ESTIMATE TSS LOADS FOR URBANIZED STREAM HEALTH

You Jen Tsai

AUTHOR: Parsons Engineering Science Inc., 5390 Triangle Parkway, Suite 100, Norcross, GA 30092.
REFERENCE: Proceedings of the 2001 Georgia Water Resources Conference, held March 26-27, 2001, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, the University of Georgia, Athens, Georgia.

Abstract. In an effort to provide a TSS guideline, a correlation analysis between TSS loading (lbs/acre/yr) and in-stream TSS concentrations (mg/L) were performed. Water quality modeling (BASINS) results for a continuous 5-year period were used for this analysis. The water quality model incorporated rainfall, land topography, soil type, land use, and channel geometry to generate the TSS loading (lbs/acre/yr), and in-stream TSS concentrations (mg/L). The in-stream TSS concentrations were the results of water column transport processes of washoff TSS and re-suspension of sediment from the channel bottom. The significance of this correlation was its application. Stream health appeared to be highly responsive to in-stream TSS guideline, or target condition. To protect, preserve, or restore stream integrity, in-stream TSS standards could be established or adopted by development communities and then the TSS mass loading was calculated for land use development planning.

INTRODUCTION

Watershed assessments were required by the State of Georgia to help control nonpoint source pollution that may be associated with degradation of surface water quality and non-attainment of designated uses of streams. In north Fulton County, the Johns Creek watershed had an area of approximately 13 square miles. Over the past 50 years, Johns Creek watershed experienced rapid residential development. Using the 1999 updated aerial photographs, the predominant land use of the watershed was residential (74%). Forest and open space covered about 13 percent of total area.

During urbanization, streams receiving runoff from newly developing areas experienced periodic 'slugs' of sediment that deposited in streambed and clogged substrate where bethic organisms lived and fed. These slugs of sediment remained until re-suspended and transported downstream by large storm events.

The results of present watershed characterization indicated that both water quality and aquatic habitat and life were poor in area streams. The habitat assessment scores showed that all sampling stations were only 'partially similar' or 'dissimilar' to the reference stations. The benthic macroinvertebrate scores for all stations were 'poor'. The IBI score for fish habitat assessment characterized the conditions as 'fair to poor'.

Attempts were made to correlate water quality parameters to aquatic health, especially the relationship between TSS concentration and aquatic habitat indicators. However, due to limited, available field data, a meaningful relationship of statistical significance could not be established. As a result, alternatively a modeling approach was used to estimate TSS loads.

In an effort to guide the watershed management of future development, the objective of the study was to establish TSS limits to reduce chances of further degradation of stream health.

METHODS

During the project, three (3) sampling sites were selected and sampled on four (4) storm events and four (4) dry periods between June and September 1999. In-stream water samples were collected and analyzed. In addition, stream flows were recorded. These field data provided the foundation for a water quality model.

BASINS was used for water quality modeling in this project. BASINS provided an integrated ARCView GIS platform for manipulating watershed geologic information, while the incorporated HSPF model was the engine for modeling water quality. A water quality model simulated generation of nonpoint pollutants from land surfaces and then calculated resultant, in-stream water quality. Water quality constituents that have been calibrated include total suspended solids (TSS), nitrate nitrogen, total phosphorous, and fecal coliform bacteria. The developed water quality model of the project produced estimates that were comparable to field observations.

The water quality model incorporated rainfall, land topography, soil type, landuse, and channel geometry to generate the TSS loading (lbs/acre/yr), and in-stream

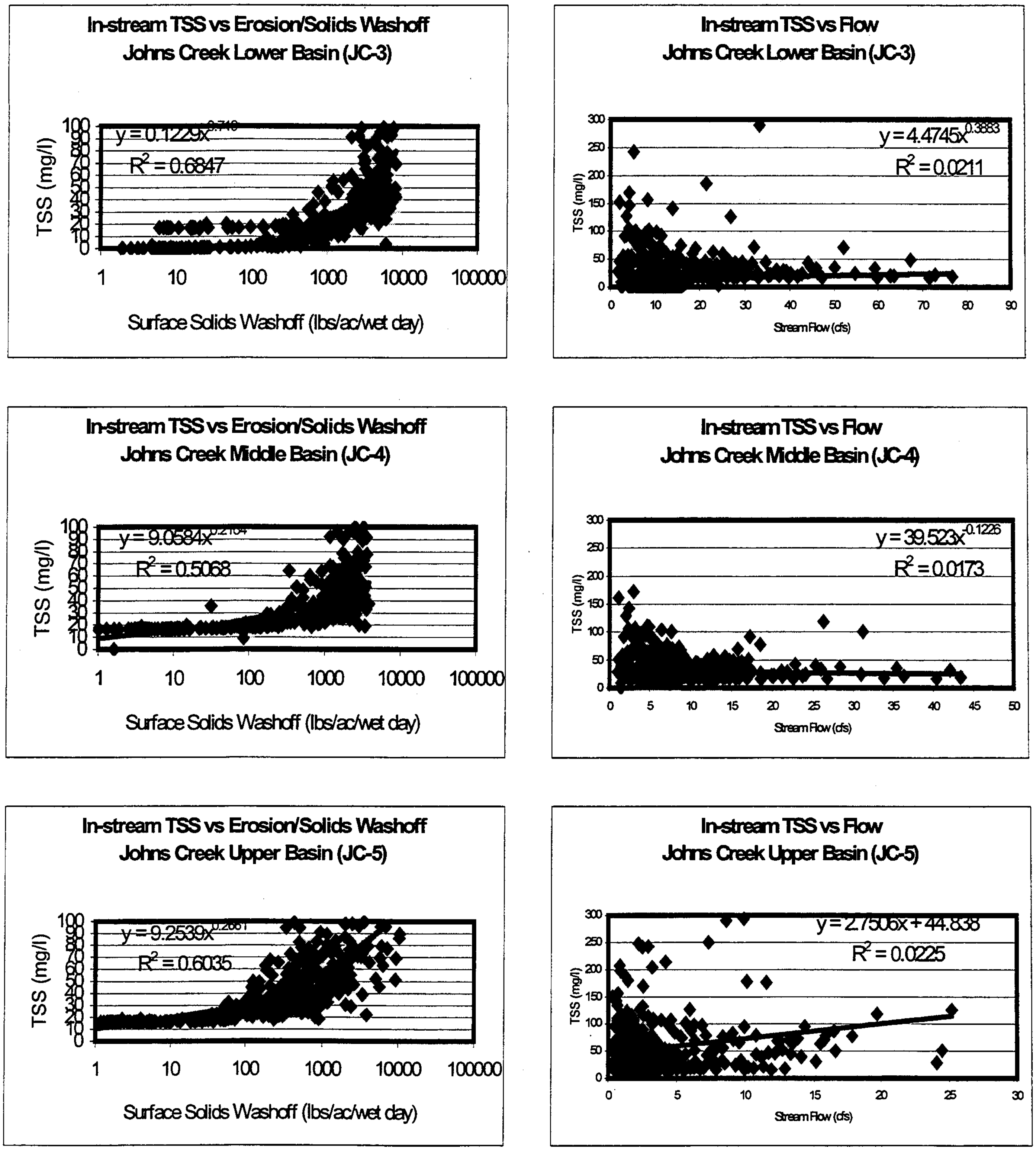

Figure 1. Correlations between in-stream levels of TSS in Johns Creek versus solids washoff or flow at each sampling station. Data were simulated results of BASINs model.

TSS concentrations (mg/L). The in-stream TSS concentrations were the results of water column transport processes of washoff TSS and re-suspension of sediment from the channel bottom. The model was incapable of simulating stream bank erosion and undercutting as results of increased stream flow velocities due to urbanized watershed.

Water quality model was run for a continuous 5-year period (1985 – 1989) using recorded weather data at the Atlanta Airport. Simulated daily stream flow, land surface TSS loading, and in-stream TSS concentration were used for correlation analysis.

DISCUSSION

Figure 1 shows the correlation results. For all three stream stations (JC-3, JC-4, and JC-5, in an order of moving upstream), the modeled land surface pollutant (eroded soil and solids) loading rates could be a good predictor of in-stream TSS values. Conversely, the weak correlation coefficients reflected in Figure 1, rendered stream flows inconclusive as a predictor for in-stream TSS values. The complex dynamics of solid suspension in the water column of streams could not be simply described by a linear relationship between instant flow measurement and TSS value.

Simply put, by knowing TSS loading rates, one can estimate in-stream TSS concentrations, or vice versa. However, estimates of in-stream TSS concentration by knowing the stream flows, will be less certain.

The significance of this correlation was its application. Stream health was highly responsive to in-stream TSS guideline or target conditions. The National Academy of Sciences (NSA) report "Water Quality Criteria" recommends the TSS maximum concentrations for different levels of in-stream protection of aquatic life (Table 1).

The use of Figure 1 is exemplified as follows. Assuming that the communities used an in-stream TSS of 80 mg/L to ensure protection of aquatic systems per the recommended levels by National Academy of Sciences (NAS), this 80 mg/L, by means of regression, corresponds to a loading of approximately 8,187 lbs/ac/wet day, (see JC-3 station). Georgia had an average of 100 rain (wet) days a year. Thus, the 8,187 lbs/ac/wet day was calculated to be 2,243 lbs/ac/yr.

Table 2 shows the additional, surface TSS loading (lbs/ac/yr) calculation at various levels of in-stream TSS concentration.

Using the same regression equation, a surface TSS loading rate of 855 lbs/ac/yr was equivalent to an in-stream concentration of 40 mg/L that provides a protection level between moderate to high. The above demonstration allows the additional TSS from streambank erosion to be incorporated in the County proposed standards to provide sufficient protection.

The reasons to choose a stringent criteria (i.e., 40 mg/l) are (1) streambank erosion is a significant contributor for total in-stream TSS, and (2) this study did not and could not simulate a streambank erosion process by the developed water quality model.

LITERATURE CITED

National Academy of Sciences, National Academy of Engineering. 1973. Water Quality Criteria 1972. EPA Ecologic Research Series. EPA-R3-73-033, U.S. Environmental Protection Agency, Washington, D.C., 594p.

Table 1. NSA Water Quality Criteria

Level of Protection	TSS Concentration
High	25 mg/l
Moderate	80 mg/l
Low	400 mg/l
Very Low	> 400 mg/l

Table 2. TSS Loading (lbs/ac/yr) for different in-stream TSS Concentration in Johns Creek Watershed, Fulton County, Georgia.

Level of Protection
In-Stream TSS Concentration

Station	Drainage Area	80 mg/l	40 mg/l	25 mg/l
		lbs / ac / yr		
JC-3	13.0 mi^2	2243	855	445