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# Impact of tile drainage on water budget and spatial distribution of sediment generating areas in an agricultural watershed

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ABSTRACT

A recently developed model, SWATDRAIN, was used to assess the alterations in water balance components, discharge, and sediment loads due to tile drainage practices in a heavily tile drained watershed in Ontario, Canada. Furthermore, the model was implemented to determine the spatial variability of sediment loads which can be explained by a combination of spatially distributed variables within a watershed, including those controlling the hydrology, geology, soil and land use. Three scenarios were examined across the watershed, including conventional drainage (existing condition), controlled drainage, and no tile drainage. The model predicted that streamflow was not significantly impacted due to tile drainage, while the total runoff and sediment loads from the basin due to controlled drainage were increased by 27.1% and 22.2%, respectively, while removing tile drain infrastructures resulted in 37.1% increase in surface runoff and 55% increase in sediment load from the watershed The areas with high sediment load generation were identified by the model and the impact of tile drainage in producing sediment in those areas was assessed. The results showed that the sediment load generation rate in the areas with the highest load (class V) increased by 8% only due to controlled drainage, while in the second ranked sediment generating areas (class IV), the sediment load generation rate was increased by 32%.



## 1. Introduction

The watersheds of Southern Ontario which provide food, feed, and fiber for millions of people and livestock are facing increasing pressure as a result of water pollution from agricultural activities. The alteration of settlements and development along the Grand River basin in Ontario has led to deterioration in water quality (Boyd et al., 2009). The Canagagigue Creek watershed, located in the Grand River Basin of south western Ontario, is one of the fastest developing areas in Ontario; this region has some of the most intensive agricultural production in the watershed. In the Canagagigue watershed, the vast majority of land (80%) is used for agricultural purposes and a high percentage of the agricultural lands (27–49% in the upper or more northern region and 0.2–6% in lower region) is enhanced with subsurface drainage infrastructure (Cooke, 2006). Subsurface drainage has the potential to reduce pollutants associated with surface runoff and sediment (Bengston and Xu, 1995). On the other hand, tile drains are the main pathways to increase the export of contaminants from fields to surface water bodies; this can result in substantial agricultural contaminants by translocation of sediments, nutrients and pesticides from the field to streams and lakes in those landscapes with intensive tile drainage, especially during the non-growing season and after heavy summer rains (Tan et al., 1993; Tan et al., 2007; Drury et al., 2007). Subsurface drainage systems have been identified as a major source of nutrients and other pollutants such as ($NO_3$-N), herbicides, insecticides and fungicides exported to water bodies (Moriasi et al., 2012; Thomas et al., 1992; Zucker and Brown, 1998). Over the past few decades, controlled drainage practices have been applied at both the field and the watershed scale to conserve water, regulate tile drainage flow, improve water quality, and increase crop yield (Tan et al., 2007; Drury et al., 2014; Busscher et al., 1992; Evans et al., 1992; Evans et al., 1995; Lalonde et al., 1996; Breve et al., 1998; Fausey. 2004; Singh et al., 2007; Ale et al., 2009). In order to quantify the effect of subsurface drainage on flow, pollutant losses and sediment transport, observed data must be collected and ana-

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lyzed. Historically, the monitoring data were collected manually and conclusions were mostly empirically based. This process was very intensive, both in terms of time and human resources. Over the past few decades, great strides have been made in technology and in modeling techniques that help users to make relatively accurate predictions of ungagged watersheds which previously would have been impractical (Frana, 2012). Nowadays, with proper calibration, the hydrologic models can be implemented to widely varying landscapes with very useful results (Frana, 2012).

The main objective of this study is to assess the impacts of tile drainage on discharge, sediment load and water budget of the Canagagigue West watershed and also to identify the potential sediment source areas under tile drainage practices; therefore, the current research has the objectives of i) predicting and analyzing the water balance components of the watershed; ii) quantifying the total sediment yield of the watershed and determining the spatial variability of sediment loads across the watershed; iii) comparing the water budget and sediment yield and assessing the susceptibility of agricultural lands under different scenarios of tile drainage. The recently developed model, SWATDRAIN (Golmohammadi et al., 2016), which is capable of simulating different water management scenarios, such as controlled drainage was selected. The SWATDRAIN model was calibrated and validated for an agricultural watershed, called Green Belt in Ontario, Canada (Golmohammadi et al., 2016) and the results showed that by using the SWATDRAIN model, the flow and water table dynamics were significantly improved compared to SWAT model. This research makes an important contribution to watershed sedimentation control practices and to planning the Best Management practices (BMPs).

## 2. Materials and methods

### 2.1. Watershed description

The Canagagigue Creek has a total drainage area of 143 $km^2$ and is a tributary of the Grand River. It lies between latitudes 43°36′ N and 43°42′ N and longitudes 80°33′ W and 80°38′ W, and is about 25 kilometers northwest of the city of Guelph, Ontario. The climate of the area, according to the Koppen-Geiger climatic classification system, can be characterized as humid continental with warm summers and moderate winters. Based on the availability of observed flow and sediment data and also the presence of tile drainage in agricultural regions mostly located in the western portion of the Canagagigue Watershed, this study targeted the upstream portion of the Canagagigue Creek west. The major land use is agriculture including winter wheat, corn, soybean, and other row crops. Table 2 provides the landuse distribution on that watershed. The observed flow data were obtained from the available hydrometric station called "Canagagigue Creek near Floradale" by the Atmospheric Environment Services of Environment Canada. Sediment loads measurements at this station for period 1974–1984 are provided as archived data at the web site of Environment Canada (www.wsc.ec.gc.ca). It has available historical observation data for the daily flow rate and sediment load for the period 1975–1984.

The topography of the watershed is flat to gently undulating with a slight slope towards the outlet in the south. The average elevation is 417 m. Fig. 1 shows the location of the Canagagigue Creek and the sub-watershed used in this study.

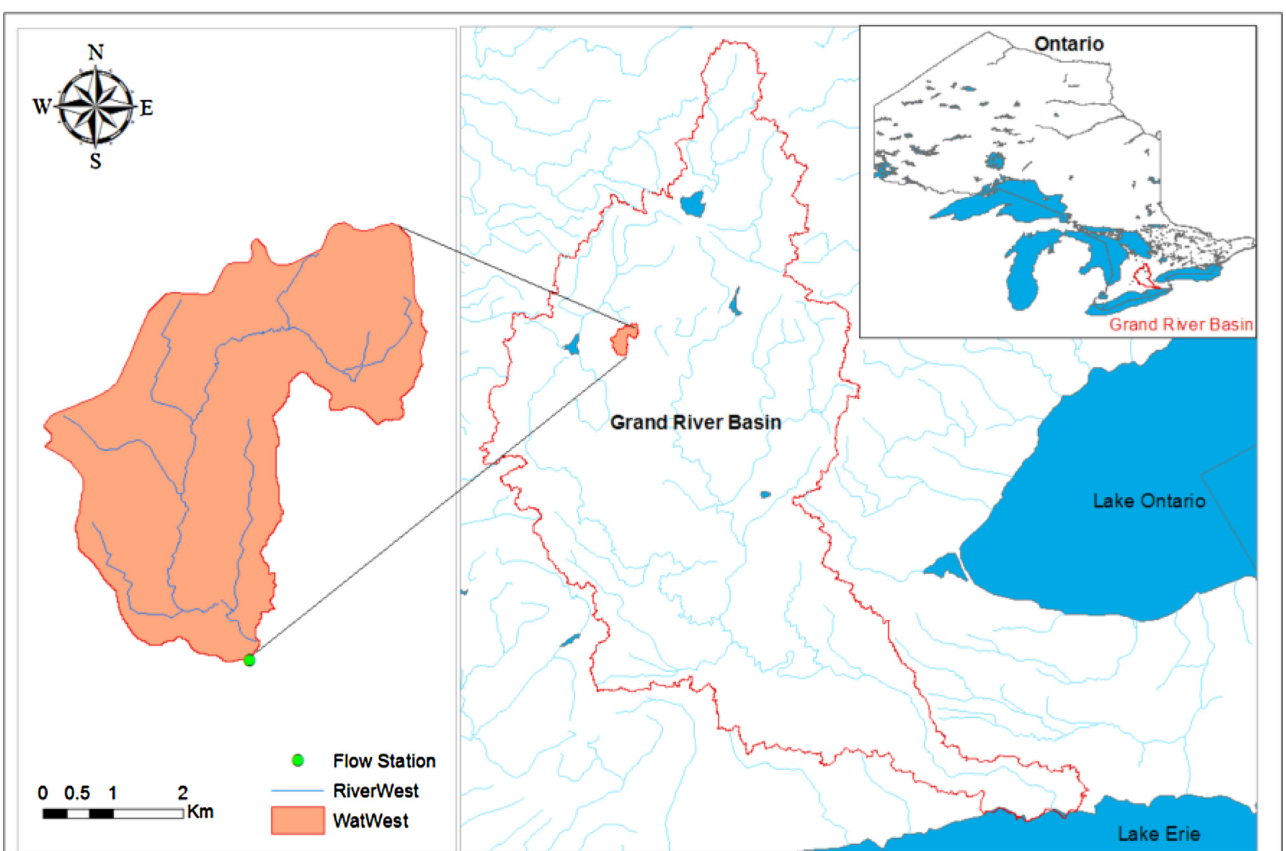


**Fig. 1.** Location of the study area, Canagagigue West watershed, in Grand River Basin.