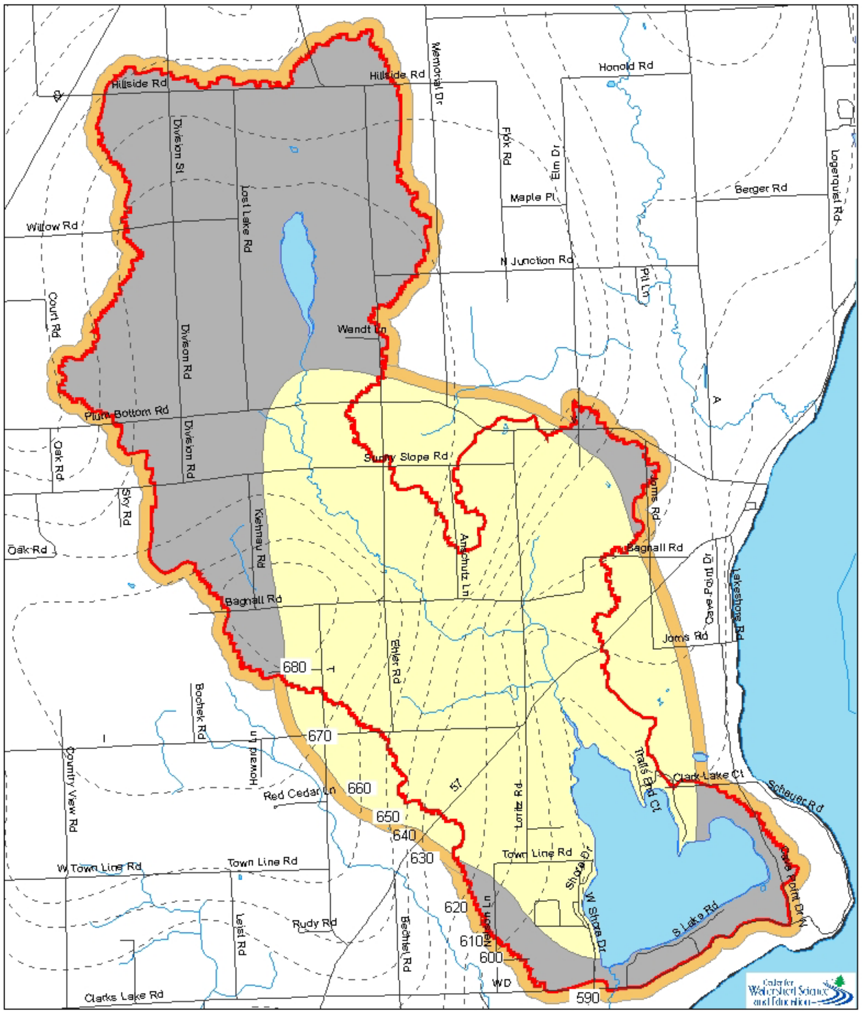
Delineation of Area Contributing to Clark Lake's Water - Door County, WI



November 2006
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Purpose

Clark Lake receives water from precipitation on the lake, runoff directly into the lake, groundwater discharging to the lake, and water flowing from Logan Creek. It is important to know the land area that contributes this water to evaluate the impact of future land management changes. In this report, the delineation of a contributing area for Clark Lake is described.

Background

The only source of water in the upper Door County peninsula is precipitation. Water that falls on land can become surface runoff and flow directly into lakes and streams, or it can become groundwater if it percolates through the soil. Surface runoff is most likely to occur near surface water features. The topography of the land can be used to identify the outer extent of the surface runoff drainage area (the surface water watershed). Within that boundary, any surface runoff could drain to the lake. Groundwater is the water that has drained through the soil or rock and entered saturated zones in the bedrock. Approximately two-thirds of the precipitation that enters the soil is eventually transpired back to the atmosphere and the remainder (approximately 9.5 inches/year) becomes groundwater (Bradbury and Muldoon, 1992).

Groundwater pathways are complex in Door County. Much of the water movement occurs within a fractured dolomite aquifer. Water travel velocity can be fast and water can move relatively rapidly through the groundwater system. Bradbury and Muldoon (1992) estimated that most of the groundwater in central Door County had recharged in the past ten years.

Groundwater elevations can be used to infer groundwater flow direction and a general contributing area for groundwater, but the complex flow pathways increase the uncertainty associated with this determination. Sherrill (1978) measured well water levels in Door County October 1971 and used them to develop a water table map within the dolomite aquifer. A later study by Bradbury and Muldoon (1992) measured water levels in an area south west of Clark Lake (Jarman Road site). Their study found evidence of both a shallow and a deeper groundwater flow system that were hydraulically connected at certain times of the year. The shallow groundwater surface followed the topography of the land. It had fluctuations in water level after spring snow-melt, but those did not change the apparent flow directions. In contrast, the deeper groundwater system did not follow the topography of the land and exhibited larger changes in water level. The water level variation also led to changes in the apparent flow direction. Following periods of high recharge, a groundwater mound formed in the deeper groundwater of central Door County and the apparent flow direction was to both the east and west. When the water level was lower, it appeared the principal direction of flow from the central portion of the county was to the west and southwest.

Contributing Area

The contributing area for Clark Lake was based on estimating a watershed for surface runoff and groundwater watersheds for both shallow and deeper groundwater flow systems. Land surface topography was used to delineate a surface watershed and the likely contributing area for the shallow groundwater flow system. The delineation was based on the WDNR digital elevation model and USGS topographic maps. The contributing area for the deeper groundwater flow system was based on the Door County water table map from October 1971 (Sherrill, 1978). Figure 1 shows the component contributing areas and their combination.

This contributing area should be useful for planning purposes, but there is uncertainty in the delineation. Bradbury and Muldoon (1992) suggested that during periods of higher aquifer recharge, such as during spring snowmelt, there may be mounding in the center of the county and increased flow to the east. That might increase the western extent of the deeper aquifer system that contributes to Clark Lake at some times of the year, but as seen in Figure 1, the shallow aquifer system is already west of the deeper contributing area. Consequently, the combined contributing area would accommodate some increased flow from west to east during periods of higher groundwater levels in the deeper aquifer.

To accommodate uncertainty in local variations in bedrock fracturing and flow paths, an additional buffer distance could be applied to this delineation. As an example, a 500 foot buffer was added to the delineation in Figure 1.

Comparison to Streamflow Measurements

One way to generally evaluate the size of the contributing area is to compare it to measured streamflow. Streamflow was measured periodically at different locations in Logan Creek as part of the Clark Lake Study in 2005 and 2006. If groundwater recharge to the area averages 9.5 inches per year (Bradbury and Muldoon, 1992), the total water yield should average approximately 0.7 cubic foot per second (cfs) per square mile over the year. Because groundwater recharge may be higher during snowmelt periods and travel times can be rapid, streamflow rates will be higher at some times and lower at others. Streamflow measurements near Clark Lake at STH 57 were normalized for the size of the upstream surface watershed and expressed as cubic foot of water per second per square mile of land in Figure 2. As anticipated, streamflow varies during the year with greater flow in the spring overall, the streamflow is not dramatically higher than 1 cfs per square mile, suggesting that the contributing area is not likely substantially undersized relative to the streamflow observed. Similar results are observed at other locations on Logan Creek as shown in Figure 3. This figure shows that there are areas where significant loss of water in the stream occurs (e.g., Lortiz Rd.), but overall the streamflow is generally below 1 cfs per square mile.

Summary

The proposed Clark Lake contributing area is based on combining estimates of a topographic watershed with a groundwater watershed. The groundwater watershed was approximated with estimates of both deep and shallow groundwater flow. This contributing area delineation should provide a useful boundary for planning purposes, but could be refined in the future by monitoring groundwater levels, determining flow directions, and measuring streamflow throughout the area.

References

Bradbury, K.R. and M.A. Muldoon. 1992. Hydrogeology and Groundwater Monitoring of Fractured Dolomite in the Upper Door Priority Watershed, Door County, Wisconsin. Final Report to the Wisconsin Department of Natural Resources, 70 p.

Sherrill, M.G. 1978. Geology and Ground Water in Door County, Wisconsin, with emphasis on Contamination Potential in the Silurian Dolomite. Geology Survey Water-Supply Paper 2047, 38 p.

Clark Lake Contributing Area

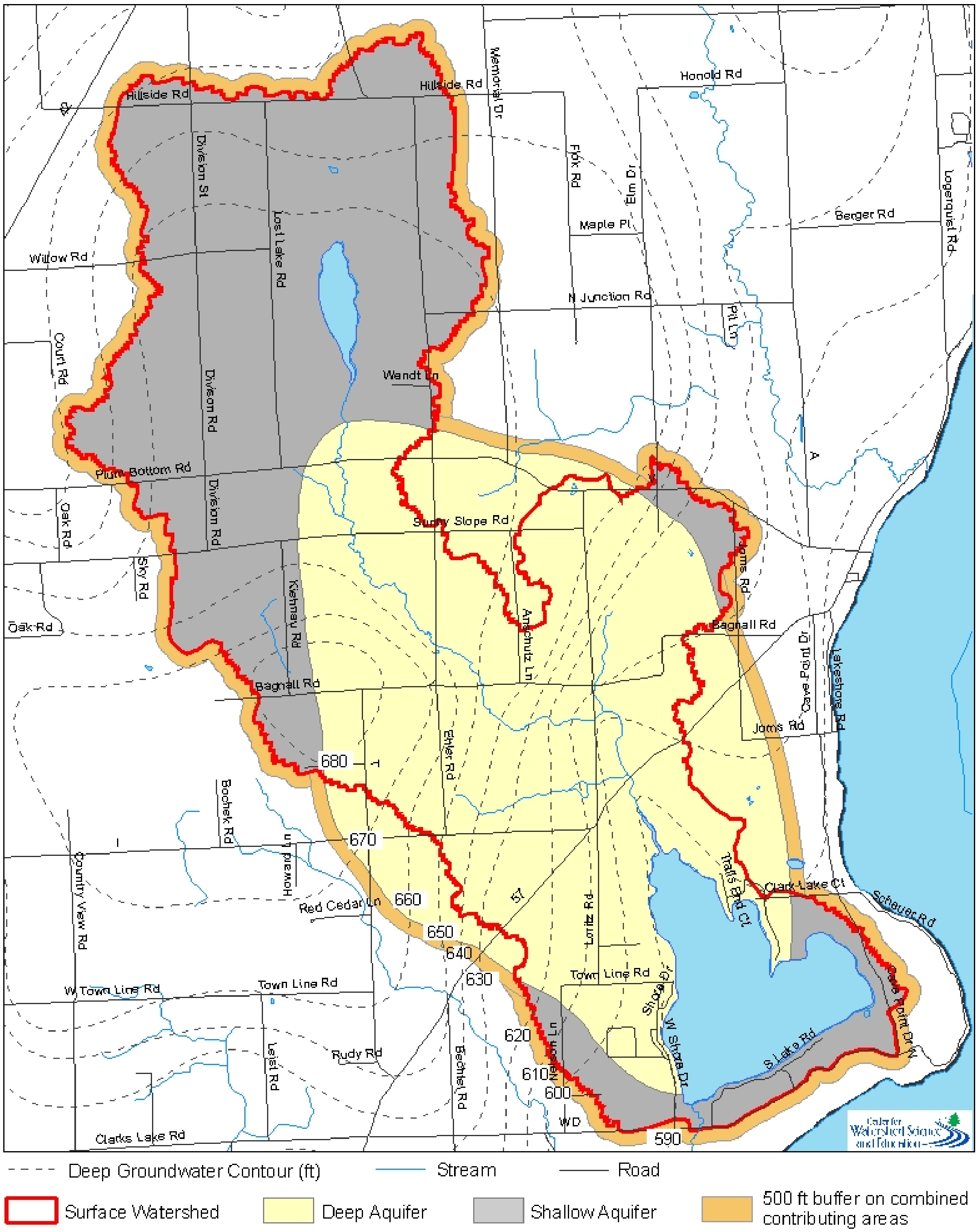

Figure 1. Contributing area for Clark Lake based on combining surface water, shallow groundwater flow and deeper groundwater flow components. Topography used to delineate surface water and shallow aquifer components. Door County water table map used to estimate deeper aquifer component.

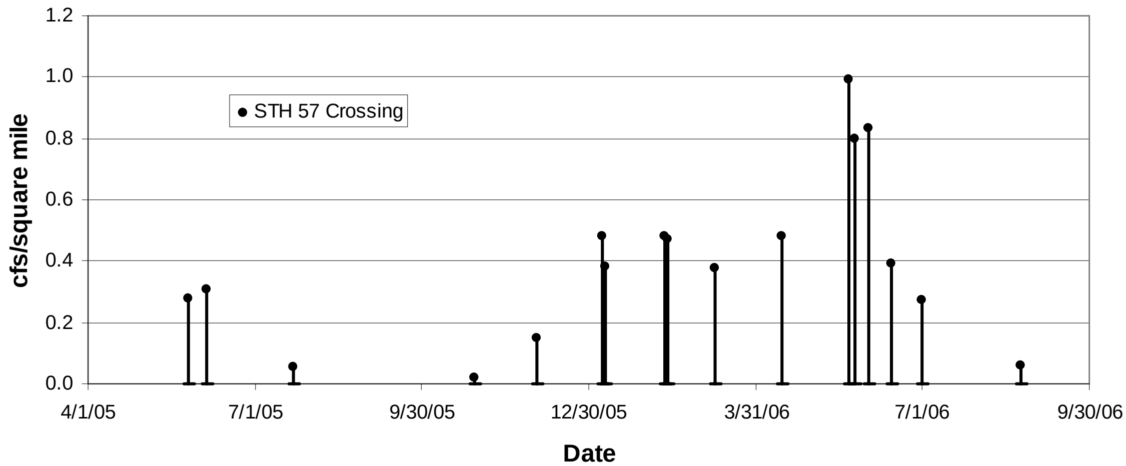

Figure 2. Streamflow measured in Logan Creek at STH 57 after normalizing for upstream surface watershed area.

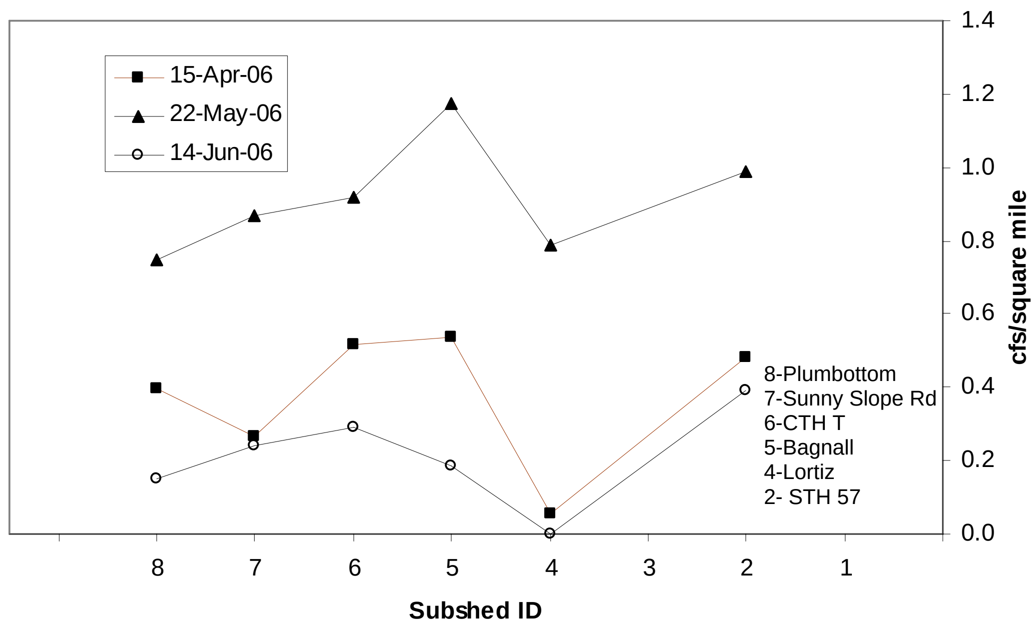

Figure 3. Streamflow measured at different Logan Creek locations in 2006 divided by the size of the upstream contributing area for each location. Sub-watershed (subshed) locations based on road crossing sampling locations. Numbers decrease with increasing distance downstream on Logan Creek.