

Water Quality Calibration Criteria for Bacteria TMDL Development

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INTRODUCTION

Hydrological Simulation Program-FORTRAN (HSPF) is a model frequently used to develop Total Maximum Daily Loads (TMDLs) to address bacterial water quality impairments.

Models like HSPF must be calibrated to insure that they adequately represent watershed characteristics and processes. Calibration is often complicated because of limited data.

Water quality calibration guidance is needed to ensure a consistent approach when simulating in-stream bacteria concentrations.

STUDY WATERSHED

The Beaver Creek watershed was used to illustrate the calibration approach presented here. The Center developed a bacteria impairment TMDL for Beaver Creek in 2005.

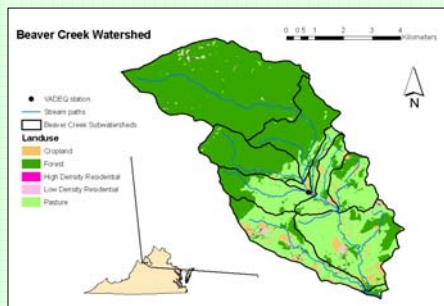


Figure 1. Beaver Creek watershed location.

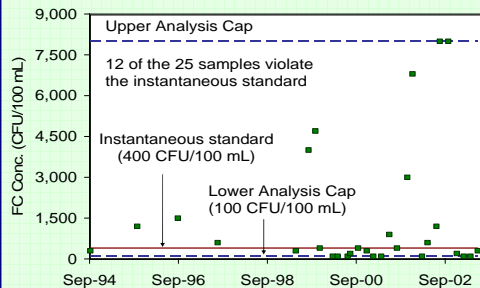


Figure 2. Observed in-stream bacteria concentrations.

APPROACH

The "temporal-window" statistic presented here compares simulated hourly-concentrations over a period of 5 days with observed data to assess model calibration. Each "temporal-window" is centered on the day an observation was collected. The frequency of observed data falling within the range of simulated data during the 5-day temporal-window, along with other performance statistics, is used to evaluate model calibration.

CALIBRATION EVALUATION STATISTICS AND RESULTS

- Conventional descriptive statistics: average, median, and geometric mean.
- Instantaneous violation rate (IVR): the percent of samples exceeding Virginia's single-sample (instantaneous) bacteria criteria of 400 colony forming units (CFU)/100 mL.
- 5-day temporal-window: each 5-day window is centered on the day an observation was made and includes 2 days before and 2 days after the observation day. The range (minimum and maximum) of simulated hourly concentrations for each 5-day window is compared with the observed data to calculate the temporal-window calibration statistics: PCT_Within, PCT_Above, and PCT_Below (Table 1).
- Graphical comparison: in addition to statistical endpoints, simulated and observed data are compared graphically to provide an overall assessment of model predictions.

Table 1. Suggested calibration statistics and criteria for simulating in-stream bacteria concentrations and model calibration results for the Beaver Creek watershed (**bold** values indicate compliance with criteria).

Statistic	Abbreviation	Criteria	Final Calibration Run		
			Obs.	Sim.	% Diff.
Average (CFU/100 mL)	Average	±100%	1,620	917	-43%
Median (CFU/100 mL)	Median	±100%	300	467	56%
Geometric Mean (CFU/100 mL)	Geomean	±100%	480	468	-2%
Instantaneous Violation Rate	IVR	±10%	48%	48%	0%
Percent of observed values within 5-day minimum- maximum range	PCT_Within	>70%			72%
Percent of observed values > 5-day maximum	PCT_Above	≈ PCT_Below			20%
Percent of observed values < 5-day minimum	PCT_Below	≈ PCT_Above			8%

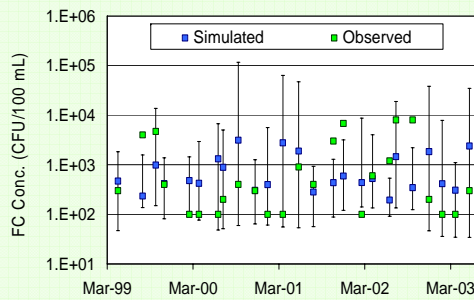


Figure 3. 5-day window of simulated bacteria concentrations surrounding each observed value. Blue squares represent the mean of 5 daily values.

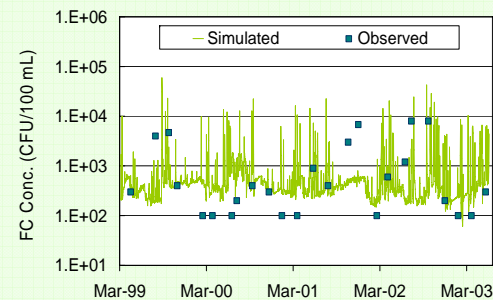


Figure 4. Comparison of observed and simulated daily in-stream bacteria concentrations.

DISCUSSION

- Temporal-window and IVR can be used to adjust and refine the model's calibration to ensure that it is adequately simulating in-stream bacteria concentration.
- Visual comparison of the simulated and observed data coupled with calibration evaluation statistics provides insight into the overall quality of the simulation both to the modeler and to stakeholders.
- Procedure has successfully been used in two-dozen TMDL studies in Virginia.

CONCLUSIONS

- Temporal-window concept provides a reasonable measure and target for calibration that accounts for variability in observed data and provides additional information to evaluate model calibration quality especially where observed data are limited.
- Statistics and criteria presented here can be used by the modeler as a guide when choosing which parameters to adjust and by how much during calibration, and to determine when sufficient agreement is achieved between the observed and simulated data.
- This water quality calibration approach represents a time-saving and logical procedure that will result in more accurate in-stream bacteria concentration simulations.
- This procedure, its underlying methodology, and a case-study application will be published in 2007 making it available for adoption by public- and private-sector TMDL developers.

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