

# United States Department of the Interior

BUREAU OF RECLAMATION Central Valley Operations Office 3310 El Camino Avenue, Suite 300 Sacramento, California 95821

IN REPLY REFER TO:

CVO-100 ENV-7.00 MAR 24 2015

VIA ELECTRONIC MAIL

Ms. Maria Rea Assistant Regional Administrator California Central Valley Area Office National Marine Fisheries Service 650 Capitol Mall, Suite 5-100 Sacramento, CA 95814

Subject: Contingency Plan for Water Year (WY) 2015 Pursuant to Reasonable and Prudent Alternative (RPA) Action I.2.3.C of the 2009 Coordinated Long-term Operation of the Central Valley Project (CVP) and State Water Project (SWP) Biological Opinion (NMFS 2009 BiOp)

Dear Ms. Rea:

By letter dated January 29, 2015, the National Marine Fisheries Service (NMFS) concurred that the Bureau of Reclamation's (Reclamation) and the Department of Water Resources' (DWR) Interim Contingency Plan for February and March 2015, is consistent with RPA Action I.2.3.C NMFS 2009 BiOp. Reclamation now requests concurrence from NMFS that the operations described in the attached *Project Description for April – September 2015 Drought Response Actions to Support Endangered Species Act Consultations* (Project Description) are within the limits of the Incidental Take Statement of the BiOp and serves as the Contingency Plan for the remainder of WY 2015 in accordance with RPA Action I.2.3.C. Additionally, Reclamation requests concurrence that CVP and SWP operations described in the Project Description concerning RPA Action IV.2.1 are within the limits of the Incidental Take Statement.

As you are aware, California is facing unprecedented critically dry conditions in the current water year, following three previous dry years. As a result of this continued aridity, the CVP and the SWP reservoir levels were significantly below average in October at the beginning of WY 2015. The State's snow survey is currently dismal at best and the State's overall water storage levels remain far below average. Adequate storage is needed throughout the year and especially in dry times of the year in order for the CVP and SWP to supply human needs, continue repelling saltwater in the Delta, and provide for cold water needs of Chinook salmon, steelhead, and green sturgeon.

The enclosed Project Description, developed in coordination with DWR, the U.S. Fish and Wildlife Service (USFWS), NMFS, the California Department of Fish and Wildlife (DFW), and

the State Water Resources Control Board (State Board), outlines proposed actions and a likely range of coordinated operation of the CVP and SWP through September 30, 2015. Modifications of the enclosed Project Description could occur based on evolving information which could include additional conditions in the State Board regulatory approvals as well as federal Endangered Species Act (ESA) and California ESA requirements. Reclamation and DWR also intend to continue to refine operations of the CVP and SWP as hydrological and biological information becomes available, in coordination with federal and state resources agencies.

In response to this water shortage crisis, Reclamation and DWR are submitting a Temporary Urgency Change (TUC) Petition Regarding Delta Water Quality, requesting that the State Board temporarily modify requirements of D-1641 for 180 days, with specific requests for April through September to enable changes in operations that will provide minimum human health and safety supplies and conserve water for later protections of instream uses and water quality. As described in the Project Description, Reclamation and DWR are specifically requesting modification of the D-1641 Delta outflow requirements, San Joaquin River at Vernalis flow requirements, export limits, Delta Cross Channel (DCC) gate operations, Rio Vista flow requirements, Western Delta salinity compliance point requirements, San Joaquin River salinity requirements, and change of compliance point for the Ripon dissolved oxygen requirement (see attached Project Description for further details). These changes would reduce reservoir releases from those otherwise required to meet D-1641 from April through September to conserve storage for later fishery protection, minimum health and safety needs, and if necessary, salinity control. The Project Description also includes: (1) a description of a framework for possible future requests for Old and Middle River flow management flexibility, if conditions warrant; (2) a list of additional modifications required in the event that Temporary Emergency Drought Barriers are installed; and (3) identification of possible future conditions warranting additional modifications that may be implemented in 2015 and beyond to address the ongoing drought conditions, or to help recover from the conditions created from the previous three years of drought in the event the hydrology becomes wetter. Lastly, specific to NMFS RPA Action IV.2.1 modifications, Reclamation and DWR continue the commitment made in 2014 to (1) provide, in a future year when hydrology allows, an amount of water equal to one half the total of additional amounts exported, due to modifications to the San Joaquin River I:E ratio, above 1,500 cubic feet per second in the April/May 2015 timeframe; and (2) preferentially pump natural or abandoned flow during the April and May period at the Jones Pumping Plant up to the federal capacity.

The Project Description will serve as the drought contingency plan for the months of April through September 2015, and are consistent with the drought exception procedures outlined in RPA Action I.2.3.C of the NMFS 2009 BiOp.

Reclamation and DWR reviewed the effects of the specific request for April through September 2015 on listed species. Based on the Biological Review, which is enclosed, Reclamation believes that the effects of the actions requested for April through September on listed salmonids, green sturgeon and their designated critical habitats will not result in violation of the incidental take limit in the NMFS 2009 BiOp, nor will these actions jeopardize the continued existence of the listed species or destroy or adversely modify their designated critical habitats.

#### Subject: Contingency Plan for Water year (WY) 2015

Similar to 2014, Reclamation and DWR will continue close coordination on current and projected operations on a weekly basis through the Real-Time Drought Operations Management Team (RTDOT) and other on-going meetings (Smelt Working Group, Delta Operations for Salmonids and Sturgeon technical work group, Delta Conditions Team, Water Operations Management Team, *etc.*). The RTDOT was formed in 2014 and includes designated representatives from Reclamation, DWR, the State Board, DFW, NMFS, and the USFWS. The RTDOT has proven effective as a forum to discuss potential changes to SWP and CVP operations to meet health and safety requirements and to reasonably protect all beneficial uses of water. The RTDOT will continue to meet at least weekly to ensure effective coordination among the pertinent agencies. The results of these efforts will inform both future determinations associated with the USFWS 2008 Coordinated Long-term Operation of the CVP and SWP Biological Opinion, the NMFS 2009 BiOp, and additional TUC petitions to the State Board, if necessary. Additionally, Delta Smelt and salmonid monitoring, as described in the *CVP and SWP Drought Contingency Plan, October 15, 2014 - January 15, 2015,* submitted to the State Board on October 15, 2014, will continue as needed to inform operational decisions.

RPA Action I.2.3.C is triggered based on a February forecast showing that end of September Shasta storage will be less than 1.9 million acre feet (MAF), or that a Clear Creek temperature compliance point is not achievable. The February 2015 forecast shows Reclamation to be unable to meet 1.9 MAF at the end of September. Also, RPA Action I.2.3.C requires a relaxation of the Wilkins Sough navigation criteria. Reclamation will target a navigation control point at Wilkins Slough not to exceed 3,800 cubic feet per second during April through September 2015. Reclamation will coordinate changes to Wilkins Slough and Keswick release requirements with NMFS.

The enclosed Biological Review supports Reclamation and DWR's conclusion that the effects associated with changes identified in the Project Description and TUC Petition are within what was analyzed in the NMFS 2009 BiOp. Any incidental take resulting from these changes are within the existing incidental take limits in the NMFS 2009 BiOp. Because these actions are contemplated within the drought exception procedures described in the NMFS 2009 BiOp, they do not jeopardize the listed species or adversely modify or destroy designated critical habitats addressed in the NMFS 2009 BiOp. Reclamation seeks NMFS' concurrence in this determination.

We look forward to working with you and your staff as we navigate through what appears to be another extremely challenging water year and appreciate your willingness to work with us on this time sensitive matter.

Sincerely,

R. Millig

Ronald Milligan Operations Manager

Enclosures – 2

Please see next page.

Continued from previous page.

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# Project Description for April - September 2015 Drought Response Actions To Support Endangered Species Act Consultations

In order to cope with a fourth consecutive year of drought, the Bureau of Reclamation (Reclamation) and the project applicant, the California Department of Water Resources (DWR), are considering temporary modifications to the operations of the Central Valley Project (CVP) and State Water Project (SWP). Coordinated long-term operation of the CVP and SWP previously underwent Endangered Species Act (ESA) consultation that resulted in biological opinions (BiOps) from the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) in 2008 and 2009, respectively. The project description describes the specific actions that Reclamation and DWR currently propose to implement from April through September 2015 related to changes in D-1641 standards in the Project Description of the 2008 and 2009 BiOps, as well as specific consultation requests not considered in the existing exception procedures of the BiOps driven by human health and safety concerns. In addition, if conditions warrant, future requests for Old and Middle River (OMR) flexibility may be proposed similar to what occurred in February 2015 and as described below. Emergency drought barriers, although not specifically included in this Project Description for April through September, 2015, may also be required to address salinity issues in the Delta. Other possible future actions related to water transfers and the San Joaquin River I:E ratio flexibility may also be proposed and are described below.

## Currently Proposed April through September 2015 Actions

Reclamation and DWR are using the February 90% exceedance forecast for Central Valley hydrology for the purpose of ESA consultation to predict the actions that are necessary to modify the Project Description and Reasonable and Prudent Alternatives (RPAs) described in the 2008 and 2009 BiOps. The March exceedance forecast is under development and at this time appears to be trending drier than the February 90% exceedance forecast. Reclamation and DWR consider the February 90% exceedance a reasonable hydrologic estimate on which to base the ESA consultation. A summary of the February 2015 Operation Forecasts is included as Attchment A. As conditions materialize, additional coordination with NMFS will be required to address water temperature plans on the upstream tributaries consistent with the RPAs contained in the NMFS Biological Opinion.

The following actions in April through September 2015 are proposed under a critically-dry hydrologic forecast, and may or may not be implemented depending on observed conditions and ability of the applicant to obtain modifications to water rights permits.

- I. Proposed Upstream Tributary Operations April Through September 2015
- A. <u>Upper Sacramento River, Trinity River, and Clear Creek Flows and Temperature</u> <u>Management Planning – NMFS RPA Action I.2.3.C</u>

Reclamation intends to integrate to the fullest extent possible the operations of the Trinity, Clear Creek, and Shasta complex to make maximum use of the limited cold water reserves in each reservoir. The highest priority for this ongoing cold water management will be to improve and maintain cold water temperatures on the upper Sacramento River to protect the endangered Sacramento River winter-run Chinook salmon.

In addition, Reclamation is working with the Sacramento River Settlement Contractors on options to shift a significant portion of their diversions for this year out of the April and May period and into the time frame where Keswick releases are higher to achieve temperature objectives on the upper Sacramento River. The cooperation of the settlement contractors in pursuing this effort would allow a modified diversion pattern and create the benefit of increased Shasta Reservoir storage at the beginning of the temperature control operations while allowing for settlement contractor diversions once the temperature purposes of the flows are achieved.

#### Trinity Operations

The Trinity River Restoration Project Record of Decision (ROD) identifies that the flow schedule for the Trinity River be determined based on the April 1, 50% exceedance inflow forecast with adjustments in May, if necessary. The February 2015 90% exceedance forecast would result in a dry-year flow schedule designation; however additional precipitation in March could boost the flow schedule to a normal year designation. Due to persistent drought conditions for the entire State of California and the currently dry forecast, Reclamation's operations forecast includes schedules using the Trinity River Division dry-year flow schedule of the ROD. If the schedule should shift to the normal designation, unavoidable low storage may result in additional adverse effects due to elevated water temperatures for Trinity River salmonids and potentially increased temperatures in the upper Sacramento River. Low-level release from Trinity Reservoir for temperature management will be implemented if necessary to meet species needs and State Water Board basin plan objectives. Pursuant to Government-to-Government obligations, Reclamation will continue to consult with Trinity Basin tribes.

## **<u>Clear Creek Operations</u>**

The Clear Creek population of spring-run Chinook salmon provides an important buffer to other Central Valley populations, but the limited cold water supplies this year, and the priority to protect winter-run Chinook salmon on the Sacramento River, may limit the ability to manage water temperatures and flows on Clear Creek.

Reclamation commits to providing the two attraction pulse flows in Clear Creek, per advice from the Clear Creek Technical Team on the timing, duration, and flow, as provided in NMFS RPA Action I.1.1. These pulse flows are, per the RPA Action, requested in April or May and June. However in an effort to preserve cold water pool storage, the technical team may provide recommendations to modify implementation of these pulse flows.

Water temperatures on Clear Creek will be managed at either an alternate compliance point or by modifying the water temperature objective at Igo.

## Shasta Operations/Keswick Release Schedule

A major goal Shasta Reservoir operations is to conserve as much water storage as possible during the winter and spring to provide cold water releases for salmonids later in the season, and provide carryover storage for the next water year. This is especially important in the event of a prolonged drought.

Given the severe drought conditions and limited availability of cold water resources this year, and consistent with NMFS RPA Action I.2.3.C, this project description incorporates the following operational actions:

- Keswick releases will be held to no greater than 3,250 cfs, or as determined necessary to reasonably target no more than 3,800 cfs at Wilkins Slough in April, May and June, unless necessary to meet nondiscretionary obligations or legal requirements;
- Keswick releases will not be increased to directly support CVP Delta diversions;
- Reclamation and DWR have worked with the State Water Board to modify a number of water quality and flow standards that help limit the need for increased Keswick releases to meet Delta objectives. Reclamation will continue to rely on other CVP reservoirs to the extent possible to meet overall CVP obligations;
- Reclamation will bypass the power penstocks at times this year if such operations will help access the remaining cold water pool or would help preserve the cold water pool if blending with warmer water early in the season is appropriate to meet temperature compliance;
- Reclamation will coordinate with the Sacramento River diverters to minimize the impact of any diversions for rice decomposition on Shasta Reservoir operations; and
- Reclamation will continue to develop monthly operational forecasts and temperature analyses to facilitate the ongoing monthly consultation under NMFS RPA Action I.2.3 and I.2.4.

The attached operational forecasts (see Attachment A) were developed, in part, using the estimated Sacramento Valley depletion forecasts calculated by DWR as part of their monthly hydrologic updates. These depletion forecasts are based on a regression analysis of historical accretions and depletions data in the Sacramento Valley.

Based on more current projected inflow data and potential in-basin depletions, productive discussions with Sacramento River Settlement Contractors about significant modifications to diversion patterns, and the bulleted parameters outlined above; a more likely estimated range of average monthly releases from Keswick Reservoir are presented below:

	90% Exceedance	50% Exceedance
April	5500	4000
May	7500	7000

#### Estimated Range of Keswick Reservoir Release (in cubic feet per second)

A release of 9,000 cfs is generally considered the minimum flow to reasonably maintain stable water temperatures in June and July due to daily air temperature fluctuations, and given the shutter configuration on the temperature control structure. Using a lower base flow (for example 8,000 cfs) results in needing to release more cold water reducing available cold water reserves and requiring higher releases when air temperatures are high. Higher base flow allows more stable operations and the ability to blend warmer and cooler water, helping to conserve cold water pool longer through the summer.

These flow schedules were calculated based on the estimated Sacramento Valley depletion forecasts developed by DWR as part of their monthly hydrologic updates.

In addition, the cold water and flow management of Shasta, Trinity and Whiskeytown reservoirs will be carried out in coordination with the SRTTG to meet temperature objectives on the Sacramento River, Clear Creek, and the Trinity River, to minimize isolation, dewatering or stranding of salmonids, and to meet in-basin water supply needs. The temperature operations will be conducted in accordance with Water Rights Order 90-05. Reclamation will provide the SRTTG with additional modeling as requested based on shaping of delivering schedules in addition to temperature release locations in order to extend the duration of cold water availability into August and September. Per the RPA, Reclamation will by-pass power generation to improve temperatures if needed for the protection of the winter-run or spring-run Chinook salmon.

As required by the NMFS BiOp, operations of other CVP reservoirs will be scheduled to support Shasta Reservoir cold water pool needs to the extent possible, provided such action would not unnecessarily cause other adverse fishery effect.

The SRTTG will continue to meet and provide advice on how to best meet temperature objectives to WOMT and RTDOT based on updated temperature modeling results from monthly forecast updates through the temperature control season as applicable. The ultimate goal will be to balance the various factors to provide the best possible, given the constraints, conditions on the Sacramento River for winter-run Chinook salmon.

## B. Folsom/American River Operations

Per the Flow Management Standard included in the NMFS BiOp, the projected March through November unimpaired inflow to Folsom Reservoir of less than 400,000 acre-feet has resulted in water year 2015 being a conference year. Under these conditions spring flows may be reduced to help conserve Folsom Lake storage. To comply with NMFS RPA Action II.2, Reclamation will coordinate closely with NMFS and the American River Group as conditions materialize to address temperature considerations on the American River.

#### C. <u>New Melones/Stanislaus River Operations</u>

The estimated flow schedule for the Stanislaus River is shown in Attachment A. Reclamation is currently estimating that projected inflows would allow for release of the required Appendix 2-E base and pulse flow volume per NMFS RPA Action III.1.3, but inflow forecasts are trending downward and available supplies for release may need to be adjusted in the near future. Once the available volumes are confirmed, the timing of releases will be coordinated with the SOG, with consideration of the other flow actions in the San Joaquin River basin this spring. The Appendix 2-E spring pulse flow will be initiated in March to early April.

To address D-1641 April-June flow requirements in 2015 on the San Joaquin River, Reclamation proposes modifications to the flows at Vernalis as described below under Proposed Delta Operations, D-1641 Provisions.

## D. Feather River Operations

DWR plans to meet all flow requirements on the Low Flow Channel and High Flow Channel on the Feather River and all temperature requirements at the Feather River Fish Hatchery and Robinson's Riffle for all periods as designated in the current FERC license which includes consultation with NMFS and USFWS, and the 1983 agreement between DWR and CDFW.

# II. Proposed Delta Operations - April Through September

## A. <u>D-1641 Provisions</u>

## Modification of Net Delta Outflow Index

D-1641 requires a Delta outflow minimum monthly average Net Delta Outflow Index (NDOI) of 7,100 cfs 3-day average and salinity requirements during the months of April, May and June. Reclamation and DWR are petitioning the State Water Board to adopt a Delta outflow standard of a minimum monthly NDOI during the months of April, May and June to be no less than 4,000 cfs; for the month of July, the monthly requirement for NDOI shall be no less than 3,000 cfs. The 7 day running average shall be no less than 1,000 cfs below the monthly average.

#### Modification of San Joaquin River Flow

Table 3 of D-1641 specifies San Joaquin River at Airport Way Bridge, Vernalis minimum monthly average flows, and a 31-day pulse flow period in April and May. Reclamation and DWR are petitioning the State Water Resource Control Board to adopt the following San Joaquin River at Airport Way Bridge, Vernalis river flow requirements:

- During the Vernalis 31-day pulse flow period, the monthly average flow to be no less than 710 cfs.
- For the period following the 31-day pulse flow through May 31<sup>st</sup>, the SJ River flow at Vernalis would be no less than 300 cfs on a 30-day running average.
- In June, the SJ River flow at Vernalis would be no less than 200 cfs average for the month.

#### Modification of Export Limits

Table 3 of D-1641 describes export limits. Generally, exports are limited to 35% of Delta inflow from February through June of each year, and 65% of Delta inflow from July through January of each year. Reclamation and DWR are petitioning the State Water Resource Control Board to adopt the following, modified from the maximum Export Limits included in Table 3 of D-1641, for the months of April, May, and June,:

- When precipitation and runoff events occur, and allow the DCC Gates to be closed and Footnote 10 of Table 3 of D-1641 is being met [3-day average Delta outflow of 7,100 cfs, or electrical conductivity of 2.64 millimhos per centimeter on a daily or 14-day running average at the confluence of the Sacramento and the San Joaquin Rivers (Collinsville station C2) if applicable], but any additional Delta outflow requirements contained in Table 4 of D-1641 are not being met, then exports of natural and abandoned flows are permitted up to D-1641 Export Limits contained in Table 3 of D-1641 at the SWP Banks Pumping Plant and the CVP Jones Pumping Plant, subject to other applicable laws and regulations including the ESA and California ESA (CESA).
- When NDOI of at least 7,100 cfs is not being met as specified above, or the DCC gates are open, then the combined maximum exports at the SWP Banks Pumping Plant and the CVP Jones Pumping Plant shall be no greater than 1,500 cfs with one exception. DWR and Reclamation may export up to a combined 3,500 cfs of natural and abandoned flows, on a 3-day running average, provided that NDOI is greater than 5,500 cfs and the DCC gates are closed. DWR and Reclamation would consult with the RTDOMT to determine if real-time conditions are consistent with predicted conditions. If consensus to implement is obtained at RTDOMT, then Reclamation or DWR would notify the State Board's Executive Director for final approval.
- During the effective period of any issued Order, if precipitation events occur that enable DWR and Reclamation to fully comply with the Delta outflow, river flows, and DCC Gate Closure requirements contained in D-1641, then D-1641 requirements shall be operative, except that any SWP and CVP exports greater than 1,500 cfs shall be limited to natural or abandoned flow, or transfers as specified in condition 1e of the March 5, 2015 SWRCB modified Order.

#### Modifications of DCC Gate Operations

D-1641 and the NMFS Biological Opinion require the closure of the DCC gates from February 1 through May 20. Reclamation and DWR petition the State Water Resource Control Board to modify the DCC gate operation requirements contained in Table 3 of D-1641 such that the DCC gates may be opened during April and May as necessary to reduce intrusion of high salinity water into the Delta while preserving limited storage in upstream reservoirs and reducing impacts to migrating Chinook salmon. The DCC gate triggers matrix (as described in Appendix G of the April 2014 Drought Operations Plan and Operational Forecast) will be used by the Projects to determine operation of the DCC gates. If the Projects determine that the DCC gates must open to provide for salinity management in the Delta during a period that requires closure under D-1641 or the NMFS Biological Opinion, then the Projects, through the RTDOT process, will provide at least a 5-day notice to the fish and wildlife agencies so that enhanced monitoring can begin. The Projects will implement enhanced monitoring and triggers to open and close the gates, as needed for protection of listed species.

#### Modification of Rio Vista Flow Requirement

D-1641 Table 3 dictates a minimum monthly Sacramento River flow requirements measured at Rio Vista of 3,000 cfs in the month of September (for critically dry water years). This requirement also states that the 7-day running average Sacramento River flow measured at Rio Vista shall be no lower than 2,000 cfs during this time. Reclamation and DWR are petitioning the State Water Resource Control Board to modify the D-1641 Table 3 Sacramento River at Rio Vista flow requirements to be no less than 2,500 cfs on a monthly average in September. The 7-day running average shall not be less than 2,000 cfs.

#### Modification of Western Delta Salinity Compliance Point

In a critical year, D-1641 requires the Agricultural Western Delta Salinity Standard at Emmaton have a 14-day running average of 2.78 millimhos per centimeter from April 1 to August 15. Reclamation and DWR are petitioning the State Water Resources Control Board to modify this requirement by moving the compliance location from Emmaton to Three Mile Slough on the Sacramento River beginning April 1.

#### Modification of San Joaquin River Salinity Requirement

In all water year types, D-1641 requires a San Joaquin River at Vernalis salinity limit of 0.7 EC from April through August. Reclamation is petitioning the State Water Resource Control Board to modify the San Joaquin River Salinity at Vernalis requirement from 0.7 EC to 1.0 EC from April to August.

#### III. Other Requested Modifications

#### A. <u>Ripon Dissolved Oxygen (DO) Requirement</u>

SWRCB D-1422 requires that water be released from New Melones Reservoir to maintain DO standards in the Stanislaus River. The 1995 revision to the WQCP established a minimum DO concentration of 7 milligrams per liter (mg/L), as measured on the Stanislaus River near Ripon. Reclamation proposes to maintain a minimum DO concentration of 7 mg/L at Orange Blossom Bridge this summer.

#### B. <u>NMFS BiOp Provisions</u>

- 1. NMFS RPA Action IV.2.1 Implementation: NMFS RPA Action IV.2.1 to be implemented by a 1:1 I:E ratio and with the following modification:
  - Prior to and after the Stanislaus River pulse flows and the 31-day Vernalis 1:1 pulse flow/export period as described in D-1641 (likely to be initiated late March to early April, 2015), Action IV.2.1 would be modified as necessary to allow for increased export pumping to capture abandoned or natural flows in the Delta (in the unlikely event that they occur) up to OMR limits, as provided in the NMFS BiOp (Action IV.2.3) and USFWS BiOp (Action 3).
  - Reclamation and DWR will, in a future year when hydrology allows, make an amount of water equivalent to half the volume of any increased exports realized over the April/May 2015 period available to provide for a larger pulse flow, for the fishery agencies to shape, in the next "dry" or better water year type based on the San Joaquin Valley Index. For example, if there is a 60 TAF gain in exports above the minimum health and safety diversion of 1,500 cfs, then 30 TAF of additional water (from some source within the San Joaquin River Basin in addition to the Appendix 2E flows or that required to meet in-river regulatory obligations on the other tributaries) would be made available in a future year for the spring pulse flow on the San Joaquin River. The release timing of this additional flow would be scheduled at the discretion of the fishery agencies in coordination with Reclamation. The additional flows gained in 2015 would be additive to those flows gained in 2014.
  - Preferential pumping of natural or abandoned flow during the 61-day duration of RPA Action IV.2.1 will be at the Jones Pumping Plant up to the federal capacity (either pumping or canal capacity); remainder of exports to be pumped at Banks Pumping Plant up to operable constraint (OMR limit outside of pulse period). Slight adjustments would be allowed to maintain minimal deliveries to the SWP South Bay Aqueduct, if necessary. This export shift will increase survival of salmonids through these facilities, since fewer fish will enter the SWP export facilities, where loss is higher due to substantial pre-screen mortality associated with Clifton Court Forebay. It is likely that shifting exports from the SWP to the CVP would increase overall survival. The amount of shifted pumping from Banks to Jones would be accounted for as part of existing sharing agreements between the two Projects.

- 2. OMR Flows: All OMR flow related actions, including those based on the NMFS salmonid density triggers, remain in place. Any flexibility that may be proposed based on hydrology will follow the framework outlined below.
- 3. DCC Gate Operations (NMFS RPA Action IV.1.2): If the Projects determine that the DCC gates must open before May 20, to provide for salinity management in the Delta, the Projects will provide at least a 5-day notice to the fish and wildlife agencies so that enhanced monitoring can begin. The Projects will implement enhanced monitoring and triggers to open and close the gates, as needed for protection of listed species (see D-1641 Provisions above regarding Modifications of DCC Gate Operations).

## C. <u>USFWS BiOp Provisions</u>

Based on forecasts, no additional modifications to the USFWS BiOp RPA actions are currently proposed. All OMR flow related actions, including the potential for USFWS determinations based on entrainment risk, remain in place. Reclamation will formally request that the OMR Index Demonstration Project as implemented in 2014 continue into 2015. Additionally, the RTDOT will continue to meet and if conditions warrant, additional modifications may be proposed in the future consistent with the framework outlined below. Any modifications would be accompanied by real-time monitoring at Prisoners Point and Jersey Point in order to evaluate in real time any changes in distribution or density of Delta Smelt in the Central Delta.

## Possible Future Conditions Warranting Additional Modifications

The description below is included to highlight specific actions and factors that may be considered throughout 2015, and identifies actions that may be included in future consultations, if necessary. This is not intended to be a fully inclusive list, nor does inclusion in the list mean the agencies will go forward with any action. Reclamation and DWR are not proposing these actions at this time, however these actions are considered in looking at the future status of the species in light of the actions proposed to date in 2015.

<u>Old and Middle River (OMR) Flow Management Consultation Framework</u>: If conditions warrant, Reclamation and DWR plan to propose short-term flexibilities similar to what occurred in February 2015 and consistent with the Interagency 2015 Drought Strategy for the CVP and SWP (2015 Drought Strategy). These flexibilities would allow OMR exceedances of the 14-day running average, measured using the OMR Index, during sporadic storm events under continued drought conditions. Limited exceedances of the -5,000 cfs OMR flow limit to -6,000 cfs, to be implemented only on the ascending limb of the hydrograph, may be requested to capture natural or abandoned flow in the Delta from sporadic storms (increase exports) under drought conditions. Any short-term flexibility in OMR would off-ramp should NMFS or USFWS determine that less negative OMR is required to protect listed fish species under the RPAs set forth in their respective BiOps, should conditions different from those that were expected during the period of operational flexibility occur. To implement this OMR flexibility, an objective of at least 7,100 cfs NDOI or 2.64 EC at Collinsville, or the objective of 4,000 cfs NDOI in May and June, whichever is applicable<sup>1</sup>, must be achieved. Additionally, operations will be consistent with the Export Limits described in Table 3 of D-1641. If warranted by continued drought conditions, Reclamation and DWR may seek additional OMR flexibility beyond what is described herein. Implementing these limited exceedances will be evaluated at that time.

To complete an ESA consultation in a timely manner, and if flexibilities are warranted, the following OMR consultation process has been developed. This process is intended to explore and evaluate risks associated with any proposal and streamline ESA compliance through ongoing coordination between Reclamation, DWR, and the state and federal fish and wildlife agencies. Any OMR proposal will be discussed as part of the RTDOT process.

#### Streamlined OMR Consultation Framework:

- 1. Identify upcoming storm event
- 2. Evaluate forecasted run-off and anticipated available in-Delta flows
- 3. Develop and model a specific OMR and outflow proposal, including specific proposed OMR flow and expected duration of action
- 4. Finalize proposed project description
- 5. Prepare listed species and critical habitat biological review including:
  - o Existing Delta conditions and supporting hydrodynamic modeling
  - $\circ$  ~ Species distribution and risk of entrainment in the South and Central Delta
  - Particle Tracking Model (PTM) results, including enhanced PTM if available for salmonids
  - Discussion of any existing RPA action that may be in place and any associated effects analysis that provides biological support for a deviation from that action

If Reclamation and DWR determine through the described streamlined process that OMR flexibility is warranted, then Reclamation and DWR will describe the requested flexibility in a reinitiation request that provides the information described above. USFWS and NMFS will provide an evaluation of the anticipated effects of the action on listed species and critical habitats. DWR and CDFW will undertake a similar process for CESA.

<u>Temporary Emergency Drought Barriers</u>: If hydrologic forecasts show there will be insufficient water in upstream reservoirs to repel the saltwater and meet health and safety and other critical needs, then installation of Emergency Drought Barriers will be considered to lessen water quality impacts. Excessive salinity increases in the Delta could render the water undrinkable for 25 million Californians and unusable by farms reliant upon this source. Temporary rock (rip-rap) Emergency Drought Barriers may be installed at up to three locations in the Delta during drought conditions in 2015, or in a subsequent year if necessary, to manage salinity in the Delta when there is not enough water in upstream reservoirs

<sup>&</sup>lt;sup>1</sup> The 7,100 cfs NDOI or 2.64 EC at Collinsville objective does not apply in May and June if the best available estimate of the Sacramento River Index for the water year is less than 8.1 MAF at the 90% exceedance level. Under this circumstance, a minimum 14-day running average NDOI of 4,000 cfs is required in May and June.

to release to rivers to repel the saltwater. Consultation on installation and operation of the barriers will be conducted on the barriers prior to installation and may require additional adjustments to D-1641.

In addition to the modifications requested above, if Temporary Emergency Drought Barriers are installed, the following preliminary list of modifications will be evaluated and may supersede some of the items described above:

- Minimum monthly NDOI described in Figure 3 of D-1641 during the months of June through October
- Critical year D-1641 Agricultural Western Delta Salinity Standard at Emmaton (14-day running average of 2.78 millimhos per centimeter through August 15)
- Mean monthly Rio Vista flow standard in September, October, and November

<u>Upstream Reservoirs</u>: Upstream reservoirs will be operated through the spring to preserve and build storage. Reclamation and DWR will be trying to develop cold water resources in the spring in those reservoirs where temperature management is needed later in the year. Cold water resources may be developed by continuing on-going discussions with the Sacramento River Settlement Contractors to shift early spring demand later into the year to conserve water in Shasta Reservoir, if warranted.

<u>Water Supply</u>: Throughout dry conditions, CVP and SWP systems will be operated to lessen critical economic losses to agricultural, municipal, and industrial uses due to water shortages through project water deliveries and by facilitating voluntary water transfers and exchanges to the extent possible, while balancing the needs of upstream storage, fishery and wildlife resource protection, and operational flexibility. A key to minimizing water supply shortages for economic purposes will be to take advantage of opportunities to export natural or abandoned flow in the spring while maintaining Delta water quality and minimizing adverse effects to listed fish. Release of stored water in summer and fall will be managed to concurrently benefit in-stream temperature objectives, wildlife objectives, meet Sacramento Valley in-basin needs, and preserve carry over storage to meet objectives in WY 2016.

<u>Refuges</u>: One of the requirements of the Central Valley Project Improvement Act (CVPIA) passed by Congress in 1992 included providing water for state, federal and private managed wetlands in order to maintain and improve wetland habitat areas. For south of Delta refuges, water from San Luis Reservoir can be made available to meet refuge needs when total demand from direct diversions from the Delta are not feasible. The CVPIA and refuge water supply contracts allow for flexibility to transfer water from refuges both within basin as well as north of the Delta to south of the Delta. Water transfers from north of Delta refuges to south of Delta refuges would occur to support priority habitat needs of south of Delta refuges given available capacity to facilitate the transfer. This water would be directly diverted or could be stored in San Luis Reservoir and used when most needed by south of the Delta refuges. Refuge deliveries are included in CVP operational scenarios and forecasts, and calculations regarding anticipated reservoir levels into the late fall and early winter.

<u>Biological Opinion Flexibilities</u>: The specific flexibilities being sought in this consultation for April through September and OMR Flow Management Consultation Framework are described above. The

items included below are potential flexibilities that may be sought through future consultations. Many of these items are further described in the Interagency 2015 Drought Strategy Working Draft dated December 11, 2014.

- NMFS BiOp Provisions
  - Head of Old River Barrier (HORB):
    - The spring HORB, as described in the 2008 Biological Assessment Project Description, will be installed and 90% operational by April 1, 2015, and 100% completed and operational by April 8, 2015. The HORB is intended to prevent downstream-migrating salmonids in the San Joaquin River from entering Old River.
    - Although not described in the NMFS RPA, the fall HORB barrier is typically installed upon the request of CDFW and is similar in design to the spring barrier, but smaller in size. The fall barrier is intended to benefit migrating adult salmon in the San Joaquin River by improving flow and dissolved oxygen conditions in the San Joaquin River downstream of the barrier.
- USFWS BiOp Provisions
  - Fall X2 Action (if Sacramento Valley classification is above normal or wet): This RPA component will not be triggered in WY 2015, however, Reclamation will work with DWR, NMFS, USFWS, CDFW, and others to refine the Fall Outflow Adaptive Management Plan (AMP) based on findings to date, including, if appropriate, proposing new experimental management strategies based on those findings.

<u>D-1641 Related Actions</u>: Reclamation and DWR may seek adjustments under D-1641, including triggers for modified X2 criteria to balance upstream storage and fish protection. Additionally, Reclamation and DWR may exercise the flexibility provided in D-1641 to adjust the E/I ratio's averaging period for sporadic storm events (similar to 2014).

<u>Transfers and Exchanges</u>: Reclamation and DWR will continue to facilitate water transfers and exchanges. If these transfers or exchanges are conveyed through the Delta outside the transfer window described in the 2008 and 2009 BiOps (July-September), Reclamation and DWR will consult with USFWS and NMFS prior to conveyance of the transfer water and DWR will request a consistency determination from CDFW.

Attachment A

February 2015 Operational Forecasts

# **DROUGHT CONTINGENCY PLAN**

# (April 1, 2015 - September 30, 2015)

# Feburary 1 - 90% HYDROLOGIC EXCEEDENCE

# **END OF MONTH STORAGES (TAF)**

				2015		
RESERVOIRS	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	1178	1017	908	806	702	642
Shasta	2590	2316	2015	1613	1319	1174
Folsom	579	578	498	332	268	238
Oroville	1707	1291	1038	786	628	628
New Melones	518	424	349	268	188	132

# MONTHLY AVERAGE RELEASES (CFS)

DESERV/OIDS				2015		
RESERVOIRS	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Trinity	550	2900	800	450	450	450
Sacramento	6600	7500	8650	9600	7800	5000
American	800	800	1650	2950	1400	800
Feather	2550	4600	1750	1650	900	800
Stanislaus	500	150	150	150	150	150

DELTA	SUMMARY	(CFS)
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				2015		
	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
Rio Vista Flows	4850	7170	2700	2150	1200	1900
Sac River at Freeport	6790	9650	7050	7850	6400	6800
SJ River at Vernalis	3030	710	1050	900	750	750
Computed Outflow	7100	7100	4000	4000	3000	3000
Combined Project Pumping	1500	1500	900	900	900	2600

# **Methods and Modeling**

Conceptual models of impacts from drought management actions were presented in the Biological Review for the February-March Project Description (Figure 1, Reclamation 2015). The potential effects of the proposed April through September 2015 operational actions are considered in the context of these conceptual models. Additionally, the biological opinions (NMFS 2009, USFWS 2008) were reviewed regarding biological linkage to the considered actions.

M A A G E M E N T		<u>DCC Gate Operation</u> (Interior delta salinity)	<u>Outflow (NDOI)</u> (Change in Location)	Inflow (Storage impacted by DOP, seasonal depletions)	<u>OMR</u> (change in BiOp criteria)	<u>Exports</u> ( E/I calculation)
L N K G E	•	Route entrainment	<ul> <li>Tidal influence</li> <li>Migration rate</li> <li>Rearing period</li> <li>Survival rate</li> </ul>	<ul> <li>Migration rate</li> <li>Rearing period</li> <li>Survival rate</li> </ul>	<ul> <li>Route entrainment</li> <li>Migration rate</li> <li>Rearing period</li> <li>Survival rate</li> </ul>	<ul> <li>Route entrainment</li> <li>Migration rate</li> <li>Facility survival</li> </ul>
A S S S S M E N T	•	DJFMP periodicity Changes in DSM2 proportion daily flow DeIta survival information	<ul> <li>Changes in DSM2 velocity characteristics</li> <li>Changes in DSM2 proportion daily flow</li> <li>Delta survival information</li> </ul>	<ul> <li>Changes in DSM2 velocity characteristics</li> <li>Changes in DSM2 proportion daily flow</li> <li>Delta survival information</li> </ul>	<ul> <li>SD/CD DJFMP presence/absence</li> <li>Facility salvage (Density, total, timing)</li> <li>Delta survival information</li> </ul>	<ul> <li>SD/CD DJFMP presence/absence</li> <li>Facility salvage (Density, total, timing)</li> <li>Delta survival information</li> </ul>

# Figure 1 Conceptual model of drought contingency plan elements and their biological linkage to salmonids and assessment information available for evaluation.

# **Operational Forecast Model**

The February 90% Operational Forecast provides potential tributary and Delta operational conditions. In particular, this information is useful for evaluating potential Central Valley Project and State Water Project (CVP and SWP) tributary operations during April through September. The reservoir releases in this forecast include implementation of RPA actions from the NMFS Biological Opinion on the Long Term Coordinated Operations of the CVP and SWP for Clear Creek, American River, and Stanislaus River. These are described in the Project Description, which includes some modifications of these actions. When these monthly average flows assume implementation different from the RPA, a qualitative description of habitat-related impacts are described. Temperature related impacts of the forecast related to divisions of the CVP are not included at this time, since the Sacramento River Temperature Task Group (SRRTG) is actively meeting to provide advice and review of the temperature forecast modeling to support development of the seasonal Sacramento Temperature Management Plan. Temperature

management for the American River Group will be considered by the American River Group (ARG).

# **DSM2 Model**

Delta Simulation Model II (DSM2) simulations were performed and evaluated for three operational management scenarios (Table 1). These simulations were designed to evaluate potential effects of the Project Description's reduced Sacramento and San Joaquin River outflow and other operational modifications on potential Delta hydrodynamics for the months of April through May when listed salmonids are most likely to be present in the Delta and hydrology forecasts are more foreseeable. These scenarios were concatenated to look at a 31-day pulse flow period ("April") and post-pulse period ("May") to evaluate DSM2 results. The Baseline scenario (Hydrology 1) represents an unmodified set of D-1641 standards for NDOI, Vernalis flows, and Delta Cross Channel Gate operations, while a Project Description scenario (Hydrology 2) included a modified NDOI and Vernalis flows.

The April modeled Vernalis average monthly flow, which were inclusive of an Appendix 2e pulse flow volume is likely positively biased compared to the predicted Vernalis average monthly flow during the pulse flow period, which in the TUCP is proposed to be no less than 710cfs. According to the modeled flows at Channel 6 (Mossdale, downstream of Vernalis but likely to have similar flow) summarized in Table 4 and 5, the modeled monthly average flow during April and May was 951 cfs, 241 cfs more than the 710 cfs proposed in the current TUCP order. Whether realized flows at Vernalis will more closely match the modeled flows or the proposed flows will depend on accretions and depletions during April and May. This uncertainty suggests modeled flows under the Project Description are likely greater than what will actually be observed, which influences the interpretation of any possible impacts on fishes resulting from the Project Description. Additionally, results from a hydrodynamic scenario with similar NDOI and Vernalis flows and an open DCC gate for two months are presented (Hydrology 2'). Other input values remained constant and reflected the best information available to DWR modelers when models were run on March 13, 2015. These flows do not necessarily reflect current forecast information and actual conditions have and will differ from the modeled scenarios. The modeled scenarios represent minimum values, yet provide the best evaluation approach to describing the worst conditions likely to be observed for the flow measures. These issues increase the uncertainty of assessments of impacts to all species reviewed.

Table 1. DSM2 Model Input for Scenarios Evaluated in the Biological Review. DSM2 Run Name is
Listed Parenthetically for Each Scenario

	ND	OI	Free flow	port (cfs)	Vernal (cf	is flow fs)	Com Expor	bined ts (cfs)	
Scenario	April	May	April	May	April	May	April	May	DCC Status
Baseline (Hydrology 1)	7,1	00	7,100- +exp	(VNS port)	710 +3 (4/1 -	100 cfs -5/1)	1,5	500	Closed
Project Description – DCC Gate Closed (Hydrology 2)	4,0	000	4,000-( VNS +(	(Lower export)	300+A flow ( 5/1	App. 2e $(4/1 - 1)^1$	1,5	500	Closed
Project Description DCC Gate Open (Hydrology 2')	4,0	000	4,000-( VNS +(	(Lower export)	300+A flow ( 5/1	App. 2e $(4/1 - 1)^1$	1,5	500	Open for 2 months

DSM2 modeling outputs for each scenario were used to evaluate the distribution of 15-minute flow and velocity values for multiple channels, including:

- Upstream of Head of Old River on San Joaquin (Channel 6)
- Downstream of Head of Old River on San Joaquin (Channel 9)
- Upstream of Stockton Deepwater Shipping Channel (Channel 12)
- Jersey Point on San Joaquin River (Channel 49)
- Sherman Island on San Joaquin River (Channel 50)
- Downstream of Head of Old River on Old River (Channel 54)
- Old River south of Railroad Cut (Channel 94)
- Old River at San Joaquin River (Channel 124)
- Middle River north of Railroad Cut (Channel 148)
- Three Mile Slough near San Joaquin River (Channel 310)
- Sacramento River near Sherwood Harbor (Channel 412)
- Sacramento River at Sutter Slough (Channel 388)
- Sacramento River upstream of Delta Cross Channel (Channel 421)
- Sacramento River downstream of Delta Cross Channel (Channel 422)

<sup>&</sup>lt;sup>1</sup> The TUCP identifies proposed modification of the average monthly flow during the Vernalis 31-day pulse flow period to be no less than 710 cfs.

- Sacramento River upstream of Georgiana Slough (Channel 422)
- Sacramento river downstream of Georgiana Slough (Channel 423)
- Sacramento River near Cache Slough (Channel 429)
- Sherman Island on Sacramento River (Channel 434)

# **Hydrodynamic Metrics**

Hydrodynamic metrics, such as daily mean velocity and flow were calculated (Tables 2-5). Additionally, mean daily proportion positive velocity, daily mean velocity, and daily mean flow were used to assess changes in the Delta at these locations. These were calculated over the separate April and May periods (Tables 6-7).

These data are also visualized spatially at both temporal steps to assess regional impacts and more complex hydrodynamics around the Delta Cross Channel and Head of Old River under each scenario. Daily proportion positive velocity is the percentage of the day that river flows have a positive velocity value (flows in downstream direction). Daily mean velocity and mean flow are the average of all values summed over the 24 hour period, which takes into account the effects of tidal stage on velocity magnitudes. These daily values are then averaged for the period of interest. The difference in the values of these hydrodynamic metrics between the Baseline and Project Description model run was calculated to assess how the metric was affected by the Project Description. We also calculated the difference in the values of these hydrodynamic metrics between the Project Description and Project Description with DCC gates open scenarios.

Density plots of DSM2 modeled 15-minute velocity data were developed for the eighteen channel nodes modeled for the two scenarios. Figures 2-23 show nodes showing variation between modeled scenarios in April and May periods for the different hydrology scenarios. These plots show low levels of change in the 15-minute velocity plots and in the lower river reaches tidal hydrodynamics and channel morphology drive channel velocities to a greater extent than the operational differences evaluated in the modeled scenarios. Figures 24-27 show spatially key channel nodes through the Delta during April and May for a few of the hydrodynamic metrics.

Differences in the river inflow between the Project Description and Baselines modeled scenarios are seen in the velocity plots at the upper extent of the tidal influence on the Sacramento near Sherwood Harbor (Figure 2-3) and San Joaquin river near Head of Old River (Figures 16-17). In the May portion of the model runs, there is a larger difference between the Baseline and Project Description modeled velocities due to reduced San Joaquin River contribution to the NDOI and thus greater flows at Freeport in May than April (Figures 2 and 3). At all other channel nodes during May and all nodes for the April portion of the model runs, the influence of these river inflows quickly dissipates as tides begin to dominate on the Sacramento (Figures 4-15). An open DCC gates during these months also impacts velocities upstream of the DCC gates (Channel node 421, Figures 6-7), and modeled results show a greater range of velocities, both negative and positive in this reach, due to increased flows rates downstream on an ebbing tide and upstream on a flooding tide. Modeled channel velocities in the Sacramento River near the DCC and Georgiana Slough differ between the Baseline and Project Description scenarios. Modeled results from the Project Description with an open DCC show a reduction in daily mean velocities in April and May downstream of the DCC (Channel node 422; Figures 8-9). At locations in the

North Delta further south, tidal conditions dominate and the range and magnitude of velocities observed in the modeling are similar into the western Delta (Figures 10-15).

Difference between the Project Description and Baseline model run influence the velocity along the San Joaquin River more during the modeled April period than May period (Figures 16-21) from upstream of Head of Old River to downstream of the Stockton Deepwater Ship Channel. These differences influence the proportion of daily positive flow (Tables 6-7), daily velocities (Tables 2-3), and daily flows (Tables 4-5). In the South Delta along Old and Middle River corridor, these changes are less significant due to the low export levels in the Baseline and Project Description model run. The modeled daily average hydrodynamic changes resulting from the proposed operations for both the April and May periods are small (Tables 4-5, approximately 62cfs for channel 148 in April and 152cfs in May) and do not show substantive differences in daily average velocities (Tables 2-3, Figure 22-23) between Baseline period at channel node 148 (Middle River north of Railroad Cut).

 Table 2. Daily Mean Velocities (ft/sec) between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes during April

		Node 6			Node 9			Node 12			Node 49			Node 50	)		Node 54			Node 94			Node 124	1		Node 148	,
Date	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	1.20	0.26	-0.94	1.29	0.20	-1.09	1.05	0.19	-0.86	0.09	0.07	-0.03	0.10	0.08	-0.02	0.36	-0.06	-0.20	-0.01	-0.03	-0.04	-0.06	-0.06	0.01	-0.02	-0.03	-0.01
2-Apr	1.21	0.34	0.87	1.38	0.30	1.08	1.14	0.26	0.88	0.08	0.06	0.02	0.10	0.07	0.02	0.37	-0.06	0.18	-0.04	-0.03	0.02	-0.07	-0.06	-0.01	-0.03	-0.03	0.01
3-Apr	1.21	0.38	0.82	1.38	0.35	1.03	1.14	0.31	0.84	0.07	0.05	0.02	0.09	0.07	0.02	0.37	-0.06	0.16	-0.03	-0.03	0.02	-0.07	-0.06	-0.01	-0.03	-0.03	0.01
4-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.14	0.31	0.83	0.07	0.04	0.02	0.08	0.06	0.02	0.37	-0.06	0.16	-0.02	-0.03	0.02	-0.07	-0.06	-0.01	-0.02	-0.03	0.01
5-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.06	0.04	0.02	0.08	0.06	0.02	0.37	-0.06	0.16	-0.02	-0.03	0.02	-0.07	-0.06	-0.01	-0.02	-0.03	0.01
6-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.05	0.02	0.02	0.06	0.04	0.02	0.37	-0.07	0.16	-0.02	-0.03	0.02	-0.07	-0.07	-0.01	-0.03	-0.03	0.01
7-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.04	0.01	0.02	0.05	0.03	0.02	0.37	-0.07	0.16	-0.02	-0.03	0.02	-0.07	-0.07	-0.01	-0.03	-0.03	0.01
8-Apr	1.20	0.38	0.82	1.38	0.36	1.02	1.15	0.32	0.83	0.02	0.00	0.02	0.03	0.01	0.02	0.37	-0.07	0.16	-0.03	-0.04	0.02	-0.08	-0.07	-0.01	-0.03	-0.04	0.01
9-Apr	1 21	0.39	0.82	1 39	0.38	1.01	1 16	0.33	0.83	0.02	-0.01	0.02	0.03	0.00	0.02	0.37	-0.06	0.17	-0.02	-0.04	0.02	-0.07	-0.06	-0.01	-0.03	-0.04	0.01
10-Apr	1.21	0.40	0.81	1.41	0.42	0.99	1.17	0.36	0.81	0.02	0.00	0.02	0.03	0.01	0.02	0.36	-0.05	0.17	0.01	-0.02	0.02	-0.06	-0.05	-0.01	-0.02	-0.02	0.01
11-Apr	1.21	0.40	0.81	1.42	0.42	0.99	1.19	0.38	0.81	0.05	0.03	0.02	0.06	0.04	0.02	0.36	-0.04	0.17	0.04	0.00	0.02	-0.05	-0.04	-0.01	0.00	0.00	0.01
12-Apr	1.22	0.40	0.82	1.41	0.41	1.00	1 19	0.38	0.82	0.09	0.06	0.02	0.09	0.07	0.02	0.36	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
13-Apr	1 21	0.39	0.82	1.41	0.40	1.01	1 18	0.36	0.82	0.10	0.08	0.02	0.11	0.09	0.02	0.36	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
14-Apr	1 21	0.39	0.82	1.40	0.39	1.01	1 17	0.35	0.82	0.11	0.09	0.02	0.12	0.10	0.02	0.36	-0.04	0.17	0.04	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
15-Apr	1 20	0.38	0.83	1 38	0.35	1.02	1 17	0.34	0.82	0.11	0.09	0.02	0.12	0.10	0.02	0.36	-0.05	0.16	0.03	0.00	0.02	-0.06	-0.05	-0.01	0.00	0.00	0.01
16-Apr	1.20	0.30	0.82	1.30	0.35	1.02	1 15	0.34	0.92	0.11	0.09	0.02	0.13	0.11	0.02	0.36	-0.05	0.16	0.03	-0.01	0.02	-0.06	-0.05	-0.01	0.00	-0.01	0.01
17-Apr	1 10	0.30	0.02	1.37	0.35	1.02	1.1.5	0.33	0.03	0.11	0.09	0.02	0.13	0.11	0.02	0.30	-0.05	0.16	0.02	-0.02	0.02	-0.07	-0.05	-0.01	-0.01	-0.02	0.01
19 Apr	1.15	0.37	0.01	1.30	0.34	1.02	1.14	0.21	0.85	0.10	0.09	0.02	0.13	0.10	0.02	0.30	0.06	0.16	0.00	0.02	0.02	0.07	0.06	0.01	0.02	0.02	0.01
10-Apr	1.10	0.37	0.01	1.35	0.34	1.01	1.13	0.31	0.82	0.10	0.00	0.02	0.12	0.10	0.02	0.30	-0.00	0.16	-0.02	-0.03	0.02	0.07	-0.00	0.01	-0.02	-0.03	0.01
20 Apr	1.10	0.37	0.81	1.35	0.35	1.00	1.15	0.31	0.82	0.05	0.03	0.02	0.10	0.05	0.02	0.30	-0.07	0.10	-0.03	-0.03	0.02	-0.00	-0.07	0.01	-0.03	-0.03	0.01
20-Apr	1.10	0.37	0.80	1.55	0.55	1.00	1.14	0.31	0.82	0.03	0.05	0.02	0.06	0.03	0.02	0.30	-0.07	0.10	-0.03	-0.04	0.02	-0.08	-0.07	-0.01	-0.05	-0.04	0.01
21-Apr	1.10	0.50	0.81	1.50	0.55	1.01	1.14	0.52	0.85	0.05	0.01	0.02	0.05	0.05	0.02	0.50	-0.07	0.10	-0.05	-0.04	0.02	-0.08	-0.07	-0.01	-0.05	-0.04	0.01
22-Apr	1.15	0.30	0.81	1.30	0.30	1.02	1.15	0.32	0.85	0.02	0.00	0.02	0.03	0.01	0.02	0.30	-0.07	0.10	-0.03	-0.04	0.02	-0.08	-0.07	0.01	-0.03	-0.04	0.01
25-Apr	1.20	0.40	0.81	1.40	0.40	1.00	1.10	0.34	0.82	0.02	-0.01	0.02	0.05	0.00	0.02	0.30	-0.00	0.10	-0.01	-0.05	0.02	-0.07	-0.00	-0.01	-0.05	-0.05	0.01
24-Apr	1.22	0.40	0.81	1.42	0.42	1.00	1.15	0.50	0.81	0.05	0.01	0.02	0.04	0.02	0.02	0.50	-0.05	0.17	0.05	-0.01	0.02	-0.05	-0.03	-0.01	0.00	-0.01	0.01
25-Apr	1.22	0.41	0.62	1.45	0.45	1.01	1.20	0.50	0.82	0.07	0.05	0.02	0.07	0.05	0.02	0.50	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
20-Apr	1.23	0.40	0.83	1.43	0.42	1.01	1.20	0.38	0.83	0.09	0.07	0.02	0.09	0.07	0.02	0.37	-0.04	0.17	0.05	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
27-Apr	1.25	0.40	0.85	1.42	0.41	1.02	1.15	0.30	0.85	0.10	0.00	0.02	0.11	0.08	0.02	0.37	-0.04	0.10	0.04	0.00	0.02	-0.05	-0.04	-0.01	0.01	0.00	0.01
20-Apr	1.25	0.50	0.67	1.42	0.50	1.00	1.10	0.52	0.80	0.10	0.00	0.02	0.11	0.09	0.02	0.57	-0.04	0.15	0.05	-0.01	0.02	-0.05	-0.04	-0.01	0.00	-0.01	0.01
29-Apr	0.79	0.38	0.41	0.92	0.34	0.58	0.75	0.28	0.47	0.09	0.07	0.02	0.10	0.08	0.02	0.20	-0.04	0.09	0.01	-0.01	0.02	-0.05	-0.04	-0.01	-0.01	-0.01	0.01
50-Api	0.57	0.54	0.05	0.50	0.27	0.05	0.23	0.25	0.02	0.08	0.07	0.01	0.05	0.06	0.01	0.10	-0.05	0.01	0.00	-0.01	0.00	-0.05	-0.05	0.00	-0.01	-0.01	0.00
		Nodo 210	2		Nodo 29	0		Node 41			Nodo 421			Nodo 42	2		Nodo 42	,		Nodo 42			Nodo 42/	1			
Date	11	Node 310	) Difference	11	Node 38	8	11	Node 412	Difference	11	Node 421	Difference	11	Node 42	2 Difference	11	Node 42	}	11	Node 429	Difference	11	Node 434	1 Difference			
Date	Hydr #1	Node 310 Hydr #2	Difference	Hydr #1	Node 38 Hydr #2	8 Difference	Hydr #1	Node 412 Hydr #2	Difference	Hydr #1	Node 421 Hydr #2	Difference	Hydr #1	Node 42 Hydr #2	2 Difference	Hydr #1	Node 423 Hydr #2	Difference	Hydr #1	Node 429 Hydr #2	Difference	Hydr #1	Node 434 Hydr #2	Difference			
Date 1-Apr	Hydr #1 0.05	Node 310 Hydr #2 0.02	Difference	Hydr #1 0.52	Node 38 Hydr #2 0.46	8 Difference -0.06	Hydr #1	Node 412 Hydr #2 0.56	Difference -0.07	Hydr #1 0.51	Node 421 Hydr #2 0.45	Difference -0.05	Hydr #1	Node 42 Hydr #2 0.40	2 Difference -0.05	Hydr #1	Node 423 Hydr #2 0.32	Difference -0.05	Hydr #1	Node 429 Hydr #2 0.29	Difference	Hydr #1	Node 434 Hydr #2 0.10	Difference -0.01			
Date 1-Apr 2-Apr	Hydr #1 0.05 0.04	Node 310 Hydr #2 0.02 0.01	Difference -0.03 0.03	Hydr #1 0.52 0.51	Node 38 Hydr #2 0.46 0.44	8 Difference -0.06 0.07	Hydr #1 0.63 0.63	Node 412 Hydr #2 0.56 0.53	Difference -0.07 0.10	Hydr #1 0.51 0.50	Node 421 Hydr #2 0.45 0.43	Difference -0.05 0.07	Hydr #1 0.45 0.44	Node 42 Hydr #2 0.40 0.38	2 Difference -0.05 0.06	Hydr #1 0.36 0.36	Node 423 Hydr #2 0.32 0.29	Difference -0.05 -0.06	Hydr #1 0.33 0.32	Node 429 Hydr #2 0.29 0.27	Difference -0.04 -0.05	Hydr #1 0.12 0.11	Node 434 Hydr #2 0.10 0.09	Difference -0.01 -0.01			
Date 1-Apr 2-Apr 3-Apr	Hydr #1 0.05 0.04 0.03	Node 310 Hydr #2 0.02 0.01 0.00	Difference -0.03 0.03 0.03 0.03	Hydr #1 0.52 0.51 0.51	Node 38 Hydr #2 0.46 0.44 0.44	8 Difference -0.06 0.07 0.07	Hydr #1 0.63 0.63 0.63	Node 412 Hydr #2 0.56 0.53 0.53	Difference -0.07 0.10 0.10	Hydr #1 0.51 0.50 0.50	Node 421 Hydr #2 0.45 0.43 0.43 0.43	Difference -0.05 0.07 0.07	Hydr #1 0.45 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38	2 Difference -0.05 0.06 0.06	Hydr #1 0.36 0.36 0.35	Node 423 Hydr #2 0.32 0.29 0.29	B Difference -0.05 -0.06 -0.06	Hydr #1 0.33 0.32 0.32	Node 429 Hydr #2 0.29 0.27 0.27 0.27	Difference -0.04 -0.05 -0.05	Hydr #1 0.12 0.11 0.10	Node 434 Hydr #2 0.10 0.09 0.09	Difference -0.01 -0.01 -0.01			
Date 1-Apr 2-Apr 3-Apr 4-Apr	Hydr #1 0.05 0.04 0.03 0.02	Node 310 Hydr #2 0.02 0.01 0.00 0.00	Difference -0.03 0.03 0.03 0.03 0.03	Hydr #1 0.52 0.51 0.51 0.52	Node 38 Hydr #2 0.46 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07	Hydr #1 0.63 0.63 0.63 0.64	Node 412 Hydr #2 0.56 0.53 0.53 0.54	Difference -0.07 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50	Node 421 Hydr #2 0.45 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38	2 Difference -0.05 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.36 0.35 0.35	Node 423 Hydr #2 0.32 0.29 0.29 0.28	B Difference -0.05 -0.06 -0.06 -0.06 -0.06	Hydr #1 0.33 0.32 0.32 0.31	Node 429 Hydr #2 0.29 0.27 0.27 0.26	Difference -0.04 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.10 0.09	Node 434 Hydr #2 0.10 0.09 0.09 0.08	Difference -0.01 -0.01 -0.01 -0.01 -0.01			
Date 1-Apr 2-Apr 3-Apr 4-Apr 5-Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01	Node 310 Hydr #2 0.02 0.01 0.00 0.00 -0.01	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03	Hydr #1 0.52 0.51 0.51 0.52 0.52	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07	Hydr #1 0.63 0.63 0.63 0.64 0.64	Node 412 Hydr #2 0.56 0.53 0.53 0.54 0.54	Difference -0.07 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38 0.38 0.38	2 Difference -0.05 0.06 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35	Node 42: Hydr #2 0.32 0.29 0.29 0.28 0.28 0.28	B Difference -0.05 -0.06 -0.06 -0.06 -0.06	Hydr #1 0.33 0.32 0.32 0.31 0.31	Node 429 Hydr #2 0.29 0.27 0.27 0.26 0.26 0.25	Difference -0.04 -0.05 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.10 0.09 0.09	Node 434 Hydr #2 0.10 0.09 0.09 0.09 0.08 0.07	Difference -0.01 -0.01 -0.01 -0.01 -0.01 0.01			
Date 1-Apr 2-Apr 3-Apr 4-Apr 5-Apr 6-Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01 0.00	Node 310 Hydr #2 0.02 0.01 0.00 0.00 -0.01 -0.02 0.02	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.51 0.52 0.52 0.51	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.63 0.63 0.64 0.64 0.64	Node 412 Hydr #2 0.56 0.53 0.53 0.54 0.54 0.54	2 Difference -0.07 0.10 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.50	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38 0.38 0.38 0.38	2 Difference -0.05 0.06 0.06 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35	Node 42: Hydr #2 0.32 0.29 0.29 0.28 0.28 0.28 0.28	B Difference -0.05 -0.06 -0.06 -0.06 -0.06 -0.06 0.07	Hydr #1 0.33 0.32 0.32 0.31 0.31 0.30	Node 429 Hydr #2 0.29 0.27 0.27 0.26 0.26 0.25 0.25	Difference -0.04 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.10 0.09 0.09 0.08	Node 434 Hydr #2 0.10 0.09 0.09 0.09 0.08 0.07 0.06	J           Difference           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01			
Date 1-Apr 2-Apr 3-Apr 4-Apr 5-Apr 6-Apr 7-Apr 8 Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01 0.00 -0.01	Node 310 Hydr #2 0.02 0.01 0.00 0.00 -0.01 -0.02 -0.03 0.05	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.51 0.52 0.52 0.51 0.51	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.07 0.07 0.08 0.08	Hydr #1 0.63 0.63 0.63 0.64 0.64 0.64	Node 412 Hydr #2 0.56 0.53 0.53 0.54 0.54 0.54 0.54	Difference -0.07 0.10 0.10 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.50 0.50	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38 0.38 0.38 0.38 0.38 0.3	2 Difference -0.05 0.06 0.06 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35 0.35	Node 42: Hydr #2 0.32 0.29 0.29 0.28 0.28 0.28 0.28 0.28 0.28	B Difference -0.05 -0.06 -0.06 -0.06 -0.06 -0.06 -0.07 -0.07	Hydr #1 0.33 0.32 0.31 0.31 0.30 0.30 0.30	Node 429 Hydr #2 0.29 0.27 0.27 0.26 0.26 0.25 0.25 0.25	Difference -0.04 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.10 0.09 0.09 0.08 0.06	Node 434 Hydr #2 0.10 0.09 0.09 0.08 0.07 0.06 0.05 0.04	Image: Difference         -0.01           -0.01         -0.01           -0.01         -0.01           -0.01         -0.01           -0.01         -0.01			
Date 1-Apr 2-Apr 3-Apr 4-Apr 5-Apr 6-Apr 7-Apr 8-Apr 8-Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01 0.00 -0.01 -0.02	Node 310 Hydr #2 0.02 0.01 0.00 -0.01 -0.02 -0.03 -0.05	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.51 0.52 0.52 0.51 0.51	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.07 0.07 0.08 0.08	Hydr #1 0.63 0.63 0.64 0.64 0.64 0.64 0.64	Node 412 Hydr #2 0.56 0.53 0.53 0.54 0.54 0.54 0.54 0.54	Difference -0.07 0.10 0.10 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.5	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0,40 0,38 0,38 0,38 0,38 0,38 0,38 0,38 0,3	2 Difference -0.05 0.06 0.06 0.06 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Node 42: Hydr #2 0.32 0.29 0.29 0.28 0.28 0.28 0.28 0.28 0.28 0.28	B Difference -0.05 -0.06 -0.06 -0.06 -0.06 -0.07 -0.07 -0.07	Hydr #1 0.33 0.32 0.31 0.31 0.30 0.30 0.30 0.30	Node 429 Hydr #2 0.29 0.27 0.27 0.26 0.26 0.25 0.25 0.25 0.25	Difference -0.04 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.10 0.09 0.09 0.08 0.06 0.05	Node 434 Hydr #2 0.10 0.09 0.09 0.08 0.07 0.06 0.05 0.04	Image: block of the second s			
Date 1-Apr 2-Apr 3-Apr 4-Apr 5-Apr 6-Apr 7-Apr 8-Apr 9-Apr 10 Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01 0.00 -0.01 -0.02 -0.02 -0.01	Node 310 Hydr #2 0.02 0.01 0.00 0.00 -0.01 -0.02 -0.03 -0.05 -0.05	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.51 0.52 0.52 0.51 0.51 0.51 0.51	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.07 0.07 0.07 0.08 0.08 0.08 0.08 0.08 0.08	Hydr #1 0.63 0.63 0.64 0.64 0.64 0.64 0.64 0.64	Node 412 Hydr #2 0.56 0.53 0.53 0.54 0.54 0.54 0.54 0.54 0.55 0.55	Difference -0.07 0.10 0.10 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.5	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38 0.38 0.38 0.38 0.38 0.3	2 Difference -0.05 0.06 0.06 0.06 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Node 423 Hydr #2 0.32 0.29 0.29 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28	<b>Difference</b> -0.05 -0.06 -0.06 -0.06 -0.06 -0.06 -0.07 -0.07 -0.07 -0.07	Hydr #1 0.33 0.32 0.31 0.31 0.30 0.30 0.30 0.30 0.30 0.30	Node 429 Hydr #2 0.29 0.27 0.27 0.26 0.26 0.25 0.25 0.25 0.25 0.25	Difference -0.04 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.09 0.09 0.08 0.06 0.05 0.04	Node 434 Hydr #2 0.10 0.09 0.09 0.08 0.07 0.06 0.05 0.04 0.02	Difference           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01			
Date 1-Apr 2-Apr 3-Apr 4-Apr 5-Apr 6-Apr 7-Apr 8-Apr 9-Apr 10-Apr 11-Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01 0.00 -0.01 -0.02 -0.02 -0.02 -0.01 0.02	Node 310 Hydr #2 0.02 0.01 0.00 -0.01 -0.02 -0.03 -0.05 -0.05 -0.05	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.52 0.52 0.51 0.51 0.51 0.51 0.51 0.58	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.07 0.08 0.08 0.08 0.08 0.08 0.07 0.07	Hydr #1 0.63 0.63 0.64 0.64 0.64 0.64 0.64 0.64 0.65 0.66 0.65	Node 412 Hydr #2 0.56 0.53 0.53 0.54 0.54 0.54 0.54 0.54 0.54 0.54 0.54	Difference -0.07 0.10 0.10 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.5	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38 0.38 0.38 0.38 0.38 0.3	2 Difference -0.05 0.06 0.06 0.06 0.06 0.06 0.06 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Node 423 Hydr #2 0.32 0.29 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28	<b>Difference</b> -0.05 -0.06 -0.06 -0.06 -0.06 -0.07 -0.07 -0.07 -0.07 -0.06 -0.06	Hydr #1 0.33 0.32 0.31 0.31 0.30 0.30 0.30 0.30 0.30 0.30	Node 429 Hydr #2 0.29 0.27 0.26 0.26 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25	Difference -0.04 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05	Hydr #1 0.12 0.11 0.09 0.09 0.08 0.06 0.05 0.04 0.03	Node 434 Hydr #2 0.10 0.09 0.08 0.07 0.06 0.05 0.04 0.02 0.02	Difference           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01           -0.01			
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Date 1-Apr 2-Apr 3-Apr 3-Apr 3-Apr 6-Apr 6-Apr 10-Apr 11-Apr 11-Apr 12-Apr 13-Apr 14-Apr 15-Apr 15-Apr 16-Apr 17-Apr 18-Apr 19-Apr 20-Apr 20-Apr 21-Apr 21-Apr 22-Apr 22-Apr 22-Apr 22-Apr 25-Apr 26-Apr	Hydr #1 0.05 0.04 0.03 0.02 0.01 0.00 0.02 0.02 0.03 0.06 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Node 310 Hydr #2 0.02 0.01 0.00 0.00 0.00 0.00 0.03 0.05 0.05 0.04 0.03 0.05 0.05 0.04 0.03 0.05 0.05 0.04 0.03 0.05 0.04 0.04 0.00 0.00 0.00 0.00 0.00	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.51 0.52 0.51 0.51 0.51 0.51 0.51 0.51 0.51 0.54 0.58 0.58 0.58 0.55 0.55 0.55 0.55 0.55	Node 38 Hydr #2 0.45 0.44 0.44 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.08 0.08 0.08 0.08	Hydr \$1 0.63 0.63 0.64 0.64 0.64 0.64 0.64 0.65 0.67 0.67 0.66 0.64 0.64 0.64 0.64 0.64 0.64 0.64	Node 412 Hydr #2 0.56 0.53 0.54 0.54 0.54 0.54 0.54 0.54 0.55 0.57 0.57 0.57 0.57 0.57 0.55 0.55	2 Difference -0.07 0.10 0.00 0.	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.5	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44 0.44 0.44 0.44	Node 42 Hydr #2 0.40 0.38 0.38 0.38 0.38 0.38 0.38 0.38 0.3	2 Difference -0.05 0.06	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Node 42 Hydr #2 0.32 0.29 0.29 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.31 0.34 0.33 0.34 0.33 0.34 0.33 0.34 0.32 0.32 0.32 0.32 0.33 0.34 0.32 0.32 0.33 0.34 0.32 0.32 0.33 0.34 0.32 0.33 0.34 0.32 0.33 0.34 0.32 0.32 0.34 0.35 0.34 0.32 0.32 0.34 0.35 0.32 0.34 0.32 0.34 0.32 0.34 0.32 0.34 0.32 0.32 0.34 0.32 0.32 0.33 0.34 0.32 0.32 0.32 0.32 0.33 0.34 0.32 0.33 0.32 0.32 0.32 0.33 0.32 0.32 0.33 0.32 0.32 0.33 0.32 0.33 0.32 0.32 0.33 0.32 0.33 0.32 0.32 0.32 0.32 0.32 0.33 0.32	Difference -0.05 -0.06 -0.06 -0.06 -0.06 -0.06 -0.07 -0.07 -0.07 -0.07 -0.06 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.07 -0.06 -	Hydr #1 0.33 0.32 0.32 0.31 0.30 0.30 0.30 0.30 0.30 0.30 0.30	Node 425 Hydr #2 0.29 0.27 0.27 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25	Difference -0.04 -0.05 -	Hydr #1 0.12 0.01 0.09 0.05 0.05 0.05 0.04 0.05 0.05 0.05 0.05	Node 434 Hydr #2 0.10 0.09 0.09 0.09 0.00 0.00 0.00 0.00	Bit           -0.01			
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Date 1-Apr 2-Apr 3-Apr 3-Apr 5-Apr 6-Apr 7-Apr 9-Apr 10-Apr 12-Apr 12-Apr 12-Apr 12-Apr 13-Apr 13-Apr 14-Apr 13-Apr 14-Apr 13-Apr 14-Apr 13-Apr 14-Apr 12-Apr 20-Apr 22-Apr	Hydr #1 0.05 0.04 0.03 0.00 -0.01 -0.02 -0.02 -0.02 -0.02 -0.03 0.06 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Node 310 Hydr #2 0.02 0.01 0.00 0.00 0.00 0.00 0.00 0.0	Difference -0.03 0.03 0.03 0.03 0.03 0.03 0.03 0.0	Hydr #1 0.52 0.51 0.51 0.52 0.51 0.51 0.51 0.51 0.51 0.51 0.51 0.54 0.58 0.58 0.58 0.58 0.58 0.58 0.58 0.58	Node 38 Hydr #2 0.46 0.44 0.44 0.44 0.44 0.44 0.44 0.44	8 Difference -0.06 0.07 0.07 0.07 0.07 0.08 0.08 0.08 0.08	Hydr #1 0.63 0.63 0.64 0.64 0.64 0.64 0.64 0.65 0.67 0.67 0.67 0.67 0.67 0.67 0.67 0.67	Node 412 Hydr #2 0.56 0.53 0.54 0.54 0.54 0.54 0.54 0.54 0.54 0.55 0.57 0.57 0.57 0.57 0.57 0.57 0.57	Difference -0.07 0.10 0.10 0.10 0.10 0.10 0.10 0.10	Hydr #1 0.51 0.50 0.50 0.50 0.50 0.51 0.52 0.54 0.55 0.54 0.53 0.54 0.53 0.54 0.55 0.50 0.50 0.50 0.50 0.50 0.50	Node 421 Hydr #2 0.45 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43	Difference -0.05 0.07 0.07 0.07 0.07 0.07 0.07 0.07	Hydr #1 0.45 0.44 0.44 0.44 0.44 0.44 0.44 0.44	Node 42 Hydr 42 0.40 0.38 0.38 0.38 0.38 0.38 0.38 0.38 0.3	2 Difference -0.05 0.06 0.	Hydr #1 0.36 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Node 422 Hydr 22 0.32 0.29 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.28 0.29 0.31 0.35 0.35 0.35 0.34 0.33 0.32 0.34 0.33 0.32 0.29 0.34 0.34 0.35 0.35 0.36 0.36 0.36 0.36 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.36 0.37 0.37 0.38 0.39 0.39 0.34 0.39 0.34 0.39 0.34 0.39 0.39 0.34 0.39 0.34 0.39 0.39 0.34 0.39 0.39 0.34 0.39 0.39 0.39 0.34 0.39 0.39 0.39 0.39 0.34 0.30 0.30 0.30 0.30 0.30 0.30 0.37 0.36 0.37 0.36 0.36 0.37 0.36 0.36 0.37 0.36 0.36 0.37 0.36 0.36 0.37 0.36 0.36 0.37 0.36 0.36 0.36 0.37 0.36 0.36 0.37 0.36 0.36 0.37 0.37 0.36 0.37 0.36 0.37 0.37 0.37 0.36 0.37	Difference -0.05 -0.06 -0.06 -0.06 -0.06 -0.06 -0.07 -0.07 -0.07 -0.07 -0.07 -0.06 -	Hydr #1 0.33 0.32 0.32 0.31 0.30 0.30 0.30 0.30 0.30 0.30 0.30	Node 4/2 Hydr 4/2 0.29 0.27 0.26 0.25 0.25 0.25 0.25 0.25 0.29 0.30 0.31 0.30 0.30 0.31 0.30 0.30 0.30	Difference -0.04 -0.05 -0.0	Hydr #1 0.12 0.11 0.00 0.09 0.08 0.05 0.04 0.03 0.05 0.04 0.03 0.05 0.04 0.03 0.12 0.13 0.13 0.13 0.13 0.14 0.13 0.09 0.04 0.09 0.04 0.09 0.04 0.01 0.09 0.02 0.09 0.02 0.00 0.09 0.00 0.00	Node 434 Hydr #2 0.10 0.09 0.09 0.009 0.007 0.005 0.004 0.002 0.004 0.002 0.004 0.002 0.004 0.002 0.004 0.002 0.004 0.002 0.009 0.111 0.12 0.12 0.12 0.12 0.12 0.007 0.009 0.000 0.009 0.010 0.009 0.011 0.012 0.009 0.012 0.009 0.012 0.009 0.012 0.009 0.012 0.009 0.012 0.009 0.012 0.009 0.012 0.009 0.000 0.009 0.009 0.009 0.009 0.000 0.009 0.0000 0.0000 0.0000 0.000000	Difference           -0.01			

 Table 3. Daily Mean Velocities (ft/sec) between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes during May

		Node 6			Node 9			Node 12			Node 49			Node 50			Node 54	-	-	Node 94			Node 12	4		Node 14	8
Date	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Differenc e	Hydr #1	Hydr #2	Differenc e	Hydr #1	Hydr #2	Differenc e	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-May	0.35	0.21	0.14	0.26	0.15	0.11	0.21	0.13	0.08	0.06	0.05	0.01	0.08	0.07	0.01	0.16	-0.06	0.04	-0.05	-0.03	0.01	-0.06	-0.06	0.00	-0.03	-0.03	0.00
2-May	0.33	0.12	0.21	0.24	0.05	0.18	0.19	0.05	0.14	0.06	0.04	0.01	0.07	0.06	0.01	0.16	-0.06	0.07	-0.08	-0.04	0.01	-0.07	-0.06	0.00	-0.04	-0.04	0.00
3-May	0.33	0.12	0.21	0.24	0.05	0.19	0.18	0.04	0.14	0.05	0.04	0.01	0.07	0.06	0.01	0.16	-0.07	0.07	-0.09	-0.05	0.01	-0.07	-0.07	0.00	-0.04	-0.05	0.00
4-Iviay 5-May	0.33	0.12	0.21	0.24	0.05	0.19	0.18	0.04	0.14	0.05	0.04	0.01	0.07	0.06	0.01	0.16	-0.07	0.07	-0.09	-0.05	0.01	-0.07	-0.07	0.00	-0.05	-0.05	0.00
6-May	0.33	0.12	0.21	0.24	0.05	0.19	0.19	0.05	0.14	0.02	0.01	0.01	0.04	0.03	0.01	0.16	-0.07	0.07	-0.10	-0.06	0.01	-0.08	-0.07	0.00	-0.05	-0.06	0.00
7-May	0.34	0.13	0.21	0.24	0.06	0.18	0.19	0.05	0.14	0.01	0.00	0.01	0.03	0.02	0.01	0.17	-0.07	0.07	-0.10	-0.06	0.01	-0.08	-0.07	0.00	-0.06	-0.06	0.00
8-May	0.35	0.15	0.20	0.27	0.09	0.18	0.20	0.07	0.13	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.07	0.07	-0.09	-0.06	0.01	-0.07	-0.07	0.00	-0.06	-0.06	0.00
9-May	0.36	0.15	0.21	0.30	0.12	0.19	0.23	0.09	0.14	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.06	0.07	-0.06	-0.05	0.01	-0.06	-0.06	0.00	-0.04	-0.05	0.00
10-May	0.37	0.15	0.22	0.31	0.12	0.19	0.24	0.11	0.14	0.01	0.00	0.01	0.02	0.01	0.01	0.16	-0.05	0.07	-0.04	-0.03	0.01	-0.06	-0.05	0.00	-0.03	-0.03	0.00
12-May	0.36	0.15	0.22	0.30	0.12	0.19	0.24	0.10	0.14	0.04	0.05	0.01	0.04	0.04	0.01	0.16	-0.05	0.08	-0.03	-0.03	0.01	-0.06	-0.05	0.00	-0.02	-0.03	0.00
13-May	0.36	0.14	0.22	0.29	0.10	0.19	0.23	0.09	0.14	0.07	0.06	0.01	0.08	0.07	0.01	0.16	-0.05	0.08	-0.04	-0.03	0.01	-0.05	-0.05	0.00	-0.02	-0.03	0.00
14-May	0.35	0.14	0.22	0.28	0.09	0.19	0.22	0.08	0.14	0.08	0.07	0.01	0.09	0.08	0.01	0.16	-0.05	0.08	-0.04	-0.03	0.01	-0.06	-0.05	0.00	-0.03	-0.03	0.00
15-May	0.33	0.12	0.21	0.26	0.07	0.18	0.22	0.08	0.14	0.09	0.07	0.01	0.10	0.09	0.01	0.16	-0.05	0.07	-0.04	-0.03	0.01	-0.06	-0.05	0.00	-0.03	-0.03	0.00
16-May	0.32	0.11	0.21	0.23	0.05	0.18	0.21	0.07	0.14	0.09	0.08	0.01	0.11	0.10	0.01	0.16	-0.06	0.07	-0.05	-0.03	0.01	-0.06	-0.06	0.00	-0.03	-0.03	0.00
17-May 18-May	0.32	0.11	0.21	0.22	0.04	0.19	0.19	0.05	0.14	0.09	0.07	0.01	0.11	0.10	0.01	0.16	-0.07	0.07	-0.06	-0.04	0.01	-0.07	-0.07	0.00	-0.03	-0.04	0.00
19-May	0.32	0.12	0.20	0.23	0.05	0.18	0.18	0.04	0.14	0.05	0.04	0.01	0.08	0.07	0.01	0.16	-0.08	0.07	-0.10	-0.06	0.01	-0.08	-0.08	0.00	-0.05	-0.06	0.00
20-May	0.32	0.12	0.21	0.23	0.05	0.19	0.19	0.05	0.14	0.02	0.01	0.01	0.04	0.03	0.01	0.17	-0.08	0.06	-0.10	-0.06	0.01	-0.08	-0.08	0.00	-0.06	-0.06	0.00
21-May	0.33	0.13	0.20	0.24	0.06	0.18	0.19	0.06	0.13	0.00	-0.01	0.01	0.02	0.01	0.01	0.17	-0.08	0.07	-0.09	-0.06	0.01	-0.08	-0.08	0.00	-0.06	-0.06	0.00
22-May	0.35	0.15	0.20	0.28	0.10	0.18	0.21	0.07	0.13	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.07	0.06	-0.08	-0.06	0.01	-0.07	-0.07	0.00	-0.06	-0.06	0.00
23-May	0.37	0.15	0.21	0.30	0.12	0.19	0.23	0.10	0.14	0.00	-0.01	0.01	0.01	0.00	0.01	0.16	-0.06	0.07	-0.06	-0.05	0.01	-0.06	-0.06	0.00	-0.04	-0.05	0.00
24-Iviay 25-May	0.37	0.15	0.22	0.31	0.12	0.19	0.24	0.10	0.14	0.02	0.01	0.01	0.02	0.01	0.01	0.16	-0.05	0.07	-0.03	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
26-May	0.37	0.15	0.23	0.30	0.11	0.19	0.23	0.09	0.14	0.05	0.04	0.01	0.06	0.05	0.01	0.16	-0.05	0.08	-0.05	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
27-May	0.36	0.14	0.23	0.29	0.09	0.19	0.22	0.08	0.14	0.06	0.05	0.01	0.06	0.05	0.01	0.16	-0.05	0.08	-0.06	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
28-May	0.36	0.13	0.22	0.28	0.08	0.19	0.21	0.07	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.05	0.07	-0.05	-0.03	0.01	-0.05	-0.05	0.00	-0.03	-0.03	0.00
29-May	0.35	0.13	0.22	0.27	0.07	0.19	0.21	0.06	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.05	0.07	-0.06	-0.04	0.01	-0.06	-0.05	0.00	-0.03	-0.04	0.00
30-May	0.33	0.12	0.21	0.26	0.07	0.19	0.21	0.06	0.14	0.06	0.05	0.01	0.07	0.06	0.01	0.16	-0.06	0.07	-0.06	-0.04	0.01	-0.06	-0.06	0.00	-0.03	-0.04	0.00
									-																		
Date		Node 31	0		Node 38	8		Node 41	2		Node 42	1		Node 422	Differenc		Node 423	Differenc		Node 429	Differenc		Node 43	4			
Date 1-May	Hydr #1	Node 31 Hydr #2	0 Difference	Hydr #1	Node 38 Hydr #2	8 Difference	Hydr #1	Node 41 Hydr #2	2 Difference	Hydr #1	Node 42 Hydr #2	1 Difference	Hydr #1	Node 422 Hydr #2	Differenc e	Hydr #1	Node 423 Hydr #2	Differenc e	Hydr #1	Node 429 Hydr #2	Differenc e	Hydr #1	Node 43 Hydr #2	4 Difference			
Date 1-May 2-May	Hydr #1 0.00 -0.01	Node 31 Hydr #2 0.00 -0.01	0 Difference 0.00 0.00	Hydr #1	Node 38 Hydr #2 0.51 0.50	8 Difference 0.21 0.20	Hydr #1 0.88 0.87	Node 412 Hydr #2 0.61 0.61	2 Difference 0.26 0.26	Hydr #1 0.69 0.69	Node 42 Hydr #2 0.50 0.49	1 Difference 0.20 0.19	Hydr #1 0.61 0.61	Node 422 Hydr #2 0.44 0.44	Differenc e 0.17 0.17	Hydr #1 0.52 0.51	Node 423 Hydr #2 0.35 0.34	Differenc e -0.17 -0.17	Hydr #1 0.45 0.44	Node 429 Hydr #2 0.32 0.31	Differenc e -0.13 -0.13	Hydr #1 0.12 0.12	Node 43 Hydr #2 0.09 0.09	4 Difference -0.03 -0.03			
Date 1-May 2-May 3-May	Hydr #1 0.00 -0.01 -0.01	Node 31 Hydr #2 0.00 -0.01 -0.01	0 Difference 0.00 0.00 0.00	Hydr #1 0.71 0.70 0.70	Node 38 Hydr #2 0.51 0.50 0.50	8 Difference 0.21 0.20 0.20	Hydr #1 0.88 0.87 0.87	Node 412 Hydr #2 0.61 0.61 0.62	2 Difference 0.26 0.26 0.26 0.26	Hydr #1 0.69 0.69 0.68	Node 42 Hydr #2 0.50 0.49 0.49	1 Difference 0.20 0.19 0.19	Hydr #1 0.61 0.61 0.60	Node 422 Hydr #2 0.44 0.44 0.44	Differenc e 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50	Node 423 Hydr #2 0.35 0.34 0.34	Differenc e -0.17 -0.17 -0.17	Hydr #1 0.45 0.44 0.44	Node 429 Hydr #2 0.32 0.31 0.31	Differenc e -0.13 -0.13 -0.13	Hydr #1 0.12 0.12 0.12	Node 43 Hydr #2 0.09 0.09 0.09	4 Difference -0.03 -0.03 -0.03			
Date 1-May 2-May 3-May 4-May	Hydr #1 0.00 -0.01 -0.01 -0.01	Node 31 Hydr #2 0.00 -0.01 -0.01 -0.01	0 Difference 0.00 0.00 0.00 0.00	Hydr #1 0.71 0.70 0.70 0.70	Node 38 Hydr #2 0.51 0.50 0.50 0.50	8 Difference 0.21 0.20 0.20 0.20	Hydr #1 0.88 0.87 0.87 0.87	Node 412 Hydr #2 0.61 0.61 0.62 0.62	2 Difference 0.26 0.26 0.26 0.26 0.26	Hydr #1 0.69 0.69 0.68 0.68	Node 42 Hydr #2 0.50 0.49 0.49 0.49	1 Difference 0.20 0.19 0.19 0.19	Hydr #1 0.61 0.61 0.60 0.60	Node 422 Hydr #2 0.44 0.44 0.44 0.44	Differenc e 0.17 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50 0.50	Node 423 Hydr #2 0.35 0.34 0.34 0.33	Differenc e -0.17 -0.17 -0.17 -0.17	Hydr #1 0.45 0.44 0.44 0.44	Node 429 Hydr #2 0.32 0.31 0.31 0.31	Differenc e -0.13 -0.13 -0.13 -0.13	Hydr #1 0.12 0.12 0.12 0.12	Node 43 Hydr #2 0.09 0.09 0.09 0.09	4 Difference -0.03 -0.03 -0.03 -0.03			
Date 1-May 2-May 3-May 4-May 5-May	Hydr #1 0.00 -0.01 -0.01 -0.01 -0.02	Node 31 Hydr #2 0.00 -0.01 -0.01 -0.01 -0.02	0 Difference 0.00 0.00 0.00 0.00 0.00	Hydr #1 0.71 0.70 0.70 0.70 0.70	Node 38 Hydr #2 0.51 0.50 0.50 0.50 0.50	8 Difference 0.21 0.20 0.20 0.20 0.20 0.20	Hydr #1 0.88 0.87 0.87 0.88 0.88 0.88	Node 412 Hydr #2 0.61 0.61 0.62 0.62 0.62	2 Difference 0.26 0.26 0.26 0.26 0.26 0.26	Hydr #1 0.69 0.69 0.68 0.68 0.68	Node 42 Hydr #2 0.50 0.49 0.49 0.49 0.49	1 Difference 0.20 0.19 0.19 0.19 0.19 0.19	Hydr #1 0.61 0.60 0.60 0.60 0.60	Node 422 Hydr #2 0.44 0.44 0.44 0.44 0.43	Differenc e 0.17 0.17 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50 0.50 0.50	Node 423 Hydr #2 0.35 0.34 0.34 0.33 0.33	Differenc e -0.17 -0.17 -0.17 -0.17 -0.17	Hydr #1 0.45 0.44 0.44 0.44 0.43	Node 429 Hydr #2 0.32 0.31 0.31 0.31 0.30	Differenc e -0.13 -0.13 -0.13 -0.13 -0.13	Hydr #1 0.12 0.12 0.12 0.12 0.12 0.11	Node 43 Hydr #2 0.09 0.09 0.09 0.09 0.09	4 Difference -0.03 -0.03 -0.03 -0.03 -0.03 -0.03			
Date 1-May 2-May 3-May 4-May 5-May 6-May 7 May	Hydr #1 0.00 -0.01 -0.01 -0.01 -0.02 -0.04 0.05	Node 310 Hydr #2 0.00 -0.01 -0.01 -0.01 -0.02 -0.04 0.05	0 Difference 0.00 0.00 0.00 0.00 0.00 0.00 0.00	Hydr #1 0.71 0.70 0.70 0.70 0.70 0.70 0.70	Node 38 Hydr #2 0.51 0.50 0.50 0.50 0.50 0.50	8 Difference 0.21 0.20 0.20 0.20 0.20 0.20 0.20	Hydr #1 0.88 0.87 0.87 0.88 0.88 0.88 0.88	Node 412 Hydr #2 0.61 0.61 0.62 0.62 0.62 0.62 0.62	2 Difference 0.26 0.26 0.26 0.26 0.26 0.26 0.26 0.26	Hydr #1 0.69 0.69 0.68 0.68 0.68 0.68	Node 42 Hydr #2 0.50 0.49 0.49 0.49 0.49 0.49 0.49	1 Difference 0.20 0.19 0.19 0.19 0.19 0.19 0.19 0.19	Hydr #1 0.61 0.60 0.60 0.60 0.60 0.60	Node 422 Hydr #2 0.44 0.44 0.44 0.43 0.43 0.43	Differenc e 0.17 0.17 0.17 0.17 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50 0.50 0.50 0.50	Node 423 Hydr #2 0.35 0.34 0.34 0.33 0.33 0.33 0.33	Differenc e -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 0.17	Hydr #1 0.45 0.44 0.44 0.44 0.43 0.43 0.43	Node 429 Hydr #2 0.32 0.31 0.31 0.31 0.30 0.29 0.29	Difference e -0.13 -0.13 -0.13 -0.13 -0.13 -0.13 0.12	Hydr #1 0.12 0.12 0.12 0.12 0.12 0.11 0.09	Node 43 Hydr #2 0.09 0.09 0.09 0.09 0.09 0.07	4 Difference -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.03			
Date 1-May 2-May 3-May 4-May 5-May 6-May 7-May 8-May	Hydr #1 0.00 -0.01 -0.01 -0.01 -0.02 -0.04 -0.05 -0.06	Node 310 Hydr #2 0.00 -0.01 -0.01 -0.01 -0.02 -0.04 -0.05 -0.06	0 Difference 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.	Hydr #1 0.71 0.70 0.70 0.70 0.70 0.70 0.70 0.7	Node 38 Hydr #2 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.50	8 Difference 0.21 0.20 0.20 0.20 0.20 0.20 0.20 0.20	Hydr #1 0.88 0.87 0.87 0.88 0.88 0.88 0.88 0.88	Node 412 Hydr #2 0.61 0.62 0.62 0.62 0.62 0.62 0.62 0.63	2 Difference 0.26 0.26 0.26 0.26 0.26 0.26 0.26 0.26	Hydr #1 0.69 0.69 0.68 0.68 0.68 0.68 0.68 0.69 0.69	Node 42 Hydr #2 0.50 0.49 0.49 0.49 0.49 0.49 0.49 0.50 0.50	1 Difference 0.20 0.19 0.19 0.19 0.19 0.19 0.19 0.19	Hydr #1 0.61 0.60 0.60 0.60 0.60 0.60 0.61 0.61	Node 422 Hydr #2 0.44 0.44 0.44 0.44 0.43 0.43 0.43 0.44 0.44	Differenc e 0.17 0.17 0.17 0.17 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50 0.50 0.50 0.50 0.50 0.50	Node 423 Hydr #2 0.35 0.34 0.34 0.33 0.33 0.33 0.33 0.33	Differenc e -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17	Hydr #1 0.45 0.44 0.44 0.43 0.43 0.43 0.43 0.42 0.42	Node 429 Hydr #2 0.32 0.31 0.31 0.31 0.30 0.29 0.29 0.29	Differenc e -0.13 -0.13 -0.13 -0.13 -0.13 -0.13 -0.13 -0.13	Hydr #1 0.12 0.12 0.12 0.12 0.11 0.09 0.08 0.06	Node 43 Hydr #2 0.09 0.09 0.09 0.09 0.09 0.07 0.05 0.04	4 Difference -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.03			
Date 1-May 2-May 3-May 4-May 5-May 6-May 7-May 8-May 9-May	Hydr #1 0.00 -0.01 -0.01 -0.01 -0.02 -0.04 -0.05 -0.06 -0.06	Node 31 Hydr #2 0.00 -0.01 -0.01 -0.01 -0.02 -0.04 -0.05 -0.06	0 Difference 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.	Hydr #1 0.71 0.70 0.70 0.70 0.70 0.70 0.70 0.7	Node 38 Hydr #2 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.50	8 Difference 0.21 0.20 0.20 0.20 0.20 0.20 0.20 0.20	Hydr #1 0.88 0.87 0.87 0.88 0.88 0.88 0.88 0.88	Node 412 Hydr #2 0.61 0.62 0.62 0.62 0.62 0.62 0.63 0.64	2 Difference 0.26 0.26 0.26 0.26 0.26 0.26 0.26 0.25	Hydr #1 0.69 0.68 0.68 0.68 0.68 0.68 0.69 0.69 0.69 0.70	Node 42 Hydr #2 0.50 0.49 0.49 0.49 0.49 0.49 0.49 0.49 0.50 0.50 0.50	1 Difference 0.20 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.1	Hydr #1 0.61 0.60 0.60 0.60 0.60 0.61 0.61 0.6	Node 422 Hydr #2 0.44 0.44 0.44 0.43 0.43 0.43 0.43 0.44 0.44	Differenc e 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.51	Node 423 Hydr #2 0.35 0.34 0.34 0.33 0.33 0.33 0.33 0.33 0.33	Differenc e -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.16	Hydr #1 0.45 0.44 0.44 0.44 0.43 0.43 0.43 0.42 0.42 0.42	Node 429 Hydr #2 0.32 0.31 0.31 0.31 0.30 0.29 0.29 0.29 0.29 0.30	Differenc e -0.13 -0.13 -0.13 -0.13 -0.13 -0.13 -0.13 -0.13 -0.13	Hydr #1 0.12 0.12 0.12 0.11 0.09 0.08 0.06 0.05	Node 43 Hydr #2 0.09 0.09 0.09 0.09 0.09 0.09 0.07 0.05 0.04 0.03	4 Difference -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.02			
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Date 1-May 2-May 2-May 4-May 5-May 4-May 5-May 10-May 11-May 11-May 11-May 11-May 11-May 11-May 12-May 21-May 20-May 21-May 22-May 22-May 24-May 24-May 25-May 25-May 24-May 25-May 25-M	Hydr #1 0.00 -0.01 -0.01 -0.01 -0.02 -0.06 -0.06 -0.06 -0.03 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.02 0.03 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.05 -0.01 -0.01 -0.02 -0.01 -0.02 -0.02 -0.02 -0.02 -0.02 -0.05 -0.	Node 310 Hydr 42 0.00 -0.01 -0.01 -0.02 -0.04 -0.05 -0.06 -0.04 -0.01 0.01 0.01 0.02 0.02 0.02 0.02 0.02	0 Difference 0.00 0.0	Hydr #1 0.71 0.70 0.70 0.70 0.70 0.70 0.70 0.7	Node 38           Hydr #2           0.51           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.50           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.57           0.53           0.53           0.53           0.53           0.53           0.59           0.59           0.59           0.58	8 Difference 0.21 0.20 0.20 0.20 0.20 0.20 0.20 0.20 0.20 0.20 0.21 0.21 0.21 0.21 0.21 0.20 0.21 0.22 0.21 0.22 0.21 0.22 0.21 0.22 0.21 0.22 0.21 0.22 0.2	Hydr #1 0.88 0.87 0.88 0.88 0.88 0.88 0.88 0.88	Node 411 Hydr #2 0.61 0.62 0.62 0.62 0.62 0.62 0.62 0.63 0.64 0.65 0.67 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.65 0.62 0.62 0.62 0.62 0.62 0.62 0.62 0.62	2 Difference 0.26 0.26 0.26 0.26 0.26 0.26 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25	Hydr #1 6,69 0,69 0,68 0,68 0,68 0,68 0,68 0,68 0,70 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,71 0,72 0,71 0,71 0,72 0,71 0,72 0,71 0,72 0,71 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,72 0,72 0,73 0,72 0,73 0,72 0,72 0,73 0,72 0,73 0,73 0,72 0,73 0,73 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,75 0,7	Node 42 Hydr #2 0.50 0.49 0.49 0.49 0.49 0.49 0.49 0.55 0.55 0.55 0.55 0.55 0.55 0.55 0.5	Difference 0.20 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.1	Hydr #1 0.61 0.60 0.60 0.60 0.61 0.60 0.61 0.62 0.63 0.65 0.65 0.65 0.65 0.65 0.65 0.65 0.64 0.63 0.62 0.64 0.62 0.64 0.62 0.62 0.62 0.62 0.62 0.62 0.62 0.62	Node 422 Hydr #2 0.44 0.44 0.44 0.44 0.43 0.43 0.43 0.43	Difference e 0.17 0.17 0.17 0.17 0.17 0.17 0.16 0.16 0.16 0.16 0.16 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17	Hydr #1 0.52 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.51 0.53 0.57 0.57 0.57 0.57 0.53 0.51 0.51 0.51 0.51 0.51 0.51 0.53 0.51 0.51 0.52 0.52 0.52 0.52 0.50 0.50 0.50 0.50	Node 423           Hydr #2           0.35           0.34           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.34           0.35           0.40           0.41           0.42           0.43	Difference e -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.17 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.17	Hydr #1 0.45 0.44 0.44 0.43 0.42 0.42 0.42 0.42 0.42 0.42 0.42 0.44 0.48 0.48 0.48 0.48 0.48 0.48 0.48	Note 429 Hydr #2 0.32 0.31 0.31 0.30 0.29 0.29 0.29 0.29 0.31 0.33 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Difference e 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13	Hydr #1 0.12 0.12 0.12 0.12 0.13 0.05 0.06 0.08 0.06 0.005 0.06 0.005 0.005 0.005 0.005 0.005 0.013 0.13 0.15 0.15 0.15 0.15 0.015 0.015 0.012 0.015 0.005 0.005 0.015 0	Node 43 Hydr 42 0.09 0.09 0.09 0.05 0.05 0.04 0.05 0.04 0.06 0.11 0.12 0.12 0.13 0.12 0.13 0.12 0.13 0.12 0.13 0.12 0.13 0.12 0.03 0.04 0.05 0.09 0.09 0.09 0.09 0.09 0.09 0.09	4 Difference -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.02 -0.02 -0.02 -0.02 -0.03 -			
Date           1-May           2-May           4-May           3-May           4-May           6-May           7-May           9-May           10-May           11-May           12-May           13-May           13-May           14-May           15-May           16-May           17-May           18-May           19-May           20-May           21-May           22-May           22-May           22-May           22-May           22-May           22-May           22-May           22-May           22-May           23-May           24-May           25-May           22-May           23-May           25-May           25-May	Hydr #1 0.00 -0.01 -0.01 -0.01 -0.02 -0.06 -0.06 -0.06 -0.06 0.01 0.01 0.01 0.02 0.02 0.02 0.02 0.02 0.03 0.02 0.03 0.02 0.03 0.02 0.03 0.02 0.05 0.03 0.02 0.05 0.03 0.01 0.02 0.05 0.03 0.02 0.05 0.03 0.05 0.03 0.05 0	Node 318 Hydr #2 0.00 -0.01 -0.01 -0.02 -0.05 -0.06 -0.06 -0.06 -0.06 -0.04 0.01 0.02 0.02 0.02 0.02 0.02 0.02 0.02	0 Difference 0.00 0.0	Hydr #1 0.71 0.70 0.70 0.70 0.70 0.70 0.70 0.7	Node 38 Hydr #2 0.51 0.50 0.50 0.50 0.50 0.50 0.50 0.50	8 Difference 0.21 0.20 0.21 0.22 0.2	Hydr #1 0.88 0.87 0.87 0.87 0.88 0.88 0.88 0.88	Node 41. Hydr #2 0.61 0.61 0.62 0.63 0.64 0.67 0.67 0.67 0.67 0.66 0.64 0.65 0.64 0.65 0.67 0.67 0.67 0.66 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.64 0.65 0.66 0.65 0.66 0.65 0.66 0.65 0.67 0.71 0.71 0.71 0.71 0.71 0.71	2 Difference 0.26 0.26 0.26 0.26 0.26 0.26 0.25 0.25 0.25 0.25 0.25 0.25 0.25 0.25	Hydr #1 6,69 0,69 0,68 0,68 0,68 0,68 0,69 0,70 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,71 0,72 0,71 0,72 0,71 0,72 0,71 0,72 0,72 0,71 0,72 0,73 0,75 0,70 0,70 0,70 0,70 0,70 0,73 0,72 0,72 0,72 0,72 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,73 0,72 0,77 0,7	Node 42 Hydr #2 0.50 0.49 0.49 0.49 0.49 0.50 0.52 0.54 0.54 0.55 0.55 0.55 0.55 0.55 0.55	Difference 0.20 0.19 0.19 0.19 0.19 0.19 0.19 0.18 0.18 0.18 0.18 0.19 0.19 0.19 0.19 0.19 0.19 0.19 0.19	Hydr #1 0.61 0.61 0.60 0.60 0.60 0.61 0.62 0.63 0.63 0.63 0.65 0.65 0.65 0.65 0.65 0.65 0.64 0.62 0.62 0.62 0.62 0.62 0.62 0.62 0.62	Node 422 Hydr #2 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.44 0.45 0.51 0.51 0.51 0.50	Difference e 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.16 0.16 0.16 0.16 0.16 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.16 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.17 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.17 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.16 0.17 0.17 0.17 0.17 0.17 0.16 0.1	Hydr #1 0.52 0.51 0.50 0.50 0.50 0.50 0.51 0.51 0.57 0.57 0.57 0.57 0.54 0.51 0.51 0.51 0.51 0.51 0.51 0.51 0.51	Node 423           Hydr #2           0.35           0.34           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.33           0.34           0.35           0.37           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.40           0.41           0.42	Difference e -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.17 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.16 -0.17	Hydr #1 0.45 0.44 0.44 0.43 0.42 0.42 0.42 0.42 0.42 0.42 0.42 0.42	Note 429 Hydr #2 0.32 0.31 0.31 0.31 0.30 0.29 0.29 0.29 0.29 0.30 0.33 0.34 0.35 0.35 0.35 0.35 0.35 0.35 0.35 0.35	Difference e 0.13 0.13 0.13 0.13 0.13 0.13 0.13 0.13	Hydr #1 0.12 0.12 0.12 0.12 0.12 0.12 0.12 0.1	Node 43 Hydr #2 0.09 0.09 0.09 0.07 0.05 0.04 0.03 0.04 0.03 0.04 0.03 0.04 0.10 0.11 0.13 0.13 0.12 0.10 0.05 0.05 0.05 0.04 0.05 0.05 0.05 0.0	4 Difference -0.03 -0.03 -0.03 -0.03 -0.03 -0.03 -0.02 -0.02 -0.02 -0.02 -0.03 -			

# Table 4. Daily Mean Flows (cfs) Between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus Hydrology 1) at All Channel Nodes During April

									J	0,																	
Date		Node 6			Node 9			Node 12			Node 49			Node 50			Node 54			Node 94			Node 124			Node 148	
	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference	Hydr #1	Hydr #2	Difference
1-Apr	2984	662	2323	2235	333	1902	2165	299	1866	5024	3052	-1972	5393	3321	-2072	629	269	-360	-404	-678	-274	-2329	-2137	192	-334	-447	-113
2-Apr	3064	865	2199	2407	497	1910	2378	460	1918	4282	2379	-1903	4567	2564	-2004	637	326	-311	-563	-727	-164	-2496	-2221	276	-428	-489	-61
3-Apr	3067	973	2094	2411	594	1817	2382	561	1820	3729	1928	-1800	4023	2126	-1897	637	354	-283	-512	-651	-139	-2534	-2259	275	-413	-464	-51
4 Apr	2067	074	2002	2414	600	101/	2202	565	1010	2122	1245	1707	2400	1605	1004	624	247	203	441	500	140	2554	2205	273	205	440	57
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5-Apr	3069	976	2093	2419	610	1809	2387	573	1814	2498	706	-1793	2901	1014	-1886	632	342	-290	-394	-549	-156	-2583	-2319	264	-369	-429	-60
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11 4 4 4	2000	1023	2005	2400	700	1734	2450	71.0	1755	2522	1705	1700	1704	2507	1040	627	325	200	70	07	100	1075	1054	245	201	350	00
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		Node 310	)		Node 388	3		Node 412			Node 421			Node 422			Node 423	3		Node 429	)		Node 434	1			
Date	Hydr #1	Node 310	) Difference	Hydr #1	Node 388	B	Hydr #1	Node 412	Difference	Hydr #1	Node 421	Difference	Hydr #1	Node 422	Difference	Hydr #1	Node 423	3 Difference	Hydr #1	Node 429	Difference	Hydr #1	Node 434	Difference			
Date	Hydr #1	Node 310 Hydr #2	Difference	Hydr #1	Node 388 Hydr #2	Difference	Hydr #1	Node 412 Hydr #2	Difference	Hydr #1	Node 421 Hydr #2	Difference	Hydr #1	Node 422 Hydr #2	Difference	Hydr #1	Node 423 Hydr #2	B Difference	Hydr #1	Node 429 Hydr #2	Difference	Hydr #1	Node 434 Hydr #2	Difference			
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Date           1-Apr           2-Apr           3-Apr           6-Apr           7-Apr           9-Apr           10-Apr           11-Apr           12-Apr           13-Apr           13-Apr           13-Apr           16-Apr           16-Apr           18-Apr           20-Apr           21-Apr           22-Apr           22-Apr           22-Apr           22-Apr           25-Apr           25-Apr	Hydr #1 152 2 -90 -198 -327 -495 -621 -759 -824 -621 -37 -416 586 579 387 262 -268 387 262 -268 -650 -837 -930 -843 -837 -930 -845 -445 1617	Node 310 Hydr #2 -271 -393 -459 -565 -695 -866 -992 -1131 -1192 -975 -384 56 218 205 218 205 218 205 131 9 9 -116 -313 -636 -1021 -1211 -1	Difference -423 -366 -367 -368 -371 -371 -371 -371 -371 -368 -354 -366 -360 -368 -373 -378 -379 -375 -368 -377 -378 -377 -378 -377 -378 -377 -378 -375 -367 -367 -364 -374 -374 -374 -374 -374 -374 -374 -37	Hydr #1 879 873 877 877 877 874 869 971 989 996 996 996 996 995 933 934 995 933 934 905 333 934 888 887 888 887 881 887 881 887 967	Node         388           Hydr #2         733           738         731           736         731           737         731           736         731           727         731           727         739           853         834           834         815           769         769           765         753           749         744           739         744           748         834           834         834	B Difference -105 -134 -141 -141 -142 -142 -142 -142 -142 -142 -142 -133 -134 -142 -135 -136 -137 -138 -138 -138 -143 -144 -144 -144 -144 -144 -143 -133 -133 -137 -138 -133 -137 -138 -138 -138 -145 -138 -145 -145 -145 -145 -145 -145 -145 -145 -138 -145 -14	Hydr #1 6492 6498 6501 6548 6556 6559 6559 6559 6649 6775 6872 6872 6873 6872 6693 6693 6616 6610 6610 6619 6628 6636 6628 6636 6636 9927 6995	Node 412 Hydr #2 5720 5505 5481 5528 5535 5529 5631 5768 5885 5883 5768 5885 5883 5768 5885 5883 5768 5885 5883 5598 5598 5598 5598 5598 559	Difference -772 -933 -1020 -1021 -1023 -1028 -1031 -1018 -1007 -1011 -1018 -1007 -1011 -1018 -1007 -1011 -1018 -1022 -1023 -1022 -1023 -1023 -1025 -1029 -1005	Hydr #1 3956 3923 3920 3921 3918 3918 3978 3978 4106 4262 4262 4262 4262 4262 4262 4262 42	Node 421 Hydr #2 3531 3364 3312 3325 3324 3319 3316 3350 3383 3545 3686 3681 3681 3681 3681 3681 3681 3681	Difference 425 -595 -595 -595 -600 -601 -603 -595 -562 -562 -562 -562 -563 -588 -581 -588 -599 -601 -602 -601 -602 -601 -602 -601 -602 -601 -585 -595 -	Hydr #1 3968 3925 3902 3900 3899 3934 4084 4251 4288 4267 4213 4086 4153 4086 4153 4086 4014 3949 3913 3907 3942 4239 4239	Node 422 Hydr #2 3543 3367 3307 3315 3310 32298 3331 3365 3522 3688 3354 3354 3354 3354 3354 3314 3314 3342 3354 3314	Difference -424 -558 -595 -595 -595 -600 -602 -600 -562 -573 -581 -581 -581 -583 -573 -581 -585 -599 -601 -599 -603 -601 -580 -592 -603 -595	Hydr #1 2178 2124 2005 20070 2070 2070 2070 2070 2070 207	Node 42: Hydr #2 1862 1733 1686 1676 1657 1657 1656 1667 1657 1650 1833 2031 2094 2081 2094 2081 2094 1845 1860 1779 1645 1866 1620 1669 1618 1699 1618 1699 1618	Bifference           -315           -390           -407           -408           -411           -413           -416           -391           -393           -403           -403           -402           -400           -399           -404           -401           -411           -414           -393           -416	Hydr #1 2247 2170 2123 2101 2002 2031 2000 2091 2004 2091 2044 2091 2448 2487 2448 2487 2448 2385 2385 2385 2385 2172 2077 1976 2172 2077 1978 1928 1928 2199 2460	Node 425 Hydr #2 1932 1780 1716 1693 1662 1618 1583 1579 1697 1928 2047 2062 2047 2062 2047 2082 2047 1933 1867 1933 1867 1773 1674 1556 1517 1556 1517 1556 1517	Difference -315 -390 -407 -408 -410 -413 -405	Hydr #1 6978 6140 5499 4954 4389 2400 1415 597 394 2265 4975 6662 7466 6988 6988 5540 3442 1584 479 -33 5442 759 3443	Node 434 Hydr #2 5912 4945 4289 3753 3187 2263 1189 194 -612 -773 1111 3796 5463 6559 6630 6559 6630 6559 6630 6559 6630 6559 374 -735 -735 -735 -414 2264 4761	Difference -1066 -1195 -1210 -1201 -1201 -1204 -1211 -1211 -1219 -1167 -1154 -1179 -1199 -1057 -1208 -1217 -1208 -1210 -1204 -1210 -1204 -1211 -1214 -1214 -1214 -1214 -1214 -1214 -1214 -1214 -1214 -1215 -1216 -1215 -121			
Date           1-Apr           2-Apr           3-Apr           3-Apr           4-Apr           5-Apr           7-Apr           8-Apr           10-Apr           11-Apr           12-Apr           13-Apr           20-Apr           20-Apr           21-Apr           22-Apr           23-Apr           23-Apr           25-Apr           25-Apr           25-Apr           26-Apr	Hydr #1 152 2 -90 -198 -327 -327 -495 -621 -759 -824 -621 -37 -37 -416 586 508 387 262 62 262 62 268 -650 -837 -930 -864 -930 -864 -445 161 161 575	Node 310 Hydr #2 -271 -393 -459 -565 -695 -866 -992 -1131 -1192 -975 -384 -56 218 205 131 -384 -384 -384 -384 -36 -116 -313 -116 -313 -1121 -1211 -1221 -121	Difference -423 -396 -367 -367 -367 -371 -371 -368 -371 -371 -368 -346 -360 -366 -373 -377 -378 -377 -378 -379 -375 -368 -371 -374 -374 -374 -374 -374 -374 -374 -374	Hydr #1 879 873 877 877 877 874 869 971 989 912 989 912 989 912 989 989 971 934 909 934 909 934 934 909 888 837 833 837 833 837 833 837 1008	Node         388  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    -403           -400           -402           -400           -399           -404           -399           -404           -393           -411           -414           -404           -393           -416	Hydr #1 2247 2170 2123 2101 2002 2004 2004 2004 2004 2004 2004	Node 425 Hydr #2 1932 1780 1716 1693 1663 1583 1578 1591 1697 1928 2047 2043 2047 2043 2047 2043 1981 1933 1981 1933 1981 1933 1967 1773 1674 1559 1516 1517 1578 1803 2055 2179 2179	Difference -315 -390 -407 -408 -413 -413 -413 -417 -4213 -4213 -4213 -401 -405 -404 -405 -404 -402 -399 -400 -402 -399 -400 -402 -399 -400 -412 -412 -412 -415 -415 -417	Hydr #1 6978 6140 5499 4954 4389 2400 1415 597 394 2400 1415 597 394 4975 6662 7466 7466 7466 7466 7466 7465 7464 7465 7441 6988 5540 3442 1584 479 -33 759 3443 759	Node 434 Hydr #2 5912 4945 4289 3753 3187 2263 1189 194 -612 -773 1111 3796 5463 6559 6630 6559 6630 6559 5782 4336 62249 374 -735 2249 374 -732 2414 4261 5982	Difference -1066 -1195 -1210 -1201 -1201 -1204 -1201 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Date           1-Apr           2-Apr           3-Apr           3-Apr           6-Apr           7-Apr           8-Apr           10-Apr           11-Apr           12-Apr           10-Apr           11-Apr           12-Apr           13-Apr           13-Apr           14-Apr           15-Apr           15-Apr           16-Apr           17-Apr           20-Apr           20-Apr           21-Apr           22-Apr           23-Apr           24-Apr           25-Apr           26-Apr           27-Apr           28-Apr	Hydr #1 152 2 -90 -198 -327 -495 -621 -759 -824 -621 -37 -37 -824 -621 -37 -38 -824 -621 -37 -38 -824 -621 -38 -837 -930 -864 -635 -637 -930 -845 -637 -837 -837 -837 -837 -837 -837 -837 -8	Node 310 Hydr #2 -271 -393 -459 -565 -695 -866 -992 -1131 -1192 -975 -384 56 218 205 218 205 218 205 131 9 9 -116 -313 -636 -1021 -1221 -1221 -1204 -187 159 222 222 222 222	Difference -423 -365 -367 -367 -368 -371 -371 -371 -371 -371 -371 -368 -354 -360 -368 -360 -368 -373 -378 -377 -378 -377 -378 -377 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4106 4262 4262 4262 4262 4262 4262 4262 42	Node 421 Hydr #2 3531 3364 3312 3325 3324 3319 3316 3350 3383 3545 3686 3681 3661 3661 3661 3661 3659 3485 3485 3485 3327 3320 3327 3324 3327 3324 3359 3485 3327 3327 3363 3456 33796 3796 3796 3796 3796	Difference -425 -595 -595 -595 -600 -601 -601 -595 -562 -562 -562 -562 -563 -574 -581 -581 -585 -587 -588 -591 -602 -601 -602 -601 -586 -595 -595 -595 -595 -595 -595 -595 -59	Hydr #1 3968 3925 3902 3907 3907 3899 3934 4084 4251 4084 4251 4288 4267 4213 4086 4014 3913 3905 3913 3905 3917 3942 4035 4239 4375 4381 4324	Node 422 Hydr #2 3543 3367 3307 3315 3310 3302 2298 3331 3365 3522 3688 3314 3685 3522 3688 3714 3685 3626 3496 3423 3354 3314 3314 3314 3314 3314 3314 331	Difference -424 -558 -595 -595 -597 -600 -602 -603 -563 -587 -587 -587 -587 -587 -588 -590 -591 -595 -595 -595 -595 -602 -603 -601 -580 -603 -601 -580 -603 -603 -603 -603 -603 -603 -603 -60	Hydr #1 2178 2124 2085 2078 2070 2072 2088 2223 2424 2466 2424 2466 2424 2466 2424 2446 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Date           1-Apr           2-Apr           3-Apr           4-Apr           5-Apr           6-Apr           7-Apr           9-Apr           10-Apr           11-Apr           12-Apr           13-Apr           12-Apr           13-Apr           12-Apr           13-Apr           12-Apr           13-Apr           12-Apr           13-Apr           12-Apr           13-Apr           2-Apr	Hydr #1 152 2 -90 -138 -327 -435 -621 -759 -824 -621 -37 -416 586 589 -37 262 62 -650 -837 -930 -864 -445 161 517 586 504 166	Node 310 Hydr #2 -271 -393 -459 -565 -695 -866 -992 -1131 -1192 -975 -384 56 218 205 -131 -384 56 218 205 -131 -313 -636 -116 -313 -636 -1021 -1211 -1201 -1211 -1211 -1230 -794 -159 -159 222 222 -39	Difference -423 -396 -367 -368 -371 -371 -371 -371 -378 -368 -354 -360 -366 -366 -366 -360 -366 -373 -375 -375 -375 -375 -375 -375 -377 -375 -367 -371 -374 -371 -374 -371 -374 -371 -374 -375 -368 -321 -371 -375 -368 -325 -325 -205	Hydr #1 879 873 872 877 877 874 869 912 996 999 996 999 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		Node 6	6		Node 9	)		Node 1	2		Node 4	9		Node 5	0		Node 5	4		Node 9	4		Node 12	4		Node 14	.8
Date	Hude #1	Hude #2	Difference	Hude #1	Hudr #2	Difforence	Under #1	Hudr #2	Difforence	Under #1	Hude #2	Difforence	Hude #1	Hudr #2	Difforence	Hude #1	Hude #2	Difforence	Hude #1	Hude #2	Difforence	Hude #1	Under #2	Difforence	Hude #1	Hudr #2	Difforence
	iliyal #1	nyui #2	Difference	inyui wi	nyu wz	Difference	Inyui wi	iiyui wz	Difference	iiyui #1	nyui wz	Difference	nyu #1	riyur #2	Difference	inyui wi	riyur w2	Difference	inyui wi	nyur #2	Difference	ilyul wi	nyui #2	Difference	iiyui #1	nyur #2	Difference
1-May	629	374	-255	335	170	-165	317	157	-159	2967	2234	-733	3114	2348	-766	263	189	-74	-591	-626	-35	-2220	-2084	136	-396	-411	-15
2-May	610	201	-409	306	24	-282	269	-11	-280	2354	1494	-860	2419	1519	-899	264	138	-126	-819	-888	-69	-2442	-2309	133	-509	-539	-29
3-May	608	195	-414	303	14	-289	255	-34	-289	2148	1295	-853	2290	1395	-896	263	138	-125	-913	-969	-56	-2562	-2422	140	-572	-595	-23
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5-May	613	201	-412	309	17	-292	256	-35	-292	812	-4	-817	1326	469	-858	264	143	-120	-987	-1049	-62	-2736	-2599	137	-648	-674	-26
6-May	617	203	-415	309	16	-293	259	-31	-290	-599	-1432	-833	-398	-1263	-865	268	151	-117	-1010	-1074	-64	-2788	-2656	132	-673	-701	-28
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8-May	645	251	-394	350	76	-274	287	8	-280	-2187	-3036	-848	-2798	-3677	-880	267	152	-115	-948	-1012	-64	-2618	-2490	128	-685	-713	-28
9-May	665	261	-404	403	118	-285	352	67	-284	-2122	-2946	-824	-2821	-3681	-860	261	142	-119	-759	-824	-64	-2314	-2192	122	-576	-604	-28
10-May	668	259	-409	413	129	-284	386	103	-284	-926	-1728	-802	-1852	-2702	-850	262	136	-126	-583	-651	-68	-2062	-1949	113	-417	-447	-30
11-May	661	250	-410	407	124	-283	394	110	-283	1273	462	-811	313	-538	-851	260	132	-128	-496	-565	-69	-2025	-1913	112	-348	-378	-30
12-May	649	237	-412	390	107	-283	379	96	-283	2889	2056	-833	2267	1395	-872	260	131	-129	-492	-561	-69	-2005	-1888	117	-344	-373	-30
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15-May	606	195	-411	329	47	-283	318	32	-286	4357	3476	-881	4650	3727	-924	264	135	-129	-612	-679	-67	-2193	-2056	137	-419	-449	-29
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22-May	656	260	-396	369	93	-276	303	23	-281	-2176	-3006	-830	-2819	-3681	-862	266	152	-114	-926	-991	-64	-2589	-2468	122	-677	-705	-28
23-May	671	266	-405	411	125	-286	366	80	-285	-1732	-2539	-807	-2398	-3243	-845	262	143	-119	-735	-799	-64	-2218	-2104	113	-546	-574	-28
24-May	669	261	-408	415	132	-283	391	108	-283	-372	-1151	-779	-1193	-2017	-825	262	135	-127	-579	-648	-69	-1922	-1819	102	-394	-423	-30
25-May	662	251	-410	408	125	-283	393	110	-283	1482	697	-784	693	-129	-822	259	130	-128	-516	-586	-71	-1842	-1741	100	-343	-373	-30
26-May	650	239	-411	392	107	-285	378	93	-285	2602	1801	-802	2121	1282	-838	257	129	-128	-541	-610	-69	-1835	-1731	104	-357	-386	-29
27-May	639	226	-413	373	87	-286	354	68	-287	2904	2085	-819	2667	1810	-858	256	128	-128	-618	-687	-69	-1896	-1788	108	-403	-432	-29
28-May	635	220	-415	361	74	-287	333	45	-288	3058	2224	-833	2976	2103	-874	255	127	-128	-554	-625	-71	-1932	-1822	110	-372	-402	-30
29-May	628	216	-413	348	58	-290	314	24	-290	2781	1945	-836	2771	1895	-876	256	131	-126	-692	-759	-67	-2105	-1988	117	-447	-475	-29
30-May	611	201	-410	337	46	-290	309	17	-291	2823	1984	-839	2892	2011	-880	258	133	-125	-711	-776	-65	-2245	-2121	123	-455	-483	-28
31-May	497	262	-235	249	71	-177	242	57	-186	2529	2053	-475	2691	2179	-512	231	158	-74	-709	-765	-56	-2230	-2198	32	-458	-483	-25
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D-t-		Node 31	10		Node 38	38		Node 41	12		Node 42	21		Node 4	22		Node 4	23		Node 4	29		Node 43	4			
Date	Hydr #1	Node 31 Hydr #2	10 Difference	Hydr #1	Node 38 Hydr #2	38 Difference	Hydr #1	Node 41 Hydr #2	12 Difference	Hydr #1	Node 42 Hydr #2	21 Difference	Hydr #1	Node 4 Hydr #2	22 Difference	Hydr #1	Node 4 Hydr #2	23 Difference	Hydr #1	Node 4. Hydr #2	29 Difference	Hydr #1	Node 43 Hydr #2	4 Difference			
Date	Hydr #1	Node 31 Hydr #2	10 Difference	Hydr #1	Node 38 Hydr #2	B Difference	Hydr #1	Node 43 Hydr #2	12 Difference	Hydr #1	Node 42 Hydr #2	21 Difference	Hydr #1	Node 4 Hydr #2	22 Difference	Hydr #1	Node 4 Hydr #2	23 Difference	Hydr #1	Node 4 Hydr #2	29 Difference	Hydr #1	Node 43 Hydr #2	4 Difference			
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Date 1-May 2-May	Hydr #1 -434 -579	Node 31 Hydr #2 -415 -593	10 Difference 19 -14	Hydr #1 1252 1234	Node 38 Hydr #2 859 848	88 Difference - 393 - 386 - 300	Hydr #1 9151 9140	Node 43 Hydr #2 6413 6435	12 Difference -2737 -2705 -276	Hydr #1 5491 5449	Node 42 Hydr #2 3887 3880	21 Difference -1604 -1569	Hydr #1 5495 5451	Node 4 Hydr #2 3887 3882	22 Difference -1608 -1569	Hydr #1 3187 3118	Node 4 Hydr #2 2106 2056	23 Difference -1081 -1061	Hydr #1 3216 3149	Node 42 Hydr #2 2128 2084	29 Difference -1087 -1065 1066	Hydr #1 7582 7286	Node 43 Hydr #2 5325 5049	4 Difference -2257 -2237			
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# Table 5. Daily Mean Flows (cfs) Between Base and Project Description Model Scenarios and Their Difference (Hydrology 2 minus<br/>Hydrology 1) at All Channel Nodes During May

Channel Nodes			Proport	tion Positive Da			Ave	rage Daily Flow	/ (cfs)		Mean Daily Velocity (ft/s)					
		Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference Between Proposed and Proposed DCC Open
6	San Joaquin	0.99	0.89	-0.10	0.89	-0.01	2943	951	-1993	951	0.0	1.16	0.38	-0.78	0.38	0.00
9	San Joaquin	0.98	0.63	-0.35	0.63	0.00	2325	608	-1717	607	-0.4	1.33	0.36	-0.97	0.36	0.00
12	South Delta	0.98	0.58	-0.39	0.58	0.00	2303	585	-1718	585	-0.4	1.11	0.32	-0.79	0.32	0.00
49	Central Delta	0.53	0.53	0.00	0.53	0.00	3344	1576	-1768	2124	547.4	0.07	0.05	-0.02	0.05	0.01
50	Central Delta	0.53	0.52	0.00	0.53	0.00	3331	1473	-1858	2050	576.3	0.08	0.06	-0.02	0.07	0.01
54	San Joaquin	1.00	0.97	-0.03	0.96	0.00	610	330	-280	331	0.4	0.35	0.19	-0.16	0.19	0.00
94	South Delta	0.52	0.52	0.00	0.52	0.00	-251	-406	-155	-404	2.0	0.00	-0.02	-0.02	-0.02	0.00
124	South Delta	0.46	0.46	0.00	0.47	0.00	-2302	-2053	249	-2209	-155.2	-0.06	-0.06	0.01	-0.06	0.00
148	South Delta	0.52	0.52	0.00	0.52	0.00	-285	-345	-60	-348	-2.3	-0.01	-0.02	-0.01	-0.02	0.00
310	Central Delta	0.52	0.52	-0.01	0.52	0.00	-110	-461	-351	-261	199.3	0.03	0.00	-0.02	0.02	0.01
388	North Delta	0.65	0.62	-0.03	0.61	-0.02	943	787	-156	683	-103.9	0.55	0.47	-0.08	0.41	-0.06
412	North Delta	0.94	0.85	-0.09	0.84	-0.01	6856	5726	-1130	5727	0.5	0.66	0.56	-0.11	0.56	0.00
421	North Delta	0.71	0.66	-0.05	0.69	0.02	4163	3515	-648	3825	310.7	0.53	0.45	-0.08	0.49	0.04
422	North Delta	0.70	0.66	-0.04	0.61	-0.05	4157	3509	-648	2636	-872.8	0.47	0.40	-0.07	0.30	-0.10
423	North Delta	0.62	0.59	-0.02	0.57	-0.02	2303	1854	-449	1376	-478.1	0.38	0.31	-0.07	0.24	-0.08
429	North Delta	0.59	0.57	-0.02	0.56	-0.01	2284	1836	-448	1359	-476.8	0.34	0.28	-0.06	0.22	-0.06
434	North Delta	0.53	0.53	0.00	0.53	0.00	4689	3418	-1271	2839	-579.0	0.09	0.07	-0.01	0.07	-0.01

# Table 6. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node for April. Differences are calculated as Hydrology 2 or 2<sup>1</sup> minus Hydrology 1

Table 7. DSM2 Results for Mean Daily Proportion Positive Flows, Mean Daily Flow, and Mean Daily Velocity at Each Channel Node for
May. Differences are calculated as Hydrology 2 or 2 <sup>1</sup> minus Hydrology 1

			Proport	ion Positive Da	aily Flow			age Daily Flow	(cfs)		Mean Daily Velocity (ft/s)					
Channel Nodes		Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference between Baseline and Proposed (Open)	Baseline	Proposed	Difference between Baseline and Proposed	Proposed (DCC Open)	Difference Between Proposed and Proposed DCC Open
6	San Joaquin	0.72	0.57	-0.15	0.57	0	627	228	-399	228	0	0.34	0.14	-0.21	0.14	0.00
9	San Joaquin	0.59	0.55	-0.04	0.55	0	343	64	-279	64	0	0.26	0.08	-0.18	0.08	0.00
12	South Delta	0.56	0.53	-0.03	0.53	0	308	30	-279	30	0	0.21	0.07	-0.14	0.07	0.00
49	Central Delta	0.52	0.52	0	0.53	0.01	1365	545	-820	1292	747	0.04	0.03	-0.01	0.04	0.01
50	Central Delta	0.52	0.52	0	0.52	0	1231	372	-859	1157	785	0.06	0.05	-0.01	0.06	0.01
54	San Joaquin	0.9	0.78	-0.12	0.77	-0.01	263	142	-120	142	0	0.16	0.09	-0.07	0.09	0.00
94	South Delta	0.51	0.5	-0.01	0.5	0	-758	-822	-64	-819	3	-0.07	-0.07	-0.01	-0.07	0.00
124	South Delta	0.46	0.46	0	0.46	0	-2352	-2230	122	-2435	-204	-0.06	-0.06	0.00	-0.07	-0.01
148	South Delta	0.51	0.51	0	0.51	0	-512	-539	-28	-543	-3	-0.04	-0.04	0.00	-0.04	0.00
310	Central Delta	0.51	0.51	0	0.52	0.01	-734	-745	-11	-476	269	-0.02	-0.02	0.00	0.00	0.02
388	North Delta	0.73	0.65	-0.08	0.62	-0.03	1311	929	-383	791	-138	0.74	0.54	-0.20	0.47	-0.07
412	North Delta	1	0.95	-0.05	0.95	0	9525	6911	-2614	6911	0	0.91	0.66	-0.25	0.66	0.00
421	North Delta	0.86	0.72	-0.14	0.75	0.03	5686	4187	-1499	4596	409	0.71	0.53	-0.18	0.58	0.05
422	North Delta	0.84	0.71	-0.13	0.63	-0.08	5677	4178	-1499	3078	-1100	0.63	0.47	-0.16	0.35	-0.12
423	North Delta	0.68	0.62	-0.06	0.59	-0.03	3281	2247	-1034	1604	-643	0.54	0.37	-0.16	0.27	-0.10
429	North Delta	0.63	0.59	-0.04	0.57	-0.02	3253	2219	-1035	1575	-644	0.46	0.33	-0.13	0.25	-0.08
434	North Delta	0.53	0.53	0	0.53	0	5980	3805	-2175	3021	-784	0.10	0.08	-0.02	0.07	-0.01



Figure 2. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the April modeled period (Sacramento River near Sherwood Harbor, North Delta)



Figure 3. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the May modeled period (Sacramento River near Sherwood Harbor, North Delta)



Figure 4. Density plot of velocity (ft/s) observed for DSM2 Channel 388, Sutter Slough and Sacramento River junction, in April



Figure 5. Density plot of velocity (ft/s) observed for DSM2 Channel 388, Sutter Slough and Sacramento River junction, in May

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Figure 6. Density plot of velocity (ft/s) observed for DSM2 Channel 421, upstream of the DCC channel junction, in April



Figure 7. Density plot of velocity (ft/s) observed for DSM2 Channel 421, upstream of the DCC channel junction, in May



Figure 8. Density plot of velocity (ft/s) observed for DSM2 Channel 422, Sacramento River between Delta Cross Channel and Georgiana Slough in April



Figure 9. Density plot of velocity (ft/s) observed for DSM2 Channel 422, Sacramento River between Delta Cross Channel and Georgiana Slough in May



Figure 10. Density plot of velocity (ft/s) observed for DSM2 Channel 423, Sacramento River downstream of the Delta Cross Channel and Georgiana Slough in April



Figure 11. Density plot of velocity (ft/s) observed for DSM2 Channel 423, Sacramento River downstream of the Delta Cross Channel and Georgiana Slough in May



Figure 12. Density plot of velocity (ft/s) observed for DSM2 Channel 424, Sacramento River between Decker Island and Sherman Island in April



Figure 13. Density plot of velocity (ft/s) observed for DSM2 Channel 424, Sacramento River between Decker Island and Sherman Island in May


Figure 14. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the April modeled period (Sacramento River near Cache Slough, North Delta)



Figure 15. Density plot of velocity (ft/s) observed at DSM2 Channel Node 412 under three scenarios during the May modeled period (Sacramento River near Cache Slough, North Delta)



Figure 16. Density plot of velocity (ft/s) observed at DSM2 Channel Node 6 under three scenarios during the April modeled period (Upstream of Head of Old River on San Joaquin, San Joaquin)



Figure 17. Density plot of velocity (ft/s) observed at DSM2 Channel Node 6 under three scenarios during the May modeled period (Upstream of Head of Old River on San Joaquin, San Joaquin)



Figure 18. Density plot of velocity (ft/s) observed at DSM2 Channel Node 54 under three scenarios during the April modeled period Downstream of Head of Old River on Old River, San Joaquin)



Figure 19. Density plot of velocity (ft/s) observed at DSM2 Channel Node 54 under three scenarios during the May modeled period (Downstream of Head of Old River on Old River, San Joaquin)



Figure 20. Density plot of velocity (ft/s) observed at DSM2 Channel Node 12 under three scenarios during the April modeled period (Upstream of Stockton Deepwater Shipping Channel , South Delta)



Figure 21. Density plot of velocity (ft/s) observed at DSM2 Channel Node 12 under three scenarios during the May modeled period (Upstream of Stockton Deepwater Shipping Channel , South Delta)



Figure 22. Density plot of velocity (ft/s) observed for DSM2 Channel 148, Middle River north of Railroad cut, in April



Figure 23. Density plot of velocity (ft/s) observed for DSM2 Channel 148, Middle River north of Railroad cut, in May



Figure 24. Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity, May 2015



Figure 25. Maps of the Delta with Key Channels Color-Coded for Daily Proportion Positive Velocity, April 2015



Figure 26. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity Generated from DSM2, May 2015



Figure 27. Maps of the Delta with Key Channels Color-Coded for Daily Mean Velocity Generated from DSM2, April 2015

#### **Particle Tracking Model**

For the purposes of the biological review, particle "entrainment" was assessed for the three scenarios: Baseline, Project Description with closed DCC gates, Project Description with open DCC gates (Table 1). Although the DSM2 particle tracking model does not currently incorporate a behavioral component, particles are considered dependable proxies for the relative effect of hydrological conditions on early-stage smelt larval movement because larvae are weak swimmers and are only minimally capable of selectively maintaining a position in the water column [*i.e.*, they tend to behave a lot like neutrally buoyant particles; see Kimmerer (2008). Six injection locations and seven flux locations were assessed (Figure 28). Daily entrainment flux fate at the CVP/SWP projects at the end of the model period (May 31) was considered and graphed for cumulative daily flux (Figure 29). Combined entrainment at the Projects was highest in both scenarios for particles inserted at Station 815 (near Prisoners Point on the San Joaquin River). The flux of particles past Chipps Island from all injection points are shown in Figures 30 and 31 for both the modeled Baseline and Project Description scenarios.



Figure 28. PTM Model injection and output locations. Six injection points are evaluated



#### Entrainment at Projects as of May 31st

Figure 29. Entrainment at Projects from multiple injection locations under the Project Description (Hydrology 2) and Unmodified (Hydrology 1) model scenarios



Figure 30. Flux Fate Past Chipps Island under the modeled Baseline scenario (Hydrology 1) for multiple injection locations



Figure 31. Flux Fate Past Chipps Island under the modeled Project Description scenario (Hydrology 2) for multiple injection locations

# Status of the Species and Effects of Project Description

### Status of Winter Run Chinook Salmon

A small number of winter-run Chinook Salmon (*Oncorhynchus tshawytscha*) (n=3,015; 90% CI= 2,741-3,290) returned to spawn in the upper Sacramento River in 2014. Of these 3,105 winterrun Chinook, 388 were collected at the Keswick trap for broodstock at Livingston Stone National Fish Hatchery. Assuming that 3-year old fish make up the majority of each spawning cohort, returning adults in 2014 were produced by a much smaller spawning escapement in 2011 (*i.e.*, 827 adult spawners). The effects of limited cold water storage and loss of temperature control out of Keswick Dam from mid-August through the fall of 2014 led to substantial egg and fry mortality. The mortality associated with this loss of temperature control was estimated to have affected up to 95% of the brood year 2014 eggs and fry (Doug Killam, CFDW, pers comm.). The average egg to fry mortality for brood year 2007-2012 was estimated to be 69% based on female escapement, fecundity, and the RBDD juvenile production index (Reclamation 2015).

As of March 11, 2015, approximately 408,704 juvenile winter-run Chinook Salmon were estimated to have migrated past the Red Bluff Diversion Dam (RBDD, Figures 32-33). The rotary screw traps at RBDD were operated for just 8 of 31 days during December 2014<sup>2</sup>, a period when the Sacramento River flows and turbidity levels were at their highest. Very few naturalorigin juvenile winter-run Chinook Salmon are hypothesized to remain upstream of the Delta and these are anticipated to migrate into the Delta and lower Sacramento River by the end of April based upon historical RBDD passage data (Tables 8-9). Monitoring data throughout the Sacramento River suggest that the majority of salmonids, including natural-origin juvenile winter-run Chinook Salmon are currently residing in the Lower Sacramento River and Delta (Figure 34, Tables 10-11). Detections of winter-run sized juveniles in the Chipps Island trawl monitoring have been low, but trending upwards, indicating that while few have migrated out of the Delta at this time, outmigration to the ocean is increasing (Figure 35). During April, the seaward migration of juvenile winter-run Chinook Salmon is likely to be completed due to changes in photoperiod and temperature, which stimulate smoltification and migratory behavior in these rearing fishes. Historical patterns indicate that the majority of out-migration typically occurs in March and is not complete until early spring (del Rosario et al. 2013). Discussions by the Delta Operations for Salmonids and Sturgeon (DOSS) team have estimated on March 17 that for the natural origin winter-run juveniles greater than 85% were rearing in the Delta, less than 15% had exited the Delta, and "few remaining stragglers" had yet to enter the Delta. A low level of salvage of winter-run sized juveniles has occurred during the winter, with a cumulative loss of 102 natural-origin winter-run sized juvenile Chinook as of March 20, 2015. This may be due to several factors, acting individually or in concert, including low population numbers, low exports, and low survival.

The entire production population of hatchery-origin winter-run Chinook Salmon were released into the upper Sacramento River in Redding from February 4-6, 2015. This segment of the

<sup>&</sup>lt;sup>2</sup> Biweekly reports from RBDD are available at: http://www.fws.gov/redbluff/RBDD%20JSM%20Biweekly/2014/rbdd\_jsmp\_2014.html

winter-run population, which was released concurrently with a storm pulse, began entering the North Delta within a week after release based on monitoring data, coded wire tag recoveries, and acoustic tag detections. Detection of acoustic tags and recoveries of CWT tags have in occurred at the Sacramento I-80 receiver, in the Knights Landing rotary screw traps (RSTs), the Sacramento regional beach seines, and the Sacramento trawls occurring near Sherwood Harbor on the Sacramento River. Discussions by the DOSS team have estimated passage into the Delta to be approximately 70-85% for the hatchery winter-run Chinook salmon. A subset of this release group from LSNFH was tagged with JSAT acoustic telemetry tags (n=500) and provided another means to track the downstream migration of the hatchery-origin winter-run juveniles, in addition to the standard river, Delta, and salvage fish monitoring efforts already in place. As of March 16, 2015, approximately 27.8% of the acoustic tagged hatchery winter-run were observed to have entered the Delta at the I-80/50 bridge in Sacramento, based on at least 2 detections of each tag by the array on the bridge abutments. If only single detections are used (which could include some false positives), the percentage of the tagged hatchery fish reaching the North Delta is 39.2%. It is worth noting that the Tisdale Weir did overtop immediately following the release of these fish and adipose fin-clipped juvenile salmonids (indicative of hatchery fish which includes both winter-run Chinook Salmon released from LSNFH and late-fall Chinook salmon concurrently released from the Coleman National Fish Hatchery [CNFH]) were rescued from the downstream apron of the weir. This observation suggests that some proportion of the hatchery release groups from both the LSNFH and CNFH releases entered the Sutter Basin and took that route downstream. As of March 20, 2015, the total observed loss of hatchery winter-run, confirmed by CWT, at the salvage facilities is 8.40. The DOSS estimates for the hatchery winterrun Chinook and the detected passage of the telemetry tagged differ considerably, which could result from, in part, detections probabilities being reduced due to high turbidity and flows, differential migration rates or holding patterns.



Figure 32. Weekly Estimated Passage of Juvenile Winter-run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by Brood-Year (BY)<sup>3</sup>

<sup>&</sup>lt;sup>3</sup> Fish sampled using rotary-screw traps for the period of July1, 2008 to present. Winter-run passage value interpolated using a monthly mean for the period October 1, 2013-October 17, 2013 due to government shutdown. Figure supplied by USFWS on March 11, 2015.



Environmental Data<sup>4</sup>

Table 8. Estimated Passage of Juvenile Winter Chinook Salmon at Red Bluff Diversion Dam(RK391) by Passage Quartile and Brood Year (BY)<sup>5</sup>

		Winter run Chinook Brood										
	2007	2008	2009	2010	2011	2012	2013					
First	1/9/08	2/20/09	1/25/10	1/5/11	1/24/12	12/21/12	2/14/14					
25%	1/25/08	3/1/09	3/3/10	3/16/11	3/22/12	3/18/13	3/5/14					
50%	3/15/08	3/12/09	3/13/10	4/4/11	4/7/12	3/26/13	3/9/14					
75%	3/25/08	3/26/09	3/31/10	4/15/11	4/11/12	4/4/13	3/14/14					
Last	4/28/08	5/19/09	4/28/10	4/22/11	4/27/12	4/15/13	4/11/14					



Figure 34. Sacramento Trawl and Sacramento Area Beach Seines Older Juvenile Chinook Salmon Catch Data and Associated Environmental Data<sup>6</sup>

<sup>&</sup>lt;sup>4</sup> Figure supplied by DWR on March 8, 2015

<sup>&</sup>lt;sup>6</sup> Figure supplied by DWR on March 18, 2015.

	Tisdale									Knight	s Landing					
		W	Vild Juveni	les		Ad C	Clipped			W	/ild Juveni	les		Ad C	lipped	
	Fall	Spring	Winter	Late fall	Steelhead	Salmon	Steelhead	Weekly Total	Fall	Spring	Winter	Late fall	Steelhead	Salmon	Steelhead	Weekly Total
10/4/2014 - 10/10/2014	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
10/11/2014 - 10/17/2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/18/2014 - 10/24/2014	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
10/25/2014 - 10/31/2014	0	2	117	2	0	0	0	121	0	1	95	4	0	0	0	100
11/1/2014 - 11/7/2014	0	1	2	0	0	0	0	3	0	0	2	0	0	0	0	2
11/8/2014 - 11/14/2014	0	0	1	0	0	0	1	2	0	0	2	0	0	0	0	2
11/15/2014 - 11/21/2014	0	0	3	1	0	0	0	4	0	0	3	0	0	0	0	3
11/22/2014 - 11/28/2014	0	0	3	0	0	0	0	3	0	0	2	0	0	0	0	2
11/29/2014 - 12/5/2014	0	0	7	0	0	2	0	9	0	0	2	0	0	0	0	2
12/6/2014 - 12/12/2014	10	14	10	2	0	5	0	41	17	50	32	8	0	24	0	131
12/13/2014 - 12/19/2014	169	9	0	2	0	2	0	182	148	88	5	1	0	4	0	246
12/20/2014 - 12/26/2014	654	35	24	5	1	6	0	725	411	112	14	4	0	8	0	549
12/27/2014 - 1/2/2015	154	22	1	1	0	0	0	178	13	6	0	1	0	0	0	20
1/3/2015 - 1/9/2015	91	61	6	0	2	0	0	160	15	13	0	2	0	2	0	32
1/10/2015 - 1/16/2015	52	16	4	0	0	1	6	79	25	13	0	1	0	0	7	46
1/17/2015 - 1/23/2015	30	7	3	0	0	0	4	44	12	6	0	0	0	0	5	23
1/24/2015 - 1/30/2015	9	0	2	0	0	0	4	15	3	1	0	0	0	1	0	5
1/31/2015 - 2/6/2015	2	1	1	0	0	0	0	4	1	0	0	0	0	0	0	1
2/7/2015 - 2/13/2015	4795	43	3	0	0	193	18	5052	6118	79	22	0	3	332	80	6634
2/14/2015 - 2/20/2015	251	11	4	0	0	40	0	306	674	21	7	0	2	102	25	831
2/21/2015 - 2/27/2015	18	0	1	0	0	5	0	24	7	0	3	0	0	5	0	15
2/28/2015 - 3/6/2015	2	0	3	0	0	4	0	9	0	0	0	0	0	0	0	0
3/7/2015 - 3/13/2015	0	1	1	0	0	0	0	2	2	0	0	0	0	1	0	3
Species Total	6237	223	196	13	3	0 258	33	6963	7446	391	190	21	5	479	117	8649

Table 9. Weekly Catch of Juvenile Winter-run Chinook Salmon at Tisdale and Knights LandingRotary Screw Traps for WY15 through March 13, 2015

 Table 10. Lower Sacramento River and Delta beach seine and trawling recoveries of salmonids during WY 2015<sup>7</sup>

		7	Vild juveni	iles		Ad c		
Beach Seine Region	Fall	LateFall	Spring	Winter	Steelhead	Chinook	Steelhead	Regional Total
Bay East	0	0	0	0	0	0	0	0
Bay West	0	0	0	0	0	0	0	0
Central Delta	36		10	1	0	0	1	48
Lower Sacramento	745	3	236	45	0	7	1	1037
North Delta	865	3	243	18	0	9	2	1140
Sacramento	216	2	55	8	2	10	0	293
South Delta					0	0	0	0
San Joaquin	2	0	0	0	0	0	0	2
Trawl								
Sacramento	116	5	17	11	0	17	0	166
Chipps				7	0	12	4	23
Jersey Point	371	1	5	2	0	0	4	383
Prisoners Pt	149	1	5	1	0	8	14	178
Species Total	2500	15	571	93	2	63	26	3270

<sup>&</sup>lt;sup>7</sup> Trawl and beach seine data updated through March 16, 2015. Provided by USFWS Delta Juvenile Fish Monitoring Program.

	Lower		Central			
Week	Sacramento	North Delta	Delta	San Joaquin	Sacramento	Grand Total
10/15/2014 - 10/21/2014	1					1
11/12/2014 - 11/18/2014		2				2
11/19/2014 - 11/25/2014		2				2
11/26/2014 - 12/2/2014	4				1	5
12/3/2014 - 12/9/2014	26	19			11	56
12/10/2014 - 12/16/2014	18	29			5	52
12/17/2014 - 12/23/2014	75	143			30	248
12/24/2014 - 12/30/2014	72	271	1		40	384
12/31/2014 - 1/6/2015	374	12			23	409
1/7/2015 - 1/13/2015	13	39	10		35	97
1/14/2015 - 1/20/2015	40	34	3		8	85
1/21/2015 - 1/27/2015	33	9				42
1/28/2015 - 2/3/2015	12	23			6	41
2/4/2015 - 2/10/2015	42	90	2		13	147
2/11/2015 - 2/17/2015	94	104			11	209
2/18/2015 - 2/24/2015	88	57	1	1	17	164
2/25/2015 - 3/3/2015	33	99	15		56	203
3/4/2015 - 3/10/2015	109	205	15		35	364
3/11/2015 - 3/13/2015	2			1		3
Grand Total	1036	1138	47	2	291	2415

Table 11. Salmonid presence in beach seines through different regions of the Delta during WY 2015



Figure 35. Chipps Island Trawl older juvenile Chinook Salmon catch data and associated environmental data<sup>8</sup>

### Effects of Project Description on Winter-Run Chinook Salmon

The predicted distribution of winter-run Chinook Salmon during the Project Description period and a summary of potential effects is presented in Table 12, followed by more details per action type and location.

<sup>&</sup>lt;sup>8</sup> Figure supplied by DWR March 17, 2015.

<b>**</b> 7• /	Ехр	Usure to I otential Effe							
Winter-run			South/Central						
Chinook			Delta						
Salmon Life	Life Stage	Tributary	Entrainment	<b>Facility Loss</b>					
Stage	Present	Habitat Effect	Effect	Effect					
Egg/Alevin	This life stag	e will be present in th	e Sacramento River	r May through					
		September for BY 15.							
Sacramento R	Yes	Yes <sup>9</sup>	N/A	N/A					
Sucramento IX	105	105							
Juvenile	This life stage w	ill be present in the D	elta during April an	nd May for BY 14					
	and in the Sacramento during August to September for BY 15.								
~ ~ ~		<b>.</b>							
Sacramento R	Yes	Reduced	N/A	N/A					
		Survival							
Delta	Ves	N/A	Ves	Uncertain					
Denta	105	1 1/1 1	105	Oncertain					
Adults	This life stage	will be present in the	Sacramento River a	nd Delta during					
	April through July								
Sacramento R	Yes	No Change	N/A	N/A					
Delta	Yes	N/A	N/A	N/A					
= 5100		/							

#### Table 12. Presence of Winter-run Chinook Salmon During the Project Description Period and Exposure to Potential Effects

#### **Sacramento River Actions**

Temperature operations remain under discussion by the Sacramento River Temperature Task Group (SRTTG). The recent 90% temperature forecasts provided to the SRTTG in January and February both suggest that a temperature compliance point of 56°F at the Clear Creek CDEC gaging station cannot be maintained through the winter-run Chinook Salmon egg incubation and fry rearing period. These forecasts suggest temperatures below 56°F would no longer be attainable in mid-August to early September, which would suggest no potential impact on spawning adults. These forecasts suggest similar impacts as described during the late summer of WY 2014 (Figure 36). Impacts to egg and alevin stages are more difficult to predict due to uncertainties with actual spawn timing, redd locations, and observed hydrological and temperature profiles. A temperature management plan for the upper Sacramento River continues to be developed and an appropriate biological review will be provided upon its completion. Forecasted Sacramento River flows during the Project Description do not include large weekly fluctuations, and will incorporate ramping rates, which minimize stranding and isolation of winter-run Chinook Salmon juveniles.

<sup>&</sup>lt;sup>9</sup> Temperature management and effects will be evaluated by the SRTTG.



Attachment 2. Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September Project Description

Figure 36. Water Temperatures at Keswick Dam (KWK) and Clear Creek Confluence (CCR, WY14 temperature compliance point) and Winter-run Chinook Salmon Early Life Stages between May 1 and November 6, 2014<sup>10</sup>

#### Net Delta Outflow Index and Water Quality Modifications

The Project Description during the remainder of WY 2015 is intended to preserve storage in Shasta Reservoir and increase the cold water pool available for management of temperatures for winter-run Chinook Salmon as late into the summer as feasible. Under the Project Description, the Net Delta Outflow Index (NDOI) will be modified from a minimum monthly daily average of 7,100 cfs to no less than 4,000 cfs during the months of April through June, and no less than 3,000 cfs during the month of July. This reduction in NDOI will lead to reduced Keswick releases during these months, which may affect out migrating winter-run Chinook Salmon during the remainder of spring 2015. DOSS estimated on March 17, 2015 that <5% of natural winterrun and <15% of hatchery winter-run remain in the riverine habitat affected by these releases upstream of the Delta. Approximately 85% of each of these groups is projected to be within the Delta and subject to effects resulting from any modified operations. These effects have been described previously (NMFS 2014a, USBR 2014a, USBR 2014b), but are reviewed here again since the distribution and proportion of winter-run Chinook Salmon in the Delta and Sacramento River have changed since these prior assessments. The changes in hydrodynamics in the modeled scenarios are representative of a range of conditions possible during April and May, and do not reflect the influence of potential Delta drought barriers that may be installed in the Delta.

<sup>&</sup>lt;sup>10</sup> Figure supplied by CDFW on January 20, 2015.

Although the NMFS BiOp (2009) does not contain outflow standards, the BiOp assumed that D-1641 standards would be met, which would afford protection to listed species and their designated critical habitats. The reduction in outflow as part of the Project Description may impact juvenile salmonids migrating through the North Delta between the Sherwood Harbor and the Sutter and Steamboat slough reach, where Sacramento River flows meet the tidally-dominated western Delta. The Project Description's reduction in Delta outflow to as low as 4000 cfs may reduce survival of out migrating winter-run Chinook Salmon, migrating through the North Delta through increased predation mediated by hydrodynamic and habitat mechanisms. Once out migrating fish reach the tidally-dominated western Delta (i.e., Sutter and Steamboat slough area downstream towards Chipps Island) or San Joaquin River under the minimum outflows identified in the Project Description, they are likely to encounter daily proportion of positive velocities and mean velocity that are similar to outflow conditions observed in the Baseline modeling (see, *e.g.*, Figures 10-15). There is a moderate level of uncertainty in these conclusions.

The Project Description's reduced outflow increases tidal excursion upstream (reduced daily proportion of positive velocities) into the waterways in the North Delta region primarily in April. In April, there is a reduction in the proportion of positive daily flows passing Georgiana Slough and/or an open Delta Cross Channel compared to May in both the Baseline and Project Description DSM2 modeling (Tables 6-7). Increased reverse flows and slower mean velocities result in longer travel times for migrating fish, which has been shown to reduce outmigration survival (Singer et al. 2013, Perry 2010, and Romine et al. 2013). Georgiana Slough flows become less positive as tidal excursion causes reversal in this channel when outflow is reduced. Reducing outflow also causes a decrease in the daily proportion of positive velocities through the Sacramento River downstream of Sutter and Steamboat sloughs confluence with the Sacramento River. These increased tidal excursions may increase juvenile entrainment into Georgiana Slough and, if open, the Delta Cross Channel. When the DCC gates are open, the daily mean channel velocity becomes even less positive in these reaches (Tables 6-7, Figures 8-9). When the DCC gates are open, the daily proportion of positive velocities further decreases in the Sacramento River upstream of the DCC gates and more noticeable between the DCC gate and Georgiana Slough. When the DCC is open, there is a reduction in the daily proportion of positive flows through Georgiana Slough. There is a low level of uncertainty in this conclusion.

At low outflow, channel margin habitat becomes exposed above the surface of the water and is unavailable to juvenile salmonids present. This lack of cover may reduce juvenile survival. It is hypothesized that lower outflows may intensify the density of littoral predators into a smaller, shallower area and/or decrease the quantity of cover available to outmigrating salmonids to avoid predators. There is a high level of uncertainty in this conclusion. Decreased daily mean velocities may result in increased residence time of juvenile winter-run Chinook Salmon, which is hypothesized to result in an increased size at ocean entry if they are rearing in areas with suitable environmental metrics and food resources. There is a high level of uncertainty in this conclusion.

#### **Delta Cross Channel Gates**

Under the Project Description, modified Delta Cross Channel Gates operations may occur based on water quality and fish presence. At this time, it is believed that an open DCC Gate has a low potential for entraining a substantial proportion of the juvenile winter-run Chinook Salmon population through this junction and into the Central Delta. This is because a majority of the natural (>95%) and hatchery (>70-85%) juvenile winter-run population is believed to already be in the Delta; many of those may have already passed this location and are currently residing downstream of the DCC gate location or have exited the system altogether and have emigrated to the marine environment. The remaining fraction of the natural and hatchery winter-run juvenile population that may still occur above the DCC location will be vulnerable to entrainment into an open DCC gate configuration as they emigrate downriver past the DCC gate location. Because outmigration of both natural and hatchery winter-run juveniles past Chipps Island is expected to be largely complete by mid-April, the Project Description's Modification of the DCC gate operations will affect winter-run in the North Delta compared to the Baseline scenario, but only for a short time. It is uncertain whether the increase in the likelihood of entrainment into the Central Delta will result in any change to facility loss of winter-run, both because the duration of the effect is expected to be short, and because the limited exports in the Project Description scenarios may not result in greater entrainment into the South Delta and facility loss (see discussion in "Exports" section).

If the DCC gates were open Sacramento River water will flow through the DCC and into the Mokelumne River system. This may result in some level of straying of upstream migrating adult Winter-run Chinook Salmon into the Mokelumne River system. It is expected that this may delay these adults on their upstream spawning migration. Adult winter-run Chinook Salmon which have entered the Mokelumne River system should be able to re-enter the Sacramento mainstem through the open DCC gates and continue their upstream movements. A delay in reaching the spawning grounds and an increase in energy expenditure may result. This could result in lower survival of juveniles produced from straying individuals, if temperatures in the upper river become unsuitable for egg and fry survival.

#### Exports

The Project Description scenario is expected to result in minimal additional entrainment of juvenile winter-run Chinook. Exports, barring a precipitation event substantial enough to produce natural and abandoned flows resulting in an NDOI greater than 5500cfs and closure of the DCC gates, if open, will be limited to combined 1500 cfs. The PTM for the Baseline and Project Description scenarios with Sherwood Harbor as the injection location (Figure 29) indicates that ~3% more particles are entrained at the export facilities in the modified scenarios (5% for Project Description (DCC Closed), 5.1% for Project Description (DCC open)) compared to the baseline (2%). The exposure to the increased risk of facility loss will occur in early April, after which the majority of juvenile winter-run Chinook are located further west and are exiting the Delta past Chipps Island. Considering that the majority of natural origin and hatchery winter-run are currently still rearing in the Delta and salvage of fish at the CVP/SWP fish collection facilities has occurred this season, concern for the entrainment risk at the projected export ranges would be a moderate risk of entrainment in early April, and low (for Winter-run) from mid-April onward.

# Summary of Effects on Winter Run Chinook Salmon

The proposed operational modifications to the D-1641 flow and operational criteria may reduce through-Delta survival of migrating juvenile winter-run Chinook Salmon by the reducing the transit rate for these migrating salmonids, which may increase the predation potential. The timing of Delta exit appears to be fairly consistent over time and while less than 15% have been projected to have migrated out of the Delta, the remaining portion should exit during April and possibly into May (del Rosario 2013). While salvage of listed juvenile Chinook is projected to remain moderate due in part to the migratory behavior being displayed by winter-run Chinook Salmon juvenile and the low levels of exports, if exports increased during the Project Description in April and May, a measure to reduce the risks associated with entrainment loss would occur by shifting exports from the SWP to the CVP.

# Status of Spring-Run Chinook Salmon

The 2014 spawning run of spring-run Chinook Salmon returning to the upper Sacramento River Basin was lower in four of seven locations compared to the 2013 escapement, with markedly lower escapement observed in Clear Creek, Butte Creek, and Feather River Hatchery (Table 13).

Tributary	2013	2014	Percent Change	Source
Battle Creek	608	429	-29	Laurie Earley, USFWS
Clear Creek	659	95	-86	
Antelope Creek	0	7	-	Matt Johnson, DFW
Mill Creek	644	679	+5.4	
Deer Creek	708	830	+17	
Butte Creek	16783	4815	-71	Clint Garman, DFW
Feather River Hatchery	4294	2825	-34	Penny Crenshaw, DWR

Table 13. Spring-run Chinook Escapement in 2013 and 2014

Spawning of spring-run Chinook salmon in the Sacramento River Basin occurs approximately from mid-August through mid-October, peaking in September. In 2014, this peak in spawning activity corresponded with the high Sacramento River temperatures downstream of Keswick Dam resulting in an elevated potential for high egg and alevin mortality. It is believed that spring-run Chinook salmon eggs in the Sacramento River underwent significant, and potentially complete mortality due to high water temperature downstream of Keswick Dam starting in mid-August when water temperatures downstream of Keswick Dam exceeded 56°Fahrenheit (F) (see water temperatures in August through October in Figure 36) in WY 2014. Spring-run Chinook

Salmon eggs spawned in the tributaries to the Sacramento River may also have experienced warmer temperatures in 2014 due to low flows through late October, as well as scouring or sedimentation during rain events from late October through December.

Juvenile spring-run Chinook salmon begin emigration from Clear Creek soon after emergence, with passage near the mouth peaking in November through December and continuing to around May. Recent year passage indices are shown in Table 14. For BY 2014, extremely few juvenile Spring-run Chinook Salmon were observed migrating downstream past RBDD (Figure 37) during high winter flows, when spring-run Chinook Salmon originating from the upper Sacramento River, Clear Creek, and other northern tributaries are typically observed to outmigrate. As of March 11, 2015<sup>11</sup>, only 35,435 BY 2014 spring-run Chinook Salmon were estimated to have passed Red Bluff Diversion Dam, and these low RBDD passage estimates are a concern. A second pulse of juvenile spring-run Chinook Salmon typically migrate past RBDD in the springtime (Poytress et al. 2014). However, this second pulse appears to positively bias estimates of spring-run Chinook passage due to the presence of millions of unmarked fall-run Chinook salmon hatchery fish released from the Coleman National Fish Hatchery on Battle Creek. These hatchery production fish typically overlap with the spring-run Chinook salmon category based on the length-at-date run assignments (Poytress et al. 2014).

Table 14. Passage Indices of Juvenile Spring-run Chinook Salmon with 90% and 95% ConfidenceIntervals for Brood Years (BY) 2003-2013 Captured by the Upper Rotary Screw Trap at RiverMile (RM) 8.4 in Clear Creek, Shasta County, California, by the U.S. Fish and Wildlife Service.The Adjusted Passage Index (Proportionate to Juveniles per Redd) Includes Redds Below the Trap,yet Above the Separation Weir. For BY 2013, Confidence Intervals and Adjusted Index Have NotBeen Calculated Yet

Brood year	95% LCI	90% LCI	Passage index	90% UCI	95% UCI	Adjusted index	Juveniles per redd
2003	88,817	90,113	108,338	130,960	137,672	110,422	2,083
2004	87,439	90,417	107,054	131,700	136,701	110,028	2,974
2005	87,516	89,516	104,197	122,580	128,418	106,201	2,004
2006	111,749	113,659	127,197	144,692	148,539	149,318	1,843
2007	92,728	94,472	110,224	130,585	135,069	114,914	2,345
2008	88,834	89,653	96,166	102,920	104,402	121,622	1,414
2009	62,213	63,214	68,296	74,319	75,384	74,084	1,158
2010	15,228	15,618	17,359	19,416	19,910	19,288	1,929
2011	49,247	49,893	53,896	58,238	59,007	57,265	3,369
2012	16,124	16,363	17,891	19,695	20,020	19,447	778
2013			227,912				1,767

<sup>&</sup>lt;sup>11</sup> Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Figure supplied by USFWS on March 11, 2015.



Figure 37. Weekly Estimated Passage of Juvenile Spring Run Chinook Salmon at Red Bluff Diversion Dam (RK 391) by brood year (BY)<sup>12</sup>

In fall 2014, yearling spring-run Chinook Salmon from Mill and Deer creeks experienced flow and temperature conditions typically associated with the outmigration of this life history expression from these tributaries. Although not currently monitored with RSTs, these tributaries have experienced flows (Figures 38-39) exceeding "First Alert" thresholds identified in the NMFS BiOp Action IV.1.2. Recent analyses of multiple years of RST data have determined that 99% of outmigrating yearlings are captured at flows greater than 95 cfs (Kevin Reece, DWR, pers. comm.).

Spring-run young-of-the-year (YOY) sized Chinook Salmon juveniles have been observed at the Tisdale Weir and Knights Landing RSTs since early December 2014 (Table 9). Likewise, juvenile YOY spring-run Chinook have been observed in the catch from multiple Delta beach seine regions, and in the standard trawling and special drought monitoring trawling surveys, including those in the Central Delta (Tables 10-11). Monitoring data suggest that the majority of surviving BY 2014 natural origin YOY juveniles are currently residing in the Delta, downstream of Knights Landing. No yearling spring-run Chinook Salmon have been caught in 2014 Delta monitoring, however, yearling spring-run observations are expected to be rare because of their relatively large size and strong swimming ability (associated with gear avoidance), and relatively low densities relative to YOY. The majority of YOY, yearling, and surrogate (hatchery late fall) spring-run are currently rearing in the Delta. This estimate is based on the best professional judgment of the biologists participating on the DOSS work team. No natural or hatchery origin spring-run Chinook Salmon have been salvaged at the fish collection facilities as of March 15, 2015.

<sup>&</sup>lt;sup>12</sup> Fish were sampled using rotary-screw traps for the period July 1, 2008 to present. Figure supplied by USFWS on March 11, 2015.

Attachment 2. Biological Review for Endangered Species Act Compliance with the WY 2015 Drought Contingency Plan April through September Project Description



Figure 38. Mill Creek Mean Daily Flow (cubic feet per second) Measured near Los Molinos (MLM) During WY2015<sup>13</sup>



Figure 39. Deer Creek Discharge (cubic feet per second) Measured Downstream of Stanford Vina Dam (DVD) During WY2015<sup>14</sup>

<sup>&</sup>lt;sup>13</sup> Downloaded from CDEC on March 16, 2015.

<sup>&</sup>lt;sup>14</sup> Downloaded from CDEC on March 11, 2015.

Adult spring-run Chinook salmon will be entering the upper Sacramento River and Clear Creek during spring and continue into the summer of 2015, then holding until they start spawning in mid-August, with peak spawning occurring in September and completing by mid-October. Spring-run Chinook salmon spawning in Clear Creek occurs primarily upstream of a barrier weir installed at river mile 7 that separates spring-run and fall-run Chinook salmon spawning based on timing of entry into the tributary and protects spring-run Chinook salmon eggs from super-imposition by fall-run Chinook salmon spawners later in the year. Table 15 shows spring-run Chinook Salmon spawning distribution in Clear Creek. Distribution has shifted upstream somewhat through the years after removal of McCormick-Seltzer diversion dam (approximately RM 6.2) in 2000 and with repeated gravel additions.

Spring-run Chinook Salmon may spawn in the Sacramento River between RBDD and Keswick Dam in very low densities with only a total of 449 redds documented from 2001 to 2014 (average 37/year; range= 0-105; no data available for 2009 or 2011; CDFW unpublished data). Most spring-run Chinook Salmon redds (93 percent) have been documented upstream of Jelly's Ferry Bridge (river mile [RM] 265.9).

Table 15. Distribution of Spring run Chinook Salmon Redds in Clear Creek, 2003–2013. River
miles (RM) Begin at the Confluence at RM 0, and End at Whiskeytown Dam at RM 18.3. Both RM
7 (0.6 miles) and RM 18 (0.3 miles) are Incomplete Miles. RM 7 was Not Available for Spring run
Spawning in 2003-2005, and 2011 When the Weir Was Located at the Lower Site

Year	RM 7	RM 8	RM 9	RM 10	RM 11	RM 12	RM 13	RM 14	RM 15	RM 16	RM 17	RM 18	Total
2003	NA	4	5	9	2	3	0	15	3	4	5	3	53
2004	NA	9	1	9	2	0	2	4	3	3	4	0	37
2005	NA	4	2	11	4	0	1	4	10	3	11	2	52
2006	4	11	8	12	13	7	0	4	8	10	5	0	82
2007	0	6	1	5	0	2	1	1	7	15	11	0	49
2008	8	18	3	11	4	6	0	11	5	13	6	1	86
2009	3	8	2	15	4	1	4	6	4	4	13	0	64
2010	1	1	0	3	0	0	0	1	1	2	1	0	10
2011	NA	1	0	5	0	2	1	5	0	2	0	0	16
2012	1	2	1	7	2	1	2	5	2	2	0	0	25
2013	5	11	2	30	5	11	6	11	10	25	23	3	142
2014	1	6	3	12	1	6	2	6	4	4	10	0	55

### Effects of Project Description on Spring-run Chinook Salmon

The predicted distribution of spring-run Chinook Salmon during the Project Description period and a summary of potential effects is presented in Table 16, followed by more details per action type and location.

Table 16. Presence of Spring run Chinook Salmon During the Project Description Period and									
a .	Ex	posure to Potential Effe	ects						
Spring-run	Life Stage	Tributary Habitat	South/Central	Facility Loss					
Chinook Salmon	Present	Effect	Delta	Effect					
Life Stage			Entrainment						
			Effect						
Egg	This life stag	ge will be present in the	e Sacramento River	in September					
Sacramento R	Yes	Yes	N/A	N/A					
Clear Creek	Yes	Yes	N/A	N/A					
Juvenile	This life stage	will be present in the S	Sacramento River a	nd Delta during					
	U	April and	d May	C					
		1	2						
Sacramento R	Yes	Reduced	N/A	N/A					
		Survival							
		-							
Clear Creek	Yes	No Modification	N/A	N/A					
		in Project							
Dalta	V	NT/A	Turneral	The sector					
Delta	res	N/A	Increased	Uncertain					
Adults	This life stage	will be present in the S	Sacramento River a	and Delta during					
	U	April through	September	U					
		ripin unough	September						
Sacramento R	Yes	No Change	N/A	N/A					
Delta	Yes	N/A	No Change	No Change					

#### **Sacramento River Actions**

Temperature operations as part of the Project Description remain under discussion by the SRTTG. The 90% temperature forecasts provided to the SRTTG in January and February both forecast a temperature compliance point of 56°F at the Clear Creek CDEC gaging station cannot be maintained during September when peak spring-run Chinook salmon spawning and egg incubation occurs. Impacts to egg and alevin stages are more difficult to predict due to uncertainties with actual spawn timing, redd locations, and observed hydrological and temperature profiles. A temperature management plan for the upper Sacramento River, including Clear Creek, continues to be developed and an appropriate biological review will be provided upon its completion. Forecasted Sacramento River flows during the Project Description include

reduced releases from Shasta during September, which may cause some spring-run Chinook redd dewatering. Chinook redd dewatering at multiple locations was documented during Fall 2014 when Keswick flows were reduced below 5,000 cfs.

#### Net Delta Outflow Index and Water Quality Modifications

Drought operational actions impacting Sacramento River outflow proposed during the remainder of WY2015 are intended to preserve storage in Shasta Reservoir and increase the potential coldwater pool available for management of temperatures for both winter-run and spring-run Chinook Salmon. Similar to winter-run Chinook Salmon, the reduction in Keswick releases to meet modified spring D-1641 NDOI standards may affect outmigrating spring-run Chinook Salmon during the remainder of spring 2015. As of March 17, 2015, DOSS estimates that the majority (80-95%) of natural-origin YOY Spring-run Chinook Salmon are rearing in the Delta, with approximately 5-20% remaining upstream of the Delta and <5% have exited the Delta. In contrast, the entire cohort of yearling spring-run Chinook Salmon are either in, or have existed the Delta (approximately 50% each), with the exception of a few possible stragglers upstream of the Delta.

Effects to individuals remaining upstream would be similar to those described above for Winterrun Chinook Salmon upstream of the Delta. To review, reductions in Delta outflow to as low as 4,000 cfs during April and May may reduce migratory survival of any YOY spring-run Chinook Salmon migrating through the Sacramento River until reaching the tidally dominated North Delta through increased predation mediated by hydrodynamic and habitat mechanisms. Increased tidal excursions are likely to increase entrainment of any downstream migrating YOY into Georgiana Slough and, if open, the Delta Cross Channel. The reduced velocities in the lower Sacramento River due to reduced inflow is evident in the DSM2 modeling and increased tidal excursion occurs in this modeling causing less positive velocities until tides reduce the force of incoming riverine flows and mute any difference observed in the modeling from the Baseline and Project Description scenarios (Figures 2-11). The possible reductions in outflow through multiple distributaries in the North Delta may increase straying and travel time of adult spring-run Chinook Salmon in this region during April and May.

Rearing juvenile spring-run Chinook Salmon within the Delta are not expected to be affected by the Project Description's modifications to NDOI and Delta water quality standard during April and May. Flows are tidally dominated in the North Delta and Central Delta areas where rearing occurs (Figures 4-15). There is low certainty in our understanding of the juvenile salmonid biological processes affected by flow in the Delta. South Delta conditions in the Project Description scenario are similar to the Baseline scenario during April and May (Figures 22 and 23). There is moderate certainty in our understanding of how hydrodynamics and suitable habitats for rearing juvenile salmonids are affected in the Delta by the Project Description .

#### **Clear Creek Actions**

Temperature management on Clear Creek attempts to achieve a temperature compliance schedule to reduce thermal stress to over-summering steelhead and to spring-run Chinook Salmon during their holding, spawning, and incubation periods. Under the 90% Operation Forecast, monthly average flows in August and September are estimated to be 85 cfs and 150 cfs, respectively, and with those lower flows, there is a potential for temperature criteria to be

exceeded during these months. Adult spring-run Chinook Salmon holding when temperatures exceed 60°F may experience higher pre-spawn mortality, and those surviving may have reduced egg viability. If temperatures exceed 56°F after September 15, there will be greater mortality of incubating eggs and pre-emergent fry. There is low uncertainty in this conclusion. The temperature management for Clear Creek will be coordinated through the Sacramento River Temperature Task Group under the SWRCB 90-5 requirements and as outlined in RPA Action I.1.5.

#### **Delta Cross Channel Gates**

Under the Project Description, modified Delta Cross Channel Gates operations may occur based on water quality and fish presence as described in the Project Description. Effects to spring-run Chinook Salmon are generally similar to those discussed above for winter-run Chinook whereby an open DCC Gate has a low potential for entraining juvenile spring-run Chinook Salmon through this junction and into the Central Delta due to most juvenile (about 85-95% YOY and 95% yearling) spring-Run Chinook Salmon having already passed this location earlier this year. There is a low potential for adult straying associated with some Sacramento River water flowing through the DCC and into the Mokelumne. Additionally, there is a low potential for temporary adult migration delays and associated lower egg viability due to physiological stress from increasing energy expenditures or increasing exposure to high water temperatures.

#### **Exports**

The Project Description scenario is expected to result in minimal additional entrainment of juvenile spring-run Chinook Salmon. Exports, barring a precipitation event substantial enough to produce natural and abandoned flows resulting in an NDOI greater than 5500cfs, and closure of the DCC gates, if open, will be limited to combined 1500 cfs. These low export levels are not expected to appreciably affect survival of juvenile spring-run Chinook Salmon emigrating through the Delta. The PTM run with Sherwood Harbor as the injection location (Figure 29) indicates that ~3% more particles are entrained at the export facilities in the modified scenarios (5% for Project Description (DCC Closed), 5.1% for Project Description (DCC open)) compared to the baseline (2%). Since export levels are the same between the Project Description and Baseline scenarios, the change in the risk of loss at the export facilities is likely unchanged between scenarios for fish in the interior delta, but, due to the expected increase in entrainment of fish into the central/south Delta, more fish might reach the interior Delta under the actions in the Project Description (even if, though to a lesser extent, if the DCC is closed). Therefore, the cumulative effect of exports due to the Project Description is uncertain, since that effect will depend on distribution of outmigrating spring-run Chinook salmon. The majority of natural origin Spring run Chinook Salmon are currently rearing in the Delta, yet as of March 15, 2015, no Spring run Chinook Salmon juveniles have been salvaged at the pumping plants. This is likely due to the very low juvenile productivity. The entrainment risk at the minimum export levels described in the Project Description is similar to the Baseline scenario, and remains low-tomoderate through April and May based on their current distribution and rarity.

#### Summary of Effects on Spring-run Chinook Salmon

The extreme drought conditions are causing increased stress to spring-run Chinook Salmon populations, with or without water project operations, in the form of low flows reducing rearing and migratory habitats, higher water temperatures affecting survival, and likely higher than

normal predation rates. Water management over the first portion of WY 2015 has focused on maintaining a level of reservoir storage which is generally higher than what would have been in place at this time without the planning that has gone into attempting to reduce adverse effects on resources. The current drought operations plan strives to continue to save some water resources for the future in the hopes of minimizing long-term adverse effects of the drought.

Cumulatively, the Project Description modification to the D-1641 flow and operational criteria may reduce through-Delta survival of juvenile migrating spring-run Chinook Salmon and may modify their designated critical habitat during April and May. Changes in Sacramento River outflow during April and May can possibly delay adult spring-run Chinook salmon migration. Drought conditions and current reservoir storage levels have forecasted to impact the ability to maintain suitable water temperatures in the Upper Sacramento River and Clear Creek. Temperature effects on Clear Creek and in the Upper Sacramento may lead to possible higher pre-spawn mortality of adult Spring-run Chinook Salmon and reduced egg viability if temperatures exceed 60°F during August and early September, as well as greater mortality of incubating eggs and pre-emergent fry if temperatures exceed 56°F after September 15.

### **Status of Green Sturgeon**

Information on green sturgeon is extremely limited. Adult green sturgeon will migrate into the upper Sacramento River through the Delta in March and April. Last year, a review of telemetric data found 26 tagged green sturgeon entered the San Francisco Bay with only half migrating upstream of RBDD (M. Thomas, UC Davis, pers. comm.). Already in 2015, one acoustically-tagged adult was recorded migrating past Sacramento this winter and based on typical migration rates, has likely reached Red Bluff (M. Thomas, UC Davis, pers. comm.).

Adult green sturgeon have been observed to overwinter in the Sacramento River, and a number of tagged 2014 adults appeared to still be present in the upper Sacramento River as of January, 2015 (R. Chase, Reclamation, pers. comm.), but it is unknown if they remained in this area during the past two months (M. Thomas, UC Davis, pers. comm.). Also, adult green sturgeon exit through the Lower Sacramento River during the summer and fall following their spawning, then return to SF Bay throughout this period also. Green sturgeon exit the San Francisco Bay late in the summer through the winter.

Spawning typically occurs from April through July. Spawning in the upper Sacramento River was documented during 2014 and associated larval green sturgeons were observed at RBDD during the summer of 2014 (n=316). This was greater than the long-term average of 186 fishes, but less than the highest number observed (i.e., >3,500 in 2011; Figure 40). At RBDD, two juvenile green sturgeon were also observed in the fall of 2014, but no additional fish have been recorded as of March 12, 2015 (Bill Poytress, USFWS, pers. comm.). At GCID, ten juvenile green sturgeon (TL= 110-285) were observed from September through October 2014 and no additional fish have been recorded as of March 9, 2015. Based on Israel and Klimley (2009), BY 2014 juvenile green sturgeon have likely migrated downstream from their natal spawning areas and are overwintering in the Lower Sacramento River and Delta.

Green sturgeon observations are extremely rare in the Delta, primarily related to the use of monitoring gear types that are not designed to sample the benthic habitats where green sturgeon

are most likely to be found if they are present. Although the lower Sacramento and Delta fish monitoring surveys do not target benthic environments, they have captured juvenile green sturgeon in the past, but none have been observed in these surveys in recent years including during 2011 when high numbers were observed migrating downstream past RBDD. One dead green sturgeon (FL= 670mm) was removed from the SWP Fish Facility on February 9, 2015. In 2011, over a thousand juvenile green sturgeons were enumerated at RBDD and none were observed in Delta or Bay fish monitoring. While this absence in the monitoring may suggest no impact from Delta Cross Channel operations or outflow operations, it may also suggest the recruitment of juveniles may be limited before the species reaches one year old due to habitat, predation, or multiple stressors; which is a phenomenon that has been observed in order to reduce this uncertainty.



Figure 40. Larval Green sturgeon counted at Red Bluff Diversion Dam rotary screw traps<sup>15</sup>

#### Effects of Project Description on Green sturgeon

The predicted distribution of Green Sturgeon during the Project Description and a summary of potential effects are presented in Table 17, followed by more details per action type and location.

#### **Sacramento River Outflow**

The Project Description's reduction in upper Sacramento River CVP reservoir releases to meet modified spring and summer NDOI and Wilkin Slough standards may affect spawning green sturgeon. Although little is known about spawning habitat, these habitats do not seem limited. Adult green sturgeon spawn in specific locations presumably based on turbulent velocities, cold water temperatures, coarse substrate, presence of conspecifics, and large riverbank expansion bars likely to provide nursery habitats for larval and juveniles. The Project Description's

<sup>&</sup>lt;sup>15</sup> The annual average catch is 426 fish. In 2011, an egg was observed directly upstream of the rotary traps; thus, the large number of fish in 2011 represents a unique sampling of a spawning event (Josh Gruber, USFWS, pers comm.). If 2011 data is removed, the annual average of juvenile green sturgeon counted is 183 fishes.

reservoir release operation, described in the 90% Forecast, is unlikely to influence habitat characteristics for larval or juvenile green sturgeon. There is low certainty in our understanding of how hydrodynamics is affected in these regions by the Project Description and suitable

Green sturgeon Life Stage	Life Stage Present	Tributary Habitat Effect	South/ Central Delta Entrainment Effect	Facility Loss Effect
Egg	This life stage	e will be presen	t in the Sacramento	o River in April-June.

habitats for rearing and spawning.

 Table 17. Presence of Green Sturgeon During the Project Description Period and Exposure to Potential Effects

Sacramento	Yes	No Change	N/A	N/A					
Juvenile	This life stage will be present in the Sacramento River and Delta April- September.								
Sacramento R	Yes	No Change	N/A	N/A					
Delta	Yes	N/A	No Change	No Change					
Subadults	This life	e stage may be pre	sent in the Delta A	April- September.					
Delta	Limited	N/A	No Change	No Change					
Adults	This life stag	e will be present i S	n the Sacramento September.	River and Delta April-					
River	Yes	No Change	N/A	N/A					
Delta	Yes	N/A	No Change	No Change					

#### Net Delta Outflow Index and Water Quality Modifications

Juveniles and sub-adult green sturgeon rearing and utilizing the Delta are not expected to be affected by the Project Description's modifications to NDOI and Delta water quality standard from April through September. Over the course of juvenile green sturgeon rearing in the Delta (1 to 3 years), the fish are exposed to a wide variety of flows, depending on where they happen to be at a particular moment. In most of the Delta where green sturgeon are expected to be rearing, flows are tidally dominated. The 90% Operational Forecast characterizes Delta flow conditions in the Central Delta (OMR flows); North Delta (NDOI flows); and South Delta (exports) where tidal conditions occur. There is low certainty in our understanding of the juvenile and sub-adult green sturgeon biological processes affected by flow in the Delta. Delta conditions in the Project Description scenario are similar to the Baseline scenario during April and May, and the 90% without a modeled 90% Forecast of the Baseline summer hydrology, it is difficult to determine the summertime impacts of the actions in the Project Description. The minimal exports during the summertime between June and September may be assumed to be less than any other hydrology, which would cause more negative summertime flows in the South and Central Delta regions due to pumping greater than the minimum health and safety diversion. This suggests the actions in the Project Description would cause a reduced risk to entrainment into these regions and the CVP/SWP fish collection facilities. There is moderate certainty in our understanding of how hydrodynamics is affected in the Delta by the Project Description and suitable habitats for foraging juvenile and sub-adult green sturgeon.

Adult green sturgeon will be potentially present in the Delta throughout the Project Description as they migrate into and out of the Sacramento River and possibly forage in the Delta during the summer. The reductions in outflow through multiple distributaries in the North Delta in the Project Description may increase straying and travel time of green sturgeon in this region during April through September. During these months, a substantial portion of adult green sturgeon will

migrate through the North Delta. Foraging green sturgeon utilize Sacramento and interior migratory routes through the Delta, and also Steamboat slough during the summer. Since these areas are normatively used by green sturgeon, the impact of increased travel time is unlikely to negatively impact adult green sturgeon.

#### **Delta Cross Channel**

The Project Description's Modification of the DCC gate operations will have a similar, but lesser, potential effect on green sturgeon, as it potentially has on salmonids in the North Delta compared to the Baseline scenario. To review, opening the DCC gates provides an alternate outmigration route through the Central Delta for juvenile, subadult, and adult green sturgeon that may pass this location during April through September. The possible effect is less since green sturgeon utilize Sacramento and interior migratory routes through the Delta, and also Sutter and Steamboat sloughs often foraging and spend summer in the Western, Interior and Central Delta regardless of the DCC gates being open. Modeling of the Baseline and Project Description scenarios show South and Central Delta condition in May to be similar with no change in this regions' proportion positive daily flow, but some negative and positive impacts on average daily flows and velocities through these regions. Thus, while the likelihood of entrainment into the Central Delta during April and May may increase, these routes are not clearly less suitable or expose green sturgeon to greater risks at the minimum level of diversions described in the Project Description. The effect of entrainment into the Central Delta is unknown since it is hypothesized that hydrodynamic and habitat characteristics in this region are similar to those in the North Delta under the Project Description's hydrodynamic scenario.

### Summary of Effects on Green sturgeon

Cumulatively, the Project Description's modifications in flow and water quality criteria should not reduce riverine or through-Delta survival of juvenile green sturgeon. The Project Description's changes in Sacramento River outflow during April and May can possibly delay juvenile, sub-adult, and adult green sturgeon migration. Modification to D-1641 Municipal and Industrial and Agricultural water quality standards in the Delta from April to September will not likely affect green sturgeon.

### **Status of Central Valley Steelhead**

#### **Sacramento River**

Adult steelhead abundance is not estimated in the mainstem of the Sacramento River or any other waterways of the Central Valley. Much of the spawning is believed to occur in the tributaries of the Central Valley rather than in the mainstem rivers. Observed levels of catches of juvenile outmigrating *O. mykiss* at Red Bluff Diversion Dam have been low in 2014-2015 in comparison with recent past years. Peaks in juvenile downstream passage generally occur in the August/September time period; however, there was no peak emigration observed this past year. Fish emigrating during the peaks are primarily YOY *O. mykiss*. For a representation of smolt production from the upstream river and tributaries, the data need to be segregated by size. Larger fish pass mostly later in the fall and winter after the peaks in passage shown in Figure 41. A slight peak occurred in March of 2014. This peak was not present in the earlier years and may indicate a smolt emigration during one of the few significant rain events in 2014.

For WY2015 (as of March 9, 2015), 10 unmarked (two on 10/15/2014; five from 1/7/2015 and 1/27/2015; and three from 3/3/15-3/5/15) and 1,109 marked steelhead (from 1/7/2015 to 2/21/2015) were captured at the GCID RST. Marked fish likely originated from a Coleman Hatchery release of 688,000 brood year 2014 steelhead (100% marked with adipose clip only) in the Sacramento River at Bend Bridge (fish released in two groups: 144,700 on January 2, 2015, and 543,300 on January 5-9, 2015). For WY2015 (as of 3/8/15), three unmarked (two captured from 1/5/2015 and 1/8/2015, and one on 12/22/2014) and 33 marked steelhead (one on 11/8/14, 32 from 1/12/15-2/13/15) were observed at the Tisdale Weir RST; and five unmarked (2/10/15-2/14/15) and 117 clipped (2/8/15-2/19/15) steelhead were captured at Knights Landing RST. A low to moderate level of salvage of natural- and hatchery-origin, respectively, juvenile steelhead has occurred this winter, with a cumulative loss of 95 natural-origin and 1,754 hatchery-origin juvenile steelhead as of March 15, 2015.



Figure 41. Weekly Estimated Passage of Juvenile Rainbow/steelhead trout at Red Bluff Diversion Dam (RK391) by Brood Year. Fish were Sampled Using Rotary-screw Traps for the Period January 1, 2009 to March 2015

#### **Clear Creek**

As of March 12, 2015, steelhead spawning surveys are underway on Clear Creek. Surveys are carried out from early December through the end of March. The preliminary steelhead redd index count for 2015 is 188 redds. Table 18 shows the redd index results through 2014. The redd index values include some mix of resident and anadromous *O. mykiss*.

The rotary screw traps on Clear Creek capture primarily YOY *O. mykiss* (not displayed here). Steelhead emigrating from Clear Creek are further monitored as they pass Red Bluff Diversion Dam in combination with other upper Sacramento River tributaries.
Year	Redd index
2003	78
2004	151
2005	144
2006	43
2007	165
2008	148
2009	409
2010	233
2011	218
2012	178
2013	239 <sup>a</sup>
2014	313 <sup>a</sup>

#### Table 18. Clear Creek Steelhead Redd Index 2003–2014

<sup>a</sup> In survey years 2013 and 2014, an additional survey reach was added at the downstream end of the study area. An additional 40 steelhead redds were counted in 2013, and 93 redds were counted in 2014 in this reach. USFWS is in the process of determining how to include these redds in the annual index for comparison to other years.

#### **American River**

Steelhead spawning in the American River occurs from late December to about late March or early April. Reclamation conducts bi-weekly steelhead spawning surveys throughout the spawning period. The American River in-river steelhead population consists primarily of hatchery-produced fish that spawn in the river, and the steelhead return is dominated by fish that return to the hatchery or are harvested prior to spawning in the river (Figure 42). Seining surveys conducted by CDFW throughout the summer and fall have shown that summer rearing distribution for steelhead essentially mirrors the spawning distribution. Mark and recapture of rearing steelhead has shown strong natal site fidelity. Although few recaptures of marked fish occur, the recaptures that do occur all happen within close proximity to the marking site (i.e., at the same riffle or the next riffle upstream or downstream). No thermal refugia have ever been found in the lower American River. The coolest water is essentially in the faster flowing sections of the river and the steelhead rear and feed primarily in the faster water areas (riffles predominantly) of the river through the summer.



Figure 42. American River Steelhead Spawner Population Estimates Compared to Nimbus Hatchery Steelhead Return (updated from Hannon 2013). The Red Bars are Area Under the Curve Population Estimates (based on observations of adults holding on redds) and the Error Bars are the Redd Count Based Estimates. No 'Area Under the Curve' Based Estimates are Available for 2009, 2010, and 2014

Steelhead spawning surveys have identified few steelhead redds in the American River in 2015 from January through March 6 and hatchery returns have been near the lowest since the 1950s. The hatchery return for 2015 is 146 steelhead as of March 10 and only 46 of those were females. Nimbus flow releases have been 800–900 cfs throughout the spawning period, less than half the median flow of 2,000-3,000 cfs typically released during this time period. The majority of spawning is now complete based on the timing of spawning from past surveys (Hannon 2013). Figure 43 shows a comparison of spawning timing between the years surveys occurred. The 2015 spawning data are still draft but escapement appears to be very low. Coleman National Fish Hatchery steelhead eggs have been transferred to Nimbus Hatchery during January and February 2015 as part of a study evaluating replacing the Nimbus Hatchery steelhead broodstock with a broodstock that would be considered a part of the Central Valley steelhead distinct population segment. The low steelhead return has provided an opportunity to test an aspect of the broodstock replacement with Central Valley steelhead from Battle Creek/Coleman Hatchery. The goal of this egg transfer is to produce 150,000 steelhead smolts and evaluate their performance in the hatchery environment and in the American River following release from the hatchery.

The hatchery-produced steelhead in 2014 were all released into the river in May 2014 as YOY fish because water temperatures that supplied the hatchery raceways were anticipated to become lethal for fish reared in the hatchery over the summer.



Figure 43. American River Steelhead Redd Observation Timing, 2002 - 2014

#### **Stanislaus River**

A weir on the Stanislaus River near Riverbank identifies *O. mykiss* passage using a VAKI camera. Two *O. mykiss* (> 16") and one *O. mykiss* (<16") were counted at the weir from October 2014 to December 15, 2014. Data after that have been unavailable.

Bergman et al. (2014) estimated a population of *O. mykiss* in an approximately 300 meter reach of the river immediately below Goodwin Dam to be 3,427 (SE =1,522) (95% CI = 1,492-7,873) using mark and recapture of trout identified using spot pattern recognition. This reach probably represents the highest density of trout in the river (based on snorkel survey observations) but indicates a much greater resident than anadromous component to the population. The stable cool water conditions in this tail-water area should allow at least the resident component of the population to persist through most drought conditions.

Steelhead spawn timing in the Stanislaus River is likely similar to other CVP rivers. Formal spawning surveys have not been conducted, but a trial survey was conducted by Reclamation and CDFW in February 2014 between Knights Ferry and Horseshoe Bar and near Goodwin Dam. Ten redds were found in the Knights Ferry reach and two were found in Goodwin Canyon at the cable crossing area. The redds are likely a mixture of resident and potentially anadromous *O. mykiss*. One of the redds was occupied by spawners with estimated lengths of 25 cm (10 inches) and 35 cm (14 inches). The California regulatory cutoff between steelhead and rainbow trout is 40 cm (16 inches) for anglers. The absence of abundant spawning near Goodwin Dam during this survey probably indicates mostly resident (later spawning) fish in that area.

Snorkel surveys conducted in 2003–2005 identified the first steelhead fry observations around mid-March to early April each year. Fry were observed between Goodwin Dam and Orange Blossom Bridge with observations in one year down to Valley Oak near the City of Oakdale.

None were observed below Valley Oak. This indicates that spawning was limited to the area mostly upstream of Orange Blossom Bridge. Higher rearing densities were always found from Goodwin Dam down to the Lover's Leap area. This likely coincides with the area of most spawning for both resident trout and steelhead. A majority of outmigrating steelhead smolts leave the Stanislaus River during the late winter and early spring. Based on recoveries of steelhead in the Caswell and Oakdale rotary screw traps, 50% of steelhead have emigrated by March 4 and 76% smolts have exited the Stanislaus River by the end of March (Figures 44-45).



Figure 44. Stanislaus River Steelhead Outmigration Timing from Caswell Park and Oakdale Screw Traps, 1998-3/6/2015 (includes only fish rated as smolt index 5). Fish Leaving in December Constitute 1.3% of Migrants and Are Not Shown



Figure 45. Stanislaus River Steelhead Outmigration Timing and Size from Oakdale and Caswell Rotary Screw Traps

Delta

Information on steelhead in the Delta is extremely limited. Steelhead smolts are seldom recovered in Sacramento River and Delta fish monitoring efforts due to sampling biases related to their large size and swimming ability. False negatives (*i.e.*, zero catches when the target species is present) are more likely with steelhead smolts than smaller older juvenile Chinook Salmon, but historic data can be assessed to consider their typical periodicity in Delta monitoring efforts. From 1998 to 2011, temporal observations of wild steelhead juveniles (n=2,137) collected in Delta monitoring efforts occurred less than 10% of the time in January, >30% of the time during February, and >20% of the time during March.

The temporal occurrence of Central Valley steelhead near and within the Delta is informed by recovery of natural steelhead in various monitoring surveys (Table 19). For WY2015 (as of March 9, 2015), 36 adipose-clipped steelhead and no unmarked steelhead have been recovered in various beach seine and trawling efforts in the Delta and Lower San Joaquin River. Of these, one marked steelhead was observed in the Chipps Island mid-water trawl (228 mm clipped fish on 3/2/15) and three marked steelhead were observed (one each) at Sacramento beach seine monitoring locations: Miller Park (300 mm acoustic tagged fish on 12/8/14); Sherwood Harbor (178 mm clipped fish on 2/17/15); and Verona (203 mm clipped fish on 2/17/15). Additionally, marked steelhead were observed at three Kodiak trawling locations including: Jersey Point (four clipped fish from 2/28/15-2/20/15), Prisoner's Point (fourteen clipped fish from 2/12/15-3/3/15), and Sherwood Harbor (fourteen clipped fish; one on 1/23/15 and thirteen from 2/9/15-2/20/15). No outmigrating steelhead have been observed in the Mossdale trawl yet; however, Figure 46 indicates that most steelhead are recorded at this location during April and May. Adipose clipped steelhead from Coleman National Fish Hatchery and Feather River Hatchery, are considered ESA listed Central Valley steelhead. No steelhead have been released from Nimbus Fish Hatchery to date in 2015. These fish were released in-river in May 2014 and marked with a secondary mark of a clipped pelvic fin. Fish monitoring at Mossdale on the lower San Joaquin River also encounter steelhead entering the Delta, and based on these information it is likely steelhead may still be migrating into the Delta from the San Joaquin in April and early May (Figure 46).

An expanded salvage of 22 natural origin and 450 adipose-clipped steelhead have been estimated at the state and federal fish collection facilities at the South Delta CVP/SWP export pumps. Of these, all 22 natural origin and 382 adipose-clipped fish were salvaged at the SWP and no natural origin and 68 adipose-clipped fish were salvaged at the CVP fish collection facilities. Most steelhead have been salvaged during the past month. The high ratio of clipped to unclipped steelhead (17:1) likely indicates a low abundance of naturally-produced steelhead compared to the number of hatchery steelhead.

Table 19. Percentage of Juvenile Sacramento River Steelhead Entering the Delta, as Recovered at Various Monitoring Locations by Month. Data from the DJFMP and Chipp Island Trawl Data are from the 1976-2011 dataset

Month	DJFMP Beach Seines	Chipps Island
January	25	5
February	20	10
March	30	15
April	5	30
May	10	35
June	0	5
July	>5	0
August	0	0
September	0	0
October	0	0
November	0	0
December	<5	0





### Effects of Project Description on Central Valley Steelhead

The predicted distribution of steelhead during the Project Description and a summary of potential effects is presented in Table 20, followed by more details per action type and location.

			South/Central Delta	
Steelhead Life Stage	Life Stage Present	Tributary Habitat Effect	Entrainment Effect	Facility Loss Effect
Egg	This life stage w	ill be present in the Sa through	acramento River and n May	d tributaries April
Sacramento R and tributaries	Yes	Yes	No	N/A
San Joaquin R and Stanislaus R	Yes	Yes	No	N/A
Juvenile	This life stage v	vill be present in the S and Delta during Apri	acramento River, S l through Septembe	an Joaquin River er
Sacramento R and tributaries	Yes	Potentially reduced survival	N/A	N/A
San Joaquin R and Stanislaus R	Yes	Potentially reduced survival	N/A	N/A
Delta (Sac River side)	Yes	N/A	Increased	Uncertain
Delta (SJR side)	Yes	N/A	Increased	Increased
Adults	This life stage wi De	ll be present in the Sa elta during April-May	cramento and San J and August-Septen	oaquin Rivers and
Sacramento R and tributaries	Yes	No Change	No Change	No Change
San Joaquin R and Stanislaus R	Yes	No Change	No Change	No Change
Delta	Yes	No Change	No Change	No Change

# Table 20. Presence of Steelhead During the Project Description Period and Potential Effects

#### **Sacramento River Actions**

Monthly average flows in the Sacramento River are forecast to be at the 3,250 cfs base flow in March and then increase to a high of a monthly average of 9,594 in July and then back down to

5,000 cfs in September. Rearing habitat limitations for steelhead have not been identified at the base flow. Water temperature management for Winter-run Chinook provides suitable conditions for the steelhead lifecycle throughout the year in habitat below Keswick Dam. During these drought conditions, the length of the suitable steelhead rearing habitat will be lower but rearing habitat availability is not expected to appreciably reduce the steelhead population in the mainstem Sacramento River. The end of the juvenile emigration period occurs during March through May. The base flows in the Sacramento River may potentially result in lower emigration survival than what would occur in wetter years. This effect of reduced emigration survival for steelhead originating from the Sacramento River basin is unquantified and is attributed to the persistent drought conditions continuing in WY 2015.

Water temperature conditions in the September time period for upstream migrating adult steelhead will be stressful and could result in delay of upstream migration through the lower Sacramento River until natural cooling with shorter day length occurs.

#### Net Delta Outflow Index and Water Quality Modifications

Similar to effects in the mainstem Sacramento River, the proposed lower outflow under drought conditions may result in lower survival of steelhead smolts emigrating to the ocean in the March through May period. This effect is unquantified and is attributed to the drought conditions necessitating modification of D-1641 Delta fish and environmental flow conditions. There is a high degree of uncertainty in this conclusion because this effect occurs largely in tidal areas so could be very slight.

#### **Delta Cross Channel Gates**

Under the Project Description, modified Delta Cross Channel Gates operations may occur based on water quality and fish presence. At this time, it is believed that an open DCC Gate has a low potential for entraining a substantial proportion of the juvenile Sacramento River steelhead. The remaining fraction of the natural and hatchery steelhead population that may still occur above the DCC location will be vulnerable to entrainment into an open DCC gate configuration as they emigrate downriver past the DCC gate location. Similar to Spring run Chinook Salmon, the Project Description's modification of the DCC gate operations will affect steelhead in the North Delta compared to the Baseline scenario, but only for a short time. It is uncertain whether the increase in the likelihood of entrainment into the Interior Delta will result in any change to facility loss of steelhead, both because the duration of the effect is expected to be short and because the limited exports in the Project Description scenarios may not result in greater entrainment into the South Delta and facility loss (see discussion in "Exports" section).

If the DCC gates were open Sacramento River water will flow through the DCC and into the Mokelumne River system. This may result in some level of straying of upstream migrating adult Winter-run Chinook Salmon into the Mokelumne River system. It is expected that this may delay these adults on their upstream spawning migration. Adult Winter-run Chinook Salmon which have entered the Mokelumne River system should be able to re-enter the Sacramento mainstem through the open DCC gates and continue their upstream movements. A delay in reaching the spawning grounds and an increase in energy expenditure may result. This could result in lower survival of juveniles produced from straying individuals, if temperatures in the upper river become unsuitable for egg and fry survival.

#### **Clear Creek Actions**

Flows on Clear Creek are forecast to range between 175 cfs and 85 cfs over the summer with the exception of springtime pulse as prescribed in the RPA to attract spring Chinook into the river. Steelhead rearing over the summer occurs in the upper reaches of Clear Creek with the downstream extent of suitable juvenile rearing habitat determined by water temperature. The extreme drought conditions will likely result in below average Trinity River diversions and thus a compressed length of the river suitable for oversummer rearing steelhead. Temperatures in the upper reaches of the stream are estimated to be suitable for rearing for the juvenile steelhead produced by the close to average number of adult spawners. A lower than average number of juvenile emigrants in 2016 per adult spawner could be expected to occur with the below normal habitat availability under the extreme drought conditions.

The temperature management for Clear Creek will be coordinated through the Sacramento River Temperature Task Group under the SWRCB 90-5 requirements and as outlined in RPA Action I.1.5. The temperature criteria are based on the Spring-run Chinook requirements and are expected to be protective of steelhead rearing through the summer. If these criteria are not met, juvenile steelhead habitat will be further restricted, predation by nonnatives may reduce survival, and disease may become more prevalent. The amount of uncertainty regarding Clear Creek effects is moderate.

#### **American River Actions**

Monthly flows in the American River are forecast to be held at 500 cfs through March and April. The lower than normal flows may enable cold water releases from Folsom to be maintained as long as possible through the summer. This will also result in a higher than normal rate of heating as water moves downstream. Flows will increase starting in May up to a peak of 3,035 cfs monthly average flows in July and then drop down to around 700 cfs in September. Reclamation will submit a draft temperature management plan to NMFS by May 1 per RPA Action II.2.

Considering the low steelhead escapement in the American River in 2015 it is hypothesized that water temperatures will be the limiting factor to the survival rate for rearing steelhead in 2015. Density dependence should not be a factor. Physical habitat and food should be less limiting than temperatures at the expected low rearing densities. However, if the Nimbus Hatchery steelhead are released in the spring or summer, as occurred in 2014, then density dependence would come into play under the low flow conditions.

American River at Hazel Avenue water temperatures were used to estimate steelhead emergence timing based on spawning timing (Figure 47). Temperatures after March 18 were estimated based on the near term weather forecast and additional warming expected to occur through April and May. The spawning timing for 2015 based on the bi-weekly spawning surveys is shown in Table 21. The emergence timing estimate used 600 accumulated temperature units to emergence (degrees C). Hazel Avenue temperatures reflect the coolest temperatures in the American River, thus emergence will be slightly earlier further downstream as water temperatures increase downstream up to a limit. The difference will be around a three to four day earlier emergence at Watt Avenue for the later season redds. High mortality is likely at over 59 F. Estimated

emergence of fry from current year spawners should be completed by around May 4 (Table 18). Note that redds were included on March 28 based on timing in past surveys. This March 28 survey has not occurred as of this writing so this is a guess. In addition the redd survey data are still draft and subject to change.



December 2014 – March 19, 2015

Tabla	21	Amoricon	Divor	staalbaad	fry	omorgonco	from	tha	arovol	timino	r in	201	5
I able	<b>41.</b> I	American	River	steemeau	IIY	emergence	ITOIII	une	graver	ummy	; III	201	5

Survey	Redds SH and	600 ATU emergence	Cumulative
Date	unknown	Date	% emerged
1/9/2015	0	3/5/2015	0%
1/23/2015	35	3/17/2015	43%
2/5/2015	35	3/27/2015	85%
2/20/2015	6	4/7/2015	93%
3/6/2015	4	4/15/2015	98%
3/28/2015 <sup>1</sup>	2	5/4/2015	100%

<sup>1</sup> The March 28 survey has not occurred so spawning on this date is a guess based on past experience.

Based on the current preliminary spawning survey results at a fecundity of 5,732 eggs/ female (based on recent past hatchery data and size of fish observed on redds in 2015) and 1.5 redds per female about 313,000 eggs would be produced by the observed redds. A 25% egg to fry survival (lower survival than typically assumed due to currently warmer water that will reach levels that will likely reduce egg to fry survival for later spawners this year) would produce about 78,250 emergent fry. Eggs from the later spawning fish may not survive to emergence. CDFW is planning to conduct juvenile steelhead monitoring during the summer. Surveys would be conducted in close proximity to spawning areas and within restoration reaches and would enable an assessment of survival in the expected stressful water temperatures over the summer.

The steelhead smolts leaving the American River in spring of 2015are expected to complete emigration by around the end of April when temperatures under these drought conditions are expected to be affecting survival for fish leaving the river later. These fish are the progeny of steelhead that spawning in 2014 when water temperatures through the summer were stressful for rearing steelhead. These fish may have suffered mortality or left early. Estimates of fry to smolt survival for naturally spawned steelhead have ranged from 4% to 11% for brood years 2002 to 2010 (Table 22). The survival rate is likely to be lower under the drought conditions.

 Table 22. Estimates of American River wild smolt production and hatchery smolt survival based on adult hatchery counts, spawner surveys and hatchery yearling releases (updated from Hannon 2013)

	2013)													
Adult Spawning Year	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000
Year smolts released or outmigrated	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Hatchery smolts released in Jan/Feb.														
of above year	426,920	439,490	250,440	422,380	394,292	454,570	410,330	455,140	419,160	281,705	467,023	402,300	400,060	385,887
In-river spawning adults	437	389	172	121	155		504		266	330	343	300		
Total Hatchery Produced Adult Return <sup>1</sup>	4,449	3,124	2,318	1,905	1,885	853	3,613	2,660	3,472	2,425	1,386	1,745	3,392	2,057
Unclipped Adults in hatchery	57	41	34	34	58	47	116		118	17	27	69	50	
Percent return of hatchery fish														
(clipped adult return divided by smolts														
released two years prior)	1.04%	0.71%	0.93%	0.45%	0.48%	0.19%	0.88%	0.58%	0.83%	0.86%	0.30%	0.43%	0.85%	0.53%
Wild smolts that outmigrated (two														
years prior) <sup>2</sup>	9,664	11,241	5,531	10,222	15,374	25,041	18,900		17,457	5,808	20,661	22,827	5,896	
Estimate of fry produced based on														
redd surveys <sup>3</sup>	825,864	182,125	181,323	175,564	246,592		272,340		230,640	402,931	447,057	325,897		
Fry to smolt survival estimated	ln 2016	ln 2015	ln 2014	6%	5%	No Estir	4%	No Estir	11%	5%	No Estir	5%		
1 assumes 20% recreational harvest based on ang	ler surveys	in 1999 and	2001 exce	pt 2009 and	2010 use a	actual cree	l survey es	stimates						
<sup>2</sup> assumes same smolt to adult survival of wild smo	olts as for ha	atchery rele	ased smolts	and that 1	0% of in-riv	er spaw ne	ers are natu	urally produ	uced fish					
<sup>3</sup> no adjustments made for potential missed redds														

Conditions in the American River have met the criteria for a conference year under the flow management standard in compliance with the RPA. Therefore, operations will be adaptively managed in partnership with the fishery agencies and the Water Forum to best meet needs under the extreme drought conditions. There is a moderate level of uncertainty in the conclusions about American River steelhead.

#### **Stanislaus River Actions**

Stanislaus River flows under Appendix 2E of the 2009 BO are being coordinated with the Stanislaus Operations Group to provide the best conditions as feasible under the current drought situation. Mean monthly flows are projected to be around 460 cfs and 380 cfs in April and May respectively and then drop to a baseflow of 150 cfs through September. The Ripon dissolved oxygen standard of 7.0 ppm, described in SWRCB D-1422, is modified in the Project Description by moving the compliance location upstream to Orange Blossom Bridge over the project period. Given the O. mykiss population in the Stanislaus which has been sustained under flows of 150 cfs in past years it is hypothesized that the limiting factor to oversummer survival in 2015 will be water temperatures under the extreme drought conditions affecting conditions in the Stanislaus watershed. Summer operations on the Stanislaus may not be able to meet the temperature compliance schedule described in NMFS RPA Action III.1.2. The RPA will be followed regarding notification and Stanislaus Operations Group (SOG) advice. Under the expected flows and temperatures the oversummer steelhead rearing habitat will confined to the area upstream of Orange Blossom Bridge. The relaxation of the dissolved oxygen standard from Ripon to 7.0 at Orange Blossom Bridge could result in dissolved oxygen levels reaching lethal levels for fish at times in the Ripon area. A DO of 7.0 is considered protective of salmonids.

Steelhead rearing habitat will be reduced due to temperatures and may be marginal at Orange Blossom Bridge. A dissolved oxygen level of 7.0 and greater at Orange Blossom would be protective of steelhead over the summer in the area between Orange Blossom and Goodwin as DO will be higher on average further upstream.

We expect that spawning of steelhead will be complete by the end of March based on observations in other watersheds. At a temperature of  $56^{\circ}F(13.3^{\circ}C)$  emergence of steelhead fry should be completed by May 15. If water temperature becomes greater than a mean daily temperature of  $56^{\circ}F$  in the redd locations, then emergence would be completed sooner, up to a limit. Mean daily water temperatures greater than  $59^{\circ}F(15^{\circ}C)$  could result in very low egg to fry survival if they occur during the incubation period. Recent water temperatures near Goodwin Dam are shown in Figure 48. Resident trout often spawn later than steelhead, so it is likely that the fry from resident fish will continue to emerge past the May 15 date. It is hypothesized that some coldwater refugia should be present, particularly in the deep pools at and upstream of Knights Ferry so that *O. mykiss* populations will persist and the resident population will continue to maintain spawner abundance and juvenile productivity of *O. mykiss* on the Stanislaus River.



Figure 48. Stanislaus River below Goodwin Dam at the cable crossing water temperature, 12/1/2014 - 3/19/2015

Rotary screw traps in the Stanislaus at Caswell provide information on size and timing of steelhead emigrating from the Stanislaus. During late 2013 through March 6, 2015, no steelhead have been captured at Caswell. Trap calibrations are not conducted for *O.mykiss* but since capture rate is size-dependent for Chinook, larger steelhead are likely much less susceptible to capture than Chinook (Joe Merz, Cramer Fish Science, pers comm). Therefore zero steelhead captured does not represent an absence of emigration from the Stanislaus. The median date of steelhead exit from the Stanislaus based on screw trap data was March 4 for the period from 1997 to 2015.

A pulse flow as specified in the NMFS RPA (2011 amendment), based on SOG advice and NMFS determination, will be scheduled to occur sometime during the late March to April time period to provide migratory cues and flows for the last of the emigrating juvenile steelhead before downstream temperatures become inhospitable. The timing is being coordinated at the SOG. Dissolved oxygen concentration varies with temperature and the warming water temperatures in the spring may also result in stressful DO levels in the lower Stanislaus River in April and May.

The low quality habitat along routes to the ocean likely results in low emigration survival, especially in extreme drought conditions such as this and is likely a large contributor to why the steelhead component of the *O. mykiss* population in the San Joaquin basin is small. It is hypothesized that steelhead escapement in two years will be lower than during previous wetter years due to lower steelhead survival through the lower San Joaquin River between Durham Ferry (near the confluence of the Stanislaus River) and Lathrop than during previous wetter years as well as along the rest of the various routes to the ocean.

Adult steelhead upstream migration generally occurs in October and later in the Stanislaus River. A few may occasionally enter the river in September but this year conditions will likely be unsuitable in the lower San Joaquin and Stanislaus in September (low flows, high temperatures, stressful dissolved oxygen levels) so any steelhead that attempt to migrate early will likely be delayed.

There is a moderate level of uncertainty in conclusions regarding Stanislaus River steelhead.

#### **Delta Exports**

Delta exports are forecast to be at a low level due to the drought conditions. The low export levels are not expected to appreciably affect survival of steelhead emigrating through the delta from the Sacramento River. This emigration should be completed by early May when water temperature is likely to be warm for emigrating steelhead. Steelhead emigrating from the San Joaquin River prior to the HORB being in place are more likely to be salvaged at the CVP facility and be trucked downstream of the Delta. Under these extreme low flow conditions the steelhead that experience this route through the fish salvage facilities are hypothesized to have a better chance of survival to the ocean than those that continue down the mainstem San Joaquin River route. The degree of uncertainty with this conclusion is moderate.

No appreciable effect of the pumping levels on the early part of the adult upstream migration in September is expected to occur.

# San Joaquin River I:E ratio and San Joaquin River downstream of Stanislaus River Confluence

The Project Description flows at Vernalis are hypothesized to result in less suitable conditions for steelhead emigration than would otherwise occur in the Baseline modeling. These conditions reduce survival of outmigrating San Joaquin basin steelhead downstream of the Stanislaus River confluence until tidal conditions dominate the South Delta. San Joaquin River flow limits are being reduced during the Vernalis pulse flow period and then will be no less than 300 cfs after the pulse until the end of May. Summer Vernalis flows would be no less than 200 cfs monthly

average. Water temperatures are likely to be unsuitable for steelhead emigration by early May due to the drought conditions. These conditions in the San Joaquin following the pulse period are expected to be lethal to steelhead so that later emigrants are not likely to survive.

The Vernalis salinity standard is modified in the Project Description. Additional flows from the Stanislaus River and San Joaquin River tributaries would be required to meet the existing standard. The change in salinity in the San Joaquin River would not affect steelhead as they would not be present in the summer. The result of the low flows over the summer in the Stanislaus, which are enabled to occur with the salinity relaxation, are discussed above in the Stanislaus River section.

If there is a precipitation event outside of the pulse period, then the Project Description modifies RPA Action IV.2.1 to allow pumping to capture abandoned or natural flows in the Delta up to the OMR limits. If precipitation occurs then that would be the same period that steelhead would likely to emigrate. Pumping will occur preferentially at the Jones Pumping Plant if condition permit, which should increase salvage rates and reduce loss, due to lower pre-screen mortality at the Tracy Fish Collection Facility. In a future year, Reclamation and DWR would make available an amount of water equal to half the volume of any increased exports realized over the April – May period for the fishery agencies to shape. This could benefit steelhead in future years but would not benefit fish this year. The degree of uncertainty with this conclusion is moderate.

### **Summary of Effects on Steelhead**

The drought conditions are causing increased stress to steelhead populations, with or without water project operations, in the form of low flows reducing rearing and migratory habitats, above normal water temperatures affecting survival, and likely higher than normal predation on juvenile steelhead. The water management over the last year has focused on maintaining a level of reservoir storage which is generally higher than what would be in place at this time without the planning that has gone into attempting to reduce adverse effects on resources. The Project Description strives to balance spring and summer operations between Shasta and Folsom divisions of the CVP to minimize affects across CVP tributaries in WY 2015. Steelhead survival will be low in 2015 in all tributaries and migratory pathways and is likely to result in a smaller returning year class of steelhead from those juvenile steelhead emigrating this year.

Battle Creek/Coleman Hatchery experienced one of the highest adult steelhead returns that has been measured and eggs from some of those fish are being provided to Nimbus Hatchery on the American River where the steelhead currently do not contribute to the Central Valley steelhead DPS. Although an experiment at this point, if these fish are successful in surviving to emigration next spring then they could contribute to increasing the proportion of Central Valley steelhead returning to the American River in the future and improving genetic diversity for Central Valley steelhead.

### **Status of Delta Smelt**

As California enters a fourth year of drought, abundance of Delta Smelt has continued to decline. The 2014 Fall Midwater Trawl (FMWT) annual index for Delta Smelt was 9, which is the lowest reported fall index since the beginning of this survey in 1967, and approximately one half of the previous lowest index values of 17 (2009) and 18 (2013). These results and a detailed account of the spatial distribution of the adult population based on survey data at that time were described in the Biological Review of the Feb-Mar 2015 TUCP (Reclamation, 2015c). The third Spring Kodiak Trawl (SKT) survey for March 9 – 12, 2015 (Figure 49) yielded six adult Delta Smelt, a record low number for March (Figure 50) and a number that has only occurred over the period of record at this level once before in May surveys, when catches typically tail off because of postspawn mortality. These winter survey results provide additional evidence that the Delta Smelt population is likely at an all-time low. The recent catch data also indicate most adult Delta Smelt may be in the Sacramento River and outside the influence of the export facilities.



Figure 49. March distribution of adult Delta Smelt from Spring Kodiak Trawl #3



Figure 50. The number of Delta Smelt collected in March for Spring Kodiak Trawl surveys from 2002-2015

#### **Drought Impacts**

Research presented at the Interagency Ecological Program (IEP) workshop (March 18-20, 2015) showed that drought impacts Delta Smelt a number of ways. It can reduce the area of low salinity habitat to which they migrate for spawning and thereby reduce food availability for adults and for juveniles moving there to rear. Drought can indirectly impact reproductive potential by lowering the number of oocytes females produce (Hammack, 2015). This is brought about by a link between low outflow and elevated water temperature. Warming temperature shortens the spawning window, which causes fewer clutches to be produced per female (Jeffries, 2015). Both of these mechanisms combine with low adult abundance to impair population fecundity. Lower outflow also tends to reduce turbidity. Delta Smelt use turbid water to avoid predators and they also use it as foraging habitat (Hasenbein, 2015a). Otolith analysis has revealed that Delta Smelt, since 1999, experienced an 8% decline in growth between dry and wet years and spawning is more successful the north Delta during drought (Hobbs, 2015). The quality of their habitat is further compromised by concentrations of herbicides such as Diuron and Hexazinone, which increase with reduced outflow and have synergistic effects that reduce food availability for juveniles (Hasenbein, 2015b). Furthermore, warm, slow moving water characterized by drought promotes conditions in which parasites like Ich (Ichthyophthirius multifiliis;) and cyanobacteria like Microcystis thrive. Ich causes skin lesions to form on a variety of fish and has an increased prevalence among captive Delta Smelt above 17°C (Frank et al., 2015). Mycrocystis is a toxic hepatotoxin that became established throughout the Delta in 2000 and also thrives in water above 17°C with low turbulence (Lehman, 2015). Because of the extended high water temperatures associated with drought, Microcystis blooms extended into December of 2014 (Lehman, 2015). This highly toxic cyanobacteria is known to kill phytoplankton, zooplankton and compromise fish health (Acuña et al., 2012). Finally, the abundance of non-native Delta Smelt predators, such as black bass, increased in the Delta in response to the drought in 2014, mainly because it expanded their preferred habitat (Barnard, 2015). The same pattern was found for non-native

competitors, such as clams like *Corbicula*, which seem to be expanding throughout the Delta despite the drought (Thompson, 2015).

#### Salvage

The estimated cumulative season total for adult Delta Smelt salvage is 68. No salvage has been reported since February 21<sup>st</sup>. The State Water Project (SWP) and Central Valley Project (CVP) initiated larval fish monitoring on March 2<sup>nd</sup> and February 24<sup>th</sup>, respectively. The frequency of larval fish samples at the CVP has been reduced at times due to heavy debris load in the salvage collections. Regardless, no larval Delta Smelt have been reported at either facility to date. However, pre-screen loss of all life stages (e.g., predation) may decouple entrainment at low densities so that fish entrained at low densities are not observed in salvage.

This is further supported by regular presence of adult Delta Smelt at Jersey Point and Prisoners point surveys for most of the winter indicate likely presence of larvae in the central Delta in spring. Daily "early-warning" sampling resumed during the week of February 2<sup>nd</sup> at Jersey and Prisoners Point in anticipation of storm conditions. Weekly sampling resumed the week of March 9<sup>th</sup> and no adult Delta Smelt have been caught at Jersey Point since March 16<sup>th</sup> (when one individual was caught) and no Delta Smelt have been caught at Prisoners Point since February 15<sup>th</sup>.

The 3-station average water temperature threshold of 12°C (Action 3 of the 2008 Biological Opinion (BO)) was first exceeded on February 2<sup>nd</sup> and was reported on March 15<sup>th</sup> to be 17.8°C. This suggests Delta Smelt spawning has occurred early this year. On March 16<sup>th</sup>, the Smelt Working Group (SWG) suggested the most likely reason for steep decline in catch of Delta Smelt in the SKT #3 survey (Figure 2) was fish may not have survived after a first spawn (SWG notes from 3/16/15) or they could have been avoiding the gear (Baxter). This hypothesis is partly supported by poor condition of the few mature fish caught in SKT #3. Hatching will likely continue over the next few weeks, although the peak of the spawning season has likely passed. As water temperatures rise, larvae are beginning to recruit to juvenile size, and a broader distribution in the central Delta may become evident by way of larval field surveys. Intermittent salvage of adult Delta Smelt indicates the likely presence of larvae in the central and southern Delta within the vicinity of the SWP and CVP pumps. Those larval and juvenile Delta Smelt hatching in the central and southern Delta are vulnerable to entrainment; however, exports are currently at minimum levels, resulting in favorable Old and Middle River (OMR) flows (SWGnotes from 3/16/15). A temperature off-ramp occurs when water temperature at Clifton Court Forebay reaches 25°C for three consecutive days (BO). This off-ramp typically occurs in late June or early July, although present unseasonably warm water temperatures may suggest an earlier temperature off-ramp (the calendar-based off-ramp is June 30<sup>th</sup>).

### **Effects of Proposed Action on Delta Smelt**

The following discussion is based on DSM2 particle tracking model (PTM) simulations described earlier. When reviewing this section, it is important to remember that adult Delta Smelt do not behave as neutrally-buoyant particles so a literal translation of results into changes in entrainment or entrainment risk is not advisable. In particular, the model predictions of westward advection are not relevant. It is the changes in central/south Delta hydrodynamics that are of interest because these flow conditions may affect tide-surfing fishes seeking turbid fresh water.

To estimate the effects of the Proposed Action on Delta Smelt, a PTM from April to June was compared to baseline hydrological conditions, assuming an equally distributed population between injection points (Figure 28). Only particles located between Railroad Cut and the pumping facilities experienced flux towards the pumps. Throughout the rest of the Delta, particles either remained in the Delta or eventually moved west regardless of the outflow scenario.

The Baseline scenario represents a constant North Delta Outflow Index (NDOI) of 7100 cfs, while the Project Description scenarios (Hydrology 2 and 2') reduces NDOI to 4000 cfs, and in 2' an open DCC Gates. The Project Description uses the February 90% Operational Forecast for Central Valley hydrologic and operation conditions during the remainder of the Project Description's period. March exceedance forecast is under development and appears to be trending drier than the February 90% exceedance forecast. Reclamation and DWR are petitioning the State Water Board to adopt a Delta outflow standard of a minimum monthly NDOI for April, May and June to be no less than 4000 cfs and for July to be no less than 3000 cfs with a 7 day running average no less than 1000 cfs below the monthly average. Other input values remained constant and reflected the best information available to Department of Water Resources (DWR) modelers when models were run on March 17<sup>th</sup>, but it should be noted that particles were injected on April 1<sup>st</sup> and tracked through May 31<sup>st</sup>. The modeled conditions of the proposed reduction in NDOI resulted in slight overall increase in the final fate of particles at the facilities compared to baseline conditions (Figure 29).



Forecasted Daily EC

Figure 51. Forecasted electrical conductivity (EC) under different hydrologic scenarios from March - June, 2015 at Rio Vista

Similar to the effects review from 2014 (Reclamation, 2014), if such changes would remain through the summer, the 2 ppt isohaline (X2) will shift upstream and, given the general decrease in habitat suitability when the low-salinity zone moves upstream of Suisun Bay, is assumed to result in higher predation rates, and greater exposure to contaminant effects, losses in irrigation diversions, water temperatures stress, etc. (Feyrer et al., 2007). Similar to the effects review from 2014 (Reclamation, 2014c), if such changes would remain through the summer, the 2 ppt isohaline (X2) will shift upstream and, given the general decrease in dynamic habitat with movement upstream of the low-salinity zone, would result in reduced spawning and rearing habitat (Feyrer et al., 2007). Further constraints on habitat for juvenile Delta Smelt towards upstream spawning areas in the lower Sacramento/San Joaquin Rivers and the Cache Slough Complex/Sacramento Deep Water Ship Channel will reduce the quantity of available habitat, but will be within the range of salinity generally occupied by Delta Smelt during the summer and fall. As Sommer and Mejia (2013) noted, Delta Smelt are not confined to a narrow salinity range and occur from fresh water to relatively high salinity, even though the center of distribution is consistently associated with X2 (Sommer et al., 2011). However, Nobriga et al. (2008) found the probability of occurrence of Delta Smelt was highest at low EC (1,000-5,000 µmhos/cm), and declines at higher EC. EC forecasts for Rio Vista and Emmaton (Figures- 51-52) and locations upstream are within this range during the period modeled. Therefore we conclude that while changes in salinity in the lower Sacramento River are within the physiological tolerances of Delta Smelt, the proposed modifications are expected to shift the Delta Smelt population further upstream. There is a relatively high level of uncertainty in these conclusions when compared to Reclamation (2014c) due to a lack of temporally projected data.



Figure 52. Forecasts of electrical conductivity (EC) under different hydrologic scenarios from March – June, 2015 at Emmaton

The upstream shift of Delta Smelt distribution on the Sacramento River will increase the potential for stochastic events to exacerbate mortality and density-dependent effects on the population (Feyrer *et al.*, 2011). As an example, there may be water temperature increases during prolonged heat waves that would pose risks to Delta Smelt. In general, summer temperatures are higher in landward channels (Wagner, 2012), so reduced inflow is expected to shift the distribution of Delta Smelt into these warmer regions. In addition, with the shifting of X2 above the Sacramento-San Joaquin confluence, salinities may be too high downstream for juvenile Delta Smelt to move substantially seaward, where the maritime influence and larger water bodies maintain cooler water temperatures.

In the San Joaquin River, modeling suggests EC at Jersey Point will increase given the proposed action although it is similar to historical EC values (Figure 53). Regardless, it is inferred there would be little physiological effect on Delta Smelt from changes in salinity in the lower San Joaquin River, as ranges are well within the physiological tolerance level for the species (Nobriga *et al.*, 2008). However, the increase in salinity may alter the distribution of Delta Smelt into less favorable areas within the lower San Joaquin (*e.g.*, Franks Tract).



Forecasted Daily EC

Figure 53. Forecasts of electrical conductivity (EC) under different hydrologic scenarios from March – June, 2015 at Jersey Point

#### Hydrodynamic Effects on Entrainment

The proposed modifications will result in lower outflows that may reduce survival of migrating young-of-year Delta smelt that are currently in the Interior Delta. For example, lower flows may expose them to loss at the CVP/SWP export facilities, and increase their travel time and exposure to degraded habitats and predators described above. For Delta Smelt residing in the north Delta, reduced outflow, while limiting available habitat, is not expected to result in additional entrainment. Modeling outputs suggest effects from the actions in the Project Description by reducing outflow are negligible through the end of May (Table 23). There is a low level of uncertainty in this conclusion.

Delta Smelt	Life stage Affected	Change in Risk of Lowered Recruitment	Change in Risk of Entrainment at Facilities	Certainty					
Eggs	Attach	ed to substrate with v	very low risk of entra	inment					
Larvae	Presence has bee Survey #1. Th	en established based o his life stage has not y	on Smelt Larva Survey yet recruited to most	ey #5 and 20 mm sampling gear					
Juvenile	Juvenile Del	ta Smelt (>20mm) ha	we not yet been dete	cted this year					
Adults	Distribution based on February 2015 Spring Kodiak Trawl survey and salvage at SWP/CVP export facilities								
No detections in South Delta	Yes	Not Applicable	Reduced	Moderate					
Present in San Joaquin River	Yes	Not Applicable	Reduced	Moderate					
Present in Sacramento River	No	Not Applicable	Not Affected	Moderate					
Present in Confluence and down	No	Not Applicable	Not Affected	High					

# Table 23. Presence of Delta Smelt During the Project Description Period and Potential Effects, based on the most recently available survey data<sup>16</sup>

#### **Food Availability**

Prey availability is constrained by habitat use, which in turn affects what types of prey are encountered. Larval Delta Smelt are visual feeders. They find and select individual prey organisms and their ability to see prey in the water is enhanced by turbidity (Baskerville-Bridges & Lindberg, 2004). Thus, Delta Smelt diets are largely comprised of small invertebrates (i.e., zooplankton) that inhabit the estuary's turbid, low-salinity, open-water habitats. Larval Delta

<sup>&</sup>lt;sup>16</sup> Distributions are based on monitoring data through March 16.

Smelt have particularly restricted diets (Nobriga, 2002). They do not feed on the full array of zooplankton with which they co-occur; they mainly consume three copepods: *Eurytemora affinis*, *Pseudodiaptomus forbesi*, and freshwater species of the family Cyclopidae. Further, the diets of first-feeding Delta Smelt larvae are largely restricted to the larval stages of these copepods. As Delta Smelt grow larger, mouth gape and swimming ability increase, enabling them to target larger copepods.

In the laboratory, a turbid environment (>25 Nephelometric Turbidity Units (NTU)) was necessary to elicit a first-feeding response (Baskerville-Bridges & Lindberg, 2004). Successful feeding seems to depend on a high density of food organisms and turbidity, and increases with stronger light conditions (Baskerville-Bridges & Lindberg, 2004; Mager *et al.*, 2003). The most common first prey of wild Delta Smelt larvae are larval stages of several copepod species which occur in the North Delta region. The variability of shallow and deep water habitat, and the resuspension of sediment due to wind and tidal action in the North Delta, may buffer effects of the proposed modifications because much, if not most, of the habitat in this region would remain suitable. Expectations for the North Delta contrast with the lower San Joaquin River where the upstream relocation of X2 may result in a greater proportion of the available habitat encompassing areas of high surface aquatic vegetation (SAV) and associated low turbidities. This could lower prey capture efficiency for Delta Smelt and increase predation rate on juveniles. There is moderate level of uncertainty in this conclusion.

In addition to turbidity effects, changes in flow may affect residence time, which in turn may influence planktonic production. Lower flows are expected to increase hydraulic residence times, potentially resulting in improved planktonic production (Lucas *et al.*, 2009). However, the specific effect is difficult to predict because benthic grazing can offset these benefits, hence the response of the food web to the changes in flow is unclear. There is a moderate level of uncertainty about this conclusion.

### **Summary of Effects on Delta Smelt**

#### Adults

Small numbers of Delta Smelt adults and larvae observed in 2015 field surveys indicates the WY 2014 drought had a significant impact on the population. Like many other species in the Delta, the Delta Smelt population is showing low recruitment again this year due to effects of continued drought. Model results indicate the Proposed Action may increase entrainment risk for Delta Smelt moving around in the San Joaquin River above baseline conditions. As indicated by forecasted daily EC results, salinity is expected to shift the centroid of the distribution associated with X2 inland. If recent SKT and USFWS Jersey Point survey results reasonably reflect the current distribution of Delta Smelt, there is a diminishing presence of adult Delta Smelt in the vicinity of Jersey Point. Entrainment of these adults is unlikely to be a management issue this year. Published analyses of a 13-year dataset of salvage records at the CVP/SWP fish collection facilities indicate that increased salvage of adult Delta Smelt at the CVP/SWP occurs when turbidities increase in the South Delta and OMR flows are highly negative (Grimaldo *et al.*, 2009). Given the present low turbidity in the South Delta, migration of remaining adults into areas of elevated entrainment risk is not expected. The salvage of adult Delta Smelt typically ends by May (Reclamation 2014c). After the onset of spawning, salvage of adult Delta Smelt

diminishes, with regulatory focus shifting from protection of adults to protection of larvae/juveniles by the end of March (as determined by water temperatures or biological triggers; BO).

#### Larvae and Juveniles

Delta Smelt have a strong positive association with the position of X2, with more downstream positions providing higher quality habitat (Feyrer *et al.*, 2011). Under the proposed action, it is likely summer Delta Smelt distributions will not be in areas optimal for growth and survival (Nobriga *et al.*, 2008). In previous low-flow years, when water quality conditions became less tolerable for Delta Smelt in the Cache Slough Complex, the North Delta population appeared to have the capability to move quickly downstream towards the low salinity zone. It is likely, given the strongly tidal nature of the Cache Slough Complex, Delta Smelt are able to ride these tidal flows to escape unfavorable habitat conditions in the North Delta. Under the current proposal, X2 would move further upstream, reducing the potential for downstream movement beyond the limitations already anticipated from the unmodified severe drought conditions. The proportion of the total population of Delta Smelt in the North Delta in summer appears to be highly variable (Feyrer, 2015), but can be relatively substantial (Sommer & Mejia, 2013). There is a moderate level of uncertainty about the expected effects in the North Delta.

Ongoing IEP monitoring, Early Warning Monitoring, and fish salvage operations, will continue to inform management and advisory groups who will be providing input to Reclamation on a near real-time basis.

### **Status of Longfin Smelt**

In Bay Study trawls conducted during the beginning of February, 2015, the majority of adult Longfin Smelt were detected in Suisun Bay, the Confluence area, and the lower Sacramento River (Figures 54-55; note the different scales between the figures). As of March 16, 2015, no adult or age-1 Longfin Smelt have been detected at either the CVP or SWP fish facilities. Earlier in the season (January), adult Longfin Smelt was detected in the Early Warning sampling in the lower San Joaquin River at Jersey Point, though recent surveys have not detected any in this area. This presence indicates that larval Longfin may be present in the central and south Delta, which is corroborated by the detection of larval Longfin in larval fish sampling at the salvage facilities (see below).



Figure 54. Distribution of adult Longfin Smelt in the Bay Study Midwater Trawl during February 2015



Figure 55. Distribution of adult Longfin Smelt in the Bay Study Otter Trawl during February 2015

The fifth Smelt Larva Survey (SLS), conducted during the week of March 2, 2015, found larval Longfin Smelt larvae were primarily distributed in the lower Sacramento River, at the confluence, and east of the confluence in Suisun Bay (Figure 56). Several larvae were also collected in the lower San Joaquin River at Jersey Point (n=1) and Oulton Point (n=3), and one larvae was collected in the south Delta at station 914 near Mildred Island. While larvae in these southern areas will be at a low to medium risk of entrainment during operations, larvae in the south Delta represent only 1% of the total larval catch in SLS #5 east of Carquinez Straights (n=101). As of March 16, 2015, one larvae each have been collected at the CVP and SWP salvage facilities, (February 27 and March 3, respectively). Compared to previous years, it appears Longfin Smelt spawning in 2015 is substantially reduced and larval abundances are low.



Figure 56. Distribution of larval Longfin Smelt from the Smelt Larva Survey #5 conducted in early March, 2015

It is likely that Longfin Smelt spawning is close to ending. However, the historical presence of recently-hatched larvae in sampling during March and April, indicates that spawning can continue into March (CDFG, 2009). It is possible Longfin Smelt distributed near the confluence may yet make spawning forays into the central and south Delta, which would put them at increased risk of entrainment, although these risks are inherently unquantifiable at this time due to the unprecedented circumstances of continued drought conditions (Table 24).

Longfin Smelt	Affected	of Lowered Recruitment	of Entrainment at Facilities	Certainty					
Eggs	Attached to substrate with very low risk of entrainment								
Larvae	Distribution based on Smelt Larva Survey #5								
~1% South Delta	Yes	Increased	Increased	High					
~11% San Joaquin River	Yes	Increased	No Change	Moderate					
~22% Sacramento River	Yes	Increased	No Change	Moderate					
~66% Confluence and Suisun	Yes	Increased	No Change	Moderate					
Juvenile	Juvenile Lo	ngfin (>20mm) have	e not yet been detecte	ed this year					
Adults	Distribu	tion based on Febru	ary 2015 Bay Study	survey					
0% South Delta	Not Applicable	Not Applicable	Not Applicable	Moderate					
0% San Joaquin River	Not Applicable	Not Applicable	Not Applicable	Moderate					
<5% Sacramento River	No	Not Affected	Not Affected	Moderate					
95% Confluence, Suisun & SF Bay	No	Not Affected	Not Affected	High					

# Table 24. Presence of Longfin Smelt During the Project Description Period and Potential Effects, based on the most recently available survey data 17 Longfin Smelt Life at age Change in Disk Change in Disk

### **Effect of Proposed Action on Longfin Smelt**

To estimate the effect of the proposed decrease in outflow on Longfin Smelt, particle tracking models were run using hydrology from the proposed action and baseline conditions, assuming an equally distributed population between injection points (Figure 29). The modeled conditions of the proposed reduced outflow to 4,000 cfs resulted in small changes in the fate of the majority of particles (at the end of the modeling period) compared to baseline conditions. Under all modeled conditions, particles originating from within the south Delta (injection node Railroad Cut) had the majority of particles arriving at the state and federal pumping facilities by May 31 (Figure 29). Of these particles, 78% were entrained at the pumping facilities as of May 31 under the proposed decrease in flows, compared to 73% under baseline. For particles originating at Prisoner's Point, 11% were entrained at the export facilities versus 5% under baseline conditions. Flux past Chipps for these particles was 17% compared to 40% for baseline conditions. Of the

<sup>&</sup>lt;sup>17</sup> Distributions are based on monitoring data through March 16.

particles injected at Jersey Point under the proposed action, the percentage that moved past Chipps Island by May 31 was 40% (vs. 68% for baseline conditions) and entrainment at the facilities was 2% (vs. 0% for baseline conditions). For particles seeded in the Sacramento River (station 707) at Three-mile Slough above Decker Island, only 1% were entrained to the export facilities versus 0% under baseline conditions. Flux past Chipps Island for these particles was 45% versus 66% under baseline conditions. As larval Longfin Smelt are distributed in the lower San Joaquin and Sacramento Rivers, the general reduction in flux past Chipps Island negatively affect downstream larval transport. However, the majority of larval Longfin detected in SLS #5 were downstream of Chipps Island, so the population level impacts of this reduced flux may not be substantial. However, it is impossible to quantify whether the differences between baseline conditions and the proposed action are truly biologically significant to the Longfin Smelt populations without knowledge of the size of the population and more detailed knowledge of their distribution. However, a qualitative prediction is possible based on the PTM results and a historical relationship between outflow and Longfin Smelt recruitment.

The proposed action will reduce outflow, and increased outflow is one of the best predictors of Longfin Smelt year class strength (CDFG 2009). Therefore, it is likely the proposed action will exacerbate poor Longfin Smelt recruitment and survival already expected in 2015 due to the severity of the drought. Given the results of the PTM model, it is likely that Longfin Smelt larvae in the San Joaquin River (Prisoner's Point and upstream) and in the south Delta will have a somewhat increased risk of entrainment into the south Delta as part of the Proposed Action, where they are not expected to survive warming water temperatures (Table 24). Longfin Smelt already located in the south Delta, near Frank's Tract and within Old and Middle Rivers will be at high risk of entrainment at the export facilities under both baseline conditions and the proposed action. Larvae in other parts of the San Joaquin River and elsewhere in the Delta will also see an increase, though slight, in export entrainment risk.

### **Summary of Effects on Longfin Smelt**

Like other species, Longfin Smelt are likely to experience poor recruitment this year due to effects of the continuing drought. Low spawning and larval detection rates this year seem to verify these low survival rates. The reduction in outflow due to the proposed action will likely have some negative impact on Longfin spawning and recruitment, though this effect is hard to quantify given the already poor environmental conditions due to the drought. The Proposed Action is unlikely to increase entrainment of Longfin Smelt to the export facilities in any substantive manner, as recent surveys indicate that the majorities of both adult and larval Longfin Smelt are distributed outside the zone of influence of the pumps. However, larval Longfin Smelt that are in the San Joaquin River (near Prisoner's Point), and especially those in the south Delta, will be at elevated risk of entrainment into the facilities.

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