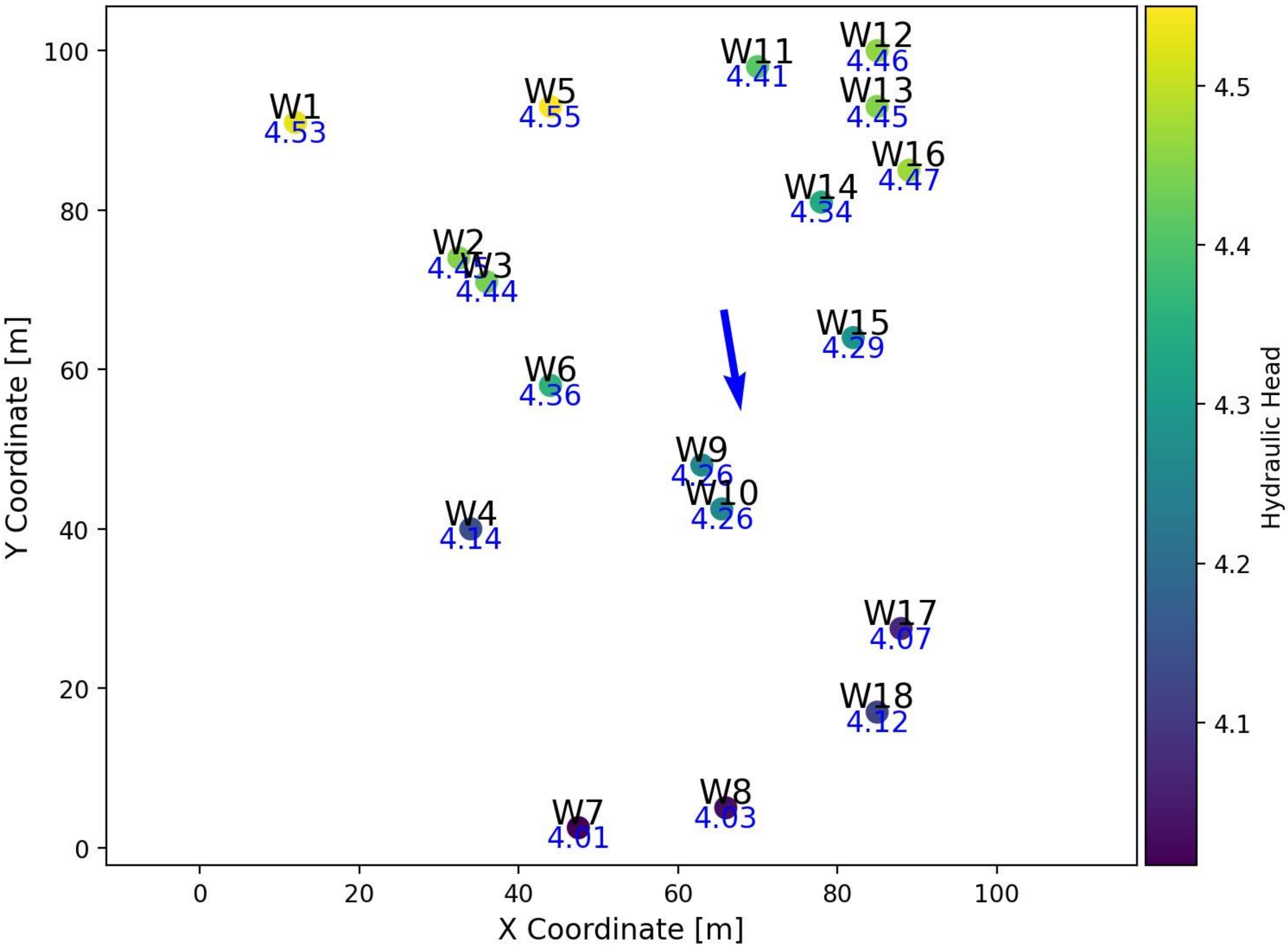
HeadAnalyser User Manual

Oliver B. Lund



User manual for version: 1.0.1

4th. June 2024

Contents

About the program

‘’HeadAnalyser’’ has been built entirely using Python (version 3.11.2, using the Tkinter and customTkinter libraries for the user interface). The coding has been performed by Oliver B. Lund, DTU Sustain. The foundation for this program is an R-code script developed by Gregory Lemaire and Anton Bøllingtoft, DTU Sustain. The idea and solution are based on the work of J. F. Devlin published in the paper: *HydrogeoEstimatorXL: an Excel-based tool for estimating hydraulic gradient magnitude and direction (Devlin og Schillig, 2017).* Poul L. Bjerg, DTU sustain, initiated the development of the program and provided in collaboration with PhD students and students input to content and layout.

Introduction

Welcome to the HeadAnalyser program, a specialized tool for visualizing groundwater flow and gradients. This program transforms hydrogeological data into clear, graphical representations, aiding in effective data analysis and interpretation.

System Requirements

The program requires the user to be using a computer with windows, as it does not support other operating systems.

Data Requirements

Before using the program, ensure you have data in one of the following formats: .csv, .xlsx or .json. The data must contain the following 4 columns:

- An ID column, such as DGU numbers.
- An X and Y-coordinates column. **<u>This should be in UTM32EUREF89 or similar UTM coordinates</u>** to ensure points can appear on map.
- A hydraulic head column

Two columns with top or bottom values for borehole intakes is **<u>optional</u>**, but if present, allows for more data filtration options.

<u>Note:</u> Datasets of very large size (40 rows or more with many different IDs/Boreholes) can be too demanding for the program and can potentially cause it to either be very slow or crash on certain systems.

Opening the Program

Open the program by opening the HeadAnalyser.exe. Unzip the zip-file to a folder and ensure that the HeadAnalyser.exe is in the same folder as the DTU_logo.png. As of version 0.9.7, the program might be flagged as a virus by windows antivirus (e.g. a trojan virus). This is due to windows defender not knowing this program and can be circumvented by either ignoring the warning message and/or by allowing the program to pass the firewall.

User Interface Overview

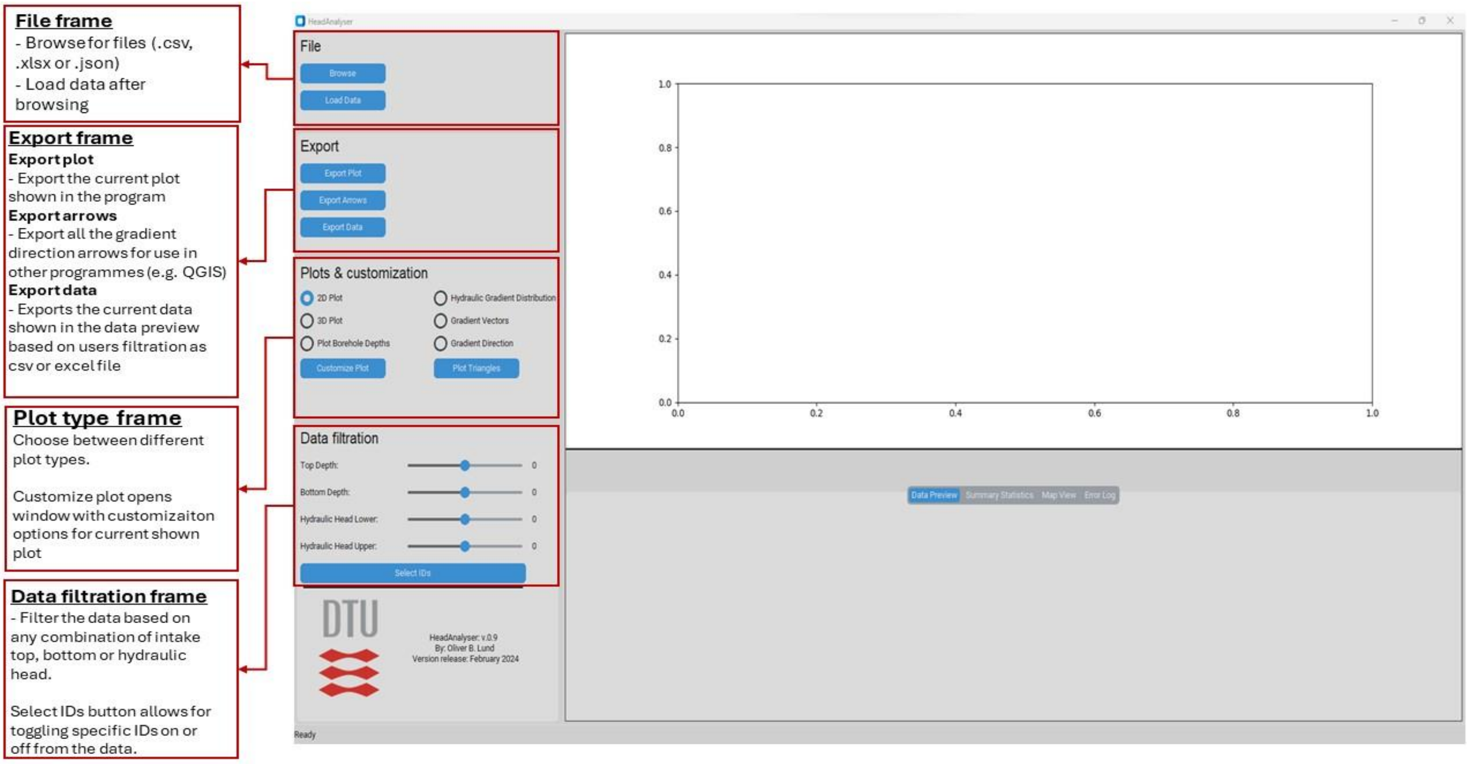


Figure 1: Overview of how the program looks, with a focus on the 4 primary frames the user interacts withs.

File Frame

The file frame is the first part of the program the user should interact with. It can be seen in the top left corner in figure 1. Here you should press the browse button and choose which file you want to load. The program defaults to only showing .csv files when browsing, so make sure to check this in the file browser window if you cannot find your file. Once a file has been selected, press the load data button.

Upon pressing the load data button, the program will prompt you for the column names of your data. Simply click the 4 dropdown menus one at a time and select the appropriate columns in your data that corresponds to the ID, x-coordinate, y-coordinate and hydraulic head columns in your own data. If the file loaded is an .xlsx file, the program first prompts you for your sheet name.

The program comes with a set of test data which can be found under ‘’test_data’’ in the folder the program came with.

Export frame

This frame contains various options for exporting the data, plots, and results from the program.

Export plot

The export plot button will allow you to save a high quality .png file of the current plot shown in the program in a desired location.

Export arrows

The export arrows button allows the user to export the gradient arrows shown on the Gradient Vectors plot. The exported file is a .csv file formatted as Well-known text (WKT), which is a text markup language for representing vector geometry objects. This is a suitable and easy to use format inside GIS software such as QGIS.

Using in QGIS

To use this .csv file inside QGIS, you should navigate to the data source manager and select the delimited text option in the side menu as shown in figure 2. At the top, select the file by pressing the button with … and browse to the location of the exported arrows file. The program should automatically detect the geometry definition as WKT.

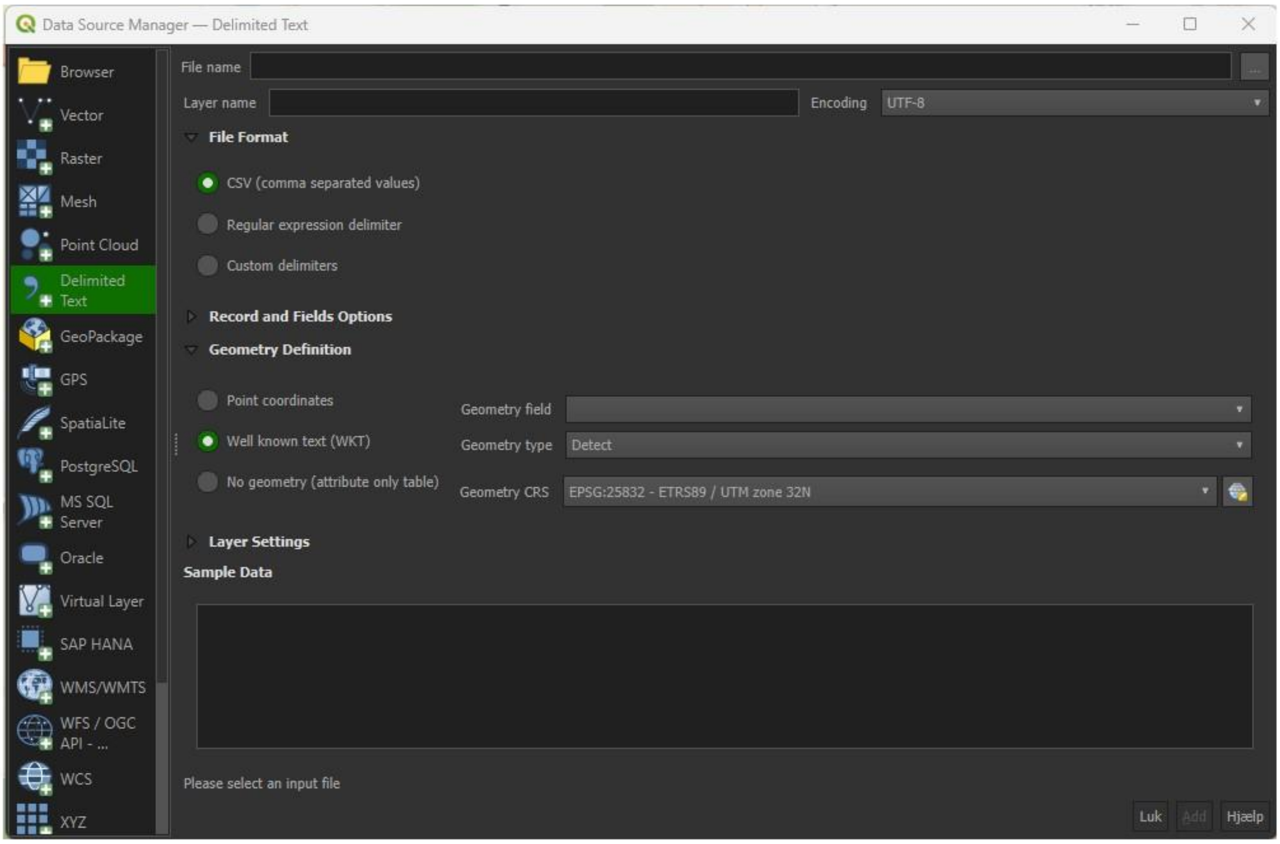


Figure 2: QGIS data source manager menu

After loading the delimited text file into the program, open the symbology for the layer by double clicking the layer. Once you have navigated to the symbology section for the layer, you will see a menu like in figure 3.

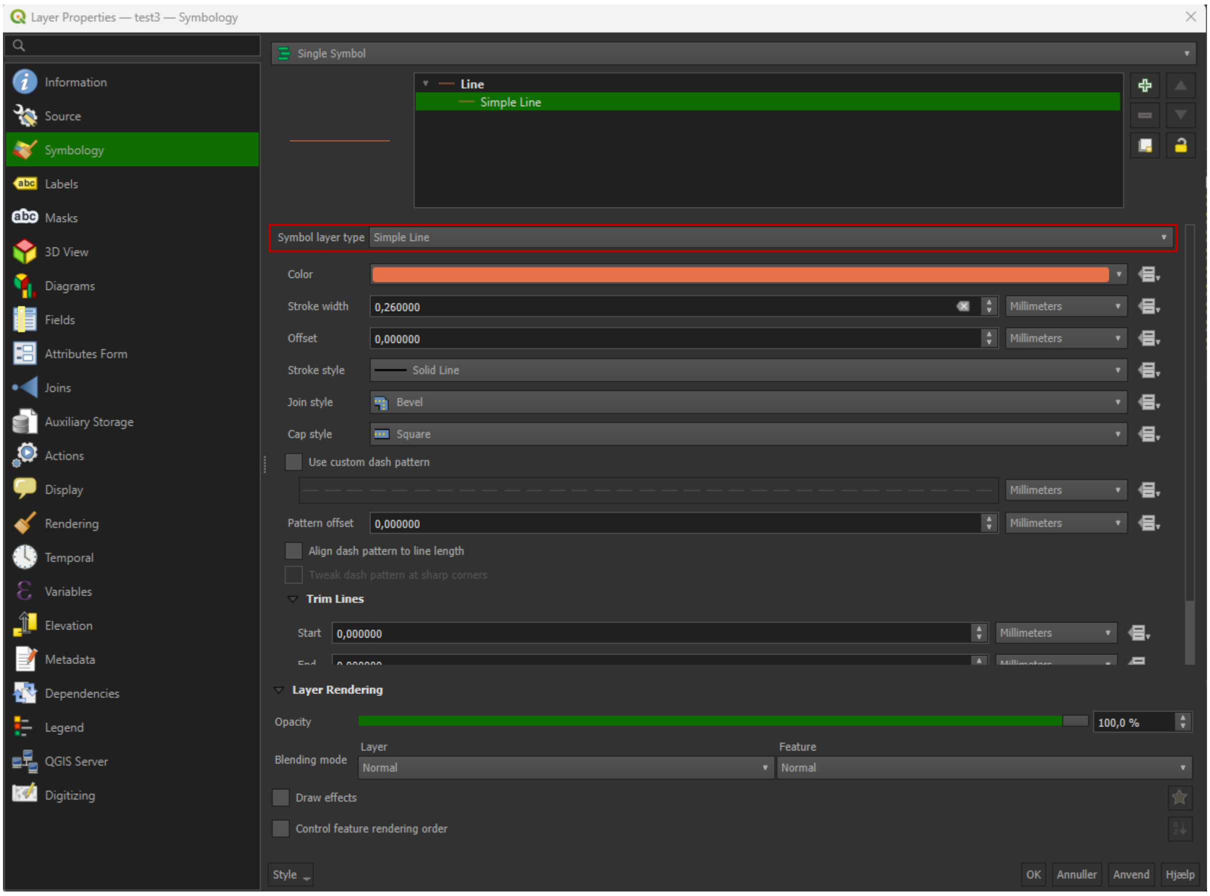


Figure 3: QGIS symbology menu.

Once looking at this menu, click the simple line and then navigate to the *symbol layer type* at the top of the menu (outlined by red in figure 3). Open this dropdown menu and select the *arrow* option. Now navigate to the top menu that says *single symbol* and choose the *Graduated* option from the dropdown menu. Choose *value* to be gradient at the top of the menu, and then press classify to classify the arrows based on their gradient values. This can be seen in figure 4.

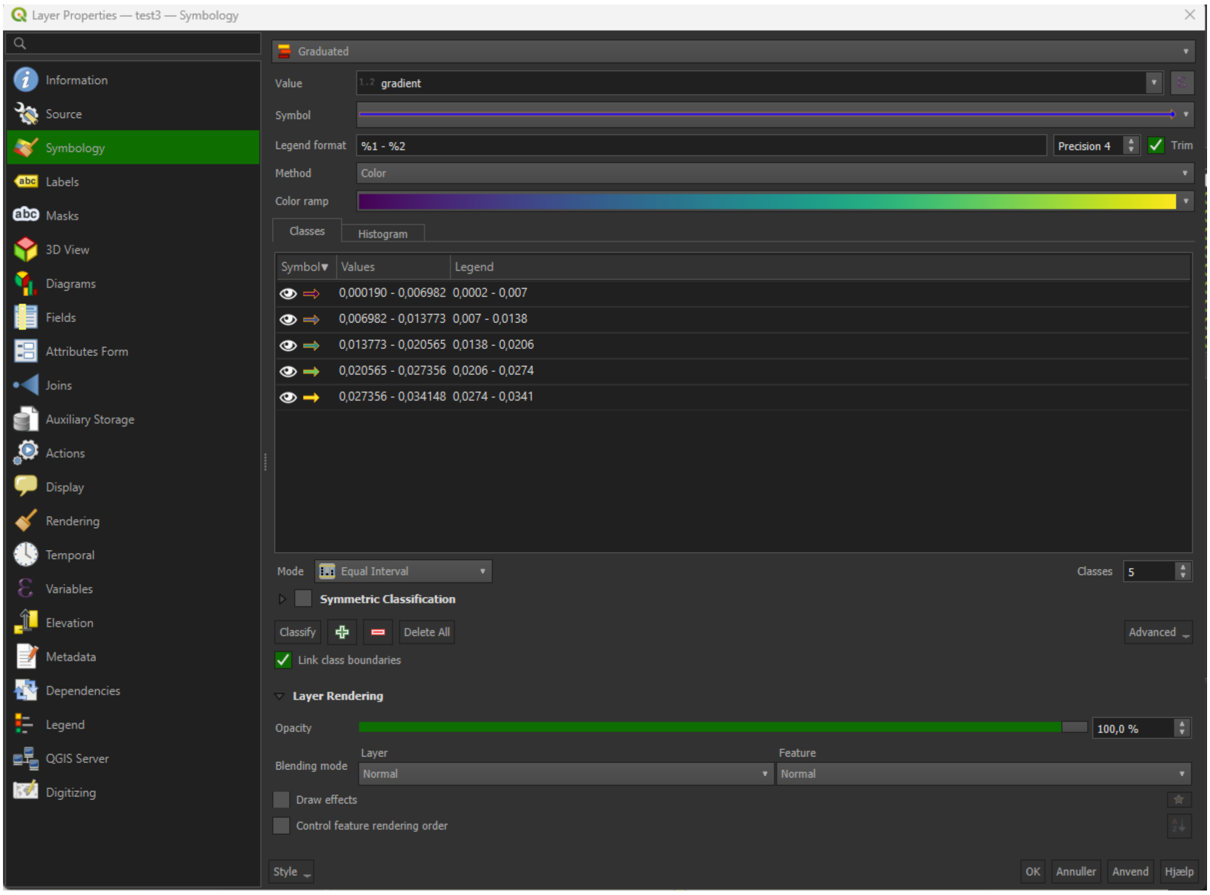


Figure 4: QGIS symbology menu for graduated symbology.

After making these changes, the arrows can be seen on the map inside QGIS (figure 5):

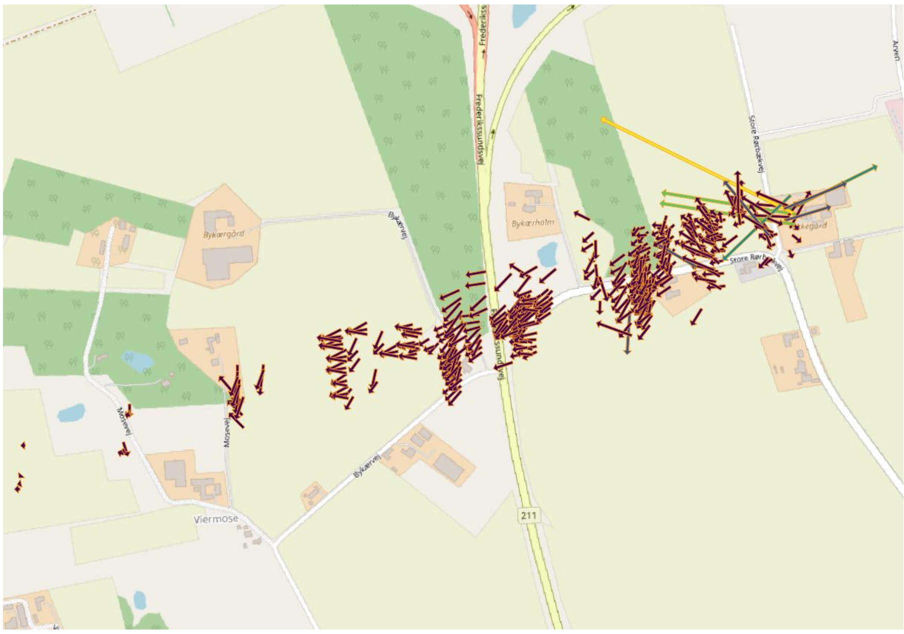


Figure 5: Arrows exported from HeadAnalyser displayed inside QGIS.

Export data

The export data button allows for the user to export the data displayed in the Data Preview tab to excel or as a .csv file. The data exported is based on the current filtration done by the user inside the program.

Plots & customization frame

The Plots & customization frame is where different plots can be chosen and displayed in the plot visualization frame. Currently, the program supports 5 different plots.

2D plot

The first plot that is displayed by default when loading data is the 2D plot, which shows the boreholes in the loaded data (figure 6). The ID and hydraulic head value can be toggled on as labels. Contour lines can also be displayed alongside many other customization options by pressing the customize plot button.

Currently, the plot is dealing with stacked points (multiple intakes for one borehole) by displaying a triangle instead of a circle if stacked points are detected.

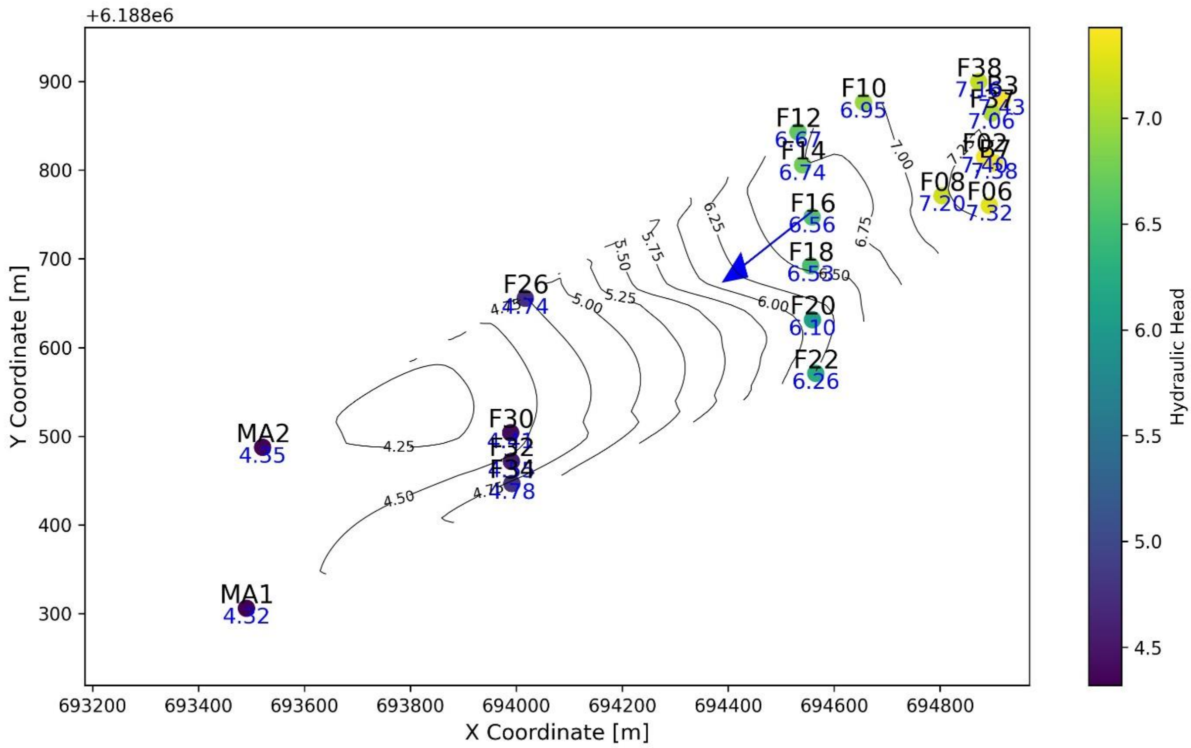


Figure 6: The first plot the program displays upon successful loading of the data.

3D plot

The 3D plot (figure 7) shows more or less the same as the 2D plot, just in 3D. Currently, the plot does not contain much that the 2D plot does not show, but more may be added in the future.

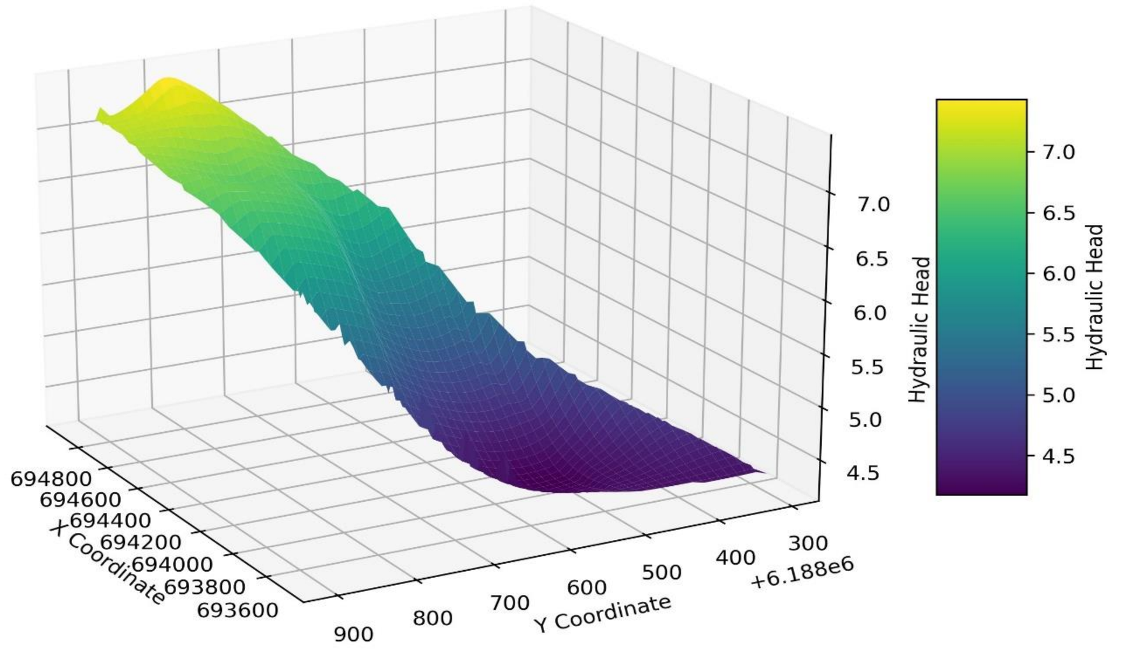


Figure 7: 3D visualization of the boreholes and their hydraulic head values.

Hydraulic gradient distribution plot

This histogram plot (figure 8) shows the distribution of the gradient magnitude for each arrow calculated for each of the triangles formed by the boreholes in the loaded data. A red line to display the mean gradient magnitude is also displayed on the plot.

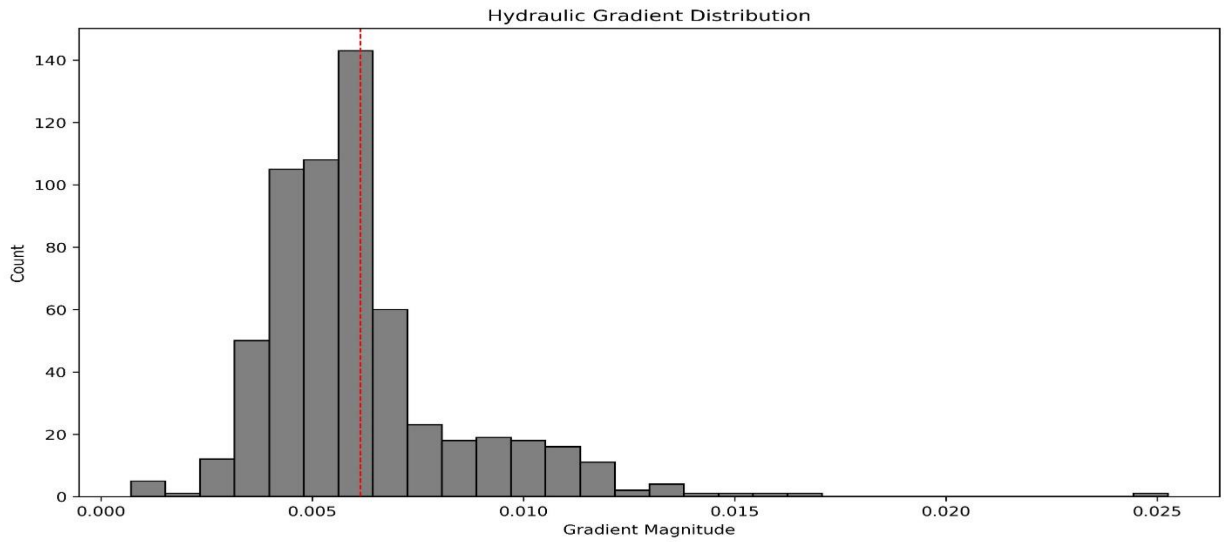


Figure 8: Histogram of the distribution of the gradient magnitudes of each of the triangles formed by the data points.

Gradient vectors plot

This plot (figure 9) shows each of the gradient vectors formed by each of the possible triangles in the loaded data. Each arrow can be clicked to see more information on which points were used to create the arrow, the angle of the arrow, and the gradient value.

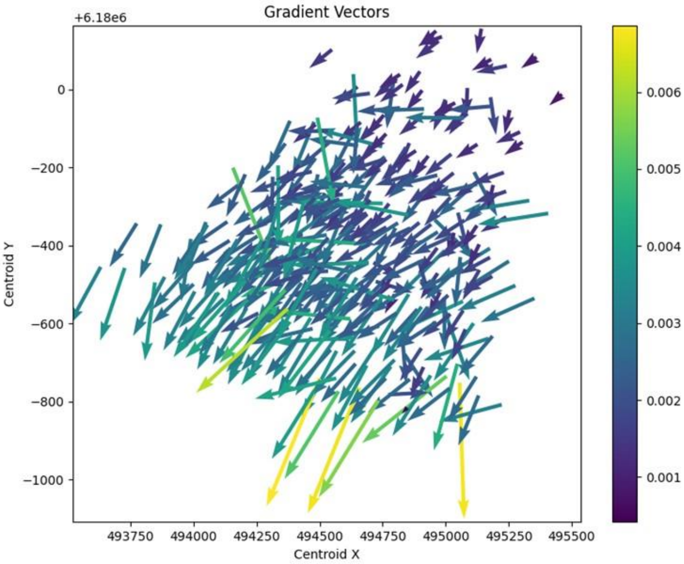


Figure 9: Arrow direction and magnitude for each arrow formed by each triangle.

Gradient direction rose plot

The gradient rose direction plot (figure 10) provides an overview of the angles of each of the arrows from each of the triangles. The plot also shows the mean and median angle (red and green line).

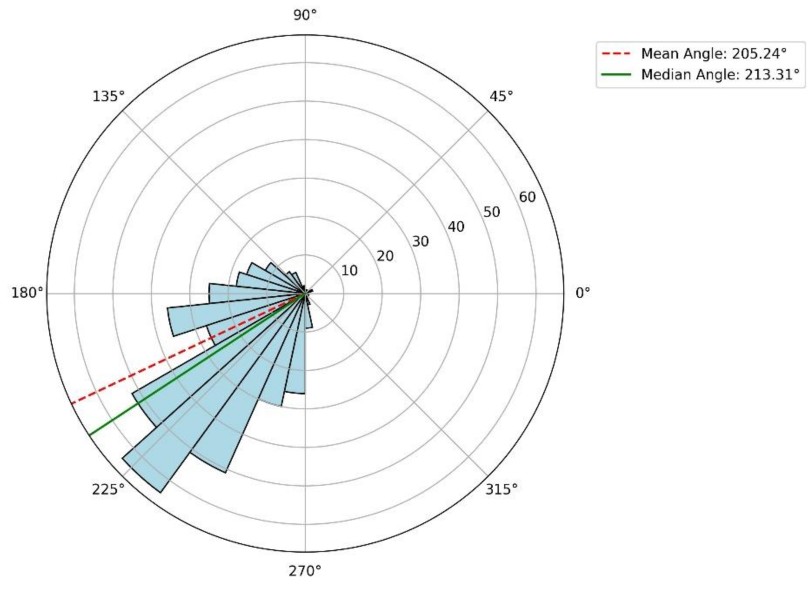


Figure 10: Angle distribution on a rose plot for each arrow formed by the triangles.

Customize plot

The customize plot button will show the currently implemented customization options for the currently displayed plot. The customization menu will thus dynamically change and only show customization options that apply to the currently displayed plot.

Data Filtration Frame

The data filtration frame allows for the filtering of data based on top or bottom of filter/borehole and/or hydraulic head columns. By default, the hydraulic head sliders filtration are the only sliders that are active as the user input a hydraulic head column upon loading the data. The top and bottom sliders will prompt the user for columns before they can be used.

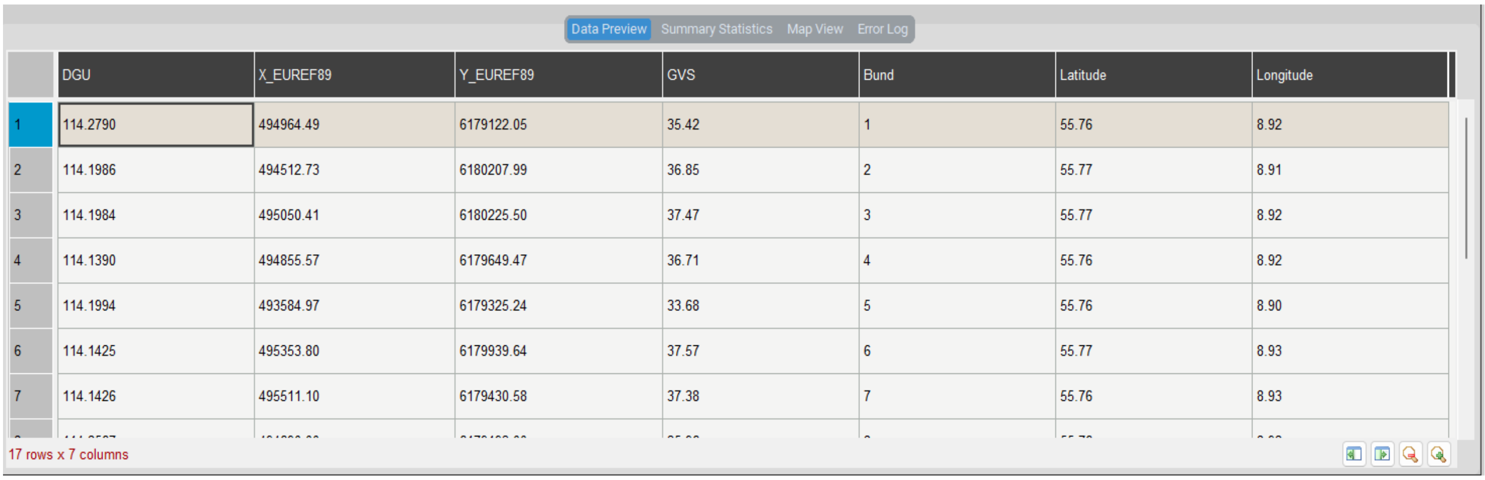
Additionally, the user can press the *select IDs* button to open a new window that shows each unique ID in the loaded data. Here the user can filter the data by enabling/disabling specific IDs. This is reflected in the plots, statistics, and the data preview tab.

Tabs Overview

Below the plot frame are 4 different tabs: Data preview, summary statistics, map view and Rejected Triangles.

Data Preview Tab

This tab shows the current loaded dataset (figure 11). The data in the table can be changed and the plot will reflect that change. Upon changing any data, the program will run all the calculations for plot and statistics again to reflect the changes. The sliders from the data filtration frame will dynamically adjust to the new data if any hydraulic head values are changed to be below or above the previous minimum or maximum hydraulic head value. Options for expanding/contracting and zooming in/out are available in the bottom right corner of the table.



	DGU	X_EUREF89	Y_EUREF89	GVS	Bund	Latitude	Longitude
1	114.2790	494964.49	6179122.05	35.42	1	55.76	8.92
2	114.1986	494512.73	6180207.99	36.85	2	55.77	8.91
3	114.1984	495050.41	6180225.50	37.47	3	55.77	8.92
4	114.1390	494855.57	6179649.47	36.71	4	55.76	8.92
5	114.1994	493584.97	6179325.24	33.68	5	55.76	8.90
6	114.1425	495353.80	6179939.64	37.57	6	55.77	8.93
7	114.1426	495511.10	6179430.58	37.38	7	55.76	8.93

Figure 11: Data preview tab.

Summary Statistics Tab

This tab contains various statistics for the loaded data (figure 12). Currently the tab shows general statistics and gradient related statistics.

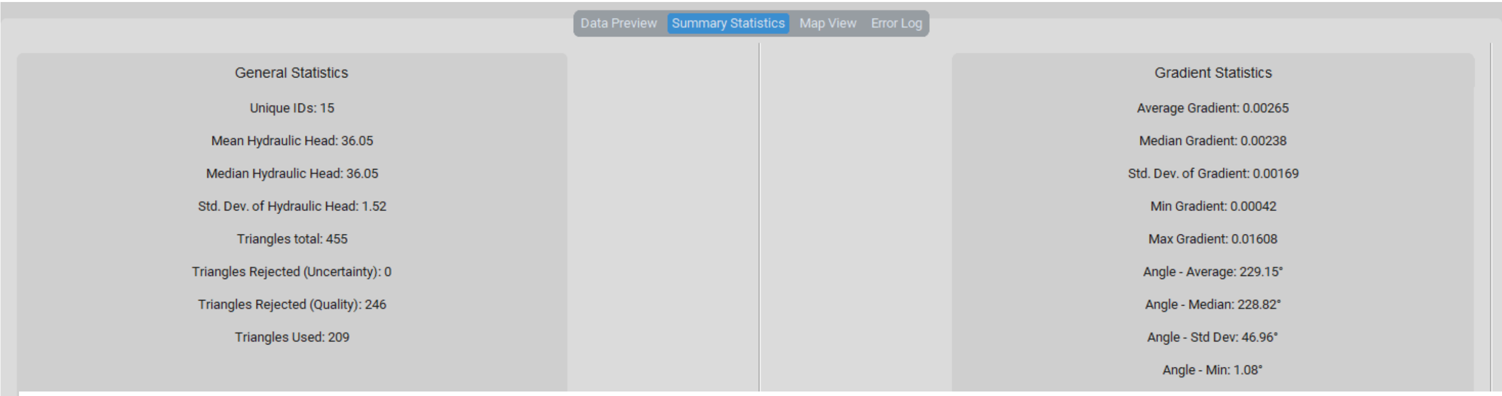


Figure 12: Statistics for the loaded data.

Map View Tab

The map view tab allows for seeing where the boreholes in your data are located (figure 13). The coordinates in your data are converted to latitude and longitude and then displayed on the map. Currently this map view does not support any additional features except for the visualization of the boreholes.

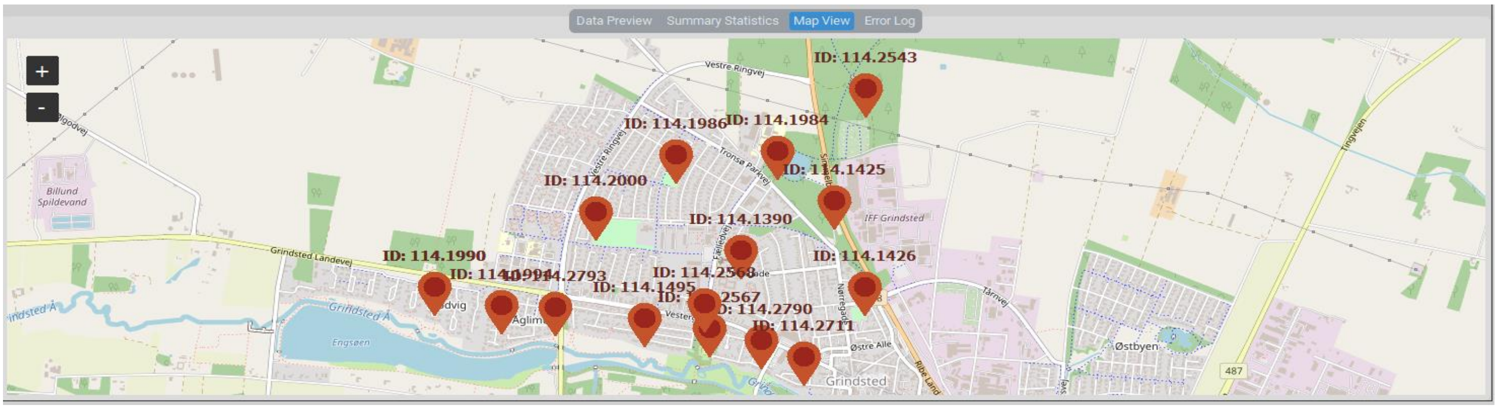


Figure13: Map view of the loaded data points.

Rejected Triangles tab

The rejected triangles tab contains information on the triangles that did not fulfill the criteria required for calculations (figure 14). Each row in the table contains a triangle made up of 3 points (point_ids column), alongside rejection information. The rejection_reasons column shows various reasons for rejection, which includes the following reasons:

1. Base-to-height ratio too high or too low.
    a. This is the most frequent reason for rejection. A base-to-height ratio higher than 8 and below 0.2 are rejected.
2. Uncertainty in hydraulic head.

   a. If the points making up a triangle contains too large a difference between hydraulic heads of each point, it is rejected.
3. Stacked points
   a. If 2 or 3 points are stacked (exact same coordinates), they are also rejected and not used for calculations.

Rejection reason 1 and 2 are described by Devlin, J. F., & Schillig, P. C. (2017).

The tab also contains a frame to the right of the table, which shows which point IDs are most frequently in rejected triangles and how many times it appears in non-rejected triangles. This is to get an overview of which points in the data are causing the most potential issues.

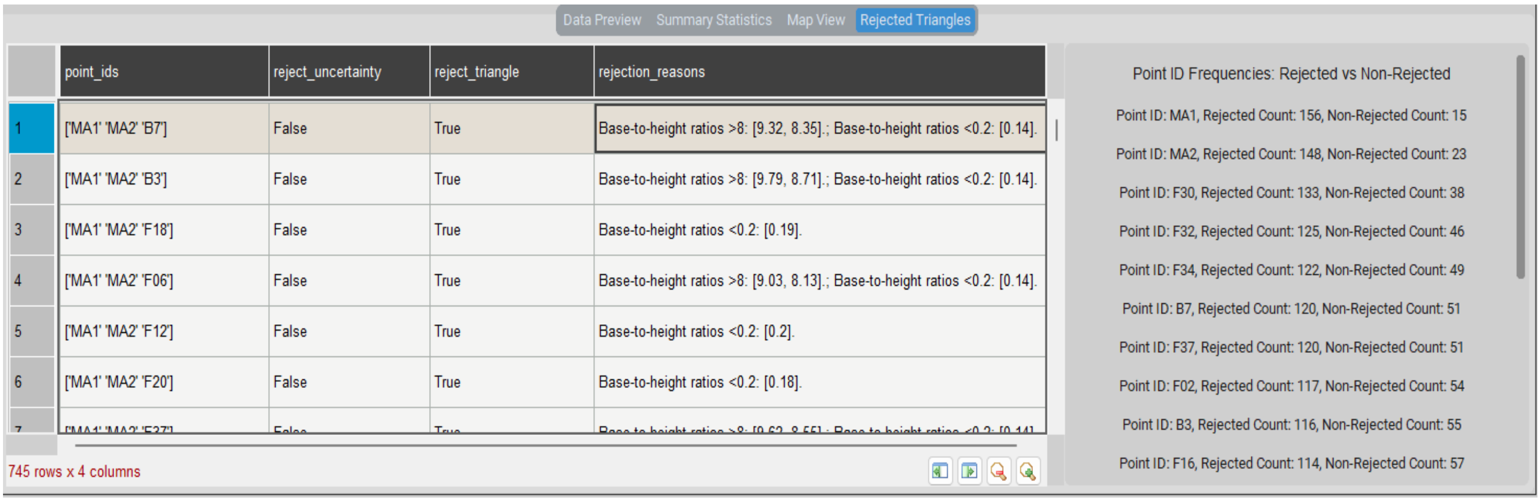


Figure 14: Rejected triangles table and statistics

References

Devlin, J. F., & Schillig, P. C. (2017). HydrogeoEstimatorXL: an Excel-based tool for estimating hydraulic gradient magnitude and direction. In Hydrogeology Journal (Vol. 25, Issue 3, pp. 867–875). Springer Science and Business Media LLC. https://doi.org/10.1007/s10040-016-1518-4