Precipitation-Conductivity-Turbidity Response for a Small Watershed in East Tennessee

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Abstract

Excess sedimentation is the primary pollutant in Tennessee's Watauga River Watershed (HUC 06010103) with 159.4 sediment-impaired stream miles (of 717 total miles). Streams impaired with *E. coli* come in second, at 117.5 impaired miles. In 2014, a restoration project for *E. coli* was completed in the Sinking Creek subwatershed (HUC 06010103046) that included projects for cattle exclusion, sewer connections, and construction of a wetlands area. During the restoration work, Sinking Creek's largest tributary was listed as impaired due to excess sediment. This study quantifies Sinking Creek's turbidity and conductivity response to precipitation downstream from the confluence of the tributary, and upstream of the wetlands. Turbidity was measured hourly from Oct. 24-Nov. 5 2015, and stream discharge was measured daily. Precipitation and electrical conductivity (EC) were measured at 5 minute intervals using data loggers and aggregated to hourly data. A lag of 3 to 4 hours between precipitation onset and increase in turbidity was identified. Principal Components Analysis was used to extract two orthogonal components representing precipitation and discharge/EC. Regression models explained between 18 and 20% of the variability in turbidity; inclusion of other factors such as antecedent precipitation and soil moisture will likely improve future models.

1. Overview

This poster presents results from a research study completed by a combined Senior and Graduate level hydrology class along a recently restored reach of Sinking Creek, Washington County, TN.

Research objectives

1. Quantify the relationship between precipitation, turbidity, conductivity, and discharge.
2. Evaluate the watershed's precipitation-turbidity response lag interval.

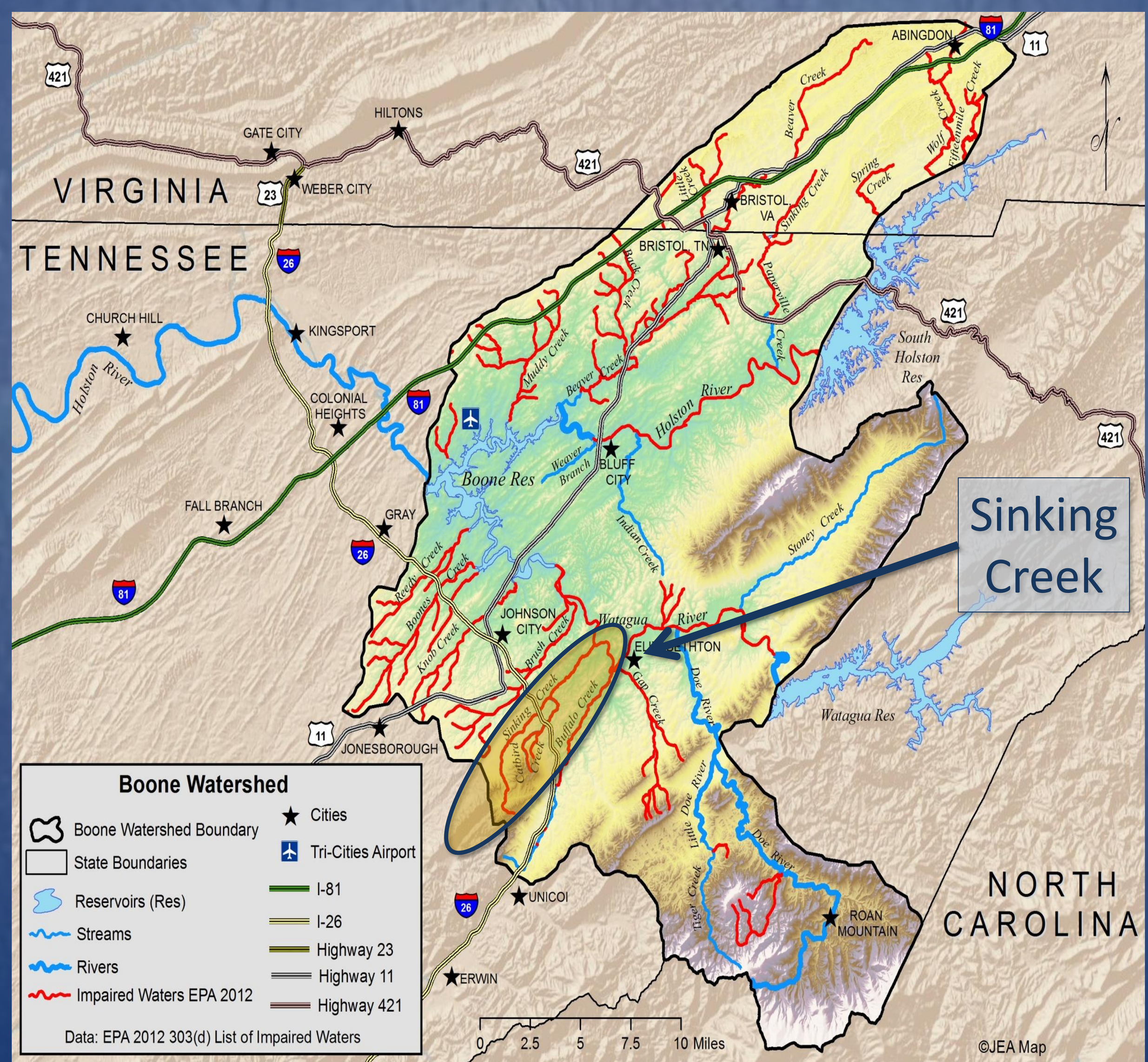


Figure 1. Sinking Creek location in Boone Watershed, TN/VA (Archer, 2015)

2. Research site

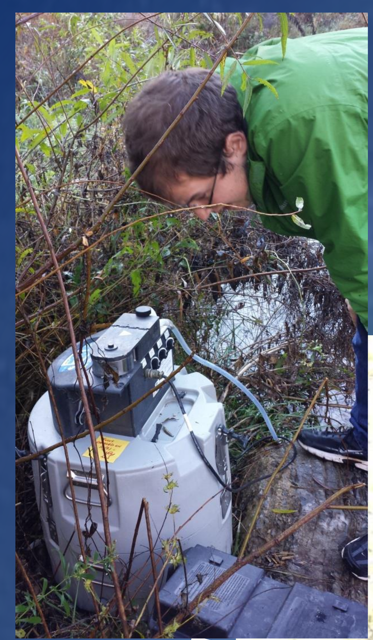
Sinking Creek is impaired for *E. coli* due to urban and agricultural runoff.

- Land use in the watershed area is forest (50%), pasture land (18%), pervious surface (i.e. residential lawns, etc) (24%), and the remaining 8% is impervious.
- Catbird Creek, a major tributary to Sinking Creek, is impaired by sediment.
- Study reach is located 365 m (1200 ft) downstream from the confluence of the two streams in a constructed wetland on the site of Jacob's Nature Park, a new city park in Johnson City, TN.

The wetland was constructed in 2013. Bank armoring was completed along an eroding cut bank, and a swale was constructed to divert flow to vernal pools during bankfull events. The wetland serves three purposes:

- Improve water quality downstream through natural attenuation and filtration,
- Provide flood storage during high flows,
- Serve as an educational park for water quality.

3. Field setup and data collection



Hourly water samples were collected using an ISCO 6712 automated sampler. Samples were later processed for turbidity using a HF Scientific DRT-15CE portable turbidimeter.

Daily discharge was measured using a pygmy flow meter.

Precipitation was logged every 10 minutes (Onset RG2 data logger). Hourly statistics were generated from aggregated data:

- Precipitation depth
- Precipitation rate

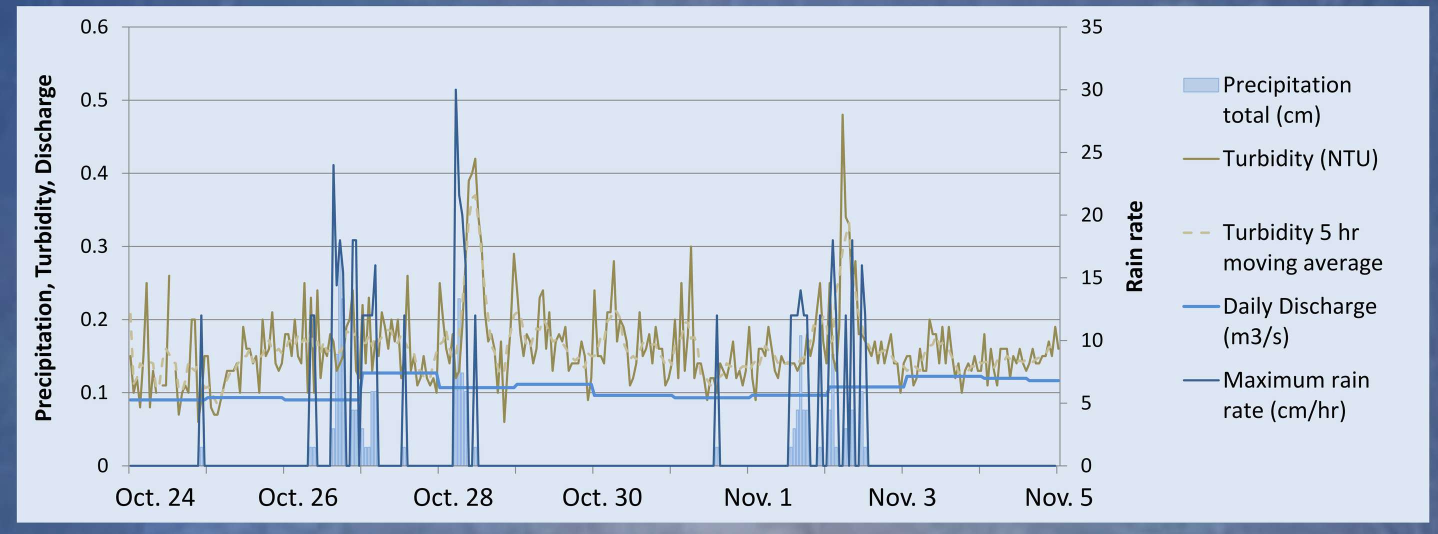
Electrical conductivity was logged every 10 minutes using an Onset HOBO U24-001 data logger, and averaged hourly.

Figure 2. Aerial view of the study reach showing sampling locations and equipment.

4. Statistical Analysis

Correlation and cross-correlation

Turbidity, precipitation and discharge are positively correlated, with an obvious lag (Fig. 3). Turbidity is significantly and positively correlated to both precipitation variables at lags of 2 through 8 hours (Fig. 4). No significant correlation exists between turbidity and air temperature, water temperature, nor electric conductivity.



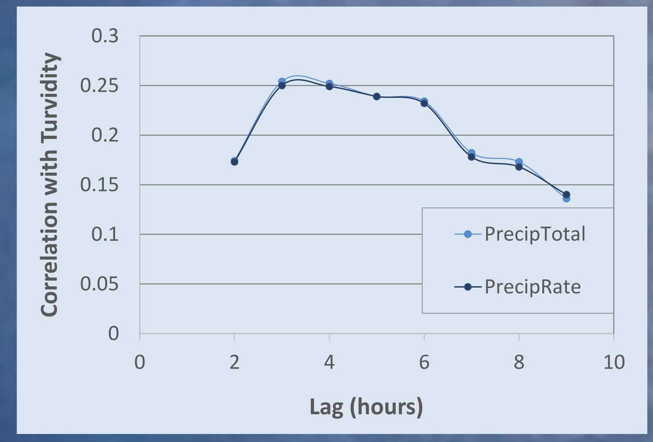


Figure 3 (above). Time series shows positive lagged correlation between turbidity and precipitation.

Figure 4 (left). Cross-correlation of lagged turbidity and precipitation for lags of 2 through 8 hours .

PCA and OLS regression

Principal Components Analysis (PCA) on discharge, electric conductivity, precipitation total, and precipitation rate generated two orthogonal components loading high on 1) precipitation and 2) conductivity/discharge (Fig. 5).

	Component	
	1	2
Discharge	-.045	-.824
Conductivity	-.022	.827
PrecipTotal	.953	.029
PrecipRate	.953	-.002

Figure 5. Rotated component matrix.

OLS regression models of turbidity using the two components explained less of the variability in turbidity at lags of 3 and 4 hours (R^2 = 0.18 and R^2 = 0.19 respectively, at p<0.001) than models developed using the original explanatory variables (R^2 = 0.2 for both, at p<0.001).

5. Summary and Conclusions

Sinking Creek shows an increase in turbidity 3-4 hours following a rainfall event; precipitation was able to explain ~20% of the variability in turbidity data. Other factors such as antecedent rainfall and soil moisture likely play an important role.

It is recommended that this project be expanded by measuring turbidity at shorter time intervals, adding soil moisture, and extending the time frame to capture larger rainfall events.

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