David Rosas

HYD 243

6/8/2021

Hydrologic Characterization and Modeling of the Upper Eel River

Abstract:

The Upper Eel River is a California waterway that has been utilized for human and environmental water needs for over a hundred years. Recent changes to the water system has caused stakeholders to revaluate the Upper Eel River and its future role in the area. This study focuses on the hydrologic characterization of the Upper Eel River and simulates unimpaired flow for the water system using water allocation modeling.

1. Introduction

The Eel River is California's third largest watershed and is an essential California waterway for human development and environmental functionality. The study area for this project starts from the headwaters of the mainstem Eel River to the Van Arsdale Dam. In between the study area is Lake Pillsbury, which is held by Scott Dam. In 1981, 398 river miles of the 800 river miles that make up the Eel River were protected under the National Wild and Scenic Rivers System (U.S. Fish and Wildlife Service, n.d.). The study area is not currently covered under the National Wild and Scenic Rivers System; however, the study area is marked as a crucial water supply to both human and environmental systems. Since 1908, the study area has been relied upon as a water supply, storage, and energy generation area for the surrounding area (Silva-Jordan, P.T., 2016). At Van Arsdale Dam water is diverted to generate hydroelectric power and divert water to the East Fork of the Russian River (Congressman Jared Huffman's Ad Hoc Group, n.d.). The facilities are called the Potter Valley Project and since 1930 the project has been owned and operated by Pacific Gas and Electric (PG&E) (Silva-Jordan, P.T., 2016). In 2019, PG&E withdrew from the Potter Valley Project by giving notice to the Federal Energy Regulatory Commission (FERC) that PG&E will not be relicensing the project (Congressman Jared Huffman's Ad Hoc Group, n.d.). The withdraw from PG&E has made local stakeholders focus even more about what water management decisions should be made for the Potter Valley Project and Upper Eel River. For example, a Water Supply Working Group suggested the removal of Scott Dam to provide better habitat for fish population (Water Supply Modeling Subgroup, 2020). Currently, in 2021, major water management decisions can be made that could affect human and environmental water supply for decades. This study seeks to support water management decision making by providing key hydrologic characterization of the area and simulating naturalization of the area.

2. Data

For this study all stream discharge data was pulled from United States Geological Survey's (USGS) National Water Information System. Four USGS gauge sites were used with daily flow data from October 1, 1928 to September 30, 2019. Figure 1 shows the number of valid data points available for each USGS gauge out of the 33,237 days possible.

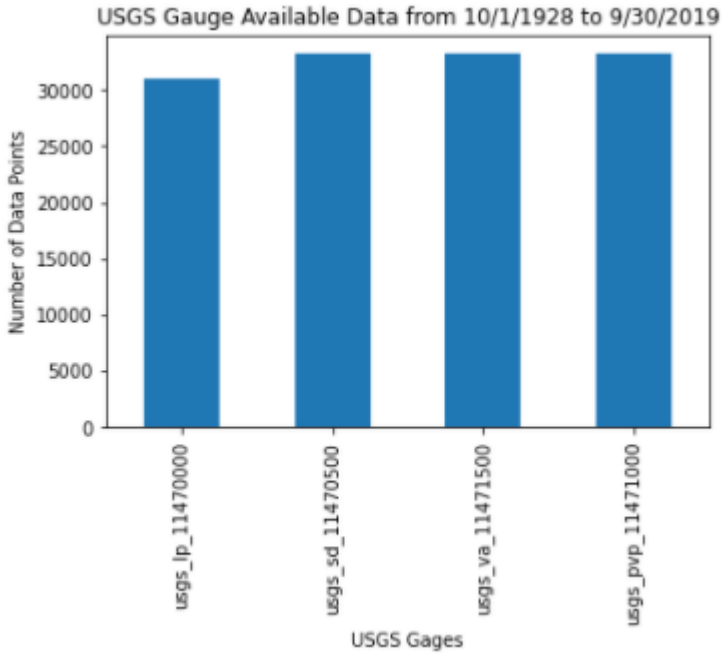

Figure 1. number of available data points at each USGS reference gauge. The naming convention includes an abbreviation of the gauge location and the USGS's site number for the gauge.

Reference functional flow data was pulled from the Nature Conservancy's natural flows database for the Eel River segment directly below Scott Dam (COMID: 8309952). The natural range of variation of functional flow metrics included for this analysis are a dry-season baseflow, fall pulse, wet-season baseflow, and spring recession in the 10th, 50th, and 90th percentile. The data was pulled from the "All" year water type and only included modelled data. Data selection was chosen based on representation (Table 1).

Flow Component	10th	50th	90th	units
Dry-seaon baseflow	0.106512	0.259835	0.90843	hafd
Dry-Season Start	May 10	June 16	July 12	date
Fall pulse magnitude	1.090909	3.193388	12.07934	hafd
Fall pulse start	Oct. 7	Oct. 23	Nov. 11	date
Fall pulse duration	2	5	13.4	days
Wet-season baseflow	7.53719	13.11074	21.22314	hafd
wet-season start	Nov. 9	Nov. 30	Dec. 16	date
spring recession magnitude	13.80496	34.90909	147.9669	hafd
Spring start	Mar. 7	April 6	May 7	date

Table 1: A compiled dataset of Natural flows

3. Methods

The hydrologic characterization for the study area was developed by using python data analysis tools on both the Lake Pillsbury reservoir gauge (usgs_lp_11470000) and the USGS gauge below Scott Dam (usgs_sd_11470500). Data analysis for Lake Pillsbury included the total annual sum and monthly flow rates. Total annual flows describes the hydrologic history of the reservoir and monthly flows show the general trend of the reservoirs operation.

The river segment was naturalized using the principle of conservation of mass to create water mass balance equations that simulate water allocation along the Upper Eel River. Two simulated data sets were generated, one at Van Arsdale and the other as an inflow into Lake Pillsbury. Lake Pillsbury unimpaired inflow was simulated by adding the recorded outflow below Scott Dam (usgs_sd_11470500) and the negative change in storage of Lake Pillsbury (usgs_lp_11470000) at a daily time-step. Van Arsdale's unimpaired flows were calculated by adding the simulated unimpaired inflow from Lake Pillsbury with a simulated incremental flow at a daily time-step. Simulated incremental flows are defined as the estimated inflow added to the Eel River after Scott Dam. Incremental flows were calculated by Adding the outflow below Van Arsdale (usgs_va_11471500) and the Potter Valley Project (usgs_pvp_11471000) and subtracting Lake Pillsbury's Outflow.

After all the necessary data was produced, the data was analysed using total annual flow calculations for simulated flows and creating a comparison of average monthly flow between unimpaired and impaired flows. Release schedule was assumed from water discharge data from the USGS gauge located below Scott Dam.

4. Results

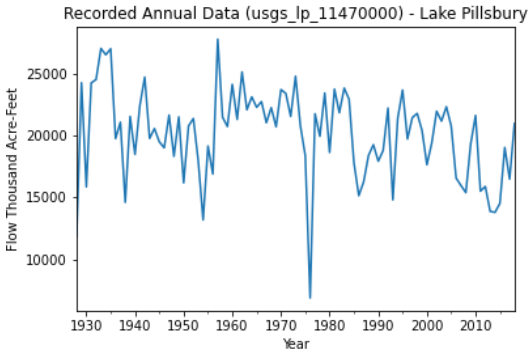

Figure 2. Total Annual Flow for Lake Pillsbury

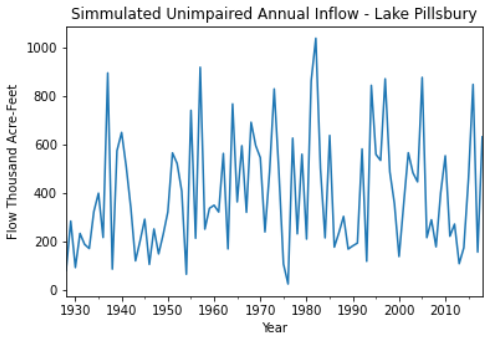

Figure 3. Total Annual Flow for Simulated Unimpaired Lake Pillsbury

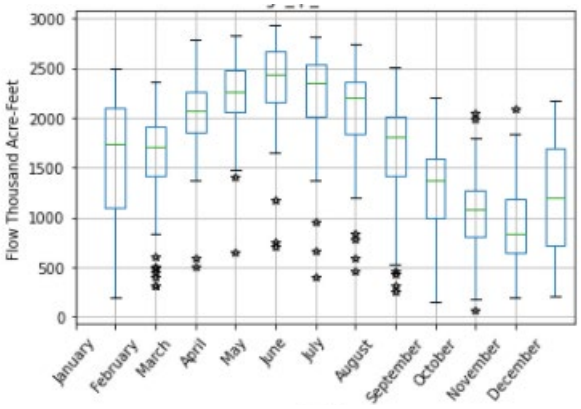

Figure 4. Monthly Flow Box Plot for Lake Pillsbury

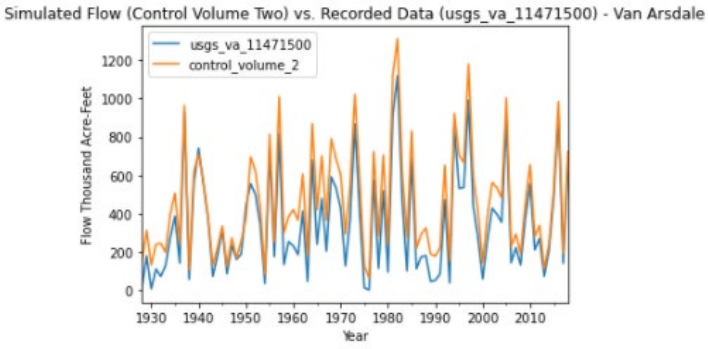

Figure 5. Total Annual Flow for Simulated Unimpaired Van Arsdale and Recorded Van Arsdale Data

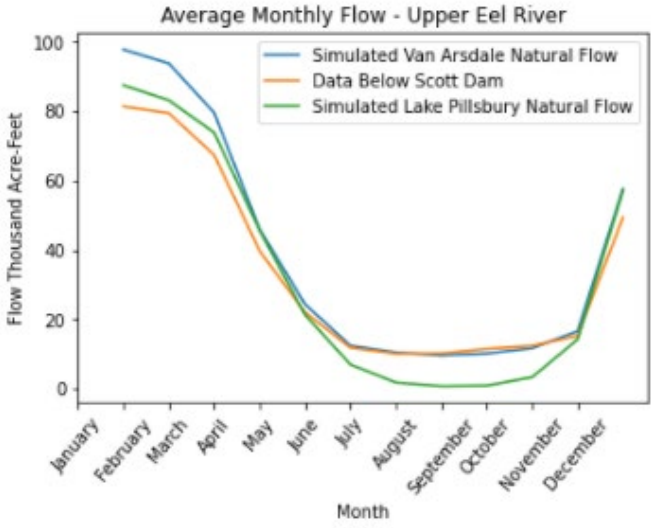

Figure 6. Monthly Flow Comparison between Impaired and Unimpaired Flows

California's hydrology follows its Mediterranean climate with wet winters and dry summers. Looking at average monthly flows for impaired and unimpaired flows (Figure 6), the upper Eel River can be best hydrologically characterized as a Flashy Ephemeral Rain flow class (Lane, 2016). This means the reach has mid-range seasonality and very low predictability in terms of discharge (Lane, 2016).

5. Discussion

The results validate that Lake Pillsbury is a water storage reservoir that dictates the water supply for the Eel River. Simulated Inflow into Lake Pillsbury (Figure 3) is a small fraction of water storage capacity. With a large water storage capacity Lake Pillsbury is able to transform its average monthly mean to store water in summer months (Figure 4). In contrast, unimpaired flows have greater variability between wet and dry years and less total annual flow available (Figure 3 and Figure 6). The biggest significance to unimpaired flows versus impaired flows is the buffer reservoir storage provides during the summer dry period on average (Figure 6). Figure 6 shows that between July and November simulated unimpaired flow drops below the real data outflow below Scott dam because there is no water storage available to supplement natural flows.

In regards to van Arsdale, the water allocation model was able to match annual patterns (Figure 5). The downstream control volume two also showed higher monthly flows than its upstream counterpart, because the simulation account for incremental flows. This is another confirmation that the allocation model matches observed data.

PG&E schedule release amounts for Lake Pillsbury and Van Arsdale are to meet minimum instream flow requirements required by the Federal Energy Regulatory Commission and to meet the Potter Valley Projects water demand (p.7, Sonoma County Water Agency). With the removal of Scott Dam both water demand and environmental flows may receive more water during winter months, but would have to compete during summer months.

6.Conclusions

With the results of this study it is clear that the Upper Eel River is an essential water supply system, but due to its variability the Upper Eel River is a difficult water source to efficiently utilize. Creation of Scott Dam increased water storage and water system reliability. A removal of Scott Dam will have a clear impact on the reliability of water supply during summer low flow months. The Upper Eel River requires a nuance multi-object water management strategy to effectively utilize the Upper Eel River's flow. Future research will expand at looking at reservoir reoperation at Scott Dam and potential trade-offs between human and environmental flows.

REFERENCES

Congressman Jared Huffman's Ad Hoc Group (No Date), Potter Valley Project – Overview, accessed 3/13/2021, http://pottervalleyproject.org/overview/

Lane, B.A., Dahlke, H.E., Pasternack, G.B., and Sandoval-Solis, S. (2016). Revealing the diversity of natural hydrologic regimes in California for environmental flows applications. J. American Water Resources Association. Accepted. August 2016 Accessed 3/12/2021, http://watermanagement.ucdavis.edu/files/2314/8652/1690/Lane_et_al_2017_Revealing_the_Diversity_of_NAtural_Hyd_Regimes_in_CA.pdf.

Silva-Jordan, P.T. (2016). Planning Alternatives for Lake Mendocino (Coyote valley Dam) In the Upper Russian River System. Storage and Water Supply Reliability Study. Master Thesis, University of California, Davis, Davis, CA, Accessed 6/10/2020, http://watermanagement.ucdavis.edu/files/9114/6975/0537/Silva-Jordan_2016_Thesis_Final.pdf.

Sonoma County Water Agency. (May, 2015). Lake Mendocino Water Supply Reliability Evaluation Report - Term 17. State Water Resources Control Board Order (2013) Accessed 5/14/2021, http://pottervalleyproject.org/wp-content/uploads/2018/05/Lake-Mendocino-Reliability-Report.pdf

U.S Fish and Wildlife Service (No Date), National Wild and Scenic Rivers System – Eel River, California, accessed 3/12/2021, https://www.rivers.gov/rivers/eel.php

Water Supply Modeling Subgroup: Addley, Craig, and Delaney, Chris, Emery… and Ticlavilca, Andres (2020), Potter Valley Project Huffman Ad-Hoc Committee Water Supply Working Group – Results of Initial Water Supply Modeling For Potter Valley Project and Russian River Alternatives, accessed 6/10/2020,http://pottervalleyproject.org/wp-content/uploads/2020/02/Water-Supply-Modeling-Grp-Combined-Deliverables_Final.pdf.