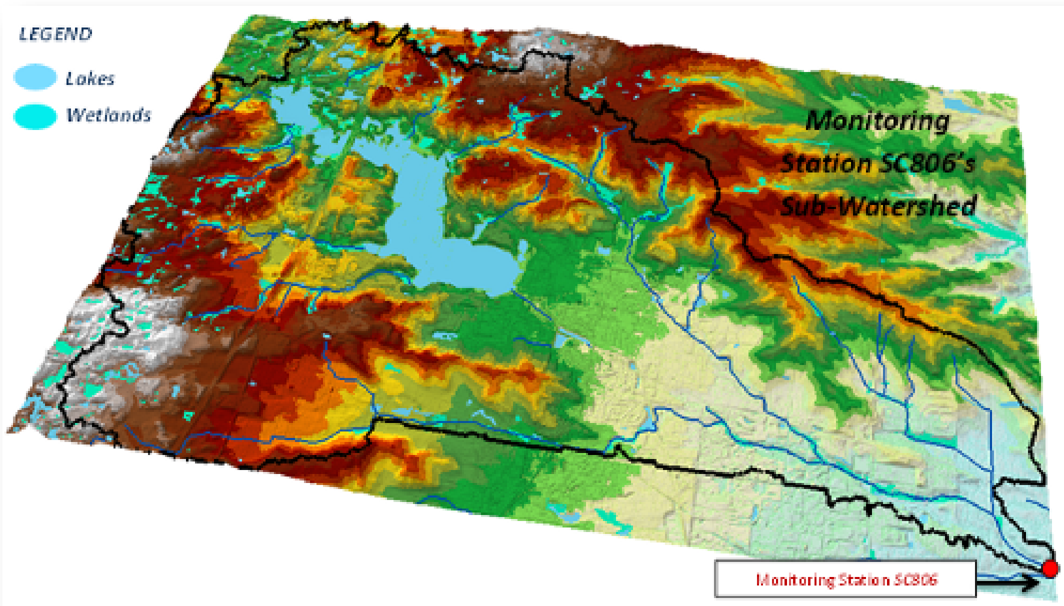
Spring 2012 - GIS 101: What Is a Watershed?

By Dave Holmen, Dakota County Soil and Water Conservation District (SWCD)

In the GIS community we often hear mention of the term watershed, or even the related term sub-watershed, but, what is a watershed exactly? The term watershed refers to a topographic depression in an area of land in which gravity causes surface water to flow downhill to a single exit point. Some other terms often used to describe a watershed are drainage basin and catchment. The related term sub-watershed refers to a smaller area of land within the previously defined larger area that empties into or contributes to that larger area. Watersheds are often identified or delineated for a designated land area or political boundary, but they can also be identified for a lake or wetland basin, a stream confluence, a specific outflow point such as a feedlot, or a water quality monitoring location within a waterway.



In the above graphic, SWCD staff was interested in determining the upstream area of land contributing to monitoring readings collected at station SC806 on the South Creek tributary of the Vermillion River. By performing a series of hydrologic modeling steps in GIS using a LiDAR-based Digital Elevation Model (DEM), the station's watershed was identified. In this case, the station's watershed is defined by the monitoring station's location, which in turn is a sub-watershed of South Creek, whose watershed is defined by its confluence with the Vermillion River. South Creek's watershed is in turn a sub-watershed of the Vermillion River Watershed.

GIS Layers of Interest: MN DNR's Major Watersheds, MN DNR's Minor Watersheds, MN DNR's Lake Catchments

More Information: What watersheds are and why they are important (MN DNR)

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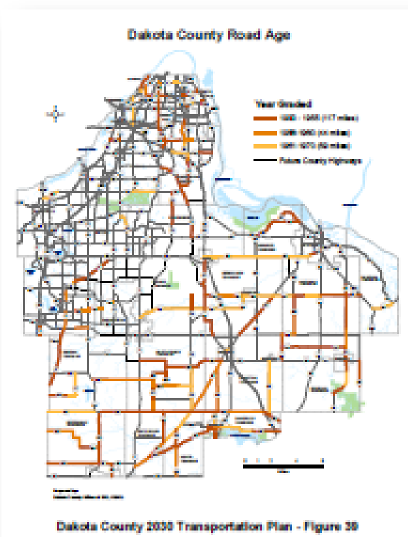
Spring 2012 - Department Spotlight: Using GIS in the Development of Dakota County's Transportation Plan

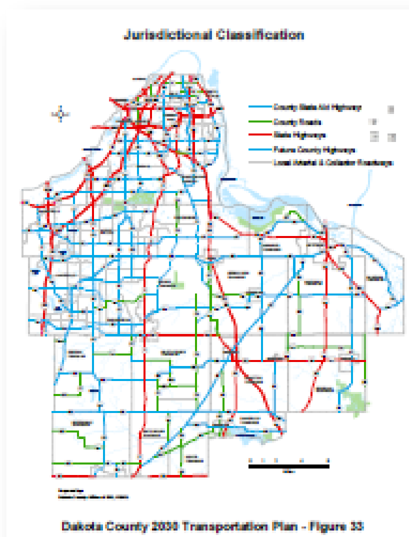
By Scott Peters, Dakota County Transportation Department

The Dakota County Transportation Department is updating the County's long-range Transportation Plan. The Plan (Dakota County 2030 Transportation Plan), is a document used by the County, its partners and residents as a guide to maintain and improve the County's transportation system through 2030. The Plan was developed in the context of regional, state and national transportation planning and funding policies and guidelines.

The Plan provides the vision for the future transportation system, supports land use goals and objectives, and documents the County's transportation policies and strategies. The Plan identifies major transportation system investment needs and prioritizes these needs. The Plan has several major goals that address areas of funding, transit and other transportation modes, preservation, management, replacement, and expansion.

The document contains details identifying how strategies and policies support specific goals. However, one of the most valuable elements of the Plan is the maps that support the Plan goals, objectives, strategies and policies. County GIS staff provided a great amount of support in developing this Plan by providing analytical support and developing corresponding maps that depict specific transportation topics or provide visual information.





Some examples of maps within the Plan include identification of roadway function, roadway jurisdiction, roadway and driveway access spacing, and analysis of existing and future travel demand. Specific examples include maps developed that identify current and future locations of roadway capacity problems using data from the County's Travel Demand Model. This assists Transportation staff to determine transportation system needs and corresponding funding needs. In some cases, the maps provide an overlay of additional information such as transit corridors and bike trails to provide staff with a better understanding of how all transportation modes tie together and what geographical areas of the county may be of concern.

The Transportation Plan also includes maps that provide a visual inventory of the County's transportation system. These include County roads that are gravel, locations of County-maintained bridges, transit routes or even highway age. Oftentimes, these maps can show geographical clusters within the county and identify locations for focused attention. This is especially helpful in a county that transitions from urban to suburban to rural land uses.

The Plan also includes maps with a planning emphasis. These maps identify areas of the county that may require future attention or planning efforts. These include maps that identify future County highways alignments or future transportation corridor study locations.

In all, GIS staff's analyzing of data and development of maps provided a very significant element of the County's Transportation Plan. The maps provide a snap shot of how a specific transportation component or issue may affect the entire county or may only occur in a specific area. Many times the maps can depict multiple items and relationships without the need for multiple pages of text describing the situation.

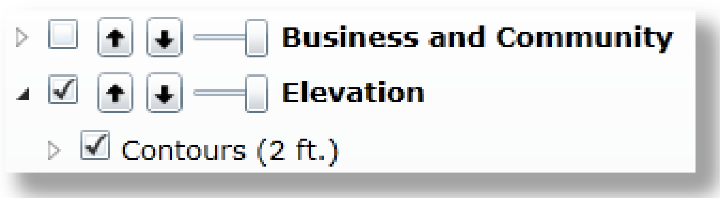
The Transportation Department staff rely heavily on the maps within the Plan because, as the saying goes, "A picture is worth a thousand words." In many instances, the maps within the plan truly reflect this and often the maps provide the most important piece of the puzzle in analyzing or describing transportation issues or topics and how they may be addressed.

Spring 2012 - Desktop GIS: Introducing DCGIS4

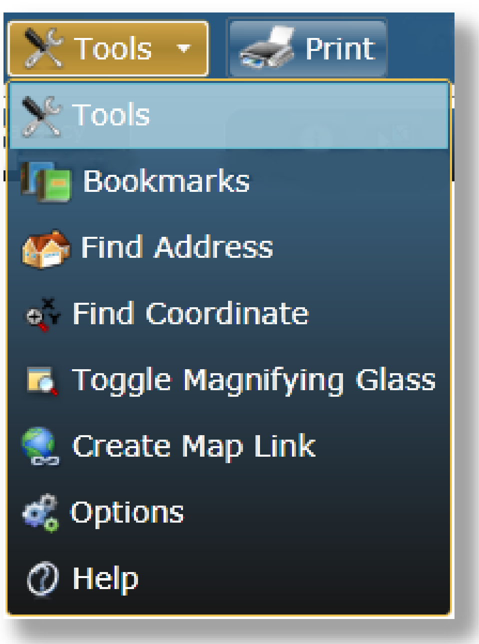
By Randy Knippel

DCGIS is the Dakota County Interactive GIS Map on the County website. It is widely used by county staff, city staff, and the general public, providing access to hundreds of GIS layers and basic analysis. The current version has been in operation since 2006 and is showing its age. The server software it requires, ArcIMS, is no longer supported.

DCGIS4 is a significant upgrade in functionality, using ArcGIS Server and Silverlight, giving it a whole new look and feel. ArcGIS Server creates very efficient map services, improving performance dramatically, while Silverlight provides fluid interactive transitions. This results in a dynamic interactive experience where there is little delay as you pan and zoom on the map. Plus, the majority of the display is occupied by the map, with additional features overlaid and popped up automatically.



DCGIS4 will give you access to all the GIS layers you are used to having, and more. Layers are grouped the same in the table of contents, but now you can also turn an entire group on and off, as well as individual layers. You can also move groups up and down in the table of contents to affect the order in which they are drawn. This gives you more control over which groups of layers draw on top of which. Finally, you can add more layers to the map by adding map services published on the Internet by other organizations such as ESRI, the Minnesota DNR, and the Metropolitan Council, to name a few.



The familiar tools are all there, too, such as find by address, set bookmarks, print maps, and search using a variety of options. You can select by point, line, rectangle, or polygon and export the results to a variety of formats, as you can now, but with greater flexibility to add and remove selected features so you can create a selection of just the features you want. Measuring and drawing are there, too, but now you will have much greater control over the graphics you draw. You can choose from a wide array of colors, symbols, and text fonts to enhance the graphic display and create maps to share. Plus, you can select graphics you have created and easily modify them or delete them.

A beta version of DCGIS4 will be available sometime this spring. Watch for announcements and new links on the Property Information website. Training will also be available to city and county staff. The current EDGE class will be migrated to the new software and special seminars will be provided to help current DCGIS users transition to using the new version. We believe most DCGIS users will be able to easily make the switch to the new version, and will be pleasantly surprised by the new features and the new look and feel.

Spring 2012 - Tech Talk: Delineating Watersheds

By Brian Welch, Engineering Resources Manager
City of Northfield

Defining the boundaries of watersheds of different scales is a common task related to studies of surface water (stormwater) runoff, tracing contaminants or nutrient transport, or land use planning (e.g. http://www.dnr.state.mn.us/watersheds/lakeshed_project.html). Readily-available data sets of regional watersheds are available from federal and state sources (e.g. National Hydrography Dataset - http://nhd.usgs.gov/, MN Subwatersheds - http://deli.dnr.state.mn.us/metadata/wshd_lev08py3.html). However, these data sets are generally too coarse for accurate work at city or county scales.

High-resolution Digital Elevation Models (DEMs) based on airborne Light Detection And Ranging (LiDAR) data, along with associated derivative analyses, provide opportunities to improve the accuracy of the existing watershed boundaries or for creating watershed boundaries from scratch. This article summarizes the two primary means for generating watershed boundaries: automated terrain analysis and manual watershed delineation. There is significantly more information available about both methods than provided here.

Before starting, it’s useful to consider the scale of the watersheds you want to delineate. Are you looking at a county level at general rivers and streams, or are you looking at all subwatersheds within a municipality in order to determine the inputs to stormwater ponds? As a general rule of thumb, the finer the resolution you seek and the more subtle the terrain, the more likely it is that you will need significant manual input to achieve the desired results (Figure 1).

Figure 1. Watersheds are relatively easy to define in areas of significant terrain. Flatter areas can be more difficult. These two maps are shown at the same scale.

Automated Terrain Analysis to Delineate Watersheds

Numerous software products are available to process and analyze DEM data and develop stream centerlines, watershed boundaries, and related hydrologic parameters. ESRI provides guidance for the tools included in the Spatial Analyst Extension to perform all of the necessary calculations. However, there are a number of caveats and considerations that are relevant to using such tools to delineate watersheds:

1. Digital terrain analysis and automatic watershed calculation is far from hands-off. Significant manual interaction is necessary to pre-process the elevation data, identify "pour points" where water leaves a subwatershed, validate results, and to continue the iterative process toward more accurate watershed boundaries. This is sometimes called "terrain conditioning".
2. DEMs generally represent the surface elevation of the ground and do not accurately represent manmade influences on surface water flow, such as culverts, bridges, dams, storm sewer pipes, agricultural drain tiling, etc. Significant pre-processing may be necessary to develop the input files necessary to allow the software to recreate the actual water flow (Figure 2).
3. The accuracy of the DEM becomes more crucial for flatter terrain. Flat areas may incorrectly result in ponds if the DEM does not depict the minor undulations and channels that normally allow water to flow through the area. Most terrain analysis software allows the user to define artificial channels to avoid unrealistic ponding. The artificial flow paths are also used to indicate how water should flow through natural or manmade water bodies (lakes, ponds, reservoirs) since the surface slope of such features is generally zero: no water flow.

In very flat regions of Minnesota the impact of artificial drainage features on the watershed may be significant. Water may "pool" behind a road because a culvert was forgotten in the input file. Following the instructions from ESRI to generate watersheds using the tools in Spatial Analyst will result in numerous iterations to ensure that all artificial flow features are correctly handled and that the resulting surface watersheds are accurate.

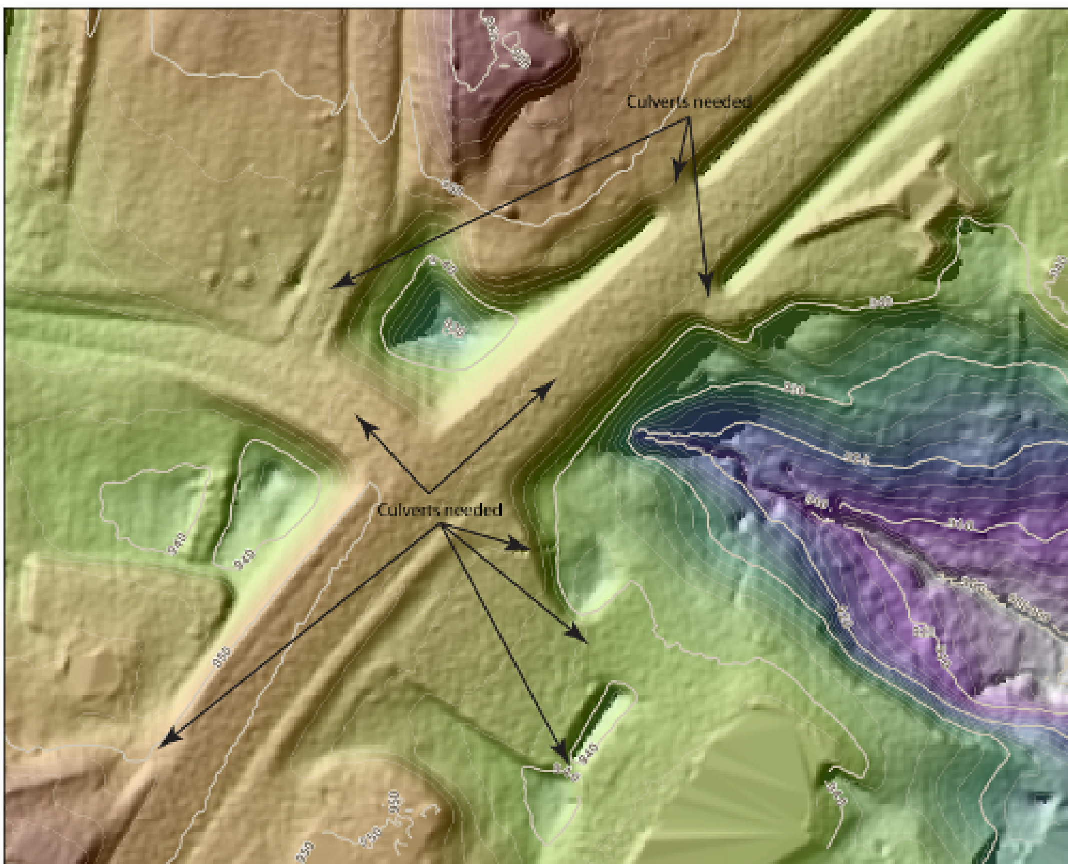


Figure 2. Pre-processing is required for automatic terrain analysis. At least nine culverts are required in this small area to allow surface water to flow past the "dams" seen in the LiDAR data.

Manual Watershed Delineation

It used to be that manually-defined watersheds were derived strictly from contour maps or stereo photogrammetry (see [this paper](#) for an example of traditional pen-and-paper watershed delineation). The new LiDAR DEMs and spatial analysis tools provide significantly more information to assist in the accurate determination of watershed boundaries.

For small projects it may be quicker to define watersheds manually than to go through the DEM processing steps necessary for digital terrain analysis. In other situations manual delineation may be more effective, such as where terrain is extremely flat or where artificial structures have a significant impact on surface water flow. It may also be helpful to use existing watershed delineations or the initial output of digital terrain analysis as the starting point for manual delineation.

Manual delineation of the watersheds is an exercise in heads-up digitizing along drainage divides. The following data sets are useful in discriminating the exact location of the divide:

- Digital Elevation Model - vary the color ramp as needed to focus on the area of interest.
- Hillshade Model - calculate multiple hillshade models of the DEM varying the vertical exaggeration (e.g. 5x, 10x, 15x, etc.) and the illumination angle (e.g. default NW illumination, NE illumination, SW and SE can also be useful but be prepared for the hillshade surface to optically “invert”). Adjust the color ramp (grayscale is best) to create a stark contrast along ridgelines.
- Aspect - calculates the direction that a surface slopes. This can help in some areas, but in very flat areas can often be indeterminate or even incorrect if there is a small channel not resolved by the DEM. Look for significant changes in the aspect direction that are related to ridges in the hillshade models.
- Contour Lines - Most LiDAR DEMs can generate 2-foot contours. Valleys and ridges each have distinctive shapes and can be used to help guide the delineation process.

Commonly you will switch back and forth between the different data sets to digitize the watershed edges as accurately as possible.

Dealing with Storm Sewer Systems

Storm sewer pipes present interesting challenges to watershed delineation since the buried pipes can pull water from one side of a surface divide to another. Most automatic watershed software cannot handle storm sewer pipes. In developed neighborhoods you may find that front yards drain to the street and one subwatershed while backyards drain to another. You may also find that street projects may change the surface hydrology by installing new storm sewer pipes (Figure 3).

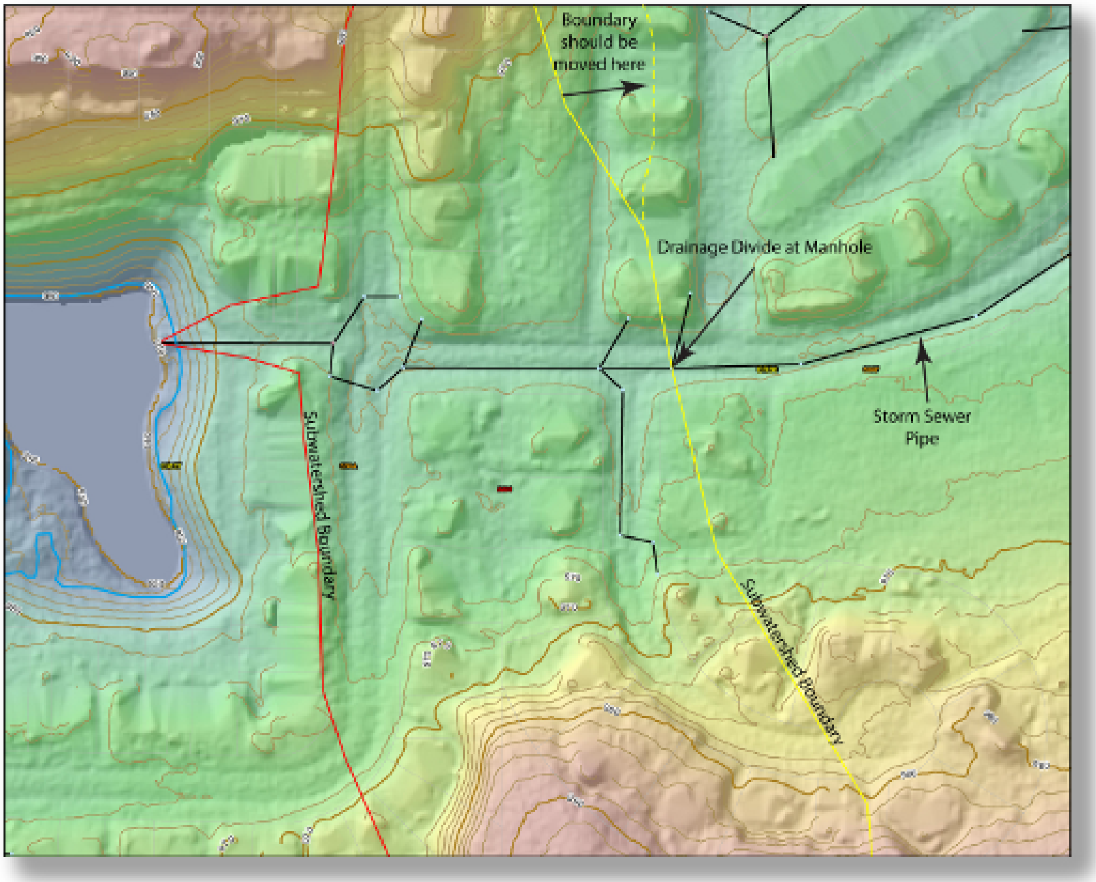


Figure 3. Storm sewer structures and local grading can modify the local watershed boundaries. In this region a manhole acts as a divide along a storm sewer pipe due to the slopes of the pipes themselves. Near the north edge of the map the watershed boundary has been altered by recent grading for new homes and must be adjusted.

Tracking surface drainage through the storm sewer system helps to trace possible sources of contamination and to plan adequate drainage for future development. In most cases the storm sewer network will resemble an arborescent river-stream network and thereby indicate the water flow direction. You may either modify the surface watershed network to accommodate the storm sewer system or create a second set of watersheds for the storm sewer. Having a set of surface watersheds without the storm sewer system may be helpful to predict the effects of blockage in the event of a flood.