RECLAMATION
Managing Water in the West

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Bottom Line

A generalized total dissolved gas (TDG) prediction tool is being collaboratively developed.

Better, Faster, Cheaper

Operators need a generalized model for predicting TDG to prioritize spills at dams to increase hydropower generation.

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Collaborators

- **Reclamation's Power Resources Office**
- **U.S. Department of Energy's Oak Ridge National Laboratory**
- **University of Iowa's IIHR—Hydroscience & Engineering**
- **University of Colorado Boulder's Center for Advanced Decision Support for Water and Environmental Systems**
- **Chelan County Public Utility District, Washington**

Predicting Total Dissolved Gas (TDG) for the Mid-Columbia River System

Classifying structural and operational parameters for a generalized TDG model

Problem

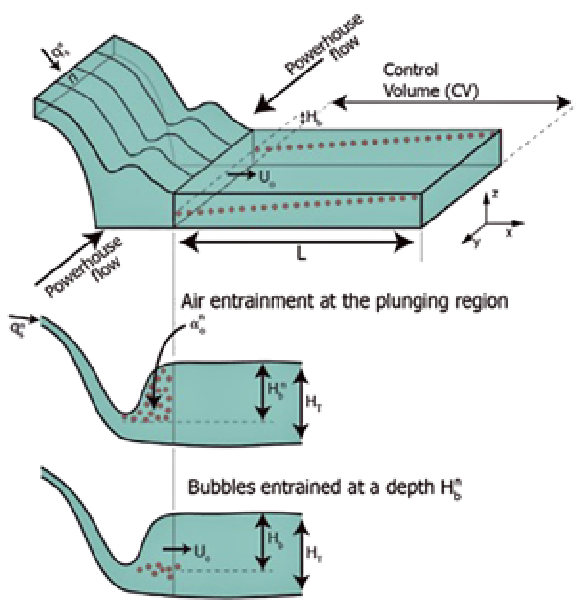
Total dissolved gas (TDG) supersaturation in tailwaters below hydropower dams can have significant effects on fish and downstream environmental conditions. Environmental constraints imposed in relation to TDG levels in tailwaters can further be a major limiting factor to operations and result in lost power generation. Yet there is no simple method for quantifying these TDG effects between or across a variety of hydropower facilities, dams, and/or water types due to the many degrees of varying conditions and operational scenarios.

Currently, no generalized predictive tools or guidelines are available to assess the effects of dam operations on downstream TDG minimization or reduction. Hydropower operators and planning groups need a generalized approach based on structural attributes to predict TDG at multiple dams based on readily available generalized parameters

Solution

Agencies are collaborating on developing a generalized TDG exchange method to predict TDG levels downstream from hydropower facilities with similar structural attributes. Steps include:

- Comparing dams where TDG is and is not a concern to identify a range of criteria needed for the predictive tool
- Determining a generalized set of parameters that affect TDG exchange (such as tailwater depth, spill discharge and pattern, project head, and entrainment of powerhouse releases)



Model parameters include plunge zone control volume, plunge point air entrainment, and bubble depth.

- Developing models based on fundamental mass, momentum, and energy conservation principles
- Using TDG data collected at Columbia River Basin dams to calibrate the generalized models using multiparameter regression analysis for various structural categorical classes

This resulted in simplified formulations to classify structural, operational, and environmental parameters to develop a predictive TDG exchange model.

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This generalized empirical approach helps develop TDG exchange formulations to apply to a whole class of projects while avoiding expensive data collection programs and complex project-specific model development formulations.

A one-dimensional model to predict TDG downstream from dams was developed based on mass, momentum, and energy conservation principles. The model consists of physically meaningful parameters including tailwater depth, powerhouse and spillway flow rates, unit spill, project head, and environmental variables such as atmospheric pressure and temperature.

Sensitivity analysis demonstrated that the most important parameters based on the variance of TDG are related to the maximum bubble depth and how the gas is vertically distributed above this depth. The model was implemented in a flexible framework to facilitate future introduction of additional processes or more comprehensive models.

Application

The network of dams throughout the Columbia River Basin are managed for irrigation, hydropower production, flood control, navigation, and fish passage that frequently result in both voluntary and involuntary spills. These dam operations are constrained by State and Federal water quality standards for TDG saturation, which balance the benefits of spill with the degradation to water quality associated with TDG saturation.

The capability of the model to predict TDG was evaluated by comparing model results against TDG data collected at Rock Island and Grand Coulee Dams on the Columbia River in Washington. The model accurately predicted TDG at Rock Island Dam; the more complicated structural and operational attributes of Grand Coulee Dam were more challenging.

Proposed Future Plans

Studies are needed to determine if generalized prediction of TDG is feasible for system operators and, if so, to develop the corresponding methodology and protocol for implementing a real-time water regulation modeling tool or guideline. Proposed future work would focus on:

1. Generically modelling the five remaining projects on the Mid-Columbia River

2. Incorporating the predictive generalized TDG equations into a real-time scheduling tool being developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder

3. Formulating a methodology for using a real-time scheduling tool for development of operational guidelines

4. Conducting an added-value analysis of a proposed real-time scheduling tool and operational guidelines

5. Disseminating information describing the generalized predictive TDG tool for development of spill priority guidelines for system operators

"Using a generalized model with other hydropower operations and planning efforts can help maximize hydropower generation while minimizing downstream TDG levels."

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More information

www.usbr.gov/research/projects/detail.cfm?id=9650

Rock Island Dam, Washington —a simpler project model.

Grand Coulee Dam, Washington—a more challenging project.

For printable version see: www.usbr.gov/research/docs/updates/2015-02-tdg.pdf