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Supplement of

Socio-hydrological modeling of the tradeoff between flood control and hydropower provided by the Columbia River Treaty

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Introduction

This supplementary material is structured in three sections. Section 1 provides the input data used for the socio-hydrological system dynamics model development. Section 2 provides the correlation plots that guided some equations used to describe the processes in the Columbia River Basin. Section 3 provides the detail of sensitivity analysis of the model. Section 4 describes the schematic of the lumped systems in the model.

To facilitate the identification of the reservoirs modelled in this study, refer to the map below. All the supplementary figures are numbered S1 to S18.

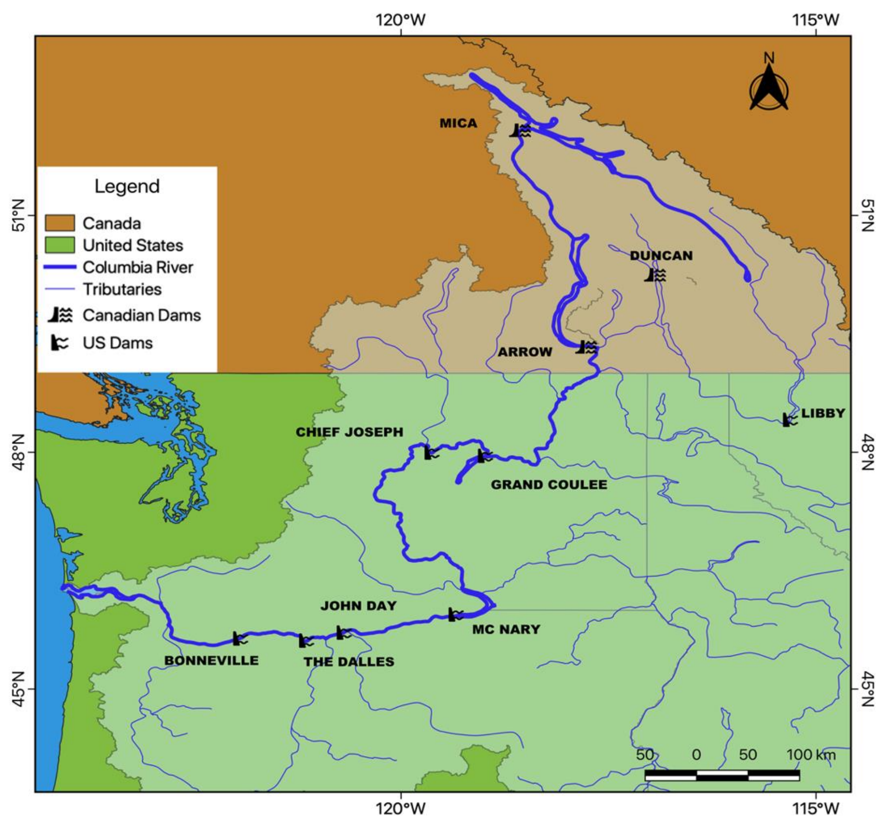


Figure S1. Dams included in the model process to understand the cooperation dynamics at the Columbia Basin scope

Section 1: Input data for system dynamics model

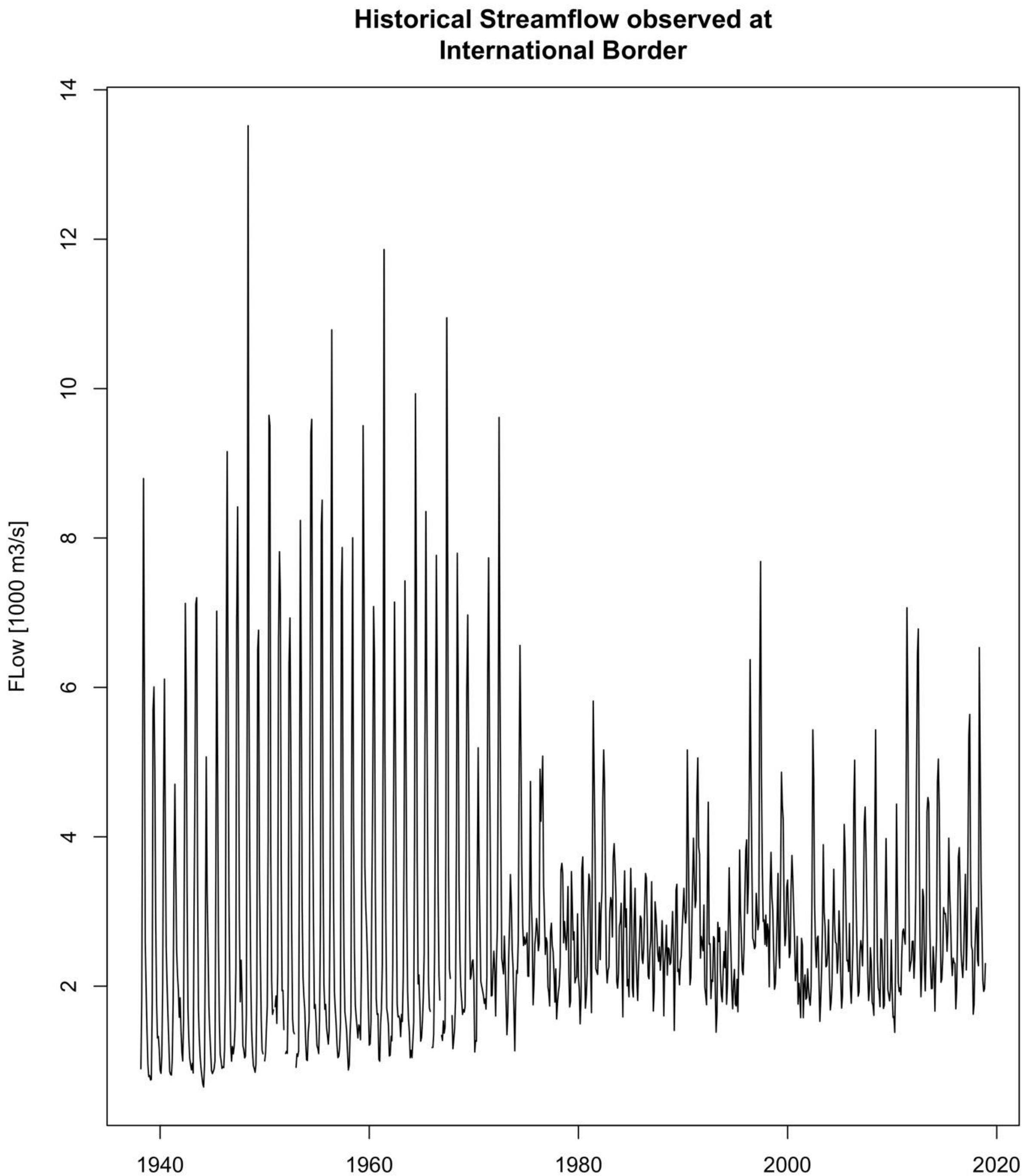


Figure S2. Historical flow observed at the international border (USGS, 2020)

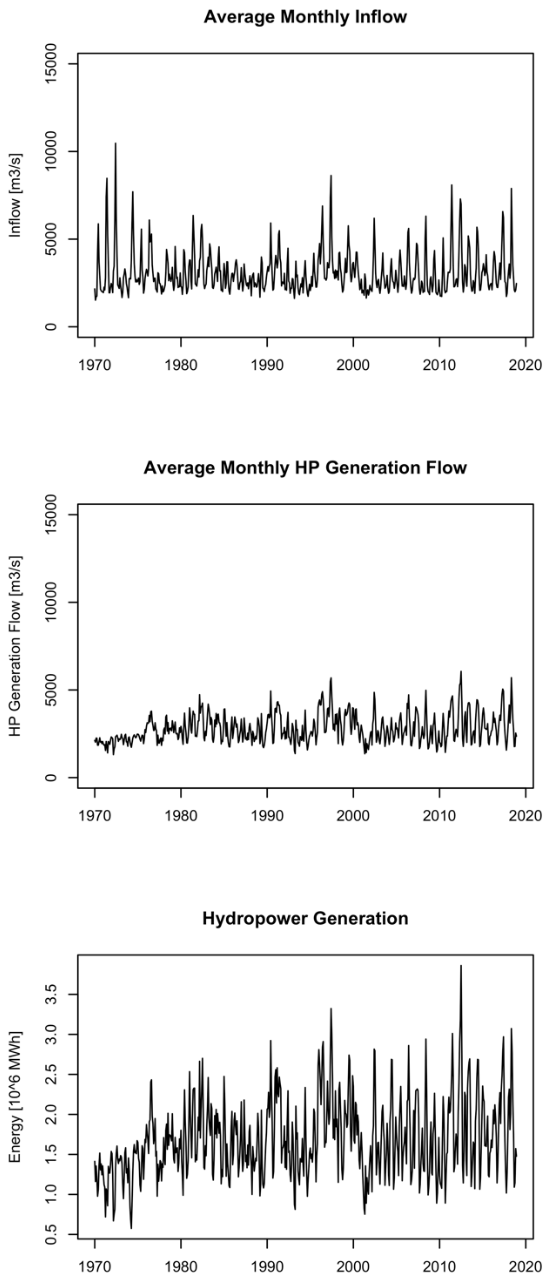


Figure S3. Inflow, outflow, generation flow, monthly spill and hydropower generation data of Grand Coulee Dam (USACE, 2020)

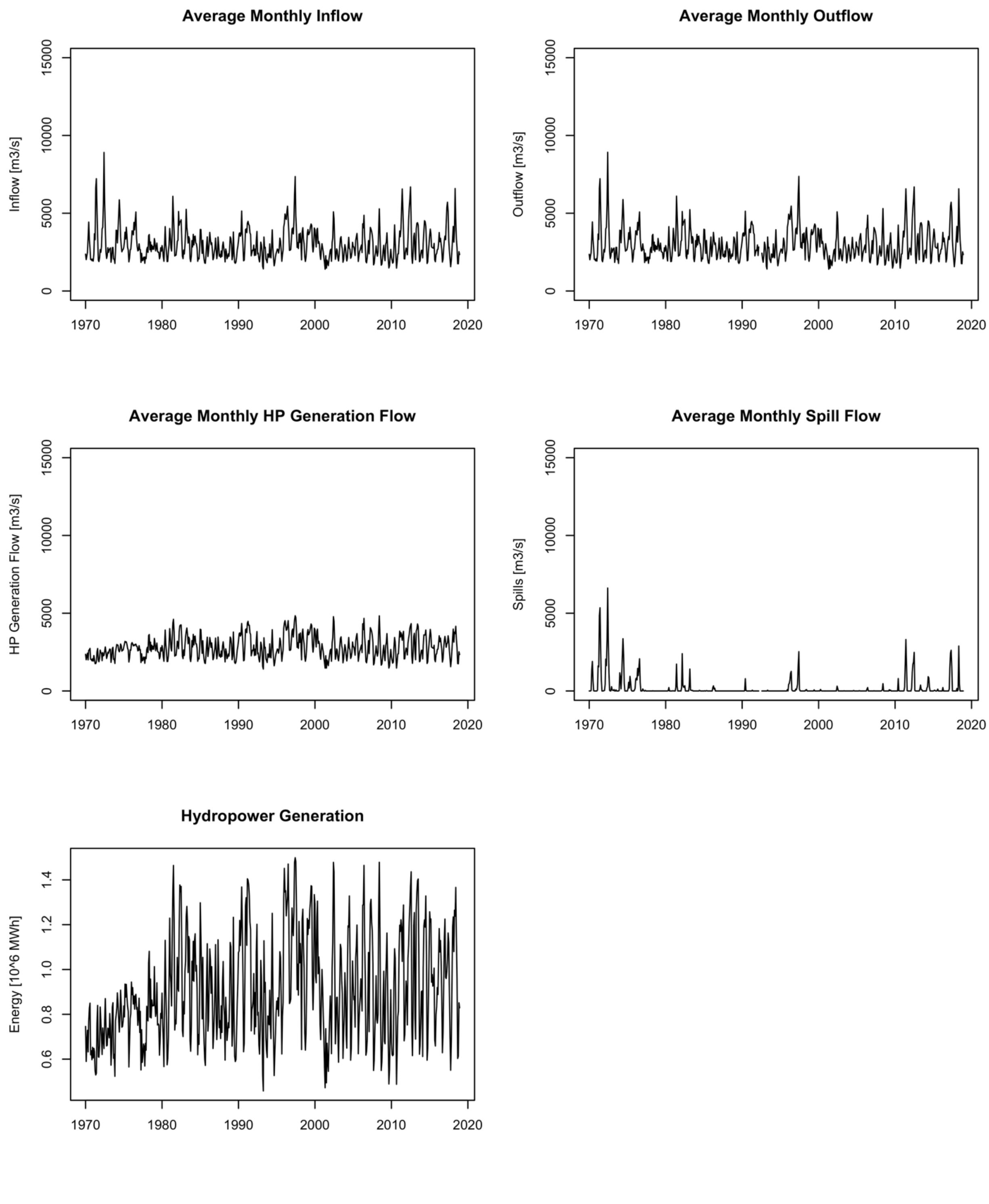


Figure S4. Inflow, outflow, generation flow, monthly spill and hydropower generation data of Chief Joseph Dam (USACE, 2020)

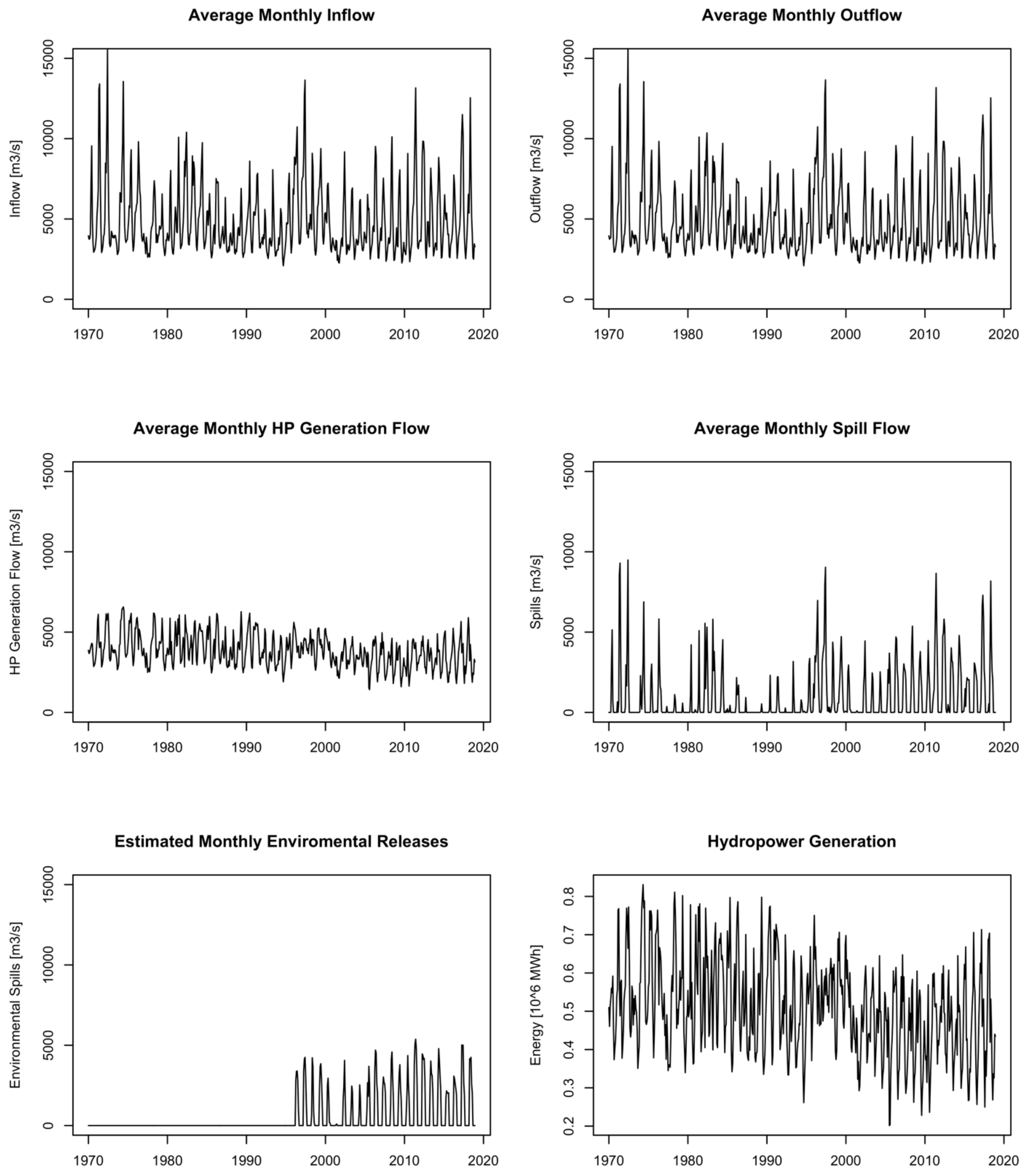


Figure S5. Inflow, outflow, generation flow, monthly spill, environmental release and hydropower generation data of McNary Dam (USACE, 2020)

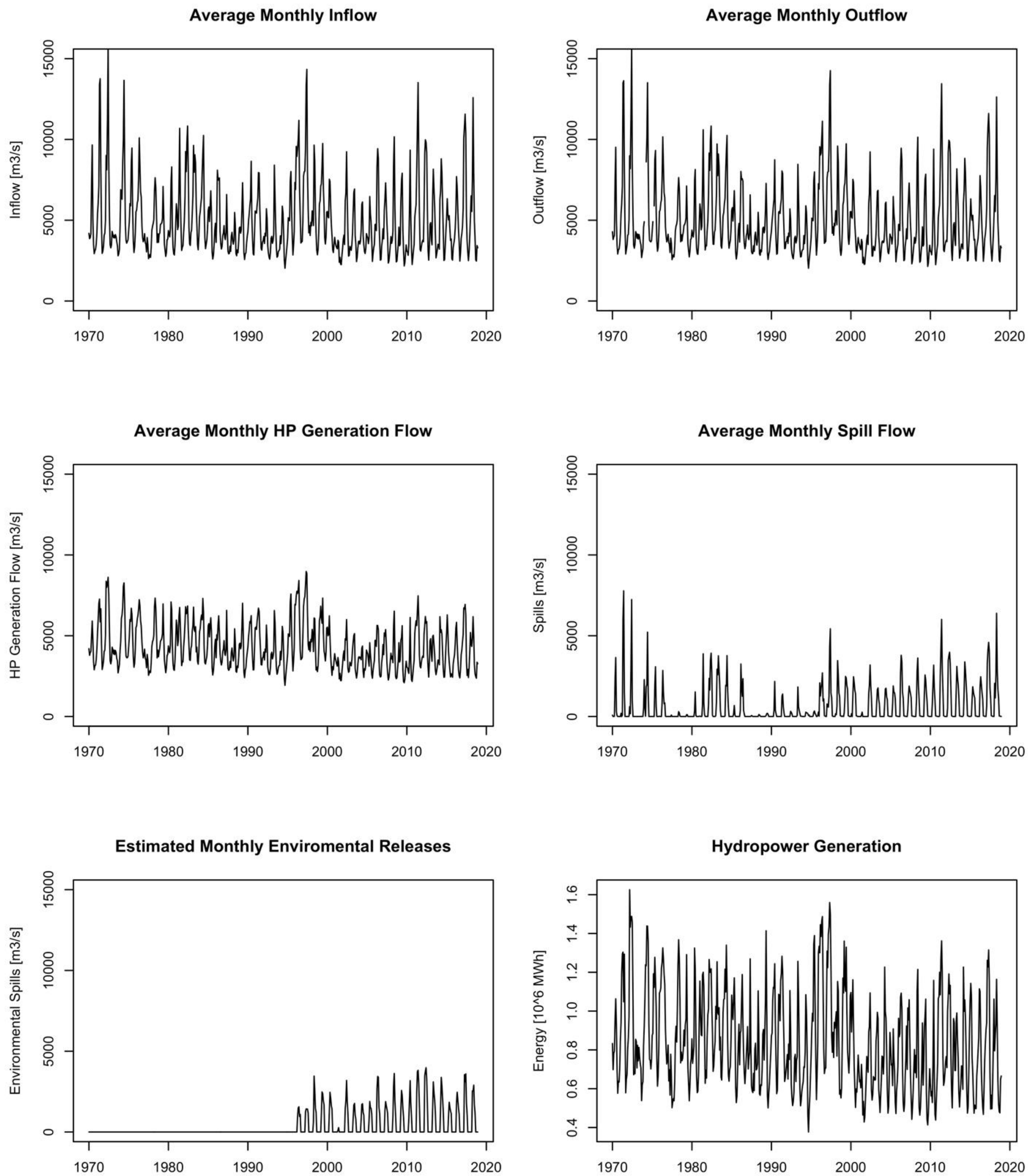


Figure S6. Inflow, outflow, generation flow, monthly spill, environmental release and hydropower generation data of John Day Dam (USACE, 2020)

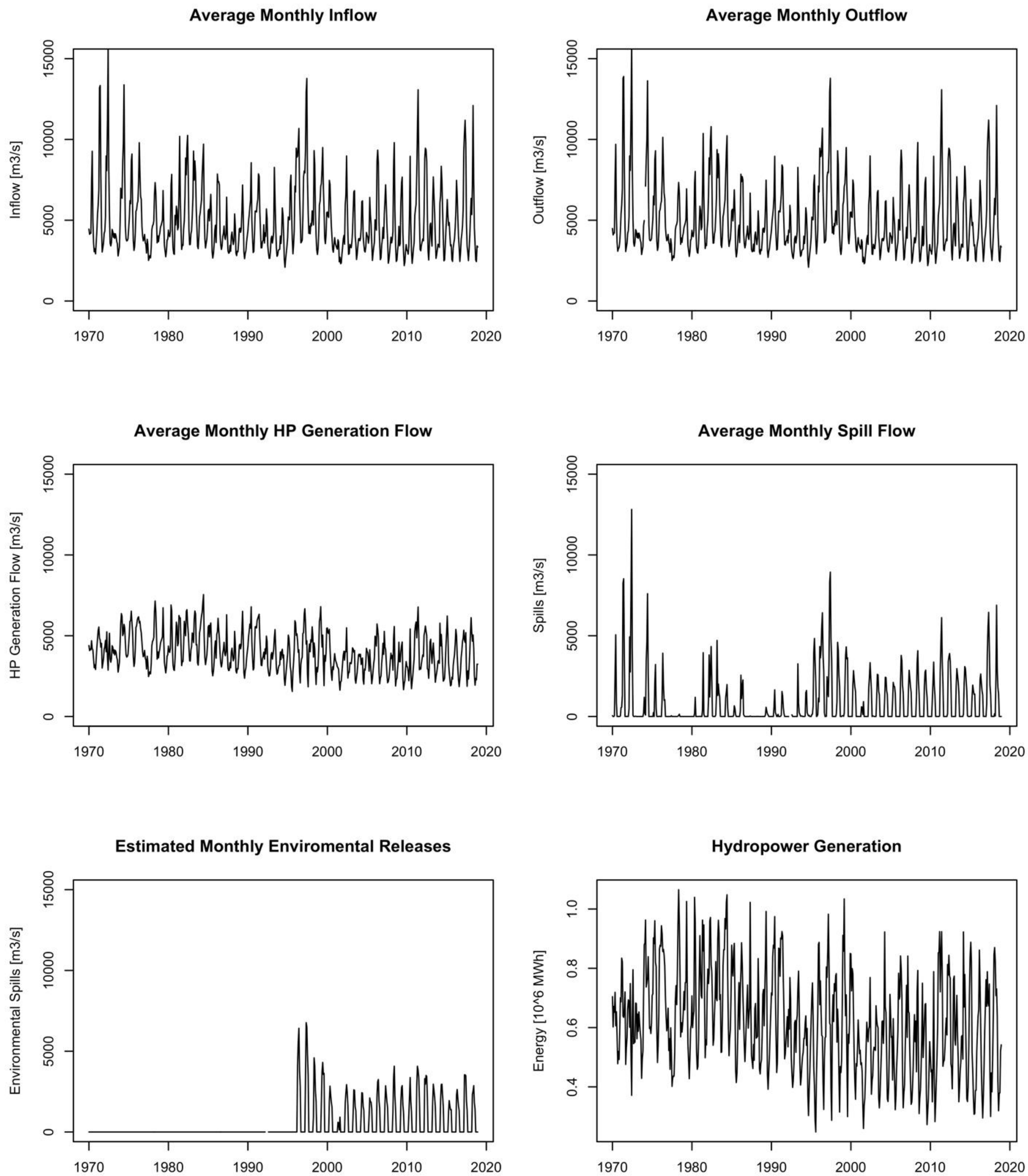


Figure S7. Inflow, outflow, generation flow, monthly spill, environmental release and hydropower generation data of The Dalles Dam (USACE, 2020)

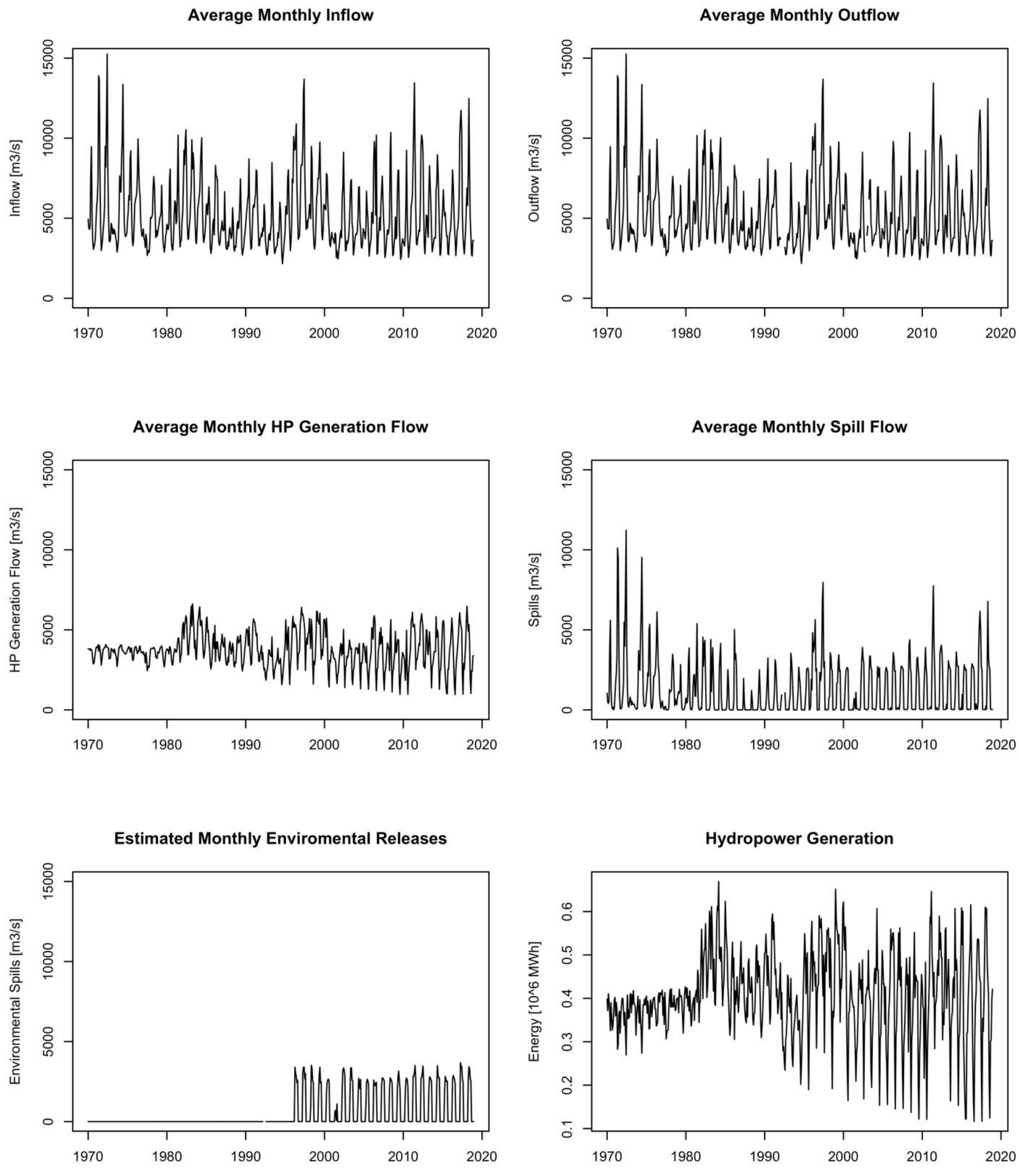


Figure S8. Inflow, outflow, generation flow, monthly spill, environmental release and hydropower generation data of Bonneville Dam (USACE, 2020)

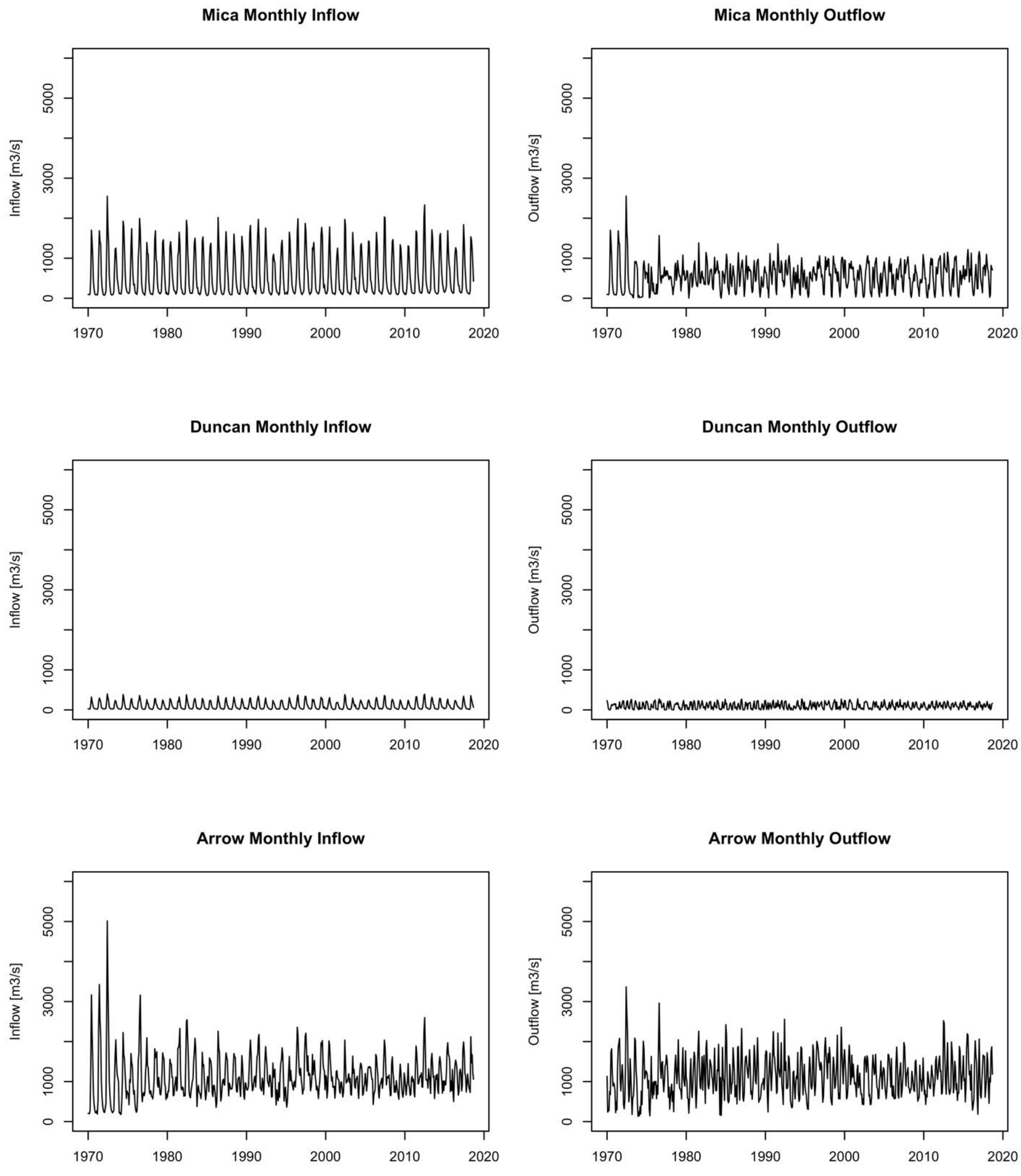


Figure S9. Canadian Dams inflow and outflow data (BPA, 2020)

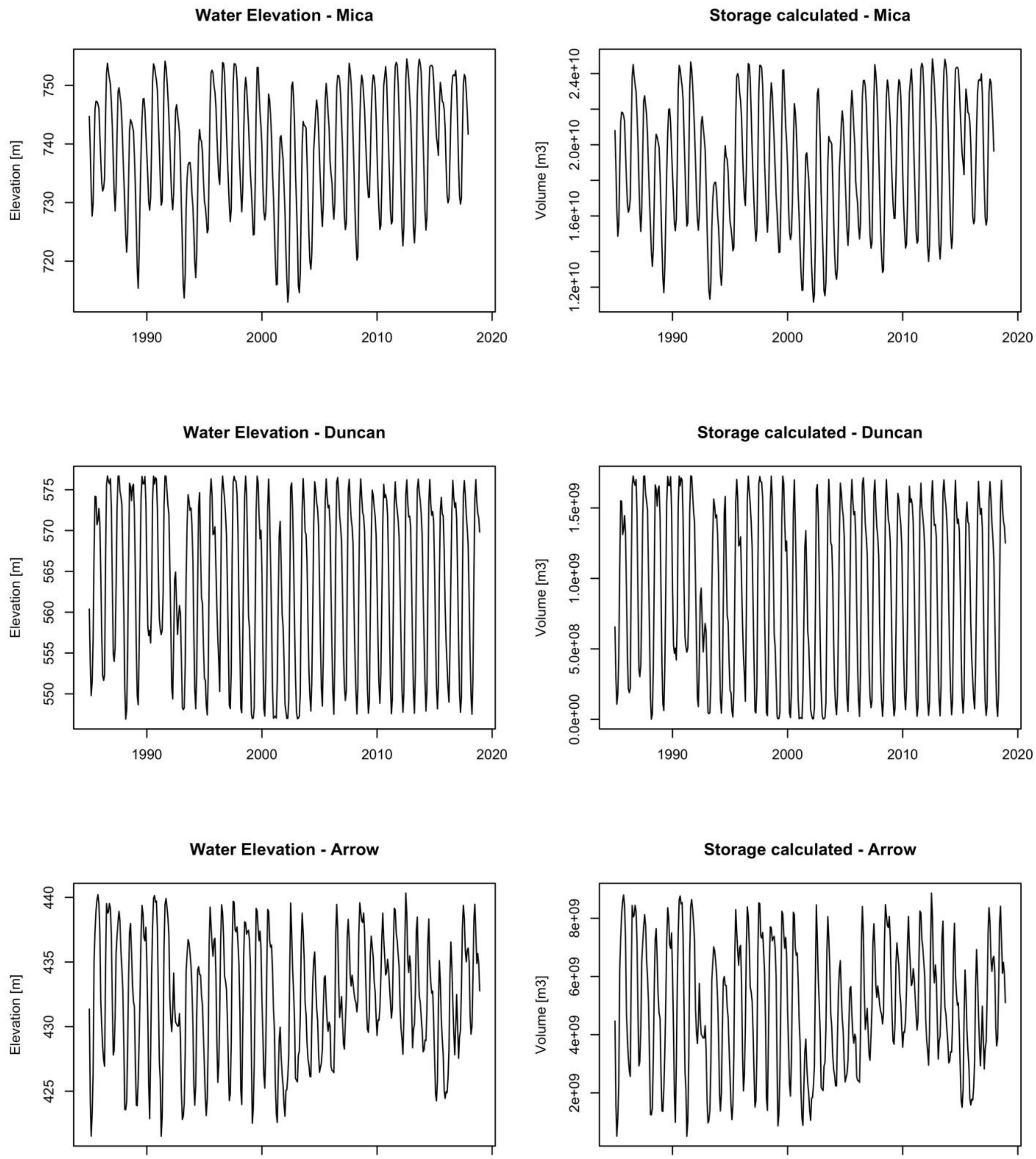


Figure S10. Canadian Dams water elevation and storage data (BPA, 2020)

Section 2: Correlation plots describing the processes in the Columbia River Basin

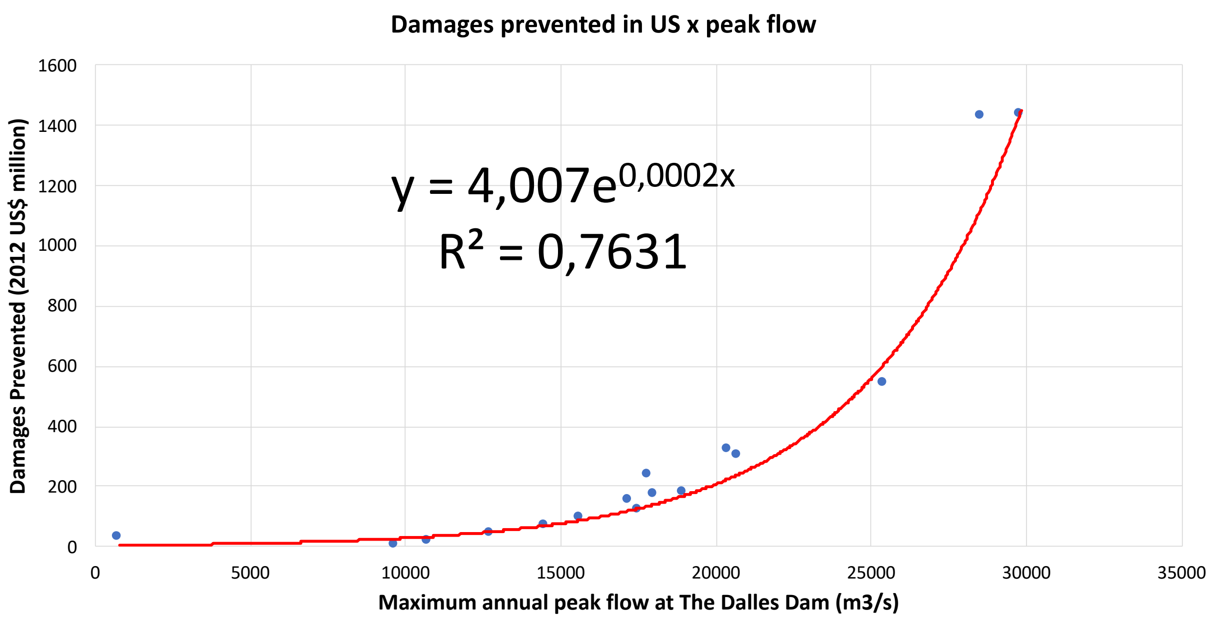


Figure S11. Equation to estimate flood damages prevented (adapted from Sopinka and Pitt (2014))

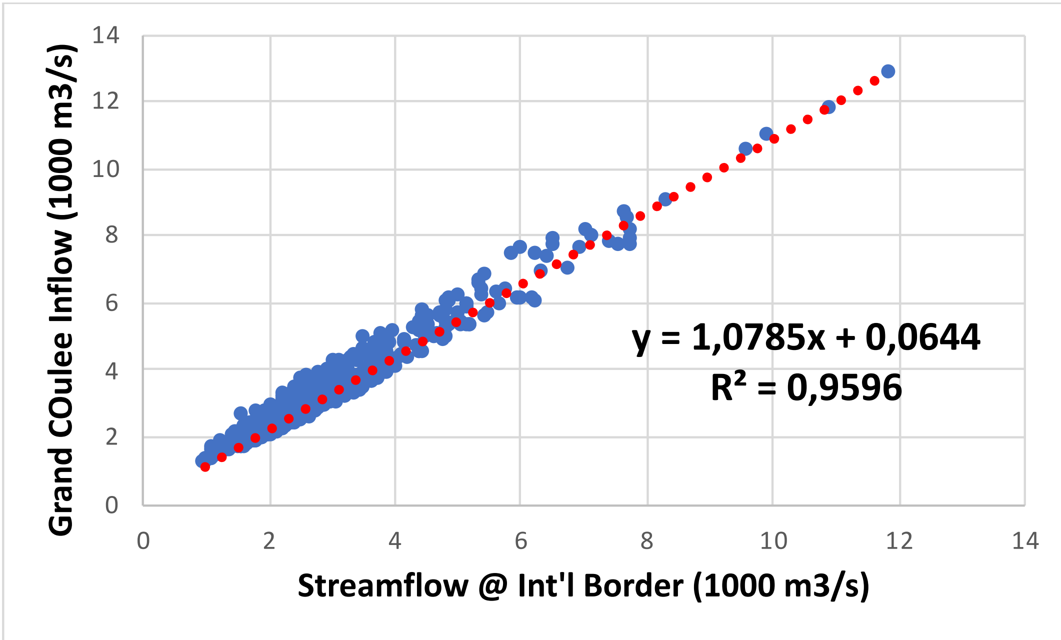


Figure S12. Correlation between streamflow observed at the international boundary (USGS 1239950) and Grand Coulee inflow (US. Army Corps of Engineers)

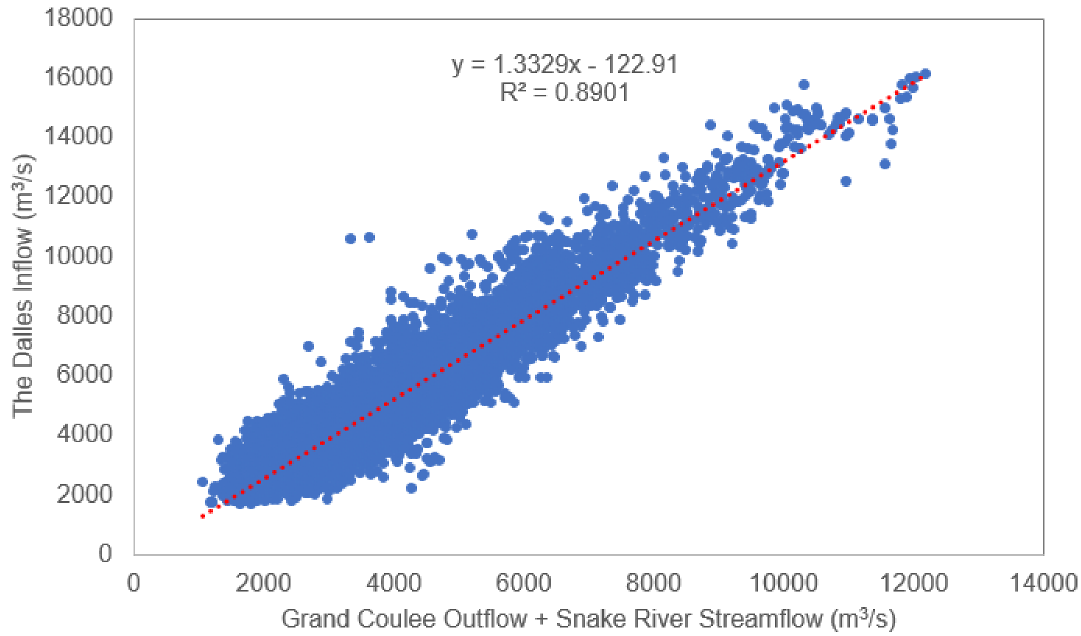


Figure S13. Correlation between inflow at the The Dalles Dam (US. Army Corps of Engineers) and the summation of Grand Coulee outflow with Snake River Discharge (US. Army Corps of Engineers and USGS)

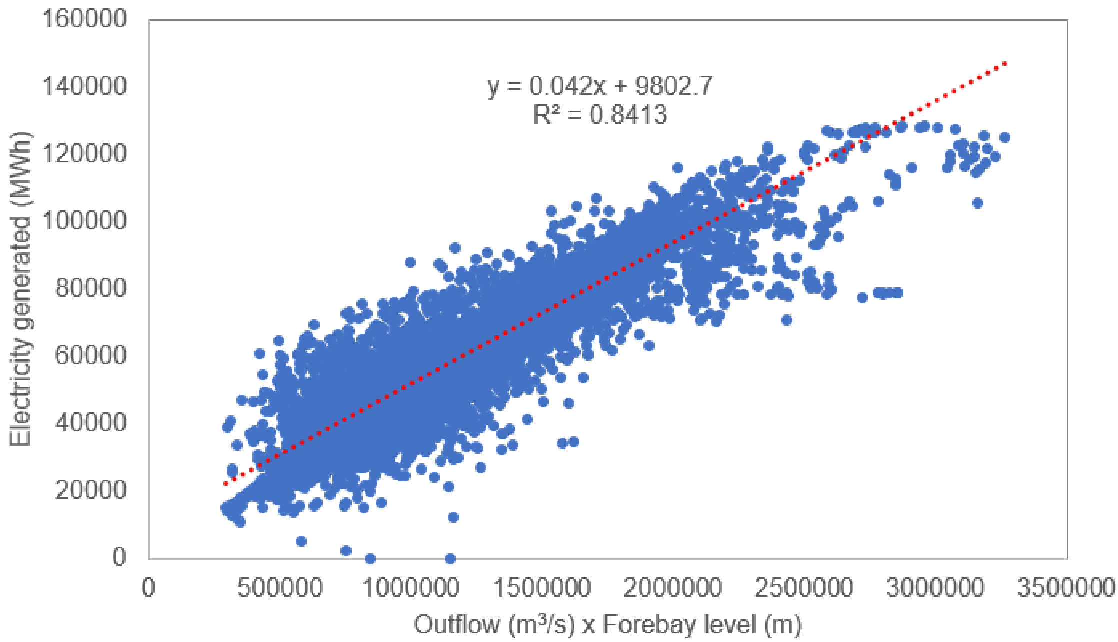
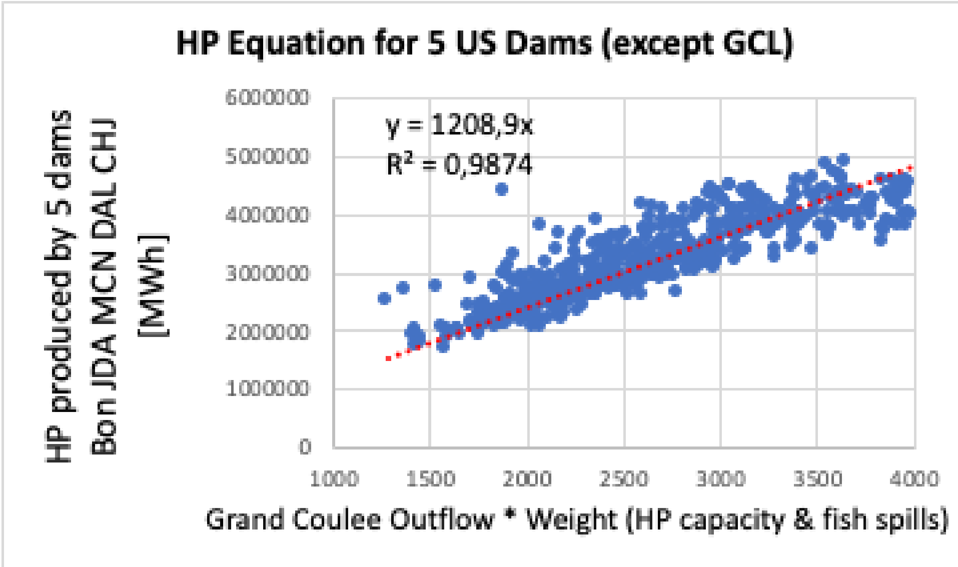


Figure S14. Correlation between Hydropower produced by Grand Coulee Dam (US. Army Corps of Engineers) and the product of Grand Coulee water level by Grand Coulee outflow (US. Army Corps of Engineers)



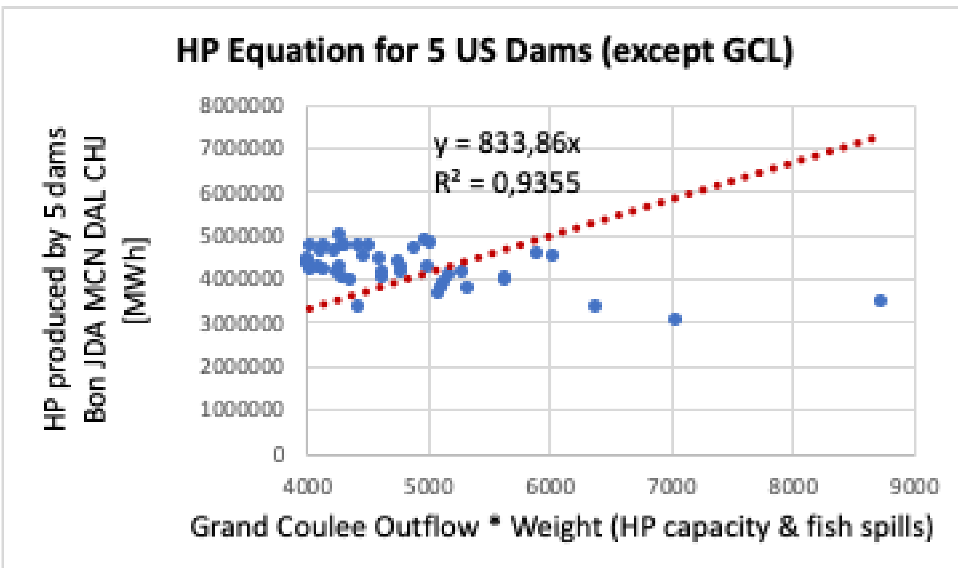


Figure S15. Correlation between Hydropower produced by Chief Joseph, McNary, John Day, The Dalles and Bonneville Dams (US. Army Corps of Engineers) and the product of Grand Coulee outflow by the Weight factor for fishes described in the methodology (US. Army Corps of Engineers)

Section 3: Sensitivity Analysis

The parameter sensitivity was tested for the calibrated model to understand the sources of possible uncertainties. The sensitivity was tested by increasing and decreasing the value of a selected parameter at a given iteration by 20% and relative changes in probability to cooperate for Canada and the U.S. was measured. The ranking of the sensitivity was done using the sensitivity index (SI) given by below

$$SI = \frac{(Mean\ of\ simulated\ metric\ - Mean\ of\ default\ metric)/Mean\ of\ default\ metric}{(New\ parameter\ value - Default\ parameter\ value)/Default\ parameter\ value}$$

The parameters as discussed in section 3.2, selected for the sensitivity analysis are for χ, W_{fish}, n_{CA}, κ, α_{US}, α_{CA}, β_{US} and β_{CA}. The overview of the sensitivity analysis is presented in Figure S16 and result of sensitivity analysis is presented in Figure 17.

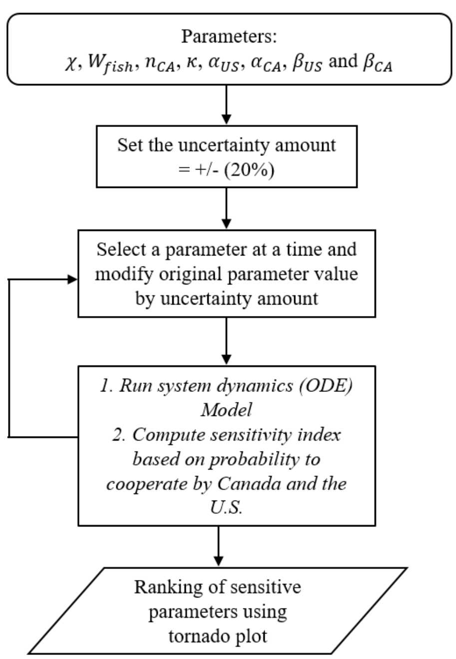


Figure S16. Overview of the sensitivity analysis

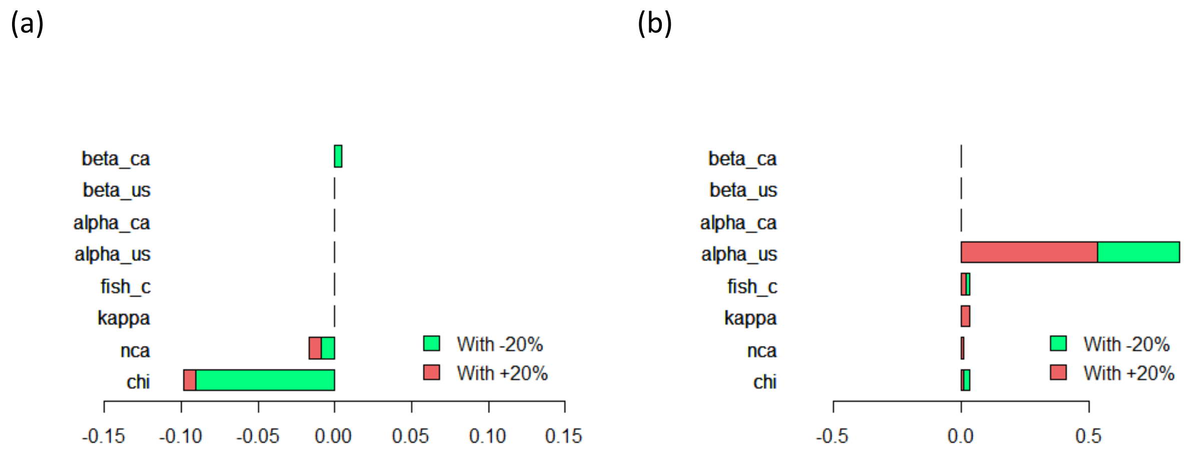


Figure S17. Tornado plots showing sensitivity of parameters to (a) Canada's probability to cooperate (C_{CA}) and (b) U.S.'s probability to cooperate (C_{US}) with 20% changes in its value

The sensitivity analysis showed that different parameters exhibit different sensitivity when comparing probability to cooperation (Fig. S17, supplementary material (SI 3)). C_{CA} is most sensitive to χ whereas (C_{US}) is most sensitive to α_{US}. χ, W_{fish} and κ are equally sensitive to (C_{US}), while n_{CA} and β_{CA} are mostly sensitive to C_{CA} only. All the parameters used for the sensitivity analysis were selected for model parameterization.

Section 4: Lumped systems in the model

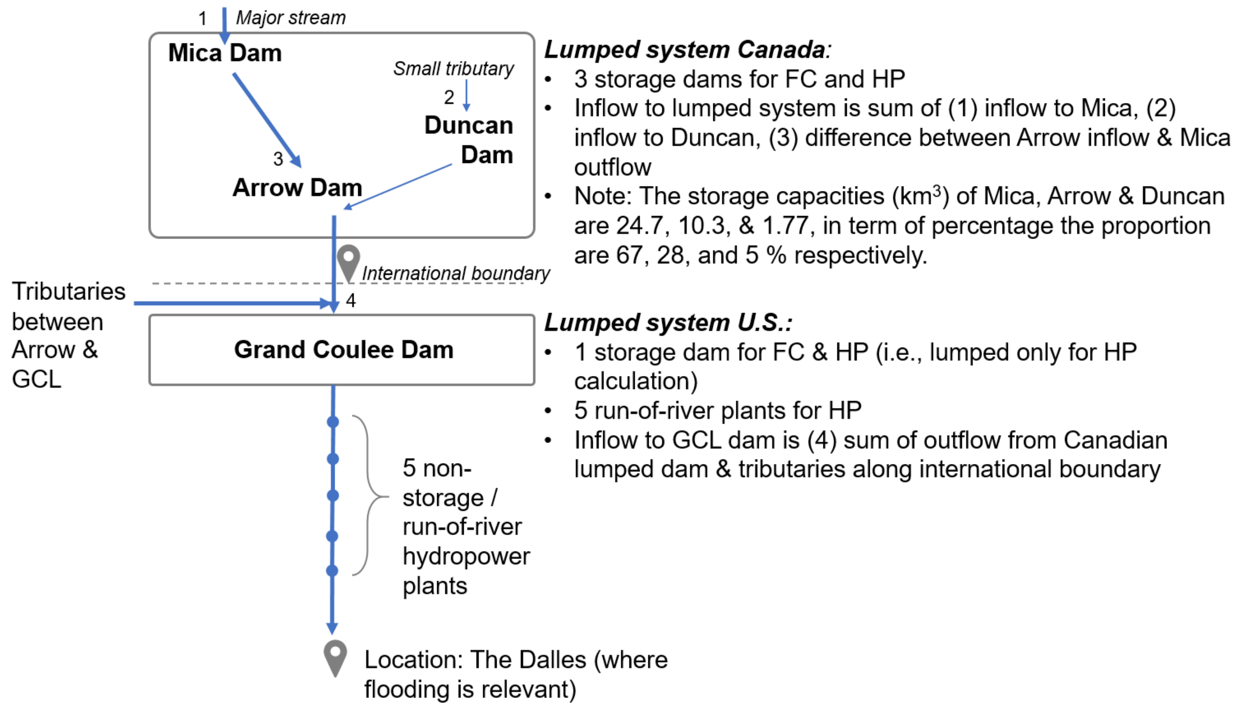


Figure S18. Schematic of lumped system in Canada and the U.S. storages

References

BPA. (2020). Monthly Data. (B. P. Administration, Producer). Retrieved August 21, 2020, from: https://www.bpa.gov/p/Power-Products/Historical-Streamflow-Data/Pages/Monthly-Data.aspx

Sopinka, A., & Pitt, L. (2014). The Columbia River Treaty: Fifty Years After the Handshake. The Electricity Journal, 27(4), 84-94.

USACE. (2020). CENWD-WM System Map. Retrieved August 21, 2020, from https://www.nwd-wc.usace.army.mil/dd/common/sysmap/www/index.html

USGS. (2020). USGS 12399500 Columbia River at International Boundary. Retrieved August 21, 2020, from https://waterdata.usgs.gov/nwis/uv?site_no=12399500