Appendix N
Comment Letters

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

FA01

FEB 14 2018

Ben Nelson, Project Manager
Bureau of Reclamation, Bay Delta Office
801 I Street, Suite 140
Sacramento, CA 95814-2536

Subject: Draft Environmental Impact Statement for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project Yolo County, California (EIS No. 20170246)

Dear Mr. Nelson:

The U.S. Environmental Protection Agency has reviewed the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project Draft Environmental Impact Statement (DEIS) pursuant to the National Environmental Policy Act (NEPA), Council on Environmental Quality regulations (40 CFR Parts 1500-1508), and our NEPA review authority under Section 309 of the Clean Air Act. EPA is a cooperating agency for this DEIS.

The U.S. Bureau of Reclamation and the Department of Water Resources are proposing to take steps to improve fish passage and rearing habitat in the Yolo Bypass. The DEIS analyzes the effects of six action alternatives that would put one or more gated notches in the Fremont Weir and increase the volume of water entering the Yolo Bypass to pull more fish onto the bypass, reduce stranding, and create a large floodplain area for foraging and rearing. The proposed project would implement Reasonable and Prudent Alternative actions, as described in the National Marine Fisheries Biological Opinion on the Long-term Operations of the Central Valley Project and State Water Project. 1

EPA is supportive of restoration actions in the Bay Delta Estuary that contribute to the health and improvement of aquatic resources. The Alternatives Comparison summary in Chapter 8 of the DEIS clearly examines the benefits of this project to salmon and sturgeon. Analytical summaries such as these provide for a meaningful evaluation and alternatives comparison for the public and decisionmakers.

While strongly supportive of aquatic habitat restoration, we advise caution to ensure that it does not result in unintended consequences that adversely affect water quality. In particular, it is critical that the formation and mobilization of methylmercury in wetlands be minimized.

The DEIS does not identify Reclamation's Preferred Alternative. It is EPA's policy to rate each alternative when a preferred alternative is not identified. Based on our review, we are rating Alternatives 1-3 as *Lack of Objections* (LO) and Alternatives 4-6 as *Environmental Concerns- Insufficient Information* (EC-2) (see enclosed "Summary of EPA Rating Definitions"). Alternatives 4-6 would have construction emissions above *de minimis* National Ambient Air Quality Standards thresholds for nitrous oxide and particulate matter, due to the larger construction footprints compared to Alternatives 1-3. The enclosed detailed comments provide recommendations for reducing air emissions and more fully disclosing potential water quality related impacts. 2

EPA appreciates the opportunity to review this DEIS. When the Final EIS is released for public review, please send one copy to the address above (mail code: ENF-4-2). If you have any questions, please contact me at (415) 972-3521, or contact Stephanie Gordon, the lead reviewer for this project, at 415-972-3098 or gordon.stephanies@epa.gov.

Sincerely,

Kathleen Martyn Goforth, Manager
Environmental Review Section

Enclosures: Summary of EPA Rating Definitions
Detailed Comments

cc: Janis Cooke, Central Valley Regional Water Quality Control Board

SUMMARY OF EPA RATING DEFINITIONS*

This rating system was developed as a means to summarize the U.S. Environmental Protection Agency's (EPA) level of concern with a proposed action. The ratings are a combination of alphabetical categories for evaluation of the environmental impacts of the proposal and numerical categories for evaluation of the adequacy of the Environmental Impact Statement (EIS).

ENVIRONMENTAL IMPACT OF THE ACTION

"LO" (Lack of Objections)

The EPA review has not identified any potential environmental impacts requiring substantive changes to the proposal. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposal.

"EC" (Environmental Concerns)

The EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact. EPA would like to work with the lead agency to reduce these impacts.

"EO" (Environmental Objections)

The EPA review has identified significant environmental impacts that should be avoided in order to provide adequate protection for the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). EPA intends to work with the lead agency to reduce these impacts.

"EU" (Environmentally Unsatisfactory)

The EPA review has identified adverse environmental impacts that are of sufficient magnitude that they are unsatisfactory from the standpoint of public health or welfare or environmental quality. EPA intends to work with the lead agency to reduce these impacts. If the potentially unsatisfactory impacts are not corrected at the final EIS stage, this proposal will be recommended for referral to the Council on Environmental Quality (CEQ). 3

ADEQUACY OF THE IMPACT STATEMENT

"Category 1" (Adequate)

EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

"Category 2" (Insufficient Information)

The draft EIS does not contain sufficient information for EPA to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the EPA reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analysed in the draft EIS, which could reduce the environmental impacts of the action. The identified additional information, data, analyses, or discussion should be included in the final EIS.

"Category 3" (Inadequate)

EPA does not believe that the draft EIS adequately assesses potentially significant environmental impacts of the action, or the EPA reviewer has identified new, reasonably available alternatives that are outside of the spectrum of alternatives analysed in the draft EIS, which should be analysed in order to reduce the potentially significant environmental impacts. EPA believes that the identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. EPA does not believe that the draft EIS is adequate for the purposes of the NEPA and/or Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS. On the basis of the potential significant impacts involved, this proposal could be a candidate for referral to the CEQ.

*From EPA Manual 1640, Policy and Procedures for the Review of Federal Actions Impacting the Environment.

EPA DETAILED COMMENTS ON THE YOLO BYPASS SALMONID HABITAT RESTORATION AND FISH PASSAGE PROJECT DRAFT ENVIRONMENTAL IMPACT STATEMENT, YOLO COUNTY, CALIFORNIA – FEBRUARY 14, 2018

Water Quality

The DEIS explains that, when the Yolo Bypass is flooded, it becomes the dominant source of
methylmercury to the Delta, and that restoration activities are likely to result in increased production, 4
mobilization, and bioavailability of methylmercury in the aquatic system (p. 6-27). It states that monitoring will be conducted, but does not specify the type of monitoring nor how the results would be applied, e.g., to support adaptive management.

The State Water Resources Control Board recently adopted new mercury water quality objectives that
apply to tribal and subsistence beneficial uses.[1] These uses are designated for the Delta, but the DEIS 5
does not discuss the impacts that the proposed project actions could have on people who consume resident fish species in the Delta (Table 6-2, p. 6-5).

Recommendation:

In the Final EIS, describe and commit to water column and fish and invertebrate tissue 6
monitoring for mercury and methylmercury in the Yolo Bypass to support adaptive management actions and coordinate with ongoing monitoring for the Delta Regional Monitoring Program.

Include a discussion in the FEIS regarding any impacts that the project would likely have on 7
attainment of the applicable subsistence fishing water quality objective in the Bay Delta.

Wetlands

As disclosed in the DEIS, some of the proposed project activities, such as construction of concrete abutments and rock-lined channels, could result in impacts to waters of the United States, which would require a permit issued by the U.S. Army Corps of Engineers pursuant to Section 404 of the Clean Water Act. We note that the DEIS states that the Corps' Least Environmentally Damaging Practicable Alternative determination is expected to be attached to the FEIS (p. 23-11).

Recommendation: 8

- In the FEIS, avoid, minimize, and mitigate impacts to aquatic resources to achieve compliance with the CWA Section 404(b)(1) Guidelines.
- Work with the Corps to obtain a formal jurisdictional delineation of waters of the U.S. in the project area and include, in the FEIS, a map of the delineated waters and the anticipated impacts to those waters, to streamline future Section 404 compliance efforts.
- Conduct a formal and reproducible assessment of the aquatic resources and ecosystem
functions in the project footprint, using a scientifically defensible method, such as the 9
California Rapid Assessment Method (CRAM), and include the results in the FEIS.

Sediment

The document states that Alternative 1 is estimated to increase the total amount of sediment entering the Yolo Bypass to approximately 743,000 cubic yards on an average annual basis (an increase of about 13 percent) (p. 12-13). Currently, sediment removal operations occur in the bypass on an as-needed basis and this would change to "at least every five years and as-needed." Reuse of all the project's dredged
material would support efforts to protect vital infrastructure from the effects of sea level rise and assist 10

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[1] https://www.waterboards.ca.gov/water_issues/programs/mercury/docs/hg_prov_final.pdf

in restoring habitat. This would also be consistent with the regional interagency dredged material management plan (the San Francisco Bay Region Long Term Management Strategy, or LTMS), which strives to maximize beneficial reuse of dredged sediments and strictly limits annual in-Bay disposal volumes.

Recommendation:
In the FEIS, discuss the feasibility of practical reuse, including possible sites and partnerships, of the sediment material that would deposit in the Yolo Bypass as a result of the project.

Air Quality
Since the proposed project would be in an area that is designated as non-attainment for PM2.5 and attainment/maintenance for PM10, and the initial analysis shows that there would be short-term degradation of air quality during construction, it is critically important that impacts to air quality be accurately analyzed, disclosed, and reduced as much as possible. According to the DEIS, Alternatives 1-3 would have mitigated emissions below the National Ambient Air Quality Standards NOx and PM10 thresholds, but Alternatives 4-6 would have mitigated emissions above the *de minimis* thresholds due to their larger construction footprints.

Recommendations:
EPA encourages Reclamation to work with Yolo-Solano Air Quality Management District (AQMD) and Feather River AQMD to develop the Draft General Conformity Determination for the project and to identify additional mitigation measures that would be necessary. For all the Alternatives, consider the following, as appropriate, to reduce adverse effects during construction of the project: 11

- Solicit bids that include use of energy and fuel-efficient fleets;
- Solicit construction bids that use Best Available Control Technology, particularly those that would deploy zero-emission technologies;
- Employ the use of alternative fueled vehicles;
- Use lighting systems that are energy efficient, such as LED technology;
- Use the minimum amount of greenhouse gas (GHG)-emitting construction materials that is feasible;
- Use cement blended with the maximum feasible amount of alternative materials (industrial materials designated for re-use, for example) that reduce GHG emissions from cement production;
- Use lighter-colored pavement where feasible;
- Recycle construction debris to maximum extent feasible;
- Plant shade trees in or near construction projects where feasible; and
- Use grid-based electricity for construction activities and/or onsite renewable electricity generation, rather than diesel and/or gasoline powered generators.

Update Table 18-43 and Table 18-51 to indicate that total NOx emissions for Alternative 5 would be above the *de minimis* threshold. 12

FA02

Buckman, Carolyn

From: Nelson, Benjamin <bcnelson@usbr.gov>
Sent: Thursday, February 15, 2018 11:17 AM
To: Buckman, Carolyn
Subject: Fwd: Yolo Bypass Salmonid Habitat Restoration
Attachments: 2017-12-29_YoloBypass_DEIS_CGAA1982.pdf

---------- Forwarded message ----------
From: **Hausner, Carl T CIV** <Carl.T.Hausner@uscg.mil>
Date: Fri, Dec 29, 2017 at 8:51 AM
Subject: Yolo Bypass Salmonid Habitat Restoration
To: "karen.enstrom@water.ca.gov" <karen.enstrom@water.ca.gov>, "bcnelson@usbr.gov" <bcnelson@usbr.gov>

Karen, Ben:

The proposed bridges for the subject project will not need Coast Guard Bridge Permits. I have determined the waterways, which the proposed bridges cross, are not considered navigable by Coast Guard Standards; therefore Coast Guard Bridge Permits are not required. Attached is documentation stating the Coast Guard Bridge Office will have no further involvement in this project as proposed. Please contact me if you have any questions. 1

Thank you,

v/r,

Carl Hausner
Chief, Bridge Section
Eleventh Coast Guard District
510-437-3516 Office
510-219-4366 Cell
510-437-5836 Fax
Carl.T.Hausner@uscg.mil

Mailing Address

Commander (dpw)
Eleventh Coast Guard District
Coast Guard Island, BLDG 50-2
Alameda, CA 94501-5100

Attn: Bridge Office

review, use, disclosure, or retention by others is strictly prohibited. If you are not an intended recipient, please contact the sender and delete this email, any attachments, and all copies.

--
Ben Nelson

Natural Resources Specialist

Bureau of Reclamation, Bay-Delta Office

801 I St, Suite 140, Sacramento, CA 95814

office - 916-414-2424

cell - 916-539-9510

Menu

Under the provisions of the Coast Guard Authorization Act of 1982, the Coast Guard has determined this project does not require Coast Guard involvement for bridge permit purposes.

Date 12/29/17 Signature

CARL T. HAUSNER
Chief, Bridge Section
11th Coast Guard District
By direction of the District Commander

1 CONT.

United States Environmental Protection Agency

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NEPA

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Environmental Impact Statement (EIS) Database

EIS Details

EIS Title

Yolo Bypass Salmonid Habitat Restoration & Fish Passage

EIS Number

20170246

Document Type

Draft

Federal Register Date

12/29/2017

EIS Comment Due/ Review Period Date

02/15/2018

Amended Notice Date

Amended Notice

Supplemental Information

Website

EPA Comment Letter Date

State or Territory

CA

Lead Agency

Bureau of Reclamation

Contact Name

Ben Nelson

Contact Phone

9164142424

Rating (if Draft EIS)

You will need Adobe Reader to view some of the files on this page. See EPA's PDF page to learn more. If you need help accessing these PDF documents, please contact NEPAdatabasesupport (NEPAdatabasesupport@epa.gov) for assistance.

EIS Document(s):

01_Yolo_Bypass_Draft_EIS_EIR_Cover-Ch_08.pdf (832 pp, 34,250 K)

02_Yolo_Bypass_Draft_EIS_EIR_Ch_09-26.pdf (772 pp, 46,843 K)

03_Yolo_Bypass_Draft_EIS_EIR_Appendix_A-Appendix_C.pdf (272 pp, 12,616 K)

04_Yolo_Bypass_Draft_EIS_EIR_Appendix_D_Part1.pdf (192 pp, 49,641 K)

05_Yolo_Bypass_Draft_EIS_EIR_Appendix_D_Part2.pdf (197 pp, 49,360 K)

06_Yolo_Bypass_Draft_EIS_EIR_Appendix_D_Part3.pdf (46 pp, 49,640 K)

07_Yolo_Bypass_Draft_EIS_EIR_Appendix_D_Part4.pdf (86 pp, 23,586 K)

08_Yolo_Bypass_Draft_EIS_EIR_Appendix_E-Appendix_H4.pdf (1454 pp, 33,093 K)

09_Yolo_Bypass_Draft_EIS_EIR_Appendix_H5-Appendix_J2.pdf (493 pp, 37,430 K)

10_Yolo_Bypass_Draft_EIS_EIR_Appendix_K1.pdf (2748 pp, 49,841 K)

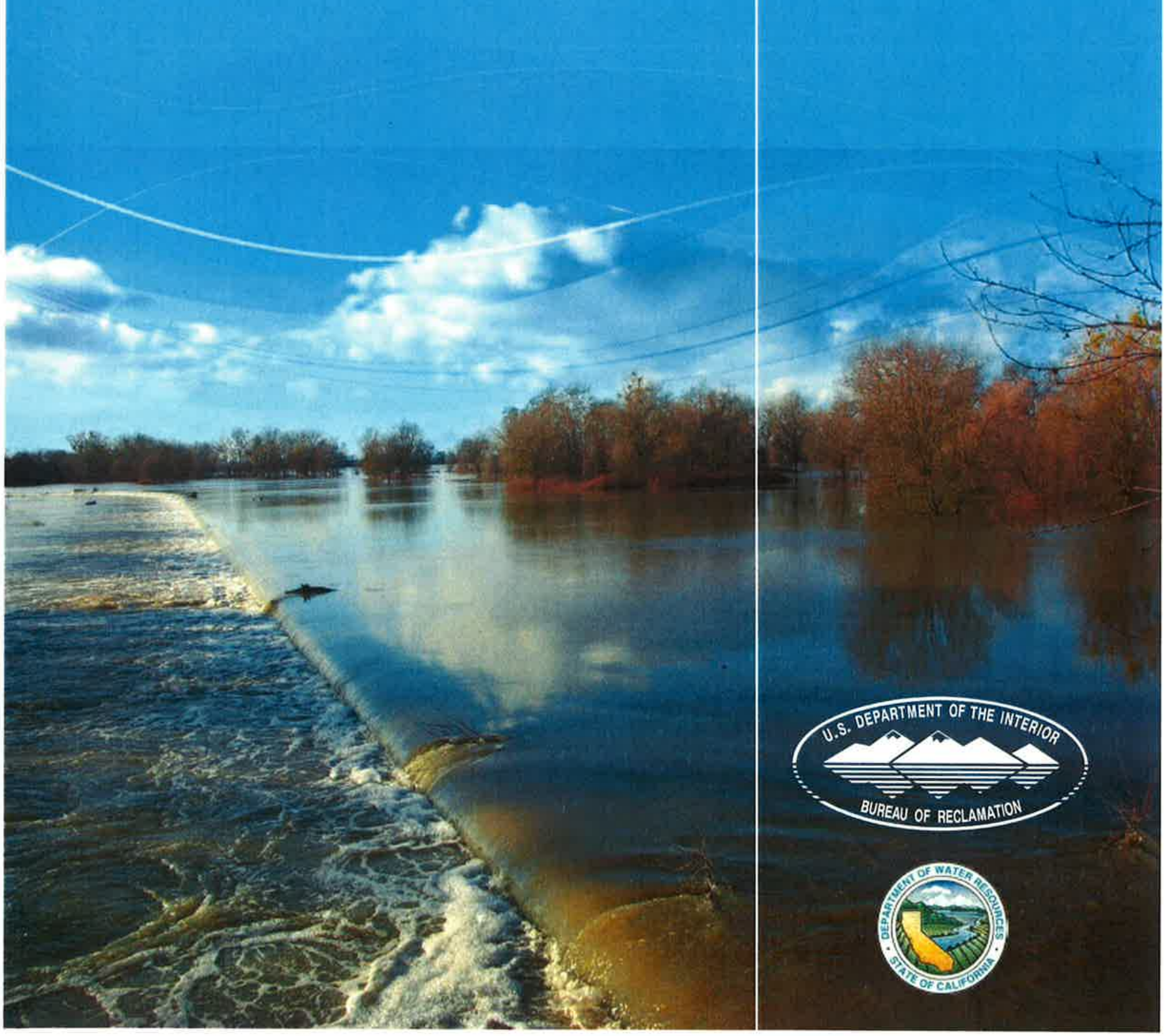
11_Yolo_Bypass_Draft_EIS_EIR_Appendix_K2-Appendix_L.pdf (305 pp, 2,135 K)

Yolo Bypass Salmonid Habitat Restoration & Fish Passage

Environmental Impact Statement
Environmental Impact Report

Draft

December 2017



U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Executive Summary

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project) has been developed to improve fish passage and increase floodplain fisheries rearing habitat in the Yolo Bypass and the lower Sacramento River basin. The United States Department of the Interior, Bureau of Reclamation (Reclamation), as the Federal lead agency under the National Environmental Policy Act (NEPA), and the California Department of Water Resources (DWR), as the State of California (State) lead agency under the California Environmental Quality Act (CEQA), have prepared this joint Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) to assess impacts of the Project. The Project actions would implement Reasonable and Prudent Alternative (RPA) action I.6.1 and, in part, RPA action I.7, as described in the 2009 National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project* (NMFS BO) and the 2012 Yolo Bypass Salmonid Habitat Restoration and Fish Passage Implementation Plan (Reclamation and DWR 2012).

Authority for combined Federal and State documents is provided in Title 40, Code of Federal Regulations (CFR), Sections 1502.25, 1506.2, and 1506.4 (Council on Environmental Quality's Regulations for Implementing NEPA [CEQ Regulations]) and California Code of Regulations Title 14, Division 6, Chapter 3 (State CEQA Guidelines), Section 15222 (Preparation of Joint Documents). This document also was prepared consistent with United States Department of the Interior regulations specified in 43 CFR, Part 46 (United States Department of the Interior Implementation of NEPA, Final Rule).

This Draft EIS/EIR evaluates reasonably foreseeable potential direct, indirect, and cumulative impacts on the environment that could result from implementing the Project alternatives. In addition, this Draft EIS/EIR includes feasible mitigation measures to avoid, minimize, rectify, reduce, or compensate for adverse impacts.

ES.1 Background

Substantial modifications have been made to the historical floodplain of California's Central Valley for water supply and flood control purposes. These activities, and other environmental stressors, have resulted in losses of rearing habitat, migration corridors, and food web production for fish, adversely affecting native fish species that rely on floodplain habitat during part or all of their life history.

DWR is responsible for operating and maintaining the State Water Project (SWP), and Reclamation is responsible for managing the Central Valley Project (CVP). The SWP and CVP are operated in a coordinated manner to deliver water to agricultural, municipal, and industrial contractors throughout California. On June 4, 2009, the NMFS BO concluded that, if left unchanged, CVP and SWP operations are likely to jeopardize the continued existence of four anadromous fish species listed under the Federal Endangered Species Act (ESA): Sacramento

FA03

Buckman, Carolyn

From: Simmons, Zachary M CIV USARMY CESPK (US) <Zachary.M.Simmons@usace.army.mil>
Sent: Wednesday, February 21, 2018 2:02 PM
To: Buckman, Carolyn
Cc: Karen Enstrom <Karen.Enstrom@water.ca.gov>; Ben Nelson <bcnelson@usbr.gov>
Subject: RE: Yolo Bypass Salmonid Habitat Restoration and Fish Passage Draft EIS/EIR
Attachments: DEIS Comments - USACE.XLSX

Hi Carrie,
Here are the Corps' comments on the Draft EIR/EIS.

Thanks,

Zachary M. Simmons

Biologist, Senior Project Manager
Regulatory Division, Enforcement/Special Projects Branch
U.S. Army Corps of Engineers, Sacramento District
1325 J Street, Room 1350, Sacramento, CA 95814
Zachary.M.Simmons@usace.army.mil
(916) 557-6746

From: Buckman, Carolyn [mailto:BuckmanCM@cdmsmith.com]
Sent: Thursday, December 28, 2017 1:23 PM
To: Julie Spezia <jaspezia@gmail.com>; Petrea Marchand <Petrea@conserosolutions.com>; Meisler,Marty <mmeisler@mwdh2o.com>; Phillis,Corey C <CPhillis@mwdh2o.com>; Alison L. Collins <acollins@mwdh2o.com>; Schmutte,Curtis <Cschmutte@mwdh2o.com>; Elisa Sabatini <Elisa.Sabatini@yolocounty.org>; Enstrom, Karen@DWR <Karen.Enstrom@water.ca.gov>; Lewis Bair <LBair@rd108.org>; Stafford, Maya R.@DWR <Maya.Stafford@water.ca.gov>; Heather Nichols <Nichols@yolorcd.org>; Roberta Goulart <RLGoulart@solanocounty.com>; Philp,Thomas S <TPhilp@mwdh2o.com>; Benjamin Nelson <bcnelson@usbr.gov>; Serup, Bjarni@Wildlife <bjarni.serup@wildlife.ca.gov>; Doug Brown <browndoug@att.net>; Chris Bowles <c.bowles@cbecoeng.com>; Chris Campbell <c.campbell@cbecoeng.com>; Swinney, Heather <heather_swinney@fws.gov>; Israel, Joshua <jaisrael@usbr.gov>; Newcomb, James@DWR <james.newcomb@water.ca.gov>; Jeremy Arrich <jeremy.arrich@water.ca.gov>; Jessica Little <jessica@caleec.com>; Jacob Katz <jkatz@caltrout.org>; John Currey <john-currey@dixonrcd.org>; JOHN BRENNAN <john@landmba.org>; Kundargi, Kenneth@Wildlife <kenneth.kundargi@wildlife.ca.gov>; Kris Tjernell <kristopher.tjernell@resources.ca.gov>; Bahia, Maninder@DWR <maninder.bahia@water.ca.gov>; maya@americanwestconservation.com; Robin Kulakow <robin@yolobasin.org>; Steve Thompson <steve@stevethompsonllc.com>; DAVID KATZ <davidkat@sonic.net>; Washburn. Timothy <washburnt@saccounty.net>; Smith, Tim@DWR <tim.smith@water.ca.gov>; Simmons, Zachary M CIV USARMY CESPK (US) <Zachary.M.Simmons@usace.army.mil>; Nagy, Meegan@rd108.org <mnagy@rd108.org>; Blodgett, Peter J CIV USARMY CESPK (US) <Peter.J.Blodgett@usace.army.mil>; aric.lester@water.ca.gov; Martha Ozonoff <mozonoff@yolobasin.org>
Subject: [EXTERNAL] Yolo Bypass Salmonid Habitat Restoration and Fish Passage Draft EIS/EIR

Good afternoon –

The attached notice of availability was distributed last week. If anyone has any difficulty accessing the documents, please contact Ben, Karen, or I for help.

Thank you!

Carrie Buckman
CDM Smith
1755 Creekside Oaks Drive, Suite 200
Sacramento, CA 95833
(916) 576-7482
buckmancm@cdmsmith.com

YBSHRFP Draft EIR/EIS Comments

USACE 2/21/2018 Zachary Simmons

Comment #	Chapter	Page	Paragraph	Comment	
1	2.7.1	2-46	2	The approximate length of the two bypass channels are identified as 2,500 feet and 3,000 feet. Paragraph 1 on page 2-49 identifies the southern bypass channel as 4,000 feet long. Which is correct?	1
2	2.7.1	2-46	2	The engineering and hydraulic impacts of the berms along the bypass channels should be coordinated with the Corps Engineering Division prior to the selection of any alternative that would construct berms within the bypass.	2
3	2.7.1.1	2-46		I checked the length of the northern bypass channel as drawn in figure 2-14. The bypass channel measures over 4,000 feet	3
4	2.7.1.1	2-48	1	The engineered embankment for the northern water control structure measure approximately 7,500 feet in Figure 2-14 while paragraph 1 on page 2-48 say's it would be 12,000 linear feet. Does the 12,000 feet include the bypass channel?	4
5	2.7.1.1	2-48	1	The impacts of the engineered armored embankment on the existing bypass levees and floodway must be assessed. What effect would the increased loading have on the levee? What does this look like compared to what it was design for and currently subjected to? How would these berms tie in to the existing levee? What other effects would this change in hydraulics have on the existing levee? The engineering and hydraulic impacts of the engineered embankment should be coordinated with the Corps Engineering Division prior to the selection of any alternative that would construct berms within the bypass.	5
6	2.7.1.2	2-49	2	See Comment #4 above.	6
7	2.7.1.2	2-49		I checked the length of the southern bypass channel as drawn in figure 2-17. The bypass channel measures over 10,000 feet	7
8	2.7.1.2	2-49	1	The engineered embankment for the northern water control structure measure approximately 37,300 feet in Figure 2-14 while paragraph 1 on page 2-48 say's it would be 42,500 linear feet. Does the 42,500 feet include the bypass channel?	8
9	2.8.1.2	2-55	1	What do you mean by a "100-foot-long headworks structure" that houses all four gates? The bullets that follow this paragraph go on to describe the four gate groups with widths at a minnimum of 30 feet, 30 feet, 100 feet, and 110 feet when adding up the gated culverts.	9
10	9.3.3.7.9	9-186	3	The sentence in the middle of the paragraph says that "Alt 6 would have the **lowest total acreage** of impacts to USACE **wetland** waters". This statement is not supported by the data presented in Table 9-9. Alternatives 1, 2, 3, and 5 all have less impacts to wetlands. Alt 5 has the lowest total impact of 8.1 acres of wetlands. That is less that half of the 17.7 acres of impacts that would result under Alt 6. Even when compared only to the western notch alternatives, Alt 3 has 0.4 acre less impacts to wetlands.	10

FA04

Buckman, Carolyn

From: Nelson, Benjamin <bcnelson@usbr.gov>
Sent: Friday, February 16, 2018 11:27 AM
To: Buckman, Carolyn
Subject: Fwd: Notice of Availability of the Draft EIS/EIR for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

---------- Forwarded message ----------
From: **Laverne Bill** <LBill@yochadehe-nsn.gov>
Date: Thu, Feb 15, 2018 at 4:35 PM
Subject: RE: Notice of Availability of the Draft EIS/EIR for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project
To: "Bahia, Maninder@DWR" <Maninder.Bahia@water.ca.gov>
Cc: "Enstrom, Karen@DWR" <Karen.Enstrom@water.ca.gov>, "Martinez, Analisa@DWR" <Analisa.Martinez@water.ca.gov>, "Nelson, Ben@usbr.gov" <bcnelson@usbr.gov>

Good afternoon, Karen. After reviewing the project details, the Tribe would like to express the following concerns with this project.

The Cultural Resources Department has reviewed the project and concluded that it is within our aboriginal territories of the Yocha Dehe Wintun Nation. Therefore, we have a cultural interest and authority in the proposed project area. Based on the information provided, the Tribe has concerns that the project could impact known archaeological/cultural sites. Yocha Dehe Wintun Nation highly recommends including cultural monitoring during the development or ground disturbance, including backhoe trenching & excavations. 1

Thanks and let me know if you have any further questions. Thanks.

Laverne Bill

Cultural Resources Department Manager &

Cultural Resources Manager

Tewe Kewe Cultural Center

PO Box 18 | Brooks, CA 95606

p 530.796.3400 | c 530.723.3891

f 530.796.2143

lbill@yochadehe-nsn.gov

www.yochadehe.org

From: Bahia, Maninder@DWR [mailto:Maninder.Bahia@water.ca.gov]
Sent: Thursday, February 15, 2018 3:13 PM
To: Laverne Bill
Cc: Enstrom, Karen@DWR; Martinez, Analisa@DWR; Nelson, Ben@usbr.gov
Subject: RE: Notice of Availability of the Draft EIS/EIR for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Laverne,

Thanks for the call this morning. As we discussed the comments are due by today and Chapter 2 will help understand the alternatives being considered and Chapter 10 is the Cultural and Paleontological Resources chapter. The below link will take you to the document and the below images provide a summary of the alternatives.

https://usbr.gov/mp/BayDeltaOffice/yolo-bypass.html

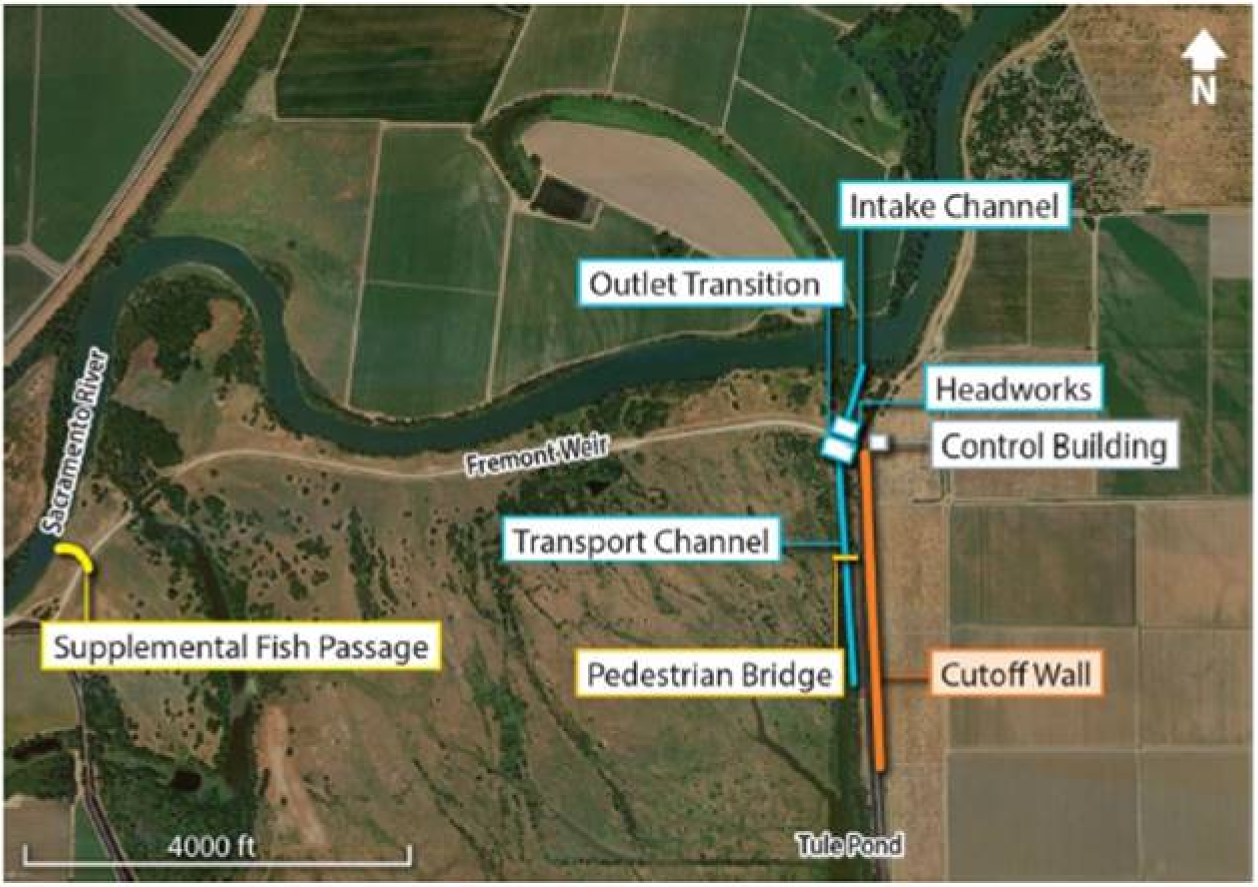


Figure 2-4. Alternative 1 Key Components

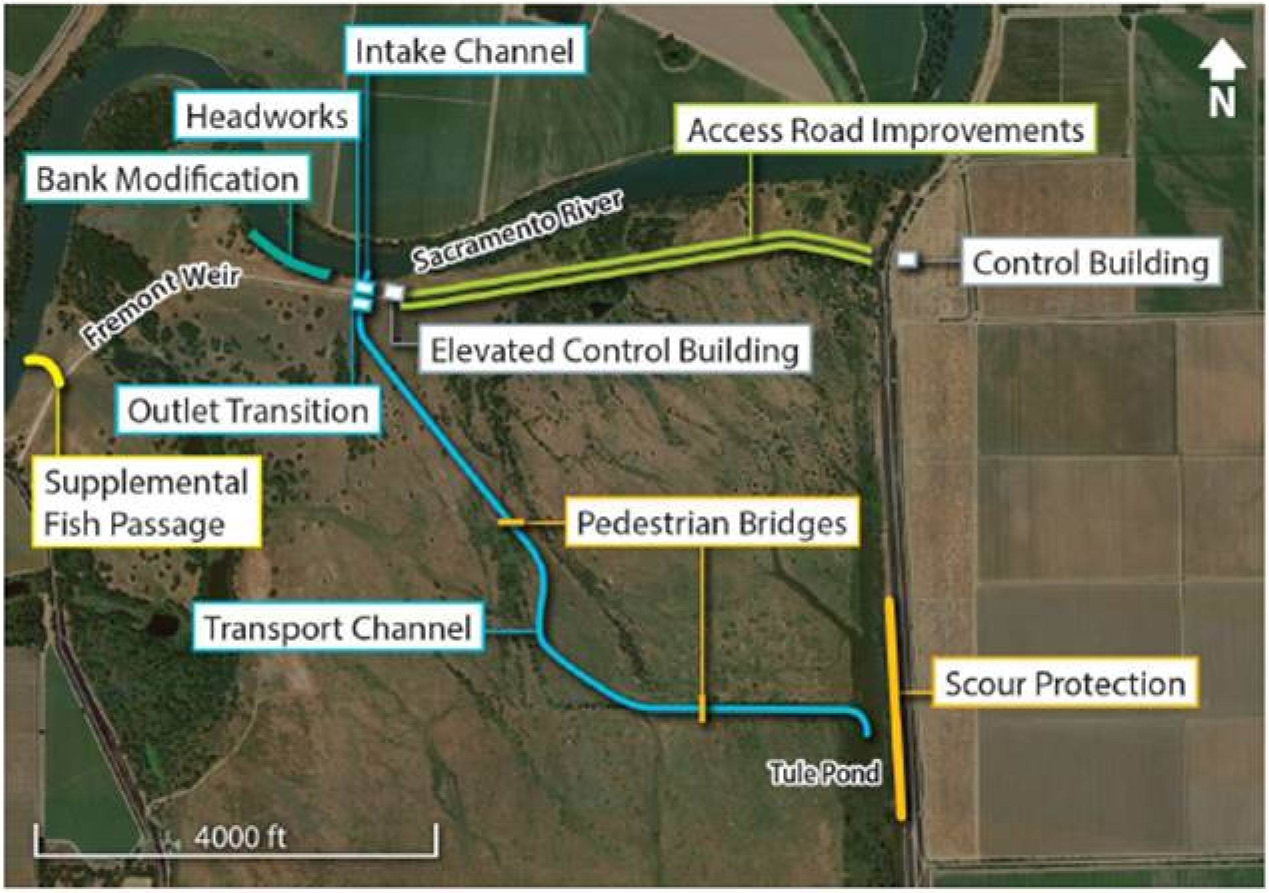


Figure 2-10. Alternative 2 Key Components

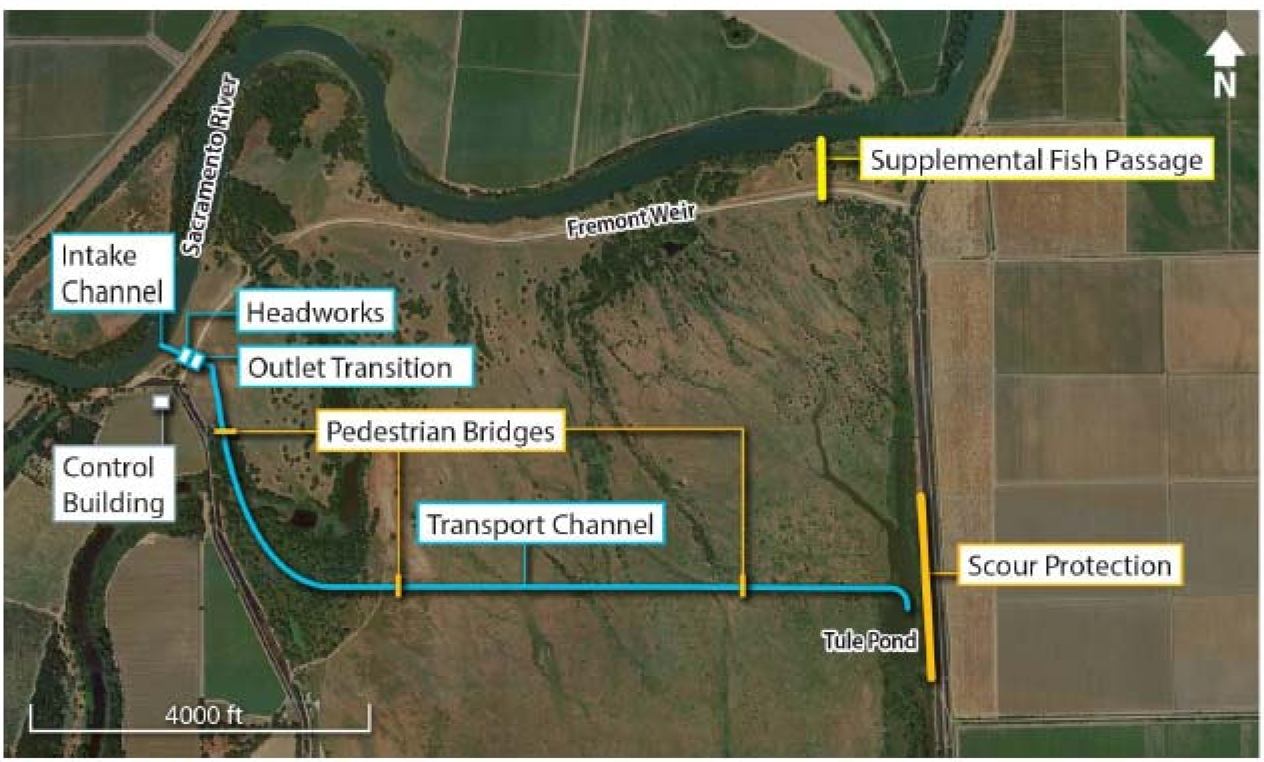


Figure 2-11. Alternative 3 Key Components

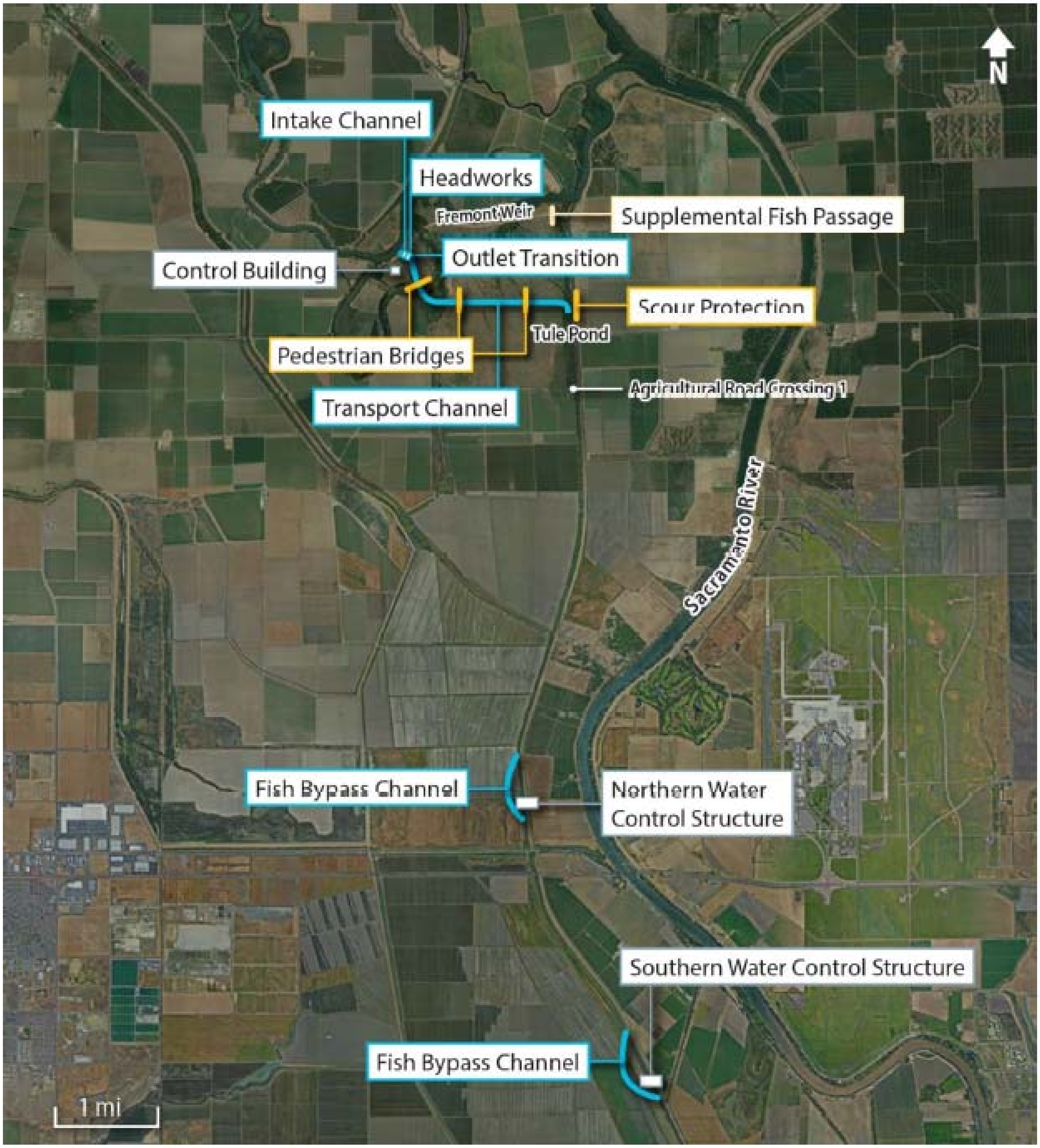


Figure 2-13. Alternative 4 Key Components

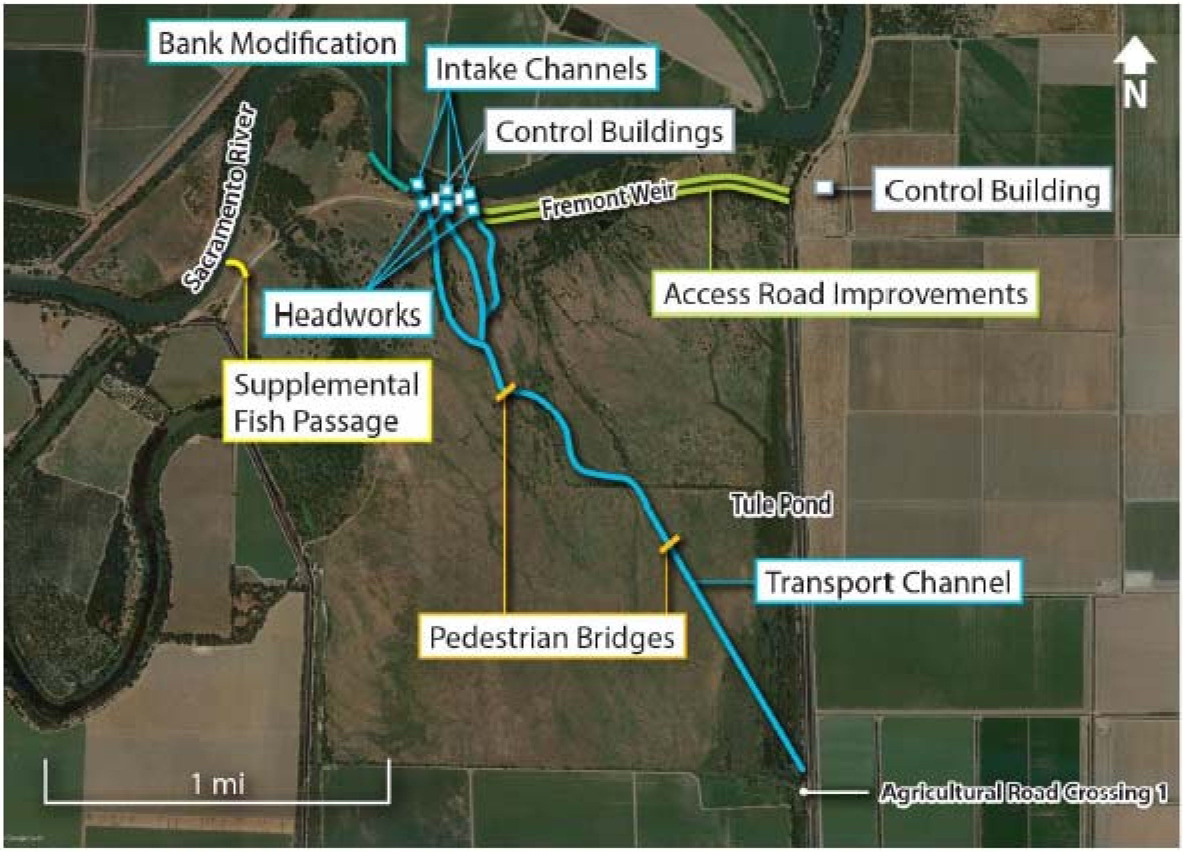


Figure 2-18. Alternative 5 Key Components

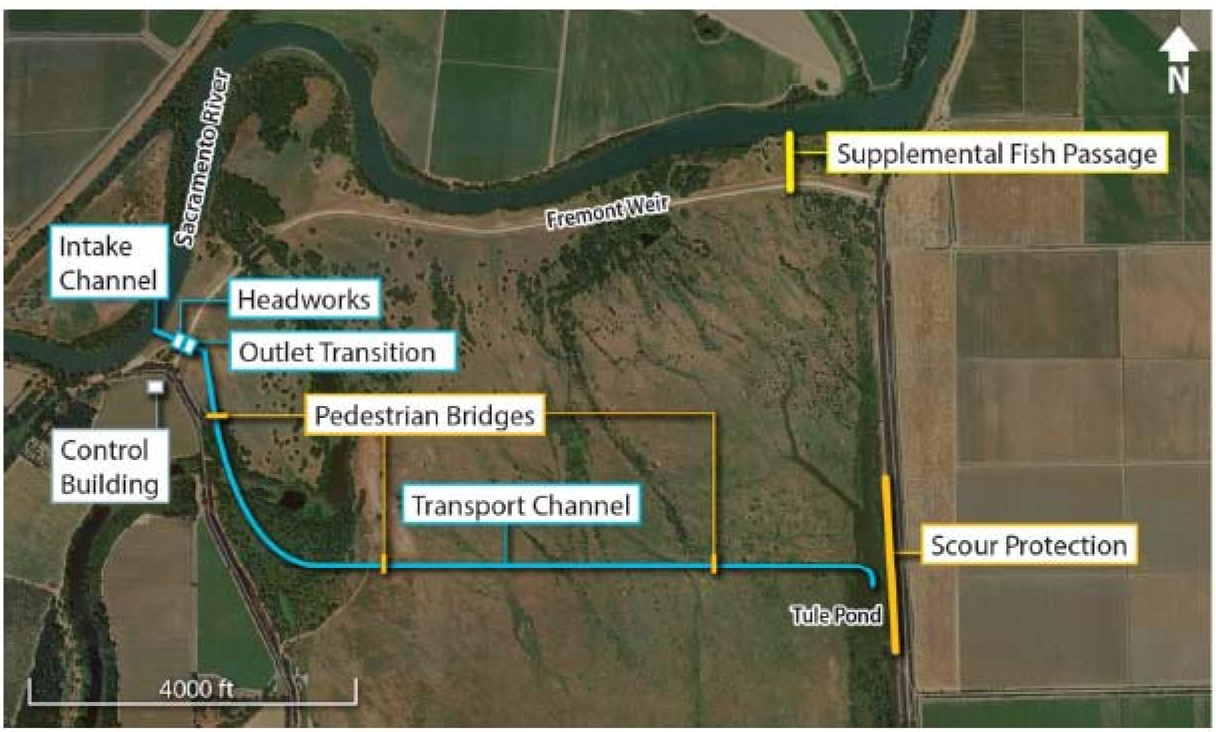


Figure 2-23. Alternative 6 Key Components

Thanks,

Manny

From: Bahia, Maninder@DWR
Sent: Thursday, January 04, 2018 4:55 PM
To: James Sarmento (JSarmento@yochadehe-nsn.gov) (JSarmento@yochadehe-nsn.gov) <JSarmento@yochadehe-nsn.gov>; Marilyn Delgado (MDelgado@yochadehe-nsn.gov) (MDelgado@yochadehe-nsn.gov) <MDelgado@yochadehe-nsn.gov>; 'lbill@yochadehe-nsn.gov' (lbill@yochadehe-nsn.gov) <lbill@yochadehe-nsn.gov>
Cc: Enstrom, Karen@DWR (Karen.Enstrom@water.ca.gov) <Karen.Enstrom@water.ca.gov>; Nelson, Ben@usbr.gov (bcnelson@usbr.gov) <bcnelson@usbr.gov>; Martinez, Analisa@DWR (Analisa.Martinez@water.ca.gov) <Analisa.Martinez@water.ca.gov>
Subject: FW: Notice of Availability of the Draft EIS/EIR for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Hello Marilyn, James, and Bill,

We just noticed that you were not on our email blast list for releasing our EIR/EIS for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project. Our apologies for the oversight. The below message and attached notice were sent out a couple of weeks ago. - Manny

Notice of Availability of the Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project. Draft environmental document released for public review and comment. See attached Notice.

--
Ben Nelson

Natural Resources Specialist

Bureau of Reclamation, Bay-Delta Office

801 I St, Suite 140, Sacramento, CA 95814

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SA01

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Ecosystem Conservation Division
1416 9th Street
Sacramento, CA 95814
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

February 15th, 2018

Ms. Enstrom, Program Manager
California Department of Water Resources
3500 West Industrial Boulevard
West Sacramento, CA, 95691

Dear Ms. Enstrom:

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project)
DRAFT ENVIRONMENTAL IMPACT REPORT (DEIR) SCH# 2013032004

The California Department of Fish and Wildlife (CDFW) received a Notice of Availability of a DEIR from California Department of Water Resources for the Project pursuant the California Environmental Quality Act (CEQA) and CEQA Guidelines.[1]

Thank you for the opportunity to provide comments and recommendations regarding those activities involved in the Project that may affect California fish and wildlife. Likewise, we appreciate the opportunity to provide comments regarding those aspects of the Project that CDFW, by law, may be required to carry out or approve through the exercise of its own regulatory authority under the Fish and Game Code.

CDFW acknowledges and appreciates the effort that has been invested in developing this DEIR for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project by the California Department of Water Resources and the United States Bureau of Reclamation. CDFW commends the project proponents on reaching this significant milestone, bringing this important restoration project one-step closer to implementation. CDFW supports the identified Preferred Alternative under CEQA, which strikes the best balance between providing benefits to fish species and impacts to other natural resources and land uses in the Yolo Bypass. 1

CDFW ROLE

CDFW is California's **Trustee Agency** for fish and wildlife resources, and holds those resources in trust by statute for all the people of the State. (Fish & G. Code, §§ 711.7, subd. (a) & 1802; Pub. Resources Code, § 21070; CEQA Guidelines § 15386, subd. (a).) CDFW, in its trustee capacity, has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species. (*Id.*, § 1802.) Similarly, for purposes of CEQA,

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[1] CEQA is codified in the California Public Resources Code in section 21000 et seq. The "CEQA Guidelines" are found in Title 14 of the California Code of Regulations, commencing with section 15000.

CDFW is charged by law to provide, as available, biological expertise during public agency environmental review efforts, focusing specifically on projects and related activities that have the potential to adversely affect fish and wildlife resources.

CDFW is also submitting comments as a **Responsible Agency** under CEQA. (Pub. Resources Code, § 21069; CEQA Guidelines, § 15381.) CDFW expects that it may need to exercise regulatory authority as provided by the Fish and Game Code. As proposed, for example, the Project may be subject to CDFW's lake and streambed alteration regulatory authority. (Fish & G. Code, § 1600 et seq.) Likewise, to the extent implementation of the Project as proposed may result in "take" as defined by State law of any species protected under the California Endangered Species Act (CESA) (Fish & G. Code, § 2050 et seq.), related authorization as provided by the Fish and Game Code will be required.

PROJECT DESCRIPTION SUMMARY

Proponent: U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR)

Objective: The objective of the Project is to enhance floodplain rearing habitat and fish passage in the Yolo Bypass by implementing RPA action I.6.1 and, in part, RPA action I.7, as described in the NMFS BO, to benefit Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and the Southern DPS of North American green sturgeon.

The objective of RPA action I.6.1 is to increase the availability of floodplain fisheries rearing habitat for juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. This action can also improve conditions for Sacramento splittail and Central Valley fall-run Chinook salmon. 2

Specific biological objectives include:

- Improve access to seasonal habitat through volitional entry
- Increase access to and acreage of seasonal floodplain fisheries rearing habitat
- Reduce stranding and presence of migration barriers
- Increase aquatic primary and secondary biotic production to provide food through an ecosystem approach

The objective of RPA action I.7 is to reduce migratory delays and loss of fish at Fremont Weir and other structures in the Yolo Bypass. Specific biological objectives include:

- Improve connectivity within the Yolo Bypass for passage of salmonids and green sturgeon
- Improve connectivity between the Sacramento River and the Yolo Bypass to provide safe and timely passage for:

- Adult Sacramento River winter-run Chinook salmon between mid-November and May when water surface elevations in the Sacramento River are amenable to fish passage
- Adult Central Valley spring-run Chinook salmon between January and May when elevations in the Sacramento River are amenable to fish passage
- Adult California Central Valley steelhead in the event their presence overlaps with the defined seasonal window for other target species when elevations in the Sacramento River are amenable to fish passage
- Adult Southern DPS green sturgeon between February and May when elevations in the Sacramento River are amenable to fish passage.

Primary Project activities include the construction of a notch in Fremont Weir located in the Northern Yolo Bypass, including the construction of the following features:

Intake channel:
The intake channel would connect the Sacramento River to the proposed headworks structure at the appropriate elevation to facilitate an upstream fish passage facility for adult fish and for passing rearing habitat flows and juvenile salmonids

Headworks structure:
The headworks structure would bisect the existing Fremont Weir at one of three locations (east, center, or west) and would control the diversion of Project flow from the Sacramento River into the Yolo Bypass. It would also serve as the primary upstream fish passage facility for adult fish and the primary facility for passing rearing habitat flows and juvenile salmonids into the Yolo Bypass. The components of the headworks would include a concrete control structure, an upstream vehicular bridge crossing, and a concrete channel transition, which transitions the rectangular sides of the control structure to the side channel slopes of the transport channel.

Transport channel:
The transport channel would serve as the primary facility for upstream adult fish passage between the existing Tule Pond and the headworks structure. It would also serve as the primary channel for conveying juvenile salmonids and rearing habitat flows from the headworks structure to the existing Tule Pond.

Downstream channel improvements:
Improvements would be made to the existing channel that extends from the Tule Pond outlet to the beginning of Tule Canal. The improvements would be made to facilitate upstream adult fish passage between the existing Tule Canal and Tule Pond

Under different alternatives, each of these facilities may be constructed in a different location as part of one of three different channel alignments (east, center, and west in the Fremont Weir) in the Yolo Bypass. Each alignment would terminate downstream into the existing Tule Pond. Each project alternative also includes a supplementary fish passage structure located in the opposite end of Fremont Weir from where the notch would be located.

Location: The project area includes the lower Sacramento River basin, including Yolo Bypass, in Sacramento, Solano, Sutter, and Yolo counties, California. Major water bodies and infrastructure located within the study area include the Sacramento River; Fremont, Sacramento, and Lisbon weirs; Knights Landing Ridge Cut (KLRC) and Wallace Weir; Cache and Putah creeks; Willow Slough Bypass; Tule Canal; and the Toe Drain. Yolo Bypass is a flood bypass along the Sacramento River located in Yolo, Solano, and Sutter counties. The bypass separates the California cities of Sacramento and Davis. Flood inflow to the bypass primarily occurs through the Fremont Weir. Fremont Weir is one of five weirs along the Sacramento River.

Major infrastructure in Yolo Bypass relevant to the Project includes:

- Fremont Weir – Fremont Weir allows relief from the Sacramento River in times of high flood stage to divert water around the City of Sacramento within Yolo Bypass.
- Sacramento Weir – Sacramento Weir is located along the right bank of the Sacramento River approximately two miles upstream from the mouth of the American River. Its primary purpose is to protect the City of Sacramento from excessive flood stages in the Sacramento River channel downstream of the American River.
- Agricultural Road Crossing 1 – Agricultural Road Crossing 1, which is the northernmost agricultural road crossing in Tule Canal at the southeastern corner of the Fremont Weir Wildlife Area (FWWA), serves as a vehicular crossing and a water delivery feature.
- Tule Pond – Tule Pond is an approximately 15-acre perennial pond in Yolo Bypass located about 13 miles north of Interstate (I-80). It is likely the pond is sustained by multiple sources, including impounded floodwater, leakage from an agricultural canal at its southern end, and groundwater.
- Tule Canal – Tule Canal is a channel along the east side of Yolo Bypass, which begins south of Tule Pond. Tule Canal receives water from west side tributaries and agricultural diversions almost year-round. Tule Canal also drains the initial flows from the Sacramento River when the river rises above the crest of Fremont Weir.
- Toe Drain – Tule Canal becomes the Toe Drain south of the I-80 Yolo Causeway. The perennially wetted Toe Drain extends south approximately 20 miles and becomes increasingly tidal as it connects with Cache Slough, past Lower Yolo Bypass.
- Lisbon Weir – Lisbon Weir is the southernmost water-control structure that crosses the Toe Drain. Lisbon Weir provides higher and more stable water levels to water users north of the weir

Figure 1-1 shows the study area location:

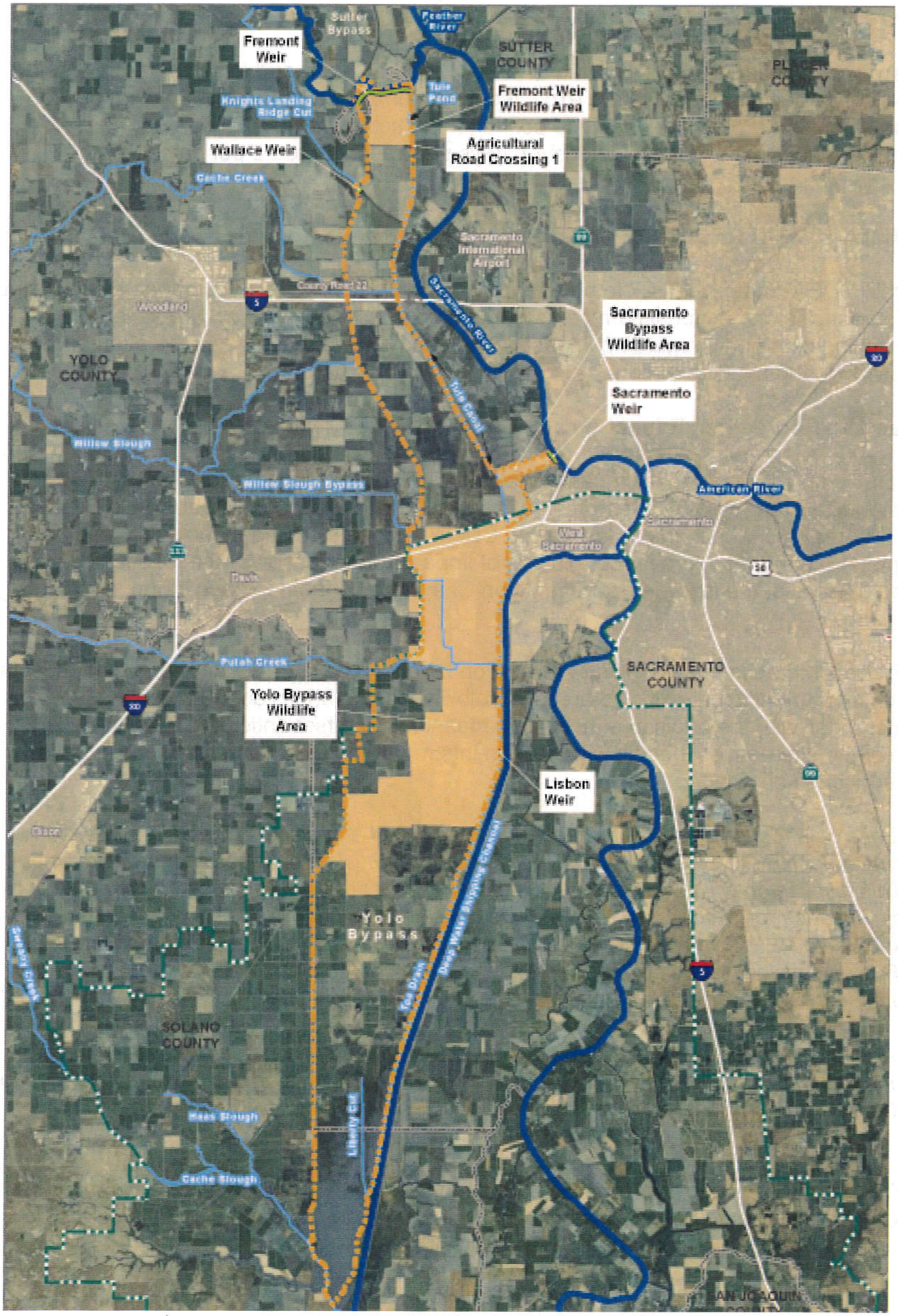
Fremont Weir
Sutter Bypass
Feather River
SUTTER COUNTY
PLACER COUNTY
Knights Landing Ridge Cut
Tule Pond
Fremont Weir Wildlife Area
Wallace Weir
Agricultural Road Crossing 1
Cache Creek
Sacramento International Airport
County Road 22
Woodland
Sacramento River
Sacramento Bypass Wildlife Area
YOLO COUNTY
Tule Canal
Sacramento Weir
Willow Slough
Willow Slough Bypass
American River
Sacramento
West Sacramento
Davis
Putah Creek
SACRAMENTO COUNTY
Yolo Bypass Wildlife Area
Lisbon Weir
Dixon
Yolo Bypass
Deep Water Shipping Channel
Toe Drain
SOLANO COUNTY
Haas Slough
Liberty Cut
Cache Slough
SAN JOAQUIN COUNTY

Figure 1. Project Area

Timeframe: Construction is projected to start in 2020 or 2021, and is estimated to last 28 weeks. All project components are expected to be completed in one construction season during times that are outside the flood period (construction from April 15 through November 1). Construction would occur 6 days per week, 10 hours per day between 7 a.m. and 6 p.m.

COMMENTS AND RECOMMENDATIONS

Overall, CDFW finds the DEIR to be a thorough and well-organized document. A table with section-specific and editorial comments is attached to this letter. Below are several overarching comments regarding impacts to fish and wildlife resources, education and recreation in the Draft document. 3

Impacts to Recreation, Education and CDFW Wildlife Areas

The DEIR describes potential impacts to all three CDFW managed wildlife areas (Fremont Weir Wildlife Area (FWWA), Sacramento Bypass Wildlife Area (SBWA) and Yolo Bypass Wildlife Area (YBWA)) in the Yolo Bypass. CDFW suggests editing these sections of Chapter 13 to further improve the analysis of impacts to recreation and education. Unless stated otherwise, the following comments on Chapter 13 pertain to each of the six alternatives.

CDFW recommends that impacts to recreation be analyzed under CEQA, and that impacts to the Department's three wildlife areas in Yolo Bypass be analyzed and described in greater detail with the addition of mitigation measures to offset anticipated impacts. For each of the alternatives the following statements regarding CEQA analysis for recreation and education are made: 4

> "*Loss of lands available for recreation is considered a social effect and is addressed subject to NEPA, whereas CEQA focuses on the physical changes to the environment. This discussion will address the social impacts and not make a CEQA finding of significance*" or "*Access for recreation is considered a social effect and is addressed subject to NEPA, whereas CEQA focuses on the physical changes to the environment. This discussion will, therefore, address the social impacts and not make a CEQA finding of significance.*"

> "*Access to lands available for educational opportunities is considered a social effect and is addressed subject to NEPA, whereas CEQA focuses on the physical changes to the environment. Therefore, this discussion will address the social impacts and not make a CEQA finding of significance.*"

CDFW suggests making the following change to the CEQA analysis of recreational and educational impacts to better explain how physical changes as a result of the Project will result in impacts to recreation and education:

"CEQA focuses on the physical changes to the environment and a social or economic change related to a physical change may be considered in determining whether the physical change is significant. (CEQA Guidelines § 15382)."

As described in the DEIR, implementing any of the Project alternatives will result in construction related impacts and/or increased inundation at all three wildlife areas, and as such, project implementation constitute a physical change to the environment, impacting recreation and management activities at all three wildlife areas, and educational opportunities at the YBWA, thereby requiring an analysis under CEQA.

Specific suggestions on how to better characterize and analyze recreation impacts, including impacts to education activities at YBWA, are described in the "Recreation and Education Impacts" subsection below. CDFW recommends adopting the proposed changes to the analysis of impacts and adding appropriate mitigation measures in the final EIR/EIS.

Fremont Weir Wildlife Area
Please see the attached comment table for specific comments regarding impacts to the FWWA.

5

Sacramento Bypass Wildlife Area
CDFW manages SBWA for upland wildlife and it primarily serves upland game hunters as well as non-hunting recreation. Upland vegetation is rare in the Sacramento River system and loss of this habitat type would impact both wildlife and recreational use. Increased inundation could alter vegetation and diminish the habitat quality for upland game. For example, increases in wetland habitat created by increased and prolonged inundation adds little value to wildlife area users and waterfowl. Because this habitat is not managed as a wetland, wetland duck use will be low and hunter success and use will be low. As a result, increased inundation of over 84% of the SBWA is a significant impact. CDFW suggests adding mitigation measures to the DEIR to reduce the impact to less than significant. Examples of appropriate mitigation could include an upland game hunting lease on another nearby DWR property and funding to support improved vegetation management on the SBWA.

Yolo Bypass Wildlife Area
<u>Closures within the wildlife area:</u>
Increases in the duration of inundation as a result of Project operations will reduce access to substantial portions of the YBWA and result in increased land management costs. While limited access to portions of the YBWA may be available after floodwater recedes, access can be significantly limited until roads are sufficiently dry to support vehicles. Furthermore, infrastructure in YBWA needs to be re-established after each flooding (installation of hunting blinds, signs, porta-potties etc. and repairs of roads and parking lots), 6

further delaying opening of the wildlife area. Depending on the magnitude and duration of flooding, weather, and time of year, opening of the wildlife area can be delayed for up to 10-14 days after Fremont Weir stops spilling.

Impacts to waterfowl hunting:
Calculations used in the DEIR to quantify impacts to waterfowl hunting are discussed in Chapter 13, page 27, Table 13-4 and impacts to managed wetlands are discussed in the 'Managed Annual Wetland Vegetation' section in Chapter 9, page 11. Impacts to managed wetlands as a result of increasing depth, flow and duration of inundation are also described in Chapter 13, page 28 (Alternative 1).

We suggest considering impacts to current management actions at the YBWA as a result of Project operations. About 4500 acres of the YBWA are managed wetlands open to waterfowl hunting, and the majority of these managed wetlands are located in areas that will be most impacted by increased inundation during Project operations. Each year, the waterfowl hunting season lasts approximately 100 days and waterfowl hunting on the YBWA is restricted to three days a week throughout the waterfowl hunting season, resulting in about 45-47 hunt days per year if Yolo Bypass is not flooded. Impacts to available waterfowl hunting days should be estimated by comparing changes to the number of days the YBWA is open for waterfowl hunting each year, not by comparing changes to the full calendar year. On average, over the past 10 years, YBWA waterfowl hunters have lost five hunting days per year due to flooding. As described above under closures of the YBWA, the YBWA area cannot be opened immediately after an inundation event, as the YBWA infrastructure needs to be reestablished before hunters can access the land. 7

As correctly stated, CDFW has a special interest in managed wetlands and their vegetation communities as part of waterfowl and shorebird management at YBWA. We suggest developing a more detailed impact analysis and associated mitigation measures for YBWA in coordination with CDFW in order to avoid or substantially lessen any significant impact of the Project. The largest increase in duration of inundation for all alternatives evaluated in the DEIR will impact the most important waterfowl hunting areas on YBWA (Figures 13-6, 13-18 and 13-30). For example, Project operations could inundate 2,263.1 acres, or 13 percent of YBWA lands, under Alternatives 1-3 (Chapter 13, page 27). 8

Farm leases
Increased inundation as a result of Project operations is likely to result in changes to vegetation types on the YBWA. Increased flooding is likely to encourage cocklebur and star thistle growth on grazing lands, thereby impacting YBWA revenue from grazing leases. We suggest analyzing the reduction in grazing lease payments as a result of Project operations. 9

Additionally, as described in the Yolo Bypass Production Model (Appendix J1), the Project will likely impact rice farming in the Yolo Bypass compared to existing 10 conditions. We suggest identifying appropriate mitigation measures for loss or reduction of farming leases at YBWA in the EIR.

<u>Education</u>
These comments pertain to the following portions of Chapter 13 for all alternatives:

- Effects on Available Lands for Recreation Opportunities at Established Wildlife Area
- Closure of Well-Established Wildlife Areas
- Conflict with the YBWA LMP by Affecting Access for the Educational Uses of the YBWA
- Specific calculations of education impacts for all alternatives (for example Chapter 13, page 37)

Increased inundation as a result of Project operations under all alternatives will increase the number of days that the YBWA is closed due to flooding and subsequent infrastructure installation and repairs. As is the case with the evaluation of impacts to waterfowl hunting, CDFW suggests revising the description of baseline conditions and impacts to the education program at YBWA, and analyzing the need for mitigation under CEQA.

To better evaluate impacts to the YBWA education program, CDFW suggests establishing more precise estimates of available education days under existing conditions and Project operations. An appropriate method to establish baseline conditions would be to subtract the average number of days that the YBWA is closed due to flooding (days of flooding + drainage time + time to re-establish infrastructure as described above) under existing conditions from the average number of school days in a year. This will likely result in substantially fewer days available for the education program than the 37 weeks currently used as baseline. To further highlight the impact of a reduction in education days it should be noted that the education program at the YBWA has a significant number of schools on the waiting list to attend the program each year. Finally, an increase in closures of the YBWA conflicts with the YBWA Land Management Plan, which includes expanding public use of the YBWA: "*Public-Use Goal 2 (PU-2): Support and expanded public use of the Yolo Bypass Wildlife Area for environmental education and interpretation*." Yolo Bypass Wildlife Area Management Plan, page 5-36. 11

<u>Examples of potential mitigation measures:</u>
CDFW suggests that Project proponents, in coordination with CDFW, add appropriate mitigation measures to reduce impacts to the YBWA to a level of less than significant.

Mitigation measures to offset the impacts described above could include the following: 12

- Infrastructure improvements (e.g. parking lots, road improvements, duck blinds, signage and installation of gates)

- Mitigation for impacts to managed wetlands and subsequent impacts to waterfowl management and hunting, education program, and increased 13
management costs through land acquisition outside of the Yolo Bypass and support for long term management
- Implementation of projects (as they relate to the YBWA) identified in the Yolo 14
Bypass Drainage and Water Infrastructure Study that are not currently being pursued

Giant Garter Snake

CDFW appreciates the analysis of impacts to giant garter snake (GGS) and the analysis of project impacts to the species from both Project construction and operations. Impacts to GGS will likely increase as a result of Project operations for all alternatives as a result of increases in the inundation of the Yolo Bypass, however the exact magnitude or extent of that impact is currently unknown. For most of the alternatives, the Water Surface Index (WSI) increase is less than one foot in depth. That in and of itself does not preclude the species from remaining on the site. However, the increase in the number of inundation 15
days better characterizes potential impacts to GGS. CDFW suggests including a table at the end of Chapter 9 or in Appendix A that quantifies the change in the number of Yolo Bypass inundation days (wet days) and acres of increased inundation of GGS upland habitat that occurs as a result of each respective alternative compared to existing conditions. This table will allow for an easier evaluation of Project operations impacts to GGS. In addition, CDFW suggests analyzing and describing potential impacts from Project operations to the GGS mitigation bank at Pope Ranch (south of YBWA).

Swainson's Hawk

CDFW suggests analyzing impacts to Swainson's hawk (SWHA) separately from other nesting birds in Chapter 9. Specifically, CDFW recommends that the existing analysis be expanded to include a more detailed discussion of potential impacts to Swainson's hawk foraging habitat (9.3.3.2.5 Impact TERR-5: Potential Disturbance or Mortality of Nesting 16
Bird Species and Loss of Suitable Nesting and Foraging Habitat) relative to the timing of inundation as a result of Project operations and the initiation of the SWHA nesting season on March 15th. Furthermore, an analysis of potential operations impacts to the Swainson's hawk mitigation bank on Pope Ranch (South of the YBWA) should also be included in Impact TERR-5.

Fremont Weir West Side Fish Passage

Fish stranding on the west side of Fremont Weir and in the Oxbow Pond located immediately south of Rattlesnake Island is well documented. CDFW appreciates that the Preferred Alternative includes a tertiary fish passage structure on the west side of Fremont 17
Weir (west of Rattlesnake Island) to reduce fish stranding in this areas. CDFW recommends that the tertiary fish passage structure be connected to the Oxbow Pond to minimize fish stranding issues, and particularly sturgeon stranding. CDFW anticipates that the combination of a notch located on the east side of Fremont Weir in combination with a centrally located fish way and a tertiary fish way on the west side of Fremont Weir, which is connected to the Oxbow Pond, will significantly reduce fish stranding in the Northern Yolo Bypass. However, if fish stranding is not significantly reduced during Project operations,

additional appropriate actions should be taken, at a minimum as described in the adaptive management and monitoring plan, Appendix C, page 8:

> "*Operate Fremont Weir fish passage structures to increase volitional passage window following end of overtopping. Re-operate Knights Landing Ridge Cut to reduce Wallace Weir attractions flows.*"

> "*For adult salmon, re-operate Fremont Weir fish passage facilities when sufficient depths are expected over a sufficient duration. Regrade Fremont Weir apron so it drains towards fish passage structures. Improve coordinated operations of the primary, modified adult, and tertiary fish passage structures.*"

Finally, CDFW emphasizes the importance of solving issues with stranding of Acipenserids throughout the Yolo Bypass, but especially in the Tule Pond and the Oxbow Pond, should Project operations not significantly reduce current levels of stranding. 18

Salmonid Passage at Sacramento Bypass

While CDFW expects the Project to significantly reduce stranding of migrating adult fish in the Yolo Bypass, CDFW recognizes the potential of increased Sacramento River flows through the Yolo Bypass leading to increased attraction of adult migrating salmonids, including fish originating from Sacramento River tributaries such as the American River, Feather River and Butte Creek. Should fish from the above mentioned tributaries enter the Yolo Bypass and consequently return to Sacramento River at Fremont Weir, they would re-enter the Sacramento River upstream of their native tributaries. This would reduce the likelihood of those fish returning to their native streams to spawn, while potentially increasing spawning by out of basin salmonids in the Sacramento River.

CDFW therefore supports the proposed adaptive management actions described in Appendix C, pages 2 and 8: 19

> "*The Project will be adaptively managed to ensure that biological goals and objectives are met and in turn will address impacts and the uncertainties of future impacts*"

> "*Evaluate if creating a connection to the Sacramento River from Wallace Weir may reduce impact of Wallace Weir stranding on ESU escapement.*"

> "*Evaluation potential for low-flow salmon fish ladder in Sacramento Weir to reduce adult stranding. For juvenile salmon, improve connectivity between stranding areas, fill in stranding locations.*"

If monitoring efforts reveal increased straying rates of salmonids from the above-mentioned rivers, CDFW recommends mitigating this problem by providing passage for salmonids back to the Sacramento River through Sacramento Weir.

ENVIRONMENTAL DATA

CEQA requires that information developed in environmental impact reports and negative declarations be incorporated into a database, which may be used to make subsequent or supplemental environmental determinations. (Pub. Resources Code, § 21003, subd. (e)). Accordingly, please report any special status species and natural communities detected during Project surveys to the California Natural Diversity Database (CNDDB). The CNNDB field survey form can be found at the following link: http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/CNDDB_FieldSurveyForm.pdf. The completed form can be mailed electronically to CNDDB at the following email address: CNDDB@wildlife.ca.gov. The types of information reported to CNDDB can be found at the following link: http://www.dfg.ca.gov/biogeodata/cnddb/plants_and_animals.asp. 20

FILING FEES

The Project, as proposed, would have an impact on fish and/or wildlife, and assessment of filing fees is necessary. Fees are payable upon filing of the Notice of Determination by the Lead Agency and serve to help defray the cost of environmental review by CDFW. Payment of the fee is required in order for the underlying project approval to be operative, vested, and final. (Cal. Code Regs, tit. 14, § 753.5; Fish & G. Code, § 711.4; Pub. Resources Code, § 21089.) 21

CONCLUSION

CDFW appreciates the opportunity to comment on the DEIR to assist DWR in identifying and mitigating Project impacts on biological resources.

Questions regarding this letter or further coordination should be directed to Brooke Jacobs Environmental Program Manager 1 at (916) 445-5313 or Brooke.Jacobs@wildlife.ca.gov.

Sincerely,

Tina Bartlett

Tina Bartlett, Acting Deputy Director
Ecosystem Conservation Division

Attachments

1. CDFW Comment Table

cc: Office of Planning and Research
State Clearinghouse, Sacramento
P.O. Box 3044
Sacramento, CA 95812-3044

ec: California Department of Fish and Wildlife

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Comment Number	Section	PDF Page #	Print Page #	Issue / Comment	Solution / Suggested Fix	
1	3.3-3	219	112	Under "Beneficial Effects of Maintenance Activities on Special-Status Fish", there is mention of the Knights Landing Outfall Gates (KLOG) currently having a fish barrier in place to prevent fish from "taking a dead-end path during upstream migration". The fish screens on KLOG are not currently in place due to a malfunction that occurred in September 2016.	CDFW suggests adjusting language to clarify that the fish screens on KLOG are not currently operational.	22
2	8.3.3.6.2	224	16	For impact FISH-15, it states that there is potential for the increased flows entering the delta from more frequent bypass inundation could attract more fish into the bypass. This impact should be considered for all alternatives regarding impacts to fish species due to changes in adult fish passage conditions. Also, depending on when flows in the bypass begin entering the delta, there is the potential for out of basin fish to enter the upper Sacramento River and its tributaries.	CDFW suggests adding language to all other alternatives regarding this impact and include language about potential for more frequent ingression of out of basin genetics into the upper Sacramento River.	23

3	CEQA conclusions for Impact 15 of all alternatives			The CEQA conclusion for impact 15 states that spawning success is expected to increase. CDFW agrees that reducing stranding and passage delays for adult migrating fish in the Yolo Bypass will allow those fish to continue their spawning migration, and that this would be a significant improvement over existing conditions. However, spawning success would mean that pairs of fish are completing the task of spawning successfully, meaning that eggs are fertilized and deposited in the gravel. Providing more frequent passage through the bypass would likely ensure that more fish are able to reach spawning grounds more so than current conditions allow, and that they are provided more opportunities to spawn, but more fish being given the opportunity to spawn does not necessarily ensure successful spawning.	CDFW suggests adjusting language to say that spawning "opportunities" are expected to increase as a result of the project.	24
4	8.1.4.4	46	46	There is mention of the installation of the temporary fyke trap downstream of Wallace Weir for the 2014 season only. The fyke trap has been installed every year since 2014 somewhere downstream of Wallace. The trap is usually installed during the fall and taken out during the late spring/early summer. Efforts have been compromised every season due to high flows in the canal.	Please add language describing seasonal return of fyke trap efforts.	25

5	2	30	30	During project implementation, DWR and Reclamation would monitor fish activity	CDFW suggest changing language to "During project implementation, DWR and Reclamation would monitor fish activity in close coordination with CDFW"	26
6	8	73	73	Juvenile steelhead are not as likely to utilize floodplain habitat in the Yolo Bypass to the extent of juvenile Chinook salmon and are not frequently caught in the Yolo Bypass.	CDFW suggest incorporating information from the "Summary of 2016-2017 Fish Rescues Conducted Within the Yolo Bypass. CDFW 2017. Prepared for U.S. Bureau of Reclamation" showing that juvenile steelhead (hatchery-origin smolts) were the most abundant fish species encountered in stranding surveys of northern Yolo Bypass scour pools and swales conducted by CDFW in 2017.	27
7	8	80	80	CDFW rescue operations may continue, but rescued sturgeon would still undergo considerable stress and potential injury during capture, which may result in delays in spawning migrations and reduced spawning success.	CDFW suggest adding to this that green sturgeon and white sturgeon have also been shown to abort spawning migrations after rescue (CDFW unpublished data).	28

8	Overall			Formulation of mitigation measures should not defer until some future date. Several mitigation measures defer the mitigation upon consultation with CDFW for species where CDFW's role is a Trustee Agency (i.e. MM-TERR-1).	CDFW recommends mitigation measures for non-state listed species that have deferred mitigation upon CDFW consultation be revised to state what measures would be implemented to bring the level of impact to less than significant.	29
9	Overall			Several mitigation measures are requiring CDFW to approve biologists, review management plans, approve changes in project limits, just to name a few. CDFW as a Trustee Agency does not have the authority to approve actions that are not required as part of a CDFW permit.	CDFW recommends the various mitigation measures that have identified CDFW to approve actions as a Trustee Agency be revised to reflect the Lead Agency.	30
10	Overall			The Project implementation may require CESA compliance and proponent should consult with CDFW.		31
11	Overall			The Project may require notification pursuant to Fish and Game Code section 1600 et seq and the Project proponent should consult with CDFW accordingly.		32
12	8.3.3.2.1		8-91	Impact FISH-3 CEQA's conclusion has identified Mitigation Measure MM-TERR-7 as reducing the impact to less than significant. MM-TERR-7 are surveys for valley elderberry beetle habitat prior to construction. MM-TERR-11 proposes the preparation of a compensatory restoration plan.	CDFW recommends the conclusion be revised to state MM-TERR-11.	33

13	9.2.2		9-32 (CESA)	This section is discussing CESA; however, this section is describing ESA as well as CESA. The first sentence states "take of species (interpreted to mean the direct killing of a species)" is incorrect. Take as defined by Fish and Game Code section 86 is defined as to hunt, pursue, catch, capture, or kill or attempt to hunt, pursue, catch, capture or kill.	CDFW recommends "interpreted to mean the direct killing of a species" either be deleted or the appropriate definition be included.	34
14	9.2.2		9-32 (CESA)	The first paragraph has included the requirements of ESA such as USFWS determining take and identifying reasonable and prudent alternatives and take being authorized under 16 USC Section 1536 (d).	CDFW recommends the first paragraph be revised to only discuss CESA as this section is only discussing the California Endangered Species Act.	35
15	9.2.2		9-32 (CESA)	Second paragraph of this section state the Fish and Game Commission is responsible for "maintaining" a list of threatened and endangered species.	CDFW recommends the word "maintaining" be revised to state "established" as described in Fish and Game Code section 2070.	36
16	9.2.2		9-32 (CEQA)	This section is citing CEQA section 21104.2 stating that CDFW be consulted regarding impacts on rare or endangered species as defined under ESA and CESA. This section of CEQA states the state lead agency shall consult when the impact of the project on the continued existence of any endangered species or threatened species pursuant to Article 4 (commencing with Section 2090) of Chapter 1.5. This section of Fish and Game Code was repealed.	CDFW recommends this section be revised to reflect the language in section 21104 of CEQA indicating that the state lead agency consult with and obtain comments from each responsible agency, trustee agency, public agency with jurisdiction by law with respect to the project.	37

17	9.3.3.2.1		9-46	This section discusses the potential mortality or loss of habitat for special-status plant species. The CEQA conclusion has stated that the introduction or spread of invasive species as significant and has provided a mitigation measure for the preparation of a management plan. The project will be removing the top soil and the seed source of special-status plants. The EIR should include a mitigation measure to stock pile the top soil and replace the top soil in the areas of temporary impact.	CDFW recommends a mitigation measure be included to stock pile the top soil of the sites located within special-status species habitat and replace the top soil in the appropriate areas to reduce the loss of special-status plant species.	38
18	9.3.3.2.1		9-46	Page 9-17 states plant surveys may not have captured some of the annual species with the potential to occur in the study area. In order to less the potential mortality for special-status plant species, pre-construction surveys should be conducted prior to ground-disturbing activities. The mitigation measure should also provide measures to avoid or minimize by collecting and then replacing the topsoil.	CDFW recommends a mitigation measure be included to conduct pre-construction surveys for special-status plants and to avoid impacts if found.	39
19	9.3.3.2.2		9-55	Mitigation measure MM-TERR-2 requires a CDFW-approved biologist. Please note that CDFW would only approve biologist as required by a permit. The Lead Agency would be responsible for all other approvals.	CDFW recommends that the MM-TERR-2 be revised to state that the Lead Agency would review the qualifications of biologist to oversee the compliance of the CEQA mitigation measures. CDFW will approve biologist as required by CDFW permits.	40

20	9.3.3.2.2		9-56	The worker awareness program should be given not just prior to construction but to all personnel new to the project.	CDFW recommends that Mitigation Measure MM-TERR-3 be revised to state the prior to the start of construction all personnel and contractors are required to complete the mandatory worker environmental awareness as well as for all new personnel before they commence with work.	41
21	9.3.3.2.2		9-58	The 6th bullet under MM-TERR-4 states that capture and relocation of wildlife can only be performed with appropriate USFWS and CDFW handling permits. CDFW Scientific Collecting Permits do not allow translocation of wildlife.	CDFW recommends that MM-TERR-4 be revised to state that the capture and relocation of injured or trapped wildlife listed under ESA or CESA can only be performed by personnel with appropriate state and/or federal permits.	42
22	9.3.3.2.2		9-59	Second paragraph of MM-TERR-5 states no work activities, materials or equipment shall be stored outside the project limits without permission from the regulatory agencies. Work outside of the project limits would need to be evaluated and approved by the CEQA lead agency with the possibility of CEQA being recirculated. CESA permits would not be able to authorize work outside of the project limits without the evaluation from the Lead Agency.	CDFW recommends that second paragraph be revised to state the no work activities, materials or equipment be stored outside of the project limits without permission from the Lead Agencies.	43

23	9.3.3.2.3		9-65	Surveys for GGS should also be conducted if construction activities stop for a period of 2 weeks or more.	CDFW recommends that MM-TERR-12 be revised to also include conducting GGS surveys if construction activities stop for a period of two weeks or more.	44
24	9.3.3.2.5		9-70	Fish and Game Code § 3503.5 states it is unlawful to take, possess, or destroy any birds in the orders of Falconiformes or Strigiformes (birds-of-prey or raptors) or take, possess, or destroy the nest or eggs of any such bird. In addition Fish and Game Code 3503 protects nest or eggs of all birds. The EIR provides buffers for raptors, state and federally listed species, and migratory birds; however, as proposed this measure could cause take of other bird species. In order to avoid the destruction of nests or take of birds, CDFW recommends pre-construction nesting bird surveys be completed for all species of birds if construction or maintenance activities are to take place between February 1 and August 31.	CDFW recommends mitigation measure MM-TERR-16 be revised to remove "migratory" from the measure. All active nests should have established buffers and the buffers remain in effect until the young have fledged and are independent or if the nests is no longer active as confirmed by a qualified avian biologist.	45
25	9.3.3.2.11		9-85	Impact TERR-11 states the proposed mitigation measures are consistent or more comprehensive than those presented in the draft Yolo HCP/NCCP. Several mitigation measures are less protective than those in the draft Yolo HCP/NCCP such as the bird and GGS mitigation. For example, the nesting buffer for Swainson's hawk is typically measured at 1,320 feet; however, the EIR does not reflect this.	As CEQA does not require same level of analysis as a NCCP/HCP, please revise language in the Draft EIR/EIS to avoid comparisons with the mitigation measures in the Draft Yolo NCCP/HCCP where these are not consistent.	46

26	9.3.3.3.1		9-91	Mitigation Measure MM-TERR-19 defers development of mitigation measures for special-status plant species prior to construction. Deferring the development of mitigation measures does not bring the level of significance to less than significant. We suggest adding measures to mitigate for special-status plants to the EIR. Please note that CDFW is only a regulatory agency for plant species that are rare, endangered, or threatened by the Fish and Game Commission.	CDFW recommends that MM-TERR-19 be revised to include measures to avoid, minimize or mitigate impacts to special-status plant species.	47
27		23	ES-17	Issues of Known Controversy: Not mentioned here are changes to recreation, public use, and loss of usable public lands.	Please add.	48
28	1.6.2	130	1.12	Issues of Known Controversy: Not mentioned here are changes to recreation, public use, and loss of usable public lands.	Please add.	49
29	2.4.1.1	17	2.17	Intake Channel: Maintenance and veg growth not described.	Please add.	50
30	2.4.1.2	18	2.18	Stop log storage?	Please specify storage of equipment and general coordination with CDFW of maintenance activities and recurring work such as installation/removal of K-rails, sediment removal, vegetation clearing etc.	51
31	2.4.1.4	22	2.22	K Rail install and removal will be intrusive to wildlife area users.	Please explore the possibility of eliminating the need for K-Rails.	52

32	2.4.1.6	22	2.22	Transport Channel: Wildlife will use this location to escape overtopping events and cross on a daily basis. Wildlife could become stranded. Mitigation could be needed to allow for wildlife escapement, including jump out “wingdam” ramps that slow flow, include vegetation, and allow wildlife to escape.	Please discuss this potential impact and appropriate mitigation measure(s).	53
33	2.4.1.6	24	2.24	Maintenance corridor: What is it constructed of? How and when will it be maintained? If materials are brought in they should be certified weed free. In addition, a 50' weed management corridor should be establish and sprayed yearly to reduce invasive weeds which establish adjacent to maintenance roads. O&M should be restricted to after August 1 to reduce impacts to ground nesting birds.	Please add text explanation.	54
34	2.4.4	29	2.29	Inspection and maintenance: Schedule of transport channel maintenance including weed removal, mowing, gravel, etc. should be included in this description. Time component is important to reduce impacts to wildlife.	CDFW suggests adding language stating that inspection and maintenance activities will be done in coordination with CDFW.	55
35	2.4.4.3	30	2.3	Vegetation Removal: Section in need of specifics. How will this be determined? Will vegetation be removed according to DBH of trees? What is the flow criteria that is met for vegetation removal? What is the timing of maintenance? To ensure proper management we suggest adding guidelines for removal and maintenance. CDFW recommends conducting maintenance after August 1.	Please add specifics and timing.	56

36	Table 2-26	84	2.84	TERR 1-8: Acreage calculations seem incorrect and do not account for additional acreage inundated. Increased inundation and frequency could convert upland vegetation to wetland or reduce value to wildlife by promoting growth of lees valuable cover types, i.e. cockle bur. I.E. - 84% of SBWA will be inundated 3-4 weeks longer. Over years of repeated inundation it may convert to an non upland vegetation type and reduce potential upland veg for GGS, VELB, ground nesting birds, badgers, etc.	Please add specific acreages to include additional habitats inundated.	57
37	Table 9-2	6	9.6	Agriculture - crop types are not specified	CDFW suggests adding specific crop types to table.	58
38	13.1.1.2	25	13.1	Sac River Facilities: A map of extent and facilities is needed.	CDFW suggests adding map of extent and facilities	59
39	13.3.3.2	41	13.17	SBWA and YBWA as alternatives to FWWA: Neither of these are adequate. SBWA is much more limited in size and YBWA is only open 3 days/week. In addition, none offer big game hunting. We suggest including mitigation for loss, disruption, and/or degradation of WA access. We suggest including mitigation for changes in acreage of usable land due to increased inundation.	Please revise.	60
40	13.3.3.2	46	13.22	"Effects to SBWA nominal in size": 84% of acreage is not nominal.	Please edit text and accurately show effects to SBWA	61
41	Figure 13.5	49	13.25	East side of SBWA not mapped.	Please include all of SBWA in the modeled change in inundation in Figure 13.5	62

42		61	13.37	Closure of Well-Established Wildlife Areas: increased inundation does not close FWWA or SBWA but it does make them of less use to the public and restrict access. This needs to be considered; not just closure.	Please revise text.	63
43	13.3.3.2.1	63	13.39	FWWA Alternative parking lot: Where will it be located?	Please add location of alternative parking lot.	64
44	13.3.3.2.1	63	13.39	DWR parking lot reclamation: Due to increased traffic and disruption from project related O&M, CDFW would prefer a new parking lot built on the west side of the FWWA to (improve) long-term disruption to users, Rehabilitation of the east side may still be necessary.	To maximize user access it may be best to provide a new parking lot on the west side of FWWA. Please consult with CDFW.	65
45	Impact REC-1, all alternatives			CDFW suggests that construction in FWWA halt on the first weekend or first two days of any hunt opening season as it has for other projects, i.e. Fremont Weir Adult Fish Passage Project.		66
46	Appendix A: 2.1.12	52	2.24	FWWA Closure: Please remove "except when river waters are present". Access is not prohibited at FWWA during overtopping. There is a warning and nothing else.	Please revise text.	67
47	Appendix A: 5.2.2.3	85	3.21	Waterfowl Impacts: While the figures in Appendix A showing changes in acreages of foraging habitat as a result of Project operations are informative, site specific maps focused on managed wetlands showing changes in inundation depth and frequency, and tables displaying change in acres of foraging habitat for specific areas, are necessary to evaluate impacts to waterfowl hunting. Changes in foraging habitat quality	Please add map as described (if not already provided).	68

				can displace waterfowl locally, potentially resulting in significant impacts to waterfowl hunting. There are at least five privately owned wetland properties (i.e. duck clubs) within the Yolo Bypass with easements and long-term contracts to benefit wintering and breeding waterfowl, and other species that utilize this niche south of the Yolo Bypass WA. More information is needed on quantification of impact to shallow water wetland dependent avian species (i.e. dabbling ducks, shorebirds etc). For example, dabbling ducks need 6-8" water depth to forage, even shallower for shorebirds. 18" deep wetlands do not provide the same benefit as 6" deep wetlands for most of these species.	
48	4.1.1	3	4-3	Figure 4-1: It is not clear to the reader why some of the creeks on the map are displayed and why others have been omitted. For example Big Chico Creek has supported Chinook salmon in years past and should be listed. Why are some of the Mill creeks and one of the Pine creeks on the map at all given their locations and drainages? Also, Deer Creek is a tributary to the Sacramento River and is not on the map.	CDFW suggest the map be revisited and corrected. 69
49	8.1.1.3	6	8-6	This sentence needs clarity as to what really is the amount of area that this document identifies as floodplain and what does fully wetted mean, "When flows within the Yolo Bypass are greater than about 75,000 cfs, the floodplain is considered fully wetted".	To avoid confusion, CDFW suggests explaining that the entire Yolo Bypass is considered floodplain habitat when inundated. 70

50	8.3.3.5.1	21	8-153	First paragraph, last sentence: "... modifications to berms.."	Is it more accurate to describe these berms as new construction?	71
51	Chapter 9			CDFW suggests that impacts to wildlife species important to recreation be analyzed to an equivalent level of detail as was done for fish species (Section 8.1.2 and Table 8-2).		72
52	9	2	2	Third paragraph, third line: "The 3,660-acre California Department of Fish and Wildlife (CDFW)Yolo Bypass Wildlife Area "	The correct size of YBWA is 16600 acres	73
53	Chapter 8 and Appendix A	5	Chap. 8, 8-189 App.A, 45	Chapter 8, 189 -MM-FISH-5 and First sentence on page 45, Appendix A: "To reduce fish passage delays..."	As described in Chapter 8, the bypass channels in Alternative 4 will have a significant impact to migrating fish. Even with MM-FISH-5 in place, there is potential for take of listed species during the monitoring program described in MM-FISH-5. To minimize and fully mitigate take of state listed winter-run and spring-run Chinook salmon, an incidental take permit will be required for both bypass channels and MM-FISH-5.	74

54	5.2.1.6	42	5-14	Last two lines on page: "Sturgeon that are unable to pass during these periods would either face passage delays at Fremont Weir or would turn around and travel to the Wallace Weir collection facility". CDFW agrees that these are likely scenarios, but the fate of sturgeon under the described conditions is unknown. Sturgeon could end up stranding in scour channels on FWWA, the Oxbow Pond, the Deep Pond, Tule Pond or anywhere in the Tule Canal/Toe Drain.	CDFW suggests providing a more detailed description of the potential fate of sturgeon that are not able to pass at Fremont Weir.	75
55	2.1.5.1	42	2-14	Third paragraph, third sentence: "During flood pulses, the Yolo Bypass provides fish in the Sacramento River an alternativemigration corridor." This sentence is accurate for juvenile fish and maybe also downstream migrating steelhead, but not for adult upstream migrating fishes.	Clarify that the sentence is referring to juvenile fish.	76
56	5.2.3.2	47	19	Last, line, first paragraph under Recreation Impacts reads: "The evaluation factors for agricultural impacts are:"	Change 'agricultural' to 'recreation'	77
57	5.2.3.2	47	19	The bullet point: "Inundation of recreational areas or access to recreational areas that could impact hunting activities (include pheasant, waterfowl, quail, turkey, mourning dove, cottontail, jackrabbit, and deer hunting)" does not capture other recreation activities.	Add language to the bullet point so that other forms of recreation besides hunting are included and analyzed. This could include, for example, wildlife viewing and fishing.	78

58	5.2.3.2	47	19	"The comparison of alternatives would follow the same patterns in the other wildlife areas"	The meaning of this sentence is unclear. The three wildlife areas are managed differently. As such, impacts from increased inundation should be evaluated differently. For example, the YBWA allows users to access the WA by vehicle. If roads are wet due to increased inundation recreational access could be limited. Another example is SBWA which is managed for upland species. Increased inundation at SBWA will likely have a negative impact on these species. Suggest including a full evaluation of impacts to each of the three wildlife areas. Please also see comment letter for a more detailed comment.	79
59	5.3	68	40	Table 5-17, evaluation factor "Juvenile stranding or predation risk" does not seem to reflect findings under Alternative 4. On page 8-190 the impacts are described as "significant and unavoidable"	Please update Table 5-17 to reflect the findings in chapter 8, Alternative 4.	80
60	General			Please consider that the Yolo Bypass Land Management Planning effort completed in 2008 may need to be revisited and revised, depending on the project outcome, to accommodate shifts in goals, management strategies and public use.		81

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STATE OF CALIFORNIA | EDMUND G. BROWN JR., *Governor*

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Established in 1938

February 15, 2018

File Ref: SCH 2013032004

Karen Enstrom
California Department of Water Resources
3500 Industrial Boulevard
West Sacramento, CA 95691

Subject: Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project; Sacramento, Solano, Sutter, and Yolo Counties

Dear Ms. Enstrom:

The California State Lands Commission (Commission) staff has reviewed the subject Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project), currently being proposed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR). Based on this review, we offer the following comments.

Based upon the information contained in the Draft EIS/EIR, and a review of in-house records, Commission staff has determined that portions of the proposed Project may cross State-owned sovereign land in the Sacramento River, which is under the jurisdiction of the Commission. On April 12, 1956, the Commission authorized the issuance of PRC 1657.9, a Right-of-Way Permit to the Sacramento and San Joaquin Drainage District (SSJDD), acting by and through the Reclamation Board of the State of California, for the construction, reconstruction, repair, operation, and maintenance of the West Levee of the Yolo Bypass, over and across the Old Channel of the Sacramento River. On the same date, the Commission also authorized the issuance of PRC 1658.9 to the SSJDD for a flowage easement over and across the Old Channel of the Sacramento River, and PRC 1659.9, for the construction, reconstruction, repair, operation, and maintenance of a dike as an integral part of the Fremont Weir. Prior to the start of the proposed Project, DWR and USBR must provide the Commission with copies of all permits of applicable public agencies having jurisdiction over such activities, including but not limited to, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, the California Department of Fish and Wildlife, the Central Valley Flood Protection Board, and the Regional Water Quality Control Board. As the Project continues, Commission staff 1 requests that DWR and USBR contact Commission staff to determine whether the Project, or any components of the Project along the Sacramento River require a lease and formal authorization from the Commission for the use of sovereign land.

Additionally, the uplands on the right bank, over which portions of the Project may extend, is located within Rancho Rio Jesus Maria. The State is precluded from asserting that it acquired sovereign title interests in ranchos in 1850 by virtue of its admission to the 2
United States, pursuant to the holdings in Summa Corporation v. California, (1984) 466 U.S. 198. Therefore, the State does not assert ownership of the Sacramento River within the rancho boundaries.

In addition, please be advised that the Sacramento River in the Project area, lies in an area subject to a public right of navigation. This public right provides that members of the public have the right to navigate and exercise the incidences of navigation in a lawful manner on State waters that are capable of being physically navigated by oar or motor-propelled small craft. Such uses may include, but are not be limited to, boating, rafting, 3
sailing, rowing, fishing, fowling, bathing, skiing, and other water-related public uses (People ex rel. Baker v. Mack (1971) 19 Cal. App.3d 1040). The proposed Project must not unduly restrict or impede the navigation and recreational rights of the public. (Civil Code § 3479).

The Commission has jurisdiction and management authority over all ungranted tidelands, submerged lands, and the beds of navigable lakes and waterways. The Commission also has certain residual and review authority for tidelands and submerged lands legislatively granted in trust to local jurisdictions (PRC §6301 and §6306). All tidelands and submerged lands, granted or ungranted, as well as navigable lakes and waterways, are subject to the protections of the Common Law Public Trust.

As general background, the State of California acquired sovereign ownership of all tidelands and submerged lands and beds of navigable lakes and waterways upon its admission to the United States in 1850. The State holds these lands for the benefit of all people of the State for statewide Public Trust purposes, which include but are not limited 4
to waterborne commerce, navigation, fisheries, water-related recreation, habitat preservation, and open space. On tidal waterways, the State's sovereign fee ownership extends landward to the ordinary high water mark, which is generally shown by the mean high tide line (MHTL), except for areas of fill or artificial accretion, or where the boundary has been fixed by agreement or a court decision. On navigable non-tidal waterways, including lakes, the State holds fee ownership of the bed of the waterway landward to the ordinary low-water mark and a Public Trust easement landward to the ordinary high-water mark, except where the boundary has been fixed by agreement or a court decision. Such boundaries may not be readily apparent from present day site inspections.

The above determinations are without prejudice to any future assertion of State ownership or public rights, should circumstances change, or should additional information come to our attention. In addition, these comments are not intended, nor should it be construed as, a waiver or limitation of any right, title, or interest of the State of California in any lands under its jurisdiction.

Should you have any questions concerning the foregoing or the leasing jurisdiction of the Commission, please contact George Asimakopoulos, Public Land Management Specialist, at (916) 574-0990, or via email at George.Asimakopoulos@slc.ca.gov

Sincerely,

Brian Bugsch, Chief
Land Management Division

cc: G. Asimakopoulos, Commission
E. Gillies, Commission
J. Garrett, Commission

SA03

CALIFORNIA
Water Boards

Edmund G. Brown Jr.
Governor

Matthew Rodriquez
Secretary for
Environmental Protection

Central Valley Regional Water Quality Control Board

15 February 2018

Karen Enstrom
California Department of Water Resources
3500 Industrial Boulevard
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91 7199 9991 7036 6989 7782

COMMENTS TO REQUEST FOR REVIEW FOR THE DRAFT ENVIRONMENTAL IMPACT REPORT, YOLO BYPASS SALMONID HABITAT RESTORATION AND FISH PASSAGE PROJECT, YOLO AND SUTTER COUNTIES

Pursuant to the California Department of Water Resources' 22 December 2017 request, the Central Valley Regional Water Quality Control Board (Central Valley Water Board) has reviewed the *Request for Review for the Draft Environment Impact Report* for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project, located in Yolo and Sutter Counties.

Our agency is delegated with the responsibility of protecting the quality of surface and groundwaters of the state; therefore our comments will address concerns surrounding those issues.

I. Specific Comment

The Central Valley Water Board supports this project because of the significant potential for this project to improve aquatic habitat conditions and contribute to the protection of native fish and wildlife beneficial uses. Cumulatively, this and other ecological restoration and enhancement projects are expected to change aquatic habitats in the Yolo Bypass and Delta. In terms of water quality, the biggest concern continues to be mercury, since over 50% of the mercury entering Delta comes through the Cache Creek/Yolo Bypass, and increased inundation in this system will increase methylation of mercury within the bypass – and currently the Delta is impaired for mercury. It is important for the Lead Agency to continue to support and engage in Delta methylmercury monitoring studies and TMDL work so that the Central Valley Water Board can work to manage the sources, and continue to consider practices that may be feasible. The Delta Regional Monitoring Program (Delta RMP) is the Central Valley Water Board's platform for this type of monitoring and studies. Towards this end, we propose the following modifications shown in underline/strikeout below that would reflect this general approach. 1

Mitigation Measure MM-WQ-4: Develop a water quality mitigation and monitoring program.

The Lead Agencies shall develop and implement a program to reduce, minimize, or eliminate increases in water quality constituents.

The program shall include ~~development of a~~ monitoring ~~plan~~, including frequent sampling and reporting, particularly for existing constituents of concern. Instead of developing a stand-alone monitoring plan, the Lead Agencies will become a funding partner and Steering Committee Member of the Delta Regional Monitoring Program (Delta RMP). Monitoring within the Delta RMP is key to understanding methylmercury impacts of this project as they affect Delta water quality. Understanding effects of this project on methylmercury and other potential contaminants of concern, and other cumulative considerations such as effects on primary production, hydrology, residence time, and effects on the lower food web, will ensure water quality information is available for TMDL and policy considerations in managing Delta Water quality.

The Lead Agencies shall coordinate with the Water Boards and implement ~~implementation of the~~ current TMDLs to comply with water quality regulations. ~~share monitoring information and~~ Additionally, the Lead Agencies shall contribute to the efforts to reduce constituents of concern within the Yolo Bypass. If monitoring levels are found to be above water quality objectives, Lead Agencies will consider means to reduce discharges throughout the bypass region. However, with respect to methylmercury levels, it is understood that water quality objectives are currently being exceeded. Therefore, the Lead Agencies will continue to support and implement TMDL requirements and participate in updating TMDL requirements in the future. 1 CONT.

Implementation of mitigation measures may include supporting upstream source controls, conducting studies for management practices to reduce constituents of concern within the Yolo Bypass, and implementing feasible management practices and monitoring to reduce those constituents. The Lead Agencies will work with the Central Valley Water Board and other coordinating agencies in developing, testing, and implementing feasible methylmercury management practices.

Implementation of the water quality mitigation and monitoring program included in MM-WQ-4 would reduce ~~any~~ impacts of the Project. However, sources of Hg, such as Cache and Putah Creeks, continue to release Hg to the bypass, which can be anticipated to sustain production of MeHg in bypass sediments. Therefore, this impact would be **significant and unavoidable.**

II. Regulatory Setting

Basin Plan

The Central Valley Water Board is required to formulate and adopt Basin Plans for all areas within the Central Valley region under Section 13240 of the Porter-Cologne Water Quality Control Act. Each Basin Plan must contain water quality objectives to ensure the reasonable protection of beneficial uses, as well as a program of implementation for achieving water quality objectives with the Basin Plans. Federal regulations require each state to adopt water quality standards to protect the public health or welfare, enhance the quality of water and serve the purposes of the Clean Water Act. In California, the beneficial uses, water quality objectives, and the Antidegradation Policy are the State's water quality standards. Water quality standards are also contained in the National Toxics Rule, 40 CFR Section 131.36, and the California Toxics Rule, 40 CFR Section 131.38.

2

The Basin Plan is subject to modification as necessary, considering applicable laws, policies, technologies, water quality conditions and priorities. The original Basin Plans were adopted in 1975, and have been updated and revised periodically as required, using Basin Plan amendments. Once the Central Valley Water Board has adopted a Basin Plan amendment in noticed public hearings, it must be approved by the State Water Resources Control Board (State Water Board), Office of Administrative Law (OAL) and in some cases, the United States Environmental Protection Agency (USEPA). Basin Plan amendments only become effective after they have been approved by the OAL and in some cases, the USEPA. Every three (3) years, a review of the Basin Plan is completed that assesses the appropriateness of existing standards and evaluates and prioritizes Basin Planning issues.

For more information on the *Water Quality Control Plan for the Sacramento and San Joaquin River Basins*, please visit our website: http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/.

Antidegradation Considerations

All wastewater discharges must comply with the Antidegradation Policy (State Water Board Resolution 68-16) and the Antidegradation Implementation Policy contained in the Basin Plan. The Antidegradation Policy is available on page IV-15.01 at: http://www.waterboards.ca.gov/centralvalleywater_issues/basin_plans/sacsjr.pdf

3

In part it states:

> *Any discharge of waste to high quality waters must apply best practicable treatment or control not only to prevent a condition of pollution or nuisance from occurring, but also to maintain the highest water quality possible consistent with the maximum benefit to the people of the State.*

This information must be presented as an analysis of the impacts and potential impacts of the discharge on water quality, as measured by background concentrations and applicable water quality objectives.

The antidegradation analysis is a mandatory element in the National Pollutant Discharge Elimination System and land discharge Waste Discharge Requirements (WDRs) permitting processes. The environmental review document should evaluate potential impacts to both surface and groundwater quality.

III. Permitting Requirements

Construction Storm Water General Permit

Dischargers whose project disturb one or more acres of soil or where projects disturb less than one acre but are part of a larger common plan of development that in total disturbs one or more acres, are required to obtain coverage under the General Permit for Storm Water Discharges Associated with Construction Activities (Construction General Permit), Construction General Permit Order No. 2009-009-DWQ. Construction activity subject to
this permit includes clearing, grading, grubbing, disturbances to the ground, such as 4
stockpiling, or excavation, but does not include regular maintenance activities performed to restore the original line, grade, or capacity of the facility. The Construction General Permit requires the development and implementation of a Storm Water Pollution Prevention Plan (SWPPP).

For more information on the Construction General Permit, visit the State Water Resources Control Board website at: http://www.waterboards.ca.gov/water_issues/programs/stormwater/constpermits.shtml.

Clean Water Act Section 404 Permit

If the project will involve the discharge of dredged or fill material in navigable waters or wetlands, a permit pursuant to Section 404 of the Clean Water Act may be needed from the United States Army Corps of Engineers (USACOE). If a Section 404 permit is required by the USACOE, the Central Valley Water Board will review the permit application to ensure
that discharge will not violate water quality standards. If the project requires surface water 5
drainage realignment, the applicant is advised to contact the Department of Fish and Game for information on Streambed Alteration Permit requirements.

If you have any questions regarding the Clean Water Act Section 404 permits, please contact the Regulatory Division of the Sacramento District of USACOE at (916) 557-5250.

Clean Water Act Section 401 Permit – Water Quality Certification

If an USACOE permit (e.g., Non-Reporting Nationwide Permit, Nationwide Permit, Letter of Permission, Individual Permit, Regional General Permit, Programmatic General Permit), or
any other federal permit (e.g., Section 10 of the Rivers and Harbors Act or Section 9 from 6
the United States Coast Guard), is required for this project due to the disturbance (i.e.,

discharge of dredge or fill material) of waters of the United States (such as streams and wetlands), then a Water Quality Certification must be obtained from the Central Valley Water Board prior to initiation of project activities. There are no waivers for 401 Water Quality Certifications.

Waste Discharge Requirements (WDRs)

Discharges to Waters of the State

If USACOE determines that only non-jurisdictional waters of the State (i.e., "non-federal" waters of the State) are present in the proposed project area, the proposed project may require a Waste Discharge Requirement (WDR) permit to be issued by Central Valley Water Board. Under the California Porter-Cologne Water Quality Control Act, discharges to all waters of the State, including all wetlands and other waters of the State including, but not limited to, isolated wetlands, are subject to State regulation. 7

Land Disposal of Dredge Material

If the project will involve dredging, Water Quality Certification for the dredging activity and Waste Discharge Requirements for the land disposal may be needed.

For more information on the Water Quality Certification and WDR processes, visit the Central Valley Water Board website at:
http://www.waterboards.ca.gov/centralvalley/help/business_help/permit2.shtml.

Dewatering Permit

If the proposed project includes construction or groundwater dewatering to be discharged to land, the proponent may apply for coverage under State Water Board General Water Quality Order (Low Risk General Order) 2003-0003 or the Central Valley Water Board's Waiver of Report of Waste Discharge and Waste Discharge Requirements (Low Risk Waiver) R5-2013-0145. Small temporary construction dewatering projects are projects that discharge groundwater to land from excavation activities or dewatering of underground utility vaults. Dischargers seeking coverage under the General Order or Waiver must file a Notice of Intent with the Central Valley Water Board prior to beginning discharge.

For more information regarding the Low Risk General Order and the application process, visit the Central Valley Water Board website at: 8

http://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2003/wqo/wqo2003-0003.pdf

For more information regarding the Low Risk Waiver and the application process, visit the Central Valley Water Board website at:

http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/waivers/r5-2013-0145_res.pdf

Low or Limited Threat General NPDES Permit
If the proposed project includes construction dewatering and it is necessary to discharge the groundwater to waters of the United States, the proposed project will require coverage under a National Pollutant Discharge Elimination System (NPDES) permit. Dewatering discharges are typically considered a low or limited threat to water quality and may be covered under the General Order for *Dewatering and Other Low Threat Discharges to Surface Waters* (Low Threat General Order) or the General Order for *Limited Threat Discharges of Treated/Untreated Groundwater from Cleanup Sites, Wastewater from Superchlorination Projects, and Other Limited Threat Wastewaters to Surface Water* (Limited Threat General Order). A complete application must be submitted to the Central Valley Water Board to obtain coverage under these General NPDES permits.

For more information regarding the Low Threat General Order and the application process, visit the Central Valley Water Board website at: http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2013-0074.pdf 9

For more information regarding the Limited Threat General Order and the application process, visit the Central Valley Water Board website at: http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/general_orders/r5-2013-0073.pdf

NPDES Permit
If the proposed project discharges waste that could affect the quality of surface waters of the State, other than into a community sewer system, the proposed project will require coverage under a National Pollutant Discharge Elimination System (NPDES) permit. A complete Report of Waste Discharge must be submitted with the Central Valley Water Board to obtain a NPDES Permit. 10

For more information regarding the NPDES Permit and the application process, visit the Central Valley Water Board website at: http://www.waterboards.ca.gov/centralvalley/help/business_help/permit3.shtml

If you have questions regarding these comments, please contact Stephanie Tadlock at (916) 464-4644 or Stephanie.Tadlock@waterboards.ca.gov.

Adam Laputz
Assistant Executive Officer

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SA04

February 15, 2018

Ben Nelson
Bureau of Reclamation
801 I Street, Suite 140
Sacramento, CA 95814

Ms. Karen Enstrom
California Department of Water Resources
3500 Industrial Boulevard
West Sacramento, CA 95691

Subject: Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project Draft Environmental Impact Statement/Environmental Impact Report (SCH #2013032004)

Dear Mr. Nelson and Ms. Enstrom:

Thank you for providing the Delta Protection Commission (Commission) the opportunity to review the Draft Environmental Impact Statement/ Environmental Impact Report (Draft EIS/EIR) for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project). The Draft EIS/EIR addresses methods to improve fish passage and increase floodplain fisheries rearing habitat in the Yolo Bypass to benefit Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern Distinct Population Segment green sturgeon.

The Commission is a State agency charged with ensuring orderly, balanced conservation and development of Delta land resources and improved flood protection. Local governments must ensure that development projects within the Primary Zone of the Legal Delta are consistent with the Commission's Land Use and Resource Management Plan (LURMP). Most of the Project area is located within the Primary Zone. Proposed Bureau of Reclamation (BOR) and California Department of Water Resources (DWR) actions are not subject to consistency requirements with the LURMP since the Project is sponsored by Federal and State agencies. However, the Commission reviewed the project for possible impacts on the resources of the Primary Zone. 1

The Commission appreciates the efforts of BOR and DWR to protect the natural resources of the Delta, particularly improvements to fisheries habitat, ensure adequate flood protection, and preserve agriculture within the Yolo Bypass. We previously commented during the Draft EIR/EIS scoping process on LURMP goals and policies that are relevant to the environmental analysis and the need to incorporate mitigation measures if there are negative impacts on agricultural or recreational land uses or activities. The Draft EIR/EIS addresses LURMP policies related to recreation. We urge BOR and DWR to review the Project for consistency with other LURMP policies, such as those related to agriculture, flood protection, natural resources, water quality, and water seepage.

Future revisions to the EIR/EIS should address the concerns of Yolo County and Yolo Habitat Conservancy about consistency between the Project and the Yolo Habitat Conservation Plan/Natural Community Conservation Plan. The Draft EIR/EIS should also provide mitigation measures for the permanent and temporary loss of agricultural land within the project footprint, which would typically be at a 1:1 mitigation ratio, and the effects of increased periods of inundation on agricultural lands, including lost economic productivity, loss of crop insurance policies or increased premiums, and potential conversion of agricultural land to non-agricultural uses. 2 3

The Commission appreciates the BOR and DWR's consideration of these comments. Please contact Blake Roberts, Senior Environmental Planner, at (916) 375-4237 for any questions regarding the comments provided.

Sincerely,

Erik Vink
Executive Director

cc: Skip Thomson, Commission Chair and Solano County Board of Supervisors
Oscar Villegas, Commission Vice Chair and Yolo County Board of Supervisors
Don Nottoli, Commission Member and Sacramento County Board of Supervisors

SA05

DELTA STEWARDSHIP COUNCIL
A California State Agency

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February 14, 2018

Karen Enstrom
Department of Water Resources
Environmental Compliance and Evaluation Branch
3500 Industrial Blvd.
West Sacramento, CA 95691

Via email: Karen.Enstrom@water.ca.gov

RE: Draft Environmental Impact Statement/Environmental Impact Report for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project, SCH#2013032004

Dear Ms. Enstrom:

Thank you for the opportunity to review and comment on the Draft Environmental Impact Statement/Environmental Impact Report (Draft EIS/EIR) for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project). The Delta Stewardship Council (Council) supports the joint effort of the Department of Water Resources (DWR) and Bureau of Reclamation to improve fish passage and rearing habitat in the Yolo Bypass. We appreciate your efforts to address the 2009 Biological Opinion by improving current conditions for four federally listed anadromous fish species.

In our previous comment letter dated May 6, 2013, we requested that you file a certification of consistency with the Council, per Water Code section 85225 and 85057.5. Based on the project description, Council staff believes your project meets the definition of a covered action. 1

Below we offer additional information on the Delta Plan consistency certification process that we hope will be useful as you complete your final environmental documentation. We also highlight several Delta Plan regulatory policies that are commonly relevant to habitat restoration projects and provide a few recommendations. We anticipate that consideration of these policies within the Draft EIS/EIR will provide a foundation for your preparation of a Delta Plan consistency certification.

"Coequal goals" means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place."

– CA Water Code §85054

Comments on the Draft EIS/EIR

We appreciate that the 2009 Delta Reform Act is referenced under section *9.2.2* of the *State Plans, Policies, and Regulations* for *Vegetation, Wetlands, and Wildlife Resources* of the Draft EIS/EIR. We recommend that you also include the Delta Plan Policies listed below in the forthcoming Final EIS/EIR "Regulatory Setting" sections: 2

- Chapter 4 – Hydrology, Hydraulics, and Flood Control
- Chapter 5 – Surface Water Supply
- Chapter 11 – Land Use and Agricultural Resources

Delta Plan Policies

The Delta Plan includes regulatory policies that are applicable to covered actions. Below, we have highlighted key regulatory policies from the Delta Plan that may be specifically relevant to the Project's certification of consistency with the Delta Plan. To better assist in your certification of consistency, we encourage you to review these recommendations and revisit the following Delta Plan policies before filing:

Mitigations Measures: The Draft EIS/EIR provides mitigation measures throughout the report. However, Council staff recommend that mitigation measures included in the Mitigation Monitoring and Reporting Program to be included in the Final EIS/EIR, be consistent with mitigation measures identified in the Delta Plan Program EIR. Alternatively, substitute mitigation measures that are equally or more effective can be included, as stated in Delta Plan Policy **G P1** (23 Cal. Code Regs. section 5002). For more information the Delta Plan's Mitigation and Monitoring Report Program is available at: (http://deltacouncil.ca.gov/sites/default/files/documents/files/Agenda%20Item%206a_attach%202.pdf) 3

Best Available Science and Adaptive Management: Delta Plan Policy **G P1** states that actions subject to Delta Plan regulations must document use of best available science as relevant to the purpose and nature of the project. The regulatory definition of "best available science" is provided in Appendix 1A of the Delta Plan (http://deltacouncil.ca.gov/sites/default/files/2015/09/Appendix%201A.pdf).

Delta Plan Policy **G P1** also requires that ecosystem restoration and water management covered actions include adequate provisions for continued implementation of adaptive management, appropriate to the scope of the action. This requirement is satisfied through A) the development of an adaptive management plan that is consistent with the framework described in Appendix 1B of the Delta Plan (http://deltacouncil.ca.gov/sites/default/files/2015/09/Appendix%201B.pdf) and B) documentation of adequate resources to implement the proposed adaptive management plan.

Please contact Eva Bush (Eva.Bush@deltacouncil.ca.gov) of the Delta Science Program for additional consultation and guidance to help with the appropriate application of best available science and adaptive management.

Restore Habitat in a Manner Consistent with the Delta Plan: The Draft EIS/EIR identifies Alternative 1 as the preferred project, as such, activities described in the Draft EIS/EIR will occur north of the Delta. These activities will affect flows, fish, and water quality downstream in the Sacramento-San Joaquin Delta by allowing up to 6,000 cfs to flow through the east side gated notch to provide open channel flow for adult fish passage. Delta Plan Policy **ER P1** (23 Cal. Code Regs. section 5005) calls for maintaining Delta flow objectives and states that the State Water Resources Control Board's Bay Delta Water Quality Control Plan flow objectives, at the time your Project files for consistency, shall be used to determine consistency with the Delta Plan.

4

The Draft EIS/EIR describes the project area including the Yolo Bypass in Sacramento, Solano, Sutter, and Yolo counties. Additionally, the Draft EIS/EIR illustrates the project area in Figure ES-1 as encompassing the entire Yolo Bypass Priority Habitat Restoration Area (PHRA). Delta Plan Policy **ER P3** (23 Cal. Code Regs. section 5007) calls for protecting opportunities to restore habitat within the PHRAs depicted in Appendix 5 of the Delta Plan. As described in 23 Cal. Code Regs. section 5006, significant adverse impacts to restore habitat must be avoided or mitigated. In the event that mitigation is warranted, those mitigation and minimization measures should be consistent with those identified in the Delta Plan Program EIR or substitute mitigation measures that are equally or more effective. (http://deltacouncil.ca.gov/sites/default/files/2015/09/Appendix%205.pdf)

Delta Plan Policy **ER P5** (23 Cal. Code Regs. section 5009) requires that nonnative invasive species be fully considered and avoided, or mitigated in a way that appropriately protects the ecosystem when improving habitat conditions. For example, an invasive species management plan shall be developed and implemented for any project that may lead to invasive species establishment. Analysis on this matter should address both nonnative wildlife species as well as terrestrial and aquatic weeds. In the event that mitigation is warranted, those mitigation and minimization measures should be consistent with those identified in the Delta Plan Program EIR (sections 4-1 through 4-5) or substitute mitigation measures that are equally or more effective. 5

Land Use: Delta Plan Policy **DP P2** (23 Cal. Code Regs. section 5011) states that water management facilities, ecosystem restoration, and flood management infrastructure must be sited to avoid or reduce conflicts with existing or planned uses when feasible, considering comments from local agencies and the Delta Protection Commission. The project area overlaps with the Yolo Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP) which is nearing completion. Council Staff recommend continued coordination with the Yolo Habitat Conservancy as the HCP/NCCP is completed and implemented. 6

Risk Reduction: The Delta Plan contains two polices that are relevant to DWR's consideration of this issue: Policy **RR P2** (23 Cal. Code Regs. section 5013) requires flood protection for residential development in rural areas; Policy **RR P4** (23 Cal. Code Regs. section 5015) restricts encroachments in floodplains, including the Yolo Bypass within the Delta. Policy RR P4 states that no encroachment shall be allowed or constructed unless it can be demonstrated by appropriate analysis that the encroachment will not have a significant impact on floodplain values and functions. 7

Delta Plan Recommendations

The Delta Plan contains 74 recommendations, which we encourage project proponents to consider as they design and implement their projects and programs. Although these recommendations are non-regulatory in nature, progress towards their implementation will help with achieving the coequal goals in a manner that protects and enhances the unique values of the Delta. The following recommendations may be relevant to your project. 8

Recreation: Delta Plan Recommendation **DP R11** encourages water management and ecosystem restoration agencies to provide new and protect existing recreation opportunities.

Protect Beneficial Uses: Delta Plan Recommendation **WQ R1** calls for maintaining water quality in the Delta at a level that supports, enhances, and protects beneficial uses identified in the applicable State Water Resources Control Board or regional water quality control board water quality control plans. 9

Closing Comments

The Council is supportive of the Project and its efforts to promote the recovery of listed species and improve fish passage within and through the Yolo Bypass. As you proceed in the next stages of your Project's approval process, Council staff are available through early consultation to continue to discuss your Project's consistency with the Delta Plan. I encourage you to contact Ron Melcer (Ronald.Melcer@deltacouncil.ca.gov) or Megan Brooks (Megan.Brooks@deltacouncil.ca.gov) of my staff with any questions. 10

Sincerely,

Terri Gaines
Acting Deputy Executive Officer
Delta Stewardship Council

LA01

CALIFORNIA CENTRAL VALLEY
FLOOD CONTROL
ASSOCIATION

February 15, 2018

***Submitted Via Email*:** bcnelson@usbr.gov

Mr. Ben Nelson
Bureau of Reclamation, Bay Delta Office
801 I Street, Suite 140
Sacramento, CA 95814-2536

SUBJECT: Comments on Draft EIR/EIS for Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

Dear Mr. Nelson:

The following comments on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project Draft EIR/EIS are submitted on behalf of the California Central Valley Flood Control Association (CCVFCA/Association).

CCVFCA was established in 1926 to promote the common interests of rural and urban local flood management agencies sharing in the responsibilities associated with reducing the risks of flooding in the Sacramento and San Joaquin Rivers and their tributaries, including the Delta. Today, CCVFCA is the premier flood protection advocacy organization comprised of over 75 members with a wide spectrum of flood control expertise: reclamation districts conducting surface drainage and routine levee maintenance; cities and counties managing stormwater and levee systems; regional agencies constructing urban flood control improvements; and associated consulting firms. 1

Project Purpose

On June 4, 2009 the National Marine Fisheries Service (NMFS) issued its Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project (BiOp) that concluded if left unchanged, the SWP and CVP operations were likely to jeopardize the continued existence of four federally-listed anadromous fish species. Subsequently, the Department of Water Resources (DWR) and the Bureau of Reclamation

(USBR) have issued their Fish Restoration Program Agreement Implementation Strategy (FRPA) to create aquatic habitat and fish passage improvements in the Delta as part of their requirement to maintain ESA incidental take permits for the operation of the SWP and CVP pumping facilities in the South Delta.

In order to comply with RPA I.6.1 and I.7 the BiOps and FRPA, this Yolo Bypass fish restoration project (Project) was initially included in the Bay Delta Conservation Plan (BDCP) as Conservation Measure 2 and is now one of the projects in the California EcoRestore Program. As such, this Project proposes significant alteration and encroachments to the most critical component of the Sacramento River Flood Control Project (SRFCP) to satisfy ESA objectives unrelated to the operation of the SRFCP.

The Yolo Bypass was designed and continues to operate as a key component of the State Plan of Flood Control, but also allows compatible uses such as agricultural production, recreation, wildlife habitat, and recreation. Physical modifications to the functionality, capacity, operation, and purpose of this important flood facility must be compatible with the flood system and not hamper Operation & Maintenance (O&M) of the adjacent and downstream levees.

Flood Protection

In 1953, the SPFC works were transferred to California with a memorandum of understanding (MOU) confirming the State's obligation to operate and maintain all completed works/facilities and to hold the federal government harmless.[1] In addition, the State has signed assurance agreements with the U.S. Army Corps of Engineers (USACE) to maintain the San Joaquin River Flood Control Project in accordance with the 1955 MOU.

Jurisdiction and authority throughout the drainage basin and for the 1.7 million acres within the state's Sacramento and San Joaquin Drainage District (SSJDD) is the responsibility of the Central Valley Flood Protection Board (CVFPB/Board).[2] Created by State legislation in 1913, the SSJDD holds the property rights on about 18,000 parcels of SPFC lands, some going back to 1900.[3] Annual inspections of the SPFC levee system are conducted twice annually by DWR.[4] 2

[1] 1953 Memorandum of Understanding (USACE and The Reclamation Board, 1953) and Supplements. Available at ftp://ftp.water.ca.gov/mailout/CVFPB%20Outgoing/Orientation%20Materials/Item%203C%20-%20LM%20Assurance%20Agreements/Example%201%20-%20srfcp_mou_1953%20--%20jsp%20copy.pdf.

[2] Authority rests in the Flood Protection Board pursuant to assurance agreements with the USACE and the USACE Operation and Maintenance Manuals under Code of Federal Regulations, Title 33, Section 208.10 and United States Code, Title 33, Section 408

[3] Central Valley Flood Protection Board webpage, "Sacramento-San Joaquin Drainage District Jurisdiction Maps." Available at http://www.cvfpb.ca.gov/cvfpb/ssjdd_maps/

[4] 2013 Inspection and Local Maintaining Agency Report of the Central Valley State-Federal Flood Projection System (providing that "DWR, under the authority of Water Code § 8360, § 8370, and § 8371, performs a verification inspection of the maintenance of the SRFCP levees performed by the local responsible agencies, and reports to the USACE periodically regarding the status of levee maintenance accomplished under the provisions of Title 33, Code of Federal Regulations (CFR), Section 208.10. While there are no specific water code provisions directing DWR to inspect and report on Maintenance of the San Joaquin River Flood Control System, DWR has

This comprehensive interconnected system of levees and channel bypasses is absolutely critical to public health and safety, including the protection of the region's transportation, agriculture, business, homes, and even water conveyance.[5] Levees in the Yolo Bypass provide this protection at all times, during two daily high tides and seasonal high-flow events.

Under California law, no modification to the SPFC system (encroachment or project) may be constructed on or near the Sacramento and San Joaquin Rivers or their tributaries until plans have been reviewed and the projects have been approved or a permit issued by the CVFPB.[6] The Board authorizes use of the SPFC facilities by issuing encroachment permits only *if the project is compatible with the flood system and will not hamper the State's O&M responsibilities.*

Unmitigated Hydraulic/Hydrology Impacts

The alteration of hydrodynamics in the Yolo Bypass through implementation of RPA I.6.1 and I.7 (Project) pose a potential threat to the integrity and function of the SRFCP. The floods of 1986 and 1997 clearly demonstrate that the Yolo Bypass currently cannot spare even an incremental interference with its flood control function. According Reclamation District 2068, at the southern end where the Bypass narrows into a funnel, the water was a little over 2 feet above the design flow in both the 1986 and 1997 flood events.

The EIR/EIS acknowledges that larger areas within the Yolo Bypass would experience increased depth and inundation under low flow conditions for longer periods of time on a more frequent basis, however, the EIR/EIS fails to analyze the increased vegetation growth that will occur in areas with more frequent and longer duration inundation and how the vegetation would impede or redirect flood flows in the bypass or unreasonably increase water surface elevations. 3

More frequent inundation of the Bypass when the Sacramento River is not at flood stage will result in growth of vegetation in the flood channel, therefore increasing the State's maintenance costs and reducing flood flow coefficients. Unfortunately, The EIR/EIS fails to provide specific mitigations to alleviate the impacts to bypass/channel capacity of flood flows or additional maintenance costs on the local agencies managing the surrounding project levees.

The EIR/EIS should analyze the hydraulic impacts from increased vegetation growth within the bypass and develop a vegetation management plan and provide funding to the State for channel maintenance as mitigation. 4 Additional mitigations would be funding levee improvements to provide more freeboard by raising the height of certain levees to accommodate any increases in

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performed inspections and provided reports for many years as a matter of practice that is consistent with Title 33, CFR.") Available at http://cdec.water.ca.gov/current_reports.html.

[5] DWR *A Framework for Department of Water Resources Integrated Flood Management Investments in the Delta and Suisun Marsh* (September 24, 2013)

[6] Central Valley Flood Protection Board , A Century of Progress: Central Valley Flood Protection Board 1911-2011 (2011). Available at http://www.cvfpb.ca.gov/Publications/DWR100Years_05.pdf

water surface elevations resulting from reduced flood flow capacity due to increased vegetation growth.

We specifically request that the Project Proponent consult with the Central Valley Flood Protection Board (CVFPB) regarding the RMA2 two-dimensional model developed for the Sutter Bypass[7] and the more than 20 modeling simulations with a dense network of 47,000 grid cells representing the underlying surface with a unique elevation and 1 of 23 vegetative cover or land use conditions presented in an October 2013 technical memorandum.[8] The RMA 2 is a two-dimensional, depth-averaged finite element hydrodynamic numerical model capable of calculating water surface elevations and horizontal velocity components for flow in two dimensions. The CVFPB developed the model in order to analyze the impacts of the vegetation in the Sutter National Wildlife Refuge on the carrying capacity of flood water in the Sutter Bypass.

Model simulations using the RMA2 model were performed with various vegetation conditions to determine the maximum water surface elevations. Five vegetation conditions were simulated:

1. Bare Soil (Minimum Roughness)
2. Existing Conditions
3. Vegetation Fully Grown (Maximum Roughness)
4. Vegetation Management
5. Structural Modifications.

5

The five conditions were simulated using the Sacramento River Flood Control Project (SRFCP) 1957 design flows in seven different locations.

Because implementation of the Yolo Bypass Fish Restoration Project, RPA I.6.1 and I.7, would likely result in increase vegetation growth within the bypass, the project proponents should use the CVFPB's two-dimensional model with grid data for the Yolo Bypass to provide modeling results and provide an analysis and mitigation measures in the Final EIR/EIS for any significant impacts to carrying capacity of floodwater in the Yolo Bypass. Included in the Final EIR/EIS analysis should be disclosure of whether there are any portions of the Yolo Bypass that cannot currently pass the 1957 design flow at the design stage (Existing Conditions).

Development of the two-dimensional hydraulic model was done with the aid of the Surfacewater Modeling System (SMS) and calibration was based on the recorded flow and stage information from the January 2006 flood event. These calibration adjustments were made to refine the estimated roughness coefficients up or down to modify the impedance of vegetation on the flow and thereby influence the computed water surface elevations.

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[7] Sutter Bypass Two Dimensional Hydraulic Modeling Project.

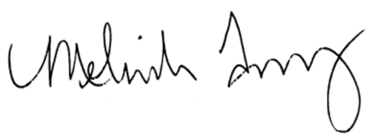
[8] "Sutter Bypass Two Dimensional Hydraulic Modeling: Simulation of Potential Management Options, Technical Report, prepared for Central Valley Flood Protection Board by CH2MHill, October 2013.

Much of the modeling information had been assembled previously for the development of the U.S. Army Corps of Engineers (USACE) Common Features Sacramento River Basin HEC-RAS model (Release 3, February 2011), which provided a one-dimensional representation of the broader flood control system but included stage and flow data useful for the development of the Sutter Bypass Two Dimensional Hydraulic Model. The high water mark data were valuable to establish general trends in the water surface profiles and to isolate areas of abrupt changes in water surface elevations.

The Tech Memo provides modeling results detailing predicted water level, freeboard to existing levee crest elevations, and a relative freeboard termed “Freeboard Deficiency” which relates the existing freeboard to that which existed in 1957 at the time when the USACE turned over management of the bypass channel to the State of California. The vegetative cover in the model simulations was represented with a roughness coefficient and varied in relation to the level of resistance to flow each vegetation type created.

The Association requests new hydraulic modeling using the RMA2 model be conducted for the Yolo Bypass and that the EIR/EIS be revised to analyze and mitigate identified impacts to flood flow capacity within the bypass due to increased vegetation growth that impedes flood flows or increases water surface elevations that encroach on the existing levee freeboard, and recirculate the EIR/EIS for additional public review and comment. 6

Sincerely,



Melinda Terry,
Executive Director

Attachments:

CVFPB Technical Memorandum, *“Sutter Bypass Two Dimensional Hydraulic Modeling: Simulation of Potential Management Options,”* prepared by CH2MHill, October 2013. 7

MBK Technical Memorandum on Sutter Bypass Hydraulic Model Development and Analysis, December 16, 2016 8

Technical Memorandum

Sutter Bypass Two Dimensional Hydraulic Modeling: Simulation of Potential Management Options

Prepared for

Central Valley Flood Protection Board

October 2013

CH2MHILL®

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Suite 600
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Acronyms and Abbreviations

2D	two-dimensional
cfs	cubic feet per second
CLD	California Levee Database
CVFED	Central Valley Floodplain Evaluation and Delineation
CVFPB	Central Valley Flood Protection Board
DWR	California Department of Water Resources
LiDAR	Light Detection and Ranging
NAVD88	North American Vertical Datum of 1988
O&M Manual	Operations and Maintenance Manual
SBFCA	Sutter Butte Flood Control Agency
SMS	Surface Water Modeling System
SNWR	Sutter National Wildlife Refuge
USED	United States Engineering Datum
USACE	United States Army Corps of Engineers
YBY	Yolo Bypass (gauge location)

SECTION 1

Introduction

This technical memorandum provides a detailed presentation of results of potential management options designed to lower peak flood water surface elevations throughout the Sutter Bypass. This memorandum builds on the main report developed for the Sutter Bypass Two Dimensional Hydraulic Modeling project delivered to the Central Valley Flood Protection Board (CVFPB) on February 20, 2013 (CH2M HILL, 2013); this technical memorandum assumes the reader is familiar with the main project report (Main Report).

This technical memorandum is organized as follows. A brief recap of the overall modeling effort, including background on the model calibration effort, is provided in Section 1. In Section 2, a detail presentation of results of over 20 model simulations is presented with a series of figures detailing predicted water level, freeboard to existing levee crest elevations, and a relative freeboard termed “Freeboard Deficiency” which relates the existing freeboard to that which existed in 1957 at the time when the U.S. Army Corps of Engineers (USACE) turned over management of the Sutter Bypass to the State of California. Finally, Section 3 provides for conclusions and recommendations.

The development of the Sutter Bypass Two Dimensional Hydraulic Model was authorized by the Central Valley Flood Protection Board on January 11, 2011. The project authorized CH2M HILL to perform tasks in support of the California Department of Water Resources’ (DWR) floodplain management activities related to the development of a two-dimensional (2D) hydraulic model for the Sutter Bypass necessary to support CVFPB and its activities. Model development was conducted with the aid of the Surfacewater Modeling System (SMS).

The model was developed with a dense network of 47,000 grid cells representing the underlying surface with a unique elevation and 1 of 23 vegetative cover or land use conditions, the distribution of which is summarized in Table 1-1. The vegetative cover was represented with a roughness coefficient and varied in relation to the level of resistance to flow each vegetative type created. A range of values was initially determined to reflect practices throughout the bypass.

A careful calibration of the model was conducted to improve the reliability of the simulation results. This calibration effort was based on the recorded flow and stage information from the January 2006 event. Much of this information had been assembled previously for the development of the USACE Common Features Sacramento River Basin HEC-RAS model (Release 3, February 2011). That model provided a one-dimensional representation of the broader flood control system but included stage and flow data useful for the development of the Sutter Bypass Two Dimensional Hydraulic Model. Using information from the Common Features Model, conditions at each inflow point and at the outflow location were defined.

The calibration process consisted of refinements to the model so that the simulated results for the 2006 event matched reasonably well with the observed flow and stage data. Calibration was conducted via adjustments to the roughness coefficients for the various grid cells. These adjustments were made to refine the estimated roughness coefficients up or down to modify the impedance of vegetation on the flow and thereby influence the computed water surface elevations.

The model calibration effort focused on matching recorded stage data at six gauges extending from the Fremont Weir upstream to the Sutter Bypass Pumping Plant 3 located just below the Highway 20 crossing of the Bypass. In addition, observed high water mark data were available for portions of the east and west banks of the Bypass above the confluence with the Feather River. The reliability of the data at the gauge locations was determined to be higher and that information was accorded higher significance in the calibration process. The high water mark data were valuable to establish general trends in the water surface profiles and to isolate areas of abrupt changes in water surface profile.

Sixteen iterations of the model were made before calibration was deemed complete. During those simulations, the absolute error at the stream gauges was reduced from a maximum of 0.45 feet to 0.27 feet. The water surface profile for the final calibration run is shown on Figure 1-2. A subsequent validation simulation was conducted using the 1997 storm event. The data for this event was somewhat unreliable, however, the results of the validation simulation had an average absolute error of _0.7’ over six water level gauges, demonstrating the reasonableness of the model to represent a range of flow rates. Following model calibration, the model was applied for a series of potential management actions with the goal of reducing peak water levels in the Sutter Bypass.

TABLE 1-1
Distribution of Materials and Final Manning’s *n* Friction Coefficient Assignments
Sutter Bypass Two Dimensional Hydraulic Model Report

Material No.	Material Description	Manning's *n* Value	Percent of Grid
1	Agricultural areas	0.028	56.74
2	Levee	0.035	1.75
3	Dense Vegetation (V1)	0.1	6.02
4	Toe drains	0.03	3.43
5	Riparian Corridors on Levees	0.06	3.99
6	Feather River	0.038	2.11
7	Sacramento River	0.035	1.21
8	Highway 20	0.06	0.02
9	Highway 113/Sutter Causeway	0.06	0.02
10	SNWR Watergrass	0.037	2.04
11	SNWR Seasonal Marsh	0.037	4.24
12	Feather River Confluence Weir	0.16	0.01
13	Medium Vegetation (V2)	0.08	2.77
14	Sparse Vegetation (V3)	0.06	3.72
15	Natural Grasses	0.045	11.56
16	Fremont Weir Crest	0.16	0.02
17	Fremont Weir Trough	0.16	0.02
18	Cache Creek Weir	0.03	0.07
19	Natomas Cross Canal Bridge	0.06	0.00
20	Natomas Cross Canal	0.035	0.01
21	Willow Slough	0.04	0.07
22	Nelson Slough	0.05	0.09
23	Gilsizer Slough	0.04	0.09
	Total		100

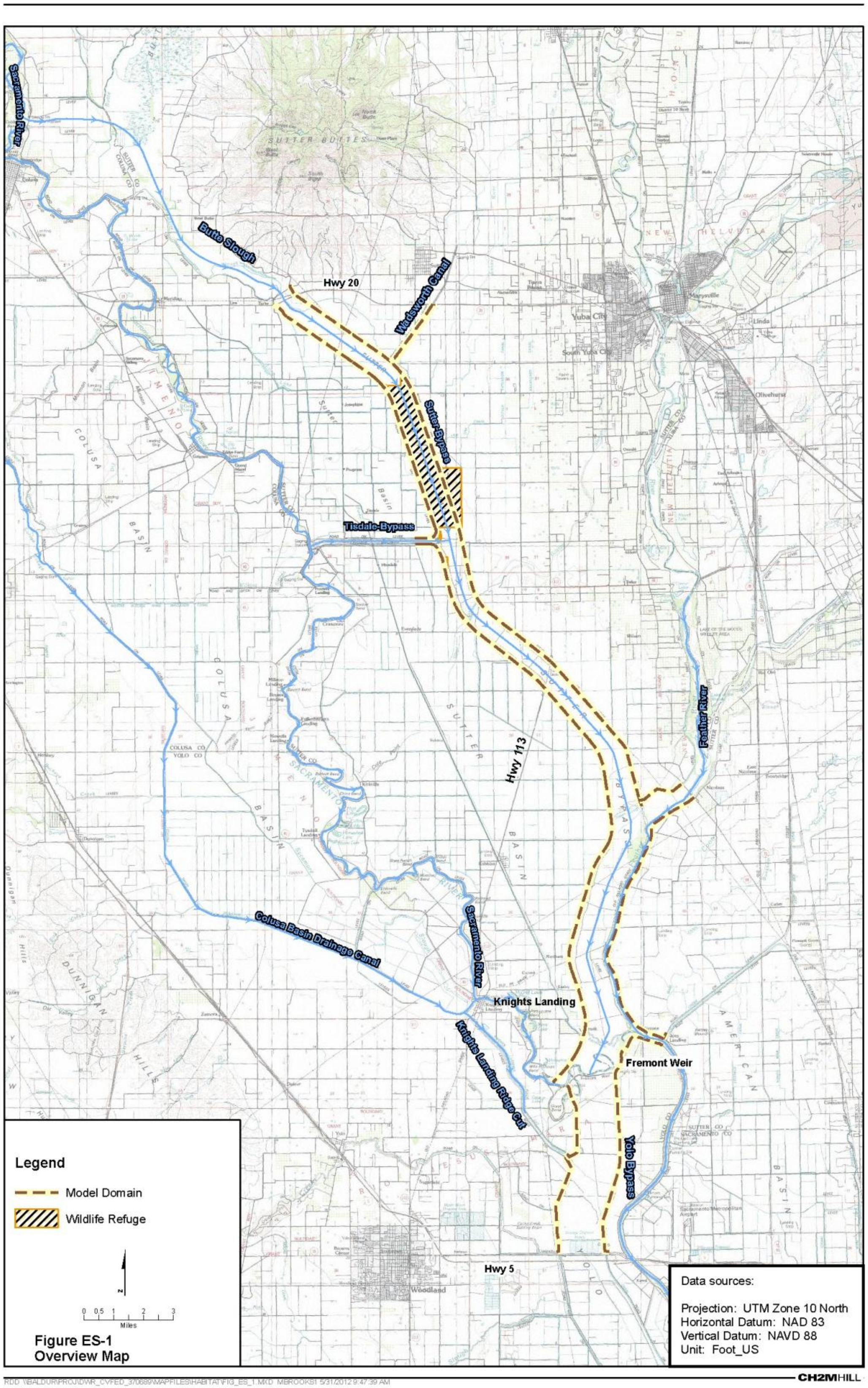

FIGURE 1-1
Overview Map

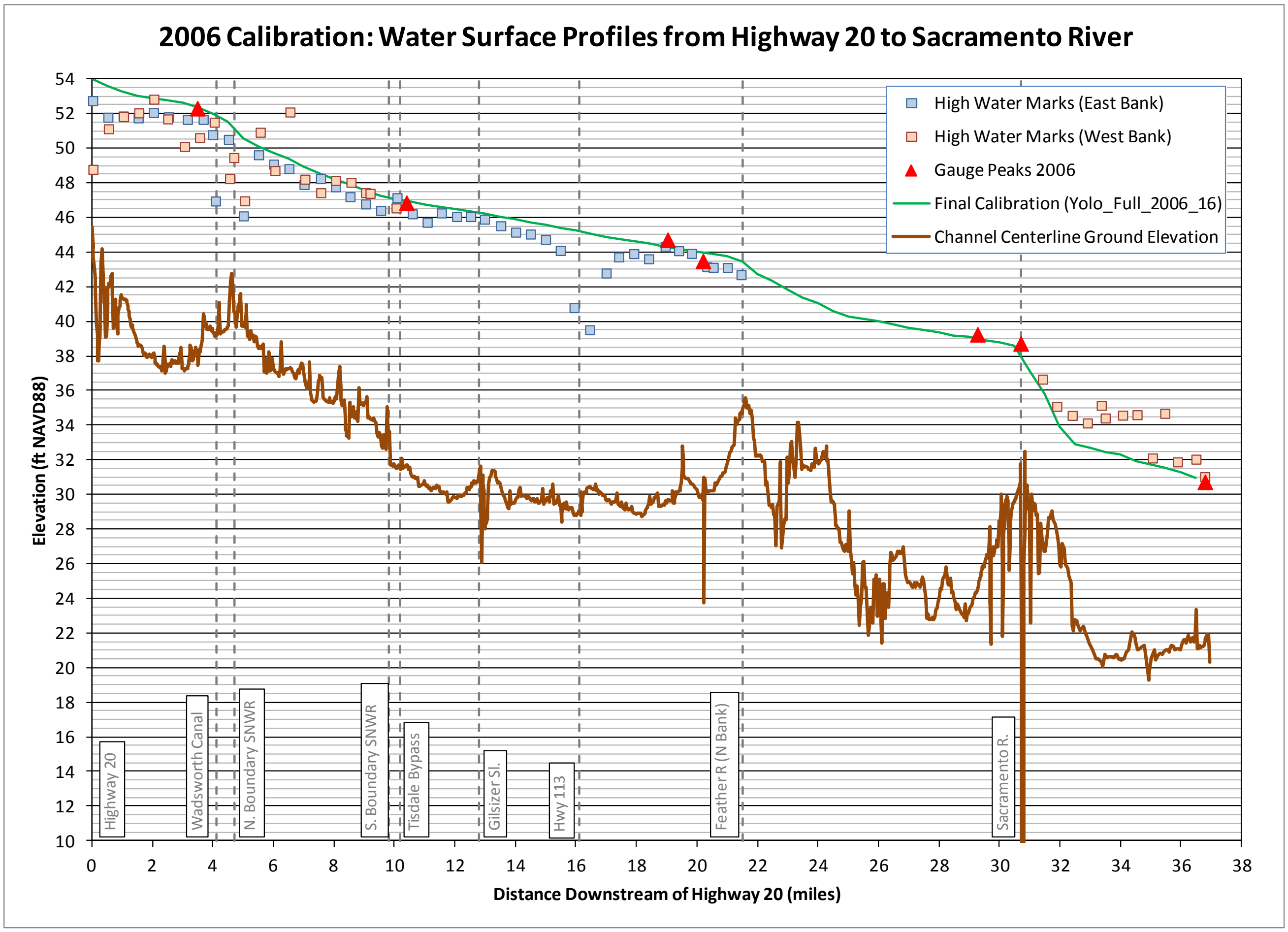

FIGURE 1-2
2006 Calibration Water Surface Profile

SECTION 2

Hydraulic Simulations (Task 6 Model Simulations)

2.1 Introduction

This section discusses the hydraulic simulations conducted under Task 6, which include a range in simulations representing variations in hydrology, land use, vegetation management, and structural modifications to the Sutter Bypass. Model simulations reported herein were developed from the calibrated model discussed in Section 1. Information on the model area, model development, boundary conditions, and calibration can also be found in Section 5 of the Main Report.

The project scope detailed five model simulations to be conducted to determine potential changes to peak water levels in the Sutter Bypass for a range of vegetative conditions. Discussions with CVFPB staff and project team members yielded a series of five simulations that would provide the most useful information to Board staff and stakeholders. These simulations include:

1. Bare Soil (Minimum Roughness)
2. Existing Conditions
3. Vegetation Fully Grown (Maximum Roughness)
4. Vegetation Management
5. Structural Modifications

This section presents the results of the above five simulations, many of which were ultimately run as a series of simulations to enhance the usefulness of the model application.

2.2 Model Simulations

This section discusses the simulations conducted under Task 6 that fall into the five main categories presented above. Unless noted, these simulations were conducted with 1957 Design Flows, with a Sacramento River centering that yields higher flows on the Sacramento River and lower flows on the Feather River. This hydrology was chosen for the simulations as it results in critical freeboard conditions in the upper Sutter Bypass. The following flow boundary conditions were applied for these simulations:

- Sutter Bypass at Longbridge: 150,000 cfs
- Wadsworth Canal: 1,500 cfs
- Tisdale Bypass: 28,500 cfs
- Feather River: 200,000 cfs
- Sacramento River at Knights Landing: 30,000 cfs
- Knights Landing Ridge Cut: 19,000 cfs
- Cache Creek: 15,000 cfs
- Natomas Cross Canal: 22,000 cfs

Results are presented as longitudinal water surface profile plots and plots of freeboard relative to local levee crest elevations as determined by the California Levee Database. Comparisons between the California Levee Database (CLD) elevations and those determined from LiDAR data collected to support the Central Valley Floodplain Evaluation and Delineation (CVFED) project indicate close agreement between the two datasets. The decision was made to retain the CLD elevations for calculating freeboard, considering the source and relative accuracy of the regular levee surveys and the previous acceptance of the survey data by DWR. The 1957 design profile is included in the longitudinal water level plots for reference. This profile was generated by manually extracting elevations at mileposts from a PDF scan of the original 1957 design sheets, as supplied to project staff by DWR. The 1957 design profile elevation near the southern end of the model boundary is noticeably higher than the water level predictions. This stems from the boundary condition applied at YBY in the numerical model. Figure 2-1a presents the observed flow and stage at the YBY gauge for the 1997 flood event. Analysis of the stage/discharge relationship (Figure 2-1b) indicates that the observed stage at 377,000 cfs (the 1957 design flow at this location) is equal to 32.52 feet. This is 1.36 feet lower than the 1957 design profile elevation, as extracted from the original profile plot and converted from United States Engineering Datum (USED) to North American Vertical Datum of 1988 (NAVD88) by subtracting 0.41 foot. The value extracted from the stage discharge curve (32.52 ft) was applied as the Yolo Bypass Stage Boundary for the 1957 Design Flow simulations. The rating curve reflects recent river conditions which could be different than those that existed during development of the 1957 Design Profile.

At Verona, model outflows of approximately 96,000 cfs occur when the 1957 Design Flows are applied at the upstream boundary locations. Based on a stage discharge curve developed from measured stages during the 1997 flood (Figure 2-2), the stage corresponding to a flow of 96,000 cfs is 41.31 feet NAVD88. The non-symmetric rating curve, with stages on the falling limb of the flood hydrograph considerably higher than those for the same flow on the rising hydrograph, indicate downstream controls (possibly from the American River) on flows at Verona during the 1997 flood event. The downstream stage at Verona was set at 41.31 feet based on the recent rating curve.

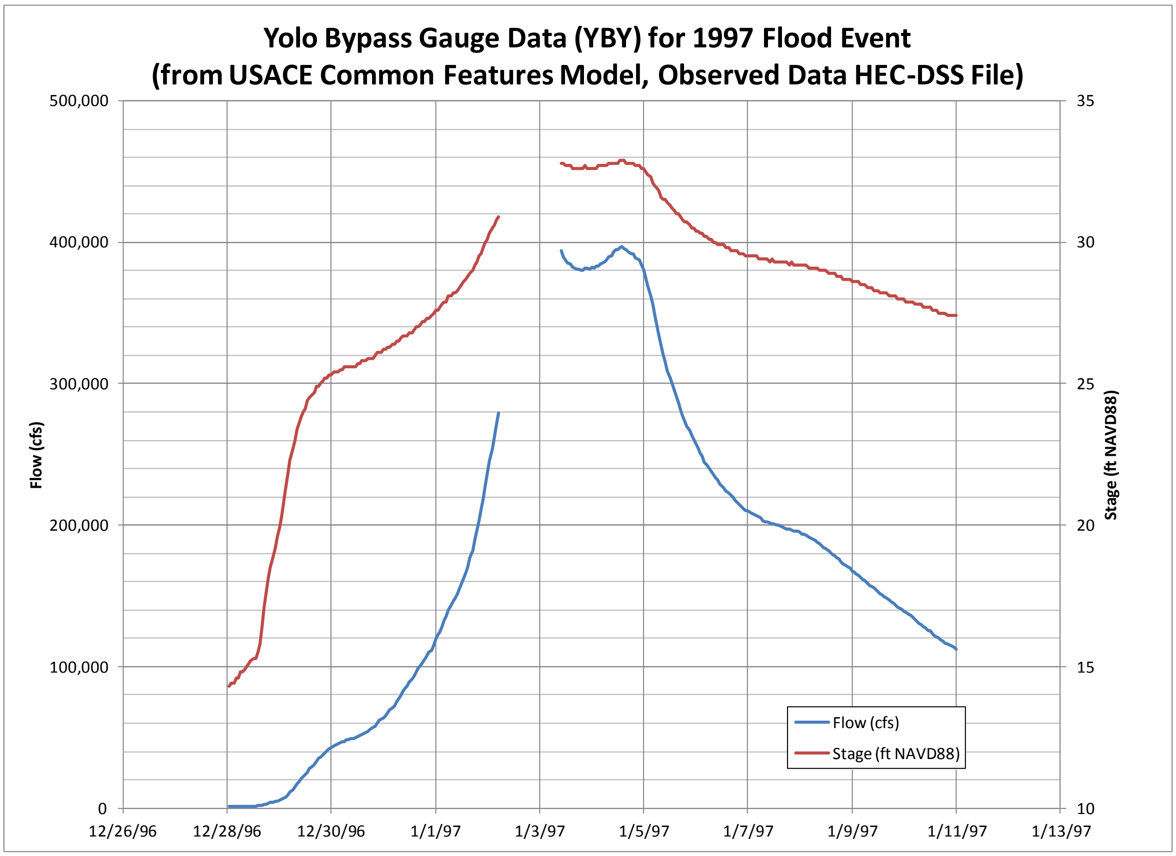

FIGURE 2-1a
Observed Flow and Stage at YBY Gauge for 1997 Flood Event

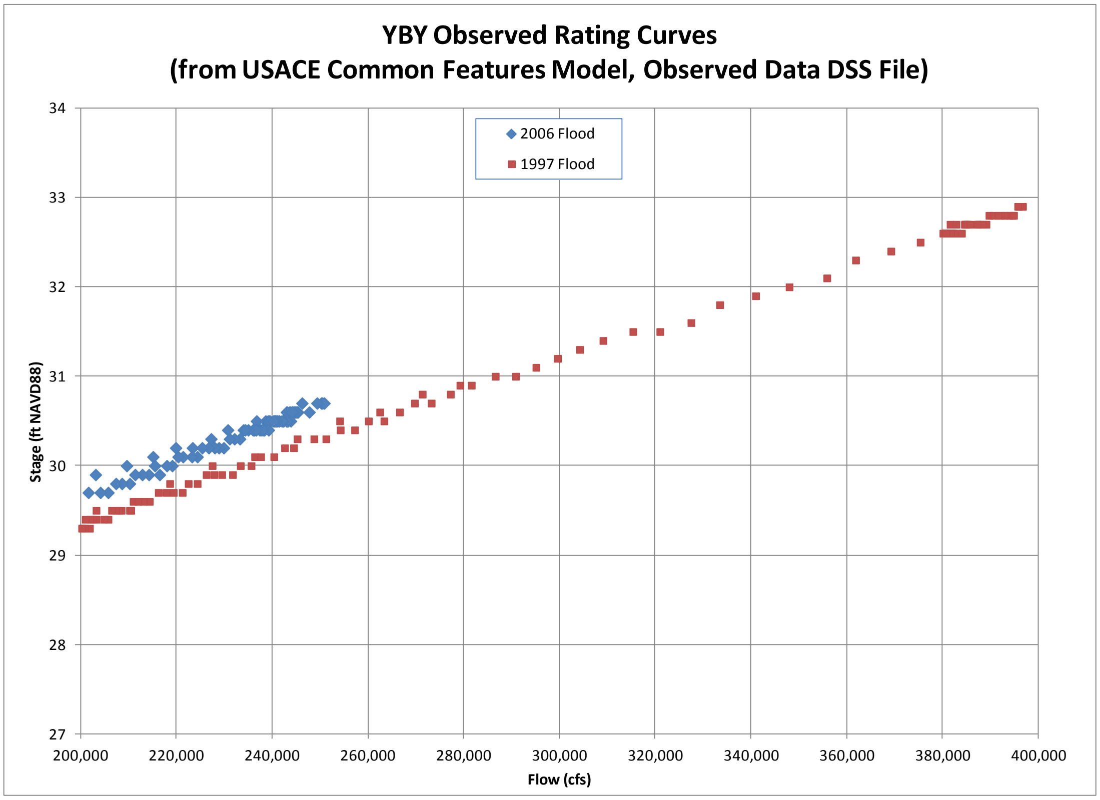

FIGURE 2-1b
Stage/Discharge Curve at YBY Gauge for 1997 Flood Event

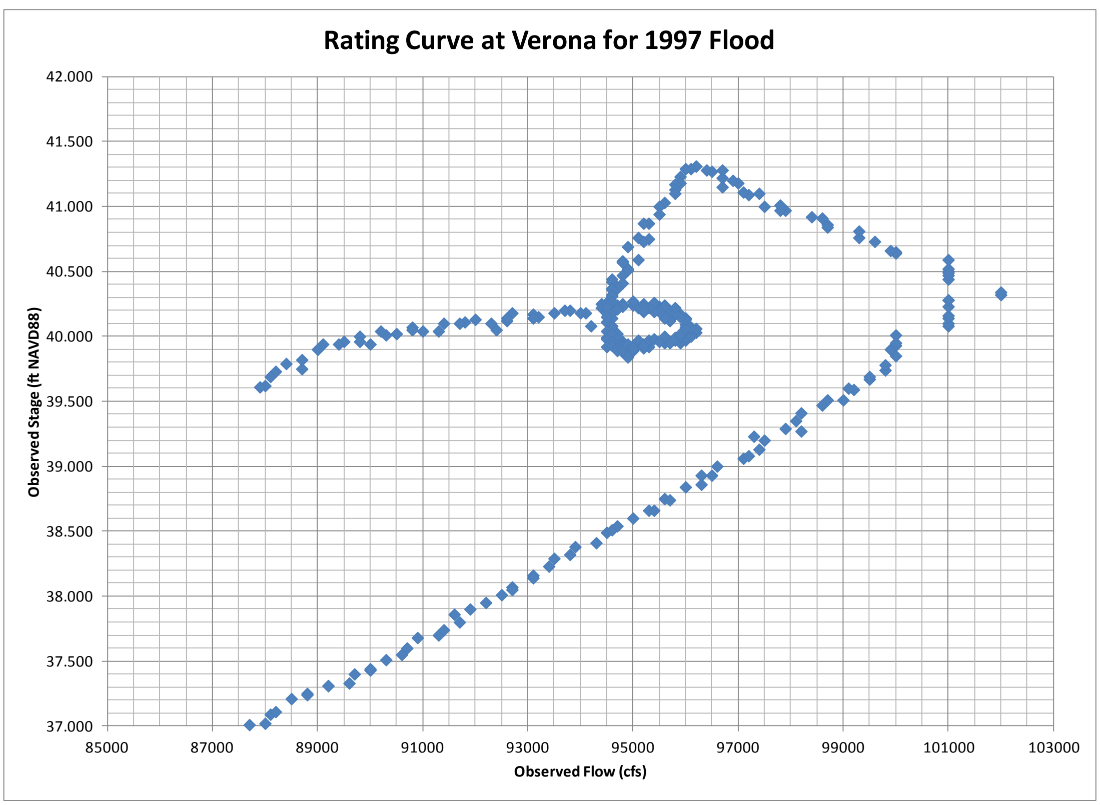

FIGURE 2-2
Stage/Discharge Curve at VON Gauge for 1997 Flood Event

2.2.1 Group 1: Bare Soil Simulations

The purpose of the first series of model simulations conducted under Task 6 was to determine the water level profiles in the Sutter Bypass under bare soil or as-built conditions. This simulation was meant to provide one bookend of potential future vegetative conditions in the Sutter Bypass. On the basis of discussions with the project team, it was concluded that a real condition which might be represented by a full bare soil simulation (no woody vegetation) was not likely to ever be achieved considering the evolution of the Sutter Bypass since construction, and the abundance of conflicting uses along the Bypass. Rather, the series of simulations was designed to establish a reasonable understanding that reflected the highest level of vegetation management that might be achieved given the environmental and land use constraints that exist along the Sutter Bypass.

The bare soil simulations reflect varying degrees of aggressive clearing of woody vegetation and undergrowth in the Sutter Bypass. The individual simulations included modification of land use to varying degrees and varying extents. Changes to the friction assignments developed during model calibration were made on a material basis. Table 2-1 summarizes the individual material types in the model domain, along with their acreage.

A total of eight model simulations were conducted under this group, split into two series of four simulations each. The difference between the two series is that one included the thinning of vegetation in the riparian corridor along the levees, while the other did not. Results from the series that included thinning of the riparian corridor vegetation are discussed first, followed by the series of four simulations that did not alter the existing riparian corridor vegetation. The first series was conducted to more closely represent as-built conditions, while the second series was conducted with the recognition of the benefits of a riparian corridor along the levee slope, namely the reduction of wind wave action on the exposed levee face during high water and storm conditions.

Results of the model simulations are presented in this section as longitudinal profile plots of predicted water level of each individual simulation as compared to the Baseline and the 1957 Design Profile. Figure 2-3 presents predicted water levels for the four Bare Soil simulations with clearing of the thin riparian corridor along the toe drains, and Figure 2-4 presents predicted water levels for the four Bare Soil scenarios with the riparian corridor intact.

Plots showing longitudinal freeboard along the Sutter Bypass levees have been developed with two versions of freeboard presented in each. First, the predicted freeboard is the local difference in elevation between the levee crest as determined by the CLDB and the predicted water surface elevation for a given simulation. Second, the Freeboard Deficiency is defined as the difference between the predicted freeboard and the freeboard as it existed in 1957. This latter freeboard, termed the 1957 freeboard, is the difference in elevation between the 1957 levee crest elevation and the 1957 design profile provided by DWR. Once caveat is that the 1957 design freeboard is capped at 6 feet. The Freeboard Deficiency is thus a measure of how much the current freeboard is below that in existence in 1957. Only positive values of Freeboard Deficiency are presented to locate areas where the existing freeboard is less than the 1957 freeboard.

Table 2-2 summarizes the eight simulations conducted to investigate a range of bare soil conditions, separated into two groups according to whether or not the riparian corridor was included in the vegetation management alternative. Table 2-2 summarizes the maximum water level benefit for each simulation (reduction in water level) compared to the baseline simulation, as well as the minimum freeboard calculated in relation to the local levee crest elevation, as obtained from the California Levee Database. The maximum Freeboard Deficiency is also presented in Table 2-2. Note that the Baseline simulation has a minimum freeboard of 3.5 feet but a maximum Freeboard Deficiency of 1.8 feet

2.2.1.1 Bare Soil Simulations with Clearing of Riparian Corridor

The first simulation (run 'Yolo_Full_1957-SAC_04_cleared01') cleared all three areas specified as woody vegetation (3,280 acres) and the riparian habitat areas (1,045 acres) to a Manning's *n* value of 0.04, reflecting extensive thinning of trees and understory brush. In addition, this simulation cleared vegetation bordering Nelson Slough, reducing the Manning's n value to 0.04 from 0.05. Results indicate a peak reduction in water level at the upstream end of the model domain of 1.49 feet as compared to the baseline simulation.

The second simulation (run 'Yolo_Full_1957-SAC_04_cleared02b') further cleared the woody vegetation and riparian corridor materials to a Manning's *n* value to 0.035, and reduced the natural grasses friction from a Manning's *n* value of 0.045 to 0.035 to simulate active management (mowing) of 3,030 acres of natural grasses. Additionally, vegetation along Willow Slough and Gilsizer Slough was thinned and represented by a Manning's *n* value of 0.035. Results indicate a peak reduction in water level at the upstream end of the model domain of 2.22 feet as compared to the baseline.

The third simulation (run 'Yolo_Full_1957-SAC_04_cleared03') was built on the second simulation, and included a conversion of 1,646 acres of managed wetland habitat in the Sutter National Wildlife Refuge (SNWR) to agricultural land use, reducing the friction value from n = 0.037 to n = 0.028. Results indicate a peak reduction in water level at the upstream end of the model domain of 2.60 feet as compared to the baseline. This condition most closely represents the conditions that were likely to be in place at the time of the Sutter Bypass construction and may be referred to as the "As-Constructed" condition which reflects a condition without the SNWR. It was assumed that the majority of woody vegetation in the Sutter Bypass, particularly along the toe drains, has grown since the construction of the Bypass, and that the majority of the Bypass was agricultural land use at the time of construction. Figure 2-5 presents predicted water surface elevations for this scenario and includes a plot of the difference in water surface elevation between the simulation and Baseline results on the right-hand axis. Note that the scale on the right-hand axis has been modified for clarity compared to the left-hand axis, which shows water surface elevation. The baseline water surface elevation is up to 2.6 feet higher than the best estimate of the As-Constructed conditions.

The final simulation in the series (run 'Yolo_Full_1957-SAC_04_cleared04c') was built on the third simulation, and included the conversion of all vegetation areas and natural grasses to agricultural land use, reducing the friction value for 6,310 acres from n = 0.035 to n = 0.028. Results indicate a peak reduction in water level at the upstream end of the model domain of 3.28 feet as compared to the baseline.

2.2.1.2 Bare Soil Simulations without Clearing of Riparian Corridor

Results from the second set of simulations are very similar to the first. By assuming that the riparian corridor vegetation would not be included in the vegetation management operations, the predicted water levels are slightly higher than if the riparian corridor vegetation was thinned considerably. Because these corridors are at the edges of the conveyance system and are very thin (accounting for 4.0 percent of the grid area), they are not expected to have a significant influence on the predicted water surface elevations. Results indicate that clearing the riparian corridor only lowers the water surface elevation by between 0.11 and 0.16 foot for the four simulations discussed above.

The first simulation (run 'Yolo_Full_1957-SAC_04_cleared01b') cleared all three areas specified as woody vegetation (3,280 acres) to a Manning's *n* value of 0.04, reflecting extensive thinning of trees and understory brush. In addition, this simulation cleared vegetation bordering Nelson Slough, reducing the Manning's *n* value to 0.04 from 0.05. Results indicate a peak reduction in water level at the upstream end of the model domain of 1.37 feet as compared to the baseline simulation. This condition is the best representation of a most likely maximum clearing scenario. That is, given the many land use interests within the Sutter Bypass, this is the maximum vegetation reduction that could plausibly be achieved. Figure 2-6 presents predicted water surface elevations for this scenario and includes a plot of the difference in water surface elevation between the simulation and Baseline results on the right-hand axis. Note that the scale on the right-hand axis has been modified for clarity compared to the left-hand axis, which shows water surface elevation. The predicted water surface elevation is up to 1.4 feet higher for the Baseline Scenario than this cleared vegetation scenario.

The second simulation (run 'Yolo_Full_1957-SAC_04_cleared02d') further cleared the woody vegetation materials to a Manning's *n* value to 0.035, and reduced the natural grasses friction from a Manning's *n* value of 0.045 to 0.035 to simulate active management (mowing) of 3,030 acres of natural grasses. Additionally, vegetation along Willow Slough and Gilsizer Slough was thinned and represented by a Manning's *n* value of 0.035. Results indicate a peak reduction in water level at the upstream end of the model domain of 2.07 feet as compared to the baseline.

The third simulation (run 'Yolo_Full_1957-SAC_04_cleared03b') was built on the second simulation, and included a conversion of 1,646 acres of managed wetland habitat in the Sutter National Wildlife Refuge to agricultural land use, reducing the friction value from n = 0.037 to n = 0.028. Results indicate a peak reduction in water level at the upstream end of the model domain of 2.49 feet as compared to the baseline.

The final simulation in the series (run 'Yolo_Full_1957-SAC_04_cleared04d') was built on the third simulation, and included the conversion of all vegetation areas and natural grasses to agricultural land use, reducing the friction value for 6,310 acres from n = 0.035 to n = 0.028. Results indicate a peak reduction in water level at the upstream end of the model domain of 3.12 feet as compared to the baseline.

Figures 2-7 and 2-8 present freeboard plots or the Baseline simulation (east and west levees, respectively). Predicted freeboard relative to the existing levee crests are included along with a profile plot of the Freeboard Deficiency defined above. Figures 2-9 and 2-10 present freeboard plots for the Cleared01b simulation, and indicate a maximum Freeboard Deficit of 0.6 feet. Freeboard plots for the As-Constructed simulation (Cleared03) are presented in Figures 2-11 and 2-12 for the East and West levees, respectively. The maximum Freeboard Deficiency for this simulation is 0.1 feet indicating consistent adherence to the 1957 Design Freeboard. A full collection of freeboard plots for all simulations performed under Task 6 can be found in Appendix A.

TABLE 2-1
Baseline Distribution of Materials and Friction Coefficients in Model Domain
Sutter Bypass Two Dimensional Hydraulic Model Report

Material No.	Material Description	Manning's *n*	Percent of Grid	Area (acres)
1	Agricultural Areas	0.028	56.74	14,875
2	Levee	0.035	1.75	459
3	Dense Vegetation (Vi)	0.1	6.02	1,578
4	Toe Drains	0.03	3.43	900
5	Riparian Corridors on Levees	0.06	3.99	1,045
6	Feather River	0.038	2.11	554
7	Sacramento River	0.035	1.21	317
8	Highway 20	0.06	0.02	5
9	Highway 113/Sutter Causeway	0.06	0.02	4
10	SNWR Watergrass	0.037	2.04	536
11	SNWR Seasonal Marsh	0.037	4.24	1,110
12	Feather River Confluence Weir	0.16	0.01	3
13	Medium Vegetation (V2)	0.08	2.77	727
14	Sparse Vegetation (V3)	0.06	3.72	974
15	Natural Grasses	0.045	11.56	3,030
16	Fremont Weir Crest	0.16	0.02	4
17	Fremont Weir Trough	0.16	0.02	5
18	Cache Creek Weir	0.03	0.07	17
19	Natomas Cross Canal Bridge	0.06	0.00	1
20	Natomas Cross Canal	0.035	0.01	4
21	Willow Slough	0.04	0.07	19
22	Nelson Slough	0.05	0.09	23
23	Gilsizer Slough	0.04	0.09	23
Total			**100**	**26,215**

TABLE 2-2

Summary of Bare Soil Simulations

Sutter Bypass Two Dimensional Hydraulic Model Report

	SMS File Name	Task 6 Goal	Simulation Description	Acres Managed	Maximum Water level Benefit (ft)	Benefit Relative to…	Minimum Freeboard (ft)	Maximum Freeboard Deficit (ft)
	Yolo_Full_1957-SAC_04b.sms	BASELINE	New spinup approach (SS and 50 hr run)	N/A	N/A	N/A	3.5	1.8
Clearing of Riparian Corridor	Yolo_Full_1957-SAC_04_cleared01.sms	Bare soil	Cleared 3 vegetation materials and riparian material to n = 0.04; cleared Nelson Slough to n = 0.04	4348	1.49	Baseline	4.9	0.5
	Yolo_Full_1957-SAC_04_cleared02b.sms	Bare soil	Cleared 3 vegetation materials, riparian corridor, natural grasses, and 3 sloughs to 0.035	7420	2.22	Baseline	5.2	0.1
	Yolo_Full_1957-SAC_04_cleared03.sms	Bare soil	Converted 1646 acres of managed habitat in SNWR to agricultural land use (n = 0.028, built on run02b)	9067	2.60	Baseline	5.2	0.1
	Yolo_Full_1957-SAC_04_cleared04c.sms	Bare soil	Converted 6310 acres of vegetation and natural grasses to agricultural land use (built on run 03)	9067	3.28	Baseline	5.3	0.0
No Clearing of Riparian Corridor	Yolo_Full_1957-SAC_04_cleared01b.sms	Bare soil	Cleared 3 vegetation materials to n = 0.04; cleared Nelson Slough to n = 0.04	3303	1.37	Baseline	4.8	0.6
	Yolo_Full_1957-SAC_04_cleared02d.sms	Bare soil	Cleared 3 vegetation materials, natural grasses, and 3 sloughs to 0.035	6376	2.07	Baseline	5.2	0.2
	Yolo_Full_1957-SAC_04_cleared03b.sms	Bare soil	Converted 1646 acres of managed habitat in SNWR to agricultural land use (n = 0.028, built on run02d)	8022	2.49	Baseline	5.2	0.2
	Yolo_Full_1957-SAC_04_cleared04d.sms	Bare soil	Converted 6310 acres of vegetation and natural grasses to agricultural land use (built on run 03b)	8022	3.12	Baseline	5.3	0.0

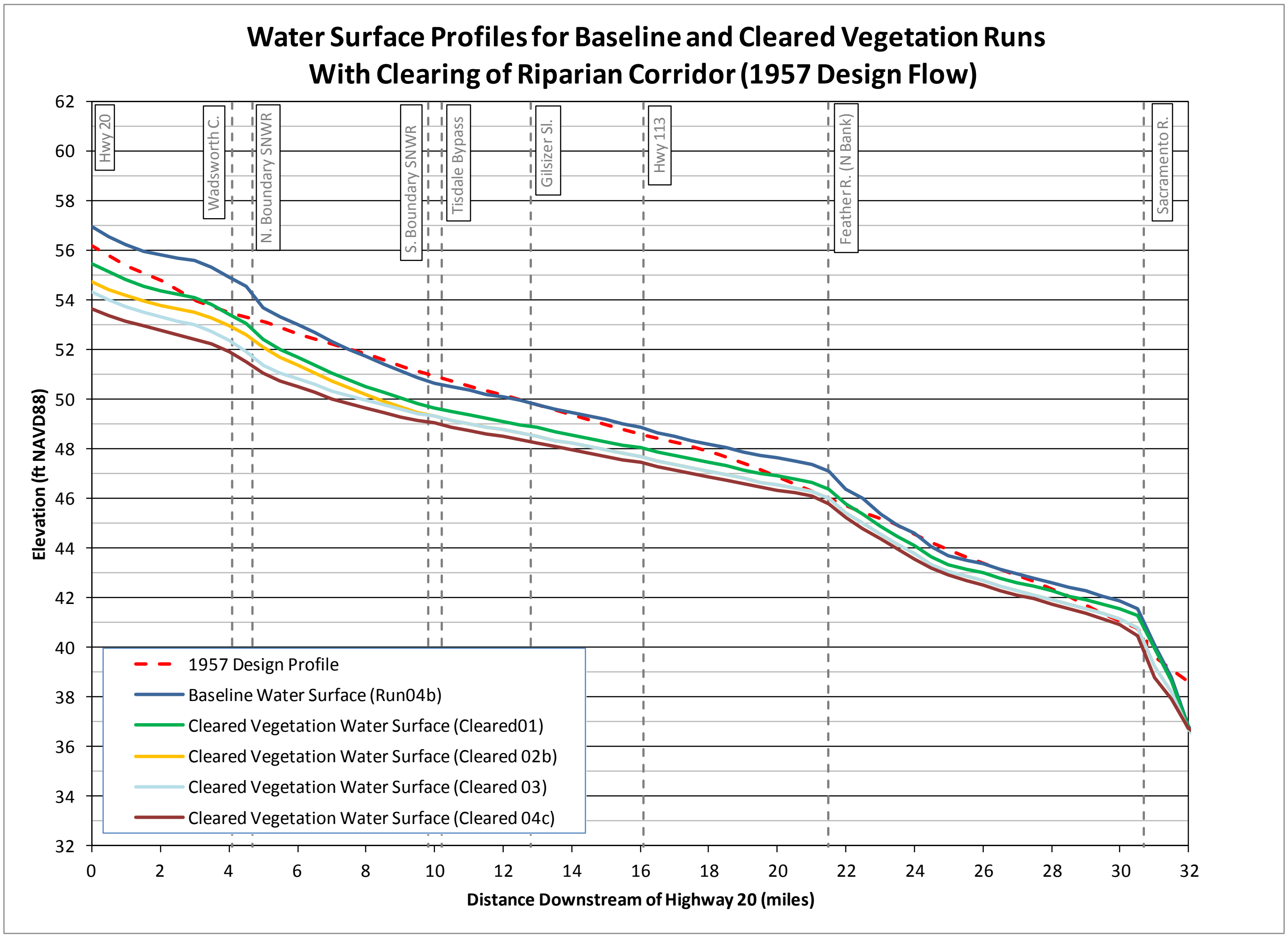

FIGURE 2-3

Bare Soil Conditions. Predicted Water Surface Elevations for Series of Cleared Vegetation Simulations with Clearing of Riparian Corridor along Levees

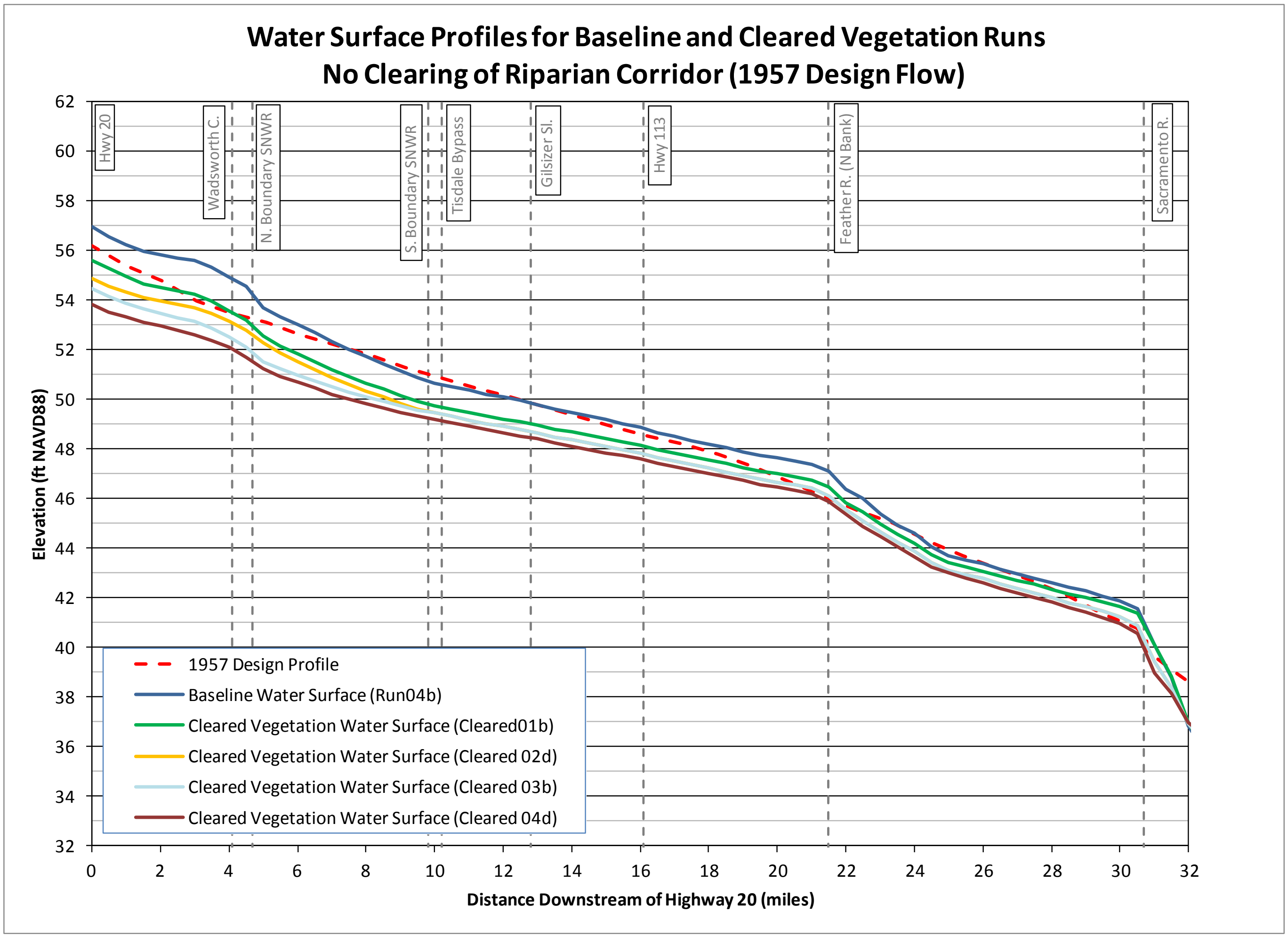

FIGURE 2-4

Bare Soil Conditions. Predicted Water Surface Elevations for Series of Cleared Vegetation Simulations without Clearing of Riparian Corridor along Levees

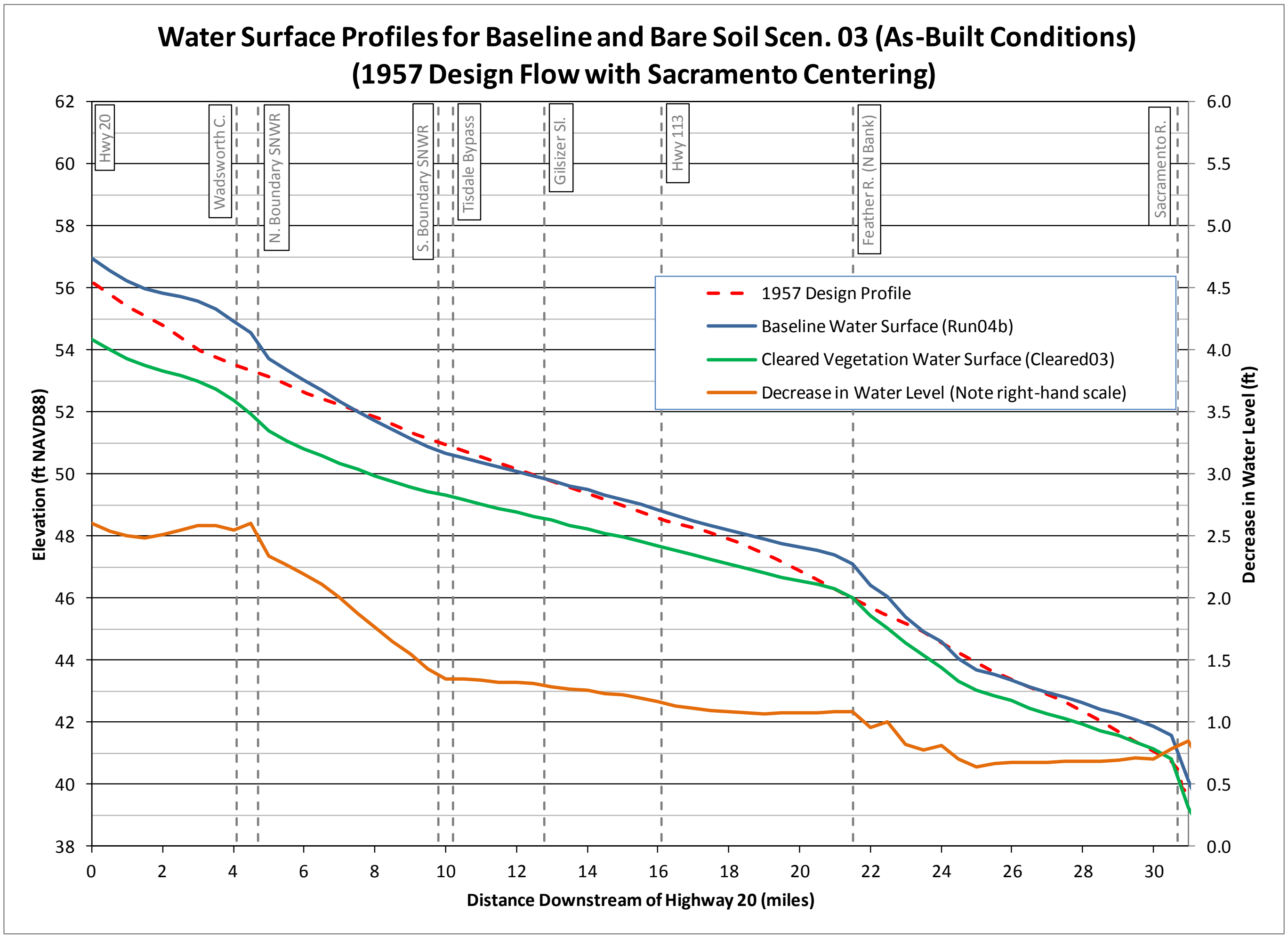

FIGURE 2-5
Bare Soil Conditions. Predicted Water Surface Elevations for Cleared03 Simulation representative of As-Built Conditions in the Sutter Bypass.

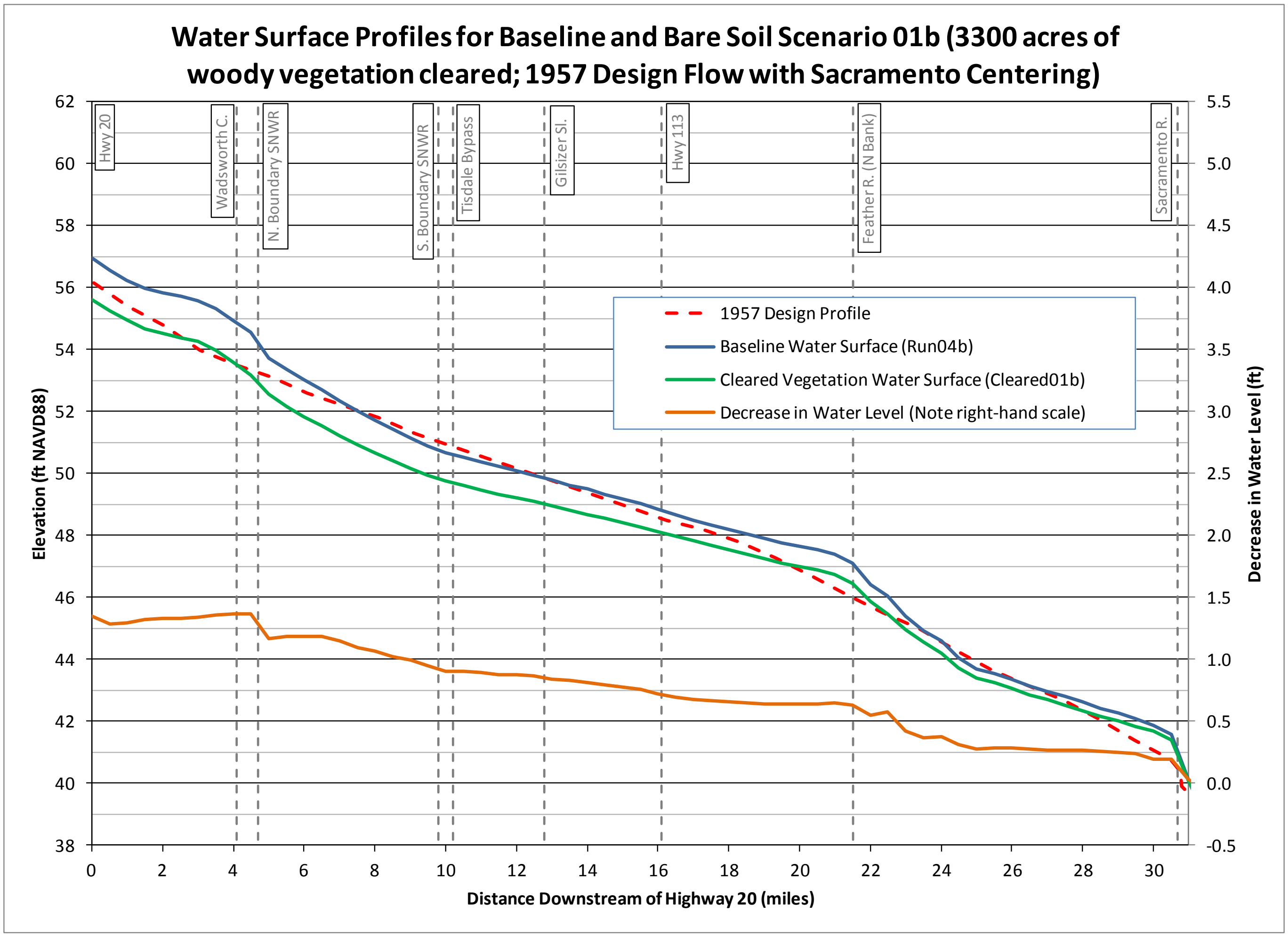

FIGURE 2-6

Bare Soil Conditions. Predicted Water Surface Elevations for Cleared01b Simulation representative of upper limit of likely future clearing of vegetation in the Sutter Bypass.

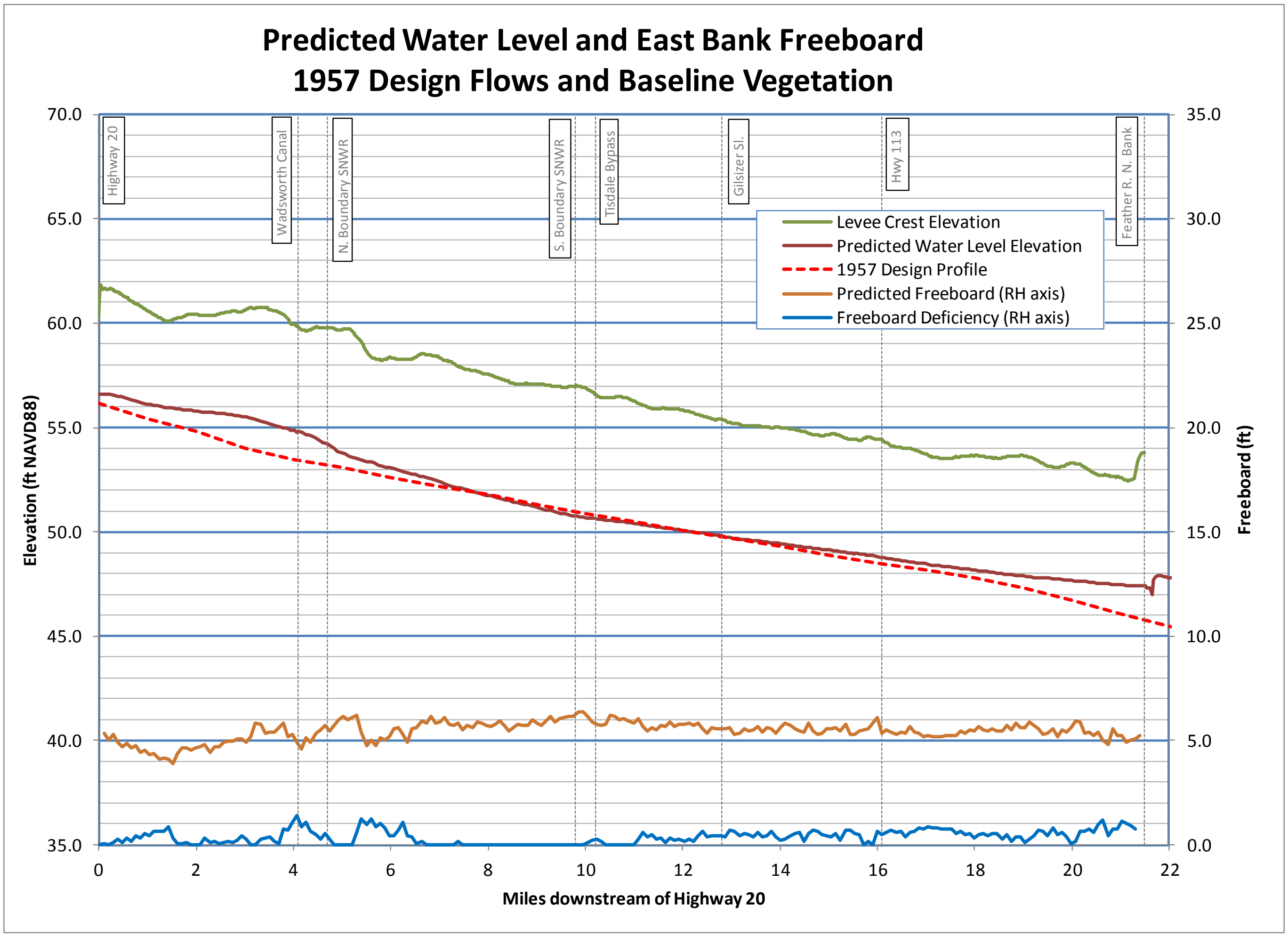

FIGURE 2-7
East Bank Freeboard Profile for Baseline Simulation

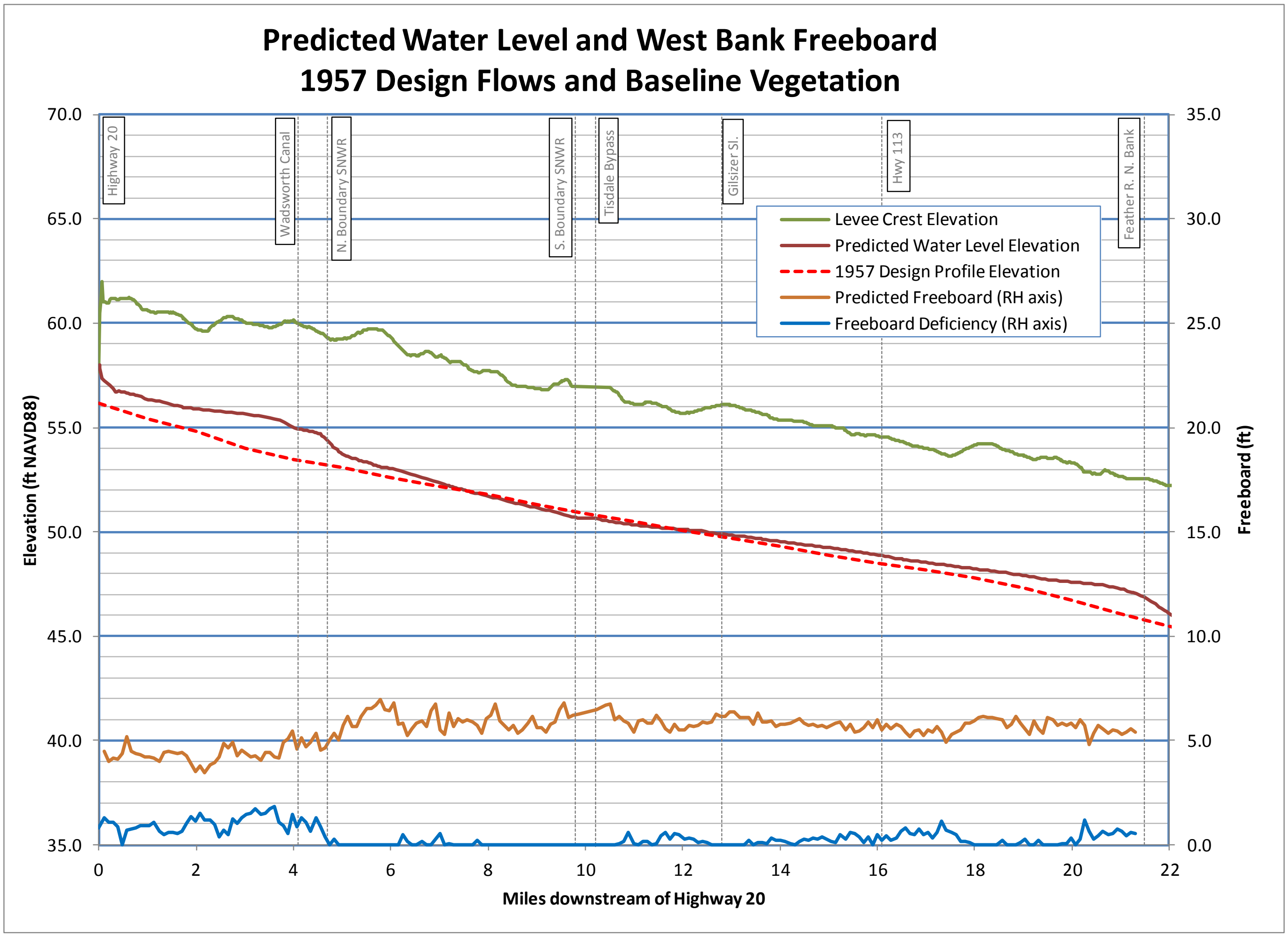

FIGURE 2-8
West Bank Freeboard Profile for Baseline Simulation

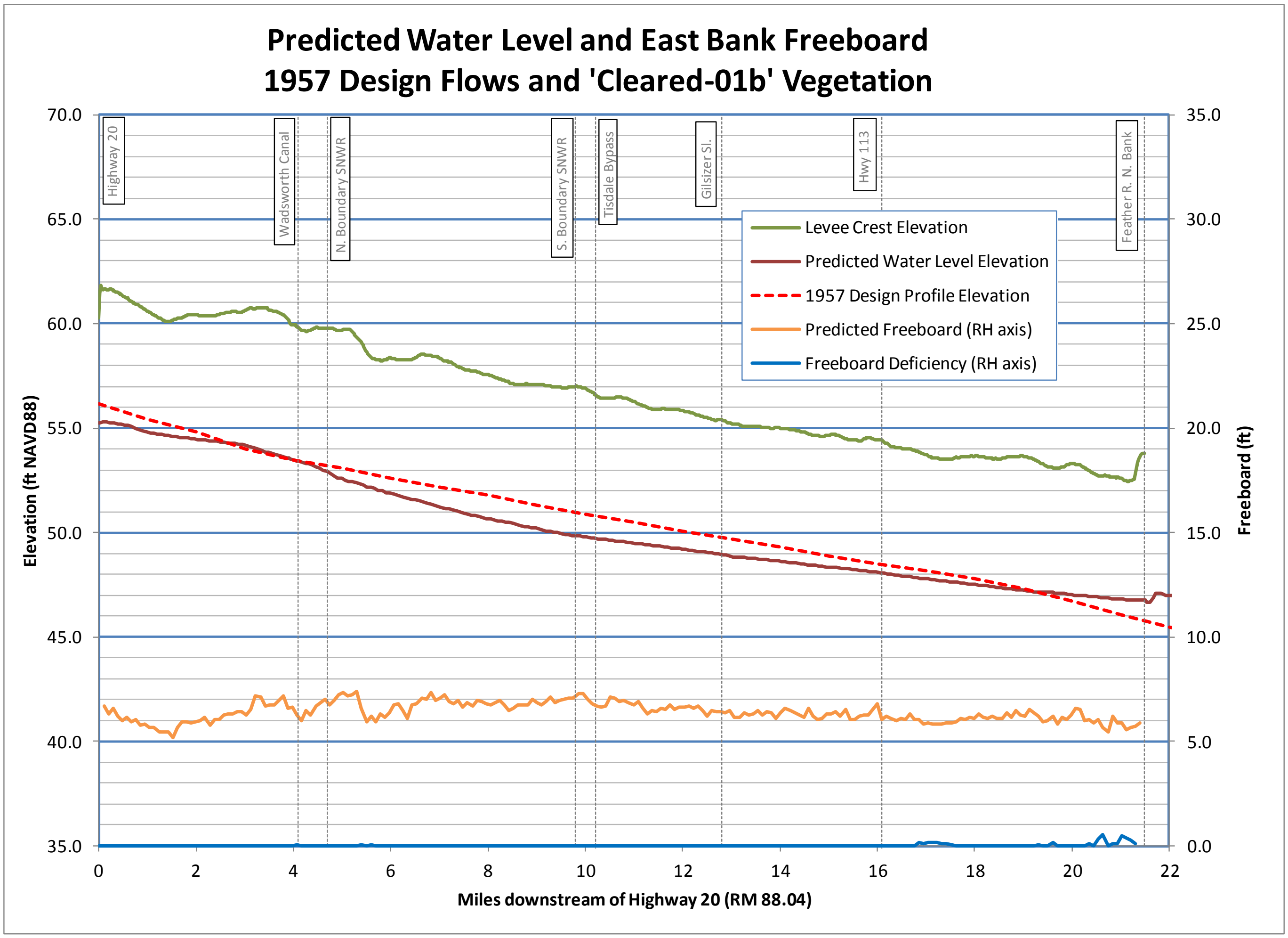

FIGURE 2-9

Predicted Water Level and East Bank Freeboard for 1957 Design Flows and Reduced Vegetation Conditions in the Sutter Bypass (Run01b)

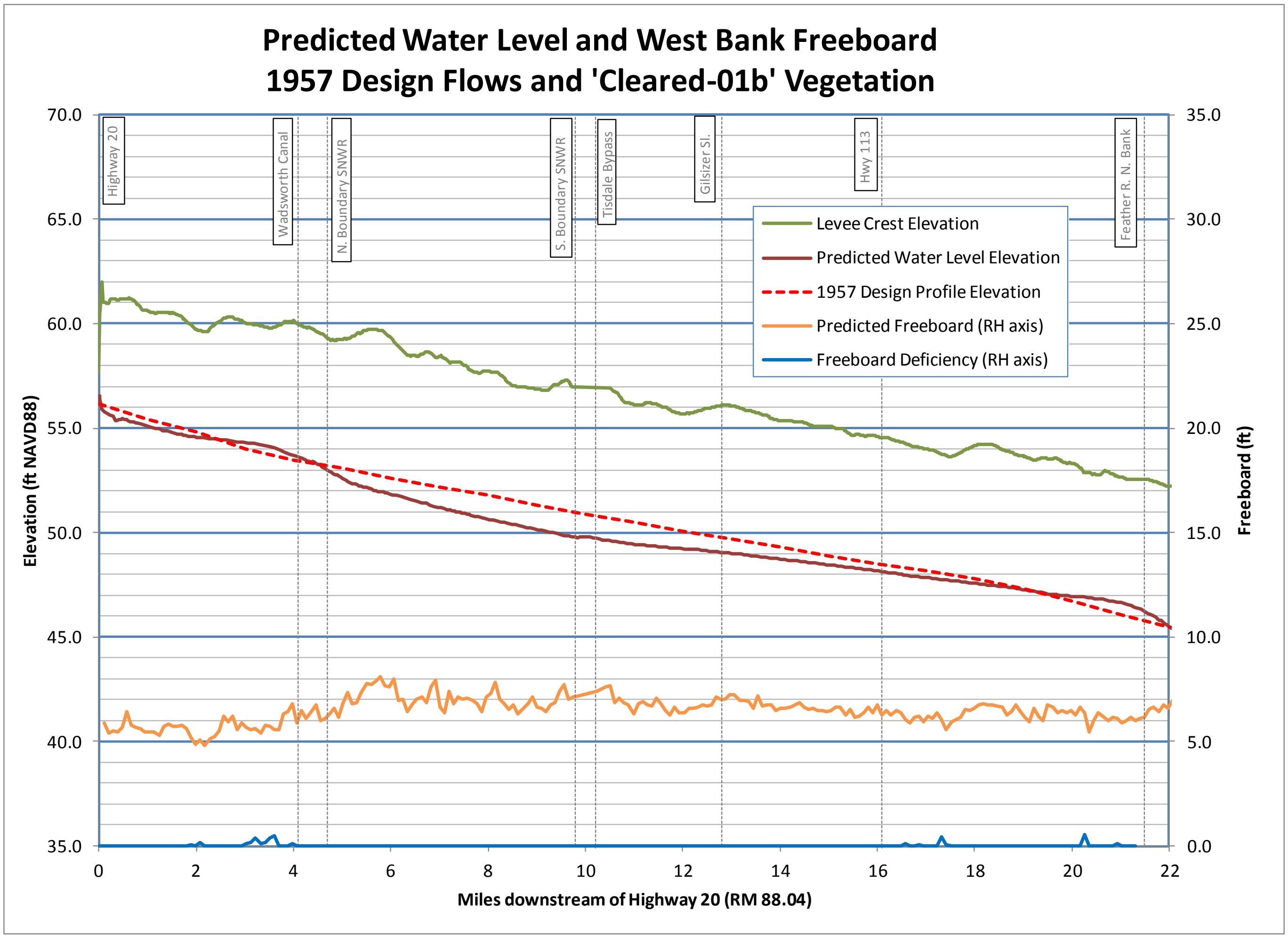

FIGURE 2-10

Predicted Water Level and West Bank Freeboard for 1957 Design Flows and Reduced Vegetation Conditions in the Sutter Bypass (Run01b)

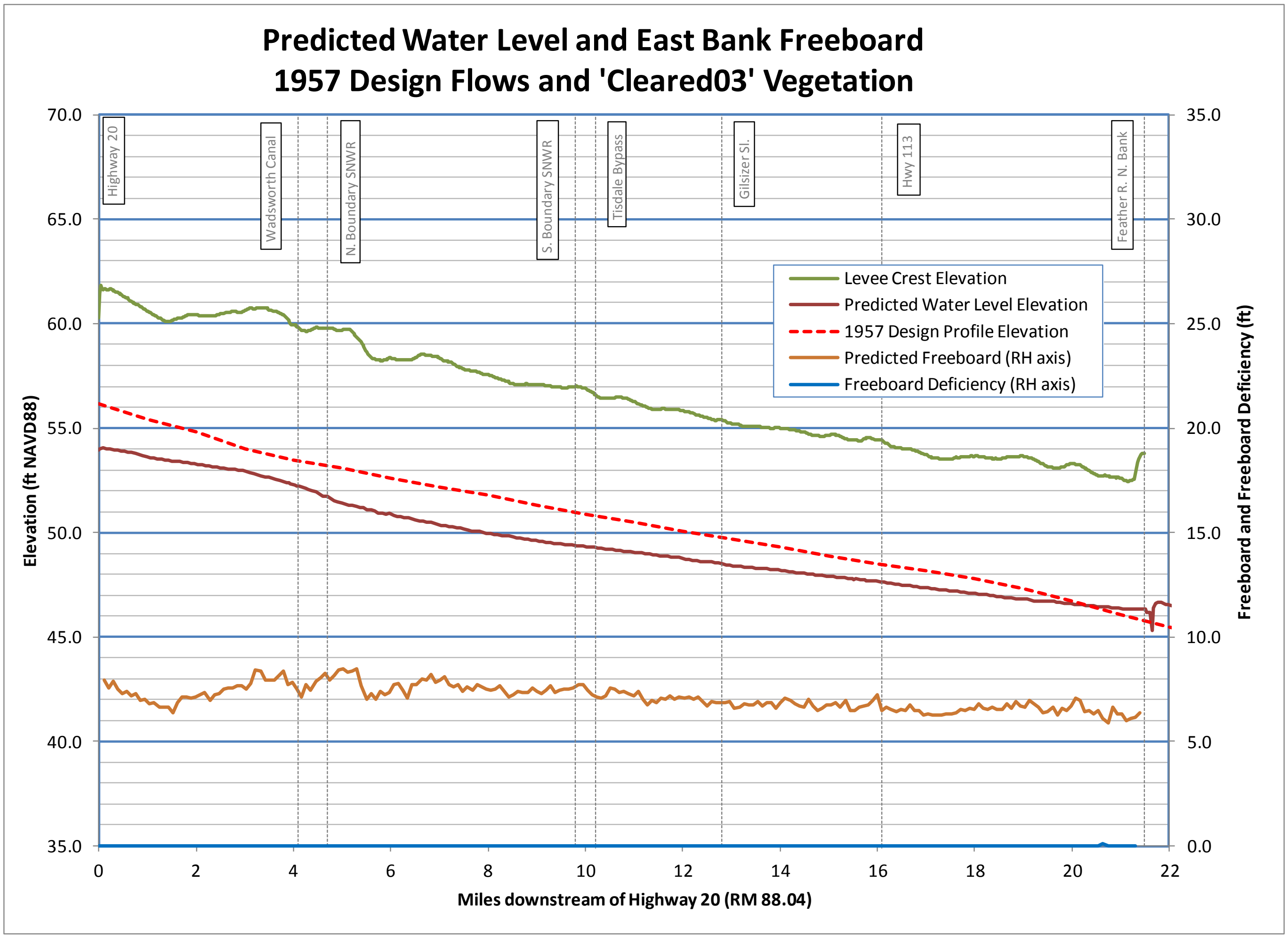

FIGURE 2-11

Predicted Water Level and East Bank Freeboard for 1957 Design Flows and Reduced Vegetation (rough As-Built) Conditions in the Sutter Bypass (Run03)

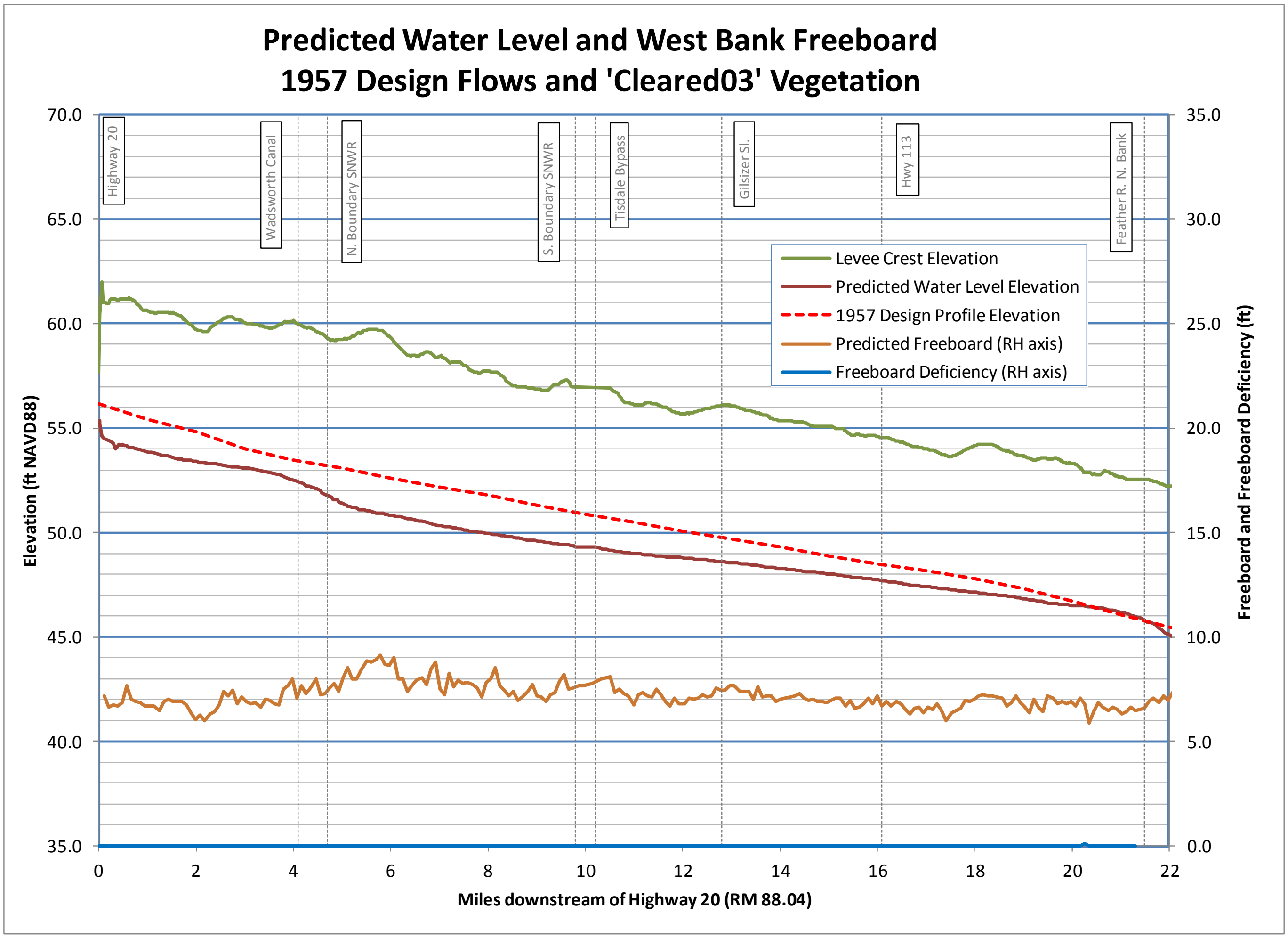

FIGURE 2-12
Predicted Water Level and East Bank Freeboard for 1957 Design Flows and Reduced Vegetation (rough As-Built) Conditions in the Sutter Bypass (Run03)

2.2.2 Existing Conditions Simulation

A single simulation was conducted to represent existing conditions in the Sutter Bypass. This simulation was built from the Baseline simulation, which used the friction distribution map from the 2006 calibration simulation. Friction was reduced at a single 25-acre parcel at the northwest corner of the SNWR to reflect recent vegetation clearing efforts by DWR Sutter Maintenance Yard. The Manning's *n* friction coefficient was reduced from 0.10 to 0.045. Model results indicate that the water level was reduced by this vegetation clearing event by a maximum of 0.15 foot compared to the Baseline condition. Figure 2-13 presents the results of this simulation with the Baseline water level presented for comparison. The difference in predicted water level between the Existing Conditions simulation and the Baseline is plotted on the right-hand axis and reflects a reduction in the water surface following thinning of the vegetation in the northwest corner of the SNWR.

As might be expected, the Existing Conditions simulation freeboard is very similar to that of the Baseline Conditions simulation. Figures 2-14 and 2-15 show the freeboard of the Sutter Bypass system for the 1957 design flows with existing vegetative conditions. Predicted freeboard relative to the current levee crest elevations and Freeboard Deficiency relative to the 1957 freeboard, are included for the east and west levees. As the figures indicates, freeboard varies across the system but is generally in the range of 5 to 7 feet along the West Bank between the Feather River and the Wadsworth Canal and 4.5 to 6 from the Feather River upstream to the Wadsworth Canal on the East Bank with some areas in excess of eleven feet below the Feather River confluence.

On both banks the freeboard is lower above the Wadsworth Canal and is between 3.5 and 6 feet. The Freeboard Deficiency has a maximum of 1.71 feet on the west levee and 1.26 feet on the east levee.

One of the important questions posed by the Board was to develop a better understanding of the freeboard under different flow conditions. In addition to conducting the existing conditions simulation for the 1957 flows, other events were also simulated. Using the Existing conditions model, flows from the Operations and Maintenance Manual (O&M Manual) and the 100-year and 200-year floods were simulated. These flow rates, in the case of the 200-year flows, are as much as 50% higher than the 1957 design flows. The computed elevations for the O&M flows are higher than the 1957 flows and decrease the freeboard for the Existing Condition to between three and five feet along both banks for most of the reach between the Feather River confluence and the Wadsworth Canal. Freeboard above and below this reach is generally decreased by almost two feet. Similar results are seen with the profiles computed for the 100-year and 200-year flows. These have an almost uniform impact on freeboard and decrease freeboard by an average of 1.9 feet and 3.8 feet respectively, compared to existing conditions with 1957 Design flows. More detail on simulations with higher inflow hydrology is provided in Section 2.3.

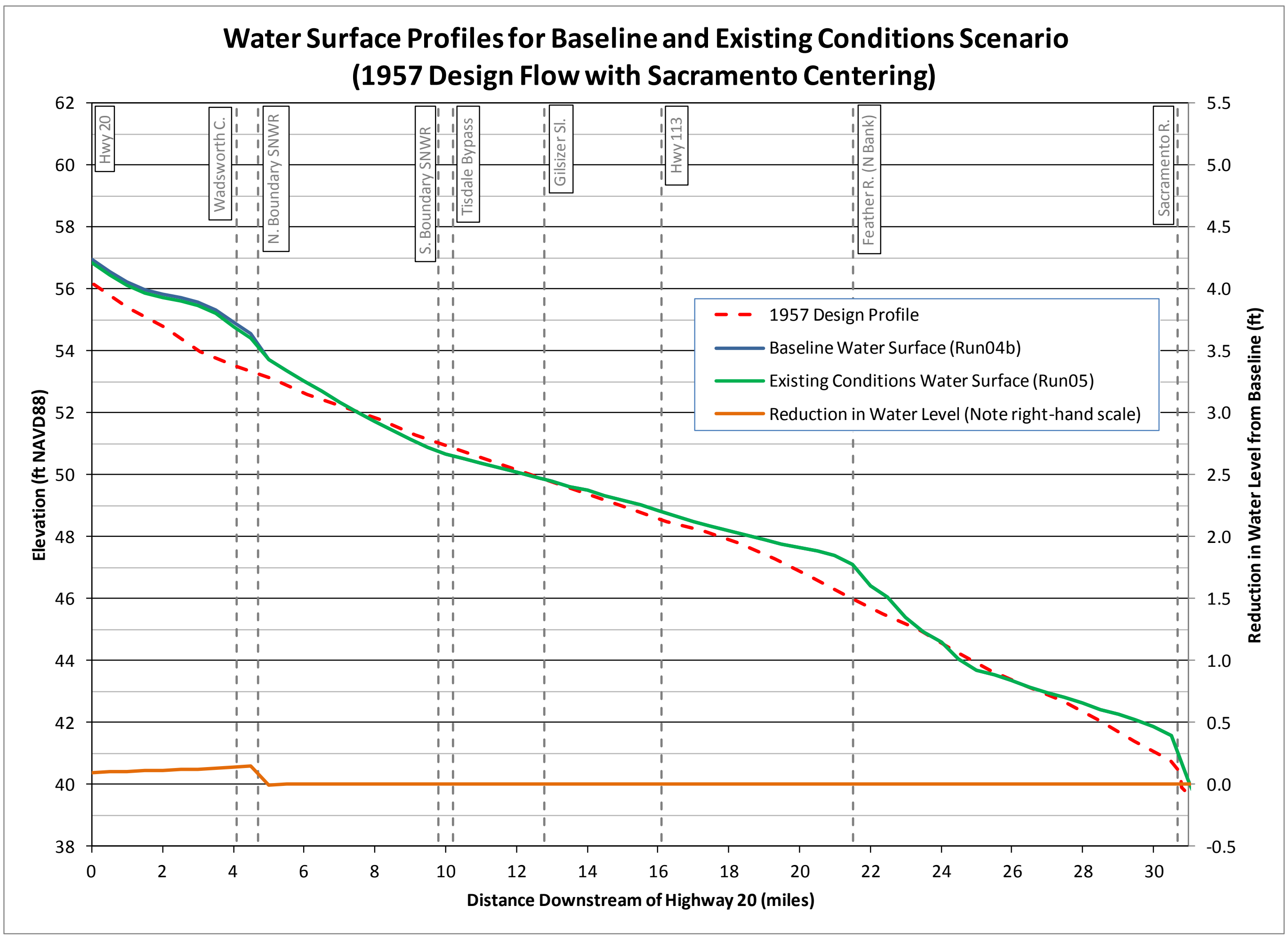

FIGURE 2-13
Existing Conditions (Run05)

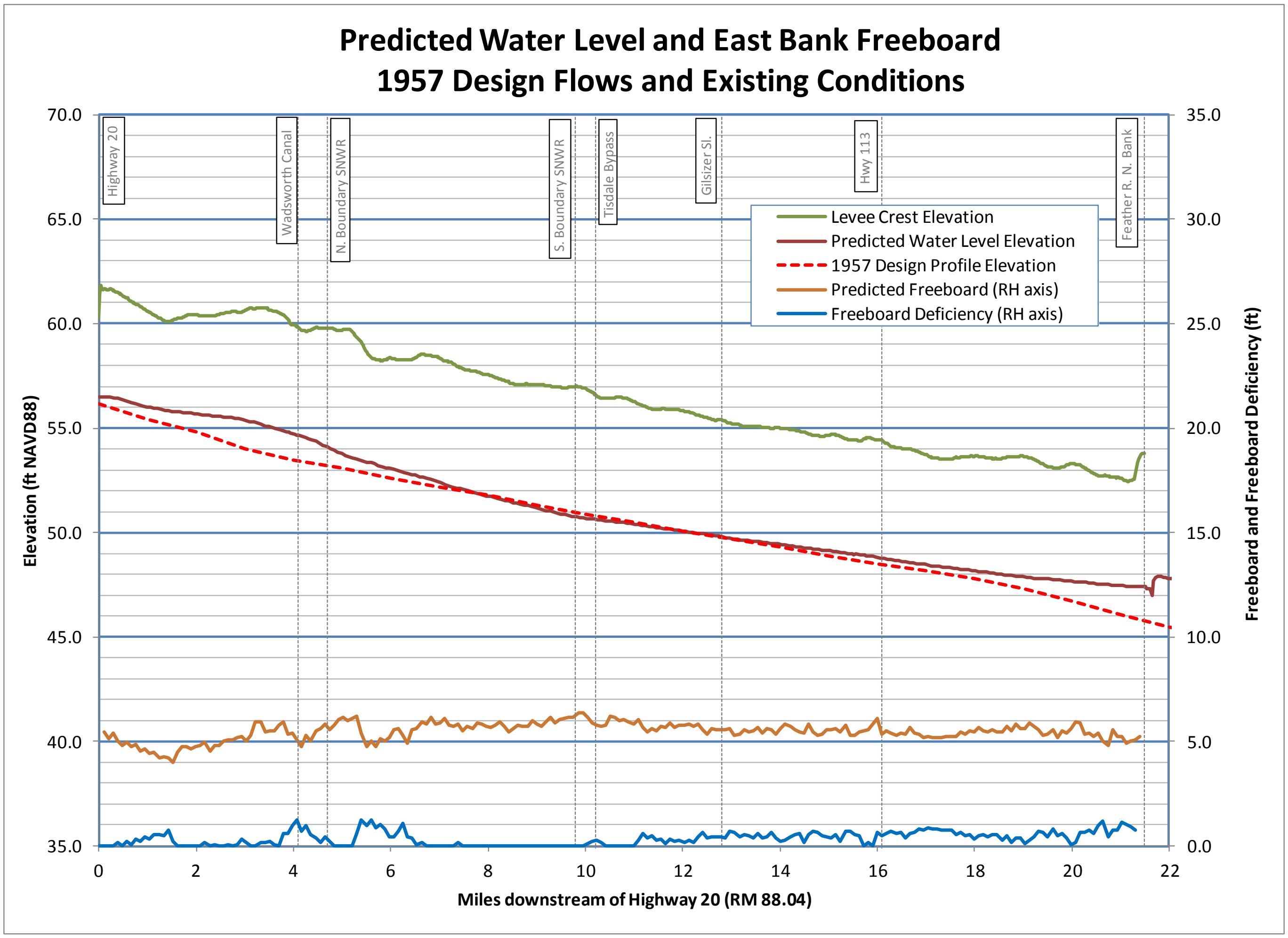

FIGURE 2-14
Predicted Water Level and East Bank Freeboard for 1957 Design Flows and Existing Vegetation Conditions in the Sutter Bypass

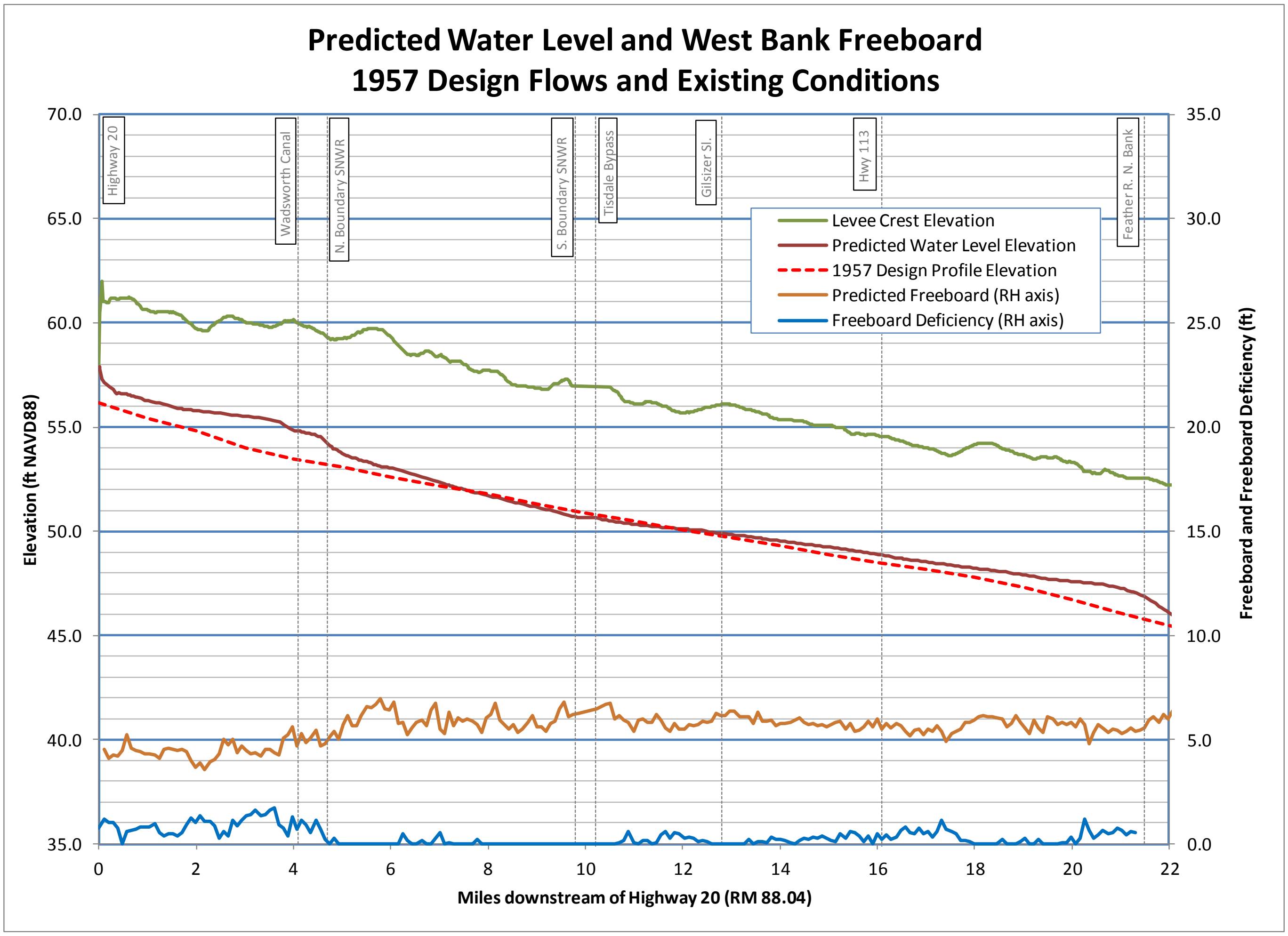

FIGURE 2-15

Predicted Water Level and West Bank Freeboard for 1957 Design Flows and Existing Vegetation Conditions in the Sutter Bypass

2.2.3 Full Growth Simulation

A single simulation was conducted to represent future conditions in the Sutter Bypass absent any vegetation management. Friction coefficients were increased by 20 percent for the following material types:

- Dense wooded vegetation
- Medium wooded vegetation
- Sparse wooded Vegetation
- Riparian Corridor
- Natural Grasses
- Sloughs (Nelson Slough, Willow Slough, and Gilsizer Slough)

Figure 2-16 presents the results of this simulation with the Existing water level presented for comparison. The difference in predicted water level between the Full Growth simulation and the Existing is plotted on the right hand axis and reflects an increase in the water surface elevation following continued growth of vegetation throughout the Sutter Bypass and Yolo Bypass. Results indicate that increased growth of vegetation in the Sutter Bypass and Yolo Bypass, reflected by an increase in the Manning's n friction coefficient of 20 percent, would raise water levels by up to 0.83 foot for the 1957 design flow conditions. Results from this simulation provide a measure of how conditions in the Sutter Bypass could deteriorate going forward, in terms of reduced freeboard, if no vegetation management operations are conducted.

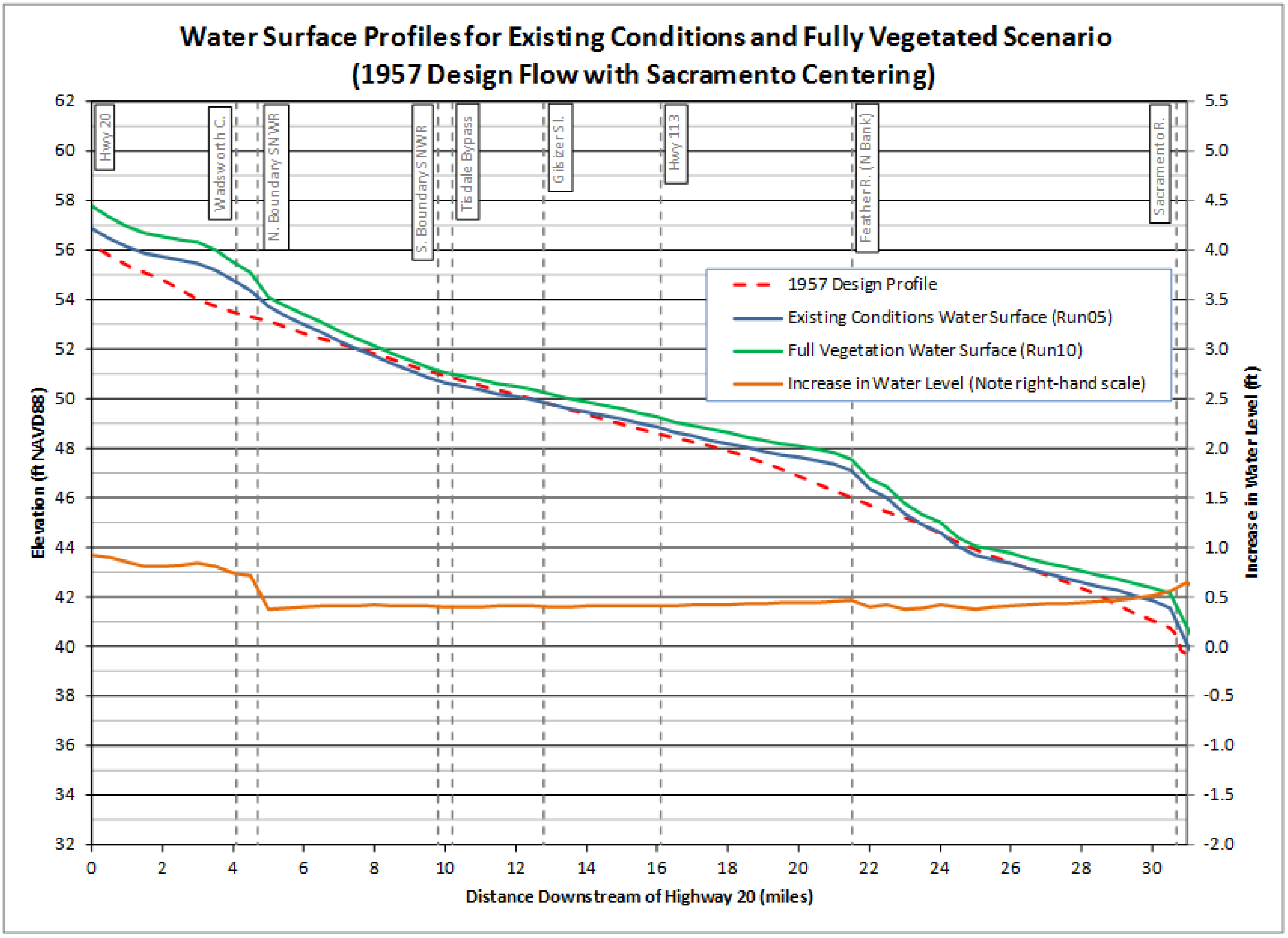

FIGURE 2-16
Future Vegetation Conditions (Run10)

2.2.4 Vegetation Management Simulations

A series of simulations was conducted to investigate the potential reduction in peak water levels for several isolated vegetation management scenarios throughout the project domain. Efforts were made to identify regions in the Sutter Bypass where vegetation management might provide the greatest reduction in water level.

The first simulation in this series (Yolo_Full_1957-SAC_06) included vegetation thinning at two locations in the SNWR. The first site is at the northwestern corner of the refuge, at the site of previous 25-acre vegetation clearing event by DWR Sutter Maintenance Yard. In this scenario, it was assumed that the vegetation thinning events would be expanded to include a larger area totaling 35 acres. The model simulation assumed reducing Manning's *n* value from 0.10 to 0.04 for the additional 10 acres and a reduction from 0.045 to 0.04 for the 25 acres previously adjusted. The second site included in this scenario is the tree line located along the eastern portion of the southern boundary of the SNWR. It was assumed that this tree line would be thinned and understory brush removed, and represented by a Manning's *n* of 0.04. These areas are shown in red on Figure 2-17. Results from this simulation are presented on Figure 2-18, and demonstrate the negligible improvement in peak water levels (0.06 foot) from the vegetation thinning events at the northern and southern boundaries of the SNWR. This is smaller than the 0.15 ft benefit seen from clearing the original 25 acres in this location (Existing Conditions simulation) partly because that clearing effort focused on dense trees closer to the center of the floodway. The minimum freeboard along the Sutter Bypass following the vegetation management assumptions in this simulation was calculated as 3.6 feet.

The second simulation in this series (Yolo_Full_1957-SAC_07c) investigated the potential reduction in peak water levels in the Sutter Bypass by removing linear vegetation features along sloughs and channels that bisect the Sutter Bypass. Vegetation thinning was assumed to occur at five locations, including Willow Slough, Nelson Slough, Sacramento Slough, Butte Slough, and along a ponded area 3 miles south of Nelson Slough. Figure 2-19 shows the extent of changes in Butte Slough, in the northern portion of the model domain, while Figure 2-20 shows the three sloughs and the ponded area in the southern portion of the Sutter Bypass where vegetation thinning was assumed to take place. These vegetation clearing efforts total approximately 5 linear miles of narrow vegetation corridor along the sloughs. Results indicate a negligible reduction in the peak water surface profile of 0.06 foot for this simulation, compared to the existing conditions simulation. The predicted water surface profile for this simulation is presented on Figure 2-21.

The third simulation in this series (Yolo_Full_1957-SAC_08c) addressed the longitudinal vegetation corridors along the toe drains, focusing on reducing the lateral width of these features and thus their incursion into the floodway and influence on the flows. A total of 189 acres in the SNWR were cleared of vegetation to a Manning's value of 0.04, and 566 acres outside the refuge were cleared of vegetation and converted to agricultural land use. Figure 2-22 presents the location of these areas. Results for this simulation indicate a reduction in peak water level of up to 0.64 foot compared to the Existing Conditions simulation, with the largest improvements in the SNWR, as demonstrated by Figure 2-23. This improvement includes the vegetation management options modeled in the previous two simulations of this series.

The fourth simulation in this series (Yolo_Full_1957-SAC_08d) converted 215 acres of natural grasslands and dense vegetation near the Feather River confluence to agricultural land use, to determine how much the higher-friction land uses in this critical area were affecting water level predictions. Figure 2-24 shows the area modified in this simulation, highlighted in dark blue. This simulation was built on the previous simulation (08c) and thus includes the three previous vegetation management options detailed above. Results indicate that conversion of these 215 acres to agricultural use provide a maximum 0.11 foot of additional benefit compared to Run08c. This simulation provides a total benefit of up to 0.75 foot from the Existing Conditions simulation, as demonstrated on Figure 2-25, increasing the freeboard to a minimum of 4.1 feet. This is still below the required 5.0-foot level.

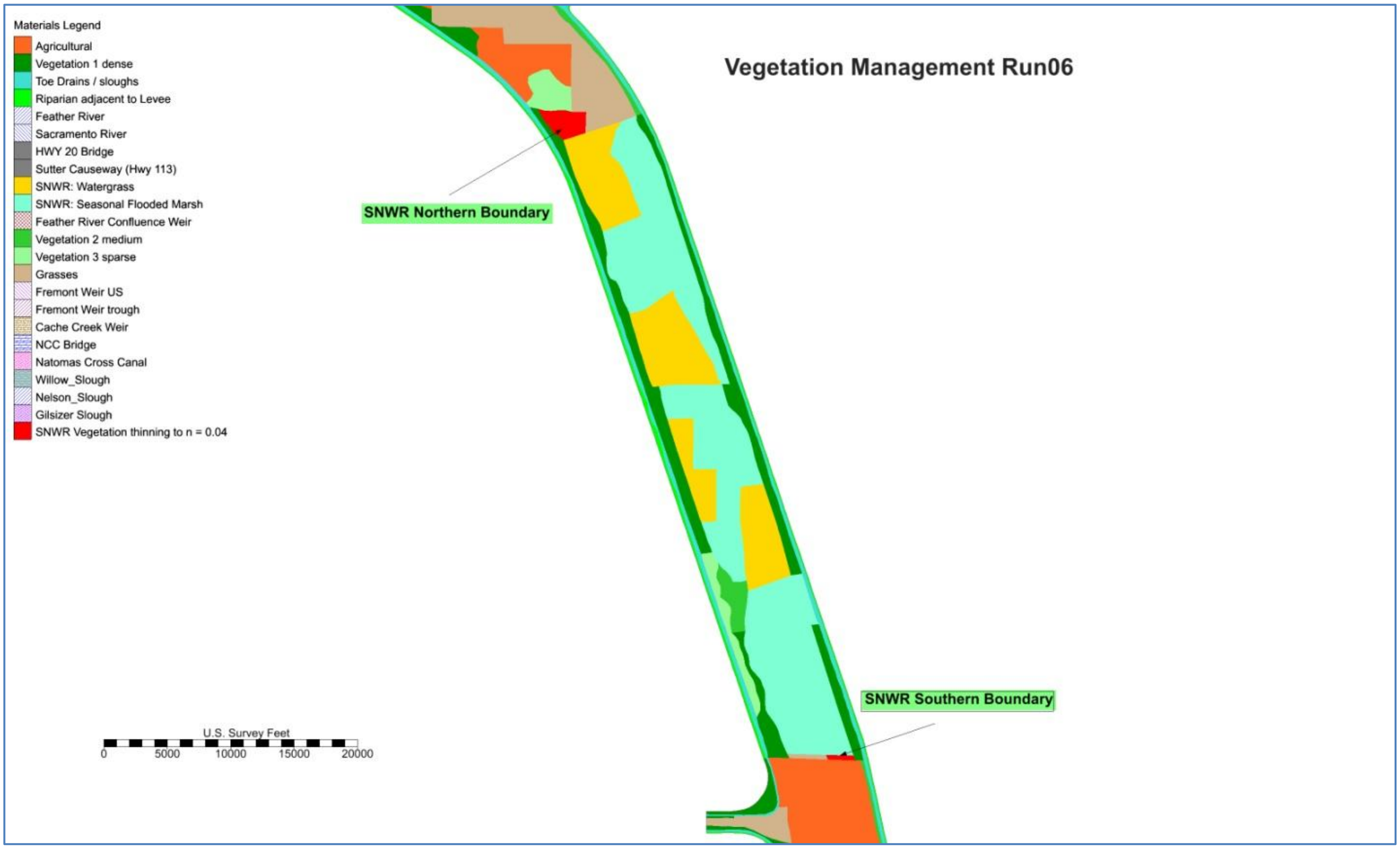

FIGURE 2-17
Location of Vegetation Thinning for Run06 (denoted in Red)

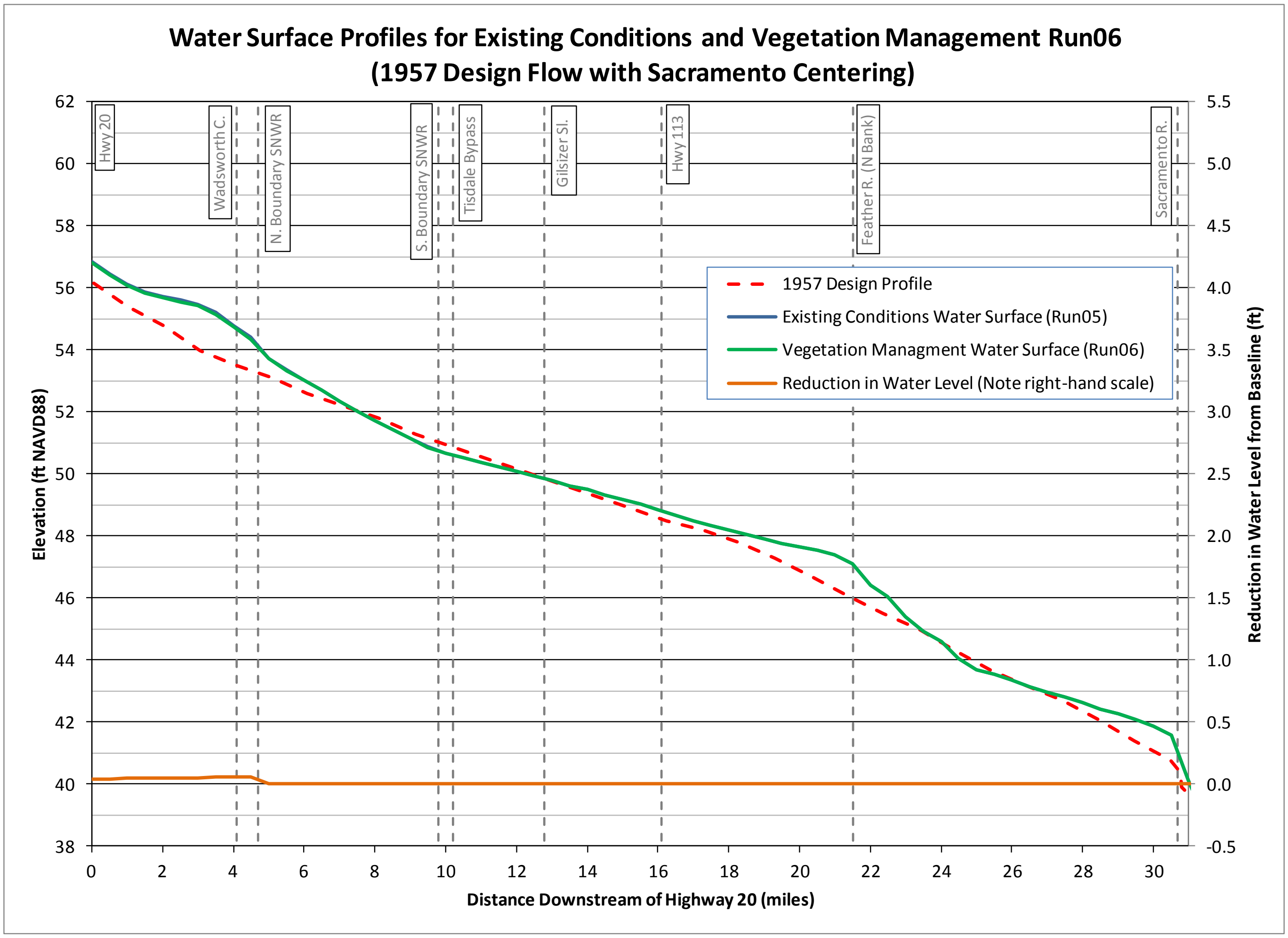

FIGURE 2-18
Water Profiles and Reduction from Existing Conditions for Vegetation Management Run06

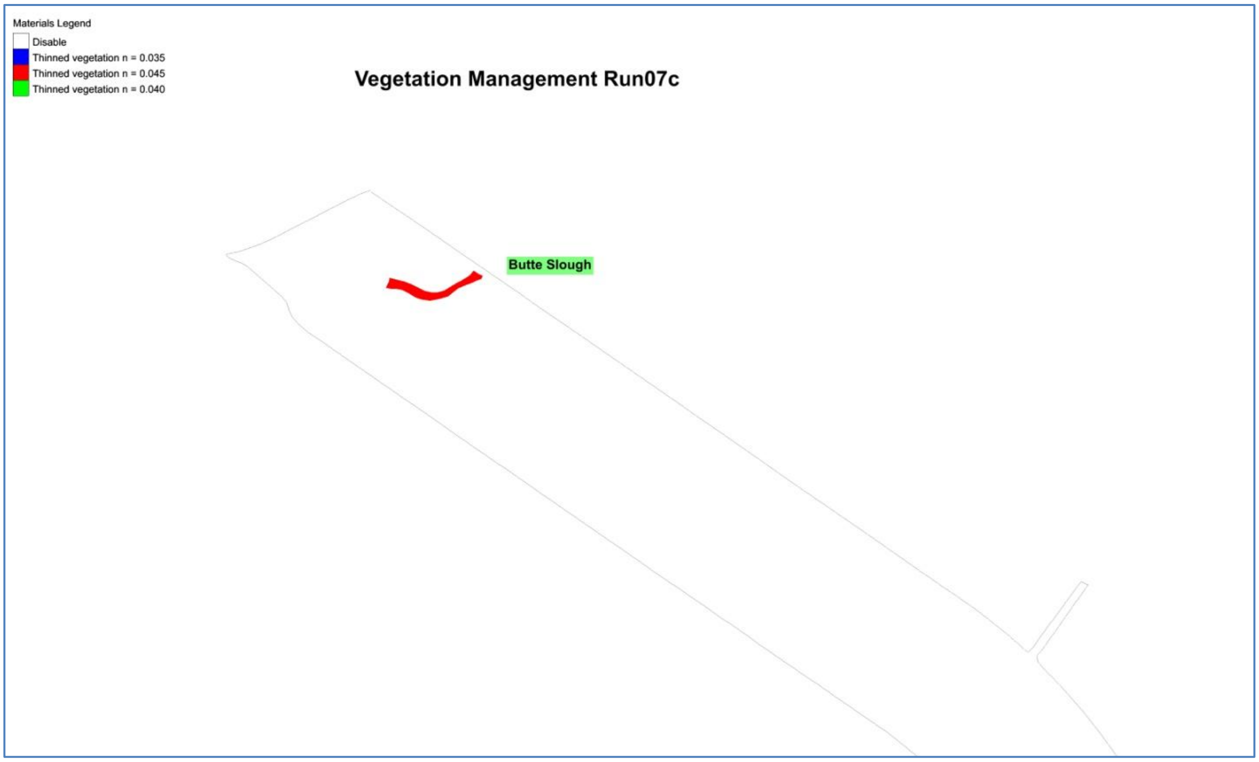

FIGURE 2-19
Location of Vegetation Thinning for Run07c (denoted in Red), North End of Sutter Bypass

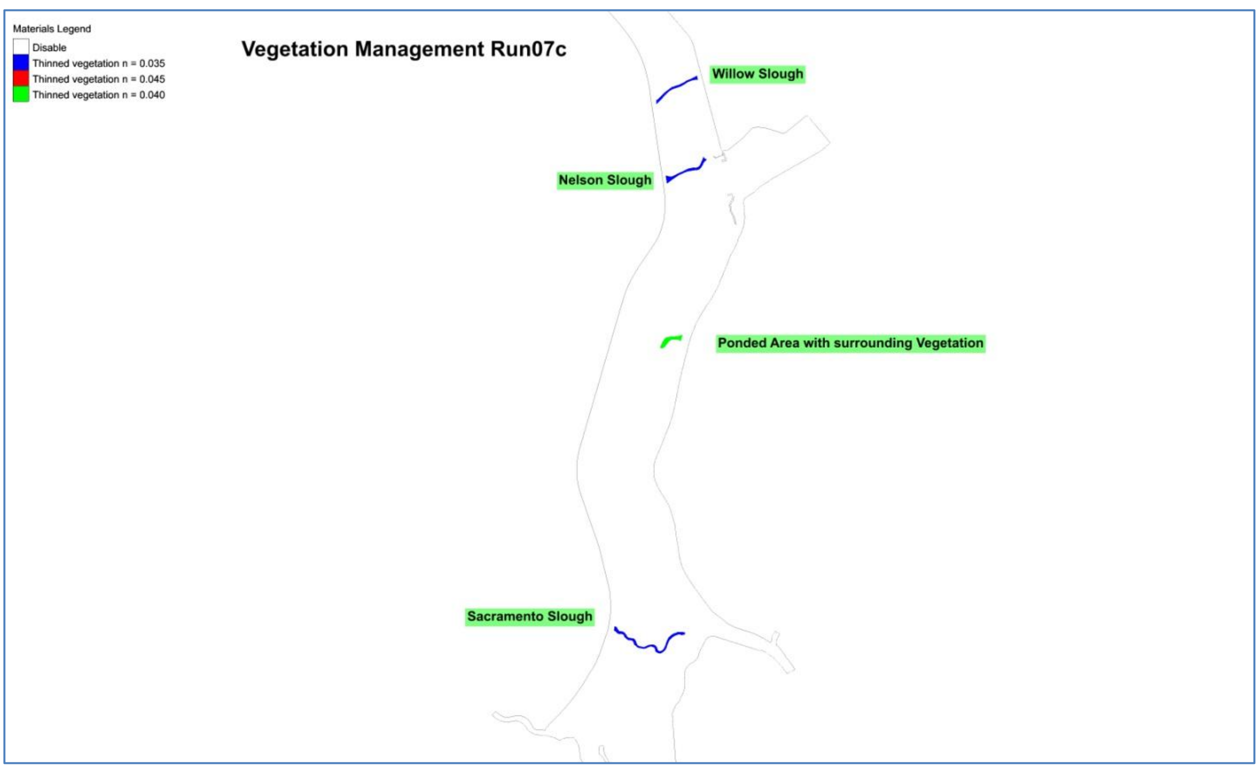

FIGURE 2-20
Location of Vegetation Thinning for Run07c (denoted in Blue); Feather River to Sacramento River Section

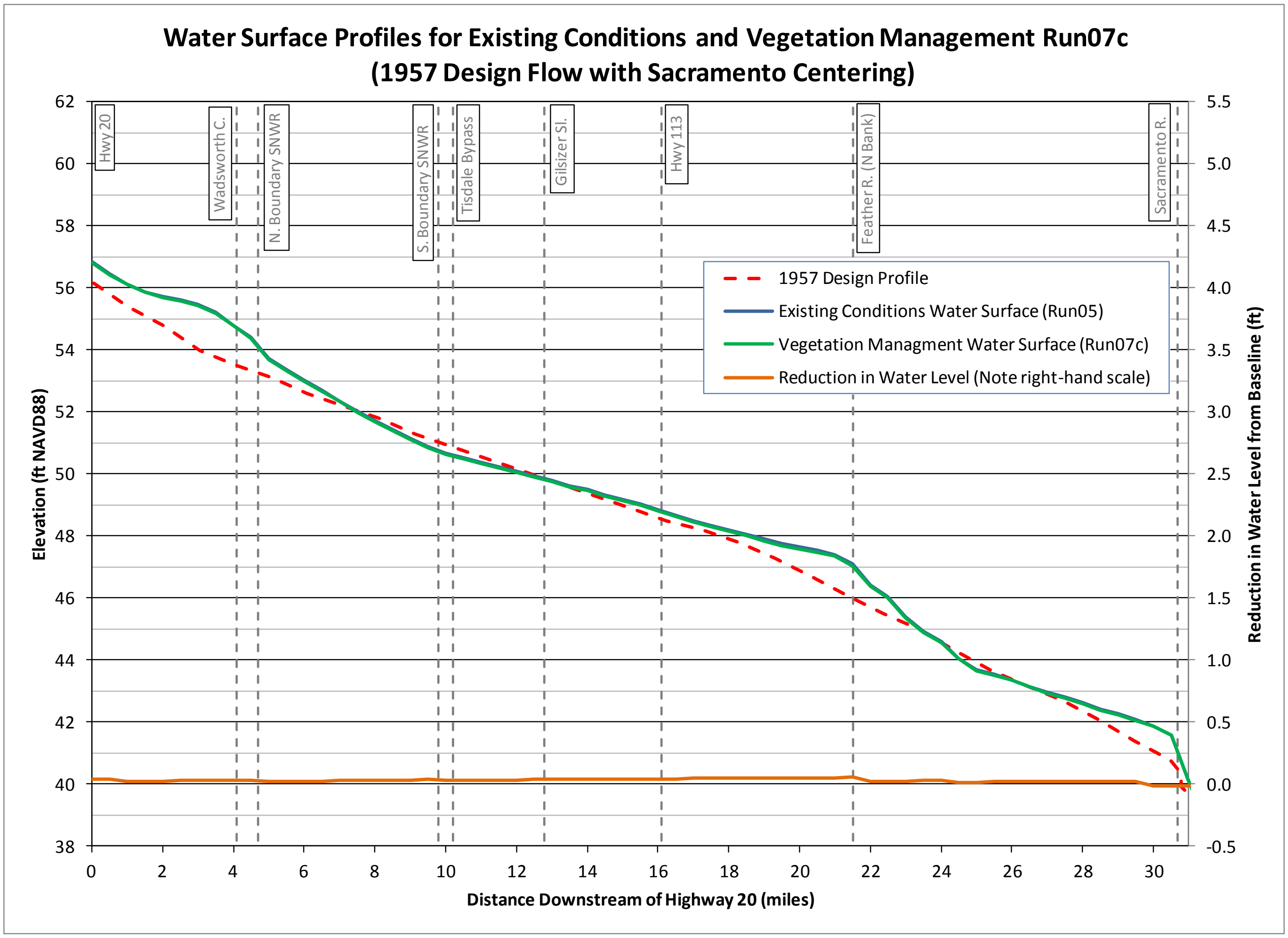

FIGURE 2-21

Water Profiles and Reduction from Existing Conditions for Vegetation Management Run07c

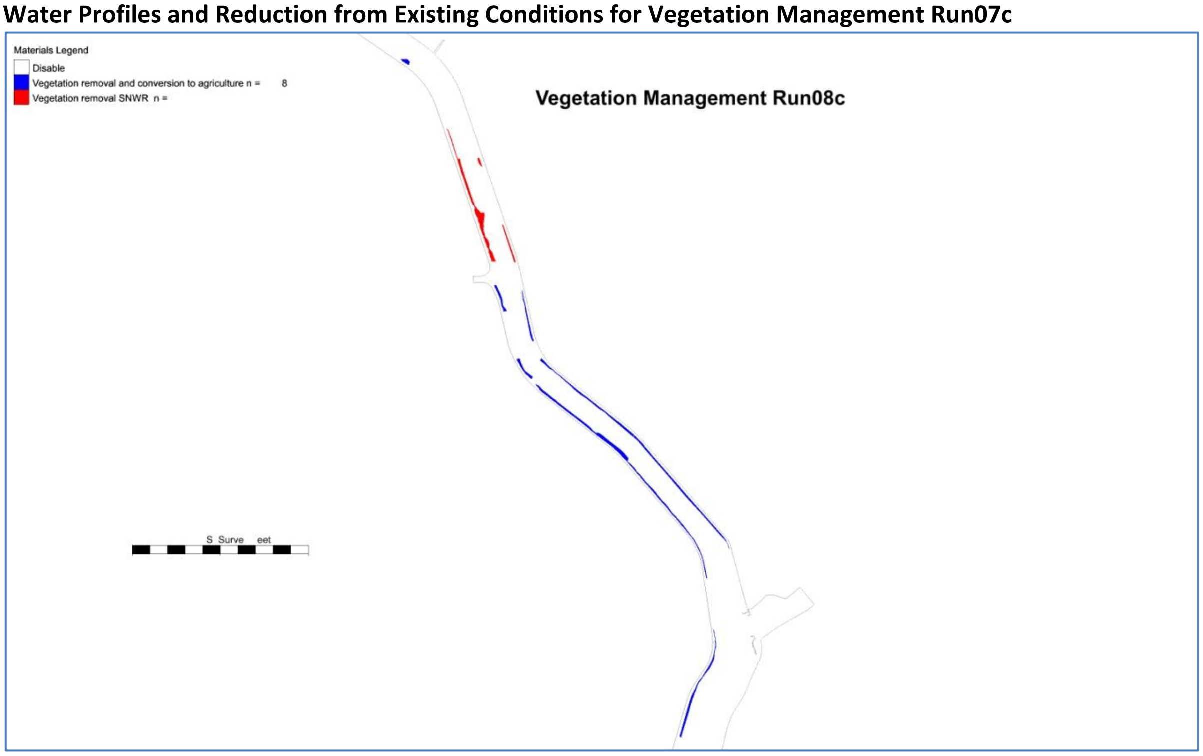

FIGURE 2-22

Location of Vegetation Thinning/Removal for Run08c (denoted in Red and Blue); Wadsworth Canal to Feather River

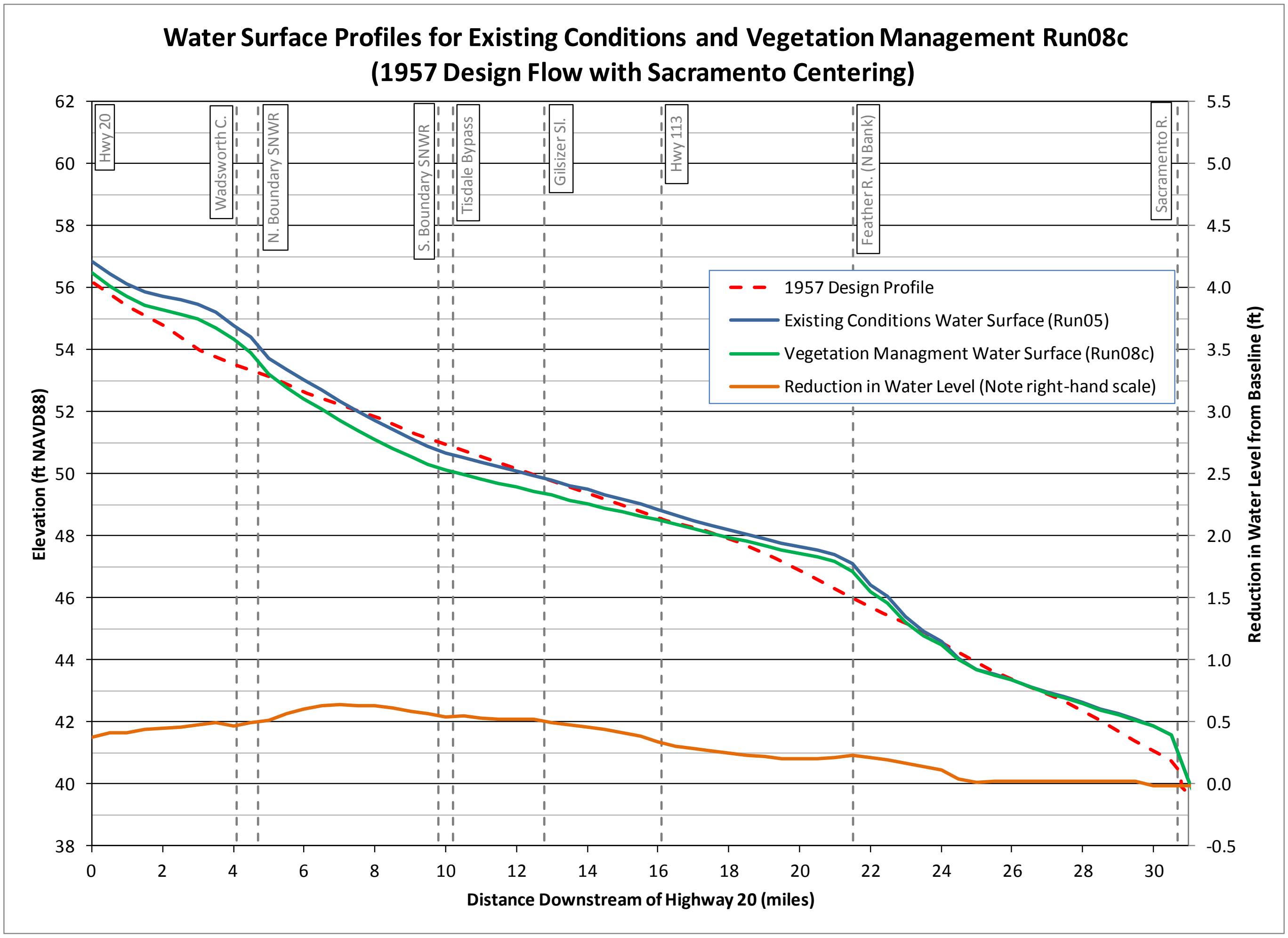

FIGURE 2-23
Water Profiles and Reduction from Existing Conditions for Vegetation Management Run08c

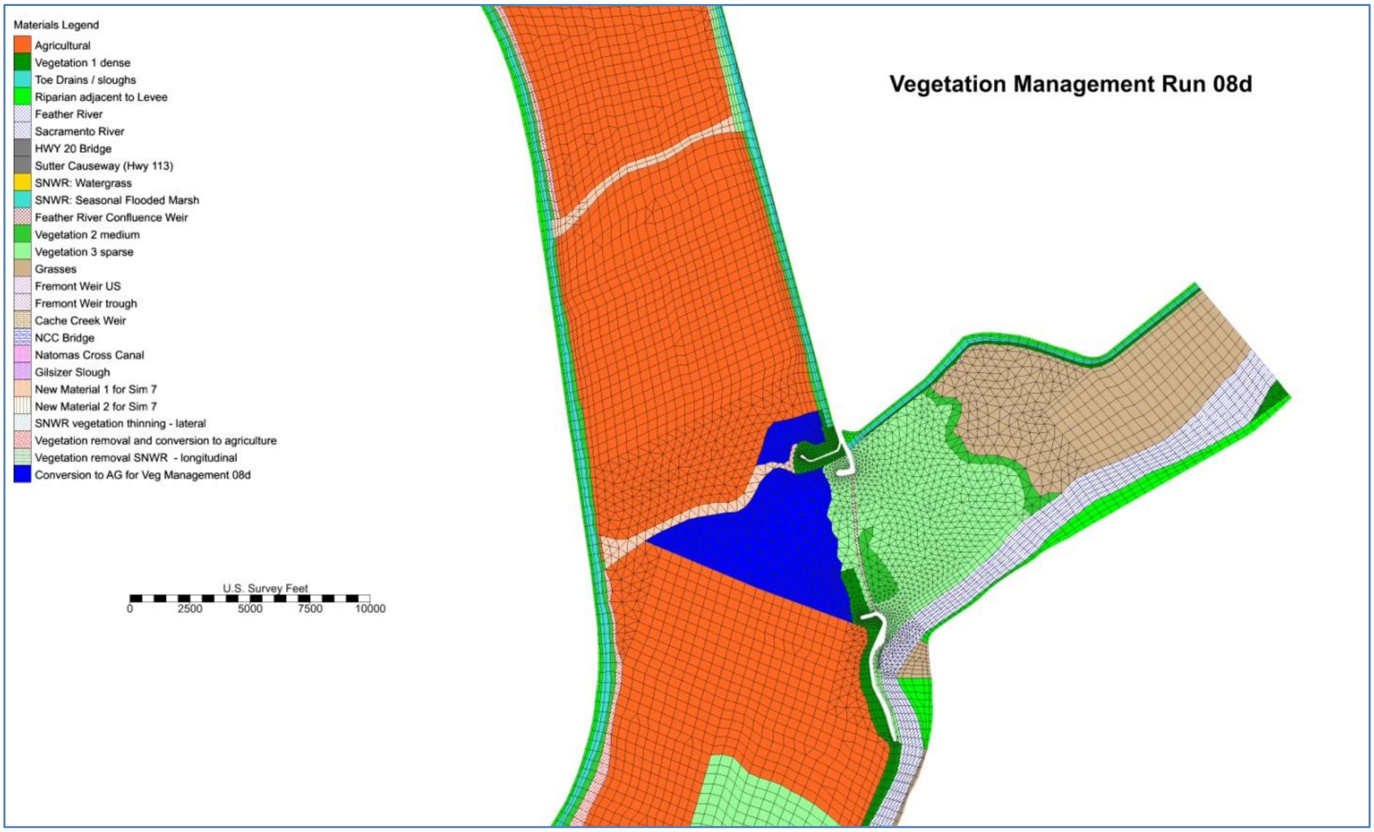

FIGURE 2-24
Location of Vegetation Removal and Conversion to Agricultural Land Use for Run 08d (noted in Blue)

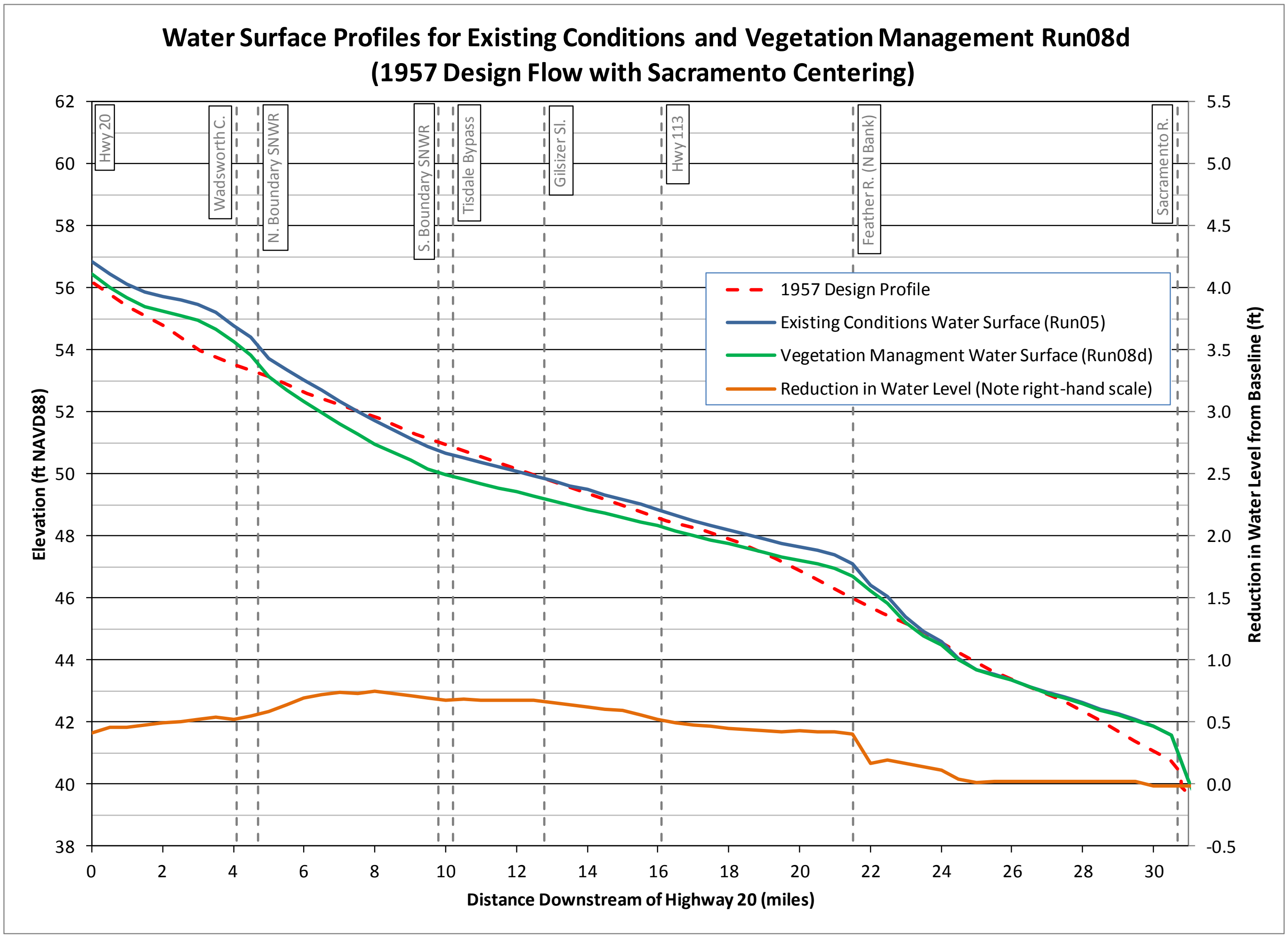

FIGURE 2-25
Water Profiles and Reduction from Existing Conditions for Vegetation Management Run08d

Table 2-3 summarizes the vegetation management simulations conducted under Task 6. Unfortunately, none of the vegetation management simulations was able to simulate a significant, isolated vegetative obstruction in the system that provided the necessary reduction in the computed water surface to achieve the target freeboard. Minimum freeboard for all simulations is between 3.6 and 4.1 feet, which is below the required freeboard. Thus, any efforts to reduce peak water levels via vegetation management will have to be significantly larger in scale than those discussed in this section.

Figure 2-26 presents a summary of the targeted vegetation management scenarios, showing the predicted water level profile for each of the 4 simulations presented in this section.

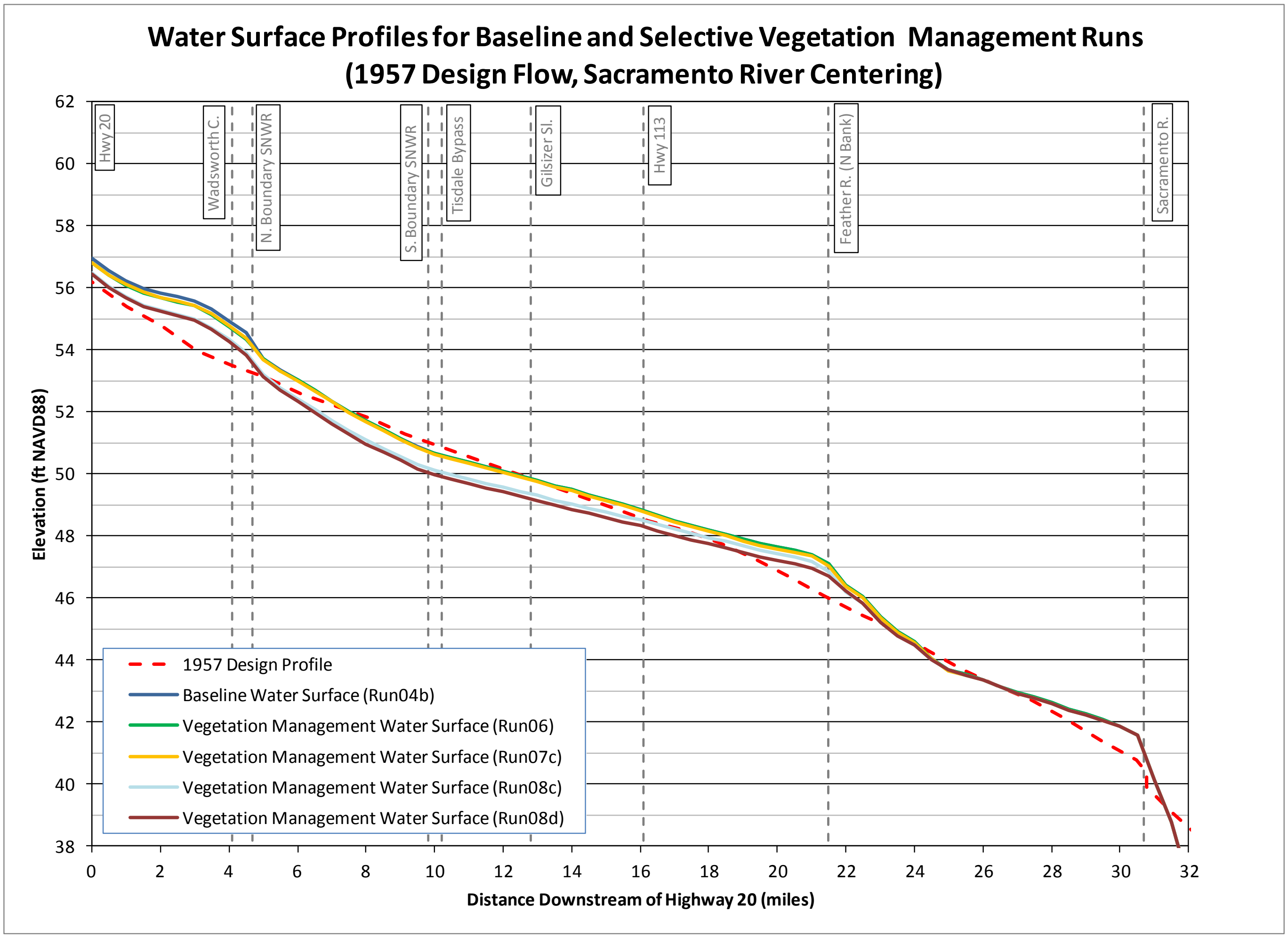

FIGURE 2-26
Water Profiles and Reduction from Existing Conditions for Vegetation Management Scenarios

TABLE 2-3

Summary of Vegetation Management Simulations

Sutter Bypass Two Dimensional Hydraulic Model Report

SMS File Name	Task 6 goal	Description	Acres Managed	Maximum WL Benefit (feet)	Benefit Relative to…	Minimum Freeboard (feet)	Maximum Freeboard Deficit (ft)
Yolo_Full_1957-SAC_05.sms	Existing Conditions	Existing Conditions	N/A	N/A	N/A	3.6	1.7
Yolo_Full_1957-SAC_06.sms	Vegetation Management	Cleared wooded vegetation at north end of SNWR and treeline at south end of SNWR to n = 0.04 (built on Run05)	39	0.06	Existing Conditions (Run05)	3.6	1.7
Yolo_Full_1957-SAC_07c.sms	Vegetation Management	Cleared linear vegetation features along sloughs and water areas that bisect Sutter Bypass to n between 0.035 and 0.045 (92 acres over five areas, built on Run06)	131	0.06	Existing Conditions (Run05)	3.6	1.7
Yolo_Full_1957-SAC_08c.sms	Vegetation Management	Cleared longitudinal wooded vegetation features along bypass to reduce friction; cleared 189 acres in SNWR to n = 0.04 and cleared and converted 566 acres to agricultural use n = 0.028 (built on Run07c)	886	0.64	Existing Conditions (Run05)	4.0	1.2
Yolo_Full_1957-SAC_08d.sms	Vegetation Management	Converted 215 acres of natural grasses and dense vegetation adjacent to the Feather River to agricultural land use (n = 0.028) to reduce friction (built on Run08c)	1101	0.75	Existing Conditions (Run05)	4.1	1.1

.

2.2.5 Structural Modification Simulations

Several simulations were conducted to investigate the influence on peak water levels of a range of structural modifications to the Sutter Bypass, including the removal of existing training levees in the vicinity of Nelson Slough at the Feather River/Sutter Bypass confluence, and grading of local high spots in the topography, primarily near the Feather River confluence.

The first simulation conducted in this series (Yolo_Full_1957-SAC_09b) investigated the removal of the northern training dikes at the Feather River confluence to see if these structures were causing elevated water levels in the Sutter Bypass. The existing levees were assumed to be graded to equal adjacent floodplain elevations. Model results indicate that removing the training levees leads to an increase in the peak water surface elevations in the Sutter Bypass, raising water levels compared to the Existing Conditions simulation by up to 0.09 foot. The removal of the training levees alters the water surface slope on the Feather River

Results indicate that the training levees were not responsible for causing a backwater effect (backing up water) in the vicinity of Nelson Slough. The northern training levee is located on the eastern bank where ground elevations are higher than average. The area around the levee is also comprised of dense forest; thus, there is not a significant flow of water through this portion of the cross section. Removal of the training levee does not significantly increase the conveyance area in the Sutter Bypass. Figure 2-27 contains water surface profile plots for Run09b and the Existing Conditions simulation (Run05). The design water profile for the 1957 design flows is included for reference. The differences in predicted water surface profiles between Runs 09b and Run05 are plotted on the right-hand axis, with positive numbers indicated a water level reduction (benefit) from the proposed action.

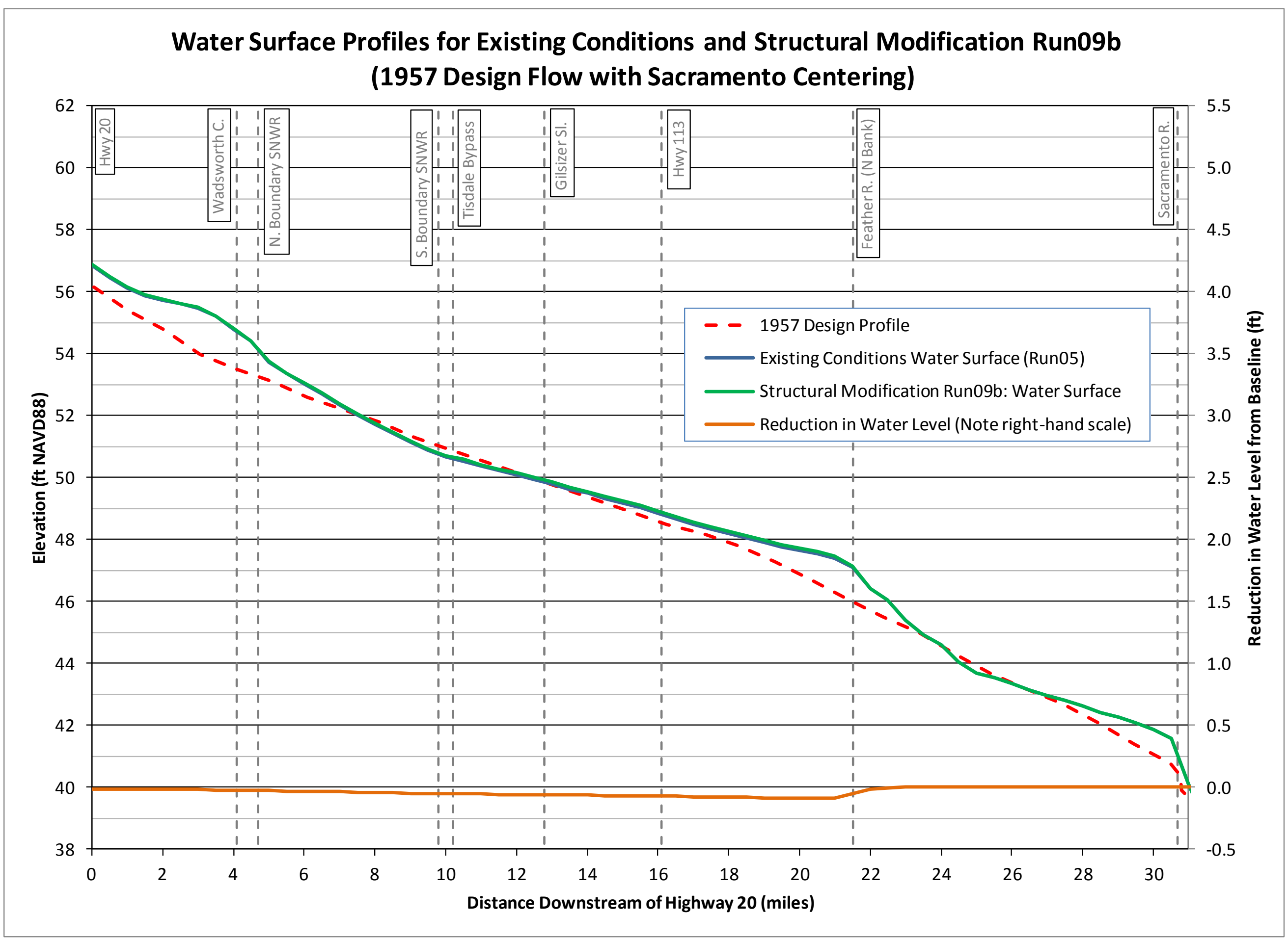

FIGURE 2-27
Structural Modification: Removal of Two Training Dikes near Nelson Slough and Feather River (Run09b)

A total of five simulations were conducted to investigate the influence of sediment deposits on the water surface profile under peak flow conditions, under the hypothesis that local sediment deposits were, in part, responsible for the water surface profile. Figure 2-28 shows three longitudinal elevation profiles, one showing water surface elevation from the Existing Conditions simulation, one showing the 1957 Design profile, and the third showing the existing ground elevation along the centerline of the Sutter Bypass. Review of toe of slope elevations from the 1957 Design documents indicates similar patterns to the presented channel centerline elevations. Three areas are noted with red circles, identifying three separate areas where there are local increases in ground elevation. Two of the three areas are most likely attributable to local sediment deposits from flood flows on the Feather River in the vicinity of Mile 21.5, and the Sacramento River at Mile 31. The third, between Wadsworth Canal and the northern boundary of the SNWR, cannot be directly tied to a river flowing out of bank and depositing sediment on the local floodplain. The sediment deposit at the Sacramento River is a textbook example of natural river levees formed through repeated deposits of sediment during flood flows. The ground profile shown on Figure 2-28 cuts directly across the Sacramento River levees, clearly showing the natural levees, which extend up to 2 miles on either side of the river.

These three areas with local increases in ground elevation correspond to areas in the predicted water surface profile where the water surface slope is notably shallower than average upstream of the local rise in ground elevation and noticeably steeper than average downstream of the local rise in ground elevation. The water surface profiles resemble the expected profile of water flowing over a sill. With this in mind, model simulations were conducted in which portions of the sediment deposits were removed to determine the effect of these features on the water surface profiles. Figure 2-29 presents the ground elevation profile for a portion of the Sutter Bypass in the vicinity of the Feather River confluence. The ground elevation has three zones, outlined in red, corresponding to the portion of the historical sediment deposit removed in three model simulations.

The first sediment grading simulation (Yolo_Full_1957-SAC_11a) removed 400,000 cubic yards of sediment upstream of Nelson Slough. The ground elevation was reduced to 33 feet NAVD88 upstream of Nelson Slough. Model results presented on Figure 2-30 show a negligible decrease in peak water levels (0.03 foot) after removing a portion of the sediment deposit. A second simulation was conducted (Yolo_Full_1957-SAC_11c) that extended the grading downstream of Nelson Slough, removing a total of 1.04 million cubic yards of historical sediment deposits. This simulation yielded a peak decrease in flood levels of 0.13 foot. Results from this simulation are presented on Figure 2-31. The level of sediment removal was increased to 5.9 million cubic yards in Run11f (Yolo_Full_1957-SAC_11f), with grading down to 30 feet NAVD88 over almost 2 miles of the Sutter Bypass, as shown on Figure 2-32. Results from this simulation area presented on Figure 2-33, and indicate a reduction in peak water levels up to 0.44 foot in the vicinity of the sediment removal. It is worth noting how the water level benefit from the sediment removal operation at the Feather River confluence decreases considerably in the upper reaches of the Sutter Bypass.

An additional simulation was conducted in which the sediment grading was extended into the Feather River floodplain, just upstream of the rock weir at the confluence (Yolo_Full_1957-SAC_11d). A total of 2.46 million cubic yards of sediment were removed in this simulation, but results, presented on Figure 2-34, indicate that the water level benefit was actually less than that seen in Run11c, which removed less than one-half as much sediment. These counter-intuitive results are explained by the area over which sediment was removed; this simulation extended the excavation into the Feather River floodplain. As seen in previous results (removal of training dikes), actions which affect Feather River flows can actually increase water levels in the Sutter Bypass.

The final simulation conducted in this series investigated the changes in predicted water levels for a sediment removal event just upstream of the SNWR. In this simulation (Yolo_Full_1957-SAC_12), 575,000 cubic yards of sediment were removed over a 220-acre site, grading the local elevation to 39 feet NAVD88. Results from this simulation show a local reduction in peak water levels of up to 0.19 foot compared to Existing Conditions. Results from this simulation are presented on Figure 2-35.

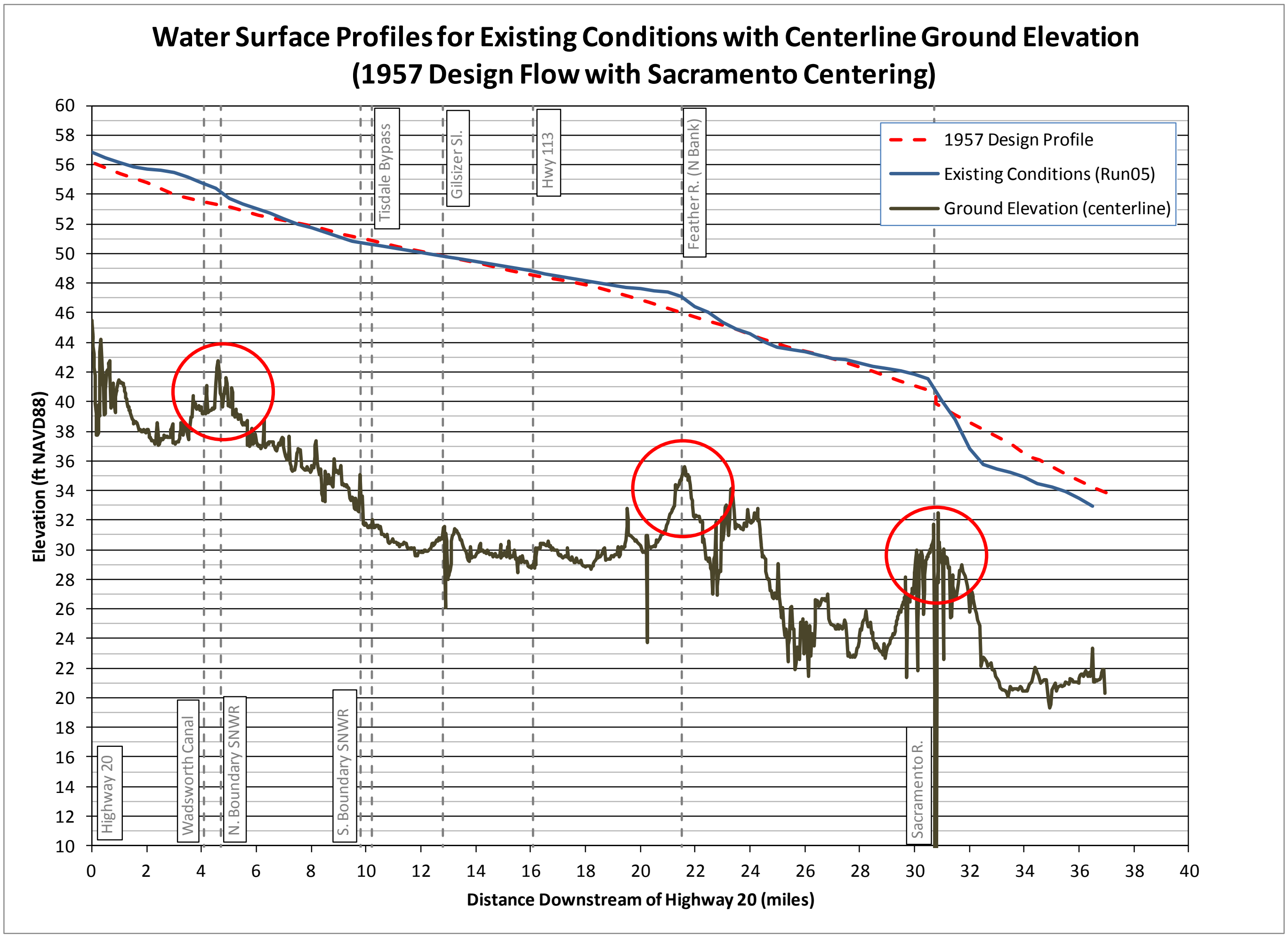

FIGURE 2-28

Ground Elevation Profile with Historical Sediment Deposits Marked

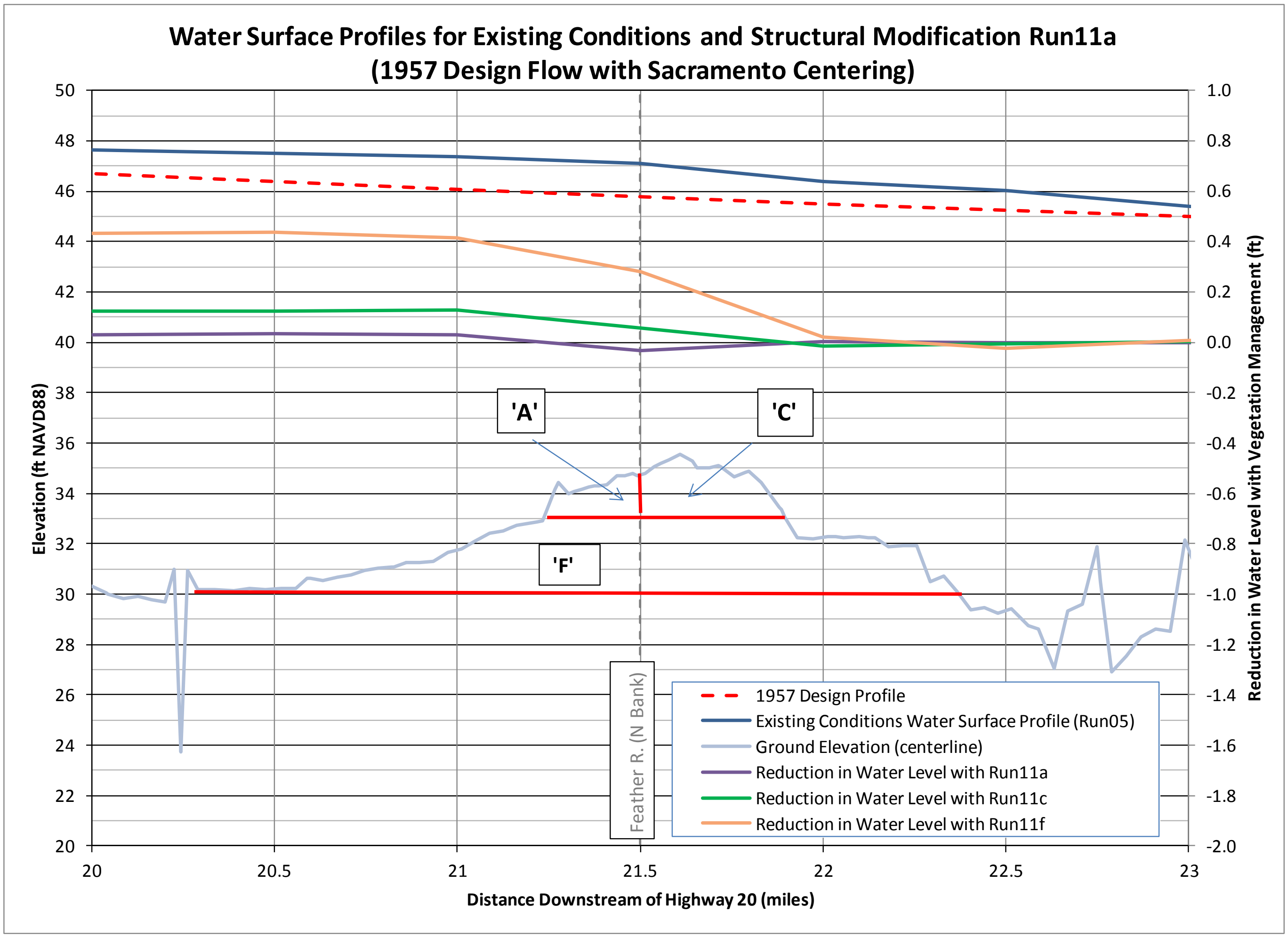

FIGURE 2-29

Schematic of Sediment Removal for Simulations 11a, 11b, and 11f

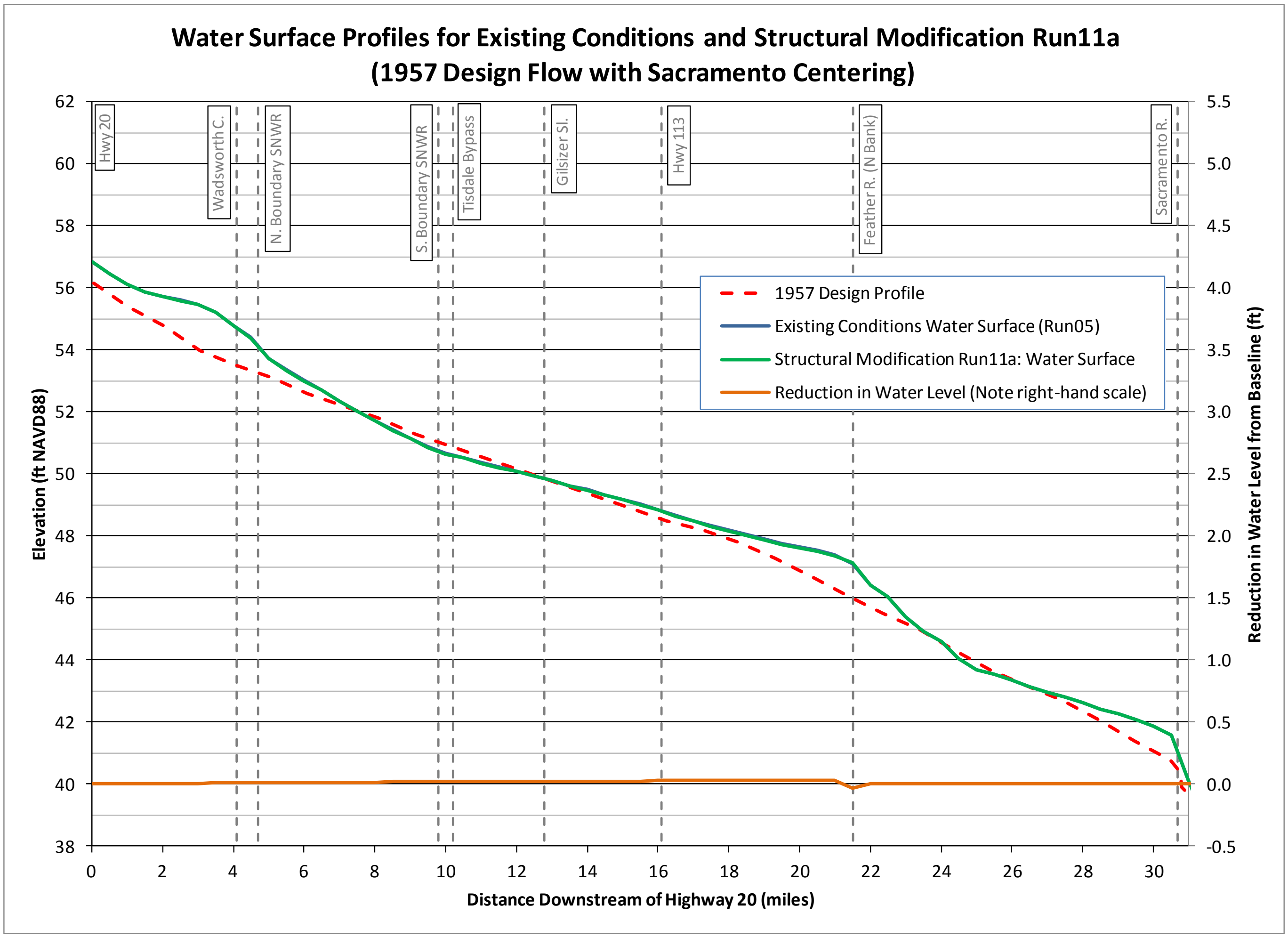

FIGURE 2-30

Structural Modification: Removal of 400,000 cubic yards of Deposited Sediment in Sutter Bypass Upstream of Nelson Slough (Run11a)

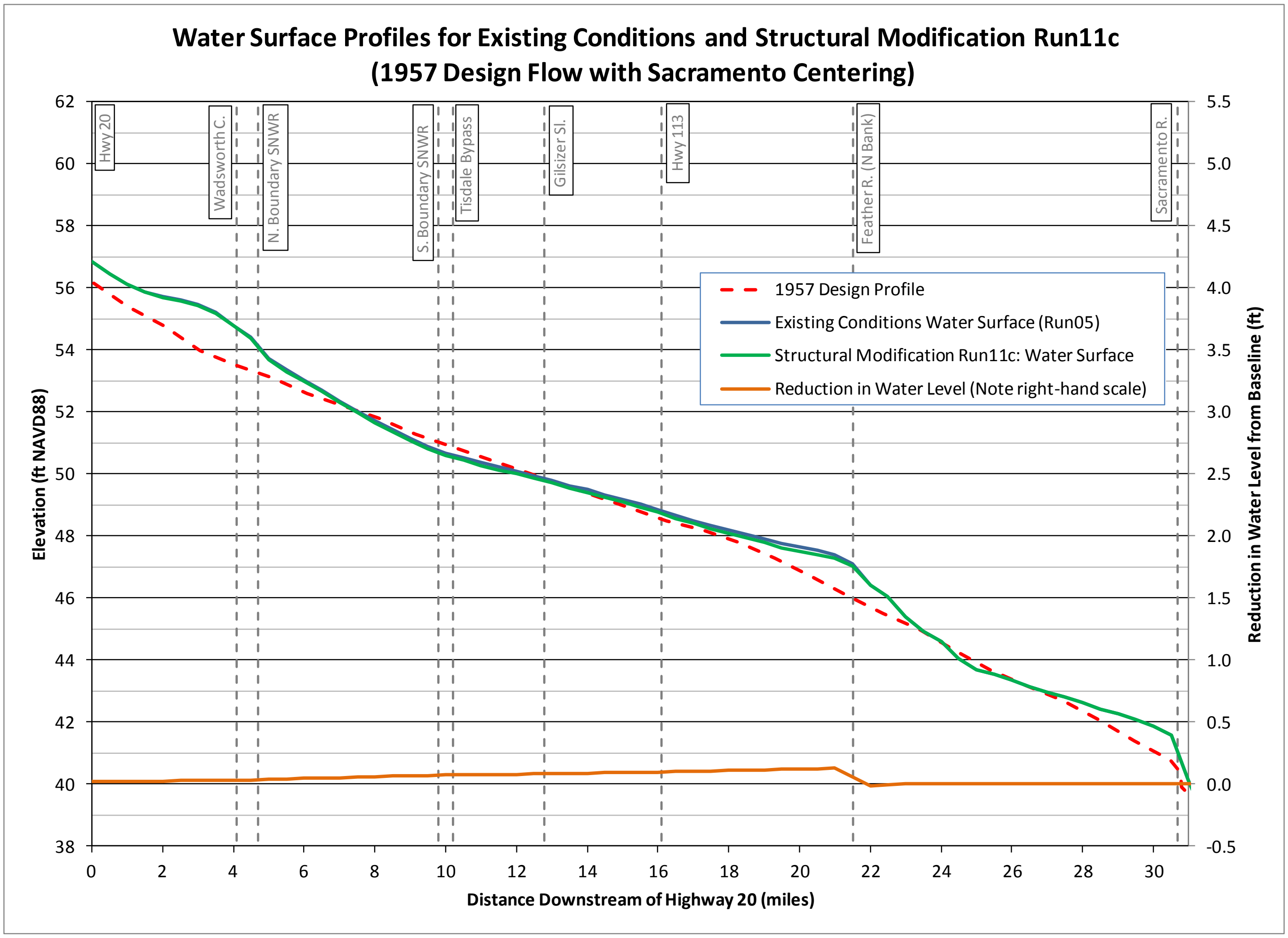

FIGURE 2-31

Structural Modification: Removal of 1.04 million cubic yards of Deposited Sediment in Sutter Bypass near Nelson Slough (Run11c)

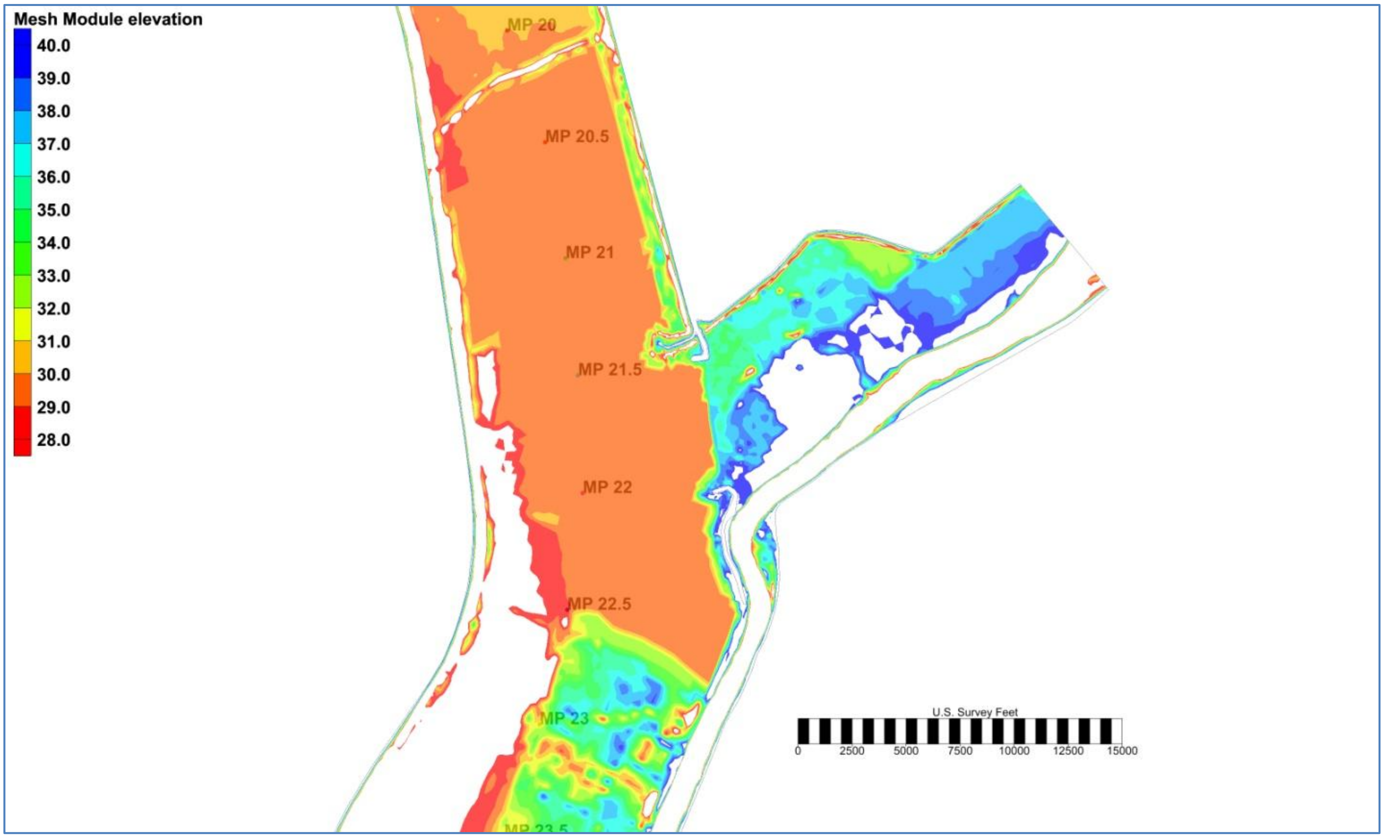

FIGURE 2-32

Topography for Run 11f (Yolo-Full-1957-SAC_11f) Showing Extent of Removal of 5.9 Million Cubic Yards of Sediment to 30 feet Elevation

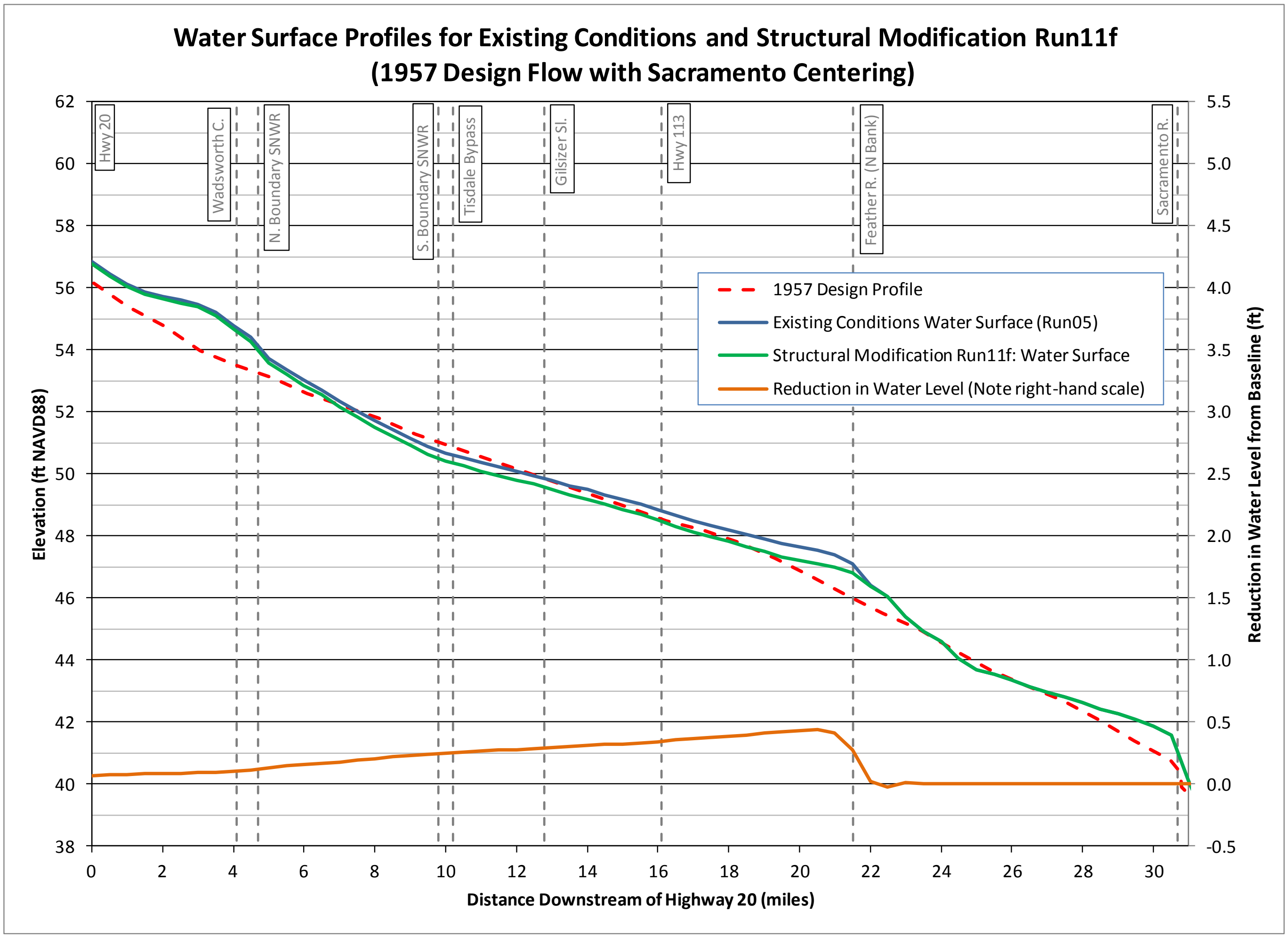

FIGURE 2-33
Structural Modification: Removal of 5.90 Million Cubic Yards of Deposited Sediment in Sutter Bypass near Feather River Confluence (Run11f)

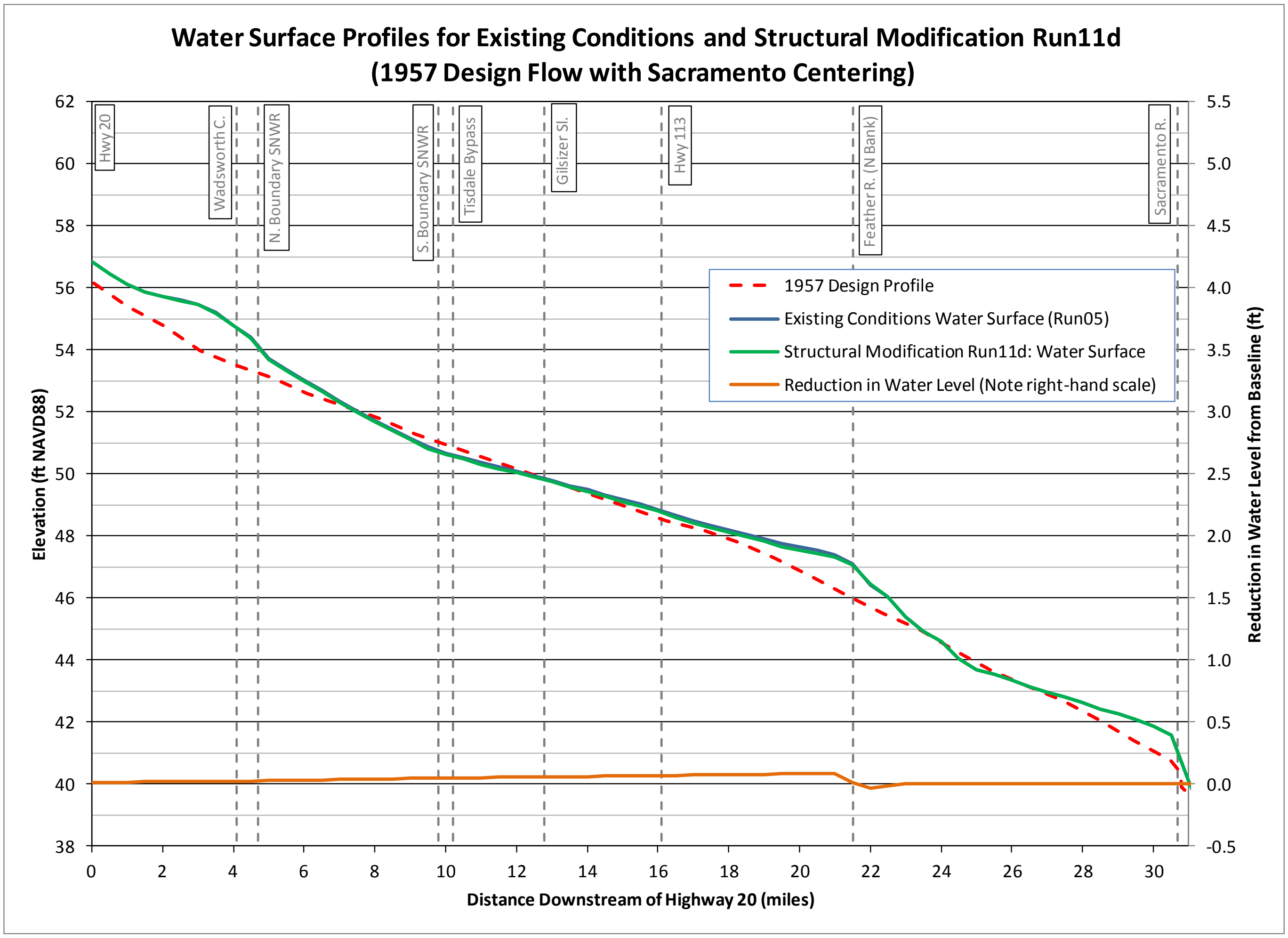

FIGURE 2-34
Structural Modification: Removal of 2.46 Million Cubic Yards of Deposited Sediment in Sutter Bypass and Feather River near Confluence (Run11d)

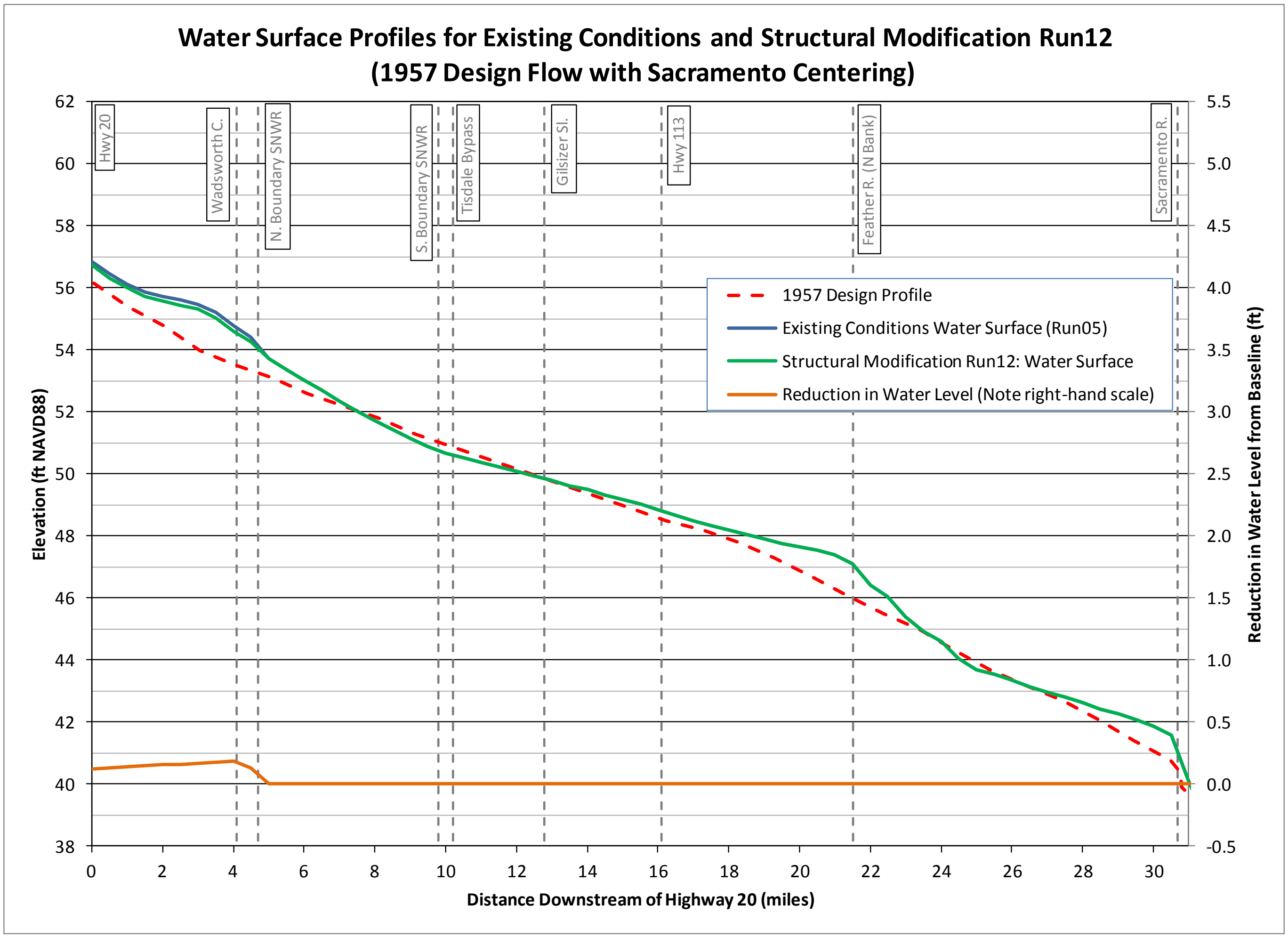

FIGURE 2-35
Structural Modification: Removal of 575,000 Cubic Yards of Deposited Sediment in Sutter Bypass Downstream of Wadsworth Canal (Run12)

Table 2-4 summarizes the six simulations conducted to determine if structural modification could result in a significant reduction in peak flood elevations in the Sutter Bypass. The maximum benefit in terms of reducing peak water surface elevations is tabulated for each simulation, as is the minimum freeboard along the Sutter Bypass levees. Note that the critical, minimum freeboard may be affected by a simulation that provides non-negligible water surface reductions in other parts of the system. For example, Run11f, which removed 5.9 million cubic yards of sediment in the Sutter Bypass near the Feather River confluence, yielded a maximum water level benefit of 0.44 foot just upstream of the Feather River, but only reduced the critical freeboard by 0.1 foot, since the critical freeboard for this simulation is in the northern Sutter Bypass near Wadsworth Canal.

The structural modifications investigated to date have shown a positive benefit in the vicinity of the improvements but have not demonstrated significant reductions in peak water levels across the entire system. These evaluations indicate that neither removal of the training dikes at the Feather River Confluence nor removal of significant volumes of historical sediment deposit in the Sutter Bypass area are, by themselves, likely to alter flood elevations so that the required freeboard along the Sutter Bypass levees is achieved.

TABLE 2-4
Summary of Structural Modification Simulations
Sutter Bypass Two Dimensional Hydraulic Model Report

SMS File Name	Task 6 goal	Description	Acres Managed	Maximum WL Benefit (feet)	Benefit relative to…	Minimum Freeboard (feet)	Maximum Freeboard Deficit (ft)
Yolo_Full_1957-SAC_05.sms	Existing Conditions	Existing Conditions	N/A	N/A	N/A	3.6	1.7
Yolo_Full_1957-SAC_09b.sms	Structural Modifications	Removed two northern training levees	N/A	-0.09	Existing Conditions	3.6	1.7
Yolo_Full_1957-SAC_11a.sms	Structural Modifications	Graded and removed 400k cu yd of sediment deposits upstream of Nelson Slough	138	0.03	Existing Conditions	3.6	1.7
Yolo_Full_1957-SAC_11c.sms	Structural Modifications	Graded and removed 1.04 mil cu yd of sediment deposits upstream and downstream of Nelson Slough	304	0.13	Existing Conditions	3.6	1.7
Yolo_Full_1957-SAC_11d.sms	Structural Modifications	Graded and removed 2.46 mil cu yd of sediment deposits near Nelson Slough, extending into the Feather River floodplain	545	0.09	Existing Conditions	3.6	1.7
Yolo_Full_1957-SAC_11f.sms	Structural Modifications	Graded and removed 5.90 mil cu yd of sediment deposits downstream of Willow Slough (Built from Run11c)	980	0.44	Existing Conditions	3.7	1.6
Yolo_Full_1957-SAC_12.sms	Structural Modifications	Graded and removed 575k cu yd of sediment deposits upstream of SNWR	218	0.19	Existing Conditions	3.7	1.5

2.3 Existing Conditions under Alternate Hydrology

This section provides a discussion of model simulation conducted with flows exceeding those used for the 1957 Design Profile. Table 2-5 summarized the model inflows for all the various hydrologic conditions used in the study.

The Existing Conditions simulation (Run05) with the 1957 Design Flows was rerun with flows from the O&M Manual, which are approximately 20 percent higher than the 1957 Design flows upstream of the Feather River. Two simulations were conducted, the first with downstream boundary conditions identical Run05, and the second with an increase in the YBY stage condition to account for the extra flow. Upstream of the Fremont Weir, results are nearly identical.

Longitudinal profile plots for the Existing Conditions simulations with 1957 Design Hydrology and O&M Manual hydrology are compared on Figure 2-36. The O&M Manual flows yield a water surface elevation up to 1.7 feet higher than those for the 1957 Design flows. Figures 2-37a and 2-37b present longitudinal plots of the calculated freeboard, demonstrating a minimum freeboard of 2.0 feet on the west levee upstream of the SNWR. The results of this analysis support the intuitive conclusion that the higher O&M flows will result in a lower freeboard and remain significantly below the target freeboard requirements.

Additional simulations were also conducted with the 100 year and 200 year inflows as developed by the US Army Corps of Engineers and used in the Common Features Study. Figure 2-38 provides results of these two simulations allowing for comparison of predicted water surface profiles through the Sutter Bypass to those found with the standard (1957 Design Flows) hydrology. Results indicate that the higher inflows have an almost uniform impact on freeboard upstream of the Feather River, yielding a decrease in freeboard by an average of 1.9 feet for the 100 year flows and 3.8 feet for the 200 year flows compared to existing conditions with 1957 Design flows.

TABLE 2-5
Peak Flows and Stages at Sutter Bypass Two Dimensional Hydraulic Model Boundaries
Sutter Bypass Two Dimensional Hydraulic Model Report

Location	January 2006 (Calibration) Flow (cfs)	January 1997 (Verification) Flow (cfs)	100-yr Flood (Common Features HEC-RAS; Sacramento Centering) Flow (cfs)	200-yr Flood (Common Features HEC-RAS; Sacramento Centering) Flow (cfs)	1957 Design Flow (Sacramento Centering) Flow (cfs)	O&M Manual Flow (Sacramento Centering) Flow (cfs)
Long Bridge	109,310	127,444	184,002	227,157	150,000	178,000
Wadsworth Canal	1,500	1,500	1,572	1,501	1,500	1,500
Tisdale Bypass	20,375	21,609	16,551	16,705	28,500	37,000
Feather River	183,612	317,716	323,826	377,289	200,000	200,000
Knights Landing/Sacramento River	29,455	34,572	39,564	40,337	30,000	30,000
Natomas Cross Canal	11,043	8,491	24,871	27,877	22,000	3,500
Knights Landing Ridge Cut	8,803	4,158	304	340	19,000	19,000
Cache Creek	27,915	25,466	39,154	40,568	15,000	15,000
	Stage (ft NAVD88)	**Stage (ft NAVD88)**	**Stage (ft NAVD88)**	**Stage (ft NAVD88)**	**Stage (ft NAVD88)**	**Stage (ft NAVD88)**
Sacramento River at Verona (VON)	37.94	41.31	42.33	43.65	41.31	41.31
Yolo Bypass Woodland Gauge (YBY)	30.73	32.86	35.20	36.55	32.52	32.70

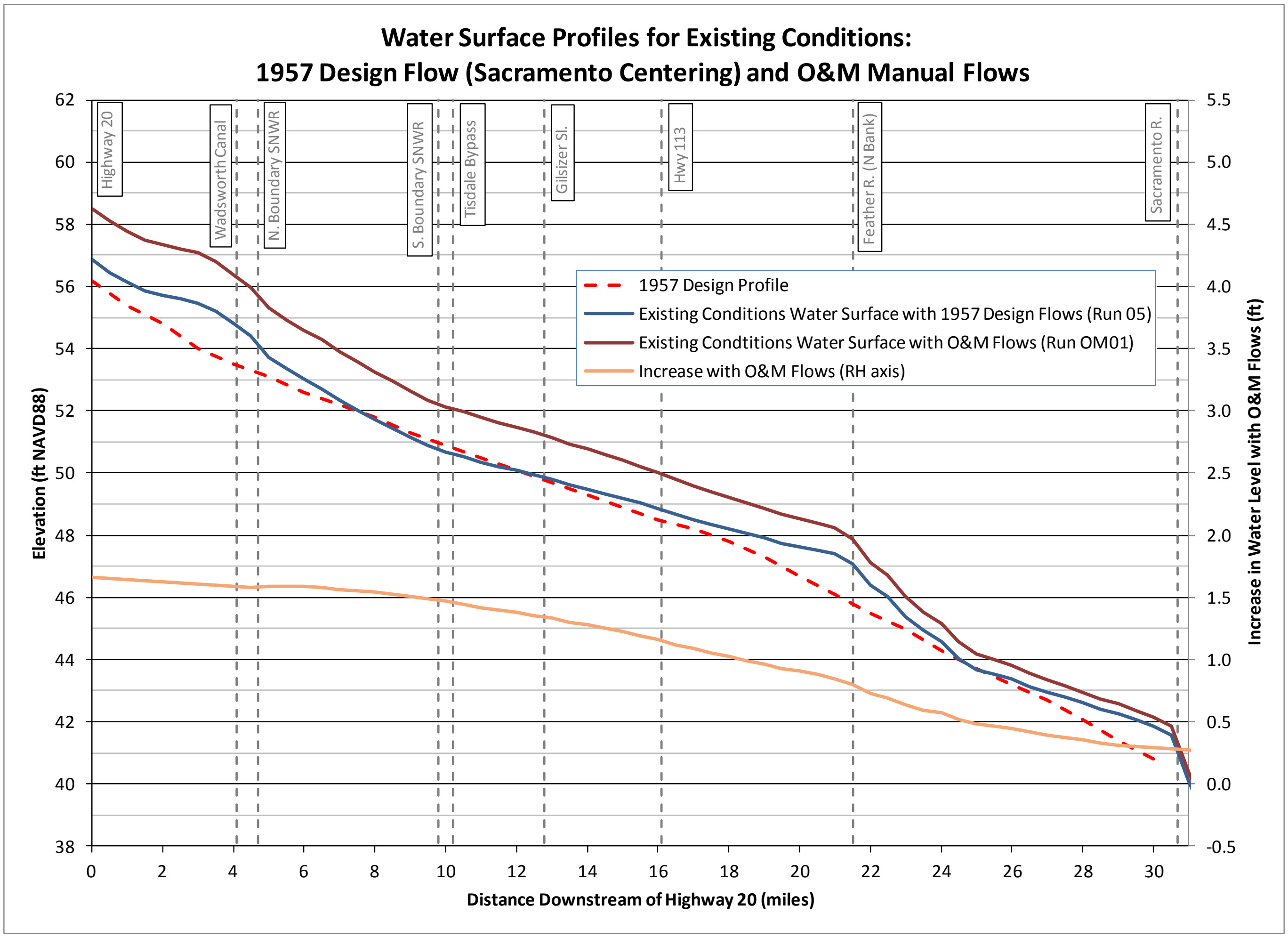

FIGURE 2-36
Water Surface Profiles for O&M Manual Flows in Upper Sutter Bypass

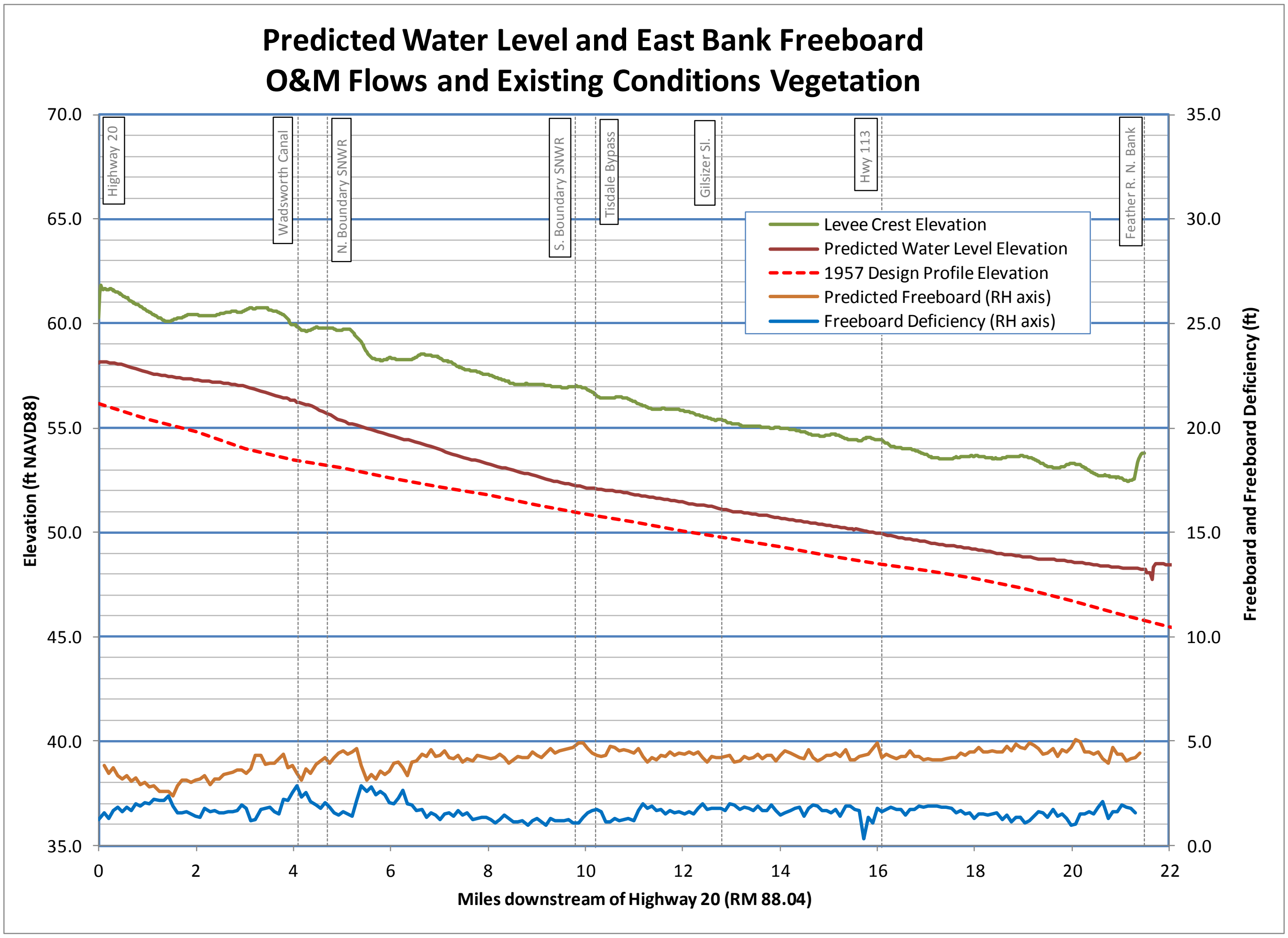

FIGURE 2-37A
East Bank Freeboard Profile for Existing Conditions Simulation with O&M Flows

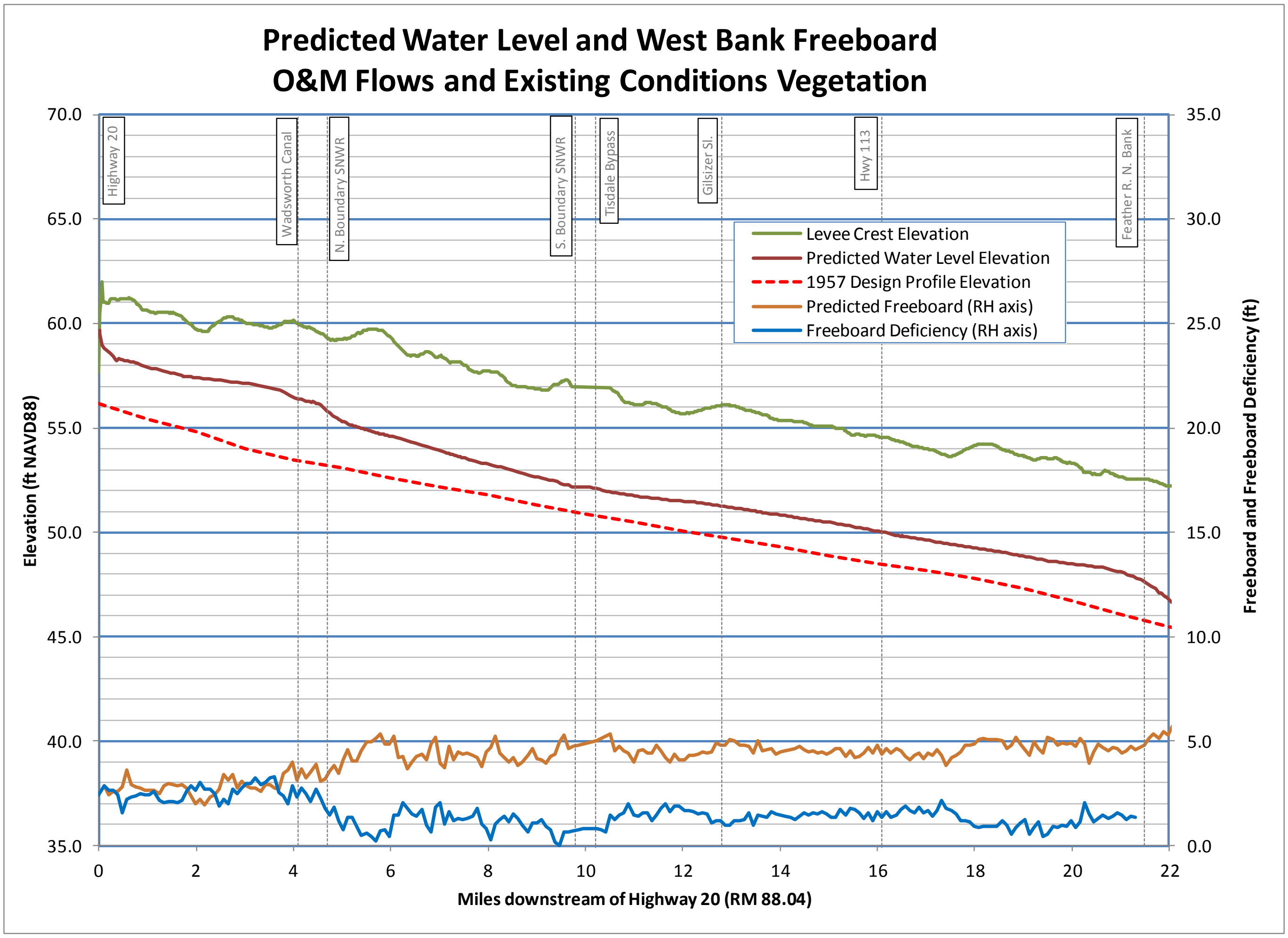

FIGURE 2-37B
West Bank Freeboard Profile for Existing Conditions Simulation with O&M Flows

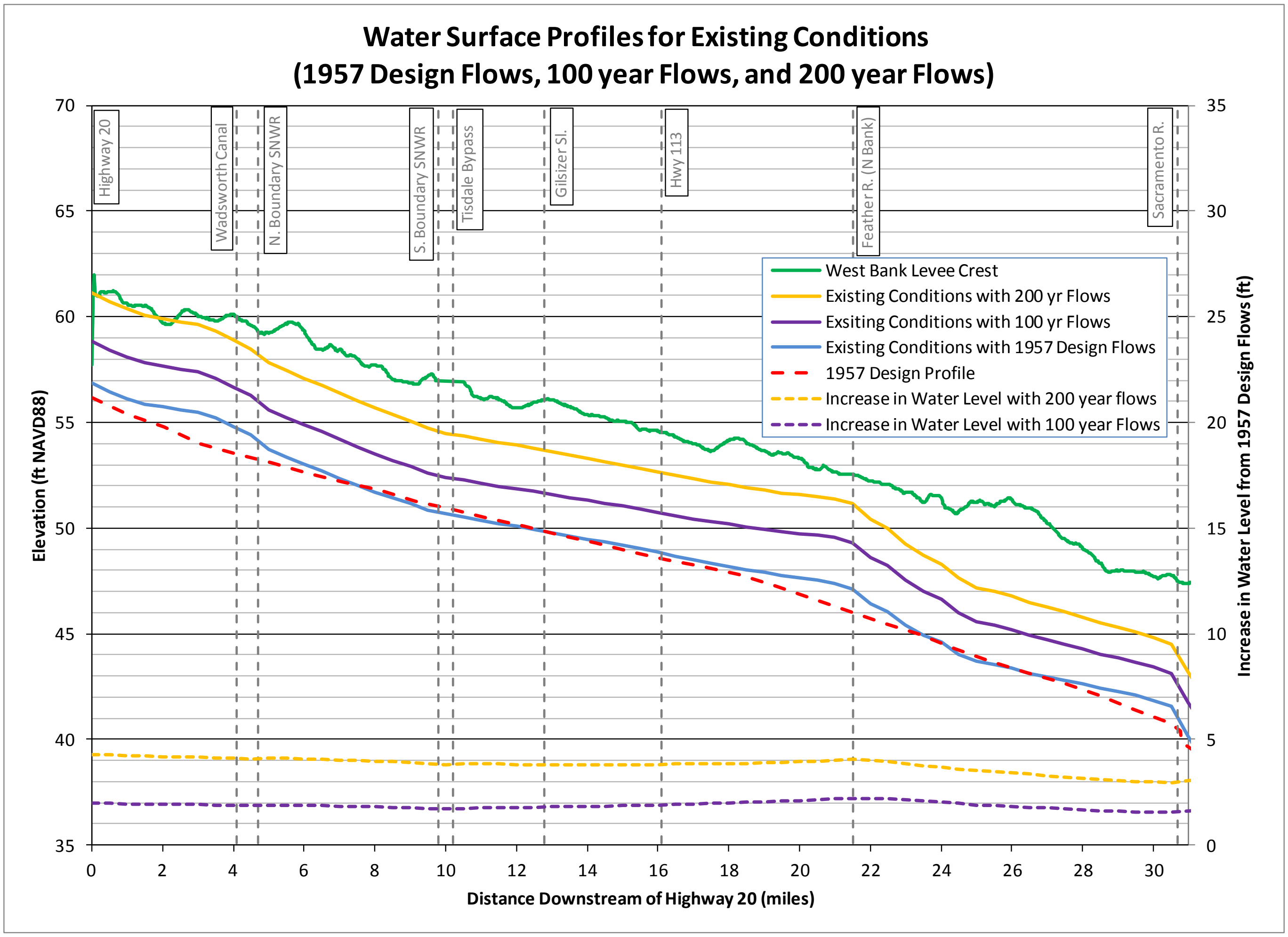

FIGURE 2-38

Water Surface Profiles for 100-year and 200-year Flows in Upper Sutter Bypass

2.4 Feather River Levee Setback Simulation

The Existing Conditions model grid was adjusted to represent a proposed levee setback on the Feather River (West Levee) just upstream of the Sutter Bypass. Three potential levee alignments have been proposed (see Figure 2-39) as part of the Sutter Butte Flood Control Agency (SBFCA) Feather River West Levee Project. Wood Rodgers examined three potential setback levee alignments in Segment 7, south of Yuba City. The modeling effort discussed below simulated conditions for Setback Levee Alignment 3, which would result in the most aggressive of the three setback alternatives.

The model grid for this simulation is presented on Figure 2-40. The model boundary on the Feather River has been extended from Highway 99 upstream 2.7 miles to Oak Avenue, just below the Bear River confluence. The existing sections of the Feather River West Levee and the Sutter Bypass East Levee that will be in the floodplain following construction of the setback levee were assumed to be graded to local floodplain elevations.

The levee setback simulation was run with the 1957 Design Flood flows, and model results were compared to the existing conditions simulation with identical boundary hydrology. Model results indicate that the setback of the Feather River West Levee leads to an increase in the water surface elevation in the Sutter Bypass by up to 0.45 foot, as measured along the channel centerline, as shown on Figure 2-41. The setback levee effectively adds the Feather River flow to the Sutter Bypass farther upstream compared to the existing geometry. This compounds one of the major impediments to flow in the Sutter Bypass, namely the Feather River confluence area. Note the water surface slope on Figure 2-41 at mile 21.5. The water surface slope is relatively shallow upstream of the confluence, indicating an obstruction in flow as water backs up in the vicinity of the confluence. This obstruction is likely a combination of several factors, including the volume of flow in the Feather River, the loss of momentum at the confluence, and historical sedimentation on the local floodplain. Recall that a previous model simulation indicated that removal of 6 million cubic yards of historical sediment deposits from the floodplain in the vicinity of the confluence reduced the local water level by only 0.44 foot, indicating the magnitude of the influence of the confluence area on the water level in the Sutter Bypass. The setback levee allows the Feather River to spill into the Sutter Bypass farther upstream, yielding the predicted water level rise shown on Figure 2-41.

The maximum increase in water level in the Sutter Bypass as a result of the setback levee is at Mile 20.5, just downstream of the new junction of the proposed Feather River Levee and the Sutter Bypass East Levee. The increase in water level along the Sutter Bypass centerline decreases with distance upstream of the Feather River to just 0.07 foot at Highway 20.

Despite the mentioned negative influence on the Sutter Bypass, model predictions indicate that the setback levee would yield significantly lower flood elevations on the Feather River. A transect starting at the Sutter Bypass west levee, crossing the Sutter Bypass, and traveling up the Feather River to the Highway 99 Bridge was generated to demonstrate the variation in water level in the Feather River between the Existing Conditions simulation and the Levee Setback simulation. This transect is shown on Figure 2-42, and model-predicted water levels along this transect are shown on Figure 2-43. The reduction in peak water level associated with the setback levee is 2.5 feet at the Highway 99 Bridge.

Figures 2-44 and 2-45 present contours of peak water levels in the vicinity of the Feather River confluence for the Existing Conditions simulation and the Levee Setback simulation, respectively. In the existing conditions simulation, the water surface slope in the lower Feather River is considerably larger (more steep) than that in the Sutter Bypass. Under current geometric conditions, flow exiting the Feather River is confined laterally by the Feather River levees and the training levees at the confluence. Under the proposed levee setback geometry, the lateral confines on the Feather River at the Sutter Bypass are expanded, and the additional contact length between the Feather River and the Sutter Bypass allows more interaction between the Feather River and the Sutter Bypass. Because the Feather River has a steeper water surface slope, this yields an increase in predicted water levels in the Sutter Bypass.

The setback levee also influences the local velocity regime at the confluence area. With the setback levee, velocities are significantly lower in the lower Feather River, which could have implications considering the sediment load in the Feather River. Figures 2-46 and 2-47 present velocity contours in the confluence region for the existing conditions and levee setback simulations, respectively. The color scale shows contours of velocity magnitude. Figure 2-48 presents the predicted velocity along the transect shown on Figure 2-42. Velocities at the confluence show an area of low velocity just south of the east-west-aligned section of the new setback levee. The reduced velocity will likely exacerbate the rate of sediment deposition in the lower Feather River. The low velocity area shown on Figure 2-47, just downstream of a sharp bend in the proposed levee alignment, indicates that the full channel is not being effectively used to transport flood waters.

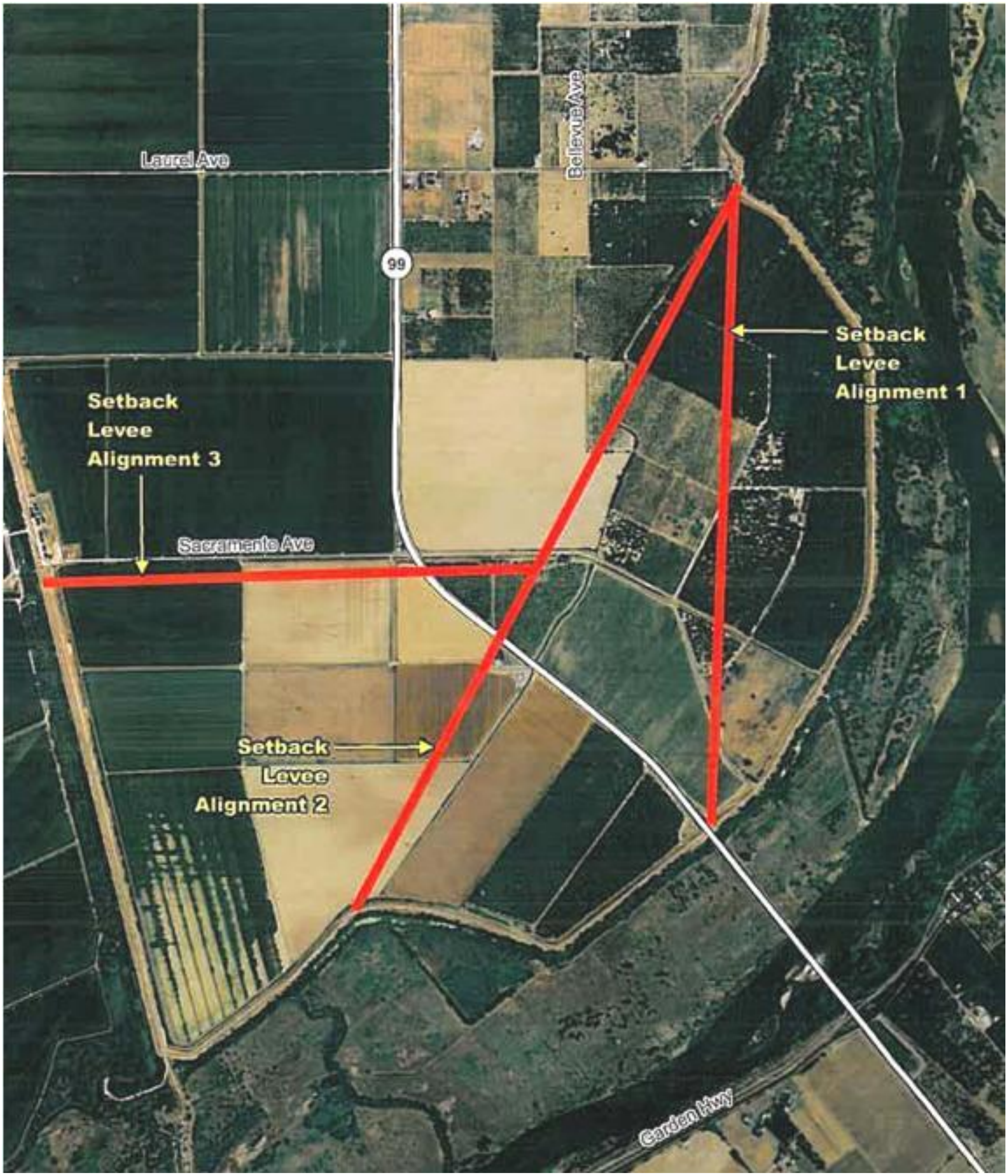

FIGURE 2-39
Proposed Levee Alignments Options for Feather River West Levee Project

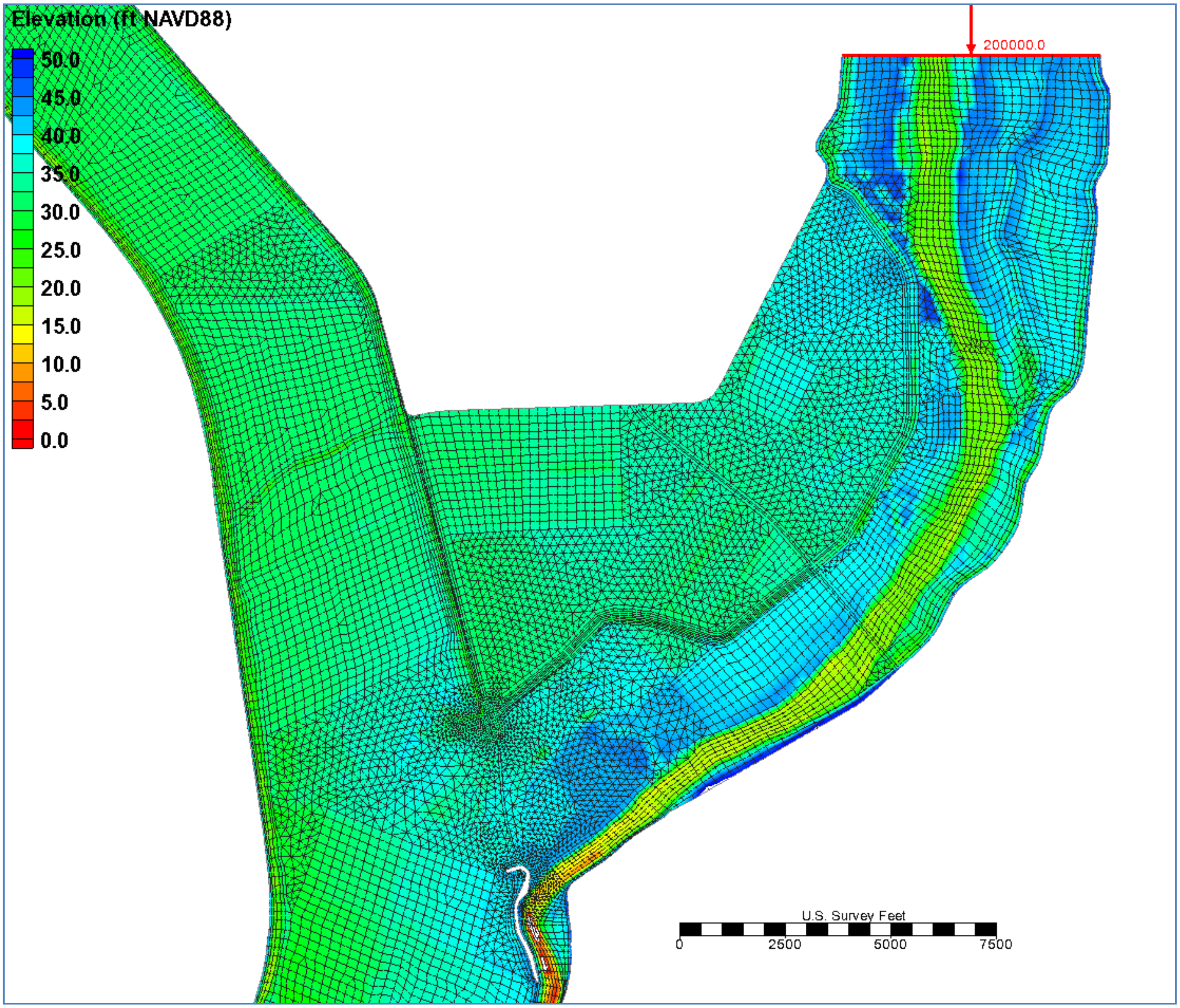

FIGURE 2-40
Model Grid and Topography for Levee Setback Simulation

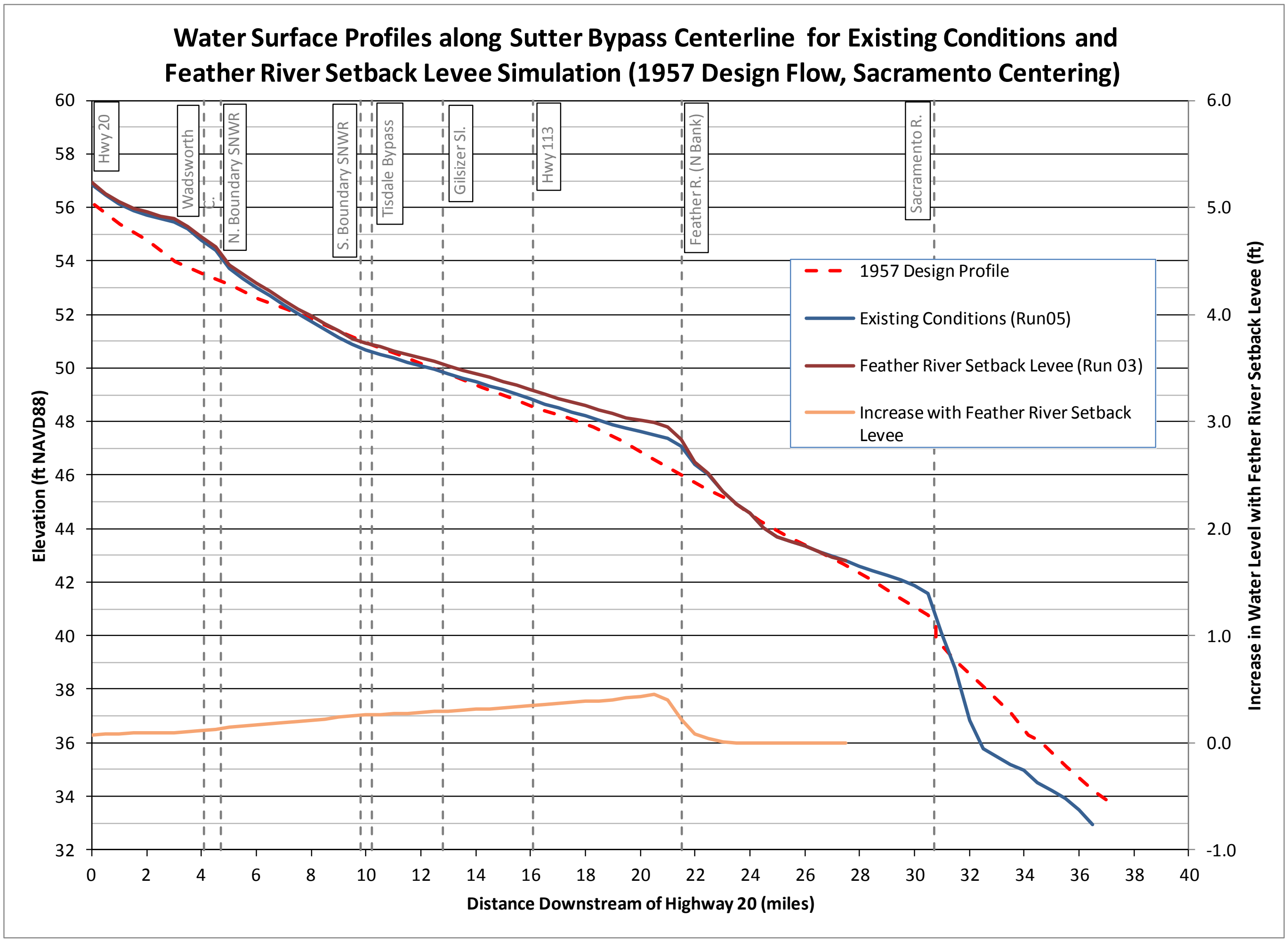

FIGURE 2-41

Water Surface Profiles along Centerline of Sutter Bypass, Demonstrating Increase in Water Level with Feather River Setback Levee

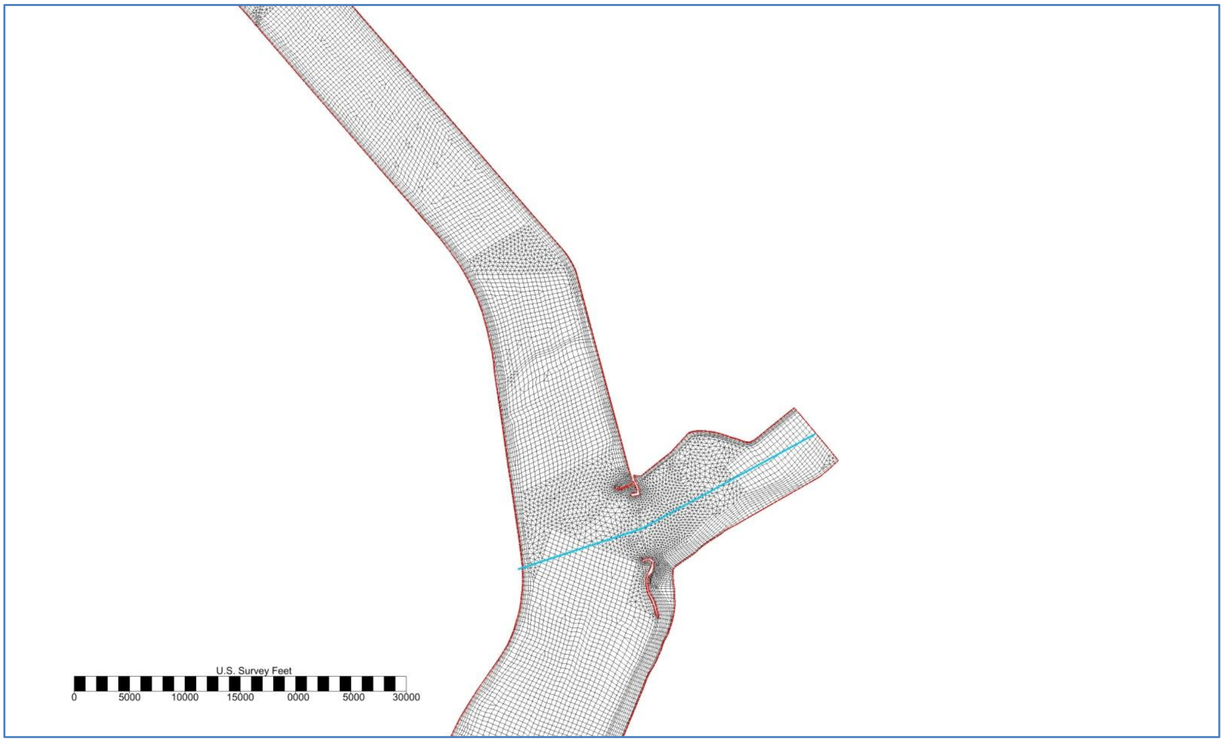

FIGURE 2-42
Feather River Transect for Demonstration of Water Level Reduction in Feather River with Setback Levee

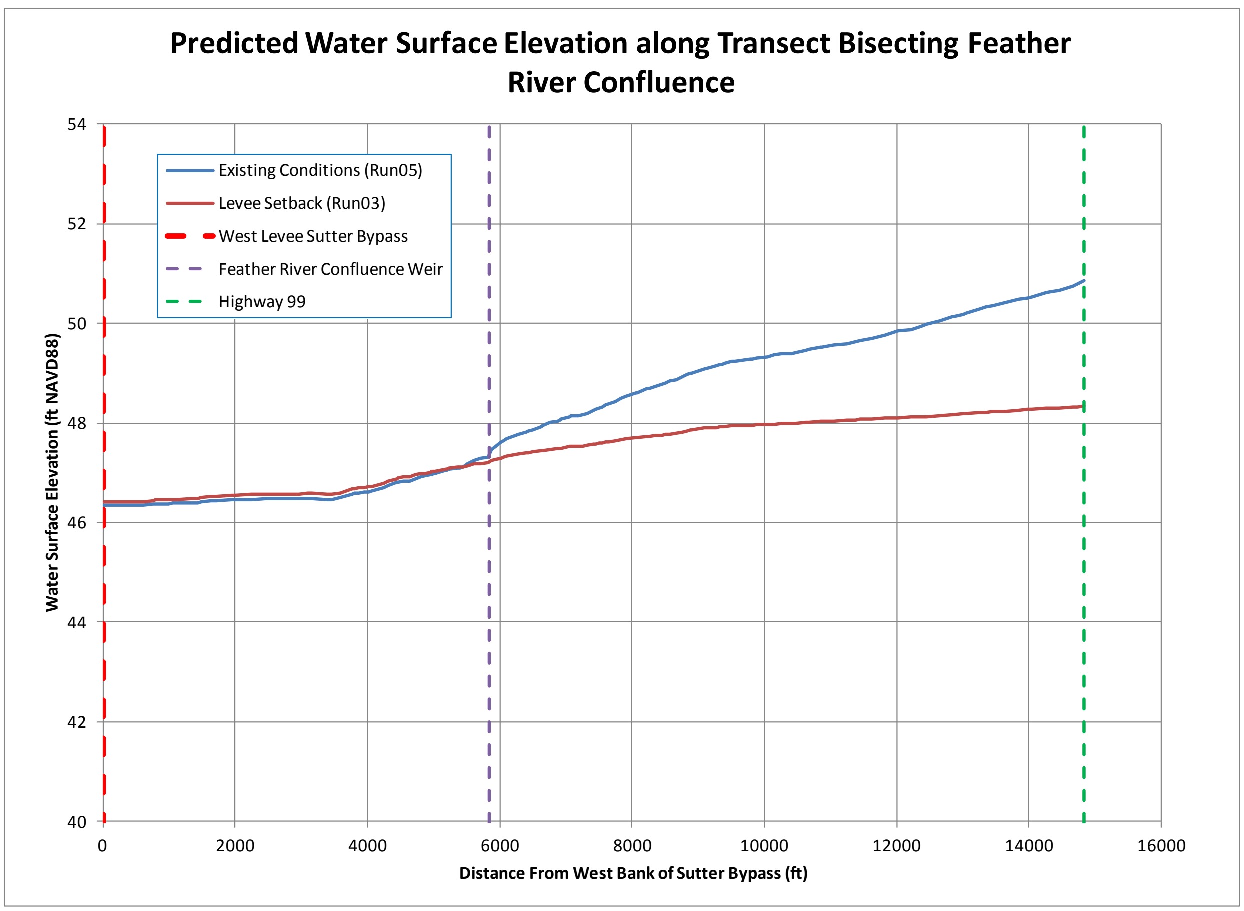

FIGURE 2-43
Predicted Water Surface Elevation along Transect through Feather River Confluence Area

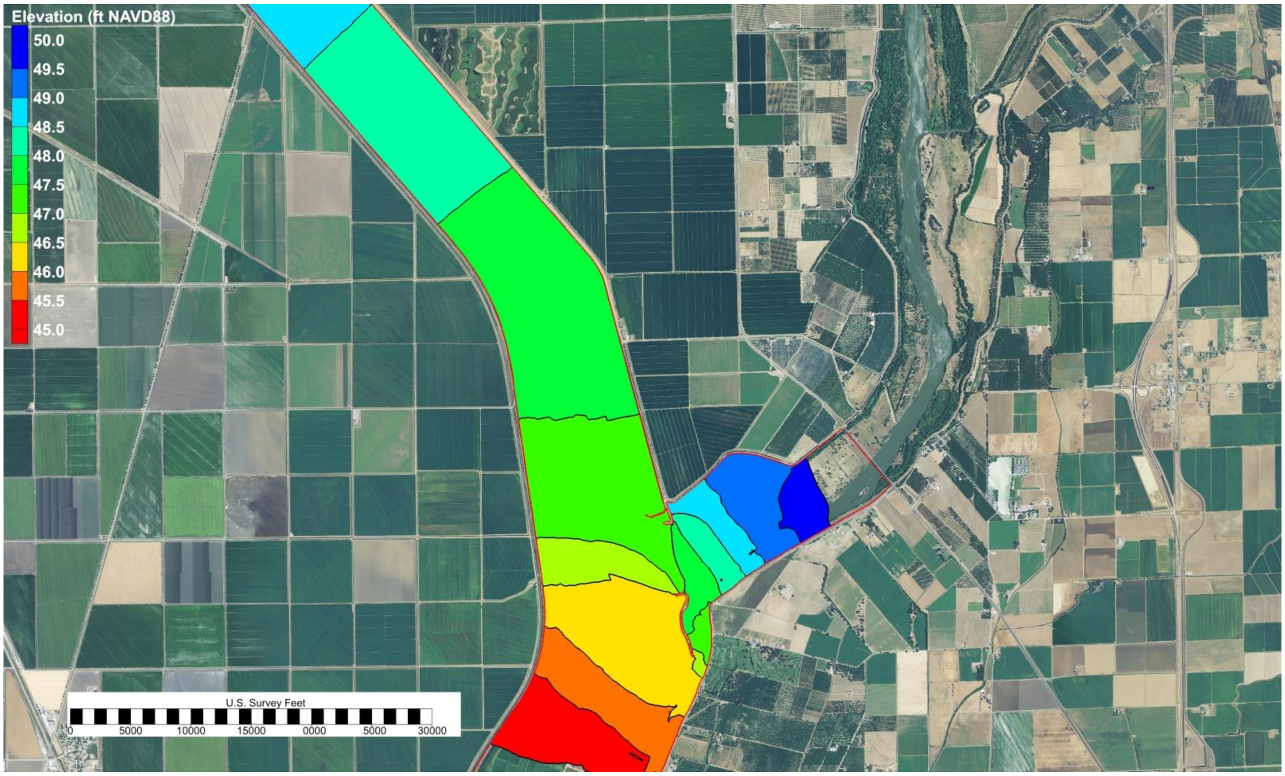

FIGURE 2-44

Predicted Peak Water Surface for 1957 Flood Condition, Existing Geometry and Vegetative Cover (Sutter Bypass/Feather River Confluence)

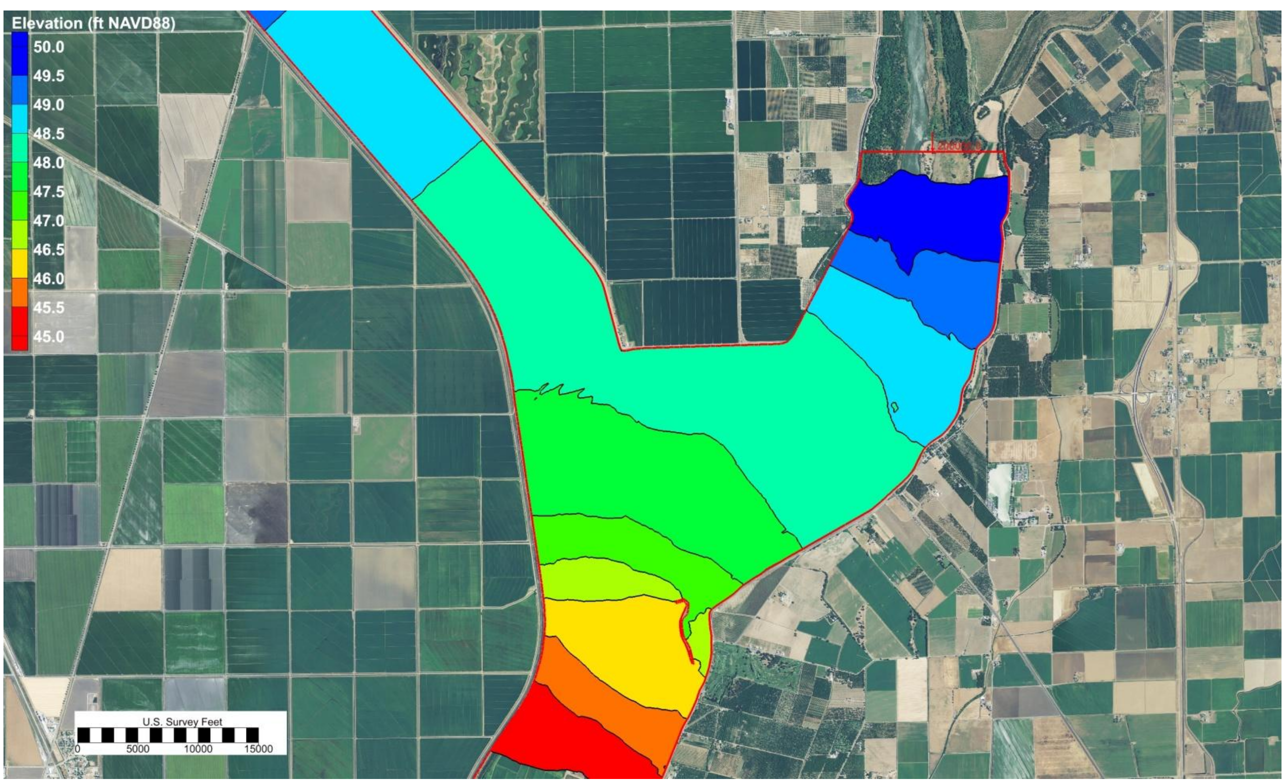

FIGURE 2-45

Predicted Peak Water Surface for 1957 Flood Condition, Levee Setback Geometry and Existing Vegetative Cover (Sutter Bypass/Feather River Confluence)

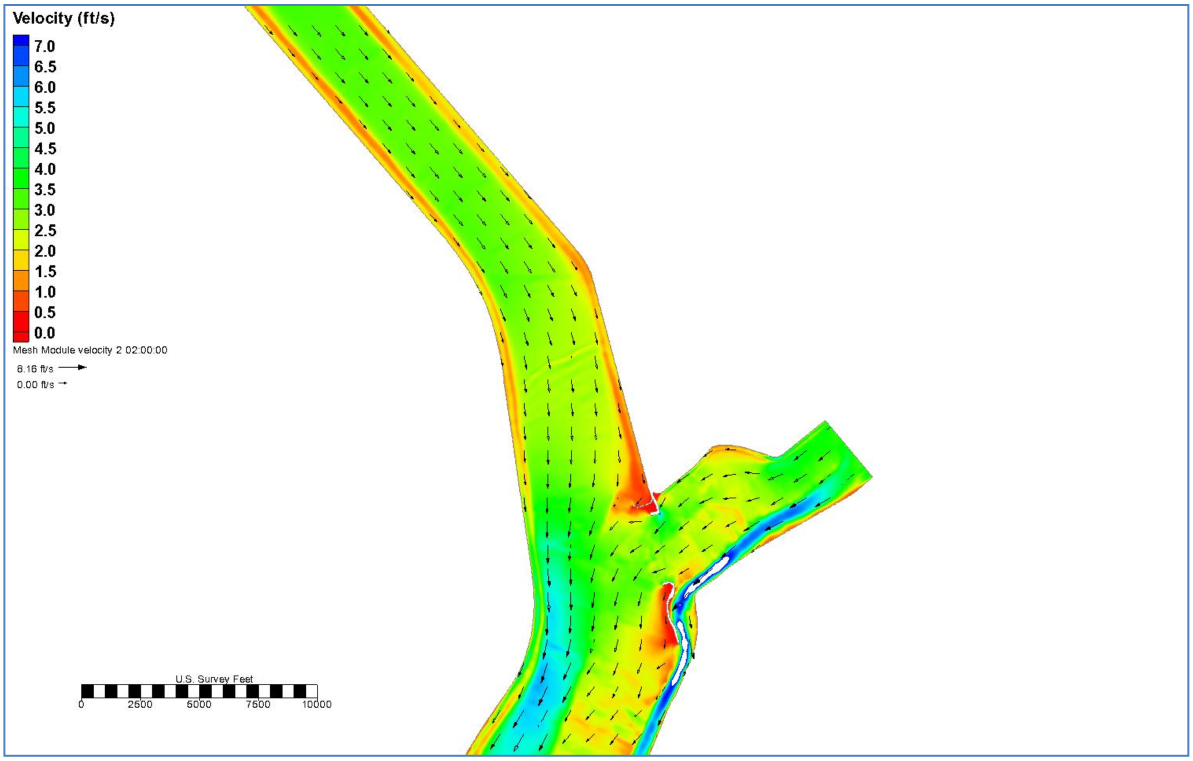

FIGURE 2-46
Velocity Vectors at Confluence for Existing Conditions and 1957 Design Flows (Sutter Bypass/Feather River Confluence)

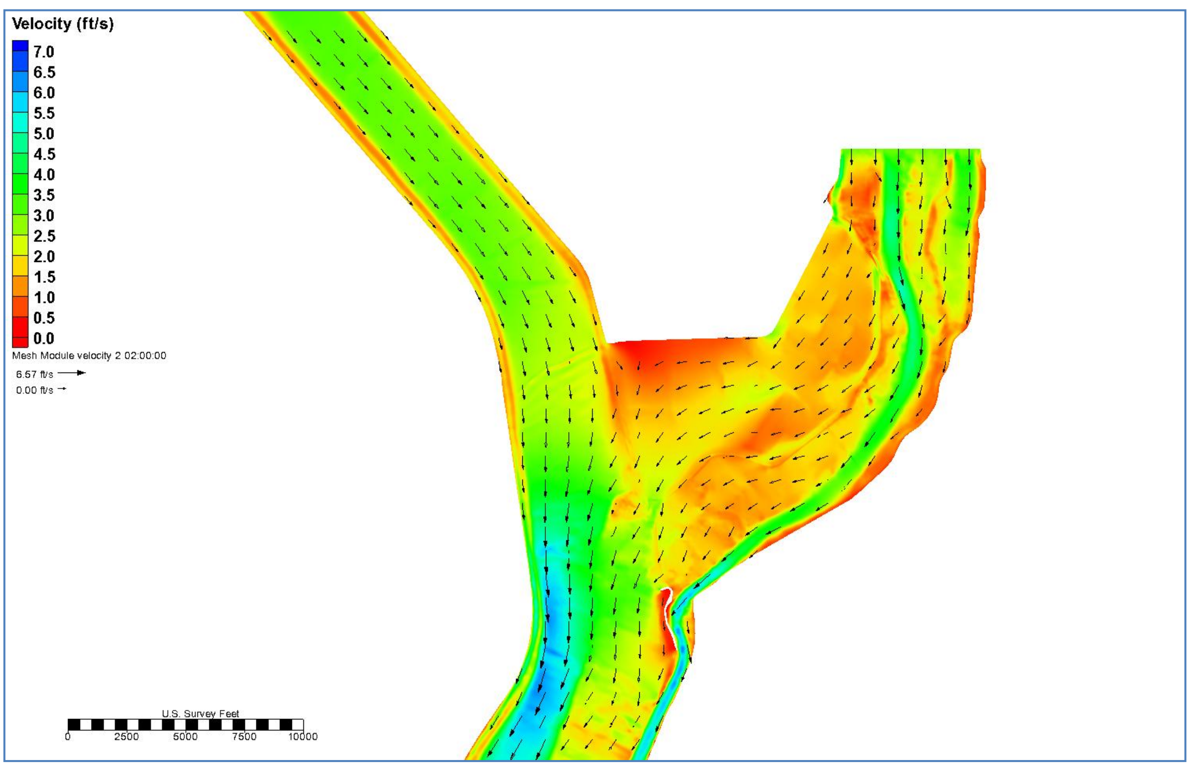

FIGURE 2-47
Velocity Vectors at Confluence for Levee Setback and 1957 Design Flows (Sutter Bypass/Feather River Confluence)

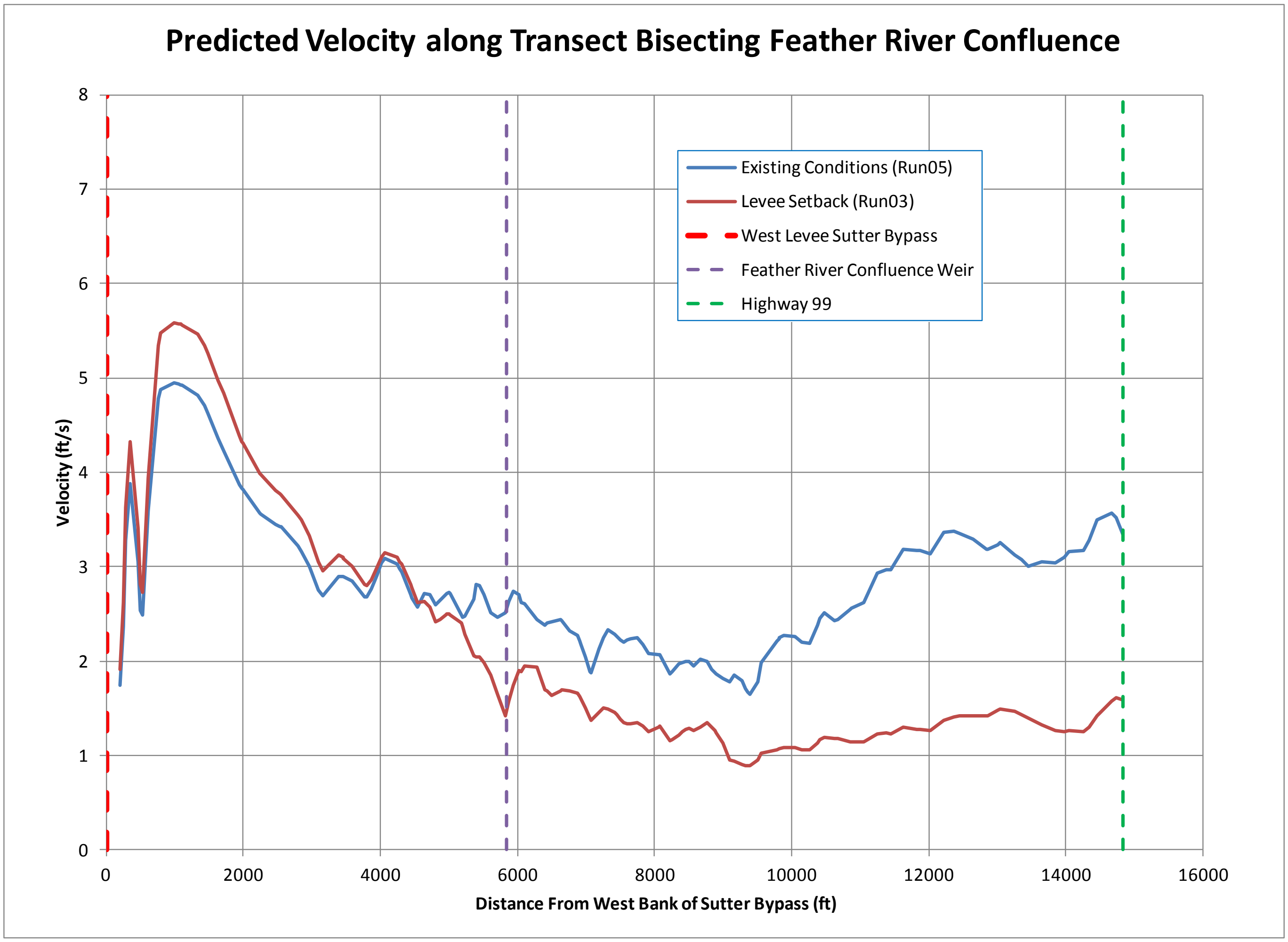

FIGURE 2-48
Predicted Velocity along Transect through Feather River Confluence Area

Figure 2-49 shows a possible setback levee alignment that, based on the insights gained from the preceding evaluations, might result in a meaningful reduction of water surfaces up the Sutter Bypass. The expected hydraulic impact would be to lower the tailwater in the Sutter Bypass below the confluence which is expected to result in a reduced water surface upstream along both the Sutter Bypass and the Feather River. The expansion to the west would reduce the likelihood of increased interaction between the Feather and Sutter flows, minimizing the translation of the steeper energy gradient from the Feather River into the Sutter Bypass. The wider conveyance in the Sutter Bypass would minimize the impacts of the elevation increases in the Sutter Bypass invert upstream of the confluence and would also be expected to reduce the hydraulic gradient in the area creating a compound benefit. Figure 2-50 shows some other possible setback levee alignments that could be considered depending on specific freeboard concerns and a willingness to invest in the necessary evaluations and subsequent construction.

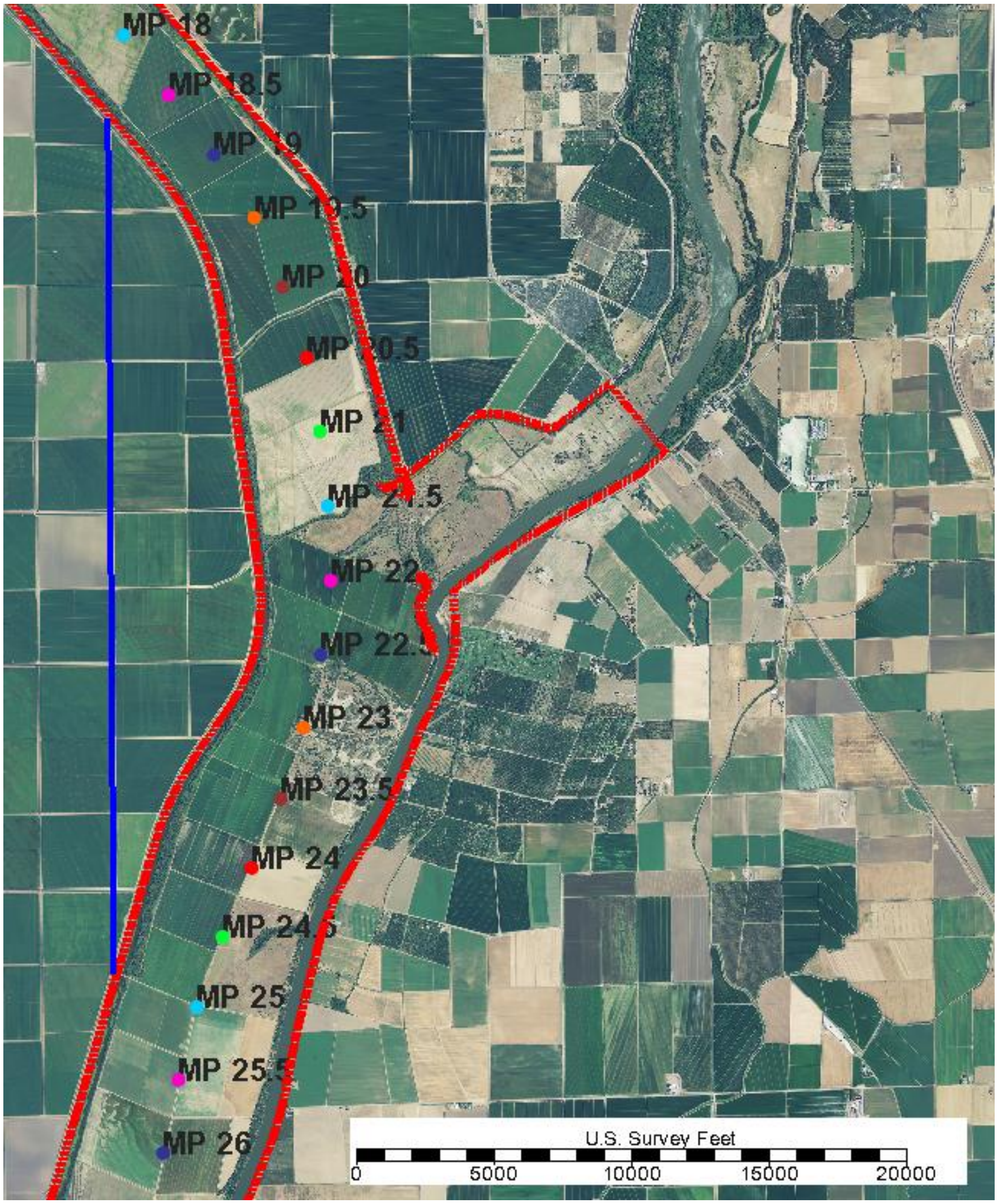

FIGURE 2-49
Potential Levee Alignment for Setback on Sutter Bypass West Levee

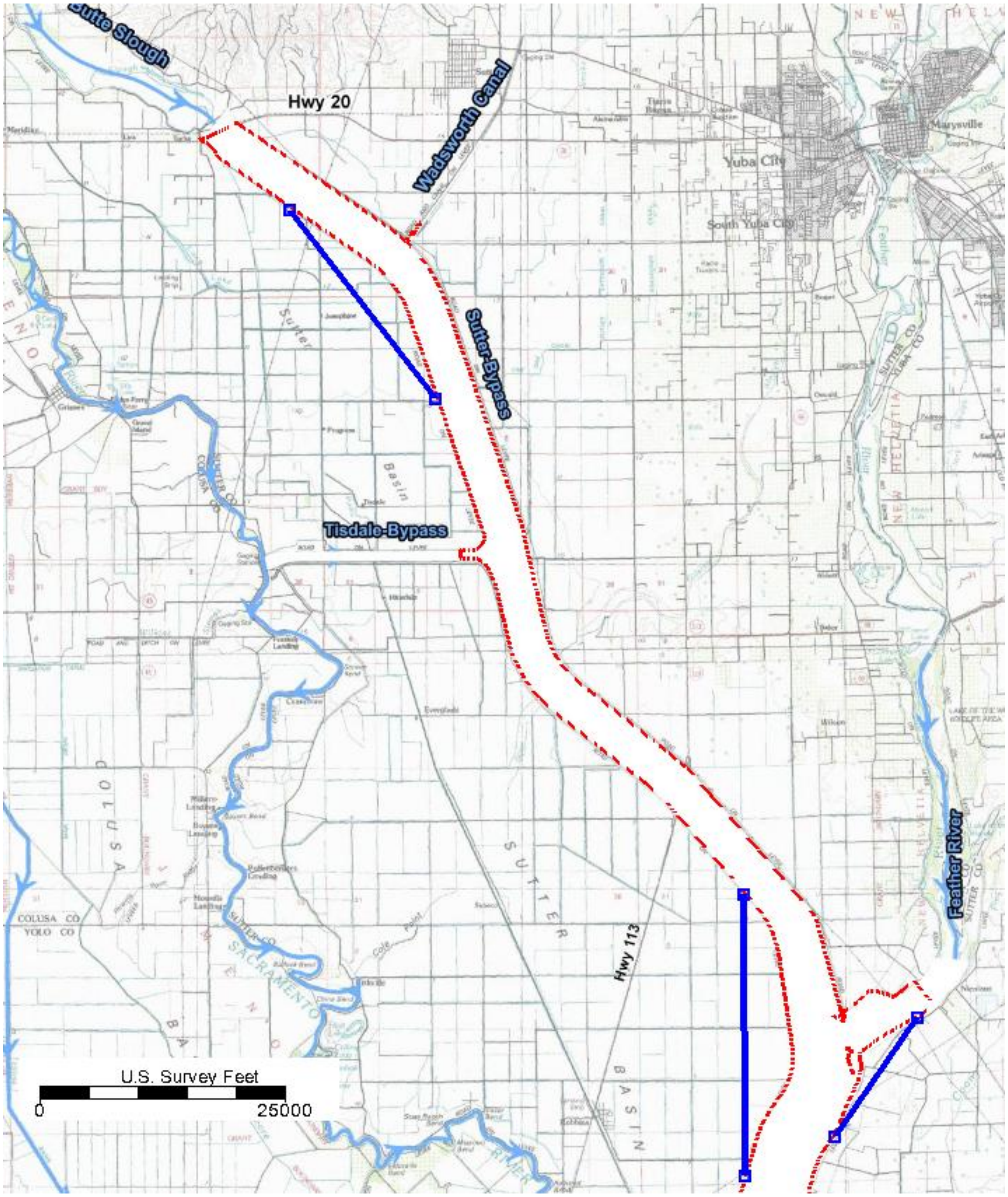

FIGURE 2-50
Potential Levee Alignments

2.5 Summary of Task 6 Simulations

Table 2-6 summarizes the simulations conducted under Task 6. The large-scale vegetation management scenarios conducted under the Bare Soil classification evaluated the ability to regain the necessary target freeboard with extensive vegetative clearing throughout the Sutter Bypass. Extensive clearing was necessary, as simulation 'Cleared01' cleared 4,348 acres of wooded vegetation and riparian corridor to a Manning's value of 0.04 and still did not achieve a 5-foot freeboard throughout the entire Sutter Bypass. It took a reduction in Manning's n to 0.035 to achieve additional improvements toward the target freeboard however none of the simulations showed the ability to achieve the O&M flow freeboard objectives with vegetation management alone.

Small-scale, targeted vegetation management on areas of less than 100 acres was found to yield only very localized and often limited improvements in flood levels and freeboard, even when seemingly critical areas, such as the heavily wooded area at the north end of the SNWR, were the subject of vegetation removal. Extensive vegetation clearing on the order of 800 to 1,000 acres and conversion to agricultural land use where feasible was found to lower flood elevations at design flows by up to 0.75 foot.

Investigations into potential benefits of structural modifications on reducing peak water levels during flood flows were also less encouraging than hoped for, providing localized and often limited benefits. Large-scale removal of sediment deposits at the Feather River confluence, on the order of 5.9 million cubic yards, was found to lower peak water levels locally by less than 0.5 foot. Removal of training dikes near the Feather River actually increased flood levels in the Sutter Bypass, as it increased the influence of the Feather River on flows down the Sutter Bypass.

Simulations conducted with increased boundary inflows corresponding to those in the O&M Manual yield water levels up to 1.7 feet higher than those for the 1957 design flows, and minimum freeboard as low as 2.0 feet in the upper Sutter Bypass.

Finally, simulations of an aggressive levee setback on the west bank of the Feather River just upstream of the Sutter Bypass indicate that while peak water levels in the Feather River were reduced with the levee setback, as expected, conditions in the Sutter Bypass were actually made worse by the realignment. Peak water levels in the Sutter Bypass increased as the levee setback increases the backwater effect of the Feather River on the Sutter Bypass. However, the information inferred from the analysis of these specific levee setbacks suggests that other setback levee alignments might be far more effective at reducing water surface elevations during future design flow simulations.

TABLE 2-6

Summary of Management Alternatives Simulations and Maximum Water Level Changes

Sutter Bypass Two Dimensional Hydraulic Model Report

	SMS File Name	Task 6 goal	Simulation Description	Acres Managed	Maximum Water Level Benefit (feet)	Benefit Relative to…	Minimum Freeboard (feet)
	Yolo_Full_1957-SAC_04b.sms	BASELINE	New spinup approach (SS and 50 hr run)	N/A	N/A	N/A	3.5
No Clearing of Riparian Corridor	Yolo_Full_1957-SAC_04_cleared01b.sms	Bare soil	Cleared three vegetation materials to n = 0.04; cleared Nelson Slough to n = 0.04	3,303	1.37	Baseline	4.8
	Yolo_Full_1957-SAC_04_cleared02d.sms	Bare soil	Cleared three vegetation materials, natural grasses, and three sloughs to 0.035	6,376	2.07	Baseline	5.2
	Yolo_Full_1957-SAC_04_cleared03b.sms	Bare soil	Converted 1,646 acres of managed habitat in SNWR to agricultural land use (n = 0.028, built on run02d)	8,022	2.49	Baseline	5.2
	Yolo_Full_1957-SAC_04_cleared04d.sms	Bare soil	Converted 6,310 acres of vegetation and natural grasses to agricultural land use (built on run 03b)	8,022	3.12	Baseline	5.3
Clearing of Riparian Corridor	Yolo_Full_1957-SAC_04_cleared01.sms	Bare soil	Cleared three vegetation materials and riparian material to n = 0.04; cleared Nelson Slough to n = 0.04	4,348	1.49	Baseline	4.9
	Yolo_Full_1957-SAC_04_cleared02b.sms	Bare soil	Cleared three vegetation materials, riparian corridor, natural grasses, and three sloughs to 0.035	7,420	2.22	Baseline	5.2
	Yolo_Full_1957-SAC_04_cleared03.sms	Bare soil	Converted 1,646 acres of managed habitat in SNWR to agricultural land use (n = 0.028, built on run02b)	9,067	2.60	Baseline	5.2
	Yolo_Full_1957-SAC_04_cleared04c.sms	Bare soil	Converted 6,310 acres of vegetation and natural grasses to agricultural land use (built on run 03)	9,067	3.28	Baseline	5.3
	Yolo_Full_1957-SAC_05.sms	Existing Conditions	Existing Conditions	25	0.15	Baseline	3.6
	Yolo_Full_1957-SAC_10.sms	Fully Grown Vegetation	Increased Manning's coefficients by 20 percent for three vegetation materials, three sloughs, natural grasses, and riparian corridor	N/A	-0.83	Baseline	2.8

TABLE 2-6

Summary of Management Alternatives Simulations and Maximum Water Level Changes

Sutter Bypass Two Dimensional Hydraulic Model Report

	SMS File Name	Task 6 goal	Simulation Description	Acres Managed	Maximum Water Level Benefit (feet)	Benefit Relative to…	Minimum Freeboard (feet)
Vegetation Management	Yolo_Full_1957-SAC_06.sms	Vegetation Management	Cleared wooded vegetation at north end of SNWR and treeline at south end of SNWR to n = 0.04 (built on Run05)	39	0.06	Existing Conditions	3.6
	Yolo_Full_1957-SAC_07c.sms	Vegetation Management	Cleared linear vegetation features along sloughs and water areas that bisect Sutter Bypass to n between 0.035 and 0.045 (92 acres over five areas, built on Run06)	131	0.06	Existing Conditions	3.6
	Yolo_Full_1957-SAC_08c.sms	Vegetation Management	Cleared longitudinal wooded vegetation features along bypass to reduce friction; cleared 189 acres in SNWR to n = 0.04 and cleared and converted 566 acres to agricultural use n = 0.028 (built on Run07c)	886	0.64	Existing Conditions	4.0
	Yolo_Full_1957-SAC_08d.sms	Vegetation Management	Converted 215 acres of natural grasses and dense vegetation adjacent to the Feather River to agricultural land use (n = 0.028) to reduce friction (built on Run08c)	1,101	0.75	Existing Conditions	4.1
Structural Modifications	Yolo_Full_1957-SAC_09b.sms	Structural Modifications	Removed two northern training levees	N/A	-0.09	Existing Conditions	3.6
	Yolo_Full_1957-SAC_11a.sms	Structural Modifications	Graded and removed 400k cu yd of sediment deposits upstream of Nelson Slough	138	0.03	Existing Conditions	3.6
	Yolo_Full_1957-SAC_11c.sms	Structural Modifications	Graded and removed 1.04 mil cu yd of sediment deposits upstream and downstream of Nelson Slough	304	0.13	Existing Conditions	3.6
	Yolo_Full_1957-SAC_11d.sms	Structural Modifications	Graded and removed 2.46 mil cu yd of sediment deposits near Nelson Slough, extending into the Feather River floodplain	545	0.09	Existing Conditions	3.6
	Yolo_Full_1957-SAC_11f.sms	Structural Modifications	Graded and removed 5.90 mil cu yd of sediment deposits downstream of Willow Slough (Built from Run11c)	980	0.44	Existing Conditions	3.7
	Yolo_Full_1957-SAC_12.sms	Structural Modifications	Graded and removed 575k cu yd of sediment deposits upstream of SNWR	218	0.19	Existing Conditions	3.7

SECTION 3

Impact of Sutter National Wildlife Refuge

3.1 Introduction

This section prevents results of two model simulations developed to quantify the impact of the Sutter National Wildlife Refuge on peak water levels in the Sutter Bypass. These two simulations were conducted to address CVFPB Resolution No. 2009-11, which reiterated the Board's interest in understanding the carrying capacity of the Sutter Bypass with a particular emphasis on understanding the impacts the Sutter National Wildlife Refuge has on that carrying capacity.

3.2 Model Setup

These model simulations were built from the existing conditions model simulation and applied the 1957 Design Flows at the inflow boundaries. The first simulation represents the full impact of the Sutter National Wildlife Refuge. In this simulation, 2098 acres within the refuge, representing all land between the toe drains, was converted to agricultural land use. A second simulation was conducted in which only the managed habitat within the refuge, consisting of 1110 acres of seasonal flooded marsh and 536 acres of watergrass habitat, were converted to agricultural land use. The 451 acres of wooded vegetation removed in the first simulation were retained as-is in the second simulation.

3.3 Model Results

Longitudinal water surface profile plots were generated to visualize predicted water levels. Figure 3-1 presents results of the first simulation in which the total land area within the boundaries of the Sutter National Wildlife Refuge was converted to agricultural land use. Results indicate a maximum reduction in water level of 1.5 feet with this land use conversion. Figure 3-2 presents results of the second simulation in which only the managed habitat within the Sutter National Wildlife Refuge was converted to agricultural land use. Results of this simulation indicate a maximum decrease in peak water level of 0.8 feet. The difference in these two simulations indicates the effects of the wooded vegetation within the confines on the Sutter national Wildlife Refuge on peak water levels.

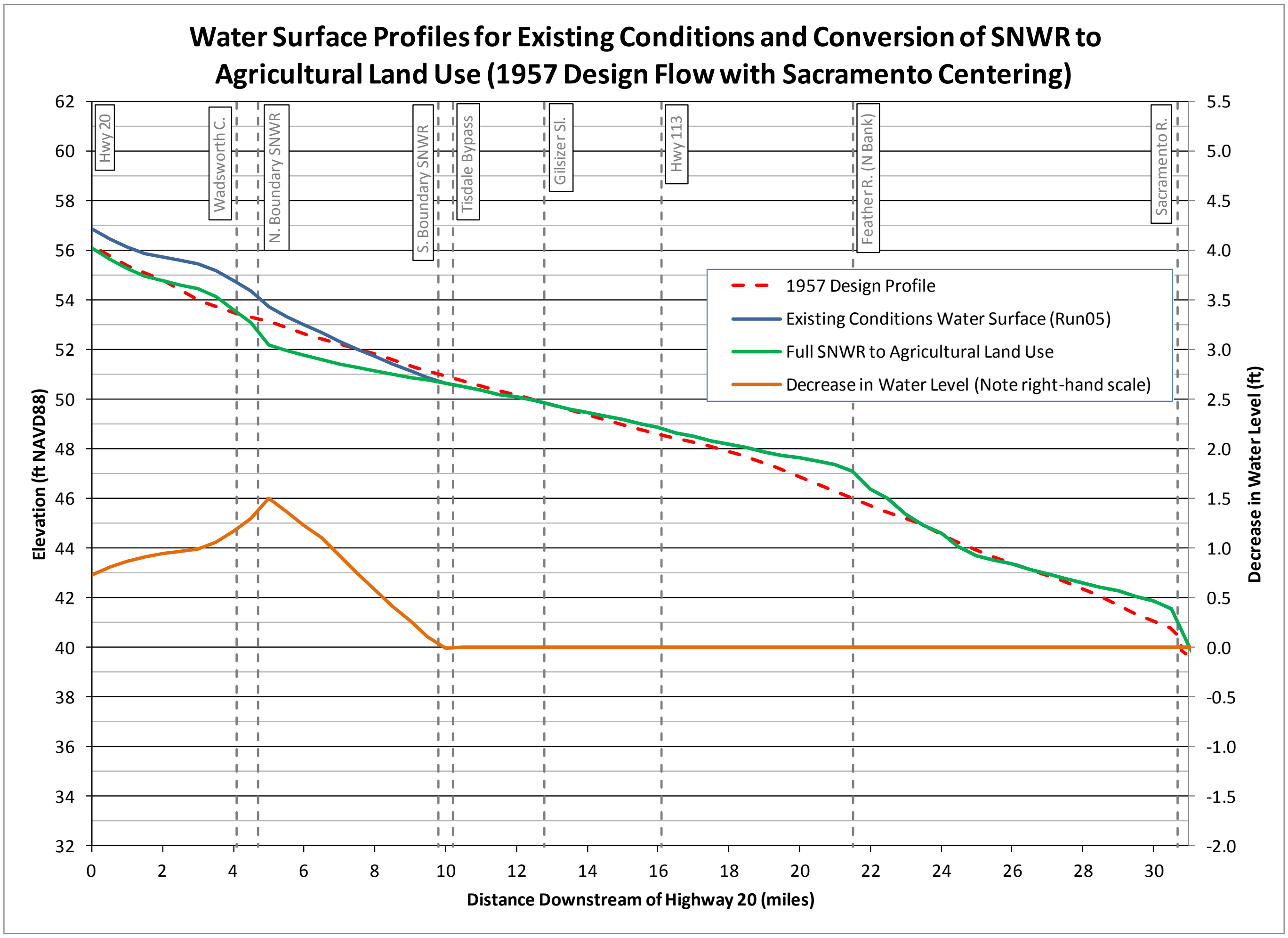

FIGURE 3-1

Water Surface Profiles indicating Influence of Sutter National Wildlife Refuge on Flood Levels in Sutter Bypass

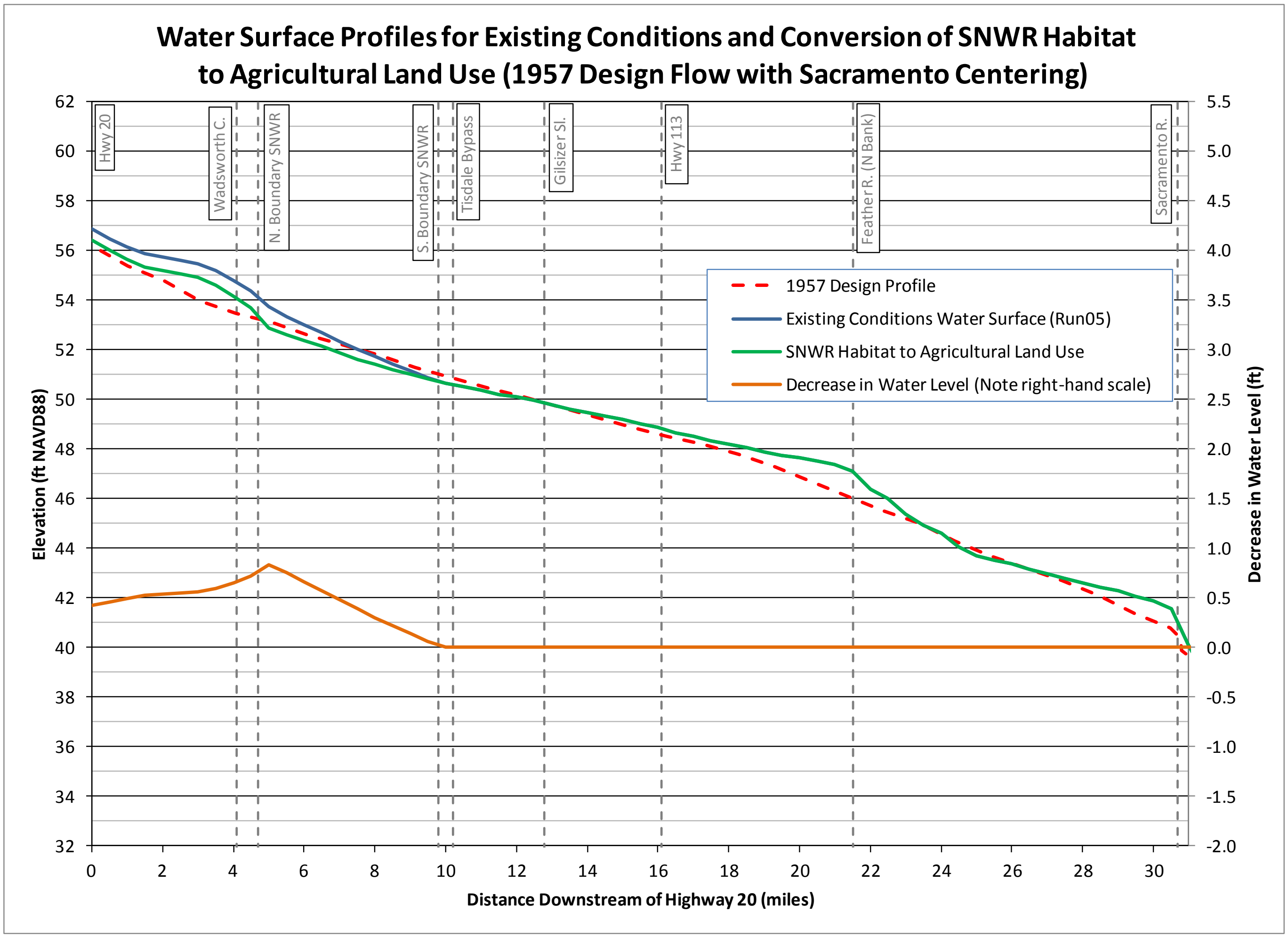

FIGURE 3-2

Water Surface Profiles indicating Influence of Sutter National Wildlife Refuge Managed Habitat on Flood Levels in Sutter Bypass

SECTION 4

Summary

4.1 Introduction

This section provides a summary of the modeling analysis of the Sutter Bypass conducted for the CVFPB. A brief review of the model setup, calibration, and hydraulic simulations is presented in the following subsections.

4.2 Model Setup

A 2D hydraulic model of the Sutter Bypass has been constructed covering the Bypass from Highway 20 in the north to the Fremont Weir in the south, and extending into the Yolo Bypass to the Woodland gauge. The model covers 41 square miles with more than 47,000 elements. It has a nominal element size of 200 ft by 200 ft, and partitions the covered area into 1 of 23 distinct land use types for the purpose of assigning friction coefficients with a high level of resolution. Topographic and bathymetric data from LiDAR surveys and hydrographic surveys were used to specify ground and bed elevations in the model grid.

4.3 Model Calibration and Verification

The Sutter Bypass Two Dimensional Hydraulic Model was calibrated to match peak water levels from the January 2006 high-flow event at a series of water level gauges throughout the Sutter Bypass. Boundary conditions were obtained from both observed conditions and output from the USACE Common Features HEC-RAS model. The calibration effort involved adjustment of boundary friction, generally one material at a time, to fine tune the model and reduce the average absolute error between model predictions and peak observed water levels at local gauges. Model results were able to reproduce peak water levels at five gauges in the Sutter Bypass with an average absolute error of less than three inches. High water survey marks were used to visually verify the longitudinal water surface profile down the Sutter Bypass, but uncertainty and scatter in the high water mark data precluded its use in the statistical analysis during the calibration effort.

The Sutter Bypass Two Dimensional Hydraulic Model was used to simulate the January 1997 high water event as a model validation exercise. Hydraulic conditions were very complex because of multiple levee failures in the Feather River and Sutter Bypass during this event. Furthermore, there is significant uncertainty in the inflow time series from Butte Slough for the 1997 event. Despite these issues, the model validation exercise demonstrated reasonably good agreement with peak measured water elevations, although the performance was not as good as the calibration.

4.4 Model Simulations

Following the calibration, as series of hydraulic simulations was conducted to determine the influence of a range of potential management options on predicted peak water levels. The majority of simulations were conducted with the 1957 design flows, although sensitivity runs were also conducted with the O&M Manual flows and the 100 year and 200 year synthetic storm events.

4.4.1 Baseline Conditions

Under 1957 design flows and baseline vegetation conditions, those equal to the 2006 conditions used in the final calibration simulation, predicted water surface elevations were found to exceed the 1957 design profile by up to 1.6 feet, and yield a minimum predicted freeboard of 3.5 feet relative to the existing levee crest elevations. In terms of Freeboard Deficiency, defined as the difference between the predicted freeboard and the freeboard as it existed in 1957, the maximum deficiency on the East levee is 1.4 feet and the maximum deficiency on the West levee is 1.8 feet. Thus, under baseline vegetation, the 1957 Design flows are predicted to produce water surface elevations above those necessary to meet the 1957 Freeboard. Plots of the predicted freeboard and Freeboard Deficiency for the Baseline scenario were presented in Figures 2-7 and 2-8. Calculations of the difference between the levee crest elevations and the predicted water surface (termed predicted freeboard) indicate that on the West

Levee, the freeboard ranges from 3.5 to 8.4 feet, and on the East Levee, the freeboard ranges from 3.9 to 11.0 feet suggesting that even the design freeboard is no longer provided in many sections.

Plots showing the calculated freeboard for the 1957 Design Profile (not a model simulation) are presented on Figures 4-1 and 4-2 for the East and West levees, respectively. The freeboard between the 1957 Design Profile and existing levee crest elevations can be two feet higher or 3.5 feet lower than the 1957 freeboard, calculated with the 1957 levee crest elevations as taken from the 19757 Design document (USACE, 1957). Thus, while the general presentation herein has been Freeboard Deficiency with respect to the 1957 profile, care must be taken to acknowledge the freeboard to the existing levee crest.

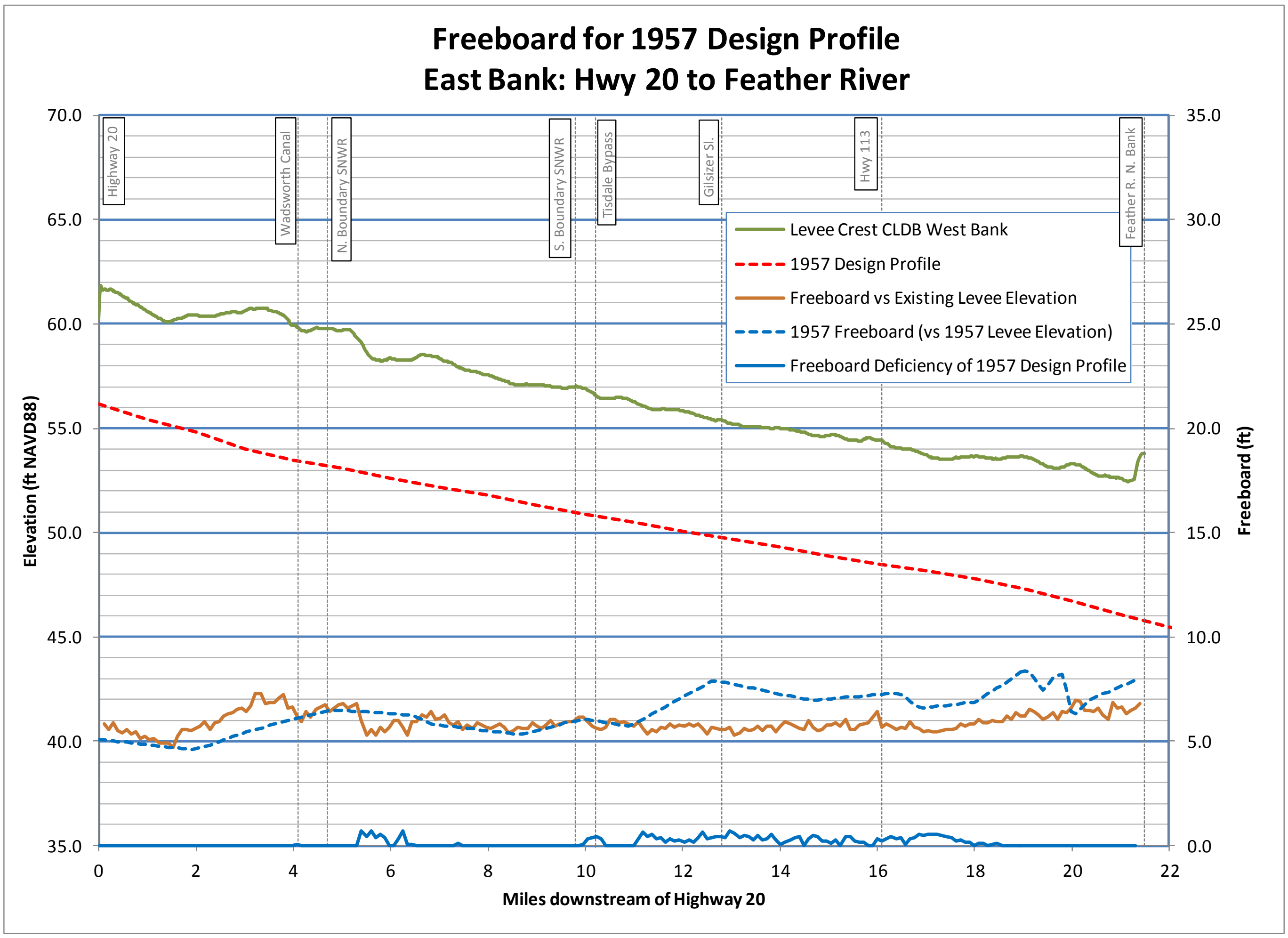

FIGURE 4-1
East Bank Freeboard Profile for 1957 Design Profile

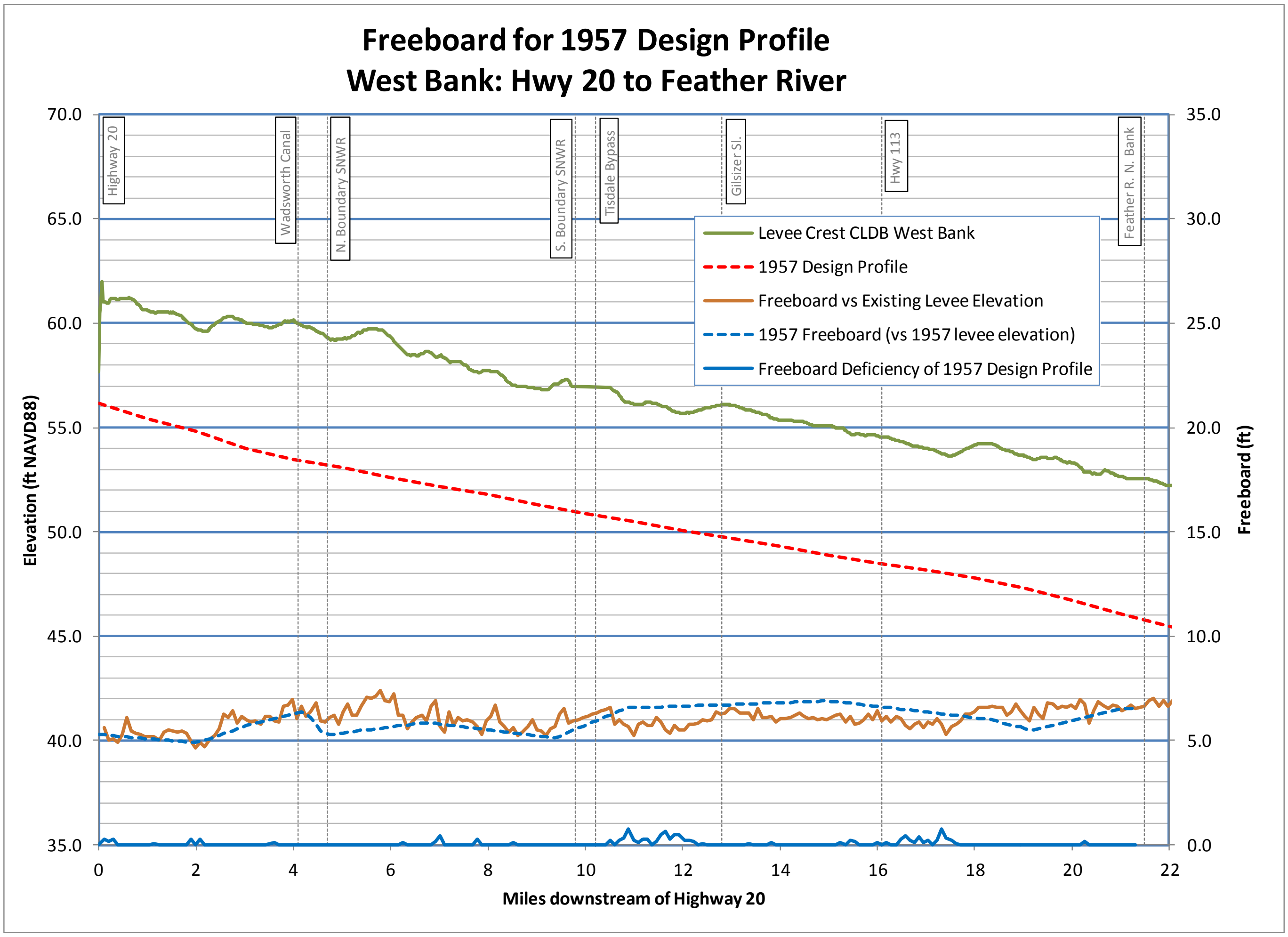

FIGURE 4-2
West Bank Freeboard Profile for 1957 Design Profile

4.4.2 Existing Conditions

The existing conditions along the Sutter Bypass are very similar to the 2006 vegetative conditions represented by the Baseline Conditions run. However, the Existing Conditions reflect an area of fairly intensive maintenance just upstream of the SNWR. This area results in a lower computed water surface elevation in one of the critical areas. The resulting freeboard conditions are depicted in Figures 2-14 and 2-15 and show that the design freeboard when considering 1957 design flows is not achieved. Maximum Freeboard Deficiencies of 1.3 feet on the East Levee and 1.7 feet on the West Levee are shown in Figures 2-14 and 2-15, respectively.

The same conditions were simulated using the O&M flows. As expected, the approximately 20% increase in flows results in an increase in the computed water surface along the entire length of the Sutter Bypass. The desired freeboard is not achieved and is further reduced when considering these flow rates.

4.4.3 Bare Soil Conditions

A series of bare soil conditions was simulated to determine the projected decrease in water levels during high-flow events associated with aggressive vegetation management in the Sutter Bypass. This condition also best represents the conditions within the Sutter Bypass at the time of the bypass construction. Results indicate that predicted water surface profiles can be reduced below the 1957 Design Profiles with extensive clearing of vegetation in the Sutter Bypass. One simulation modeled the removal of dense vegetation and understory brush over a total of 3303 acres and found a maximum reduction in water level of 1.4 feet. This simulation (Cleared01b, Figure 2-6) yields a maximum Freeboard Deficiency of 0.6 feet on both the East and West levees. Additional management including mowing of natural grasses over 3,073 acres and found a maximum reduction in water level of 2.1 feet relative to Existing Conditions, and a further reduction of the maximum Freeboard Deficiency to 0.2 feet (Table 2-2). Unfortunately, the computed water surface profile for this condition, when considering the O&M flows, does not comply with the target freeboard along many segments of the Sutter Bypass. This indicates that even the most aggressive removal of vegetation, in the absence of other actions, is unlikely to provide the desired level of protection as prescribed in the O&M Manual.

4.4.4 Vegetation Management

The water level benefit associated with small scale, targeted vegetation management in the Sutter Bypass was investigated with a series of simulations. Targeted thinning of stands of wooded vegetation with dense undergrowth was found to have a localized benefit but to be of limited benefit in reducing computed water surface profiles along the full length of the Bypass. For example, one simulation modeled vegetation removal along three sloughs that bisect the Sutter Bypass, but found a negligible reduction in peak water levels of only 0.06 feet (Figures 2-20 and 2-21). Another simulation targeted the longitudinal vegetation corridors parallel to the toe drains on either side of the Sutter Bypass, and simulated removal of dense vegetation and conversion to agricultural land use for areas where the dense vegetation encroached into the floodway (Figures 2-22 and 2-23). This simulation had the most promising results among the alternatives that looked at vegetative management alone, indicating a peak reduction in water level of 0.64 feet for clearing of 886 acres (Table 2-3).

4.4.5 Structural Refinements

Several simulations were conducted to investigate potential water level benefits with structural refinements to the Sutter Bypass. One simulation investigated the removal of the northern training levee at the Feather River confluence, but found that peak water elevations in the Sutter Bypass were higher as a result of the levee removal (Figure 2-27). The training levee held back water in the Feather River, and removal of the levee increased the back water effect in the Sutter Bypass from the Feather River.

Additional simulations investigated removal of historical sediment deposits in the vicinity of the Feather River confluence and also upstream of the SNWR. Model results indicate that only localized decreases in peak water levels were found for sediment removal actions of several million cubic yards. The final simulation in this series removed 6 million cubic yards of material, reducing local ground elevations by up to 6 feet. Peak water levels were reduced by a maximum of 0.44 foot near the excavation site, but the water level benefit decreased upstream away from the project site (Figure 2-33).

4.4.6 Setback Levees

A model simulation was undertaken with a setback levee on the Feather River to determine the influence of changes in levee alignment on peak water levels. The levee alignment considered was presented on Figure 2-39 (Alignment 3). Model results indicate that although peak water levels in the Feather River are reduced significantly by the setback levee, water levels in the Sutter Bypass increased as a result of the revised levee configuration.

In spite of these results, a careful evaluation of the hydraulic characteristics of the Sutter Bypass suggests that other setback alignments might hold more promise in reducing water surface elevations. The unique hydraulics at the confluence, with water surfaces and the hydraulic gradients being so much higher in the Feather River, made the investigated alternatives ineffective. However, alternatives that reduce the hydraulic gradient along the Sutter Bypass by increasing the conveyance area are predicted to reduce water surfaces both locally and for a certain distance above the setback levees.

4.4.7 Simulation Interpretation

Model simulations indicate that the 1957 Design freeboard would be exceeded by up to 1.7 feet upstream of Wadsworth Canal on the west bank for existing vegetation conditions in the Bypass and with 1957 design flow conditions (Figure 2-15). Freeboard requirements would be consistently exceeded upstream of the Feather River under flow conditions detailed in the O&M Manual (Figures 2-37 and 2-38) with Freeboard Deficiencies of up to

3.3 feet on the West Levee. Peak water levels increase further under simulation of synthetic storm events such as the 100 year or 200 year events.

Results of the simulations conducted in this study indicate that the required freeboard, using only vegetative management actions, might be regained only through extensive clearing of woody vegetation and understory. Section 2.2.1 and Table 2-2 summarize examples of the actions required to reduce the Freeboard Deficiency to 0.0 feet along the entire system. Maintenance of the required 5,000 or 6,000 acres of existing dense understory and woody vegetation, in addition to changes in land use to increase agricultural use in the Bypass, may not be realistic.

The simulations also suggest that structural improvements such as excavation of sediment deposits have a limited benefit and, by themselves, cannot achieve the desired freeboard. Compounding the limited effectiveness is the improbability of finding cost effective ways to manage the excavation of such large quantities.

The setback levees evaluated demonstrated no significant reduction in the computed water surface elevations along the Sutter Bypass.

4.5 Impact of Sutter National Wildlife Refuge

Two simulations were conducted to determine the influence of the Sutter National Wildlife Refuge on flood elevations in the Sutter Bypass. The first simulation cleared 2098 acres of wooded vegetation and managed habitat and assumed a conversion to agricultural land use. Results of this simulation indicate a maximum reduction in water level of 1.5 feet. The second simulation cleared 1646 acres of managed habitat, again assuming conversion to agricultural land use. Results for this simulation indicate a maximum reduction in water level of 0.8 feet.

4.6 Next Steps

4.6.1 RMA2 Model Use

The Sutter Bypass Two Dimensional Hydraulic Model is available as a tool to determine relative changes in peak water level throughout the Sutter Bypass associated with land use or geometric changes in the Bypass. The model was calibrated to high water conditions seen January 2006, and verified with a second high water event, demonstrating its ability to correctly calculate high water levels over the model domain.

The Sutter Bypass Two Dimensional Hydraulic Model is being incorporated into DWR’s Library of Models. The intent of this inclusion is to allow other state and federal agencies access to this tool so that a common platform is available for future evaluation of projects along the Bypass. By using the common platform, the CVFPB has a reasonable assurance that the impacts of any proposed projects can be assessed fairly and accurately.

The scope of the current study was focused on the development of the model and documentation to allow it to be a tool to assess future projects. The tools should be used to fully explore other alternatives that have been recommended but not explicitly simulated during this study. The Recommendations presented in Section 3.6 of this report should be among the first alternatives evaluated.

4.6.2 Management Actions for Consideration

The simulations conducted as part of this study provide a useful foundation for the understanding of the hydraulic performance of the Sutter Bypass under 1957 design flow conditions and for other higher flows. Based on this understanding, some possible actions have been identified that, in combination, might improve the performance of the Sutter Bypass to convey flows in relation to the desired freeboard.

4.6.2.1 Thin vegetation

The simulations indicated that thinning of vegetation would be an impractical approach to achieving the desired freeboard by itself. However, the simulations did identify a number of approaches that would have a positive benefit and still not present an onerous burden to landowners or the CVFPB.

Heavily Wooded Areas – DWR Maintenance has conducted vegetation thinning and removal of understory brush in a 25 acre parcel at the northwest corner of the Sutter National Wildlife Refuge. This showed some benefit and could be expanded to other areas of dense vegetation. Such actions are expected to have some localized benefits.

Vegetation along Toe Drains – Thinning of the longitudinal vegetation corridors along the inside of the toe drains to reduce the encroachment into the active conveyance area is likely to have a positive impact on computed water surface profiles. The current vegetative buffer provides protection against the effects of wind and wave erosion but may be excessive and impact conveyance. Providing a more uniform buffer of approximately 300 feet along the toe drain might continue to provide adequate protection against wind and wave erosion but also reduce encroachment into the conveyance zone.

Thinning in the SNWR – This option includes the thinning of dense vegetation within the SNWR. This has only a localized benefit but some of the areas where water surface elevations might be reduced areas are those where freeboard is lowest.

4.6.2.2 Structural improvements

The simulations indicated that removal of accumulated sediments, or even sediments evident at the time of Bypass construction, would not, in themselves, make significant improvements toward achieving the target freeboard. However, the sediment deposits seem to correspond to localized increases in the computed water surface elevations. Targeted removal of some of these obstructing sediment deposits might provide some benefit.

4.6.2.3 Levee improvements

The simulations indicated that vegetative thinning and removal of accumulated sediments generally had localized benefits and, even in combination, might not achieve the desired freeboard. These types of improvements also present a number of other considerations that may make them impractical. With or without the vegetative and structural improvements, several areas of the existing levee are expected to still not be compliant with the target freeboard, even with the recommended actions above. Another option to consider might be the selective increase in the elevation of the levee crest where the identified freeboard deficiency remains unacceptable.

4.6.2.4 Setback levee construction

While the setback levees explicitly evaluated for this study showed no positive benefit, the use of setback levees to reduce water surface elevations is common. Water levels in the Sutter Bypass might be reduced considerably by a setback levee on the Sutter Bypass itself, as opposed to one on the Feather River.

SECTION 5

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Appendix A
Freeboard Plots

Appendix A. Longitudinal Freeboard Plots for East And West Levees

This appendix contains a collection of plots presenting predicted freeboard and Freeboard Deficiencies along the East and West levees of the Sutter Bypass. Plots are presented for the following scenarios:

- Baseline Simulation
- Bare Soil Simulations (2 sets of 4 runs)
- Existing Conditions (1957 Design Flows and O&M Manual Flows)
- Future Conditions without Vegetation Management
- Target Cleared Vegetation (set of 4 runs)
- Structural Modifications (set of 7 simulations)

Plots include the Freeboard Deficiency, calculated as the difference between the calculated freeboard and the 1957 freeboard. This shows the location and magnitude of the amount of freeboard needed to match that which existed in 1957, based on DWR data.

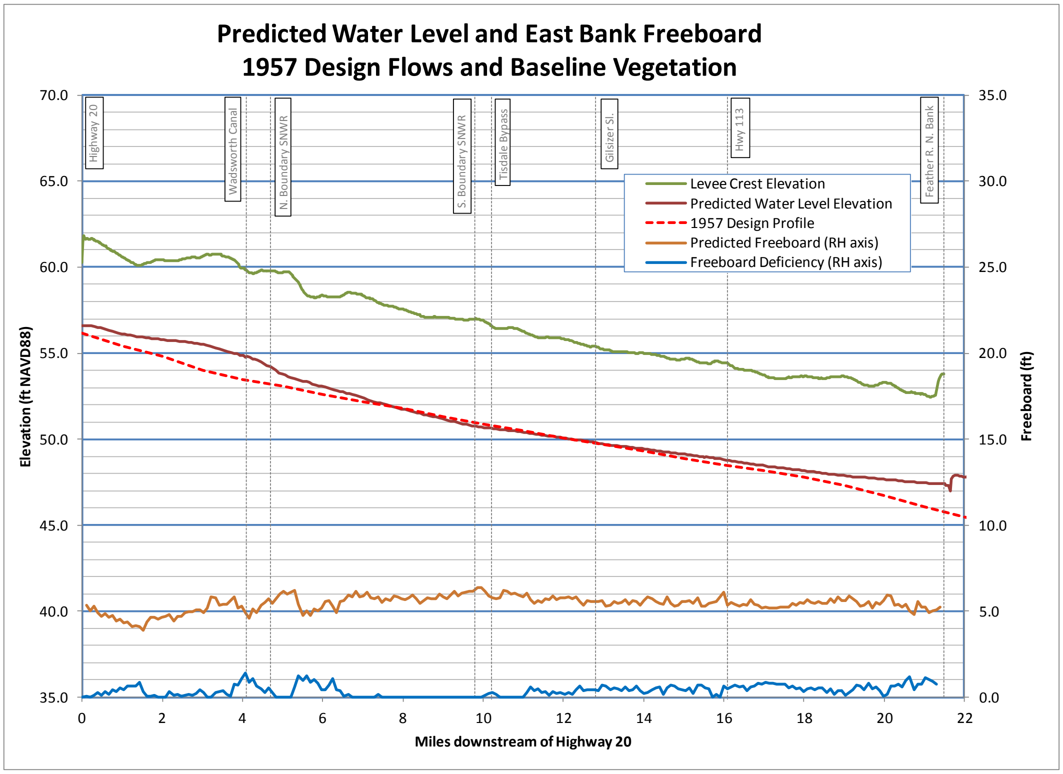

Figure A-1. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Baseline Vegetation

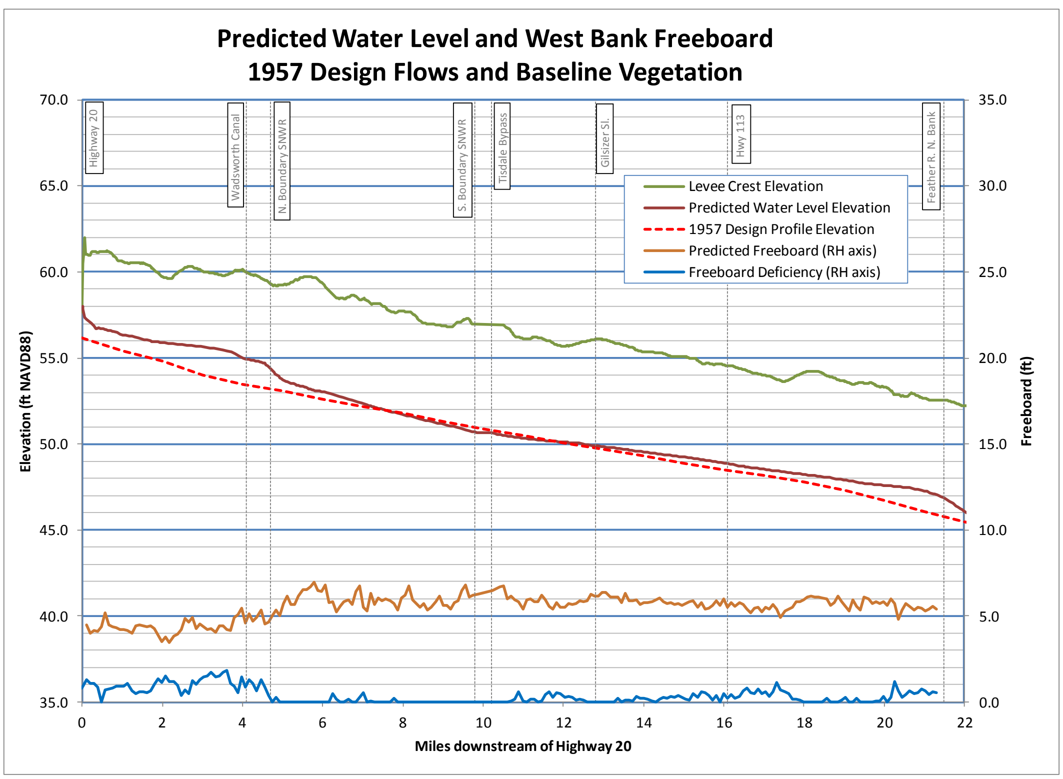

Figure A-2. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Baseline Vegetation

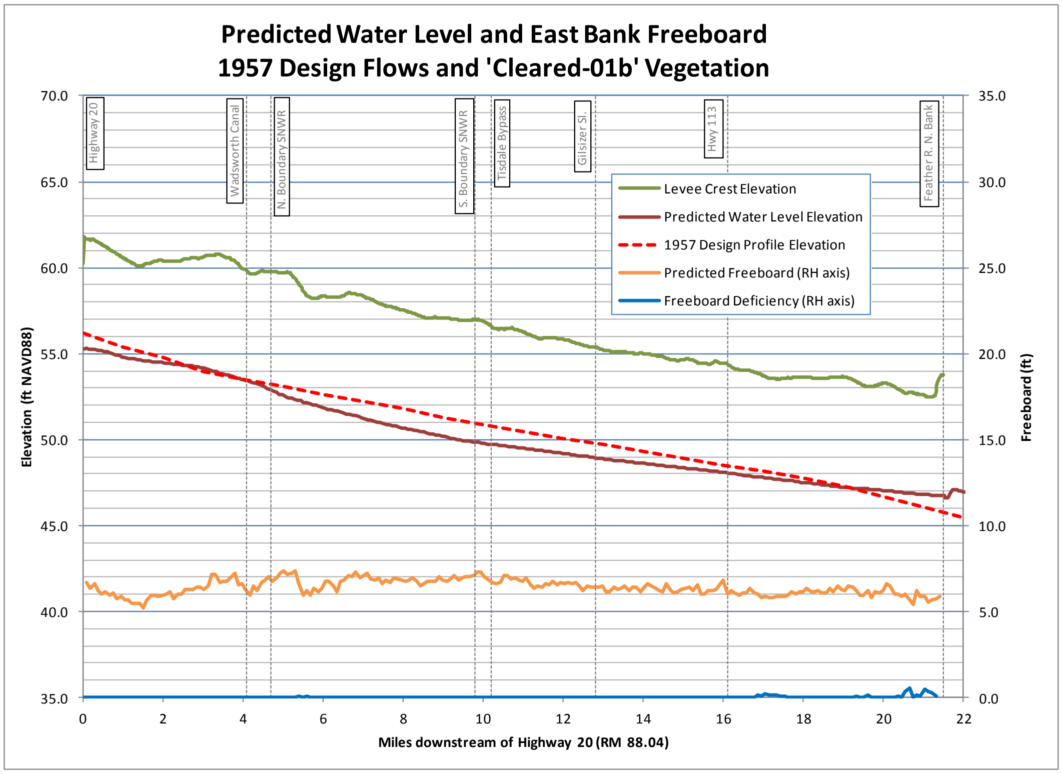

Figure A-3. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared-01b' Vegetation

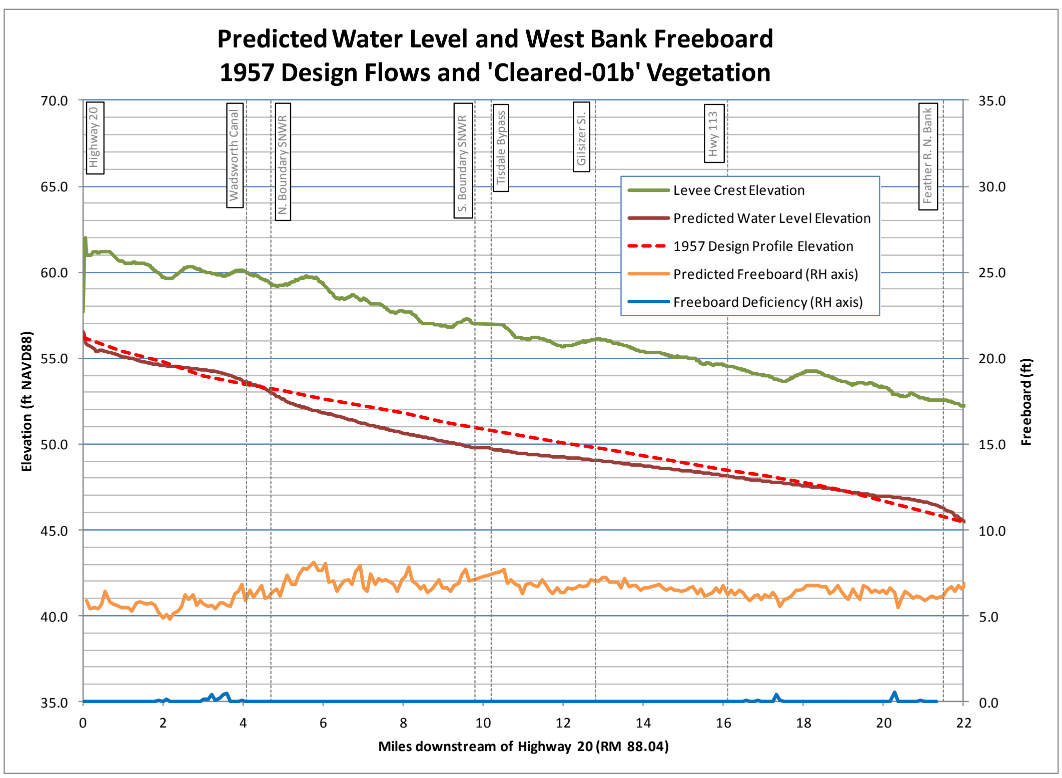

Figure A-4. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared-01b' Vegetation

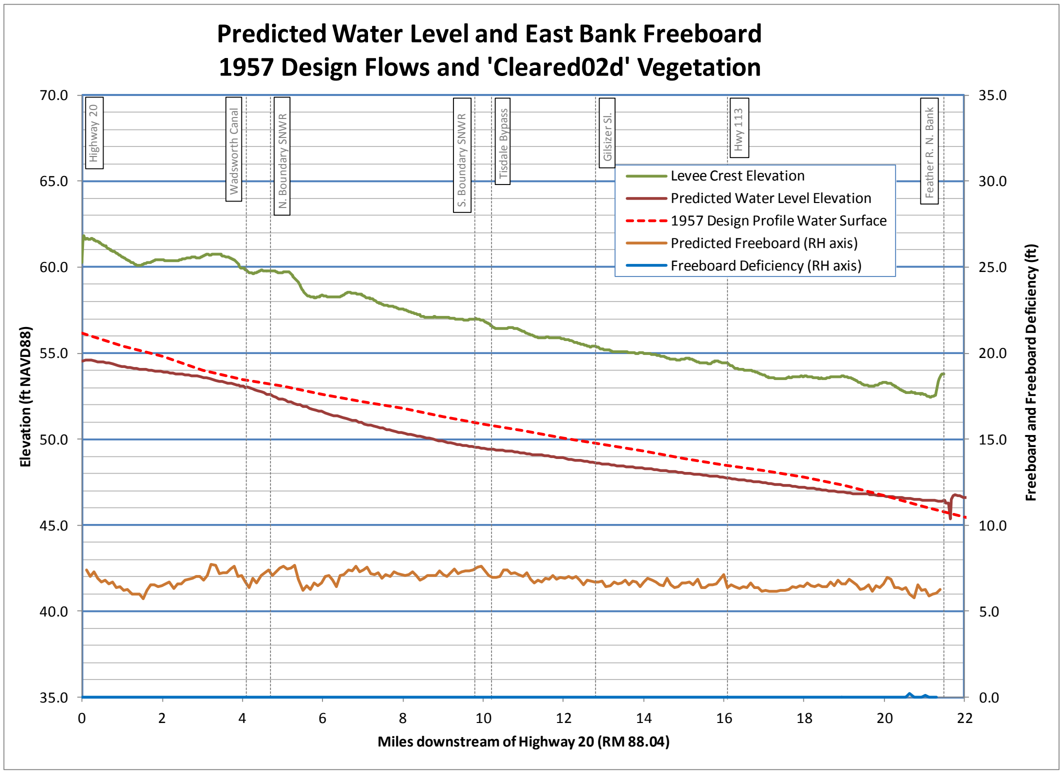

Figure A-5. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared02d' Vegetation

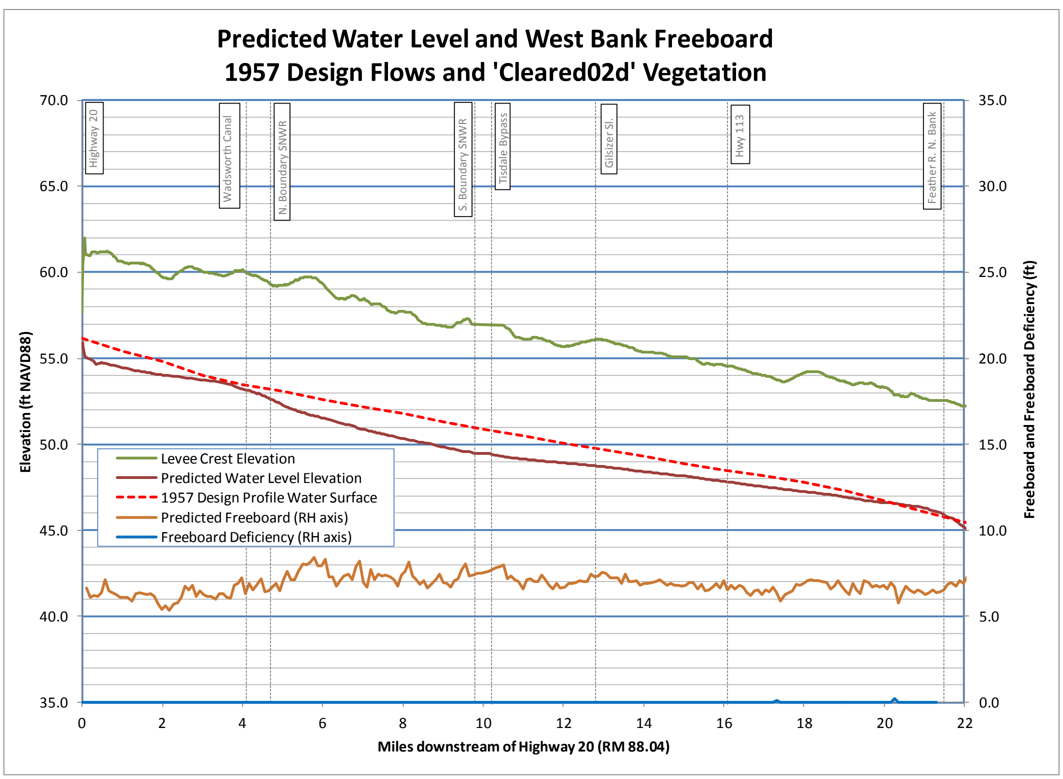

Figure A-6. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared02d' Vegetation

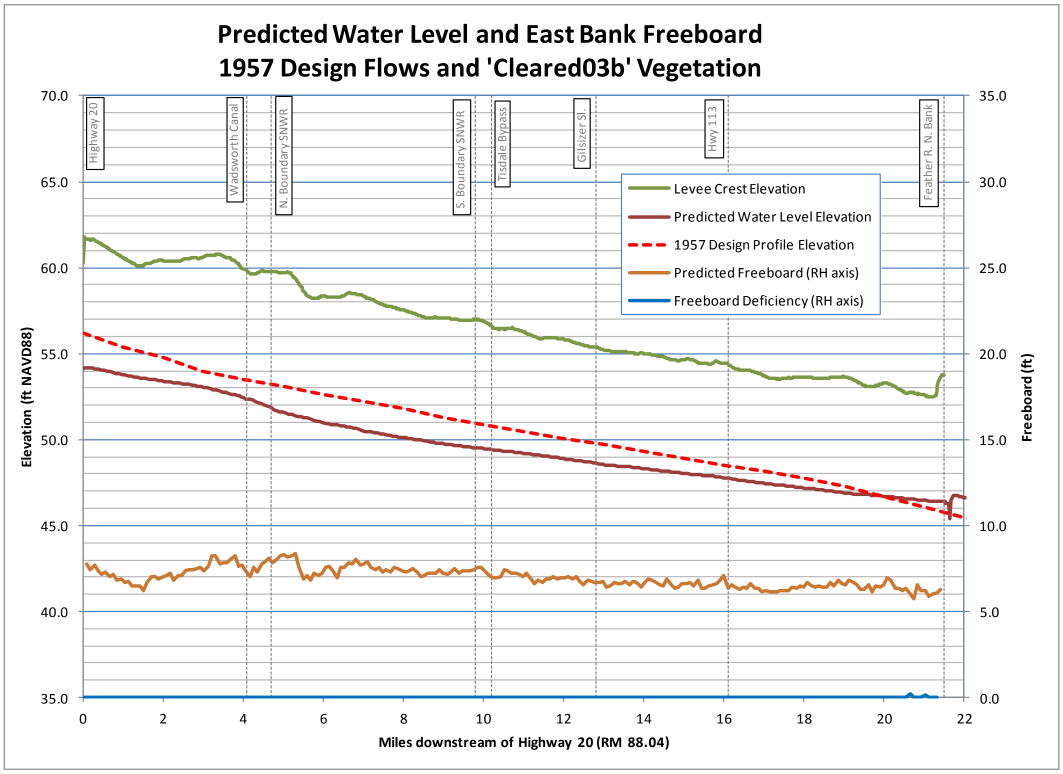

Figure A-7. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared03b' Vegetation

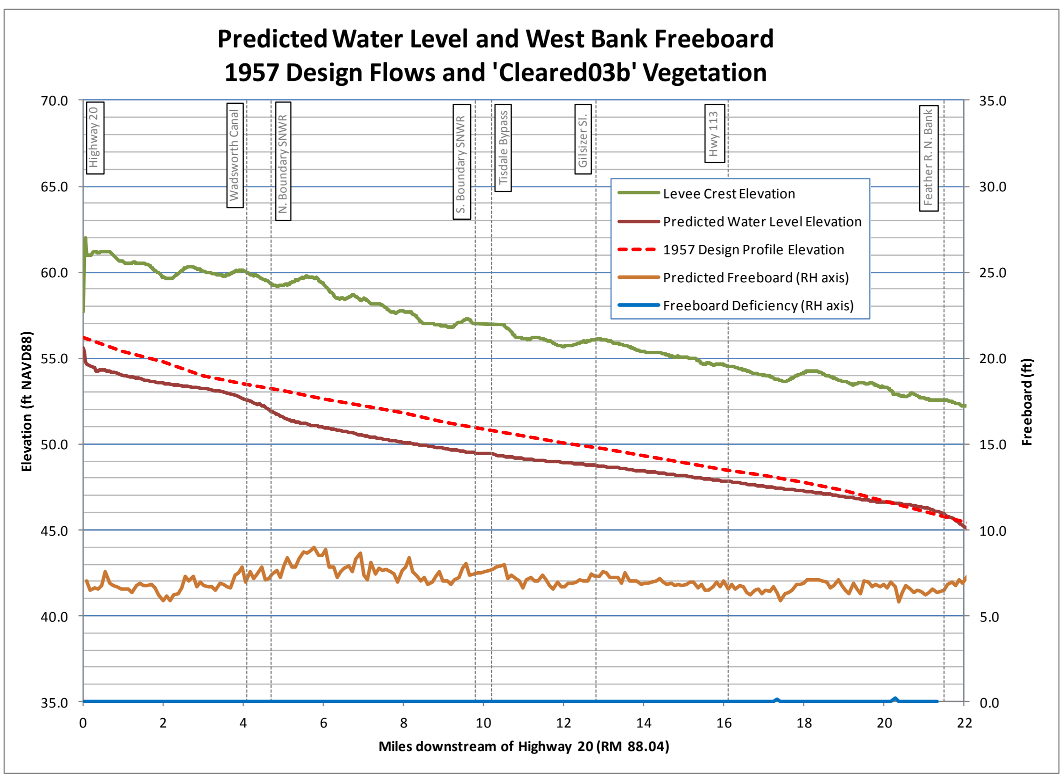

Figure A-8. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared03b' Vegetation

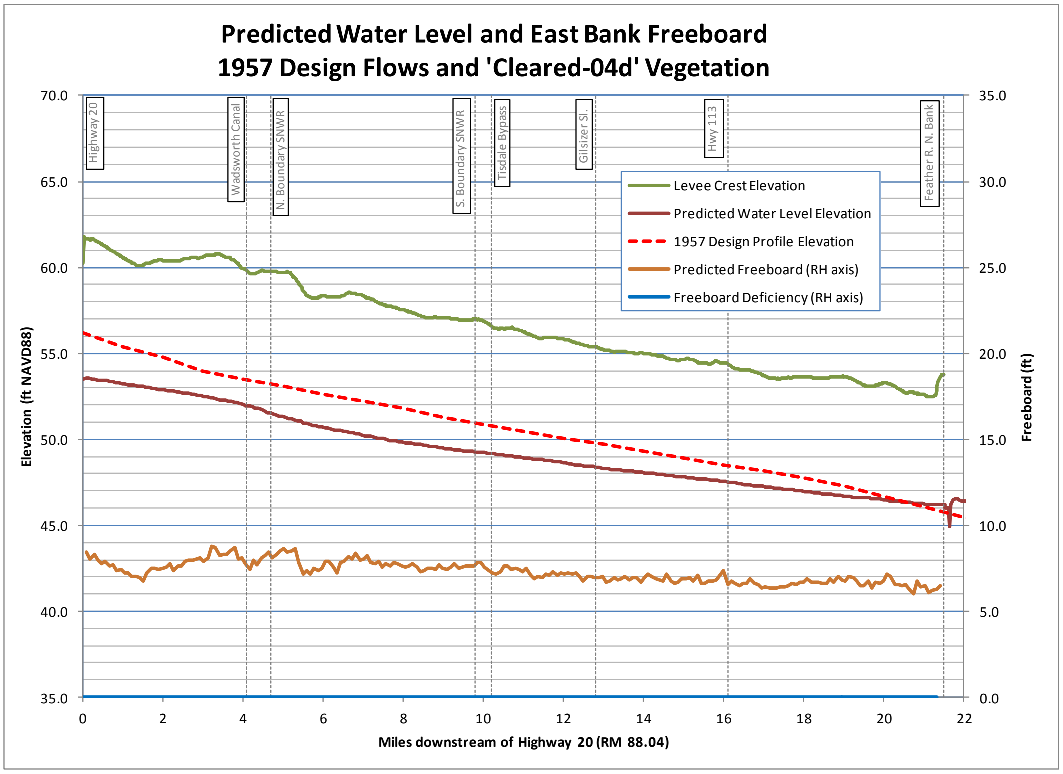

Figure A-9. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared-04d' Vegetation

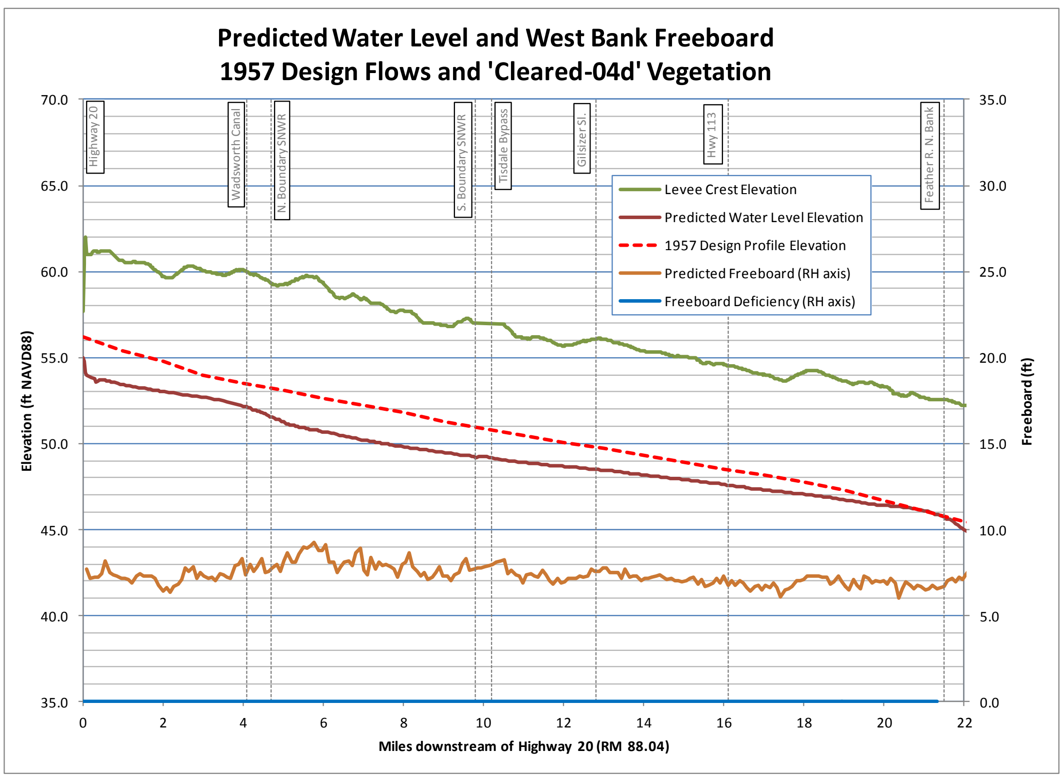

Figure A-10. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared-04d' Vegetation

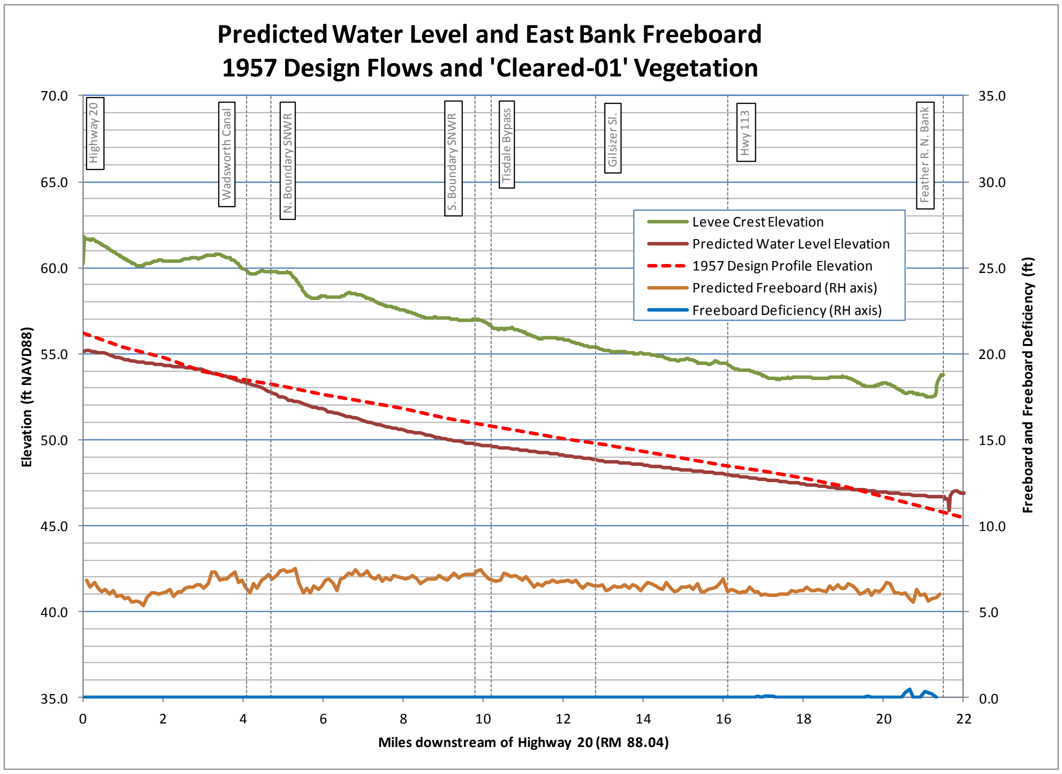

Figure A-11. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared-01' Vegetation

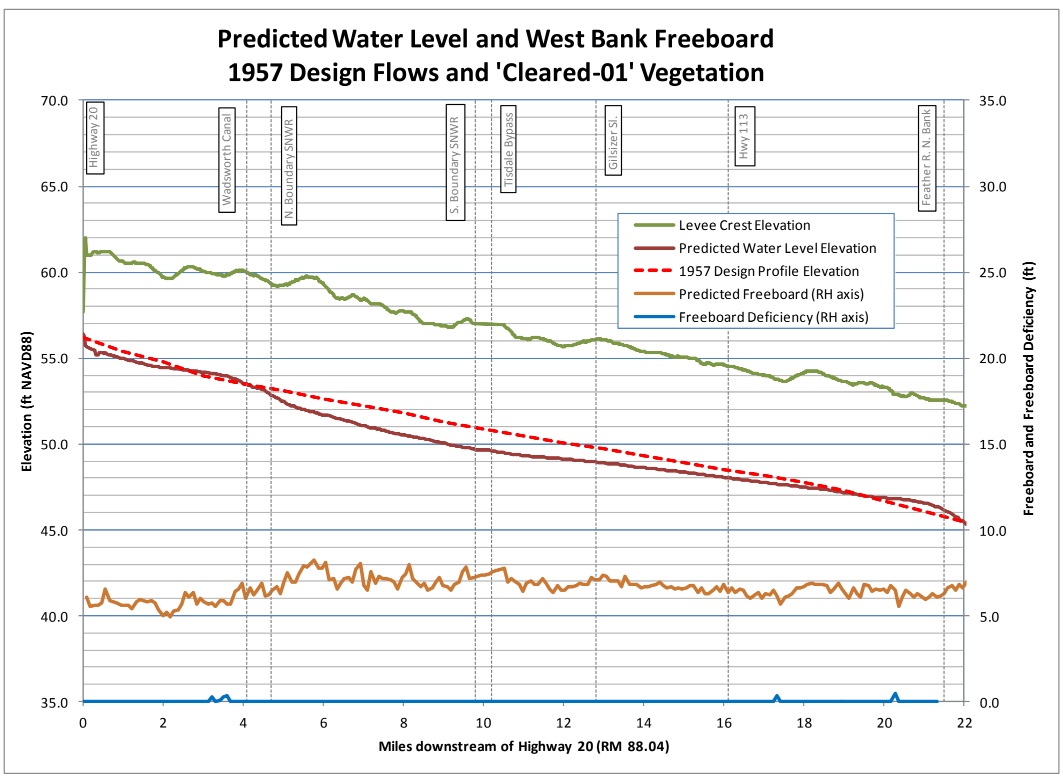

Figure A-12. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared-01' Vegetation

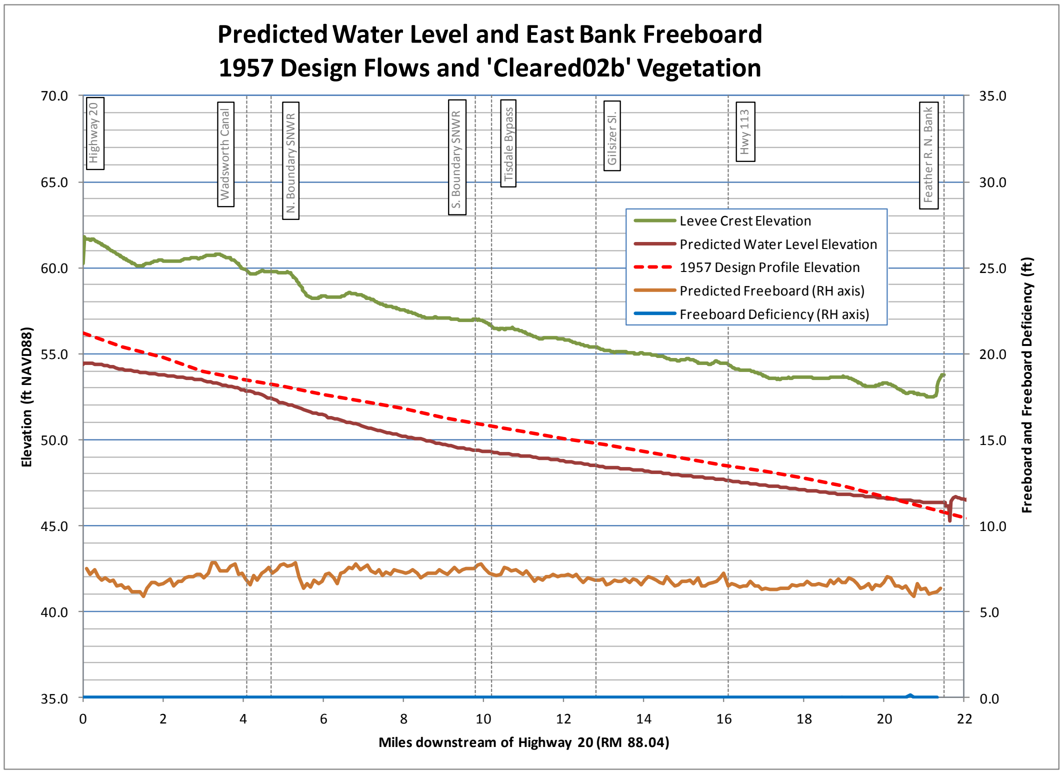

Figure A-13. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared02b' Vegetation

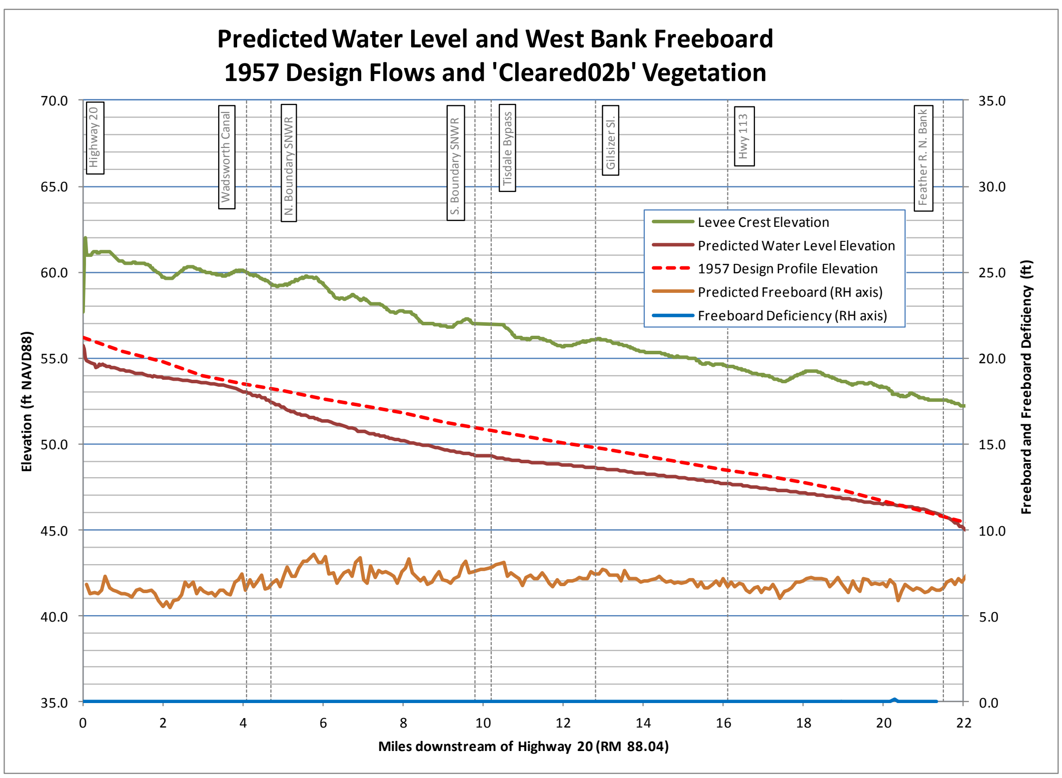

Figure A-14. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared02b' Vegetation

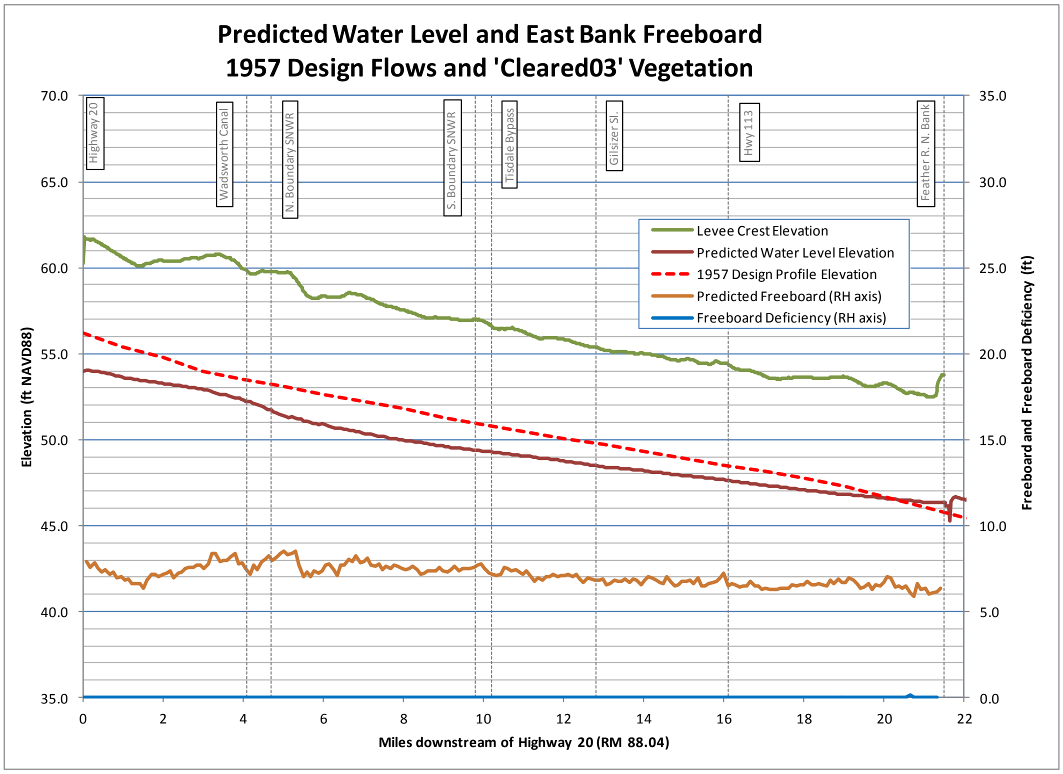

Figure A-15. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared03' Vegetation

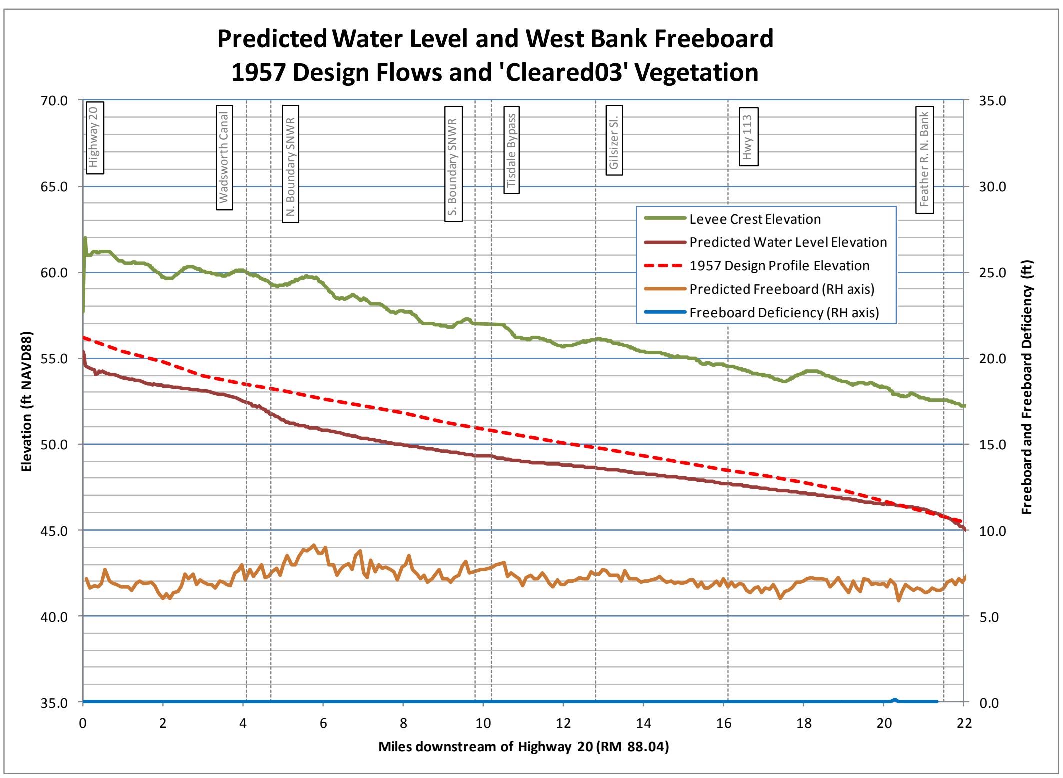

Figure A-16. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared03' Vegetation

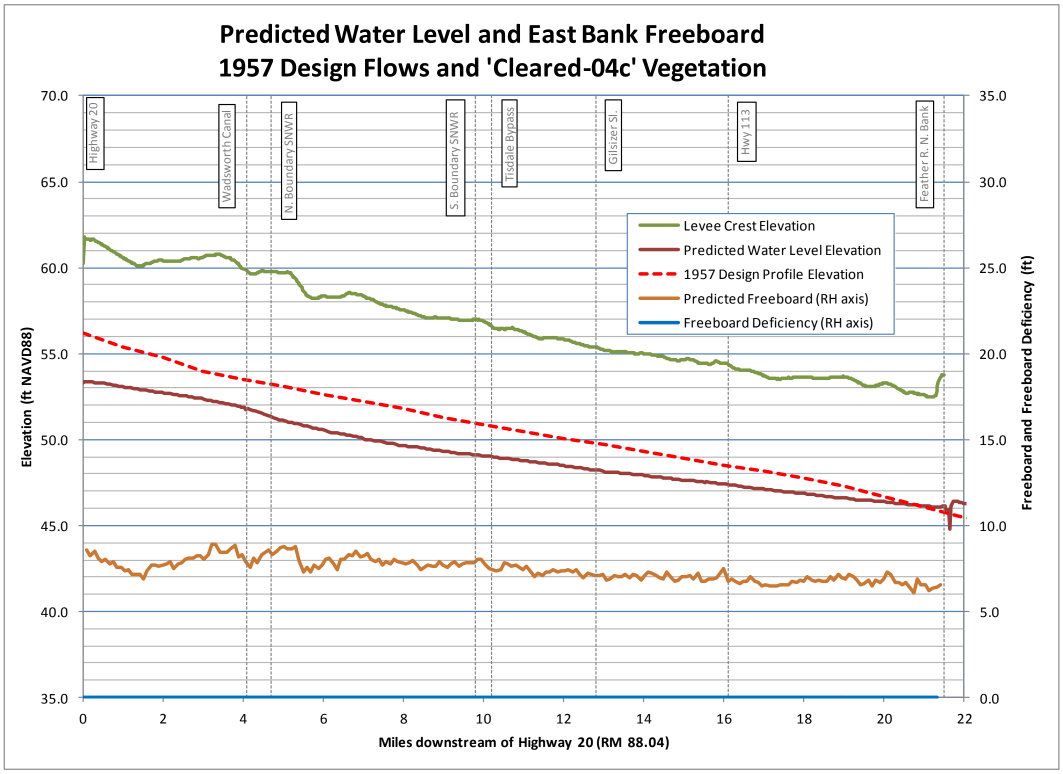

Figure A-17. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and 'Cleared-04c' Vegetation

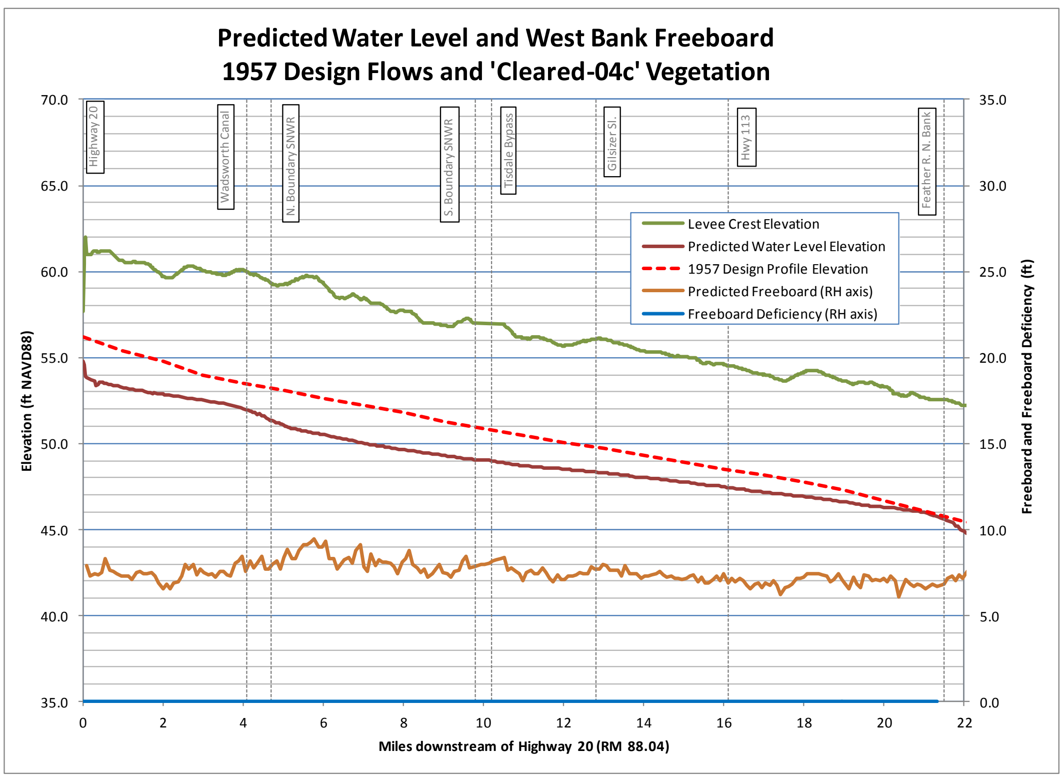

Figure A-18. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and 'Cleared-04c' Vegetation

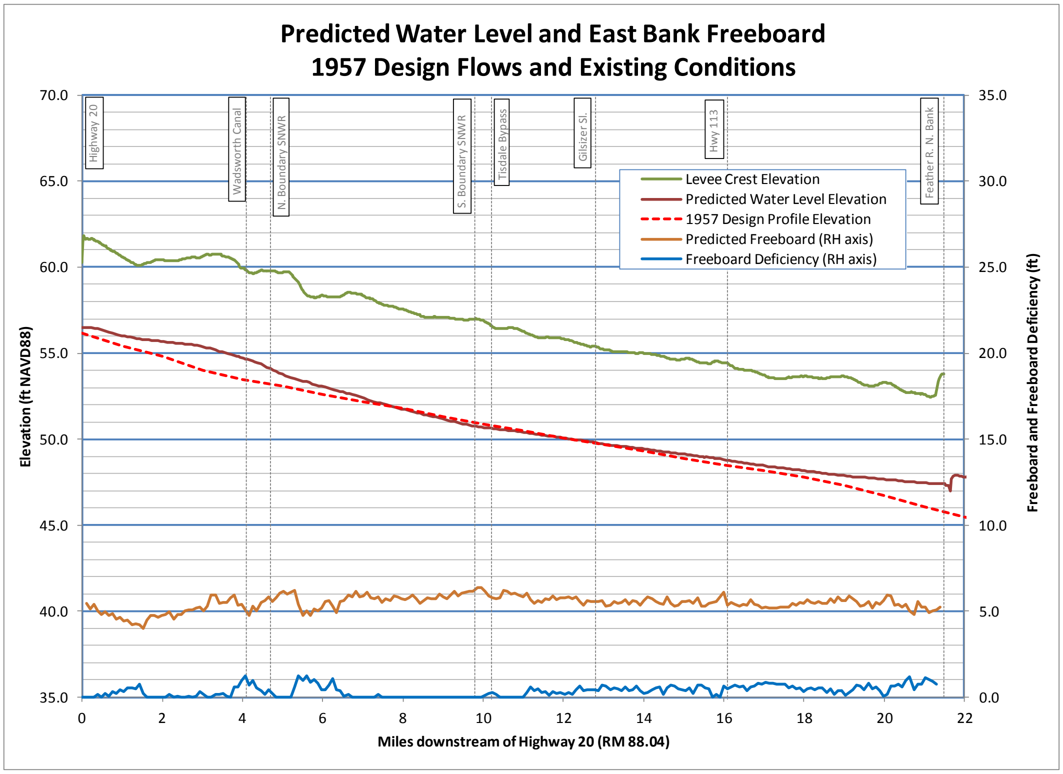

Figure A-19. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Existing Conditions

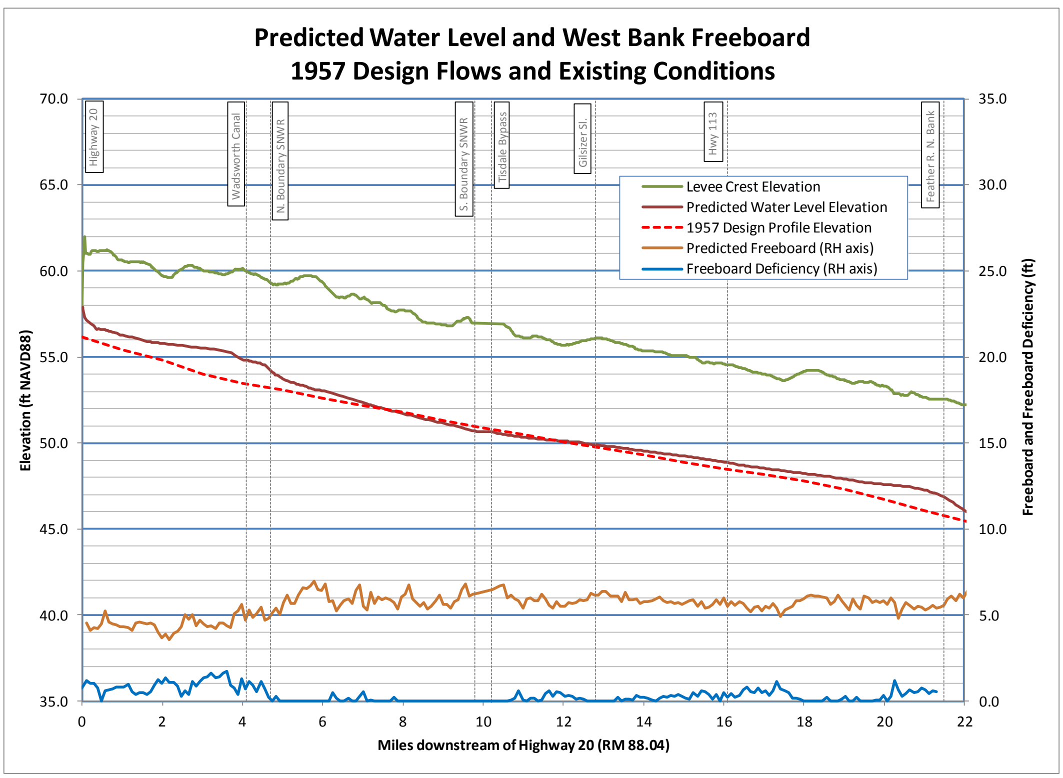

Figure A-20. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Existing Conditions

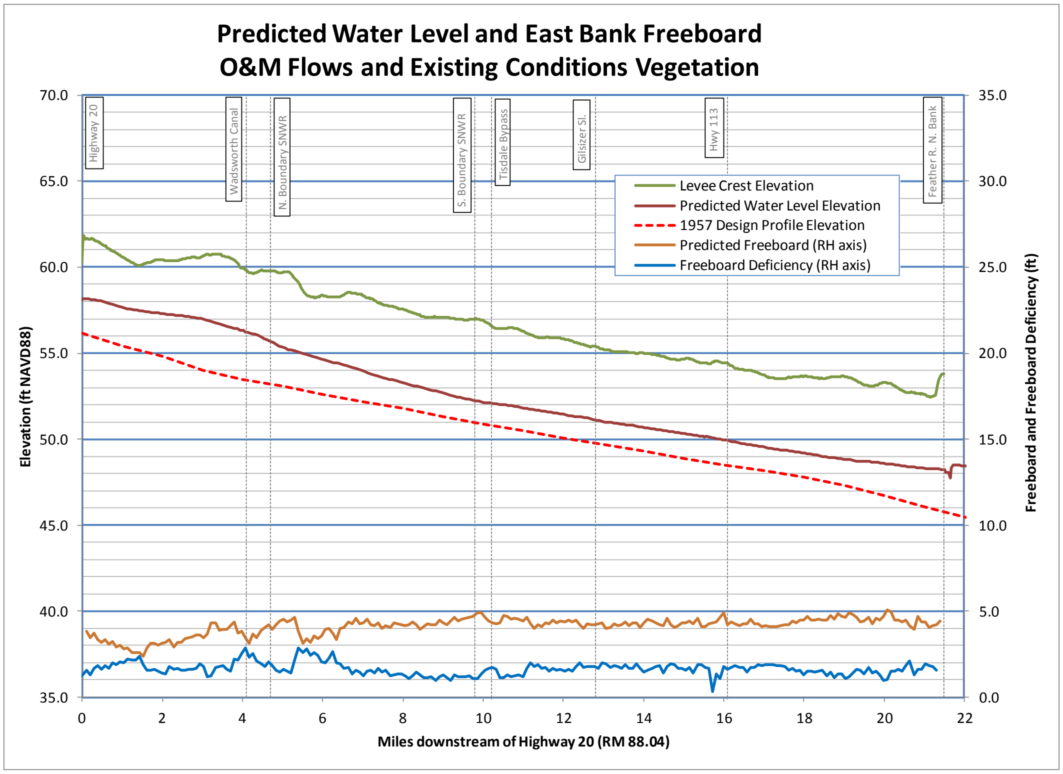

Figure A-21. Predicted Water Level and East Bank Freeboard, O&M Flows and Existing Conditions Vegetation

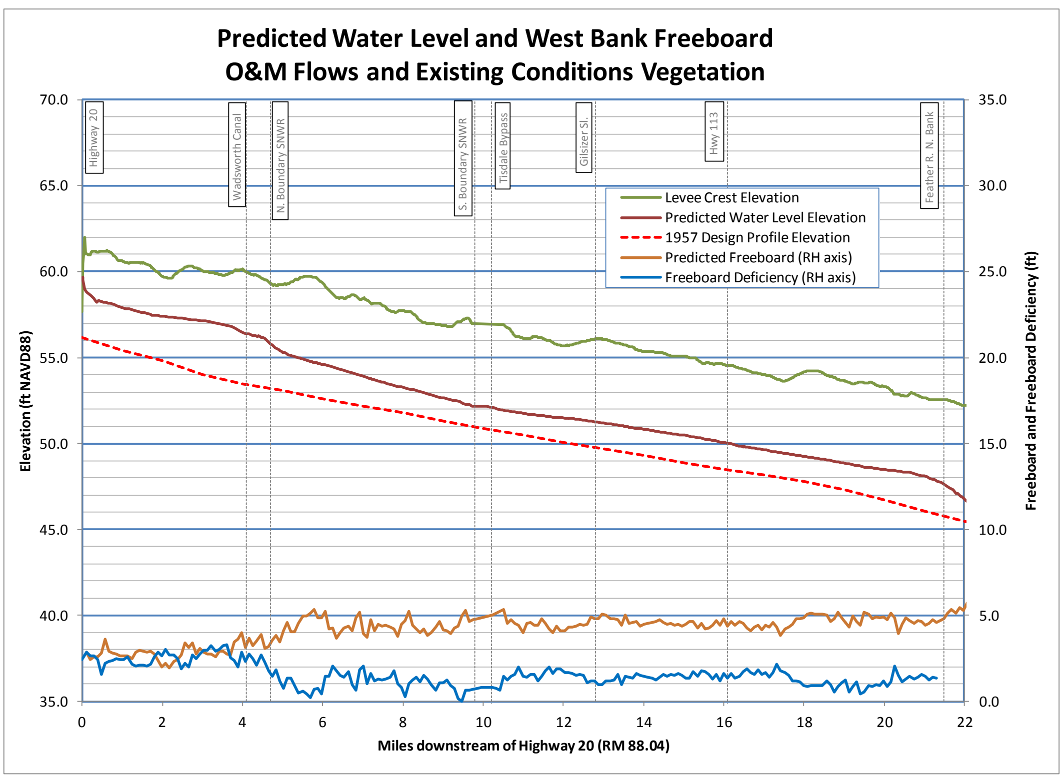

Figure A-22. Predicted Water Level and West Bank Freeboard, O&M Flows and Existing Conditions Vegetation

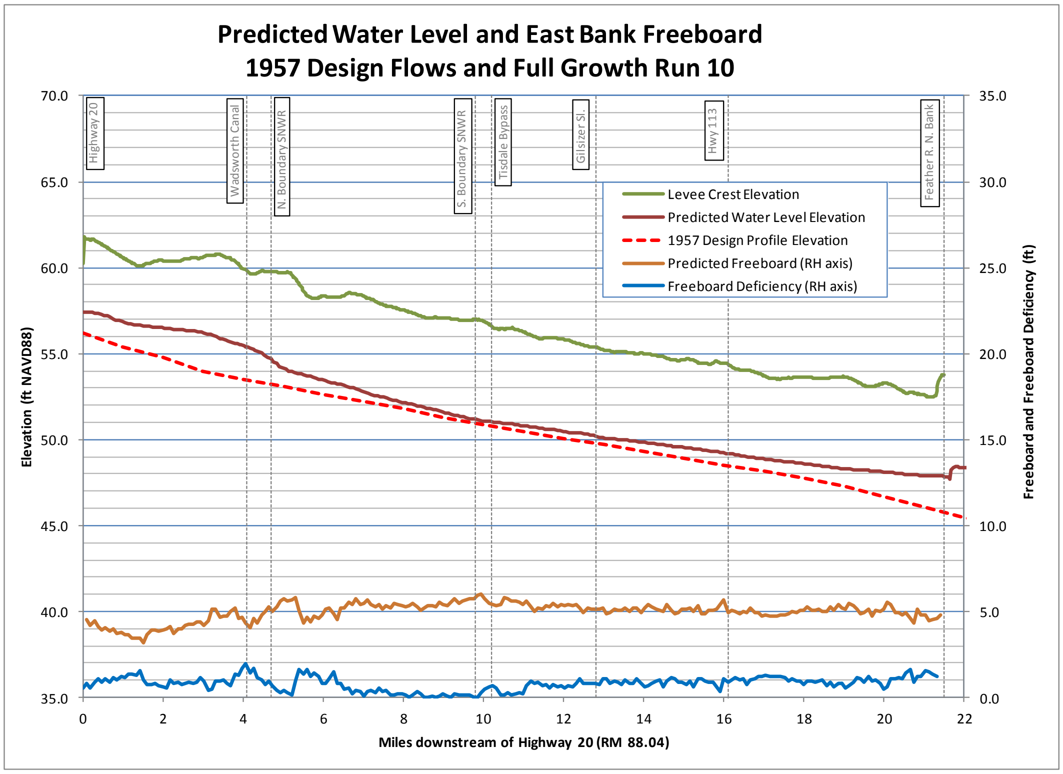

Figure A-23. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Full Growth Run 10

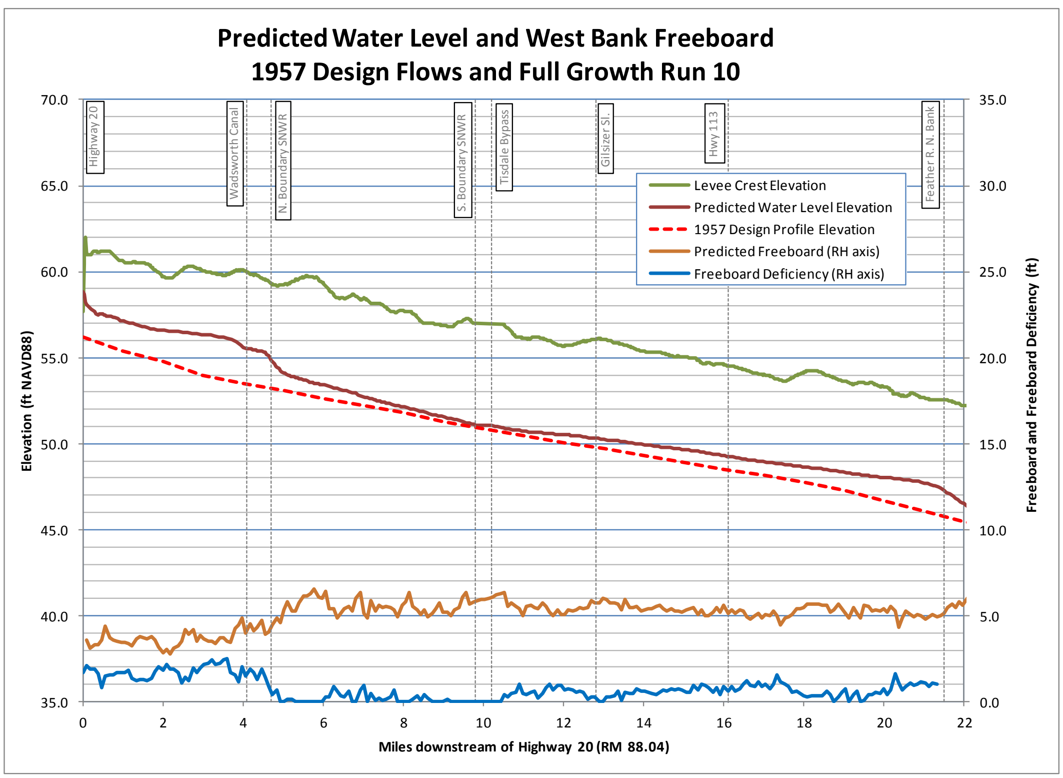

Figure A-24. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Full Growth Run 10

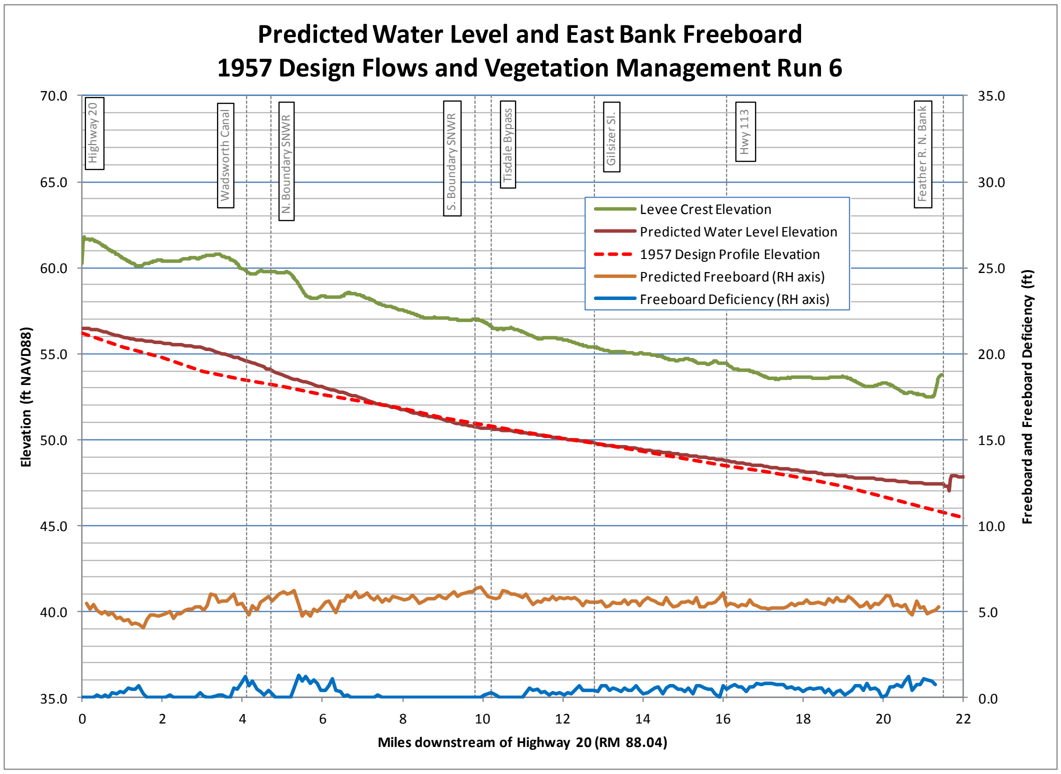

Figure A-25. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Vegetation Management Run 6

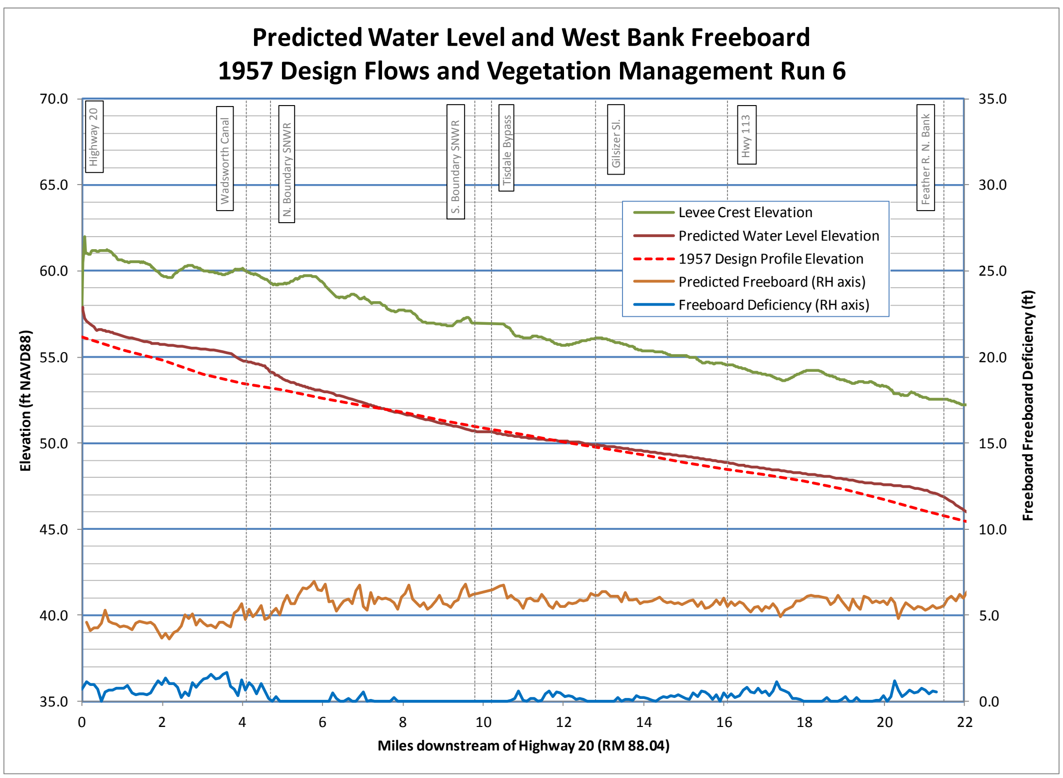

Figure A-26. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Vegetation Management Run 6

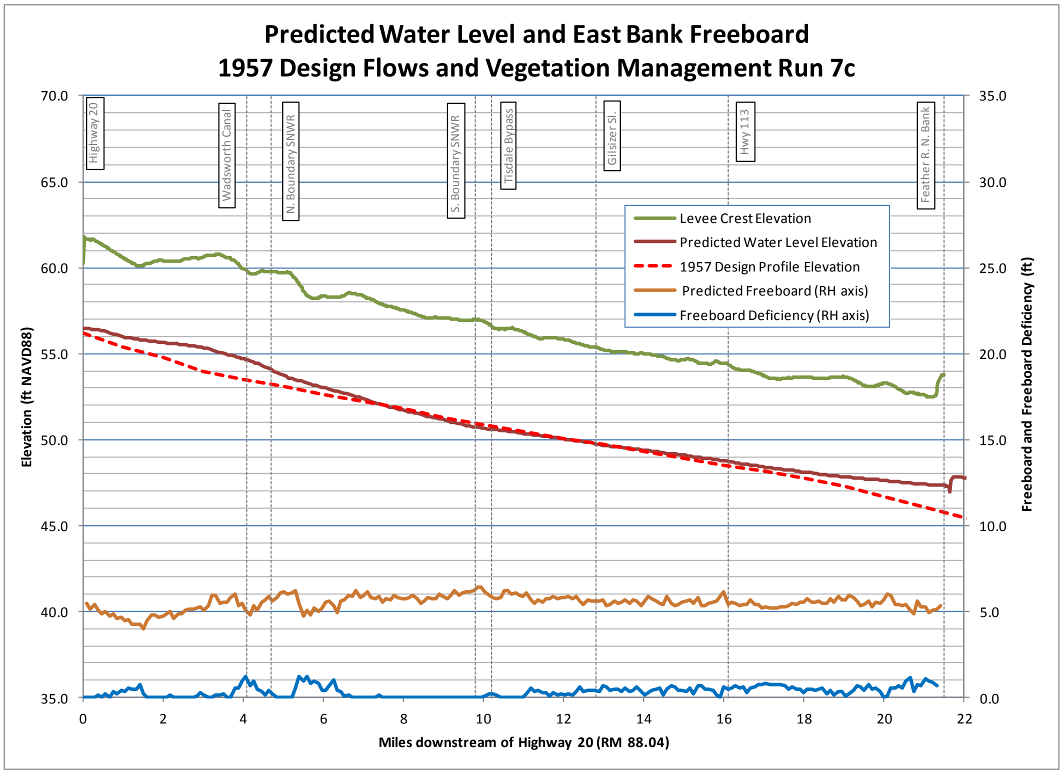

Figure A-27. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Vegetation Management Run 7c

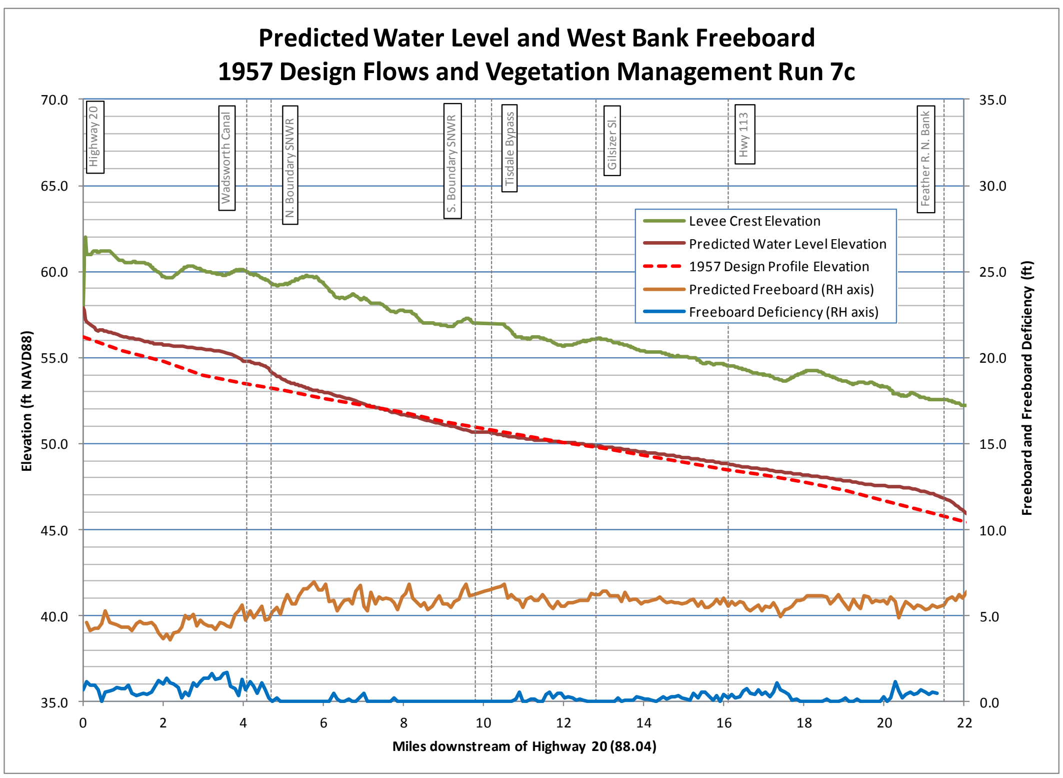

Figure A-28. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Vegetation Management Run 7c

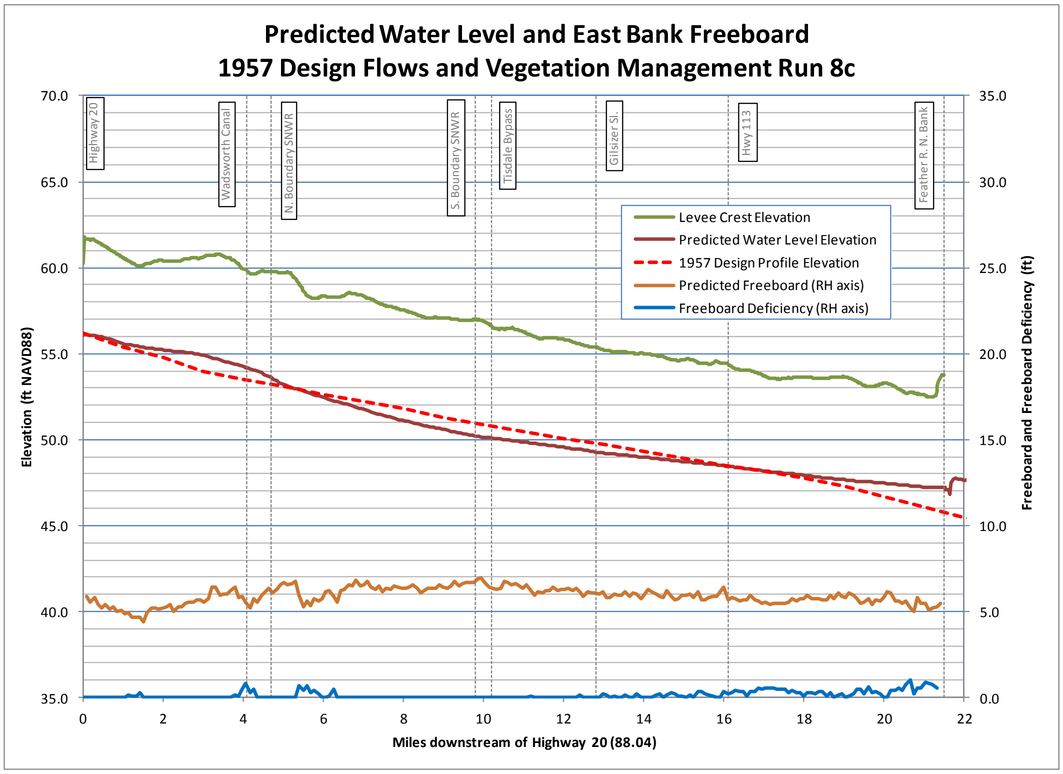

Figure A-29. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Vegetation Management Run 8c

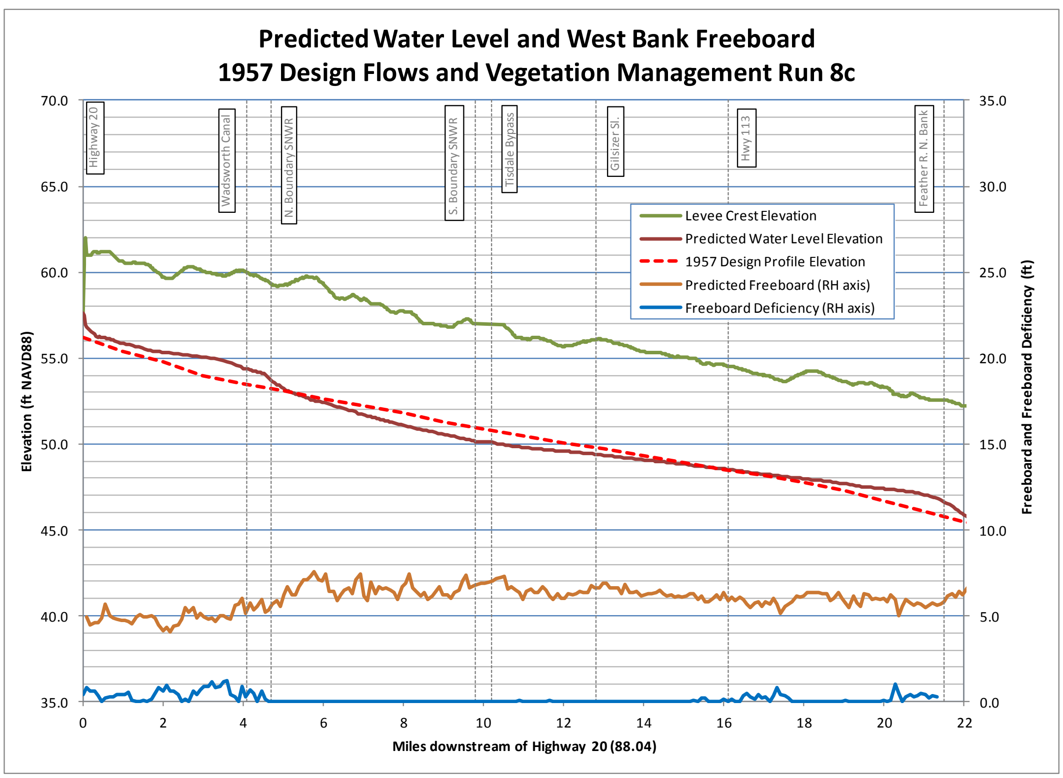

Figure A-30. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Vegetation Management Run 8c

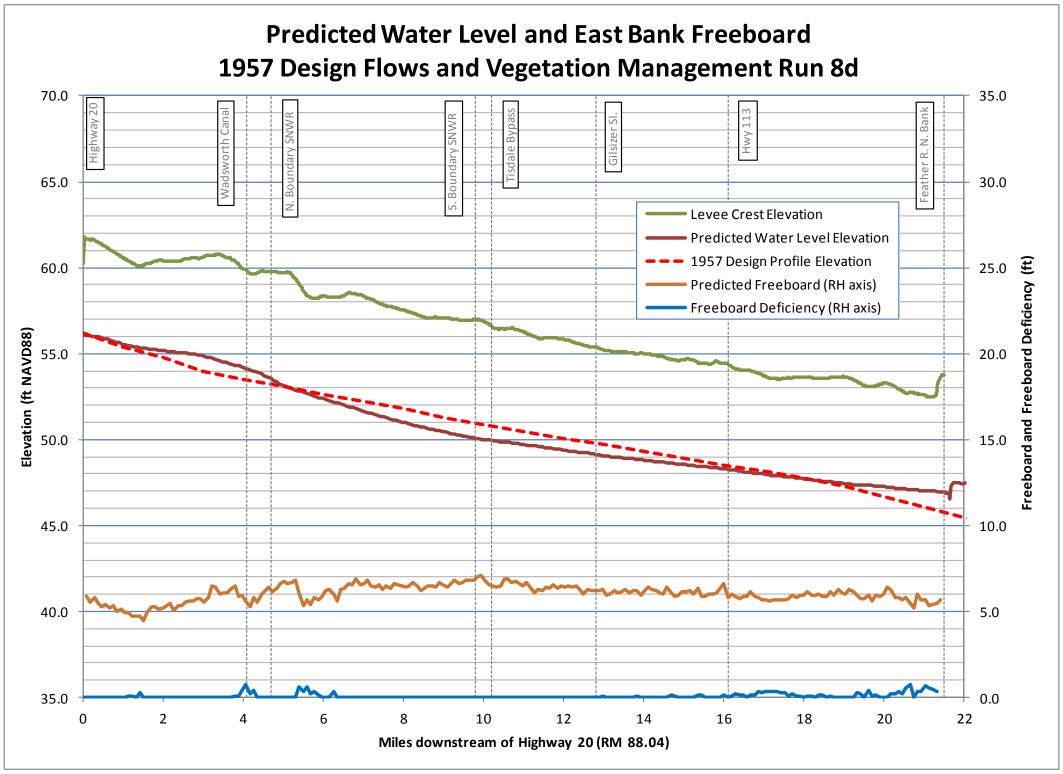

Figure A-31. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Vegetation Management Run 8d

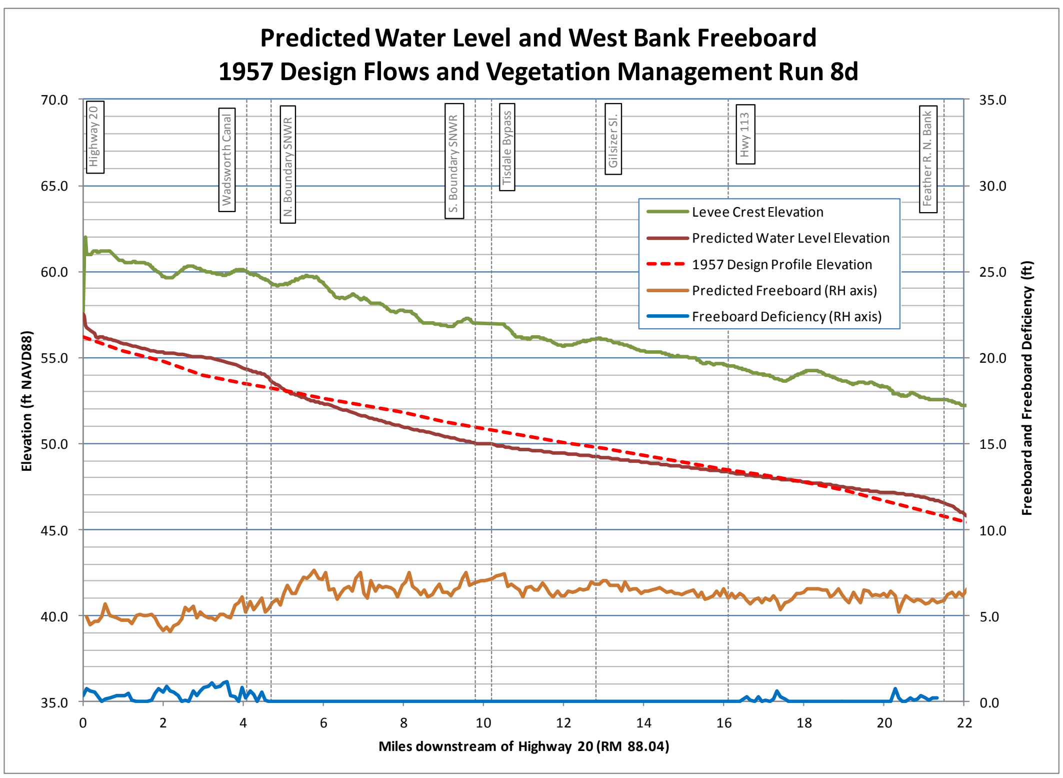

Figure A-32. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Vegetation Management Run 8d

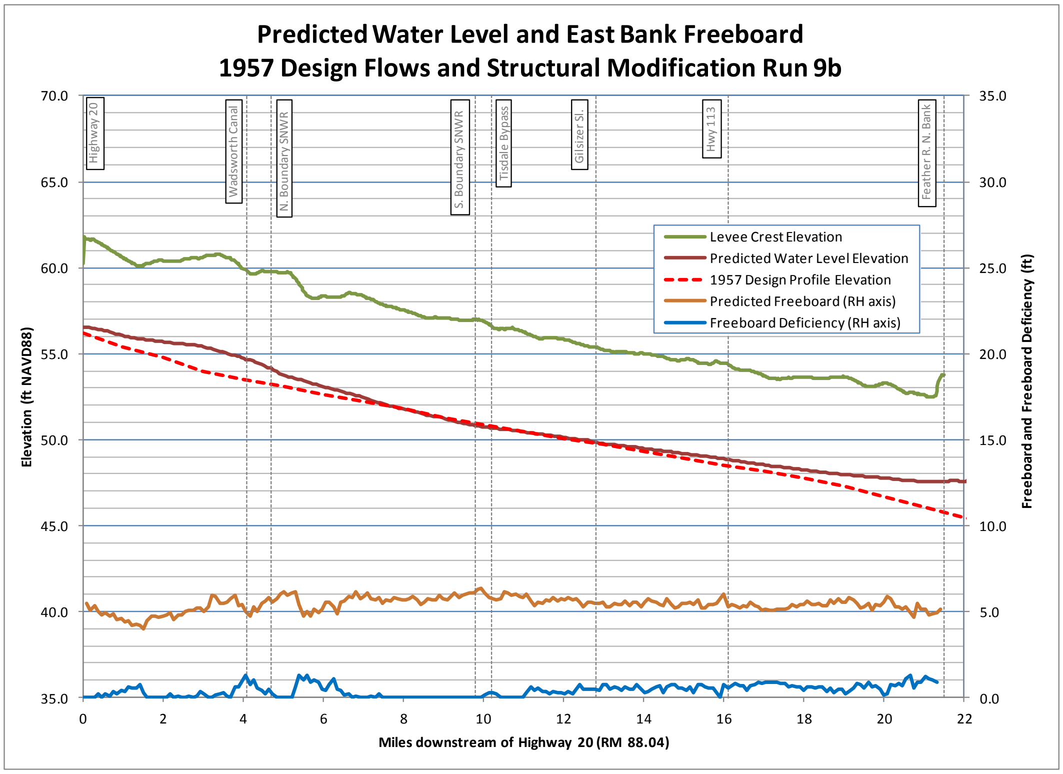

Figure A-33. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Structural Modification Run 9b

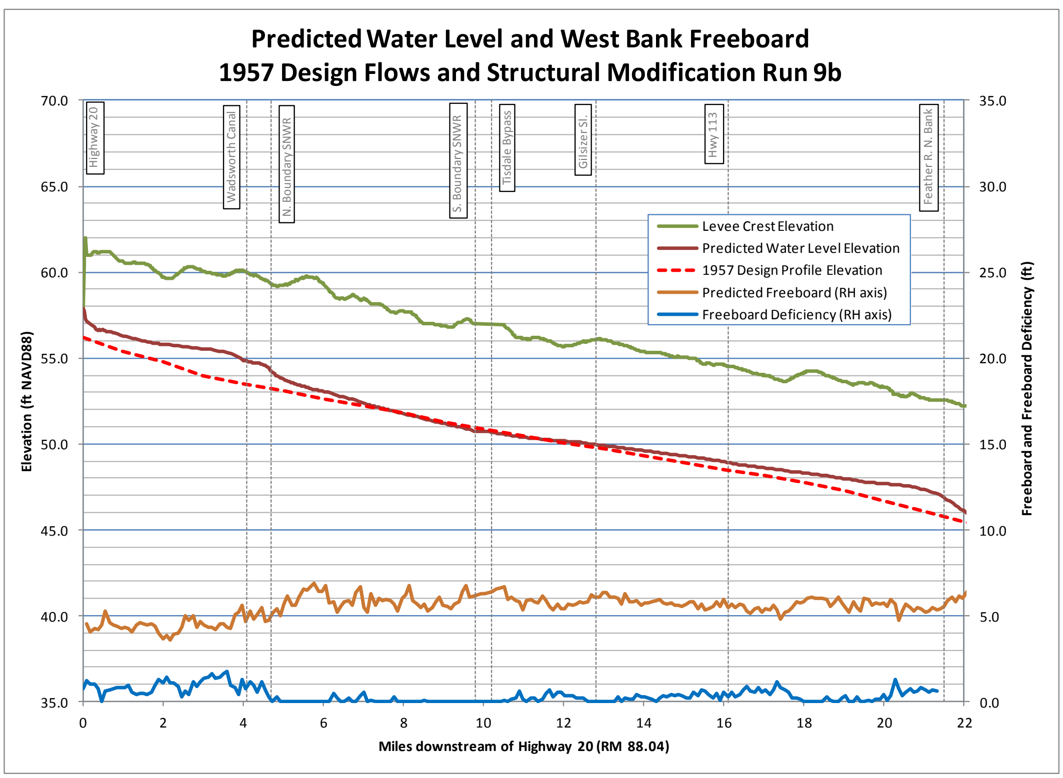

Figure A-34. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Structural Modification Run 9b

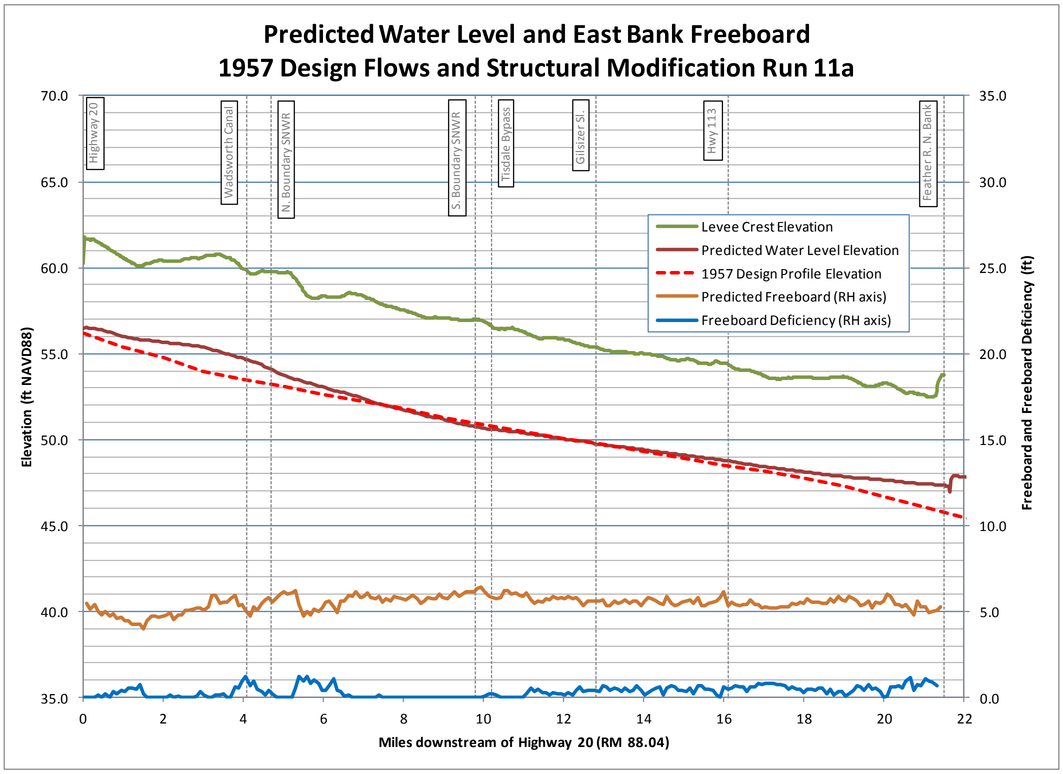

Figure A-35. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Structural Modification Run 11a

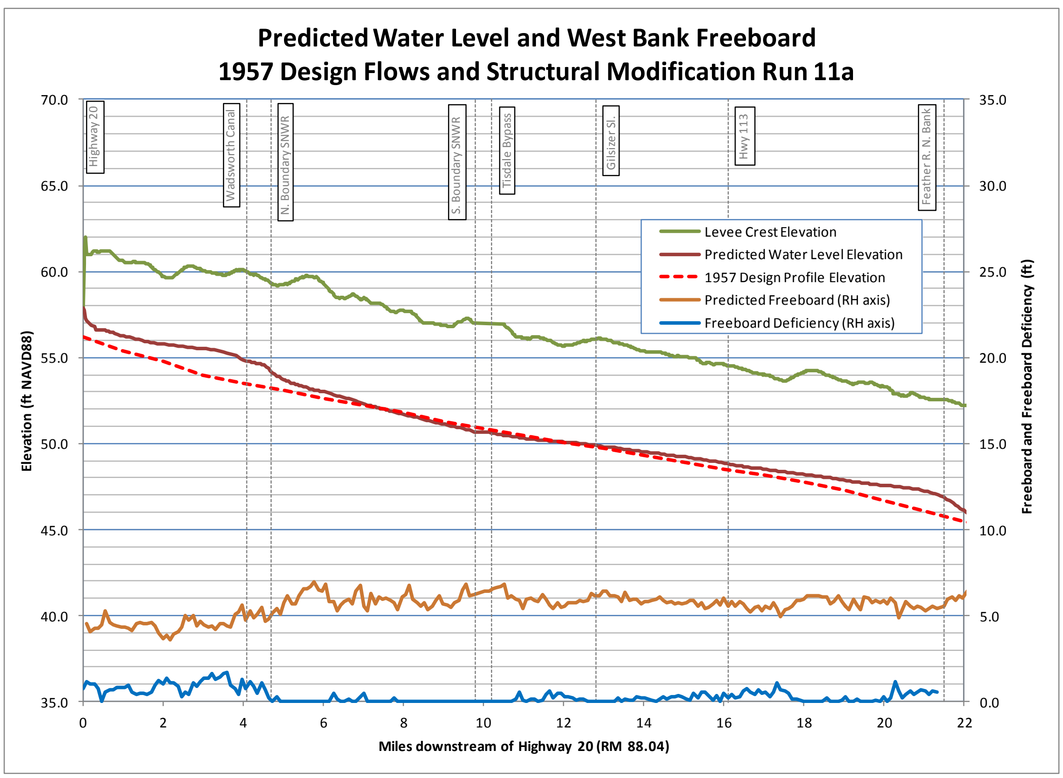

Figure A-36. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Structural Modification Run 11a

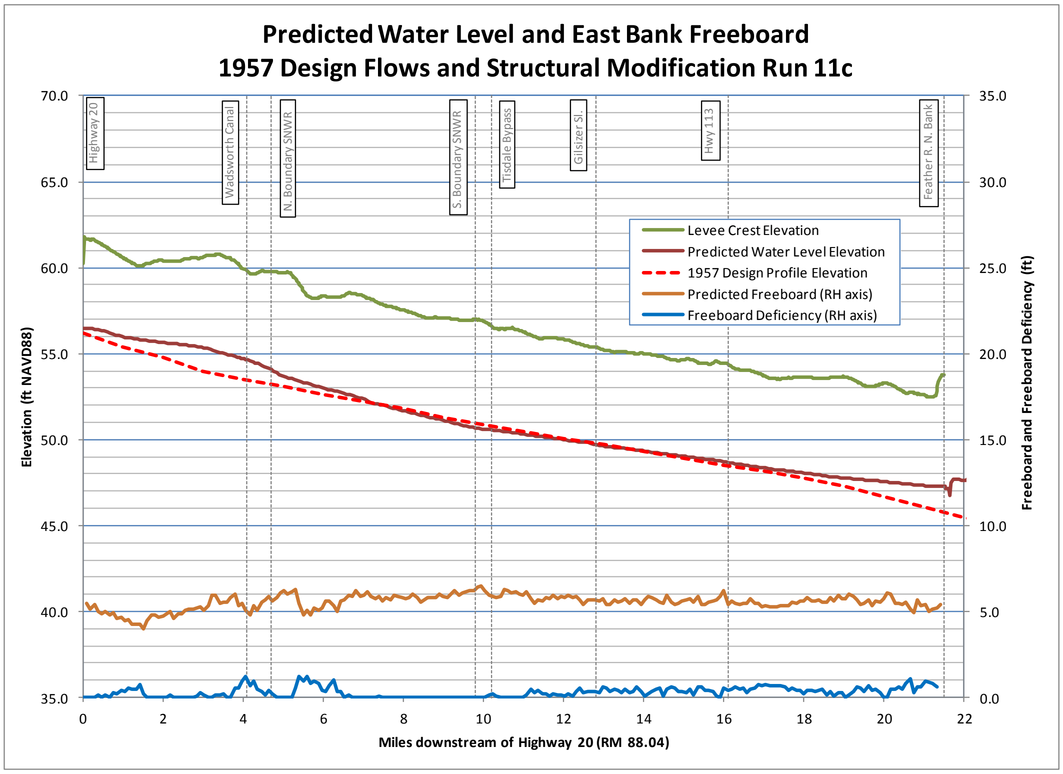

Figure A-37. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Structural Modification Run 11c

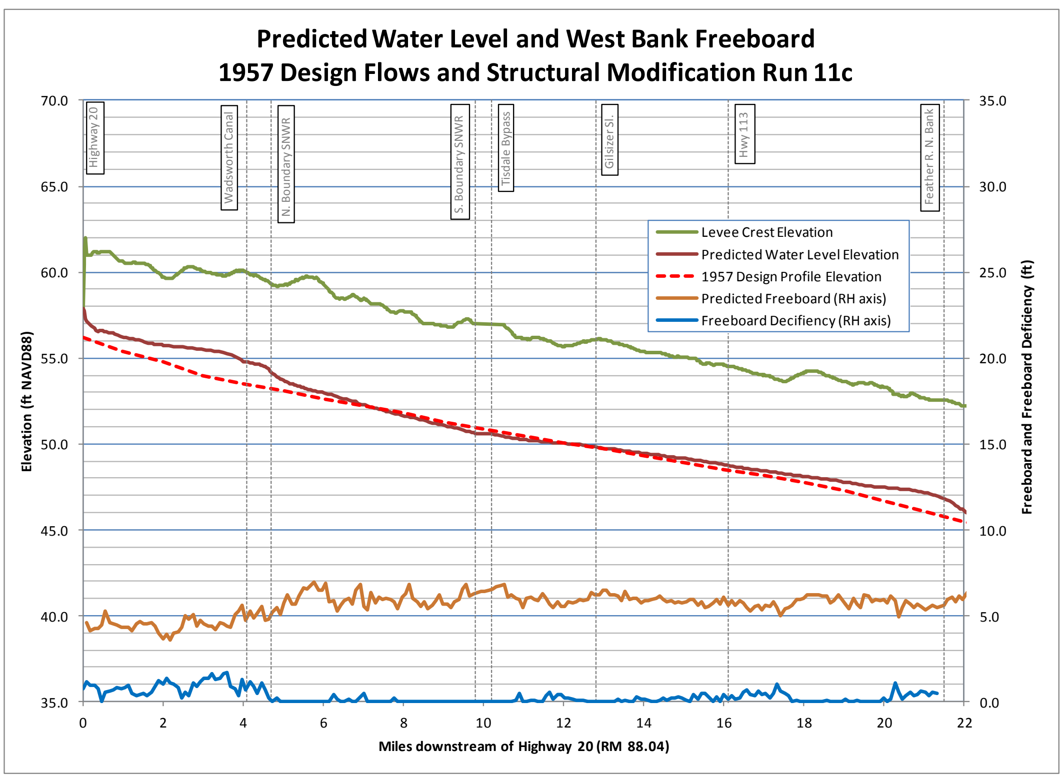

Figure A-38. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Structural Modification Run 11c

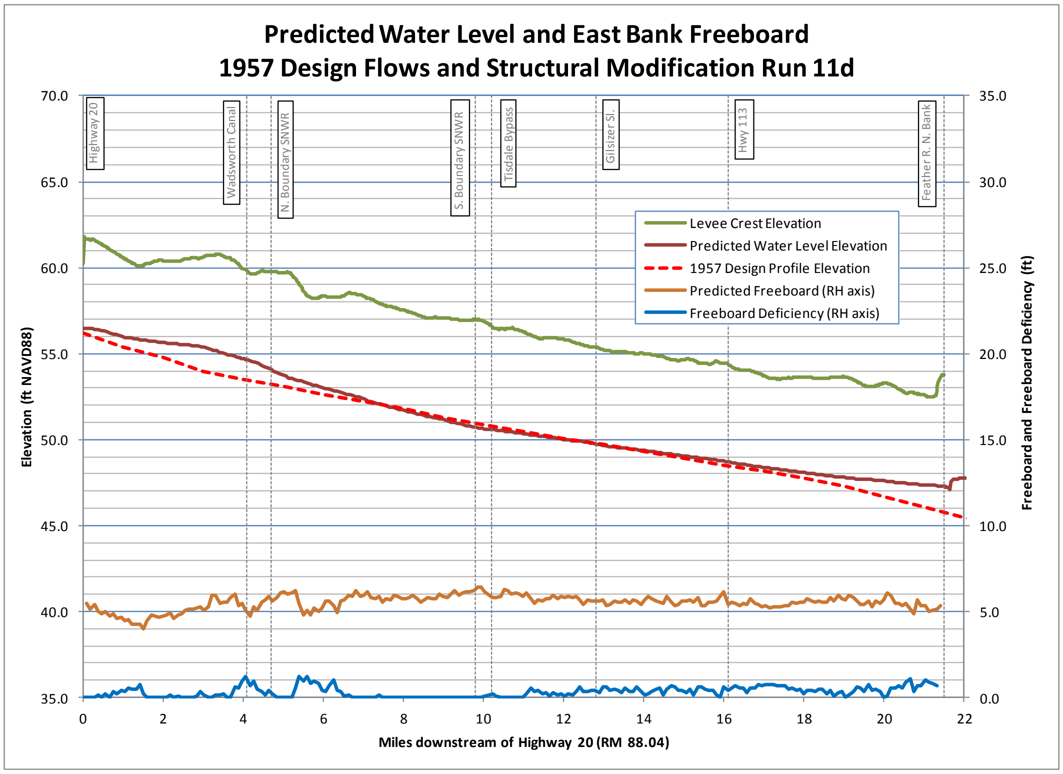

Figure A-39. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Structural Modification Run 11d

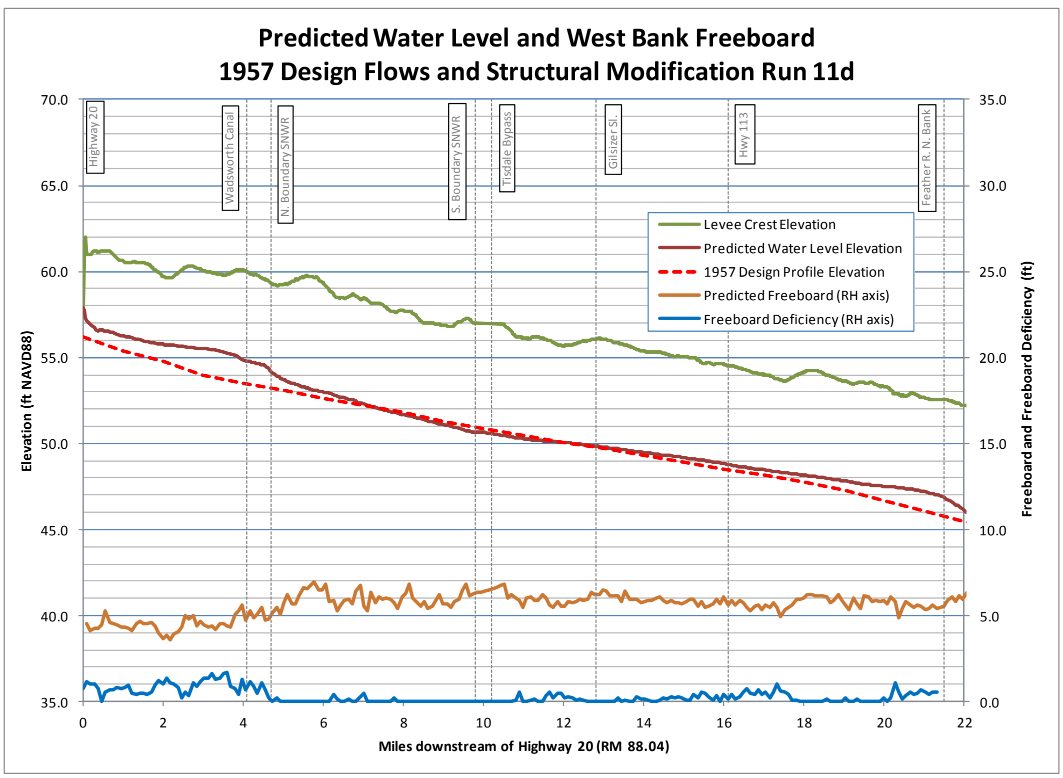

Figure A-40. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Structural Modification Run 11d

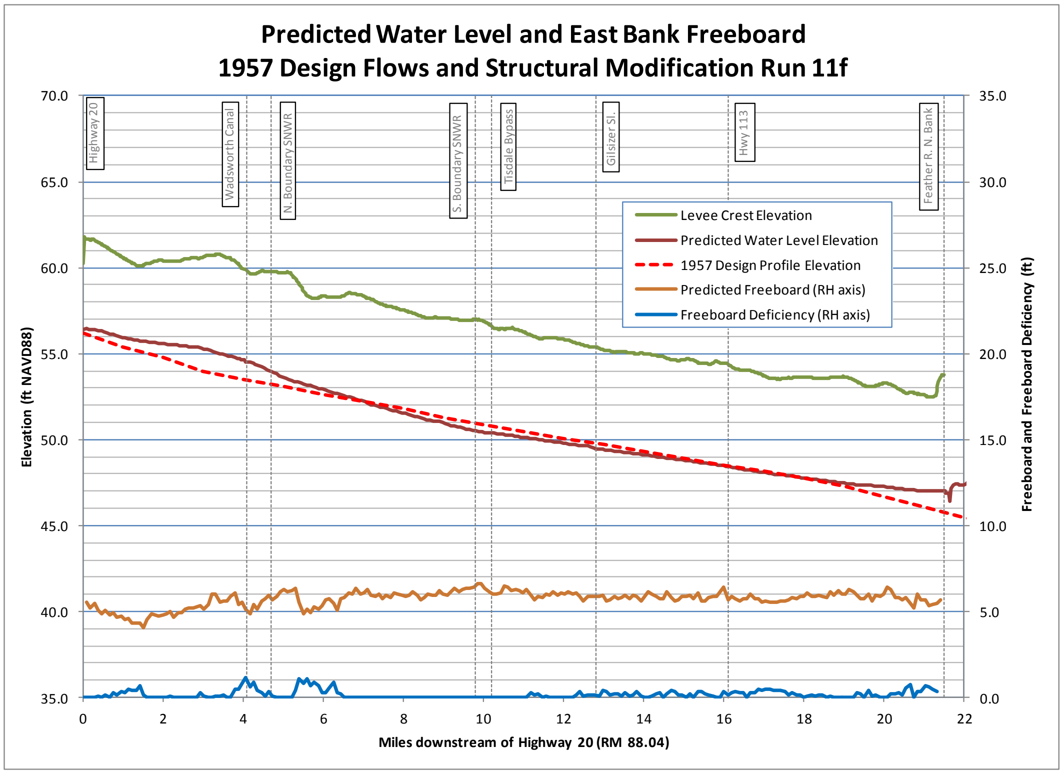

Figure A-41. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Structural Modification Run 11f

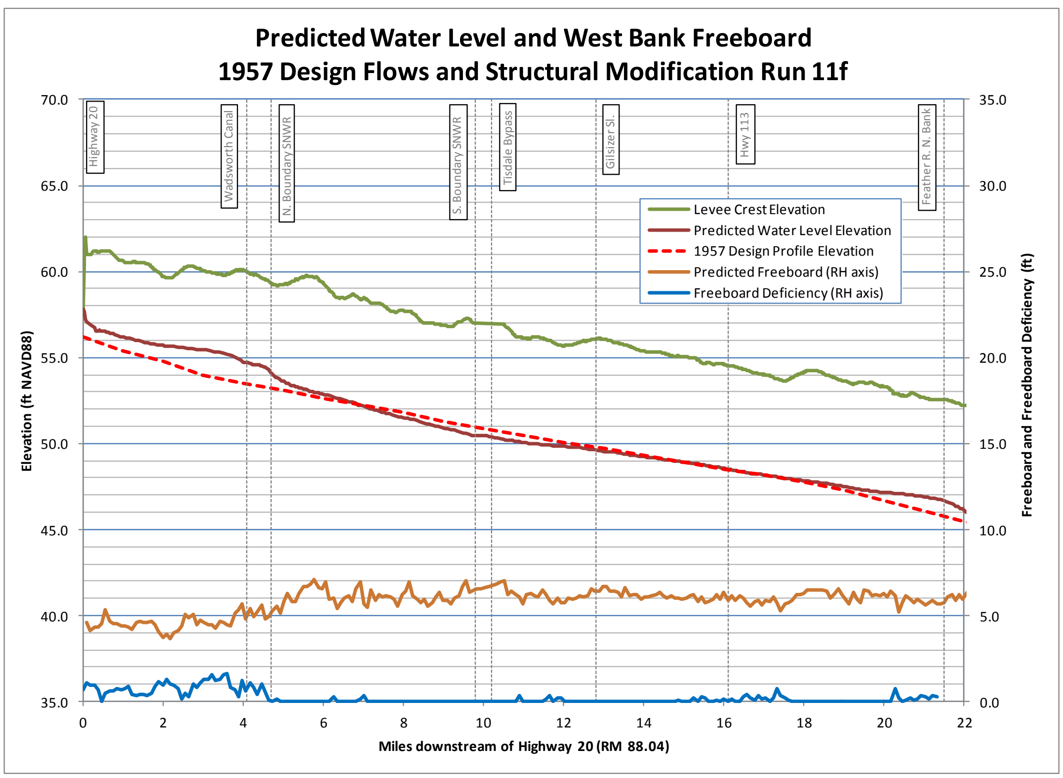

Figure A-42. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Structural Modification Run 11f

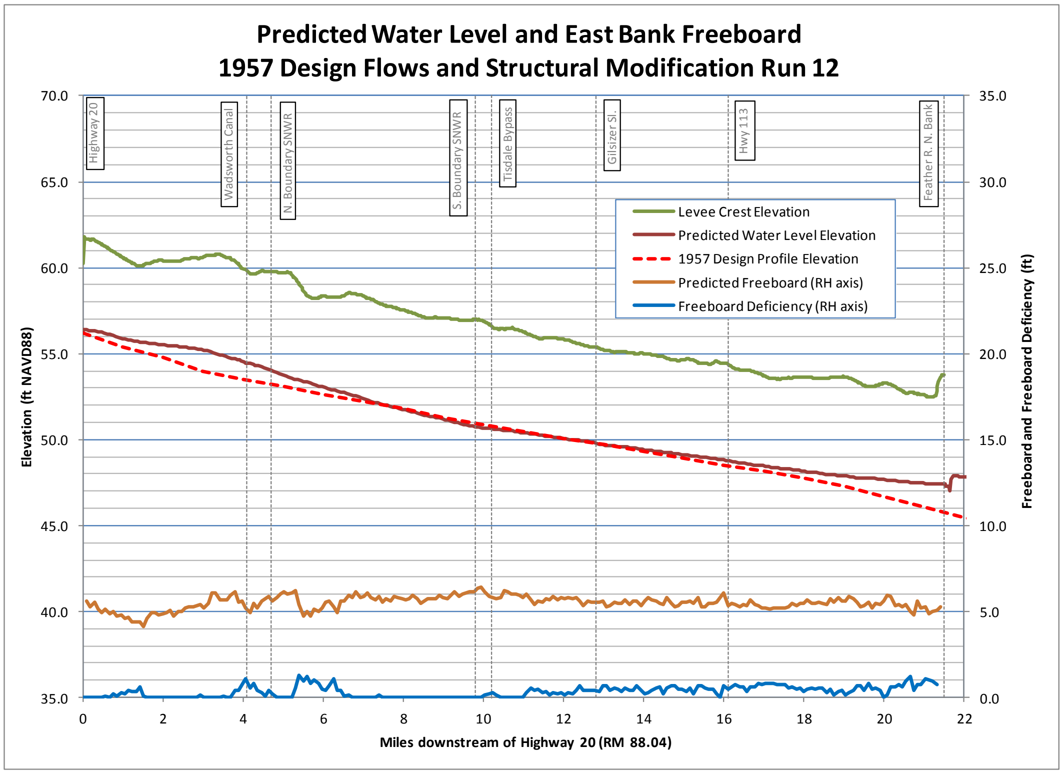

Figure A-43. Predicted Water Level and East Bank Freeboard, 1957 Design Flows and Structural Modification Run 12

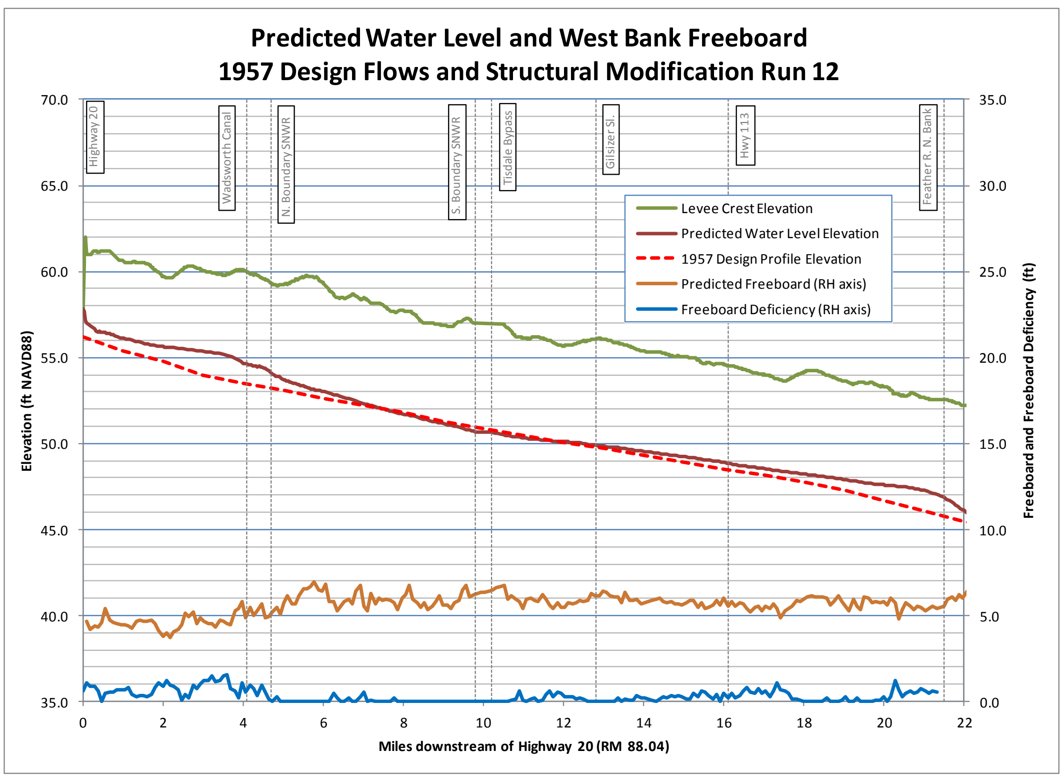

Figure A-44. Predicted Water Level and West Bank Freeboard, 1957 Design Flows and Structural Modification Run 12

MBK ENGINEERS
Water Resources • Flood Control • Water Rights

TECNICAL MEMORANDUM

DATE: December 16, 2013

TO: Sutter Butte Flood Control Agency
c/o Mike Inamine, P.E.

FROM: Don Trieu, P.E.

SUBJECT: CVFPB - Sutter Bypass Hydraulic Model Development and Analysis

Introduction

MBK Engineers has reviewed the model development and hydraulic analysis of the Sutter Bypass completed by the Central Valley Flood Protection Board (CVFPB). As part of CVFPB Board Resolution 2009-11, a two dimensional (2-D) hydraulic model of the Sutter Bypass was developed to analyze the impacts of the Sutter National Wildlife Refuge (SNWR) on the carrying capacity of the Sutter Bypass. This review was performed on behalf of the Sutter Butte Flood Control Agency. This memorandum summarizes the results of our review.

Scope of Review

The scope of MBK's review was limited to the following:

1. We reviewed the model development, calibration and verification.
2. We reviewed the model inputs and outputs for the Existing Condition and SNWR Vegetation management simulations.
3. We reviewed the plots of computed water surface profiles.

Background

The CVFPB contracted with CH2m Hill to develop the 2-D model and perform analysis of various vegetation management and structural alternatives. The 2-D model of the Sutter Bypass was developed using RMA2, hydraulic modeling software developed by the United States Army Corps of Engineers (Corps). RMA2 is a 2-D, depth-averaged finite element hydrodynamic numerical model capable of calculating water surface elevations and horizontal velocity components for flow in two dimensions.

The RMA2 model of the Sutter Bypass simulates the Sutter Bypass from Highway 20 to the Sacramento River (Figure 1). It also extends into the Yolo Bypass, terminating near I-5 and simulates portions of the Sacramento River to the gage at Verona and the Feather River to Highway 99. The model development and calibration is documented in (CH2m Hill 2013a).

Simulations

Model simulations using the RMA2 model were performed of various vegetation conditions to determine the maximum water surface elevation. Adjustments were made to the model parameters (Manning's roughness coefficient) to reflect the condition being simulated. Five conditions were simulated and are as follows:

1. Bare Soil (Minimum Roughness)
2. Existing Conditions
3. Vegetation Fully Grown (Maximum Roughness)
4. Vegetation Management
5. Structural Modifications

Full description of the simulations and results are documented in (CH2M Hill 2013b).

The five conditions were simulated using the Sacramento River Flood Control Project (SRFCP) 1957 design flows and are as follows:

1. Sutter Bypass at Longbridge: 150,000 cfs
2. Wadsworth Canal: 1,500 cfs
3. Tisdale Bypass: 28,500 cfs
4. Feather River: 200,000 cfs
5. Sacramento River at Knights Landing: 30,000 cfs
6. Cache Creek: 15,000 cfs
7. Natomas Cross Canal: 22,000 cfs

The conditions that pertain most to determine the effects of the SNWR on carrying capacity of the Sutter Bypass are results from Existing Conditions and Vegetation Management Condition.

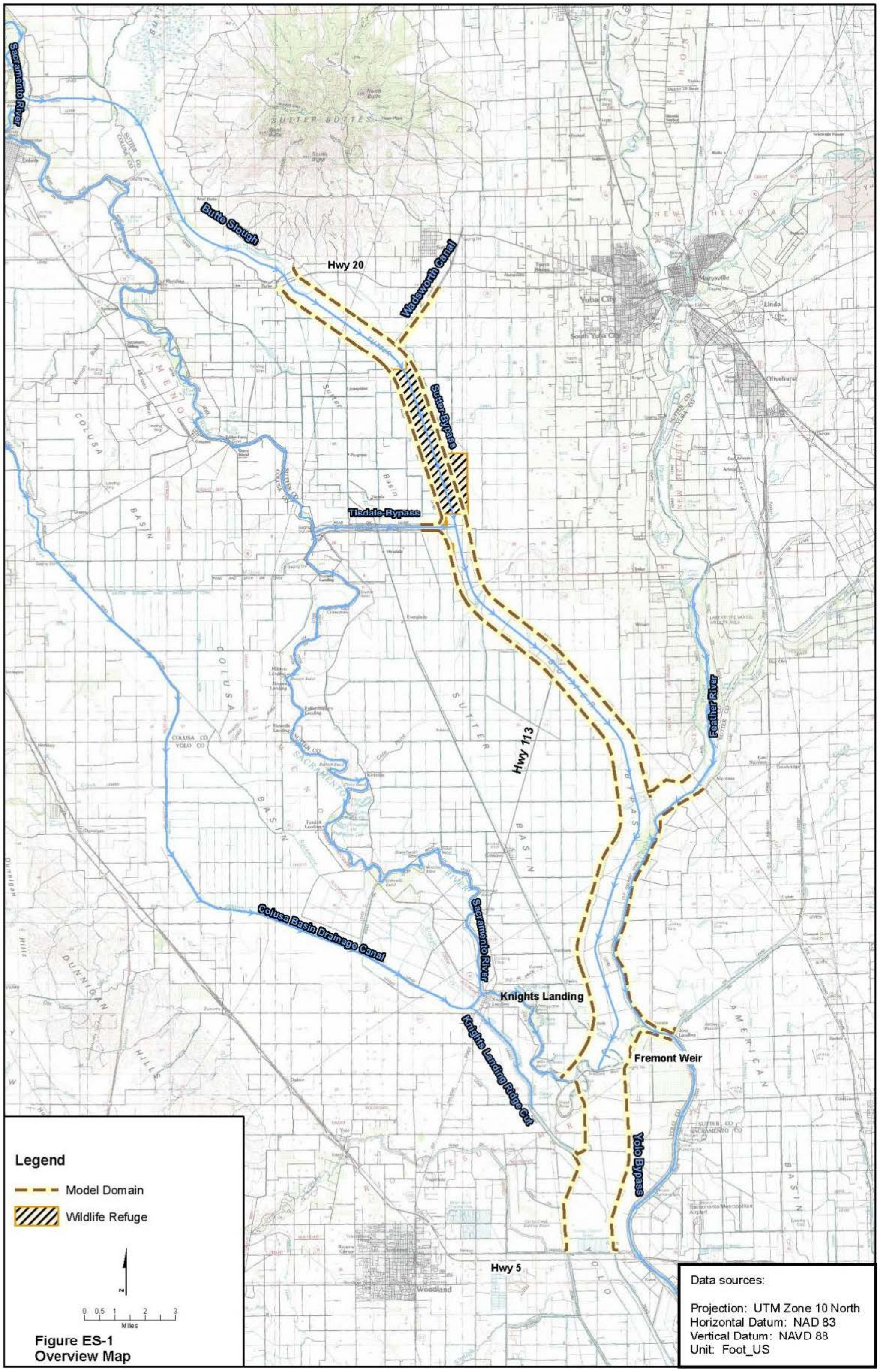
Sacramento River
Butte Slough
Hwy 20
Wadsworth Canal
Sutter Bypass
Tisdale Bypass
Hwy 113
Feather River
Colusa Basin Drainage Canal
Sacramento River
Knights Landing
Fremont Weir
Knights Landing Ridge Cut
Yolo Bypass
Hwy 5
Legend
Model Domain
Wildlife Refuge
Miles
Figure ES-1
Overview Map
Data sources:
Projection: UTM Zone 10 North
Horizontal Datum: NAD 83
Vertical Datum: NAVD 88
Unit: Foot_US

Figure 1

Existing Condition

The Existing Condition represents the present vegetation condition in the Sutter Bypass. Since the model was calibrated to the January 2006 flood event, the Manning's roughness coefficient in the model reflects vegetation conditions at the time of the flood. Since 2006, DWR Sutter Maintenance Yard has been performing some vegetation clearing within a 25-acre parcel in the SNWR. The Manning's roughness coefficient was adjusted in that parcel for the simulation of the Existing Conditions. Figure 2 plots the computed water surface elevation for the 1957 design flow. Also plotted is the 1957 Design Flood Plane (USACE 1957).

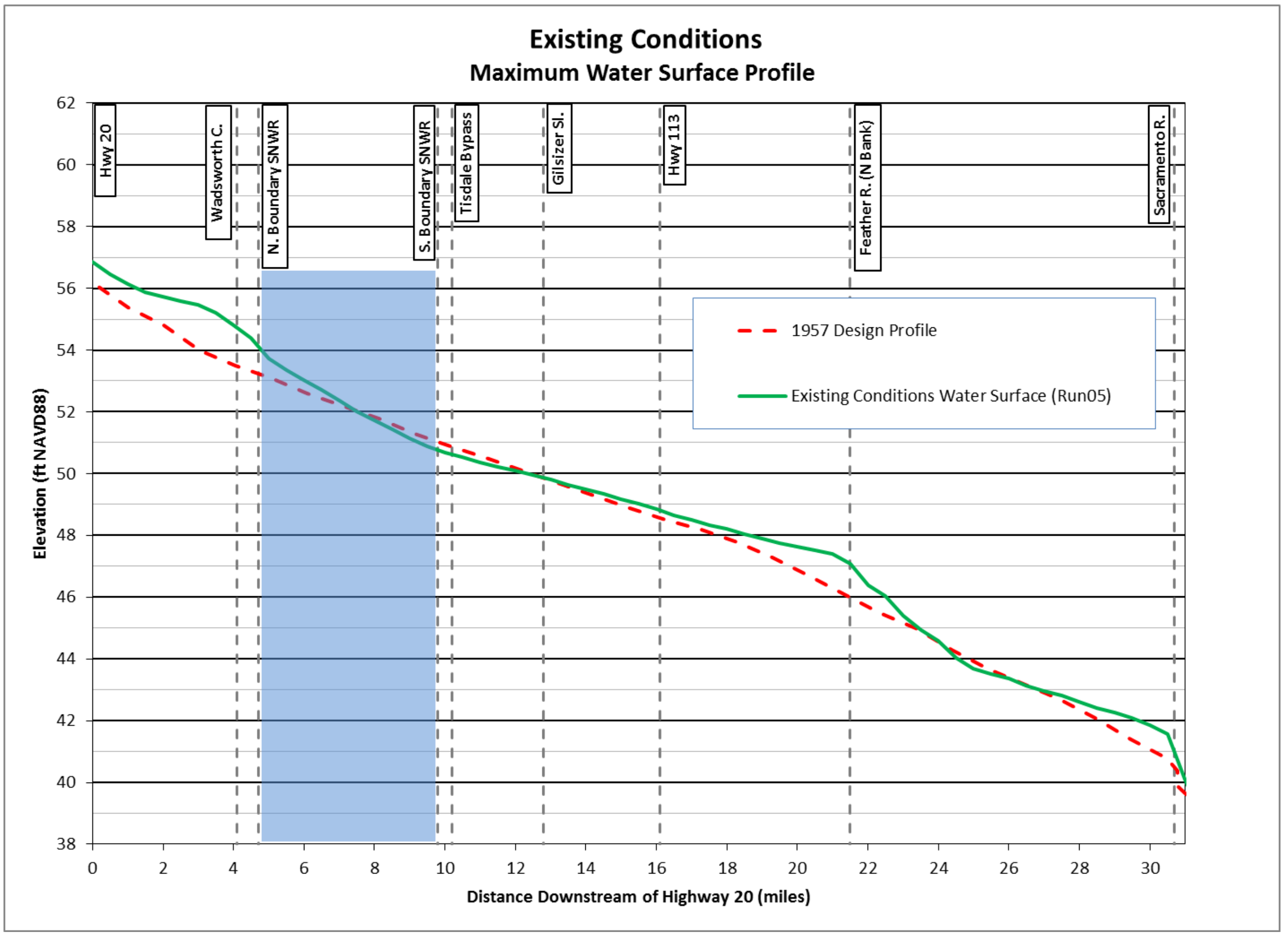

Figure 2

Review of the plot shows that for significant reaches of the Sutter Bypass, the Existing Condition water surface (green line) is higher than the 1957 Design flood plane (dashed red line). Approximately 22 miles of the Sutter Bypass is unable to pass the design flow at the design stage. Upstream of the SNWR (shaded in blue), the maximum difference between the Existing Condition water surface elevation and the 1957 Design flood plane is approximately 1.6 feet.

Vegetation Management

Two simulations were performed to quantify the impact of vegetation in the SNWR. The first, Vegetation Management Condition 1, converts all parcels located between the toe drains and within the SNWR boundary to agriculture. The total acreage of the SNWR is 2591 acres but only 2098 acres are within the levees of the Sutter Bypass. The conversion to agriculture within the SNWR assumes a crop type (i.e. rice) similar to other adjacent agriculture parcels within the Sutter Bypass. This condition was simulated by assigning a Manning's roughness coefficient of 0.028 to the 2098 acre parcels within the Sutter Bypass. Figure 3 shows the results of the simulations.

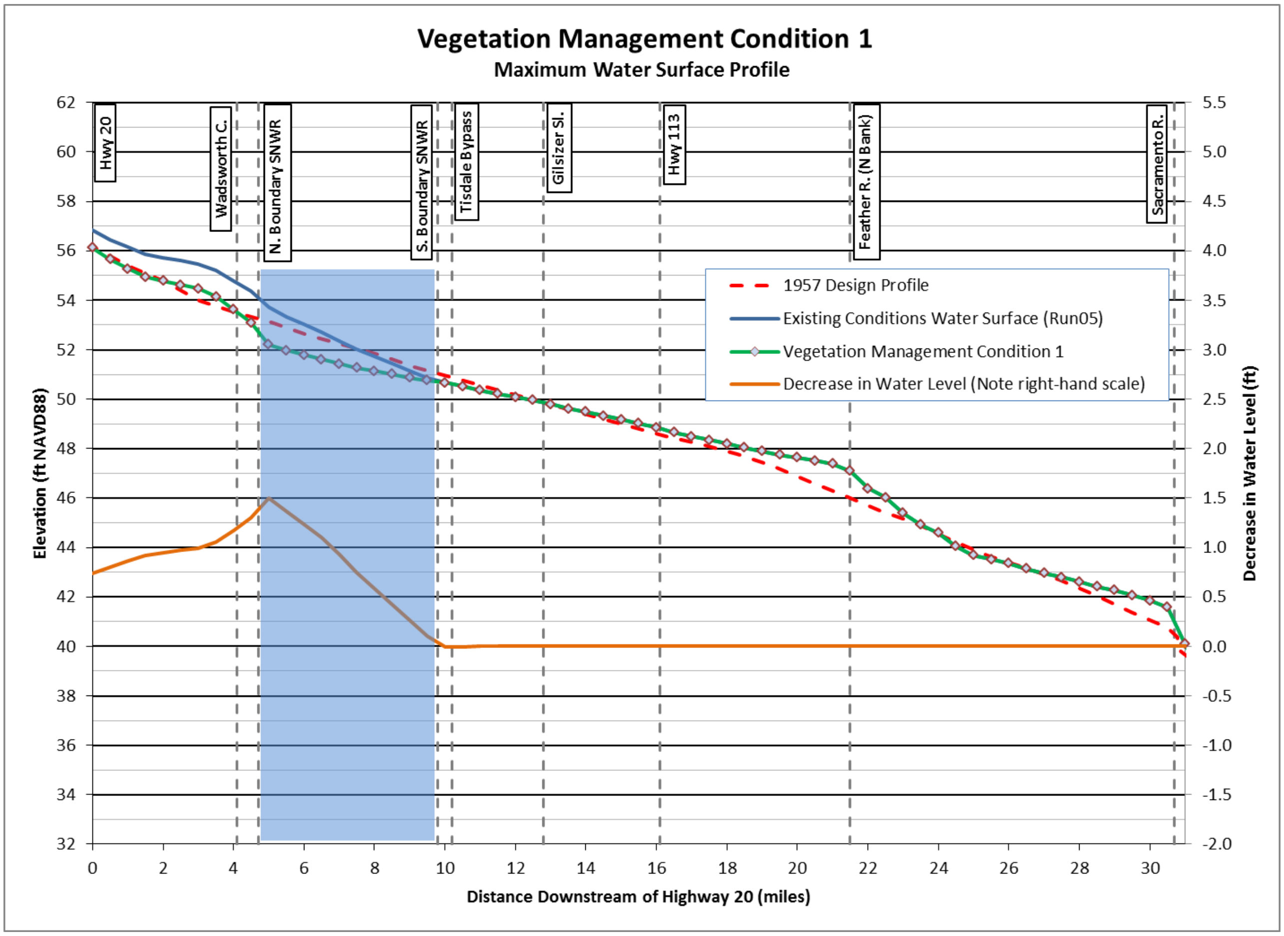

Figure 3

Review of Figure 3 shows that converting 2098 acres of the SNWR to agriculture would reduce water surface elevations upstream and within the boundaries of the SNWR (shaded in blue). The water surface elevation would decrease by as much as 1.5 feet over the Existing Condition. However, there still remains a short reach where the water is higher than the Existing Condition by as much as 0.5 feet. Downstream of the SNWR, the water surface profile does not change over the Existing Condition. Under this vegetation management condition, approximately 16 miles of the Sutter Bypass is unable to pass the design flow at the design stage, a 6-mile reduction from Existing Conditions.

A second simulation was performed, Vegetation Management Condition 2, which consists of converting only the managed habitat parcels within the SNWR to agricultural land use. The managed parcels total 1646 acres, of which 1110 acres is seasonal flood marsh and 536 acres of watergrass habitat. To simulate this condition, the Manning's roughness coefficient for the 1646 acres was reduced to 0.028. Figure 4 presents the results of the simulation.

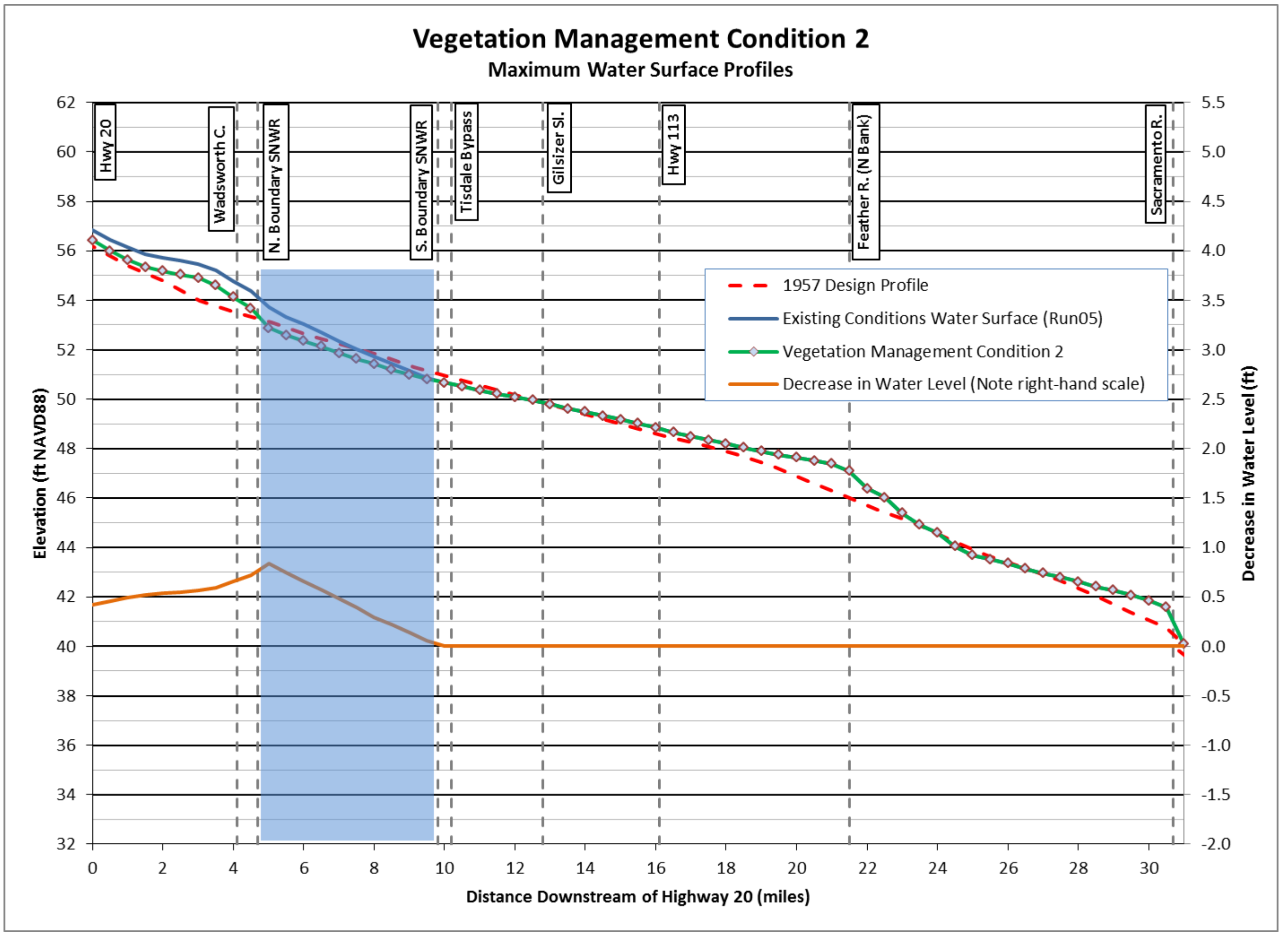

Figure 4

Converting the managed parcels within SNWR to agriculture land use would reduce water surface elevations by a maximum of 0.8 feet over the Existing Condition. The reduction in water surface elevation would occur within the boundary of the SNWR and extend upstream. Downstream of the SNWR, there is no reduction in water surface elevation. Under this condition, there remains 19.5 miles of the Sutter Bypass where the water surface elevation is higher than the design stage, a 2.5-mile reduction from Existing Conditions.

Conclusions:

- The RMA2 model of the Sutter Bypass was developed using the latest topography and bathymetry information available. The model was calibrated to the January 2006 flood event and verified with the January 1997 flood event. The results of the calibration and verification are reasonable and show that the model can reproduce observed peak water surface elevations within the Sutter Bypass.
- The CVFPB prepared analysis using the RMA2 model to analyze impacts to water surface elevation as a result of various vegetation management conditions within the Sutter Bypass. The application of the RMA2 model for this purpose and the assumptions made were reasonable and appropriate.

Based on the analysis prepared by CVFPB:

1. Under Existing Conditions, the Sutter Bypass cannot pass the 1957 design flow at the design stage along a cumulative distance of 22 miles.
2. Water surface elevations would be reduced by as much as 1.5 feet if 2098 acres within the SNWR were converted to agriculture land use. 16 miles of the Sutter Bypass would still be unable to pass the 1957 design flow at the design stage.
3. Water surface elevations would be reduced by as much as 0.8 feet if 1646 acres of the managed parcels in the SNWR were converted to agriculture land use. 19.5 miles of the Sutter Bypass would still be unable to pass the 1957 design flow at the design stage.
4. The 1957 design flow in the Sutter Bypass from Wadsworth Canal to the Tisdale Bypass is 155,000 cfs. The design flow simulated in model for this reach was 151,500 cfs. The computed maximum water surface elevations, upstream of the Tisdale Bypass, presented in the figures would likely be higher by a maximum of 0.4 feet had a flow of 155,000 cfs been simulated.
5. At the downstream end (Sacramento River at Verona and Yolo Bypass at Woodland gage) of the model, the simulations utilized a fixed water surface elevation set to the 1957 design flood plane elevation for the respective locations. A fixed water surface elevation is likely to influence the computed water surface elevations in the Yolo Bypass and lower portions of the Sutter Bypass. Users should be aware of this assumption in interpretation of any results in the vicinity. However, the downstream boundary condition should not have a significant impact on the computed water surface elevations at the SNWR.

References

CH2M Hill, 2013a. Final Model User's Guide, Sutter Bypass Two Dimensional Hydraulic Model. Prepared for Central Valley Flood Protection Board. October 2013.

CH2M Hill, 2013b. Technical Memorandum, Sutter Bypass Two Dimensional Hydraulic Modeling: Simulation of Potential Management Options. Prepared for Central Valley Flood Protection Board. October 2013.

U.S. Army Corps of Engineers (USACE). 1957. Sacramento River Flood Control Project, California: Levee and Channel Profiles. 1957 Design Flows. March 1957.

Don Trieu, P.E.

LA02

February 15, 2018

Ben Nelson
Bureau of Reclamation
801 I Street, Suite 140
Sacramento, CA 95814
email to bcnelson@usbr.gov

Subject: Contra Costa Water District's Comments on the Draft EIS/EIR Yolo Bypass Salmonid Habitat Restoration and Fish Passage

Dear Mr. Nelson,

Contra Costa Water District (CCWD) appreciates the opportunity to comment on the Draft Environmental Impact Statement/Environmental Impact Report for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (DEIR/EIS). CCWD supports habitat restoration in the Delta, but we are concerned that the environmental impacts of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (the Project) have not been fully and properly evaluated.

CCWD provides water diverted at its four intakes in the Sacramento-San Joaquin Delta to approximately 500,000 people in Contra Costa County. Small changes in water quality at CCWD intakes, even in the absence of water quality objective violations, can impact operations, water supply, and the water quality served to customers. CEQA guidelines require that such impacts be analyzed both on a project and cumulative basis.

1

The assessment of the potential water quality impacts of the Project in the DEIR/EIS is not adequate, so the DEIR/EIS does not fully disclose the potential environmental impacts of the Project and does not offer appropriate mitigation. The following deficiencies in the DEIR/EIS must be corrected.

The DEIR/EIS does not include an explicit evaluation of potential water quality impacts such as changes in compliance with water quality objectives set by the State Water Resources Control Board Decision 1641, changes in the position of X2, changes in upstream reservoir releases needed to meet water quality objectives, and changes in salinity at Delta drinking water intakes, including increases in salinity that could otherwise substantially degrade water quality in the absence of standards violations. The DEIR/EIS indicates that models were run that could have enabled the project proponents to evaluate changes in Delta water quality, but such an analysis was not included in the document.

The Project has the potential to have significant impacts on CCWD's water supply and water
quality even in the absence of water quality objective violations. The California Natural
Resources Agency has commissioned a modeling study to quantify the potential cumulative
effects that the Project and other Eco Restore projects may have on Delta salinity. The 2
preliminary results from the modeling study indicate that there may be cumulative impacts to
Delta salinity. The Project's impact assessment should include the results of the salinity
modeling study. If the modeling and water quality analysis described above reveals such
impacts, they must be avoided or mitigated. The Project should select a design configuration 3
that minimizes salinity increases in the Delta. The Project may also contribute to significant
cumulative impacts on CCWD caused by impacts to water quality at CCWD's intakes.
Significant cumulative water quality and supply impacts could be avoided if habitat restoration
projects throughout the Delta are sequenced so that there is no net significant water quality
degradation at any time. If the significant water quality impacts cannot be fully mitigated by 4
alterations of the habitat design, and coordinating the implementation schedule of the Project
with other restoration projects, additional mitigation must be identified to ensure the impacts are
fully mitigated.

CCWD would be happy to meet with you to discuss this information further, and we look forward to reviewing the revised analysis of the environmental impacts of the Project. If you have any questions about this letter, please call me at (925) 688-8083 or call Maureen Martin at (925) 688-8323.

Sincerely,

Leah Orloff
Water Resources Manager

LO/MM:wec

LA03

COUNTY OF YOLO

Office of the County Administrator

Patrick S. Blacklock
County Administrator

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February 15, 2018

Mr. Ben Nelson
Bureau of Reclamation
801 I Street, Suite 140
Sacramento, CA 95814

Ms. Karen Enstrom
California Department of Water Resources
3500 Industrial Blvd.
West Sacramento, CA 95691

Dear Mr. Nelson and Ms. Enstrom:

This letter describes the County of Yolo's ("County") principal concerns with the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project ("Yolo Bypass Salmonid Project") Draft Environmental Impact Statement/Environmental Impact Report ("EIS/EIR"). Additional comments are also included in a table enclosed with this letter **(Attachment 1)**.

I. INTRODUCTION

Yolo County appreciates the efforts made by California Department of Water Resources ("DWR") and the U.S. Bureau of Reclamation ("Bureau") to study the impacts of a project of this magnitude. The County's concerns with the EIS/EIR mainly relate to some aspects of the analysis of the project's potential impacts on the existing uses and functions of the Yolo Bypass. The long-term sustainability of agriculture is a leading concern because of the economic, habitat and flood protection benefits of Yolo Bypass agriculture, as the County has expressed repeatedly for nearly a decade. Maintaining the flood protection and conveyance functions of the Yolo Bypass are also leading concerns, along with potential impacts to terrestrial species habitat and the rich educational and recreational opportunities the Yolo Bypass affords the residents of Yolo County and California. 1

The County's comments focus on these concerns and the analysis of related environmental and other effects of the project in the EIS/EIR. This letter and the accompanying table identify shortcomings in the analytical content of the EIS/EIR and, where possible, offer recommendations for consideration. The County also incorporates herein by this reference the comment letters (including attachments) of the Yolo Basin Foundation **(Attachment 2)** and the Yolo Habitat Conservancy **(Attachment 3),** as well as a letter submitted by the six local agencies participating in the Regional Flood Management Plan effort for the Lower Sacramento/Delta North Region. While Yolo County highlights comments from these organizations in this letter, the references to specific comments does not indicate a lack of support for the comments submitted by these organizations in their entirety. 2

Despite the relatively short comment period following the release of the EIS/EIR in late-December, the County has attempted to thoroughly review the document and provide all relevant comments. The County is nonetheless disappointed that your agencies could not accommodate our request (and similar requests by numerous other entities) for a short extension of the comment period, particularly given the timing of the document release and the long delay preceding publication of the Federal Register notice 3 (which eroded the original 90-day comment period to a timeframe that only slightly exceeded the statutory minimum). At least some of the problems identified in the County's comments will require further analysis and—in all likelihood—substantial revisions to the EIS/EIR and recirculation for additional public review. The County reserves the right to provide additional comments on the legal adequacy of the EIS/EIR prior to agency action on the proposed project.

II. ENVIRONMENTAL AND PUBLIC POLICY CONSIDERATIONS.

In preparing its comments on the EIS/EIR, the County was keenly aware of the environmental and public policy considerations that have influenced project planning efforts over the past decade. The project's 4 intended role in addressing the 2009 Biological Opinion and the ongoing ecological crisis in the Delta estuary is well-documented and needs no elaboration here. Similarly, the role of the Yolo Bypass in regional flood protection and the characteristics of its existing setting—including a diverse agricultural industry, wetlands and terrestrial species habitat, and educational and recreational opportunities—are also values that receive recognition and protection in many local, state, and federal laws and policies.

For much of the past decade, discussions around the project have focused on how it can be integrated into the Yolo Bypass in a manner that sustains these values. The County's April 5, 2010 letter **(Attachment 4)** framed this question and set the foundation for the County's subsequent engagement in project planning efforts and related discussions. In turn, a February 25, 2014 letter from Secretary John Laird of the California Natural Resources Agency ("CNRA") **(Attachment 5)** reinforced the importance of sustaining the existing values of the Yolo Bypass in the course of implementing Conservation Measure 2 of the Bay Delta Conservation Plan ("BDCP") and expressed several objectives that remain relevant today with respect to the project. For example:

- The opening paragraph of the letter concludes by stating: "It is the Natural Resource Agency's goal to continue balancing the need of the BDCP to enhance habitat for covered 5 species with the existing uses of the Yolo Bypass such as agriculture, waterfowl and other terrestrial species habitat, bird watching, hunting, and other recreation."

- The letter recognizes concerns expressed with "late season flooding" and expresses optimism that "the frequency and acreage affected by late flows could be managed well enough such that current land uses in the Yolo Bypass would be largely maintained."

- Further, the letter acknowledges the uncertainties associated with project operation will be "addressed through the adaptive management and monitoring program of the BDCP, a process in which we expect Yolo County will have a significant level of involvement."

- Finally, the letter concludes by expressing the state's interest in developing a memorandum of understanding with the County on issues such as ". . . 1) funding for county participation in BDCP planning and implementation; 2) mitigation for the loss of farmland and economic

> impacts; 3) assurances and benefits for the Yolo Bypass Wildlife Area; and 4) other topics as needed."

Today, a fundamental question is whether the proposed project is designed and capable of implementation in a manner that will achieve the shared objectives of the County and CNRA (and presumably, DWR and the Bureau). The County's view is that efforts over the three years following Secretary Laird's letter have brought the project closer to realizing many of the outcomes described therein. But the effort is not yet complete. Several key areas of uncertainty and potential conflict remain, particularly with regard to the remaining potential for project impacts on Yolo Bypass agriculture and wetlands, including endangered and threatened terrestrial species habitat.

Given the uncertainty associated with the benefits to fish of the proposed project as discussed in this letter and the remaining potential for impacts (as well as the high level of uncertainty) to existing Yolo Bypass land uses, Yolo County recommends working with stakeholders to craft a preferred alternative that limits inundation to 3,000 cfs or less and ends inundation March 7th or earlier. The development of such an alternative, as well as the application of additional mitigation measures (or related actions, such as a voluntary intergovernmental agreement as contemplated by Secretary Laird), a robust adaptive management process, and an inclusive governance structure, could build on the extensive progress made over the years to deliver a landmark environmental restoration project that also achieves the intergovernmental collaboration necessary to accomplish future projects of a similarly ambitious scale. 6

III. SPECIFIC COMMENTS ON THE EIS/EIR

As noted above, the County has included a long list of specific comments in **Attachment 1**. The following discussion incorporates some of those comments (often in summary form) to highlight issues of particular concern for consideration by your agencies. Each chapter of the EIS/EIR is addressed sequentially below, excepting only a handful of chapters that are covered exclusively in **Attachment 1**.

Executive Summary 7

- **Comment ES-1: Issue of Known Controversy.** CEQA requires that the EIR address areas of controversy and issues to be resolved (CEQA Guidelines Section 15123(b)(2) and (3)). Page ES-17 and Section 23-9 make no mention of concerns raised by multiple stakeholders, including Yolo County (beginning in its April 4, 2010 letter, mentioned above) and the Yolo Habitat Conservancy among others, that the project is designed and analyzed with only superficial consideration of consistency with the impending Yolo HCP/NCCP. These discussions also fail to identify that as proposed the project will potentially adversely affect the success of the HCP/NCCP by potentially limiting the number of giant garter snake and other habitat conservation easements available for purchase in the Yolo Bypass. Please expand these sections to include an adequate discussion of these areas of controversy and issues to be resolved.

Chapter Three: Approach to the Environmental Analysis

- **Comment 3-1: Alternatives Analysis**. The EIS/EIR does not clearly recognize that the requirements for alternatives analysis under CEQA are substantively different from the requirements for alternatives analysis under NEPA. For CEQA the proper point of comparison for alternatives is the Proposed Project/Preferred Action/Alternative 1 (CEQA 8

Guidelines Section 15126.6(d)). Under NEPA the proper point of comparison for alternatives is the No Project/No Action Alternative. This distinction is not consistently apparent in the EIS/EIR, yet is required by law. Please revise the EIS/EIR to clearly reflect this analysis and conclusions, and recirculate the document to allow stakeholders such as the County to properly consider the analysis and results.

Chapter Four: Hydrology, Hydraulics, and Flood Control

- **Comment 4-1: No evaluation of impact of increased flows leading to natural recruitment of riparian vegetation.** The EIS/EIR discusses, but does not analyze, the impact of increased flows leading to natural recruitment of riparian vegetation. The analysis should evaluate a 9
baseline for woody vegetation along the Tule Canal and Toe Drain and the project should have an operation and maintenance element that maintains this vegetation annually. The impacts should be evaluated as part of the project so that at the time the maintenance is conducted, mitigation for potential impacts to listed species is not required. The Section 7 and CESA consultation should also cover this activity.

Chapter Six: Water Quality

- **Comment 6-1: Inadequate mitigation for methylmercury impacts**. In general, the County recognizes the difficulty of predicting project effects on methylmercury production in Bypass sediments and related environmental effects described in portions of Chapter 6. This difficulty is appropriately described in Chapter 6 and, along with other factors, cited as the basis for the "significant and unavoidable" impact conclusion in the discussion of Impact 10
WQ-2. However, the mitigation offered for this impact (MM-WQ-4) is described in a cursory and vague fashion without any objective standards for the performance of "frequent sampling and reporting" or "coordinat[ing] with the implementation of the current TMDLs for various constituents of concern within the Yolo Bypass." Other aspects of MM-WQ-4 are similarly cryptic and undefined. This mitigation measure must be substantially revised and clarified with respect to methylmercury and other pollutants described in Chapter 6.

Chapter Eight: Aquatic Resources and Fisheries

To estimate the benefits to fish of the proposed Yolo Bypass Salmonid Project, DWR and the Bureau hired Cramer Fish Sciences to develop the Salmon Benefits Model. The Salmond Benefits Model simulates changes in annual size, size variation, ocean entry timing variation, and survival of juvenile Chinook salmon emigrating through the Yolo Bypass and lower Sacramento River and Delta and resulting changes in adult returns by run. Such a model is difficult to develop because of the high level of uncertainty associated with assumptions. Yolo County worked with fish biologists to identify and 11
document this uncertainty through a review of the scientific literature early in the project development process (Quiñones and Lusardi 2017, see **Attachment 6**). The Salmon Benefits Model also relies on the use of other models with inherent uncertainty in their assumptions, such as the Juvenile Entrainment Evaluation Tool (JEET), to estimate these parameters. As discussed below, Yolo County believes DWR and the Bureau's handling of this uncertainty is inadequate because the agencies did not present key information about the uncertainty or perform additional sensitivity analysis critical to the understanding of project benefits. As a result, the agencies likely overestimated the benefits to fish of the project in the analysis. The alternative models show that entrainment of fish into the Yolo Bypass may be quite low,

thereby indicating the high costs of the project may not justify the benefits. More work is necessary to ensure the proposed project achieves significant benefits for fish.

- **Comment 8-1: Reliance on Juvenile Entrainment Evaluation Tool ignores importance of the Eulerian-Lagrangian Agent Method and Critical Streakline Analysis as the best available tools for conducting impact assessments.** Entrainment is perhaps the most important input variable that influences Salmon Benefits Model output and viable salmon population parameters conceptual model criteria under the different alternatives. Yet the EIS/EIR relies on the Juvenile Entrainment Evaluation Tool, the least robust of available entrainment models, as the source of 12
entrainment estimates for the Salmon Benefits Model. On Page 60, paragraph 4 of Chapter 8, the EIS/EIR states "The requirements for conducting analyses under CEQA and NEPA include utilizing the best available information to conduct impact assessments." To achieve this standard, the Juvenile Entrainment Evaluation Tool should (at a minimum) be used in concert with other entrainment estimates from the Eulerian-Lagrangian Agent Method (ELAM) and Critical Streakline Analysis because of the superiority of these tools and because these tools will provide some estimate of entrainment variance and increase confidence levels.

  ELAM and Critical Streakline Analysis represent the best available tools to estimate entrainment of juvenile salmon resulting from the proposed project because: 1) the ELAM is based on hydraulic modeling and acoustically tagged fish movement to evaluate the proportion of juvenile Chinook salmon the project is predicted to entrain in the Yolo Bypass at particular flows; and 2) the Critical Streakline Analysis also evaluates entrainment potential at various notch locations based on modeling of hydraulic conditions and acoustically tagged fish tracks.
  The Juvenile Entrainment Evaluation Tool, on the other hand, relies on a simple hypothesis that 13
  entrainment is directly proportional to flow diverted onto the Bypass. (This hypothesis has not been tested and there is no empirical data to support the hypothesis of which the County is aware.) Further, it is generally recognized that an individual fish's position relative to the point of diversion will influence potential entrainment and fish do not evenly distribute throughout a channel due to secondary flow circulations (Lemasson et al. 2017, see **Attachment 7**)[1]. According to the *Yolo Bypass Salmon Habitat Restoration and Fish Passage Analytical Tool Review,* a report by an independent science panel to the Delta Science Program of the Delta Stewardship Council in October 2017 **(Attachment 8)**, these two models:

  > "Significant integration of the ELAM model with the Streakline tool had not yet occurred at the time of this review. While the Panel understands that the compressed schedule did not allow integration of the ELAM and Streakline projects, the Panel highly
  > recommends that both groups integrate approaches and data to collaborate in 14
  > providing guidance in finalizing the notch design, implementation and future monitoring." (p. 21)

  While the independent science panel appears to have agreed that the Juvenile Entrainment Evaluation Tool is sufficient to compare alternatives (a conclusion with which Yolo County disagrees), the panel made it abundantly clear that better modeling options exist and should be undertaken. The entrainment estimates and the output from the Salmon Benefits Model are therefore deficient if the analysis does not include use of ELAM and Critical Streakline Analysis.

[1] Lemasson et al. 2017. Two-dimensional movement patterns of juvenile winter-run and late-fall-run chinook salmon at the Fremont Weir, Sacramento River, CA. US Army Corps of Engineers.

- **Comment 8-2: Did not include sensitivity analysis of rearing rule and rearing survival, and choice of model for entrainment in Public Review Draft EIS/EIR.** DWR and the Bureau conducted sensitivity analysis at the request of Yolo County on key parameters in 2016 and 2017, such as percent of fish that will survive on the floodplain (rearing survival) and the length of time juvenile fish will remain on the floodplain (rearing rules). DWR and the Bureau reported the benefits to fish changed significantly with changes in these two assumptions in *Salmon Benefits Model Appendix G4, Yolo Bypass Salmon Benefits Model: Modeling the Benefits of Yolo Bypass Restoration Actions on Chinook Salmon* (Hinkelman et al., August 2017). On Page 66, paragraph 3 of Chapter 8, the EIS/EIR states:

  > "Hinkelman et al. (August 2017) reported that although all the effects examined in the SBM have the potential to influence the fish benefit results of the alternatives, there is a particularly strong interactive effect of the rearing rule and rearing survival value. Hinkelman et al. (2017) recommended that the rearing rule and rearing survival assumptions be targets for additional investigations..."

  Hinkelman et al. (2017) estimate rearing survival at 0.99, but the Hinkelman et al. evaluation showed benefits of rearing survival at .97 and .95 under Alternative 6 were too low or negligible to yield project benefits. Despite this finding, DWR and the Bureau did not conduct additional investigations regarding the sensitivity of the rearing rules and rearing survival on the fish benefits of the project prior to the release of the EIS/EIR. DWR and the Bureau could incorporate a range of rearing survival estimates into their final model to provide greater confidence in model output. The agencies also could conduct a more thorough sensitivity analysis of the effects of the rearing survival estimates and rearing rules on all alternatives, instead of only the alternative with the largest estimates of benefits to fish (Alternative 6). Without this additional work, the analysis is deficient because it likely overstates the project's fish benefits. 15

- **Comment 8-3: Did not include an analysis demonstrating that the ELAM model predicts lower entrainment estimates in the EIS/EIR.** On p. 26 of the draft *Yolo Bypass Salmon Benefits: Modeling the Benefits of Yolo Bypass Restoration Actions on Chinook Salmon* (Hinkelman et al. May 2017) **(see Attachment 8)**, a graph and discussion of the entrainment estimates from the ELAM are provided demonstrating the entrainment estimates are lower with the ELAM than the Juvenile Entrainment Evaluation Tool. This graph and discussion is not present in the same document included in the EIS/EIR, also called *Yolo Bypass Salmon Benefits Model: Modeling the Benefits of Yolo Bypass Restoration Actions on Chinook Salmon* (Hinkelman et al. August 2017, Appendix G4). The County was not able to identify any discussion in the Chapter 8 demonstrating why DWR and the Bureau removed this analysis. The County recommends including this sensitivity analysis and using this information to evaluate the alternatives. 16

- **Comment 8-4: Additional discussion needed on limitations of the Juvenile Entrainment Evaluation Tool.** On Page 65, paragraph 4, please discuss the additional limitations of the Juvenile Entrainment Evaluation Tool with respect to the other entrainment tools. As discussed previously, both the ELAM and Critical Streakline Analysis consider fish movement (behavior and tracks, respectively) and hydraulics associated with the different alternatives, but the Juvenile Entrainment Evaluation Tool does not. The Juvenile Entrainment Evaluation Tool assumes simplistically that entrainment is directly proportional to flow diverted onto the Bypass, in spite 17 of scientific data to the contrary. In looking at acoustic movement data near Fremont Weir, Steel et al. 2016 found that different runs (winter and late fall) displayed non-uniform distributions across the channel. Finally, Smith et al. (2017) found that while larger notches generally increased entrainment, entrainment was not proportional to flow. Blake et al. (2017) found that the location of each modification scenario significantly impacted entrainment with entrainment varying as much as 400% based on *where* the scenario was located. The analysis should cite these studies in its description of the limitations of the Juvenile Entrainment Evaluation Tool.

Chapter Nine: Vegetation, Wetlands, and Wildlife Resources

The Yolo Habitat Conservancy (YHC) has commented extensively on consistency of the Yolo Bypass Salmonid Project with the Yolo HCP/NCCP. Similarly, the Yolo Basin Foundation has commented extensively on deficiencies in the analysis related to impacts on vegetation, wetlands, and wildlife resources. The County highlights some of these comments below:

- **Comment 9-1: Standard for Adequacy**. The basic CEQA standard for adequacy is an evaluation of the environmental effects of a proposed project in light of what is reasonably foreseeable 18
(CEQA Guidelines Section 15151). Implementation of the Yolo HCP/NCCP is reasonably foreseeable. The final HCP/NCCP and related EIS/EIR were delivered to the U.S. Fish and Wildlife Service and California Department of Fish and Wildlife on January 23, 2018 and are awaiting the authorization of those agencies for formal release and final action. Both the federal and state governments have extensive investments in this plan and common interests in ensuring its success. In light of this please revise the second to last threshold of significance in Chapter 9 (Vegetation, Wetlands, and Wildlife Resources) related to HCP consistency to include “impending” as well as adopted HCPs, such as the Yolo HCP/NCCP. Also, please revise this chapter generally (and Impact TERR-11 in particular) to include a complete analysis of the potential for conflict with the Yolo HCP/NCCP, such as the overlap of the project with areas the Yolo Habitat Conservancy has identified as important giant garter snake habitat, and recirculate the document to allow stakeholders such as the YHC to properly consider the analysis and results.

- **Comment 9-2: Approach**. Section 9.3.2 (Thresholds of Significance – CEQA) is missing the mandatory discussion of the following issues (CEQA Guidelines Section 15065(a)(1)): 1) whether the project has the potential to substantially degrade the quality of the environment; 2) whether the project has the potential to substantially reduce the habitat of a fish or wildlife 19
species; 3) whether the project has the potential to cause a fish or wildlife population to drop below self-sustaining levels; and 4) whether the project threatens to eliminate a plant or animal community. Please revise Section 9.3.2 to include these mandatory thresholds, and please revise this Chapter to include an analysis of these impacts, including substantiated conclusions, and feasible mitigation.

- **Comment 9-3: Mitigation Measures.** All of the missing areas of impact analysis identified above, plus the other areas of impact that are identified in this Chapter, could be feasibly lessened or avoided by including the following reasonable and feasible mitigation measures: 20

    - Implement all aspects of the project in a manner consistent with and not in conflict with the Yolo HCP/NCCP.
    - Coordinate with the YHC to provide mitigation through the Yolo HCP/NCCP.

- Ensure that no aspect of the proposed project is implemented in a manner that precludes the Yolo HCP/NCCP from successful implementation of the identified Yolo HCP/NCCP conservation measures, conservation strategy, or conservation reserve system.
- Modify the project as necessary to avoid adverse effects to properties identified as Yolo HCP/NCCP priority conservation lands.

- **Comment 9-4: Inadequate analysis of impact on wetlands and nesting and foraging habitat.** No analysis is presented to support the conclusion that there is no impact from operations of the Yolo Bypass Salmonid Project on wetlands and nesting and foraging habitat. The Yolo Basin Foundation has pointed out that nesting can start as early as February and additional inundation in the Bypass could affect food supply[3]. The County also could not find any analysis in the EIS/EIR to support the conclusion that the Yolo Salmonid Project will not affect wetlands. The analysis is deficient and should include additional analysis of these potential impacts. 21

- **Comment 9-5: Impact TERR-3 – Insufficient analysis of impact on giant garter snake.** The analysis provided in Section 9.3.3.2.3 and elsewhere in this chapter related to the impact of operations on giant garter snake resulting from changes in the duration of inundation acknowledges that "inundation of occupied burrows below the elevation of floodwaters may result in the loss of giant garter snake individuals" but considers these direct or indirect adverse effects on giant garter snake less than significant. The analysis relies on an increased number of days of inundation as the metric for making this determination; however, there is no discussion of any analysis that was conducted to determine the increase in areas that will be inundated as a result of the project that would not otherwise be inundated (such as during below-average water years). The annual inundation of areas not currently inundated every year may cause a significant impact to giant garter snakes and should be evaluated and discussed in the EIS/EIR. Analyzing only a potential increase to the number of days of inundation could artificially deflate the magnitude of the impact by failing to account for the fact that the occurrence of inundation, not just its length, will also be influenced by project implementation. 22

- **Comment 9-6: Impact TERR-9: Potential effects on USACE, RWQCB, and CDFW jurisdictional wetlands, waters, and riparian areas are underestimated (p. 9-76).** The EIS/EIR analyzes construction impacts on wetland and riparian areas, but fails to analyze the impact of operations. The EIS/EIR states only:

  > **"**Under Alternative 1, operations would not result in adverse effects on areas subject to USACE and CDFW jurisdiction as no fill materials would be placed in waters during operations." (p. 9-81) 23

  The EIS/EIR fails to analyze the impact of additional flooding from the proposed project on USACE, RWQCB, and CDFW jurisdictional wetlands. DWR and the Bureau should complete this analysis and recirculate the EIS/EIR so the public can review this important analysis.

- **Comment 9-7: Impact TERR-11**. The analysis provided in Section 9.3.3.2.11 and elsewhere in this chapter relating to conflicts with the Yolo HCP/NCCP is conclusory. No evidence or analysis 24

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[3] Petrik, K. et at. 2012. Waterfowl Impacts of the Proposed Conservation Measure 2 for the Yolo Bypass: An Effects Analysis Tool. Bay Delta Conservation Plan – Yolo Bypass Fisheries Enhancement Planning Team.

is provided to support the discussion. Also, please correct the citation used. While ICF is a YHC consultant, they are not the lead agency or regulatory author of the plan. Please cite the YHC as the author of the Yolo HCP/NCCP and its related EIR.

- **Comment 9-8: No analysis of potential conflicts with Yolo HCP/NCCP species habitat.** The project footprint overlaps with habitat for species covered by the Yolo HCP/NCCP, such as giant 25 garter snake impacts in Comment 9-5 and western pond turtle. The Yolo Habitat Conservancy is providing maps of this habitat as part of its comment letter on the project. The agencies did not sufficiently analyze potential conflicts as part of the EIS/EIR.

Chapter Ten: Cultural and Paleontological Resources

- **Comment 10-1: Inadequate analysis of cultural resources.** A cultural resources inventory has never been conducted in the majority of the footprint of Alternative 1 even though additional prehistoric archaeological resources are likely to be found in the portion of the footprint where surveys have not been conducted. Surveys of identified construction disturbance areas are being deferred to after completion of the environmental review process. Without providing decision makers and the public with an opportunity to understand the project's actual impacts on 26 sensitive cultural resources and to determine whether the identified mitigation measures would actually reduce these impacts to less-than-significant levels, the Draft EIR/EIS is not meeting CEQA's fundamental disclosure purposes. Complete surveys of the sensitive cultural resources located within the area of potential effect should be conducted and a full assessment of the project's effects on these resources should be prepared and circulated for public comment prior to finalizing the environmental documents. The same comments apply with equal force to the other action alternatives analyzed in the EIS/EIR.

- **Comment 10-2. Inadequate mitigation measure.** It is difficult to understand why the impact conclusion following implementation of feasible mitigation is reduced from "significant" to "less than significant" for CULT-1, CULT-2, and CULT-4. While the County understands that mitigation proposed to reduce impacts CULT-1, CULT-2, and CULT-4 may be somewhat effective, the discussion in Chapter 10 makes clear it is unlikely to be entirely effective and that some damage 27 or destruction of cultural resources may result. On this basis, it seems each impact should be "significant and unavoidable" for the same reason that the impact analyzed in CULT-3 is deemed "significant and unavoidable"—i.e., there is insufficient information about the potential magnitude of each impact, even with implementation of feasible mitigation, to determine whether the permanent destruction of affected resources will be "less than significant." These impact conclusions are thus unsubstantiated and legally improper.

Chapter Eleven: Land Use and Agricultural Resources

- **Comment 11-1: Assumes project will not convert cropland because USDA will continue to offer preventative planting insurance.** Chapter 11 assumes the project will not convert 28 farmland, despite a discussion in Chapter 16: Socioeconomics that whether the USDA will continue to support preventative planting insurance remains unknown. (Prominent Yolo Bypass farmers have asserted they will not continue to farm if preventative planting insurance is not offered. See **Attachments 10 and 11**; see also comments on Chapter 16: Socioeconomics on this issue.) According to James Otto with the USDA, the USDA Risk Management Agency will need to evaluate whether the flooding is "man-made" and if so, whether to continue to offer preventative planting insurance.

Further analysis of the potential for this change should appear in the EIS/EIR because, if preventative planting insurance is eliminated and farmland is effectively converted as a result, it could lead numerous other indirect impacts on habitat values, flood conveyance, and other aspects of the current environment setting evaluated in the EIS/EIR. It's critical to have this information now in assessing the potential impacts of the project under both CEQA and NEPA. Presumably, if requested by DWR and the Bureau, the USDA can complete its evaluation of this issue in a timely manner and provide the information necessary to enable a much more informed assessment of whether the project will result in a conversion of substantial farmland acreage in the Yolo Bypass. Absent such information, the analysis of this potential effect is speculative and legally inadequate.

- **Comment 11-2: The analysis of the impacts on agricultural land is inadequate because of the lack of sensitivity analysis.** Given the large number of variables that affect farmers' planting decisions in the Yolo Bypass, and the potential impact of changes in assumptions (e.g. availability of preventative planting insurance), the lack of sensitivity analysis is remarkable. The existing analysis provides results of average impacts from project alternatives. Environmental conditions may include consecutive years in which additional inundation from the proposed project delays planting every year over a three- to five-year period – or even longer. But results are presented over time and do not consider cumulative effects through time. Although figures show the effects each year, there is no evaluation of the implications from frequency of repeated annual flooding. This analysis deficiency and other long-term hydrologic conditions are important to test, especially in light of recent climate extreme events in California. 29

- **Comment 11-3: The cumulative impact analysis is deficient.** The analysis does not even attempt to quantify or even qualitatively describe potential farmland conversions with the Lower Elkhorn Basin Levee Setback Project (e.g. hundreds of acres) and other projects, such as Lower Yolo Ranch (over 1,000 acres). This analysis should be updated to reflect the potential farmland conversions that will result from these and other reasonably foreseeable projects. 30

- **Comment 11-4: Analysis of field preparation time needs to include evaluation of additional Toe Drain/Tule Canal flows.** Similar to the RD 1600 issue mentioned in the County's comments on Chapter 4, the County is concerned that the estimate of 34 days for drying, preparation, and planting does not include additional drainage time that will result because the Toe Drain/Tule Canal contains additional water from the operable gate in the Fremont Weir. The estimate of 34 days should be updated after this analysis is completed. 31

Chapter Twelve: Geology and Soils

- **Comment 12-1: Impact GEO-1.** The analysis identifies a 13 percent increase in annual sedimentation rates and states that that while sediment removal will need to occur more frequently, it is a less than significant impact. It has become increasingly difficult to secure permits for sediment removal in the floodway, as well as more costly due to mitigation requirements. As a result, any change in sedimentation rates should be considered significant. As a mitigation measure, the project should include CESA and ESA coverage for all O&M activities, including sediment removal. Without such coverage, the likelihood that sediment 32 removal will occur at frequent intervals (as assumed in the analysis in this Chapter) is substantially diminished. The assumed frequency of sediment removal is already highly questionable—and thus, the impact conclusion is flawed—because removal activities currently occur on a highly irregular basis and there is no objective reason to believe this will change in the future.

Chapter Thirteen: Recreation

- **Comment 13-1: Inadequate analysis of recreation impacts**. As discussed in the Yolo Basin Foundation letter **(Attachment 2)**, the calculation of a 2% reduction in days available for educational programs and activities is not properly supported because the analysis does not include the days the Wildlife Area will remain closed to drain and dry out. The calculation of a 4.1% reduction in hunting days also is not properly supported for the same reason. The Yolo Basin Foundation estimates the lost education and hunting days are 2-3 times the estimates in the EIS/EIR because of the additional time needed to drain the Wildlife Area that is not included in the analysis. Yolo County supports the Yolo Basin Foundation's suggestion that this analysis should be updated. 33

Chapter Sixteen: Socioeconomics

- **Comment 16-1: Omits analysis of potential for USDA to discontinue support for preventative planting insurance.** As discussed in the EIS/EIR, the USDA Risk Management Agency will need to evaluate whether the flooding is "man-made" and if so, whether the federal government will continue to provide financial support for preventative planting insurance offered by private insurance companies. The analysis of the potential for this change should occur in the EIS/EIR because, if it occurs, it could lead to a reduction in farmed acreage with numerous other indirect impacts on habitat values, flood conveyance, etc. As discussed in Yolo County's comments on Chapter 11, further analysis of this issue should appear in the EIS/EIR because of the potential for farmland conversion and additional regional economic effects not currently captured by the EIS/EIR analysis. Presumably, if requested by DWR and the Bureau, the USDA can complete its evaluation of this issue in a timely manner and provide the information necessary to enable a much more informed assessment of potential impacts. Absent such information, the analysis of the regional economic effects summarized in Table 16-15 for Alternative 1 and similar tables for Alternatives 2 and 6 is speculative and legally inadequate. 34

- **Comment 16-2: Inadequate analysis of Impacts on RD 1600 gravity drain.** The project as proposed will have an adverse impact on RD 1600 drainage, but no hydraulic analysis was completed to analyze these impacts. When the notch has water flowing through it, the backwater in the Tule canal will prevent the gravity drain from draining the district. This will require the pump station to be used more often resulting in increased electrical costs and wear and tear on the pump station requiring more frequent maintenance, repair and rehabilitation. The increase in sedimentation that is associated with the project will also reduce the effectiveness of the gravity drain. The EIS/EIR should further analyze this impact and include as a mitigation measure the periodic removal of sediment in the Tule Canal to avoid impacting the gravity drain, as well as CESA and ESA coverage for this O&M activity. 35

- **Comment 16-3: Inadequate analysis of ability of crops to survive in saturated soil conditions.** The discussion in the second paragraph on page 16-17 states that an increase in shallow groundwater levels could increase saturation near the crop root zone, thereby reducing crop yields. The discussion then states that this reduction in yields would not result in permanent cropland conversions due to crop shifting. However, no evidence is provided to justify the 36
conclusion that other crops could survive in saturated soil conditions. The discussion then states that the Elkhorn area and the west side of the Bypass only account for 1.5 to 3 percent of the total agriculture of Yolo County, presumably indicating that the loss of agricultural production in this area would be insignificant. As summarized in Table 11-3 in the Land Use Chapter, Yolo County lost nearly 3,000 acres of important farmland between 2012 and 2014; therefore, any additional losses would be considered by the County to be significant.

- **Comment 16-4. Inadequate analysis of regional economic effects.** Table 16-15 identifies the direct, indirect, induced, and total regional economic effects associated with implementation of Alternative 1 and similar tables are provided for Alternatives 2 through 6. The discussion on subsequent pages, however, identifies a number of additional potential impacts on the regional economy that were not analyzed, including increased inundation of pasture areas resulting in decreased productivity, the Elkhorn Area issues described in previous comments related to increases in shallow groundwater levels, the increase in loan rates, and the increase in crop insurance premiums. (Per Comment 16-1, the County believes the impacts may be greater than 37
just an increase in crop insurance premiums and an analysis of the potential loss of preventative planting insurance is warranted.) These economic losses were not accounted for in the estimation of total regional economic effects identified in Table 16-15. Due to the uncertainty regarding all of these additional costs, the analysis in the Socioeconomic section may have substantially underestimated the adverse economic effects associated with implementation of the project alternatives.

- **Comment 16-5: Inadequate sensitivity analysis.** This chapter reports the results from an assessment of direct, indirect and induced effects of implementing the six project alternatives across the affected regions using IMPLAN. Results from the Bypass Production Model under each alternative are used in the IMPLAN analysis. As such, concerns raised regarding Bypass Production Model also affect the IMPLAN analysis. Primarily, the dependence on annual 38
average outcomes ignores other potentially feasible climatic scenarios. Scenarios that depict the worst annual cases over multiple years, as we might expect more so than average events, may affect the conclusions of the analysis, potentially bring into question inferences drawn from them. As with the Bypass Production Model discussed in Chapter 11 and in Appendix J1, a lack of sensitivity analysis limits reliability on conclusions.

Chapter Seventeen: Transportation

- **Comment 17-1: No analysis of County Road 22 closure**. The EIS/EIR does not analyze the impacts of increases in the closure of County Road 22 from operation of the notch in dry years when no overtopping of the Fremont Weir occurs and could extend closure of this roadway 39
following overtopping events. Closure will affect area farming operations, general movement of vehicles that use the road between Woodland and the West Sacramento area, and oversize truck hauling (CR22 is a route used by trucks that are too high to go under the private I-5 overpass that is about 1 mile east of CR102). The County will likely receive complaints when the

road is closed and the weir has not crested, especially from people that live along CR117 and the Old River Road/CR124 area. Oversize trucking routes may have to be greater distances to reach destinations. The Public Works Division would have to mobilize to close the road more frequently, incurring additional costs. The analysis of transportation impacts is therefore deficient and the EIS/EIR should include a mitigation measure to address these impacts.

- **Comment 17-2: Insufficient analysis of impact of truck trips from sediment removal.** The EIS/EIR does not adequately analyze the number of truck trips related to removal of sediment to disposal sites within 2 miles of the project site. As identified in the Public Services, Utilities, and Power Chapter, the amount of sediment removal required for the alternatives would vary from 265,820 cubic yards for Alternative 1 to 3,149,312 cubic yards for Alternative 5. To give some perspective, the volume of sediment to be removed with Alternative 5 is nearly equivalent to the annual amount of gravel mined in the County by several major firms operating along Cache Creek. The estimated additional truck trips generated during the 28-week construction period for the six alternatives would range from 33,227 to 393,664 trips. In addition, the site's long-term sediment removal requirements would extend the project's localized traffic impacts indefinitely into the future. This level of heavy truck traffic on rural county roads that are clearly not designed to accommodate such use could be so destructive as to make them unusable by local residents and by emergency vehicles. As defined in the thresholds of significance on page 17-8, this would represent a significant impact. The Final EIR/EIS should fully describe this significant traffic and roadway impacts and identify appropriate mitigation measures to minimize the adverse effects on local residences. 40

Also, the County is skeptical of the feasibility of MM-TRAN-2, which proposes establishing a "road repair agreement with Yolo County and its Public Works Division prior to initiating project construction."

First, while a similar measure is included in the EIS/EIR for the California WaterFix (MM-TRANS-1c), as of the date of this letter, DWR has not even contacted the County or its Public Works Division to initiate discussions regarding a mitigation agreement despite the February 8, 2018 testimony of Director Karla Nemeth (at the State Water Resources Control Board) that it intends to commence WaterFix construction by the end of 2018. 41

Second, the measure should be revised to recognize that affected road segments will <u>need to be entirely reconstructed</u> following project construction (as well as possibly during project construction, and potentially following sediment removal activities during project operations). The measure refers only to potential reconstruction of road shoulders and suggests "chip sealing"—a technique that involves applying a very thin layer of asphalt to an existing roadway surface—will be employed for road repairs. But heavy trucks will effectively destroy the affected road segments and only full reconstruction will restore them to their prior level of functionality. Put simply, there is no such thing as restoring destroyed roads to "pre-project conditions." 42

Third and finally, the EIS/EIR does not appear to include any analysis (and hence, it provides no environmental clearance) of the environmental impacts of road repair projects. This analysis is legally required and should be included in the document. 43

Chapter 18: Air Quality and Greenhouse Gases

- **Comment 18-1: Inadequate analysis of exposure of residents to toxic diesel emissions.** The EIS/EIR does not include a health risk assessment, even though Impact AQ-3 states that to determine if sensitive receptors are exposed to substantial pollutant concentrations, potential health risks must be assessed. It further states that diesel particulate matter is listed as a Toxic Air Contaminant in California and would be subject to a human health risk assessment under CEQA. However, without actually conducting a health risk assessment, the impact discussion concludes that the exposure of residents to toxic diesel emissions would be less than significant due to their distance from the construction activities. This conclusion ignores the significant 44
number of heavy trucks that will pass directly in front of multiple rural residences when accessing the site. If the residences are located along the sediment disposal route, they will further be exposed to toxic diesel emissions throughout the project's life. The preparation of a health risk assessment is necessary to appropriately quantify the potentially significant health risks for residents located along the project's proposed haul routes, consistent with CEQA. The results of such an assessment should be circulated for public review and comment prior to finalizing the environmental document.

Chapter 20: Noise

- **Comment 20-1: Inadequate analysis and mitigation measures for noise increases.** This chapter states that traffic levels would need to increase by at least nine times to double noise levels. The analysis on page 20-17 then states that county roads are expected to experience enough of a traffic increase to double the traffic noise levels. In effect, the analysis acknowledges that traffic levels on county roads will increase by at least nine times, without specifically stating it and without providing any information regarding existing traffic volumes on these roads. Since truck 45
traffic associated with long-term maintenance activities are actually expected to generate more daily traffic than construction activities, this nine-time increase in traffic on local county roads would occur over the entire life of the project, which could span the lifetimes of the residents along these rural roads. More aggressive noise mitigation measures clearly need to be included in the EIS/EIR to address this significant long-term noise impact on residences located adjacent to the identified haul routes, including installation of double-paned windows, planting of trees to reduce noise, and potentially hay walls to provide a sound barrier.

- **Comment 20-2: Insufficient analysis regarding noise impacts of maintenance activities.** The discussion concludes that no long-term project operations would occur under Alternative 1 that would generate excessive vibrations or groundborne noise. This statement again ignores road vibration impacts associated with long-term operations and maintenance, particularly for sediment removal. The discussion states there may be up to 112 daily worker trips and 801 haul truck trips associated with Alternative 1's long-term maintenance activities. Project construction is projected to generate only 668 daily truck trips, or 133 less than anticipated during long-term 46
sediment removal activities. The other alternatives identify even higher levels of long-term maintenance vehicle trips including 1,719 daily haul trips and 178 daily construction worker trips for Alternative 4. It is unclear how the noise and vibration impacts generated by the construction haul truck traffic at local residences along county roads can be identified as significant due to project construction while concluding that there would be no long-term noise or vibration impacts associated with project implementation.

- **Comment 20-3: No existing traffic volume data used to calculate noise levels along the County roads.** According to the last sentence of the first paragraph on page 20-12, the analysis of noise generated from construction-related traffic was compared against the 2015 annual average daily traffic volumes published by Caltrans. However, in the traffic noise tables included in Appendix L, traffic volumes were only provided for Interstate 5. No existing traffic volume data was used to calculate the noise levels along the County roads. The noise section should clarify how noise levels associated with haul vehicle traffic were calculated when no information is provided regarding the existing traffic volumes on these roads. 47

Chapter Twenty-two: Environmental Justice

- **Comment 22-1. Impacts on low-income students.** The County agrees with the EIS/EIR impact statement regarding the impact on low-income students; however, the County also finds that the Yolo Basin Foundation can provide more accurate and up-to-date data on the percent of Davis Joint Unified School District and Sacramento City Unified School District Title 1 schools whom attend Yolo Bypass Wildlife Area field trips. During the 2016-17 school year, approximately 44% of the Discover the Flyway participants were from low-income Title 1 schools, or approximately 1,600 students. 48

APPENDIX J1: BYPASS PRODUCTION MODEL TECHNICAL APPENDIX

- **Comment J1-1: Substitution of inundation for irrigation requirements not addressed.** Inundation can provide soil moisture and decrease the need for irrigation. The Bypass Production Model is a fixed proportions model, which might not be able to capture this condition. Whether this has an effect on the yields from the other end (deficit irrigation) or moves water needs with respect to the base amounts could alter the conclusions and should be addressed. 49

- **Comment J1-2: Age of data used to parameterize the Bypass Production Model needs to be rationalized.** Yolo County worked with University of California, Davis economists to update the Bypass Production Model for the Yolo Bypass in 2013, hence the use of Yolo Bypass crop data from 1997 to 2012[4]. Five years have passed since UC Davis and the County completed that work, so the use of this crop data needs to be re-evaluated to ensure it is representative of current and future cropping patterns and pricing trends (cropping decisions are influence by price). Moreover, the appendix describing the Bypass Production Model states that the data for years 2005 - 2009 are used to calibrate the model. More recent data could provide a clearer picture of effects today and into the future and more importantly generate results and conclusions that differ from those contained in the EIS/EIR. 50

- **Comment J1-3: Lacks sensitivity analysis.** As with earlier comments, there is no apparent sensitivity analysis to get a sense of range of consequences or the robustness of results for given parameter value uncertainty. For example, environmental conditions may include consecutive "bad" years when inundation could delay planting every year over a three- to five- year period 51

[4] Howitt, R. et al. 2013. Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals. Yolo County.

or longer. Results are presented over time but do not consider cumulative effects through time. With a fuller range of values and assumptions, the results would more clearly reflect the range of possibilities rather than relying on annual average outcomes.

APPENDIX J2: YOLO BYPASS RICE AND TOMATO TIPPING POINTS: MILLING AND PROCESSING, CROP INSURANCE, AND LOAN RATES

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- **Comment J2-1: No analysis of the reduction in processed goods.** For processing, an impact analysis on reduction of processed goods as a result of a reduction in available crop production from the Bypass is not conducted. Yolo County suggests providing a bracket for the potential impacts. If the impact is minor and within the range of normal year to year fluctuations, this outcome should be justified in the conclusions or the limitations of the analysis.

- **Comment J2-2: Age of data used to parameterize the tipping point analyses needs to be rationalized.** Similar to comment J1-2, the tipping point analyses use data from 2005 to 2009. It is likely that economic conditions over the past 5 to 10 years look differently than they did over a decade ago. Re-evaluating these analyses with current data appears warranted. 53

* * *

Yolo County appreciates the opportunity to comment on this document. We look forward to your response to the issues and concerns raised in this letter.

Sincerely,

Patrick Blacklock
County Administrator

cc: Yolo County Board of Supervisors
John Laird, Secretary, California Natural Resources Agency
Kris Tjernell, Special Assistant for Water Policy, California Natural Resources Agency
Karla Nemeth, Director, California Department of Water Resources
David Murillo, Regional Director, Mid-Pacific Region, U.S. Bureau of Reclamation
Rep. Doris Matsui
Rep. John Garamendi
Senator Dianne Feinstein
Senator Kamala Harris
Senator Bill Dodd
Assemblymember Cecilia Aguiar-Curry
Assemblymember Kevin McCarty
Senator Richard Pan

Yolo County Comment Letter Attachments for
The Yolo Bypass Salmonid Project Draft EIS/EIR

Attachments

Attachment 1	Yolo County Comments Spreadsheet
Attachment 2	Yolo Basin Foundation Yolo Bypass Salmonid Project comment letter
Attachment 3	Yolo Habitat Conservancy Yolo Bypass Salmonid Project comment letter
Attachment 4	Yolo County April 5, 2010 comment letter: Bay Delta Conservation Plan—Yolo Bypass/Freemont Weir Modification
Attachment 5	California Natural Resources Agency February 25, 2014 response letter to Yolo County Board of Supervisors
Attachment 6	Potential Fish Benefits Associated with Yolo Bypass Salmonid Habitat Restoration and Fish Passage Proposals
Attachment 7	Two-Dimensional Movement Patterns of Juvenile Winter-Run and Late-Fall-Run Chinook Salmon at the Fremont Weir, Sacramento River, CA
Attachment 8	Yolo Bypass Salmon Habitat Restoration and Fish Passage Analytical Tool Review
Attachment 9	Yolo Bypass Salmon Benefits Model: Modeling the Benefits of Yolo Bypass Restoration Actions on Chinook Salmon
Attachment 10	J.W DeWit Farms, Inc. Yolo Bypass Salmonid Project comment letter
Attachment 11	Cobra Farms Yolo Bypass Salmonid Project comment letter

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Executive Summary					
Executive Summary	ES-19	Table ES-2	Impact HYD-1: In reading the no action, the text reads as if there is no change from the existing condition. If that's correct, how can it have "two additional occurrences of monthly flows greater than the maximum existing conditions monthly flow, 136,869 cfs?" Is this due to unrelated changes to reservoir operations or planned projects upstream of the Fremont Weir?		54
Executive Summary	ES-19	Table ES-2	Impact HYD-2: Same comment as above		55
Executive Summary	ES-21	Table ES-2	Impact WS-3, 4, 5: These should be reviewed by water supply interests to confirm they agree with the findings and significance.		56
Executive Summary	ES-17	ES.7	There is no mention of concerns raised by multiple stakeholders, including Yolo County and the Yolo Habitat Conservancy among others, that the project is designed and analyzed with only superficial consideration of consistency with the impending Yolo HCP/NCCP.	Letter Comment ES-1	57
Chapter 2					
Description of Alternatives	2-26		Section 2.4.2.1: Identifies 7-8 acres of land that would be purchased for disposal. Long term sediment removal will require an additional 38-43 acres for disposal of soils from periodic maintenance removal of sediment. It's not clear that the impacts of converting Ag land for sediment disposal has been evaluated.		58
Description of Alternatives	2-30		Section 2.4.4.3: Identifies that grasses and woody vegetation can remain in the channel unless it is an obstruction to flow. Chapter 4 does not evaluate the impacts of leaving the woody vegetation in the channel. Removal of woody vegetation in the floodway has become increasingly challenging from a regulatory perspective. The project description should be revised to remove woody vegetation annually and provide the ESA clearance for the removal. The project should also mitigate for any long term impacts that result from this O&M activity.		59

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Description of Alternatives	2-30		Section 2.4.5: Says DWR will monitor groundwater and work with property owners to implement a physical solution if necessary. Who determines what is necessary? Consideration should be given to empowering an independent third party to make the determination of whether there is an impact and what the appropriate mitigation is. I don't think you want DWR deciding this. I also questions whether their approach to this issue is sufficient to meet CEQA requirements to disclose the project impacts. The safe thing to do would be to identify the impact and mitigation measure and then only implement if the groundwater data confirmed the impact.		60
Chapter 3					
Approach to the Environmental Analysis			The EIS/EIR does not clearly recognize that the requirements for alternatives analysis under CEQA are substantively different from the requirements for alternatives analysis under NEPA.	Letter Comment 3-1	61
Chapter 4					
Hydrology, Hydraulics, and Flood Control			The impact of increased flows leading to natural recruitment of riparian vegetation was discussed, but not evaluated. A baseline for woody vegetation along the Tule Canal should be evaluated and the project should have an O&M element that maintains this annually. The impacts should be evaluated as part of the project so that at the time the maintenance is conducted mitigation is not required. The Section 7 and CESA consultation should also cover this activity.	Letter Comment 4-1	62
Chapter 6					

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Water Quality	6-6		6.3.3.2.1 Impact WQ-1: Construction activities under Alternative 1 would involve demolition of a portion of the existing Fremont Weir; construction of a headworks structure, intake channel and outlet channel; and grading of the transport channel. These activities could affect water quality temporarily during the construction period. Possibilities include mobilizing sediment and associated contaminants during excavation and grading, release of construction-related chemicals such as oils, fuels, cement, solvents, etc. from improper handling or accidents. Maintenance activities would include sediment removal every five years within the Fremont Weir Wildlife Area using construction equipment to load and haul it from the bypass; these maintenance activities have the potential to affect water quality in the Yolo Bypass in the same ways as construction activities at the beginning of the project. Maintenance activities would not include dredging in the Sacramento River or Tule Canal." In addition, the cost and wear and tear on RD1600's pumps could be significant and should be addressed. Without any analysis of the Tule Canal or the pumps, RD1600 has no ability to determine just what the impact will be, whether the existing infrastructure can handle the discharge, and what the additional costs to the District will be. The owners in RD1600 cannot foot the bill to implement this project.		63
Water Quality	6-28		MM-WQ-4: Mitigation offered is described in a cursory and vague fashion without any objective standards for the performance of “frequent sampling and reporting” or “coordinat[ing] with the implementation of the current TMDLs for various constituents of concern within the Yolo Bypass.” Other aspects of MM-WQ-4 are similarly cryptic and undefined. This mitigation measure must be substantially revised and clarified with respect to methylmercury and other pollutants described in Chapter 6.	Letter Comment 6-1	64
Chapter 8					

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Aquatic Resources and Fisheries	8-6		Splittail also spawn in numerous other floodplain habitats in the American River, Sutter Bypass, Sacramento and Tuolumne River, but also in the Napa and Petaluma Rivers. These latter populations overlap with CV splittail during certain years. Please see: Quinones and Lusardi 2017. Potential benefits associated with Yolo Bypass Salmonid Habitat Restoration and fish passage proposals. Technical memorandum. April		65
Aquatic Resources and Fisheries	8-9		"Both winter-run and spring-run Chinook salmon tend to enter freshwater in a sexually immature state and delay spawning for months while holding in freshwater." COMMENT: Please include citation (e.g., Moyle 2002)		66
Aquatic Resources and Fisheries	8-9		There are other major factors that control the abundance and range of Chinook including, at a minimum, other water quality parameters (e.g., dissolved oxygen), food quality and quantity, and biotic interactions (e.g., predation and competition).		67
Aquatic Resources and Fisheries	8-11		There are other rearing habitats known to support winter-run Chinook. Please also include non-natal habitats recently found in Phillis, C.C., Sturrock, A.M., Johnson, R.C., and Weber, P.K. 2018. *Endangered winter-run Chinook salmon rely on diverse rearing habitats in a highly altered landscape* . Biological Conservation 217 358-362		68
Aquatic Resources and Fisheries	8-11		Moyle 2002 states that winter-run Chinook spawn between late April and early August with peak spawning between May and June.		69
Aquatic Resources and Fisheries	8-12		Size at date criteria are highly suspect with up to 40-50% of identified juveniles potentially occurring outside of pre-conceived length brackets. This may particularly be the case for spring-run but also a problem with winter run identification. See Harvey et al. 2014: Harvey, B.N., D.P. Jacobson, and M.A. Banks. 2014. Quantifying the uncertainty of a juvenile Chinook salmon race identification method for a mixed-race stock. North American Journal of Fisheries Management **34**: 11777-1186. The limitation of such criteria should be addressed in the document. Perhaps the best place to do so would be in reference to the Salmon Benefits Model considering that Knights Landing data are based on size at date and may over- or under-estimate the contribution of certain runs.		70

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Aquatic Resources and Fisheries	8-12		Moyle 2002 states that spring-run Chinook spawning occurs between late August through October with a peak in mid-September.		71
Aquatic Resources and Fisheries	8-22		Paragraph 4's topic sentence directly references Yolo Bypass but the supporting literature following discusses floodplains in general. Please clarify if the references referred to the Yolo Bypass floodplain singularly or floodplains in general, including the Yolo Bypass.		72
Aquatic Resources and Fisheries	8-30		Section 8.1.3.2.1 - Primary Production seems to largely rely on what's known about suspended primary and secondary production, but benthic processes (benthic algae, periphyton, and benthic invertebrates) are also important. For instance, when referencing "algae" it's not clear if that's being defined as phytoplankton, benthic algae, or a combination of the two. Some discussion of detrital pathways would also be helpful in this section.		73
Aquatic Resources and Fisheries	8-31		"chironomic" typo. Replace with "chironomid"		74
Aquatic Resources and Fisheries	8-32		Section 8.1.3.2.3 - Downstream Productivity. We think additional studies are warranted on the potential effects of floodplain draining and downstream subsidies to the Delta. The spatial and temporal scale at which such subsidies may exist, and how they may differ between water years, is not clear. While we think that the potential for food web subsidies to exist is possible and may be supported by the literature, we do not think it's appropriate to try and capture "the potential" (page 308) of downstream productivity subsidies based on wetted area inundation scenarios for the purposes of this document because the processes leading to such subsidies are likely complex. The description of such processes and the potential effects are correctly worded (i.e., "may exist") throughout the document, but the potential benefits of such subsidies appear to be qualitatively tied back to the different alternatives. Recognizing that there may be benefits associated with floodplain exports downstream is important but there is probably not enough data to parse the effects of such subsidies between different alternatives primarily because the magnitude, timing, and spatial extent of floodplain subsidies downstream to the Delta is not well understood nor defined.		75

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-36		Paragraph 4 “Ahearn et al. (2006) found that after the floodplain became disconnected after a previous inundation event, a subsequent flood event redistributed elevated amounts of algae on the floodplain, such that hypoxic zones (areas of low dissolved oxygen) were created, resulting in mortality of juvenile Chinook salmon confined to enclosures in a hypoxic zone (Jeffres et al. 2008).” COMMENT: This is confusing because Ahearn et al. (2006) discusses the implications of low oxygen levels and mortality of Chinook but cites ‘Jeffres, unpublished data’ in the Ahearn et al. 2006. However, the citations provided in the EIR/EIS is Jeffres 2008. Mortality in Jeffres (2008) was related to high flow on the floodplain during an inundation event. Please clarify or make sure that the “unpublished data” referenced in Ahearn et al. (2006) is correctly attributed to Jeffres (2008).	76
Aquatic Resources and Fisheries	8-42		Paragraph 1 “Although entrainment by agricultural diversions is not frequently identified as a factor in the decline of Delta fish species, most of these small diversions are not screened (Herren and Kawasaki 2001).” Another citation to support the sentence: Moyle, P. B., and J. A. Israel. 2005. Untested assumptions: effectiveness of screening diversions for conservation of fish populations. Fisheries 30:20-28.	77
Aquatic Resources and Fisheries	8-43		Paragraph 1. “Even in the deeper, cooler waters of the Toe Drain, water temperatures typically approach the incipient upper lethal temperature for salmonids by late April to early May (Reclamation and DWR 2012).” Please include either the range of temperatures experienced or a citation for the upper lethal temperature for salmonids and life stage to which the sentence notes.	78
Aquatic Resources and Fisheries	8-49		Paragraph 1. “Due to the predominance of private land in the Yolo Bypass and the occurrence of avian predation on juvenile salmonids in isolated ponds,…” please provide a citation to support the sentence.	79
Aquatic Resources and Fisheries	8-49		Section 8.1.4.6 - Predation: Please include a brief discussion of the role of avian predators or the potential for avian predation on juveniles Chinook associated with shallow water and floodplain habitat.	80

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-58		Paragraph 4. "Hydrologic, hydraulic, fish behavior, and fish population modeling was performed to provide a quantitative basis from which to assess potential operations-related impacts of the alternatives on fish species of focused evaluation and aquatic habitats." COMMENT: We're not sure how fish behavior was used to provide a quantitative basis for comparison. ELAM, in part, modeled fish behavior but ELAM was not included in the Salmon Benefits Model (SBM) which was the source of quantitative comparison for the alternatives. In the cumulative impacts section ELAM, critical streakline and proportion of flow are qualitatively compared with respect to alternatives, but they are not used as inputs to the SBM. The SBM was the primary model to assess salmon benefits quantitatively (i.e., VSP criteria) and for alternative comparison. However, SBM only used the proportion of flow method to estimate entrainment and the proportion of flow method does not account for fish behavior.	

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-60		Paragraph 4. "The requirements for conducting analyses under CEQA and NEPA include utilizing the best available information to conduct impact assessments." COMMENT: ELAM and CSA represent the best available information with respect to entrainment potential onto the Bypass. Entrainment is one of, if not the most, key input variables/rules that determines SBM output and VSP criteria under the different alternatives. While ELAM and CSA were assessed qualitatively at the end of the chapter, they were not explicitly used in the SBM as inputs/rules. These methods, in our opinion, are superior to the proportion of flow method which is essentially a hypothesis with no supporting empirical data. They are superior because both ELAM and CSA look at fish movement (behavior and tracks, respectively) and hydraulics associated with the different alternatives while proportion of flow does not. The proportion of flow method relies on the hypothesis that entrainment is directly proportional to flow diverted onto the bypass. The hypothesis has not been tested and there is no empirical data to support the hypothesis that we are aware of. Further, it's generally recognized that an individual fish's position relative to the point of diversion will influence potential entrainment and that fish do not evenly distribute throughout a channel due to secondary flow circulations (Smith et al. 2017 and references therein).	Letter Comment 8-1

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Aquatic Resources and Fisheries	8-61		Section 8.3.1.2.1 - Analytical Tools. Habitat suitability criteria for Sacramento River juvenile Chinook salmon were used to define suitable floodplain rearing habitat for fry and smolts in the SBM. Those criteria only consider depth and velocity habitat as "suitable" habitat. At a minimum, water temperature should be included. Other factors affecting habitat suitability include food production and/or species interactions. Species interactions may be too difficult (though not impossible) to model, but food production less so. See Corline et al. (2017) for comparison of food resources between floodplain and riverine habitats. Food production, in particular, has the ability to strongly affect habitat selection by salmonids and other fishes. This has been shown to occur even in oligotrophic systems (Weber et al. 2014). Citations: 1) Weber, N., N. Bouwes, and C. E. Jordan. 2014. Estimation of salmonid habitat growth potential through measurements of invertebrate food abundance and temperature. Canadian Journal of Fisheries and Aquatic Sciences **71**:1158-1170, 2) Corline, N.J., T. Sommer, C.A. Jeffres and J. Katz. 2017. *Zooplankton ecology and trophic resources for rearing native fish on an agricultural floodplain in the Yolo Bypass* , California, USA. Wetlands Ecology and Management. DOI 10.1007/s11273-017-9534-2		83
Aquatic Resources and Fisheries	8-62		Section 8.3.1.2.1 - Analytical Tools. With respect to the different entrainment models and SBM, please explicitly state how each was used to quantitatively assess alternatives. As presented, it appears that each of the three entrainment models were used *equally* in the alternative analysis, but only the proportion of flow tool was used in the SBM. The SBM was the primary model to assess and compare alternatives with respect to VSP criteria. Some context on how each of the three entrainment models was specifically used with respect to quantitative analysis would be useful.		84
Aquatic Resources and Fisheries	8-63		Last paragraph (ELAM). COMMENT: Please explicitly state how ELAM was used for analyses purposes and that ELAM was not used in the SBM.		85
Aquatic Resources and Fisheries	8-64		Paragraph 4 (Critical Streakline Analysis). COMMENT: Please explicitly state how CSA was used for analyses purposes and that CSA was not used in the SBM.		86

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-65		Paragraph 2 (proportion of flow tool). COMMENT: Please explicitly state that the proportion of flow tool was the only entrainment tool used in the SBM in order to assess salmon benefits which are tied back to VSP criteria which serve as the basis for alternative comparison.	

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Attachment 1 - Yolo Bypass Salmonid Project EIS/EIR
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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-65		Paragraph 4. COMMENT: Please discuss the additional limitations of the proportion of flow tool with respect to the other entrainment tools. Considering that both ELAM and critical streakline analysis (CSA) look at fish movement (behavior and tracks, respectively) and hydraulics associated with the different alternatives, we're wondering if the 'proportion of flow' method is still useful. The proportion of flow tool has serious limitations because, unlike the other two methods, it does not actually consider the behavior or movement of fish. Instead, it relies on a simple hypothesis that entrainment is directly proportional to flow diverted onto the bypass. The hypothesis has not been tested and there is no empirical data to support the hypothesis that we are aware of. Further, it's generally recognized that an individual fish's position relative to the point of diversion will influence potential entrainment and that fish do not evenly distribute throughout a channel due to secondary flow circulations (Smith et al. 2017 and references therein). In looking at acoustic movement data near Fremont Weir, Steel et al. 2016 found that different runs (winter and late fall) displayed non-uniform distributions across the channel. Finally, Smith et al. (2017) found that while larger notches generally increased entrainment, entrainment was not proportional to flow. Blake et al. (2017) found that the location of each modification scenario significantly impacted entrainment with entrainment varying as much as 400% based on *where* the scenario was located. We remain concerned about the proportion of flow tool as used to estimate entrainment in the SBM and believe it's the weakest of the three tools that are available. Specifically, some acknowledgement and reasoning of why the proportion of flow tool was used in SBM instead of the more robust models is warranted. Our understanding is that ELAM and CSA tools came online a bit later and the proportion of flow tool may be an artifact of earlier analysis with respect to the SBM. Still, some discussion of why an inferior tool was used in the SBM (especially considering that SBM is the primary model to assess salmon benefits) despite its limitations is necessary.	Letter Comment 8-4

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-65		Paragraph 4. "One limitation of this tool is that entrainment onto the Yolo Bypass is assumed to equal the proportion of flow diverted onto the floodplain from the Sacramento River." COMMENT: This relies on the assumption that fish are equally distributed throughout the channel and water column in the Sacramento River near Fremont Weir. We know this is not true and that the acoustic telemetry data from Steel et al. 2016 does not support this assumption. We also know that fish entrainment is not equal to the proportion of flow diverted onto the floodplain based on Smith et al. (2017) (i.e., ELAM).		89
Aquatic Resources and Fisheries	8-66		Paragraph 2. COMMENT: Thank you for including qualitative analysis of the effects of different entrainment tools on potential SBM output results at the end of Chapter 8, under alternative comparison. We recommend incorporating the results of ELAM, CSA and Proportion of flow into some sort of composite prediction of entrainment onto the bypass. We continue to be uncomfortable with the use of proportion of flow as the sole predictor of entrainment onto the bypass when we believe other superior entrainment models could add value to the SBM and outputs with respect to alternative analysis.		90
Aquatic Resources and Fisheries	8-66		Paragraph 2. "The SBM uses the "proportion of flow" approach such that the number of juveniles assumed to be entrained into the Yolo Bypass is proportional to the amount of Sacramento River flow diverted into the Yolo Bypass." COMMENT: Please specifically explain why proportion of flow was used as opposed to ELAM or CSA despite 1) the latter two methods being far more robust and 2) the results of ELAM specifically found that entrainment was not proportional to flow. Please discuss why a combination of models which may provide associated estimates of entrainment error were not used.		91

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Aquatic Resources and Fisheries	8-66		Paragraph 3. COMMENT: Hinkelman et al. 2017 parameterized rearing survival at 0.99 and when they evaluated rearing survival at .97 and .95 in the Effects Analysis, the benefits accrued under Alternative 6 were too low to yield a benefit or were negligible. Considering the importance of the model and assumptions to the overall project analysis, we think it would be appropriate to discuss why the rearing rule and rearing survival assumptions were not targeted for additional investigation prior to finalizing the SBM document. At a minimum, a range of model results based on different rearing survival parameters (and possibly entrainment tools) that quantify the expected extent of deviation base on the use of different parameters would be useful.	Letter Comment 8-2	92
Aquatic Resources and Fisheries	8-66		Paragraph 3. COMMENT: In the draft version of the SBM (Hinkelman et al. 2017, May 4th), an Effects Analysis was used to understand model sensitivity to different input parameters or modeling rules and included analysis on entrainment by examining SBM sensitivity to entrainment rules as estimated by 1) the proportion of flow method and 2) ELAM. Please include the results of this analysis in this paragraph in addition to the rearing rule and rearing survival analysis that is already present. Please also include the entrainment effects analysis results (proportion of flow vs. ELAM or "entrainment rules" effects analysis) in the appropriate appendix that accompanies the draft EIR/EIS (G4). Please discuss the implications of these results with respect to all SBM output with specific mention of the ability of the entrainment rule to influence SBM output. Alternatively, if that analysis is for some reason presented elsewhere in the draft EIR/EIS, please acknowledge that here. Currently, we do not see the results of the ELAM effects analysis in Chapter 8 of the EIR/EIS nor the SBM appendix (G4).	Letter Comment 8-3	93
Aquatic Resources and Fisheries	8-71		Paragraph 3. "Multiple methods were applied by the Lead Agencies to assess and evaluate the proportion of emigrating juvenile Chinook salmon that could be entrained into the Yolo Bypass associated with different Fremont Weir notch configurations and different notch flow capacities, as described below." COMMENT: Please note here how each model was used with respect to alternative analysis and that only the proportion of flow method was used in the SBM.		94

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Aquatic Resources and Fisheries	8-71		Paragraph 4. "Similar dispersion assumptions have been used to evaluate juvenile salmon entrainment into the central Delta using particle tracking (Kimmerer and Nobriga 2008)." COMMENT: Kimmerer and Nobriga 2008 state: "To the extent that *fish behave passively* (emphasis added), this model is probably suitable for describing Delta-wide movement, but is less suitable for smaller scales or alternative configurations of the Delta." We're not sure this article supports the use of the proportion of flow approach because we know that salmon are not passive nor particles subject to fate and transport and exhibit strong swimming behaviors. We also know from the other entrainment models (ELAM and CSA) that entrainment is likely not proportional to flow.		95
Aquatic Resources and Fisheries	8-72		Paragraph 1. COMMENT: Please explicitly state that ELAM was not included in the SBM to estimate entrainment.		96
Aquatic Resources and Fisheries	8-72		Paragraph 2. COMMENT: Please explicitly state that CSA was not included in the SBM to estimate entrainment.		97
Aquatic Resources and Fisheries	8-72		Paragraph 3. "It should be recognized that the suitability of floodplain habitat for a given species and life stage may be affected by factors other than water depth and velocity, including substrate type, the presence and type of instream cover, water temperature, and dissolved oxygen levels." COMMENT: Please also include biotic interactions (predation and competition) and food availability. In addition to depth and velocity, there should be some discussion of other abiotic factors affecting floodplain suitability including (at a minimum): timing of floodplain inundation, period of inundation, and rate of recession off the floodplain, residence time, and temperature.		98
Aquatic Resources and Fisheries	8-114		Paragraph 3. "Modeling results indicate that annual average adult returns under Alternative 1 relative to Existing Conditions would be higher over the entire simulation period and by water year type for fall-run and spring-run Chinook salmon (Table 8-8)." COMMENT: Replace "higher" with "somewhat higher" (i.e., <10%) for spring run (7%) and fall run (6%).		99

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Aquatic Resources and Fisheries	8-114		Paragraph 3. "Annual average adult returns would be similar or slightly lower for late fall-run Chinook salmon and similar or slightly higher for winter-run Chinook salmon under Alternative 1 relative to Existing Conditions." COMMENT: For winter-run, it should be "similar" under all scenarios (<5%). Also, not sure where "slightly higher" is defined in the document. The terminology reflective of the percentages can be somewhat confusing. Recommend including a table defining substantial (10% or greater), somewhat higher (5-9%) or similar (0-4%) (definitions from page 106, paragraph 1) in addition to the text already provided.	
Aquatic Resources and Fisheries	8-122		Section Comment - Entrainment into the Yolo Bypass: We appreciate the addition of ELAM and other entrainment inputs/methods as discussed here, the other alternative sections, and again at the end of the chapter when the three methods and estimates are qualitatively compared. We think this is an important improvement. However, we still do not know the sensitivity of the SBM to different entrainment values/inputs/rules based on the different methods used. Our suggestion is to run the different entrainment estimates (where they have already been calculated for different alternatives from ELAM, CSA, and Prop. of flow) through the SBM to 1) provide an idea of SBM sensitivity to entrainment rules or 2) provide a range of entrainment values as inputs into the SBM, which would produce a range of SBM outputs. The latter situation would provide greater confidence in the estimates produced for alternative comparison purposes.	

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Aquatic Resources and Fisheries	8-151		Section Comment - CEQA Conclusion and throughout: We think there is uncertainty related to the number of fish entrained because the proportion of flow method was the only entrainment method used in the SBM despite its clear limitations. We appreciate the addition of all qualitative analysis aiming to compare potential differences between the three entrainment models and their potential effects on SBM and VSP criteria. However, we think the SBM analysis would be strengthened if all three models were explicitly applied in the SBM which would provide a range of entrainment inputs and, thus, a range of response variable outputs from the SBM. Such an approach would provide a confidence interval around entrainment and SBM model output and allow for better comparison between alternatives. The other alternative is to provide a sensitivity analysis on the entrainment rule and its ability to produce changes in SBM output (based on prop of flow, ELAM, CSA). If SBM output exhibits little change regardless of which entrainment rule is used, then a qualitative analysis (such as currently presented) should suffice. However, if the entrainment rule has the potential to produce large swings in SBM output and thus VPS criteria, it appears that the SBM would benefit from a range of entrainment estimates to produce a range of outputs which could provide greater confidence in overall comparison between alternatives.		102
Aquatic Resources and Fisheries	8-152		Paragraph 4. "However, because 1) the SBM modeling was conducted using the proportion of flow approach to estimate juvenile entrainment into the Yolo Bypass, 2) the ELAM modeling indicates lower maximum entrainment rates for Alternative 3 relative to Alternative 1, and 3) the critical streakline analysis predicts lower total annual average entrainment rates by run than the proportion of flow approach, the indicators of the VSP parameters under Alternative 3 may be less beneficial than shown for Alternative 1." COMMENT: Please quantify specific numerical changes in the indicators of VSP using ELAM, proportion of flow, and CSA.		103

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Aquatic Resources and Fisheries	8-176		Paragraph 2. “Therefore, inundation extent and/or duration of the Yolo Bypass would increase during these months, potentially providing for increased hydraulic habitat availability for fish species of focused evaluation, particularly juvenile salmonids and adult and juvenile Sacramento splittail.” COMMENT: It's not clear why "potentially" is used here but not in other locations in the document. We agree that increased inundation extent/duration would lead to increases in hydraulic habitat for fishes of interest.		104
Aquatic Resources and Fisheries	8-179		Paragraph 2. “Modeling results indicate that Chinook salmon smolt hydraulic habitat availability would be higher under Alternative 1 relative to Existing Conditions over about 60 percent of the cumulative probability exceedance distribution (Figure 8-30).” COMMENT: This should be alternative 4a and 4b, not Alternative 1. Alternative 1 is not part of Figure 8-30.		105
Aquatic Resources and Fisheries	8-201		Last paragraph (here and throughout document). “Because the SBM modeling was conducted using the proportion of flow approach to estimate juvenile entrainment into the Yolo Bypass, the indicators of the VSP parameters presented for Alternative 4 may be less beneficial than shown if the critical streakline entrainment estimates were applied." COMMENT: Entrainment estimates based on different methods (CSA vs. prop of flow, etc.) may not produce linear responses within the SBM. So, a small decrease in the number of entrained fish (based on method) may actually lead to large differences in SBM output and VSP criteria. Without quantifying the sensitivity of the SBM to different entrainment rules, it’s difficult to understand how changes in those rules will actually affect SBM output.		106
Aquatic Resources and Fisheries	8-223		Last paragraph. See comment for PG. 8-32. We think additional studies are warranted on the potential effects of floodplain draining and downstream subsidies to the Delta. Please provide citation of such instances where such subsidies or floodplain exports have been linked to the growth and survival of Delta resident species such as delta smelt.		107
Aquatic Resources and Fisheries	8-279	Figures 8-88; 8-89; 8-90	COMMENT: Please include percentages entrained relative to existing conditions as estimated by ELAM and Critical Streakline Analysis for those alternatives where it has been calculated.		108

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Aquatic Resources and Fisheries	8-281		Paragraph 3. "The ELAM modeling also was used by the Lead Agencies to estimate relative entrainment rates of juvenile salmonids into the Yolo Bypass for each Alternative (see Appendix 1 of Smith et al. 2017)." COMMENT: Please explicitly state that despite the discussion of ELAM in estimating percent entrained in this section, ELAM was not used in the SBM and the SBM it key to the VSP and to salmonids benefits analysis regarding alternative analysis. Please see comment for PG. 8-65 RE paragraph 2, proportion of flow tool.		109
Aquatic Resources and Fisheries	8-283		Last paragraph. "For Alternatives 3 and 4, reduced critical streakline entrainment estimates relative to the proportion of flow estimates indicate that fewer juveniles would be entrained into the Yolo Bypass; therefore, benefits shown for the SBM juvenile and adult metrics would be reduced with the critical streakline entrainment rates." COMMENT: What benefits would be reduced and how much would they be reduced by?		110
Aquatic Resources and Fisheries	8-283		Last paragraph. "However, for Alternative 6, application of the proportion of flow entrainment estimates underestimate the number of juveniles entrained into the Yolo Bypass relative to the critical streakline analysis; therefore, the SBM output may underestimate the benefits of Alternative 6 with respect to the juvenile and adult metrics relative to the other alternatives." COMMENT: Which benefits might be underestimated and by how much?		111
Aquatic Resources and Fisheries	8-296		Section header (8.5.4) "Increase Aquatic Primary and Secondary Biotic Production to Provide Food Through an Ecosystem Approach." COMMENT: The word "biotic" is unnecessary as used here.		112
Chapter 9					
Vegetation, Wetlands, and Wildlife Resources	9-76	9.3.3.2.9	Impact TERR-9: The EIS/EIR fails to analyze the impact of additional flooding from the proposed project on USACE, RWQCB, and CDFW jurisdictional wetlands. DWR and the Bureau should complete this analysis and recirculate the EIS/EIR so the public can review this important analysis.	Letter Comment 9-5	113

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Vegetation, Wetlands, and Wildlife Resources	9-85	9.3.3.2.11	Impact TERR-11: Please revise this impact (and this chapter more generally) to include a complete analysis of the potential for conflict with the Yolo HCP/NCCP, such as the overlap of the project with areas the Yolo Habitat Conservancy has identified as important giant garter snake habitat, and recirculate the document to allow stakeholders such as the YHC to properly consider the analysis and results.	Letter Comment 9-1	114
Vegetation, Wetlands, and Wildlife Resources	9-85	9.3.3.2.11	Impact TERR-11: The analysis provided in this section and elsewhere in this chapter relating to conflicts with the Yolo HCP/NCCP is conclusory. No evidence or analysis is provided to support the discussion. Also, please correct the citation used. While ICF is a YHC consultant, they are not the lead agency or regulatory author of the plan. Please cite the YHC as the author of the Yolo HCP/NCCP and its related EIR.	Letter Comment 9-6	115
Vegetation, Wetlands, and Wildlife Resources	9-42	9.3.2	Section is missing the mandatory discussion of the following issues (CEQA Guidelines Section 15065(a)(1)): 1) whether the project has the potential to substantially degrade the quality of the environment; 2) whether the project has the potential to substantially reduce the habitat of a fish or wildlife species; 3) whether the project has the potential to cause a fish or wildlife population to drop below self-sustaining levels; and 4) whether the project threatens to eliminate a plant or animal community. Please revise Section 9.3.2 to include these mandatory thresholds, and please revise this Chapter to include an analysis of these impacts, including substantiated conclusions, and feasible mitigation.	Letter Comment 9-2	116
Vegetation, Wetlands, and Wildlife Resources			All missing areas of impact analysis identified in this chapter could be feasibly lessened or avoided by including reasonable and feasible mitigation measures.	Letter Comment 9-3	117
Vegetation, Wetlands, and Wildlife Resources			No analysis is presented to support the conclusion that there is no impact from operations of the Yolo Bypass Salmonid Project on wetlands and nesting and foraging habitat. The Yolo Basin Foundation has pointed out that nesting can start as early as February and additional inundation in the Bypass could affect food supply. The County also could not find any analysis in the EIS/EIR to support the conclusion that the Yolo Salmonid Project will not affect wetlands. The analysis is deficient and should include additional analysis of these potential impacts.	Letter Comment 9-4	118

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Vegetation, Wetlands, and Wildlife Resources			The project footprint overlaps with habitat for species covered by the Yolo HCP/NCCP, such as giant garter snake and western pond turtle. The Yolo Habitat Conservancy is providing maps of this habitat as part of its comment letter on the project. The agencies did not analyze potential conflicts as part of the EIS/EIR	Letter Comment 9-7	119
Chapter 10					
Cultural Resources	10-3		The first paragraph on page 10-3 states that the Reclamation District 1600 Tule Canal (P-57-000414) is not eligible for listing on the California Register of Historical Resources (CRHR) or the National Register of Historic Places (NRHP). However, this same resource is listed in Table 10-1 as potentially eligible for both the CRHR and the NRHP. The Final EIR/EIS should clarify this discrepancy and discuss whether the project could adversely affect this potentially eligible resource.		120
Cultural Resources	10-4		The discussion of paleontological resources on page 10-4 references the fossil bearing Pleistocene Modesto formation whereas the discussion on page 10-12 references non-fossil bearing Holocene-age sediments. The Final EIR/EIS should clarify these two references and indicate whether the project site has the potential to contain paleontological resources, and if so, whether mitigation measures are necessary to minimize the potential disturbance of these resources during construction activities.		121
Cultural Resources	10-5		The Final EIR/EIS should explain why additional georchaeological testing was conducted in October 2017 and why the results of this testing were not included in the Draft EIR/EIS.		122

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Cultural Resources	10-23		The discussion under Impact CULT-2 for the six alternatives acknowledges that a cultural resources inventory has never been conducted in the majority of the footprint of Alternative 1 and states that additional prehistoric archaeological resources are likely to be found in the portion of the footprint where surveys have not been conducted. It is unclear why the entire area of potential effect has not been surveyed, considering the initial cultural resource investigations for this project commenced in 2014. It is also unclear why these surveys are being deferred to after completion of the environmental review process. If the unevaluated areas are assumed to contain prehistoric sites that are large and rich in material remains, including human burials and associated ornaments and beads, as acknowledged under Impact CULT-2, then it is inappropriate to defer the evaluation of these resources until after completion of the environmental review process. Without providing decision makers and the public with an opportunity to understand the project's actual impacts on sensitive cultural resources and to determine whether the identified mitigation measures would actually reduce these impacts to less-than-significant levels, the Draft EIR/EIS is not meeting CEQA's fundamental disclosure purposes. Complete surveys of the sensitive cultural resources located within the area of potential effect should be conducted and a full assessment of the project's effects on these resources should be prepared and circulated for public comment prior to finalizing the environmental documents.	Letter Comment 10-1

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Cultural Resources			It is difficult to understand why the impact significance conclusion following implementation of feasible mitigation is reduced from "significant" to "less than significant" for CULT-1, CULT-2, and CULT-4. While the County understands that mitigation proposed to reduce impacts CULT-1, CULT-2, and CULT-4 may be somewhat effective, the discussion in Chapter 10 makes clear it is unlikely to be entirely effective and that some damage or destruction of cultural resources may result. On this basis, it seems each impact should be "significant and unavoidable" for the same reason that the impact analyzed in CULT-3 is deemed "significant and unavoidable"—i.e., there is insufficient information about the potential magnitude of each impact, even with implementation of feasible mitigation, to determine whether the permanent destruction of affected resources will be "less than significant." These impact conclusions are thus unsubstantiated and legally improper.	Letter Comment 10-2	124
Chapter 11					
Land Use and Agricultural Resources			Chapter 11 assumes the project will not convert farmland, despite a discussion in Chapter 16: Socioeconomics that whether the USDA will continue to support preventative planting insurance remains unknown. Further analysis of the potential for this change should appear in the EIS/EIR because, if preventative planting insurance is eliminated and farmland is effectively converted as a result, it could lead numerous other indirect impacts on habitat values, flood conveyance, and other aspects of the current environment setting evaluated in the EIS/EIR. It's critical to have this information now in assessing the potential impacts of the project under both CEQA and NEPA.	Letter Comment 11-1	125
Land Use and Agricultural Resources			When evaluating the cumulative impacts in the Yolo Bypass, the analysis assumes away any incompatability between this project and those identified in the EIS/EIR or any changes in land use designation, even though there may be changes in land use. The basis for these assumptions is not altogether clear. Incompatabilities or changes in land use or land use designation could change the conclusions drawn from this analysis. A sensitivity analysis would reveal potential cumulative impacts that are significant. A sensitivity analysis would likely reveal a wide range of possibilities that are not apparent when considering avg. annual outcomes.	Letter Comment 11-2	126

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Land Use and Agricultural Resources			The analysis does not even attempt to quantify or even qualitatively describe potential farmland conversions with the Lower Elkhorn Basin Levee Setback Project (e.g. hundreds of acres) and other projects, such as Lower Yolo Ranch (over 1,000 acres). This analysis should be updated to reflect the potential farmland conversions that will result from these and other reasonably foreseeable projects.	Letter Comment 11-3	127
Land Use and Agricultural Resources			Analysis of field preparation time needs to include evaluation of additional Toe Drain/Tule Canal flows. The County is concerned that the estimate of 34 days for drying, preparation, and planting does not include additional drainage time that will result because the Toe Drain/Tule Canal contains additional water from the operable gate in the Fremont Weir. The estimate of 34 days should be updated after this analysis is completed.	Letter Comment 11-4	128
Land Use and Agricultural Resources			The analysis provides results of avg. impacts from the alternative projects; however, environmental conditions may include consecutive bad years when flooding could delay planting every year over a 3-5 year period, as is considered in the tipping point analyses or even longer. Results are presented over time but do not consider cumulative effects through time. Figures show effects each year, however, there is no evaluation of the implications from frequency of repeated annual flooding. Long-term hydrological conditions seem relevant, especially in light of recent and expected future climatic conditions.		129
Land Use and Agricultural Resources			It is not clear how grazing lands are handled. What are these lands used for if not for grazing? How were these lands parameterized for the analysis if they were used for a purpose other than grazing? Grazing land acreage comprises over 40% of the farmed acreage in the Yolo Bypass. How are the returns to these lands reflected in the analysis so they capture these other uses so as not to distort the conclusions?		130
Land Use and Agricultural Resources			A better explanation of the threshold on what it means to be designated significant is needed if it is not given elsewhere in the EIS/EIR.		131
Land Use and Agricultural Resources	11-5	Table 11-1	Add total land for the Bypass area in table.		132

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Land Use and Agricultural Resources	11-6-9	Tables 11-2; 11-3; 11-4; 11-5	It is not clear what purpose this information serves in analyzing land use in the Bypass.		133
Land Use and Agricultural Resources	11-7		Report states "Yolo County acres in the Yolo Bypass are 82 perent or 57,689 acres." This measure is inconsistent with the total area shown in Table 11-1. Should be corrected.		134
Land Use and Agricultural Resources	11-15		It is not clear what the methods for analysis implies about conversion of unique farmland, prime farmland, or farmland of statewide importance, partiularly under Alt. 4, where we see declines in these acres. If we see large changes in land use, it should affect the net returns in the area and subsequently the IMPLAN analysis reported in Chap. 16 that relies on the results from the BPM analysis.		135
Land Use and Agricultural Resources	11-15	11.3.1	What are some of the incompatible uses and adverse effects of changes in land use? Why is this statement relevant to the EIS/EIR?		136
Land Use and Agricultural Resources	11-19		What happens if land is not protected by the Williamson Act? What is the implication of protection? Does it matter?		137
Land Use and Agricultural Resources	11-29		What is the range of fluctuations in loss acreage?		138
Land Use and Agricultural Resources	11-30		EIS/EIR states, "While project implementation could temporarily affect up to seven percent of Yolo County's Prime Farmland, Unique Farmland, and Farmland of Statewide Importance because of increased periods of inundation, the lands would not be permanently taken out of production although it is possible that farms might shift to alternative crops or experience changes in agricultural yield." This would be all of the Prime Farmland, Unique Farmland, and Farmland of Statewide Importance in the Bypass given the numbers shown in this chapter (24,700 acres in the bypass and 365,535 acres in Yolo County). Should this read up to 7 percent of the Prime Farmland, Unique Farmland, and Farmland of Statewide Importance in the Bypass?		139
Land Use and Agricultural Resources	11-34	11.3.3.6.2	It is not clear if the loss in yield referred to is per unit area or for total project area.		140

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Land Use and Agricultural Resources	11-41		Impact AGR-2: EIS/EIR reports, "the additional wet period experienced by most of the lands in the bypass is not anticipated to cause a delay that would result in planting dates beyond June 1 or change FMMP land use classifications. There are still potential yield losses, however, because the proposed date (Mar 15) for the end of inundation flow releases at Fremont Weir could delay planting relative to existing conditions." Without sensitivity analysis we do not know how significant these delays might be. These delays could affect the conclusions and thus alter this analysis and the IMPLAN analysis as well.		141
Land Use and Agricultural Resources	11-43	Table 11-6	Useful to provide estimated acres of affected areas under each FMMP denomination.		142
Land Use and Agricultural Resources	11-44		EIS/EIR states, "The Lower Yolo Restoration Project is intended to restore tidal flux to 1,100 acres of existing pasture land. Additionally, EcoRestore Projects in or near the Yolo Bypass, including Agricultural Road Crossing #4, Lisbon Weir Modification Project, and Lower Putah Creek Realignment Project, could affect small areas of agricultural land. These actions have the potential to change land use in these parts of the bypass but would not likely change land use designations." On what basis can it be stated that land use will change but not land use designation?		143
Land Use and Agricultural Resources	11-45		EIS/EIR states "It is also assumed that construction-related impacts to agricultural lands would be temporary and would not result in the conversion of Prime Farmland, Unique Farmland, and Farmland of Statewide Importance to non-agricultural uses or substantial reductions to crop yields."Why is it realistic to assume these construction-related impacts will be temporary? How long is the lag until it returns to its prior use? Would future crop yields be affected from long delays?		144
Chapter 12					

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Geology & Soils	12-13		Impact GEO-1: The analysis identifies a 13 percent increase in annual sedimentation rates and that while sediment removal will need to occur more frequently, it's a less than significant impact. Sediment removal in the floodway has become increasingly more difficult to get permitted and more costly due to mitigation requirements. Any change should be considered significant. The project should include CESA and ESA coverage for all O&M activities, including sediment removal.	Letter Comment 12-1	145
Geology & Soils			Impacts on RD 1600 gravity drain: The project as proposed will have an adverse impact on RD 1600 drainage. When the notch has water flowing through it, the backwater in the Tule canal will prevent the gravity drain from draining the District. This will require the pump station to be used more often resulting in increased electrical costs and wear and tear on the pump station requiring more frequent maintenance, repair and rehabilitation. The increase in sedimentation that is associated with the project will also reduce the effectiveness of the gravity drain. The project should include periodic removal of sediment in the Tule Canal to avoid impacting the gravity drain. CESA and ESA coverage should include coverage for this O&M activity.		146
Chapter 13					
Recreation			The calculation of a 2% reduction in days available for educational programs and activities is not properly supported because the analysis does not include the days the Wildlife Area will remain closed to drain and dry out. The calculation of a 4.1% reduction in hunting days also is not properly supported for the same reason. The Yolo Basin Foundation estimates the lost education and hunting days are 2-3 times the estimates in the EIS/EIR because of the additional time needed to drain the Wildlife Area that is not included in the analysis. Yolo County supports the Yolo Basin Foundation's suggestion that this analysis should be updated.	Letter Comment 13-1	147

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Recreation	13-39		Yolo County strongly supports implementation of Mitigation Measure MM-REC-1, particularly the rehabilitation of the Fremont Weir Wildlife Area (FWWA) recreational access parking area. This mitigation measure states that DWR shall, in consultation with CDFW, rehabilitate the existing parking area to provide adequate public parking for long-term access and use of the FWWA. Yolo County requests that these rehabilitation efforts be conducted in coordination with the County to ensure that the rehabilitated parking area adequately accommodates the FWWA's long-term recreational demands.	
Chapter 14				
Visual Resources	14-13		Impact VIS-2 concludes that the headwork structures and associated support facilities would alter views into the Fremont Weir Wildlife Area (FWWA), would provide a stark contrast with the surrounding vegetation, and could impede scenic views and vistas for visitors to the FWWA. This impact is identified as significant in the Visual Resources section. Mitigation Measure MM-VIS-1, which is intended to reduce the significance of this adverse visual impact, states that all new structures, including bridges, will be screened to soften the views of the facilities. This mitigation further states that screening could include landscaping with shrubs, ground cover, vegetated berms, and floodplain restoration. However, the headwork structures, including the bridge proposed to be constructed over the new notch in the Fremont Weir, will be substantially elevated above the surrounding ground surface. Therefore, substantial vegetative planting would be required to feasibly screen these facilities from surrounding viewpoints including the planting of tall trees. However, any planting within the Yolo Bypass is likely to increase the vegetative roughness, which will diminish its flood conveyance capacity. As this approach would likely not be acceptable to the U.S. Army Corps of Engineers, the implementation of this mitigation is likely to be infeasible and the visual impact would remain significant and unavoidable. The visual resource impact discussion should be revised to address this deficiency.	

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Visual Resources	14-13		Impact VIS-2 addresses the long-term changes in scenic vistas, scenic resources, and existing visual character associated with construction of the facilities within the Yolo Bypass but ignores the visual impacts associated with construction of a large sediment mound outside of the Yolo Bypass. As described on page 15-17 of the Public Services, Utilities, and Power section, the total excavation is expected to range from 265,820 to 3,149,312 cubic yards, depending upon the alternative selected. This material is proposed to be transported off site to a designated spoils area within two miles of the Yolo Bypass. Also, additional long-term sediment removal and disposal would be necessary due to ongoing maintenance requirements. Based on the proposed acreages of the spoil site for the individual alternatives, the height of the spoil piles would range between 25 and 50 feet over an area as large as 48 acres. This large soil mound would clearly represent a change in the existing visual character of the rural lands within two miles of the bypass. This impact was ignored in the Visual Resources section. This visual impact needs to be evaluated in the EIR/EIS and appropriate mitigation measures need to be provided to minimize the adverse effects on the regions visual character.		150
Chapter 16					
Socioeconomics			Chapter 16 does not clearly state the area of analysis of the impact analysis using IMPLAN. Is it Yolo County and the surrounding counties or just Yolo County? The selection of the counties or areas included in the IMPLAN analysis, affect the multiplier effects. A small area may have more economic leakage hence understating the region-wide multiplier effects. Conversely, a larger area may overstate the region wide multiplier effects.	Letter Comment 16-5	151
Socioeconomics			The analysis does not provide details on what sectors in IMPLAN are considered quantifying construction impacts. The selection of sectors affected by construction does not have an effect on the direct impacts on gross revenues (output), but it does on employment and labor income, and the overall indirect and induced effects. There are 8 sectors for construction in the 2014 Yolo IMPLAN database.	Letter Comment 16-5	152

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Socioeconomics			The IMPLAN sectors associated to operation and maintenance are not specified. The selection of the sector may have an effect on the overall multipliers (and estimated benefits of each crop alternatives).		153
Socioeconomics			The matching of BPM commodities analyzed with IMPLAN Yolo 2014 agricultural sectors should be clearly stated in the document. Same as for construction, and operation and maintenance of facilities, commodity groups vary in their multipliers which ultimately drive indirect and induced effects.		154
Socioeconomics	16-1	16.3.1.1	IMPLAN description is not provided in this section.		155
Socioeconomics	16-2	Table 16-2	Are dollar values current dollars or real dollars? It is not clear from the presentation.		156
Socioeconomics	16-3	Table 16-3	Table uses 2008 as the base year for determining real dollars. It seems possible to update this and make it easier to put into current context. As noted earlier, dollar base years differ throughout the economic analyses. Consistency across all analyses should make results simpler to evaluate across analyses.		157
Socioeconomics	16-8		"To summarize Guidelines 15131[a] and 15131[a], the economic or social effect of a project may be used to determine the significance of physical changes caused by the project." Should one of the underlined guidelines be 15358[b]?		158
Socioeconomics	16-9	16.3	The title for this section is written as "Environmental Consequences." Should this be titled "Socioeconomic Consequences" or "Economic Consequences?" The first sentence in this section talks about economic effects.		159
Socioeconomics	16-9		Bottom of page states, ".....a 10% design cost estimate..." and "..on site worker estimates..." Is it standard to use a 10% design cost estimate? What were the onsite worker estimates used? How were they obtained?		160
Socioeconomics	16-10		"... Alternatives 1, 2, 3, 5, and 6 would not affect any land outside the FWWA. Alternative 4 could affect land that is currently used for farming, but these small quantities are not addressed through BPM. Alternative 4 land conversion effects from construction are assessed qualitatively." Why doesn't BPM evaluate this potential land change? What does it mean to qualitatively assess?		161

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Socioeconomics	16-11		The term conservative assumption is used with regard to assuming all YBP rice and tomatoes come out of production. Why say it is conservative? Why not call it the worst case scenario?		162
Socioeconomics	16-12		"Employment is the number of jobs, including..." should there be a 'measured by' in there? Also this appears "...economic effects would be less." Would it be less severe or fewer?		163
Socioeconomics	16-12		EIS/EIR states "....because existing conditions for regional economics are not....." Should this read the regional economy? Why is the term economics used here? There are many occurences in this chapter where regional economy appears and others where regional economics is used. Are these different ideas?		164
Socioeconomics	16-12		"This section provides a project-level evaluation of the direct and indirect socioeconomic effects." Does this also include induced effects?		165
Socioeconomics	16-13		EIS/EIR states, "The duration of these jobs would vary and most would not likely be over the entire construction period." Does this phenomenon need to be explained? Why is this the case? Is it because different labor does different aspects of the construction?		166
Socioeconomics	16-14		The EIS/EIR states, "The annual maintenance cost for Alternative 1 would be approximately $0.5 million annually. These estimates were developed considering a 50-year project life cycle." Is this a common assumption about the project life cycle? What is the basis for using this age? A shorter lifespan could change the results.		167
Socioeconomics	16-15	Table 16-15	The analysis of the regional economic effects summarized in Table 16-15 for Alternative 1 and similar tables for Alternatives 2 and 6 is speculative and legally inadequate.	Letter Comment 11-1; Letter Comment 11-4	168

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Socioeconomics	16-16		The EIS/EIR states, "A potential increase in groundwater levels due to increased inundation has the potential to cause shallow groundwater levels to rise. Shallower groundwater levels have the potential to increase saturation near the root zones of crops, thereby reducing crop yields. Different types of crops have different root zone depths, which result in different potential for effects from shallow groundwater. The crops grown around the bypass are primarily deciduous fruits and nuts (walnuts or pistachios); field crops (alfalfa, corn, sudan grass, or safflower); truck and berry crops (tomatoes); or grain crops (rice). " Where does this information come from? It should be easy to find references for this content. Having that information make these statements more credible.		169
Socioeconomics	16-17		The EIS/EIR states, "Reduced crop yields could result in crop shifting but would not result in permanent cropland conversions. Additionally, the Elkhorn area and the west side of the bypass (near I-80) only accounts for 1.5 to 3 percent of total agriculture in Yolo County." Is this a result from the BPM? Without supporting evidence it takes away from the weight of the result.	Letter Comment 11-3	170
Socioeconomics	16-17		The EIS/EIR states, "These increases in duration and quantity of pumping would increase groundwater pumping costs to Reclamation District 1600." Would these increased pumping costs be large enough to change the results?	Letter Comment 11-2	171
Socioeconomics	16-19	Table 16-17	Table shows the direct effect of employment is 347 jobs. The text above reports a direct effect of 321 jobs. This appears to be an inconsistency.		172
Socioeconomics	16-32		EIS/EIR states, "Alternative 5 would extend periods of inundation and could cause increased invasive growth on pasture." Are the costs to control this invasive growth on pastures enough to change the conclusions about this alternative?		173
Chapter 17					

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Traffic	17-10		Impact TRAN-2 states that Alternative 1 would require a total of 463 three-axle dump truck trips per day over six weeks of the 28-week construction period during the project's riprap and rock slope protection (RSP) installation portion. These trucks would access the site by way of County Roads 117 and 16 (east). This impact further states that sediments generated during construction would be disposed of within two miles of the project area. However, this impact discussion does not acknowledge the substantial number of truck trips that would be generated by the sediment removal requirements. As identified in the Public Services, Utilities, and Power Chapter, the amount of sediment removal required for the alternatives would vary from 265,820 cubic yards for Alternative 1 to 3,149,312 cubic years for Alternative 5. Assuming haul trucks with an average capacity of 16 cubic yards, the estimated additional truck trips generated during the 28-week construction period for the six alternatives would range from 33,227 to 393,664. All of these truck trips would occur on the local roads in the project vicinity, which would represent a substantial increase in traffic in relation to the existing traffic load and capacity. In addition, the site's long-term sediment removal requirements would extend the project's localized traffic impacts indefinitely into the future. As defined in the thresholds of significance on page 17-8, this would represent a significant impact. The Final EIR/EIS should fully describe this significant traffic impact and identify appropriate mitigation measures to minimize the adverse effects on local residences.	Letter Comment 17-1

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Traffic	17-12		Impact TRAN-4 states that traffic associated with project-related maintenance activities following construction, such as maintenance vehicle use for sediment removal, is expected to be similar to existing conditions and would not substantially alter traffic conditions in the areas. This conclusion ignores the additional truck traffic associated with long-term sediment removal on local roads. According to the Draft EIR/EIS (page 15-9), the project alternatives would require the removal and disposal of an additional 37,800 cubic yards of accumulated sediment every five years when compared to existing conditions. Although a disposal site has not yet been selected for this sediment, it seems certain that residences located along the county roads in the project vicinity would be adversely affected by this increase in truck traffic. The Final EIR/EIS should discuss these long-term localized traffic impacts and identify mitigation measures to minimize their effects on local residents.	Letter Comment 17-2	175
Chapter 18					
Air Quality	18-42		Mitigation Measures MM-AQ-1 through MM-AQ-4 are focused on reducing construction emissions and it is unclear whether these same measures would be consistently implemented during annual maintenance activities. Because the annual maintenance activities would require substantial vegetation removal, sediment excavation, and offsite sediment transport and disposal, it is critical that these mitigation measures be applicable to these long-term project activities. The air quality discussion should clarify the applicability of these mitigation measures to the long-term maintenance activities and address whether these activities were considered in quantifying the emissions identified in the operational emission tables for the project alternatives.		176
Air Quality	18-42		Bullets 2 and 9 of Mitigation Measure MM-AQ-4 reference the Department of Public Works. Does this reference imply that County Public Works Departments will be expected to monitor the construction mitigation measures? If so, coordination with these departments will be necessary prior to project construction to define their involvement.		177

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Air Quality	18-42		The use of the word "should" in Mitigation Measure MM-AQ-4 for bullets 4 and 7 gives the impression these measures are recommendations rather than requirements. This word should be changed to "shall" to ensure these measures are enforceable during project construction activities. Also, the applicability of the construction mitigation measures to the offsite sediment disposal site needs to be clearly articulated, particularly related to cover and stabilization requirements to ensure that significant wind-blown particulate emissions are not generated during and following sediment placement.		178
Air Quality	18-45		Impact AQ-3 states that to determine if sensitive receptors are exposed to substantial pollutant concentrations, potential health risks must be assessed. It further states that diesel particulate matter is listed as a Toxic Air Contaminant in California and would be subject to a human health risk assessment under CEQA. However, without actually conducting a health risk assessment, the impact discussion concludes that the exposure of residents to toxic diesel emissions would be less than significant due to their distance from the construction activities. This conclusion ignores the significant number of heavy trucks that will pass directly in front of multiple rural residences when accessing the site. If the residences are located along the sediment disposal route, they will further be exposed to toxic diesel emissions throughout the project's life. As referenced in the impact discussion, the preparation of a health risk assessment is necessary to appropriately quantify the potentially significant health risks for residents located along the project's proposed haul routes, consistent with CEQA. The results of such an assessment should be circulated for public review and comment prior to finalizing the environmental document.	Letter Comment 18-1	179

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Air Quality	18-57		Mitigation Measure MM-AQ-5 includes staggering maintenance activities so that total daily emissions are less than the significance thresholds. However, no detail is provided regarding how this will be accomplished or even what activities need to be staggered. Without more information regarding the mechanics of this mitigation measure, it is difficult to conclude that it would actually reduce daily emissions below the significance thresholds. Also, if maintenance activities will be staggered, presumably they will occur over a longer timeframe. More information needs to be provided regarding the expected duration of annual maintenance activities and the effects of this mitigation measure on these durations.		180
Air Quality	18-58		Table 18-30 identifies mitigated maximum daily operational emissions for Alternative 3 that exceed the significance threshold (i.e., 32 lbs/day vs. 25 lbs/day threshold) but concludes that this emission level would be less than significant. Footnote #2 references Mitigation Measure MM-AQ-5 as justification for this conclusion but this table identifies emission levels with the identified mitigation measures already implemented. Therefore, the NOx emissions associated with Alternative 3 operations would presumably remain significant and unavoidable. The CEQA conclusion should be revised to accurately reflect the significance of this impact. This same issue occurs in Table 18-36 for Alternative 4 and Table 18-48 for Alternative 6.		181
Air Quality	18-62		The CEQA conclusion for Impact AQ-5 states that because NOx emissions associated with Alternative 4 would exceed the general conformity de minimus threshold, this impact would be significant. The CEQA conclusion further states that the general conformity applicability evaluation already assumes mitigation is incorporated. However, if mitigation measures are already assumed to be included and the projected emission levels still remain above the de minimus threshold, than this impact would correctly be identified as significant and unavoidable. By not correctly identifying this impact as significant and unavoidable in the Draft EIR/EIS, the document preparers have deprived the public of the opportunity to fully comprehend the adverse impacts of project implementation.		182

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Air Quality	18-74		The CEQA conclusion for Impact AQ-5 states that because NOx emissions associated with Alternative 5 would not exceed the general conformity de minimus threshold, this impact would be less than significant. However, as indicated in Table 18-43 on page 18-73, the construction emissions generated by Alternative 5 would exceed the NOx de minimus threshold by 4.4 tons per year (i.e., construction emissions of 29.4 tpy with a threshold of 25 tpy). This represents a significant impact that has not been disclosed to the public. In addition, as described for Alternative 4 in the page 18-62 response above, this impact would correctly be identified as significant and unavoidable. Not identifying the impact as such violates CEQA by depriving the public of the opportunity to fully comprehend the adverse impacts of project implementation.		183
Air Quality	18-76		For the Tule Canal Floodplain Improvements, the CEQA conclusion for Impact AQ-5 states that construction-related emissions are expected to be equivalent to the channel improvement emissions for Alternative 5 and that they are not expected to exceed the general conformity de minimus thresholds. However, as discussed in the response to this issue for Alternative 5 on page 18-74 above, the CEQA conclusion incorrectly identifies the impact as less than significant. According to Table 18-43 on page 18-73, Alternative 5 is projected to generate 29.4 tons per year of NOx emissions, which is in excess of the 25 tpy de minimus threshold. This again represents a significant and unavoidable impact that has not been disclosed in the Draft EIR/EIS.		184
Chapter 20					

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Noise	20-11		The Methods for Analysis section states that the focus of the noise analysis is on potential temporary noise impacts during construction. This section further states that long-term noise impacts are not anticipated from operation and maintenance of new facilities but then acknowledges that short-term and intermittent noise impacts would occur from maintenance activities, such as from sediment removal. No information is included in this section regarding the duration of these sediment removal activities even though the analysis acknowledges that more peak truck trips would be generated during maintenance activities than during project construction. Because more daily truck trips are expected from long-term sediment removal maintenance activities than from project construction, the project would clearly result in a significant long-term noise impact. The noise discussion needs to be modified to reflect this reality.		185
Noise	20-12		According to the last sentence of the first paragraph on page 20-12, the analysis of noise generated from construction-related traffic was compared against the 2015 annual average daily traffic volumes published by Caltrans. However, in the traffic noise tables included in Appendix L, traffic volumes were only provided for Interstate 5. No existing traffic volume data was used to calculate the noise levels along the County roads. The noise section should clarify how noise levels associated with haul vehicle traffic were calculated when no information is provided regarding the existing traffic volumes on these roads.	Letter Comment 20-3	186

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Noise	20-12		This first paragraph states that traffic levels would need to increase by at least nine times to double noise levels. The analysis on page 20-17 then states that county roads are expected to experience enough of a traffic increase to double the traffic noise levels. In effect, this analysis is acknowledging that traffic levels on county roads will increase by at least nine times, without specifically stating so and without providing any information regarding existing traffic volumes on these roads. Because truck traffic associated with long-term maintenance activities are actually expected to generate more daily traffic than associated with construction activities, this nine-time increase in traffic on local county roads would occur over the entire life of the project, which could span the lifetimes of the residents along these rural roads. More aggressive noise mitigation measures clearly need to be included in the Final EIR/EIS to address this significant long-term noise impact on residences located adjacent to the identified haul routes.	

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Noise	20-15		The discussion concludes that no long-term project operations would occur under Alternative 1 that would generate excessive vibrations or groundborne noise. However, this statement again ignores road vibration impacts associated with long-term operations and maintenance, particularly for sediment removal. The discussion in the first full paragraph on page 20-18 states that there may be up to 112 daily worker trips and 801 haul truck trips associated with Alternative 1's long-term maintenance activities. Project construction is projected to generate only 668 daily truck trips, or 133 less than anticipated during long-term sediment removal activities. The other alternatives identify even higher levels of long-term maintenance vehicle trips including 1,719 daily haul trips and 178 daily construction worker trips for Alternative 4. It is unclear how the noise and vibration impacts generated by the construction haul truck traffic at local residences along county roads can be identified as significant due to project construction while concluding that there would be no long-term noise or vibration impacts associated with project implementation. Impact NOI-3 on page 20-17 further states that maintenance activities, including road regarding, debris and vegetation removal, sediment removal, channel repairs, and other basic upkeep, would occur periodically throughout the year and that these activities are not anticipated to have a significant effect on ambient noise levels. This statement is again contradicted by the fact that more daily maintenance truck trips would be generated than during peak construction periods. No information is provided regarding the duration of these maintenance activities, other than to state that they would occur periodically throughout the year. The noise section needs to clearly address these deficiencies in the analysis.	

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference
Noise	20-16		Mitigation Measure MM-NOI-1 includes noise reduction measures that are intended to offset the significant vibrations generated at residences from loaded haul trucks along the haul routes. However, the only measure included in this mitigation list that would actually reduce haul vehicle noise levels for residences includes limits on the number of passby trips per hour and on vehicle speeds. No information is included regarding these limits. Alternative 4 identifies a total of 1,719 haul trips per day associated with long-term maintenance activities, which represents approximately one truck every 20 seconds over a 10-hour day. This calculation does not even include the 178 daily worker trips necessary for the maintenance activities. Without knowing the limits on passby trips that would be required by this mitigation measure, it is not possible to determine whether it would actually have any beneficial effect on noise levels at the residences. The noise section should specifically quantify the limitations on passby trips needed to ensure the hourly average noise level is maintained below 60 dBA along all affected haul routes. In addition, the duration of the annual maintenance activities should be specifically defined. It is unacceptable to state that periodically there will be between 801 and 1,719 daily heavy construction vehicles and between 112 and 178 daily construction worker trips (depending upon which alternative is selected) travelling on rural county roads adjacent to existing residences without specifying when or for how long these trips will occur. The noise section needs to be revised to include this information.	Letter Comment 20-2

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Noise	20-16		Mitigation Measure MM-NOI-1 states that the identified noise reduction measures are intended to offset the significant vibrations generated at residences from loaded haul trucks along the haul routes. This measure specifically identifies the construction of sound attenuation (i.e., stationary barriers placed between the source(s) of construction noise and the noise-sensitive receptors) to minimize noise levels. Because the noise at the residences is caused by haul truck trips, this mitigation measure seems to suggest thta sound attenuation barriers will be installed between the residences and the haul routes. However, no information is included regarding the feasibility of constructing these barriers or their effectiveness. This noise section text should clarify how noise attenuation barriers will actually reduce the haul vehicle noise levels at residences adjacent to the haul routes and how these barriers will be constructed and maintained over the long-term so that they effectively reduce noise levels associated with long-term maintenance truck traffic. Alternative noise attenuation options should also be included in Mitigation Measure MM-NOI-1 for home owners who do not want noise attenuation barriers adjacent to their residences. These options could include upgrading the building materials for the residences to reduce interior noise levels (e.g., adding wall insulation, installing double pane windows, etc.).		190
Noise	20-17		Analysis states that county roads are expected to experience enough of a traffic increase to double the traffic noise levels. In effect, the analysis acknowledges that traffic levels on county roads will increase by at least nine times, without specifically stating it and without providing any information regarding existing traffic volumes on these roads. Since truck traffic associated with long-term maintenance activities are actually expected to generate more daily traffic than construction activities, this nine-time increase in traffic on local county roads would occur over the entire life of the project, which could span the lifetimes of the residents along these rural roads. More aggressive noise mitigation measures clearly need to be included in the EIS/EIR to address this significant long-term noise impact on residences located adjacent to the identified haul routes, including installation of double-paned windows, planting of trees to reduce noise, and potentially hay walls to provide a sound barrier.	Letter Comment 20-1	191

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Chapter 22					
Environmental Justice	22-15		The analysis under Impact EJ-1 states that minority populations were identified in Census Tracts 101.02, 112.06 and 114, and that these tracts were considered minority-affected areas. The analysis further states that the project would result in very small and localized noise impacts. Because the project is specifically located within Tract 101.02, these noise impacts would affect residents within this tract. However, the analysis states that sensitive receptors are not known to be in a minority area and that adverse and disproportionately high noise impacts would not occur to minority populations surrounding the project area. This conclusion directly contradicts the fact that the project is acknowledged to be located within minority-affected areas. The environmental justice section should be revised to acknowledge the project's direct effect on minority-affected areas.	Letter Comment 22-1	192
Appendix J1					
Bypass Production Model Technical Appendix			Inundation can also provide soil moisture and decrease the need for irrigation to irrigation requirements. The BPM is a fixed proportions model, which might not be able to capture this condition. Whether this has an effect on the yields from the other end (deficit irrigation) or moves water needs with respect to the base amounts could alter the conclusions and should be addressed.	Letter Comment J1-1	193
Bypass Production Model Technical Appendix			The BPM uses data from 1997 to 2012 to evaluate the different alternatives for improving salmonid passage and rearing habitat. Cropping patterns, prices, yields during these years may not be representative of current or future conditions. Moreover, the appendix describing the BPM states that the data for years 2005 - 2009 are used to calibrate the model. Can more current data or even the data from 1997 to 2012 be used to calibrate the model?	Letter Comment J1-2	194
Bypass Production Model Technical Appendix			There is no sensitivity analysis to get a sense of consequences or the robustness of results for given parameter value uncertainty. Results are presented over time but do not consider cumulative effects through time. With a fuller range of values and assumptions, the results would more clearly reflect the range of possibilities rather than relying on a single average outcome.	Letter Comment J1-3	195

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Bypass Production Model Technical Appendix			Alternatives 2 and 3 are not mentioned. Is this because they are virtually the same projects as Alternative 1 but with slightly different notch location? Should this be mentioned?		196
Bypass Production Model Technical Appendix			The discussion on fallowed land is confusing. Statements are made about this land being held constant. Then later we read about changes in fallowed land when the impacts for each alternative are discussed. Further, the justification for holding fallowed land constant could use more justification. Why avoid calibrating to the fallowed acreage too? Would it help justify if there were further description of relevance of idle land with respect to the rest of agricultural area in the bypass?		197
Bypass Production Model Technical Appendix			It is not always clear what data come from what sources and how data are combined.		198
Bypass Production Model Technical Appendix			Appendix table and figure numbering starts from 1 with each new appendix, making it difficult to list. Appendices also do not appear in Table of Content; their tables and figures are not in the list of tables or figures either.		199
Bypass Production Model Technical Appendix	J1-1		Elaborate on consistency of inputs between BPM and the P&G, and which version of these (e.g. 1983?). It would aid the reader if there were details on what inputs to the model are. Also providing description of P&G and why these are relevant in the context of the economic assessment of impacts to agriculture would add clarity to this discussion.		200
Bypass Production Model Technical Appendix	J1-2		DAYCENT is a biophysical model not TUFLOW, which is hydrodynamic.		201
Bypass Production Model Technical Appendix	J1-3		On model mechanics provide a description of what the various years in datasets are (e.g. land use, versus cooperative extension budgets, and historical hydrologic dataset).		202

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Bypass Production Model Technical Appendix	J1-3		Appendix states, "This is a rigid production technology specification that does not allow for intensive margin adjustments (e.g., input substitution) by farmers. This specification was chosen because it does not allow for input substitution and economic impacts estimated using the BPM are conservative (more significant). Parameters are calculated using a combination of prior information and the PMP method." In the second sentence input substitution is redundant. Furthermore, to see that the estimated impacts are conservative (more significant) is hard to interpret. Would it be useful to report how this assumption overestimates the impacts because they do not allow for input substitution?		203
Bypass Production Model Technical Appendix	J1-5		If the time scale of the gross revenues is daily by crop and inundation region, it is confusing to see that the cost is not also daily. Is there a reason costs are not also on a daily basis?		204
Bypass Production Model Technical Appendix	J1-6		"The BPM has important interactions with the hydrodynamic analysis. In particular, the TUFLOW model provides last day wet information for each field to the BPM" This is inconsistent with page J1-2 which says TFLOW is biophysical.		205
Bypass Production Model Technical Appendix	J1-6		"It is noteworthy in some years farmers are able to prep and plant fields in a shorter timeframe." What are the implications from this statement? Would we expect that the results then overestimate the impacts of the alternatives? Knowing this would be helpful to the reader in understanding the implications of the assumptions. It would also alleviate the need to explain why it was not evaluated in a sensitivity analysis.		206
Bypass Production Model Technical Appendix	J1-8		"In most years the Yolo Bypass includes a significant amount of fallow land. As discussed previously, including the fallow land footprint as potential irrigable acreage could incorrectly understate the economic impacts of the Project by allowing irrigated acreage to switch these areas. This BPM does not allow for this crop switching to occur by excluding these fallow fields from the potential irrigated footprint." Later, when reporting results, we read that the number of fallowed acreages changes when alternatives are simulated. This apparent inconsistency needs clarification.		207

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Bypass Production Model Technical Appendix	J1-9		It is important to note that prices and yields vary over time and by crop. The economic impacts are defined as the incremental change from the baseline (ExCon/NAA) and these underlying prices yields are, by definition, the same across all alternatives." Is there a typographical error in the underlined passage?		208
Bypass Production Model Technical Appendix	J1-19	Table 4	Table reports results in 2009 dollars. Elsewhere we see 2016 and 2012 dollars. For clarity, one base year should be considered.		209
Bypass Production Model Technical Appendix	J1-14		"Each UCCE budget uses interest rates for capital recovery and interest on operating capital specific to the year of the study. These range from 4 percent to over 8 percent, and as such, require adjustment to a common base year interest rate. A common rate of 6 percent is used for all data." How was a 6 percent interest rate determined? It is not clear that changing this parameter would change the results or conclusions but clarity of parameter determination is warranted. Sensitivity analysis may clarify too.		210
Bypass Production Model Technical Appendix	J1-25		"1. The P&Gs requires that the federal discount rate be used for all interest and capital recovery calculations. The current federal discount rate is 3.125 percent. A post-processing adjustment is applied to cost data components to adjust the interest rate to 3.125 percent." Is this consistent with the 6 percent interest rate used in the pre-processing adjustments mentioned earlier on this page and on page J1-14? Does it matter if these rates are real or nominal?		211
Bypass Production Model Technical Appendix	J1-25		"2. Machinery capital recovery costs are removed from the NED analysis under all alternatives. Additional land out of production would be quite small ..." Would it be more clear if the reader were told the underlined passage follows from the analysis?		212
Bypass Production Model Technical Appendix	J1-25		Post adjustment 4 needs to specify an interest rate. The source for post adjustment 5 should be noted. For post adjustment 6, would higher rates be worth considering? What is the basis for considering the lower bound? What are the implications?		213

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Bypass Production Model Technical Appendix	J1-26		"An average of 106 acres is fallowed annually as a result of the Project, at an average annual fallow land maintenance cost of $5,708. In addition to fallowing, the Project may cause yield losses in some years as farmers are forced to delay planting until fields are dry. Crop revenue losses resulting from yield losses and fallowing average $173,903 per year under Alternative 4." A discussion and quantification of the yield-related monetary losses would be beneficial for the report for each of the alternatives. It is not clear what the base year is for the dollar amounts.		214
Bypass Production Model Technical Appendix	J1-27	Table 7	The base NED farm income should be defined.		215
Bypass Production Model Technical Appendix	J1-29	Table 8	Presenting fractions of jobs lost ignores the variability in economic conditions. With sensitivity analysis the EIS/EIR and a range of job losses would provide more acurate information. Should this also be defined as Socioeconomic Impacts given the chapter is quantifying socioeconomic impacts?		216
Bypass Production Model Technical Appendix			Statements that are noteworthy should be followed up with an explanation for why and what the takeaway message is.		217
Bypass Production Model Technical Appendix	J1-29		"Table 6 summarizes the total economic impact of Alternative 1." It appears as though the underlined table number should be an 8.		218
Bypass Production Model Technical Appendix	J1-31		"This includes 2005 and 2006. The most significant fallowing occurs in 2010, when Alternative 1 causes an increase in wetted area during the edge of the standard planting window. It is noteworthy that significant Yolo Bypass fallowing occurs in wet years such as 2005 and 2006." The underlined alternative should probably be numbered as alternative 4. Also, clarity on noteworthiness is warranted.		219
Bypass Production Model Technical Appendix	J1-31		"A change in Yolo Bypass farming activity may have multiplier effects on ancillary industries as growers purchase fewer inputs and there are fewer farm jobs available." An inference about why this is relevant is warranted.		220

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Bypass Production Model Technical Appendix			For completeness, provide information on the IMPLAN database employed and the methodology or its caveats in avoiding overstatement of impacts.		221
Appendix J2					
Yolo Bypass Rice and Tomato Tipping Points			For processing, an impact analysis on reduction of processed goods as a result of a reduction in available crop production from the Bypass is not conducted. Perhaps providing a bracket for the potential impacts is adequate for the tipping point analysis. If the impact is minor and within the range of normal year to year fluctuations, that should be better justified in the conclusions or the limitations of the analysis.	Letter Comment J2-1	222
Yolo Bypass Rice and Tomato Tipping Points			The tipping point analyses appears dated using data from 2005 to 2009. It is likely that economic conditions over the past 5 to tens years looks differently than it did over a decade ago. Re-evaluating these analyses with current data may be warranted.	Letter Comment J2-2	223
Yolo Bypass Rice and Tomato Tipping Points			BPM analysis uses 2016 dollars. Tipping point uses 2012 dollars. For clarity, one base year throughout EIR/S seems warranted. It is not always clear what data comes from which sources and how the data are combined. Clarity on this would help understanding of results and conclusions.		224
Yolo Bypass Rice and Tomato Tipping Points			Some of the tables have narrow columns so numbers are wrapped within their cells.		225
Yolo Bypass Rice and Tomato Tipping Points	ES-2	Figure ES-1	Figure mistakenly listed as Table ES-1		226
Yolo Bypass Rice and Tomato Tipping Points	ES-4		"2. The scenario evaluates a "representative" mill or processor. The representative mill or processor is modeled after the existing businesses that process Yolo Bypass production, as described below, but business names are omitted to preserve confidentiality." Later in the text the names of the mills and processors are identified. Presumably the costs and returns data used are not easily connected to a specific mill or processor.		227
Yolo Bypass Rice and Tomato Tipping Points	ES-5		"It is also noteworthy that during the current drought California rice acreage fell by more than 25 percent, from 563,000 acres in 2012 to 416,000 acres in 2015 (USDA ERS 2015)." Whenever something is noteworthy it helps to know why and what the implications are. Please explain why and the implications.		228

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Yolo Bypass Rice and Tomato Tipping Points	ES-5		Crop Insurance section insurance policies are described as commonly used. You assess the implications of insurance coverage and premium increases and it would be useful to know how common.		229
Yolo Bypass Rice and Tomato Tipping Points	ES-6		"Insurance companies may increase insurance premiums to compensate for higher expected indemnity payouts even if USDA RMA does not increase the risk classification for rice or processing tomatoes." An explanation of what determines when this happens and how it would affect the tipping points is needed.		230
Yolo Bypass Rice and Tomato Tipping Points	ES-6		"It is important to note that agriculture is one of the most heavily regulated and highly variable industries in California. Any increase in costs due to policy action or regulation places significant financial strain on growers" Evidence is needed to support these assertions. Furthermore, as discussed above, explanation is needed on why this is important.		231
Yolo Bypass Rice and Tomato Tipping Points	ES-6		"Net returns to land and management per acre decrease by 1.4 to 3.0 percent for rice growers and 0.3 to 0.6 percent for tomato growers…" Discussion is needed on how these numbers are for different years in the data set and are not the result of a sensitivity analysis.		232
Yolo Bypass Rice and Tomato Tipping Points	ES-8		"The same increase in production risk used in the crop insurance analysis is applied to the bank loan analysis. Namely, there is an increase in Yolo Bypass flooding in all years. The analysis quantifies the effect of increased production risk on access to credit and interest rates using data from the USDA, a local representative at a large lending institution in Yolo County, data from USDA NASS, and a farm loan manager from the Farm Services Agency (FSA). These data and interviews with local lenders were combined to quantify the potential change in loan access and interest rates in response to an increase in bypass farming risk." An explanation of what data come from which sources and how they are combined is needed.		233
Yolo Bypass Rice and Tomato Tipping Points	ES-9		"In all cases, farm profitability is reduced but growers are maintain a positive margin over variable production costs in the scenarios considered in this analysis. Table ES-2 summarizes the results of the analysis." The underlined "are" should probably be removed.		234

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Yolo Bypass Rice and Tomato Tipping Points	ES-9		"Average annual net return above operating cost falls as interest rates on seasonal loans increase." It is not clear whether these operating costs are annual fixed costs or variable costs, which would already be net returns.		235
Yolo Bypass Rice and Tomato Tipping Points	1-1		"… Yolo Bypass agriculture also varies with market conditions, but generally averages $25 million per year, representing approximately 4 percent of the total value in Yolo County." Clarity on base dollar year needed.		236
Yolo Bypass Rice and Tomato Tipping Points	1-2		"This section includes a description of current and historical trends in acreage and the value of production for major crops produced in the county. Yolo County and the Yolo Bypass are summarized separately so that the reader can understand the proportional contribution of bypass agriculture to the agricultural economy of the county. The following two sections describe the tomato processing and rice milling tipping points, respectively. The following two sections describe the loan rate and crop insurance tipping point analyses. Each of these sections provides a narrative and describes the problem, data, methods, results, and sensitivity analysis." The data are as of 2012 or 2009. A more recent data set is needed to reflect current conditions. It would be more clear if "after that the next two sections describe…" replaces "The following two sections describe," or something like that.		237
Yolo Bypass Rice and Tomato Tipping Points	2-1		"..in total harvest acreage over the last 30 years can be described as stable." A look at the data in Table 1 suggests it has increased significantly (~16%) over the past 10 years. This inconsistency should be clarified.		238
Yolo Bypass Rice and Tomato Tipping Points	2-1		"… primarily driven by changes in market conditions for crops produced in the county. The recent increase in acreage since 2010/2011 has been driven by strong demand for fresh fruit, vegetables, and nuts." Documentation on these conditions and how they affect change are warranted.		239
Yolo Bypass Rice and Tomato Tipping Points	3-4		"As such, approximately 24 percent of total Yolo County processing tomatoes are sent to the representative facility to meet the production capacity of the processor (300,000 – 400,000 tons)." It is not clear where this 24 percent come from. Additional guidance is needed.		240

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Yolo Bypass Rice and Tomato Tipping Points	3-5		"Again using 2009 as an example, the processor processes 386,000 tons with bypass production, but only 230,000 tons (155,000 tons less) without bypass production." A footnote regarding any rounding issues would clarify these numbers.		241
Yolo Bypass Rice and Tomato Tipping Points	3-6		"The processor determines the optimal solids mix and ensures this is met through grower contracts. This analysis assumes that 50 percent of the representative plant's processing activity generates high solids content products and 50 percent of production is low solids content products." It is not clear why this assumption is being made. It would seem more direct to consider at least the worst case scenario to see if it affects tipping points.		242
Yolo Bypass Rice and Tomato Tipping Points	4-3		"This forces independent mills to be more focused on profit maximization." Evidence of independent mills being more focused is needed.		243
Yolo Bypass Rice and Tomato Tipping Points	4-4		"…local rice mill capacities may exceed this estimate." An explanation of the implications seems necessary here.		244
Yolo Bypass Rice and Tomato Tipping Points	4-5		"This analysis assumes growers receive prices as reported by the USDA NASS, which combines pooled prices (cooperative) and cash prices to create a weighted average for the county (CalAgTrader 2014; USDA NASS various years)." Clarity on how these prices were combined is needed.		245
Yolo Bypass Rice and Tomato Tipping Points	4-6		"This cost is estimated to equal $3.04 per cwt." A source for this estimate is needed.		246
Yolo Bypass Rice and Tomato Tipping Points	4-6	Table 18	Table title says variable costs while the column header uses operating costs. The text above the table refers to operating costs and variable costs. Consistency on terms needs to be reconciled here.		247
Yolo Bypass Rice and Tomato Tipping Points	4-7	Table 21	"Row 1 and 2 in Table 13 summarize the contribution margin and break-even (tipping point) quantity, respectively." Should this refer to Table 21?		248
Yolo Bypass Rice and Tomato Tipping Points	5-1		"Insurance contracts in California decreased by 7 percent, but the total crop insurance coverage increased by 25 percent. That is, the level of coverage per contract has increased. In 2012, there were 1,818 rice crop insurance contracts in California with a net indemnity payout of $1.2 million and 1,061 tomato crop insurance contracts with a total payout of $2.5 million (RHIS 2013)." Numbers for Yolo Bypass contracts would be helpful to understand the scale of any changes.		249

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Yolo Bypass Rice and Tomato Tipping Points	5-3		"Table 23 summarizes 2014 California rice and tomato premium subsidy rates in California." The underlined passage is not needed.		250
Yolo Bypass Rice and Tomato Tipping Points	5-3		"Reinsurance also helps insurance companies may not have enough capital to cover potential indemnity payments (USDA RMA 2014; Sanchez 2014; Otto 2014)." Could the underlined passage use a "who" between "companies" and "may?"		251
Yolo Bypass Rice and Tomato Tipping Points	5-5		"The most popular insurance policies used in the Yolo Bypass are yield and revenue protection (USDA RMA 2014; Sanchez 2014; Otto 2014)." Data on how popular would be helpful here.		252
Yolo Bypass Rice and Tomato Tipping Points	5-10		"Yolo Bypass farmer costs of production are likely to differ from the UCCE budgets..." It would be useful to know how different so we can appreciate the use of UCCE budget data here.		253
Yolo Bypass Rice and Tomato Tipping Points	5-11		"By increasing production risk in the Yolo Bypass in all years, premium rates could increase by \$6.48 to \$12.96 per acre for rice growers and by \$1.36 to \$2.73 per acre for tomato growers." The use of the word could seems to be unnecessary. If these are results from the model, then there should be no need to hedge. If these are the different values for the different years in the analysis then that is what should be stated too.		254
Yolo Bypass Rice and Tomato Tipping Points	5-12		"In summary, the tipping point analysis of the cost and availability of crop insurance policies for Yolo Bypass processing tomato and rice growers was completed before the final EIR/S Project alternatives were specified. As such, the insurance tipping point analysis considered a hypothetical "high risk" scenario where there would be an increasing in wetted acreage in the Yolo Bypass in all (or most) years. The Project alternatives have been defined subsequent to the initial analysis and it is clear that the Project causes a marginal incremental increase in wetted acreage in some—but not all—years. As of the publication date of the draft EIR/S there is uncertainty over the incremental effect of the Project on rice and processing tomato crop insurance cost, and availability." It is not clear why this analysis was not updated. An explanation seems necessary.		255

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Chapter or Appendix	Page Number	Figure or Table Number	Comment	Comment Letter Reference	
Yolo Bypass Rice and Tomato Tipping Points	6-1		"Growers use agricultural loans to purchase land, make improvements, and cover production expenses. Short-term loans are used primarily for operating finance and are the most frequently occurring agricultural loans." Data on how frequent would be useful to understand scope.		256
Yolo Bypass Rice and Tomato Tipping Points	6-2		"For this analysis, production interest rates are estimated to equal 5.75 percent, based on the recommendation of an agricultural lending agency (Monaco 2014)." This differs from the estimate on Page 6-1 of 5.5 attributed to Elliessy (2014). This inconsistency needs to be addressed.		257
Yolo Bypass Rice and Tomato Tipping Points	6-5		"The analysis uses 2009 USDA NASS prices and yields for Yolo County production to reflect local production conditions." It is not clear why this year is selected. An explanation is needed.		258
Yolo Bypass Rice and Tomato Tipping Points	6-5		"The nominal interest rate provided by a representative farm lending agency for a production loan is 5.75 percent (Elliessy 2014), which is confirmed with the UCCE budgets (UCCE various years)." The Elliessy citation is in conflict with past Elliessy citation. This 5.75 is associated with Monaco (2014) earlier in this report. This inconsistency needs to be addressed.		259

YOLO BASIN FOUNDATION

February 14, 2018

Mr. Ben Nelson
Bureau of Reclamation
801 I Street, Suite 140, Sacramento, CA 95814

Ms. Karen Enstrom
California Department of Water Resources
3500 Industrial Blvd., West Sacramento, CA 95691

RE: Response to the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project Draft EIS/EIR

Dear Mr. Nelson and Ms. Enstrom:

Thank you for the opportunity to comment on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project ("Yolo Bypass Salmonid Project") Draft Environmental Impact Statement/Environmental Impact Report ("EIS/EIR"). We recognize the tremendous effort of the California Department of Water Resources and the U.S. Bureau of Reclamation to develop the alternatives, model fisheries and hydraulic impacts, and produce the document and appendices. Our comments focus on the need to balance the long history of state, federal, and local partnerships in the Yolo Bypass to conserve habitat for terrestrial species with the interest in providing habitat for threatened and endangered fish species. Additional comments are also included in a table enclosed with this letter (Attachment 1).

The Yolo Basin Foundation asks the state and federal government to take no action that will undermine the decades of successful conservation work already providing benefits to countless species in the Yolo Bypass that enjoy the support of thousands of local citizens, as well as foundations, conservation organizations, and federal, state, and local agencies. The Yolo Basin Foundation believes we can help the state and federal government identify a sustainable and successful mix of project actions and mitigation measures that will provide both benefits to fish and continue the conservation work already underway for terrestrial species. We can only develop this solution if the Yolo Basin Foundation, farmers, wetlands managers, other stakeholders with a land management interest in the Yolo Bypass, the Yolo Habitat Conservancy, and Yolo County are an integral part of the process to develop a preferred alternative. Now that the EIS/EIR is publicly available and we have information about potential impacts, the Yolo Basin Foundation hopes to start an important conversation about project details.

Our comments focus on four areas:

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- **Background on existing Yolo Bypass habitat conservation.** The Yolo Basin Foundation believes it is critical for representatives of the state and federal government responsible for the EIS/EIR to have a thorough understanding of conservation efforts successfully undertaken over decades in the Yolo Bypass. These efforts required tens of millions of dollars in state, federal, and local investments, as well as thousands of hours of volunteer and government agency staff time. In addition to the Yolo Bypass Wildlife Area; hereafter Wildlife Area (see Exhibit A), the Yolo Bypass currently contains approximately 14,000 acres of state and federal wetland conservation easements (see Exhibit B), including easements consistent with the Central Valley Joint Venture Implementation Plan (see Exhibit C). The Bypass also contains giant garter snake and Swainson's hawk easements purchased by the Yolo Habitat Conservancy, the California Department of Water Resources, and the Wildlife Conservation Board.

- **Background on stakeholder outreach efforts**. The Yolo Basin Foundation is uniquely qualified to comment on this EIS/EIR and work with the state and federal government to craft solutions to issues identified in this letter because of our history of stakeholder outreach in the Yolo Bypass. The Yolo Basin Foundation coordinates with stakeholders through the Yolo Bypass Working Group (see Exhibit L) and has long led efforts to provide input into the development of the Yolo Bypass Salmonid Project. This participation resulted in partnerships with Yolo County, farmers, wetlands managers, and the University of California, Davis to fill information gaps and propose new approaches for achieving the necessary balance between existing and new conservation goals.

- **Comments on the EIS/EIR analysis.** The analyses of the impacts to recreation, education, and environmental justice in the EIS/EIR are unclear, vague, and not properly supported. The analysis also does not include impact conclusions for biological impacts to wetlands, including impacts on migratory and resident birds. In addition, some of the impact determinations are not supported by substantial evidence. In this letter and Attachment 1, the Yolo Basin Foundation provides comments to help improve the clarity and accuracy of the document. The Yolo Basin Foundation looks forward to working with the California Department of Water Resources and the U.S. Bureau of Reclamation to improve the analysis and develop a preferred alternative.

- **Proposed Mitigation Measures.** The Yolo Basin Foundation recognizes there will be some impacts on wetlands and existing educational programs as a result of the Yolo Bypass Salmonid Project and further recognizes the need to provide habitat for threatened and endangered fish species in the Yolo Bypass. As a result of our long history of involvement in Yolo Bypass conservation efforts, our leadership in stakeholder coordination, and our dedicated participation in public forums related to development of the Yolo Bypass Salmonid Project alternatives (see Exhibit H), the Yolo Basin Foundation asks for a leadership role in helping the California Department of Water Resources and the U.S. Bureau of Reclamation develop a preferred alternative. This letter also outlines potential and specific opportunities to mitigate for impacts from the proposed project on terrestrial species habitat in the Wildlife Area.

Background on Existing Yolo Bypass Conservation

Yolo Bypass is home to the Yolo Bypass Wildlife Area and is habitat for countless terrestrial species, including rare, threatened, and endangered terrestrial species prioritized for conservation by the Yolo Habitat Conservancy, the California Department of Fish and Wildlife, and the U.S. Fish and Wildlife Service through the Yolo Habitat Conservation Plan and Natural Community Conservation Plan. The Yolo Bypass is a key component of habitat restoration planned as part of prior largescale state conservation efforts (e.g. CALFED Ecosystem Restoration Program) and is a vital element of the Central Valley Habitat Joint Venture's habitat restoration goals associated with implementation of the North American Waterfowl Management Plan (see Exhibit D) and the United States' international commitment to the 1918 Migratory Bird Treaty Act (see Exhibit E).

The state and federal government has invested millions of dollars in grant funding to support the construction and management of wetlands in the Yolo Bypass (see Exhibit F). These funds are from the federal North American Wetlands Conservation Act (see Exhibit G), an act passed in part to support activities under the North American Waterfowl Management Plan and to create the infrastructure to manage wetland ecosystems in the Yolo Bypass; and, in the U.S. Fish and Wildlife (wetlands conservation easements on Swanston Ranch north of I-80 and south of the Wildlife Area) and the Natural Resources Conservation Services' wetland conservation easements (Exhibit G). This funding supported the conservation of wetlands and associated upland habitats for waterfowl and other migratory birds in North America. The agencies must recognize these easements require landowners to manage for wetlands habitat in perpetuity.

The 16,800-acre Wildlife Area is a critical part of the history of partnerships to create terrestrial species habitat in the Yolo Bypass. Local citizens and elected officials started plans to develop the Wildlife Area in the 1980s, eventually succeeding in securing a $4.75 million Wildlife Conservation Board grant to purchase the initial 3,700 acres. Interior Secretary Bruce Babbitt spoke at the groundbreaking ceremony of the new wetlands project in 1995 and President Bill Clinton dedicated the Wildlife Area in 1997. In 2001, the Nature Conservancy helped facilitate another $16 million grant to add 12,000 acres to the Wildlife Area. The state then secured an additional $8 million in federal NAWCA funds to implement restoration projects on these new acres.

In addition to providing a significant link in the chain of wetlands that comprise the Pacific Flyway for migrating birds, the Wildlife Area is home to pockets of riparian forests, uplands, vernal pools, and wildlife-friendly agriculture (Exhibit F). Agricultural and grazing lease revenue provides $600,000 annually in funding for Wildlife Area management and public access, as well as implementation of a successful adaptive management program. The Yolo Basin Foundation complements the Wildlife Area's amenities by offering its signature "Discover the Flyway" education program to over 70,000 K-12 school children since 1997. As a result of decades of demonstrated success, the Wildlife Area is considered a national model of sustainability, illustrating that flood protection, agriculture, wildlife habitat and public use can cooperatively exist in close proximity to a large metropolitan area.

BACKGROUND ON STAKEHOLDER OUTREACH EFFORTS

Yolo Basin Foundation looks forward to building on our long history of coordinating with local stakeholders to work with the state and federal government to provide input into development of the Yolo Bypass Salmonid Project preferred alternative. Throughout the history of proposals to modify the Fremont Weir to increase the frequency and duration of flooding for fish habitat, the Yolo Basin Foundation has consistently provided comments, participated in public forums, identified opportunities for analytical improvements based on on-the-ground information, and worked to find positive solutions. The Yolo Basin Foundation has also maintained strong relationships with the farmers, ranchers, and wetlands managers who intimately know the Yolo Bypass, as well as local government staff, elected officials, state and local Farm Bureau representatives, and other stakeholders in Yolo County and Solano County.

The Yolo Basin Foundation's participation in stakeholder forums related to the proposed Fremont Weir modification, originally proposed by the CALFED Bay-Delta Authority, dates back to the first meeting of the Yolo Bypass Working Group in 1999 (Exhibit L). The Yolo Basin Foundation and other stakeholders involved with the development of the Wildlife Area realized the proposal to modify the Fremont Weir would have an adverse impact on the goals described in the Wildlife Area Land Management Plan (hereafter LMP), a long-term management plan developed in coordination with local stakeholders[1]. As a result of stakeholder advocacy, the California Department of Fish and Wildlife committed to work with CALFED to minimize the impacts on the Wildlife Area of the proposed project:

> "This LMP represents the commitment of DFG to manage the resources of the Yolo Bypass Wildlife Area…[it] proposes practical, science-based management and conservation of the natural resources, consistent with the necessary flood water conveyance purpose of the Bypass, including provisions for compatible agriculture and public recreation use. It is based on an ecosystem approach to habitat management consistent with the principles of the Ecosystem Restoration Program (ERP) included in the CALFED Bay-Delta Program (CALFED) as implemented by the California Bay-Delta Authority (CBDA) and DFG." (2008, p 1-6)

Since the inaugural meeting in 1999, the Working Group raised concerns about impacts to managed wetlands and agriculture at many of the next 46 meetings (Exhibit L). The Yolo Basin has also commented numerous times on this and similar projects since 2008 (Exhibit H).

After the CALFED Bay-Delta Authority proposal stalled, the California Department of Water Resources included the project in the proposed Bay-Delta Conservation Plan in the mid-2000s as Conservation Measure 2. The Yolo Basin Foundation participated for over four years in meetings of the Yolo Bypass Fisheries Enhancement Planning Team to further discuss the proposal. Early on in these discussions, it became clear the California Department of Water Resources did not have the data necessary to complete an analysis for development of project alternatives. As a

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[1] 2008. Yolo Bypass Wildlife Area Land Management Plan. California Department of Fish and Game & Yolo Basin Foundation.

result of these discussions, the Yolo Basin Foundation proactively developed a partnership with Yolo County to help fill many identified information gaps, such as working with University of California, Davis economists to adopt the existing Bypass Production Model to analyze the agricultural impacts of project alternatives[2] and a review by Ducks Unlimited of potential impacts on waterfowl foraging habitat and hunting opportunities[3].

After the state and federal government transitioned the Bay-Delta Conservation Plan into California Water Fix and California EcoRestore, the Yolo Bypass Fisheries Enhancement Planning Team ceased to meet and was replaced by a series of stakeholder meetings associated with implementation of the Yolo Bypass Salmonid Project. These meetings included the U.S. Bureau of Reclamation's Value Planning Exercise, the locally-led Post Value Planning Team, the Locally Preferred Alternative stakeholder group, and the Yolo Bypass Biological Opinion Working Group. Also, during this time, the Yolo Basin Foundation worked with Yolo County to develop the Yolo Bypass Drainage and Water Infrastructure Improvement Study[4], which identified 12 priority projects to improve drainage and water infrastructure to benefit agricultural production and wetlands management in the Bypass. More information is available in Exhibit I regarding the timing and extent of Yolo Basin Foundation involvement in different iterations of this Yolo Bypass Salmonid Project.

EIS/EIR Analysis Questions and Comments

The Yolo Basin Foundation highlights the most significant comments on the EIS/EIR in this letter but has also compiled a detailed document with specific comments on the EIS/EIR and references to additional exhibits in Attachment 1. The Yolo Basin Foundation believes the analysis of impacts to managed wetlands, recreation, education, and environmental justice is inadequate and incomplete. In addition, the EIS/EIR lacks impact conclusions related to the impacts on migratory and resident birds (including food supply and nesting habitat), education, wildlife viewing, hunting, increased operations and maintenance activities due to additional flooding, and increased sedimentation. In addition, the impact conclusions are not supported by substantial evidence. We look forward to helping the state and federal government improve the analysis.

The Yolo Basin Foundation agrees with the following findings in the EIS/EIR:

- Impact HAZ-8: Risk of exposure to mosquito-borne viruses could increase as a result of inundation period expansion in the Yolo Bypass for fish passage and rearing
- Impact EJ-4: Project actions would reduce educational opportunities offered in the Yolo Bypass Wildlife Area for low-income students
- Impacts associated with methylmercury in the Yolo Bypass are expected to be a cumulatively significant impact, and the increased inundation from the Project would be cumulatively considerable

[2] Howitt, R. et al. 2013. Agricultural and Economic Impacts of Yolo Bypass Fish Habitat Proposals. Yolo County.
[3] Petrik, K. et al. 2012. Waterfowl Impacts of the Proposed Conservation Measure 2 for the Yolo Bypass: An Effects Analysis Tool. Bay Delta Conservation Plan – Yolo Bypass Fisheries Enhancement Planning Team.
[4] Bowles, C. et al. 2014. Yolo Bypass Drainage and Water Infrastructure Improvement Study. Yolo County.

The Yolo Basin Foundation also urges the California Department of Water Resources and the Bureau of Reclamation to further analyze the Sutter Bypass as a location for floodplain habitat. The California Department of Water Resources and the Bureau of Reclamation rejected this alternative in 2014 in part because the Reasonable and Prudent Alternative in the Biological Opinion required the development of Yolo Bypass fish passage improvements, regardless of the location of floodplain habitat[5]. The agencies at the time proposed to combine Yolo Bypass fish passage and floodplain habitat improvements into a single project. A couple of years later, the Bureau of Reclamation and the Department of Water Resources decided to separate these two projects. Now that they are separate, the agencies should again evaluate the Sutter Bypass as an appropriate location for floodplain habitat to benefit threatened and endangered fish species.

The Yolo Basin Foundation has identified a number of serious deficiencies in the analysis, described below.

General

1. **Failure to analyze entire project.** The EIS/EIR fails to adequately analyze the impacts from operations of the proposed project downstream of Ag Crossing #1. There is a significant amount of analysis regarding construction impacts, but insufficient analysis of long-term project operational impacts associated with additional flooding. These impacts include the increase in operation and maintenance costs and related activities a result of additional flooding, increased sedimentation impacts to both farmers and wetlands managers, impacts to movement of wildlife, impacts to nesting and foraging bird habitat, impacts to wetlands management, and impact of revenue needed to sustain habitat management and other operations of the Wildlife Area from potential loss of lease revenue.

Chapter 9: Vegetation, Wetland, and Wildlife Resources

1. **Impact TERR-5: Potential disturbance or mortality of nesting bird species and loss of suitable nesting and foraging habitat (p. 9-69).** The determination that the impact on nesting and foraging habitat from operations is less than significant is not supported by substantial evidence. The only language in the EIS/EIR is as follows:

   > "Under Alternative 1, the Lead Agencies do not expect operations to result in adverse effects on suitable nesting habitat for special-status bird species because operations would extend the duration of inundation only between November and March, which is outside of the nesting season. Operational effects on foraging habitat may vary by species based on the effects of inundation on their prey. The small expected change in average number of wet days under Alternative 1 may reduce foraging habitat for some species, particularly in the eastern part of the Yolo Bypass; however, the effects on foraging habitat are not expected to be substantial."

[5] Yates, G. et al. 2002. Habitat Improvement for Native Fish in the Yolo Bypass. CALFED Bay-Delta Program.

The Yolo Basin Foundation has repeatedly described the potential impacts to nesting and foraging habitat in the Wildlife Area from increased frequency and duration of flooding since 2008[6], such as reduced food supply. The LMP, for example, acknowledges flooding constrains management of the Wildlife Area's biological resources:

> "These constraints include: adverse effects of spring flooding on management and operations, wildlife nesting, and farming" (p. 5-6).

Nesting in the Yolo Bypass could start as early as February. In addition, inundation later than the date the California Department of Fish and Wildlife would normally drain the wetlands increases production of invasive weeds and decreases production of favored waterfowl foods. There is no analysis referenced in the EIS/EIR to support the statements above. Additional analysis is required to evaluate the impacts on nesting and foraging habitat.

2. **Impact TERR-9: Potential effects on USACE, RWQCB, and CDFW jurisdictional wetlands, waters, and riparian areas (p. 9-76).** The EIS/EIR analyzes construction impacts on wetland and riparian areas, but fails to analyze the impact of operations. The EIS/EIR states only:

> **"**Under Alternative 1, operations would not result in adverse effects on areas subject to USACE and CDFW jurisdiction as no fill materials would be placed in waters during operations." (p. 9-81)

The EIS/EIR fails to analyze the impact of additional flooding from the proposed project on USACE, RWQCB, and CDFW jurisdictional wetlands.

Chapter 13: Recreation

1. **Calculation of 2% reduction in days available for educational programs and activities is not properly supported.** The analysis states the project will result in a 2% reduction in educational days and therefore there will not be an elimination or substantial reduction in the educational uses of the Wildlife Area (e.g. Table 13-4, Page 13-27). This analysis is not properly supported. There is no reference to an appendix showing the source of the calculations. According to email communication with agency staff, the Wildlife Area closure was estimated based on the number of additional days the water level at Lisbon Weir is higher than 12 feet, which is an indicator of when the Wildlife Area typically has to close due to flooding. However, the Yolo Basin Foundation believes the Wildlife Area may have to close when the water level at Lisbon Weir is as low as eight feet. Through email communication, agency staff also provided a table not included in the EIS/EIR that shows the number of additional closure days resulting from the TUFLOW model for each of the 16 years modeled, based on 12 feet water elevation at the Lisbon Weir. The TUFLOW output ranged from 0-21 days of additional closure as a

[6] 2008. Yolo Bypass Wildlife Area Land Management Plan. California Department of Fish and Game & Yolo Basin Foundation.

result of the project, with an average of 5.3 days. The Yolo Basin Foundation requests the following improvements to this analysis:

- ***Include the table showing the number of estimated closure days in the EIS/EIR.*** This information is helpful to the reader to understand the basis for the calculation.

- ***Provide a range of potential closure dates based on a sensitivity analysis of TUFLOW model outputs.*** The TUFLOW model is based on a number of assumptions that Yolo County documented in their review of the model[7], therefore the analysis should provide a range of estimated closure days for each year, not a point estimate for each year. The final estimate should provide a range of closure days, as well as the average number of closure days.

- ***Account for drainage time.*** The analysis does not take into account that the Wildlife Area will stay closed until the water has drained from the Wildlife Area. The addition of drainage time will increase the number of days the Wildlife Area is closed as a result of the project and should be included in the analysis of impacts.

- ***Account for time to dry.*** Once enough of the area has drained for roads to be accessible, the roads still need to dry out. The Yolo Basin Foundation believes that it takes at least a week to dry under the best of circumstances, such as warm weather and no rain. Next, CDFW personnel must perform required maintenance before public access is allowed. The time needed depends on the severity of the damage, usually related to the length of time flooded and the velocity of the flood water. If there is less than two weeks between spill events, then the area does not open at all until this whole process starts over.

The Yolo Basin Foundation believes the addition of these factors to the analysis will double, if not triple, the number of estimated education days lost as a result of the project.

2. **Estimate of 4.1% reduction in hunting days is not properly supported.** Similar to the estimate of lost education days, the estimate of lost hunting days is not properly supported. The analysis should include a table showing the lost days by year, sensitivity analysis, and include the additional days the Wildlife Area will remain closed to drain and dry out.

3. **Impact conclusions for education, wildlife viewing, and hunting days are lacking.** The EIS/EIR should contain impact conclusions for the loss of education, wildlife viewing, and hunting days in the Wildlife Area, along with appropriate mitigation measures.

4. **Failure to analyze increase in operation and maintenance costs.** The project alternatives will all result in a significant increase in operations and maintenance activities on the Wildlife

[7] Fleenor, W. 2015. Review of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Hydrodynamic Modeling Draft Report. Center for Watershed Sciences, University of California, Davis.

Area. The increase in frequency and duration of flooding will result in more staffing and equipment expense to remove flood deposited debris and repair damage to roads, supply and drainage ditches, signs, fences, and gates. An increase in flood frequency and duration will also mean additional expense to mow and disk invasive plants, including emergent vegetation to meet requirements of the Memorandum of Understanding between the California Department of Fish and Wildlife, the California Department of Water Resources, and the Central Valley Flood Protection Board (see Exhibit J).

5. **Failure to analyze impacts on wildlife viewing.** Although the Wildlife Area is open and used all year round, November to February is the peak wildlife viewing season. Additional closures as a result of the project will impact wildlife viewing, which should be analyzed in this EIS/EIR.

6. **Comparison of new shallow floodplain habitat to existing wetlands habitat is not supported by substantial evidence.** The EIS/EIR analysis assumption that the large areas of temporary shallow water created when the Yolo Bypass drains after a flood event is the equivalent of existing managed floodplain habitat for waterfowl is incorrect (Impact TERR-9). While some birds may utilize the receding flood waters, the habitat created is not comparable to habitat values provided by managed wetlands in the Wildlife Area and on private lands. The seasonal wetlands in the Wildlife Area and on private wetlands (duck clubs) are intensively managed to provide food and cover for terrestrial species. The management regime for these wetlands is based on Best Management Practices developed over many years (see Exhibit K). Management activities include controlled fall flood up to maximize primary and secondary food production in time for the arrival of migratory birds traveling the Pacific Flyway. Drawdown in the spring is timed to maximize seed germination that will provide protein resources for migratory and residents birds. Early spring drawdown is important for controlling invasive species, such as cocklebur and sweet clover, that have no food value. Early spring drawdown is also important in preventing growth of emergent vegetation including tules and cattails that can impede the flow of floodwaters (Exhibit J). The timing of flood up and drawdown is also important in preventing mosquito larvae production.

7. **Inaccurate assertion of benefits from food production (p. 8-112, p. 9-3).** The EIS/EIR states the proposed alternatives all increase floodplain food production to benefit juvenile salmonids, and that this food could also be exported to the Delta. This conclusion is questionable. The predicted floodplain inundation would occur in December at the earliest under all proposed alternatives. By December 1, the majority of the floodplain is already inundated in the form of tens of thousands of acres of flooded rice fields and managed wetlands. (Managed wetlands are flooded up as early as September 1). As a result of this targeted Wildlife Area management, wetland food production is well underway at least one month before additional flooding would occur due to the six proposed alternatives. The Bureau of Reclamation and the Department of Water Resources should remove or caveat this conclusion of benefits in their analysis.

<u>Chapter 22: Environmental Justice</u>

1. **Analysis of reduction in educational opportunities for low-income students in the Yolo Bypass Wildlife Area is vague and general.** The analysis uses the percent of Title 1 schools in the Davis Joint Unified School District and the Sacramento City Unified School District as a proxy for percent of low-income students who attend Wildlife Area field trips. The Yolo Basin Foundation can provide more accurate data (see Exhibit N). For the 2016-17 school year, for example, there were 181 Discover the Flyway field trips. Approximately 3,656 students and over 200 adults attended the field trips. This equals nearly 4,000 participants in Discover the Flyway field trips in 2016-17. On average, approximately 44% of the Discover the Flyway participants are low-income students from Title 1 schools, approximately 1,600 students in 2016-17. The Yolo Basin Foundation appreciates the conclusion that "disproportionately high or adverse effects to the educational opportunities offered in the YBWA on low-income students could occur due to increases in inundation in the YBWA" and offers potential mitigation measures in the next section.

Proposed Mitigation Measures

Improving rearing habitat for juvenile salmonids and passage for adult winter, spring and fall run Chinook salmon, steelhead and green sturgeon is an urgent need. The Yolo Basin Foundation has long recognized this need, as demonstrated by Foundation staff participation in discussions regarding increased juvenile floodplain habitat in the Yolo Bypass since the 1990s and staff participation in development of the Putah Creek Accord. All six project alternatives define the end date of project operations as either March 7th or March 15th as a result of robust stakeholder discussions and stakeholder sponsored studies. This illustrates the importance of stakeholder input and the potential for developing alternatives with local support.

Yolo Basin Foundation believes there is a sustainable and successful mix of project actions and mitigation measures that will provide both benefits to fish and continue the conservation work already underway for terrestrial species in the Wildlife Area. To begin the discussion, we recommend the mitigation measures briefly described in the following section to mitigate for the impacts on operations and maintenance in the Wildlife Area, education, and recreation, including wildlife viewing and hunting. Many of the proposed actions are described in the Yolo Bypass Wildlife Area LMP (see Exhibit M) Chapter 5, Section 5.2.4 beginning on Page 5-32.

The analysis fails to include feasible mitigation measures for the following identified impacts:

- **Impact TERR-5: Potential disturbance or mortality of nesting bird species and loss of suitable nesting and foraging habitat**
- **Impact TERR-9: Potential effects on USACE, RWQCB, and CDFW jurisdictional wetlands, waters, and riparian areas**
- **Impact EJ-4: Project actions could reduce educational opportunities offered in the YBWA on low-income students**
- **Reduction in education days (Yolo Basin Foundation requests an impact conclusion)**
- **Reduction in hunting days (Yolo Basin Foundation requests an impact conclusion)**

- **Reduction in wildlife viewing days (Yolo Basin Foundation requests an impact conclusion)**
- **Impacts associated with methylmercury in the Yolo Bypass are expected to be a cumulatively significant impact, and the increased inundation from the Project would be cumulatively considerable**

The Yolo Basin Foundation suggests the following mitigation measures to include for the impacts listed above. In addition, the Yolo Basin Foundation supports the efforts of Yolo County to ensure farming will continue in the Yolo Bypass, including economic mitigation for loss of yield from late flooding and other impacts. Wildlife friendly agriculture is a critical element of the habitat provided in the Yolo Bypass Wildlife Area.

1. **Develop additional wetlands to offset those that will be inundated more often due to proposed project.** The Yolo Basin Foundation can work with the California Department of Fish and Wildlife to identify potential projects, such as wetland habitat restoration outside the Bypass in partnership with DWR, CDFW, City of Davis, Yolo Habitat Conservancy, Yolo Land Trust, and others. This mitigation measure will help address impacts identified in Impact TERR-5 and TERR-9 because it will provide additional wetlands and more nesting and foraging habitat, as well as Impact EJ-4 because it will provide areas to visit with low-income children outside of the Yolo Bypass.

2. **Increase in maintenance and operations funding to CDFW for the Yolo Bypass Wildlife Area.** Due to the increase in frequency and duration of flooding, the following will occur in the Wildlife Area: increased sediment deposition, road damage, loss of road gravel, flood debris removal, replacement/repair of signs, invasive weed removal, increase in mosquito control costs, and damage to gates and fences. Project proponents should provide CDFW with additional staffing, funding, and equipment for operations and maintenance. This mitigation measure will help address the impacts in TERR-9.

3. **Maintain and improve public use.** Improve the current wildlife viewing loop, including development of interpretive and directional signage and facilities, viewing blinds, board walks, and platforms (Refer to Yolo Bypass Wildlife Area LMP Page 5-32). This mitigation measure will address the loss of education and wildlife viewing days.

4. **Develop new public access for wildlife viewing**. The Yolo Basin Foundation can work with project proponents to identify new public access opportunities for wildlife viewing, such as: 1) access to Tule Ranch with westside public access south of Putah Creek; 2) a new public viewing loop using Tule Ranch wetlands (refer to Exhibit M: Yolo Bypass Wildlife Area LMP Page 5-35); improve trail designations and maintenance (Exhibit M: Yolo Bypass Wildlife Area LMP Page 5-36); and 3) improve physical separation of wildlife viewing and hunting by creating new, westside hunter check station on Tule Ranch. This mitigation measure will address the loss of wildlife viewing days.

5. **Improve current hunting program**. Project proponents could improve the current hunting program by: 1) providing westside access for hunting on higher areas that may not flood as frequently due to Fremont Weir modification for more frequent and longer duration of flooding; 2) moving hunter access to the Tule Ranch by creating new, westside hunter check station on Tule Ranch (refer to Yolo Bypass Wildlife Area LMP Page 5-35); and 3) provide additional hunting area outside the Yolo Bypass. This mitigation measure will help address the loss of hunting days.

6. **Implement remaining recommendations in the Yolo Bypass Drainage and Water Infrastructure Improvement study.** These projects include the Parker United water supply project, water supply for wetlands south of the umbrella barn, and improvements to the South Davis Drain. In addition to reducing the time the Wildlife Area stays closed because of improved drainage times, some of these projects will also increase wetlands acreage. This mitigation measure addresses the impacts of a reduction in education days, wildlife viewing days, and hunting days, as well as Impact EJ-4.

7. **Develop an Adaptive Management Plan for the proposed project.** The Adaptive Management Plan should include wetlands and public use elements in the Wildlife Area, not just operation of gates and canals associated with the Fremont Weir modification.

8. **Implement and fund methylmercury Best Management Practices**. Project proponents should develop a cost share agreement with CDFW and private landowners on implementation of Methylmercury BMPs to meet Bay-Delta Methylmercury TMDL future requirements. This is proposed as a mitigation measure for cumulatively significant impacts associated with methylmercury.

Thank you for the opportunity to comment. The Yolo Basin Foundation looks forward to working with you to identify a preferred alternative and identify opportunities to improve wildlife habitat, educational and recreational opportunities in the Yolo Bypass Wildlife Area.

Sincerely,

Pete Bontadelli
Chair, Yolo Basin Foundation Board of Directors

cc: Congressman John Garamendi, U.S. Representative
Senator Bill Dodd, California State Senate
Assemblymember Cecilia Aguiar Curry, California State Assembly
Kris Tjernell, Special Assistant for Water Policy, California Natural Resources Agency
Yolo County Board of Supervisors
Yolo Basin Foundation Board of Directors

Yolo Habitat Conservancy

County of Yolo • City of Davis • City of Winters • City of West Sacramento
City of Woodland • University of California, Davis

February 15, 2018

Mr. Ben Nelson
Bureau of Reclamation
801 I Street, Suite 140
Sacramento, CA 95814

Ms. Karen Enstrom
California Department of Water Resources
3500 Industrial Blvd.
West Sacramento, CA 95691

Subject: Draft Environmental Impact Statement/Environmental Impact Report for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (State Clearinghouse # 2013032004)

Dear Mr. Nelson and Ms. Enstrom,

Thank you for the opportunity to review and comment on the Yolo Bypass Salmonid Habitat Restoration and Fish Passage ("Yolo Bypass Salmonid Project") Draft Environmental Impact Statement/ Environmental Impact Report ("EIS/EIR"). As you know, the Yolo Habitat Conservancy is in the final stages of completing the Yolo Habitat Conservation Plan/Natural Community Conservation Plan (Yolo HCP/NCCP) and expects the California Department of Fish and Wildlife and the U.S. Fish and Wildlife Service to issue permits by June 2018. The Yolo HCP/NCCP is a comprehensive, countywide plan to provide for the conservation of 12 sensitive species ("covered species")[1] and the natural communities and agricultural land on which they depend. The Yolo HCP/NCCP's Plan Area encompasses the entire area of Yolo County and prioritizes conservation of habitat in the Yolo Bypass, especially for giant garter snake and western pond turtle.

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[1] Yolo HCP/NCCP covered species include: palmate-bracted bird's beak (*Chloropyron palmatum*), Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), California tiger salamander (*Ambystoma californiense*), western pond turtle (*Actinemys marmorata*), giant garter snake (*Thamnophis gigas*), Swainson's hawk (*Buteo swainsoni*), white-tailed kite (*Elanus leucurus*), western yellow-billed cuckoo (*Coccyzus americanus hypugaea*), western burrowing owl (*Athene americanus occidentalis*), least Bell's vireo (*Vireo bellii pusillus*), bank swallow (*Riparia riparia*), and tricolored blackbird (*Agelaius tricolor*).

611 North Street, Woodland, CA 95695 • Phone: 530-723-5504 • www.yolohabitatconservancy.org

The Conservancy understands the need to improve habitat in the Yolo Bypass for endangered and threatened fish species, but urges the Bureau of Reclamation and the Department of Water Resources to work with the Yolo Habitat Conservancy to develop a preferred alternative that minimizes the impact of the project on endangered and threatened terrestrial species, including the species covered by the Yolo HCP/NCCP. After over 15 years of work on the Yolo HCP/NCCP, the investment of $3.7 million in state and federal planning grants, and the investment of over $5 million in local funding, it is critical that the Yolo Bypass Salmonid Project complement, and not conflict with, the Yolo HCP/NCCP.

Based on our review of the Yolo Bypass Salmonid Project Draft EIS/EIR, we have identified several areas of this document warranting further clarification and analysis. Descriptions and recommendations for your consideration are provided below.

Page ES-17 (Issues of Known Controversy) and Section 23-9 (Controversies and Issues Raised by Agencies and Public – CEQA requires that the EIR address areas of controversy and issues to be resolved (CEQA Guidelines Section 15123(b)(2) and (3)). Page ES-17 and Section 23-9 make no mention of concerns raised by multiple stakeholders, including Yolo County and the Yolo Habitat Conservancy among others, that the project is designed and analyzed in a silo with only superficial consideration of consistency with the impending Yolo HCP/NCCP. These discussions also fail to identify that, as proposed, the project will potentially adversely affect the success of the Yolo HCP/NCCP and the ability of the YHC to successfully establish the Yolo HCP/NCCP conservation reserve system. The Yolo HCP/NCCP identifies approximately 22,316 acres of the Yolo Bypass as Priority 1 acquisition lands and approximately 6,237 acres of the Yolo Bypass as Priority 2 acquisition lands for the Yolo HCP/NCCP reserve system (See **Attachment A**). These lands have been identified as having a high acquisition priority for the conservation of the Yolo HCP/NCCP's covered species based on the potential habitat that they provide to multiple Yolo HCP/NCCP covered species including giant garter snake, western pond turtle, Swainson's hawk, white-tailed kite, yellow-billed cuckoo, and least Bell's vireo (See **Attachments B-G**). Please expand the sections of the EIS/EIR identified above to include an adequate discussion of these areas of controversy and issues to be resolved.

Preferred Project Analysis -- The EIS/EIR acknowledges that NEPA and CEQA have different requirements but does not accurately or completely articulate the relevant extent of these differences. As a result, the impact analysis is inadequate and it is not possible to discern the required CEQA impact conclusions. The requirements for analysis of the impacts of the preferred project under CEQA are substantively different from the same requirements under NEPA. For CEQA the proper baseline for determining whether the Proposed Project/Preferred Action/Alternative 1 will have adverse impacts is existing conditions or setting (CEQA Guidelines Section 15125), whereas under NEPA the baseline is the No Project/No Action Alternative. This distinction is not apparent in the EIS/EIR, yet is required by law. Please revise the EIS/EIR to clearly reflect this analysis and conclusions, and recirculate the document to allow stakeholders such as the YHC to properly consider the analysis and results.

Alternatives Analysis – The EIS/EIR also does not clearly recognize that the requirements for alternatives analysis under CEQA are substantively different from the requirements for alternatives analysis under NEPA. For CEQA the proper point of comparison for alternatives is the Proposed Project/Preferred Action/Alternative 1 (CEQA Guidelines Section 15126.6(d)). Under NEPA the proper point of comparison for alternatives is the No Project/No Action Alternative. This distinction is not apparent in the EIS/EIR, yet is required by law. Please revise the EIS/EIR to clearly reflect this analysis and conclusions, and recirculate the document to allow stakeholders such as the YHC to properly consider the analysis and results.

Standard for Adequacy – The basic CEQA standard for adequacy is an evaluation of the environmental effects of a proposed project in light of what is reasonably foreseeable (CEQA Guidelines Section 15151). Implementation of the Yolo HCP/NCCP is reasonably foreseeable. The final HCP/NCCP and related EIS/EIR were delivered to the FWS and CDFW on January 23, 2018 and are awaiting the authorization of those agencies for formal release and final action. Both the federal and state governments have extensive investments in this plan and common interests in ensuring its success. In light of this please revise the second to last threshold of significance in Chapter 9 (Vegetation, Wetlands, and Wildlife Resources) related to HCP consistency to include “impending” as well as adopted HCPs, such as the Yolo HCP/NCCP. Also, please revise this chapter generally, and in Impact TERR-11 in particular, to include a complete analysis of the potential for conflict with the Yolo HCP/NCCP, and recirculate the document to allow stakeholders such as the YHC to properly consider the analysis and results.

Chapter 9 (Vegetation, Wetlands, and Wildlife Resources) Analysis and Approach – Section 9.3.2 (Thresholds of Significance – CEQA) is missing the mandatory discussion of the following issues (CEQA Guidelines Section 15065(a)(1)): 1) whether the project has the potential to substantially degrade the quality of the environment; 2) whether the project has the potential to substantially reduce the habitat of a fish or wildlife species; 3) whether the project has the potential to cause a fish or wildlife population to drop below self-sustaining levels; and 4) whether the project threatens to eliminate a plant or animal community. Please revise Section 9.3.2 to include these mandatory thresholds, and please revise this Chapter to include an analysis of these impacts, including substantiated conclusions, and feasible mitigation.

Impact TERR-3 – The analysis provided in Section 9.3.3.2.3 and elsewhere in this chapter related to the impact of operations on giant garter snake resulting from changes in the duration of inundation acknowledges “inundation of occupied burrows below the elevation of floodwaters may result in the loss of giant garter snake individuals,” but considers these direct or indirect adverse effects on giant garter snake less than significant. The analysis relies on an increased number of days of inundation as the metric for making this determination; however, there is no discussion of any analysis that was conducted to determine the increase in inundation area resulting from the project that would not otherwise have occurred (such as during below-average water years). This additional inundation may cause a significant impact to giant garter snake and should be evaluated and discussed in the EIS/EIR. Analyzing only a potential incease to the number of days of inundation could artificially deflate the magnitude of the impact by failing to account for the fact that the occurrence of inundation, not just its length, will also be influenced by project implementation.

Impact TERR-5 – The analysis provided in Section 9.3.3.2.5 and elsewhere in this chapter discusses the impact of operations on foraging habitat for bird species. The EIS/EIR contemplates the potential effects on foraging habitat based on the inundation of their prey. This analysis neglects to evaluate the impact of changes to foraging habitat types and cultivation patterns that may result from inundation periods and how those changes may impact the availability and accessibility of prey. For example, Swainson's hawks utilize tomato fields harvested just prior to their migration period as an important source of prey (Estep 2015). Section 16.3.3.2.2 (Impact SOC-2) states that "rice and processing tomatoes are the dominant Yolo Bypass crops likely to be affected by Project alternatives"; however, there is no evaluation regarding the potential impact that changes to these crops will have on species that utilize them for foraging habitat. (See Yolo County's comment letter for more information about the potential for the project to impact cropping patterns in the Yolo Bypass. Yolo County's letter and attachments are incorporated by reference into this letter.) These potential impacts should be evaluated as part of the overall assessment associated with TERR-5.

Impact TERR-11 – The analysis provided in Section 9.3.3.2.11 and elsewhere in this chapter related to conflict with the Yolo HCP/NCCP is conclusory. No evidence or analysis is provided to support the discussion. Also, please correct the citation used. While ICF is a YHC consultant, they are not the lead agency or regulatory author of the plan. Please cite the YHC as the author of the Yolo HCP/NCCP and its related EIR.

Mitigation Measures MM-TERR-10 and MM-TERR-14 – Both of these measures should include mitigating for impacts within Yolo County to the extent that mitigation options are available, and that mitigation coverage is to be sought through the Yolo HCP/NCCP prior to seeking the purchase of mitigation credits elsewhere.

Chapter 9 Mitigation Measures -- All of the missing areas of impact identified above, plus the other areas of impact that are identified in this Chapter, could be feasibly lessened or avoided by including the following reasonable and feasible mitigation measures:

- Implement all aspects of the project in a manner consistent with and not in conflict with the Yolo HCP/NCCP.
- Coordinate with the YHC to provide mitigation through the Yolo HCP/NCCP.
- Ensure that no aspect of the proposed project is implemented in a manner that precludes the Yolo HCP/NCCP from successful implementation of the identified Yolo HCP/NCCP conservation measures, conservation strategy, or conservation reserve system.
- Modify the project as necessary to avoid adverse effects to properties identified as Yolo HCP/NCCP priority conservations lands.

Mitigation Measures Not Identified -- As explained in these comments, there are simple, reasonable, prudent mitigation measures the lead agencies can and should adopt that will address many of the concerns raised in this comment letter.

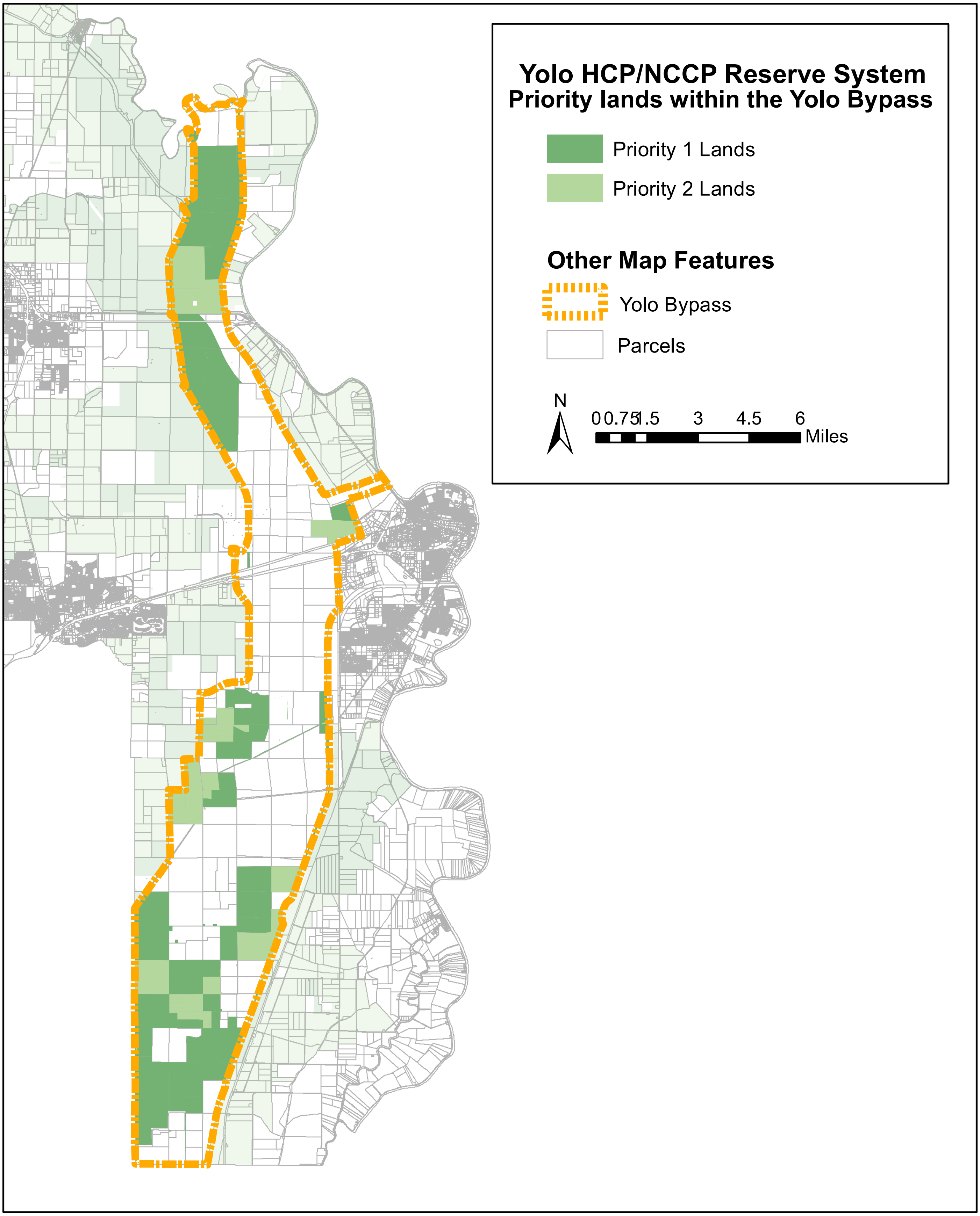
Thank you for the opportunity to comment. We look forward to working with you to develop a preferred alternative that further protects habitat for both terrestrial and fish species in the Yolo Bypass.

Sincerely,

Jim Provenza
Chair, Yolo Habitat Conservancy

cc: Yolo County Board of Supervisors
John Laird, Secretary, California Natural Resources Agency
Kris Tjernell, Special Assistant for Water Policy, California Natural Resources Agency
Karla Nemeth, Director, California Department of Water Resources
David Murillo, Regional Director, Mid-Pacific Region, U.S. Bureau of Reclamation
Rep. Doris Matsui
Rep. John Garamendi
Senator Dianne Feinstein
Senator Kamala Harris
Senator Bill Dodd
Assemblymember Cecilia Aguiar-Curry
Assemblymember Kevin McCarty
Senator Richard Pan

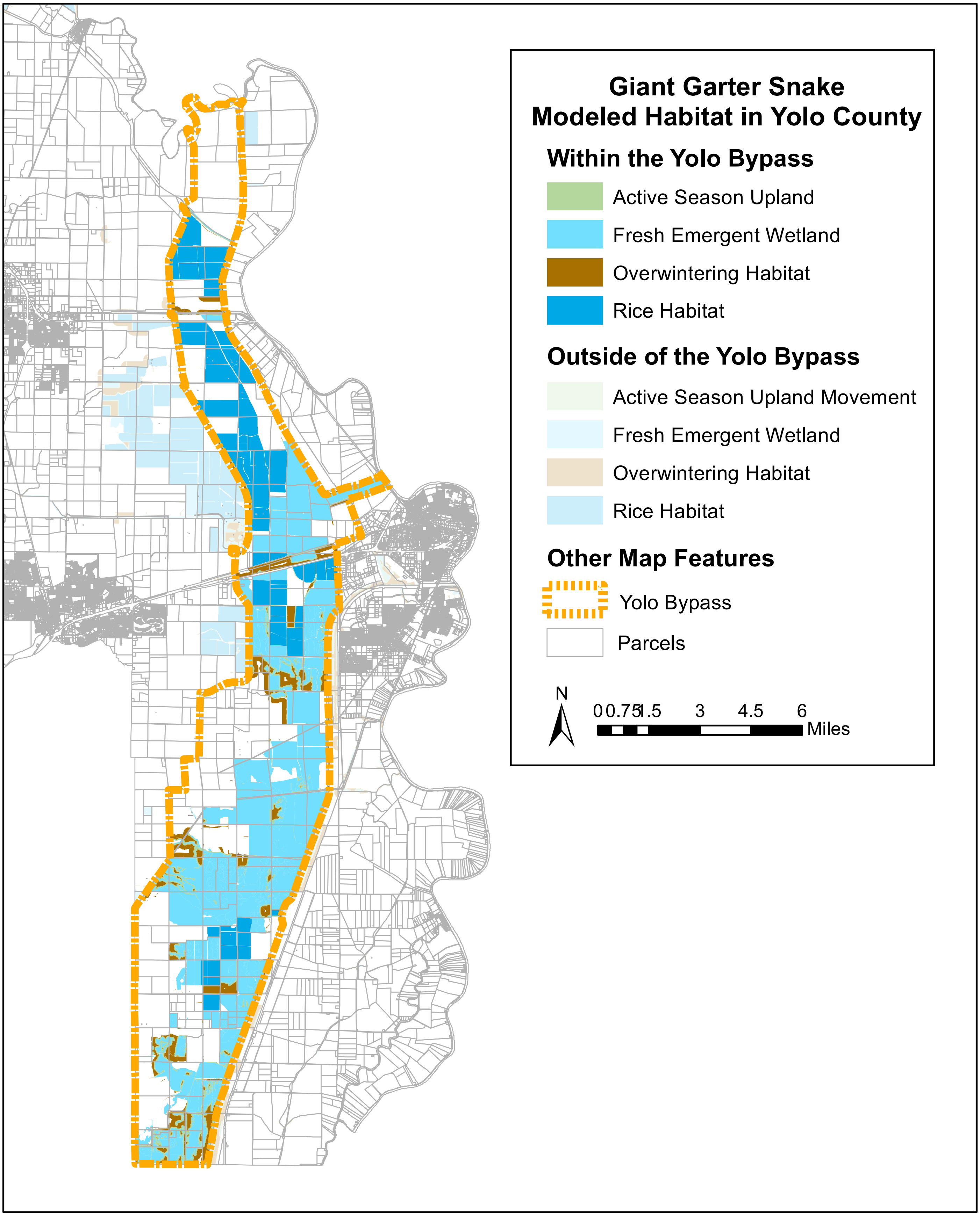
ATTACHMENT A

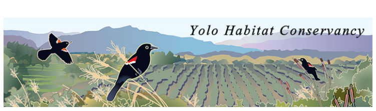


Yolo Habitat Conservancy 2/9/18

Yolo HCP/NCCP Reserve System Priority Lands in the Yolo Bypass

ATTACHMENT B

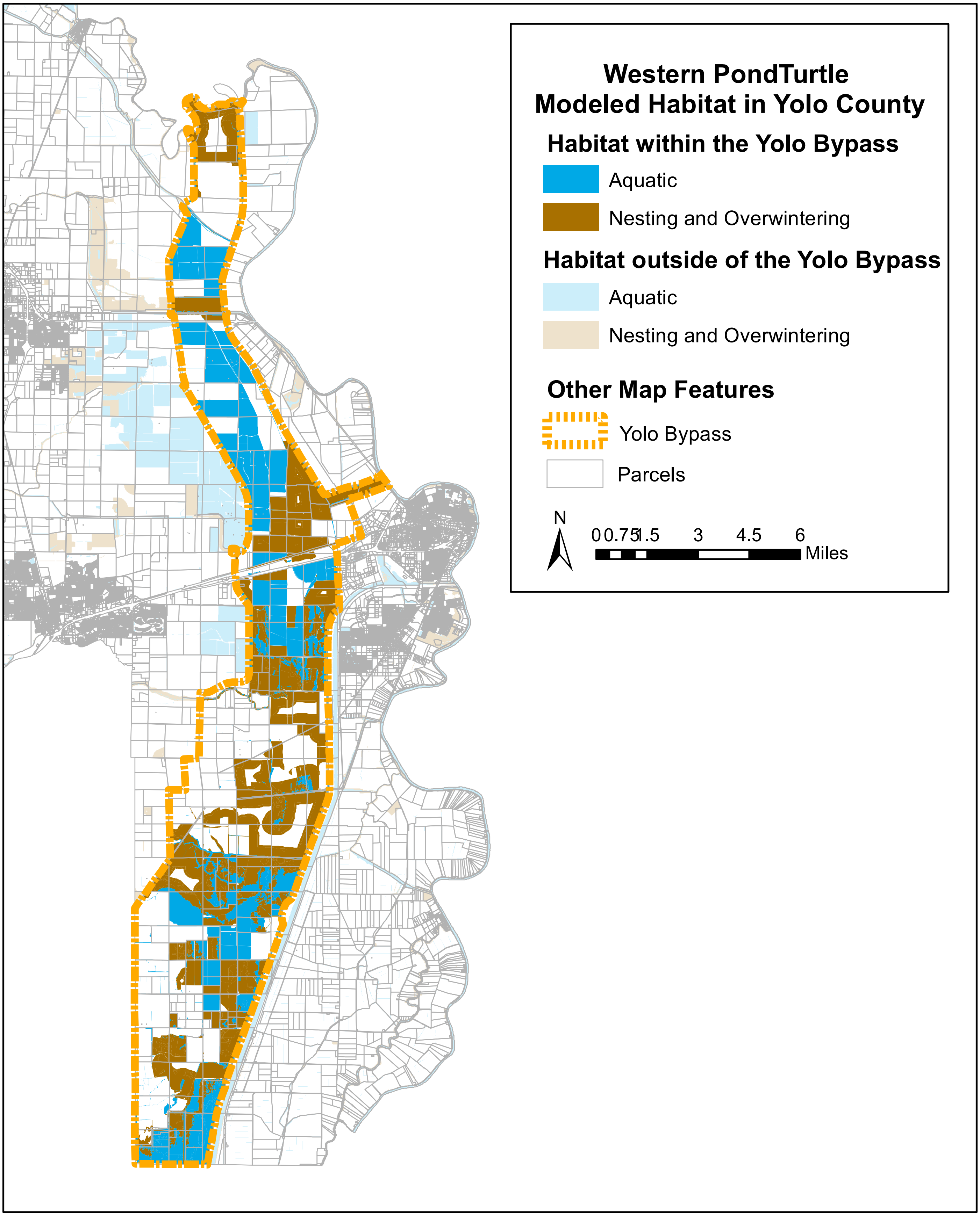




Yolo Habitat Conservancy 2/9/18

Giant Garter Snake Modeled Habitat in the Yolo Bypass

ATTACHMENT C

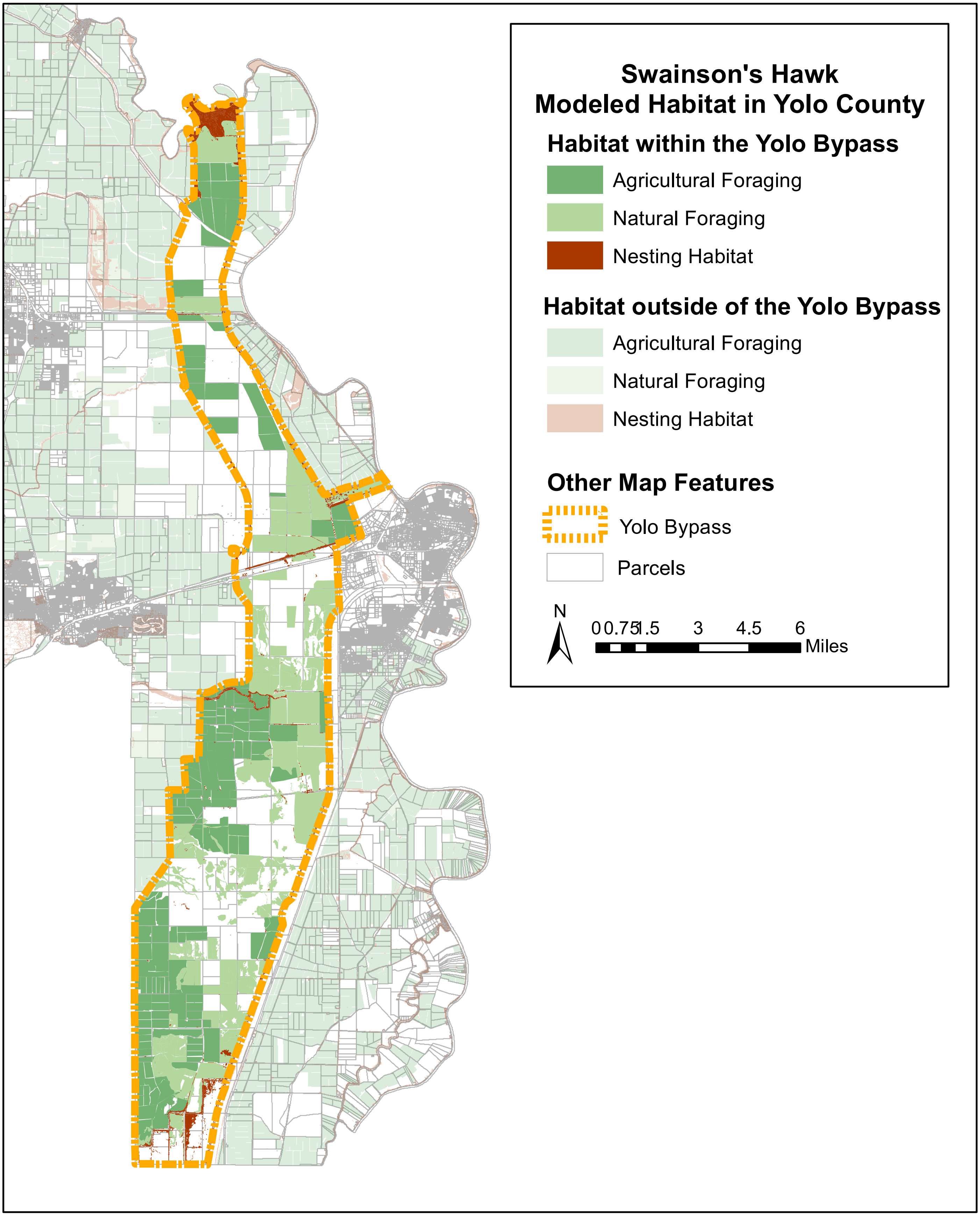


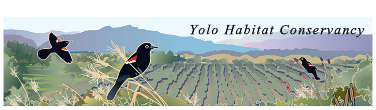
Yolo Habitat Conservancy

Western Pond Turtle Modeled Habitat in the Yolo Bypass

Yolo Habitat Conservancy 2/9/18

ATTACHMENT D

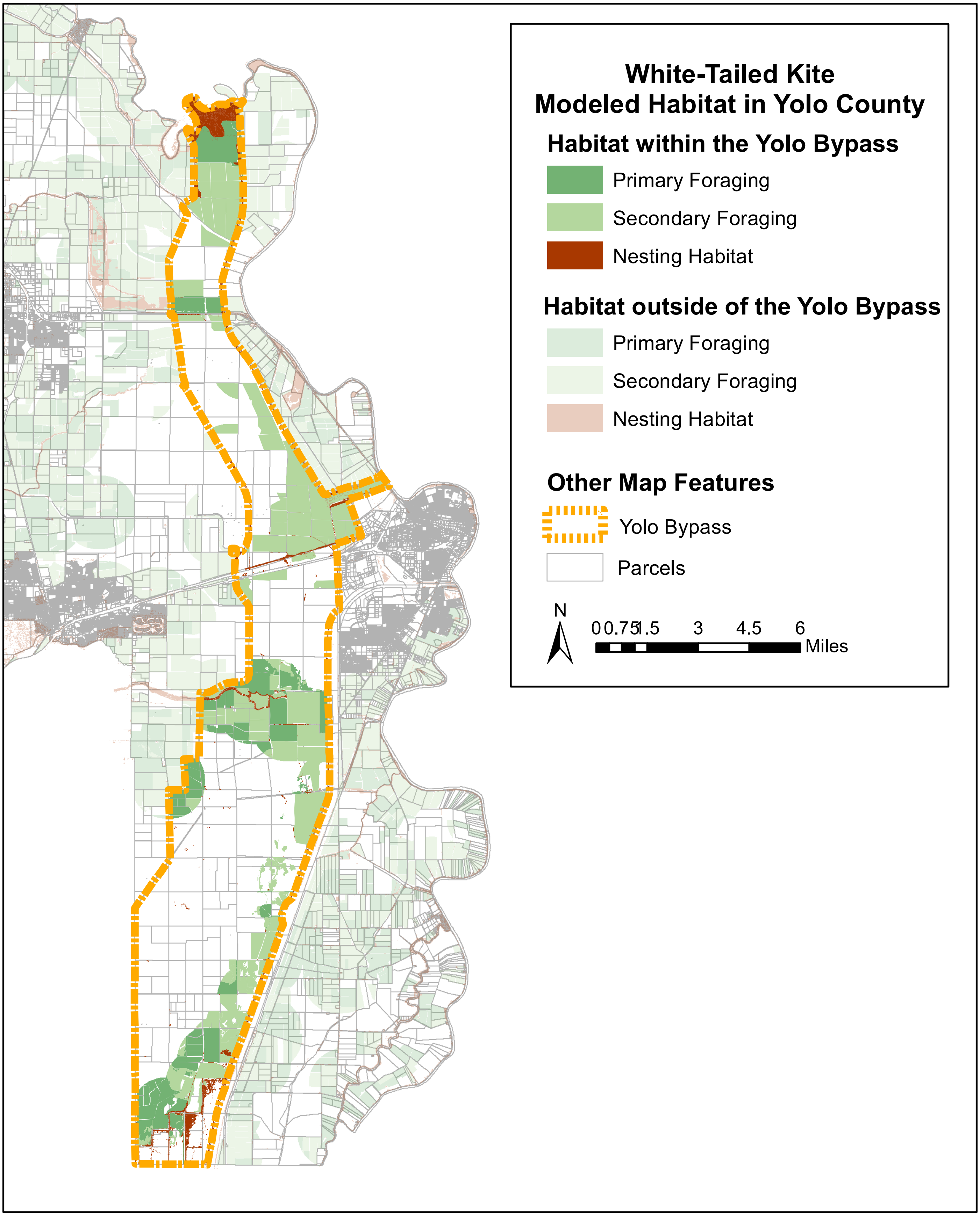




Yolo Habitat Conservancy 2/09/18

Swainson's Hawk Modeled Habitat in the Yolo Bypass

ATTACHMENT E



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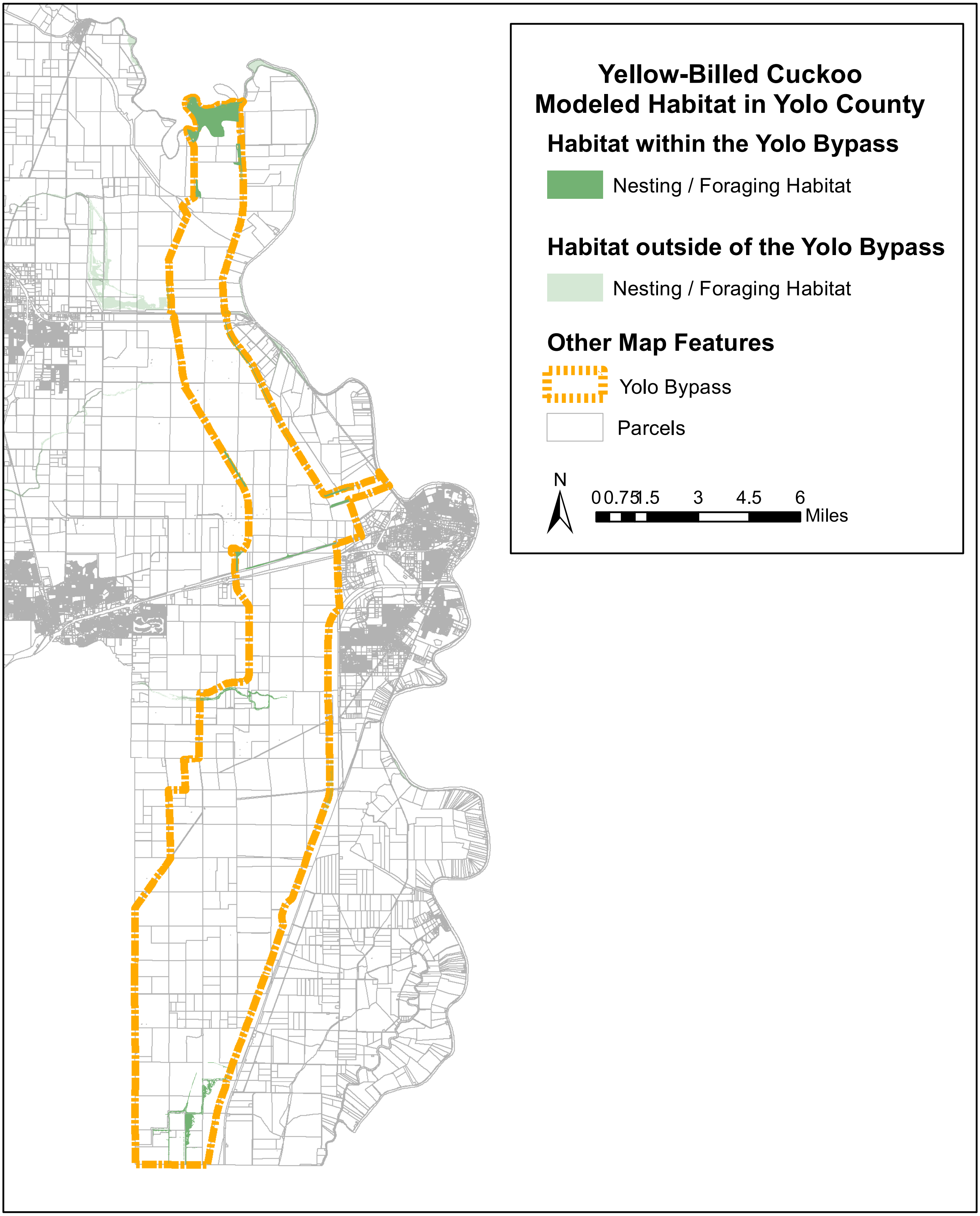
White-Tailed Kite Modeled Habitat in the Yolo Bypass

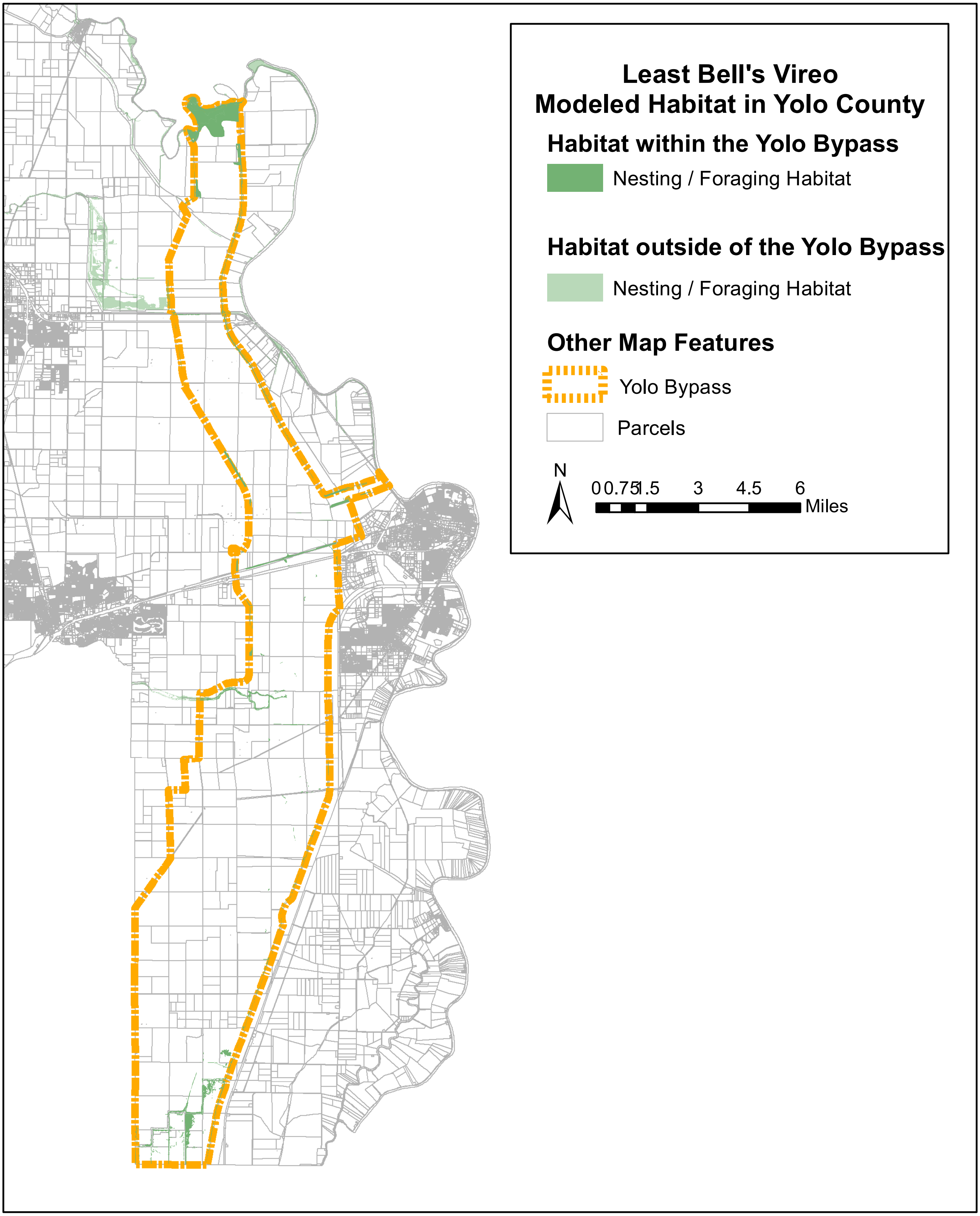
ATTACHMENT F

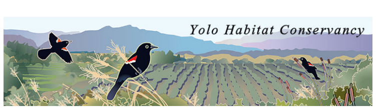


Yolo Habitat Conservancy 2/09/18

Yellow-Billed Cuckoo Modeled Habitat in the Yolo Bypass

ATTACHMENT G





Yolo Habitat Conservancy 2/09/18

Least Bell's Vireo Modeled Habitat in the Yolo Bypass

County of Yolo

BOARD OF SUPERVISORS

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April 5, 2010

Secretary Lester Snow
California Natural Resources Agency
1416 Ninth Street, Suite 1311
Sacramento, CA 95815

Re: Bay Delta Conservation Plan—Yolo Bypass/Fremont Weir Modification

Dear Secretary Snow:

This letter sets forth the position of the County of Yolo ("County") on the development of the "Fremont Weir/Yolo Bypass Habitat Improvements Conservation Measure" (the "Conservation Measure") and related projects.

As an initial matter, the County cannot commit to a position on the Conservation Measure until all of its details have been developed, made public, and thoroughly reviewed. Under no circumstances, however, will the County support the Conservation Measure unless the following conditions are assured:

- **Flood protection afforded by the Yolo Bypass is maintained.** The County cannot accept changes in the Yolo Bypass that increase the level of flood risk to local properties. The design and operation of the Conservation Measure must not have an adverse effect on the flood protection function of the Bypass.

- **Agriculture in the Yolo Bypass is preserved.** Agricultural activities in the Bypass are a significant contributor to the County's agricultural economy, the operation of the Yolo Bypass Wildlife Area, and the flood protection afforded by the Bypass. The Conservation Measure must include appropriate design and operational criteria to avoid jeopardizing agriculture—particularly the cultivation of rice—in the Yolo Bypass.

- **The Yolo Bypass Wildlife Area is protected.** The habitat, recreational, and educational opportunities afforded by the Wildlife Area make it an invaluable asset to Yolo County and the surrounding region. The Conservation Measure should not jeopardize the Wildlife Area and, if possible, it should be enhanced and preserved in perpetuity as part of the Bay Delta Conservation Plan ("BDCP").

- **Completion and implementation of the Yolo Natural Heritage Program are assured.** The County and the four cities (Woodland, Davis, West Sacramento, and Winters) have worked for years to complete a local HCP/NCCP through a joint powers authority. This effort is nearing completion and BDCP must not interfere with—and should assist where possible—in the completion and implementation of this effort.

- **Local economic impacts are addressed.** All appropriate steps must be taken to identify and fully mitigate local economic impacts of the Conservation Measure, including but not limited to its effects on County revenues and the agricultural industry. The County should be closely consulted as financial assistance programs or other mitigation measures are developed.

This is a partial list of the most pressing concerns of the County and many of its local stakeholders and constituents with regard to the Conservation Measure. We expect the Natural Resources Agency ("Agency") to carefully study all of the issues underlying these concerns as part of the BDCP planning process. Similarly, meaningful local participation in these issues is also vital to the success of the planning effort.

To facilitate local participation, the County asks the Agency to take action on several items. First, the County needs financial resources to enable it to perform an independent technical review of the local effects of the BDCP on flood protection, agriculture, and other issues identified above. We have previously requested $500,000 for this purpose, and we now urge the Agency to act promptly upon this request. Independent local review of these issues is necessary if the County and its constituents are expected to have a meaningful role in the BDCP planning process, particularly regarding this Conservation Measure.

Second, the Agency must engage in a robust local outreach effort to develop stakeholder input regarding the design and operation of the Conservation Measure. We recognize that the Agency proposes to convene a "local issues group" for the Yolo Bypass and certain related issues. The County encourages the Agency to convene such a group so long as it proceeds in the following manner, which we believe is the only reasonable way of assuring its success:

- **Identify key stakeholders.** Many stakeholders have a sincere interest in the flood protection, agriculture, habitat, and recreational attributes of the Yolo Bypass and the Yolo Bypass Wildlife Area. Appropriate representatives of these diverse stakeholders must be included in the local issues group.

- **Give them a meaningful role.** The issues group must be a forum for meaningful review and discussion of the Conservation Measure, suggested alternatives and mitigation measures, and other issues of concern. The Agency will need to devote the time and resources necessary to review and respond to concerns, suggestions, and other matters appropriately raised by the group.

- **Provide the group with the resources it needs to succeed.** Additional technical modeling and studies may be needed to address certain topics with the local issues group. Similarly, the Agency should make appropriate staff and outside consultants available for local issues group meetings.

- **Assure that the County plays a key role.** A proper role for the County must include an Agency commitment to promptly respond in writing to the County's written comments, to provide the County with reasonable access to Agency decision makers, and to otherwise assure a true cooperative relationship between the County and the Agency in the manner envisioned in the Natural Community Conservation Planning Act.

- **Integrate local stakeholder input into the final text of the Conservation Measure.** If stakeholder input demonstrates that changes to the Conservation

Measure are appropriate (before or after the September 2010 draft is released), the Agency should make such changes. For example, if the work of the issues group shows that additional options for the design and operation of the Conservation Measure are reasonable, they should be integrated into the final Conservation Measure. An Agency commitment of this nature is fundamental to the success of the issues group and is of great importance to the County.

The County expects to have a prominent role in the local issues group and to work closely with the Agency on each of these matters. (We appreciate your initial efforts to include the County in this manner.) This role is appropriate in light of the County's jurisdiction over local land use matters, its interest in ensuring a strong local agricultural industry, and its general responsibility to ensure the continued health, safety, and welfare of local residents.

We look forward to confirmation that the Agency concurs with each of these points and is committed to taking all actions necessary to respond. Assuming this is the case, the County looks forward to working collaboratively with the Agency to make the local issues group a success. Consistent with our prior correspondence, we look also forward to working out the details of County participation in the overall BDCP planning process in the near future, and we expect to provide you with an additional letter on that topic shortly.

As a final matter, the County has long sought payment of nearly $1,000,000 owed by the Department of Fish and Game for payments in lieu of taxes and local assessments on the Yolo Bypass Wildlife Area. We recently raised this issue with Agency staff and hereby reiterate our request for prompt Agency assistance with this matter. A productive long-term relationship between the County and state agencies on BDCP depends on the fulfillment of the state's financial obligations to the County, both now and in the future. Payment of this debt would be a significant demonstration of good faith.

Altogether, while the BDCP has an opportunity for meaningful success in Yolo County, many challenges lie ahead. The success of BDCP in Yolo County will require a strong commitment by the Agency, the County, and local stakeholders to confront and resolve obstacles to the effective integration of the Conservation Measure into the existing land use regime of the Yolo Bypass. At the end of the process, the County sincerely hopes that, on balance, the Conservation Measure and related actions provide an overall benefit to our constituents.

We hope to work closely with you to achieve this outcome, and we look forward to your response to this letter.

Sincerely,

Helen M. Thomson

Helen M. Thomson, Chairwoman
Yolo County Board of Supervisors

cc: Senator Lois Wolk
Assemblywoman Mariko Yamada
Assemblyman Jim Nielsen

CALIFORNIA natural resources AGENCY

EDMUND G. BROWN JR., Governor
JOHN LAIRD, Secretary for Natural Resources

February 25, 2014

Chair Don Saylor and Members of the Board
Yolo County Board of Supervisors
625 Court Street
Woodland, CA 95695

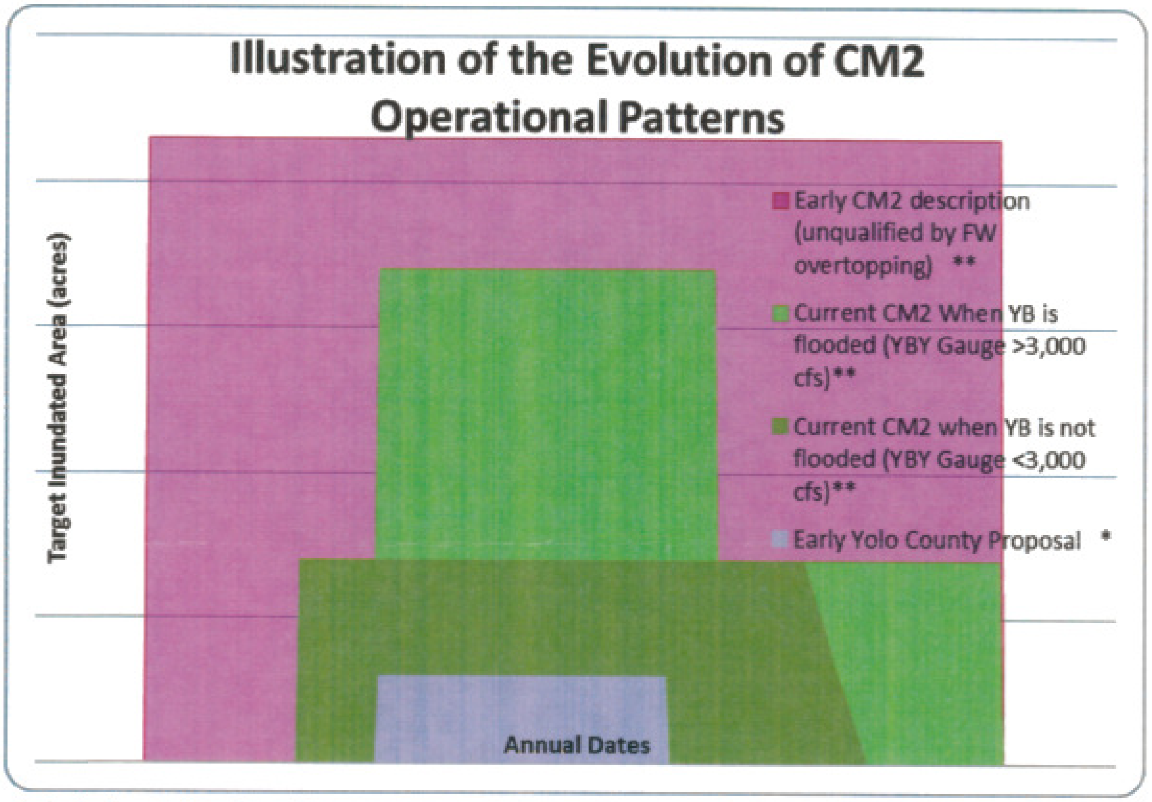
Dear Chair Saylor and Members of the Board:

I am writing to provide an update on the Bay Delta Conservation Plan (BDCP) Conservation Measure 2 (CM2) and to reassure you the state will continue to coordinate with Yolo County staff and elected officials to refine CM2 to address any further concerns prior to the final BDCP. This update will illustrate how extensively the conservation measure has been modified over the last two years in response to Yolo County requests and concerns. It is the Natural Resources Agency's goal to continue balancing the need of BDCP to enhance habitat for covered species with the existing uses of the Yolo Bypass such as agriculture, waterfowl and other terrestrial species habitat, bird watching, hunting, and other recreation.

The intent of CM2 is to provide high quality rearing habitat to achieve the greatest biological benefit (i.e., 30 days of inundation of 7,000 acres in 70 percent of years). In 2011, DWR established the Yolo Bypass Fishery Enhancement Planning Team (YBFEPT) to develop and refine CM2 in collaboration with the many stakeholders in and near the Yolo Bypass. This planning team has met 23 times since June 2011; Yolo County staff was present at many of these planning team meetings. Over the course of these meetings, revisions to CM2 in response to Yolo County concerns have been incorporated based on ongoing discussions and joint evaluations that have provided an improved appreciation of the design of a project that balances new and existing uses.

Figure 1 below highlights the changes that have occurred related to the CM2 operational patterns as a result of discussions with Yolo County. Figure 1 highlights the differences between the earlier CM2 inundation patterns proposed in the 2010 BDCP Administrative Draft compared to those proposed by Yolo County, in terms of extent and duration of Yolo Bypass inundation. The figure was developed to show the operational range that may be typical of, but not necessarily identical to, actual operational guidelines that will be developed in the course of subsequent project-specific design, planning and environmental documentation. As a result of discussions with Yolo County, the extent and duration of Yolo Bypass inundation described in the Public Draft BDCP is currently somewhere in the middle of these two starting points, though of course that description is subject to further refinement.

1416 Ninth Street, Suite 1311, Sacramento, CA 95814 Ph. 916.653.5656 Fax 916.653.8102 http://resources.ca.gov



* Only in years when Fremont Weir overtopping occurs
** When hydrology allows

It is important to recall that the ranges of amount and timing of flooding in the Yolo Bypass presented in the programmatic CM2 are flexible and do not dictate the outcome of the project-level planning process that will follow. The Department of Water Resources (DWR) will work with the YBFEPT and Yolo County to define operational parameters based on the needs of covered species, seasonal hydrologic conditions, agricultural operations, and other variables yet to be defined; moreover, it is not DWR's intention to make operational parameters for the extent, duration, timing and frequency of flooding events binding.

DWR recognizes that late season flooding in the bypass is of the greatest concern to Yolo County. While late-season flows may be necessary in some years to meet the BDCP biological goals and objectives, the frequency and acreage affected by late flows could be managed well enough such that current land uses in the Yolo Bypass would be largely maintained. Furthermore, BDCP acknowledges the uncertainty associated with the operation of the Yolo Bypass. A reasonable degree of flexibility is also provided, allowing for refinement of the metrics within objectives as the uncertainty is addressed over time. The biological objectives for the BDCP, for example, state "Create a viable alternate migratory path through Yolo Bypass in >70% of years for out-migrating fall-run/late fall-run Chinook salmon juveniles by year 15". Such language allows for flexibility in achieving the objective because the objective does not specify the number of acres or other criteria. Uncertainty will be addressed through the adaptive management and monitoring program of the BDCP, a process in which we expect Yolo County will have a significant level of involvement.

As described in the BDCP, the YBFEP and the YBFEP EIR/S will further refine CM2 during project-level planning. Through this process, the component projects of CM2 will be evaluated and refined with scientific and stakeholder input, including Yolo County. Part of this evaluation will include the development and evaluation of alternatives. These alternatives are expected to vary in ways that include the duration, extent and timing of Bypass inundation. DWR plans to fully engage with Yolo County and its representatives during the development and evaluation of these alternatives to ensure your concerns are heard and a sustainable balance of important land uses is achieved. Furthermore, the state is interested in developing a memorandum of understanding with Yolo County that could address issues related to CM2, such as: 1) funding for county participation in BDCP planning and implementation; 2) mitigation for the loss of farmland and economic impacts; 3) assurances and benefits for the Yolo Bypass Wildlife Area; and 4) other topics as needed.

As proponents of the BDCP, the state expects to develop a governance structure that includes Yolo County as a partner in the planning, environmental review, and operation of CM2. Since there is uncertainty associated with future operations of the gate in the Fremont Weir and other elements of CM2, BDCP will allow a reasonable degree of flexibility and refinement of the metrics within biological objectives as research and monitoring efforts provide new information for consideration by the state and Yolo County, as well as other relevant state and federal agencies. The state will work with Yolo County and other stakeholders to determine the manner, timing and extent of new seasonal floodplain habitat in the Yolo Bypass to achieve a sustainable balance of conservation projects and existing land uses.

Thank you for your participation in the BDCP process. I look forward to continuing to work together to improve the Delta ecosystem and provide a more reliable water supply for California.

Sincerely,

John Laird

John Laird
Secretary for Natural Resources

cc: David Murillo, Mike Connor, Mark Cowin, Chuck Bonham

I hope this letter is just one point in our continued discussions that in good faith work to resolve outstanding issues consistent with all of our goals.

Final Technical Memorandum

Potential Fish Benefits associated with Yolo Bypass Salmonid Habitat Restoration and Fish Passage Proposals

Winter Willows, Vic Fazio Yolo Wildlife Area. Photo courtesy of James Scott

Prepared for: Yolo County

Prepared by: Rebecca M. Quiñones, Ph.D
Robert A. Lusardi, Ph.D

April 2017

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BACKGROUND

This technical memorandum answers questions Yolo County posed in response to state and federal proposals to increase the frequency and duration of Yolo Bypass inundation as part of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage project ("Salmonid Project"). The Salmonid Project is under development to address the Reasonable and Prudent Alternatives (RPA) I.6.1 and I.7 in the National Marine Fisheries Service's (NMFS) Biological Opinion (BiOp) on the Coordinated Long Term Water Operations of the Central Valley Project (CVP) and State Water Project (SWP) for winter-run Chinook salmon, spring-run Chinook salmon, Central Valley steelhead and southern green sturgeon. The U.S. Bureau of Reclamation ("Bureau") and the California Department of Water Resources (DWR) are the lead agencies charged with implementation of the Salmonid Project, which contains two major elements: 1) a fish passage structure to replace the existing Fremont Weir fish ladder scheduled for construction in 2018; and 2) the construction of a structure in the Fremont Weir with operable gates to allow inundation of the Yolo Bypass for floodplain habitat, as well as additional fish passage structures, in 2021. The agencies have already released the Initial Study/Environmental Assessment for the 2018 fish passage structure and are scheduled to release the first draft of the Environmental Impact Statement/Environmental Impact Report (EIS/EIR) for the 2021 operable gates by the end of 2017. Special emphasis was placed on reviewing potential benefits to target fish species from actions proposed in the EIS/EIR for the new operable gates (see Table 1).

Table 1. List of species considered in the EIS/EIR. Federal and state listed threatened and endangered species are noted as "T" and "E".

Species	State Listing	Federal Listing
Central Valley winter-run Chinook	E	E
Central Valley spring-run Chinook	T	E
Central Valley steelhead	--	T
Southern green sturgeon	--	T

INTRODUCTION

Floodplains include those areas adjacent to an active river channel that seasonally flood during high water events. Floodplains support high biodiversity and yet are among the most altered and threatened habitats in the world (Opperman et al. 2010). In the Central Valley, the Yolo Bypass is the largest contiguous floodplain remaining in the Sacramento River basin at 57,000 acres (Howitt et al. 2013). Native fish that evolved to use floodplains, such as Chinook salmon and Sacramento splittail, benefit from relatively high productivity (e.g., chlorophyll a concentration) as compared to altered habitat provided in the channelized mainstem river (Sommer et al. 2004, Jeffres et a. 2008). Existing data also supports the idea that high productivity can result in increased prey availability to higher order consumers on or immediately downstream of floodplain habitat (Sommer et al. 2001a). Additionally, increased food availability and other factors associated with floodplain rearing habitat have been shown to improve juvenile salmonid growth when compared to mainstem river conditions (Sommer et al 2001c, Jeffres et al. 2008). Less understood, however, is how differences in salmonid growth associated with floodplain habitat affect survival (Sommer et al. 2001c, Sommer et al. 2005). Habitat structure associated with floodplains (i.e., density of aquatic vegetation, reduced water velocity, etc.) can also provide refuge to juvenile fishes from predators and high river velocities, which can flush fish downstream into the interior delta. Adults of some species (e.g., splittail) are known to benefit from floodplain inundation, as these species use such habitats for spawning. Uncertainty exists, however, regarding the magnitude of inundation required to achieve significant biological benefits for the fish species targeted by the Salmonid Project.

Growth benefits to fishes associated with floodplain habitat may not increase at a constant rate over time due to bioenergetic trade-offs and changing floodplain conditions. Such trade-offs can occur when growth rates are slowed or reversed due to exceedingly high temperatures or low dissolved oxygen concentration. Sommer et al. (2001c), however, suggested that juvenile salmon may be able to metabolically compensate for increases in water temperature with concomitant increases in prey availability associated with floodplain habitat and, thus, obtain superior growth rates when compared with mainstem conditions. With respect to water temperature, Katz (2012) suggested that juvenile Chinook temperature tolerances may be exceeded during the late spring (late April or May) and trigger floodplain exit. However, the authors found strong evidence that juvenile Chinook salmon permitted to access seasonally inundated floodplain habitat on the Yolo Bypass experienced more rapid growth, substantially improved body condition, and delayed out-migration timing[1]. The authors also suggested that juvenile Chinook salmon experience a superior out-migration route by avoiding the interior Delta. Katz et al. (2013) concluded that in general, even with the anomalous weather patterns during 2013 (the winter of 2013 was one of the driest and warmest on record at the time), water conditions within experimentally inundated rice fields provided excellent growing conditions for

[1] Source of water for the Knaggs Ranch project was the Colusa Basin Drain and is not Sacramento River water as would be the case with an overtopping event at the Fremont Weir.

juvenile Chinook salmon. So, while the quality of water (e.g., water temperature) inundating the floodplain may affect the duration of floodplain use by fishes, there is ample evidence that significant biological benefits are provided to juvenile Chinook salmon by inundated floodplain habitat (Sommer et al. 2001c, Jeffres et al. 2008, Katz 2012, Katz et al. 2013).

Topics & Questions

In 2014, Yolo County identified topics and generated pertinent questions regarding proposed projects to increase inundation in the Yolo Bypass to benefit targeted fish species. This document was generated to address these topics and questions, as well as identify areas of scientific uncertainty. Some of the questions asked and answered in this paper are not relevant to the Salmonid Project, as they pertain to splittail and other species covered by the Bay Delta Conservation Plan. The state and federal government replaced the Bay Delta Conservation Plan in 2016 with California WaterFix and California EcoRestore, neither of which contains the proposals to inundate the Yolo Bypass for floodplain habitat contained in the Bay Delta Conservation Plan. The authors maintained the information about the topics relevant to the Bay Delta Conservation Plan in the event there are future discussions about modifying the Salmonid Project for other species.

1. Abundance of Juvenile Salmon in the Sacramento River

1a. How many juvenile salmon are in the Sacramento River at different times of the year?

1b. Of these fish, how many juvenile salmon can be reasonably expected to access floodplain habitat in the Yolo Bypass under different proposed alternatives? What are the factors that influence their ability to access the floodplain? What is the level of certainty associated with these estimates and what additional research would be necessary to improve that level of certainty?

2. Hatchery Fishes

2a. How many of the fish expected to access the Yolo Bypass floodplain habitat are of hatchery origin?

2b. What is the likelihood that these hatchery fish will reproduce in the wild?

3. Other Floodplains

3a. Is the Yolo Bypass the only floodplain habitat important to fish species of interest in the lower Sacramento River watershed? If not, what other areas are important to fish species of interest (e.g., Sutter Bypass)?

4. Toe Drain Versus Floodplain Habitat

4a. Is floodplain habitat along the Toe Drain in the Yolo Bypass higher or lower quality than other floodplain habitat in the Yolo Bypass, such as the western portion of Knaggs Ranch?

5. Benefits of Flood Timing

5a. What are the benefits of providing floodplain habitat before March 1st for each species of interest? After March 1st? What are the factors that influence level of benefit to fish species of interest, such as temperature? What does the scientific community know about these factors and what information is not available?

5b. How will climate change affect these benefits?

5c. What are the different mechanisms through which splittail spawning success in the Yolo Bypass can be measured, considering that different organizations may define spawning success differently?

5d. Do splittail need 10,000 acres of floodplain habitat to "successfully" spawn (i.e. realized population benefits associated with a smaller inundation footprint) in the Yolo Bypass? Would "success" be possible if splittail floodplain habitat is limited to the lower Yolo Bypass, such as areas in Cache Slough? Are there other opportunities for creation of successful splittail spawning habitat outside of the Yolo Bypass?

5e. How long do juvenile salmonids and splittail need to stay on the Yolo Bypass floodplain to realize significant benefits?

1. ABUNDANCE OF JUVENILE SALMON IN THE SACRAMENTO RIVER

1a: How many juvenile salmon are in the Sacramento River at different times of the year?

The timing and estimate of juvenile salmon abundance occurring throughout the Sacramento River varies inter-annually. Changes in both river flow and water temperature provide cues for juvenile salmon to initiate migration and are dependent on climatic and hydrologic influences (Groot and Margolis 1991). For instance, Del Rosario et al. (2013) found that juvenile winter-run Chinook peak emigration timing in the Sacramento River varied between water type years and found a strong correlation between initial emigration timing and early season high discharge events. Based on rotary screw trap data from Knights Landing (1997-2007), juvenile salmon (all runs) can be found in the Sacramento River from October through July (Roberts et al. 2013). Migration of juvenile salmon past Knights Landing likely occurs in three phases (as in Snider and Titus 2000). Between September 1997 and June 1998, late-fall and winter-run Chinook juveniles produced in the wild and spring-run Chinook dominated Phase 1 (November 16-January 3). Fall-run Chinook dominated Phase 2 (December 28 - March 7), while fall-run Chinook released from Coleman National Fish Hatchery principally comprised Phase 3 (March 8 - June 21) (Snider and Titus 2000).

Rotary screw trap data can provide valuable estimates on the timing of outmigration and catch per unit effort (CPUE) of salmon between different water type years, although uncertainty is introduced into the data as a result of the use of length-at-date criteria to identify runs (see Harvey et al. 2014). Though CPUE is not a direct measure of abundance, it is a valuable tool that standardizes catch (number of salmon) based on the level of effort (time) and is particularly useful when comparing inter-annual data to better understand trends in timing and relative abundance. As such, we examined differences in run timing and CPUE of salmon between years using annual Knights Landing Rotary Screw Trap data. These data describe the relative number of juvenile salmon of different runs based on size criteria (length-at-date) caught at the trap by Julian Week. There are inherent weaknesses, however, associated with run-type identification by length-at-date criteria. Harvey et al. (2014) found extensive fork length overlap between the different Central Valley Chinook races with approximately half of all length-at-date identifications receiving different genetic assignments. In particular, the authors found a very high degree of overlap between fall- and spring-run Chinook, although fork length distributions of all run types overlapped to some extent. This and other work by Merz et al. (2014) suggest the use of length-at-date criteria may significantly under- or over-estimate the contribution of different run types to the total number of out-migrants. Thus, the proportion of different run-types between water years should be viewed with caution.

To estimate how many juvenile salmon are in the Sacramento River at different times of year, we focused on two time steps. First, we examined a snapshot in time using data provided to Yolo County by the California Department of Fish and Wildlife from September 1997 to June 1998 to determine run-type abundance during different times of year in the Sacramento River. This single year analysis focuses on estimates derived from the number of juvenile salmon caught at

Knights Landing (from Snider and Titus 2000) with proportions caught by Julian Week (Roberts et al. 2013, unpublished data). Detailed methods used to estimate abundance of juvenile salmon passing Knights Landing are described in Table 2. Considerable uncertainties are associated with estimating abundance of juvenile salmon from one year of trap data (1997-1998). As such, and to understand patterns over a longer period of time, we also used Knights Land Rotary Screw Trap data from Appendix A in Roberts et al. 2013 (water years 1997-2010). These data describe mean emigration timing during wet, above normal, below normal, and dry water type years and the relative CPUE of total salmon and run-types during 1997-2010. Both analyses should be viewed as an initial effort.

Table 2. Estimates used to calculate total number of fishes moving in the Sacramento River past Knights Landings (Phase 1-3) and number of fish that may have entered Yolo Bypass without and with and operable gate at Fremont Weir, November 1997-June 1998

Chinook Run	Phase 1*	Phase 2	Phase 3	Estimated 1998 Entrainment without gate**	Estimated 1998 Entrainment with gate**
Late Fall	20587.5	25162.5	0	10215.98	12910.65
Winter	45050	61943.75	5631.25	17851.06	25295.58
Spring	16275	4882.5	33092.5	7144.725	11446.75
Fall	1737748	2652353	4755943	1461538	1681043
Subtotals	1819661	2744342	4794667	1496750	1730696
1997-1998 Total number			9358669		

Steps used in calculations:

1. Determined Julian weeks corresponding to each Phase as defined in Snider and Titus 2000.
2. Determined the portion of each run traveling past Knights Landings during each Phase as defined in Roberts et al. 2013, unpublished data of Knights Landing Rotary Screw Trap catches (1997-2007).
3. Used abundance numbers in Snider and Titus 2000 and proportion from Roberts et al. 2013 to estimate numbers of each run migrating during each phase; sum total (~ 9.3 million) became an estimate of the number of fishes found in the Sacramento River from November 1997-June 1998
4. Used proportion of fishes entering Yolo Bypass (without and with operable gate at Fremont Weir; Roberts et al. 2013 *An empirical approach to estimate juvenile salmon entrainment over Fremont Weir*, Fisheries Branch Administrative Report 2013-01, Sacramento) with estimated total abundances to estimate number of fishes entering Yolo Bypass in 1998 WY.
5. Subtracted estimated number of fishes entering Yolo Bypass without operable gate from estimated number fishes entering Yolo Bypass with operable gate to estimate differences between the two scenarios (~234 000 fishes).

Between 1997 and 2010, a total of 613,035 juvenile salmon were collected at the Knights Landing Rotary Screw Trap site over 169,220 hours (3.6 fish/hour). During this period, fall-run Chinook comprised nearly 97% of the entire catch with spring-, winter-, and late-fall-run juveniles comprising the remaining 3% (see Table 3). Annual total catch per unit effort (CPUE) peaked during the 2003 water year (56,049), with the lowest CPUE during 2010 (2,905) (see Figure 1A). Juvenile outmigration varied by water type year with generally greater catch per unit effort of out-migrants on average during wet (n=4, mean=23,722±13,920) and above normal (n=3, mean=33,929±19,680) years and less during below normal (n=2, mean=13,511±15,000), and dry years (n=5, mean=17,149±8553) (Figure 1A and Table 3), although there was significant variability within like water type years. Over all water years, (1997-2011) mean juvenile emigration began on average during week 46 (approximately the second week of November) and ended during week 23 (approximately the second week of June) (see Figure 1B). During this time period, peak emigration generally occurred between weeks 46 and 14 (approximately the first week of April), followed by a second smaller peak during weeks 14 and 23 (Figure 1B). While the length of the total emigration period was similar between years, though somewhat shorter during dry and critical dry years, the magnitude and timing of salmon emigration pulses between water years was different (see Figure 2). For instance, during dry and critically dry years, peak emigration occurred, on average, over three shortened and distinct periods between weeks 49 (mid-December) and week 11 (mid-March). During wet years, peak emigration generally occurred at greater magnitudes and over a sustained period of time between weeks 52 (late-December) and 13 (late March). Differences in emigration timing are likely related to a range of environmental variables, with hydrologic influences likely playing a particularly important role (Del Rosario et al. 2013).

Table 3. Annual catch per unit effort of Central Valley Chinook run-types between 1997 and 2010 at Knights Landing. Percent total composition of each run-type for each year follows CPUE numbers. Water year types: W = wet, AN = Above Normal, D = Dry, BN = Below Normal, C = Critical Dry.

Year	Water Type	Annual Catch Per Unit Effort				
		Total CPUE	**Fall-run**	**Spring-**	**Winter-**	**Late Fall-**
1997	W	37,701	36,815 (97.6)	211 (0.6)	521 (1.4)	154 (0.4)
1998	W	33,504	32,710 (97.6)	297 (0.9)	435 (1.3)	63 (0.2)
1999	W	13,823	13,728 (99.3)	45 (0.3)	30 (0.2)	20 (0.1)
2000	AN	27,381	27,190 (99.3)	48 (0.2)	139 (0.5)	4 (0.01)
2001	D	15,324	14,763 (96.3)	241 (1.6)	297 (1.9)	23 (.15)
2002	D	30,909	29,225 (94.5)	1,135	495 (1.6)	54 (.17)
2003	AN	56,049	54,173 (96.7)	975 (1.7)	886 (1.6)	15 (.03)
2004	BN	24,118	23,201 (96.2)	440 (1.8)	345 (1.4)	132 (0.5)
2005	AN	18,358	16,998 (92.6)	468 (2.5)	746 (4.1)	146 (0.8)
2006	W	9,858	9,432 (95.7)	94 (1.0)	327 (3.3)	5 (0.05)
2007	D	19,066	18,707 (98.1)	138 (0.7)	215 (1.1)	6 (0.03)
2008	C	9,833	9,640 (98)	137 (1.4)	54 (0.5)	2 (0.02)
2009	D	10,613	10,402 (98)	102 (1.0)	68 (0.6)	42 (0.4)
2010	BN	2,905	2,596 (89.4)	168 (5.8)	137 (4.7)	4 (0.13)
Mean		22,103	21,399 (96.8)	321 (1.5)	335 (1.5)	48 (0.2)

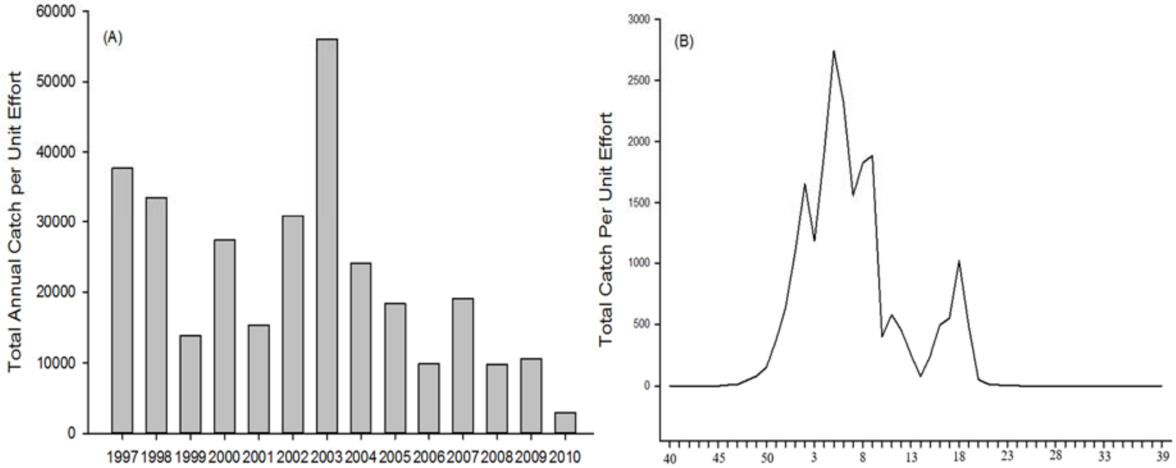

Figure 1. (A) Total annual catch per unit effort at Knights Landing from 1997-2010 and (B) mean emigration timing of all salmon from 1997-2010 at Knights Landing. week 40 corresponds to the beginning of the water year (October 1st).

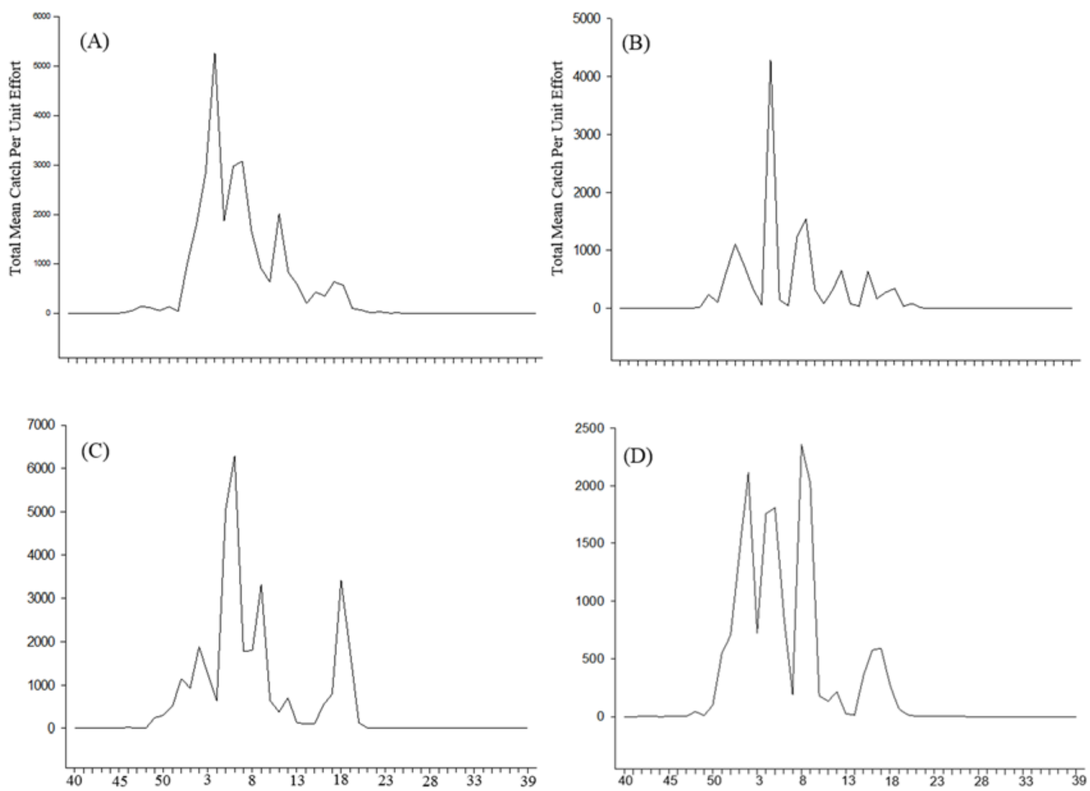

Figure 2. Mean emigration timing (total mean catch per unit effort) over different water years for all run types from 1997-2010 at Knights Landing. Week 40 corresponds to the beginning of the water year (October 1st). (A) Wet years (1997, 1998, 1999, 2006), (B) Above normal years (2000, 2003, 2005), (C) Below normal years (2004, 2010), and (D) Dry and critical dry years (2001, 2002, 2007, 2008, 2009). Note different y-axis scales.

As mentioned previously, estimating juvenile salmon abundance from one year of rotary screw trap data (1997-1998) provides information of limited use. Trap data may be more useful in understanding differences in CPUE and timing between years rather than as a predictive estimate of total abundance. For instance, using a mark recapture study in Alaska, Thedinga et al. (1994) found that trap efficiency ranged between 3% and 24% for steelhead and Chinook salmon, respectively. Trap efficiency is known to be influenced by flow (Gaines and Martin 2002) and turbidity (McKibbin 2012) with fewer fish caught during periods with high flow or low turbidity. In addition, the number of juvenile salmon trapped varies greatly between years (J. Roberts, unpublished data). Likewise, juvenile salmon abundance in the Sacramento River is expected to vary greatly because juvenile abundance reflects the spawning stock size and is affected by the survival of earlier life stages (i.e., incubating eggs, alevin, fry), which can be affected by various environmental conditions, such as water type year, river flow, water temperature, predation, incubation success, and food availability. Finally, Knights Landing trap data could be affected if overflow from the Sacramento River enters the Sutter Bypass (upstream of Knights Landing), providing another migration route to juvenile salmon. In 1998, flows were sufficiently high for fish migrating in the Sacramento River to enter the Sutter Bypass in January (Snider and Titus 2000), so there is considerable uncertainty associated with these estimates.

1b: Of these fish, how many juvenile salmon can be reasonably expected to access floodplain habitat in the Yolo Bypass under different proposed alternatives? What are the factors that influence their ability to access the floodplain? What is the level of certainty associated with these estimates and what additional research would be necessary to improve that level of certainty?

The level of certainty associated with estimates of the number of juvenile salmon that may access floodplain habitat in the Yolo Bypass in any given year, also known as “entrainment,” is low due to high variability in juvenile production and survival each year. Acierto et al. (2014) is the first attempt to answer this question, but uncertainties remain regarding estimates of entrainment. For instance, standardized use of rotary screw trap data can provide valuable catch per unit effort numbers among sites and between years for relative comparison, though spatiotemporal variability in capture efficiency often precludes accurate year to year abundance estimates. In general, abundance and entrainment estimates are highly uncertain due to annual variability in discharge and water temperature. The reliability of estimates is most often confounded by changes in trap orientation, changes in the rate of trap rotation, water velocity, and debris accumulation in and around the trap (USFWS 2008). Further, it is difficult to predict how climate change may alter juvenile migration patterns (as in Crozier et al. 2008; Moyle et al. 2013). The level of certainty should be greatly improved by tracking fish movements as juvenile salmon migrate downstream, monitoring the number of fish migrating past Fremont Weir under different conditions and during different water type years, and evaluating the effects of water temperature and flow on run-timing, habitat preferences and selection of migration routes. Some of this is ongoing and will provide important data regarding gate operation at Fremont Weir.

The number of juvenile salmon accessing the Yolo Bypass in any given year will largely depend on the synchrony between migration timing and flow events of sufficient magnitude to overtop

Fremont Weir, flow under the proposed gated channel, or pass through a notch. Roberts et al. (2013) estimated that an operable gate at Fremont Weir could increase the number of juvenile salmon accessing the Yolo Bypass by 185%. The estimate was based on an evaluation of historical Sacramento River discharge at Fremont Weir from 1997-2011 and combined with juvenile salmon emigration data from rotary screw traps at Knights Landing (approximately five miles upstream of Fremont Weir) over the same time period. The authors assumed an even distribution of juvenile Chinook salmon throughout the entire water column and that entrainment was directly proportional to volume of Sacramento River flow overtopping Fremont Weir or moving through an operable gate. Roberts et al. (2013) also based entrainment estimates of different run types on size-at-date criteria and there is considerable uncertainty associated with this method (see Harvey et al. 2014), suggesting that specific run entrainment estimates may be over- or under-estimated. More information is needed regarding the actual distribution of juvenile salmon in the water column, behavioral patterns regarding entrainment, and how the distribution of juvenile Chinook changes in response to different stimuli (i.e., diel behavior, flow events, etc.).

More recent research has focused on the behavior and movement of Chinook salmon in the water column in the Sacramento River near Fremont weir. Using acoustic telemetry, Steel et al. (2016a) found that hatchery juvenile late-fall and winter-run Chinook were not uniform in their use of the channel during outmigration, but that they generally used the outside bend of the Sacramento River near Fremont Weir. The behavior and movement data from this study is being used to further improve resolution on the magnitude and extent of entrainment onto the Yolo Bypass under the different proposed flooding alternatives and will be directly compared with the methods from Roberts et al. (2013). Telemetry results from Steel et al. (2016a and 2016b) are also currently being applied to the Eulerian-Lagrangian-agent method (ELAM), which is being used to model juvenile salmon entrainment onto the Yolo Bypass. ELAM considers both the fluid dynamics associated with potential inundation scenarios and fish behavioral response in an effort to make more robust estimates of entrainment.

The position, size, and run type of juvenile Chinook salmon prior to reaching Fremont Weir may affect their migration route and whether they enter the Bypass via an operable gate. For instance, Steel et al. (2016a) found that hatchery winter-run Chinook migration tracks were farther to the outside of the bend than late-fall-run Chinook over short distances. Tracking of juvenile Chinook salmon near the Delta Cross Channel suggests that both river position and size of individuals can influence migration route selection, although water velocity was the strongest predictor (Steel et al. 2012). Due to size discrepancies, yearling juvenile salmon are better swimmers than sub-yearlings (Groot and Margolis 1991) and, therefore, may access the Bypass at different rates. Larger fish, in general, are also less likely to be entrained involuntarily, suggesting that enhanced swimming performance may aid in preferable route selection or enable yearling juvenile salmon to maneuver through the operable gate more efficiently than sub-yearling juveniles. Conversely, larger individuals may be able to avoid the operable gate all together. Differences in entrainment rates between yearling and subyearling juvenile salmon (or different size classes), however, have not been estimated for the Yolo Bypass and may be of future research interest. Steel et al. (2016a) found that out-migrating late-fall-run juvenile Chinook size classes ranging approximately between 100-180 mm showed little difference in movement, but the direction and movement of smaller individuals (30-70 mm), characteristic of outmigrating juvenile winter-run Chinook, were not studied.

Tracking the movement of juvenile salmon as they approach Fremont Weir should help improve percent entrainment estimates. The lead agencies are currently working on applying two additional methods which should provide further insight on salmonid movement near Fremont Weir. These methods include ELAM (referenced above) and Critical Streakline Analysis. Critical Streakline Analysis examines the spatial distribution and movement of salmon under different velocity conditions through the analysis of acoustic telemetry data and resulting salmonid movement “tracks”. Environmental covariates can also be collected in order to statistically assess how individuals are moving under particular environmental conditions.

Until empirical data is available, the Roberts et al. (2013) estimate regarding improved access under an operable gate scenario is valuable. Based on the proportional estimates and abundance estimates discussed under Topic #1, the number of juvenile salmon (including both wild and hatchery fish) estimated to have entered the Yolo Bypass in Water Year 1998 is about 1.5 million juveniles between November 1997 and June 1998 (Table 2). Based on percentages reported in Roberts et al. (2013), an additional 200,000 juvenile salmon may have accessed the Bypass if an operable gate were in place at Fremont Weir during this period (this estimate is specific to the 1997-1998 data). These numbers are illustrative and only provide an estimate, for discussion purposes. As noted, the Department of Water Resources is working with the state and federal fish and wildlife agencies to develop more robust models for estimating the biological benefits associated with an operable gate at the Fremont Weir. While the agencies are unlikely to use the Roberts et al. (2013) methodology in the EIS/EIR, current models (ELAM and Critical Streakline Analysis) will require peer review.

2. HATCHERY FISHES

2a: How many juvenile salmon expected to access the Yolo Bypass floodplain habitat are of hatchery origin?

This section focuses on fall-run Chinook due to the well-documented use of hatcheries to supplant historically diminishing returns throughout the Central Valley. From September 1997-June 1998, about 97% of unmarked salmon and 67% of marked salmon caught at the Knights Landing Rotary Screw Trap were fall-run Chinook (Snider and Titus 2000) (see Table 3 for additional years between 1997-2010). The Central Valley fall-run Chinook population as a whole is now dominated (> 90%) by hatchery produced salmon (Barnett-Johnson 2007, Johnson et al. 2013). If the proportion of juvenile salmon accessing the Yolo Bypass is likewise dominated by fall-run Chinook, then we can estimate that the large majority (> 90%) of juvenile salmon using the Bypass are of hatchery origin. Based on past hatchery release dates, most fall-run Chinook juveniles would migrate through the Bypass between March and June. We also anticipate that individuals of natural origin (i.e. not hatchery produced), despite currently low numbers (including winter- and spring-run), would benefit from improved lateral connectivity associated with a flooded Yolo Bypass. Such habitat may be particularly important to improve runs currently exhibiting extremely low abundances or contributions to overall population dynamics, in addition to improving life history diversity and population resiliency. Of course, such improvements would depend on migration timing coinciding with improved access to the Yolo Bypass and the timing, duration, and magnitude of flooding extent. Recent studies suggest that improving historically important floodplain habitat in the Central Valley vastly improves juvenile Chinook growth and body condition, delays out-migration timing, and may provide a superior out-migration route (Katz et al. 2013, Sommer et al. 2001c, Jeffres et al. 2008).

2b: What is the likelihood that these hatchery fish will reproduce in the wild?

Reproduction of hatchery-origin adult salmon in the wild appears to differ by run type. Such spawning occurs mainly in rivers below hatcheries. While hatchery origin salmon that spawn in the wild often produce large numbers of young, survival of these young appears to be low. Generally, hatchery reared salmonids show a decline in fitness in the wild (Allendorf and Phelps 1980, Ford 2002), which may be due to the selection of maladaptive traits (Christie 2012), competition associated with hatchery reared individuals (see Weber and Fausch 2003), or manipulations of river flows for benefits other than salmon production (P. Moyle, personal communication).

Straying occurs when adult salmon return to spawn in watersheds other than their natal watershed. Straying is a natural part of salmon behavior but is usually less than 10% in wild populations (Groot and Margolis 1991). Releases of hatchery produced juvenile salmon in locations away from the hatchery promote higher rates of straying in returning adults (reviewed in California HSRG 2012) and may have detrimental effects on the ability of a wild populations to cope with changing environmental conditions if the genes from those hatchery-origin adult fish are introduced into the wild population. Straying is thought to be the principal cause of genetic homogenization of Central Valley fall-run Chinook (Williamson and May 2005), making the entire run more susceptible to collapse (Lindley et al. 2009) from both inter-annual variations in environmental cues such as river flows, water temperatures, and other longer-term processes such as climate change.

Fall-run Chinook reproduction in the Mokelumne River was recently studied by Johnson et al. (2013). Upon evaluating the chemical signature of otoliths, Johnson et al. (2013) proposed that 90-99% of fall-run Chinook salmon spawning in the Mokelumne River were of hatchery origin. Similarly, about 86% of spring-run Chinook reared in the Feather River Hatchery between 2004 and 2007 and released in San Pablo Bay strayed when they returned as adults (California HSRG 2012b). Of the groups of Chinook likely to use the Yolo Bypass (see Table 4), we can infer that straying of returning adults is most likely from Coleman National Fish Hatchery releases (both Battle Creek and San Pablo off site releases). Juvenile releases in San Pablo Bay may be particularly problematic. CDFG and NMFS (2001) found that up to 90% of off-site released juveniles strayed upon return as adults and that straying rates and distance of release from the hatchery of origin were positively correlated. Despite juveniles initially being released downstream of the Yolo Bypass, there is a high likelihood that subsequent generations could use the bypass for rearing. However, it is currently impossible to estimate how many of those juvenile progeny will use the Yolo Bypass and subsequently return to the Sacramento River as spawners. Tagging and individual tracking of fishes through their entire life cycle from hatchery rearing through seaward migration to adult spawning could provide valuable estimates of the number of hatchery fish rearing in the Bypass.

Table 4. Run type, percentage marked, and release target, location and month of Central Valley Chinook salmon reared in hatcheries. Two asterisks (**) marks groups most likely to use the Yolo Bypass for rearing, one asterisk marks groups likely to use Yolo Bypass as a migration corridor. FR: fall-run Chinook, SR: spring-run Chinook, LFR: late fall-run Chinook, WR: winter-run Chinook. Note: Livingston Stone National Fish Hatchery is a substation of the Coleman National Fish Hatchery and is operated as a conservation hatchery program to assist in population recover of ESA-listed winter-run Chinook salmon. Source: California HSRG 2012a.

Hatchery Facility	Run	Marked	Release target/year	Release location/month
Nimbus	FR	25%	4,000,000 smolts	San Pabo Bay; mid- May to mid-June
Mokelumne	FR	25%	5,000,000 smolts; 2,000,000 post-smolts	San Pablo Bay & Woodbridge Dam; March to June
Merced	FR	25%	1,000,000 smolts	Var. locations, San Joaquin basin; April to mid-May
Feather	FR	25%	6,000,000 smolts; 2,000,000 post-smolts	Carquinez Straits; April to June
	SR*	100%	2,000,000 smolts	Feather R., Carquinez Straits; April or May
Coleman	FR**	25%	12,000,000 YOY	Battle Creek, San Pablo Bay; April
	LFR*	100%	1,000,000 yearling	Battle Creek
Livingston Stone	WR**	100%	250,000 YOY	Sacramento River; late Jan. to early Feb.

3. OTHER FLOODPLAINS

3a: Is the Yolo Bypass the only floodplain habitat important to fish species of interest in the lower Sacramento River watershed? If not, what other areas are important to the fish species of interest (e.g., Sutter Bypass)?

The Yolo Bypass is the largest floodplain habitat available and is strategically located to encourage alternate routing through the Delta and, thus, provides significant ecological benefits to fish in the lower Sacramento River. However, others have shown that species of concern in this document do use other floodplain type habitats in the Central Valley to complete their lifecycle. For instance, Chinook salmon rear in the Cosumnes River floodplain (Jeffres et al. 2008), Natomas East Main Drainage Canal (Jones and Stokes Assoc. 1999) and Sutter Bypass (Hill and Webber 1999, Ward et al. 2004). Additionally, splittail are known to spawn in floodplain habitats in the lower Cosumnes River, American River, Sutter Bypass, Sacramento River, and lower Tuolumne River (San Joaquin basin; Moyle et al., unpublished report; Moyle et al. 2004). Outside of the Central Valley, splittail are also present in the Napa and Petaluma Rivers (Baerswald et al. 2007) and recent data suggests that these populations overlap with Central Valley splittail during certain years (Feyrer et al. 2015). Sommer et al. (1997) found that larval densities were not statistically different in the Sutter and Yolo Bypasses, suggesting that reproductive success is similar between sites. Furthermore, splittail can successfully spawn along stream banks and in backwaters during small increases in flow (reviewed in Moyle et al. 2004) when the Bypass may not flood. This also suggests that channel margin enhancement projects may strongly benefit splittail.

4. TOE DRAIN VERSUS FLOODPLAIN HABITAT

4a: Is the floodplain habitat along the Toe Drain in the Yolo Bypass higher or lower quality than other floodplain habitat in the Yolo Bypass, such as the western portion of Knaggs Ranch?

The floodplain habitat along the Toe Drain may be of equal quality to other floodplain habitat in the Yolo Bypass, assuming these areas are also seasonally flooded and have similar depth, velocity, and food web characteristics. Toe Drain habitat suitability and juvenile salmon growth is currently being compared to experimental floodplains on Knaggs Ranch, so we anticipate additional information (Katz, personal communication). The Toe Drain may currently be more suitable for some species (e.g., splittail) since they are flooded for longer periods of time (i.e., the Toe Drain is the first to inundate and last to drain), although we anticipate that a range of habitat diversity (floodplain, Toe Drain, etc.) is of particular importance to species of concern. Installing an operable gate at Fremont Weir would allow for the management of floodplain inundation and make a greater area of Yolo Bypass suitable for species such as splittail and juvenile Chinook salmon, depending on water year. Aside from increasing habitat area, bypass inundation will also improve habitat heterogeneity (i.e., shallow, low velocity, high food production) which is expected to benefit species of interest.

One concern regarding floodplain habitat along the Toe Drain is that fish that occur in these areas may be more susceptible to predation. Another concern is the potential for rapid changes in water depth associated with cessation of overtopping of the Fremont Weir under current conditions. The rate of flood recession is presumably important and, if too fast, could contribute to the desiccation of splittail eggs and potentially cause increases in mortality. The proposed operable gate at Fremont Weir would provide more flexibility concerning the management of floodplain inundation (i.e., extent, duration, and timing) and likely improve the chances of realizing biological benefits to fish through an adaptive management framework.

5. BENEFITS OF FLOOD TIMING

5a: What are the benefits of providing floodplain habitat before March 1st, and after March 1st for each species of interest? What are the factors influencing the level of benefit to fish species of interest, such as water temperature? What does the scientific community know about these factors and what information is not available?

Species of interest will benefit from use of the Yolo Bypass in the fall and winter (before March 1st), but juvenile salmon, splittail, sturgeon and lamprey will also benefit from floodplain use after March 1st. However, the magnitude of benefits and how they differ by run timing, size and age of fish has not been evaluated. Further, the area of inundation necessary to achieve the biological goals associated with the BiOp is unknown. The NMFS (2009) OCAP BiOp RPA I.6.1 calls for an initial performance measure of 17,000-20,000 acres of inundation (excluding tidally influenced areas), however, the acreage requirement could be revised if scientific information supports such a change.

Beneficial conditions for growth and survival of individual fish (water temperature, dissolved oxygen, etc.) are expected to last only as long as favorable habitat exists for those species. Currently, favorable habitat is expected to be readily available before March 1st because flooding is more likely and air temperatures are generally cooler, though this may change with the proposed operable gate at Fremont Weir or under different water year type conditions (e.g., cool, wet springs). However, determining the duration of benefits after March 1st is difficult under current and future flood inundation scenarios. Benefits to fish using floodplain habitat are generally governed by numerous abiotic and biotic factors including water quality, temperature, velocity, depth, habitat heterogeneity, prey availability, and predation among others. These factors are expected to vary spatio-temporally and by water type year. As water recedes from the floodplain during late spring, we anticipate that the potential costs of rearing begin to outweigh the benefits, with water temperature, dissolved oxygen content, the potential for stranding, and predation playing increasingly important roles. Jeffres et al. (2008) notes that despite there being tradeoffs between accelerated growth rates and the potential for mortality from poor water quality and possibly stranding, floodplains generally offer a range of habitats enabling juvenile salmon to seek better conditions during tough times.

The magnitude of potential benefits to juvenile salmonids is dependent on floodplain habitat conditions, particularly water temperature and food availability (Railsback and Rose 1999). For instance, Katz et al. (2013) suggested that warmer water temperatures in exceedance of 20°C may have contributed to declines in growth of juvenile Chinook during mid- to late March on experimental floodplains located in the Yolo Bypass. However, the authors suggested that growth was likely sustained prior to this temperature by abundant food resources. Others have suggested that juvenile salmon may be able to sustain or even improve growth under seemingly stressful water temperatures if food is abundant (Bisson 1988). Floodplains are incredibly productive when compared with mainstem river conditions and, thus, juvenile salmonids may be able to metabolically compensate for increases in water temperature to some extent (Sommer et al. 2001). Less clear, however, is our understanding of the magnitude and duration of specific temperature thresholds and how these variables interact with food availability to affect fish growth during late season floodplain inundation.

Temperature, dissolved oxygen concentration, and predation pressure likely become increasingly more stressful to salmonids and potentially other fishes using the floodplain after March 1st as air temperatures increase and flooding depths decrease. Dissolved oxygen concentrations are generally inversely related to water temperature and depth (Allan and Castillo 2007) and are known to exhibit strong seasonal and spatial variability on floodplains (Ahearn et al. 2006). While the Department of Water Resources has an extensive data set of temporal changes in water temperature and dissolved oxygen at specific points within the bypass (i.e, Yolo Bypass at Lisbon), these factors and the potential for predation effects on floodplain fish assemblages have not been extensively spatially monitored during different water years or seasons. Consequently, it is difficult to determine whether suitable conditions end after March 1st or if they persist in certain inundated areas of the Bypass for longer periods. Much of this may depend on water type year with wetter, cooler years providing extended benefits to juvenile salmon. An operable gate at the Fremont Weir allowing freshwater diversion from the Sacramento River into the Bypass may increase the potential for suitable habitat conditions to persist in the Bypass for longer periods than currently and should be the focus of further research efforts.

Monitoring of growth and survival of floodplain fishes and environmental conditions, such as water temperature, dissolved oxygen, prey availability, and potential predation effects is needed to establish the duration of biological benefits that may persist in the Bypass before and after modifications to the Fremont Weir. Monitoring should be extensively implemented (particularly for temperature, dissolved oxygen concentration, and prey availability) throughout the Bypass and collected over multiple water type years to capture spatial (see Ahearn et al. 2006) and temporal variability. A stronger understanding of the effects of predation (both terrestrial and aquatic predators) on juvenile fishes and the interaction between food availability and temperature on fish growth may also be required.

Sommer et al. (2005) estimated juvenile Chinook salmon densities within the Yolo Bypass ranged from 126 to 890 fish per hectare (51 to 360 fish per acre). Based on a density of 300 fish per acre and the abundance estimates from Snider and Titus (2000) (see Topic #1), approximately 6,000 acres of Yolo Bypass floodplain habitat could support all 1.8 million juvenile Chinook salmon estimated to be present in the Sacramento River at Knights Landing. This equates to essentially all of the late-fall-, winter-, and spring-run Chinook migrating from November to December 1997. In comparison, approximately 9,000 and 16,000 acres could support all 2.7 million fishes (wild fall-run Chinook) migrating between December to March and 4.7 million fishes (hatchery fall-run Chinook) migrating between March to June, respectively, in that same water year. If fish can survive at even higher densities, which is suggested by Katz et al. (2013), then they may benefit from even less inundated acreage in the Yolo Bypass. Additionally, not all of these fish would be diverted into the Bypass through an operable gate at Fremont Weir because the large majority of river flow and associated fish would remain in the Sacramento River. Roberts et al. (2013) estimate that up to 38% (late fall-run Chinook in 2006) of some runs may enter the Bypass via an altered Fremont Weir. However, based on 1997-2011 averages, the proportion of fishes entering the Bypass via an operable gate in any given year will more likely range from 13-18% (Roberts et al. 2013). These estimates, however, are speculative because they are based on the proportion of flow moving past Fremont Weir rather than observed numbers.

As discussed under Topic #1, these estimates simply demonstrate that a smaller inundation footprint within the Yolo Bypass has the potential to provide significant biological benefits for covered fish species. Imperative to such estimates is the assumption that habitat availability or acreage and habitat quality are synonymous, which they probably are not, though we anticipate that thousands of acres of inundated floodplain habitat would provide significant habitat heterogeneity for rearing fish. We also note that an improved migration corridor and access to floodplain rearing habitat suggests that future survival rates of salmonids entering the marine stage may also improve with cascading population effects, though this is also dependent on other factors including ocean conditions. Still, we recognize that an operable gate at the Fremont Weir would provide some flexibility in terms of varying potential inundation acreage based on run forecasts. Additional data, modeling, and analysis will be needed to further determine the magnitude of inundation RPA actions must achieve to realize the biological benefits necessary to contribute toward achieving the covered fish species biological goals.

In general, benefits to migratory adults (i.e., salmon, steelhead, sturgeon and lamprey) associated with RPA actions include an alternate route during upstream migration and reduced stranding and migratory delays at Fremont Weir. In addition, adult salmon, sturgeon, and Pacific lamprey fish passage would also improve with the proposed re-design of the fish ladder at Fremont Weir. Such benefits may ultimately improve adult survival to upstream spawning habitat. Conversely, juvenile salmonids are expected to benefit directly from floodplain use during rearing. Juvenile salmonids are better adapted to use shallower, more complex habitats, such as those provided on an inundated floodplain such as the Yolo Bypass, and experience benefits found in Katz (2012), which included more rapid growth, improved body condition, and delayed out-migration timing. Rearing on the Bypass may also provide a superior outmigration route through the Delta (Katz 2012). Splittail will also likely benefit from improved feeding associated with floodplain habitat and spawning over aquatic vegetation in the Bypass (Moyle 2002).

Winter-run Chinook (*Oncorhynchus tshawytscha*) adults typically migrate from January through May, peaking in mid-March (Williams 2006). Juveniles migrate downstream from October to June, with peak numbers at the end April, generally staying upstream of Red Bluff Diversion Dam (Williams 2006, Moyle et al. 2008). Juveniles typically rear 5-10 months before ultimately leaving the Delta (Moyle 2008). Del Rosario et al. (2013) found that the juvenile migration period lasted about eight months, with individuals passing the Red Bluff Diversion Dam in early October and leaving the Delta at Chipps Island in late March through early May. However, there is some uncertainty associated with the length-at-date criteria used to identify winter-run Chinook and the potential to misidentify run-specific stocks (Harvey et al. 2014, Merz et al. 2014). Most juveniles reach the Delta in early winter (Moyle et al. 2008) and outmigration was historically timed to correspond with winter flooding in the Sacramento basin, which provided floodplain habitat for rearing. Juveniles could rear in the Yolo Bypass (when accessible) and much of this could occur prior to March 1st, but juvenile salmonid outmigration may continue through June.

Spring-run Chinook (*O. tshawytscha*) adults spawning migrations typically occur from February through early-July. Adult upstream migration typically peaks in upper Sacramento River tributaries (Butte, Deer, and Mill Creeks) in mid-April to mid-May (Moyle et al. 2008). Adults hold in streams for several months before spawning in fall. Juveniles hatch and subsequently rear in streams through at least the following spring, although there is some variability in emigration timing with individuals also outmigrating as young of year (YOY) and rearing in downstream habitats (Williams 2006). Rotary screw traps at Knights Landing catch juveniles from March to July (J. Roberts, unpublished data; based on length criteria), but hatchery juveniles dominate trap catches in April/May (California HRSG 2013). The relative size of juveniles seems to determine how quickly they migrate to the ocean. Larger juveniles rearing in Sutter Bypass migrate quickly to the ocean (Hill and Webber 1999). Consequently, larger juveniles (i.e., those older than one year) usually migrate after March 1 and are not expected to benefit from Yolo Bypass rearing as much as younger juveniles due to differences in relative size. However, YOY may be more likely to rear for extended periods in Central Valley floodplains such as the Yolo Bypass. Most YOY are expected to migrate through and or rear in the Yolo Bypass before March 1st, but spring-run Chinook rearing has also been documented in April during wetter type water years in similar floodplain habitats, such as the Sutter Bypass (Hill and Weber 1999).

Fall-run Chinook (*O. tshawytscha*) adults typically spawn October to December. Juveniles migrate as fry and smolts in winter and spring. Historically, fall-run Chinook juveniles likely reared in floodplains extensively, benefitting from accelerated growth due to warmer water temperatures and higher prey densities (Sommer et al. 2001c, Jeffres et al. 2008). Today, more than 90% of fall-run adults are considered to be hatchery produced (Barnett-Johnson et al. 2007, Johnson et al. 2013). Naturally-produced (wild) fall-run Chinook have very low survival rates and are largely considered to be the progeny of hatchery-reared adults (Moyle et al., unpublished report). Most wild YOY fry are expected to migrate through the Bypass prior to March 1st, with smolts potentially migrating as late as May or June (Williams 2006).

Late-fall-run Chinook (*O. tshawytscha*) adult migration occurs from November through April (Williams 2006), typically peaking in December and January (Moyle et al. 2008). Size criteria suggest that late-fall-run Chinook juveniles migrate most of the year (Williams 2006), but migration usually peaks in October (Moyle et al. 2008). Most juvenile late-fall-run Chinook likely migrate through the Yolo Bypass before March 1st, with peak smolt migration during October (Moyle et al. 2008).

Central Valley steelhead (anadromous *Oncorhynchus mykiss*) juveniles migrate from the Sacramento-San Joaquin River system from late December to the beginning of May, peaking in mid-March, with a smaller peak in fall. There is generally a lack of evidence to suggest that steelhead require floodplain rearing habitat prior to their marine stage (P. Moyle, personal communication), although Sommer et al. (2001b) noted the presence of a few individuals within the Yolo Bypass. Flooding of the Yolo Bypass is expected to only negligibly benefit Central Valley steelhead juveniles and may only benefit adult steelhead as an alternate migration route through mid-March.

Splittail (*Pogonichthys macrolepidotus*) adults migrate upstream from brackish water (low saline waters) in response to stream flow pulses from November to February (Moyle et al. 2015). Adults will usually spawn from March through April over submerged annual vegetation, although earlier spawning has been observed (Moyle et al. 2004). Juveniles rear in shallower floodplain habitats from March through April and migrate off the floodplain during April and May, as high flows recede. Both adult and juvenile splittail would benefit from flooding of the Yolo Bypass after March 1st. The Yolo Bypass is expected to flood in years when other areas would also be flooded due to high flows, making spawning habitat available in other areas (Sacramento-San Joaquin Delta, Suisun Marsh, Suisun Bay, and Yolo Bypass; see Topic #5). Consequently, spawning habitat is readily available elsewhere in years when the Bypass currently floods. During low water years, flow through an altered Fremont Weir may not be sufficient to cue spawning migration onto the floodplain, though we are unaware of any studies identifying threshold flows that cue such migrations. Consequently, it is uncertain how much splittail will benefit from an operable gate at Fremont Weir. A larger inundation (beyond just the Toe Drain) footprint could provide important rearing habitat for juvenile splittail in the Yolo Bypass. The exact number of acres needed for successful spawning and rearing to achieve biological goals for splittail is unknown.

Little is known about **white sturgeon** (*Acipenser transmontanus)* habitat use in the Central Valley. Prior to spawning, adults begin to move into the lower parts of rivers during winter and then move upstream when flows increase. Spawning occurs in response to increases in flow, typically in late-February to early-June. Spawning in the Sacramento River takes place between Knights Landing and Colusa, although adults historically accessed the Feather River as well, as noted in Moyle (2002). No recent spawning activity has been reported in the Feather River. Spawning takes place in deep water over gravel/rocky substrate (Moyle 2002). Juveniles in the Fraser River use deep water areas (> 5m) with soft sediments and lots of prey (including dipteran flies and mysid shrimp) (Bennett et al. 2005). Harrell and Sommer (2003) suggested that adult sturgeon may use the Yolo Bypass as an alternate migration route and numerous individuals have been rescued at the Fremont Weir due to insufficient flow and lack of passage in recent years. As proposed in RPA I.6.1 and I.7, adult white sturgeon would benefit from Yolo Bypass flooding and the use of the Bypass as an alternate migration route (Harrell and Sommer 2003). In addition, adult white sturgeon passage would benefit from plans to improve the fish ladder at Fremont Weir. Juvenile white sturgeon may also benefit from feeding opportunities on the floodplain after March 1st, but juveniles generally prefer deeper habitat and specific floodplain use of juveniles in the Central Valley (including Yolo Bypass) is unknown.

Green sturgeon (*Acipenser medirostris)* migrate into the Sacramento River to spawn in March to May, generally peaking between May and June (Adams et al. 2002, Heublein et al. 2009), though they are more rare in the Sacramento-San Joaquin drainage than white sturgeon. Adults prefer to migrate in deeper parts of the channel and will hold in deep pools, suggesting that the Yolo Bypass is not considered optimal habitat for adults. Similar to white sturgeon, adult green sturgeon presence has been noted on the Yolo Bypass and numerous individuals have been stranded and subsequently rescued at Fremont Weir (Thomas et al. 2013). Larval green sturgeon have lethal temperature tolerances near summer temperatures in the Sacramento River. YOY sturgeon do best (i.e., bioenegetic performance) under a temperature range between 15-19°C (reviewed in Beamesderfer et al. 2007). Larvae (20-60 mm) migrate downstream between May and August and juveniles can spend 1-4 years in freshwater.

As with adult white sturgeon, adult green sturgeon would benefit from Yolo Bypass flooding if RPA actions provided a viable alternate migration route for adults straying into the Bypass. In addition, adult green sturgeon passage would benefit from plans to improve the fish ladder at Fremont Weir. Juvenile green sturgeon are unlikely to directly benefit from floodplain habitat associated with the Yolo Bypass and there is no evidence of deliberate systematic use of the Yolo Bypass by juvenile green sturgeon (P. Moyle, personal communication).

Little is known about **river lamprey (***Lampetra ayresi)*. They have not been extensively studied in California and the following information is largely based on Moyle (2002). Adults migrate into freshwater in fall and spawn in tributaries in winter or spring. Upon hatching, larval lamprey (ammocoetes) burrow into silt-sand deposits in backwaters that are within the wetted channel. Ammocoete transformation occurs during summer and metamorphosis typically takes 9-10 months. Newly transformed juveniles aggregate just upstream of salt water and enter the ocean in late-spring. Juveniles spend 3-4 months in saltwater. Most of the Yolo Bypass is not considered suitable for ammocoetes because they need perennial water with soft sediments where they can easily burrow. Adults migrating upstream to spawn (before March 1st) and ammocoetes beginning their transformation (after March 1st) may benefit from Yolo Bypass flooding if RPA actions provide a viable alternate migration route.

Adult **Pacific lamprey** (*Entosphenus tridentatus)* spawning migrations begin from early-March to late-June, but migration has also been noted as early as January/February and as late as July (Moyle et al. 2015). Adults use gravel substrates in rivers to build nests and deposit eggs (Moyle 2002). Juvenile metamorphosis and downstream migration is associated with increases in flow in winter and spring. Similar to river lamprey, the Yolo Bypass is not thought to be suitable for ammocoetes because they need perennial water with soft sediments where they can easily burrow. In addition, ammocoetes are filter feeders and, as such, require water velocity to transport food resources (i.e., reduced residence time of water associated with floodplain habitat may affect food capture efficiency). Adults migrating upstream to spawn (before March 1st) and ammocoetes beginning their transformation (after March 1st) may benefit from Yolo Bypass flooding if RPA actions provide a viable alternate migration route.

Delta smelt (*Hypomesus transpacificus)* are mainly found downstream of the Yolo Bypass (Moyle 2002). Spawning success is highest at temperatures 15-20°C (Moyle 2002). Increased mortality is thought to be associated with contaminants, food limitation, predation, water withdrawals, and other environmental factors (Bennett 2005, Hammock et al. 2015, in press). Delta smelt distribution is confined to freshwater and low salinity areas of the San Francisco Estuary. Temperatures over 25°C are lethal to adults, while temperatures above 18°C may increase larval mortality (Moyle 2002). Komoroske et al. (2014), however, found that thermal tolerance shifted with ontogeny and that larval delta smelt were more tolerant of increasing water temperatures than adults. Actual spawning locations are unknown. However, spawning seems to take place between late- February and June, with larvae most abundant from mid-April through May (but are observed from February to mid-July). Spawning in the wild takes place with temperatures between 7-15°C. Delta smelt generally reside in close proximity to the west Delta and Suisun Bay and spawning migrations are initiated by the first winter pulse flow with individuals moving upstream at an average of 3.6 km/day where they generally hold prior to spawning, though variability in spawning behavior is evident (Moyle 2002, Sommer 2011). Copepods are preferred prey of Delta smelt. Delta smelt may benefit indirectly from Yolo Bypass flooding if carbon inputs are sufficient to substantially enhance prey availability in those areas they occupy (as in Schemel et al. 1996 in NHI et al. 2002). Studies suggest, however, that under some conditions bivalve grazing (i.e. from invasive non-native clams) may reverse benefits from increased primary productivity (Greene et al. 2011, Lucas and Thompson 2012) that would otherwise increase delta smelt prey. It is unknown if an increase in the inundation of the Yolo Bypass as a result of RPA actions would increase primary production sufficient to benefit delta smelt and, therefore, additional research is necessary.

Longfin smelt (*Spirinchus thaleichthys)* live in open water bays and channels (Moyle 2002), including areas in the San Francisco Estuary and Delta (CDFG 2009). A few adult longfin smelt have been collected from the Yolo Bypass, most commonly in the winter and spring when flows are low (CDFG 2009). Overall, longfin smelt are rare upstream of Georgiana Slough (CDFG 2009), but have been observed as far upstream as Rio Vista (Moyle 2002). Adults prefer open water with temperatures < 18°C (Moyle 2002). Adults move upstream to spawn over stream substrate or aquatic plants (see Moyle 2002). Most spawning occurs between February and April at temperatures <14.5°C (Moyle 2002). Larvae are most abundant from January to March and are also common in April-July (as in 1989-1990). Juvenile numbers peak in June and July (CDFG 2009). Larvae and juveniles seem to tolerate slightly warmer water, up to approximately 22°C (CDFG 2009). Use of the Bypass and other floodplain habitats by longfin smelt adults and juveniles is minimal (P. Moyle, personal communication). Over a four-year period that examined the use of the Yolo Bypass by native fishes, Sommer et al. (2001) did not note the presence of longfin smelt. Other factors, besides water temperature that influence habitat use by adult and juvenile longfin smelt include prey type and density, predator presence and abundance (including birds and piscivorous fish), dissolved oxygen concentrations, and levels of aquatic toxins (including pesticides).

5b: How will climate change affect these benefits?

The following is a modified excerpt from Moyle et al., unpublished report:

Climate change is already altering fish habitats in California and will continue to do so at an accelerating pace if current trends continue. In general, conditions are declining for native fishes and improving for many alien fishes. For most species of native fish, the predicted outcomes of climate change are likely to accelerate current declines, potentially leading to extinction in the next 50-100 years if nothing is done to offset climatic impacts (Moyle et al. 2013). This section is focused on two major aspects of climate change that affect fish distribution and abundance in California rivers: water temperature and precipitation.

Water Temperature. Water temperatures have been rising in streams for some time and are continuing to rise (Kaushal et al. 2010). In California, there are diverse climate change models to predict future water temperatures, but the more conservative models generally converge on scenarios that assume that within 50–100 years, water temperatures will increase between 1°C–4°C (1.8°F–7.2°F) and 1.5°C–6°C (2.7°F–10.8°F) (Miller et al. 2003, Cayan et al. 2009). Further, annual snowpack in the Sierra Nevada and Cascade mountain ranges is expected to diminish greatly, resulting in stream flows increasingly driven by rainfall events. An increase in the ratio of rain to snow will result in more peak flow events during winter, increased frequency of high flow events (floods), diminished spring pulses, and protracted periods of low (base) flow. In addition, there will be more extended droughts. These conditions will translate into warmer water temperatures at most elevations, reflecting both increases in air temperatures and reduced summer flows. The impacts of climate change on fish are likely to be most severe on cold water species (<18°C–20°C, or 64°F–68°F), especially salmon and trout (Katz et al. 2013). Warming (more days with maximum temperatures > 20°C or > 68°F) of the more freshwater regions of the San Francisco Estuary is regarded as an additional threat to declining endemic species such as delta smelt (Wagner et al. 2011).

Precipitation. Models indicate that precipitation in California will become more variable, with an increase of precipitation falling as rain and less as snow (Cayan et al. 2009). Generally, the total amount of precipitation by 2100 is projected to be less, although the extent of loss is highly uncertain (Cayan et al. 2009). Runoff type streams seem particularly vulnerable to climate change effects with snowmelt streams, in particular, becoming more similar to rain-fed streams. Earlier snowmelt has already resulted in high flow events occurring earlier by an average of 10 to 30 days (Stewart et al. 2005), with annual peak discharges also occurring earlier (Cayan et al. 2009). These changes dramatically affect flows in low-elevation rivers in the Central Valley and are leading to modified reservoir operations (dam releases). Overall, the amount of water carried by streams in California (and the rest of the western United States), will decrease by 10 to 50 percent during drier months, if current trends continue (e.g., Cayan et al. 2001).

There is considerable uncertainty on the effects of climate change on floodplain habitat, particularly in the Central Valley. However, increased water temperature and changes in discharge patterns will broadly affect ecological processes including habitat suitability for cold water species. We can infer that an earlier runoff period (Stewart et al. 2005), broad reductions in snowpack (Hayhoe et al. 2004), and higher magnitude winter peak events (Das et al. 2011) will likely also affect the timing and magnitude of floodplain inundation making the seasonal occurrence of such habitat less predictable. For instance, flooding may occur earlier, but for less sustained periods of time in the Central Valley. This suggests that an operable gate at the bypass and the ability to manipulate flood timing or periods of inundation may be a valuable tool to promote juvenile salmonid rearing and adult passage.

5c: What are the different mechanisms through which splittail spawning success in the Yolo Bypass can be measured, taking into consideration that different organizations will define spawning success differently?

Successful splittail spawning could be measured in a number of different ways, including the number of adults spawning on the floodplain or the number of eggs deposited per acre of inundated floodplain. While such methods would provide some insight on successful reproduction, it is probably more useful to measure juvenile splittail recruitment associated with the Yolo Bypass. The most practical way to measure spawning success is to measure the number of age-0 splittail emigrating off the floodplain during the flood recession using some type of juvenile trap such as a rotary screw trap (e.g., Feyrer et al. 2006) or fyke nets. Such methods would not only provide valuable insight on population recruitment, but also enable evaluation of the benefits of floodplain habitat on juvenile splittail reproduction and rearing.

5d: Do splittail need 10,000 acres of floodplain habitat to spawn successfully in the Yolo Bypass? Would success be possible if splittail floodplain habitat is limited to the lower Yolo Bypass, such as areas in Cache Slough? Are there other opportunities for creation of successful splittail spawning habitat outside of the Yolo Bypass?

Adult splittail generally migrate upstream during late fall and winter and cue off increasing discharge associated with runoff events (Sommer et al. 1997). Their life history is tightly tied to floodplain habitat, as spawning adults require submerged vegetation where eggs can be effectively deposited (Sommer 1997, Moyle 2002, Feyrer et al. 2006). Habitat quantity (i.e., 10,000 acres) is probably not as important as habitat quality (i.e., presence of submerged vegetation, abundant food resources, cover from predators, etc.) and the timing of floodplain inundation and recession. However, the relationship between spawning success, juvenile recruitment, and size of flooded area has not been evaluated. Presumably, there is an optimal area of floodplain inundation required where population benefits are realized, but this likely depends on adult spawning population size, size and fecundity of spawning adults, access to suitable habitat by migrating fish, amount of suitable spawning and larval habitat (annual submerged vegetation), production of food for larvae and juveniles, duration and extent of inundation of suitable rearing habitat, and presence of ‘escape routes’ for juveniles to allow movement off the floodplain and downstream to rearing habitats in places such as Suisun Marsh as inundation recedes (P. Moyle, personal communication). The latter may depend on sufficient production of juveniles to compensate for predation during the outmigration period, though splittail are particularly fecund, which may reduce such threats. Successful spawning is known to occur in other parts of the system (e.g., Sutter Bypass, Cache Slough, Napa River, Cosumnes River) and, thus, splittail are not solely reliant on the Yolo Bypass. For instance, recent work by Feyrer et al. (2015) suggests that splittail populations from the Napa and Petaluma River complex and those from the Central Valley exhibit a metapopulation dynamic where gene flow between populations occurs during periods of heightened freshwater inflow to the delta. Access to floodplain habitat on the Yolo Bypass, however, would likely improve splittail population dynamics, especially during wet periods, because floodplain habitat is generally limited on the Sacramento River. Further research is required regarding the balance between habitat quality, quantity, and timing of inundation. Please refer to Topics # 5, 6 and 7, above, for additional details.

5e: How long do juvenile salmon and splittail need to stay on the Bypass floodplain to realize significant benefits?

We define 'significant benefits' as improved body condition and growth for juvenile salmonids and improved splittail juvenile recruitment rates relative to mainstem river conditions. Sommer et al. (2001b) found that splittail year class strength was stronger when juvenile splittail were able to spawn and rear on the Yolo Bypass for greater than three weeks between March and April. Jeffres (2008) found that after 17 and 20 days, enclosed juvenile salmon on a Cosumnes floodplain showed significant differences in growth when compared with fish reared in the Cosumnes River during 2004 and 2005, respectively. On experimental floodplains at Knaggs Ranch, Katz et al. (2013) found that apparent growth rate (mm/day) was greatest between the third and fourth week of the study, but that growth continued to increase (despite the rate slowing) until the experiment ended between week five and six. Sommer et al. (2005) determined that Yolo Bypass residence times of planted, tagged hatchery Chinook juveniles ranged from 30-56 days between 1998 and 2000. It is probable that a longer event (i.e. >3 weeks) would increase primary and secondary production with cascading benefits to higher order consumers such as juvenile salmonids, though even short inundation periods may provide some ecological benefits to species that use the Bypass (Sommer et al. 2004). There are many interacting factors to consider with such an assumption, however. For instance, the time between initial flooding of the Bypass and subsequent juvenile Chinook emigration to the floodplain appears to be an important consideration. If the inundation period is long enough to catalyze important food web processes (i.e., initial phytoplankton production followed by zooplankton), the duration required to realize significant biological benefits may be shorter than if initial floodplain inundation and juvenile salmon access occur simultaneously or of similar timing (see Schemel et al. 2004 for discussion regarding floodplain inundation and phytoplankton production). In addition, juvenile salmon and splittail floodplain residence time will vary by individual, suggesting that an increased inundation period would benefit larger proportions of respective populations. In all likelihood, the time necessary for juvenile fishes to realize ecological benefits likely varies and is dependent on water type year, flood inundation magnitude, timing, recession rates, residence time, depth, water temperature, and food production.

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Two-Dimensional Movement Patterns of Juvenile Winter-Run and Late-Fall-Run Chinook Salmon at the Fremont Weir, Sacramento River, CA

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Final report

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Sacramento, CA 95814-2536

Under Project R13PB20203, “Habitat Restoration and Fish Passage Research and Evaluation”

Abstract

To improve modeling of juvenile salmon behavior and movement in the Sacramento River, smaller winter-run Chinook and larger late-fall-run Chinook salmon were tagged and released into a 2D telemetry array during the winter of 2015. Detection positions were filtered and discretized to create two-dimensional tracks and measure movement characteristics, evaluate space use, and assess whether these runs displayed distinct behavioral differences. Speed over ground and turning angle were not significantly different between release times, fish size, or run. Only the initial movement rate between release and array locations was significantly different between the runs. Both runs displayed a non-uniform distribution within the channel and tended to use space along the outer bend more frequently than the inner bend. Winter-run Chinook salmon tracks were slightly farther towards the outer bend than late-fall-run Chinook. A similar result was not observed in smaller and larger late-fall-run Chinook, which suggested that differential space use may be influenced more by run identity than variation in size between runs. Although small differences between runs were measured, it is reasonable to aggregate these results for a singular juvenile salmon behavior model, rather than developing independent juvenile behavior models based on adult run-timing.

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Preface

This study was conducted for and funded by the US Bureau of Reclamation under Project Number R13PB20203, “Habitat Restoration and Fish Passage Research and Evaluation.” The technical monitor was Dr. Pat Deliman, Technical Director, Environmental Engineering and Science.

The work was performed by the Water Quality and Contaminant Modeling Branch (CEERD-EPW) of the Environmental Processes and Engineering Division (CEERD-EP), US Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL).

The authors extend special thanks to the ACOE Sacramento Division, US Geological Survey California Water Science Center, California Department of Water Resources Division of Environmental Services; the US Fish and Wildlife Service (USFWS) Livingston Stone National Fish Hatchery; and the USFWS Coleman National Fish Hatchery.

At the time of publication, Mark Noel was Acting Chief, CEERD-EPW; Warren P. Lorentz was Chief, CEERD-EP; and Dr. Pat Deliman, CEERD-EZT, was the Technical Director for Environmental Engineering and Science. The Deputy Director of ERDC-EL was Dr. Jack E. Davis and the Director was Dr. Beth C. Fleming.

COL Bryan S. Green was the Commander of ERDC, and Dr. David W. Pittman was the Director of ERDC.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
cubic feet	0.02831685	cubic meters
degrees (angle)	0.01745329	Radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
feet	0.3048	Meters
hectares	1.0 E+04	square meters
miles (US statute)	1,609.347	Meters
miles per hour	0.44704	meters per second
ounces (mass)	0.02834952	Kilograms
ounces (US fluid)	2.957353 E-05	cubic meters
pints (US liquid)	0.473176	Liters

1 Introduction

1.1 Background

On June 4, 2009, the National Marine Fisheries Service (NMFS) issued its final Biological Opinion and Conference Opinion on the Long-Term Operation of the Central Valley Project (CVP) and State Water Project (SWP) (NMFS Operation BO). The NMFS Operation BO concluded that, if left unchanged, CVP and SWP operations were likely to jeopardize the continued existence of four federally listed anadromous fish species: Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead (*O. mykiss*), and Southern Distinct Population Segment (DPS) North American green sturgeon (*Acipenser medirostris*). The NMFS Operation BO sets forth Reasonable and Prudent Alternative (RPA) actions that would allow continuing SWP and CVP operations to remain in compliance with the federal Endangered Species Act (ESA). These include restoration of floodplain rearing habitat, through a "notched" channel that increases seasonal inundation within the lower Sacramento River Basin. A significant component of these risk reduction actions is lowering a section of the Fremont Weir (Figure 1) to allow juvenile fish to enter the bypass and to allow adult fish to more easily ascend this hazard. Questions remain on the details of notch implementation (size, location), fish entrainment efficiency, and species-specific and ontology-based behaviors.

1.2 Objective

The purpose of this study is to quantify the behavior of winter-run Chinook and late-fall-run Chinook (*Oncorhynchus tshawytscha*) in the Sacramento River adjacent to the Fremont Weir. This weir serves as the boundary between the main channel of the river and the Yolo Bypass (Bypass), a major flood bypass reach.

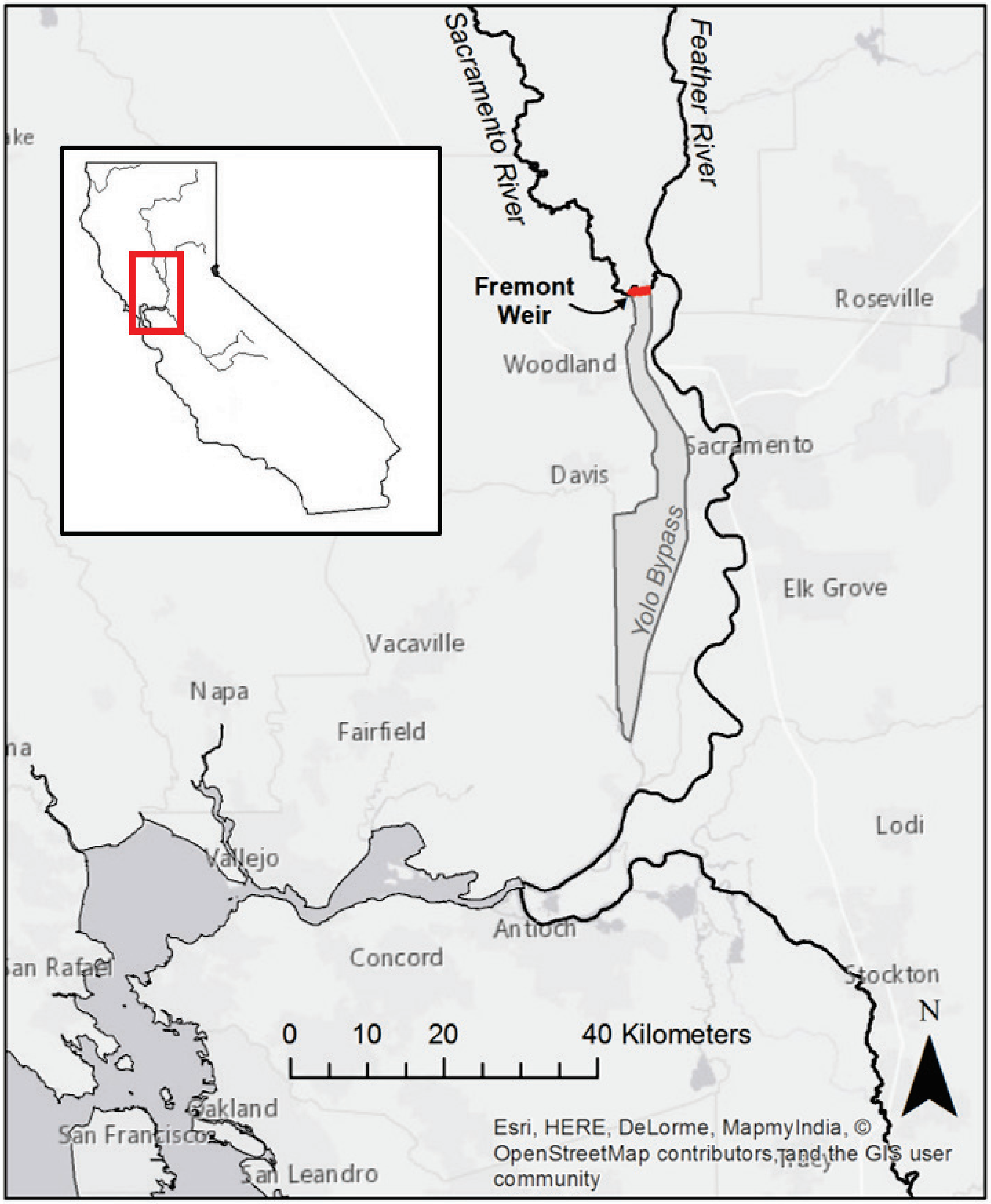
Results from this study will be used to inform a fish behavioral model using the Eulerian–Lagrangian–Agent Method (ELAM) to predict fish behavior in the region for floodplain restoration planning. Floodplain restoration is needed because there have been significant modifications made to the historic floodplain of California's Central Valley for flood damage reduction purposes and water supplies. The resulting losses of rearing habitat, migration corridors, and food web production for fish have significantly hindered native fish species that rely on floodplain habitat during part or all of their life history. The Bypass, which currently experiences at least some flooding in approximately 80% of years, still retains many characteristics of the historic floodplain habitat that are favorable to various fish species. In approximately 70% of years, Fremont Weir overtops, connecting the Bypass to the Sacramento River along its northern boundary, and Sacramento flows join flows from western tributaries. In approximately 10% of years, localized flooding is due to western tributary contributions only. The primary function of the Bypass is flood damage reduction, with most of it also managed as agricultural land. The Bypass has also been identified by several state and federal entities as a potential site for habitat restoration to ease pressure on and increase benefits to threatened and endangered fish species.

1.3 Approach

The system of weirs on the Sacramento River was designed with the understanding that runoff from many of the storm events experienced in the Sacramento River watershed cannot be contained within the banks of the river. Nor could this flow be fully contained within a levee system without periodically flooding adjacent property. Thus, the weirs were designed to occasionally spill through a system of weirs and flood relief structures into adjacent basins. These basins are designed to contain flood waters and channel them downstream to eventually be conveyed back into the Sacramento River near Knights Landing and Rio Vista. Dry weather flows are contained within levees near the river banks, and land within the flood basins is then used for agricultural purposes.

Fremont Weir is one weir on the Sacramento River (Figure 1). It was completed in 1924 by the USACE. It is the first overflow structure on the river's right bank and its two-mile overall length marks the beginning of the Yolo Bypass. It is located about 15 miles northwest of Sacramento and eight miles northeast of Woodland. South of this latitude, the Yolo Bypass conveys 80% of the system's floodwaters through Yolo and Solano Counties until it connects to the Sacramento River a few miles upstream of Rio Vista. The weir's primary purpose is to release overflow waters of the Sacramento River, Sutter Bypass, and the Feather River into the Yolo Bypass. The crest elevation is approximately 33.5 ft (USED) and the project design capacity of the weir is 343,000 cfs. Adding the notch to this weir will change the amount of time that water flows over it and increase access to the floodplain for juvenile salmon.

Figure 1. Map of the lower Sacramento River, California, indicating the Yolo Bypass and Fremont Weir.



2 Study Design and Data Collection

2.1 Acoustic positioning array

2.1.1 Equipment

This study used acoustic tracking technology developed by Vemco (Halifax, NS, Canada). Fish are outfitted with acoustic transmitters, or tags, that emit a series of pulses, which include a uniquely identifiable code. The signals are received by autonomous units with hydrophones and processing software that includes high-precision internal clocks. To position tagged fish in two dimensions, 40 high-resolution receivers (HR-1, 180 kHz) were deployed through the study area. HR-1 receivers were used because they can detect tags using both pulse-coding and frequency-modulated coding technologies. The latter format reduces concern about overlapping tag signals and loss of detections common with pulse-coded transmissions (Voegeli et al. 2001). When a single tag signal is detected at multiple receivers, the differences in the time of detection can be used to calculate the distance of the tag from each receiver, thus allowing its position to be calculated. For further discussion of 2D positioning see Espinoza et al. (2011), Roy et al. (2014), and Steel et al. (2014).

Because receivers are autonomous units, the clocks must be synchronized during post processing to avoid positioning errors due to clock drift. To achieve this, each receiver is deployed with a co-located sync tag, which allows for later synchronization. To provide information about the accuracy of the positioning array, reference tags are also deployed throughout the study area to estimate positioning error. In this study, 21 reference tags were placed at known locations, primarily along the center of the channel.

2.1.2 Deployment and retrieval

Receivers, sync tags, and reference tags were deployed by US Geological Survey based on the suggested positioning provided by Vemco. Equipment mounts were designed to maintain the receivers in position at an upright orientation (Figure 2). Receivers were located with hydrophone tips approximately 65 cm above the substrate. Each receiver was co-located with a sync tag, attached to the mount at approximately 112 cm above the substrate. At five of the forty mounts, the receiver and sync tags were placed an additional 56 cm above the substrate.

Figure 2. Image of a receiver as deployed within the study area.

Mounts were deployed with the assistance of divers to ensure mounts were in a stable and upright location. Two to four mounts were attached to a cable, which was then anchored to shore. When complete, the array included 14 cabled lines of receivers, which covered approximately 0.7 river km. This section of the river ranged from 60 to 100 m wide (Figure 3).

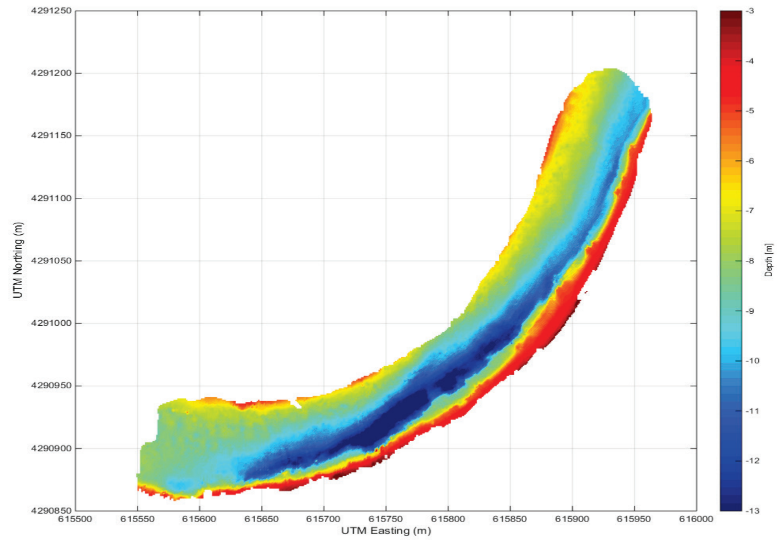
Figure 3. Forty tag-detecting receivers (Vemco) were deployed along approximately 0.7 km of the Sacramento River at the site of the Fremont Weir. The array design allowed for the fine-scale positioning of tagged juvenile salmon as they migrated through the river.

The retrieval of equipment began on 6 Feb 2015. A storm was forecast with large expected increases in river stage, which raises the likelihood of equipment becoming buried in sediment or snagged by debris, preventing retrieval. The loss of data from a few receivers would jeopardize the ability of the entire system to accurately calculate fish positions; consequently, the team removed the equipment to ensure quality data for those fish that had already passed through the array. Array removal was also conducted by US Geological Survey.

2.2 Hydraulic and bathymetry data

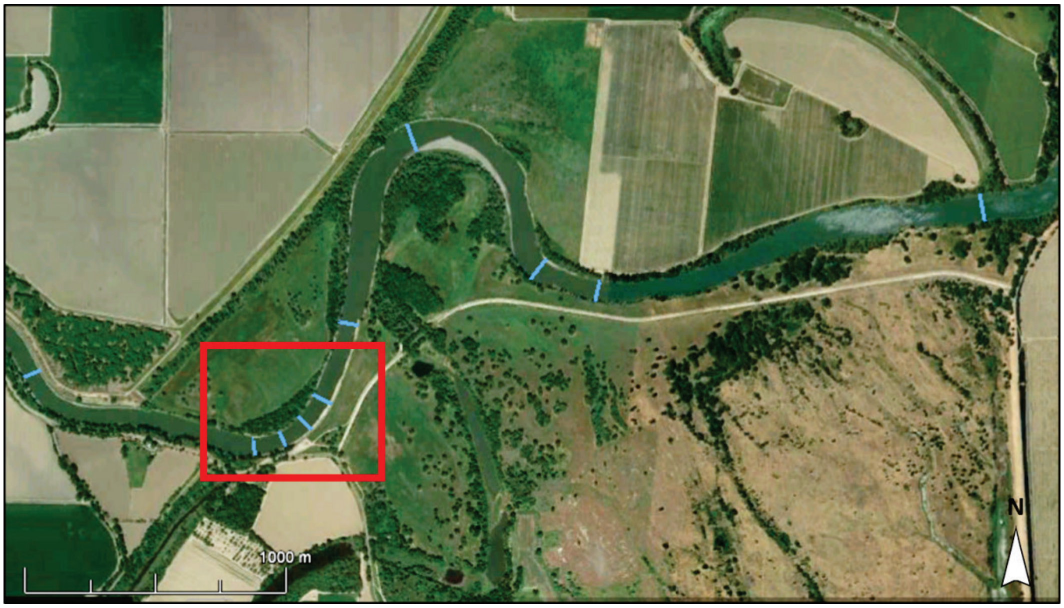
Initial surveys of the geomorphology and hydrology of the study reach were completed in November and December 2014 by the United States Geological Survey (USGS). River velocities and bathymetry were mapped from a boat with an RDI Rio Grande Workhorse acoustic Doppler current profiler (ADCP) and a differential GPS. The results from these surveys were used to create bathymetry maps for the study coordination team to complete successful planning of the study design (Figure 4). Additional extensive surveys were conducted by the California Department of Water Resources (DWR) with a Knudsen Engineering Limited Sounder 1612 survey-grade echosounder and transducer. Surveys were conducted between 21 January and 27 January 2015 to create bathymetric maps of the entire region (See Appendix H for cross-section locations). Cross-sectional sweeps from these surveys were combined with a longitudinal profile collected on 8 April 2015 to create final bathymetric maps for use in computational fluid dynamic modeling (see Lai 2016 for details).

Figure 4. Bathymetric map of local study area, from data collected by ADCP surveys.



To estimate current profiles in the study region during the period of fish releases, additional ADCP surveys were conducted by California DWR. Surveys were not conducted concurrently with fish passage windows to avoid unwanted interference between the ADCP equipment and the acoustic receivers, as noise created by ADCP equipment can reduce fish-tag detection. An initial survey was completed on 26 January 2015 just prior to the first release of fish, at a river stage of 14.5 ft. Ten cross-sectional transects were surveyed, with six separate passes at each cross-section during a single survey (Figure 5). The processed data were used to verify results from the computational fluid dynamic modelling (Lai 2016), which is used to support ELAM modeling of fish behavior in the study area.

Figure 5. Map of cross-sectional transects in Sacramento River surveyed with ADCP equipment to map hydrodynamics. Area outfitted with acoustic receivers indicated by red box.



2.3 Study fish

2.3.1 Tagging

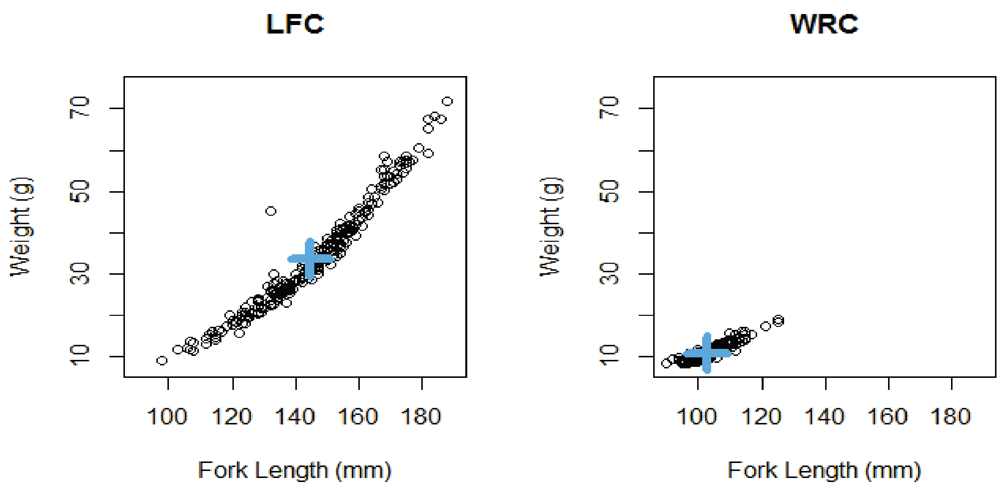
Acoustic tags were surgically implanted in the study fish following the methods outlined in Appendices A and B. Tags were manufactured by Vemco, model V4, measuring 11 mm and 0.42 g in air. They emitted a signal at 180 kHz, and were programmed to transmit at a random interval every 1-2 sec. Surgical procedures were derived from Liedtke et al. (2012), and from procedures used by Cramer Fish Sciences, by DOI's Interior South Delta telemetric studies, and by the US Army Corps of Engineers, Sacramento District telemetric studies. A total of 499 fish were tagged and released, consisting of 249 winter-run and 250 late-fall-run juvenile Chinook (there was one winter-run mortality before release). Winter-run Chinook (WFC) were acquired, tagged, and held at Livingston Stone National Fish Hatchery, and late-fall-run Chinook (LFC) were acquired, tagged, and held at Coleman National Fish Hatchery. Due to the size of the tag and a desire to keep the tag burden less than 5%, study fish were limited to those >8.2 g at the time of tagging.

Before surgery, fish were anaesthetized individually in a 19L bucket. The water was super-saturated with oxygen, to a level of 120-150%. Dissolved oxygen levels were maintained using an airstone and pump. Due to differing regulations for groups listed under the Endangered Species Act, different anesthetic drugs were used for the two runs. WRC were anesthetized with tricaine methanesulfonate (MS222), beginning at dosages of 70 mg L-1, and buffered to a pH of 7 - 8 with sodium bicarbonate. LFC were anesthetized with AquiS®, beginning at dosages of 30mg L-1. Both dosages were adjusted as needed to ensure that fish reached anesthesia within 2-4 min. Fish were rejected from the study if they were anesthetized in less than 1 or more than 5 min (N_{LFC} = 11, N_{WRC}=6). A small amount of Stress Coat® (a water conditioner and artificial slime coat) was also added to anesthetic baths to protect fish from loss of the slime layer during tagging.

Upon reaching surgical anesthesia, fish were weighed and measured (fork length, FL) and assessed on a categorical scale for condition (eyes, fins, scales). Full anesthesia was defined as loss of equilibrium and no response to firm pressure on the caudal fin (Neiffer and Stamper 2009). Any fish classified as poor were rejected from the study (N_{LFC} = 7, N_{WRC}=6). Fish were then transferred to a microcell foam surgical cradle where the gills were bathed with a maintenance dose of anesthesia (20 mg L^{-1} MS-222; 10 mg L^{-1} AquiS®). An incision approximately 5 mm long was made parallel to and offset from the ventral line, anterior to the pelvic girdle. A disinfected tag was placed into the peritoneal cavity of the fish and positioned to lie immediately under the incision. The incision was then closed with a simple suture, using a 3/8 circle needle with 4/0 Mono-Dox (violet monofilament polydoxanone) suture material. All surgical materials were disinfected before surgery and between fish. Any surgery that did not meet quality standards resulted in the fish not having been implanted with a tag and the specimen was allowed to recover (N_{LFC} = 4, N_{WRC}=14).

Due to differences in life-history timing, juveniles from each run were different in size during the period of tagging. Fish were selected from available stock at random, and rejected if they were below 8.2 g or greater than 200 mm fork length (FL; N_{LFC} = 1, N_{WRC}=21). The tagged LFC had a mean length of 145 mm FL, and WRC had a mean length of 103 mm FL. The mean weight of tagged LFC was 34 g, while the WRC mean weight was 11.0 g (Figure 6).

Figure 6. Comparison of the size of tagged fish used in the study. LFC = late-fall-run Chinook juveniles; WRC = winter-run Chinook juveniles. Blue crosses indicate mean size.



Post-surgery, fish were allowed to recover alone in a 19L bucket for 10 min. After confirming the fish was upright and actively swimming, it was transferred to a circular holding tank. If a fish did not recover to a state of active swimming within a reasonable period of time (>1 hr), it was euthanized and the tag was removed (N_{LFC} = 1). Each circular holding tank contained 25 fish with known tag IDs, with the exception of four circulars at Coleman National Fish Hatchery; each of these four tanks held 50 LFC. Fish were held in these circular tanks for 1-2 weeks, depending upon their assigned release date, and were fed daily except for the final day before release. Each day tanks were scanned for mortalities, and the water was monitored for dissolved oxygen (mg L^{-1} and % saturation) and water temperature (°C). Throughout the surgical and recovery process, water temperatures in all tagging and transport containers were never greater than 2°C different from the reference water source where the fish were raised.

2.3.2 Transport and release

To transport fish from the hatchery to the release site, fish were loaded into oxygenated coolers and driven roughly 2.5 hr to a private dock near the town of Knights Landing. No more than 13 fish were transported in a single cooler, and rock salt was used to increase the salinity of the transport water to around 3 ppt. Transporting fish in mildly brackish water reduces the osmotic gradient between a fish and its environment. This is considered a good practice, as stress from handling causes fish to produce epinephrine, which, in turn, increases gill surface area (Wedemeyer

1996). The physiological change allows freshwater to diffuse inward more rapidly, and if the osmotic gradient is large, this diffusion can overwhelm the osmotic and ionic regulatory controls of the fish. Adding salt to the transport water reduces this ion imbalance and reduces stress for the fish (Moyle and Cech 2004). In addition, Stress Coat®, a water conditioner and artificial slime coat, was added to transport water to help the fish to maintain a mucus layer as a barrier against disease and infection, as handling of fish can also reduce the natural mucus layer (Harnish et al. 2011).

Water quality parameters (dissolved oxygen, water temperature, and salinity) were measured upon transfer of fish from hatchery tanks into coolers, halfway through transport, and upon arrival at the release site. Upon arrival at the release site, if there was greater than 2°C of difference in water temperature between the coolers and the river, a slow exchange of water was used to equilibrate the coolers to river temperature without shocking the tagged fish.

Once the temperatures were within 2°C of one another, fish were transferred from the coolers into in-river holding pens using sanctuary nets. Before fish were removed from coolers, a customized HR-180kHz-EXT receiver was placed in each cooler to record the tags present.

In-river holding pens were circular, made of perforated heavy-duty plastic (1/4 in. holes), approximately 120 L, and had a tight-fitting lid. All pens floated in the river alongside a dock, with air-space between the top of the water and the lid so smolts could fill their swim bladder at the surface if needed. Each pen contained the same 25 individuals, which were held together in circular tanks at the hatchery prior to transport, except for those hatchery tanks that contained 50 fish. In these cases, two in-river pens contained the individuals originally held together. Fish were habituated to the river in these pens for a minimum of 24 hr, while the team checked dissolved oxygen in the adjacent river every 4 hr to ensure fish were experiencing suitable water quality conditions.

After the initial holding period, fish from two pens constituting 25 WRC and 25 LFC were released in the center of the channel every 5 hr throughout the following 24 hr period (Figure 7). At each release, fish were allowed to volitionally swim from the pens. Water quality measurements were recorded at the time of release. When fish were released, the river stage was approximately 14.6 ft at the Fremont Weir gauge, corresponding to a discharge of approximately 5700 cfs (Table 1).

Figure 7. Release times of study fish indicated by vertical red lines, overlaid on a hydrograph of the Sacramento River near the release site. All fish experienced very similar release conditions.

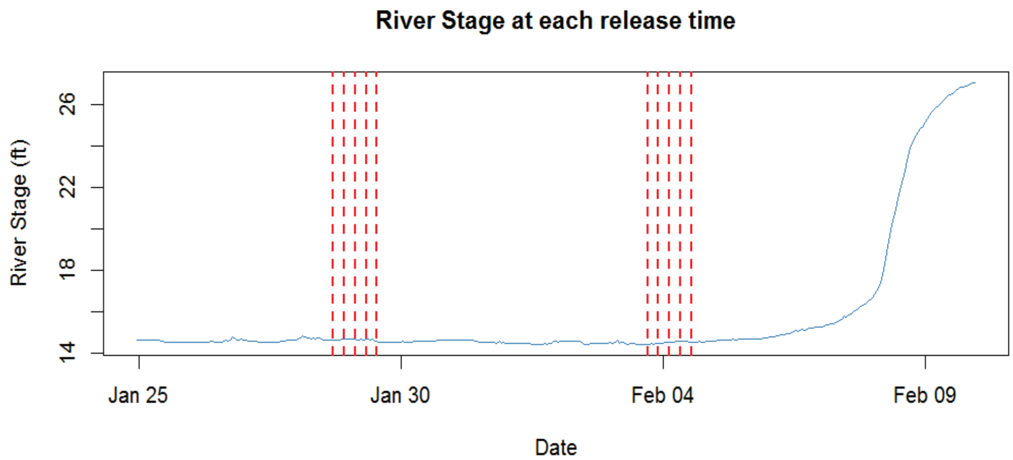


Table 1. Release groups (ca. 25 individuals from each run) were released every five hours during each 24 hr release period. The river stage, measured at Fremont Weir (FRE), and the neighboring discharge gauge 56 rkm upstream at Wilkins Slough (WLK) both suggest similar release conditions for each group. Two winter-run individuals were not released; one was a mortality before release and the second escaped during transfer to the river holding pens.

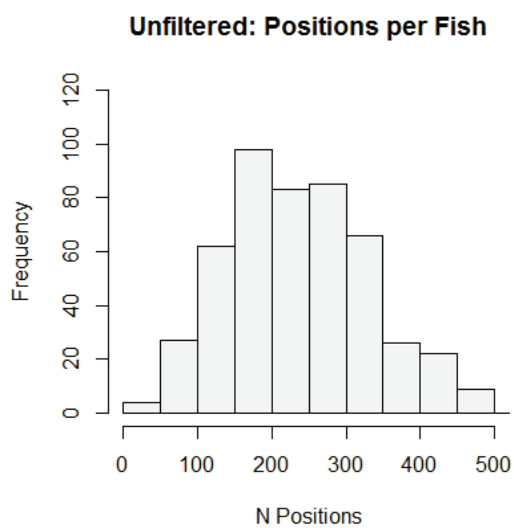
Release Date	Release Hour (PST)	Stage @ FRE (ft)	Q @ WLK (cfs)	N_{LFC}	N_{WRC}
01-29-2015	17:00	14.63	5710	25	25
01-29-2015	22:00	14.65	5710	25	24
01-29-2015	03:00	14.65	5710	25	25
01-29-2015	08:00	14.68	5700	25	25
01-29-2015	13:00	14.54	5690	25	24
02-04-2015	17:00	14.39	5600	25	25
02-04-2015	22:00	14.42	5610	25	25
02-04-2015	03:00	14.52	5600	25	25
02-04-2015	08:00	14.58	5590	25	25
02-04-2015	13:00	14.52	5630	25	25

3 Statistical Analysis and Results

3.1 Array performance

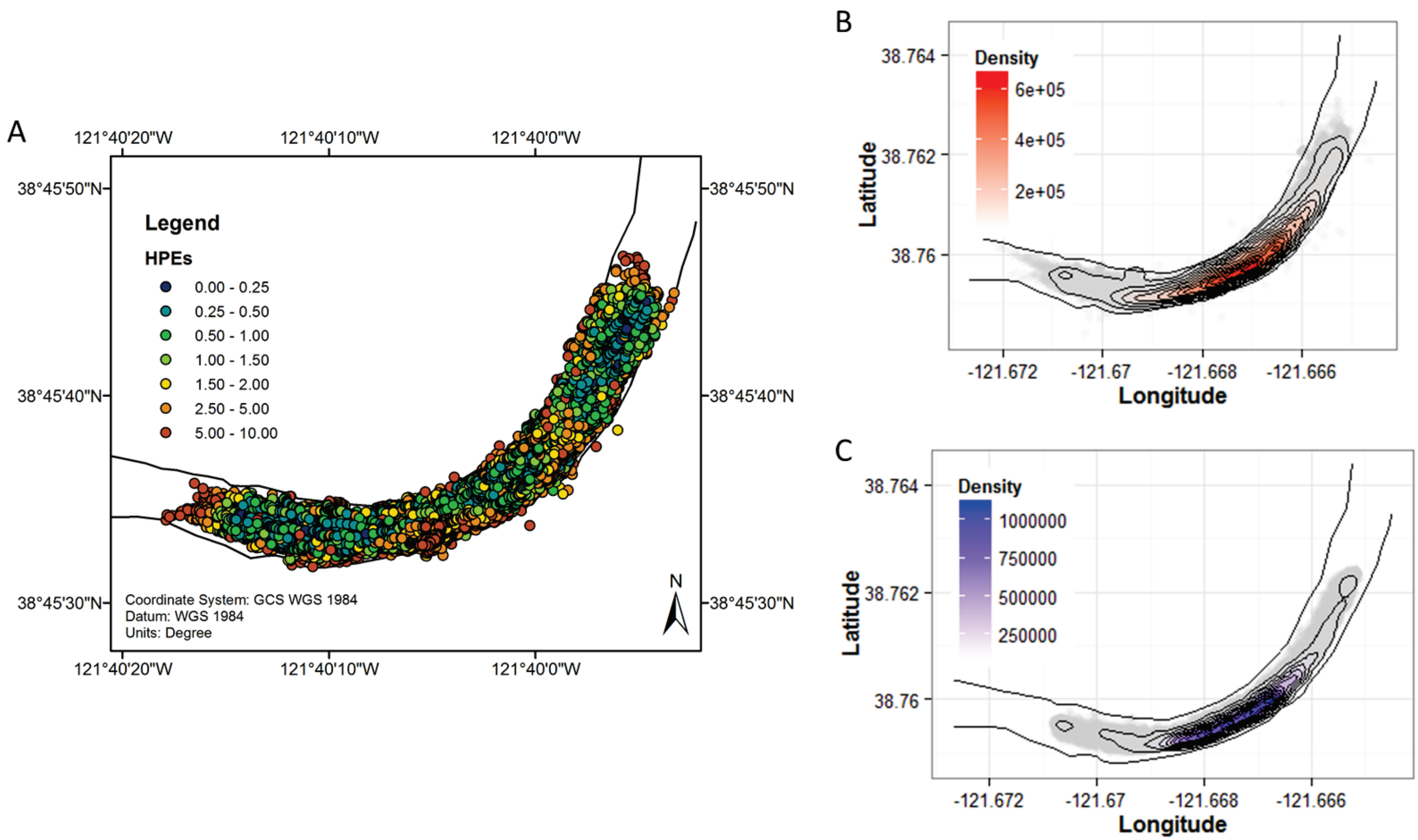
The 2D positioning array performed very well, with frequent detections and low error. A total of 168,234 positions were recorded during the study from 28 Jan 2015 to 6 Feb 2015, comprising positions for 490 of the 499 fish released. The remaining nine fish are presumed to have died within the 8 rkm between the release site and the array. The median number of positions per fish was 233, equating to approximately one position every 3 m if the positions were evenly spaced (Figure 8). Estimates of system precision made by Vemco's post-processing team used positions calculated for the sync and reference tags and were on the order of 2 m.

Figure 8. The number of positions recorded per fish, with a median of 233 positions.



There was low spatial variability in array performance within the study area. During post-processing, Vemco calculated a metric of quality for each position referred to as the Synthesized Position Error Sensitivity, and termed HPEs due to historical naming convention. This error estimate is described as a "relative, unitless estimate of error sensitivity" (Smith 2013) and should not be interpreted in terms of distance. Overall, the calculated values of HPEs were low, indicating that positional errors were low. There was also no specific region of poor detection or high error within the array; thus, when positions were filtered using a set threshold of HPEs, there was no substantial difference in the distribution of points removed versus those retained (Figure 9).

Figure 9. Map showing error associated with recorded positions. (A) Color indicates associated HPEs' value (an estimate of positional error). Positions shown with HPEs<10; fewer than 1% of total positions are omitted. (B) Density of positions and associated contour lines for all positions with an estimated error (HPEs) > 0.5 and (C) all positions with an estimated error <0.5. Darker colors indicate greater density of positions.



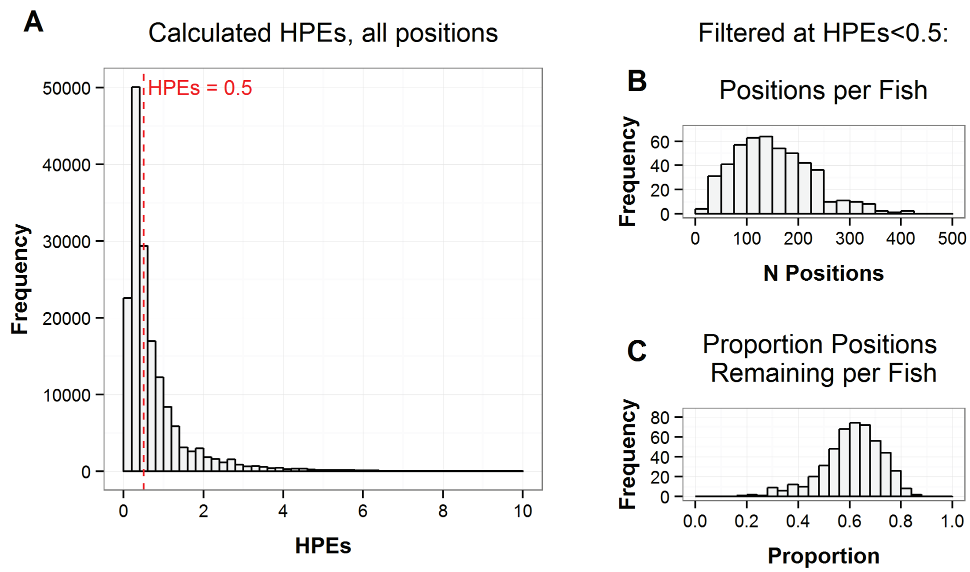
3.2 Data filtering

3.2.1 Primary filtering

Data manipulation and analysis was primarily conducted with the software program R (R Core Team 2015), and spatial analyses were done within the geographic coordinate system WGS84, with an azimuthal equidistant projected coordinate system for X, Y projected coordinates of fish positions. Primary data filtering was based upon the estimated positional uncertainty, HPEs, associated with each position. This value is calculated during post-processing at Vemco, as described previously. All positions with HPE values greater than 0.5 were removed from analysis (Figure 10). This threshold was selected based upon a detailed assessment of positional precision for both stationary reference tags and mobile fish tags, conducted by Vemco during post processing. Of the thresholds assessed, the research team determined that this choice provided the best tradeoff between data quality and quantity. Using an HPE threshold of 0.5 retained 52.8% of the original positions (88,752), with a median of 144 detections per fish (Figure 10, inset). This averages to approximately one position every 5 m, if the positions were evenly spaced, indicating that there is still a high density of positions remaining per fish after the primary filtering.

A visual assessment of tracks before and after preliminary filtering suggests no change in the fundamental properties of the tracks. Additionally, assessment of the spatial distribution of positions removed versus those retained suggests there was not a substantial bias in HPE values; thus, the filtering process should not lead to erroneous conclusions about space use by the study individuals (Figure 9). Based on the assessment by Vemco, the median estimated error of remaining animal positions was 1.21 m, while 95% of the positions had estimated errors <4.17 m, and 90% had estimated errors < 2.84 m. These estimates are biased high due to the estimation method, which used the variance of the distances between all pairs of points detected within 2 sec of one another. Therefore, a portion of this error is attributable to true movement of fish, while the remainder is due to error in the positioning itself. Much of this true error likely results from imprecision in the assumed fish depth (1.5m) or from multipath effects of the acoustic transmission as it travels between the tag and the receiver. There are additional environmental factors that can result in error (e.g., water temperature), but the authors expect these errors to be smaller than others discussed here.

Figure 10. Filtering level and resulting data set. (A) Distribution of estimated HPE values (estimation of positional error) for all positions recorded by the array, with vertical red line indicating chosen filtering level of HPEs < 0.5; (B) positions per fish after filtering at selected level; and (C) proportion of positions remaining per fish after filtering at selected level.



3.2.2 Secondary filtering

In addition to filtering the dataset by the HPEs values, the research team used several secondary filtration methods to remove problematic detections. The team used three criteria to identify tags which had likely been consumed by predatory fish: tags that remained in the array for extensive time periods (2 fish @ 317 and 2891 min); tags that moved into the array but never proceeded downstream out of the array (2 fish); and groups of fish that moved simultaneously through the entire 2D array and remained together through subsequent presence-absence detection stations downstream (2 sets of 2 fish each). It was possible that these sets of fish were eaten by the same predator and the tags were transported in its gut as it moved downstream. The team also removed detections for an individual that escaped into the river during the transition from transport containers into in-river net pens; the individual thus transited the array a day earlier than any other tagged fish. Overall, this filtering step removed nine additional individual fish from the analysis.

The secondary filtering process also identified single positions that resulted in biologically unreasonable rates of movement, defined as any ground speed between detections that was >5 m sec^{-1}. This threshold is the

99.5th percentile of all measured movement speeds in the dataset. Manual assessment of points which exceeded this threshold also indicated that the high speeds generally corresponded to a single position that was unaligned with the track, suggesting positioning error rather than burst swimming behavior as the cause of the increased ground speed. Additionally, Castro-Santos et al. (2013) showed a maximum sprinting capacity of similar-sized salmonids to those in the present study of around 25 body lengths per second. For the present study's fish (mean FL = 133 mm), this equates to approximately 3.3 m sec^{-1}. This max sprint speed, combined with water velocities measured through the study reach, support a threshold of 5 m sec^{-1} as a maximum biologically reasonable swim speed. An automated process was implemented, which scanned all tracks and removed these points. This removed an additional 322 positions from the dataset (0.4%). After the secondary filtration process, a mean of 150 positions remained per fish.

3.2.3 Track discretization

Juvenile Chinook migrate from their natal streams along continuous movement paths. Two-dimensional acoustic tracking arbitrarily divides these continuous movement paths into discrete linear segments between positions recorded irregularly in space and time. For some of the statistical analyses applied to the dataset, the tracks need to be rediscretized to create uniform time or distance intervals between positions (Turchin 1998). To illustrate the importance of this step, consider how the frequency at which positions are recorded along a continuous path will impact the magnitude of calculated turning angles. Thus, to control for the discrete nature of our positions yet still allow for comparisons between tracks, the team can rediscretize the positions to be at uniform distances. The simplest method to achieve rediscretization is to recreate a continuous path using linear interpolation between existing points, then subdivide this path at equal distance- or time-increments (Dray et al. 2009), depending upon the goals of the subsequent analysis.

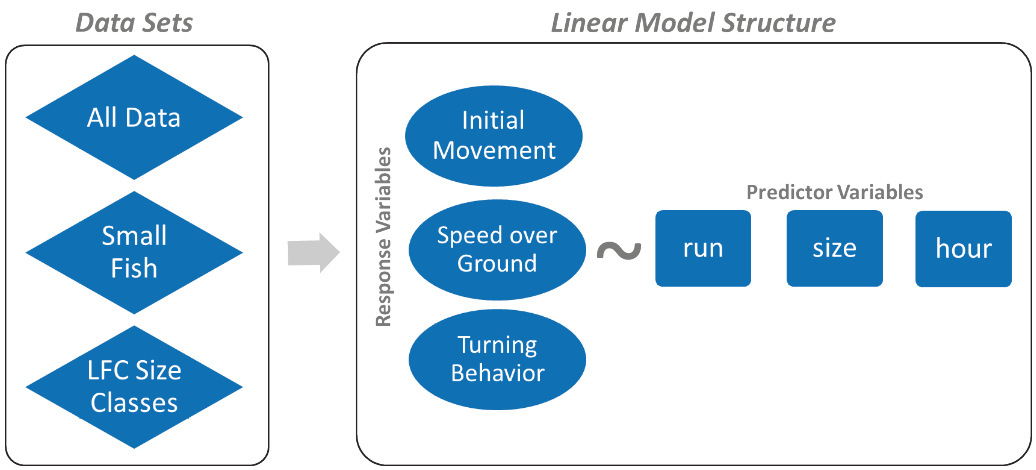
The team used the R package 'adehabitatHR' (Calenge 2006) to conduct these rediscretizations of individual tracks. Fish that had long gaps between detections (>150 m) were removed from the analysis because of the large uncertainty in interpolating between widely spaced positions. This removed 38 of 481 individuals (7.9%). It is unclear why there were large gaps in the detection histories of this handful of fish, but there were higher proportions of these individuals in later release groups, suggesting there may have been an influence of temporal variation in array performance. Fish with fewer than 10 positions after rediscretization were also removed.

To spatially rediscretize the track for analysis of turning angles, the team set the interval between positions to 21 m because this was the minimum distance possible due to computational limitations within the software package. The number of positions remaining was 12,632, or 17.5% of the previously filtered positions, leaving 439 individual fish with an average of 28.7 positions per fish. To temporally rediscretize the track for analysis of speed and space use, the team set the interval between positions to 20 sec. The team chose this threshold because it reduced the dataset to approximately 1 of every 3 detections, and seemed to be an appropriate trade-off between over-interpolation across sparse positions and loss of data. Also, it provided similar resolution to the temporally rediscretized dataset. The number of positions remaining at this threshold was 20,335, or 28.2% of the previously filtered positions, leaving 442 individual fish with an average of 46.0 positions per fish. While the lag at which data are no longer autocorrelated in ground speed or position is much longer than 21 m or 20 sec, this is not a concern for the majority of the following analyses because positions from individual tracks are not assumed to be independent. When this is an important statistical assumption, the data are resampled to remove autocorrelation. The temporal rediscretization process also included staggering the starting point of the track to a random position within the first 100 m of the array. This was done to reduce the discretization bias in the calculation of subsequent utilization distributions.

3.3 Movement analyses

To assess differences in behavior between the late-fall-run and winter-run Chinook, the team considered three primary movement patterns. This included the initial movement rates from release to arrival at the array, as well as speed over ground and turning behavior within the array. These later two combine to determine the total transit time through the array; to avoid redundancy, the team did not analyze transit time itself. For these three movement metrics (initial movement, speed over ground, and turning behavior) the team used linear regression to quantify the effect of run, while simultaneously considering effects of size and hour of release (Figure 11). Discharge was not considered in the models because it was very consistent across all releases. The team applied similar model structures to three different datasets: (1) the full dataset; (2) a reduced dataset with only comparable sized fish (98 - 125 mm FL); and (3) a reduced dataset with only late-fall-run fish of two size classes (98 - 125 mm FL and 160 - 180 mm FL). The subsets of data were included to provide a second approach to controlling for differences in size or run, because these two metrics are not independent (Figure 11). Unless otherwise stated, an alpha of <0.05 was considered significant.

Figure 11. Schematic of nested analysis. Three datasets were each used to build three linear models. Each linear model used the same predictor variable to predict one of three response variables.



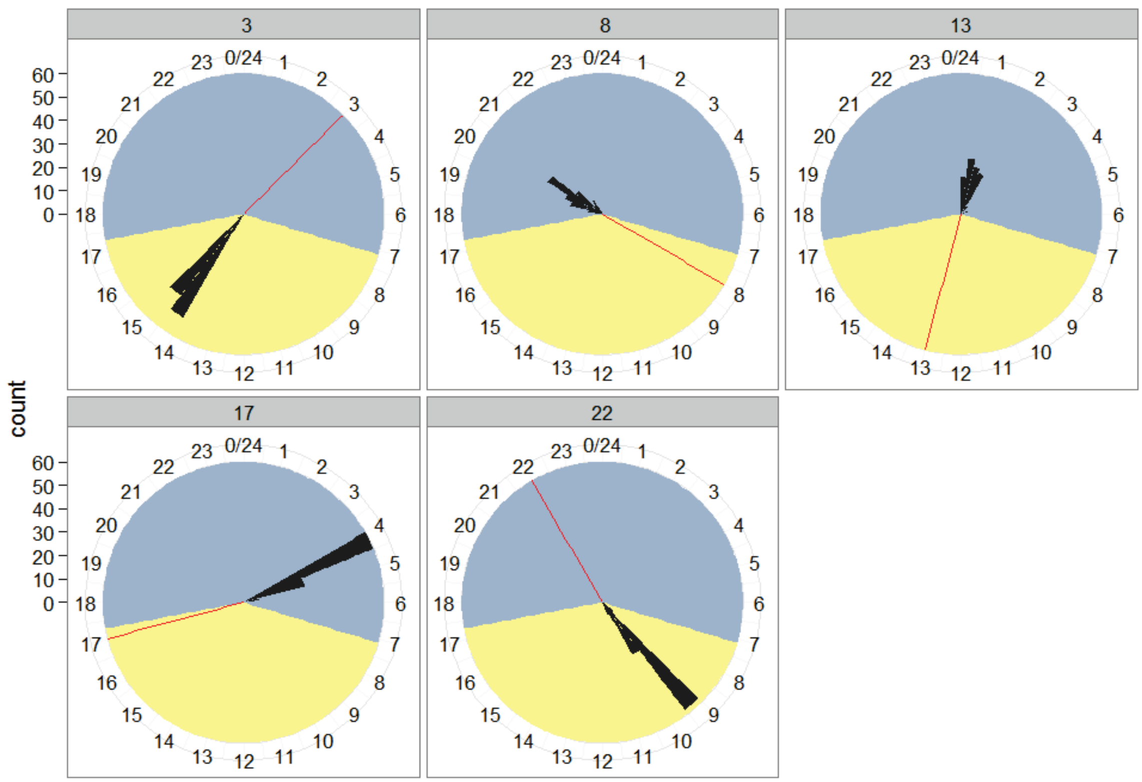
3.3.1 Initial movement

The filtered dataset was used to calculate the time of arrival at the array for each fish. Arrival times can indicate preferences for travel during specific diels, or can indicate variation in travel rate by time of day. To determine whether the fish released at the same hour but on different days could be analyzed as a single group, linear regression was used to assess differences in the time elapsed between release and the mean arrival time for each release group (N_{LFC}=25, N_{WRC}=25) and for each release hour (N_{LFC}=50, N_{WRC} =50). The model indicated significant differences in delay time by release group, with post-hoc contrasts indicating the only difference between paired hourly releases was at the 8:00 hour. This difference was driven by two outlying data points that had extremely long delays of 25.9 and 26.9 hr. When these outliers were removed, there were no significant differences between releases that occurred at the same hour, so the outliers were removed and each pair of releases were combined for further analysis.

Rose diagrams, histograms of circular data, show the arrival time by hour of release and illustrate a tight clustering of arrival times approximately

11-12 hr after the release time for all release groups, regardless of time of day (Figure 12). A Wilcoxon paired-sample test for skewness of circular data did not reject the null hypothesis that the data were symmetrical around the median (p = 1 for all groupings; Zar 1999).

Figure 12. Each panel shows circular histograms of arrival times for fish released at each hour, including fish from both runs. The red line indicates time of release. Overall, the mean travel time was approximately 11.7 hr.



To assess the influence of run on the time between release and arrival at the array, the team used a linear model with run, size, and release hour as predictor variables. The results from this model indicated that run is a significant indicator of delay time (Table 2), as was suggested by the raw data (Figure 13). There was not a significant effect of the interaction between run and fish size, and generalized variance inflation factors (GVIF; Fox and Monette 1992) for the model parameters were all less than 4. Therefore, the team doesn't believe the correlation between run and fish size has a strong impact on the model estimates or confidence intervals. However, the team also constructed linear models from subsets of data to test for the effects of run while isolating the influence of run or size. The model built from data for fish of comparable size (98 - 125 mm FL) also indicated that run was a significant effect, further indicating it is not a spurious correlation between run and size that leads to this result.

This conclusion is further supported by the model built from the subset of data including only LFC of two size classes (98 - 125 mm FL and 160 - 180 mm FL). This model, as well as that built from the full data set, indicated that fish size was not a significant predictor. While the model built from the subset of data for small fish indicated that size was a significant predictor, this was over a much-reduced range of sizes and the effect was small. Additionally, it appears as though one outlier (LFC of 98 mm FL and delay time of 19.1 hr) exerts a strong influence on the results (Cook's distance > 0.5, Cook 1977). When it is removed, none of the three models indicate fork length as a significant effect.

Finally, for all three linear models, there were significant differences among release hours as predictors of the time between release and arrival at the array (Table 2, Figure 14). Post hoc comparisons between levels of release hour, using Tukey contrasts, indicated that those fish released during the day at 08:00 and 13:00 had significantly longer delays than those released during the night ($p < .001$), but the effect size was less than one hour (Figure 14).

Table 2. Parameter estimation for models predicting the initial movement between release and arrival at the array. Models of similar structure were built for the full dataset and two subsets of data. Parameter estimates are presented, as well as confidence intervals and p-values of the estimate, along with the adjusted R^2 value, indicating model goodness-of-fit. Significance of each level of release hour indicates difference from the overall mean. All significant p-values are shown in bold.

All Data (n=472) - adj. R2 = .319		
	Estimate [95% Conf. Int.]	p-value
(Intercept)	12.74 [11.96, 13.51]	**<0.001**
Run (WRC)	-0.90 [-1.17. -0.64]	**<0.001**
Fork Length (mm)	0.00 [-0.01, 0.00]	0.109
Release Hour		
3:00	-0.37 [-0.5, -0.24]	**<0.001**
8:00	0.50 [0.36, 0.63]	**<0.001**
13:00	0.42 [0.29, 0.56]	**<0.001**
17:00	-0.22 [-0.35, -0.09]	**0.001**
22:00	-0.33 [-0.46, -0.19]	**<0.001**

Small fish only (n=56) - adj. R2 = .260		
	Estimate [95% Conf. Int.]	p-value
(Intercept)	20.43 [14.10, 26.76]	**<0.001**
Run (WRC)	-2.04 [-3.05, -1.03]	**<0.001**
Fork Length (mm)	-0.07 [-0.12, -0.01]	0.015
Release Hour		
3:00	-0.66 [-1.25, -0.06]	**0.031**
8:00	0.25 [-0.37, 0.88]	0.422
13:00	0.69 [-0.01, 1.40]	0.053
17:00	0.15 [-0.59, 0.90]	0.683
22:00	-0.44 [-1.07, 0.19]	0.166

LFC size classes (n=72) - adj. R2 = .177		
	Estimate [95% Conf. Int.]	p-value
(Intercept)	12.12 [11.78, 12.46]	**<0.001**
Size Class (sm) (Small)	0.40 [-0.14, 0.95]	0.142
Release Hour		
3:00	-0.80 [-1.27, -0.32]	**0.001**
8:00	0.58 [0.03, 1.13]	**0.039**
13:00	0.64 [0.07, 1.20]	**0.028**
17:00	-0.01 [-0.54, 0.51]	0.959
22:00	-0.40 [-0.95, 0.14]	0.146

Figure 13. Boxplots showing differences in initial movement by run or size class. Each panel displays trends from a different subset of data: (a) all data, (b) small fish only, and (c) LFC size classes. Two data points for LFC are not shown in panel a (25.9 hr and 27.0 hr).

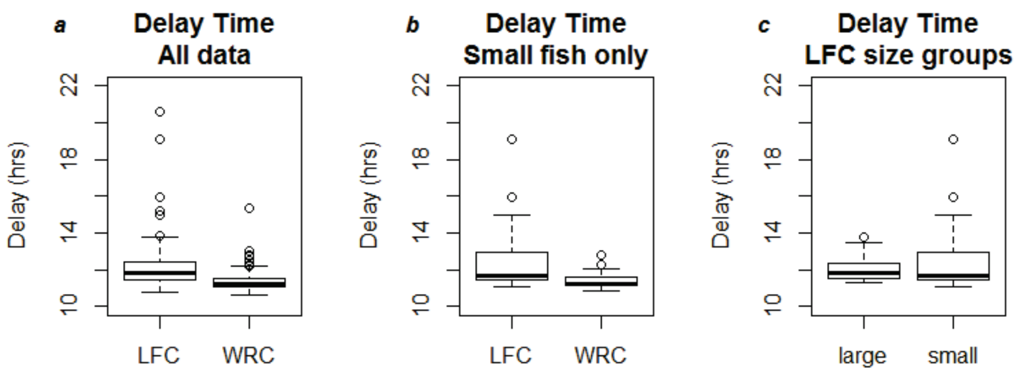
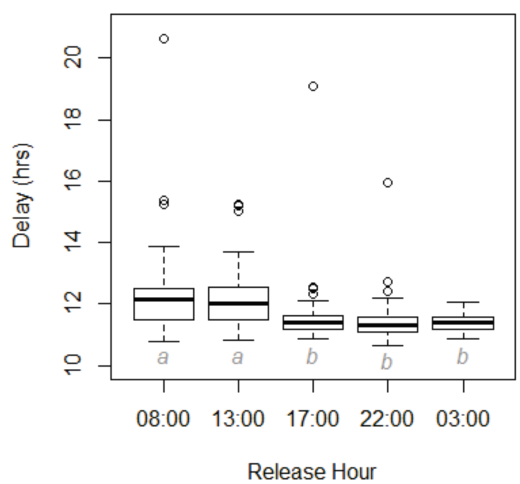


Figure 14. Boxplots indicating variation in initial movement between release and arrival time at the array for each unique release hour (N=100: NLFC = 50, NWRC=50). Boxes show 25th to 75th percentiles, while whiskers extend 1.5*IQR. Bold bar indicates the median. Two outliers were removed from the 8:00 release hour (Delay = 25.9 and 26.9 hr). Letters below the boxes indicate significance groupings from the Tukey HSD post-hoc test.



3.3.2 Speed over ground

Differences in behavior between LFC and WRC may be indicated by differences in migration speeds through the array. This can be quantified either through an individual's total transit time, or by estimating the path and calculating approximate ground speed within the array. The team considers the later metric here as it provides richer information about behavior. Some individuals may move slowly but directly while others may move rapidly with greater sinuosity, yet each could demonstrate similar total transit times. To reduce the influence of inconsistent positioning efficiency within the 2D array on calculated path-lengths, the filtered tracks of individual fish were rediscretized to create positions separated by equal time intervals of 20 sec (see Section 3.2.3). While this level of rediscretization retains autocorrelation in speed over ground at sequential steps, the analysis aggregates all segments from an individual into a single track, thus providing one metric per fish and eliminating statistical problems commonly associated with autocorrelation (Legendre 1993). Using this rediscretized dataset, the length of each fish's path through the array was calculated and combined with passage time to provide an estimate of average speed over ground.

A linear model was used to assess the influence of run on ground speed, while also accounting for size and hour of release. Hour of release was used instead of release event because paired release events were not significantly different at the alpha = 0.01 level. There was not a significant effect of the interaction between run and fish size, and generalized variance inflation factors (GVIF) for the model parameters were all less than 3.5. Therefore, the team doesn't believe the correlation between run and fish size has a strong impact on the model estimates or confidence intervals. The model showed there was no detectable effect of run on ground speed through the array, nor was there an effect of size (Table 3). This statistical result supports trends seen in the raw data (Figure 15). Post hoc comparisons between levels of release hour, using the full dataset with Tukey contrasts, indicated that fish released at 8:00 and 13:00 were significantly different from one another, and each moved significantly slower than those released at 3:00, 17:00, or 22:00 ($p < 0.001$, Figure 16).

Table 3. Parameter estimation for models predicting speed over ground through the positioning array. Models of similar structure were built for the full dataset and two subsets of data. Parameter estimates are presented, as well as confidence intervals and p-values of the estimate, along with the adjusted R^2 value indicating model goodness-of-fit. Significance of each level of release hour indicates difference from the overall mean. All significant p-values are shown in bold.

All Data (n=442) - adj. R2 = .301		
	Estimate [95% Conf. Int.]	**p-value**
(Intercept)	0.67 [0.56, 0.79]	**<0.001**
Run (WRC)	0.00 [-0.04, 0.04]	**0.946**
Fork Length	0.00 [0.00, 0.00]	0.640
Release Hour		
3:00	0.06 [0.04, 0.08]	**<0.001**
8:00	-0.11 [-0.13, -0.09]	**<0.001**
13:00	-0.06 [-0.08, -0.04]	**<0.001**
17:00	0.07 [0.05, 0.09]	**<0.001**
22:00	0.04 [0.02, 0.06]	**<0.001**

Small fish only (n=48) - adj. R2 = .234		
	Estimate [95% Conf. Int.]	**p-value**
(Intercept)	0.33 [-0.59, 1.26]	**0.470**
Run (WRC)	0.05 [-0.08, 0.17]	**0.446**
Fork Length)	0.00 [-0.01, 0.01]	**0.516**
Release Hour		
3:00	0.08 [0.01, 0.14]	**0.020**
8:00	-0.12 [-0.19, -0.06]	**<0.001**
13:00	-0.03 [-0.10, 0.04]	0.361
17:00	0.07 [-0.01, 0.16]	0.091
22:00	0.01 [-0.06, 0.08]	0.817

LFC size classes (n=63) - adj. R2 = .201		
	Estimate [95% Conf. Int.]	**p-value**
(Intercept)	0.63 [0.59, 0.67]	**<0.001**
Size Class (sm)	0.01 [-0.06, 0.07]	0.804
Release Hour		
3:00	0.04 [-0.02, 0.09]	0.187
8:00	-0.13 [-0.19, -0.07]	**<0.001**
13:00	0.00 [-0.06, 0.07]	0.973
17:00	0.07 [0.00, 0.13]	**0.042**
22:00	0.02 [-0.04, 0.08]	0.441

Figure 15. Boxplots showing differences in speed over ground by run or size class. Each panel displays data from a different subset of data: a) all data, b) small fish only, and c) LFC size classes.

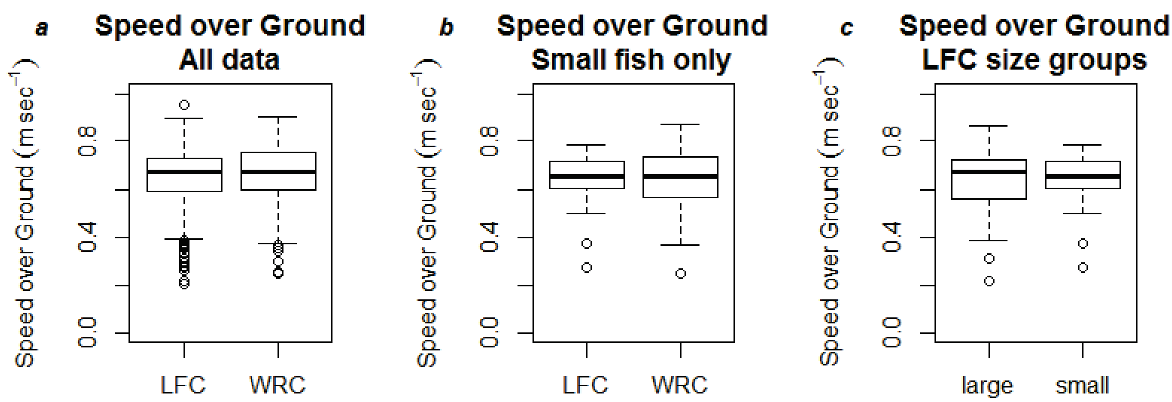
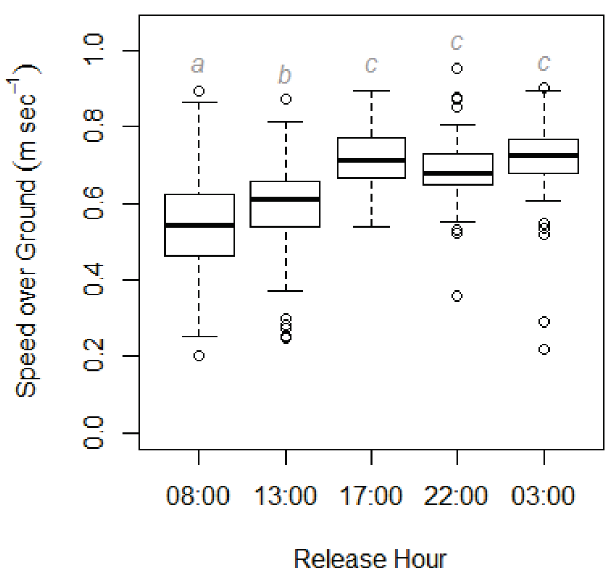


Figure 16. Boxplots indicating variation in ground speed (calculated over the entire reach) for each unique release hour (N=100: N_{LFC} = 50, N_{WRC}=50). Boxes show 25th to 75th percentiles, while whiskers extend 1.5*IQR. Bold bar indicates the median. Letters above boxes indicate significance groupings from the Tukey HSD post-hoc test.



3.3.3 Turning behavior

Low sinuosity of a fish track may indicate a greater propensity to migrate. To estimate sinuosity, the team uses the mean magnitude of the turn angles as an approximate measurement, where positive values are turns to the left and negative values are turns to the right. To compare turn angles across continuous tracks, the team must use positions separated by constant distances, as the distance of each step will influence the measured turn angle between steps and therefore must be set at a constant distance. Thus, to assess differences in turn angle by run and size, the team used rediscretized tracks with 21 m steps between positions (see section 3.2.2 for additional details). To provide additional context for the mean turn angles from each fish track, the team calculated the mean turn angle for the centerline of the river, also rediscretized to 21 m. This mean turn angle was 2.9 (SD=11.8) degrees.

To compare the magnitude of turn angles between runs, the team analyzed the mean angle for each track, using an inverse transformation of the data (equivalent to step length traveled per 1 degree turned). The linear models also accounted for fish size and hour of release. Hour of release was used instead of release event because paired release events were not significantly different at the alpha = 0.01 level. Generalized variance inflation factors (GVIF) for the model parameters were all less than 4. Turn angles did not vary by run for either model when run was considered (Table 4), as illustrated by the raw data (Figure 17). In the model built from the full dataset, there was a significant yet small effect of size (0.021, SD= 0.008), with smaller fish displaying larger mean turn angles (p=0.005, Table 4). However, fish size showed an effect in the opposite direction, and of a larger magnitude, within the model built from the subset of data including only LFC of two size classes (-1.71, SD=1.46, p=0.022; Figure 17). This suggests that fish size may impact turn angle, but is not conclusive. Adding further complexity, when the models were tested with an interaction term between run and size, this interaction term has a small effect size and was not statistically significant.

Finally, the model constructed for the complete dataset indicated that mean turn angles within the array were significantly different between release times (Figure 18). A Tukey HSD test indicated that the releases at 08:00 had a slightly larger mean turn angle than those released at 03:00 or at 17:00 (p = 0.041, p = 0.045); however, this was a very small effect. It was not considered significant in either model built from data subsets, likely because the power to detect differences was reduced with smaller sample sizes.

Table 4. Parameter estimation for models predicting turn angles within the positioning array. Models of similar structure were built for the full dataset and two subsets of data. Parameter estimates are presented, as well as confidence intervals and p-values of the estimate, along with the adjusted R^2 value indicating model goodness-of-fit. All significant p-values are shown in bold.

All Data (n=439) - adj. R2 = .903		
	Estimate [95% Conf. Int.]	**p-value**
(Intercept)	3.86 [1.64, 6.08]	**0.001**
Run (WRC)	0.62 [-0.14, 1.38]	0.108
Fork Length	0.02 [0.01, 0.04]	**0.005**
Release Hour		
3:00	-0.33 [-0.72, 0.06]	0.095
8:00	0.51 [0.10, 0.91]	0.150
13:00	0.14 [-0.25, 0.54]	0.473
17:00	-0.33 [-0.70, 0.05]	0.085
22:00	0.01 [-0.37, 0.39]	0.955

Small fish only (n=54 - adj. R2 = .956		
	Estimate [95% Conf. Int.]	**p-value**
(Intercept)	1.32 [-7.68, 10.32]	0.769
Run (WRC)	1.10 [-0.22, 2.42]	0.099
Fork Length	0.04 [-0.04, 0.12]	0.294
Release Hour		
3:00	-0.11 [-0.83, 0.62]	0.763
8:00	0.01 [-0.68, 0.71]	0.966
13:00	-0.39 [-1.14, 0.36]	0.297
17:00	0.19 [-0.72, 1.09]	0.680
22:00	0.30 [-0.47, 1.07]	0.439

LFC size classes (n=69) - adj. R2 = .825		
	Estimate [95% Conf. Int.]	**p-value**
(Intercept)	7.78 [6.86, 8.70]	**<0.001**
Size Class (sm)	-1.71 [-3.17, -0.25]	**0.022**
Release Hour		
3:00	-0.53 [-1.84, 0.78]	0.419
8:00	0.67 [-0.78, 2.11]	0.359
13:00	0.90 [-0.65, 2.44]	0.25
17:00	-0.92 [-2.30, 0.46]	0.187
22:00	-0.11 [-1.56, 1.34]	0.881

Figure 17. Boxplots of the mean turn angles of each fish, grouped by run or size. Positive turn angles indicate turns towards the left-bank. Each panel displays data from a different subset of data: a) all data, b) small fish only, and c) LFC size classes. The red dotted line indicates the mean turn angle of the river calculated along the river center line. One data point for LFC is not shown in panel a (12.2°).

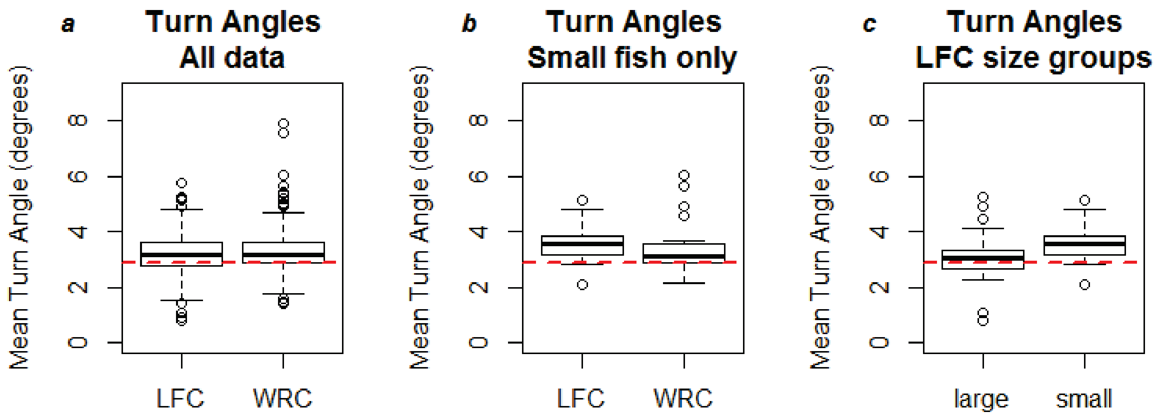
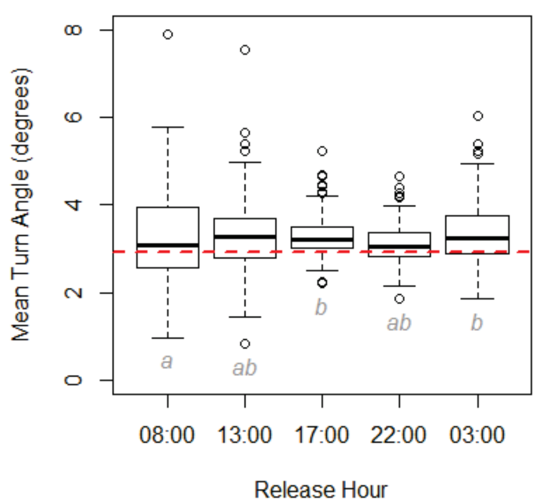


Figure 18. Boxplots indicating variation in turning angles along a track for each unique release hour (N=100: N_{LFC} = 50, N_{WRC}=50). Positive turn angles indicate turns towards the left-bank. The red dotted line indicates the mean turn angle of the river calculated along the river center line. Boxes show 25th to 75th percentiles, while whiskers extend 1.5*IQR. Bold bar indicates the median. Letters below boxes indicate significance groupings from the Tukey HSD post-hoc test.



3.4 Space use analysis

3.4.1 Cross-channel distribution

To better understand how juvenile salmon move in the vicinity of the Fremont Weir, the team examined their distribution within the channel. The positional data were collapsed to one dimension by projecting each fish's 2D position onto its distance to the center of the channel (D2C), creating an empirical distribution of fish locations across the channel. Evidence for any bank preference was then assessed by looking for evidence that D2C data are skewed.

The D2C data across the entire sampling area are moderately skewed towards the outside bend of the river (Figure 19a; skew = -0.68, t = -5.05, $p<<0.05$, N = 482). These data were pooled across runs because there was little evidence of any difference in their distributions (Figure 19b). The data do show temporal correlations that vary widely across individuals, with no clear patterns emerging as a function of time of day or run type. Because this violates assumptions of independence required to calculate the team's test statistics, the team eliminated any correlations within individual tracks by performing a modified bootstrap. In each iteration, the team randomly sampled one position from each track and reported the mean skew and associated t-value from those 481 data points (repeated with replacement for 1,000 iterations). The team noted that directional variograms did show a strong anisotropic trend in spatial correlations across all relocation data, but this is not surprising given the proximity of the relocations and the nature of the advective environment. However, spatial and temporal correlations were deemed more problematic within individual tracks than across them.

The team also considered variation in the cross-channel distribution of fish as they move downstream. Each fish's relocation points were coded by step, beginning with their first relocation position upstream of the bend and ending with their last downstream position. At each step, the team then calculated the average D2C value across all fish, as well as the average position downstream. Confidence in each mean value is then weighted by the number of relocations (w). Mean D2C values shifted towards the outer bank before the bend and this bias persisted for the remainder of the recorded positions in this area (Figure 20), although there was an increase in variability farther downstream and as the number of supportive observations decreases.

Figure 19. Fish distribution patterns in space. (a) shows the full distribution of D2C values, and their relative position with respect to the center of the channel (N = 481 fish), while (b) shows the D2C densities across the channel plotted as a function of run. Light blue bars represent distribution of WRC, red bars represent distribution of LFC, and dark blue areas show overlap between runs.

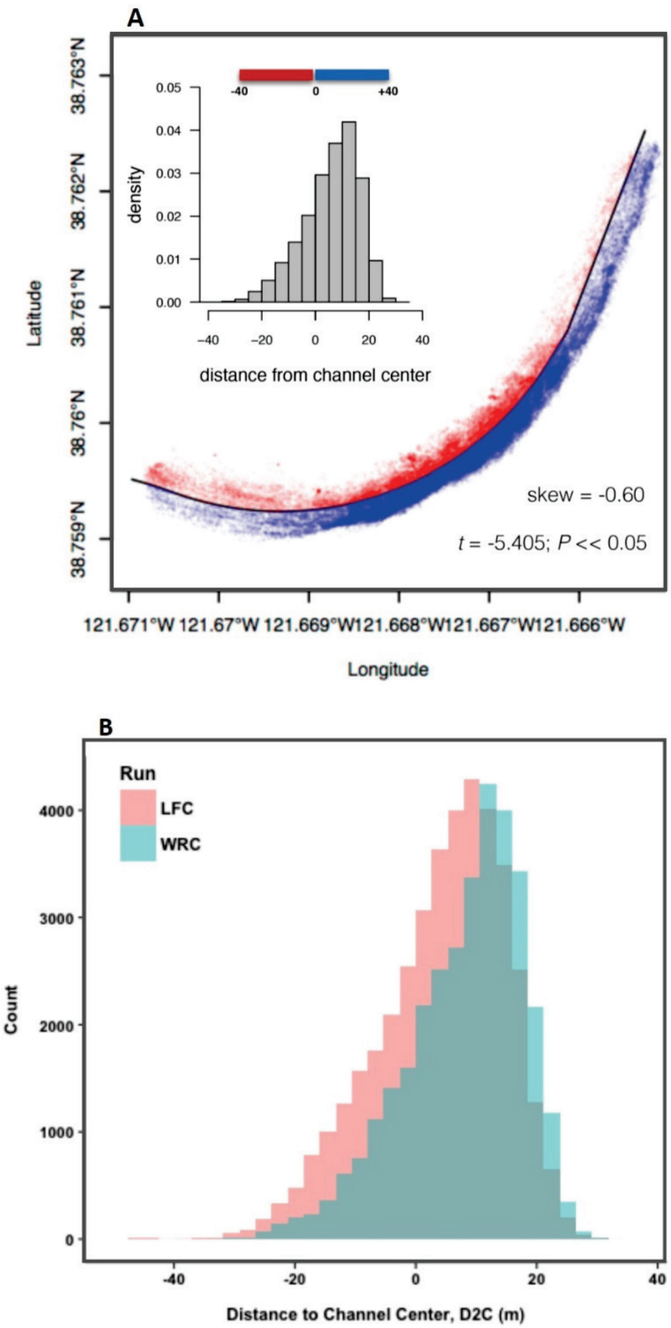
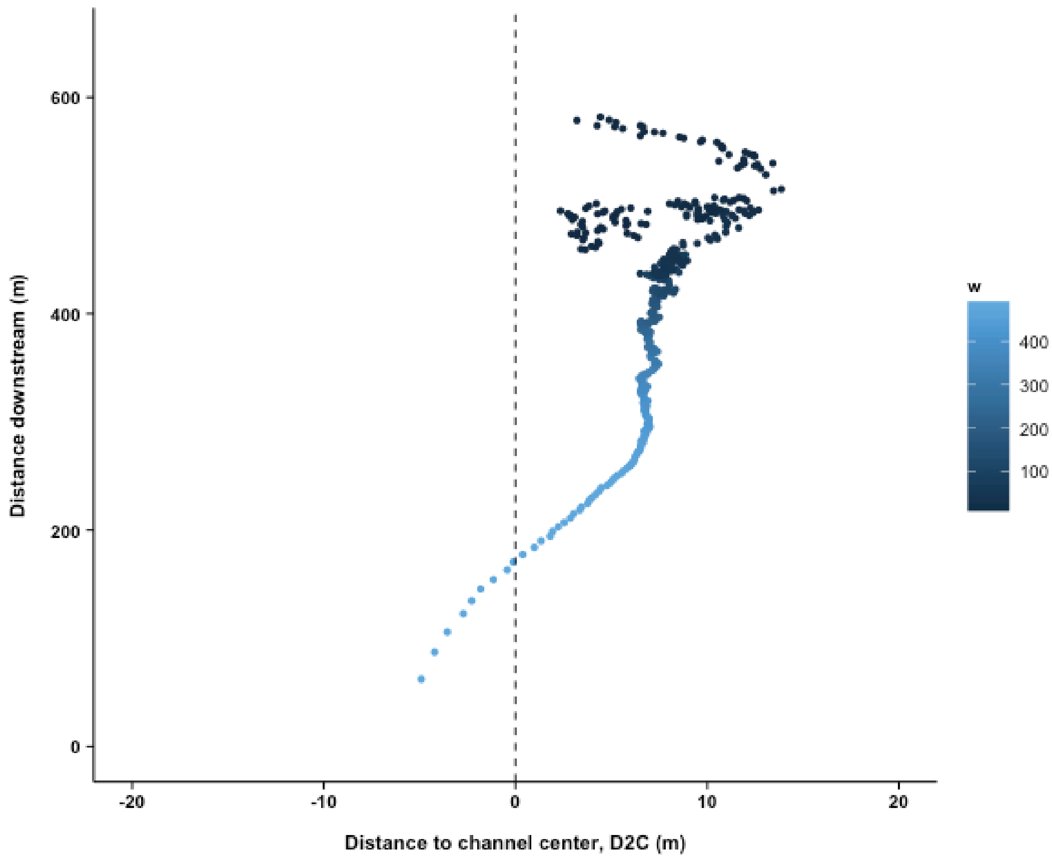


Figure 20. Trends in mean D2C values as a function of the downstream distance. Bias towards the outer bank is indicated by positive D2C values, while negative values indicate a bias towards the inner bank. Confidence in each mean value is weighted by the number of relocations (*w*), and indicated by the color gradient. Notice that as the number of supportive observations decreases (smaller *w*, darker color) the trend becomes more variable, although still biased towards the outer bank.



3.4.2 Kernel Utilization Distributions

To assess the degree of spatial overlap between the two runs of Chinook within the positioning array, the team created kernel utilization distributions (UDs) from the temporally rediscretized detections of each run. The rediscretized tracks were used to reduce bias that may result from fish that were detected more frequently. This approach uses known locations to create a probability density map of space use, and can output polygons of contours along that two-dimensional distribution. The team used the function provided in the adehabitatHR package within R (Calenge 2006), with a least squares cross-validation approach for identifying a smoothing parameter. In addition to creating UDs from positions of all fish in each run, the team created parallel UDs for the two subsets of data discussed above (small fish from both runs, and LFC in two size classes).

By examining the UDs produced from all positions of each run, the team again saw that both runs were more likely to be along the outside edge of the bend as they migrated through the array. Generally, the area used by LFC was larger than that used by WRC (Table 5). This seems to be an effect of run, not size, because large and small LFC showed similar space use. There was also a subtle trend for the WRC distributions to be more condensed along the outer bend (Figure 21).

Despite these minor differences, at all contours examined, there was substantial overlap between the runs. In the contour of the 50th percentile, 81% of the area of the WRC distribution was overlapped by the same percentile contour of LFC. In the contour of the 90th percentile, 93% of the area of the WRC distribution was overlapped by the same percentile contour of LFC (Table 5; Figure 22). The same trend of high overlap between runs at the 90th percentile contours was also demonstrated for the subset of similarly sized fish from each run.

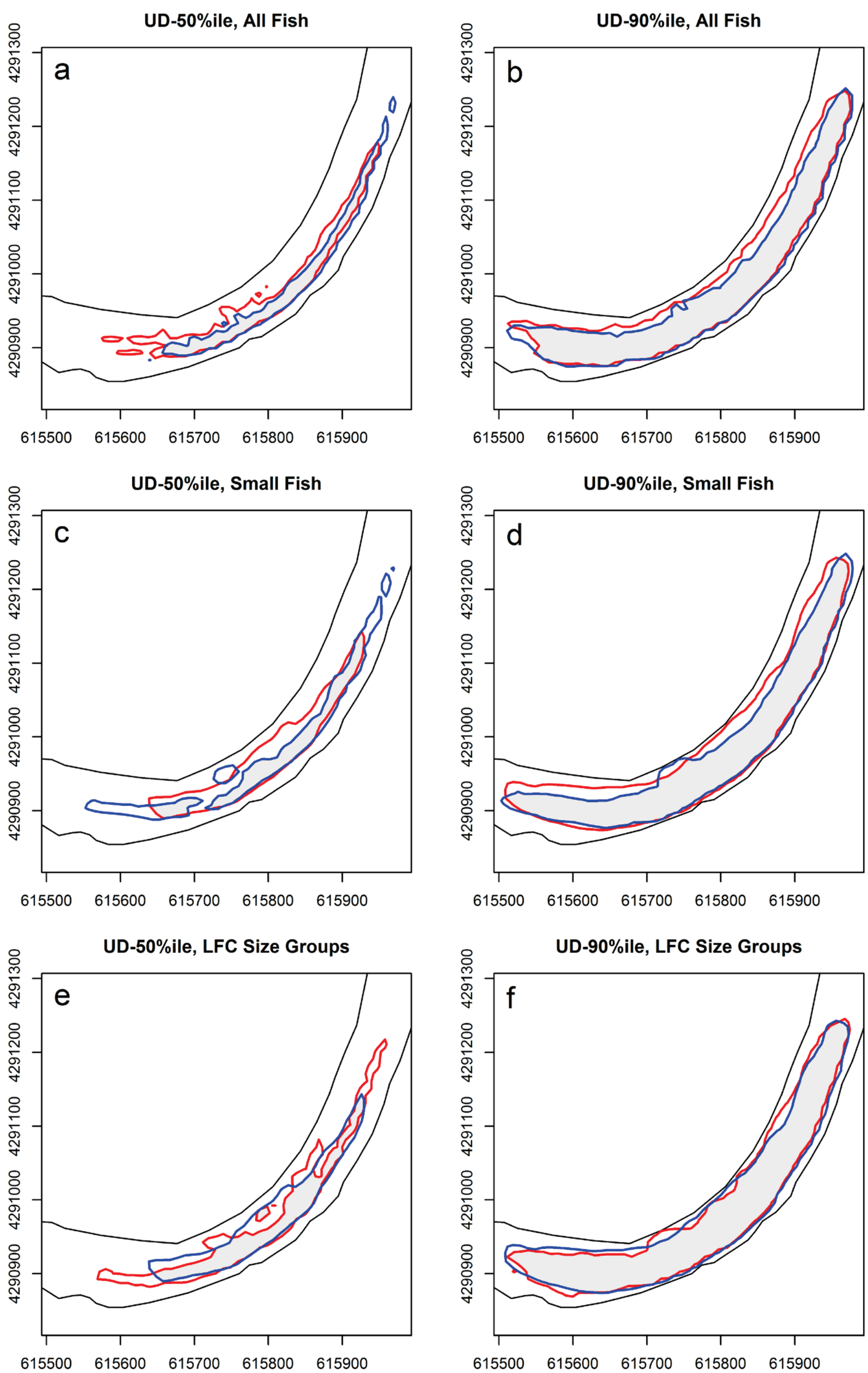
Table 5. The area of utilization distributions at the 50^{th} and 90^{th} percentile contours for the three subsets of the data. Also shown are the percent of area overlapped by the same contour calculated for the other run or size class.

All Fish			
Run	Contour	Area (hectares)	% Overlapped by alternate run
LFC	50	9.9	58%
WRC	50	7.1	81%
LFC	90	27.8	82%
WRC	90	24.8	93%
Small Fish			
Run	Contour	Area (hectares)	% Overlapped by alternate run
LFC	50	11.2	57%
WRC	50	9.7	66%
LFC	90	31.0	77%
WRC	90	25.1	95%

LFC size class			
Group	Contour	Area (hectares)	% Overlapped by alternate size class
Large	50	11.3	67%
Small	50	11.2	67%
Large	90	29.9	93%
Small	90	31.0	89%

Figure 21. Full utilization distributions calculated for all fish from each run. Hotter colors indicate greater probability of use. Contour lines are shown for perspective, and approximate river banks are shown.

Figure 22. Selected utilization distribution (UD) contours (50th and 90th percentiles). In panels a-d, UD for LFC are represented by red lines and UD for WRC are represented by blue lines. Panels a-b show results for all individuals of each run, while panels c-d show results for 'small fish," defined as fish between 98 - 125 mm FL. In panels e-f, UD for large LFC (160 - 180 mm FL) are represented by red lines and UD for small LFC (98 - 125 mm FL) are represented by blue lines. The area of overlap is shaded grey.



4 Discussion

4.1 Array performance and study design

This project's study design and execution resulted in very good quality information on fish movement at the location of the Fremont Weir. The Vemco equipment and positioning array design were efficient in the detection of surgically implanted tags. The surgical and release procedures were effective in limiting immediate handling-associated mortality of juvenile Chinook. The release location did not result in high mortality before study fish arrived at the positioning array, which was a driving factor in selecting the study release site. As a result, there is a possibility of moving the release location further upstream for future work. During the planning phase of this study, there were concerns that fish were being released too close to the study site, so fish may not have sufficient time to acclimate to river conditions. Therefore, fish may not behave like wild or "run of the river" fish. However, the release location was not changed due to concerns about mortality. Results in 2015 would support a release location that is further upstream.

Furthermore, the release schedule resulted in fish arriving at the positioning array across a variety of diels, allowing for the detection of any behavioral changes that may have been associated with time of day. Unfortunately, the river flows remained consistent throughout the entire study period, reducing the flow variability at which behavioral data was collected.

4.2 Behavior patterns

Overall, the behavior within the positioning array was dominated by direct, downstream movement, and generally rapid speed over ground. This is similar to two-dimensional observations for juvenile late-fall-run Chinook salmon migrating through a reach approximately 2.5 rkm upstream (Sandstrom et al. 2013). This behavior suggests the study fish had a strong propensity to migrate, and is in agreement with our understanding that juveniles in the size range from 100 - 200 mm FL have begun the process of smoltification (Muir et al. 1994, Giorgi 1997). While there was no effect of size on speed over ground, the team did see a subtle effect of size on turning angle. Together, these two metrics determine total travel time, synonymous with exposure time. Thus, because smaller LFC had slightly larger turn angles but similar speed over ground, the team expects these smaller fish may also have greater exposure time as they migrate. Both the increased turning behavior and the increased exposure time could result in size selective mortality beyond what is expected, due to the effects of predator gape limitation (Anderson et al. 2005).

One purpose of this study was to determine whether there were distinct behavioral differences between winter-run and late-fall-run Chinook salmon. Overall, there seemed to be very little difference between the two runs. Behavior was quantified with three primary metrics, including transit time from release to positioning array, speed over ground through the array, and mean magnitude of turn angles within the array. The only metric that was significantly related to run identity was the transit time from release to the positioning array, with WRC moving more quickly than LFC. The result remained significant even when size and release time were accounted for. This may suggest that the two runs differ in their response to novel situations, such as release into the river. However, overall, the team saw very little behavioral differentiation.

Differences between WRC and LFC juveniles were also assessed through space use. In considering both the cross-channel distribution of individuals and kernel utilization distributions, the fish showed a non-random and non-uniform distribution. Both runs had a tendency to be closer to the outside bend than the inside bend. These data also indicate a tendency for winter-run fish to be slightly farther toward the outer bend than late-fall-run (Figure 21). While there is a noticeable size difference between the runs, the similarity in space use of large and small LFC individuals suggests that the differential space use between runs is driven by run identity — not variation in size, at least within the size range tested here. Differences in swimming depth may be a potential explanation, as there is depth-related variability in hydrodynamic conditions. However, for this study, individual fish positions were not recorded in three dimensions; thus, the team cannot directly test this hypothesis.

There was little evidence of consistent differentiation in movement patterns between sizes of juvenile Chinook. It is also important to note that the individuals considered in this study were within a size range frequently classified as smolts or pre-smolts (95 - 188 mm FL), and thus may not have shown the full range of variation expected across all sizes of naturally outmigrating juvenile salmon. When compared directly, small LFC showed a greater increase in mean turn angle than large LFC. There are several hypotheses for the mechanism behind this slight difference. It could correspond with previous work that showed smaller fish at earlier stages of ontogeny show less propensity to migrate (Giorgi 1997), and consequently may be expected to display less directed movement paths. However, given the limited size range of fish in this study and the limited evidence in the scientific literature about the relationship between size and behavioral state, the team does not expect that this small variation in turn angle is due to ontogenetic habitat preferences. Alternatively, the greater mean turn angle toward the left bank shown by the smaller LFC could correspond with a change in the river hydrodynamics as it flows out of a left bend. At the upstream end of the receiver array fish concentrated towards the river-right bank as it entered the turn, while at the downstream end of the array, these advective forces were relaxed. As the hydrodynamic forcing of fish towards the right was reduced, individuals may have moved from channel right to channel center or left, resulting in mean turn angles that were larger than the mean turn angle of the river itself (Figure 17). It is feasible that fish of unequal size classes could be differentially affected by these hydrodynamics, with smaller fish having slower burst swim speeds experiencing a higher degree of susceptibility to advection by hydraulic forces. Finally, size-based differences in mean turn angles could also occur if size impacted an individual's active behavioral response to flow fields. Smaller fish have shorter lateral lines, thus impacting their ability to resolve flow fields and perhaps altering the outcomes of a decision process based on perceived hydrodynamics. It will be valuable in the future to collect movement data on a wider size range of juvenile salmonids to help resolve this question.

The most consistently influential variable across all models was the hour of release. Those fish released during the day (08:00 or 13:00) took more time to move between the release site and the positioning array. Interestingly, daylight hours also composed a large portion of the transit period for fish released at 03:00, but these fish did not show longer transit times. This suggests there may be a relationship between light intensity and behavior at the time of release. Previous work in the Sacramento River has shown differing responses of juvenile salmon to time of day (Chapman et al. 2013).

The slower movement of fish released during the day persisted through the positioning array even though these fish reached the array at night. Slower ground speeds were not observed in the groups released at 17:00, which also arrived at the array during night. Those fish released at 8:00 showed slightly larger turn angles than two of the groups of fish released at night (03:00 and 17:00). In addition, eight of the nine sets of fish detected schooling through the array in groups of two or more were released during day time releases. These observations suggest that, in addition to immediate effects, the time of release may have lingering effects on the behavior of the juvenile salmon.

4.3 Surrogacy potential

The detectable differences between winter-run Chinook and late-fall-run Chinook during their migration past Fremont Weir were very minor. They included slightly different responses to the novel situation of release from net-pens into the river, and slight differences in space use. Given this information on behavioral response and space use, it seems reasonable to use hatchery late-fall-run juveniles as surrogates for studies on the behavior of hatchery winter-run juveniles within the mainstem of the Sacramento River at the size classes tested for the study. This is an important observation because there are many studies of late-fall-run Chinook movement in the Sacramento Basin that could be consulted.

4.4 Future work

This study was conducted in a single year under unusually low stable discharges. It may be beneficial to have similar data under additional flows in order to gain insight into how these fish respond to different or more complex hydrologic conditions. The Fremont Weir notch will operate over a wide range of potential discharges and additional data at those discharges has potential to assist with design. This recommendation is tempered by the observation that late-fall-run Chinook may be a suitable surrogate for winter-run Chinook over the size ranges tested in this study.

Additional hydraulic complexity could be added as part of a study design as well. A floating boom could be installed to assess fish response. In addition, future notch operations may benefit from the knowledge of fish guidance potential near the Fremont Weir. Specifically, fish guidance may improve notch efficiency by entraining more fish with less water.

Perhaps the biggest uncertainty is related to the lack of very small fish (30 to 70 mm) in the data set. Natural spawning WRC often pass the

Fremont Weir in this size range. Due to our understanding of juvenile salmon ontogeny, there is reason to believe that smaller fish may behave differently than the large fish tracked in this study. However, the team is limited with regard to the size of fish that can be observed using the current technology due to concerns about the potential for large tag burdens to alter behavior (Adams 1998). It would be beneficial to develop a plan for future assessment of fish typically classified as fry in order to gain a more holistic understanding of the behavior of all migratory juvenile Chinook within the mainstem of the Sacramento River. This additional work would also profit from the inclusion of naturally spawned individuals, as hatchery salmonids have been shown to display different behaviors than naturally reared fish (Alvarez et al. 2003, Swain and Riddell 2011).

Information from this study will be used with hydraulic modeling (Lai 2016) to provide quantitative information regarding ELAM modeling of juvenile fish entrainment at Fremont Weir. Modeled Fremont Weir "notches" will vary in base elevation, dimensions, and location and will be evaluated at multiple hydrostatic conditions to learn about sensitivity to these factors and potential success and risks of these modeled scenarios. In 2016, a second phase of interagency ecohydraulic investigations is continuing at Fremont Weir and these data sets should be useful for further improving our fish behavior and hydraulic modeling tools. These additional data sets will enhance these tools for interagency teams to quantify and evaluate adult and juvenile fish passage designs.

4.5 Conclusion

Juvenile Chinook moved quickly and in a highly directional manner through the study reach. They displayed a non-uniform distribution within the channel, with a tendency to use space along the outer bend more frequently than the inner bend. This successful study provided evidence for little difference between the behavior of late-fall-run and winter-run Chinook salmon juveniles at the Fremont Weir. Thus, further plans to aggregate information from multiple runs to inform parameterization of fish behavioral models for use in evaluating juvenile entrainment at potential Fremont Weir "notch" alternatives is reasonable and will capture variation reflecting fish size and run timing. The ability to generalize from these data to all juvenile Chinook of the Sacramento River would be further enhanced by similar studies with additional hydrodynamic complexity, smaller fish, and wild fish, as the team has reason to believe each of these scenarios may result in subtle behavioral differences that should be reflected in expectations of migration behavior of juvenile salmonids in rivers.

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Appendix A: Tagging Winter-Run Chinook Salmon at the Livingston Stone National Fish Hatchery

Standard Operating Procedure (SOP)

Adapted from Liedtke et al. (2012), the 2011 procedures from Cramer Fish Sciences, the SOPs used for Department of Interior's south Delta telemetric studies, and the 2011 work instructions used for the U.S. Army Corps of Engineers telemetric studies

Purpose and scope:

This SOP provides the steps needed to tag hatchery winter-run Chinook salmon at the Livingston Stone National Fish Hatchery for the 2015 Fremont Weir Fish Behavior Study. Over the course of two days, 250 winter-run Chinook salmon will be tagged at the hatchery and held in circulars until the salmon are ready for release. At a minimum, the following staff will be required to implement this SOP:

- Two surgeons to tag salmon and to work on equipment setup;
- Two data recorders to help with entering data in a Microsoft Access database and to help prepare the acoustic tags; and
- Two fish runners to help with moving tagged Chinook salmon to the circulars and to help with preparing recovery buckets.

When applicable, this SOP identifies the tasks that are assigned to the data recorders and fish runners. Any tasks not assigned to these staff are directed to the surgeons. However, the surgeons can seek assistance from the data recorders and fish runners when appropriate.

Materials:

1. Hach HQ40d meter with dissolved oxygen/water temperature and pH probe
2. User manual available at http://www.hach.com/asset-get.download.jsa?id=7648131637
3. Thermometer for quick temperature checks

4. pH meter or litmus paper
5. Acoustic tags (V-4)
6. VEMCO acoustic tag activator with manual. Manual found at http://vemco.com/wp-content/uploads/2013/03/vta_manual.pdf.
7. VEMCO acoustic tag verification equipment (VR-100 with VH180 hydrophone) with manual. Manual found at http://vemco.com/wp-content/uploads/2013/02/vr100hw_manual.pdf.
8. Chlorhexidine solution (Nolvasan; 30 mL/L D-H_2O)
9. Distilled or de-ionized water (D-H_2O)
10. Tricaine methanesulfonate (MS-222; 100 g/L)
11. Sodium bicarbonate solution (buffer; 100 g/L)
12. Stress coat - stock concentration and 25% solution (250 mL/L D-H_2O)
13. Disinfectant solution (i.e., 70% ETOH)
14. PVP iodine (Argentyne)
15. 19 L black bucket(s) marked at 10 L and clearly labeled "Anesthesia"
16. 19 L buckets for post-surgical recovery of fish and for rejecting fish
17. Liedtke et al. (2012) does not recommend the use of white or black buckets. White buckets are not ideal for restricting light penetration, while black buckets are too dark and absorbs large amounts of solar radiation. However, the color of the bucket will not be an issue for this study since tagging occurs indoors.
18. Cooler for storing fish before tagging
19. Two large water containers marked at 38 L
20. Water pump, with extension cord and rubber tubing with in-line shut-off valve and terminal narrowing
21. Rubber tubing to return water from drain tray to maintenance anesthetic bath
22. Designated syringes (5 mL) for measuring anesthetic and stress coat
23. Oxygen delivery system (cylinder, regulator, airline, air diffusers) for recovery buckets
24. Fish nets (e.g., sanctuary nets, dip nets)
25. Nitrile gloves (in all sizes)
26. Scale measuring to the nearest 0.01g (weighing fish and tags)
27. Large sponge to weigh fish
28. Measuring board with ruler to the nearest mm
29. Surgical platform (cradle)
30. Trays for holding solutions used to disinfect surgical tools
31. Trays to rinse disinfected tools
32. Needle drivers (multiple sets)

33. Forceps (multiple sets)
34. Scalpel handle and blades (multiple sets)
35. Scissors (multiple sets)
36. Tissue collection supplies: scissors, blotter paper, labeled coin envelopes
37. Sutures: 19 mm 3/8 circle needle with 4/0 Mono-Dox (violet monofilament polydoxanone) suture material
38. Spray bottles for disinfectant solution
39. Timers and stopwatches
40. Sharps container
41. Datasheets, clipboards, and writing tools
42. Laptops
43. Carabiner tag labels to identify fish in recovery buckets
44. Clean rags for keeping tagging areas clean and dry
45. Tables

Pre-tagging activities:

- Prior to the tag implantation, the tagging coordinator will need to get in touch with the Livingston Stone National Fish Hatchery about the following items:
    - Notify hatchery staff on the pre-tag fish-holding period requirements. The pre-tag fish-holding period should be 18 to 36 hr.
        - Food should be withheld during the pre-tagging holding period.
    - Notify hatchery staff on the list of study personnel that will be at the hatchery. All study personnel must bring government issued identification, such as a California driver's license.
    - Coordinate with the hatchery staff on a list of materials that the hatchery should provide. In terms of using water quality meters, check with the hatchery on when the meters were calibrated.
- Disinfect all buckets and coolers with PVP iodine (e.g., Argentyne) before arriving to the hatchery. If this step is not done before arriving, then all equipment must be disinfected at the hatchery before use.

Equipment Setup:

- Datasheet Setup

  - Start the electronic *Tagging Datasheet* in a Microsoft Access database for each tagging station. Each data recorder should have a separate database.
  - Prepare a hard copy *Daily Fish Reject Tally Datasheet* for each tagging station to account for fish that are handled, but are not used for the study.
  - Prepare a hard copy *Circular Chain of Custody*.
- Tag Activation

  - The data recorder should activate the transmitters the day before or the day that they are to be implanted using the VEMCO tag activator.
  - Afterwards, the data recorder will confirm the operational status with the VR-100 and a VH180 hydrophone.
  - Once this is done, sterilize the acoustic tag in a solution of Nolvasan for a few minutes. Following disinfection, thoroughly rinse transmitters in distilled or deionized water prior to implantation.
  - Record the tag serial ID, the tag code ID, the surgeon's name, and the data recorder's name in the electronic *Tagging Datasheet* after tag verification.
  - Calibrate the scale and weigh a tag to the nearest 0.01 g in the electronic *Tagging Datasheet*. This value will be used for every fish.
- Setting up Circulars

  - Check to make sure that the ten circulars for tagged Chinook salmon have water circulating through it. Afterwards, label each circular with a study circular ID with white duct tape and a Sharpie pen. For the study, there should be ten circulars.
  - In the end, each circular should have 25 fish and five circulars will be used for each day.
- Filling and Preparing Trays and Buckets

  - Fill disinfection trays for surgical instruments with Nolvasan.
  - Fill disinfection trays for surgical instruments with diluted Nolvasan.
  - Fill rinse trays with de-ionized or distilled water.
    - See Figure 1 for example of tray setup.
  - Clip on numerical tag labels to recovery buckets, which will serve as the bucket ID.
- Water Temperature Checks for Anesthesia Bucket, Surgical Bath, and Holding Cooler

  - Water temperatures during all aspects of the tagging operations cannot exceed 2°C difference from the reference water source. The fish runners or surgeons will check all water sources periodically and record results in the *Tagging Datasheet* to ensure that water temperature levels are within criteria. For this study, the rectangular tank where source fish are held is the reference water source.
    - Anesthesia buckets, maintenance bath containers, and recovery buckets should not be filled until near the time that they are needed to avoid warming.
    - Anesthesia buckets and maintenance bath containers should be replaced regularly to prevent increasing water temperatures over time.
- Equipment Setup for Recovery/Reject Buckets
  - Set up the oxygen cylinder with a trigger.
    - The oxygen cylinder will be used for the recovery/reject buckets. Prior to use, conduct an experiment to see how long you should hold the trigger to target a DO saturation of 120 to 150% in the recovery bucket. Seven sec was used in past SOPs, but this may differ for this study.
      - This recovery bucket should be attached with an air stone and air pump.
  - With guidance from the hatchery, identify the tank that will be used for placing reject fish.

Fish Selection Criteria:

- For all experimental groups, handling protocols will be standardized to reduce potential bias (i.e., fish length, number of times handled, tagging procedures, transport methods, transport time, and release protocol).
- VEMCO V4 tags weigh about 0.41 g in the air. The estimated minimum length and weight of the Chinook salmon for surgical tagging should be >8.2 g (tag weight ≤ 5 % of the body weight), respectively. Fish should be targeted between 90–100 mm in FL.

Fish Tagging:

- *Equipment setup*
  - Prepare surgical table and equipment for use.

        - The surgeon should wear clean gloves during all procedures that involve handling fish.
        - The surgical station will be cleaned and wiped down with a solution of disinfectant, and surgical instruments will be placed in a disinfectant bath (e.g., dilute Nolvasan, chlorhexidine solution) before fish handling and surgical procedures.
        - Surgical instruments will be transferred to a freshwater rinse bath before surgery and rinsed twice.
        - Rinse tray should be changed often to avoid accumulation of disinfectant in rinse water.
        - To minimize the chances for pathogen transfer between fish populations, all equipment used for capture, holding, anesthesia, surgery, recovery, and movement of fish during the project will be thoroughly cleaned and disinfected before use with a different fish population.
        - Soiled gloves should be changed immediately and after handling 10 fish.
    - Set up measuring board and scale.
        - Put approximately 1–2 mL of diluted stress coat on the weighing sponge and the measuring board.
    - For each tagging station, the fish runner must fill a 19 L bucket halfway with circular water. In addition, the bucket should be supplied with a small amount of undiluted stress coat and with oxygen using an oxygen cylinder. The bucket should also be fitted with an air stone/air pump before tagging.
        - The concentration of DO in the buckets should be between 120% and 150% saturation by holding the trigger for a few sec.
        - These 19 L buckets serve as both the recovery bucket and the reject bucket. The bucket becomes the recovery bucket if the fish was tagged and it becomes the reject bucket if the fish was handled, but not used for the study.
        - No fish should be euthanized since winter-run Chinook salmon are listed under the U.S. and California Endangered Species Act.
- Administration of Anesthetic

    - The effectiveness of MS-222 as an anesthetic varies with factors, such as temperature, fish density, and individual sensitivity. Adjustments of the anesthesia concentration should be based on the amount of time it takes for a fish to lose equilibrium. Any adjustments should be recorded in the *Tagging*

Datasheet with a separate treatment ID.
    - Fill the anesthesia bucket with 2 L of circular water. As a suggestion for a starting concentration, add 7 mL (1 mL= 1 cc) of the MS-222 stock solution. This will yield an anesthetic concentration of 70 mg/L. Base the daily starting concentration on fish responses during the tagging operation from the previous days.
    - All anesthetic solutions will be buffered between a pH of 7 and 8 using sodium bicarbonate dissolved in solution.
  - Prepare the maintenance bath containers with water from the circular and with a water pump/tubing (see Figure 2 for setup). This is done by completing the following procedures:
    - Fill the container with 38 L of circular water.
    - Place the pump into water and ensure tubing is fit properly.
    - As a suggestion for a starting concentration, add 7.6 mL (1 mL= 1 cc) of MS-222 stock solution (100 g/L) and 7.6 mL of bicarbonate solution (100 g/L). This will yield an anesthetic concentration of 20 mg/L. Base the daily starting concentration on fish responses during the tagging operation from the previous days.
    - Water in all containers (anesthesia and maintenance) should be changed regularly to minimize dilution of anesthesia water and temperature changes. Moreover, this is done to ensure you do not run out of water during a procedure.
    - Add a small amount of diluted stress coat for each liter of water in the anesthesia and maintenance bath to protect fish from loss/damage to the slime layer.
- Anesthetizing the Fish
  - With help from the hatchery, identify the rectangular tank with fish that will be used for the study and place the fish into a cooler with an air pump and air stone.
    - Having fish in a cooler will help the surgeons gather fish for tagging and avoid a long commute from the tank to the tagging station.
  - Use a sanctuary net or dip net to remove one fish from the pre-tag holding cooler and place directly into an anesthesia bucket.
    - Remove the fish from the net by hand, taking care not to dilute the anesthesia bath with water from the net.
      - <u>Note:</u> The most significant source of stress that fish experience is usually from being netted.

Every effort should be made to minimize handling. Sanctuary nets should be used when feasible.

- Secure the lid as soon as the fish is in the bucket.
- Call out "fish in drugs" and start a timer to keep track of how long a fish has been in the anesthesia bucket. The data recorder will record the start time of when the fish was placed in the anesthesia bucket in the electronic *Tagging Datasheet* based on when the surgeon called out "fish in drugs." Time is recorded in the 12-hour clock notation in the following format: hh:mm:ss am/pm.

- Remove the lid after about 1 minute to observe the fish for loss of equilibrium. Once the fish loses equilibrium, keep the fish in the water for an additional 30 to 60 sec. When you take the fish out of the anesthesia bucket, call out "fish out of drugs." At that point, the data recorder will record the end time of when the fish was placed in the anesthesia bucket in the "Time out of Drugs" column in the electronic *Tagging Datasheet*. Time is recorded in the 12-hour clock notation in the following format: hh:mm:ss am/pm.
  - Relay any information to the data recorder. Time of sedation should normally be 2 to 4 min, with an average of about 3 min. If loss of equilibrium takes less than 1 minute or if a fish is in the anesthesia bucket for more than 5 min, then reject that fish. If after sedating a few fish and they are consistently losing equilibrium in more or less time than what is typical, then the anesthesia concentration may need to be adjusted. This should only be done after consultation with the field lead, and should be done in 0.5 mL increments. Concentration changes should be executed for all surgeons simultaneously and recorded on the *Tagging Datasheet*.
- Start a timer when a fish is removed from the anesthesia bucket to document the time the fish is out of the water. Once the fish is out of the anesthesia bucket, measure fish length, weight, and condition in the *Tagging Datasheet* using the steps described below:
  - Transfer the fish to the scale and weigh to the nearest 0.01 g.
  - Transfer the fish to the measuring board and measure fork length (FL) to the nearest mm.
  - Evaluate eye, scale, and fin condition and rate them as "good" (g), "fair" (f), or "poor" (p).

      - If a fish is unacceptable for tagging, then place the fish in the reject bucket and inform the data recorder to update the *Daily Fish Reject Tally Datasheet* and to update the *Tagging Datasheet*.
        - In addition, inform the fish runner to transport the fish in the reject bucket to the reject tank. Fish should be transferred through water-to-water transfers.
  - Data must be vocally relayed to the data recorder and the data recorder should repeat the information back to the surgeon to avoid miscommunication.
  - Any fish that is dropped on the floor during this process must be rejected.
    - A fish dropped on the table during surgery may still be tagged.
    - If a fish is dropped on the floor after it is tagged, then remove the tag and reject the fish. Afterwards, the fish should go in the reject bucket and should be placed back into the reject tank by the fish runner.
    - The data recorder should document this information in the *Daily Fish Reject Tally Datasheet* and update the *Tagging Datasheet*.
- Implanting a Surgical Tag
  - Selected fish will be bathed in cool (< 14°C), aerated water during surgery. Surgery will be performed in as sterile an environment as possible.
  - Fish will be placed ventral-side up on a surgery cradle made of Microcell foam with a size-specific mold to hold the fish in position.
    - See *Figure 3 to 5* at the end of this SOP for general reference of surgical procedures.
  - Water diffused with a maintenance anesthesia solution (20 mg/L) will be passed through the tubing using a pump and will continually flow into a reservoir in the mold where the fish's head will be submerged. This will gently flush the anesthetic solution over the gill membranes to ensure oxygen and anesthesia is carried to, and metabolic wastes are efficiently moved away from, the gills continuously throughout the procedure. Using the in-line valve, adjust the flow as needed, so that the gilling rate of the fish is steady.
  - Using a Sharppoint 15° stab point (3.0 mm or 5.0) mm restricted blade depth scalpel, an approximate 5 mm incision will be made parallel to and 2 mm to the side of the ventral midline, and anterior to the pelvic girdle.
    - One scalpel blade can be used on 5 to 7 fish before it

becomes dull. If the blade is pulling roughly or making jagged incisions, it needs to be changed.

- Use blunt-tipped forceps or hemostat to open the incision to ensure you did not damage any internal organs or cause excessive bleeding.
    - Do not implant the tag and reject that fish if you observe damage or think you damaged an organ. Excessive bleeding indicates likely organ damage. Therefore, it should be noted on the *Tagging Datasheet* if the surgery continues.
    - In order to avoid cutting into the pelvic girdle with the scalpel incision, consider making the incision from the tail towards the head. This will reduce the chance of tearing skin near the pelvic girdle. Even a small nick in the pelvic girdle will compromise swimming ability.
- A disinfected transmitter will be inserted through the incision into the peritoneal cavity of the fish. Transmitters should only be handled by gloved hands or clean surgical instruments such as forceps after the disinfection step.
    - The tag will be positioned, so it is lying immediately under the incision.
    - If a battery side is evident on the tag, it should be inserted first with the battery oriented parallel to the incision. As the tag is placed into the peritoneal cavity, the battery should be pushed towards the tail and the transducer of the tag should be towards the head.
    - This positioning will provide a barrier between the suture needle and internal organs. Through time, the tag location will naturally move posterior in the fish.
- The incision will be closed with one simple suture using the 3/8 circle needle with 4/0 Mono-Dox (violet monofilament polydoxanone) suture material.
    - Note: While suturing in and out, forceps should be used to separate the skin from muscle and organs to avoid suturing anything but the skin.
- To make a stitch, lock the needle (at the end of the suture) in the hemostat so the needlepoint faces you. Enter the outside edge of the incision on the side farthest from you and exit through the other edge of the incision, pulling the suture perpendicular through the two edges. The needle should enter and exit the skin as close to the edge of the incision as possible without tearing the skin (~ 2 mm from edge of incision).
    - Pull the needle and suture through the skin to leave a tag end of about 2 to 3 cm of suture material, protruding from the needle entrance location. Afterwards, release the needle from the needle drivers.

  - With your non-dominant hand, grasp the long end of the suture material (usually with thumb and forefinger) at or below the needle, and make two forward wraps (i.e., away from your body) around the tip of the needle driver, which should be held in your dominant hand.
  - With the two wraps still around the needle driver, grasp the short tag end of the suture material with the needle driver. Tighten the stitch by pulling the wraps off the needle driver and pull both ends of the suture material, perpendicular to the incision.
  - On the first knot, the dominant hand holding the needle driver should pull toward your body and the non-dominant hand should pull away from your body. Tighten the suture lightly, just so the edges of the incision meet, but do not overlap, pucker, or bulge the edges of the incision. The second knot is the same as the first, but in reverse order.
  - On the second knot, grasp the long end of suture material with your non-dominant hand, make two reverse wraps (i.e., toward your body) around the end of the needle driver, grasp the short end of suture with the needle driver, and tighten the stitch. This time, the knot should be tightened by pulling your dominant hand (holding the needle drivers) away from you and your non-dominant hand toward you. The second knot can be slightly tighter than the first, again taking care not to overlap, pucker, or bulge the edges of the incision. This completes one knot.
  - Cut the suture with the hemostat or scissors, leaving ends approximately 2 mm in length.
- If the incision is too long to close with one stitch, it is acceptable to add a second suture knot. Relay this information to the data recorder to document in the “Notes” section of the *Tagging Datasheet*. Furthermore, the surgeon will tell the data recorder if the incision, suturing, and tag placement was “good” (g), “fair” (f), or “poor” (p). Lastly, the surgeon should determine the level of bleeding (0, 1, 2, 3).
  - If the fish is in bad condition, then the fish should be rejected.
- Call out “surgery complete” and transfer the fish from the surgical platform to the appropriate recovery bucket for ten minutes. This should be done with minimal handling by moving the platform as close as possible to the bucket or using a liner material to lift the fish for transfer.
  - After the surgeon calls out “surgery complete,” the fish

runner should start the timer for ten minutes and the data recorder should record the actual time in the "Time out of Surgery" column of the *Tagging Datasheet*. Actual time should be recorded in the 12-hour clock notation (hh:mm:ss am/pm). In addition, there should be one fish per recovery bucket.
- When ten minutes is up, the fish runner will transport the fish to the circular (see next section).

▪ Each individual suture (one packet) can be used on five fish. Disinfect the suture material and the attached suture needle in the sanitizing solution used for instruments.

▪ Between surgeries, the surgeon should replace the tools that were just used into the disinfectant bath. Each surgeon will have at least 3 sets of surgical instruments to rotate through to ensure that tools get a thorough soaking in disinfectant for between uses (about 10-minute minimum contact time with disinfectant). Each surgery station will have one tray of Nolvasan, one tray of diluted Nolvasan, and one of distilled or de-ionized water.
- Once disinfected in Nolvasan solution, rinse the tools thoroughly with distilled or de-ionized water and ensure that the scalpel blade and suture are ready to use on the next fish. Organic debris in the disinfectant bath reduces its effectiveness, so be sure to change the bath regularly. If necessary, replace the scalpel blade.

Placing Tagged Fish into the Circulars:

- After the fish has stayed in the recovery bucket for ten minutes, the fish runner should remove the lid and make sure the fish has "recovered." This means that the fish has regained orientation and is maintaining upright swimming.
  - o If the fish is no longer alive, then the fish runner should bring back the fish in the bucket to the surgeon. Afterwards, the surgeon will perform a necropsy and retrieve the tag (see *Performing a Necropsy of Tagged Chinook Salmon* SOP for procedures).
  - o If the fish recovered, then the fish runner will move the bucket and clipboard over to the circular for holding the fish.
    - ▪ Once at the circular, the fish runner should release the fish into the tank. This is done by partially submerging the bottom of the recovery bucket into the circular and

gently tilting the bucket until the fish is released into the circular.
    - When the fish is released, the fish runner will call out "recovery complete" with the bucket ID. Afterwards, the data recorder will record the time in the 12-hour clock notation in the "Recovery" column of the *Tagging Datasheet*.
- It is the responsibility of the fish runners to keep track of the number of fish that are placed into a circular. This should be done through tallies on the *Circular Chain of Custody*.
- When there are 25 fish in the circular, the tagging coordinator should record the total number of fish in the tank and document any mortality in the *Circular Chain of Custody*. Any dead salmon should be bagged in separate Ziploc bags and labeled with the date of bagging, the time of bagging using the 24-hour clock notation (hh:mm), and the circular in which the dead salmon was found. Afterwards, the surgeon will perform a necropsy and retrieve the tag (see *Performing a Necropsy of Tagged Chinook Salmon* SOP for procedures).
- After 25 fish are placed into a single circular, the fish runner should move on to the next circular using similar procedures. Five circulars should be filled per day with 25 fish.
- At the end of each day, the fish runner or data recorder should record the number of fish, the mean weight of fish (nearest 0.01 g) and the mean fork length of fish (nearest whole fish in mm) for each circular in the *Daily Feed Log*. This information is used to determine the rough amount of feed to place into each tank (see the *Daily Fish Care after Tagging at the Livingston Stone National Fish Hatchery* SOP).
    - In addition, the fish runner should measure the dissolved oxygen levels (mg/L and % saturation) and water temperature (°F) of one of the circulars at the end of the tagging session. Additional circulars should be checked if there are water quality concerns.
        - Record all parameters as measured with the Hach meter.

End of Session Activities:

- Validate the tag data and datasheet accuracy.
    - Working together, each tagger and assistant team will review the transmitter tubes/serial numbers against the *Tagging Datasheet* to verify that all of the transmitters provided for the session were implanted into study fish. The steps of the verification process could include reading the serial number on each tag tube and finding that the serial number on the datasheet to confirm that it was implanted.
- Review information on the *Tagging Datasheet* and complete any

missing information.

- Organize tagging solutions and surgical instruments to be ready for the next tagging session.
- Provide the Livingston Stone National Fish Hatchery with any datasheets that they need for the fish care process. This includes all of the datasheets needed for the fish care process and the necropsies that have to be performed in case there are morts.

End of Day Clean up:

- At the end of each tagging day, wipe down or spray all surfaces with 70% ETOH to disinfect.
- Move rejected fish back into the circulars based on the protocols by the hatchery. Dispose of any morts from the reject coolers in the dumpster.
- Use a toothbrush to remove all large organic debris from instruments, rinse them and dry them to prevent rust.
- Make surgical tagging solutions as needed to be ready for the next tagging session.
- Inventory chemical solutions and tagging supplies (blades and suture).
- Return any soiled rags to the office and have them washed.
- Rinse buckets with hose and place upside down to dry.
- Turn off the oxygen cylinder.

General Fish Handling Reminders:

- Anesthesia and freshwater containers and buckets should be filled just prior to tagging to avoid temperature changes and should be changed often. Check levels of carboys before each surgery to be certain that you will not run out of water during a surgery.
- **USE CAUTION and COMMUNICATION** when adding MS-222 and bicarbonate to any container to avoid adding two doses or no doses to the container.
- Keep a lid on any bucket or cooler that contains fish.
- Any fish dropped on the floor should be rejected. If a fish is dropped on the floor after it has been tagged, then remove the tag, and place it into another fish. The dropped fish then goes into the reject cooler for sutured fish.
- **CAREFULLY HANDLE BUCKETS**. Try not to bang them around, slam the handles, or otherwise handle in a rough manner as this can stress fish.

- **USE A SANCTUARY NET** to capture source fish and place them into an anesthesia bucket. A recommended approach is to use a non-sanctuary net in the container of source fish in order to capture the fish without them detecting the pressure wave in front of the sanctuary net. Once a fish is in the traditional net, place the sanctuary net immediately below the fish so that the handles of the two nets are aligned and can be handled together.

Figures

Figure A1. Example of setup for disinfecting and rinsing surgical equipment. The figure shows one container of Nolvasan, one container of diluted Nolvasan, and one container of distilled water.

Figure A2. Example of setup for maintenance bath (large container) with drain tray (smaller container) and surgical platform.

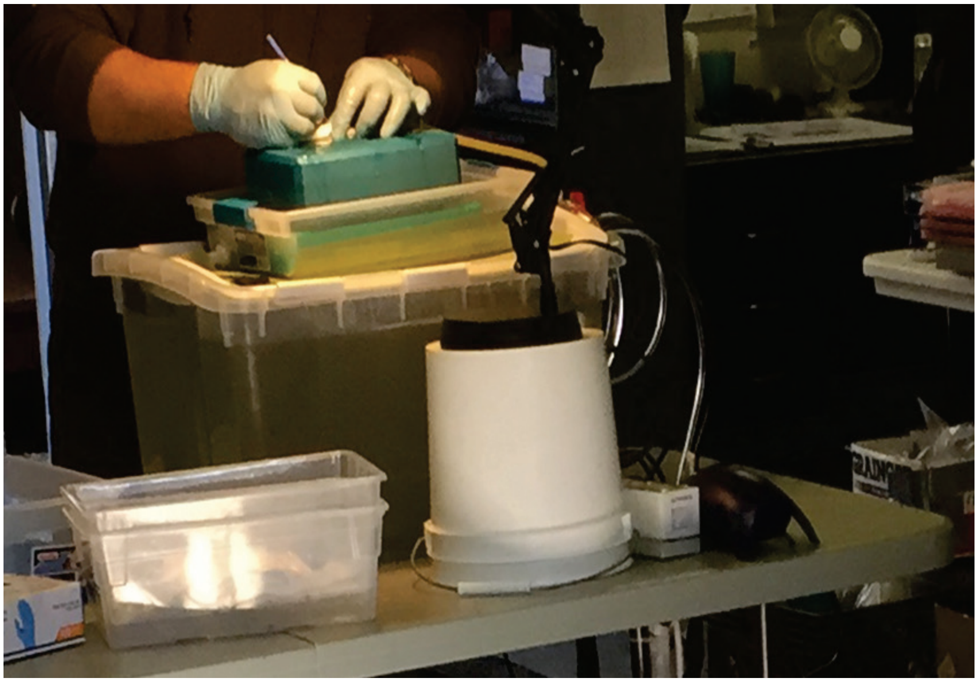


Figure A3. Lateral view of a juvenile salmonid, showing the location of internal organs. Courtesy of Liedtke et al. (2012).

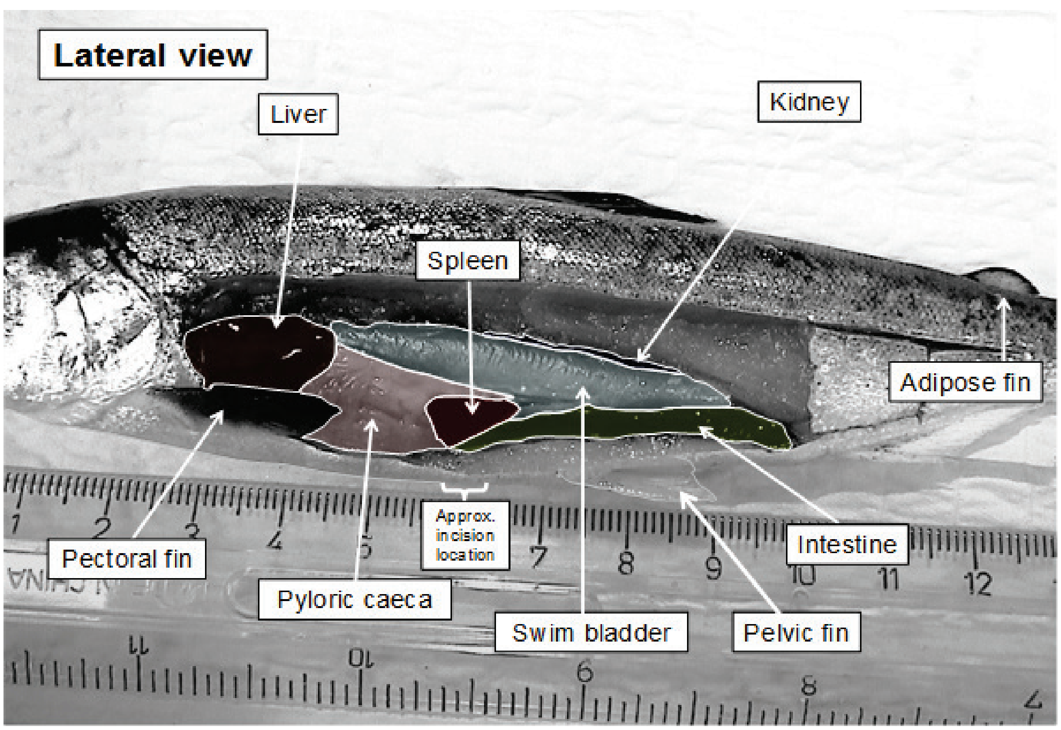


Figure A4. Proper surgical procedures help ensure rapid recovery and incision healing (note proper incision healing on photo right). Courtesy of Cramer Fish Sciences.

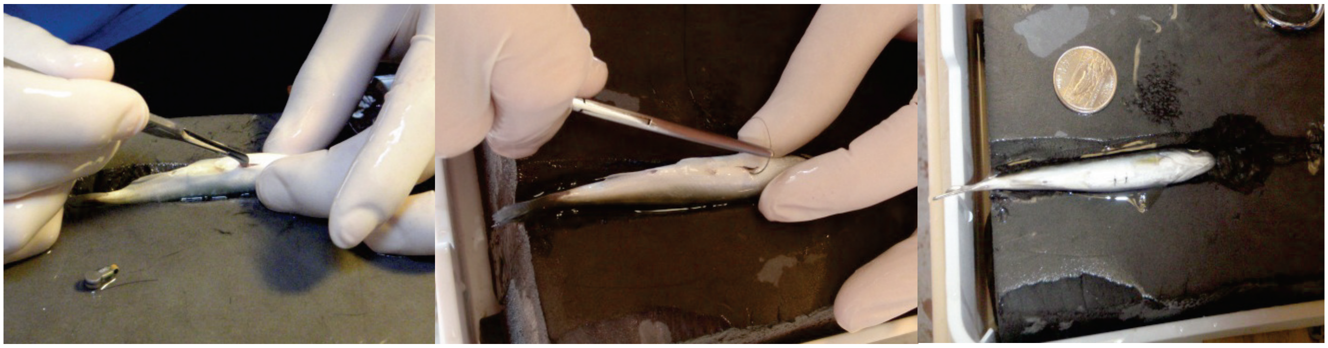
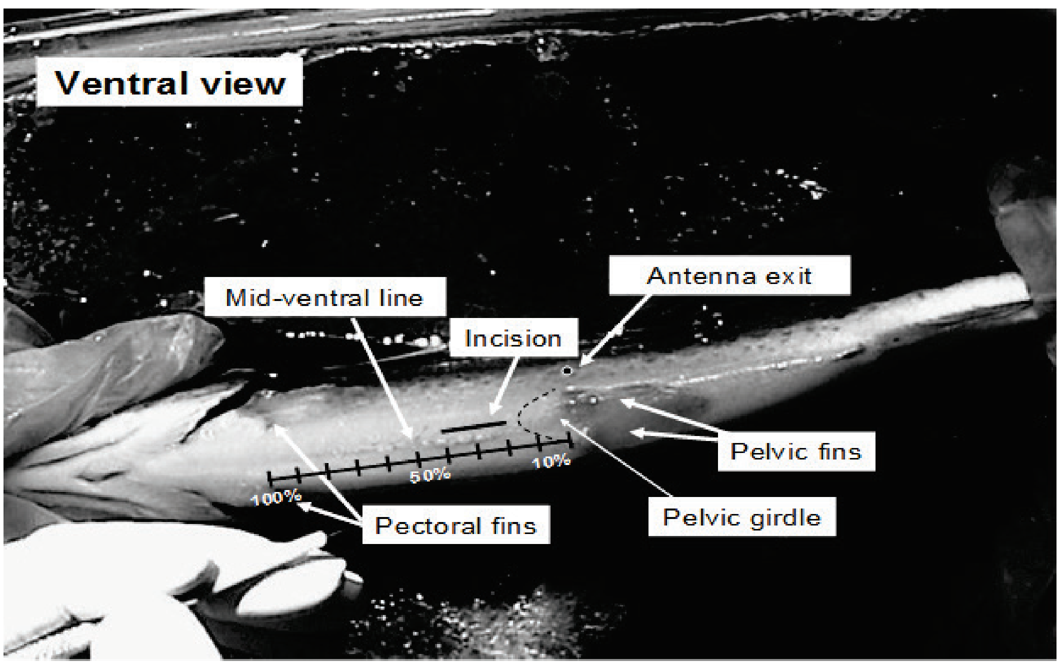


Figure A5. Ventral view of a juvenile salmonid. This shows the location external organs and proper placement of incision and antenna exit (if applicable). Courtesy of Liedtke et al. (2012).



References

Liedtke, T. L., J. W. Beeman, and L. P. Gee. 2012. A standard operating procedure for the surgical implantation of transmitters in juvenile salmonids: U.S. Geological Survey Open-File Report 2012-1267.

Appendix B: Tagging Late-Fall-Run Chinook Salmon at the Coleman National Fish Hatchery

Standard Operating Procedure (SOP)

Adapted from Liedtke et al. (2001), and the 2011 procedures from Cramer Fish Sciences, the SOPs used for the Department of Interior's South Delta telemetric studies, amd the 2011 work instructions used for the U.S. Army Corps of Engineers telemetric studies.

Purpose and scope:

This SOP provides the steps needed to tag hatchery late-fall-run Chinook salmon at the Coleman National Fish Hatchery for the 2015 Fremont Weir Fish Behavior Study. Over the course of two days, 250 late-fall-run Chinook salmon will be tagged at the hatchery and held in circulars until the salmon are ready for release. At a minimum, the following staff will be required to implement this SOP:

- Two surgeons to tag salmon and to work on equipment setup,
- Two data recorders to help with recording data in a Microsoft Access database and to help prepare the acoustic tags, and
- Two fish runners to help with moving tagged Chinook salmon to the circulars,preparing recovery buckets, and taking water quality data.

When applicable, this SOP identifies the tasks that are assigned to the data recorders and fish runners. Any tasks not assigned to these staff are directed to the surgeons. However, the surgeons can seek assistance from the data recorders and fish runners when appropriate.

Materials:

1. YSI ODO dissolved oxygen meter
2. Hardness ($CaCO_3$) water quality test kit
3. Thermometer for quick temperature checks
4. pH meter or litmus paper
5. Acoustic tags (V-4)

6. VEMCO acoustic tag activator with manual. Manual found at http://vemco.com/wp-content/uploads/2013/03/vta_manual.pdf.
7. VEMCO acoustic tag verification equipment (VR-100 with 180 VH hydrophone) with manual. Manual found at http://vemco.com/wp-content/uploads/2013/02/vr100hw_manual.pdf.
8. Distilled or de-ionized water (D-H_2O)
9. Chlorhexidine solution (Nolvasan ; 30 mL/L D-H_2O)
10. Aqui-S 20E (10% eugenol)
11. Stress coat - stock concentration and 25% solution (250mL/L D- H_2O)
12. Disinfectant solution (i.e., 70% ETOH)
13. PVP iodine (Ovadine)
14. 19 L black bucket(s) marked at 10 L and clearly labeled "Anesthesia"
15. 19 L buckets for post-surgical recovery of fish and for rejecting fish
    a. Liedtke et al. (2012) does not recommend the use of white or black buckets. White buckets are not ideal for restricting light penetration, while black buckets are too dark and absorbs large amounts of solar radiation. However, the color of the bucket will not be an issue for this study since tagging will either be conducted indoors or under a canopy for shading.
16. Cooler for storing fish before tagging
17. Two large water containers for surgical stations
18. Water pumps with extension cord and rubber tubing with in-line shut-off valve and terminal narrowing
19. Rubber tubing to return water from drain tray to maintenance anesthetic bath
20. Designated syringes (5 mL) for measuring anesthetic and stress coat
21. Oxygen delivery system (cylinder, regulator, airline, air diffusers) for recovery buckets
22. Fish nets (e.g., sanctuary nets, dips)
23. Nitrile gloves (in all sizes)
24. Scale measuring to the nearest 0.01 g (weighing fish and tags)
25. Large sponges
26. Measuring board with ruler to the nearest mm
27. Surgical platform (cradle)
28. Trays for holding solutions used to disinfect surgical tools
29. Trays to rinse disinfected tools
30. Needle drivers (multiple sets)
31. Forceps (multiple sets)
32. Scalpel handle and blades (multiple sets)
33. Scissors (multiple sets)

34. Tissue collection supplies: scissors, blotter paper, labeled coin envelopes
35. Sutures: 19 mm 3/8 circle needle with 4/0 Mono-Dox (violet monofilament polydoxanone) suture material
36. Spray bottles for disinfectant solution
37. Timers and stopwatches
38. Sharps container
39. Datasheets, clipboards, and writing tools
40. Three laptops for data recording
41. Carabiner tag labels to identify fish in recovery buckets
42. Clean rags for keeping tagging areas clean and dry
43. Tables and chairs

Pre-tagging Activities:

- Prior to the tag implantation, the tagging coordinator will need to get in touch with the Coleman National Fish Hatchery on the following items:
    - Notify hatchery staff on the pre-tag fish-holding period requirements. The pre-tag fish-holding period should be 18 to 36 hr.
        - Food should be withheld during the pre-tagging holding period.
    - Notify hatchery staff on the list of study personnel that will be at the hatchery and tagging schedule. All study personnel must bring government issued identification, such as a California driver's license.
- Disinfect all buckets and coolers with PVP iodine (e.g., Ovadine) either at the hatchery or prior to arriving. If this step is not completed prior to arrival, then all equipment must be disinfected at the hatchery before use.

Equipment Setup:

- *Datasheet Setup*
    - Start the electronic *Tagging Datasheet* in a Microsoft Access database for each tagging station. Each data recorder should have a separate database.
    - Prepare a hard copy *Daily Fish Reject Tally Datasheet* for each tagging station to account for fish that are handled, but are not used for the study.

- *Tag Activation*
    - All tags will have been activated prior to tagging.
    - The data recorder will sterilize the acoustic tag in a solution of Nolvasan for a few minutes. Following disinfection, thoroughly rinse transmitters in distilled or deionized water prior to implantation.
    - The data recorder will record the tag serial ID, the tag code ID, and the surgeon and data recorders name in the electronic *Tagging Datasheet* after tag verification.
    - Calibrate the scale and weigh one tag to the nearest 0.01 g in the *Tagging Datasheet* to verify the tag weight and determine minimum weight requirements for tagged fish.
- *Setting up Circulars*
    - Check to make sure that the six circulars for tagged Chinook salmon have water circulating through them. Afterwards, label each circular with a study circular ID with white duct tape and a Sharpie pen.
    - Circular 1,2,4, and 5 will contain 50 tagged fish each.
    - Circular 3 and 6 will contain 25 tagged fish each.

- *Filling and Preparing Trays and Buckets*
    - Fill disinfection trays for surgical instruments with diluted Nolvasan.
    - Fill rinse trays with de-ionized or distilled water.
        - See Figure 1 for example of tray setup.
    - Clip on numerical tag labels to recovery buckets, which will serve as the bucket ID.
- *Water Temperature Checks for Anesthesia Bucket, Surgical Bath, and Holding Cooler*
    - Water temperatures during all aspects of the tagging operations cannot exceed 2°C difference from the reference water source. The fish runners or surgeons will check all water sources periodically and record results in the *Tagging Datasheet* to ensure that water temperature levels are within criteria. For this study, the rectangular tank where source fish are held is the reference water source.
        - Anesthesia buckets, maintenance bath containers, and recovery buckets should not be filled until near the time that they are needed to avoid warming.
        - Anesthesia buckets and maintenance bath containers should be replaced regularly to prevent increasing water temperatures over time.
- *Equipment Setup for Recovery/Reject Buckets*
    - Set up the oxygen cylinder with a trigger.
        - The oxygen cylinder will be used for the recov-

ery/reject buckets. Prior to use, conduct an experiment to see how long you should hold the trigger to target a DO saturation of 120 to 150% in the recovery bucket. Seven sec was used in past SOPs, but this may differ for this study.
  - This recovery bucket should be attached with an air stone and air pump.

- *Euthanasia*
  - Set up a separate bucket for any necessary euthanasia. An Aqui-S solution of 175 mg/L should be used for 20 min to euthanize any fish that cannot be returned to the raceway.

Fish Selection Criteria:

- For all experimental groups, handling protocols will be standardized to reduce potential bias (i.e., fish length, number of times handled, tagging procedures, transport methods, transport time, and release protocol).
- VEMCO V4 tags weigh about 0.41 g in the air. The estimated minimum length and weight of the Chinook salmon for surgical tagging should be >8.2 g (tag weight $\leq$ 5 % of the body weight), respectively. Fish should be targeted between 90 – 100 mm in FL.

Fish Tagging:

- *Equipment setup*
  - Prepare surgical table and equipment for use.
    - The surgeon should wear clean gloves during all procedures that involve handling fish.
    - The surgical station will be cleaned and wiped down with a solution of disinfectant, and surgical instruments will be placed in a disinfectant bath (e.g., dilute Nolvasan, chlorhexidine solution) before fish handling and surgical procedures.
    - Surgical instruments will be transferred to a freshwater rinse bath before surgery and rinsed twice.
    - Rinse tray should be changed often to avoid accumulation of disinfectant in rinse water.
    - To minimize the chances for pathogen transfer between fish populations, all equipment used for capture, holding, anesthesia, surgery, recovery, and movement of

fish during the project will be thoroughly cleaned and disinfected before use with a different fish population.
    - Soiled gloves should be changed immediately and after handling 10 fish.
  - Set up measuring board and scale. A sponge should be placed on the scale when weighing the fish to reduce the stress to fish and for the ease of handling.
    - Put approximately 1-2 mL of diluted stress coat on the weigh sponge and the measuring board.
  - For each tagging station, the fish runner must fill a 19 L bucket halfway with circular water. In addition, the bucket should be supplied with a small amount of undiluted stress coat, with oxygen using an oxygen cylinder. The bucket should also be fitted with an air stone/air pump before tagging.
    - The concentration of DO in the recovery buckets should be between 120% and 150% saturation by holding the trigger for a few sec.
    - These 19 L buckets serve both as the recovery bucket and the reject bucket. The bucket becomes the recovery bucket if the fish was tagged and it becomes the reject the bucket if the fish was handled, but not used for the study.
    - Fish rejected during surgery can not be returned to the raceway and will be euthanized in a concentrated solution of Aqui-S (175mg/L).
- *Administration of Anesthetic*
  - The effectiveness of Aqui-S as an anesthetic varies with factors, such as temperature, fish density, and individual sensitivity. Adjustments of the anesthesia concentration should be based on the amount of time it takes for a fish to lose equilibrium. Any adjustments should be recorded in the *Tagging Datasheet* with a separate treatment ID.
    - Fill the anesthesia bucket with 3 gallons of circular water. As a suggestion for a starting concentration, add 3.4 mL of Aqui-S to the water using a syringe. This will yield an anesthetic concentration of 30 mg/L. Base the daily starting concentration on fish responses during the tagging operation from the previous days. Rinse the syringe with treatment water to ensure all Aqui-S is dispensed.
    - Aqui-S should be added directly, while constantly mixing, to the full volume of treatment water. Do not make stock solutions or any other dilute solutions of Aqui-S prior to use.
  - Prepare the maintenance bath containers with water from the

circular and with a water pump/tubing (see Figure 2 for setup). This is done by completing the following procedures:

- Fill the container with 10 gallons of circular water.
- Place the pump into water and ensure tubing is fit properly.
- As a suggestion for a starting concentration, add 5.7 mL of Aqui-S to the water using a syringe. This will yield an anesthetic concentration of 15 mg/L. Base the daily starting concentration on fish responses during the tagging operation from the previous days. Rinse the syringe with treatment water to ensure all Aqui-S is dispensed.
- Water in all containers (anesthesia and maintenance) should be changed regularly to minimize dilution of anesthesia water and temperature changes. Moreover, this is done to ensure you do not run out of water during a procedure.
- Add a small amount of diluted stress coat for each liter of water in the anesthesia and maintenance bath to protect fish from loss/damage to the slime layer.

- *Anesthetizing the Fish*
  - With help from the hatchery, identify the proper raceway containing fish that will be used for the study and place a subset of those fish into a cooler with an air pump and air stone.
    - Having fish in a cooler will help the surgeons gather fish for tagging and avoid a long commute from the raceway to the tagging station.
  - Use a sanctuary net or dip net to remove one fish from the pre-tag holding cooler and place directly into an anesthesia bucket.
    - Remove the fish from the net by hand, taking care not to dilute the anesthesia bath with water from the net.
      - Note: The most significant source of stress that fish experience is usually from being netted. Every effort should be made to minimize handling and sanctuary nets should be used when feasible.
    - Secure the lid as soon as the fish is in the bucket.
    - Call out “fish in drugs” and start a timer to keep track of how long a fish has been in the anesthesia bucket. The data recorder will record the start time of when the fish was placed in the anesthesia bucket in the electronic *Tagging Datasheet* based on when the surgeon called out “fish in drugs.” Time is recorded in the 12-hour clock notation in the following format: hh:mm:ss am/pm.

- Remove the lid after about 1 minute to observe the fish for loss of equilibrium. Once the fish loses equilibrium, keep the fish in the water for an additional 30 to 60 sec. When you take the fish out of the anesthesia bucket, call out "fish out of drugs." At that point, the data recorder will record the end time of when the fish was placed in the anesthesia bucket in the "Time out of drugs" column in the electronic *Tagging Datasheet*. Time is recorded in the 12-hour clock notation in the following format: hh:mm:ss am/pm.
    - Relay any information to the data recorder. Time of sedation should normally be 2 to 4 min, with an average of about 3 min. If loss of equilibrium takes less than 1 min or if a fish is in the anesthesia bucket for more than 5 min, then reject that fish. If after sedating a few fish and they are consistently losing equilibrium in more or less time than what is typical, then the anesthesia concentration may need to be adjusted. This should only be done after consultation with the field lead, and should be done in 0.5 mL increments. Concentration changes should be executed for all surgeons simultaneously and recorded on the *Tagging Datasheet*.
- Start a timer when a fish is removed from the anesthesia bucket to document the time the fish is out of the water. Once the fish is out of the anesthesia bucket, measure fish length, weight, and condition for the *Tagging Datasheet* using the steps described below:
    - Transfer the fish to the scale and weigh to the nearest 0.01 g.
    - Transfer the fish to the measuring board and measure fork length (FL) to the nearest mm.
    - Evaluate eye, scale, and fin condition and rate them as "good" (g), "fair" (f), or "poor" (p).
        - If a fish is determined to be unacceptable for tagging prior to surgery, place the fish in the reject bucket and inform the data recorder to update the *Daily Fish Reject Tally Datasheet* and to update the *Tagging Datasheet*.
            - In addition, inform the fish runner to transport the fish in the reject bucket to the reject tank. Fish should be transferred through water-to-water transfers.
        - If the fish is determined to be unacceptable during surgery, the fish will be euthanized.
- Data must be vocally relayed to the data recorder and the data recorder should repeat the information back to the

surgeon to avoid miscommunication.
  - Any fish that is dropped on the floor during this process must be rejected.
    - A fish dropped on the table during surgery may still be tagged.
    - If a fish is dropped on the floor after it is tagged, then remove the tag and reject the fish.
    - The data recorder should document this information in the *Daily Fish Reject Tally Datasheet* and update the *Tagging Datasheet*.
- *Implanting a Surgical Tag*
  - Selected fish will be bathed in cool (<14 °C), aerated water during surgery. Surgery will be performed in as sterile an environment as possible.
  - Fish will be placed ventral-side up on a surgery cradle made of Microcell foam with a size-specific mold to hold the fish in position.
    - See Figure 3 to 5 at the end of this SOP for general reference of surgical procedures.
  - Water diffused with a maintenance anesthesia solution (15 mg/L) will be passed through the tubing using a pump and will continually flow into a reservoir in the mold where the fish's head will be submerged. This will gently flush the anesthetic solution over the gill membranes to ensure oxygen and anesthesia is carried to, and metabolic wastes are efficiently moved away from, the gills continuously throughout the procedure. Using the in-line valve, adjust the flow as needed, so that the gilling rate of the fish is steady.
  - Using a Sharppoint 15° stab point (3.0 mm or 5.0 mm) restricted blade depth scalpel, an approximate 5 mm incision will be made parallel to and 2 mm to the side of the ventral midline and anterior to the pelvic girdle.
    - One scalpel blade can be used on 5 to 7 fish before it becomes dull. If the blade is pulling roughly or making jagged incisions, it needs to be changed.
  - Use blunt tipped forceps or hemostat to open the incision to ensure you did not damage any internal organs or cause excessive bleeding.
    - Do not implant the tag and reject that fish if you observe damage or think you damaged an organ. Excessive bleeding indicates likely organ damage. Therefore, it should be noted on the *Tagging Datasheet* if the surgery continues.
    - In order to avoid cutting into the pelvic girdle with the scalpel incision, consider making the incision from the tail towards the head. This will reduce the chance of

tearing skin near the pelvic girdle. Even a small nick in the pelvic girdle will compromise swimming ability.

- A disinfected tag will be inserted through the incision into the peritoneal cavity of the fish. Tags should only be handled by gloved hands or clean surgical instruments such as forceps after the disinfection step.
    - The tag will be positioned, so it is lying immediately under the incision.
    - If a battery side is evident on the tag, it should be inserted first with the battery oriented parallel to the in. As the tag is placed into the peritoneal cavity, the battery should be pushed towards the tail and the transducer of the tag should be towards the head.
    - This positioning will provide a barrier between the suture needle and internal organs. Through time, the tag location will naturally move posterior in the fish.
- The incision will be closed with one simple suture using the 10.5 mm (NP-1) precision point, 3/8 circle needle with 4/0 Mono-Dox (violet monofilament polydoxanone) suture material.
    - Note: While suturing in and out, forceps should be used to separate the skin from muscle and organs to avoid suturing anything but the skin.
- To make a stitch, lock the needle (at the end of the suture) in the hemostat so the needlepoint faces you. Enter the outside edge of the incision on the side farthest from you and exit through the other edge of the incision, pulling the suture perpendicular through the two edges. The needle should enter and exit the skin as close to the edge of the incision as possible without tearing the skin (~ 2 mm from edge of incision).
    - Pull the needle and suture through the skin to leave a tag end of about 2 to 3 cm of suture material protruding from the needle entrance location. Afterwards, release the needle from the needle drivers.
    - With your non-dominant hand, grasp the long end of the suture material (usually with thumb and forefinger) at or below the needle, and make two forward wraps (i.e., away from your body) around the tip of the needle driver, which should be held in your dominant hand.
    - With the two wraps still around the needle driver, grasp the short tag end of suture material with the needle driver and tighten the stitch by pulling the wraps off the needle driver and pulling both ends of suture material perpendicular to the incision.

        - On the first knot, the dominant hand holding the needle driver should pull toward your body and the non-dominant hand should pull away from your body. Tighten the suture lightly, just so the edges of the incision meet, but do not overlap, pucker, or bulge the edges of the incision. The second knot is the same as the first, but in reverse order.
        - On the second knot, grasp the long end of suture material with your non-dominant hand, make two reverse wraps (i.e., toward your body) around the end of the needle driver, grasp the short end of suture with the needle driver, and tighten the stitch. This time, the knot should be tightened by pulling your dominant hand (holding the needle drivers) away from you and your non-dominant hand toward you. The second knot can be slightly tighter than the first, again taking care not to overlap, pucker, or bulge the edges of the incision. This completes one knot.
        - Cut the suture with the hemostat or scissors, leaving ends approximately 2 mm in length.
    - If the incision is too long to close with one stitch, it is acceptable to add a second suture knot. Relay this information to the data recorder to record in the "Notes" section of the *Tagging Datasheet*. Furthermore, the surgeon will tell the data recorder if the incision, suturing, and tag placement was "good" (g), "fair" (f), or "poor" (p). Lastly, the surgeon should determine the level of bleeding (0, 1, 2, 3).
        - If the fish is in bad condition, then the fish should be rejected.
    - Call out "surgery complete" and transfer the fish from the surgical platform to the appropriate recovery bucket for ten minutes. This should be done with minimal handling by moving the platform as close as possible to the bucket or using a liner material to lift the fish for transfer.
        - After the surgeon calls out "surgery complete," the fish runner should start the timer for ten minutes and the data recorder should record the actual time in the "Time out of Surgery" column of the *Tagging Datasheet*. Actual time should be recorded in the 12-hour clock notation (hh:mm:ss am/pm). In addition, there should be one fish per recovery bucket.
            - When ten minutes is up, the fish runner will transport the fish to the circular (see next section).
        - Each individual suture (one packet) can be used on approximately five fish. Disinfect the suture material and

the attached suture needle in the sanitizing solution used for instruments.

- Between surgeries, the surgeon should replace the tools that were just used into the disinfectant bath. Each surgeon will have at least 3 sets of surgical instruments to rotate through to ensure that tools get a thorough soaking in disinfectant between uses. Each surgery station will have one tray of Nolvasan, one tray of diluted Nolvasan, and one of distilled or de-ionized water.
    - Once disinfected in Nolvasan solution, rinse the tools thoroughly with distilled or de-ionized water and ensure that the scalpel blade and suture are ready to use on the next fish. Organic debris in the disinfectant bath reduces its effectiveness, so be sure to change the bath regularly. If necessary, replace the scalpel blade.

Placing Tagged Fish into the Circulars:

- After the fish has stayed in the recovery bucket for ten minutes, the fish runner should remove the lid and make sure the fish has "recovered." This means that the fish has regained orientation and is maintaining upright swimming.
    - If the fish is no longer alive, then the fish runner should bring back the fish in the bucket to the surgeon. Afterwards, the surgeon will perform a necropsy and retrieve the tag (see *Performing a Necropsy of Tagged Chinook Salmon* SOP for procedures).
    - If the fish recovered, then the fish runner will move the bucket and clipboard over to the circular for holding the fish.
        - Once at the circular, the fish runner should release the fish into the tank. This is done by partially submerging the bottom of the recovery bucket into the circular and gently tilting the bucket until the fish is released into the circular.
        - When the fish is released, the fish runner will call out "recovery complete" with the bucket ID. Afterwards, the data recorder will record the time in the 12-hour clock notation in the "Recovery" column of the *Tagging Datasheet*.
- It is the responsibility of the fish runners to keep track of the number of fish that are placed into a circular. This should be done through tallies on a field notebook.
- When there are 25 or 50 fish in the circular, the tagging coordinator should record the total number of fish in the tank and document any

mortality on a field notebook. Any dead salmon should be bagged in separate Ziploc bags and labeled with the date of bagging, the time of bagging using the 24-hour clock notation (hh:mm), and the circular in which the dead salmon was found. Afterwards, the surgeon will perform a necropsy and retrieve the tag (see *Performing a Necropsy of Tagged Winter-run Chinook Salmon* SOP for procedures).

- After 25 or 50 fish are placed into a single circular, the fish runner should move on to the next circular using similar procedures. Three circulars should be filled per day (two with 50 fish and one with 25 fish).
- At the end of each day, the fish runner or data recorder should record the number of fish and total fish weight in each cooler. This information should be given to the hatchery and is used to determine the rough amount of feed to place into each tank.
    - Water quality will be taken through out the day and used to ensure conditions in the holding tanks remain acceptable.

End of Session Activities:

- Validate the tag data and datasheet accuracy.
    - Working together, each tagger and assistant team will review the transmitter tubes/serial numbers against the *Tagging Datasheet* to verify that all of the transmitters provided for the session were implanted into study fish. The steps of the verification process should include reading the serial number on each tag tube, finding that serial number on the datasheet to confirm that it was implanted.
- Export the Access datasheets to Excel and review the information on the *Tagging Datasheet* and complete any missing information.
- Organize tagging solutions and surgical instruments to be ready for the next tagging session.
- Provide the Coleman National Fish Hatchery with any datasheets that they need for the fish care process. This includes all of the datasheets needed for the fish care process and the necropsies that have to be performed in case there are morts.

End-of-Day Clean up:

- At the end of each tagging day, wipe down or spray all surfaces with 70% ETOH to disinfect.
- Move rejected fish back into the circulars and dispose of any euthanized fish based on the protocols by the hatchery.

- Use a toothbrush to remove all large organic debris from instruments, rinse them and dry them to prevent rust.
- Make surgical tagging solutions as needed to be ready for the next tagging session.
- Inventory chemical solutions and tagging supplies (blades and suture).
- Return any soiled rags to the office and have them washed.
- Rinse buckets with hose and place upside down to dry.
- Turn off the oxygen cylinder.

General Fish Handling Reminders:

- Anesthesia and freshwater containers and buckets should be filled just prior to tagging to avoid temperature changes and should be changed often. Check levels of carboys before each surgery to be certain that you will not run out of water during a surgery.
- **USE CAUTION and COMMUNICATION** when adding Aqui-S to any container to avoid adding two doses or no doses to the container.
- Keep a lid on any bucket or cooler that contains fish.
- Any fish dropped on the floor should be rejected. If a fish is dropped on the floor after it has been tagged, then remove the tag, and place it into another fish. The dropped fish will then be euthanized.
- **CAREFULLY HANDLE BUCKETS**. Try not to bang them around, slam the handles, or otherwise handle in a rough manner as this can stress fish.
- **USE A SANCTUARY NET** to capture source fish and place them into an anesthesia bucket. A recommended approach is to use a non-sanctuary net in the container of source fish in order to be able to capture the fish without them detecting the pressure wave in front of the sanctuary net. Once a fish is in the traditional net, place the sanctuary net immediately below the fish so that the handles of the two nets are aligned and can be handled together.

Figures

Figure B1. Example of setup for disinfecting and rinsing surgical equipment. The figure shows one container of Nolvasan, one contained of diluted Nolvasan, and one container of distilled water.

Figure B2. Example of setup of maintenance bath (large container) with drain tray (smaller container) and surgical platform.

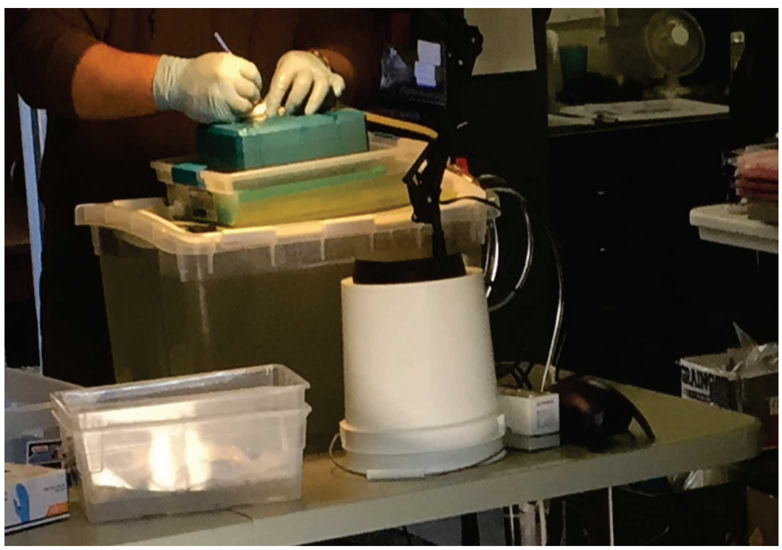


Figure B3. Lateral view of a juvenile salmonid, showing the location of internal organs. Courtesy of Liedtke et al. (2012).

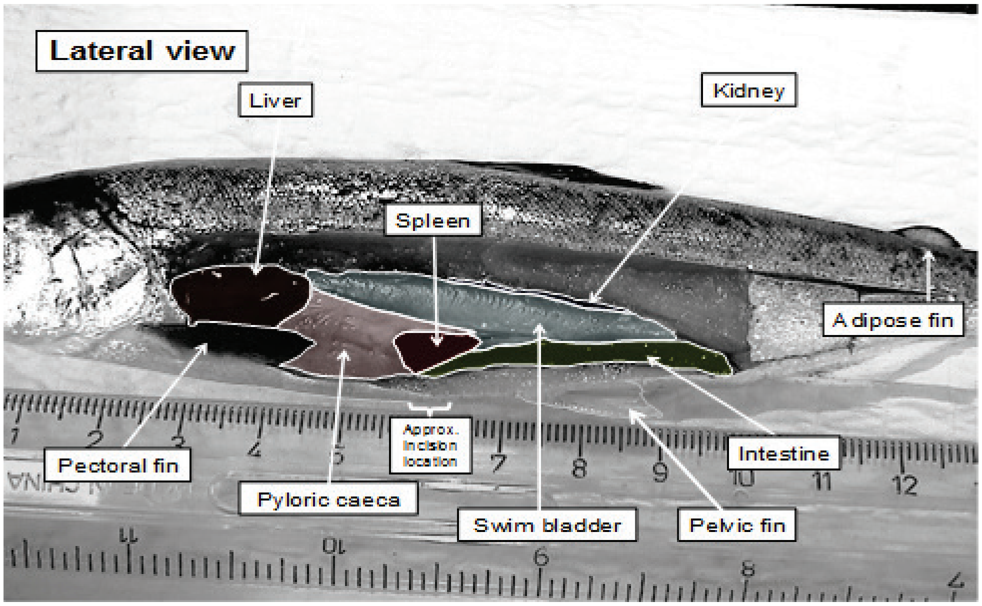


Figure B4. Proper surgical procedures help insure rapid recovery and incision healing (note proper incision healing on photo right). Courtesy of Cramer Fish Sciences.

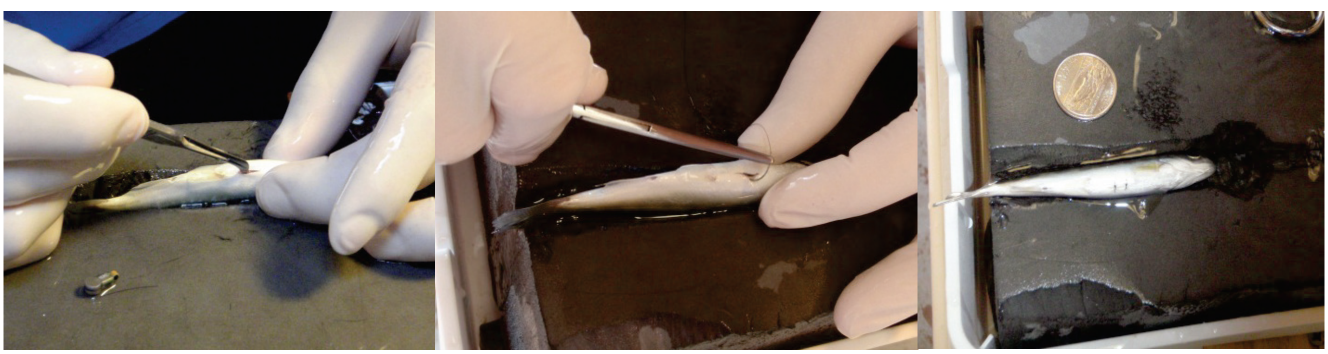
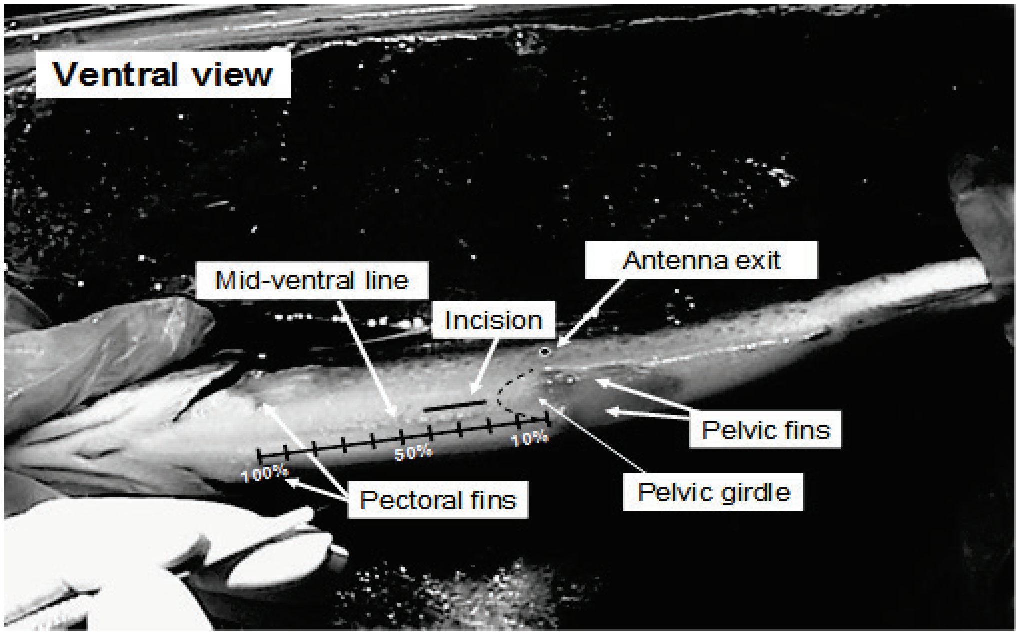


Figure B5. Ventral view of a juvenile salmonid. This shows the location external organs and proper placement of incision and antenna exit (if applicable). Courtesy of Liedtke et al. (2012).



References

Liedtke, T. L., J. W. Beeman, and L. P. Gee. 2012. A standard operating procedure for the surgical implantation of transmitters in juvenile salmonids: U.S. Geological Survey Open-File Report 2012-1267.

Daily Reject Tally Datasheet

2015 Fremont Weir Fish Behavior Study

Tag Date:____________ Surgeon:______________

Data Recorder:______________

Species (circle one): **WCHN or LFCHN**

REJECTS	TALLY
Disease	______________________
Descaling	______________________
Dropped	______________________
Injury	______________________
Fungus	______________________
Anesthesia	______________________
Too small	______________________
Too large	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Specify Other	______________________
Total:	

Tagging Datasheet

2015 Fremont Weir Fish Behavior Study (Late-fall-run Chinook Salmon)

Background: The *Tagging Datasheet* is entered electronically in a Microsoft Access database. The following fields need to be created for this datasheet.

Field	Description
Date Tagged	Enter as mm/dd/yyyy.
Date Released	Enter as mm/dd/yyyy. This data is entered after fish are released.
Time Released	This data is entered after fish are released.
Treatment ID	Used to identify the concentration of Aqui-S used in the surgical bath and anesthesia bucket. The use of A and B is used to identify the surgeon.
Study ID	Used to ID the study. All records should be recorded as FY 15 Tracking.
Fish ID	Used to identify the fish for the study. Recorded as LFC ###.
Species	All records should be LFC (late-fall-run Chinook)
Tag SN	Serial number of the V4 tag
Tag ID	Enter tag code ID
Tank	Enter the circularID where fish was placed after tagging.
Bucket	Enter the bucket ID for the fish, which is used to identify the fish during the tagging process. This number is not unique for every fish.
Cooler	The cooler that the fish was placed into during the transport process.
Tag Type	All should be V4
Weight (g)	Enter the weight, measured to the nearest 0.01 g
FL (mm)	Enter the fork length (FL), measured to the nearest whole fish
Time in Drugs	Recorded in 12-hour clock notation
Time out of Drugs	Recorded in 12-hour clock notation
Time out of Surgery	Recorded in 12-hour clock notation

Recovery Time	Recorded in 12-hour clock notation
Fins	Entered as “good” (g), “fair” (f) or “poor” (p)
Scales	Entered as “good” (g), “fair” (f) or “poor” (p)
Eyes	Entered as “good” (g), “fair” (f) or “poor” (p)
Parr Marks	Entered as “yes” (y) or “no” (n)
Incision	Entered as “good” (g), “fair” (f) or “poor” (p)
Tag Placement	Entered as “good” (g), “fair” (f) or “poor” (p)
Suture	Entered as “good” (g), “fair” (f) or “poor” (p)
Bleeding	Evaluated as 0,1,2,3
Tag Tested	Enter Y (yes) or N (no) if tag is verified with VR-100.
Tag Weight (g)	Measured to the nearest 0.01 g.
Surgeon	Enter the name of surgeon.
Data Recorder	Enter the name of the data recorder.
Days starved	Enter the amount of days the fish were starved.
Surgical Temp (°**F)**	Enter water quality data as measured in the surgical bath.
Surgical pH	
Surgical DO (mg/L)	
KO Temp (°**F)**	Enter water quality data as measured in the anesthesia (knock out) bucket.
KO pH	
KO DO (mg/L)	
Holding Temp (°**F)**	Enter water quality data as measured in the holding cooler.
Holding pH	
Holding DO (mg/L)	
Notes	Anything interesting of note that could impact the results.

Appendix C: Daily Fish Care after Tagging at the Livingston Stone National Fish Hatchery

Standard Operating Procedure (SOP)

Adapted from Afentoulis et al. (2014).

Purpose and Scope:

The following procedures and guidelines shall be implemented by Fish and Wildlife Service (FWS) staff to maintain the health of all acoustically tagged winter-run Chinook salmon at the Livingston Stone National Fish Hatchery. This will have to be done when salmon are held at the hatchery after tagging for the Fremont Weir Fish Behavior Study. These salmon will be held at the hatchery until they are ready for release. In total, 250 winter-run Chinook salmon will be tagged and these salmon will be placed in circulars that are inside the hatchery in groups of 25 fish. These circulars operate as a flow through system and should be covered with a screen. In addition, each circular should be clearly labeled with white duct tape for the study.

All data collected during the fish care process will be recorded on the *Daily Feed Log* and the *Daily Water Quality after Tagging Log*. These logs will be stored in a binder or folder with the hatchery coordinator. The "General" section of the *Daily Feed Log* should be filled out by the tagging crew with the average weight of salmon, the average fork length of salmon and the exact number of salmon in each circular. If this is not the case, then please contact the tagging coordinator.

Points of Contact:

Any reference to the tagging coordinator or the hatchery coordinator in this SOP refers to the following staff. Please contact the lead contact before the back up.

Tagging Coordinator

Role	Name	E-mail	Office Phone	Cell Phone
Lead Contact	Josh Israel	jaisrael@usbr.gov	916-414-2417	916-296-8792
Back Up	Jason Hassrick	jhassrick@usbr.gov	916-414-2416	916-425-9121

Hatchery Coordinator

Role	Name	E-mail	Office Phone	Cell Phone
Lead Contact	John Rueth	john_rueth@fws.gov	530-275-0549	

Materials:

1. Daily Water Quality after Tagging Log from the hatchery coordinator
2. Daily Feed Log from the hatchery coordinator
3. Dissolved oxygen and water temperature meter
4. Feed and feeder
5. Manufacture feed chart
6. Tank mort net
7. Ziploc bags
8. Sharpie marker
9. Calculator

With the exception of datasheets, all materials are provided by the hatchery. The tagging crew will provide the hatchery coordinator with the appropriate datasheets.

Daily Tasks:

The tasks below are essential for maintaining salmon health, so that the salmon are in optimal conditions when they are released into the Sacramento River. Note that not all tasks may need to be performed each day. Tasks that do not have to be completed daily are described below.

A. *Water flow checks*
    1. Check that there is water flow into and out of the circular before and after fish care. This is just a cautionary step. There should

never be any issues with not having water flow into and out of each circular.

B. *Mortality counting and removal*
   1. On a daily basis, visually scan each circular for dead salmon and remove any dead salmon with the tank mort net. Document any morts in the comments section of the *Daily Feed Log* (e.g., “one mort in circular #1 on 1/14/1900 at 1700 hours”).
   2. Place morts in a plastic Ziploc bag and label it with a Sharpie marker with the date and time (24-hour clock notation, hh:mm) of bagging, and the circular ID from the study. Each salmon should have its own plastic bag. Afterwards, perform a necropsy and retrieve the acoustic tag using the *Performing a Necropsy of Acoustically Tagged Chinook Salmon* SOP. All retrieved tags should be placed in its own-labeled Ziploc bag and returned to the hatchery coordinator. The hatchery coordinator will provide the retrieved tags to the transport crew who will return the tags to the tagging coordinator.

C. *Dissolved oxygen and temperature checks*
   1. Any meters used should be calibrated as necessary.
   2. On a daily basis, measure dissolved oxygen (mg/L and % saturation) and water temperature (°C) in a circular. One circular should be measured each day. The circular that needs to be measured each day is provided in the *Daily Water Quality after Tagging Log*.
   3. Record your measurements in the appropriate columns in the *Daily Water Quality after Tagging Log*.

D. *Circular cleaning*
   1. Cleaning of the circulars should occur when needed to remove accumulated debris.

E. *Feeding*
   1. Salmon should be fed no later than 0900 hours each day. Feeding should occur daily after 24 hr of tagging, except for the last day of holding. Plan arrival times and fish care activities accordingly.
   2. To determine the amount of feed per day, please follow the following procedures:
      i. Using the manufacturer’s feed chart, locate the appropriate size range column along the top of the table.
      ii. Find the temperature column on the far right of the table that corresponds with the temperature of the circulars. If the exact temperature is not on the table, then round down to the next temperature.
      iii. The box where these two columns intersect is the % of fish biomass to feed per day.
      iv. Multiply the number of fish in the circular by the average weight to get the biomass.

   v. Multiply the biomass by the % biomass number from the table to determine the daily feed ration.
   vi. Remember this ration is only used as a guideline. Other factors may come into play when deciding on the feed ration, such as feeding methods, water quality conditions, and fish feeding behavior.
   vii. Weigh out an appropriate amount of feed into the designated feed cup. Record the amount of feed per day in the *Daily Feed Log*.
3. Pull the feeder belt back and pour feed onto the feeder. Feed should be distributed onto the feeder so that it falls during day light hours.
4. Sweep up any spilled food near the circulars or the feed station.

F. Equipment cleaning and disinfection

1. All equipment should be cleaned following the current protocols at the Livingston Stone National Fish Hatchery.

References

Afentoulis, V., B. Kozak, J. Miranda. 2014. Fish Holding Procedures. California Department of Water Resources, Bay-Delta Office. Sacramento, CA. November 2014.

Appendix D: Transporting, Holding, and Releasing Acoustically Tagged Chinook Salmon

Standard Operating Procedure (SOP)

Adapted from the SOPs used for Department of Interior's south Delta telemetric studies, the 2011 work instructions used for the Army Corps of Engineers' telemetric studies, and the recommendations by Gabe Singer (UC Davis Biotelemetry Lab).

Purpose and Scope:

On January 27, 2015, and February 2, 2015, a transport crew will head down to the Livingston Stone National Fish Hatchery or the Coleman National Fish Hatchery to load and transport 125 tagged Chinook salmon of each salmon run for the 2015 Fremont Weir Fish Behavior Study. These salmon will be transported to Jerry Rose's dock in Knights Landing, California, and placed into holding pens at the dock for at least 24 hours before release.

This SOP describes the steps needed to transport, hold, and release acoustically tagged Chinook salmon into the Sacramento River.

Materials:

- Transport Crew
    - YSI ProODO for dissolved oxygen and water temperature measurements
        - Manual available at http://www.ysi.com/media/pdfs/626279-YSI-ProODO-User-Manual-RevC.pdf
    - YSI Pro1030 for salinity measurements
        - Manual available at http://www.ysi.com/media/pdfs/605182A-English-Web.pdf
    - Datasheets
    - Buckets
    - Coolers
    - Nets
    - Stress Coat
    - Rock Salt

- Air Stone and Air Pump (with extra batteries)
- HR-180kHz-EXT Receiver
- Holding Pen Setup Crew
    - See SOP #5 (Constructing and Deploying Trash Can Style Holding Pens)

Pre-transport Activities:

- Notify hatchery staff of the study personnel that will be at the hatchery at least 24 hours in advance. For the Livingston Stone National Fish Hatchery, all study personnel must bring government issued identification, such as a California driver's license.
- Disinfect all buckets, coolers, and nets with the proper disinfectant solution before heading down to the hatchery. A rinse station is also available at the hatchery.
- Calibrate the YSI ProODO and YSI Pro1030.
- Make sure all transport vehicles have been rinsed before heading down to the hatchery.
- Label coolers with white duct tape. Ten coolers will be used for each transport day and each cooler should hold no more than 13 fish.
    - Each cooler should be labeled with the cooler ID. The cooler ID is based on the species code (LF for late-fall-run or WC for winter-run), the circular ID#, and a letter designation (a, b, etc.). The letter designation is used to differentiate fish in different coolers from the same circular. This is needed since a circular can contain more than 13 fish.
        - For example, circular #1 at the Livingston Stone National Fish Hatchery should contain 25 winter-run Chinook Salmon. Since only 13 fish should be in a cooler, 13 fish will go into one cooler and 12 fish would go into another cooler. Therefore, the coolers will be labeled as WC 1a and WC 1b.
- Pre-measure the amount of rock salt that should be placed into each cooler to target 3 ppt. This amount of rock salt should be placed into Ziploc bags.
    - To target 3 ppt, add 3 g of rock salt for every liter of water.
        - Salting the water in the transport coolers reduces the external-internal osmotic gradient between the fish and their environment. When fish are stressed, they produce epinephrine, a hormone that increases the gill surface area (Wedemeyer 1996). As a result, stressed salmonids may rapidly diffuse freshwater into the body, which overwhelms osmotic and ionic regulatory controls. Salting helps to prevent ion imbalance due to

this response (Moyle and Cech 2004).

- Load all items into the transport truck.
- Prepare datasheets used for the transport and release process.

Transport

- Drive down to the hatchery.
- Record the arrival time using the 24-hour clock notation (hh:mm) on the *Transport Datasheet*.
- Start dissolving pre-packaged rock salt with water in buckets. This is done to avoid dropping rock salt on salmon when they are in coolers. This step should be done as soon as the crew arrives at the hatchery since it takes time to dissolve rock salt.
    - Afterwards, mix the water and rock salt with about 15 ml of stress coat.
        - Stress coat is a water conditioner and artificial slime coat. Stress coat keeps the mucus layer intact, which is important because it is the fish's primary barrier against disease and infection. In addition, it plays a role in ionic and osmotic balance. The mucus layer is easily lost during the handling and netting process (see Harnish et al. 2011).
- Identify the circulars with fish that will be loaded into coolers for the day. There should be ten circulars in use at the Livingston Stone National Fish Hatchery and six circulars in use at the Coleman National Fish Hatchery.
    - For each transport day, five circulars would be loaded into coolers at the Livingston Stone National Fish Hatchery, and three circulars would be loaded into coolers at the Coleman National Fish Hatchery.
        - At the Livingston Stone National Fish Hatchery, each circular would have 25 salmon.
        - At the Coleman National Fish Hatchery, only circular 3 and 6 would have 25 salmon. The other circulars have 50 salmon.
- Fill the coolers with water from the hatchery and insert air stones with air pumps for each cooler. At this point, coolers should be filled about 1/4 full to avoid injuries to fish and people.
- For a single circular, transfer the appropriate amount of fish into each cooler.
- Load the cooler onto the transport truck and fill the cooler to near capacity with hatchery water.
- Evenly pour dissolved rock salt with stress coat into the cooler.

- Carefully mix the water in the cooler and check for any dead salmon in the cooler. If there are dead salmon, then place the dead salmon in a plastic Ziploc bag and label it with a Sharpie marker with the date/time of bagging (24-hour clock notation, hh:mm), and the cooler ID from the study (e.g., WC 1a). Each salmon should have its own plastic bag. Afterwards, perform a necropsy and retrieve the acoustic tag using the *Performing a Necropsy of Acoustically Tagged Chinook Salmon* SOP. Measure salinity (ppt), dissolved oxygen (mg/L and % saturation), and water temperature (°C) in each cooler.
    - The dissolved oxygen concentration in all holding containers should be around 80–130% saturation (Liedtke et al. 2012).
    - When using the YSI ProODO for dissolved oxygen and water temperature measurements, make sure to make an adjustment for the salinity value by pressing the probe symbol, highlighting salinity on the screen, and pressing enter. Afterwards, use the numeric entry screen to enter the salinity value of water that you will be testing.
        - This is needed since the ability of water to dissolve oxygen decreases when the salinity of water increases.
    - If water quality measurements are taking a substantial amount of time to record, then only take measurements for a few coolers.
- Repeat these steps until all fish have been placed in coolers.
- At the end, the driver should contact the holding pen setup crew and let them know that the transport crew is leaving the hatchery. The driver should let the holding pen setup crew know the temperature range in the coolers. This will allow the holding pen setup crew to assess the need for tempering the coolers at the release site.
- The driver will record the time that the transport crew leaves the hatchery on the *Transport Datasheet* and head down to Jerry Rose's dock.
    - Time should be recorded in the 24-hour clock notation to the nearest minute.
- During the transportation process, make a stop at Granzella's Restaurant in Williams, California (451 6th Street, Williams, California 95987) for a water quality check.
    - Salinity (ppt), water temperature (°C), and dissolved oxygen (mg/L and % saturation) concentrations should be taken again from each cooler near the halfway point to Jerry Rose's dock. Record the data on the *Transport Datasheet* as measured. In addition, check for any dead salmon and follow similar procedures for handling mortalities that were previously described in the SOP.
        - If water quality measurements are taking a substantial amount of time to record, then only take measurements for a few coolers.

Release Site

- Record the time of arrival at Jerry Rose's dock. The release site should already be set up with holding pens and a field crew trailer by the holding pen setup crew.
- Measure salinity (ppt), water temperature (°C), and dissolved oxygen (mg/L and % saturation) concentrations for each cooler in the *Transport Datasheet*. In addition, check for any dead salmon and follow similar procedures that were previously described for handling mortalities.
- Place the customized HR-180kHz-EXT receiver into the cooler to document which fish are in the coolers. Record the tag codes from the HR receiver in a notebook.
- Take the water temperature and dissolved oxygen concentrations at the release site to determine the need for tempering. Record the information on the *Transport Datasheet.*
    - If water temperature in the coolers is within the 2˚C difference of the river temperature, then start loading coolers into the holding pens in the river. This should be done by bucketing out water from the coolers for ease of carrying to the dock.
    - If the water temperature in the coolers is different from the river by more than 2˚C, then take out a bucket full of water from each cooler and add a bucket of river water to each cooler. Hold fish for a few minutes prior to retaking water temperature in the coolers. If water temperature in the coolers is now within the 2˚C difference, then start loading the fish from the coolers.
        - Otherwise, repeat the procedure until the difference is less than 2˚C.
- The fish should be transferred to the holding pen with a sanctuary net. Each holding pen should have 25 fish. This means two coolers of fish (one consisting 12 fish and one consisting of 13 fish) should be loaded per pen.
        - Document which coolers go into which holding pen on the *Release Datasheet*.
        - Record the time of loading on the *Release Datasheet* in the 24-hour clock notation.
        - During this process, check for any dead salmon and follow similar procedures for handling mortalities that were previously described in the SOP.
        - In the end, there should be five holding pens for winter-run Chinook salmon and five holding pens for late-fall-run Chinook salmon for each transport day. Each holding pen should have 25 fish and labeled with a laminated sign (e.g., WHP 1 or LHP 1). "WHP" stands for winter-run

Chinook salmon holding pen and "LHP" stands for late-fall-run Chinook salmon holding pen.

- Once all fish have been placed in holding pens, the transport crew should leave a few buckets and coolers for the release crew. The remaining coolers should be returned to Bryte Yard.

Releasing Tagged Fish:

- After fish have been placed into holding pens, there should always be at least two study personnel present at the release site even when releases are not occurring.
    - At a minimum, the study crew should check the holding pens every hour to make sure that all of the cans are in place and all are upright. Also, check to see if there is enough clearance between the bottom of the holding pens and the substrate. If not, the study crew needs to come up with a plan to provide enough clearance.
        - Any interesting observations should be recorded on the back page of the *Holding Pen Water Quality Datasheet*.
    - Dissolved oxygen concentration (mg/L, % saturation) and water temperature (°C) should be measured around every four hours in the area adjacent to the holding pens.
        - All data should be recorded as measured in the *Holding Pen Water Quality Datasheet*.
        - The schedule for water quality checks should also be posted in the field crew trailer.
- Field crew will release fish at the times provided on the schedule posted in the field crew trailer. Releases should occur every five hours after 24 hours of holding.
    - Release crews should wear appropriate field gear. This includes the appropriate outerwear and PFD when on the boat. There should also be a headlamp at night.
    - During release shifts at night, the release crew will consist of three staff: one boat operator, one boat assistant, and one on-shore staff. The boat operator is responsible for bringing the boat to the release site.
- Identify which holding pens with fish are to be released. Each container is equipped with two tethers with two quick-links attached to the main anchor line. Detach the quick-links from the main anchor line and attach to the transport line located near the starboard side gunnel of the release boat. Two holding pens will be released at a time: one with winter-run Chinook salmon and one with late-fall-run Chinook salmon.
    - If releases are occurring at night, make sure there is one other crewmember on shore and observing the release. He/she is on

site to call for help, assist if the boat capsizes or assist with other emergency-type events.

- Once you have attached the transport containers to the vessel, aboard the vessel and start the outboard engine. The outboard is equipped with a key start; make sure that the outboard is in neutral with the throttle set at start. Once the outboard is running, safely engage the shifter into forward or reverse, depending on orientation of the boat. Afterwards, move away from the holding area and into the center of the channel.
- Maintain a slow and steady speed; making sure that the holding pens are not tipping or submerging. If the holding pens appear to be tipping or submerging, then slow down the rate of speed. If the holding pens are hitting the bottom because the river is too shallow, then pull the cans up further in the water column using a rope looped around the holding pen and the cleat on the boat.
- Once the release location has been reached, remove the wing nuts holding the lid of the holding pen in position. Pull the lid off and place into boat. Once the lid is removed, pull the container slowly up; allowing some of the water to drain. DO NOT COMPLETELY DEWATER THE HOLDING PEN!
- Observe the fish inside of the container; making sure there are no mortalities. If you observe a dead fish, then remove it as gently as possible from the container and place it into a Ziploc bag. Record the number of mortalities for each holding pen on the *Release Datasheet*. Once you have retrieved any mortalities from the holding pen, slowly invert and push the can down so that one end of the opening is just under the surface of the water. Allow the fish to swim out of the holding pen.
    - If necessary, turn the can upside down to empty the contents of the container into the river. Make sure that all fish have left the container prior to bringing the container on board the boat. Once the container is empty, place it inside of the boat.
- Using the atomic clock, record the date and actual time of release (to the nearest minute in 24-hour time) on the *Release Datasheet* for each holding pen.
    - Do not write down the time from the schedule if this is not the actual time of release. Also, remember to change the date if the release is after midnight.
- On the boat, measure dissolved oxygen concentration (mg/L, % saturation) and water temperature (°C) after the release.
    - All data should be recorded as measured in the *Release* Datasheet.
- Repeat the procedure for the remaining holding pens. Make sure that you record release date and time for each group of fish. Return to shore.

- Remove the empty holding pens from the vessel and place on shore. Make sure that the holding pens are placed upside down (frame facing ground). This ensures that the holding pens are not damaged. You can stack up to four holding pens inside of each other if time allows.
- If you encountered any mortality, then retrieve the acoustic tag using the *Performing a Necropsy of Acoustically Tagged Chinook Salmon* SOP.
- Continue to release fish throughout the shift according to the schedule posted in the field crew trailer. At the end of your shift, make sure that the next shift of personnel arrives prior to leaving. The crew handling the last release will bring all supplies and equipment remaining at the release site and trailer back to the office.

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Appendix E: Constructing and Deploying Trash-Can-Style Holding Pens

Standard Operating Procedure (SOP)

Adapted from the SOP prepared by Mike Marshall (U.S. Fish and Wildlife Service)

Purpose and Scope:

Acoustically tagged hatchery winter-run Chinook salmon and late-fall-run Chinook salmon from the 2015 Fremont Weir Fish Behavior Study have to be held for a minimum of 24 hr to acclimatize to the conditions of the Sacramento River before release. To accomplish this task, a holding pen setup crew for the study will have to construct and deploy trash can style holding pens at Jerry Rose's dock at Knights Landing. Deployment of the trash can style holding pens must occur before the transport crew arrives to Jerry Rose's dock with the salmon for release. Salmon should be placed into the holding pens on January 27, 2015, and February 2, 2015.

The SOP provides the steps that need to be taken to construct and deploy trash can style holding pens.

Materials (per pen):

1. Perforated 32-gallon Rubbermaid Brute trash can and lid
2. Float frames. If new ones need to be constructed, then the following materials are needed:
    a. 3" diameter PVC pipe
    b. 3" diameter t-fittings (4 per frame)
    c. End cap (4 per frame)
    d. PVC primer
    e. PVC cement
3. 1/4x20x1" full-thread bolts (qty 4)
4. 1/4x20 washers (qty 4)
5. 1/4x20 nuts (qty 8)
6. 1/4x20 wing nuts (qty 4)
7. Heavy duty zip ties (qty 4, 18" minimum)
8. 1/4" to 1/2" rope (depending on flow)
9. Carabineers (qty 2)
10. Tools for constructing new perforated holding pens and float frames

   a. Putty knife
   b. Sandpaper
   c. Chop saw or saw with metal cutting blade
   d. Reciprocating saw
   e. Drill (cordless preferable, but not necessary)
   f. 1/4” drill bits or smaller (depends on the size of fish)
11. Laminated label for the trash can/lid
12. Duct tape for placing laminated label on the trash can/lid

Label Setup:

1. Print out and laminate 10 labels for the trash can lids, which include the information shown in the example below.

2015 Fremont Weir Fish Study
WHP 1
Call Josh Martinez if found at 916-709-0763

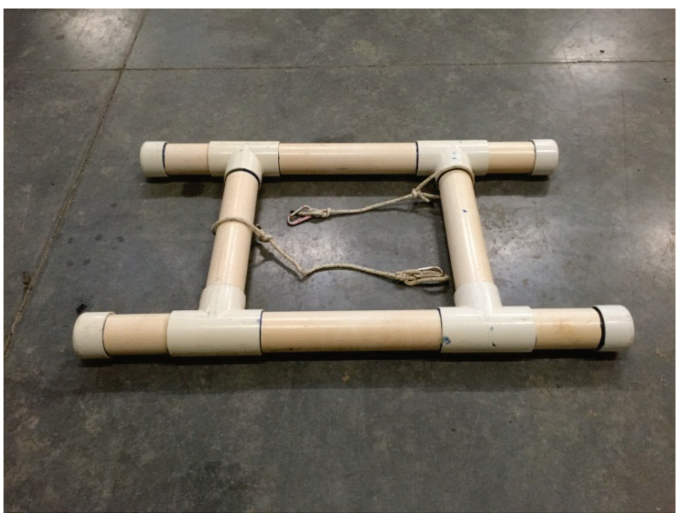
   “WHP 1” stands for winter-run Chinook salmon holding pen #1. These labels are printed out from Microsoft Word. Each document should be labeled with either a “WHP” (winter-run holding pen) code or a “LFHP” (late-fall-run holding pen) code and numbered from one to five. These labels are 8.5” by 11”.

2. Print out the table below, cut out each individual square, and laminate. These labels are for the trash cans.

WHP 1	WHP 2	WHP 3	WHP 4	WHP 5
LFHP 1	LFHP 2	LFHP 3	LFHP 4	LFHP 5

Inspection and Construction:

1. Gather the “II” float frames to inspect equipment.
2. If not already present, attach one length of rope, approximately 2’ to 2.5’ long, to each of the pillars of the “II” float frame using a bowline knot. At the other end of each length of rope, attach a carabineer using a bowline knot. These ropes with carabineers will be used to attach the float frames to Jerry Rose’s dock. In the end, each float frame should look like the image below:



3. Inspect all of the float frames to make sure that they are functional and can float when placed in water. The following steps must be taken if more float frames need to be built:
    a. Measure unused PVC pipe to the 19.5” mark and cut four lengths. Glue one of the openings of the t-fitting to one length of the PVC pipe. Continue gluing and connecting the straight pipes to the openings of the t-fitting until you create a square shape.
    b. Once you have a square shape, measure the PVC pipe to the 10” mark and cut four lengths. Glue each remaining opening of the t-fitting to one length of the PVC pipe to create a “II” shape. Afterwards, close the PVC pipe by gluing on an end cap.

         i. Note: When gluing PVC, it is recommended that each connection is primered using PVC primer prior to gluing per manufacturer's recommendations.

4. Inspect all perforated trash cans to make sure the holes are appropriate for the size of fish that will be used for the study, and to make sure that there are no damages to the trash can that could affect its functionality. The minimum fork length of fish used for the study will be 90 mm. If the holes are not appropriate or if there are damages to the trash can, then the following steps must be performed to build new perforated trash cans:
    a. Use a reciprocating saw to cut the lower part of the handle off, which will allow the float frame to set much higher on the can. As a result, this will increase the amount of water that is available for the fish.
        i. Note: You need to make sure that there is an air/water interface so the fish can come up and "gulp" air.
    b. Once you have removed the lower portion of the handle, you can begin drilling the holes in the sides and bottom of the holding container using the appropriate size drill bit. Drill holes from just below where the float frame attaches to all the way to the bottom.
        i. Space the holes, in straight lines approximately 1" to 1.5" apart. Space the lines of holes approximately 1" to 1.5" apart.
            1. Note: Make sure that you are using a sharp, new drill bit. If you do not, then you will leave burrs on the interior of the container, which can harm the fish. If you do have burrs, use a flat edge or putty knife, along with sandpaper, to clean the burrs off.
5. Gather the lid to the trash can and place it on the trash can. The lid and the top of the can should have drilled holes. See if you can align the holes of the lid with the trash can. If the holes do not align or if there are no holes, then the following steps must be taken:
    a. Attach the lid to the trash can and drill four holes at equal distances from each other, around the can. These holes should go through both the can and lid.
    b. Mark each lid and orientation so in the future you will use the exact lid with the exact can so that all lids fit securely. As an example, you may want to letter side A and side B on both the can and the lid. This will assist with proper alignment in the future.
6. Once you are able to align the holes of the lid with the trash can, remove the lid and take a 1/4x20x1" bolt and thread a 1/4x20 nut up to the head of the bolt.
7. Fit the bolt through the hole in the trash can with the threads facing up. Once you have the bolt through the can, add a 1/4x20 washer and second nut. This will hold the hardware on the can so it will not fall out

or move. Continue this process until you have all four holes fitted with hardware.

8. Once the trash can and lid are in place, duct tape a laminated 8.5” by 11” label with the holding pen number on the trash can lid. Afterwards, duct tape a laminated box label to the trash can itself. This allows you to identify which lid belongs to which trash can.
9. To attach the frame to the trash can, use four heavy duty zip-ties and attach it using the holes in the trash can that are above where the float frame attaches (see red circle in image below). Make sure that the connection of the zip-tie is on the outside of the can.

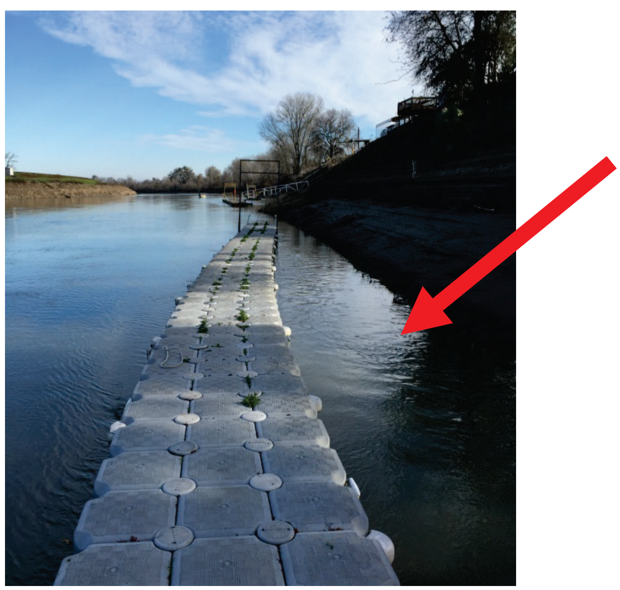
If the holes are not adequate or if no holes are present, complete the following tasks:

a) Determine where you would like to attach the trash can to the frame by test fitting a frame to the trash can. Once you have determined this location, drill two vertical holes in the trash can, just above where the float frame attaches. In the end, there should be four paired holes.

10. When holding containers are not in use, remove the float frames, lids, and hardware as damage to the holding containers will occur and storage will be problematic.

Deployment:

1. Before heading to Jerry Rose's dock during the day of deployment, gather all the necessary materials:
    a. Perforated trash cans with lids and mounting hardware attached
    b. Float frames
    c. 1/4x20 wing nuts (4 per trash can, keep spares on-hand)
    d. Heavy duty zip ties (18" minimum)
    e. Field notebook for taking notes
    f. YSI ProODO (will be used to measure water temperature and dissolved oxygen the site)
    g. PFDs
    h. Headlamps, lanterns, and flashlights (to set up in field crew trailer)
    i. First aid kit (to set up in field crew trailer)
    j. Atomic clock (to set up in field crew trailer)
    k. Throw ropes (to set up in field crew trailer and attached to the dock)
    l. DWR pool phone (to set up in field crew trailer)
2. Upon arriving at Jerry Rose's dock, the holding pens will be deployed on the side of the dock closest to shore (see picture below).



3. Evaluate the water levels of the area where you will deploy the holding pens. If water levels are too low, then plan on deploying the holding pens on the other side of the dock where the water is deeper.
4. Once you have identified the area for deployment, create loops in the rope at approximately 24" to 30" apart. You will use these loops to attach the carabineer from the float frame (attached to the holding container) to the rope.

5. Connect your rope line with the loops by using the cleats on the dock. As you do this, pull the rest of your rope downstream to make the rope tight.
    a. Note: Make sure that you have an adequate number of loops for the number of cans you have.
6. To attach the float frames to the holding pens, use heavy-duty zip ties based on the process described in the “Inspection and Construction” section of the SOP.
7. To attach the lids to the trash cans, follow steps 7 and 8 in the “Inspection and Construction” section of the SOP.
8. To attach the float frame with trash can, clip the carabineer to the first loop on the rope line. Afterwards, clip the second carabineer of the frame to the second loop. The next can’s first carabineer should be clipped to the second loop. This means that the second loop will have two carabineers.
    a. Follow this method until all of the holding pens are attached to the rope line. In the end, the holding pens should be set up in chronological order by species:

WHP 1	**LFHP 1**	**WHP 2**	**LFHP 2**	**WHP 3**	**LFHP 3**	**WHP 4**	**LFHP 4**	**WHP 5**	**LFHP 5**

9. As the setup crew is working to deploy the holding pens, a transport crewmember will call a release crewmember and will provide the water temperatures in the coolers containing fish at the water quality check station near Granzella's Restaurant in Williams, California. This is done so the holding pen setup crew can assess the need for tempering the fish at the release site. The holding pen setup crew should have a YSI ProODO meter with them during the deployment process.
10. As the setup crew is deploying the holding pens, the trailer and portable toilet should arrive at the release site. The setup crew should provide access to staff transporting the trailer and portable toilet.
11. Upon assembling the holding pens, the headlamps, lanterns, flashlights, atomic clock, first aid kit, throw ropes, and a YSI ProODO should be placed into the trailer. The release crew will be responsible for cleaning up after all the fish releases have occurred.

Appendix F: Performing a Necropsy of Acoustically Tagged Chinook Salmon

Standard Operating Procedure (SOP)

Adapted from the SOPs used for the Department of Interior's south Delta telemetric studies.

Purpose and Scope:

Mortality of tagged hatchery Chinook salmon could occur during the tagging, fish care, transport, or release process during the 2015 Fremont Weir Fish Behavior Study. The dead salmon (mort) should be bagged in a Ziploc bag and labeled with the date, the time and the location of bagging (e.g., circular ID or holding pen ID). The only time the study crew would not bag a mort is when the study crew notices the mortality in the recovery bucket since the tag can be reused after the necropsy. Specific instructions on how to handle the morts are described in the following SOPs for the 2015 Fremont Weir Fish Behavior Study:

1. SOP #1a: Acoustically Tagging Winter-run Chinook Salmon at the Livingston Stone National Fish Hatchery,
2. SOP #1b: Acoustically Tagging Late Fall-run Chinook Salmon at the Coleman National Fish Hatchery,
3. SOP #3: Daily Fish Care after Tagging at the Livingston Stone National Fish Hatchery, and
4. SOP #4: Transporting, Holding and Releasing Acoustically Tagged Winter-run Chinook Salmon.

Once the mort has been bagged or is in a recovery bucket, the study crew must evaluate the conditions of the fish, perform a necropsy, and retrieve the acoustic tag. This SOP describes the steps that need to be taken for performing these tasks.

Points of Contact:

Any reference to the tagging coordinator in this SOP refers to the following staff. Please contact the lead contact before the back up.

Role	Name	E-mail	Office Phone	Cell Phone
Lead Contact	Josh Israel	jaisrael@usbr.gov	916-414-2417	916-296-8792
Back Up	Jason Hassrick	jhassrick@usbr.gov	916-414-2416	916-425-9121

Materials:

1. *Hatchery Fish Condition Assessment Datasheet* (used during the tagging and fish care process; one for each hatchery)
2. *Hatchery Acoustic Tag Envelope* (used during the tagging and fish care process; one for each hatchery)
3. Hatchery designated camera
4. *Transport/Release Fish Condition Assessment Datasheet* (used during the transport and release process; one for each species)
5. *Transport/Release Acoustic Tag Envelope* (used during the transport and release process; one for each species)
6. Transport/release designated camera
7. Forceps
8. Tray
9. Dissecting probe
10. Scalpel handle, holder and blades
11. Ziploc bags and Sharpie marker
12. Nitrile gloves
13. VR100 with 180 VH hydrophone (only needed for the tagging coordinator)

Items 1 to 3 will remain at the hatchery until there are no more study fish.

Procedures:

G. Put on gloves when handling fish.

H. Remove the salmon from the Ziploc bag. If the mortality occurred in a recovery bucket, then remove the salmon from the recovery bucket instead of a Ziploc bag.

I. Label the Ziploc bag using a Sharpie marker with an unused fish ID (e.g., label it as “Fish ID # W1”) from the hatchery or the transport/release *Fish Condition Assessment Datasheet*. The fish ID is used to identify the salmon until the tag code ID is known.
    a. If the mortality was from a recovery bucket, then write the fish ID on a piece of paper.

J. Take a picture of the Ziploc bag with the fish ID. Make sure the camera date and time stamp are on. This picture is used to identify the number of pictures taken per fish.
    1. If the mortality was from a recovery bucket, then take a picture of the piece of paper with the fish ID. Afterwards, the piece of paper can be recycled.

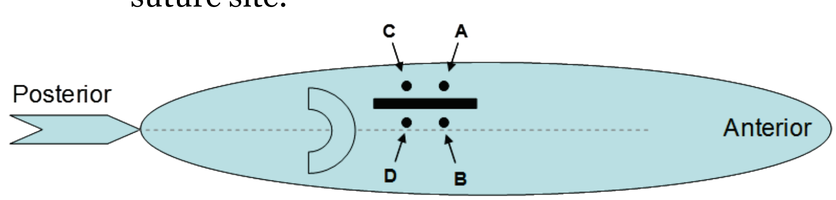
K. Afterwards, take a picture of the salmon showing the sutures.
    1. At a minimum, there should be two pictures per fish ID: one of the Ziploc bag and one of the sutures. However, the study crew should take as many pictures as they feel are necessary. In the end, the study crew needs to keep track of how many pictures are taken per fish ID. This should be recorded in the hatchery or transport/release *Fish Condition Assessment Datasheet*.

L. Fill out the general section of the *Fish Condition Assessment Datasheet*.
    1. Examples of how to record the location of bagging is below:
        i. CIR 1= Mortality found in circular #1 at the hatchery
        ii. WC 1= Mortality found in cooler #1 of winter-run Chinook salmon
        iii. WHP 1= Mortality found in holding pen #1 for winter-run Chinook salmon
        iv. RB= Mortality found in the recovery bucket. There is no need for a numeric designation after the RB code since recovery buckets are reused during the tagging process (see SOP #1a/1b).

M. Check the five characteristics of condition (scale condition, body color, gill color, eye condition, and fin hemorrhaging) and record the information on the *Fish Condition Assessment Datasheet*:
    1. <u>Scale</u>: Determine whether there is any descaling. Scale condition is noted as “N” (Normal), “P” (Partial), or “D” (Descaled) and is assessed on the most compromised side of each fish. The codes are defined as follows:
        i. N= Loss of less than 5% of the scales on one side of the fish
        ii. P= Loss of 6 to 19% of the scales on one side of the fish

   iii. D= Loss of 20% or more of the scales on one side of the fish
2. <u>Body Color</u>: Determine the color on the dorsal side of the salmon using the following codes:
   i. G= Dark pigmentation and good contrast
   ii. B= Lighter or faded pigmentation and weak contrast
3. <u>Gill Color</u>: Lift the operculum using forceps and rank the darkness of the gills using the following codes:
   i. G= Beet red to dark cherry red
   ii. B= Lighter red to grayish/whitish color
4. <u>Eyes</u>: Determine if the eyes appear normally shaped or are bulging. To record the information, use the following codes:
   i. G= Normal appearance
   ii. B= Abnormal appearance and some bulging seen
5. <u>Fin Hemorrhaging</u>: Determine if there are spots of blood on or at the base of the fins. To record the information, use the following codes:
   i. G= No hemorrhaging seen
   ii. B= Hemorrhaging seen

N. Evaluate and record the conditions of the suture on the *Fish Condition Assessment Datasheet*:
1. <u>Suture Present</u>: Evaluate whether the suture is present on both the anterior and posterior side.
   i. Record the information in fractional form (i.e., anterior/posterior).
   ii. Use 1 if the suture is present and 0 if the suture is not present.
      1. Example: A “1/1” code indicates that both the anterior and posterior suture are present.
2. <u>Irritation</u>: Determine if there is irritation present at any suture site.
   i. Use A, B, C, D code in the diagram below to refer to the suture site:



View looking down onto incision; suture entry and exit points

   ii. Use the following codes to evaluate suture condition:
      1. 0= No irritation
      2. 1= Mild irritation (redness or swelling)
      3. 2= Moderate irritation (redness or swelling)

4. 3= Severe irritation (purulent discharge)
5. 4= Ulceration

3. Incision Apposition: Record "Y" if completely closed or "N" if not completely closed.
4. Incision Healing: Record "Y" if completely healed or "N" if not completely healed.
5. Fungus: Record "Y" if fungus is growing around the suture or "N" if no fungus is present.
6. Tag Expulsion: Record "Y" if there is tag expulsion or "N" if there is no tag expulsion.

O. Using a scalpel blade and dissecting probe, cut open the incision area of the fish and note the location of the tag in the fish. Record the location of the tag in the "Tag Location" column using the following codes:
1. 0= Tag is directly under the incision.
2. 1= Tag has shifted toward the anterior side of the fish.
3. 2= Tag has shifted toward the posterior side of the fish.

P. Describe any organ damage that may have occurred from the acoustic tag or if there are any indications of disease in the comments section on page 2 of the hatchery or transport/release *Fish Condition Assessment Datasheet*.

Q. Retrieve the acoustic tag from the fish and place the tag back in the Ziploc bag that was used to hold the fish. The carcass can be tossed into the river if the mortality occurred at the river site. If the mortality occurred at the hatchery, then dispose the carcass in the dumpster at the hatchery
1. Note that the use of a Ziploc bag in Steps 11 and 12 are not applicable if the mortality occurred in the recovery bucket and the acoustic tag can be reused again.

R. Place the Ziploc bag with the acoustic tag in the *Acoustic Tag Envelope*. The *Acoustic Tag Envelope* is used to store all retrieved acoustic tags for each species at a given location.
1. The transport crew is responsible for picking up the **hatchery** *Acoustic Tag Envelope* and the **hatchery** *Fish Condition Assessment Datasheet* from the fish care crew on the last transport day. Afterwards, the transport crew will bring back the materials to the tagging coordinator.
2. The release crew for the last release of each week is responsible for returning the **transport/release** *Acoustic Tag Envelope(s),* the **transport/release** *Fish Condition Assessment Datasheet(s),* and other materials back to the tagging coordinator.

S. Once the *Acoustic Tag Envelope(s)* are back with the tagging coordinator, the tagging coordinator will identify the tag code ID of each tag using a VR-100 with a 180 VH hydrophone. Afterwards, the tagging coordinator will record the information on the hatchery or transport/release *Fish Condition Assessment Datasheet(s)*.

Hatchery Fish Condition Assessment Datasheet

2015 Fremont Weir Fish Behavior Study

General					Fish Condition Evaluation					Suture and Tag Evaluation							
Fish ID	Crew Initials	Date/Time of Bagging	Location of Bagging	# of Pic Taken	Scales	Body Color	Gill Color	Eyes	Fin Hemor-rhage	Suture Present	Irritation	Incision Apposition	Incision Healing	Fungus	Tag Ex-pulsion	Tag Loca-tion
Ex	EY	1/1/1900 1800 hours	WC1	2	D	G	G	G	B	1/1	A1, B0, C1, D0	N	N	Y	Y	0
W1																
W2																
W3																
W4																
W5																
W6																
W7																

Hatchery Fish Condition Assessment Datasheet (cont)

2015 Fremont Weir Fish Behavior Study

Fish ID	Comments	Tag Code ID
Ex	Kidney is damaged, ribs are broken, and the incision is too far from the midline. Organs look inflamed.	
W1		
W2		
W3		
W4		
W5		
W6		
W7		
W8		

Transport/Release Fish Condition Assessment Datasheet

2015 Fremont Weir Fish Behavior Study

General					Fish Condition Evaluation					Suture and Tag Evaluation						
Fish ID	Crew Initials	Date/Time of Bagging	Location of Bagging	# of Pic Taken	Scales	Body Color	Gill Color	Eyes	Fin Hemor-rhage	Suture Present	Irritation	Incision Apposition	Incision Healing	Fungus	Tag Ex-pulsion	Tag Loca-tion
Ex	EY	1/1/1900 1800 hours	WC1	2	D	G	G	G	B	1/1	A1, B0, C1, D0	N	N	Y	Y	0
W19																
W20																
W21																
W22																
W23																
W24																
W25																

Transport/Release Fish Condition Assessment Datasheet (cont)

2015 Fremont Weir Fish Behavior Study

Fish ID	**Comments**	**Tag Code ID**
Ex	Kidney is damaged, ribs are broken, and the incision is too far from the midline. Organs look inflamed.	
W19		
W20		
W21		
W22		
W23		
W24		
W25		
W26		

Appendix G: ADCP Data Collection for 3D Computational Fluid Dynamic Modeling

Standard Operating Procedure (SOP)

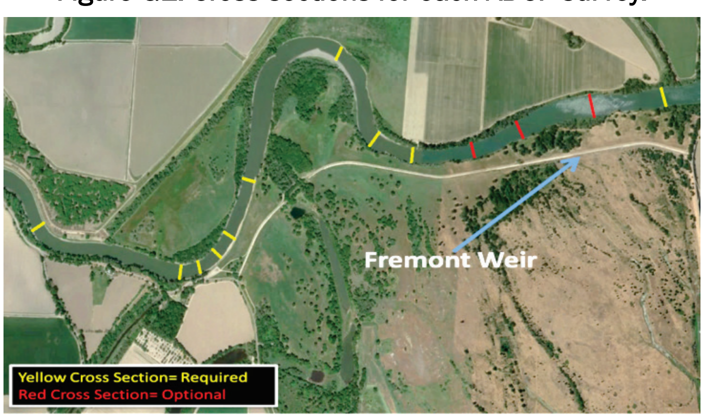
Adapted from the protocols written by Paul Stumpner of the US Geological Survey.

Purpose and Scope:

The primary purpose of this SOP is to outline the expectations and guidelines for the ADCP surveys that will be performed by the California Department of Water Resources (DWR) for the 2015 Fremont Weir Fish Behavior Study. Each survey will require three crewmembers. At a minimum, DWR will conduct two to four surveys under different flow conditions at 10 cross sections (see yellow cross sections in Figure 1). Each cross section should have six passes in order to measure secondary circulation. Results from these surveys will be used to verify results from the computational fluid dynamic modeling for the 2015 Fremont Weir Fish Behavior Study.

However, there is flexibility to adjust the location of the cross sections if field conditions warrant a change. If there is a change, then this must be documented for the Fremont Weir Study Coordination Team. Moreover, the study crew can survey more cross sections if time permits on a given day. In particular, the study crew could survey the three red-cross sections in Figure G1.

Figure G1: Cross sections for each ADCP survey.



The first survey will occur before the first fish release into the Sacramento River, which is expected to occur on January 28, 2015. To avoid data collection that could influence the reception of the acoustic receivers or juvenile swimming behavior, ADCP surveys should not be collected within three to five days of a fish release.

The remaining three surveys will be performed under different flow conditions than the first survey and will be scheduled based on the recommendations from the coordination team. There is a possibility that four surveys may not be needed.

Field Methods:

1. Equipment Setup
   - Velocity mapping will be conducted with a RDI Rio Grande Workhorse acoustic Doppler current profiler (ADCP) and a differential GPS. The ADCP and GPS will be mounted on the side of a manned boat with the GPS located directly over the ADCP to ensure geo-referencing consistency, and high enough to avoid multipath errors to the extent possible. The ADCP mount needs to be guyed down to the stern and bow of the boat to prevent excessive pitch. The ADCP baud rate should be set at 38400. The GPS should be set up to output data at 4 or 5 Hz, and a baud rate of 19200 or higher.
2. Weather Conditions
   - Weather conditions at the start of each day must be recorded and changes in weather conditions should be documented with the time of day for each survey date.
3. WinRiver II Data Collection Setup
   - WinRiver II is the data collection software used for the ADCP and GPS. A user's guide is available for more in-depth information about the principles of operation and setup. Below are a few general remarks on the specific information that is needed.
   - Make sure units are set to SI.
   - Use the configuration wizard to create a new measurement.
   - The max water depth, water speed, and boat speed should be set at reasonable high values, but not too high (i.e., if you expect the max depth to be 10m, set the max depth at 12 or 13m). A preliminary transect can be taken to refine these values if necessary.
   - Use water mode 1 (WM1) and bottom mode 5 (BM5).
   - Enter the correct transducer depth and magnetic variation.
   - The configuration wizard will set the bin size (WS) and number of bins (WN). The team want 25 cm bins (WS25). If the WS command is changed, then WN needs to be changed inversely

proportional to reflect this change. For example, a change from WS50 to WS25 would result in a change of WN10 to WN20.
- If the wizard does not allow for WM1 and BM5 to be set, then these need to be entered in the user commands.
- Lastly, the following additional user commands should be entered: water pings 3 (WP3) and bottom pings 2 (BP2). This does some initial low-level averaging.

4. Data Collection
   - Cross-section locations should be determined beforehand. If possible, a navigational software should be used to ensure boat course consistency. The same practices as those used for the moving boat discharge measurements should be made for velocity mapping. Nonetheless, the following are basic guidelines for data collection.
   - First, perform pre-data collection tests (i.e., ADCP test and compass calibration). You should first calibrate the compass. Ideally, the total error should be less than 1°, but 2° is acceptable. An evaluation should be done after calibration.
   - The cross section should be normal to the flow direction.
   - Six repeated transects for each cross section of the river should be collected. Four transects may be sufficient to analyze secondary circulation. However, if there are GPS errors, boat course errors or any other errors, then the transects can be sub-sectioned or disregarded.
   - The repeated transects should be as close to one another as possible.
   - For each cross section, a separate file should be generated (i.e., 6 files for each cross-section). At the start and end of each transect (or file), the edge estimates should be inputted.

Processing Methods:

Ideally, the files can be preliminarily processed in the field to determine whether the data has been collected correctly. After all data has been collected, the final processing can occur at the office.

1. Initial Processing in WinRiver II
   - Perform any necessary processing (i.e., corrections to transducer depth or magnetic variation) or sub-sectioning of data in WinRiver II.
   - Make sure units are in SI.
   - Once all files have been processed, output ASCII files under Configure → ASCII Output → Classic ASCII Output. Choose Output Backscatter Intensity.

- Now reprocess all transects under Playback → Reprocessed Checked Transects. This will create files with the _ASC.txt extension.

2. Processing in Velocity Mapping Toolbox (VMT)
   - Each cross-section needs to be processed separately. Open VMT and then open ASCII files; select all files for a particular cross section.
   - To process the data, you need to choose Plot Cross Section; prior to that, the following parameters should be set.

     Grid Node Spacing: Horz – 1, Vert – 0.25
     Contour Variable: Streamwise Velocity (u)
     Vertical Exaggeration: 2 or 3
     Vector Scale: 0.2
     Vector Spacing: Horz – 4, Vert – 0.25
     Smoothing Window: Horz – 7, Vert – 5
     Check the box: Plot Secondary Flow Vectors
     Secondary Flow Variable: Secondary (Roz)
     Check the box: Include Vertical Velocity Component in Secondary Flow
     Vector
   - The Vertical Exaggeration and Vector Spacing can be changed for plotting purposes, and these will probably be cross-section specific. The Grid Node Spacing and Smoothing Windows should remain consistent for each cross section; changes to these will change the final results.
   - Save the log file.
   - Save the MAT file.
3. Export Final Data Products
   - Run the MATLAB script. WriteVMTOutputToCSV.m. This can be done in batch mode and will output seven files for each cross section. The following extensions with the filename as a prefix will be created:

'Filename_Timerange.csv' – time range that data was collected

'Filename _Easting.csv' – N x M array of UTM Eastings for each cross-section

'Filename _Northing.csv' – N x M array of UTM Northings for each cross-section

'Filename _Depth.csv' – N x M array of depth below water surface for each cross-section

'Filename _U.csv' – N x M array of U component of velocity for each cross-section

‘Filename _V.csv’ – N x M array of V component of velocity for each cross-section

‘Filename _W.csv’ – N x M array of W component of velocity for each cross-section

Format of Deliverable:

DWR will compile the dataset for delivery to the Fremont Weir Study Co-ordination Team and will be available to draft up descriptions about the results and field measurements. In addition, any weather conditions and field observations that could have affected the data should be reported. This includes adding additional cross sections or adjusting the location of the proposed cross sections.

The coordinate system provided to the coordination team should be in the same format that was used for the bathymetric deliverables.

Appendix H: Bathymetry for 3D Computational Fluid Dynamic Modeling

Standard Operating Procedure (SOP)

Adapted from the field descriptions by Jim West of the California Department of Water Resources.

Memorandum

Date: April 2015

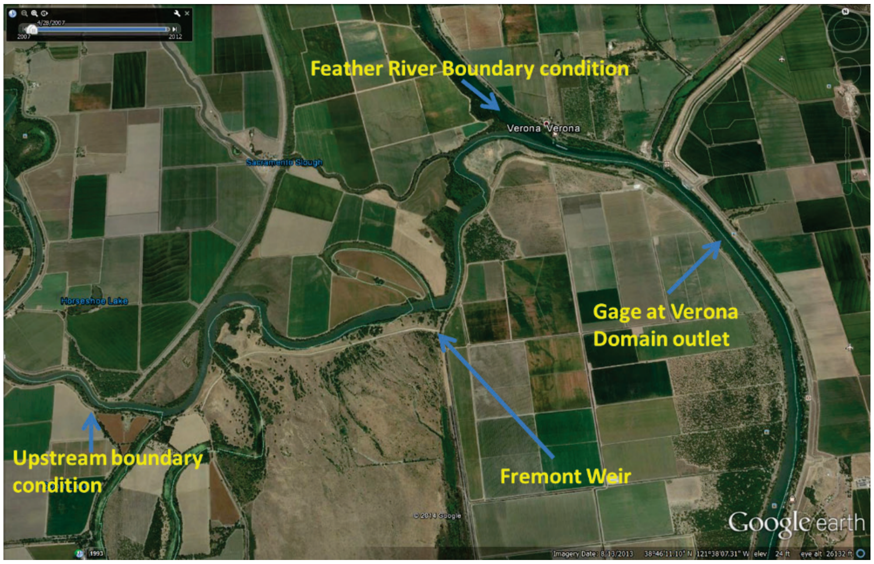
To: Edmund Yu
Dept of Water Resources, Division of Environmental Services

From: Jim West
Dept of Water Resources,
Division of Integrated Regional Water Management

Subject: Field Memo on Collecting Bathymetry for the 2015 Fremont Weir Fish Behavior Study

From January 21, 2015, to January 27, 2015, my field crew collected bathymetry on the Sacramento River, near the Fremont Weir area. Our survey covered three boundaries: the upstream boundary condition, the Feather River boundary condition, and the gage at the Verona domain outlet (see Figure 1). Although the team were able to complete the survey, my crew encountered numerous problems during the survey, such as laptop issues and the radio failure of the Global Navigation Satellite System (GNSS) equipment that the team was using to collect Global Positioning System (GPS) data. Because of this, the team had to rent equipment and make changes to the standard operating procedure (SOP) that was developed for the survey.

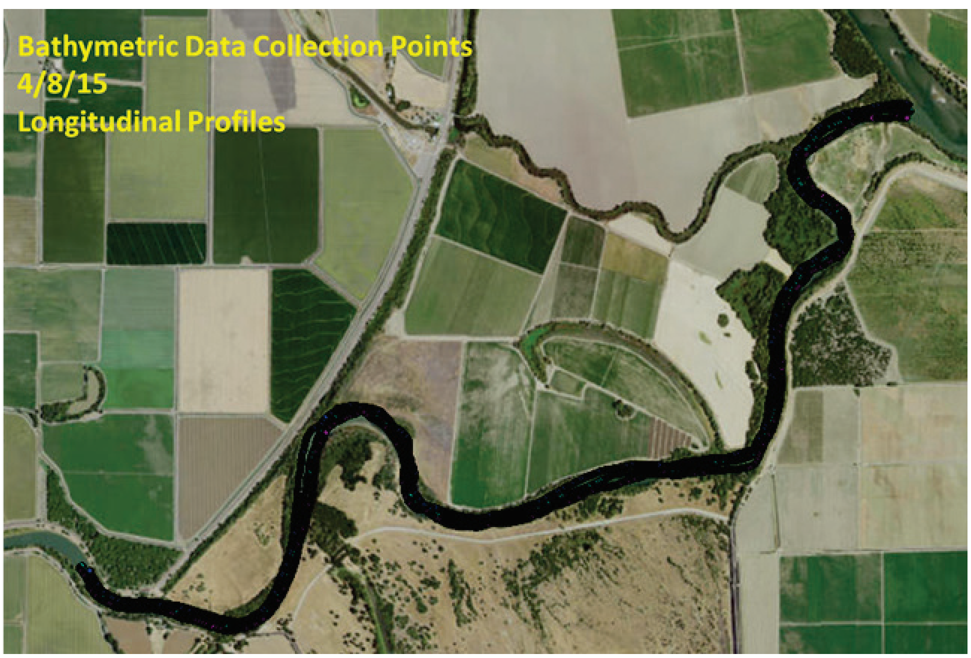
Figure H1: Boundaries for the bathymetric survey.



The changes made to the SOP is documented at the end of this memorandum in tracked changes. A few of the key changes are described below.

- For the first part of the survey, the team had three Trimble R8 GNSS receivers. One served as the primary control point, while the other two served as the rovers in the boat. Due to a hardware failure in the radio component of one of the R8 receivers, the Trimble R10 receivers had to be used for the second part of the survey. Even so, the performance and accuracy of these receivers is nearly identical to that of the R8.
- For the bathymetry soundings, the team was planning to use the SonTek M9 with HydroSurveyor firmware. However, the team had to make a change to the Knudsen Engineering Limited Sounder 1612 survey-grade echosounder and transducer due to equipment issues with the SonTek M9. The change in field gear resulted in primarily cross sectional sweeps without longitudinal profiles, which were needed to inform the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project. As a result, the team went back out on April 8, 2015, to collect longitudinal profiles at the center line, left bank, and right bank of the river (see Figure 2).

Figure H2: Data collection points from surveys.



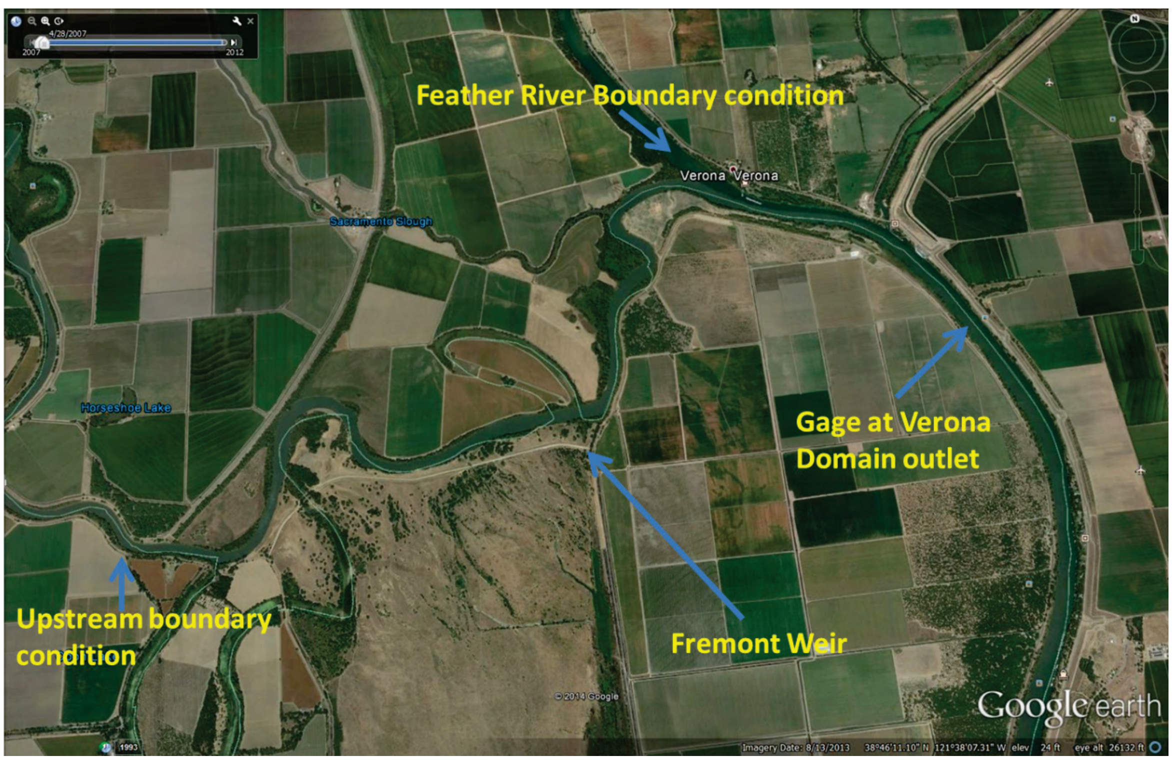
All data collected from our surveys have been processed and transmitted to the appropriate staff for their analyses. If you have any questions, please let Jim West, California Department of Water Resources (DWR), know.

Purpose and Scope:

The primary purpose of this SOP is to outline the expectations and guidelines for the bathymetric survey that will be performed by the DWR during the week of January 19, 2015. During the survey, bathymetric measurements will be taken throughout the project domain. This domain covers three boundaries: the upstream boundary condition, the Feather River boundary condition, and the gage at Verona domain outlet (see Figure 1). A single survey will take approximately one week to conduct and will require three crewmembers.

Results from this survey will be used for computational fluid dynamic modeling for the 2015 Fremont Weir Fish Behavior Study.

Figure H3. Boundaries for the bathymetric survey.



Field Methods

A. GPS Data Collection

DWR will use the Global Navigation Satellite System (GNSS) survey instruments for the survey(s). There will be a Trimble R8 GNSS receiver at the primary control point. In addition, there will be two Trimble R8 GNSS receivers that will serve as the rovers in the boat. These receivers have 220 channels and can track signals from both the United States Global Positioning System (GPS) and the Russian GLObal NAvigation Satellite System (GLONASS) satellites.

Due to a hardware failure in the radio component of one of the R8 receivers, Trimble R10 receivers had to be used for the second part of the survey. These receivers are also GNSS receivers with 440 channels. The performance and accuracy of these receivers is nearly identical to that of the R8. Datasheets for both instruments are provided for reference.

All of these receivers (R8 and R10) are survey-grade and are dual-frequency. These receivers observe carrier phase satellite measurements on both the L1 and L2 frequencies for both GNSS systems. Moreover, they can compute a position using a combination of satellites from both systems. As such, these receivers will provide centimeter level accuracy in both the horizontal and vertical positioning. For all RTK points, the GNSS elevations (ellipsoid heights) will be reduced to orthometric heights (ground elevations) using Geoid09. GNSS data processing will be done using the Trimble Business Center software.

B. *Bathymetric Soundings*

Equipment used for acquiring the bathymetric soundings consisted of a Knudsen Engineering Limited Sounder 1612 survey-grade echosounder and transducer. This type of echosounder is an acoustic echo ranging device; the depths are calculated by measuring the time it takes for a pulse of ultrasound to be transmitted downward from the transducer, to be reflected off the bottom, and to be returned to the transducer. Several factors affect the accuracy of soundings, including the following: bottom characteristics, depth, pulse length used, applied speed of sound through water (which is affected by clarity, salinity, and temperature), and field techniques. The field procedures and techniques used for this bathymetric project were designed to provide a high level of precision and have been used on several previous projects with good results. These procedures included, but were not limited to, the following: the use of suitable control, the daily check and calibration of the echosounder and transducer, and the use of survey-grade GNSS receivers to provide centimeter-level positioning.

The GPS and bathymetric data were compiled in real-time using Coastal Oceanographic's Hypack software. This program uses the time stamps from the computer, GPS, and echosounder to correlate the data. The GPS antenna was placed directly over the transducer to greatly reduce the errors that can occur during turns and vessel heave. Soundings were measured every 50 msec. By maintaining a speed of less than four miles per hour, this procedure resulted in approximately twenty measurements per six feet of horizontal movement.

To convert the sounding data to the NAVD88 vertical datum, GNSS elevations (ellipsoid heights) will be reduced to orthometric heights (ground elevations) with the use of Geoid09.

C. Bar Checks

DWR will check and calibrate the bathymetric equipment on a daily basis by performing a bar check. The process of the bar check involves adjusting the draft to yield the correct depth to a known point in shallow water. Afterwards, the echo return from a deeper point of known depth is measured and the speed of sound in water is adjusted until the proper depth is obtained.

D. Weather Conditions

Weather conditions at the start of each day must be recorded and changes in weather conditions should be documented with the time of day for each survey date.

Data Processing and Format of Deliverable

DWR will decide on the appropriate software for compiling the GNSS and bathymetric sounding data after the survey. Soundings will be measured every few msec, which will result in more data points than what may be necessary. To help with data interpretation, DWR will work on thinning the data, which would involve removing false soundings and erroneous data.

Afterwards, DWR will compile the dataset into an X, Y, and Z file for delivery to the Fremont Weir Study Coordination Team and will be available to draft up descriptions about the results and field measurements. In addition, any weather conditions and field observations that could have affected the data should be reported.

The delivered data should be referenced horizontally to NAD83, CCS83, State Plane Zone 2, and the vertical datum is NAVD88. All units should be provided in meters.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

To improve modeling of juvenile salmon behavior and movement in the Sacramento River, smaller winter-run Chinook and larger late-fall-run Chinook salmon were tagged and released into a 2D telemetry array during the winter of 2015. Detection positions were filtered and discretized to create two-dimensional tracks and measure movement characteristics, evaluate space use, and assess whether these runs displayed distinct behavioral differences. Speed over ground and turning angle were not significantly different between release times, fish size, or run. Only the initial movement rate between release and array locations was significantly different between the runs. Both runs displayed a non-uniform distribution within the channel and tended to use space along the outer bend more frequently than the inner bend. Winter-run Chi-nook salmon tracks were slightly farther towards the outer bend than late-fall-run Chinook. A similar result was not ob-served in smaller and larger late-fall-run Chinook, which suggested that differential space use may be influenced more by run identity than variation in size between runs. Although small differences between runs were measured, it is reasonable to aggregate these results for a singular juvenile salmon behavior model, rather than developing independent juvenile behavior models based on adult run-timing.

15. SUBJECT TERMS

Salmon behavior, winter-run Chinook, late-fall-run Chinook, juvenile salmon behavior models

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**	SAR	131	Dr. David L. Smith
Unlimited	Unlimited	Unlimited			**19b. TELEPHONE NUMBER** *(Include area code)* (601) 634-4267

Yolo Bypass Salmon Habitat Restoration and Fish Passage Analytical Tool Review

A report to the

Delta Science Program

Prepared by

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October 2017

Delta Stewardship Council
Delta Science Program

Table of Contents

Executive Summary

The suite of data collection, analytical tools, and models applied to evaluate alternative notches in the Fremont Weir is an impressive and useful body of work to support decision-making required to proceed with the Program Environmental Impact Statement/Environmental Impact Report (EIR/EIS) process. The Panel found all of the selected approaches and tools appropriate for selecting a notch location and configuration. While the Panel found the approaches and tools appropriate, the effectiveness of the tools in differentiating between alternatives varied. Further, the limited treatment of uncertainties by the suite of tools resulted in an inability to differentiate between alternatives without making major assumptions about inputs that, if changed, could significantly change the results of the evaluations. However, the Panel ultimately decided that the assumptions made in the suite of applied tools were reasonable and allowed enough analytical differentiation between alternatives to support their use in the evaluation of alternative Fremont Weir notches.

The Panel also concluded that work on some of the tools and approaches should continue, but in support of design, implementation, and performance monitoring of the selected notch, as opposed to supporting notch selection for the EIR/EIS process. The Panel's recommended improvements are detailed in the body of this report. Notably, the Panel concluded that significant uncertainties in the tools regarding hydrodynamic boundary conditions, juvenile salmon behavior, and floodplain survival and growth need to be first resolved and then the tools applied in an adaptive management approach in which potential improvements in the selected notch are hypothesized and tested through monitoring. To this end, selection of the preferred notch alternative should rely on this suite of tools to provide scientific support and insights that will maximize the flexibility (configuration and operation) of the implemented notch.

Approach and Tool-Specific Findings

Hydrodynamics

The SRH-2D model is well established and appropriately applied in this evaluation. The Panel identified a number of areas, including boundary conditions, calibration, and mass balance, where improvements could be made, especially with better integration with other studies assessed by this Panel that collected empirical data on hydrodynamics in the region being considered for a notch in Fremont Weir. The Panel concluded that the selected hydrodynamic model is effective as an input to the Eulerian-Lagrangian-Agent Method (ELAM) model for relative comparisons of entrainment with alternative notches. However, the Panel also determined that revisions to the documentation that more clearly document model limitations with respect to boundary conditions, calibration, and mass balance would enhance the level of support that this model provides to the EIR/EIS decision-making and documentation.

Entrainment

The Juvenile Entrainment Evaluation Tool (JEET), Critical Streakline Analysis (Streakline) and ELAM models characterize fish entrainment with differing levels of detail. All three predicted that more flow capacity results in more entrainment. JEET did not address notch location or configuration. Streakline characterized potential differences in entrainment in the Western section of the weir but did not address effects of configuration. ELAM addressed entrainment for all alternative locations and configurations (Table 1 and 2). In addition, it explored configurations beyond those in the six alternatives. As denoted in the summary results of the ELAM analysis below (Table 2), Alternative 6, with the largest capacity results in the highest entrainments at all river stages. Of the other alternatives the model predicted that all but Alternative 2 results in highest entrainment at some river stage. Notably, Alternatives 1 and 3 have high entrainment as several stages. The Panel suggests that only Alternative 6 unequivocally ranks highest. Of the other alternatives 1 and 3 are functionally equivalent. It is not clear from the analysis why Alternative 2, which differs in location but not significantly in configuration from 1 and 3, ranks lower in entrainment. The Panel also suggests that further differentiation of the alternatives is not possible without improvements in the models and data. Thus, application of the models in an adaptive management context to improve notch efficiency is not warranted without out resolving the uncertainties in the tools.

TABLE 1: Summary of EIS/EIR Yolo Bypass Notch Alternatives (Newcomb & Nelson 2017)

Feature	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**Alt 6**
Notch Location	Eastern Fremont	Central Fremont	Western Fremont	Western Fremont	Central Fremont (Multiple)	Western Fremont
Maximum Notch Flow	6,000 cfs	6,000 cfs	6,000 cfs	3,000 cfs	3,400 cfs	12,000 cfs
Notch Invert Elevation	14	14.8	16.1	16.1	Multiple	16.1
Channel Bottom Widths	30’ bottom, 30’ bench	50’ bottom, 30’ bench	50’ bottom, 30’ bench	50’ bottom, 30’ bench	West: 40’ 30’ bench; Center: 90’; East: 90’	200’ bottom
N. Bypass Water Control Structure?	No	No	No	Yes	Secondary channels (program level)	No

Supplemental Fish Passage	West	West	East	East	West	East
Inundation Operations	Nov 1 – Mar 15	Nov 1 – Mar 15	Nov 1 – Mar 15	Nov 1 – Mar 7 or Mar 15	Nov 1 – Mar 15	Nov 1 – Mar 15

TABLE 2: Entrainment estimates across flows and stage referenced to Fremont Weir Summary of EIS/EIR Yolo Bypass Notch Alternatives (Table 5 in Smith et al 2017)

Statge (ft) Fremont	Q (cfs) Fremont	EIS/EIR Alt 1	EIS/EIR Alt 2	EIS/EIR Alt 3	EIS/EIR Alt 4	EIS/EIR Alt 5	EIS/EIR Alt 6
20.23	14952	0.2	0.2	0.8	1.2	0	1.8
21.16	16161	0.4	0	0.4	0.6	0.8	3.6
22.32	17717	1	0.4	0.8	0.8	1.6	4.4
25.54	21261	4.8	3	5.8	4.4	5.6	17
27	22806	9.4	5.4	9	7.2	5	24
28.83	24640	13.8	9.4	11.4	5.4	2.6	37.4

Floodplain Rearing Benefit

The Salmon Benefits Model (SBM) appropriately applies juvenile salmon migration, growth, and timing relationships to inform understanding of the benefits to Chinook salmon of migration and rearing on the Yolo Bypass compared to in the Sacramento River. The Panel recognizes that the uncertainty around survival and growth rates for juvenile salmon on the Yolo Bypass and in the Sacramento determines the results from the model, but accepts the differentiation between notch alternatives illuminated by this model with relatively high assumed survival on the floodplain. As for the entrainment approaches and models, the Panel believes that the SBM effectively differentiates between notch capacities, but does not differentiate between notch locations or configurations. Therefore, the Panel considers the SBM as a useful framework for visualizing the tradeoffs of alternative notches and resolving uncertainty about notch performance if implemented in an adaptive management framework supporting alternative notch design, implementation, and performance monitoring.

Adult Fish Passage

The Yolo Bypass Adult Fish Passage (YBPASS) evaluation tool appropriately uses 1-D hydraulics, adult fish passage hydraulic criteria, and hydrology to assess how frequently alternative notches achieve fish passage criteria. The Panel concluded that this tool was effective in differentiating the performance of alternative notches for adult fish passage. The Panel also noted that while all notch alternatives shows significant improvements in adult fish passage at Fremont Weir, the results from the tool highlight significant proportions of time when fish passage criteria are not met, even with a notch. The Panel urges careful communication of these results so that reviewers are aware of the improvements in adult fish passage with notches and not focused only on the periods that still do not meet adult fish passage criteria even with a notch. This tool does not appear to need additional development, however, the project proponents should continue to refer to the information from this tool during design, implementation, and monitoring to optimize adult passage with the chosen notch alternative. The Panel urges more complete documentation for design criteria used for acipenserids (Sturgeons). Lastly, the Panel also urges the differentiation of model results for salmonid criteria and for acipenserid criteria, as the latter are both more restrictive from a design perspective and more poorly represented from a population perspective.

Agricultural Economics

The Bypass Production Model appropriately describes differences in agricultural production between project alternatives. Agriculture economic outcomes evaluated include the change in crop acreage, agricultural production value, and net farm income from a projected baseline to a projected outcome under each alternative. The panel concluded that this tool was effective in differentiating between project alternatives in terms of their effects on local agricultural production. The panel recommends that the consideration of the uncertainty and variability in the model results be further developed and notes that supporting documentation for some aspects of the modeling approach was not provided. Further, additional information on the relative magnitude of the effects of the project alternatives, the inter-annual variability of the projected impacts, and the spatial distribution of the impacts of each project alternative would make the results of the analysis more useful and easier to interpret.

Charge Question Findings

Appropriateness

The Panel agreed that all of the tools applied were appropriate for the questions being asked in the EIR/EIS process for the notch in Fremont Weir. Further, the models were developed by leading experts in their respective fields, and supported by significant validation and calibration field data.

Effectiveness

The Panel found that the effectiveness of the approaches and tools applied in differentiating between the performance of alternative notches varied substantially, and in most cases depended significantly on assumptions about model inputs and relationships. In some cases, relatively small changes in these assumptions could change the resulting relative performance shown by model outputs. The Panel strongly recommends that these assumptions and their uncertainties be more clearly documented and communicated very transparently as the EIR/EIS process for the notch alternatives moves forward. The Panel also recommends that work continue on the hydrodynamic model (improvements in boundary conditions, calibration, and mass balance), ELAM (improvements in the understanding of behavior of small juvenile salmon at proposed notches under a range of flows), and the SBM (improvements in the understanding of floodplain and river survival and growth). While the Panel feels these improvements are extremely important for future development of this project, the Panel concluded that the assumptions made in applying the suite of tools were founded on sound professional and scientific judgement, and therefore the differentiation they are able to quantify between notch alternatives is a reasonable foundation to support EIR/EIS decisions.

More specifically, the Panel found that the suite of tools is effective for differentiating between ***flow capacities*** of notch alternatives. The suite of tools is also effective differentiating between notch configurations (i.e. angled vs. perpendicular to Sacramento River flow direction). The suite of tools is less effective differentiating between alternative notch locations. While the suite of tools does indicate that eastern and western locations perform better than the central location, the Panel recommends that alternatives evaluation consider performance similar across locations, and prioritize the location shown by the suite of tools to offer the most flexibility to maximize capacity, implement the lowest invert elevation, and incorporate engineering elements to optimize adult fish passage. In other words, the Panel concluded that the suite of tools are best suited to supporting an EIR/EIS decision that prioritizes notch operational flexibility so that operation of the notch can be managed adaptively as performance monitoring reduces the critical uncertainties identified in this peer review that limit quantitative evaluation of alternative notches.

Integration

The Panel found the integration and coordination between the principal investigators working on each tool to be lacking. The Panel recognizes the structural and scheduling challenges that prevented better integration, but noted that significant synergies between tools and improvements to one tool using information from other tools were precluded by the lack of integration. More specifically, the Panel recommends that the ELAM and Critical Streakline tools complete as much integration as possible prior to completion of the EIR/EIS process to address as many of the issues raised in this peer review as possible. In addition, the Panel recommends that the SRH-2D and Critical Streakline tools complete as much integration as possible. While significant uncertainties will still remain after improved integration, it is possible that near-term integration could strengthen the scientific justification provided by the suite of tools for differentiation between notch alternatives in the EIR/EIS process.

Reporting

As with the integration across the suite of tools, the Panel found the reporting available on the suite of tools lacking. Again, the Panel recognizes the structural and scheduling challenges that prevented more detailed and refined reporting. Individual reports were mostly sufficient for a basic understanding of each tool as a stand-alone product. The more significant challenge in interpreting the appropriateness and effectiveness of the suite of tools was the lack of an overarching report clarifying the connections between individual tools, where tools could incorporate additional information from other tools, and how the scenarios and alternatives considered by each tool align. The Public Meeting presentations on each tool improved the Panel's understanding of the suite of tools immensely, but this information will not be easily accessible to reviewers of and stakeholders in the EIR/EIS when released for public comment. Therefore, the Panel strongly recommends that the EIR/EIS team craft a concise and well-illustrated report that clearly identifies and documents the connections between individual tools and the conditions evaluated by the suite of tools.

Next Steps

The Panel found the suite of models together present a sufficient analysis to move forward with notch selection. The information is not without uncertainties but, as is the case with many models, small differences between alternatives (e.g. table above) are unlikely to be significant. However, several consistent trends do emerge. Larger notch flow capacity produces larger juvenile salmon entrainment, a consistent finding across all three entrainment evaluation approaches. For determining the notch location, only the ELAM provides enough information to be useful for decision making in support of the EIR/EIS. For evaluating the basic notch configuration the ELAM model is most useful but a more complex form, including 3-D hydrodynamics and higher order fish responses, will be required for optimizing the design. The Panel notes that optimizing entraining fish is only the first step in using Yolo Bypass to benefit fish; improving growth and survival are equally important. For this task the Salmon Benefits model provides a framework for adaptive management of actions within the floodplain.

1. Background & Purpose

NOAA's National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) have issued a Biological Opinion (BiOp) on the long-term operations of the Central Valley Project (CVP) and State Water Project (SWP) that includes Reasonable and Prudent Alternatives (RPA) designed to alleviate jeopardy to listed species and adverse modification of critical habitat. NMFS' RPA requires the U.S. Bureau of Reclamation (Reclamation) to increase juvenile floodplain rearing habitat and improve adult fish passage for ESA-listed salmonids and sturgeon. The BiOp requires seventy-three (73) habitat restoration actions, five of which are specific to the Yolo Bypass. The California Department of Water Resources (DWR) and Reclamation have developed project alternatives for the Draft Yolo Bypass Fish Passage and Habitat Restoration EIS/EIR focused on the following two Yolo Bypass actions, which are the subject of this review:

- I.6.1 - Increase seasonal floodplain inundation in the lower Sacramento River Basin
- I.7 - Improve fish passage throughout the Yolo Bypass Alternatives

The alternatives developed to address these two actions consist of a notch in the Fremont Weir, with alternative locations and configurations (width and weir crest elevations), designed to increase the frequency and duration of hydraulic connectivity between the mainstem Sacramento River and the Yolo Bypass and to improve fish passage. Six alternative locations/configurations for a notch were identified (Figure 1)

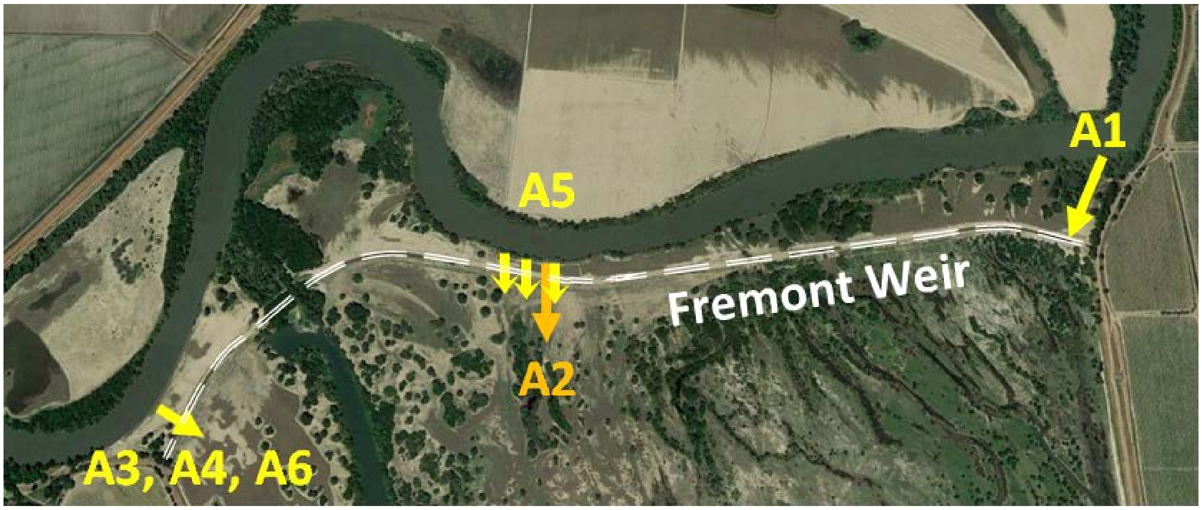

FIGURE 1. Alternative notch locations across the Fremont Weir. Derived from Newcomb and Nelson 2017). See Table 1 for dimensions of Alternative notches.

Several different types of analytical tools have been developed and applied to evaluate the performance of the alternative notch locations and configurations with respect to hydrodynamics, fishes (including their habitat and movement), and agricultural economics. The tools reviewed by this Panel are:

1. ***Hydrodynamics:*** SRH-2D and U^2RANS models;
2. ***Juvenile Salmon Entrainment***: Juvenile Entrainment Evaluation Tool (JEET) model, Eulerian Lagrangian Agent-Based Model (ELAM), and Critical Streakline Analysis;
3. ***Juvenile Salmon Floodplain Rearing:*** Yolo Bypass Salmon Benefits Model (SBM);
4. ***Adult Fish Passage***: Yolo Bypass Passage for Adult Salmon and Sturgeon (YBPASS) tool; and
5. ***Agricultural Economics***: Bypass Production Model (BPM).

The overall purpose of this review is to independently and externally evaluate these analytical tools for assessing the project alternatives being considered in the Draft Yolo Bypass Fish Passage and Habitat Restoration EIS/EIR. The goal is a scientific assessment of the tools and whether they use the best available science, appropriately applied assumptions, and adequately documented and interpreted results to support comparisons and differentiation between alternatives.

1.1 Panel Charge

The Panel was tasked with reviewing each of the modeling tools for appropriateness, effectiveness, integration, and reporting with specific application to differentiating between the alternatives identified in the Draft Yolo Bypass Fish Passage and Habitat Restoration Program EIS/EIR. Specific charge questions for the Panel are listed below. Not all charge questions apply to all tools. It is important to note that the Panel was not tasked with determining whether or not the Yolo Bypass Fish Passage and Habitat Restoration Program being evaluated will alleviate jeopardy to listed species and adverse modification of critical habitat. Rather, the charge to the Panel was to evaluate the ability of the tools as applied to differentiate between the alternative Fremont Weir notch locations and configurations. Any reference to potential preference by the Panel for an alternative location or configuration is unintended.

Model Appropriateness

The Panel considered the following questions with respect to the appropriateness of each tool to differentiate between the performance of alternative notch locations and configurations.

1. Does the tool consider appropriate spatial and temporal scales (i.e., periods simulated, duration of simulations, time step used)?
2. Does the tool use appropriate input data sufficient to justify the assumptions, parameter estimates, and conclusions?
3. How well does the tool explicitly incorporate variability and uncertainty?

Model Effectiveness

The Panel considered the following questions with respect to the effectiveness of each tool to differentiate between the performance of alternative notch locations and configurations.

1. Does the tool effectively capture the distribution and timing of fishes impacted by the project?
2. Does the tool effectively capture differences in growth rates and survival between floodplain and river channel habitats?
3. Does the tool effectively characterize effects on agricultural resources in the Yolo Bypass?

Model Integration and Reporting

The Panel considered the following questions with respect to the integration between tools and the documentation provided in reports for each tool.

1. Are the tools sufficiently integrated to evaluate and differentiate between alternative notch locations and configurations?
2. How well are the tools defined and discussed?
3. Where results from related tools differ or conflict, are the differences and conflicts clearly stated and appropriately addressed?
4. Are the conclusions drawn justified by the analytical outputs of each tool?
5. Where tools are integrated and/or linked, how well are the assumptions and uncertainties in one tool accounted for and communicated to the other tool?
6. How well do the tools characterize and convey uncertainties?
7. How clear are the presentation of results from each tool?

1.2 Review Panel Members

James Anderson, Ph.D., University of Washington (Panel Chair)
Mark Tompkins, Ph.D., P.E., FlowWest LLC (Lead Author)
Peter Goodwin, Ph.D., P.E., University of Maryland
Greg Ruggerone, Ph.D., Natural Resources Consultants, Inc.
Cameron Speir, Ph.D., NOAA Southwest Fisheries Science Center
Joshua Viers, Ph.D., University of California Merced & Pacific Agroecology LLC

2. Peer Review Panel Findings

The following sections provide detailed summaries of review Panel findings for each tool.

2.1 Hydrodynamic Models

Introduction

Multiple hydrodynamic models are being used to evaluate the very challenging problem of simulating alternative significant flow diversions from the Sacramento River into the Yolo Bypass through a new notch in Fremont Weir. SRH-2D is a hydrodynamic model developed by the Bureau of Reclamation. In this implementation, the model was used to provide hydrodynamic input data to the ELAM model representing existing conditions as well as alternative notch locations and configurations. SRH-2D has been applied elsewhere on the Sacramento River and on the San Joaquin River in California, as well as other rivers across the western United States. The SRH-2D model results have been compared with the ADH model applied to the same region by the US Army Corps of Engineers. In addition, the findings of SRH-2D were compared to a full 3-D hydrodynamic model (U^2RANS) to compare the results between a 2-D and 3-D representation of Fremont Weir.

Some of the challenges are outlined in the assumptions and uncertainties in the hydrodynamic simulations and captured in the review reports (Reclamation SRH-2015-33, SRH-2017-19) and the model documentation (references such as Lai, 2008). For the simulation of diversion flows at Fremont Weir these uncertainties include inaccurate or non-stationary bathymetry, lack of detailed information on tributary inflows (for example, Sutter Bypass Outflow) and uncertainties in water surface elevations for model calibration.

These hydrodynamic modeling studies are bolstered by one of the most comprehensive sets of field observations of the flow structure in the Sacramento River using Acoustic Doppler Current Profiler (ADCP) data collected by the USGS as part of the Yolo Bypass Utilization Study (YBUS). The combination of high-resolution modeling and detailed field measurements result in a robust approach to determine the effectiveness of the flow diversion.

Backwater effects result in a non-unique relation between water surface elevation and discharge that poses difficulties in setting the boundary conditions for the models that can potentially have a significant influence on the relationship between river discharge and water surface elevation along the Fremont Weir. If the boundary forcing cannot be specified accurately for a given flow condition, the model boundary should be set beyond the maximum influence of the boundary condition.

Calibration of the model is also difficult as the conditions change significantly between high and low flows – particularly complicating effects of backwater effects at confluences where the zone of influence can vary significantly with flow and tidal conditions

Model Appropriateness

SRH-2D is a model developed by Dr. Lai in the Technical Services Center, U.S. Bureau of Reclamation. The model is well documented and has been used extensively by agencies, consultants and academia over the past decade. U^2RANS solves the unsteady Reynolds averaged Navier Stokes equations. Originally developed by the Iowa Institute of Hydraulic Research, this model has been widely used for more than a decade. The modeling team is led by a respected computational hydrodynamics expert that was the developer of the former model and with extensive experience in the development and application of the latter. The models are appropriate for evaluating the hydrodynamic performance of alternative Fremont Weir notch sizes, locations, and configurations.

Model Effectiveness

Overall, the SRH-2D model provides effective hydrodynamic output for use as input to the ELAM evaluation for relative comparisons of Sacramento River and notch flow entrainment characteristics. Several important improvements must be made to the SRH-2D model for it to accurately simulate boundary conditions, mass balance, and, potentially, three dimensional hydrodynamics.

The assessment of bathymetry resolution and mesh size was informative and contributes to an understanding of the sensitivity and uncertainty of the SRH-2D modeling. This careful analysis demonstrated that discrepancies are not due to grid selection, but rather the accuracy of bathymetric information (Chapter 4 SRH-2017-19, for example Figure 15). However, the hydrodynamic modeling analyses do not provide a comprehensive summary of uncertainty and sensitivity to important factors such as ungauged inflows, backwater effects created by Sutter Bypass and other tributaries, or potential changes in bathymetry in the region proposed for alternative notches in Fremont Weir. Consideration should be given to estimating differences in water surface elevations at proposed notch locations that considers the empirical understanding of hydrodynamics in the region developed by Stumpner (2017), which are described below.

The SRH-2D and U^2RANS models appear to give similar results for predicting water surface elevations and discharge. U^2RANS is more computationally intensive, with significantly longer run times than SRH-2D. However, care should be taken in selecting the appropriate model for future hydrodynamic simulations related to design, implementation, and monitoring of the selected notch in Fremont Weir. The selection of the model should be driven by the type of question posed by the ELAM modelers and fish biologists. If juvenile fish behavior must be simulated at a range of depths in the water column, upwelling on the upstream face of Fremont Weir or other large scale turbulent structures could initiate attraction or repulsion responses from the fish. For these conditions, the U^2RANS may be warranted.

Juvenile salmon behavior in the region of proposed notches in Fremont Weir is sensitive to the volume of flow being diverted, the location in the water column where fish are present, turbulent structures such as eddies as well as the local flow characteristics such as the local strain and/or shear. Therefore, the Panel does not agree with the conclusion that the 2-D hydrodynamic model is adequate, unless the fish are known to frequent close to the surface of the Sacramento River. Observations from the Streakline evaluation (described below) indicate that juvenile salmon behavior does vary with depth and in response to vertical flow dynamics. The decision on the choice of the model depends on the question that is posed by the fish behavior experts. If the fish are capable of dynamic responses to changes in the flow characteristics such as strain (or lateral shear), eddies or upwelling at the weir crest, the 3-D hydrodynamic model would be warranted. If the water surface elevations and depth averaged velocities are adequate, then the 2-D model would suffice. A meeting of the experts on fish behavior to share data and knowledge of where fish have been observed and how they respond at other areas of flow separation or channel intersections would help inform this decision. The Streakline analysis based on field measurements is a very valuable tool in guiding the final selection of the location of the diversion along the weir if the desire is to maximize entrainment.

Model Integration and Documentation

The SRH-2D model was well-documented, but included some unresolved issues (e.g. Sutter Bypass boundary conditions) and presented some unexpected results (e.g. cross sectional velocity distributions) that would benefit from improved reporting. The integration of detailed field measurements under existing conditions to calibrate the high resolution 2-D and 3-D models is an appropriate approach. The analysis has demonstrated that the model results are relatively insensitive to the computational mesh established for these simulations. The model results were shown to be very sensitive to the bathymetry, and after the 2015 report, updated bathymetry was used where available in the model domain and high resolution bathymetry was shown to be very important. The low resolution model (large domain from River Mile 47.6 to 117) results from this study were also compared to earlier simulations with the ADH model (US Army Corps of Engineers, 2013). Close comparisons were reported in SRH-2015-33.

From the presentations and SRH-2015-33 and SRH-2017-19, there has been an evolution in the model calibration. In the initial model simulations, it was difficult to match the model results with the field observations and adjustments were made to the inflows in the model domain to match water surface elevations and achieve a mass balance of the water (i.e. total inflows match total outflows within the model domain under a steady discharge). The model was then recalibrated using updated bathymetry and high resolution bathymetry and a better match to the field observations was obtained. However, recent field observations (see Critical Streakline section below) have highlighted the complexities of the flow characteristics in the region of the proposed notch in Fremont Weir, raising concerns about the potential variance in water surface elevations for a given discharge.

Appendix 1 of *ERDC TR/EL-17-Draft* summarized the differences between the field observations of stage, discharge, and velocity with the model simulation results. Given the date of these reports and when the latest field data was used, there was insufficient time for the study team to complete a thorough analysis. Similarly, there is insufficient information provided in the reports for the Panel to conduct a structured analysis as there are differences in the scenarios analyzed. Examples include differences in the Sacramento River of up to 3 feet in river stage and up to 70% in estimate of river discharge.

From the reports and materials presented to the Panel it is difficult to draw definitive comparisons between the two modeling approaches, but there appear to be some significant discrepancies between the stage-discharge relationships derived from the two approaches. There is inadequate comparison of the model and field water surface profiles in the reports to understand these differences.

In this simulation exercise, it is assumed that fish respond passively to the flow structure based on field observations in the region. However, the results of the modeling indicate that the effects of the notch in Fremont Weir could trigger very different turbulence characteristics and flow structure than is experienced in the confined trapezoidal channel of the Sacramento River. The ‘entrapment zone’ for diverting flow into the Yolo Bypass is going to be highly dependent on the location, alignment and size of the notch in Fremont weir.

In addition, there are differences between the observed and predicted velocity distribution across the channel (for example Figures 19d, SRH-2017-19). This indicates a potential difference between predicted and observed discharge at the section and the difficulties with mass conservation have not been fully resolved. This could also be significant if the ELAM modelers require more detail on the lateral velocity structure to simulated more complex fish behavior, as discussed in the ELAM section below. A joint collaborative analysis between the field team and modeling team will allow a systematic analysis of the predictive ability of the model under existing conditions and with the diversion. This integration is not expected to be a major undertaking, and specifically the following questions could be addressed:

1. Can the hydrodynamic model adequately capture the backwater effects detected in the field studies? If not, remedies should be considered such as relocating the boundaries of the high-resolution model and supplementing discharge and water surface elevations measurements with additional gauging stations as recommended by Stumpner et al., 2017.
2. What is the expected accuracy of predictions in water surface elevation at the weir under different discharges, and if this elevation is influenced by tidal elevation or other backwater effects due to Sutter Bypass, what is this variation? Since the flow over the Fremont Weir varies with the water depth in a non-linear manner, it is important to accurately capture the stage.
3. The choice between the 2-D or 3-D simulation should be made by the ELAM modelers and fish behavior experts on the basis of whether the fish respond passively or to cues in the turbulence or flow structure.
4. It is worth noting that several other hydrodynamics models (e.g. TUFLOW and HEC-RAS 2D) have been applied to this region. While this review focused specifically on the SRH-2D model, future analyses related to Fremont Weir and Yolo Bypass should leverage all available models (and supporting data) as well as the unique set of field observations amassed during this study.

2.2 Juvenile Entrainment Evaluation Tool (JEET)

Introduction

The Juvenile Entrainment Evaluation Tool (JEET) (DWR, 2017a) is designed to evaluate the effects of notch dimensions on juvenile salmon entrainment for different fish runs and river stage levels. It does not evaluate effects of notch location, fish distributions across the river, or effects of notch-induced changes in the hydrodynamic field on entrainment. The model assumes the proportion of fish entrained is equal to the proportion of water entrained. The model provided information for the SBM model, the adult upstream passage model and the economics model. The flows in the model are generated from the TUFLOW Classic hydraulic model (only evaluated by this Panel as background information).

Model Appropriateness

The model's strength is its simplicity and clear characterization of the historical passage distributions of juvenile salmon migrations past Fremont Weir. The model characterizes notches by their invert elevation, width, and maximum flow. JEET does not consider effects of location and notch hydraulic flow properties, or fish spatial distribution. Thus, the JEET entrainment index is appropriate for identifying the relative effects of notch dimension on run-specific entrainment (i.e., the interaction of migration timing river stage and notch dimension). The model assumes fish are distributed uniformly in the flow so that the fraction of fish entrained equals the fraction of flow entrained. In actuality, fish are not distributed uniformly. The fish entrainment fraction can be greater than or less than the water entrainment fraction. Fish distributed closer to a notch entrance might have greater proportional entrainment than that predicted by JEET, with the opposite result for fish distributed farther away from the notch entrance. However, the interaction of flow and fish distributions cannot be inferred by qualitative models. The Streakline model (Section 2.1) illustrates the complexities typical of flow and fish distributions with data, while the ELAM model attempts to computationally capture these complexities.

The JEET model is used to define fish inputs in the Salmon Benefits Model (Section 2.5), and Agricultural Economic Model (Section 2.7). Given the uncertainties associated with results of these models, arguably the JEET has the appropriate level of complexity for evaluating these secondary aspects of different notch alternatives.

Model Effectiveness

The model is effective in identifying the relative of notch flow capacity on entrainment. Like most of the models, JEET uses species composition and timing of juvenile salmon migration at Knights Landing for input. These juvenile outmigration trapping data are a valuable resource for evaluation of fish entrainment.

Model Integration and Documentation

The model documentation is clear and the model is appropriately integrated with the SBM and Agricultural Economic models. The fact that JEET is implemented on a spreadsheet adds to its accessibility to a wider audience. The model contains many simplifying assumptions, which for the most part are identified in the report. The Panel suggests that the uncertainties generated from the assumptions are not significant if the model output is viewed as an index of entrainment.

2.3 Critical Streakline Analysis

Introduction

Two USGS reports describe an analysis of entrainment potential of 63 potential notch locations across the Fremont Weir. The analysis was based on a comprehensive set of high-resolution hydrodynamic flow/stage data (Stumpner et al. 2017) and hatchery fish acoustic tag data (Blake et al. 2017). The data sets were collected simultaneously along the western side of the Fremont Weir in Water Year 2016, a “Below Normal” flow year according to DWR’s Sacramento River Index (http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST). The study area corresponded to Alternatives 3, 4 and 6. The study did not include the eastern (Alternative 1) and central (Alternatives 2 and 5) locations. The entrainment potentials at incremental distances along the western section were defined by comparing the cross-channel fish distributions to cross-channel locations of the “critical streakline”—defining the point separating water that continues downstream from water predicted to enter a notch. The fraction of the fish distribution inside the streakline location immediately upstream of a notch defines the entrainment potential of the notch.

The analysis found that at some locations of the study area, more of the fish cross-channel distribution was located within the entrainment zone, and therefore at these locations the fraction of fish entrained into a notch would be higher than other locations. The report concluded these locations are candidates for a notch in the Fremont Weir. One location was also identified where entrainment potential was very low.

Model Appropriateness

The model is based on high-resolution spatial hydrodynamic data that characterizes the 3-dimensional patterns of velocity and stage for a measured range of flows. Importantly, the model characterizes the secondary flow field that interacts with fish behavior to shape the vertical and cross-channel distribution of fish as they move along the Fremont Weir. The resolution of the measured primary and secondary flow fields was impressive and appears to be of very high quality. Importantly, the hydrodynamic analysis revealed stage-discharge patterns that affected the position of the entrainment zone. The model trajectories of fish were also of high resolution. The intersections of the critical streaklines with fish cross-sectional distributions provide high-resolution estimates of entrainment potential under the observed conditions.

The temporal scale of entrainment was more difficult to assess because the hydraulic and fish data were collected for one migration season only. Validity of extrapolation to years with different stages and discharges and with different fish trajectories would be difficult to assess with the existing data.

The model appears appropriate for identifying potentially viable locations for a notch as well as identifying locations that are less viable, based on the 2016 large-fish telemetry data used in the model (avg. ~165 mm). The analysis did not address notch configuration, nor possible perturbations of the hydrodynamic field and fish trajectories that would result from the presence of a notch. In other words, the model provides an initial evaluation of entrainment potential for each location while noting that actual entrainment would depend on specific characteristics of the notch, such as absolute dimension, relative position, and structural geometry.

The stage-discharge probability distribution was determined from historical data (1996-2010). This analysis characterized across-year entrainment as a function of water year. The pattern of entrainment potential with location across the weir was insensitive to water year type except in wet years where Yolo Bypass would be overtopped more than 200 hours over the season.
The conclusions from the study are expected to be valuable for identifying notch locations. Of particular value, the study identified a 100m long zone of near-maximum entrainment for all runs of salmon (based on telemetry of large hatchery fish only) and seasonal hydrology.

Critical Uncertainties

A strong assumption of the study is that conditions observed in the 2016 study are sufficient to infer entrainment patterns in a weir with one or more notches. The report listed a number of uncertainties associated with this assumption. Brief comments on these and other uncertainties are listed below.

1. The study characterized behavior of large hatchery fish (~165 mm late fall run). It is uncertain how these findings can be extrapolated to smaller wild juvenile salmonids, especially those that are approximately 30-90 mm. These smaller salmon would likely benefit more from rearing and growth on the Yolo Bypass than the large salmon examined in this model. The Panel agrees this is an important uncertainty and realize it is difficult to assess with acoustically-tagged fish that must be relatively large (~>90 mm). In the Appendix, the Panel identifies information from other studies indicating small Chinook salmon typically inhabit shallow, low velocity habitats including the inside of river bends. One potential approach might be to assess size effects with an analysis of the ELAM model (see Section 2.2 below) in which fish swimming velocity is determined by fish length. However, such an analysis would not characterize length-dependent responses to acceleration thresholds that induce fish behaviors (e.g. see Enders et al. 2012, Goodwin et al. 2014, Vowles et al. 2014), nor would it assess possible skewed distribution of small fish to the inside of the river bend. This skewed cross-channel distribution of small Chinook salmon might be examined with a beach seine (electrofishing is less effective for these smaller salmon (Friesen et al. 2007)).

2. The Panel agrees with the authors that the limited range of backwater conditions limits the extrapolation of the study to other conditions. The Panel also notes that the notch, which may at times divert a sizable fraction of the river flow, will affect both backwater conditions and cross-channel velocities. Determining the details of the effects will require computational fluid dynamics modeling to characterize the flow fields and ELAM-type models to characterize the response of fish to the flows. For example, the streamline analysis captures the downwelling on the outside of a bend, but the presence of a notch is likely to introduce some upwelling as the flow goes over the weir crest.

3. The study identified a 10 m long zone of minimum entrainment associated with a scour hole. The region had up to 400% lower entrainment than the zone of maximum entrainment located 40 m downstream. This strong lateral variation in entrainment may suggest that modifications in the topography of the river at Fremont Weir may have strong effects on the properties of the locations that are identified as optimum from the current analysis. Thus, the predictions of potential notch locations based on 2016 observations have an unresolved level of uncertainty for predicting the optimal location of notch. However, the Panel could not determine the significance of the uncertainty and

therefore recommends the selected notch location and configuration be managed adaptively to address this uncertainty.

4. Although this model and other models provide valuable information for identifying the location of the notch and important notch characteristics, remaining critical uncertainties highlight the need for monitoring, evaluation, and active adaptive management.

Model Effectiveness

The model focused on evaluating location-specific entrainment potential under varying conditions. For each scenario, the model also characterized notch discharge and fraction of total fish abundance entrained for stages. This information may be valuable in better defining the weir arrival spatial distributions of fish for ELAM and SBM models. In particular, the model identified weir locations where entrainment would be expected to be relatively low or high. However, the analysis was only relevant to western located alternatives.

Model Integration and Documentation

The study's integration of hydrodynamic and acoustic tag data was excellent. In particular, the analysis provides important insights on the complexity of stage/discharge relationships that affect the efficiency of alternative entrainment zone locations. The analysis also provides insights on the importance of secondary flows in determining the cross-stream movements of fish. The report highlights evidence that fish behavior and secondary circulation together influence cross-channel movements of fish. The report suggests that fish entrainment might be enhanced by modifying the secondary flow upstream of a notch location. These finding should motivate additional studies on the response of fish to complex flow patterns expected around a notch. For integration with the ELAM model, see section 2.4: Model Integration and Documentation

2.4 Eulerian-Lagrangian-agent method (ELAM)

Introduction

The ELAM models fish movement in response to variations in the flow field and fish behavior. The model was used to evaluate juvenile salmon entrainment potential of 12 notch scenarios varying in notch location and configuration in the Fremont Weir (Smith et al. 2017). Near the end of the project additional simulations were conducted to better capture the six alternatives. The model characterized the movement of juvenile salmonids through complex flow fields by resolving the combined effects of changes in the flow field and the induced swimming behavior in response to the changes. The model tracks four potential behaviors: [B1] in steady flow, fish drift downstream; [B2] encountering moderate flow acceleration, fish swim across the streamlines into the higher velocity; [B3] encountering strong flow acceleration, fish swim upstream against flow; [B4], fish swim against changes in vertical velocity in order to maintain depth. The switch from B1 to B2 and from B2 to B3 behaviors depends on the particle acceleration experienced by the fish, with higher accelerations required for B3 than B2. For this project, the flow field was characterized by a 2-D model (see Section 2.4 on SRH-2D); therefore, the modeled fish exhibit no B4 behavior. The ELAM model was described in a series of publications, the major ones being Goodwin, Nestler et al. (2006), and Goodwin, Politano et al. (2014).

Model Appropriateness

The ELAM model was initially developed to resolve the effects of complex small-scale spatial velocity patterns on passage of salmon smolts through Columbia River dams. Similar conditions are expected in a Fremont Weir notch, therefore the model spatial scales are highly appropriate for evaluating alternative notch entrance configurations for the weir.

In the current form, the ELAM model may under-predict the entrainment of the modeled fish (i.e, fish > 98mm) because of limitations in the SRH-2D hydrodynamic model. The authors speculated that the bias involves the inability of the 2D hydrodynamic model to capture the secondary currents associated with cross-channel differences in the vertical circulation. They suggest that the current report is for planning purposes. Once a design and location are further resolved, Smith et al (2017) suggest that a 3-D hydraulic model may be required. However, applying the more complex flow fields would only make sense in the context of evaluating more complex fish behaviors that respond to vertical flow characteristics.

Appropriate Behavior Responses

The simulations characterized fish movement using the B1 behavior only, in which fish drift with the flow in a 2-D velocity field. This behavior is typical of larger salmon smolts that are actively migrating, but it may not reflect behavior of smaller Chinook salmon that seek shallow, low velocity habitats (see Technical Appendix). The calibration of behavior was qualitative. As written in Smith et al. (2017), "The [fish trajectory] estimates were compared to the measured data, adjustments made to model parameters, and the model rerun until measured and computed values were similar." To fit the model to data two parameters were adjusted: lambda_xy affected speed through the reach and c_xy affected the spatial distribution across the reach.

The model calibration illustrated in Fig. 8 of Smith et al. (2017) demonstrates the fish distribution (Fig. 8A) being more dispersed than was found for the measured fish positions (Fig. 8B). This suggests, as noted by Blake et al (2017), that fish exhibit some cross channel behavior that moves them towards the outer bend of the river. This is the type of response the model is expected to generate with the B2 behavior; as the water accelerates in the river bend, the B2 behavior would move the fish into the higher velocity in the outer region of the bend. Correspondingly, closer to the bank the B3 behavior potentially could move the fish back into the channel. While the actual model response would be complex and not easy to describe, the point is that B2 and B3 behavior are likely to be important, especially in a notch configuration in which the acceleration/deceleration patterns within the fish sensory ovoid can be significantly different from what fish experienced in the river and over the Fremont Weir in its current condition. Importantly, depending on the acceleration fields at a notch entrance, fish might be entrained at rates greater than or less than the rate water enters the notch. It appears that the current calibration and analysis with the ELAM model may not fully exploit the capabilities of the full model for evaluating the characteristics of the alternative notch configurations.

However, the Panel also realizes that behaviors B2 and B3 may have been in the model, but not invoked because the default acceleration thresholds were too high (possibly because they were calibrated for dam passage?). However, the full set of model parameters, and in particular the acceleration thresholds (k_beta(2) and k_beta(3)) for B2 and B3 were not reported. Furthermore, it seems plausible that B2 and B3 behaviors would be infrequently invoked in the existing Fremont Weir environment. Thus, while the general spatial distribution of fish tracks appear to be reasonably represented with B1, it is plausible that B2 and B3 are important during notch approach and boundary avoidance. Furthermore, it is plausible that a dominance of B2 behaviors will produce notch attraction while B3 produces notch rejection. Such patterns might then depend on the relationship of fish size to the acceleration thresholds that trigger the behaviors such that entrainment and rejection patterns would vary with fish size.

Model Effectiveness
The model evaluates both notch configurations and locations. When the calibration issues of the hydrodynamic and behavioral components of the model are resolved it is likely to be an effective tool for evaluating notch design. However, the model may not represent small Chinook salmon if smaller fish do not behave similarly to the fish modeled in the report. See Section 2.6 for a discussion of habitat selection by small Chinook salmon.

Model Integration and Documentation
Significant integration of the ELAM model with the Streakline tool had not yet occurred at the time of this review. While the Panel understands that the compressed schedule did not allow integration of the ELAM and Streakline projects, the Panel highly recommends that both groups integrate approaches and data to collaborate in providing guidance in finalizing the notch design, implementation and future monitoring. The model conclusions were generally comprehensive and useful. The general summary of findings notes that larger notch flows entrain more fish, but not proportionally with flow; western side notches entrain more fish than other locations, and intake entrained more fish than shelf configurations. The model persistently predicted entrainment levels below 5% for stages below 25 ft. These conclusions are particularly useful when considered in the concert with those of the Streakline analysis (Blake et al. 2017).
The presentation and discussion of results was limited and did not illustrate fully or support the general conclusions. The report also did not illustrate the character of fish responses to notches; for example paths and behavior modes of fish approaching and entering a notch. Such trajectory/behavior maps in Figure 4 of Goodwin, Politano et al. (2014) were instructive in

revealing the factors underlying fish trajectories at dams. Such maps are likely to be useful for designing and understanding fish behavior to notches and during downstream passage

Critical Uncertainties

The acceleration thresholds for behavior transitions and their dependence on fish size are critical uncertainties in the model. If size-dependent differences in thresholds exist, conditions that entrain one size of fish could repel fish of another size. From the information in the report it was not possible to assess the threshold levels or if they would be induced in notch passage. These uncertainties were noted in the report but no solutions to resolve them were discussed. Additionally, the cross-channel distribution of small Chinook salmon (30-90 mm) was not evaluated because these fish are too small to receive acoustic tags. In other watersheds, smaller Chinook salmon often inhabit shallow, low velocity habitat along the inside of river bends. If this behavior occurs in the lower Sacramento River, then entrainment of small fish may be less than expected based on the results of this ELAM evaluation (see Technical Appendix on cross channel distribution of juvenile Chinook salmon).

Recommendation

The ELAM model could be more extensively calibrated so that effects of the parameters (e.g. acceleration thresholds) on deviations between the observed and model simulated fish trajectory are identified. One step in an expanded calibration might include a sensitivity analysis showing the effects of the acceleration threshold parameters on the cross-channel fish distributions and entrainment efficiencies. To gain further insight into the differences between alternative notches it would be useful to characterize the spatial/temporal distributions of behavior transitions (B1 B2 and B3) for the different alternatives and locations.

<u>Cross channel distribution of Juvenile Chinook salmon</u>

In both the Streakline and ELAM models a key factor influencing the number and size of juvenile Chinook salmon entrained into the Yolo Bypass via a notch is the cross channel distribution of the fish. This issue is well-recognized by the investigators and detailed cross channel distribution measurements were taken from acoustically-tagged fish in 2015 (low flow, winter-run and late fall-run Chinook; Steel et al. 2017) and 2016 (higher flows, late fall-run Chinook, Blake et al. 2017). The detail and resolution of these fish distributions is excellent; however, the distributions represent relatively large juvenile Chinook salmon that may not represent the distribution of smaller salmon. In 2015, the tagged fish size averaged 145 mm (late fall run range: ~98-180 mm) and 103 mm (winter run range: 98-125 mm). The tagged fish distribution reportedly followed the centerline regardless of discharge (Smith et al. 2017) or skewed slightly toward the outside bend (Steel et al. 2017). The cross channel distributions of the two salmon runs and two size classes of fish were generally similar but winter-run salmon tended to be distributed toward the outside river bend. In 2016, the average size of tagged Chinook salmon was 165 mm and these fish were distributed toward the outside of the river bend, a distribution that might enhance entrainment into a notch created along the outside bend (Blake et al. 2017). The 2015 fish telemetry data were used in the ELAM model, whereas the 2016 data were used in the Critical Streakline model.

Information about the cross channel distribution of small salmon is important when designing the notch configuration because entrainment into Yolo Bypass is likely to be most beneficial for smaller Chinook salmon that rear in floodplain habitats for extended periods, as described in the Salmon Benefits Model and other studies (Perry et al. 2016, Schroeder et al. 2016). No information was presented by any investigators on the cross channel or depth distribution of small Chinook salmon (30–95 mm) in the lower Sacramento River, although the investigators recognized that distribution and behavior of small salmon may differ from that of the larger tagged salmon and this may influence entrainment. Smith et al. (2017) state that:

> "USACE studies suggest very limited numbers of fry size salmon near the banks. Susceptibility of fry size salmon to a notch may be greater than smolts or, if fry size fish are migrating similarly to parr and smolts then entrainment estimates may correspond to results in this study."

Detailed information about these USACE studies, such as time, location and sampling gear type, was not provided in the reports, although electrofishing was identified as the gear type at the public meeting. Other studies show that electrofishing can be less efficient at capturing small wild Chinook salmon compared with beach seine (Friesen et al. 2007).

These smaller fish are important to runs of Chinook salmon in the Central Valley. For example, Miller et al. (2010) reported that 20% of fall Chinook salmon sampled in the ocean fishery had migrated as fry (<55 mm), 48% as parr (56-75 mm), and 32% as smolts (>75 mm), based on otolith analyses. Simenstad et al. (2017) examined USFWS beach seine data at Chipps Island (i.e., shallow estuarine habitat below Yolo Bypass) and reported that 51% of winter-run Chinook Salmon (549 fish sampled) were 35-70 mm long and 74% of spring-run Chinook salmon (1233 fish sampled) were 31-70 mm long. USFWS beach seine sampling in the lower Sacramento River (Oct-May, 2012-2016) yielded 20,800 Chinook salmon averaging 46 mm (mostly fall run); only 43 Chinook salmon exceeding 100 mm were captured in the nearshore areas (https://www.fws.gov/lodi/juvenile_fish_monitoring_program/jfmp_index.htm).

Smaller juvenile Chinook salmon (~30-70 mm) typically seek and rear in shallow, low velocity habitats, whereas larger fish exhibit smolt behavior and often migrate downstream in higher velocities near the deepest portion of the river. For example, in the lower Willamette River, Friesen et al. (2007) reported that nearshore, shallow beaches were an important habitat for small subyearling Chinook salmon, whereas larger Chinook salmon (>100 mm) were evenly distributed across the mid-channel area. Few small Chinook salmon were captured by electrofishing compared with beach seining. They noted that electrofishing primarily captured larger Chinook salmon (a common pattern) that were hatchery salmon and distributed farther offshore compared with the smaller (<100 mm) unmarked salmon (mostly natural) that were captured primarily by beach seine. These findings about habitat use by small Chinook salmon are supported by other observations, including those of Panel members, that indicate small juvenile Chinook salmon are often associated with the shallow, low velocity water along the inside of river bends rather than at mid-channel or along the outside of bends where velocity and depth is greater (Schroeder et al. 2013, 2016, van Remoortere 2014, S. Gregory, OSU, personal communication (Sept 18, 2017)).

2.5 Juvenile Salmon Benefits Model (SBM)

Introduction

The Yolo Bypass Salmon Benefits Model (SBM) (Hinkelman et al. 2017) was developed as a means to evaluate potential benefits to Chinook salmon of six alternatives related to improving juvenile salmon entrainment and rearing in the Yolo Bypass area and subsequent survival at sea. This tool is being used to evaluate alternative notch performance with respect to RPA Action I.6, to restore floodplain-rearing habitat through the increase of seasonal inundation within the lower Sacramento River.

The SBM is a mechanistic, deterministic simulation model used to evaluate juvenile salmon growth, survival, variability in size and timing of ocean entry, and subsequent adult returns from juveniles passing through Yolo Bypass versus migration through the mainstem Sacramento River. The SBM is a production model rather than a life cycle model in that it estimates adult returns from a scenario but it does not use these adults to begin the next generation. Rather, the model starts with observed escapement of Chinook salmon by race (spring-run, fall-run, late-fall-run, winter-run, 1997-2011), calculates juveniles produced by the spawning escapement based on simple egg to fry relationships, then applies these juvenile abundance values to daily proportions of Chinook salmon by race estimated at the Knights Landing rotary screw trap (11 km above Fremont Weir). The daily proportion of juvenile Chinook salmon at Knights Landing entrained into Yolo Bypass is assumed equal to the proportion of Sacramento River water entering the Yolo Bypass that day for each alternative as predicted by the JEET model of entrainment (see preceding Section on JEET).

Juvenile salmon entering Yolo Bypass are assumed to stop migration and rear when suitable habitat is available in inundated areas adjacent to the Yolo Canal Complex, then resume migration depending on size, temperature, density of juveniles, and date. In contrast, fish remaining in the mainstem Sacramento River are assumed to continually to migrate through the lower river without stopping to rear. Survival and migration rates are based on empirical estimates of large hatchery tagged juvenile salmon passing through Yolo Bypass and the mainstem Sacramento River during 2012, 2013, and 2016. Modeled survival in Yolo Bypass is dependent on time in the floodplain (assumed daily survival rate: 0.99) and extended rearing leads to higher mortality, whereas survival in the mainstem Sacramento River appears to be linked to one of the three years of survival measurement (no change in rearing or migration time). Modeled rearing and growth of salmon along the Yolo Bypass floodplain leads to greater size when the fish reach Chipps Island compared with similar sized fish that remained in the mainstem Sacramento River and migrated without rearing. Survival at sea is based on an empirical relationship between salmon size when released into San Francisco Bay and subsequent return of adult salmon (tagged hatchery fall-run Chinook salmon, 1978-2011).

The survival benefit estimated by the SBM primarily reflects a trade-off between the risk of mortality by rearing for an extended period in Yolo Bypass to gain greater size versus the benefit of greater survival at sea associated with extended rearing and growth in Yolo Bypass. This tradeoff provides an important framework for evaluating benefits of habitat restoration in the lower river. However, the assumptions of the modeled functional relationships are critical, and empirical data are limited. The SBM is the only model reviewed by the Panel that attempts to evaluate the benefit of the six alternatives to juvenile Chinook salmon.

Model Appropriateness

The SBM is appropriate for highlighting the tradeoffs between rearing benefits and mortality risk in Yolo Bypass versus reduced mortality at sea associated with greater smolt size of fish that reared in Yolo Bypass. The model is also appropriate for evaluating potential relative benefits to each run of Chinook salmon in relation to the body size and migration timing of each run. The model assumes fish entrainment is proportional to flow, such that fish outcomes are directly linked to entrainment flows associated with each alternative. The model does not attempt to address unique characteristics of each alternative, such as location or configuration of the notch, or effects of fish size on their behavior. It is important for readers and policymakers to recognize that the outcomes of SBM depend upon the assumptions of the functional relationships that drive the model. Data are limited for many of the functional relationships, therefore the investigators conducted a sensitivity analysis to evaluate the effect of some key assumptions, such as daily survival of salmon rearing in Yolo Bypass. The investigators appropriately discussed a number of model assumptions and limitations.

The model has three submodels: an arrival submodel generating the size and arrival timing of fish to Fremont Weir, an entrainment submodel describing entrainment based on flow entering Yolo Bypass, and a survival submodel describing adult survival based on the tradeoff between mortality and growth in the floodplain vs. length-dependent survival in the ocean.

The arrival submodel is unique in that it is the only one reviewed that addresses arrival time, size of salmon, and race of Chinook salmon, based on data collected at Knights Landing. Size is important to characterize survival in the floodplain.

Salmon size is key to behavior of fish approaching and entering the notch, but neither this model nor any of the other models directly considered salmon size and behavior at the notch.
The entrainment submodel describes entrainment as a function of flow and does not differentiate well between alternatives other than indicating that more flow (Alt06) should pass more fish into Yolo Bypass. The submodel is likely not sufficient for determining the location and configuration of a notch in the weir. The model assumes entrainment is independent of size of Chinook salmon (see discussion of cross channel distribution of juvenile Chinook salmon in Technical Appendix). This submodel could be enhanced if integrated with the ELAM or Streakline entrainment models.

The survival submodel is unique and important because it is the only one evaluating benefits of floodplain vs. river passage in terms of adult returns. The submodel reasonably characterizes the general relationships between residence time, and growth and mortality in the floodplain and ocean. The model has five critical parameters: floodplain residence time, growth rate, migration survival, rearing mortality rate, size-dependent ocean mortality rate. These parameters interact multiplicatively so they have equal importance in determining benefits (Eq. 1). Comments on these elements follow.

- Floodplain residence time (T) – Extended residence time in Yolo Bypass depends on temperature (<20°C in the Toe Drain), fish length (<120 mm), availability of habitat, and a day of year exit time. These factors have been observed to some extent, but may vary by run type. Fish greater than 120 mm are assumed to migrate rather than rear along the floodplain. Missing from the residence time calculation is the contribution of flow through the weir notch. This term may be important and provide additional criteria for determining notch size and operation schedule. Residence time (migration rate) among fish remaining in the mainstem Sacramento River was assumed not to affect survival per kilometer of river travelled.
- Growth rate (g) – Growth rate is set from studies. A power function form is applied, which may potentially overestimate the rate. The key assumption of this model is that fish of all sizes grow by the same proportion in a day, such that larger fish will increase their size by a greater absolute amount. This simple relationship is assumed because more detailed information is apparently not available in the Yolo Bypass. Not included in the SBM model is the effect of forage base, salmon density, and temperature on growth. These factors change with season and with flooded area. While the floodplain area and fish territory requirements are calculated it is not clear from the documentation how or if they relate to growth rate.
- Migration survival (S_{km}) – Migration survival is measured with three years of data and applied according to water year. This survival is applied to large migratory salmon (>120 mm) and is assumed independent of the migration rates in the river and floodplain.

- Rearing mortality rate (*r*) – This rate is not measured and it is unclear from the model if migration-phase mortality rate, which has been estimated, is replaced by *r* or whether both rates are applied in the floodplain. In either case, this is a critical determinant of floodplain rearing benefit. The model simply assumes that salmon <120 mm experience a daily survival of 0.99 while rearing on the floodplain, such that smaller fish that rear longer experience lower survival. This rate may depend on amount of water flowing through the floodplain and many other factors but these complex relationships are not easily measured or included in the model. Avian predation is expected to be important in rearing mortality and should be highlighted since additional habitat actions in the Yolo Bypass may reduce this source of mortality.
- Ocean mortality rate (*k*) – The mortality rate expresses the effect of fish length on adult returns and is generated from a logit function applied to tagged hatchery fall-run Chinook salmon released into San Francisco Bay, 1978-2011. Under the parameter range explored, the function is equivalent to an exponential function, which simplifies the representation of how the processes interact (see Eq. 1 below). The function assumes ocean survival is only determined by fish size when entering San Francisco Bay. It does not address stock specific factors, date when fish enter the ocean, and the year-to-year variability in ocean survival. These factors are less known but are important for assessing the benefits of floodplain vs. river passage routes. Recent research on factors affecting the survival of central California Chinook salmon could be examined as a means to refine the survival relationship (e.g., Wells et al. 2012, 2016). This information would be especially important if there is an interaction between smolt size and ocean conditions, such that the size/survival relationship changes with ocean conditions.

The SBM is a deterministic model that does not yet incorporate variability and uncertainty associated with parameters in the simulations. For example, mean length of juvenile Chinook salmon by date and run was estimated from Knights Landing data for input into the model; the high degree of salmon size variability was not utilized (see Fig. 4 in the SBM report). Also, mean survival at sea in relation to smolt size was used rather than attempting to incorporate the great variability in the size/survival relationship shown in Fig. 7 in the SBM report. This means that the precision of predicted benefits associated with each alternative is much lower than that expressed in summary Figures 8-12 of the SBM report, which provide error bars stemming from 15 years of mean estimates. The investigators noted that future versions of the model could incorporate variability and uncertainty. More specifically, given the non-linearity of the function, it is highly sensitive to small changes in smolt size though the underlying data are not highly determined (i.e., high variance). As such, the model would benefit from exploring the sensitivity of the function with respect to the envelope of confidence of the fitted function (e.g., upper and lower bounds, or quartiles of fit) to provide a greater sense of uncertainty in the SBM.

The SBM model was also used to examine diversity by examining variability in size when juveniles enter the estuary and the timing at which juveniles enter the estuary. Such diversity can be important to stabilizing overall production of Chinook salmon (Schroeder et al. 2016). Creation of the large floodplain-rearing habitat supports growth of smaller juvenile Chinook and contributed to maintenance of life history diversity.

Model Effectiveness
The model is effective and useful in capturing the timing of entrainment of each run of juvenile Chinook salmon because it relies on 15 years of data collected at the Knights Landing rotary screw trap. This long-term monitoring effort has been very beneficial. There may be some error associated with identification of fish by run, but this error is likely small compared with other relationships or uncertainties in the model. Mean size of entrained salmon by date of migration is empirically derived from long-term monitoring, but the model has not yet attempted to incorporate variability in fish size on growth and mortality.

Model survival and migration rates are based on empirical estimates of large acoustically-tagged late-fall run juvenile salmon passing through Yolo Bypass and the mainstem Sacramento River during 2012, 2013, and 2016. The investigators linked values from these three years to other years, based on a statistical comparison (Euclidian distance) of seasonal hydrology among the years. This is a simple approach for expanding the modeled dataset to 15 years. Values from these three years therefore have a significant effect on model outcomes. Values from 2016 were unique: fast migration rates and higher survival in both routes. Migration rates (km/day) were slower and survival rates (per kilometer) were lower in Yolo Bypass than the mainstem Sacramento River. Importantly, these critical values were based on large juvenile salmon, which would benefit less from passage through Yolo Bypass compared with smaller salmon that would rear in the lower velocity, shallower floodplain habitat. Ideally, survival and migration rates would be based on information from smaller individuals. In response to the lack of empirical data, the model assumed a daily survival of 0.99 per day for fish rearing in Yolo Bypass and developed functional relationships to estimate potential rearing time based on several factors. These assumptions have a significant effect on model outcomes, i.e., survival when passing through Yolo Bypass and abundance of adult returns.

Survival of fish remaining in the mainstem Sacramento River appears to be based on the survival values derived from tagging large salmon in 2012, 2013, and 2016. Potential changes in survival of Chinook salmon remaining in the mainstem after water diversion into Yolo Bypass do not appear to be considered, apparently as a means to focus on changes in Yolo Bypass rather than on the overall population of Chinook salmon. Peak flows into Yolo Bypass occur when flows in the Sacramento River are extremely high and this spillage may have less effect on salmon remaining in the mainstem. But diversion of more moderate flows may have some effect on migration time, growth, and survival of salmon remaining in the mainstem Sacramento River (Perry et al. 2016).

The SBM model considers density dependence by incorporating a functional relationship involving territory size of salmon in the Yolo Bypass. Density dependence is an important factor affecting juvenile salmon growth, emigration, and survival, even in depleted populations (ISAB 2015). Passage of Chinook salmon into Yolo Bypass could have mixed effects on growth of the juvenile salmon passing through the mainstem. To further address this issue, the report could present graphs for each run of Chinook salmon showing residence time and growth of salmon in Yolo Bypass and the frequency at which capacity of habitat was reached in each location of the Yolo Bypass. At the public meeting, the investigators mentioned that capacity was rarely reached, a finding that was not clearly presented in the report. This finding, while considering uncertainty of model assumptions, is important because it supports the concept of trying to maximize entrainment of juvenile salmon relative to water.

Model Integration and Documentation

The model documentation, selection of submodel forms, and implementation of the model in NetLogo limited the transparency. The elements and properties of the model could have been improved by casting the model in an analytical form as illustrated below. An analytical representation illustrates the interactions and sensitivity of parameters and highlights both model properties and how the parameters might relate to possible future actions. For example, Eq. 1 below illustrates the tradeoff of growth vs. mortality rate and Figure 2 below illustrates how the rearing mortality rate affects the benefits of floodplain passage relative to river passage.

The model presents a number of metrics, many of which may be valuable for assessing dynamics of Chinook salmon on the floodplain, but they are not particularly useful for selecting between alternative notch configurations. Figure 12 of the SBM report contains useful information on relative change in adults (each alternative versus existing conditions) and synthesizes entrainment, floodplain rearing, and the survival submodels. Thus, relative change involves a mixed measure, which does not partition the individual effects. This measure might be problematic since the entrainment model is limited. By producing a benefits measure (e.g. Eq. 1) the survival submodel of SBM can be integrated with the other entrainment models. Additionally, as noted in the report, the model can be readily updated with new information and additional functional relationships, if desired.

Uncertainties in the other key model parameters (see model discussion below) are not well explored. It is unlikely that the uncertainties can be readily resolved. Effects of freshwater experience on saltwater survival are difficult to quantify and are an active area of research. However, an expanded discussion and further analysis of the uncertainties in how freshwater factors affect ocean survival is important. These carryover effects of experience in one environment on mortality in the next is an active topic in the ecological literature. The important point is that floodplain passage may not be beneficial for all runs and in all years. For example, the model indicates large late-fall Chinook salmon do not have an overall survival advantage because they are entrained into the Bypass at a large size and do not benefit from growth (Figure 12 in Hinkelman et al. 2017)).

Analytical Form of Mortality Submodel

The following analytical form of a mortality submodel highlights the Panel's reading of the SBM properties and parameters. In this example, growth and ocean mortality equations are simplified, expressing growth as linear and ocean survival as exponential with length. The Panel suggests these simplifications result in no difference in the model results while simplifying the presentation. In the example, carrying capacity is assumed not limiting.

- River passage survival: $P_{river} = 0.44$
- Yolo passage survival: $P_{yolo} = 0.39$
- Yolo rearing survival: $R_{yolo} = \exp(-rT)$ with r survival rate and T floodplain residence time
- Fish length exiting floodplain: $L = L_0 + gT$ with g growth rate and L_0 length entering floodplain
- Ocean survival: $O_j = O_0 \exp(kL_j)$ for passage route j with O_0 base ocean survival and k incremental length benefit on survival
- The adult survival A_j from juvenile Fremont Weir passage to the adult returns to the river for passage route j: $A_j = P_j R_j O_j$
- Benefit of Yolo passage: $B = \dfrac{P_{yolo} R_{yolo} O_{yolo}}{P_{river} O_{river}}$ signifies relative increase of fish survival if entrained into Yolo Bypass compared to continuing in river

The net benefit B of Yolo passage vs. river passage is defined as the ratio of adult returns from fish reaching the Fremont weir as

$$B = \frac{P_{yolo}}{P_{river}} \times \frac{\exp(-rT)}{1} \times \frac{O_0 \exp\left(k\left(L_0 + gT\right)\right)}{O_0 \exp(kL_0)} = C \exp\left(\left(kg - r\right)T\right)$$

where $C = P_{yolo} / P_{river}$.

The benefit of yolo passage then depends on whether $kg > r$. Figure 2 (below) illustrates the nature of the benefit with residence time T using estimates from Hinkelman et al. (2017) with k = 0.025 (mm^{-1}), g = 1 ($mm\ d^{-1}$), $C = S_{yolo} / S_{river} = 0.88$ and r = 0.01, which equates to a one day survival of 0.99. The figure illustrates two important properties of the SBM. First, floodplain residence is only beneficial when $kg > r$, which simply states that the rate of gain in ocean survival from floodplain growth must exceed the mortality rate on the floodplain. Second, because Yolo migration survival is lower than in the river migration survival, i.e. $C < 1$, the fish must remain on the floodplain for a critical time length of time, perhaps a few weeks if the mortality rate is high.

The properties of Eq. 1 are essentially equivalent to the SBM survival dynamics and express the benefits of the Yolo Bypass and the importance of the effects of the important parameters k, g, r and T.

The total relative benefit (TB) of Yolo entrainment for an entire run can be expressed

$$TB = \frac{fA_{yolo} + (1-f)A_{river}}{A_{River}} = f(B-1)+1$$

where f is the fraction of Knights Landing fish entrained into Yolo Bypass. The terms can represent either at annual or daily averages for a specific run. The f term could be supplied by other entrainment models or the flow proportion model used in the report and by CDWR.

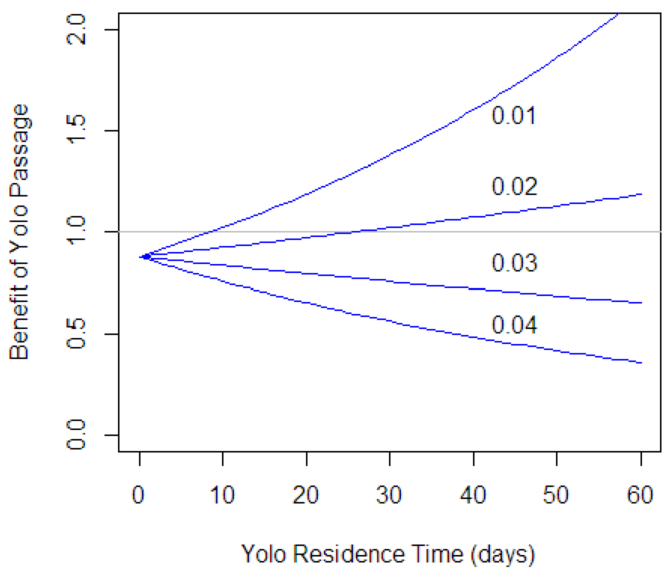

FIGURE 2. Relationship of Yolo passage benefits as a function of floodplain residence time and mortality rate r in 0.01 to 0.04 day^{-1}. Based on Eq. 1 using parameters extracted from the SBM (Hinkelman et al. 2017).

2.6 Adult Fish Passage (YBPASS)

Introduction

The goal of the adult salmon and sturgeon passage tool (YBPASS) is to:

> *"use modeled water depths and velocities to determine the frequency that adult fish passage criteria are met for planned facilities at the Fremont Weir."*

This effort supports Reasonable and Prudent Alternative (RPA) Action I.7 to improve fish passage through the Yolo Bypass and several studies that indicate that hydrologic connectivity is a major bottleneck for successful migration (e.g., Sommer et al. 2014). The YBPASS Tool was developed to evaluate six alternatives considered by the EIS/EIR for the Yolo Bypass Project. The species of interest are winter-run and spring-run Chinook salmon, steelhead, and green sturgeon, all of which are protected under the Endangered Species Act.

The fish passage tool compares modeled hydraulics (using a one dimensional HEC-RAS model) with fish passage criteria (velocity, depth, channel width, and channel length) that were established by the project team to maximize the probability of successful passage by all target species. The YBPASS Tool report is the only analysis examined by the Panel that evaluates upstream passage of salmon, steelhead and sturgeon. Currently, passage by these fishes is blocked or significantly constrained for a majority of flow conditions (Sommer et al. 2014).

Model Appropriateness

Salmon

The report states that the adult fish passage criteria used in this analysis are conservative because they want to ensure safe passage by the "weaker swimming fish" of each species. This approach could potentially mislead decision makers because the criteria are too conservative for all species. For example, the report states that fish passage criteria are met only 18% to 23% of the days depending on the alternative, implying significant adult migration constraints for all species. Passage criteria were primarily applied to the species most limited by migration conditions (large bodied acipenserids), rather than to individual species with better swimming performance. This all-in-one approach limited the evaluation of passage conditions for each species, which is necessary to develop engineering solutions for safe fish passage. In other words, if the passage constraints (i.e., velocity, depth) were relaxed, it is highly likely that the performance metrics for salmonids would markedly improve.

Realistic fish passage criteria should be identified for each species and used with modeled hydraulics to evaluate passage for each species separately, depending on species-specific criteria and migration timing. This information can then be used to better design structures that would allow safe passage. For example, the minimum depth criterion of 3 ft (if channel is <60 ft long) or 5 ft (channel >60 ft) are much deeper than the minimum depth of one foot recommended by NMFS (2011) for salmonids. Failure to meet the 3-5 ft depth criteria was the primary factor causing overall passage criteria to not be met (failure on 106-111 days per season depending on alternative evaluated).

Steelhead and Chinook salmon have burst speeds (duration <15 s) of 13.7-26.5 ft/s and 10.8-22.4 ft/s, respectively (Aaserude and Orsborn 1985, Powers and Orsborn 1985). Prolonged swimming speeds (15 s to 200 min) are reported to be 4.6-13.7 ft/s and 3.4-10.8 ft/s for steelhead and

Chinook salmon, respectively. Burst and prolonged swimming speeds are influenced by many factors, as discussed by Powers and Orsborn (1985). The velocity criterion used in the YBPASS Tool are conservative but suitable if the velocity encountered by migrating salmon is 6 ft/s over a ~60 ft reach or 4 ft/s for a longer reach (~100-200 ft). The report should identify the distances that fish would encounter high velocities when passing through the transport channel and weir notch of each alternative; Table 3 in the report only shows channel widths associated with each alternative.

Holding and resting areas should be evaluated in conjunction with the duration of flows that inhibit migrations. Are there any structures in the transport channels that would block high velocities and provide holding and resting areas? Salmon and steelhead are good at holding in the river, then resuming migration when flow conditions improve. Periodic flows that support passage may lead to successful migration of most fish compared with a prolonged period of inhibitory flows. As noted in the report, temperature and oxygen content of the water should be considered since water quality can inhibit migration or cause mortality if severe.

Sturgeon

Although the model criteria were developed to be conservative (i.e., specific to green sturgeon, using white sturgeon as a proxy, which is both larger-bodied and lesser in swimming ability than other targeted taxa), the model report and the supporting information provide insufficient information to determine the validity of the parameters used to accommodate acipenserids. For example, the underlying basis for the model report is a Department of Water Resources report (DWR, 2017b). In this report, the underlying scientific basis for coming to conclusions about passage design criteria are listed as FETT 2015 and FETT 2016. Upon further investigation, it has been concluded that FETT 2015 is an unpublished spreadsheet and FETT 2016 is an 8-slide presentation. The key bullets from FETT 2016 were from slide 4, which indicted that design parameters of minimum depth, width, and velocity were unknown (i.e, "?" or literally question marks), and the following bullet points: "Needed additional design guidance for sturgeon; Literature review for Sturgeon Passage; Sought input through Sturgeon Project Work Team." The subsequent slide had parameter values for depth, width, and velocity, but there was no indication as to how those values were determined. Reference is also made to Turek et al. (2016) about sturgeon design criteria, using shortnose and Atlantic acipenserid species as surrogates. In this case, depth and width parameters are well documented, but velocity is listed as unknown with yet additional surrogate species used to justify reported values. That said, based on first principles of body size of adult sturgeon, the design requirements make sense as a function of body length (and tail beat frequency, amplitude, etc). Furthermore, the maximum velocities are supported by the studies of Webber et al. (2007), who showed that sections of low velocity are needed for rest and recovery, and that maximum velocities of 4.5 ft/s (140 cm/s) are required for lake sturgeon (Peake et al. 1997) and pallid sturgeon (USFWS 2014) alike. At minimum, further evidence should be provided as to the design criteria developed by FETT.

Model Effectiveness

The fish passage model adequately considered the overall migration timing of each species. However, as stated in the report, passage of steelhead in October, winter-run and spring-run Chinook salmon in May, and sturgeon migration in May were not evaluated because flow conditions were considered too low during these periods. As noted above, the YBPASS tool should be used to evaluate passage of each species based on their unique migration timing, hydrology during the period of migration, and species-specific migration criteria.

Model Integration and Documentation

The YBPASS tool has a number of assumptions and limitations discussed in its documentation. In some cases the presentation of results are limited by the assumptions of the model (e.g., relaxed passage criteria for salmonids would result in different results). The HEC-RAS model used by YBPASS is a well-tested and expedient model to estimate flow velocities in the vicinity of this type of structure. The model is well documented and easy to apply without extensive model set up required. While this analysis only requires the difference in water surface between the Sacramento River and Yolo Bypass to estimate the velocity through the notch structure, some level of QA/QC may be warranted to address the potentially significant backwater effects due to Sutter Bypass (described in Section 2.1 above). For consistency it would be worth evaluating if the number of days the passage criteria is met would vary significantly due to the complex stage discharge relationship revealed by the recent 2017 study.

The report recognized that the passage criteria were conservative, leading to a large number of days when passage was inhibited. Nevertheless, as stated above, the report should use more realistic criteria for each species. This may facilitate engineering solutions to improve passage for specific species and, given the significant differences between salmonids and acipenserids in swimming performance, separate passage solutions may be required. Designing to the lowest common denominator (i.e., *Acipenseridae*) results in overly conservative solutions for salmonids. While the Panel recognizes that resource agencies are limited in approach by regulatory requirements, more flexible solutions for ensuring adult passage of various species are possible.

Further, it is the understanding of the Panel that several adult passage solutions are currently under consideration in Yolo Bypass. These analyses, including those in the YBPASS effort, should be integrated to include the Wallace Weir improvement activity and other passage efforts, such as the Ag Crossing 2, 3, and 4. In other words, assessing Fremont Weir passage in isolation may not yield sufficient benefits if other locations remain problematic.

Other points of consideration are also warranted. One, the report itself does not present the details of the model domain or the suite of results typically available from HEC-RAS so it is difficult to assess efficacy of summary statistics. Two, the summary statistics lack sufficient detail to determine the reasonableness of the negligible differences between alternatives. Three, the model assumptions, with respect to swimming performance and passage criteria cite a NMFS 2011 publication (pg. 3, 4), but the bibliography lists a NMFS 2009 proceeding. There are other issues with the model documentation; however, the Panel recognizes that this critical concern can be addressed in the detailed design phase. Further, passage is presented as one of many considerations, and therefore its findings or lack thereof are not critical to decision making. If this observation is incorrect, further work is needed to better articulate potential differences in water year type, alternative passage threshold criteria, and lower invert elevations.

Conclusion
If the central question is whether YBPASS Tool is adequate to differentiate between alternatives with respect to differences in infrastructural design, the answer is presumably yes. However, too few data are presented to conclude that actual differences do not exist (as the difference of 18-24% between alternatives of successfully meeting criteria is arguably within margin of error). The HEC-RAS modeling approach is generally appropriate and technically sound and thus the failure to show differences, real or not, is likely around the design specifications and passage criteria. Simple simulations and sensitivity analyses should be able to expose any deficiencies in design or criteria. These results were not presented, however, and thus it is difficult to assess the quantitative and qualitative uncertainty inherent to the results.

There are a range of structural and non-structural features that could be incorporated into a final design to reduce the average velocity across the proposed structure and provide refuge or resting areas.

2.7 Agricultural Economic Impacts (BPM)

Introduction
The Bypass Production Model forecasts the number of acres for each crop and agricultural production quantities. The model, developed by the authors with the underlying approach applied in many other contexts and venues, was created specifically for the Yolo Bypass region and results for each of over 450 parcels can be identified. Agricultural economic outcomes are measured in terms of farm net income and crop acreage. Project alternatives are compared to the ExConn/No Action Alternative and are evaluated using hydrologic conditions from 1997-2012. Differences between project alternatives are driven by the last day wet for each field, as projected by the TUFLOW model, which is a function of the different flow conditions implied by each project alternative.

Overall, the BPM is useful and appropriate for evaluating differences in agricultural production between project alternatives. The agricultural economic model is linked to physical conditions that are determined by hydrologic conditions in the Yolo Bypass (last day wet for each farm field) and projects relevant economic outcomes in an appropriate way. Weaknesses of the approach, as presented in the review materials, include the absence of any consideration of uncertainty and lack of documentation for some aspects of the modeling approach. Providing additional information on the relative magnitude of the effects of the project alternatives, the inter-annual variability of the projected impacts, and the spatial distribution of the impacts of each project alternative would make the results of the analysis more useful and easier to interpret.

Model Appropriateness

1. How appropriate are the models' spatial and temporal scales (i.e., periods simulated, duration of simulations, time step used) to compare performance of the alternatives?

The BPM is run at the appropriate spatial and temporal scale. The model is run to generate annual crop production and land allocation results, which is an appropriate way to compare alternatives. The BPM generates results based on conditions observed over a select set of test years, 1997-2012. It is unclear whether this set of years accurately characterizes the distribution of hydrologic conditions that can be expected over the life of the proposed project. Therefore, reported "average annual change" are only the average over the selected years, not necessarily the expected future change from baseline conditions.

The spatial resolution of the BPM is a strength of the modeling approach. Model output is at the field level, which allows for the identification of which fields are impacted by each alternative. Though the analysts reported these findings in their presentation to the review Panel, the differences in the spatial distribution of impacts between alternatives was not well-treated in the report. The Panel recommends that the final EIR/EIS contain a more detailed description of where the projected agricultural impacts occur within the Yolo Bypass. This information could be useful in identifying any disproportionate impacts (i.e., if only a few property owners have large impacts versus many property having small impacts) and possible mitigation measures.

2. How appropriate are the models for evaluating and discriminating among the alternatives?

The agricultural economic results are differentiated by the projected last day wet (LDW) on each parcel. The LDW varies according which project alternative is modeled. Therefore, the methods used are able to appropriately discriminate between alternatives. The LDW input to the BPM is output from the TUFLOW model.

3. Are the data used in the models sufficient to justify the assumptions, parameter estimates, and conclusions?

The only observed data used in analysis is field-level land use from 2005-2009. The remainder of the quantitative information in the BPM are model outputs (last day wet and crop yield) elicited qualitative judgments from farmers and extension agents (field preparation time and dry-down adjustment factor).

4. How well do the models explicitly incorporate variability and uncertainty associated with parameters in their simulations?

Some treatment of potential variability of the results is illustrated by presenting the impacts for individual years in a test period (1997-2012). While these results are useful in showing a few potential outcomes, the range of years may not reflect the true distribution of flows that can be expected in any given year. Therefore, labeling the "average" annual change in the results in somewhat misleading. This representation of the inter-annual variability is used in other analyses in the EIS/EIR as well, so it is not unique to the agricultural economic analysis. It is beyond the scope of this analysis to determine if the period of performance is representative under current or future hydrologic conditions, though the period does include some categorical wet and dry years.

Uncertainty in the model is not incorporated and all results are presented as point estimates only. Again, this non-treatment of model uncertainty is found in other analyses in the EIS/EIR as well, so it is not unique to the agricultural economic analysis. However, there are several sources of possible uncertainty that are present, but not treated, in the analysis. First is prediction error associated with the Positive Math Programming approach. PMP generates an optimized prediction of farmer behavior (acreage, crop mix, input use, etc.) using parameters from structural models derived from technical production relationships. The prediction model parameters are then calibrated by reproducing observed outcomes in a test year (in this case, average values from outcomes observed over 5 years 2005-2009). The calibrated model is then used to generate a forecast. Mathematical programming models do not estimate the standard error associated with such predictions and previous studies typically do not attempt to quantify them (e.g. Howitt et al 2012, included in the supplemental materials). It is, however, possible to generate estimates of this prediction error by doing sensitivity analysis. For example, in this case, there is observed data from 5 years (2005-2009). The model can be calibrated to each of the five observed years and then used to forecast each of the four remaining years in the data set. Each forecast could be compared to each set of observed outcomes to generate a prediction error. There would therefore be 20 "residual values" that could be used to describe the uncertainty associated with a typical forecast.

A second source of uncertainty is uncertainty in the input data. The differences between alternatives are driven by outputs from two models. The TUFLOW model gives the last wetted day on each parcel. TUFLOW output appears to be deterministic and the documentation for the agricultural economic analysis does not describe how results might be affected by uncertainty in this input to the BPM. The DAYCENT model gives a relationship between the loss in crop yield and the last wetted day value. The DAYCENT model is based on a statistical (regression) model and can provide estimates of uncertainty surrounding the yield-loss curve parameters. The agricultural economic analysis does not describe how uncertainty in yield loss estimates might affect the reported results.

Model Effectiveness
The model does not explicitly address issues related to fish distribution, timing, growth or survival and therefore was not evaluated as such.

Model Integration and Documentation
8. How appropriate is the model integration for evaluating and discriminating among the alternatives?

The agricultural economic results are differentiated by the projected last day wet (LDW) on each parcel. The LDW varies according to which project alternative is modeled. The LDW input to the agricultural economic model is based on outputs from the TUFLOW model. Implicit within this approach is that the range of alternatives within TUFLOW reflect the range of hydrologic conditions to be incurred into the future. Not included in this analysis are simulations of potential future hydrologic conditions with respect to wet to dry year dynamics. Further, it is also implicit that the differences between modeled alternatives against base case conditions are sufficiently precise to be used to discriminate between such alternatives. However, given that these differences are modest, it is difficult to tell if such quantitative differences are qualitatively different.

9. How well are the proposed analytical tools defined and discussed?

One shortcoming of the analysis, as presented, is that the most of the documentation for the models used in the agricultural economic analysis is contained in materials not included in review material, supplemental material, or background documents. For example, most of the analysis used in the EIR/EIS appendix I2 is developed in a consultant's report (Yolo County 2013). It is not clear whether the models and analysis in this report are peer-reviewed or not, but the review Panel did not review them.

11. Are the conclusions drawn justified by the model output?

The model outputs are straightforward differences between the projected base case and projected agricultural output and associated economic impacts for each project alternative. Implicit in this approach is that the base case is a reasonable representation, and that modeled differences are discernable. Given that the magnitude of change is modest, interpretation of model results should be used with caution as the projected differences may very well be within the margin of error, so to speak. Given that the model has no formal means of quantifying uncertainty, it is impossible to know if the results are or are not in fact within this margin. The documentation in Appendix I1 does not explicitly draw additional conclusions.

12. When models are integrated and/or linked, how well are assumptions and uncertainties accounted for and communicated?

Appendix I1 briefly acknowledges that the BPM model results are dependent on TUFLOW model outputs and therefore sensitive to assumptions in the TUFLOW model. However, the appendix does describe or discuss these assumptions or describe how they might affect the results. The documentation does not describe how assumptions and uncertainties in the DAYCENT crop yield model affect model results.

13. How well do the models characterize and convey uncertainties?

Discussion of uncertainties is absent from the documentation. All model inputs and outputs are treated as deterministic and no attempt is made to describe possible sources of variation in the results.

14. How clear are the presentation of results?

Overall, the results of the analysis are straightforward. These are the change in crop acreage and agricultural production value from a projected baseline to a projected outcome under each alternative.

The results are presented for each alternative in a relatively clear manner. Clarity would be improved with two minor revisions to the results. First, the results of the baseline scenario (i.e., the ExCon/NAA) should be summarized so that the magnitude of the effects of each project alternative can be conveyed. It may also be useful to report the percent change in each metric in Tables 7-12 (note that the tables currently include this percentage change only for NED Farm Income). It appears that the economic effects of all of the alternatives are quite small on average, but more information would help the reader evaluate this. Second, the tables should contain more information on the inter-annual variability of the results. Currently only the average of the 16 year simulation is reported in Tables 7-12. The maximum and minimum values should also be reported as well as results for a representative wet year and dry year. The two figures provided for each alternative are useful for interpreting this inter-annual variability, but the additional results in tabular form are needed. Third, a more detailed description of the spatial distribution of the projected agricultural impacts should be provided. This information, in the form of maps of projected impacts, was provided in the presentation to the review Panel and is useful in interpreting the scale of the results and informing possible mitigation measures.

3. Recommendations

It should be recognized that this body of scientific investigation represents a remarkably comprehensive assessment of options for a notch at Fremont Weir. This is very important since the success of the implemented notch will depend on a well-resolved understanding of the flow structure and fish behavior at and adjacent to the notch, as well as the ability to adaptively manage the notch and its operation as the uncertainties identified in this review are resolved. The main shortcoming of this evaluation effort is the lack of integration between different teams, primarily due to the diverse sources of information (not all directly focused on the EIR/EIS) and lack of time for synthesis. Due to these time constraints in the preparation of reporting, the full potential of the remarkably detailed field observations of hydraulics and juvenile salmon behavior with fine scale hydrodynamic modeling has yet to be realized. Since the models are developed and data is available, the Panel does not consider some additional integration work to be a major undertaking in terms of time or personnel effort compared to the investment to date.

3.1 Tool Specific Recommendations

Hydrodynamics Models

Simulating flows in the Sacramento River and Delta using hydrodynamic models is a very challenging problem, particularly at the fine scale required to assess the various proposed configurations of the modifications to Fremont Weir. The modeling completed to date has made major progress but could benefit by including data from the most recent field campaign conducted in support of the Critical Streakline evaluation. There are advantages in running different hydrodynamic models to address this challenging simulation problem, particularly when a very significant investment such as a notch in Fremont weir is being evaluated. The following recommendations should be considered for both near-term (i.e. prior to completion of the EIR/EIS) efforts in support of implementing the notch at Fremont Weir.

1. The hydrodynamic alteration of Fremont Weir to entrain fish into the Yolo Bypass. This requires close collaboration modeling and field measurements are critical to the evaluation of the potential effectiveness of the proposed between the field scientists and modelers. This integration would be an ideal demonstration of the '*Modeling Collaboratory*' concept proposed by Medellin-Azuara et al., 2017. The Panel believes that this could be conducted quickly and efficiently. The agencies may also wish to consider adding another hydrodynamic model – perhaps one that is already covering the region of interest (examples include TUFLOW, RMA-2, UNTRIM, or DELFT-3d). This recommendation does not imply that U^2RANS or SRH-2D are inadequate but rather it would allow the various model assumptions, closure relations and grids to be tested rigorously. This analysis should also explore the 'optimum location' of the weir as

predicted by the semi-empirical (Streakline) method of the USGS. This additional step is warranted for a project of this magnitude where the fine design details of location, alignment and size of the inlet could make the difference between project success and failure. Based on the findings of this integration of modeling and field measurements, the design team may wish to assess the value of a physical model of the immediate locale of the diversion structure to confirm the numerical model findings about diversion alignment and design details. This effort could also be used to quantify the uncertainty and expected variance in duration and water surface elevations at the selected notch diversion.

2. The Panel was not charged with selecting a preferred notch alternative. However, based on the comprehensive review of notch alternative analyses, the Panel recommends that the final design include flexibility to allow for future modifications of depth and width of the diversion (perhaps 2 or 3 gates at different crest elevations).

3. Fish behavior is very sensitive to the volume of flow being diverted. In addition, fish behavior is sensitive to flow discontinuities such as eddies and vortices as well as local strain and/or shear caused by flow discontinuities. The Panel disagrees with the conclusion that the 2-D hydrodynamic model is adequate, unless the fish are known to frequent close to the surface of the Sacramento River. It all depends on the question that is posed by the fish behavior and ELAM experts. If the fish are capable of dynamic responses to changes in the flow characteristics such as strain (or lateral shear), eddies or upwelling at the weir crest, the 3-D hydrodynamic model would be warranted. Based on the USGS analysis, the location of the diversion along the weir could be critically important if the desire is to maximize entrainment.

Salmon Benefits Model (SBM)

The SBM highlights the tradeoff between the reduction in survival while growing in Yolo Bypass versus the resulting increase in ocean survival as a result of entering the ocean at a larger size. Whether the tradeoff is beneficial depends on assumptions of the growth and survival rates in the two environments, which are based on limited data. This is an important concept for decision makers because it highlights the potential actions to improve growth and survival in Yolo Bypass and subsequent adult returns. Current models do not attempt to incorporate alternative scenarios, such as enhanced rearing habitat in Yolo Bypass, and the only parameter that currently differentiates potential outcomes is discharge through the Yolo Bypass. Additional scenarios, such as enhanced habitat actions that could occur in Yolo Bypass are not yet incorporated, but should be considered in an adaptive management framework to enhance growth and survival of salmon in the Yolo Bypass. For example, having the ability to simulate the effect of discharge volume on floodplain fish residence time or the effects of direct habitat enhancements, such as adding structure (e.g., large wood) and complexity (pools) on providing shelter to rearing juveniles from piscivorous fishes and birds, could quantify the resulting response in both higher growth rates and survivorship. The lack of model extensibility, in other words the incorporation of difference scenarios such as potential enhancements, do not preclude the model's use in its current state. Rather it is to say that more complex actions within an adaptive management framework would require a more complex and extensible model.

Adult Fish Passage (YBPASS)

The Panel suggests that the selection of fish passage alternatives be based primarily on the passage of juvenile salmonids rather than on adult passage, and secondarily sturgeon passage. The YBPASS tool, as presently configured and applied, does not readily discriminate between these alternatives. Since there is strength in the use of HEC-RAS to evaluate depth and velocity around finely resolved features, the Panel suggests that once an alternative is selected for juvenile salmonid passage, a more precise approach to evaluating alternative engineering solutions be developed to facilitate safe passage of each species at a given location. Habitat that supports holding and resting should be identified in Yolo Bypass.

Critical Streakline Analysis

The model provides valuable information on the complexity of flows and fish distributions in the western portion of the weir. The analysis did not address effects of notches for the central and eastern alternatives. The estimates of entrainment along a series of locations along the western weir are based on the assumption that the fish follow flow into a notch, independent of how the hydrodynamics might be altered by the notch presence. These assumption cannot be evaluated without either hydrodynamic modeling or observing the flow field after the notch is constructed. For these reasons, predictions from the existing Streakline model are of limited value for decision making on notch location and of less value for selecting a notch configuration.

ELAM

The model, in combining CFD and fish behavior models, predicts entrainment for specific notch locations and configurations. In principle, it is the most appropriate model for selecting a notch in the Fremont Weir. However, there several caveats to consider in using the model. Firstly, the boundary conditions for CFD simulations were not fully resolved resulting in some uncertainty in representing the flow field that fish would experience. Secondly, the model only characterized fish movement with the follow-the-flow behavior (i.e. B1). Given these caveats, it appears to the Panel that in its current calibration the ELAM model acts very much like the Streakline model except the fish and flow distributions were simulated, rather than observed.

In essence, it appears the two models currently apply the same behavior rules using different levels of detail. Streakline applies a simple B1-type behavior to observed data, ELAM applies a complex B1 behavior to simulated date. Because of the equivalence of algorithms, further development of the Streakline approach is not likely to improve on the existing ELAM model. However, parallel development of models of differing complexity can be of value especially if the developers collaborate in the process and compare results. The Panel recommends that the value of further development of either model depends on whether uncertainty on decisions of site location and notch configuration will be reduced significantly. The Panel's suggestions on this matter are elaborated in the Executive Summary. However, if the entrainment models are to be used to refine a notch design the Panel recommends that the ELAM model be improved in collaboration with the Streakline model team. In particular, first steps could involve collaboration in calibrating the existing CDF and further calibration of ELAM behavioral rules using available data from Sacramento River fish movement studies.

Additionally the Panel recommends further field sampling to clarify the behavior of small salmonids. The Panel notes that while all investigators recognized the uncertainty in entrainment related to salmon size and behavior, none directly addressed the issue of smaller Chinook salmon being concentrated along the inside bend in the lower Sacramento River. Smith et al. (2017) noted that USACE sampling found few small Chinook along the river nearshore, but the Panel understands that this sampling was conducted by electrofishing which may catch fewer smaller Chinook compared with the beach seine (Friesen et al. 2007). Details about this electrofishing effort were not presented. Small juvenile Chinook salmon have been captured by beach seine on the lower Sacramento River according to the USFWS beach seine surveys described in section 2.6. Given the importance of entraining smaller Chinook salmon into Yolo Bypass, the Panel recommends that field sampling occur along the inside of select river bends and that entrainment of small salmon be considered in a monitoring and an active adaptive management framework. Additionally, it may be prudent to consider engineering solutions that enhance entrainment of smaller Chinook salmon.

Materials Provided for Review

Cut and paste from: http://deltacouncil.ca.gov/yolo-bypass-salmon-habitat-restoration-and-fish-passage-analytical-tool-independent-scientific

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YOLO BYPASS SALMON BENEFITS MODEL:
MODELING THE BENEFITS OF YOLO BYPASS RESTORATION ACTIONS ON CHINOOK SALMON

Model Documentation, Alternatives Analysis, and Effects Analysis

Prepared for:

United States Bureau of Reclamation and California Department of Water Resources

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EXECUTIVE SUMMARY

The Yolo Bypass Salmonid Habitat Restoration and Fish Passage Draft Implementation Plan (Implementation Plan) was prepared to evaluate the potential to restore floodplain rearing habitat through increased seasonal inundation within the lower Sacramento River basin, and reduce migratory delays and loss of salmon, steelhead, and sturgeon, through the modification of Fremont Weir and other structures of the Yolo Bypass. Prior to Implementation Plan execution, potential benefits of restoration actions on all four CV Chinook salmon runs are to be evaluated quantitatively through a targeted modeling effort.

The Yolo Bypass Chinook Salmon Benefits Model (SBM) is a mechanistic, simulation model that quantifies potential benefits of Yolo Bypass restoration actions on CV Chinook salmon runs that spawn upstream of the Yolo Bypass. Four key benefit measurements were identified: juvenile (1) survival, (2) size, and (3) size variability (portfolio) at entrance to the Marine Environment (Chipps Island) and (4) adult returns (escapement). Using the SBM, we quantified lifestage-specific and cumulative impacts of restoration actions on each Chinook salmon run and compared the benefits identified for the runs under each of five Implementation Plan management alternatives against existing conditions.

Key Model Outcomes: Relative fork length variation shows high inter-annual variation, but consistently indicates a benefit from Alternative 6 relative to existing conditions. Alternative 6 provides access to the Yolo Bypass at lower flows than under existing conditions and, presumably, introduces variability in the accessibility of suitable rearing habitat for fish that, in turn, increases fork length variation at Chipps Island.

Under most scenarios and years, the alternative scenarios produce more returning adults than existing conditions (median annual relative percent change: 0.6-22.5%). The number of returning adults depends on both the number and size of juvenile salmon that arrive at Chipps Island because the ocean survival relationship is a function of size. The number of returning adults (returning adults metric) captures the trade-off between floodplain growth and rearing survival (fork length and juvenile survival metrics).

Key Management Implications: For both returning adults and fork length variation, Alternative 6 generated the biggest relative changes. This alternative has the largest notch and highest max design flows (12,000 cfs) of the modeled scenarios. For fork length variation, there is very little difference among the other alternatives. However, for returning adults, there are some years where Alternative 1 out-performed Alternatives 4, 4b, and 5 (e.g., 2001 for late-fall-run fish).

The largest relative changes in fork length variation at Sacramento-San Joaquin Delta exit and returning adults generally do not occur in the same years.

The Alternative 6 notch is beneficial under all effects examined for late-fall-run fish, which benefit greatly from entering the model at a large size. For the other runs, rearing survival is the key factor in determining the benefit of Alternative 6; at a value of 0.95, rearing survival on the floodplain is too low to yield a benefit to implementing the Alternative 6 notch. Because Alternative 6 exhibited the biggest differences in the Alternatives Analysis, we might expect that the other notches would not yield a benefit at a rearing survival of 0.95 or 0.97.

All of the effects examined have the potential to influence the Alternatives Analysis, but there is a particularly strong interactive effect of the rearing rule and rearing survival value. We suggest that both should be targets for additional investigations, but recognize the challenges in the design of such studies.

This includes studies of fall- and spring-run survival through the Yolo Bypass. A better understanding of survival on and carrying capacity of the Yolo Bypass are warranted.

BACKGROUND

Significant modifications have been made to California's Central Valley (CV) floodplains for mining, agriculture, urban development, and (more recently) water supply and flood control purposes. The resulting loss of floodplain rearing habitat, migration corridors, and food web production has significantly impacted native fish species whose life history strategies depend upon seasonally inundated habitat. The Yolo Bypass, which currently experiences at least some flooding in approximately 80% of years, still retains many characteristics of historic floodplain habitat that are favorable to a suite of fish species (CDWR 2012). In approximately 70% of years, the Fremont Weir overtops, joining flows from the Sacramento River with flows entering the Yolo Bypass from western tributaries (CDWR 2012).

Although the primary function of the Yolo Bypass is to provide flood control management for the surrounding metropolitan areas, the Yolo Bypass is also managed as mixed-use, providing land for both private agriculture and public recreation. In recent years, the Yolo Bypass has also been recognized as important rearing, spawning, and migratory habitat for numerous native fish species (CDWR 2012), accessed perennially through a narrow channel that spans the eastern edge of the Yolo Bypass. Studies in the region document favorable outcomes for ecosystem functions and desirable species assemblages as a result of targeted management action (Kiernan 2012, Jeffres et al. 2008, Sommer et al. 2001b). When combined with the Yolo Bypass's current role in successful, multi-faceted land uses, this suggests that the floodplain can support human demands without eliminating the processes needed to sustain aquatic species (Opperman et al. 2009). Thus, the Bypass is identified by several state and federal entities as a potential site for habitat restoration, with the goal of benefitting threatened and endangered fish species.

As part of the effort to evaluate the site for restoration, the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Draft Implementation Plan (Implementation Plan) was prepared jointly by the California Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (Reclamation) to address two specific Reasonable and Prudent Alternative (RPA) Actions set forth in the NMFS Operation Biological Opinion:

- RPA Action I.6.1: Restoration of floodplain rearing habitat, through the increase of seasonal inundation within the lower Sacramento River basin; and
- RPA Action I.7: Reduce migratory delays and loss of salmon, steelhead, and sturgeon, through the modification of Fremont Weir and other structures of the Yolo Bypass.

Prior to execution of the Implementation Plan, the potential benefits of restoration actions (via the Implementation Plan) on all four CV Chinook salmon runs will be evaluated quantitatively through a targeted modeling effort. The goals of this modeling effort are as follows:

- Create a mechanistic, simulation model to quantify and visualize the potential benefits of Yolo Bypass restoration actions on CV Chinook salmon runs that spawn upstream of the Yolo Bypass.
- Using the simulation model, quantify lifestage-specific and cumulative impacts of restoration actions on each Chinook salmon run.

- Conduct a comparison of the benefits identified for Chinook salmon runs under each Implementation Plan management alternative.

Study Species

In the CV, Chinook salmon evolved a range of diverse life history strategies (Williams 2006). This "portfolio effect" allowed them to combat the risk posed by highly variable environmental conditions (Carlson and Satterthwaite, 2011). Four distinct populations ("runs") of Central Valley Chinook are named for the timing of spawning adult migrations (fall, late-fall, winter, and spring), and are genetically distinguishable. Each run reflects genetically-based adaptations to seasonal conditions in the local environment. Through investment in this diverse portfolio, the species, as a whole, has enormous capacity for resilience and adaptation to local conditions (Carlson and Satterthwaite 2011; Hilborn 2003).

Apart from those runs that remain in freshwater and migrate the following year (as yearlings), most young CV salmon migrate to the ocean during the first few months following emergence. Juveniles may rear in floodplains, mainstem rivers, and/or estuaries for varying lengths of time before entering the ocean at an appropriate size for survival (between 80-170 mm FL, depending on the run). Chinook salmon spend 1-5 years in the ocean before returning to the river as spawning adults. These runs and the large populations they once supported (at least 1 to 2 million adults annually; Yoshiyama et al. 1998, 2000) reflect the diverse and productive habitats that historically existed within the region. Over the past 180 years anthropogenic effects—including mining, flood protection, power generation, water development, stream and floodplain conversion, water quality degradation, invasive species, harvest, and hatchery management—have stressed, altered, and depleted these resources (Yoshiyama et al. 1998, 2000; Williams 2006; Israel et al. 2011). Global parameters, such as ocean conditions, have also demonstrated a marked effect on adult escapement (Lindley et al. 2007, 2009). In the past 3 decades, the CV spring and winter runs were listed under the United States Endangered Species Act (ESA) of 1973. Habitat modification on nearly all major CV rivers has resulted in selective loss of habitats, which disproportionately affect certain life history components of each run (Carlson and Satterthwaite 2011; McClure et al. 2008; Lindley et al. 2007).

Study System

The Yolo Bypass Salmon Benefits Model (hereafter SBM) is comprised of the following key locations and systems (Figure 1).

Sacramento River: The mainstem Sacramento River is the primary migratory route for model fish through the system. In the model, the only place where fish can choose another route is at Fremont Weir.

Knights Landing: The location of a rotary screw trap on the Sacramento River and the point where fish enter the model.

Fremont Weir: A passive weir, located about 11 km downstream of Knights Landing, that serves as the primary location for flow to enter the Yolo Bypass from the Sacramento River during periods of high flows. The alternative management scenarios involve designing a notch in the Fremont Weir to increase flow management capabilities (see Modeled Scenarios). Model fish are only able to enter the Yolo Bypass via the Fremont Weir.

Verona: Location in Sacramento River, about 3 km downstream of Fremont Weir, where Sacramento River flow is modeled. Because the hydrodynamic properties of the system are complex at Fremont Weir, Sacramento River flow immediately above Fremont Weir is estimated partly based on the flow in the Sacramento River at Verona (see Entrainment).

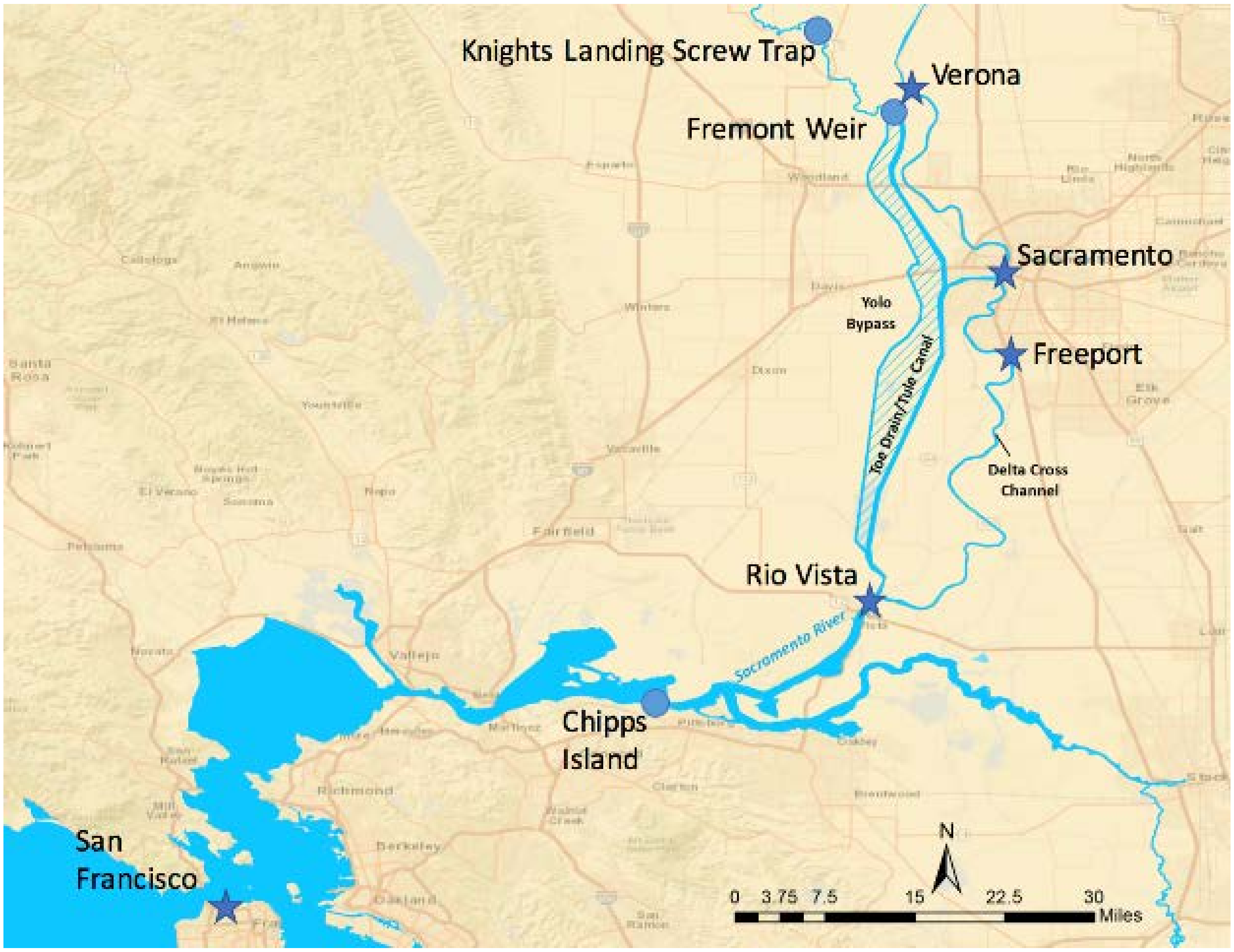

Figure 1. The spatial extent of the Salmon Benefits Model, which tracks Chinook salmon life history from emigrating juveniles to adult escapement, beginning in the mainstem Sacramento River just upstream of Fremont Weir at the location of the Knights Landing screw trap. Circles identify key locations relevant to model functions; stars represent cities.

Feather River: Flow from the Feather River enters the Sacramento River just upstream of Verona and is used in the estimation of flow in the Sacramento River above Fremont Weir (see Entrainment).

Canal Complex: The primary migratory pathway through the Yolo Bypass comprised of the Tule Canal and the Toe Drain. The Canal Complex is perennially watered and provides a passage route for juvenile salmon. The route through the Canal Complex is approximately 30 km shorter than staying in the Sacramento River.

Yolo Bypass: Throughout this document, Yolo Bypass is generally used inclusively to refer to the Canal Complex and the adjacent floodplain habitat.

Rio Vista: The approximate location of the confluence between the Canal Complex and the Sacramento River. Model fish that are in the Sacramento River continue migrating without any change in migration rate, growth rate, or survival. Model fish that are re-entering the Sacramento River from the Canal Complex continue migrating at the same rate, but grow at the Sacramento River rate and survive based on flows in the Sacramento River (with a time lag).

Modeling Approach

Unlike a life cycle model, where progeny from one brood year are allowed to influence outcomes of the next, the SBM takes a production model approach to simulation, where individual brood year-classes are tracked separately. The model simulates and tracks key stages of Chinook salmon life history, from the point of freshwater emigration (just upstream of the Yolo Bypass entrance) to the number of returning adults (escapement), and quantifies the potential life stage-specific and cumulative impacts of restoration actions on fish size and abundance. As a general modeling approach, simulation has been successfully applied to evaluate the effects of other restoration actions on CV Chinook salmon populations, including the following:

- The San Joaquin River Emigrating Salmonid Habitat Estimation (ESHE) model to quantify the rearing and emigration habitat needs of future restored populations of fall-run and spring-run Chinook salmon in the San Joaquin River as part of the San Joaquin River Restoration Program (SJRRP 2012).
- The Interactive Object-oriented Simulation (IOS) life cycle model (Zeug et al. 2012) to evaluate the effects of the NMFS alternative scenarios of Central Valley water operations on the life cycle and abundance trends of winter-run Chinook salmon.
- The Delta Passage Model (DPM) to evaluate the effects of Bay Delta Conservation Plan (BDCP) water scenarios on the Delta emigration survival of all Central Valley runs of Chinook salmon (BDCP 2013).

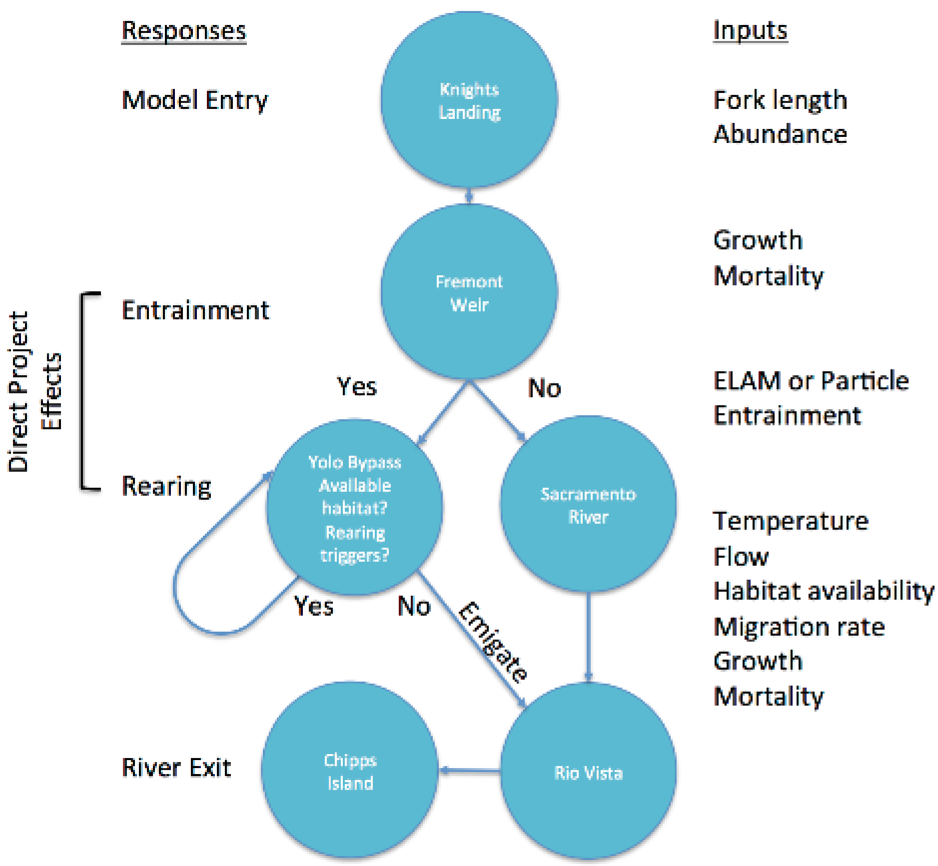

Figure 2. Conceptual overview of Salmon Benefits Model. The input parameters and relationship that affect model components are shown on the right. The potential responses of model fish are shown on the left. The

project effects of the alternative management scenarios directly affect the entrainment and rearing responses of model fish.

The SBM begins tracking juvenile Chinook salmon in the mainstem Sacramento River just upstream of Fremont Weir, at the location of the Knights Landing screw trap (Figure 1). The model runs on a daily time-step during the CV Chinook salmon juvenile emigration period, from October 2nd until all modeled fish have died or entered the Pacific Ocean, usually by June 30th of the following year. Although the Chinook salmon life cycle occurs over a 2 to 4-year period, the model only explicitly tracks the daily movement and abundance of Chinook salmon until ocean entry. Once modeled fish enter the ocean, the model instantaneously calculates ocean survival and upstream adult migration survival to estimate the number of returning adults. Importantly, the estimates of the number of returning adults for each brood year-class do not influence the number of juveniles entering the model in subsequent years. Finally, the model quantifies the effects of management alternatives on individual life stages to estimate the number of returning adults produced under each scenario (see Modeled Scenarios).

It is important to note that the SBM cannot predict all possible trajectories of Chinook salmon populations under the proposed management scenarios. Like all simulation models, it instead provides an experimental system in which the consequences of various sets of assumptions can be rigorously examined, and the range of outcomes for modeled scenarios can be compared (Peck 2004).

Modeled Scenarios

The SBM uses the output of the 2D hydrodynamic model TUFLOW (BMT WBM 2013) under existing conditions and five scenarios involving a notch in Fremont Weir (Table 1). The TUFLOW output includes daily raster files (cell size = 50x50') of depth and velocity over a 15-yr period (1997-2011) across the entire study area for each scenario. Depth and velocity data were aggregated to a coarser resolution (cell size = 300x300') to reduce computational demands of frequent loading of raster files in the SBM. The TUFLOW output also includes a 15-yr time series of flow overtopping Fremont Weir, flow through the notches in the alternative scenarios, Sacramento River flow at Verona, and Feather River flow entering the Sacramento River (just upstream of Verona). These time series are used to calculate entrainment into the Yolo Bypass (see Entrainment) and survival while migrating through the Sacramento River and Yolo Bypass (see Migrating).

Table 1. Description of scenarios evaluated with the Salmon Benefits Model. The alternative scenarios differ in the design of a notch in Fremont Weir. Alt02 and Alt03 were not provided for analysis in the Salmon Benefits Model.

Scenario	Description	Alignment	Design Flow (cfs)	Closure Date
Alt01	30' bottom width, 30' bench, no levee	East	6,000	March 15th
Alt04	60' bottom width, 30' bench, no levee, downstream water control structures	West	3,000	March 15th
Alt04b				March 7th
Alt05	Intake A & B: 80' bottom width; Intake C: 130' bottom width; Intake D: 142' bottom width	Central	3,900	March 15th
Alt06	200' bottom width	West	12,000	March 15th
Exg	Flow over existing weir	--	--	--

The extent of hydrological data available to the SBM is both an asset and limitation: the SBM is designed to leverage the hydrological data to capture the substantial intra- and inter-annual variation in entrainment, growth, and survival, allowing for a 'bottom-up' approach to modeling where model fish are able to respond to changing hydrological conditions. The downside of this approach is that running the SBM is a computationally intensive process. Thus, very little stochasticity is incorporated in model parameters and a detailed sensitivity analysis is intractable. However, running the model across 15 years provides considerable variation in model behavior and the effect of parameters (or model rules) on model outputs can be evaluated with more restricted simulation experiments (i.e., limited parameter combinations).

MODEL DOCUMENTATION

Modeling Platform

The SBM was developed in NetLogo, an integrated modeling environment that is a powerful tool for scientific modeling (Lytinen and Railsback 2012). NetLogo is free, open source, and cross platform. The highly readable syntax of the programming language, thorough documentation, and widgets for graphical-user-interface (GUI) elements allow for rapid prototyping of new models in NetLogo. The GUI elements allow users to explore the effects of changing parameters on model behavior without any programming experience.

Model Components

Model Entry

Initial Abundance

To determine the initial abundances of juveniles of each Chinook salmon run entering the model, we converted historical spawner abundance estimates from each water year (California Department of Fish and Wildlife GrandTab database) to juvenile emigrants, using Chinook salmon populations that spawn upstream of Fremont Weir in the Sacramento River Basin (Table 2). We achieved this first by converting spawner abundance to number of female spawners, assuming a sex ratio of 0.5. Next, the number of female spawners was converted to number of deposited eggs by multiplying female spawners by run-specific estimates of fecundity (spring-run = 4,900; fall-run = 5,500, late-fall-run = 5,800, winter-run = 3,700; Moyle 2002). Finally, the number of eggs was converted to juveniles by multiplying estimated deposited eggs by 0.25, which is the average egg-fry survival estimate for the Upper Sacramento River (Martin et al. 2001). The resulting numbers of juveniles entering the model for each run are presented in Table 2.

Table 2. Annual run-specific historical estimated escapement values for Chinook salmon populations that spawn upstream of Fremont Weir in the Sacramento River Basin and resulting number of Chinook salmon juveniles of each run entering the Salmon Benefits Model under each water year.

Water Year	Spring-run		Fall-run		Late-fall-run		Winter-run	
	Escapement	Juveniles	Escapement	Juveniles	Escapement	Juveniles	Escapement	Juveniles
1997	2,658	1,628,025	263,653	181,261,438	1,385	1,004,125	1,012	468,050
1998	1,431	876,488	326,558	224,508,625	5,056	3,665,600	836	386,650
1999	23,677	14,502,163	166,380	114,386,250	42,965	31,149,625	2,992	1,383,800
2000	6,092	3,731,350	329,982	226,862,625	15,758	11,424,550	3,288	1,520,700
2001	5,342	3,271,975	329,996	226,872,250	12,883	9,340,175	1,350	624,375

2002	12,952	7,933,100	446,938	307,269,875	21,813	15,814,425	8,224	3,803,600
2003	12,769	7,821,013	702,409	482,906,188	43,017	31,187,325	7,441	3,441,463
2004	8,583	5,257,088	397,094	273,002,125	11,198	8,118,550	8,218	3,800,825
2005	9,562	5,856,725	240,767	165,527,313	15,282	11,079,450	7,869	3,639,413
2006	14,044	8,601,950	329,442	226,491,375	18,614	13,495,150	15,839	7,325,538
2007	8,013	4,907,963	247,739	170,320,563	16,450	11,926,250	17,290	7,996,625
2008	6,755	4,137,438	77,836	53,512,250	13,442	9,745,450	2,541	1,175,213
2009	4,489	2,749,513	63,350	43,553,125	10,483	7,600,175	2,830	1,308,875
2010	2,492	1,526,350	39,385	27,077,188	10,084	7,310,900	4,537	2,098,363
2011	1,904	1,166,200	128,904	88,621,500	10,039	7,278,275	1,596	738,150

Entry Timing and Size

Model entry for Chinook salmon is the location of the Knights Landing (KL) rotary screw trap (RST) operated by the California Department of Fish and Wildlife (CDFW), 11 kilometers upstream of Fremont Weir (River KM 144) on the Sacramento River (Figure 1). Knights Landing RST data was then used to inform the initial entry timing and size of the daily cohorts of juvenile salmon entering the model for all 15 water years (1997-2011). Because variation in daily RST catch rates can be highly influenced by variability in capture efficiency, we used catch per unit effort data (CPUE) as summarized by Roberts and Israel (2012). Daily CPUE for each run was divided by the sum of all daily run-specific CPUEs throughout a water year to estimate the daily proportion of each run entering the model each day (Figure 3). We used generalized additive models (GAMs) to fit smooth functions of fork length (FL) versus date for each run and water year. The GAMs were used to estimate the size of daily cohorts of each run entering the model and allow for predictions on days where fish were caught in the RST but not measured (Figure 4). There is a strong correlation ($r = 0.98$) between the GAM predictions and the mean daily fork length.

Length-at-date criteria were used to assign fish captured at KL RST to each run. Specifically, fish were assigned to a run using the River Model, which was developed by CDFW to classify individual salmon to temporal runs in the upper Sacramento River (Fisher 1992). The logic behind length-at-date criteria is that CV Chinook salmon runs spawn at different times of year, and if the same growth trajectory is assumed, the size of any run is unique on any date, therefore allowing for differentiation of these stocks.

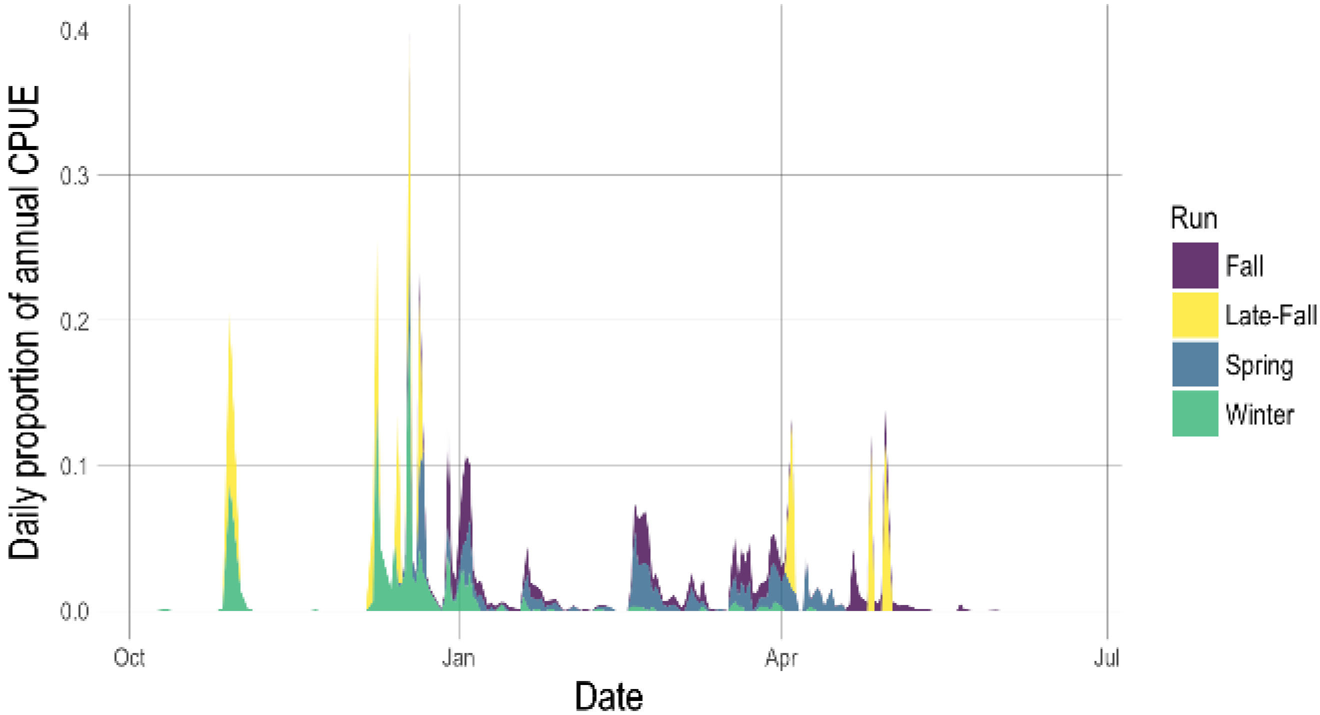

Figure 3. The daily proportion of juvenile Chinook salmon of each run entering the model during water year 2011**.**

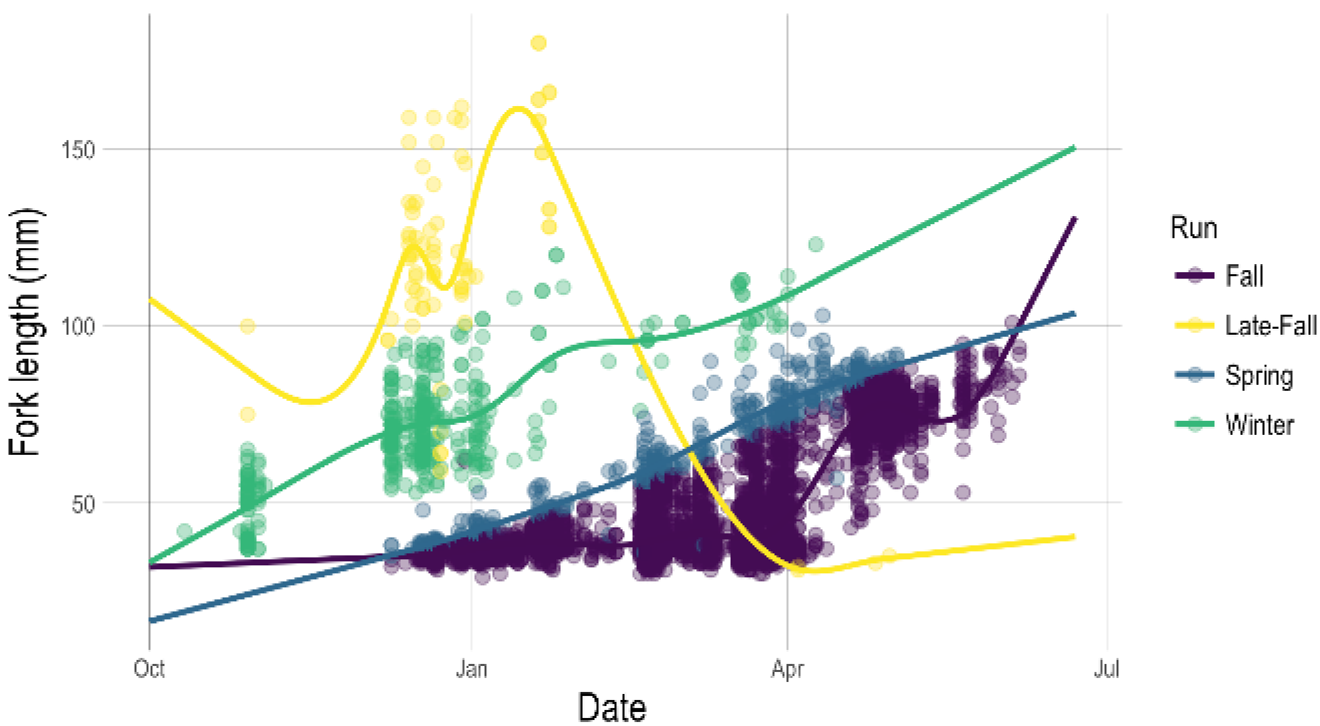

Figure 4. The size of fish captured in the Knights Landing RST (points) and the GAM smooth functions (lines) for water year 2011. Predictions from the GAMs can become unreliable during time periods with no (or few) points, but those time periods typically have no (or very low) catch (compare Figures 2 and 3) and, thus, no fish entering the model at that time. For example, the smoothing function suggests that the size of late-fall Chinook is decreasing through February and March, but no late-fall fish are actually migrating during that time period.

Entrainment

The daily proportion of juvenile Chinook salmon of each run entrained onto the Yolo Bypass is estimated by multiplying the daily abundance of juvenile salmon of each run arriving at Fremont Weir by the proportion of Sacramento River flow entering the Bypass. The proportion of flow entering the Yolo Bypass (P_{YB}) is calculated as

$$P_{YB} = (Q_{FRE} + Q_{Notch})/Q_{Sac} \qquad \text{(Eq. 1)}$$

where Q_{FRE} is the flow overtopping Fremont Weir, Q_{Notch} is the flow through the proposed notch (where applicable), and Q_{SAC} is the Sacramento River flow upstream of Fremont Weir, which is calculated as

$$Q_{SAC} = Q_{FRE} + Q_{Notch} + Q_{VON} - Q_{FEA} \qquad \text{(Eq. 2)}$$

where Q_{VON} is the Sacramento River flow at Verona (River KM 127.9) and Q_{FEA} is the Feather River flow as it enters the Sacramento River (upstream of Verona). Daily values of P_{YB} below zero or above one (based on above calculation) are set to zero and one, respectively. Similar to Roberts and Israel (2012), we assume that juvenile Chinook salmon (regardless of size or abundance) are equally distributed across and throughout the water column and enter the Yolo Bypass in proportion to the flow at the Weir.

Migration

The behavior of model juvenile salmon migrating from Knights Landing to Chipps Island depends on the migratory route in the SBM. Model fish migrating through the Sacramento River move quickly through the system, grow slowly, and do not engage in explicit rearing behavior. Model salmon migrating through the Yolo Bypass move slowly, grow quickly, and engage in rearing behavior based on the availability of suitable rearing habitat. The primary migratory pathway through the Yolo Bypass is the Toe Drain/Tule Canal complex (Canal Complex), which remains watered year-round and provides a passage route for juvenile salmon. When floodplain habitat is available adjacent to the Canal Complex, model salmon stop migrating to rear in the shallow-water habitat. Fish move back to the Canal Complex and resume their migration downstream when floodplain habitat recedes or when they experience a migration trigger (see Floodplain Rearing).

When a cohort enters the model at Knights Landing, a daily migration rate is drawn from a Gamma distribution with mean of 40 km/day (variance = 40) and the cohort migrates at the randomly drawn rate through the Sacramento River from Knights Landing to Chipps Island. For cohorts that are entrained to the Yolo Bypass at Fremont Weir, a new daily migration rate is drawn from a Gamma distribution with a mean of 20 km/day (variance = 20) and the cohort migrates at the randomly drawn rate (not including time spent rearing on the floodplain) through the Canal Complex and Sacramento River from Fremont Weir to Chipps Island.

Even though the SBM is a deterministic model, we included a small amount of stochasticity into this component of the model to improve the visualization of migrating juvenile salmon and to reflect some of the variation in travel times found in empirical data. For example, in the preliminary results from 2016 Yolo Bypass Utilization Study (YBUS), tagged, juvenile, late-fall-run Chinook salmon had a median travel time of ~2.75 days with a range of about 2-10 days while migrating ~134 km from the Feather River to Chipps Island (Russell Perry, *unpublished data*). In the SBM, the expected distribution of migration rates in the Sacramento River is about 20-60 km/day (Figure 5), which falls within the range observed in the YBUS and other studies (Myfanwy Johnston, *unpublished data*; Steve Zeug *unpublished data*).

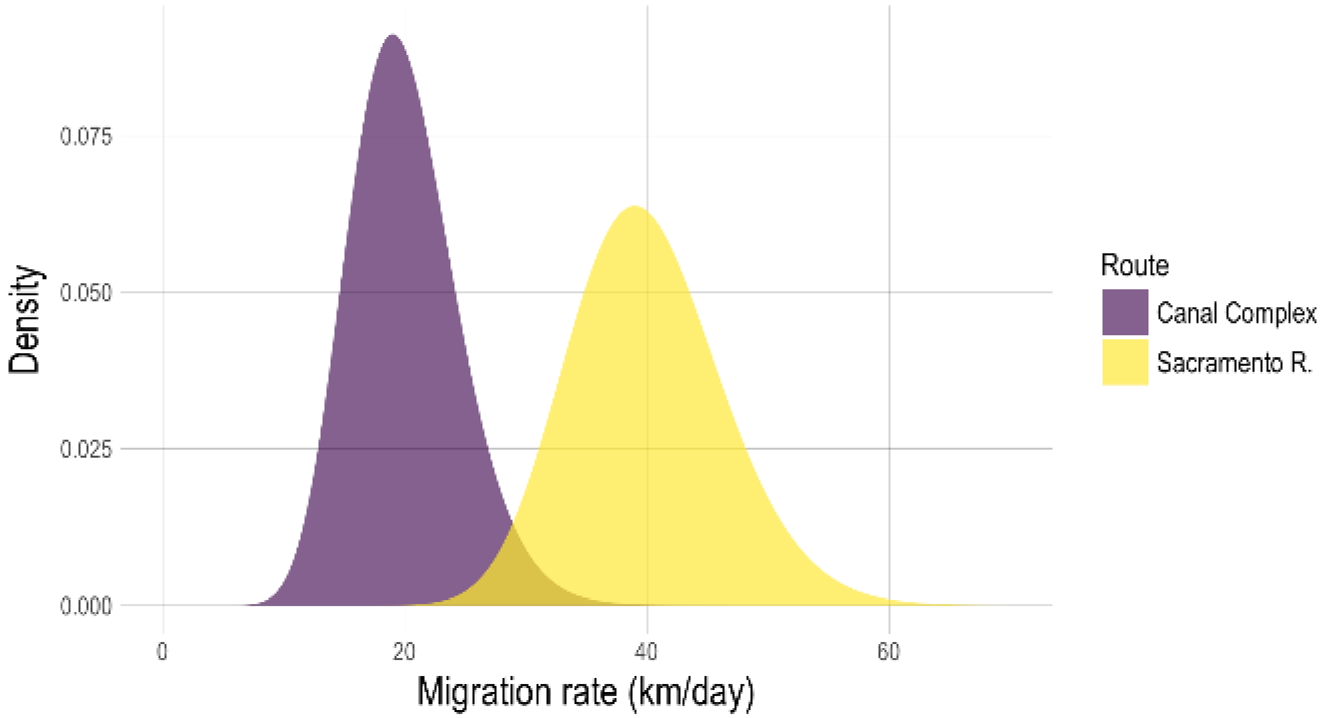

Figure 5. Expected distributions of daily migration rates along the Canal Complex and Sacramento River routes in the Salmon Benefits Model.

Fewer data are available on migration rates through the Canal Complex and Yolo Bypass. However, the preliminary results from the 2016 YBUS suggest that despite being the shorter route (by ~30 km), travel times through the Canal Complex are roughly twice those through the Sacramento River (Russell Perry, *unpublished data*).

Floodplain Rearing

Suitable Habitat

As a daily cohort of juvenile salmon moves downstream in the Canal Complex, they can access the floodplain when suitable floodplain rearing habitat becomes available adjacent to their location. The model assumes that suitable floodplain habitat is only available for a given cohort within a search radius defined by the distance a fish could travel in a day based on their migration rate (see Migration). If suitable habitat is available within this radius for a given cohort on a given day, the cohort will move onto the available suitable habitat and rear on the floodplain. Habitat suitability criteria for Sacramento River juvenile Chinook salmon (USFWS 2005) were used to define suitable floodplain rearing habitat for fry (<70 mm FL) and smolts (≥70 mm FL; Kjelson et al. 1982). Suitable habitat for fry was characterized as 0.39–4 ft deep with velocities less than 1.6 ft/s, and for smolts as 0.39–8 ft deep with velocities less than 1.6 ft/s (USFWS 2005).

On any given day, the model estimates the daily habitat area requirements of the cohort to determine whether enough suitable floodplain rearing habitat is available within a cohort's search radius to support all or a part of the cohort. The territory size required by each fish is modeled as a function of fish fork length based on the mean relationship from a territory size versus fork length relationship estimated for salmonids (Grant and Kramer 1990; Figure 6). The amount of suitable habitat claimed by a given cohort within their search radius is the sum of the territory sizes of all individuals in the cohort. Suitable habitat is occupied in 900-ft^2 patches by the first cohort that reaches the unoccupied habitat. If there is enough suitable habitat for the full cohort within its search radius, then the cohort claims the number of habitat patches that it needs. If there is only enough suitable habitat for part of the cohort, then the cohort is split, with part of the cohort claiming the available patches, and the other cohort part continuing to migrate downstream in the Canal Complex. Each day the amount of suitable habitat available within a cohort's search radius is updated and the above process is repeated.

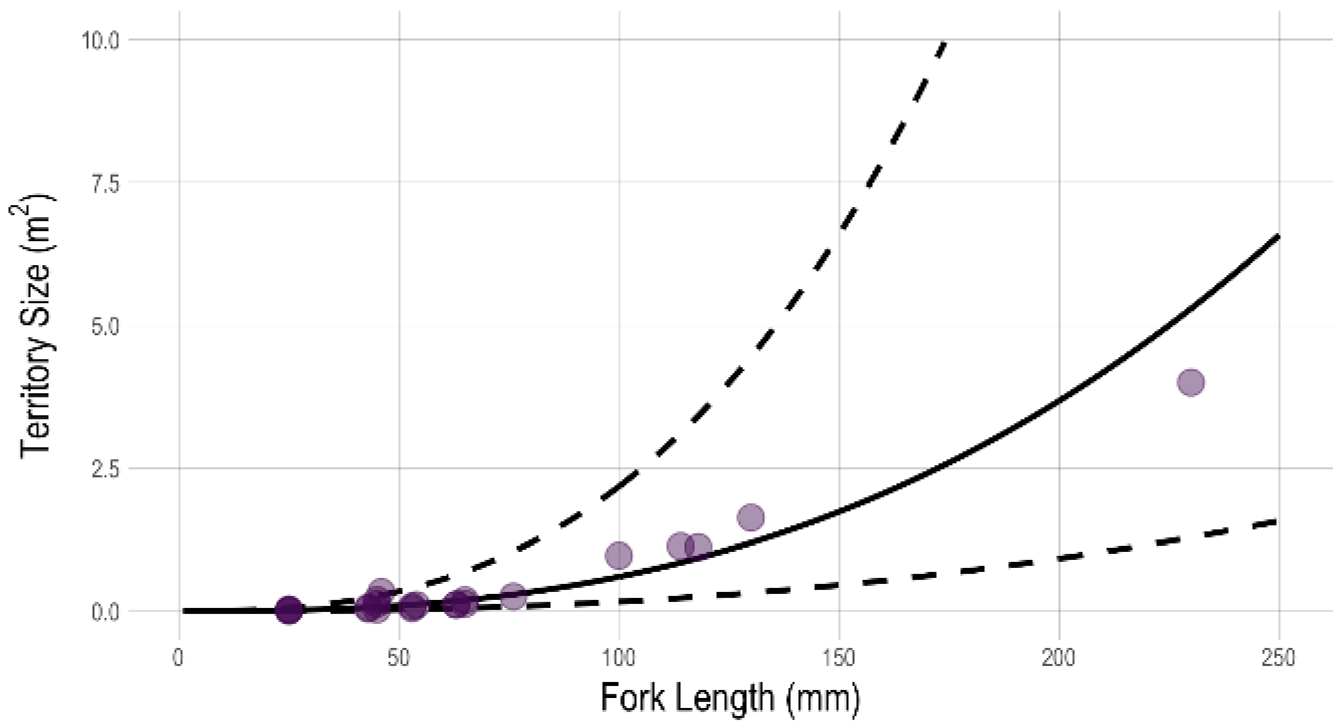

Figure 6. Territory size versus fork length relationship for salmonids from Grant and Kramer (1990). Circles are fish observations, solid line is mean relationship, and dashed lines are upper and lower 95% prediction interval limits. The mean relationship was applied in the Salmon Benefits Model to estimate fish territory size.

Rearing Rules

Because Chinook salmon do not rear in freshwater indefinitely, we incorporated rearing rules that constrain the time that a cohort spends rearing on the floodplain. The model uses these rearing rules to decide whether a cohort migrating through the Canal Complex continues to migrate, or whether it will rear in adjacent suitable habitat. The two rearing rules are simple heuristics based on temperature and flow.

The water temperature rule is based on daily water temperature data collected by the California Department of Water Resources (DWR) Aquatic Ecology Section RST site located in the Toe Drain near the north-east tip of Little Holland Tract for years 1998-2011. Because both growth rates and smoltification (ATPase activity) of juvenile Chinook salmon have been shown to decrease at water temperatures above 20^{o}C (Marine 1997; Marine and Cech 2004), the first day that average water temperatures exceeded 20^{o}C was set as a maximum date that fish would rear on the floodplain. The Toe Drain water temperature data indicated that June was the first month that average daily water temperatures consistently exceeded the 20^{o}C threshold across nearly every year. Thus, June 1st was set as the date when rearing fish would stop rearing and continue migrating through the Canal Complex.

The flow rule is based on the 10-day average flow in the Sacramento River upstream of Fremont Weir (Q_{SAC}; see Entrainment). We chose 10 days to modulate the flow signal and allow for movement of flow through system because cohorts at the top and bottom of the Canal Complex are using the same flow value on the same date. A cohort starts rearing if current flow is greater than flow 31 days earlier and stops rearing if current flow is less than flow 31 days earlier. The flow rule is inspired by the 'loitering' conceptual model of floodplain rearing where a delay is expected between a flow pulse through the system and fish exiting the system (Sommer et al. 2005). The 31-day lag was chosen to allow for potential rearing over periods of several consecutive weeks while still reliably triggering emigration as water on the floodplain begins to recede.

Growth

In the SBM, growth is calculated as

$$L_t = g^t L_0 \quad \text{(Eq. 3)}$$

where L_t is fork length at time t, L_0 is fork length at time 0, and g is the daily proportional growth rate. The key assumption of this model is that fish of all sizes grow by the same proportion in a day, but larger fish will increase their size by a greater absolute amount. For example, if g is 1.01, a 30-mm fish will grow 0.3 mm in one day, but a 100-mm fish will grow 1.0 mm in one day.

The proportional growth rate can be estimated from empirical studies of fish growth (e.g., Jeffres et al. 2008) by re-arranging the growth equation as follows

$$g = \left(\frac{L_t}{L_0}\right)^{1/t} \quad \text{(Eq. 4)}$$

We used this equation to estimate growth rates for the Sacramento River, Canal Complex, and floodplain as 1.0029, 1.0059, and 1.013, respectively (Figure 7). These growth rates were estimated from available data for the different habitat types; the Sacramento River and Canal Complex values were derived from Jeffres (2016), while several studies informed the floodplain growth value (Jeffres and Katz, *unpublished data*; Jeffres et al. 2008), For example, Jeffres et al. (2008) found that juvenile Chinook salmon that were placed in enclosures on ephemeral floodplain habitats with flooded herbaceous vegetation grew 16mm on average in 2004, and 33 mm on average in 2005, during 32 and 56 days of rearing, respectively. The resulting growth rates were 1.0083 and 1.0085 body lengths per day. All observed floodplain growth rates from all available relevant studies were averaged together to determine the floodplain growth rate used in the model (i.e., 1.013).

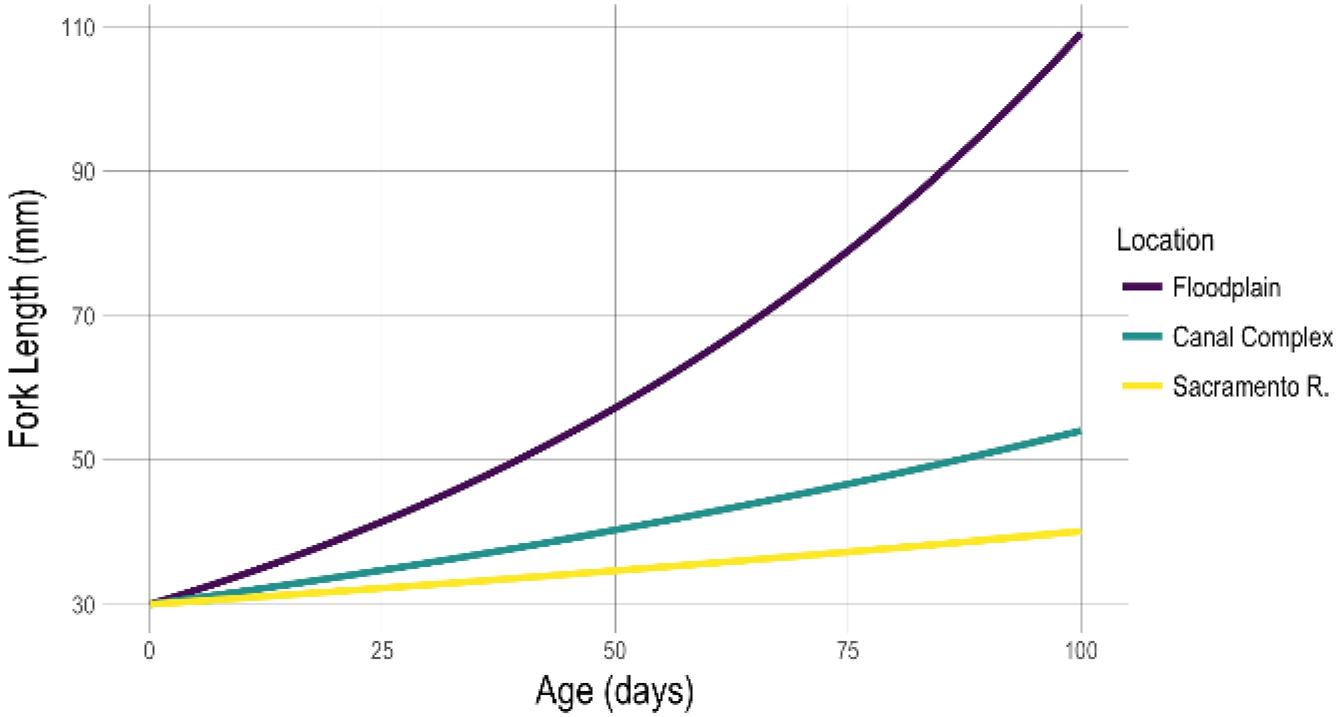

Figure 7. Example growth curves for each location (Floodplain, Canal Complex and Sacramento River) included in the Salmon Benefits Model.

Survival

Migrating

In the SBM, survival through the Sacramento River and the Canal Complex depends on cohort fork length and Sacramento River flow (Figure 8). The relationship is based on an analysis of 11 release groups of late-fall juvenile Chinook salmon in the Sacramento River over 3 years (Perry 2010). The survival model is

$$S = \text{logit}^{-1}\left(-0.11 + 0.26\frac{L-156.5}{11.6} + 0.52\frac{Q_{SAC10}-5127}{3764}\right) \quad \text{(Eq. 5)}$$

where S is survival in a 51.9 km stretch of the Sacramento River from the Delta Cross Channel to Chipps Island, L is the fork length of the cohort, and Q_{SAC10} is the 10-day averaged flow in the Sacramento River upstream of Fremont Weir (see Entrainment). The original model was estimated with normalized values for fork length and flow. Thus, the input fork length and flow are converted to the normalized scale by subtracting the mean and dividing by the standard deviation before multiplying by the model coefficients. The survival value is then converted to survival per kilometer (S_{km}):

$$S_{km} = S^{(1/51.9)} \quad \text{(Eq. 6)}$$

Applying survival on a per kilometer basis is known as a gauntlet model (Anderson et al. 2005) because migrating fish need to move through a gauntlet of predators to reach the ocean and cannot reduce their predation risk by migrating at a faster rate. Thus, migration rate does not affect survival in the SBM.

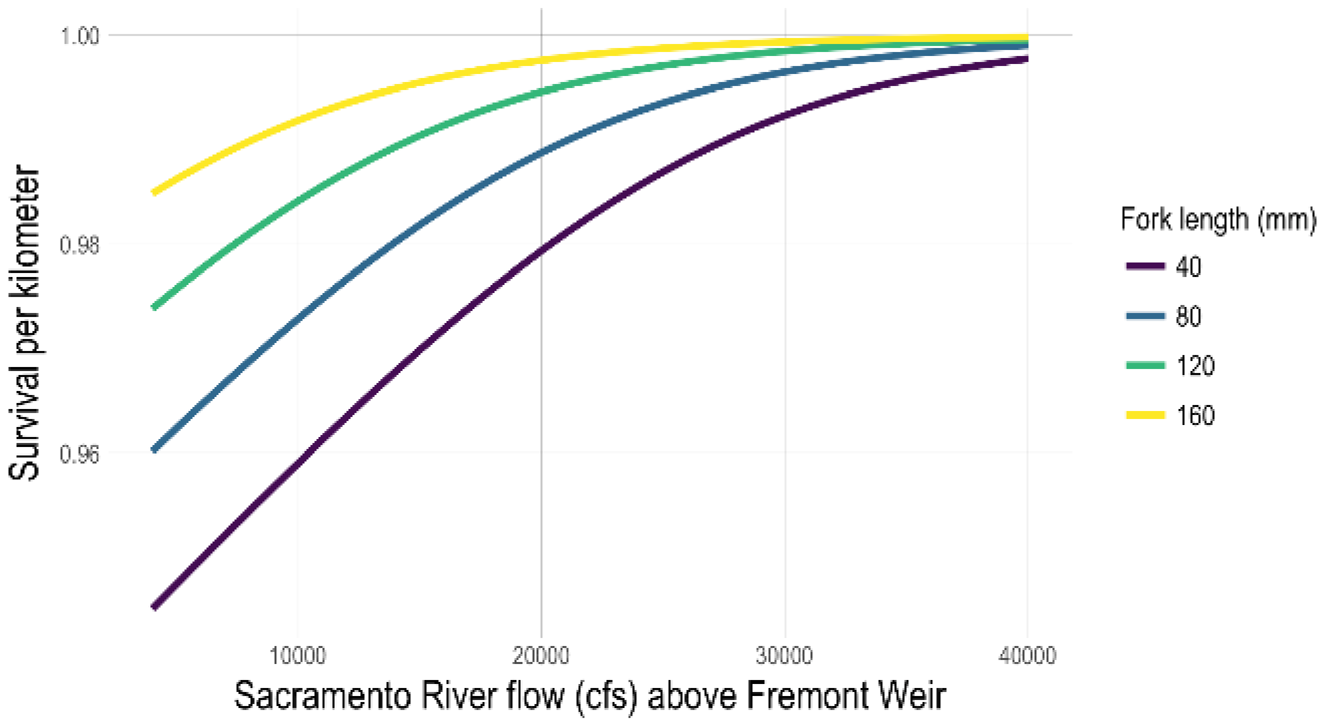

Figure 8. Example survival curves for cohorts of four different fork lengths over a range of 10-day averaged flows in the Sacramento River above Fremont Weir. Note, survival predictions are made beyond the ranges of flow and fork length in the data used to fit the original survival model.

When a cohort enters the model at Knights Landing, the S_{km} for that cohort is calculated based on its size at Knights Landing and Q_{SAC10} on the day of model entry. For cohorts that stay in the Sacramento River, S_{km} is calculated once at Knight Landing and applied throughout the 157-km journey from Knights Landing to Chipps Island. For cohorts that are entrained to the Yolo Bypass at Fremont Weir, a new S_{km} for that cohort is based on its size at Knights Landing and Q_{SAC10} for 3 days after entering Yolo Bypass because Sacramento flow lagged Yolo Bypass flow by an estimated 3 days. Using California Data Exchange Center (CDEC; https://cdec.water.ca.gov/) data for the YBY station (Yolo Bypass near Woodland), we found a strong correlation between 10-day averaged flows on the Yolo Bypass and in the Sacramento River with a 3-day lag (r = 0.94; Figure 9). Basing survival through the Canal Complex on Sacramento River flows is almost certainly an overestimate of survival for cohorts that move directly through the Canal Complex without rearing. However, cohorts that rear on the floodplain as they migrate through the Yolo Bypass experience additional rearing mortality (see Rearing). Moreover, when a cohort returns to the Canal Complex after rearing, a new value of S_{km} for that cohort is calculated based on their current size and Q_{SAC10} with a 3-day lag. If a cohort reared during a period of high flow and returned to the Canal Complex to finish migrating during a period of lower flow, then it would experience lower survival during the remainder of its migration (unless it increased in size enough to compensate for the lower flow). Finally, when a cohort moving through the Canal Complex reaches the Sacramento River near Rio Vista, a new value of S_{km} for that cohort is calculated based on their current size and Q_{SAC10} with an 8-day lag because Rio Vista is 80% of the distance from Knights Landing to Chipps Island and flow is averaged over a 10-day window.

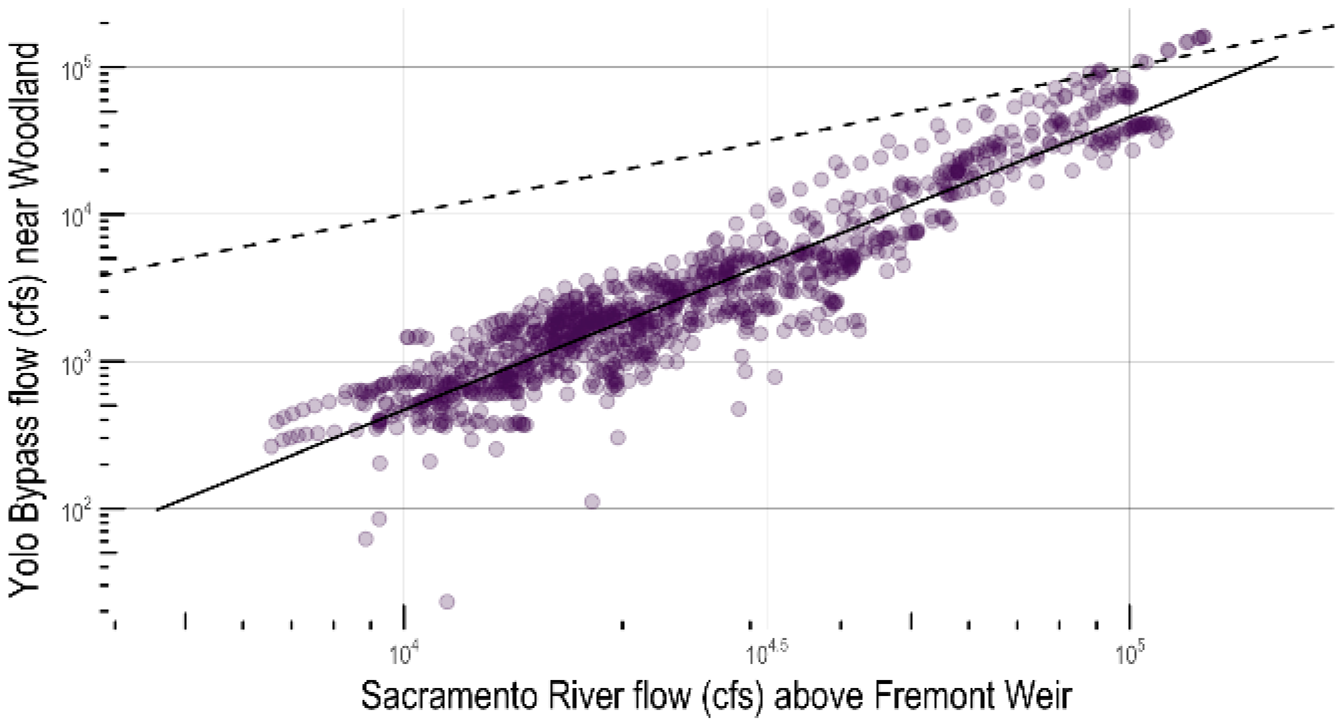

Figure 9. Relationship between 10-day averaged flows in the Sacramento River above Fremont Weir and in the Yolo Bypass near Woodland.

Rearing

In the SBM, cohorts rearing on the floodplain experience a daily survival of 0.99. A survival model with survival as a function of time is known as an exposure model (Anderson et al. 2005) because the probability of survival is decreased with an increase in time spent rearing and exposure to predators. In the model, fish are trading off increased growth on the floodplain (see Growth) with the additional mortality incurred during rearing (relative to not rearing). [Note, this is not an optimality model; the rearing rules could produce sub-optimal rearing durations depending on the value chosen for rearing survival.] The growth-survival trade-off is reflected in the probability of returning as an adult because ocean survival is modeled as a function of fork length at ocean entry (see Ocean Residence). Floodplain rearing reduces the probability that a juvenile fish reaches the ocean, but the increased size from floodplain rearing increases the probability of surviving during ocean residence. Given the floodplain growth rate and the ocean survival relationship used in the model, and ignoring survival during migration, the minimum daily rearing survival value to make rearing worthwhile (i.e., growth benefit outweighs rearing mortality) can be calculated as 0.99 (not shown here).

Ocean Residence

Following ocean entry, Chinook salmon survival prior to returning to freshwater as adults to spawn was modeled. Satterthwaite et al. (2014) found that ocean survival of hatchery Chinook salmon released in the Bay was significantly related to release size. Therefore, survival to age 3 data for Feather River Hatchery releases of juvenile Chinook salmon in the San Francisco Bay for years 1981-2010 from Satterthwaite et al. (2014) informed ocean survival in the model. Similar to Satterthwaite et al. (2014), only age 3 recoveries were considered when estimating ocean survival because prior to being caught at age 3, the predominant source of mortality is from natural causes, and recoveries of age 2 and age 4 fish are comparatively rare. The model uses a generalized linear model with a quasi-binomial error distribution and a logit link to predict survival, S, at age 3 from fish fork length, L, at release (Figure 10):

$$S = \text{logit}^{-1}(-7.63 - 0.03L) \quad \text{(Eq. 7)}$$

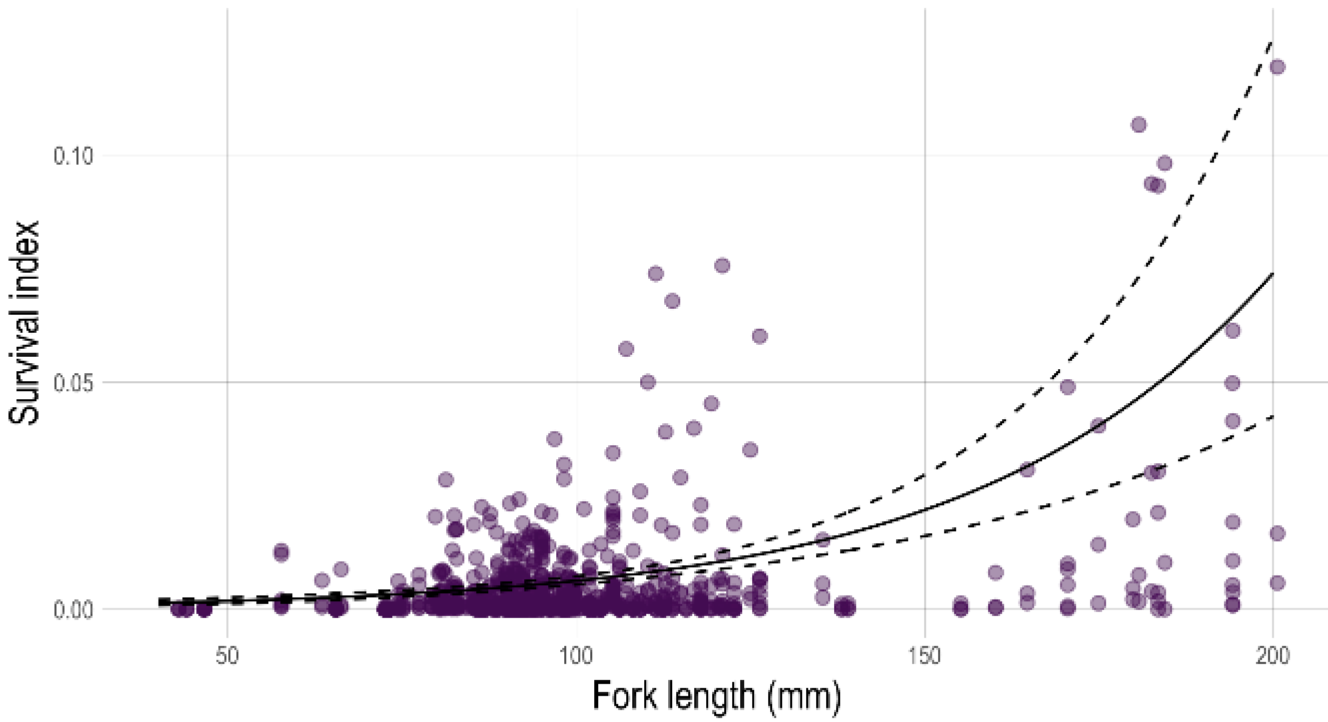

Figure 10. Age 3 survival index versus fish fork length at release for Feather River Hatchery juvenile Chinook salmon released in the Bay, 1981-2010 (data from Satterthwaite et al. 2014). Circles are observed values, solid line is the best-fit generalized linear model, and dashed lines are 95% confidence limits.

Upstream Migration

Following ocean residence, upstream migration of returning adults from the Bay to Fremont Weir on the Sacramento River was modeled. Because data were lacking, the model assumes that 100% of adult Chinook salmon successfully return upstream to Fremont Weir. If data becomes available to inform different upstream migration survival rates for each management alternative, model functionality can be refined.

Model Assumptions and Limitations

Due to limited data available for several CV Chinook salmon life stages, traditional statistical estimation models become difficult to apply when attempting to predict outcomes of future management actions (Williams 2006). Unlike predictive models, simulation models can be useful for organizing existing knowledge and identifying gaps in understanding, even if the model predictions are imprecise (Williams 2006). Simulation models should be thought of as experimental systems or aids that are distinct from the “real world” in which the consequences of various sets of assumptions can be examined (Peck 2004). However, model usefulness is measured by how well it captures the interactions of the most important factors and leaves out unimportant ones (Ford 1999), thereby limiting model complexity and simplifying interpretation of results. More complex models can be too dataset-specific and have poor predictive ability, mainly due to estimation error, while simpler models can be too general and incorporate error due to system oversimplification (Astrup et al. 2008). Therefore, we attempted to model the benefits of Yolo Bypass restoration actions on Chinook salmon with a level of complexity that captures the most recent key factors thought to influence fish survival and size, while limiting the inclusion of factors that have low utility for evaluating project effects, or that are unsupported by existing scientific knowledge.

Data Availability

Simulation models depend upon available data to inform model relationships, resulting in a complexity level that matches the depth of knowledge known about a subject (Astrup et al. 2008). When local data is limited, model relationships can often be informed by populations outside the study region, laboratory studies in controlled experimental settings, or artificially raised (hatchery) surrogates. For example, many of our model relationships rely on data from tagged hatchery surrogates. This is because most experimental studies are of hatchery-origin fish, conducted under the assumption that outcomes and behavior are at least similar between fish of different natal origins. In addition to limited data on wild fish, many of our relationships are informed by data from a single Chinook salmon run (i.e., fall-run), thereby assuming that all runs move, grow, and survive according to the same rules.

Habitat Suitability

For juvenile salmon to successfully rear, numerous physical requirements must be met including suitable cover (McMahon and Hartman 1989), food availability (citation) and water quality (Marine and Cech 2004). Furthermore, flood duration of seasonally inundated habitats can dictate the strength of biotic response to the flood (King et al. 2003). Unfortunately, spatial modeling of water temperature, cover, and biotic production were not available to inform the complex response between Bypass inundation duration and juvenile growth. However, a key assumption of salmonid rearing habitat modeling is that depth and velocity are major predictors of habitat suitability (Raleigh et al. 1986; Keeley and Slaney 1996). Therefore, we simplified our approach and defined suitable habitat based on water depths and velocities alone and modeled juvenile salmon to exhibit an average, consistent growth rate while rearing on the floodplain. We currently assume depth and velocity suitability criteria developed in the adjacent habitat of the Sacramento River (USFWS 2005) is transferable to Yolo floodplain. However, if more information becomes available to inform a more sophisticated relationship between floodplain habitat and juvenile salmon rearing success, model functionality can be changed.

Water Temperature

Water temperature can affect juvenile Chinook salmon survival and health (Marine and Cech 2004), and migratory behavior has been associated with long-term accumulated response to water temperatures, with smoltification rates increasing with increased accumulated thermal units unless the upper threshold is met (ATU; Sykes and Shrimpton 2010; Marine and Cech 2004). However, apart from the water temperature movement trigger, these temperature effects are excluded from the model due to lack of modeled temperature data. The water temperature movement trigger assumes that historical Yolo Bypass water temperatures will likely relate to future water temperatures under the different management alternatives, at least in a very coarse way. If water temperatures are modeled for Yolo Bypass management alternatives in the future, new model functionality could be incorporated to evaluate how different temperature regimes under each alternative affect model outcomes.

Yolo Bypass Entrainment

Models for how juvenile Chinook salmon are distributed in the channel and throughout the water column at the Fremont Weir junction are currently unavailable. Therefore, we assumed that juvenile Chinook salmon are equally distributed across the channel and throughout the water column and enter the Yolo Bypass in proportion to the flow entering the bypass. Similar dispersion assumptions have been used to estimate juvenile salmon entrainment (Kimmerer and Nobriga 2008). However, if more information becomes available to inform a more sophisticated relationship between flow and juvenile salmon entrainment, or if different entrainment alternatives are examined in the future, model functionality can be changed to evaluate alternative mechanisms of entrainment (e.g., see Entrainment Rules).

Movement

Juvenile salmon movement in the riverine and floodplain portions of the model is greatly simplified and limited by data availability. Modeled fish in the Sacramento River and Canal Complex move one-dimensionally and at an average rate. Migratory behavior in juvenile salmonids is a complex process related to growth, hormonal development, and environmental parameters, all of which may influence habitat use and movement throughout the emigration period (Iwata 1995). While juveniles may shift between rearing and actively migrating during the emigration process (Hoar 1953; Iwata 1995), the mechanisms that inform these complex movements are not well understood or easily modeled. Therefore, we instead modeled the average downstream movement of juvenile Chinook based on simple movement rules. A simplified model was then applied for juveniles rearing on the floodplain. Data is not available to inform model rules for how fish should progress across the floodplain in two dimensions, nor is data available to inform simulation of high-resolution territorial behavior on floodplains. Therefore, the model allows fish to immediately colonize habitat that is within a radius of a single day's distance from their location in the Canal Complex, without explicitly modeling individual movement. We assume that all juvenile Chinook set up a territory in the most immediately available and suitable habitat, without prioritization for juveniles of different sizes or runs.

Growth

We assumed that growth rate depends only on fork length and approximate location (i.e., Sacramento River, Canal Complex, floodplain). It is unlikely that growth is homogenous throughout each of these locations, but we assume that our estimates of growth rate reflect average behavior across these locations.

Survival

River

We assumed that mortality in the Sacramento River and Canal Complex is a function of both flow and fork length. The flow-survival relationship was developed for relatively large juvenile Chinook (135-195 mm) over a relatively small range of flows (1,300-18,000 cfs; Perry 2010). We made the simplifying assumption that the relationship holds for fork lengths and flows outside of those ranges. We also assumed that flow in the Sacramento River predicts survival while migrating through the Canal Complex. This is almost certainly an overestimate of survival through the Canal Complex. However, the combined mortality from the Canal Complex and floodplain rearing yields survival values that are comparable to empirical results (Perry, *unpublished data*; Johnston, *unpublished data*). We used the flow-survival relationship to predict survival per km, which is a gauntlet model of survival. Survival might be better represented by a survival model that incorporates both distance and time traveled (i.e., XT model; Anderson et al. 2005), but mechanisms underlying the XT model are not yet well understood. Instead, flow is treated as a “master control” that is potentially related to several factors influencing survival, including temperature, turbidity, and migration rate (Perry et al. 2016).

Floodplain

We assumed that floodplain survival operates under an exposure model where time spent rearing reduces the overall survival. Other factors that my influence floodplain survival include the behavior (e.g., habitat selection, activity level) and physical attributes of the fish (e.g., size). We also assumed that floodplain survival is the same throughout the migration season, across Chinook salmon runs and years, and over the whole floodplain. The floodplain survival component of the model can be updated as more data becomes available.

Ocean

Studies have shown that juvenile Chinook salmon survival in the ocean can vary due to many factors including entry timing, physical ocean conditions, trophic dynamics, and size or condition of fish upon entry (Satterwaite et al. 2014). However, because the focus of the model was to evaluate the potential benefits of different Yolo Bypass inundation strategies, we wanted to isolate the effect of fish growth rates on individual survival during ocean residence. Therefore, we only incorporated the effect of fish size on ocean survival.

ALTERNATIVES ANALYSIS

In this section, we present the results of an analysis of alternative scenarios involving different designs for a notch in Fremont Weir (see Modeled Scenarios). The analysis of the SBM focused on four metrics to assess the relative benefits of the management alternatives: (1) juvenile survival from Knights Landing to Chipps Island, (2) mean fork length of fish at Chipps Island, (3) coefficient of variation of fish at Chipps Island, and (4) number of returning adults.

The benefits metrics consider the population as a whole rather than by route (i.e., Sacramento River and Yolo Bypass). The proportion of the population entrained onto the Yolo Bypass is relatively small and highly variable. Across all years, runs, and scenarios, the average proportion entrained is 11% (range: 0-57%). Thus, big effects on the Yolo Bypass route can be misleading if not placed in context of the whole population.

The benefits metrics are calculated on a yearly time scale. Within-year results are available for additional analysis, but are not presented here. The benefits metrics figures are presented on a relative scale to highlight differences between alternatives.

$$relative\ change = \frac{alternative - existing}{existing} \qquad \text{(Eq. 8)}$$

Percentage change can be calculated by multiplying relative change by 100. The difference between each alternative and existing conditions is calculated on an annual basis because of large inter-annual variation in the benefits metrics. The values used to calculate the relative change in benefits metrics are included as tables in Appendix A.

Juvenile Survival to Estuary Entry

Juvenile survival is calculated as the total number of juvenile Chinook salmon that arrive at Chipps Island divided by the total number that entered the model at Knights Landing for each water year. Generally, juvenile survival is lower under alternative scenarios than existing conditions (Figure 11; Table A-1). Several model mechanisms interact to produce relative juvenile survival that is negative in some years and positive in others.

The main mechanism of lower juvenile survival under alternative scenarios than existing conditions is additional mortality from increased time spent rearing because fish survival is negatively related to the time spent rearing. Relative to existing conditions, the alternative scenarios increase entrainment (Figure 16) and potentially increase time spent rearing on the floodplain. Another potential mechanism of lower relative juvenile survival is increased mortality during migration after rearing. Survival during migration depends partly on flow. If a fish is entrained onto the Yolo Bypass at the beginning of a short flow pulse, rears on the floodplain for the flow pulse duration, and resumes migration at a time of low flow, then the fish will experience higher mortality during migration through the Canal Complex than if it had not reared at all.

The main mechanism of higher juvenile survival under alternative scenarios than existing conditions is migrating through the Canal Complex with little or no floodplain rearing. Because the Canal Complex is a shorter route than the Sacramento River, and migrating survival is based partly on distance traveled, fish that are entrained onto the Yolo Bypass at a time of relatively low availability of suitable rearing habitat could experience higher survival on that route. Juvenile survival is likely overestimated in the model for the situation where fish migrate through the Canal Complex without rearing on the floodplain.

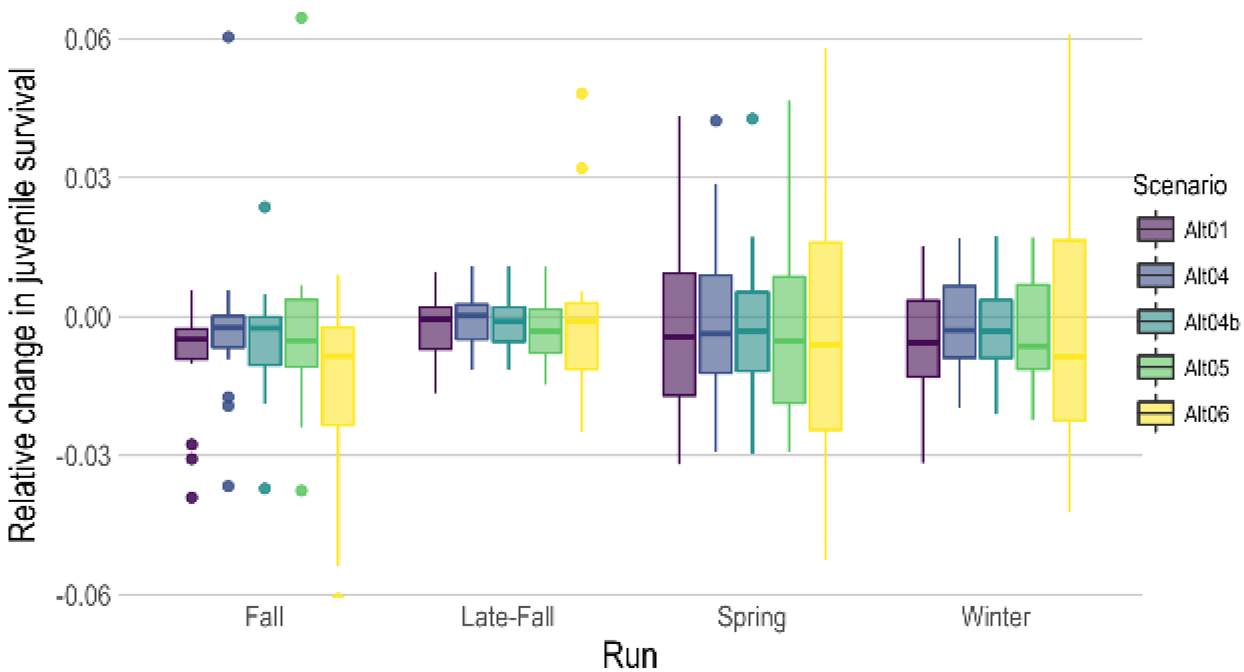

Figure 11. Relative change in juvenile survival from Knights Landing to Chipps Island for 15 years under five alternative scenarios for notches in Fremont Weir. The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively). Note, the y-axis has been truncated to exclude some outliers. See Table A-1 for full set of values.

Juvenile Fork Length at Estuary Entry

Fork length is calculated as the mean fork length of all juvenile Chinook cohorts that arrive at Chipps Island weighted by the abundance of fish in the cohort. Fish grow faster on the floodplain than in the Sacramento River and, thus, mean fork length at Chipps Island is higher under the alternative scenarios than under existing conditions (Figure 12; Table A-2). Because the growth rate is proportional, bigger fish increase their size by a larger absolute amount than smaller fish.

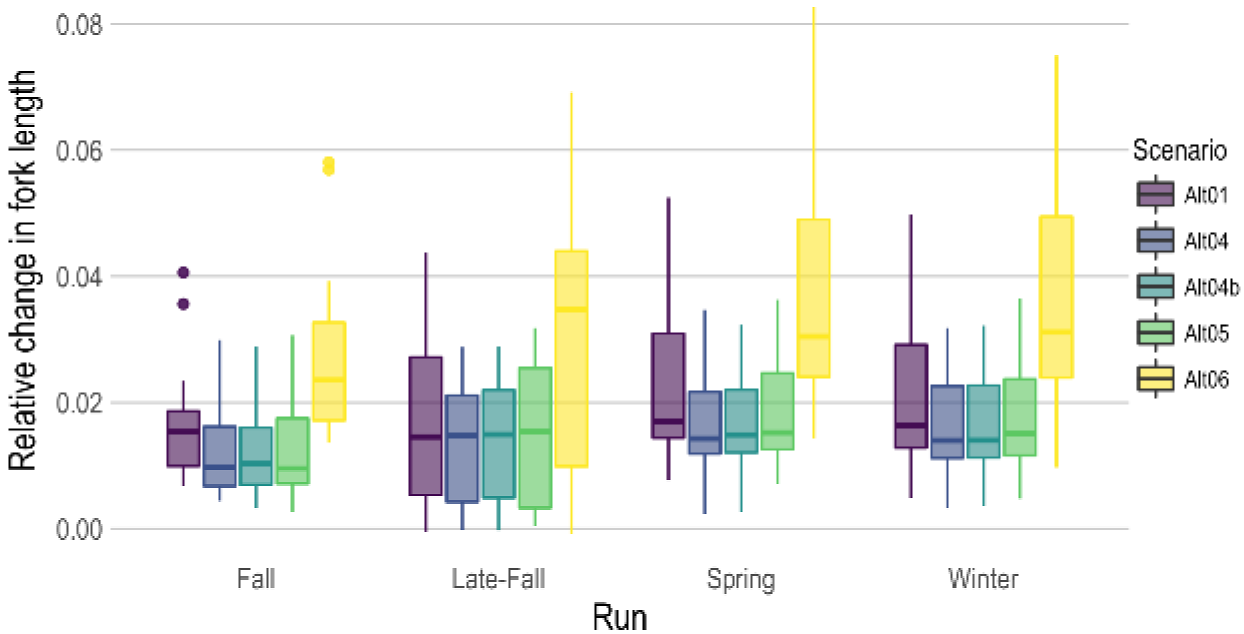

Figure 12. Relative change in mean fork length at Chipps Island for 15 years under five alternative scenarios for notches in Fremont Weir. The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively).

Juvenile Fork Length Variation at Estuary Entry

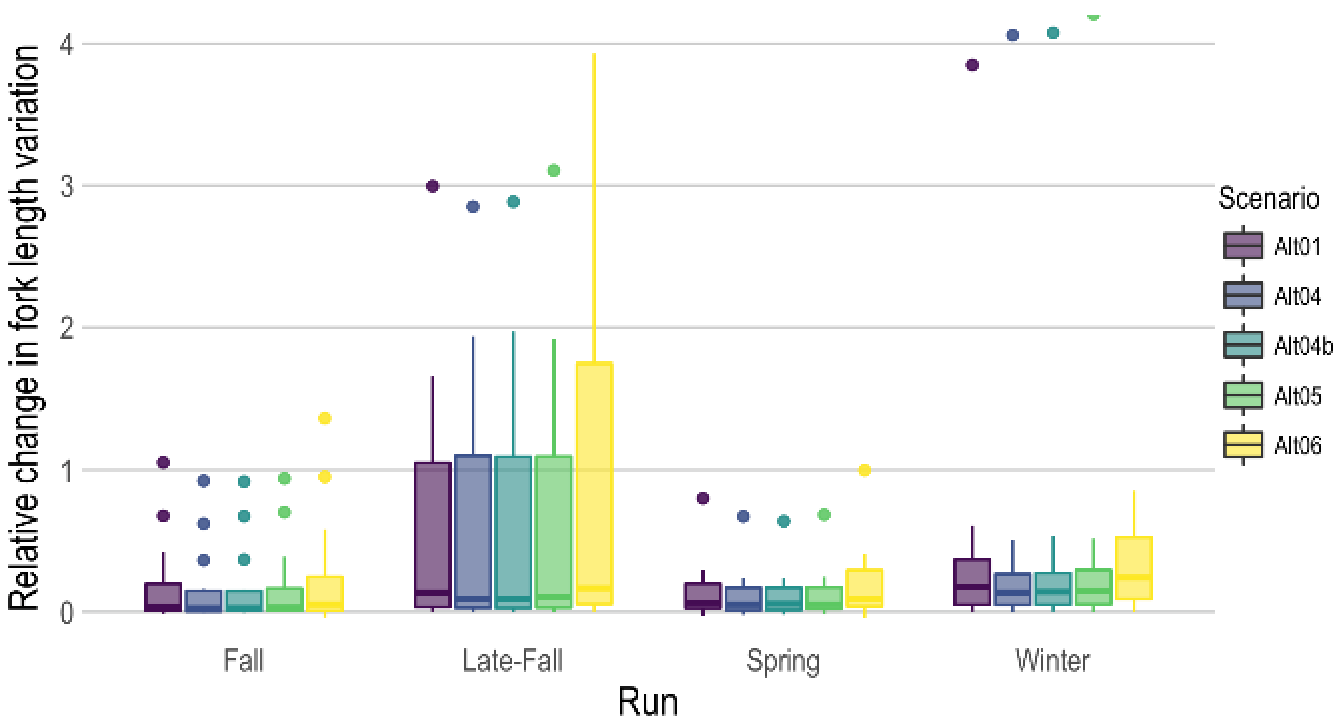

Figure 13. Relative change in coefficient of variation in fork length at Chipps Island for 15 years under five alternative scenarios for notches in Fremont Weir. The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are

outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively). Note, the y-axis has been truncated to exclude some outliers. See Table A-3 for full set of values.

Fork length variation is calculated as the coefficient of variation in fork length of all cohorts that arrive at Chipps Island weighted by the abundance of fish in the cohort. Using fork length variation as a fish benefits metric reflects the importance of trait variation in ecological dynamics, including those assumed for CV Chinook salmon (Goertler et al. 2016; Bolnick et al. 2011). Fork length variation is higher under alternative scenarios than under existing condition (Figure 13; Table A-3). The alternative scenarios provide access to the Yolo Bypass at lower flows than under existing conditions and, presumably, introduce variability in the accessibility of suitable rearing habitat for fish that, in turn, increases fork length variation at Chipps Island.

Returning Adults

The number of returning adults depends on both the number and size of fish that arrive at Chipps Island because the ocean survival relationship is a function of size. The returning adults metric shows the combined effect of the juvenile survival and fork length metrics. In other words, the number of returning adults captures the trade-off between floodplain growth and rearing survival. Under most scenarios and years, the alternative scenarios produce more returning adults than existing conditions (Figure 14; Table A-4).

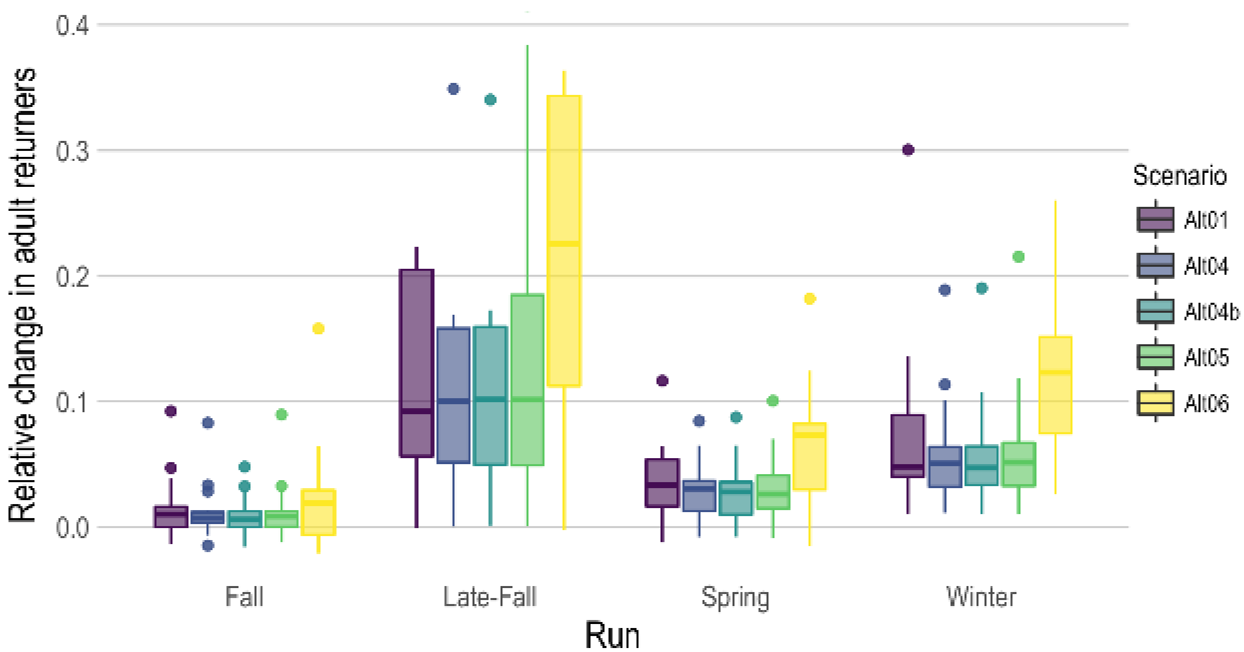

Figure 14. Relative change in number of returning adults for 15 years under five alternative scenarios for notches in Fremont Weir. The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively). Note, the y-axis has been truncated to exclude some outliers. See Table A-4 for full set of values.

Conclusions

In drawing conclusions for the analysis of alternatives, we focus on two of our fish benefits metrics: returning adults and fork length variation. The number of returning adults measures the productivity of the population and incorporates the combined effects of juvenile growth and survival. Moreover, the returning adults metric includes benefits for larger fish in several model components (i.e., survival during migration, growth, ocean survival). In contrast, fork length variation provides an alternative benefits metric that reflects the value of trait variation. Although fish size at ocean entry is a significant predictor of ocean survival, the relationship is noisy (Figure 10). It’s possible that smaller fish may be favored under some ocean conditions, which may increase population stability across years.

For both returning adults and fork length variation, Alt06 generated the biggest relative changes. Alt06 has the largest notch and highest max design flows (12,000 cfs) of the modeled scenarios. For fork length variation, there is very little difference among the other alternatives (i.e., Alt01, Alt04, Alt04b, Alt05), but, for returning adults, there are some years where Alt01 outperformed Alt04, Alt04b, and Alt05 (e.g., 2001 for late-fall-run fish). And, in 2001, Alt04b noticeably underperformed Alt01, Alt04, and Alt05 for fall- and spring-run fish. Alt04b has an earlier closure date (March 7th) than the other alternatives (March 15th) and in 2001 the earlier closure coincided with a March flow pulse where no overtopping of Fremont Weir occurred under existing conditions.

The largest relative changes in returning adults and fork length variation generally do not occur in the same years. For example, fall-run fish experienced the largest relative change in returning adults in 2001 and in fork length variation in 2009. Both 2001 and 2009 were classified as dry years with prominent flow pulses in February/March. Understanding between-year differences will require a more detailed analysis of within-year patterns.

EFFECTS ANALYSIS

The SBM includes numerous modeling decisions derived from best available data, expert opinion, and modeling experience. The conclusions drawn from the results of the model depend on the details of model implementation and it is an important step in the model development process to explore the implications of changing model rules and input parameters on the model results. If changing a model rule produces little or no change in the results, then it suggests that model component is not particularly important and could be simplified or removed from the model. Conversely, if changing a model rule produces a large change in the results, then it suggests that model component requires additional investigation and development. In this Appendix, we report on the results of an effects analysis to explore how two modeling rules and one input parameter affect the results of the SBM.

Methods

As with the analysis of alternatives, the effects analysis uses the relative change in the response variables, but only includes one scenario. Alt06 was chosen because it consistently showed the largest difference from existing conditions in the analysis of alternatives. If the effects analysis shows a change in the results for Alt06, then we might expect a smaller magnitude change for the other alternatives.

We focused the effects analysis on components of the model with the highest uncertainty and largest potential impact on the analysis of alternatives. In the next few sections, we will briefly describe the model rule used in the analysis of alternatives, which is described in detail in the Model Documentation above, and then we will describe in detail the other rules included in the effects analysis.

Entrainment Rules

As a default entrainment rule, we assumed that fish are entrained into the Yolo Bypass in the same proportion as flow. The flow proportion entering the Yolo Bypass is based on the combined flow overtopping Fremont Weir and through the notch. We contrasted the default entrainment rule with a rule based on detailed modeling of fish movement behavior at proposed notches using the Eulerian-Langrangian-Agent-Method (ELAM; Goodwin et al. 2006). We were provided with ELAM output (Dave Smith, *unpublished data*) of the proportion of fish entrained for one of the early proposed notch designs (but not a notch design included in the SBM analysis) and fitted a four-parameter logistic equation to the output (Figure 15).

$$P_{YB} = D + \left(\frac{A-D}{1+\left(\frac{Q_{Notch}}{C}\right)^{B}}\right) \quad \text{(Eq. 9)}$$

where P_{YB} is the proportion of flow entering the Yolo Bypass, Q_{Notch} is the flow through the notch, A (0.0091) is the value of P_{YB} when Q_{Notch} is zero, B (73.9) is the slope factor, C (1978) is the inflection point, and D (0.0761) is the asymptotic value of P_{YB}. [Note, fitted values for A, B, C, and D are given in parentheses.]

The ELAM entrainment rule only applies to flow through the notch. On any day where flow is overtopping Fremont Weir, the proportional flow rule is applied to both overtopping and notch flows. The ELAM rule predicts $P_{YB} = 0.0091$ when $Q_{Notch} = 0$, but we set $P_{YB} = 0$ when $Q_{Notch} = 0$.

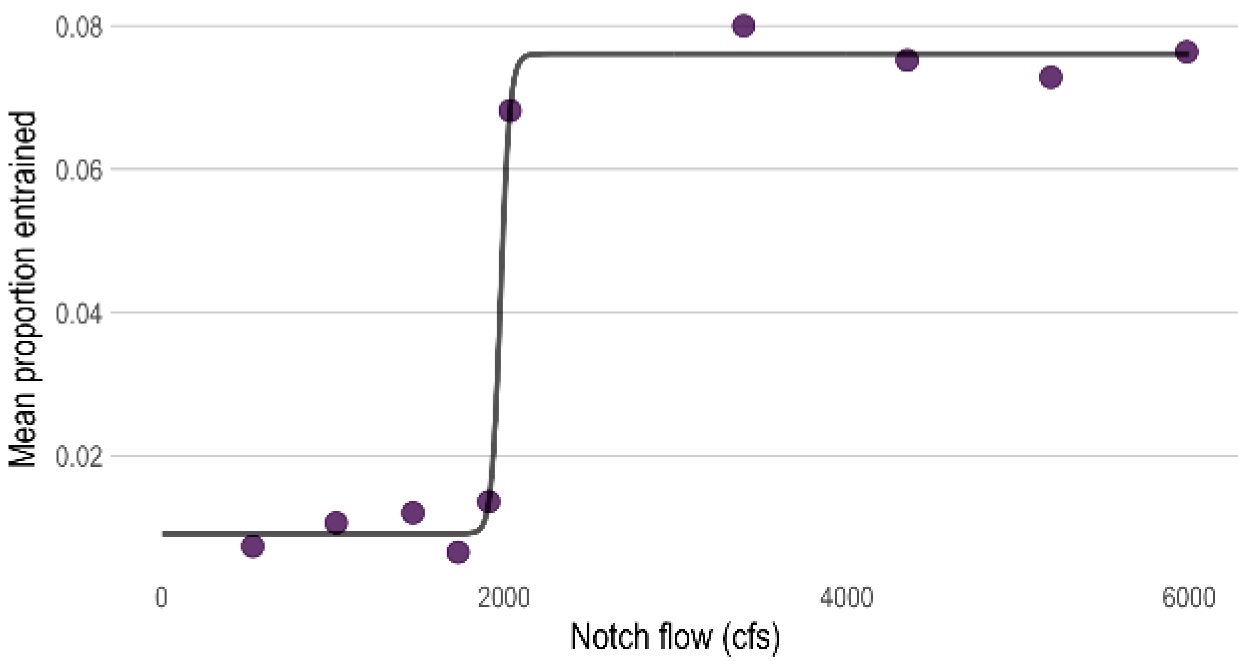

Figure 15. ELAM entrainment rule. Points represent output from Eulerian-Langrangian-Agent-Method (ELAM) analysis of potential entrainment at one of proposed notches in Fremont Weir. The line is a 4-parameter logistic curve fitted to the ELAM output.

Rearing Rules

The default rearing rules are based on temperature and flow. The temperature rule was simply a critical date (June 1st) when temperatures in the Yolo Bypass were likely to be too warm for floodplain rearing. The flow rearing rule uses flow in the Sacramento River above Fremont Weir to decide about rearing. If the current flow is greater than the flow 31 days ago, then fish will start (or continue) rearing. If the current flow is less than the flow 31 days ago, then fish will stop rearing and resume migration through the Canal Complex. Because the temperature rule is also included in the other rearing rule (described below), the default rearing rule is referred to as the flow rearing rule.

The flow rearing rule was contrasted with a rule based on a threshold size and run-specific critical dates (size/date rule). Under the assumption that there is a theoretical maximum size when fish smoltification and resulting directed movement toward the ocean will occur, the largest Chinook salmon juvenile observed to be entering the ocean in recent years was used to determine a threshold size used to move fish off of the floodplain and back to the Canal Complex to resume downstream migration. The threshold fish size was based on the maximum size of Chinook salmon historically observed to emigrate out of the Central Valley. The maximum fork length of un-marked Chinook salmon observed migrating past Chipps Island in 2010 and 2011 was 120 mm (Speegle et al. 2013). Therefore, modeled fish move back to the Canal Complex and resume downstream migration once reaching a fork length of 120 mm.

One of the main seasonal triggers of smoltification and resulting downstream migration for salmonids is changes in photoperiod as the season progresses (Thorpe 1988). Because photoperiod is tied to time-of-year, a second migration trigger was applied (run timing trigger) that was based on the last dates that each run was observed passing Chipps Island during years 2007-2011 (USFWS 2010; USFWS 2012; Speegle et al. 2013). The last observed dates at Chipps Island were May 15 for winter-run, May 31 for spring-run, July 31 for fall-run, and February 15 for late-fall-run. Because run timing triggers needed to be applied for fish on the Bypass, these last migration dates at Chipps Island were backed-up to the top of the Yolo Bypass by applying the 2.5% quantile of the Canal Complex migration rate distribution (12.2 km/day). The resulting run timing triggers were set as May 7 for winter-run, May 23 for spring-run, July 23 for fall-run, and February 7 for late-fall-run. The critical date for fall-run is superseded by the critical date for temperature (June 1).

Rearing Survival

The default value of daily rearing survival is 0.99 based on an analysis (not shown) of floodplain growth and ocean survival that suggested that 0.99 is the minimum value of rearing survival to make rearing worthwhile, i.e., growth benefits outweigh survival costs of rearing. In the effects analysis, we evaluated two additional levels of rearing survival: 0.97 and 0.95. The levels are arbitrarily chosen to try to identify a value of a floodplain survival where adding a notch to Fremont Weir provides no fish benefits relative to existing conditions.

Results

We report results of the effects analysis for the same four metrics (juvenile survival, fork length, fork length variation, returning adults) described in the analysis of alternatives. We also include two additional metrics (entrainment and travel time) that are not metrics of fish benefits but provide additional information for understanding the fish benefits metrics.

Juvenile Entrainment into Yolo Bypass

The ELAM rule entrains fewer fish of all runs than the proportional rule (Figure 16). Note, the entrainment rule only affects the number of fish entrained, not the timing of entrainment.

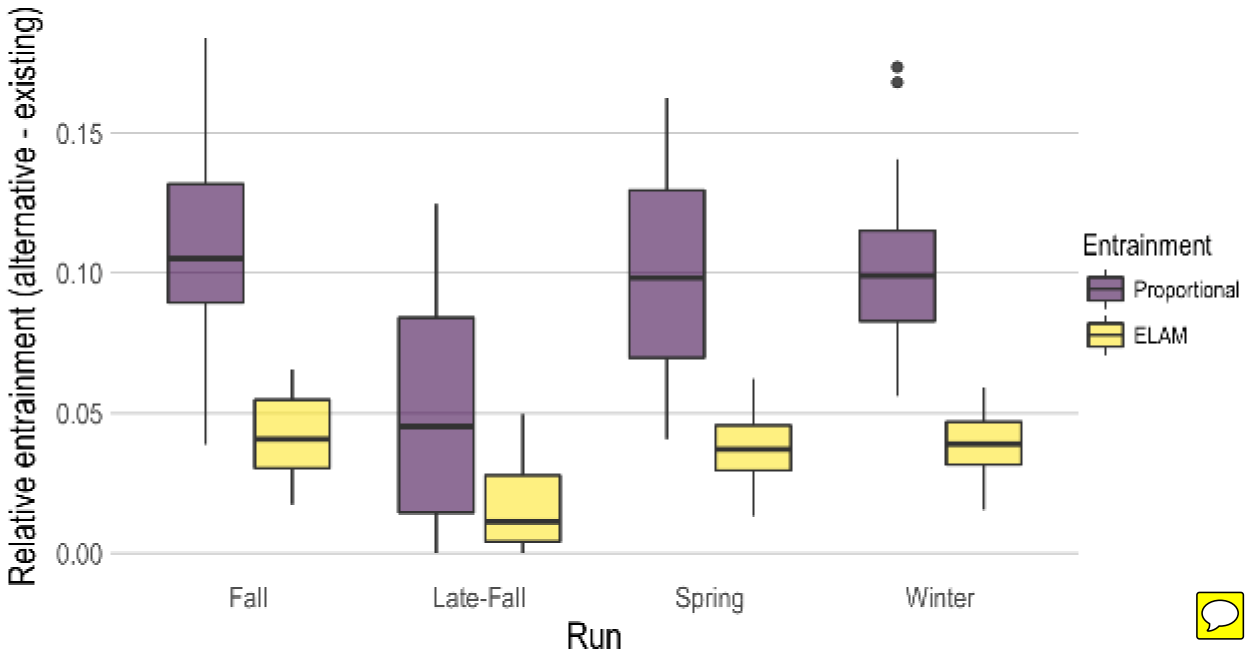

Figure 16. Relative proportion of fish entrained onto the Yolo Bypass for 15 years under two entrainment rules. Relative change not calculated for entrainment because several years where there was no entrainment under existing conditions (i.e., divide by zero error). The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively).

Juvenile Travel Time to Estuary Entry

Travel time is calculated as the mean travel time from Knights Landing to Chipps Island weighted by the abundance of fish in the cohort. For fish migrating through the Yolo Bypass route, travel time also includes time spent rearing. Travel times were longest at high rearing survival under the size/date rearing rule, particularly for fall- and spring-run fish (Figure 17). Fall- and spring-run fish enter the model at the smallest size and have the latest run-specific critical dates, and, thus, have the longest potential rearing times under the size/date rule. If rearing survival is high, more of the fish that spent a long time rearing on the floodplain make it to Chipps Island, which increases the mean travel time. The flow rearing rule produces shorter travel times under high rearing survival than the size/date rule because small spring- and fall-run fish are prompted to resume migration sooner. Under low rearing survival, travel times are slightly longer for the flow rule because the long rearing fish in the size/date rule do not survive to Chipps Island. The travel time patterns for fall-, spring-, and winter-run fish generally do not hold for late-fall fish because many late-fall fish enter the model above the 120 mm threshold and, thus do not rear on the floodplain under the size-date rule. The travel time patterns are similar between the two entrainment rules, but the ELAM rule reduces both the magnitude and variation in relative change in travel time because fewer fish enter the Yolo Bypass under the ELAM rule than under the proportional rule.

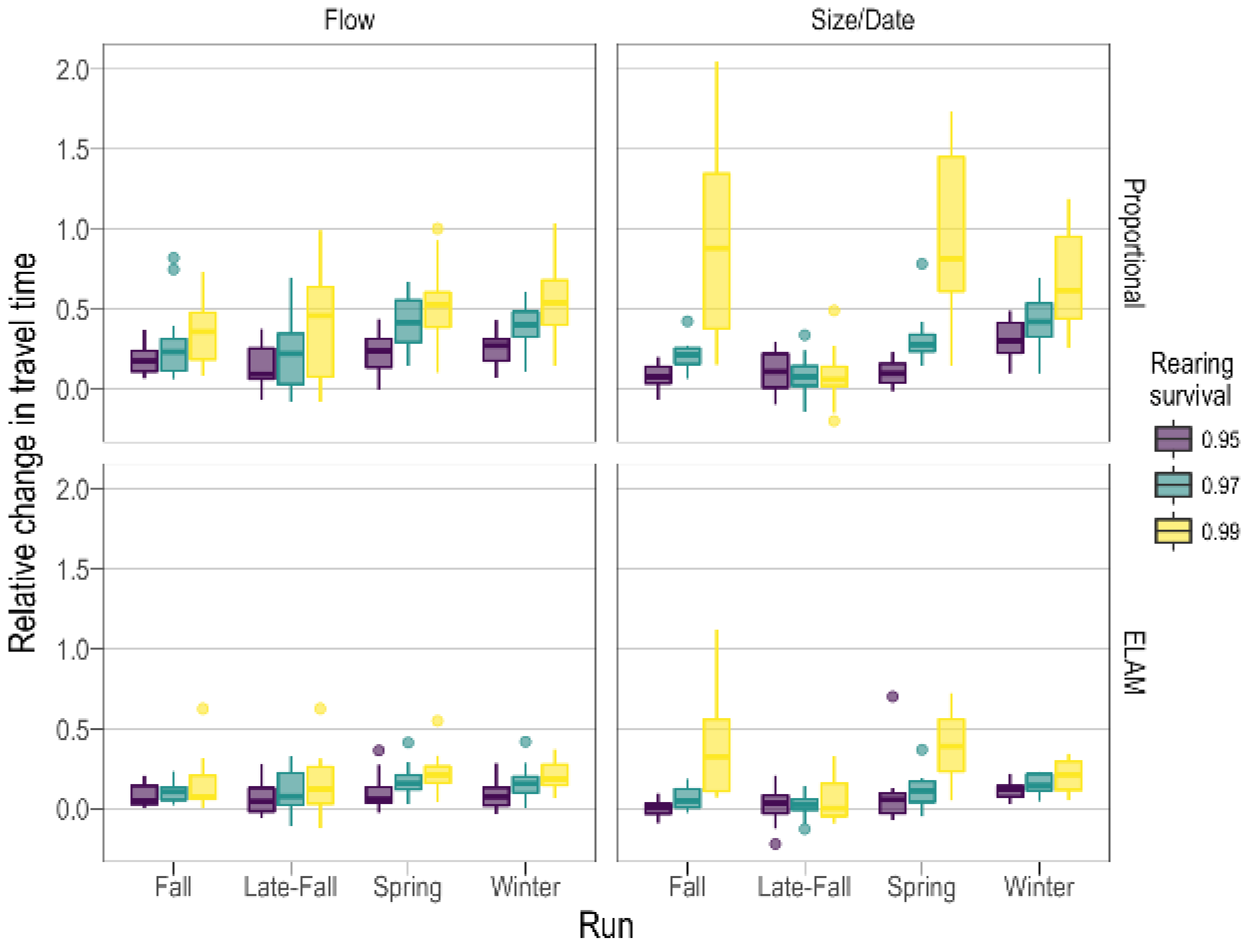

Figure 17. Relative change in mean travel time from Knights Landing to Chipps Island for 15 years under two entrainment rules (Proportional, ELAM), two rearing rules (Flow, Size/Date), and three levels of rearing survival (0.95, 0.97, 0.99). The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively).

Juvenile Survival to Estuary Entry

Juvenile survival is calculated as the proportion of fish that survive from Knights Landing to Chipps Island. Because floodplain rearing incurs a survival cost, factors that increase rearing behavior reduce juvenile survival in the model. Generally, the increased entrainment of fish onto the Yolo Bypass via a notch in Fremont Weir reduces juvenile survival relative to existing conditions (Figure 18). A key exception is the late-fall-run fish under the size/date rearing rule where relative change in juvenile survival is typically positive because most late-fall-run fish enter the model above the size threshold used in the size/date rule (i.e., they do not rear and incur the cost of rearing).

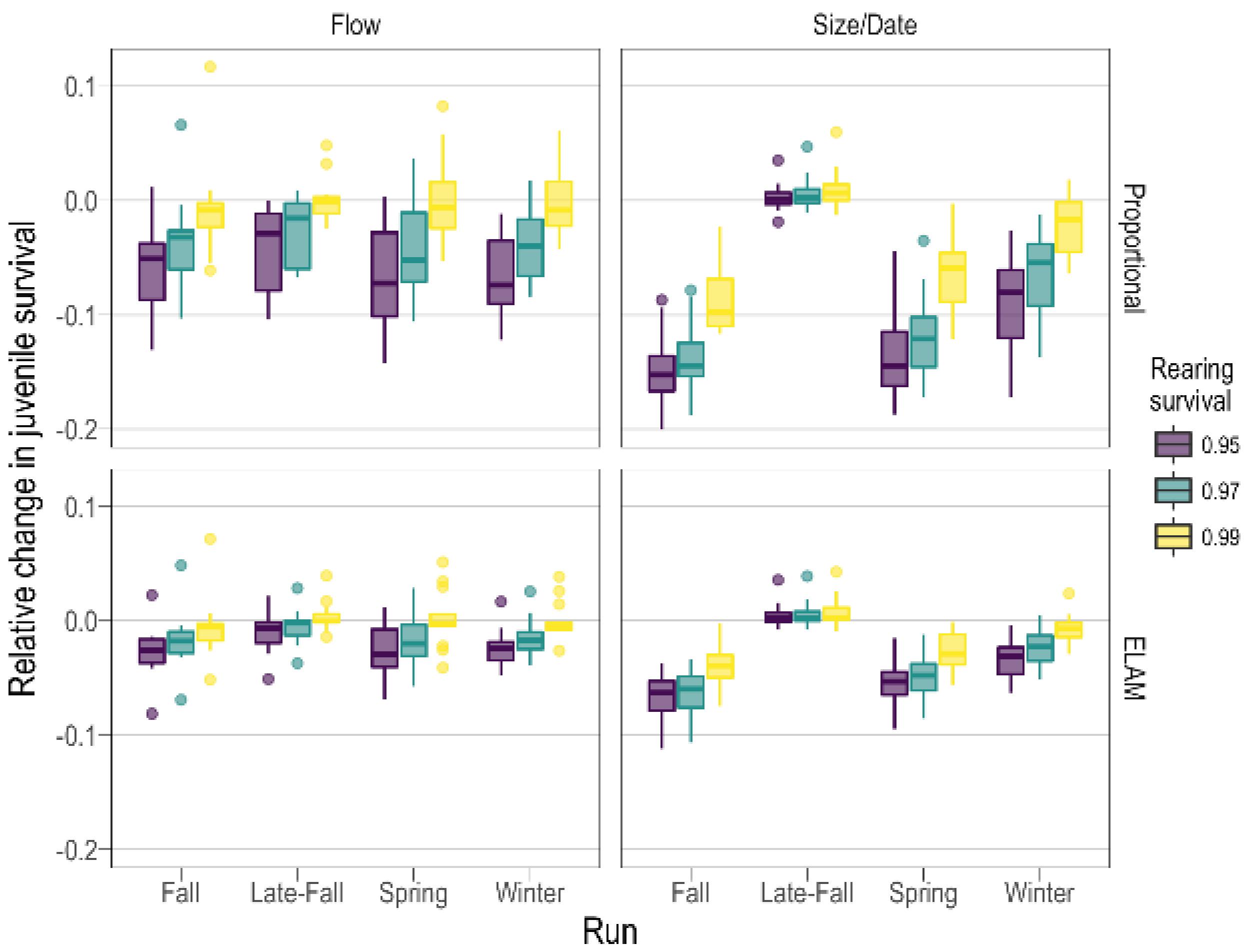

Figure 18. Relative change in juvenile survival from Knights Landing to Chipps Island for 15 years under two entrainment rules (Proportional, ELAM), two rearing rules (Flow, Size/Date), and three levels of rearing survival (0.95, 0.97, 0.99). The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively).

Juvenile Fork Length at Estuary Entry

Fork length is calculated as the mean fork length of all cohorts that arrive at Chipps Island weighted by the abundance of fish in the cohort. The patterns in the effects analysis of fork length (Figure 19) closely resemble the patterns observed for travel time (Figure 16). The underlying mechanisms that create the patterns in travel time (see Juvenile Travel Time) are the same as for fork length.

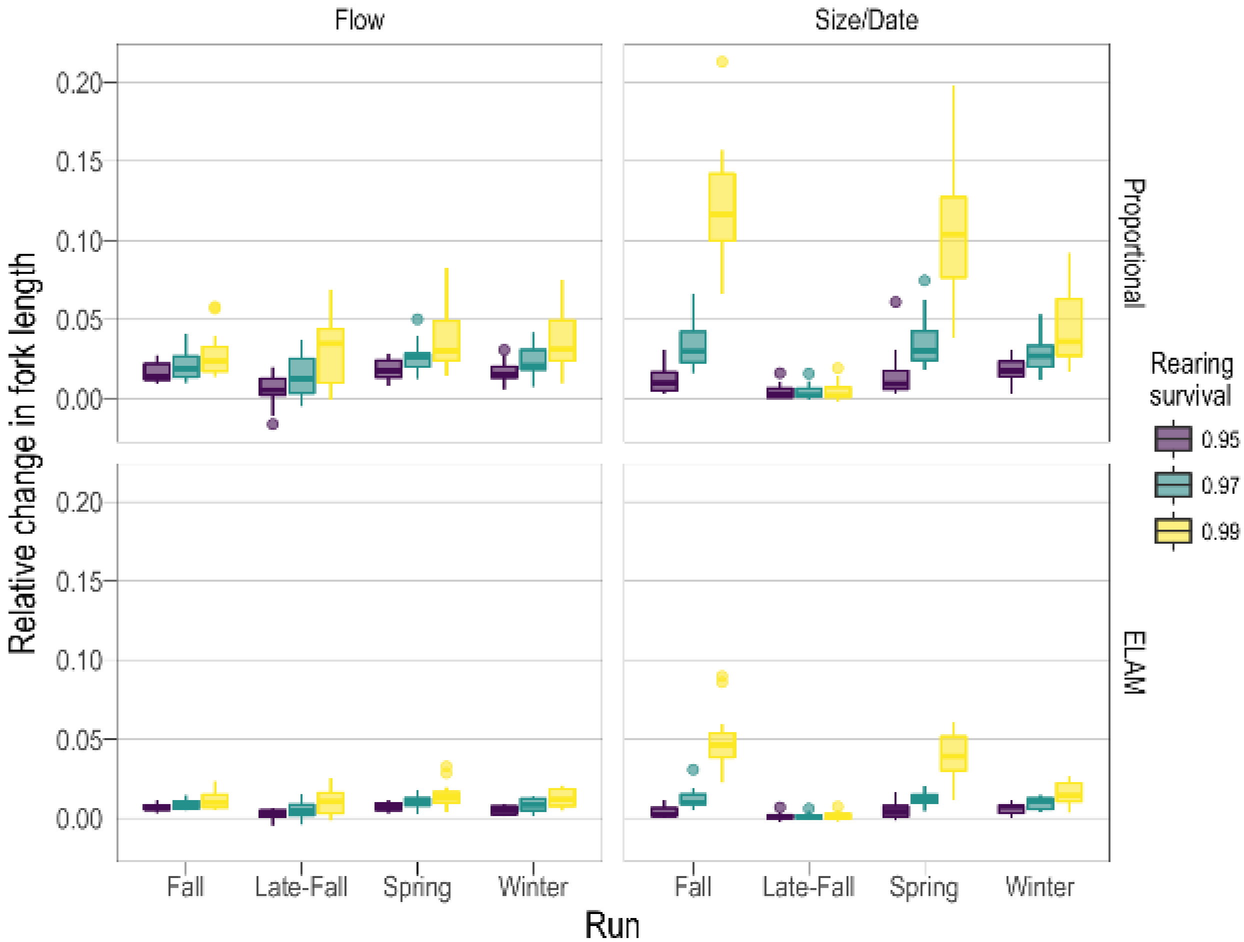

Figure 19. Relative change in mean fork length (mm) at Chipps Island for 15 years under two entrainment rules (Proportional, ELAM), two rearing rules (Flow, Size/Date), and three levels of rearing survival (0.95, 0.97, 0.99). The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively).

Juvenile Fork Length Variation at Estuary Entry

Fork length variation is calculated as the coefficient of variation in fork length of all cohorts that arrive at Chipps Island weighted by the abundance of fish in the cohort. Across most effects, runs, and years, fork length variation is higher under the alternative scenario than existing conditions (Figure 20). Late-fall-run fish show small relative change in fork length variation under the size/date rearing rule because most late-fall-run fish enter the model above the size threshold used in the size/date rule and do not rear on the floodplain. Relative change in fork length variation tends to be higher when rearing survival is higher and varies considerably from year to year.

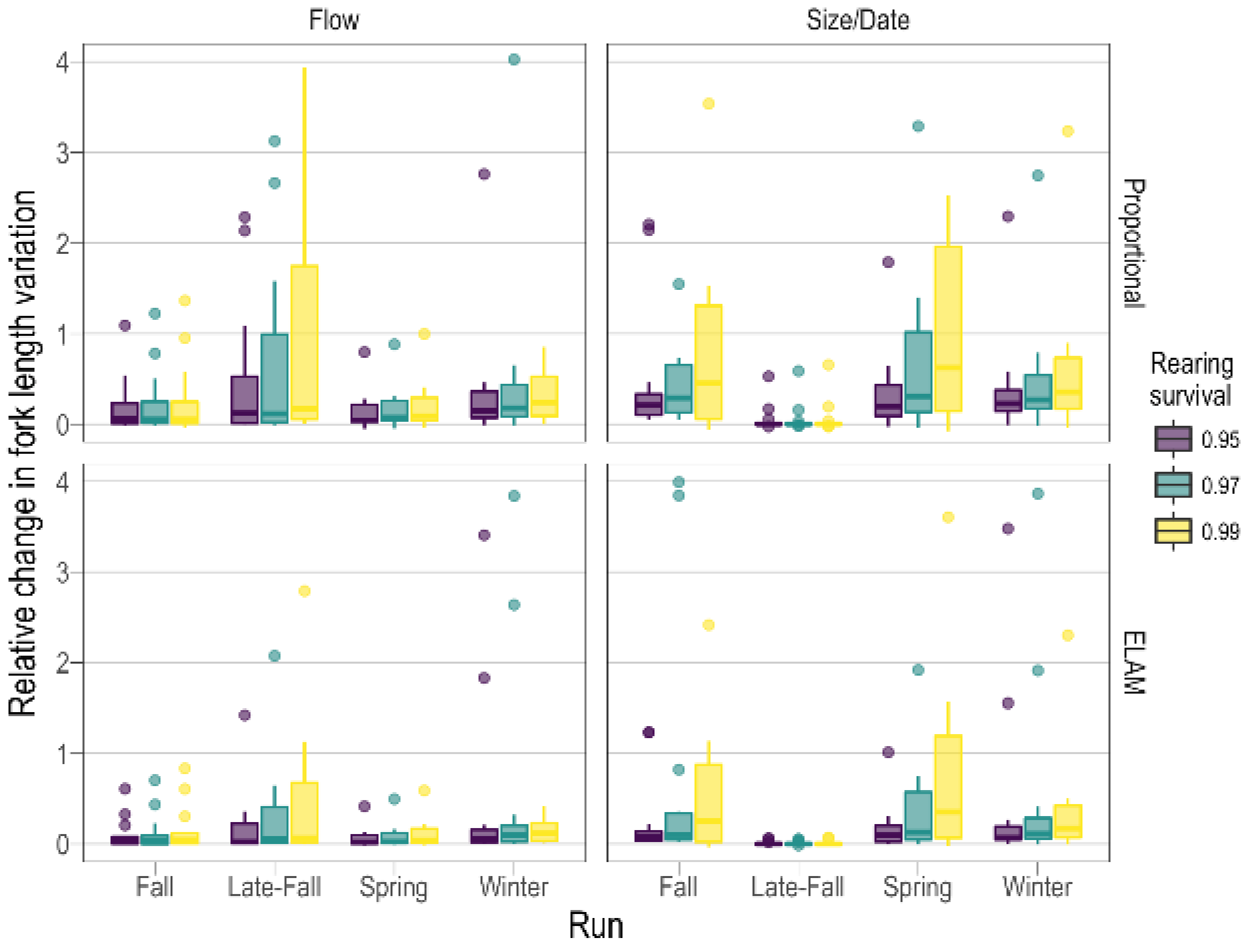

Figure 20. Relative coefficient of variation in fork length at Chipps Island for 15 years under two entrainment rules (Proportional, ELAM), two rearing rules (Flow, Size/Date), and three levels of rearing survival (0.95, 0.97, 0.99). The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively). Note, the y-axis has been truncated to exclude some outliers. The non-truncated figure is available upon request.

Returning Adults

The number of returning adults depends on both the number and size of fish that arrive at Chipps Island because the ocean survival relationship is a function of size. The returning adults metric shows the combined effect of the juvenile survival and fork length metrics. For all runs, except late-fall, a daily rearing survival of 0.99 is required for the potential benefits of increased floodplain access provided by the alternative scenario to outweigh the costs of additional time spent rearing (Figure 21). The effect of rearing survival on relative returning adults is strongest for fall-run fish under the size/date rearing rule. Across nearly all effects and years, late-full-run benefits from the presence of a notch in Fremont Weir, mostly because they enter the model at a large size, which carries benefits throughout the model (e.g., migration survival, growth, and ocean survival).

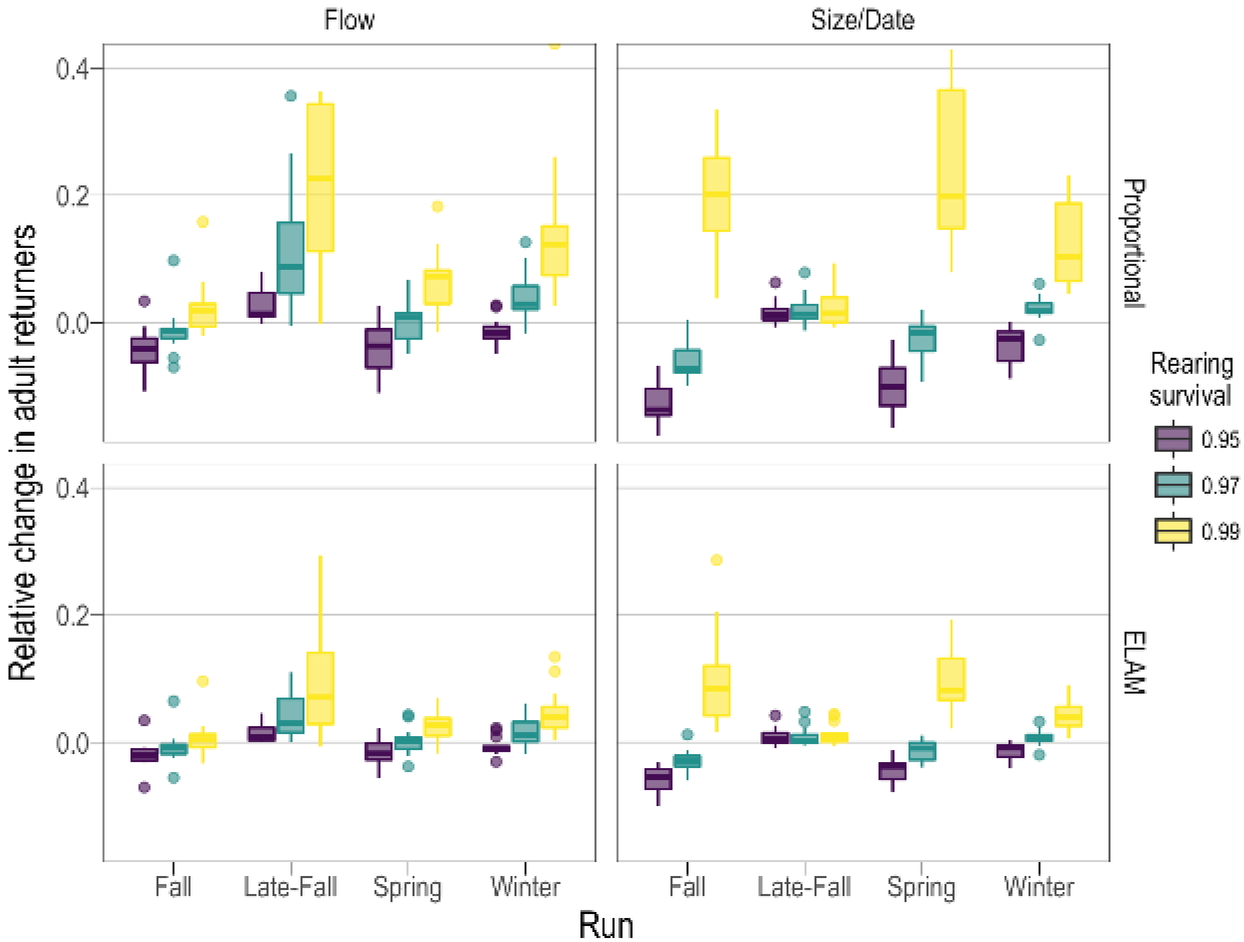

Figure 21. Relative number of returning adults for 15 years under two entrainment rules (Proportional, ELAM), two rearing rules (Flow, Size/Date), and three levels of rearing survival (0.95, 0.97, 0.99). The line near the center of the box is the median, the bottom and top of the box are the 25th and 75th percentiles, respectively, the whiskers show the min/max (unless there are outliers), and the points are outliers (+/- 1.5x interquartile from 75th and 25th percentile, respectively). Note, the y-axis has been truncated to exclude some outliers. The non-truncated figure is available upon request.

Conclusions

We examined the effect of two entrainment rules (Proportional, ELAM), two rearing rules (Flow, Size/Date), and three levels of rearing survival (0.95, 0.97, 0.99) on the results produced by the SBM. As in the Alternatives Analysis, we focus here on results of these model rules on fork length variation and returning adults. Fork length variation is our measure of trait variation that may reflect population resilience to changing ocean conditions from year to year. The number of returning adults measures the productivity of the population and incorporates the combined effects of juvenile growth and survival.

Fork length variation shows high inter-annual variation, but consistently indicates a benefit to the Alt06 notch relative to existing conditions. Alt06 provides access to the Yolo Bypass at lower flows than under existing conditions and, presumably, introduces variability in the accessibility of suitable rearing habitat for fish that, in turn, increases fork length variation at Chipps Island.

The Alt06 notch is beneficial under all effects examined for late-fall-run fish, which benefit greatly from entering the model at a large size. For the other runs, rearing survival is the key factor in determining the benefit of Alt06; at a value of 0.95, rearing survival on the floodplain is too low to yield a benefit to implementing the Alt06 notch. Because Alt06 exhibited the biggest differences in the Alternatives Analysis, we might expect that the other notches (Alt01, Alt04, Alt04b, Alt05) would not yield a benefit at a rearing survival of 0.95 or 0.97.

All of the effects examined have the potential to influence the Alternatives Analysis, but there is a particularly strong interactive effect of the rearing rule and rearing survival value. We suggest that both should be targets for additional study, but recognize the challenges in the design of such studies. For example, acoustic telemetry studies can estimate survival from release at the top of the Yolo Bypass to arrival at Chipps Island, but those studies are not able to partition survival into migrating and rearing components. Using net pens to study fish on the floodplain can provide estimates of rearing survival, but those estimates are probably lower bounds on actual rearing survival because the pens constrain the ability to evade predators, find more suitable habitat, etc.

While studies that directly inform modeling rules and parameters are ideal, it is also useful to design studies that provide data to calibrate or validate the model. For example, median survival from Fremont Weir to Chipps Island through the Yolo Bypass was less than 5% for spring- and fall-run under the size/date rule and rearing survival of 0.95. There are no studies of fall- and spring-run survival through the Yolo Bypass, but it seems improbable that overall survival is so low for those runs, which suggests that either 0.95 is too low of a value for rearing survival or the size/date rule does not adequately capture rearing behavior (or both).

The two rearing rules examined in this effects analysis represent different modeling approaches. The size/date rule limits rearing behavior by placing constraints on rearing that do not change from year to year. The flow rule allows fish to respond to changing conditions. Because the SBM is not an optimality model, some combinations of the rearing rules and rearing survival potentially yield sub-optimal behavior (e.g., if goal is to optimize probability of returning as an adult).

An earlier version of the SBM identified entrainment as the key factor in maximizing fish benefits from a notch in the Fremont Weir. That version of the model was parameterized such that fish did not incur a survival cost for rearing. Thus, more time spent rearing yielded the benefit of increased growth without the cost of increased mortality. That earlier model also suggested that suitable habitat on the Yolo Bypass, based on depth and velocity, was not often limiting. The combination of high rearing survival and abundant suitable habitat meant that the limiting factor was entrainment onto the Yolo Bypass. If the current version of the model is underestimating rearing survival, or implementing sub-optimal rearing rules, then the importance of entrainment for fish benefits may be underestimated. As it is, fish benefits were reduced under the lower entrainment experienced with the ELAM entrainment rule.

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APPENDIX A: ALTERNATIVES ANALYSIS

Tables of Salmon Benefits Metrics

Table A-1. Juvenile survival from Knights Landing to Chipps Island under existing conditions (Exg) and five alternative scenarios for notches in Fremont Weir.

Run	Water Year	Exg	Alt01	Alt04	Alt04b	Alt05	Alt06
Fall	1997	0.285	0.285	0.285	0.285	0.285	0.284
Fall	1998	0.653	0.650	0.652	0.651	0.651	0.649
Fall	1999	0.433	0.431	0.432	0.432	0.431	0.429
Fall	2000	0.614	0.610	0.611	0.611	0.610	0.608
Fall	2001	0.037	0.040	0.039	0.038	0.039	0.041
Fall	2002	0.104	0.103	0.104	0.104	0.104	0.102
Fall	2003	0.565	0.562	0.563	0.563	0.561	0.561
Fall	2004	0.280	0.280	0.281	0.281	0.281	0.280
Fall	2005	0.086	0.084	0.085	0.085	0.084	0.083
Fall	2006	0.759	0.754	0.756	0.755	0.753	0.749
Fall	2007	0.024	0.023	0.023	0.023	0.023	0.023
Fall	2008	0.100	0.101	0.101	0.101	0.101	0.101
Fall	2009	0.286	0.285	0.283	0.281	0.281	0.287
Fall	2010	0.452	0.439	0.444	0.444	0.444	0.428
Fall	2011	0.359	0.355	0.359	0.359	0.361	0.349
Late-Fall	1997	0.838	0.824	0.828	0.828	0.825	0.817
Late-Fall	1998	0.366	0.367	0.367	0.367	0.367	0.368
Late-Fall	1999	0.326	0.324	0.325	0.325	0.325	0.324
Late-Fall	2000	0.385	0.379	0.381	0.381	0.380	0.378
Late-Fall	2001	0.098	0.098	0.098	0.098	0.098	0.098
Late-Fall	2002	0.402	0.403	0.403	0.403	0.403	0.404
Late-Fall	2003	0.714	0.708	0.709	0.709	0.708	0.703
Late-Fall	2004	0.416	0.420	0.420	0.420	0.420	0.436
Late-Fall	2005	0.259	0.259	0.259	0.258	0.257	0.259
Late-Fall	2006	0.715	0.715	0.714	0.714	0.712	0.714
Late-Fall	2007	0.086	0.087	0.087	0.087	0.087	0.089
Late-Fall	2008	0.395	0.390	0.390	0.390	0.390	0.387
Late-Fall	2009	0.104	0.104	0.104	0.104	0.104	0.104
Late-Fall	2010	0.076	0.076	0.076	0.076	0.076	0.076
Late-Fall	2011	0.422	0.423	0.423	0.423	0.420	0.422
Spring	1997	0.564	0.552	0.555	0.556	0.549	0.547

Spring	1998	0.199	0.199	0.199	0.199	0.199	0.200
Spring	1999	0.311	0.309	0.310	0.310	0.309	0.306
Spring	2000	0.373	0.372	0.372	0.372	0.372	0.371
Spring	2001	0.066	0.068	0.068	0.067	0.068	0.070
Spring	2002	0.114	0.119	0.119	0.119	0.120	0.124
Spring	2003	0.567	0.564	0.563	0.563	0.559	0.561
Spring	2004	0.186	0.189	0.189	0.189	0.189	0.195
Spring	2005	0.141	0.136	0.138	0.138	0.138	0.135
Spring	2006	0.512	0.505	0.507	0.507	0.501	0.502
Spring	2007	0.034	0.032	0.033	0.033	0.033	0.032
Spring	2008	0.057	0.058	0.058	0.058	0.058	0.059
Spring	2009	0.188	0.187	0.187	0.187	0.187	0.189
Spring	2010	0.564	0.548	0.554	0.555	0.555	0.535
Spring	2011	0.424	0.427	0.428	0.426	0.426	0.428
Winter	1997	0.580	0.572	0.574	0.574	0.572	0.567
Winter	1998	0.199	0.200	0.200	0.200	0.200	0.201
Winter	1999	0.508	0.503	0.507	0.507	0.505	0.499
Winter	2000	0.748	0.736	0.739	0.739	0.739	0.730
Winter	2001	0.176	0.179	0.178	0.176	0.178	0.180
Winter	2002	0.234	0.234	0.235	0.235	0.236	0.234
Winter	2003	0.774	0.767	0.768	0.768	0.766	0.761
Winter	2004	0.253	0.257	0.258	0.258	0.258	0.269
Winter	2005	0.210	0.203	0.206	0.205	0.205	0.201
Winter	2006	0.424	0.418	0.420	0.420	0.417	0.414
Winter	2007	0.042	0.042	0.042	0.042	0.042	0.043
Winter	2008	0.194	0.194	0.194	0.194	0.194	0.195
Winter	2009	0.428	0.425	0.425	0.424	0.425	0.424
Winter	2010	0.666	0.658	0.661	0.661	0.661	0.650
Winter	2011	0.410	0.416	0.415	0.415	0.413	0.420

Table A-2. Mean fork length (mm) at Chipps Island under existing conditions (Exg) and five alternative scenarios for notches in Fremont Weir.

Run	Water Year	Exg	Alt01	Alt04	Alt04b	Alt05	Alt06
Fall	1997	43.3	43.7	43.5	43.4	43.5	44.0
Fall	1998	45.9	46.6	46.3	46.3	46.3	47.0
Fall	1999	41.3	43.0	42.3	42.2	42.4	43.7
Fall	2000	40.0	41.4	41.2	41.2	41.2	42.3
Fall	2001	40.5	41.3	41.3	41.4	41.4	41.9
Fall	2002	37.6	37.9	37.8	37.8	37.8	38.1
Fall	2003	38.2	38.8	38.6	38.6	38.6	39.1
Fall	2004	40.5	40.9	40.8	40.8	40.8	41.2
Fall	2005	45.0	45.5	45.4	45.4	45.5	46.0
Fall	2006	44.9	45.4	45.2	45.2	45.2	45.7
Fall	2007	39.5	40.4	40.3	40.2	40.4	41.0
Fall	2008	39.2	39.5	39.5	39.6	39.6	39.8
Fall	2009	40.1	40.8	40.6	40.6	40.6	41.1
Fall	2010	41.9	42.6	42.4	42.4	42.4	43.2
Fall	2011	45.4	45.8	45.7	45.5	45.5	46.2
Late-Fall	1997	140.9	144.8	143.4	143.4	144.2	146.7
Late-Fall	1998	116.7	117.3	117.2	117.1	117.0	117.9
Late-Fall	1999	117.0	122.2	120.4	120.4	120.8	124.7
Late-Fall	2000	142.8	147.4	146.4	146.3	146.8	150.3
Late-Fall	2001	136.9	139.4	139.5	139.6	139.5	142.3
Late-Fall	2002	119.7	120.8	120.9	121.1	121.1	122.5
Late-Fall	2003	81.0	82.6	82.3	82.3	82.3	83.8
Late-Fall	2004	113.4	115.1	115.1	115.1	115.2	117.6
Late-Fall	2005	45.8	45.8	45.8	45.8	45.8	45.8
Late-Fall	2006	43.1	43.3	43.2	43.3	43.2	43.4
Late-Fall	2007	112.5	113.8	114.0	113.9	113.9	115.5
Late-Fall	2008	138.3	142.0	141.6	141.7	142.3	144.8
Late-Fall	2009	153.1	153.0	153.0	153.2	153.1	153.0
Late-Fall	2010	123.0	123.1	123.4	122.9	123.0	123.7
Late-Fall	2011	98.8	102.6	101.2	101.2	101.6	105.6
Spring	1997	41.6	43.7	43.0	42.9	43.1	45.0
Spring	1998	55.4	55.8	55.5	55.5	55.8	56.2
Spring	1999	46.7	48.4	47.8	47.8	47.9	49.3
Spring	2000	64.1	65.8	65.3	65.4	65.5	66.7

Spring	2001	67.2	68.2	68.1	68.2	68.2	68.9
Spring	2002	43.0	43.8	43.8	43.8	43.9	44.4
Spring	2003	40.7	42.3	41.9	41.9	41.9	43.3
Spring	2004	46.8	47.4	47.4	47.4	47.4	47.9
Spring	2005	57.8	58.7	58.3	58.4	58.5	59.2
Spring	2006	56.1	58.1	57.6	57.6	58.1	59.4
Spring	2007	57.8	59.1	58.8	58.9	59.0	59.9
Spring	2008	52.9	53.5	53.5	53.5	53.6	54.0
Spring	2009	64.9	65.9	65.7	65.7	65.8	66.5
Spring	2010	50.1	51.0	50.7	50.7	50.7	51.6
Spring	2011	69.2	69.7	69.6	69.5	69.6	70.2
Winter	1997	102.3	105.0	104.1	104.1	104.3	106.8
Winter	1998	104.1	104.6	104.5	104.5	104.6	105.1
Winter	1999	83.1	87.2	85.7	85.7	86.1	89.3
Winter	2000	109.7	113.3	112.4	112.5	112.6	115.2
Winter	2001	98.3	99.9	100.0	100.0	100.0	102.2
Winter	2002	78.2	78.9	78.9	78.9	79.0	79.4
Winter	2003	78.3	80.6	80.0	80.0	80.0	82.2
Winter	2004	77.1	78.2	78.2	78.2	78.3	79.5
Winter	2005	85.5	86.9	86.5	86.5	86.6	87.8
Winter	2006	79.2	81.4	81.0	81.0	81.2	83.0
Winter	2007	82.4	83.4	83.3	83.3	83.4	84.2
Winter	2008	93.7	94.8	94.8	94.8	95.0	95.8
Winter	2009	103.0	104.7	104.3	104.5	104.1	105.6
Winter	2010	105.4	106.9	106.4	106.3	106.4	108.2
Winter	2011	78.4	81.1	80.2	80.3	80.4	82.6

Table A-3. Coefficient of variation in fork length at Chipps Island under existing conditions (Exg) and five alternative scenarios for notches in Fremont Weir.

Run	Water Year	Exg	Alt01	Alt04	Alt04b	Alt05	Alt06
Fall	1997	0.152	0.154	0.154	0.153	0.154	0.155
Fall	1998	0.196	0.199	0.198	0.197	0.198	0.200
Fall	1999	0.137	0.169	0.159	0.158	0.163	0.177
Fall	2000	0.108	0.153	0.147	0.147	0.150	0.171
Fall	2001	0.193	0.192	0.193	0.196	0.193	0.192
Fall	2002	0.110	0.114	0.112	0.113	0.113	0.115
Fall	2003	0.146	0.155	0.152	0.152	0.152	0.159
Fall	2004	0.097	0.106	0.103	0.104	0.105	0.112
Fall	2005	0.331	0.328	0.329	0.329	0.330	0.326
Fall	2006	0.266	0.268	0.267	0.268	0.267	0.270
Fall	2007	0.117	0.136	0.133	0.133	0.134	0.141
Fall	2008	0.028	0.048	0.046	0.048	0.048	0.055
Fall	2009	0.028	0.058	0.054	0.054	0.055	0.067
Fall	2010	0.258	0.260	0.258	0.258	0.259	0.259
Fall	2011	0.186	0.183	0.186	0.185	0.187	0.178
Late-Fall	1997	0.154	0.175	0.168	0.168	0.170	0.180
Late-Fall	1998	0.546	0.547	0.547	0.546	0.546	0.548
Late-Fall	1999	0.162	0.251	0.223	0.223	0.231	0.274
Late-Fall	2000	0.062	0.157	0.144	0.143	0.149	0.191
Late-Fall	2001	0.090	0.169	0.168	0.168	0.166	0.215
Late-Fall	2002	0.094	0.113	0.117	0.116	0.117	0.134
Late-Fall	2003	0.547	0.572	0.568	0.568	0.568	0.589
Late-Fall	2004	0.038	0.085	0.090	0.091	0.090	0.125
Late-Fall	2005	0.580	0.594	0.590	0.591	0.592	0.600
Late-Fall	2006	0.535	0.557	0.556	0.552	0.557	0.575
Late-Fall	2007	0.021	0.056	0.062	0.063	0.062	0.086
Late-Fall	2008	0.026	0.104	0.100	0.101	0.107	0.128
Late-Fall	2009	0.089	0.089	0.090	0.089	0.089	0.089
Late-Fall	2010	0.377	0.379	0.378	0.377	0.379	0.383
Late-Fall	2011	0.368	0.397	0.389	0.389	0.393	0.403
Spring	1997	0.229	0.256	0.252	0.250	0.250	0.264
Spring	1998	0.194	0.198	0.194	0.195	0.196	0.200
Spring	1999	0.356	0.377	0.372	0.371	0.374	0.384

Spring	2000	0.161	0.172	0.170	0.171	0.169	0.176
Spring	2001	0.079	0.090	0.090	0.091	0.091	0.097
Spring	2002	0.161	0.166	0.165	0.164	0.166	0.169
Spring	2003	0.137	0.178	0.170	0.170	0.171	0.194
Spring	2004	0.243	0.240	0.240	0.241	0.241	0.239
Spring	2005	0.287	0.280	0.281	0.281	0.281	0.275
Spring	2006	0.337	0.382	0.369	0.370	0.377	0.397
Spring	2007	0.095	0.119	0.115	0.115	0.118	0.129
Spring	2008	0.102	0.105	0.105	0.106	0.106	0.107
Spring	2009	0.034	0.060	0.056	0.055	0.056	0.067
Spring	2010	0.079	0.099	0.095	0.094	0.094	0.109
Spring	2011	0.336	0.328	0.335	0.333	0.334	0.321
Winter	1997	0.186	0.193	0.192	0.191	0.192	0.197
Winter	1998	0.243	0.243	0.243	0.244	0.242	0.242
Winter	1999	0.197	0.271	0.246	0.246	0.252	0.292
Winter	2000	0.105	0.142	0.134	0.135	0.137	0.154
Winter	2001	0.019	0.090	0.094	0.094	0.097	0.132
Winter	2002	0.144	0.149	0.149	0.151	0.150	0.153
Winter	2003	0.080	0.129	0.121	0.123	0.122	0.149
Winter	2004	0.154	0.162	0.164	0.163	0.164	0.174
Winter	2005	0.084	0.099	0.096	0.096	0.096	0.105
Winter	2006	0.186	0.201	0.198	0.198	0.200	0.208
Winter	2007	0.126	0.147	0.143	0.142	0.145	0.154
Winter	2008	0.073	0.088	0.087	0.088	0.089	0.097
Winter	2009	0.008	0.051	0.047	0.045	0.048	0.061
Winter	2010	0.067	0.089	0.082	0.081	0.081	0.104
Winter	2011	0.182	0.190	0.187	0.186	0.188	0.191

Table A-4. Number of adults returners under existing conditions (Exg) and five alternative scenarios for notches in Fremont Weir.

Run	Water Year	Exg	Alt01	Alt04	Alt04b	Alt05	Alt06
Fall	1997	76,731	77,350	77,120	76,973	76,956	77,909
Fall	1998	235,484	239,159	237,349	237,035	237,547	241,365
Fall	1999	69,552	72,826	71,536	71,508	71,641	74,029
Fall	2000	188,286	195,533	194,572	194,397	194,443	199,989
Fall	2001	11,767	12,853	12,743	12,332	12,820	13,626
Fall	2002	40,678	40,622	40,946	40,921	41,136	40,426
Fall	2003	355,165	359,728	358,371	358,244	356,768	361,933
Fall	2004	104,791	105,875	105,814	105,964	105,949	106,863
Fall	2005	23,790	23,461	23,635	23,650	23,538	23,375
Fall	2006	276,093	277,922	276,944	277,050	276,362	278,326
Fall	2007	5,493	5,420	5,413	5,407	5,425	5,387
Fall	2008	7,065	7,164	7,164	7,163	7,167	7,236
Fall	2009	16,771	17,055	16,841	16,716	16,764	17,339
Fall	2010	18,151	17,953	18,040	18,056	18,070	17,772
Fall	2011	50,263	50,341	50,633	50,471	50,799	49,962
Late-Fall	1997	17,181	19,973	18,940	18,963	19,387	21,055
Late-Fall	1998	36,237	37,394	37,225	36,854	36,870	38,588
Late-Fall	1999	106,644	180,022	152,128	152,408	158,743	211,036
Late-Fall	2000	81,604	117,017	110,088	109,378	112,930	141,958
Late-Fall	2001	15,058	21,678	21,533	21,568	21,307	28,309
Late-Fall	2002	67,330	71,399	72,194	72,455	72,470	77,415
Late-Fall	2003	167,774	191,451	188,168	187,963	188,506	211,765
Late-Fall	2004	29,526	32,243	32,476	32,521	32,514	37,574
Late-Fall	2005	7,040	7,430	7,305	7,284	7,273	7,568
Late-Fall	2006	19,897	21,499	21,388	21,339	21,367	22,942
Late-Fall	2007	8,707	9,206	9,276	9,270	9,274	10,048
Late-Fall	2008	62,785	74,524	73,412	73,646	75,439	83,073
Late-Fall	2009	19,557	19,533	19,561	19,652	19,581	19,505
Late-Fall	2010	9,062	9,224	9,236	9,074	9,202	9,530
Late-Fall	2011	24,366	29,803	27,946	27,918	28,474	33,228
Spring	1997	1,328	1,390	1,369	1,365	1,355	1,429
Spring	1998	360	366	362	362	364	371
Spring	1999	7,960	8,452	8,274	8,291	8,318	8,637

Spring	2000	3,583	3,750	3,706	3,710	3,716	3,850
Spring	2001	586	622	620	607	623	652
Spring	2002	1,344	1,431	1,431	1,431	1,438	1,511
Spring	2003	6,137	6,413	6,338	6,339	6,298	6,584
Spring	2004	1,639	1,693	1,690	1,693	1,695	1,769
Spring	2005	1,911	1,888	1,896	1,896	1,895	1,882
Spring	2006	10,385	11,594	11,262	11,293	11,429	12,276
Spring	2007	352	354	353	353	354	357
Spring	2008	446	460	458	459	461	471
Spring	2009	1,310	1,347	1,337	1,337	1,336	1,378
Spring	2010	1,506	1,500	1,506	1,507	1,507	1,491
Spring	2011	1,637	1,664	1,671	1,660	1,665	1,683
Winter	1997	1,997	2,146	2,098	2,091	2,100	2,243
Winter	1998	657	670	667	670	668	683
Winter	1999	3,115	4,051	3,704	3,708	3,786	4,480
Winter	2000	9,431	10,711	10,384	10,446	10,481	11,363
Winter	2001	651	724	725	717	728	820
Winter	2002	3,300	3,374	3,397	3,402	3,413	3,428
Winter	2003	9,633	10,412	10,219	10,235	10,182	10,931
Winter	2004	3,517	3,686	3,706	3,699	3,716	4,035
Winter	2005	3,334	3,370	3,372	3,368	3,367	3,420
Winter	2006	12,387	13,316	13,135	13,137	13,195	13,933
Winter	2007	1,373	1,431	1,425	1,424	1,434	1,507
Winter	2008	1,220	1,266	1,262	1,264	1,272	1,311
Winter	2009	3,737	3,915	3,876	3,878	3,855	4,016
Winter	2010	10,071	10,501	10,354	10,344	10,368	10,879
Winter	2011	1,189	1,305	1,268	1,267	1,271	1,374

J.W DE WIT FARMS, INC.
44718 South El Macero Drive
Davis, CA. 95618

February 12, 2018

Mr. Oscar Villegas
Chair, Yolo County Board of Supervisors
625 Court Street, #204
Woodland, CA 95695

Chair Villegas:

On behalf of DeWit Farms, I'm writing to thank Yolo County for your work to protect the interests of Yolo Bypass farmers from the potential impacts of the proposed Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project). We know it as a result of your work that the Public Review Draft of the EIS/EIR for this Project contains an end date to inundation for each alternative of either March 7th or March 15th. I am writing today to express additional concerns I have with the proposed Project in the hope that Yolo County will include these concerns in their comments on the Project.

DeWit Farms produces rice and wild rice on over 5,000 acres in the Sacramento Valley, including 4,000 acres in the Yolo Bypass. We have been farming rice on the Yolo Bypass Wildlife Area since 1998. DeWit Farms' lease payments provide revenue for the operations and maintenance of the Yolo Bypass Wildlife Area. I have also personally led numerous field trips and tours to teach government agency staff, children, and adults about the benefits of wildlife-friendly farming. The existing system of farming and wetlands in the Yolo Bypass Wildlife Area represents decades of careful work to achieve a balance that works both for waterfowl, shore birds and for agriculture.

Often the water supply system must be repaired after prolonged flooding. Farming in the Yolo Bypass is risky and requires specialized expertise. There are few alternatives to the cultivation of rice in the Yolo Bypass because of the hard, clay soil the drainage and water supply infrastructure required for rice farming. If flooding occurs too late in the Bypass, we can switch to wild rice (which has a shorter growing season) only on a limited number of acres. Because of contract restrictions (demand for wild rice is limited) and the extensive preparation required for cultivation of wild rice, such as placing seeds in storage the year before planting. The additional risk placed on rice farming from the proposed Project will make it more difficult, if not impossible, to continue rice farming in the Yolo Bypass.

I would like to offer the following concerns for your consideration:

First, DeWit Farms supports a March 1st end date to flooding from the operable gate in the Fremont Weir proposed by the Project. While we appreciate the inclusion of a March 7th and March 15th end date to flooding in the EIS/EIR. This flooding is still too late in the season to allow fields to dry in time for field preparation in April and planting in May. There are many different factors that can affect the time it takes fields to dry, such as late rain, lack of wind, or cool temperatures. A March 1st end date will ensure farmers can continue to plant rice and offer the many benefits that wildlife-friendly agriculture provides in the Yolo Bypass, including lease revenue for management of the Yolo Bypass Wildlife Area and habitat for waterfowl and other important California species.

Second, DeWit Farms will not continue farming in the Yolo Bypass if prevented planting insurance is not offered or the price is too high. Farming in the Yolo Bypass is dependent on a number of factors, such as the price of rice, the risk of flooding, and the cost of leases and other input prices. Fundamental to making a decision to renew our five-year lease on the Yolo Bypass Wildlife Area is the knowledge that DeWit Farms can access prevented planting insurance for unanticipated flooding. The U.S. Department of Agriculture determines the level of risk and associated premiums for prevented planting insurance based on the number of claims. If increased inundation increases the number of claims, premiums will go up. This increased price may make farming in the Yolo Bypass unaffordable to DeWit Farms. In addition, the U.S. Department of Agriculture may determine that flooding from the Project is "man-made" or "induced" flooding and is therefore likely to not offer prevented planting insurance. The lack of availability of prevented planting insurance would make continued farming in the Yolo Bypass Wildlife Area extremely difficult, if not impossible.

Thank you for your consideration of our concerns. My family and I remain committed to partnering with the California Department of Fish and Wildlife and Yolo County to provide the benefits of wildlife-friendly agriculture in the Yolo Bypass, but we need your assistance in ensuring it remains economically feasible to continue.

Sincerely,

Jack DeWit

Jack DeWit
President, DeWit Farms

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Mr. Oscar Villegas
Chairman, Yolo County Board of Supervisors
625 Court Street, #204
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February 6, 2018

RE: Yolo Bypass Salmonid Project and Rice Farming

Dear Chairman Villegas:

I have worked with Yolo County staff for the last eight years to track development of the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project). I have provided input into the analyses of the agricultural impacts commissioned by the County, because of its potential impact on my family farm's cultivation of rice in the Yolo Bypass. On behalf of Cobra Farms, I want to express my appreciation for Yolo County's work to represent Yolo Bypass agriculture and also my continued concern with the impact of the proposed Project on wildlife-friendly agriculture.

Cobra Farms produces rice annually on an average of 600 acres in the Yolo Bypass. We lease ground from landowners on an as-needed basis. Depending on drought or other conditions, the amount of acreage we lease ranges from 350 to 1,000 acres. Cobra Farms has been farming rice in the Yolo Bypass since 2009 and produces the premium grains used in risotto, paella, and sushi. Nearly all U.S. sushi restaurants use medium-grain rice grown in the Sacramento Valley, including rice from Cobra Farms. The Sacramento Valley, including the Yolo Bypass, with its water-retaining heavy clay soils and long, warm summer days and nights is an excellent location to produce high-quality medium grain rice.

Increased flooding from the proposed Project will increase the risk of farming rice in the Yolo Bypass. To use 2017 as an example, I fallowed 800 acres because the bypass remained to wet to plant (late May). As a result of this fallowing, I hired once less worker, rented one less tractor, and idled a combine harvester. Additionally after harvest, I did not reflood the 800 acres for straw decomposition. Reflooding the rice fields post-harvest provides a food source for 60 percent of the migrating waterfowl in the Sacramento Valley each winter. Environmental groups have helped offset the costs of this additional flooding as they recognize the potential impact of habitat. The proposal to increase inundation for fish in the Yolo Bypass will have an impact on rice farming if the project is not designed to allow the continuation of rice production.

Cobra Farms cannot and will not continue farming in the Yolo Bypass if preventative planting insurance is not offered or the premium paid for said insurance is too high . A critical element of our decision to sign an annual lease in February of each year is the availability of preventative planting insurance. Cobra Farms has filed preventative planting claims as a result of flooding and/or drought in two out of the last three years. My concern is that the proposed Project will increase the need to utilize the preventative planting program, therefore increasing the insurance premiums and potentially making it unavailable to farmers. It is our understanding that the Risk Management Agency of the U.S. Department of Agriculture may also determine that the inundation from the proposed Project is "induced" flooding and will not offer preventative planting insurance as a result. Cobra Farms will no longer farm in the Bypass if preventative planting insurance is not available. Cobra Farms also supports a March 1st end date to flooding from the proposed Project. Any date after March 1 will not allow adequate time for fields to dry and field preparation to take place. As a second-generation Yolo Bypass farmer, I look forward to working with you to ensure rice farming in the Yolo Bypass, with all the ancillary benefits to wildlife, can continue if the proposed Project moves forward.

Sincerely,

Mike DeWit

Owner, Cobra Farms

LA04

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Office of the General Manager

February 15, 2018

Ms. Karen Enstrom
California Department of Water Resources
3500 Industrial Blvd.
West Sacramento, CA 95691

VIA EMAIL:
Karen.Enstrom@water.ca.gov

Mr. Ben Nelson
Natural Resources Specialist
Bureau of Reclamation, Bay-Delta Office
801 I St., Suite 140
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VIA EMAIL:
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Dear Ms. Enstrom and Mr. Nelson:

Comments on the Draft Environmental Impact Statement/Report for the
Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

The Metropolitan Water District of Southern California (Metropolitan[1]) has reviewed the Draft Environmental Impact Statement/ Environmental Impact Report (DEIS/R) for the Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project (Project). The California Department of Water Resources and the U.S. Bureau of Reclamation are acting as Lead Agencies under the California Environmental Quality Act and National Environmental Policy Act, respectively, for this project.

1

Metropolitan is a cooperating agency and potentially impacted party. Metropolitan fully supports the Project. Our comments identify concerns with technical aspects of the Project, which we urge your agencies to address prior to the next phase of Project design and optimization, to ensure the project is designed and implemented to be as biologically and cost-effective as possible. One issue that we believe needs to be fully analyzed prior to a final EIS/R and decision on the Project is a potential North Delta discharge-dependent juvenile salmonid survival impact that may be influenced by Project operations. Additionally, we believe flexibility and a robust adaptive

[1] Metropolitan is a special district authorized under state law to develop, store and distribute water for domestic and municipal purposes, and to provide, generate and deliver electric power to do so. Metropolitan's 26 member agencies either directly or through retail water purveyors within their own service areas, provide water to the 19 million people in Metropolitan's six-county 5,200 square mile service area. In round figures, Metropolitan develops and supplies nearly half of the total water supply used in its Southern California service area.

management program will be essential for the success of this project, and recommend selection of Alternative 5 due to its enhanced ability to be adaptively managed to maximize benefits while avoiding potentially significant impacts. We look forward to working with your agencies to ensure the Project succeeds.

The proposed Project, as described in the DEIS/R, is designed to address requirements of the 2009 National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS) *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project* (NMFS BiOp), specifically Reasonable and Prudent Alternative Actions I.6.1 and, in part, I.7.

The purpose of the Project is to enhance floodplain rearing habitat and fish passage in the Yolo Bypass. The objective of Action I.7 is to reduce migratory delays and stranding of adult fish on the Yolo Bypass. The objective of Action I.6.1 "is to increase the availability of floodplain fisheries rearing habitat for juvenile" salmonids, specifically the listed winter-run and spring-run Chinook, and steelhead. The Project seeks to accomplish this by improving access to seasonal habitat on the floodplain, increase access to, and acreage of, season floodplain rearing habitat, and increase aquatic primary and secondary biotic production to provide food, presumably to benefit rearing salmonids. All sizes and life stages of sub-adult salmonids are commonly referred to as juveniles. However, the target life stage under Action I.6.1 is smaller juveniles, or fry. The DEIS/R cites references defining Chinook fry as <60mm fork length (FL) (Appendix G3, Part 2, page 1), identifies these as the life stage that would likely benefit the most from implementation of the Project, and indicates that larger "fry-sized" Chinook salmonids, up to 80 mm FL (page 8-65) would also benefit from access to rearing habitat. 2

Metropolitan strongly supports implementation of projects that comply with the requirements of the 2009 BiOp and contribute towards recovery of the listed fish species. This is an extremely important and potentially highly beneficial project. Due to year-to-year and intra-year variability in hydrologic conditions and salmonid population demographics, it will be critical to ensure your agencies use the best available data and modeling tools as you continue to the design and optimization phases of the project. 3

General comments on the Project and DEIS/R are provided below; specific comments with recommended changes to the text are included in Attachment A.

General Comments

1. Discharge-Dependent North Delta Juvenile Salmon Survival

The Lead Agencies should determine whether project operations have potential to impact
downstream juvenile salmonids in the Sacramento River as a result of North Delta discharge-
dependent effects described by Perry, et al. (2017), and if so, provide those analyses and
identify measures that would avoid or minimize those effects, if found to be significant. 4

Perry, et al., (2017) describes certain hydrologic conditions under which North Delta juvenile salmon survival is adversely impacted. These conditions appear to coincide with conditions under which the Project would operate, and may be exacerbated by Project operations. The DEIS/R needs to analyze this relationship and ascertain the relative benefits and impacts of different operational scenarios. If the analyses reveal a potentially significant impact, the revised DEIS/R or Final EIS/R should also identify feasible Project operations to avoid or minimize any potentially significant impacts to fisheries and water supplies.

Based on review of Knights Landing and Tisdale Weir Rotary Screw Trap catch data
prepared by CDFW and provided by DWR, appropriately sized juvenile Chinook are not
present at all times when the proposed Project would be operational. If operated to divert
water onto the bypass when fry are not present to be entrained, the Project could exacerbate
any downstream impacts on juvenile survival without providing the majority of intended
Project benefits. One potential mitigation option might be a real-time monitoring system that 5
would include genetics testing to confirm presence and sufficient numbers of out-migrating
fry of listed species as a basis for a decision to open the gates to divert water and entrain
juveniles onto the Yolo Bypass. Such a system might be based at the Tisdale Weir Rotary
Screw Trap, rather than at Knights Landing, to provide sufficient time to implement a
comprehensive decision-making process that would take into consideration potential benefits
on the Yolo Bypass, downstream survival impacts, and water supply.

2. Need to augment understanding of hydrodynamic conditions and Chinook fry distribution and behavior to support further design and optimization of the selected alternative, and development of the adaptive management program. 6

The 2017 Independent Science Panel (Panel) convened by the Delta Science Program noted unresolved issues with the various models used to support alternative evaluation in the DEIS/R. These include, for example, the hydrologic model (SRH-2D) used as input to the ELAM model. Issues include lack of calibration and validation with detailed field conditions, documentation of uncertainty, incorrect hydrodynamic boundary conditions that failed to account for Sutter Bypass inflows and backwater effect, incorrect bathymetry and river stage/discharge data (off by up to 3 feet in river stage and 70% in river discharge. Page 14), and use of a 2-D model instead of a 3-D model ("The Panel does not agree with the conclusion that the 2-D hydrodynamic model is adequate . . . ." Page 13), which is needed to simulate important secondary circulation features such as up- and down-welling, and eddies, to better understand how the fish will interact with the different configurations of the structures in different locations. If the hydrology model is wrong, the fish behavior analyses will be wrong; therefore, it is critically important to gain a more complete understanding of hydrodynamics and fish behavior, and how both will interact with, and be impacted by, potential notch configurations, to inform final design, as well as development of an effective adaptive management program.

The Panel's recommendations relative to the hydrologic modeling are (Page 15):

a. Use a 3-D hydrologic model because the secondary circulation patterns are important to simulating fish behavior and understanding interactions;
b. Re-do the boundary conditions, and incorporate better bathymetry, which was found to be critical to fish distribution;
c. Obtain additional and more accurate discharge and elevation data from additional gauging stations, and incorporate backwater effect;
d. Leverage other hydrodynamic models and calibrate with field data
e. Improve documentation of uncertainty and how it is propagated to other models to inform decision-makers on the validity of model conclusions.

The Panel identified similar significant issues with the other models, which we are unable to comment on here due to the limited time available for comprehensive review of the DEIS/R, but which we would like to discuss, along with potential remedies, as technical studies proceed.

3. Refinement of evaluation criteria and identification of metrics that focus on the target life stage for the project (appropriately-sized Chinook juveniles; i.e., fry) to monitor and substantiate specific benefits will be essential for development of an effective adaptive management program. 7

The models and analyses used to support evaluation of the alternatives are based on studies on smolts, which are considerably larger than the target fry stage. Smolts differ from the smaller fry with respect to life strategies and physiology, and are much stronger swimmers that would be expected to respond differently to in-river hydrodynamic conditions and to potential rearing opportunities on the floodplain. The evaluation criteria used to assess relative performance of the Project alternatives were developed 18 months ago, and have not evolved with the increased understanding of differential needs and behaviors of large and small juveniles. For example, as the smaller fry are the intended primary beneficiary of the Project, evaluation criteria, such as, “Increase access to floodplain habitat” and “Increase seasonal floodplain fisheries rearing habitat” would provide a better discriminating metric for refinement and final design of the Project by focusing them on how much benefit they would provide specifically to fry. Our suggestions are: “Increase access to floodplain habitat when fry are present” and “Increase frequency of floodplain fisheries habitat when fry are present to take advantage of it.” Coupling Rotary Screw Trap catch data with historic hydrologies would provide additional insights for assessing performance of alternative design and operations scenarios.

Similarly, performance metrics for the adaptive management program should focus on fry rather than on the larger smolts, which would not enjoy as much, if any, benefit from increased access and availability of rearing habitat as fry-sized fish would. 8

Additionally, the DEIS/R states that peak abundance of Chinook fry occurs in the Upper Sacramento River in September. Review of historic hydrology and Rotary Screw Trap catch data shows pulses of large numbers of out-migrating winter-run fry occurring in the Project vicinity in October. In some years these pulses have occurred at lower flows and river stages than the Project would operate, and in some years at appropriate levels. These early out-migrating fish represent a source of diversity that may be important to the “portfolio effect” and enhanced resiliency of the population, and should be considered for inclusion, rather than being excluded based on an arbitrary November 1 start date for project operations. If agricultural impacts are the basis for selection of this date, it is our understanding that there may be some flexibility based on weather conditions during the summer, with farmers knowing when they will harvest as early as August. We would recommend development of a more flexible set of operational rules as design proceeds. 9

4. Enhanced food production

Despite being identified as one of the biological objectives for the Project, enhancement of food production is only being addressed by one of the Alternative 4 options. We believe project benefits would be greatly enhanced if the selected alternative included measures to promote inundation water residence time to provide additional food production and rearing time for Chinook fry when they are present. 10

The Project should seek to maximize benefits to Chinook fry of enhanced access to the floodplain wherever possible. This would be achieved by (1) maximizing opportunities for food production on rearing habitat in advance of the arrival of fish, (2) providing additional features to achieve more natural floodplain characteristics (such as a benched floodplain) 11 with better volitional passage, (3) seeking dynamic inundation characteristics with more wetting and drying, and (4) retaining water on inundated areas for a long enough period for development of the food web. Currently only one of the alternatives seeks to provide for these, while another identifies programmatic elements. We would recommend placing additional emphasis on this important potential benefit of the Project.

Preferred Alternative

We urge further consideration of Alternative 5, which we believe provides the best opportunity for maximal operational flexibility and adaptive management options. Based on the original design and current set of evaluation criteria, Alternative 5 did not perform especially well relative to its ability to entrain juveniles. We believe that would change if the evaluation criteria focused on potential benefits specific to fry-sized fish and when they have been present historically with the appropriate hydrology. Additionally, USGS has explored several additional configurations for this, and some of the other, alternatives, with the goal of enhancing their 12
entrainment performance. That analysis is provided in Attachment B. For example, by reducing the spacing between arrays of gates in Alternative 5, and lowering the invert to provide 1000 cfs at 19’ river stage, its performance is greatly enhanced; by as much as 100%, as compared to previous analyses.

Summary

In summary, we fully support the Project. At the same time, we believe there is still considerable effort needed to be successful in the design and optimization phases of the Project, and look forward to engaging fully with your agencies and other stakeholders in these technical aspects.

Thank you for the opportunity to comment on the DEIS/R, and your extensive involvement of stakeholders throughout this process. Please feel free to contact me or Dr. Marty Meisler at (213) 217-6364 or mmeisler@mwdh2o.com to discuss these comments or if you have any questions.

Very truly yours,

Stephen N. Arakawa
Manager, Bay-Delta Initiatives

MM:rrw

Attachments:
Attachment A -- Specific Comments
Attachment B – Alternative Optimization

Attachment A

Specific Comments on the Yolo Bypass DEIS/R

Issue	Page	Comment
Executive Summary		
	ES-18	***Flood Control.*** *There is a controversy on flood impacts associated with <u>any</u> rise in WSELs associated with the Project.* 13 Mitigate potential impacts by closing all gates when stages are forecast to rise to moderate flood levels in the Bypass.
	ES-17	***Fish Section.*** There is uncertainty on overall fish benefits that is unrecognized and may require changes in Project operations to avoid potentially significant impact on salmon survival. 14 Perform appropriate analyses to examine effects suggested by recently published papers (e.g., Perry, et al., 2017), which suggest a possible significant impact to North Delta juvenile salmon survival due to Fremont Weir diversions and corresponding North Delta reduced flows which may require revised Project operational criteria to avoid any such impact.
	ES-20	*Decreases in peak WSE in the Yolo Bypass … of up to 0.15 feet compared to existing conditions* There is no explanation for how this occurs and does not seem logical since none of the proposed actions reduce flow or increase conveyance. Please explain this anomaly since none of the other alternatives cause a reduction in WSELs. What is different about this alternative? 15
	ES-58	*Increasing levels of juvenile Chinook salmon stranding and predation above existing levels could reduce survival of juvenile Chinook salmon rearing in the Yolo Bypass under Alternatives 4 and 5.* 16 The discussion does not take into account the reduction in stranding that would result from creation of more natural floodplain habitat under Alternative 5, so it misrepresents the potential impact.
Ch 5 -- Description of Alternatives		
	2-4	*The Value Planning team concluded that more focus should be placed on integrating flood projects with restoration efforts and recommended including water control structures to help increase inundation on the Yolo Bypass. Reclamation and DWR have worked to coordinate closely with the ongoing flood projects.* 17

		To be accurate, the Value Planning group was unanimously dissatisfied with the proposed alternatives and strongly suggested new alternatives that were smaller, more flexible, thoroughly integrated with local needs, all other Bypass programs/actions, and based upon the best available science.	
	2-4	*Percent increase in winter- run Chinook salmon escapement (Salmon Benefit Model)* The salmon benefits model is based upon incomplete science, faulty assumptions and does not include important North Delta discharge dependent survival impacts. We urge development of a fully calibrated 3D hydrodynamic model and then develop a behavior model that is calibrated to the 2016 tagging results as input to an improved Salmon Benefit Model for use in design and optimization phases of the project. Acoustic tracking of fry behavior should be completed prior to evaluating entrainment rates.	18
	2-4	*Entrainment of winter-run* The Juvenile Entrainment model is based upon the faulty assumption that fry and smolts are equally distributed in the river and does not consider important behaviors that could significantly change entrainment. We urge development of a fully calibrated 3D hydrodynamic model and then develop a behavior model that is calibrated to the 2016 tagging results as input to a SBM. Acoustic tracking of fry behavior should be completed prior to evaluating entrainment rates.	19
	2-13	*Juvenile salmonid out-migration typically begins during early storms in November* As in indicated in other locations in the DEIS/R, and in the Knights Landing and Tisdale Weir Rotary Screw Trap catch data, outmigration begins as early as August, with peaks through September and October. This is important because a flexible start date, rather than a fixed November 1 date, would enable the Project to capture greater diversity represented by the early out-migrants that is needed for the portfolio effect and resiliency of the population. Appendix G, Part 2, Figure 1 depicts winter-run catch at the KL RST on October 3 during the period from 1997-2011.	20
	2-14, 2-37	*Final Design BMP* Sediment accumulation and disposal costs appear to be underestimated, especially for alternatives with channels crossing the floodplain perpendicular to flood flows. Consider partially filling the large scour pond that is currently head-cutting into the weir structure. Partial filling could reduce stranding, predation, and weir maintenance. Sedimentation and maintenance costs may be significant for the Westside alternatives. Recommend modeling with a sediment transport model before selecting one of these options as a preferred alternative.	21

Chapter 3 – Cumulative Impacts			
	Table 3-2, 3-20	*North Delta Flood Control and Ecosystem Restoration Project* The North Delta Flood-Eco project is also known as the McCormick Williamson project. Cumulative impacts analyses should include reasonably foreseeable projects that may affect North Delta flow-dependent impacts, such as California WaterFix, the 8,000 acre Smelt BiOp projects, California EcoRestore projects, McCormick-Williamson Tract project, and DCC/Georgiana Slough potential gate operations.	22
Chapter 4 – Hydrology			
	4-5	*Table 4-1 shows the annual exceedance probability (AEP) of flows in the Sacramento River at Freeport, as computed through the CVFPP.* This appears to be in error. The design capacity of the Sacramento River at Freeport is 110,000 cfs. This should say that the flows are at the latitude of Freeport and represent the combined flows of the River and Yolo Bypass.	23
	4-9	*Flood management facilities along the Yolo Bypass include Fremont Weir at the northern end of the bypass, levees on either side of the bypass, and the bypass itself, which conveys floodwaters from the Sacramento, American, and Feather rivers away from West Sacramento.* Should say "…from Sacramento and West Sacramento."	24
	4-10	*Along this reach, Miner Slough has a design inflow of 10,000 cfs from a series of Delta sloughs that are distributary from the Sacramento River.* Should read: "Along this reach, Steamboat and Miner Sloughs enter into the lower Bypass. Miner Slough has a design inflow of 10,000 cfs from a series of Delta sloughs that are distributary from the Sacramento River. Steamboat Slough has a design inflow of 43,500 cfs."	25
		The flood control effect of changing the long-term flow patterns into the Sacramento River below Freeport was evaluated by comparing the number of times the monthly average flow exceeded 72,231 cfs in the CalSim II results for each of the alternatives. 72,231 cfs represents the maximum existing conditions modeled monthly average flow of 72,231 cfs at Freeport. Monthly time steps are inadequate for evaluating the flood impacts at Freeport since the Project changes on the peak flows are critical on a daily and weekly basis. Furthermore, the design capacity of the Sac River at Freeport is 110,000 cfs. It is unclear why the DEIS/R uses the monthly average of 72,231 cfs as the criterion for assessing flood control impacts.	26
	4-21	*For the highest historic flood flow routed in TUFLOW, which occurred during the 1997 event, TUFLOW indicated that some portions of the bypass experienced increases in maximum WSE between 0.02 and 0.05 feet for the alternatives relative to the existing conditions hydrodynamic model, as described in Appendix D,*	27

		Hydrodynamic Modeling Report. This agrees with the general range of changes in WSE between alternatives as modeled in HEC-RAS. *An alternative would result in a significant impact under CEQA on hydrology, hydraulics, and flood control if, relative to existing conditions, it would increase the frequency or severity of damaging flood flows, as indicated by the following:* There is a controversy on flood impacts associated with <u>any</u> rise in WSELs associated with this project. Significant impacts must be evaluated on the changes to short-term peak stages. Using a monthly time-steps to analyze impacts is not appropriate because it fails to disclose significant impacts that may occur on a shorter time-frame. Impact evaluation should be based upon the TuFlow 1997 flood modeling results. We recommend the Lead Agencies recognize and mitigate impacts by requiring all gates be closed when stages are forecast to rise to moderate flood levels in the Yolo Bypass.
Ch. 5 -- Surface Water		
	5-16, 5-20	*Multiple references to 2030 and 2070 <u>hydrology</u>.* Hydrology is not the proper term; future years do not have specific hydrologic conditions associated with them. 28 Change references from 2030 and 2070 hydrology to 2030 and 2070 <u>conditions</u>.
	5-19	*For this analysis, a substantial reduction in long-term reliability is defined as a five percent or greater reduction in average annual or average dry and critical year reliability. This amount is assumed to represent a reduction that could not be replaced reliably from other sources such as groundwater pumping or water transfers.* *For this analysis, a substantial reduction in monthly reliability is defined as a greater than 10 percent reduction in average monthly water supply.* Five and ten percent changes in reliability represent a potentially large amount of water supply and resulting economic impact due to the need for replacement supplies, alternative operations, storage actions, or shortage. A recent study: Economic Analysis of Sequential Species Protection and Water Quality Regulations in the Delta (Sunding 2017), describes the direct and indirect costs of shortages and fallowing of agricultural lands associated with reductions in SWP supplies. 29 In addition, future implementation of SGMA regulations will limit the ability of some water users to reliably replace reductions in surface water supplies through groundwater pumping. Please provide additional rationale or justification for why these thresholds were selected that includes a discussion of potential economic impacts. If a smaller impact could be significant in light of the inability to find alternative supplies or in light of the economic impacts, the threshold should be lowered.

Chapter 7 – Groundwater			
	7-14	*The total storage capacity of the groundwater basin is estimated to be approximately 66,000,000 AF, with a natural safe yield of 70,500,000 AF (MWD 2007).* The natural safe yield number shown is incorrect. The total storage capacity of the groundwater basin is estimated to be approximately 66,000,000 AF, with a natural safe yield of 70,500 AF (MWD 2007).	30
Chapter 12 – Geology and Soils			
	12-16, 12-20	*NOTE: Similar text is included for all west side alternatives* *Approximately 75,600 cubic yards would be removed in addition to existing maintenance activities, increasing the annual amount of sediment removal to 372,150 cubic yards from 296,550 cubic yards. From 1986 to 2006, five sediment removal operations were performed on an as-needed basis (1986, 1987, twice in 1991, and 2006). Within that 20-year span, between approximately 530,000 and 1,450,000 cubic yards of soil were removed, per operation, for a total of 4,390,000 cubic yards of soils removed (HDR, Inc. 2017b). The increased sediment deposition from operation of Alternative 6 would require a change from the current frequency of sediment removal actions (as needed) to at least every five years and as needed. Although Alternative 6 would increase the amount and frequency of sediment removal within the bypass, it would remove all sediment deposited between Fremont Weir and Agricultural Road Crossing 1.* The west side alternatives with the conveyance channel running perpendicular to flood flows and bedload transport will be a natural and effective sediment trap. It is highly likely that this feature will require annual sediment removal with specialized equipment (not scrapers) at a significant annual cost. The current text assumes that added deposition is handled in a manner similar to all previous removal projects by DWR. The concentrated buildup of sediment in a critical part of the project cannot wait up to 15 years for the next interval of removal, as has been the practice. The DEIS/R does not address this issue, and should include an analysis of annual deposition into the east-west channel and the method/frequency and cost of sediment removal.	31

Attachment B

Summary of entrainment simulation results for supplementary multiple-gate scenarios

Aaron Blake, U.S. Geological Survey, West Sacramento, CA
February 14th, 2018

The USGS entrainment simulation (Blake et al., 2018) estimated that Alternative 5 would have lower entrainment than single gate designs with a similar overall rating curve, because the discharge ratios for each of the three gate groups that made up Alternative 5 were too low to entrain water from areas of the river with high fish concentrations. (Note that Blake et al. did not account for the effects of preferentially entraining water from the river surface.) In addition, the USGS entrainment simulation predicted that lowering the invert elevation of alternatives would result in higher entrainment of winter run and spring run Chinook salmon, because Knights Landing catch data suggests that these fish are likely to emigrate during smaller outflow events that result in lower Sacramento River stages at the Fremont Weir (ibid). As a result of these findings we performed supplementary simulation runs to explore the possible effects of modifying the spacing between gates for scenarios based on Alternative 5, as well as exploring the effects of lowering the invert elevations for scenarios based on Alternative 5. This document summarizes the results of these additional entrainment simulation runs and compares the performance of these supplementary scenarios to the scenarios described in Blake et al. in 32
Table1. For more information on the USGS entrainment simulation see Blake et al. We recognize that lowering invert elevations for the proposed alternatives may not be possible, the purpose of these additional simulation runs is to explore the possible effects of entraining water at lower stages.

The scenarios shown in Table 1 include:

- Scenario 1, simple notch based on the design for Alternative 3
- Scenario 2, simple notch based on the design for Alternative 4
- Scenario 3, simple notch based on the design for Alternative 6
- Scenario 4, simple notch based on the design for Alternative 4, but with the **invert elevation lowered to reach a target notch flow of 1,000 cfs at a Sacramento River stage of 19’**
- Scenario 5, multiple gate scenario based on Alternative 5, with the invert elevation raised to account for the change in water surface elevation due to moving Alternative 5 to the western end of the Fremont Weir.
- Scenario 6, multiple gate scenario based on Alternative 5, using the original rating curve for Alternative 5 (lower invert elevations than Scenario 5).

- Scenario 7, multiple gate scenario based on Alternative 5, with all the gates grouped together and the invert elevation raised to account for the change in water surface elevation due to moving Alternative 5 to the western end of the Fremont Weir. All gates in Scenario 7 are modeled as being adjacent to their upstream neighbor with no separation between gates.
- Scenario 8, multiple gate scenario based on Alternative 5, with all the gates grouped together and the **invert elevation lowered to achieve a target net notch flow of 1,000 cfs at a Sacramento River stage of 19'**. All gates in Scenario 8 are modeled as being adjacent to their upstream neighbor with no separation between gates.
- Scenario 9, multiple gate scenario based on Alternative 5, gates separated into two groups: gates A and B are grouped together and CD are grouped together with a 150 meter gap between groups. The gate separation is based on the observed "zig-zag" behavior in the fish tracks. For scenario 9 the **invert elevations were lowered to achieve a target net notch flow of 1,000 cfs at a Sacramento River stage of 19'**.

The results from these supplementary simulations match my expectations given the data underlying the entrainment simulation: these new results predict that Scenario 7 (Four sets of gates adjacent to each other) will perform very similarly to Scenario 2 (A single notch based on Alternative 4). This result is expected because Scenario 7 and Scenario 2 have very similar peak notch flows and notch stage-discharge relationships. If the vertical distribution of juvenile Salmon is biased towards the surface of the river then it is reasonable to expect that Scenario 7 will produce greater entrainment than the simulation predicts because the simulation is strictly two-dimensional. Further, the simulation predicted that lowering the invert elevation for Scenario 7 to achieve a similar stage-discharge curve to Scenario 4 would result in a dramatic increase in the entrainment of winter run and spring run (See results for Scenario 8 and 9 in Table 1).

The results for scenarios 5 and 6 suggest that widely spaced multiple notch designs will be less efficient than notch designs (Table 1, Figure 1 & 2) because each of the notches has a relatively low discharge ratio, and as a result, is not entraining water from portions of the river cross-section with high fish densities. Although I have not performed a comprehensive analysis using constant discharge ratio alternatives, the results from the scenarios which I have simulated indicate that entrainment efficiency increases rapidly as the notch discharge ratio approaches 0.2, and, entrainment efficiency decreases to unity for large notch discharge ratios (DR > .4, see the figures in my report). Given these results it is likely that a notch discharge ratio of around 0.2 will result in the greatest entrainment efficiency, and will provide the most fish entrainment for the volume of water diverted. The exception is that the multiple notch scenarios appear to be more efficient at stages above bankfull (Figure 1) when the study fish became less concentrated on the outside of the bend. One possible explanation is that in this case the notch discharge ratio for either the single or multiple notch configurations is not high enough to entrain water from the more central portion of the river where fish are concentration, so, entrainment becomes more of a stochastic process in which only the fish that happen to be on the outside of the bend are entrained. If this is the case, then the multiple notch configurations may entrain more fish because each notch represents an additional opportunity to take fish from the outside of the bend. This mechanism does not significantly contribute to entrainment under these simulations, but, if the risks analysis suggest a high minimum stage for diverting water without significant downstream effects then a multiple notch configuration may be the best approach for maximizing entrainment at higher stages.

References

Blake, A., Stumpner, P., and Burau, J. (2018) Appendix G2 of Draft Environmental Impact Statement/Environmental Impact Report, Yolo Bypass Salmonid Habitat Restoration & Fish Passage. December 2017. U.S. Department of the Interior, Bureau of Reclamation and the California Department of Water Resources.

Table 1 - Mean annual fraction of population entrained under each scenario (90% CI)

	Scenario 1	Scenario 2	Scenario 3	Scenario 5	Scenario 7	Scenario 6	Scenario 8	Scenario 9	Scenario 4
Type of opening	Simple notch	Simple notch	Simple notch	Multiple gates	Multiple gates	Multiple gates	Multiple gates	Multiple gates	Simple notch
Gate separation	NA	NA	NA	AB,C,D	None	AB,C,D	None	AB, CD	NA
Winter Run	8% (3%-17%)	7% (3%-13%)	19% (5%-39%)	5% (2%-11%)	7% (3%-14%)	7% (4%-13%)	17% (9%-22%)	14% (8%-19%)	16% (9%-20%)
Spring Run	8% (2%-17%)	6% (2%-14%)	18% (3%-40%)	5% (1%-11%)	6% (2%-14%)	7% (2%-13%)	15% (8%-25%)	12% (6%-22%)	14% (7%-24%)
Fall Run	10% (3%-18%)	8% (2%-20%)	23% (7%-44%)	6% (2%-12%)	9% (1%-21%)	8% (2%-15%)	15% (3%-29%)	14% (3%-28%)	14% (3%-27%)
Late Fall Run	3% (0%-13%)	3% (0%-11%)	7% (0%-31%)	2% (0%-10%)	3% (0%-10%)	3% (0%-12%)	9% (0%-21%)	7% (0%-17%)	9% (0%-21%)
Max Flow	6,100 cfs	3,200 cfs	12,300 cfs	3,400 cfs	3,400 cfs	3,400 cfs	3,400 cfs	3,400 cfs	3,200 cfs
Flow at 19' Stage	218 cfs	218 cfs	0 cfs	175 cfs	175 cfs	316 cfs	**1073 cfs**	**1073 cfs**	**1142 cfs**
Max DR*	0.26	0.17	**0.57**	0.17	0.17	0.19	0.24	0.24	0.23

* DR = Discharge Ratio, fraction of Sacramento River flow entrained in notch

Table 1 shows the results of additional simulation runs performed to evaluate alternative versions of the multiple gate designs based on Alternative 5.

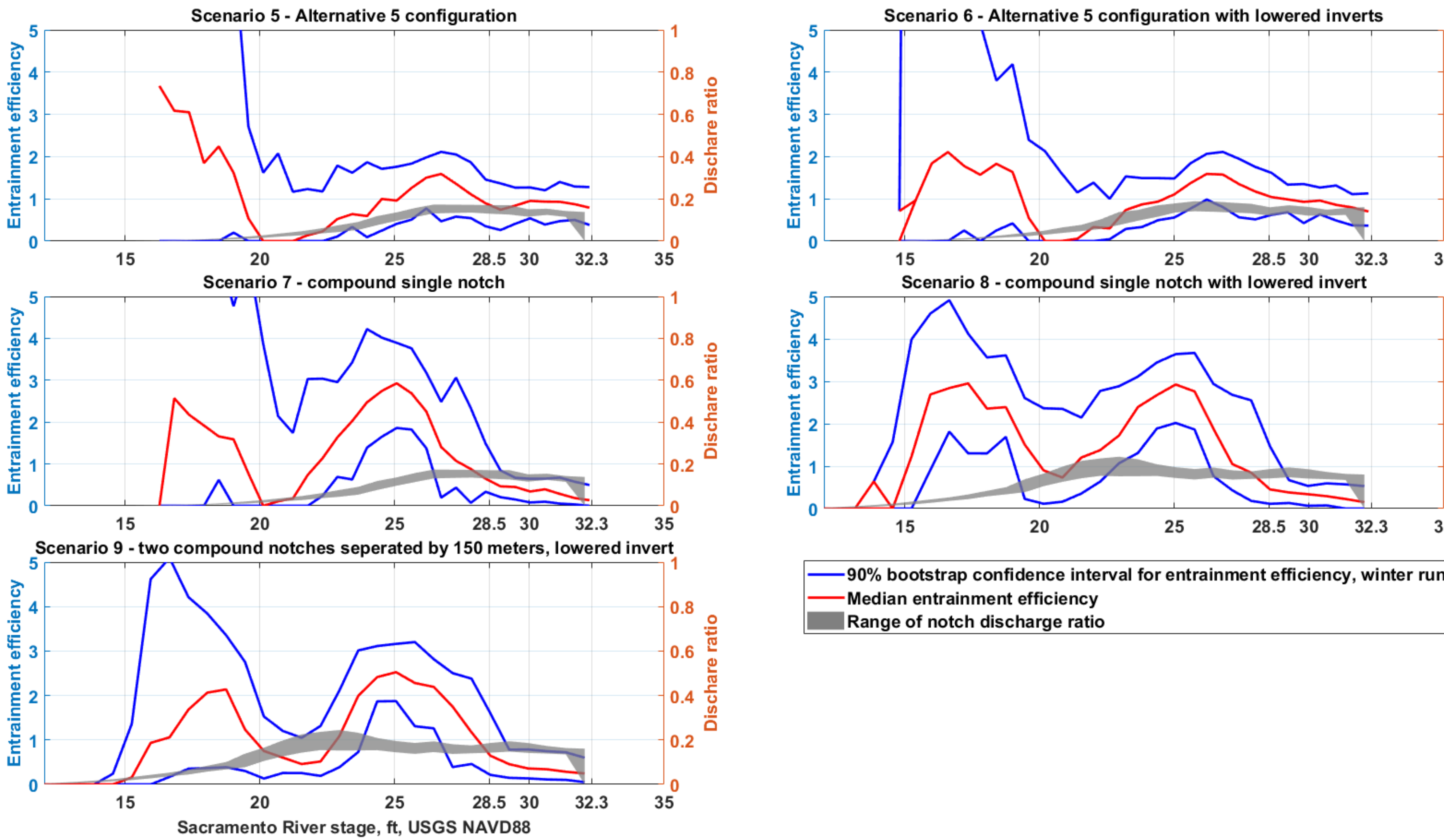

Figure 1 - Entrainment efficiency and notch discharge ratio as a function of Sacramento River stage