I heard back from Deanna Jackson last week and she says Angiola WD is not interested in participating in Sites but there are growers in the SE portion of their GSA that may be interested but economy of scale and conveyance likely make participation not viable for them. She will be talking to the larger growers in the SE area soon. If you had suggestions for conveyance paths available to get Sites water from the CA to these SE area growers, aside from the Angiola WD, this would be most helpful.
2. I had another meeting with WWD staff and it sounds like they will be seeking input from the 10/19 Water Policy Cmte meeting on asking the Board to consider expressing interest in participation.

Thanks again for your attention to this matter and let us know if there is anything else we can do to be of assistance to your helpful outreach on the Sites project. We very much appreciate your efforts.

Jerry

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 10/5/2021 9:43:48 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: FW: Sites - Follow up on EBMUD Meeting

Flag: Follow up

We are working through this.

John Spranza

D 916.679.8858 M 818.640.2487

From: Greenwood, Marin <Marin.Greenwood@icf.com>
Sent: Monday, October 4, 2021 3:21 PM
To: Spranza, John <John.Spranza@hdrinc.com>; Lecky, Jim <Jim.Lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>; Hassrick, Jason <Jason.Hassrick@icf.com>
Subject: RE: Sites - Follow up on EBMUD Meeting

Hello John – the CalSim data were provided for Alternatives 1–3 didn't include number of days with DCC open – I expect Jacobs could do monthly exceedance plots as one way to look at it, or mean number of days open by month and water year type.

On the "central Delta route entrainment" piece, I'm not exactly sure what the specific angle is that's of interest to them – are they meaning fish coming off the mainstem Sac and entering the central Delta (e.g., through Georgiana Slough), or (more likely?) fish moving down the forks of the Mokelumne and potential changes in hydrodynamics and therefore susceptibility to south Delta entry/entrainment? If the latter, there is little difference in south Delta exports between NAA and alternatives, and little difference in through-Delta survival from the Sacramento, indicating little difference in interior Delta routing for fish from the Sacramento basin.

MARIN GREENWOOD | **ICF** | marin.greenwood@icf.com | **+1.530.400.8081 mobile**

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, October 4, 2021 12:23
To: Lecky, Jim <Jim.Lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>; Hassrick, Jason <Jason.Hassrick@icf.com>; Greenwood, Marin <Marin.Greenwood@icf.com>
Subject: RE: Sites - Follow up on EBMUD Meeting

Hey Guys, I wanted to follow up on this email that Ali sent. I looked in the EIR/S and we don't really discuss the DCC or analyzes any effects, have you had an opportunity to think about this?

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, September 29, 2021 1:20 PM
To: Spranza, John <john.spranza@hdrinc.com>; Lecky, Jim <jim.Lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>
Subject: Sites - Follow up on EBMUD Meeting

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi all – I wanted to follow up on the remaining action items from the EBMUD meeting. I had the following remaining action items:

1. Provide any analysis or information on changes, if any, of opening/closure of the Delta Cross Channel as a result of the Project.
2. Provide any analysis or information on changes that may result in increases / decreases in central Delta route entrainment.

Can we get these together for EBMUD by the Wednesday aquatics meeting next week? Lets make this easy on us and try to pull from the RDEIR/SDEIS text and analysis as much as we can (versus creating new stuff).

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/5/2021 3:59:51 PM
To: John Spranza (john.spranza@hdrinc.com) [john.spranza@hdrinc.com]; Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Subject: Sites - HDR Modeling on Fremont Weir Notch

John and Erin – It looks like HDR did a lot of the modeling for the EIR/EIS. Would you all have the stage / flow relationships?

Check Chapter 25 of this document for names of folks from HDR involved:

https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=38605

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

Potential New Sites Participant Frequently Asked Questions

- Can you provide the annual breakdown of the $400/ac-ft for the 2022, 2023, 2024 cash call covered under the Amendment 3 Work Plan? see table below, please note 2022 is firm and '23/'24 are "up to" amounts to be determined based on annual budgets.

- Can you provide information that describes how the costs of the project are to be allocated? The Authority has been engaged over the past 12 months developing a Plan of Finance which includes answering three questions 1) what do you get?, 2) what does it cost? 3) how do we pay for it?. A separate file has been provided that includes current assumptions about share participation and cost allocations for the total project cost.

- Do you have a projected cost per year for years 2025 – 2029 (i.e. prior to when debt payments + O&M costs begin)? The table below describes a very rough estimation of cost per year that is based on several conceptual assumptions subject to change. The two scenarios shown as "pay go" and "pooled financing". These are the two options being discussed to pay for the project. For the purposes of the table, the assumption is initiation of project financing in 2025. The participants have indicated that if critical permits and the water right can be secured sooner bank financing could be initiated as early as mid 2023.

- Why does the 2029 cost in the table below exceed the $700 - $800/af projection range included in the overview presentation? The table provided below applies the bifurcation of cost that the Sites participants have applied to ensure beneficiary pays and would apply to a participant that is using all of the new facilities (ie generally any participant receiving their water after the release from Sites is conveyed to the Sacramento River). The figures in the table are based on projected financing costs and the 7% federal participation (low end, potentially could be as high as 25%).

- Can I assume that this projection is the worst case (i.e. higher financing rates, lower Federal participation)? I guess you could call this a worst case relative to current financing costs. The construction cost estimate has a range of accuracy which could be considered as well to arrive at a worst case but we have not done this analysis. I don't believe at this stage that federal participation factors into local agency cost so this would not affect worst case/best case analysis.

	Cash Calls							
	2022	2023	2024	2025	2026	2027	2028	2029
Financing ($/AF Yield)	100	140	160	183	351	537	756	886
Pay Go ($/AF Yield)	100	140	160	1,577	3,087	4,065	3,951	2,389

- Can you confirm what needs to be provided if an agency is interested in being a new participant in the project? The following should be provided in a letter from the agency 1) the amount of annual average water supply desired, and 2) confirm you've reviewed the project agreement as amended and you would be willing to take to your board for approval. Examples can be provided upon request. The project agreement can be found here on our website under attachment B: https://sitesproject.org/meetings/september-2-2021/

- How are losses in the reservoir dealt with? Loss assumptions are included in the operations modeling. Evaporation and seepage within the conveyance and storage of water will be proportionately allocated among participants per the storage principles. Nothing more specific than this has been developed yet. Downstream losses for salinity control (ie carriage water in the Delta) are allocated to participants proportionate to deliveries. We are working with DWR and Reclamation on the methodology for assessing salinity costs (ie carriage water) to Sites deliveries through the Delta. We assume any point of rediversion occurring within the statutory Delta would be subject to carriage water loss. The estimated supplies produced from the project is FOB outlet of the Sites Reservoir. The losses are deducted from the releases for each participant.

- Please confirm that stored water in the reservoir can be used by each entity as desired (i.e. if 12,000 ac-ft were stored, an agency could elect to use 2,000 ac-ft over 6 years, or 3,000 ac-ft over 4 years, etc.). Based on current board direction this is correct. We do not expect to see this change as we go forward but we are developing "guiding principles and preliminary terms" for the service contract each participant is expected to enter into with the Authority (~2023) which represents "what the participant gets" (see Attachment C on the same web page referenced above).

- Is there a document that describes how the reservoir will be managed? The board has adopted a set of "storage principles" that describe the conceptual oversight of the reservoir and the individual participant rights and obligations. Any changes to this document requires a vote of the board and it is envisioned as further project development occurs changes to this document may be necessary. Also an operations plan is being developed during Q4 of 2021 that describes the proposed operations of the project as modeled (see item 02-01 on this webpage https://sitesproject.org/meetings/april-21-2021/)

- Can you provide a summary table of the expected cost by agency? Do the figures in the table above inclusive of variable costs and wheeling costs within the Sites facilities? A separate file has been provided that includes current assumptions about share participation and cost allocations for the total project cost. Variable costs and wheeling charges have been updated from prior appraisal level estimates and are included in the cost projections previously provided. We don't have firm agreements for pricing so these costs are still subject to change.

From: Lecky, Jim [Jim.Lecky@icf.com]
Sent: 10/6/2021 7:46:18 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Spranza, John [john.spranza@hdrinc.com]; steve.micko@jacobs.com; Hassrick, Jason [Jason.Hassrick@icf.com]; Hendrick, Mike [Mike.Hendrick@icf.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
Subject: Flow Stage relationship
Attachments: stumpner et al. 2018. Hydrology and hydrodynamics on the Sacramento River near the.pdf

Here is the paper from which I pulled the graph (figure 18) of the stage flow relationship I showed during our call yesterday. Most of the hydraulic analysis in this paper is based on eight river cross sections a the western end of the weir and not at the location of that eastern end which was selected as the preferred option.

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(206) 801 2805 direct

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science for a changing world

Prepared in cooperation with the California Department of Water Resources and U.S. Bureau of Reclamation

Hydrology and Hydrodynamics on the Sacramento River Near the Fremont Weir, California—Implications for Juvenile Salmon Entrainment Estimates

Scientific Investigations Report 2018–5115

U.S. Department of the Interior
U.S. Geological Survey

Cover photographs:

Front: Aerial photo looking downstream (east) on the Sacramento River. The Fremont Weir, a concrete structure, lies to the right of the river (south) in the photograph. The river bend where the field study was conducted is on the right side of the image. Photograph courtesy of Patrick Huber, University of California, Davis, taken July 26, 2013.

Top rear: Looking downstream along the Sacramento River near the apex of the river bend at the western end of the Fremont Weir. Taken October 2013, at a river stage of about 15 feet, referenced to the North American Vertical Datum of 1988. Photograph courtesy of Chris Austin, Maven's Notebook.

Bottom rear: Looking downstream along the Sacramento River near the apex of the river bend at the western end of the Fremont Weir. Taken December 2014, at a river stage of about 32 feet, referenced to the North American Vertical Datum of 1988. Boat, acoustic Doppler current profiler, and global positioning system mount used for velocity mapping. Photograph courtesy of Chris Valle, U.S. Geological Survey.

Hydrology and Hydrodynamics on the Sacramento River Near the Fremont Weir, California—Implications for Juvenile Salmon Entrainment Estimates

By Paul R. Stumpner, Aaron R. Blake, and Jon R. Burau

Prepared in cooperation with the California Department of Water Resources and U.S. Bureau of Reclamation

Scientific Investigations Report 2018–5115

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
RYAN K. ZINKE, Secretary

U.S. Geological Survey
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2018

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Stumpner, P.R., Blake, A.R., and Burau, J.R., 2018, Hydrology and hydrodynamics on the Sacramento River near the Fremont Weir, California—Implications for juvenile salmon entrainment estimates: U.S. Geological Survey Scientific Investigations Report 2018–5115, 50 p., https://doi.org/10.3133/sir20185115.

ISSN 2328-0328 (online)

Acknowledgments

The authors would like to thank the State and Federal water contractors and the California Department of Water Resources for their support in funding the 2016 experiment, the analysis of the data, and the writing of this report. Appreciation is extended to Curt Schmutte (California Department of Water Resources, retired) and managers at the Metropolitan Water District for recognizing the critical need and generating contractor's funding support for this effort. To the California Department of Water Resources program manager, Brett Harvey, and the California Department of Water Resources contracting manager, Jacob McQuirk, thank you for dealing with all of the contracting and purchasing issues associated with doing things on short notice and helping to guide the experiment and facilitating interagency coordination and communication. Ted Sommer, at the California Department of Water Resources, provided insightful comments on the initial draft proposal for this work and, along with Brett Harvey, helped guide the adaptive management of the study.

These experiments involved many dedicated and talented people who worked in the field under challenging conditions—bad weather and high water, in this case. None of the results from this study would be possible without the heroic efforts of the fish-tagging and release teams, led by Marty Liedtke, and the instrument programming, deployment, and recovery teams, led by Chris Vallee; all are gratefully acknowledged.

Finally, thanks to the following for their reviews of the draft report: Chris Campbell, CBEC Engineering; Brett Harvey, California Department of Water Resources; Josh Israel, Bureau of Reclamation; and Maureen Downing-Kunz and Paul Work, U.S. Geological Survey. Their feedback improved this report immensely.

Contents

Figures

Figures—Continued

Tables

Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.092903	square meter (m^2)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Datums

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88) and the National Geodetic Vertical Datum of 1929 (NGVD 29).

Elevation of land surface, as used in this report, refers to distance above the vertical datum.

Abbreviations

BRW	Bear River at Wheatland
BSL	Butte Slough at Meridian
CDF	cumulative distribution function
CLW	Sacramento River at Colusa Weir
DL-ADCP	downward-looking acoustic Doppler current profiler
DWR	California Department of Water Resources
FBL	Feather River at Boyd's Landing
FRE	Sacramento River near the Fremont Weir
FRE.temp	Sacramento River above Fremont Weir near Knights Landing
IQR	interquartile range
NCC	Natomas cross canal
Reclamation	Bureau of Reclamation
RPA	reasonable and prudent alternative
TIS	Tisdale Weir
UL-ADCP	upward-looking acoustic Doppler current profiler
USGS	U.S. Geological Survey
VMT	Velocity Mapping Toolbox
VON	Sacramento River at Verona
WLK	Sacramento River below Wilkins Slough
YBUS	Yolo Bypass Utilization Study

Hydrology and Hydrodynamics on the Sacramento River Near the Fremont Weir, California—Implications for Juvenile Salmon Entrainment Estimates

By Paul R. Stumpner, Aaron R. Blake, and Jon R. Burau

Abstract

Estimates of fish entrainment on the Sacramento River near the Fremont Weir are a critical component in determining the feasibility and design of a proposed notch in the weir to increase access to the Yolo Bypass, a seasonal floodplain of the Sacramento River. Detailed hydrodynamic and velocity measurements were made at a river bend near the Fremont Weir in the winter and spring of 2016 to examine backwater conditions and estimate the hydraulic entrainment zone, a zone where fish would be predicted to be entrained into the notch. Secondary circulation near the river bend was shown to shift the velocity and discharge distributions toward the outside of the bend. Variability in the stage-discharge relation was shown to be the biggest source of uncertainty in determining the location of the hydraulic entrainment zone. Outflow from the Sutter Bypass and high flow on the Feather River resulted in backwater conditions near the Fremont Weir about 25 percent of the time over the 27-year period from April 1990–April 2017. Velocity measurements used to estimate the critical streakline position (the outer edge of the hydraulic entrainment zone) were not made over a sufficient range of conditions to explicitly quantify the variability in the location of the critical streakline. The variability in the critical streakline position was therefore represented stochastically with a random effects model. The estimated position of the critical streakline and the random effects model are input parameters used in a simulation designed to estimate fish entrainment over a 15-year period. The estimates of the critical streakline and likely fish entrainment could be much improved with velocity measurements over a broader range of stage and discharge conditions.

Introduction

The Sacramento River watershed supplies water for human use (drinking and agricultural) for approximately 30 million people in the State of California. A massive infrastructure has been built to effectively manage water routing and delivery, but this infrastructure and routing of water have placed a great deal of stress on the ecosystem in the Sacramento–San Joaquin Delta and the San Francisco Bay estuary. As a result, there has been a major decline in pelagic organism populations, partly due to decades-long water management by State and Federal agencies. For instance, winter and spring runs of Chinook salmon (*Oncorhynchus tshawytscha*) are listed as threatened and endangered, respectively, under the Federal Endangered Species Act (National Marine Fisheries Service, 1989, 1999). In 2009, the National Marine Fisheries Service issued a Biological and Conference Opinion that stated State and Federal water management was likely to jeopardize federally listed species including salmon, and established reasonable and prudent alternatives (RPAs) that would allow water export operations to continue. The RPA Action I.6.1 states that Restoration of Floodplain Rearing Habitat, through the increase of seasonal inundation in the lower Sacramento River Basin, is needed to allow water export operations to continue (National Marine Fisheries Service, 2009). In response to this RPA, the California Department of Water Resources (DWR) and the Bureau of Reclamation (Reclamation) developed the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Plan (Bureau of Reclamation and California Department of Water Resources, 2012). This project is designed to increase access for out-migrating juvenile salmon and inundate the Yolo Bypass, a floodplain that receives excess water from the Sacramento River, more frequently during the months of December–March.

The Yolo Bypass is typically inundated when the Fremont Weir overtops, at an elevation of approximately 32.5 feet (ft). The Fremont Weir, approximately 20 miles (mi) north of Sacramento, Calif. (fig. 1), was designed primarily to provide flood control for the city. Historically, the frequency of inundation is low, about 12 percent of the time from December to March, based on the frequency of occurrence from stage data at the Fremont Weir (fig. 2); therefore, access to the Yolo Bypass for out-migrating juvenile salmon is also low. A notch in the Fremont Weir is proposed that will be activated for stages below the elevation of the weir crest, at an elevation ranging from approximately 19 to 32.5 ft, and operational from December to mid-March. The operational window was chosen to minimize impact to stakeholders who use the Yolo Bypass for agriculture during the spring through fall months. The operational design is intended to increase the frequency at which water flows into the Yolo Bypass via the Fremont Weir. On the basis of historical stage data, the frequency will increase from about 12 to 45 percent of the time during December to mid-March, and this will also increase access for juvenile salmon out-migrants to the Yolo Bypass. Six locations are being considered for the proposed notch (fig. 3). Alternatives 1 and 2 are near the eastern end of the Fremont Weir, alternative 5 is near the central part of the weir, and alternatives 3, 4, and 6 are near the western end of the weir.

To facilitate informed decision making about the amount of water required to entrain fish, the U.S. Geological Survey (USGS), in collaboration with DWR and Reclamation, conducted an acoustic telemetry and hydrodynamic field study, the Yolo Bypass Utilization Study (YBUS), in the winter and spring of 2016 to assess a range of river conditions and associated fish movements through the river bend near the western end of the Fremont Weir. The data collection and analysis for this study included a two-dimensional acoustic telemetry array to track movements of fish and estimate spatial distributions, an acoustic receiver network to determine survival probabilities through the Sacramento River versus the Yolo Bypass (Pope and others, 2018), hydrodynamics measurements at the river bend, which is covered in this report, and combining fish spatial distributions and hydrodynamic data to estimate entrainment into the proposed notch (Blake and others, 2017).

Purpose and Scope

Initially, this project was aimed at making fish entrainment estimates at the western notch alternatives (3, 4, and 6), based solely on data collected in the 2016 YBUS study. Because the field study was near the western end of the Fremont Weir, the hydrodynamics at alternatives 1, 2, and 5 are beyond the scope of this report. Analysis of the 2016 and historical data indicated substantial variability in the stage-discharge relation on the Sacramento River near the Fremont Weir. River stage controls the notch flow, and the ratio of notch flow to the Sacramento River flow determines the fraction of Sacramento River discharge entrained into the Yolo Bypass, which in turn affects the juvenile salmon entrainment rate. Determining the correct discharge on the Sacramento River is critical for making accurate predictions of juvenile salmon entrainment into the Bypass, therefore, an additional component of this analysis quantified and accounted for this large variability in the stage-discharge relation. One of the major challenges with a project of this magnitude is that water withdrawn from the Sacramento River at this location results in water that is not available for downstream use. Downstream effects on the ecosystem and human consumption should be considered but are beyond the scope of this report.

This report has several objectives. The first objective was to document and explain the variability in the stage-discharge relation due to backwater effects using data collected in 2016, historical data, and discharge on the Sacramento River near the Fremont Weir estimated with a statistical model. The second objective was to describe the hydrodynamic processes that can influence the distribution of fish in a river bend, and how these processes apply to the river bend near the western end of the Fremont Weir using data collected in the 2016 YBUS study. The third objective was to present the methodology used to estimate the hydraulic entrainment zone, with application to this river bend. The hydraulic entrainment zone includes regions in the river where fish entrainment would be expected to occur. The hydraulic entrainment zone will inform estimates of actual fish entrainment. The conceptual models of using river hydraulics to maximize entrainment and the method used to estimate the hydraulic entrainment zone are discussed in the following section.

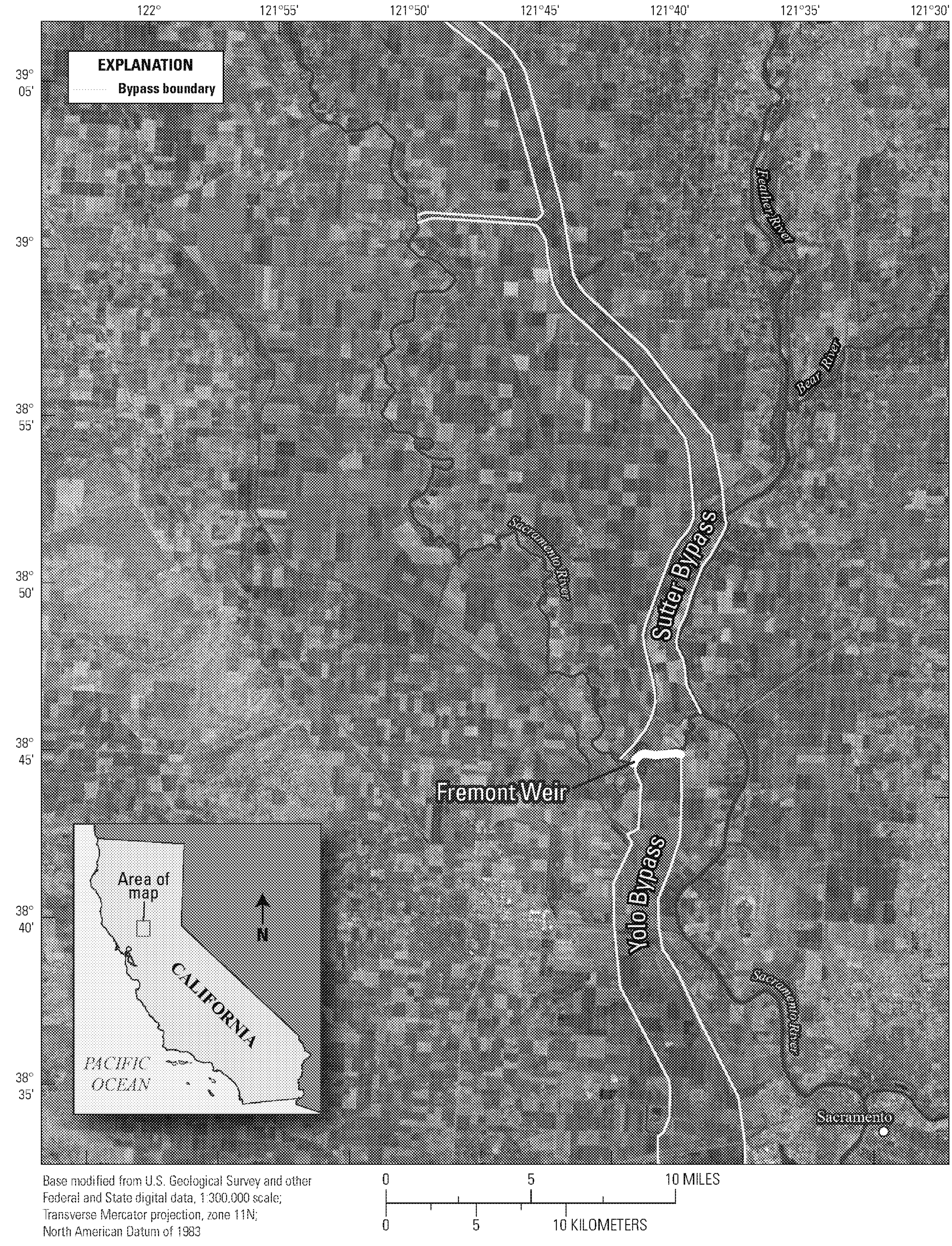

Figure 1. Location of the study area along the Sacramento River near the Fremont Weir, California.

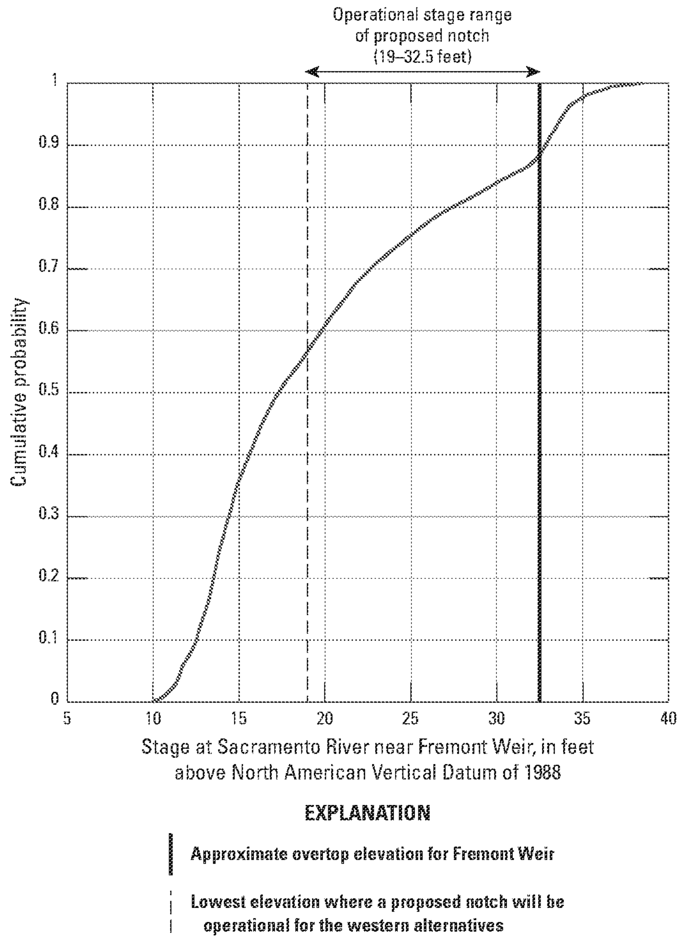

Figure 2. Empirical cumulative probability distribution of stage measured at the Fremont Weir along the Sacramento River, California, from 1984 to 2017. Only the months of December to mid-March are included because that is the proposed time frame of notch operation. The vertical black line indicates the approximate elevation at which the Fremont Weir overtops. The vertical dashed line indicates the lowest elevation where a proposed notch will be operational for the western alternatives.

Conceptual Models Used in Analyses

The first conceptual model central to an analysis of fish entrainment at a river bend, is that secondary circulation (lateral flow structures perpendicular to primary flow direction) will accumulate fish along the outside of the bend, such that a notch location can be optimized to maximize fish entrainment rates (fig. 4). As water is transported through a river bend, along-stream momentum is transferred to cross-stream momentum, which creates cross-stream flow structures perpendicular to the primary flow direction, termed secondary circulation. Secondary circulation is characterized by surface currents that move toward the outside of a river bend, which creates a down-welling region near the outside of the bend and return flow near the streambed toward the inside of the bend. The magnitude of the secondary currents peaks near the apex of the bend where the secondary currents also skew the velocity and discharge distribution toward the outside of the bend (Blanckaert, 2010). The interaction among secondary circulation, fish movement and behavioral responses, and the ways in which this interaction varies with stage and discharge is not only crucial to an understanding of how fish are distributed in the river, but also is critical for determining notch location and design to maximize entrainment of fish into the notch.

In order for the outside of a river bend to function as a hydraulic entrainment zone that could transport fish into another channel, fish must accumulate in the near-surface zone. Because secondary circulation induces down-welling at the outside of a bend, fish must exhibit behavior that keeps them surface-oriented for the notch to function as intended. There are a few consistent features in a number of data sets that allow inferences about fish behavior to be made and demonstrate that the resultant fish mass distributions are not equal to water mass distribution. First, there is typically a deficit of fish mass near riverbanks and a sharp gradient in distribution that are generally coincident with bathymetric gradient-induced cross-channel velocity gradients (California Department of Water Resources, 2015, 2016). This implies that fish may be avoiding zones of increased velocity shear, down-welling, or other turbulent features near the river bank. Second, if fish are surface-oriented and can overcome or avoid down-welling zones, then the fraction of fish mass may become disproportionately higher than the fraction of flow toward the outside of the bend because they will not get caught in the bottom layer return flow.

Figure 3. Alternative locations (green circles) that are being considered for a notch in the Fremont Weir along the Sacramento River, California. Alternative 5 is a multi-gate option with three locations. Alternatives 1 and 2, and Alternatives 4 and 6 are at the same location, and are represented by a single circle.

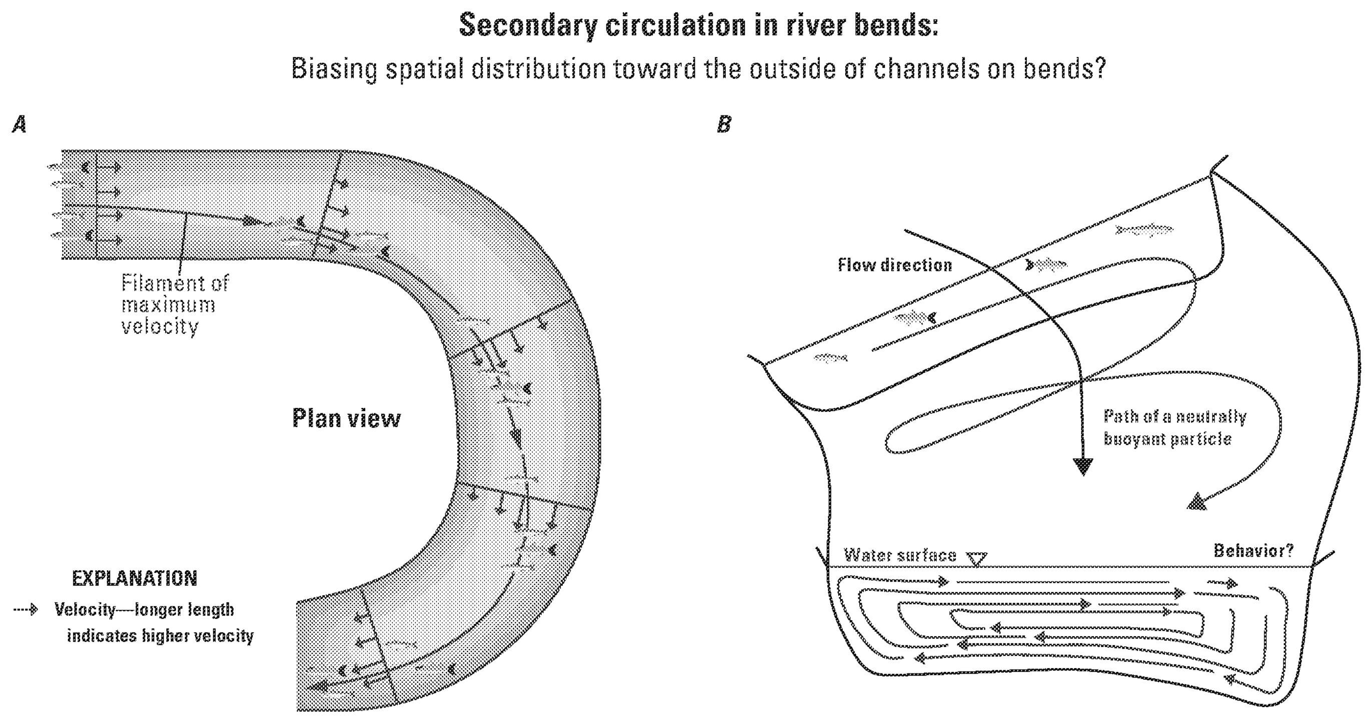

Figure 4. How river hydraulics at a river bend can bias the spatial distribution of fish toward the outside of the bend: *A*, plan view map shows the velocity distribution in the primary flow direction; and *B*, cross-section view shows how fish will accumulate near the outside of the bend in greater proportion than that of neutrally buoyant particles, if surface orientation is maintained.

Last, the majority of fish tracks from other studies (California Department of Water Resources, 2012, 2015, 2016) show cross-stream fish velocities on the order of 0.60 foot per second (ft/s) in riverine environments with very low mean cross-stream water velocities, indicating that the observed cross-stream velocity in the fish track was the result of swimming behavior. If fish swim at an equal cross-stream velocity to river right and river left, then in sections of river without strong secondary currents, one would expect fish to be distributed equally on both sides of the river center. However, in river bends with stronger cross-stream currents toward the outside of the bend, a population of fish with equal left and right swimming speeds will have a net cross-stream velocity that is higher toward the outside of the bend. After the cross-stream currents decrease downstream from the bend, fish that have been transported near the outside riverbank will initiate a cross-stream movement away from the bank, possibly to avoid elevated velocity shear or turbulence, in a direction toward the inside bank. In this case, the fish mass distribution toward the bank will decrease faster than water mass distribution given a sufficiently high cross-stream swimming speed.

The second conceptual model used in the analysis is that the entrainment of water and fish can be predicted upstream from a river junction using an approach called the critical streakline (fig. 5; see California Department of Water Resources, 2016, for details on the theory behind this method). In this analysis, the critical streakline represents the outer boundary of the hydraulic entrainment zone, which is the zone where water is entrained into a proposed notch. The critical streakline has been shown to be a primary predictor of entrainment of acoustically tagged juvenile salmon at tidal river junctions in the Sacramento–San Joaquin Delta, such that fish on the distributary channel side of the critical streakline will have a higher probability of entrainment down that distributary channel (Perry and others, 2014; Perry and others, 2016; Romine and others, 2017). Because the proposed modifications to the Fremont Weir will create an engineered distributary river junction, an estimate of fish distribution superimposed on the location of the critical streakline can be used to provide estimates of fish entrainment for proposed modifications to the weir given a set of hydraulic conditions. The critical streakline can be accurately estimated given detailed velocity and bathymetry information.

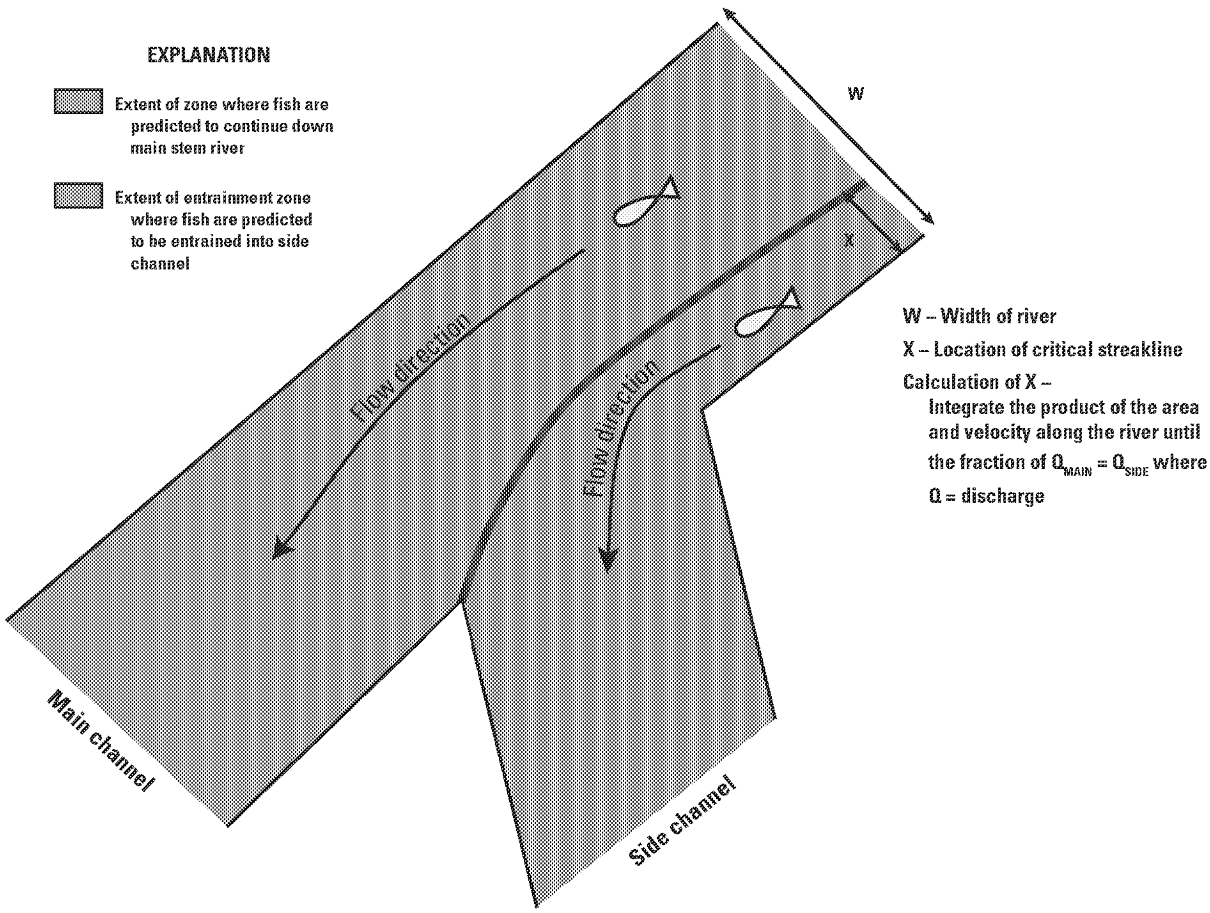

Figure 5. Hydraulic entrainment zone based on the critical streakline approach.

Methods

The first component of the 2016 YBUS study was to examine backwater effects near the western end of the Fremont Weir using discharge data from the 2016 YBUS study and historical data. For the 2016 YBUS study, a temporary gage (FRE.temp) was installed 1.24 mi upstream from the western end of the Fremont Weir (fig. 6) to estimate discharge from January 22 to April 22, 2016. This location was chosen because there are no discharge data available, and a more accurate estimate of discharge at this location was needed to make entrainment estimates. The second component of the 2016 YBUS study was to document the evolution of secondary circulation and estimate the hydraulic entrainment zone for various notch configurations using velocity transects at river cross sections through the study domain for a range of river stage and discharge conditions.

River Stage and Velocity Data

River stage at FRE.temp (fig. 6) was measured using a Campbell Scientific CS456 vented pressure sensor (accuracy = 0.05 percent of full scale). The stability (drift or fouling) of the sensor was not verified until after February 9, 2016, but there were no obvious shifts in the data during the data-collection period, and typically this sensor does not significantly drift over months of deployment, based on the authors' experience.

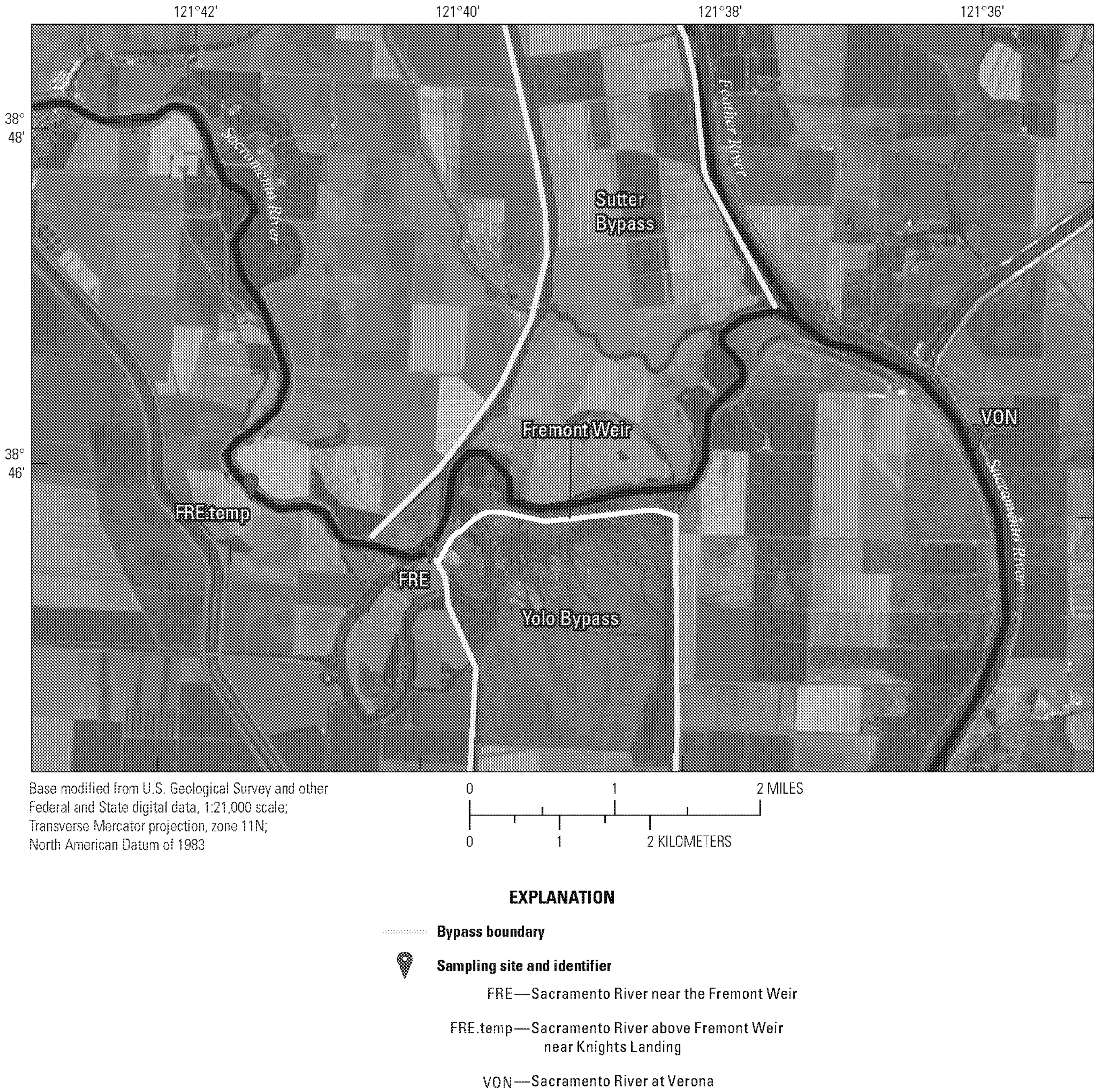

Figure 6. Locations of the temporary Fremont Weir gage (FRE.temp) and two longer-term monitoring locations (FRE and VON) on the Sacramento River, California. The Yolo Bypass Utilization Study was done at the western end of the Fremont Weir near the FRE.temp station.

The datum of the stage gage at FRE.temp was initially set to the same value as the FRE gage (fig. 6). It was not possible to survey the FRE.temp gage datum to an absolute elevation because there were no control points near this location, but setting the datum to the same value as FRE allowed for easy comparison. On February 9, 2016, a survey using a Real-Time Kinematic–Global Positioning System was done by the USGS near the FRE gage, because there were control points at that location. The precision and accuracy of the survey were acceptable, as demonstrated by the close agreement between the control points (between 0.01 and 0.03 ft in the vertical direction). The datum of the stage measurement was then set to the water-surface elevation (North American Vertical Datum of 1988 [NAVD 88]) as surveyed at the location of FRE. The USGS survey also showed that the water-surface elevation reported at FRE was 0.5-foot higher than the surveyed water-surface elevation. The USGS survey also included measurements of the elevation of the crest of the Fremont Weir, which were 32.23 ft and 32.34 ft at different concrete sections of the weir. These values are in close agreement with the weir elevation that is used in the Hydrologic Engineering Center's River Analysis System model (Rajat Saha, California Department of Water Resources, written commun., March 28, 2017). Based on these lines of evidence the 2016 USGS survey was chosen as the correct elevation (NAVD 88) at the FRE gage, with the assumption that the relative elevation measurements at FRE are sufficiently accurate and need only be corrected by the offset determined during the USGS survey. In this document and any USGS analyses that use elevation data from the FRE gage, an offset of –0.5 ft was applied to correct the elevation data to the NAVD 88 datum.

Stage data were also compiled from upstream at the Sacramento River below Wilkins Slough (WLK) gage and downstream at the Sacramento River at Verona (VON) gage (fig. 7 and table 1). These two gaging stations are operated by the USGS and the elevation at both stations is based on the National Geodetic Vertical Datum of 1929 (NGVD 29) with a +3.0-foot offset. To convert these stages to the datum at FRE (NAVD 88), a –0.615-foot conversion factor was used for WLK stage data and a –0.572-foot conversion factor was used for the VON stage data. The conversions were done using the North American Vertical Datum Conversion software available online (National Geodetic Survey, 2017). These data were used as input data for the statistical model used to predict discharge at the Fremont Weir from historical records (see "Statistical Model to Predict Discharge on the Sacramento River Near the Fremont Weir" section).

River velocity at FRE.temp was measured by using a Workhorse Monitor 1,200-kilohertz upward-looking acoustic Doppler current profiler (UL-ADCP) deployed on the riverbed to measure a three-dimensional velocity profile with up to 27 depth bins at 1.64-foot increments through the water column. The UL-ADCPs have a stated accuracy of 0.3 percent of water velocity, plus or minus 0.001 foot per second (ft/s). The UL-ADCP was programmed to measure velocity in an east-north-up coordinate system, and the east and north velocity components were rotated (in post processing) into along-channel and cross-channel velocity components. The along-channel velocity profile was averaged over all depth bins to produce a single velocity measurement that was used as the index velocity for developing a regression to estimate discharge. The water depth varied by approximately 20 ft (from 10 to 30 ft) during the course of the deployment; therefore, the number of depth bins averaged to produce the index velocity was variable for the length of the record. The stage and velocity data were averaged over a 15-minute time span and recorded continuously for the duration of the study.

Discharge Estimates

The methods used to estimate discharge with field measurements on the Sacramento River near the Fremont Weir, an estimate of Sutter Bypass outflow using mass balance, and the notch-stage discharge ratings developed by DWR are discussed in this section.

Sacramento River Near Fremont Weir

For the 2016 YBUS study, discharge at FRE.temp was estimated using two techniques: the stage-discharge (Buchanan and Somers, 1969) and index velocity (Ruhl and Simpson, 2005; Levesque and Oberg, 2012) methods. The stage-discharge method is widely used for estimating discharge in riverine environments that are not influenced by tides or backwater conditions. When tides or backwater conditions are present, the relation between stage and discharge becomes either nonlinear or poorly correlated, and the index-velocity method is often used. Empirical evidence of backwater conditions on the Sacramento River at the western end of the Fremont Weir associated with higher magnitude flows in the Sutter Bypass and the Feather River suggests that discharge estimated from the index-velocity method rather than the stage-discharge method would be more accurate.

The velocity and stage data were used to develop regressions with discrete discharge measurements and estimate a continuous time series of discharge for the study period (table 1). Discharge measurements (table 2) were made using a moving boat with a mounted downward-looking acoustic Doppler current profiler (DL-ADCP), on 7 separate days to cover an adequate range of conditions observed for the study period and processed in accordance with USGS standards (Mueller and others, 2009). A linear regression between the stage data and discharge measurements was developed for the stage-discharge relation. For the index-velocity method, two regressions are needed: (1) a linear regression between the measured (index) velocity from the UL-ADCP and the mean cross-sectional velocity from the moving boat measurements, and (2) a quadratic fit regression between the river stage and the cross-sectional area obtained from the moving boat measurements.

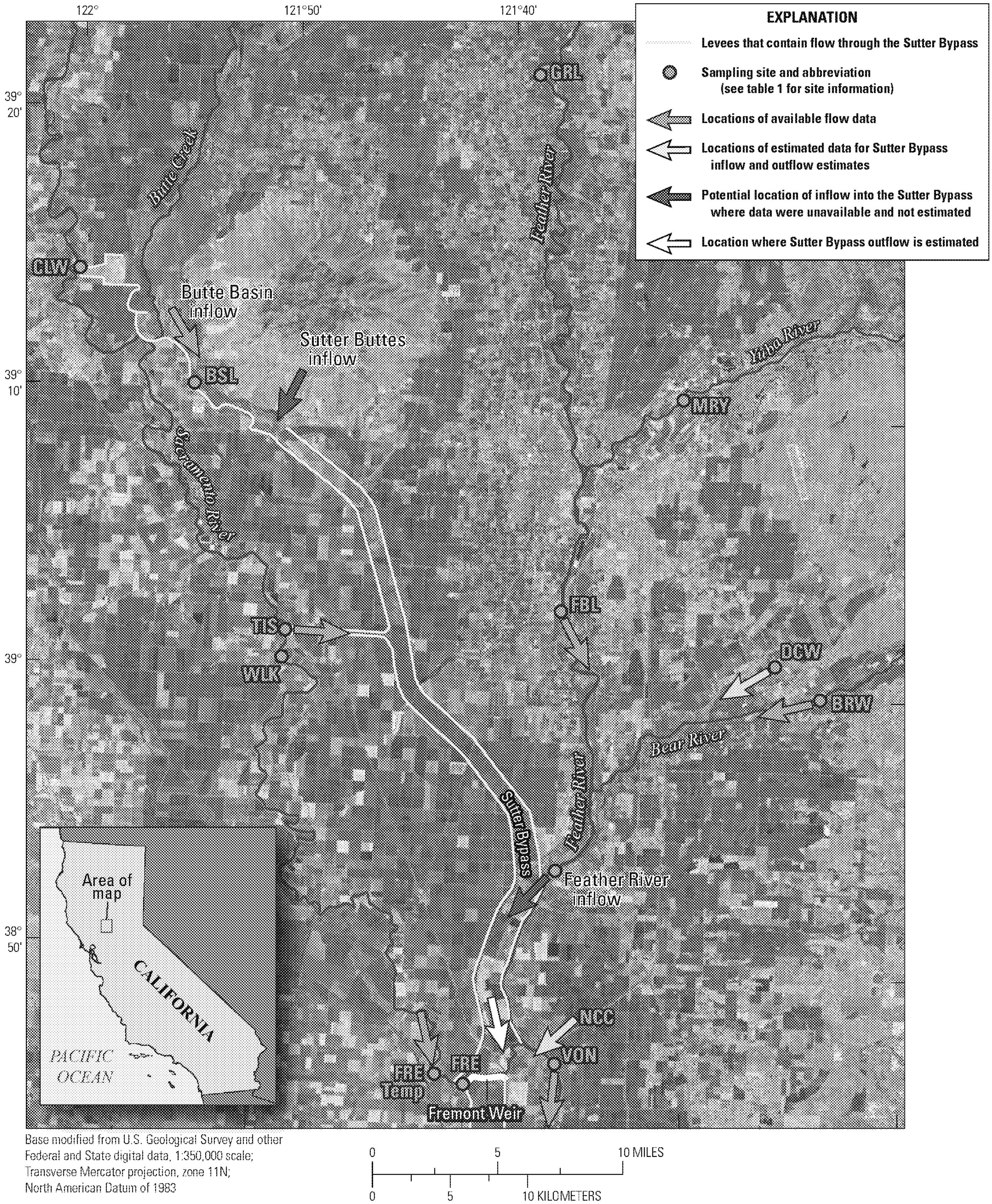

Figure 7. Locations of gaging stations (orange circles) along the Sacramento, Feather, Yuba, and Bear Rivers, California, that were used to analyze discharge conditions for this study.

Table 1. Summary of data accessed for this report from gaging stations along the Sacramento River and its tributaries, California.

[All stations are located in California. **Abbreviations**: CDEC, California Data Exchange Center, http://cdec.water.ca.gov/; NWIS, National Water Information System, https://waterdata.usgs.gov/nwis; N/A, not applicable; USGS, U.S. Geological Survey]

Station name	CDEC identifier or abbreviation	USGS station number	Type of data accessed	Location where data were accessed
Bear River near Wheatland	BRW	11424000	Discharge	NWIS
Butte Slough near Meridian	BSL	N/A	Discharge	CDEC
Sacramento River at Colusa Weir	CLW	N/A	Discharge	CDEC
Dry Creek near Wheatland	DCW	11390500	Discharge	NWIS
Feather River near Gridley	GRL	N/A	Discharge	CDEC
Feather River at Boyd's Landing	FBL	N/A	Discharge	CDEC
Sacramento River near the Fremont Weir	FRE	N/A	Stage	CDEC
Sacramento River above Fremont Weir near Knights Landing	FRE.temp[1]	384553121412301	Discharge, stage, velocity	Collected for this report and available on NWIS
Yuba River near Marysville	MRY	11421000	Discharge	NWIS
Natomas cross canal	NCC[1]	N/A	N/A	N/A
Sacramento River at Tisdale Weir	TIS	N/A	Discharge	CDEC
Sacramento River at Verona	VON	11425500	Discharge, stage	NWIS
Sacramento River below Wilkins Slough	WLK	11390500	Discharge, stage	NWIS

[1]Not a CDEC identifier; abbreviation used for this report.

Table 2. Summary of discharge measurements on the Sacramento River above Fremont Weir near Knights Landing, California, used for regressions to estimate a discharge time series, and comparison of estimates to measured discharge.

[ft, foot; ft/s; foot per second; ft^2, square foot; ft^3/s, cubic foot per second; hh:mm, hour:minute; mm/dd/yyyy, month/day/year; NAVD 88, North American Vertical Datum of 1988; PST, Pacific Standard Time]

Measurement date (mm/dd/yyyy)	Time, PST (hh:mm)	Stage, NAVD 88 (ft)	Velocity (ft/s)	Area (ft^2)	Measured discharge (ft^3/s)	Stage-discharge estimated discharge (ft^3/s)	Percent difference from measured	Index-velocity estimated discharge (ft^3/s)	Percent difference from measured
01/22/2016	13:40	30.46	3.31	7,940	26,800	24,300	9.3	25,800	3.7
01/22/2016	13:42	30.46	3.28	7,940	26,600	24,300	8.6	25,700	3.4
01/22/2016	13:45	30.46	3.27	7,940	26,200	24,300	7.3	25,600	2.3
01/22/2016	13:47	30.46	3.28	7,940	26,400	24,300	8.0	25,600	3.0
01/22/2016	13:53	30.46	3.29	7,940	25,800	24,300	5.8	25,700	0.4
01/22/2016	13:55	30.46	3.30	7,940	25,700	24,300	5.4	25,700	0.0
01/22/2016	13:58	30.46	3.30	7,940	26,400	24,300	8.0	25,800	2.3
01/22/2016	14:02	30.45	3.30	7,940	24,900	24,300	2.4	25,700	–3.2
01/22/2016	14:04	30.45	3.29	7,940	25,600	24,300	5.1	25,700	–0.4
01/22/2016	14:06	30.45	3.29	7,940	25,700	24,300	5.4	25,700	0.0
01/22/2016	14:08	30.45	3.28	7,940	26,200	24,300	7.3	25,600	2.3
01/22/2016	14:10	30.45	3.27	7,940	25,200	24,300	3.6	25,600	–1.6

Table 2. Summary of discharge measurements on the Sacramento River above Fremont Weir near Knights Landing, California, used for regressions to estimate a discharge time series, and comparison of estimates to measured discharge.—Continued

[ft, foot; ft/s; foot per second; ft^2, square foot; ft^3/s, cubic foot per second; hh:mm, hour:minute; mm/dd/yyyy, month/day/year; NAVD 88, North American Vertical Datum of 1988; PST, Pacific standard time]

Measurement date (mm/dd/yyyy)	Time, PST (hh:mm)	Stage, NAVD 88 (ft)	Velocity (ft/s)	Area (ft^2)	Measured discharge (ft^3/s)	Stage-discharge estimated discharge (ft^3/s)	Percent difference from measured	Index-velocity estimated discharge (ft^3/s)	Percent difference from measured
01/22/2016	14:12	30.45	3.27	7,940	25,900	24,300	6.2	25,600	1.2
01/22/2016	14:14	30.45	3.26	7,940	25,500	24,300	4.7	25,600	–0.4
02/04/2016	09:45	22.45	2.78	5,500	16,300	16,200	0.6	16,100	1.2
02/04/2016	09:50	22.45	2.74	5,500	17,400	16,200	6.9	16,000	8.0
02/04/2016	09:55	22.45	2.71	5,500	16,000	16,200	–1.3	15,900	0.6
02/04/2016	09:58	22.45	2.68	5,500	16,900	16,200	4.1	15,800	6.5
02/04/2016	10:03	22.45	2.69	5,500	16,200	16,200	0.0	15,900	1.9
02/04/2016	10:07	22.45	2.72	5,500	17,300	16,200	6.4	16,000	7.5
02/09/2016	16:07	16.98	2.26	3,950	10,700	10,700	0.0	10,400	2.8
02/09/2016	16:10	16.97	2.28	3,950	10,900	10,700	1.8	10,400	4.6
02/09/2016	16:14	16.97	2.29	3,950	10,600	10,700	–0.9	10,500	0.9
02/09/2016	16:17	16.97	2.29	3,950	10,900	10,700	1.8	10,500	3.7
02/18/2016	14:38	15.05	1.98	3,430	8,200	8,700	–6.1	8,500	–3.7
02/18/2016	14:41	15.05	1.98	3,430	8,200	8,700	–6.1	8,400	–2.4
02/18/2016	14:44	15.05	1.97	3,430	8,100	8,700	–7.4	8,400	–3.7
02/18/2016	14:48	15.05	1.98	3,430	8,300	8,700	–4.8	8,500	–2.4
03/09/2016	14:01	30.23	3.14	7,870	25,400	24,100	5.1	24,800	2.4
03/09/2016	14:03	30.23	3.17	7,870	24,700	24,100	2.4	24,900	–0.8
03/09/2016	14:07	30.23	3.21	7,870	24,000	24,100	–0.4	25,100	–4.6
03/09/2016	14:10	30.23	3.23	7,870	24,800	24,100	2.8	25,200	–1.6
03/09/2016	14:12	30.23	3.26	7,870	23,300	24,100	–3.4	25,300	–8.6
03/16/2016	12:49	33.84	2.83	9,030	24,900	27,800	–11.6	26,800	–7.6
03/16/2016	12:55	33.84	2.80	9,030	27,400	27,800	–1.5	26,600	2.9
03/16/2016	13:02	33.84	2.77	9,030	25,300	27,800	–9.9	26,500	–4.7
03/16/2016	13:09	33.85	2.77	9,040	26,300	27,800	–5.7	26,500	–0.8
03/16/2016	13:16	33.85	2.77	9,040	24,900	27,800	–11.6	26,500	–6.4
03/16/2016	13:22	33.84	2.81	9,030	25,700	27,800	–8.2	26,700	–3.9
03/16/2016	13:28	33.84	2.84	9,030	23,900	27,800	–16.3	26,800	–12.1
03/16/2016	13:30	33.84	2.84	9,030	27,000	27,800	–3.0	26,900	0.4
03/30/2016	15:15	23.95	2.29	5,940	15,500	17,700	–14.2	15,700	–1.3
03/30/2016	15:18	23.95	2.29	5,940	15,900	17,700	–11.3	15,700	1.3
03/30/2016	15:21	23.94	2.29	5,940	15,600	17,700	–13.5	15,700	–0.6
03/30/2016	15:24	23.94	2.29	5,940	16,000	17,700	–10.6	15,700	1.9

Sutter Bypass Outflow

Backwater effects near the western end of the Fremont Weir were investigated using discharge records from all the channels upstream from the Sacramento and Feather River junction (fig. 7). The outflow from the Sutter Bypass into the Sacramento River had to be estimated for this analysis. Because the Sutter Bypass enters the Sacramento River upstream from the Fremont Weir, there was no way a measurement could be made. The most significant inflows into the Sutter Bypass are runoff from Butte Basin, and the Colusa (CLW) and Tisdale (TIS) Weirs that release water from the Sacramento River (fig. 7). Additional uncontrolled flows from the Sutter Buttes, along with storage and travel time within the Sutter Bypass, make it difficult to estimate outflow from the Sutter Bypass from the sum of the inflows. However, flow from channels downstream from inputs can be used to estimate outflow from the Sutter Bypass using a mass-balance approach and correcting for travel times based on the following equation:

$$\text{Sutter Bypass outflow} = \text{VON} - \text{FBL} - \text{BRW} - \text{DCW} - \text{FRE.temp} - \text{NCC} \quad (1)$$

VON = Discharge on the Sacramento River at Verona,
FBL = Discharge on the Feather River at Boyd's Landing 22 miles upstream with a 5-hour travel time to VON,
BRW = Discharge on the Bear River near Wheatland 27 miles upstream with a 5-hour travel time to VON,
DCW = Discharge on Dry Creek near Wheatland 27 miles upstream, estimated as a fraction of BRW from 0 to 0.35,
FRE.temp = Discharge on the Sacramento River above Fremont Weir near Knights Landing 7 miles upstream with a 2-hour travel time to VON, and
NCC = Discharge on the Natomas cross canal 0.5 mile upstream from VON, estimated as a fraction of VON from 0 to 0.1.

This calculation was only valid when the Fremont Weir did not overtop because a portion of the Sacramento River upstream from the weir and some unknown portion of the Sutter Bypass outflow enter the Yolo Bypass. Because of the distances of each channel from VON, each was lag corrected to account for travel time of water to VON.

A range of flow conditions were estimated for the NCC and additional flow from the Feather River watershed at Dry Creek (DCW). Discharge data from NCC were not available and were estimated based on a range of flow ratios relative to VON from 0 to 0.1. Estimates of channel capacity at NCC and VON were 22,000 and 107,000 cubic feet per second (ft^3/s), respectively (California Department of Water Resources, 2003), or a capacity ratio of 0.2. Because the channel capacity ratio is low, the potential for backwater is high, so the ratio was adjusted by half to account for this.

The Bear River has one significant tributary downstream from BRW, which has historical daily flow data, but no data were available for the period of analysis. A 20-year period (1946–67) of overlapping peak flows were examined for BRW and DCW, and the average peak flow ratio was 0.35 (range of 0.1–0.7). A range of flow ratios from 0 to 0.35 was applied to estimate the flow from BRW for the analysis period.

Data from FBL were checked because previous investigations indicated this gage might not be accurate. On the basis of measurements in June 2012, it was found that the FBL gage may underestimate discharge on the Feather River by 1,000–1,500 ft^3/s and that a combination of upstream gages Feather River at Gridley and Yuba River at Marysville provided a better estimate of discharge (CBEC, 2012). Discharge records for these gages were examined for the period analyzed and the results were mixed; for some periods the combination of upstream gages was either higher, lower, or in close agreement. Because it could not be determined what the source of error was for all three of these gages for the period analyzed, a decision was made to use the discharge record from the FBL gage.

Notch Stage-Discharge Ratings

As was stated in the "Introduction" section, the analysis described in this report applies to the three notch alternatives that were at the western end of the Fremont Weir (alternatives 3, 4, and 6). The first step for critical streakline estimates was to calculate the notch discharge based on the notch stage-discharge rating for a given stage, which is explained in greater detail in the "Hydraulic Entrainment Zone Estimate" section. The DWR provided the notch stage-discharge ratings for these alternatives, which were calculated by the engineering team working on notch design (Rajat Saha, California Department of Water Resources, written commun., March 28, 2017). These stage-discharge ratings are shown in table 3.

Table 3. Stage-discharge ratings for 2016 discharge on the Sacramento River near the western end of the Fremont Weir and for notch alternatives 3, 4, and 6 in the Fremont Weir along the Sacramento River, California.

[ft, foot; ft³/s, cubic foot per second; NAVD 88, North American Vertical Datum of 1988]

Stage, NAVD 88 (ft)	2016 Stage-discharge rating for discharge (ft³/s)	Alternative 3, notch flow (ft³/s)	Alternative 4, notch flow (ft³/s)	Alternative 6, notch flow (ft³/s)
18	0	0	0	0
19	12,733	218	218	0
20	13,746	349	349	679
21	14,759	551	551	1,195
22	15,722	804	804	1,831
23	16,785	1,142	1,142	2,661
24	17,798	1,547	1,547	3,664
25	18,811	2,013	2,013	4,787
26	19,825	2,555	2,555	6,067
27	20,838	3,166	3,166	7,502
28	21,851	3,845	3,166	9,041
29	22,864	4,624	3,166	10,675
30	23,877	5,365	3,166	12,253
31	24,890	6,105	3,166	12,253
32	25,903	6,105	3,166	12,253
33	26,916	6,105	3,166	12,253
34	27,930	6,105	3,166	12,253
35	28,943	6,105	3,166	12,253

Velocity Transect Measurements and Processing

To investigate the evolution of secondary circulation and estimate the hydraulic entrainment zone for various notch configurations, velocity transects at eight cross-section locations were made over a 0.4-mile stretch of river that extended upstream from the river bend near the western end of the Fremont Weir, to just upstream from the river bend near the central notch alternative (fig. 8). The river stages and corresponding discharge at which these measurements were made are shown in table 4. Five measurement sets were made during the 2016 YBUS study, but initial analysis of these data indicated that additional measurements were needed to document variability in the stage-discharge relation; therefore, three additional measurement sets were made in May 2017.

Four repeated transects were made at each cross section to average out instrumental bias and small-scale turbulence to better define the large-scale coherent features (Dinehart and Burau, 2005). The velocity transects were made with a 1,200-kilohertz DL-ADCP that was mounted on a moving boat using methodologies similar to those used in making standard discharge measurements (Mueller and others, 2009). The velocity transect processing and averaging was done using the USGS Velocity Mapping Toolbox (VMT; Parsons and others, 2013). The four repeated transects were combined into a single transect line using least squares regression. The single transect line has a horizontal and vertical spacing of 3.28 and 0.82 ft, respectively. The velocity transects were smoothed using windows of three and two cells (or 9.84 ft and 1.64 ft) in the horizontal and vertical direction, respectively. These smoothing windows are applied to improve the visualization of large coherent secondary circulation structures (Parsons and others, 2013; Bever and MacWilliams, 2016). Results for a single transect, the average of four transects, and the four-transect average with smoothing applied are illustrated on figure 9. These plots demonstrate the need for averaging and smoothing by comparing the cross-stream velocities measured from a single transect to the average of four smoothed transects; the large-scale secondary-circulation cell in the center of the channel is not obvious from a single transect.

The VMT processing software has two rotation schemes that can be chosen to define along-stream and cross-steam velocity vectors: (1) zero-net discharge, and (2) Rozovskiĭ. In the zero-net discharge method the cross-stream velocity vectors are rotated in the horizontal, so that the discharge in the cross-stream plane equals zero. In the Rozovskiĭ method the cross-stream velocity vectors at each ensemble are rotated to obtain a zero-net discharge for that ensemble (Rozovskiĭ, 1957; Lane and others, 2000; Parsons and others, 2013). Bever and MacWilliams (2016) tested these rotation schemes and reported that results from the Rozovskiĭ method were insensitive to the angle of the boat transect (up to about 20 degrees) relative to the predominant direction of flow for a given cross section. This is important to note, particularly because the angle of flow can be variable along the cross section with strong secondary currents; therefore, the Rozovskiĭ rotation method was used. The data processed through VMT are available in a Science Base data release (Stumpner, 2018).

The DL-ADCP was used to measure most of the river cross section, but there were some areas on the edge of the cross section that could not be measured due to a combination of blanking distance (about 3.3 ft below the surface), side lobe interference (3.3–6.6 ft above the riverbed) and boat operational constraints (a range of 3.3–49.5 ft from the riverbanks). The distance from the end of the boat transect to the riverbanks was estimated by field crews using a laser range finder. Bathymetric data were collected multiple times during higher river stages to refine estimates of bank locations and to define the shape of the riverbed. In areas near the riverbanks where the bathymetric survey is incomplete, the location of the banks was determined by duplicating the slope of the banks from observed locations, which introduced some uncertainty in these estimates.

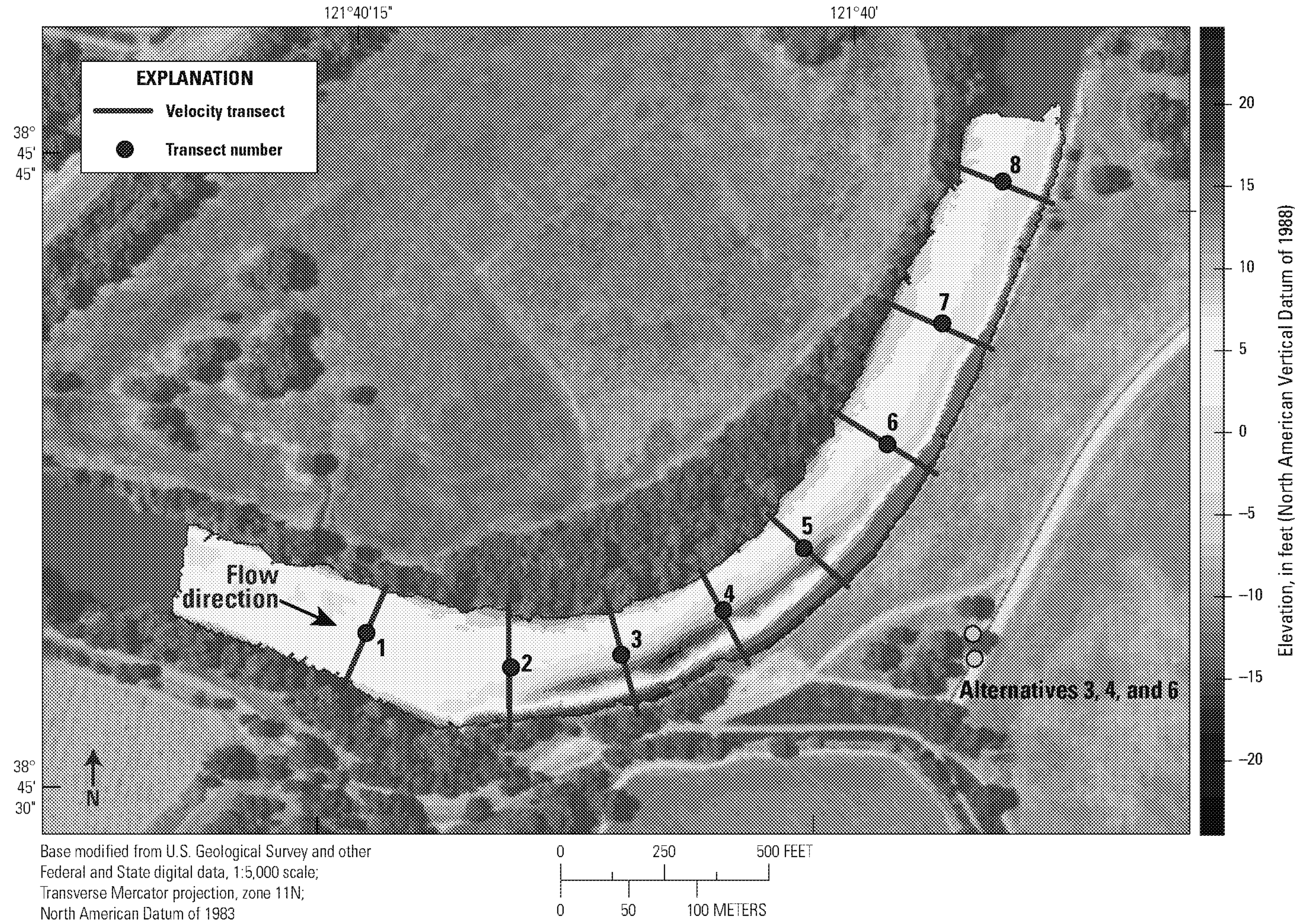

Figure 8. Locations of velocity transects, overlain on bathymetry, for the 2016 Yolo Bypass Utilization Study, and the locations of notch alternatives 3, 4, and 6 along the Fremont Weir, California.

Table 4. Summary of velocity profile measurements and discharge statistics for transects along the Sacramento River near the Fremont Weir, California.

[See figure 8 for locations of transects along the Sacramento River near the Fremont Weir. **Abbreviations**: FRE, Sacramento River near the Fremont Weir; ft, foot; ft^3/s, cubic foot per second; mm/dd/yyyy, month/day/year; NAVD88, North American Vertical Datum of 1988; N/A, not applicable; VON, Verona; WLK, Wilkins]

Measurement date (mm/dd/yyyy)	Stage[1], NAVD88 (ft)	Discharge[2] (ft^3/s)	Percent difference from index-velocity discharge	Percent unmeasured discharge[2, 3]	Percent discharge extrapolated to riverbanks[2]	Ratio of WLK to VON discharge[4]
02/18/2016	15.1	8,800 (350)	3.7	36.7 (4.9)	4.4 (2.4)	0.60
02/09/2016	16.7	11,200 (490)	6.5	35.3 (2.2)	4.8 (2.7)	0.63
02/04/2016	21.8	16,400 (490)	4.1	29.8 (2.0)	3.6 (2.2)	0.58
03/30/2016	24.2	15,900 (360)	–3.4	28.7 (1.5)	2.2 (1.7)	0.47
05/11/2017	24.6	12,300 (330)	N/A	30.9 (2.0)	6.4 (1.5)	0.39
05/16/2017	28.2	12,000 (430)	N/A	26.5 (2.8)	6.1 (4.2)	0.29
03/09/2016	30.2	23,600 (600)	–4.6	23.4 (2.2)	3.7 (3.1)	0.52
05/03/2017	31.2	18,000 (730)	N/A	25.4 (2.6)	6.3 (3.0)	0.35

[1]Stage measured at a temporary gage in 2016 (FRE.temp in fig. 6). For data collected in 2017, a –0.5-foot offset from the FRE gage was applied.

[2]Values are mean for all eight cross sections. Numbers in parentheses are standard deviations for the cross sections.

[3]Percentage of unmeasured discharge that was extrapolated to riverbanks, water surface, and riverbed.

[4]Refer to figure 7 for location of these gages.

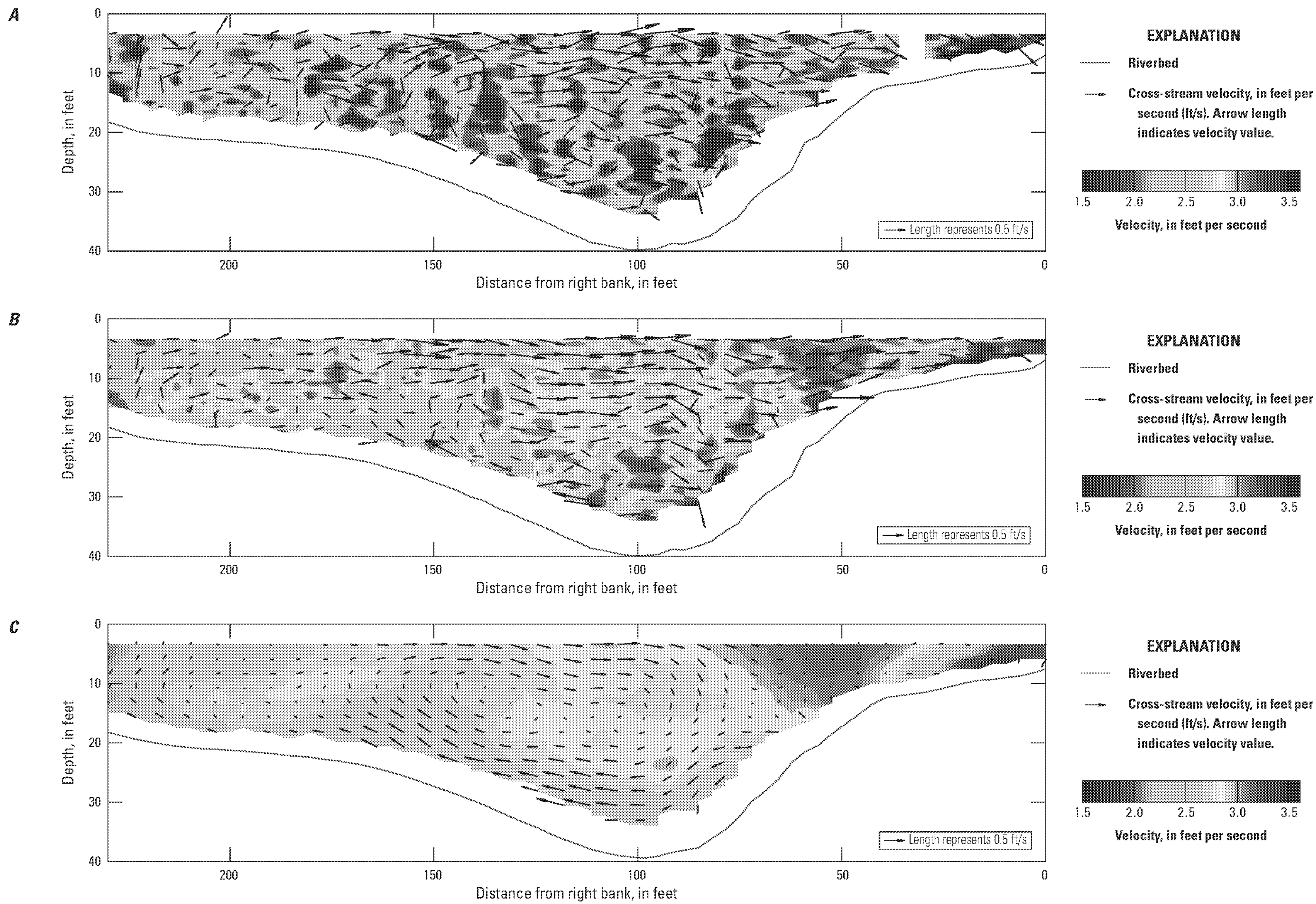

Figure 9. Cross-sectional velocity profiles for transect 5 along a bend in the Sacramento River near the Fremont Weir, California, March 30, 2016. Colored contours are along-stream velocities and arrows indicate a cross-stream velocity of 0.5 foot per second for *A*, 1 transect; *B*, 4-transect average—no smoothing; and *C*, 4-transect average with horizontal and vertical smoothing windows of 3 and 2 bins, respectively. Data are shown for a stage of 24.2 feet and discharge of 15,900 cubic feet per second.

The velocity transects were processed to extrapolate velocity vertically (to the riverbed and water surface) and horizontally to the riverbanks. A widely accepted technique uses either a power law or log law to extrapolate velocity in the vertical direction. The one-sixth power law was used for this application for several reasons: (1) it is insensitive to noisy data (Simpson, 2001); (2) it is the most widely accepted method that describes a wide range of flows (Chen, 1991); and (3) it has been adopted as a default processing protocol for USGS measurements unless the data warrant other power fits (Mueller, 2013).

There are several techniques that are used to extrapolate velocity near the banks. A standard technique is to use the ratio method, where the ratio of the water velocity to the square root of the depth is assumed to be constant for the unmeasured portion near the banks (Simpson, 2001). The ratio method is a form of the Froude number that assumes the ratio of kinetic to potential energy remains constant through the cross section (Le Coz and others, 2008). Although this method might be adequate for applications to estimate one-dimensional river discharge, it was not chosen for several reasons. First, the assumption of constant ratio was not valid at these cross sections based on analysis of measured regions, and secondly, tests of this method have qualitatively shown that the velocity estimates could be substantially biased at some cross sections using this approach. More sophisticated methods exist that use a modified momentum equation that requires a turbulence closure model (Nihei and Kimizu, 2008), or bed roughness length that requires knowledge of grain size and composition of the riverbed (Hoitink and others, 2009; Sassi and others, 2011). Given that the data were not available to correctly parameterize these methods and the percentage of discharge near the riverbanks was on the order of 5 percent or less compared to the total discharge, more sophisticated methods were unwarranted for this analysis.

The one-sixth power law was used to extrapolate velocity near the banks in the horizontal direction, and this method produced qualitatively good results for all cross sections, but there was not a way to validate this method. Several cross sections near the river bend were visually analyzed where the velocity deficit extended well into the cross section, but this is likely due to flow separation and recirculation zones created by the river bend and not an extrapolation error. Additionally, some of the cross sections did not have typical vertical distributions of velocity, where the highest velocity was near the surface and gradually decreased in the water column before rapidly decreasing near the bed. In some cases, particularly near the river bend, the highest velocities were near mid-depth or deeper. Typical practice in velocity extrapolation is to fit the whole profile to a power curve and extrapolate the top, bottom, and near-bank velocities. Because the hydrodynamics were complex enough in this study area, these values were extrapolated on the basis of the last measured values for the top, bottom, and near-bank velocities. An example of the measured and extrapolated along-stream velocities in relation to the riverbed is shown on figure 10. Once a full three-dimensional velocity profile and bathymetry were properly defined, the discharge at each cross section was computed by numerical integration.

Because the Rozovskiĭ method was used in the velocity transect processing, the lateral discharge at a cross section is not zero, but is small enough (typically less than 1 percent of total river discharge) that only the velocity in the along-stream direction was used to compute discharge. Table 4 shows the statistics for the discharge estimate for each velocity transect. For the set of eight cross sections, the average discharge was in close agreement with the index-velocity calculated discharge (under 7-percent difference for all conditions measured), and for each transect the discharge was within 4 percent of the average for that set of transects. A set of transect measurements were therefore, internally consistent for a given condition, and the mean along-river discharge was accurate compared to the discharge estimate using the index-velocity method. The range in the percentage of unmeasured discharge was roughly between 25–35 percent, and the unmeasured percentage generally decreased as the river stage increased. Most of the unmeasured discharge was in the vertical extrapolation because the unmeasured discharge near the riverbanks was 6 percent or less for all cross sections. Errors that arose from the vertical extrapolation likely did not bias the entrainment estimates because these errors were likely similar throughout the cross section. Entrainment prediction errors that propagated from errors in riverbank estimates and velocity extrapolation are discussed in more detail in the "Effect Due to Uncertainty in Bank Estimates" section.

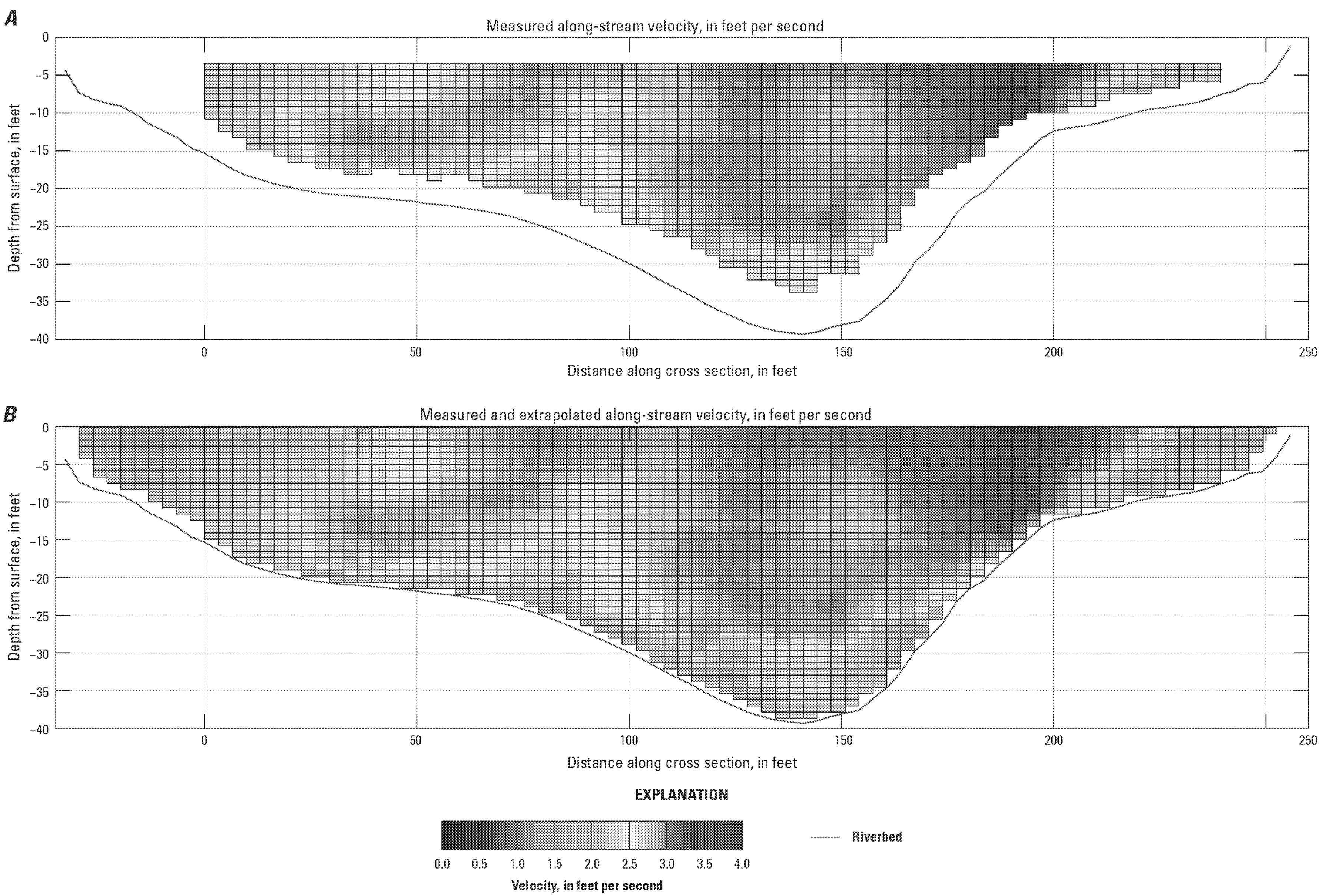

Figure 10. Measured and extrapolated along-stream velocity on the numerical grid used to integrate the discharge at cross-section 5 at a stage of 24.2 feet and discharge of 15,900 cubic feet per second: *A*, measured, averaged, and smoothed velocity in the along-stream direction; and *B*, same as "*A*," with velocities extrapolated to the surface, streambed, and near the riverbanks.

Analysis of Hydrologic Conditions on the Sacramento River Near the Fremont Weir

Hydrologic conditions near the western end of the Fremont Weir were assessed using discharge data collected in the 2016 YBUS study combined with historical discharge records from a number of sites upstream and downstream from the study site. First, the hydrologic results from the 2016 study are presented, and the observations of backwater at the study site are discussed. Outflow from the Sutter Bypass was estimated using equation 1 because this boundary condition is not gaged. Next, a statistical model to predict discharge of the Sacramento River near the Fremont Weir was developed to examine the variability in the stage-discharge relation for a 27-year period. It was important to understand and quantify the variability in the stage-discharge relation at this location because it had a significant effect on entrainment predictions.

Discharge Estimates From 2016 Measurements

Results of discharge estimates from field measurements on the Sacramento River near the Fremont Weir, and an estimate of the Sutter Bypass outflow using a mass-balance approach, are presented in this section.

Sacramento River Discharge Estimate Near the Fremont Weir

Discharge of the Sacramento River was estimated 1.24 miles upstream from the western end of the Fremont Weir (FRE.temp; Sacramento River above Fremont Weir near Knights Landing) using the stage-discharge and index-velocity methods. The stage-discharge and index-velocity regressions are shown on figure 11, and a summary of discharge measurements and discharge estimates from the two techniques are shown in table 2. Compared to the moving boat discharge measurements used to develop the regressions, neither method shows bias in predicting discharge, but on average, the index-velocity method produces a lower average absolute error of 3.0 percent compared to 5.9 percent for the stage-discharge method.

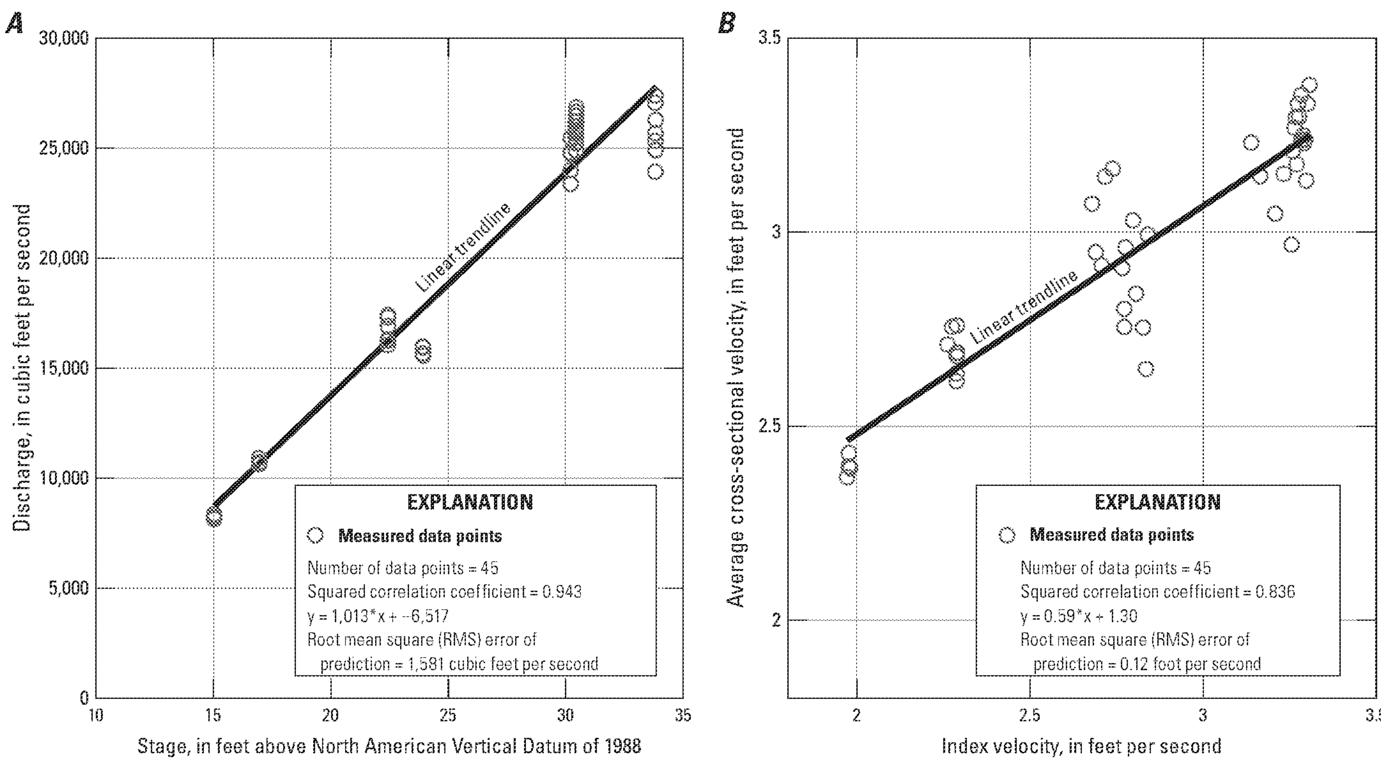

Figure 11. Discharge and velocity estimates during the 2016 data-collection period (January 22–April 22, 2016) at the temporary gage (FRE.temp) Sacramento River above Fremont Weir near Knights Landing, California: *A*, discharge measured with a moving boat versus measured stage; and *B*, average cross-sectional velocity computed from moving boat measurements versus measured index velocity.

There are several well-known sources of instrument, measurement, and computational errors in discharge estimates using both techniques (Simpson, 2001). Generally, a plus or minus 10-percent error between discharge estimates (based on the regression methods) compared to the measured discharge is considered reasonable. The index-velocity method has a lower incidence of measurements outside of the 10-percent error band—2 percent compared to 16 percent of the measurements obtained from the stage-discharge relation. It was concluded that for the period of study, the index-velocity method produced a better estimate of discharge on the Sacramento River near the Fremont Weir.

The difference between the stage-discharge and index-velocity methods is greatest during the rising limb of the hydrograph, a time when juvenile salmon outmigration typically peaks. While the bulk of the discharge data estimated by both methods are in reasonable agreement, a notable discrepancy occurred after March 6, 2016, during the rising limb of the hydrograph when the stage-discharge rating overpredicted discharge by as much as 4,000 ft^3/s or about 40 percent (fig. 12). Initially, when the stage increased at the western end of the Fremont Weir, there was a corresponding decrease in the index velocity. Non-linearity in the relation between water velocity and stage on this date was evidence of backwater effects due to increased flow from the Sutter Bypass and (or) Feather River.

Sutter Bypass Outflow Estimate

The Sutter Bypass outflow estimate and discharge hydrographs used to compute the estimate are shown on figure 13. The magnitude of the Sutter Bypass outflow is shown as a range due to the estimated range in discharge for the Bear River and NCC. During baseline conditions (most of February and April), flow in the Sutter Bypass outflow is generally lower than in the Feather River system. When flows are higher, the magnitude of the Sutter Bypass outflow is equal to or greater than the Feather River system, except for two periods when there was a significant increase in the Feather River, and the Sutter Bypass outflow estimate went close to, or below zero. This is an unrealistic estimate, as it is likely that either (1) some portion of the Feather River flow enters the Sutter Bypass, or (2) that the peak flow from the Feather River is attenuated and has a longer tail close to its junction with the Sacramento River, due to backwater effects from the Sacramento River and Sutter Bypass outflow.

As a first-order check on the accuracy of the SUT outflow estimate, the estimates for inflows and outflows for the Sutter Bypass from mid-January to the beginning of February were examined (fig. 14). The main inputs for the Sutter Bypass are the Butte Basin inflow, the Colusa Weir (CLW), and the Tisdale Weir (TIS; fig. 7). Discharge of the Feather River increased on January 18 and 30, which could account for a portion of the Sutter Bypass outflow; otherwise, the bulk of the outflow from the Sutter Bypass was assumed to be due to inflow from the Butte Basin and upstream weirs on the Sacramento River. Integrating the estimated inflow and outflow for this period showed that the cumulative outflow was overestimated by a factor of three compared to the inflow estimate, so there were either inputs unaccounted for into the Sutter Bypass (some portion of the Feather River or uncontrolled runoff from Butte Basin) or inputs unaccounted for in the mass-balance equation (eq. 1) used to estimate the Sutter Bypass outflow. The Sutter Bypass outflow estimate was likely more accurate when the magnitude of flow in the Feather River was lower and there were not rapid increases in the hydrograph. It was assumed that during these conditions all of the inflows were accounted for; therefore, the mass-balance equation was more accurate. The peaks in the Sutter Bypass outflow were of lower magnitude and lagged behind the peaks in the Sutter Bypass inflow, which was expected from storage and increased travel time in the Sutter Bypass.

Causes of Backwater Conditions Near the Fremont Weir

The combined effects of increased discharge on the Feather River and Sutter Bypass outflow can cause backwater conditions on the Sacramento River near the Fremont Weir. The Feather River discharge increased from 4,000 to 25,000 ft^3/s, 16 hours before a corresponding increase on the Sacramento River on March 7, 2016 (fig. 13). The Sutter Bypass outflow increased, but the estimated magnitude was likely incorrect for this period, as discussed previously. Additionally, the river level on the Sacramento River was not high enough to engage the upstream Sutter Bypass weirs, so the contribution of the Sacramento River to the Sutter Bypass outflow was likely minimal during this period. Therefore, for this event, it was concluded that the Feather River was likely solely responsible for the backwater effects observed on the Sacramento River near the Fremont Weir.

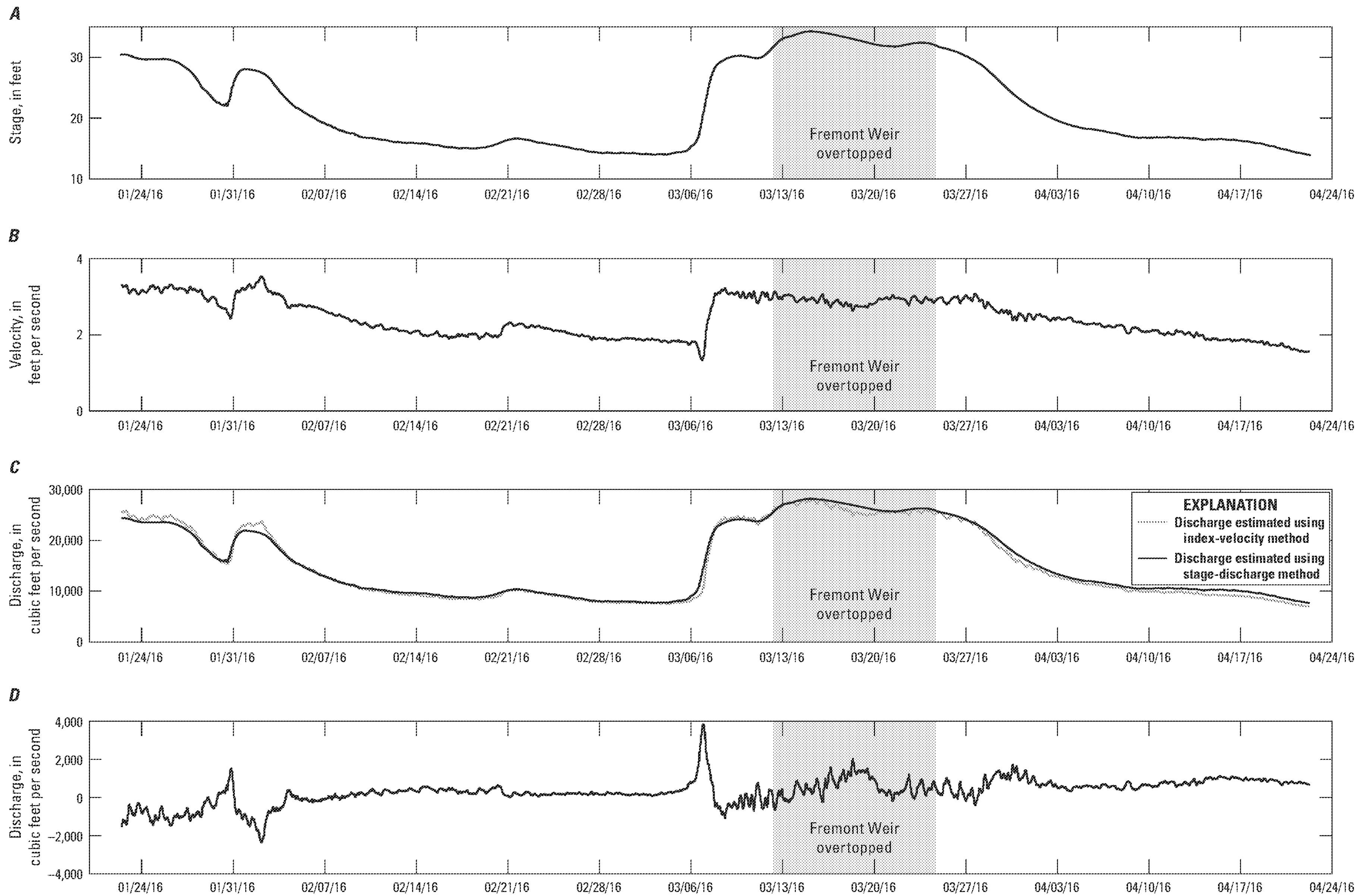

Figure 12. Time series of hydrodynamic measurements at the temporary gage (FRE.temp) along the Sacramento River near the Fremont Weir, California: *A*, river stage; *B*, measured water velocity; *C*, discharge estimated using the stage-discharge and index-velocity methods; and *D*, difference in discharge using the index-velocity and stage-discharge methods.

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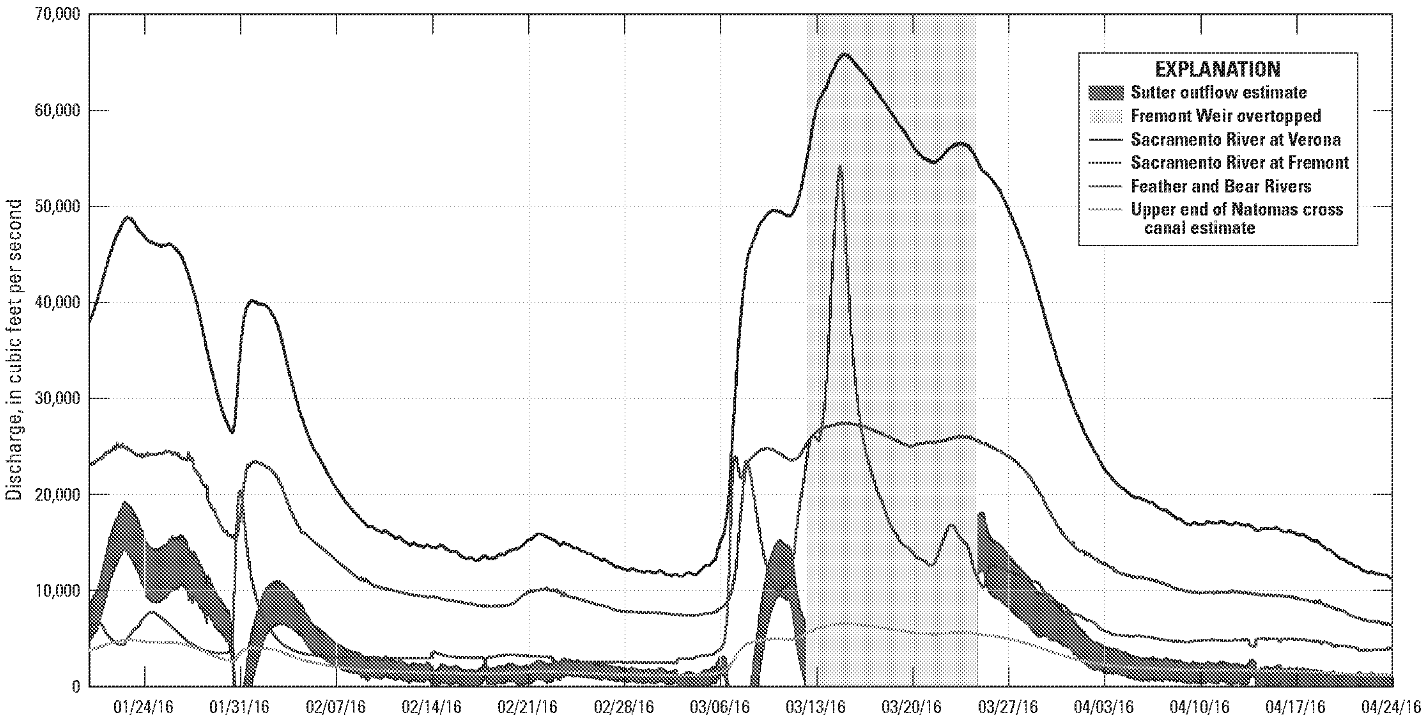

Figure 13. Time series of hydrographs at gaging stations used to estimate Sutter Bypass outflow, flow in the Sacramento River at Fremont Weir and at Verona, the Feather and Bear Rivers, and flow in the Natomas cross canal, California.

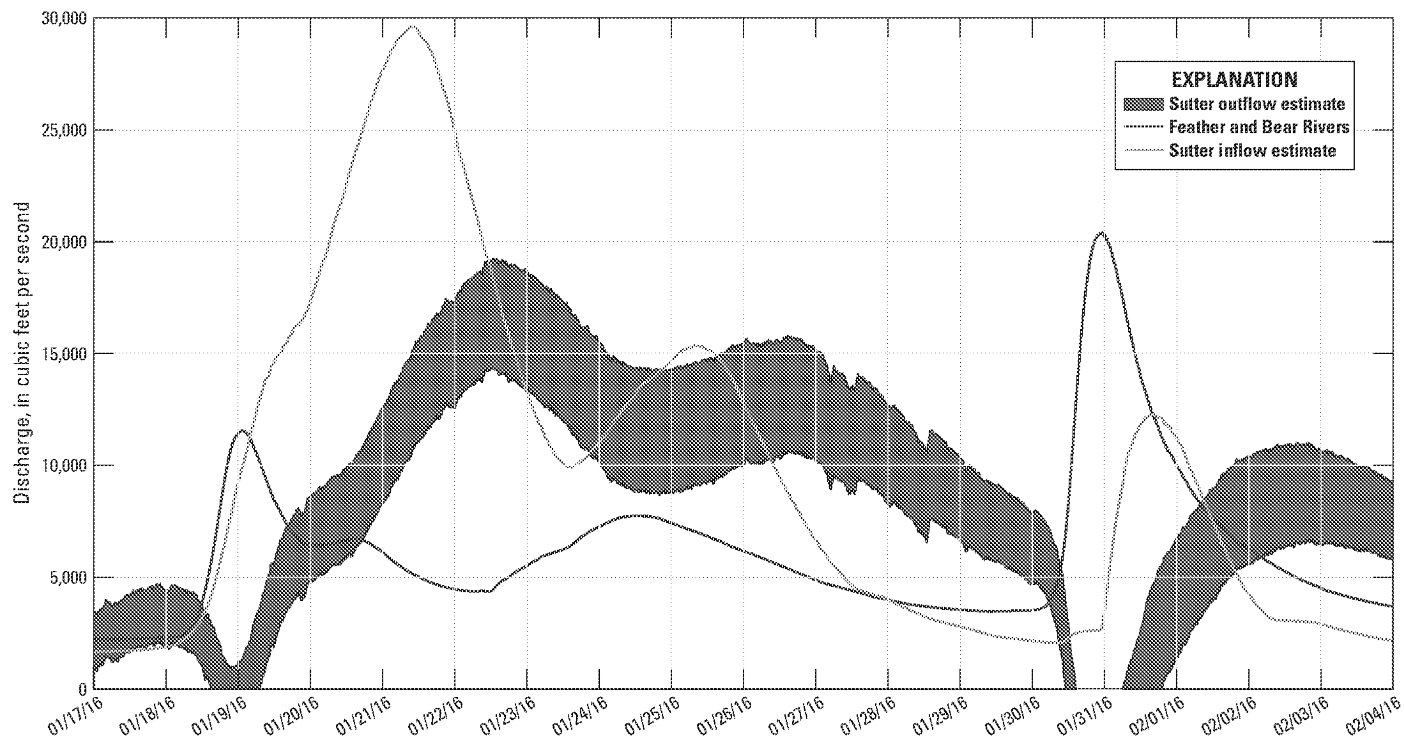

Figure 14. Time series of inflow and outflow estimates for the Sutter Bypass compared to the Feather and Bear Rivers, California, from January 17 to February 4, 2016.

Discharge events on the Feather River were flashy and short lived, compared to discharge events on the Sacramento River, which were generally longer in duration and steadier (fig. 13). The magnitude of variability in Sacramento River discharge, as observed at the FRE.temp station, caused by the Feather River was greater than that caused by the Sutter Bypass, but the Sutter Bypass outflow typically was longer duration so the integrated effect of outflow from the Sutter Bypass might have been greater overall. Furthermore, the area of discharge for the Sutter Bypass into the Sacramento River was likely spatially variable as a function of outflow magnitude. The width of the Sutter Bypass is about 4.5 mi along the Sacramento River. The eastern side of the Sutter Bypass near the Sacramento and Feather River junction exchanged water with the Sacramento River at lower magnitudes of Sutter Bypass outflow, but as the Sutter Bypass outflow magnitude increased, the outlet near the Fremont Weir became engaged. An estimate of the water level at which this occurred was not possible, and it is worthy of investigation because this exchange likely affected the local hydrodynamics in the Sacramento River at this location.

The magnitude and duration of flow on the Feather River and Sutter Bypass outflow shows that both of these boundary conditions are needed for two reasons: (1) to accurately characterize the hydrology of this region, whether this be with field data or hydrodynamic models, and (2) to understand the degree of variability in the stage-discharge relation for the Sacramento River in the vicinity of the Fremont Weir, which is needed to accurately make entrainment estimates.

Statistical Model to Predict Discharge on the Sacramento River Near the Fremont Weir

The range of conditions in 2016 did not include the full range of variability in backwater effects, and therefore, variability in the stage-discharge relation that exists at this location. A statistical model to predict discharge on the Sacramento River near the western end of the Fremont Weir was developed to assess the range of variability in the stage-discharge relation in the historical data. Historical data and data collected in 2016 were used to estimate discharge near the Fremont Weir for a 27-year period (April 1990 to April 2017). Hourly historical stage data on the Sacramento River near the Fremont Weir (FRE) are available back to 1984, stage and discharge data for Sacramento River below Wilkins Slough (WLK) are available back to 1987, and stage and discharge data for the Sacramento River at Verona (VON) are available back to April 1990 (table 1). Daily data existed for these gages before the dates mentioned earlier, but were not used for this analysis because river stages in this region can change greatly over a daily time step. For example, stage at FRE often increases at a rate of 0.4 foot per hour during flow pulses. Predicted discharge was output at hourly time steps for the 27-year period to match the sampling frequency of data collected at FRE. Stage data at WLK and VON were lag corrected to account for travel time. Discharge data at the temporary Fremont Weir gage (FRE.temp) for 2016 showed no lag compared to VON, so historical WLK discharge data were lag corrected to VON. The average lag correction from WLK to VON was about 12 hours for an approximate 37-mile stretch of river.

Five predictor variables (X) were used for the response variable (Y) in the development of the statistical model for discharge:

$X1$ = Stage at FRE
$X2$ = Discharge at WLK
$X3$ = Discharge at VON
$X4$ = Stage difference: WLK–FRE (water-surface slope)
$X5$ = Stage difference: FRE–VON (water-surface slope)
Y = Discharge at FRE.temp

The $X4$ and $X5$ variables were used in the regression because all surface-water flows are driven by barotropic pressure gradients (in this case the water-surface slope). A stepwise linear regression was used in the Matlab statistical toolbox to determine the best model from the predictor variables (MathWorks® Inc., 2017). The stepwise regression is a procedure to automatically choose the best predictor variable by systematically adding or removing terms based on their statistical significance to the response variable. The Matlab function—stepwiselm—used a forward and backward regression; at each step in the regression, terms were added or removed based on minimizing the sum of the squared error using the p value of an F-statistic to select the optimal model. The final model equation and Matlab output is provided in the appendix, and has 15 terms in 5 predictor variables, which include products of pairs from almost all distinct predictors, has an R^2 of 0.998, and a root mean square error of 361 ft^3/s.

The linear regression model developed from stepwise regression explains much of the variability ($R^2 = 0.998$) in the 2016 observed data at FRE.temp (fig. 15). Most of the variability in model residuals was likely due to the noise in the velocity data used in the measured discharge estimate. The range of measured discharge (6,900–28,400 ft^3/s) was narrower than the range of predicted discharge (3,800–32,600 ft^3/s), but the extrapolated discharge was likely outside the range of operable notch stages and discharge, given that the range of discharge measured in 2016 spanned Sacramento River stage values lower than 19 ft (minimum stage for the notch stage-discharge rating), to Sacramento River stage values higher than the crest of the Fremont Weir (32.5 ft). The discharge at FRE.temp was generally less than at WLK for higher stage/discharge conditions due to backwater effects. On the hydrograph recession, the discharge at FRE.temp increased above that at WLK as the backwater was released (fig. 16).

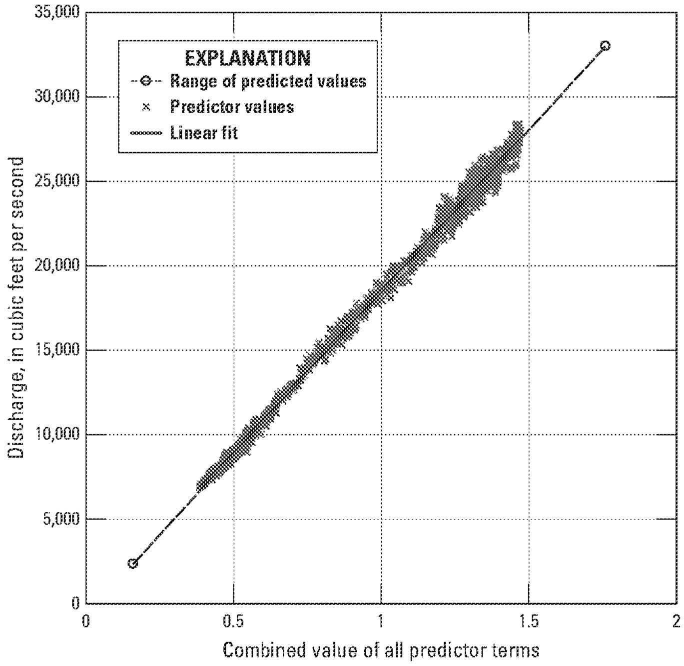

Figure 15. Fit of linear regression model used to predict discharge on the Sacramento River above Fremont Weir near Knights Landing, California.

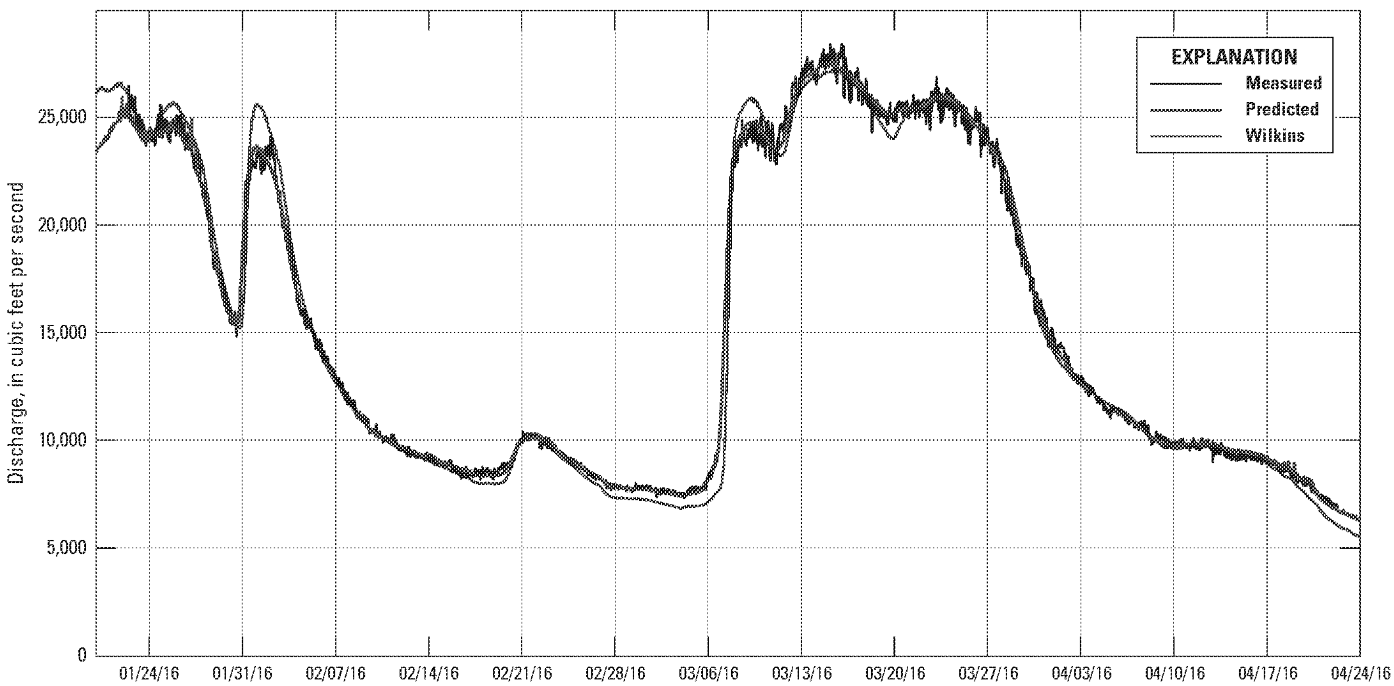

Figure 16. Discharge measured on the Sacramento River above Fremont Weir near Knights Landing, predicted discharge based on a linear regression model at the same location, and measured discharge of Sacramento River at Wilkins Slough, California, January 22–April 24, 2016.

Variability in the Stage-Discharge Relation

Variability in the stage-discharge relation near the western end of the Fremont Weir was due to backwater conditions caused by increased discharge from the Sutter Bypass and the Feather River. A first order approximation of the degree of backwater was made using the ratio (Qr) of the discharge at WLK (Q_{WLK}) to the discharge at VON (Q_{VON}):

$$Qr = \frac{Q_{WLK}}{Q_{VON}} \qquad (2)$$

The discharge ratio was used to parameterize the variance in the critical streakline estimate (see "Variance Used in Hydraulic Entrainment Zone Calculation" section). The consequences of variability in the stage-discharge relation on the Sacramento River near the Fremont Weir are critical to notch design. River stage controls the notch flow, and the ratio of notch flow to the Sacramento River flow determines the fraction of Sacramento River discharge entrained into the notch, which in turn affects the juvenile salmon entrainment rate.

The degree of backwater near the Fremont Weir can be estimated if it is assumed that the discharge at WLK is upstream of backwater effects from the Sutter Bypass and Feather River. On the basis of the minimal scatter in the stage-discharge relation at WLK (not shown) this appears to be a reasonable assumption. The difference in discharge (Q_{VON}–Q_{WLK}) is equal to the combined discharge from the Feather River and Sutter Bypass. The Qr is therefore an estimate of the degree of backwater, where a ratio more than 0.5 signified more discharge from the Sacramento River, and a ratio less than 0.5 indicated more discharge from the Feather River and (or) Sutter Bypass and likely increased backwater effects on the Sacramento River near the Fremont Weir.

The probability of a given Qr for the 27-year historical record and for the 2016 data is shown on figure 17. The mean Qr of 0.58 for the historical record indicates that typically the Sacramento River has more discharge than the Feather River. The conditions measured in 2016 were closer to the mean (0.58), but there were some periods of backwater conditions (Qr less than 0.50), and some short periods where Qr was at or near the historical low value, indicating the highest degree of backwater. On the basis of the historical record, backwater conditions occurred less frequently than non-backwater conditions, but were still frequent enough that backwater had to be accounted for (Qr less than 0.5 occurred 24 percent of the time).

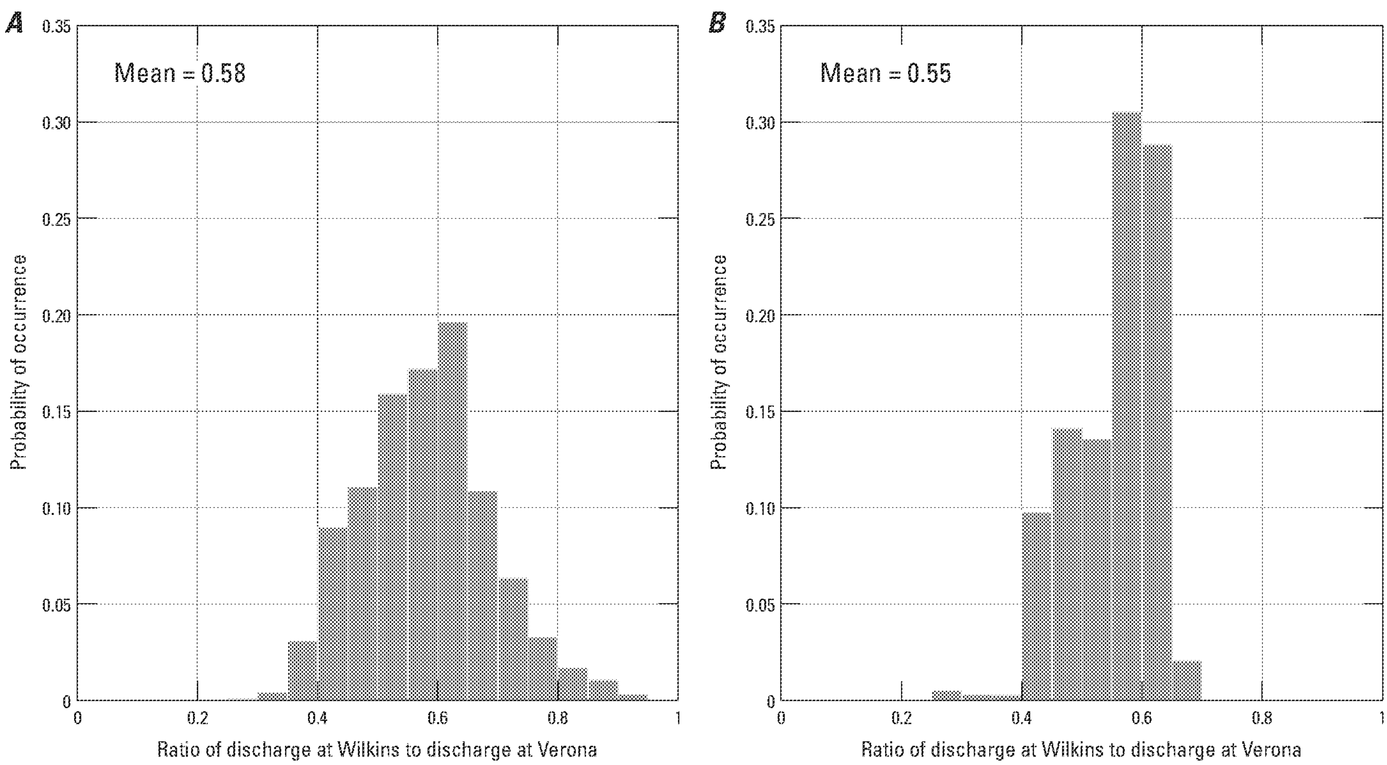

Figure 17. Probability of occurrence of the discharge ratio of Sacramento River at Wilkins Slough to the Sacramento River at Verona, California. The discharge ratio was used as an index for degree of backwater on the Sacramento River near the Fremont Weir: *A*, historical data from April 1990 to April 2017, for the period December 1–March 15, where western alternative notches will be operational; and *B*, data for the 2016 data-collection period (January 22–April 22, 2016).

Next, the variability in the stage-discharge relation and the frequency of occurrence based on the 27-year statistically modeled discharge and stage at the Fremont Weir were examined to determine the likely consequences of backwater conditions. For this analysis, a stage range of 19 to 32.5 ft and the period December 1–March 15 of an operable notch were used for the western alternatives (table 3). Figure 18 shows the statistically modeled discharge versus stage binned and colored to represent the number of occurrences, with the stage-discharge rating curve developed from 2016 data (see "Sacramento River Near Fremont Weir" section) overlain in black. This plot has several salient attributes. First, lower stages and correspondingly lower flow into the notch occurred more frequently. Second, at the lower and higher stages the frequency of discharge occurrence was in close agreement with what would be predicted by the stage-discharge curve, while at mid-range stage values the most frequent discharge was higher than what would be predicted by the stage-discharge curve. For the full range of stage, discharge was higher than what would be predicted by the 2016 stage-discharge curve. This indicates that backwater effects are less frequent, which is consistent with the bulk measure of backwater conditions. The stage-discharge rating curve developed from the 2016 data has a large range of discharge for higher stage values, so the rating curve could be more skewed toward measuring backwater effects. Likely, the true mean is not known because of the short duration of the 2016 deployment. Lastly, there was a considerable variability in the discharge for a given stage, on the order of 5,000 ft^3/s. Regardless of the true mean in the stage-discharge relation, the probability of not knowing the magnitude of flow for a given stage on the Sacramento River is fairly high if a stage-discharge rating curve is used to estimate discharge.

To quantify the influence that variability in the stage-discharge relation can have on entrainment, the variability in the ratio of river discharge to notch discharge was examined based on the notch stage-discharge ratings. Figures 19–21 are similar to figure 18, except the y-axis has the notch discharge ratio for each of the western alternatives colored by number of occurrences for a given stage and the discharge ratio predicted by the stage-discharge rating curve developed from the 2016 data. The notch stage-discharge rating curves show a constant flow at higher stage values (these values varying for alternatives 3, 4, and 6), which accounts for a decrease in flow ratio at the higher end of the curve. Similar to the stage-discharge plot, lower and higher stage values were in close agreement between the frequency of occurrence and what would be predicted by the 2016 stage-discharge rating curve. At mid-range stage values the central tendency of the estimated notch discharge ratio was generally lower than what the stage-discharge rating curve would predict for all alternatives. For alternatives 3 and 4, the variability in discharge ratio was on the order of 0.05 and for alternative 6, variability was on the order of 0.1, with a general increase in variability for higher discharge ratio values.

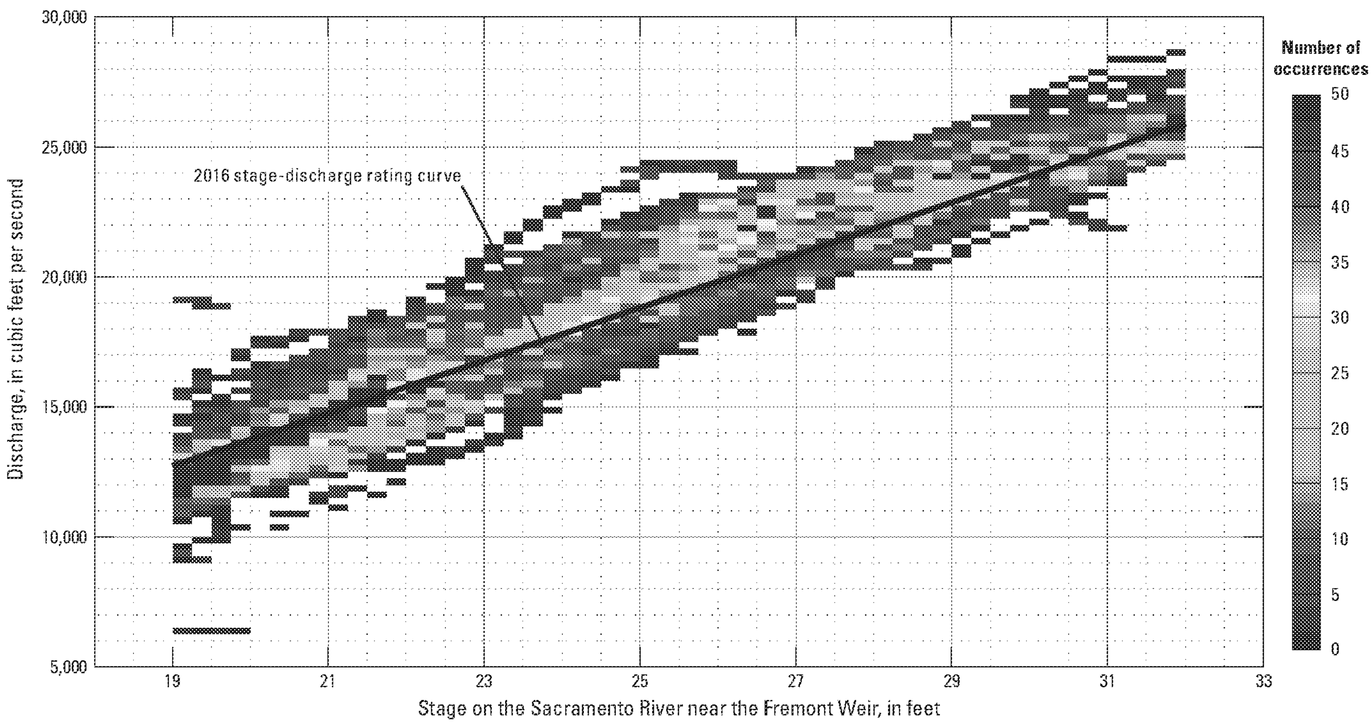

Figure 18. Discharge versus stage (19–32 feet) for the 27-year period (April 1990–April 2017) of modeled discharge on the Sacramento River near the Fremont Weir, California. Only data for the period December 1–March 15 of notch operation are included. Stage and discharge ratio are binned in 0.25-foot stage and 250 cubic foot per second discharge increments and colored by number of occurrences.

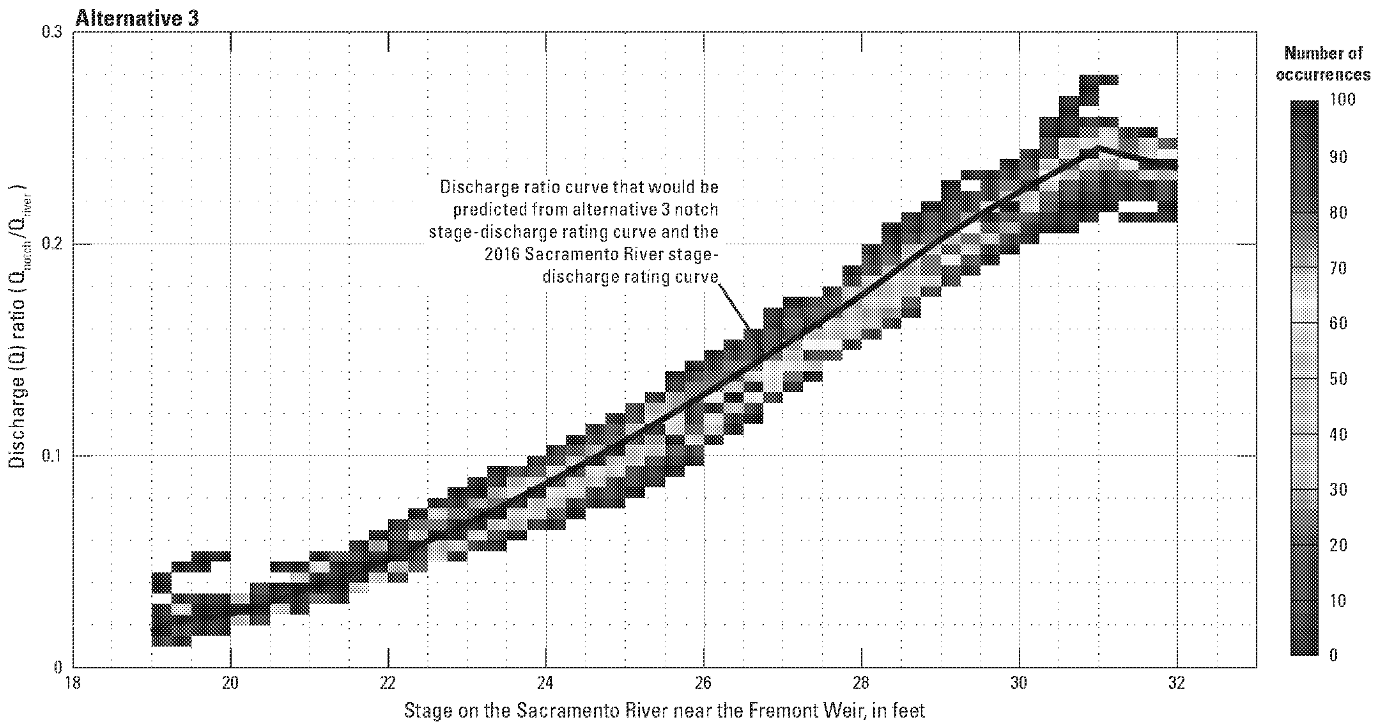

Figure 19. Discharge ratio (Q_{notch}/Q_{river}) versus stage (19–32 feet) for the 27-year period (April 1990–April 2017) of modeled discharge on the Sacramento River near the Fremont Weir, California, using the notch stage-discharge rating for alternative 3. Only data for the period December 1–March 15 of notch operation are included. Stage and discharge ratio are binned in 0.25-foot stage and 0.005 discharge ratio increments and colored by number of occurrences.

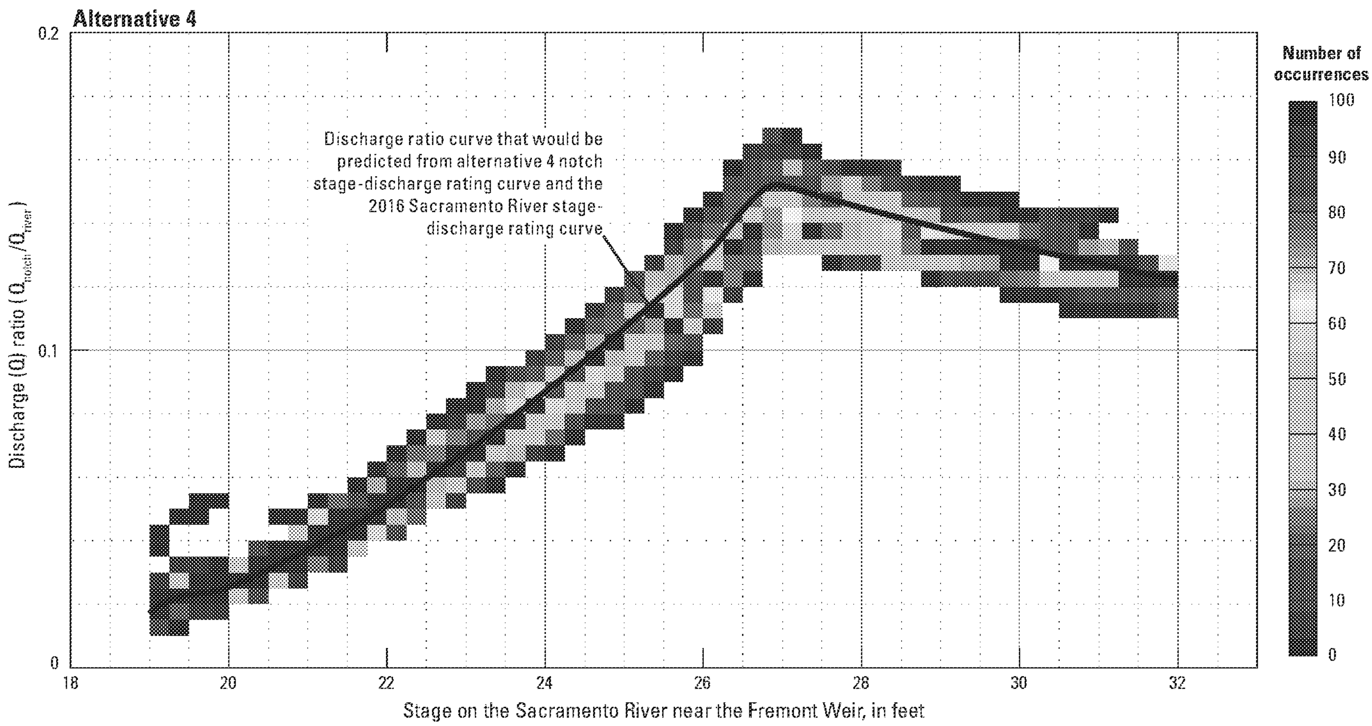

Figure 20. Discharge ratio (Q_{notch}/Q_{river}) versus stage (19–32 feet) for the 27-year period (April 1990–April 2017) of modeled discharge on the Sacramento River near the Fremont Weir, California, using the notch stage-discharge rating for alternative 4. Only data for the period December 1–March 15 of notch operation are included. Stage and discharge ratio are binned in 0.25-foot stage and 0.005 discharge ratio increments and colored by number of occurrences.

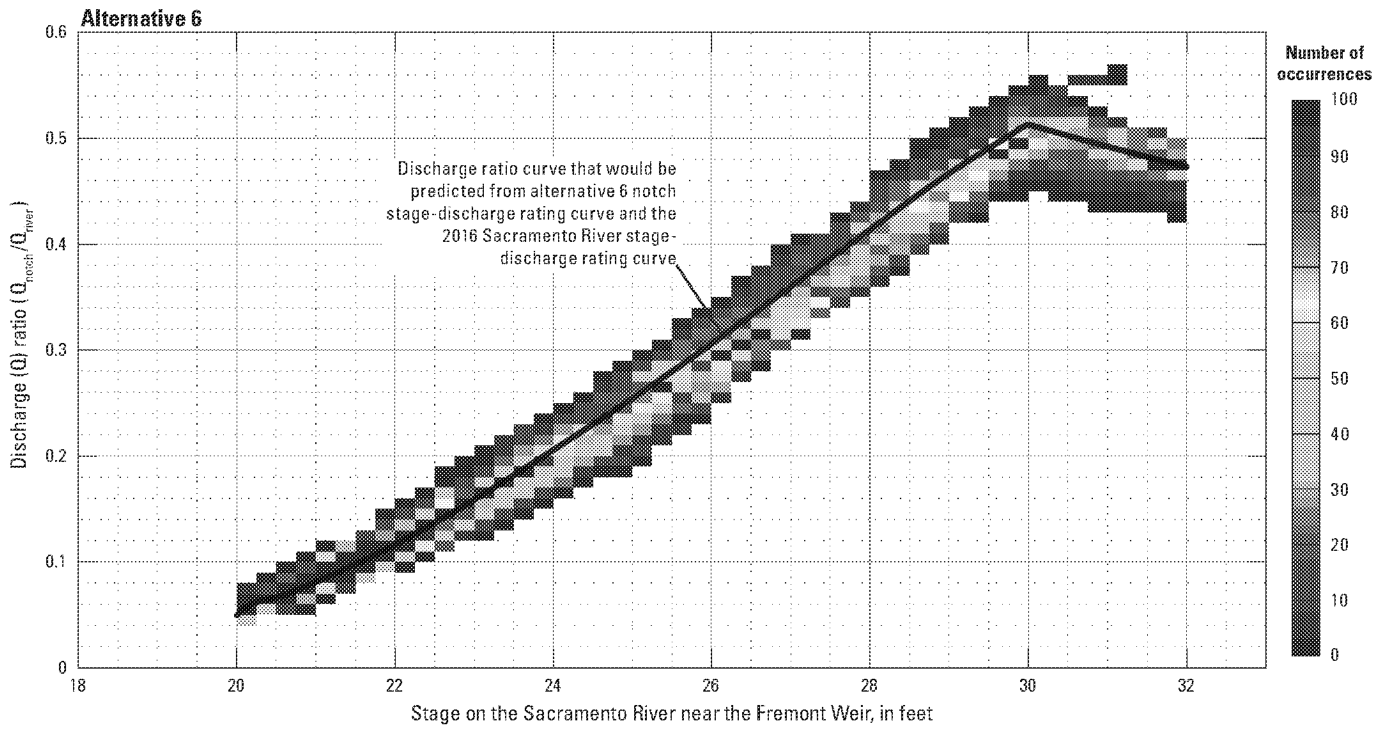

Figure 21. Discharge ratio (Q_{notch}/Q_{river}) versus stage (20–32 feet) for the 27-year period (April 1990–April 2017) of modeled discharge on the Sacramento River near the Fremont Weir, California, using the notch stage-discharge rating for alternative 6. Only data for the period December 1–March 15 of notch operation are included. Stage and discharge ratio are binned in 0.25-foot stage and 0.01 discharge ratio increments and colored by number of occurrences.

Integrating fish entrainment rates into a notch over time without knowing the variability or the true river discharge can seem unimportant because water entrainment into a notch will likely average out to the mean. However, in the context of maximizing population-level survival based on juvenile salmon entrainment into the notch that may happen over short periods (days to weeks), errors in water entrainment estimates may be magnified, fish entrainment may be grossly misestimated, and the direction of bias (either positively or negatively) will not be known.

In the "Hydraulic Entrainment Zone" section, the effect on entrainment estimates due to variability in the stage-discharge relation is discussed in greater detail. Generally, there are fairly sharp cross-stream gradients in fish distributions based on studies completed in the tidally affected Sacramento River and Georgiana Slough junction (California Department of Water Resources, 2012, 2015, 2016), so small changes in the discharge ratio could produce disproportionately larger changes in the number of fish entrained.

The authors postulate that the variability in the stage-discharge relation will have two effects. The first-order effect is that the magnitude of discharge at any particular stage will deviate significantly from the historical average discharge observed at that stage, as is shown on figure 18. The second-order effect is the velocity distribution at any particular stage will vary as a function of backwater conditions (see "Secondary Circulation at the Sacramento River Bend Near the Fremont Weir" section), and this effect can change the cross-channel distribution of discharge in a cross section. In the "Variance and Uncertainty in Hydraulic Entrainment Zone Estimate" section, it can be shown that the first-order effect on discharge can be reasonably accounted for, but the second-order effect on the velocity distribution and resulting cross-channel distribution of discharge in the river bend is more difficult to quantify.

Influence of Secondary Circulation on Velocity and Discharge Distributions

In the previous section the regional-scale hydrology using river-discharge data was examined and the conclusion was reached that there is a substantial amount of variability in the stage-discharge relation that can lead to errors in entrainment estimates if this variability is not taken into account. In this section the local-scale hydrodynamics at a river bend are examined, including multidimensional velocity and discharge distributions, and how these distributions vary as a function of river discharge, location along the river, and backwater conditions. Velocity transects taken along the river bend are used to (1) document the setup and relaxation of secondary circulation through the river bend, (2) investigate the variability and strength of secondary circulation over a range of discharge conditions, and (3) estimate the distribution of discharge at discrete cross sections. These results will be used to discuss the potential hydrodynamic influence on fish distributions along the 0.4-mile reach shown on figure 8.

Secondary Circulation at the Sacramento River Bend Near the Fremont Weir

The evolution of the velocity distribution and the strength of the secondary circulation for one stage and discharge condition is shown on figure 22. At the first cross section upstream from the bend, the channel was prismatic and the along-stream velocity distribution had a maximum (red values) near the center and a broad distribution of higher velocities. The secondary currents, indicated by the velocity arrows, are weak and there were no apparent coherent structures. Moving down river at cross-section 2, the velocity distribution was similar, and the secondary currents were a little stronger near the right bank. Moving farther into the river bend (cross-sections 3 and 4) the velocity distribution was more skewed toward the outside of the bend and the secondary currents were stronger (about 0.5 ft/s) with a significant down-welling zone and return flow along the bottom. In both of these cross sections the peak along-stream velocities were at a depth of about 18 ft, whereas the peak velocities at cross-sections 1 and 2 were near the surface. At cross-section 4 there was a narrow range of peak velocities compared to the preceding cross sections. At cross-section 5, the velocity distribution was still skewed toward the outside of the bend with a fairly strong and coherent secondary circulation cell, with the vortex in the center of the channel. The velocity distribution began to relax at cross-section 5, where strong velocities are apparent to the left of channel center. At cross-sections 6 and 7, the secondary currents were weaker and the higher velocities were more distributed through the cross section, but still slightly skewed toward the right bank. At cross-section 8, the channel was fairly prismatic, and the velocity distribution and secondary currents were similar to those in cross-sections 1 and 2, indicating relaxation of the secondary circulation and leftward shifting of the velocity distribution.

The strength of secondary circulation and velocity distribution also varied over the range of conditions that were measured (fig. 23). Data collected in 2016 at river stages of 15, 17, 22, 24, and 30 ft indicated there was little to no backwater influence, on the basis of the Wilkins to Verona discharge ratio (table 4). Data collected in 2017 at stages of 25, 28, and 31 ft evidenced significant backwater conditions. The banks of the river near the outside of the bend were overtopped at a stage of about 29 ft, and a large field between the river and the weir became inundated, so conditions measured at stages of 30 and 31 ft included effects of the overbank region. For conditions with neither backwater nor overbank flow (stages of 15, 17, 22, and 24 ft), the structure of the velocity profiles was qualitatively similar, with the peak along-stream velocity skewed toward the outside of the bend and the center of the circulation cell positioned close to mean depth at the center of the channel. However, the magnitude of along-stream and cross-stream velocity changed when either backwater or overbank flows were present.

For backwater present but no overbank-flow conditions, the velocity distribution and positioning of the circulation cell were similar at river stages of 25 and 28 ft, but the peak velocity was lower and the location of the down-welling zone was positioned closer to the center of the channel, as compared to river stages where no backwater was observed (river stages of 15, 17, 22, and 24 ft). For overbank conditions without and with backwater (river stages of 30 and 31 ft, respectively), the velocity profiles were different than for the previous conditions. Here, the peak velocity magnitude was close to the center of the channel, and there were two circulation cells to the left and right of the center of the channel (based on width) with the cell on the left located deeper due to the greater water depth. The salient feature for backwater and overbank conditions was a shift in peak velocity and down-welling zone toward the channel center. When the riverbank was overtopped, the transfer of momentum from the floodplain to the river (Morvan and others, 2002) increased the influence of the side-wall boundary layer, which caused a shift in the velocity distribution and location of secondary cells at river stages greater than 29 ft. For backwater conditions, both the along-stream and cross-stream velocity magnitudes were reduced compared to lower stage values; therefore, the strength of the secondary circulation cell did not have enough force to overcome the inertia of water mass near the riverbanks, which resulted in a shift in peak velocity and location of the down-welling zone. There were not enough data at discrete stage values to fully understand or quantify the range of variability in velocity distributions, but from the available data, it appears that backwater effects in the Sacramento River near the western end of the Fremont Weir resulted in significant observable first- and second-order effects on the cross-sectional velocity distributions at this river bend.

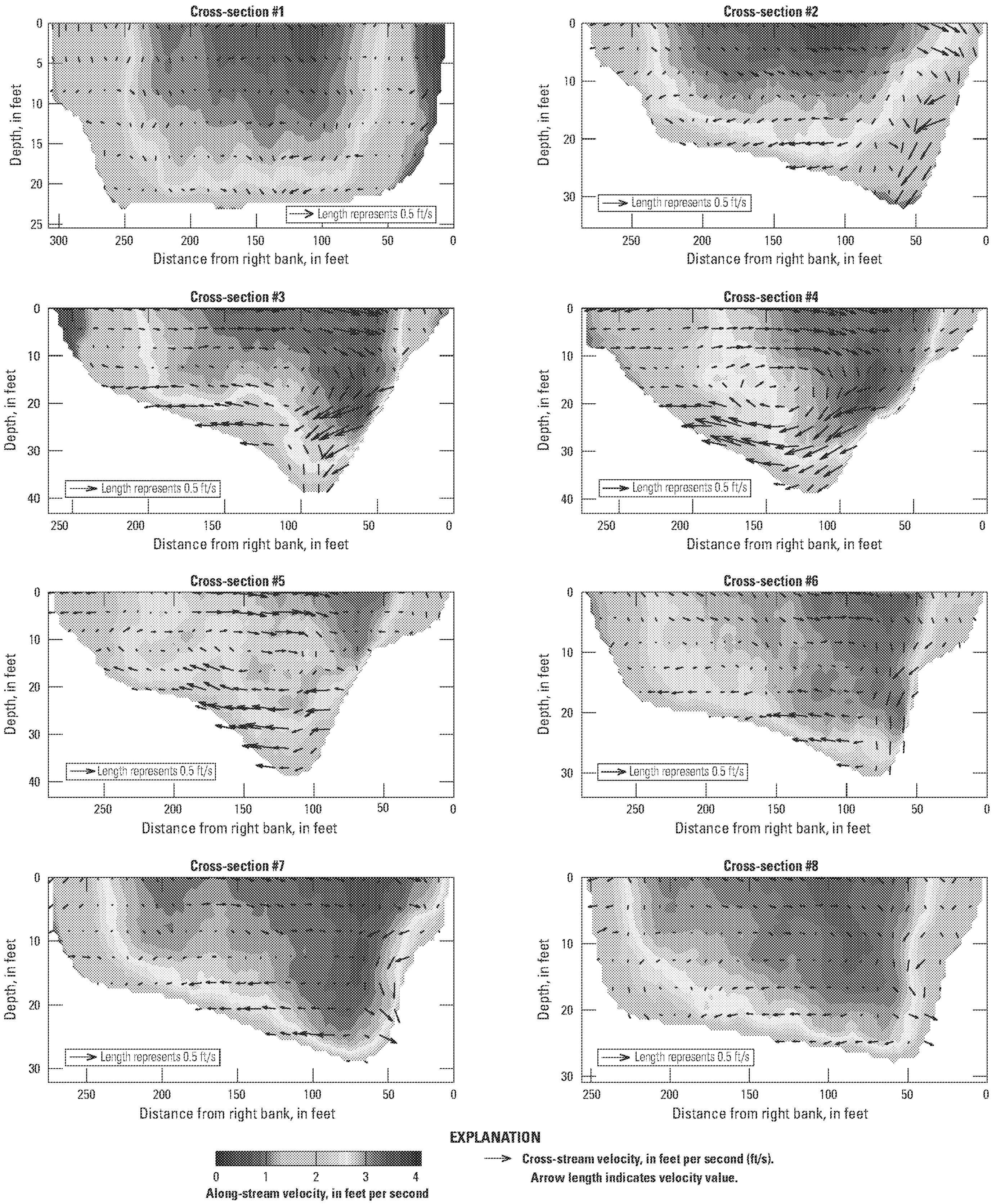

Figure 22. Velocity profiles along the Sacramento River near the river bend at the western end of the Fremont Weir, California, showing along-stream and cross-stream velocity in relation to depth and distance from the right bank. Profiles measured March 30, 2016, at a stage of 24.2 feet and discharge of 15,900 cubic feet per second.

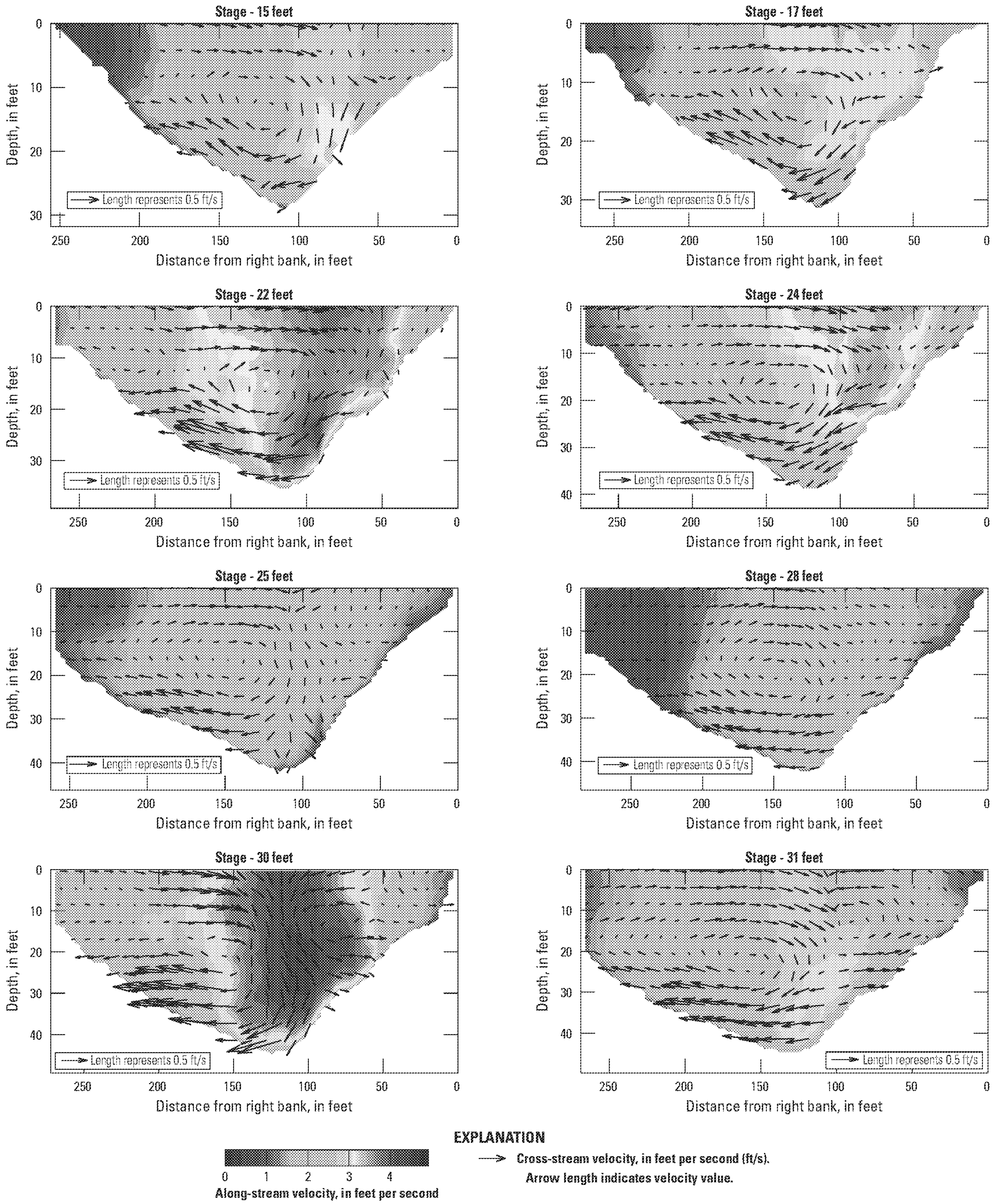

Figure 23. Velocity profiles for various stages at cross-section 4 along the Sacramento River at the western end of the Fremont Weir, California, showing along-stream and cross-stream velocity in relation to depth and distance from the right bank.

Discharge Distribution Along the River Bend

The conceptual model central to this analysis is that secondary currents will accumulate fish mass along the outside of the channel bend, such that notch locations can be optimized to maximize fish entrainment rates. The velocity distribution and magnitude of the secondary circulation were variable over the range of conditions measured, therefore, the rate of accumulation and the location of the peak in the fish spatial distribution varied as well (Blake and others, 2017).

As a first-order estimate, the ratio of the integrated cross-stream to along-stream velocity can be used to examine the concentration of discharge. The maximum surface layer velocity components at each cross section are presented on figure 24*A*–*C*. The along-stream velocities had a range of 2.3 to 4.6 ft/s, but did not increase monotonically with stage due to backwater conditions. There was minimal variability in the along-stream velocities for a given condition among the cross sections. The cross-stream velocities had more variability among the cross sections, but less variability across stage conditions. The cross-stream velocity increased and reached a maximum near the apex of the river bend (cross-sections 3–5) for all conditions, with a range of about 0.3 to 0.8 ft/s. The downward velocity showed a trend similar to the cross-stream velocity with a maximum near the apex of the river bend (cross-sections 3–5), but for some conditions there was a fairly uniform maximum along the river. The ratio of the mean cross-stream velocity to mean along-stream velocity is shown on figure 24*D*. For all conditions the discharge concentrated fastest at the river bend apex (cross-section 4) where secondary circulation was the strongest.

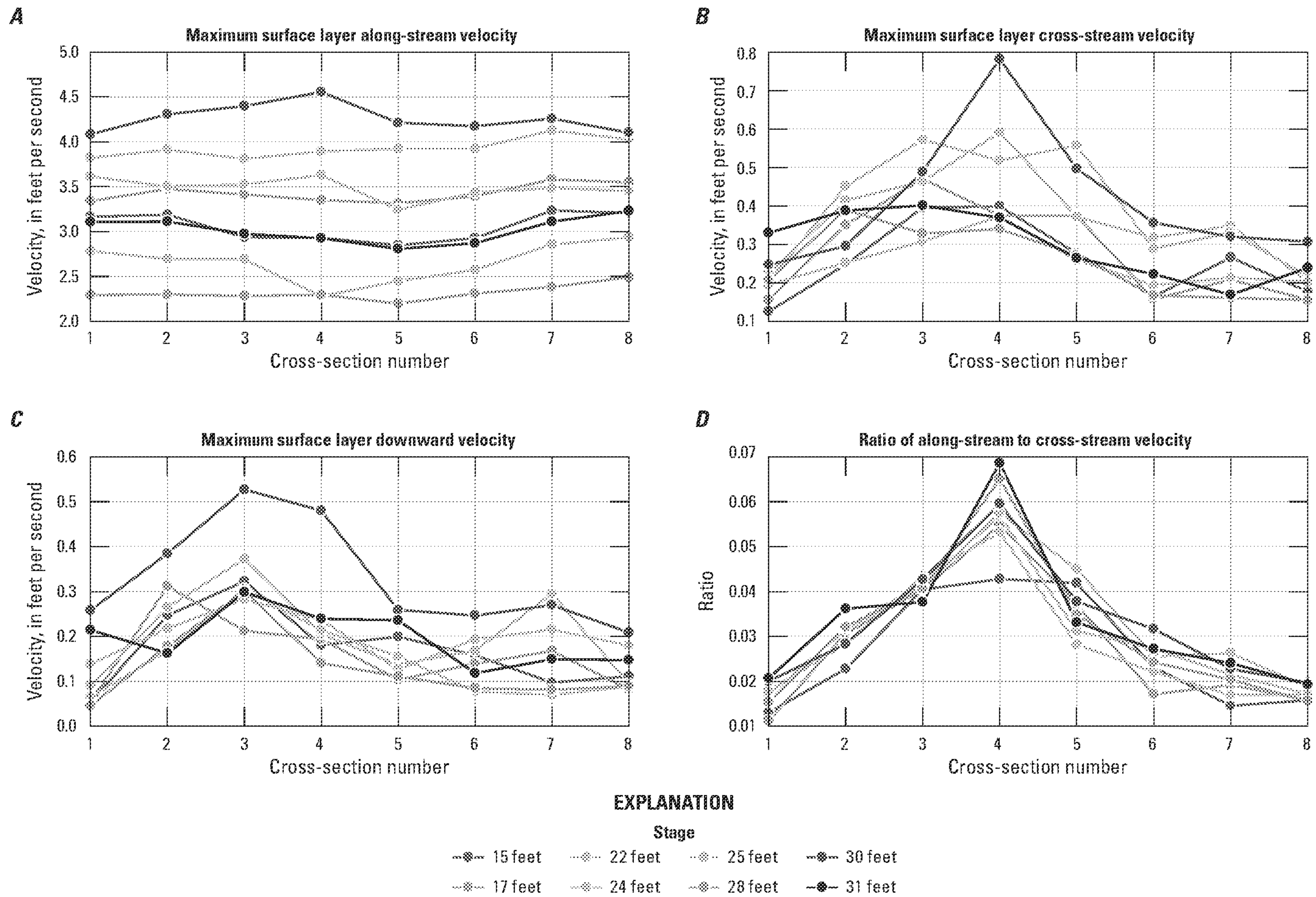

Figure 24. Surface layer velocity components in relation to stage at each cross section of the Sacramento River at the western end of the Fremont Weir, California: *A*, maximum along-stream velocity; *B*, maximum cross-stream velocity; *C*, maximum downward velocity; and *D*, ratio of mean cross-stream velocity to along-stream velocity.

The width of each cross section and the depth-integrated discharge along each cross section are normalized by using the maximum values of each per cross section to compare the cross sections and the range of conditions (fig. 25). The discharge profiles showed variability with respect to their shape and in the location of the peak flow over the range of conditions, but the following general pattern held: At cross-sections 1 and 2 the discharge profile was fairly normally distributed along the cross section, with total discharge divided about equally between the left and right halves of the river width. At the apex of the river bend (cross-sections 3–5) the discharge was skewed slightly toward the outside of the bend, and the shape of the discharge profile changed with a narrower zone of high discharge. Just downstream from the apex of the bend, at cross-sections 6 and 7, the discharge was skewed more toward the outside of the bend, but the cross-stream range of higher discharge was broader. By cross-section 8 the discharge was still skewed toward the outside of the bend, but the cross-stream range in higher discharge was closer to what was seen in cross-sections 1 and 2. At this river bend the secondary currents distributed the highest along-stream velocities toward the outside of the bend near the bend apex, but the maximum river depth was near channel center, resulting in discharge profiles that are only slightly outward-skewed near the apex. Downstream from the apex the maximum river depth was skewed toward the outside of the bend, and the resultant discharge profile was more skewed toward the outside of the bend, but the broader cross-stream range of higher discharge indicated that the velocity profile had become less outwardly skewed due to return flow along the bottom water layer.

Bed topography in a river bend is the integrated effect of strong secondary currents and down-welling that produces deeper scour holes toward the outside of the bend (Blanckaert, 2010). The overbank and backwater conditions that tended to shift the peak velocities and down-welling zone to nearly mid-channel at the apex of the bend could have been responsible for defining the bathymetry at the apex of the bend, resulting in a discharge distribution that was not skewed as much as one would expect near the apex of the river bend. At cross-sections 6 and 7, the along-stream velocity distribution was skewed toward the outside bank, but the magnitude of secondary and down-welling currents was reduced, and therefore, the deeper bathymetry was toward the outside of the bend. This resulted in a discharge distribution that was outwardly skewed equally or greater than at the apex of the bend.

To illustrate this effect, the ratio of discharge on river right (toward the outside of the bend), versus the discharge on river left, is shown on figure 26. All conditions show that at some point discharge was skewed toward the outside of the river bend, with two distinct peaks at cross-sections 3 and 7. There was considerable variability in how much discharge was distributed toward the outside of the bend, but there was a positive correlation between the discharge ratio of WLK to VON (or lack of backwater) and the percent discharge on river right averaged for all cross sections. Qualitatively, backwater and overbank conditions tended to centralize discharge for those particular conditions, which bears out in this example. An additional effect was deepening of the river bathymetry toward the center of the channel. As a result, during non-backwater conditions, the discharge did not become strongly skewed at cross-sections 4 and 5.

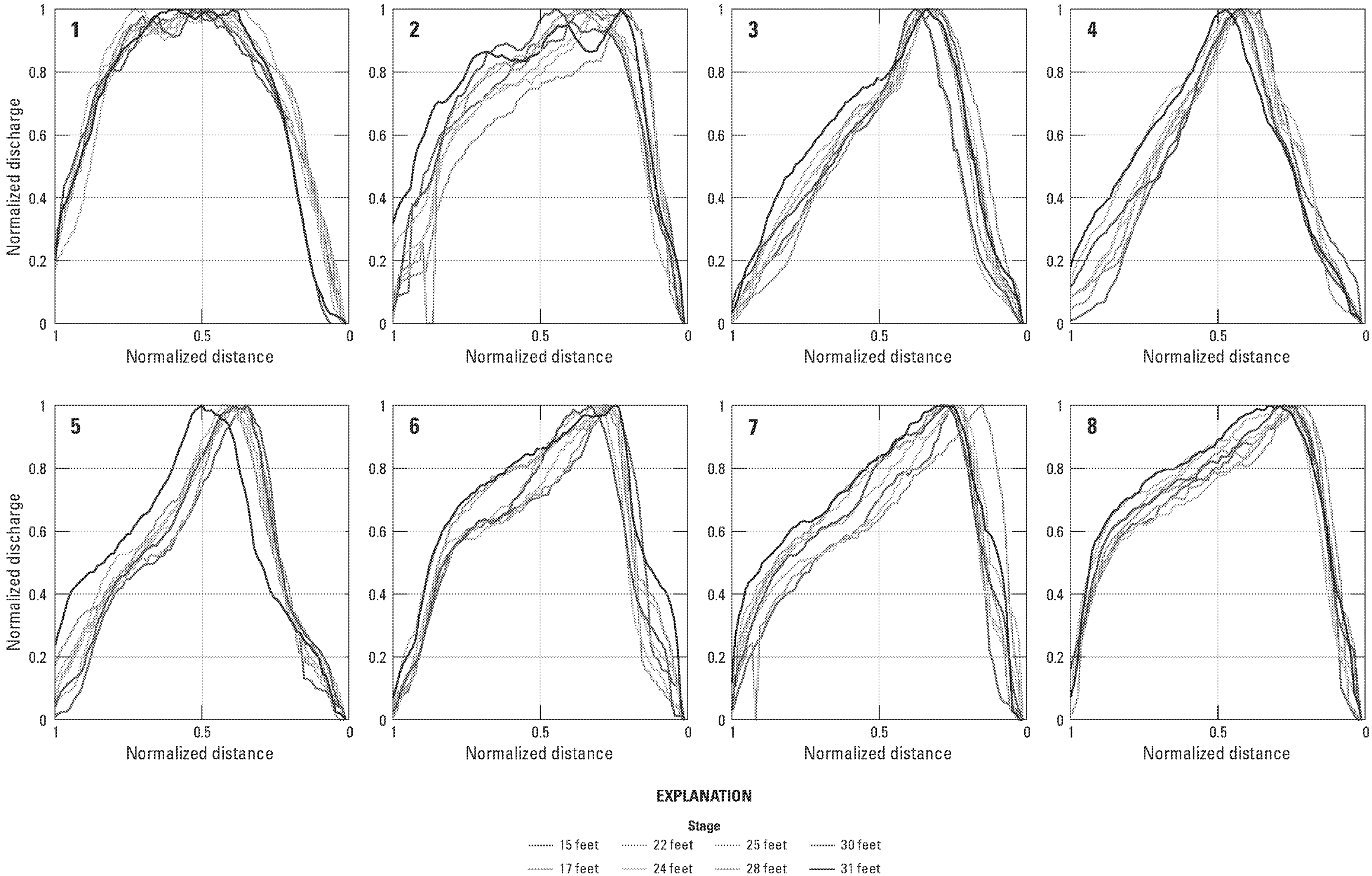

Figure 25. Normalized discharge profiles for cross-sections 1–8 in relation to stage of the Sacramento River at the western end of the Fremont Weir, California.

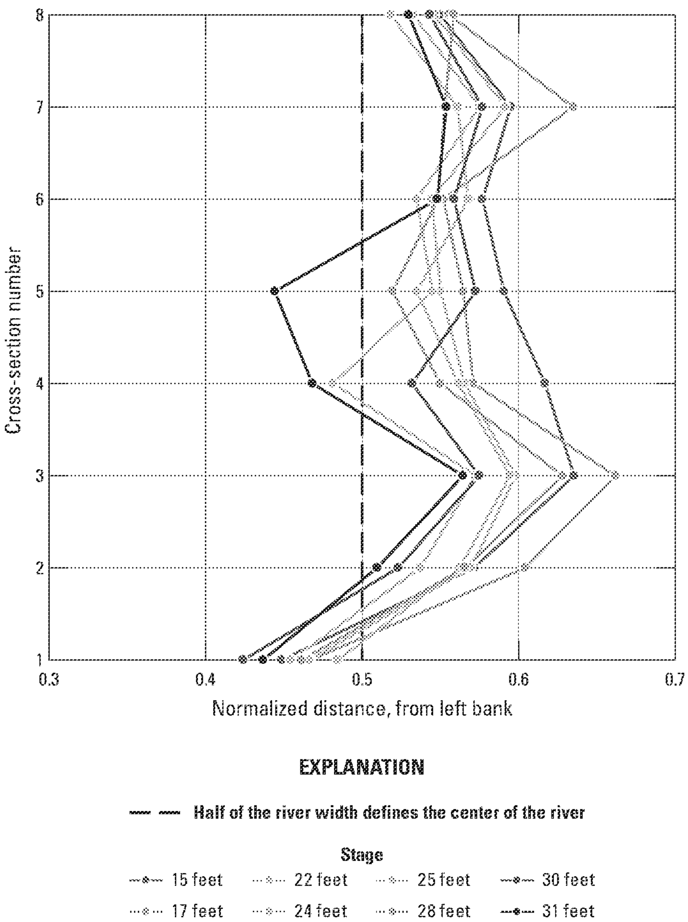

Figure 26. Position along a cross section where fraction of flow equals 0.5 to illustrate how discharge is skewed toward the outside of the bend in the channel as a function of stage of the Sacramento River, California.

Hydraulic Entrainment Zone

The critical streakline method is used to define the extent of the hydraulic entrainment zone. This is a two-dimensional approach to estimate a line extending upstream from a river junction, or engineered notch diversion, which separates the water that will be entrained down either side of the junction. The fish distribution data that were collected are in two dimensions in the horizontal plane. Detailed velocity measurements along the river bend were made, and the three-dimensional effects of secondary circulation on the redistribution of velocity and discharge along a cross section are accounted for. The velocity measurements were distilled into two dimensions to compare to the fish distributions for entrainment estimates.

The accuracy of fish entrainment estimates is reliant upon accurate estimates of the critical streakline location for proposed notch scenarios. The accuracy of critical streakline estimates is affected by (1) the variability in the stage-discharge relation, and (2) the influence of a specific notch design on the local small-scale (for example, velocity variability within several feet) hydrodynamics. Inaccuracies in critical streakline estimates could lead to relatively large errors in fish entrainment estimates, given that gradients in cross-channel fish mass near the riverbanks can be high relative to gradients in cross-channel flow distribution.

The method of hydraulic entrainment zone estimation is straightforward, and an estimate is provided to account for the variance in the critical streakline due to second-order effects of backwater conditions in the Sacramento River (first- and second-order effects are discussed in more detail in the "Variability in the Stage-Discharge Relation" section). The entrainment rate estimates based on the critical streakline approach are expected to be conservative (that is, underestimate fish entrainment) given the expectation that the momentum of secondary circulation toward the outside of the bend will improve the entrainment of surface-oriented fishes in surface-oriented notches.

Hydraulic Entrainment Zone Estimate

The width of the hydraulic entrainment zone, as defined by the cross-stream location of the critical streakline (X), was estimated from the right bank at eight locations where the velocity transects were made. The following process was used to calculate X.

1. The measured velocity was extrapolated to the surface, streambed, and riverbanks (fig. 27*A*) with the one-sixth power law using equation 3:

$$\frac{U}{U_A} = \left(\frac{y}{y_A}\right)^{\frac{1}{6}} \tag{3}$$

where

U is the last measured velocity at a point y, and
U_A is the unmeasured velocity to be extrapolated at a point y_A.

Extrapolation to the water surface and riverbed occur in the vertical plane, and then the velocities are extrapolated to the riverbanks in the horizontal plane. The vertical and horizontal planes are normalized (from 0 to 1) by the depth of water or the width of the cross section, respectively. An example of extrapolation to the surface is as follows: The last measured velocity $U = 1$ ft/s is at a point 7 ft above the riverbed for a depth of 10 ft, therefore $y = 0.7$; to extrapolate U at 7 ft to 8 ft above the riverbed then $y_A = 0.8$, and the extrapolated velocity is $U_A = 1 \times (0.8/0.7)^{1/6}$ or $U_A = 1.02$ ft/s.

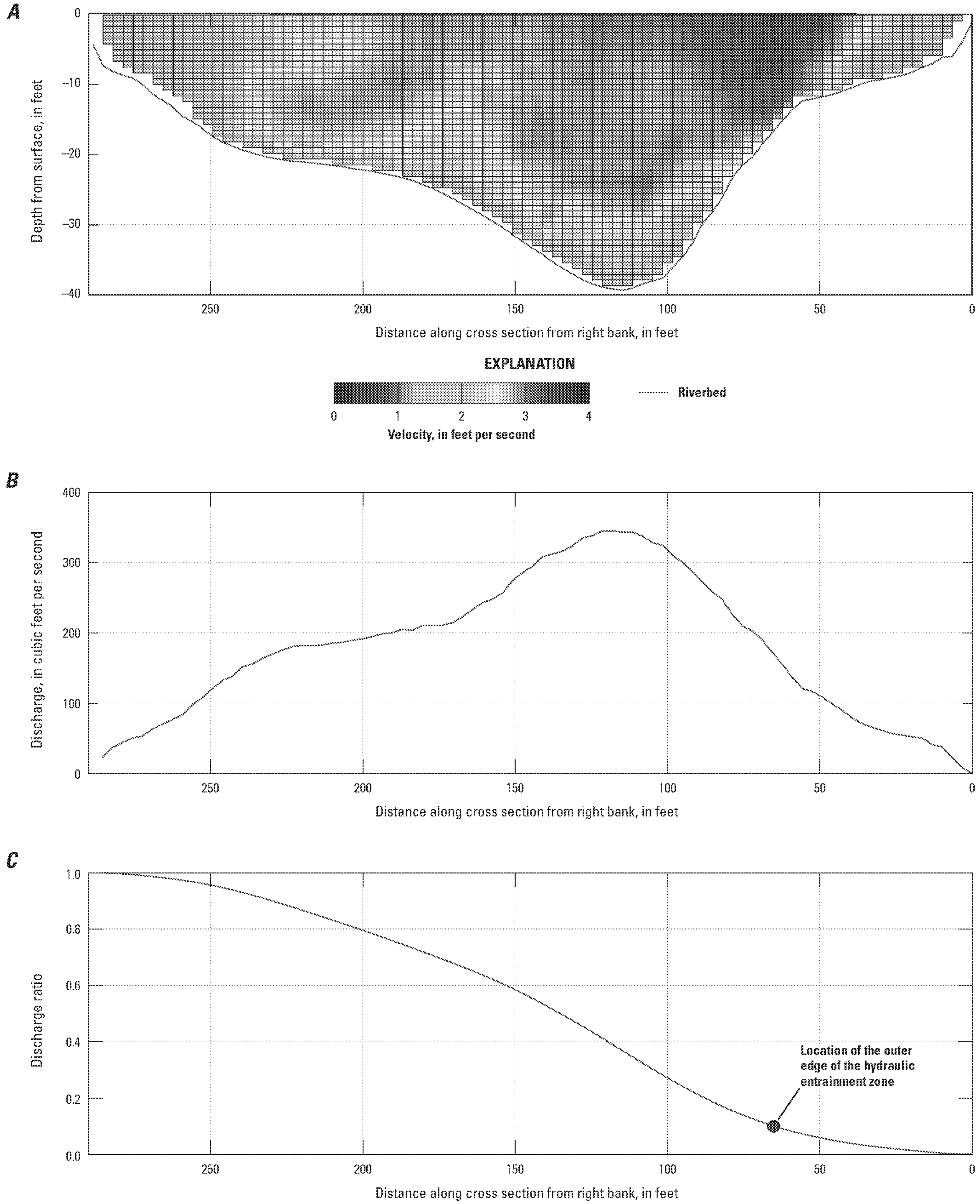

Figure 27. Critical streakline location at cross-section 4 along the Sacramento River near the Fremont Weir, California, at a stage of 24.2 feet, river discharge of 15,900 cubic feet per second, and a notch discharge of 1,550 cubic feet per second (alternative 4 notch stage-discharge rating): *A*, along-stream velocity distribution in relation to depth and distance from the right bank; *B*, discharge (velocity integrated to depth) in relation to distance from the right bank; and *C*, cumulative discharge distribution in relation to distance from the right bank.

2. The river discharge (Q_{river}) was calculated by numerically integrating velocity (V) with respect to the depth of the water (h) and distance along the river cross section (W) at each increment along the river (dy) (eq. 4; fig. 27B).

$$Q_{river} = \int_0^W V\ h\ dy \quad (4)$$

3. The cumulative sum of discharge along each cross section was calculated and normalized by the total discharge for that cross section to produce an empirical cumulative distribution function (CDF) of discharge along the river cross section from 0 to 1 (eq. 4; fig. 27C). The discharge CDFs were normalized so that they scaled equivalently to the discharge ratio. Additionally, normalizing the cross-section discharge CDFs by the total discharge in the cross section allows a correction for first-order effects to be made to account for variability in the stage-discharge relation as a result of backwater conditions. On the discharge CDF the value of the discharge ratio is found for a given Q_{river} and notch discharge (Q_{notch}).
4. The Q_{notch} from the notch stage-discharge rating for a given stage and alternative (see table 3) was divided by Q_{river} to determine the discharge ratio.
5. The point on the discharge CDF that equals the discharge ratio (red dot on fig. 27C) was used to determine the corresponding value of X (along the x-axis on fig. 27C). The position of X is the estimate of the outer edge of the hydraulic entrainment zone, shown by the red dot on figure 27C. For each cross section the location of X has an associated geo-referenced position. This allowed direct comparison of the hydraulic entrainment zone for an alternative (given stage, Q_{river}, and Q_{notch}) to fish spatial distribution.
6. From the discharge CDFs at each measured stage, a continuous three-dimensional interpolant was created to cover the range of conditions that were unmeasured. Only the CDFs collected at stages of 17, 22, 24, and 30 ft were used because these measurements were made during mean backwater conditions, whereas the measurements at other stages (25, 28, and 31 ft) were made during extreme backwater conditions; incorporating these measurements skewed the interpolation.

For the entrainment simulation, the location of the critical streakline was estimated from a continuous time series (27-year period) of statistically modeled discharge (see "Statistical Model to Predict Discharge on the Sacramento River Near the Fremont Weir" section) and measured stage at the Fremont Weir. Although limited data on the true range of variance associated with second-order effects of backwater conditions are available, an estimate of variance was generated by using a random effects model (Diggle, 2002).

Variance and Uncertainty in Hydraulic Entrainment Zone Estimate

One primary source for both the variance and uncertainty was identified in the procedure used to estimate the location of the critical streakline. The primary source of variance was due to variability in the stage-discharge relation at the western end of the Fremont Weir. Because the notch flow will be fixed for a given stage, this resulted in variability in the ratio of flow from the river into the notch (see "Variability in the Stage-Discharge Relation" section and fig. 19). The primary source of uncertainty was the estimate of the distance from the end of the velocity transect to the riverbank and the resultant velocity extrapolation to the riverbanks. The range of critical streaklines that resulted from changes to these computations were investigated to determine the best approximation on how to account for variance and uncertainty in the estimate of the critical streakline.

Effect of Variability in the Stage-Discharge Relation on Critical Streakline Location

The range of discharge for a given stage value was up to approximately 10,000 ft^3/s (fig. 18). The first-order effect was that at a given stage the discharge either increased or decreased. First-order effects were accounted for by normalizing the discharge CDF (from 0–1) to scale to the discharge ratio (notch flow to river flow) and looking up the value of X that corresponds to the discharge ratio. The second-order effect was a change in the velocity distribution, which resulted in a change to the shape of the discharge CDF. There is some evidence that this occurred when backwater effects increased. Two sets of velocity transects were made at similar stages (24.2 and 24.6 ft, and 30.2 and 31.2 ft) under varying degrees of backwater, and the velocity distribution and discharge CDFs differed for two transects collected at the same location and at similar river stages between each set of measurements.

An example of estimated values of critical streakline location X for stages 24.2 and 24.6 ft and notch alternatives 3, 4, and 6 is shown on figure 28. In this example, it was assumed that the two discharge CDFs represented first- and second-order effects of variability in discharge at similar stages. The vertical blue line in the figure shows an estimated value of X for a stage of 24.2 ft and a river flow of 15,900 ft^3/s. The dashed blue line shows the estimated value of X adjusted for the first-order effect at a stage of 24.2 ft and a river discharge of 12,500 ft^3/s, which was obtained by moving along the 24.2-foot CDF. The true estimate of X for a stage of 24.6 ft and discharge of 12,500 ft^3/s is shown by the dark blue line, which accounted for both first- and second-order effects of variability in discharge at similar stage values. Thus, if the 24.6-foot, 12,500 ft^3/s discharge CDF were not available, then the estimate of X would have been biased low by about 8 ft at this location for this condition.

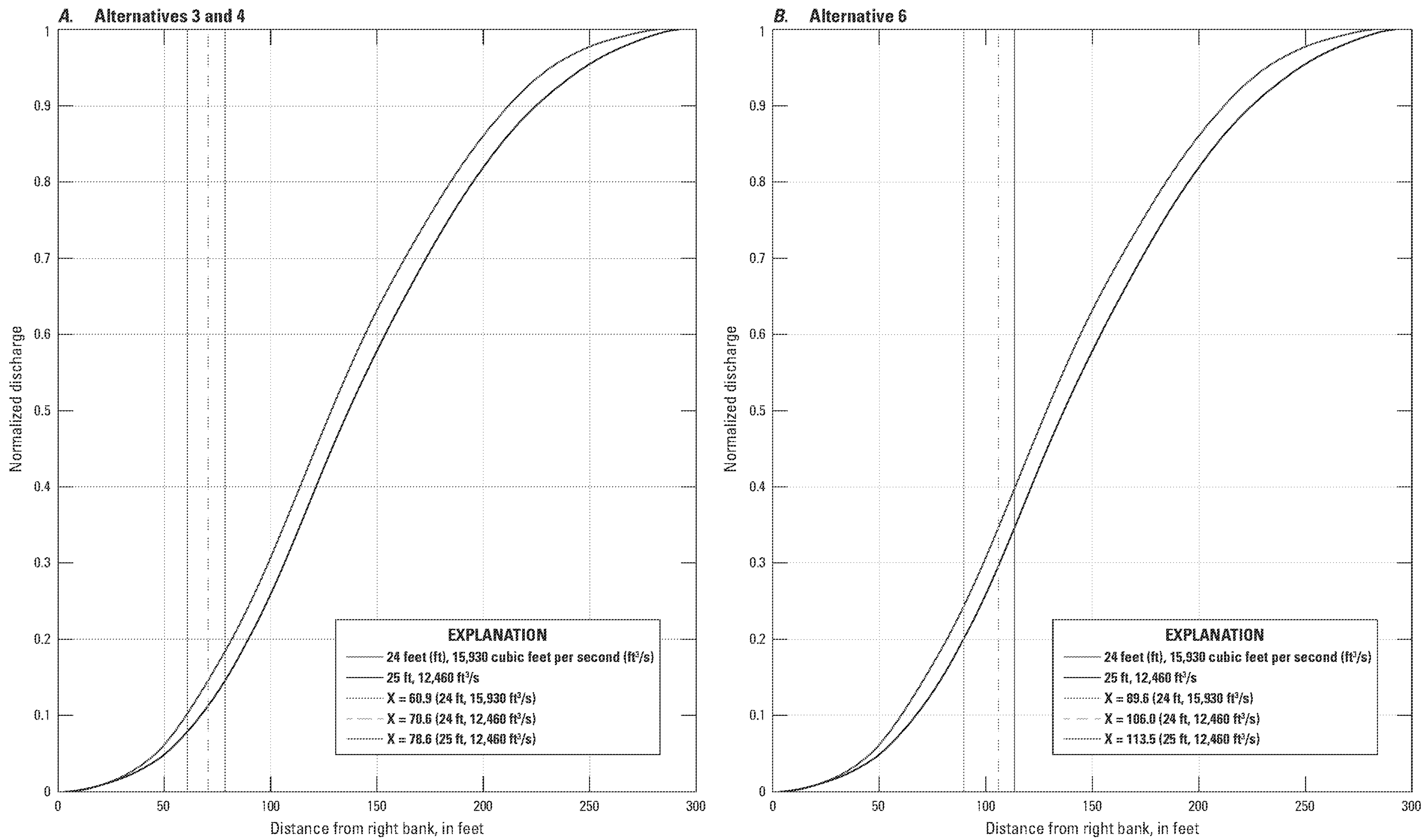

Figure 28. Critical streakline location at cross-section 4 along the Sacramento River, California, using different empirical cumulative discharge distributions for two similar stage conditions: *A*, estimates for alternatives 3 and 4; and *B*, estimates for alternative 6.

This analysis was extended for each cross section for the two sets of conditions at similar stages with varying degrees of backwater effects. The 24.2-foot and 30.2-foot stages are more representative of mean backwater conditions, given where they plotted on the stage-discharge relation calculated from the 2016 USGS gage data, and given their associated Wilkins to Verona discharge ratios (table 4). In contrast, the 24.6-foot and 31.2-foot stages were outliers in terms of where they plotted on both of these curves. The difference in *X* between using the 24.2-foot discharge CDF to correct for first-order effects compared with using the 24.6-foot discharge CDF to correct for both first- and second-order effects is shown on figure 29*A*. The mean difference in *X* for alternatives 3, 4, and 6 across all of the cross sections was −2 ft, and cross-section 3 had the greatest difference at 13 ft. The difference in *X* among alternatives 3, 4, and 6 is fairly small. The difference in *X* between using the 30.2- and 31.2-foot CDFs is shown on figure 29*B*. The mean difference for all alternatives across all of the cross sections was −0.01 ft, and cross-section 5 had the largest difference for alternative 6 of 18 ft. The discharge ratio for a given alternative was higher for the 30.2-foot and 31.2-foot stages; therefore, the true location of *X* moved farther toward the center of the river as backwater effects increased.

Effect Due to Uncertainty in Bank Estimates

The primary source of uncertainty in the location of *X* was due to uncertainty in the amount of discharge between the last measured point and the location of the riverbank at each cross section. The uncertainty in the true riverbank location is because of imperfect bathymetry data, the uncertainty of field estimates of the bank locations made during the velocity data collection, and the velocity extrapolation method, all of which changed the amount of unmeasured velocity and discharge near the riverbanks. As shown in table 4, the percentage of measured flow based on bank location and extrapolated velocity ranged from about 2 to 6 percent, which included both banks. To quantify the errors in both the location of the riverbanks and the velocity extrapolation method, a sensitivity analysis was done to determine how changes in the bank location and the discharge ratio affected the estimate of *X*.

The best estimates of the unmeasured distance to the riverbank for each velocity transect ranged from 3 to 50 ft with a mean of 25 ft. A sensitivity analysis of what the effects would be by changing the location of the riverbanks from 3 to 33 ft was done for all discharge CDFs used in the three-dimensional interpolant when the notch will be operational (stages of 22, 24, and 30 ft), and for notch alternatives 3, 4, and 6. Figure 30 shows the range in change of *X* in relation to the range of adjustment of riverbank location. There was a non-linear increase and more variation in the change of *X* for larger riverbank location errors. Likely, the error in the distance to the riverbanks was only 3–7 ft, so the uncertainty in *X* due to uncertainty in riverbank location was less than 3 ft. The change in *X* resulting from the change in bank location showed little dependency on downstream (cross-section) location (fig. 31), although cross-sections 1 and 7 showed the most variation at different stage or discharge conditions, but there was no consistent bias among conditions or location.

Changes in the discharge ratio were used to illustrate the effect that incorrect velocity extrapolation to the riverbanks will have on estimates of *X*. The average percentage of discharge extrapolated to the riverbanks was 4.5 percent with a range of 2–6 percent. A sensitivity analysis of what the effects would be by adjusting the discharge ratio from 0.5 to 5 percent was done for all alternatives but only for discharge CDFs corresponding to stages when the notch will be operational (fig. 32). If the velocity extrapolation method was 100 percent incorrect, then the discharge ratio would change, on average, by about 5 percent, which would amount to a change in *X* that is generally less than 13 ft. More likely, the velocity extrapolation method was not 100 percent incorrect, and the change in discharge ratio is on the order of 1 percent due to errors in the velocity extrapolation method, which would equate to a change in *X* of less than 3 ft. Therefore, the effects of errors in riverbank location and the velocity extrapolation method are estimated to amount to an uncertainty in the critical streakline that is 3 ft or less.

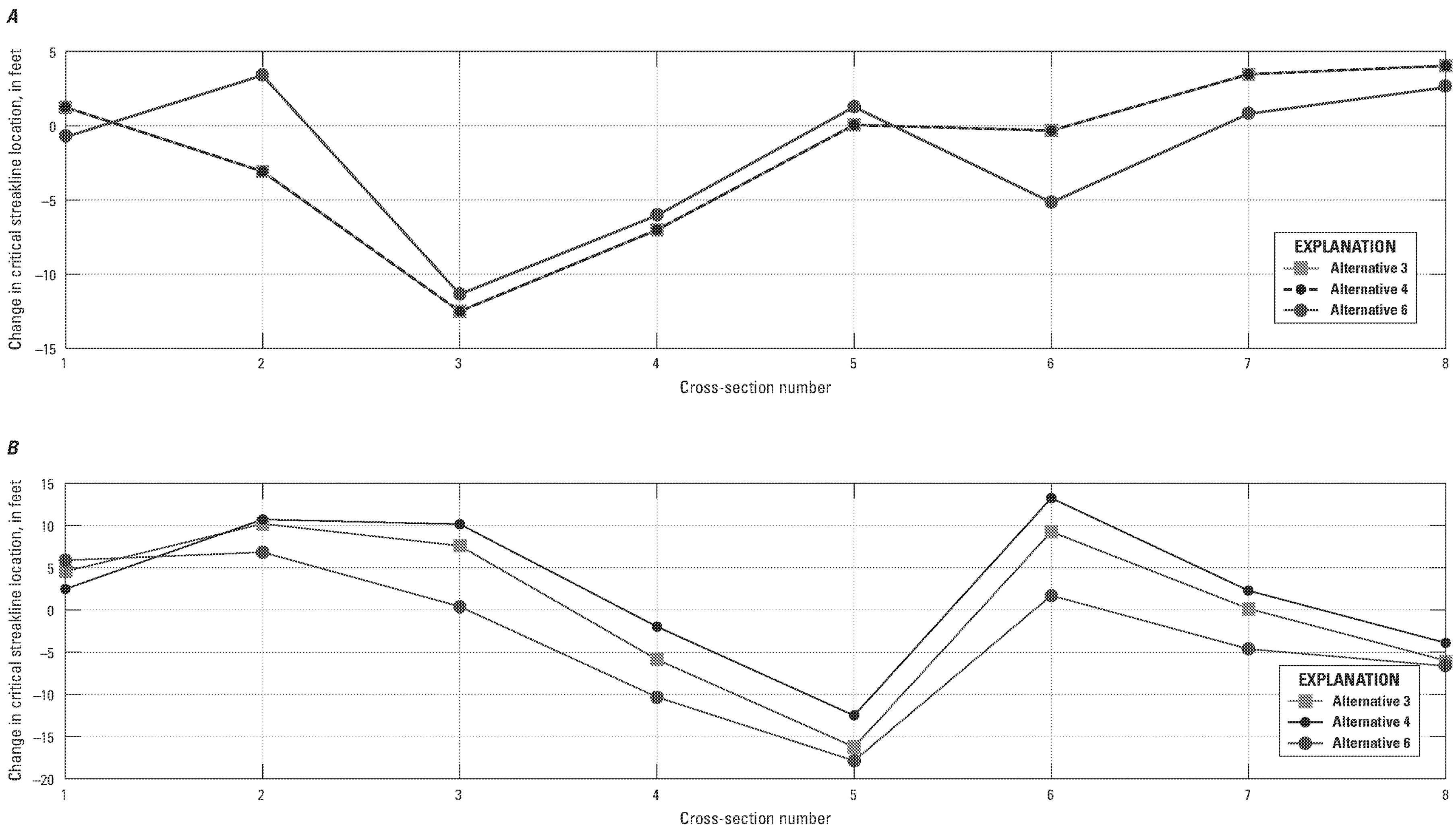

Figure 29. Difference in critical streakline location at each cross section along the Sacramento River, California, due to second-order effects of variability in the stage-discharge relation for alternatives 3, 4, and 6: *A*, comparison of 24- and 25-foot stage cumulative distribution functions (CDFs); and *B*, comparison of 30- and 31-foot stage CDFs.

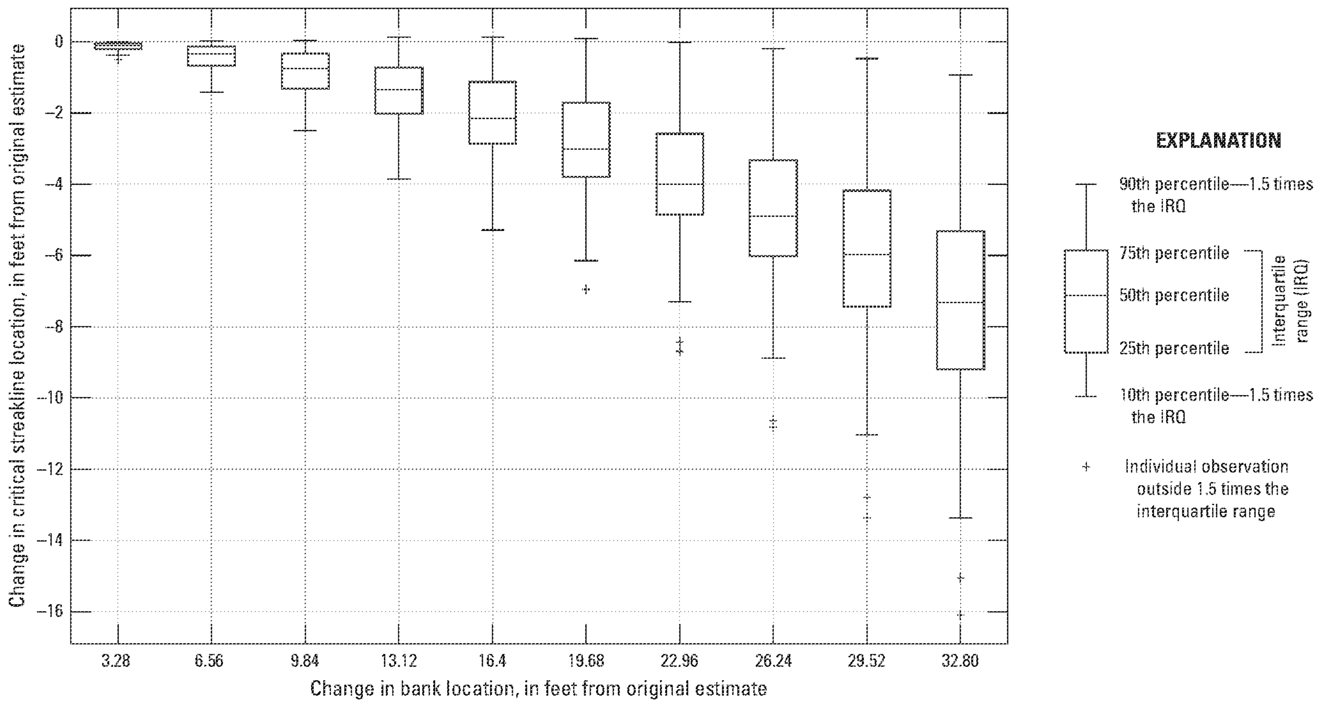

Figure 30. Range of change in critical streakline location as a function of change in bank location from original estimates. The fixed levels of change in bank location were based on a range of values chosen for the sensitivity analysis.

Variance Used in Hydraulic Entrainment Zone Calculation

Uncertainty in *X* due to uncertainty in riverbank locations and velocity extrapolation error was likely less than 3 ft. Because results were consistent over a range of a few conditions, and because techniques to estimate riverbank locations are consistent, this is a reasonable estimate of uncertainty in *X* due to uncertainty in bank estimates. It was more difficult to quantify the variance in *X* caused by second-order effects resulting from variability in the stage-discharge relation. Data to explicitly define the variability for a range of discharge at a given stage were insufficient; therefore, estimation of the variance using a random effects model served to represent stochastically the variance in *X*.

The random effects model included both the variance and uncertainty in *X*. Because estimates in the variance in *X* were larger than the estimates in the uncertainty of *X*, the random effects model was parameterized based solely on the estimated variance in *X*. There are two underlying assumptions used to parameterize the random effects model. First, the WLK/VON discharge ratio distribution can be used to approximate the degree of backwater at the Fremont Weir; therefore, the frequency of occurrence can be estimated for measured conditions. The second assumption was that the WLK/VON discharge ratio can be approximated as a normal distribution, which is a reasonable assumption (fig. 33). The two sets of conditions, discussed in the "Effect of Variability in the Stage-Discharge Relation on Critical Streakline Location" section, were examined by comparing mean backwater to extreme backwater conditions. The greatest uncertainty in *X* was estimated to be 18 ft, with a frequency of occurrence of less than 0.3 percent of the time based on where this condition plotted on the WLK/VON discharge ratio empirical CDF (fig. 33). Therefore, it was assumed that an error in the critical streakline of 18 ft was present less than 0.3 percent of the time due to backwater effects. The random effects model was represented as a normal distribution, with a mean of 0 ft (representing mean backwater conditions) and a standard deviation of 7 ft. This fit resulted in an error of 18 ft that occurred less than 0.3 percent of the time (representing extreme backwater conditions). The random effects model was used in the entrainment simulation to account for variance in the location of the critical streakline (Blake and others, 2017); as such, it accounted for uncertainty due to errors in bank location estimates, errors in velocity extrapolations, and variability in the cross-stream distribution of flow at a given stage because of backwater conditions on the Sacramento River near the western end of the Fremont Weir.

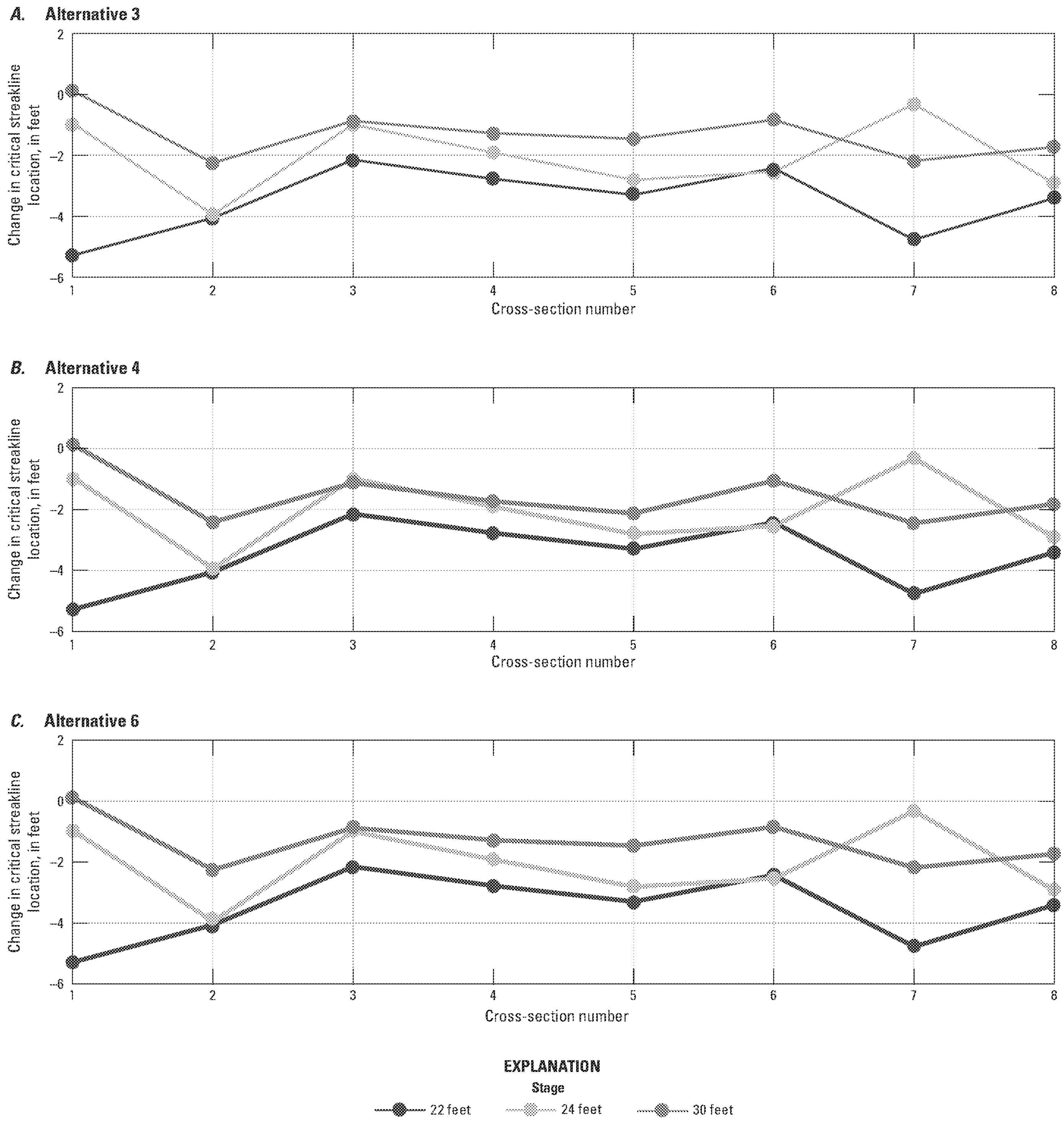

Figure 31. Differences in critical streakline location at each cross section along the Sacramento River, California, due to errors in bank distance estimates of 16.4 feet at each cross section for stage conditions of 22, 24, and 30 feet for *A*, alternative 3; *B*, alternative 4; and *C*, alternative 6.

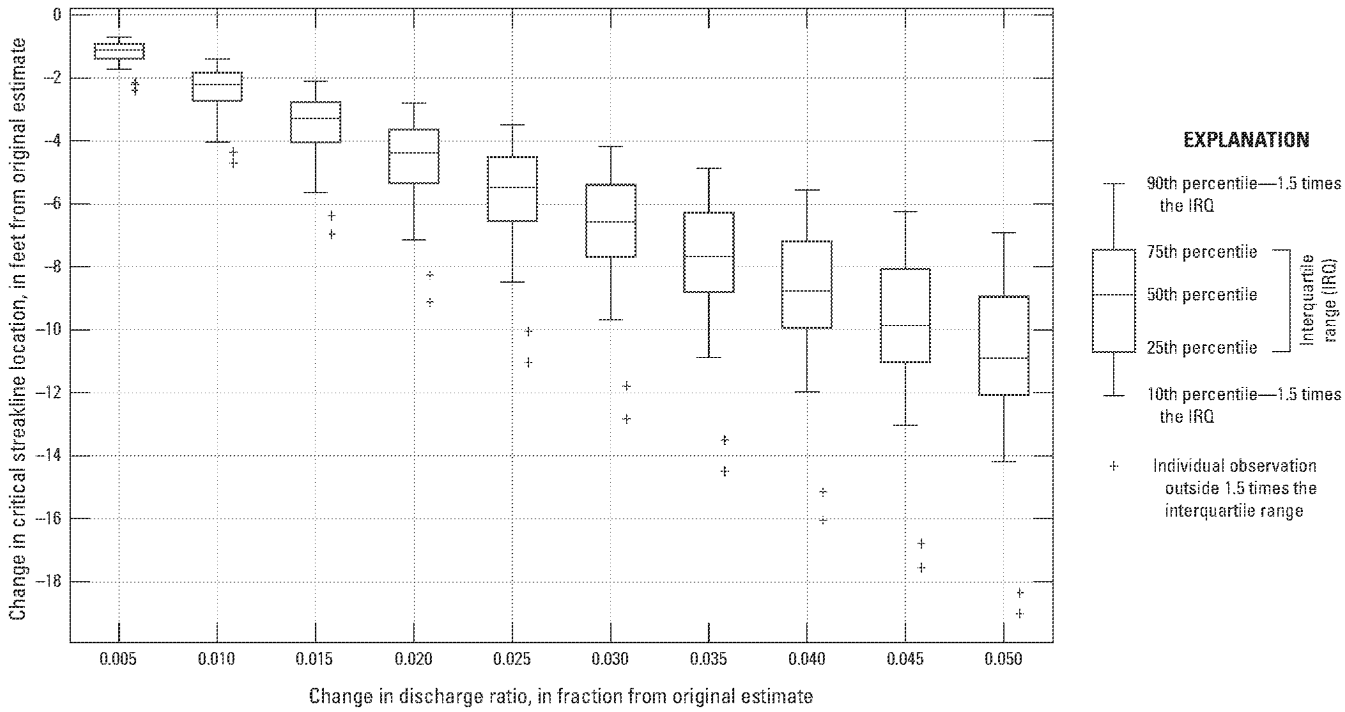

Figure 32. Range of change in critical streakline location as a function of change in discharge ratio from original estimates. The change in the discharge ratio was based on a range of values chosen for the sensitivity analysis.

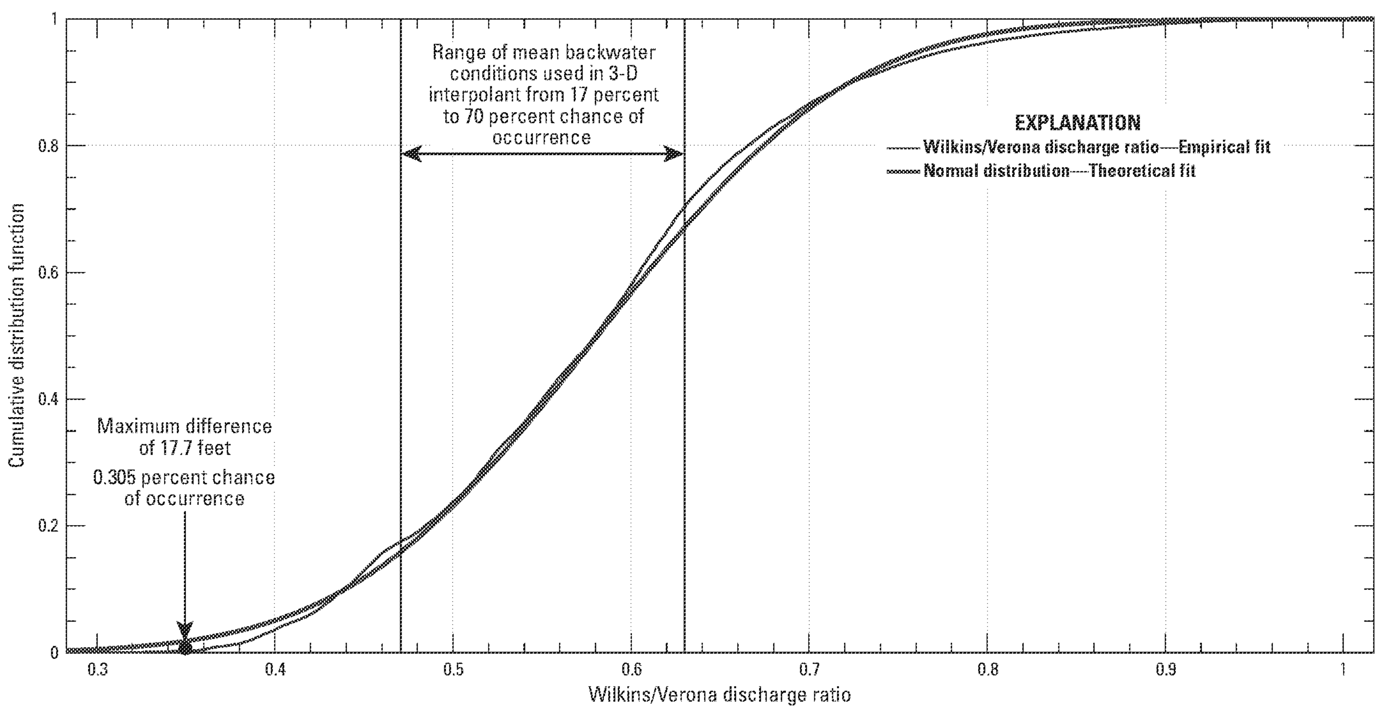

Figure 33. Empirical and theoretical cumulative distribution functions for the Wilkins/Verona discharge ratio for the 27-year period (April 1990–April 2017) of record. The theoretical distribution fit was used for the random effects model.

Conclusions and Recommendations

Detailed velocity measurements made near the western end of the Fremont Weir along the Sacramento River were used to estimate the width of the hydraulic entrainment zone and provide a framework to make predictions of fish entrainment into a proposed notch at the Fremont Weir. The variability in the stage-discharge relation that was observed will affect the ratio of notch discharge to river discharge, the location of the critical streakline, and eventually predictions of fish entrainment into the proposed notch. The degree of complex hydrologic conditions that exist in this region were not recognized when this study was initiated. Thus, estimates of the degree of variability in the stage-discharge relation are poorly understood and based on limited data. The key findings from this study are as follows:

1. The index-velocity method was better for estimating discharge near the western end of the Fremont Weir than the stage-discharge method because of backwater effects in the Sacramento River.

2. The Sutter Bypass was a significant inflow into the Sacramento River system prior to the Fremont Weir overtopping; therefore, this boundary condition needs to be accounted for in hydrodynamic numerical models. Because of the uncertainty of inputs into the mass-balance equation, additional measurements and analysis of Sutter Bypass flows are required.

3. There was a secondary circulation cell at the river bend for the conditions that were measured, and this acted as a mechanism to shift the distribution of water velocity and discharge toward the outside of the river bend.

4. The statistical model for predicting an hourly time series of discharge on the Sacramento River above Fremont Weir near Knights Landing, for the 27-year period from April 1990 to April 2017, based on a stepwise linear regression with 5 predictor variables and 15 terms, has an R^2 value of 0.998 and a root mean square error of 360 cubic feet per second. The discharge was predicted based on a range of measured discharge of approximately 7,000 to 28,000 cubic feet per second.

5. Because of the effects of backwater and overbank flow, the critical streakline moves toward the channel center when the Sacramento River overtops the right riverbank.

6. Uncertainty in the position of the critical streakline due to uncertainty in estimated bank locations and velocity extrapolation error was estimated to be less than 3 feet. The width of the river varies from about 250 to 300 feet, depending on river stage and cross-section location.

7. Uncertainty in the position of the critical streakline due to backwater effects was estimated to be greater than 3 feet, and the maximum observed was approximately 18 feet.

8. The cross-channel empirical cumulative distribution function for discharge at specific cross sections was a useful metric for comparing measurements taken at different conditions at a cross-section location, because it captures the spatial variability in the discharge at a cross section, which is a key factor in determining the critical streakline location.

9. Given the variability in the hydrodynamics along the Sacramento River near the Fremont Weir caused by backwater effects, numerical modeling of the hydrodynamics of this system should incorporate the variability in river conditions associated with backwater.

10. Our results show that three-dimensional aspects of the flow, such as secondary circulation, are important to consider; therefore, a three-dimensional numerical model should be used.

11. The critical streakline location estimates discussed in this report are appropriate for use in computing fish entrainment rates by superimposing the critical streakline estimates on the fish spatial distributions.

In order to refine estimates of the error in the critical streakline due to backwater effects and provide better entrainment estimates from a hydrodynamic standpoint, the following recommendations are made:

1. Estimates in the location of the critical streakline could be improved if a greater range of velocity transects were made to better define the variability in the velocity structure at a particular river cross section. The largest estimated uncertainty was 18 feet, and presumably would be greatly reduced if a more representative range of conditions were used. Velocity transects made over a range of discharge conditions for a particular stage would allow better quantification of the uncertainty in the critical streakline estimates.

2. Estimates of discharge immediately upstream from the western end of the Fremont Weir, based on a long-term record using the index-velocity method, are critical for correct entrainment estimates. The statistical model was a good first order estimation, but having a direct measurement of discharge that is unaffected by backwater conditions (index-velocity) would reduce uncertainty. As a result, an installation upstream from the western end of the Fremont Weir is recommended.

3. Because of frequent backwater effects caused by flow from the Sutter Bypass and Feather River, a stage gage should be installed immediately downstream from the Fremont Weir to monitor the water-surface slope in the Sacramento River in the vicinity of the weir. In the absence of these data there could be errors in the elevation of the water surface at the downstream notch locations.
4. An agreement amongst working groups and agencies is needed regarding the datum to use for stage measurements near the western end of the Fremont Weir. The survey completed during this study indicated that the river stage could be overestimated by 0.5 foot. Comparison of the stage data collected in 2016 and that collected at FRE showed that the FRE stage data could be biased high during higher river stages, but because the two data sets were collected from sites 1.24 miles apart, some differences may reflect actual changes in water slope due to backwater effects. A coordinated effort with agencies involved in this study (California Department of Water Resources, Bureau of Reclamation and the U.S. Geological Survey) to improve discharge and stage measurements at this location is necessary.

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Appendix. Linear Regression Model to Predict Discharge at the Fremont Weir

The final form of the modeled equation from the stepwise regression was

$$Y = \text{Intercept} + aX1 + bX2 + cX3 + dX4 + eX5 + fX1X2 + gX1X4 + hX1X5 + iX2X3 + jX3X4 + kX2X5 + lX3X4 + mX3X5 + nX4X5 \quad (1\text{–}1)$$

where the independent and dependent variables used in the linear model are

Y = Discharge (cubic feet per second [ft^3/s]) on the Sacramento River above Fremont Weir near Knights Landing (FRE.temp),
$X1$ = Stage (feet [ft]) on the Sacramento River near the Fremont Weir (FRE),
$X2$ = Discharge (ft^3/s) on the Sacramento River below Wilkins Slough (WLK),
$X3$ = Discharge (ft^3/s) on the Sacramento River at Verona (VON),
$X4$ = Stage difference (head loss in ft) between the Sacramento River below Wilkins Slough (WLK) and Sacramento River near Fremont Weir (FRE), and
$X5$ = Stage difference (head loss in ft) between the Sacramento near the Fremont Weir and Sacramento River at Verona (VON).

Parameter Estimations for Linear Regression Model

Intercept = –579.19 ft^3/s

a = 479.66

b = –0.69017

c = 0.0006358

d = 900.21

e = –19,018

f = 0.098745

g = –107.31

h = 896.64

i = –0.000034491

j = 0.013777

k = –0.77084

l = 0.037772

m = –0.047459

n = 801.59

Final Regression Model Output and Summary Statistics

Output from Matlab stepwise regression tool (Matlab function—stepwiselm):

1. Adding x1, FStat = 215432.8601, pValue = 0
2. Adding x2, FStat = 4703.7847, pValue = 0
3. Adding x1:x2, FStat = 34.656, pValue = 4.57467e-09
4. Adding x5, FStat = 16.553, pValue = 4.9075e-05
5. Adding x1:x5, FStat = 55.321, pValue = 1.48865e-13
6. Adding x3, FStat = 104.3061, pValue = 6.300758e-24
7. Adding x2:x3, FStat = 21.7334, pValue = 3.33176e-06
8. Adding x4, FStat = 37.3692, pValue = 1.16437e-09
9. Adding x3:x5, FStat = 18.0732, pValue = 2.21989e-05
10. Adding x2:x5, FStat = 48.0542, pValue = 5.51509e-12
11. Adding x4:x5, FStat = 44.6301, pValue = 3.04771e-11
12. Adding x2:x4, FStat = 13.6676, pValue = 0.00022385
13. Adding x1:x4, FStat = 4.2823, pValue = 0.038634
14. Adding x3:x4, FStat = 9.0694, pValue = 0.0026307

Linear regression model output:

y ~ [Linear formula with 15 terms in 5 predictors]

Estimated coefficients:

Model term	Coefficient estimate	Standard error	*t*-stat	*p*-value (significance)
Intercept	–579.19	8,177.5	–0.070827	0.94354
x1	479.66	590.8	0.81189	0.41695
x2	–0.69017	0.32931	–2.0958	0.036218
x3	0.0006358	0.2161	0.0029422	0.99765
x4	900.21	422.25	2.1319	0.033129
x5	–19,018	2,821.2	–6.741	2.0328e-11
x1:x2	0.098745	0.0094089	10.495	3.8501e-25
x1:x4	–107.31	31.143	–3.4457	0.00058095
x1:x5	896.64	109.98	8.1526	6.0967e-16
x2:x3	–3.4491e-05	3.1341e-06	–11.005	2.0469e-27
x2:x4	0.013777	0.0062975	2.1877	0.028804
x2:x5	–0.77084	0.11417	–6.7516	1.8932e-11
x3:x4	0.037772	0.012542	3.0115	0.0026307
x3:x5	–0.047459	0.013065	–3.6325	0.00028754
x4:x5	801.59	131.32	6.104	1.2316e-09

Number of observations: 2,086.

Error degrees of freedom: 2,071.

Root mean squared error: 361 ft^3/s.

R-squared: 0.998; Adjusted R-squared: 0.998.

F-statistic vs. constant model: 6.09e+04, p-value < 0.0001.

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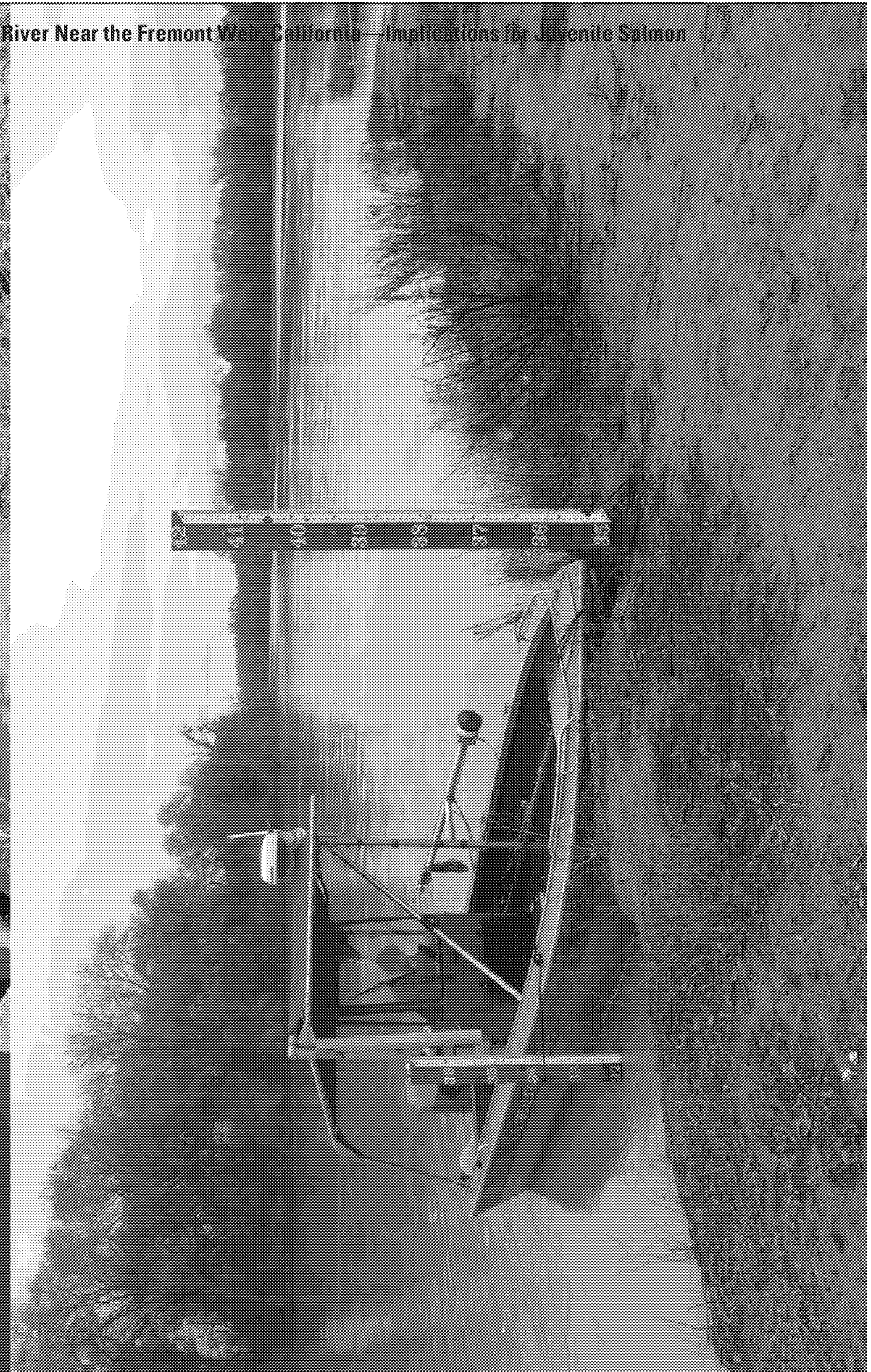

USGS

Stumpner and others—Hydrology and Hydrodynamics on the Sacramento River Near the Fremont Weir, California—Implications for Juvenile Salmon Entrainment Estimates—Scientific Investigations Report 2018–5106

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Subject: Re: Flow Stage relationship
Attachments: 2018_Blake_etal_Entrainment Analysis_FinalVersion_Released.pdf

Figure 23 of this Blake paper is key to understanding that relationship as well.

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Subject: Flow Stage relationship

Here is the paper from which I pulled the graph (figure 18) of the stage flow relationship I showed during our call yesterday. Most of the hydraulic analysis in this paper is based on eight river cross sections a the western end of the weir and not at the location of that eastern end which was selected as the preferred option.

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A Simulation Method for Combining Hydrodynamic Data and Acoustic Tag Tracks to Predict the Entrainment of Juvenile Salmonids onto the Yolo Bypass Under Future Engineering Scenarios

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July 21, 2017

Table of Contents

1. Executive Summary

During water year 2016 the U.S. Geological Survey California Water Science Center (USGS) collaborated with the California Department of Water Resources (DWR) to conduct a joint hydrodynamic and fisheries study to acquire data that could be used to evaluate the effects of proposed modifications to the Fremont Weir on outmigrating juvenile Chinook salmon. During this study the USGS surgically implanted acoustic tags in juvenile late fall run Chinook salmon from the Coleman National Fish Hatchery, released the acoustically tagged juvenile salmon into the Sacramento River upstream of the Fremont Weir, and tracked their movements as they emigrated past the western end of the Fremont Weir.

The USGS analyzed tracking data from the acoustically tagged juvenile salmon along with detailed hydrodynamic data collected in the Sacramento River during the winter/spring of water year 2016 in the vicinity of the western end of the Fremont Weir to assess the potential for enhancing the entrainment of Sacramento River Chinook salmon onto the Yolo Bypass under six different Fremont Weir modification scenarios. Each modification scenario consists of a notch or multiple notches in the Fremont Weir which are designed to divert a portion of the Sacramento River onto the Yolo Bypass when the Sacramento River is below the crest of the Fremont Weir. The primary goal of this entrainment analysis was to investigate how the location of the notch or notches in each scenario affected the entrainment of juvenile Chinook salmon onto the Yolo Bypass, and to predict the notch location or locations that would result in maximum entrainment under each modification scenario.

Stumpner et al.'s (in review) analysis of hydraulic data collected during the 2016 study period showed that backwater effects in the Sacramento River created significant variability in the relationship between Sacramento River stage and the proportion of the Sacramento River flow that we expect to be diverted onto the Yolo Bypass under the modification scenarios. Because of this variability, accurately evaluating the entrainment potential of possible notch locations for each scenario required combining historic abundance data for juvenile Sacramento River Chinook salmon with historic hydraulic data for the Sacramento River in the vicinity of the Fremont Weir, so that the entrainment estimates would reflect the covariance between Sacramento River stage, Sacramento River discharge, and juvenile salmon abundance within the historic record.

We used a Monte Carlo simulation framework to combine the high resolution hydrodynamic data and acoustic tag track data collected in 2016 with historic juvenile salmon abundance, Sacramento River stage, and Sacramento River discharge data from a period spanning water years 1996-2010 to assess the entrainment potential of different weir modification scenarios under historic conditions. The scenarios we simulated consisted of four single notch configurations, and two multiple notch configurations in the vicinity of the western end of the Fremont Weir. For each notch configuration the 15-water-year entrainment simulation was repeated for 63 possible notch locations in the vicinity of the western end of the Fremont Weir. This approach allowed us to assess the effect of notch location on the entrainment of juvenile salmonids onto the Yolo Bypass for each of the six notch configurations that we evaluated.

The entrainment simulations showed that the location of each notch configuration had a major impact on the entrainment for each scenario; the predicted entrainment of some scenarios varied by as much as 400% based on where the notch (or notches) was (were) located in the study area. All of the single notch scenarios performed best when they were located within a 330 ft (100 meter) long section of the Sacramento River bank adjacent to the western terminus of the Fremont Weir (Table 1). Both of the multiple notch scenarios performed best when their upstream notches were located about 660 ft (200 meters) upstream of the western terminus of the Fremont Weir (Table 1). The results of the entrainment simulations indicated that for each notch configuration the same notch location produced near-maximum entrainment regardless of run abundance timing; this result suggests that there are areas within the study are where a notch (or notches) can be sited to achieve maximum entrainment for all runs (barring significant behavioral or physiological differences between runs). In addition, the simulation results indicate that for each notch configuration the same location is expected to produce near-maximum entrainment for both wet water years and dry water years.

Based on the results of the entrainment simulation we make three general recommendations for strategies to improve the entrainment potential of a notch in the Fremont Weir:

1) Comparisons between the maximum entrainment potential for each scenario suggested that total entrainment of winter run, spring run, and fall run salmon onto the Yolo Bypass can be increased by increasing the amount of water entering a notch when the Sacramento River stage is between 19 ft and 22 ft NAVD88; this could be accomplished by lowering notch invert elevations or by adding a control section to the Sacramento River to raise stage for a given discharge.
2) The relationship between Sacramento River stage and entrainment for each scenario indicated that entrainment efficiency for each scenario declined significantly once Sacramento River stage exceeded bankfull (approximately 28.5 ft NAVD88). This effect was likely due to inundation of the floodplain between the Sacramento River and the Fremont Weir; Stumpner et. al (In Review) have documented a reduction in the strength of the secondary circulation and centralization of the downwelling zone in the Sacramento River when this floodplain is inundated. Therefore, increasing the height of the river right bank of the Sacramento River to coincide with the height of the Fremont Weir is recommended to increase entrainment at higher stages.
3) Bathymetric features upstream of notch openings appeared to have a major impact on the entrainment potential of the simulated notches. For this reason we recommend taking care to avoid siting notches immediately downstream of bank features that alter the sidewall boundary layer, and we expect that smoothing the bank bathymetry upstream of a notch will enhance entrainment.

Finally, we caution that the entrainment simulation was based on the behavior of large hatchery smolts, so it is likely that our results will be sensitive to any differences in behavior and physiology between these hatchery surrogates and naturally migrating juvenile salmon.

Table 1 - Summary of scenario performance

Percent of yearly juvenile salmon abundance entrained onto the Yolo Bypass under each scenario, by run, for the notch locations that resulted in maximum fall run entrainment for each scenario. The mean yearly percent of yearly abundance entrained is given along with 90% bootstrap confidence intervals in parentheses. The final row gives the along-stream coordinate of the notch location that resulted in peak entrainment for fall run under each scenario; see figure 4 for a map showing the along-stream coordinate system in the study area.

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Fall Run	12% (6%-21%)	9% (2%-21%)	28% (12%-43%)	15% (3%-28%)	6% (2%-12%)	8% (2%-15%)
Spring Run	9% (4%-15%)	7% (4%-14%)	22% (6%-42%)	16% (9%-20%)	5% (1%-11%)	7% (2%-13%)
Winter Run	9% (2%-17%)	7% (2%-15%)	23% (4%-42%)	15% (8%-23%)	5% (2%-11%)	7% (4%-13%)
Late Fall Run	5% (0%-12%)	4% (0%-11%)	11% (0%-38%)	9% (1%-20%)	2% (0%-10%)	3% (0%-12%)
Location of notch at peak entrainment (UTM Zone 10S, m, NAD83)	615849E, 4290952N	615849E, 4290952N	615780E, 4290905N	615849E, 4290952N	615636E, 4290860N	615636E, 4290860N
Along stream coordinate of notch at peak entrainment	495 m	495 m	415 m	495 m	265 m	265 m

2. Acknowledgements

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3. Introduction

During the winter and spring of water year 2016 the U.S. Geological Survey California Water Science Center (USGS) collaborated with the California Department of Water Resources (DWR) to conduct a joint hydrodynamic and fisheries study to acquire data that could be used to evaluate the effects of proposed modifications to the Fremont Weir on outmigrating Chinook salmon. During this study the USGS and CADWR deployed and operated an array of hydrophones in a bend in the Sacramento River upstream of the confluence with the Feather River (figure 1, figure 2), that allowed researchers to track acoustically tagged juvenile Chinook salmon in the horizontal plane as they emigrated through the hydrophone array. During the winter and spring of water year 2016 researchers surgically implanted juvenile late fall run Chinook salmon from the Coleman National Fish Hatchery with acoustic tags and released the fish in small batches upstream of the study area, with the goal of obtaining fish tracks over the range of Sacramento River stage values that were likely to be relevant to the design of weir modifications (Liedtke and Hurst, 2017). During this time period the USGS and CADWR collected high resolution water velocity measurements throughout the study area over a range of Sacramento River stage values. Additionally, the USGS deployed, rated, and operated a temporary index velocity gauge in the vicinity of the study area to estimate the discharge in the Sacramento River entering the study area.

The USGS analysis of the data from the 2016 study was focused on three primary areas:

1) summarizing the information obtained from the acoustic tag tracking array and estimating the spatial distribution of the acoustically tagged study fish;
2) analyzing the hydrodynamic data to improve our understanding of the physical processes in the Sacramento River that may influence the design of weir modifications, and
3) Combining the hydrodynamic analysis with the acoustic tag data to estimate the entrainment potential of notch modification scenarios.

The USGS's hydrodynamic analysis is presented in Stumpner et al., In Review, while this report focuses on combining the fish tracking data with the high resolution hydrodynamic data to evaluate the entrainment potential of weir modification scenarios in order to answer the following questions: (1) Which location or locations resulted in maximum entrainment for each run under each scenario? (2) How robust are these locations to changes in run abundance and water year? (3) What can we learn from the relationship between stage and entrainment for each scenario that may be useful for optimizing weir modifications?

In past studies the USGS has found that the spatial distribution of acoustically tagged fish can be combined with hydrodynamic data to reveal, and in some cases predict, the entrainment rate of juvenile Chinook salmon at tidally forced riverine junctions on the Sacramento River (California Department of Water Resources, 2012, 2015, and 2016). This past research at the Georgiana Slough junction showed that the proportion of water diverted into a junction branch was a key variable affecting the entrainment of acoustically tagged juvenile Chinook salmon transiting a junction (California Department of Water Resources, 2012, 2015, and 2016).

Our analysis of the temporary index velocity gauge data from the Sacramento River upstream of the Fremont Weir (Stumpner et al., In Review) showed that backwater effects in the Sacramento River caused by the Sutter Bypass and the Feather River created substantial variability in the stage-discharge relationship for the Sacramento River at the study area (Figure 3). This variability meant that the proportion of Sacramento River discharge that was expected to be diverted onto the Yolo Bypass under each modification scenario would not be a constant function of Sacramento River stage (The ratio of Sacramento River discharge to notch discharge is called the scenario Discharge Ratio, see Stumpner et al., In Review, for a more detailed discussion). As a result, our expectation was that entrainment under each scenario would vary as a function of Sacramento River backwater condition, because the proportion of the Sacramento River that was diverted onto the Yolo Bypass would be controlled by backwater conditions.

Because of the variation in scenario discharge ratios caused by backwater effects, assessing the entrainment potential of each scenario required an approach that accounted for the structure of the joint probability distribution that describes the probability of a fish belonging to a specific run of Sacramento River Chinook salmon transiting the study area under any possible backwater condition. We addressed this challenge by using a Monte Carlo simulation approach for evaluating the entrainment potential of modification scenarios using historical time series of Sacramento River stage, Sacramento River discharge, and the abundance of fall run, winter run, spring run, and late fall run Chinook salmon. The result of this simulation approach was a time series of estimated entrainment for each run under each modification scenario; when these time series were summed they produced an estimate of total entrainment for a run that was a function of the hydraulic conditions (discharge, stage, backwater condition) during the simulation period weighted by the relative abundance of the run over the range of hydraulic conditions measured during the simulation period. Thus, this approach implicitly accounted for the joint probability of run abundance and backwater condition within the simulation period.

The basic structure of the entrainment simulation was a Monte Carlo bootstrap simulation; at each time step within the simulation a bootstrap sample of acoustic tag tracks for each run was drawn from the pool of all acoustic tag tracks collected during the 2016 study, and then hydrodynamic data collected during the 2016 study period was used to determine which of the tracks in each bootstrap sample were entrained under each modification scenario. The key to the entrainment simulation was that at every time step the bootstrap sample size for each run was determined by the historic abundance data for each run, and the sampling weights used for the bootstrapping were a function of the hydraulic conditions when each acoustic tag passed through the study area relative to the hydraulic conditions for the simulation time step.

The primary goal of the entrainment simulation was to estimate the effect of notch location on the entrainment of juvenile Chinook salmon for each modification scenario in order to provide insights that can be used to aid in site selection for each of the proposed alternatives. Because the cross-stream distribution of discharge at any location within the study area is a function of Sacramento River stage and discharge (see Stumpner et al., In Review for more details), we expect that differences in entrainment between possible scenario locations will also be a function of Sacramento River stage and discharge. As a result, we performed the full Monte Carlo bootstrap simulation process for each run of Sacramento River Chinook salmon under each modification scenario **at each of the 63 alternative scenario locations within the study area** (Figure 5, Appendix A). This approach allowed us to explore the effects of notch location on entrainment over a range of hydraulic conditions given the historic abundance timing for fall run, winter run, spring run, and late fall run Chinook salmon. The entrainment stimulation resulted in an extremely rich dataset that consisted of covariate values and the resulting entrainment estimates for each run, at each location, under each scenario for every time step.

4. Methods

The basic structure of the entrainment simulation was a Monte Carlo bootstrap simulation that performed three fundamental functions at each time step: (1) Estimating covariate values (Sacramento River stage, Sacramento River discharge, notch discharge) and run abundance for each time step, (2) Selecting a bootstrap sample of acoustic tag tracks based on time step covariate values for each run of Chinook salmon, and (3) determining whether each track was entrained under each scenario. In this section we will provide an overview of the simulation with pseudocode summarizing the simulation process, followed by a detailed description of the methods used to perform each of the core simulation functions. The final section of the methods contains a detailed description of the weir modification scenarios included in the entrainment simulation.

4.1. Overview of entrainment simulation process

4.1.1. Along-channel cross-channel coordinate system

We created an along-channel, cross-channel curvilinear coordinate system for the study domain that was used to place each of the 63 scenario evaluation location cross-sections at uniform increments in the along-channel direction. The along-channel axis is roughly parallel to the river right bank of the Sacramento River in the study area at a stage of 28 ft, USGS survey, NAVD88, and the cross-channel axis is defined as always instantaneously normal to the along-channel axis. The along-stream coordinate systems is shown in figure 4, and the 63 notch evaluation cross-sections are shown for a Sacramento River stage of 28.5 ft in figure 5.

4.1.2. Simulation Period

For consistency with other analyses we used Knights Landing catch data provided by the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project team to estimate abundance for each run of juvenile Chinook salmon within the entrainment simulation (see California Department of Water Resources, 2017). The abundance time series limited the simulation period to water years 1997-2011. Within these water years the simulation only estimated entrainment during the prescribed structural operational window of November 1 through March

15, outside of this period entrainment was set to zero within the simulation. Within this document we refer to the structural operational window as the "notch operation season" or "season". Within this document notch operation seasons are named by the year in which operations began for the season, so the notch operation season from November 1, 1996 - March 15, 1997 is referred to herein as the 1996 season.

4.1.3. Simulation Time Step

Our analysis of historic data from the Fremont Weir gauge operated by CADWR showed that Sacramento River stage in the vicinity of the Fremont Weir can increase rapidly during the winter and spring freshets associated with juvenile salmon outmigration on the Sacramento River. For example, during the 2016 study period Sacramento River stage increased 13.45 feet over a two day period (Figure 6). Additionally, the Knights Landing rotary screw trap data Catch Per Unit Effort (CPUE) is highly episodic in nature; a large percentage of the yearly CPUE for a run can occur of the course of several days (Figure 7). The combined effect of these two factors is that there are days within the simulation period when there is significant CPUE for a run of Sacramento River Chinook salmon and Sacramento River stage changes rapidly (Figure 8). As a result, we chose a time step of 4 hours for the simulation, because this time step would limit the maximum change in stage between time steps to about 1 foot during days when the yearly fraction of CPUE was much greater than 1%.

4.1.4. Pseudocode summary of entrainment simulation

The core functionality of the entrainment simulation is summarized in pseudocode below:

For every time step

1. Estimate Sacramento River Discharge, Sacramento River Stage and Abundance of each run of Chinook salmon

   For every location in the study area

   1. Estimate the cross stream distribution of discharge at this location, given Sacramento River Stage; F(Sacramento River stage, notch location)

      For every scenario

      (There is another loop nested here for multi notch scenarios that is not shown)

      1. Estimate the discharge through the notch(es) given Sacramento River Stage; F(Sacramento River stage)
      2. Estimate the location of the critical streakline (see Stumpner et al, in review) given Sacramento River discharge, notch discharge, and the cross stream distribution of Sacramento River discharge; F(Sacramento River stage, Sacramento River discharge, notch discharge)

         For every run

         1. Estimate a discrete abundance for this run using the Knights Landing catch data

2. Draw a weighted random sample of tracks from the pool of observed 2016 tracks with weights determined by the Sacramento River Stage and Sacramento River discharge when each fish track was collected, based on the time step's Sacramento River Stage and Sacramento River discharge. The size of this sample is determined by the discrete abundance estimated above.

   For every track

   1. Determine if the track is entrained in the notch; if the track is to the notch side (river right) of the critical streakline at the cross section being evaluated, it is entrained, otherwise it is not entrained.
   2. Increment all entrainment logs
   3. Store all covariates for this location, run, scenario, and time step.

End All

4.2. Estimating covariate values at every time step

4.2.1. Estimating Sacramento River Stage and Sacramento River Discharge

The methods used to develop time series for the physical covariates used in the entrainment simulation are described in detail in Stumpner et al., In Review. Sacramento River stage in the study area was estimated by applying a correction of -0.5 ft to hourly historical data collected at the Fremont Weir gauge by CADWR, after this historical data had been corrected to the 2016 CADWR NAVD88 datum. The reasons for this correction are discussed in depth in Stumpner et al., In Review; in brief, this correction produced good agreement between the CDEC data and the USGS temporary index velocity gauge measurements (figure 6, lower panel), and this correction improved the agreement between CDEC data and USGS surveys of the water surface elevation. **Within this report and its figures we refer to the USGS estimate of Sacramento River stage at the western end of the Fremont Weir as "USGS survey, NAVD88",** to avoid confusion between the USGS estimates of Sacramento River stage and the CDEC data.

Sacramento River discharge in the study area was estimated using a regression model using historic data from other stage and discharge gauges in the region (see Stumpner et al., In Review for details). This regression model produced hourly discharge estimates that are in good agreement with our 2016 index velocity data (Figure 6, upper panel), however, there were a limited number of time steps (2.3% of simulation time steps during notch operational periods) when the historic data needed for this regression was not available. For these time steps Sacramento River discharge was estimated by means of a weighted random draw on Sacramento River stage using the full range of historic stage and discharge estimates available

(Water years 1990-2016). The weights for each draw were calculated using a normal distribution with the distribution mean equal to the time step's stage, and a std of 0.167 ft; this weighting function resulted in ~95% of the randomly drawn discharge samples being selected from historic estimates for time periods when Sacramento River stage was within 4 inches of the stage value for the simulation time step. We used this stochastic approach to fill in missing data in order to assure that the resampled data reflected the historical covariance between Sacramento River stage and Sacramento River discharge at the study site.

4.2.2. Estimating abundance at each time step

At each time step the bootstrap sample size for each of four runs of Sacramento River Chinook salmon (fall run, spring run, winter run, and late fall run) was determined using historic estimates of abundance of these runs. We used the estimated daily percent of yearly catch per unit effort (CPUE) time series from the Knights Landing catch data provided by the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project team to estimate abundance for each run. The daily percent of yearly CPUE time series for each run normalized each run's daily CPUE by the total CPUE for that run over the trap operational season for each year, so that each water year's CPUE was weighted equally within the simulation; the total abundance for the 15-water-year simulation period sums to 1500% (see California Department of Water Resources, 2017 for more information on this normalization). Using the normalized daily CPUE data assured that the results of the entrainment simulation were not weighted towards years of extremely high CPUE because each water year's daily percent of yearly CPUE summed to 100%. For consistency with other analysis performed by the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project team we filled in missing values in the Knights Landing daily percent of yearly CPUE data with zeroes.

In order to use the Knights Landing data to calculate a bootstrap sample size for each time step the daily Knights Landing data had to be apportioned between 4 hour time steps. We chose to apportion the daily catch data uniformly between the six time steps that occurred within each day (based on a 4 hour time step), with a new day's catch beginning at the time step that occurred at 00:00 hours on each day. With this approach the catch for time step 1-6 on any day summed to the Knights Landing catch for the entire day (Figure 9). Within the context of the entrainment simulation this approach was analogous to assuming a uniform probability distribution for abundance as a function of hour for each hour within a day; this approach allowed us to run the simulation at a fine enough time scale to capture rapid changes in stage and discharge while maintaining the temporal resolution of the Knights Landing catch data.

The final step in converting the Knights Landing daily percent of yearly CPUE data into a discrete bootstrap sample size for each run was to convert time step proportion of daily percent of yearly CPUE to a discrete sample size. Because daily percent of yearly CPUE could be quite low, we multiplied the time step fraction of daily percent of yearly CPUE by 1000 and rounded the result to the nearest integer to obtain a discrete sample size for each time step (Figure 9). We chose the multiplier of 1000 so that the majority of time steps with low abundance would have a non-zero sample size. This approach resulted in bootstrap sample sizes of one or two tracks for periods of extremely low abundance, sample size of 100-1000 for many of the time steps when abundance was non-zero, and extremely high sample sizes for a small number of time steps when abundance was large (Figure 10). Within this report we refer to the time series of discrete sample sizes for each run at each time step as the "discrete abundance" for each run. These time series summed to slightly less than 1500% for the entire simulation period due to the conversion from continuous catch data to discrete sample sizes. For the purpose of our analyses we used the discrete abundance time series for all entrainment normalizations.

4.3. Drawing the bootstrap sample

At each time step, we drew a discrete sample of acoustic tag tracks to represent the fish available for entrainment for each run based on the discrete abundance time series. For each bootstrap sample tracks were drawn from the pool of all 2016 tracks using weighted random sampling with replacement. Bivariate weights for each of the 2016 tracks were calculated at each time step based on the stage and discharge at the time that each 2016 track entered the study area, given the stage and discharge for each simulation time step. The bivariate weights were calculated using the Matlab ® mvnpdf function (MathWorks ®, Inc. 2017) to estimate a bivariate normal distribution with mean discharge and stage values equal to the time step discharge and stage values, and the covariance matrix computed from a subset of the USGS estimates of historic Sacramento River stage and discharge for water years 1990-2016. The subset of data used to compute the covariance matrix at each time step was defined as all historic data having a stage value within +/- 0.623 ft of the time step stage, and having a discharge value within +/- 638 cfs of the time step discharge. The stage and discharge radii criteria used to select the covariance data for each time step were 1/10th the standard deviation of the stage and discharge values for the entire pool of 2016 fish tracks. The radii criteria was chosen as a balance between the need to maintain diversity in the bootstrap pool against the need to select a bootstrap pool that reflected the covariate values for each time step. Figure 12 and figure 13 illustrate the bivariate weighting function and resulting sampling for two combinations of Sacramento River stage and discharge.

We chose to use a bivariate weighting function because of the variance in the relationship between stage and discharge within simulation period and within the period when the 2016 acoustic tag tracks were collected (figure 11). Because of this variance the relative "suitability" of a track for estimating entrainment should be a function of both the stage and discharge when the track was collected (figure 12, figure 13). By computing the covariance matrix for the weighting function at every time step we allowed the historic covariance between stage and discharge to determine the relative importance of stage and discharge to the weighting function at any point in the stage-discharge space. Finally, the bivariate weighting improved sample selection over univariate approaches (not shown) at locations in the stage-discharge space where the pool of acoustic tag tracks was sparse by allowing the sampling to select tracks based on both stage and discharge (figure 13). The same bootstrap sample drawn for each run at a given time step was used to evaluate entrainment under each scenario at each of the 63 evaluation locations.

4.4. Determining entrainment of bootstrap sample tracks

For every time step, each track in a run's bootstrap sample was classified as either entrained or not entrained under each scenario based on the cross-stream location of each fish track relative to the cross-stream location of the critical streakline, at each of the notch evaluation locations shown in figure 5. The techniques used to estimate the location of the critical streakline are discussed in detail in Stumpner et al. (In Review), and the theory behind using the location of the critical streakline to predict the routing of juvenile Chinook salmon in river junctions is covered in detail in California Department of Water Resources, 2016. We present a summary of the critical streakline method below, followed the application of this approach to the methods used in the entrainment simulation. Within these sections we describe the approach to estimating entrainment at a single possible notch location; these steps are repeated for each of the 63 possible notch locations shown in Figure 5. The details of each simulated notch are discussed in section 4.5 below.

4.4.1. Fundamentals of the critical streakline method

For the purpose of this analysis, the critical streakline was the hypothetical cross-stream dividing line upstream of the notch that separated water that would go into the notch from water that would continue down the Sacramento River under each scenario. The cross-stream location of the critical streakline upstream of the notch was estimated from the cross-stream distribution of bathymetry and discharge immediately upstream of the notch, using techniques that the USGS developed for estimating the location of the critical streakline in tidally forced river junctions.

The USGS hydrodynamics group has worked on refining and testing various techniques for estimating the location of the critical streakline in tidally forced river junctions since 2009, and we have worked with members of the USGS Columbia River Research Lab to test whether the location of the critical streakline can be used to predict the fate of fish moving through tidally forced river junctions, using data collected during the CADWR Georgiana Slough studies (CADWR, 2012, 2015, 2016). Our analysis of the 2011, 2012, and 2014 Georgiana Slough barrier studies showed that the cross-stream location of the critical streakline relative the cross stream location of a fish immediately upstream of a junction is a good predictor of an individual fish's fate within the junction, and a very good predictor of aggregate entrainment rates when these predictions are summed over a group of fish (ibid). Based on this body of work, the USGS hydrodynamics group has developed the critical streakline approach to estimating entrainment in tidally forced riverine junctions, which can be simply summarized as follows:

1. Use hydrodynamic data to estimate the location of the critical streakline immediately upstream of a junction (or notch), and
2. Use the cross stream location of the critical streakline to apportion fish mass into the downstream branches of the junction, either in an aggregate sense (using fish density distributions), or on an individual basis (one track at a time).

For the purpose of this analysis we considered the upstream end of each scenario's notch to be a river junction, with the one branch of the junction being the Sacramento River, the other branch of the junction being flow passing through the notch. Fish tracks were classified as either entrained or not entrained based on their cross-channel location relative to the critical streakline when they reached the junction of the notch and the Sacramento River.

4.4.2. General approach to estimating the location of the critical streakline

Over the course of previous Georgiana Slough studies the USGS hydrodynamics group has explored various techniques for estimating the location of the critical streakline (ibid). The most accurate approach (CADWR 2016) developed by the USGS, and the approach used herein, is to integrate an estimate of the two-dimensional cross-stream velocity distribution upstream of the junction to estimate the cross-stream distribution of discharge immediately upstream of the junction. The first step in this approach is to estimate a cross-stream velocity field upstream of the junction.

For this analysis we estimated the cross-stream velocity field at multiple locations in the Sacramento River by combining multiple velocity profiles measured at uniform intervals in the river cross-section using downward-looking ADCPs (see Stumpner et al., In Review) along with extrapolated velocity profiles for unmeasured areas near each bank. We extrapolated velocity profiles using a ⅙-power law for the shape of the horizontal and vertical velocity profile (see Stumpner et al., In Review). The mean location of the critical streakline was then determined by integrating the resulting velocity field from the river bed to the water surface across the channel starting from the river right bank until the discharge from this integration matched the discharge entering the notch. This location was the estimated mean location of the critical streakline; we refer to this location as the "mean location" because in real flows turbulent perturbations to the mean velocity field will result in changes in the instantaneous location of the critical streakline.

4.4.3. Estimating entrainment within the simulation: estimating cross stream distribution of discharge at each location given Sacramento River Stage.

4.4.3.1 Estimating cross-stream distribution of discharge at measured transect locations and stages

During 2015, 2016, and the spring of 2017 the USGS and DWR collected downward looking ADCP transects at 9 transect locations throughout the western end of the study area at multiple Sacramento River stage values (see Stumpner et al., In Review). The USGS then processed this data to develop an estimate of the cross-stream distribution of Sacramento River discharge at each cross-section, for each stage value sampled (ibid).

4.4.3.2 Estimating the cross stream distribution of discharge at unmeasured locations and stages

In order to implement the critical streakline method within the simulation, we needed to use our estimates of the cross-channel distribution of Sacramento River discharge obtained from our ADCP measurements to estimate the cross-channel distribution of Sacramento River discharge over the full range of hydraulic conditions represented in the simulation. Further, we needed to estimate the cross-channel distribution of Sacramento River discharge at all 63 notch evaluation locations in the study area. We accomplished this by using our measurements to perform multidimensional linear interpolation to estimate the cross-stream distribution of discharge for combinations of along-stream location and Sacramento River stage that we did not measure.

Because we could only measure the cross-channel distribution of Sacramento River discharge for a small subset of all possible Sacramento River stage and discharge conditions we could not estimate the location of the critical streakline with a high degree of precision; to account for this limitation we added a stochastic perturbation to our estimated location for the critical streakline (see section 4.4.5). Additionally, we did not perform any hydrodynamic measurements when the weir was overtopping (due to safety concerns), so our estimates of the cross-channel distribution of discharge during overtopping periods contain additional uncertainty. However, our simulated entrainment for all scenarios is extremely low during overtopping events due to low notch discharge ratios when the weir was overtopping, so the overall entrainment for single notch scenarios will not be very sensitive to the estimated cross-channel distribution of Sacramento River discharge during overtopping events (recall that the multiple notch scenarios are closed during overtopping events).

This interpolation was performed as follows: First, the cross-stream discharge distributions obtained from measured data were normalized to give the cross-stream distribution of discharge as a function of fraction of channel width (because channel width varied greatly within the study area). Second, the normalized cross-stream discharge distributions were integrated to create CDFs of the cumulative fraction of Sacramento River discharge as a function of distance from the river right bank expressed as a fraction of channel width. We then combined these CDFs using multidimensional linear interpolation to estimate cumulative fraction of cross-stream discharge as a function of: stage, along-channel coordinate, and fraction of cross-channel width. The multidimensional interpolation was performed via gridded interpolation using the Matlab ® griddedInterpolant function (MathWorks ® , Inc., 2017), and this interpolation allowed us to estimate the cross-channel cumulative fraction of Sacramento River discharge as a function of fraction of channel width for unmeasured combinations of along-channel location and stage.

We did not include Sacramento River discharge as an independent variable in the interpolation because we lacked the measurements needed to explain changes in the cross-channel distribution of Sacramento River discharge at each measurement location as both a function of stage and discharge (recall that there is not a constant relationship between stage and discharge in the study area due to backwater effects). As a result, we modeled the effects of discharge (at any given stage) stochastically as a random effect. We chose a normal distribution to represent the effects of discharge (and other unmeasured covariates) on the location of the critical streakline. This process is described below in Section 4.4.5.

4.4.4. Estimating entrainment within the simulation: estimating the discharge through each notch

We used linear interpolation to estimate discharge through each notch as a function of the estimated stage for each time step based on the stage-discharge relationships for each scenario. The stage discharge relationships for each scenario are discussed in detail below, and are summarized in Table 3.

4.4.5. Estimating entrainment within the simulation: estimating the cross-channel location of the critical streakline

At each time step we divided the notch discharge by the estimated Sacramento River discharge to calculate the notch discharge ratio. The estimated cross-channel discharge CDF obtained from the gridded interpolant was then used to find the cross-channel location where the fraction of Sacramento River discharge equaled the discharge ratio. This was the estimated location of the mean critical streakline. We then added a random perturbation to this location to account for uncertainty in the location of the critical streakline.

The random perturbation was added to account for uncertainty in the location of the critical streakline due to the fact that the hydrodynamic measurements used for this simulation were made during a small subset of all possible Sacramento River stage and discharge conditions. For each time step this perturbation was drawn from an error distribution which we parameterized by measuring the cross-stream distribution of discharge during periods of extreme backwater using vessel based ADCP transects, and then calculating the difference between the measured cross-channel distribution of discharge and the estimated cross-channel distribution of discharge produced by the interpolant described in section 3.4.3.2 at multiple locations within the study area. Based on this approach we modeled the error distribution using a normal distribution with a mean of zero, and a standard deviation of 6.5 ft; see Stumpner et al., In Review for more details on the parameter selection for this distribution.

4.4.6. Estimating entrainment within the simulation: estimating entrainment for each track a bootstrap sample

For each track in each of the bootstrap samples drawn for each run the cross-channel location of the track was computed at the point where the track crossed a line instantaneously normal to the along stream axis at each of the notch evaluation locations (These locations are shown in figure 5). If the track's location was to the river right of the location of the critical streakline, then the track was marked as entrained, if the track was to the river left of the critical streakline, the track was not entrained. There were a few additional details for multiple notch scenarios (scenario 5 and scenario 6)

- Only fish tracks from the bootstrap pool that were not entrained in upstream notches were available for entrainment in subsequent downstream notches, thus, the number of fish tracks available for entrainment in each notch decreases for downstream notches to prevent "double entrainment" for a single fish track.
- Entrainment for all notches in a scenario had to be estimated for each of the 63 evaluation locations. In the case of multiple notch scenarios, we assumed that the center of the upstream-most notch was at the evaluation location being used, and then compute entrainment for each downstream notch as occurring at a point located in the center of each downstream notch. The location of each downstream notch was based on the spacing of the notches in the engineering drawings provided for Alternative 5, see Appendix C. As the simulation iterated through along stream evaluation locations, the whole multiple notch simulation was shifted downstream.
- The fish tracks in the bootstrap pool were not altered to account for possible effects of the upstream notches on water velocity or fish behavior prior to downstream notches. As a result, entrainment estimates for multiple notch scenarios have an additional source of uncertainty that is not shared by the single notch scenarios, and which may result in a negative bias in our entrainment estimates for these scenarios.

4.4.7. Estimating entrainment within the simulation: estimating entrainment over the Fremont Weir during overtopping events

The purpose of the entrainment simulation was to explore the effects of scenario location and scenario design on the entrainment of juvenile Chinook salmon under each scenario. As a result, the entrainment simulation did not estimate entrainment over the Fremont Weir. During periods when the weir was overtopping entrainment for each scenario was based only on the computations described above, and thus, represents an estimate of the entrainment during overtopping events that would be due to modifications made to the Fremont Weir under each scenario.

4.5. Simulated scenarios

We simulated entrainment onto the Yolo Bypass for six weir modification scenarios that included four single notch configurations and two multiple notch configurations (Table 2). Four of the scenarios (Scenarios 1,2,3, and 5) used notch stage-discharge rating curves based on real design alternatives, the other two scenarios (scenario 4 and 6) used notch stage-discharge rating curves that were created for analytical purposes. The California Department of Water Resources (DWR) provided stage vs discharge rating tables for the notches simulated in Scenario 1,2,3, and 5.

Scenario 4 and scenario 6 were simulated for analytical purposes only, because including these scenarios allowed us to draw inferences about how changing a notch's invert elevation might affect entrainment if the notch rating curve was held constant with respect to the difference between invert elevation and Sacramento River stage. The stage discharge relationships for scenario 4 and scenario 6 were derived by modifying the alternative 3 and the alternative 5 notch rating curves so that scenario 4 and scenario 6 would both begin taking water through the notch at a Sacramento River stage value of 15 ft. Scenario 4 and scenario 6 are not indicative of any alternatives currently under review.

Table 2 summarizes the key parameters of the scenarios analyzed in the entrainment simulation, and Table 3 summarizes the notch rating curves for all scenarios in 1 ft increments from 15 ft to 35 ft, and gives an estimate of the magnitude of the Sacramento River discharge that is likely to occur at each stage value based on the USGS 2016 stage-discharge rating. Because of backwater effects there can be a wide range of Sacramento River discharge values which occur at any Sacramento River stage, so the discharge given in Table 3, Column 1 is only indicative of the order of magnitude of Sacramento River discharge for each stage value. A spreadsheet containing more details on the multi-notch configuration simulated in scenario 5 and scenario 6 is contained in Appendix B.

Table 2- Summary of scenario parameters

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Notch Configuration	Based on Alternative 3	Based on Alternative 4	Based on Alternative 6	Based on Alternative 4, with a lower invert	Based on Alternative 5	Based on Alternative 5, with a lower invert
Stage when notch flow exceeds 200 cfs	19 ft	19 ft	19.5 ft	15 ft	20 ft	18.5 ft
Stage when maximum notch flow is reached	31 ft	27 ft	30 ft	23 ft	27 ft	24 ft
Maximum notch flow	6,105 cfs	3,166 cfs	12,253 cfs	3,166 cfs	3,400 cfs	3,400 cfs
Notch flow ends at overtopping	No	No	No	No	Yes	Yes
Notes				This scenario was included for analytical		This scenario was included for analytical

				purposes only		purposes only

Table 3- Notch rating curves for simulated scenarios

DWR provided the USGS with notch ratings as a function of Sacramento River stage for scenarios 1, 2, 3, and 5. The USGS developed the ratings for the analytical scenarios (scenarios 4 and 6). In Table 1 the Sacramento River stage and discharge values shown are USGS estimates.

Sacramento River Stage, ft, NAVD88	2016 Stage – Discharge Rating For Sacramento River Discharge, CFS	Scenario 1 Notch Flow, CFS	Scenario 2 Notch Flow, CFS	Scenario 3 Notch Flow, CFS	Scenario 4 Notch Flow, CFS	Scenario 5 Notch Flow, CFS (Total flow through all notches)	Scenario 6 Notch Flow, CFS (Total flow through all notches)
15	8,680	0	0	0	218	0	12
16	9,693	0	0	0	349	0	45
17	10,706	0	0	0	551	35	94
18	11,720	0	0	0	804	79	177
19	12,733	218	218	0	1,142	152	316
20	13,746	349	349	679	1,547	274	498
21	14,759	551	551	1,195	2,013	443	769
22	15,772	804	804	1,831	2,555	678	1,073
23	16,785	1,142	1,142	2,661	3,166	982	1,776

24	17,798	1,547	1,547	3,664	3,166	1,565	2,381
25	18,811	2,013	2,013	4,787	3,166	2,200	3,084
26	19,825	2,555	2,555	6,067	3,166	2,873	3,223
27	20,838	3,166	3,166	7,502	3,166	3,171	3,259
28	21,851	3,845	3,166	9,041	3,166	3,405	3,182
29	22,864	4,624	3,166	10,675	3,166	3,424	3,407
30	23,877	5,365	3,166	12,253	3,166	3,182	3,246
31	24,890	6,105	3,166	12,253	3,166	3,376	3,403
32	25,903	6,105	3,166	12,253	3,166	3,325	3,863
33	26,916	6,105	3,166	12,253	3,166	0	0
34	27,930	6,105	3,166	12,253	3,166	0	0
35	28,943	6,105	3,166	12,253	3,166	0	0

5. Results

5.1. Simulation of entrainment as a function of notch location

The primary goal of this analysis was to understand how the performance of each notch scenario was affected by the location of the notch or notches within the study area given historical relationships between Sacramento River stage, Sacramento River discharge, and run abundance. To this end we used a Monte Carlo simulation to estimate time series of entrainment for each run, for each scenario, at each of 63 locations within the study area spaced 32.8 ft (10 meters) apart in the along stream direction (figure 5, Appendix A). This approach allowed us to use a variety of metrics to compare entrainment at each of the potential locations for the six simulation scenarios. The rich dataset provided by the simulation also allowed us to consider strategies for optimizing entrainment rates in future designs.

The entrainment simulation period (water years 1997 - 2011) included a mix of dry years when the weir did not overtop during the notch operation period (November 1 - March 15), years when the weir overtopped infrequently during the notch operation period, and wet years when the weir frequently overtopped during the notch operation period (Figure 14). Because the simulation period contains a mix of water year types, estimates of the total entrainment and the total entrainment ***rate*** for each location over the course of the simulation provide a good summary of how notch location affects scenario performance in the long run by incorporating a wide range of conditions. Figure 15 shows the overall total entrainment for each run for each scenario at each location in the study area; this data is summarized below in table 4, while Appendix B contains tables showing mean yearly total entrainment with 90% confidence intervals for each run under each scenario at each of the 63 notch evaluation locations.

For this analysis, total entrainment is expressed as the overall fraction of the yearly abundance time series for each run that is entrained in the notch over the period indicated (usually the 15-water-year simulation period); because the yearly abundance time series sums to 100% for each season, entrainment for each year is weighted equally. This Normalization allows between year comparisons. Figure 16 is similar to Figure 15, but expresses scenario performance as overall entrainment rate for each scenario, which is calculated as the fraction of the simulation fish that passed through the study area during the notch performance period when notch flow was greater than zero which were entrained under each scenario. Figure 15 addresses the question “where should a notch be located to maximize the overall entrainment of a run”, while Figure 16 addresses the question “where should a notch be located to maximize the entrainment of that proportion of each run that passes through the study area when the notch is operating”.

The good news is that the total entrainment and entrainment rate curves for each run show similar trends in scenario performance as a function of notch location. For single notch scenarios (scenarios 1 - 4) notch performance for all run has a peak around 902 ft (275 meters), a sharp decrease in performance between 984 ft (300 meters) and 1,230 ft (375 meters), followed by a broad peak in performance that slowly drops off after 1,640 ft (500 meters). For single notch scenarios the maximum entrainment and entrainment rate for all run is located between 1,312 ft (400 meters) and 1,640 ft (500 meters). Figure 4 shows the along-channel coordinate system for the study area, figure 17 shows the zones of maximum and minimum entrainment described above, and Appendix A provides a table that can be used to convert between along-channel coordinates and UTM.

The relationship between notch locations and performance for multiple notch scenarios (scenario 5 and scenario 6) is similar, but these scenarios had the highest entrainment and entrainment rate for all run between 853 ft (260 meters) and 916 ft (280 meters). For multiple notch scenarios the location indicated on the entrainment and entrainment rate plots is the along-channel location of the center of the first notch, so a peak entrainment listed at 886 ft (270 meters) indicates that peak entrainment occurred for the scenario when the center of the first notch was located 886 ft (270 meters), the center of the second notch was located at 925 ft (282 meters), the center of the third notch was located at 1,410 ft (430 meters), and the center of the fourth notch was located at 1,673 ft (510 meters) (See Appendix C for notch spacing for scenario 5 and scenario 6). The spacing of the notches for the multiple notch scenarios explains why these scenarios reached peak performance when the center of the first notch was located near 885 ft (270 meters), because this location placed all 4 notches in regions where the single notch scenarios had high entrainment.

It is likely that the dramatic drop in entrainment and entrainment rate for all scenarios shown in Figures 15 and 16 around 984 ft (300 meters) is caused by interactions between the study fish's behavior and hydrodynamic effects of the sudden change in bathymetry near the river right bank (Figure 17) in this area of the river. Figure 18 shows the location of the notch evaluation cross-section at 1,198 ft (365 meters) on a bathymetry map of the study area with some example fish tracks; it appears that fish near the river right bank of the study area upstream of the scour hole on the outside of the bend avoid the area around the scour hole. Additionally, it appears that the geometry of the bend interacts with the outmigration behavior of the study fish in a way that resulted in many fish on the river left side of the Sacramento River passing by this portion of the bend (Figure 19). The net result of these effects is that there is a drop in the density of fish tracks in the near-bank area in the vicinity of this scour hole (Figure 20), while the area of peak water velocity moves closer to the bank in the scour hole. Accordingly, a notch located in the vicinity of the scour hole will likely need to entrain a large amount of water to move the critical streakline into locations in the cross-section with high fish densities. The effects of the scour hole on scenario performance suggest that the bathymetry and hydrodynamics immediately upstream of a notch can have significant impacts on the notches entrainment rate.

Because the entrainment simulation is based on tracks of acoustically tagged hatchery late fall run Chinook, the differences between the simulated entrainment for each run are entirely the result of the difference in abundance timing for each run during the simulation period. Thus, differences in scenario performance between run show the expected effect of each run' outmigration timing on the entrainment of hatchery late fall run Chinook, and are not indicative of any behavioral differences between run. Nevertheless, the differences between scenario performance for each run can inform our understanding of how the covariance between abundance timing, Sacramento River stage, Sacramento River discharge and scenario notch rating curves combine to affect entrainment.

The most significant observation from Figures 15-16 is that the entrainment and entrainment rate curves for each run suggest that differences in abundance timing between runs determine the maximum entrainment and entrainment rate for each run under each scenario, but, differences in abundance timing do not significantly alter the relationship between along-channel location and scenario performance. In other words, these results suggest that a notch location that maximizes entrainment for fall run abundance timing is likely to have near maximum entrainment for winter and spring run abundance timing as well. Again, we caution that these results are based only on run abundance timing, and do not incorporate behavioral and physiological differences between runs, nor between the size and degree of smoltification of the juvenile salmon that can vary between years and throughout any given outmigration season.

Table 4 - Summary of scenario performance

Percent of yearly juvenile salmon abundance entrained onto the Yolo Bypass under each scenario, by run, for the notch locations that resulted in maximum fall run entrainment for each scenario. The mean yearly percent of yearly abundance entrained is given along with 90% bootstrap confidence intervals in parentheses. The final row gives the along-stream coordinate of the notch location that resulted in peak entrainment for fall run under each scenario, see figure 4 for a map showing the along-stream coordinate system in the study area.

Run	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
Fall Run	12% (6%-21%)	9% (2%-21%)	28% (12%-43%)	15% (3%-28%)	6% (2%-12%)	8% (2%-15%)
Spring Run	9% (4%-15%)	7% (4%-14%)	22% (6%-42%)	16% (9%-20%)	5% (1%-11%)	7% (2%-13%)
Winter Run	9% (2%-17%)	7% (2%-15%)	23% (4%-42%)	15% (8%-23%)	5% (2%-11%)	7% (4%-13%)
Late Fall Run	5% (0%-12%)	4% (0%-11%)	11% (0%-38%)	9% (1%-20%)	2% (0%-10%)	3% (0%-12%)
Location of notch at peak entrainment (UTM Zone 10S, m, NAD83)	615849E, 4290952N	615849E, 4290952N	615780E, 4290905N	615849E, 4290952N	615636E, 4290860N	615636E, 4290860N
Along stream coordinate of notch at peak entrainment	495 m	495 m	415 m	495 m	265 m	265 m

5.2. Effects of notch rating curves and run abundance timing on entrainment

While differences in abundance timing between each run did not result in significant differences in the relationship between notch location and notch performance for each run, the differences in abundance timing did have a significant effect on the maximum entrainment rate and maximum total entrainment for each run. With the exception of scenario 4, all scenarios showed the same pattern in the relative entrainment rate between run throughout the study area: fall run had the highest entrainment rate, spring run and winter run had similar entrainment rates that were lower than fall run, and late fall run had the lowest entrainment rates (Figure 16).

Scenario 4 is the exception, as all run experienced similar entrainment rates under this scenario (Figure 16, panel 4). Patterns in the relative differences between total entrainment for each run are similar to the patterns in the relative difference between entrainment rate for each run, with scenarios 1,2,3,5, and 6 showing the highest total entrainment for fall run, the lowest entrainment for late fall run, and middle values for spring run and winter run. Again, the exception was scenario 4, which showed similar total entrainment for fall run, spring run, and winter run, and the highest overall entrainment for winter run rather than fall run.

The reason that scenario 4 had the most consistent entrainment rates between runs is that this scenario had the highest notch flows for stages below 22 ft, when a large proportion of spring run, winter run, and fall run were present in the study area during the simulation period (Figure 21). The cumulative distribution functions (CDFs) for each run' simulation abundance as a function of stage shown in figure 21 show that during the simulation period around half of the spring run, winter run, and late fall run yearly abundance passed through the study area when stage was below 22 ft, while only about 30% of fall run abundance passed through the study area when stage was below 22 ft. Additionally, the CDFs for spring run, winter run, and late fall run all show a rapid increase in cumulative abundance between 19 ft and 22 ft that does not occur in the CDF for fall run. This rapid rise in abundance between 19 ft and 22 ft for spring run, winter run, and late fall run suggests that there is some interaction between watershed hydrology and the life history of these run that consistently results in these runs moving through the study area during outflow events that result in Sacramento River stages in the study area between 19 ft and 22 ft. As a result, scenario 4, which entrains about 10% of Sacramento River water at 19 ft, and reaches a peak discharge ratio at 23 ft has the second highest total entrainment for all run. Scenario 3 has higher total entrainment for all run, but, scenario 3 reaches a peak discharge of 12,000 cfs, while scenario 4 has a peak discharge of only 3,166 cfs.

Finally, scenario 4 has similar entrainment rates for all runs, and similar total entrainment for fall run, spring run, and winter run, but lower total entrainment for late fall run. The lower total entrainment for late fall run under scenario 4 (and all other scenarios) is the result of two factors: first, during the simulation period about 25% of late fall run yearly abundance passed through the study area at stages below 16 ft, while only about 10% of other run yearly abundance passed through the study area below 16 ft during the simulation (all scenarios entrained little to no water below 16 ft), and second, during the simulation period, late fall run had lowest proportion of total yearly abundance that occurred during the notch operation period (Table 5). Thus, even though scenario 4 entrained late fall run at the same rate as other run, there was a lower overall proportion of late fall run available for entrainment during periods when the notch was operating.

Table 5 - Percent of simulation abundance for each run that passed through the study area during notch operation periods over the 15-water-year simulation.

Run	Percent of simulation total yearly abundance for the simulation period that transited the study area during notch operation periods (Abundance present during notch operation period / total yearly abundance)*100%
Fall Run	79%
Spring Run	81%
Winter Run	98%
Late Fall Run	68%

5.3. Entrainment rate and entrainment efficiency for each scenario as a function of stage.

As discussed above, the entrainment simulation is only based on acoustic tag tracks from hatchery late fall run chinook, so the differences in simulated entrainment between run reflects the differences in the frequency of the relative timing of stage, discharge and run abundance during the simulation period. In order to better understand how abundance timing affected entrainment under each scenario we computed stage vs entrainment rate curves for each scenario (Figure 22), and stage vs entrainment efficiency curves for each scenario (Figure 23). Entrainment rate indicates the fraction of the bootstrap sample at each time step that was marked as entrained under each scenario, and entrainment efficiency is the ratio of the time step entrainment rate for each scenario divided by the time step discharge ratio for each scenario. When entrainment efficiency is greater than one a notch is entraining a greater proportion of fish than water.

The underlying stage vs entrainment relationship for each scenario is the same for each run, so we chose to compute the relationship for winter run because the winter run abundance timing resulted in the largest number of entrainment “trials” within the simulation. Because the spatial distribution of discharge and fish tracks changes throughout the study area and, thus, the stage vs entrainment rate/efficiency curves for each scenario change throughout the study area; it is possible to compute a stage-entrainment rate curve for each of the 63 along-channel notch locations evaluated in the simulation. For the sake of brevity, we chose to present curves for the location in the study area that had the highest total entrainment of winter run for each scenario (These locations are shown in Figure 17).

Because of backwater effects in the study area, a range of Sacramento River discharge values occur in the historical record for any Sacramento River stage value (Stumpner et al., in review). As a result, there is a range of notch discharge ratios for each scenario at any stage, and, because of this variability in discharge ratio and variability in behaviors and other environmental covariates, we expect that run of the river fish will experience a range of entrainment rates at any Sacramento River stage under all future notch scenarios. Within the entrainment simulation the range of entrainment rates predicted for any stage is a function of three processes: firstly, the entrainment simulation is driven by historic stage and discharge data, so the historic variance in discharge ratio for each scenario is captured in the simulation. Secondly, there is stochasticity inherent in the bootstrapping approach used to draw the track pools at each timestamp, so any particular stage-discharge pair will not always draw from the same track pool. Thirdly, we add stochastic error to the computed critical streakline location for each scenario at each time step to account for uncertainty in our ability to predict the critical streakline location given the effects of backwater condition on cross-channel velocity distributions within the study area (Stumpner et al., in review). As a result of these three factors the stage vs entrainment rate and stage vs entrainment efficiency curves presented in Figures 22 and 23 are in the form of a 90% confidence interval and median value for scenario entrainment rate as a function of stage. The range of discharge ratios at each stage is shown for each scenario to illustrate the variability in discharge ratio. For the multiple notch scenarios the entrainment rate and median discharge ratio are based on total entrainment of water and fish through all notches operating at any stage value.

The scenario stage vs entrainment rate curves shown in Figure 22 indicate how efficient each scenario is at entraining fish at any stage: when the scenario entrainment rate is greater than the scenario discharge ratio the scenario is entraining proportionally more fish than water, and when the entrainment rate is lower than the discharge ratio the scenario is entraining proportionally more water than fish. Figure 23 shows the range of entrainment efficiency values for all time steps at a particular stage. The entrainment efficiency of each scenario at any location is controlled by the balance between the cross-channel distribution of fish and the cross-channel distribution of flow. Figures 24 and 25 illustrate the cross-channel distribution of fish and flow in the study area. The interaction between fish distribution, flow distribution, and notch rating curves controls entrainment efficiency. This interaction is complex; however, in general, the effects of discharge ratio on entrainment can be summarized for the locations in the study area that produced maximum scenario entrainment as follows:

1. There is a zone very near the river bank where there are few fish, so extremely low discharge ratios produced low entrainment rates for all scenarios.

2. There is a zone a little further from the bank where fish densities are high and water velocities are not the peak within the cross section: increasing the discharge ratio to the point where the critical streakline enters this zone will result in rapid increase in entrainment and entrainment efficiency for all scenarios (this is a highly non-linear

relationship - almost a step function process due to the high gradient in the fish densities).

3. There is a zone beginning at about 49 ft - 82 ft (15-25 meters) from the river right bank (Figure 25) where water velocities reach a peak. A large proportion of the total discharge in the cross-section is contained in this region. Once a scenario's discharge ratio is high enough that the critical streakline reaches this zone, a large increase in discharge ratio is required to move the critical streakline further out into the river cross section, and entrainment efficiency decreased.

4. The spatial distribution of 2016 study fish tracks for periods when Sacramento River was below bankfull (see figure 24) was dramatically different than the spatial distribution of 2016 fish tracks for periods when the Sacramento River was above bankfull (Figures 26, 27). In general, fish tracks collected after the Sacramento River stage exceeded bankfull (28.5 ft) were less concentrated on the outside of the bend, so that at higher stage scenarios needed a very high discharge ratio to entrain many fish. This observation is likely related to the influence of the slow velocity water associated with the overbank region pushing the influence of the sidewall boundary layer into the center of the channel (See Stumpner et al., In Review). It is important to note that the accuracy of the acoustic tag tracking array decreased when the Sacramento River was above bankfull so we cannot be sure of the exact magnitude of the effect, but, the spatial extent of the shift in the observed spatial distribution of tracks between below bankfull conditions and bankfull conditions was large enough that we believe that the effect is due to true changes in the location of study fish.

The entrainment rate and entrainment efficiency curves shown in Figures 22 and 23 reflect these general trends. For all scenarios entrainment efficiency increased rapidly once the discharge ratio exceeded 10%, with most scenarios reaching a peak entrainment efficiency between 25 ft and 27 ft and a discharge ratio of about 15%. Because of the covariance between stage and discharge ratio for all of the scenarios tested, we cannot ascertain whether the location of peak entrainment efficiency is a function of discharge ratio, a result of the spatial distribution of fish and flow at 25 ft - 27 ft of stage, or some combination of the two. In the future, we recommend simulating scenarios with constant discharge ratios which will allow us to explore the effects of stage and discharge ratio independently.

For all scenarios except scenario 3, entrainment rate and entrainment efficiency dropped off rapidly once stage exceeded bankfull. Scenario 3 maintained high entrainment rates and an entrainment efficiency near 1 for stages greater than bankfull because of the high discharge ratio for this scenario places the critical streakline near the center of the river at high stage values. The multiple notch scenarios had lower entrainment rates that scenarios 2 and 4 (which have similar overall notch rating curves), because at many stages the discharge for these scenarios was spread between multiple notches, so the lower discharge ratio for each individual notch (not shown) was less likely to push the critical streakline into the region in the cross-section where fish were more concentrated.

Finally, there are several features of the entrainment rate and entrainment efficiency curves that are a result of the mechanics of the simulation process. First, the dip in the entrainment rate for scenario 4 at 20 ft is a result of the small number of study fish tracks that passed through the study area at 20 ft of stage (figure 11); because of the limited fish tracks collected at this stage the bootstrap samples for stages around 20 ft are heavily influenced by a small number of fish tracks that happened to be far away from the bank at the location which we chose to compute the stage vs entrainment curves. When stage vs entrainment curves are computed for locations where these fish tracks were closer to the bank (not shown) the dip in entrainment is not evident, and the plots showed a smooth entrainment curve for scenario 4 from 15 ft to the peak in entrainment located around 24.5 ft. Secondly, the extremely high entrainment efficiency for scenarios 1,2,5, and 6 at low notch flows are due to the extremely low discharge ratios for these scenarios when the notches first begin to take water. Entrainment efficiency is calculated using discrete numbers and cannot change with the same precision as discharge ratio, which is a continuous variable. As a result, when discharge ratios are very low entrainment of a single fish track can cause the entrainment rate to increase out of proportion with the discharge ratio, and entrainment efficiency becomes large. Note that the two scenarios that took more water at low flows do not indicate the very high entrainment efficiencies at the lowest notch flows.

5.4. Entrainment as a function of water year

Because of the complex relationship between Sacramento River stage, run abundance, and scenario entrainment rate, we wanted to be sure that the along-stream location vs entrainment curves we computed for the entire simulation were not being disproportionately influenced by water years with extremely high or low Sacramento River stage values. To explore the effects of water year on simulated entrainment, we placed each notch operation season (November 1 - March 15) into one of three water year categories based on the number of hours within the operation season that the weir overtopped (Tables 6 and 7), and then computed total entrainment vs along-stream location curves for each water year category (overtopping was defined as Sacramento River stage > 32.3 ft). The operation season classifications are shown in Table 7, and the entrainment vs along-stream location curves for each water year class, run, and scenario are shown in figure 28 through figure 33. The most important result of analysis of the water year entrainment vs along-stream location curves is that these curves suggest that water year type has a large influence on the maximum entrainment for each run under each scenario, but, water year type doesn't change the overall trends in scenario performance vs along-stream location. This is a positive result because it suggests that the same location in the cross section will produce maximum entrainment for a variety of abundance timing and water years.

The entrainment vs along-stream location curves shown in Figures 28 through 33 show many interesting differences in the maximum entrainment for each water year category for each run and scenario. Some of the most important observations are:

1. Most scenarios entrained the most fall run in seasons when the weir did not overtop. This is because fall run are most likely to be present in the study area at high Sacramento River stage values when entrainment efficiency for most scenarios is lowest; in dry years fall run most likely pass through the study area at lower stages when entrainment efficiency was higher.

2. During years when the weir did not overtop, scenario 4 had the highest peak entrainment for spring run, winter run, and late fall run. This is despite the fact that scenario 3 has maximum notch flows that are nearly 4 times higher than the maximum notch flows for scenario 4. This observation suggests that lowering scenario stage-discharge curves to capture fish passing through the study area between 19 ft and 22 ft could be an efficient way to increase entrainment of these run in dry years.

3. Late fall run tended to experience the highest overall entrainment during wet or moderately wet years, as opposed to the other runs which experienced the highest overall entrainment during dry or moderately wet years.

Table 6 - Water year type classifications based on number of hours that the weir overtopped during each season in the simulation

Number of hours that the weir overtopped per season (Overtopping is defined as Sacramento River stage>32.3 ft, USGS survey, NAVD88)	
0	No overtopping, Category 1
1-200	Few overtopping, Category 2
200 +	Wet, Category 3

Table 7 - Number of hours that the Fremont Weir overtopped during each season in the simulation

Season	Hours of weir overtopping per season	Season classification
1996	1204	Wet
1997	1268	Wet
1998	744	Wet
1999	712	Wet
2000	0	No Overtopping
2001	112	Few Overtopping
2002	156	Few Overtopping
2003	448	Wet
2004	0	No Overtopping
2005	1120	Wet
2006	0	No Overtopping
2007	0	No Overtopping
2008	0	No Overtopping
2009	12	Few Overtopping
2010	36	Few Overtopping

6. Discussion

6.1. Primary sources of uncertainty in the entrainment simulation

The entrainment simulation uses hydrodynamic data and acoustically tagged fish track data collected under a limited range of field conditions to predict entrainment for future weir modification scenarios over a range of hydraulic conditions and run abundance timing scenarios. As a result, we view the entrainment simulation results primarily as a tool for exploring the interaction between factors which we expect to be the primary drivers of scenario efficacy: a scenario's stage-discharge rating, a scenario's location within the study area, the covariance between stage and discharge at the study location, and the timing of salmon run abundance. However, the entrainment simulation was not designed to explore the fifth factor that we expect to control scenario entrainment: the physiology and behavior of naturally migrating juvenile salmon, both smolts and pre-smolts. The entrainment simulation is entirely based on a limited sample of tracks from acoustically tagged hatchery late fall run Chinook salmon smolts. At this time we lack the data to evaluate the suitability of using large (~150mm fork length) hatchery-raised late fall run smolts as surrogates to predict the high resolution movement patterns of juvenile salmon from multiple runs that emigrate as both smolts and pre-smolts, but it is reasonable to expect that the behavior of the hatchery surrogates will not be a good predictor of the behavior of some, or all, of the naturally migrating juvenile salmon that are the focus of this project. Given the physiological differences between naturally migrating winter run and spring run juveniles and the large hatchery origin smolts used for this experiment, we expect that the use of large, hatchery origin smolts to predict the movement patterns of naturally migrating juvenile salmon is the single largest source of uncertainty within the entrainment simulation. Nevertheless, there is little that can be done to directly address this uncertainty in the absence of detailed data on the fine scale movement patterns of the naturally migrating juvenile salmon that will be affected by modifications to the Fremont Weir.

There are additional sources of uncertainty in the entrainment simulation that we view as secondary to the fundamental limitation of using hatchery surrogate fish to predict the movements of naturally migrating juvenile salmonids. These other primary sources of uncertainty are:

1. The limited range of Sacramento River backwater conditions and other covariates represented in the 2016 track data set. The bivariate weighting function used in the

bootstrap sample selection process helps to mitigate the limited range of backwater conditions within the 2016 track data set, but given the limited data collection window for the 2016 track data there may be covariates which are first order drivers of entrainment that we do not account for within the entrainment simulation.

2. The possibility that weir modifications will alter the hydrodynamics within the study area. We expect that weir modifications will alter the water velocity patterns within the study area in the immediate vicinity of a notch, but, with the exception of Scenario 3 we do not expect that modifications to the weir will greatly change the cross-channel distribution of flow at a notch because of the low ratio (0.1-0.2) of notch flow to Sacramento River flow. As a result, we only expect local changes to water velocity patterns to affect entrainment if these velocity changes cause fish to alter their behavior in the vicinity of a notch, and, if water velocities in the vicinity of the notch are low enough for the altered behavior to affect entrainment. Scenario 3 is the exception because it is likely to entrain up to 50% of the flow in the Sacramento River for stage values between 28 ft and the crest of the Fremont Weir; it is difficult to predict the effects of such large notch flows on the cross channel distribution of discharge in the Sacramento River, so the results for Scenario 3 should be viewed with greater skepticism than the results for scenarios with lower peak discharge ratios.

3. The effects of backwater condition on the cross-channel distribution of flow in the study area. We have directly incorporated this uncertainty into the simulation by adding a stochastic perturbation to our estimated location for the mean critical streakline; the uncertainty in the stage-entrainment rate curves for each scenario are a direct result of this stochastic error.

7. Recommendations

The USGS's past analyses of entrainment at the Georgiana Slough junction demonstrated that the location of the critical streakline in a riverine junction is a good predictor of entrainment probabilities for individual acoustically tagged juvenile salmon, and a good predictor of the entrainment rate for aggregated groups of acoustically tagged juvenile salmon (CADWR 2012, 2015, 2016). For this reason, the critical streakline approach was used in the entrainment simulation to estimate entrainment under future scenarios based on fundamental hydrodynamic principles and observed acoustic tag tracks. We view the entrainment simulation as a sophisticated "back of the envelope calculation" that combines physical principals with the observed track data to produce entrainment estimates. We expect that the results of the entrainment simulation are a good order-of-magnitude predictor for the entrainment and entrainment rate of **fish that are physiologically and behaviorally similar to the 2016 study fish** under each scenario. While we caution that the results of the entrainment simulation may not be applicable to naturally migrating fish, the reality is that we lack the high resolution tracking data needed to improve on these estimates for naturally migrating salmonids. Given these limitations, the results of the entrainment simulation suggest the following:

- Locating single notch configurations in a ~100 meter (328 ft) long region adjacent to the western terminus of the Fremont Weir (Figure 17, see Appendix A for UTM locations) will result in near maximum entrainment, and near maximum entrainment rates for all single notch scenarios. Performance of scenarios located in this area will likely be robust to changes in abundance timing and water year type.

- Locating multiple notch configurations with the first notch approximately 705 ft (215 meters) upstream of the western terminus of the Fremont Weir (Figure 17, see Appendix A for UTM locations) will result in near maximum entrainment, and near maximum entrainment rates for alternatives with notch spacing similar to Alternative 5. Further, the performance of scenarios located in this area will likely be robust to changes in abundance timing and water year type.

- Bathymetry and hydrodynamics upstream of a weir modification could have large impacts on performance. Care should be taken to avoid siting modifications in areas where fish are likely to respond to bathymetric gradient in the along-channel direction. It may be possible to enhance entrainment in a weir modification by altering (reducing) the along channel bathymetric gradients upstream of the modification.

- Either lowering notch invert elevation or installing a control section downstream of a notch will likely increase the entrainment of winter run, spring run, and late fall run, especially during very dry years. Specifically, entrainment of winter run and spring run may be greatly increased by designing a weir modification to enhance entrainment of fish at Sacramento River discharges that currently occur between Sacramento River stage values of 19 ft NAVD88 and 22 ft NAVD88. This result is likely to be robust to differences between naturally migrating salmonids and the hatchery surrogates used in the analysis, because it is primarily driven by run abundance timing. If physical constraints, such as land surface elevations in the Yolo Bypass adjacent to the Fremont Weir, make it impractical to lower the notch invert elevation sufficiently to achieve an adequate notch discharge ratio at 19 ft stage, it may be possible to design a hydraulic control section in the Sacramento River to increase entrainment through notches with higher invert elevations at lower Sacramento River stage values. Specifically, a control section installed downstream of the notch could be used to increase water levels at the notch for Sacramento River discharges that initiate winter run and spring run outmigration during very dry years.

- It is likely that the entrainment efficiency of multiple notch configurations could be improved by optimizing the tradeoff between the number of notches utilized, and the discharge ratio for each notch. Further analysis could be performed to estimate the most efficient discharge ratio for each notch location as a function of stage, and then the total number of notches could be set based on the targeted total discharge as a function of stage.

- The decrease in entrainment efficiency observed for Sacramento River stages above bankfull for all scenarios was likely the result of the hydrodynamic effects of inundation of the floodplain between the Sacramento River and the weir (Stumpner et al., In Review), combined with the study fish's response to these hydrodynamic effects. In another bend on the Sacramento River that lacks a floodplain the USGS has observed increased cross channel velocities towards the outside of the bend (Dinehart and Burau, 2005); in general we would expect increased cross channel velocities to enhance entrainment under most scenarios. For this reason it may be possible to increase entrainment in the study area for most scenarios by extending the Sacramento River levee from the western end of the Fremont Weir to the upstream end of a notch to prevent this floodplain area from inundating prior to weir overtopping.

8. References

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9. Figures

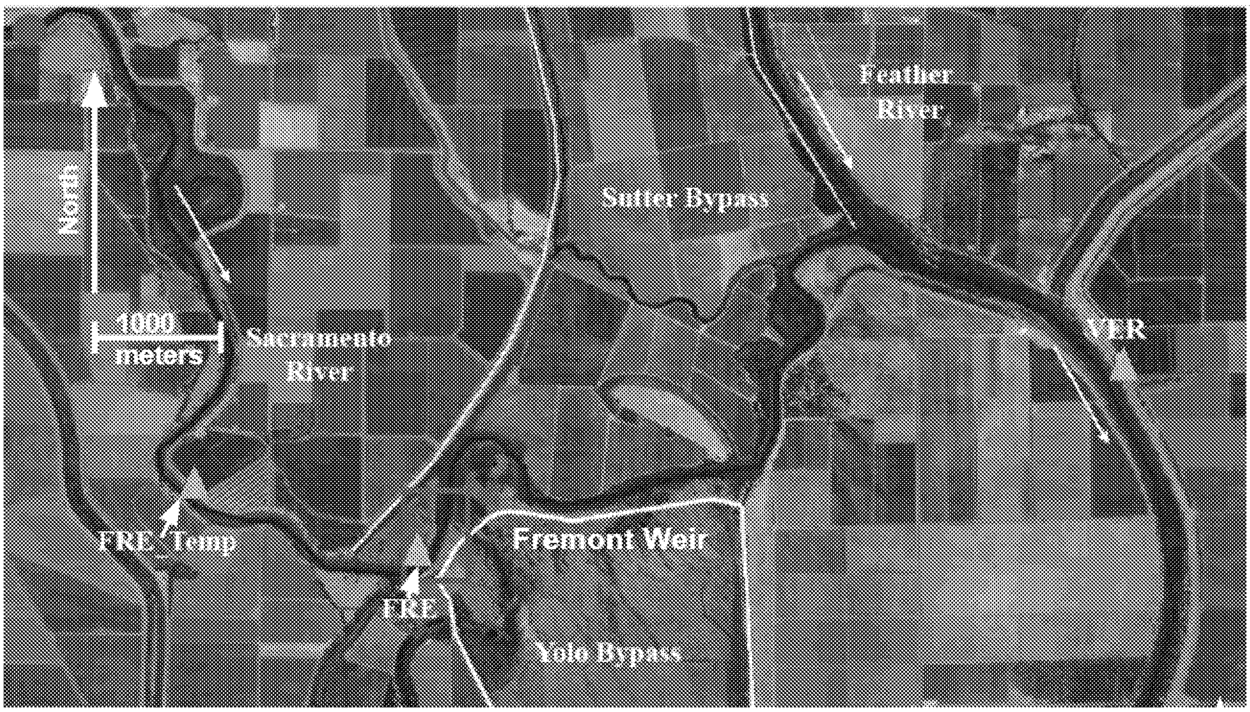


Figure 1 - Aerial photograph showing the approximate boundary of the USGS study area

The portion of the Sacramento River on the western end of the Fremont Weir where the USGS collected water velocity data and high resolution two dimensional acoustic tag tracks is outlined in red. The Fremont weir is highlighted with a thick white line, and the approximate boundary of the northern end of the Yolo Bypass is shown in yellow. The location of gauging locations is indicated with orange triangles; the USGS temporary index velocity gauge is labeled "FRE_Temp", the location of the DWR gauge at the western end of the Fremont Weir is labeled "FRE", and the location of the DWR gauge on the Sacramento River at Verona is labeled "VER". The large red dot in the upper left corner of the image shows the approximate location of the Knights Landing rotary screw traps which provided the abundance timing data used in the simulation.

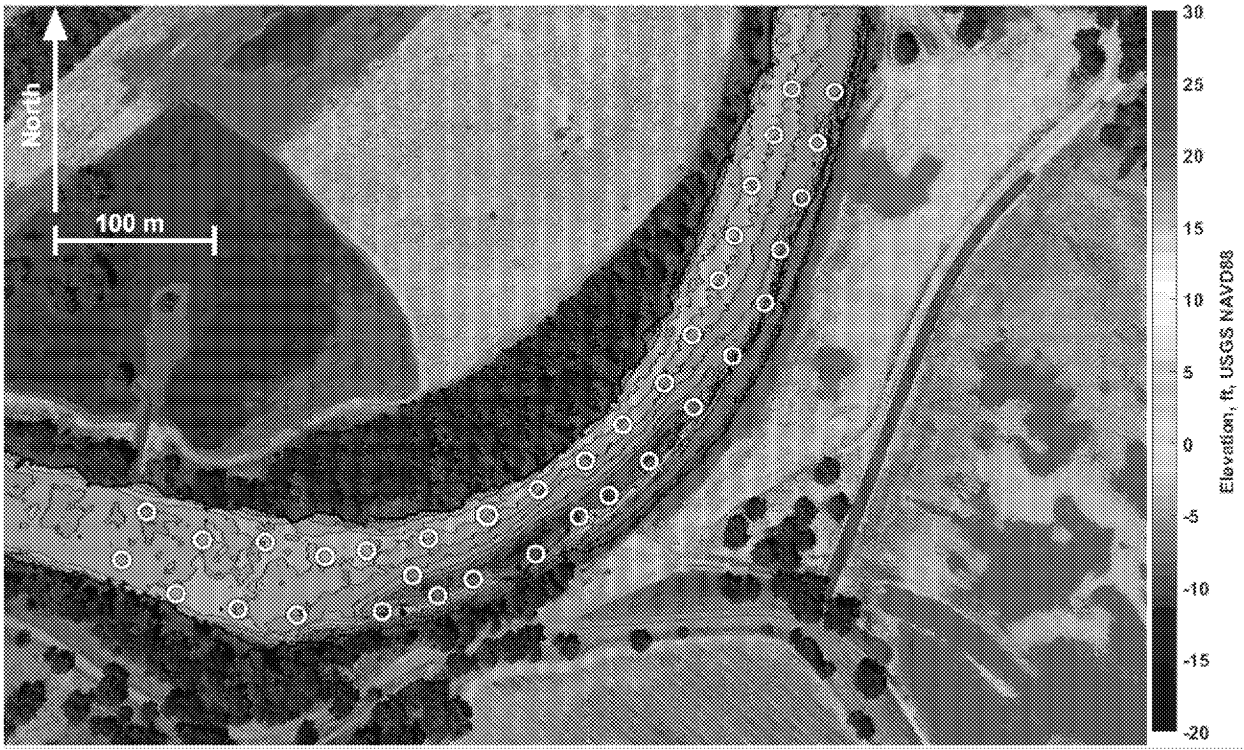


Figure 2 - Aerial photograph showing the bathymetry and hydrophone locations in study area

Aerial photo showing the portion of the Sacramento River on the western end of the Fremont Weir where the USGS collected water velocity data and high resolution two-dimensional acoustic tag tracks. The photo is overlaid with a bathymetry map in the study area, cooler colors on the bathymetry map denote deeper areas. Hydrophone locations are shown as white circles.

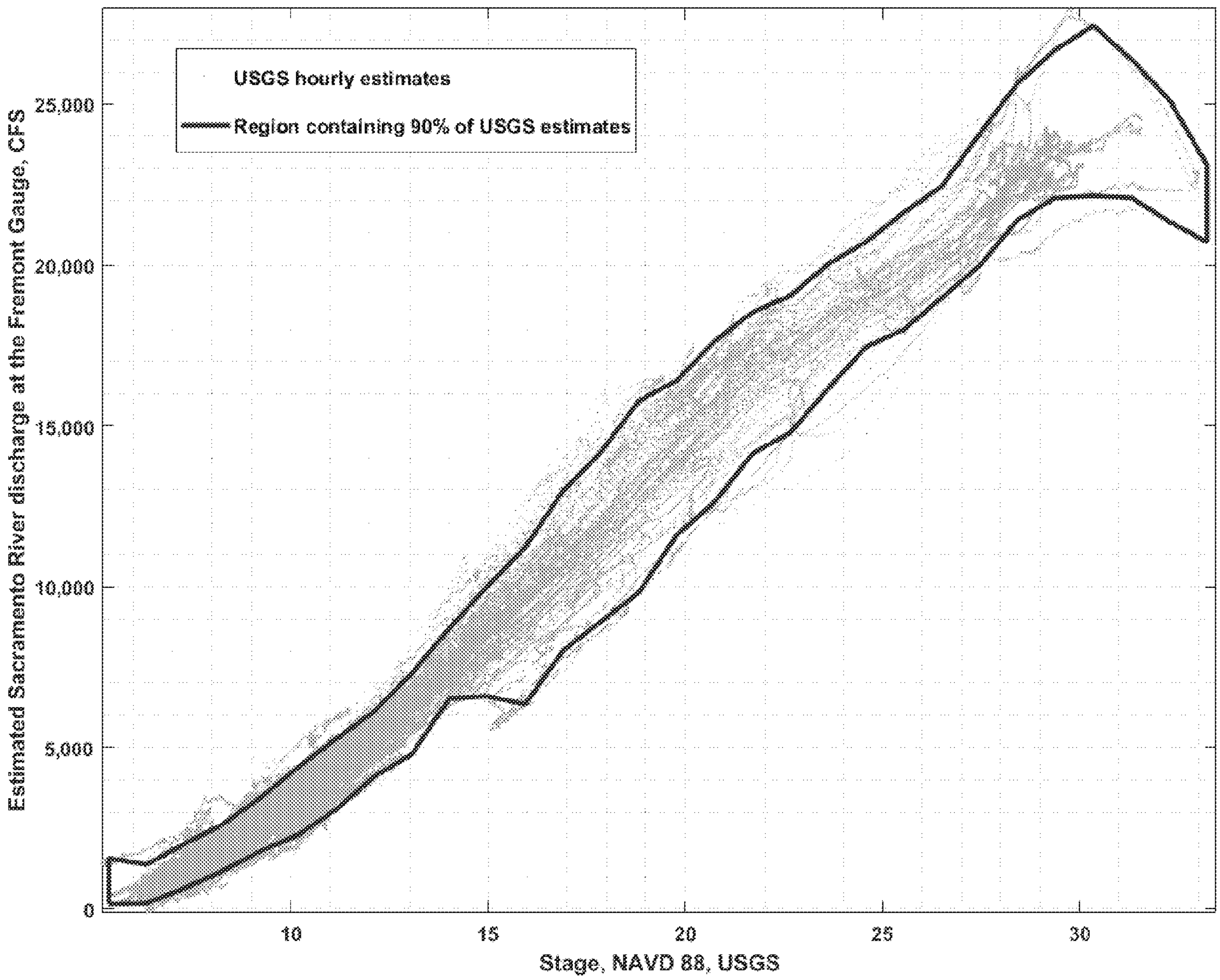


Figure 3 - Plot showing the range of estimated stage-discharge values for the Sacramento River in the vicinity of the western end of the Fremont Weir from 1996 to 2011.

Red dots indicate hourly stage-discharge estimates, and the thick red line indicates the region containing 90% of the discharge observations for any given stage. Because discharge through the proposed notch scenarios will be a function of stage only, the variability in the relationship between Sacramento River stage and Sacramento River discharge will result in variability in the fraction of Sacramento River water diverted under each scenario.

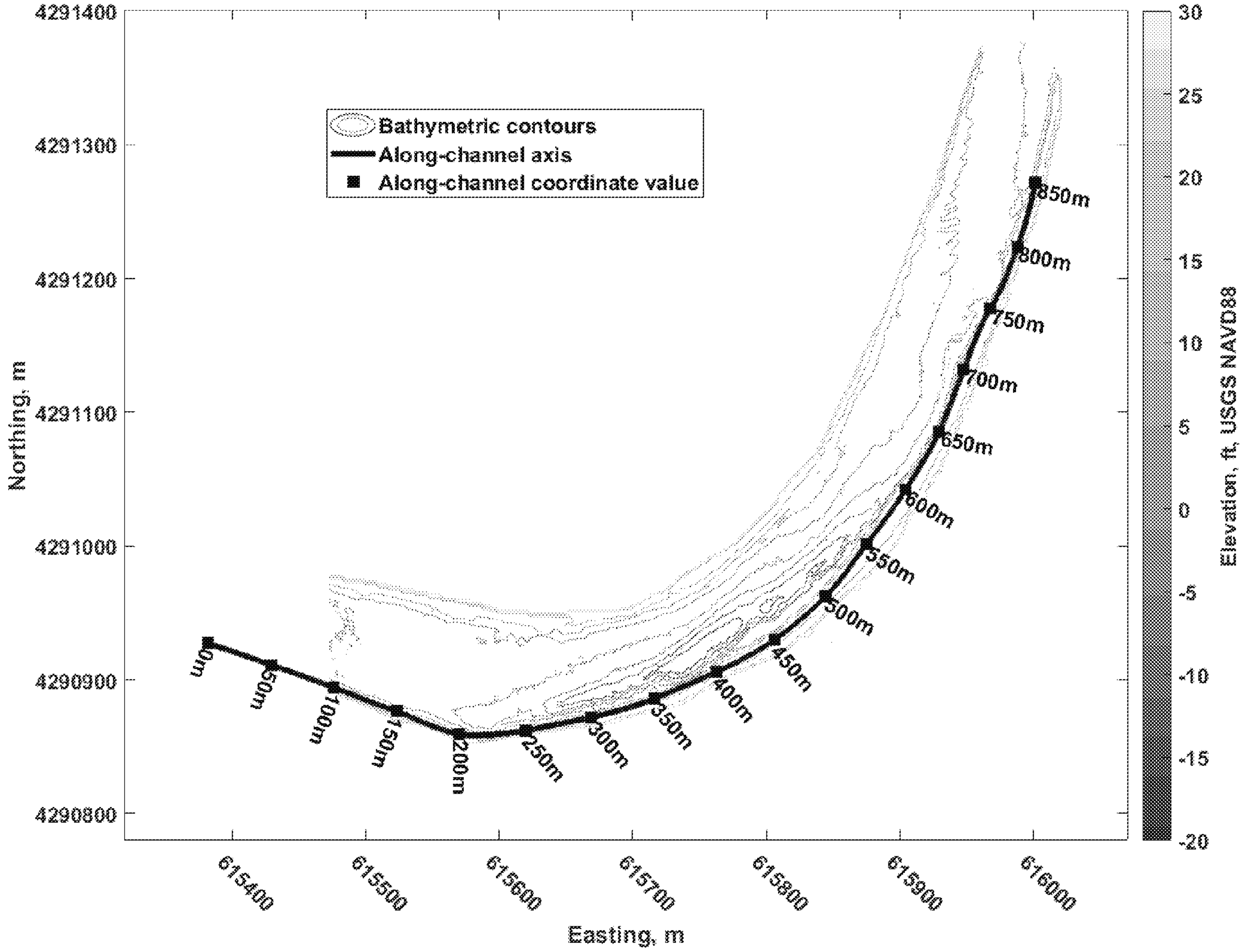


Figure 4 – Along-stream coordinate system

Plot showing the along-stream axis used to locate notch evaluation locations. The thick black line is the along-stream axis, the cross-stream axis is always perpendicular to this line. The black squares on the along-stream axis demarcate 50 meter increments in the along-stream direction. The thin colored lines indicate bathymetric contours.

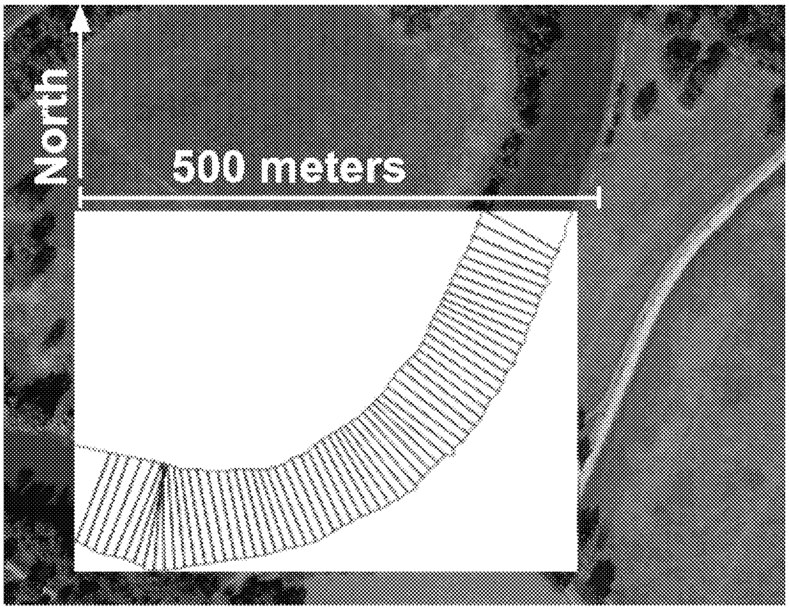


Figure 5 – Notch evaluation locations

The white box indicates the study area for the simulation; the black lines indicate the 63 notch evaluation cross-sections where entrainment was estimated for each scenario at each time step. See Appendix A for UTM coordinates for these locations.

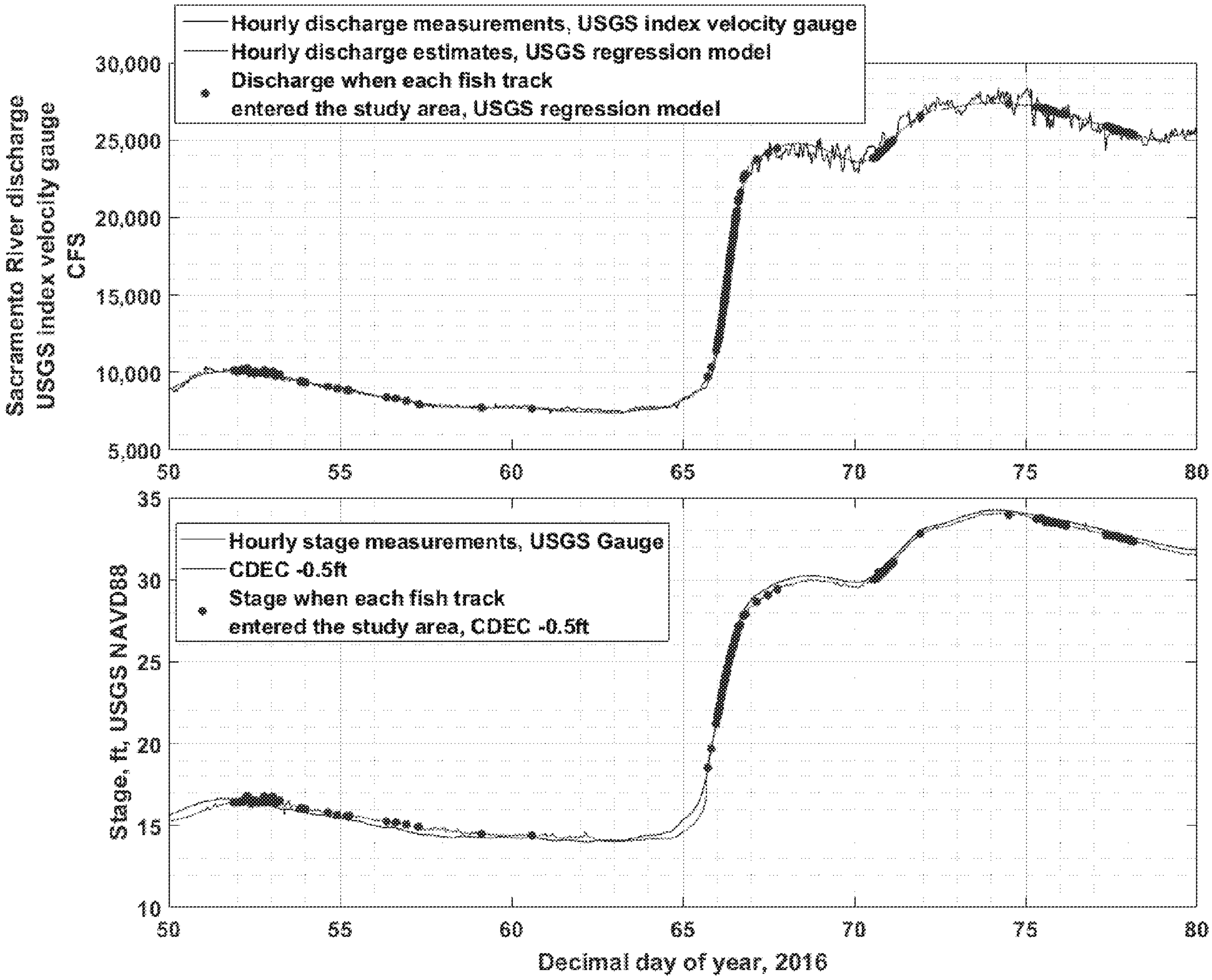


Figure 6 - Plot showing Sacramento River discharge and Sacramento River stage during the time period that 2016 acoustic tag tracks were collected

The top panel shows a time series of Sacramento River discharge based on the temporary index velocity gauge (black line) and the regression equation developed to estimate historic discharge (red line), and the discharge estimates when 2016 acoustic tag tracks were collected (red dots) (See Stumpner et al., in review for details on the discharge estimates). The bottom panel shows time series of Sacramento River stage measurements during time periods when 2016 acoustic tag tracks were collected, and USGS stage estimates when 2016 acoustic tag tracks were collected (red dots). Note the rapid rise in stage and discharge following day 65.

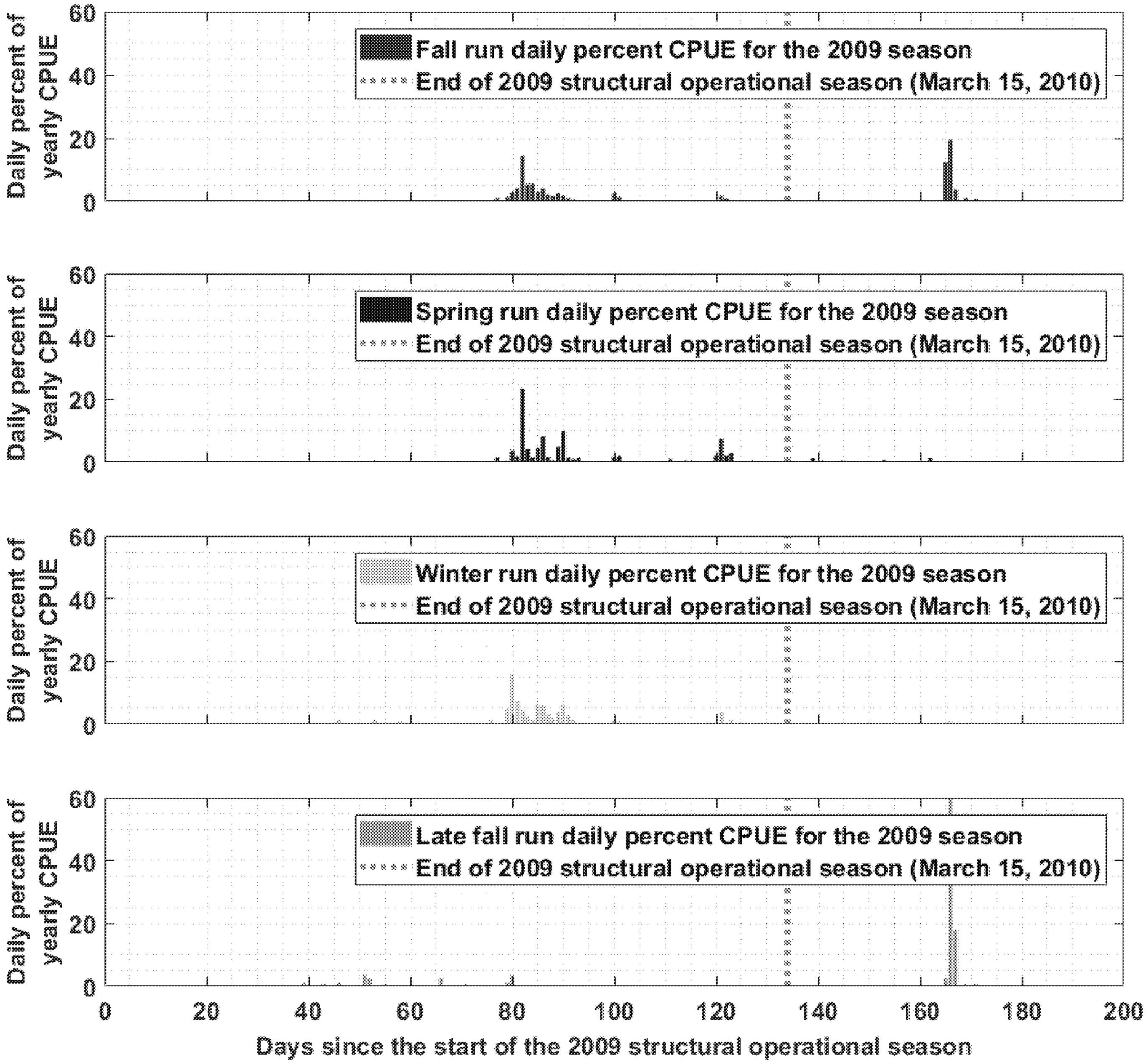


Figure 7 - Daily catch data from the Knights Landing rotary screw trap for the 2009 season (Water year 2010)

Catch is expressed as daily percent of the yearly total Catch Per Unit Effort (CPUE):

Daily percent of yearly CPUE =((Daily Catch/Daily Effort) / (Yearly Catch/Yearly Effort)) *100%

The location of the Knights Landing rotary screw traps is shown in Figure 1.

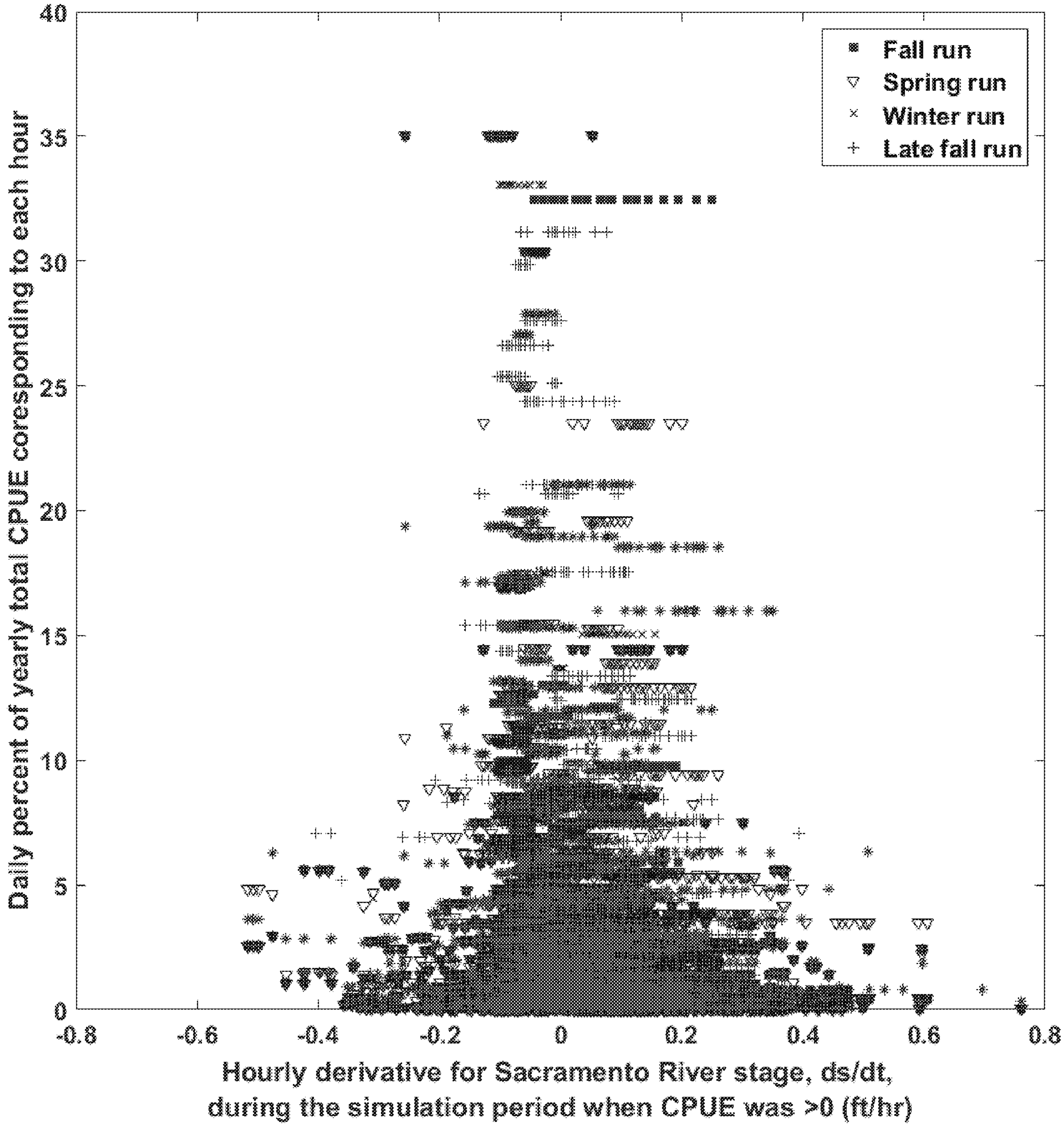


Figure 8 - Plot showing the hourly derivative for Sacramento River stage during the simulation period when Knights Landing catch was greater than zero during the notch operational window (November 1 – March 15).

There are many time steps when Sacramento River stage was changing at a rate faster than 0.2 feet/hr (1 foot change in 5 hours) when naturally migrating fish were likely to be passing the Fremont Weir. Because naturally migrating fish are likely to pass the Fremont Weir during periods when Sacramento River stage changes rapidly we chose to use a 4 hour timestep.

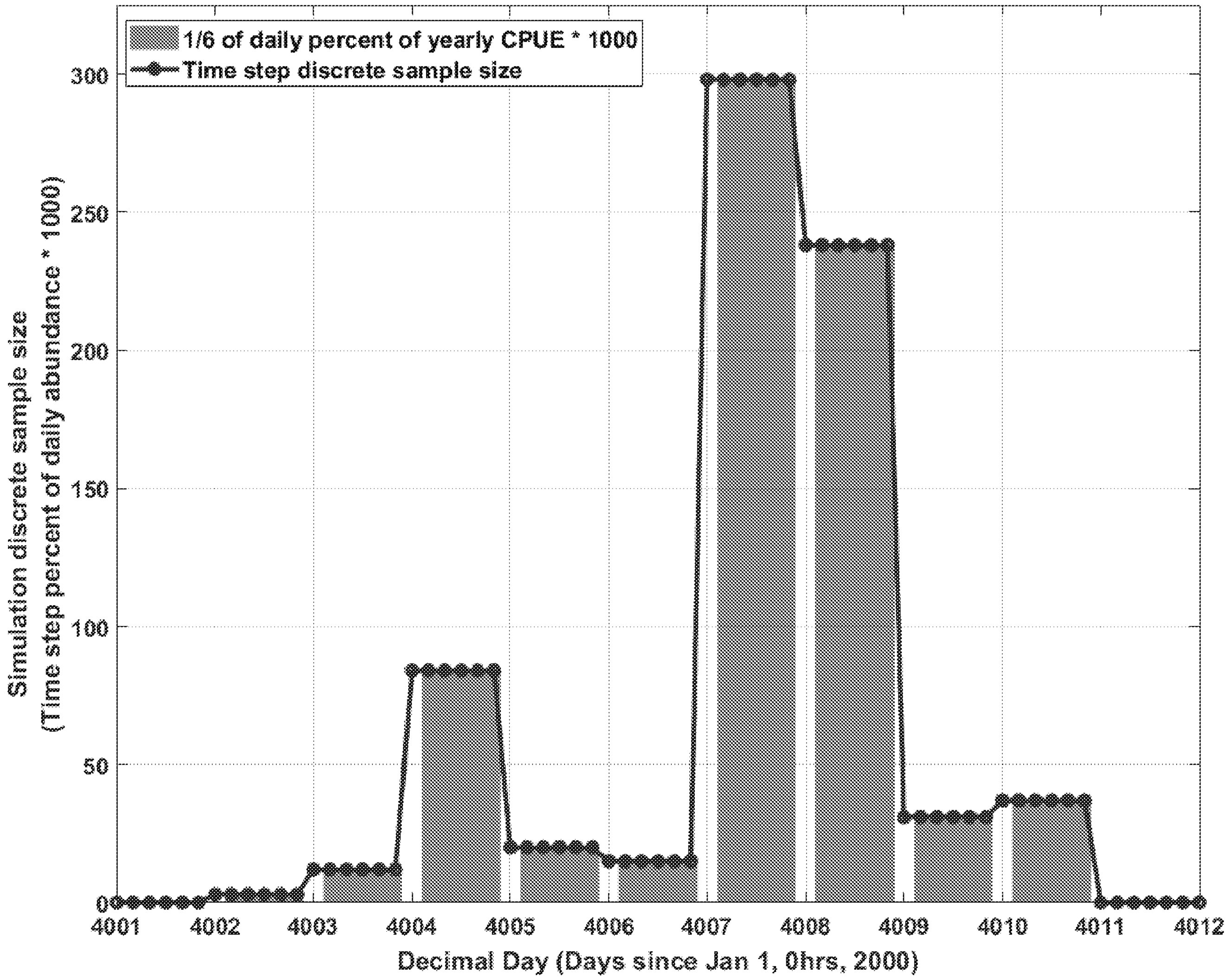


Figure 9 – Daily percent yearly CPUE data converted into discrete sample sizes for each time step.

The blue bars indicate a value that is 1/6 (for a four hour time step) of the daily discrete abundance. Daily discrete abundance is calculated as:

Daily discrete abundance = round(Daily CPUE * 1000)

The red line shows the resulting time series time step discrete abundance showing that each time step within a day has the same abundance.

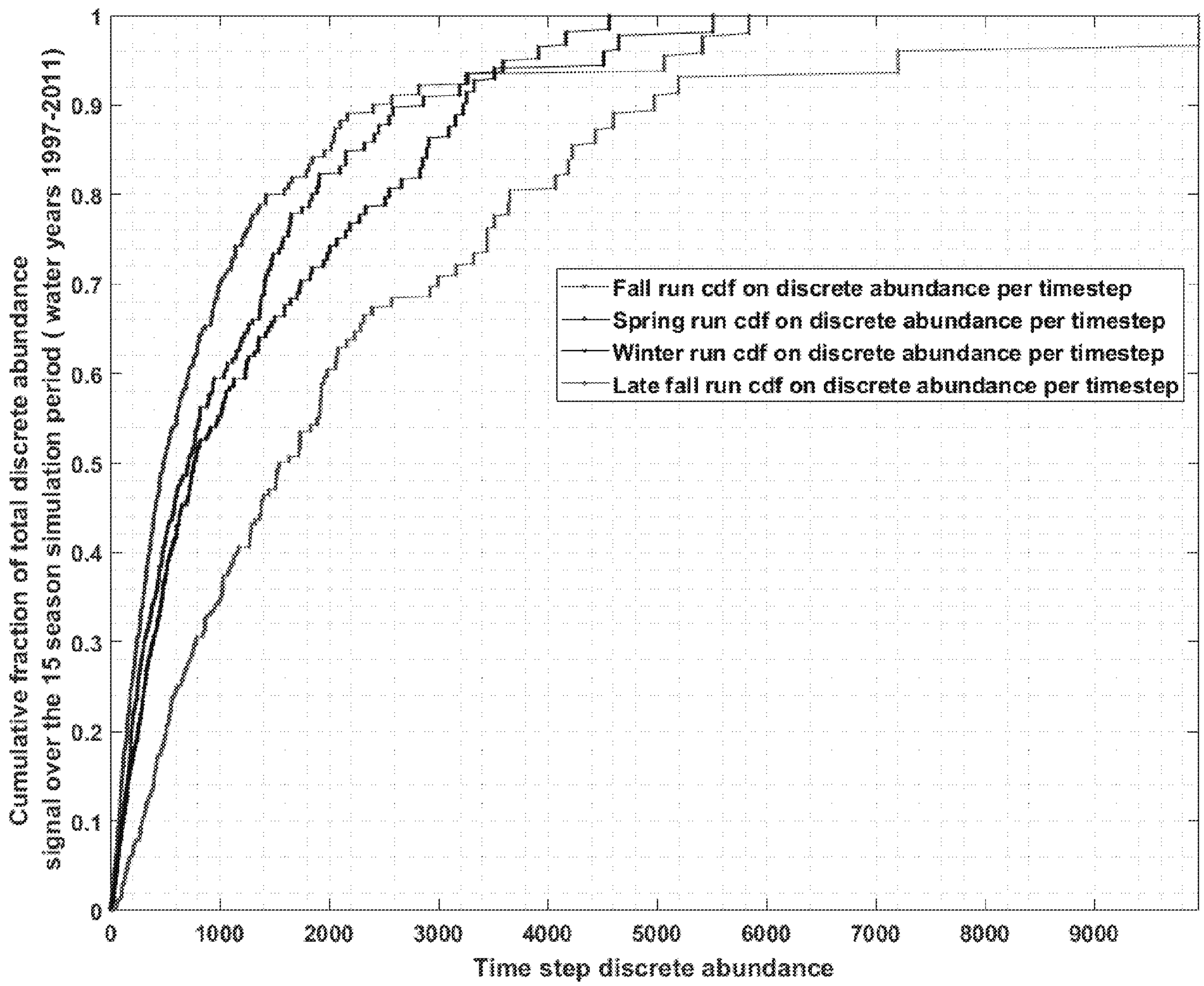


Figure 10 - Plot showing cumulative distribution functions for time step discrete abundance for time steps with non-zero discrete abundance values.

Within the entrainment simulation the size of the bootstrap sample for each time step is set by the discrete abundance for each run at the time step. The lines for each run above indicate the fraction of time steps within the 15-water-year simulation period that had discrete abundance values less than or equal to the sample sizes shown on the x axis; this plot shows the relative frequency of the size of bootstrap sample pools drawn over the simulation period.

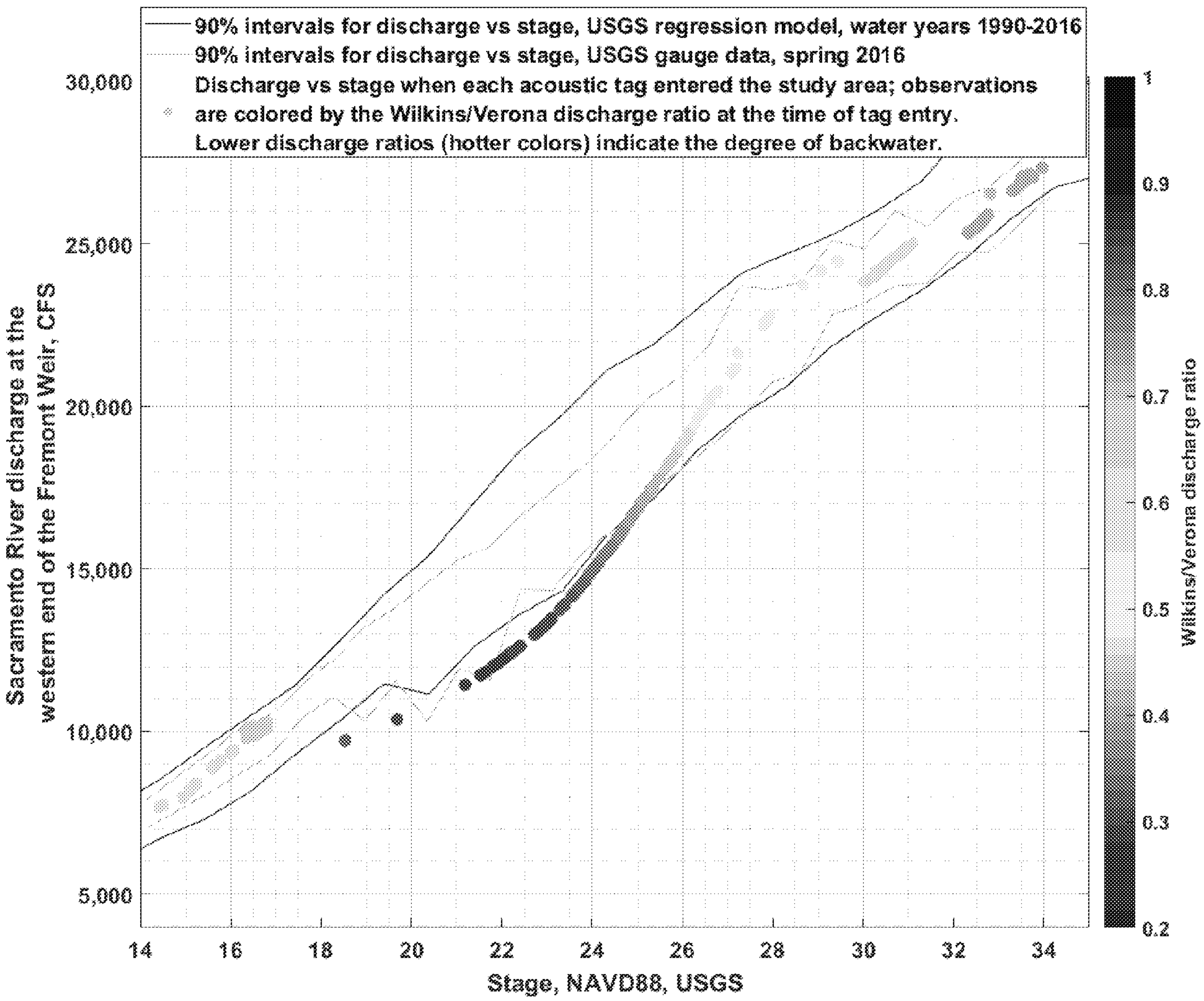


Figure 11 - Plot showing the range of stage and discharge conditions associated with each of the 2016 acoustic tag tracks

The colored lines indicate the 90% intervals (bounded by the 5th and 95th percentiles for discharge vs stage) for the USGS index velocity data (green lines), and the USGS estimate of Sacramento River hourly discharge at the Fremont Weir for water years 1990-2016. The colored dots indicate the stage and discharge value at the time when each acoustic tag entered the study area; the color of the dots indicates the severity of the backwater conditions when each tag entered the study area. Hotter colors indicate more extreme backwater conditions (lower discharge for a given stage). See Stumpner et al., in review, for more details on the Wilkins/Verona discharge ratio.

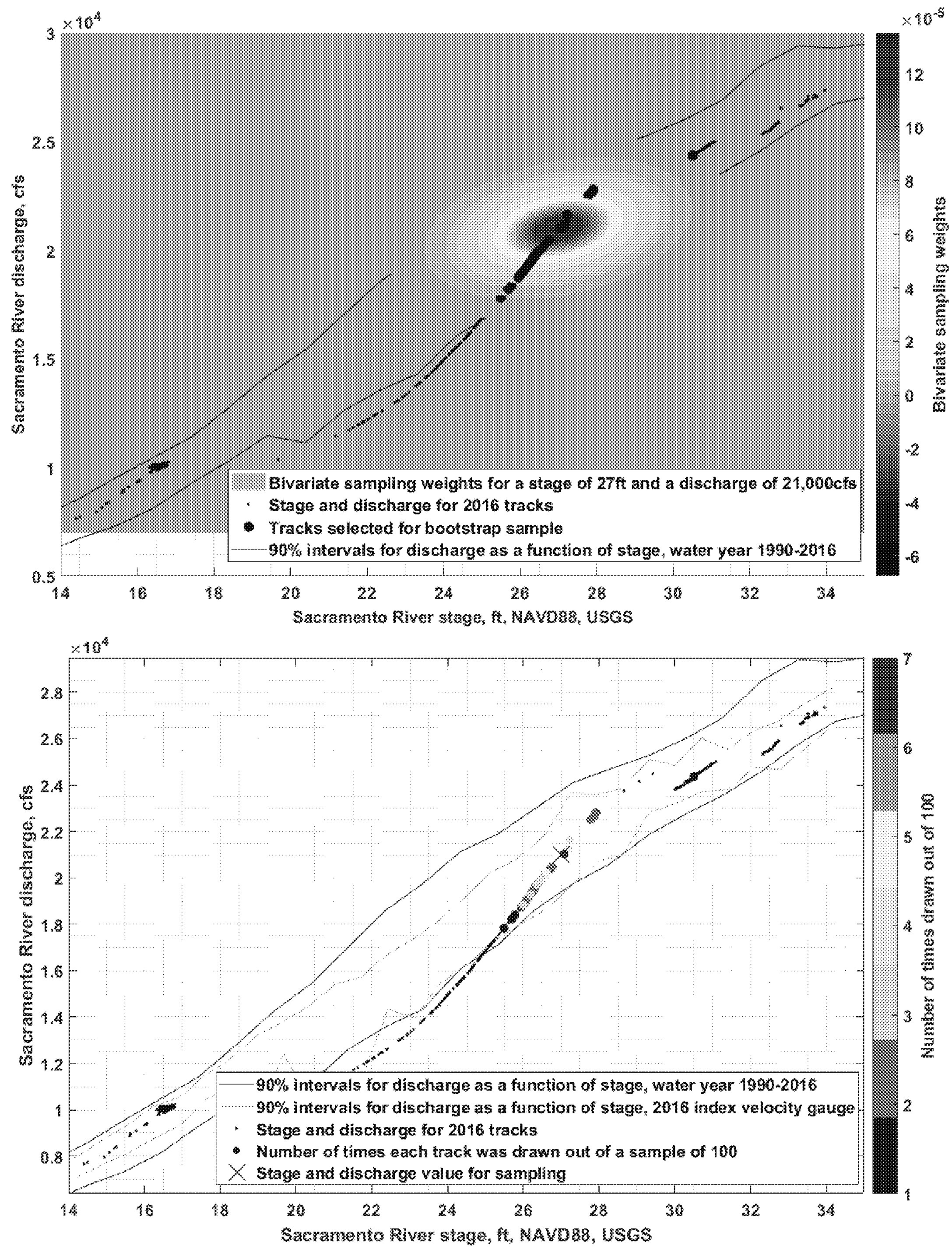


Figure 12 - Plots illustrating the bivariate weighting and the resulting bootstrap sampling for a stage of 27ft and a discharge of 21,000 cfs.

A heat plot indicating the bivariate weighting distribution for this combination of discharge and stage (upper panel), and a scatter plot indicating the frequency of selection for each fish track for a bootstrap sample of 100 tracks (lower panel).

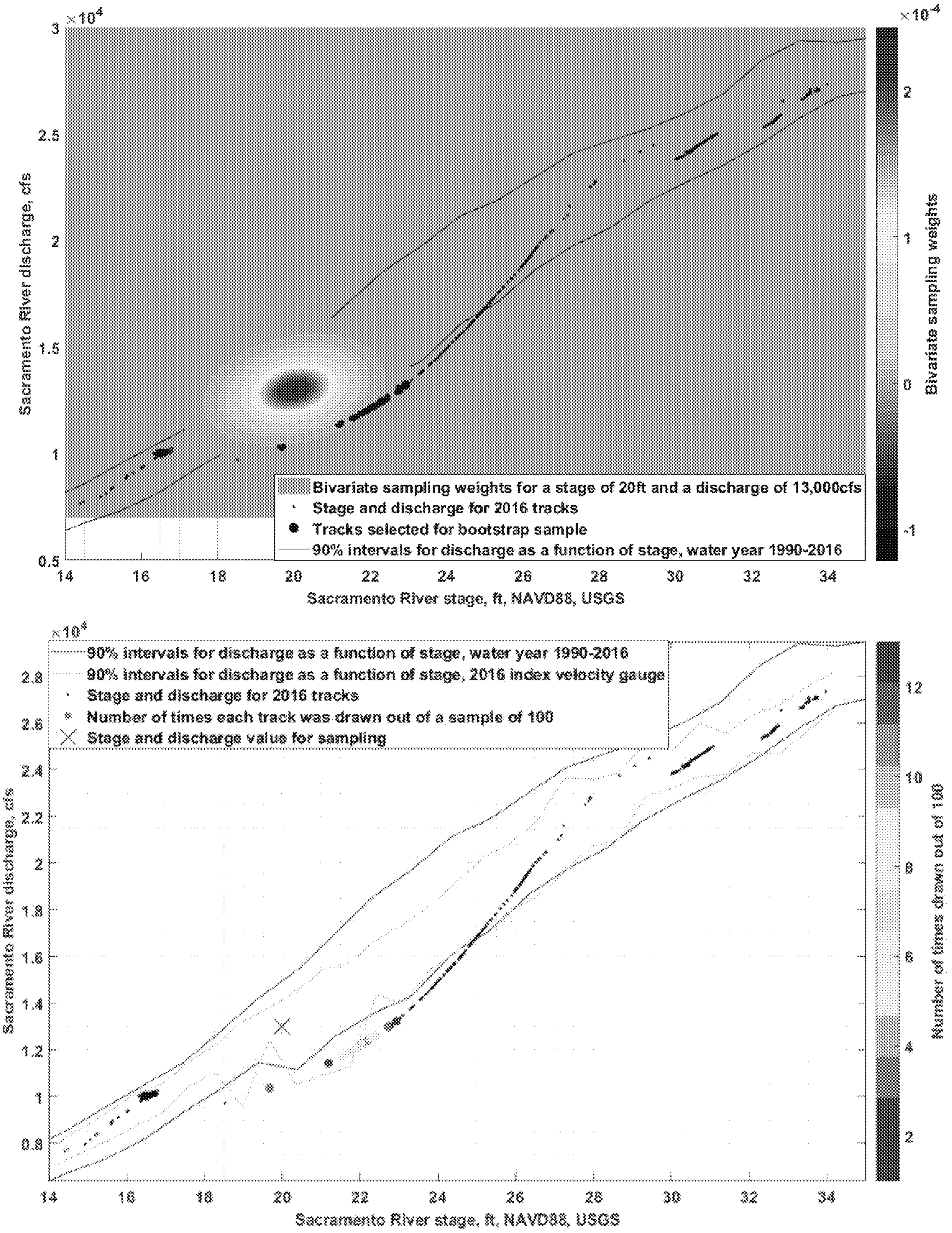


Figure 13 - Plots illustrating the bivariate weighting and the resulting bootstrap sampling for a stage of 20ft and a discharge of 13,000 cfs.

A heat plot indicating the bivariate weighting distribution for this combination of discharge and stage (upper panel), and a scatter plot indicating the frequency of selection for each fish track for a bootstrap sample of 100 tracks (lower panel).

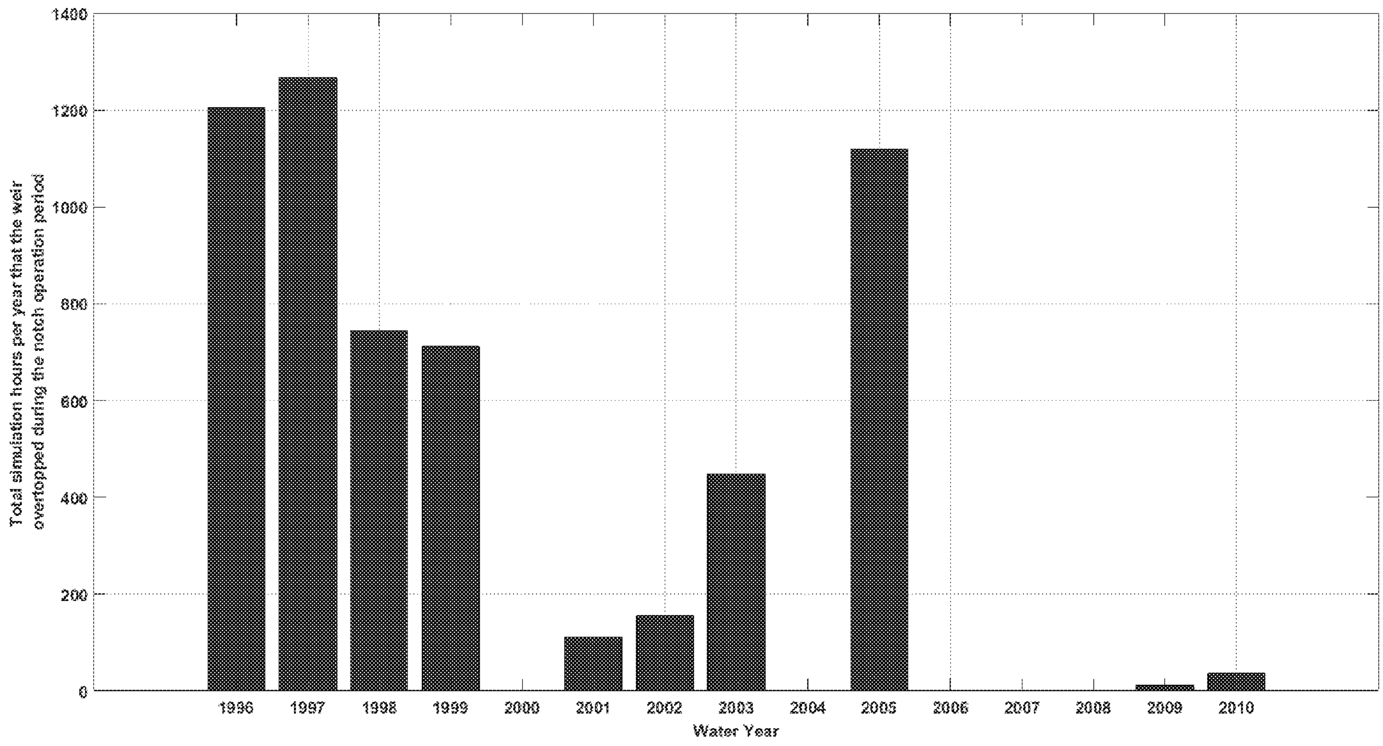


Figure 14 - Number of hours per year that the weir overtopped during the prescribed notch operation period for water years simulated.

The blue bars indicate the number of hours per season that the weir overtopped during the prescribed notch operation period (November 1 - March 15) for water years simulated. Missing bars indicate water years when the weir did not overtop during the simulation. For the purposes of the simulation overtopping is defined as periods when Sacramento River stage is greater than 32.3 ft, USGS survey, NAVD88.

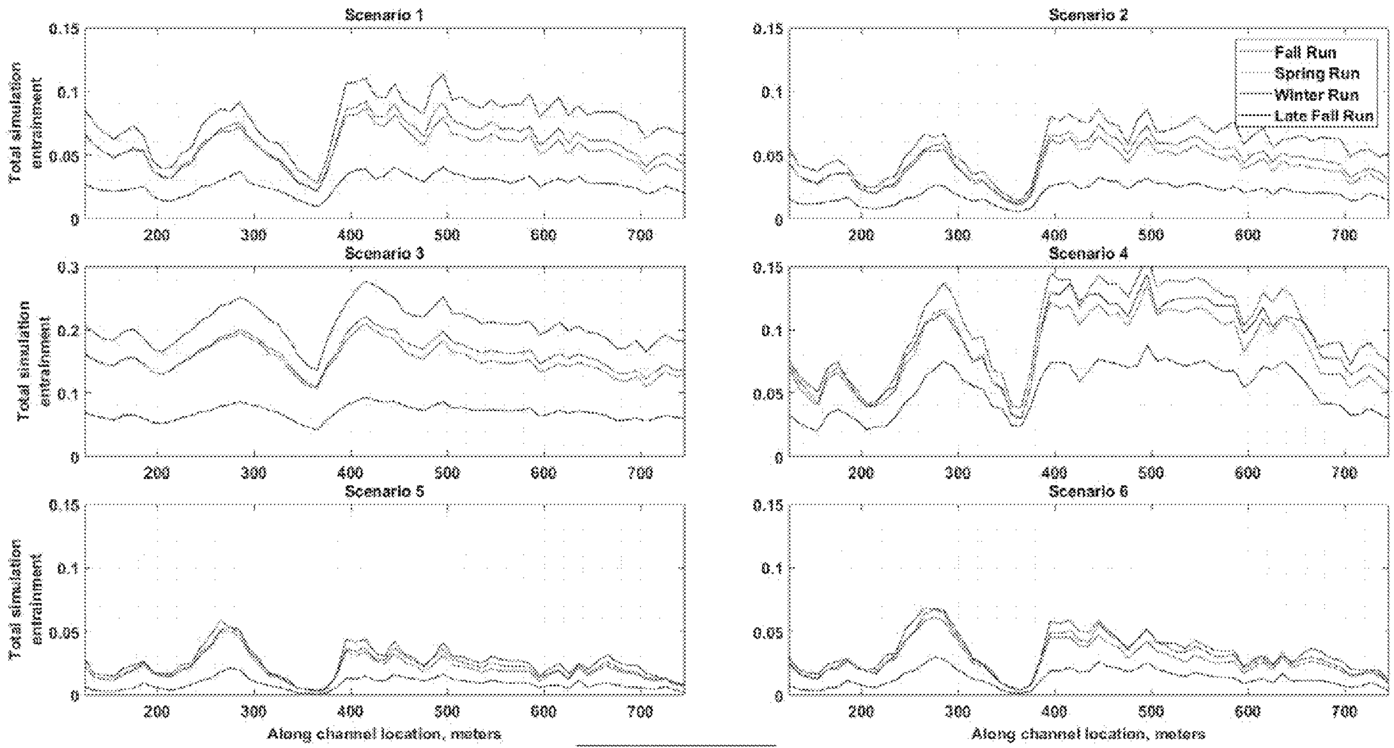


Figure 15 - Total entrainment as a function of notch location for each scenario.

Each panel shows the total entrainment for each scenario at each location in the study area, by run. Total simulation entrainment is expressed as the fraction of the total yearly abundance for the entire simulation period entrained in each scenario location. The blue, pink, orange, and black lines indicate the total entrainment for fall run, spring run, winter run, and late fall run, respectively. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences evident in the acoustic tag data. Also note that the range of the y axis is greater in panel 3 due to the large notch flows for scenario 3. The along-channel coordinate system referenced on the x axis of these plots is shown in Figure 4.

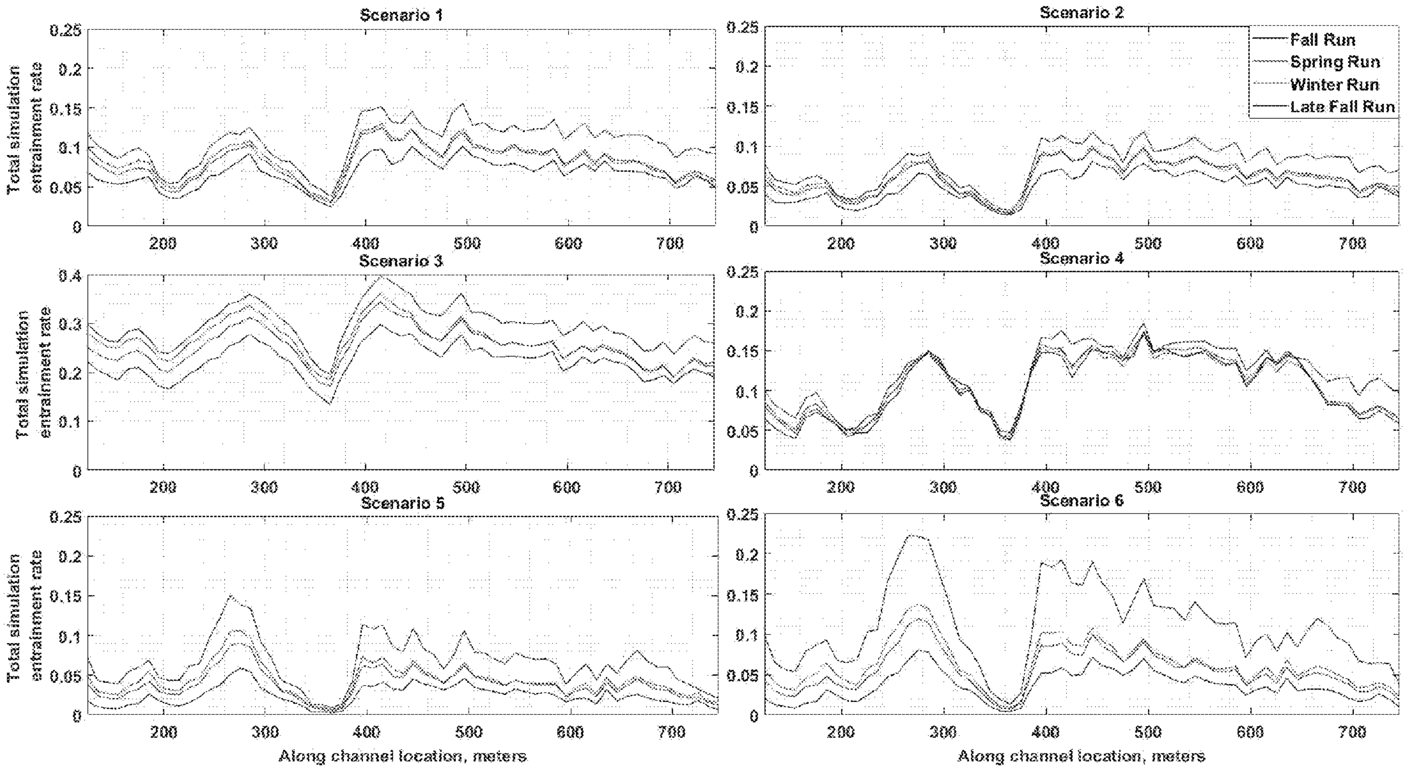


Figure 16 - Entrainment rate as a function of notch location for each scenario

Each panel shows the total entrainment for each scenario at each location in the study area, by run. Entrainment rate is expressed as the fraction of fish passing the notch that are entrained in the notch when notch flow was greater than zero for each scenario. Entrainment rate differs from total entrainment in that entrainment rate reflects the fraction of the fish which are present when the notch is flowing that are entrained, while total entrainment reflects the fraction of the overall yearly abundance that is entrained. The blue, pink, orange, and black lines indicate the total entrainment rate for fall run, spring run, winter run, and late fall run, respectively. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment rates are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences evident in the acoustic tag data. Also note that the range of the y axis is greater in panel 3 due to the large notch flows for scenario 3. The along-channel coordinate system referenced on the x axis of these plots is shown in Figure 4.

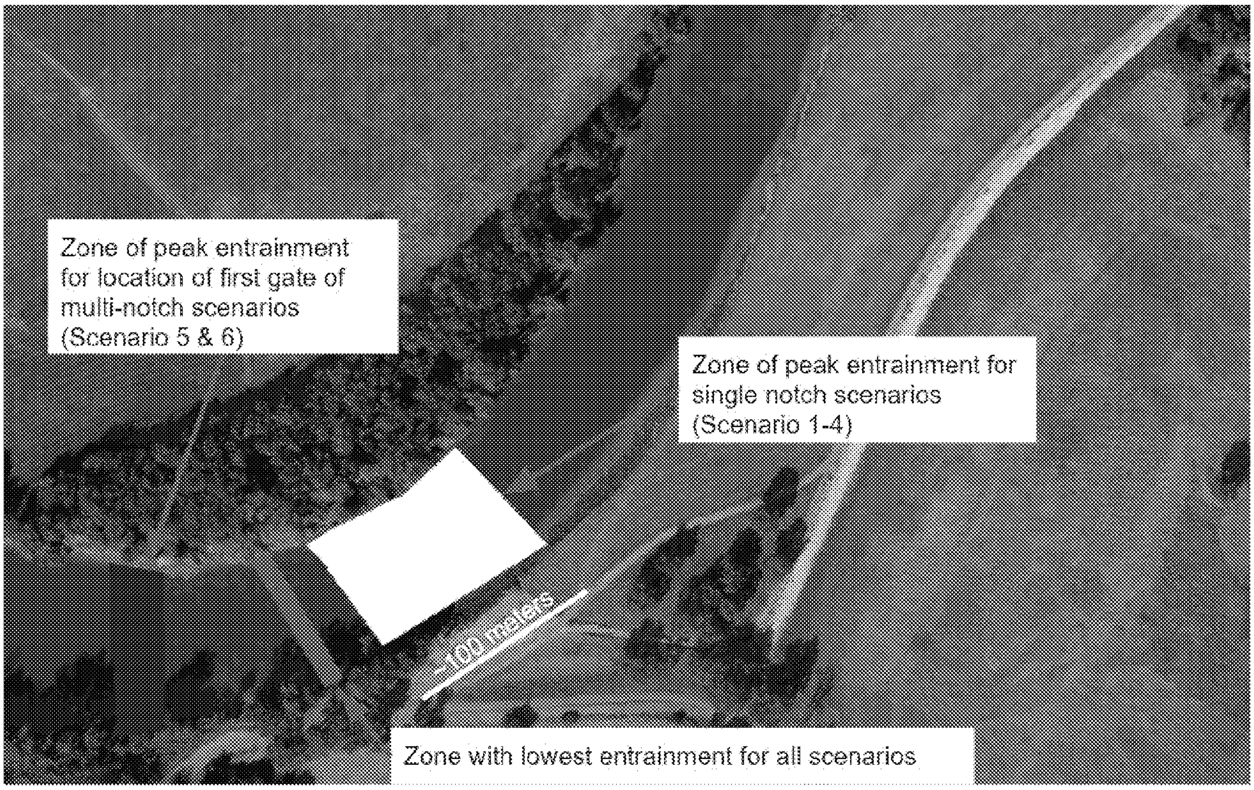


Figure 17 - Figure showing the location of maximum and minimum entrainment for fall run for all scenarios overlaid on an aerial photograph of the study area.

We simulated entrainment under six different weir modification scenarios: scenarios 1 – 4 included a single notch in the Fremont Weir, scenario 5 and 6 included multiple notches in the Fremont Weir. The simulation predicted the highest entrainment under single notch scenarios when the notch was located in the zone indicated by the white box, and the simulation predicted the highest entrainment under multiple notch scenarios when the upstream notch was located in the zone indicated by the blue box. The simulation predicted the lowest entrainment for all scenarios when the notch or upstream most notch was located in the zone indicated by the red box.

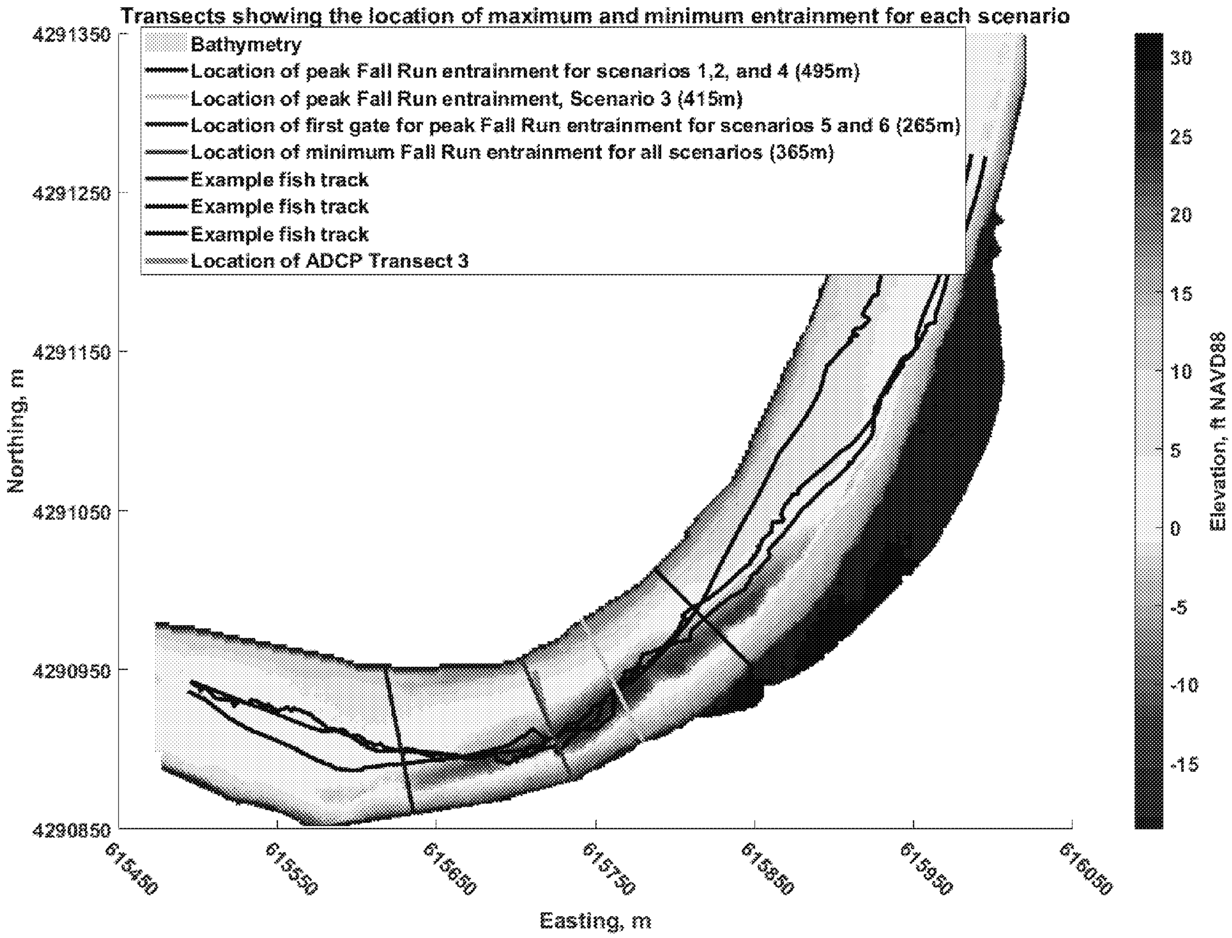


Figure 18 - Plan view of study area showing the location of minimum and maximum entrainment along with example fish tracks.

Colored surface indicates the study area bathymetry, the black lines show fish tracks that entered the study area on the river left half of the Sacramento River and then moved towards the river right bank until encountering a scour feature and moving back towards the river left bank of the Sacramento River. The colored cross section lines indicate locations where the entrainment simulation predicted maximum and minimum fall run entrainment for each scenario.

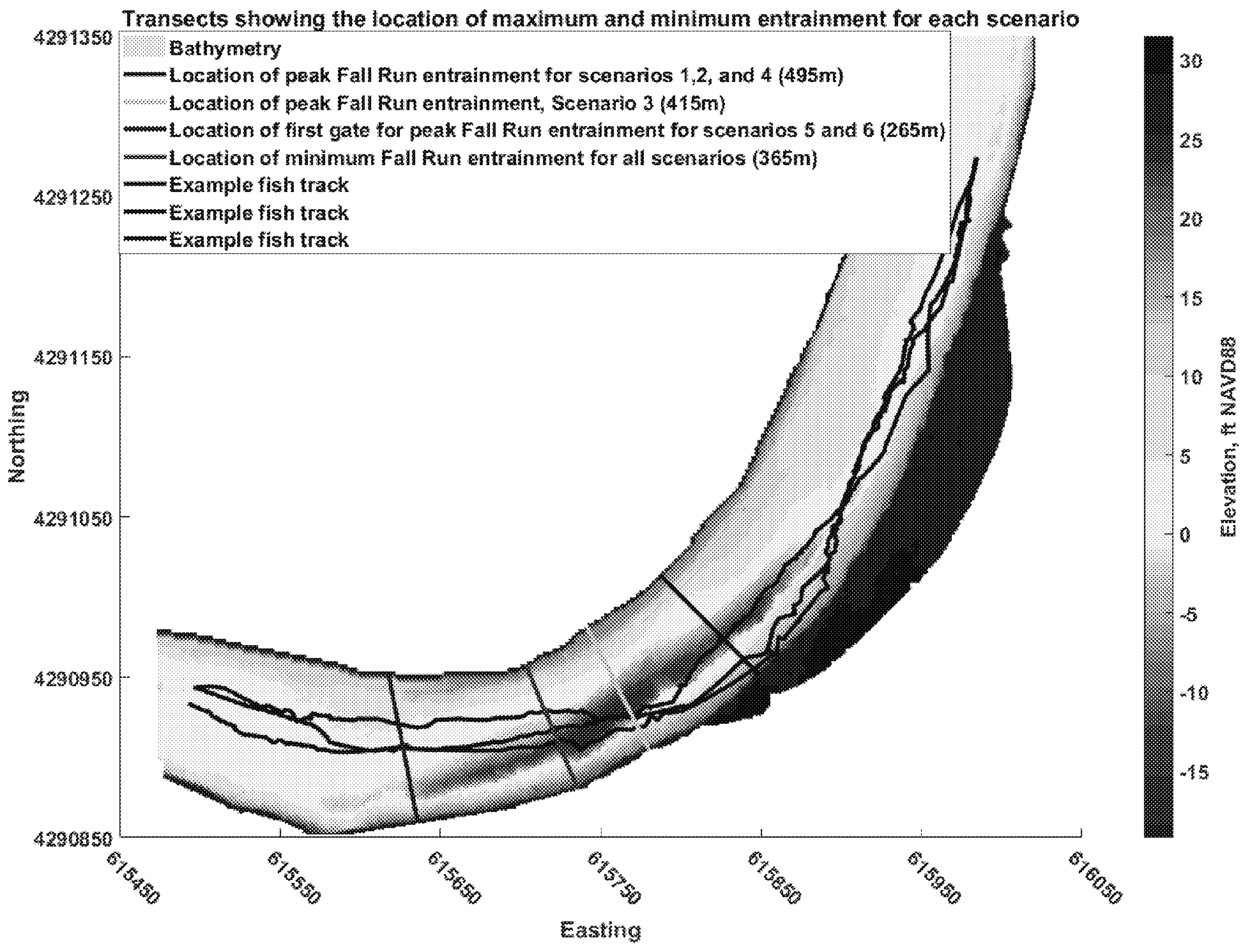


Figure 19 - Plan view of study area showing the location of minimum and maximum entrainment along with example fish tracks.

Colored surface indicates the study area bathymetry, the black lines show fish tracks that entered the study area on the river left half of the Sacramento River and then moved towards the river right bank passing the scoured area corresponding to the lowest predicted notch entrainment. The colored cross section lines indicate locations where the entrainment simulation predicted maximum and minimum fall run entrainment for each scenario.

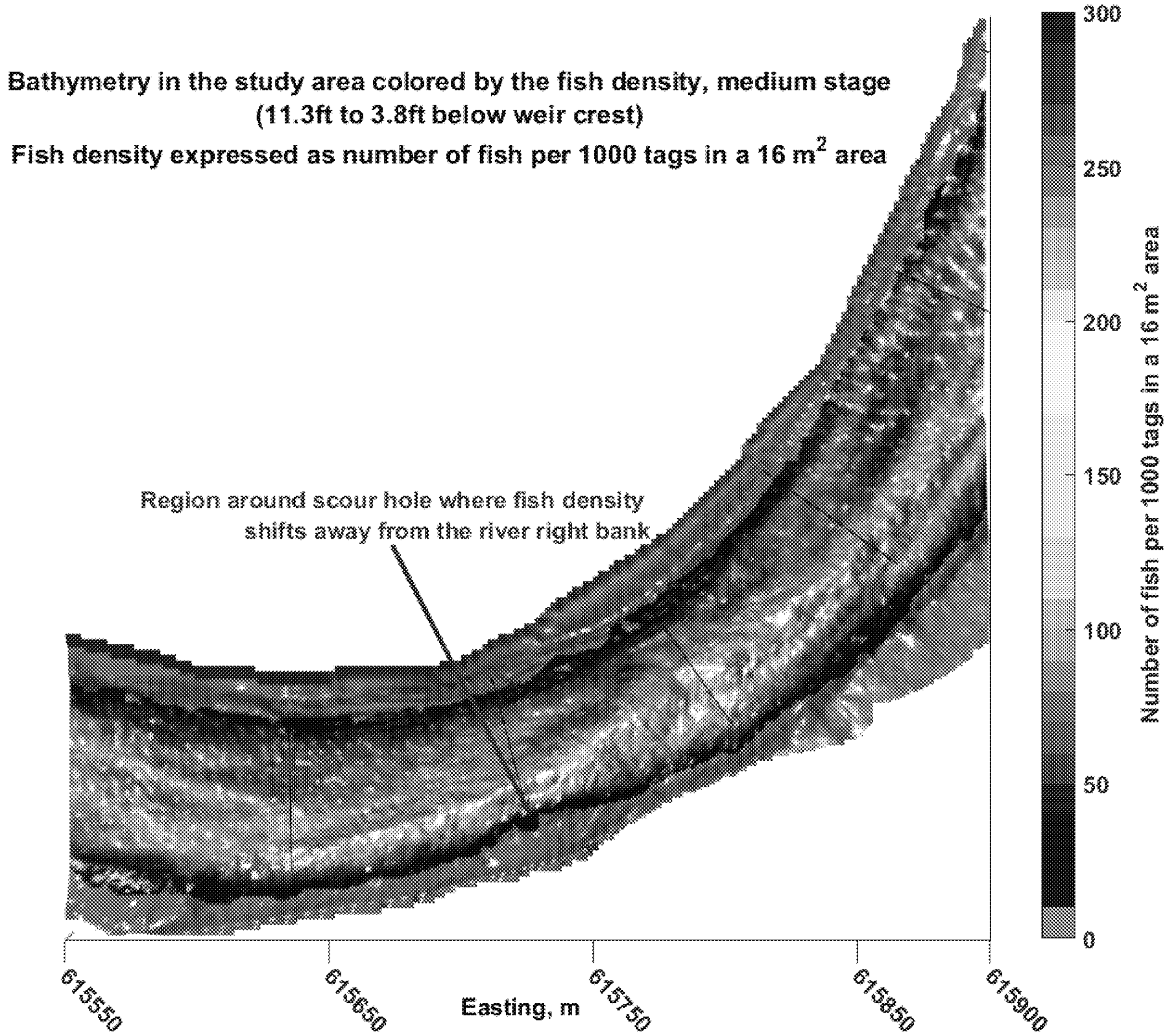


Figure 20 - Plan view of the study area bathymetry colored by fish density

Plan view of a surface representing the study area bathymetry, colored by the spatial density of 2016 fish tracks during medium stage periods. Gray areas on the bathymetry indicate areas where there were no fish tracks. The red arrow indicates the region in the vicinity of along-channel coordinate 370 where fish density near the bank decreases in the vicinity of a scoured section in the levy. Note that in the area around the black arrow the cross-stream gradients in fish density are stronger, and the area where the density colormap transitions from blue (low density) to green (moderate density) shifts towards the center of the channel.

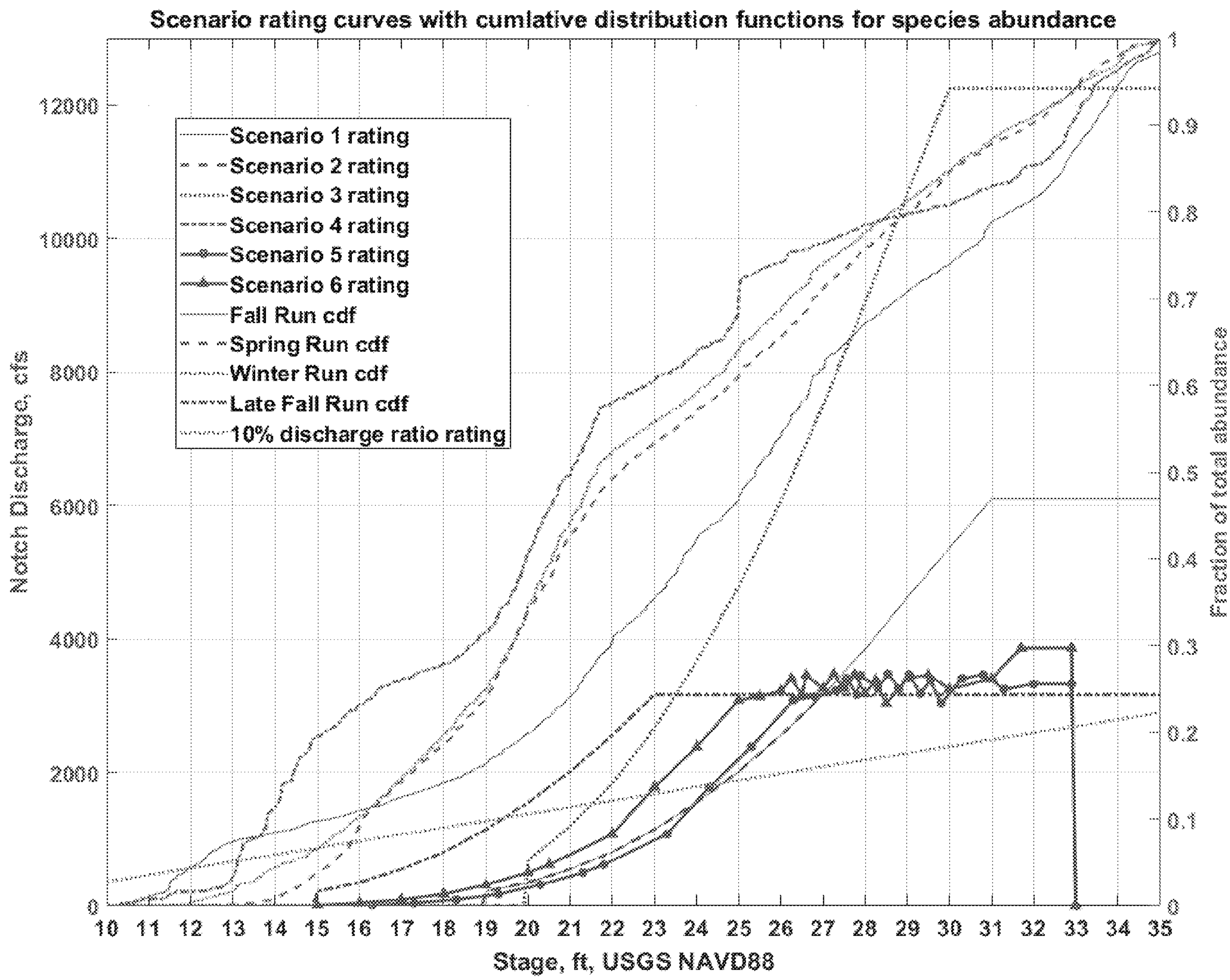


Figure 21 - Stage-discharge curves for each scenario and run abundance CDFs on stage

Stage discharge curves for each scenario are shown in blue, with scenario discharge shown on the left (blue) y-axis. The stage-discharge curves for multiple notch scenarios indicate the total flow through all notches in the scenario at each stage. The rating curves for scenario 1 and scenario 2 overlap for stages below 27 ft. Cumulative distribution functions for the simulation period showing the cumulative fraction of run abundance passing through the study area at each stage in red. These curves show the fraction of each run that pass through the study area at a stage less than or equal to the stage given on the x axis. Note the rapid increase in cumulative abundance between 19 ft and 22 ft for winter run and spring run. The dotted gray line indicates the amount of notch flow that corresponds to 10% of the Sacramento River stage-discharge rating from the 2016 USGS gauge data. The location of each scenario's rating curve relative to the 10% discharge ratio line is an indicator of the fraction of the Sacramento River flow that is passing through the notch at any stage: if the a rating curve is above the grey line at any stage the notch is likely entraining more than 10% of the Sacramento River at that stage.

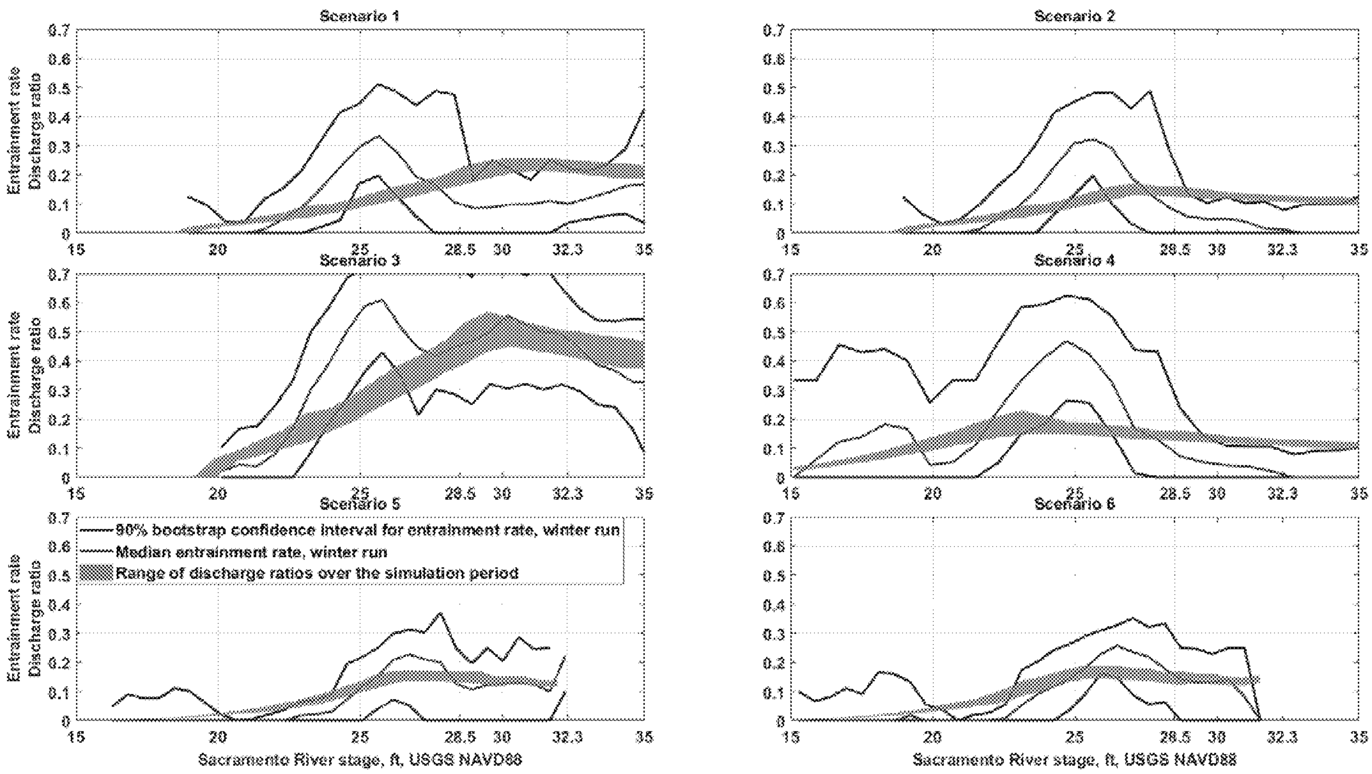


Figure 22 - Entrainment rate and discharge ratio for each scenario as a function of Sacramento River stage.

Panels 1-6 show entrainment rate and discharge ratio as a function of stage for scenarios 1-6, respectively. For each scenario the blue lines indicate the 90% bootstrap confidence interval for entrainment rate at each stage, the red line indicates the bootstrap median entrainment rate for each stage, and the gray region indicates the range of discharge ratios each scenario experienced during the simulation period. The notch discharge ratio indicates the fraction of Sacramento River discharge flowing into each scenario at each stage; because of backwater effects there are a range of possible discharge ratios for each stage, as indicated by the vertical range of the gray band at each stage. When the entrainment rate is greater than the discharge ratio the notch is entraining proportionally more fish than water. Note that the Sacramento River reaches a bankfull state in the study area at a stage value of around 28.5 ft, and the weir overtops at a stage value of 32.3 ft.

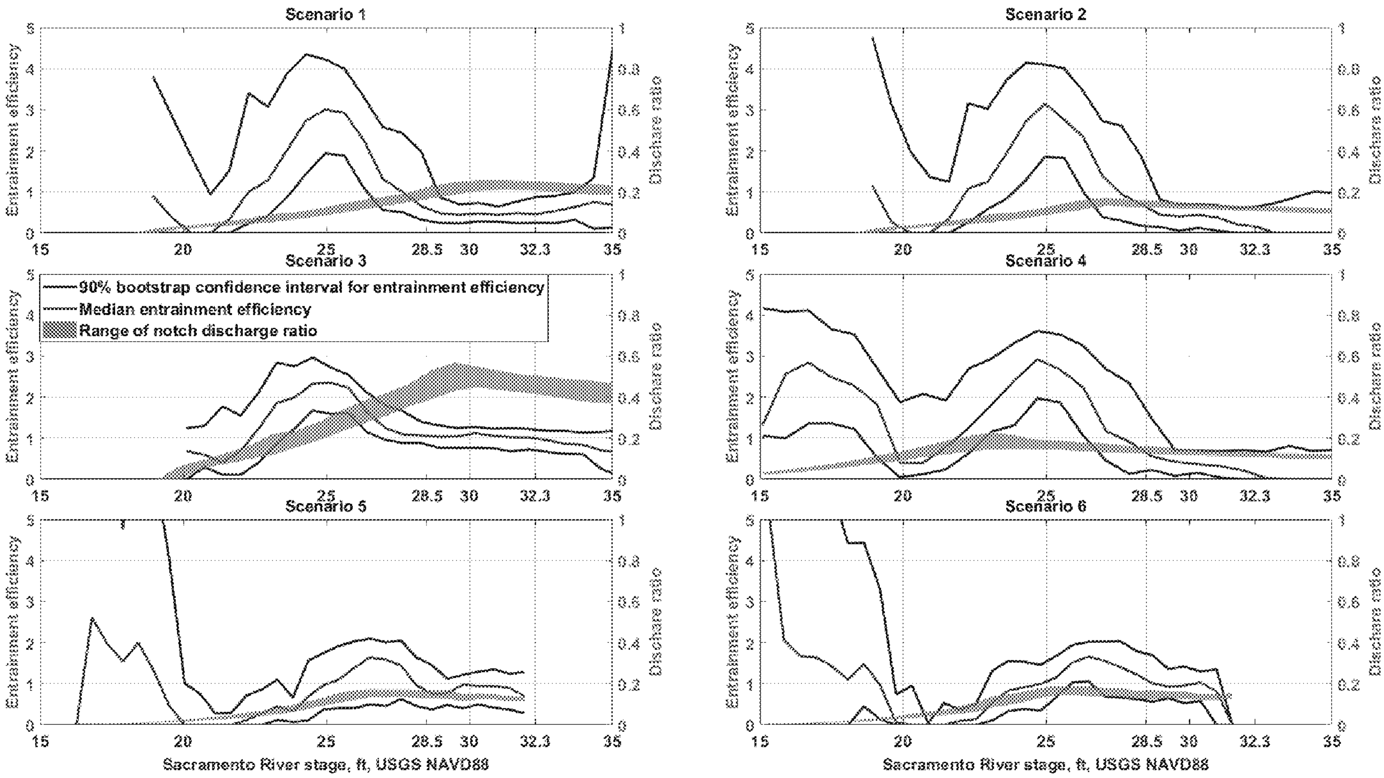


Figure 23 - Entrainment efficiency and discharge ratio for each scenario as a function of Sacramento River stage, with small sample sizes removed.

Panels 1-6 show entrainment efficiency and discharge ratio as a function of stage for scenarios 1-6, respectively, for days when more than 0.5% of the yearly total abundance transited the study area. Removing time steps from days when less than 0.5% of the yearly total abundance transited the study area removed 10% of the time step entrainment data from the fall run entrainment estimates used to produce these curves. The y-axis on the left of each panel (blue) indicates the scale for the entrainment efficiency. The y-axis on the right of each panel (red) indicates the scale for the discharge ratio. For each scenario the blue lines indicate the 90% bootstrap confidence interval for entrainment efficiency for each stage, the red line indicates the bootstrap median entrainment efficiency for each stage, and the gray region indicates the range of discharge ratios each scenario experienced during the simulation period. The notch discharge ratio indicates the fraction of Sacramento River discharge flowing into each scenario at each stage; because of backwater effects there are a range of possible discharge ratios for each stage, as indicated by the vertical range of the gray band. When the entrainment efficiency is greater than one the notch is entraining proportionally more fish than water. Note that the Sacramento River reaches a bankfull state in the study area at a stage value of around 28.5 ft, and the weir overtops at a stage value of 32.3 ft.

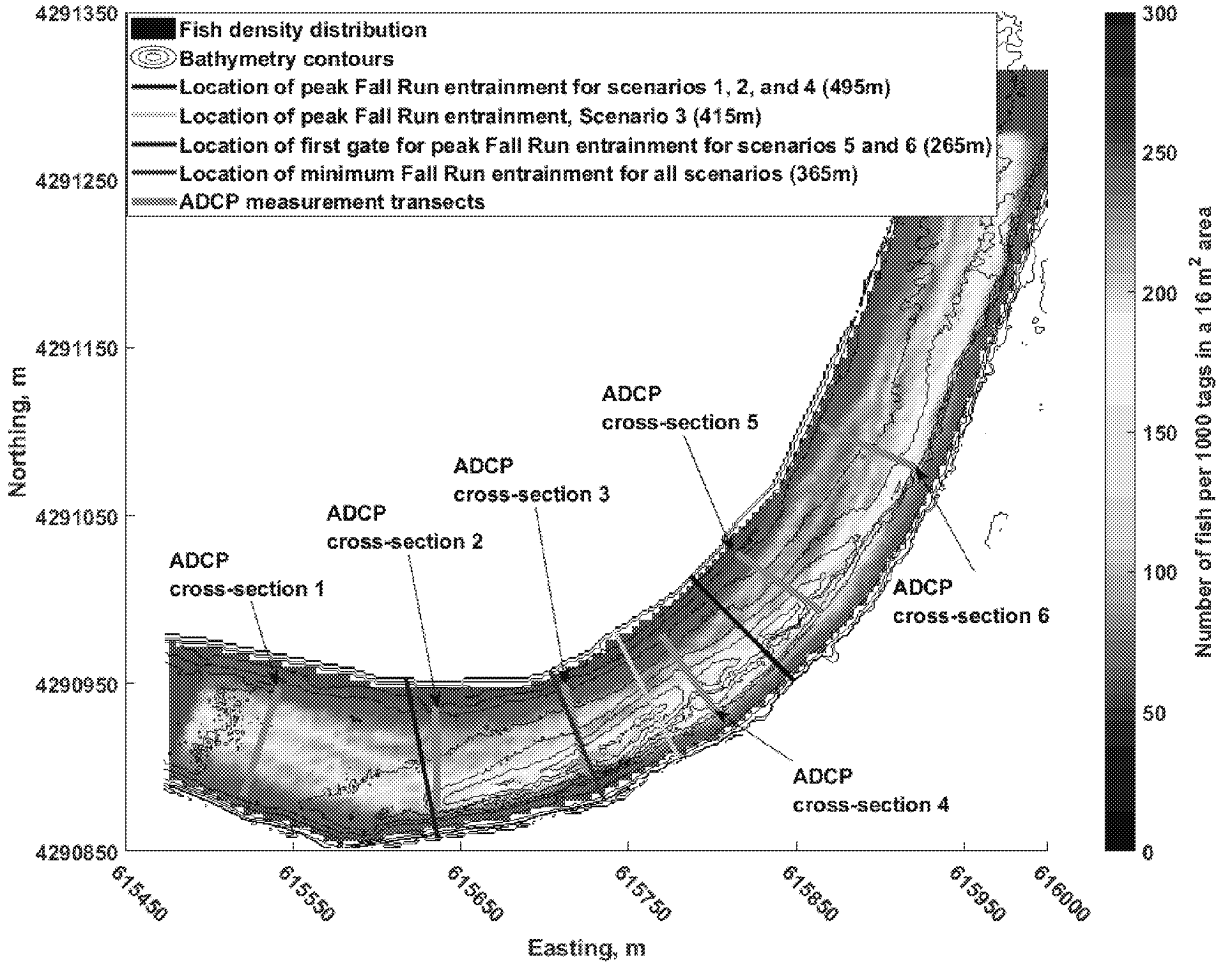


Figure 24 - Figure showing the location of maximum and minimum entrainment for fall run for all scenarios overlaid on fish density distribution for medium stage covariate group.

The colored surface shows the fish density distribution for all acoustic tag tracks recorded during the 2016 study when Sacramento River stage was between 21 ft and 28.5 ft. The location of downward looking ADCP transects are shown as gray lines and labeled, the cross-channel velocity distribution computed from these measurements made at a Sacramento River stage of 24.2 ft are shown on Figure 25. The notch locations corresponding to maximum and minimum entrainment for single notch and multiple notch configurations are shown with colored lines. Note that the Sacramento River reaches bankfull in the study area at around 28.5 ft.

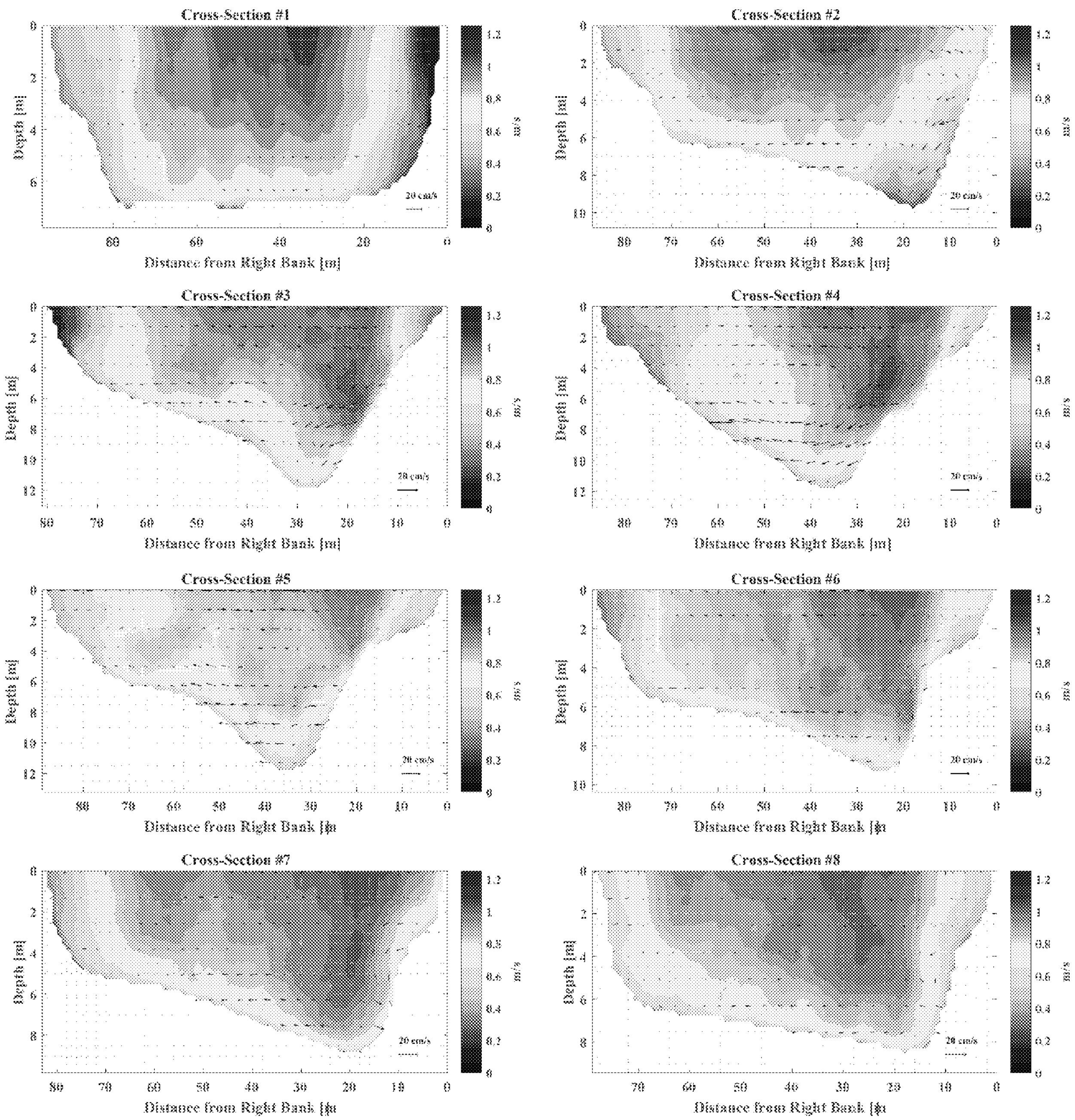


Figure 25 - Figure from cross-channel velocity transect data collected during 2016

Contour plot showing along-stream velocity magnitude and arrows indicating secondary velocity currents for each velocity cross-section (1-8) at a stage of 24.2 ft. and discharge of 15,930 cfs. Taken from Stumpner et al., In Review.

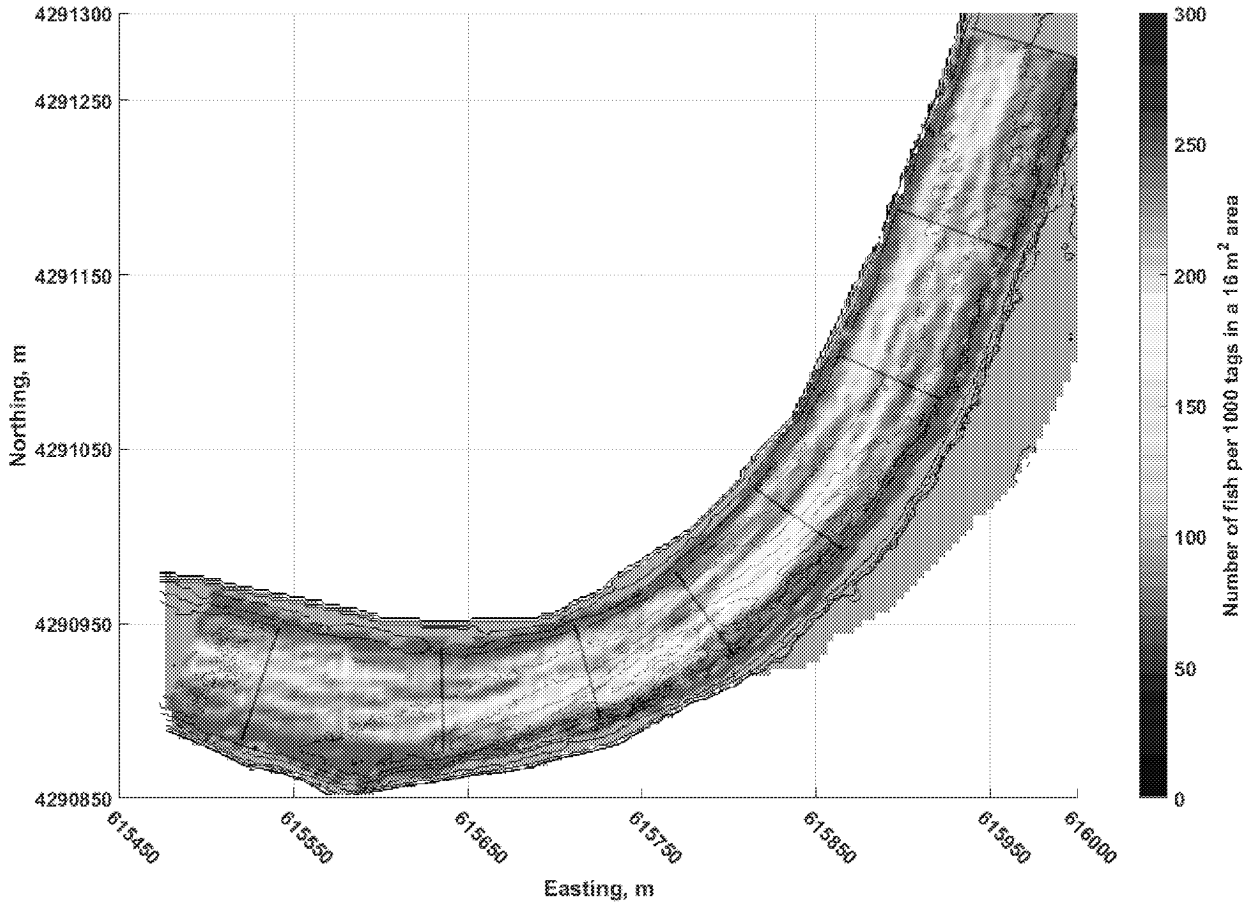


Figure 26 - Spatial distribution of 2016 study fish tracks for periods when Sacramento River was greater than bankfull and below the weir crest.

Plan view of the study area colored by the spatial density of 2016 fish tracks collected when the Sacramento River was above bankfull (28.5 ft), but below the crest of the Fremont Weir. Gray areas on the bathymetry indicate areas where no fish were detected. Thin black lines indicate bathymetric contours.

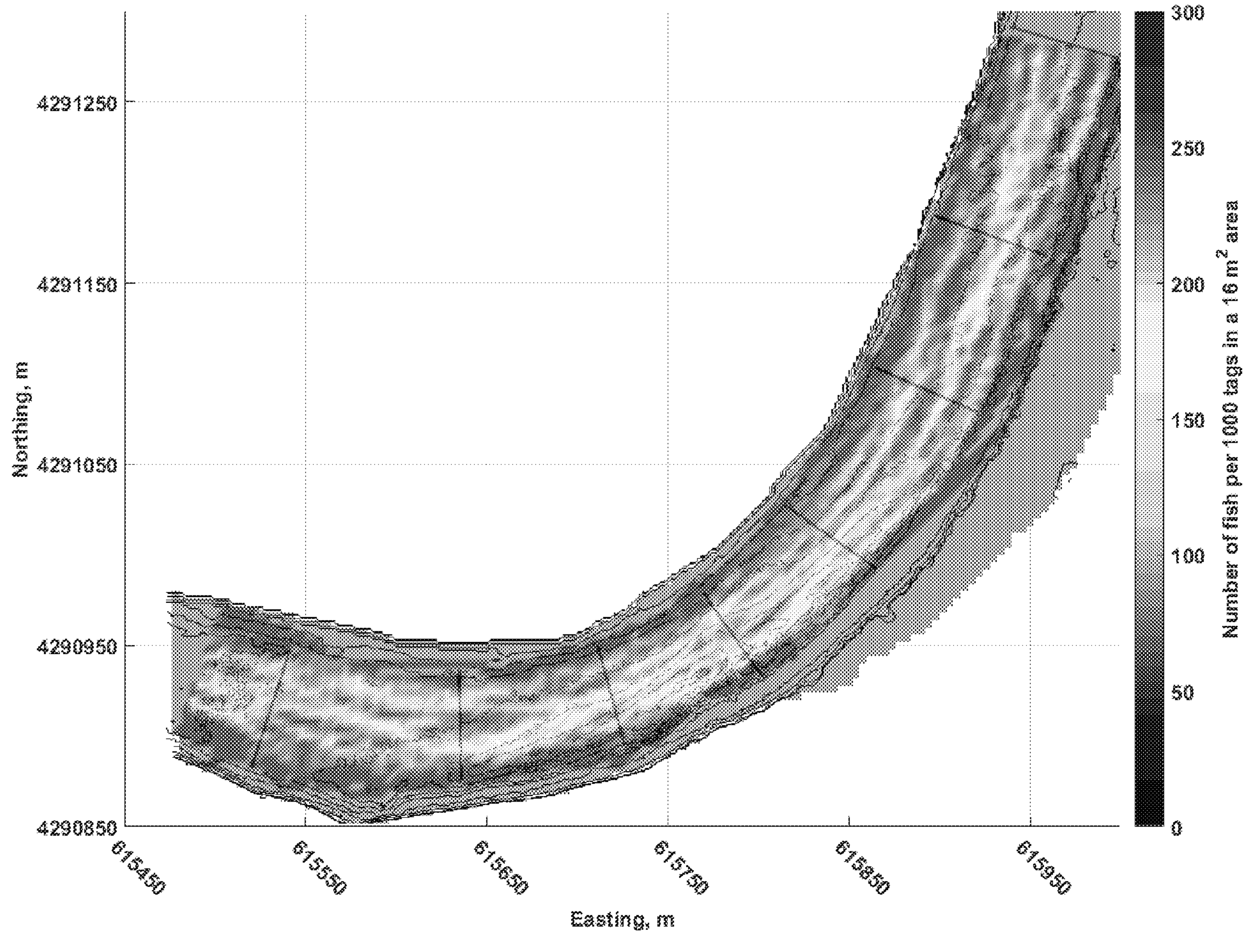


Figure 27 - Spatial distribution of 2016 study fish tracks for periods when the Fremont Weir was overtopping

Plan view of the study area colored by the spatial density of 2016 fish tracks collected when the Fremont Weir was overtopping. Gray areas on the bathymetry indicate areas where no fish were detected. Thin black lines indicate bathymetric contours.

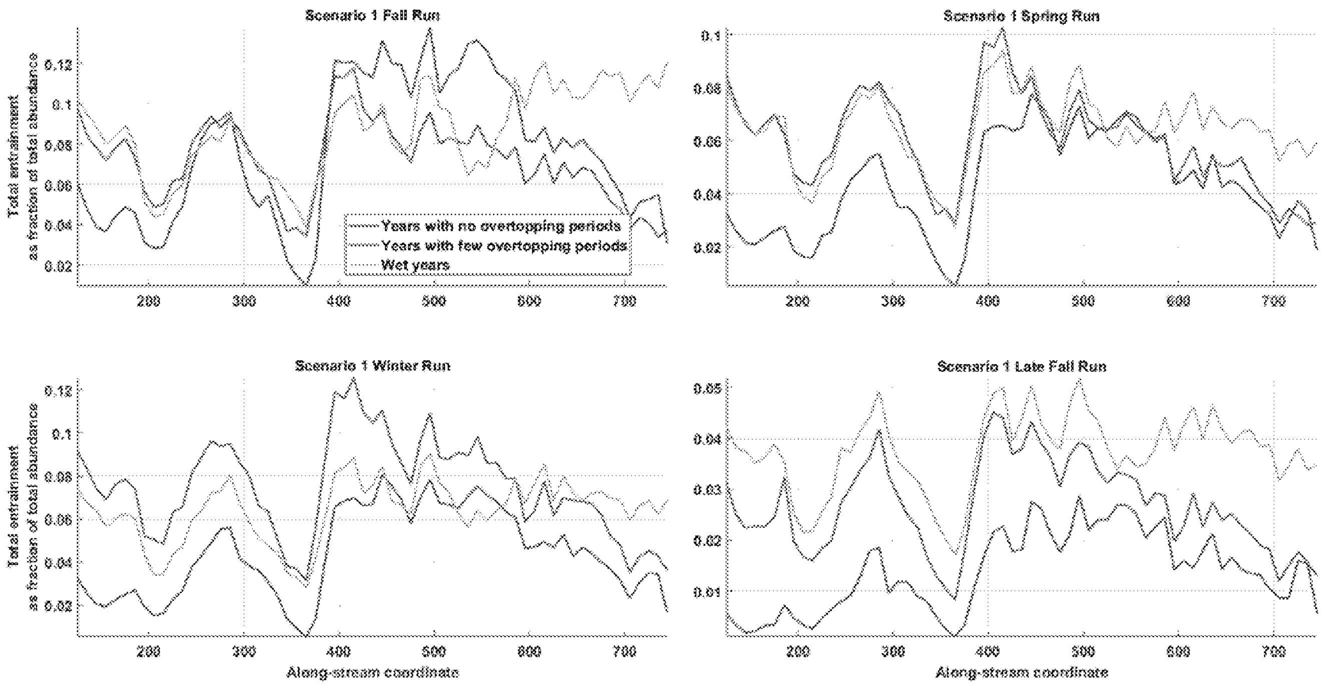


Figure 28- Scenario 1 water year type total entrainment curves.

Plots showing total entrainment for each run as a function of notch along-channel location within the study area calculated for three water year types for scenario 1. The blue lines indicates total entrainment over all seasons when Fremont Weir did not overtop, the red line indicates total entrainment over all seasons when the Fremont Weir overtopped for fewer than 200 hours, and the gold line indicates total entrainment over all seasons when the Fremont Weir overtopped for more than 200 hours (wet years). Each panel shows water year entrainment for a run. For the purposes of the simulation weir overtopping was defined as Sacramento River stage exceeding 32.3 ft, USGS survey, NAVD88 . Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences between runs.

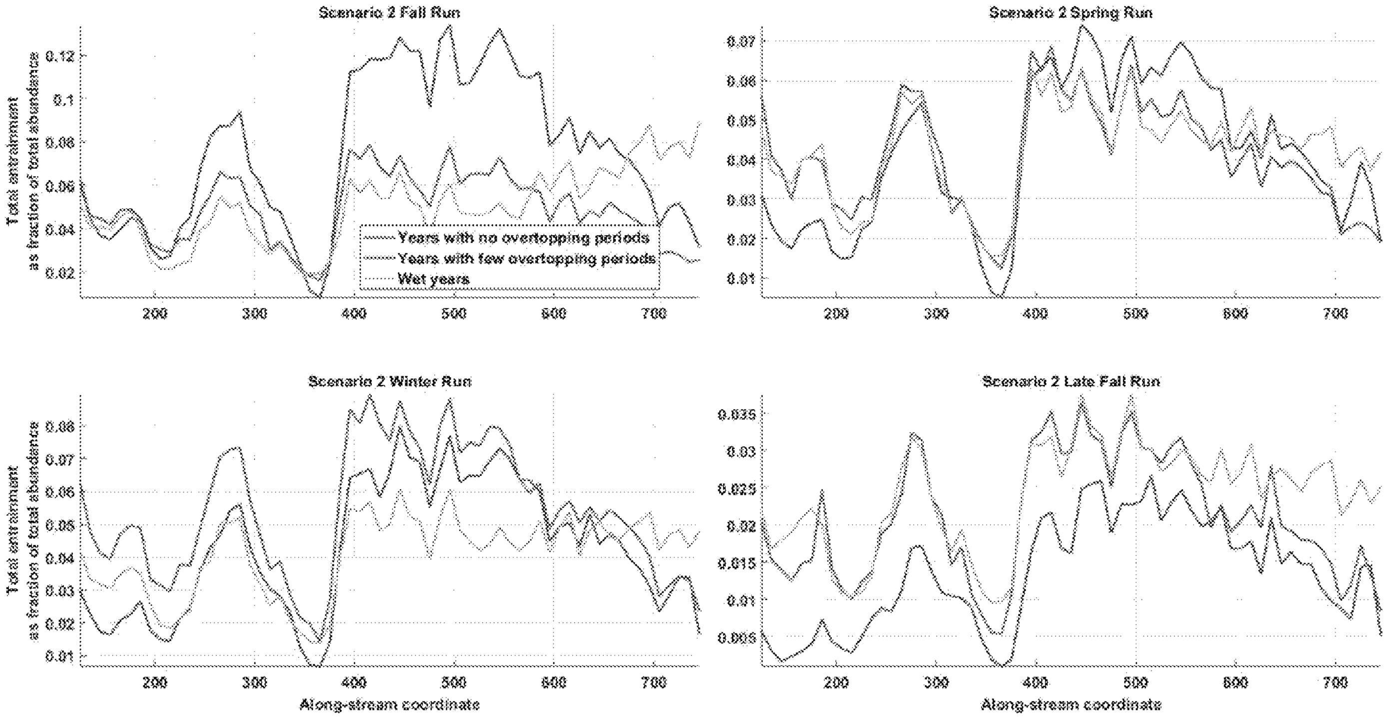


Figure 29- Scenario 2 water year type total entrainment curves.

Plots showing total entrainment for each run as a function of notch along-channel location within the study area calculated for three water year types for scenario 2. The blue lines indicates total entrainment over all seasons when Fremont Weir did not overtop, the red line indicates total entrainment over all seasons when the Fremont Weir overtopped for fewer than 200 hours, and the gold line indicates total entrainment over all seasons when the Fremont Weir overtopped for more than 200 hours (wet years). Each panel shows water year entrainment for a run. For the purposes of the simulation weir overtopping was defined as Sacramento River stage exceeding 32.3 ft, USGS survey, NAVD88. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences between runs.

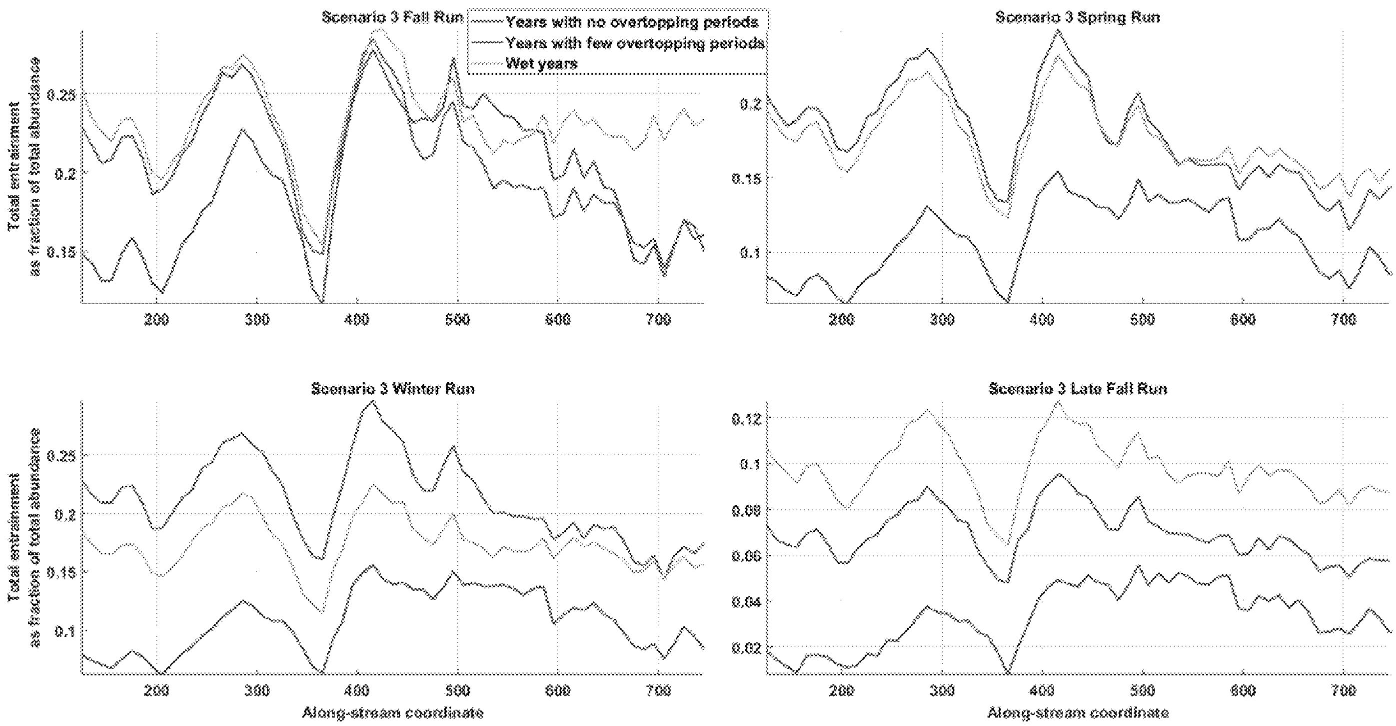


Figure 30- Scenario 3 water year type total entrainment curves

Plots showing total entrainment for each run as a function of notch along-channel location within the study area calculated for three water year types for scenario 3. The blue lines indicates total entrainment over all seasons when Fremont Weir did not overtop, the red line indicates total entrainment over all seasons when the Fremont Weir overtopped for fewer than 200 hours, and the gold line indicates total entrainment over all seasons when the Fremont Weir overtopped for more than 200 hours (wet years). Each panel shows water year entrainment for a run. For the purposes of the simulation weir overtopping was defined as Sacramento River stage exceeding 32.3 ft, USGS survey, NAVD88. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences between runs

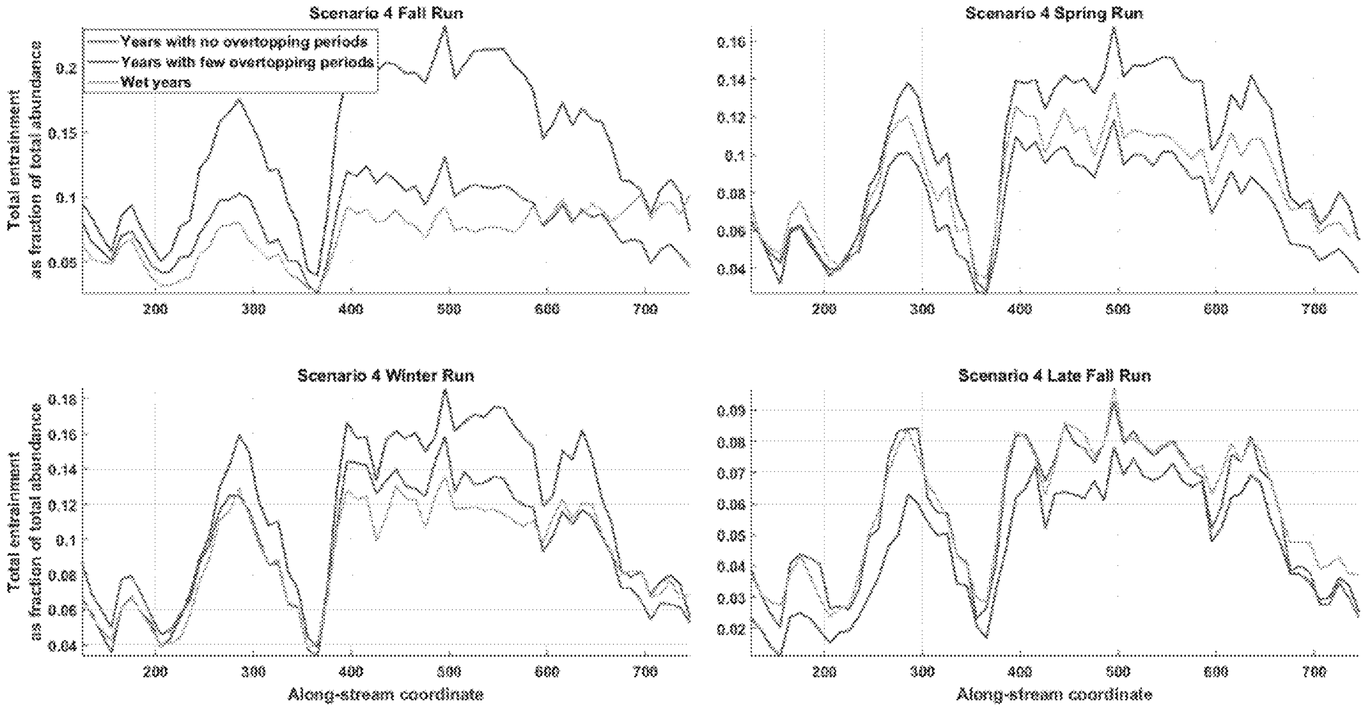


Figure 31- Scenario 4 water year type total entrainment curves

Plots showing total entrainment for each run as a function of notch along-channel location within the study area calculated for three water year types for scenario 4. The blue lines indicates total entrainment over all seasons when Fremont Weir did not overtop, the red line indicates total entrainment over all seasons when the Fremont Weir overtopped for fewer than 200 hours, and the gold line indicates total entrainment over all seasons when the Fremont Weir overtopped for more than 200 hours (wet years). Each panel shows water year entrainment for a run. For the purposes of the simulation weir overtopping was defined as Sacramento River stage exceeding 32.3 ft, USGS survey, NAVD88. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences between runs.

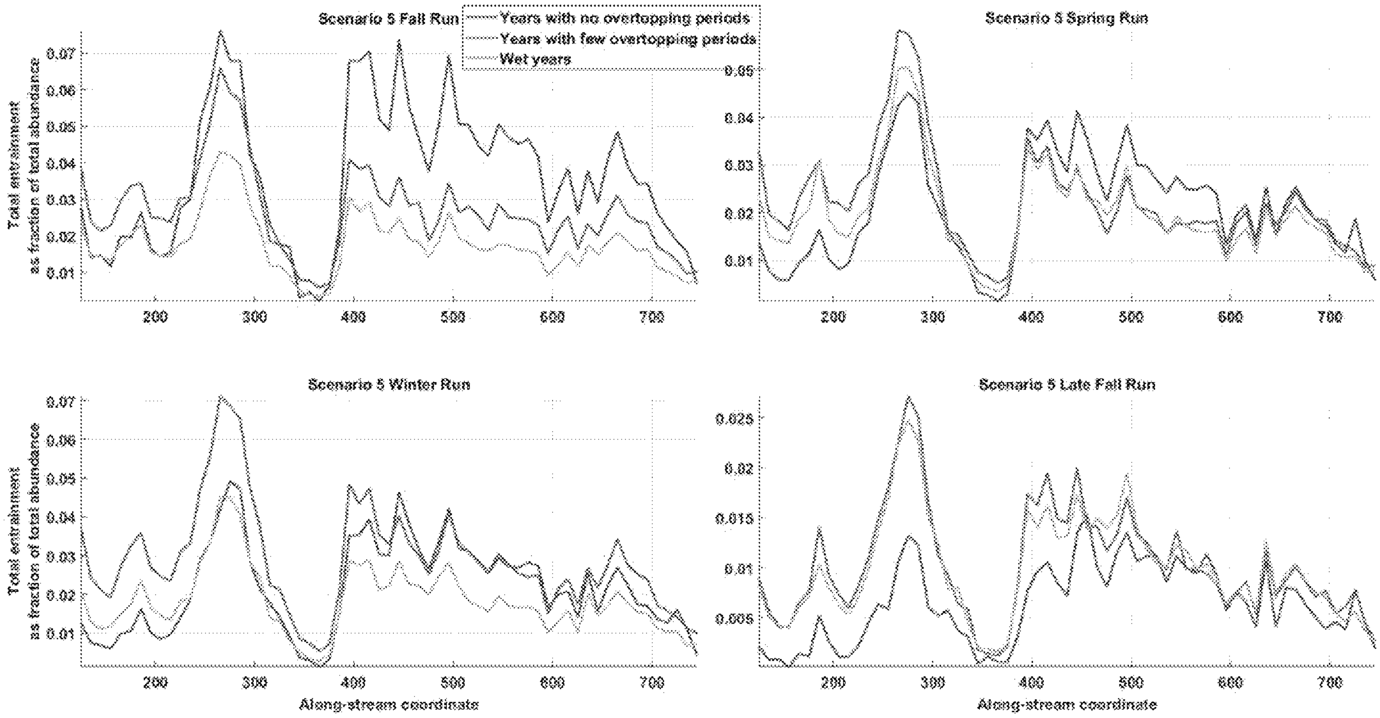


Figure 32- Scenario 5 water year type total entrainment curves

Plots showing total entrainment for each run as a function of notch along-channel location within the study area calculated for three water year types for scenario 5. The blue lines indicates total entrainment over all seasons when Fremont Weir did not overtop, the red line indicates total entrainment over all seasons when the Fremont Weir overtopped for fewer than 200 hours, and the gold line indicates total entrainment over all seasons when the Fremont Weir overtopped for more than 200 hours (wet years). Each panel shows water year entrainment for a run. For the purposes of the simulation weir overtopping was defined as Sacramento River stage exceeding 32.3 ft, USGS survey, NAVD88. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences between runs.

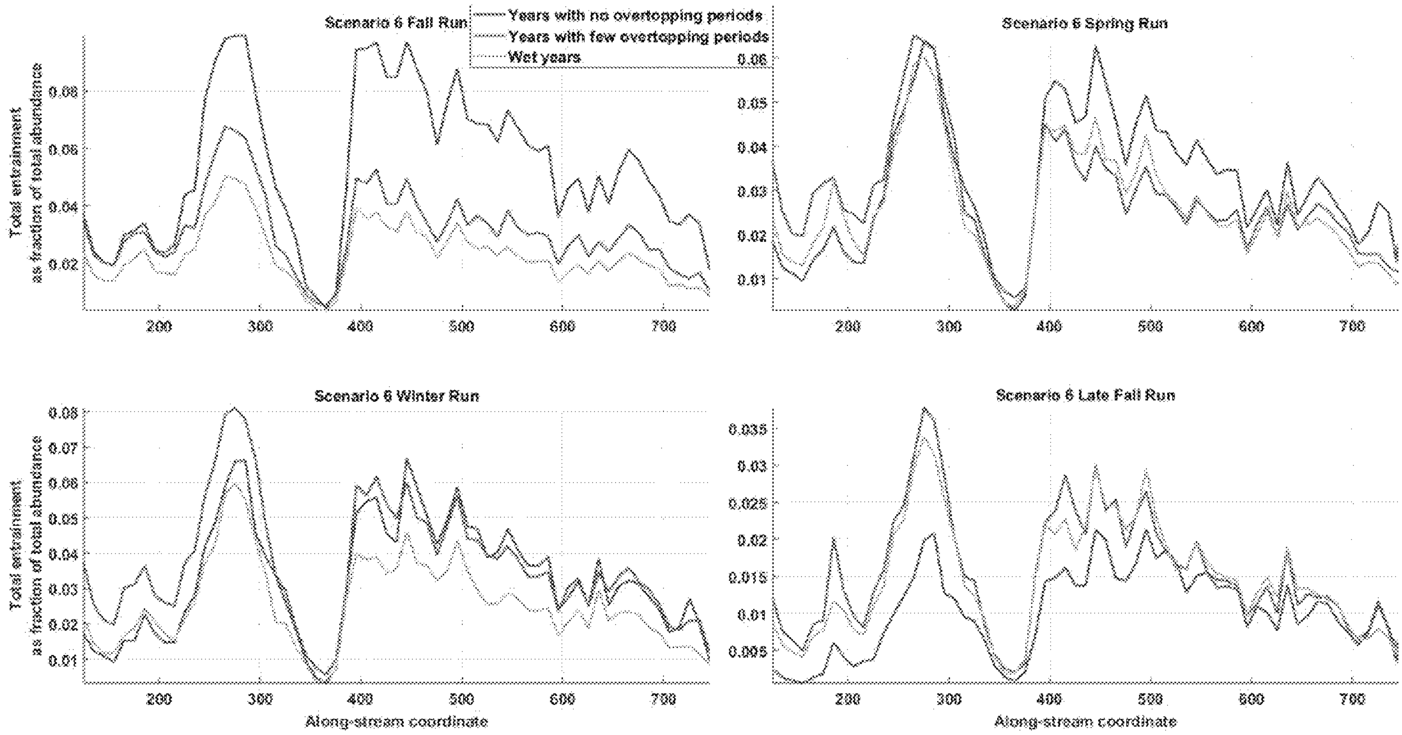


Figure 33- Scenario 6 water year type total entrainment curves

Plots showing total entrainment for each run as a function of notch along-channel location within the study area calculated for three water year types for scenario 6. The blue lines indicates total entrainment over all seasons when Fremont Weir did not overtop, the red line indicates total entrainment over all seasons when the Fremont Weir overtopped for fewer than 200 hours, and the gold line indicates total entrainment over all seasons when the Fremont Weir overtopped for more than 200 hours (wet years). Each panel shows water year entrainment for a run. For the purposes of the simulation weir overtopping was defined as Sacramento River stage exceeding 32.3 ft, USGS survey, NAVD88. Note that the simulation is based on data from acoustically tagged hatchery surrogates, and so differences between run entrainment are entirely driven by differences in the historical timing of run abundance, and are not indicative of behavioral differences between runs.

10. Appendix A - Conversion between along-channel coordinates and UTM for the River Right bank of the Sacramento River

Table A1 - Conversion between along-channel location and UTM coordinates

Table giving the along stream coordinate and UTM coordinates of the river right bank of the Sacramento River at 29 feet stage, USGS survey, NAVD88, from the bathymetric model used in the simulation. The along stream coordinate system is shown in plan view in figure 4.

Notch evaluation location	Along-stream coordinate, m	Easting, UTM Zone 10S, m, NAD83	Northing, UTM Zone 10S, m, NAD83
1	124.9	615497.6	4290880.5
2	134.9	615506.8	4290876.3
3	144.9	615515.8	4290871.8
4	155.0	615524.9	4290868.0
5	165.2	615535.1	4290866.2
6	175.5	615545.3	4290863.8
7	185.6	615555.0	4290860.1
8	195.6	615564.3	4290855.0
9	205.4	615574.7	4290851.9
10	215.3	615585.2	4290852.0

11	225.3	615595.5	4290854.0
12	235.3	615605.6	4290855.1
13	245.3	615615.6	4290857.1
14	255.3	615625.7	4290858.2
15	265.3	615635.7	4290860.0
16	275.4	615645.6	4290861.6
17	285.4	615655.5	4290863.3
18	295.4	615665.6	4290864.3
19	305.4	615675.7	4290865.5
20	315.4	615685.7	4290867.4
21	325.4	615695.4	4290870.7
22	335.3	615705.4	4290873.2
23	345.3	615715.6	4290875.3
24	355.4	615725.6	4290878.1
25	365.4	615735.6	4290880.5
26	375.4	615744.4	4290885.6
27	385.4	615753.4	4290890.3

28	395.4	615761.8	4290896.2
29	405.5	615771.4	4290899.7
30	415.5	615780.0	4290905.4
31	425.5	615789.9	4290908.7
32	435.4	615799.4	4290913.0
33	445.5	615808.6	4290918.1
34	455.4	615818.3	4290922.7
35	465.4	615826.0	4290929.9
36	475.5	615835.5	4290934.8
37	485.6	615841.8	4290943.7
38	495.6	615848.5	4290951.8
39	505.6	615856.9	4290958.3
40	515.5	615864.4	4290965.9
41	525.5	615872.6	4290972.9
42	535.5	615881.0	4290979.3
43	545.6	615887.5	4290986.8
44	555.6	615894.7	4290993.8

45	565.6	615899.9	4291002.6
46	575.6	615904.8	4291011.8
47	585.6	615909.0	4291021.4
48	595.6	615917.0	4291028.5
49	605.6	615920.8	4291038.2
50	615.6	615925.2	4291047.6
51	625.7	615932.2	4291055.5
52	635.7	615935.7	4291065.6
53	645.6	615940.0	4291075.3
54	655.6	615943.3	4291085.4
55	665.6	615947.0	4291095.2
56	675.6	615952.2	4291104.1
57	685.6	615955.0	4291113.7
58	695.6	615957.9	4291123.4
59	705.6	615962.8	4291132.3
60	715.7	615964.9	4291142.1
61	725.7	615967.4	4291151.6

62	735.6	615971.6	4291159.9
63	745.6	615976.1	4291168.1

11. Appendix B - Summary of simulation entrainment at each evaluation location for each run

Table B1 - Percent of yearly fall run abundance entrained under each scenario for each evaluation location

Notch evaluation location	**Percent of yearly abundance entrained. The mean for the 15-year simulation period is given along with the 90% bootstrap confidence interval in parentheses**					
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	9% (2%-15%)	6% (1%-10%)	22% (5%-36%)	8% (4%-13%)	3% (1%-6%)	3% (1%-6%)
2	8% (1%-14%)	4% (1%-8%)	20% (5%-33%)	7% (3%-11%)	2% (0%-4%)	2% (0%-5%)
3	7% (1%-13%)	4% (1%-7%)	19% (3%-32%)	6% (3%-9%)	2% (0%-3%)	2% (0%-5%)
4	6% (1%-12%)	4% (1%-7%)	19% (4%-32%)	5% (3%-9%)	2% (0%-4%)	2% (0%-4%)
5	7% (1%-12%)	4% (1%-8%)	20% (5%-33%)	7% (4%-11%)	2% (0%-5%)	2% (0%-5%)
6	8% (1%-13%)	5% (1%-8%)	21% (5%-34%)	8% (4%-12%)	2% (0%-5%)	3% (1%-5%)

7	7% (1%-11%)	4% (1%-7%)	19% (5%-31%)	6% (3%-9%)	3% (1%-5%)	3% (1%-6%)
8	5% (1%-8%)	3% (1%-6%)	17% (4%-29%)	5% (2%-7%)	2% (1%-4%)	2% (1%-4%)
9	4% (1%-8%)	3% (1%-4%)	17% (3%-29%)	4% (2%-6%)	2% (1%-4%)	2% (1%-4%)
10	4% (1%-7%)	3% (1%-5%)	18% (4%-30%)	4% (2%-7%)	2% (0%-4%)	2% (0%-4%)
11	5% (1%-9%)	3% (1%-6%)	19% (5%-31%)	5% (1%-11%)	2% (0%-5%)	3% (1%-7%)
12	6% (2%-10%)	3% (1%-7%)	21% (6%-32%)	6% (1%-10%)	3% (1%-5%)	3% (1%-7%)
13	7% (2%-12%)	5% (2%-11%)	22% (7%-34%)	8% (2%-16%)	4% (1%-8%)	5% (1%-12%)
14	8% (3%-13%)	6% (2%-13%)	23% (8%-35%)	9% (2%-17%)	5% (1%-10%)	6% (1%-14%)
15	9% (4%-15%)	7% (2%-13%)	24% (8%-38%)	11% (4%-19%)	6% (2%-12%)	7% (1%-15%)
16	9% (4%-14%)	6% (3%-13%)	25% (8%-37%)	11% (4%-19%)	5% (2%-11%)	7% (2%-14%)
17	9% (4%-13%)	7% (2%-14%)	26% (9%-38%)	12% (4%-20%)	5% (2%-11%)	7% (2%-15%)
18	8% (3%-13%)	5% (2%-12%)	25% (10%-37%)	11% (3%-17%)	4% (1%-7%)	6% (1%-13%)
19	7% (3%-11%)	5% (2%-9%)	24% (9%-36%)	9% (2%-17%)	3% (1%-7%)	4% (1%-10%)

20	6% (3%-10%)	4% (2%-7%)	22% (7%-33%)	8% (3%-14%)	2% (1%-3%)	3% (1%-7%)
21	6% (2%-9%)	4% (2%-8%)	21% (8%-32%)	8% (3%-14%)	2% (1%-3%)	3% (1%-6%)
22	5% (2%-9%)	3% (2%-5%)	19% (6%-29%)	6% (2%-12%)	1% (0%-2%)	2% (0%-4%)
23	4% (1%-8%)	2% (1%-4%)	17% (6%-25%)	6% (2%-9%)	1% (0%-1%)	1% (0%-2%)
24	4% (1%-8%)	2% (1%-3%)	15% (4%-23%)	4% (2%-5%)	1% (0%-1%)	1% (0%-2%)
25	3% (0%-6%)	2% (0%-3%)	14% (3%-23%)	3% (2%-4%)	0% (0%-1%)	0% (0%-1%)
26	5% (1%-10%)	2% (1%-5%)	19% (5%-29%)	6% (2%-11%)	1% (0%-1%)	1% (0%-2%)
27	8% (3%-14%)	5% (1%-12%)	22% (9%-34%)	10% (2%-20%)	2% (0%-4%)	3% (1%-7%)
28	11% (4%-20%)	8% (3%-18%)	25% (10%-38%)	13% (4%-25%)	4% (1%-11%)	6% (1%-14%)
29	11% (5%-19%)	8% (2%-17%)	27% (12%-40%)	13% (3%-25%)	4% (1%-11%)	6% (1%-13%)
30	11% (5%-20%)	8% (2%-19%)	28% (12%-43%)	14% (3%-28%)	4% (1%-11%)	6% (1%-14%)
31	10% (4%-18%)	8% (2%-18%)	28% (12%-42%)	13% (3%-25%)	3% (1%-8%)	5% (1%-13%)
32	10% (4%-18%)	8% (2%-20%)	27% (13%-38%)	13% (3%-26%)	3% (0%-7%)	5% (1%-13%)

33	11% (6%-20%)	9% (3%-18%)	26% (13%-37%)	13% (4%-25%)	4% (1%-12%)	6% (1%-13%)
34	9% (4%-18%)	8% (2%-18%)	23% (12%-34%)	12% (3%-24%)	3% (0%-8%)	5% (1%-13%)
35	9% (4%-18%)	7% (2%-19%)	23% (12%-35%)	12% (2%-24%)	3% (0%-8%)	5% (0%-11%)
36	8% (4%-16%)	6% (1%-15%)	23% (12%-34%)	11% (2%-23%)	2% (0%-6%)	4% (0%-9%)
37	11% (6%-18%)	8% (2%-19%)	24% (12%-36%)	13% (2%-26%)	3% (0%-8%)	4% (1%-11%)
38	12% (6%-21%)	9% (2%-21%)	26% (14%-39%)	15% (3%-28%)	4% (0%-11%)	5% (1%-12%)
39	9% (5%-16%)	7% (1%-16%)	23% (12%-37%)	12% (2%-23%)	3% (0%-8%)	4% (1%-10%)
40	10% (6%-17%)	7% (1%-16%)	23% (12%-36%)	13% (2%-24%)	3% (0%-8%)	4% (1%-10%)
41	9% (4%-19%)	7% (1%-18%)	22% (12%-38%)	13% (2%-26%)	3% (0%-7%)	4% (0%-10%)
42	9% (3%-20%)	8% (1%-19%)	21% (12%-37%)	13% (2%-27%)	3% (0%-6%)	4% (0%-9%)
43	9% (3%-19%)	8% (1%-19%)	22% (12%-35%)	13% (2%-26%)	3% (0%-8%)	4% (0%-10%)
44	9% (4%-19%)	7% (1%-18%)	22% (13%-33%)	13% (2%-26%)	3% (0%-7%)	4% (0%-10%)
45	9% (5%-17%)	7% (1%-16%)	21% (13%-32%)	12% (2%-23%)	3% (0%-6%)	4% (0%-8%)

46	9% (5%-15%)	7% (2%-15%)	21% (13%-31%)	12% (3%-23%)	3% (0%-7%)	4% (0%-8%)
47	10% (5%-16%)	8% (4%-16%)	22% (12%-32%)	12% (5%-20%)	3% (0%-6%)	4% (0%-9%)
48	8% (4%-13%)	6% (3%-11%)	20% (10%-30%)	10% (4%-17%)	2% (0%-4%)	2% (0%-5%)
49	9% (4%-16%)	7% (3%-12%)	21% (9%-31%)	11% (5%-18%)	2% (0%-5%)	3% (0%-6%)
50	10% (5%-17%)	7% (3%-14%)	22% (11%-33%)	12% (5%-20%)	3% (0%-5%)	3% (0%-7%)
51	8% (4%-15%)	6% (3%-11%)	20% (9%-30%)	11% (4%-18%)	2% (0%-4%)	2% (0%-5%)
52	9% (5%-15%)	6% (3%-12%)	21% (11%-31%)	12% (5%-18%)	3% (1%-5%)	3% (1%-7%)
53	8% (4%-14%)	6% (3%-12%)	20% (10%-29%)	11% (6%-18%)	2% (0%-4%)	3% (1%-6%)
54	9% (4%-14%)	7% (3%-12%)	20% (10%-30%)	11% (5%-19%)	3% (0%-6%)	3% (0%-8%)
55	9% (4%-15%)	6% (3%-11%)	19% (9%-28%)	10% (5%-17%)	3% (0%-7%)	4% (0%-9%)
56	9% (4%-16%)	7% (3%-12%)	18% (8%-28%)	9% (5%-14%)	3% (1%-6%)	3% (0%-8%)
57	8% (3%-17%)	6% (3%-12%)	18% (7%-29%)	9% (5%-15%)	2% (0%-5%)	3% (0%-7%)
58	8% (3%-17%)	6% (2%-13%)	19% (7%-30%)	9% (5%-14%)	2% (1%-6%)	3% (0%-7%)

59	7% (2%-16%)	5% (2%-11%)	17% (6%-28%)	8% (4%-12%)	2% (0%-4%)	2% (0%-5%)
60	7% (2%-17%)	6% (2%-12%)	19% (7%-30%)	9% (4%-14%)	2% (0%-3%)	2% (0%-5%)
61	7% (3%-17%)	6% (2%-12%)	20% (9%-30%)	9% (4%-15%)	1% (1%-3%)	2% (1%-5%)
62	7% (2%-16%)	5% (2%-11%)	19% (8%-29%)	8% (4%-13%)	1% (0%-2%)	2% (0%-4%)
63	7% (1%-19%)	5% (1%-15%)	19% (6%-30%)	8% (4%-15%)	1% (0%-2%)	1% (0%-3%)

Table B2 - Percent of yearly spring run abundance entrained under each scenario for each evaluation location

Notch evaluation location	**Percent of yearly abundance entrained. The mean for the 15 year simulation period is given along with the 90% bootstrap confidence interval in parenthesis**					
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	7% (1%-15%)	4% (1%-10%)	16% (2%-34%)	7% (4%-13%)	2% (0%-6%)	2% (0%-7%)
2	6% (0%-13%)	3% (1%-9%)	15% (2%-33%)	6% (4%-10%)	1% (0%-3%)	2% (0%-5%)
3	5% (0%-12%)	3% (0%-8%)	15% (2%-32%)	5% (3%-9%)	1% (0%-3%)	1% (0%-4%)
4	5% (0%-11%)	3% (0%-7%)	15% (2%-32%)	4% (2%-7%)	1% (0%-3%)	1% (0%-4%)
5	5% (1%-12%)	3% (1%-8%)	15% (2%-34%)	7% (4%-11%)	2% (0%-4%)	2% (0%-5%)
6	5% (1%-12%)	4% (1%-8%)	16% (2%-34%)	7% (5%-10%)	2% (0%-5%)	2% (0%-6%)
7	5% (1%-11%)	4% (1%-7%)	15% (2%-33%)	6% (4%-9%)	2% (1%-5%)	3% (1%-5%)
8	4% (1%-8%)	2% (1%-5%)	13% (2%-29%)	5% (4%-7%)	2% (1%-4%)	2% (1%-4%)
9	3% (1%-8%)	2% (1%-5%)	13% (2%-29%)	4% (3%-6%)	2% (0%-4%)	2% (1%-4%)
10	3% (0%-7%)	2% (0%-5%)	14% (2%-31%)	4% (3%-6%)	1% (0%-4%)	2% (0%-4%)

11	4% (1%-9%)	3% (1%-6%)	15% (2%-33%)	5% (3%-8%)	2% (0%-5%)	3% (1%-7%)
12	5% (1%-9%)	3% (1%-6%)	16% (3%-34%)	6% (4%-9%)	2% (1%-5%)	3% (1%-7%)
13	6% (1%-12%)	4% (1%-9%)	17% (3%-37%)	8% (5%-11%)	3% (1%-8%)	4% (2%-10%)
14	6% (2%-14%)	5% (1%-10%)	18% (4%-38%)	10% (7%-13%)	4% (1%-9%)	5% (2%-11%)
15	7% (2%-14%)	5% (2%-12%)	19% (4%-40%)	12% (9%-15%)	5% (2%-11%)	6% (3%-13%)
16	7% (3%-14%)	6% (3%-11%)	19% (5%-40%)	13% (9%-16%)	5% (2%-10%)	7% (4%-12%)
17	8% (3%-14%)	6% (3%-11%)	20% (5%-40%)	14% (10%-18%)	5% (2%-10%)	7% (3%-12%)
18	6% (2%-13%)	4% (2%-9%)	20% (5%-39%)	13% (8%-17%)	3% (1%-6%)	5% (3%-10%)
19	6% (2%-11%)	4% (1%-7%)	18% (4%-37%)	11% (7%-14%)	3% (1%-5%)	4% (2%-7%)
20	5% (2%-9%)	3% (1%-5%)	17% (4%-34%)	9% (6%-13%)	2% (1%-3%)	3% (1%-5%)
21	5% (1%-8%)	3% (1%-5%)	17% (4%-32%)	10% (5%-13%)	2% (1%-3%)	2% (1%-4%)
22	4% (1%-7%)	2% (1%-4%)	15% (3%-28%)	7% (3%-10%)	1% (0%-2%)	2% (1%-2%)
23	3% (1%-6%)	2% (0%-3%)	13% (3%-25%)	7% (3%-9%)	1% (0%-1%)	1% (0%-2%)

24	3% (0%-6%)	1% (0%-3%)	12% (1%-24%)	4% (2%-5%)	0% (0%-1%)	1% (0%-1%)
25	2% (0%-5%)	1% (0%-2%)	11% (2%-23%)	4% (2%-7%)	0% (0%-1%)	0% (0%-1%)
26	4% (0%-9%)	2% (0%-5%)	14% (3%-30%)	7% (4%-10%)	0% (0%-1%)	1% (0%-2%)
27	6% (1%-13%)	5% (1%-10%)	16% (4%-33%)	11% (7%-15%)	2% (1%-3%)	3% (1%-5%)
28	9% (2%-17%)	7% (2%-14%)	20% (5%-38%)	15% (10%-18%)	4% (1%-8%)	5% (2%-10%)
29	9% (3%-17%)	7% (2%-12%)	21% (5%-42%)	14% (8%-18%)	3% (1%-7%)	5% (2%-9%)
30	9% (3%-18%)	7% (2%-13%)	22% (6%-42%)	14% (9%-19%)	4% (1%-7%)	5% (2%-10%)
31	8% (2%-16%)	6% (2%-12%)	21% (5%-39%)	12% (7%-16%)	3% (1%-6%)	4% (2%-8%)
32	8% (3%-15%)	6% (2%-13%)	20% (5%-38%)	13% (8%-18%)	3% (1%-5%)	4% (2%-8%)
33	9% (4%-15%)	7% (4%-13%)	20% (6%-37%)	14% (9%-19%)	4% (2%-7%)	6% (2%-9%)
34	8% (3%-14%)	7% (3%-12%)	18% (5%-33%)	14% (8%-17%)	3% (2%-5%)	5% (2%-7%)
35	7% (3%-13%)	6% (3%-12%)	18% (5%-31%)	14% (8%-18%)	3% (1%-5%)	4% (2%-7%)
36	6% (3%-11%)	5% (2%-9%)	17% (5%-31%)	13% (7%-16%)	2% (1%-4%)	4% (2%-6%)

37	8% (3%-14%)	6% (3%-12%)	19% (5%-34%)	14% (8%-17%)	3% (1%-5%)	4% (2%-7%)
38	9% (4%-15%)	7% (4%-14%)	20% (6%-37%)	16% (9%-20%)	4% (2%-6%)	5% (2%-8%)
39	8% (4%-13%)	6% (3%-11%)	18% (5%-33%)	13% (8%-18%)	3% (1%-5%)	4% (2%-6%)
40	7% (3%-12%)	6% (3%-11%)	18% (5%-32%)	14% (8%-19%)	3% (1%-5%)	4% (2%-7%)
41	7% (2%-13%)	6% (2%-12%)	17% (5%-30%)	14% (8%-19%)	2% (1%-5%)	3% (1%-6%)
42	7% (2%-14%)	6% (2%-12%)	16% (5%-28%)	14% (8%-19%)	2% (1%-4%)	3% (2%-6%)
43	8% (3%-15%)	7% (2%-13%)	17% (6%-28%)	14% (8%-19%)	3% (1%-4%)	4% (2%-7%)
44	7% (2%-13%)	6% (2%-13%)	17% (5%-28%)	14% (8%-19%)	2% (1%-4%)	3% (1%-6%)
45	7% (2%-13%)	6% (2%-11%)	16% (5%-28%)	13% (8%-18%)	2% (1%-4%)	3% (1%-5%)
46	7% (2%-11%)	6% (2%-10%)	17% (5%-27%)	13% (8%-18%)	2% (1%-4%)	3% (1%-5%)
47	7% (2%-11%)	6% (2%-9%)	17% (6%-28%)	13% (9%-17%)	2% (1%-4%)	3% (1%-6%)
48	6% (2%-10%)	4% (2%-8%)	15% (4%-26%)	10% (7%-13%)	1% (1%-3%)	2% (1%-3%)
49	6% (2%-12%)	5% (2%-9%)	16% (4%-27%)	11% (8%-15%)	2% (1%-3%)	3% (1%-4%)

50	7% (2%-13%)	5% (2%-10%)	16% (5%-28%)	13% (9%-17%)	2% (1%-3%)	3% (1%-5%)
51	6% (2%-10%)	4% (2%-8%)	16% (5%-27%)	12% (8%-16%)	1% (0%-3%)	2% (1%-4%)
52	7% (3%-11%)	5% (3%-7%)	16% (5%-28%)	13% (8%-18%)	2% (1%-4%)	3% (2%-5%)
53	6% (2%-11%)	5% (2%-8%)	16% (4%-27%)	13% (8%-17%)	2% (1%-3%)	2% (1%-5%)
54	6% (2%-10%)	5% (2%-9%)	15% (5%-27%)	11% (8%-14%)	2% (1%-4%)	3% (1%-5%)
55	6% (2%-11%)	5% (1%-8%)	14% (4%-25%)	10% (7%-13%)	3% (1%-5%)	3% (1%-6%)
56	6% (2%-11%)	5% (2%-8%)	13% (3%-23%)	8% (5%-10%)	2% (1%-5%)	3% (1%-5%)
57	5% (1%-11%)	4% (1%-8%)	13% (3%-23%)	8% (5%-9%)	2% (1%-3%)	2% (1%-5%)
58	5% (1%-11%)	4% (1%-9%)	14% (3%-24%)	8% (5%-11%)	2% (0%-3%)	2% (1%-4%)
59	4% (1%-10%)	3% (1%-7%)	12% (2%-22%)	6% (4%-8%)	1% (0%-3%)	2% (1%-3%)
60	5% (1%-11%)	4% (1%-8%)	14% (3%-24%)	7% (4%-10%)	1% (0%-2%)	2% (1%-3%)
61	5% (2%-11%)	4% (1%-7%)	15% (4%-25%)	7% (4%-10%)	1% (1%-2%)	2% (1%-4%)
62	5% (1%-10%)	4% (1%-7%)	14% (3%-24%)	7% (4%-10%)	1% (0%-2%)	2% (0%-3%)

63	4% (1%-12%)	3% (1%-9%)	14% (2%-26%)	6% (3%-10%)	1% (0%-1%)	1% (0%-2%)

Table B3 - Percent of yearly winter run abundance entrained under each scenario for each evaluation location

Notch evaluation location	**Percent of yearly abundance entrained. The mean for the 15 year simulation period is given along with the 90% bootstrap confidence interval in parenthesis**					
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	3% (0%-15%)	2% (0%-10%)	9% (0%-35%)	4% (0%-11%)	1% (0%-5%)	1% (0%-7%)
2	3% (0%-13%)	2% (0%-7%)	8% (0%-33%)	3% (0%-9%)	1% (0%-3%)	1% (0%-4%)
3	3% (0%-13%)	2% (0%-7%)	8% (0%-33%)	3% (0%-8%)	0% (0%-2%)	1% (0%-4%)
4	3% (0%-13%)	2% (0%-7%)	7% (0%-31%)	2% (0%-8%)	0% (0%-2%)	1% (0%-3%)
5	3% (0%-12%)	2% (0%-7%)	8% (0%-33%)	4% (0%-9%)	1% (0%-3%)	1% (0%-5%)
6	3% (0%-13%)	2% (0%-7%)	8% (0%-33%)	4% (0%-9%)	1% (0%-4%)	1% (0%-5%)
7	3% (0%-12%)	2% (0%-6%)	8% (0%-31%)	4% (0%-8%)	1% (0%-4%)	1% (0%-5%)
8	2% (0%-8%)	1% (0%-4%)	7% (0%-27%)	3% (0%-6%)	1% (0%-3%)	1% (0%-4%)
9	2% (0%-7%)	1% (0%-4%)	7% (0%-27%)	2% (0%-5%)	1% (0%-3%)	1% (0%-4%)
10	2% (0%-7%)	1% (0%-4%)	7% (0%-29%)	3% (0%-5%)	1% (0%-3%)	1% (0%-4%)

11	2% (0%-8%)	1% (0%-5%)	8% (0%-31%)	3% (0%-7%)	1% (0%-4%)	1% (0%-6%)
12	2% (0%-8%)	1% (0%-5%)	8% (0%-32%)	3% (0%-7%)	1% (0%-4%)	1% (0%-5%)
13	3% (0%-11%)	2% (0%-8%)	9% (0%-35%)	5% (0%-11%)	2% (0%-7%)	2% (0%-8%)
14	3% (0%-12%)	2% (0%-8%)	9% (0%-36%)	5% (0%-11%)	2% (0%-8%)	2% (0%-9%)
15	4% (0%-13%)	3% (0%-9%)	10% (0%-37%)	7% (0%-13%)	2% (0%-10%)	3% (0%-11%)
16	4% (0%-12%)	3% (0%-9%)	10% (0%-37%)	7% (0%-14%)	3% (0%-8%)	4% (0%-11%)
17	4% (0%-13%)	3% (0%-9%)	11% (0%-38%)	8% (0%-15%)	2% (0%-9%)	3% (0%-10%)
18	3% (0%-12%)	2% (0%-7%)	10% (0%-36%)	8% (0%-15%)	1% (0%-5%)	3% (0%-9%)
19	3% (0%-10%)	2% (0%-6%)	10% (0%-34%)	6% (0%-13%)	1% (0%-3%)	2% (0%-5%)
20	3% (0%-9%)	2% (0%-4%)	9% (0%-31%)	6% (0%-12%)	1% (0%-2%)	1% (0%-3%)
21	3% (0%-9%)	2% (0%-4%)	8% (0%-30%)	6% (0%-13%)	1% (0%-2%)	1% (0%-3%)
22	2% (0%-8%)	1% (0%-4%)	7% (0%-26%)	4% (0%-9%)	1% (0%-1%)	1% (0%-2%)
23	2% (0%-7%)	1% (0%-3%)	6% (0%-22%)	4% (0%-8%)	0% (0%-1%)	0% (0%-1%)

24	1% (0%-7%)	1% (0%-3%)	6% (0%-21%)	3% (0%-6%)	0% (0%-1%)	0% (0%-1%)
25	1% (0%-6%)	1% (0%-3%)	5% (0%-22%)	3% (0%-6%)	0% (0%-0%)	0% (0%-1%)
26	2% (0%-8%)	1% (0%-4%)	7% (0%-27%)	4% (0%-8%)	0% (0%-1%)	0% (0%-1%)
27	3% (0%-12%)	2% (0%-7%)	8% (0%-30%)	7% (0%-13%)	1% (0%-3%)	1% (0%-4%)
28	4% (0%-15%)	3% (0%-11%)	10% (0%-33%)	8% (0%-16%)	2% (0%-7%)	2% (0%-8%)
29	5% (0%-15%)	3% (0%-10%)	11% (0%-36%)	8% (0%-17%)	2% (0%-6%)	2% (0%-7%)
30	5% (0%-15%)	3% (0%-11%)	11% (0%-38%)	8% (0%-19%)	2% (0%-6%)	3% (0%-7%)
31	4% (0%-12%)	3% (0%-9%)	11% (0%-36%)	7% (0%-15%)	1% (0%-5%)	2% (0%-7%)
32	4% (0%-13%)	3% (0%-10%)	10% (0%-34%)	7% (0%-17%)	1% (0%-5%)	2% (0%-6%)
33	5% (0%-13%)	4% (0%-10%)	10% (0%-32%)	8% (0%-16%)	2% (0%-5%)	3% (0%-7%)
34	4% (0%-12%)	3% (0%-10%)	9% (0%-29%)	8% (0%-16%)	2% (0%-4%)	2% (0%-6%)
35	4% (0%-10%)	3% (0%-10%)	9% (0%-26%)	8% (0%-16%)	1% (0%-3%)	2% (0%-5%)
36	3% (0%-9%)	3% (0%-7%)	9% (0%-26%)	7% (0%-17%)	1% (0%-2%)	2% (0%-4%)

37	4% (0%-11%)	3% (0%-10%)	10% (0%-30%)	8% (0%-16%)	1% (0%-4%)	2% (0%-5%)
38	5% (0%-12%)	4% (0%-11%)	10% (0%-32%)	9% (1%-20%)	2% (0%-5%)	3% (0%-6%)
39	4% (0%-11%)	3% (0%-9%)	9% (0%-28%)	8% (0%-18%)	1% (0%-4%)	2% (0%-5%)
40	4% (0%-10%)	3% (0%-10%)	9% (0%-27%)	8% (0%-19%)	1% (0%-4%)	2% (0%-6%)
41	4% (0%-10%)	3% (0%-9%)	9% (0%-25%)	8% (0%-18%)	1% (0%-4%)	2% (0%-6%)
42	4% (0%-11%)	3% (0%-10%)	9% (0%-24%)	8% (0%-17%)	1% (0%-3%)	2% (0%-4%)
43	4% (0%-12%)	3% (0%-11%)	9% (0%-25%)	8% (0%-18%)	1% (0%-4%)	2% (0%-5%)
44	4% (0%-11%)	3% (0%-9%)	9% (0%-24%)	8% (0%-19%)	1% (0%-4%)	2% (0%-5%)
45	3% (0%-9%)	3% (0%-9%)	9% (0%-24%)	8% (0%-17%)	1% (0%-3%)	2% (0%-5%)
46	4% (0%-9%)	3% (0%-7%)	9% (0%-24%)	7% (0%-16%)	1% (0%-4%)	2% (0%-5%)
47	4% (0%-10%)	3% (0%-8%)	9% (0%-26%)	7% (0%-17%)	1% (0%-3%)	2% (0%-4%)
48	3% (0%-9%)	2% (0%-6%)	8% (0%-23%)	6% (0%-13%)	1% (0%-2%)	1% (0%-3%)
49	3% (0%-11%)	3% (0%-7%)	8% (0%-26%)	7% (0%-13%)	1% (0%-3%)	1% (0%-3%)

50	4% (0%-12%)	3% (0%-8%)	9% (0%-27%)	8% (0%-15%)	1% (0%-3%)	2% (0%-4%)
51	3% (0%-10%)	2% (0%-5%)	8% (0%-25%)	7% (0%-15%)	1% (0%-2%)	1% (0%-3%)
52	4% (0%-11%)	3% (0%-7%)	8% (0%-26%)	8% (0%-17%)	1% (0%-3%)	2% (0%-4%)
53	3% (0%-11%)	2% (0%-6%)	8% (0%-26%)	7% (0%-15%)	1% (0%-3%)	1% (0%-4%)
54	3% (0%-10%)	2% (0%-6%)	8% (0%-25%)	6% (0%-14%)	1% (0%-4%)	1% (0%-4%)
55	3% (0%-11%)	2% (0%-6%)	8% (0%-25%)	5% (0%-12%)	1% (0%-4%)	1% (0%-5%)
56	3% (0%-11%)	2% (0%-6%)	7% (0%-23%)	4% (0%-10%)	1% (0%-3%)	1% (0%-4%)
57	3% (0%-11%)	2% (0%-7%)	7% (0%-25%)	4% (0%-11%)	1% (0%-3%)	1% (0%-4%)
58	3% (0%-12%)	2% (0%-8%)	7% (0%-26%)	4% (0%-10%)	1% (0%-3%)	1% (0%-3%)
59	2% (0%-10%)	2% (0%-6%)	7% (0%-23%)	3% (0%-8%)	1% (0%-2%)	1% (0%-3%)
60	3% (0%-11%)	2% (0%-6%)	7% (0%-26%)	4% (0%-9%)	1% (0%-2%)	1% (0%-3%)
61	3% (0%-12%)	2% (0%-7%)	8% (0%-26%)	4% (0%-10%)	1% (0%-2%)	1% (0%-3%)
62	3% (0%-10%)	2% (0%-7%)	7% (0%-25%)	4% (0%-10%)	0% (0%-1%)	1% (0%-2%)

63	2% (0%-12%)	2% (0%-8%)	7% (0%-27%)	3% (0%-9%)	0% (0%-1%)	0% (0%-1%)

Table B4 - Percent of yearly late fall run abundance entrained under each scenario for each evaluation location

Notch evaluation location	Percent of yearly abundance entrained. The mean for the 15 year simulation period is given along with the 90% bootstrap confidence interval in parenthesis					
	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**	**Scenario 6**
1	7% (1%-16%)	5% (1%-10%)	17% (2%-37%)	7% (3%-12%)	2% (0%-6%)	3% (0%-7%)
2	6% (0%-14%)	4% (0%-8%)	16% (2%-35%)	6% (2%-11%)	1% (0%-4%)	2% (0%-5%)
3	6% (0%-13%)	3% (0%-7%)	16% (1%-34%)	5% (2%-8%)	1% (0%-4%)	2% (0%-4%)
4	5% (0%-12%)	3% (0%-6%)	15% (1%-34%)	4% (1%-7%)	1% (0%-3%)	1% (0%-4%)
5	6% (0%-12%)	4% (0%-7%)	17% (2%-35%)	7% (3%-10%)	2% (0%-5%)	2% (0%-6%)
6	6% (0%-14%)	4% (0%-8%)	17% (2%-35%)	7% (3%-10%)	2% (0%-5%)	2% (0%-6%)
7	6% (1%-12%)	4% (1%-7%)	16% (2%-33%)	6% (2%-8%)	3% (0%-6%)	3% (1%-6%)
8	4% (0%-9%)	3% (0%-5%)	14% (1%-30%)	5% (2%-7%)	2% (0%-4%)	2% (1%-5%)
9	4% (0%-8%)	2% (0%-5%)	14% (1%-30%)	4% (2%-6%)	2% (0%-4%)	2% (0%-4%)
10	3% (0%-8%)	2% (0%-4%)	15% (1%-31%)	4% (2%-6%)	2% (0%-4%)	2% (0%-4%)

11	4% (1%-9%)	3% (0%-6%)	16% (2%-34%)	5% (2%-9%)	2% (0%-5%)	3% (0%-6%)
12	5% (1%-10%)	3% (1%-5%)	17% (2%-35%)	6% (3%-9%)	2% (0%-5%)	3% (1%-6%)
13	6% (1%-12%)	4% (1%-9%)	18% (2%-37%)	8% (4%-12%)	3% (1%-8%)	5% (1%-10%)
14	7% (1%-13%)	5% (1%-11%)	19% (3%-38%)	9% (5%-14%)	4% (1%-9%)	5% (1%-11%)
15	7% (1%-14%)	6% (1%-11%)	20% (3%-40%)	11% (6%-16%)	5% (1%-11%)	6% (2%-12%)
16	7% (1%-13%)	6% (1%-11%)	20% (3%-39%)	12% (7%-16%)	5% (1%-10%)	7% (2%-12%)
17	8% (1%-13%)	6% (1%-11%)	21% (4%-40%)	12% (7%-17%)	5% (1%-10%)	6% (2%-12%)
18	7% (1%-13%)	5% (1%-9%)	20% (4%-39%)	11% (7%-16%)	3% (1%-7%)	5% (2%-9%)
19	6% (1%-12%)	4% (1%-7%)	19% (3%-38%)	10% (6%-13%)	3% (1%-5%)	4% (1%-7%)
20	5% (1%-10%)	3% (1%-6%)	18% (3%-35%)	8% (4%-12%)	2% (0%-3%)	3% (1%-5%)
21	5% (1%-10%)	3% (1%-6%)	17% (3%-33%)	9% (5%-14%)	2% (0%-3%)	2% (1%-5%)
22	4% (1%-8%)	3% (1%-5%)	15% (3%-30%)	6% (3%-10%)	1% (0%-2%)	2% (1%-3%)
23	3% (0%-7%)	2% (0%-4%)	13% (2%-25%)	6% (3%-11%)	1% (0%-2%)	1% (0%-2%)

24	3% (0%-7%)	1% (0%-3%)	12% (2%-24%)	3% (2%-5%)	0% (0%-1%)	1% (0%-1%)
25	2% (0%-6%)	1% (0%-3%)	12% (1%-24%)	3% (2%-5%)	0% (0%-1%)	0% (0%-1%)
26	4% (0%-10%)	2% (0%-4%)	15% (2%-30%)	6% (3%-9%)	1% (0%-1%)	1% (0%-1%)
27	6% (1%-13%)	5% (1%-10%)	17% (3%-33%)	11% (6%-16%)	2% (0%-4%)	3% (1%-6%)
28	9% (2%-17%)	7% (1%-14%)	20% (4%-36%)	13% (7%-19%)	4% (1%-9%)	5% (1%-10%)
29	9% (2%-16%)	7% (1%-13%)	21% (4%-40%)	13% (6%-20%)	3% (1%-7%)	5% (1%-11%)
30	9% (2%-17%)	7% (2%-13%)	23% (4%-42%)	13% (7%-20%)	4% (1%-8%)	5% (1%-10%)
31	8% (1%-15%)	6% (1%-12%)	21% (4%-40%)	11% (5%-20%)	3% (1%-8%)	4% (1%-9%)
32	8% (2%-15%)	6% (2%-14%)	21% (5%-38%)	12% (6%-20%)	3% (1%-6%)	4% (1%-8%)
33	9% (2%-16%)	7% (2%-14%)	20% (5%-35%)	13% (7%-21%)	4% (1%-7%)	5% (2%-10%)
34	8% (2%-15%)	7% (2%-13%)	18% (4%-31%)	12% (6%-19%)	3% (1%-6%)	4% (2%-8%)
35	7% (2%-14%)	6% (2%-13%)	17% (4%-29%)	12% (6%-20%)	3% (1%-5%)	4% (2%-8%)
36	6% (2%-11%)	5% (2%-11%)	17% (4%-29%)	11% (5%-19%)	2% (1%-4%)	3% (1%-6%)

37	8% (2%-15%)	6% (2%-12%)	18% (5%-32%)	13% (6%-21%)	3% (1%-6%)	4% (1%-8%)
38	9% (2%-17%)	7% (2%-15%)	20% (5%-35%)	15% (8%-23%)	3% (1%-7%)	5% (2%-8%)
39	7% (2%-13%)	6% (2%-11%)	18% (4%-31%)	12% (6%-19%)	3% (1%-6%)	4% (2%-7%)
40	7% (2%-13%)	6% (2%-12%)	18% (4%-31%)	12% (6%-20%)	2% (1%-6%)	4% (1%-7%)
41	7% (2%-14%)	6% (1%-13%)	17% (5%-30%)	12% (6%-20%)	2% (1%-6%)	3% (1%-7%)
42	7% (2%-14%)	6% (1%-13%)	16% (4%-28%)	12% (6%-21%)	2% (1%-5%)	3% (1%-6%)
43	7% (2%-14%)	6% (2%-14%)	17% (5%-29%)	13% (6%-20%)	2% (1%-5%)	4% (1%-7%)
44	7% (2%-14%)	6% (2%-13%)	16% (5%-27%)	13% (6%-21%)	2% (1%-5%)	3% (1%-6%)
45	7% (2%-13%)	6% (2%-12%)	16% (5%-27%)	12% (6%-19%)	2% (1%-5%)	3% (1%-6%)
46	7% (2%-12%)	5% (2%-11%)	16% (5%-27%)	11% (6%-19%)	2% (1%-5%)	3% (1%-6%)
47	7% (2%-13%)	6% (2%-11%)	17% (5%-28%)	11% (7%-19%)	2% (1%-4%)	3% (1%-5%)
48	5% (2%-9%)	4% (2%-9%)	14% (4%-24%)	9% (5%-14%)	1% (0%-2%)	2% (1%-4%)
49	6% (2%-10%)	5% (2%-8%)	15% (4%-25%)	10% (6%-14%)	2% (1%-4%)	2% (1%-4%)

50	7% (2%-11%)	5% (1%-10%)	16% (4%-27%)	12% (7%-17%)	2% (1%-4%)	3% (1%-5%)
51	6% (1%-9%)	4% (1%-8%)	15% (4%-25%)	10% (6%-15%)	1% (0%-3%)	2% (1%-4%)
52	7% (2%-10%)	5% (2%-9%)	16% (5%-27%)	12% (6%-18%)	2% (1%-4%)	3% (1%-5%)
53	6% (2%-10%)	5% (2%-9%)	15% (4%-26%)	11% (6%-17%)	2% (0%-3%)	2% (1%-4%)
54	6% (2%-9%)	5% (2%-9%)	15% (4%-26%)	10% (6%-16%)	2% (0%-4%)	3% (1%-5%)
55	6% (2%-10%)	4% (1%-8%)	14% (4%-25%)	9% (5%-13%)	3% (1%-5%)	3% (1%-6%)
56	6% (1%-10%)	4% (2%-8%)	13% (3%-24%)	7% (4%-11%)	2% (0%-5%)	3% (1%-6%)
57	5% (1%-10%)	4% (1%-7%)	13% (3%-24%)	7% (4%-11%)	2% (0%-4%)	2% (1%-5%)
58	5% (1%-10%)	4% (1%-7%)	14% (3%-25%)	7% (4%-11%)	2% (0%-4%)	2% (0%-4%)
59	4% (1%-8%)	3% (1%-5%)	12% (3%-22%)	6% (3%-9%)	1% (0%-3%)	2% (0%-4%)
60	4% (1%-9%)	3% (1%-7%)	13% (3%-25%)	6% (3%-9%)	1% (0%-3%)	2% (1%-4%)
61	5% (1%-9%)	4% (1%-7%)	14% (4%-25%)	7% (4%-12%)	1% (0%-3%)	2% (1%-4%)
62	4% (1%-8%)	3% (1%-6%)	14% (3%-23%)	6% (3%-11%)	1% (0%-2%)	2% (0%-4%)

63	4% (1%-10%)	3% (1%-7%)	14% (2%-26%)	5% (3%-8%)	1% (0%-2%)	1% (0%-2%)

12. Appendix C - Detailed rating curves and drawings for Scenario 5 and Scenario 6

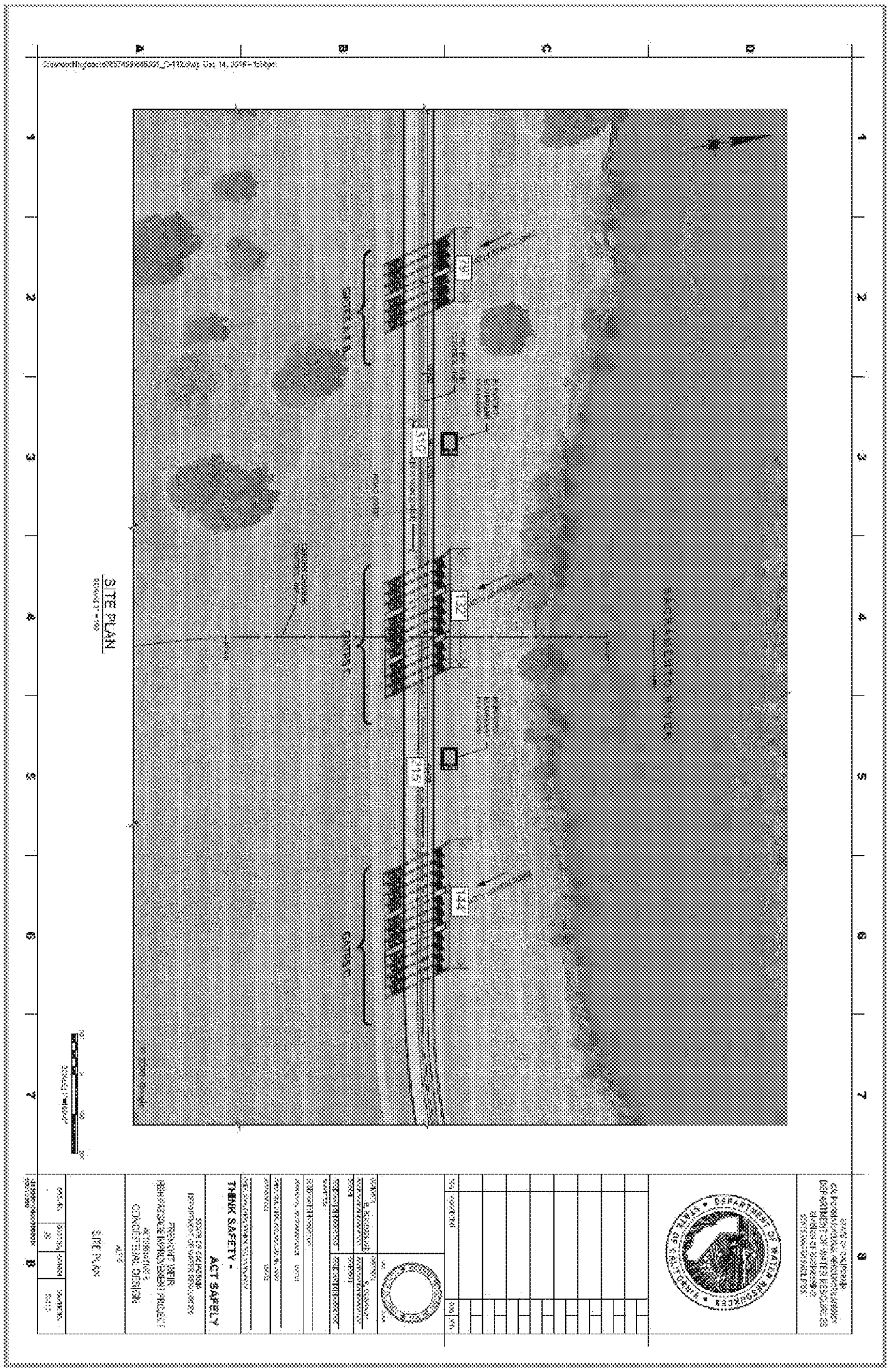


Figure C1 – Plan view of alternative 5 showing the gate spacing used for scenario 5 and scenario 6

Note that alternative 5 is located outside of the 2016 study area, while scenario 5 and scenario 6 evaluated notch locations within the 2016 study area.

Table C1 - Stage - discharge relationships for scenario 5 and scenario 6

Stage, Scenario 6, ft, USGS survey, NAVD88.	Stage, Scenario 5, ft, USGS survey, NAVD88.	Intake A discharge, cfs	Intake B discharge, cfs	Combined Discharge, Intake A and B, cfs	Intake C discharge, cfs	Intake D discharge, cfs
15.00	16.30	12		12		
16.00	17.30	45		45		
17.00	18.30	94	0	94		
18.00	19.30	157	20	177		
19.00	20.30	245	71	316		
20.00	21.30	340	158	498		
20.50	21.80	398	219	617		
22.00	23.30	659	414	1073	0	
23.00	24.30	711	428	1139	636	
24.00	25.30	860	607	1467	915	
25.00	26.30	1025	800	1825	1259	
25.50	26.80	0	1464	1464	1671	
26.00	27.30		1169	1169	2054	
26.25	27.55		1220	1220	2188	

26.50	27.80		672	672	2493	0
26.60	27.90		0	0	2084	1369
27.00	28.30				1400	1859
27.25	28.55				1476	1998
27.50	28.80				1032	2226
27.75	29.05				1084	2381
28.00	29.30				563	2619
28.25	29.55				589	2790
28.50	29.80				0	3032
29	30.30					3407
29.5	30.80					3463
30	31.30					3246
31	32.00					3325
32.3	32.30					0

Table C2 - Notch spacing for scenario 5 and scenario 6

For scenario 5 and Scenario 6 entrainment for each notch is calculated based on the location of the bootstrap sample fish tracks relative to the location of the critical streakline at the along stream location that corresponds to the center of each notch. The location of the center of the downstream notches (B, C, and D) is calculated by adding the offsets listed below to the along-stream location of Notch A.

Notch	Offset from center of Notch A, meters in the along stream direction
A	0
B	40 ft (12.2 meters)
C	436 ft (133 meters)
D	789 ft (240.5 meters)

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 10/6/2021 1:02:16 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Luu, Henry [henry.luu@hdrinc.com]
Subject: RE: Diversion data

Hi Ali,

Yes, those tables are still the latest. Note that those are under the WSIP climate change hydrology.

Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, October 6, 2021 11:52 AM
To: Heydinger, Erin <erin.heydinger@hdrinc.com>; Luu, Henry <Henry.Luu@hdrinc.com>
Subject: FW: Diversion data

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Erin and Henry – I totally forgot that I had promised Anthony information on our Proposition 1 water. A description and quantities by year type. I found some stuff in the draft CWC feasibility report here: https://sitesreservoirproject.sharepoint.com/:f:/r/Engineering%26Geotechnical/WSIP%20Feasibility/CWC%20Feasibility%20Report/Drafts?csf=1&web=1&e=KfEtOx

In table 5-4 and 5-6. Are these numbers still accurate? I assume they haven't changed as this is from the CALSIM modeling, but would like to confirm before I send then external.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Tuesday, October 5, 2021 4:20 PM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Diversion data

Hi guys,

Were you still planning on sending the diversion information? I'm starting to get asked questions about it and it would be helpful to come up to speed.

Cheers,

Anthony M. Saracino
www.asaracino.com
916-952-8573

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 10/6/2021 5:21:13 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Spranza, John [john.spranza@hdrinc.com]
Subject: Diversion Criteria
Attachments: AttA-Sites-DRAFTModelingCriteria-20210323.pdf; DiversionCriteriaFigure.jpg

A couple of old items without Wilkins Slough that could be modified. The table would be very easy to do tonight.

Erin

Erin Heydinger, PE, PMP
Project Manager
Water/Wastewater

HDR
2379 Gateway Oaks Dr, #200
Sacramento, CA 95833
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

Criteria	Purpose	Description
Baseline		
Baseline Model	Update assumed operations to reflect current requirements and conditions.*	CalSim II 2020 Benchmark developed by Reclamation in coordination with DWR and CDFW.
Fixed Flows		
Trinity River Fixed	Reflect real conditions	Yes - flows held constant
Sites Facilities		
Sites Reservoir		
Reservoir capacity	Reflect project design	1.5 MAF for Alternatives 1 and 3, 1.3 MAF for Alternative 2
Dead pool size	Reflects project design and water quality considerations	120 TAF for export, 60 TAF for local use
Red Bluff Diversion/Tehama-Colusa Canal Authority Canal		
Diversion capacity	Reflect capacity at site	Up to 2,100 cfs - see following pages for description of diversion function **
Bypass flow	Stabilize flow, protect redds	3,250 cfs
Hamilton Diversion/Glenn-Colusa Irrigation District Main Canal		
Diversion capacity	Reflect capacity at site	1,800 cfs - see following pages for description of diversion function**
Bypass flow	Ensure proper fish screen function in oxbow	Up to 4,000 cfs
Glenn-Colusa Irrigation District maintenance window	Maintain earthen canal	2 weeks (January/February)
Dunnigan Pipeline		
Release capacity	Reflect design limit	1,000 cfs
Terminus	Reflect design	Colusa Basin Drain for Alt 1 and Alt 3, Sacramento River with turnout to Colusa Basin Drain for Alt 2
Location-Specific Regulations		
Bend Bridge Pulse Protection	Survival of emigrating juvenile salmon	Every pulse
Scaled Diversions	Ensure proper screen function	Rate of diversion controlled by screen design (see following pages)
Wilkins Slough Bypass Flow	Facilitate hatchery fish release	8,000 cfs in April and May; 5,000 cfs all other times

Note: Diversion criteria as of March 23,2021. Subject to change.

Criteria	Purpose	Description
Fremont Weir Notch Criteria	Limit encroachment on Reclamation obligation, maintain frequency and duration of spills	Versus no action alternative, there can be no more than 1% reduction in flow over weir when spill is less than 600 cfs and no more than a 10% reduction when flow over weir is between 600 and 6,000 cfs. No restriction when flows are greater than 6,000 cfs.
Net Delta Outflow Index (NDOI)	Do not impact implementation of existing regulations	Operations consistent with D-1641 as amended. CA SWP ITP requirements considered.
X2	Do not impact implementation of existing regulations	Operations consistent with 2019 BO, CA SWP ITP.
Delta Water Quality	Do not impact implementation of existing regulations	Operations consistent with Delta water quality requirements
*Spring pulse flow protection as identified in the 2019 ROC on LTO BiOp is included in the baseline and is preserved in all action alternatives. **Actual diversions would be slightly higher to account for losses between diversion locations and pumping-generating plants.		

Note: Diversion criteria as of March 23,2021. Subject to change.

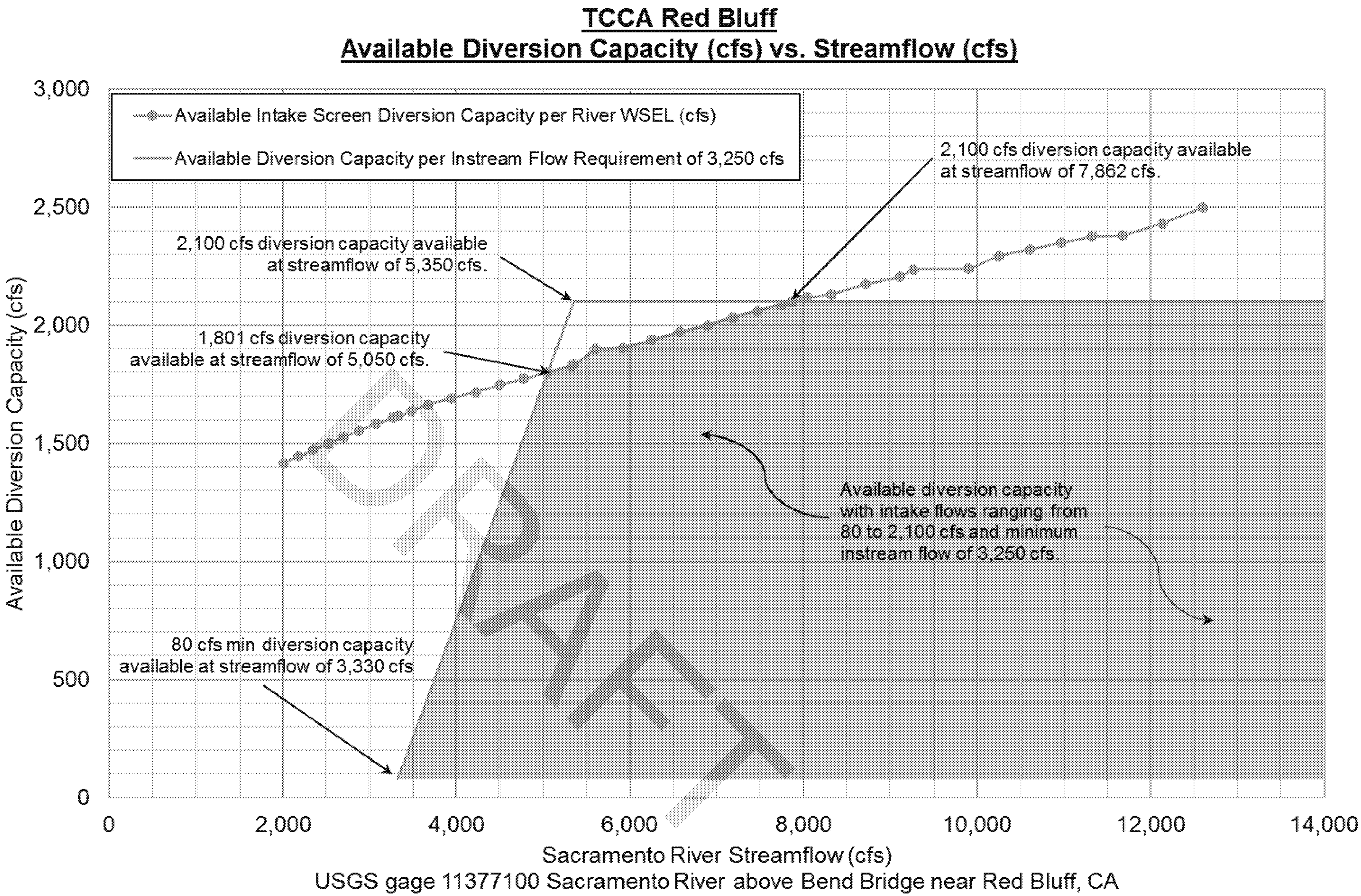
TCCA Red Bluff Facility Operations

Table 3. TCCA Red Bluff Available Diversion Capacity by Streamflow
Sites Project Authority – Sacramento River Intake Fish Screen Operations

Streamflow at Gage (cfs)	River WSEL at U/S Work Point (feet, NAVD88)	Available Facility Diversion Capacity (cfs)
2,010	241.2	1,417
2,175	241.3	1,445
2,350	241.4	1,472
2,525	241.5	1,500
2,700	241.6	1,527
2,875	241.7	1,554
3,075	241.8	1,582
3,275	241.9	1,609
3,330	241.9	1,617
3,475	242.0	1,637
3,675	242.1	1,664
3,950	242.2	1,692
4,225	242.3	1,719
4,500	242.4	1,746
4,775	242.5	1,774
5,050	242.6	1,801
5,325	242.7	1,829
5,350	242.7	1,835
5,600	242.9	1,900
5,925	243.1	1,904
6,250	243.2	1,938
6,575	243.4	1,973
6,900	243.5	2,000
7,184	243.6	2,034
7,468	243.7	2,062
7,751	243.8	2,089
7,862	243.8	2,100
8,035	243.9	2,117
8,319	244.0	2,130

8,714	244.1	2,175
9,109	244.3	2,206
9,266	244.4	2,237
9,898	244.5	2,240
10,254	244.6	2,295
10,610	244.7	2,322
10,965	244.8	2,350
11,321	244.9	2,377
11,677	245.0	2,380
12,139	245.1	2,432
12,600	245.2	2,500

(light shading)	Diversions limited by instream flow requirement of 3,250 cfs
(medium shading)	Diversions limited by River WSEL and submerged screen area
(dark shading)	No restrictions (assumes use of future Pump Nos. 2 and 10)



Draft_0013243

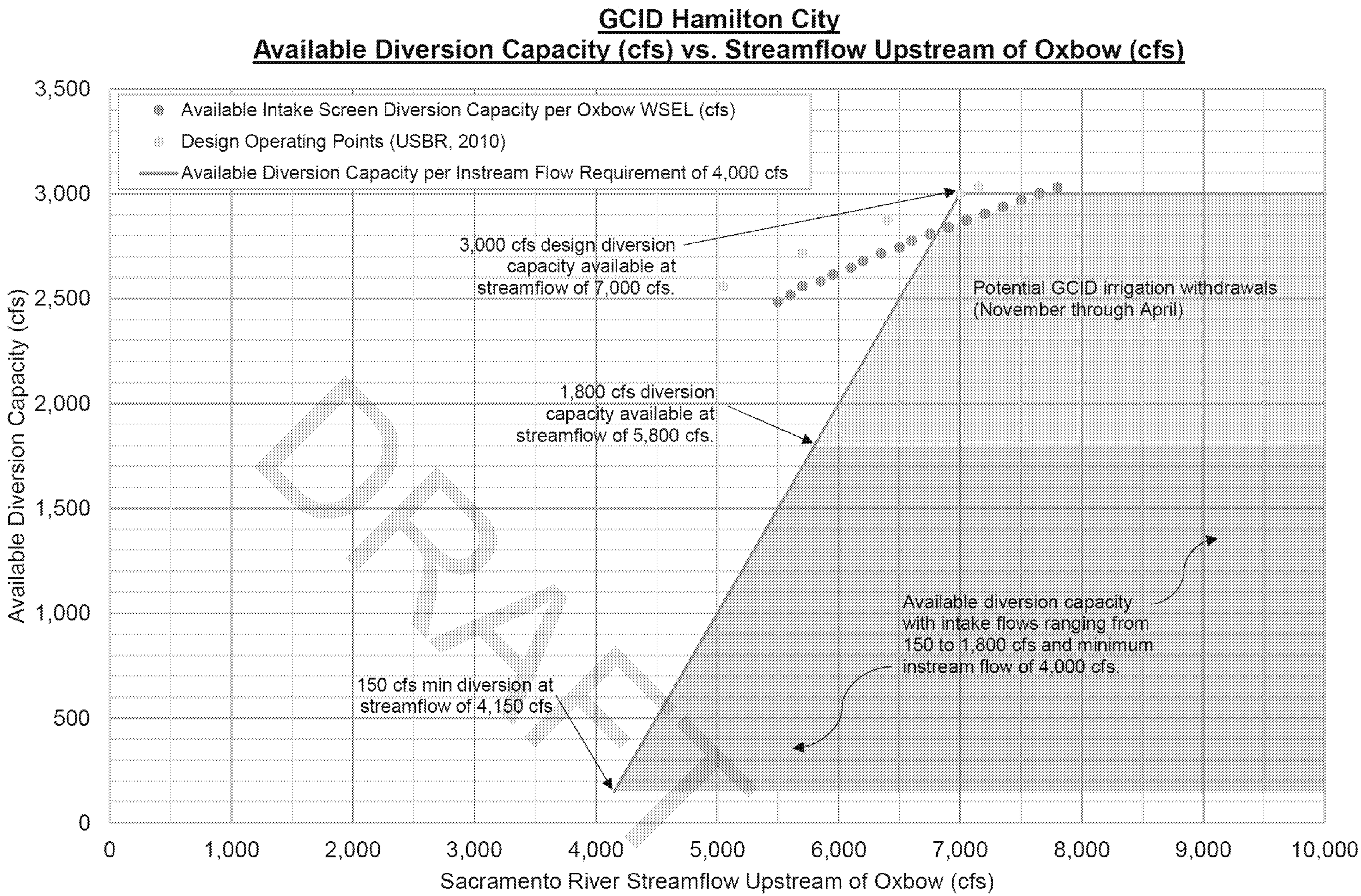
GCID Hamilton City Facility Operations

Table 4. GCID Hamilton City Available Diversion Capacity by Streamflow
Sites Project Authority – Sacramento River Intake Fish Screen Operations

Streamflow Upstream of Oxbow (cfs)	River WSEL at U/S Oxbow (feet, NGVD29)	Available Facility Diversion Capacity (cfs)
900	132.5	1,744
938	132.6	1,777
977	132.7	1,809
1,018	132.8	1,841
1,061	132.9	1,873
1,105	133.0	1,906
1,151	133.1	1,938
1,200	133.2	1,970
1,250	133.3	2,002
2,690	133.4	2,035
2,765	133.5	2,067
2,842	133.6	2,099
2,921	133.7	2,131
3,002	133.8	2,164
3,086	133.9	2,196
3,172	134.0	2,228
3,260	134.1	2,260
3,351	134.2	2,292
3,445	134.3	2,325
3,541	134.4	2,357
3,639	134.5	2,389
3,741	134.6	2,421
3,845	134.7	2,454
3,952	134.8	2,486
4,062	134.9	2,518
4,176	135.0	2,559
4,292	135.1	2,583
4,412	135.2	2,615
4,534	135.3	2,647
4,661	135.4	2,679

4,791	135.5	2,717
4,924	135.6	2,744
5,061	135.7	2,776
5,203	135.8	2,808
5,348	135.9	2,841
5,497	136.0 (begin possible gravity diversion)	2,874
5,650	136.1	2,905
5,807	136.2	2,937
5,969	136.3	2,969
6,135	136.4	3,002
6,306	136.5	3,031

(light shading)	Diversions limited by instream flow requirement of 4,000 cfs
(dark shading)	No restrictions, assuming GCID irrigation withdrawals are less than approximately 1,000 cfs


GCID Hamilton City
Available Diversion Capacity (cfs) vs. Streamflow Upstream of Oxbow (cfs)
Available Intake Screen Diversion Capacity per Oxbow WSEL (cfs)
Design Operating Points (USBR, 2010)
Available Diversion Capacity per Instream Flow Requirement of 4,000 cfs
3,000 cfs design diversion capacity available at streamflow of 7,000 cfs.
Potential GCID irrigation withdrawals (November through April)
1,800 cfs diversion capacity available at streamflow of 5,800 cfs.
Available diversion capacity with intake flows ranging from 150 to 1,800 cfs and minimum instream flow of 4,000 cfs.
150 cfs min diversion at streamflow of 4,150 cfs
DRAFT
Available Diversion Capacity (cfs)
0
500
1,000
1,500
2,000
2,500
3,000
3,500
Sacramento River Streamflow Upstream of Oxbow (cfs)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000

Sites Project Diversion Criteria Summary

Bend Bridge Pulse Protection
Fish presence and migration detection ceases diversion for 7 days.

Sacramento River at RBPP
3,250 cfs minimum bypass flow at all times.
Up to 2,100 cfs diverted to project during high flow events.

Sacramento River at Hamilton City Pump Station
4,000 cfs minimum bypass flow at all times.
Up to 1,800 cfs diverted to project during high flow events.

Sacramento River at Wilkins Slough
5,000 cfs minimum bypass flow. 8,000 cfs (Apr-May).

Fremont Weir Notch
Versus baseline conditions:

No more than 1% flow reduction when weir spill is less than 600 cfs.

No more than 10% flow reduction when weir spill is between 600 and 6,000 cfs.

No restriction with weir spills over 6,000 cfs.

Sacramento – San Joaquin River Delta
Delta must be in excess conditions and operations consistent with all applicable laws, regulations, biological opinions, and incidental take permits, and court orders in place at the time the diversion occurs.

Notes:
- **Diversions will only occur when the Sacramento River is not fully appropriated (Sept. 1st – June 15th)**
- **ALL conditions must be met to permit diversion to Sites**

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/6/2021 5:33:00 PM
To: Jerry Brown [jbrown@sitesproject.org]
Subject: RE: Diversion data
Attachments: Sites_Prop 1 Benefits Summary_20211006.docx

Hi Jerry – Below is an email to Anthony along with the attachment materials. Feel free to modify as you see fit. And happy for you to send or I can send. We have some summary PowerPoints and graphics on diversion criteria, but none have been updated with 10,700 cfs yet. We can do this tomorrow and get him a summary graphic if you think that would be more useful.

Anthony – Thanks again for your patience on this. Attached is a document that summarizes the Project's Proposition 1 benefits and provides a summary table of ecosystem benefits by water year type. Note that the water year type estimates for the refuge deliveries are deliveries at the refuge boundaries – so there is more Prop 1 water but some is removed for transportation losses. The same is true for the Yolo Bypass water, but there are minimal losses for this use.

In regard to diversion criteria, the Preliminary Project Description posted on the Authority's website provides quite a bit of detail on diversion criteria. I recently took a look at this and its generally all still applicable and relevant. However, one notable change is that we have added a mitigation measure into the Aquatics Resources Chapter (fisheries chapter) that includes a Wilkins Slough Bypass Flow of 10,700 cfs March through May. This is not reflected in the Preliminary Project Description but will be in the Revised Draft EIR/Supplemental Draft EIS when its released in mid-November. The Preliminary Project Description is here: Informational Materials - Sites Reservoir (sitesproject.org). Clink on the Fact Sheets and Documents tab. See the discussion starting on page 2-68 or page 73 of the PDF file.

Hope this information helps. Happy to answer any questions.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 12:45 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Can I look at these before you send to Anthony?

Sent from my iPhone

On Oct 6, 2021, at 11:54 AM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Sounds good. I am working on both of these and should have them to you later today or early tomorrow. Apologies for the delay and thank you for the reminder!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Wednesday, October 6, 2021 11:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

Yes, sorry for my lack of clarity. In addition to the description and quantities of Prop. 1 water, it would be good to get a summary of the latest on diversion criteria since it seems some of our eco colleagues are a bit focused on that… I don't need to get into the weeds on diversion criteria, but anything you have that could be easily transmitted would be great.

Thanks again,

Anthony M. Saracino
www.asaracino.com
916-952-8573
On Oct 6, 2021, 11:45 AM -0700, Alicia Forsythe <aforsythe@sitesproject.org>, wrote:

> Apologies Anthony. I had in my notes that we were going to send you a description and quantities for the Prop 1 water. Your email below says "diversion information". Is this referring to diversion criteria? Just want to make sure that I am getting you the correct info.
>
> Ali
>
> ----------------------
>
> Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org
>
>
>
> **From:** Anthony Saracino <anthony@asaracino.com>
> **Sent:** Tuesday, October 5, 2021 4:20 PM
> **To:** Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
> **Subject:** Diversion data

Hi guys,

Were you still planning on sending the diversion information? I'm starting to get asked questions about it and it would be helpful to come up to speed.

Cheers,

Anthony M. Saracino

www.asaracino.com

916-952-8573

Sites Reservoir Project
Summary of Proposition 1 Benefits and Estimated Ecosystem Benefits by Water Year Type
October 6, 2021

Summary of Proposition 1 Benefits

The Project was conditionally awarded Proposition 1 funding by the CWC to provide public benefits for flood damage reduction, recreation, and ecosystem benefits. The Project would provide these benefits by entering into a contract with DWR for the flood damage reduction and recreation benefits, a contract with CDFW for the ecosystem benefits, and a contract with the CWC for final funding award.

The Project would provide flood damage reduction benefits to portions of Colusa County, including Maxwell and the surrounding agricultural areas. Incidental storage in Sites Reservoir would capture and store flood flows from the Funks Creek and Stone Corral Creek watersheds. These flood damage reduction benefits are inherent to the Project design and would occur regardless of the Project's operations for water supply and water-related environmental benefits. The Project would provide recreation benefits through the three planned recreational areas around the reservoir.

The ecosystem benefits funded by the CWC include providing water for Incremental Level 4 Refuge water needs for Central Valley Project Improvement Act (CVPIA) refuges both north and south of the Delta and providing additional flow into the Yolo Bypass to benefit delta smelt (*Hypomesus transpacificus*). Incremental Level 4 Refuge water deliveries could occur in any water year type and at any time of year. For those refuges located south of the Delta, it is assumed that water would be moved from July to November through the Delta. Additional flows into the Yolo Bypass could occur at any time of year but are assumed to occur during the summer and fall months (August through October) of all water year types. These deliveries increase desirable food sources for delta smelt and other fish species in the late summer and early fall. The Authority envisions that CDFW would take an active role in managing the ecosystem water and would work with CDFW to schedule and adjust releases of ecosystem water to address real-time conditions and needs.

Estimated Proposition 1 Ecosystem Benefits by Water Year Type

ESTIMATED INCREMENTAL LEVEL 4 REFUGE WATER SUPPLY INCREASES DELIVERED TO THE REFUGE BOUNDARY (2030 AND 2070) (TAF/YEAR)

Period	North-of-the-Delta	South-of-the-Delta [b]	Total
2030 Results			
Long-Term Average [a]	5	11	17
Wet	0	0	0
Above Normal	9	5	14
Below Normal	9	13	22

Period	North-of-the-Delta	South-of-the-Delta [b]	Total
Dry	8	27	34
Critical	6	17	23
2070 Results			
Long-Term Average [a]	5	10	15
Wet	0	0	0
Above Normal	9	1	10
Below Normal	7	8	16
Dry	7	10	17
Critical	6	21	27

Source: CALSIM II.
Notes:
(a) Average weighted based on water-year frequency rates
(b) Includes both San Joaquin and Tulare Lake Refuge deliveries and based on San Joaquin Valley 60-20-20 Index Year Class.
TAF = thousand acre-feet

YOLO BYPASS SUPPLY INCREASES (2030 AND 2070) (TAF/YEAR)

Period	North-of-the-Delta
2030 Results	
Long-Term Average [a]	36
Wet	46
Above Normal	48
Below Normal	39
Dry	27
Critical	15
2070 Results	
Long-Term Average [a]	31
Wet	35
Above Normal	38
Below Normal	34
Dry	29
Critical	18

Source: CALSIM II. (2021)
Note:
(a) Average weighted based on water-year frequency rates
TAF = thousand acre-feet

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/6/2021 7:39:02 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Marcia Kivett [MKivett@sitesproject.org]
Subject: FW: Cumulative Flow

Please handle getting Stantec the Sites CalSim model runs requested that are reflected in our RDEIR/SDEIS. Please cc me and Marcia on your response. Thanks

---

From: "Okita, David@DWR" <David.Okita@water.ca.gov>
Date: Wednesday, October 6, 2021 at 4:23 PM
To: Jerry Brown <jbrown@sitesproject.org>, Fiona Sanchez <sanchezf@irwd.com>, "slee@ieua.org" <slee@ieua.org>, "Cowin, Mark" <mcowin@geiconsultants.com>, Mark Beuhler <mbeuhler@wswaterbank.com>
Cc: "Smith, Steven (Oakland)" <Steven.Smith6@aecom.com>, "Sun, Yung-Hsin" <yung-hsin.sun@stantec.com>
Subject: Cumulative Flow

As we discussed, we are doing some additional analysis for the Cumulative Flow Analysis to refine the results. We will be doing CalSim II post processing using data from Sites, Los Vaqueros, Harvest Water, Chino, Willow Springs and Kern Fan.

Stantec, a sub consultant to AECOM for the CEQA Initial study is doing the work with review and input from Aaron Miller (DWR) and Chandra Chilmakuri (State Water Contractors).

Below is the request of information from Stantec. Note that we will not be doing the future climate change scenarios in this analysis. We know that each project may be updating their feasibility studies and doing new modeling. If you have new modeling that you can share that would be preferred over modeling done for the original application please provide this. **Please send information directly to Yung-Hsin Sun at Stantec at the email address above.**

If your project did not use CALSIM, any modeling or spreadsheets that represents your project is requested.

Note that we will be using a new version of CALSIM2 for this analysis. This is the same version that will shortly be sent out to WSIP projects for your use that includes updated regulatory conditions and other updates.

If you have any questions about the request please contact Yung-Hsin directly - I am not familiar with CalSim modeling.

Additional information that we would need is the complete CalSim II model packages (i.e., input and output files) for each project.

In addition to the CalSim II model packages, we would also need any pre-processing and/or post-processing tools (e.g., Excel spreadsheets) that were used in the analysis of pulse flows. This will help us in understanding how individual projects were implemented in the WSIP application and start determining an approach to evaluate the cumulative effects of these projects implemented together.

David Okita, PE
Department of Water Resources
530 902-7588

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/7/2021 5:54:22 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Re: Diversion data

Forgot to mention in my other email on this subject - we should add a mention about how the federal feasibility identified how reclamation's investment could go toward environmental purposes. Right now this is modeled as ops flex (need to verify) but there is potential for these benefits to go towards additional refuge supplies, anadrymous fish and/or delta smelt. Not prop 1 but certainly for environmental purposes.

Sent from my iPhone

On Oct 6, 2021, at 5:33 PM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Hi Jerry – Below is an email to Anthony along with the attachment materials. Feel free to modify as you see fit. And happy for you to send or I can send. We have some summary PowerPoints and graphics on diversion criteria, but none have been updated with 10,700 cfs yet. We can do this tomorrow and get him a summary graphic if you think that would be more useful.

Anthony – Thanks again for your patience on this. Attached is a document that summarizes the Project's Proposition 1 benefits and provides a summary table of ecosystem benefits by water year type. Note that the water year type estimates for the refuge deliveries are deliveries at the refuge boundaries – so there is more Prop 1 water but some is removed for transportation losses. The same is true for the Yolo Bypass water, but there are minimal losses for this use.

In regard to diversion criteria, the Preliminary Project Description posted on the Authority's website provides quite a bit of detail on diversion criteria. I recently took a look at this and its generally all still applicable and relevant. However, one notable change is that we have added a mitigation measure into the Aquatics Resources Chapter (fisheries chapter) that includes a Wilkins Slough Bypass Flow of 10,700 cfs March through May. This is not reflected in the Preliminary Project Description but will be in the Revised Draft EIR/Supplemental Draft EIS when its released in mid-November. The Preliminary Project Description is here: Informational Materials - Sites Reservoir (sitesproject.org). Clink on the Fact Sheets and Documents tab. See the discussion starting on page 2-68 or page 73 of the PDF file.

Hope this information helps. Happy to answer any questions.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 12:45 PM

To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Can I look at these before you send to Anthony?

Sent from my iPhone

On Oct 6, 2021, at 11:54 AM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Sounds good. I am working on both of these and should have them to you later today or early tomorrow. Apologies for the delay and thank you for the reminder!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Wednesday, October 6, 2021 11:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

Yes, sorry for my lack of clarity. In addition to the description and quantities of Prop. 1 water, it would be good to get a summary of the latest on diversion criteria since it seems some of our eco colleagues are a bit focused on that… I don't need to get into the weeds on diversion criteria, but anything you have that could be easily transmitted would be great.

Thanks again,

Anthony M. Saracino
www.asaracino.com
916-952-8573
On Oct 6, 2021, 11:45 AM -0700, Alicia Forsythe <aforsythe@sitesproject.org>, wrote:

Apologies Anthony. I had in my notes that we were going to send you a description and quantities for the Prop 1 water. Your email below says "diversion information". Is this referring to diversion criteria? Just want to make sure that I am getting you the correct info.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Tuesday, October 5, 2021 4:20 PM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Diversion data

Hi guys,

Were you still planning on sending the diversion information? I'm starting to get asked questions about it and it would be helpful to come up to speed.

Cheers,

Anthony M. Saracino
www.asaracino.com
916-952-8573

<Sites_Prop 1 Benefits Summary_20211006.docx>

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 10/7/2021 8:52:09 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Williams, Nicole [Nicole.Williams@icf.com]; Briard, Monique [Monique.Briard@icf.com]
CC: Linda Fisher [Linda.Fisher@hdrinc.com]
Subject: RE: Revision Requests: Sites RDEIR/SDEIS

Yes, I sent Melissa an email yesterday requesting sample text for mitigation. I will also request a sentence to include for No Project Alternative. However, I thought Chapter 3 lays out the approach pretty well:

NEPA has no baseline requirement, but, similar to CEQA, it requires analysis of the No Action Alternative, which represents a projection of current and reasonably foreseeable future conditions, including the continuation of preexisting, ongoing plans, programs, and operations, without Alternatives 1, 2, or 3 being implemented. Like the CEQA No Project Alternative, the NEPA No Action Alternative is intended to provide a comparative analysis of the impacts of the proposed action and the impacts of not proceeding with the action.

I will ask for a sample sentence.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, October 7, 2021 7:56 AM
To: Williams, Nicole <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Briard, Monique <Monique.Briard@icf.com>
Cc: Linda Fisher <Linda.Fisher@hdrinc.com>
Subject: RE: Revision Requests: Sites RDEIR/SDEIS

Laurie – Can you work on these items with Melissa?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Williams, Nicole <Nicole.Williams@icf.com>
Sent: Thursday, October 7, 2021 7:35 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Briard, Monique <Monique.Briard@icf.com>
Cc: Linda Fisher <Linda.Fisher@hdrinc.com>
Subject: RE: Revision Requests: Sites RDEIR/SDEIS

Morning -

- For the discussion of NEPA mitigation regulatory requirements and how they differ from CEQA mitigation requirements in Section 3.2.6 – **Melissa confirmed it was okay to reference mitigation in the NEPA conclusions when we were working Batch 1 and I'm trying to find the email because she included some text related to NEPA and Mitigation. However, absent that, I too would prefer they send an example of exactly what they are looking for.**

- For Please revise all NEPA conclusions to reference back to No Project Alternative. Currently many of them do not explicitly reference/compare to any baseline **– need confirmation that this every NEPA conclusion in every chapter. Need the sentence they would like so we can just drop it in.**

Cheers, Nicole

NICOLE L. WILLIAMS
Senior Environmental Planner
ICF
o 916.231.9614
icf.com

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, October 6, 2021 5:39 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Williams, Nicole <Nicole.Williams@icf.com>; Briard, Monique <Monique.Briard@icf.com>
Cc: Linda Fisher <Linda.Fisher@hdrinc.com>
Subject: RE: Revision Requests: Sites RDEIR/SDEIS

Wow. These comments are more than I am used to seeing.

I am good with ICF making these changes.

I think we should ask for any example text on the **discussion of NEPA mitigation regulatory requirements and how they differ from CEQA mitigation requirements in Section 3.2.6.** Or we should send them the text that we plan to add so they can review it.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Wednesday, October 6, 2021 4:55 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Nicole Williams <Nicole.Williams@icf.com>; Monique Briard <monique.briard@icf.com>
Cc: Linda Fisher <Linda.Fisher@hdrinc.com>
Subject: Fwd: Revision Requests: Sites RDEIR/SDEIS

Direction from Reclamation is below. Ali, please confirm that ICF can start making these changes. Nicole, please let me know if you have questions and I can schedule a quick call with Melissa.

Begin forwarded message:

From: "Dekar, Melissa D" <mdekar@usbr.gov>
Date: October 6, 2021 at 4:18:55 PM PDT
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>, "Fisher, Linda" <Linda.Fisher@hdrinc.com>

Cc: "King, Vanessa M" <vking@usbr.gov>
Subject: Revision Requests: Sites RDEIR/SDEIS

Hi Laurie,

In an effort to provide a more time for requested revisions beyond what we intend to share back as tracked changes, here are three revision requests.

Please add language regarding the use of the term "significance".
Would you please adjust the following example text to be applicable to our document and insert it upfront in the description of how the document is organized – probably somewhere within or near Section 3.2.5?
Please include the highlighted text verbatim.

The impacts of each alternative are discussed by resource area and alternative. Each resource area section is structured so that an *italicized* impact statement introduces potential changes that could occur from implementation of each alternative. A discussion of how the resource area would be affected by the impact then follows this initial statement. The impact discussions for the No Project Alternative is concluded with a determination that indicates if there is no impact to a resource area or if the impact to a resource area is beneficial, less than significant, or significant. Pursuant to NEPA, significance is used to determine whether an EIS or some other level of documentation is required, and once the decision to prepare an EIS is made, the magnitude of the impact is evaluated and no further judgment of significance is required. Therefore, any determinations of significance are for CEQA purposes only.

Please add a discussion of NEPA mitigation regulatory requirements and how they differ from CEQA mitigation requirements in Section 3.2.6.

Please revise all NEPA conclusions to reference back to No Project Alternative. Currently many of them do not explicitly reference/compare to any baseline.

- since this the no project alternative is defined upfront as identical to the NAA, referencing back to the no project alternative is OK in the draft. We would like this changed in the final so that the term "No Project Alternative/No Action Alternative" is used in each place where "no project alternative" is currently used.

Please let me know if you have questions.

Thanks,
Melissa

Melissa Dekar
Natural Resources Specialist
Environmental Compliance and Conservation Branch, CGB-152
2800 Cottage Way, Sacramento, CA, 95825
Interior Region 10, Bureau of Reclamation
916-978-6153 mdekar@usbr.gov

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 10/7/2021 8:57:36 AM
To: steve.micko@jacobs.com; Hassrick, Jason (Jason.Hassrick@icf.com) [Jason.Hassrick@icf.com]; Lecky, Jim [jim.lecky@icf.com]; Hendrick, Mike [Mike.Hendrick@icf.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]
Subject: FW: Sites Fremont Weir Diversion Criteria

FYI

John Spranza

D 916.679.8858 M 818.640.2487

From: Sherrick, Robert@Wildlife <Robert.Sherrick@Wildlife.ca.gov>
Sent: Wednesday, October 6, 2021 4:35 PM
To: Spranza, John <John.Spranza@hdrinc.com>
Subject: RE: Sites Fremont Weir Diversion Criteria

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

I haven't made any effort to isolate Feather River impacts. Right now I'm looking at hourly flows, and I think the travel time might be a bigger issue, one that even daily simulations won't represent accurately. If I can get a rough handle on the attenuation of the Sacramento hydrograph, afterward I might see if I can tease out a dual-flow rating curve.

Rob Sherrick
916-516-4233

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Wednesday, October 6, 2021 2:24 PM
To: Sherrick, Robert@Wildlife <Robert.Sherrick@Wildlife.ca.gov>
Subject: RE: Sites Fremont Weir Diversion Criteria

WARNING: This message is from an external source. Verify the sender and exercise caution when clicking links or opening attachments.

Thanks for sending this over Rob, the Feather component is noted, we have been seeing the same thing in the modeling done for the big notch project. Have you guys been able to isolate the backwater effect at all?

John Spranza

D 916.679.8858 M 818.640.2487

From: Sherrick, Robert@Wildlife <Robert.Sherrick@Wildlife.ca.gov>
Sent: Wednesday, October 6, 2021 2:16 PM
To: Spranza, John <John.Spranza@hdrinc.com>
Subject: FW: Sites Fremont Weir Diversion Criteria

Hi John,

Kristal asked me to send this to you. As you can see it was developed in collaboration with Steve Micko after we met last week. The Fremont_Stage/Verona_Flow was roughly estimated from hourly CDEC data. You can see from some of the plots that there is a large range of observed values. The issue leading to this change was that the Calsim rating for the notch is based on the Sacramento river at Verona (including Feather River). As you can see the updated curve doesn't make a large difference in the estimated notch flow.

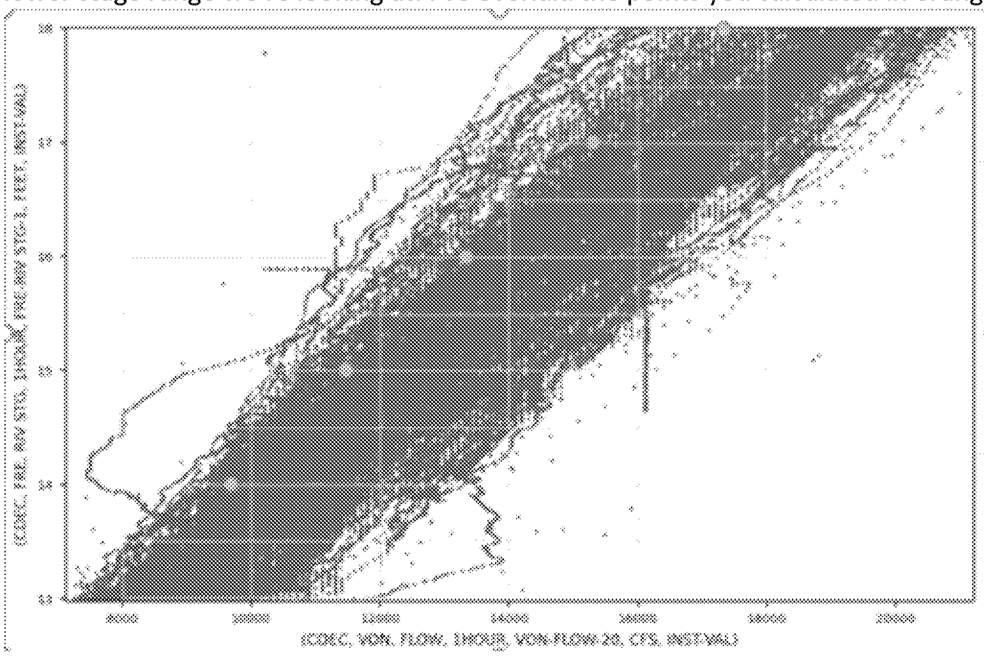
This rating curve spreadsheet was made to explore potential notch protection alternatives and does not imply an endorsement or agreement from the Dept. of Fish and Wildlife.

Rob Sherrick, PE
Senior Hydraulic Engineer
Conservation Engineering
California Department of Fish and Wildlife
M: 916-516-4233

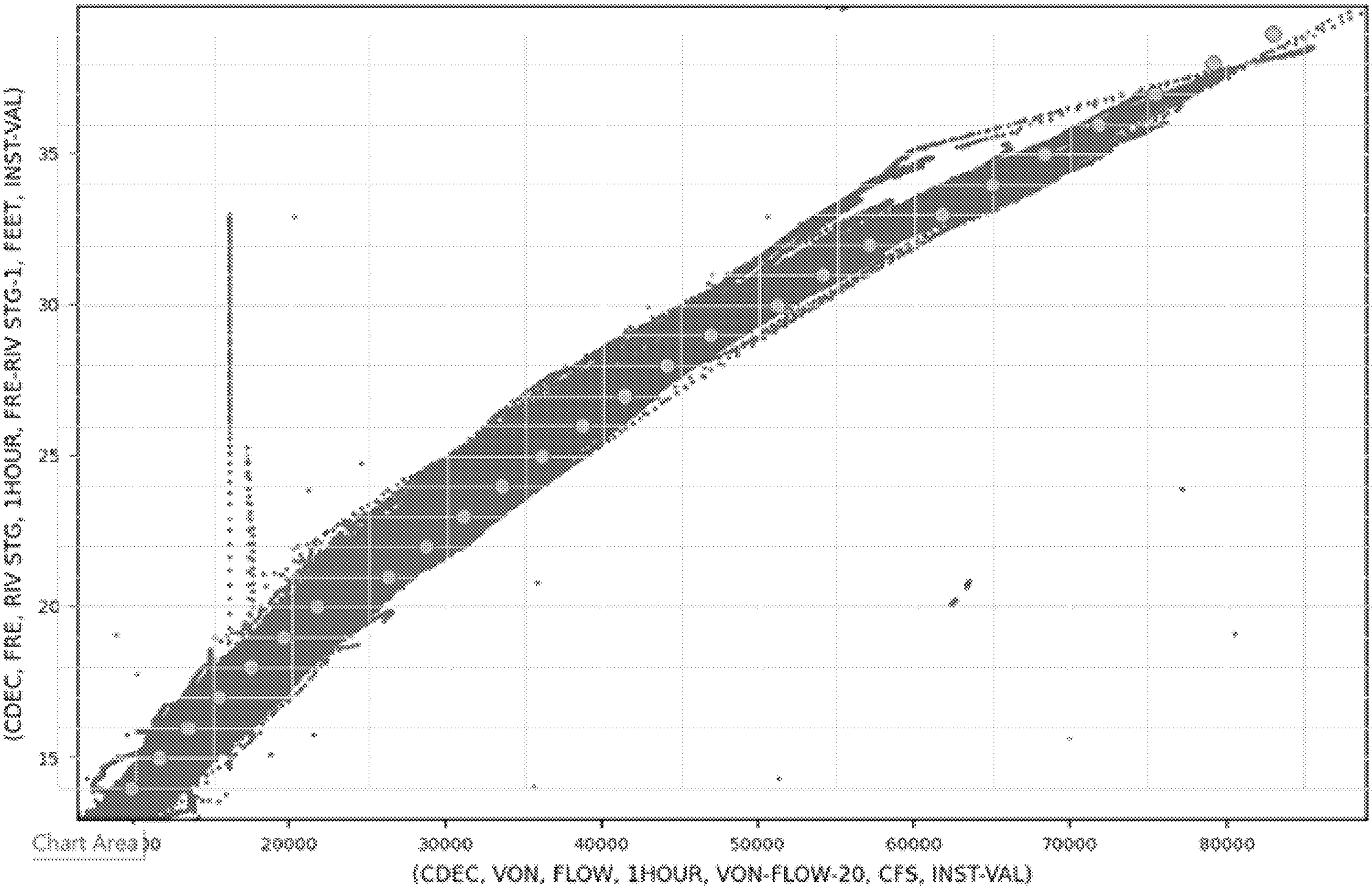
From: Sherrick, Robert@Wildlife
Sent: Friday, October 1, 2021 3:34 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Paccassi, Michael@Wildlife <Michael.Paccassi@Wildlife.ca.gov>
Cc: Heydinger, Erin <erin.heydinger@hdrinc.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: Sites Fremont Weir Diversion Criteria

Hi Steve,

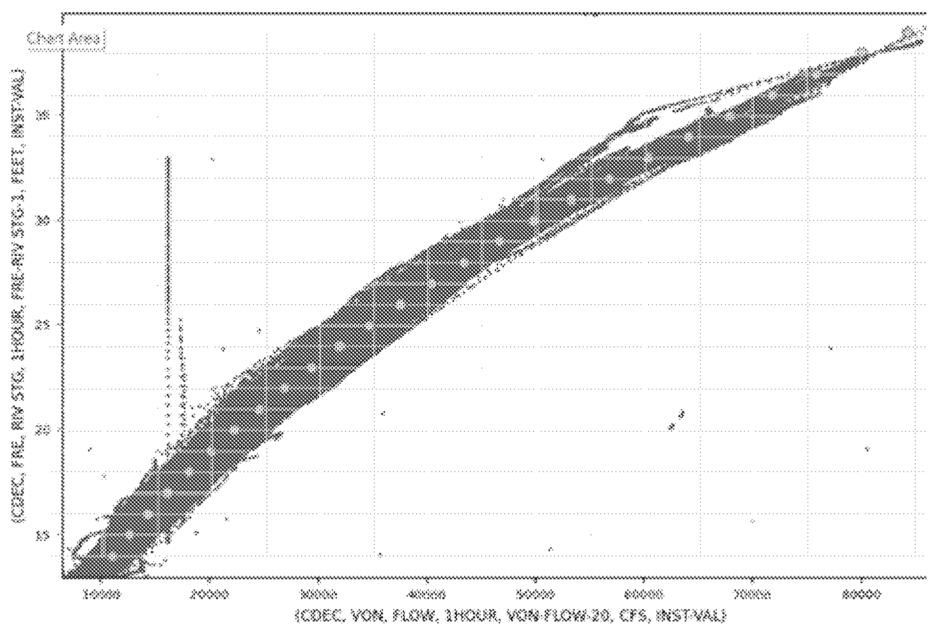
I took a bit of a different approach. I have CDEC hourly data from 1984 to present (282,000 data pairs), and I've made the stage adjustment to Fremont stage prior to 2016. Here is a scatter plot of FRE stage to VER flow zoomed in on the lower stage range we're looking at. I've overlaid the points you calculated in orange.



And here's the full curve:



Visually you can see the discontinuity switching from a 2 ft offset at 20 feet, to a 1 ft offset at 21 feet. Even still, almost all of your values except at 38, 39 feet fall within the range of observed values. Still, I'd like to try to distill this down to a middle, high, and low curves. For now, I have estimated a middle curve, which I think plots a little better, and doesn't have a discontinuity from 20-21 feet. I've put the numbers in the attached copy of the workbook, and plotted here (and off to the right on the main worksheet):



As for the substance, I see that the percent values are higher flow rates (good), but with close to the same stage change in the notch. Looks good to me.

Thank you!

Rob Sherrick
916-516-4233

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Friday, October 1, 2021 12:02 PM
To: Paccassi, Michael@Wildlife <Michael.Paccassi@Wildlife.ca.gov>; Sherrick, Robert@Wildlife <Robert.Sherrick@Wildlife.ca.gov>
Cc: Heydinger, Erin <erin.heydinger@hdrinc.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: Sites Fremont Weir Diversion Criteria

Hi Michael and Rob,

Following-up on yesterday's call...

I took a wag at adjusting the proposed Fremont Weir diversion criteria to consider Sac R at Verona instead of Sac R at Fremont.
See columns Q through V on the "RatingCurves" sheet for the resulting criteria.
I also added two new sheets:

- SacR_Verona_RatingCurve
  - CDEC rating table for Sacramento River at Verona
- StageDifferential
  - Compares difference in stage at Sac R at Verona and Sac R at Fremont

Let me know what you think about approach.
I'm open to making adjustments. Just want to make sure I'm going in the right direction.

Best,
Steve

-----Original Appointment-----
From: Micko, Steve/SAC
Sent: Thursday, September 30, 2021 11:47 AM
To: Micko, Steve/SAC; Michael.Paccassi@Wildlife.ca.gov; Sherrick, Robert@Wildlife; Thayer, Reed/SAC
Cc: Heydinger, Erin; Leaf, Rob/SAC
Subject: Sites Fremont Weir Diversion Criteria
When: Thursday, September 30, 2021 4:00 PM-5:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Hi Mike, Rob and Reed,

Let me now if you're available to meet at 4 PM today to discuss details on the proposed Fremont Weir diversion criteria.
If no, I'm available anytime before noon on Friday.

Feel free to forward the meeting invite to anyone you see fit.

Best,
Steve

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Join with a video conferencing device
493366865@t.plcm.vc
Video Conference ID: 116 052 869 5
Alternate VTC instructions

Or call in (audio only)
+1 323-886-6924,,359696212# United States, Los Angeles
Phone Conference ID: 359 696 212#
Find a local number | Reset PIN

Learn More | Meeting options

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/7/2021 10:23:28 AM
To: Jerry Brown [jbrown@sitesproject.org]
Subject: RE: Diversion data

Yep. I pulled the benefit deliveries from the State Feasibility Report and confirmed with Erin that these numbers are still current. I also saw your other email on the Reclamation Feasibility and opportunities for more environmental benefits there. I'll get an email to Anthony shortly and copy you.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 |
aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 7:32 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

I'm fine with you sending to Anthony and cc me. Before you do so can you confirm:

1. You pulled the ecosystem benefit deliveries from the state feasibility report.

Thanks

From: Alicia Forsythe <aforsythe@sitesproject.org>
Date: Wednesday, October 6, 2021 at 5:33 PM
To: Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Diversion data

Hi Jerry – Below is an email to Anthony along with the attachment materials. Feel free to modify as you see fit. And happy for you to send or I can send. We have some summary PowerPoints and graphics on diversion criteria, but none have been updated with 10,700 cfs yet. We can do this tomorrow and get him a summary graphic if you think that would be more useful.

Anthony – Thanks again for your patience on this. Attached is a document that summarizes the Project's Proposition 1 benefits and provides a summary table of ecosystem benefits by water year type. Note that the water year type estimates for the refuge deliveries are deliveries at the refuge boundaries – so there is more Prop 1 water but some is removed for transportation losses. The same is true for the Yolo Bypass water, but there are minimal losses for this use.

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Hope this information helps. Happy to answer any questions.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 12:45 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Can I look at these before you send to Anthony?

Sent from my iPhone

On Oct 6, 2021, at 11:54 AM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Sounds good. I am working on both of these and should have them to you later today or early tomorrow. Apologies for the delay and thank you for the reminder!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.

From: Anthony Saracino <anthony@asaracino.com>
Sent: Wednesday, October 6, 2021 11:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

Yes, sorry for my lack of clarity. In addition to the description and quantities of Prop. 1 water, it would be good to get a summary of the latest on diversion criteria since it seems some of our eco colleagues are a bit focused on that… I don't need to get into the weeds on diversion criteria, but anything you have that could be easily transmitted would be great.

Thanks again,

Anthony M. Saracino
www.asaracino.com
916-952-8573
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Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Tuesday, October 5, 2021 4:20 PM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Diversion data

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Cheers,

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916-952-8573

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/7/2021 10:34:50 AM
To: Anthony Saracino [anthony@asaracino.com]
CC: Jerry Brown [jbrown@sitesproject.org]
Subject: Diversion data
Attachments: Sites_Prop 1 Benefits Summary_20211006.docx

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It is important to note that the Federal Feasibility Report identified the opportunities for Reclamation's investment in the Project. Right now Reclamations investment is modelled as "op flex" – meeting CVP obligations, including environmental and contractual obligations. Op Flex is relatively new "use" in Feasibility Studies – previously, feasibility reports focused on specific environmental benefits for the Reclamation investment. We do see the possibility for Reclamation to dedicate its water to environmental purposes, such as additional IL4 Refuge Water Supply, anadromous fish benefits, delta outflow, etc., increasing the overall ecosystem benefits of the project beyond those current planned under Proposition 1.

In regard to diversion criteria, the Preliminary Project Description posted on the Authority's website provides quite a bit of detail on diversion criteria. I recently took a look at this and its generally all still applicable and relevant. However, one notable change is that we have added a mitigation measure into the Aquatics Resources Chapter (fisheries chapter) that includes a Wilkins Slough Bypass Flow of 10,700 cfs March through May. This is not reflected in the Preliminary Project Description but will be in the Revised Draft EIR/Supplemental Draft EIS when its released in mid-November. The Preliminary Project Description is here: Informational Materials - Sites Reservoir (sitesproject.org). Clink on the Fact Sheets and Documents tab. See the discussion starting on page 2-68 or page 73 of the PDF file.

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---

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www.asaracino.com
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>
> ----------------------
>
> Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org
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> **From:** Anthony Saracino <anthony@asaracino.com>
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> **Subject:** Diversion data

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Cheers,

Anthony M. Saracino
www.asaracino.com
916-952-8573

Sites Reservoir Project
Summary of Proposition 1 Benefits and Estimated Ecosystem Benefits by Water Year Type
October 6, 2021

Summary of Proposition 1 Benefits

The Project was conditionally awarded Proposition 1 funding by the CWC to provide public benefits for flood damage reduction, recreation, and ecosystem benefits. The Project would provide these benefits by entering into a contract with DWR for the flood damage reduction and recreation benefits, a contract with CDFW for the ecosystem benefits, and a contract with the CWC for final funding award.

The Project would provide flood damage reduction benefits to portions of Colusa County, including Maxwell and the surrounding agricultural areas. Incidental storage in Sites Reservoir would capture and store flood flows from the Funks Creek and Stone Corral Creek watersheds. These flood damage reduction benefits are inherent to the Project design and would occur regardless of the Project's operations for water supply and water-related environmental benefits. The Project would provide recreation benefits through the three planned recreational areas around the reservoir.

The ecosystem benefits funded by the CWC include providing water for Incremental Level 4 Refuge water needs for Central Valley Project Improvement Act (CVPIA) refuges both north and south of the Delta and providing additional flow into the Yolo Bypass to benefit delta smelt (*Hypomesus transpacificus*). Incremental Level 4 Refuge water deliveries could occur in any water year type and at any time of year. For those refuges located south of the Delta, it is assumed that water would be moved from July to November through the Delta. Additional flows into the Yolo Bypass could occur at any time of year but are assumed to occur during the summer and fall months (August through October) of all water year types. These deliveries increase desirable food sources for delta smelt and other fish species in the late summer and early fall. The Authority envisions that CDFW would take an active role in managing the ecosystem water and would work with CDFW to schedule and adjust releases of ecosystem water to address real-time conditions and needs.

Estimated Proposition 1 Ecosystem Benefits by Water Year Type

ESTIMATED INCREMENTAL LEVEL 4 REFUGE WATER SUPPLY INCREASES DELIVERED TO THE REFUGE BOUNDARY (2030 AND 2070) (TAF/YEAR)

Period	North-of-the-Delta	South-of-the-Delta [b]	Total
2030 Results			
Long-Term Average [a]	5	11	17
Wet	0	0	0
Above Normal	9	5	14
Below Normal	9	13	22
Dry	8	27	34
Critical	6	17	23
2070 Results			
Long-Term Average [a]	5	10	15
Wet	0	0	0
Above Normal	9	1	10
Below Normal	7	8	16
Dry	7	10	17
Critical	6	21	27

Source: CALSIM II.
Notes:
(a) Average weighted based on water-year frequency rates
(b) Includes both San Joaquin and Tulare Lake Refuge deliveries and based on San Joaquin Valley 60-20-20 Index Year Class.
TAF = thousand acre-feet

YOLO BYPASS SUPPLY INCREASES (2030 AND 2070) (TAF/YEAR)

Period	North-of-the-Delta
2030 Results	
Long-Term Average [a]	36
Wet	46
Above Normal	48
Below Normal	39
Dry	27
Critical	15
2070 Results	
Long-Term Average [a]	31
Wet	35
Above Normal	38
Below Normal	34
Dry	29
Critical	18

Source: CALSIM II. (2021)
Note:
(a) Average weighted based on water-year frequency rates
TAF = thousand acre-feet

From: Anthony Saracino [anthony@asaracino.com]
Sent: 10/7/2021 10:48:36 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Jerry Brown [jbrown@sitesproject.org]
Subject: Re: Diversion data

Hi Ali,

Thanks very much, this is very helpful. I will reach out if I have any questions.

Cheers,

Anthony M. Saracino
www.asaracino.com
916-952-8573

On Oct 7, 2021, 10:34 AM -0700, Alicia Forsythe <aforsythe@sitesproject.org>, wrote:

Anthony – Thanks again for your patience on this. Attached is a document that summarizes the Project's Proposition 1 benefits and provides a summary table of ecosystem benefits by water year type. Note that the water year type estimates for the refuge deliveries are deliveries at the refuge boundaries – so there is more Prop 1 water but some is removed for transportation losses. The same is true for the Yolo Bypass water, but there are minimal losses for this use.

It is important to note that the Federal Feasibility Report identified the opportunities for Reclamation's investment in the Project. Right now Reclamations investment is modelled as "op flex" – meeting CVP obligations, including environmental and contractual obligations. Op Flex is relatively new "use" in Feasibility Studies – previously, feasibility reports focused on specific environmental benefits for the Reclamation investment. We do see the possibility for Reclamation to dedicate its water to environmental purposes, such as additional IL4 Refuge Water Supply, anadromous fish benefits, delta outflow, etc., increasing the overall ecosystem benefits of the project beyond those current planned under Proposition 1.

In regard to diversion criteria, the Preliminary Project Description posted on the Authority's website provides quite a bit of detail on diversion criteria. I recently took a look at this and its generally all still applicable and relevant. However, one notable change is that we have added a mitigation measure into the Aquatics Resources Chapter (fisheries chapter) that includes a Wilkins Slough Bypass Flow of 10,700 cfs March through May. This is not reflected in the Preliminary Project Description but will be in the Revised Draft EIR/Supplemental Draft EIS when its released in mid-November. The Preliminary Project Description is here: Informational Materials - Sites Reservoir (sitesproject.org). Clink on the Fact Sheets and Documents tab. See the discussion starting on page 2-68 or page 73 of the PDF file.

Hope this information helps. Happy to answer any questions.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 12:45 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Can I look at these before you send to Anthony?

Sent from my iPhone

On Oct 6, 2021, at 11:54 AM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Sounds good. I am working on both of these and should have them to you later today or early tomorrow. Apologies for the delay and thank you for the reminder!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Wednesday, October 6, 2021 11:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

Yes, sorry for my lack of clarity. In addition to the description and quantities of Prop. 1 water, it would be good to get a summary of the latest on diversion criteria since it seems some of our eco colleagues are a bit focused on that… I don't need to get into the weeds on diversion criteria, but anything you have that could be easily transmitted would be great.

Thanks again,

Anthony M. Saracino

www.asaracino.com

916-952-8573

On Oct 6, 2021, 11:45 AM -0700, Alicia Forsythe <aforsythe@sitesproject.org>, wrote:

Apologies Anthony. I had in my notes that we were going to send you a description and quantities for the Prop 1 water. Your email below says "diversion information". Is this referring to diversion criteria? Just want to make sure that I am getting you the correct info.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Anthony Saracino <anthony@asaracino.com>
Sent: Tuesday, October 5, 2021 4:20 PM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Diversion data

Hi guys,

Were you still planning on sending the diversion information? I'm starting to get asked questions about it and it would be helpful to come up to speed.

Cheers,

Anthony M. Saracino

www.asaracino.com

916-952-8573

From: Luu, Henry [Henry.Luu@hdrinc.com]
Sent: 10/7/2021 11:49:04 AM
To: Marcia Kivett [MKivett@sitesproject.org]; Marcia Kivett [MKivett@sitesproject.org]; Jerry Brown [jbrown@sitesproject.org]; Michael Azevedo [mjazevedo@countyofcolusa.com]; Thad Bettner [tbettner@gcid.net]; Rob Kunde [rkunde@wrmwsd.com]; Eric Leitterman [ELeitterman@valleywater.org]; Robert Cheng [RCheng@cvwd.org]; William Vanderwaal [wvanderwaal@rd108.org]; druiz@westsidewd.com; Bob Tincher [bobt@sbvmwd.com]; fhernandez@cityofamericancanyon.org; AFlores (AFlores@zone7water.com) [AFlores@zone7water.com]; JSutton@tccanal.com; Randall Neudeck [rneudeck@mwdh2o.com]; Dirk Marks [dmarks@scvwa.org]; Wang,Chuching [cwang@mwdh2o.com]; Petya Vasileva [PVasileva@cvwd.org]; Xie, Lillian [lxie@zone7water.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Rude, Pete/RDD [Pete.Rude@jacobs.com]; Forrest, Michael [michael.forrest@aecom.com]; jeff.herrin@aecom.com; Alicia Forsythe [aforsythe@sitesproject.org]; bennett@irwd.com
CC: Kayla Mendonca [kmendonca@gcid.net]; mspooner@gcid.net; Holly Dawley [hdawley@gcid.net]; Alexander, Jeriann [jalexander@fugro.com]; Smith, Michael (orange) [michael.g.smith@aecom.com]
Subject: RE: Reservoir Operations & Engineering Workgroup
Attachments: OpsEngWG-20211007.pdf

All,

Attached are today's presentation slides.

Thank you for your time,

Henry H. Luu, PE
D 916.679.8857 M 916.754.7566

hdrinc.com/follow-us

-----Original Appointment-----
From: Marcia Kivett <MKivett@sitesproject.org>
Sent: Thursday, April 29, 2021 7:12 AM
To: Marcia Kivett; Jerry Brown; Luu, Henry; Michael Azevedo ; Thad Bettner ; Rob Kunde; Eric Leitterman; Robert Cheng; William Vanderwaal; druiz@westsidewd.com; Bob Tincher; fhernandez@cityofamericancanyon.org; AFlores (AFlores@zone7water.com); JSutton@tccanal.com; Randall Neudeck; Dirk Marks; Wang,Chuching; Petya Vasileva; Xie, Lillian; Heydinger, Erin; Rude, Pete/RDD; Forrest, Michael; Herrin, Jeff; Ali Forsythe; bennett@irwd.com
Cc: Kayla Mendonca; mspooner@gcid.net; Holly Dawley; Alexander, Jeriann; Smith, Michael (orange)
Subject: Reservoir Operations & Engineering Workgroup
When: Thursday, October 7, 2021 10:00 AM-11:30 AM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Please see the attached agenda.

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)

+1 213-379-5743,,698502891# United States, Los Angeles

(888) 404-2493,,698502891# United States (Toll-free)

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A Brown and Caldwell Teams meeting has been created for this event.

Learn More | Help | Meeting options

Ad Hoc Operations and Engineering Workgroup

October 7, 2021

Sites

Introductions and Opening Remarks

Rob Kunde and Mike Azevedo

Sites

Preliminary Planning for Design-Level Geotechnical Investigations

Henry Luu and Jeriann Alexander

Sites

Proposed Preliminary Design-Level Field Investigation

Design Investigations are an Iterative Process with Numerous Constraints

Goals

- Goal - Collect data to support advancing engineering for all Elements to 30% design.
- Goal - Collect data to support 65% design level to meet Project Level Environmental permitting requirements.

Design Investigation Principals

- Principal: Collect data only when right of access is secured and environmental permitting allows.
- Principal: Review existing data and geologic information along with understanding of features
- Principal: Collect data to inform design using recent experience with regulatory agencies and standard of engineering practice to guide development of investigation plan.

Historic Field Investigations

- In areas of dams, saddle dams, and dikes.
- Along proposed conveyance pipelines.
- In areas of previously proposed features which are no longer part of the project.
- Insufficient data for Design-Level Studies

Historic Data Evaluation

Completed To support Engineering Feasibility Studies

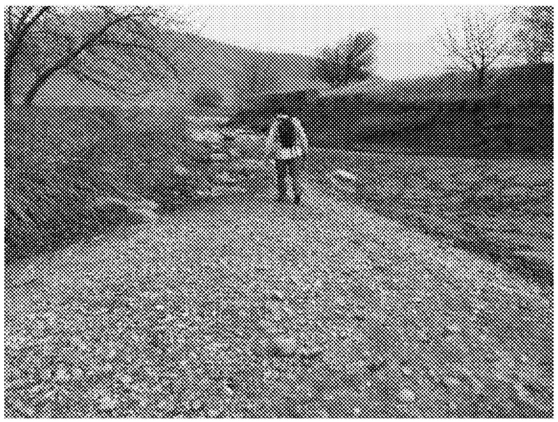
- Sufficient to support concept assessments and preliminary alternative evaluations.
- Sufficient to develop feasibility level construction cost estimates.
- Sufficient to identify scope for future design-level investigations.

Insufficient to:

- complete engineering analysis and designs.
- garner regulatory acceptance of designs.
- refine construction cost estimates.

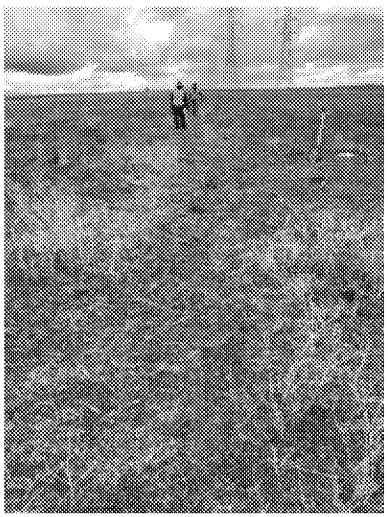
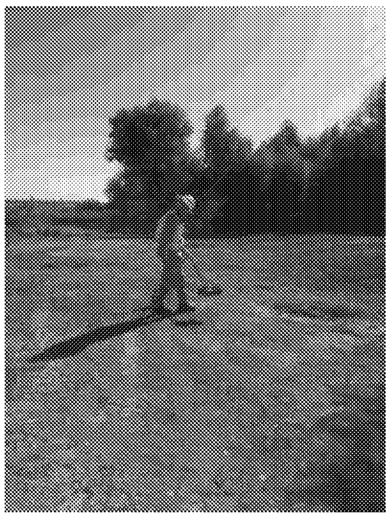
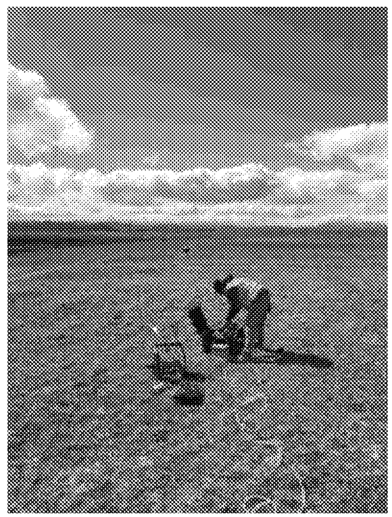
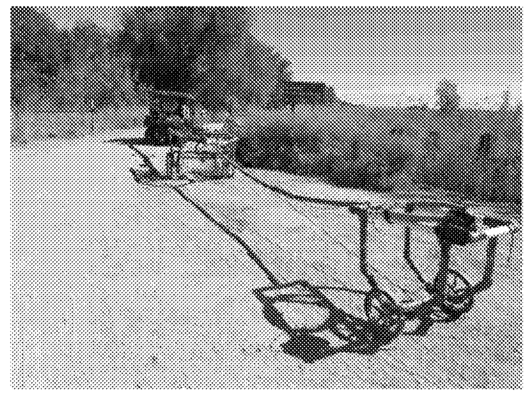
Proposed Preliminary Design-Level Field Investigation - Types of Disturbance to be Expected

- Geologic Mapping and Reconnaissance - Pedestrian Surveys.
  - ✓ Value-added – increased understanding of topographic features and surficial geologic expressions such as stratigraphy in drainages and cuts.



Proposed Preliminary Design-Level Field Investigation - Types of Disturbance to be Expected

- Utility Locating and Screening – Pedestrian Surveys with hand-held equipment.
  - ✓ Value-added – Jobsite hazard assessment.
- Surficial Geophysics – light equipment and net of sensors placed on the ground in survey area which is moved to cover area of concern.
  - ✓ Value-added – less invasive tools able to cover more area between borings and CPTs. Can be used to screen areas for buried changes in subsurface conditions.

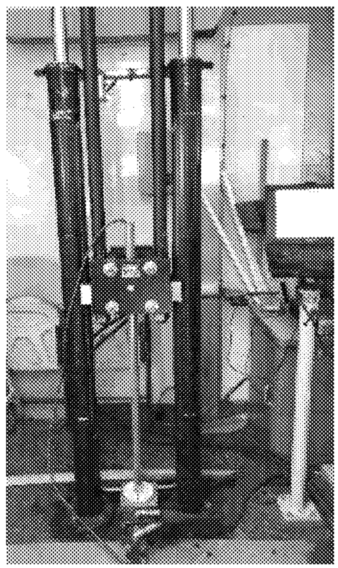
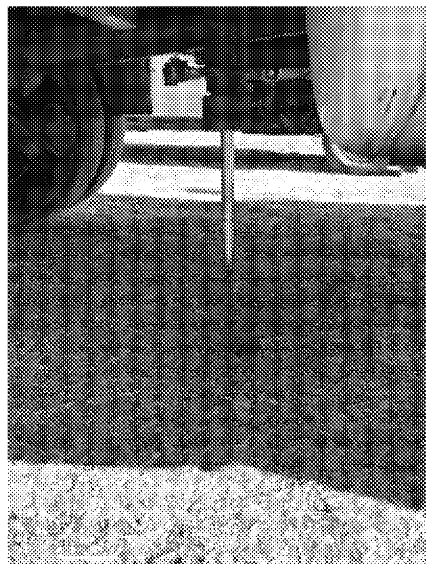
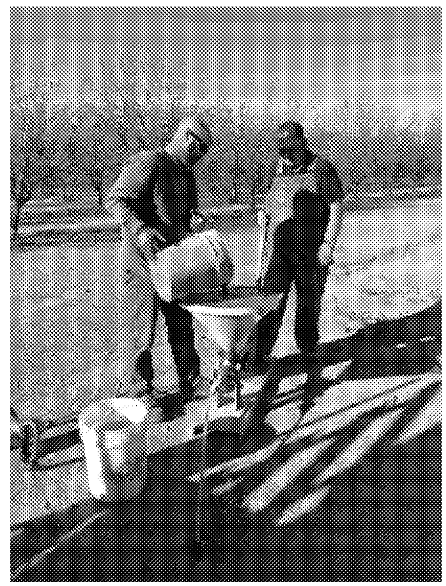





Proposed Preliminary Design-Level Field Investigation - Types of Disturbance to be Expected

- Borings –1 to 7 field days depending on data needed, with equipment and vehicles covering 500 to 2000 sq ft footprints.
- Deeper borings will have multiple passes with various probes and sensors after sample collection.
  - ✓ Value-added, sample collection for laboratory testing, stratigraphy logging.

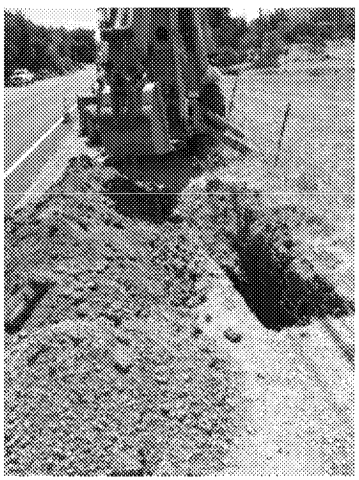
Proposed Preliminary Design-Level Field Investigation - Types of Disturbance to be Expected

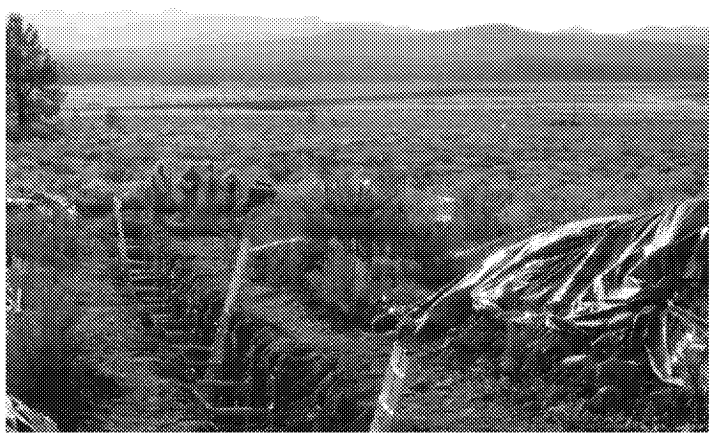
- CPTs – 1-2 days at each location, with equipment and vehicles covering 500 sq ft footprints.
  - ✓ Value-added – less invasive than borings, faster production rates for stratigraphy, and soil response characterization, great when you need more definition on soft soil behavior.

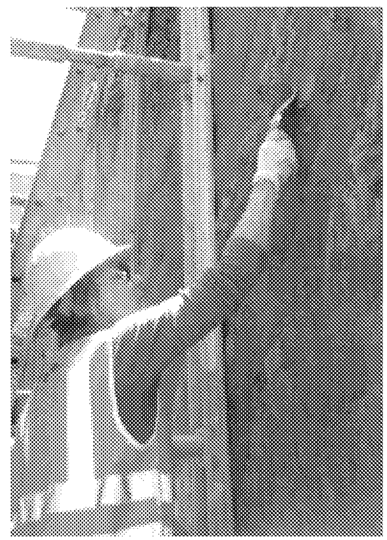





Proposed Preliminary Design-Level Field Investigation - Types of Disturbance to be Expected

- Test Pits, 10-18 feet deep, sides sloped back 2:1, can be completed and backfilled in a day.
- Fault Trenches, trench shores installed to keep staff safe while observing geologic stratigraphy and evidence of faulting, left open several days to weeks, access restriction required.
- Dozer Trenches, minimize work areas to what can be opened and backfilled on a given day.
  - ✓ Value-added – there is nothing better than being able to explore an area by open cutting it. Increased visualization of subsurface conditions. Build understanding of variations.
- Test Fill Construction
  - ✓ Value-added – provides the ability to observe and create a mini dam shell and core out of existing materials. Able to try different means and methods on a pilot scale.



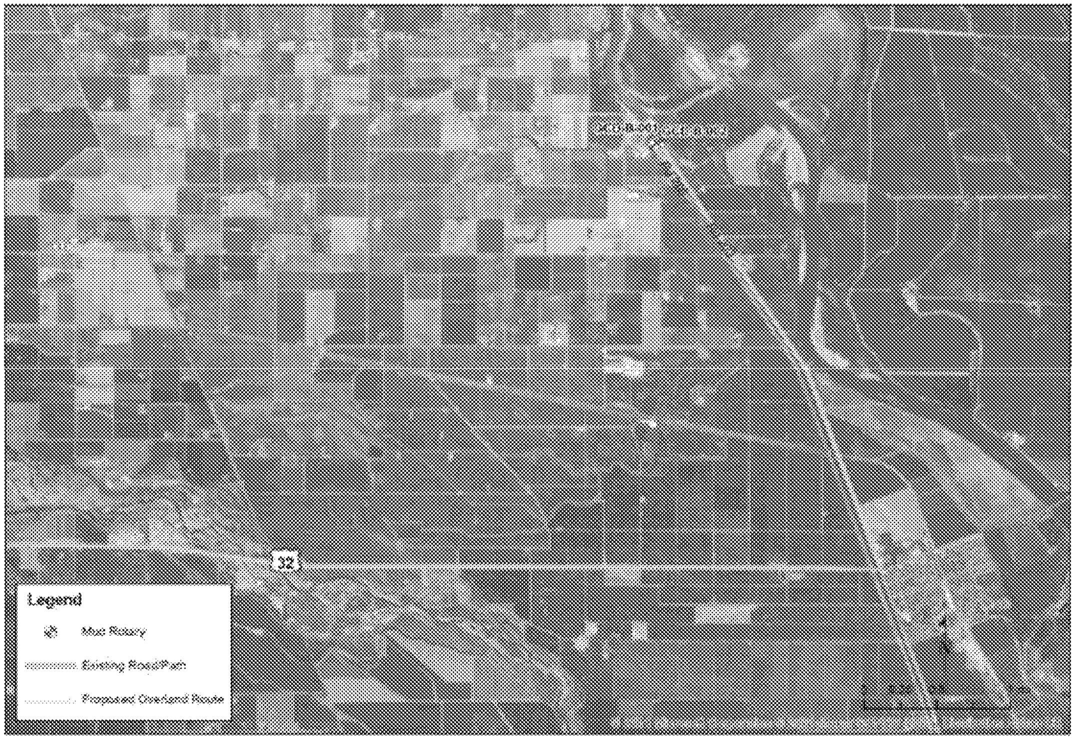


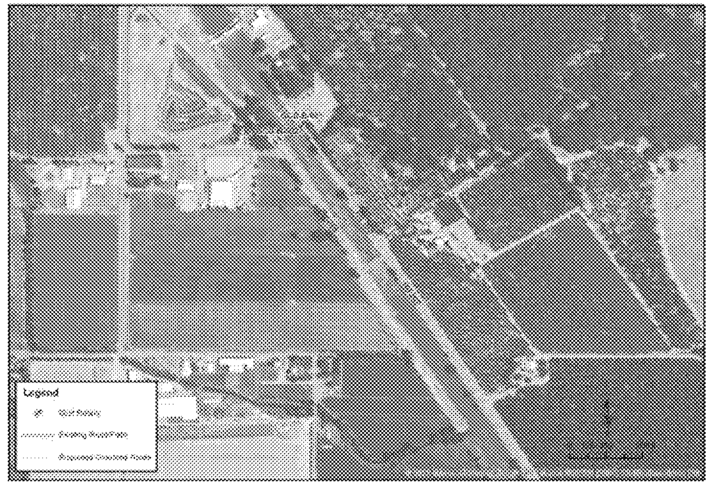


Glenn County Proposed Work

- GCID Headworks
- County Road Improvements: Road 68 and 69, and Road B
- New North Construction Access Road
- Saddle Dams
- Saddle Dikes
- Saddle Dam and Dike Borrow and Quarry Areas

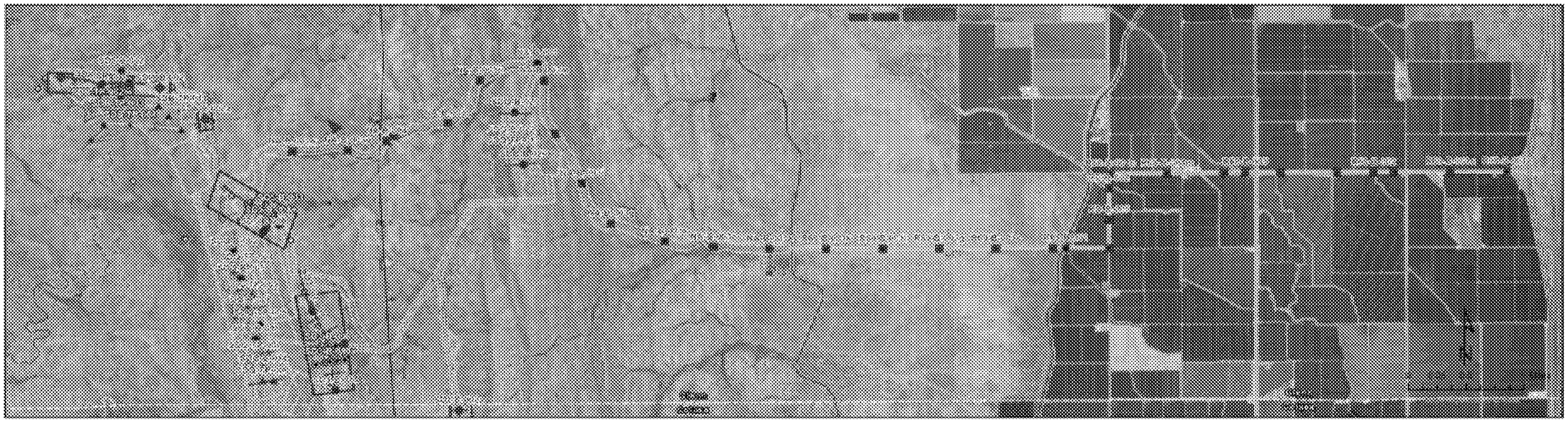
Conceptual Team Travel Routes





Proposed Preliminary Design-Level Field Investigation

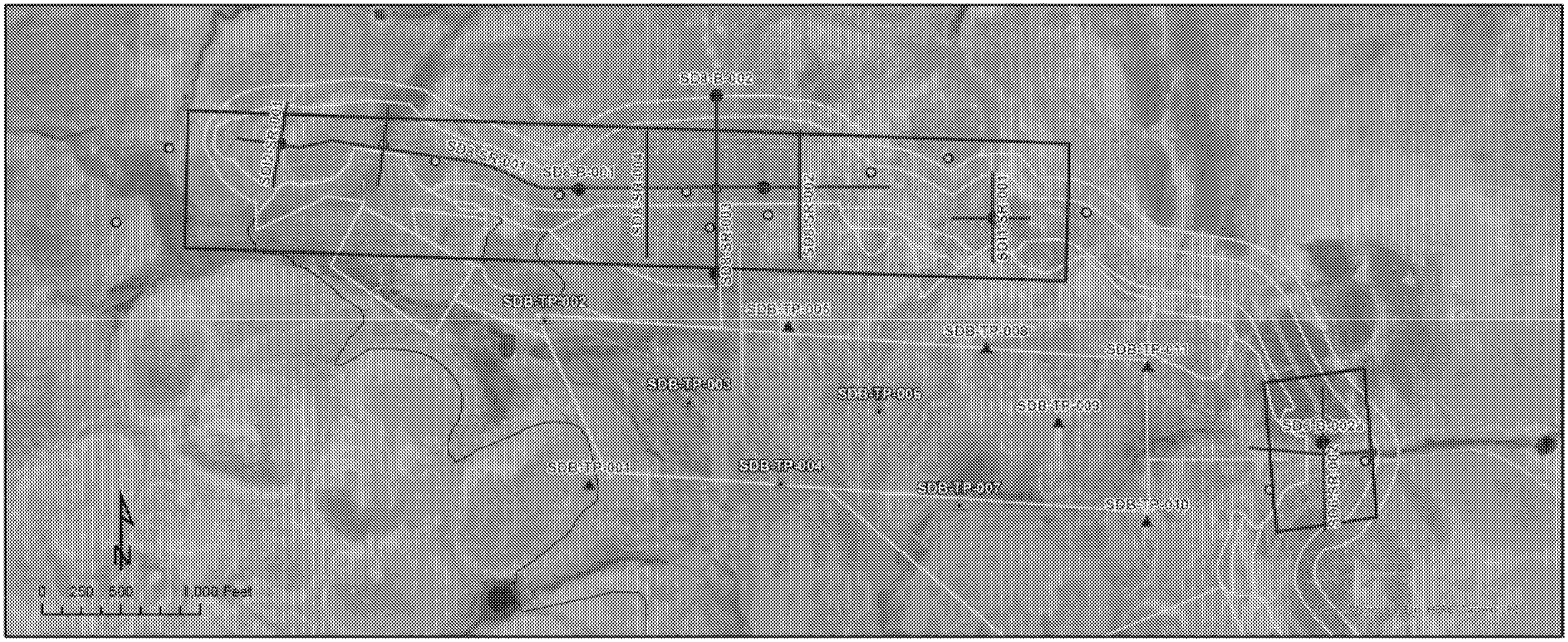
Glenn County – Geologic Mapping, Surficial Geophysics, Borings, CPTs, Test pits, Piezometers, Fault Trenching, and Dozer Trenching.



Important to note the scale, as the density is not really what it seems. Future slides will be enlarged to better show the density in a few areas.

Proposed Preliminary Design-Level Field Investigation

Saddle Dams 6 and 8, Saddle Dike 1 and 2, and Saddle Dam Borrow Areas.



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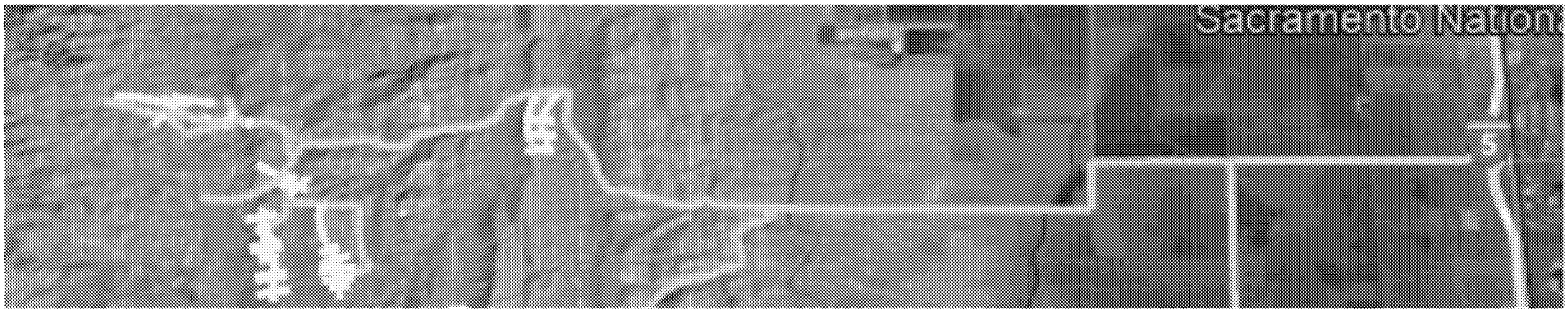
Conceptual Team Travel Routes

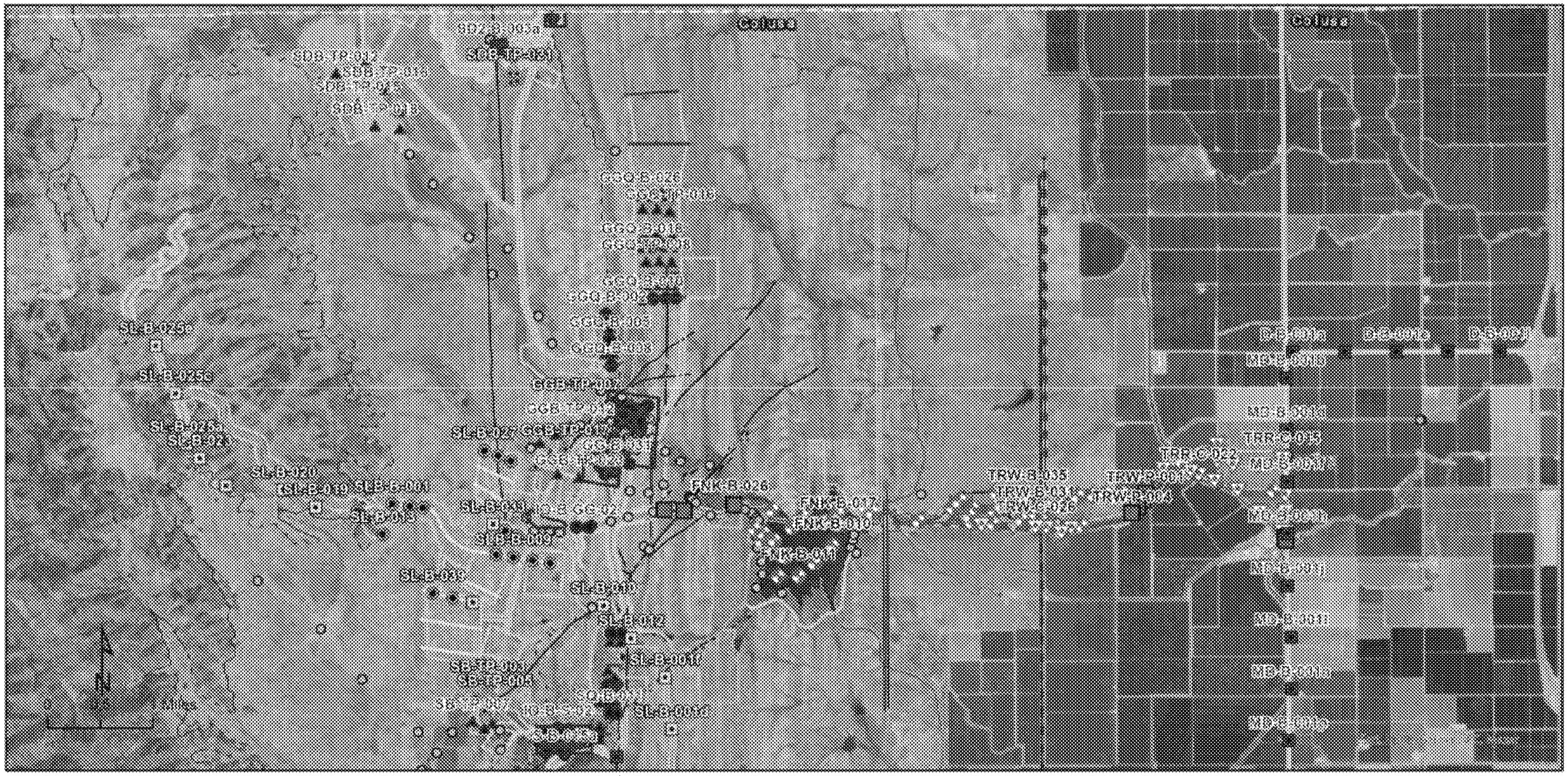


Colusa County Proposed Work

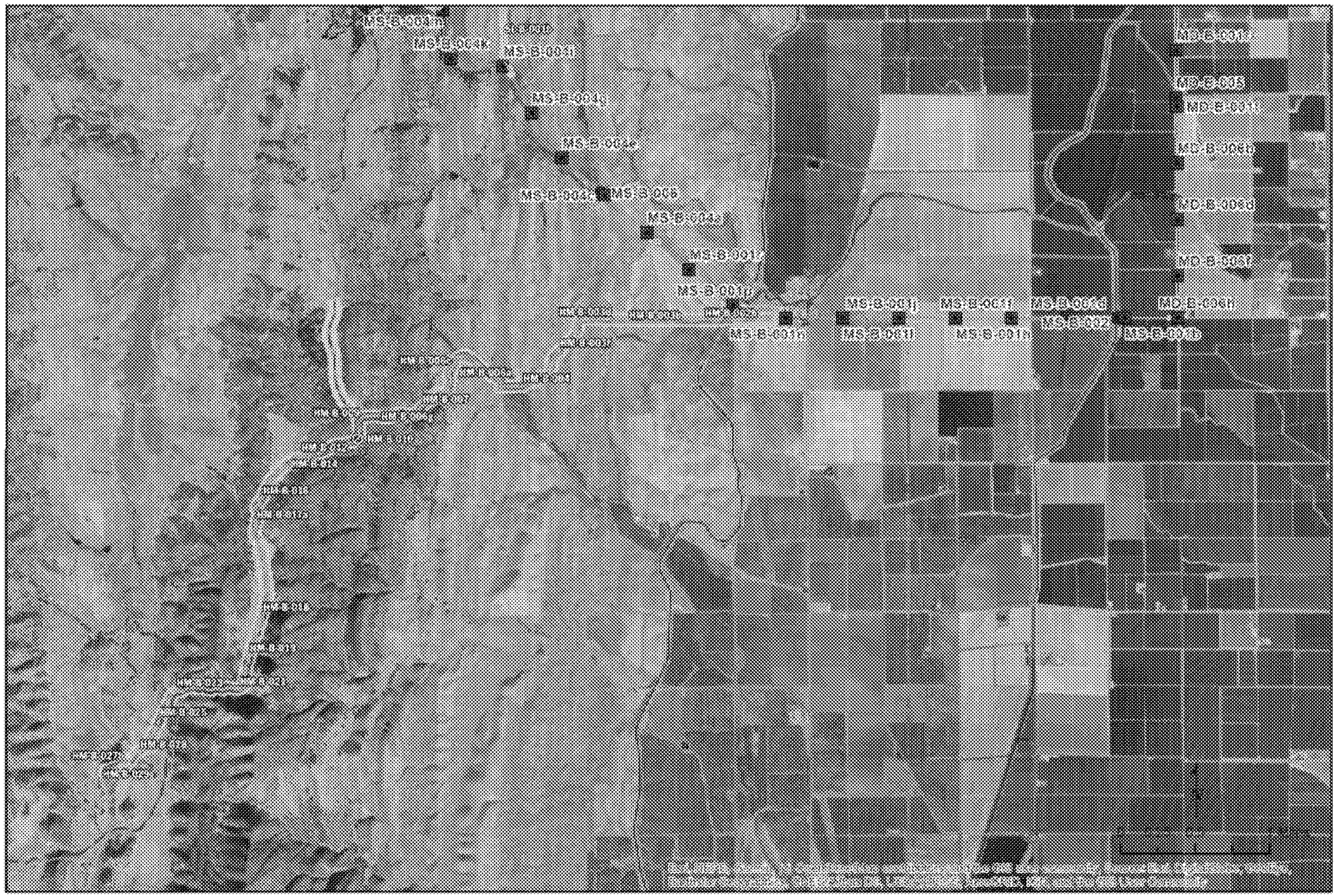
- County Road Improvements: Delevan, McDermott, Sites Lodoga, and Maxwell Sites
- New Huffmaster Road
- New Sites Lodoga Road with Bridge
- Golden Gate Dam
- Sites Dam
- Inlet-Outlet Structure
- Quarry and Borrow Areas
- Saddle Dams
- TRR
- TRR and Funks Pipeline and Structures

Proposed Preliminary Design-Level Field Investigation

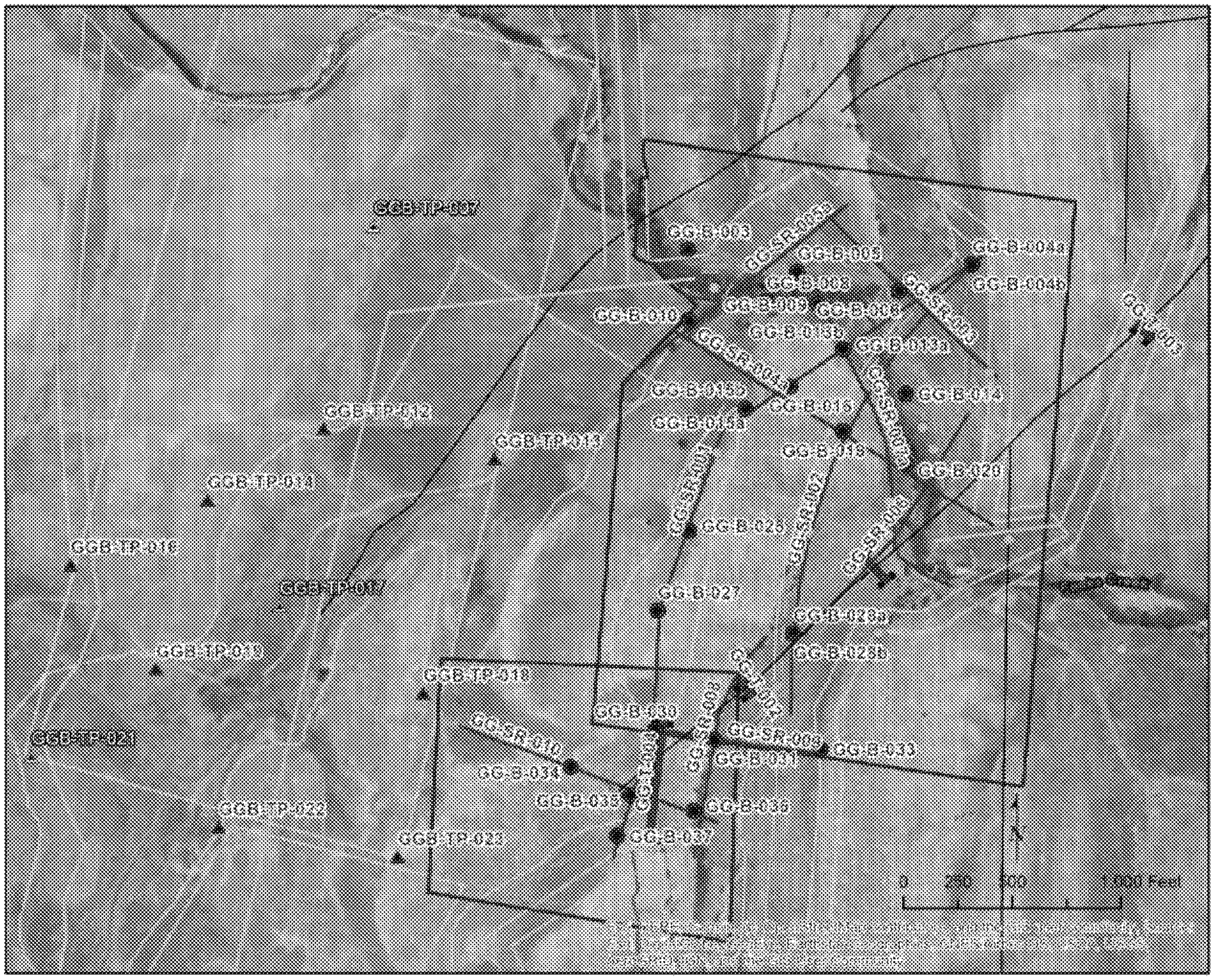
Colusa County – Geologic Mapping, Surficial Geophysics, Borings, CPTs, Test pits, Piezometers, Fault Trenching, and Dozer Trenching.



Proposed Preliminary Design-Level Field Investigation

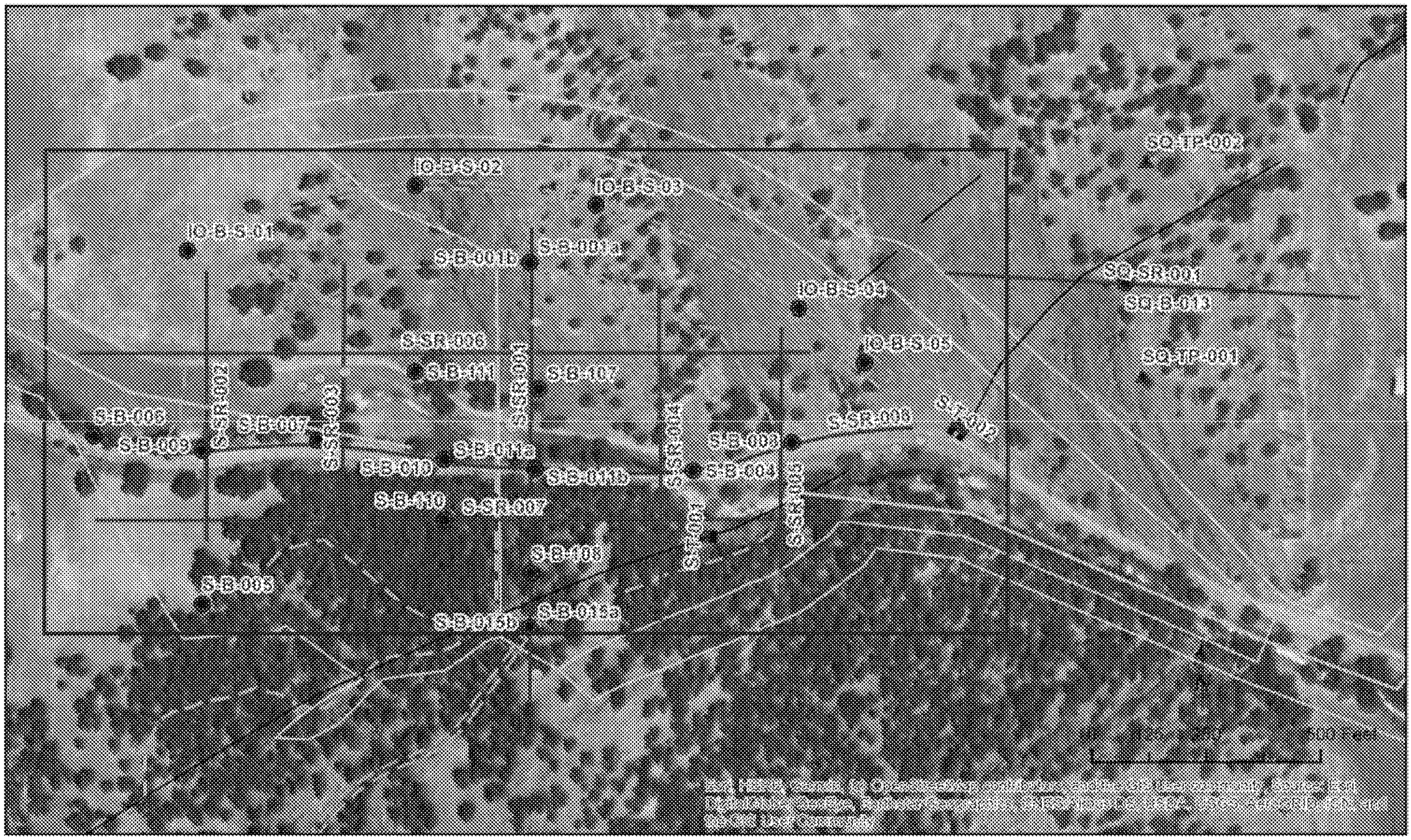


Proposed Preliminary Design-Level Field Investigation



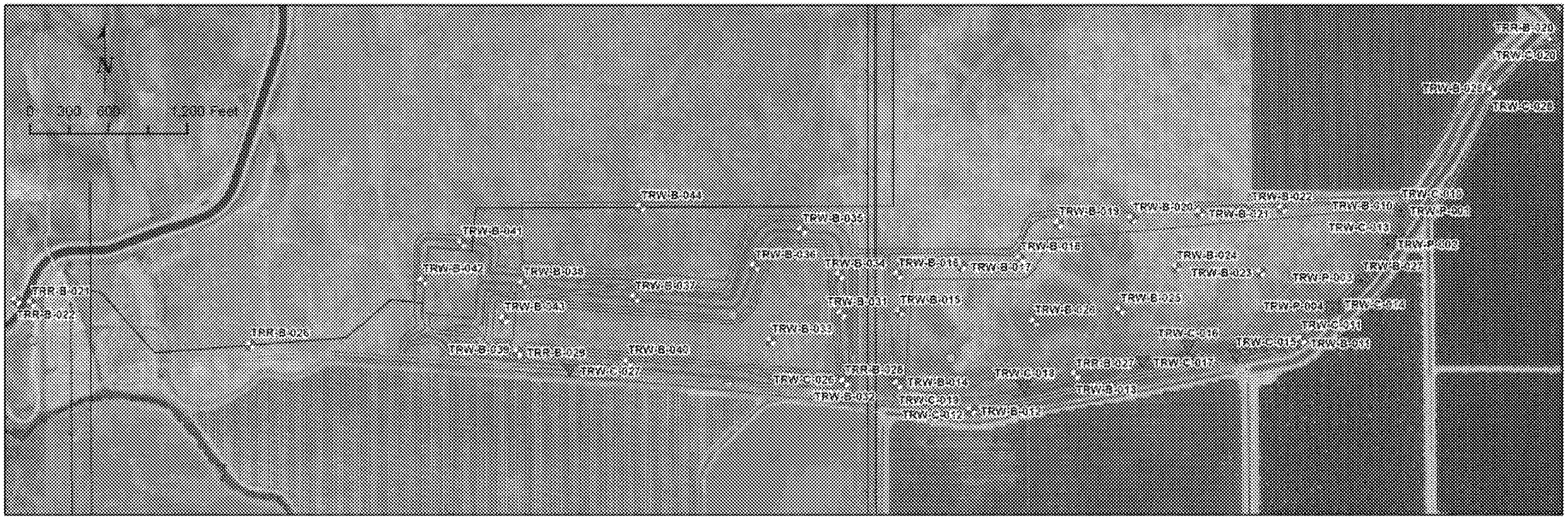
Golden Gate Dam area.

Proposed Preliminary Design-Level Field Investigation

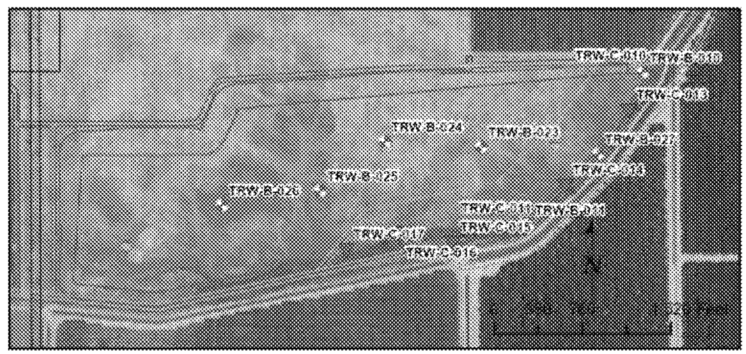


Sites Dam area.

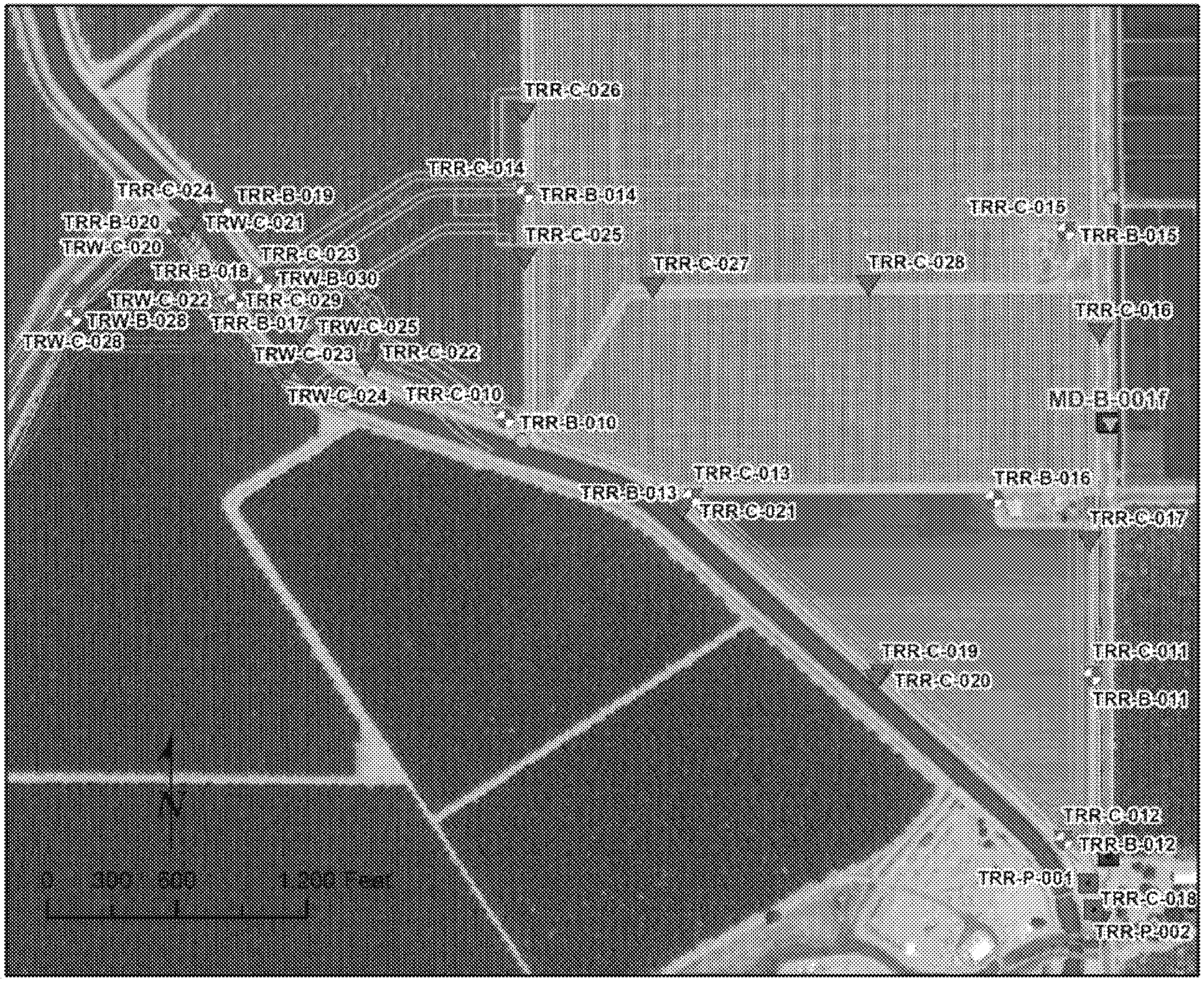
Proposed Preliminary Design-Level Field Investigation



TRR West Location



Proposed Preliminary Design-Level Field Investigation



TRR East Location

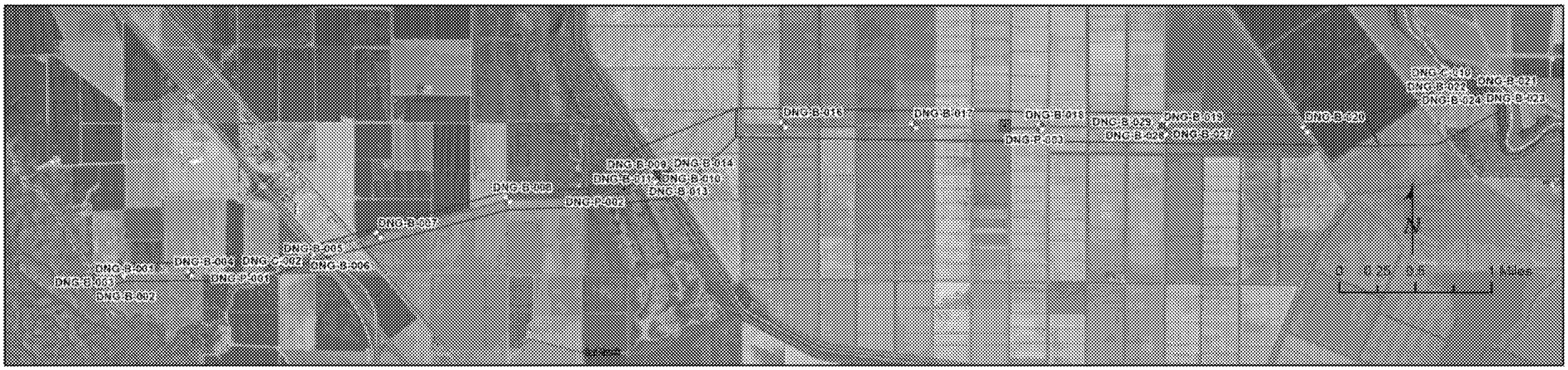
Conceptual Team Travel Routes

Yolo County Proposed Work

- Dunnigan Pipeline Alignment
- TCC intake structure
- CBD outlet structure
- Sacramento River discharge structure
- Access and facility roads

Proposed Preliminary Design-Level Field Investigation

Yolo County – Geologic Mapping, Borings, CPTs, Test pits, Piezometers, Well Pump Testing



Conceptual Team Travel Routes

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Next Steps

- Continue refinement and prioritization of exploration activities to meet project objectives
- Prepare a Draft Geotechnical Workplan in preparation for coordination with DSOD
- Continue working with the real estate and permitting teams to ensure requirements are met prior to commencing work

Questions?

Sites

Operations Plan Input

Erin Heydinger

Sites

Last Month

- Provided input on Plan outline
- Provided input on annual operating process
- Feedback:
  - Covers information needed
  - Add losses to all sections (includes carriage water)
  - Consider 1-page fact sheet or summary
  - Continue evaluating timing for delivery requests

Additional Feedback?

January
- Initial requests for Sites water provided by participants for delivery or transfer
- Coordination with GCID and TCCA on diversions

February
- Coordination with GCID and TCCA on diversions
- Final requests for Sites water releases before transfer window (further requests accommodated when possible)

March
- Sites begins releasing water for DWR and Reclamation exchanges
- Coordination with GCID and TCCA on diversions
- Coordination with CDFW on Prop 1 water deliveries
- Some releases for NOD use

April
- Final requests for Sites water releases to SOD (further requests accommodated when possible)
- Releases for NOD purposes
- Coordination with CDFW on Prop 1 water deliveries

May
- SOD participants notify DWR of final Sites requests for season
- Peak release month for exchange water
- Releases for NOD purposes
- Prop 1 water schedule finalized with CDFW

June
- Peak month for water backed into Oroville and Shasta
- Releases for NOD use
- Carriage water costs determined (proposed)

July
- Transfer window opens, SOD deliveries begin
- Water exchanged into Shasta and Oroville begins to release
- Key month: Coordination with TCCA, CBD, DWR on releases to river
- Coordination with Reclamation and DWR on exports
- Releases for NOD use

August
- Exports for SOD use
- Yolo Bypass Prop 1 deliveries
- Key month: Coordination with TCCA, CBD, DWR on releases to river
- Coordination with Reclamation and DWR on exports
- Releases for NOD use

September
- Exports for SOD use
- Key month: Coordination with TCCA, CBD, DWR on releases to river
- Yolo Bypass Prop 1 deliveries
- Coordination with Reclamation and DWR on exports
- Releases for NOD use

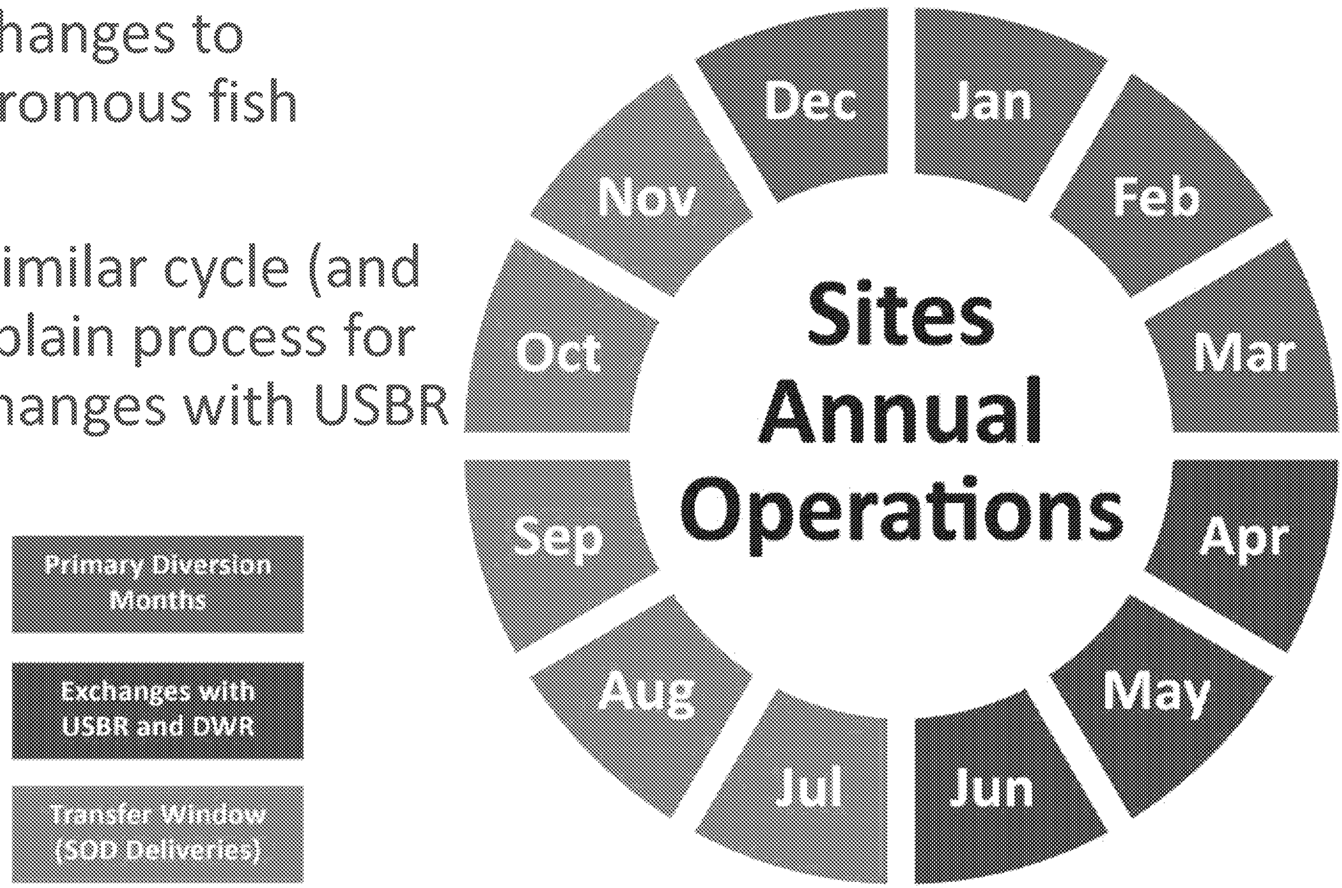
October
- Exports for SOD use
- Continued coordination with TCCA, CBD, DWR, Reclamation on releases and deliveries
- Releases for NOD use

November
- Last month for SOD exports
- Coordination with GCID and TCCA on diversions
- Releases for NOD use

December
- Coordination with GCID and TCCA on diversions

Next Step: Annual Exchanges Cycle

- Reclamation proposing expanded exchanges to improve anadromous fish benefits
- Will develop similar cycle (and graphic) to explain process for proposed exchanges with USBR and DWR



Tracking and Accounting

- Proposing a real-time, web-based water accounting system
- Would track the following:
  - Diversions
  - Pumping into storage
  - Storage account "balance"
    - Can be separate to include leased space or sold water
  - Reservoir levels
  - Releases
  - Power generation
  - Deliveries to turnout or export facilities
  - Exchanged water and location
  - Losses estimated based on the above
- Will allow for transparency between participants and facilitate agency reporting

Does your agency need anything else tracked?

What to Expect in Versions 1 and 2

Version 1 - 2021

- Details of project operations, including diversions, storage, and releases with level of information known today
- Explanation of exchanges
- Description of coordination between Sites JPA and other entities
- Mechanisms and accounting for leasing and selling water
- Annual requests and cycle for project participants

Version 2 - 2023

- Expanded detail on diversions, storage, and releases as additional information is known on permits and design
- Detailed description of exchanges based on operating agreements
- Detailed description of coordination based on operating and benefits agreements
- Specifics based on contracts developed on leasing and selling water
- Specifics on priorities, conflict resolution, etc. not yet evaluated

Next Steps

- Work with GCID and TCCA for input on relevant sections
- Complete Operations Plan, Version 1
  - Review with Workgroup in November
- Continue work on DWR/USBR operations agreements, permits, Prop 1 benefits agreement with CDFW, and water right
  - Revised Operations Plan (Version 2) developed during Amendment 3 prior to next round of funding/debt issuance

Questions?

Sites

Thank You!

Next Meeting: Wednesday, November 10th

Sites

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 10/7/2021 1:36:59 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
CC: Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; Briard, Monique [monique.briard@icf.com]; Hendrick, Mike [Mike.Hendrick@icf.com]; Mitrovich, Milan [Milan.Mitrovich@icf.com]
Subject: AMP and TCCA/GCID input

Ali,
ICF is about to submit the 75% draft of the AMP to us and as a follow up to yesterday's meeting and a previous email from Monique to me, how would you suggest we engage TCCA and GCID about the detailed high flow studies at RBPP and Hamilton City that we had removed from the EIR (Appendix 2D) but need to include in the AMP? Jeff had mentioned that there should be "a preamble about all of the work, permitting, analysis, consultation with resource agencies, and studies that went into the effort of implementing the state of the art Fish Passage Improvement Project at Red Bluff" and suggests that a site visit occur. How do you want us to tackle this? Should we have Milan do research on his own to find the info, contact Jeff directly, or start with a clean slate during a meeting to set the framework of how we will approach it? Although we don't need a 100% complete AMP to submit in the BA and IPT applications as we can include a "less developed version" to allow more time to work with the agencies and members, this does need to start moving as my guess is this will not be a quick process with either TC or GCID.
John

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR
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D 916.679.8858 M 818.640.2487
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hdrinc.com/follow-us

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 10/7/2021 4:30:47 PM
To: yung-hsin.sun@stantec.com
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Marcia Kivett [MKivett@sitesproject.org]; Jerry Brown [jbrown@sitesproject.org]
Subject: Sites Project CalSim Model

Hello Yung-Hsin,

I'm a consultant for the Sites Project and received the request below from the Jerry Brown, the Sites Executive Director. Here is a link to the CalSim model used in the Sites Draft EIR/EIS (expected to be released publicly in November).

CalSim II

Note that the Sites Authority's preferred alternative is Alternative 1B. The link also includes reporting spreadsheets with select CalSim outputs.

Please let me know if you have any questions or if you have trouble accessing the model.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: "Okita, David@DWR" <David.Okita@water.ca.gov>
Date: Wednesday, October 6, 2021 at 4:23 PM
To: Jerry Brown <jbrown@sitesproject.org>, Fiona Sanchez <sanchezf@irwd.com>, "slee@ieua.org" <slee@ieua.org>, "Cowin, Mark" <mcowin@geiconsultants.com>, Mark Beuhler <mbeuhler@wswaterbank.com>
Cc: "Smith, Steven (Oakland)" <Steven.Smith6@aecom.com>, "Sun, Yung-Hsin" <yung-hsin.sun@stantec.com>
Subject: Cumulative Flow

As we discussed, we are doing some additional analysis for the Cumulative Flow Analysis to refine the results. We will be doing CalSim II post processing using data from Sites, Los Vaqueros, Harvest Water, Chino, Willow Springs and Kern Fan.

Stantec, a sub consultant to AECOM for the CEQA Initial study is doing the work with review and input from Aaron Miller (DWR) and Chandra Chilmakuri (State Water Contractors).

Below is the request of information from Stantec. Note that we will not be doing the future climate change scenarios in this analysis. We know that each project may be updating their feasibility studies and doing new modeling. If you have new modeling that you can share that would be preferred over modeling done for the original application please provide this. **Please send information directly to Yung-Hsin Sun at Stantec at the email address above.**

If your project did not use CALSIM, any modeling or spreadsheets that represents your project is requested.

Note that we will be using a new version of CALSIM2 for this analysis. This is the same version that will shortly be sent out to WSIP projects for your use that includes updated regulatory conditions and other updates.

If you have any questions about the request please contact Yung-Hsin directly - I am not familiar with CalSim modeling.

Additional information that we would need is the complete CalSim II model packages (i.e., input and output files) for each project.

In addition to the CalSim II model packages, we would also need any pre-processing and/or post-processing tools (e.g., Excel spreadsheets) that were used in the analysis of pulse flows. This will help us in understanding how individual projects were implemented in the WSIP application and start determining an approach to evaluate the cumulative effects of these projects implemented together.

David Okita, PE

Department of Water Resources

530 902-7588

From: Williams, Nicole [Nicole.Williams@icf.com]
Sent: 10/7/2021 4:49:45 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]; Briard, Monique [Monique.Briard@icf.com]
Subject: RE: [EXTERNAL] RE: Revision Requests: Sites RDEIR/SDEIS

Ali – yup. Understood. I just wanted to confirm I was proceeding in the right direction.

Laurie – do you need to get confirmation from Melissa on my example below? I'd like to start adding text tomorrow across all the chapters.

Cheers, Nicole

NICOLE L. WILLIAMS
Senior Environmental Planner
ICF
o 916.231.9614
icf.com

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, October 7, 2021 1:31 PM
To: Williams, Nicole <Nicole.Williams@icf.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>
Subject: RE: [EXTERNAL] RE: Revision Requests: Sites RDEIR/SDEIS

Hi all – I realize this is a lot. But I think this needs to be completed. This NEPA review process was implemented when I was Deputy RD. It was my role to get reviewers ready for the DC briefings. The two questions that I always prepped the RD and the Regional Solicitor to get from Deputy Secretary were 1. Have you read the document and 2. Have all of your changes been incorporated. I also always prepped the Regional Solicitor to get the question of – do you think this document is legally defensible. They MUST answer YES to all of these to get clearance to release the document. No waffling, no yes but, it had to be YES period to all three.

Now things may have relaxed in this administration, but I suspect the questions are similar and the firmness of the response needs to be similar.

The Regional Solicitor will need to affirm to DOI that this document is legally defensive and meets the NEPA requirements. They will be putting their credibility with the Department on the line when they do this. No Regional Solicitor is going to do this unless they are confident in the document and their critical issues have been addressed. We don't really have a choice but to make these changes so we can release the document.

It might be best to have a call with Melissa to talk through the changes and make sure she is on board / that these address the concern. She may have ways that we can simplify things and still meet the need.

But the changes will need to be made.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Williams, Nicole <Nicole.Williams@icf.com>
Sent: Thursday, October 7, 2021 12:30 PM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>
Subject: RE: [EXTERNAL] RE: Revision Requests: Sites RDEIR/SDEIS

Hello –

Based on my review of the ROC-ON-LTO examples below, this request will require us to read every single NEPA conclusion paragraph for every single impact (minimum of 2) for each alternative (maximum of 3, excluding No Project) across 25 resource chapters in order to customize sentences similar to the ROC-ON-LTO examples. As an example, in chapter 5 there are 3 impacts and there are 3 NEPA conclusions because the discussion of Alts 1, 2 and 3 are bundled. So we would customize 3 locations in Chapter 5. It becomes more complicated and numerous when alternatives are not bundled. In addition, we frequently refer back to the CEQA determination under the NEPA conclusion – see below the example from Chapter 5. This means we'll now need to pull information from the CEQA determination to further customize, if I'm understanding the request correctly. Please confirm the proposed revision is appropriate.

EXAMPLE FROM CHAPTER 5:

Impact HYDRO-1: Reduce water supply for non-Sites Storage Partner water users

NEPA Conclusion

Project effects would be the same as described above for CEQA. Water supply for other water users would not be adversely affected.

PROPOSED REVISION IN *bold/italic*:

Impact HYDRO-1: Reduce water supply for non-Sites Storage Partner water users

NEPA Conclusion

Project effects would be the same as described above for CEQA. ***Project alternatives would not substantially reduce water supply to other water users as compared to the No Project Alternative***. Water supply for other water users would not be adversely affected.

Cheers, Nicole

NICOLE L. WILLIAMS
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From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Thursday, October 7, 2021 10:15 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Williams, Nicole <Nicole.Williams@icf.com>; Linda Fisher (linda.fisher@hdrinc.com) <linda.fisher@hdrinc.com>; Briard, Monique <Monique.Briard@icf.com>
Subject: FW: [EXTERNAL] RE: Revision Requests: Sites RDEIR/SDEIS

Further direction is below. I had provided some examples of language from ROC on LTO.

From: Dekar, Melissa D <mdekar@usbr.gov>
Sent: Thursday, October 7, 2021 10:04 AM
To: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: Fisher, Linda <Linda.Fisher@hdrinc.com>; King, Vanessa M <vking@usbr.gov>
Subject: RE: [EXTERNAL] RE: Revision Requests: Sites RDEIR/SDEIS

Hey Laurie,

I believe what we're looking for is for each NEPA conclusion statement to compare back to the No Project Alternative (in the draft using the term *No Project Alternative* will be fine because we clarify upfront that it is synonymous with the No Action Alternative, in the final we'd like to change that). So revising the NEPA conclusions consistent with the examples provided below should be adequate to address the request.

Thanks,
Melissa

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Thursday, October 7, 2021 9:26 AM
To: Dekar, Melissa D <mdekar@usbr.gov>
Cc: Fisher, Linda <Linda.Fisher@hdrinc.com>; King, Vanessa M <vking@usbr.gov>
Subject: [EXTERNAL] RE: Revision Requests: Sites RDEIR/SDEIS

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

Hi Melissa,

ICF would like some more guidance on these text edits. In addition to sample text regarding NEPA mitigation regulatory requirements, can you provide an example of the text that you would need to reference back to No Project Alternative in the NEPA conclusions? I have reviewed the Coordinated Long-Term Operation of the Central Valley Project and State Water Project EIS and found the following language:

"…implementation of Alternatives 1 through 5 as compared to the No Action Alternative would result in.."

"Groundwater levels decrease under Alternative 5 in the central and southern San Joaquin Valley Groundwater Basin as compared to the No Action Alternative.."

"The CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified Old and Middle River flow criteria…"

Is this what you are looking for or should we draft a simple statement that would be included in each NEPA determination? For example: "The following provides a comparative analysis of the impacts of the proposed project and the impacts of not proceeding with the project (No Project)."

Thanks,

Laurie

From: Laurie Warner Herson
Sent: Wednesday, October 6, 2021 6:37 PM
To: Dekar, Melissa D <mdekar@usbr.gov>
Cc: Fisher, Linda <Linda.Fisher@hdrinc.com>; King, Vanessa M <vking@usbr.gov>
Subject: Re: Revision Requests: Sites RDEIR/SDEIS

Thank you, we will start making those changes. Do you have sample text that you can share on the NEPA mitigation regulatory requirements ? If not, we will draft something for you to review before we add it.

On Oct 6, 2021, at 4:18 PM, Dekar, Melissa D <mdekar@usbr.gov> wrote:

Hi Laurie,

In an effort to provide a more time for requested revisions beyond what we intend to share back as tracked changes, here are three revision requests.

Please add language regarding the use of the term "significance".
Would you please adjust the following example text to be applicable to our document and insert it upfront in the description of how the document is organized – probably somewhere within or near Section 3.2.5?
Please include the highlighted text verbatim.

The impacts of each alternative are discussed by resource area and alternative. Each resource area section is structured so that an *italicized* impact statement introduces potential changes that could occur from implementation of each alternative. A discussion of how the resource area would be affected by the impact then follows this initial statement. The impact discussions for the No Project Alternative is concluded with a determination that indicates if there is no impact to a resource area or if the impact to a resource area is beneficial, less than significant, or significant. Pursuant to NEPA, significance is used to determine whether an EIS or some other level of documentation is required, and once the decision to prepare an EIS is made, the magnitude of the impact is evaluated and no further judgment of significance is required. Therefore, any determinations of significance are for CEQA purposes only.

Please add a discussion of NEPA mitigation regulatory requirements and how they differ from CEQA mitigation requirements in Section 3.2.6.

Please revise all NEPA conclusions to reference back to No Project Alternative. Currently many of them do not explicitly reference/compare to any baseline.

- since this the no project alternative is defined upfront as identical to the NAA, referencing back to the no project alternative is OK in the draft. We would like this changed in the final so that the term "No Project Alternative/No Action Alternative" is used in each place where "no project alternative" is currently used.

Please let me know if you have questions.

Thanks,
Melissa

Melissa Dekar

Natural Resources Specialist
Environmental Compliance and Conservation Branch, CGB-152
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Interior Region 10, Bureau of Reclamation
916-978-6153 mdekar@usbr.gov

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/7/2021 5:53:39 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: FW: Salmon facts. They're not what you've been told...
Attachments: SalmonMythsFacts.oct2021.pdf

Lets discuss during our 1v1 tomorrow.

From: Mike Wade <mwade@farmwater.org>
Date: Thursday, October 7, 2021 at 3:10 PM
To: Mike Wade <mwade@farmwater.org>, Katie Evans <kevans@cvwd.org>, Jeff Sutton <jsutton@tccanal.com>, Constance Anderson <cjanderson@tid.org>, Dan Vink <dan@six33solutions.com>, Josh Weimer <jmweimer@tid.org>, Tal Eslick <tal@vistaconsultinginc.com>, Debbie Murdock <dmurdock@cgfa.org>, Jeana Hultquist <jhultquist@agloan.com>, Justin Fredrickson <JEF@cfbf.com>, "Sara M. Katz" <SKatz@katzandassociates.com>, Mark Looker <marklooker@yahoo.com>, Erin Huston <Ehuston@cfbf.com>, "Jay.vanrein@cdfa.ca.gov" <Jay.vanrein@cdfa.ca.gov>, Jeanne Varga <jvarga@kcwa.com>, Tim Johnson <tjohnson@calrice.org>, Melissa Williams <Melissa.Williams@mid.org>, Melissa Williams <melissaw@mid.org>, Tom van der List <TvanderList@ka-pow.com>, Alexis Silveira <alexis@cacitrusmutual.com>, Joshua Rahm <JRahm@walnuts.org>, Rylin Lindahl <rlindahl@farmwater.org>, Shelley Ostrowski <sostrowski@wwd.ca.gov>, Jacob DeBoer <jdeboer@agloan.com>, Lorraine Garcia <Lorraine.Garcia@cvwd.org>, "h2otoole@gmail.com" <h2otoole@gmail.com>, Jane Townsend <jane@agamsi.com>, Dennis Nuxoll <dnuxoll@wga.com>, Nadine Bailey <nadine.bailey@sbcglobal.net>, Priscilla Rodriguez <priscilla@agprocessors.org>, William Bourdeau <william.bourdeau@harrisranch.com>, Brent Walthall <bwalthall@kcwa.com>, Joan Webster <joanwebster33@msn.com>, Cannon Michael <cannon@bfarm.com>, Cory Lunde <CLunde@wga.com>, "diana@rosestrategicpr.com" <diana@rosestrategicpr.com>, Robert Schettler <rdschettler@iid.com>, Casey Creamer <casey@cacitrusmutual.com>, Jenny Holtermann <jenny@wakc.com>, Peter Hecht <phecht@cfbf.com>, Austin Ewell <austin@ewellgroup.com>, Dan Keppen <dan@familyfarmalliance.org>, Roger Isom <roger@agprocessors.org>, Rebecca Quist <RQuist@krcd.org>, Brandon Souza <bsouza@farmwater.org>, Michael Boccadoro <mboccadoro@westcoastadvisors.com>, Daniel Merkley <dmerkley@cfbf.com>, Kathryn Boren <kboren@wwd.ca.gov>, Emily Rooney <emily@agcouncil.org>, Anja Raudabaugh <anja@wudairies.com>, Cynthia Davis <cdavis@gcid.net>, Daren Williams <dwilliams@almondboard.com>, Karen Kapler <kekapler@gmail.com>, Tina Shields <tlshields@iid.com>, Jason Peltier <jepelt@me.com>, Jerry Brown <jbrown@sitesproject.org>, Scott Seus <scott@seusfarms.com>, Dayna Ghirardelli <dghirardelli@cmab.net>, Todd Manley <tmanley@norcalwater.org>, Bill Diedrich <agspray@sbcglobal.net>, Alicia Rockwell <arockwell@bdgrowers.com>, "J. Scott Petersen" <scott.petersen@sldmwa.org>, Shelly Ostrowski <sostrowski@westlandswater.org>, Kylie Fryar <KFryar@norcalwater.org>, Jennifer Giambroni <jgiambroni@cmab.net>, Heather Engel <HeatherE@acwa.com>, Chris Scheuring <cscheuring@cfbf.com>, Dana Ferreira <Dana.Ferreira@mid.org>, Adam Borchard <aborchard@cafreshfruit.com>, "jlauria@mazzei.net" <jlauria@mazzei.net>, Brandon Harder <harder@farmersrice.com>, Alyssa Houtby <alyssa@cacitrusmutual.com>, Kathryn Boren <kathryn@rosestrategicpr.com>, Ian LeMay <ilemay@cafreshfruit.com>, Cristel Tufenkjian <ctufenkjian@krcd.org>, Maddie Munson <mmunson@westcoastadvisors.com>, Tricia Geringer <tricia@agcouncil.org>, Anjanette Shadley <anjanette@westerncanal.com>, Johnny Amaral <jamaral@friantwater.org>, Rayne Thompson <rthompson@sunkistgrowers.com>, "Aubrey@aubreybettencourt.com" <Aubrey@aubreybettencourt.com>, Rick Kushman <rkushman@almondboard.com>, Mike Jensen <mjensen@mercedid.org>
Subject: Salmon facts. They're not what you've been told...

Please read and share this excellent piece by Todd Manley at the Northern California Water Association. Salmon populations are strong despite the negative media coverage claiming that populations are on the brink of extinction. This message needs to get out in order to counter the false narrative about the health of this important fishery.

Please share NCWA's link on your social channels!

Thank you!

Mike

https://norcalwater.org/2021/10/07/the-myths-and-facts-sacramento-valley-salmon/

Mike Wade
California Farm Water Coalition
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Sacramento, CA 95822
(916) 391-5030
www.farmwater.org

On Sep 27, 2021, at 9:27 AM, Mike Wade <mwade@farmwater.org> wrote:

We are being told that the bi-partisan infrastructure vote is now set for Thursday.

Please post your social content and make calls ASAP.

THANK YOU ALL!

https://thehill.com/homenews/house/574030-pelosi-sets-thursday-for-vote-on-infrastructure-bill

---

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NCWA
Northern California Water Association

To advance the economic, social and environmental sustainability of Northern California by enhancing and preserving the water rights, supplies and water quality.

The Myths and Facts--Sacramento Valley Salmon
What are we seeing in the rivers in 2021 during a very dry and hot year?

October 2021

Much of the reporting and hyperbole (see below) surrounding Sacramento Valley salmon population health this year has not told the complete story, as there has been premature reporting and the stories have not used accurate numbers based on what biologists are seeing in the rivers.

The following describes in more detail what state and federal agencies and biologists are seeing in the different parts of the Sacramento Valley in 2021. To be sure, the dry and hot conditions in 2021 are not ideal for salmon nor any other part of the ecosystem that depends upon water and they are having challenging years. Yet, despite these dry and hot conditions, salmon are amazingly resilient and they: 1) have returned to the Sacramento Valley in record numbers; 2) will continue to spawn, and 3) are now beginning their journey down the river in large numbers. Importantly, there continues to be a concerted effort throughout the region to improve conditions for every freshwater life-cycle stage of all four runs of Chinook salmon.

Sacramento River Winter-Run Salmon

Myth: The headlines have proclaimed a "near-complete loss of young salmon," "massive salmon die-off this summer," "catastrophic summer salmon slaughter," and a "California salmon wipeout." (*See* hyperbole below.)

Facts: There was a large adult salmon run that returned up the Sacramento River to spawn earlier this year and there are already more than 200,000 young salmon migrating downstream and many more still rearing.

Spawning: Adult winter-run salmon migrate upstream and seek out the upper river and side channels to lay their eggs in the loose gravel that has collected below Keswick Dam. This year,

- It appears more than 9,500 adult winter-run Chinook salmon returned to the Sacramento River to spawn this year. This is the largest number of returning adults based on CDFW carcass counts[1] in the last 15 years and follows similar returns of 8,128 in 2019 and 7,428 in 2020.

- Approximately 75% of these in-river spawners appeared to be natural-origin winter-run Chinook (not hatchery returns).

- Fry and juvenile salmon are currently being observed utilizing rearing habitat, including side channels constructed since the last drought (see e.g., Nur Pon Side Channel video).

- This returning class is the second-generation descendants of salmon from 2015, the last very dry year when many commentators proclaimed the same complete loss of winter-run salmon.

Rearing and Early Life Stages: When the young salmon fry release from their eggs, they seek out shelter in woody debris or among rocks for protection from predators and the swift current. This allows the young fish to eat and grow as they prepare for and are now beginning their journey down river to the ocean. This year,

- More than 200,000 juvenile winter-run Chinook salmon have already (as of September 23) begun their journey downstream past the city of Red Bluff, 60 miles downstream from their spawning grounds.

- In most years, the peak out-migration is not until October and November, and it is estimated that more than 500,000 juvenile winter-run Chinook will successfully migrate downstream of Red Bluff this year.

In sum, the monitoring this year is showing that there are significant numbers of salmon in the Sacramento River, even though it has been dry and hot. This reveals that the predictions for losing a whole "year class" of salmon are hyperbole and simply not accurate.

Butte Creek Spring-Run Salmon

Myth: The headlines have proclaimed that "record spring salmon run on Sacramento River tributary turns into disaster as most fish die before spawning" and "thousands of salmon washing up dead on California creek banks due to climate crisis." (*See* hyperbole below.)

Facts:

- The return of spring-run Chinook to the holding pools in the upper reach of Butte Creek this year was extraordinary and one of the largest runs seen in the past several decades, with estimates ranging from 15,000 to 20,000 adult fish.

- When the salmon reached their spawning grounds in the upper creek, the holding fish were exposed to periods of high temperatures, which appeared to be lethal for some adult fish.

- There remain a substantial number of spring-run Chinook salmon in Butte Creek that are now spawning. It will be several months before spawning success and migrating numbers can be determined.

- The adult fish mortality in Butte Creek is not attributable to water management actions as the creek benefits from cold water diverted from the Feather River and the upper creek

455 Capitol Mall, Suite 703, Sacramento, California 95814-4496 Telephone (916) 442-8333 www.norcalwater.org

essentially functions as a natural system, with the holding pools in Butte Creek similar to the state of nature, where dry and hot years have always challenged salmon and other species.

- There is coordinated effort among conservation organizations and water suppliers, working with the state and federal fish agencies, to continue to improve passage and conditions for spring-run salmon.

- We will continue to update this information as new reporting becomes available for spring-run salmon.

Investments in Sacramento Valley Salmon

Local water management entities, conservation organizations and state and federal fisheries and water management agencies have joined together to form the Sacramento Valley Salmon Recovery Program, a collaborative partnership to complete projects and improve science to promote recovery of salmon and other species of fish in the region. These actions are implementing both the National Marine Fisheries Service's Recovery Plan for the Sacramento River and the California Natural Resources Agency's Sacramento Valley Salmon Resiliency Strategy. The investments in this program have significantly improved salmon conditions in the Sacramento Valley and there is more work ahead to further improve salmon conditions, knowing that salmon are and have always been challenged in dry and hot years. See Aiding Salmon in the Upper Sacramento River and the Sacramento Salmon Recovery Program for more details. If you would like to join in these efforts to improve salmon conditions in the Sacramento Valley, please contact us at info@norcalwater.org.

The Hyperbole

Sacramento River:

"'Near-complete loss' of young salmon in Sacramento River possible, California officials say" (*SF Gate*, July 20,2021);

"Fears of a massive salmon die-off this summer in Sacramento River water conflict" *San Francisco Chronicle*, May 13, 2021;

California preps for catastrophic summer salmon slaughter" *Courthouse News Service*, July 27, 2021;

"Final plan for water releases into Sacramento River could kill up to 88% of endangered salmon run" *San Francisco Chronicle*, June 15, 2021;

"Conservationists say time running out to save endangered salmon in Sacramento River" *The New York Times*, July 15, 2021;

"Editorial: California salmon wipeout is even worse than you think" *Los Angeles Times*, July 26, 2021;

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“Heat Isn’t the Only Thing That Could Kill ‘Nearly All’ Young Salmon in the Sacramento River.” *Gizmodo*, July 14, 2021.

Butte Creek:

“Record spring salmon run on Sacramento River tributary turns into disaster as most fish die before spawning” *Sacramento News and Review*, August 5, 2021;

“Thousands of salmon washing up dead on California creek banks due to climate crisis” *The Independent*, September 14, 2021.

Note: We are providing this information to these publications and have offered an opportunity to tour the region and see the rivers and creeks first-hand.

If you have any questions or have additional thoughts on how to improve conditions for salmon in the Sacramento Valley, please contact us at: info@norcalwater.org.

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[1] California Department of Fish and Wildlife monitoring found 4,849 winter-run Chinook carcasses in the Sacramento River spawning grounds this year, which is the largest count in fifteen years. Importantly, observed carcasses are used to model and expand to an estimate of the total number of adult fish that successfully migrated to the spawning grounds. The estimated total returning fish is substantially greater than those counted. For example, in 2020, the carcass count was 3,678 fish and the final estimated return was nearly doubled to 7,428 fish and in 2019, the count of 3,026 fish was more than doubled to a final estimate of 8,128 fish. In addition, the carcass monitoring this year counted 1,588 female winter-run Chinook that had spawned before dying. This was also the largest number counted in fifteen years. (See California Department of Fish and Wildlife 2021 Winter-run Chinook Update File, “ALL YEAR SUMMARY by date” tab (available here). California Department of Fish and Wildlife “California Central Valley Chinook Population Database Report” (Grand Tab 2021.06.30); California Department of Fish and Wildlife 2021 Winter-run Chinook Update File, “Fresh spawn Female by week-year” tab (available here).

455 Capitol Mall, Suite 703, Sacramento, California 95814-4496 Telephone (916) 442-8333 www.norcalwater.org

From: Alicia Forsythe [aforsythe@sitesproject.org]
Sent: 10/7/2021 8:39:09 PM
To: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Subject: Re: Sites - Filing Fees for Final Doc

Thanks Laurie. We can fit this amount in.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Sent: Thursday, October 7, 2021 6:10:27 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Sites - Filing Fees for Final Doc

Yes, the fish and wildlife fee for an EIR is currently $3,343.25. Not huge in the overall budget but should be accounted for within Amendment 3.

Sent from my iPhone

On Oct 7, 2021, at 5:52 PM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Laurie – Do we have any filing fees of substance for the Final EIR? What about the fish and game filing fee for EIRs – does that still exist and how much is it? Just thinking about anything that needs to be budgeted in Amendment 3.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Dekar, Melissa D [mdekar@usbr.gov]
Sent: 10/8/2021 10:01:04 AM
To: Fisher, Linda [Linda.Fisher@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Kim Floyd [kim@floydcommunications.com]; Kevin Spesert [kspesert@sitesproject.org]; Pitzer, Gary R [gpitzer@usbr.gov]; King, Vanessa M [vking@usbr.gov]; Navarro, Lisa M [LNavarro@usbr.gov]; Sara M. Katz [SKatz@katzandassociates.com]; Elizabeth Cox [ecox@katzandassociates.com]; Emily Fan Michaelson [emichaelson@katzandassociates.com]; Laurie Warner Herson [laurie.warner.herson@phenixenv.com]; Taylor Davies [tdavies@sitesproject.org]
Subject: RE: [EXTERNAL] RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

Good morning again, 😉

Please incorporate the edits to clarify the potential effects of each alternative in the ad.

Thanks,
Melissa

From: Dekar, Melissa D
Sent: Friday, October 8, 2021 9:26 AM
To: Fisher, Linda <Linda.Fisher@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Kim Floyd <kim@floydcommunications.com>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; King, Vanessa M <vking@usbr.gov>; Navarro, Lisa M <LNavarro@usbr.gov>; Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Taylor Davies <tdavies@sitesproject.org>
Subject: RE: [EXTERNAL] RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

Hi Linda,

As we discussed over the phone, I will get back to you on your question below.

Here is a link to the Reclamation NEPA page that can be included in the ad.
https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=29024

Thanks,
Melissa

From: Fisher, Linda <Linda.Fisher@hdrinc.com>
Sent: Thursday, October 7, 2021 4:22 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Dekar, Melissa D <mdekar@usbr.gov>; Kim Floyd <kim@floydcommunications.com>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; King, Vanessa M <vking@usbr.gov>; Navarro, Lisa M <LNavarro@usbr.gov>; Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Taylor Davies <tdavies@sitesproject.org>
Subject: RE: [EXTERNAL] RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

Thank you all for the feedback and comments.

Ali – yes, the newspaper ad with revisions still meets the CEQA noticing requirements per the CEQA Guidelines. For everyone's awareness, the newspaper ad is a shorter version of the Draft NOA. The Draft NOA provides additional background information and a longer summary of the potential effects of the project.

Melissa – we are happy to incorporate your edits to clarify the potential effects of each alternative, however, this will add additional text and we are trying our best to keep the ad concise. With this in mind and that the NOA provides more information, please let us know if you are ok with the previous general statement regarding effects or if you would like the text to be expanded.

Thank you, Linda

Linda Fisher, M.S.
D 916.817.4962 M 530.400.3212

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, October 7, 2021 4:04 PM
To: Dekar, Melissa D <mdekar@usbr.gov>; Kim Floyd <kim@floydcommunications.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; King, Vanessa M <vking@usbr.gov>; Navarro, Lisa M <LNavarro@usbr.gov>; Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Taylor Davies <tdavies@sitesproject.org>
Subject: RE: [EXTERNAL] RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

I am good with these changes. Linda or Taylor, can you confirm that this still meeting the CEQA newspaper noticing requirements with these changes. I think this does, but I just want to be sure. (Taylor, I realized you were not on this email trial, so I will send the file to you now.)

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Dekar, Melissa D <mdekar@usbr.gov>
Sent: Thursday, October 7, 2021 2:51 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Kim Floyd <kim@floydcommunications.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; King, Vanessa M <vking@usbr.gov>; Navarro, Lisa M <LNavarro@usbr.gov>; Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: [EXTERNAL] RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

My comments/revisions attached.

Thanks,
Melissa

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Thursday, October 7, 2021 10:50 AM
To: Kim Floyd <kim@floydcommunications.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; Dekar, Melissa D <mdekar@usbr.gov>; King, Vanessa M <vking@usbr.gov>; Navarro, Lisa M <LNavarro@usbr.gov>; Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: [EXTERNAL] RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

Hi all - I had just a few minor comments/changes in the attached. This looks good. Its long – so anything we can do to shorten it or more it less stuff government jargon would be great.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Kim Floyd <kim@floydcommunications.com>
Sent: Thursday, October 7, 2021 9:00 AM
To: Fisher, Linda <Linda.Fisher@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; Dekar, Melissa D <mdekar@usbr.gov>; King, Vanessa M <vking@usbr.gov>; lnavarro@usbr.gov
Cc: Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

Thank you, Linda! We'll wait until COB tomorrow to submit this to design to allow everyone an opportunity to review and provide edits.

To address your question about the virtual meetings, we'll be using Zoom Webinar. It doesn't require registration and does allow for people to call in. I'm going to recommend we advertise a shortened link (e.g. Bitly) and the call-in number. The links will also be posted to the Sites website.

Kim

Kim Floyd Communications
(916) 838-2666 (cell)
kim@floydcommunications.com

From: Fisher, Linda <Linda.Fisher@hdrinc.com>
Sent: Wednesday, October 6, 2021 4:44 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; Pitzer, Gary R <gpitzer@usbr.gov>; Dekar, Melissa D <mdekar@usbr.gov>; King, Vanessa M <vking@usbr.gov>; lnavarro@usbr.gov
Cc: Sara M. Katz <SKatz@katzandassociates.com>; Kim Floyd <kim@floydcommunications.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Subject: RE: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

Hi All,

Attached please find the Draft Ad for notice of availability of the RDEIR/SDEIS and public meetings. Please let us know if you have any comments/questions. A few items in the ad are noted and will need to be firmed up before it is finalized.

Thank you, Linda

Linda Fisher, M.S.
D 916.817.4962 M 530.400.3212

hdrinc.com/follow-us

From: Kim Floyd <kim@floydcommunications.com>
Sent: Monday, October 4, 2021 9:51 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Kevin Spesert <kspesert@sitesproject.org>; Sara M. Katz <SKatz@katzandassociates.com>; Elizabeth Cox <ecox@katzandassociates.com>; Emily Fan Michaelson <emichaelson@katzandassociates.com>; Pitzer, Gary R <gpitzer@usbr.gov>; Dekar, Melissa D <mdekar@usbr.gov>; King, Vanessa M <vking@usbr.gov>; Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Fisher, Linda <Linda.Fisher@hdrinc.com>; lnavarro@usbr.gov
Subject: 10/5 Sites RDEIR/SDEIS Public Outreach Planning Meeting Agenda

All:

Attached please find the agenda for tomorrow's 9 a.m. meeting for coordination on RDEIR/SDEIS public outreach. We'd like to spend a significant portion of the meeting brainstorming and discussing questions that should be included in our FAQs and priority topics for the Community Guide.

In addition, we have a choice of days for our in-person community meeting (based on anticipated release date): Dec. 6, 7 or 9. If possible, I'd like to firm up the date tomorrow so we can complete the reservation for the VFW hall.

Please let me know if you have any questions, and thank you!

Kim

Kim Floyd Communications
(916) 838-2666 (cell)
kim@floydcommunications.com

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/11/2021 7:13:57 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]
Subject: FW: CALSIM2- climate change

Seems a little late for this for us to get much use from it. Let me know if you see anything of interest.

From: "Okita, David@DWR" <David.Okita@water.ca.gov>
Date: Sunday, October 10, 2021 at 7:21 AM
To: Maureen Martin <mmartin@ccwater.com>, Jerry Brown <jbrown@sitesproject.org>, Fiona Sanchez <sanchezf@irwd.com>, Mark Beuhler <mbeuhler@wswaterbank.com>, "slee@ieua.org" <slee@ieua.org>, Terrie Mitchell <mitchellt@sacsewer.com>, "chakes@valleywater.org" <chakes@valleywater.org>
Cc: Dave Richardson <drichardson@woodardcurran.com>, "Cowin, Mark" <mcowin@geiconsultants.com>
Subject: CALSIM2- climate change

As requested by some of the WSIP projects, DWR has prepared updated CALSIM2 runs that include climate change scenarios for your use.

It took longer than expected to get USBR validation of the results, but the final product has been reviewed by both DWR and USBR.

Below is a link to the documents. Please distribute to whomever needs this information.

We uploaded 5 WSIP modeling scenarios to the following link:
https://cadwr.box.com/s/n763qucwdb1ktq0rwrfky10e74qu5cx1

These model scenarios apply the previous sets of WSIP hydrology to the updated CalSim II operations model. Where:

1. WSIP_Existing_CalSim_20210930.7z – Historical hydrology
2. WSIP_2030_CalSim_20210930.7z – Climate change centered on 2030
3. WSIP_2070_CalSim_20210930.7z – Climate change centered on 2070
4. WSIP_2070DEW_CalSim_20210930.7z – 2070 Dry Extreme Warming
5. WSIP_2070WMW_CalSim_20210930.7z – 2070 Wet Moderate Warming

David Okita, PE
Department of Water Resources
530 902-7588

From: Laurie Warner Herson [laurie.warner.herson@phenixenv.com]
Sent: 10/11/2021 8:44:27 AM
To: Williams, Nicole [Nicole.Williams@icf.com]; Briard, Monique [Monique.Briard@icf.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Linda Fisher (linda.fisher@hdrinc.com) [linda.fisher@hdrinc.com]
CC: Taylor Davies [tdavies@sitesproject.org]
Subject: RE: Biweekly EIR/EIS Team Meeting

Our biweekly EIR/EIS meeting is scheduled for 3:30 pm today. Please see draft agenda here: https://sitesreservoirproject.sharepoint.com/:w:/r/EnvPlanning/Meetings/Biweekly%20EIR_EIS%20meetings/20211011_EIR_EIS_Biweekly_Meeting-Agenda.docx?d=wae9d1bf8b2bc4411951bf1691c0bb14e&csf=1&web=1&e=KQ5GLJ

The meeting will focus on the Reclamation management review comments received to date. A list of comments that need Authority direction and/or input have been included in the agenda, based on an email from Nicole on Sunday.

-----Original Appointment-----
From: Laurie Warner Herson
Sent: Monday, July 27, 2020 10:57 AM
To: Laurie Warner Herson; Williams, Nicole; Briard, Monique; Alicia Forsythe; Linda Fisher (linda.fisher@hdrinc.com)
Cc: Taylor Davies
Subject: Biweekly EIR/EIS Team Meeting
When: Monday, October 11, 2021 3:30 PM-4:30 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Webex

As previously mentioned, the goal of these meetings is to make sure we are communicating on key issues and that Integration is doing enough to facilitate ICF's work. Agendas will be sent out prior to each meeting

-- Do not delete or change any of the following text. --

When it's time, join your Webex meeting here.

Meeting number (access code): 126 649 4794
Meeting password: 6DizN6kGem6 (63496654 from phones and video systems)

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+1-510-338-9438,,1266494794#63496654# USA Toll
Some mobile devices may ask attendees to enter a numeric meeting password.

Join by phone
+1-510-338-9438 USA Toll
Global call-in numbers

Join by video system, application or Skype for business
Dial 1266494794@webex.com
You can also dial 173.243.2.68 and enter your meeting number.

If you are a host, click here to view host information.

Need help? Go to http://help.webex.com

From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 10/11/2021 11:38:00 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Lecky, Jim [jim.Lecky@icf.com]; Hendrick, Mike [Mike.Hendrick@icf.com]
CC: Briard, Monique [monique.briard@icf.com]; Greenwood, Marin [Marin.Greenwood@icf.com]
Subject: RE: Sites - Follow up on EBMUD Meeting
Attachments: DRAFT_Sites_Mokelumne_fish_impacts_10072021.docx

Ali,

The team has spent some time discussing your question please see below for our responses in red.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, September 29, 2021 1:20 PM
To: Spranza, John <john.spranza@hdrinc.com>; Lecky, Jim <jim.Lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>
Subject: Sites - Follow up on EBMUD Meeting

Hi all – I wanted to follow up on the remaining action items from the EBMUD meeting. I had the following remaining action items:

1. Provide any analysis or information on changes, if any, of opening/closure of the Delta Cross Channel as a result of the Project.
a. The CalSim data were provided for Alternatives 1–3 didn't include number of days with DCC open – we expect Jacobs could do monthly exceedance plots as one way to look at it, or mean number of days open by month and water year type.
2. Provide any analysis or information on changes that may result in increases / decreases in central Delta route entrainment.
a. We are thinking that the main concern is fish moving down the forks of the Mokelumne and potential changes in hydrodynamics and therefore susceptibility to south Delta entry/entrainment. Marin believes that there is little difference in south Delta exports between NAA and alternatives, and little difference in through-Delta survival from the Sacramento, indicating little difference in interior Delta routing for fish from the Sacramento basin. Marin has created an impact assessment reflecting this should you wish to include it in the existing Impact Fish 4 in the Draft EIR/S to acknowledge and address EBMUD's concern.

Can we get these together for EBMUD by the Wednesday aquatics meeting next week? Lets make this easy on us and try to pull from the RDEIR/SDEIS text and analysis as much as we can (versus creating new stuff).

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Greenwood, Marin [Marin.Greenwood@icf.com]
Sent: 10/11/2021 11:56:33 AM
To: Spranza, John [john.spranza@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Lecky, Jim [Jim.Lecky@icf.com]; Hendrick, Mike [Mike.Hendrick@icf.com]
CC: Briard, Monique [Monique.Briard@icf.com]
Subject: RE: Sites - Follow up on EBMUD Meeting

Just to clarify – the attached word doc is the thing to look at; ignore the red responses, they were earlier in the thought process (and I overlooked that I already had the DCC outputs, for example).

MARIN GREENWOOD | **ICF** | marin.greenwood@icf.com | **+1.530.400.8081 mobile**

From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Monday, October 11, 2021 11:38
To: Alicia Forsythe <aforsythe@sitesproject.org>; Lecky, Jim <Jim.Lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>
Cc: Briard, Monique <Monique.Briard@icf.com>; Greenwood, Marin <Marin.Greenwood@icf.com>
Subject: RE: Sites - Follow up on EBMUD Meeting

Ali,

The team has spent some time discussing your question please see below for our responses in red.

John Spranza

D 916.679.8858 M 818.640.2487

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Wednesday, September 29, 2021 1:20 PM
To: Spranza, John <john.spranza@hdrinc.com>; Lecky, Jim <jim.Lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>
Subject: Sites - Follow up on EBMUD Meeting

Hi all – I wanted to follow up on the remaining action items from the EBMUD meeting. I had the following remaining action items:

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a. The CalSim data were provided for Alternatives 1–3 didn't include number of days with DCC open – we expect Jacobs could do monthly exceedance plots as one way to look at it, or mean number of days open by month and water year type.
2. Provide any analysis or information on changes that may result in increases / decreases in central Delta route entrainment.
a. We are thinking that the main concern is fish moving down the forks of the Mokelumne and potential changes in hydrodynamics and therefore susceptibility to south Delta entry/entrainment. Marin believes that there is little

difference in south Delta exports between NAA and alternatives, and little difference in through-Delta survival from the Sacramento, indicating little difference in interior Delta routing for fish from the Sacramento basin. Marin has created an impact assessment reflecting this should you wish to include it in the existing Impact Fish 4 in the Draft EIR/S to acknowledge and address EBMUD's concern.

Can we get these together for EBMUD by the Wednesday aquatics meeting next week? Lets make this easy on us and try to pull from the RDEIR/SDEIS text and analysis as much as we can (versus creating new stuff).

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC [Steve.Micko@jacobs.com]
Sent: 10/11/2021 9:45:51 PM
To: Spranza, John [john.spranza@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Lecky, Jim [jim.lecky@icf.com]; Hassrick, Jason [jason.hassrick@icf.com]; Hendrick, Mike [mike.hendrick@icf.com]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
CC: Thayer, Reed/SAC [Reed.Thayer@jacobs.com]
Subject: RE: Discuss Fremont weir
Attachments: DRAFT Sites_2081 Aquatic Tables _2021-1011.xlsx

Hi all,

Reed completed a draft of "Study 11" this evening.
High-level results are presented below.
I also incorporated these results into the "Aquatics Tables" spreadsheet (attached).

We started with diversion criteria proposed by CDFW (Study 8).
Then, incorporated the following Fremont Weir Diversion Criteria logic:

- Notch flow (Nov 1st through Mar 15th):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
  - When Sacramento River at Fremont Weir stage is between 21 ft and 28 ft, 2% of total Sacramento River flow may be diverted.
  - When Sacramento River at Fremont Weir stage is between 28 ft and 32 ft, 5% of total Sacramento River flow may be diverted.
- Potential Notch flow (Mar 16th through May 31st):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
- Fremont Weir Spill:
  - When Sacramento River stage at Fremont Weir is increasing and is between 32 ft and 33.25 ft, diversions may not occur for seven days.
  - If Sacramento River stage at Fremont Weir is greater than 33.25 ft, diversion may occur.
  - After a restricted diversion event has been initiated, another restricted diversion event may not initiate until Sacramento River stage at Fremont Weir is less than 32 ft for seven days.

As these mechanisms are incorporated into the CalSim II model, we can readily run them with other sets of Wilkins Slough or Pulse Flow Protection diversion criteria.

Please let us know if you have any questions.

Best,
Steve

Name	Study 8	Study 11
Wilkins Slough	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept
Fremont Weir Notch Protections	Y	Proposed CDFW Criteria

Pulse Flow Protection	Y	Y
Releases (TAF)	206	179
Diversions (TAF)	225	197
Dry & Critical Diversions (TAF)	69	37
Comment	Current mitigation plus added flow requirement October-February	Current mitigation plus added flow requirement October-February and Fremont Weir notch flow and weir spill criteria

-----Original Appointment-----
From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, September 30, 2021 12:08 PM
To: Spranza, John; Alicia Forsythe; Heydinger, Erin; Micko, Steve/SAC; Lecky, Jim; Hassrick, Jason; Hendrick, Mike; Greenwood, Marin; Chris Fitzer (CFitzer@esassoc.com); Leaf, Rob/SAC
Subject: [EXTERNAL] Discuss Fremont weir
When: Friday, October 1, 2021 11:00 AM-12:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Short notice on this but we are hoping we can get a group together to chat about what we heard on today's cdfw call.

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)
+1 213-514-6883,,308800884# United States, Los Angeles
(833) 255-2803,,308800884# United States (Toll-free)
Phone Conference ID: 308 800 884#
Find a local number | Reset PIN

Learn More | Meeting options

File Provided Natively

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/12/2021 1:20:48 PM
To: Micko, Steve/SAC [Steve.Micko@jacobs.com]; Spranza, John [john.spranza@hdrinc.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Lecky, Jim [jim.lecky@icf.com]; Hassrick, Jason [jason.hassrick@icf.com]; Hendrick, Mike [mike.hendrick@icf.com]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
CC: Thayer, Reed/SAC [Reed.Thayer@jacobs.com]
Subject: RE: Discuss Fremont weir

Thanks Steve, Rob, Reed and team for getting this completed so quickly. I really appreciate it.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Monday, October 11, 2021 9:46 PM
To: Spranza, John <john.spranza@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: Discuss Fremont weir

Hi all,

Reed completed a draft of "Study 11" this evening.
High-level results are presented below.
I also incorporated these results into the "Aquatics Tables" spreadsheet (attached).

We started with diversion criteria proposed by CDFW (Study 8).
Then, incorporated the following Fremont Weir Diversion Criteria logic:

- Notch flow (Nov 1st through Mar 15th):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
  - When Sacramento River at Fremont Weir stage is between 21 ft and 28 ft, 2% of total Sacramento River flow may be diverted.
  - When Sacramento River at Fremont Weir stage is between 28 ft and 32 ft, 5% of total Sacramento River flow may be diverted.
- Potential Notch flow (Mar 16th through May 31st):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
- Fremont Weir Spill:
  - When Sacramento River stage at Fremont Weir is increasing and is between 32 ft and 33.25 ft, diversions may not occur for seven days.
  - If Sacramento River stage at Fremont Weir is greater than 33.25 ft, diversion may occur.
  - After a restricted diversion event has been initiated, another restricted diversion event may not initiate until Sacramento River stage at Fremont Weir is less than 32 ft for seven days.

As these mechanisms are incorporated into the CalSim II model, we can readily run them with other sets of Wilkins Slough or Pulse Flow Protection diversion criteria.

Please let us know if you have any questions.

Best,
Steve

Name	Study 8	Study 11
Wilkins Slough	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept
Fremont Weir Notch Protections	Y	Proposed CDFW Criteria
Pulse Flow Protection	Y	Y
Releases (TAF)	206	179
Diversions (TAF)	225	197
Dry & Critical Diversions (TAF)	69	37
Comment	Current mitigation plus added flow requirement October-February	Current mitigation plus added flow requirement October-February and Fremont Weir notch flow and weir spill criteria

-----Original Appointment-----
From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, September 30, 2021 12:08 PM
To: Spranza, John; Alicia Forsythe; Heydinger, Erin; Micko, Steve/SAC; Lecky, Jim; Hassrick, Jason; Hendrick, Mike; Greenwood, Marin; Chris Fitzer (CFitzer@esassoc.com); Leaf, Rob/SAC
Subject: [EXTERNAL] Discuss Fremont weir
When: Friday, October 1, 2021 11:00 AM-12:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Short notice on this but we are hoping we can get a group together to chat about what we heard on today's cdfw call.

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Sent: 10/12/2021 2:05:37 PM
To: Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Andrew Garcia [AndrewGarcia@valleywater.org]
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin,

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Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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Sent: Friday, October 1, 2021 12:56 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

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To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

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Alternative 1B	1.5 MAF 7% federal funding	X	X	X	X
Alternative 2	1.3 MAF No federal funding	X	X		
Alternative 3	1.5 MAF 25% federal funding	X	X		

I will also send this out to the full workgroup after next week's meeting.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Wednesday, May 26, 2021 1:51 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Erin

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, April 19, 2021 10:08 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; Dwayne Chisam <DChisam@avek.org>; 'Robert Cheng' <RCheng@cvwd.org>; pvasileva@cvwd.org; Mark Krause <MKrause@dwa.org>; Paul Weghorst <weghorst@irwd.com>; Kellie Welch <welch@irwd.com>; 'Randall Neudeck' <rneudeck@mwdh2o.com>; 'CWang (cwang@mwdh2o.com)' <cwang@mwdh2o.com>; Bradshaw,Dee <VBradshaw@mwdh2o.com>; Sheehan,Rebecca D <RSheehan@mwdh2o.com>; Dan Bartel <dbartel@rrbwsd.com>; 'Bob Tincher' <bobt@sbvmwd.com>; Heather Dyer <heatherd@sbvmwd.com>; Jeff Davis <jdavis@sgpwa.com>; Eric Leitterman <ELeitterman@valleywater.org>; 'Dirk Marks' <dmarks@scvwa.org>; 'AFlores (AFlores@zone7water.com)' <AFlores@zone7water.com>; Xie, Lillian <lxie@zone7water.com>; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde <rkunde@wrmwsd.com>
Cc: Jerry Brown <jbrown@sitesproject.org>; JP Robinette <JRobinette@BrwnCald.com>; Alicia Forsythe <aforsythe@sitesproject.org>; steve.micko@jacobs.com; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites South of Delta/SWP Modeling

Good morning,

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Best,
Erin

Erin Heydinger PE, PMP

D 916.679.8863 M 651.307.9758

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-----Original Appointment-----
From: Heydinger, Erin
Sent: Wednesday, March 31, 2021 5:13 PM
To: Heydinger, Erin; fhernandez@cityofamericancanyon.org; Dwayne Chisam; Robert Cheng; pvasileva@cvwd.org; Mark Krause; Paul Weghorst ; Kellie Welch; Randall Neudeck; CWang (cwang@mwdh2o.com); Bradshaw,Dee; Sheehan,Rebecca D; Dan Bartel; Bob Tincher; Heather Dyer; Jeff Davis; ELeitterman@valleywater.org; Dirk Marks; AFlores (AFlores@zone7water.com); Xie, Lillian; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde
Cc: Jerry Brown; JP Robinette (JRobinette@BrwnCald.com); Alicia Forsythe; steve.micko@jacobs.com; Thayer, Reed/SAC; Leaf, Rob/SAC
Subject: Sites South of Delta/SWP Modeling
When: Tuesday, April 13, 2021 2:00 PM-4:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Good afternoon – the meeting agenda is attached. Thanks!

Thanks for your responses to the Doodle poll. This invite is to discuss Sites modeling assumptions for Delta and South of Delta participants. **Please RSVP** so we can ensure we do not exceed the quorum limit. Agenda coming soon.

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From:	Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent:	10/12/2021 2:15:19 PM
To:	Eric Leitterman [ELeitterman@valleywater.org]
CC:	Alicia Forsythe [aforsythe@sitesproject.org]; Andrew Garcia [AndrewGarcia@valleywater.org]
Subject:	Re: Sites South of Delta/SWP Modeling

Hi Eric,

Yes! Sorry for the delay on this. I have a spreadsheet drafted, just confirming with the modeling team that I have the latest WSIP data since we are finalizing the Feasibility Study. I should have this over to you this evening or tomorrow morning.

Thanks,
Erin

From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Tuesday, October 12, 2021 2:05:37 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
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From: Spranza, John [John.Spranza@hdrinc.com]
Sent: 10/12/2021 2:50:58 PM
To: Arsenijevic, Jelica [Jelica.Arsenijevic@hdrinc.com]; (MVondergeest@icfi.com) [mvondergeest@icfi.com]; Markham, John [John.Markham@icf.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Briard, Monique [monique.briard@icf.com]
Subject: Rational for Value Planning Selected Alternative

I reviewed the value planning report and the following rational for recommendation of the proposed project over the other 1.5 and the 1.3 option are below. I hope this helps

The recommended Project was developed by the Ad Hoc Value Planning Workgroup through a sequential process that included initial and refined alternatives. Important considerations included total project cost, impacts on landowners, impacts on traffic and public safety, ability to meet participant demands, ability to provide public benefits to the State, relative magnitude of environmental impacts, and the estimated cost per acre-foot of water delivered. The recommended Project and two options for consideration are shown in Table 8-1.

TABLE 8-1. VALUE PLANNING GROUP RECOMMENDED PROJECTS

	VP5	VP6	VP7
	Option 1	Option 2	Recommended
Reservoir Size	1.3 MAF	1.3 MAF	1.5 MAF
Dunnigan Release Capacity (cfs)	1,000 cfs to CBD	1,000 cfs to River	1,000 cfs to CBD
Estimated Cost (2019 dollars)	$2,855,000,000	$2,988,000,000	$3,037,000,000
Estimated Cost per Acre-Foot with WIFIA* (2020)	$592	$621	$611
Estimated Deliveries (Long-Term Average in TAF)	234	234	243

* Water Infrastructure Finance and Innovation Act

The Value Planning Workgroup recommends the Project proceed as Alternative VP7. Although Alternative VP5 had the lowest overall cost and lower cost per acre-foot, the Value Planning Workgroup recommends VP7 based on higher deliveries at a comparable cost and improved operational flexibility with a 1.5 MAF reservoir. The proposed facility locations associated with VP7 are shown in Figure 8-1.

The Value Planning Workgroup also recommends the subsequent analyses of the Project include a 1.3 MAF reservoir (per VP5) and a Dunnigan to Sacramento River 1000 cfs release pipeline (per VP6) in order to provide flexibility to respond to any future condition changes that might result in such facilities becoming preferable.

The Recommended Project results in the following significant changes to the original Alternative D 1.8 MAF Project:

- Reduced project size and footprint
- Reduced Sacramento River diversions
- Elimination of Delevan Sacramento River diversion and release facility
- Elimination of Delevan Pipeline and associated impacts to landowners and wildlife refuges along that alignment
- Reduced costs and improved affordability to the Project's funding participants

John Spranza, MS, CCN
Senior Ecologist / Regulatory Specialist

HDR

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Sacramento, CA 95833
D 916.679.8858 M 818.640.2487
john.spranza@hdrinc.com

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From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 10/12/2021 3:29:53 PM
To: Jerry Brown [jbrown@sitesproject.org]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: CALSIM2- climate change

Looks like MBK did this modeling (Walter and Shankar) and the only change that might impact us would be some modifications to Oroville operations. It looks like this is really just a baseline model and doesn't include all the Prop 1 projects, but I wonder if they plan to have Stantec add those projects in (thus their request for our model last week). I agree there's not much to do with it at this point – I wonder what their goal was with updating it now.

We can ask MBK at our next water rights check in if there's anything significant in here that I missed that we should be aware of.

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Jerry Brown <jbrown@sitesproject.org>
Sent: Monday, October 11, 2021 7:14 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: FW: CALSIM2- climate change

Seems a little late for this for us to get much use from it. Let me know if you see anything of interest.

From: "Okita, David@DWR" <David.Okita@water.ca.gov>
Date: Sunday, October 10, 2021 at 7:21 AM
To: Maureen Martin <mmartin@ccwater.com>, Jerry Brown <jbrown@sitesproject.org>, Fiona Sanchez <sanchezf@irwd.com>, Mark Beuhler <mbeuhler@wswaterbank.com>, "slee@ieua.org" <slee@ieua.org>, Terrie Mitchell <mitchellt@sacsewer.com>, "chakes@valleywater.org" <chakes@valleywater.org>
Cc: Dave Richardson <drichardson@woodardcurran.com>, "Cowin, Mark" <mcowin@geiconsultants.com>
Subject: CALSIM2- climate change

As requested by some of the WSIP projects, DWR has prepared updated CALSIM2 runs that include climate change scenarios for your use.

It took longer than expected to get USBR validation of the results, but the final product has been reviewed by both DWR and USBR.

Below is a link to the documents. Please distribute to whomever needs this information.

We uploaded 5 WSIP modeling scenarios to the following link:
https://cadwr.box.com/s/n763qucwdb1ktq0rwrfky10e74qu5cx1

These model scenarios apply the previous sets of WSIP hydrology to the updated CalSim II operations model. Where:

1. WSIP_Existing_CalSim_20210930.7z – Historical hydrology

2. WSIP_2030_CalSim_20210930.7z – Climate change centered on 2030
3. WSIP_2070_CalSim_20210930.7z – Climate change centered on 2070
4. WSIP_2070DEW_CalSim_20210930.7z – 2070 Dry Extreme Warming
5. WSIP_2070WMW_CalSim_20210930.7z – 2070 Wet Moderate Warming

David Okita, PE
Department of Water Resources
530 902-7588

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 10/12/2021 5:42:25 PM
To: Eric Leitterman [ELeitterman@valleywater.org]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Andrew Garcia [AndrewGarcia@valleywater.org]
Subject: RE: Sites South of Delta/SWP Modeling
Attachments: Sites-SOD-StorageExports-20211009.xlsx

Hi Eric,

Thanks for your patience on this. Attached is a spreadsheet with monthly CalSim outputs from the historic hydrology as well as WSIP 2030 for storage levels and exports at Banks. Please note that because of the way salinity costs are estimated and applied to the model, the storage levels/releases don't always match up perfectly with export amounts at a monthly level. It's recommended the values be summarized on an annual basis whenever possible. Please let me know if you have questions on that or anything else provided.

Thank you,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Tuesday, October 12, 2021 2:06 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin,

Following up on my request for modeling result. Will you be able to send me something this week.

ERIC LEITTERMAN
ASSOCIATE ENGINEER - CIVIL
Imported Water Unit
Water Supply Division
Tel. (408) 630-2669 / Cell. (408) 784-4966
eleitterman@valleywater.org

Valley Water

SANTA CLARA VALLEY WATER DISTRICT
5750 Almaden Expressway, San Jose CA 95118
www.valleywater.org

Clean Water · Healthy Environment · Flood Protection

From: Eric Leitterman
Sent: Friday, October 1, 2021 2:20 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

I am looking for Exports at Banks.

Next week should be just fine for me.

ERIC LEITTERMAN
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eleitterman@valleywater.org

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Friday, October 1, 2021 1:54 PM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

This information should be pretty easy to pull together. I should be able to send you something next week. Are you looking for exports at Banks or reservoir releases (no losses accounted for).

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Friday, October 1, 2021 12:56 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin,

I would like to request results from the CALSIM runs for Alternative 1B with Historic hydrology and for Alternative 1B with 2030 WSIP Hydrology. Specifically, what I am looking for are the monthly time step results for SOD exports of Sites Water for SOD of Delta PWAs only (No Refuge Water, No transfers from NOD PWAs).

I would also like to request the end of month storage levels in the SOD PWA bucket from the same two runs.

I know these requests may take some post processing to accomplish. Please let me know if staff have the bandwidth to accommodate my request and if so when I can expect to have my requests to be fulfilled.

ERIC LEITTERMAN
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eleitterman@valleywater.org

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www.valleywater.org

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Friday, June 11, 2021 9:52 AM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

Apologies for the delay on this and thanks for the reminder. I thought I had sent this out but looked back and could not find it. Here is the table, where an X indicates model runs that have been performed and are available.

	Project Size/Level of Federal Investment	Historic hydrology	2035 Central Tendency Climate Change	2030 WSIP Climate Change	2070 WSIP Climate Change
No Action	No project	X	X	X	X
Alternative 1A	1.5 MAF No federal funding	X	X		
Alternative 1B	1.5 MAF 7% federal funding	X	X	X	X
Alternative 2	1.3 MAF	X	X		

	No federal funding				
Alternative 3	1.5 MAF 25% federal funding	X	X		

I will also send this out to the full workgroup after next week's meeting.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Wednesday, May 26, 2021 1:51 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin

Did you ever send out the table of alternatives you mentioned your email below? I can't find it in my records and may have missed it.

ERIC LEITTERMAN
ASSOCIATE ENGINEER - CIVIL
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Water Supply Division
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eleitterman@valleywater.org

Valley Water

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www.valleywater.org

Clean Water · Healthy Environment · Flood Protection

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, April 19, 2021 10:08 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; Dwayne Chisam <DChisam@avek.org>; 'Robert Cheng' <RCheng@cvwd.org>; pvasileva@cvwd.org; Mark Krause <MKrause@dwa.org>; Paul Weghorst <weghorst@irwd.com>; Kellie Welch <welch@irwd.com>; 'Randall Neudeck' <rneudeck@mwdh2o.com>; 'CWang (cwang@mwdh2o.com)' <cwang@mwdh2o.com>; Bradshaw,Dee <VBradshaw@mwdh2o.com>; Sheehan,Rebecca D <RSheehan@mwdh2o.com>; Dan Bartel <dbartel@rrbwsd.com>; 'Bob Tincher'

<bobt@sbvmwd.com>; Heather Dyer <heatherd@sbvmwd.com>; Jeff Davis <jdavis@sgpwa.com>; Eric Leitterman <ELeitterman@valleywater.org>; 'Dirk Marks' <dmarks@scvwa.org>; 'AFlores (AFlores@zone7water.com)' <AFlores@zone7water.com>; Xie, Lillian <lxie@zone7water.com>; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde <rkunde@wrmwsd.com>
Cc: Jerry Brown <jbrown@sitesproject.org>; JP Robinette <JRobinette@BrwnCald.com>; Alicia Forsythe <aforsythe@sitesproject.org>; steve.micko@jacobs.com; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites South of Delta/SWP Modeling

Good morning,

Thank you for your participation in last week's modeling meeting. Attached is the PowerPoint presentation. I will also be following up with a table describing the alternatives that have been modeled and the associated hydrology. Please reach out if you would like any of the data or available results we discussed. For those of you who have already requested information, I will be getting back to you shortly.

Best,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

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-----Original Appointment-----
From: Heydinger, Erin
Sent: Wednesday, March 31, 2021 5:13 PM
To: Heydinger, Erin; fhernandez@cityofamericancanyon.org; Dwayne Chisam; Robert Cheng; pvasileva@cvwd.org; Mark Krause; Paul Weghorst ; Kellie Welch; Randall Neudeck; CWang (cwang@mwdh2o.com); Bradshaw,Dee; Sheehan,Rebecca D; Dan Bartel; Bob Tincher; Heather Dyer; Jeff Davis; ELeitterman@valleywater.org; Dirk Marks; AFlores (AFlores@zone7water.com); Xie, Lillian; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde
Cc: Jerry Brown; JP Robinette (JRobinette@BrwnCald.com); Alicia Forsythe; steve.micko@jacobs.com; Thayer, Reed/SAC; Leaf, Rob/SAC
Subject: Sites South of Delta/SWP Modeling
When: Tuesday, April 13, 2021 2:00 PM-4:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Good afternoon – the meeting agenda is attached. Thanks!

Thanks for your responses to the Doodle poll. This invite is to discuss Sites modeling assumptions for Delta and South of Delta participants. **Please RSVP** so we can ensure we do not exceed the quorum limit. Agenda coming soon.

Microsoft Teams meeting

Join on your computer or mobile app
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(833) 255-2803,,895164312# United States (Toll-free)

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Colusa County Water District
Sites Participant Workshop
OCTOBER 20, 2021

Time Well Spent

01

INTRODUCTIONS

PROJECT REVIEW
- MONEY SPENT TO DATE

02

WHAT'S NEW
-Sizing
-Facilities
-Move to AF of Storage vs AF of Water

03

FUTURE –
-SHORT-TERM CASH CALL
-LONG-TERM FINANCING
- IMPROVEMENT DISTRICT FORMATION

SITES RESERVOIR
PHASES OF DEVELOPMENT

Phase 1 – Formation of JPA and state funding Prop 1 award (Complete)

Phase 2 – Certification of environmental impact report and statement and acquisition of key permits (In-progress)

Phase 3 – Final design and right-of-way acquisition (Mid 2023-2024)

Phase 4 – Construction and commissioning (Mid-late 2024-2030)

Phase 5 – Construction close-out and operations (2030 and beyond)

**Delays in securing permits or water rights, could affect the Construction schedule & it will be adjusted accordingly.

SHOW ME THE MONEY…

PHASE 1

$60/af Initial Cash Call

Actual $48.50/af
(Balance used for Sites JPA membership and/or held in interest bearing account for refund later)

Money facilitated work on application for State Prop 1 Grant funding

Successful grant application
Awarded $816 million

PHASE 2

2A - $60/af Cash Call
(Mar 2019-Dec 2019)

Value Planning resulting in smaller reservoir size and new "foot-print" with anticipated cost savings

2B - $100/af Cash Call
(Sept 2020- Dec 2021)
plus $10/af for Sites JPA yearly membership fee

Updating environmental documents, feasibility study; working on permitting and water rights issues

PHASE 2C (proposed)

Up to - $400/af Cash call

$100- Apr 2022; $140-Jan 2023; $160-Dec 2023

Per AF or Per AF of Storage??

Continue work on Permits/water rights

Environmental review

Financing

Design & Pre-Construction

WHAT'S NEW…

How does it affect my participation?

"Right-sizing" – decreased reservoir size from 1.8 to a 1.3-1.5 MAF to meet participation levels

Use of existing facilities vs constructing new Maxwell/Delevan pipeline. Discharge via TC Canal - Dunnigan – Colusa Basin Drain – Sac River via Knights Landing for SOD

Change from cost per AF of supply to Storage based per AF cost

1 AF = 6.234 AF/storage

Prior presentations:

2016	AF cost estimate	$700/af
2018	AF cost estimate	$1,400/af

After 2018 Value Planning identifying the "right-size" project

2018	AF cost estimate	$650-750/af

June 2021 updated cost estimate = $3.9 Bil (2021 $)

2021	AF cost estimate	$ 518
	1 af = 6.234 af/storage	$ 3,229

WHAT DOES AF of STORAGE MEAN?

AF of Water Supply vs AF of Storage

Cost of Storage vs Water?

Sale of water, leasing or selling storage space

Building facility doesn't guarantee water supply – dependent on "mother nature"

Cost of Construction must be repaid regardless of whether water is able to be diverted and/or delivered to participant

Potential to divert more in good years and hold in storage for use or sale later.

FUTURE OF FUNDING & PLAN OF FINANCE

FEDERAL & STATE PARTICIPATION

STATE:

Prop 1 – Awarded $816 mil

Early funding received $xx

FEDERAL:

WINN Act - $10 mil to date

Drought Resiliency – $80 mil (10/2021)

Infrastructure Bill - $

PROJECT PARTICIPANTS (LANDOWNERS/DISTRICTS)

SHORT TERM:

- Cash Calls = $620/af (2016-2024)
- Interim Financing – Potential before last $150 cash call (2023) if permitting & water rights application are complete

LONG-TERM Financing (Phase 3 thru 5)

- WIFIA Loans = Water Infrastructure Finance Innovation Act $5.5 Billion available in 2021
- USDA Loans
- Fixed Rate Bonds
- Pay-go

IMPROVEMENT DISTRICT FORMATION

WHY IS IT NEEDED

Project financing will require source of repayment to be identified.

Not all landowners within District are participants in Sites therefore, all lands will not benefit.

Beneficiary pays concept

WHAT IS REQUIRED OF LANDOWNERS

Petition requesting District to form Improvement District

Identify parcels to be included

Signed agreement to pay for cost of formation and AF of Sites water/storage

Engineers analysis of benefiting lands/parcels to insure "payment capacity"

Next Steps

Complete Phase 2C Sites Participation Agreement

- Committing to AF of water/storage @ $400/af
- Formation of "Sites Improvement District #1"
- Identifying parcels to be included in improvement district

Rebalancing –

Decreasing AF can happen now or before entering financing agreement (Phase 3).
Increasing AF is dependent on decreases made by others, active participants will have "first right of refusal" before new participants are given opportunity.

From: Micko, Steve/SAC [Steve.Micko@jacobs.com]
Sent: 10/14/2021 10:05:54 AM
To: Alicia Forsythe [aforsythe@sitesproject.org]; Spranza, John [john.spranza@hdrinc.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Lecky, Jim [jim.lecky@icf.com]; Hassrick, Jason [jason.hassrick@icf.com]; Hendrick, Mike [mike.hendrick@icf.com]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
CC: Thayer, Reed/SAC [Reed.Thayer@jacobs.com]
Subject: RE: Discuss Fremont weir
Attachments: DRAFT Sites_2081 Aquatic Tables _2021-1014.xlsx

You bet!

Results from the CDFW requested diversion criteria are tabulated below.
Studies 8 through 10 utilize the Draft EIR/EIS Fremont Weir diversion criteria.
Studies 11 through 13 utilize the Fremont Weir diversion criteria proposed by CDFW.

A spreadsheet, with results from all sensitivity runs, is attached.

Best,
Steve

Study 8	Study 9	Study 10	Study 11	Study 12	Study 13
10,700 Mar-May 8,000 Oct-Feb 5,000 Jun-Sep	10,700 Oct-May 5,000 Jun-Sep	10,700 Mar-May 6,000 Oct-Feb 5,000 Jun-Sep	10,700 Mar-May 8,000 Oct-Feb 5,000 Jun-Sep	10,700 Oct-May 5,000 Jun-Sep	10,700 Mar-May 6,000 Oct-Feb 5,000 Jun-Sep
Y	Y	Y	Proposed CDFW Criteria	Proposed CDFW Criteria	Proposed CDFW Criteria
Y	Y	Y	Y	Y	Y
206	198	214	179	174	186
225	216	234	197	191	204
69	56	79	37	31	44
Current mitigation plus added flow requirement October-February	Higher Wilkins Slough requirement year-round, preserve Fremont Weir criteria and pulse flow protection criteria	Current mitigation plus added flow requirement October-February	Current mitigation plus added flow requirement October-February and Fremont Weir spill criteria	Higher Wilkins Slough requirement year-round, adjusted Fremont Weir criteria (per CDFW), and preserve pulse flow protection criteria	Current mitigation plus added flow requirement October-February and Fremont Weir spill criteria

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, October 12, 2021 1:21 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Spranza, John <john.spranza@hdrinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: [EXTERNAL] RE: Discuss Fremont weir

Thanks Steve, Rob, Reed and team for getting this completed so quickly. I really appreciate it.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Monday, October 11, 2021 9:46 PM
To: Spranza, John <john.spranza@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: Discuss Fremont weir

Hi all,

Reed completed a draft of "Study 11" this evening.
High-level results are presented below.
I also incorporated these results into the "Aquatics Tables" spreadsheet (attached).

We started with diversion criteria proposed by CDFW (Study 8).
Then, incorporated the following Fremont Weir Diversion Criteria logic:

- Notch flow (Nov 1st through Mar 15th):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
  - When Sacramento River at Fremont Weir stage is between 21 ft and 28 ft, 2% of total Sacramento River flow may be diverted.
  - When Sacramento River at Fremont Weir stage is between 28 ft and 32 ft, 5% of total Sacramento River flow may be diverted.
- Potential Notch flow (Mar 16th through May 31st):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
- Fremont Weir Spill:
  - When Sacramento River stage at Fremont Weir is increasing and is between 32 ft and 33.25 ft, diversions may not occur for seven days.
  - If Sacramento River stage at Fremont Weir is greater than 33.25 ft, diversion may occur.
  - After a restricted diversion event has been initiated, another restricted diversion event may not initiate until Sacramento River stage at Fremont Weir is less than 32 ft for seven days.

As these mechanisms are incorporated into the CalSim II model, we can readily run them with other sets of Wilkins Slough or Pulse Flow Protection diversion criteria.

Please let us know if you have any questions.

Best,
Steve

Name	Study 8	Study 11
Wilkins Slough	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept
Fremont Weir Notch Protections	Y	Proposed CDFW Criteria
Pulse Flow Protection	Y	Y
Releases (TAF)	206	179
Diversions (TAF)	225	197
Dry & Critical Diversions (TAF)	69	37
Comment	Current mitigation plus added flow requirement October-February	Current mitigation plus added flow requirement October-February and Fremont Weir notch flow and weir spill criteria

-----Original Appointment-----
From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, September 30, 2021 12:08 PM
To: Spranza, John; Alicia Forsythe; Heydinger, Erin; Micko, Steve/SAC; Lecky, Jim; Hassrick, Jason; Hendrick, Mike; Greenwood, Marin; Chris Fitzer (CFitzer@esassoc.com); Leaf, Rob/SAC
Subject: [EXTERNAL] Discuss Fremont weir
When: Friday, October 1, 2021 11:00 AM-12:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Short notice on this but we are hoping we can get a group together to chat about what we heard on today's cdfw call.

Microsoft Teams meeting

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From: Micko, Steve/SAC [Steve.Micko@jacobs.com]
Sent: 10/14/2021 10:52:26 AM
To: Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]; Thayer, Reed/SAC [Reed.Thayer@jacobs.com]
Subject: SPJPA Sites: Draft Excess Conditions Memo
Attachments: SPJPA_Sites_ExcessDeltaOutflowDiversionCriterion_rev02_20210923.docx

Hi Erin,

Draft memo, describing the excess conditions diversion criterion, is attached.

Please let me know if you have any questions.

Best,
Steve

Steve Micko, PE | Jacobs | Project Manager
O:916.286.0358 | M:408.834.6614 | Steve.Micko@jacobs.com
2485 Natomas Park Drive Suite 600 | Sacramento, CA 95833

Excess Conditions Diversion Criterion

Objective

In the CalSim II model, the "Excess Conditions" diversion criterion restricts diversions from Sites Reservoir to "excess water conditions". According to the Coordinated Operations Agreement (COA), excess water conditions are "periods when it is agreed that releases from upstream reservoirs plus unregulated flow exceed Sacramento Valley in-basin uses, plus exports". For the purposes of this document, the quantity of water above Sacramento Valley in-basin uses and exports is defined as Surplus Delta Outflow.

The objective of the "Excess Conditions" diversion criterion is to preserve excess conditions. It is inherently conservative to ensure that Sites diversions do not impact CVP and SWP operations.

Assumptions

Delta water quality, an in-basin use, is affected by antecedent flow conditions in the Delta. Therefore, Sites diversions in January could impact CVP and SWP operations for meeting Spring X2 requirements in February. To prevent potential impacts to CVP and SWP operations in February, the "Excess Conditions" diversion criterion commences in January.

CalSim II prevents Sites from diverting the first 3,000 cfs of Surplus Delta Outflow from January through March, a period of overlap in the Sites diversion season and Spring X2 requirements. The protection of 3,000 cfs of Surplus Delta Outflow is implemented to confirm that, with Sites diversions, excess conditions are maintained in the Delta.

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/15/2021 6:10:36 AM
To: Micko, Steve/SAC [Steve.Micko@jacobs.com]; Spranza, John [john.spranza@hdrinc.com]; Heydinger, Erin [erin.heydinger@hdrinc.com]; Lecky, Jim [jim.lecky@icf.com]; Hassrick, Jason [jason.hassrick@icf.com]; Hendrick, Mike [mike.hendrick@icf.com]; Leaf, Rob/SAC [Rob.Leaf@jacobs.com]
CC: Thayer, Reed/SAC [Reed.Thayer@jacobs.com]
Subject: RE: Discuss Fremont weir

Excellent! Thanks Steve and Team!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Thursday, October 14, 2021 10:06 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Spranza, John <john.spranza@hdrinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: Discuss Fremont weir

You bet!

Results from the CDFW requested diversion criteria are tabulated below.
Studies 8 through 10 utilize the Draft EIR/EIS Fremont Weir diversion criteria.
Studies 11 through 13 utilize the Fremont Weir diversion criteria proposed by CDFW.

A spreadsheet, with results from all sensitivity runs, is attached.

Best,
Steve

Study 8	Study 9	Study 10	Study 11	Study 12	Study 13
10,700 Mar-May 8,000 Oct-Feb 5,000 Jun-Sep	10,700 Oct-May 5,000 Jun-Sep	10,700 Mar-May 6,000 Oct-Feb 5,000 Jun-Sep	10,700 Mar-May 8,000 Oct-Feb 5,000 Jun-Sep	10,700 Oct-May 5,000 Jun-Sep	10,700 Mar-May 6,000 Oct-Feb 5,000 Jun-Sep
Y	Y	Y	Proposed CDFW Criteria	Proposed CDFW Criteria	Proposed CDFW Criteria
Y	Y	Y	Y	Y	Y

206	198	214	179	174	186
225	216	234	197	191	204
69	56	79	37	31	44
Current mitigation plus added flow requirement October-February	Higher Wilkins Slough requirement year-round, preserve Fremont Weir criteria and pulse flow protection criteria	Current mitigation plus added flow requirement October-February	Current mitigation plus added flow requirement October-February and Fremont Weir spill criteria	Higher Wilkins Slough requirement year-round, adjusted Fremont Weir criteria (per CDFW), and preserve pulse flow protection criteria	Current mitigation plus added flow requirement October-February and Fremont Weir spill criteria

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, October 12, 2021 1:21 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Spranza, John <john.spranza@hdrinc.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: [EXTERNAL] RE: Discuss Fremont weir

Thanks Steve, Rob, Reed and team for getting this completed so quickly. I really appreciate it.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Monday, October 11, 2021 9:46 PM
To: Spranza, John <john.spranza@hdrinc.com>; Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>; Lecky, Jim <jim.lecky@icf.com>; Hassrick, Jason <jason.hassrick@icf.com>; Hendrick, Mike <mike.hendrick@icf.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Cc: Thayer, Reed/SAC <Reed.Thayer@jacobs.com>
Subject: RE: Discuss Fremont weir

Hi all,

Reed completed a draft of "Study 11" this evening.
High-level results are presented below.

I also incorporated these results into the "Aquatics Tables" spreadsheet (attached).

We started with diversion criteria proposed by CDFW (Study 8).
Then, incorporated the following Fremont Weir Diversion Criteria logic:

- Notch flow (Nov 1st through Mar 15th):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
  - When Sacramento River at Fremont Weir stage is between 21 ft and 28 ft, 2% of total Sacramento River flow may be diverted.
  - When Sacramento River at Fremont Weir stage is between 28 ft and 32 ft, 5% of total Sacramento River flow may be diverted.
- Potential Notch flow (Mar 16th through May 31st):
  - When Sacramento River at Fremont Weir stage is between 15 ft and 21 ft, diversions may not occur.
- Fremont Weir Spill:
  - When Sacramento River stage at Fremont Weir is increasing and is between 32 ft and 33.25 ft, diversions may not occur for seven days.
  - If Sacramento River stage at Fremont Weir is greater than 33.25 ft, diversion may occur.
  - After a restricted diversion event has been initiated, another restricted diversion event may not initiate until Sacramento River stage at Fremont Weir is less than 32 ft for seven days.

As these mechanisms are incorporated into the CalSim II model, we can readily run them with other sets of Wilkins Slough or Pulse Flow Protection diversion criteria.

Please let us know if you have any questions.

Best,
Steve

Name	**Study 8**	**Study 11**
Wilkins Slough	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept	10,700 Mar-May 8,000 Oct-Feb 5,000 June-Sept
Fremont Weir Notch Protections	Y	Proposed CDFW Criteria
Pulse Flow Protection	Y	Y
Releases (TAF)	206	179
Diversions (TAF)	225	197
Dry & Critical Diversions (TAF)	69	37

Comment	Current mitigation plus added flow requirement October-February	Current mitigation plus added flow requirement October-February and Fremont Weir notch flow and weir spill criteria

-----Original Appointment-----
From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Thursday, September 30, 2021 12:08 PM
To: Spranza, John; Alicia Forsythe; Heydinger, Erin; Micko, Steve/SAC; Lecky, Jim; Hassrick, Jason; Hendrick, Mike; Greenwood, Marin; Chris Fitzer (CFitzer@esassoc.com); Leaf, Rob/SAC
Subject: [EXTERNAL] Discuss Fremont weir
When: Friday, October 1, 2021 11:00 AM-12:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Short notice on this but we are hoping we can get a group together to chat about what we heard on today's cdfw call.

Microsoft Teams meeting

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+1 213-514-6883,,308800884# United States, Los Angeles
(833) 255-2803,,308800884# United States (Toll-free)
Phone Conference ID: 308 800 884#
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From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/16/2021 7:32:45 AM
To: Anthony Saracino [anthony@asaracino.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Re: Diversion data
Attachments: Sites-Prop1Storage-20302070Hydro-10-2021[2].pdf

Anthony – I wanted to chime in on something here. I think an important element of the contribution of the project gets lost in the "averages". I've circled in red on the attached 82 yr hydrology plot (with climate change) the drier periods which shows up to 250 taf available as stored water for environmental purposes. This seems to me to be a significant amount of water in times where its badly needed.

I'm reminded of the adage – I put one hand in the oven and I put other in the freezer but on average I don't feel anything.

I look forward to our meeting Oct 26 where we can discuss further.

Jerry

From: Alicia Forsythe <aforsythe@sitesproject.org>
Date: Thursday, October 7, 2021 at 10:34 AM
To: Anthony Saracino <anthony@asaracino.com>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: Diversion data

Anthony – Thanks again for your patience on this. Attached is a document that summarizes the Project's Proposition 1 benefits and provides a summary table of ecosystem benefits by water year type. Note that the water year type estimates for the refuge deliveries are deliveries at the refuge boundaries – so there is more Prop 1 water but some is removed for transportation losses. The same is true for the Yolo Bypass water, but there are minimal losses for this use.

It is important to note that the Federal Feasibility Report identified the opportunities for Reclamation's investment in the Project. Right now Reclamations investment is modelled as "op flex" – meeting CVP obligations, including environmental and contractual obligations. Op Flex is relatively new "use" in Feasibility Studies – previously, feasibility reports focused on specific environmental benefits for the Reclamation investment. We do see the possibility for Reclamation to dedicate its water to environmental purposes, such as additional IL4 Refuge Water Supply, anadromous fish benefits, delta outflow, etc., increasing the overall ecosystem benefits of the project beyond those current planned under Proposition 1.

In regard to diversion criteria, the Preliminary Project Description posted on the Authority's website provides quite a bit of detail on diversion criteria. I recently took a look at this and its generally all still applicable and relevant. However, one notable change is that we have added a mitigation measure into the Aquatics Resources Chapter (fisheries chapter) that includes a Wilkins Slough Bypass Flow of 10,700 cfs March through May. This is not reflected in the Preliminary Project Description but will be in the Revised Draft EIR/Supplemental Draft EIS when its released in mid-November. The Preliminary Project Description is here: Informational Materials - Sites Reservoir (sitesproject.org). Clink on the Fact Sheets and Documents tab. See the discussion starting on page 2-68 or page 73 of the PDF file.

Hope this information helps. Happy to answer any questions.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 12:45 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Can I look at these before you send to Anthony?

Sent from my iPhone

On Oct 6, 2021, at 11:54 AM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

Sounds good. I am working on both of these and should have them to you later today or early tomorrow. Apologies for the delay and thank you for the reminder!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Anthony Saracino <anthony@asaracino.com>
Sent: Wednesday, October 6, 2021 11:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

Yes, sorry for my lack of clarity. In addition to the description and quantities of Prop. 1 water, it would be good to get a summary of the latest on diversion criteria since it seems some of our eco colleagues are a bit focused on that… I don't need to get into the weeds on diversion criteria, but anything you have that could be easily transmitted would be great.

Thanks again,

Anthony M. Saracino
www.asaracino.com
916-952-8573

On Oct 6, 2021, 11:45 AM -0700, Alicia Forsythe <aforsythe@sitesproject.org>, wrote:

Apologies Anthony. I had in my notes that we were going to send you a description and quantities for the Prop 1 water. Your email below says "diversion information". Is this referring to diversion criteria? Just want to make sure that I am getting you the correct info.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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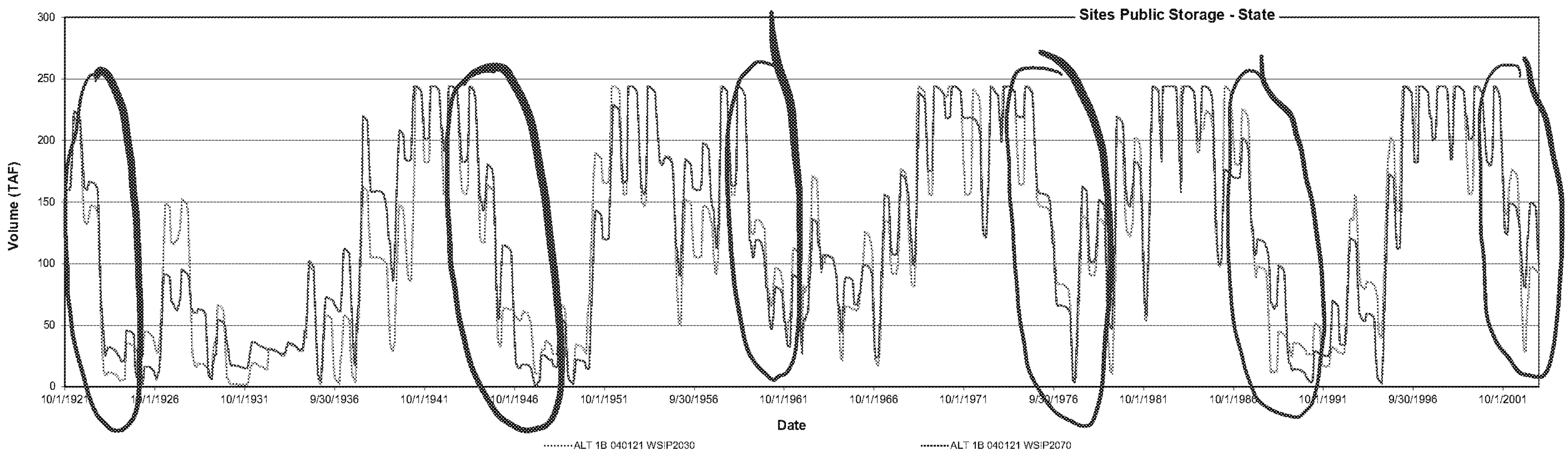
From: Anthony Saracino <anthony@asaracino.com>
Sent: Tuesday, October 5, 2021 4:20 PM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Diversion data

Hi guys,

Were you still planning on sending the diversion information? I'm starting to get asked questions about it and it would be helpful to come up to speed.

Cheers,

Anthony M. Saracino
www.asaracino.com
916-952-8573



Sites Public Storage - State
Volume (TAF)
300
250
200
150
100
50
0
10/1/1921
10/1/1926
10/1/1931
9/30/1936
10/1/1941
10/1/1946
10/1/1951
9/30/1956
10/1/1961
10/1/1966
10/1/1971
9/30/1976
10/1/1981
10/1/1986
10/1/1991
9/30/1996
10/1/2001
Date
ALT 1B 040121 WSIP2030
ALT 1B 040121 WSIP2070

Sites

MEMORANDUM

DATE: October 11, 2021

TO: Sites Authority Board and Reservoir Committee

FROM: Jerry Brown, Executive Director

SUBJECT: **Executive Director's Annual Performance Plan**

The following are my performance objectives for October 2021 to September 2022 which serve as the basis for the Board to evaluate my performance over the next year as Executive Director.

Key Job Responsibility	Results to Be Achieved
Staff Support to and Working with Authority Board and Reservoir Committee	Provide assistance that may be required by the Board and Committee to improve communications, teamwork, and professional relationships between Board, Committee, consultants and staff.
	Continue providing timely and significant information through regular meetings with the Coordination Committees of the Board and Committee.
	Anticipate issues of concern to the Board and Committee and communicate them as soon as possible.
	Ensure the Strategic Plan is updated as needed and guides the regular conduct of the business of the organization. Ensure any follow-up items are satisfactorily completed and make regular reports on progress.
	Review rolling 3-month look ahead for the agenda schedule with Board and Committee chairs to enable their effective facilitation of the Board and Committee functions.
	Continue to make improvements to agendas, staff project reports and workgroups/committee activity to ensure an inclusive, effective and efficient decision-making process.
	Annually review and evaluate the performance of Agents and consultants working on the Project and report results to the Board.
Management of the Project	Manage the revenues and expenditures of the Project to always be cash positive unless otherwise directed by the Board and Committee. Manage to the 2022 Annual Budget.
	Implement the Amendment 3 Project Agreement work plan.

	Ensure project's organizational structure (including consultant and agent staffing) is appropriate to complete the Amendment 3 Project Agreement work plan.
	Develop the 2022 Amendment 3 Work Plan key deliverables and ensure they are tracked and completed on time. If delays occur, identify effects on overall project schedule and approaches for mitigating negative effects.
Project Information, Education and Outreach	Continue outreach to key local and NGO stakeholders with the objective of maintaining a collaborative environment for addressing concerns and issues groups might have with the project.
	Continue effective communications and outreach to stakeholders, local community groups and associations to ensure that factual information is presented and support for the project continues.
	Continue outreach to "home boards" as requested by members to garner continued project support and ensure clear communication of project direction and timing.
	Conduct effective and timely outreach to State and Federal legislative offices to achieve continued support for the Project.
State and Federal Agency Cooperation	Cooperatively work with Reclamation to identify their level of investment in the Project, if any, and secure terms and funds for their continued participation.
	Ensure completion of the "Final" Supplemental EIS to support the "Final" Revised EIR. Ensure the final document complies with NEPA requirements and supports issuance of all federal agency permits and approvals.
	Continue discussions with State and Federal environmental and water rights permitting agencies and establish a collaborative environment that leads to meeting the overall project schedule.
	Keep the California Water Commission informed and supportive of the Project. Be competitive for any additional funds that might reallocated from other projects and at least secure the MCED for Sites.
	Continue working with DWR to ensure Sites benefits are delivered to participants that are also State Water Contractors in the manner members need to continue participation in the Project.

	Continue working with CDFW and DWR to define the terms and conditions of the benefits agreements that will need to be reached to achieve final award of Prop 1 funds. Coordinate with the other storage projects on standard terms and conditions.
Leadership in the Water Community	Stay abreast of other major storage and conveyance project activity across the state. Identify opportunities and threats and take action to best position the Project for success in spite of or in conjunction with these other activities.
	Monitor water related developments in the State and Federal legislative and regulatory arenas for opportunities for funding and/or regulatory streamlining that could be beneficial to project implementation.
	Participate in ACWA Conference activities and use this as an opportunity to efficiently have meetings and discussions with the water community to ensure good communications and understanding of the Project.
	Seek out opportunities for staff to speak with groups and others about the statewide importance of this project.
	Maintain a strong presence in the water community and promote the project whenever possible.
	Continue to coordinate with other WSIP funded projects and seek out opportunities to share best practices and coordinate efforts on key activities (e.g. funding, environmental, and water rights permitting). Maintain an effective dialogue with other project proponents at all times.

Table 1. Work Plan Key Deliverables

Key Deliverable by Subject Area*	Target completion in			Notes
	12 Months	18 Months	36 Months	
Engineering				
Initiate Application for Permit to Construct from DSOD		✓		
Advance Engineering of Project Feature Encroachments to 65% Design Level in Support of Permitting		✓	✓	Key permit support in first 18 months
Determine Procurement and Delivery Strategy	✓			
Determine Overall Project Schedule	✓			
Preliminary Engineering (30% design level) and P1A/P1B Geotechnical Investigations		✓	✓	Complete P1A in first 18 months
Program Ops				
Execute Benefits Contracts with DWR and CDFW		✓		
Secure Final Funding with CWC			✓	
Execute Final Operations Agreement with Facility Partners, and Federal and State Agencies	✓			
Secure Federal Funding		✓		
Complete Loan Applications		✓	✓	Dependent on bank financing decision
Determine Organization Structure		✓		
Execute Benefits and Obligations Contracts		✓	✓	Dependent on bank financing decision
Permitting				
Obtain Environmental Permits Required for WSIP Final Award		✓		
Develop Mitigation Acquisition Master Plan	✓			
Receive Water Right Order and Permit		✓		
Obtain Local Agency Agreements and Permits			✓	
Planning				
Complete Final EIR/EIS	✓			NOD & ROD in August 2022
Real Estate				
Develop Land Acquisition Master Plan and ROW Manual		✓		
Acquire Land (from willing sellers)			✓	

*Communications, External Affairs, and General Project Activities subject areas serve a support function to the key deliverables provided in Table 1.

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/18/2021 11:58:08 AM
To: Jerry Brown [jbrown@sitesproject.org]
CC: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Subject: FW: Sites - More Modeling Quickly
Attachments: DRAFT Sites_2081 Aquatic Tables _2021-1018.xlsx

Jerry – I had the team run a revised scenario – Study 14 – to see what 10,700 Dec-June WITH our original Fremont Weir Notch Protection. I was thinking that we should know what this looks like in case we head down this road. See results below. We're at 202 TAF for releases. Thus, the Fremont Weir Notch Protection, in this scenario, costs 27 TAF of release.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Monday, October 18, 2021 11:41 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Cc: Leaf, Rob/SAC <Rob.Leaf@jacobs.com>; Whittington, Chad/SAC <Chad.Whittington@jacobs.com>
Subject: RE: Sites - More Modeling Quickly

Hi Ali,

Results for Study 7 with our Fremont Weir criteria (aka "Study 14") are tabulated below.
With Wilkins Slough at 10,700 cfs from Dec – Jun and pulse flow protection in Oct – Nov, incorporating our Fremont Weir criteria reduces long-term average releases by 27 TAF..

A spreadsheet with all CalSim II sensitivity analysis results is attached.

Let me know if you have any questions.

Best,
Steve

Name	Alt 1B	Study 7	Study 14
Wilkins Slough	8,000 Apr/May 5,000 all other	10,700 Dec-Jun 5,000 all other	10,700 Dec-Jun 5,000 all other
Fremont Weir Notch Protections	Y	N	Y

Pulse Flow Protection	Y	Y, Only in Oct- Nov	Y, Only in Oct- Nov
Releases (TAF)	234	229	202
Diversions (TAF)	255	250	221
Dry & Critical Diversions (TAF)	120	98	62
Comment	Admin Draft EIR	Higher Wilkins Slough criteria Dec-June replace need for Fremont Weir Notch and Oct-Nov Pulse Flow Protection	Higher Wilkins Slough criteria Dec-June, Pulse Flow Protection Oct-Nov, and Fremont Weir spill criteria

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From: Micko, Steve/SAC
Sent: Sunday, October 17, 2021 5:14 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites - More Modeling Quickly

You bethcya! See ELAM and YB Pass results below (also in attached spreadsheet).

Note that Michael Paccassi requested we extend the seasonal duration of YB Pass analysis to Nov 1 – Apr 30 (it used to be from Nov 1 – Mar 15).
As such, YB Pass outputs for each alternative may be greater than what you've last seen.
Despite changes to outputs, relative changes (Sites as compared to w/out Sites) have remained the same. Sites diversions have no effect on adult fish passage (YB Pass days).

We'll have CalSim results of Study 7 with our Fremont Weir notch criteria tomorrow morning.

Best,
Steve

Study Name	**W/out Sites**	**ALT1B 011221**	**Study 3**	**Study 5**	**Study 7**
Wilkins Slough	NA	8,000 Apr/May 5,000 all other	10,700 Mar-May 5,000 all other	10,700 Oct-Jun 5,000 all other	10,700 Dec-Jun 5,000 all other
Fremont Weir Protections	NA	Y	N	N	N

Pulse Flow Protection	NA	Y	Y, Except for Mar-May	N	Y, Only in Oct-Nov

Water Year	WYT	Average Entrainment November 1 - March 15					YB Pass Days (Adult Fish Passage) November 1 - April 30				
		W/out Sites	ALT1B 011221	Study 3	Study 5	Study 7	W/out Sites	ALT1B 011221	Study 3	Study 5	Study 7
2009	D	2.3%	2.3%	2.3%	2.3%	2.3%	25	24	25	25	25
2010	BN	4.4%	4.4%	3.7%	3.8%	3.8%	48	46	56	57	57
2011	W	7.3%	7.2%	6.4%	6.4%	6.4%	118	110	113	118	118
2012	BN	0.4%	0.4%	0.4%	0.3%	0.3%	27	23	23	25	25
2013	D	3.8%	3.7%	3.1%	3.7%	3.7%	75	75	59	75	75
2014	C	0.5%	0.5%	0.5%	0.5%	0.5%	21	21	21	21	21
2015	C	3.0%	3.0%	2.9%	2.9%	2.9%	35	35	32	35	35
2016	BN	3.1%	3.1%	2.9%	2.9%	2.9%	74	72	66	69	69
2017	W	9.6%	9.6%	9.3%	9.4%	9.4%	151	149	150	150	150
2018	BN	0.2%	0.2%	0.1%	0.2%	0.2%	41	39	33	40	39
Avg Ann	**N/A**	**3.4%**	**3.4%**	**3.2%**	**3.2%**	**3.2%**	**61.5**	**59.4**	**57.8**	**61.5**	**61.4**

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Friday, October 15, 2021 4:55 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Subject: [EXTERNAL] RE: Sites - More Modeling Quickly

You're awesome! Thank you so much!

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Friday, October 15, 2021 4:16 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: RE: Sites - More Modeling Quickly

Sure thing! I'll send that over this weekend.

Best,
Steve

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Friday, October 15, 2021 4:13 PM
To: Heydinger, Erin <erin.heydinger@hdrinc.com>; Micko, Steve/SAC <Steve.Micko@jacobs.com>
Subject: [EXTERNAL] Re: Sites - More Modeling Quickly

Thank you! I am super sorry to ask this, but it would be fantastic if you could also run Study 5 though ELAM and YB Pass.

Ali

—————————
Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Micko, Steve/SAC <Steve.Micko@jacobs.com>
Sent: Friday, October 15, 2021 2:54:53 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: RE: Sites - More Modeling Quickly

Yep! We'll have it by noon on Monday.

Best,
Steve

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Friday, October 15, 2021 2:51 PM
To: Micko, Steve/SAC <Steve.Micko@jacobs.com>; Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: [EXTERNAL] Sites - More Modeling Quickly
Importance: High

Can you run Study 7 with OUR Fremont Weir Notch criteria ASAP? Would it be possible to have this by noon on Monday?

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

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From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/19/2021 9:25:00 AM
To: Jerry Brown [jbrown@sitesproject.org]
Subject: FW: CDFW / Sites Funks and Stone Corral Flows

Here's the email to CDFW. We had a short follow up on this on one of our construction ITP calls.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Alicia Forsythe
Sent: Tuesday, September 14, 2021 11:01 AM
To: Wallen, Carol@Wildlife <Carol.Wallen@Wildlife.ca.gov>; Tores, Juan Lopez <Juan.Torres@wildlife.ca.gov>; Kearns, Zachary <Zachary.Kearns@Wildlife.ca.gov>; Barker, Kelley@Wildlife <Kelley.Barker@wildlife.ca.gov>
Cc: Laurie Warner Herson <laurie.warner.herson@phenixenv.com>; Monique Briard <monique.briard@icf.com>; Hassrick, Jason <Jason.Hassrick@icf.com>; Spranza, John <John.Spranza@hdrinc.com>; Berryman, Ellen <Ellen.Berryman@icf.com>; Jim Lecky <jim.lecky@icf.com>; Hendrick, Mike <Mike.Hendrick@icf.com>; Spranza, John <John.Spranza@hdrinc.com>
Subject: RE: CDFW / Sites Funks and Stone Corral Flows

Juan and CDFW Team – Thanks for the good chat on August 23 on Funks and Stone Corral Creek releases and apologies for taking so long to close the loop on this item.

We discussed this with our engineering lead. We have some limited LIDAR data for the creeks from the CV Feds project and conducted some modeling as part of the emergency release efforts to determine inundation area of emergency releases. This analysis indicates that flows of 2,485 cfs from Sites Dam into Stone Corral Creek would cause downstream flooding in Maxwell. This is merely one data point as the analysis has its limitations – there is limited LiDAR data in some areas, we modelled this for an emergency release perspective so have releases from other locations also, and the Golden Gate Dam/Funks Creek release is too high to be a relevant data point (emergency release at this location is around 15,000 cfs). I also cant share this analysis due to the sensitive nature. But it is an indication that 2,500 cfs is problematic.

However, and on the brighter side of things – In discussions with the engineering team, we do have the ability to increase the non-emergency releases into both Funks and Stone Corral creeks. Both would require some re-work of the current preliminary (about 10%) design. Both would increase costs. But it is possible to increase releases if we find that it what is necessary. We would like to get our arms around this just as soon as possible in 2022 to inform the design team and, hopefully, reflect a final "upper bound" number in the EIR/EIS. To that end, we have a few things on-going or planned –

1. The design team is working on some preliminary modeling using the LiDAR data to determine the amount that could be released into each creek without flooding. We expect to have this later this calendar year. This will help us but we will have to assess the quality of the results once we have these considering some of the limitations of the current LiDAR data.

2. We are also working on two other items for early 2022 that will help us gauge the upper bound – new LiDAR and surveys in the creeks. We're hopeful to get new LiDAR in early 2022 to continue the design process and the flights will include the creeks. We're also hopeful to get access to the creeks or at least portions of them in early 2022 to begin on-the-ground surveys. What we are able to actually survey for will depend on what landowners allow. But I am hopeful that we can at least get stream bed/bank characteristics and profiles/topography so we can begin to assess channel capacity and bank full flows, etc.

I am hopeful that these items will give us a better sense of the upper bound number in time for the Final EIR/EIS publication in summer 2022 and can reflect that in the document.

So, long story short, while we remain skeptical that we can go above 100 cfs in either creek without downstream flooding, we continue with and are committed to the data collection and analysis that will inform this and the design is not set in stone right now (but we do need to refine and finalize ASAP in 2022).

Hope this helps. Happy to chat on this if you would like.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

-----Original Appointment-----
From: Spranza, John <John.Spranza@hdrinc.com>
Sent: Tuesday, August 17, 2021 12:21 PM
To: Spranza, John; Spranza, John; Alicia Forsythe; Berryman, Ellen; Jim Lecky; Hendrick, Mike; Wallen, Carol@Wildlife; Tores, Juan Lopez; Kearns, Zachary
Cc: Laurie Warner Herson; Monique Briard; Hassrick, Jason; Barker, Kelley@Wildlife
Subject: CDFW / Sites Funks and Stone Corral Flows
When: Monday, August 23, 2021 12:00 PM-1:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Changing to an hour.

Continued discussion of the proposed flow regimes on funks and stone corral creeks.

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)
+1 213-514-6883,,270422959# United States, Los Angeles
(833) 255-2803,,270422959# United States (Toll-free)

Phone Conference ID: 270 422 959#
Find a local number | Reset PIN

Learn More | Meeting options

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/19/2021 12:03:45 PM
To: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Subject: FW: Diversion data
Attachments: Sites-Prop1Storage-20302070Hydro-10-2021[2].pdf

Importance: High

Erin – See below and attached. Anthony asked the following – and my responses. Are my responses correct?

What document is this graph from and is it referencing storage space or actual environmental water in storage?

Anthony – The graph is storage space in Sites Reservoir dedicated to the Proposition 1 benefits. Based on our current analysis, we expect to dedicate 244 TAF of storage space to the Proposition 1 benefits to be managed flexibility by the State. This is out of our CALSIM II modeling and is showing the utilization of that storage space based on the Project's diversion criteria (and the Prop 1 account getting a proportional share of diversions into the reservoir) and a set of release assumptions (how the Prop 1 water would be used).

This graphic has not been released publicly in any of our documents.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Saturday, October 16, 2021 7:33 AM
To: Anthony Saracino <anthony@asaracino.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

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I look forward to our meeting Oct 26 where we can discuss further.

Jerry

From: Alicia Forsythe <aforsythe@sitesproject.org>
Date: Thursday, October 7, 2021 at 10:34 AM
To: Anthony Saracino <anthony@asaracino.com>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: Diversion data

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Hope this information helps. Happy to answer any questions.

Ali

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From: Jerry Brown <jbrown@sitesproject.org>
Sent: Wednesday, October 6, 2021 12:45 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Can I look at these before you send to Anthony?

Sent from my iPhone

On Oct 6, 2021, at 11:54 AM, Alicia Forsythe <aforsythe@sitesproject.org> wrote:

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Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Anthony Saracino <anthony@asaracino.com>
Sent: Wednesday, October 6, 2021 11:50 AM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

Yes, sorry for my lack of clarity. In addition to the description and quantities of Prop. 1 water, it would be good to get a summary of the latest on diversion criteria since it seems some of our eco colleagues are a bit focused on that… I don't need to get into the weeds on diversion criteria, but anything you have that could be easily transmitted would be great.

Thanks again,

Anthony M. Saracino
www.asaracino.com
916-952-8573

On Oct 6, 2021, 11:45 AM -0700, Alicia Forsythe <aforsythe@sitesproject.org>, wrote:

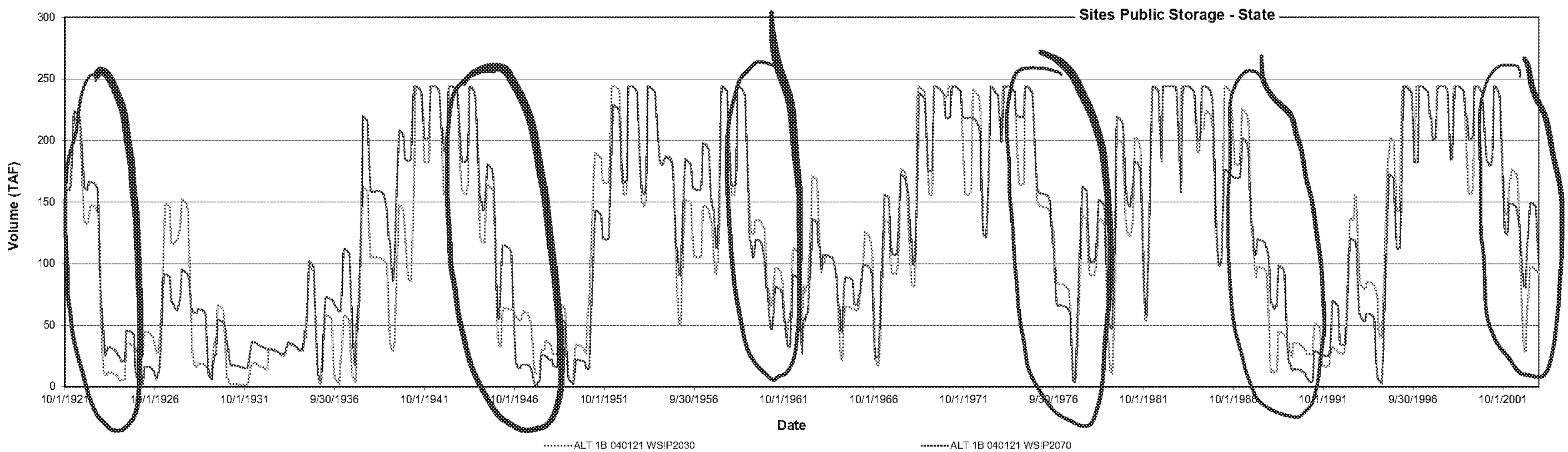
> Apologies Anthony. I had in my notes that we were going to send you a description and quantities for the Prop 1 water. Your email below says "diversion information". Is this referring to diversion criteria? Just want to make sure that I am getting you the correct info.
>
> Ali
>
> ----------------------
>
> Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org
>
> CONFIDENTIALITY NOTICE: This communication with its contents may contain confidential and/or legally privileged information. It is solely for the use of the intended recipient(s). Unauthorized interception, review, use or disclosure is prohibited and may violate applicable laws including the Electronic Communications Privacy Act. If you are not the intended recipient, please contact the sender and destroy all copies of the communication.
>
> ---
>
> **From:** Anthony Saracino <anthony@asaracino.com>
> **Sent:** Tuesday, October 5, 2021 4:20 PM
> **To:** Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
> **Subject:** Diversion data

Hi guys,

Were you still planning on sending the diversion information? I'm starting to get asked questions about it and it would be helpful to come up to speed.

Cheers,

Anthony M. Saracino
www.asaracino.com
916-952-8573



Sites Public Storage - State
Volume (TAF)
300
250
200
150
100
50
0
10/1/1921
10/1/1926
10/1/1931
9/30/1936
10/1/1941
10/1/1946
10/1/1951
9/30/1956
10/1/1961
10/1/1966
10/1/1971
9/30/1976
10/1/1981
10/1/1986
10/1/1991
9/30/1996
10/1/2001
Date
ALT 1B 040121 WSIP2030
ALT 1B 040121 WSIP2070

From: Heydinger, Erin [Erin.Heydinger@hdrinc.com]
Sent: 10/19/2021 12:15:21 PM
To: Alicia Forsythe [aforsythe@sitesproject.org]
Subject: RE: Diversion data

Yep, this is correct. While it hasn't been released publicly yet, the data behind the graph will be included in the CWC Feasibility Study, so it will become available in that respect. You might also add that the different lines show how the Prop 1 account might look under both 2030 and 2070 climate change conditions.

Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Alicia Forsythe <aforsythe@sitesproject.org>
Sent: Tuesday, October 19, 2021 12:04 PM
To: Heydinger, Erin <erin.heydinger@hdrinc.com>
Subject: FW: Diversion data
Importance: High

Erin – See below and attached. Anthony asked the following – and my responses. Are my responses correct?

What document is this graph from and is it referencing storage space or actual environmental water in storage?

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This graphic has not been released publicly in any of our documents.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Saturday, October 16, 2021 7:33 AM
To: Anthony Saracino <anthony@asaracino.com>

Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

Anthony – I wanted to chime in on something here. I think an important element of the contribution of the project gets lost in the "averages". I've circled in red on the attached 82 yr hydrology plot (with climate change) the drier periods which shows up to 250 taf available as stored water for environmental purposes. This seems to me to be a significant amount of water in times where its badly needed.

I'm reminded of the adage – I put one hand in the oven and I put other in the freezer but on average I don't feel anything.

I look forward to our meeting Oct 26 where we can discuss further.

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From: Alicia Forsythe <aforsythe@sitesproject.org>
Date: Thursday, October 7, 2021 at 10:34 AM
To: Anthony Saracino <anthony@asaracino.com>
Cc: Jerry Brown <jbrown@sitesproject.org>
Subject: Diversion data

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Hope this information helps. Happy to answer any questions.

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aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
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To: Alicia Forsythe <aforsythe@sitesproject.org>
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To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Diversion data

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Sent: Tuesday, October 5, 2021 4:20 PM
To: Jerry Brown <jbrown@sitesproject.org>; Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Diversion data

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From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/19/2021 12:39:22 PM
To: Anthony Saracino [anthony@asaracino.com]; Jerry Brown [jbrown@sitesproject.org]
Subject: RE: Diversion data

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This graphic has not been released publicly in any of our documents but the back up data for it will be released in our upcoming State Feasibility Report.

Hope this helps.

Ali

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Sent: Saturday, October 16, 2021 3:22 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Re: Diversion data

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Anthony M. Saracino

www.asaracino.com

916-952-8573

UPDATED November 15, 2021

Milestones and Dates Involving State Agencies for the Sites Reservoir Project

Description	Needed Completion Date	Agency(ies) Involved
Activities Related to Prop 1		
Initiate public review of RDEIR/SDEIS	~~September 3, 2021~~ November 12, 2021 (done)	Sites
Complete State Feasibility Determination	December 15, 2021	CWC
Confirm 75% Non-Public Benefit Cost Share Commitment	December 15, 2021	DWR
Complete Final EIR/EIS, CEQA Findings, and Adopt Project	~~July 2022~~ September 2022	Sites
Initiate Benefit Agreements	January 2022	Sites, DWR, CDFW
Consider increasing the amount of early funding levels for eligible Prop 1 projects	March 2022	CWC
Complete Benefit Agreements and Final Award of Prop 1 Funds	June 2023	DWR, CDFW, CWC
Activities Related to Water Rights		
Support Development of Sites Water Right Application	~~December 20, 2021~~ January 2022	DWR, CDFW, SWRCB
Submit Sites Water Right Application	~~December 20, 2021~~ January 30, 2022	Sites
Complete Application Review and Issue Public Notice	~~February 14, 2022~~ March 14, 2022	SWRCB
Complete Resolution of Protests	December 2022	Sites, SWRCB
Conduct Hearing on Any Remaining Issues	March 2023	SWRCB
Issue Final Order and Water Right Permit	July 2023	SWRCB
Activities Related to Critical Permits		
State Incidental Take Permits		
Develop and Submit ITP <u>Construction</u> Application	December 20, 2021	Sites, CDFW
Develop and Submit ITP <u>Operations</u> Application	~~December 20, 2021~~ February 25, 2022	Sites, CDFW
Issue Incidental Take Permits	~~August 2022~~ October 2022	CDFW
401 Water Quality Certification		
Develop and Submit Draft Permit Application	December 20, 2021	Sites, SWRCB
Review and Refinement of Draft Application	June 2022	Sites, SWRCB
Submit Application	~~July 2022~~ September 2022	Sites
401 Certification Issued	~~November 2022~~ January 2023	SWRCB
Permit to Construct Dams		
Concurrence with Design Approach	December 2022	DWR/DSOD
Activities Related to Operations Coordination		
Confirm State Water Project Contract modifications needed for Sites	~~October 1, 2021~~ October 29, 2021 (done)	DWR
Execute Agreement to Coordinate Operations of SWP and Sites	December 2022	DWR

From: Eric Leitterman [ELeitterman@valleywater.org]
Sent: 10/19/2021 3:30:07 PM
To: Heydinger, Erin [erin.heydinger@hdrinc.com]
CC: Alicia Forsythe [aforsythe@sitesproject.org]; Andrew Garcia [AndrewGarcia@valleywater.org]
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin,

There appears to be some data missing. I don't appear to have the monthly values for end of September 2003. I also don't have the initial storage value, which is usually recorded in CalSIM results as the end September 1921 storage value.

ERIC LEITTERMAN
ASSOCIATE ENGINEER - CIVIL
Imported Water Unit
Water Supply Division
Tel. (408) 630-2669 / Cell. (408) 784-4966
eleitterman@valleywater.org

Valley Water

SANTA CLARA VALLEY WATER DISTRICT
5750 Almaden Expressway, San Jose CA 95118
www.valleywater.org

Clean Water · Healthy Environment · Flood Protection

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Tuesday, October 12, 2021 5:42 PM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

Thanks for your patience on this. Attached is a spreadsheet with monthly CalSim outputs from the historic hydrology as well as WSIP 2030 for storage levels and exports at Banks. Please note that because of the way salinity costs are estimated and applied to the model, the storage levels/releases don't always match up perfectly with export amounts at a monthly level. It's recommended the values be summarized on an annual basis whenever possible. Please let me know if you have questions on that or anything else provided.

Thank you,
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Tuesday, October 12, 2021 2:06 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin,

Following up on my request for modeling result. Will you be able to send me something this week.

ERIC LEITTERMAN
ASSOCIATE ENGINEER - CIVIL
Imported Water Unit
Water Supply Division
Tel. (408) 630-2669 / Cell. (408) 784-4966
eleitterman@valleywater.org

Valley Water

SANTA CLARA VALLEY WATER DISTRICT
5750 Almaden Expressway, San Jose CA 95118
www.valleywater.org

Clean Water · Healthy Environment · Flood Protection

From: Eric Leitterman
Sent: Friday, October 1, 2021 2:20 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

I am looking for Exports at Banks.

Next week should be just fine for me.

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From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Friday, October 1, 2021 1:54 PM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

This information should be pretty easy to pull together. I should be able to send you something next week. Are you looking for exports at Banks or reservoir releases (no losses accounted for).

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Friday, October 1, 2021 12:56 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>; Andrew Garcia <AndrewGarcia@valleywater.org>
Subject: RE: Sites South of Delta/SWP Modeling

CAUTION: [EXTERNAL] This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hi Erin,

I would like to request results from the CALSIM runs for Alternative 1B with Historic hydrology and for Alternative 1B with 2030 WSIP Hydrology. Specifically, what I am looking for are the monthly time step results for SOD exports of Sites Water for SOD of Delta PWAs only (No Refuge Water, No transfers from NOD PWAs).

I would also like to request the end of month storage levels in the SOD PWA bucket from the same two runs.

I know these requests may take some post processing to accomplish. Please let me know if staff have the bandwidth to accommodate my request and if so when I can expect to have my requests to be fulfilled.

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Clean Water · Healthy Environment · Flood Protection

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Friday, June 11, 2021 9:52 AM
To: Eric Leitterman <ELeitterman@valleywater.org>
Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Eric,

Apologies for the delay on this and thanks for the reminder. I thought I had sent this out but looked back and could not find it. Here is the table, where an X indicates model runs that have been performed and are available.

	Project Size/Level of Federal Investment	Historic hydrology	2035 Central Tendency Climate Change	2030 WSIP Climate Change	2070 WSIP Climate Change
No Action	No project	X	X	X	X
Alternative 1A	1.5 MAF No federal funding	X	X		
Alternative 1B	1.5 MAF 7% federal funding	X	X	X	X
Alternative 2	1.3 MAF No federal funding	X	X		
Alternative 3	1.5 MAF 25% federal funding	X	X		

I will also send this out to the full workgroup after next week's meeting.

Thanks!
Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

From: Eric Leitterman <ELeitterman@valleywater.org>
Sent: Wednesday, May 26, 2021 1:51 PM
To: Heydinger, Erin <Erin.Heydinger@hdrinc.com>

Cc: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: RE: Sites South of Delta/SWP Modeling

Hi Erin

Did you ever send out the table of alternatives you mentioned your email below? I can't find it in my records and may have missed it.

ERIC LEITTERMAN
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Water Supply Division
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eleitterman@valleywater.org

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www.valleywater.org

Clean Water · Healthy Environment · Flood Protection

From: Heydinger, Erin <Erin.Heydinger@hdrinc.com>
Sent: Monday, April 19, 2021 10:08 AM
To: 'fhernandez@cityofamericancanyon.org' <fhernandez@cityofamericancanyon.org>; Dwayne Chisam <DChisam@avek.org>; 'Robert Cheng' <RCheng@cvwd.org>; pvasileva@cvwd.org; Mark Krause <MKrause@dwa.org>; Paul Weghorst <weghorst@irwd.com>; Kellie Welch <welch@irwd.com>; 'Randall Neudeck' <rneudeck@mwdh2o.com>; 'CWang (cwang@mwdh2o.com)' <cwang@mwdh2o.com>; Bradshaw,Dee <VBradshaw@mwdh2o.com>; Sheehan,Rebecca D <RSheehan@mwdh2o.com>; Dan Bartel <dbartel@rrbwsd.com>; 'Bob Tincher' <bobt@sbvmwd.com>; Heather Dyer <heatherd@sbvmwd.com>; Jeff Davis <jdavis@sgpwa.com>; Eric Leitterman <ELeitterman@valleywater.org>; 'Dirk Marks' <dmarks@scvwa.org>; 'AFlores (AFlores@zone7water.com)' <AFlores@zone7water.com>; Xie, Lillian <lxie@zone7water.com>; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde <rkunde@wrmwsd.com>
Cc: Jerry Brown <jbrown@sitesproject.org>; JP Robinette <JRobinette@BrwnCald.com>; Alicia Forsythe <aforsythe@sitesproject.org>; steve.micko@jacobs.com; Thayer, Reed/SAC <Reed.Thayer@jacobs.com>; Leaf, Rob/SAC <Rob.Leaf@jacobs.com>
Subject: RE: Sites South of Delta/SWP Modeling

Good morning,

Thank you for your participation in last week's modeling meeting. Attached is the PowerPoint presentation. I will also be following up with a table describing the alternatives that have been modeled and the associated hydrology. Please reach out if you would like any of the data or available results we discussed. For those of you who have already requested information, I will be getting back to you shortly.

Best,

Erin

Erin Heydinger PE, PMP
D 916.679.8863 M 651.307.9758

hdrinc.com/follow-us

-----Original Appointment-----
From: Heydinger, Erin
Sent: Wednesday, March 31, 2021 5:13 PM
To: Heydinger, Erin; fhernandez@cityofamericancanyon.org; Dwayne Chisam; Robert Cheng; pvasileva@cvwd.org; Mark Krause; Paul Weghorst ; Kellie Welch; Randall Neudeck; CWang (cwang@mwdh2o.com); Bradshaw,Dee; Sheehan,Rebecca D; Dan Bartel; Bob Tincher; Heather Dyer; Jeff Davis; ELeitterman@valleywater.org; Dirk Marks; AFlores (AFlores@zone7water.com); Xie, Lillian; cchilmakuri@swc.org; leckhart@sgpwa.com; Rob Kunde
Cc: Jerry Brown; JP Robinette (JRobinette@BrwnCald.com); Alicia Forsythe; steve.micko@jacobs.com; Thayer, Reed/SAC; Leaf, Rob/SAC
Subject: Sites South of Delta/SWP Modeling
When: Tuesday, April 13, 2021 2:00 PM-4:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

Good afternoon – the meeting agenda is attached. Thanks!

Thanks for your responses to the Doodle poll. This invite is to discuss Sites modeling assumptions for Delta and South of Delta participants. **Please RSVP** so we can ensure we do not exceed the quorum limit. Agenda coming soon.

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)
+1 213-514-6883,,895164312# United States, Los Angeles
(833) 255-2803,,895164312# United States (Toll-free)
Phone Conference ID: 895 164 312#
Find a local number | Reset PIN

Learn More | Meeting options

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/21/2021 3:25:25 PM
To: John Spranza (john.spranza@hdrinc.com) [john.spranza@hdrinc.com]
Subject: FW: EBMUD Follow-up and SJ County WR

FYI

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

From: Jerry Brown <jbrown@sitesproject.org>
Sent: Thursday, October 21, 2021 8:43 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Cc: Heydinger, Erin <erin.heydinger@hdrinc.com>; JP Robinette <jrobinette@brwncald.com>
Subject: EBMUD Follow-up and SJ County WR

I just had a follow-up call with Mike Tognolini @ EBMUD. He appreciated the briefing on the EIR and WR application you gave to his staff a few weeks ago. He said they are awaiting more information from us on a couple of follow-up questions. Is this tracking with your understanding?

He said depending on the result of their evaluation of the remaining information to be provided, he does not expect they would have any issues with our EIR or water right application. This is good news.

Also, he did not expect they would have an interest in becoming a new participant in Sites at this time but they will continue to monitor the project and their situation (which is continually changing) and let us know if anything changes on their end.

Finally I asked him about the SJ situation. It was recently reported that SJ has resumed pursuit of their 1990 "winter" water right application for American River diversions and using the Freeport facilities. EBMUD is in the middle of SJ and Sac county division over this proposal because of agreements they have with each entity and because of their interest in the Freeport facilities. I mention it here because SJ County would be another party we need to talk to in advance of our WR application.

From: Alicia Forsythe <aforsythe@sitesproject.org>
Date: Thursday, September 9, 2021 at 1:59 PM
To: Jerry Brown <jbrown@sitesproject.org>
Cc: "Heydinger, Erin" <erin.heydinger@hdrinc.com>
Subject: FW: Scheduling a Sites Reservoir Project Briefing

Jerry – I lost track of this email from Jose and just let him know that I am working on this. Do you have a sense of what they are looking for? Just thinking about who from Sites is best to lead this / who to invite. If not, I can circle back with Jose and see if I can get more specifics so we have the right team there.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

From: Setka, Jose <jose.setka@ebmud.com>
Sent: Monday, September 6, 2021 12:50 PM
To: Alicia Forsythe <aforsythe@sitesproject.org>
Subject: Scheduling a Sites Reservoir Project Briefing

Hi Alicia,
I am following up on some emails between Mike and Jerry regarding the Sites Project. Based on those communications we'd like to setup a meeting with your team to get an update on the project and what it might look like if EBMUD would participate in the project. In order to get a jump on scheduling I can propose the afternoon (1 -3) Friday September 24 as an option. If that does not work feel free to give me some additional options that I can try and fit. Thanks. Jose

Jose D. Setka
Environmental Affairs Officer
Bay – Delta Team Manager
375 11th Street
Oakland, CA 94607
ph: 510-287-2021cell: 510-517-2169
jsetka@ebmud.com

EBMUD *Stewardship ~ Integrity ~ Respect ~ Teamwork*

From: Alicia Forsythe [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=A6CDF06A7E904B65BAA21702A82AD329-AFORSYTHE]
Sent: 10/21/2021 3:26:36 PM
To: Jerry Brown [jbrown@sitesproject.org]
CC: Heydinger, Erin [erin.heydinger@hdrinc.com]; JP Robinette [jrobinette@brwncald.com]
Subject: RE: EBMUD Follow-up and SJ County WR

Jerry – I will check in with John on the supplemental information. I am still tracking it. The fish team has been really busy on the EIR/EIS and CDFW stuff so we haven't wrapped this one up yet. I expect we will be able to close this out next week.

Ali

Alicia Forsythe | Environmental Planning and Permitting Manager | Sites Reservoir Project | 916.880.0676 | aforsythe@sitesproject.org | www.SitesProject.org

---

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Environmental Affairs Officer
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jsetka@ebmud.com

EBMUD *Stewardship ~ Integrity ~ Respect ~ Teamwork*

NOTICE OF AVAILABILITY AND PUBLIC MEETINGS FOR THE SITES RESERVOIR PROJECT

REVISED DRAFT ENVIRONMENTAL IMPACT REPORT/ SUPPLEMENTAL DRAFT ENVIRONMENTAL IMPACT STATEMENT

State Lead Agency Pursuant to the California Environmental Quality Act (CEQA): Sites Project Authority
Federal Lead Agency Pursuant to the National Environmental Policy Act (NEPA): U.S. Department of the Interior, Bureau of Reclamation
Location: Tehama, Glenn, Colusa, and Yolo Counties, California

The Sites Project Authority (Authority) and the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) have prepared a joint Revised Draft Environmental Impact Report/ Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS) to evaluate the potential environmental impacts of the construction and operation of the Sites Reservoir Project (Project). In August 2017, the Authority and Reclamation jointly issued a Draft Environmental Impact Report/Environmental Impact Statement (2017 Draft EIR/EIS) for the Project. The RDEIR/SDEIS includes a complete revision of the 2017 Draft EIR/EIS to reflect changes to the Project that have occurred since the issuance of the 2017 Draft EIR/EIS.

The Project would involve the construction and operation of an offstream surface water reservoir to provide direct and real benefits to instream flows, the Sacramento–San Joaquin Delta ecosystem, and water supply reliability. The Project would use existing infrastructure to divert unregulated and unappropriated flow from the Sacramento River at Red Bluff and Hamilton City and convey the water to a new offstream reservoir west of the community of Maxwell, California. New and existing facilities would move water into and out of the reservoir, with ultimate release back to the Sacramento River system via existing canals and a new pipeline located near Dunnigan, California. Water released from Sites Reservoir would be used to benefit local, State, and federal water use needs, including municipal, industrial, and agricultural public water agencies, anadromous fish species in the Sacramento River watershed, wildlife refuges and habitats, and the Yolo Bypass to help supply food for delta smelt. Construction of Sites Reservoir would necessitate construction of a bridge or bypass road to connect Maxwell with the community of Lodoga. Additional components also include the development of new recreation facilities at the reservoir. In addition to the no project/no action alternative, the RDEIR/SDEIS evaluates three action alternatives. Based on analysis in the RDEIR/SDEIS, all action alternatives would result in some significant and unavoidable impacts/adverse or substantially adverse effects.

Public Review Period: The RDEIR/SDEIS will be available for a 60-day public review from Nov. 12, 2021 to Jan. 11, 2022.

Availability of the RDEIR/SDEIS: Copies are available for public review at the following locations:
1. Sites Project Authority, 122 Old Highway 99 West, Maxwell, CA 95955
2. Bureau of Reclamation, California-Great Basin Regional Office Library, 2800 Cottage Way, Sacramento, CA 95825
3. Maxwell Branch Library, 34 Oak Street Maxwell, CA 95955
4. Sacramento Public Library, Central Branch, 828 I Street, Sacramento, CA 95814
5. Colusa County Free Library, Main Branch, 738 Market Street, Colusa, CA 95932
6. Glenn County Public Library, Willows Branch, 201 N. Lassen Street, Willows, CA 95988
7. Tehama County Library, Red Bluff Branch, 645 Madison Street, Red Bluff, CA 96080
8. Yolo Branch Library, 37750 Sacramento Street, Yolo, CA 95697
9. Mary L. Stephens – Davis Branch Library, 315 E. 14th Street, Davis, CA 95616

The RDEIR/SDEIS is also accessible from the following websites: https://sitesproject.org/resources/environmental-review/
https://www.usbr.gov/mp/nepa/nepa_project_details.php?Project_ID=29024
Please contact the Authority at 530-438-2309 if you need additional assistance to review the RDEIR/SDEIS.

Comments: Please submit comments on the RDEIR/SDEIS to the Authority or Reclamation via email at EIR-EIS-Comments@SitesProject.org or via U.S. Mail, Sites Project Authority, P.O. Box 517, Maxwell, CA 95955, or U.S. Bureau of Reclamation, 2800 Cottage Way, W-2830, Sacramento, CA 95825 by 5:00 p.m. PST on January 11, 2022.

Meetings: Two virtual public meetings will be held to receive comments from individuals and organizations on the RDEIR/SDEIS. [insert link to meetings]

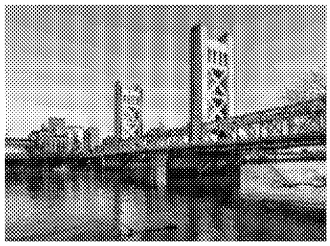
Wednesday, December 15, 2021, 2:00 p.m. to 4:00 p.m. PST
Thursday, December 16, 2021, 6:00 p.m. to 8:00 p.m. PST

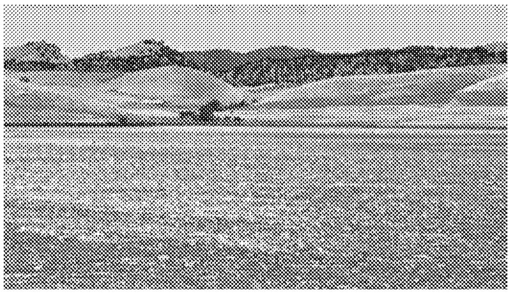
Further Information: Please contact Alicia Forsythe, Sites Project Authority, at 530-438-2309 or Vanessa King, Bureau of Reclamation, at 916 978-5077.

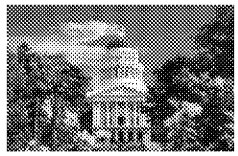

Sites Reservoir
Sites

21st Century Solution to California's Water Reliability Challenges

Sites Reservoir is a generational opportunity to construct a multi-benefit water storage project that helps **restore flexibility, reliability, and resiliency** to our statewide water supply



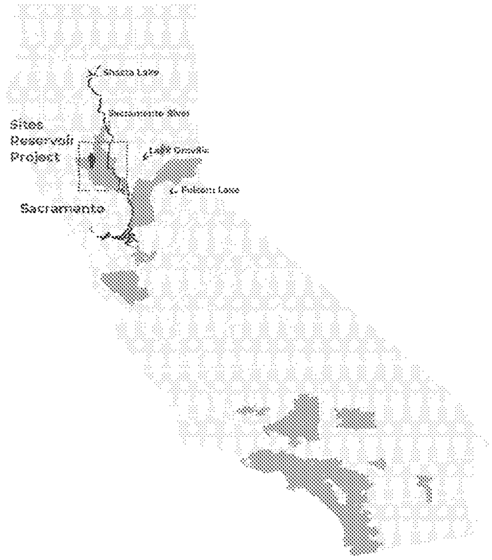




Sites

Our Strength is in Our Broad Statewide Participation

Diverse statewide representation of public agencies advancing Sites Reservoir



Participants include **counties, cities, water and irrigation districts**

Urban and **Rural**

Sacramento Valley

San Joaquin Valley

Bay Area

Southern California

Sites

Our Strength is in Our Broad Statewide Participation

Sacramento Valley

Carter Mutual Water Company
City of American Canyon
Colusa County
Colusa County Water Agency
Cortina Water District
Davis Water District
Dunnigan Water District
Glenn County
Glenn-Colusa Irrigation District
LaGrande Water District
Placer County Water Agency
Reclamation District 108
City of Roseville
Sacramento County Water Agency
City of Sacramento
Tehama-Colusa Canal Authority
Westside Water District
Western Canal Water District

Bay Area

Santa Clara Valley Water District
Zone 7 Water Agency

San Joaquin Valley

Wheeler Ridge-Maricopa Water Storage District

Southern California

Antelope Valley – East Kern Water Agency
Coachella Valley Water District
Desert Water Agency
Metropolitan Water District
San Bernardino Valley Municipal Water District
San Gorgonio Pass Water Agency
Santa Clarita Valley Water Agency

Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Sites Reservoir has been designed and optimized to meet our water supply needs for today and in the future

The Sites Project Authority conducted a **rigorous Value Planning effort** to review the project's proposed operations and facilities **to develop a project that is "right sized" for our investors and participants** while still providing water supply reliability and enhancing the environment

Rightsizing the reservoir was **responsive to input** from **state and federal agencies, NGOs, elected officials, landowners and local communities**

The **feedback we received** through a robust outreach effort was **critical** to developing a reservoir that is the **right size for both people and the environment**

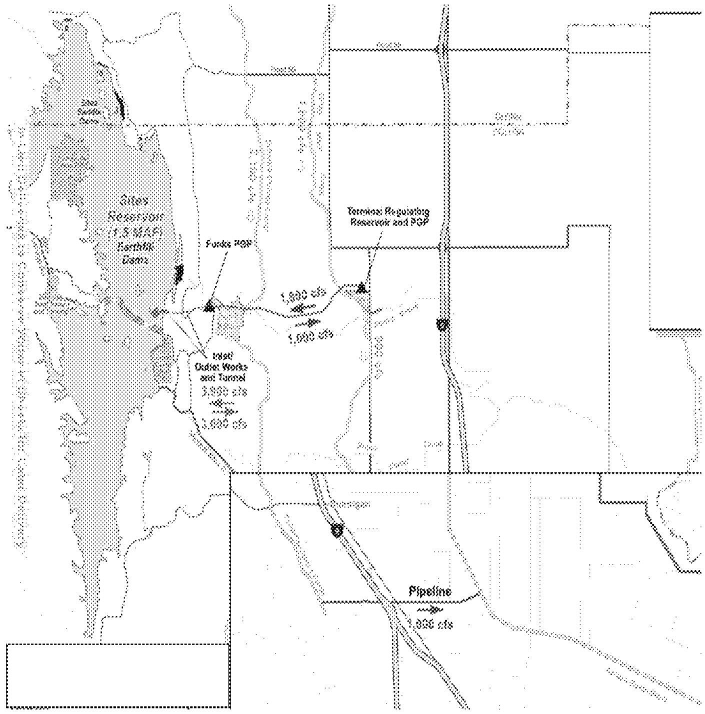
Sites

Rightsized to Meet Our Current and Future Water Supply Needs

1.5 million acre-feet

Utilizes the existing **Glenn-Colusa Irrigation District** and **Tehama-Colusa Canal Authority** canals to convey water to Sites Reservoir from the Sacramento River

Delivers water back to the Sacramento River through the **Tehama-Colusa Canal** and through the **Colusa Basin Drain** for participant deliveries and for the environment



Rightsized to Meet Our Current and Future Water Supply Needs

Member	Reservoir Participation(AFY)
Public Water Agencies	
North of Delta	52,142
South of Delta	140,750
Subtotal Public Water Agencies	192,892
State of CA	~ 40,000
Total Requirement	~230,000

Participant Demand

Participant water subscriptions allocated in the **current participation agreement**

Allocation of State of California water subscription is based on the **Proposition 1 water investment**

- Water for Delta Smelt
- Water for Refuges

Release Capacity from Sites

The "rightsized" project can deliver water to meet the demands of our participants and California's investment of water for the environment

Long term average ~240,000 AFY

Year Type	1,000 cfs Release Capacity (AFY) to the Colusa Basin Drain
Wet	90 - 120
Above Normal	260 - 290
Below Normal	245 - 275
Dry	355 - 385
Critically Dry	210 - 240

Sites

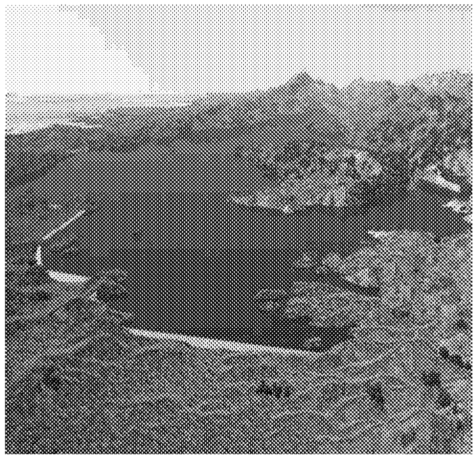
Rightsized to Meet Our Current and Future Water Supply Needs

The Value Planning process has **resulted** in a project that has a **smaller footprint** and **operated in a different manner** then originally designed

Due to these changes the Authority will **revise and recirculate its Draft EIR**

Work with **landowners, tribes, stakeholders, NGOs, and local communities** to develop a **collaborative environmental review process**

It is essential that we **build a project now that makes sense for all our participants** – local, state, and federal



Sites

Rightsized to Meet Our Current and Future Water Supply Needs

Reservoir Size (MAF)	1.5
Project Cost (2019$, billions)	$2.4 - $2.7
Contingency Cost (2019$, billions)	$0.6
Total Project Cost (2019$, billions)	$3.0 - $3.3
Annualized AF/year release (AFY)	240,000
Range of Annual Costs During Repayment Without WIFIA Loans (2020$, $/AF)	$650 - $710
Range of Annual Costs During Repayment With WIFIA Loans (2020$, $/AF)	$600 - $660

The rightsized project is **roughly $2 Billion less** then the 2017 preferred alternative

Cost savings primarily from the **removal** of the **Delevan Diversion** facility on the Sacramento River and the **Delevan Pipeline**

Lowered the Annual Cost during repayment ($/AF)

Significant savings to participants with finance through a **WIFIA** government backed loan

Sites

Provides Statewide Benefits for Generations to Come

Sites Reservoir provides many multi-layered benefits

Off-stream Storage

Does not create a barrier to native fish migration

Federal and State Agencies Manage Environmental Water

Adaptable to current and future conditions and priorities

Local Leadership and Cooperation

Aligns with Sacramento Valley's values and fosters regional and statewide collaboration

Cooperative Operation

Increases effectiveness and efficiency of existing water storage infrastructure

Adaptable to Climate Change

Contributes to system reliability and performance with climate change

Dry Year Water Supply

Reliable dry year water supply for California communities, farms and businesses

Recreational Opportunities

Provides northern Sacramento Valley with additional opportunities for recreation

Environmental Support

Provides environmental water in drier periods for native fish, and habitat for native species and birds

Sites

Provides Statewide Benefits for Generations to Come

Sites Reservoir provides water dedicated to environmental use

A significant portion of the **Sites Reservoir Project's annual water supplies will be dedicated to environment uses:**

- **Preserve cold-water** pool in **Lake Shasta** later into the summer months to support **salmon development, spawning and rearing**
- Provide a **reliable supply of refuge water** to improve **Pacific Flyway** habitat for **migratory birds** and other **native species**
- Provide **water dedicated** to help improve conditions for the **Delta Smelt**

Water dedicated for the environment provided by Sites Reservoir will be **managed by state resources agency managers** who will decide how, and when, this water would be used - creating a water asset for the state that **does not currently exist**

Sites

Draft_0013442

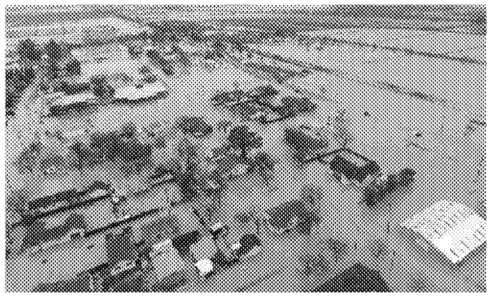
Provides Statewide Benefits for Generations to Come

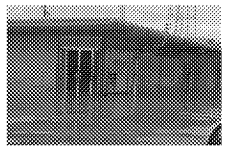
Sites Reservoir provides regional flood protection benefits

Provides significant **regional flood protection benefits** for the Sacramento Valley

Will capture and store **flood flows** that would normally impact the community of **Maxwell** - protecting homes, business and farms

Will help to **limit "down stream" flooding issues** by capturing storm flows that sometimes overwhelm the regions flood control facilities





Sites

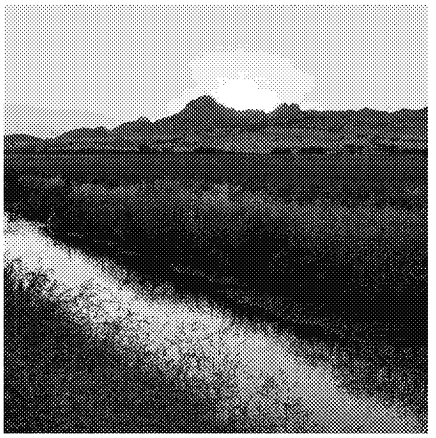
Provides Statewide Benefits for Generations to Come

Sites Reservoir will benefit the local and regional economy

Create hundreds of construction-related jobs during each year of the construction period, and **long-term jobs related to operations**

Creates **new recreation opportunities** in the Sacramento Valley which adds to the **region's economy**

Adding **resiliency** to the water supply will **strengthen the statewide economy** and **business** that rely on a reliable source of water for their operations – particularly agriculture



Sites

We are On-Track to Deliver This Vital Project for the People of California

Key Milestones Through 2021

Meet **eligibility requirements under Prop 1 (WSIP)** in order to access the remainder of the $816 Million in funding

Recirculate Draft EIR for public comment, proactively engage stakeholders, develop responses to comments to support environmental feasibility determination

Complete Feasibility Report

Secure environmental permit certainty and **draft permit applications**

Update and **refine cost estimate** and **affordability analysis**

Develop Plan of Finance

Improve definition of **SWP/CVP** exchange, including **Operations Plan**

Enhance landowner, stakeholder & NGO engagement

Develop Operating Agreement Term Sheets with: DWR, USBR, TCCA, GCID, CBD Authority

Sites

Federal Priorities for Next Stage of Project Development

Completion of the **Federal Feasibility** analysis no later then **December 2020** - needed to support a state required feasibility report to fulfill the Prop 1 WSIP requirement.

Completion of a **coordinated operations agreement** for Sites Project operations relative to Reclamation operations of CVP facilities

Supportive consultation with Federal permitting agencies to advance federal permitting activities

Completion of the Recirculated Draft Environmental Impact Statement (EIS) no later than **July 2021** - Record of Decision (ROD) by **May 2022**

Continued **funding support for pre-construction activities** under **WIIN Act** authority

Support development of a **RIFIA loan program for Sites Reservoir -** if RIFIA is unavailable , then support a similar **WIFIA loan program** under EPA

Sites

Questions

Sites

From: Kevin Spesert [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=DEF2E3FB8FBE4310BB65B7A20F658C0F-KSPESERT000]
Sent: 10/28/2021 10:02:17 AM
To: Garrett Durst [garrett@naturalresourceresults.com]; Jeff Sutton [jsutton@tccanal.com]
Subject: RE: Sites Handout
Attachments: Sites_Overview.pptx

Here is the updated PPT that we have been working off of...I am waiting for a couple of additional slides from Jerry...

From: Garrett Durst <garrett@naturalresourceresults.com>
Sent: Thursday, October 28, 2021 6:30 AM
To: Jeff Sutton <jsutton@tccanal.com>; Kevin Spesert <kspesert@sitesproject.org>
Subject: Re: Sites Handout

I heard from Ken this week that the call is scheduled for 2:30pm ET next Monday. I'm pretty flexible this afternoon if we need to do a meeting of the minds.

From: Jeff Sutton <jsutton@tccanal.com>
Date: Wednesday, October 27, 2021 at 5:54 PM
To: Garrett Durst <garrett@naturalresourceresults.com>, Kevin Spesert <kspesert@sitesproject.org>
Subject: Fwd: Sites Handout

Had a call from and good visit with Lombardi today. Primary thing was he wanted to know about Ken LaGrande that wanted to meet with his boss to discuss Sites. Lol. See his request below. We should coordinate some tomorrow. And I will update Garrett a little more on the visit as well in regard to asks and timing.

Jeffrey P. Sutton
General Manager
Tehama-Colusa Canal Authority
P.O. Box 1025
Willows, CA 95988
Ph: (530) 934-2125
Cell: (530) 301-1030
jsutton@tccanal.com

Sent from my I Phone

Begin forwarded message:

From: "Lombardi, Kyle" <Kyle.Lombardi@mail.house.gov>
Date: October 27, 2021 at 2:44:34 PM PDT
To: Jeff Sutton <jsutton@tccanal.com>
Subject: FW: Sites Handout

Hi Jeff. Thanks for taking my call today. If you have an update version of this handout that you can share with me that includes new/updated key future dates, that would be great. Thanks. Kyle

Kyle Lombardi
Rep. Kevin McCarthy

202-225-2915

From: Jessica Dohmen <jdohmen@tfgnet.com>
Sent: Tuesday, May 19, 2020 12:33 PM
To: Lombardi, Kyle <Kyle.Lombardi@mail.house.gov>
Subject: Sites Handout

Good Afternoon,

I wanted to make sure you had the most recent version of the handout for today's meeting.

Thanks,
Jessica

Jessica Dohmen
202.331.8500 OFFICE
202.454.3941 DIRECT
1901 Pennsylvania Ave. NW, Suite 700, Washington, DC 20006
TheFergusonGroup.com

Sites Reservoir

Sites

Our Strength is in Our Broad Statewide Participation

Sacramento Valley

- Carter Mutual Water Company
- City of American Canyon
- Colusa County
- Colusa County Water Agency
- Cortina Water District
- Davis Water District
- Dunnigan Water District
- Glenn County
- Glenn-Colusa Irrigation District
- LaGrande Water District
- Placer County Water Agency
- Reclamation District 108
- City of Roseville
- Sacramento County Water Agency
- City of Sacramento
- Tehama-Colusa Canal Authority
- Westside Water District
- Western Canal Water District

Bay Area

- Santa Clara Valley Water District
- Zone 7 Water Agency

San Joaquin Valley

- Wheeler Ridge-Maricopa Water Storage District
- Rosedale-Rio Bravo Water Storage District

Southern California

- Antelope Valley - East Kern Water Agency
- Coachella Valley Water District
- Desert Water Agency
- Irvine Ranch Water District
- Metropolitan Water District
- San Bernardino Valley Municipal Water District
- San Gorgonio Pass Water Agency
- Santa Clarita Valley Water Agency

Sites

Affordable, Permittable, Buildable

Sites underwent a rigorous value planning effort that resulted in a “right-sized” project. The Sites Reservoir of today:

- Has a smaller footprint than the previous iteration
- Meets the water supply needs of current participants
- Comes at a lower cost
- Supports State’s environmental goals
- Creates flexibility for participants
- Performs under most challenging climate change scenarios

The right-sized project cuts roughly $2 billion from the original proposal.

Sites is now more affordable, permittable, and buildable.

Sites

Provides Climate Change Resiliency

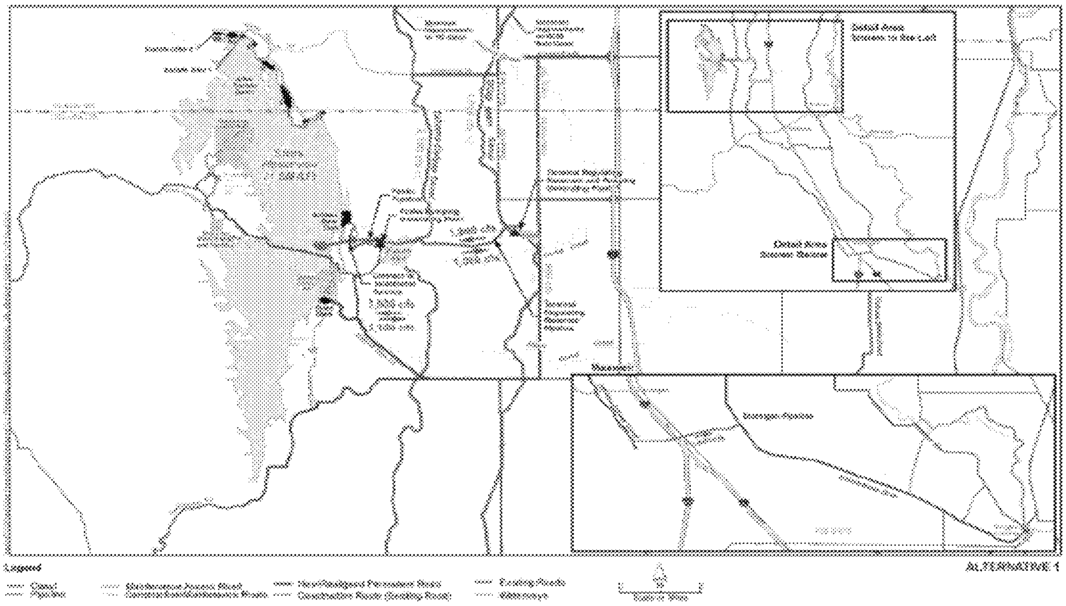
How does Sites Reservoir address these challenges?

- Captures excess flows from Sacramento River – rain instead of snowmelt
- Off-river storage increases environmental benefits by not damming major river system
- Adds 1.5 million acre-feet of water into the statewide system, easing pressure on other sources during droughts
- Supplies water for people, farms and environment during the longer dry spells California experiences
- Allows other reservoirs, like Shasta, to conserve more cold water during dry periods in order to benefit fisheries

Project performance is expected to improve by approximately 5% under anticipated climate change conditions

Sites

Affordable, Permittable, Buildable



Sites

Provides a Resilient Supply of Water

SITES PROJECT NEW WATER SUPPLY

Year Type	Water Supply (thousand acre-feet)
Wet	80-90
Above Normal	92-292
Below Normal	190-296
Dry	398-429
Critically Dry	308-348
Long-Term Average	207-260

One thousand acre-feet of water supply can serve about 2,000-3,000 households for one year, or 200-500 acres of productive California agriculture.

Sites

Provides Important Environmental Benefits

Sites Reservoir provides water dedicated to environmental use

A significant portion of the **Sites Reservoir Project's annual water supplies will be dedicated to environment uses:**

- **Preserve cold-water** pool in **Lake Shasta** later into the summer months to support **salmon development, spawning and rearing**
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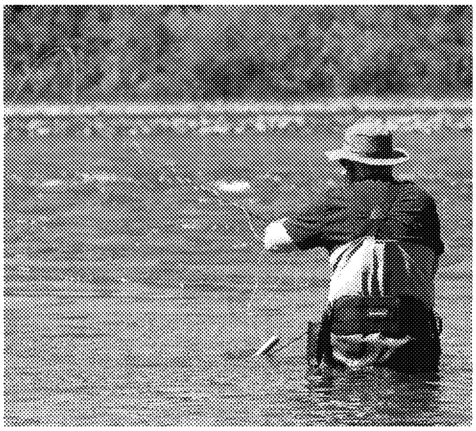


Sites

Environmental Protections

- Diverting during excess conditions, when all senior water rights and water quality and flow requirements are met
- Using existing diversion locations and state-of-the-art fish screens
- Relying to the extent possible on existing infrastructure for releases
- Diversion criteria have been shifted upstream for operations at diversion locations
- Additional pulse protection criteria added to protect migrating juvenile salmon

Sites

EIR Project Alternatives

Facilities / Operations	Alternative 1	Alternative 2	Alternative 3
Reservoir Size	1.5 MAF	1.3 MAF	1.5 MAF
Hydropower	Incidental upon release	Same as Alt 1	Same as Alt 1
Diversion Locations	Red Bluff Pumping Plant and Hamilton City	Same as Alt 1	Same as Alt 1
Conveyance Release / Dunnigan Release	1,000 cubic feet per second (cfs) into new Dunnigan Pipeline to Colusa Basin Drain	1,000 cfs into new Dunnigan Pipeline to Sacramento River. Partial release into the Colusa Basin Drain	Same as Alt 1
Reclamation Involvement	1. Funding Partner 2. Operational Exchanges a. Within Year Exchanges b. Real-time Exchanges	Operational Exchanges a. Within Year Exchanges b. Real-time Exchanges	Same as Alt 1, but up to 25% investment
DWR Involvement	Operational Exchanges with Oroville and use of SWP facilities South-of-Delta	Same as Alt 1	Same as Alt 1
Route to West Side of Reservoir	Bridge across reservoir	Paved road around southern end of reservoir	Same as Alt 1

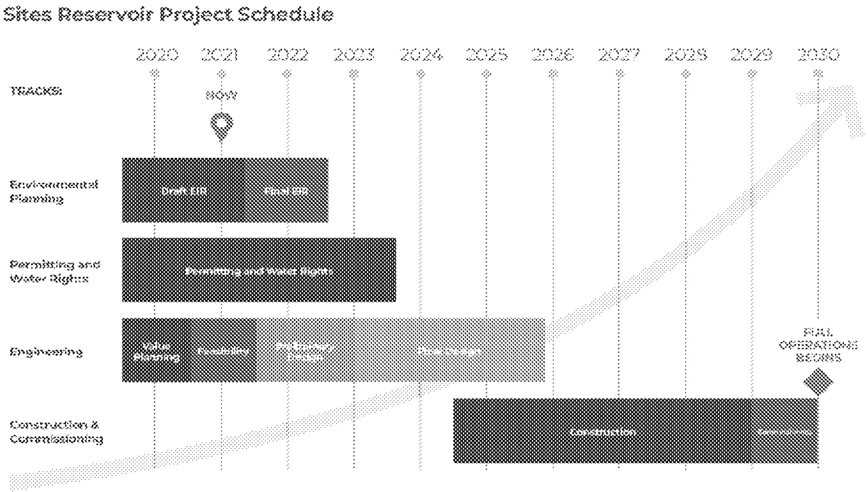
Project Costs and Affordability

Reservoir Size (MAF)	Alternative 1 (1.5MAF)
Total Project Cost (2019$, billions)	$3.3 +/-
Annualized AF/year release (AFY)	230,000
Range of Annual Costs During Repayment Without WIFIA Loans (2020$, $/AF)	$650 - $710
Range of Annual Costs During Repayment With WIFIA Loans (2020$, $/AF)	$600 - $660

Sites

Looking Ahead

Sites Reservoir Project Schedule



Sites

Creating an Affordable, Permittable & Buildable Project

2021 Goals

- Submit key project permits
- Meet the Proposition 1 (WSIP) requirement for 75% local cost share
- Update and refine cost estimate to support Water Commission Feasibility Determination
- Update and refine Master Project Schedule through construction completion
- Circulate the revised Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement for public review and comments
- Develop Operating Agreement Term Sheets with DWR, Bureau of Reclamation and local facility partners
- Continue to collaboratively engage with landowners, tribes and local communities

Sites

info@sitesproject.org

sitesproject.org

Sites

From: Jerry Brown [jbrown@sitesproject.org]
Sent: 10/29/2021 8:50:30 AM
To: Spranza, John [john.spranza@hdrinc.com]; Alicia Forsythe [aforsythe@sitesproject.org]
Subject: Re: Sites Project Fishery Resources NGO Discussion Group

Please make sure in our comments today we specifically raise and identify where in the RDEIR/SDEIS they can find our analysis and results of their preferred diversion criteria. thanks

---

From: "Spranza, John" <John.Spranza@hdrinc.com>
Date: Tuesday, October 26, 2021 at 10:29 AM
To: Alicia Forsythe <aforsythe@sitesproject.org>, "Lecky, Jim" <jim.lecky@icf.com>, "Hendrick, Mike" <Mike.Hendrick@icf.com>, "Hassrick, Jason (Jason.Hassrick@icf.com)" <Jason.Hassrick@icf.com>, "Greenwood, Marin" <Marin.Greenwood@icf.com>, "steve.micko@jacobs.com" <steve.micko@jacobs.com>, "tstokely@att.net" <tstokely@att.net>, "jimb@aqualliance.net" <jimb@aqualliance.net>, Doug Obegi <dobegi@nrdc.org>, "reis@bayecotarium.org" <reis@bayecotarium.org>, "rzwillinger@defenders.org" <rzwillinger@defenders.org>, "DLucero@ButteCounty.net" <DLucero@ButteCounty.net>, "rebeccadawnwu@yahoo.com" <rebeccadawnwu@yahoo.com>, "chicojerry@yahoo.com" <chicojerry@yahoo.com>, "regina@californiasalmon.org" <regina@californiasalmon.org>, "Williams, Nicole" <Nicole.Williams@icf.com>, David Zelinsky <zelinsky.david@gmail.com>, "asanchez@calwild.org" <asanchez@calwild.org>, Ron Stork <RStork@friendsoftheriver.org>, "Nowlin, Kayla Ann" <Kayla.Nowlin@hdrinc.com>, Laurie Warner Herson <laurie.warner.herson@phenixenv.com>
Cc: "Leaf, Rob/SAC (Rob.Leaf@jacobs.com)" <Rob.Leaf@jacobs.com>, "Dekar, Melissa D" <mdekar@usbr.gov>, "King, Vanessa M" <vking@usbr.gov>, "Heydinger, Erin" <erin.heydinger@hdrinc.com>, Jerry Brown <jbrown@sitesproject.org>
Subject: RE: Sites Project Fishery Resources NGO Discussion Group

Hello,
Attached is the proposed agenda for our Friday discussion group. Please let me know if you have any questions.
John

John Spranza

D 916.679.8858 M 818.640.2487

-----Original Appointment-----
From: Spranza, John
Sent: Thursday, October 7, 2021 12:16 PM
To: Spranza, John; aforsythe (aforsythe@sitesproject.org); Lecky, Jim; Hendrick, Mike (Mike.Hendrick@icf.com); Hassrick, Jason (Jason.Hassrick@icf.com); Greenwood, Marin; Micko, Steve/SAC (Steve.Micko@jacobs.com); tstokely@att.net; jimb@aqualliance.net; dobegi@nrdc.org; reis@bayecotarium.org; rzwillinger@defenders.org; DLucero@ButteCounty.net; rebeccadawnwu@yahoo.com; chicojerry@yahoo.com; regina@californiasalmon.org; Williams, Nicole (Nicole.Williams@icf.com); David Zelinsky; asanchez@calwild.org; Ron Stork; Nowlin, Kayla Ann; Laurie Warner Herson
Cc: Leaf, Rob; Melissa Dekar (mdekar@usbr.gov); King, Vanessa M; Erin Heydinger (Erin.Heydinger@hdrinc.com); Jerry Brown
Subject: Sites Project Fishery Resources NGO Discussion Group
When: Friday, October 29, 2021 2:00 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: Microsoft Teams Meeting

The Authority would like to schedule a meeting to discuss the changes made to the diversion criteria and aquatic mitigation. Agenda to follow.

Microsoft Teams meeting

Join on your computer or mobile app
Click here to join the meeting

Or call in (audio only)
+1 213-514-6883,,335745359#   United States, Los Angeles
(833) 255-2803,,335745359#   United States (Toll-free)
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