THE GEOMORPHOLOGY AND GEOCHEMISTRY OF VALLEY GROVE CREEK, RICE COUNTY, MINNESOTA

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INTRODUCTION

Valley Grove Creek, located in southeastern Minnesota, is a tributary of Prairie Creek. The water from Prairie Creek eventually reaches the Mississippi River and flows into the Gulf of Mexico. The Mississippi and its major tributaries have been heavily studied, but less attention has been paid to smaller tributaries. Valley Grove Creek, draining approximately 2.58 km^2, flows east through a variety of different land uses, including agriculture, forested state park, and a newly restored stretch of native prairie. Nerstrand Big Woods State Park and a Scientific Natural Area on the south border the studied reach of Valley Grove Creek. Newly restored prairie, previously used for agriculture borders it on the north. Valley Grove Creek cuts two Ordovician units, the Decorah and Platteville Formations, as well as pre-Wisconsin till and loess. A knickpoint is formed where the creek cuts the Platteville Formation. Gullying is widespread in the area.

The purpose of this paper is to characterize the geomorphology and geochemistry of Valley Grove Creek, with a special focus on the gullying. Data were collected to compare a gully from the forested (south) slope and two gullies from the prairie (north) slope, one of which is fed by a drainage tile. Water quality data were collected from the gullies as well as several points in Valley Grove Creek. The study will also show that the drainage tile should be plugged or removed because it promotes excessive erosion and contributes excess nitrate to the stream water.

METHODOLOGY

Slope Profiles

Three slope profiles were taken at different locations across Valley Grove Creek using a pantometer. The three profiles were evenly spaced to better characterize the study area. The easternmost and westernmost slope profiles indicate the boundary of our area of study.

Cross-Sections

A total of ten cross-sections were taken at various points of the study area (see **Appendix**). Three stream cross-sections were measured across the main channel near the location of the three slope profiles, while seven cross-sections were measured in the three gullies studied. The gully cross-sections were measured every 10 m along the length of the gully.

Stream and Gully Gradient

Longitudinal profiles of the gullies were measured to determine differences in gully shape. Also, stream gradient was measured between the three slope profiles.

Water Quality

Five sample sites were chosen (see **Appendix**): Sites **1**, **2**, and **5** in Valley Grove Creek and Site **4** at a forested gully, and Site **3** at a tile-fed gully. Water quality indicators measured included temperature, pH, salinity/TDS, conductivity, phosphate, nitrate, and sulfate. Turbidity was measured at the head and mouth of the tile-fed gully.

RESULTS AND DISCUSSION

Geomorphology

Slope Morphology

The slopes in the study area differed in length and steepness. At the location of profile **1**, the crest of the hill on the north slope is approximately twice as high in vertical elevation and twice as long in horizontal distance as the south slope (see **Figure 1**).

On the northernmost slope profile, concave and convex regions indicate mass wasting: concave areas indicate slump and convex areas indicate placement of slumped sediment as well as creep. The boundary between the newly restored prairie and forest is 99 m from the crest of the hill. A break in slope is 10 m from the boundary. Further down river, the Platteville Limestone forms a cliff, creating a 47° slope. On this steep portion of the north slope, there is minimal understory vegetation. Since vegetation holds soil and slows runoff, the lack of low groundcover probably sends more surface water and sediment into Valley Grove Creek (Connecticut River Joint Commissions, 1996). Across the creek, on the southern forested slope, there is a much denser understory and this portion of the south slope is characterized by slump, as opposed to the north slope, which is characterized by gully erosion, slump, and creep.

Profile **2** is upstream of the Platteville knickpoint, a 1.5 m tall waterfall. Above this, the north and south slopes are similar in gradient and total length from crest to crest. The North Slope has a steeper gradient near the stream.

Further upstream, the channel narrows. At the location of Slope Profile **3**, the north and south slopes are gradual and similar (see **Figure 1**). The shape of the slope near the creek is “V” like. Forest and understory is thick on the north and south slopes.

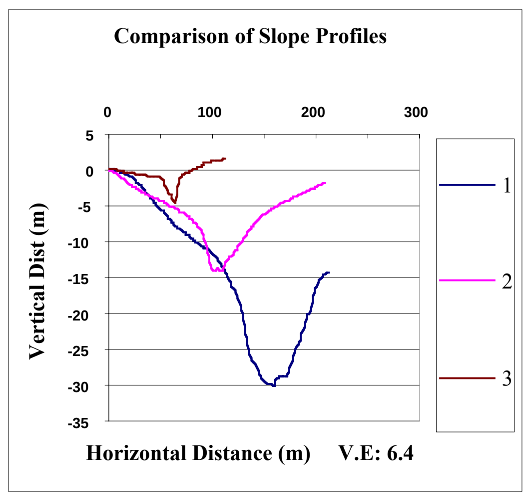


Figure 1 A comparison of the three cross-sections.

From upstream to downstream the valley widens and erosion increases. The erosion is especially dramatic downstream of the knickpoint in the Platteville Limestone. As the waterfall has migrated upstream, it has left a deeper and wider valley in its wake, leading to steeper, longer, and more erodable slopes. At no point in the valley bottom is there significant storage of fine-grained materials, indicating that silts and clays are being washed out of the Valley Grove Creek area and into Prairie Creek.

Gully Morphology

While there were many gullies present, including more tiled gullies, the three gullies studied are represenitive. The gullies are all approximately the same length (tile-fed gully = 42 m long, non tile-fed gully = 42.8 m long, forested gully = 31.3 m long) but each exhibits unique characteristics.

The tile-fed gully is continuously fed by a drainage tile at its head, even during drier months, while the non tile-fed gully is dry, except during periods of heavy surface runoff. The tile-fed gully erodes a convex slope both in plan view and in profile view. This is an unnatural topographic location for a gully. The non tile-fed gully erodes a concave slope, both in plan view and in profile view, which is a natural location for a gully channel (see **Figure 3;** in this figure the gully labels are reversed) (Bettis, 1983).

The channel at the head of the tile-fed gully is wider than that of the non tile-fed gully. At each 10 m interval down slope, the tile-fed gully has a larger cross sectional area (see **Figure 2**), as well as a higher frequency of Platteville Limestone cobbles. At the head of both of these gullies, there are no leaves, no vegetation, and many exposed roots. However, compared to the non tile-fed gully, there is less vegetation and more exposed roots in the tile-fed gully for a longer distance down slope.

At the head of the tile-fed gully, transparency was above the equipment detection limit (1.2 meters). Water clarity at the base was to 0.86 m in a transparency tube. This suggests that there is active erosion in the gully, even during drier months, which does not occur in the non tile-fed gully.

The forested gully on the south slope has a dry channel. This gully is considerably shallower than its north slope, prairie counterparts. At 10 m down slope, its channel width is 2.2 m with a maximum channel depth of 0.2 m. This gully is more heavily vegetated than the gullies on the prairie slope. Also, as this gully reaches the base of the slope, it completely loses its definition, so channel depth and width are negligible.

Gullying is a natural process that is well understood (Bettis, 1983). Due to increased steepness, longer slope length, and less understory vegetation, gullying is more prolific on the prairie side of the slope than the forested in the Valley Grove Creek area. However, the tile-fed gully appears to be experiencing excessive and constant erosion. We recommend that this tile be plugged or removed, to prevent further erosion.

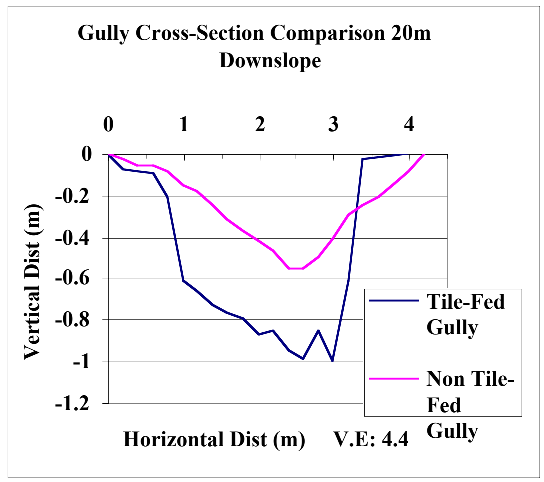


Figure 2 Comparison of tiled gully and non-tiled gully cross-sections at 20m down slope.

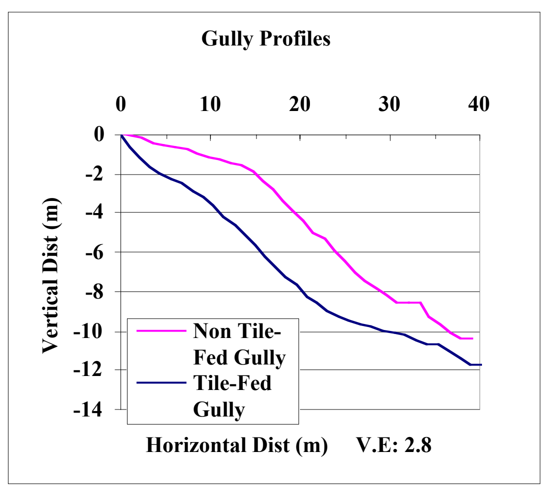


Figure 3 Gully profile comparison.

Geochemistry

Nitrate

The average NO_3-N concentration was highest at the tile-fed gully (see **Figure 5**). NO_3-N levels at the tile-fed gully were continuously high, peaking on July 24, a day after a rain event. The tile is draining newly restored prairie.

Nitrate is used often in agricultural fertilizers, and is highly soluble in water (Chapman, 1996). Average NO_3-N levels for natural waters are below 1 mg/l. Levels above 5.0 mg/l usually suggest anthropogenic inputs (Chapman, 1996). Because the NO_3-N levels in the tile-fed gully are higher than those in the forested gully and in the stream, we believe that the tile is a major source of nitrate in the study area.

Sulfate and Phosphate

According to Chapman (1996), normal levels for sulfate, (SO_4^{2-}), in natural waters are between 2.0 and 80.0 mg/l. The tile-fed gully and the stream both have average concentrations well within this range (see **Figure 5**). The high values at the forested gully may result from groundwater in contact with sulfur bearing minerals (such as pyrite and chalcopyrite) in the sedimentary rock underlying the gully (Chapman, 1996).

Phosphorus in streams comes from rocks, fertilizers, organic decay, and detergents (Chapman, 1996). An average range for PO_4-P (orthophosphate) in natural waters is 5.0 μg/l PO_4-P to 20.0 μg/l PO_4-P, although some especially saline systems can have concentrations as high as 200 mg/l PO_4-P (Chapman, 1996). The water along our stream section has values higher than this range, but well below 200 mg/l. Since the values from the tile-fed gully actually have the lowest concentration of PO_4-P, agricultural sources, such as fertilizers, are not a significant source of phosphorus in this area. Perhaps the steep slopes of the stream valley promote large amounts of erosion from the slopes into the stream, with the sediment carrying phosphorus released by organic decay on the slopes.

pH, Conductivity, and Dissolved Oxygen

Conductivity, pH, and dissolved oxygen levels for all sites are within or close to state goals for class 2C (recreational) waters (see **Figure 4**)

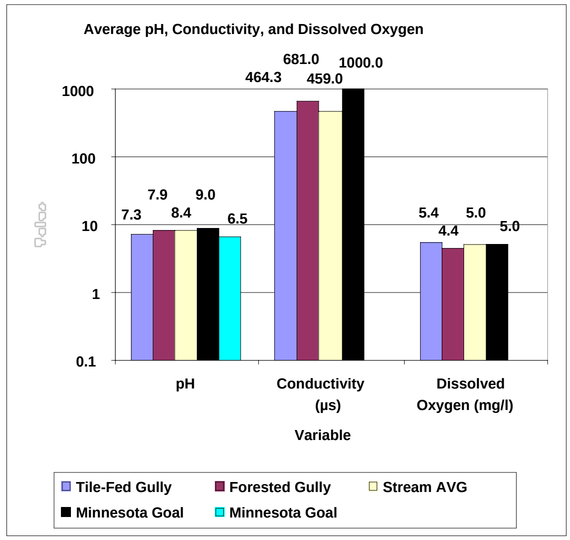


Figure 4 Average pH, conductivity, and dissolved oxygen levels for the tiled gully, forested gully, and stream.

(MPCA, 2001).

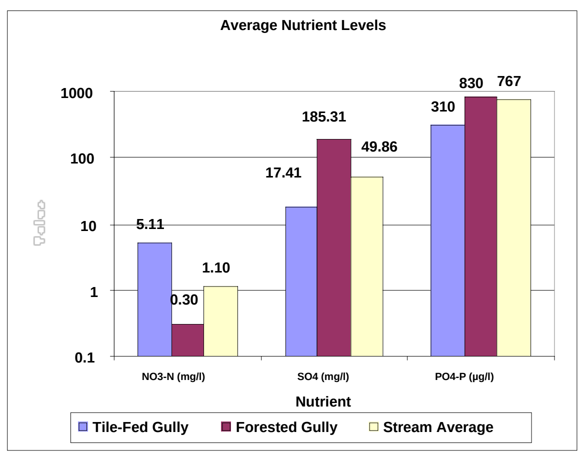


Figure 5 Average nutrient levels for the tiled gully, the forested gully, and Valley Grove Creek.

CONCLUSIONS

Valley Grove Creek is a unique area in southeastern Minnesota because it runs through the combination of land use types including agriculture, state park, and a newly restored stretch of native prairie grass. Erosion is greatest on the northern slope, east of the knickpoint in the Platteville Limestone due to longer, steeper, and less vegetated slopes. Gullying is most prolific in this area as well, especially in a gully fed by a tile drain. The water quality of Valley Grove Creek meets or exceeds state recommendations and requirements, though water coming from the tile drain has high levels of nitrate. Also, since the area being drained by the tile is no longer agricultural, the tile is of no economic value. In summary, we recommend that this tile be removed or plugged to prevent future erosion and nitrate input.

SUGGESTIONS FOR FUTURE STUDY

Suggestions for future study include: (1) Study of the retreat rates of the heads of the gullies; (2) Long-term monitoring of the tile drain as the prairie becomes more well established; (3) Study of the retreat rate of the knickpoint in the Platteville Limestone; (4) Study of nitrate levels in soil to determine their role in measured concentrations; (5) Investigation of the relationship of leaf litter loss to the incursion of the European Earth Worm.

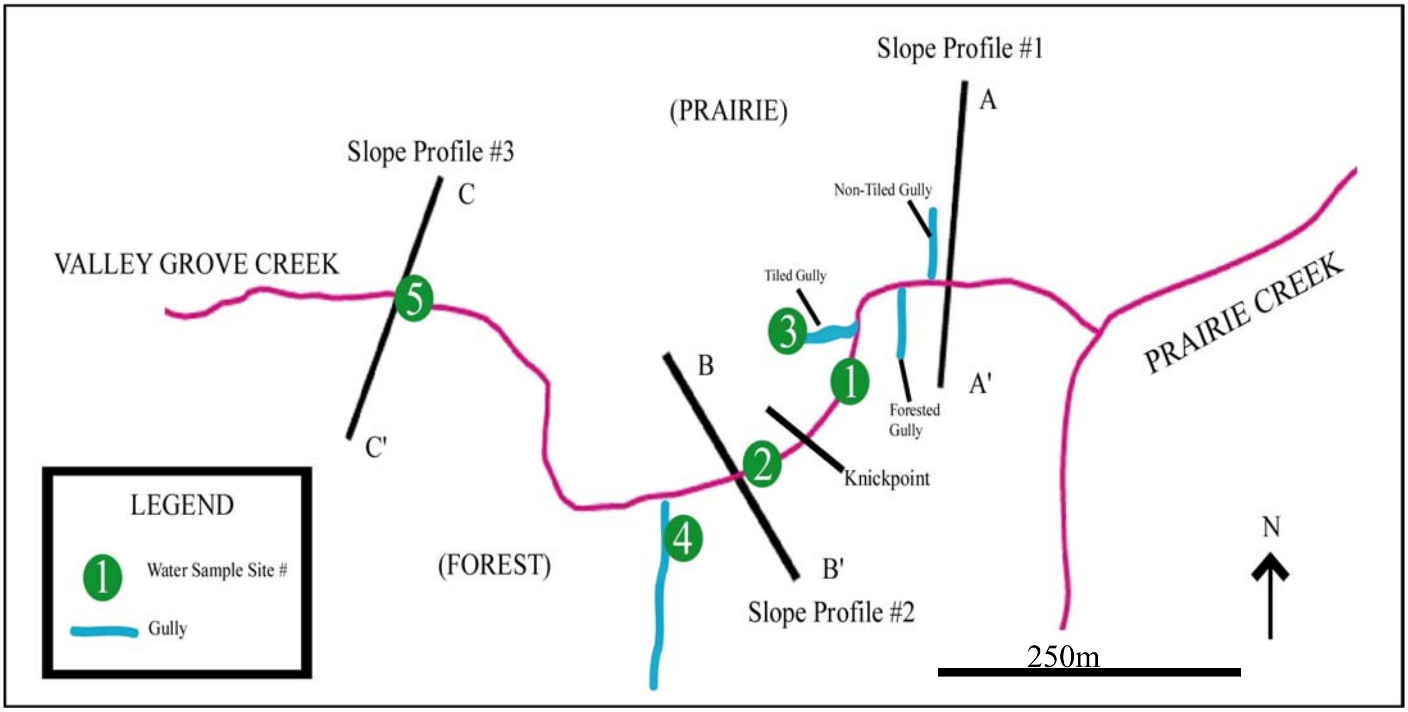
WORKS CITED

Connecticut River Joint Commissions, 1996. *Living with the River*. www.crjc.org/buffers/Field%20Assessment.pdf (viewed Aug 2, 2001)

Bettis, Arthur, 1983. *Gully Erosion*. http://www.igsb.uiowa.edu/browse/gullyero/gullyero.htm (viewed Aug 2, 2001)

Chapman, Deborah, 1992, *Water Quality Assessments*. Cambridge: Cambridge University Press. p. 77-100.

Minnesota Pollution Control Agency, 2001. Chapter 7050/220. http://www.revisor.leg.state.mn.us/arule/7050/0220.html (viewed Aug 4,2001).



Appendix: Site Map