Onsite Wastewater Treatment System Effect on Stream Flow and Nitrogen: SWAT Model Predictions

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Introduction

- During the droughts of the last decade in the Southeastern US, the extent to which water use by onsite wastewater treatment systems (OWTS) represents consumptive use (defined here as water that does not return to streams) has been debated. The contribution of OWTS to nitrogen (N) in streams is also unknown. To answer these questions, we used the Soil Water Assessment Toll (SWAT) model to simulate stream flow and N in a suburban watershed in metropolitan Atlanta.

Methods

Watershed

- Big Haynes Creek watershed 44 km^2 in area (Fig. 1)
- Landuse: 28% low density urban, 38% medium density urban, 24% forest
- 162 OWTS/km^2
- USGS gage station at outlet
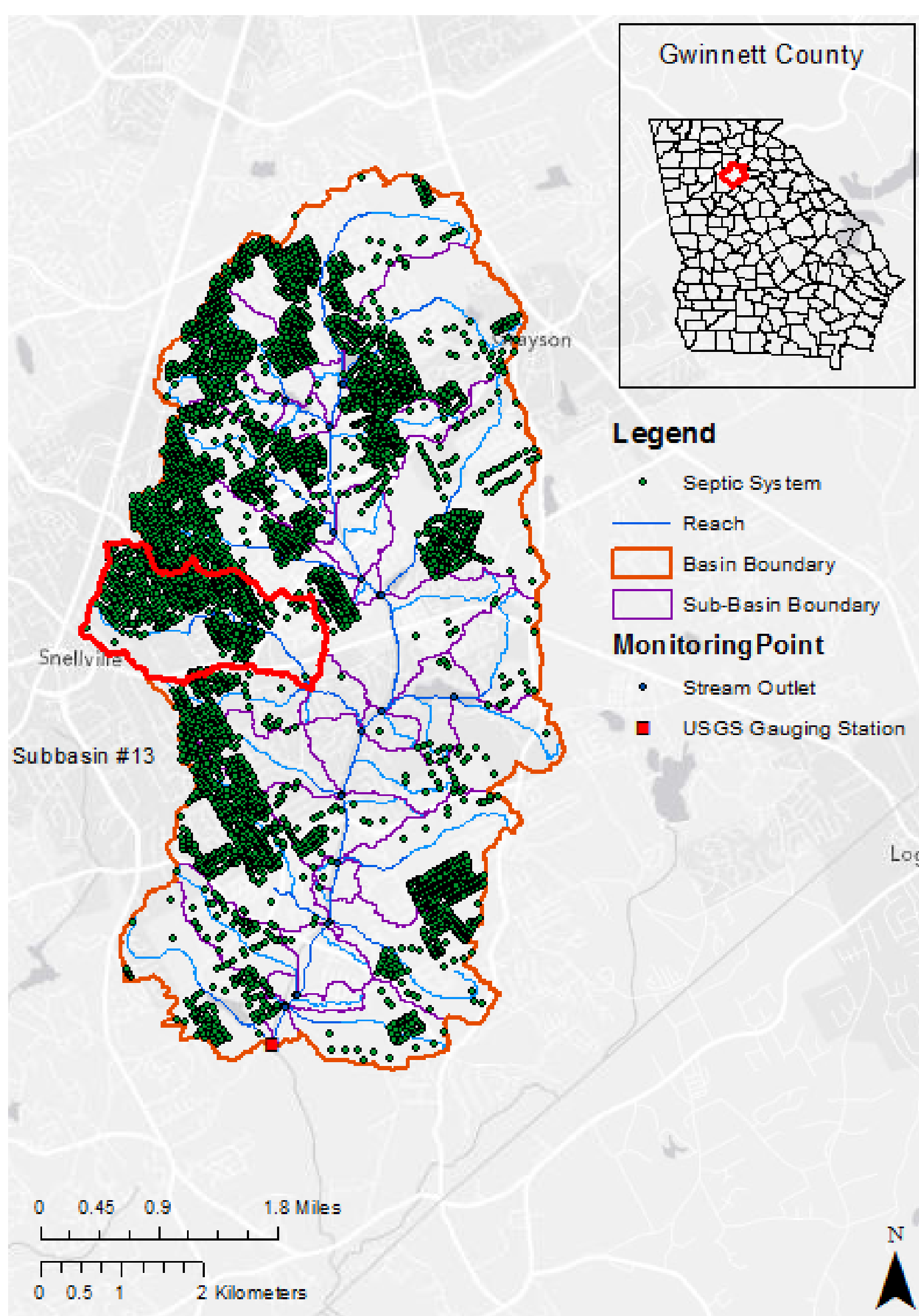- 35 subbasins
- Subbasin # 13 highest density OWTS

Figure 1: Big Haynes Creek Watershed.

SWAT Model

- New OWTS routine in SWAT (Fig. 2)
- Simulated using daily time step
- SWATCup calbration (Table 1)
- Calibration period 2003-2006
- Validation period 2007-2010
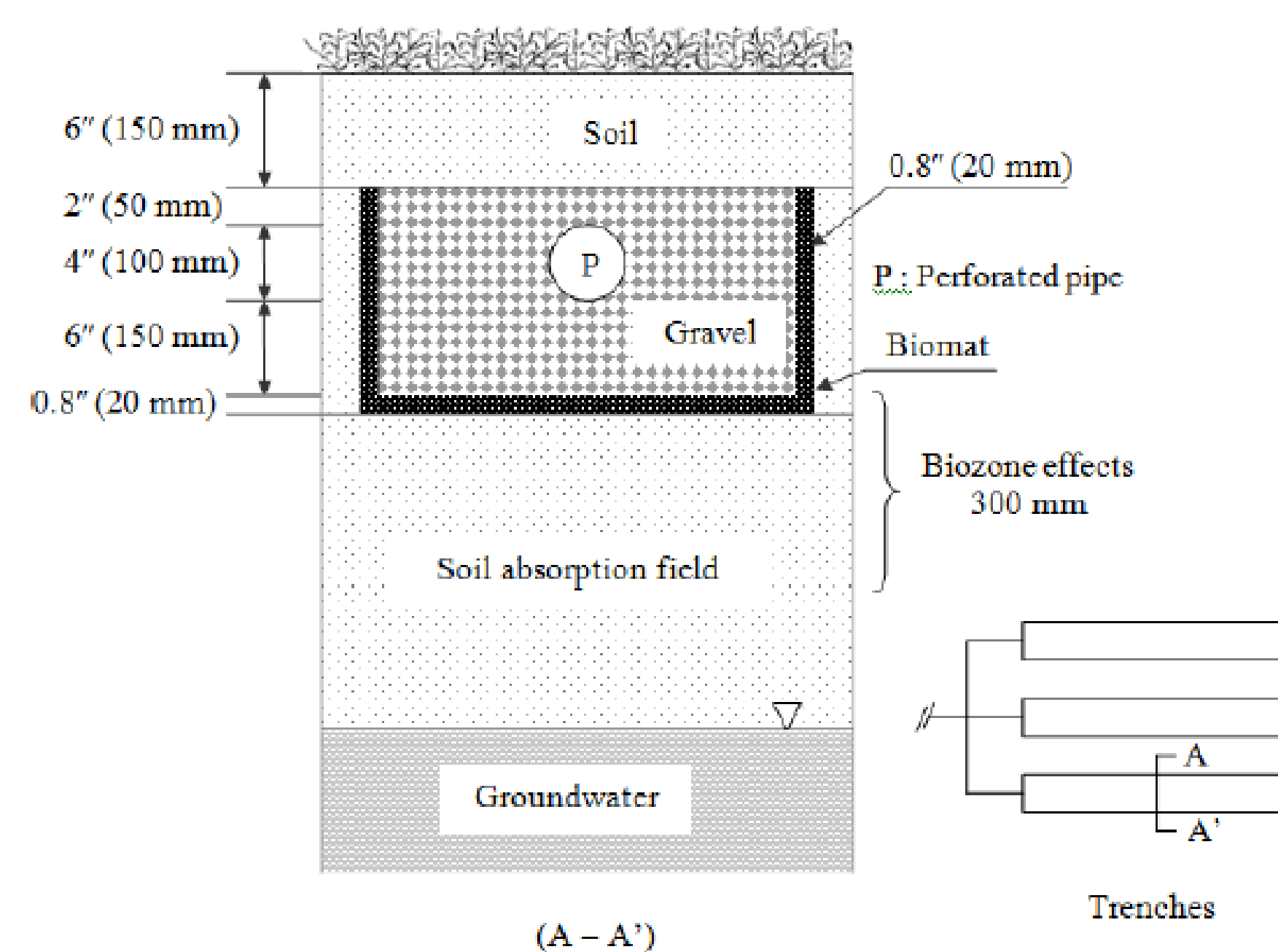- After calibration simulated with and without OWTS to see effect on flow

Figure 2: SWAT OWTS schematic (Jeong et al., 2011)

Table 1: SWATCup parameters for flow.

SWAT Parameter	P-Value for Sensitivity
CN2	0.0049
ESCO	0.0545
SOL_K	< 0.001
GW_DELAY	0.0211
ALPHA_BNK	< 0.001
CH_K2	< 0.001
CH_N2	< 0.001

Results

Table 2: Nash-Sutcliffe values for flow.

Simulation Period	NS Daily	NS Monthly
Calibration: 2003-2006	0.49	0.71
Validation: 2007-2010	0.37	0.68
2003-2010	0.44	0.72

- Good fit for calibration, validation, and entire period (Table 2 & Fig. 3).
- OWTS effect on stream flow at watershed scale was small but beneficial: 1.8-5.2% increase (Fig. 4).
- OWTS effect on stream flow was more significant in high density subbasin (# 13): 4.7-9.9% increase (Fig. 4).
- Effect of OWTS on stream flow was greatest in low rainfall years (2006-2008) (Fig. 4).
- Only 5.2% of OWTS water use was consumptive (lost to ET or deep aquifer recharge).
- N concentrations with uncalibrated model are overpredicted (Fig. 5 & 6)
- Cannot get SWATCup to run for N
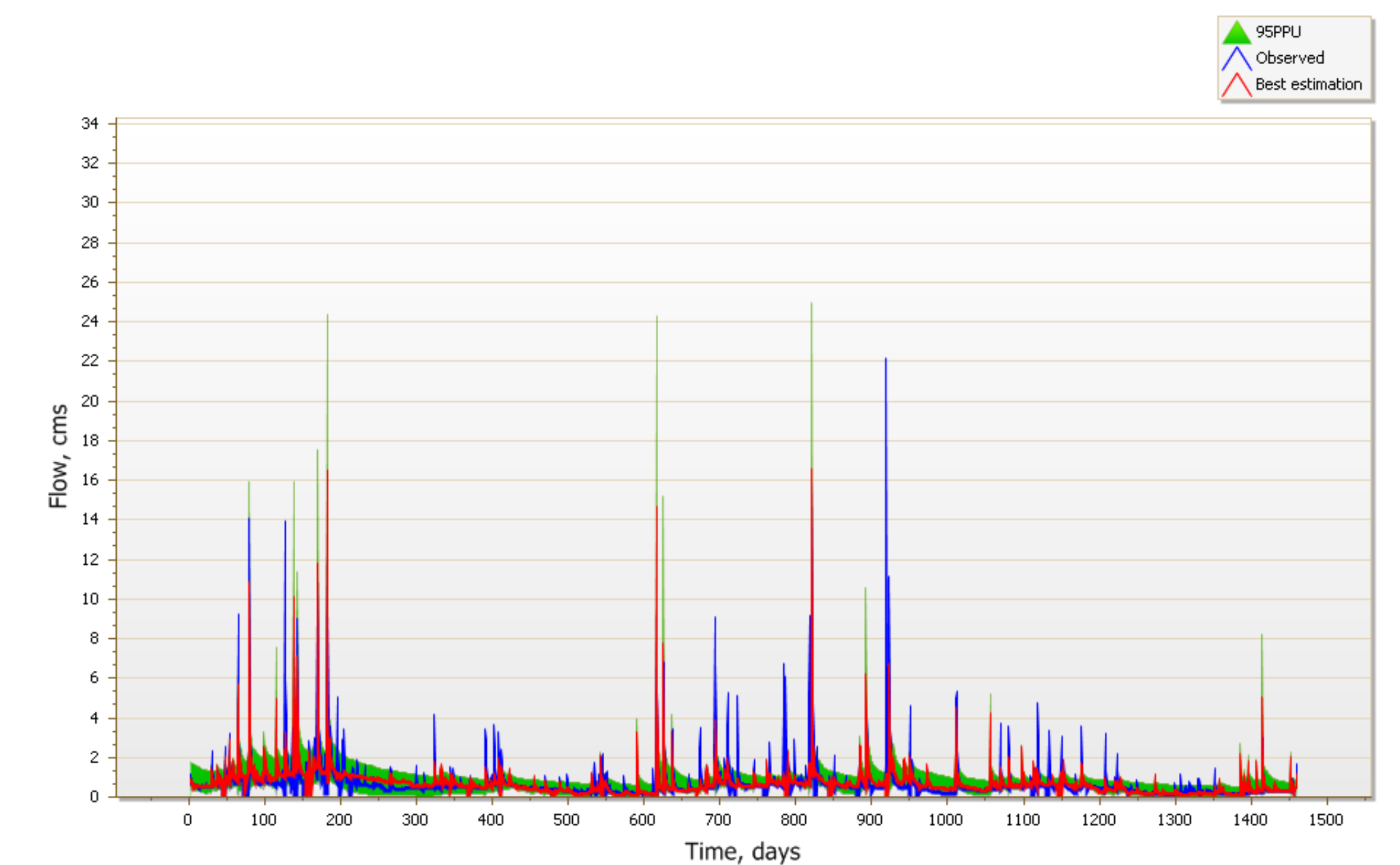- Future work: determine N contribution from OWTS

Figure 3: SWAT predicted flow (red), observed flow (blue), and 95% uncertainty band (green), 2003-2006.
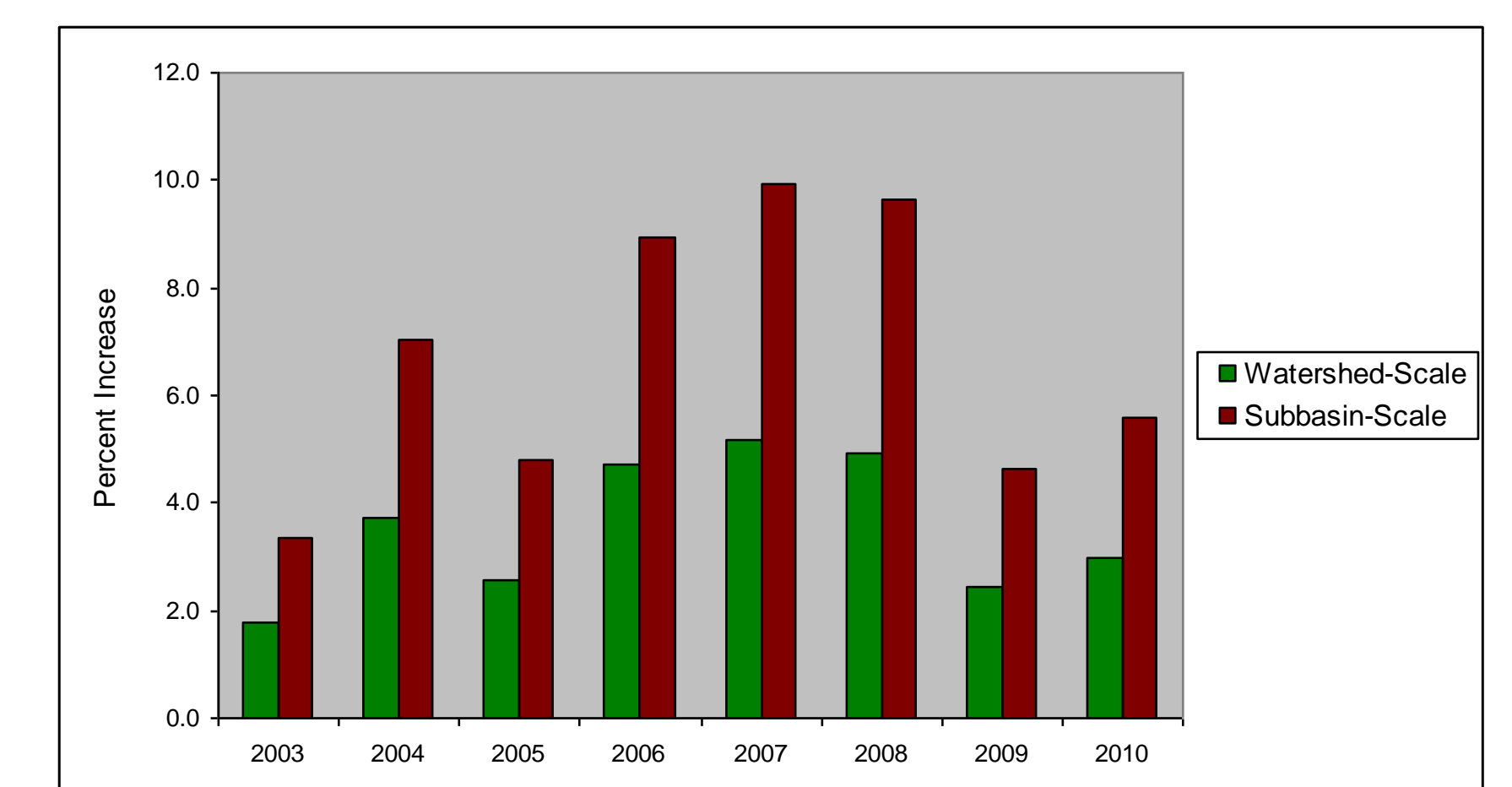

Figure 4: Percent increase in stream flow due to OWTS at watershed- and high-density scale by year.
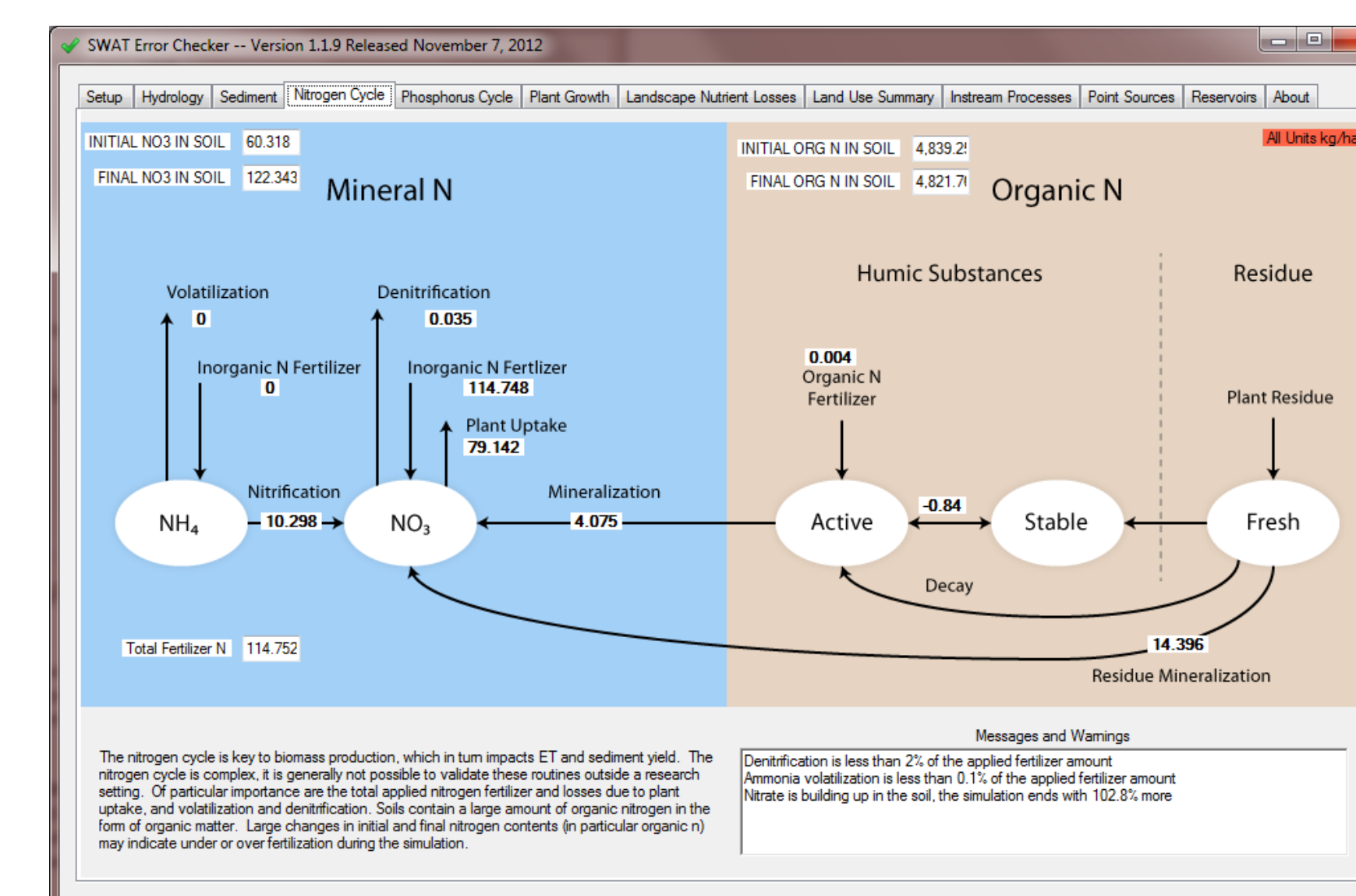

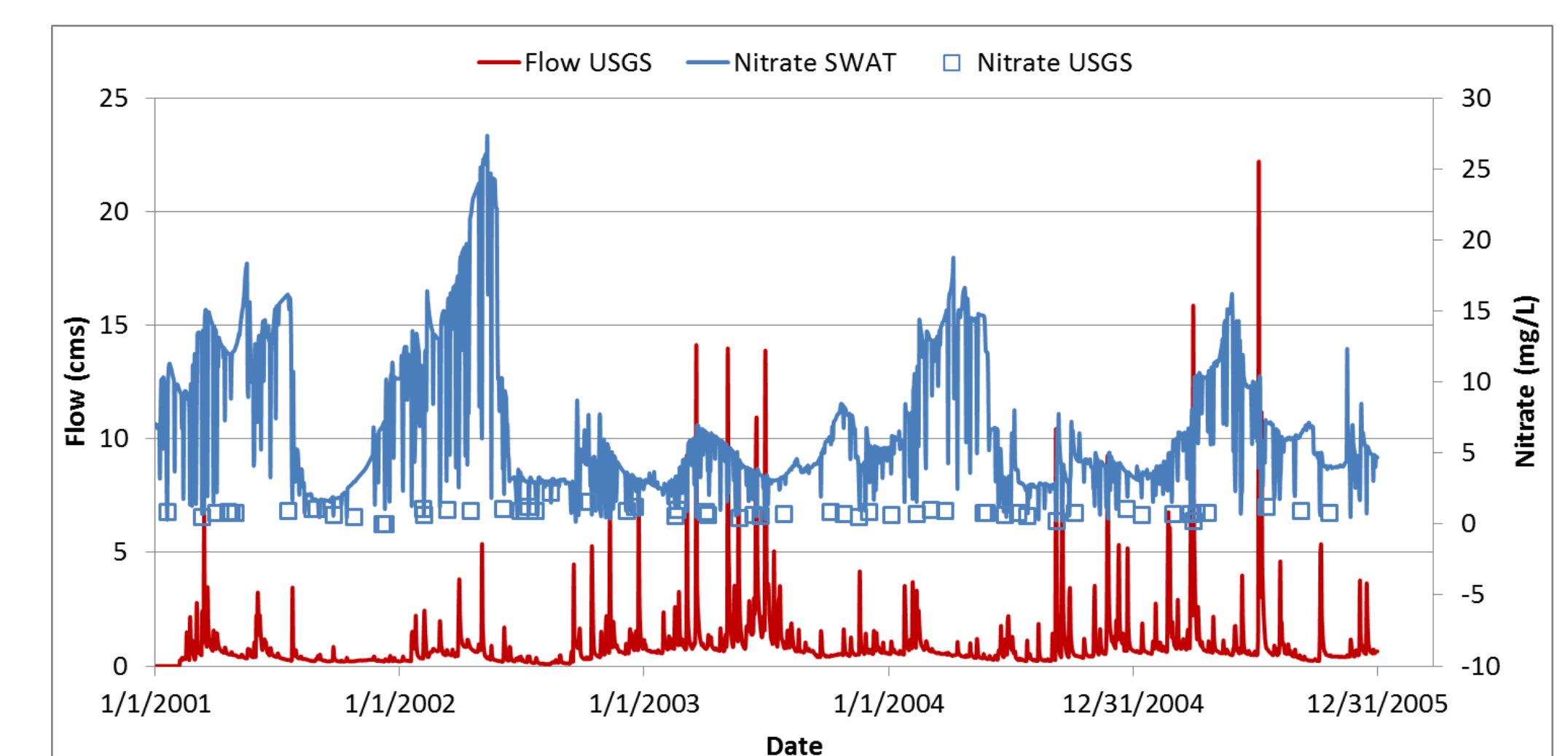**Figure 5**: SWATCheck N cycle for un-calibrated model.

Figure 6: Observed and predicted nitrate from SWAT from model un-calibrated for N.

References:
- Abbaspour, K. C. 2011. SWAT-CUP4: SWAT Calibration and Uncertainty Programs-A User Manual. Eawag: Swiss Federal Institute of Aquatic Sciences and Technology.
- Arnold, J. G., J. R. Kiniry, R. Srinivasan, J. R. Williams, and S. L. Neitsch. 2011. Soil and Water Assessment Tool Input/Output File Documentation, Version 2009. Texas Water Resources Institute Technical Report No. 365.
- Jeong, J., C. Santhi, J. G. Arnold, R. Srinivasan, S. Pradhan, and K. Flynn. 2011. Development of algorithms for modeling onsite wastewater systems within SWAT. Transactions of the ASABE 54(5):1693-1704.