Report for 2003NV41B: Quantifying Potential Economic Impacts of Water Quality Modeling Uncertainty for the Lower Truckee River, Nevada

Publications

- Articles in Refereed Scientific Journals:
  - Kish, S.M., Bartlett, J., Warwick, J.J., McKay, A., and Fritsen, C., In Press. "A long-term dynamic modeling approach to quantifying attached algal growth and associated impacts on dissolved oxygen in the lower Truckee River, Nevada," Journal of Environmental Engineering, ASCE.
- Conference Proceedings:
  - McKay, W. A., Warwick, J.J., Kish, S., Fritsen, C., and Bartlett, J., 2003. "Modeling linkages between groundwater, surface water and periphyton-driven oxygen dynamics in the lower Truckee River, Nevada," Fall Meeting of the American Geophysical Union, San Francisco, California, December 8-12.
  - Bartlett, J.A. and Warwick, J.J., 2005. "Assessing the Impacts of Nutrient Load Uncertainties on Predicted Truckee River Water Quality," Fall Meeting of the American Geophysical Union, San Francisco, California, December 5-9.

Report Follows

Project Identification

USGS water quality modeling - Truckee River, Nevada.
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Problem and Research Objectives

Because dissolved oxygen (DO) is essential to aquatic life, it is important that DO concentrations do not drop too low. Periphyton, or algae attached to the substrate, produces oxygen via photosynthesis and uses up oxygen during cellular respiration, and the result is diel swings in dissolved oxygen concentrations. Periphyton growth is controlled largely by nutrient (nitrogen and phosphorous) availability, meaning that nutrient concentrations indirectly impact DO concentrations by influencing the amount of periphyton biomass. This study aims to refine an existing water quality model to more accurately predict the concentrations of a suite of water quality constituents, including dissolved oxygen, on the lower Truckee River, Nevada. Using this refined model, several hypothetical scenarios are modeled to determine how changes to nutrient loads impact daily minimum DO concentrations. Uncertainty analysis is then used to assess the influence of model boundary condition uncertainty on model predictions.

Methodology

All water quality modeling in this study are computer simulations using a modified version of the U.S. Environmental Protection Agency's Water Quality Analysis Simulation Program, Version 5 (WASP5). While there are too many model inputs and parameters to list, they include a flow balance derived from USGS stream gages, water quality data provided by the Truckee Meadows Water Reclamation Facility (TMWRF), and rate coefficients provided by previous studies on the Truckee River. Hypothetical scenarios are modeled by adjustment of flows and nutrient loads. Uncertainty analysis is employed to quantify the impacts of boundary condition uncertainty on model predictions. More specifically, this analysis will be done using Monte Carlo techniques, and the quantification will be achieved by developing probabilistic confidence intervals around model predictions.

Principal Findings and Significance

<u>Work Completed to Date</u>

This study began with the refinement of an existing long-term, dynamic water quality model for the lower Truckee River. Changes were made in order to reduce error between model predictions and observed data. Predictions from the refined model and observed data both show the Truckee River failing to meet the minimum dissolved oxygen standard prescribed by the Nevada Department of Environmental Protection. Hypothetical scenarios were then modeled to predict the impacts of nutrient removal on periphyton biomass and DO concentrations. A model simulating the removal of a permit discharge excursion from TMWRF and a separate model simulating removal of agriculture nutrient loads both predicted that the dissolved oxygen standard would not be met at all locations in the modeled reach at all times in the model domain. It was eventually determined that the inability of the river to meet the DO standard was a result of low flows. A final scenario set a minimum upstream flow, which was increased until the dissolved oxygen standard was met at all locations at all times. These results suggest that simply decreasing nutrient loads, be it through the removal of the discharge permit excursion or via the removal of agricultural nutrient loads, would still not cause the prescribed dissolved oxygen standard to be met at all times. Instead, these findings indicate that a minimum flow must be maintained in order for the Truckee River to continuously meet the standard.

A Monte Carlo approach was employed using the developed model to perform uncertainty analysis. Calculations indicate that the upstream organic nitrogen boundary condition is the model's most important boundary condition, so uncertainty analysis first focused on determining how uncertainty in upstream organic nitrogen concentrations affects model predictions of other constituents, particularly dissolved oxygen. Another significant source of model uncertainty is the effect of irrigation ditch returns, as nutrient loads from these largely unmonitored ditches are not well known. Additional uncertainty analysis focused on these ditch returns to determine their influence on predicted concentrations of constituents in the river. As mentioned previously, uncertainty analysis will result in confidence intervals around model predictions. Large confidence intervals show a great deal of uncertainty in model predictions and might indicate that more data is required in order to properly model water quality in the lower Truckee River. Small confidence intervals, on the other hand, indicate more certainty in model predictions and might suggest that additional or more frequent sampling is not necessary. The final analyses indicated that uncertainty due to unknown ditch return loading was small, while

Outreach/Publications

Conference Presentations

McKay, W. A., Warwick, J.J., Kish, S., Fritsen, C., and Bartlett, J., 2003. "Modeling linkages between groundwater, surface water and periphyton-driven oxygen dynamics in the lower Truckee River, Nevada," Fall Meeting of the American Geophysical Union, San Francisco, California, December 8-12.

Bartlett, J.A. and Warwick, J.J., 2005. "Assessing the Impacts of Nutrient Load Uncertainties on Predicted Truckee River Water Quality," Fall Meeting of the American Geophysical Union, San Francisco, California, December 5-9.

Peer Reviewed Journal Publications

Kish, S.M., Bartlett, J., Warwick, J.J., McKay, A., and Fritsen, C., In Press. "A long-term dynamic modeling approach to quantifying attached algal growth and associated impacts on dissolved oxygen in the lower Truckee River, Nevada," *Journal of Environmental Engineering, ASCE*.