GIS-based analysis of a geotechnical-geological 3D model of periglacial Quaternary rocks in the southern Leine valley, Lower Saxony

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1. Introduction

Geometric 3D models are a very efficient tool to visualize geological units and structural features that used to be and for simplicity still are presented in only two dimensions on maps or cross-sections.

3D views, virtual wells, or horizontal and vertical cross sections are the preferred choice to present most of the model information within a 3D modeling software environment. However, are there further options to adequately customize the complex information of a 3D model to the needs of the potential spectrum of users? Especially, when integrated geoscientific data are applied in the context of urban development it appears to be very powerful and promising to analyse 3D objects like surfaces or volumes in GIS software. This integration step significantly enhances the creation of required thematic maps.

The investigation area is located in southern Lower Saxony and covers the city of Goettingen and surrounding regions within the valley of the river Leine. The valley is filled by unconsolidated, periglacial sediments of Quaternary age with a variable thickness ranging from 1 to 70 m.

2. Methods

In our investigation we performed a GIS based analysis of an existing geotechnical-geological 3D model of periglacial sediments. The two steps involved were multiple raster calculations to create geotechnical maps and a digital analysis of surface parameters based on geomorphological techniques and statistics.

The analysed 3D model was constructed with GoCAD in a former project (Nix et al. 2009). The model is based on a heterogenous dataset comprising well data, thematic maps, and outcrop descriptions. Finally, the surfaces and volumes of the following units were modeled, with a special focus on their different geotechnical properties: (1) anthropogenic material, (2) floodplain and slope deposits, (3) freshwater limestone, peat and organic clay, (4) loess, displaced loess, and loess loam, (5) fluvial gravel, (6) outwash fan material, (7) solifluction material, (8) mixed, hetereougenous fillings of subrosion sinks and (9) the surface of the underlying hardrocks.

Each top and bottom surface of the various model units was exported as raster file with additional model properties stored in an associated attribute table. In ArcGIS various geoprocessing tools were used to calculate and analyse these rasters and to develope thematic geotechnical and geological maps. The geomorphological analysis was subdivided in several steps. First, the surfaces were described visually, concerning their outline, shape and distribution, as well as superficial structures like distinct edges, holes, channels. Second, descriptive statistic parameters of thickness, area and elevation of each surface were calculated. Third, ArcGIS Spatial Analyst geoprocessing tools were applied to perform on each surface. Finally, several surfaces were combined to analyse them together, calculating ratios and overlay combinations.

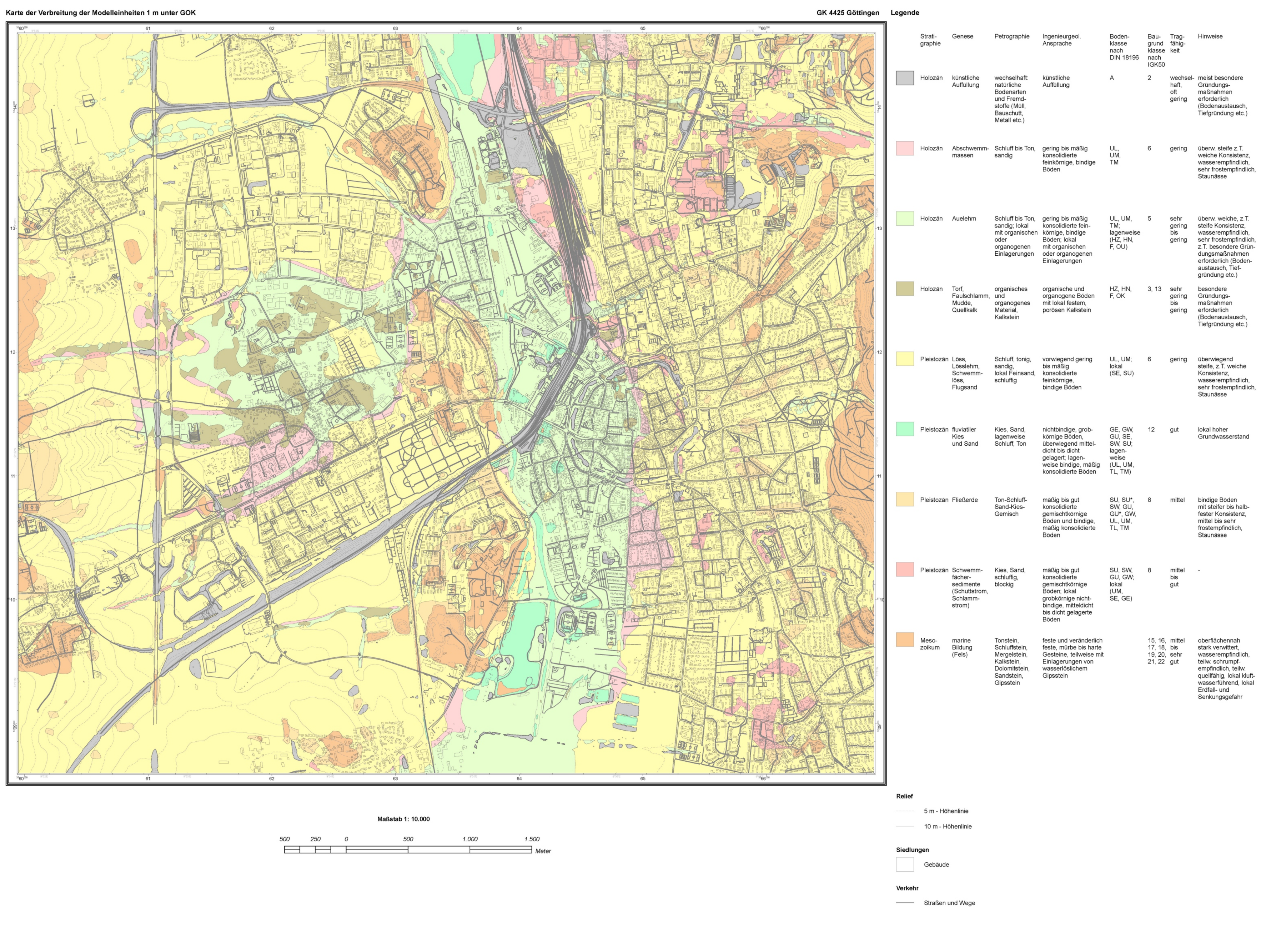

Fig. 1: Distribution map of model units 1 m below ground level

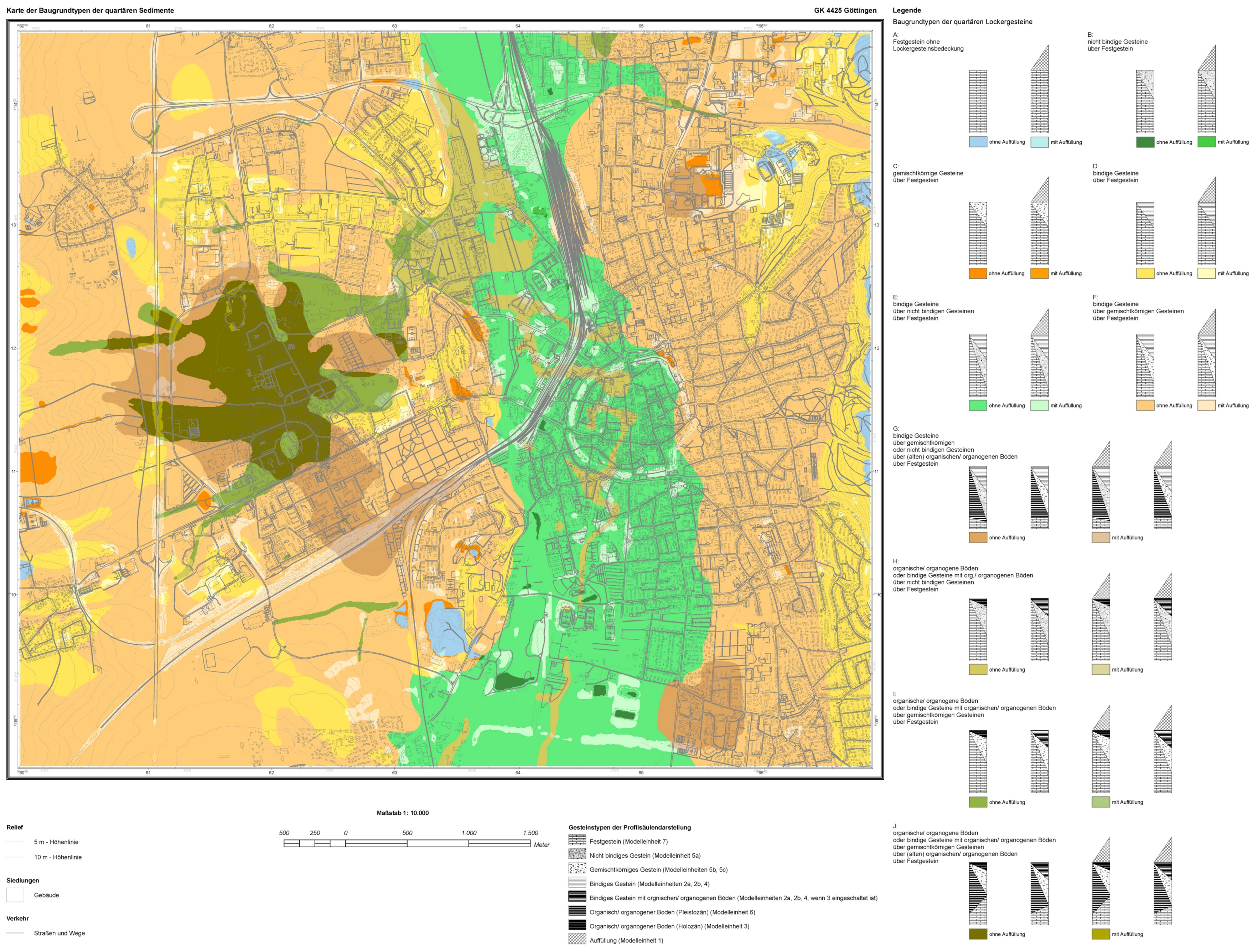

Fig. 2: Map of types of different foundation soils

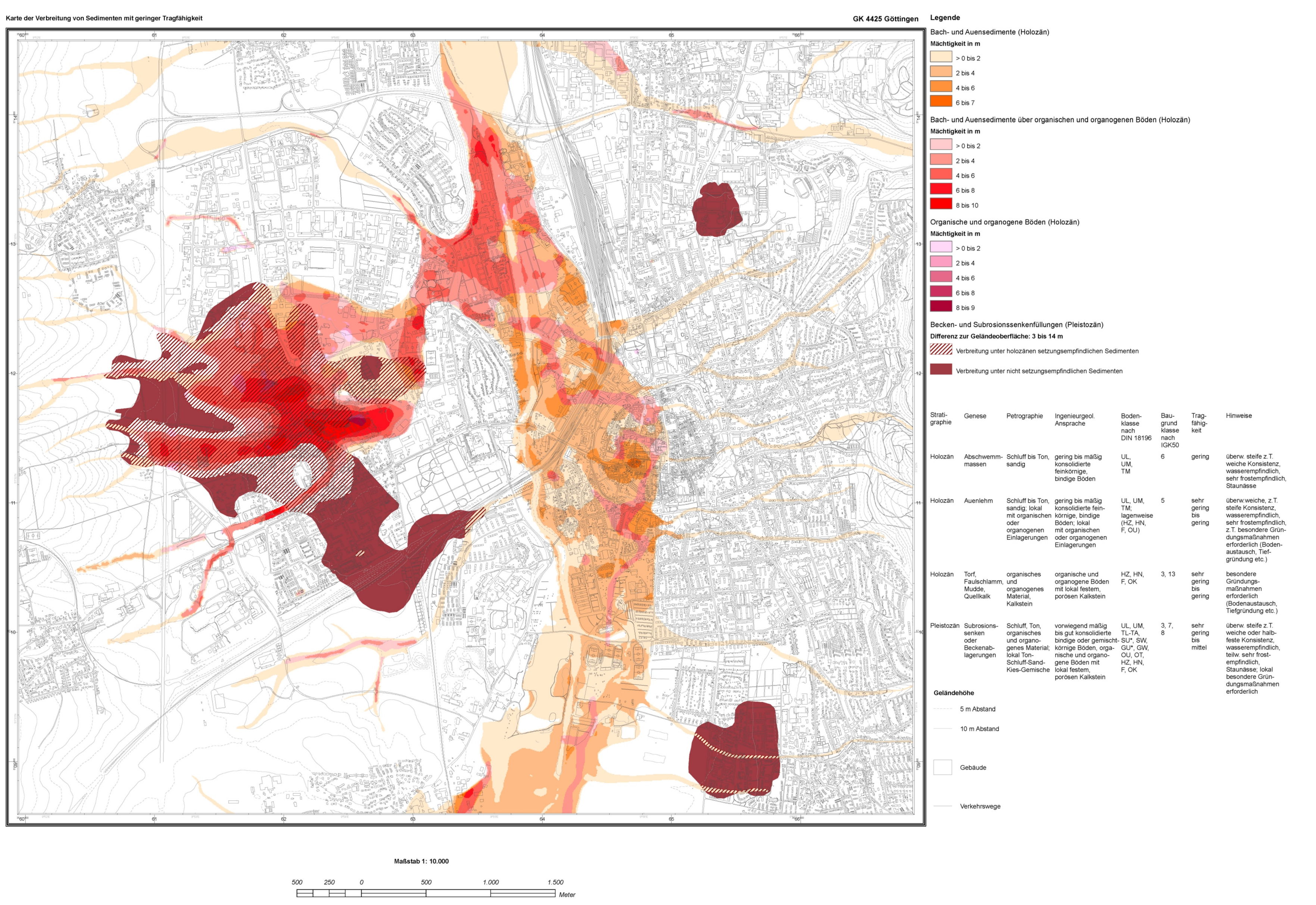

Fig. 3: Distribution map of sediments with low loading capacity

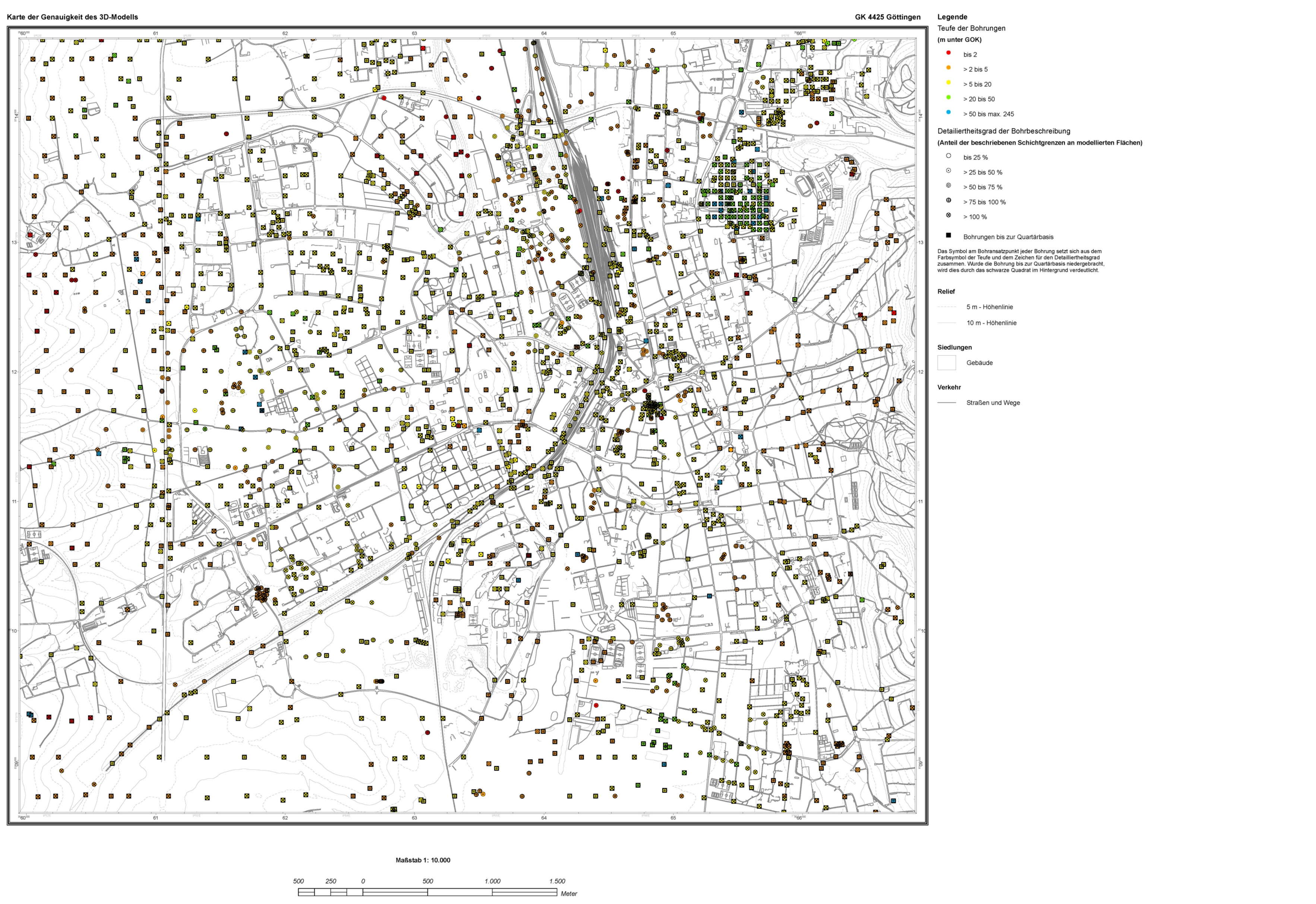

Fig. 4: Map of distribution and quality of the wells

3. Results

As a result, seven thematical geoengineering and geological maps were produced. Each of them presents the qualified interpretation of one portion of the three-dimensional dataset: Map of the stratigraphy and depth of the Quaternary base, Map of the thickness of the Quaternary sediments, Distribution map of model units 1 m below ground level (Fig. 1), Distribution map of model units 2 m below ground level, Map of types of different foundation soils (Fig. 2), Distribution map of sediments with low loading capacity (Fig. 3) and Map of distribution and quality of the wells (Fig. 4). While the map creation focused on the geotechnical aspects of the model, the applied geomorphological analysis revealed various parameter patterns that are related to the geological formation of the model units. Despite the complex dataset represented by the analysed 3D model, thematical information could be transfered into 2D as thematic maps. More detailed geological characteristics and parameters of the model units were extracted by the descriptive and GIS-based analysis.

(Nix, T., Wagner, B., Lange, T. , Fritz, J., Sauter, M. (2009): 3D-Baugrundmodell der quartären Sedimente des Leinetals bei Göttingen. – 17. Tagung für Ingenieurgeologie, S. 223-227, Zittau)