Adding friction to hydrodynamic simulations

In real life, you will find different land uses throughout your domain that will account for different friction coefficients and thus, different results for the variables acting up. To account for this, TELEMAC2D allows for the usage of different frictions coefficients if the data is available by either:

- Creating subroutines in FORTRAIN that account for friction information per every node/element of the geometry mesh.
- Add friction coefficient as an additional variable that should be accounted just as with the bottom bathymetric properties.

The aim of this tutorial is to show how to use the available resources that include land use within the domain of the river Rhein, specifically for the Melhrum polder, and use BlueKenue for including the friction coefficient as an additional variable.

GIS manipulation

Nowadays, different private and public research centers have available information in most of Germany as well as in other territories that shows the different land uses for specific areas. This information is available in many formats, but the most useful one is GIS Shapefiles, because they can be manipulated using whichever GIS software. For this tutorial, we will be using the information for the upper area of the Rhein in the north side of Duesseldorf from Geofrabrik. Information about this data is available in collaboration with OpenStreetMpas and can be found in the following site:

http://download.geofabrik.de/europe/germany/nordrhein-westfalen/duesseldorf-regbez-latest-free.shp.zip

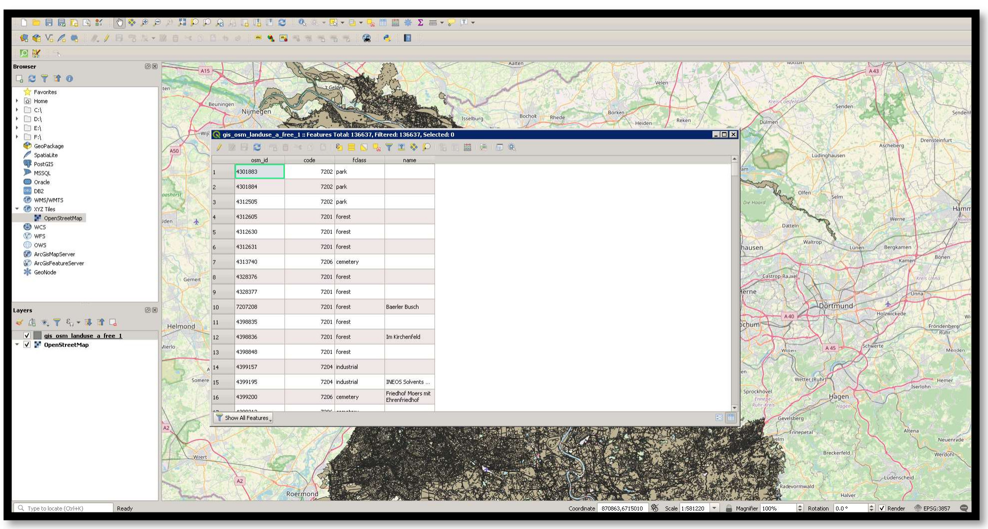
The following data can be found inside the shapefiles:

- Buildings
- Land uses
- Natural areas
- Places of interests
- Roads
- Railways
- Traffic
- And many more..

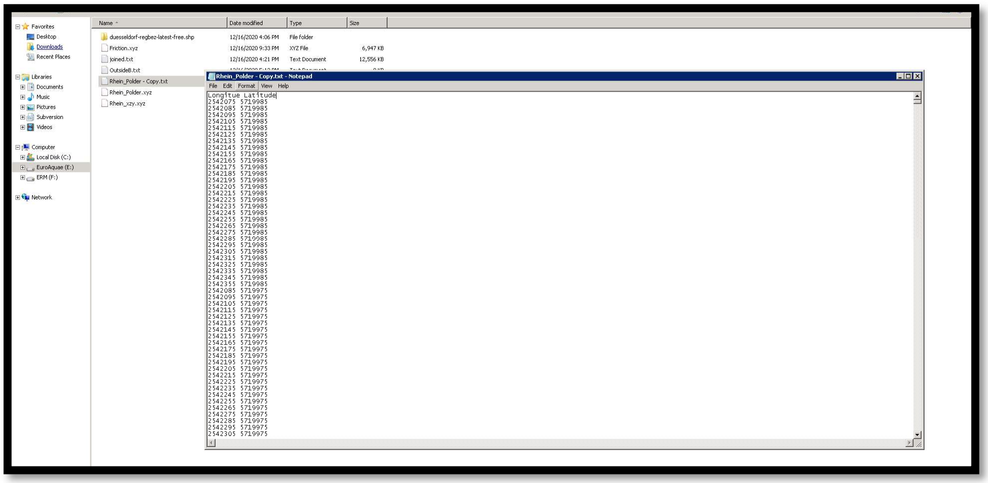
Only include the land uses for this tutorial. If you'd like, you can try and see how export building data in terms of shapefiles to create islands within the mesh by adding hardlines. The explanations will be done using QGIS but is the same process as for ArcMap software.

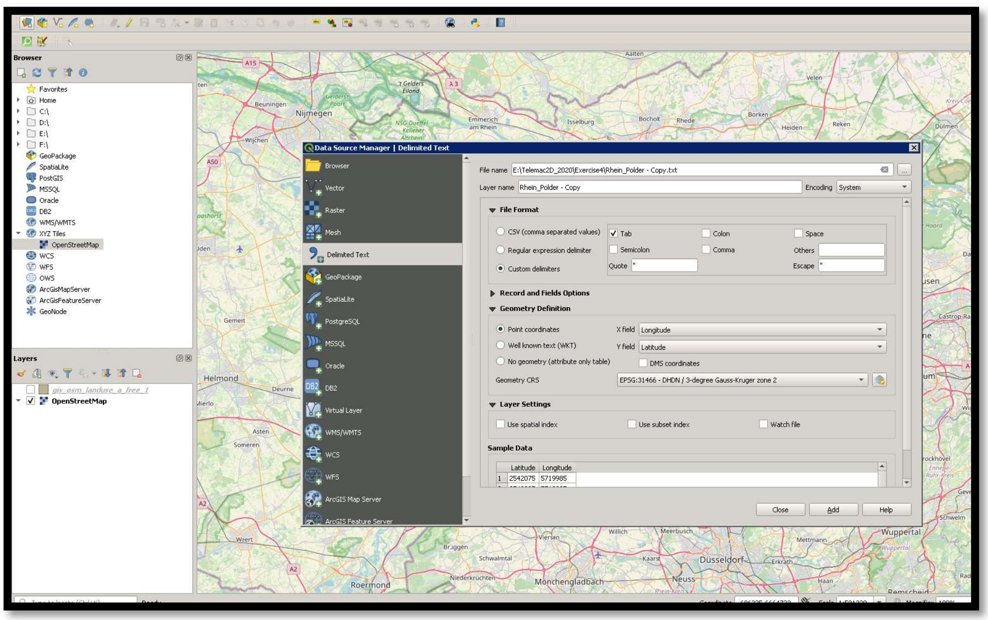
Open QGIS and create a new project and import the OpenStreetMaps on to the project. This will automatically add a coordinate reference system.

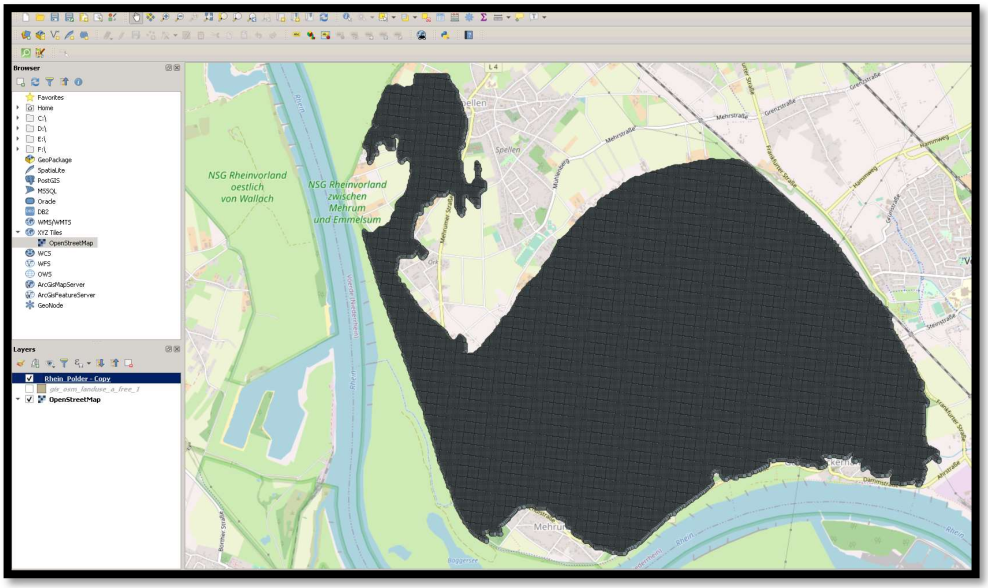
Go the folder where the shapefiles downloaded are and add the land uses. If done correctly, you should be able to see the extent of the areas for land use. Right click on the layer, click on show attribute table to see the different types of land uses. The shapefile has more than 116 thousand features, so do not be surprised if it takes some time to load.



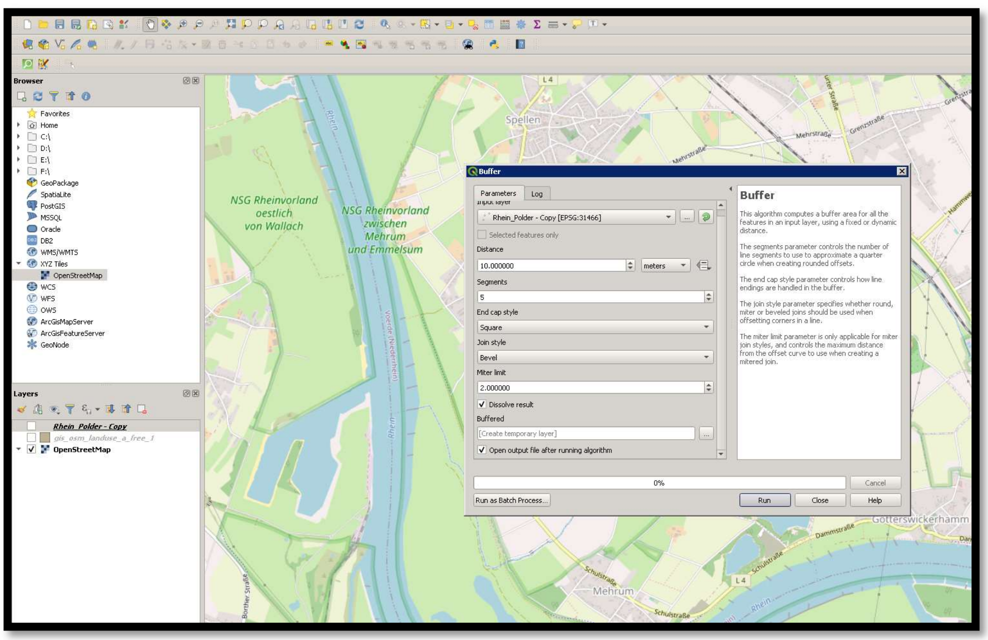
Go to the file where you have included the polder points in format xyz and copy them into a new txt file, including a header of Latitude and Longitude on each corresponding column, and delete the third column that accounts for elevation. You can do the latter by using any means you want (excel, for instance). Import this file into QGIS by create a new delimited layer, add space as the delimiter.


Rhein_Polder - Copy.txt - Notepad
Longitue Latitude

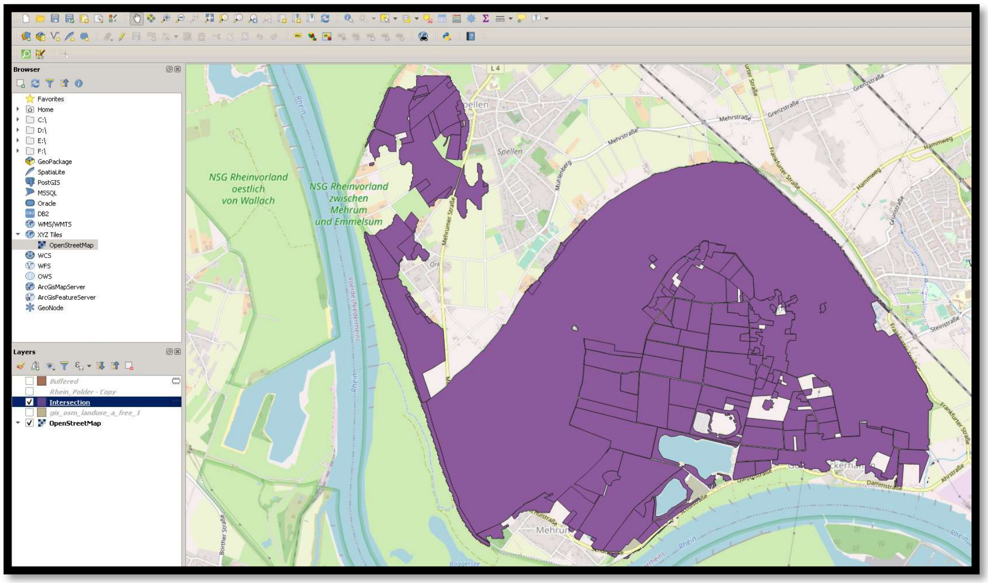

Browser
Layers
OpenStreetMap
Data Source Manager | Delimited Text
Browser
Vector
Raster
Mesh
Delimited Text
GeoPackage
SpatiaLite
PostgreSQL
MSSQL
Oracle
DB2
Virtual Layer
WMS/WMTS
WCS
WFS
ArcGIS Map Server
File name E:\Telemac2D_2020\Exercise4\Rhein_Polder - Copy.txt
Layer name Rhein_Polder - Copy
Encoding System
File Format
CSV (comma separated values)
Regular expression delimiter
Custom delimiters
Tab
Colon
Space
Semicolon
Comma
Others
Quote
Escape
Record and Fields Options
Geometry Definition
Point coordinates
Well known text (WKT)
No geometry (attribute only table)
X field Longitude
Y field Latitude
DMS coordinates
Geometry CRS
EPSG:31466 - DHDN / 3-degree Gauss-Kruger zone 2
Layer Settings
Use spatial index
Use subset index
Watch file
Sample Data
Latitude
Longitude
2542075
5719985
Close
Add
Help
Nijmegen
Helmond
Roermond
Mönchengladbach
Dusseldorf
Neuss
Wuppertal



After adding the polder, we can use the buffer layer creator from the vector tools to generate a point map based on the points we recently added.



Use the command intersection to grab the land use type from the newly created buffered based on the land use shapefile. Once the algorithm stops, then you should have a shapefile that includes the features that intersected within.

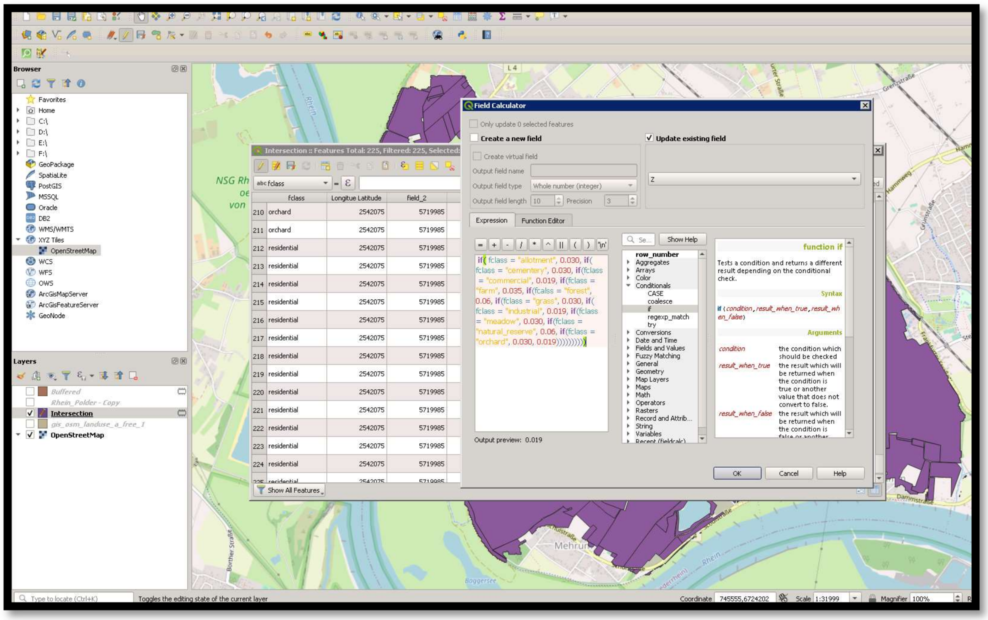


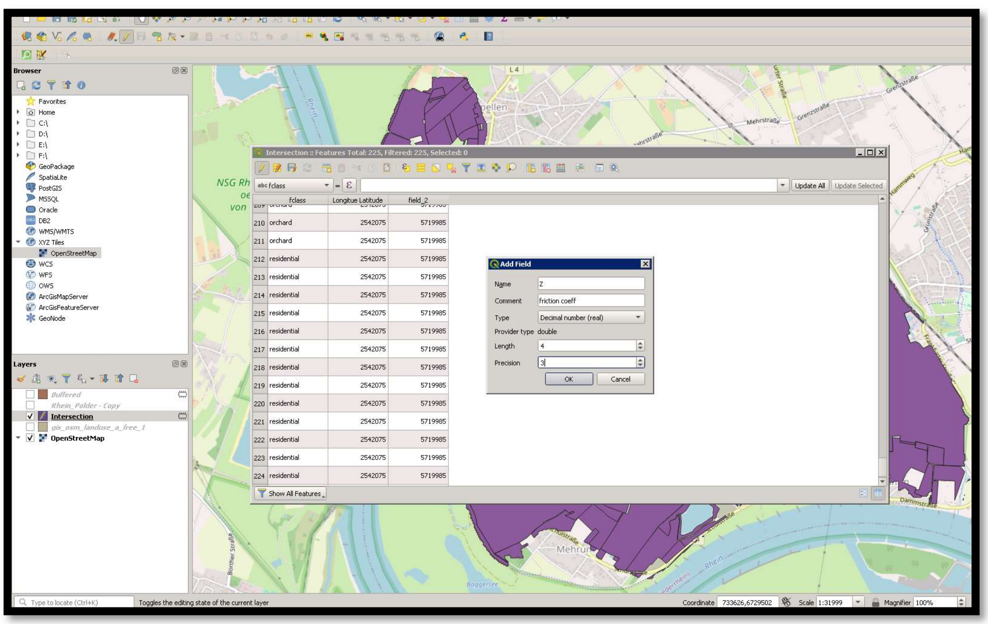
Based on the results, we need to categorize or give values to the Manning or Strickler coefficients. We have the following land use types with the corresponding Manning values as:

- Allotments with n = 0.030
- Cemeteries with n=0.030
- Commercial areas with n= 0.019
- Farm with n = 0.035
- Forest with n = 0.06
- Grass with n = 0.030
- Industrial with n = 0.019
- Meadow with n = 0.030
- Natural reserve with n = 0.06
- Orchards with n = 0.030
- Residential with n = 0.019

We can use QGIS in built query capabilities to create fields based on the fclass that corresponds. We do this by editing the attribute table -> New Field call it Z -> and enter the query using if conditionals. Make sure that you use only one ‘ when including in the fields.

if ("fclass" = farm, 0.035, if("fclass" = cemetery, 0.030, 0))



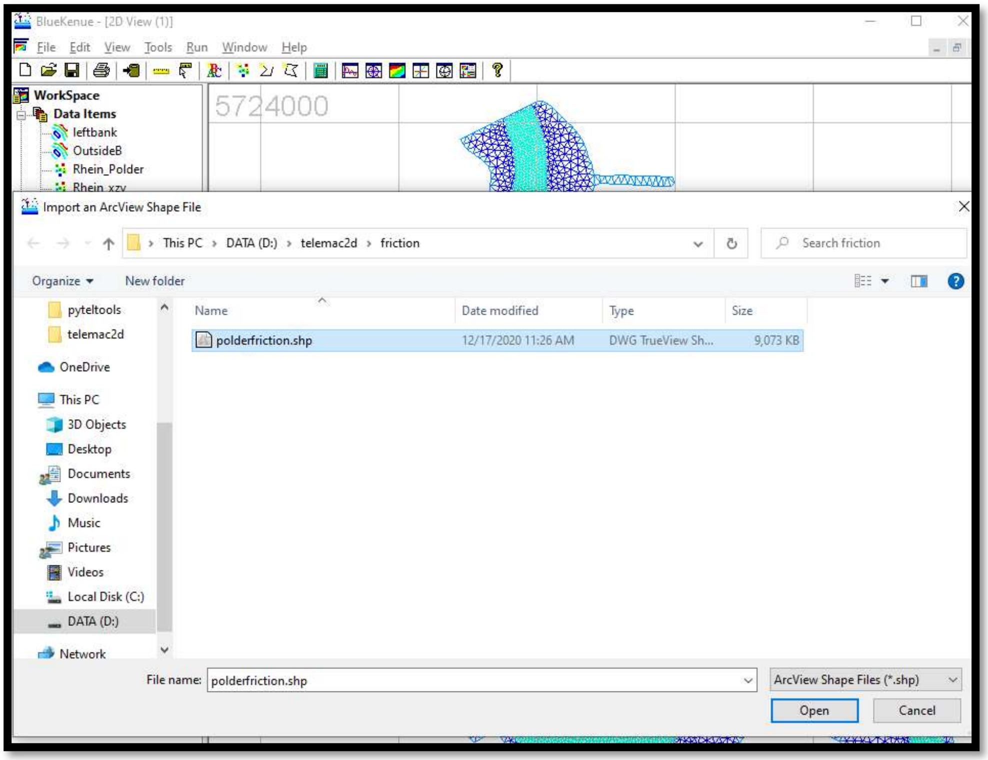


Open the field calculator and add the definitions for Z that we added before and use intersection to map the friction coefficient. Once the data has been correctly modified, export it as a shapefile that only has attributes the coordinates in x and y along with the friction coefficient.

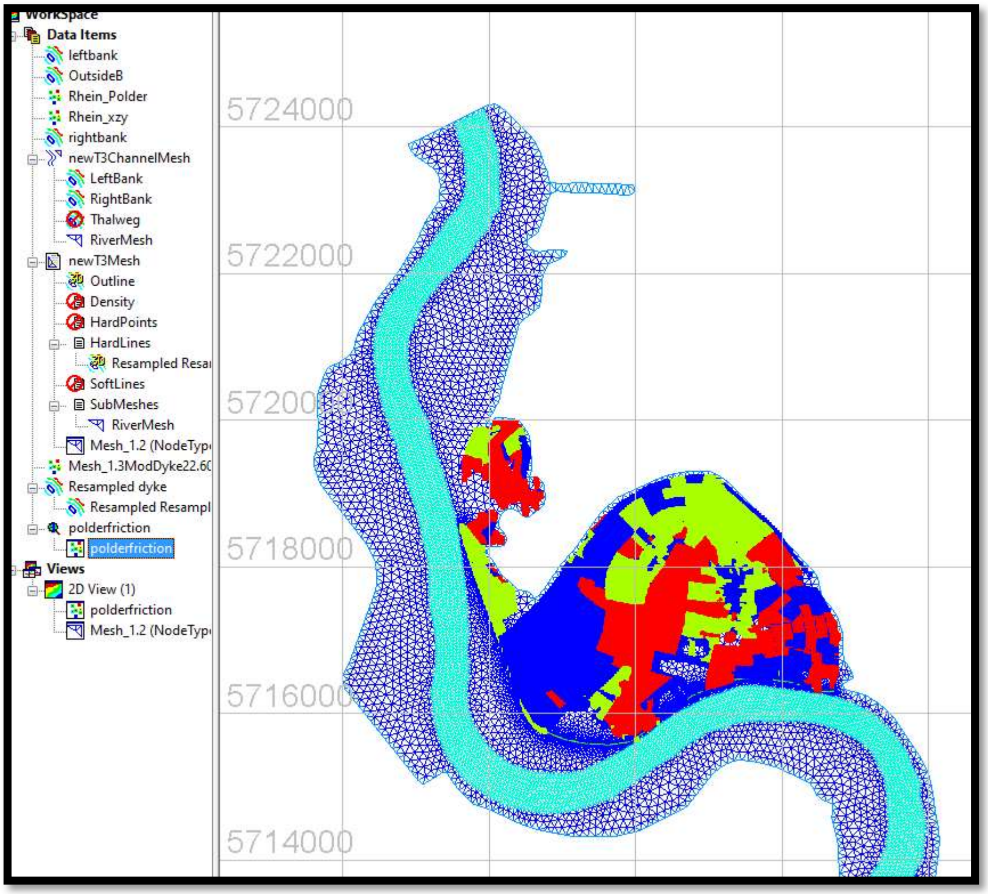
Manipulating data in BlueKenue

Just as with other data types that include features which can be imported to SELAFIN objects, the data from shapefile is extracted as point sets. They are mapped into the nodes of a mesh and added as a new feature. This feature should be included when generating the SELAFIN object, previous to running any simulation so that all necessary variables should be considered. If running an unsteady simulation based upon a steady simulation (hotstart) the hotstart as well as the geometry should have included the friction variable.

Open the bluekenue window where you have generated the mesh, and import the shapefile created previously. Use File -> Import -> ArcView Shapefile. Make sure you that you have in the folder where you have shapefile all necessary connection to database systems—.dbf files.



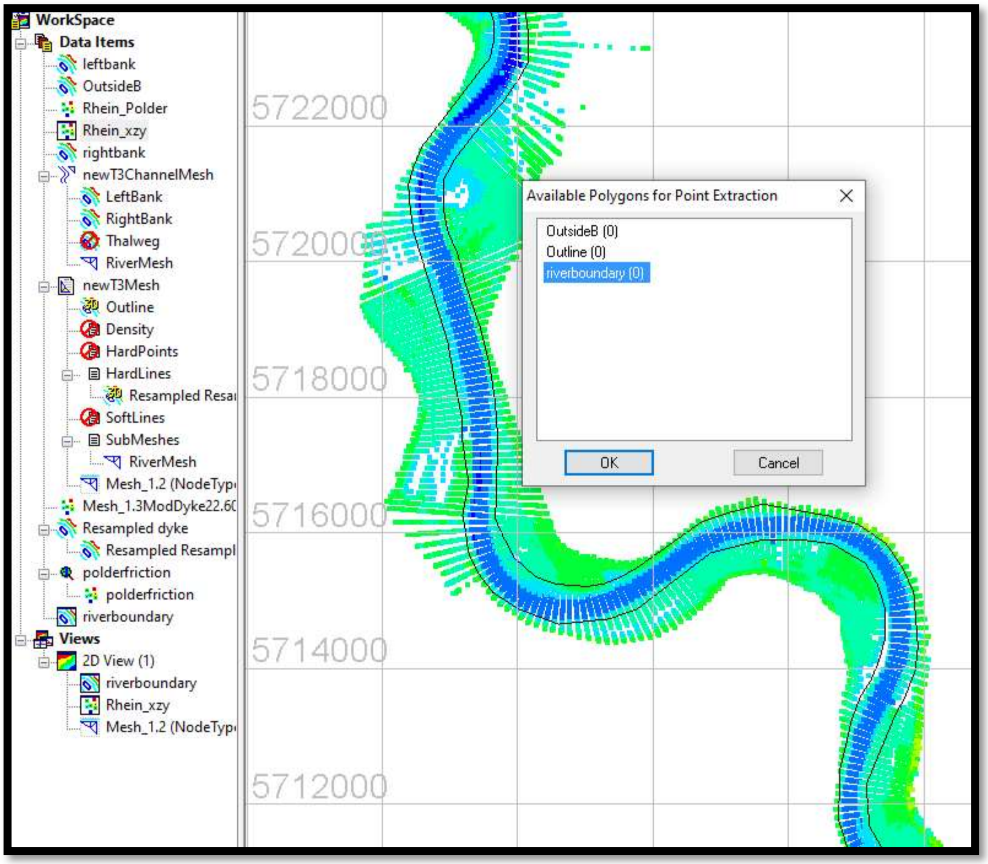
Import the points from the shapefile to the 2D View to see how these results look like.



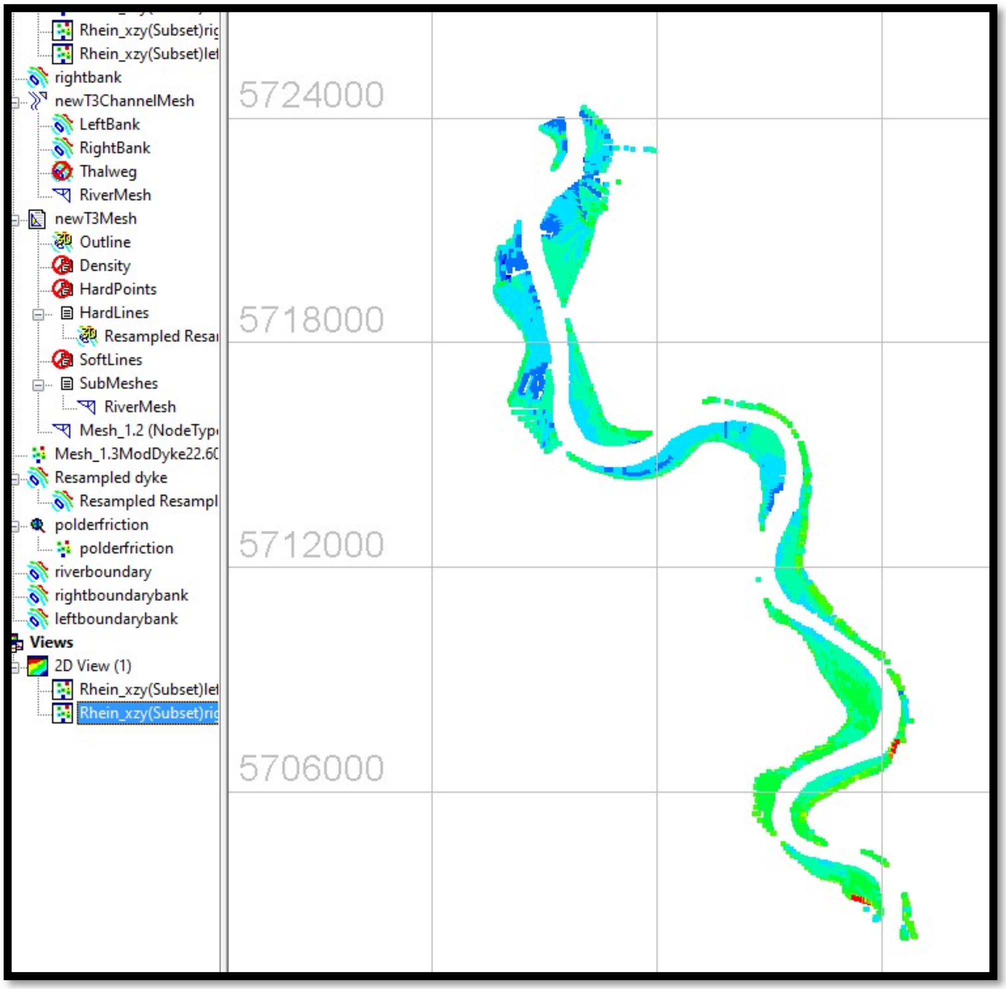
If you want to extract data from the shapefile, select the points and save them on your local directory as an xyz point data. Since what we will be doing is creating a friction data set, and previously we just added information only for the polder area, we need to extract the datapoints pertaining to the banks of the river as well as the river itself by creating closed lines and using the extract point options from BlueKenue.

Extracting points

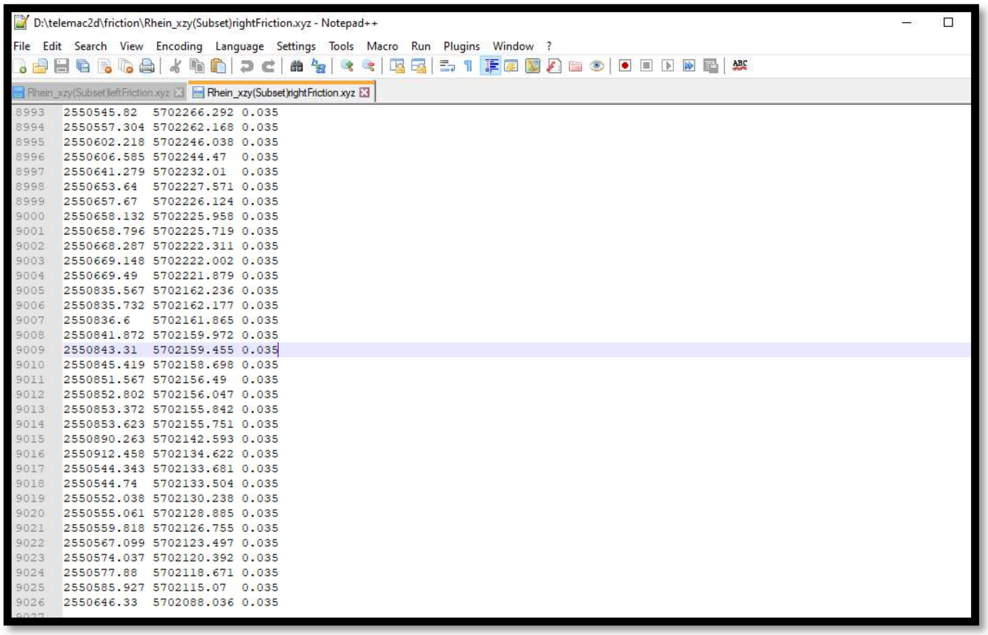
Draw a boundary within the datapoints that you want to extract. Make sure that you are using closed lines. Once this has been done, select the data set, click on tools -> extract points and select the boundary just created. Save these points as xyz



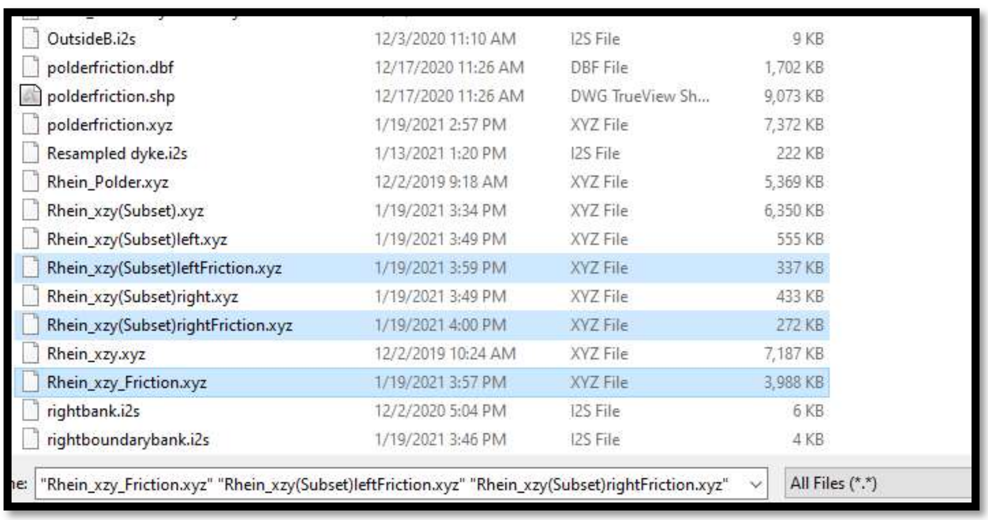
From this point onwards, it is possible to do the same procedure for extracting the points of the banks. You can also do this by creating a simple routine in whichever programming language you might be used to, specifying deletion of text based on another file.

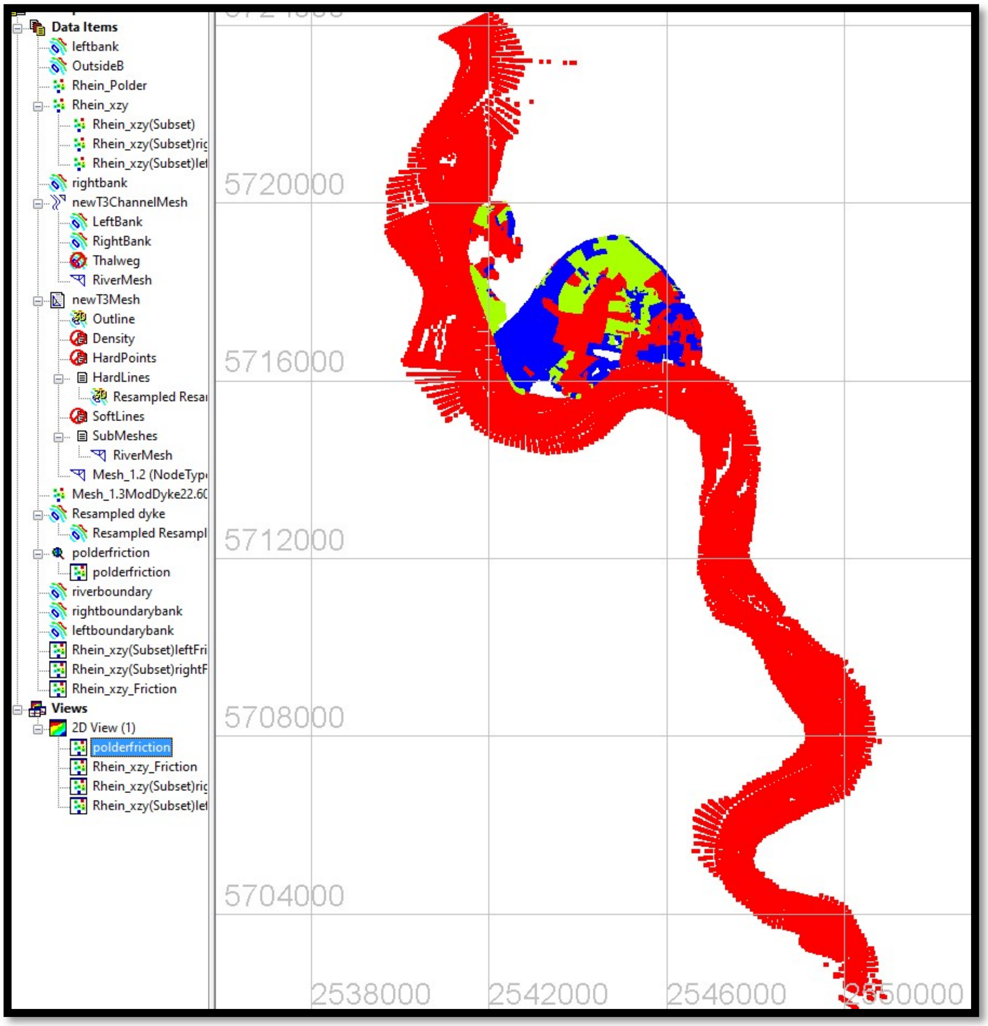


Using excel or a text editor, modify the z component of the riverbanks and the river area to a friction coefficient that can be consider correct for the area. In this example, we will be using 0.015 for the riverbed and 0.04 for the right bank and 0.035 for the left bank. The selection is based on the type of land use observed in the area. Of course, these values are left to criteria of the user.

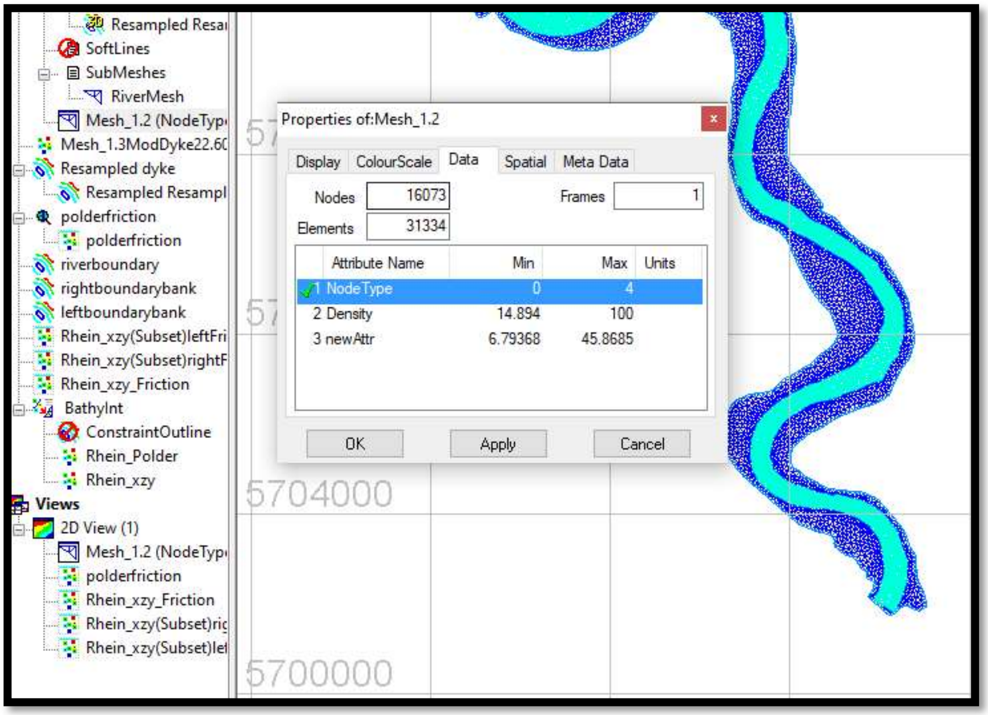


Import the modified data points to BlueKenue and use them for creating a new 2D interpolator.

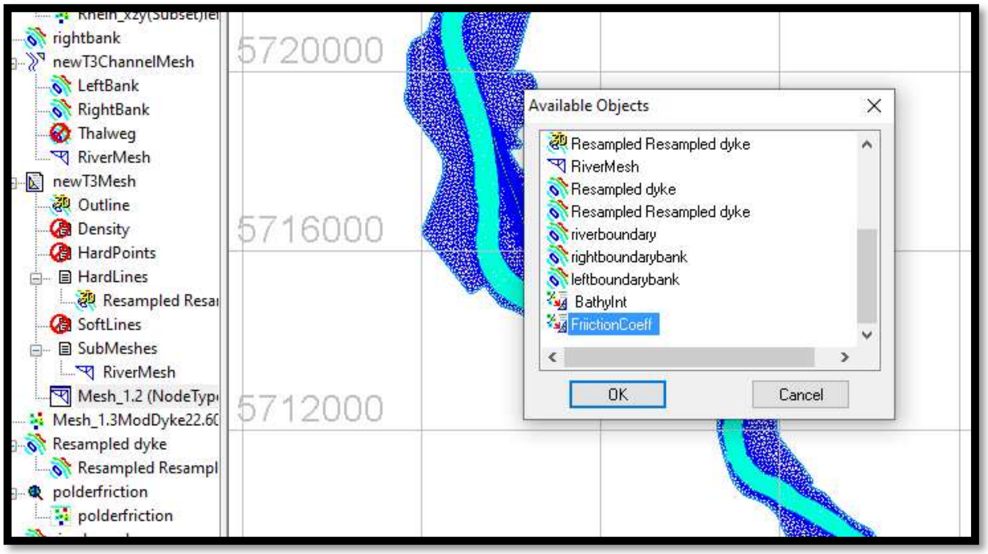




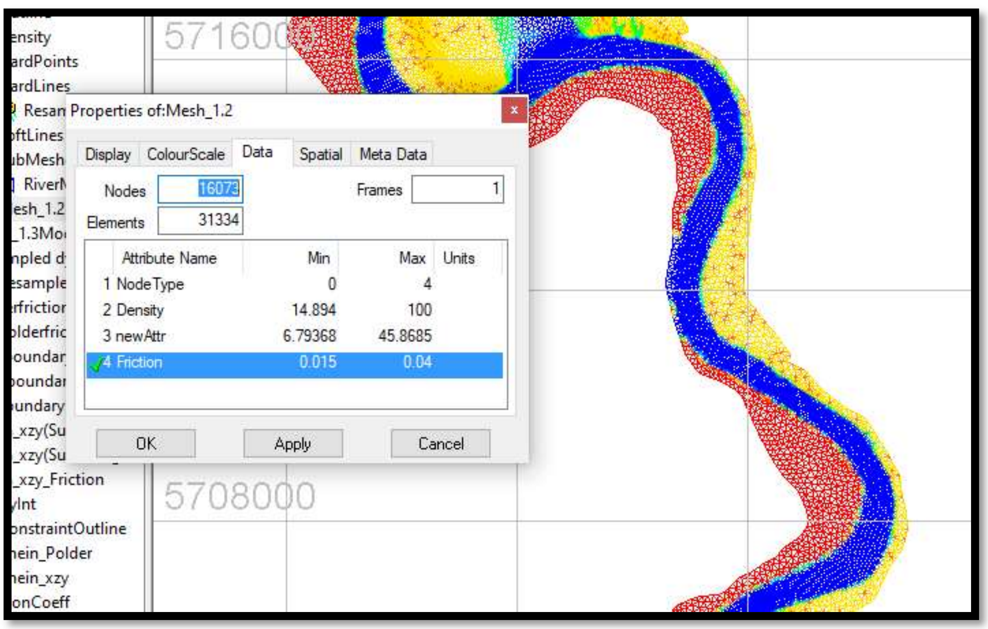
Map the first 2D interpolator that includes the bathymetry of your domain over your mesh. Once this has been done, right click on the mesh -> properties -> select the data tab and change the check mark from new Attribute to NodeType. What we are going to do is assign the over the nodes of the mesh the friction according to the coordinates.



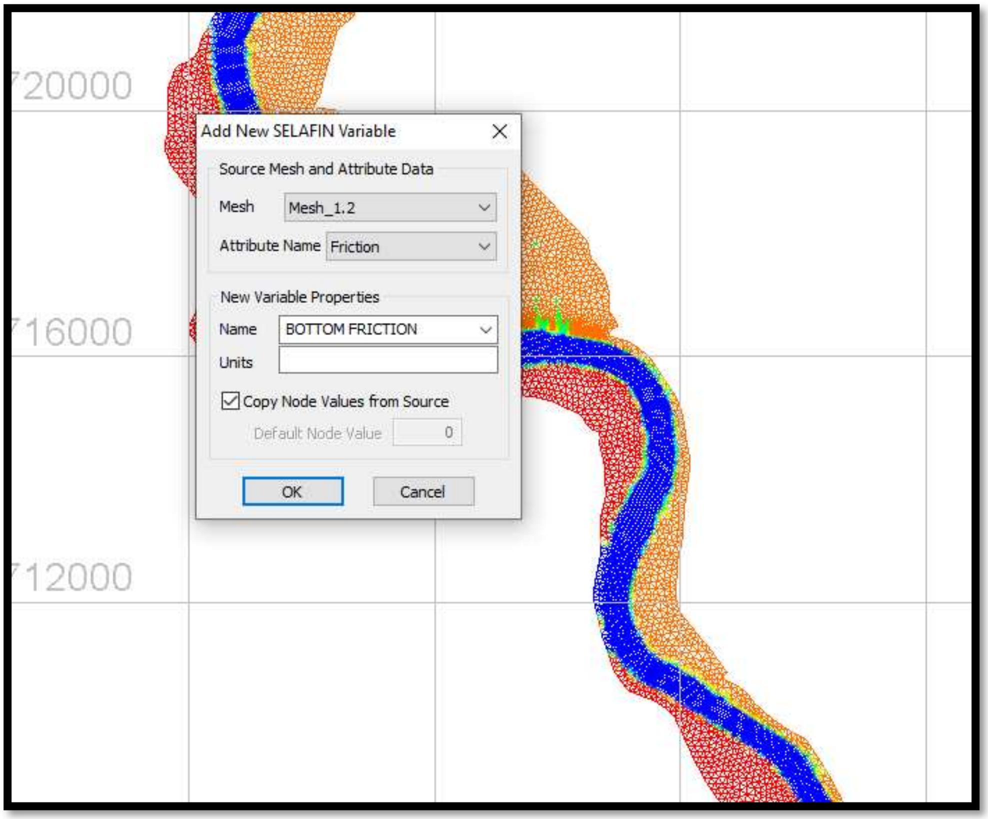
Go to File -> 2D interpolator -> Change the name of the file so you don't get confused with the interpolators. Select the Mesh -> Tools -> Map Object -> Select the Friction interpolator -> newAttr change the name to Friction, leave the space unitless.

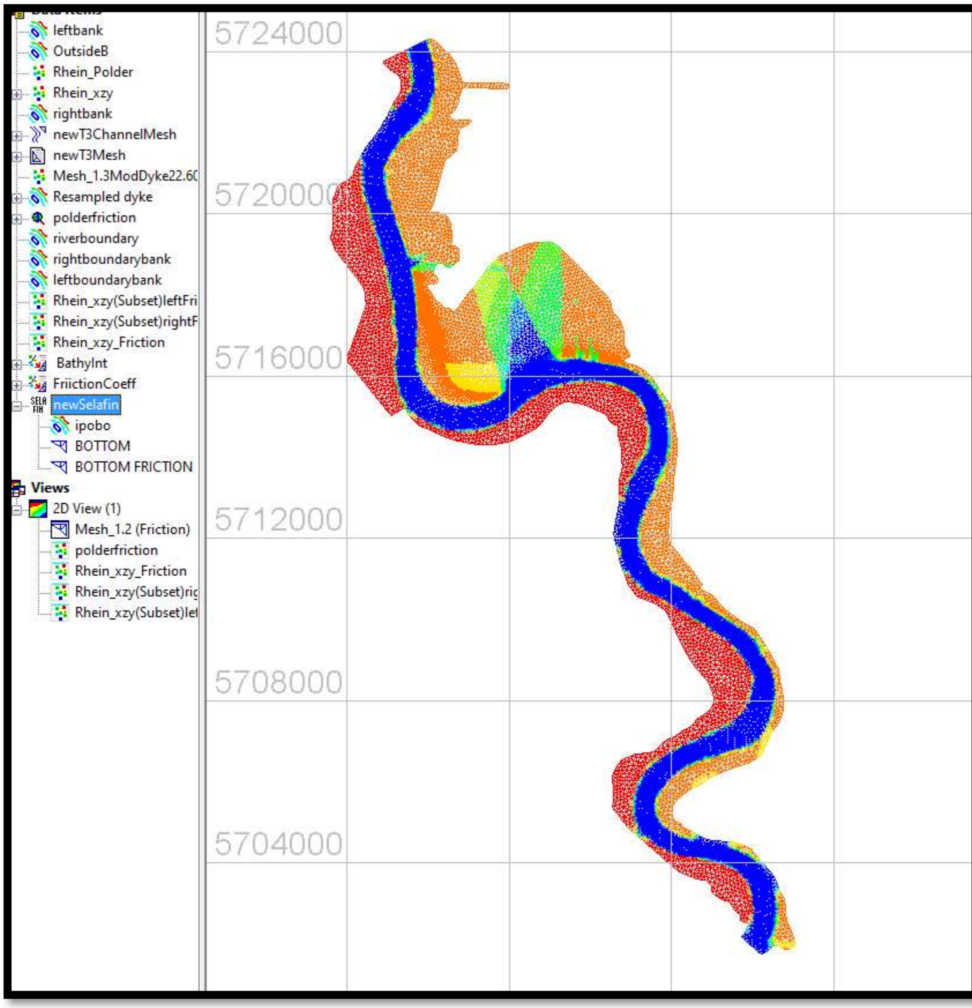


Once the interpolation has been done, right click on the mesh and verify that there are 4 objects now inside the mesh. Also, the interpolation can be seen in the 2D View.



Once this is done, create a new SELAFIN object -> right click on it -> Add Variable -> Select the mesh you created, select bottom and copy the node values from source. Make sure you select the newAttr file. Map the bathymetry interpolator. Create a new variable, select the mesh you created, in name of new variable properties select the BOTTOM FRICTION name and once again, copy node values from source. Again, as before, map the friction interpolator over the new variable.


720000
716000
712000
Add New SELAFIN Variable
Source Mesh and Attribute Data
Mesh
Mesh_1.2
Attribute Name
Friction
New Variable Properties
Name
BOTTOM FRICTION
Units
Copy Node Values from Source
Default Node Value
0
OK
Cancel



Once this is done, save the SELAFIN object which is ready for simulations. In the CAS file, specify the correct BOTTOM FRICTION LAW, which is #4 and specify a value for friction. In this case, we will use 0.035. This number will be overridden by the information already contained within the SELAFIN object, just put in so that TELEMAC works properly.

```
PRESCRIBED ELEVATIONS          = 0;0
OPTION FOR LIQUID BOUNDARIES    = 1;1
/---------------------------------------------------------------------
/ Bed roughness
/---------------------------------------------------------------------
LAW OF BOTTOM FRICTION          : 4
FRICTION COEFFICIENT            : 0.035
/BOTTOM SMOOTHINGES              = 1
/---------------------------------------------------------------------
/Initial conditions
/---------------------------------------------------------------------
INITIAL CONDITIONS ='CONSTANT ELEVATION'
INITIAL ELEVATION  =23.0
/---------------------------------------------------------------------
/ INPUT-OUTPUT; GRAPHICS AND LISTING
/---------------------------------------------------------------------
INFORMATION ABOUT SOLVER       =YES
LISTING PRINTOUT PERIOD        =100
GRAPHIC PRINTOUT PERIOD        =100
```