Replication of Unimpaired Flow Calculations for Three San Joaquin Basin Tributaries in California's Central Valley

By

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Abstract

In December 2018, the State Water Resources Control Board (State Water Board) adopted amendments to the Bay-Delta Plan that include flow objectives for the Lower San Joaquin River (LSJR) and its three salmon-bearing tributaries, requiring that a portion of inflows (% unimpaired flow) for specific rivers remain in the tributaries to protect fish and wildlife for beneficial uses (State Water Resources Control Board, 2018).

This report details the procedures used to estimate daily unimpaired flow (UF) on the Stanislaus, Tuolumne, and Merced Rivers and replicates the UF procedures used to produce daily FNF (referred to as "Full Natural Flow" or FNF) values published on the California Data Exchange Center (CDEC) website. For each river, these procedures are used to reproduce the daily UF computation for a two-month (April 2018 and April 2019) and an 11-year (October 2008-September 2019) period. The two-month period is the main exercise highlighted and described in this report while the 11-year exercise is only summarized. The 11-year exercise is discussed and described further in Pulido et al. (2020).

Reproduced daily UF values were compared to those reported on CDEC. Results of the two-month exercise show that for the Stanislaus, Tuolumne, and Merced Rivers, provisional data used to compute daily FNF sometimes are updated, and the original (unrevised) data are not retained online. Also, this exercise highlights how daily FNF equations are not documented in a formal report, unlike monthly FNF equations.

Procedures and data sources varied from those described by the California Department of Water Resources (DWR) for some tributaries. Access to data and procedures that are not easily available to the public (e.g., published to a website) are necessary for reliable reproducibility of FNF and support implementing an instream flow requirement based on daily FNF. Refinements to improve overall reproducibility of daily FNF computations are proposed for consideration.

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Chapter 1

Introduction

Calculating unimpaired flow (UF) is done for a variety of purposes including flood management, water supply estimation and allocation, and determining instream flow requirements. Monthly and daily UF is estimated by DWR Division of Flood Management (DWR-DFM) and published to CDEC using the term "Full Natural Flow," (FNF). The State Water Board is now considering using these unimpaired flow estimates for the additional purpose of environmental flow regulations, which will bring additional scrutiny for reproducibility and transparency.

This report provides a detailed description of procedures for estimating daily UF that is reported to CDEC as FNF and examines the reproducibility of daily FNF published on CDEC for the Stanislaus, Tuolumne, and Merced Rivers. Procedures for estimating monthly UF were developed by DWR-DFM and are summarized in an agency report that is available by request to DWR-DFM. Daily UF estimates described in this report are based on procedures for monthly UF estimates described by DWR-DFM and informed by discussions with DWR-DFM staff and staff from a computing agency (Definition #6, Chapter 1.1). Procedures for estimating daily and monthly UF are similar but not always identical due to variations in data availability and the size of equation terms. The detailed description of daily UF estimation procedures and data sources for the Stanislaus, Tuolumne, and Merced Rivers in this report are not available in other agency reports or external reviews. Specific details for estimating daily UF for the three evaluated rivers include equations, detailed description of specific equation terms, flow gages, and data sources. The accuracy of daily UF estimation procedures described in this report were evaluated by comparing results of estimation procedures to published daily FNF on CDEC. This analysis includes a detailed two-month reproduction and a general overview of the 11-year reproduction of daily UF calculations for the Stanislaus, Merced, and Tuolumne Rivers.

1.1 Terminology

This report uses definitions one through five to differentiate common terms used in discussions of UFs. This chapter for terminology includes the definition of UF by DWR-DFM and by DWR Bay-Delta Office (DWR-BDO). For this report, UF and FNF have the same definition though UF is used throughout the report unless DWR-DFM's product of UF, FNF, is referred to in the chapter. Daily FNF is used when referring specifically to daily flow values published to CDEC under that abbreviation.

Definitions six through eight explains differences between computing agency, daily FNF spreadsheet reports, and computing agency data. These terms are used consistently in Chapters 3 and 4 to describe data sources used to compute daily FNF. Lastly, definition nine also is used in Chapters 3 and 4 to present a metric that numerically explains the difference between the reproduced daily FNF and the daily FNF posted on CDEC.

1. **Gage flows (GF):** Flows measured or estimated at a stream gage.
2. **Unimpaired flows (UF):** "Unimpaired runoff or "Full Natural Flow" represents the natural water production of a river basin, unaltered by upstream diversions, storage, or by export or

import of water to or from other watersheds."
(https://cdec.water.ca.gov/snow/current/flow/fnfinfo.html).
"Unimpaired flow is used to describe a theoretically available water supply assuming existing river channel conditions in the absence of (1) storage regulation for water supply and hydropower purposes and (2) stream diversions for agricultural and municipal uses. (DWR-BDO, 2016b). The concept of UF does not incorporate groundwater.

3. **"Full Natural Flows (FNF)":** Term used by DWR on CDEC for estimated daily and monthly unimpaired flows at specific locations. Despite its name, FNF is not "natural" flow, as it does not account for changes in upstream runoff, evapotranspiration, floodplain storage, and groundwater seepage from flood infrastructure and land development normally included in pre-development "natural flow" estimates. Daily and monthly FNF estimates produced by DWR-DFM are estimates of unimpaired flow.
4. **Natural flows (NF):** Flows that would have occurred at a gage location without human management of land and water, including effects on groundwater pumping and seepage, wetlands, and levees usually not included in UF estimates.
5. **Impairment:** Term used in this document to describe diversion, export, imports, reservoir evaporation, and reservoir storage change datasets that are input datasets needed to calculate daily and monthly FNF. Impairments to UF cumulatively result in GF.
6. **Computing Agency:** CDEC uses the term computing agency to refer to local water agencies or other organizations that calculate daily FNF.
7. **Daily FNF Spreadsheet Reports:** Spreadsheet documents generated by computing agencies and sent to DWR-DFM daily that report the daily FNF values and all data used to compute daily FNF. Daily FNF spreadsheet reports contain provisional data used to compute daily FNF. Data from these reports are uploaded onto CDEC by DWR-DFM. In this document, daily FNF spreadsheet reports refer to Turlock ID and Merced ID spreadsheet reports. These reports were requested and obtained from DWR-DFM for the April 2018 and April 2019 study. The data contained within these spreadsheet reports were used for the Tuolumne and Merced River daily FNF reproductions presented in Chapter 3.
8. **Computing Agency Data:** Data that were obtained from computing agencies, which may include datasets that are not available online. Computing agency data may or may not be provisional depending on data management practices of the computing agency. In this document, computing agency data refer to Tuolumne River flow and impairment datasets obtained from Turlock ID for WY 2009-2019. These datasets were used for the Tuolumne River daily FNF reproduction presented in Chapter 4.
9. **Discrepancy:** Defined as the difference between FNF reported on CDEC and the reproduced FNF value on a given day. Here, a positive discrepancy indicates the reproduced value is less than the CDEC FNF value on that day, whereas a negative discrepancy indicates the reproduced FNF is exceeding the CDEC FNF value.

Chapter 2

Unimpaired Flow Estimates

This chapter describes daily and monthly UF estimates routinely developed by DWR-DFM, DWR-BDO, and CNRFC. Daily and monthly UFs are estimated for locations in the Bay-Delta watershed by several agencies, including DWR-DFM, DWR-BDO, and the California-Nevada River Forecast Center (CNRFC). DWR-BDO and DWR-DFM calculate recent and historic UF while CNRFC calculates forecasts of unimpaired inflow.

Estimates of UF are made using two general types of hydrologic modeling, causal (physical process-based) and empirical (statistical) (Guisan and Zimmermann, 2000), summarized in Tables 2-1 and 2-2. Water balance (physical) approaches generally adjust a measured release from a reservoir (gaged outflow) to estimate UF. The gaged flow measurements are adjusted for water operations such as diversions, storage, return flows, or imports from other water basins to estimate UF. Statistical models often use regression or other curve-fitting methods based on historical data or estimates for past years and preceding months to estimate UF for time periods of interest, sometimes including future time periods.

Table 2-1 summarizes the DWR-DFM and DWR-BDO UF products, producing agency, update frequency, flow estimation basis, and the intended purpose for the products. Daily and monthly UF estimates are developed regularly by DWR-DFM. DWR-BDO maintains a separate set of monthly UF estimates for modeling and planning, based on adjustments to DWR-DFM's methods; these are updated once every few years.

Table 2-2 presents similar information for DWR-BDO UF and CNRFC forecasts of unimpaired inflow. Unimpaired runoff and inflow estimates are made regularly by DWR-DFM and CNRFC, respectively. DWR-DFM's unimpaired runoff forecasts are made seasonally for the February to May period for reservoir and water project operation. CNRFC's unimpaired inflow forecasts are made daily year-round for routine weather, streamflow, and flood forecasting.

Table 2-1: Recent and Historical Unimpaired Flow Estimates for California River Basins

Product	Agency	Update Frequency	Estimation basis	Purpose
FNF – daily	DWR-DFM	Mostly daily, 5 times a week	Water balance	Flood forecasting
FNF - monthly	DWR-DFM	Once a month	Water balance	Flood forecasting
UF - monthly	DWR-BDO	Every few years	Water balance	Water supply planning and delivery

Table 2-2: Forecast Unimpaired Flow and Inflow Estimates for California River Basins

Product and Agency	Forecast period	Update Frequency	Estimation basis	Purpose
UF – DWR-DFM's Bulletin 120	Seasonal	Monthly from February to May	Statistical	Forecasting for flood risk
Unimpaired Inflow – CNRFC	5-day	Daily	Statistical - Deterministic	Data sharing
Unimpaired Inflow – CNRFC	365-day	Daily	Statistical - Probabilistic	Data sharing

The daily FNF estimates described in Table 2-1 are calculated by DWR-DFM for some rivers, and by local computing agencies for other rivers.

FNF estimates computed by DWR-DFM for some rivers (like Stanislaus River) are calculated daily using input data available online. Because FNF for the Tuolumne and Merced Rivers is computed by computing agencies, daily FNF is reported to CDEC through an email exchange: DWR-DFM receives daily FNF spreadsheet reports (Definition #7, Chapter 1.1) for the Tuolumne and Merced Rivers from respective local FNF computing agencies every weekday, except holidays and breaks. For weekends and breaks, computing agencies send daily FNF spreadsheet reports on the following business day. DWR-DFM typically posts daily FNF data to CDEC five times per week, but can vary with staff availability and flood operations.

2.1 DWR Monthly Full Natural Flow (FNF)

Monthly FNF estimates are published by DWR-DFM on the CDEC website for seventy-seven river basins for flood forecasting (Source: https://cdec.water.ca.gov/cdecstations).

The monthly FNF values for the Stanislaus, Tuolumne, and Merced Rivers are reported here: http://cdec.water.ca.gov/reportapp/javareports?name=FNFSUM.

Equations 2-1 through 2-3 are used to compute monthly FNF for the Stanislaus, Tuolumne, and Merced Rivers. These equations are adapted from DWR's Unimpaired Runoff Memorandum (DWR-DFM, 2016). This report was provided by DWR-DFM and is not available online. DWR's Unimpaired Runoff Memorandum is a foundational source created by DWR-DFM to describe how monthly FNF is calculated by the California Cooperative Snow Surveys program; coordinated by DWR-DFM, for each of the major streams for which monthly FNF estimates are made, and some additional coastal streams needed to estimate the overall statewide runoff. Relevant excerpts from this report are presented in Appendix A.

Equation 2-1: Monthly FNF Equation for Stanislaus River at Goodwin Dam

$$FNF_{S_M} = Q_{S_M} + X_{S1_M} + X_{S2_M} + X_{S3_M} + X_{S4_M} + D_{S_M} + E_{S_M} + \Delta S_{S1_M} + \Delta S_{S2_M} + \Delta S_{S3_M} + \Delta S_{S4_M} + \Delta S_{S5_M} + \Delta S_{S6_M} + \Delta S_{S7_M} + \Delta S_{S8_M}$$

Where:

FNF_{S_M} = Monthly FNF for Stanislaus River at Goodwin Dam (ac-ft)

Q_{S_M} = Monthly Measured Gage Flow for Stanislaus River at Goodwin Dam (ac-ft)
X_{S1_M} = Monthly Export from Goodwin N Main Canal (ac-ft)
X_{S2_M} = Monthly Export from Goodwin S Main Canal (ac-ft)
X_{S3_M} = Monthly Export from Farmington Central ID Canal (ac-ft)
X_{S4_M} = Monthly Export from Farmington Stockton E Canal (ac-ft)
D_{S_M} = Monthly Diversion from Tuolumne Canal (ac-ft)
E_{S_M} = Monthly Evaporation from New Melones Reservoir (ac-ft)
ΔS_{S1_M} = Monthly Storage Change at New Melones Reservoir (ac-ft)
ΔS_{S2_M} = Monthly Storage Change at Spicer Meadows Reservoir (ac-ft)
ΔS_{S3_M} = Monthly Storage Change at Beardsley Lake Reservoir (ac-ft)
ΔS_{S4_M} = Monthly Storage Change at Donnells Reservoir (ac-ft)
ΔS_{S5_M} = Monthly Storage Change at Tulloch Reservoir (ac-ft)
ΔS_{S6_M} = Monthly Storage Change at Strawberry Reservoir (ac-ft)
ΔS_{S7_M} = Monthly Storage Change at Relief Reservoir (ac-ft)
ΔS_{S8_M} = Monthly Storage Change at Lyons Reservoir (ac-ft)

Equation 2-2: Monthly FNF Equation for Tuolumne River below La Grange Dam

$$FNF_{T_M} = Q_{T_M} + \Delta S_{T1_M} + \Delta S_{T2_M} + \Delta S_{T3_M} + \Delta S_{T4_M} + E_{T1_M}$$
$$+E_{T2_M} + E_{T3_M} + E_{T3_M} + D_{T1_M} + D_{T2_M} + D_{T3_M}$$

Where:
FNF_{T_M} = Daily FNF for Tuolumne River below La Grange Dam (ac-ft)
Q_{T_M} = Monthly Measured Gage Flow for Tuolumne River below La Grange Dam (ac-ft)
ΔS_{T1_M} = Monthly Storage Change at Don Pedro Reservoir (ac-ft)
ΔS_{T2_M} = Monthly Storage Change at Lake Eleanor Reservoir (ac-ft)
ΔS_{T3_M} = Monthly Storage Change at Cherry Valley Reservoir (ac-ft)
ΔS_{T4_M} = Monthly Storage Change at Hetch Hetchy Reservoir (ac-ft)
E_{T1_M} = Monthly Evaporation from Don Pedro Reservoir (ac-ft)
E_{T2_M} = Monthly Evaporation from Lake Eleanor Reservoir (ac-ft)
E_{T3_M} = Monthly Evaporation from Cherry Valley Reservoir (ac-ft)
E_{T4_M} = Monthly Evaporation from Hetch Hetchy Reservoir (ac-ft)
D_{T1_M} = Monthly Diversion from Diversion to S.F. Pipeline (ac-ft)
D_{T2_M} = Monthly Diversion from Turlock Canal near La Grange, CA (ac-ft)
D_{T3_M} = Monthly Diversion from Modesto Canal near La Grange, CA (ac-ft)

Equation 2-3: Monthly FNF Equation for Merced River below Merced Falls Dam

$$FNF_{M_M} = Q_{M_M} + \Delta S_{M1_M} + \Delta S_{M2} + E_{M1_M} + E_{M2_M} + D_{M_M}$$

Where:
FNF_{M_M} = Monthly FNF for Merced River below Merced Falls Dam (ac-ft)
Q_{M_M} = Monthly Measured Gage Flow for Merced River below Merced Falls Dam (ac-ft)
ΔS_{M1_M} = Monthly Storage Change at Lake McClure ‘Exchequer’ Reservoir (ac-ft)

ΔS_{M2_M} = Monthly Storage Change at Lake McSwain Reservoir (ac-ft)
E_{M1_M} = Monthly Evaporation at Lake McClure 'Exchequer' (ac-ft)
E_{M2_M} = Monthly Evaporation at Lake McSwain (ac-ft)
D_{M_M} = Monthly Diversion at North Side Canal (ac-ft)

Table 2-3 shows the CDEC station IDs for the Stanislaus, Tuolumne, and Merced Rivers, and identifies the agency that computes the daily and monthly FNF values for these three rivers. The daily and monthly FNF calculation for the Stanislaus River is computed by DWR-DFM staff. The daily and monthly FNF calculation for the Tuolumne River is computed by Turlock Irrigation District (Turlock ID) staff. The daily FNF calculation for the Merced River is computed by Merced Irrigation District (Merced ID) staff while DWR-DFM calculates the monthly FNF based on the raw input data provided by Merced ID. Figure 2-1 shows the location of the CDEC stations for each FNF computation of study.

Table 2-3: Summary of DWR's Division of Flood Management FNF San Joaquin River Tributary Locations

River Basin	CDEC Station ID	Computing Agency	Data Delivery Method
Stanislaus	GDW	DWR	N/A
Tuolumne	TLG	Turlock ID	Daily Email (provided to DWR)
Merced	MRC	Merced ID	Daily Email (provided to DWR)

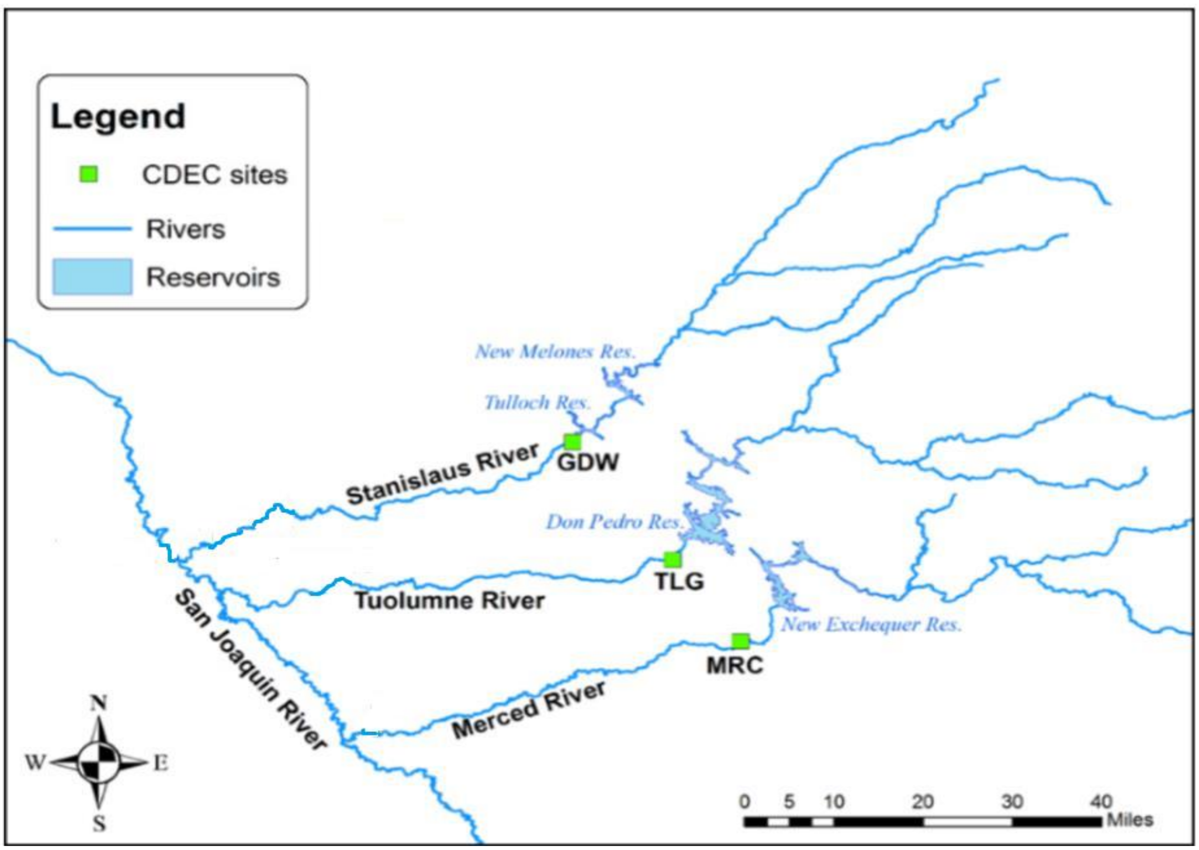


Figure 2-1: Map of locations of full natural flow stations for the Stanislaus, Tuolumne, and Merced Rivers. (Source: State Water Board, 2018). *Adapted by A. Pulido.*

2.2 DWR Daily Full Natural Flow (FNF)

DWR-DFM publishes daily FNF estimates for sixteen river basins on the CDEC website. Despite the naming convention, FNF has the same definition as UF.

As mentioned previously, this report focuses on documenting and reproducing the DWR-DFM daily FNF values for the Stanislaus, Tuolumne, and Merced Rivers, reported here: http://cdec.water.ca.gov/reportapp/javareports?name=FNF.

Unlike the monthly FNF computation, equations for daily FNF are not published by DWR-DFM in the Unimpaired Runoff Memorandum. Although DWR-DFM's equation for daily UFs at each river location is based on the monthly FNF equation, some impairment terms included in the monthly equation may be excluded from the daily equation (S. Nemeth, personal communication, February 28, 2019). According to DWR, these additional impairments have been excluded from the daily FNF calculation because they have a negligible impact on daily FNF (S. Nemeth, personal communication, February 28, 2019). The procedures used to confirm the daily FNF equation for the Stanislaus, Tuolumne, and Merced Rivers are discussed in Chapter 3.1.

2.3 California Central Valley Monthly Historical Unimpaired Flows

DWR-BDO develops and occasionally updates a set of monthly historical UF data, based on adjustments to DWR-DFM monthly FNF estimation methods. DWR-BDO's estimates of monthly historical UF records are extended and updated every few years for water planning, policy, operations modeling, reports, and studies, particularly for the CalSim model. The most recent DWR-BDO 2016 report, "Estimates of Natural and Unimpaired Flows for the Central Valley of California: WY 1922-2014" (DWR-BDO, 2016b), includes monthly UF estimates for 24 sub-basins in the Central Valley for October 1921 through September 2014. This report summarizes estimates of "natural" and "unimpaired" flows for locations within the Bay-Delta watershed for water years 1922-2014.

The report describes the conceptual differences between natural and UF as for the Central Valley where natural flows are described by DWR-BDO as accounting for reductions in wetland and floodplain evapotranspiration and groundwater interactions and tend to be smaller than UFs (represented in "full natural flows" calculations) estimated on the modern landscape with modern water development. DWR-BDO calculates UF by "adjusting observed gaged data to remove the effects of (1) upstream changes in surface water storage, (2) basin imports, and (3) basin exports" (DWR-BDO, 2016b). More information on the details of the impairments, such as gage location and type of impairment, that were included to estimate monthly UF can be found on https://data.cnra.ca.gov/dataset/estimates-of-natural-and-unimpaired-flows-for-the-central-valley-of-california-wy-1922-2014/.

2.4 Forecast of Unimpaired Runoff

DWR-DFM is the lead agency coordinating the California Cooperative Snow Surveys (CCSS) program, which provides seasonal and water runoff forecasts for California's major snow bearing watersheds for flood planning and operations. CCSS forecasts the volume of seasonal runoff from the state's major watersheds and summarizes precipitation, snowpack, reservoir storage, and runoff in various regions of the State four times per year, in the months of February, March, April, and May, in a forecast memo known as Bulletin 120. The Bulletin 120 forecasts are posted online at http://cdec.water.ca.gov/b120up.html.

DWR-DFM uses statistical regressions to produce unimpaired runoff forecasts for April through July, the percent of average for the unimpaired runoff, and the 80% probability range for the April through July unimpaired runoff forecasts. Bulletin 120 also presents the water year forecast, monthly distributions for February through September, the 80% probability range for the water year forecast, and the percent average for the water year forecast. These results are regularly compared with CNRFC unimpaired inflow forecasts to ensure a consistent and broadly-supported message.

CNRFC and DWR-DFM work closely to operate multiple continuous hydrologic models of different watersheds for developing unimpaired runoff forecasts. Each day the models receive real-time precipitation, temperature, and flow data. CNRFC uses the Community Hydrologic Prediction Service (CHPS) to calculate the five-day unimpaired inflow forecasts and the Hydrologic Ensemble Forecast Service (HEFS) to calculate the 365-day unimpaired inflow forecasts. These estimates are derived from precipitation and runoff models for major streams throughout California and can be found on https://www.cnrfc.noaa.gov/rfc_guidance.php.

CHPS is the open source river forecasting system operated by the National Weather Service (NWS) to promote model and data sharing. CNRFC uses a six-hour time-step for their CHPS to simulate and project river flows and stages in its area of responsibility. Area of responsibility is the regions that CNRFC are responsible for computing forecasts. CHPS uses hydrologic expertise, the operational Hydrometeorological Analysis and Support (HAS) function, set parameters for model guidance, and data from the observing system. Forecasts for precipitation and temperature are inputs to the CHPS to provide a five-day "deterministic" forecast of inflow. HEFS provides ensemble forecasts and verification to quantify and trace the uncertainty through the CHPS. CNRFC uses a six-hour time-step for the HEFS in the CHPS to estimate probabilistic 365-day hydrologic forecasts. In the CHPS environment, various components within HEFS produce ensemble and probabilistic forecast products. More information about CHPS and HEFS can be found at: www.nws.noaa.gov/oh/hrl/general/HEFS_doc/HEFS-1.0.1_HEFSOverviewAndGettingStarted.pdf.

Chapter 3

Reproduction of DWR Daily FNF Calculations: April 2018 and 2019

To illustrate how daily FNF is computed, this chapter reproduces daily FNF calculations during the months of April 2018 and April 2019 for the Stanislaus, Tuolumne, and Merced Rivers. April is the selected month for reproduction of daily FNF calculations since April is historically a month of highly variable flow. 2018 and 2019 are the selected years due to their water year (WY) type on CDEC being polar on the WY type index, with 2018 being below normal (BN) and 2019 being wet (W) (CDEC: https://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST). From varying flow and WY type, April 2018 and 2019 are useful for illustrating potential differences of daily FNF.

3.1 Procedures

This chapter describes the data, equations, and computational procedures used to reproduce the daily FNF values for the Stanislaus, Tuolumne, and Merced Rivers for the months of April 2018 and April 2019.

3.1.1 Data Availability

Most data needed to reproduce daily FNF for the Stanislaus, Tuolumne, and Merced Rivers are available online via the CDEC and/or the United States Geological Survey's (USGS) National Water Information System (NWIS) websites. Bulk data (gage flow (GF) or impairment) were extracted from CDEC by inputting the station ID, sensor number, start date, and end date on https://cdec.water.ca.gov/dynamicapp/wsSensorData. Flow and storage data were also extracted from NWIS by inputting the site number on https://nwis.waterdata.usgs.gov/nwis/inventory and clicking the "detailed descriptions with links to available data for each site" option to see all data available for that specific site.

Some values on CDEC for the daily FNF have notes of "r" or "e", meaning "revised" and "estimated". Revised means that the posted provisional daily FNF value was revised at a later date to a more accurate value. Estimated means that the daily value for the FNF was missing on the posted date and estimated later. These notes are important as they update only the CDEC value of daily FNF and make the daily FNF value, GF and impairment data on the Turlock ID and Merced ID daily FNF spreadsheet reports outdated. According to DWR-DFM staff, the CDEC daily FNF values tend to be updated retrospectively when daily FNF values are extremely outside the normal seasonal range for that month (i.e., daily FNF values are either negative or an unreasonable/uncommon value that DWR-DFM simply cannot agree with). In addition, GF and impairment data on CDEC and NWIS may not be updated retrospectively when the CDEC daily FNF is updated.

While the daily FNF values on CDEC can be updated retrospectively and the corresponding components used to calculate that daily FNF are not, the same is true for the reverse situation. GF and impairment data on NWIS or CDEC can sometimes be updated retrospectively, but the corresponding daily FNF value is not updated retrospectively. These retrospective updates to GF and impairment data on NWIS and CDEC cause the corresponding daily FNF on CDEC and daily FNF spreadsheet to be outdated. Chapters 3.1.4 through 3.1.6 highlight which dates for measured GF, impairments, and daily FNF are marked as "r" or "e" to discuss later in Chapter 3.2.

For some GF and impairments, data are available on both NWIS and CDEC websites. Although these sources represent the same GF or impairment, they sometimes have different numerical values (Appendix C). This is a result of the different data management practices of USGS and DWR. For both NWIS and CDEC data, GF and impairment data used to compute daily FNF are considered provisional and may be subject to retroactive adjustments. However, the observed data management practices of USGS are more thorough than DWR. USGS has an established data review process for NWIS data which is described on https://www.usgs.gov/products/data-and-tools/data-management/manage-quality. For this reason, it was assumed that daily GF and impairment data presented on CDEC more closely represent the provisional data used to compute daily FNF than NWIS data. This supports the idea that CDEC data will provide the best daily FNF reproduction for April 2018 and 2019.

For the Stanislaus River, all GF and impairment data used in the Stanislaus River daily FNF equation are available online from the CDEC and/or NWIS websites. Since DWR is the Stanislaus FNF computing agency, no daily FNF spreadsheet reports are produced or used for the Stanislaus River.

For the Tuolumne and Merced Rivers, daily FNF is calculated by Turlock Irrigation District (Turlock ID) and Merced Irrigation District (Merced ID), respectively, and reported to DWR through a daily email exchange that includes the daily FNF spreadsheet report (Chapter 1.1, Definition #7). Turlock ID and Merced ID report all daily FNF, GF (USGS NWIS streamflow data), and impairment values on the daily FNF spreadsheet reports. DWR uploads some, but not all, of the GF and impairment datasets to CDEC based on information provided in the daily FNF spreadsheet reports (S. DeGuzman, personal communication, August 14, 2019). For example, Turlock ID's daily FNF spreadsheet report for April of 2018 and 2019 (Appendix B) reports the Diversion to S.F. Pipeline (cfs), but this impairment is not available on CDEC.

The daily FNF spreadsheet reports are not available online. The Turlock ID and Merced ID daily FNF spreadsheet reports were requested and obtained from DWR-DFM for April 2018 and April 2019 (Appendix B). However, the procedure to compute the related impairment terms and daily FNF are not documented in the daily FNF spreadsheet reports. Procedures for calculating individual impairment terms could be determined by contacting the organization that measures or estimates each impairment term. Using the daily FNF spreadsheet reports to reproduce daily FNF will not always result in a precise and accurate reproduction due to some refinements in underlying data that may occur at a later date.

3.1.2 Daily FNF Equations

As discussed in Chapter 2.2, DWR-DFM's equation for daily FNF at each river location is based on the monthly FNF equation, although some impairment terms included in the monthly equation may be excluded from the daily equation. Equations 3-1 through 3-3 identify the GF and impairments (such as exports, diversions, evaporation, and storage change) accounted for in the daily FNF estimates for the Stanislaus River at Goodwin Dam, Tuolumne River below La Grange Dam and Merced River below Merced Falls Dam.

Equation 3-1: Daily FNF Equation for Stanislaus River at Goodwin Dam

$$FNF_S = Q_S + X_{S1} + X_{S2} + X_{S3} + X_{S4} + D_S + E_S + \Delta S_{S1} + \Delta S_{S2} + \Delta S_{S3} + \Delta S_{S4} + \Delta S_{S5} + \Delta S_{S6} + \Delta S_{S7} + \Delta S_{S8}$$

Where:
FNF_S = Daily FNF for Stanislaus River at Goodwin Dam (cfs)
Q_S = Daily Measured Gage Flow for Stanislaus River at Goodwin Dam (cfs)
X_{S1} = Daily Export from Goodwin N Main Canal (cfs)
X_{S2} = Daily Export from Goodwin S Main Canal (cfs)
X_{S3} = Daily Export from Farmington Central ID Canal (cfs)
X_{S4} = Daily Export from Farmington Stockton E Canal (cfs)
D_S = Daily Diversion from Tuolumne Canal (cfs)
E_S = Daily Evaporation from New Melones Reservoir (cfs)
ΔS_{S1} = Daily Storage Change at New Melones Reservoir (cfs)
ΔS_{S2} = Daily Storage Change at Spicer Meadows Reservoir (cfs)
ΔS_{S3} = Daily Storage Change at Beardsley Lake Reservoir (cfs)
ΔS_{S4} = Daily Storage Change at Donnells Reservoir (cfs)
ΔS_{S5} = Daily Storage Change at Tulloch Reservoir (cfs)
ΔS_{S6} = Daily Storage Change at Strawberry Reservoir (cfs)
ΔS_{S7} = Daily Storage Change at Relief Reservoir (cfs)
ΔS_{S8} = Daily Storage Change at Lyons Reservoir (cfs)

Equation 3-2: Daily FNF Equation for Tuolumne River below La Grange Dam

$$FNF_T = Q_T + \Delta S_{T1} + \Delta S_{T2} + \Delta S_{T3} + \Delta S_{T4} + E_T + D_{T1} + D_{T2} + D_{T3}$$

Where:
FNF_T = Daily FNF for Tuolumne River below La Grange Dam (cfs)
Q_T = Daily Measured Gage Flow for Tuolumne River below La Grange Dam (cfs)
ΔS_{T1} = Daily Storage Change at Don Pedro Reservoir (cfs)
ΔS_{T2} = Daily Storage Change at Lake Eleanor Reservoir (cfs)
ΔS_{T3} = Daily Storage Change at Cherry Valley Reservoir (cfs)
ΔS_{T4} = Daily Storage Change at Hetch Hetchy Reservoir (cfs)
E_T = Daily Evaporation from Don Pedro Reservoir (cfs)
D_{T1} = Daily Diversion from Diversion to S.F. Pipeline (cfs)
D_{T2} = Daily Diversion from Turlock Canal near La Grange, CA (cfs)
D_{T3} = Daily Diversion from Modesto Canal near La Grange, CA (cfs)

Equation 3-3: Daily FNF Equation for Merced River below Merced Falls Dam

$$FNF_M = Q_M + \Delta S_{M1} + \Delta S_{M2}$$

Where:
FNF_M = Daily FNF for Merced River below Merced Falls Dam (cfs)
Q_M = Daily Measured Gage Flow for Merced River below Merced Falls Dam (cfs)

ΔS_{M1} = Daily Storage Change at Lake McClure 'Exchequer' Reservoir (cfs)
ΔS_{M2} = Daily Storage Change at Lake McSwain Reservoir (cfs)

Because daily FNF equations are not identified in the DWR-DFM's Unimpaired Runoff Memorandum (see Chapter 2.2), the daily FNF equations were inferred by the UC Davis team through trial and error and preliminary calculations. These preliminary calculations, procedures, adjusted the monthly FNF equations to exclude some terms.

For the Stanislaus River the daily FNF equation is the same as the monthly FNF equation, so Equation 3-1 uses the same gage flow and impairments as Equation 2-1. This equation was confirmed by DWR-DFM staff. For the Tuolumne River, Equation 3-2 was developed from Equation 2-2 and adjusted to exclude the evaporation impairment for Lake Eleanor, Cherry Valley, and Hetch Hetchy by the UC Davis research team and was confirmed by DWR-DFM staff. For the Merced River, Equation 3-3 was developed from Equation 2-3 and adjusted to exclude evaporation from Lake McClure and Lake McSwain and diversions to the North Side Canal by the UC Davis Team. Equation 3-3 has not been confirmed by DWR-DFM but appears to be the correct equation based on the results of calculations in this chapter.

3.1.3 Computational Procedures

This chapter presents three calculation procedures used to compute daily FNF. These procedures are similar, but use different data sources:

- **Procedure 1**: Online Data Only – Uses only datasets that are currently easily accessible and published on NWIS (operated by USGS) and/or CDEC (operated by DWR). Any dataset not available on the NWIS or CDEC websites is excluded (i.e., treated as zero) from the daily FNF equations, which tends to provide lower bound estimates of daily FNF.
    - Chapter 3 (two-month reproduction of daily FNF, April 2018 and 2019) always used the datasets from CDEC over NWIS unless it was reported on DWR-DFM's Unimpaired Runoff Memorandum to use NWIS or if the data are **only** available on NWIS.
    - For Chapter 4 (11-year reproduction of daily FNF, Water Years 2009-2019), if estimates for a component flow were accessible on both NWIS and CDEC but had different numerical values, the data source that provided the best FNF reproduction was identified and used.
- **Procedure 2:** Prioritizes Online Data, but also uses Data from Computing Agency – Similar to Procedure 1 but includes data supplied by computing agencies for components of the calculation not easily accessible online. Procedure 2 is computed when online data are not available on CDEC or NWIS for every component of the daily FNF computation.
    - Chapter 3 used data from daily FNF spreadsheet reports wherever necessary.
    - Chapter 4 used computing agency data wherever necessary.
- **Procedure 3:** Prioritizes Data from Computing Agency – Uses data supplied by computing agencies wherever possible. Procedure 3 is computed where data from computing agencies are available and have numerical values that differ from those available on CDEC or NWIS.
    - Chapter 3 used only data from daily FNF spreadsheet reports.
    - Chapter 4 used computing agency data wherever necessary.

For the April 2018 and 2019 study, all three procedures, Procedures 1, 2, and 3, were used to calculate daily FNF for the Tuolumne River while only Procedures 1 and 3 were used for the Merced River. Procedure 2 was not used for the Merced River since all impairment and measured GF were available online from CDEC or NWIS. For the Stanislaus River, Procedure 1 only was applied because all daily FNF input datasets are available online from CDEC and daily spreadsheet reports are not used by the Stanislaus FNF computing agency (DWR-DFM).

Procedures 1 and 2 were established to present the relative level of data availability online. Procedure 1 only includes flow and impairment data that are easily accessible on NWIS and/or CDEC, while Procedure 2 also includes data from the daily spreadsheet reports for datasets that are not easily accessible online. Procedure 3 was developed to attempt to reproduce daily FNF values for the Tuolumne and Merced Rivers exactly for April 2018 and 2019. By comparing Procedures 1 and 2 to Procedure 3, the effects of using online data verses computing agency data can be shown.

The daily FNF values computed for the Stanislaus, Tuolumne, and Merced Rivers using these three procedures were compared to the daily FNF values posted on CDEC. Equations 3-1 and 3-3 were used accordingly and then compared to the corresponding CDEC daily FNF values. The reproduced daily FNF and CDEC daily FNF were compared using a metric called discrepancy.

For this study, discrepancy is defined as the difference between FNF reported on CDEC and the reproduced FNF value on a given day, as described in Chapter 1.1.

3.1.4 Stanislaus River

Equation 3-1 was used to reproduce daily FNF calculations for the Stanislaus River. This equation contains one river GF and 14 impairment terms, for a total of 15 terms in the Stanislaus River daily FNF calculation. All datasets used for the Stanislaus River daily FNF calculation are available on CDEC and were downloaded for April 2018 and 2019. Daily spreadsheet reports are not used by DWR-DFM to calculate the Stanislaus River daily FNF. Therefore, only Procedure 1 was used to replicate daily FNF for the Stanislaus River.

Procedure 1 is compared to CDEC's daily FNF for corresponding days in April 2018 and 2019. Appendix C contains comparison graphs for all days having both measured GF and impairments reported on CDEC and NWIS. These comparison graphs present the difference between the same impairment or measured gage flow reported on CDEC or NWIS. Table 3-1 lists all input data sources available online that could be used to reproduce the daily FNF calculation for the Stanislaus River. As shown below, some of these datasets are available on both NWIS and CDEC, though only one dataset was used for the reproduction of each method.

Table 3-1: Datasets Available Online for Stanislaus River Daily FNF Calculation

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Stanislaus River at Goodwin Dam	Measured Gage Flow (cfs)	11302000	GDW – 71
Goodwin North Main (South San Joaquin) Canal	Export (cfs)	11300500	GDJ – 85

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Goodwin South Main (Oakdale) Canal	Export (cfs)	11301000	GDS – 85
Farmington Central ID Canal	Export (cfs)	-	FR1 – 85
Farmington Stockton East Canal	Export (cfs)	-	FR2 – 85
Tuolumne Canal near Long Barn	Diversion (cfs)	11297500	STU – 110
New Melones Reservoir	Evaporation (cfs)	-	NML – 74
New Melones Reservoir	Storage Change (ac-ft)	11299000	NML – 22
Beardsley Lake	Storage Change (ac-ft)	11292800	BRD – 22
Donnells Reservoir	Storage Change (ac-ft)	11292600	DON – 22
Tulloch Reservoir	Storage Change (ac-ft)	11299995	TUL – 22
Spicer Meadows	Storage (ac-ft)	11293770	SPM – 15
Strawberry Reservoir	Storage (ac-ft)	-	SWB – 15
Relief Reservoir	Storage (ac-ft)	-	RLF – 15
Lyons Reservoir	Storage (ac-ft)	11297700	LYS – 15

Procedure 1: Online Data Only

Equation 3-1 was used to calculate daily FNF for each day in April 2018 and April 2019. Table 3-2 identifies each of the datasets used for the daily FNF calculation, including the site name, term type, and CDEC station ID and sensor number. For any given day during April 2018 and 2019, all terms listed below in Table 3-2 were converted to units of cubic feet per second (cfs) and then summed together to calculate the daily FNF for the Stanislaus River, in cfs.

In cases where both NWIS and CDEC data are available for the impairment or measured gage flow, as seen in Table 3-1, only one dataset was used. CDEC data (April 2018 and April 2019) was used for all impairment terms and the measured GF term in Equation 3-1 because it was assumed that daily data presented on CDEC more closely represent the provisional data used to compute daily FNF than NWIS data. Also, DWR-DFM is responsible for calculating daily FNF of the Stanislaus River and reports the GF and impairment data on CDEC.

Discharge data for the Stanislaus River, in cfs, was obtained from CDEC to calculate the daily FNF for the Stanislaus River. The daily diversion datasets for the South San Joaquin Canal, Oakdale Canal, Central ID Canal, Stockton E Canal, Tuolumne Canal and the daily reservoir storage dataset for the New Melones Reservoir were obtained from CDEC, in cfs. Stanislaus River, Goodwin N Main Canal, and Farmington Central ID Canal daily discharge for April 14th, 2018 were noted as a “revised” value on CDEC, and Farmington Stockton East Canal's daily discharge for April 14th, 2018 was noted as an "estimated" value on CDEC.

Daily storage data is available on CDEC for all of Stanislaus Rivers' reservoirs identified in Table 3-2. CDEC also reports daily storage change data for some of these reservoirs such as New Melones, Beardsley, Donnells, and Tulloch. The daily storage change datasets for New Melones Reservoir, Beardsley Lake, Donnells Reservoir, and Tulloch Reservoir were obtained from CDEC in units of acre-feet (ac-ft) and converted to cfs. Spicer Meadows, Strawberry Reservoir, Relief Reservoir, and Lyons Reservoir's daily storage datasets were obtained from CDEC, in units of ac-ft; the daily storage change for each reservoir was determined by determining the difference between the daily storage amount (ac-ft) and the daily storage amount (ac-ft) for the prior date, and then converting the volume difference to mean daily flow (cfs). Spicer Meadows's daily storage for April 2nd, 2018 was noted as a "revised" value on CDEC.

Table 3-2: Datasets Used for the Procedure 1 Stanislaus River Daily FNF Calculation (April 2018 and April 2019)

Name	**Term Type**	**CDEC (Station ID – Sensor Number)**
Stanislaus River at Goodwin Dam	Measured Gage Flow (cfs)	GDW – 71
Goodwin N Main (South San Joaquin) Canal	Export (cfs)	GDJ – 85
Goodwin S Main (Oakdale) Canal	Export (cfs)	GDS – 85
Farmington Central ID Canal	Export (cfs)	FR1 – 85
Farmington Stockton E Canal	Export (cfs)	FR2 – 85
Tuolumne Canal near Long Barn	Diversion (cfs)	STU – 110
New Melones Reservoir	Evaporation (cfs)	NML – 74
New Melones Reservoir	Storage Change (ac-ft)	NML – 22
Beardsley Lake	Storage Change (ac-ft)	BRD – 22
Donnells Reservoir	Storage Change (ac-ft)	DON – 22
Tulloch Reservoir	Storage Change (ac-ft)	TUL – 22
Spicer Meadows	Storage (ac-ft)	SPM – 15
Strawberry Reservoir	Storage (ac-ft)	SWB – 15
Relief Reservoir	Storage (ac-ft)	RLF – 15
Lyons Reservoir	Storage (ac-ft)	LYS – 15

3.1.5 Tuolumne River

Equation 3-2 was used to reproduce the daily FNF calculations for the Tuolumne River. The Tuolumne River daily FNF calculation contains one river flow and eight impairment terms for a total of nine terms (Equation 3-2). Because one of the datasets identified in Equation 3-2 is not readily available online (diversion to S.F. pipeline), all three procedures were used to estimate daily FNF on the Tuolumne River. The data for eight out of nine terms are available online from CDEC and/or NWIS for April 2018 and 2019 (missing term is diversion to S.F. pipeline).

As seen in Table 2-3, Tuolumne River daily FNF is calculated by Turlock ID. Turlock ID provides DWR-DFM a daily FNF spreadsheet report for the Tuolumne River by a daily email exchange except on weekends and high flooding conditions (S. DeGuzman, personal communication, August 14, 2019). The daily FNF spreadsheet reports for April 2018 and April 2019 are presented in Appendix B. Appendix C contains comparison graphs between all the data of the measured GF and impairments received by Turlock ID and reported on CDEC and NWIS. These comparison graphs present the difference between the same impairment data or measured GF data received by Turlock ID or reported on CDEC or NWIS. Table 3-3 lists all data sources available online that could be used to reproduce the daily FNF calculation for the Tuolumne River. Some datasets are available on both CDEC and NWIS.

Table 3-3: Datasets Available Online for Tuolumne River Daily FNF Calculation

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Tuolumne River below La Grange Dam	Measured Gage Flow (cfs)	11289650	LGN-41
Don Pedro Reservoir	Storage Change (ac-ft)	11287500	DNP - 22
Lake Eleanor Reservoir	Storage (ac-ft)	11277500	ENR - 15
Cherry Valley Reservoir	Storage (ac-ft)	11277200	CHV - 15
Hetch Hetchy Reservoir	Storage (ac-ft)	11275500	HTH - 15
Don Pedro Reservoir	Evaporation (cfs)	-	DNP - 74
Modesto Canal near La Grange, CA	Diversion (cfs)	11289000	-
Turlock Canal near La Grange, CA	Diversion (cfs)	11289500	-

Procedure 1: Online Data Only

For Procedure 1, daily FNF for the Tuolumne River was calculated by revising Equation 3-2 into Equation 3-2a. These equations only include the datasets available online through NWIS or CDEC. The Diversion to S.F. Pipeline term, as seen in Equation 3-2, was not included in Equation 3-2a, because this dataset is not available online via NWIS or CDEC. To calculate daily FNF, Procedure 1 starts the calculation starts with measured GF data from NWIS for Tuolumne River, then adds the impairment values that are available on NWIS or CDEC, and lastly replaces the impairment values that are not available online with zero.

Equation 3-2a: Daily FNF Equation for Tuolumne River below La Grange Dam – Procedure 1

$$FNF_{T_a} = Q_T + \Delta S_{T1} + \Delta S_{T2} + \Delta S_{T3} + \Delta S_{T4} + D_{T2} + D_{T3}$$

Where:

FNF_{T_a} = Daily FNF for Tuolumne River below La Grange Dam – Procedure 1(cfs)

Q_T = Daily Measured Gage Flow for Tuolumne River below La Grange Dam (cfs)

ΔS_{T1} = Daily Storage Change at Don Pedro Reservoir (cfs)
ΔS_{T2} = Daily Storage Change at Lake Eleanor Reservoir (cfs)
ΔS_{T3} = Daily Storage Change at Cherry Valley Reservoir (cfs)
ΔS_{T3} = Daily Storage Change at Hetch Hetchy Reservoir (cfs)
E_T = Daily Evaporation from Don Pedro Reservoir (cfs)
D_{T2} = Daily Diversion from Turlock Canal near La Grange, CA (cfs)
D_{T3} = Daily Diversion from Modesto Canal near La Grange, CA (cfs)

Table 3-4 identifies each of the eight terms used in Equation 3-2a to estimate daily FNF in April 2018 and the data sources (NWIS or CDEC) for Procedure 1. The table also reports the dataset units available on CDEC or NWIS for each term, and the station ID and sensor number (for CDEC data) or site number (for NWIS data). For any given day during April 2018, all terms listed in Table 3-4 were converted to units of cfs and summed together to calculate the daily FNF for the Tuolumne River in cfs.

Table 3-4: Datasets Used for the Procedure 1 Tuolumne River Daily FNF Calculation (April 2018)

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Tuolumne River below La Grange Dam	Measured Gage Flow (cfs)	11289650	-
Don Pedro Reservoir	Storage Change (ac-ft)	-	DNP - 22
Lake Eleanor Reservoir	Storage (ac-ft)	11277500	-
Cherry Valley Reservoir	Storage (ac-ft)	-	CHV - 15
Hetch Hetchy Reservoir	Storage (ac-ft)	-	HTH - 15
Don Pedro Reservoir Evaporation	Evaporation (cfs)	-	DNP - 74
Turlock Canal near La Grange, CA	Diversion (cfs)	11289500	-
Modesto Canal near La Grange, CA	Diversion (cfs)	11289000	-

Table 3-5 identifies each of the eight terms used in Equation 3-2a to estimate daily FNF in April 2019 and the data sources for Procedure 1. For any given day during April 2019, all terms listed below in Table 3-5 were converted to units of cfs and then summed together to calculate daily FNF for the Tuolumne River in cfs. Table 3-4 and Table 3-5 differ by the data source changing for "Lake Eleanor Reservoir" from NWIS for April 2018 to CDEC for April 2019.

Table 3-5: Datasets Used for the Procedure 1 Tuolumne River Daily FNF Calculation (April 2019)

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Tuolumne River below La Grange Dam	Measured Gage Flow (cfs)	11289650	-
Don Pedro Reservoir	Storage Change (ac-ft)	-	DNP - 22
Lake Eleanor Reservoir	Storage (ac-ft)	-	ENR - 15
Cherry Valley Reservoir	Storage (ac-ft)	-	CHV - 15
Hetch Hetchy Reservoir	Storage (ac-ft)	-	HTH - 15
Don Pedro Reservoir Evaporation	Evaporation (cfs)	-	DNP - 74
Turlock Canal near La Grange, CA	Diversion (cfs)	11289500	-
Modesto Canal near La Grange, CA	Diversion (cfs)	11289000	-

Tuolumne River discharge data were obtained from NWIS to calculate daily FNF for April 2018 and 2019. This dataset was taken from NWIS instead of CDEC because it is not available on CDEC. The dataset was available and downloaded in 15-minute intervals, and the mean daily flow (cfs) was calculated using Excel.

The daily storage data are available on CDEC for all reservoirs, Don Pedro, Lake Eleanor, Cherry Valley, and Hetch Hetchy, but daily storage change data are only available for some of them on CDEC. Don Pedro is available as storage and storage change data while Lake Eleanor, Cherry Valley, and Hetch Hetchy are only available as storage data on CDEC. Some datasets on CDEC or NWIS are only available in 15-minute intervals or hourly intervals, respectively, instead of the average daily intervals. In these cases where only 15-minute or hourly intervals were available, the daily average was calculated for the corresponding impairment.

Don Pedro Reservoir daily storage change data were obtained from CDEC in units of ac-ft and converted to cfs. The daily storage data for Cherry Valley and Hetch Hetchy in April 2018 and 2019 were extracted from CDEC. Lake Eleanor reservoir storage data were retrieved from NWIS for April 2018 and included in Equation 3-2a. Since this data set was available in 15-minute intervals, the daily average storage (ac-ft) was calculated in Excel. The daily storage change data for Lake Eleanor are not available before October 1st, 2018 on CDEC. For April 2019, daily storage data for Lake Eleanor were extracted from CDEC and included in Equation 3-2a. The daily storage change values for Lake Eleanor, Cherry Valley, and Hetch Hetchy Reservoirs were calculated by subtracting a date's storage amount from the prior date's storage amount, converted into cfs.

NWIS data were used for Modesto and Turlock Canal daily diversions because CDEC daily discharge data for the Modesto Canal are unavailable after April 19th, 2016, and CDEC daily discharge data for the Turlock Canal are not available for any dates. Diversion data for both canals were obtained as mean daily flows, in cfs, from the NWIS website.

Procedure 2: Prioritizes Online Data, but also uses Data from Computing Agencies

For Procedure 2, daily FNF for the Tuolumne River was calculated using Equation 3-2. Procedure 2 is similar to Procedure 1, but Procedure 2 also includes impairment values that are not available on the NWIS or CDEC websites. The impairments that were not available online are available on Turlock ID's daily FNF spreadsheet reports. The Diversion to S.F. Pipeline is the only term that is not available online for the Tuolumne River daily FNF calculation.

Table 3-6 identifies each of the nine terms used in Equation 3-2 to estimate daily FNF in April 2018 and the data source locations for Procedure 2. The table also reports the dataset units available on CDEC or NWIS for each term, and the data source locations by their station ID and sensor number (for CDEC data) or site number (for NWIS data). For any given day during April 2018, all terms listed in Table 3-6 were converted to units of cfs and summed together to calculate the daily FNF for the Tuolumne River in cfs.

Table 3-6: Datasets Used for the Procedure 2 Tuolumne River Daily FNF Calculation (April 2018)

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)	Other Data Source
Tuolumne River below La Grange Dam	Measured Gage Flow (cfs)	11289650	-	
Don Pedro Reservoir	Storage Change (ac-ft)	-	DNP - 22	
Lake Eleanor Reservoir	Storage (ac-ft)	11277500	-	
Cherry Valley Reservoir	Storage (ac-ft)	-	CHV - 15	
Hetch Hetchy Reservoir	Storage (ac-ft)	-	HTH - 15	
Don Pedro Reservoir	Evaporation (cfs)	-	DNP - 74	
Diversion to S.F. Pipeline	Diversion (cfs)	-	-	Turlock ID data*
Turlock Canal near La Grange, CA	Diversion (cfs)	11289500	-	
Modesto Canal near La Grange, CA	Diversion (cfs)	11289000	-	

Turlock ID data* - not available online and retrieved from daily FNF spreadsheet reports

Table 3-7 identifies each of the nine terms used in Equation 3-2 to estimate daily FNF in April 2019 and the data sources used for Procedure 2. For any given day during April 2019, all terms listed below in Table 3-7 were converted to units of cfs and then summed together to calculate daily FNF for the Tuolumne River in cfs. Table 3-6 and Table 3-7 differ by the data source changing for "Lake Eleanor Reservoir" from NWIS for April 2018 to CDEC for April 2019. Both tables differ from Table 3-4 and 3-5, in Procedure 1, from the "Diversion to S.F. Pipeline" impairment being included in Procedure 2 and not Procedure 1.

Table 3-7: Datasets Used for the Procedure 2 Tuolumne River Daily FNF Calculation (April 2019)

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)	Other Data Source
Tuolumne River below La Grange Dam	Measured Gage Flow (cfs)	11289650	-	
Don Pedro Reservoir	Storage Change (ac-ft)	-	DNP - 22	
Lake Eleanor Reservoir	Storage (ac-ft)	-	ENR - 15	
Cherry Valley Reservoir	Storage (ac-ft)	-	CHV - 15	
Hetch Hetchy Reservoir	Storage (ac-ft)	-	HTH - 15	
Don Pedro Reservoir	Evaporation (cfs)	-	DNP - 74	
Diversion to S.F. Pipeline	Diversion (cfs)	-	-	Turlock ID data*
Turlock Canal near La Grange, CA	Diversion (cfs)	11289500	-	
Modesto Canal near La Grange, CA	Diversion (cfs)	11289000	-	

Turlock ID data* - not available online and retrieved from daily FNF spreadsheet reports

Tuolumne River discharge data were obtained from NWIS to calculate the daily FNF in April 2018 and 2019, as described in DWR's Unimpaired Runoff Memorandum (Appendix A). Since the dataset was in 15-minute intervals, the mean daily flow was calculated using Excel.

Don Pedro Reservoir daily storage change data were obtained from CDEC in ac-ft and converted cfs for April 2018 and 2019. The daily storage data for Cherry Valley and Hetch Hetchy in April 2018 and 2019 were extracted from CDEC. Lake Eleanor reservoir storage data were retrieved from NWIS for April 2018. Since the dataset was available in 15-minute intervals, the mean daily storage (ac-ft) was calculated in Excel. Lake Eleanor reservoir storage data were retrieved from CDEC for April 2019. The daily storage change for Lake Eleanor, Cherry Valley, and Hetch Hetchy were calculated by subtracting each date's storage amount from the prior date's storage amount, converted into cfs.

The Diversion to S.F. Pipeline data were unavailable online but were reported on Turlock ID's daily FNF spreadsheet report, in cfs, for April 2018 and 2019. Modesto and Turlock Canal daily discharge data were obtained from NWIS because CDEC has not reported daily discharge for the Modesto Canal since April 19th, 2016 and does not have daily discharge for the Turlock Canal. Discharge data for both canals were obtained as daily average flow, in cfs, on NWIS.

Procedure 3: Prioritizes Data from Computing Agencies

For Procedure 3, daily FNF for Tuolumne River was calculated using Equation 3-2. Using Procedure 3, the river GF and all eight-impairment data are taken from Turlock ID's daily FNF spreadsheet reports instead of CDEC or NWIS to try to reproduce daily FNF values posted on CDEC exactly. Table 3-8 identifies each of the nine terms used in Equation 3-2 to estimate daily FNF for April 2018 and 2019 and their data source locations for Procedure 3. For any given day during April 2018 and 2019, all the terms listed below in Table 3-8 were converted to units of cfs and then summed together to calculate the daily FNF for the Tuolumne River in cfs.

Table 3-8: Datasets Used for the Procedure 3 Tuolumne River Daily FNF Calculation (April 2018 and April 2019)

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)	Other Data Source
Tuolumne River below La Grange Dam	Measured Gage Flow (cfs)	-	-	Turlock ID data*
Don Pedro Reservoir	Storage Change (cfs)	-	-	Turlock ID data*
Lake Eleanor Reservoir	Storage Change (cfs)	-	-	Turlock ID data*
Cherry Valley Reservoir	Storage (ac-ft)	-	-	Turlock ID data*
Hetch Hetchy Reservoir	Storage (ac-ft)	-	-	Turlock ID data*
Don Pedro Reservoir	Evaporation (cfs)	-	-	Turlock ID data*
Diversion to S.F. Pipeline	Diversion (cfs)	-	-	Turlock ID data*
Turlock Canal near La Grange, CA	Diversion (cfs)	-	-	Turlock ID data*
Modesto Canal near La Grange, CA	Diversion (cfs)	-	-	Turlock ID data*

Turlock ID data* - not available online and retrieved from daily FNF spreadsheet reports

Procedure 3 replaced the USGS Tuolumne River flow data, used in Procedure 1 and 2, with Turlock ID's Tuolumne flow data. Don Pedro and Lake Eleanor Reservoir daily storage change datasets and Cherry Valley and Hetch Hetchy Reservoir daily storage datasets were extracted from Turlock ID's spreadsheets, in cfs, for April 2018 and 2019; however, the reported values from Turlock ID are identical to the posted values on CDEC. Daily storage change values for Cherry Valley and Hetch Hetchy reservoirs were calculated by subtracting each date's storage amount from the prior date's storage amount, converted to cfs. Data for the diversions (diversion to S.F. Pipeline, Turlock Canal near La Grange, CA, and Modesto Canal near La Grange, CA) and Don Pedro Reservoir evaporation, listed in Table 3-8, replaced available online data with Turlock ID's spreadsheet values accordingly.

3.1.6 Merced River

Equation 3-3 was used to reproduce daily FNF calculations for the Merced River. The Merced River daily FNF equation contains one river GF and two impairment terms for a total of three terms in Equation 3-3. Data for each of the three terms are available online from CDEC and NWIS for April 2018 and 2019. As seen in Table 2-3, Merced River daily FNF is calculated by Merced ID. Procedure 2 was not needed to calculate the daily FNF of Merced River since all necessary data were available online. Procedure 1 and Procedure 3 were needed to understand how the results differ using only data available online versus using only data from daily FNF spreadsheet reports (data not available online).

Merced ID provides DWR-DFM a daily FNF spreadsheet report for the Merced River by a daily email exchange. Merced ID daily FNF spreadsheet reports for April 2018 and April 2019 are presented in Appendix B. Appendix C contains comparison graphs between all the data of the measured gage flow and impairments received by Merced ID and reported on CDEC and NWIS. These comparison graphs present the difference between the same impairment data or measured gage flow data received by Merced ID or reported on CDEC or NWIS. Table 3-9 lists all data sources available online that could be used to reproduce the daily FNF calculation for the Merced River.

Table 3-9: Datasets Available Online for Merced River Daily FNF Calculation

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Merced River below Merced Falls Dam	Measured Gage Flow (cfs)	11270900	MMF - 20
Lake McClure (Exchequer) Reservoir	Storage (ac-ft)	11269500	EXC - 15
Lake McSwain Reservoir	Storage (ac-ft)	11270600	MCS - 15

Procedure 1: Online Data Only

For Procedure 1, daily FNF for the Merced River was calculated using Equation 3-3 with data obtained from NWIS or CDEC. Table 3-10 identifies each of the 3 terms used in Equation 3-3 to estimate daily FNF in April 2018 and 2019, and the data source locations for Procedure 1. For any given day during April 2018 and 2019, all terms listed in Table 3-10 were converted to units of cfs and then summed together to calculate the daily FNF for the Merced River in cfs.

Table 3-10: Datasets Used for the Procedure 1 Merced River Daily FNF Calculation (April 2018 and 2019)

Name	Term Type	NWIS (Site Number)	CDEC (Station ID – Sensor Number)
Merced River below Merced Falls Dam	Measured Gage Flow (cfs)	11270900	-

Lake McClure (Exchequer) Reservoir	Storage (ac-ft)	-	EXC - 15
Lake McSwain Reservoir	Storage (ac-ft)	-	MCS - 15

Merced River discharge data were obtained from NWIS for April 2018 and 2019 to estimate Merced River daily FNF, as stated in the DWR's Unimpaired Runoff Memorandum (Appendix A). The daily average discharge for Merced River was calculated in Excel, because the dataset from NWIS was extracted in hourly intervals and in units of cfs. Lake McClure and Lake McSwain's daily storage data for April 2018 and 2019 were gathered from CDEC since they were not available on NWIS. The daily storage change for these reservoirs was calculated by subtracting each date's storage amount from the prior date's storage amount, in ac-ft, which was then converted into cfs. The average of daily storage change, in cfs, for Lake McSwain was calculated using Excel since the dataset was in intervals of 15-minutes and units in ac-ft.

Procedure 3: Prioritizes Data from Computing Agencies

For Procedure 3, daily FNF for the Merced River was calculated using Equation 3-3. Procedure 3 for the Merced River uses data only from Merced ID for all three terms identified in Table 3-11. Table 3-11 identifies each of the three terms used in Equation 3-3 to estimate daily FNF in April 2018 and 2019 using Procedure 3. For any given day during April 2018 and 2019, all terms listed in Table 3-11 were converted to cfs and then summed together to calculate daily FNF for the Merced River in cfs.

Table 3-11: Datasets Used for the Procedure 3 Merced River Daily FNF Calculation (April 2018 and April 2019)

Name	**Term Type**	**NWIS (Site Number)**	**CDEC (Station ID – Sensor Number)**	**Other Data Sources**
Merced River below Merced Falls Dam	Measured Gage Flow (cfs)	-	-	Merced ID data*
Lake McClure (Exchequer) Reservoir	Storage (ac-ft)	-	-	Merced ID data*
Lake McSwain Reservoir	Storage (ac-ft)	-	-	Merced ID data*

Merced ID data* - not available online and retrieved from daily FNF spreadsheet reports

USGS river GF data were replaced with river GF data from Merced ID's daily spreadsheet report. Method 3 uses Merced ID's April 2018 and 2019 daily storage change values for Lake McSwain and McClure. These values were obtained in ac-ft and then converted to cfs.

3.2 Results

This chapter presents daily FNF reproductions for the Stanislaus, Tuolumne, and Merced Rivers, and compares calculated daily FNF values with daily FNF values posted on CDEC. The calculated daily FNF values and daily FNF values posted on CDEC are presented as time series graphs. The daily FNF values and the calculated discrepancy between the CDEC FNF and the reproduced FNF are presented in tables.

3.2.1 Stanislaus River

Figure 3-1 presents a time series of the Stanislaus River daily FNF values reproduced using Procedure 1 and the Stanislaus River daily FNF values posted on CDEC for the month of April 2018. Similarly, Figure 3-2 presents the same information for the month of April 2019.

Procedure 1 is the procedure used by DWR since Equation 3-1 was confirmed by DWR and it provides a significantly close match to the daily FNF values posted on CDEC. Table 3-12a shows tabulated results for the daily FNF using Procedure 1 and the daily FNF posted on CDEC for the month of April 2018. Table 3-12a also compares these two daily FNF values by reporting the daily discrepancy for each day in the month of April 2018. Similarly, Table 3-12b presents the same information for the month of April 2019. These tables and figures show that the Stanislaus River CDEC FNF values are identical to the reproduced (Procedure 1) daily FNF values for all days during April 2018 and 2019, except on days 2, 3, 6, 8, 9, 10, and 12 in April 2018 and days 11 and 29 in April 2019.

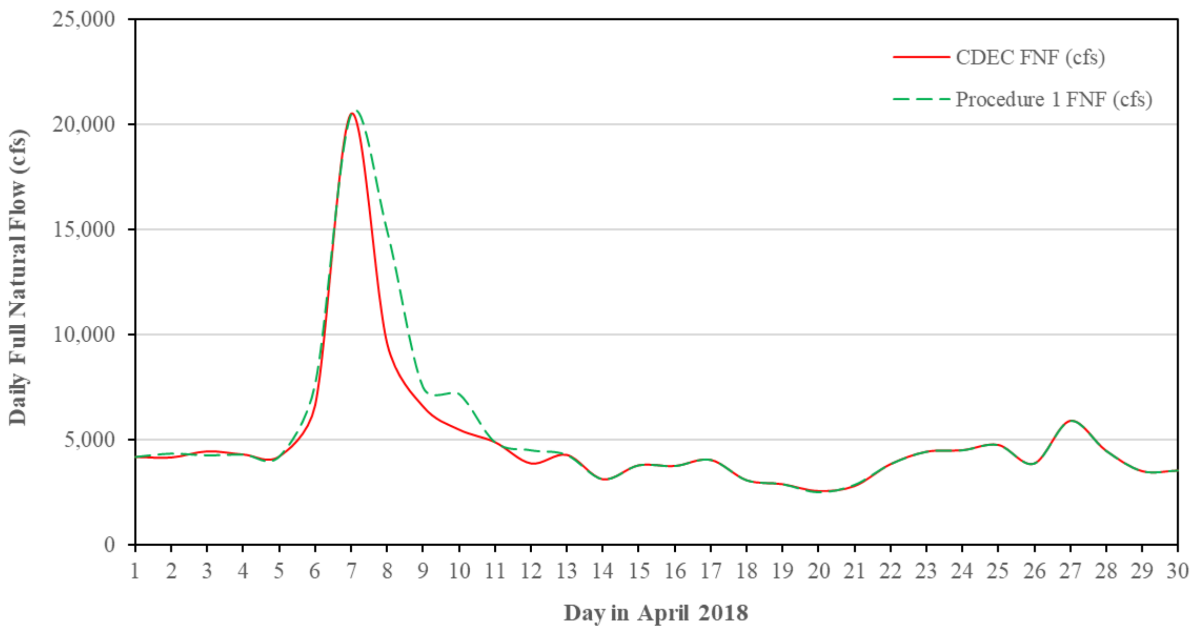


Figure 3-1: CDEC Daily FNF and Reproduced (Procedure 1) Daily FNF for the Stanislaus River at Goodwin Dam, April 2018

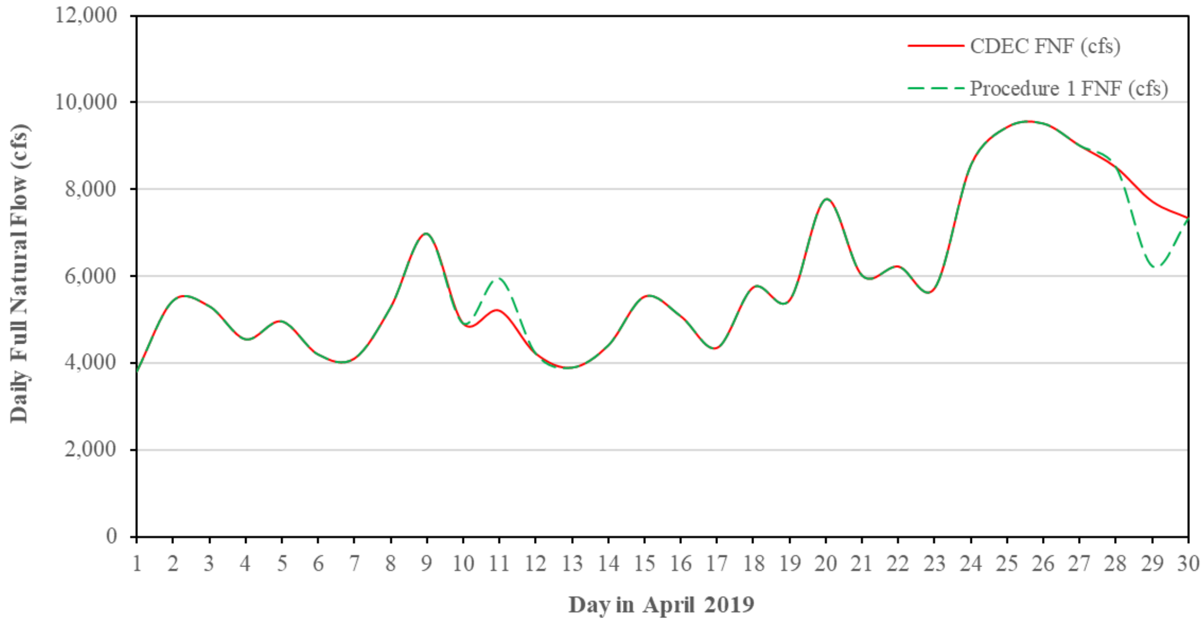


Figure 3-2: CDEC Daily FNF and Reproduced (Procedure 1) Daily FNF for the Stanislaus River at Goodwin Dam, April 2019

Table 3-12a shows that discrepancies between -5,400 cfs and 190 cfs occurred on days 2, 3, 6, 8, 9, 10, and 12 in April 2018. Table 3-12b shows that discrepancies between -750 cfs and 1,490 cfs occurred on days 11 and 29 in April 2019.

Table 3-12a: Comparison of CDEC Daily FNF and Reproduced (Procedure 1) Daily FNF for the Stanislaus River at Goodwin Dam, April 2018

		Reproduced Daily FNF (cfs)	Discrepancy (cfs)
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 1**
4/1/2018	4,221	4,223	-2
4/2/2018	4,196	4,382	-186
4/3/2018	4,487	4,301	186
4/4/2018	4,338	4,338	0
4/5/2018	4,244	4,243	1
4/6/2018	6,682	7,694	-1012
4/7/2018	20,527	20,528	-1
4/8/2018	9,611	14,983	-5372
4/9/2018	6,621	7,539	-918
4/10/2018	5,520	7,222	-1702
4/11/2018	4,924	4,925	-1
4/12/2018	3,914	4,541	-627
4/13/2018	4,316	4,318	-2
4/14/2018	3,163	3,163	0
4/15/2018	3,826	3,826	0
4/16/2018	3,791	3,791	0
4/17/2018	4,083	4,083	0

		Reproduced Daily FNF (cfs)	Discrepancy (cfs)
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 1**
4/18/2018	3,116	3,115	1
4/19/2018	2,926	2,928	-2
4/20/2018	2,604	2,546	58
4/21/2018	2,836	2,893	-57
4/22/2018	3,876	3,876	0
4/23/2018	4,469	4,470	-1
4/24/2018	4,540	4,539	1
4/25/2018	4,793	4,794	-1
4/26/2018	3,908	3,908	0
4/27/2018	5,935	5,936	-1
4/28/2018	4,517	4,517	0
4/29/2018	3,550	3,551	-1
4/30/2018	3,577	3,577	0
Average			-321

Table 3-12b: Comparison of CDEC Daily FNF and Reproduced (Procedure 1) Daily FNF for the Stanislaus River at Goodwin Dam, April 2019

		Reproduced Daily FNF (cfs)	Discrepancy (cfs)
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 1**
4/1/2019	3,819	3,818	1
4/2/2019	5,447	5,446	1
4/3/2019	5,322	5,322	0
4/4/2019	4,564	4,563	1
4/5/2019	4,973	4,974	-1
4/6/2019	4,214	4,214	0
4/7/2019	4,118	4,119	-1
4/8/2019	5,295	5,295	0
4/9/2019	6,988	6,988	0
4/10/2019	4,925	4,925	0
4/11/2019	5,220	5,962	-742
4/12/2019	4,234	4,234	0
4/13/2019	3,911	3,910	1
4/14/2019	4,421	4,422	-1
4/15/2019	5,544	5,543	1
4/16/2019	5,091	5,092	-1
4/17/2019	4,365	4,365	0
4/18/2019	5,758	5,759	-1
4/19/2019	5,461	5,461	0
4/20/2019	7,781	7,781	0
4/21/2019	6,025	6,025	0
4/22/2019	6,234	6,233	1
4/23/2019	5,738	5,737	1

		Reproduced Daily FNF (cfs)	Discrepancy (cfs)
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 1**
4/24/2019	8,574	8,574	0
4/25/2019	9,441	9,441	0
4/26/2019	9,520	9,520	0
4/27/2019	9,011	9,011	0
4/28/2019	8,511	8,511	0
4/29/2019	7,727	6,240	1487
4/30/2019	7,344	7,344	0
Average			25

A possible cause for discrepancies larger than a value of 2 in Table 3-12a could be that the CDEC daily FNF for April 2nd, 2018, April 3rd, 2018, and April 6th, 2018 to April 12th, 2018 are flagged as "revised" values. The large magnitude discrepancies on April 11th, 2019 and April 29th, 2019 could be from the daily storage change of Beardsley and Donnells Reservoirs being reported as zero on CDEC. Both sets of large discrepancies are related to retrospective data corrections by DWR-DFM at times. The retrospective data corrections are only applied to the daily FNF values on CDEC and does not apply to the measured gage flow or impairment terms that are used by DWR-DFM to calculate daily FNF.

A potential refinement for this discrepancy is using the daily storage data (sensor 15) from CDEC for these days. Storage change values (CDEC - sensor 22) were originally used for New Melones, Beardsley, Donnells, Tulloch Reservoir instead storage values (CDEC - sensor 15) since they were provided by DWR as the data source locations for the daily FNF calculation of Stanislaus River. Using storage data instead of storage change data from CDEC provides closer results to the unrevised and provisional CDEC daily FNF values since storage data (sensor 15) are not "revised" or "estimated" like the storage change (sensor 22). All other dates for April and 2018 and 2019 have low discrepancy values since all impairment data values are reported onto CDEC by DWR in real-time and not "revised" later. Overall, the daily FNF calculation for Stanislaus River was reproducible without discrepancies for most days in April 2018 and April 2019 using the FNF equation by inputting datasets that are accessible on CDEC.

3.2.2 Tuolumne River

Figure 3-3 presents a time series of Tuolumne River daily FNF values reproduced using Procedures 1, 2, and 3, and Tuolumne River daily FNF values posted on CDEC for April 2018. Similarly, Figure 3-4 presents the same information for April 2019. As expected, Procedure 3 resulted in an exact match of the daily FNF values posted on CDEC for all days in April 2018 and 2019 (Figures 3-3 and 3-4). This shows that Equation 3-2 is the correct daily equation for reproducing FNF which was confirmed by DWR-DFM.

Tables 3-13a and 3-13b show the Tuolumne River daily FNF values calculated using Procedures 1, 2, and 3, as well as daily FNF posted on CDEC for April 2018 and April 2019, respectively. These tables also compare the daily FNF values posted on CDEC with the reproduced daily FNF values by reporting daily discrepancies between the CDEC FNF values and the reproduced FNF values. Figures

3-3 and 3-4 highlight that FNF values on CDEC exactly match Procedure 3 FNF values, while Procedures 1 and 2 do not provide an exact match.

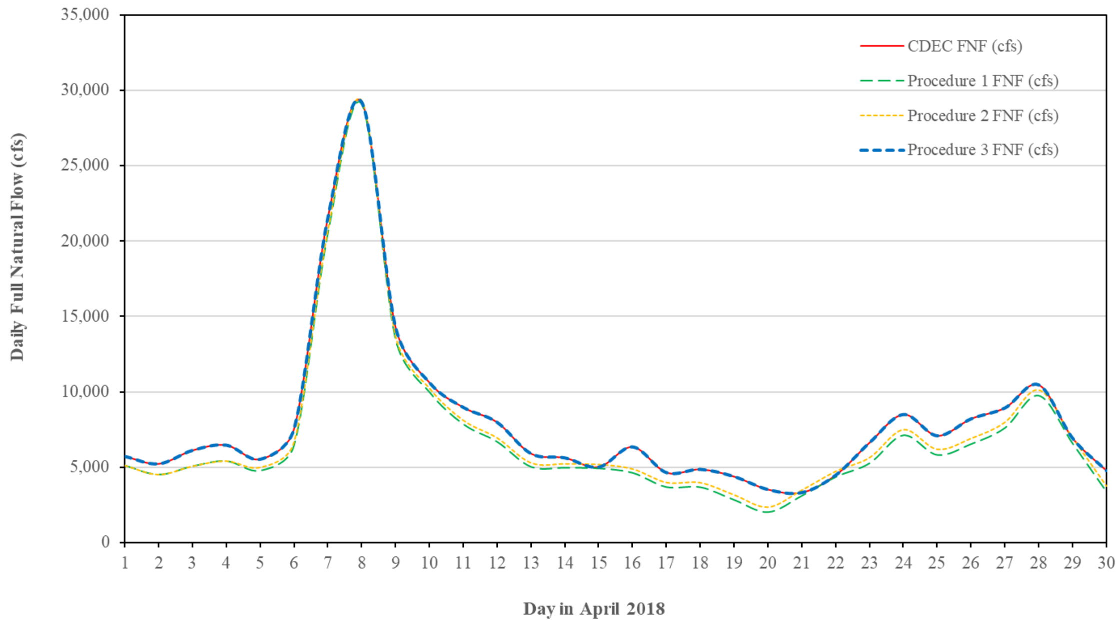


Figure 3-3: CDEC Daily FNF and Reproduced (Procedure 1, 2, and 3) Daily FNF for the Tuolumne River below La Grange Dam, April 2018

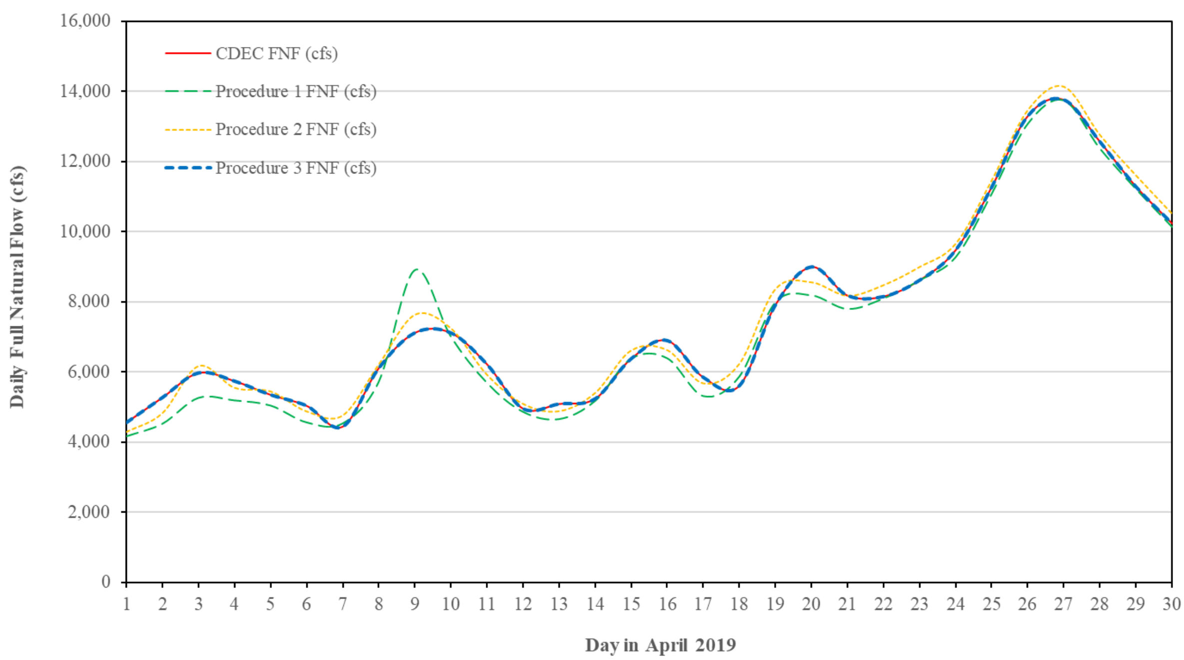


Figure 3-4: CDEC Daily FNF and Reproduced (Procedure 1, 2, and 3) Daily FNF for the Tuolumne River below La Grange Dam, April 2019

Table 3-13a shows the discrepancy values for April 2018 vary between 70 cfs and 1,800 cfs for Procedure 1 and between -270 cfs and 1,500 cfs for Procedure 2. Table 3-13b shows the discrepancy values for April 2019 vary between -1,800 cfs and 850 cfs for Procedure 1 and between -520 cfs and 450 cfs for Procedure 2.

Table 3-13a: Comparison of CDEC Daily FNF and Reproduced (Procedure 1, 2, 3) Daily FNF for the Tuolumne River below La Grange Dam, April 2018

		Reproduced Daily FNF (cfs)			Discrepancy (cfs)		
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 2**	**Procedure 3**	**Procedure 1**	**Procedure 2**	**Procedure 3**
4/1/2018	5,724	5,128	5,128	5,724	596	596	0
4/2/2018	5,225	4,524	4,524	5,225	701	701	0
4/3/2018	6,120	5,077	5,077	6,120	1043	1043	0
4/4/2018	6,467	5,423	5,423	6,467	1044	1044	0
4/5/2018	5,531	4,786	5,000	5,531	745	531	0
4/6/2018	7,529	6,451	6,664	7,529	1078	865	0
4/7/2018	21,562	20,507	20,720	21,562	1055	842	0
4/8/2018	29,237	29,108	29,322	29,237	129	-85	0
4/9/2018	14,306	13,504	13,718	14,306	802	588	0
4/10/2018	10,624	9,998	10,253	10,624	626	371	0
4/11/2018	8,975	7,871	8,126	8,975	1104	849	0
4/12/2018	7,985	6,698	6,959	7,985	1287	1026	0
4/13/2018	5,905	5,039	5,300	5,905	866	605	0
4/14/2018	5,627	4,972	5,234	5,627	655	393	0
4/15/2018	5,010	4,933	5,195	5,010	77	-185	0
4/16/2018	6,352	4,638	4,900	6,352	1714	1452	0
4/17/2018	4,645	3,697	4,000	4,645	948	645	0
4/18/2018	4,860	3,687	3,991	4,860	1173	869	0
4/19/2018	4,381	2,843	3,177	4,381	1538	1204	0
4/20/2018	3,521	2,032	2,367	3,521	1489	1154	0
4/21/2018	3,319	3,115	3,492	3,319	204	-173	0
4/22/2018	4,475	4,364	4,742	4,475	111	-267	0
4/23/2018	6,634	5,272	5,650	6,634	1362	984	0
4/24/2018	8,504	7,127	7,505	8,504	1377	999	0
4/25/2018	7,094	5,827	6,205	7,094	1267	889	0
4/26/2018	8,217	6,547	6,924	8,217	1670	1293	0
4/27/2018	8,940	7,619	7,997	8,940	1321	943	0
4/28/2018	10,464	9,759	10,137	10,464	705	327	0
4/29/2018	6,923	6,581	6,959	6,923	342	-36	0
4/30/2018	4,771	3,383	3,760	4,771	1388	1011	0
Average					947	683	0

Table 3-13b: Comparison of CDEC Daily FNF and Reproduced (Procedure 1, 2, 3) Daily FNF for the Tuolumne River below La Grange Dam, April 2019

		Reproduced Daily FNF (cfs)			Discrepancy (cfs)		
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 2**	**Procedure 3**	**Procedure 1**	**Procedure 2**	**Procedure 3**
4/1/2019	4,551	4,162	4,302	4,551	389	249	0
4/2/2019	5,268	4,523	4,839	5,268	745	429	0
4/3/2019	5,970	5,261	6,176	5,970	709	-206	0
4/4/2019	5,737	5,188	5,560	5,737	549	177	0
4/5/2019	5,346	5,041	5,456	5,346	305	-110	0
4/6/2019	5,033	4,560	4,888	5,033	473	145	0
4/7/2019	4,438	4,532	4,773	4,438	-94	-335	0
4/8/2019	6,106	5,721	6,223	6,106	385	-117	0
4/9/2019	7,115	8,903	7,634	7,115	-1788	-519	0
4/10/2019	7,115	7,010	7,251	7,115	105	-136	0
4/11/2019	6,220	5,690	5,931	6,220	530	289	0
4/12/2019	4,953	4,863	5,104	4,953	90	-151	0
4/13/2019	5,084	4,655	4,894	5,084	429	190	0
4/14/2019	5,232	5,172	5,412	5,232	60	-180	0
4/15/2019	6,376	6,380	6,620	6,376	-4	-244	0
4/16/2019	6,895	6,389	6,630	6,895	506	265	0
4/17/2019	5,846	5,311	5,687	5,846	535	159	0
4/18/2019	5,603	5,868	6,239	5,603	-265	-636	0
4/19/2019	7,910	7,985	8,364	7,910	-75	-454	0
4/20/2019	8,997	8,184	8,560	8,997	813	437	0
4/21/2019	8,180	7,795	8,177	8,180	385	3	0
4/22/2019	8,152	8,097	8,479	8,152	55	-327	0
4/23/2019	8,618	8,615	8,996	8,618	3	-378	0
4/24/2019	9,477	9,273	9,653	9,477	204	-176	0
4/25/2019	11,278	11,084	11,460	11,278	194	-182	0
4/26/2019	13,305	13,078	13,454	13,305	227	-149	0
4/27/2019	13,770	13,743	14,123	13,770	27	-353	0
4/28/2019	12,574	12,372	12,752	12,574	202	-178	0
4/29/2019	11,288	11,219	11,600	11,288	69	-312	0
4/30/2019	10,242	10,138	10,514	10,242	104	-272	0
Average					196	-103	0

Procedure 1 mostly results in lower Tuolumne River daily FNF estimates than FNF values posted on CDEC for April 2018 and 2019 because diversions to S.F. pipeline were replaced with values of zero. Procedure 2 results in mostly lower estimates than the daily FNF posted on CDEC for April 2018 as opposed to April 2019 resulting in mainly higher estimates. In Table 3-13a and 3-13b, the daily discrepancy values of 0 suggests that Procedure 3 is used by Turlock ID for calculating their daily FNF.

A potential refinement to minimize discrepancies is using the daily storage data (sensor 15) from CDEC since it contains closer values to Turlock ID's daily spreadsheet report storage data, as seen in Appendix C. Procedure 3 results show that the Tuolumne River daily spreadsheet reports produce an exact match with daily FNF posted on CDEC for April 2018 and April 2019. In general, the discrepancy values observed using Procedures 1 and 2 to reproduce daily FNF could be caused by retrospective data correction by USGS on NWIS and Procedure 1 lacking an input dataset for the S.F. pipeline diversion.

3.2.3 Merced River

Figures 3-5 and 3-6 present time series of Merced River daily FNF reproduced using Procedures 1 and 3 and daily FNF posted on CDEC for April 2018 and April 2019. As expected, Procedure 3 resulted in an exact match with daily FNF values posted on CDEC except for April 30th, 2019 (Figures 3-5 and 3-6). This suggests that Equation 3-3 is the correct daily equation for reproducing FNF, though this equation was not confirmed by Merced ID or DWR-DFM staff.

Tables 3-14a and 3-14b show the Merced River daily FNF values calculated using Procedures 1 and 3, as well as daily FNF values posted on CDEC for April 2018 and April 2019, respectively. These tables also compare Procedures 1 and 3 reproduced daily FNF values to the daily FNF values posted on CDEC by reporting daily discrepancies. Figures 3-5 and 3-6 highlight that the FNF values on CDEC exactly match the Procedure 3 FNF values, while Procedure 1 does not provide an exact match for most of the study period. Also, Figure 3-5's daily FNF values for Procedure 1 appear to be closer to the CDEC FNF value than Figure 3-6's daily FNF for Procedure 1 with average discrepancies of --36 and -68 cfs, respectively.

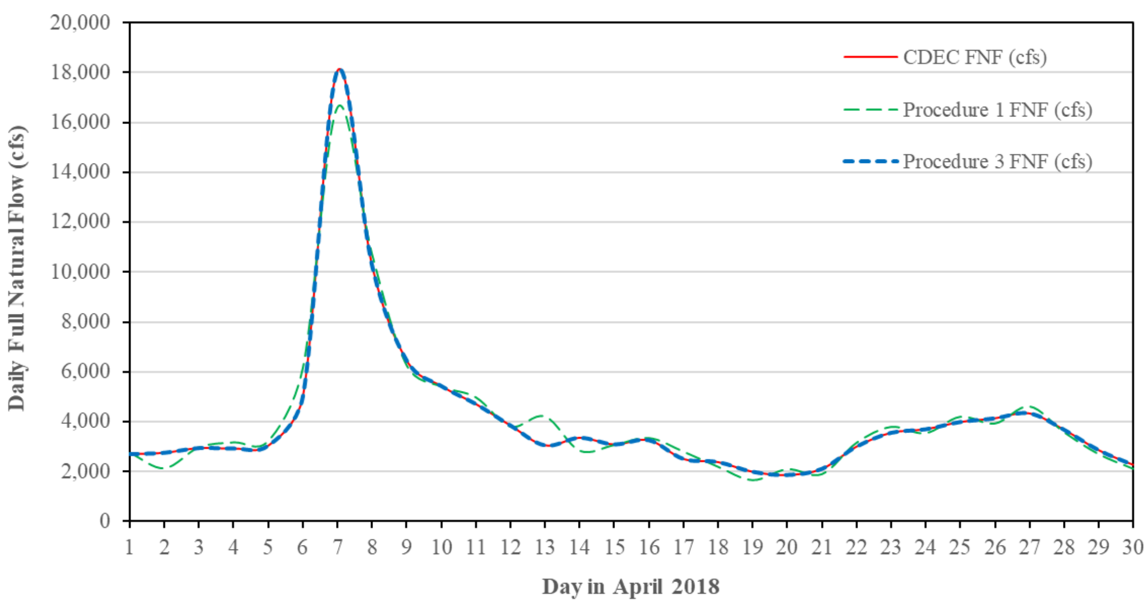


Figure 3-5: CDEC Daily FNF and Reproduced (Procedures 1 and 3) Daily FNF for the Merced River below Merced Falls Dam, April 2018

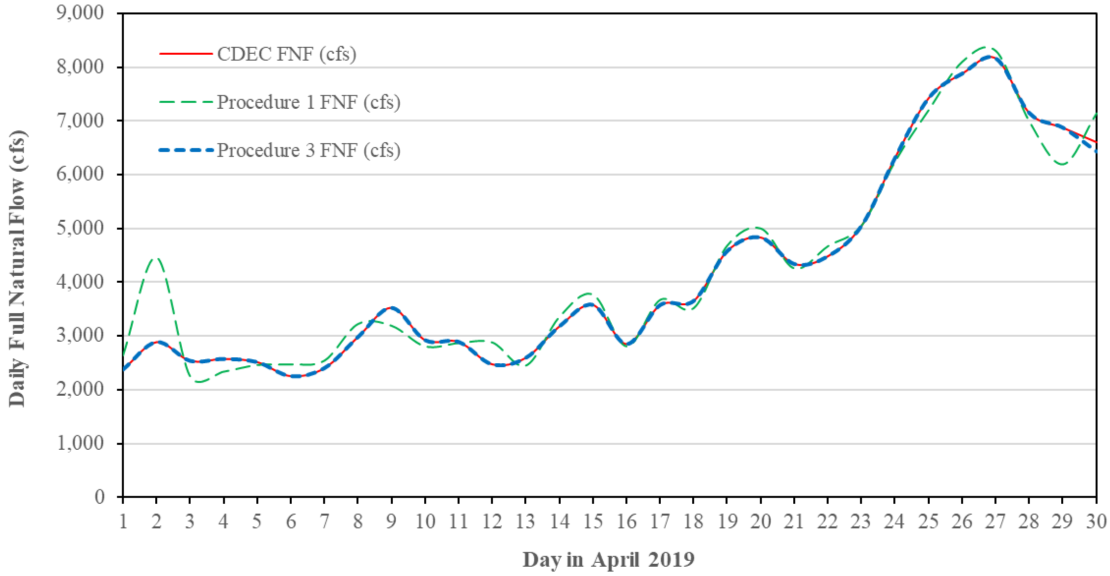


Figure 3-6: CDEC Daily FNF and Reproduced (Procedures 1 and 3) Daily FNF for the Merced River below Merced Falls Dam, April 2019

Table 3-14a shows discrepancy values for April 2018 varying between -1,200 cfs and 1,500 cfs for Method 1, averaging -36 cfs. Table 3-14b shows that the discrepancy values for April 2019 vary between -1,600 cfs and 700 cfs for Procedure 1, with an average discrepancy of 68 cfs. For Procedure 3, the discrepancies are less than 1 cfs for all days during April 2018 and April 2019, except for April 30th, 2019.

Table 3-14a: Comparison of CDEC Daily FNF and Reproduced (Procedures 1 and 3) Daily FNF for the Merced River below Merced Falls Dam, April 2018

		Reproduced Daily FNF (cfs)		Discrepancy (cfs)	
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 3**	**Procedure 1**	**Procedure 3**
4/1/2018	2,703	2,774	2,703	-71	0
4/2/2018	2,759	2,155	2,758	604	1
4/3/2018	2,948	2,996	2,947	-48	1
4/4/2018	2,929	3,191	2,929	-262	0
4/5/2018	3,044	3,247	3,044	-203	0
4/6/2018	5,005	6,163	5,005	-1158	0
4/7/2018	18,085	16,606	18,085	1479	0
4/8/2018	10,271	10,724	10,271	-453	0
4/9/2018	6,462	6,275	6,462	187	0
4/10/2018	5,435	5,431	5,435	4	0
4/11/2018	4,715	4,995	4,715	-280	0
4/12/2018	3,853	3,822	3,853	31	0
4/13/2018	3,052	4,230	3,052	-1178	0
4/14/2018	3,359	2,858	3,359	501	0
4/15/2018	3,093	3,084	3,093	9	0

		Reproduced Daily FNF (cfs)		Discrepancy (cfs)	
Date	CDEC Daily FNF (cfs)	Procedure 1	Procedure 3	Procedure 1	Procedure 3
4/16/2018	3,262	3,367	3,262	-105	0
4/17/2018	2,509	2,821	2,509	-312	0
4/18/2018	2,384	2,215	2,384	169	0
4/19/2018	1,996	1,680	1,996	316	0
4/20/2018	1,866	2,119	1,866	-253	0
4/21/2018	2,110	1,919	2,111	191	-1
4/22/2018	3,001	3,171	3,001	-170	0
4/23/2018	3,557	3,810	3,557	-253	0
4/24/2018	3,702	3,559	3,701	143	1
4/25/2018	3,993	4,217	3,993	-224	0
4/26/2018	4,140	3,947	4,140	193	0
4/27/2018	4,338	4,632	4,338	-294	0
4/28/2018	3,682	3,598	3,682	84	0
4/29/2018	2,861	2,724	2,861	137	0
4/30/2018	2,275	2,135	2,275	140	0
Average				-36	0

Table 3-14b: Comparison of CDEC Daily FNF and Reproduced (Procedures 1 and 3) Daily FNF for the Merced River below Merced Falls Dam, April 2019

		Reproduced Daily FNF (cfs)		Discrepancy (cfs)	
Date	CDEC Daily FNF (cfs)	Procedure 1	Procedure 3	Procedure 1	Procedure 3
4/1/2019	2,375	2,632	2,375	-257	0
4/2/2019	2,886	4,457	2,886	-1571	0
4/3/2019	2,537	2,243	2,537	294	0
4/4/2019	2,572	2,329	2,573	243	-1
4/5/2019	2,513	2,453	2,514	60	-1
4/6/2019	2,253	2,465	2,253	-212	0
4/7/2019	2,402	2,534	2,403	-132	-1
4/8/2019	2,981	3,217	2,981	-236	0
4/9/2019	3,522	3,185	3,521	337	1
4/10/2019	2,922	2,800	2,922	122	0
4/11/2019	2,891	2,861	2,890	30	1
4/12/2019	2,472	2,875	2,472	-403	0
4/13/2019	2,594	2,443	2,594	151	0
4/14/2019	3,179	3,351	3,179	-172	0
4/15/2019	3,575	3,765	3,575	-190	0
4/16/2019	2,849	2,802	2,849	47	0
4/17/2019	3,574	3,667	3,574	-93	0
4/18/2019	3,653	3,513	3,653	140	0
4/19/2019	4,579	4,680	4,579	-101	0

		Reproduced Daily FNF (cfs)		Discrepancy (cfs)	
Date	**CDEC Daily FNF (cfs)**	**Procedure 1**	**Procedure 3**	**Procedure 1**	**Procedure 3**
4/20/2019	4,828	4,997	4,828	-169	0
4/21/2019	4,336	4,252	4,336	84	0
4/22/2019	4,483	4,668	4,483	-185	0
4/23/2019	5,049	5,051	5,048	-2	1
4/24/2019	6,315	6,251	6,315	64	0
4/25/2019	7,423	7,206	7,423	217	0
4/26/2019	7,877	8,104	7,877	-227	0
4/27/2019	8,156	8,302	8,155	-146	1
4/28/2019	7,139	6,985	7,138	154	1
4/29/2019	6,868	6,193	6,868	675	0
4/30/2019	6,600	7,144	6,426	-544	174
Average				-68	6

A possible cause for discrepancies larger than a value of one in Table 3-14b could be that the CDEC daily FNF for April 30th, 2019 is flagged as an "estimated" value. This discrepancy is related to retrospective data corrections by DWR-DFM at times. The retrospective data correction is only applied to the daily FNF values on CDEC and not apply to the measured gage flow or impairment terms used by DWR-DFM to calculate daily FNF. This data correction to only the CDEC daily FNF value makes the GF and impairment data on the daily FNF spreadsheet report for Merced ID outdated.

3.3 Summary

Two primary challenges in replicating daily FNF calculations for April 2018 and 2019 were lack of public access to the daily FNF equations, and availability of unrevised source data for daily FNF computations.

Although daily FNF equations are based on monthly FNF equations that are publicly available, daily FNF equations are not published in DWR's Unimpaired Runoff Memorandum. Therefore, to reproduce daily FNF for the Stanislaus, Tuolumne, and Merced Rivers, one must infer the equation and/or confirm the equation with DWR-DFM, which creates a barrier to overall daily FNF reproducibility.

Additionally, the results of the April 2018/2019 analysis show that it is more difficult to accurately reproduce the daily FNF calculation for the Tuolumne River than for the Stanislaus and Merced Rivers because all datasets needed to reproduce the daily FNF for the Stanislaus and Merced Rivers are available online. Although, only one dataset that is needed to reproduce daily FNF for the Tuolumne River is not available online (Diversion to S.F pipeline), the exclusion of this dataset from the daily FNF computation causes the Tuolumne Procedure 1 computation to consistently underestimate daily FNF values.

Also, for the Tuolumne daily FNF computation, Procedure 1 consistently had larger and more frequent discrepancies than Procedures 2 and 3, where Procedure 3 provided a perfect reproduction.

Similarly, Procedure 3 provided a better reproduction than Procedure 1 for the Merced daily FNF computation. This indicates that availability of unrevised source data (provided by the daily FNF spreadsheet reports) improves computation reproducibility. Since most data from daily FNF spreadsheet reports are recorded onto CDEC (S. DeGuzman, personal communication, August 14, 2019), and since GF and impairments values are not updated retrospectively, discrepancies in the Procedures 1 and 2 computations (where applicable) are likely caused by retrospective revisions to daily FNF data posted online.

Finally, from this exercise, the following additional observations are made:

- Reservoir storage change for some (not all) upstream reservoirs are included in FNF calculations.
- Using daily storage change data from CDEC (sensor 22) instead of storage data (sensor 15) results in a worse reproduction of daily FNF. This was found for Beardsley, Donnells and Tulloch Reservoirs on Stanislaus River, and Don Pedro Reservoir on Tuolumne River.

Chapter 4

Summary of the Reproduction of DWR Daily FNF Calculations: WY 2009-2019

Chapter 4 provides a closer examination of the reproducibility of daily FNF estimates for the Stanislaus, Tuolumne, and Merced Rivers with metrics, statistical tests, and plots to assess any seasonal or annual trends within the Water Year (WY) 2009-2019. From the two-month analysis, in Chapter 3, a better understanding of the complexity and challenges that come with reproducing daily FNF was found and highlighted the need for an expanded and closer examination of the reproducibility of daily FNF calculations. This chapter outlines the generalized procedure for reproducing daily FNF and summarizes the main findings for an 11-year study. This study is further discussed in Pulido et al. (2020).

4.1 Procedures

Equations 3-1 through 3-3 and Procedures 1 through 3 (see Chapter 3.1.3) were used to reproduce the historical daily FNF for WY 2009-2019 for the Stanislaus, Tuolumne, and Merced Rivers. Similarly, to Chapter 3, the comparison between the results for Procedures 1 and 2 provides insight on how online data availability impacts daily FNF reproducibility. The comparison between Procedures 2 and 3 show how differences between online and computer agency data change reproducibility.

The data availability for the Stanislaus, Tuolumne, and Merced Rivers vary and are not similar to the data availability in Chapter 3. Daily FNF spreadsheet reports for the Tuolumne and Merced Rivers were not available for this expanded study. Turlock ID did provide a complete record of computing agency data for the GF and the eight impairments of the Tuolumne FNF calculation for WY 2009-2019. For the Stanislaus River, only Procedure 1 was reproduced using Equation 3-1 since all data are available online and additional computing agency data do not exist. Procedures 1, 2, and 3 were reproduced using Equation 3-2 for the daily FNF calculation of Tuolumne River since data are available online and additional computing agency data was provided by Turlock ID. For the Merced River, only Procedure 1 was reproduced since all data are available online and additional computing agency data was not provided by Merced ID.

In this 11-year study, a generalized procedure was established to fill data gaps consistently, although the authors noted that daily FNF computation reproducibility could be improved by investigating river-specific data management practices. A challenge that this study came across was deciding if using the GF or impairment dataset from NWIS was better than using CDEC data to reproduce daily FNF estimates. So, a second generalized procedure was created to determine what combination of online data sources provides the best reproduction of FNF. One more generalized procedure was developed to provide an overview of the procedures used for reproducing the daily FNF estimates. This procedure included confirming the daily FNF equation, extracting all relevant GF and impairment data, formatting the data for analysis (i.e., filling gaps), identifying the best data sources, calculating daily FNF, and lastly computing performance metrics and reproducibility tests for comparison between results. Performance metrics and reproducibility tests are discussed further in Pulido et al. (2020).

4.2 Summary of Results

The Stanislaus, Tuolumne, and Merced daily FNF calculations were found to be largely reproducible for WY 2009-2019, though there were two seasonal and annual trends. Seasonally and for drier years, overall reproducibility decreased when flow is low. Also, during the summer and/or fall of the WY 2013-2015 drought, all daily FNF computations were not sufficiently repeatable. Another important finding was that overall computational reproducibility is not significantly impacted by high-magnitude discrepancies. This was seen for WY 2017 where the daily discrepancies were largest in magnitude, but the reproducibility tests indicated that no computations were insufficiently repeatable.

Lastly, performance metric comparisons between Procedures 1, 2, and 3 for Tuolumne River highlighted that access to unrevised daily FNF source data is key to reproducing accurate daily FNF calculations. Procedure 1 for the Tuolumne River was determined to be the worst reproduction of daily FNF out of all five computation procedures within the 11-year study. Also, in the two most recent water years (i.e. WY 2018-2019), Procedures 1 and 2 were significantly outperformed by Procedure 3 for the Tuolumne River since the computing agency data provided by Turlock ID were provisional for the last two water years. This indicates that the reproducibility of the Tuolumne daily FNF computation decreases for WY 2009-2017 from retrospective revisions made by Turlock ID.

Chapter 5

Conclusion

This study came across many logistical obstacles that made reproducing the daily FNF estimates for the Stanislaus, Tuolumne, and Merced Rivers challenging and complex. Reproducing daily FNF includes confirming the mass balance daily FNF equation, procuring relevant data (i.e. online or computing agency data), and lastly deciding what combination of data sources provide the best daily FNF reproduction for each river. Each step is challenging for the following reasons:

1. Finding the exact state or regional agency that can confirm the daily FNF equation, since DWR-DFM does not always know the exact daily FNF equation used by computing agencies.
2. Connecting with the state or regional agency, themselves, to provide guidance to overcome any challenges from reproducing daily FNF (i.e. understanding data availability and revisions).
3. Identifying and extracting provisional data in an accessible format (such as daily FNF spreadsheet reports) from computing agencies to directly compute daily FNF estimates.

Even if these obstacles are overcome, this analysis showed that the reproduction of daily FNF estimates are not always completely reliable as seen during droughts with low flow. In the near future, the reproducibility of the daily FNF computation for the Tuolumne River may improve by DWR-DFM becoming the FNF computing agency for this river. DWR-DFM intends to get approval from Turlock ID to make all data used in FNF computations available on CDEC, and to assume the role of calculating daily FNF for the Tuolumne River (S. Nemeth, personal communication, February 28, 2019). Though, even with these changes, it is still possible for daily FNF estimates computed by DWR-DFM (i.e. Stanislaus River daily FNF) to not be completely reproducible due to retrospective revisions to daily FNF values. As seen in Chapter 3, daily FNF values may be revised at a later date and the unrevised daily FNF values that are based on provisional GF and impairment data may not have been retained by any state or regional agency in an accessible format. These retrospective revisions can happen vice versa also where GF and impairment data are revised and not the corresponding daily FNF values. Provisional data are important for confirming reproduced daily FNF estimates.

Therefore, to improve overall reproducibility of daily FNF values, the following refinements are proposed for consideration:

1. Publish daily FNF equations for public view in coordination with DWR-DFM, potentially posted on CDEC.
2. Retain provisional daily FNF, GF, and impairment data in a publicly accessible format.

Lastly, further research on the reproduction of daily FNF could investigate how the use of provisional data affects the computation of daily FNF, and if this impact is substantial enough to affect the implementation of minimum flow requirements based on daily FNF computations.

Appendices

A Excerpts from DWR's 2016 Revised Report

Tuolumne River above La Grange Dam (Inflow to New Don Pedro Reservoir)

The computations begin with the measured flow at the USGS station No. 1128965 "Tuolumne River below La Grange Dam" and add:

1. Diversions by the City and County of San Francisco through the Hetch Hetchy Aqueduct.
2. Change in storage at Hetch Hetchy, Lake Eleanor, and Lake Lloyd (Cherry Valley) reservoirs.
3. Estimated net evaporation of 2.0 feet per year at Hetch Hetchy, Lake Eleanor, and Lake Lloyd based on surface area. This is summed from daily computations based on a fixed monthly rate and combined surface reservoir area.
4. Change in storage at New Don Pedro Reservoir beginning in November 1970 and at the Old Don Pedro Reservoir prior to then.
5. Evaporation at Don Pedro reservoir, estimated at 50.2 inches per year net, computed from daily reservoir area and an average monthly rate, varying by month.
6. Diversion into Modesto and Turlock Canals near La Grange.

The natural flows at La Grange Dam are computed by Turlock Irrigation District and provided to DWR.

Merced River below Merced Falls Dam (Inflow to Lake McClure)

Computed unimpaired flows start with measured flow at the above station, USGS No. 1127090, and add:

1. Diversions in the North Side Canal.
2. Change in storage at Lake McClure (Exchequer), enlarged in 1967, and McSwain Reservoir.
3. Estimated monthly average evaporation at Lake McClure and McSwain.

Estimated annual evaporation is 22.45 TAF and is listed below, by month, in 1000 AF:

October	1.55	April	1.60
November	1.00	May	2.60
December	.60	June	3.25
January	.50	July	3.85
February	.70	August	3.30

March	1.30	September	2.20

Stanislaus River below Goodwin Dam, near Knights Ferry

Computations begin with the USGS gage No. 113020 of the same name which has been operated since 1957.

To the observed flow are added Tuolumne Canal near Long Barn, Oakdale Canal, and South San Joaquin Canal diversions. (Diversions to the CVP contractors in eastern San Joaquin County via the new Stockton East tunnel at Goodwin Dam are currently being made and included, but did not start until after 1994.)

Adjust for change in storage at New Melones (Old Melones prior to November 1978) Relief, Strawberry, Lyons, Donnell, Beardsley,Tulloch, Spicer Meadows (since 1989) and, prior to 1989, the Utica system reservoirs. The Utica system includes Lake Alpine (4.1 TAF) and Union (3.1 TAF) Reservoirs and also the old 4 TAF capacity Spicer Meadows reservoir. When the Utica System was accounted for, the storage change for a month was considered the same each year as follows: Units are 1000 AF:

October	-3.2	April	11.6
November	-0.8	May	0
December	0	June	- 1.7
January	0	July	- 3.0
February	0	August	- 2.0
March	0	September	- 0.9

The estimated evaporation from New Melones Reservoir is added. Prior to completion of New Melones Reservoir an estimate of monthly evaporation was used which was based on a curve of storage versus evaporation.

B Turlock ID and Merced ID Daily Full Natural Flow Spreadsheet Reports, April 2018 and April 2019

Table B-1: Turlock ID's daily FNF spreadsheet report for April 2018

Note from Pulido: This is combined reported data created by Pulido that was managed by Turlock Irrigation District which was collected from CDWR-DFM.

Tuolumne River Report (Information Given to Department of Water Resources)

All Data Are For

	4/30/2018 Monday	4/29/2018 Sunday	4/28/2018 Saturday	4/27/2018 Friday	4/26/2018 Thursday	4/25/2018 Wednesday	4/24/2018 Tuesday	4/23/2018 Monday	4/22/2018 Sunday	4/21/2018 Saturday	4/20/2018 Friday	4/19/2018 Thursday	4/18/2018 Wednesday	4/17/2018 Tuesday	4/16/2018 Monday
Don Pedro															
DP Elevation (Feet)	818.12	817.67	817.16	816.64	816.56	816.53	815.99	815.52	815.45	815.19	814.97	814.77	814.63	814.45	814.26
Storage (AF)	1,880,262	1,875,382	1,869,296	1,862,012	1,862,012	1,860,800	1,854,751	1,848,716	1,847,511	1,845,103	1,842,697	1,840,294	1,837,893	1,835,494	1,834,296
Gain/(-Loss) cfs	2,460	3,068	3,672	-	611	3,050	3,043	608	1,214	1,213	1,212	1,211	1,209	604	1,810
Flow Below Dam (cfs)	3,876	3,811	3,676	3,588	3,538	3,232	3,470	2,647	1,415	1,335	1,657	2,344	2,499	2,672	3,548
TID Canal (cfs)	1,004	1,567	1,806	1,658	1,716	1,345	1,395	1,628	960	695	736	986	821	634	1,056
MID Canal (cfs)	611	606	603	605	555	472	353	236	237	187	108	111	114	115	116
River (cfs)	2,261	1,639	1,266	1,325	1,267	1,415	1,722	782	218	453	813	1,246	1,564	1,922	2,376
Total (cfs)	3,876	3,811	3,676	3,588	3,538	3,232	3,470	2,647	1,415	1,335	1,657	2,344	2,499	2,672	3,548
Inflow (cfs)	6,336	6,880	7,348	3,588	4,150	6,282	6,513	3,254	2,629	2,548	2,869	3,554	3,709	3,276	5,358
Computed Natural Flow (cfs)	4,771	6,923	10,464	8,940	8,217	7,094	8,504	6,634	4,475	3,319	3,521	4,381	4,860	4,645	6,352
Hetch Hetchy Reservoir															
Elevation (Feet)	3,787.6	3,789.5	3,790.3	3,788.7	3,784.8	3,782.0	3,783.3	3,783.5	3,782.1	3,781.7	3,782.0	3,782.2	3,782.3	3,782.4	3,782.4
Storage (AF)	324,720.0	328,345.0	329,873.0	326,817.0	319,412.0	314,130.0	316,577.0	316,955.0	314,318.0	313,566.0	314,130.0	314,506.0	314,694.0	314,882.0	314,882.0
Gain/(-Loss) cfs	(1,828)	(770)	1,541	3,733	2,663	(1,234)	(191)	1,329	379	(284)	(190)	(95)	(95)	-	(569)
Release (cfs)	4,444	4,453	3,288	1,030	1,748	5,219	3,526	1,424	1,424	1,425	1,427	1,653	1,891	1,991	2,795
Inflow (cfs)	2,616	3,683	4,829	4,763	4,411	3,985	3,335	2,753	1,803	1,141	1,237	1,558	1,796	1,991	2,226
Cherry Valley Reservoir															
Elevation (Feet)	4,662.4	4,662.3	4,661.7	4,660.4	4,659.2	4,658.2	4,656.4	4,654.6	4,652.9	4,651.7	4,650.9	4,650.2	4,649.5	4,648.4	4,647.2
Storage (AF)	205,002.0	204,839.0	203,863.0	201,747.0	199,824.0	198,234.0	195,372.0	192,510.0	189,807.0	187,899.0	186,627.0	185,514.0	184,421.0	182,715.0	180,855.0
Gain/(-Loss) cfs	82	492	1,067	970	802	1,443	1,443	1,363	962	641	561	551	860	938	1,173
Release (cfs)	981	980	980	979	612	81	59	59	60	61	52	49	51	51	51
Inflow (cfs)	1,063	1,472	2,047	1,949	1,414	1,524	1,502	1,422	1,022	702	613	600	911	989	1,224
Lake Eleanor Reservoir															
Elevation (Feet)	4,656.2	4,656.7	4,656.9	4,656.7	4,656.2	4,655.8	4,655.4	4,654.7	4,654.1	4,653.9	4,653.9	4,654.1	4,654.1	4,654.0	4,653.8
Storage (AF)	22,611.0	23,076.0	23,262.0	23,076.0	22,611.0	22,239.0	21,867.0	21,224.0	20,683.0	20,503.0	20,503.0	20,683.0	20,683.0	20,593.0	20,412.0
Gain/(-Loss) cfs	(234)	(94)	94	234	188	188	324	273	91	-	(91)	-	45	91	91
Release (cfs)	495	521	486	254	242	255	180	179	179	189	247	248	248	213	283
Inflow (cfs)	261	427	580	488	430	443	504	452	270	189	156	248	293	304	374
Diversion to S.F. Pipeline (cfs)	377	377	377	377	377	377	377	377	377	377	334	334	303	303	261
Rain Fall (Inches)															
Hetch Hetchy	-	-	-	-	-	-	-	-	-	-	-	-	-	0.44	0.70
Cherry Valley	-	-	-	-	-	-	-	-	-	-	-	-	-	0.25	0.39
Moccasin	-	-	-	-	-	-	-	-	-	-	-	-	-	0.20	0.12
Sonora	-	-	-	-	-	-	-	-	-	-	-	-	-	0.84	0.20
Yosemite	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24	0.46
Don Pedro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Area (acres)															
Hetch Hetchy Reservoir	1901.9	1909.1	1912.1	1906.1	1891.2	1880.6	1885.5	1886.3	1881	1879.5	1880.6	1881.4	1881.7	1882.1	1882.1
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cherry Valley Reservoir	1618.4	1618.1	1616	1611.4	1606.8	1602.8	1595.6	1588.4	1581.6	1576.8	1573.6	1570.8	1568.1	1563.8	1559.1
	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
Lake Eleanor Reservoir	922.4	925.4	926.7	925.4	922.4	920	917.5	913.9	911.5	910.7	910.7	911.5	911.5	911.1	910.3
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCSF TOTAL EVAPORATIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Don Pedro Evaporation															
Surface Area (acres)	12213	12188	12158	12121	12121	12115	12084	12054	12047	12035	12023	12011	11999	11986	11980
Evaporation (cfs)	38	38	37	37	37	37	37	37	37	37	37	37	37	37	37

	4/15/2018 Sunday	4/14/2018 Saturday	4/13/2018 Friday	4/12/2018 Thursday	4/11/2018 Wednesday	4/10/2018 Tuesday	4/9/2018 Monday	4/8/2018 Sunday	4/7/2018 Saturday	4/6/2018 Friday	4/5/2018 Thursday	4/4/2018 Wednesday	4/3/2018 Tuesday	4/2/2018 Monday	4/1/2018 Sunday
Don Pedro															
DP Elevation (Feet)	814.04	813.71	813.23	812.88	812.50	812.05	811.37	810.66	809.75	808.17	808.13	808.46	808.87	809.33	809.76
Storage (AF)	1,830,705	1,827,119	1,821,154	1,817,583	1,812,830	1,806,902	1,799,808	1,791,560	1,780,998	1,762,338	1,761,177	1,765,826	1,770,484	1,775,151	1,780,998
Gain/(-Loss) cfs	1,808	3,007	1,800	2,396	2,989	3,577	4,158	5,325	9,408	585	(2,344)	(2,348)	(2,353)	(2,948)	(1,772)
Flow Below Dam (cfs)	3,466	2,975	3,824	4,147	4,371	3,847	4,138	4,341	4,306	5,517	6,269	6,378	6,168	5,996	5,574
TID Canal (cfs)	848	355	742	875	941	453	702	902	230	529	1,306	1,406	1,184	981	602
MID Canal (cfs)	117	116	117	117	302	250	332	332	336	339	338	339	338	339	340
River (cfs)	2,500	2,503	2,965	3,156	3,127	3,144	3,104	3,107	3,740	4,650	4,624	4,633	4,646	4,676	4,632
Total (cfs)	3,466	2,975	3,824	4,147	4,371	3,847	4,138	4,341	4,306	5,517	6,269	6,378	6,168	5,996	5,574
Inflow (cfs)	5,274	5,982	5,624	6,544	7,359	7,424	8,296	9,666	13,714	6,103	3,925	4,030	3,815	3,048	3,802
Computed Natural Flow (cfs)	5,010	5,627	5,905	7,985	8,975	10,624	14,306	29,237	21,562	7,529	5,531	6,467	6,120	5,225	5,724
Hetch Hetchy Reservoir															
Elevation (Feet)	3,783.0	3,784.5	3,786.0	3,787.0	3,787.2	3,787.5	3,786.8	3,784.0	3,772.8	3,770.0	3,770.2	3,770.3	3,769.8	3,769.0	3,768.3
Storage (AF)	316,010.0	318,845.0	321,680.0	323,580.0	323,960.0	324,530.0	323,200.0	317,900.0	296,992.0	291,840.0	292,208.0	292,392.0	291,474.0	290,010.0	288,729.0
Gain/(-Loss) cfs	(1,429)	(1,429)	(958)	(192)	(287)	671	2,672	10,541	2,597	(186)	(93)	463	738	646	461
Release (cfs)	3,430	3,452	3,456	3,371	4,278	4,282	3,765	3,007	2,540	2,098	1,865	847	816	816	837
Inflow (cfs)	2,001	2,023	2,498	3,179	3,991	4,953	6,437	13,548	5,137	1,912	1,772	1,310	1,554	1,462	1,298
Cherry Valley Reservoir															
Elevation (Feet)	4,645.7	4,644.3	4,642.9	4,641.4	4,639.5	4,637.2	4,634.2	4,630.7	4,623.1	4,618.1	4,615.9	4,613.7	4,611.0	4,608.9	4,606.7
Storage (AF)	178,529.0	176,358.0	174,187.0	171,862.0	168,936.0	165,462.0	160,930.0	155,643.0	144,467.0	137,215.0	134,083.0	130,950.0	127,105.0	124,155.0	121,104.0
Gain/(-Loss) cfs	1,095	1,095	1,172	1,475	1,751	2,285	2,666	5,635	3,656	1,579	1,580	1,939	1,487	1,538	1,469
Release (cfs)	53	51	57	51	50	118	294	292	212	52	54	135	60	64	51
Inflow (cfs)	1,148	1,146	1,229	1,526	1,801	2,403	2,960	5,927	3,868	1,631	1,634	2,074	1,547	1,602	1,520
Lake Eleanor Reservoir															
Elevation (Feet)	4,653.6	4,654.1	4,654.8	4,655.3	4,655.6	4,655.9	4,656.0	4,655.1	4,648.1	4,645.0	4,645.5	4,645.8	4,645.8	4,645.7	4,645.8
Storage (AF)	20,232.0	20,683.0	21,315.0	21,774.0	22,053.0	22,332.0	22,425.0	21,588.0	15,349.0	12,682.0	13,112.0	13,370.0	13,370.0	13,284.0	13,370.0
Gain/(-Loss) cfs	(227)	(319)	(231)	(141)	(141)	(47)	422	3,145	1,345	(217)	(130)	-	43	(43)	(43)
Release (cfs)	458	475	483	501	730	902	800	600	500	457	260	47	6	6	6
Inflow (cfs)	231	156	252	360	589	855	1,222	3,745	1,845	240	130	47	49	(37)	(37)
Diversion to S.F. Pipeline (cfs)	261	261	261	261	255	255	213	213	213	213	213	-	-	-	-
Rain Fall (Inches)															
Hetch Hetchy	-	-	-	0.27	-	-	-	0.42	1.77	0.13	-	-	-	-	-
Cherry Valley	-	-	-	0.12	-	-	-	0.04	2.85	0.15	-	-	-	-	-
Moccasin	-	-	-	0.24	-	-	-	0.31	1.44	0.09	-	-	-	-	-
Sonora	-	-	-	0.20	-	-	-	0.41	1.57	0.11	-	-	-	-	-
Yosemite	-	-	-	0.22	-	-	-	0.62	2.13	0.07	-	-	-	-	-
Don Pedro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Area (acres)															
Hetch Hetchy Reservoir	1884.4	1890.1	1895.8	1899.6	1900.4	1901.5	1898.8	1888.2	1845.6	1835	1835.8	1836.1	1834.1	1830.7	1827.7
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cherry Valley Reservoir	1553.2	1547.8	1542.3	1536.5	1529	1519.5	1507.2	1492.9	1457.6	1435.8	1427.4	1419.1	1408.8	1401	1393.1
	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
Lake Eleanor Reservoir	909.4	911.5	914.3	916.9	918.7	920.6	921.2	915.7	869.2	831.5	837.7	841.4	841.4	840.1	841.4
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCSF TOTAL EVAPORATIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Don Pedro Evaporation															
Surface Area (acres)	11962	11944	11914	11895	11871	11841	11804	11762	11708	11616	11611	11634	11657	11680	11708
Evaporation (cfs)	37	37	37	37	37	36	36	36	36	36	36	36	36	36	36

Table B-2: Turlock ID's daily FNF spreadsheet report for April 2019

Note from Pulido: This is combined reported data created by Pulido that was managed by Turlock Irrigation District which was collected from CDWR-DFM.

Tuolumne River Report (Information Given to Department of Water Resources)

All Data Are For	4/30/2019	4/29/2019	4/28/2019	4/27/2019	4/26/2019	4/25/2019	4/24/2019	4/23/2019	4/22/2019	4/21/2019	4/20/2019	4/19/2019	4/18/2019	4/17/2019	4/16/2019	4/15/2019	4/14/2019	4/13/2019	4/12/2019	4/11/2019	4/10/2019	4/9/2019	4/8/2019	4/7/2019	4/6/2019	4/5/2019	4/4/2019	4/3/2019	4/2/2019	4/1/2019
	Tuesday	Monday	Sunday	Saturday	Friday	Thursday	Wednesday	Tuesday	Monday	Sunday	Saturday	Friday	Thursday	Wednesday	Tuesday	Monday	Sunday	Saturday	Friday	Thursday	Wednesday	Tuesday	Monday	Sunday	Saturday	Friday	Thursday	Wednesday	Tuesday	Monday
Don Pedro																														
DP Elevation (Feet)	802.83	801.59	800.32	798.99	797.96	797.38	796.87	796.42	795.90	795.87	795.96	796.03	796.15	796.35	796.56	796.73	796.88	797.07	797.24	797.36	797.45	797.40	797.29	797.21	797.18	797.12	797.08	797.14	797.17	797.26
Storage (AF)	1,700,444	1,686,915	1,672,350	1,657,855	1,646,790	1,640,178	1,634,683	1,629,203	1,623,737	1,623,737	1,624,829	1,624,829	1,625,922	1,629,203	1,631,394	1,632,490	1,634,683	1,636,880	1,637,978	1,640,178	1,640,178	1,640,178	1,639,078	1,637,978	1,637,978	1,636,880	1,636,880	1,636,880	1,637,978	1,639,078
Gain/(-Loss) cfs	6,821	7,343	7,308	5,579	3,334	2,770	2,763	2,756	-	(551)	-	(551)	(1,654)	(1,105)	(553)	(1,106)	(1,108)	(554)	(1,109)	-	-	555	555	-	554	-	-	(554)	(555)	(1,109)
Flow Below Dam (cfs)	5,828	5,865	5,855	5,834	5,946	6,228	6,410	5,788	5,911	5,738	5,722	5,895	6,057	5,961	5,980	5,983	5,885	5,660	5,517	5,407	5,227	5,233	4,998	4,912	4,788	5,317	5,742	5,735	5,717	6,056
TID Canal (cfs)	1,262	1,294	1,283	1,272	1,353	1,609	1,764	1,192	1,512	1,549	1,542	1,507	1,336	1,153	1,128	1,039	925	702	667	680	524	519	444	369	377	373	439	434	467	495
MID Canal (cfs)	719	734	729	721	747	760	789	648	325	114	114	114	352	447	503	609	610	613	617	623	628	634	630	467	136	133	131	129	127	127
River (cfs)	3,847	3,837	3,842	3,841	3,846	3,858	3,857	3,948	4,074	4,075	4,067	4,275	4,369	4,361	4,349	4,336	4,350	4,345	4,233	4,105	4,075	4,080	3,923	4,076	4,275	4,810	5,172	5,173	5,122	5,434
Total (cfs)	5,828	5,865	5,855	5,834	5,946	6,228	6,410	5,788	5,911	5,738	5,722	5,895	6,057	5,961	5,980	5,983	5,885	5,660	5,517	5,407	5,227	5,233	4,998	4,912	4,788	5,317	5,742	5,735	5,717	6,056
Inflow (cfs)	12,649	13,208	13,163	11,413	9,280	8,998	9,172	8,544	5,911	5,188	5,722	5,344	4,402	4,857	5,427	4,878	4,778	5,106	4,408	5,407	5,227	5,788	5,552	4,912	5,341	5,317	5,742	5,181	5,162	4,947
Computed Natural Flow (cfs)	10,242	11,288	12,574	13,770	13,305	11,278	9,477	8,618	8,152	8,180	8,997	7,910	5,603	5,846	6,895	6,376	5,232	5,084	4,953	6,220	7,115	7,115	6,106	4,438	5,033	5,346	5,737	5,970	5,268	4,551
Hetch Hetchy Reservoir																														
Elevation (Feet)	3,765.6	3,768.7	3,771.3	3,772.9	3,771.6	3,768.4	3,766.8	3,767.0	3,767.9	3,766.9	3,765.3	3,763.6	3,762.3	3,761.8	3,761.4	3,760.7	3,760.0	3,759.9	3,760.0	3,759.8	3,759.5	3,758.6	3,758.0	3,757.8	3,758.1	3,758.4	3,758.6	3,758.7	3,758.7	3,758.9
Storage (AF)	283,802.0	289,461.0	294,232.0	297,176.0	294,784.0	288,912.0	285,986.0	286,350.0	287,997.0	286,168.0	283,256.0	280,176.0	277,830.0	276,930.0	276,210.0	274,953.0	273,700.0	273,522.0	273,700.0	273,344.0	272,810.0	271,208.0	270,140.0	269,786.0	270,318.0	270,852.0	271,208.0	271,386.0	271,386.0	271,742.0
Gain/(-Loss) cfs	(2,853)	(2,405)	(1,484)	1,206	2,960	1,475	(184)	(830)	922	1,468	1,553	1,183	454	363	634	632	90	(90)	179	269	808	538	178	(268)	(269)	(179)	(90)	-	(179)	(449)
Release (cfs)	7,605	7,167	6,836	4,154	2,105	2,495	3,276	3,354	1,490	1,173	1,081	1,079	1,081	1,077	1,078	1,077	1,120	1,122	1,122	1,222	1,220	1,220	1,219	1,221	1,221	1,221	1,222	1,221	1,220	1,220
Inflow (cfs)	4,752	4,762	5,352	5,360	5,065	3,970	3,092	2,524	2,412	2,641	2,634	2,262	1,535	1,440	1,712	1,709	1,210	1,032	1,301	1,491	2,028	1,758	1,397	953	952	1,042	1,132	1,221	1,041	771
Cherry Valley Reservoir																														
Elevation (Feet)	4,661.8	4,661.7	4,661.5	4,660.8	4,659.9	4,659.2	4,659.0	4,659.2	4,659.0	4,658.4	4,657.6	4,656.7	4,656.0	4,655.8	4,655.7	4,655.4	4,655.0	4,655.0	4,655.2	4,655.2	4,655.2	4,654.9	4,654.8	4,655.0	4,655.6	4,656.1	4,656.4	4,656.8	4,657.0	4,657.4
Storage (AF)	204,026.0	203,863.0	203,537.0	202,398.0	200,937.0	199,824.0	199,506.0	199,824.0	199,506.0	198,552.0	197,280.0	195,849.0	194,736.0	194,418.0	194,259.0	193,782.0	193,146.0	193,146.0	193,464.0	193,464.0	193,464.0	192,987.0	192,828.0	193,146.0	194,100.0	194,895.0	195,372.0	196,008.0	196,326.0	196,962.0
Gain/(-Loss) cfs	82	164	574	737	561	160	(160)	160	481	641	721	561	160	80	240	321	-	(160)	-	-	240	80	(160)	(481)	(401)	(240)	(321)	(160)	(321)	(481)
Release (cfs)	1,648	1,644	1,457	1,576	1,805	1,792	1,763	1,122	799	727	727	703	737	735	741	742	744	728	701	896	901	925	928	936	898	863	933	926	926	932
Inflow (cfs)	1,730	1,808	2,031	2,313	2,366	1,952	1,603	1,282	1,280	1,368	1,448	1,264	897	815	981	1,063	744	568	701	896	1,141	1,005	768	455	497	623	612	766	605	451
Lake Eleanor Reservoir																														
Elevation (Feet)	4,658.2	4,658.3	4,658.5	4,658.7	4,658.7	4,658.5	4,658.0	4,657.5	4,656.8	4,655.9	4,654.9	4,653.6	4,652.7	4,652.3	4,652.0	4,651.3	4,650.7	4,650.5	4,650.6	4,650.4	4,649.8	4,648.5	4,647.5	4,646.9	4,646.9	4,646.7	4,646.3	4,646.0	4,644.4	4,643.3
Storage (AF)	24,472.0	24,565.0	24,751.0	24,937.0	24,937.0	24,751.0	24,286.0	23,821.0	23,169.0	22,332.0	21,405.0	20,232.0	19,420.0	19,059.0	18,788.0	18,157.0	17,616.0	17,435.0	17,525.0	17,345.0	16,812.0	15,693.0	14,833.0	14,317.0	14,317.0	14,145.0	13,801.0	13,542.0	12,205.0	11,331.0
Gain/(-Loss) cfs	(47)	(94)	(94)	-	94	234	234	329	422	467	591	409	182	137	318	273	91	(45)	91	269	564	434	260	-	87	173	131	674	441	361
Release (cfs)	1,513	1,173	1,201	1,230	1,208	1,177	1,056	850	827	776	756	738	648	645	645	698	704	702	681	577	558	558	558	558	558	556	556	35	149	10
Inflow (cfs)	1,466	1,079	1,107	1,230	1,302	1,411	1,290	1,179	1,249	1,243	1,347	1,147	830	782	963	971	795	657	772	846	1,122	992	818	558	645	729	687	709	590	371
Diversion to S.F. Pipeline (cfs)	376	381	381	381	376	376	381	381	382	382	376	379	371	376	241	240	240	240	241	241	241	241	241	241	241	241	241	241	131	139
Rain Fall (Inches)																														
Hetch Hetchy	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	0.36	-	-	-	0.02	-	-	0.33	-	-	0.11	0.18	-	0.34	0.25	-
Cherry Valley	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12	0.26	-	-	-	0.01	-	0.01	0.05	-	-	0.19	0.31	-	0.16	0.56	-
Moccasin	-	-	-	-	-	-	-	-	-	-	-	-	-	0.15	0.08	-	-	-	-	-	-	0.06	-	-	0.02	-	-	0.05	0.10	-
Sonora	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	0.14	-	-	-	-	-	-	-	-	-	0.08	-	-	0.12	0.18	-
Yosemite	-	-	-	-	-	-	-	-	-	0.02	-	-	-	0.14	0.48	-	-	-	-	-	-	0.09	-	-	0.19	-	-	0.73	0.28	-
Don Pedro	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface Area (acres)																														
Hetch Hetchy Reservoir	1816.1	1829.4	1839.9	1846	1841.1	1828.1	1821.2	1822.1	1826	1821.7	1814.8	1807.5	1801.9	1799.7	1798	1795	1792	1791.5	1792	1791	1789.4	1784.7	1781.6	1780.6	1782.1	1783.7	1784.7	1785.2	1785.2	1786.3
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cherry Valley Reservoir	1616.3	1616	1615.3	1612.8	1609.6	1606.8	1606	1606.8	1606	1603.6	1600.4	1596.8	1594	1593.2	1592.8	1591.6	1590	1590	1590.8	1590.8	1590.8	1589.6	1589.2	1590	1592.4	1594.4	1595.6	1597.2	1598	1599.6
	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5	-5
Lake Eleanor Reservoir	934.6	935.2	936.4	937.6	937.6	936.4	933.3	930.3	926	920.6	914.7	909.4	905.8	903.7	901.8	897.4	893.6	892.4	893	891.7	887.2	874	862	854.8	854.8	852.4	847.5	843.8	823.6	809
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CCSF TOTAL EVAPORATIO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Don Pedro Evaporation																														
Surface Area (acres)	11308	11240	11167	11093	11037	11003	10975	10947	10919	10919	10924	10924	10930	10947	10958	10964	10975	10986	10992	11003	11003	11003	10997	10992	10992	10986	10986	10986	10992	10997
Evaporation (cfs)	35	35	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34

Table B-3: Merced ID's daily FNF spreadsheet report (McSwain Reservoir) for April 2018

Note from Pulido: This is reported data managed by Merced Irrigation District that was collected from CDWR-DFM.

MCSWAIN

Month: APRIL 2018 **MERCED IRRIGATION DISTRICT DAILY WATER TABULATION AND USE REPORT FOR THE MONTH OF APRIL**

DATE	MCSWAIN RESERVOIR **ELEVATION**	(+) or (-) FT ELEVATION CHANGE	MCSWAIN RESERVOIR **STORAGE**	(+) or (-) FT STORAGE CHANGE	AVE. PH DRAFT 24 HOURS	ACRE FEET DISCHARGED 24 HOURS	AVERAGE **INFLOW** 24 HOURS	TOTAL ACRE FT DISCHARGED YEAR TO DATE	DISCHARGE DEMAND CFS	MCSWAIN ACRE FT SPILLED	MCSWAIN ACRE FT BYPASSED
1	393.58	0.17	7,861	47	2,460	4,878	2,734	68,415	2,710	0	496
2	399.71	6.13	9,642	1,781	2,460	4,878	3,608	73,789	2,710	0	496
3	401.01	1.30	10,042	400	2,499	4,955	4,493	82,298	2,710	3,541	13
4	401.04	0.03	10,051	9	2,500	4,958	4,400	91,093	4,435	3,837	0
5	401.01	-0.03	10,042	-9	2,500	4,958	4,431	99,888	4,435	3,837	0
6	395.09	-5.92	8,280	-1,762	2,500	4,958	1,957	105,530	2,700	331	353
7	400.82	5.73	9,983	1,703	2,500	4,958	4,263	112,280	4,000	1,610	182
8	400.95	0.13	10,024	41	2,500	4,958	4,404	120,971	4,000	3,733	0
9	401.21	0.26	10,106	82	2,500	2,958	5,016	130,836	4,400	4,907	0
10	401.18	-0.03	10,097	-9	2,500	4,958	4,996	140,751	5,000	4,957	0
11	400.80	-0.38	9,977	-120	2,481	4,920	4,147	149,095	5,000	3,388	36
12	400.86	0.06	9,996	19	2,047	4,060	4,010	157,027	4,000	2,986	886
13	396.05	-4.81	8,556	-1,440	2,242	4,446	1,570	161,580	2,200	107	0
14	396.19	0.14	8,596	40	2,200	4,363	2,220	165,943	2,200	0	0
15	396.45	0.26	8,672	76	2,200	4,363	2,239	170,306	2,200	0	0
16	396.99	0.54	8,828	156	1,850	3,669	1,929	173,975	2,200	0	0
17	394.17	-2.82	8,026	-802	1,800	3,569	1,395	177,544	1,800	0	0
18	393.34	-0.83	7,794	-232	1,800	3,569	1,683	181,113	1,800	0	0
19	395.19	1.85	8,310	516	1,800	3,569	2,060	184,682	1,800	0	0
20	394.99	-0.20	8,251	-59	1,800	3,569	1,770	188,251	1,800	0	0
21	396.69	1.70	8,741	490	1,800	3,569	2,047	191,820	1,800	0	0
22	397.90	1.21	9,096	355	1,800	3,569	1,979	195,389	1,800	0	0
23	397.02	-0.88	8,837	-259	1,800	3,569	1,669	198,958	1,800	0	0
24	398.34	1.32	9,227	390	1,417	2,810	1,614	201,768	1,800	0	0
25	397.13	-1.21	8,869	-358	1,400	2,776	1,219	204,544	1,400	0	0
26	397.69	0.56	9,033	164	1,400	2,776	1,483	207,320	1,400	0	0
27	395.74	-1.95	8,466	-567	1,400	2,776	1,114	210,096	1,400	0	0
28	394.76	-0.98	8,189	-277	1,400	2,776	1,260	212,872	1,400	0	0
29	395.11	0.35	8,287	98	1,400	2,776	1,449	215,648	1,400	0	0
30	395.94	0.83	8,523	236	1,400	2,776	1,519	218,424	1,400	0	0
31											
TOT.											
	Fax: D.W.R. - 1 (916) 574-2771 (#2 speed dial)						tot. X 1.9835				
	E-mail (as attachment only): nemeth@water.ca.gov						78,678.00				

DATE	M FALLS R.G. GAUGE HT.	M FALLS R.G. FLOW CFS	NORTH CANAL GAUGE HT	NORTH CANAL FLOW CFS	MAIN CANAL GAUGE HT.	MAIN CANAL FLOW CFS	FISHFARM SPAWNING USAGE	C.H. DAM GAUGE GAUGE HT.	C.H. DAM GAUGE FLOW CFS	SHAFFER BRIDGE GAUGE HT	SHAFFER BRIDGE FLOW CFS	AVERAGE **DISCHARGE** 24 HR - CFS	GROSS GENERATION K W H
1	7.62	2,721	0.28	7	1.72	428		3.98	2,276	5.30	2,187	2,710	190,000
2	7.59	2,688	0.27	7	1.72	428		3.93	2,231	5.34	2,214	2,710	209,000
3	9.12	4,597	0.27	7	1.72	428		5.74	4,071	7.27	3,710	4,291	224,000
4	9.17	4,660	0.28	7	1.73	432		5.80	4,139	7.41	3,830	4,435	223,000
5	9.12	4,597	0.27	7	1.73	432		5.79	4,128	7.48	3,891	4,435	224,000
6	7.62	2,721	0.00	0	0.53	71		4.37	2,639	6.28	2,903	2,845	211,000
7	8.75	4,104	0.00	0	0.56	75		5.67	3,992	7.11	3,574	3,404	216,000
8	8.97	4,406	0.37	11	1.42	317		5.70	4,026	7.60	3,996	4,383	223,000
9	9.42	4,981	0.37	11	1.43	320		6.19	4,623	8.18	4,521	4,975	225,000
10	9.42	4,981	0.37	11	1.75	440		6.11	4,514	8.06	4,410	5,000	224,000
11	8.57	3,865	0.37	11	1.77	448		5.14	3,415	7.04	3,515	4,208	222,000
12	8.8	4,171	0.37	11	1.77	448		5.38	3,672	7.13	3,591	4,000	182,000
13	7.12	2,197	0.37	11	1.77	448		3.30	1,693	4.94	1,945	2,296	201,000
14	7.12	2,197	0.37	11	1.77	448		3.31	1,701	4.81	1,860	2,200	188,000
15	7.12	2,197	0.37	11	1.78	452		3.32	1,709	4.74	1,815	2,200	190,000
16	6.7	1,803	0.37	11	1.89	500		2.73	1,256	4.03	1,360	1,850	164,000
17	6.7	1,803	0.37	11	1.89	500		2.73	1,256	3.99	1,334	1,800	156,000
18	6.72	1,821	0.60	23	2.21	640		2.55	1,129	3.80	1,217	1,800	152,000
19	6.72	1,821	0.62	24	2.21	640		2.55	1,129	3.76	1,194	1,800	154,000
20	6.72	1,821	0.62	24	2.23	650		2.54	1,122	3.74	1,183	1,800	157,000
21	6.72	1,821	0.80	35	2.23	650		2.54	1,122	3.75	1,189	1,800	159,000
22	6.72	1,821	0.80	35	2.42	740		2.41	1,034	3.59	1,099	1,800	167,000
23	6.72	1,821	0.79	34	2.42	740		2.41	1,034	3.52	1,059	1,800	166,000
24	6.21	1,398	0.79	34	2.42	740		1.82	650	2.82	678	1,417	135,000
25	6.14	1,345	0.91	42	2.42	740		1.73	599	2.65	604	1,400	128,000
26	6.14	1,345	0.90	41	2.41	735		1.74	605	2.62	594	1,400	128,000
27	6.14	1,345	0.94	44	2.64	851		1.57	520	2.44	531	1,400	127,000
28	6.14	1,345	0.95	45	2.63	846		1.57	520	2.41	521	1,400	125,000
29	6.12	1,330	1.03	50	2.83	951		1.39	439	2.24	463	1,400	124,000
30	6.14	1,345	1.04	51	2.93	1,006		1.28	382	2.04	390	1,400	124,000
31													
TOT.		79,068		627									
		156,829		1,244		tot.X 1.9835	tot.X 1.9835		tot.X 1.9835		tot.X 1.9835	tot.X 1.9835	
		79,068		627.00		0			0		0	0	

Table B-4: Merced ID's daily FNF spreadsheet report (McSwain Reservoir) for April 2019

Note from Pulido: This is reported data managed by Merced Irrigation District that was collected from CDWR-DFM.

LAKE MCSWAIN

APRIL 2019

MERCED IRRIGATION DISTRICT DAILY WATER TABULATION AND USE REPORT FOR THE MONTH OF APRIL

DATE	MCSWAIN RESERVOIR **ELEVATION**	(+) or (-) FT ELEVATION CHANGE	MCSWAIN RESERVOIR **STORAGE**	(+) or (-) FT STORAGE CHANGE	AVE. PH DRAFT 24 HOURS	ACRE FEET DISCHARGED 24 HOURS	AVERAGE **INFLOW** 24HOURS	TOTAL ACRE FT DISCHARGED YEAR TO DATE	DISCHARGE DEMAND CFS	MCSWAIN ACRE FT SPILLED	MCSWAIN ACRE FT BYPASSED	DATE	M FALLS R.G. GAUGE HT.	M FALLS R.G. FLOW CFS	NORTH CANAL GAUGE HT	NORTH CANAL FLOW CFS	MAIN CANAL GAUGE HT.	MAIN CANAL FLOW CFS	FISH FARM SPAWNING USAGE	C.H. DAM GAUGE GAUGE HT.	C.H. DAM GAUGE FLOW CFS	SHAFFER BRIDGE GAUGE HT	SHAFFER BRIDGE FLOW CFS	AVERAGE **DISCHARGE** 24HR.-CFS	McSwain **DISCHARGE** ACRE FEET	GROSS GENERATION K W H
1	401.27	-0.09	10,125	-29	2,500	4,958	5286	365,177	5300	5,552	0	1	9.89	5567	0.31	9	1.42	317		6.62	5055	8.46	4784	5300	10510	234000
2	397.41	-3.86	8,952	-1,173	1,813	3,595	1446	369,218	5300	446	0	2	6.49	1,675	0.31	9	1.37	300		2.78	1,382	4.32	1,559	2,038	4,041	166,000
3	395.66	-1.75	8,444	-508	1,685	3,341	1429	372,559	1685	0	0	3	6.49	1,698	0.31	9	1.37	300		2.78	1,382	4.01	1,373	1,685	3,341	143,000
4	395.77	0.11	8,475	31	2,092	4,148	2107	376,707	1,685	0	0	4	7.04	2,150	0.31	9	1.38	303		3.34	1,818	4.61	1,739	2,092	4,148	176,000
5	396.43	0.66	8,666	191	2,158	4,279	2254	380,986	2,110	0	0	5	7.06	2,169	0.31	9	1.51	351		3.33	1,810	4.60	1,732	2,158	4,279	180,000
6	396.18	-0.25	8,593	-73	2,160	4,283	2123	385,269	2,160	0	0	6	7.06	2,169	0.31	9	1.51	351		3.33	1,810	4.58	1,720	2,160	4,283	184,000
7	395.02	-1.16	8,261	-332	2,208	4,378	2040	389,647	2,210	0	0	7	7.13	2,236	0.31	9	1.63	395		3.34	1,818	4.59	1,726	2,208	4,378	184,000
8	391.65	-3.37	7,333	-928	2,282	4,525	1814	394,172	2,210	0	0	8	7.18	2,284	0.31	9	1.81	464		3.32	1,802	4.56	1,707	2,282	4,525	178,000
9	392.11	0.46	7,456	123	2,290	4,541	2352	398,713	2,285	0	0	9	7.19	2,294	0.46	15	1.81	464		3.32	1,802	4.59	1,726	2,290	4,541	174,000
10	393.22	1.11	7,761	305	2,482	4,922	2636	403,635	2,290	0	0	10	7.39	2,566	0.46	15	2.27	669		3.33	1,810	4.59	1,605	2,482	4,922	187,000
11	394.40	1.18	8,089	328	2,490	4,938	2656	408,573	2,490	0	0	11	7.41	2,587	0.46	15	2.25	660		3.34	1,818	4.60	1,612	2,490	4,938	193,000
12	392.45	-1.95	7,549	-540	2,562	5,080	2290	413,653	2,490	0	0	12	7.49	2,671	0.45	15	2.42	740		3.32	1,802	4.57	1,591	2,562	5,080	195,000
13	393.78	1.33	7,916	367	2,565	5,086	2750	418,739	2,565	0	0	13	7.51	2,692	0.45	15	2.44	750		3.33	1,810	4.60	1,612	2565	5,086	199,000
14	393.59	-0.19	7,864	-52	2,579	5,114	2553	423,853	2,565	0	0	14	7.51	2,692	0.73	30	2.44	750		3.34	1,818	4.62	1,626	2,579	5,114	202,000
15	391.72	-1.87	7,351	-513	2,580	5,116	2321	428,969	2,580	0	0	15	7.51	2,692	0.73	30	2.44	750		3.33	1,810	4.60	1,612	2,580	5,116	195,000
16	394.35	2.63	8,075	724	2,116	4,196	2481	433,165	1,235	0	0	16	5.91	1,295	0.80	35	2.31	689		1.50	523	4.51	1,555	2,116	4,196	163,000
17	394.47	0.12	8,109	34	1,245	2,469	1262	435,634	1,235	0	0	17	5.88	1,274	0.92	43	2.33	698		1.43	486	2.38	527	1,245	2,469	101,000
18	396.43	1.96	8,666	557	1,365	2,707	1646	438,341	1,245	0	0	18	6.08	1,416	0.92	43	2.60	830		1.47	507	2.35	515	1,365	2,707	119,000
19	396.42	-0.01	8,663	-3	1,418	2,812	1417	441,153	1,370	0	0	19	6.13	1,453	0.92	43	2.64	851		1.47	507	2.31	498	1,418	2,812	123,000
20	395.58	-0.84	8,421	-242	1,415	2,806	1293	443,959	1,420	0	0	20	6.14	1,461	0.89	40	2.64	851		1.47	507	2.31	498	1,415	2,806	123,000
21	395.26	-0.32	8,329	-92	1,415	2,806	1369	446,765	1,415	0	0	21	6.14	1,461	0.89	40	2.64	851		1.47	507	2.30	494	1,415	2,806	120,000
22	394.92	-0.34	8,232	-97	1,243	2,465	1194	449,230	1,225	0	0	22	5.91	1,295	1.02	49	2.78	925		0.97	268	1.75	267	1,243	2,465	108,000
23	394.84	-0.08	8,211	-21	1,225	2,429	1214	451,659	1,225	0	0	23	5.91	1,295	1.02	49	2.77	920		0.98	272	1.71	253	1,225	2,429	106,000
24	395.11	0.27	8,287	76	1,188	2,356	1226	454,015	1,075	0	0	24	5.68	1,139	1.02	49	2.64	851		0.77	192	1.49	176	1,188	2,356	94,000
25	396.98	1.87	8,825	538	1,080	2,142	1352	456,157	1,075	0	0	25	5.68	1,139	1.08	54	2.64	851		0.77	192	1.47	169	1,080	2,142	94,000
26	396.34	-0.64	8,640	-185	1,224	2,427	1131	458,584	1,080	0	0	26	5.93	1,309	1.09	54	2.91	996		0.83	213	1.44	158	1,224	2,427	111,000
27	394.12	-2.22	8,012	-628	1,636	3,244	1319	461,828	1,230	0	0	27	6.53	1,768	1.12	57	2.91	996		1.77	690	2.34	510	1,636	3,244	142,000
28	392.63	-1.49	7,598	-414	1,970	3,907	1762	465,735	1,730	0	0	28	6.83	2,026	1.10	55	3.00	1,047		2.05	877	2.74	691	1,970	3,907	157,000
29	396.10	3.47	8,570	972	2,478	4,914	2968	470,649	1,980	0	0	29	7.44	2,618	1.13	57	2.99	1,040		2.82	1,412	3.60	1,090	2,478	4,914	194,000
30	392.93	-3.17	7,680	-890	2,500	4,958	2051	475,607	2,500	0	0	30	7.41	2,587	1.13	57	2.82	945		2.93	1,495	3.82	1,197	2,500	4,958	195,000
31												31														
TOT.																										
	Fax: D.W.R. - 1 (916) 574-2771 (#2 speed dial)						tot.X1.9835							tot.X1.9835		tot.X1.9835		tot.X1.9835	tot.X1.9835		tot.X1.9835		tot.X1.9835	tot.X1.9835		
	E-mail (as attachment only): nemeth@water.ca.gov						59742							0		0.00		0			0		0	0		

Table B-5: Merced ID's daily FNF spreadsheet report (McClure (Exchequer) Reservoir) for April 2018

Note from Pulido: This is reported data managed by Merced Irrigation District that was collected from CDWR-DFM.

EXCHEQUER

Month: APRIL 2018 **MERCED IRRIGATION DISTRICT DAILY WATER** **TABULATION AND USE REPORT FOR THE MONTH OF APRIL**

DATE	EXCHEQUER RESERVOIR FT **ELEVATION**	(+) or (-) FT ELEVATION	EXCHEQUER RESERVOIR AF **STORAGE**	(+) or (-) FT STORAGE AF CHANGE	AVE. PH DRAFT CFS 24 HOURS	ACRE FEET DISCHARGED 24 HOURS	AVERAGE **INFLOW CFS** 24 HOURS	TOTAL ACRE FT DISCHARGED YEAR TO DATE	DISCHARGE DEMAND CFS	PRECIPITATION (IN.) DAILY	PRECIPITATION (IN.) SEASON TOTAL	DATE	TEMPERATURE F° HIGH	TEMPERATURE F° LOW	TEMPERATURE F° OBS	EXCHEQUER ACRE FEET SPILLED	EXCHEQUER ACRE FEET BYPASSED	WEATHER	AVERAGE **DISCHARGE** CFS	LEAKAGE WEIR CFS	GROSS GENERATION KWH
1	836.61	-0.01	825,182	-61	1,836	3,641	2,703	68,000		0.00	13.95	1	77	53	55	0	1,766	CLEAR	2,734	7	14
2	836.33	-0.28	823,497	-1,685	1,815	3,599	2,759	75,155		0.00	13.95	2	73	54	56	0	3,544	CLEAR	3,608	6	1,450,000
3	835.82	-0.51	820,432	-3,065	0	0	2,947	84,065		0.00	13.95	3	75	56	60	0	8,898	CLOUDY	4,493	6	0
4	835.32	-0.50	817,436	-2,996	803	1,592	2,929	92,868		0.00	13.95	4	77	55	57	0	7,200	CLOUDY	4,400	6	640,000
5	834.86	-0.46	814,687	-2,749	1,340	2,657	3,044	101,654		0.04	13.99	5	73	57	59	0	6,117	CLOUDY	4,431	6	1,070,000
6	835.87	1.01	820,732	6,045	644	1,277	5,005	105,534		1.35	15.34	6	65	59	60	0	2,591	RAIN	1,957	6	1,020,000
7	840.38	4.51	848,141	27,409	910	1,804	18,085	113,987		0.42	15.76	7	70	52	53	0	6,635	CLEAR	4,263	7	660,000
8	842.26	1.88	859,775	11,634	896	1,777	10,271	122,719		0.00	15.76	8	68	51	56	0	6,941	CLEAR	4,404	7	710,000
9	842.72	0.46	862,641	2,866	1,950	3,867	6,462	132,666		0.00	15.76	9	75	56	65	0	6,066	PT CLOUDY	5,016	7	1,530,000
10	842.86	0.14	863,513	872	1,962	3,891	5,435	142,572		0.00	15.76	10	75	54	57	0	6,001	CLOUDY	4,996	7	1,540,000
11	843.04	0.18	864,638	1,125	1,822	3,613	4,715	150,796		0.08	15.84	11	71	49	51	0	4,597	CLEAR	4,147	7	1,430,000
12	842.99	-0.05	864,327	-311	1,606	3,184	3,853	158,747		0.00	15.84	12	62	44	47	0	4,753	CLEAR	4,010	7	1,260,000
13	843.46	0.47	867,266	2,939	1,376	2,729	3,052	161,860		0.00	15.84	13	67	47	52	0	368	CLEAR	1,570	8	1,080,000
14	843.82	0.36	869,524	2,258	1,808	3,585	3,359	166,263		0.00	15.84	14	73	52	61	0	802	PT CLOUDY	2,200	8	1,410,000
15	844.09	0.27	871,219	1,695	1,569	3,111	3,093	170,702		0.05	15.89	15	77	49	53	0	1,312	PT CLOUDY	2,239	8	1,220,000
16	844.51	0.42	873,863	2,644	1,757	3,484	3,262	174,527		0.24	16.13	16	60	41	47	0	325	CLEAR	1,929	8	1,360,000
17	844.86	0.35	876,071	2,208	1,367	2,711	2,509	177,294		0.00	16.13	17	63	45	52	0	40	CLOUDY	1,395	8	960,000
18	845.08	0.22	877,461	1,390	1,655	3,281	2,384	180,631		0.00	16.13	18	63	46	48	0	40	CLEAR	1,683	8	1,230,000
19	845.06	-0.02	877,334	-127	1,636	3,244	1,996	184,716		0.00	16.13	19	67	48	51	0	825	CLEAR	2,060	8	1,260,000
20	845.09	0.03	877,524	190	1,428	2,832	1,866	188,226		0.00	16.13	20	73	51	60	0	662	CLEAR	1,770	8	1,100,000
21	845.11	0.02	877,650	126	1,934	3,835	2,110	192,285		0.00	16.13	21	78	57	61	0	208	CLEAR	2,047	8	1,490,000
22	845.43	0.32	879,676	2,026	1,952	3,870	3,001	196,209		0.00	16.13	22	82	58	66	0	40	CLEAR	1,979	7	1,540,000
23	846.02	0.59	883,419	3,743	1,642	3,256	3,557	199,519		0.00	16.13	23	84	59	60	0	40	CLEAR	1,669	7	1,240,000
24	846.67	0.65	887,559	4,140	1,587	3,146	3,702	202,719		0.00	16.13	24	85	57	60	0	40	CLEAR	1,614	7	1,240,000
25	847.53	0.86	893,058	5,499	1,192	2,364	3,993	205,137		0.00	16.13	25	83	56	59	0	40	CLEAR	1,219	7	850,000
26	848.35	0.82	898,327	5,269	1,454	2,884	4,140	208,077		0.00	16.13	26	81	55	58	0	40	CLEAR	1,483	8	1,090,000
27	849.34	0.99	904,720	6,393	1,087	2,155	4,338	210,286		0.00	16.13	27	72	52	56	0	40	CLEAR	1,114	7	760,000
28	850.08	0.74	909,522	4,802	1,232	2,443	3,682	212,785		0.00	16.13	28	71	53	56	0	40	PT CLOUDY	1,260	8	890,000
29	850.51	0.43	912,321	2,799	1,421	2,818	2,861	215,659		0.00	16.13	29	70	50	54	0	40	CLEAR	1,449	8	1,050,000
30	850.74	0.23	913,821	1,500	1,491	2,956	2,275	218,671		0.00	16.13	30	71	51	55	0	40	CLOUDY	1,519	8	1,130,000
31												31									
							(tot. X 1.9835)												(tot. X 1.9835)		

E-mail (as attachment only): nemeth@water.ca.gov

Table B-6: Merced ID's daily FNF spreadsheet report (McClure (Exchequer) Reservoir) for April 2019

Note from Pulido: This is reported data managed by Merced Irrigation District that was collected from CDWR-DFM.

EXCHEQUER

APRIL 2019 MERCED IRRIGATION DISTRICT DAILY WATER TABULATION AND USE REPORT FOR THE MONTH OF APRIL

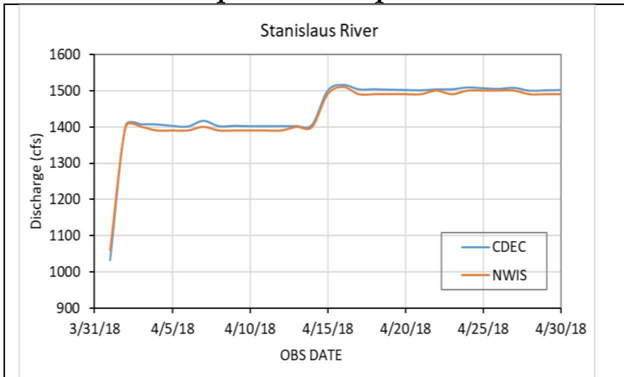
DATE	EXCHEQUER RESERVOIR FT ELEVATION	(+) or (-) FT ELEVATION	EXCHEQUER RESERVOIR AF STORAGE	(+) or (-) FT STORAGE AF CHANGE	AVE. PH DRAFT CFS 24 HOURS	ACRE FEET DISCHARGED 24 HOURS	AVERAGE INFLOW CFS 24 HOURS	TOTAL ACRE FT DISCHARGED YEAR TO DATE	DISCHARGE DEMAND CFS	PRECIPITATION (IN.) DAILY	PRECIPITATION (IN.) SEASON TOTAL
1	807.70	-1.13	664,597	-5,771	1,177	2,334	2,375	367,153		0.07	20.35
2	808.26	0.56	667,452	2,855	976	1,935	2,886	370,021		0.05	20.40
3	808.69	0.43	669,650	2,198	1,424	2,823	2,537	372,854		0.00	20.40
4	808.87	0.18	670,572	922	2,102	4,169	2,572	377,033		0.00	20.40
5	808.97	0.10	671,086	514	1,813	3,595	2,513	381,503		0.00	20.40
6	809.02	0.05	671,343	257	2,093	4,150	2,253	385,713		0.00	20.40
7	809.16	0.14	672,061	718	2,010	3,986	2,402	389,759		0.00	20.40
8	809.61	0.45	674,375	2,314	1,312	2,602	2,981	393,356		0.00	20.40
9	810.06	0.45	676,694	2,319	1,726	3,423	3,522	398,020		0.00	20.40
10	810.17	0.11	677,261	567	1,308	2,594	2,922	403,247		0.00	20.40
11	810.26	0.09	677,727	466	1,847	3,663	2,891	408,513		0.00	20.40
12	810.33	0.07	678,089	362	2,077	4,119	2,472	413,053		0.00	20.40
13	810.27	-0.06	677,779	-310	1,969	3,905	2,594	418,506		0.00	20.40
14	810.51	0.24	679,020	1,241	2,110	4,184	3,179	423,568		0.00	20.40
15	810.99	0.48	681,507	2,487	1,949	3,865	3,575	428,171		0.06	20.46
16	811.13	0.14	682,236	729	1,559	3,091	2,849	433,091		0.00	20.46
17	812.01	0.88	686,821	4,585	1,232	2,443	3,574	435,594		0.00	20.46
18	812.77	0.76	690,801	3,980	1,616	3,204	3,653	438,858		0.00	20.46
19	813.96	1.19	697,072	6,271	1,386	2,749	4,579	441,667		0.00	20.46
20	815.28	1.32	704,081	7,009	1,263	2,504	4,828	444,231		0.00	20.46
21	816.38	1.10	709,966	5,885	1,338	2,654	4,336	446,945		0.00	20.46
22	817.59	1.21	716,487	6,521	0	0	4,483	449,313		0.00	20.46
23	818.99	1.40	724,090	7,603	0	0	5,049	451,721		0.00	20.46
24	820.83	1.84	734,181	10,091	0	0	6,315	454,153		0.00	20.46
25	823.00	2.17	746,221	12,040	725	1,438	7,423	456,833		0.00	20.46
26	825.38	2.38	759,598	13,377	1,099	2,180	7,877	459,075		0.00	20.46
27	827.76	2.38	773,154	13,556	1,288	2,554	8,156	461,691		0.00	20.46
28	829.61	1.85	783,817	10,663	1,730	3,431	7,139	465,184		0.00	20.46
29	830.94	1.33	791,550	7,733	1,218	2,415	6,868	471,070		0.00	20.46
30	832.42	1.48	800,226	8,676	1,315	2,608	6,427	475,138		0.00	20.46
31											
							248,381	AF			

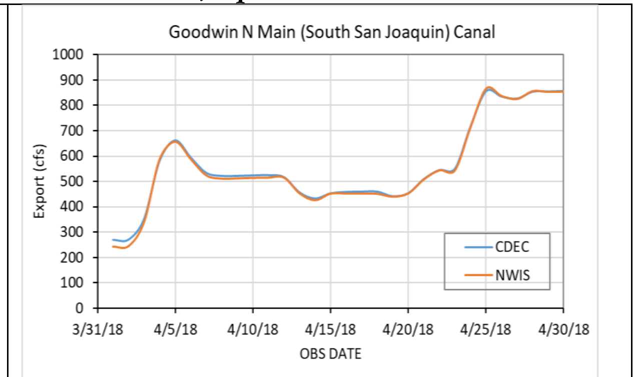
DATE	TEMPERATURE F° HIGH	TEMPERATURE F° LOW	TEMPERATURE F° OBS	EXCHEQUER ACRE FEET SPILLED	EXCHEQUER ACRE FEET BYPASSED	WEATHER	AVERAGE DISCHARGE CFS	EXCHEQUER DISCHARGE ACRE FEET	LEAKAGE WEIR CFS	GROSS GENERATION KWH
1	71	58	58	0	8,139	CLOUDY	5,286	10,481	4	850,000
2	69	51	51	0	925	PT CLOUDY	1,446	2,868	4	710,000
3	68	51	56	0	0	CLOUDY	1,429	2,833	5	920,000
4	66	52	55	0	0	CLOUDY	2,107	4,179	5	1,470,000
5	65	54	56	0	865	CLOUDY	2,254	4,470	5	1,330,000
6	72	54	58	0	50	CLEAR	2,123	4,210	5	1,460,000
7	75	58	61	0	50	CLEAR	2,140	4,046	5	1,410,000
8	75	56	57	0	987	PT CLOUDY	1,814	3,597	4	970,000
9	67	47	49	0	1,233	CLEAR	2,352	4,664	4	1,280,000
10	69	49	53	0	2,623	CLEAR	2,636	5,227	5	970,000
11	67	49	50	0	1,593	CLEAR	2,656	5,266	5	1,370,000
12	71	50	57	0	413	CLEAR	2,290	4,540	4	1,540,000
13	74	56	60	0	1,538	CLEAR	2,750	5,453	5	1,460,000
14	78	60	64	0	868	CLOUDY	2,553	5,062	5	1,570,000
15	70	56	57	0	728	PT CLOUDY	2,321	4,603	5	1,450,000
16	67	52	55	0	1,819	CLEAR	2,481	4,920	5	1,160,000
74	74	55	60	0	50	CLEAR	1,262	2,503	5	780,000
18	82	59	61	0	50	PT CLOUDY	1,646	3,264	5	1,140,000
19	83	61	63	0	50	PT CLOUDY	1,417	2,809	5	930,000
20	74	52	53	0	50	CLEAR	1,293	2,564	5	830,000
21	74	53	60	0	50	CLEAR	1,369	2,714	5	890,000
22	78	60	64	0	2,358	CLEAR	1,194	2,368	5	0
23	83	64	69	0	2,398	CLEAR	1,214	2,408	5	0
24	87	65	71	0	2,432	CLEAR	1,226	2,432	5	0
25	89	64	69	0	1,230	CLEAR	1,352	2,680	6	560,000
26	89	62	66	0	50	CLEAR	1,131	2,242	6	740,000
27	85	58	61	0	50	CLEAR	1,319	2,616	6	880,000
28	82	58	60	0	50	CLEAR	1,762	3,493	6	1,210,000
29	76	56	60	0	3,459	PT CLOUDY	2,968	5,886	6	990,000
30	71	52	55	0	1,448	CLEAR	2,051	4,068	6	1,040,000
31										
							118,691			

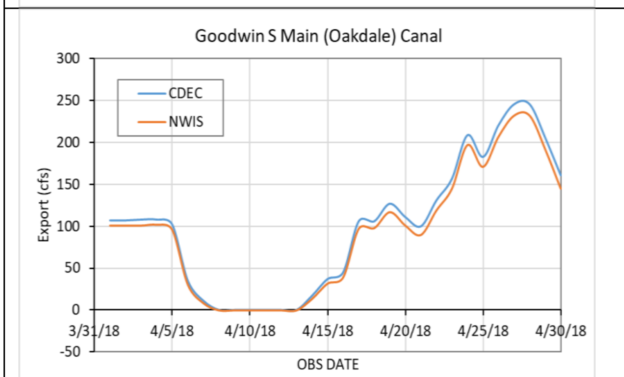
E-mail (as attachment only): nemeth@water.ca.gov

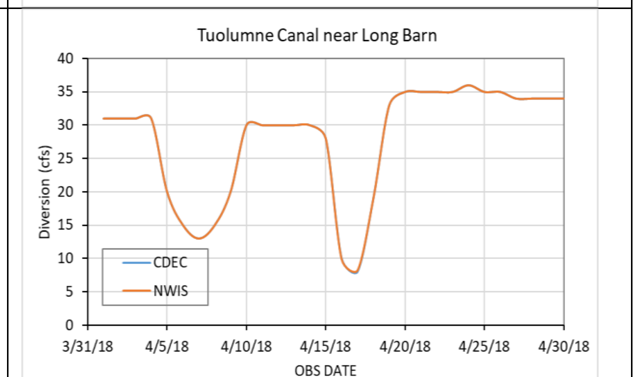
C Comparison Graphs for Stanislaus, Tuolumne, and Merced River Datasets, April 2018 and 2019

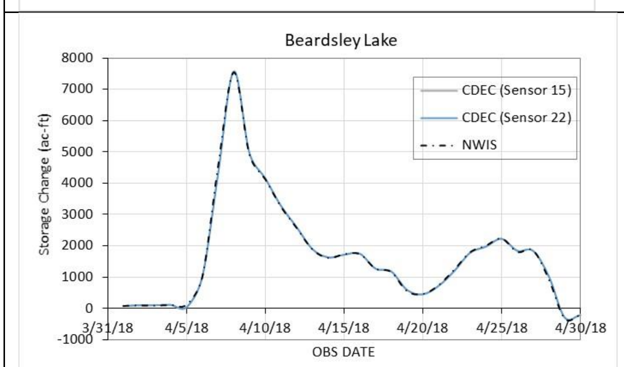
Table C-1: Comparison Graphs for Stanislaus River Datasets, April 2018

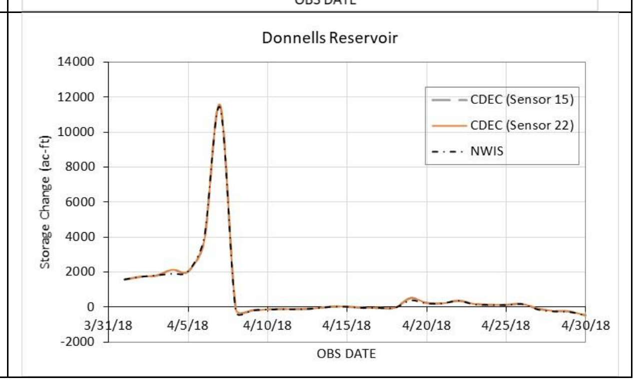


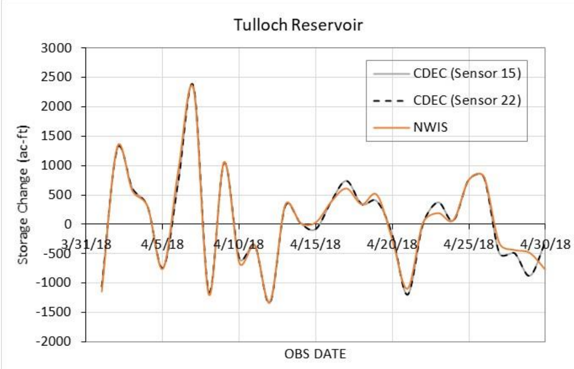


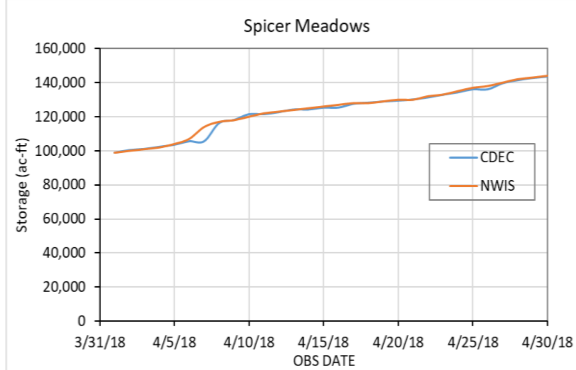









Tulloch Reservoir
CDEC (Sensor 15)
CDEC (Sensor 22)
NWIS
Storage Change (ac-ft)
3000
2500
2000
1500
1000
500
0
-500
-1000
-1500
-2000
3/31/18
4/5/18
4/10/18
4/15/18
4/20/18
4/25/18
4/30/18
OBS DATE


Spicer Meadows
CDEC
NWIS
Storage (ac-ft)
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
3/31/18
4/5/18
4/10/18
4/15/18
4/20/18
4/25/18
4/30/18
OBS DATE

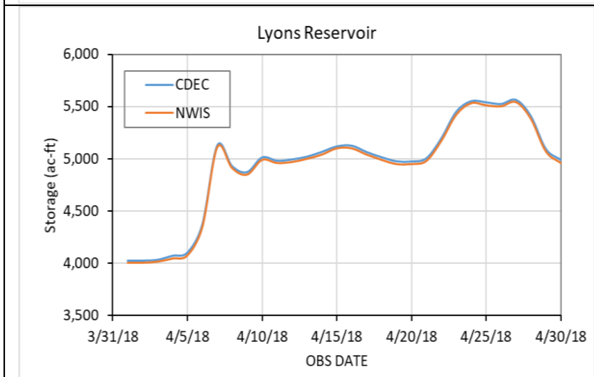
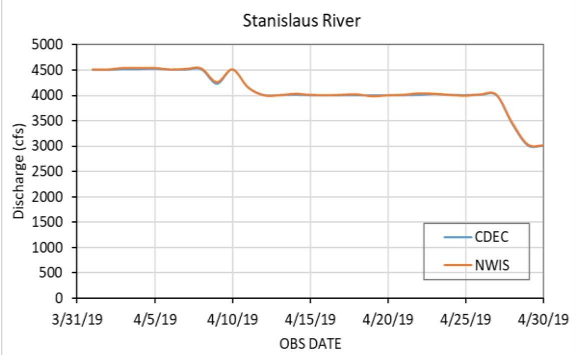
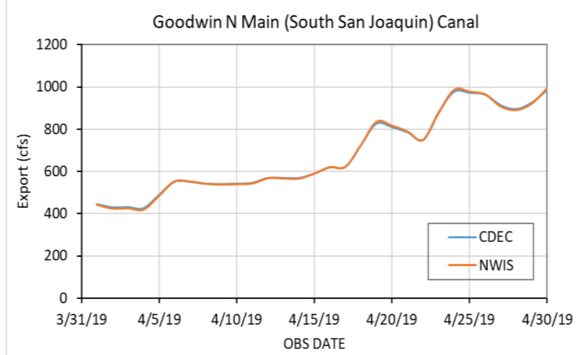
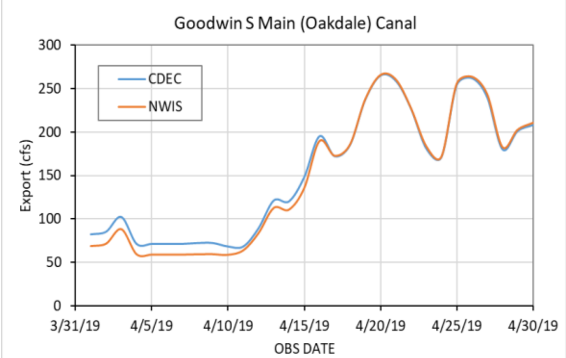
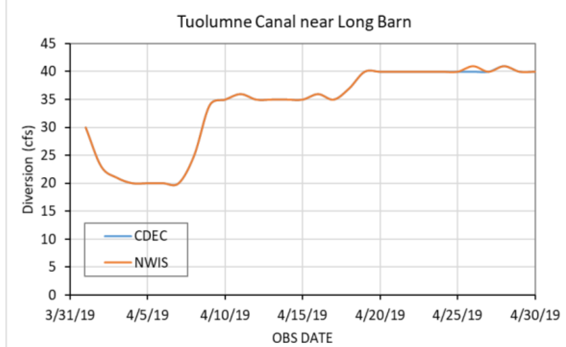

Lyons Reservoir
CDEC
NWIS
Storage (ac-ft)
6,000
5,500
5,000
4,500
4,000
3,500
3/31/18
4/5/18
4/10/18
4/15/18
4/20/18
4/25/18
4/30/18
OBS DATE

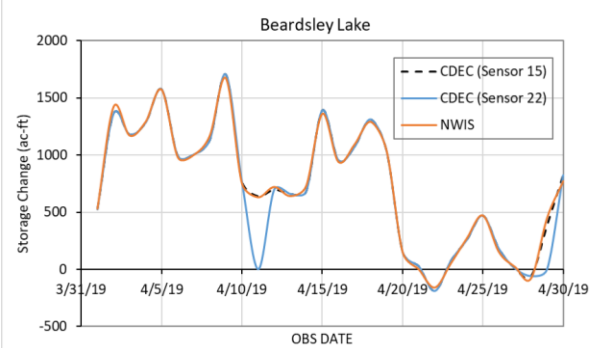
Table C-2: Comparison Graphs for Stanislaus River Datasets, April 2019

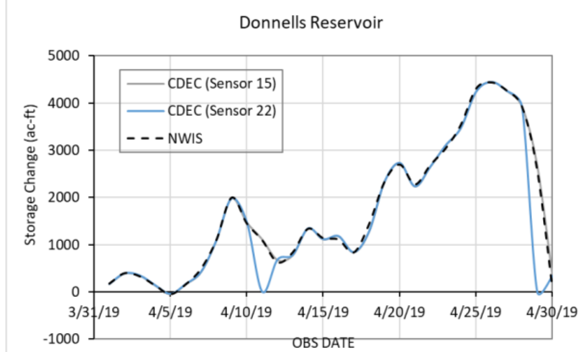


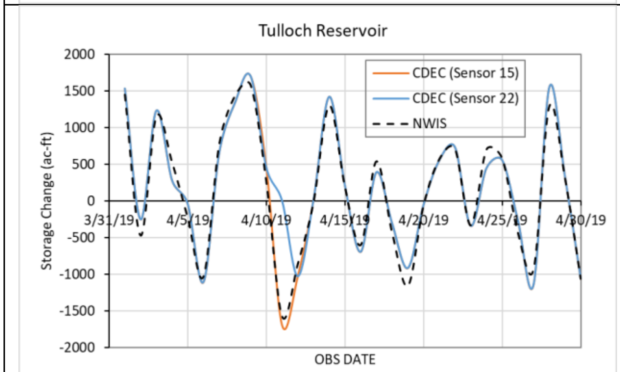


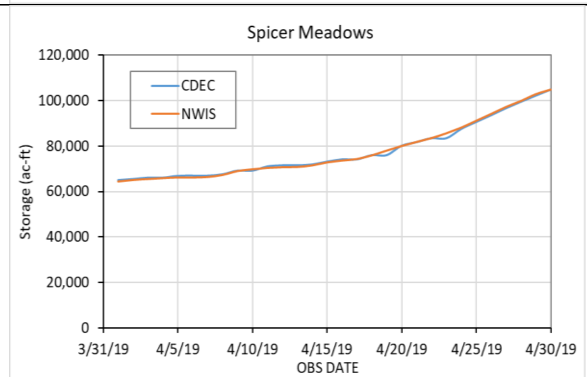












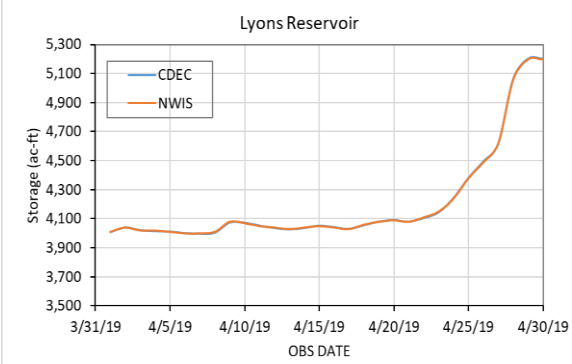
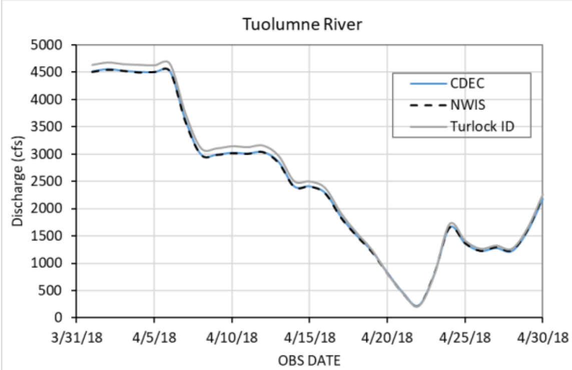
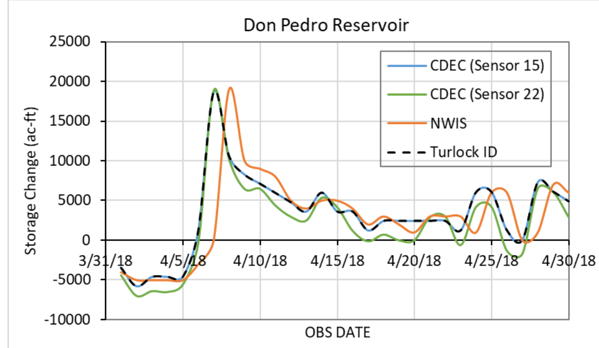
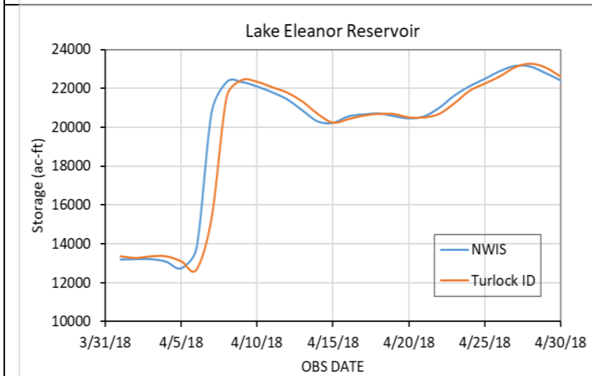
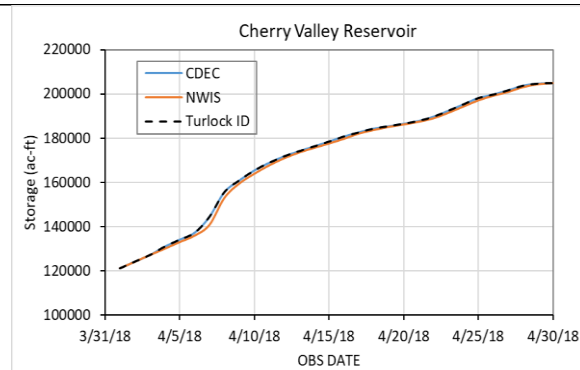


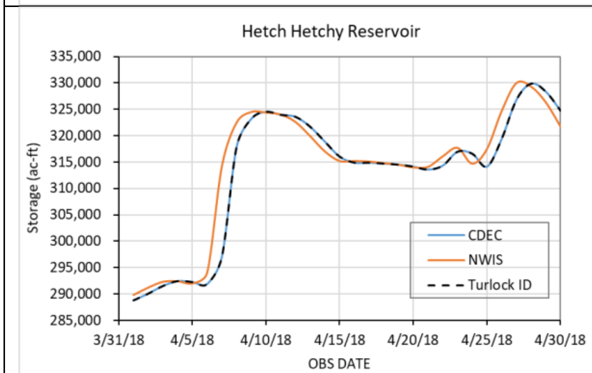
Table C-3: Comparison Graphs for Tuolumne River Datasets, April 2018

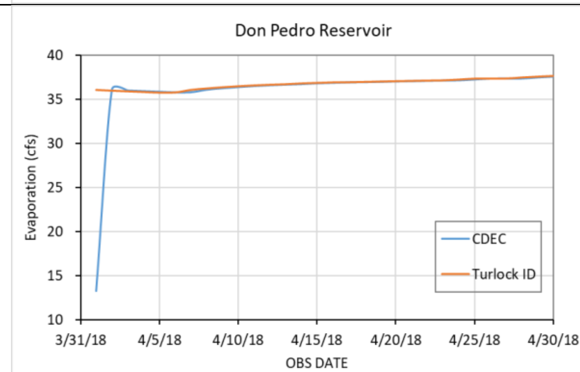


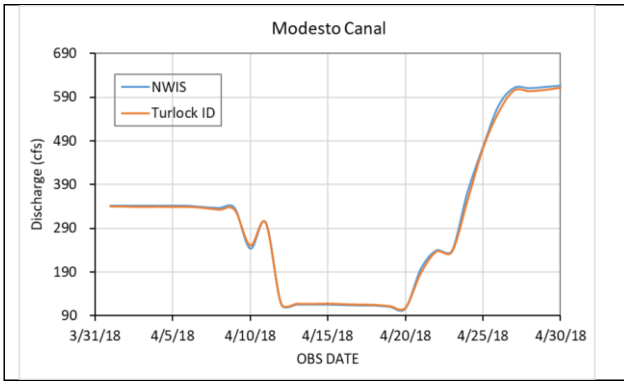












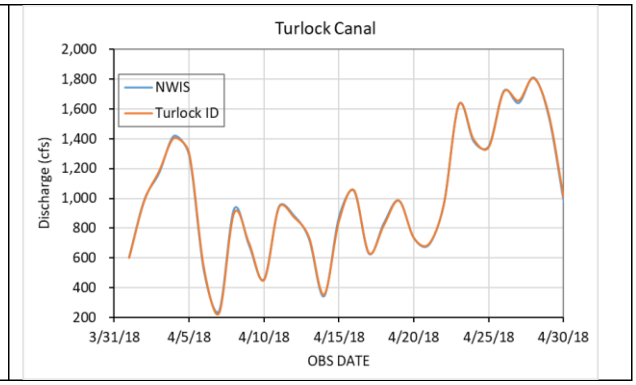
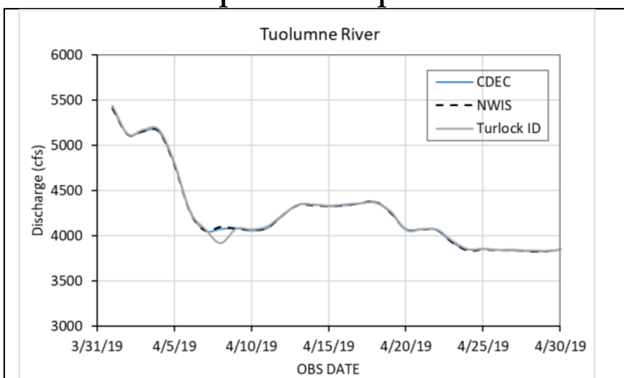
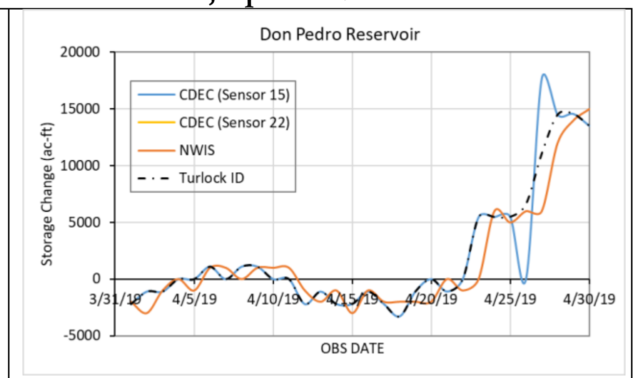
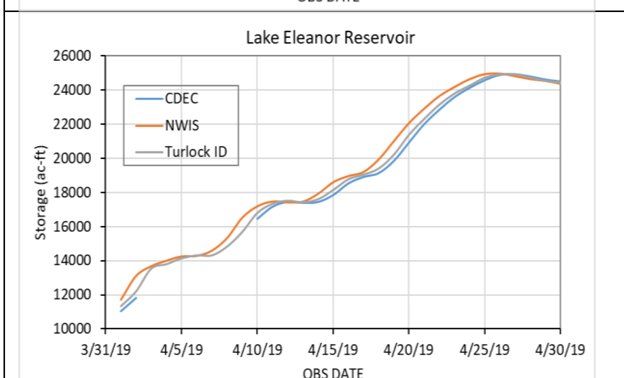
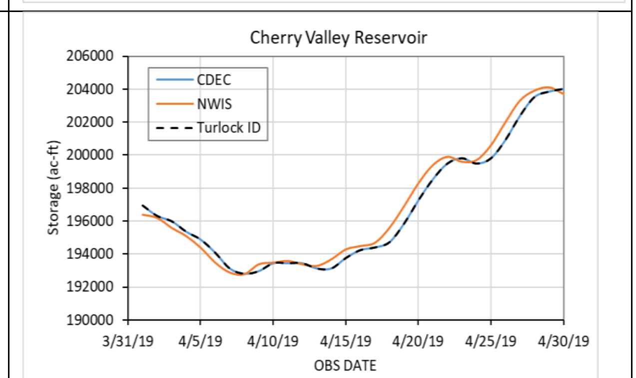


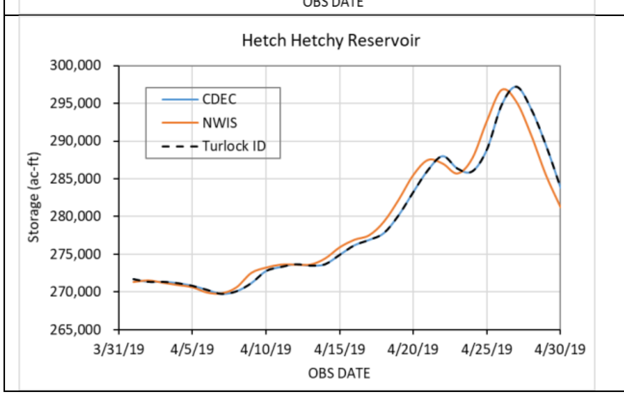
Table C-4: Comparison Graphs for Tuolumne River Datasets, April 2019

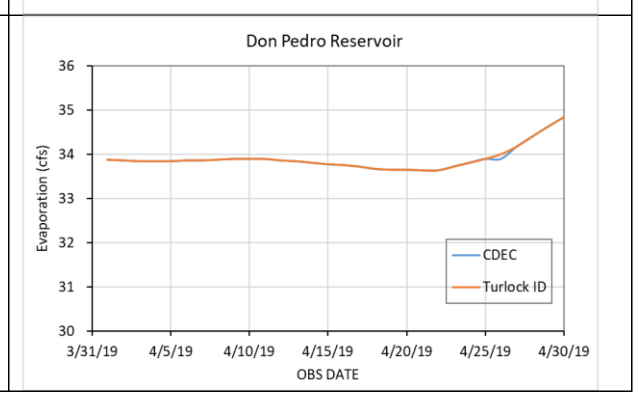


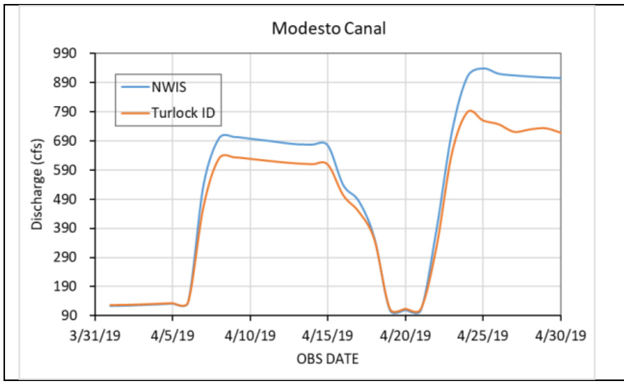












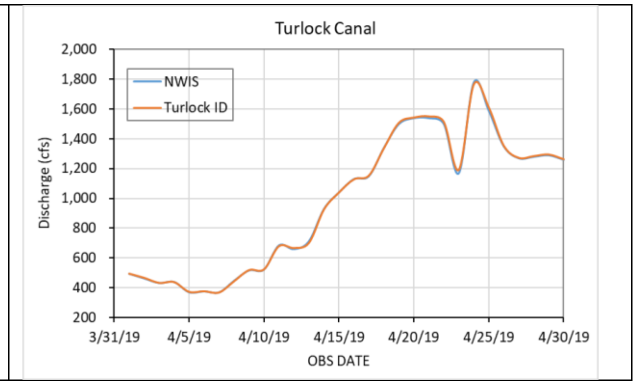
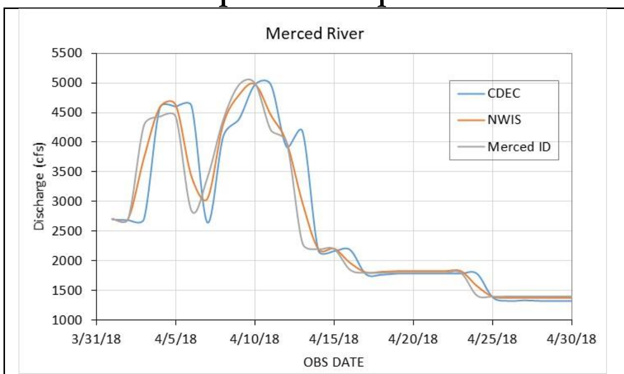
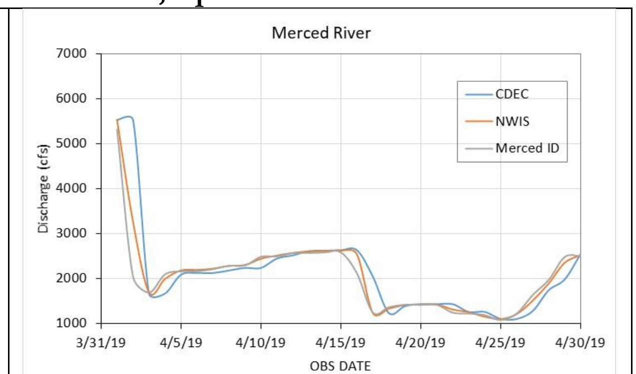
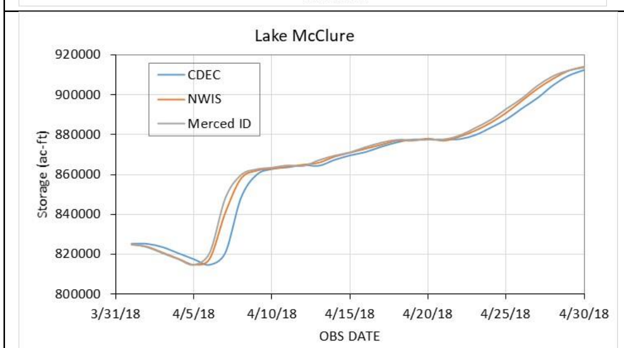
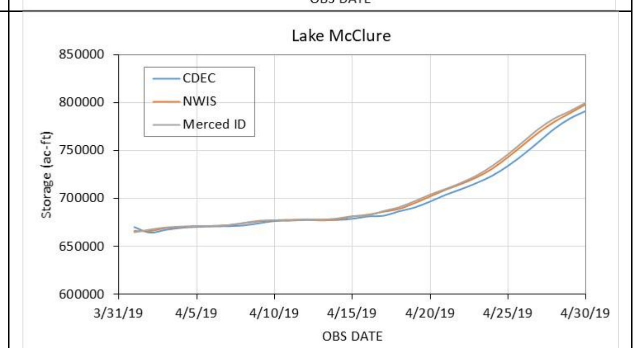


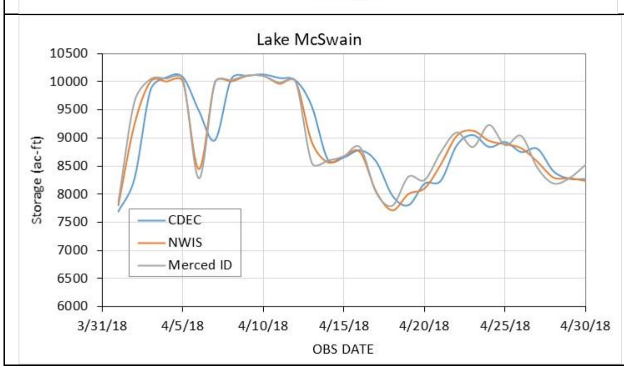
Table C-5: Comparison Graphs of Merced River Datasets, April 2018 and 2019

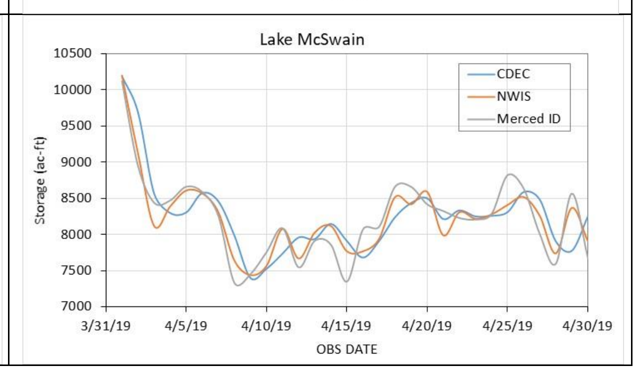












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