The Upper Mississippi River System—Topobathy

The Upper Mississippi River System (UMRS), the navigable part of the Upper Mississippi and Illinois Rivers, is a diverse ecosystem that contains river channels, tributaries, shallow-water wetlands, backwater lakes, and flood-plain forests. Approximately 10,000 years of geologic and hydrographic history exist within the UMRS. Because it maintains crucial wildlife and fish habitats, the dynamic ecosystems of the Upper Mississippi River Basin and its tributaries are contingent on the adjacent flood plains and water-level fluctuations of the Mississippi River. Separate data for flood-plain elevation (lidar) and riverbed elevation (bathymetry) were collected on the UMRS by the U.S. Army Corps of Engineers' (USACE) Upper Mississippi River Restoration (UMRR) Program (fig. 1). Using the two elevation datasets, the U.S. Geological Survey (USGS) Upper Midwest Environmental Sciences Center (UMESC) developed a systemic topobathy dataset.

What is Topobathy?

Topobathy is a seamless surface model that contains terrestrial and riverbed elevation. The terrestrial elevation is a product of airborne lidar, Light Detection and Ranging, converted to digital elevation models (DEMs). Lidar is a pulsed laser remote sensing method used to measure the surface of the Earth. Bathymetry, a water depth measurement collected using hydroacoustics, is used to calculate riverbed elevation. To create a seamless topobathy dataset, lidar and bathymetry datasets are combined (fig. 2).

What Data Were Used to Generate Topobathy?

From 2007 to 2011, the UMRR Program acquired a one-meter resolution, bluff-to-bluff lidar acquisition of the UMRS. Additional lidar data from Minnesota, Missouri, and Illinois, as well as further data from the USGS and the USACE, were used to supplement remaining parts of the UMRS. The lidar derivatives consist of one-meter DEMs, one-meter hillshades, and half-meter contours. Lidar processing was completed in 2015 on all lidar derivatives.

In addition to the lidar data, the UMESC and the UMRR Long Term Resource Monitoring (LTRM) element have administered the collection, handling, and serving of UMRS bathymetric data since 1989. The collection of systemic UMRS bathymetry data was completed in 2010 and is essential for the calculation of riverbed elevation. When water-surface elevations at select flow conditions are applied to bathymetry, water depth is converted to riverbed elevation. Other benefits of bathymetric data include monitoring ecology of the river, analyzing sedimentation, assessing possible impacts of hydrodynamic changes, and modeling vegetation distribution.

How Can Topobathy be Used?

Researchers, scientists, local and Federal governments, and private companies are focusing on topobathy data as a vital and innovative elevation dataset. For the UMRS, topobathy is a crucial data layer for understanding, monitoring, and restoring the flood plain and river ecosystem (fig. 3). Topobathy data may be applied to flood-plain and fluvial geospatial models, research projects, resource monitoring, and mapping. Until recently, hydrodynamic models have been limited to predictions in low-water conditions; but now, hydrodynamic models can be developed under multiple flow conditions when using a topobathy dataset.

A Decision Support System has been developed at UMESC to utilize topobathy data—the Connectivity and Inundation tool. The Connectivity and Inundation tool generates spatial data layers that summarize hydrologic conditions over a user specified date range. The produced data layers help to examine the cumulative effects of irregular water flow and depth.

Topobathy offers the ability to predict nearshore elevations. Nearshore areas are nearly impossible to measure because airborne lidar does not penetrate turbid waters or thick vegetation and because of shallow conditions, bathymetric surveys by boat cannot reach shorelines. These two limitations cause a slight data gap to exist along river shorelines. Fortunately, when creating a topobathy dataset, interpolation of elevation between the bathymetry survey and shoreline lidar will generate a predictive representation of unnavigable nearshore areas. The UMRS topobathy dataset will provide managers and researchers with a continuous elevation dataset of nearshore areas that previously has not been available. This is information that may be important when assessing the impacts of water-level management on critical flood-plain transition zones (fig. 4).
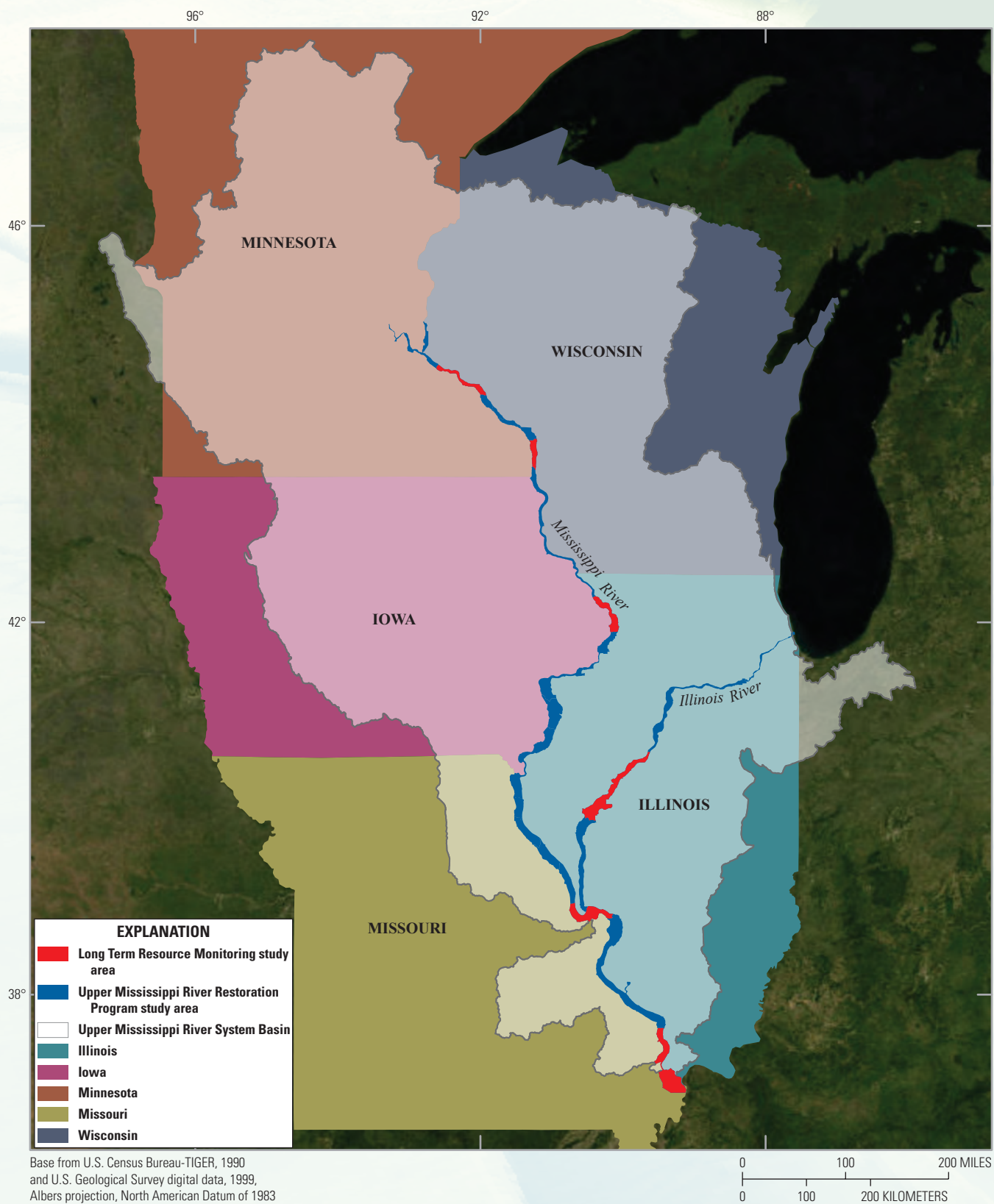
Figure 1. The Upper Mississippi River System (UMRS) and the Upper Mississippi River Restoration (UMRR) Program area, where topobathy data are available. The area is located in five Midwestern States: Minnesota, Wisconsin, Iowa, Illinois, and Missouri. Topobathy is a valuable dataset used by flood-plain managers, scientists, Federal and State agencies, and other researchers as a tool to understand river ecosystems, landscape modeling, habitat restoration planning, and research amongst flood-plain communities.
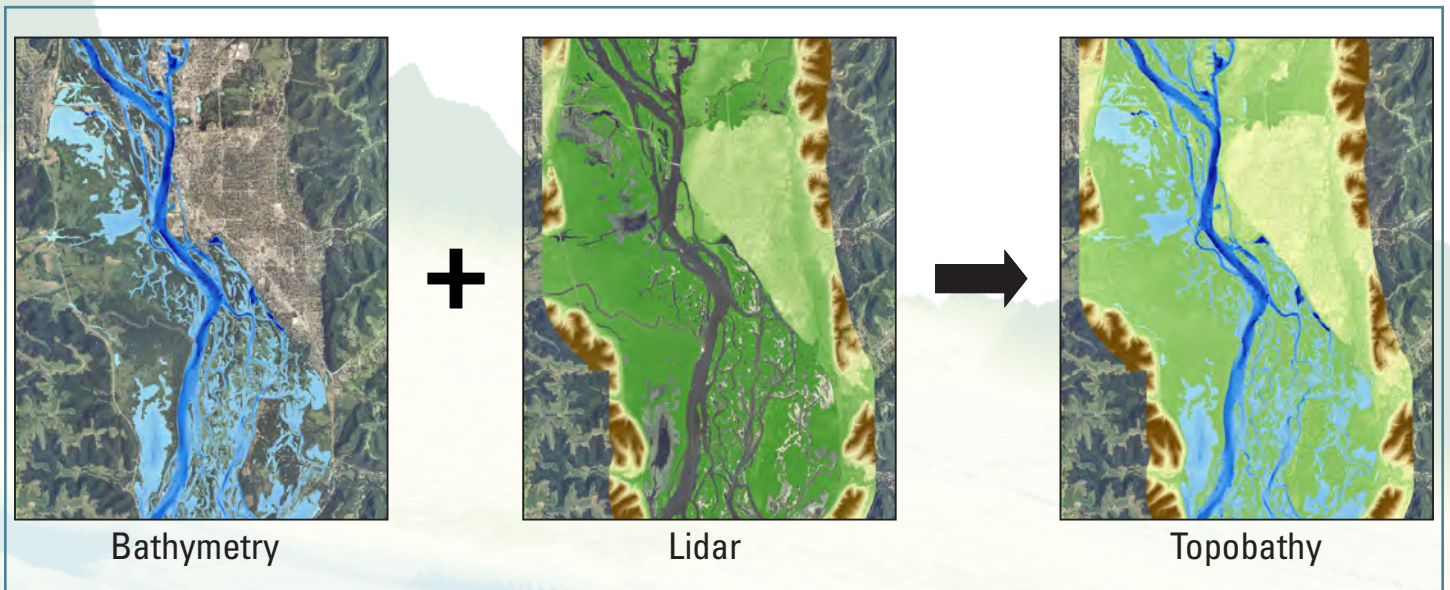
Figure 2. Datasets combined to develop the seamless topobathy coverage.
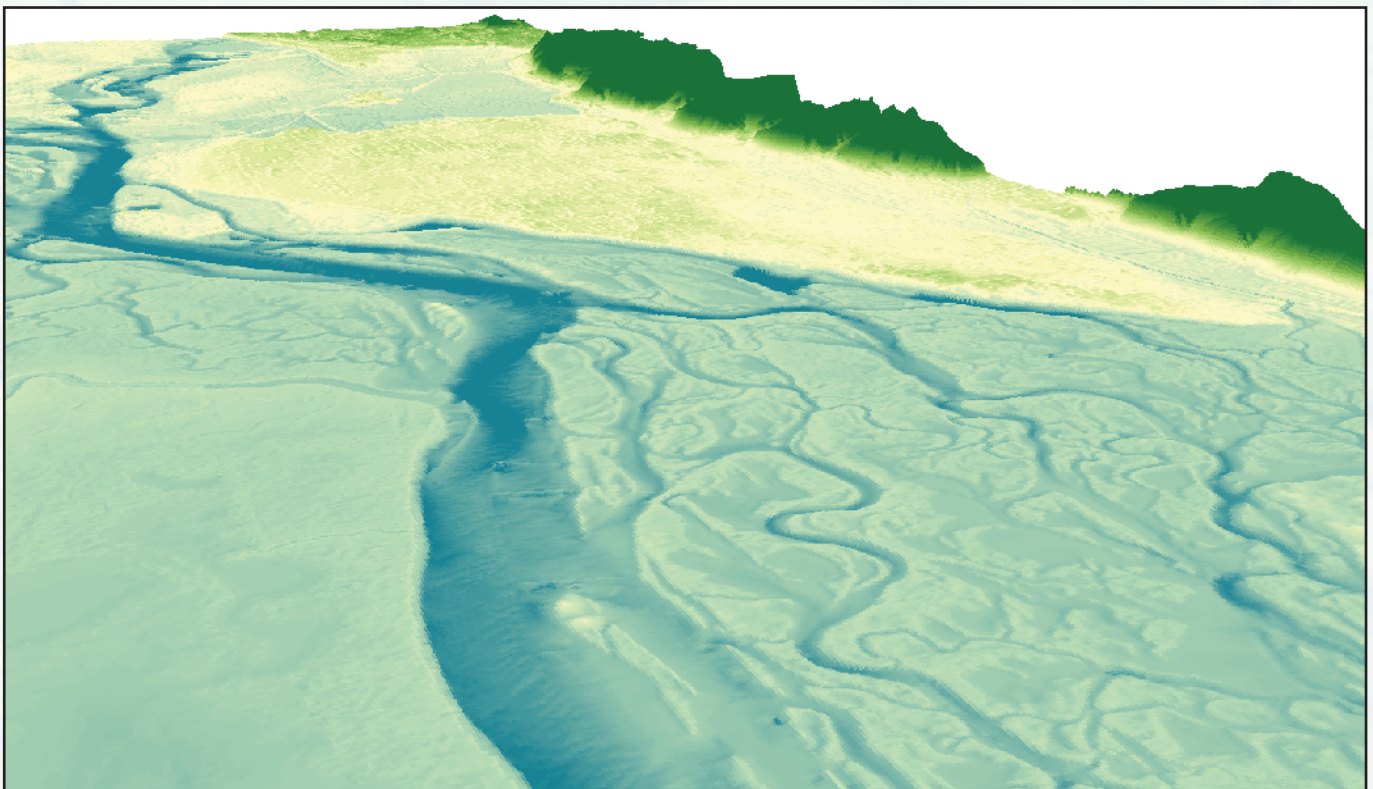
Figure 3. Topobathy surface of Mississippi River Navigation Pool 8 south of La Crosse, Wisconsin. This three-dimensional image provides a visual representation of a braided channel and backwater complex.
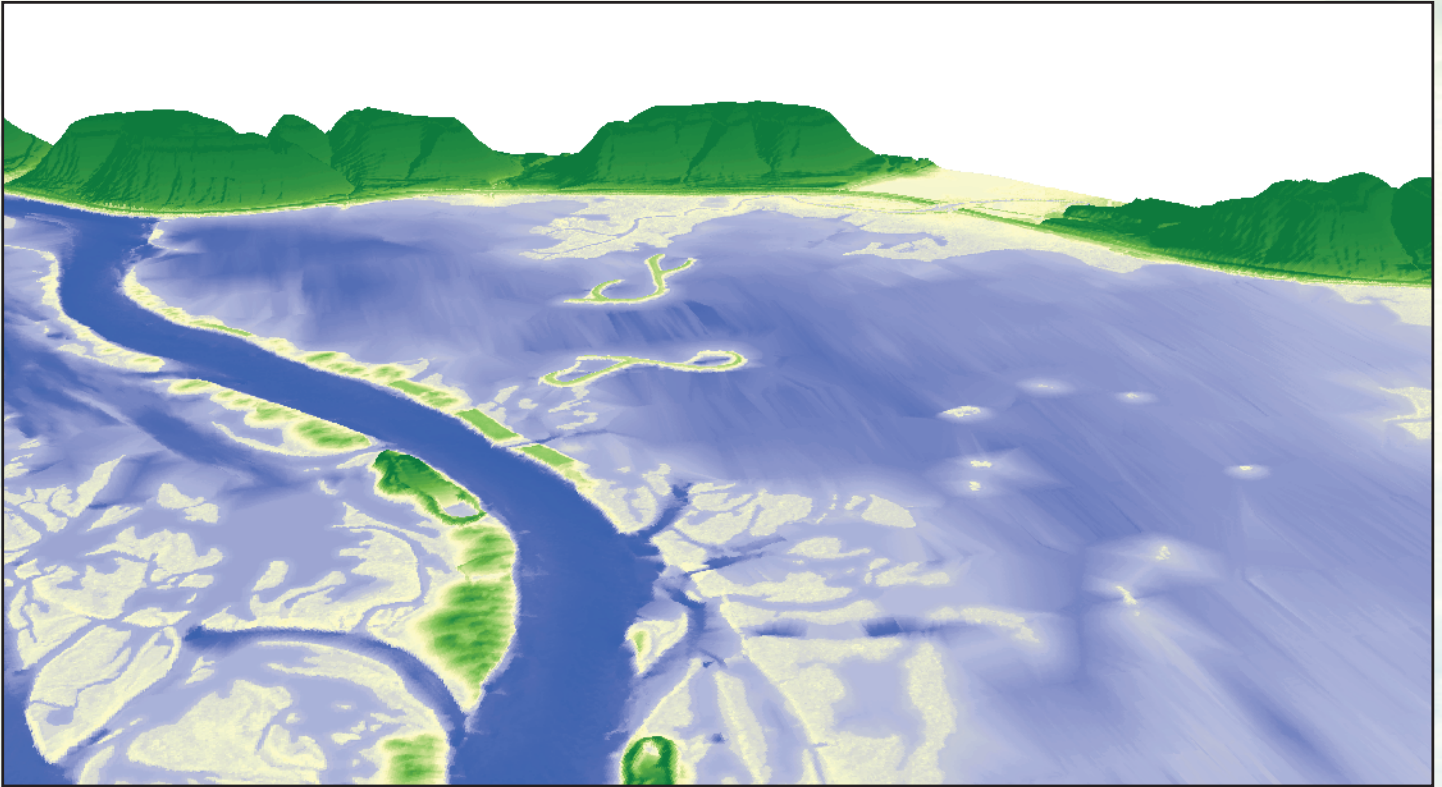
Figure 4. A topobathy, three-dimensional view of the U.S. Army Corps of Engineers' restoration project of Weaver Bottoms, south of Weaver, Minnesota, on Mississippi River Navigation Pool 5.

What is the Future of Topobathy?

Topobathy is one of the fastest growing geospatial products related to benthic habitats, nearshore habitats, and flood plains. Topobathy lidar, a high-resolution sensor consisting of green waveform lasers, is an advanced and powerful technology. An advantage of topobathy lidar is that terrestrial and aquatic conditions may be measured on the same day using only one sensor, which results in the reduction of acquisition cost. Topobathy lidar does have limitations such as limited penetration into turbid or thickly vegetated waters, depth restrictions, and weather conditions. The UMRS is generally too turbid for current topobathy lidar technology; hydroacoustics are presently the most effective technology to measure bathymetry in the UMRS to determine riverbed elevation. As airborne topobathy lidar technology advances, topobathy of the entire UMRS may eventually be acquired using only airborne collected data. Currently, a plan is being developed to replace outdated lidar and bathymetry datasets that make up parts of the UMRS topobathy. Lidar and topobathy data are publicly available at http://www.umesc.usgs.gov/data_library/topobathy.html.

For more information contact:

USGS Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, WI 54603
Jayme M. Stone, 608-781-6290, jmstone@usgs.gov
Jenny L. Hanson, 608-781-6372, jhanson@usgs.gov
Stephanie R. Sattler, 608-781-6272, ssattler@usgs.gov