Carole Ryu
Hydrological Modeling
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Module 3

Introduction

This report aims to generate a map of the average groundwater level between two ditches in Buschhagenniederung, a nature protection area near the North Sea in northwestern Germany. The study area is between Osterburg canal and the Hunte canal, both of which are ditches that help regulate water levels.

Methods

The data used was:

-A raster file of the street view map of the area (called TK5.tif)
-an elevation shapefile containing point data with discrete elevation data over the area (called ditches)
-a .csv file of point features containing data on average water level height and coordinate data of each point feature (called Heights)

All files are in the coordinate reference system Gauss-Kruger zone 3 (E-N).

Preparing the data:
-extra notes were eliminated and columns were reformatted in Hydrology_data.xls . Then, it was saved as a CSV file.

Importing the data:
-TK5.tif was imported to the project
-ditches was imported into the project

-the .csv file was imported: (In QGIS: Layer > Add Layer > Add Delimited Text Layer > let auto filled X & Y columns remain > set the CRS to WGS 84. In ArcGIS Pro: turn the CSV into a shapefile using tool “XY Table to Point”)

Make DEM:
-use IDW Interpolation tool on heights.shp
-clip the DEM to the study area only

Make the points:
-make a new layer & digitize line features that line the ditches within the study area. Name one h0 and the other hr.
-Use Points Along Geometry tool > enter points to be made every 20 meters > save as points, hr_points, and h0_points
-Intersect points, h0_points, and hr_points with DEM to get their elevations

Find the distances between h0 and hr:
-in the layer you created, add line features and digitize all 47 lines between h0 and hr
-their distances are automatically calculated. This is R.

Find the distances between h0 and the points made:
-Use the tool “Near” to find the distances between the points and h0

Calculate:
-export to excel the attribute tables of the points, h0_points, and hr_points
-calculate Hx values using Hx = sq rt [(h0^2)+(((hr^2)-(h0^2))/R)*x+(0.000137)*(Rx-(x^2))]

Add excel values to shapefile:
-import the excel file containing Hx values
-join to points.shp

Calculate groundwater level (Hx):
-use IDW tool on points.shp to get a raster that contains Hx values

Adjust groundwater level for impermeable layer:
-use Raster Calculator to subtract 7m from Hx values

Find depth to water values:
-use Raster Calculator to subtract points.shp from DEM

Results

The average water heights in ditches in the study area are visualized (Fig. 1).

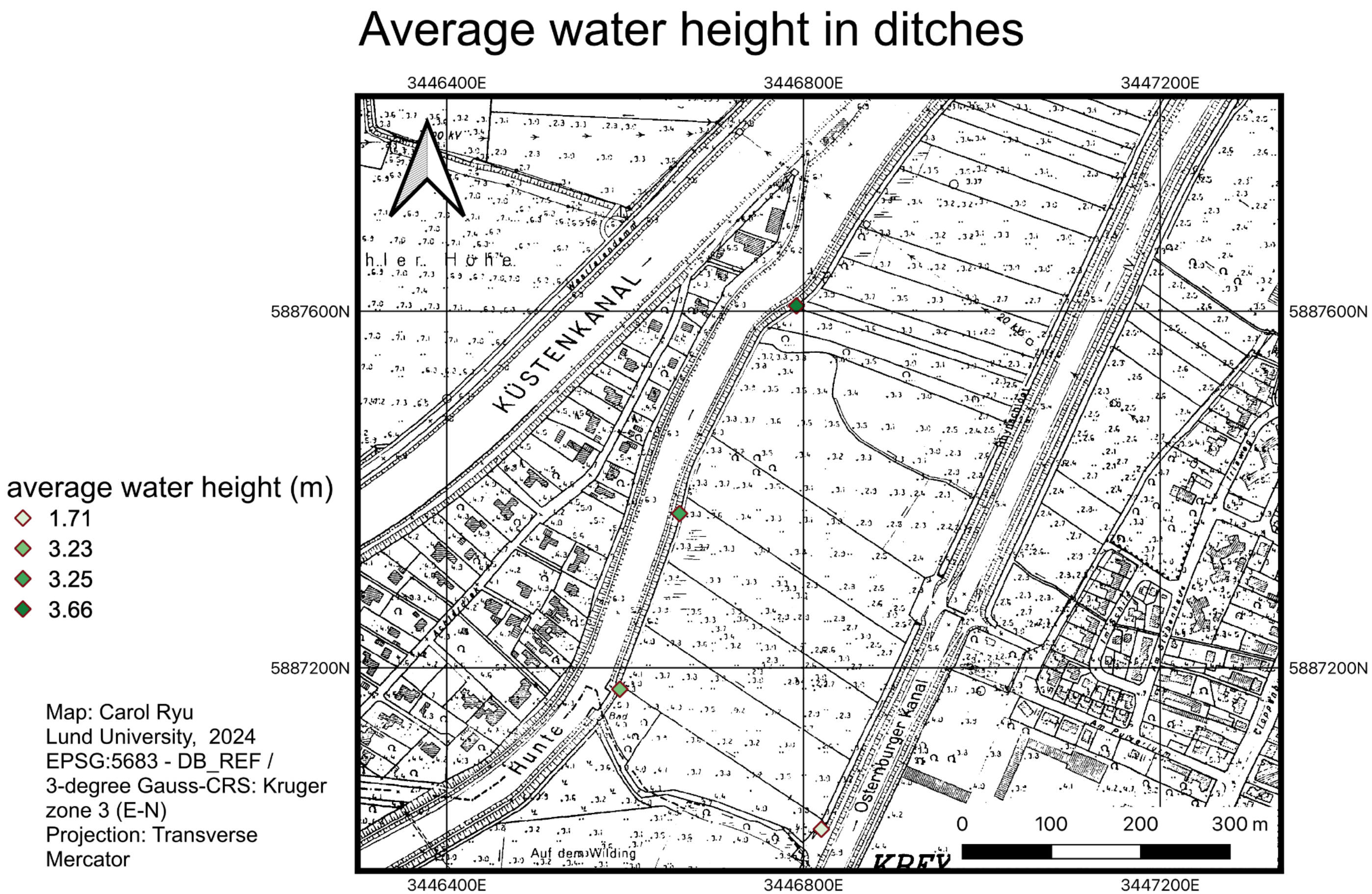

Figure 1. The average water heights in the ditches.

The elevation of the study area is highest in the southwest corner (Fig. 2). The elevation is higher in the southwest and west and gets lower in the east, with values ranging from 4.8m to 2.2m.

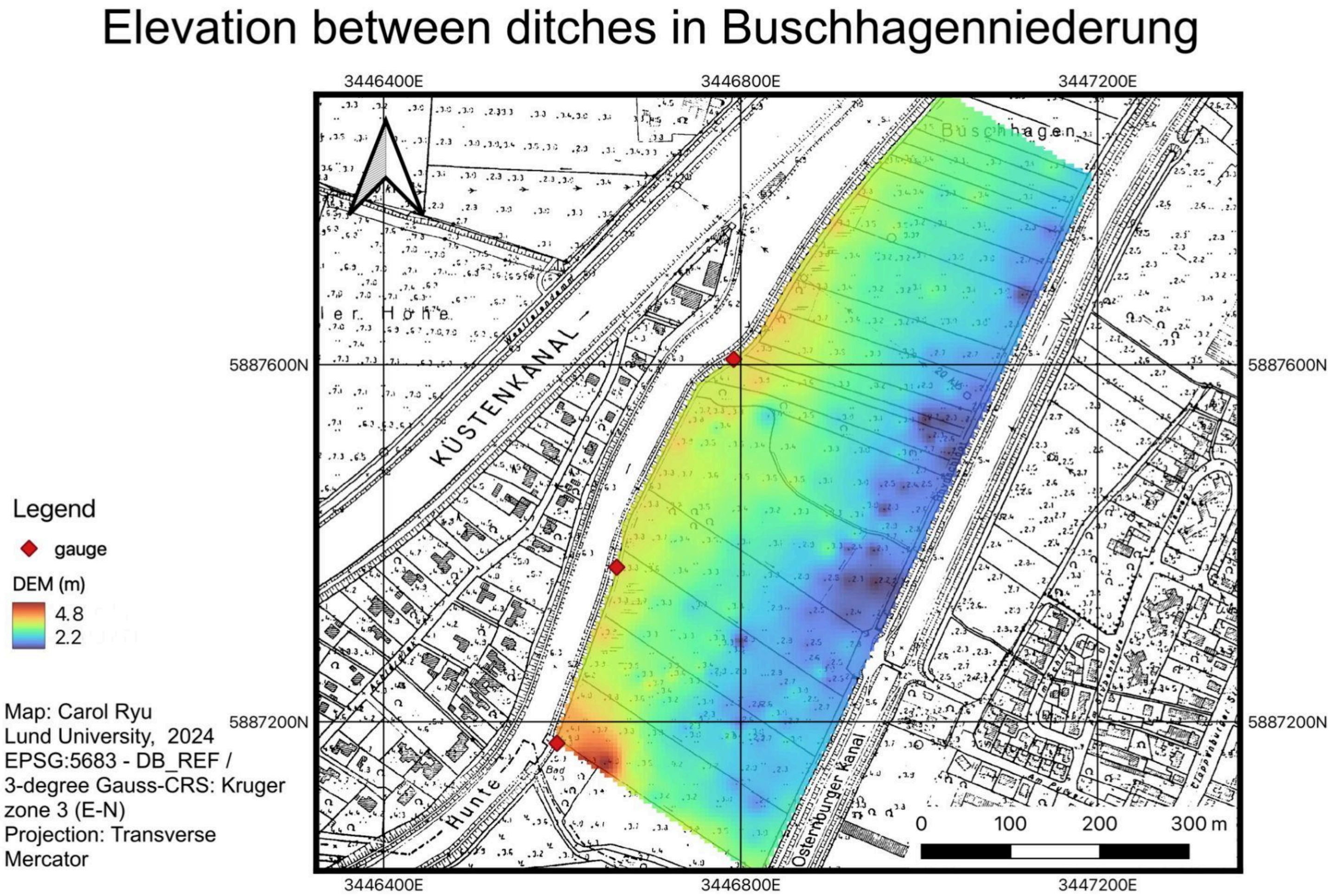

Figure 2. DEM of the study area.

The groundwater level is highest in the center of the study area at up to 10.5m, and lower around the western edge (Fig. 3).

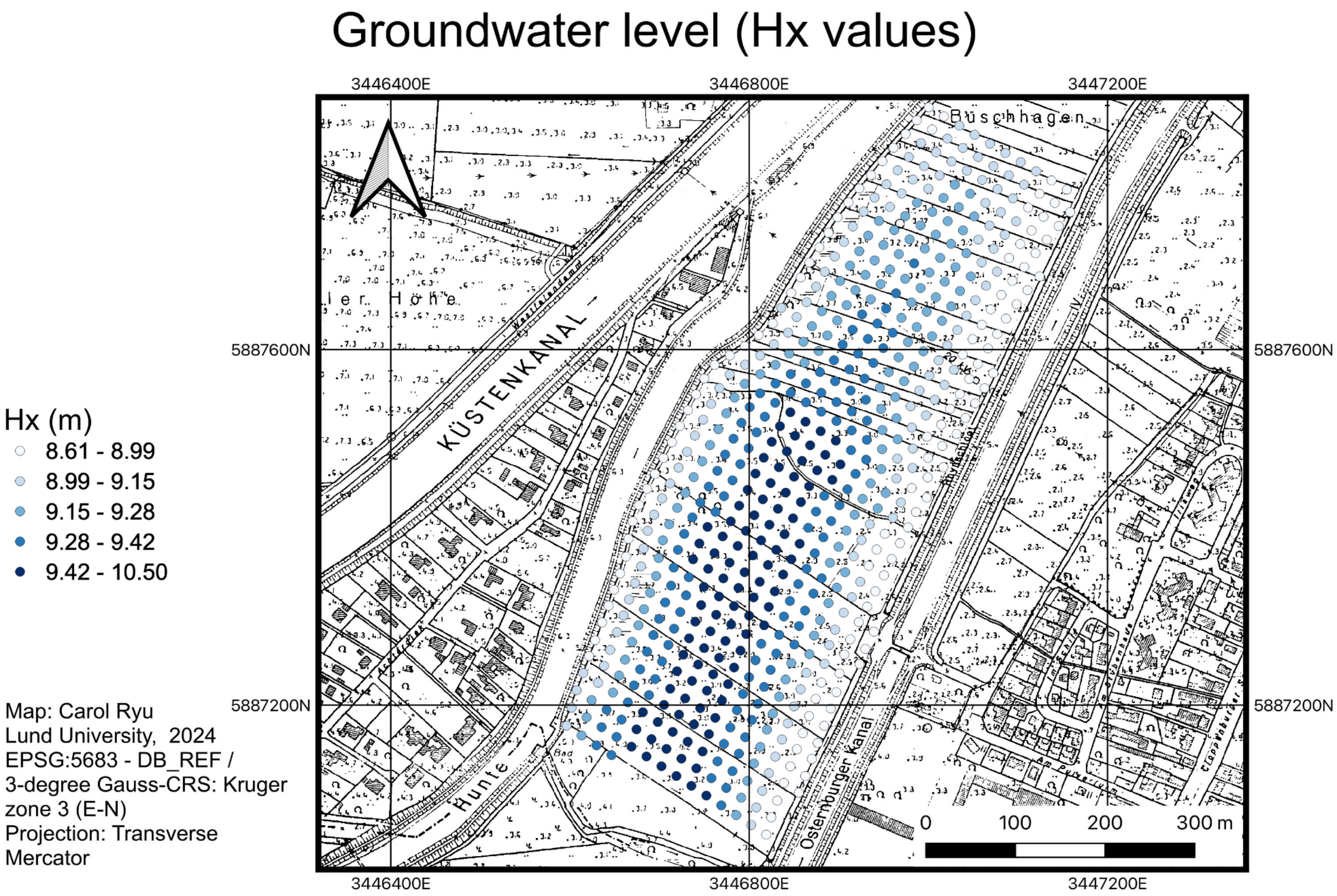

Figure 3. Groundwater level values (Hx) in the study area.

Then, IDW was performed on Figure 3 (Fig. 4).

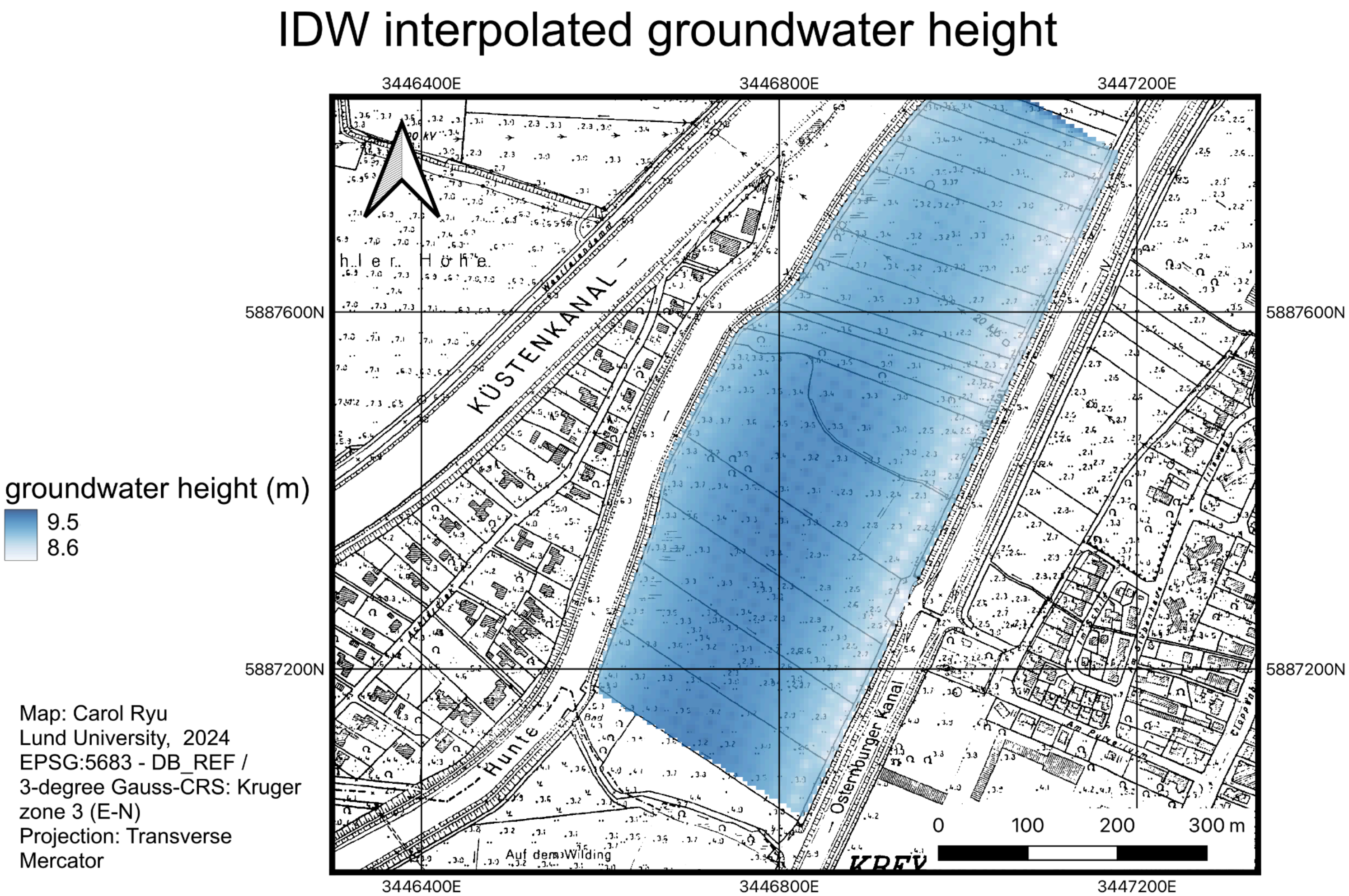

Figure 4. IDW interpolated groundwater between the ditches.

Raster Calculator was used to subtract 7m from Figure 4 to account for the bedrock (Fig. 5). The groundwater level height above the bedrock ranges from 2.5m - 1.6m, with higher values in the center of the study area and lower values near the eastern edge.

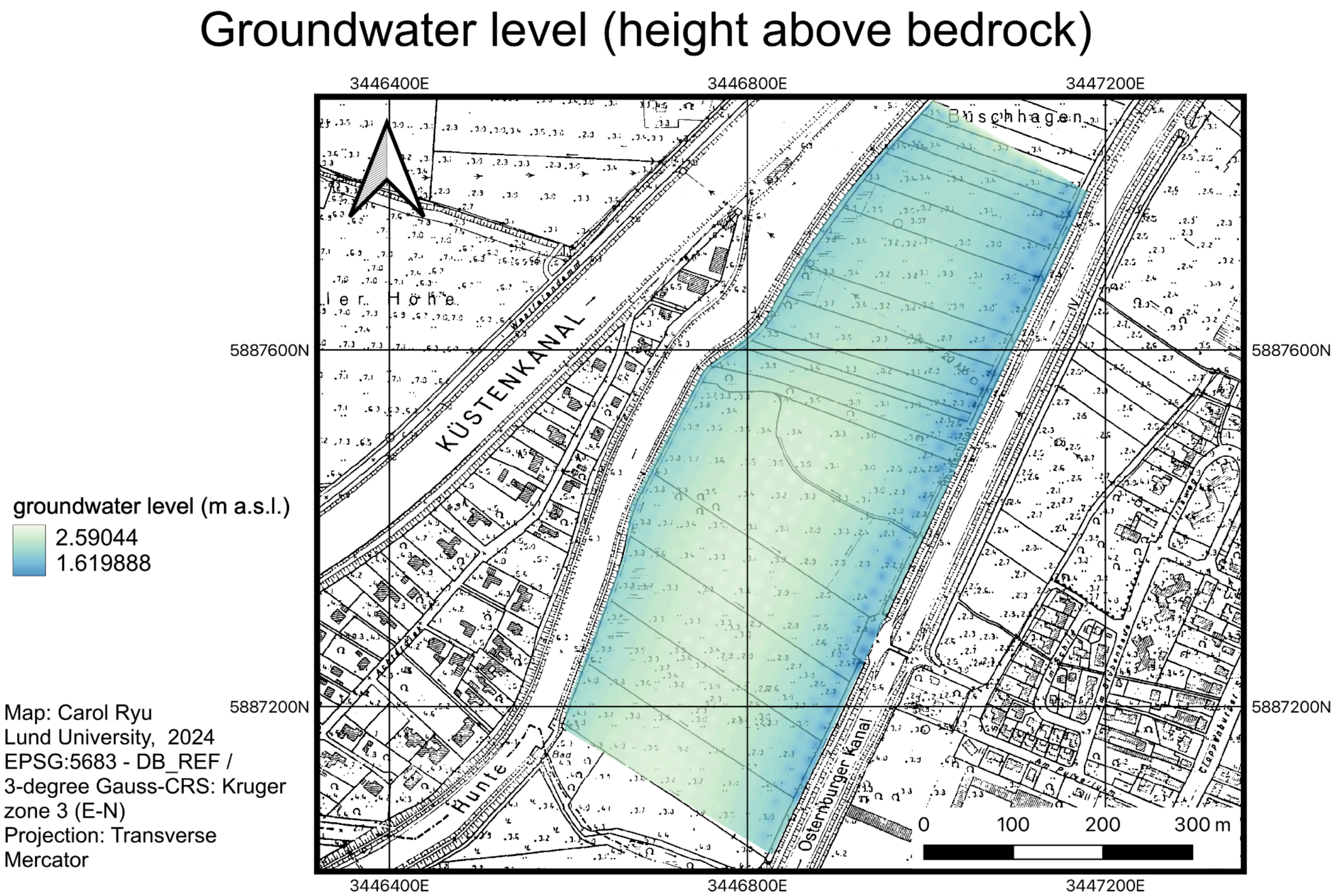

Figure 5. The groundwater level height accounting for the bedrock in the study area.

The depth to water table shows that there are negative depth ranges in the center and east of the study area, which indicates that the groundwater table is higher than the surface elevation (Fig. 6).

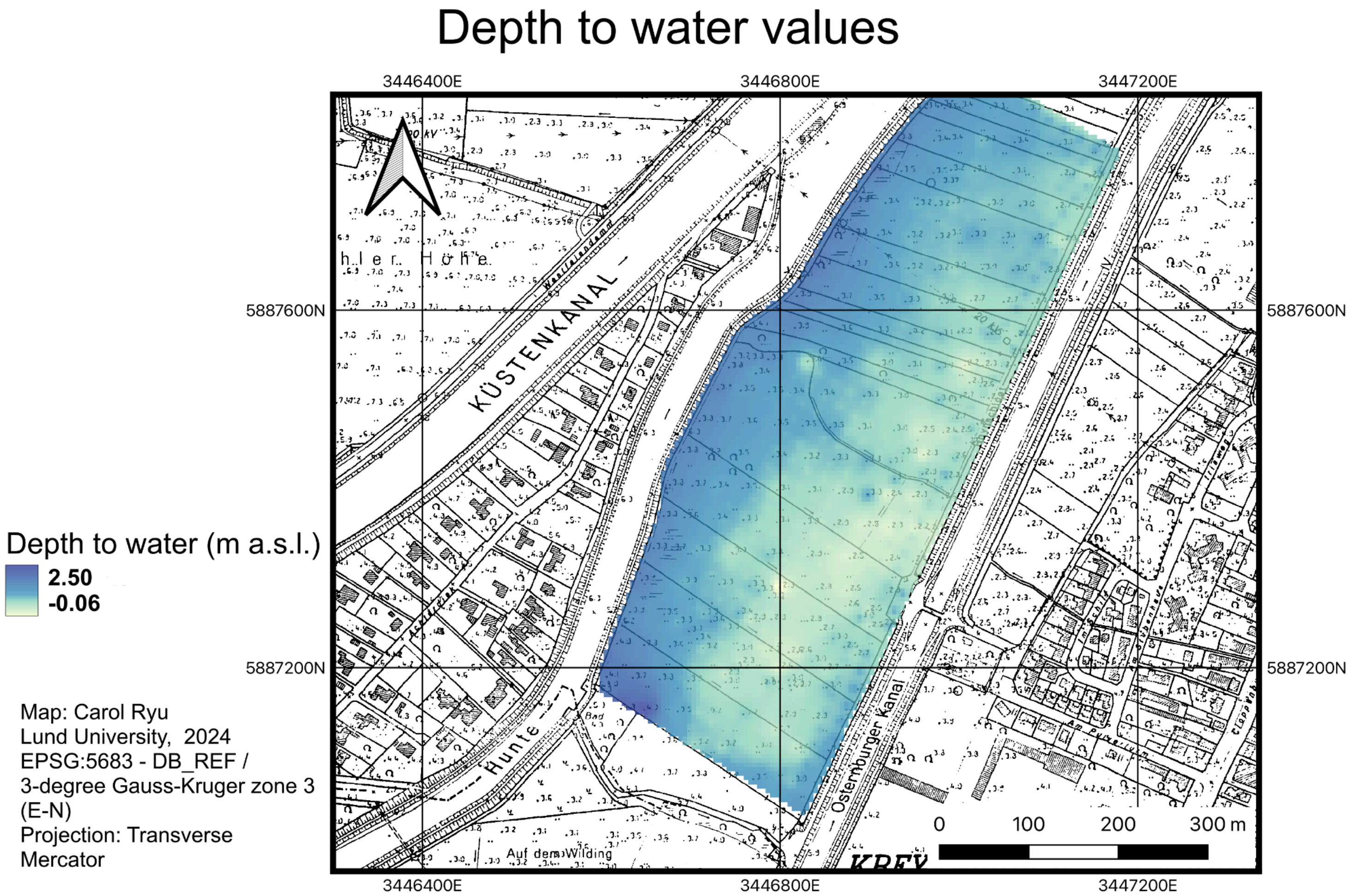

Figure 6. Depth to water table in the study area.

Discussion

The depth to water table shows that there are negative depth ranges in the center and east of the study area, which indicates that the groundwater table is higher than the surface elevation (Fig. 6). This may be due to a waterlogged, shallow ecosystem, such as a marsh or wetland.

The elevation of the study area is highest in the southwest corner (Fig. 2). The elevation is higher in the west and gets lower in the east, with values ranging from 4.8m to 2.2m. This suggests a slope in the study area with land descending towards the eastern study area.

The groundwater level height above the bedrock has higher values in the center of the study area and lower values near the edges (Fig. 5). This may be due to topographical formations or proximity to sources of water flow.

This method could have more accuracy if more sample points were taken to add to the dataset containing average water levels. This would provide more accurate water level data to calculate Hx values. The analysis undertaken in this study may be used by policymakers to address flood risk and the use of ditches to manage flooding.