Interactive comment on "Mass imbalances in EPANET water-quality simulations" *by* Michael J. Davis et al.

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We appreciate the interest in our work and the comments provided.

To briefly summarize, three comments were provided: (1) The water-quality time step should be less than or equal to one-tenth of the hydraulic time step; (2) The discussion of water quality at dead-end junctions should include an explanation of how EPANET calculates concentrations at junctions; and (3) The paper should examine how changing the hydraulic time step while maintaining the water-quality time step equal to one-tenth of the hydraulic time step affects results and recommendations.

(1) We appreciate the discussion related to best practices for water-quality modeling with EPANET. The comment provides empirical suggestions for improving the results of

water-quality simulations. However, the fundamental issue being raised in the paper is that, in general, the water-quality routing algorithm used in EPANET does not conserve constituent mass. The paper assumes that the hydraulic solution is accurate. The only issue being examined is mass conservation given a hydraulic solution. As the examples in the paper show, a water-quality time step much shorter than one-tenth of the hydraulic time step may be needed to obtain acceptable mass balance and constituent concentrations. Simply decreasing the hydraulic time step and reducing the water quality time step so that it equals one-tenth of the hydraulic time step does not address the fundamental issue, which is the limitations in the water-quality routing algorithm. The purpose of the paper is to demonstrate the limitations in the current algorithm and, hopefully, as a result motivate its replacement with a new algorithm that conserves mass and provides accurate results for constituent concentrations. If an algorithm similar to the even-driven algorithm presented in the paper were available in EPANET, the water-quality time step could be set equal to the hydraulic time step. Selecting a water-quality time step would not then be a significant issue. We do not anticipate a discussion in the paper of best practices for water-quality simulations using the current version of EPANET. If an algorithm similar to the event-driven one presented in the paper were incorporated in EPANET, the issues raised in the comment should disappear.

(2) We will add a parenthetical note on p. 11 at the end of the first sentence on Line 11 stating that in dead-end areas with anomalous flows a potential also exists for anomalous concentrations: "(EPANET determines concentrations of constituents in outflows from a node using the flow weighted sum of inflow concentrations. If other inflows are very small, such anomalous flows could be significant in relative terms and result in concentration anomalies as well.)"

(3) The purpose of the paper is to demonstrate that EPANET does not always conserve mass, explain why this occurs, and show that a different water-quality routing algorithm can eliminate the problem. The results of further analysis using different hydraulic time

steps and a fixed ratio for the water-quality and hydraulic time steps would not affect the conclusions and recommendations of the paper, which are related to the subject of mass conservation. Mass imbalances can occur for networks with very short pipe segments when there is a spatial gradient in concentration. An improved algorithm is needed. See the response to the first comment.

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