Modeling the Influence of Subsurface Drainage Systems on Downstream Flooding in the Midwest

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Introduction

- Subsurface drainage systems are common in agricultural regions of the Midwestern United States.
- Drainage systems remove excess water from both the surface and soil profile of agricultural fields.
- The drainage of agricultural fields allows crop production in previously unsuitable locations.
- Drainage systems impact watershed hydrology and could potentially influence downstream flooding events.

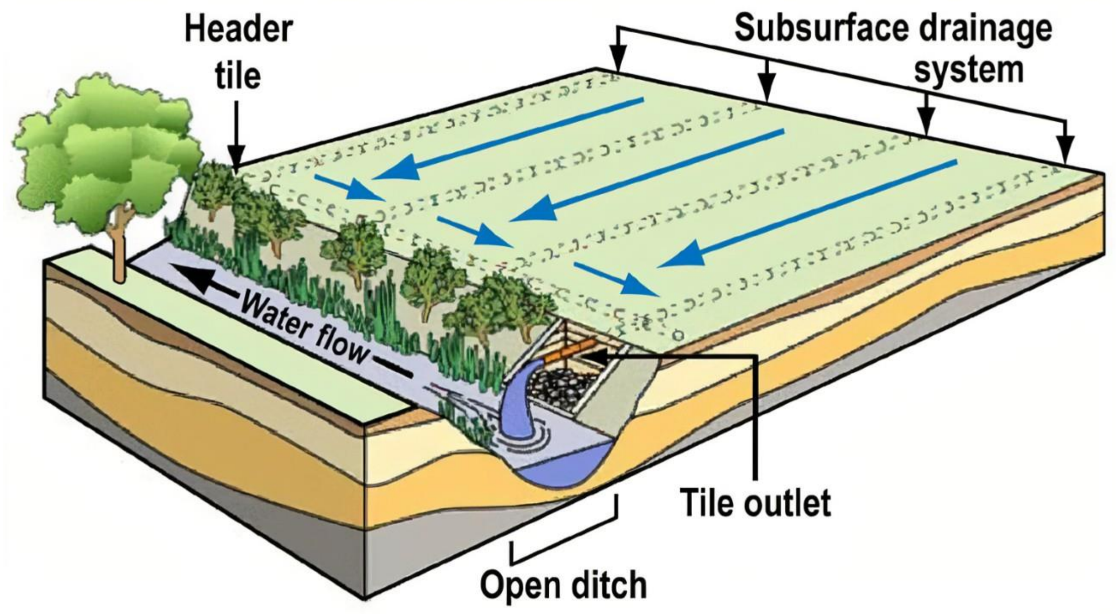

Figure 1: Subsurface Drainage System Diagram (Ontario, 2022)

Objectives

- Construct a Soil and Water Assessment Tool (SWAT) model to simulate streamflow in Skunk Creek Watershed.
- Calibrate and validate the SWAT model using SWAT Calibration and Uncertainty Program (SWAT-CUP) to ensure both fit and accuracy of the model.
- Implement and analyze the effects of subsurface drainage systems on downstream flooding from the watershed.

Materials and Methods

The following datasets were downloaded and modified to represent the watershed of interest:

- 10-meter Digital Elevation Model from the USDA-NRCS.
- 2019 National Land Cover Dataset from the Multi-Resolution Land Characteristics Consortium.
- SSURGO Soil Data from the USDA-NRCS Web Soil Survey.
- PRISM Climatic Data from the Northwest Alliance for Computational Science and Engineering.

Streamflow data was downloaded from Streamflow Gauge Station USGS 06481500 for the years 2004-2021 (Figure 1).

Literature reviewed parameters were selected for model calibration and validation for daily streamflow in SWAT-CUP.

- Nash Sutcliffe Efficiency (NSE), Percent Bias (PBIAS), and RMSE-Observations Standard Deviation Ratio (RSR) were used to evaluate the fit and accuracy of the model.

Materials and Methods

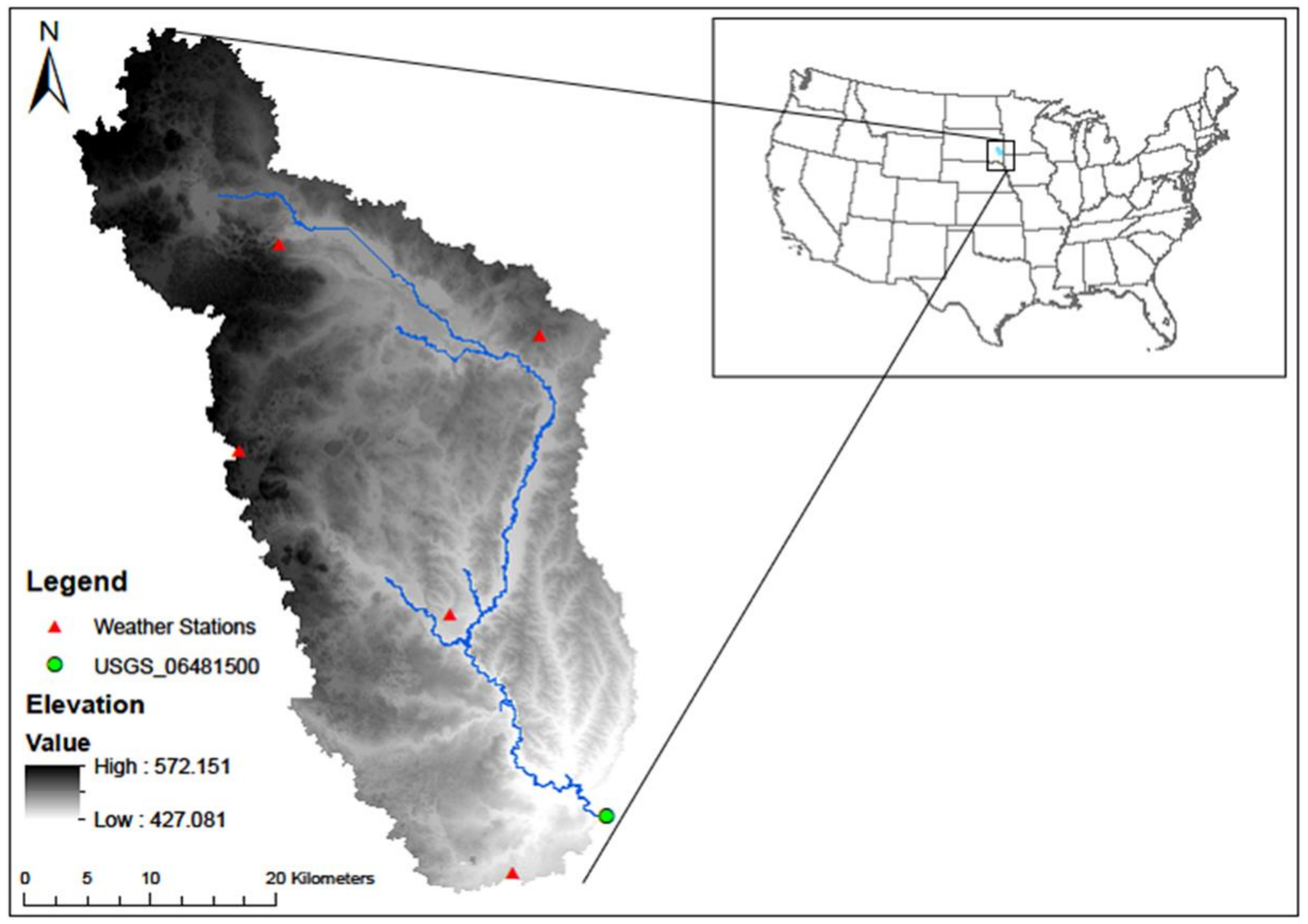

Figure 2: Skunk Creek Watershed

Results

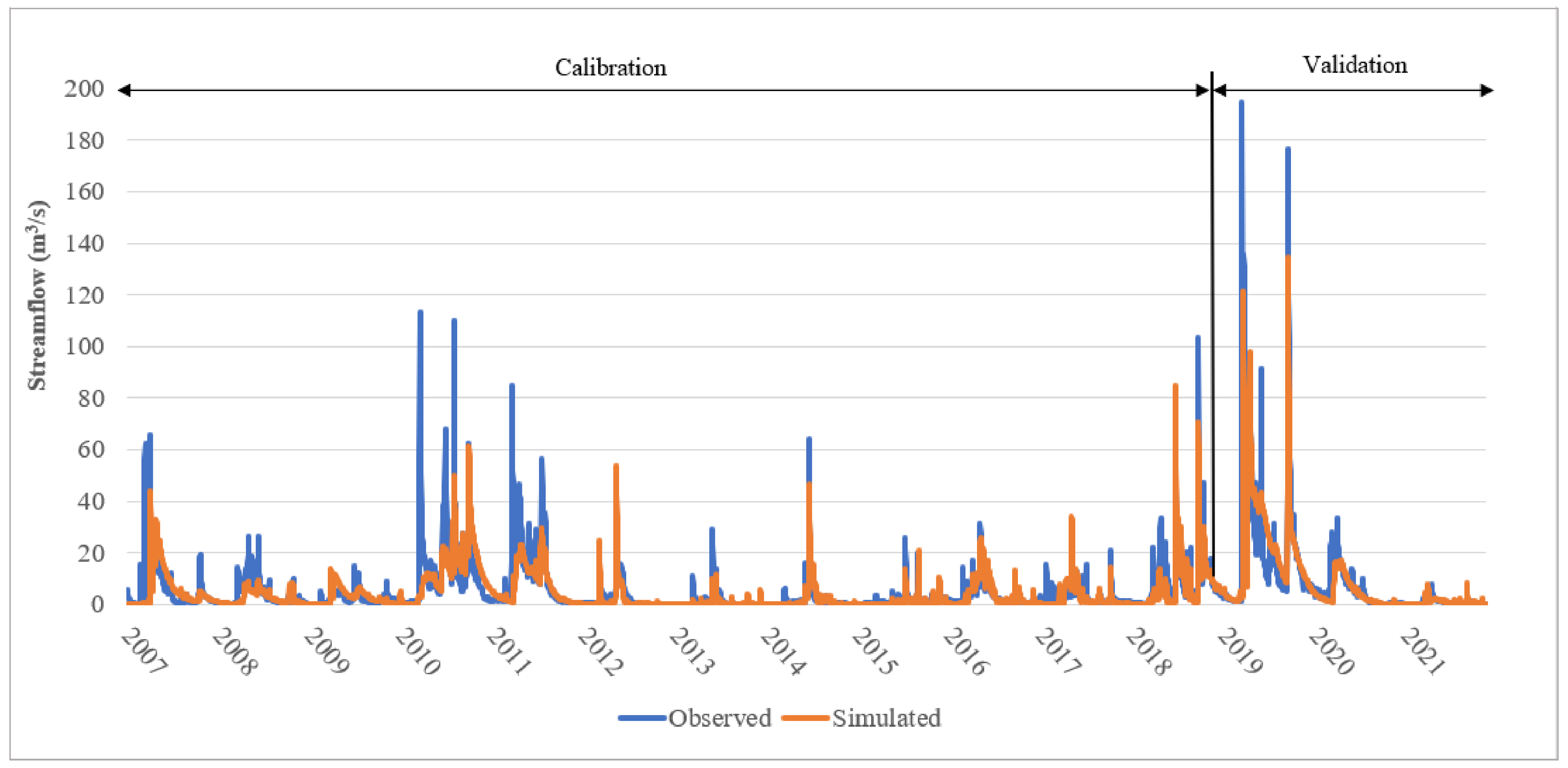

Figure 3: Daily Streamflow Calibration and Validation of Skunk Creek Watershed

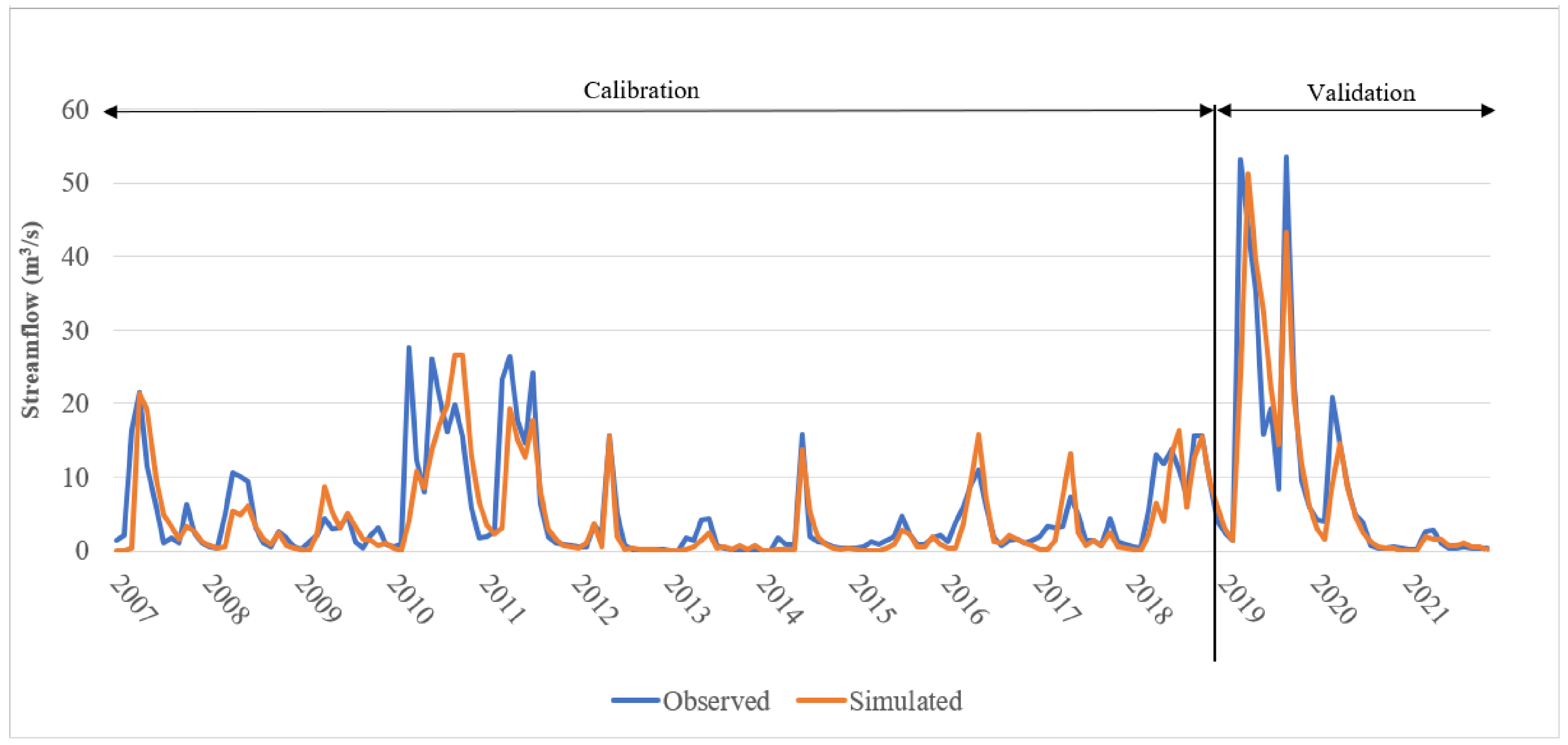

Figure 4: Monthly Streamflow Calibration and Validation of Skunk Creek Watershed

Results

Table 1: Statistics for Daily, Monthly, and Yearly Model Calibration

	Calibration (2007-2018)		
	NSE	PBIAS	RSR
Daily	0.510	14.2	0.700
Monthly	0.604	14.2	0.143
Annual	0.914	-27.6	0.155

Table 2: Statistics for Daily, Monthly, and Yearly Model Validation

	Validation (2019-2021)		
	NSE	PBIAS	RSR
Daily	0.660	5.70	0.580
Monthly	0.797	5.57	0.057
Annual	0.992	5.72	0.086

- Satisfactory statistics for streamflow calibration at a monthly time step are as follows:
  - NSE: 0.50 < NSE < 0.65
  - PBIAS: +/-15 < PBIAS < +/-25
  - RSR: 0.60 < RSR < 0.70 (Moriasi et al., 2007).
- Calibration of the SWAT model achieved satisfactory monthly statistics with NSE=0.604, PBIAS=14.2, and RSR=0.143.
- Validation of the SWAT model obtained even better monthly statistics with NSE=0.797, PBIAS=5.57, and RSR=0.057.

Conclusions

- Both calibration and validation statistics indicate that this SWAT model can be used to evaluate different subsurface drainage, management, or climatic scenarios.

Future Work

- Model and simulate subsurface tile drainage systems in select agricultural lands of Skunk Creek Watershed.
- Analyze the downstream model output to determine whether subsurface drainage systems influence downstream flooding.

Further Information

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