Shaw et al, 2017: *Hydropower Optimization Using Artificial Neural Network Surrogate Models of a High-Fidelity Hydrodynamics and Water Quality Model*

Amelia Shaw, formerly a Ph.D. student at Vanderbilt University, and others explore a multi-disciplinary approach to hydropower optimization. A reservoir operations scheme is developed that maximizes hydropower production subject to hydraulic (e.g. water surface elevation targets), logistic (e.g. turbine operation), and water quality constraints. In order to evaluate outflow water quality (temperature, dissolved oxygen), the authors train an artificial neural network (ANN) surrogate model to emulate temperature and dissolved oxygen model outputs from the popular CE-QUAL-W2 surface water quality model. The use of a nonlinear autoregressive exogenous model (NARX) ANN is successfully trained to capture CE-QUAL-W2 output at a fraction of the computing time (2 seconds versus 6 minutes). The trained ANN along with several simpler models are used in a single-objective genetic algorithm (GA) to optimize revenue at an hourly scale over a ten day period. Ultimately, hydropower production was predicted to increase by ~6% relative to standard operations while maintaining an acceptable water quality at the outlet. Through the use of an ANN model emulator, the authors are able to develop an operations schedule in ~40 hours as opposed to the 7 months it would've taken if the CE-QUAL-W2 models were employed directly in the GA. It is important to note that a significant effort is required to develop a calibrated CE-QUAL-W2 model, making this approach difficult to immediately implement in other hydropower reservoirs.