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Testing the Waters: Integrating Hydrography and Elevation in National Hydrography Mapping

Silvia Terziotti, Karen Adkins, Stephen Aichele, Rebecca Anderson and Christy-Ann Archuleta

RELIABLE AND ACCURATE hydrography data are critical to sound decision-making for many natural resource activities, ranging from traditional water resources subjects like surface water flow management, water resources planning, water quality and flood risk management to conservation and management of aquatic ecosystems, wildlife and habitat, forests and coastal zones. To better understand user requirements and associated benefits of improved hydrography data, the U.S. Geological Survey (USGS) and Natural Resources Conservation Service (NRCS) interviewed respondents from federal, state and local government agencies, private industry, and nonprofit organizations for the Hydrography Requirements and Benefits Study (2016, https://nationalmap.gov/HRBS.html). Results regarding mission critical activities found that annual benefits of existing hydrography data exceed $530 million. Implementing all reported requirements was estimated to add an additional $600 million in benefits. Respondents identified integrated hydrography and elevation data as necessary to their most critical activities, and notably, their greatest need was for hydrography data to align with elevation data at 1:12,000 or better scale.

From the beginning of USGS topographic mapping in 1884 and throughout the era of manual cartography, hydrography and elevation information were collected simultaneously and presented jointly on single map sheets. With the arrival of the digital age, hydrography and elevation data were acquired and managed separately due to disparities in data formats and relative accuracies. Although the national elevation and hydrography datasets have diverged, the user need for integration remains strong as noted in the Hydrography Requirements and Benefits Study.

The USGS is responding to the need for integrated hydrography and elevation data in two ways. First, the USGS is developing the National Hydrography Dataset Plus High Resolution (NHDPlus HR), which is built from 10-meter data from the 3D Elevation Program (3DEP), the National Hydrography Dataset (NHD), and the Watershed Boundary Dataset (WBD). These three data sources are integrated into a geospatial framework that determines the path that water would flow from any point in a stream or on the land surface. The tools to build the NHDPlus HR alter the elevation surface to conform to the hydrography, which is a quick, practical solution if the elevation data are less accurate than the hydrography layer, as has been the case in the past. However, recent growth in high resolution elevation data in 3DEP light detection and ranging (lidar) collections has provided a new opportunity to use another approach to the integration of hydrography and elevation data.

A new technique for providing integrated hydrography and elevation data is being developed using the 1-meter 3DEP lidar-derived elevation data across the nation. The USGS elevation and hydrography programs are currently exploring how to derive hydrography data directly from lidar data, with the goal of updating the National Hydrography Dataset (NHD). This approach of using high accuracy elevation data from 3DEP to create lidar-derived hydrography will greatly enhance the vertical and horizontal spatial integration between landscapes and the stream network, providing the level of accuracy and detail required for local scale applications (Figure 1).

In 2017, the USGS funded a pilot project in five geographic areas to better understand the costs and utility of deriving hydrographic features from lidar data and adding attributes to allow users to relate the lidar-derived linework to the NHD (Figure 2). The USGS developed a data dictionary with a simplified set of hydrographic features that match features in the NHD, such as Stream/River, Artificial path, Lake/Pond, or Canal/Ditch, and developed a set of additional feature

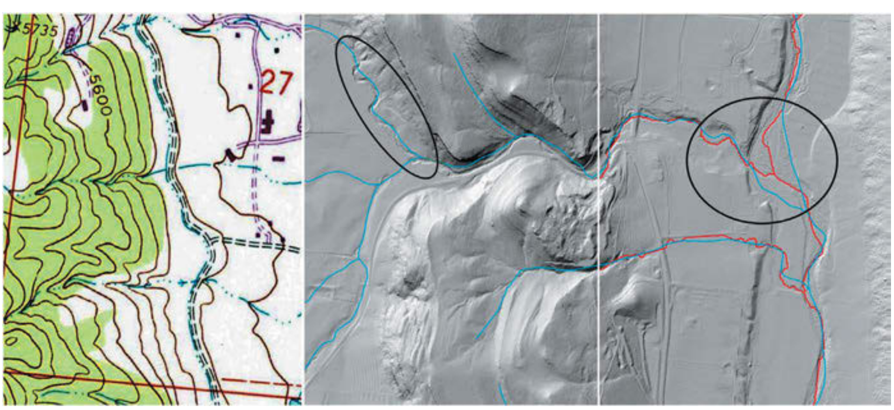

Figure 1. Elevation and hydrography datasets collected separately will have some misalignment of features (circled areas). *(A)* USGS topographic map: streams and contours match at the 1:24,000 scale; *(B)* the NHD high resolution streams and a lidar-derived shaded relief elevation surface showing some misalignment; *(C)* comparison of horizontal alignment of NHD and densified lidar-derived stream network. *Base credit: U.S. Historic Topographic Map Collection, 3D Elevation Program, National Hydrography Dataset, The National Map*

codes that include Culverts and Dams to support derivative elevation surfaces, hydro-enforcement, and hydro-flattening (Figure 3).

The results of the pilot project documented the need to provide training on the NHD data model, as well as clearer data capture guidelines to ensure that new hydrography linework is spatially integrated with lidar-derived elevation surfaces. Additionally, the pilot project found that the integrity of the linework and proper application of the NHD attribution coding is essential for integration into the NHD database. The pilot also emphasized that elevation and hydrography information for a location should be collected based on the same data source.

To facilitate integrated collection, the USGS is providing new guidelines within the USGS Lidar Base Specification. The Lidar Base Specification v1.2, (https://pubs.er.usgs.gov/publication/tm11B4) currently requires the collection of a limited set of hydrography features that are horizontally and vertically integrated into the elevation data. The subsequent version (v1.3), currently in press, will provide optional guidelines and a data dictionary for a more complete collection of hydrographic linework. By expanding the features for collection, the hydrographic linework may be used as a source to enhance the NHD.

While the pilot project provided one example of how to efficiently and accurately integrate hydrography and elevation data, the USGS continues to investigate how to provide better integrated, current elevation and hydrography products to increase the return on geospatial data infrastructure investments for the nation.

Readers are encouraged to visit the 3DEP website (https://nationalmap.gov/3DEP/) and the USGS Hydrography website (https://nhd.usgs.gov/index.html) to learn about USGS-integrated topographical mapping. ■

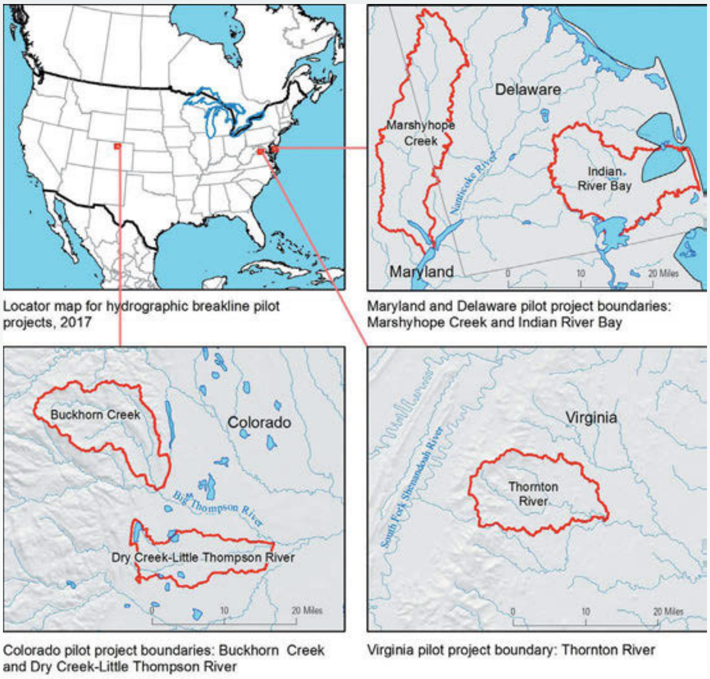

Figure 2. Pilot project study areas. Each pilot area had quality level 2 lidar available and shapefiles that contained the hydro-flattening linework. The drainage areas within the study areas ranged in size from 104 square miles to 220 square miles. The study areas were chosen to represent five landscapes: humid flat, humid coastal, arid mountainous, arid flat, and humid mountainous. The five landscapes were chosen to evaluate differences in cost based on topographic setting. *Base credit: 3D Elevation Program, National Hydrography Dataset, The National Map*

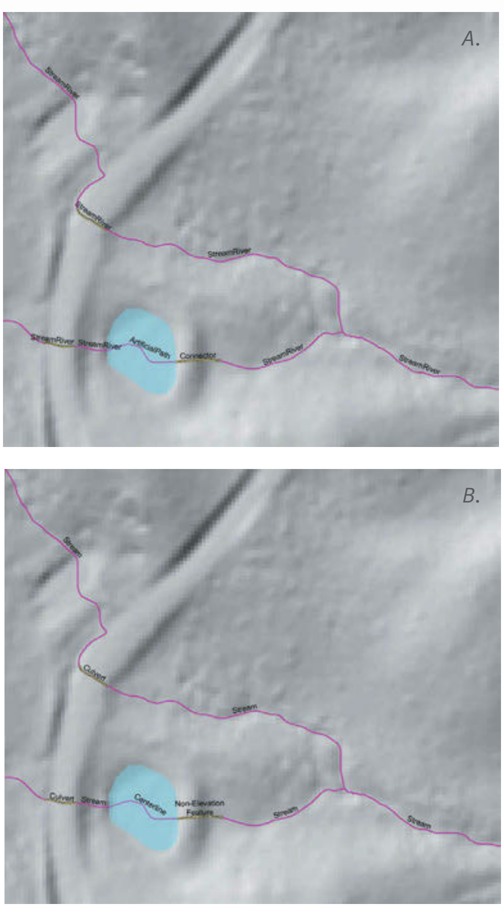

Figure 3. Examples of (A) hydrography codes and (B) elevation codes used to differentiate stream features.

Silvia Terziotti is the associate national map liaison for North Carolina and South Carolina. She has worked with the USGS as a GIS specialist with Water Science Centers since 1988. She currently splits her time between geospatial support of USGS Water Mission Area projects and support of National Geospatial Program activities. Contact: seterzio@usgs.gov.

Coauthors

Karen Adkins, ATA Services Inc., contractor to the U.S. Geological Survey, kadkins@usgs.gov
Stephen Aichele, U.S. Geological Survey, saichele@usgs.gov
Rebecca Anderson, U.S. Geological Survey, rdanderson@usgs.gov
Christy-Ann Archuleta, U.S. Geological Survey, carchule@usgs.gov