

# Publishing Surficial Geologic Maps of Delaware

By Lillian T. Wang

Delaware Geological Survey  
University of Delaware  
Delaware Geological Survey Building  
Newark, DE 19716  
Telephone: (302) 831-1096  
Fax: (302) 831-3579  
e-mail: [lillian@udel.edu](mailto:lillian@udel.edu)

## Abstract

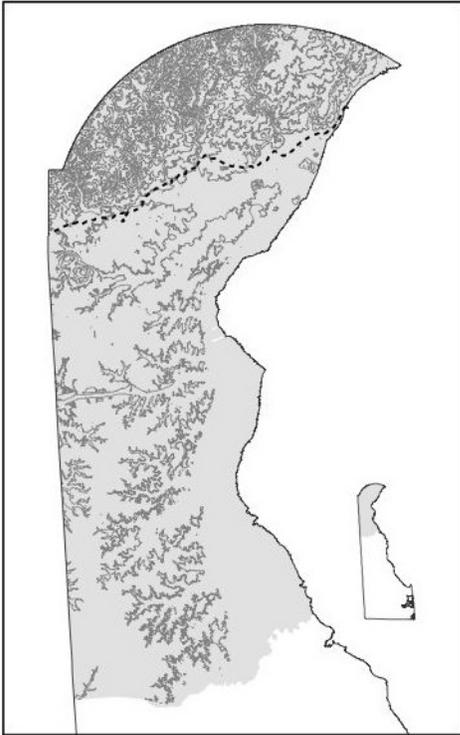
The Delaware Geological Survey (DGS) geologic map series began in 1970. Map publications were compiled by an outside vendor with DGS providing text and hand-drawn illustrations. As the DGS entered the 21st century, a gradual transition toward digital mapping began. A full-time position was created to maintain a geographic information system (GIS) and produce publication-quality maps and illustrations. During the transitional period (2000 to 2003), the DGS began to deliver digital data to a vendor, who produced the finished map product. By 2005, the DGS had the ability to create an entire digital map publication in-house. The final layout is created in Adobe Illustrator, and a digital file is delivered to the vendor for printing paper maps. This workflow has resulted in significant time and cost reduction, and discussions of discontinuing printing paper maps to further reduce publication costs are ongoing. A downloadable PDF copy of the map and associated digital data are also available on the DGS website (DGS, 2011a).

## Base Map Layers

Earlier DGS geologic maps used the U.S. Geological Survey (USGS) topographic map as the base layer. USGS discontinued updating these layers for Delaware in 1993, requiring a search for other base map options during the transitional period. During this time, a pilot project for the USGS National Map was being developed called the Delaware Data and Mapping Integration Laboratory (DataMIL, 2011).

DataMIL provided a crowdsourcing digital update tool for the major layers found on a USGS topographic map. Later, these same layers were also adopted by Delaware as the State’s Spatial Data Framework Layers, or base map geographic datasets. The framework layers selected as the necessary base map layers and extracted from DataMIL include boundaries, water features, transportation, and elevation. These data layers were symbolized to mimic original USGS topographic maps using the digital cartographic standard for geologic map symbolization developed by the Federal Geographic Data Committee (FGDC) Geologic Data Subcommittee (FGDC, 2006). The Geologic Data Subcommittee Web site includes a PostScript format for use in Illustrator and other graphic design software (USGS, 2006).

The most challenging dataset to work with was Delaware’s elevation layer. This layer consists of 2-foot (ft) contours that were generated from 2005 to 2007 LiDAR data. High-resolution data are beneficial for research purposes, but are a cartographic challenge to present on a smaller scale map. Showing 50- or 100-ft contour intervals on a 1:100,000-scale map was reasonable for the Piedmont area in northernmost Delaware, but was not effective or possible for the majority of the State, which lies within the Atlantic Coastal Plain (fig. 1). Therefore, in lieu of using contours, a shaded relief image constructed from a digital elevation model (DEM) is displayed on DGS countywide 1:100,000-scale maps to show elevation as it relates to the underlying geology. Elevation data on the larger scale, 1:24,000-scale maps use this shaded relief image but also include the 10-ft index and 6-ft intermediate contour intervals. Contours are simplified by removing 75 to 85 percent of the vector points to reduce pixelation and thereby smooth the lines.

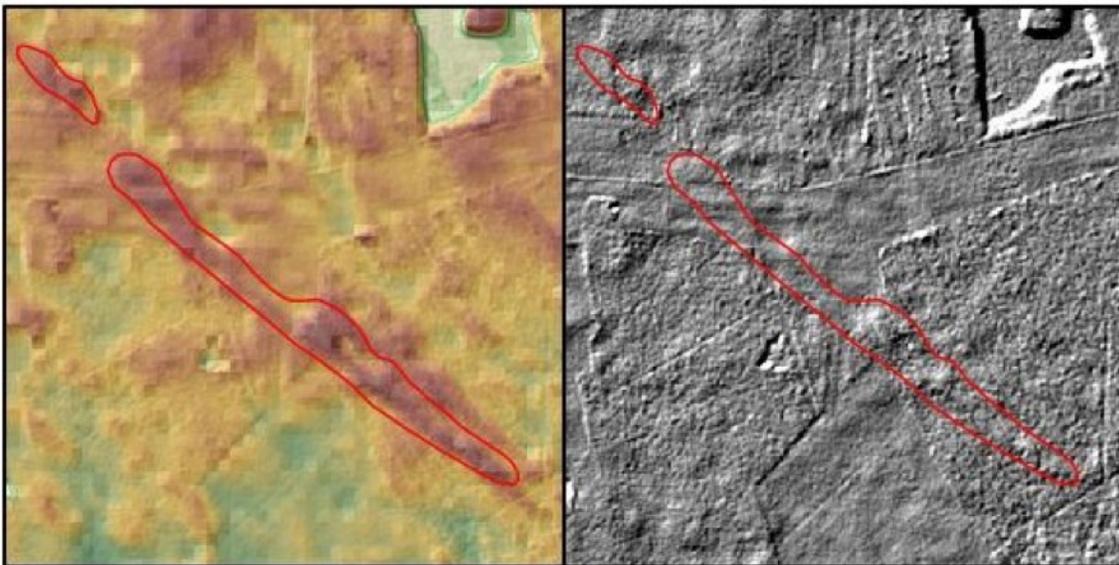


**Figure 1.** New Castle County, Delaware, with 50-ft contour intervals from 2007 LiDAR data. Dashed line indicates the Fall Zone, which divides the Piedmont (to the north) and Coastal Plain (to the south).

## Geologic Mapping

Boring, well, and hand auger data are used in describing geologic formations in the shallow subsurface and at the land surface. DEM data have been used to assist in identifying periglacial and other types of geomorphic features. These data are subjected to cartographic enhancement techniques such as the Swiss Hillshade (shaded relief) method (Esri Mapping Center, 2007), which utilizes the ArcGIS Spatial Analyst extension to vertically exaggerate DEM datasets and accentuate geomorphic features in the relatively flat Coastal Plain areas. Figure 2 shows an area where dune deposits were enhanced with the Swiss Hillshade method, because the DEM shaded relief alone did not highlight these features.

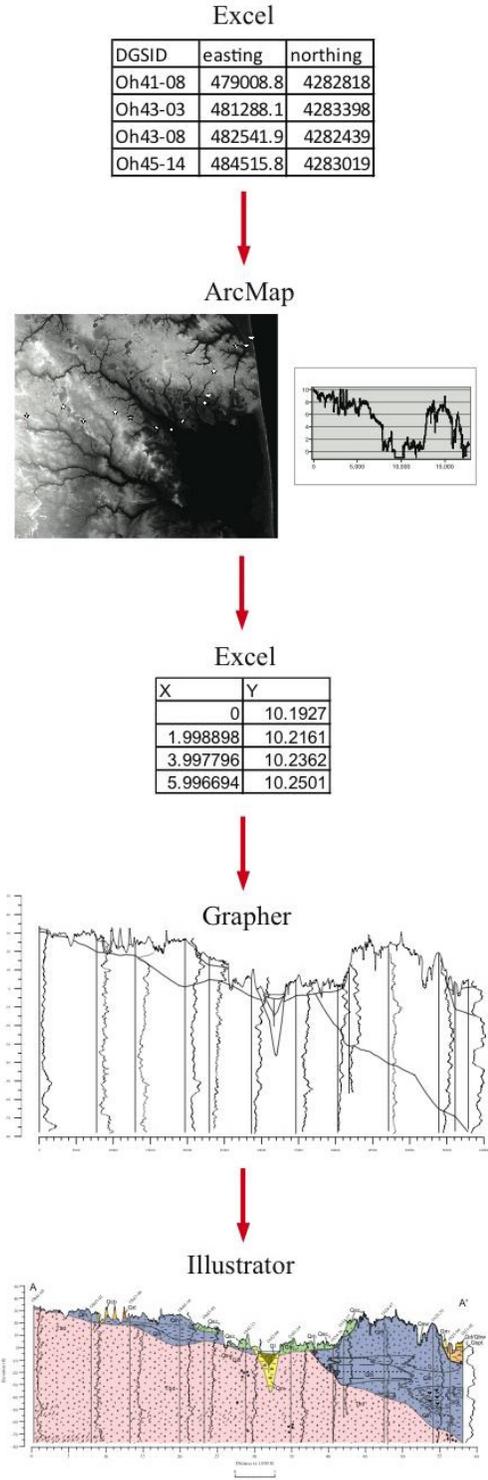
Although the DGS edits and finalizes a geologic map in digital format, the geology contact lines are still hand drafted on a 1:24,000-scale paper map. The drafted map consists of well and hand-auger point locations, the surrounding surficial geology, elevation contours, roads, water features, and surface cover from Delaware's most recent land-use and land-cover data. When the geologist is satisfied with the lines, the map is scanned as a digital image. The next step is to georeference the image and heads-up digitize the geology as polygons in ArcMap. The geology polygon layer is exported from ArcMap at 1:24,000-scale to Adobe Illustrator file format (.ai). The roads layer is used to correctly align any digital layers imported into Illustrator separately.



**Figure 2.** Area where dune deposits are enhanced with the Swiss Hillshade method (left). In the unenhanced DEM shaded relief (right), these features are not readily seen.

## Cross Sections

Cross-section illustrations also were hand drawn until DGS transitioned to digital mapping. Creating a digital cross section requires a combination of different software packages and file formats. The geologist selects well and soil-auger boring locations from the DGS Oracle database. A data table of well and boring identifiers and their corresponding x- and y-coordinates then are plotted in ArcMap. These point locations and a DEM are used in the ArcGIS 3D Analyst extension to create an elevation profile graph. Data from the profile are exported to a data table, which contains distance and elevation values. This data table is used in Grapher (Golden Software, <http://www.goldensoftware.com>) to create a digital sketch of a cross section. This basic sketch is exported to Illustrator for publication-quality modifications. Geophysical logs that have been digitized separately are easily incorporated with corresponding wells on the final cross section (fig. 3).



**Figure 3.** Illustrations of steps and software used to create digital cross sections for DGS geologic map publications.

## Offshore Deposits

Large-scale DGS map publication areas are defined by USGS 7.5-minute quadrangle boundaries. Geologic maps that contain portions of the Delaware Bay and Atlantic Ocean included bottom sediment texture descriptions in these offshore areas. Grab sample data used for this interpretation were from various University of Delaware unpublished Master's and Ph.D. theses and dissertations. Since southeastern Delaware quadrangles along the Atlantic Ocean contain 50 percent or more offshore area, discussions arose whether to use these traditional boundaries. It was decided to continue publishing surficial geology by quadrangle for continuity with previous geologic map publications. This decision gave DGS an opportunity to utilize an additional DGS data source, the Delaware Offshore Geologic Inventory (DOGI) (DGS, 2011b). DOGI tracks sediment samples, radiocarbon and amino acid racemization dates, seismic profiles, and vibracores taken from the nearshore and Inner Continental Shelf in State and Federal waters. In 2011, an offshore cross section was used to further define areas as named deposits with detailed descriptions (Ramsey, 2011). These additional data allowed for the boundaries of offshore formation extensions to be generally outlined in relation to the onshore geomorphology. Paleovalleys, interfluves, and ancient offshore features are also identified in this manner.

## Summary

In recent years, there has been a major shift at the DGS with both the map printing process and amount of work involved in publishing surficial geologic maps. Map production gradually evolved from manual to digital techniques, and the majority of the workload switched from outside DGS to within the office. The publication review process is expedited at a faster pace with the ability to create and edit maps in-house. This shift has resulted in efficient and cost-effective changes to disseminating Delaware earth science information to Delaware's stakeholders.

## References

- DataMIL, 2011, The Delaware DataMIL, accessed December 8, 2011, at <http://www.datamil.delaware.gov>.
- DGS, 2011a, DGS Digital Datasets (Web site): The Delaware Geological Survey, accessed December 8, 2011, at <http://www.dgs.udel.edu/data>.
- DGS, 2011b, Delaware Offshore Geologic Inventory (Web site): The Delaware Geological Survey, accessed December 8, 2011, at <http://www.dgs.udel.edu/projects/delaware-offshore-geologic-inventory>.
- Esri Mapping Center, 2007, Esri Mapping Center – Ask a Cartographer, accessed December 8, 2011, at <http://mappingcenter.esri.com/index.cfm?fa=ask.answers&q=21>.
- FGDC [prepared for the FGDC by the USGS], 2006, FGDC Digital Cartographic Standard for Geologic Map Symbolization: Reston, Va., FGDC Document Number FGDC-STD-013-2006, 290 p., 2 plates, accessed December 8, 2011, at [http://ngmdb.usgs.gov/fgdc\\_gds/geolsymstd.php](http://ngmdb.usgs.gov/fgdc_gds/geolsymstd.php).
- Ramsey, K. W., 2011, Geologic map of the Fairmount and Rehoboth Beach Quadrangles, Delaware: Delaware Geological Survey Geologic Map Series No. 16, scale 1:24,000, accessed December 8, 2011, at [http://ngmdb.usgs.gov/Prodesc/proddesc\\_95103.htm](http://ngmdb.usgs.gov/Prodesc/proddesc_95103.htm).
- U.S. Geological Survey (USGS), 2006, FGDC digital cartographic standard for geologic map symbolization (Post-Script implementation): U.S. Geological Survey Techniques and Methods 11–A2, accessed December 8, 2011, at <http://pubs.usgs.gov/tm/2006/11A02>.