FTABLE Generation Method Effects on In-stream Fecal Bacteria Concentrations Simulated with HSPF

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FTABLE Generation

Channel and floodplain dimensions (width, depth, and slope) are required to generate FTABLES (Figure 1). Field-based FTABLES offer good detail but require significant time to develop. Digital-based FTABLES are developed relatively quickly but are significantly less detailed than field-based FTABLES.

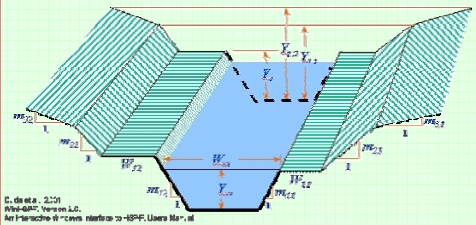

Figure 1. FTABLE conceptualization of stream channel cross-section.

Four "field-based" FTABLE scenarios were developed using detailed cross-sectional surveys collected from 14 subwatersheds within the Pigg River watershed (906 km^2) in South Central Virginia. Four cross-sections were surveyed within each subwatershed and processed to generate the field-based FTABLE scenarios (Figure 2, Table 1).

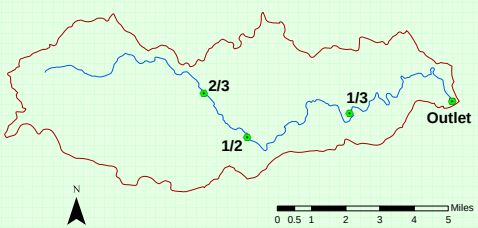

Figure 2. Four cross-sections were surveyed in each subwatershed.

Table 1. Cross-section profiles were combined to increase FTABLE detail for the four field-based scenarios (Staley et al., 2006).

Field Scenario	Profiles used
"out"	outlet
"half"	outlet, 1/2
"third"	outlet, 1/3, 2/3
"all"	outlet, 1/3, 1/2, 2/3

A fifth "digital-based" FTABLE scenario was developed using 30-meter digital elevation data and NRCS Regional Hydraulic Geometry Curves to relate channel dimensions to discharge.

Background

The Hydrological Simulation Program-FORTRAN (HSPF) is a lumped parameter model frequently used to develop bacteria impairment TMDLs. In HSPF, the total volume of water in a stream reach is used to compute discharge, stage, and surface area by linear interpolation using a Hydraulic Function Table (FTABLE). When developing FTABLES, the modeler has two basic options: use some manner of field data, such as cross-sectional profile surveys ("field-based"); or digital data, such as digital elevation models (DEMs) combined with Natural Resources Conservation Service (NRCS) Regional Hydraulic Geometry Curves ("digital-based"). Staley et al. (2006) compared simulated daily-flow discharge rates using field-based and digital-based FTABLEs and concluded that FTABLE generation method did not significantly affect simulated average-daily discharge. This study extends Staley et al. by comparing the effects of FTABLE generation method on simulated in-stream fecal bacteria concentrations.

Analysis

We conducted Monte Carlo simulations using 75 stochastically generated climate input time series. Pair-wise Student's t-tests were used to compare:

- long-term average in-stream fecal bacteria concentration
- in-stream fecal bacteria die-off
- violation rate of the Virginia single-sample bacteria water quality criterion

Results

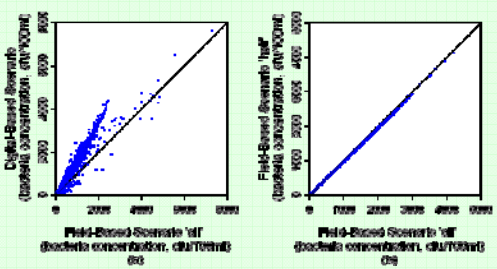

Figure 4. Digital-based FTABLEs yielded concentrations higher than any field-based FTABLE scenario (a) while all field-based FTABLE scenarios produced similar results (b).

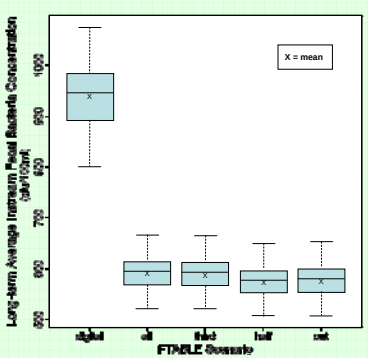

Figure 5. Digital-based FTABLEs yielded higher concentrations and more variability.

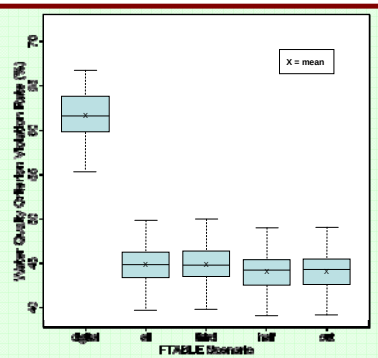

Figure 6. Digital-based FTABLEs produced more water quality criterion violations.

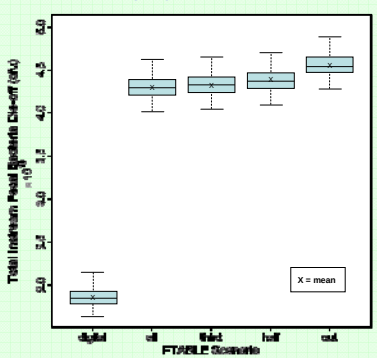

Figure 7. Digital-based FTABLEs produced less bacteria die-off due to shorter in-stream residence time.

Discussion

Shorter in-stream fecal bacteria residence times seen with the digital-based FTABLE scenarios yielded increased in-stream bacteria concentrations (Figure 4), higher water quality criterion violation rates (Figure 6), and less in-stream die-off (Figure 7). Hydrographs produced using digital-based and field-based FTABLES illustrate differences in runoff timing (Figure 8). This difference in timing impacts in-stream fecal bacteria concentration by altering the in-stream fecal bacteria residence time. The volume under the two hydrographs is equal.

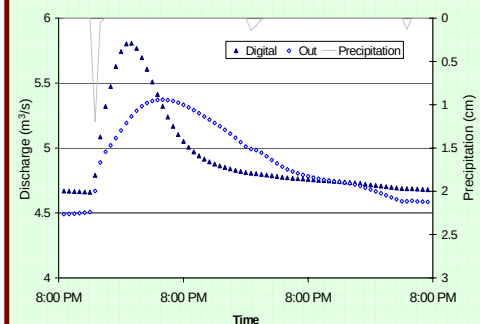

Figure 8. Hydrograph illustrating differences in hourly discharge rates simulated using digital- and field-based FTABLEs.

Conclusions

- Use of digital-based FTABLE scenarios may make achieving an acceptable bacteria load TMDL allocation scenario more difficult by simulating
  - less in-stream fecal bacteria residence time
  - less bacteria die-off
  - higher in-stream bacteria concentrations
  - more water quality criterion violations
- Using multiple cross-sectional profiles to develop more refined field-based FTABLES has no significant effect on simulated in-stream fecal bacteria concentrations. A single cross-section is sufficient.

References

- Hall, K.M., R.W. Zeckoski, K.M. Brannan, and B.L. Benham. 2007. Analysis of HSPF simulated in-stream bacteria concentration using FTABLES generated with field survey and digital data. *J. Amer. Water Res. Assoc.* (under review).
- Staley, N.A., T. Bright, R.W. Zeckoski, B.L. Benham, and K.M. Brannan. 2006. Comparison of HSPF outputs using FTABLES generated with field survey and digital data. *J. Amer. Water Res. Assoc.* 42(5): 1153-1162.