Appendix D

Truckee River Basin Historical Data Development Methodologies: Water Years 1986-2000

TECHNICAL MEMORANDUM

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TO: U.S. Bureau of Reclamation

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FROM: Curtis Lawler

JOB NO: 1336

RE: Truckee River Basin Historical Data Development Methodologies: Water Years 1986-2000

1.0 Introduction and Objective

The purpose of this draft technical memorandum is to document the procedures used to compile the daily hydrologic data for use in the Truckee-Carson RiverWare™ models for the period 1986-2000 (15 years). This dataset is intended to complement the RiverWare daily dataset developed for 2001-2016 (Precision, 2022a). The RiverWare Model runs on a daily timestep, and the primary data inputs include hydrologic inflows into each reservoir and into various river reaches.

Previously, monthly hydrologic data for each water year from 1901 through 2000 (100 years) was available in Truckee River Operations Model (TROM) and was disaggregated into a daily timestep for use in RiverWare (Stetson, 2010 and Stetson, 2011). However, to create a more consistent data set, this technical memorandum documents a new effort to compile Truckee Basin hydrologic data before 2001 using the same methodologies that were used to develop more recent data for RiverWare including 2001 through present (Precision, 2022a). The objective of this technical memorandum is to provide a summary of these methodologies (1986-present) and provide notes to file for this dataset 1986-2000.

2.0 Procedures Summary

Precision Water Resources Engineering created instructions on how to utilize the same tools that were used for the development of daily data from 2001 through present (Precision, 2022b). These instructions are included as **Attachment 1**. These procedures can be summarized in the following steps: gaged data collection, data estimation for missing data, RiverWare and VBA tools processing, and manual review.

The same data that was generated as for 2001-2016 is generated for this study, as shown below from Table 4 (Precision, 2022a):

Table 1: Summary of the datasets developed in this effort, all ranging from Oct. 1, 1985 – Sep. 30, 2000 (Water Years 2001 – 2016) *Tahoe's Hydrologic Inflow is a net inflow, meaning that it includes precipitation and evaporation (Source: Table 4, Precision, 2022a)

	Precipitation Rate	Hydrologic Inflow	Local Inflow	Other Stream Gage Flows
Above Farad				
Boca	✓	✓		
Donner	✓	✓		
Independence	✓	✓		
Martis	✓	✓		
Prosser	✓	✓		
Stampede	✓	✓		
Tahoe*		✓		
Below Donner			✓	
Below Tahoe			✓	
Sidewater			✓	
Farad Natural Flow		✓		
Below Farad				
Farad to Mogul			✓	
Mogul to Reno			✓	
Reno to Glendale			✓	
Glendale to Sparks			✓	
Sparks to Vista			✓	
Vista to Derby			✓	
Below Derby			✓	
Wadsworth To Nixon			✓	
Hunter Creek				✓
Steamboat Creek at Steamboat				✓
Carson River at Ft Churchill				✓

In general, mass balance equations for reservoir and reaches were used to compute local inflows (Change in Storage = Inflows minus Outflows). Please refer to "Truckee River Basin Historical Data Development Methodologies: Water Years 2001-2016" (Precision, 2022a) for more details on the methodologies. Below are notes to file that are specific to this time period 1986-2000. Section 3 discusses Above Farad data inputs and Section 4 discusses Below Farad data inputs. The final dataset from this study 1986-2000 for daily inputs for both Above and Below Farad were compiled into one spreadsheet "RW Daily Inputs1986-2000_9-26-22.xls" (**Attachment 2).**

3.0 Above Farad Data

Please see Section "3.1 ABOVE FARAD DATA DEVELOPMENT" in the 2001-2016 documentation (Precision, 2022a) for more background on Above Farad input data compilation. Special notes include Lake Tahoe's hydrologic inflow also including precipitation and evaporation compared to the other reservoirs (Donner, Prosser, Martis, Independence, Stampede, and Boca).

3.1 Above Farad 1986-2000 Data Collection and Estimation

To calculate Above Farad local inflows, about 25 gages are needed to be compiled. The 1986-2000 time period relied more on the USGS database rather than the TROA Information System (TIS) compared to the 2001-2016 dataset. So, the 1986-2000 daily data is not corrected for time travel. In addition, reservoir elevation data or reservoir storage data was not available for entire period of record for this study for Donner, Prosser, Martis, and Independence (see Table 2 below).

Table 2. Availability of Daily Reservoir Storage Data in USGS Database for Water Years 1986-2000

Reservoir	Pool Elevation/ Storage Data
Lake Tahoe*	10/1/1985-9/30/2000
Donner Lake	1/5/1989-09/30/1990
Prosser Creek Reservoir	10/2/1987-9/30/2000
Martis Creek Reservoir	10/1/1985-09/30/1990
Independence Lake	11/10/1988-9/30/2000
Stampede Reservoir	10/1/1985-9/30/2000
Boca Reservoir	10/1/1985-9/30/2000

In addition to the whole periods of missing reservoir elevation or storage data shown in the table 2 above, there were also random miscellaneous days of missing data in the period 1986-2000. This missing reservoir storage or elevation data in the USGS database was supplemented by the daily database for the upper Truckee River watershed developed by Reclamation in 2005 (Rieker, 2005), which included review of previous data compilations, handwritten reservoir operation materials and interpolation.

The 2005 Rieker study (Rieker, 2005) was also utilized for the daily precipitation data for the upper six reservoirs listed above from October 1, 1948, through September 30, 2000. These calculations were based on procedures specified in a 1994 TROA Draft Agreement and involved utilizing available gaged data and an annual conversion factor (Technical Committee, 1994). The Tahoe precipitation is from the TIS database.

The prerequisite data needed to calculate inflows was available from the USGS, the Rieker study, and TIS except for:

1. Truckee River near Truckee gage (USGS 10338000) missing data in water years 1986-1992 and 1996.

2. Donner Creek At Hwy 89 (USGS 10338700) missing data in water years 1986-1993.

3. Sierra Valley daily diversion data not available for period 1986-1999.

The missing data for items 1 and 2 (gaged flows used to disaggregate the Sidewater) were estimated by regression with the Sagehen Creek gage (USGS 10343500). Figures 1 and 2 show the regression equation used for Tahoe and Donner Creek gages, respectively. For each gage, the outflow from the upstream lake (Tahoe and Donner, respectively) were subtracted from the downstream gage and then added back into the total gage flow for the RiverWare model.

Figure 1. Regression of Sagehen Gage (10343500) and Truckee near Truckee Gage (10338000), 1993-2000.

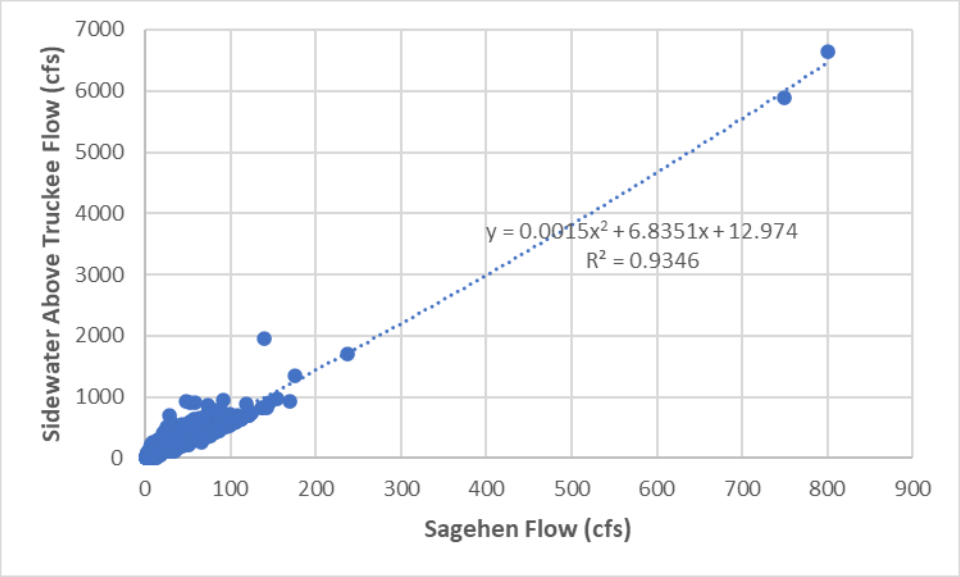
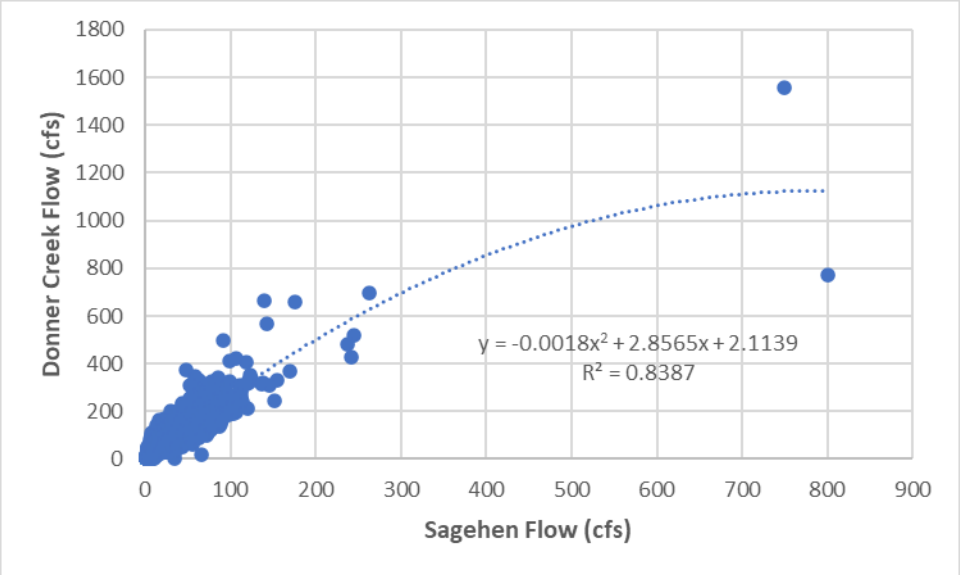


Figure 2. Regression of Sagehen Gage (10343500) and Donner Creek Gage (10338700), 1992-2000.



Monthly Sierra Valley diversions were obtained from the WaterMaster via email for the period 1986-1999. Daily Sierra Valley diversion data was available from TIS for year 2000. The monthly diversion data was disaggregated daily by dividing the number of days in the month. For months with the diversion close to the maximum allowable diversion, the daily diversion was ramped up to 60 cfs. The Sierra Valley diversions for 1986-2000 are shown in Table 3.

Table 3. Historical Diversions by Sierra Valley Upstream of Stampede Reservoir, 1986-2000

WY	AFY
1986	6,655
1987	7,598
1988	10,595
1989	6,319
1990	6,999
1991	8,271
1992	7,505
1993	5,023
1994	7,550
1995	3,336
1996	5,782
1997	9,722
1998	9,527
1999	6,959
2000	9,387
AVG	**7,415**

All the above input data (reservoir elevations, precipitation, outflow, and diversion data) are compiled into the spreadsheet "AboveFaradInputData_1986-2000.xlsx" (**Attachment 2**). The "AboveFaradDataDevelopment_1986-2000_9-26-22.xlsx" (**Attachment 2**) spreadsheet is then used to run RiverWare via macros to calculate the hydrologic inflow into the seven upper reservoirs and three sidewater reaches. This daily inflow dataset is referred to as the "Raw" data and includes anomalies caused primarily by gaging errors. Although not perfect, this dataset is important because it based on measured data. Also, the "Raw" dataset is important as the benchmark for total annual volumes that need to be conserved in the next steps.

3.2 Above Farad 1986-2000 RiverWare/VBA Macro Processing and Manual Review

The Above Farad data compilation for the 1986-2000 includes three additional steps after calculating the "Raw" data: 1) smoothing; 2) processing after smoothing, and 3) manual review. The "AboveFaradDataDevelopment_1986-2000_9-26-22.xlsx" spreadsheet contains a macro that does the first level of smoothing. The "DataDevelopmentOutput_WY1985-2000_UpstreamFarad_9-26-22.xlsx" (**Attachment 2**) spreadsheet contains the macros that do the next round of processing and assist in manual review.

Manual edits to the data are logged in the "ManualEditLogs" page of the data development spreadsheet after the raw, smoothing, and macros after smoothing are completed. In addition, a peer review group consisting of stakeholders for the Truckee Basin Water Management Options Pilot project ("WMOP") reviewed the DataDevelopment spreadsheet. Their comments are included in the spreadsheet "CommentSheet_DailyData_Pre2000s_TrackChangesforPeerReview_7-8-2022.xls" (**Attachment 2**). Out of the 121 comments on the April daily dataset, there were 37 with additional backcheck comments remaining on the 9-26-22 dataset. The other 84 comments were addressed with additional manual changes or explanations as logged in the DataDevelopment spreadsheet. While most the anomalies of the inflows based on measured data are able to be smoothed out, not all of them could be while at the same time maintaining a close mass balance based on measured data. This 9-26-22 dataset may need to be modified in the future depending upon the purpose of any given study.

A summary of the 9-26-22 daily dataset is shown in Table 4 below. It is anticipated that edits could be made to this dataset depending on the particular use of this data in the future. Attachment 2 has the key electronic files used during this process. "AboveFaradInputData_1986-2000.xlsx"; "AboveFaradDataDevelopment_1986-2000_9-26-22.xlsx"; and "DataDevelopmentOutput_WY1985-2000_UpstreamFarad_9-26-22.xlsx"

Table 4. Historical Average Flows, 1986-2000, in Acre-feet/Year as compiled on 9-26-22

	Raw	***Manual***	**Difference %**
Tahoe	164,174	164,156	0.0%
Donner	27,351	27,349	0.0%
Prosser	63,662	63,548	0.2%
Martis	19,525	19,525	0.0%
Independence	15,674	15,677	0.0%
Boca	12,421	12,358	0.5%
Stampede	112,501	112,554	0.0%
Sidewater Tahoe-Truckee	69,450	70,193	-1.1%
Sidewater Donner	25,347	25,531	-0.7%
Sidewater Truckee-Farad	59,236	58,256	1.7%
Total Sidewater	154,033	153,981	0.0%
TOTAL UPPER INFLOW	**569,341**	**569,148**	**0.0%**

4.0 Below Farad Data

Please see Section "3.2 BELOW FARAD DATA DEVELOPMENT" in the 2001-2016 documentation (Precision, 2022a) for more background on Above Farad input data compilation.

4.1 Below Farad 1986-2000 Data Collection and Estimation

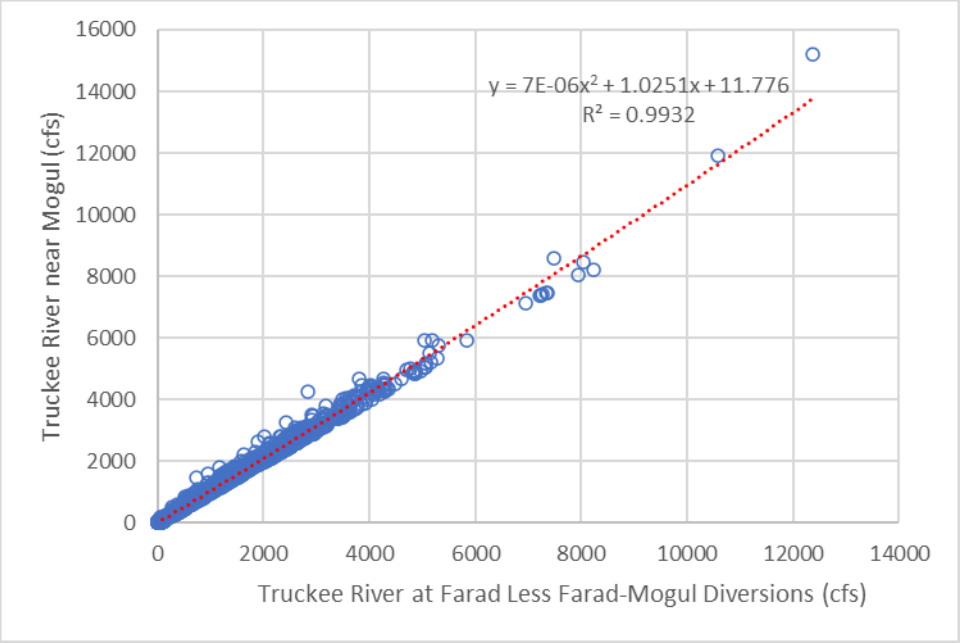
To calculate Below Farad local inflows, about 35 gages are needed to be compiled. The prerequisite 1986-2000 data needed to calculate inflows was available from the USGS and TIS except for:

1. Truckee River near Mogul gage (USGS 10347460) missing data in water years 1986-1992 and 1996.

2. Hunter Creek near Reno gage (USGS 10347600) missing data in all water years 1986-2000.

The Truckee River at Mogul gaged flow was estimated based on a regression analysis with the Truckee River at Farad gage (ID 10346000) less Farad to Mogul diversions (Steamboat, Highland/ Chalkbluff, and Coldron). Figure 3 shows the regression relationship used to estimate the missing gaged flow at Mogul.

Figure 3. Regression of Upstream Flow Data and Truckee River near Mogul, 1993-2020.



The Hunter Creek near Reno gage was more difficult to estimate. After testing different variables and combinations, three variables were used to estimate Hunter Creek flows including Carson River at Fort Churchill, the Sidewater between Truckee and Farad, and Independent Reservoir inflows. The equation used is Carson River * 0.010706 + Independent * 0.074155 + 3-day average of Sidewater * 0.022109. The R-squared value for the period 2002-2017 is 0.82. If the Sidewater was less than 100 cfs, then just the Carson River was used: Carson River * 0. 005857 + 4.354359.

All the above input data (gaged flows and diversion data) is compiled into the spreadsheet "Truckee Local Inflow Calc_v12_WY1986_2000 DownFarad 7-8-22.xls" (**Attachment 2**). Then the "Populate Data" button build all reach sheets and compute the local inflow data. This daily inflow dataset is referred to as the "Raw" data and includes anomalies caused primarily by gaging errors. Although not perfect, this dataset is important because it based on measured data. Also, the "Raw" dataset is important as the benchmark for total annual volumes that need to be conserved in the next steps. For the Below Farad reach, the total volume between Farad and Nixon gages is an important parameter to match with the gaged data.

4.2 Below Farad 1986-2000 RiverWare/VBA Macro Processing and Manual Review

The Below Farad data compilation for the 1986-2000 includes two additional steps after calculating the "Raw" data: 1) smoothing/processing and 2) manual review. The same spreadsheet "Truckee Local Inflow Calc_v12_WY1986_2000 DownFarad 7-8-22.xls" contains macros that do the smoothing and processing and it's also where the manual review occurs. The QA/QC page contains the manual edits that were added to the daily dataset.

A summary of the 7-8-22 daily dataset is shown in Table 5 below. The total volume of local inflow between Farad and Nixon is the key component that is conserved based on the gaged data. Figures 4, 5, and 6 show the gaged versus simulated using these calculated local inflows for Reno, Vista, and Nixon gages. Bothe the R-squared and the Nash–Sutcliffe model efficiency coefficient (NSE) indicate very good estimates over 0.9. Please see the 2001-2016 documentation (Precision, 2022a) for additional verification of this methodology. Attachment 2 has the key electronic file used during this process "Truckee Local Inflow Calc_v12_WY1986_2000 DownFarad 7-8-22.xls".

Table 5. Historical Average Flows, 1986-2000, in Acre-feet/Year as compiled on 9-26-22

	Raw	***Manual***	**Difference %**
Truckee River at Reno	491,924	504,684	2.6%
Truckee River at Vista	581,717	570,534	-1.9%
Truckee River at Nixon	451,036	451,036	0.0%
TOTAL LOCAL INFLOW FARAD TO NIXON	**73,439**	**73,439**	**0.0%**

Figure 4. Gaged versus Simulated Daily Flows at Truckee River at Reno, 1993-2020.

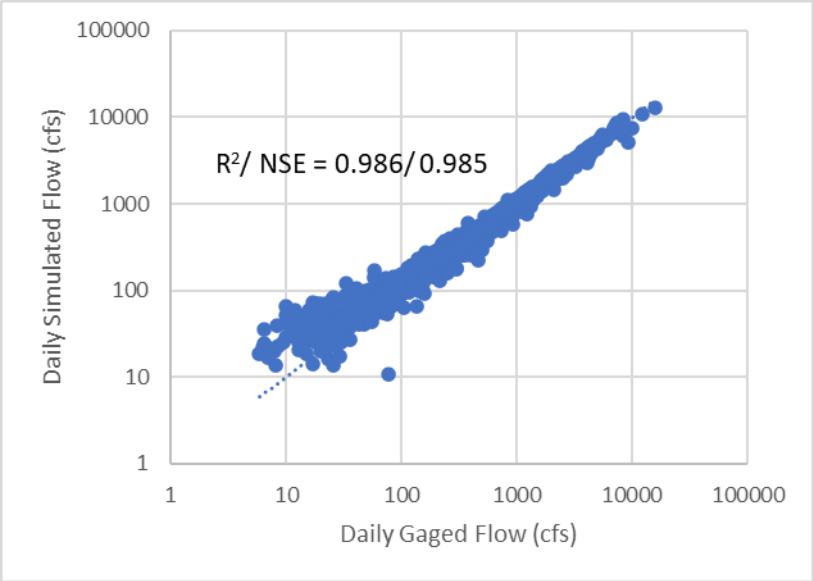


Figure 5. Gaged versus Simulated Daily Flows at Truckee River at Vista, 1993-2020.

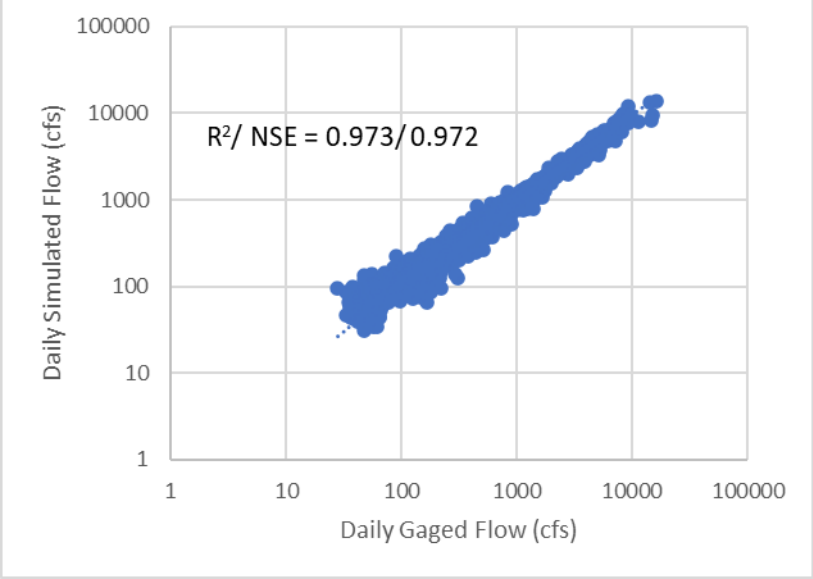
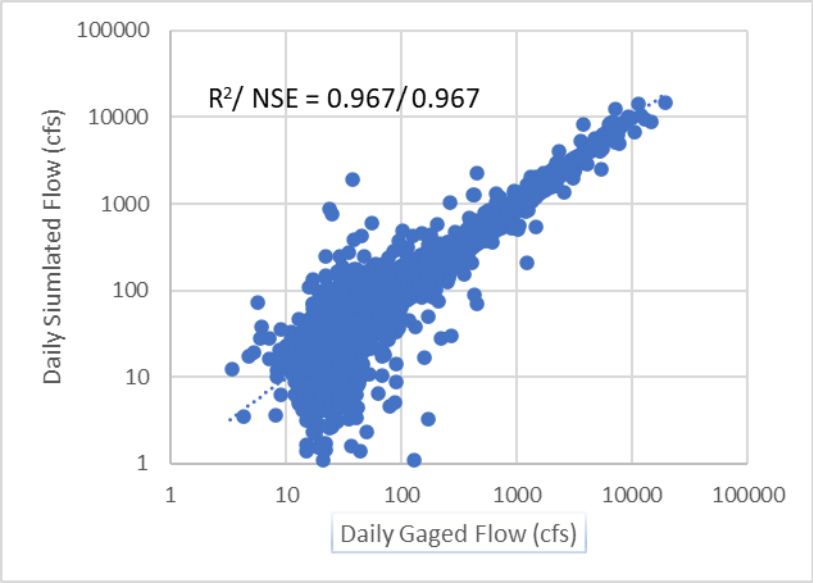


Figure 5. Gaged versus Simulated Daily Flows at Truckee River at Nixon, 1993-2020.



5.0 References

Precision Water Resources Engineering. Truckee River Basin Historical Data Development Methodologies: Water Years 2001-2016. August 19, 2022.

Precision Water Resources Engineering. Instructions to Develop Above and Below Farad Datasets. January 2022.

Rieker, et. al. Bureau of Reclamation. Documentation for Hydrologic Data, Truckee RiverWare Model. August 2005.

Stetson Engineers Inc (Stetson). Fulwiler, J., & Lawler, C. TCDATFIL Disaggregation to Daily Data. Draft Technical Memorandum. November 10, 2010.

Stetson Engineers Inc. Fulwiler, J., & Lawler, C. Truckee Meadows Local Inflow Dataset. Draft Technical Memorandum. Oct 26, 2012.

Technical Committee, Truckee River Operating Agreement Development. Draft Reservoir and Lake Losses. May 24, 1994.

Attachment 1 Instructions
Attachment 2 Spreadsheets
"AboveFaradInputData_1986-2000.xlsx"
"AboveFaradDataDevelopment_1986-2000_9-26-22.xlsx"
"DataDevelopmentOutput_WY1985-2000_UpstreamFarad_9-26-22.xlsx"
"CommentSheet_DailyData_Pre2000s_TrackChangesforPeerReview_7-8-2022.xls"
"Truckee Local Inflow Calc_v12_WY1986_2000 DownFarad 7-8-22.xls"
"RW Daily Inputs1986-2000_9-26-22.xls"