

8. Small Landslides

The hummocky topography in the interior of Hennepin County and the banks of the Crow River present steep, short slopes where numerous, small, “nuisance” slides have occurred. These landslides occur in various parent materials and attempts to correlate them with soil types were unsuccessful. It appears that the location and depth of failure depend on a density increase at depth where porewater pressure can build up. Loose sediment and vaguely layered sediment that lie above a denser sediment are more prone to move, especially when saturated. Site investigations of an appropriate scale on steep slopes like those identified on the maps that accompany this report (start on p. 74) can help localize the search for discontinuities on site that may lead to failure. Landslides along the valley of the Crow River are exacerbated by changes in hydrology including river widening and meander migration that destabilize the base of slopes and oversteepen them.

Geologic Background

Loamy to clay loamy glacial sediment that forms the hummocky, stagnant ice terrain in most of the county was formed as saturated glacial sediment moved on top of melting, stagnant ice of the Grantsburg sublobe. The composition and texture of this supraglacial material varies with the degree of sorting that it underwent as it moved on top of the wasting ice and with the amount of incorporation of the underlying Superior lobe sediment. The hummocky glacial sediments have at least 45% fines (silt plus clay). In contrast, sediment along the banks of the Crow River is generally sandy, having originated as meltwater stream deposits and reworked by the modern stream.

Methods

Field work was conducted with the assistance of Dr. John Beck, former Natural Resources Conservation Service (NRCS) State Soil Scientist, to expose and identify the upper soil horizon of various parent materials to look for evidence of textural variability, density contrast or water retention. Dr. Beck has experience with shallow water flow in soils and has mapped and correlated soils and their parent materials across Minnesota and nearby Des Moines lobe deposits of a similar origin.

The Soil Survey of Hennepin County (*Steffen, 2003*) shows that all of the soil parent material in the county was glacially derived. However, soil texture and color vary. Four sites were chosen that had experienced failure but were mapped as having three different glacial parent materials.

Table 8.1 — Sites Chosen for Soil Study

Site	latitude	longitude
Bush Lake	44.833371	-93.381276
Interlachen Golf Course	44.912868	-93.380471
Theodore Wirth Park	44.995018	-93.322657
York Park	44.904094	-93.321402

Results

The main commonality in these sites in the interior of the county was a sharp increase in density at shallow depth, typically within a meter or two of the surface. This was determined by ease of coring and by inspection with a shovel (Figure 8.1). A decrease in density of the surface layer could result from frost heave, bioturbation or human disturbance. It may also result from the original processes that deposited the glacial sediment with normally consolidated supraglacial sediment overlying over-consolidated subglacial sediment. In the case of the site in Theodore Wirth Park, some degree of compaction appeared to have resulted from trail use by people on foot and bicycle. More loosely consolidated sediment appeared to have been spread in attempts to improve the site through re-grading and planting (Figure 8.1).



Figure 8.1— Soil Investigation

Twin Cities Formation parent material with sand seams exposed in a shallow slide on Interlachen Golf Course. The dense glacial sediment was covered with loose sediment of similar texture and composition. A horizon where density increased was the base for the shallow slide according to Dr. John Beck, NRCS.

Along the Crow River where the slopes are formed in sandy parent material, the stability issue results from oversteepening of slopes composed of sediment with low cohesion. An increase in steepness will result in failure in sediment that is not cohesive. This happens naturally as a meander migrates into a stream's outer, downstream bank; and it happens somewhat unnaturally where rivers are widening because of alterations to hydrologic conditions upstream and where they are constrained by infrastructure (Figure 8.2).

Discussion

The NRCS-team effort to look for a robust statistical correlation between landslides and the kinds of parameters that are recorded during a soil survey was unsuccessful. As part of that work, Kristin Brennan, NRCS, did a frequency analysis of 87 landslide points that had 80 different soil map units. Dr. John Beck then grouped the map units into soil groups: loess soils; alluvial and colluvial soils; sandy outwash; till; and a till-outwash complex. The properties of most importance that could be gleaned from a soil survey are: hydrologic soil group, water transmissivity and the depth to the soil layer with the lowest transmissivity. Seventy-five percent of the soils were Hydrologic Class A or B. Class A is typically less than 10% clay and greater than 90% sand. Class B is typically 10-20% clay and 50-90% sand (Steffen, 2003).

Available water storage was another parameter of interest that is recorded in soil surveys. However, there was not much variability in this property among the soils affected by the mapped landslides. The average particle-size class also did not vary significantly. Bulk density and average saturated conductivity (KSat) and depth to a restrictive layer emerged in discussions as the most likely variable to have an effect.

Crow River Near Sportsman's Club



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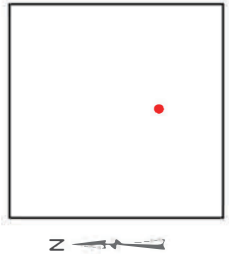
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Note: Elevation images and contours were generated from LIDAR derived elevation surfaces acquired 2007-2012.



Scale: 1:6,029



Created on 4/3/2020

Figure 8.2 — Crow River Near Sportsmen’s Club

One example of this is near the Crow River Sportsmen’s Club, west of County Road 22. The red bracket in the figure shows where the slope has been protected along the outer meander bend. However, river widening and infrastructure effects are creating similar failures on inner meander bends and near bridges.

Recommendations

The shallow failures of glacial sediment in the interior of the county are likely to result from saturated soils. Their impact comes where they occur in inconvenient or dangerous places, for example when failures block or undermine roads or affect structures at the top or base of a slope.

Glacial sediment descriptions in the Surficial Geology map of the Geological Atlas of Hennepin County (*Berthold, 2018*) are based on the dominant particle size and are used to make stratigraphic correlations. These texture-based descriptions do not necessarily best describe the engineering behavior of the sediment because fine-grained glacial sediment (15% to 35% fines) behaves differently depending on the confining stress (*Clarke, 2018*).

Glacial sediment common in the interior of Hennepin County that was deposited gravitationally as debris that melted out on top of stagnating ice is variable in texture and bedding both vertically and horizontally and can contain many small discontinuities (e.g., thin silt or clay layers, small sand bodies or gravel concentrations). Careful site design in variable glacial sediment like this requires a geotechnical investigation that exposes a large enough area to determine the scale and extent of any discontinuities present.

A site analysis of important soil parameters would involve determining the depth to a restrictive layer, if present. Approaches such as penetration tests or geophysical tools like electrical resistivity imaging (*Hazreek et al., 2018*) can be deployed to look for discontinuities in undisturbed or minimally disturbed material over a broader area.

A next step could be an assessment of the local hydrology of a site, that is, how quickly the sediment can become saturated and the rate at which it would drain. Once this is determined for a site, it would be helpful to know the conditions under which the material above the restrictive layer would fail using appropriate geotechnical tests (e.g., Atterberg limits, liquid limits, plasticity).

Glacial sediment that has been disturbed will not return to a consolidation state that matches subglacially deposited till. Normal grading and construction practices will therefore spread looser,

disturbed glacial sediment over undisturbed, dense sediment and will result in a density contrast.

In the absence of geotechnical investigations, setbacks from the top and bottom of steep slopes, water management that avoids saturating surficial sediment on or near slopes, and retaining the natural slope profile may help minimize the chances of reactivating slopes in hummocky glacial sediment and avoid the negative consequences when slopes fail naturally under a changing precipitation regime.