

Mason Flood

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Flow Regime Analysis Pre and Post Folsom
Dam Construction on The American River

Abstract:

The American River is a river located in Northern California that stretches approximately 119 miles from the Sierra Nevadas to its intersection with the Sacramento River in Sacramento. In 1956 a dam was built by the United States Army Corps of Engineers (USACE) in the Folsom area through the Central Valley Project in order to control floods, produce hydroelectricity, and supply irrigation and municipal water to the surrounding area. This study will focus on the change in flow regime from before the dam was built and after the dam was built. Through this study, one can see that the natural flow regime has been greatly altered after the dam was built.

Introduction:

The American river consists of three main forks that all start in the Sierra Nevadas and converge upstream of the Folsom dam. The river travels approximately 119 miles until it meets with the Sacramento river and from that point on it is considered the Sacramento River. Once the dam was put into place, the reservoir behind it holds approximately 1,010,000 acre-feet of water in what is now considered Folsom Lake. Upstream and downstream of this dam, the American River is home to many important aquatic and riparian communities. In this study we will break down the differences in flow regime from pre and post dam. We will do this by analyzing different scopes of the same data set that is continuous flow data from 1904 to 2013.

This study will use a data set recorded and maintained by the United States Geological Survey (USGS). This data consists of daily measurements of the American River below the dam and is continuous from before and after the dam was constructed. With this data we will attempt to analyze the differences in streamflow from when the river was a natural unimpaired system to when it was anthropocentrically minded and maintained or impaired stream.

Data:

The data used in this study was taken from the USGS in which one can find long term continuous flow data. The data in particular was from the Fair Oaks Gauging Station (USGS 11446500) and is from October 1, 1904 to September 30, 2013 and is the daily flow average in cubic feet per second. The Fair Oaks Gauging Station is located below the dam to give an accurate representation of how the constriction and installation of the dam has affected the flow regime underneath it.



Figure 1: This figure is a map that shows where the Folsom Dam is located as well as where the Fair Oaks Gauging Station is located in relation to it.

Methods:

The methods used for this analysis primarily consisted of using Indicators of Hydrologic Alteration Software (IHA), a free software program offered by The Nature Conservancy's Conservation Gateway section. This program analyzes streamflow data from before and after a certain point that is selected.

The first step in the IHA program is to set your working directory so the program knows where to look for the flow data file. The next step is to import the data and answer the prompts of naming the data, naming the project. Once the data is input and named, the water year is selected to be analyzed before and after that specific point in time. From there, the continuous data could be zoomed in on certain sections of the graph to see similarities or differences in timelines. These different scopes within the IHA program are then compared for pre and post dam timelines.

Still within the IHA program, monthly mean of streamflow was observed. The two monthly mean flows that were graphed were October (representing the beginning of the water year) and March (representing the start of the Spring recession). Mean yearly flow data by month was extracted

from IHA and split into two sections (pre and post dam). From this data, two flow duration curves were produced.

Results:

Figure two consists of the whole data set put into the IHA program. In this graph, different types of flow such as extreme low flows, low flows, high flows pulses, small floods and large floods can be seen. Although the scope of this graph is 108 years, the construction of the dam can be seen in 1956 with the substantial decrease in high flow pulses. On the other hand, the yearly variation of flow rate in a natural river can be seen on the left side of the graph, or the pre 1956 side.

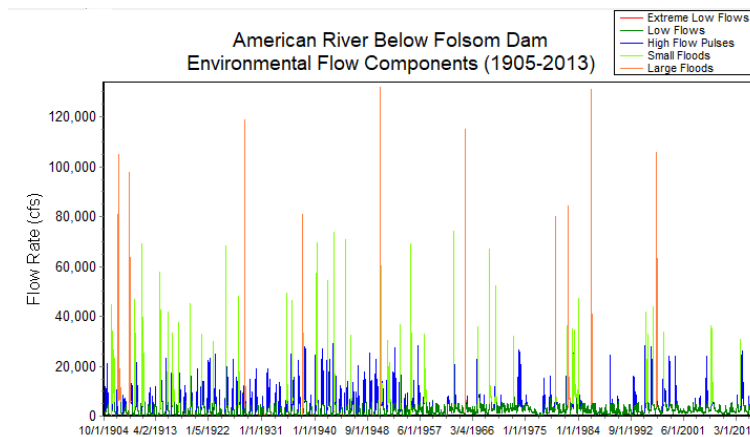


Figure 2: Entire Record Period (1904 - 2013)

Once all of the data was input and the change in natural flow regime could be seen from figure two, pre and post dam timelines were zoomed in on to get a better perspective. Figure three, which highlights the unimpaired flow from 1904 to 1955, shows the natural flow regime of the river system well. Each water year can be clearly seen with the raised winter flow levels and the decline in flow rate for the spring recession followed by a summer low flow. One thing to note is the drought in 1924. This water year compared to others looks flat. Although that year had significantly less water, this was still a natural system experiencing a drought which is normal to see in a large time span such as the time span in figure three.

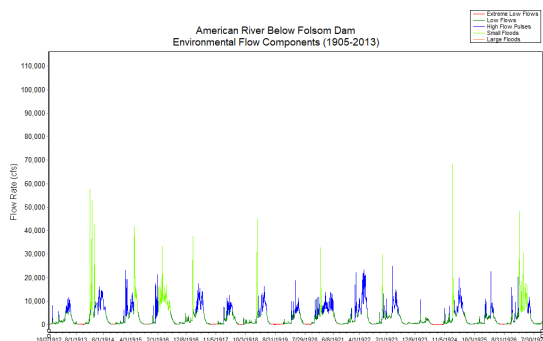


Figure 3: Unimpaired Flow Regime

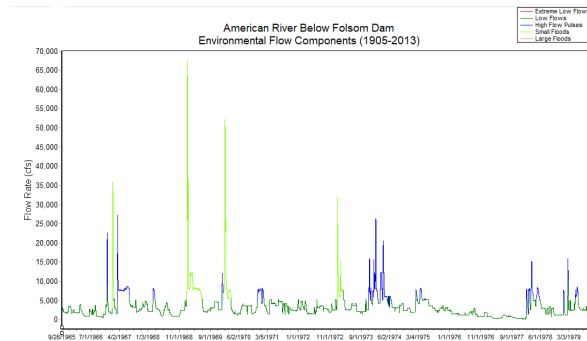


Figure 4: Impaired Flow Regime

Figure four on the other hand was the data graphed after the dam was constructed. The natural flow regime was impaired due to the dam blocking the water flushing through the system unless it was a controlled release by the dam itself. Almost all of the functional flow components have been lost. Although figure three and four are the same river and same gauging station, they do not look like the same system at all.

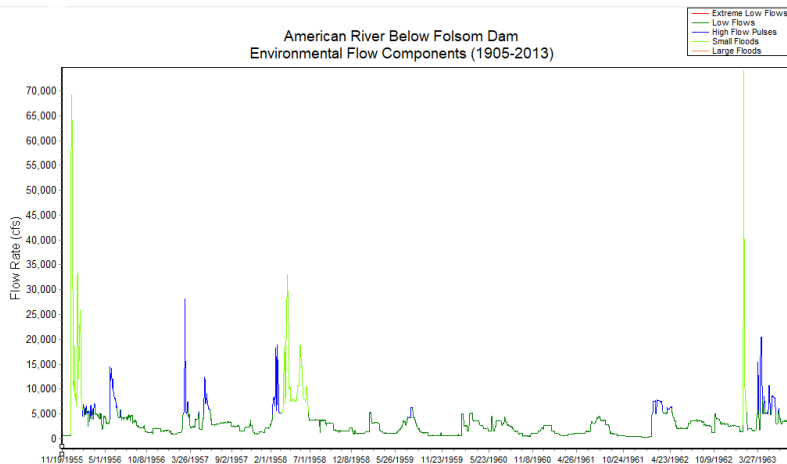


Figure 5: Transitional Period After the Dam Was Built

Figure 5 shows the transitional period after the dam was built. Once again, the figure shows an almost complete loss of the functional flow components. The 1967 to 1958 water year looks to be more of a natural flow rate change throughout the year, but once analyzed further, one can see that this is actually the dam releasing large amounts of water starting in March into July, which should be a spring recession and a drop in flow rate. This flow during that time period is not normal for natural flowing river systems in Northern California.

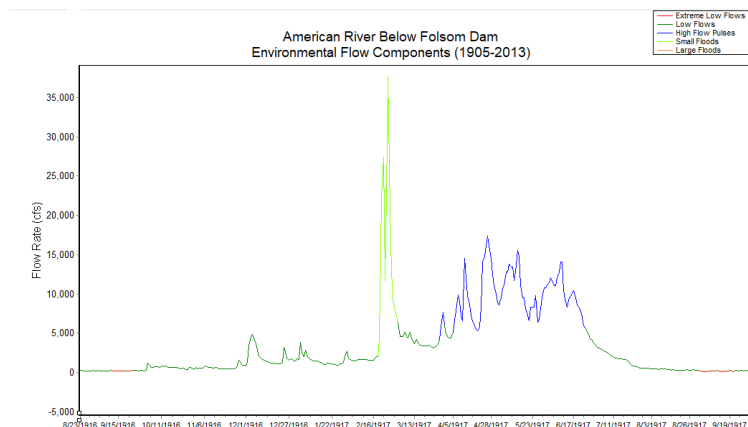


Figure 6: Pre Dam Water Year (1916 - 1917)

Before the dam was constructed, the American River was thought to be a healthy naturally flowing system. Figure six is showing a normal water year before the dam was constructed. In

this figure, one can see the summer low flow followed by short fall pulse flows. These fall pulse flows help to flush toxins and fine sediments that have accumulated during the summer months and purifies the water for the ecosystem. The fall pulse flows are followed by winter storms where precipitation raises the water level and flow rate which is followed by a spring recession and a drop in flow.

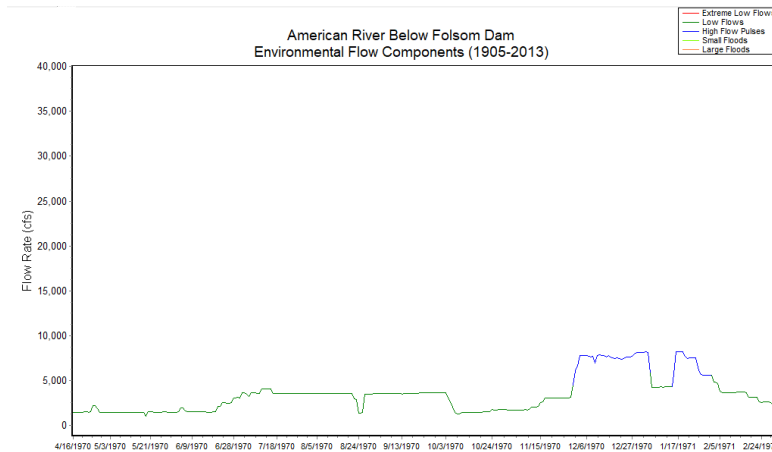


Figure 7: Post Dam Water Year (1970 - 1971)

Contrastingly to figure six, figure seven shows the 1970 to 1971 water year which was after the dam was constructed. Compared to figure six, there are no Fall, Winter, or Spring functional flow components. Another thing to note is that the summer low flow time period has a sustained higher flow level than figure six, or before the dam was built. This artificial flow in the summer as well as plateau of low flow in the winter compared to figure six is where the dam is releasing a certain amount of water for long periods of time. Through this figure, it shows when the agency running the operations of the dam increase or decrease the water that flows through it. Through figures two through seven, although the same graph with different scopes, paints a picture of the damage that the dam has caused to the natural system of the American River.

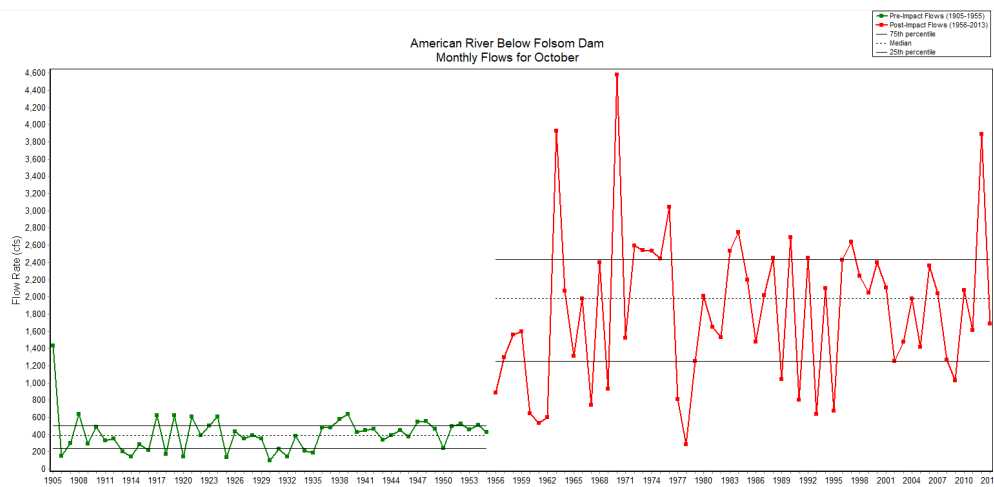


Figure 8: Mean Monthly Flows in October

It was shown in figure seven that the dam had increased summer low flow levels to higher than the unimpaired system. To analyze how much more sustained flow occurred after the dam was built compared to before, a mean monthly flow for October was calculated for each year throughout the data set. October first is considered day one of the water year so it is assumed there has not been rainfall all throughout summer and flow is low. Through figure eight, it can be seen that there is significantly higher flow in October after the dam was built. Before the dam was built the average monthly flow in October was approximately 400 cfs. After the dam was built however, the average monthly flow was approximately 2,000 cfs. That is about a five fold increase in monthly flow for October after the dam was built. This is due to the fact that the dam would release water in preparation for the water year.

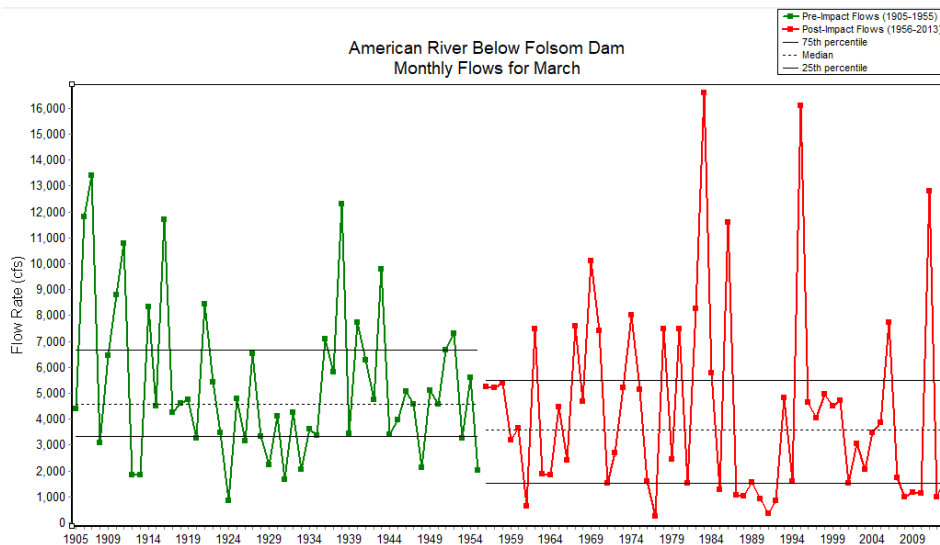


Figure 9: Mean Monthly Flows in March

Once the monthly mean flow in October was produced to represent the beginning of the water year, the March mean flow was then calculated to look into the impacts the dam had in a time frame that represents the spring recession functional flow component. Figure nine, which shows the monthly mean flow for March, shows that after the dam was constructed, there was less flow in the American River than before during this time. Before the dam was constructed the mean monthly flow in March was approximately 4,500 cfs. After the dam was constructed in 1956, the mean monthly flow in March was approximately 3,500 cfs. Although this isn't as drastic as the change in October flow, there is still a 1,000 cfs decrease once the dam was built. This decrease in flow is due to the fact that the agency facilitating the dam, is retaining water behind the dam to prepare for the dryer summer months. This water storage was meant to help the humans around the area, but it ultimately harms the ecosystem in and around the American River.

Month	Pre Dam Flow	Post Dam Flow
October	392	1980
November	574	1980
December	940	2055
January	1880	1985
February	3830	2750
March	4580	3570
April	8095	2908
May	8320	2925
June	4030	3200
July	869	3520
August	289	2570
September	236	1848

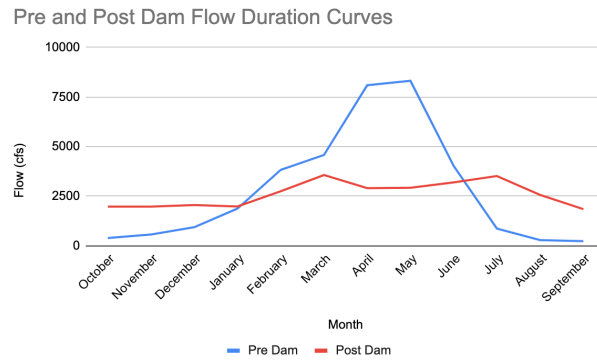


Figure 10: Flow Duration Table and Curves for the American River

The final analysis done for this study was to extract the flow duration tables and create flow duration curves to compare the differences pre and post dam. The flow duration curve created from the data after the dam was constructed shows that the flow has been almost completely homogenized throughout the year. This is not natural for rivers and streams in Northern California.

Discussion:

Through the analysis in the results, it is clear that the Folsom Dam has significantly altered the hydrology and natural stream flow system in the American River. The clearest change that can be seen is the lower water level in the winter time when there is supposed to be a sustained increase in flow. It is also observed that there is higher flow duration in the summer months when historically there was very low flow. Through the flow duration curves, it can be seen that after the dam was built, the flow was homogenized throughout the whole year which is not representative of a healthy riverine system. Although there were many alterations within the streamflow after the dam was built, the most important change was the loss of almost all of the functional flow components. Without these natural changes in streamflow, the ecosystem in and around the American River is negatively affected.

Taking this data into account, an interesting study to follow this one would be to how the change in streamflow has affected the riverine and riparian ecosystems downstream of the Folsom Dam. This new study would help highlight the negative effects that occur to an ecosystem after dams are built. This relation has been recorded before and it is most likely the same for the Folsom Dam.

Conclusion:

All in all, the American River flow regime was greatly altered after the Folsom Dam was built. This change in streamflow downstream is directly linked to the dam creating the Folsom Lake reservoir and holding water that should have been kept into the stream. It is understood that the dam was built for the benefit of humans but there is also a necessity to manage the water correctly in order to protect humans and the environment as a whole around us.

Sources:

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