NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY

Faculty of Engineering

Department of Ocean Operations and Civil Engineering

Application of MIKE URBAN and GIS for Sewer Collection Systems Modeling and Simulation

Tutorial 2

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07/2022

Objectives of this tutorial

The overall aim of this tutorial is to provide a user with a step-by-step guideline for modeling and simulation urban sewer collection systems using MIKE URBAN and GIS. This tutorial applies QGIS, a free and open-source cross-platform GIS software, to organize and process data for simulation.

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1. Introduction

A sewer network is one of the most important components of the urban water infrastructure. This network plays a vital role in the collection and transportation of wastewater and stormwater from the residential areas to the Wastewater Treatment Plants or storage units. This network is one of the elements that contribute to protecting the environment, and public health, and reducing the incidence of flooding (Figure 1-1).

Figure 1-1. The role of the sewer collection network

MIKE URBAN is the urban water modeling software of choice when important parameters for model selection are stability, workflow, openness, flexibility, GIS integration, and physical soundness. MIKE URBAN covers all water networks in the city, including water distribution systems, stormwater drainage systems, and sewer collection in separate and combined systems.

MOUSE is a comprehensive modeling system for the analysis of urban drainage and sewer systems including links to GIS. MOUSE simulates spatial variations in flows, water levels, sediment transport, and pollution in pipes and open drains. MOUSE can be used for the prediction of hydraulic deficiencies, overflow sites, flood inundation areas, the effect of real-time control, etc. MOUSE engine is used in the MIKE-URBAN widely used in modeling city water networks, including water distribution systems, stormwater drainage systems, and sewer collection in separate and combined systems.

MOUSE can deal with the below problems:

- What are the return periods for overloading of various parts of the existing sewer system?

- What are the main causes of that overloading - backwater or insufficient local pipe capacity?
- What are the implications of replacing critical sewers, installing new basins, weirs, etc.?
- How is the long-term environmental impact affected by changing the operational strategy?
- Where and why are sediments deposited in the sewer network?
- What are the peak concentrations of pollutants at the overflow weir or the treatment plant after a rainstorm?

1.1. MIKE URBAN Installation

In this tutorial, related software will be installed on the Windows Operating System computer. Installation steps on other operating systems (such as macOS, Linus, etc.,) can be slightly different. Please note that MIKE URBAN is commercial software, the user, therefore, needs to buy a license for using this software

The user can download MIKE URBAN via the DHI website or the NTNU portal.

a. Downloading via the DHI website

The user visits the DHI homepage: https://www.mikepoweredbydhi.com/products/mike-urban (Figure 1-2).

MIKE URBAN will be decommissioned after November 2019. The next generation of MIKE URBAN is MIKE+[1]. Materials for MIKE+ can be referenced at: https://www.mikepoweredbydhi.com/products/mikeplus.

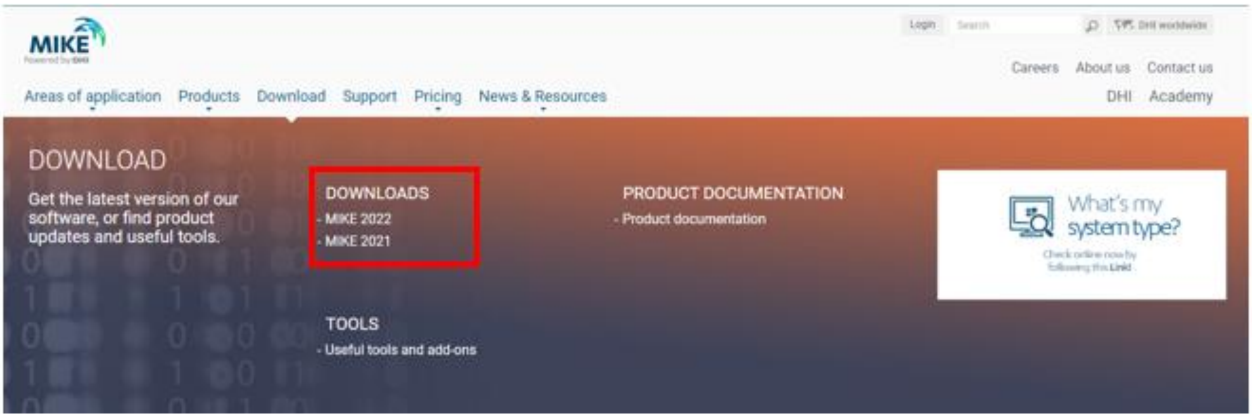


Figure 1-2. Downloading MIKE URBAN via the DHI homepage

[1] https://www.mikepoweredbydhi.com/products/mike-urban

b. Downloading via the NTNU portal

To download MIKE URBAN from the NTNU portal, the user needs to access an NTNU OneDrive[2] and download all included files and folders (Figure 1-3).

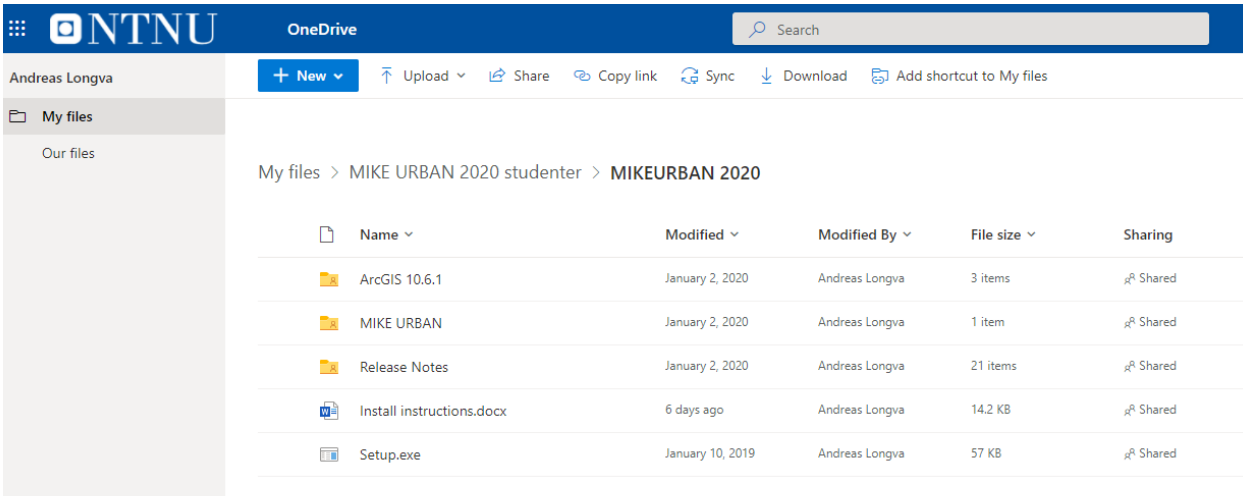


Figure 1-3. Downloading MIKE URBAN via the NTNU portal

In this tutorial, we used the MIKE URBAN 2019 software download from the NTNU portal for building and running simulation purposes.

Installing MIKE URBAN includes several steps:

- *Step 1:* Installing MIKE URBAN 2019 requires the ArcGIS version 10.6.1 to be installed on your computer. Therefore, the user needs to uninstall/remove the ArcGIS if the installed ArcGIS version is not 10.6.1.
- *Step 2:* It is recommended to restart the computer after the user uninstalls ArcGIS to make sure all data of the previously installed ArcGIS is removed completely.
- Step 3: Run the ***"Setup.exe"*** file as administrator from the MIKE URBAN folder.
- *Step 4:* In the installation selection window, select ***"MIKE URBAN"*** in the left menu. After that, select the ***"Install MIKE URBAN"*** button to install MIKE URBAN (Figure 1-4).

[2] https://studntnu-my.sharepoint.com/personal/andrlong_ntnu_no/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fandrlong%5Fntnu%5Fno%2FDocuments%2FMIKE%20URBAN%202020%20studenter%2FMIKEURBAN%202020

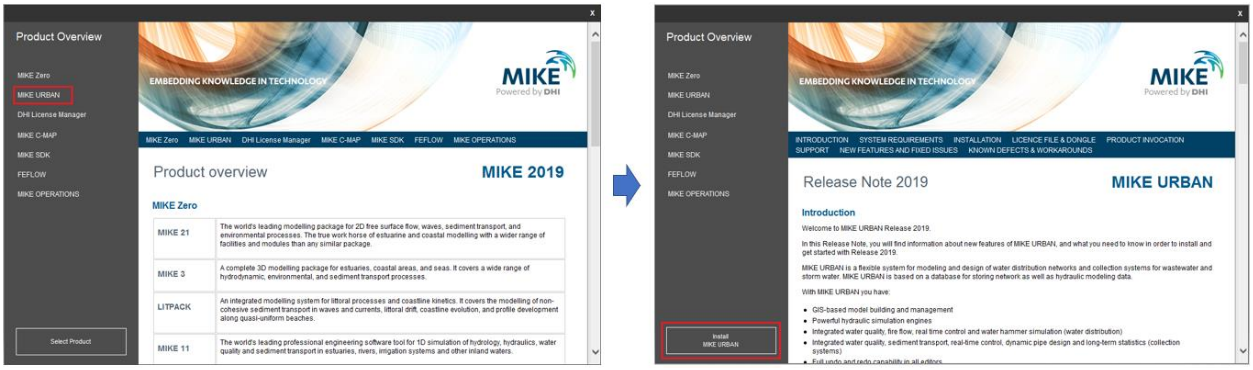


Figure 1-4. MIKE URBAN installation

- *Step 5:* The installation process will be continued by selecting the ***"Next"*** button in several steps (Figure 1-5).

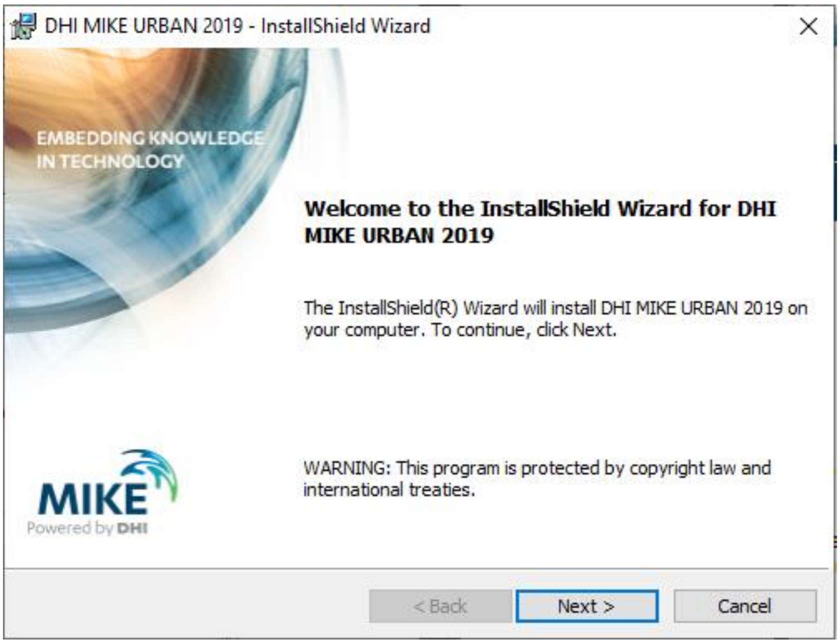


Figure 1-5. Installation process

- *Step 6:* If the user gets a message saying you need ***".NET Framework 4.7.1 or later"***, the user needs to download and install .NET Framework and come back to *Step 3*.

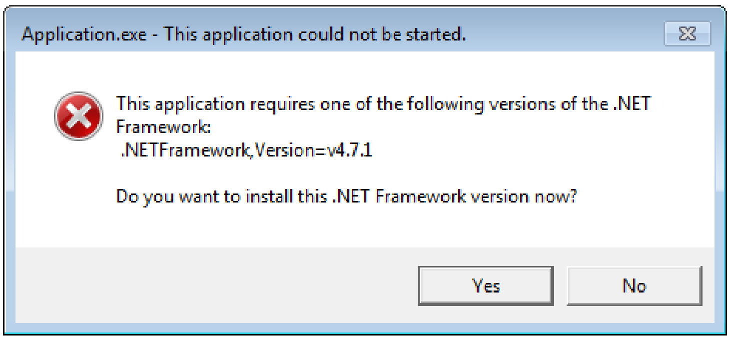


Figure 1-6. Installing .NET Framework

- *Step 7:* To use the license through the NTNU portal, the user has to select the ***"Network"*** option in the ***"License selection"*** window (Figure 1-7).

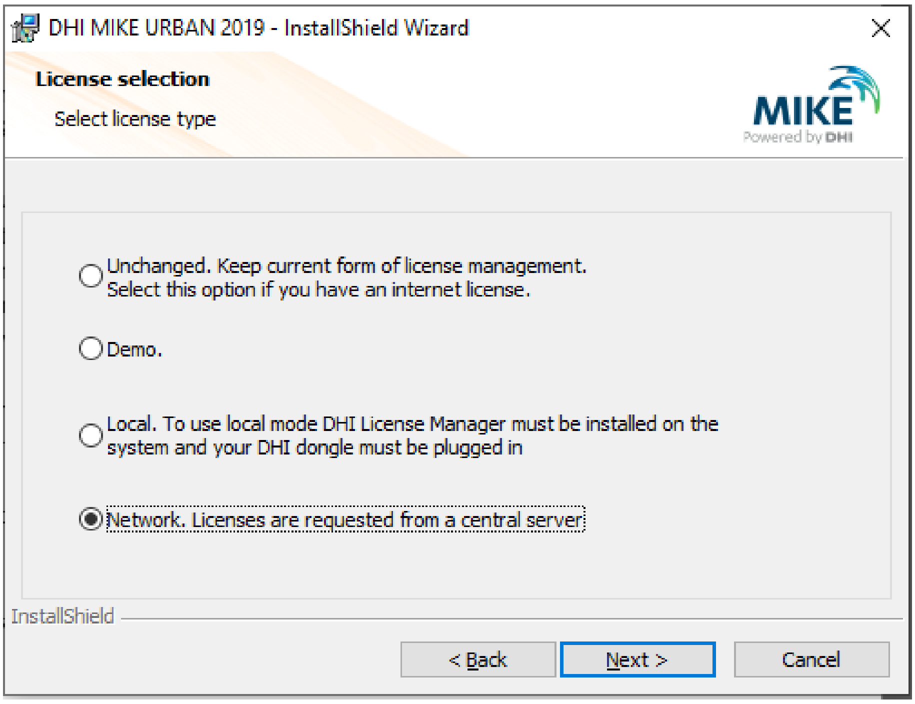


Figure 1-7. Registering a license for MIKE URBAN

- *Step 8:* Provide a local license for MIKE via the ***"MIKE local license"*** window (Figure 1-8).

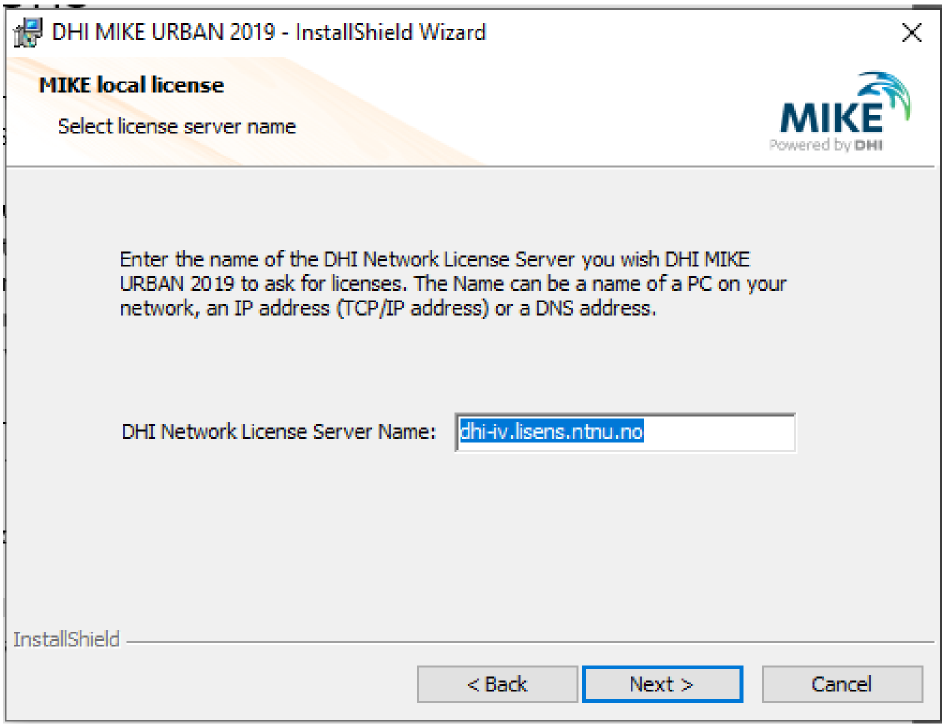


Figure 1-8. Providing the local license for MIKE URBAN

- *Step 9:* During the installation process, MIKE requires the user to install ArcGIS Desktop 10.6.1 as a part of the installation (Figure 1-9). The installation will continue by clicking the ***"Next"*** button in several windows afterward.

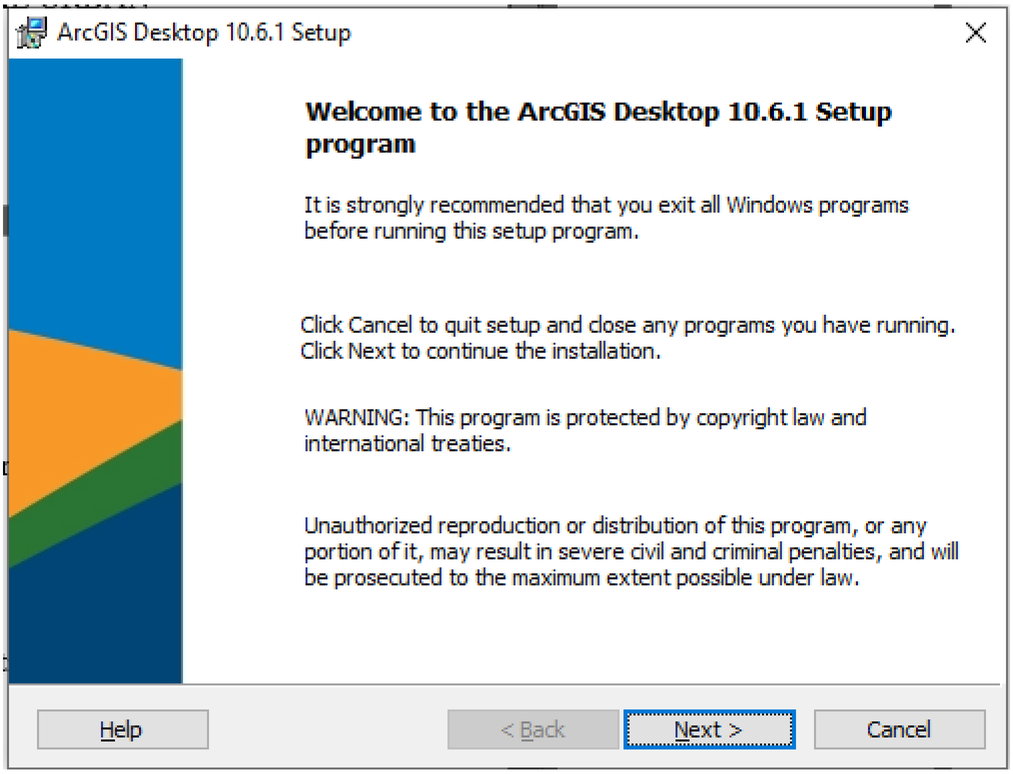


Figure 1-9. ArcGIS Desktop installation

- *Step 10:* Finish ArcGIS Desktop installation. The user chooses ***"Standard (ArcEditor) Concurrent Use"*** in the ArcGIS Administrator Wizard and clicks ***"OK"*** (Figure 1-10).

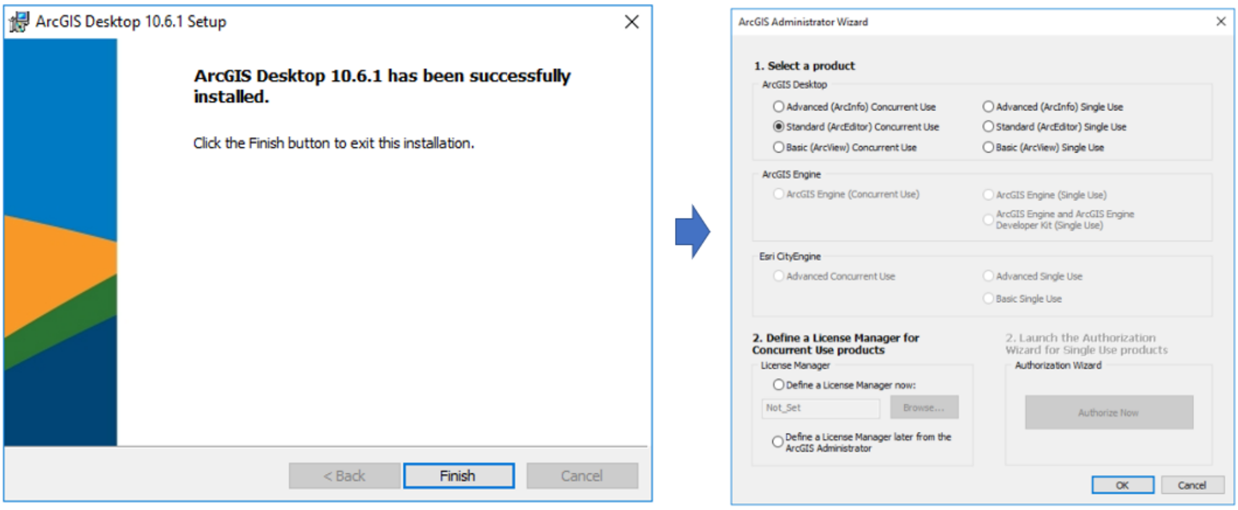


Figure 1-10. Finishing ArcGIS installation

- *Step 11:* The ***"ArcGIS Administrator"*** window will appear. To register a license for

ArcGIS through the NTNU portal, the user clicks on the ***"Desktop"*** folder in the left menu, clicks the ***"Change…"*** button, and enters "*arcgis10.lisens.ntnu.no*" into the ***"Change License Manager"*** dialog (Figure 1-11). MIKE URBAN will be installed continuously.

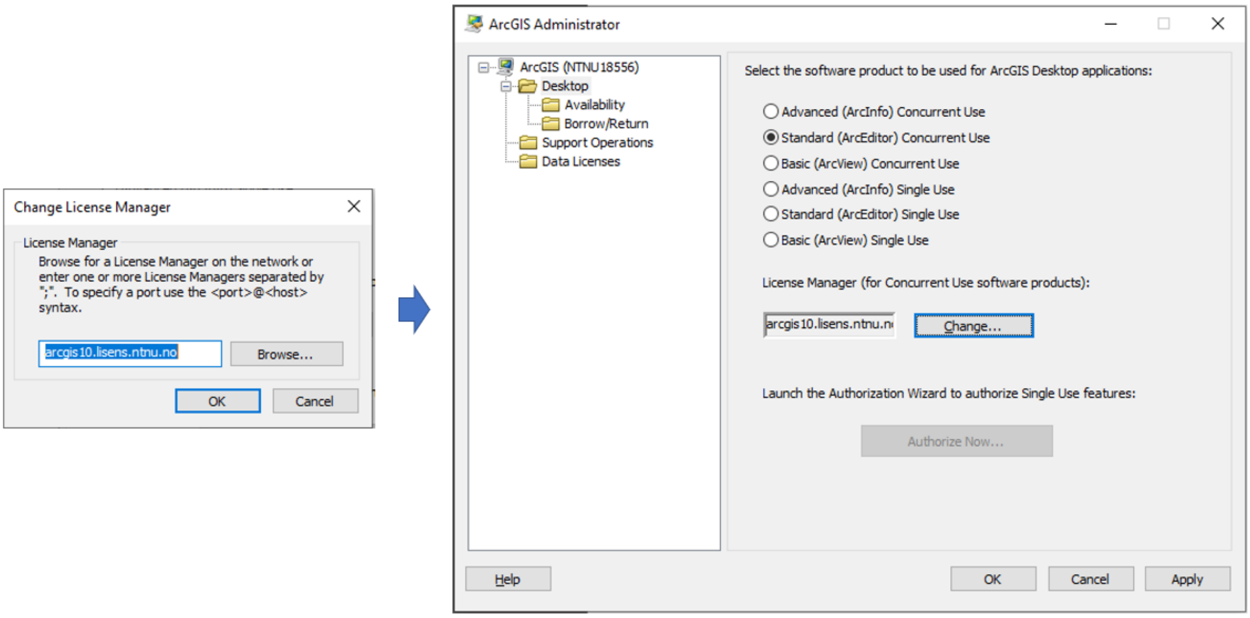


Figure 1-11. Registering a license for ArcGIS Desktop

- *Step 12:* Finish installing MIKE URBAN (Figure 1-12).

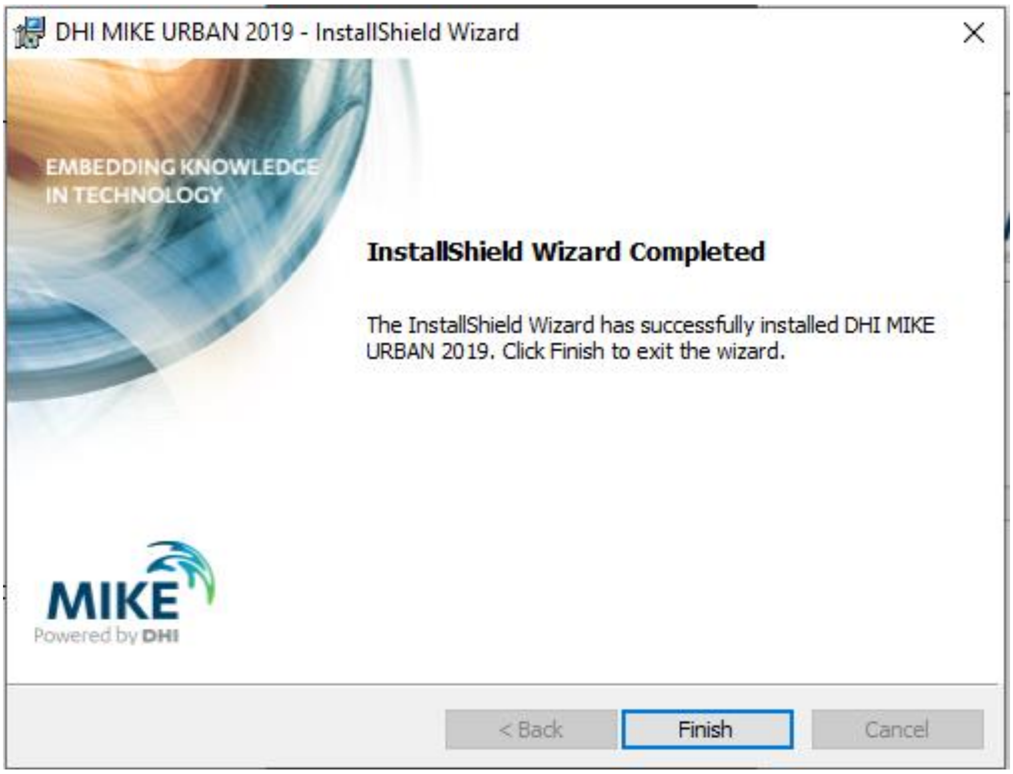


Figure 1-12. Finishing MIKE URBAN installation

➢ *Step 13:* Start a new MIKE URBAN project (Figure 1-13).

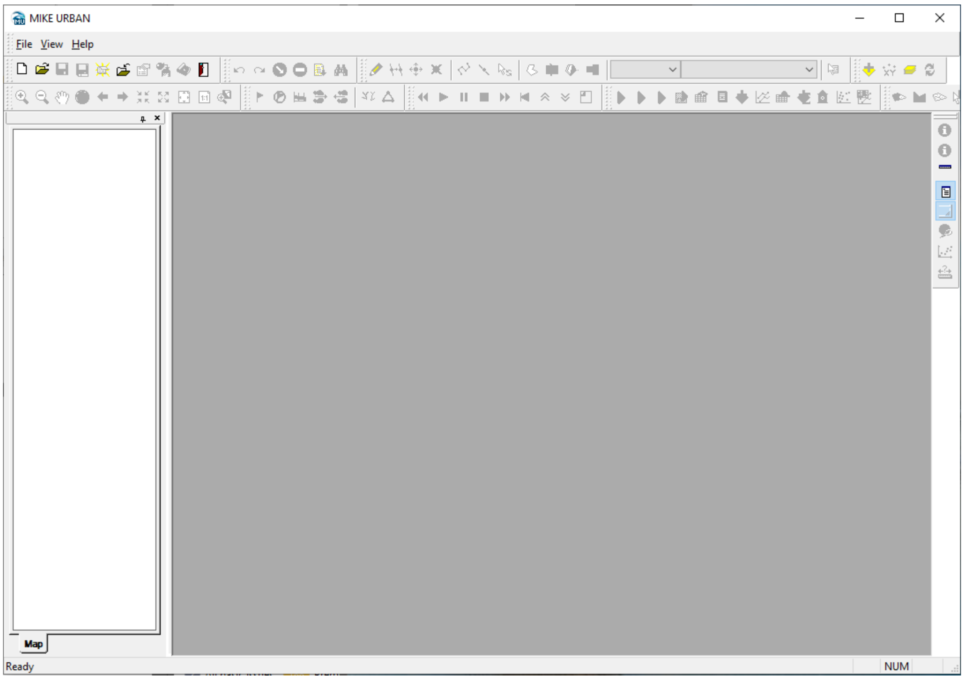


Figure 1-13. A new MIKE URBAN project

1.2. QGIS Installation

QGIS is one of the most widely used Geographic Information System (GIS) software, likely ArcMap, or ArcGIS Pro. QGIS is a free and open-source cross-platform desktop GIS application that supports viewing, editing, printing, and analysis of geospatial data.

To download QGIS, the user can follow the below steps:

➢ *Step 1:* Visit this link: https://www.qgis.org/en/site/ and download QGIS software (Figure 1-14). Documentations for using QGIS can be found at this address.

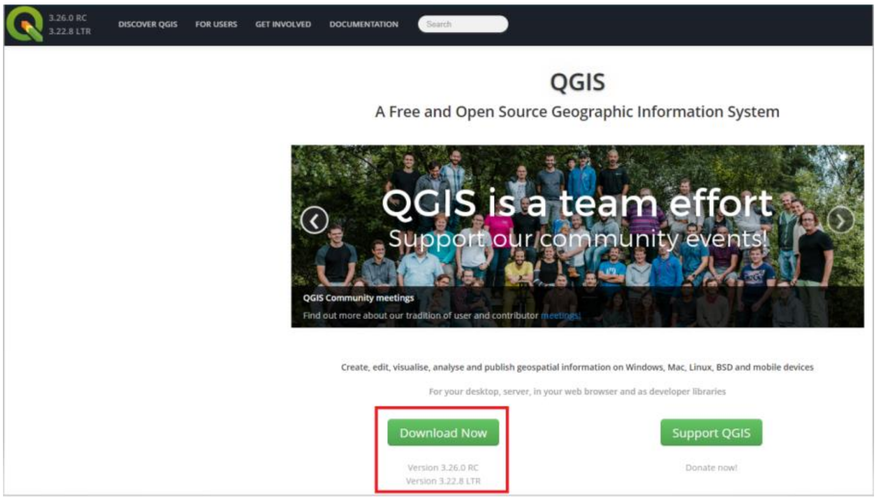


Figure 1-14. QGIS downloading homepage

➢ *Step 2:* Download the correct QGIS version depending on the user's operating system (Figure 1-15).

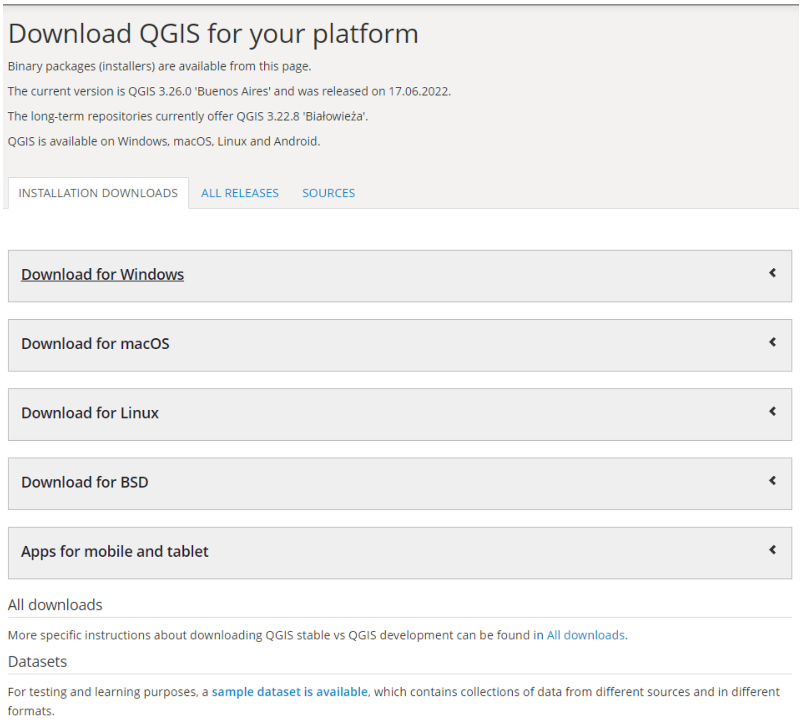


Figure 1-15. Multi-platform QGIS

➢ *Step 3:* Select to download the QGIS. In this tutorial, we used QGIS version 3.22 (the most stable long-term release version) (Figure 1-16).

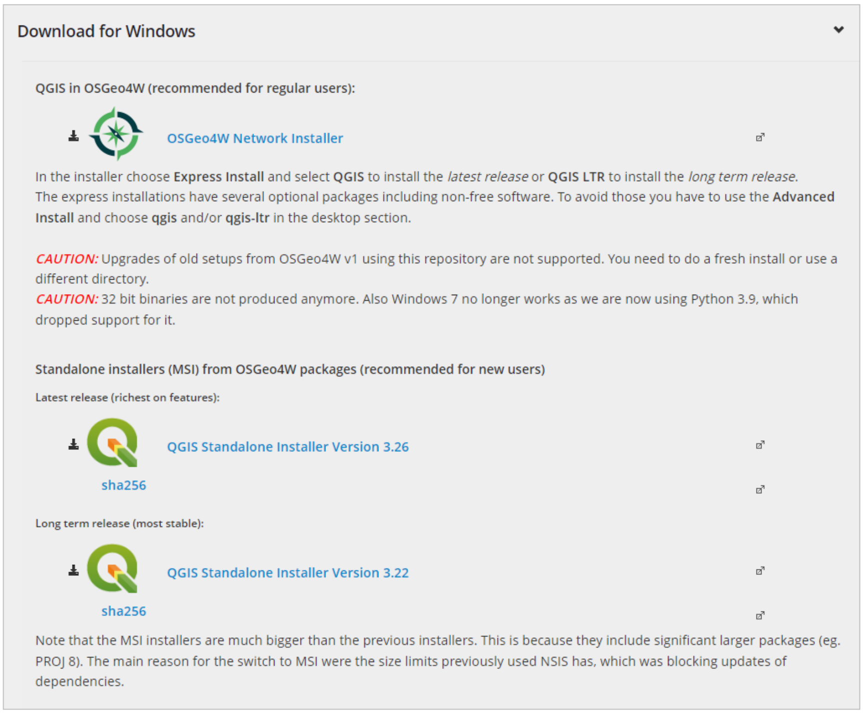


Figure 1-16. Select the wanted QGIS version to download

- *Step 4:* Store the downloaded QGIS software on the PC or hard disk. Install QGIS by double click on the downloaded item.
- *Step 5:* Complete the installation process by clicking the *"Next"* button in the next steps (Figure 1-17).

Figure 1-17. QGIS installation process

- *Step 6:* Finish installation and start a new QGIS project (Figure 1-18).

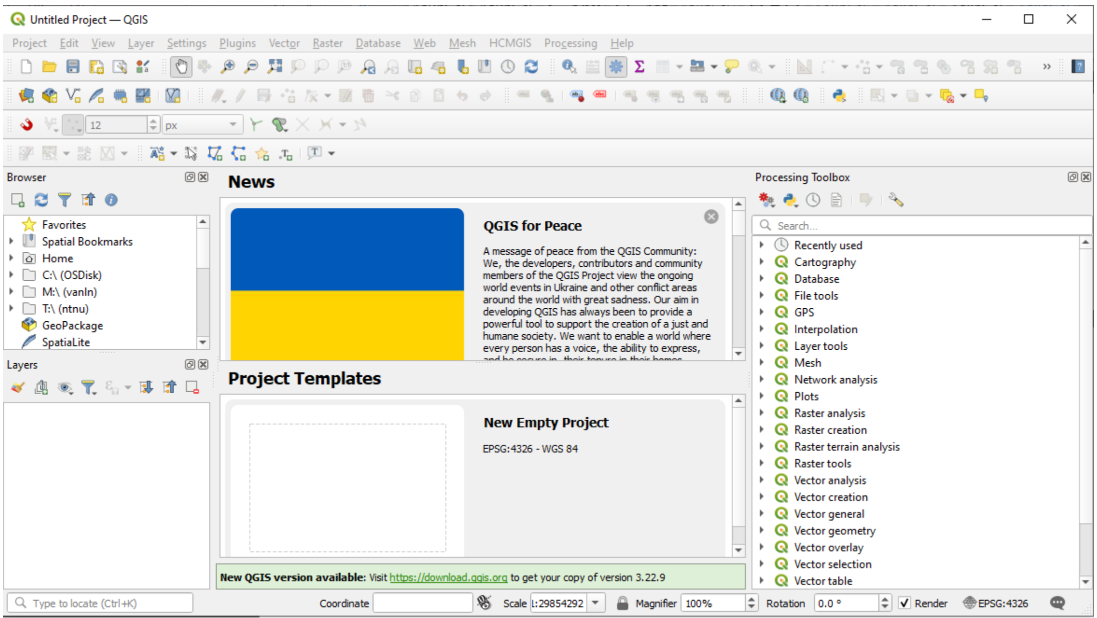


Figure 1-18. Opening a new QGIS project

2. Data Preparation

2.1. Elements of Wastewater Network in MOUSE

The basic components of a collection network in MOUSE are shown in Figure 2-1.

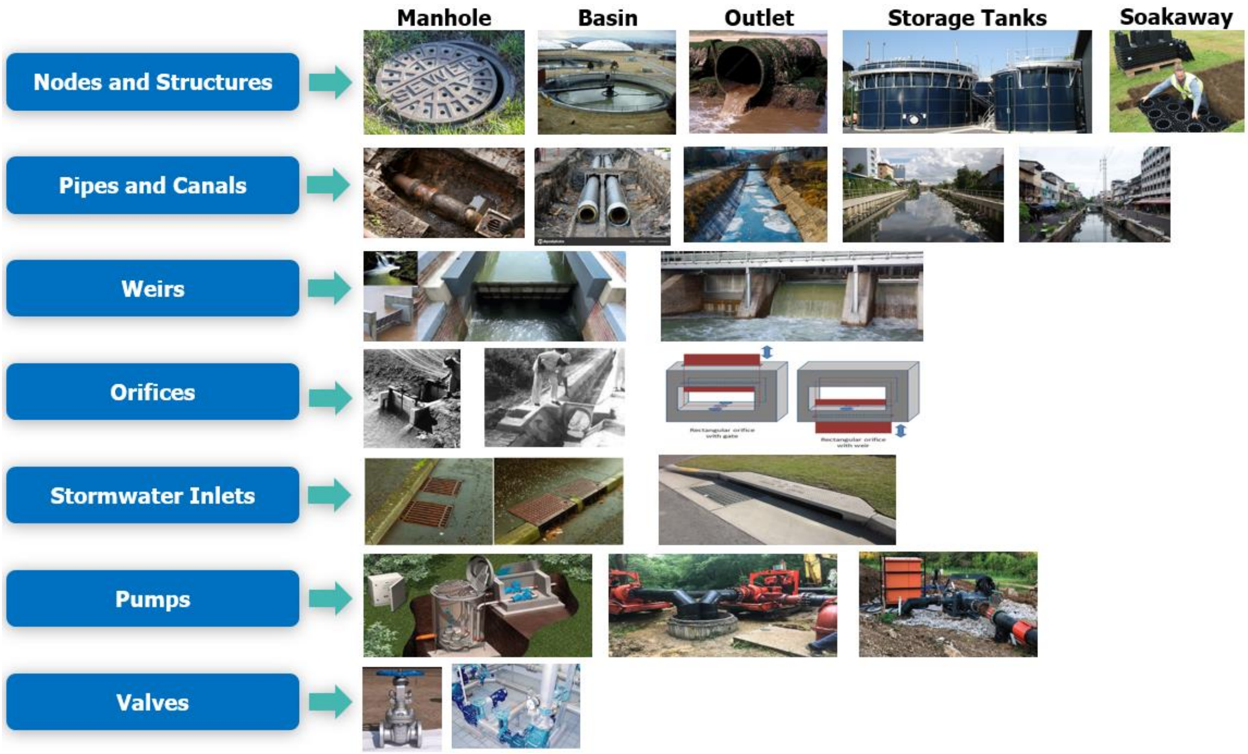


Figure 2-1. Basic components in a collection network system in MOUSE

The function of basic components in MOUSE is represented in Table 2-1.

Table 2-1. Basic components of collection network in MOUSE

Component	**Description**
Nodes and Structures	These elements represent manholes, outlets, and basins in a collection system MOUSE storm and sewer collection system
Pipes and Canals	They are either straight lines or drawn polylines between two nodes and per default are assumed to connect the adjacent nodes at the bottom levels
Weirs, Orifices, and Pumps	They are connections between two nodes of a MOUSE network (two-directional flow and submerged flow possible) or are associated with only one node (free flow "out of the system")
Stormwater Inlets	The connections between pipe systems and overland flow networks to simulate the capture capacity (and surcharge) of side inlet pits
Valves	They are functional relations that connect two nodes of a MOUSE network

2.2. Creating a new MOUSE project

A MOUSE project in MIKE URBAN can be created in several ways:

- Importing from existing MOUSE project
- Importing from existing SWMM project
- Copying network data from MIKE URBAN Collection Systems SWMM network into MIKE URBAN Collection Systems MOUSE network
- Copying network data from MIKE URBAN Collection Systems Asset network into MIKE URBAN Collection Systems MOUSE network
- Graphically digitizing and manual data typing within MIKE URBAN
- Importing of external data (e.g., GIS) into MIKE URBAN Collection Systems MOUSE network

Creating a MOUSE project from another existing project (MOUSE, SWMM, or Asset) is quite straightforward. In this tutorial, we will introduce to the user how to create a new MOUSE project by manual data typing within MIKE URBAN and importing from GIS and Excel data.

2.3. Data Used

Data used in this tutorial is represented in Figure 2-2. This data is divided into two types including physical and environmental data. The physical properties are managed by Ålesund Community, the environmental properties are collected and processed from many sources which are shown in Table 2-2.

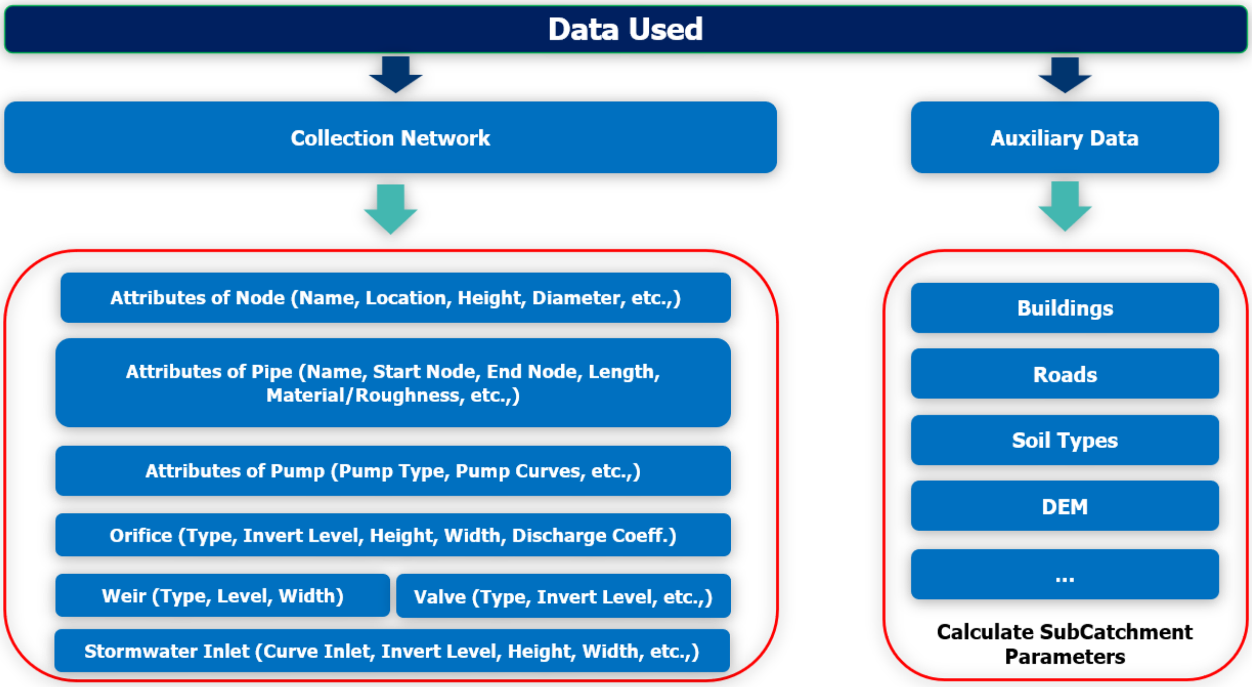


Figure 2-2. Data was used in this tutorial

Table 2-2. Data is used in this tutorial

Environmental factors	Spatial Resolution	Data Type	Source
Land Cover	5m×5m	GRID	Sentinel-2 Images
Building Area	1:5,000	Polygon	The Norwegian Mapping Authority
Road	1:5,000	Polygon	The Norwegian Mapping Authority

Maps of the environmental data are represented in Figure 2-3.

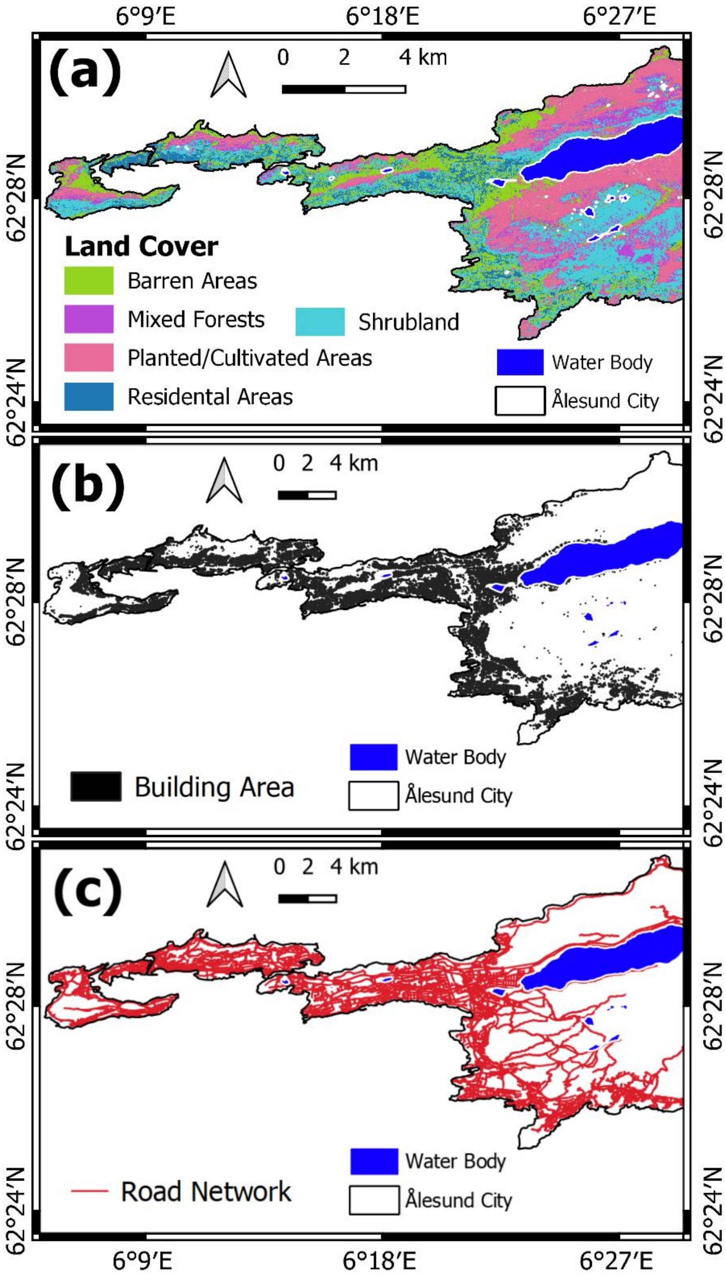


Figure 2-3. Maps of environmental properties

The user can download the demo data for this MOUSE project from our GitHub:

https://github.com/Lam-V-Nguyen/MOUSE_Demo

2.4. Preparing Data in QGIS

In this section, we will introduce to the user two ways to create components before importing them into MOUSE using QGIS: 1) create components manually, and 2) import components automatically from CSV files.

- Creating components manually is a suitable way for people who work with small MOUSE projects or for people who do not have an existing sewer network.
- Importing components from CSV files is a better choice when the attributes of the components are available in tabular format.

a. Georeferencing Background Image

To support the design of a sewer network in MOUSE, it is recommended to put a background image on a real scale in the MOUSE project. As GIS-based software, the background image must be converted into raster type before importing to the MOUSE project. In this tutorial, we will introduce the way to create and convert the background image for MOUSE using QGIS.

❖ *Installing Plugin*

In QGIS, to displace the background image, some plugins (such as HCMGIS or QuickMapServices) can be installed. The plugin HCMGIS is used in this tutorial. The process for installing a plugin is represented in Figure 2-4.

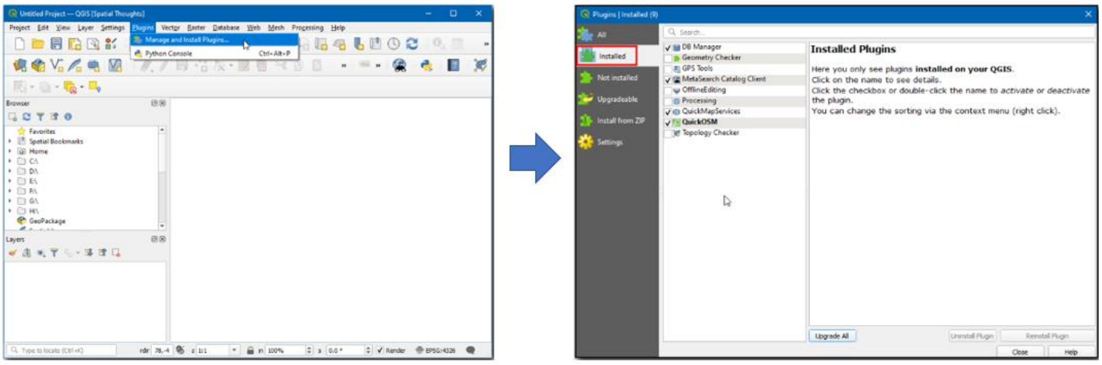


Figure 2-4. Install a plugin in QGIS

Type the keyword *"HCMGIS"* (or *"QuickMapServices"*) into the search address to download and install HCMGIS (or QuickMapServices) plugin. To insert a background image into QGIS, select the wanted type of background image from the list (Figure 2-5).

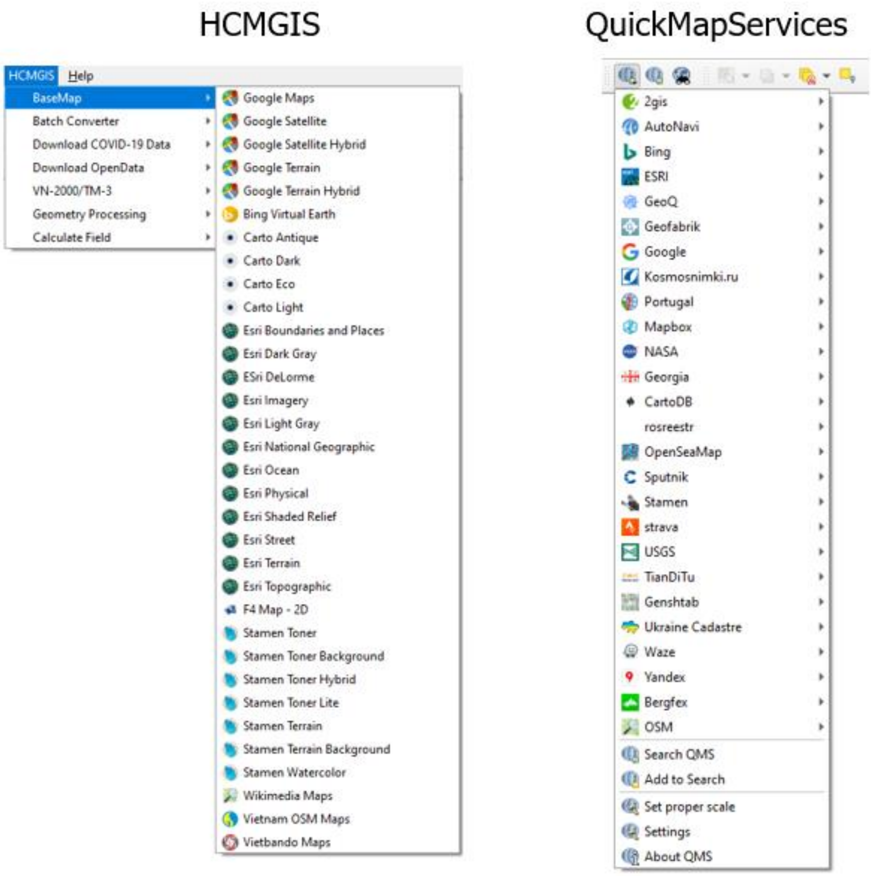


Figure 2-5. Background images in QGIS

❖ *Specifying the Study Area*

In QGIS, the user uses Zoom/Move functions to look for the interesting area (Figure 2-6).

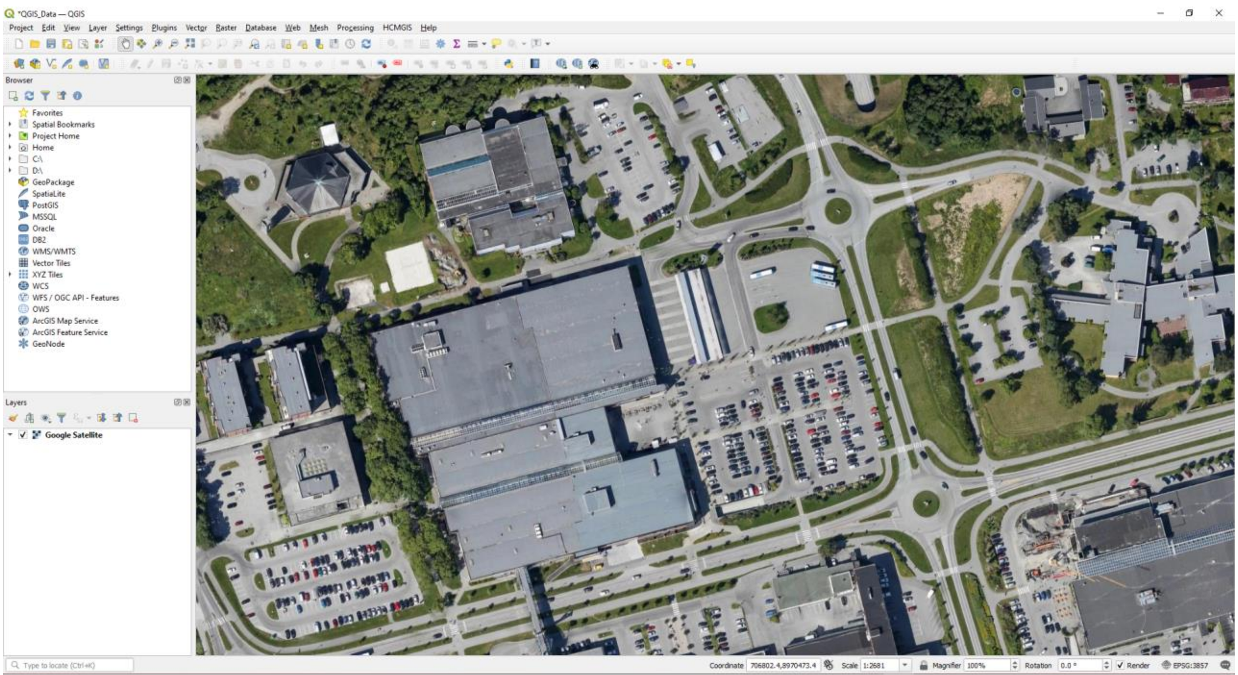


Figure 2-6. Select the study area in QGIS

❖ *Exporting Background Image to Raster File*

Right-click on the background image layer and select Export → Save As... (Figure 2-7).

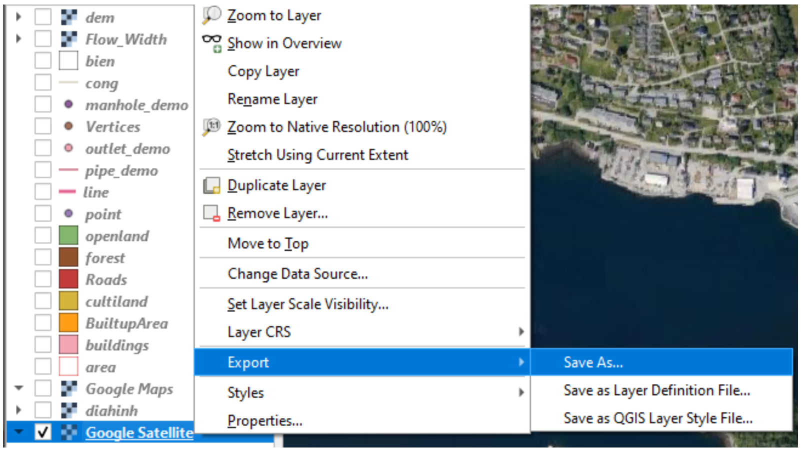


Figure 2-7. Export image in QGIS

In the next step, the user selects the data format, the boundary, and the resolution of the exported image (Figure 2-8).

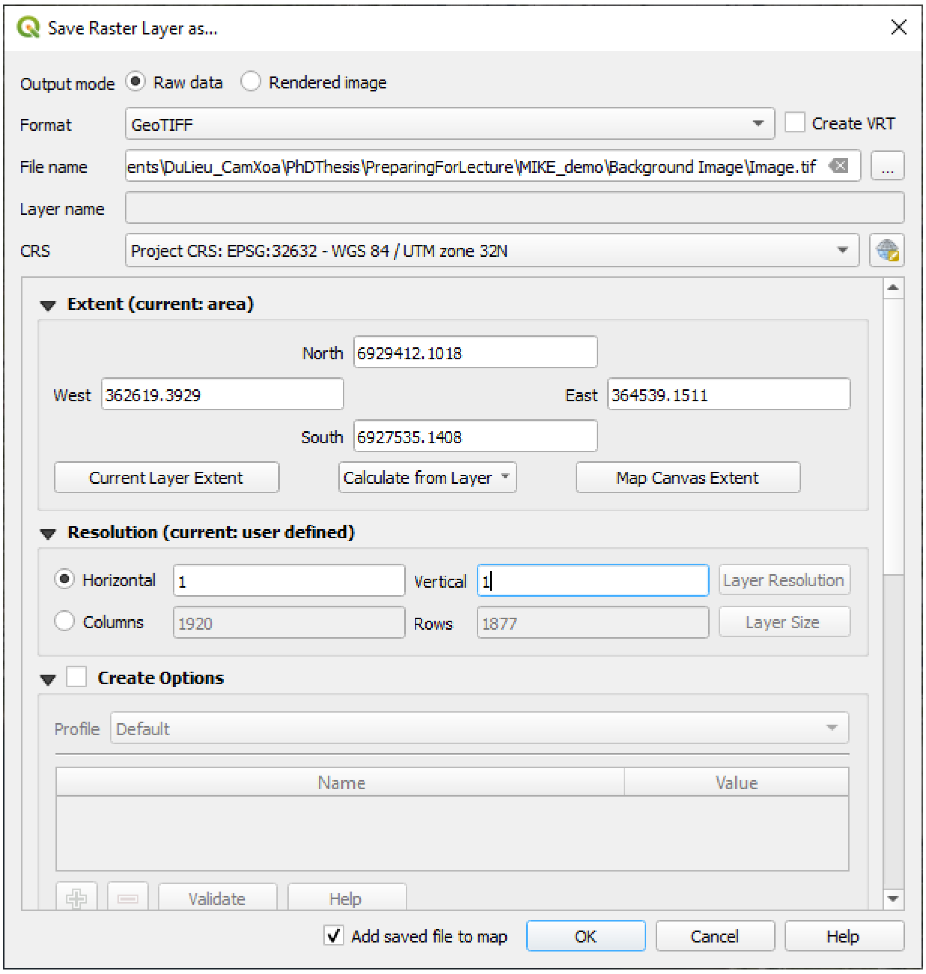


Figure 2-8. The exported image information

b. Creating Node Layer

Table 2-3 shows the important attributes of the node layer in MOUSE.

Table 2-3. Basic attributes of node layer in MOUSE

Point's Attributes	**Type/Value**
MUID	String/Real
NetTypeNo	0: Null; 1: Wastewater; 2: Stormwater; 3: Combined
TypeNo	0: Null; 1: Manhole; 2: Basin; 3: Outlet; 4: Storage Node; 5: Soak away
InvertLevel	Real
GroundLevel	Real
Diameter	Real

❖ *Creating Node manually*

Node layer is created by following steps:

➢ *Step 1:* Create a new layer in QGIS: Layer → Create layer→ New Shapefile Layer… (Figure 2-9a).

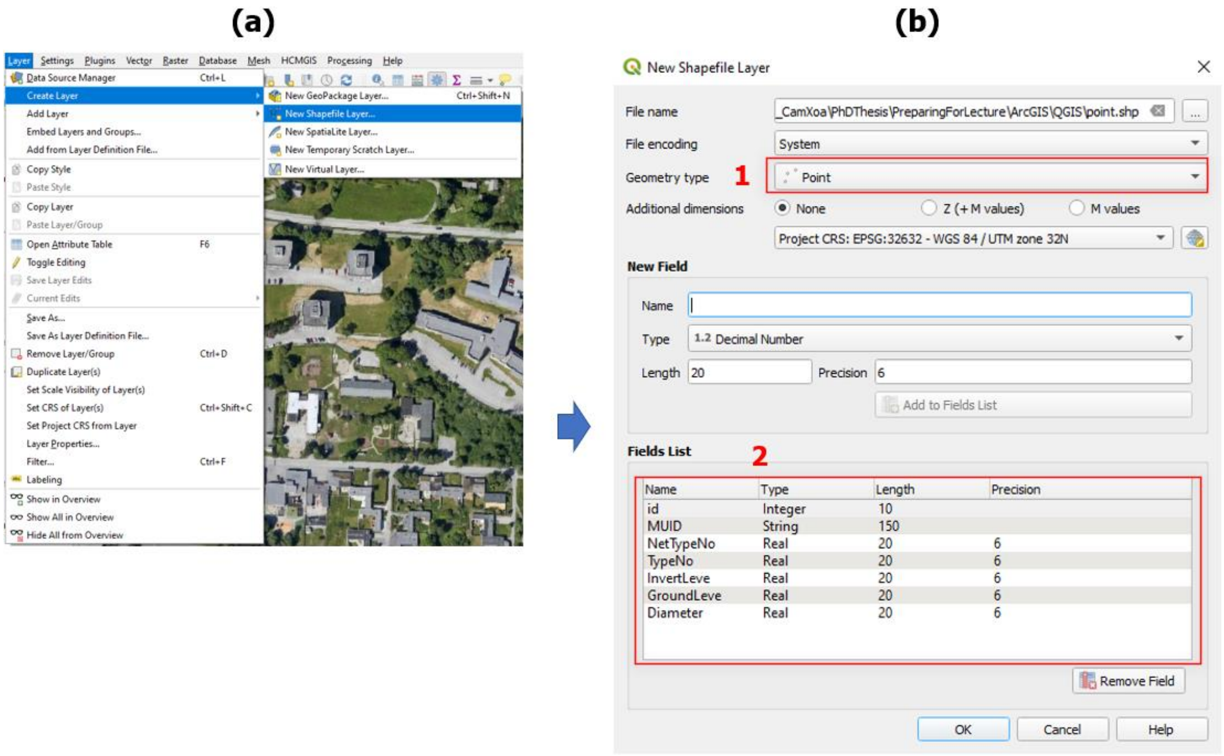


Figure 2-9. Creating a node layer in QGIS

➢ *Step 2:* Assign wanted properties for the node component. It is noticed that the

"Geometry type" is selected as ***"Point"*** (Figure 2-9b).

- *Step 3:* Select created node layer and activate the edit mode in QGIS (Figure 2-10).

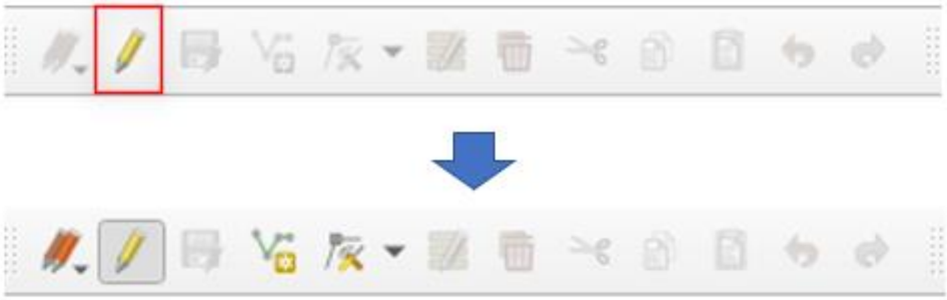


Figure 2-10. Editing mode in QGIS

- *Step 4:* Select the ***"Add Point Feature"*** button, pick points where nodes are located on the map, and change their attributes (if necessary) (Figure 2-11).

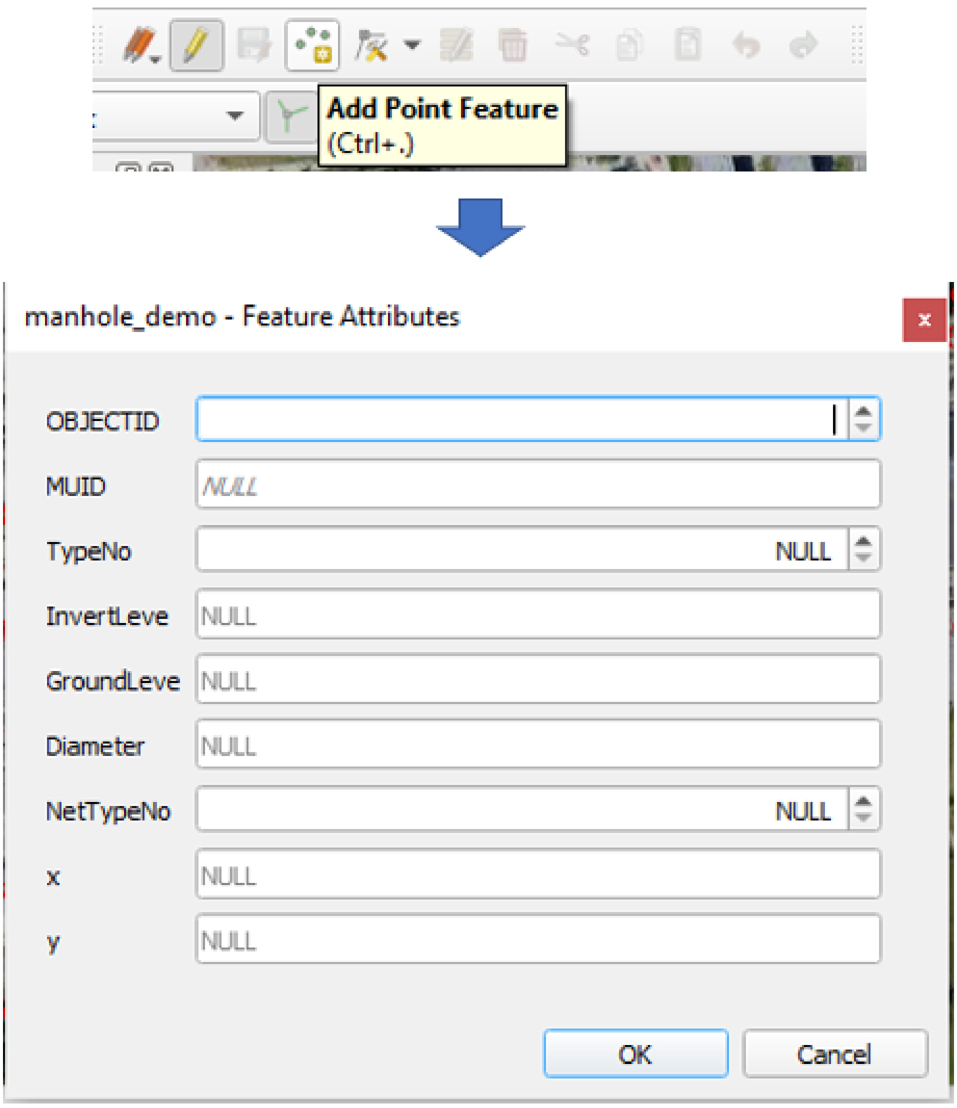


Figure 2-11. Add a new point and assign its attributes in QGIS

➢ *Step 5:* Check the location of nodes on the map (Figure 2-12).

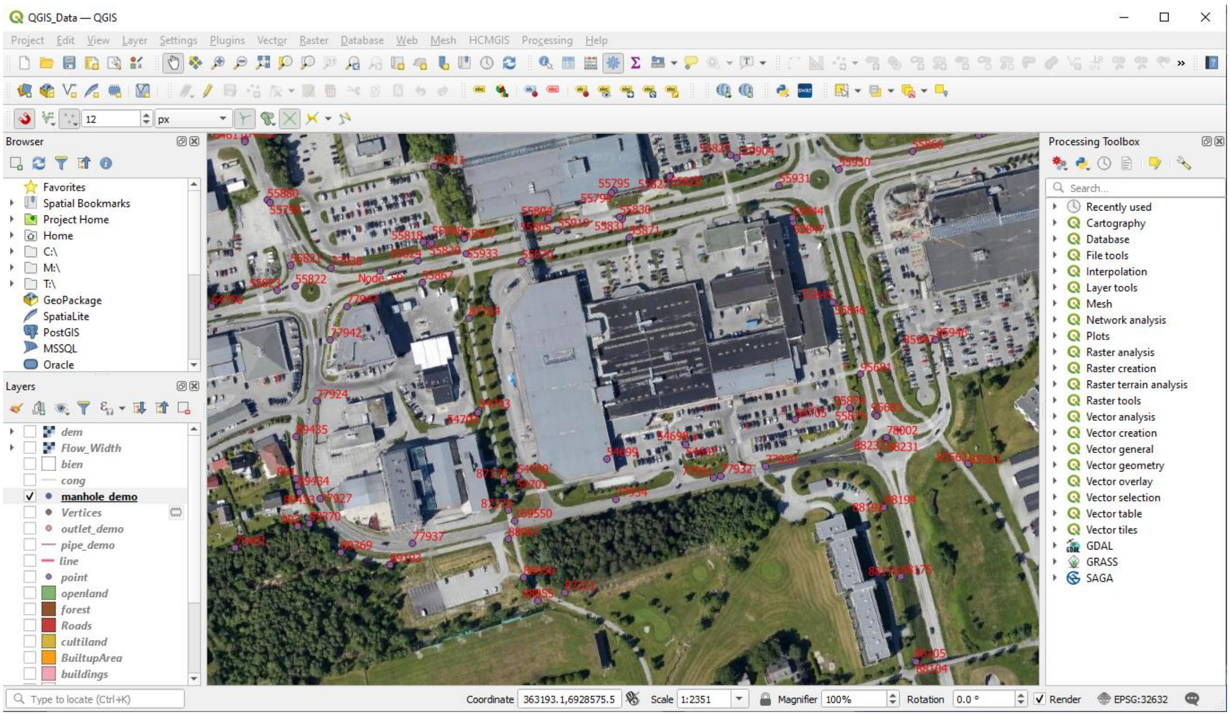


Figure 2-12. Nodes on the map

➢ *Step 6:* To adjust the attributes of the nodes, the user must open the attribute table of the node layer (Figure 2-13).

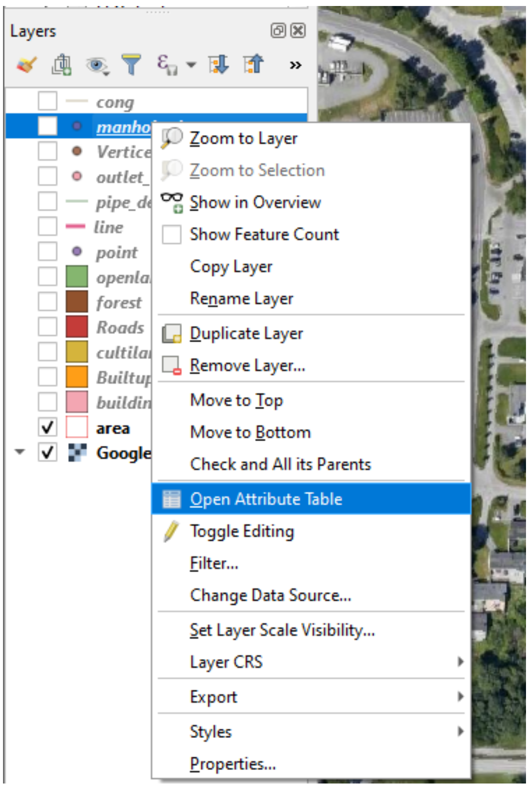


Figure 2-13. Nodes' attribute table in QGIS

➢ *Step 7:* Change the attribute of node objects (Figure 2-14).

manhole_demo — Features Total: 857, Filtered: 857, Selected: 0

	BJECTI	MUID	TypeNo	InvertLeve	GroundLeve	Diameter	NetTypeNo	x	y
1	19830	83016	1	6.29000000000	7.39000000000	0.94	3	363747.813	6927917.180
2	19828	99824	1	43.48000000000	44.91000000000	0.9	1	363986.410	6929156.500
3	19822	87176	1	40.18000000000	43.48000000000	0.67	2	363335.590	6928692.850
4	19794	54713	1	33.44000000000	36.47000000000	1.20000000000	1	363885.420	6928713.300
5	19793	54962	1	24.52000000000	26.85000000000	1.17000000000	3	364038.130	6928629.140
6	19792	54992	1	23.74000000000	26.42000000000	1.00000000000	1	364236.270	6928634.070
7	19788	54631	1	15.88000000000	18.59000000000	0.95	2	363603.250	6928248.660

Show All Features

Figure 2-14. Attributes of Nodes

❖ *Importing Nodes from CSV file*

A CSV (Comma-Separated Values) file is a text file that has a specific format that allows data to be saved in a table structured format. A CSV file is easily created using Microsoft Excel.

	A	B	C	D	E
1	PSID	Coord_X	Coord_Y	Invert_Elevation	MaxDepth
2	472	364142.57	6928717.76	23.45	1.2
3	592	364073.05	6928421.09	21.2	1
4	596	364160.62	6929145.44	46.59	0.89
5	649	363933.52	6928924.23	35.44	1
6	653	364054.79	6928917.08	36.93	0.65
7	658	364336.09	6929013.79	40	1
8	772	363182.82	6928287.94	8.42	1
9	775	363187.36	6928306.91	12.94	0.4
10	776	363214.05	6928320.2	16.93	0.32
11	836	363207.93	6928273.21	7.73	0.75
12	901	363188.12	6928714.96	46.57	1
13	902	363189.48	6928681.79	46.49	1
14	2700	362874.71	6928864.79	56.58	1
15	2701	362823.73	6928867.38	57.22	1
16	54139	363463.31	6927750.18	28.4	1.2
17	54143	363408.17	6927779.41	23.09	1.2
18	54145	363384.71	6927795.64	20.77	1.2
19	54147	363374.54	6927814.2	19.7	1.2
20	54149	363389.46	6927838.1	18.15	1.2
21	54151	363451.27	6927826.62	14.63	1.2
22	54152	363501.02	6927803.07	13.72	1.2
23	54156	363604.91	6927789.99	6.71	1.2
24	54157	363635.57	6927810.8	3.38	1.2
25	54158	363670.12	6927839.21	1.87	0.32
26	54159	363670.1	6927817.18	3.16	1.38
27	54160	363676.07	6927807.75	4.61	1.18
28	54161	363674.21	6927809.54	4.35	1.2

Figure 2-15. Node file example

In the CSV file, the number of rows and columns is unlimited and depends on the user's definition. An example of the node file used in this tutorial is represented in Figure 2-15. In this file, the locations of nodes (geographical location or plan coordinate) are the most important elements because these values define a particular point on the map. Other values can be added afterward, even after points are created.

The process for creating a node layer is illustrated in Figure 2-16.

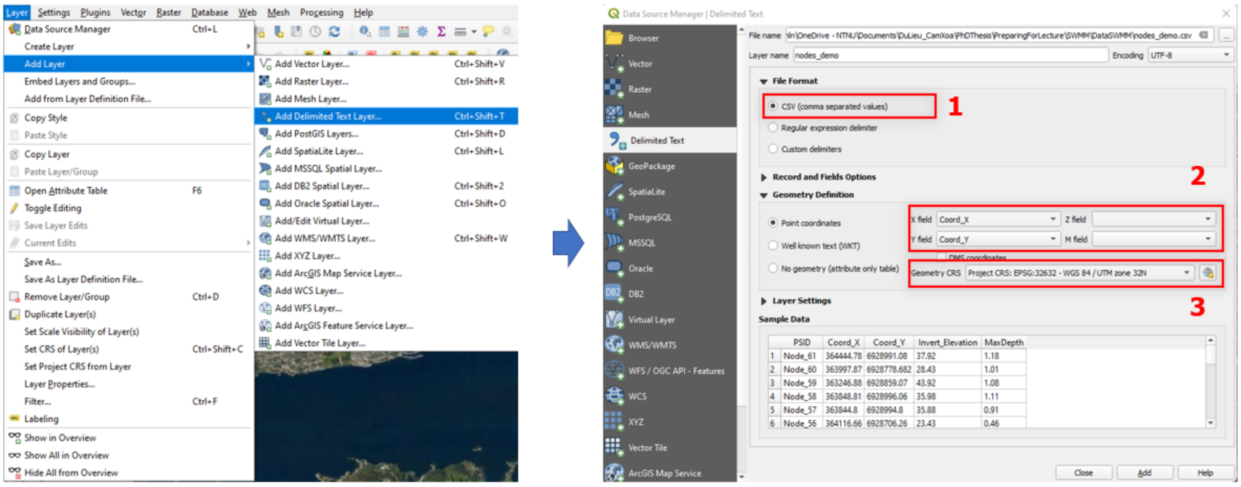


Figure 2-16. Creation of node layer from CSV file

The most important steps while creating a node layer from a CSV file are to select coordinating elements and a geometry coordinate reference system (CRS) correctly. In this tutorial, we use ***EPSG: 32632 – WGS84/UTM Zone 32N*** as the default CRS (steps 2 and 3 in Figure 2-16).

c. Creating Link Layer

In QGIS, a link is a line that connects many nodes. The important attributes of the link layer in MOUSE are illustrated in Table 2-4.

Table 2-4. Basic attributes of link layer in MOUSE

Line's Attributes	Type/Value
MUID	String/Real
NetTypeNo	0: Null; 1: Wastewater; 2: Stormwater; 3: Combined
TypeNo	0: Null; 1: Circular; 2: CRS; 3: Rectangular; 4: O Shape; 5: Egg Shape; 6: Natural Channel
UpLevel	Real
DwLevel	Real

Diameter	Real
Length	Real

❖ *Creating Link manually*

➢ *Step 1:* Create a new layer in QGIS: Layer → Create layer → New Shapefile Layer… (Figure 2-17a).

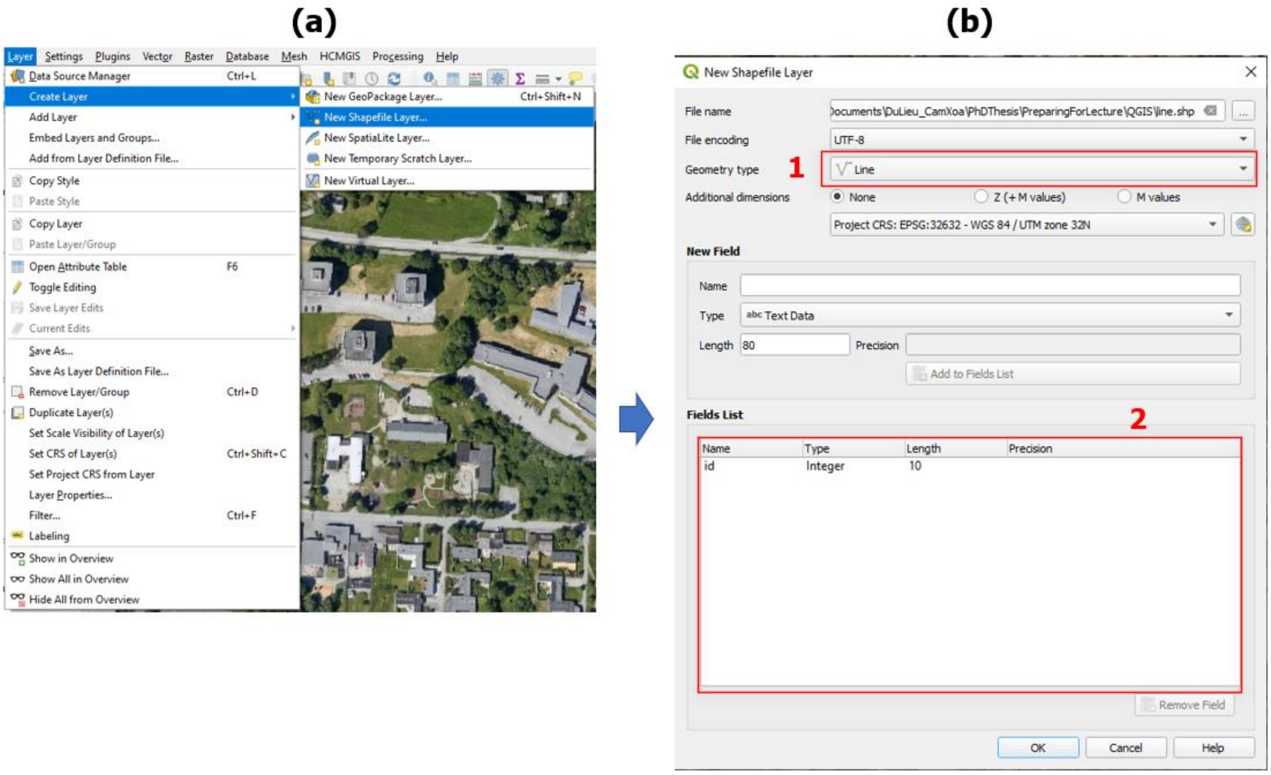


Figure 2-17. Creating a link layer in QGIS

➢ *Step 2:* Assign wanted properties for the link component. It is noticed that the ***"Geometry type"*** is selected as ***"Line"*** (Figure 2-17b).

➢ *Step 3:* Select created link layer and activate the edit mode in QGIS (Figure 2-10).

➢ *Step 4:* Select the ***"Add Line Feature"*** button and pick points where the line goes through on the map by clicking the left mouse button. A line can be created by a simple line (between two points) or a complex line (between multi-points). Click the right mouse button to finish creating a particular line. After that, a ***"Feature Attributes"*** dialog appears to allow the user to change/assign the link's attributes (Figure 2-18).

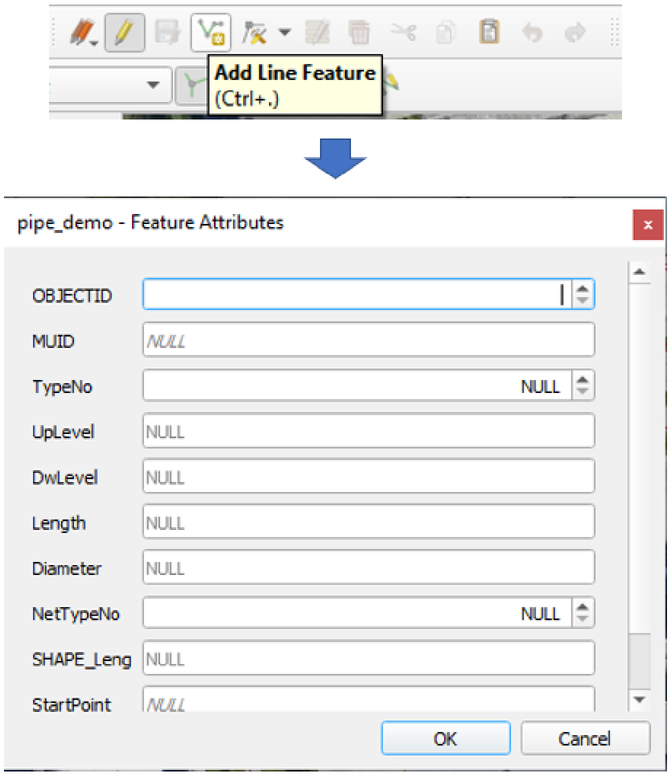


Figure 2-18. Add a new line and assign its attributes in QGIS

➢ *Step 5:* Check created links on the map (Figure 2-19).

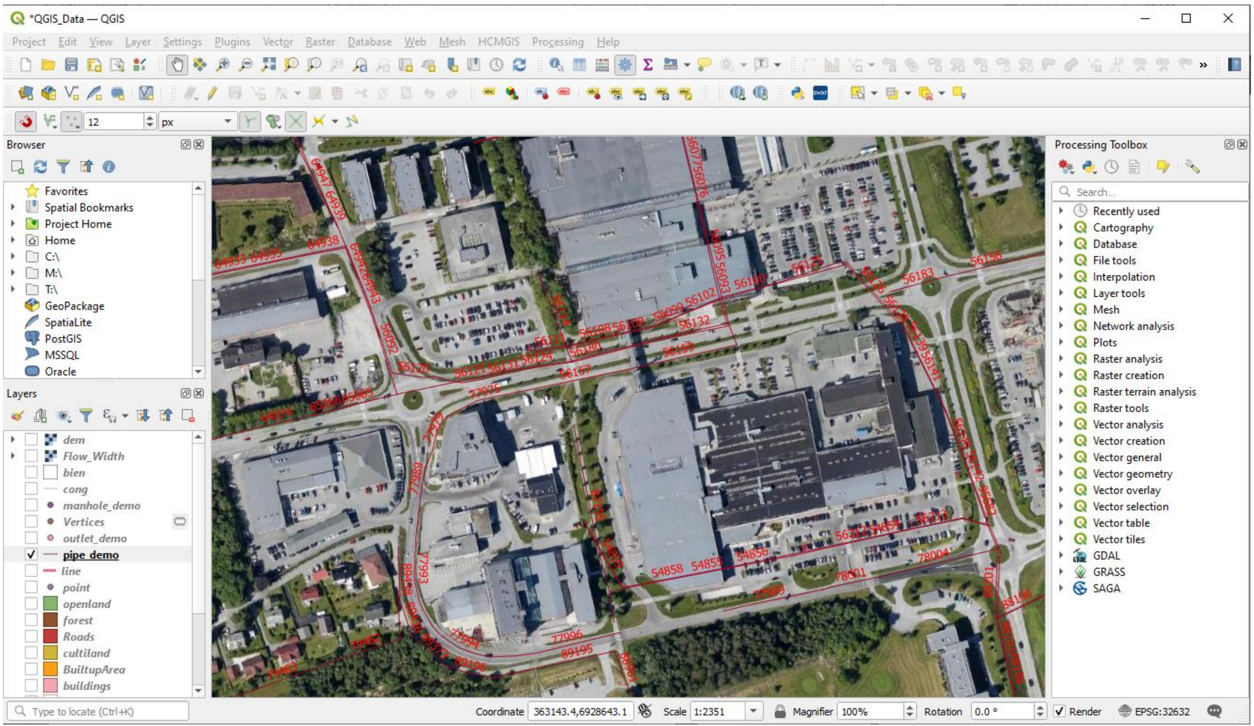


Figure 2-19. Links on the map

➢ *Step 6:* To adjust the attributes of the links, the user must open the attribute table of the link layer (Figure 2-20).

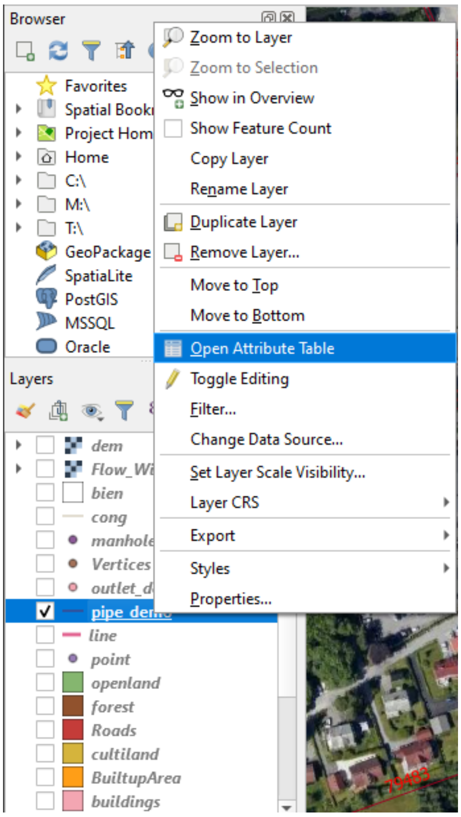


Figure 2-20. Links' attribute table in QGIS

❖ *Importing Links from CSV file*

An example of a link file is shown in Figure 2-21. It is worth noticing that all points of one line (including start point, end point, and vertices points) must have the same name or index.

	A	B	C	D	E	F	G
1	LSID	LNO	X	Y	Z	Q_XY	Q_Z
2	76	1	355479.8	6929662	15.48	1	1
3	76	2	355476.8	6929676	15	1	1
4	77	1	355476.8	6929676	14.48	1	1
5	77	2	355474.4	6929688	7.79	1	1
6	78	1	355474.4	6929688	7.79	1	1
7	78	2	355415.5	6929692	6.68	1	1
8	79	1	355415.5	6929692	6.68	1	1
9	79	2	355403	6929707	6.44	1	1
10	82	1	355475.6	6929676	14.5	1	1
11	82	2	355473	6929687	7.37	1	1
12	83	1	355473	6929687	7.16	1	1
13	83	2	355414.8	6929692	6.04	1	1
14	84	1	355414.8	6929692	6.04	1	1
15	84	2	355401.4	6929707	5.7	1	1
16	86	1	355481.3	6929660	15.89	1	1
17	86	2	355475.6	6929676	15.28	1	1
18	87	1	355514.4	6929673	14.99	1	1
19	87	2	355476.8	6929676	14.48	1	1

Figure 2-21. Link file example

The first step in creating a line in QGIS is to import all vertices points into QGIS (Figure 2-16). The next step is to join all points with the same name/index into one line. To merge points into one line, the user can use the function ***"Points to path"*** in QGIS (steps 3 and 4 in Figure 2-22) from the ***"Processing Toolbox"*** dialog (step 2 in Figure 2-22). If this dialog is disabled, the user can enable it by selecting Processing → Toolbox from the main menu (step 1 in Figure 2-22).

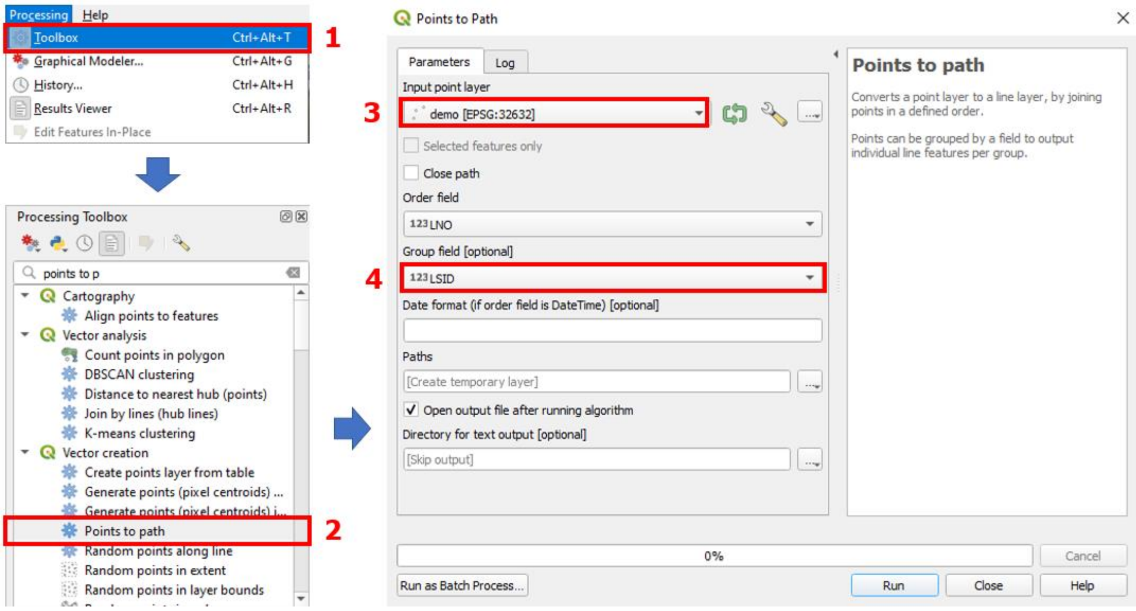


Figure 2-22. Convert points to a line in QGIS

Check the links on the map (Figure 2-23).

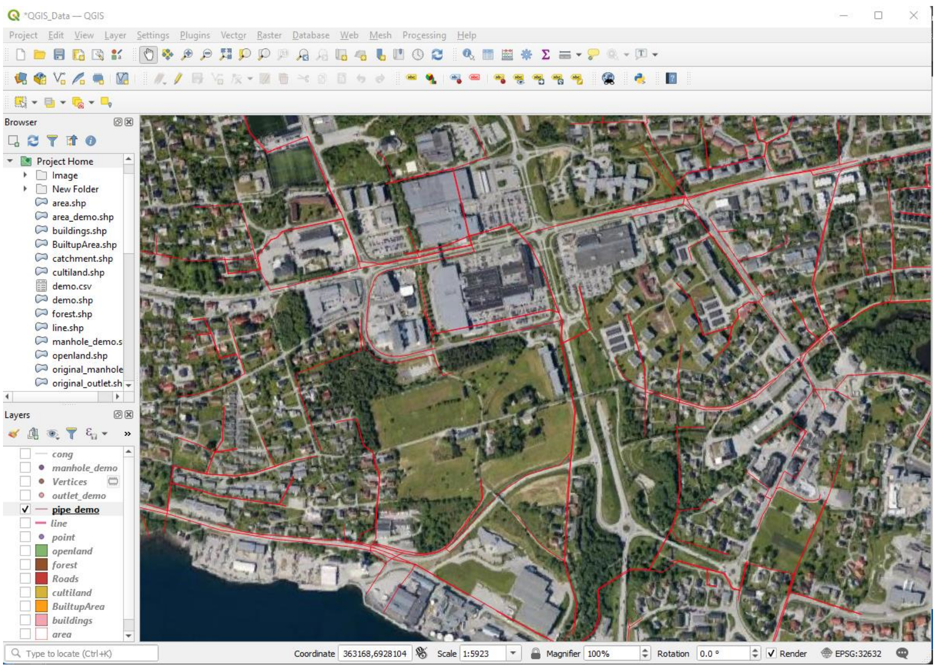


Figure 2-23. Links in QGIS

Links created by the above steps do not have any attributes. If the user has a CSV file that contains links' properties like Figure 2-24, this file can be joined with the lines in Figure 2-23.

	A	B	C	D	E	F	G
1	LSID	FCODE	DIM	LENGTH	FROM_PSID	TO_PSID	Roughness
2	981	AF	0.23	46.93	151886	981_83019	0.020982467
3	1187	OV	0.16	25.06	459	54676	0.023396565
4	1221	SP	0.23	11.51	55137	1221_Outlet	0.024614898
5	1222	AF	0.3	66.61	472	54956	0.024749715
6	1229	SP	0.12	69.31	596	56495	0.02525517
7	1231	OV	0.15	2.85	1231_Inlet	153852	0.024614898
8	1272	SP	0.15	18.63	649	55950	0.02525517
9	1280	SP	0.15	16.14	653	56516	0.02525517
10	1328	OV	0.2	34.56	733	732	0.024405479
11	1330	OV	0.2	2.1	56353	152323	0.024405479
12	1341	AF	0.3	26.25	772	54663	0.022710703
13	1345	SP	0.16	15.98	775	89074	0.021309238
14	1346	SP	0.16	29.82	776	775	0.021309238
15	1358	OV	0.3	61.81	863	868	0.024405479
16	1363	SP	0.23	33.2	901	902	0.023549279
17	4956	OV	0.16	23.56	459	153455	0.023396565
18	4970	OV	0.2	23.83	1812	1813	0.021807907

Figure 2-24. Links' attributes CSV file

To join a CSV file with a link layer, the user needs to do the following steps:

- *Step 1:* Add a CSV file into QGIS as a layer (Figure 2-25a). In this step, the CSV file can be loaded as a simple table (the ***"No geometry"*** option is selected) (Figure 2-25b). Select the ***"Add"*** button to add the CSV file as a layer.

(a) **(b)**

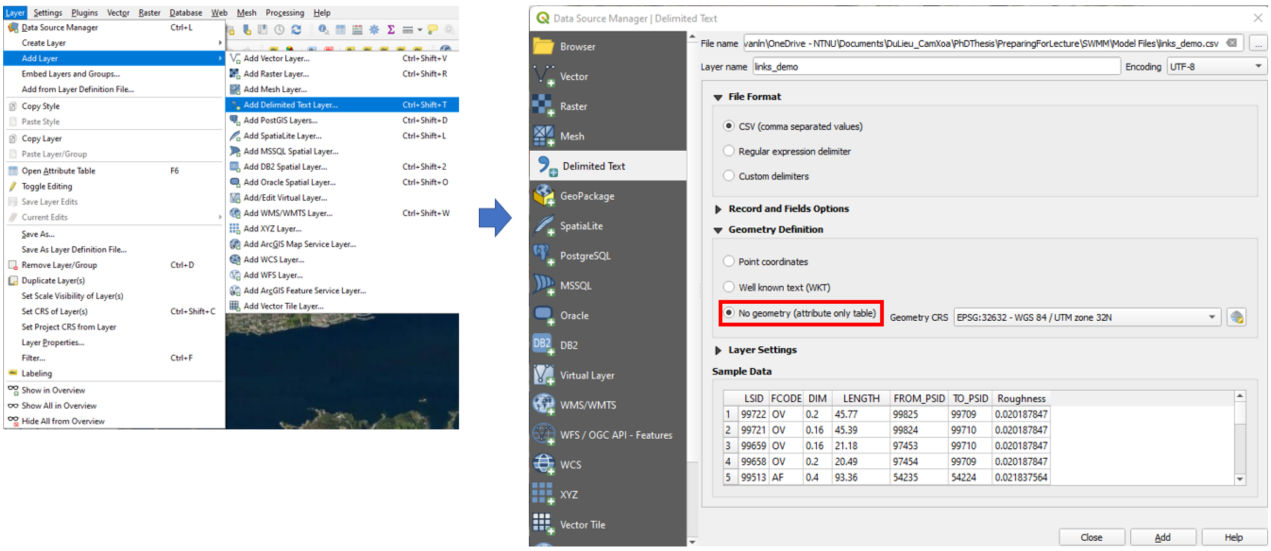


Figure 2-25. Add a CSV file to QGIS

- *Step 2:* Open the ***"Layer Properties"*** dialog (step 1 in Figure 2-26), add the above

CSV layer (steps 2 and 3 in Figure 2-26), select attribute to join (step 4 in Figure 2-26), and fields to join (step 5 in Figure 2-26).

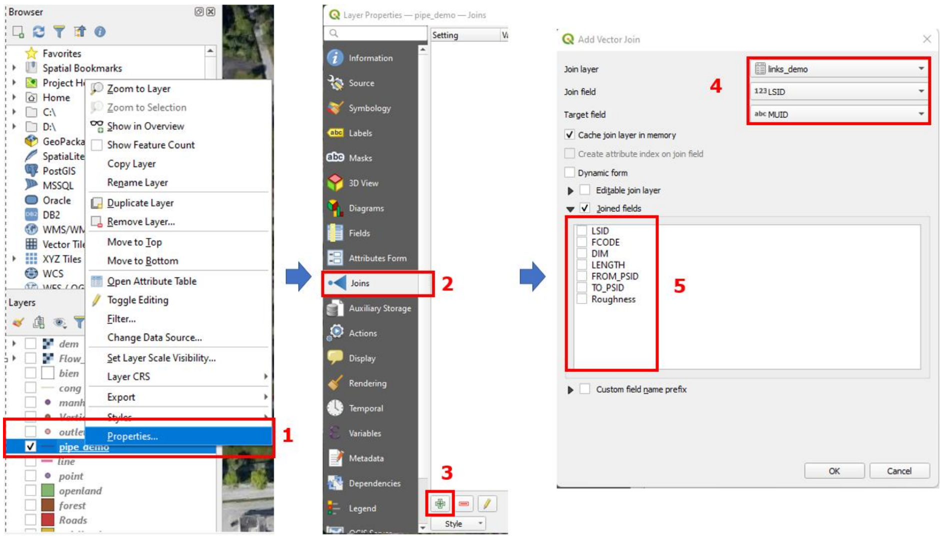
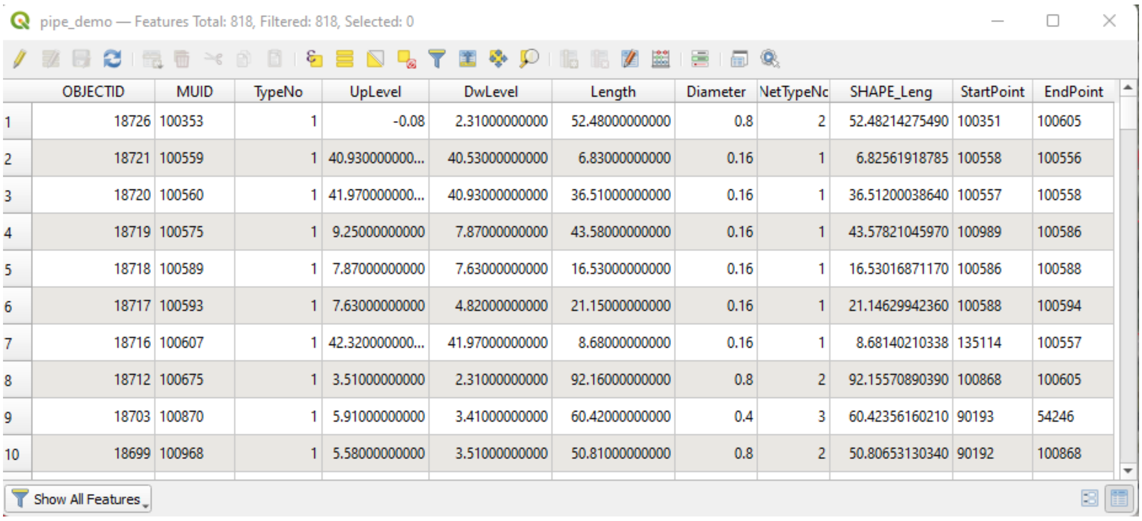


Figure 2-26. Join attributes in QGIS

➢ *Step 3:* Open the attribute table to check the attributes of links (Figure 2-27).



pipe_demo — Features Total: 818, Filtered: 818, Selected: 0

	OBJECTID	MUID	TypeNo	UpLevel	DwLevel	Length	Diameter	NetTypeNc	SHAPE_Leng	StartPoint	EndPoint
1	18726	100353	1	-0.08	2.31000000000	52.48000000000	0.8	2	52.48214275490	100351	100605
2	18721	100559	1	40.930000000...	40.53000000000	6.83000000000	0.16	1	6.82561918785	100558	100556
3	18720	100560	1	41.970000000...	40.93000000000	36.51000000000	0.16	1	36.51200038640	100557	100558
4	18719	100575	1	9.25000000000	7.87000000000	43.58000000000	0.16	1	43.57821045970	100989	100586
5	18718	100589	1	7.87000000000	7.63000000000	16.53000000000	0.16	1	16.53016871170	100586	100588
6	18717	100593	1	7.63000000000	4.82000000000	21.15000000000	0.16	1	21.14629942360	100588	100594
7	18716	100607	1	42.320000000...	41.97000000000	8.68000000000	0.16	1	8.68140210338	135114	100557
8	18712	100675	1	3.51000000000	2.31000000000	92.16000000000	0.8	2	92.15570890390	100868	100605
9	18703	100870	1	5.91000000000	3.41000000000	60.42000000000	0.4	3	60.42356160210	90193	54246
10	18699	100968	1	5.58000000000	3.51000000000	50.81000000000	0.8	2	50.80653130340	90192	100868

Show All Features

Figure 2-27. Links' attribute table

The user can calculate some geometry-related properties such as coordinates of points, area of polygons, length of lines, etc., In this section, we introduce computing the length of the line using QGIS because this attribute is compulsory property when importing into MOUSE. To compute the length of a line, the user needs to do the following steps:

➢ *Step 1:* Select the link layer that the user wants to compute length, open the attribute table (Figure 2-20), and activate the edit mode in QGIS (Figure 2-10).

➢ *Step 2:* In the attribute table, select the column where the user wants to compute the length (step 1 in Figure 2-28), and click on the ***“Expression”*** button (step 2 in Figure 2-28) to display the expression dialog.

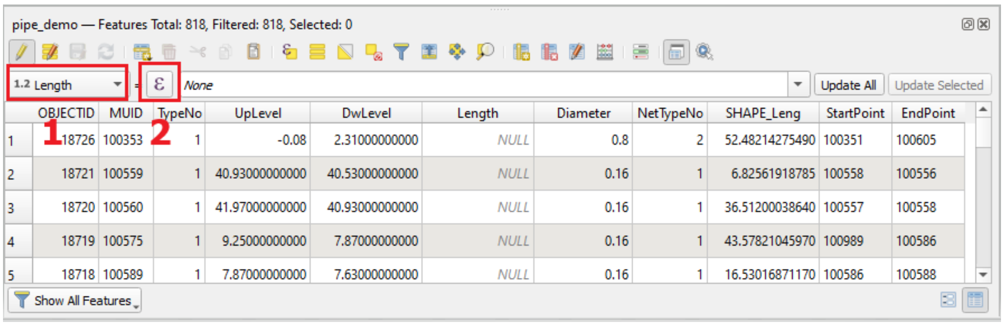


Figure 2-28. Line's length calculation in QGIS

- *Step 3:* In the expression dialog, select the ***“Geometry”*** option (Figure 2-29a), scroll down and select the ***“$length”*** function (Figure 2-29b). Click ***OK*** to finish this step.

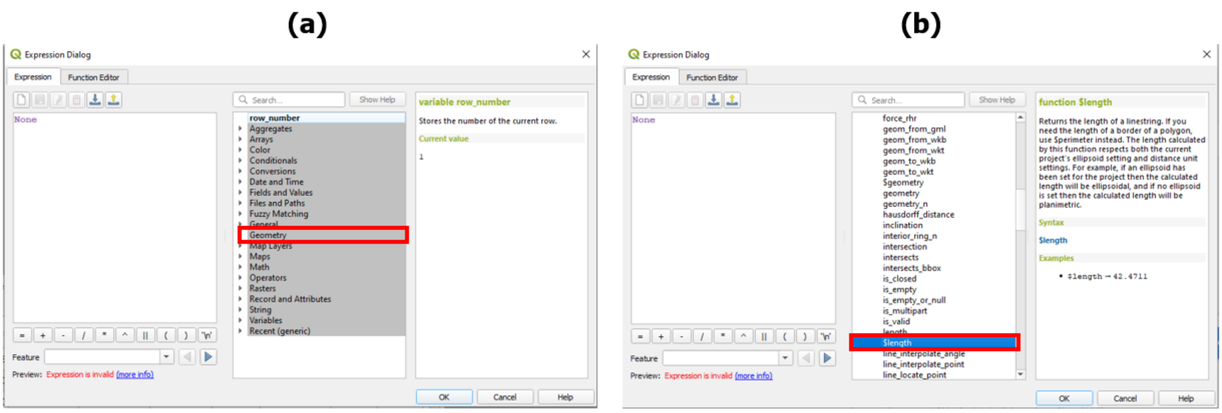


Figure 2-29. Length computation

- *Step 4:* The ***“$length”*** selection will appear in the attribute table (step 1 in Figure 2-30). After that, the user hits the “Update All” button to compute the length of all links (step 2 in Figure 2-30). Finally, select the ***“Save Edit”*** button to save all calculated information (step 3 in Figure 2-30).

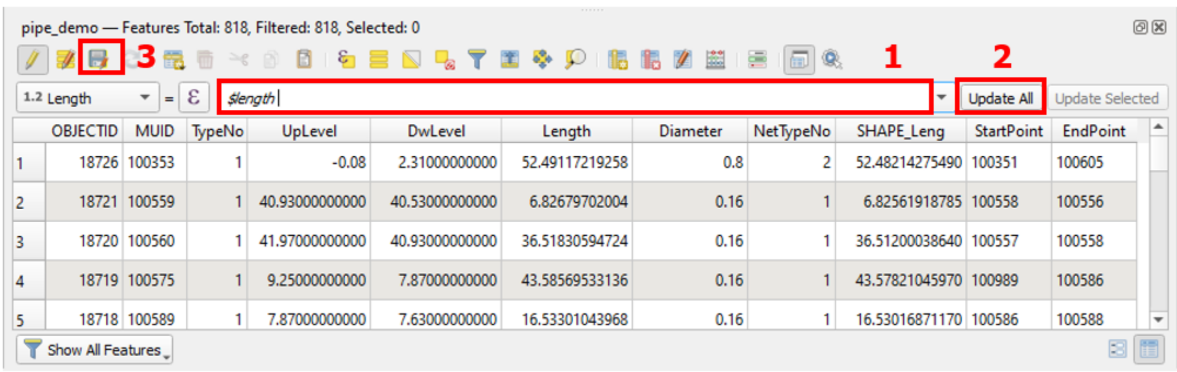


Figure 2-30. Finish calculation

d. Exporting Layer to Shapefile

After Node/Link layers are created and modified in QGIS, they can be exported and stored as shapefile (*.shp). The shapefile format is a geospatial vector data format for GIS software. It is developed and regulated by Esri as a mostly open specification for data interoperability among Esri and other GIS software products. The shapefile format can spatially describe vector features: points, lines, and polygons.

Steps for exporting a layer to a shapefile are illustrated in Figure 2-31. Firstly, the user right-clicks on the exported layer, selects Export → Save Feature As… (step 1 in Figure 2-31), selects data format and location (step 2 in Figure 2-31) and selects wanted CRS (step 3 in Figure 2-31).

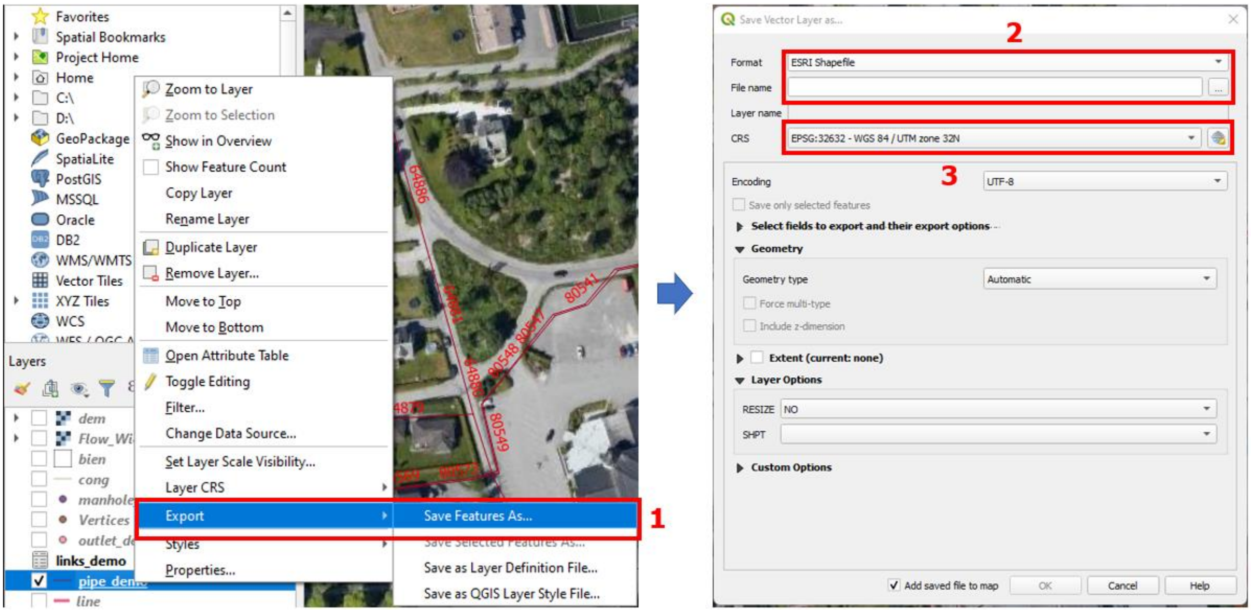


Figure 2-31. Export layer to shapefile

3. Designing a MOUSE project

3.1. Creating a MOUSE project

To create a new MOUSE project, the user does the following steps:

- *Step 1:* Open MIKE URBAN by clicking this symbol MIKE on the computer (this symbol can be found in the start menu of the computer).
- *Step 2:* Select File → New → Select ***"Collection System"*** → Tick ***"MOUSE"*** option (Figure 3-1). Define name (step 1 in Figure 3-1), destination (step 2 in Figure 3-1), and unit system for the project (step 3 in Figure 3-1).

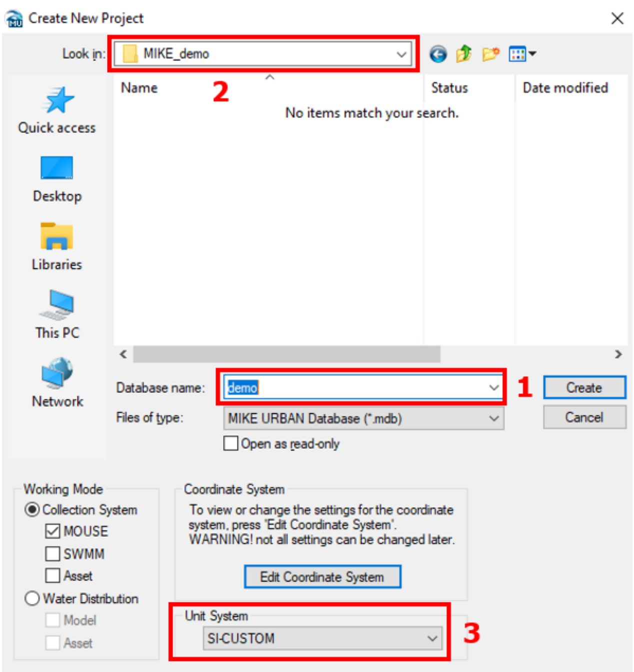


Figure 3-1. Open a new MOUSE project

- *Step 3:* Define a coordinate system for the project. MIKE URBAN supports a lot of coordinate reference systems (CRS). The user can select the CRS from the list or import the *.prj file from GIS software (QGIS, ArcGIS Desktop, ArcGIS Pro, etc.,) (Figure 3-2).

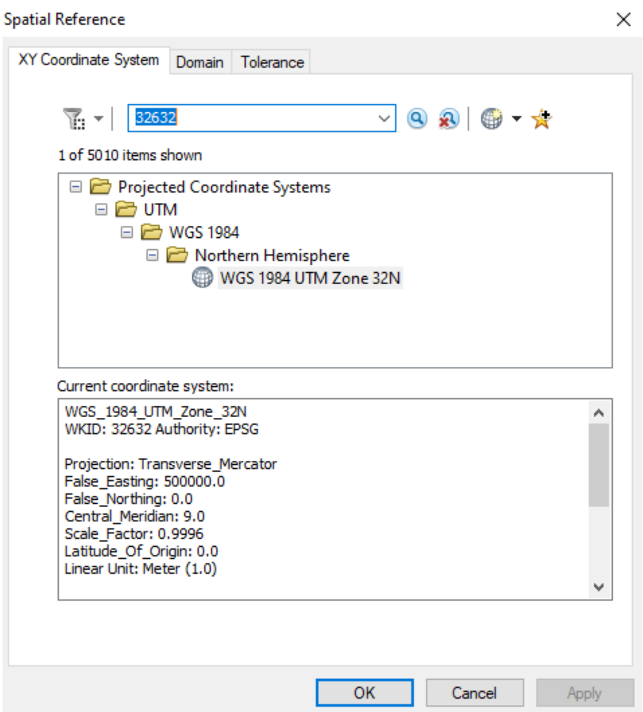


Figure 3-2. The coordinate system in MOUSE

- *Step 4:* Select the ***"Create"*** button (Figure 3-1) to create a new MOUSE project.

3.2. *Importing Background Image*

Right-click on the ***"Background Layers"*** folder → Insert Layer and choose the location of the imported image that was exported from QGIS in Section 2.4 (Figure 3-3).

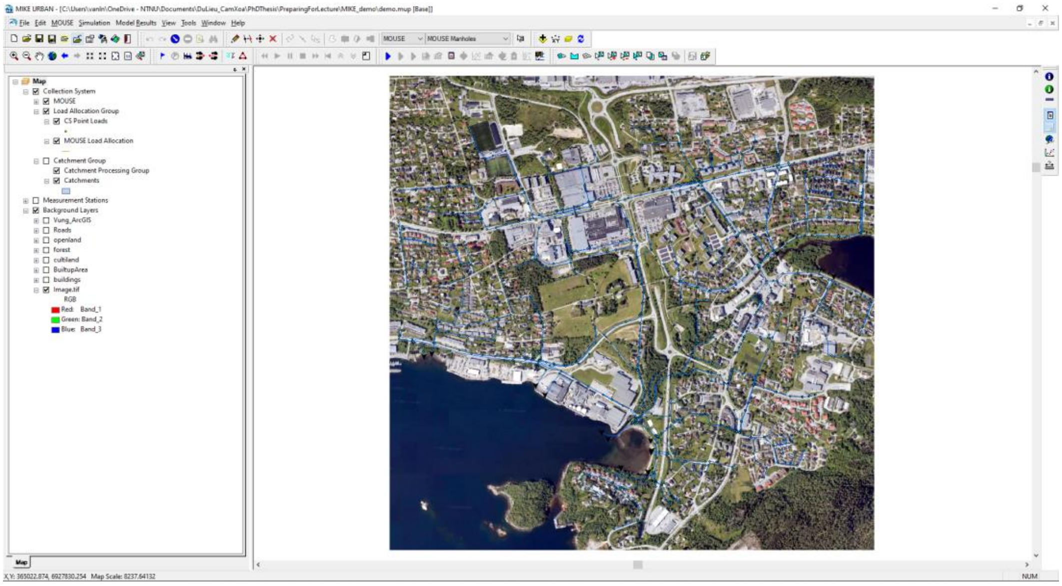


Figure 3-3. Import background image into MOUSE

3.3. *Importing and Adjusting Attributes of Nodes*

a. Importing Nodes

Nodes have been imported into MOUSE from shapefiles that are obtained in section 2.4. To import nodes from a shapefile, the user can do the following steps:

➢ *Step 1:* Select the ***"Import/Export…"*** option from the main menu ***"File"*** (Figure 3-4a).

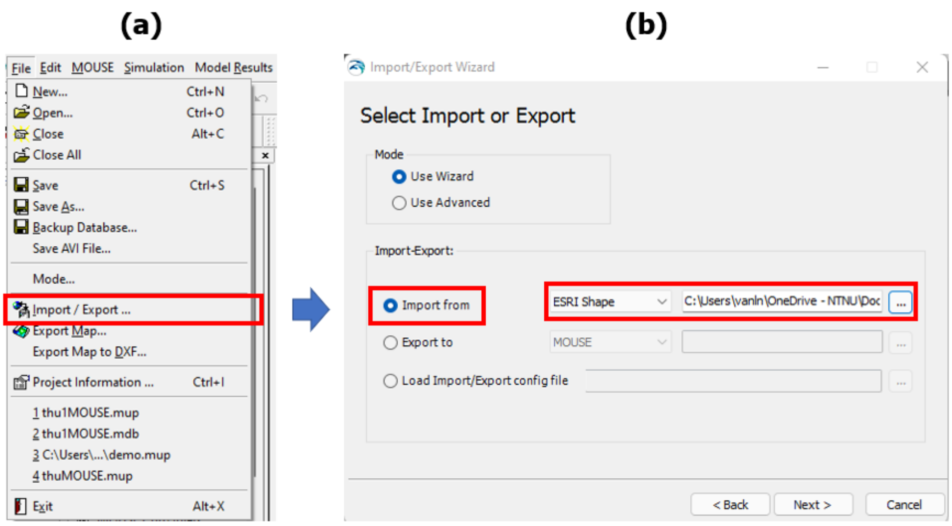


Figure 3-4. Import shapefile into MOUSE

➢ *Step 2:* Select the ***"Import from"*** option and specify the location of the shapefile on the computer (Figure 3-4b).

➢ *Step 3:* Set up a new job for importing shapefile (Figure 3-5a).

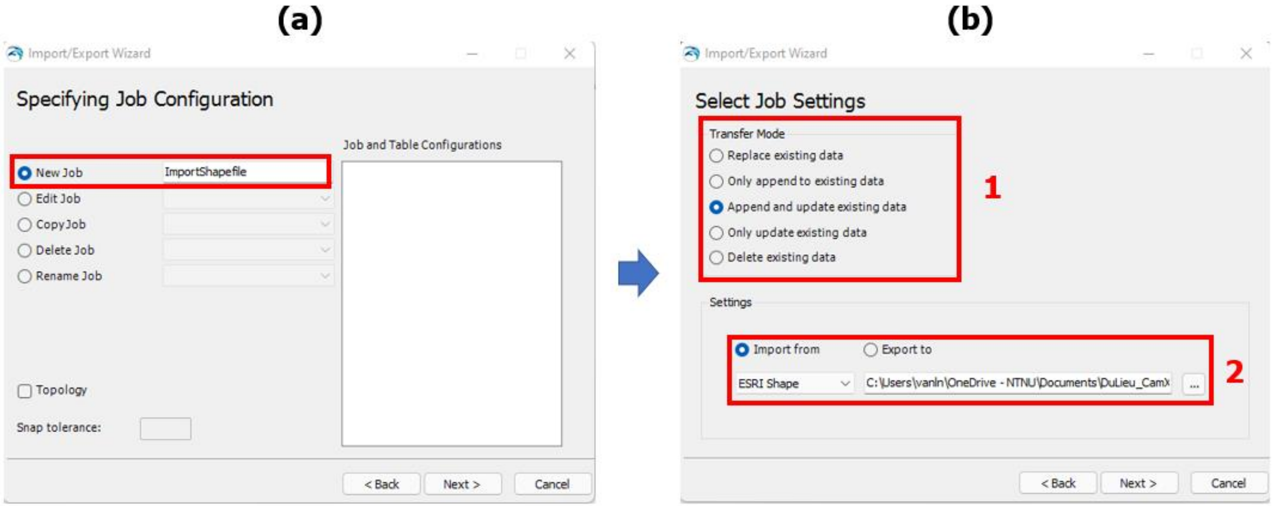


Figure 3-5. Setup job configuration

➢ *Step 4:* Set up the transfer mode depending on the importing purpose and shapefile source (Figure 3-5b).

➢ *Step 5:* Set up a new table for shapefile data (Figure 3-6a). In the step setting up the target table for importing shapefile (Figure 3-6b), the user must choose the option ***"msm_Node"*** to import *"node"* components for the MOUSE project.

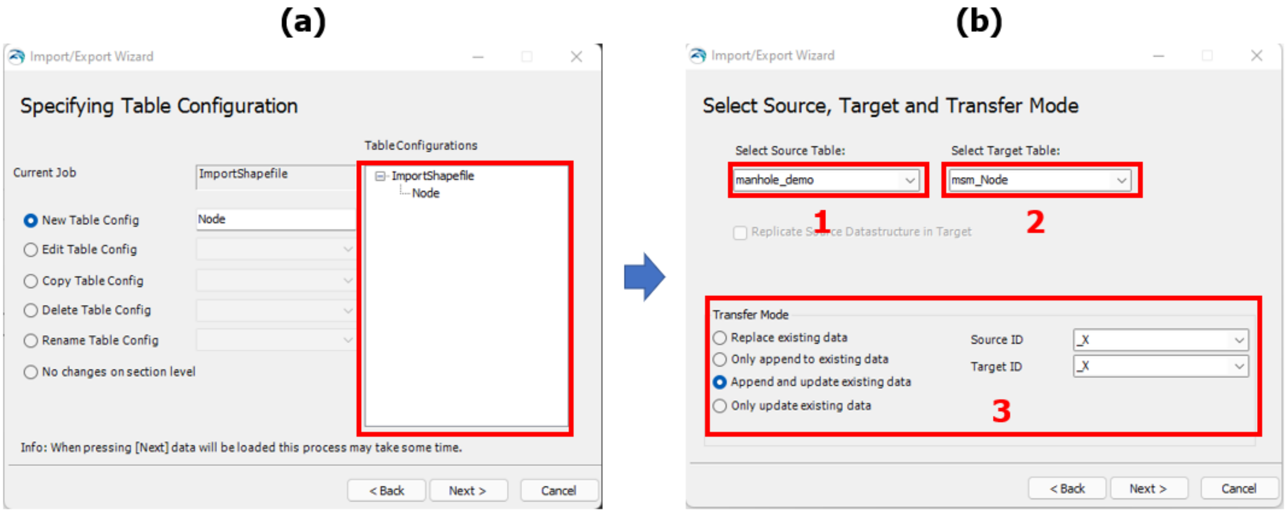


Figure 3-6. Setup table configuration

➢ *Step 6:* The essential attributes in Table 2-3 should be assigned to the target table (Figure 3-7). It is worth noticing that if the names of points' components are maintained in Table 2-3, the names of target attributes will be automatically assigned when the user clicks on the ***"Automap"*** button.

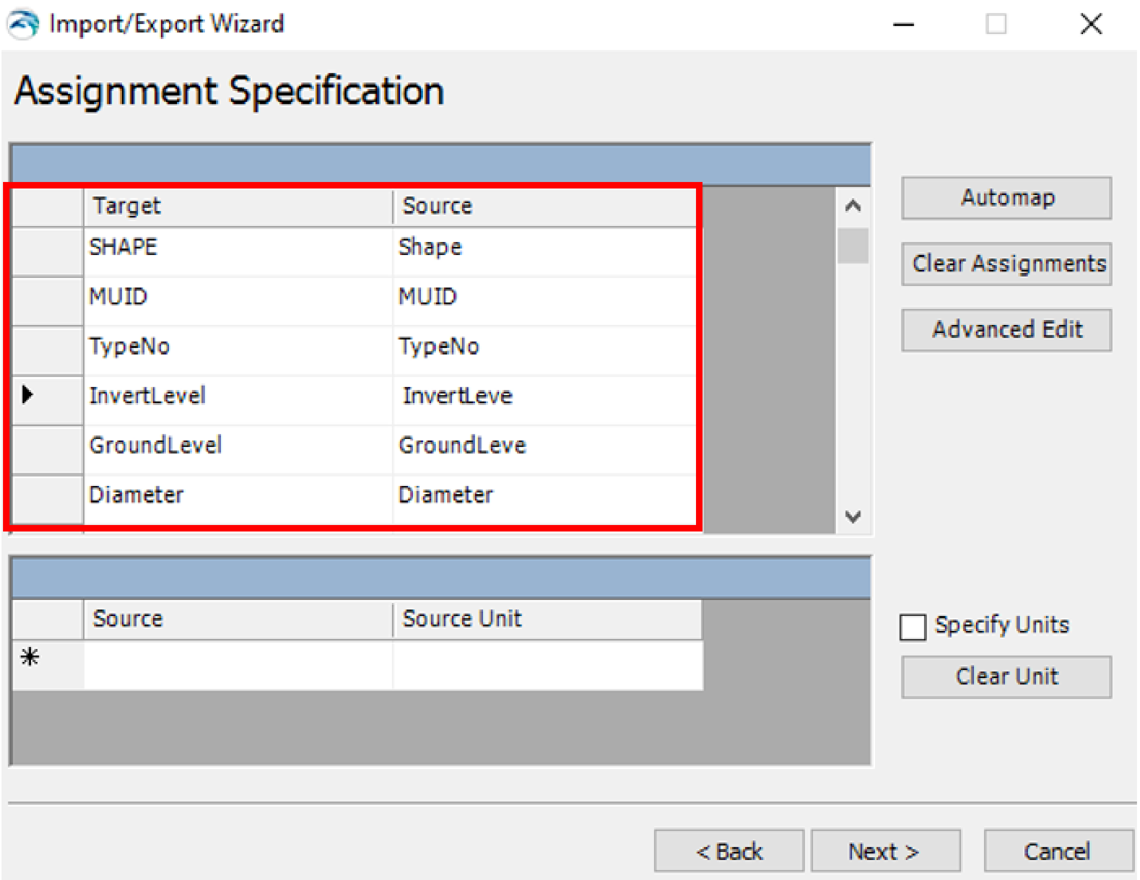


Figure 3-7. Assign attributes for node component in MOUSE

➢ *Step 7:* Finish importing node components into MOUSE (Figure 3-8).

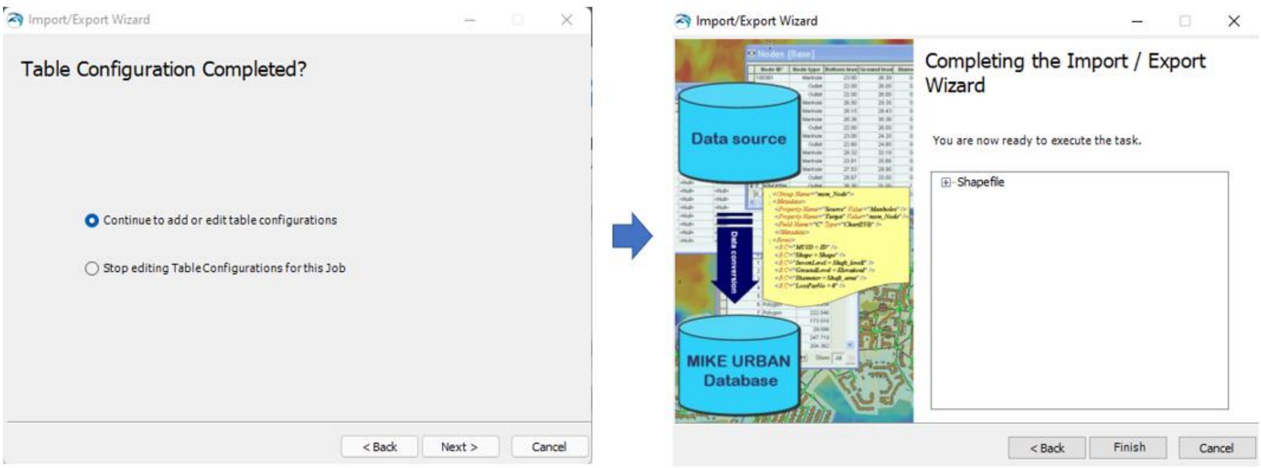


Figure 3-8. Finish importing node

➢ *Step 8:* After importing nodes into MOUSE, the user should check to make sure all nodes are imported completely and correctly (Figure 3-9).

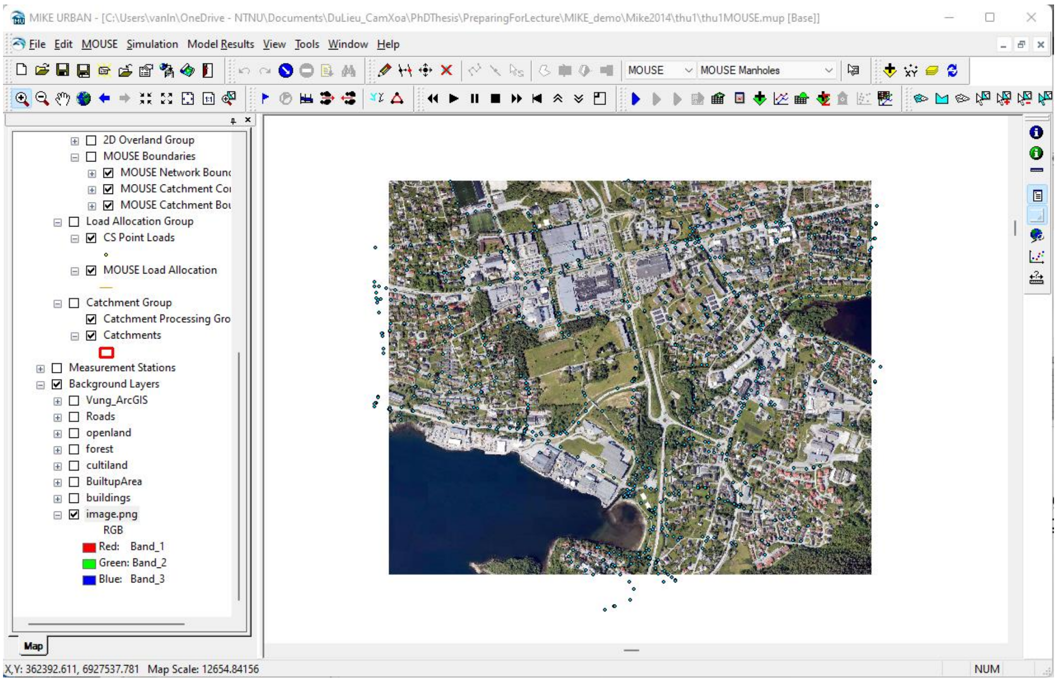


Figure 3-9. Check locations of nodes

b. Adjusting Nodes' Attributes

To adjust the attributes of nodes, select ***MOUSE*** → ***Nodes and Structures*** to open the node dialog. In this dialog, the user can change and modify various attributes of node-based objects.

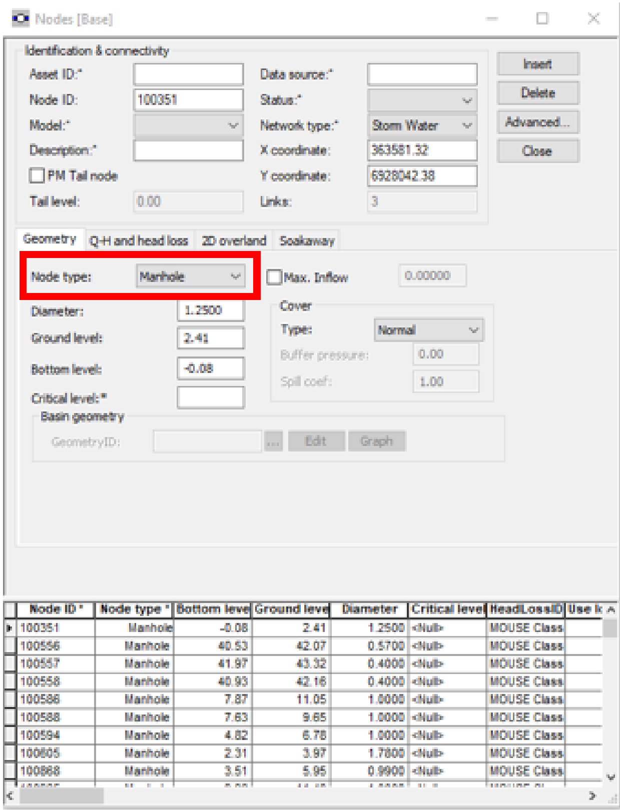


Figure 3-10. Manhole attributes

To define a node as a manhole, the user changes the ***"Node type"*** option to ***"Manhole"*** (Figure 3-10). With this selection, the user can change the diameter, ground level, and bottom level of the manhole.

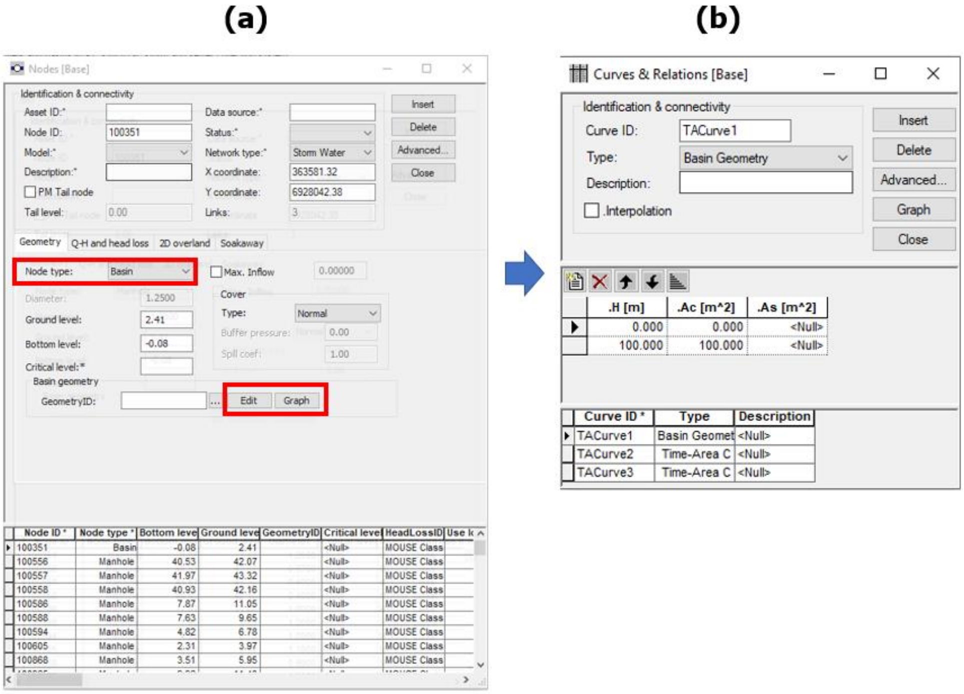


Figure 3-11. Basin attributes

To work with a basin, the user changes the ***"Node type"*** option to ***"Basin"*** (Figure 3-11a). With this selection, the user can change the ground level and bottom level of the basin. The geometry of the basin can be defined by selecting the ***"Edit"*** button (Figure 3-11b).

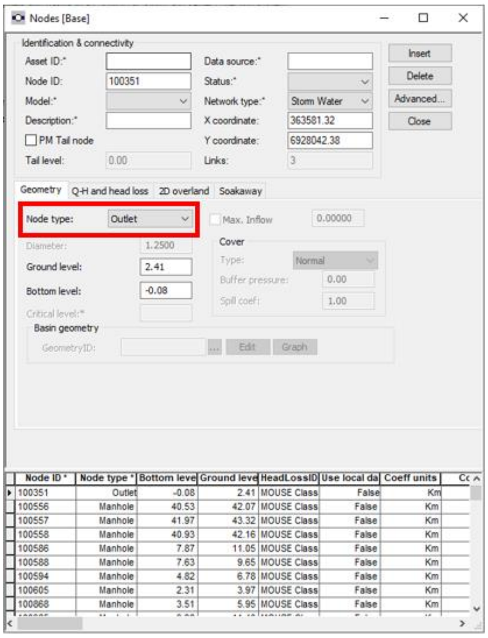


Figure 3-12. Outlet attributes

An outlet node is defined by changing the ***"Node type"*** to ***"Outlet"*** (Figure 3-12). The essential properties of an outlet include ground and bottom levels.

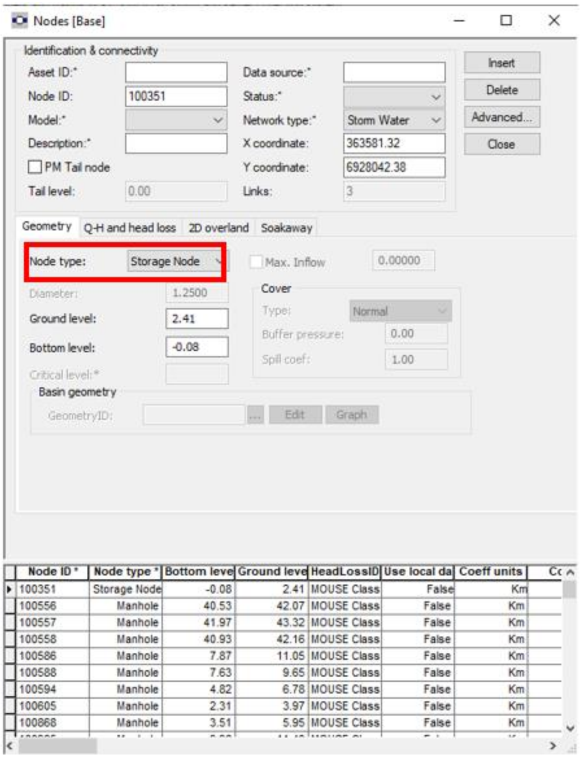


Figure 3-13. Storage attributes

The ground and bottom levels of the storage node are defined after changing the ***"Node type"*** option into ***"Storage Node"*** (Figure 3-13).

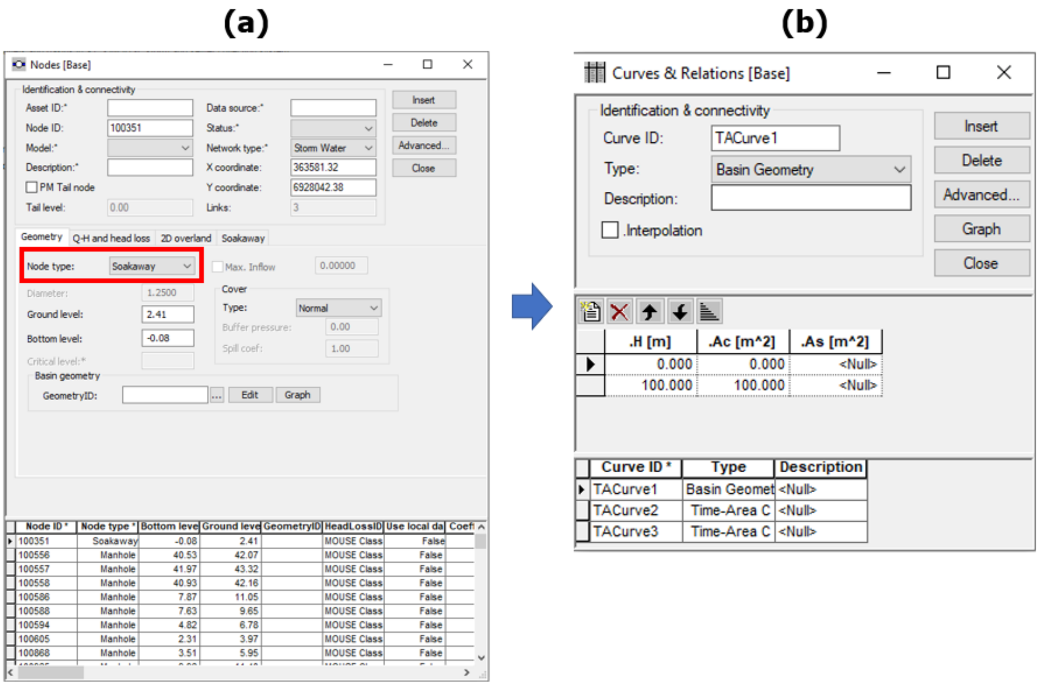


Figure 3-14. Soakaway attributes

By changing the ***"Node type"*** option to ***"Soakaway"***, the user can modify the ground and bottom levels (Figure 3-14a). Its geometry can be defined by clicking on the ***"Edit"*** button (Figure 3-14b).

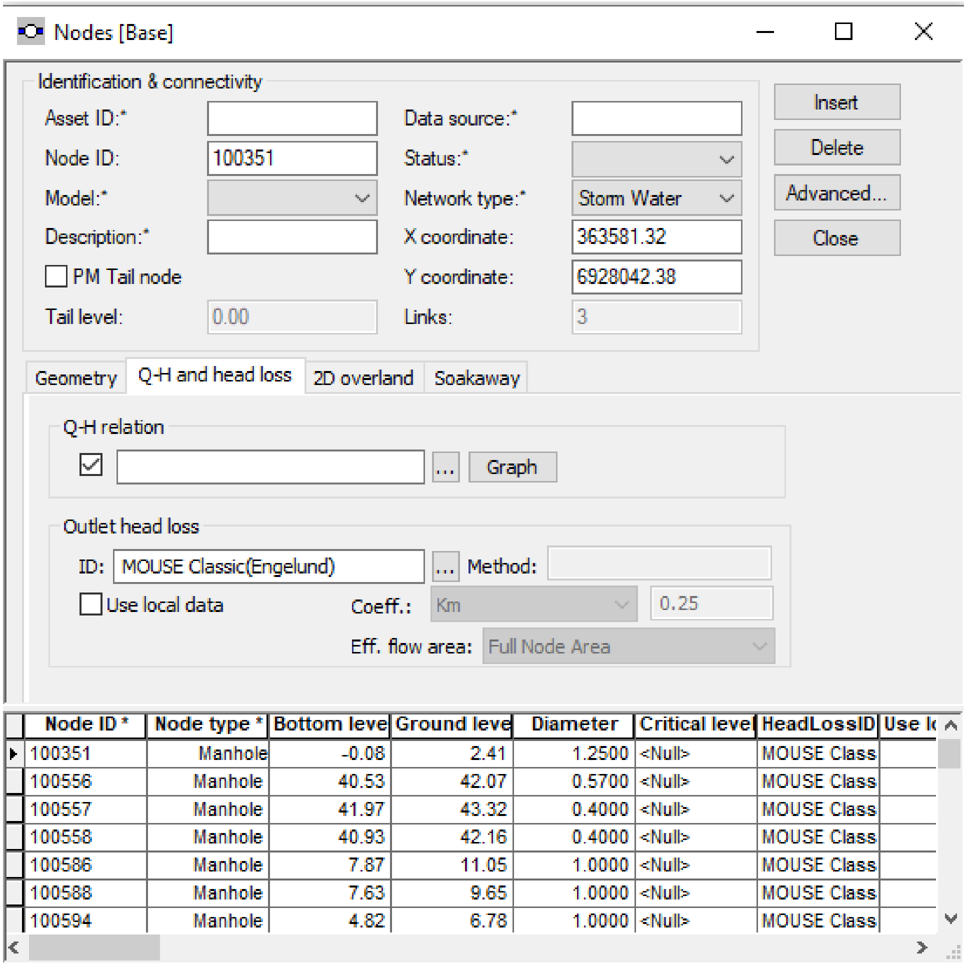


Figure 3-15. Flow-Height relation and head loss attributes

Flow-Height (Q-H) relation: controls infiltration to the node. The flow (Q) value should be given as a positive value when water enters the node and a negative value for specifying a loss of water from the network model. Outlet head loss controls the head loss of the node (Figure 3-15).

3.4. Importing and Adjusting Attributes of Links

a. Importing Links

Importing links into MOUSE from shapefile is done similarly to importing nodes from shapefile. However, there is a slightly different in selecting the option at the target table. Specifically, steps for importing links from shapefile are done as follows:

- *Step 1:* Repeat from *step 1* to *step 4* in section 3.3.
- *Step 2:* Select the option ***"msm_Link"*** to assign attributes for link components

(Figure 3-16).

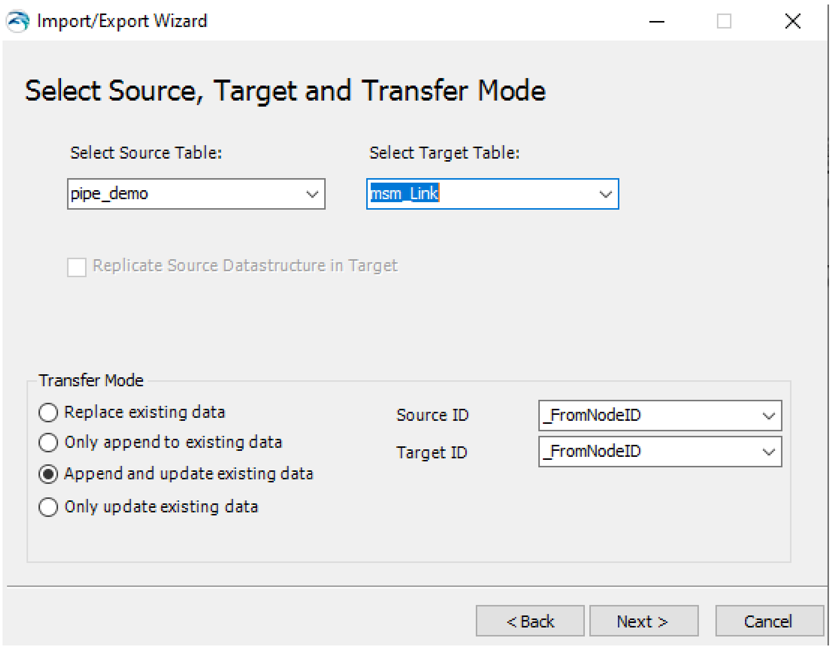


Figure 3-16. Convert junctions into SWMM

➢ *Step 3:* Assigned links' attributes for the target table (Figure 3-17). The ***"Automap"*** function will automatically assign attributes for link components if their names are maintained as Table 2-4.

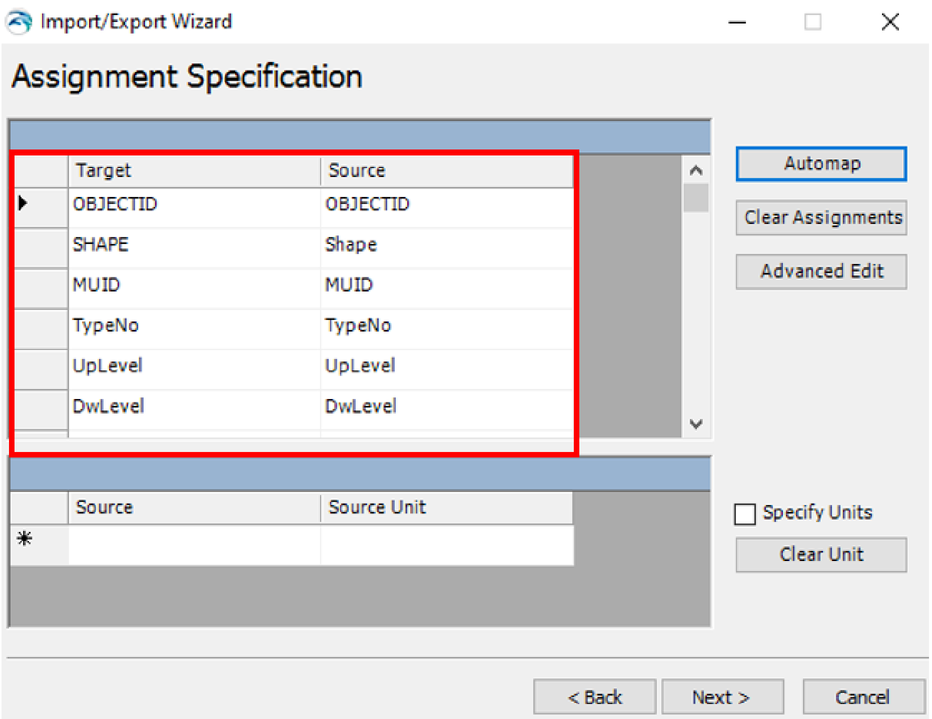


Figure 3-17. Assign attributes for link component in MOUSE

➢ *Step 4:* It is recommended to check all links after importing them into MOUSE.

b. Adjusting Links' Attributes

To open the link's attribute dialog, select ***MOUSE*** → ***Pipes and Canals*** (Figure 3-18).

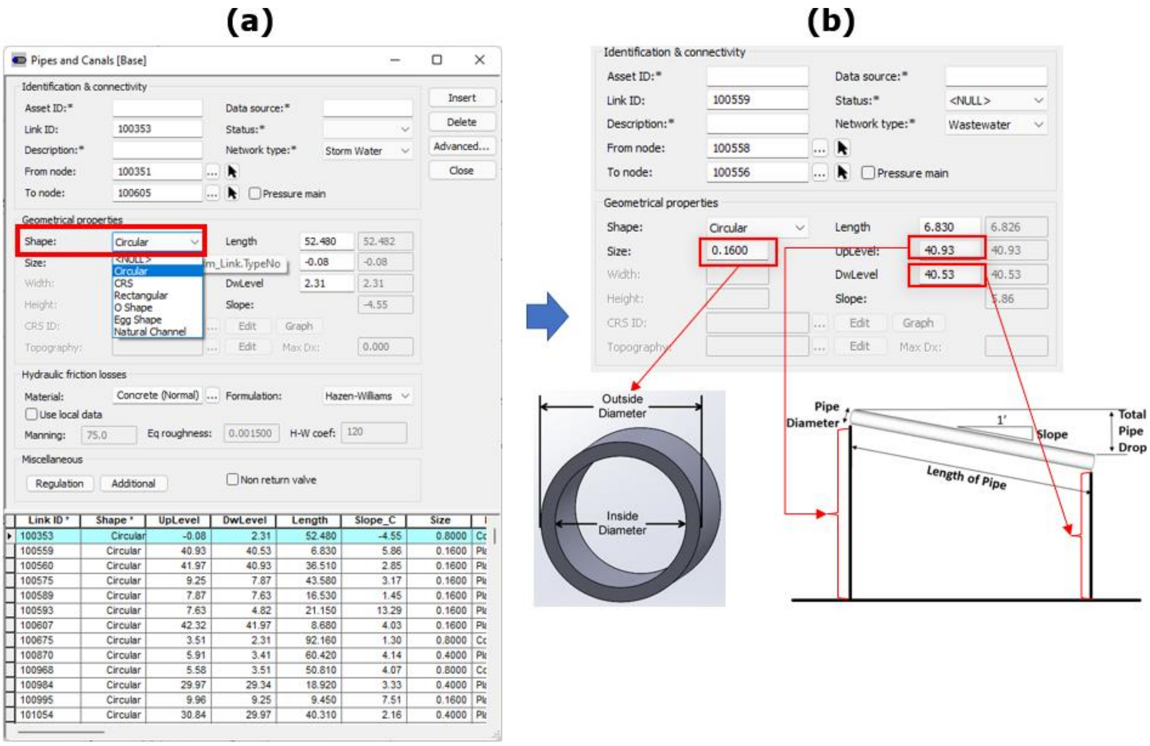


Figure 3-18. Links' attributes

In this dialog, the user can change inlet and outlet nodes, and select various links' shapes (Figure 3-18a). Many attributes of the link such as diameter, length, upstream, and downstream levels can be changed in this dialog (Figure 3-18b).

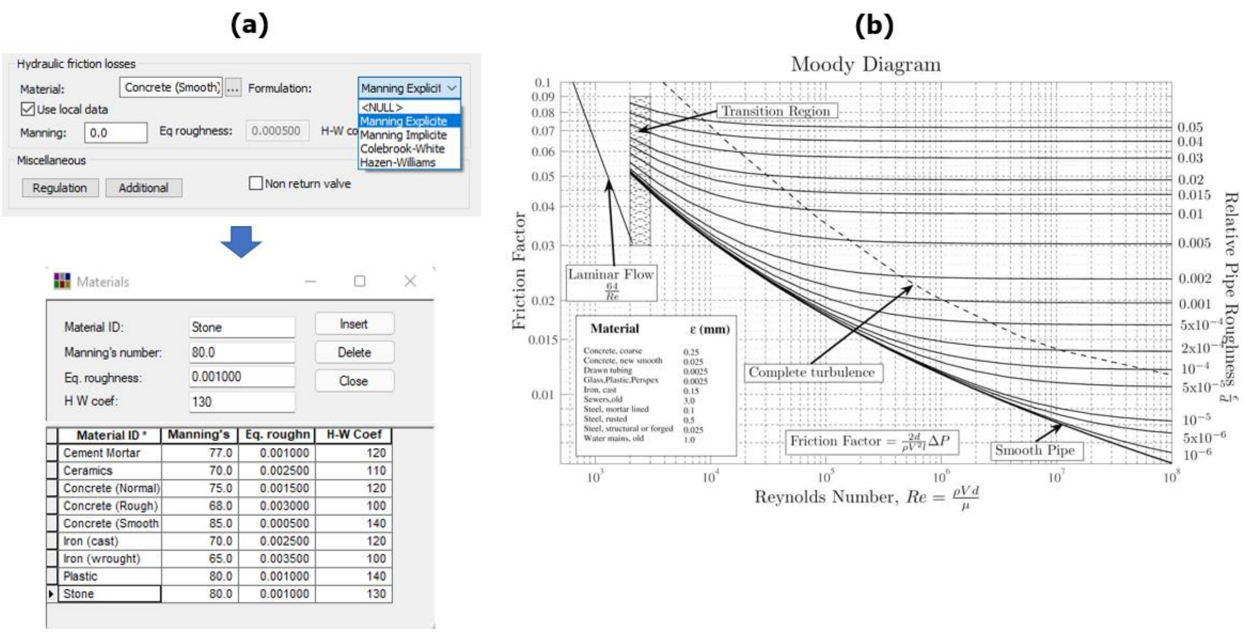


Figure 3-19. Roughness of link

The material of links can be defined in this dialog (Figure 3-19a). MOUSE provides various materials of links. The roughness values of the link can be imported for a particular link (Figure 3-19b). Moreover, the relative roughness value can be calculated by the following formula[3]:

$$Relative\ Roughness = \frac{Avg.\ Heigh\ of\ Surface\ Irregularities\ (mm)}{Diameter\ (mm)}$$

3.5. Creating Other Links

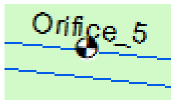
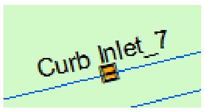
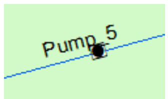
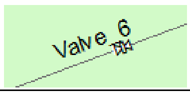
Other links can be imported with the similar process described in section 3.4. However, MOUSE provides an editing tool that converts links to other components such as weirs, orifices, curb inlets, pumps, or valves.

The first step in converting links to other components is to start the editing process (Figure 3-20).

Figure 3-20. Start the editing tool

Steps for converting links to other components are described in Table 2-1.

Table 3-1. Editing functions in MOUSE

Description	Step in MOUSE	Symbol in MOUSE
Create Weirs		
Create Orifices		
Create Curb Inlets		
Create Pumps		
Create Valves		

After converting links to other components, the user needs to save changes and stop the

[3] Relative Roughness of Pipe, https://www.nuclear-power.com/nuclear-engineering/fluid-dynamics/major-head-loss-friction-loss/relative-roughness-of-pipe/#:~:text=The%20quantity%20used%20to%20measure,the%20pipe%20diameter%20(D)

editing process (steps 1 and 2 in Figure 3-21).

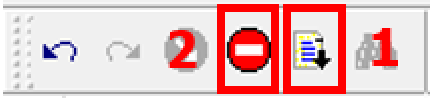


Figure 3-21. Stop the editing tool

3.6. Creating Time-Series Data

Time-series data reflect the dynamic property of input data, these data include rainfall data, inflow wastewater patterns, etc., The user can import time-series data (*.dfs0) from other software (such as MIKE ZERO, EPANET, SWMM, etc.,) or directly create these data in MOUSE. In this tutorial, we are going to introduce creating time-series data from an Excel (*.xlsx) file. An example of time-series in CSV format is described in Figure 3-22a.

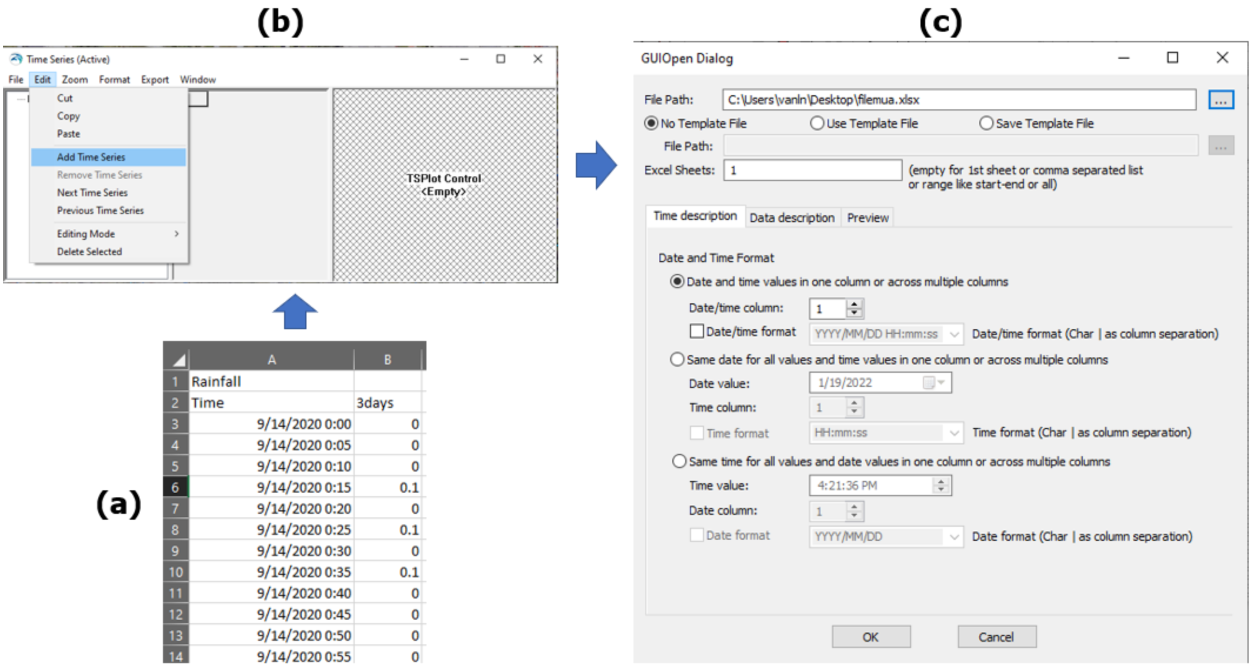


Figure 3-22. Create time-series data in MOUSE

Steps for creating time-series data using an Excel file in MOUSE are shown in Figure 3-22b and Figure 3-22c. In Figure 3-22c, the user can modify the format of the Excel file. In this case, we use the default settings.

After creating time-series data in MOUSE, the data will be displayed as a graph (Figure 3-23). In this dialog, the user can add, delete, or change values in the time series data. After the editing process, the user can save this data as *.dfs0 type to use for simulation by selecting: ***File →Save As…*** from the main menu.

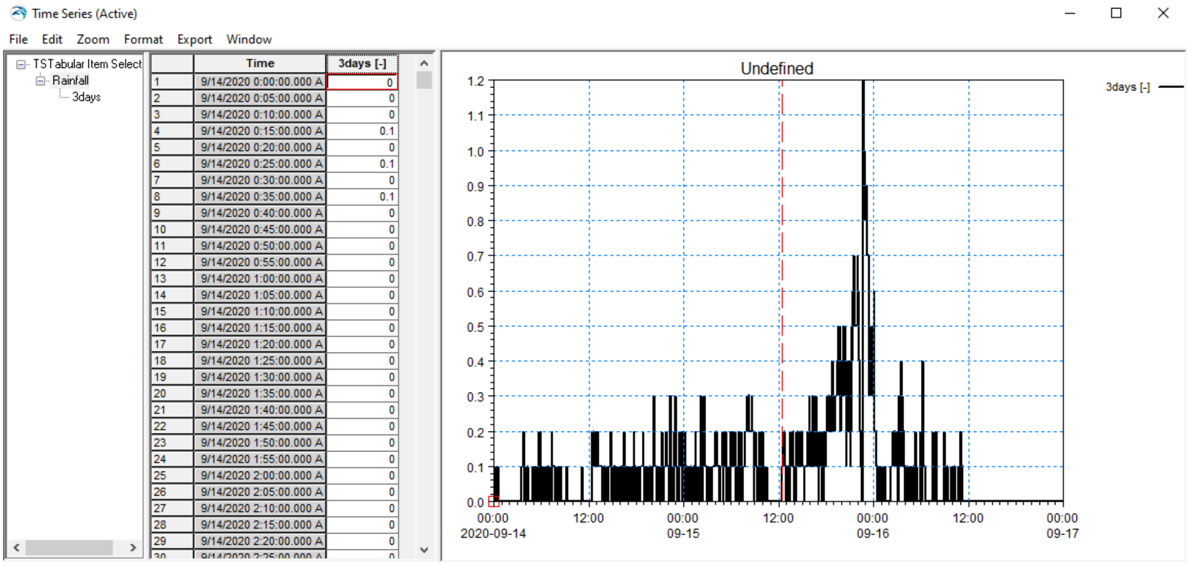


Figure 3-23. Time-series dialog in MOUSE

3.7. Preparing Sub-catchment Data

Catchments are essential for any hydrological model. MOUSE allows the user to define sub-catchment before starting a simulation.

a. Catchment Delineation

In this tutorial, we will introduce two ways to delineate sub-catchments in MOUSE:

- Manual sub-catchments delineation: is used when the user wants to focus on specific areas or when the user clearly understands the surface flow in the study area.
- Automatical sub-catchments delineation: is used when the user wants to quickly simulate a MOUSE project.

❖ *Delineating Sub-catchment Manually*

➢ *Step 1:* Start the editing tool in MOUSE (Figure 3-20).

➢ *Step 2:* Change the current layer to "Catchments" (step 1 in Figure 3-24).

Figure 3-24. Catchment layer in MOUSE

➢ *Step 3:* Click on the ***"Create feature"*** tool in the toolbar to insert a new catchment (step 2 in Figure 3-24). Click on the map and draw a polygon following the contours of your total catchment area. End with a double-click.

➢ *Step 4:* Switch to the ***"Split Polygon"*** tool to split the catchment into smaller sub-catchments describing your system concerning the network (step 3 in Figure 3-24).

➢ *Step 5:* Check sub-catchments on the map (Figure 3-25).

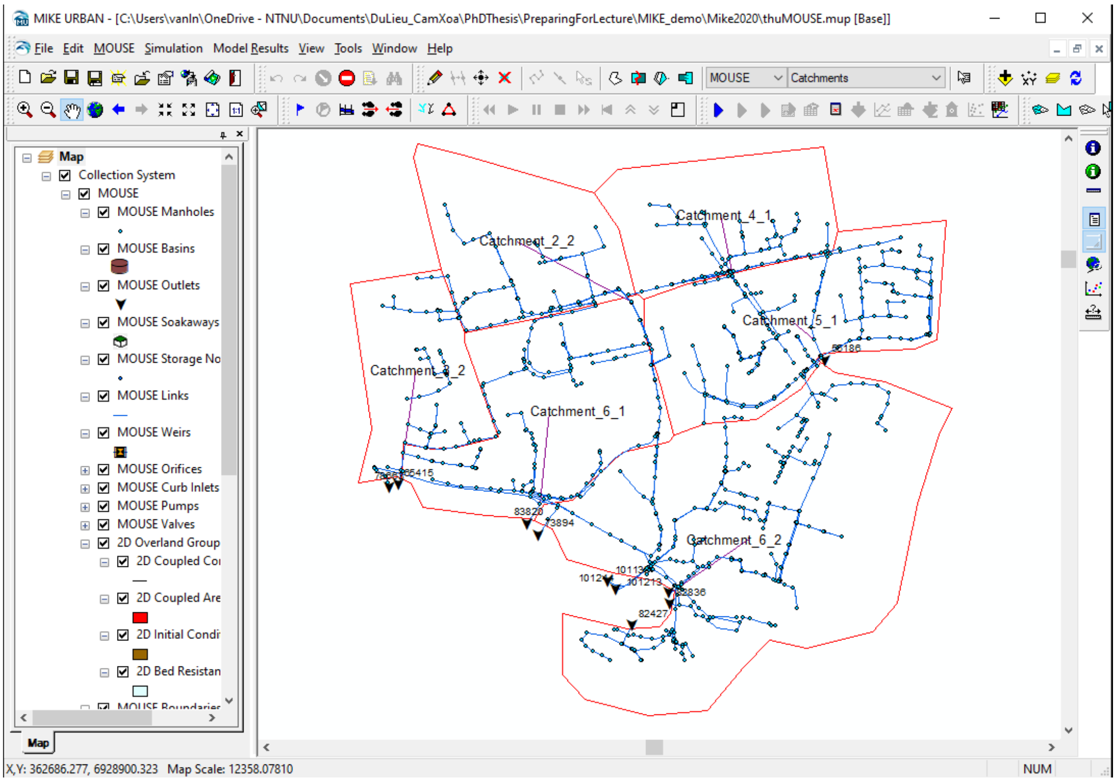


Figure 3-25. Sub-catchments in MOUSE

➢ *Step 6:* To modify properties of sub-catchments: ***MOUSE*** → ***Catchments & Catchment Parameters*** → ***Catchment*** (Figure 3-26).

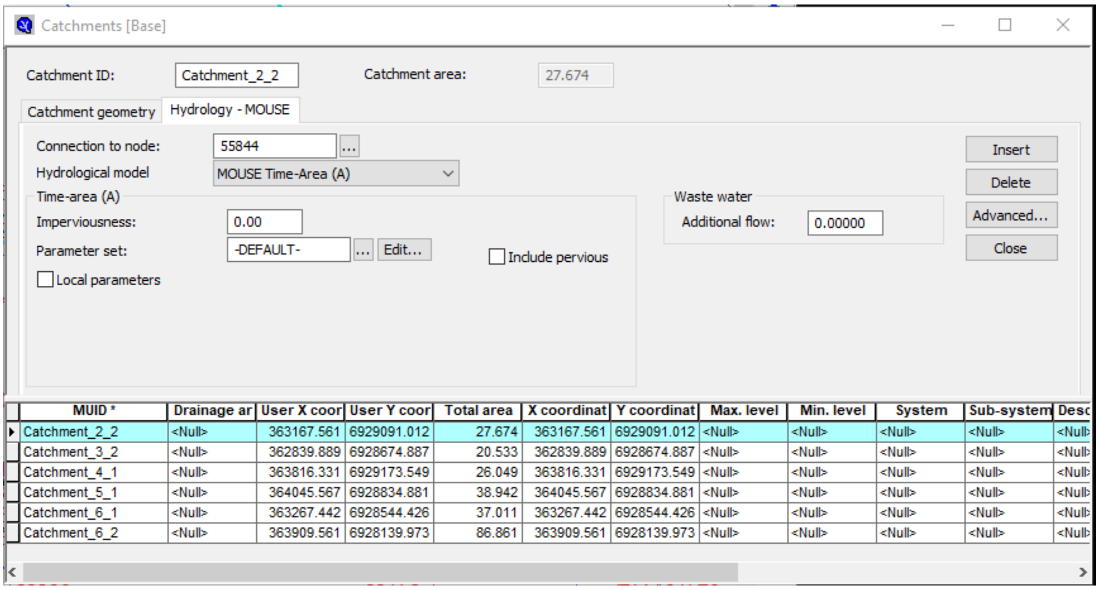


Figure 3-26. Properties of sub-catchments

➢ *Step 7:* Stop the editing process (Figure 3-21).

❖ *Delineating Sub-catchment Automatically*

- *Step 1:* Start the editing tool in MOUSE (Figure 3-20).
- *Step 2:* Open the ***"Catchment Delineation Wizard"***: ***MOUSE → Catchment Tools → Catchment Delineation Wizard…*** (Figure 3-27).

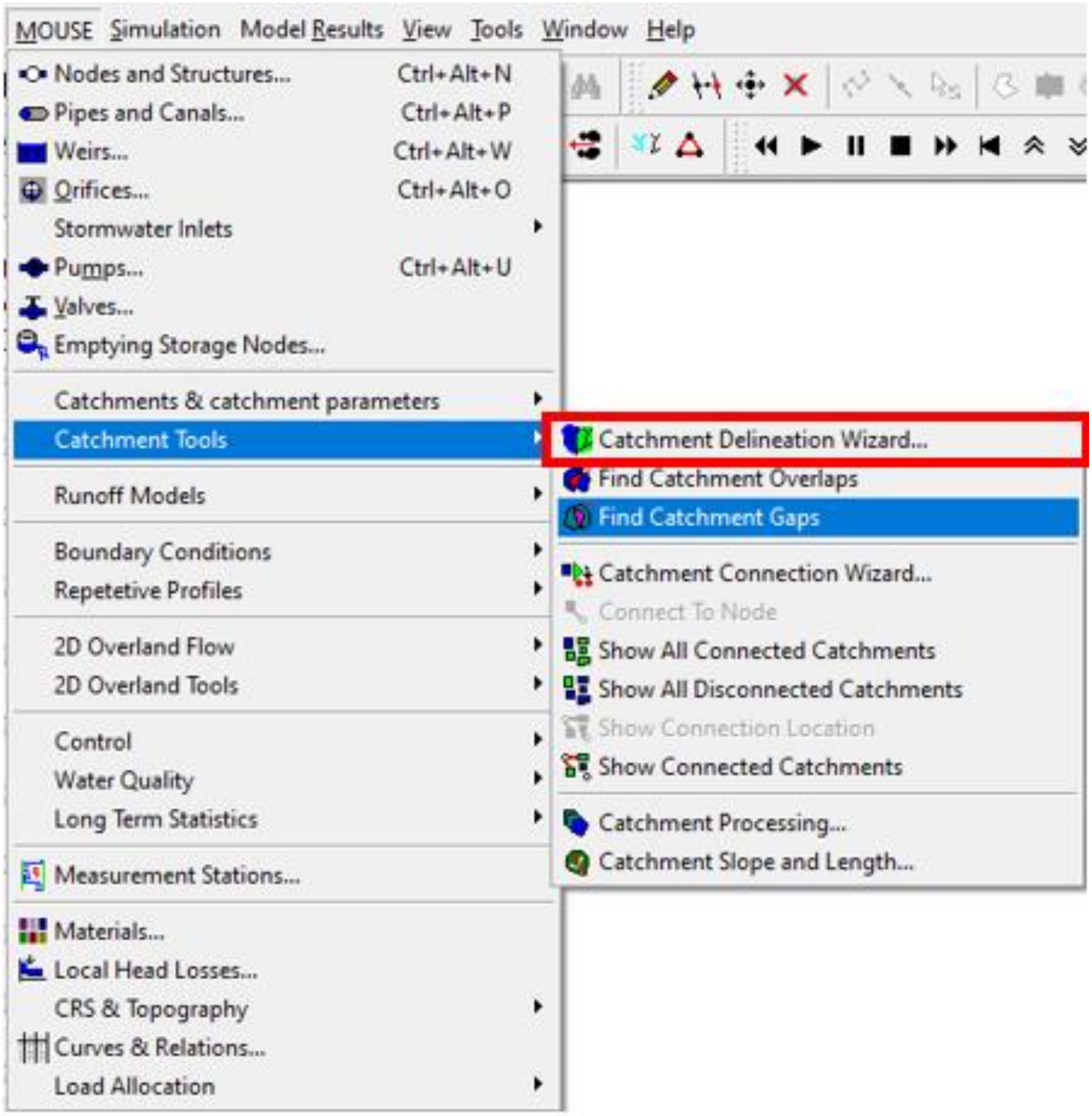


Figure 3-27. Catchment Delineation Wizard

- *Step 3:* Set up parameters for delineating sub-catchments (Figure 3-28). In step 3, the user can either select a shapefile polygon or draw a polygon in MOUSE directly. A shapefile can be simply imported into MOUSE as a layer (see section 3.2). For the re-used purpose, we use the area that is created in QGIS and is imported into MOUSE as a layer in this tutorial.

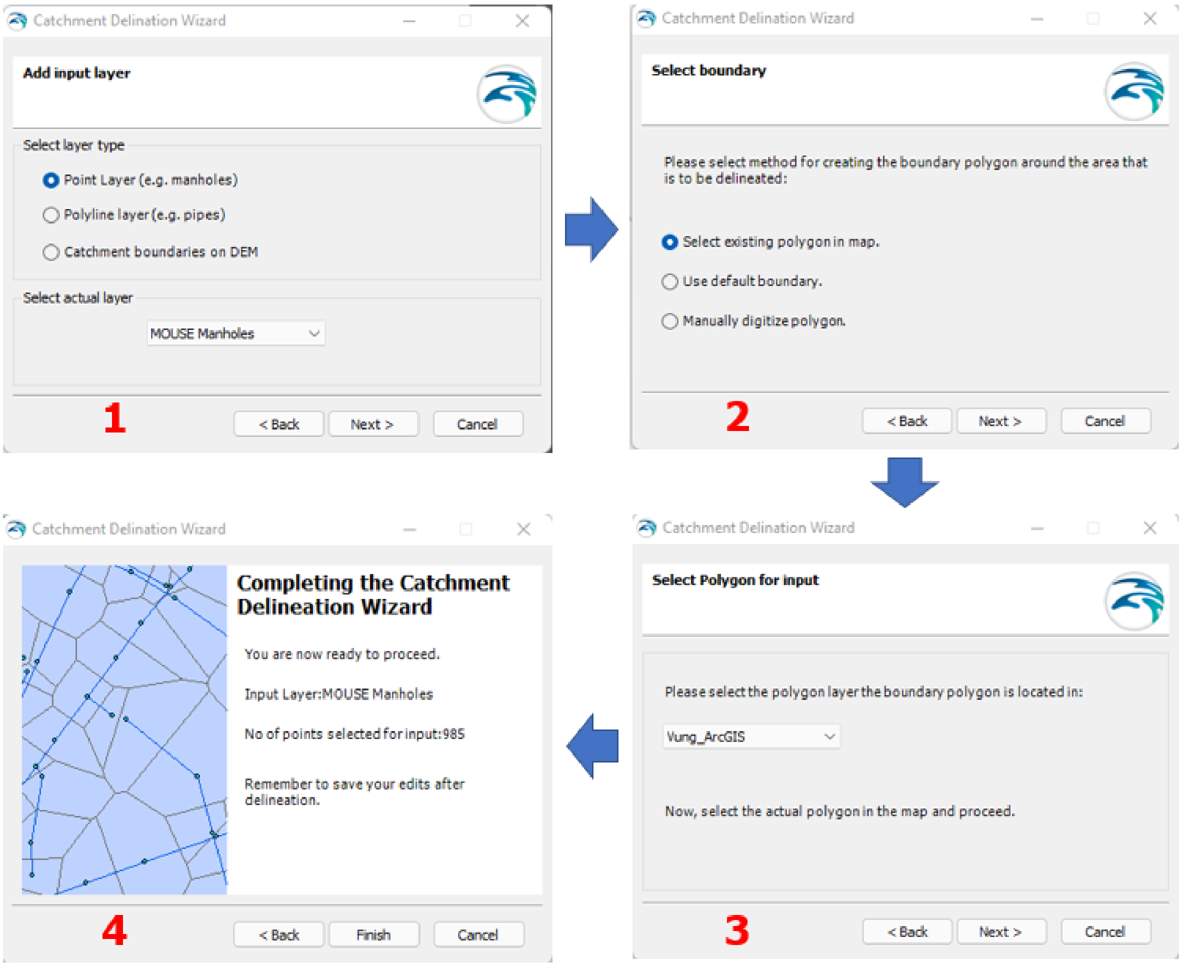


Figure 3-28. Catchment delineation process

b. Sub-catchment – Node Connection

Runoff in each sub-catchment needs to be transferred into the network. To do so we need to connect the created catchments to the network. To connect sub-catchments to nodes, the user can do it manually or automatically.

❖ *Connecting Sub-catchments to Nodes Manually*

➢ *Step 1:* Go to ***MOUSE → Catchments & Catchment Parameters → Catchments*** (Figure 3-26).

➢ *Step 2:* For each sub-catchment, go to ***MOUSE → Catchment Tools → Connect to Node***, and select the desired node on the map.

❖ *Connecting Sub-catchments to Nodes Automatically*

This is normally selected if the sub-catchments are created automatically. Steps for assigning sub-catchments to nodes are illustrated in Figure 3-29.

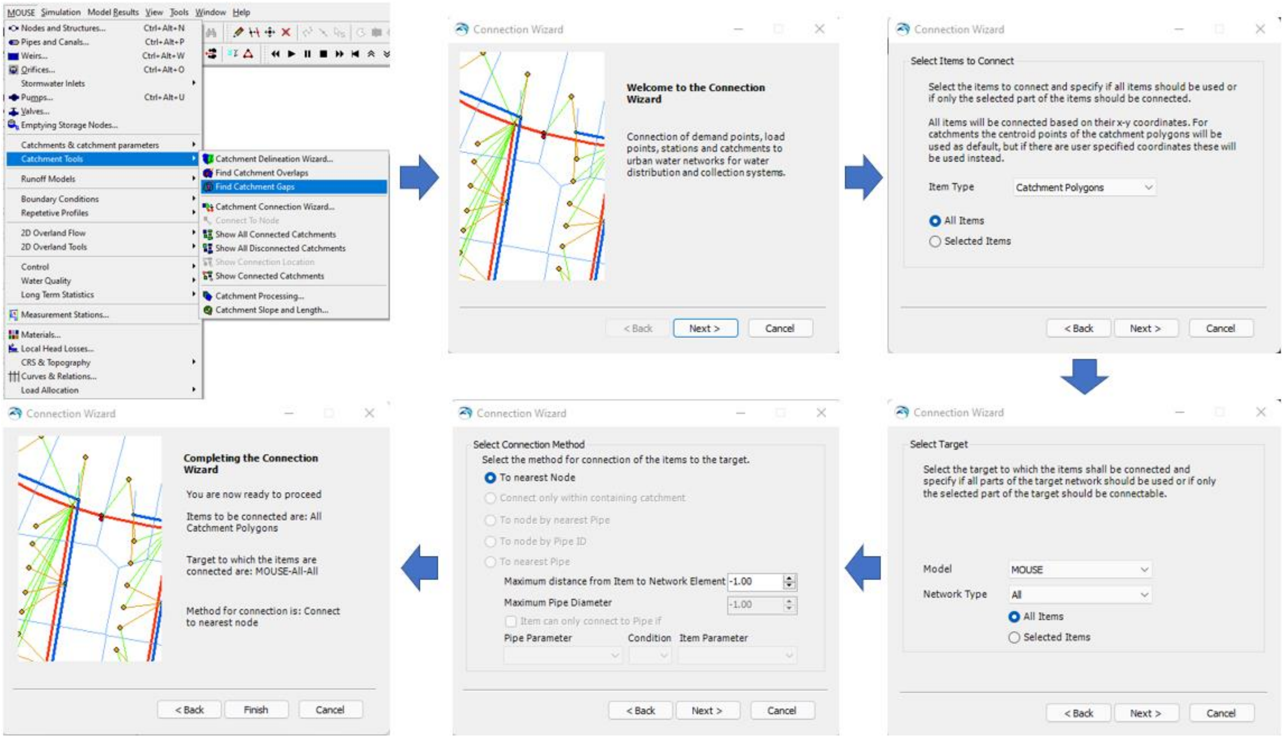


Figure 3-29. Sub-catchment - Node connection process

After connecting sub-catchments to nodes, one line connects the centroid point of each sub-catchment and its corresponding node will appear on the map (Figure 3-30).

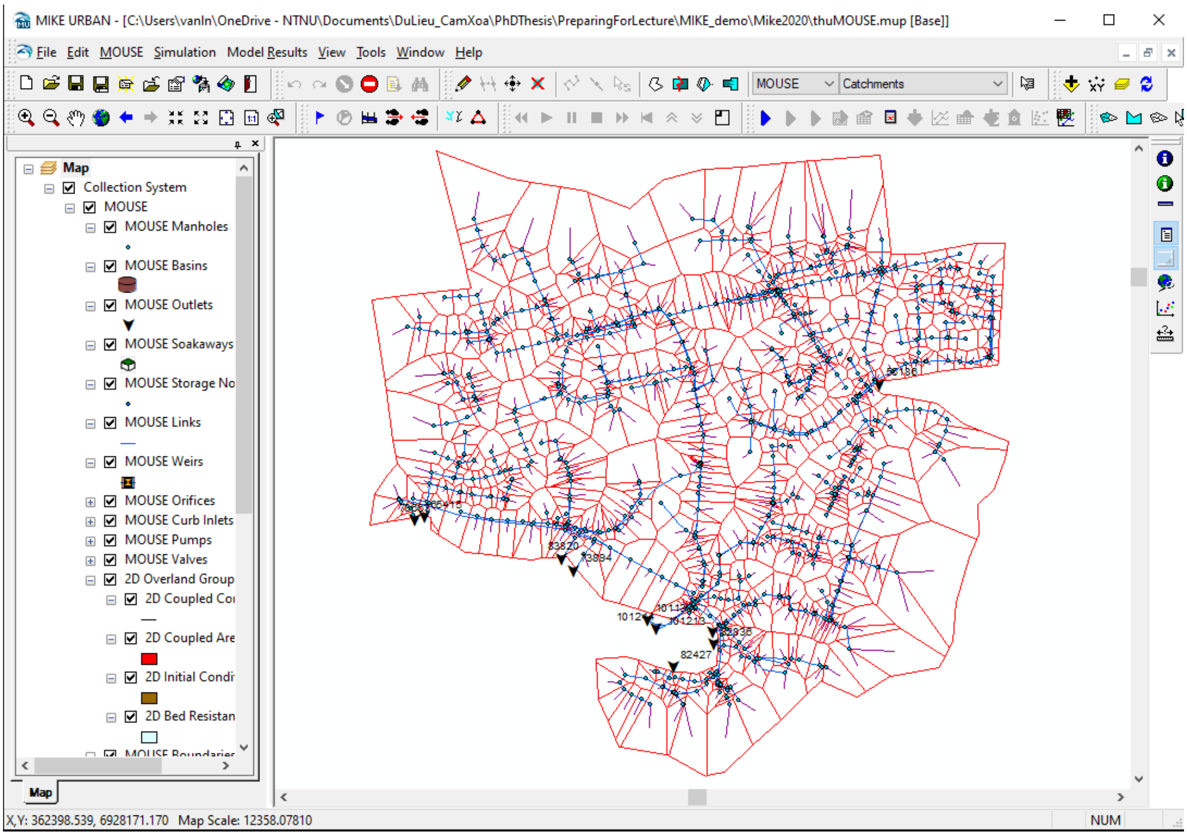


Figure 3-30. Connections between nodes and sub-catchments

c. Impervious Calculation

Imperviousness is one of the important properties of the catchment. It is defined as the area that prohibits penetration of water into underlying ground layers, as a result, rain, and snow are unable to infiltrate into the ground. Impervious surfaces include residential rooftops, public buildings, parking lots, commercial structures, and bedrock close to the soil surface.

To automatically calculate imperviousness for sub-catchments, the user does the following steps:

➢ *Step 1:* Import all shapefile data that affect the imperviousness of sub-catchment (soil types, roads, residential area, building area, etc.,) (Figure 3-31).

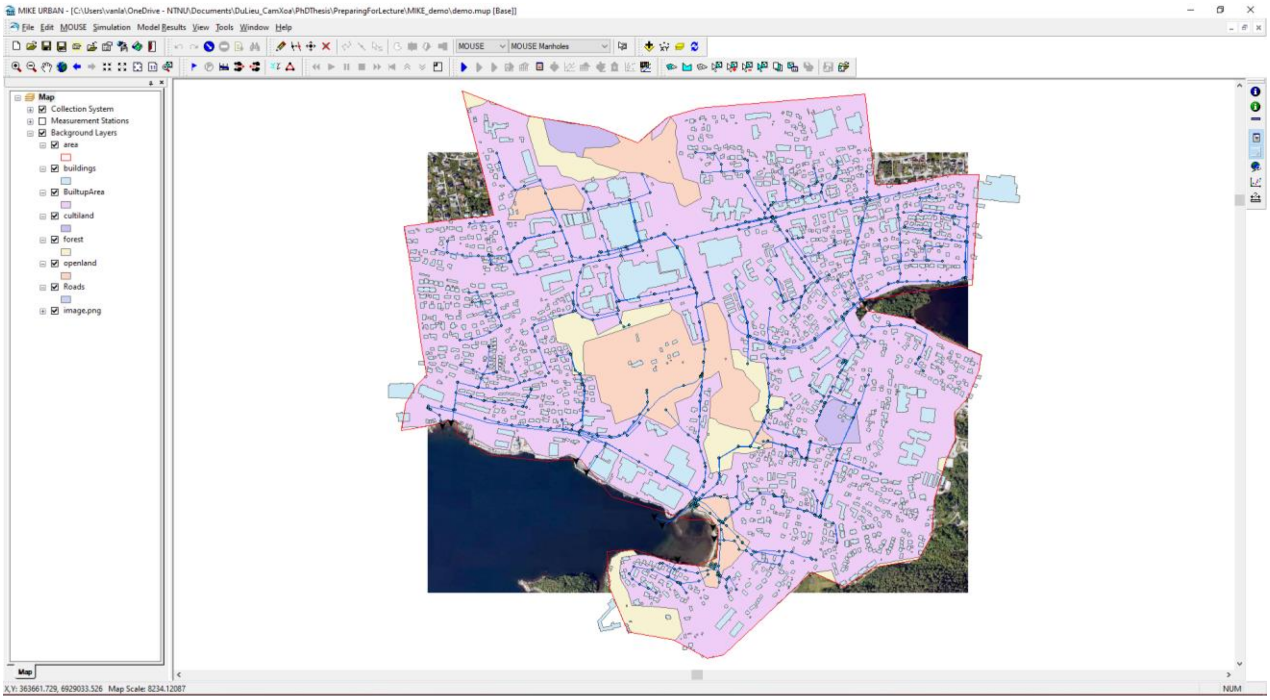


Figure 3-31. Impervious surfaces

➢ *Step 2:* Calculate the percentage of imperviousness: ***MOUSE → Catchment Tools → Catchment Processing*** (Figure 3-32).

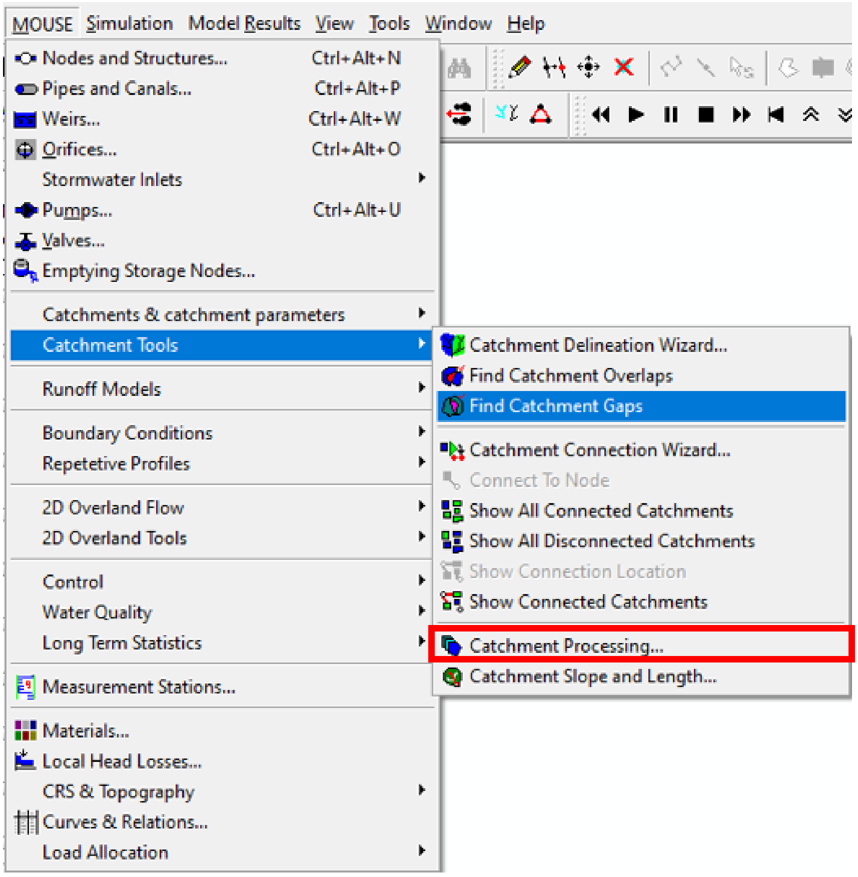


Figure 3-32. Catchment processing dialog

➢ *Step 3:* Add layers (Figure 3-33a) and assign the impervious percentage of each (Figure 3-33b) layer for calculating imperviousness.

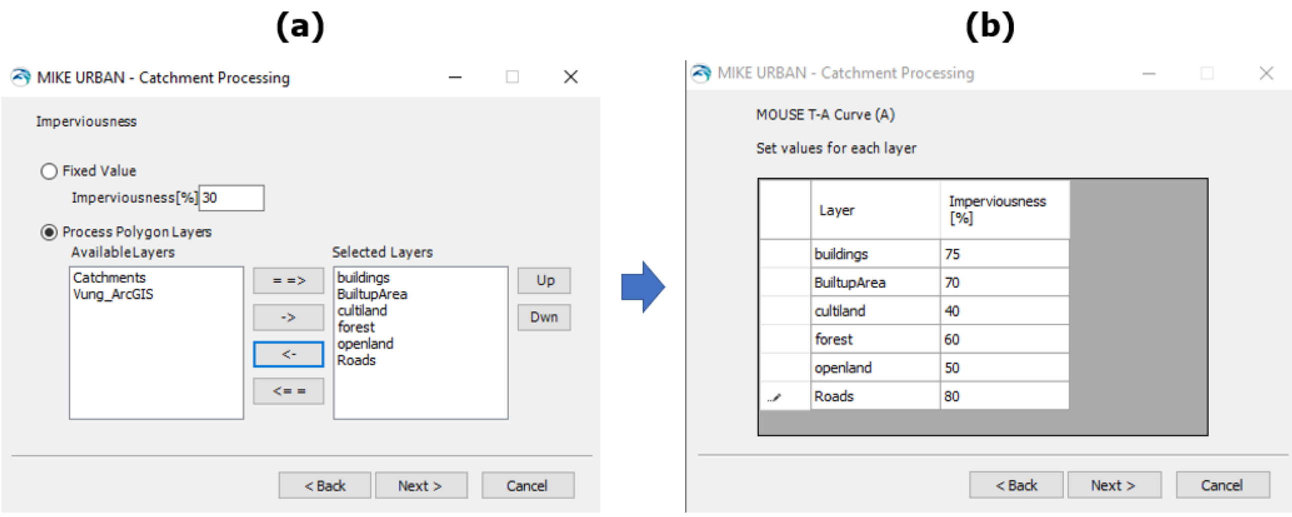


Figure 3-33. Impervious layers

➢ *Step 4:* Recheck the imperviousness of each sub-catchments: ***MOUSE*** → ***Catchments & Catchment Parameters*** → ***Catchment*** (Figure 3-34).

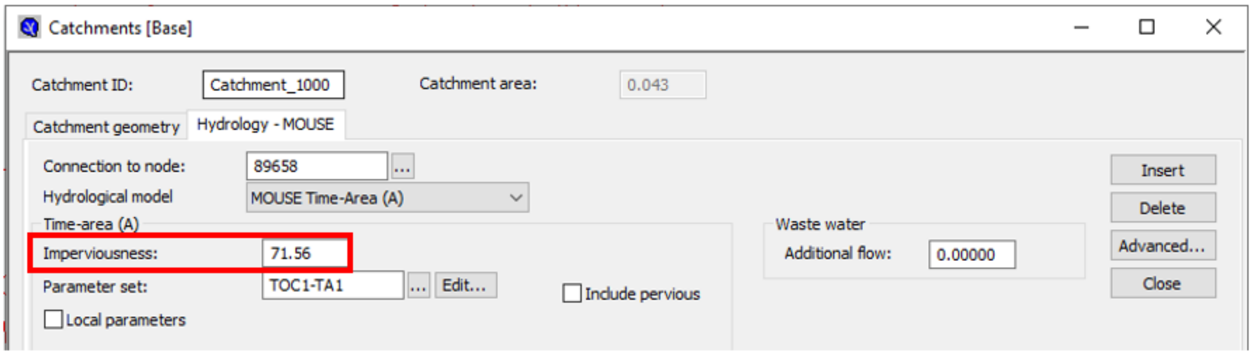


Figure 3-34. Sub-catchment's imperviousness

d. Hydrological Models

The hydrological model determines the runoff based on the effects of several components of the hydrologic cycle i.e., evapotranspiration, surface storage, interception, etc. All these components are a function of catchment parameters and give the output as runoff. Hydrological models for urban catchments include two distinct classes of models:

- *Surface runoff models:* these are the most common type in urban runoff analysis. These models are suitable for rel-atively densely urbanized catchments with the dominant amount of runoff generated on impervious surfaces, and for single-event analyses. These models fail to pro-vide realistic results in dominantly rural catchments and for long-term analyses involving multi-event rainfall series. There are four basic surface runoff models in MOUSE:
  - Time-Area Method (A)
  - Kinematic Wave (B)
  - Linear Reservoir (C1 and C2)
  - Unit Hydrograph Method (UHM)
- *Continuous hydrological models:* These models generate runoff in both the overland and sub-surface runoff components. This type of model is essential for any long-term analy-sis and dominantly rural catchments. MOUSE provides Rainfall Dependent Inflow and Infiltration (RDI) as a continuous hydrological model.

For details for these aforementioned hydrological models, the user can refer to the MOUSE manual[4]. The user can use the surface runoff model independently or combine it with the

[4] MOUSE (2019). *Rainfall Dependent Inflow and Infiltration: Reference Manual.*

continuous hydrological models (Figure 3-35).

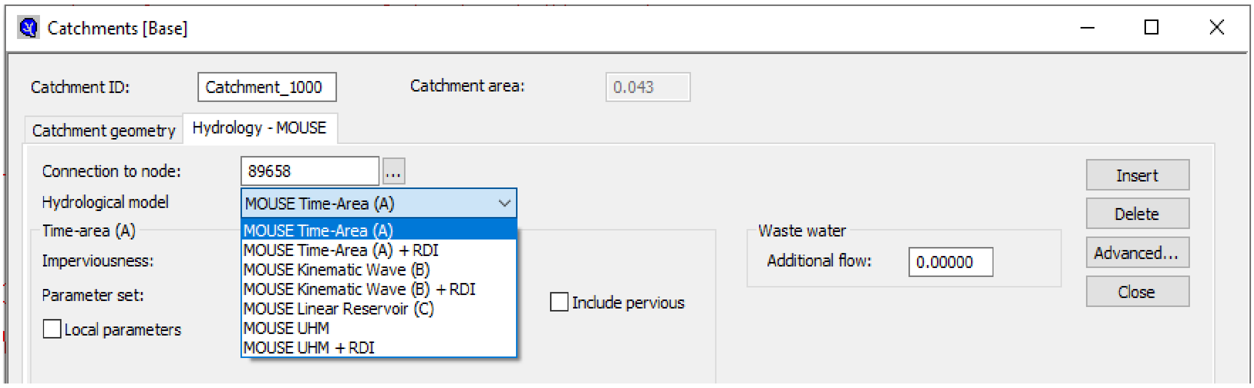


Figure 3-35. Hydrological models in MOUSE

e. Wastewater Volume Calculation

MOUSE allows the user to add wastewater as additional flow during simulation. By default, these values are equal to zero for all sub-catchments (Figure 3-36).

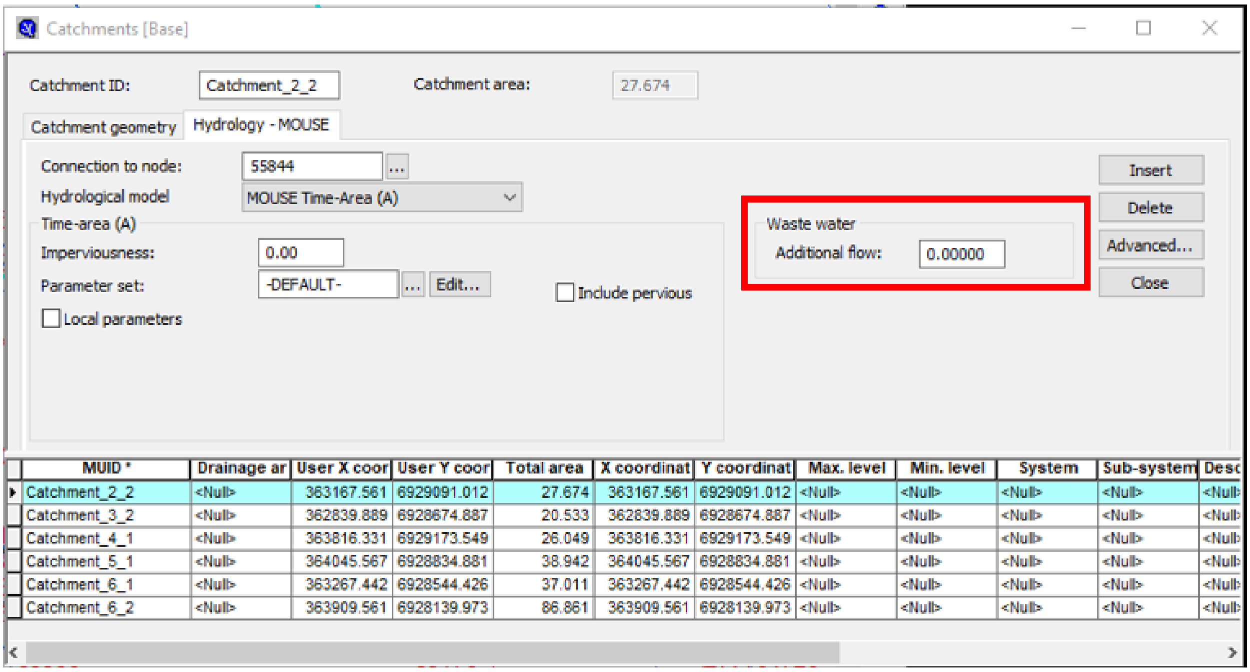


Figure 3-36. Additional flow for wastewater in sub-catchment

The user can either add this value for each sub-catchment one by one or calculate and add them outside MOUSE. In this tutorial, we will introduce how to calculate these values based on the number of people in each sub-catchment and add these values to the MOUSE project via the Microsoft Access application. We assume the user already has the shapefile (in point) that contains the number of people as its attribute.

➢ *Step 1:* Export sub-catchment from MOUSE to shapefile, exit MOUSE, and import the exported shapefile into QGIS.

- *Step 2:* Import the layer that contains the number of people into QGIS.
- *Step 3:* To get the number of people in each sub-catchment: ***Processing Toolbox → Join attributes by location (summary)***
- *Step 4:* Select the catchment layer (step 1 in Figure 3-37), the people layer (step 2 in Figure 3-37), and the column that contains the number of people (step 3 in Figure 3-37).

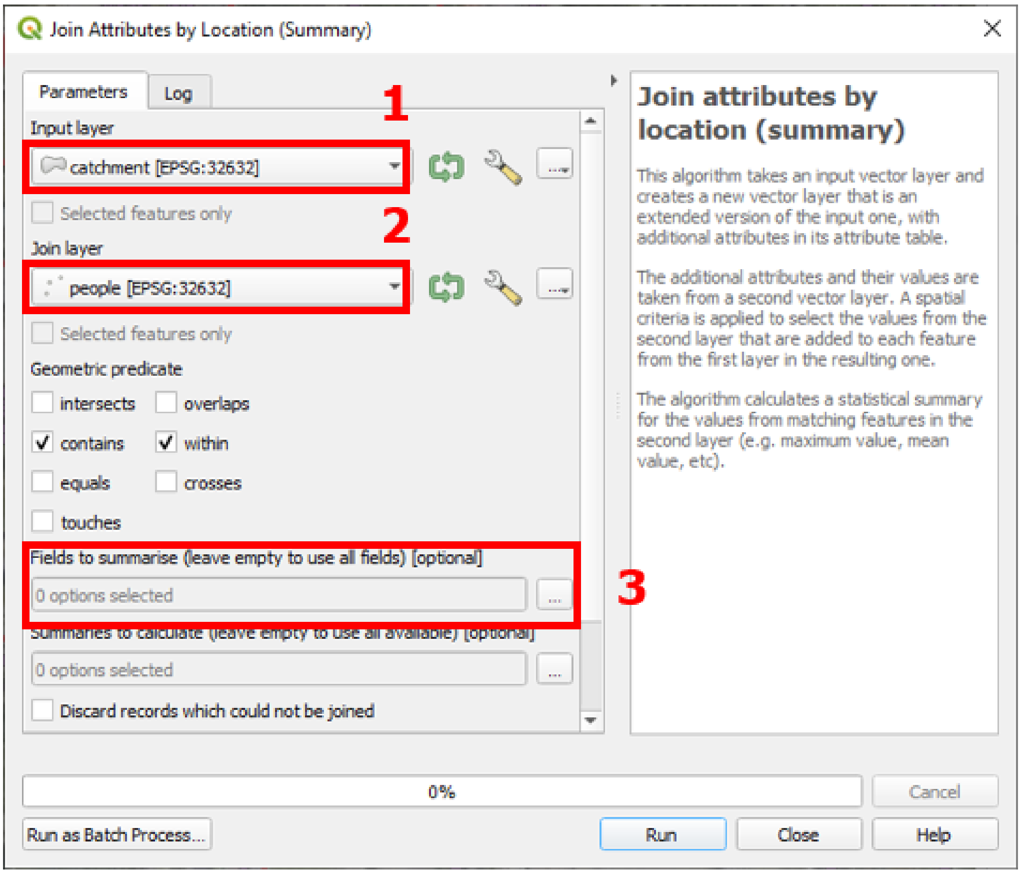
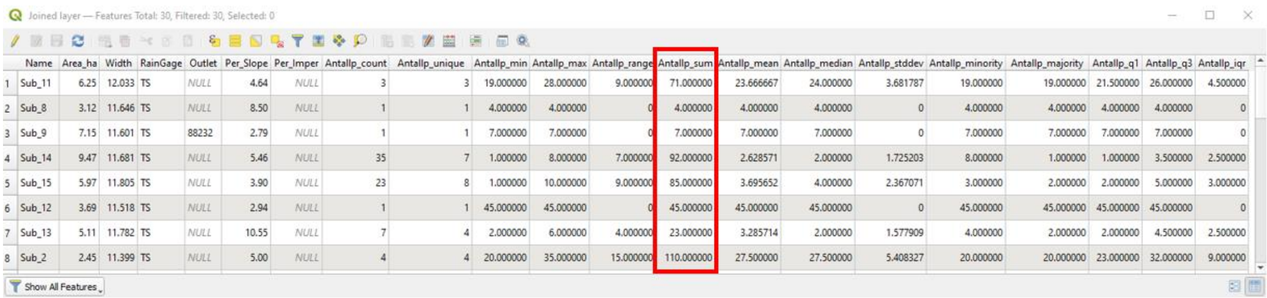


Figure 3-37. Calculate the number of people in each sub-catchment

- *Step 5:* Some statistical values of the layer are shown in Figure 3-38.



Joined layer — Features Total: 30, Filtered: 30, Selected: 0

	Name	Area_ha	Width	RainGage	Outlet	Per_Slope	Per_Imper	Antallp_count	Antallp_unique	Antallp_min	Antallp_max	Antallp_range	Antallp_sum	Antallp_mean	Antallp_median	Antallp_stddev	Antallp_minority	Antallp_majority	Antallp_q1	Antallp_q3	Antallp_iqr
1	Sub_11	6.25	12.033	TS	NULL	4.64	NULL	3	3	19.000000	28.000000	9.000000	71.000000	23.666667	24.000000	3.681787	19.000000	19.000000	21.500000	26.000000	4.500000
2	Sub_8	3.12	11.646	TS	NULL	8.50	NULL	1	1	4.000000	4.000000	0	4.000000	4.000000	4.000000	0	4.000000	4.000000	4.000000	4.000000	0
3	Sub_9	7.15	11.601	TS	88232	2.79	NULL	1	1	7.000000	7.000000	0	7.000000	7.000000	7.000000	0	7.000000	7.000000	7.000000	7.000000	0
4	Sub_14	9.47	11.681	TS	NULL	5.46	NULL	35	7	1.000000	8.000000	7.000000	92.000000	2.628571	2.000000	1.725203	8.000000	1.000000	1.000000	3.500000	2.500000
5	Sub_15	5.97	11.805	TS	NULL	3.90	NULL	23	8	1.000000	10.000000	9.000000	85.000000	3.695652	4.000000	2.367071	3.000000	2.000000	2.000000	5.000000	3.000000
6	Sub_12	3.69	11.518	TS	NULL	2.94	NULL	1	1	45.000000	45.000000	0	45.000000	45.000000	45.000000	0	45.000000	45.000000	45.000000	45.000000	0
7	Sub_13	5.11	11.782	TS	NULL	10.55	NULL	7	4	2.000000	6.000000	4.000000	23.000000	3.285714	2.000000	1.577909	4.000000	2.000000	2.000000	4.500000	2.500000
8	Sub_2	2.45	11.399	TS	NULL	5.00	NULL	4	4	20.000000	35.000000	15.000000	110.000000	27.500000	27.500000	5.408327	20.000000	20.000000	23.000000	32.000000	9.000000

Show All Features

Figure 3-38. Statistical values of the layer

- *Step 6:* Calculate wastewater discharge based on the number of people:

$$Watewater\ Volume = No.people \times discharge_{person} + other$$

- *Step 7:* Export table from QGIS to CSV file.
- *Step 8:* Open *.mdb file that was simultaneously created with the MOUSE project using Microsoft Access. Find the file with the name ***"msm_HModCRC"*** (Figure 3-39).

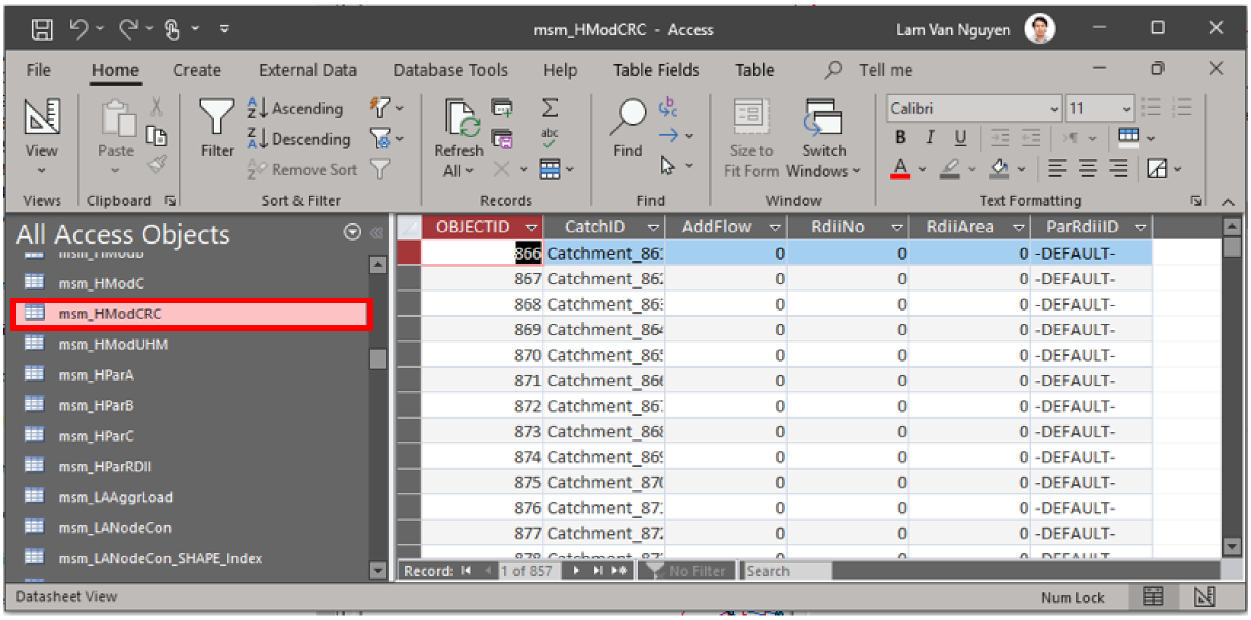


Figure 3-39. Modify wastewater volume

- *Step 9:* Copy the column that contains wastewater volume in step 6 and paste it to the column ***"AddFlow"*** in Figure 3-39. Save *.mdb file and exit Microsoft Access.
- *Step 10:* Create a new MOUSE project and open the above *.mdb file. Check all sub-catchment to ensure that all additional flows of wastewater have been assigned for each sub-catchment.

3.8. Adding Time-Series to MOUSE Project

The first step to adding any time-series data into MOUSE is to create a boundary item for MOUSE (Figure 3-40a). In the next step, the user needs to define the name for the boundary item (step 1 in Figure 3-40b), data type (step 2 in Figure 3-40b), data format (step 3 in Figure 3-40b), and source of data (step 4 in Figure 3-40b). In this step, MOUSE only uses *.dfs0 as the type of data source.

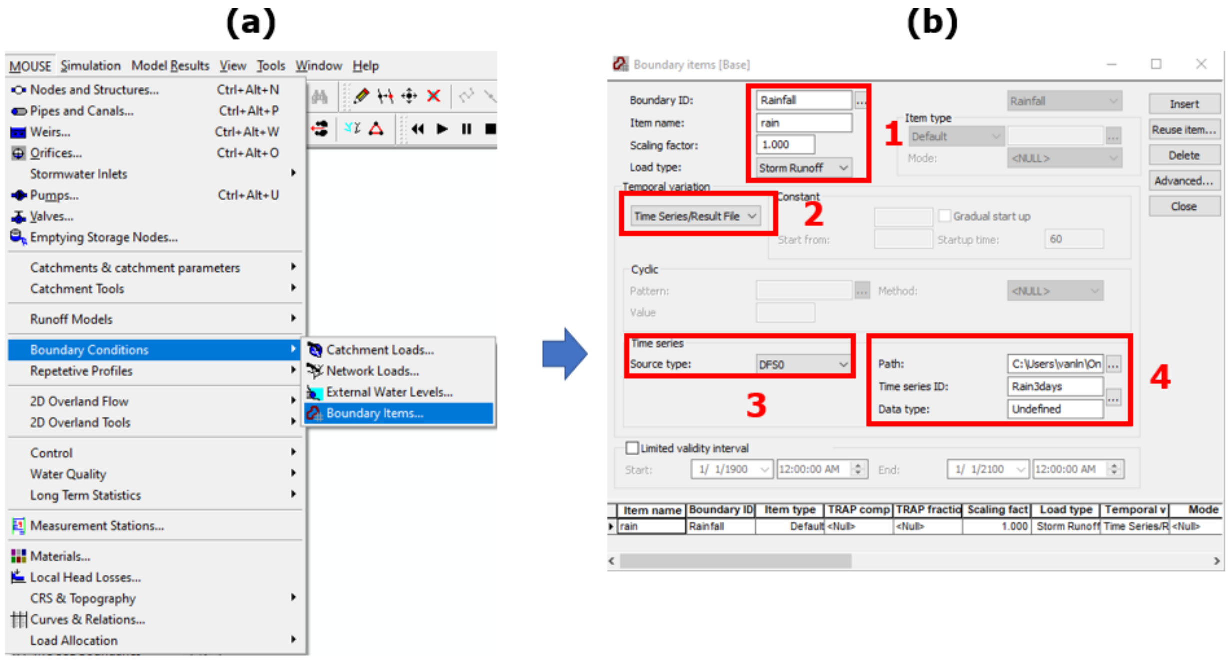


Figure 3-40. Add time-series into MOUSE

To assign the boundary items for a particular component (catchment or network), the user must specify the ***"Boundary ID"*** option (Figure 3-41).

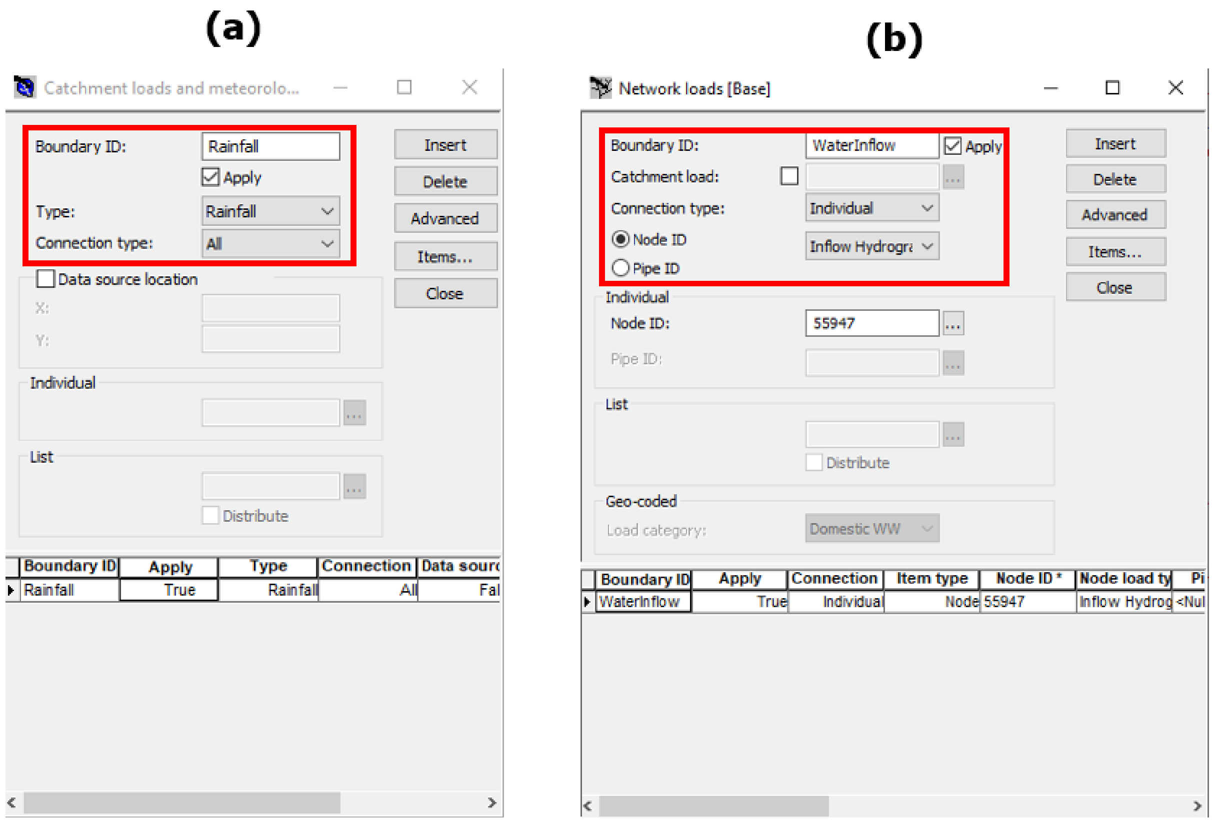


Figure 3-41. Assign time series for component

3.9. Adding Time-Series Data to Network

To add time-series data to a particular component such as a node or a link during simulation, the user first creates time-series data (*.dfs0) for this data (Figure 3-22) and next assigns a boundary item for this data (Figure 3-40). Figure 3-42 illustrates steps to add time-series flow to a particular node in MOUSE. After adding this additional data, the user can run another simulation to see results with external load.

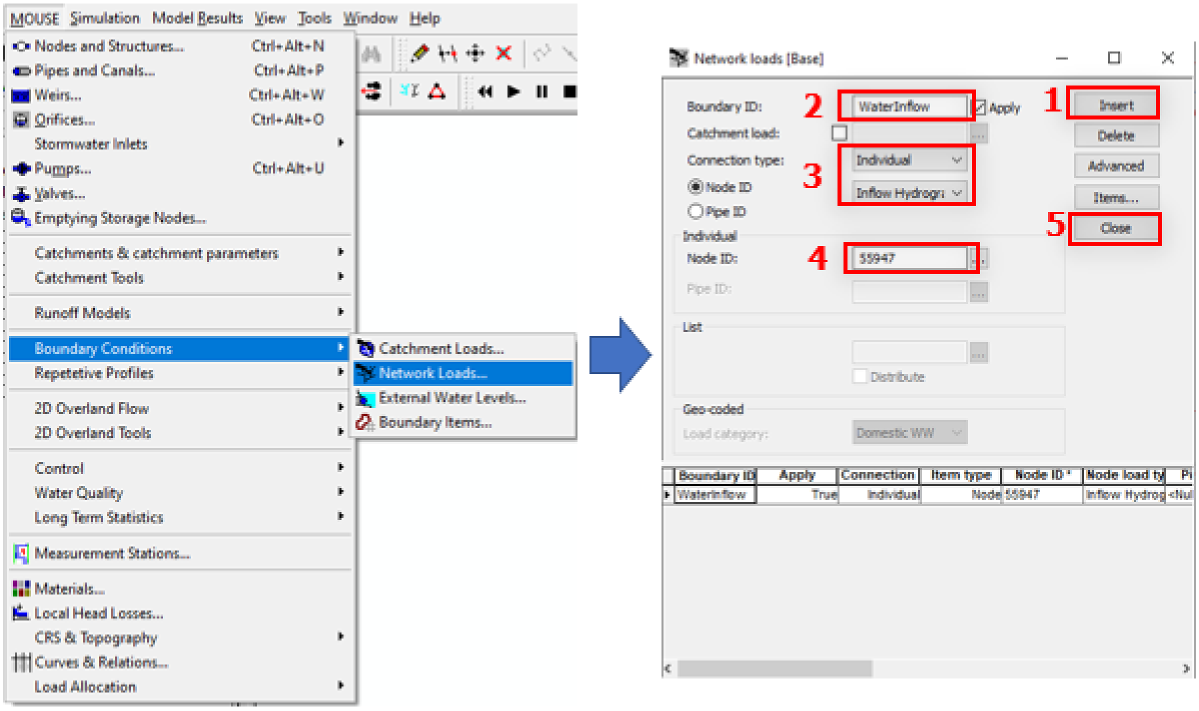


Figure 3-42. Add external flow to a node

4. Starting a Simulation and Viewing Results

4.1. Starting a Simulation

After checking the network in MOUSE and ensuring the values of components are consistent, the user can run a simulation.

To simulate a network in MOUSE, the user selects ***Simulation → Run MOUSE…*** on the main menu (Figure 4-1a) or clicks on the symbol  in the toolbar ((Figure 4-1b).

(a) **(b)**

Figure 4-1. Starting a simulation in MOUSE

a. Runoff Simulation

Runoff simulation provides runoff on the surface of sub-catchment under rainfall events. In the ***“Computation”*** dialog, the user can set up parameters for runoff simulation. Steps for setting up parameters and running a simulation are shown in Figure 4-2.

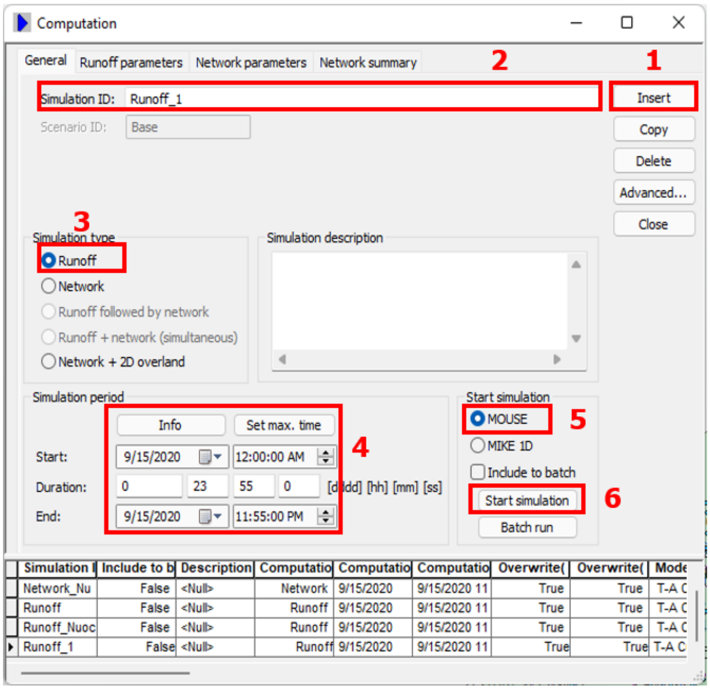


Figure 4-2. Runoff simulation in MOUSE

b. Combined Sewer Network Simulation

Simulation of a combined sewer network will combine runoff on the surface of sub-catchments and flow in pipes. Therefore, the user needs to run a runoff simulation first. Steps for running a network simulation are represented in Figure 4-3.

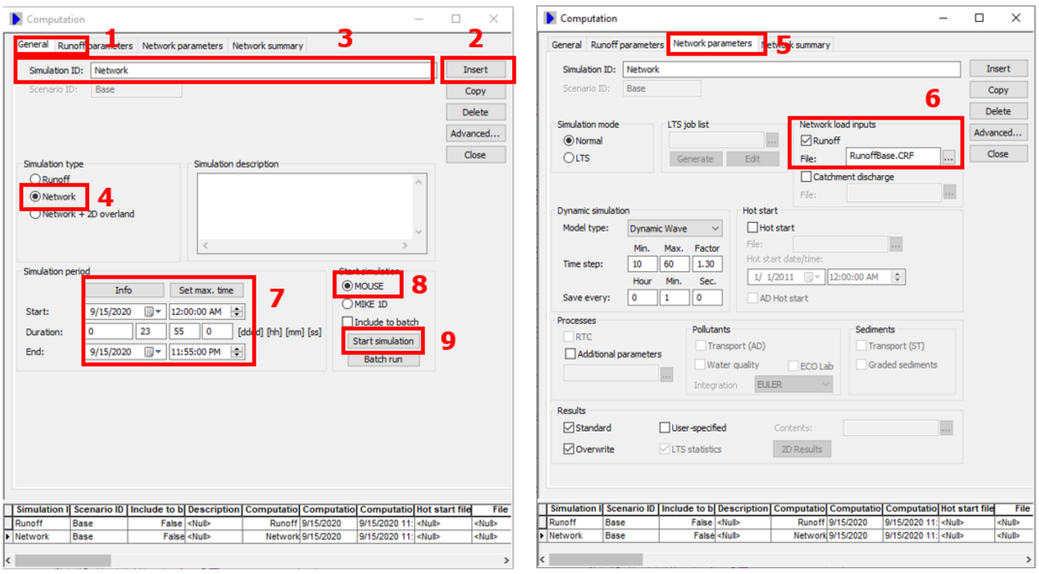


Figure 4-3. Network simulation in MOUSE

4.2. *Viewing Simulation Results*

a. Loading Runoff Simulation Result

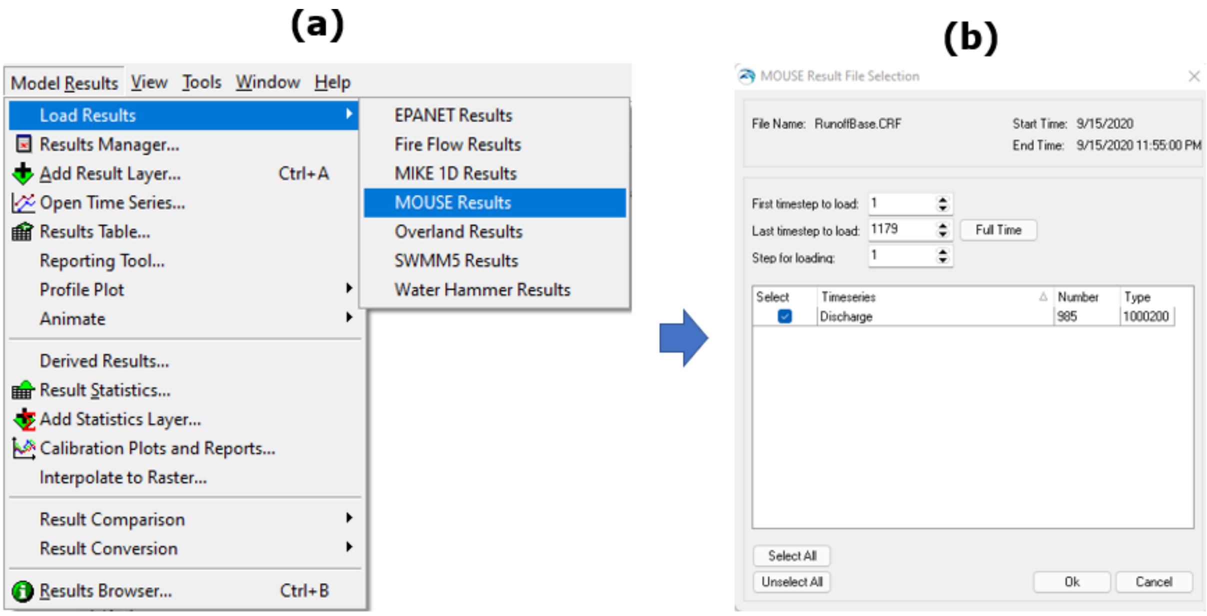


Figure 4-4. Load runoff simulation result

Figure 4-4 shows steps to load runoff simulation results. After importing the result, the user needs to add these results as a layer in MOUSE to see the dynamic simulation. To do this, select ***Model Results → Add Result Layer…*** (Figure 4-5).

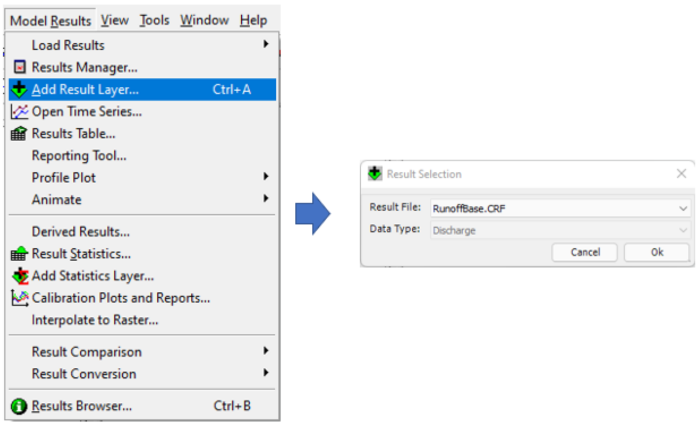


Figure 4-5. Add simulation layer

To see the dynamic simulation, the user clicks on the ***"Play"*** button on the animation toolbar (Figure 4-6).

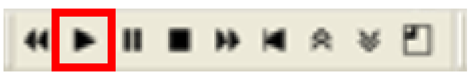


Figure 4-6. Animation in MOUSE

The simulation results will run dynamically according to a particular time step (Figure 4-7).

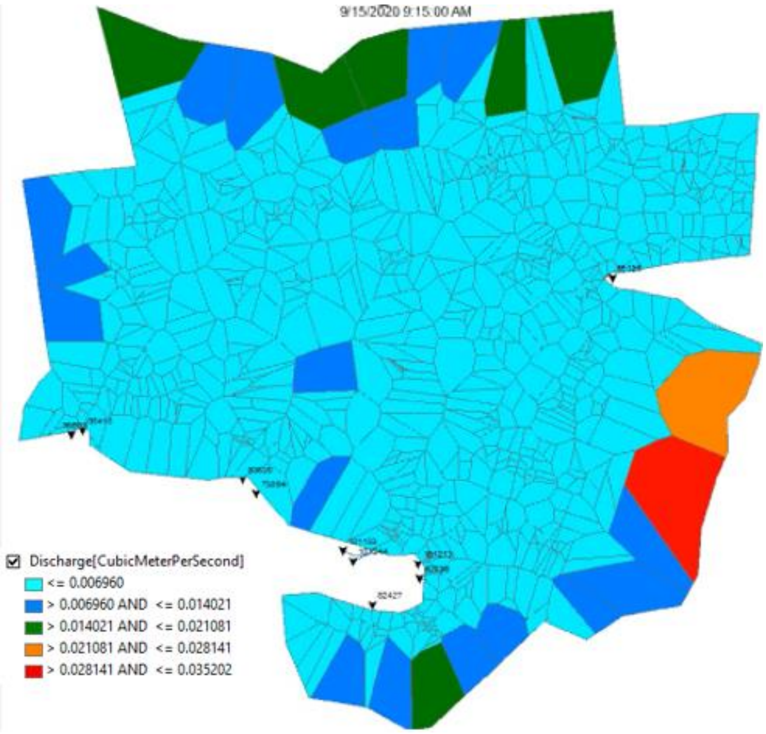


Figure 4-7. Dynamic simulation in MOUSE

b. Loading Network Simulation Result

Loading network simulation result is quite similar to loading runoff simulation result (Figure 4-4). However, instead of loading the *.crf file for runoff simulation, the network simulation requires loading the *.prf file (Figure 4-8).

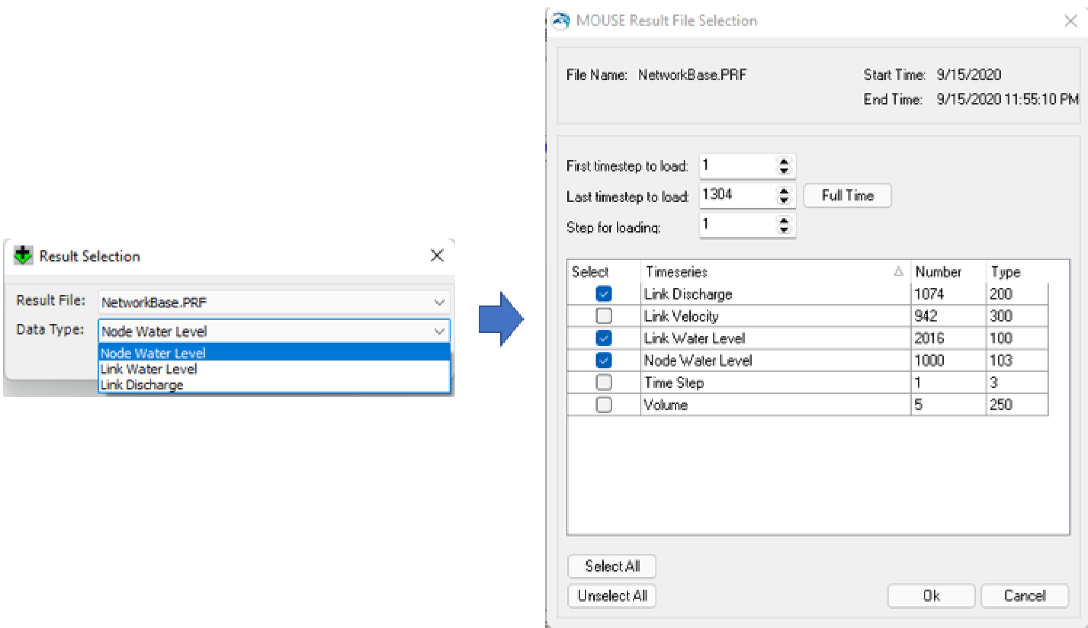


Figure 4-8. Load network simulation result

After loading the network simulation result and adding this result as a layer (Figure 4-5), the user can play animation (Figure 4-6) and see the dynamic simulation (Figure 4-9).

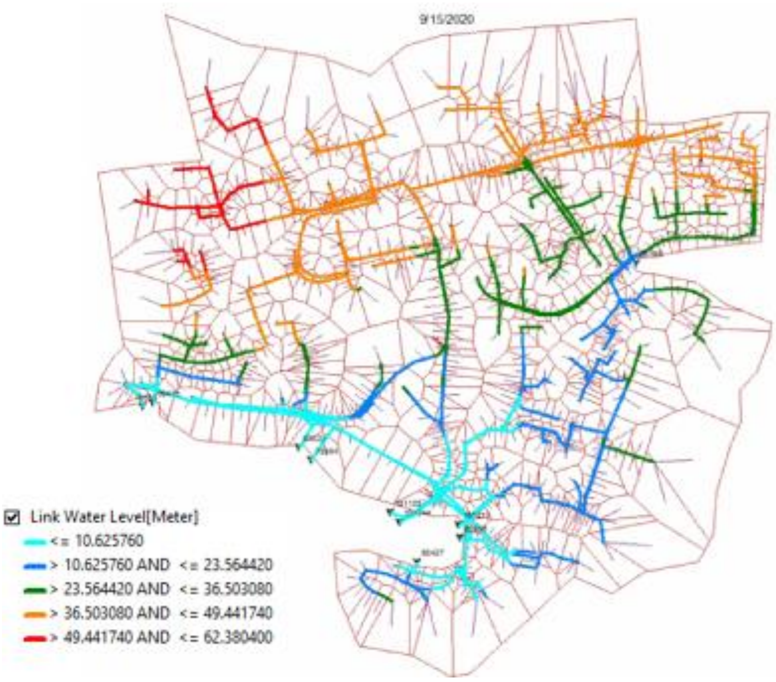


Figure 4-9. Dynamic network simulation in MOUSE

The user can directly view the time-series results of each component (such as nodes or links) on the map: ***Model Results → Open Time Series…*** (Figure 4-10).

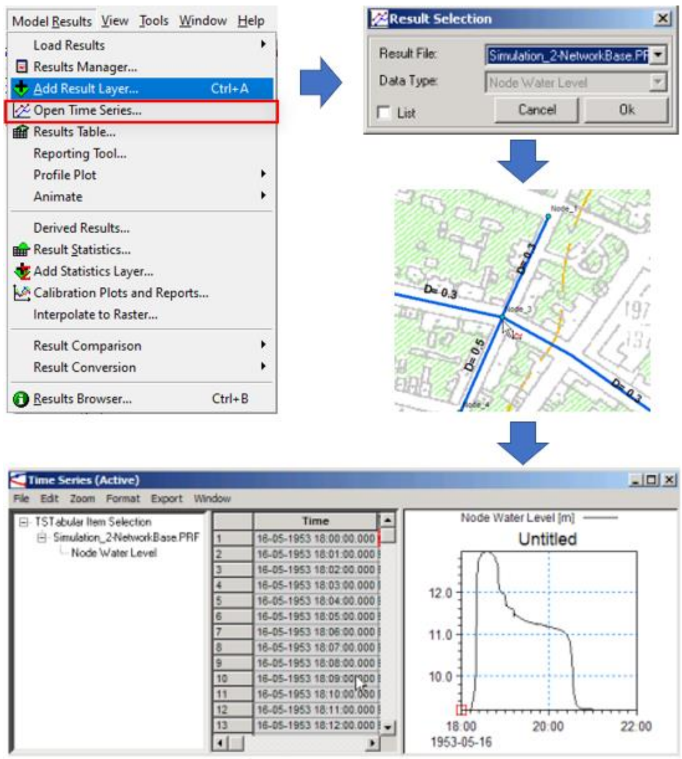


Figure 4-10. Time-series result

The profile plot is drawn between specified flags: ***Model Results → Profile Plot → Define Path Flags*** (Figure 4-11).

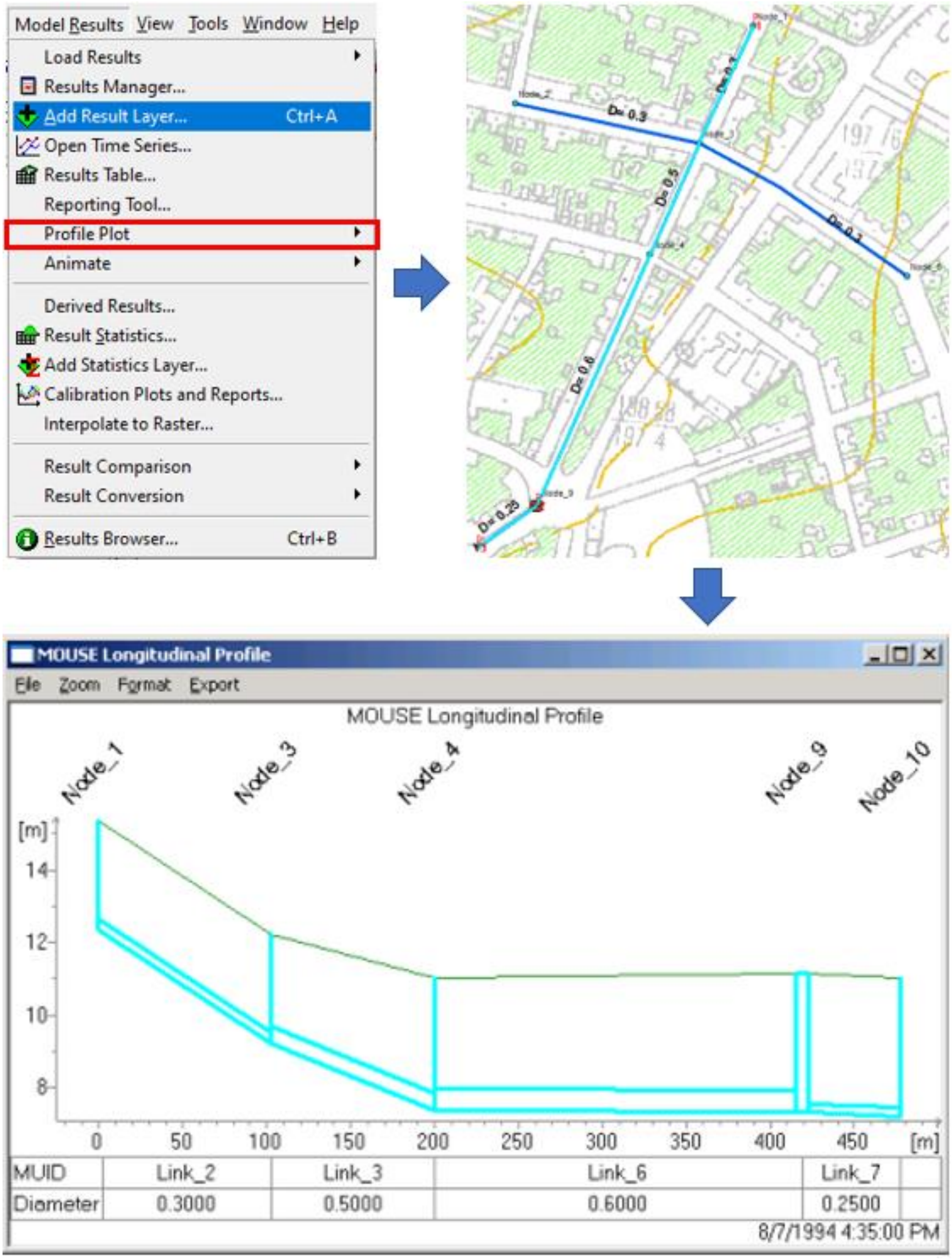


Figure 4-11. Profile plots in MOUSE

References

1. MIKE (2017). *MIKE URBAN Tutorials: Step-by-Step Training Guide*. https://manuals.mikepoweredbydhi.help/2017/Cities/MIKEURBANTutorials.pdf
2. MIKE (2019). *Collection System: Modelling of storm water drainage networks and sewer collection systems*. https://manuals.mikepoweredbydhi.help/2019/Cities/CollectionSystem.pdf
3. QGIS Development Team (2022). QGIS Geographic Information System. Open Source Geospatial Foundation Project. http://qgis.osgeo.org.
4. MOUSE (2019). *Rainfall Dependent Inflow and Infiltration: Reference Manual*. https://manuals.mikepoweredbydhi.help/2019/Cities/MOUSERDIIReference.pdf
5. Relative Roughness of Pipe, https://www.nuclear-power.com/nuclear-engineering/fluid-dynamics/major-head-loss-friction-loss/relative-roughness-of-pipe/#:~:text=The%20quantity%20used%20to%20measure,the%20pipe%20diameter%20(D)