Creation and Implementation of a Suite of Tools for Analyzing Hydrology and Geomorphology in Impounded Rivers

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Large impoundment dams dot the landscape of the United States. Dam building has slowed since the mid-20th Century, and there is now a movement advocating for dam removal. In spite of this, dams, both large and small, are likely to remain on America's rivers for the foreseeable future. Dams are built for various reasons, including flood control, hydroelectric power generation, navigation, water for civil and industrial purposes, and recreation. Despite these seemingly positive impacts of dams, dams also affect the downstream hydrology and geomorphology, which is the physical characteristics of a river channel including width, bed elevation, and sediment size. These effects have been well documented in scientific literature. In 1984, Williams and Wolman published a seminal paper quantifying these effects. They found that downstream hydrology is generally controlled by the dam release schedule with high flows commonly decreasing. They also found that changes in geomorphology vary from dam to dam and are dependent on various controls. In the last 40 years, more papers have been published that contain metrics meant to quantify the effect large impoundment dams have on riverine hydrology or geomorphology. Despite the creation of these metrics, there has not been a comprehensive study that employs multiple metrics across a wide swath of dam impounded watersheds. Metrics are often only applied in a small number of studies and rarely in concert with each other.

To solve this gap in the published literature, I spent my summer creating DAMS – the Dam Analysis and Metrics Suite. DAMS is a tool meant to incorporate a multitude of the previously published metrics into a series of scripts complied in the open-source programming language R. Inputs are meant to be minimal: dates over which the analysis is being done and the USGS stream gauge that collected raw data. Outputs are graphs, plots, and data tables that include relevant statistical tests related to each metric. Once completed, DAMS will allow for analysis to be done on how riverine geomorphology and hydrology has changed due to impoundment over time scales designated by the user. This summer, I completed the scripts used for hydrologic analysis. These include the 33 metrics included in the Indicators of Hydrologic Alteration (Richter et al., 1996), recurrence intervals for annual instantaneous peak flow, top 10% of daily mean flows, and annual mean flow. Future work that will be done over the course of my honors project will incorporate various geomorphic metrics reported in Smelser and Schmidt (1998) and Schmidt and Wilcock (2008) into the DAMS framework.

As a proof of concept, I applied the complete scripts for DAMS to a series of USGS stream gauges upstream and downstream of the Buford Dam on the Chattahoochee River in Georgia and downstream of the Harris Station Dam on the Kennebec River in Maine. Results in the changes in hydrology are varied yet within the expected results based on past papers. Generally, high flows decreased but exact changes are reliant on dam release schedules and individual watershed characteristics. Once the geomorphic elements of DAMS is written, they will also be applied to the same stream gauges.

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