Application of two-dimensional water quality model, CE-QUAL-W2, to the Spokane River

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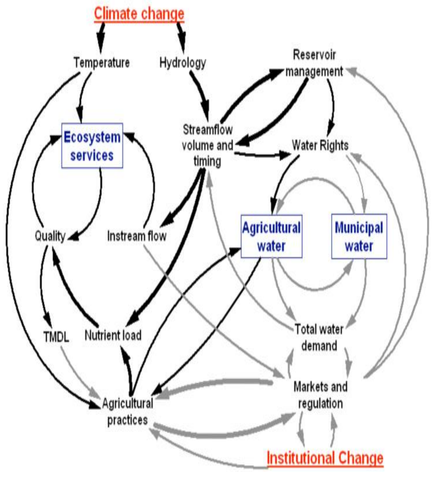
Introduction

TMDLs have been established in the Spokane River for phosphorus to control excessive algae blooms. The river has low dissolved oxygen (DO) levels during low flow in the summer months. Portions of the river violate the Washington State water quality standards for DO, and are listed on the 2008 list of impaired water bodies. This study aims at application of the CE-QUAL-W2 model to the Spokane River as a case study to predict water quality changes in response to various modeling scenarios, with particular attention to phosphorus, nitrogen, dissolved oxygen (DO) and river temperature.

One particular intention of the study is to reduce the number of cells in the vertical dimension (depthwise) of the CE-QUAL-W2 model used by Department of Ecology, to reduce the computation time. Improvement in phosphorus, nitrogen, and DO upon groundwater reinjection will also be examined. It is anticipated that addition of water will lower phosphorus and nitrogen levels and raise dissolved oxygen.



WISDM

- The WISDM approach integrates a system of existing and widely-applied models into an interdisciplinary framework that allows to address the key issues surrounding the sustainability of water resources.
- The projects aims to understand how climate and land use changes have affected water quantity and quality, and how will climate variability impact water quantity and quality in the next few decades.
- The project also aims to determine what agricultural practices will promote agricultural productivity under a new hydrologic regime

Model Description

CE-QUAL-W2 Model

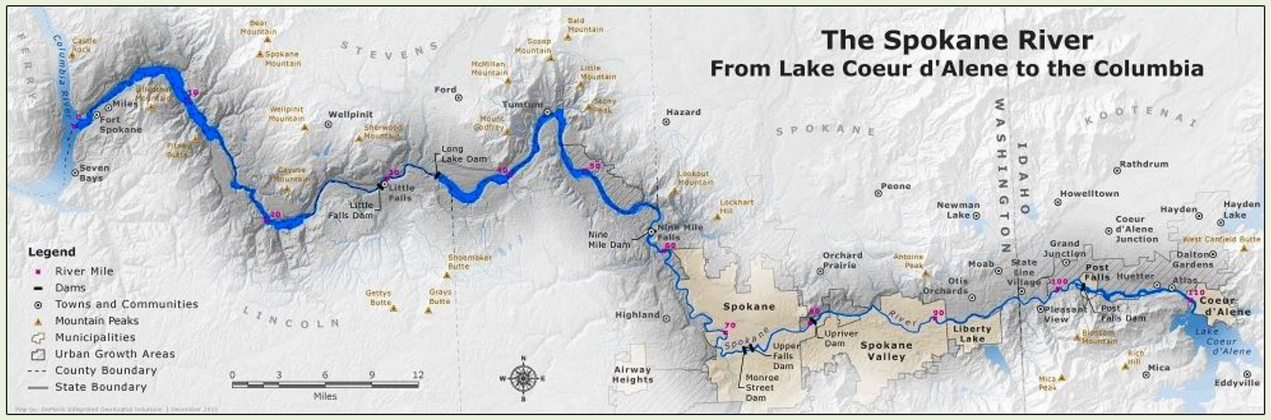
- CE-QUAL-W2 is a two dimensional, longitudinal/vertical, hydrodynamic and water quality model
- The model is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients
- The model can predict water surface elevations, velocities, & temperatures; can be applied to geometrically complex waterbodies and any number of rivers, reservoirs, lakes, and estuaries linked in series. Provisions are made for inflow loadings from point/nonpoint sources and precipitation; it can calculate the vertical extent of the withdrawal zone

Model limitations

- The governing equations are laterally and layer averaged- inappropriate for large waterbodies exhibiting lateral variations in water quality
- The model is best suited for relatively long and narrow waterbodies exhibiting longitudinal and vertical water quality gradients
- The model does not have a sediment compartment that models kinetics in the sediment and at the sediment water interface
- The model still places computational and storage burdens on a computer when making long-term simulations

Spokane River Basin

- The Spokane river subbasin is characterized by a continental climate that is influenced by maritime air masses from the Pacific Coast
- Average annual temperature is 49 F, with July being the warmest month and January being the coldest
- Annual precipitation for the area is 17.60 inches with 8.36 inches of snowfall
- Spokane river has both gaining reach and loosing reach, making it's study complex



Expected Outcome- Why Important

- Increasing Spokane River flows using aquifer storage and recovery is currently being evaluated by the State of Washington Water Research Center (SWWRC). Injecting water from nearby Lake Pend Oreille into the Spokane Valley-Rathdrum Prairie aquifer could augment low streamflows in the Spokane River, thus improving supply and water quality.
- Higher flows with lower temperatures could help reduce concentrations of phosphorus and nitrogen and increase dissolved oxygen, and therefore help reduce algal blooms (Ecology 2008). Because it has the potential to pass through the turbines at the five dams in the study area, the additional flow in the Spokane River may also be used to determine how much more power could be generated at Upriver, Upper Falls, Monroe Street, Nine Mile, and Long Lake Dams.
- The CE-QUAL-W2 model is used as the primary tool in determining whether these benefits will occur in the Spokane River. However, phosphorus, nitrogen, dissolved oxygen (DO), and river temperature are not always improved upon after groundwater reinjection.

Conclusions

- Higher streamflows in the Spokane River due to aquifer injections clearly show a high economical benefit, but in order to observe more meaningful water quality results, certain parameters of the original Scenario should be modified to better represent the injected water. These might include groundwater constituent concentrations, groundwater temperature, or changes in boundary conditions.

References

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