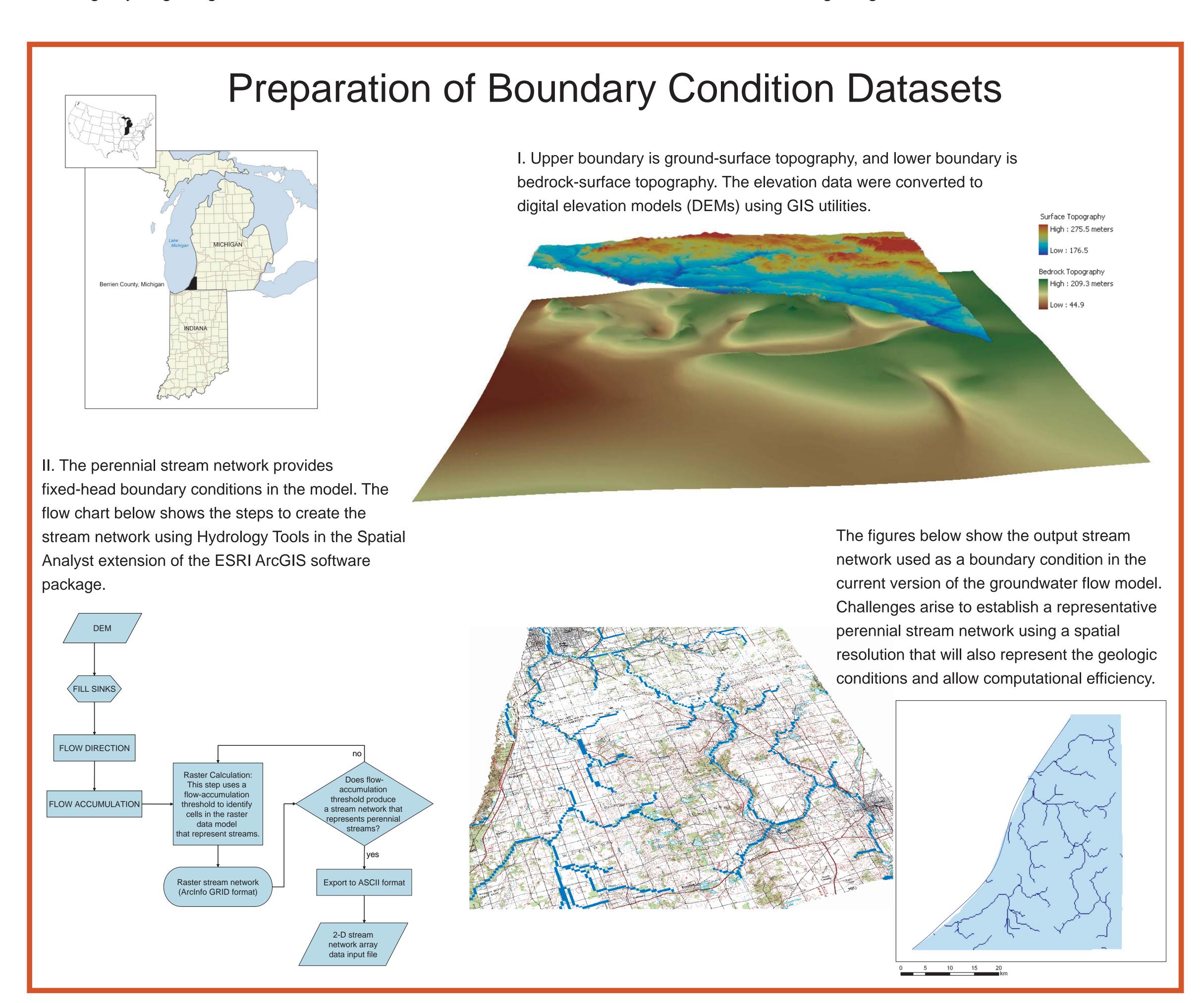


Dressing the Emperor: The Role of GIS in the Development of Three-Dimensional Hydrogeologic Models



Abstract No. 114594

Stone and others (USGS, 2001) mapped structure contours for the tops of each of 20 individual units in intersecting and overlapping glacial morphosequences in Berrien County, Michigan (1,350 km²), as part of the mapping program of the Central Great Lakes Geologic Mapping Coalition (CGLGMC). We have developed a methodology to translate this detailed morphostratigraphy first into a solid three-dimensional geologic model, and then into a three-dimensional block of data that can be used as input to a finite-difference groundwater-flow model. The technique involves a hybrid approach involving geographic information systems (GIS), threedimensional information visualization software (3DIVS), and customized data-processing code. The methodology begins by converting Stone's structure contours (they are attributed vector contours) for each individually mapped unit into a raster surface at a defined grid resolution (200 m x 200 m). The top of the geologic model is the surface topography (digital elevation model), which is also used to derive the drainage network that is an important boundary condition in the groundwater-flow model. The bottom of the geologic model is the bedrock topography, which was also mapped and contoured by Stone (USGS, 2001). Stone constructed his structure contour model such that the bottom of each map unit is described by the surface contours of the unit that lies immediately below it. Complex interrelationships dictate that the tops of a number of individually mapped units are sometimes required to describe the bottom surfaces of laterally more extensive units. Once all of the requisite raster grids have been derived, they can be manipulated to provide input that is necessary for development of a detailed solid geologic model using 3DIVS. GIS software and custom code are also used to assign hydrogeologic attributes to the elements of the final three-dimensional finite-difference geologic model.



Preparation of Geologic Surface Data Sets

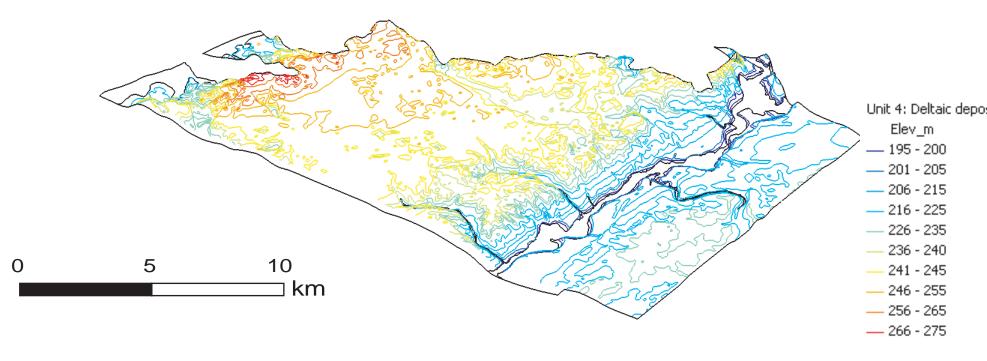
The surficial geologic mapping completed by the Central Great Lakes Geologic Mapping Coalition is the basis for the geologic model used in this groundwater modeling project. Several steps are required in the conversion of the two-dimensional geologic mapping to a threedimensional geologic model.

I. Morphostratigraphic Unit Surface Contours. Byron Stone (USGS) deconstructed the surficial geologic mapping into separate morphostratigraphic units. He then identified the extent of each unit, the shape and configuration of the unit, and its elevation. Each unit was provided to the CGDA groundwater modeling team as a georeferenced vector GIS data layer (shapefile), with attributed contour lines that represent the elevation of the top of the morphostratigraphic unit. The example shown below is for a deltaic unit in the southeastern corner of the county.

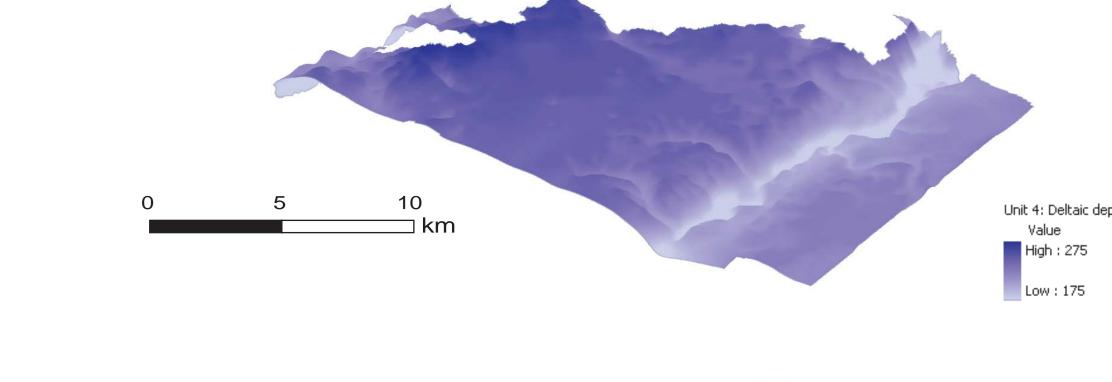
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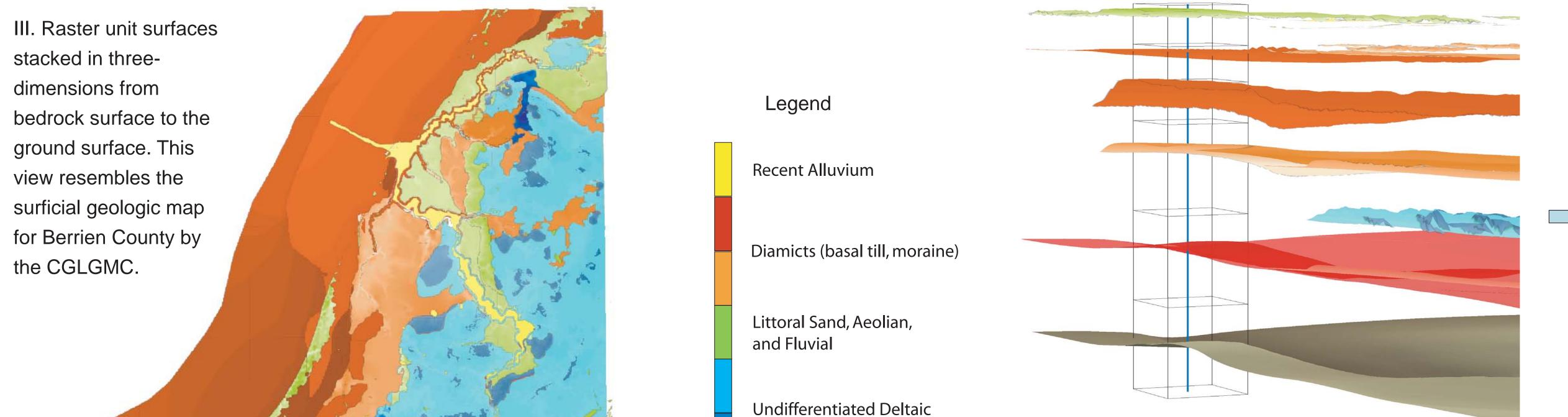
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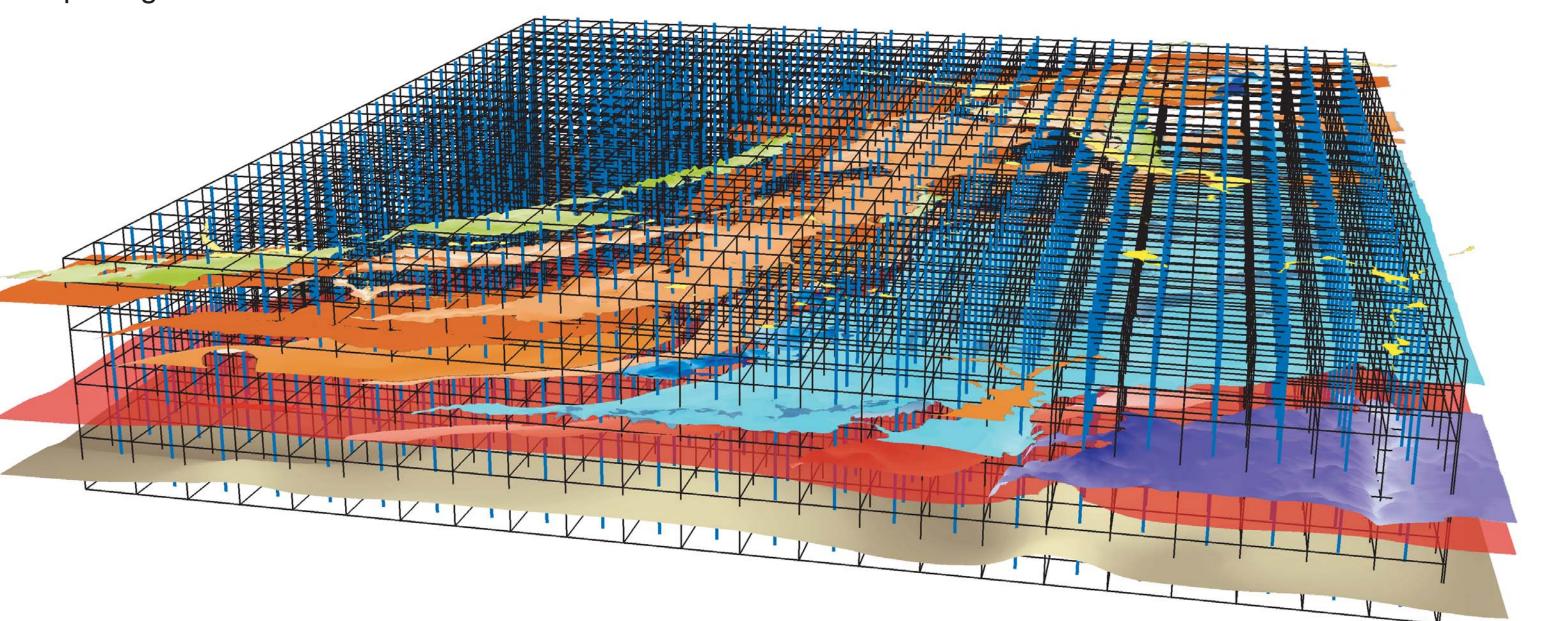
II. Creation of Raster Surfaces for each Morphostratigraphic Unit. Using utilities in GIS software (ESRI ArcGIS), the unit surface contours are converted to raster surfaces at the model resolution (200m x 200m).



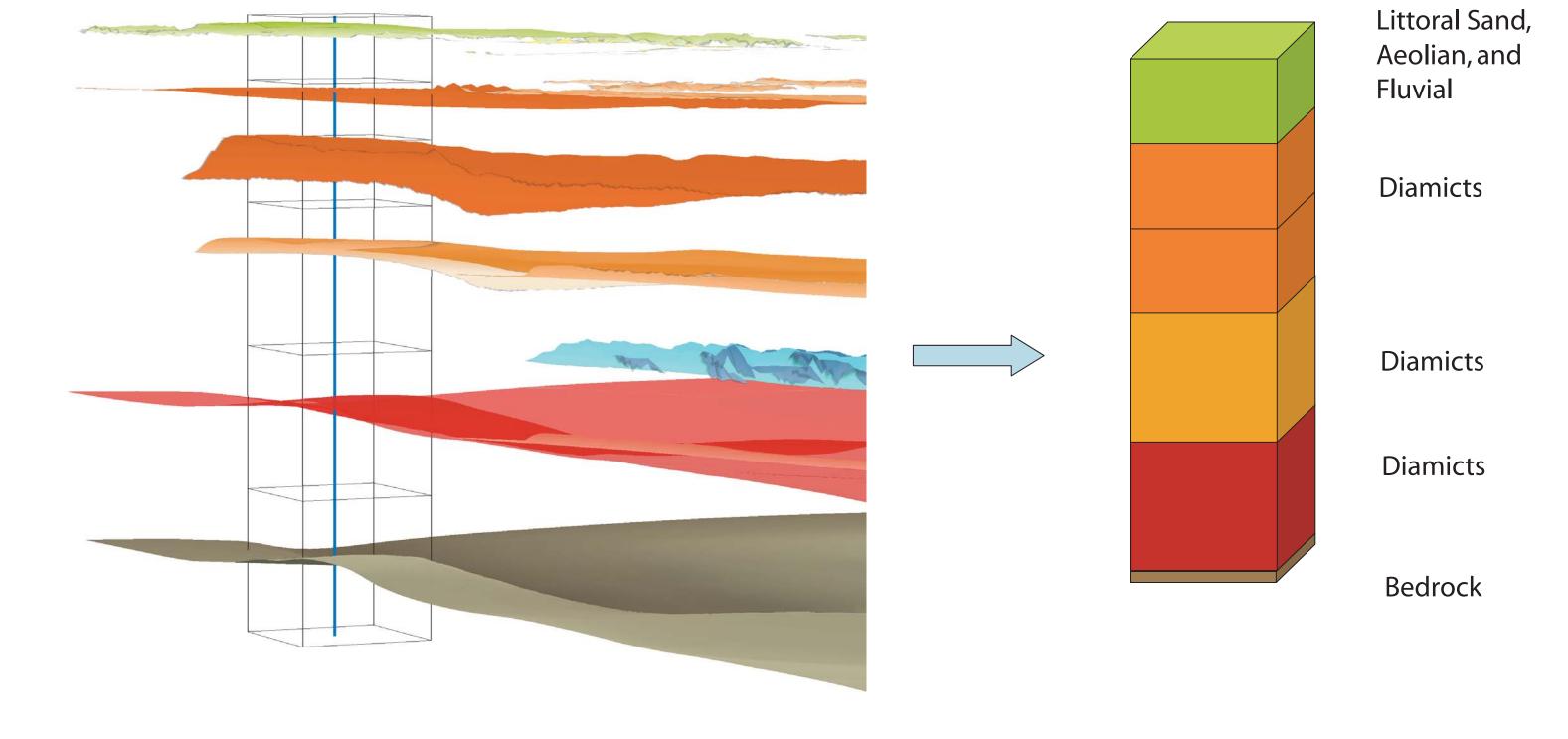


Coarse Grained Deltaic

IV. Conceptual depiction of "virtual well field." This is the method by which the morphostratigraphic units are converted from surfaces to three-dimensional volumes. This figure shows the regular X-Y grid imposed on the domain, and the variable Z-direction grid

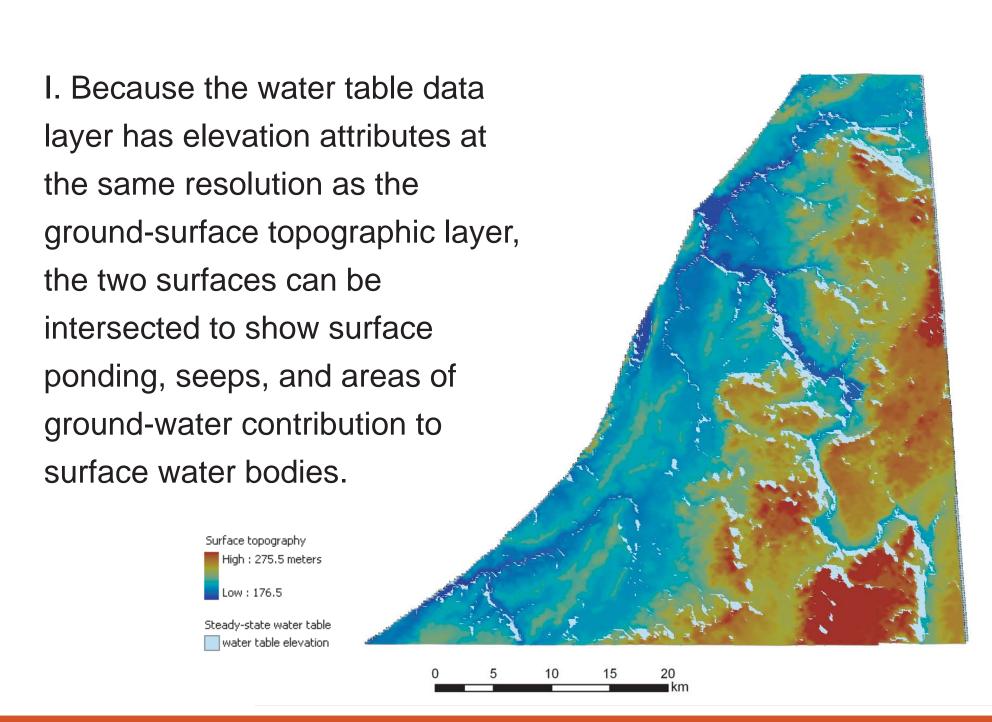


V. Custom computer code is used to identify the elevation of each morphostratigraphic unit surface encountered in each "virtual well." Then, custom programming assigns a code to each grid cell in the three-dimensional array that represents the geologic model. The 3-D array is then imported into 3-D information visualization software (3DIVS, in this case, C Tech's Environmental Visualization System software package).



Model Output Processing and Analysis

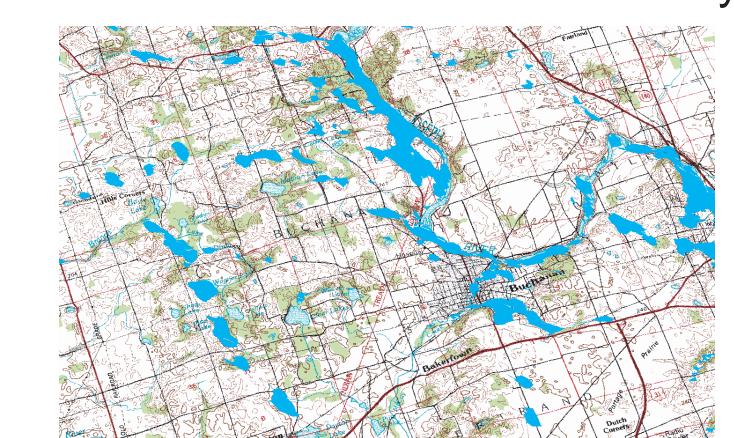
Using GIS software to convert model output to visual images in order to assess model results. These examples show the ability of GIS software to visualize the water-table surface, which is a resultant output data set generated by the solution of the steady-state groundwater model of Berrien County, Michigan.



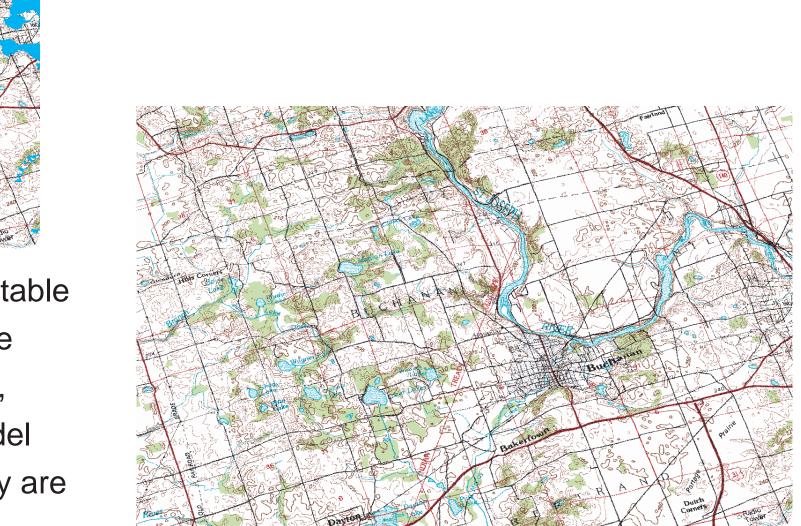
IDCELL Array for Groundwater

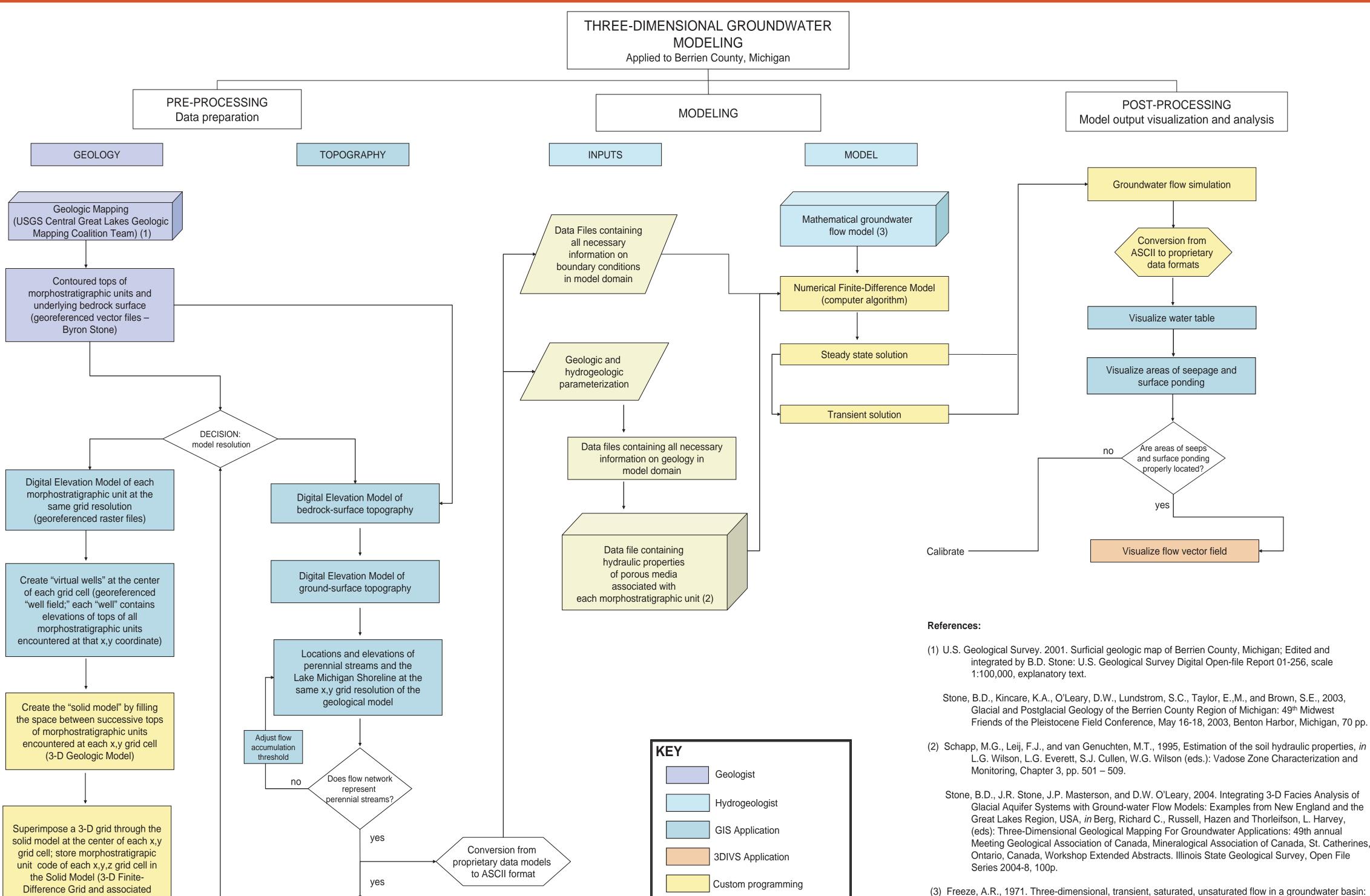
Flow Modeling)

study area



II. This image (top) shows areas where the water table intersects the ground surface. These areas can be compared with known areas of perennial streams, lakes, and wetlands (right image) to evaluate model performance. Areas that are not modeled correctly are calibration targets for future model improvement.





Input files for custom

Published work

programming

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