The Use of GIS for the Delineation of the Little Mac Ravine Watershed

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1. Sediment Sources

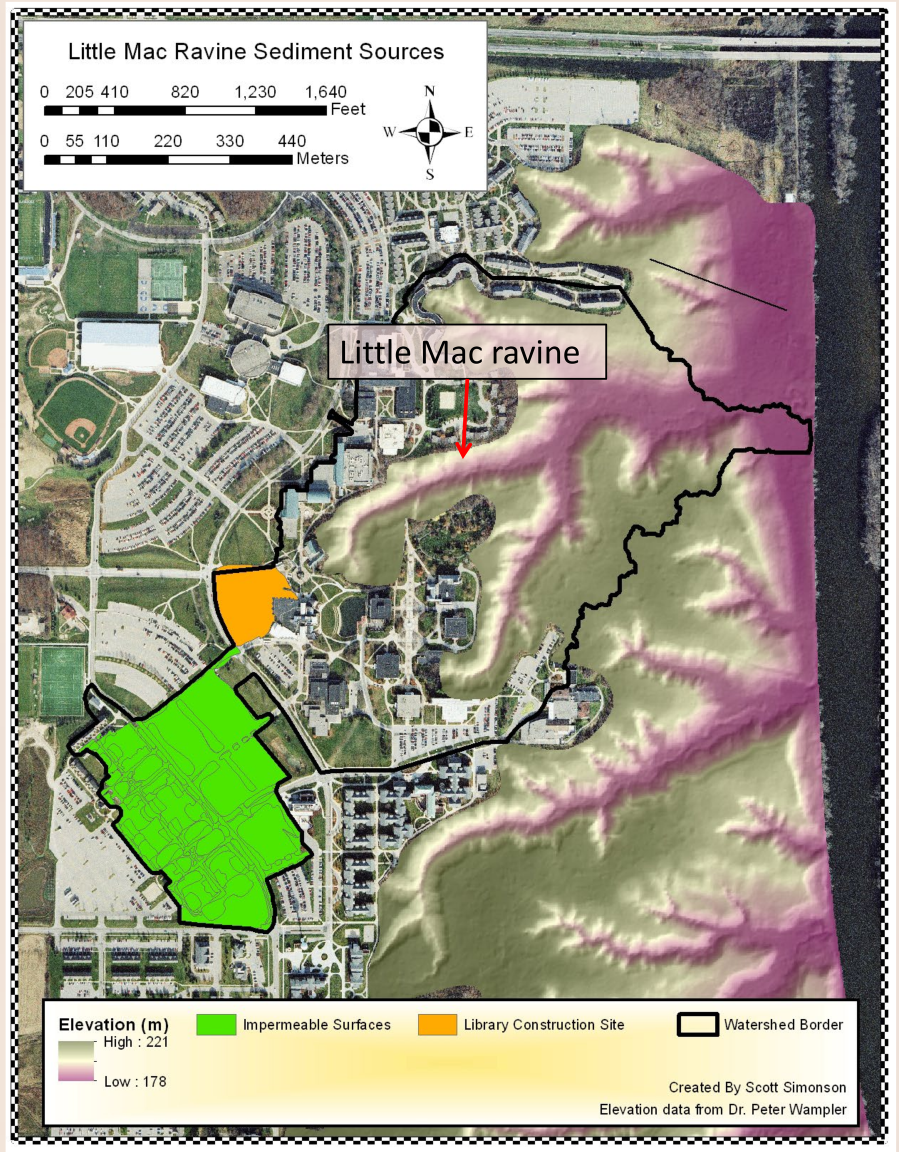

Figure 2: Possible sediment sources . Creation of digital elevation model (DEM) employed LIDAR data and 3D Analyst Tools.

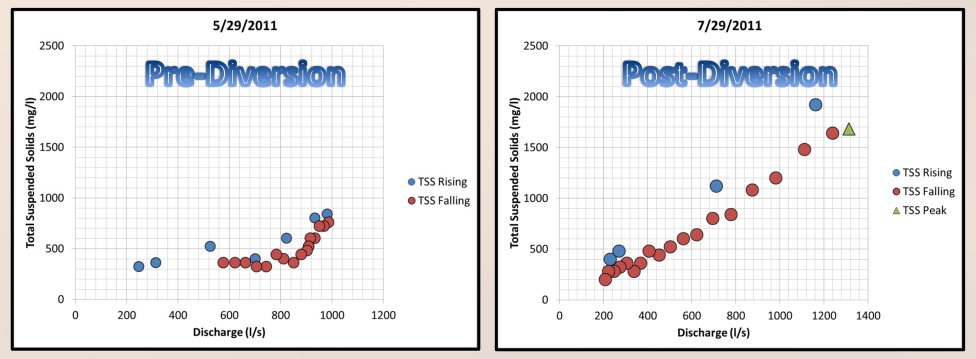

Figure 3: Total suspended solids (TSS) vs. discharge curves (hysteresis) . Clockwise rotation suggests that sediment source for each was from within stream channel (Williams, 1989).

Date	Rainfall (in)	Mean TSS (mg/l)	Total Sediment (metric tons)
May 29th, 2011	0.44	505	3.5
July 29th, 2011	0.41	757	4.3
Change	-6.82%	49.90%	22.86%

Table 1: TSS concentration post-diversion suggests low sediment concentration in runoff from diverted impermeable surfaces. Total sediment load post-diversion suggests more sediment coming from slopes or construction site runoff.

Acknowledgement

This project would not have been probable without the guidance of Dr. Peter Wampler.

References

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Abstract

Grand Valley State University was founded in 1960 and since then over 120 acres of impermeable surfaces, whose runoff was channeled into the ravines, have been constructed. This resulted in erosion, slope instability, and sediment discharge into the Grand River. As part of the June, 2011 library construction project, stormwater runoff from impermeable surfaces was redirected from the Little Mac Ravine to a new wetland west of campus.

In order to observe how runoff diversion alters certain water quality parameters, water samples were collected from the Little Mac ravine throughout the summer of 2011. Different surfaces in the Little Mac ravine watershed affect runoff and stream discharge in distinctive ways, these will be mapped using a Geographic Information System (GIS), Aerial photos, and LIDAR topographic data. The rational runoff equation, combined with watershed surface delineation, allowed for a semi-quantitative analysis of peak discharge changes resulting from 2011 storm water diversion. Modeled results show a decrease of impermeable surfaces, and with that a decrease in peak discharge during storm events.

Introduction and Research Questions

Development of land in a watershed means the addition of impermeable surfaces, the clearing of vegetation and the packing of soil (Booth, 1991). A consequence is significant erosion on unpaved slopes and increased stormwater runoff (Sciera et al., 2008; Jacobson, 2011). Constructed wetlands have been identified as a worthwhile practice for reducing suspended sediment loads increased by urbanization (Shammaa and Zhu, 2001). Since 1960, more than 120 acres of impermeable surfaces have been added to Grand Valley State University's (GVSU) campus (Womble and Wampler, 2006; Wampler, 2009). GVSU facilities, in 2011, approved a project that diverted stormwater runoff from approximately 33 acres of impermeable surfaces to constructed wetlands built that year. This study examines the changes to the Little Mac ravine watershed as a result of the diversion (Fig 1).

A GIS was used to model peak discharge for pre- and post-stormwater diversion. ArcMap 10 was used for map creation, spatial calculations, and peak discharge calculations using the Rational Runoff Equation (RRE). Polygons outlining different land use types were mapped within the watershed and attributed with runoff coefficients for the RRE calculation.

1. Sediment Sources

   Is sediment supply originating from the stream channel margins, impermeable surfaces, construction site runoff, or a combination of all three? (Figs. 2&3; Table 1)

2. Watershed Area

   How much area of the watershed was removed due to stormwater diversion? (Fig. 4)

3. Relative Land Use

   How will stormwater diversion effect the relative relationship between impermeable and permeable surfaces within the Little Mac ravine watershed? (Fig. 5)

4. Peak Discharge

   Will stormwater diversion significantly alter peak discharge values during storm events? (Table 2)

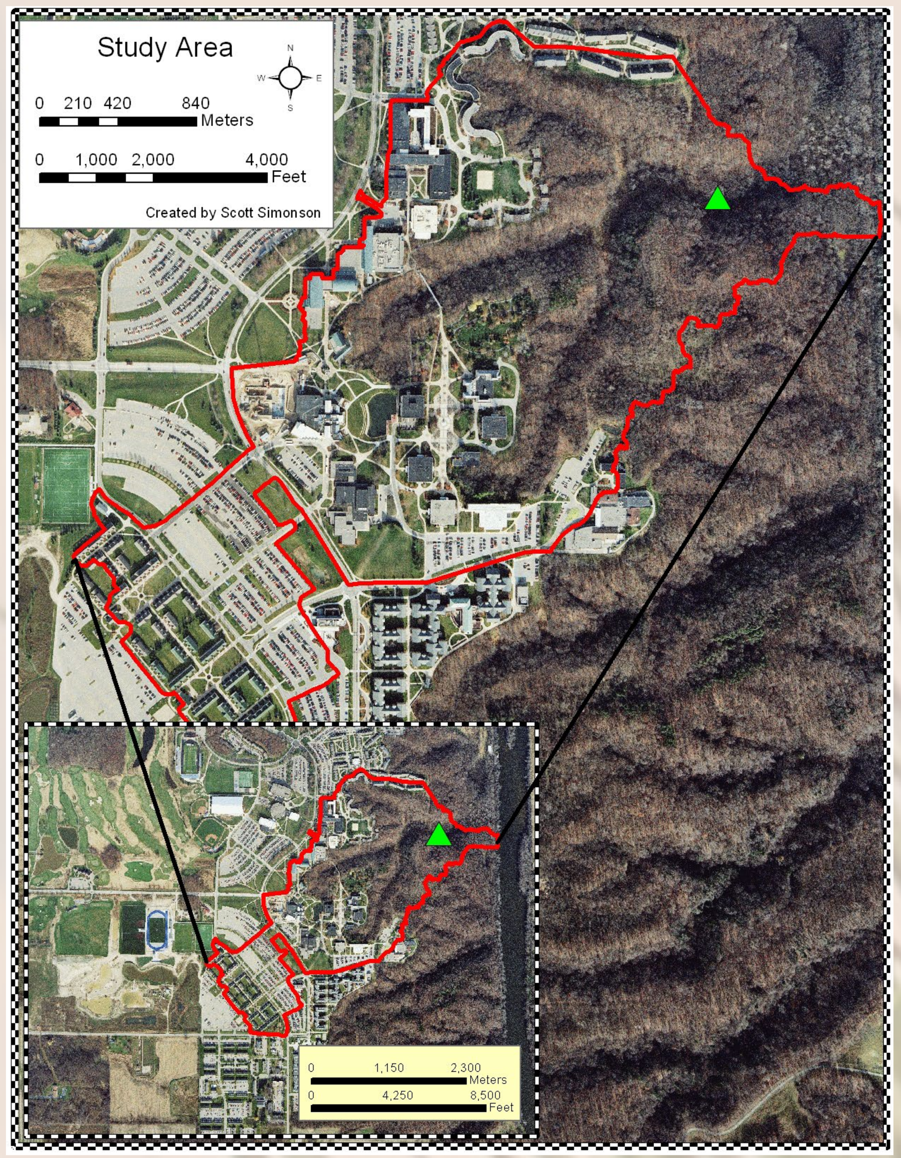

Figure 1: Map of study area at GVSU. Green triangle marks sampling location.

2. Watershed Area

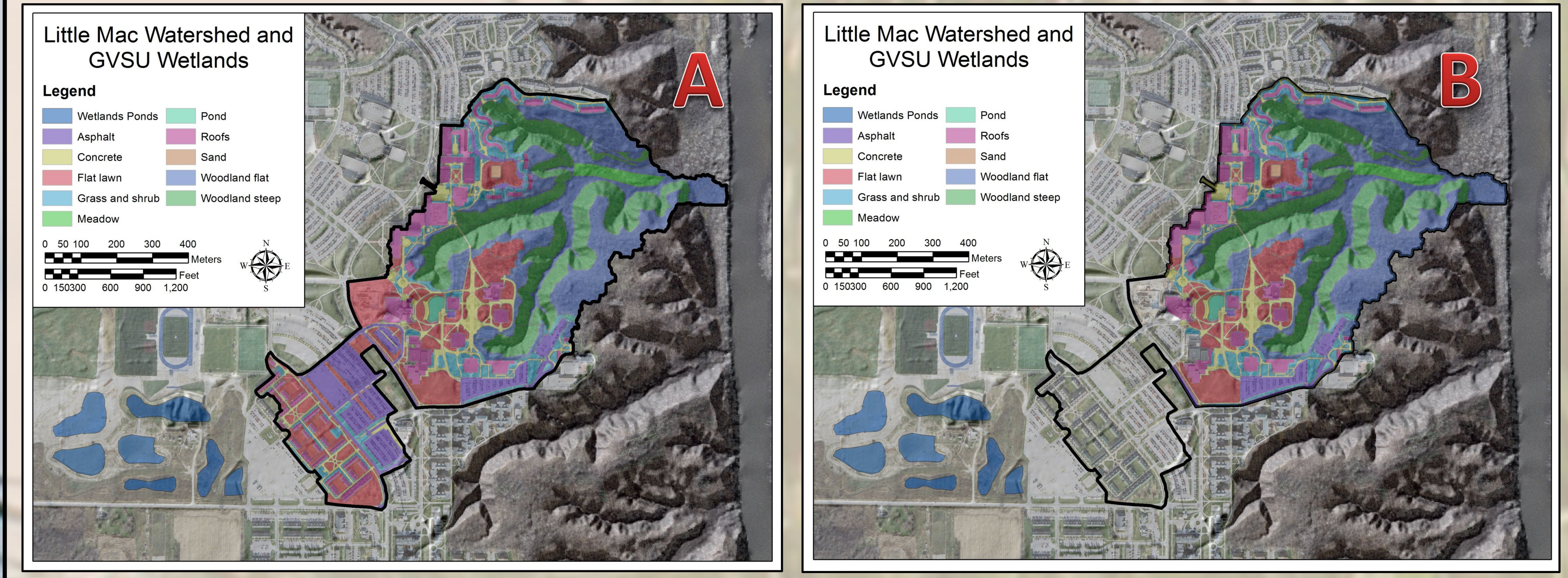

Figure 4: A) Little Mac ravine watershed pre-diversion. 147.8 acres. B) Little Mac ravine watershed post-diversion. 119.5 acres. Emptied section inside border now diverted to wetlands. Land use categories majorly based off of Dunne and Leopold (1978) classification. Each polygon has area data tied to it.

3. Relative Land Use

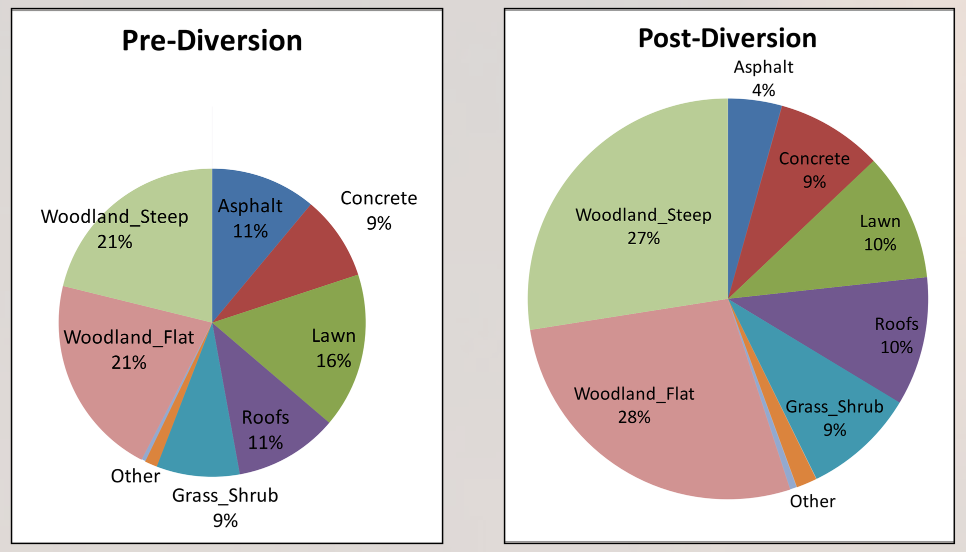

Figure 5: Pie charts created using area data taken directly from Fig. 4 maps. Impermeable surfaces (concrete, asphalt and roofs) decreased by 8% of the total watershed area. Permeable surfaces (woodlands, lawns, etc.) increased by 7% of the total watershed area.

4. Peak Discharge

$$Q_p = CIA$$

C = Rational Runoff Coefficient
I = Rainfall Intensity (inches)
A = Area (m^2)

• Rational runoff equation used to model peak discharge (Q_p) during a storm event.
•C-values tied to polygons in Fig. 4.
•Rainfall intensity from Midwest U.S. Climate Survey (Huff and Angel, 1992).
•Area values tied to polygons in Fig. 4.

	2-year 1 hr	100-year 1 hr
Intensity (in)	1.1	3.0
Pre Q_p m^3/s	2.625	14.32
Post Q_p m^3/s	1.938	10.57
% Difference	26.2	26.2

Table 2: Summary of peak discharge change between pre- and post-diversion. Peak discharge decreased by approximately 26%

Conclusions

•GIS proved to be an extremely valuable tool for modeling the Little Mac ravine watershed.
•Impermeable surfaces likely not source of sediment.
•Percentage of watershed area with permeable surfaces increased post-diversion.
•Peak discharge from the Little Mac watershed decreased by 26 %