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

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Thank you for your work and effort in this analysis as I believe this is an important topic. However, I did have a few comments on the paper that are more based on using the software for roughly 18 years as an engineering consultant that may be relevant to you. In EPANET and any hydraulic modeling work, the general Rule of thumb requires that the Water Quality timestep and rule timestep be no larger than 1/10th the hydraulic timestep or significant errors can occur. This is why this ratio is stated as the default value for the water quality timestep. The article on page 4 line 13 notes that "Except as noted, all simulations used a hydraulic time step of 3600 s" but the discussion does not seem to recognize that the reason the default WQ timestep is set at a limit of 1/10th the hydraulic timestep is due to accuracy concerns. Your results seem to confirm this

quite clearly that WQ timesteps in excess of 1/10th of the hydraulic timestep can result in significant Mass Balance errors and that this is why this rule of thumb ratio is so critical. If I read Figure 1 properly, the results for 300 s and smaller WQ timestep result in predictions with Mass Balance ratios that appear to mostly fall between 1.0 and 1.1 with an occasional outlier closer to 1.2. This needs to be an essential point to this analysis that EPANET already recommends this key ratio in the WQ timestep in order to get reasonable WQ results as it appears to fail to acknowledge this key point. I would highly recommend that this key ration of hydraulic timestep to WQ timestep be incorporated in the report as it is clearly very critical and essential for good WQ results. The modeler always has to make sure the WQ timestep is always 1/10th (or smaller) than the Hydraulic timestep as the ratio of these two values is often the key factor in reasonable WQ results. Simply shrinking the WQ timestep without any acknowledgement of its ratio to the hydraulic timestep is generally not recommended. The ratio of the two values is often the key to good WQ results. As a hydraulic modeler and engineering consultant of over 18 years I can attest that this ratio is always the most important ratio necessary to get reasonable results in any WQ model. In addition, I recommend that users who are concerned with verifying that the predicted results are as close as possible to actual values that the user test his hydraulic timestep by reducing the hydraulic timestep in half and adjusting his WQ timestep accordingly and comparing results between the two runs until both sets of results match within a reasonable tolerance, as this has been demonstrated in multiple models I have been aware of to verify that the hydraulic results are as accurate as possible, before proceeding to using them for WQ analyses. If the results do not match favorably, then the user should again half the hydraulic timestep and adjust the WQ timestep accordingly and repeat the analysis. If the two sets compare favorably, the user can be confident in using the larger of the two hydraulic timesteps and adjusted WQ timestep as what is needed for the most accurate WQ results for that model. This is essentially critical for models with multiple tanks in close proximity to each other that can create mathematical anomalies in EPANET (large induced flows between the tanks) when larger hydraulic timesteps of 1 hour are used. Under those circumstances reducing the hydraulic timestep to between 5 and 15 minutes and reducing the WQ timestep appropriately to 1/10th of the Hydraulic timestep is often sufficient to improve WQ predictions significantly. In light of this, I always recommend anyone looking to get highly accurate WQ concentrations to verify for their model if they need to reduce their hydraulic timestep The only downside to reducing the hydraulic timestep is often that run times for the analysis get longer and longer as the hycraulic timestep is reduced. This can be significant though as WQ simulations are often need to be run for long periods of time in order for them to achieve "steady state" conditions where the results follow a consistent repeating pattern over time.

I would also recommend that the user have a brief explanation of how EPANET calculates Concentrations at junctions (See EPANET 2.0 Help Page 193-199) in regards to discussions of WQ at dead end junctions. Since all flows in the pipes are "numerical calculations" even pipes connected to junctions that are on dead ends "can" have very small flows in them. Due to this, when pipe flows are low that WQ anomalies can occur at junctions connected to dead ends as the mass concentration at the junction is a weighted average based on the flows of all pipes flowing into the junction. This can periodically create short term anomalies in WQ results if the other pipes connected to the junction are also very small as the numerical "flow" in the dead end line can become more significant. This is usually seen as more of an issue in Water age calculations where the dead end junction can have a large water age, but is one reason dead end junctions in WQ analysis are a known issue that can cause short term oddities under certain conditions. Reducing the hydraulic timestep can often assist in this as you note at the bottom of page 12. Lastly in regards to the Conclusions and recommendations, a reduction in the Hydraulic timestep coupled with a WQ timestep 1/10th are often sufficient to improve WQ results. It would be of interest to see how changing the Hydraulic timestep and maintaining the correct ratio of WQ timestep would impact your results and recommendations as well.

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