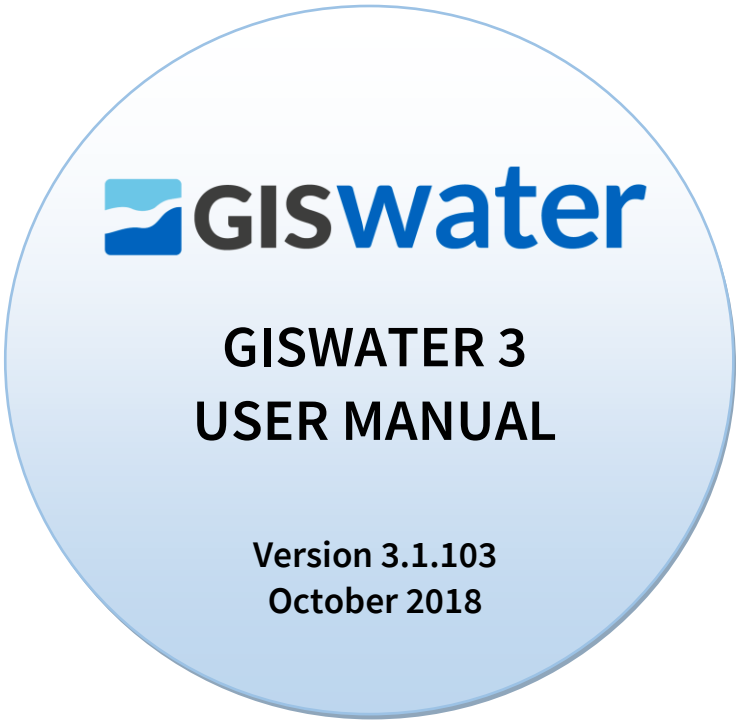

GISWATER 3
USER MANUAL

Version 3.1.103
October 2018

PREAMBLE

The *Giswater 3 User Manual* aims to answer questions regarding the installation and execution of the Giswater program. This document covers all the necessary information that users and interested parties know how to install, configure and operate with Giswater 3.

The software has been licensed under the GNU-GLP 3 license (https://www.gnu.org/licenses/gpl-3.0).

The index gives information about the list of available elements and is structured in two main blocks such as: installation and use

Gratefulness

This manual and the Giswater 3 code has been funded by different water companies in Catalonia, which have opted to share the development of a software product that can meet both their present and future needs in the world of Geographic Information Systems. With this objective, the development of the Giswater program has been carried out, of which you have the manual in your hands.

A deep appreciation to the water companies that have made it possible:

Aigües de Banyoles, SA

Aigües de Castellbisbal, SA

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Aigües de Girona, Salt i Sarriá de Ter, SA

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Consorci d'Aigües de Tarragona

Proveïments d'Aigua, SA

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Sabemsa

Aigües de Blanes, SA

Aigües del Prat, SA

Granollers, April 23, 2018

INDEX

1. INTRODUCTION

Welcome to Giswater, the first open source software for water cicle management (water supply and urban drainage).

This user's guide will help you start working with Giswater.

1.1 What is Giswater?

Giswater is an oprn source application for management and exploitation of hydraulic infrastructure elements in both wáter supply and urbain drainage. It's accesible using database and graphic representation using any kind of geographic information system (GIS).

At the same time Giswater can act as a driver connecting spatial database with tools used for hydraulic analysis.

Currently the fird versión of Giswater software is available for users. Many improvements have been made, compaing with previous versions, not only graphically but also in usability and capabilities.

As presente don image 1, Giswater is located between the applications, which used all together allow a solid and global management in relation to wáter supply and urban drainage models.

The central element of the set is the **database**, where all the information and most of the functionalities of each Giswater project is located. Giswater uses PostgreSQL database, which together with its PostGIS extension allows to conveniently link it with the next application of the set: QGIS.

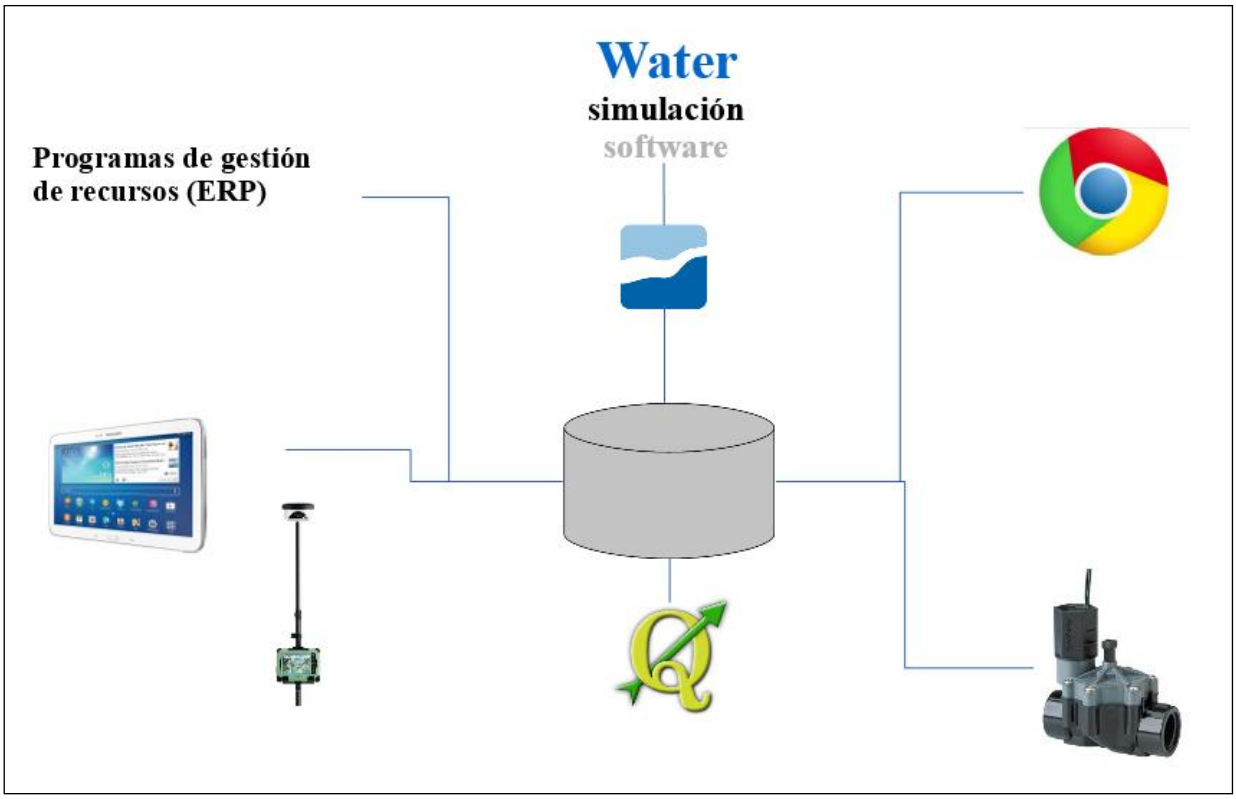


Image 1: Schema of the applications used by Giswater with a database in its central point.

QGIS is the geographic information system software on which the development of the Giswater project has been based. QGIS is related through PostGIS to the database, showing organized spatial data and always taking into account all the rules, relationships and processes established in the database.

The central point of the project (Database - GIS) also allows to connect with SCADA, in order to update in real time, the information that comes directly from the physical elements of the network. In this way, Giswater

is also a global management system that allows its users to always work with data that is updated automatically.

Apart from the data management through GIS software there is also the possibility of working with Giswater data in web and mobile environment. This functionality is separate from the usual desktop use, since it is only for customers that require it, and it is managed from the BMAPS platform.

1.2 What is the goal of this user's guide?

The most important goal of this guide is to provide the user a document which will help to carry out any task with Giswater, from the initial installation process of the necessary programs to the most complex management operations.

The improvements made in the version 3.0 will be reflected throughout the manual and the purpose of those improvemnets, together with the instructions of how to make use of them, will be explained in the best possible way.

1.3 Suggested system architecture

The suggested system is composed of three machines that act as a server, and two clients. Heavy clients which use QGIS as a GIS engine, and thin clients, which use Google Chrome as a GIS engine.

Given the architecture of the system on image 2, it is necessary to install different technologies in different machines that are listed below.

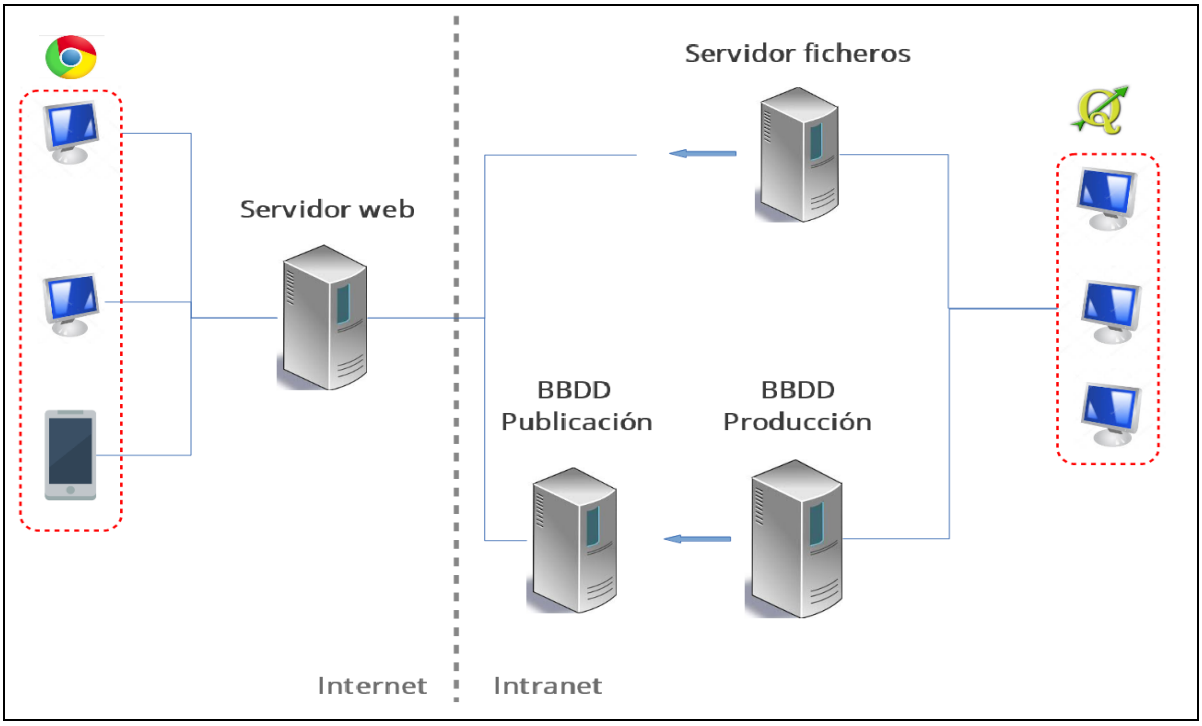


Image 2: Suggested system architecture with three servers.

- **DATABASE SERVER (DB)**

  First, it's necessary to install the database of the new corporate GIS, in this case PostgreSQL (https://www.postgres.org) and its spatial extension, PostGIS (https://www.postgis.net).

  The operating system can be either LINUX or WINDOWS. In relation to terms of speed, performance, customization and reliability we recommend a machine (virtualized or not) with operating system DEBIAN 9 or higher. However, there is no problem if that it is a Windows machine with a current operating system. This decision depends entirely to the preference of the personnel of IT department of a company.

  What needs to be kept in mind is that depending on the number of users and records in the organization, it is highly recommended to install the database in a highly available environment with the aim that simultaneous queries, especially those that consume a large amount of resources, can be attended without high penalties.

  Considering the fact that the database usually works with the disk to recover or display information, it is essential that the machine has a solid hard disk (SSD) as well as a controller with enough bandwidth to access the information in a massive and fast way. From now on, the architecture of virtualization and the software layer that manages it, will mostly depend on the number of users and the volume of managed data.

- **WEB SERVER**

  The web server is another piece of the project's architecture. This server is the one that needs a lower number of resources since it simply has to publish the information provided by the database. In this part of the system, the determining factor is no longer the speed or capacity of the system, but its safety.

  For this purpose, it is necessary to install all the required technologies to provide security, reliability and performance to the web environment. There are shown on image 3:

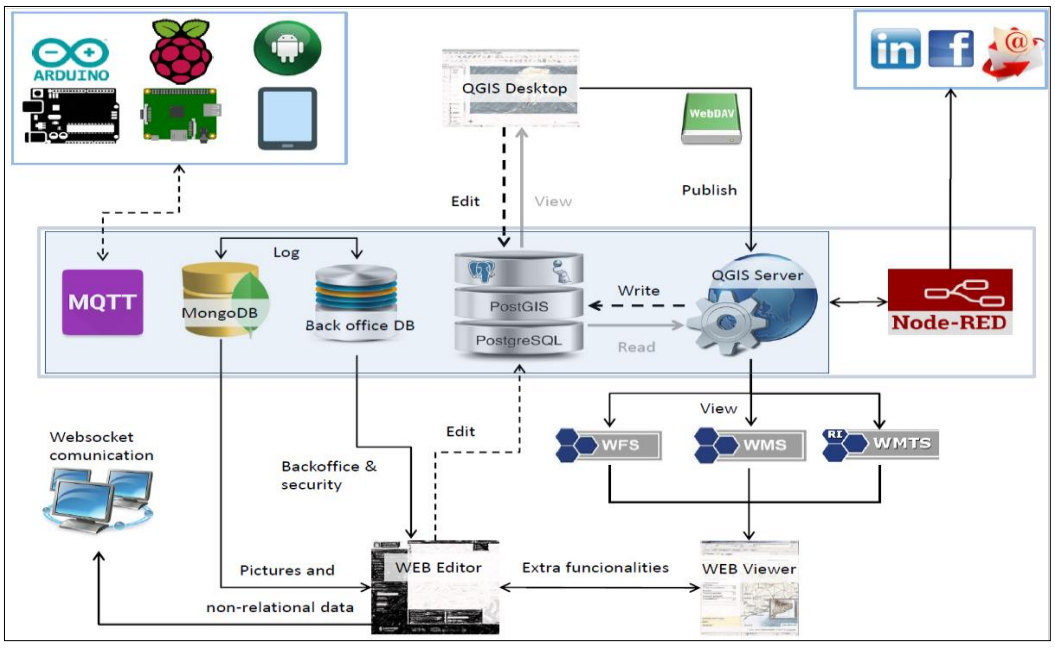


Image 3: All the technologies that should be installed in order to use Giswater with the most relialibity.

Unlike the previous server, this has to be obligatorily a LINUX in DEBIAN distribution, version 9.

- **PUBLICATION SERVE**

  Because of security reasons, an additional server is defined specifically for publication. The functions of this server are:

  1) Publish the corporate data, so that the production database is never exposed in case of a hacking attack. A determined process (nocturnal, in real time) will be responsible for keeping updated the data on this server.

  2) Enable web writing options, if they are operative. All the inserts from the outside will be made in this database, and then a determined process (nocturnal, in real time) will be responsible for accessing this machine in order to collect the necessary data and place it where necessary.

  The firewall is generated using this intermediate machine. It allows that the access to the corporate information is beeing protected from the outside in both write and read mode.

- **FILE SERVER**

  The file server[1] must be a centralized repository of all documents that have to be managed by the system (photographs, files, plans, administrative documentation, etc.). The architecture and technology of this server depends on what is used in a company and it is recommended to develop a specific connection device for each case.

  Topics such as publishing the files on network or not, serving an URL or folder routes are the decisions on which depends the final architecture of the system and the reuse or not of the current file server organization.

  So that the Giswater project could work, the only files that have to be served, and which are the part of the architecture of the project and to which all the users need to have access in a READING MODE, are files located in a corporate plugin folder:

  - Giswater plugin
  - Time manager
  - Table manager
  - Folder used for sharing QGIS projects

- **HEAVY GIS CLIENT MACHINES (QGIS)**

  As presented in the image 2 there are two types of client machines. The one with the highest requirements is the one with QGIS as a GIS client. In this case it is necessary to have at least the following software:

  - QGIS (https://www.qgis.org) – last stable LTR
  - Notepad++ (https://notepad-plus-plus.org)
  - JRE (http://www.oracle.com/technetwork/java/javase/downloads)
  - Giswater (https://www.giswater.org/descarga)

[1] File server doesn't have to be a spetial, separated machine. It can be any file server used by a company or a folder located on a database server, shared with all the network.

In case that a hydraulic model compatible with Giswater is necessary, the EPA software can be downloaded from the Giswater website:

- EPA SWMM (https://www.giswater.org/descarga)
- EPA NET (https://www.giswater.org/descarga)

In order to have a better user experience with the GIS software, it is recommended to have an office suite installed, as well as a PDF reader.

- **GIS THIN CLIENT MACHINES (CHROME)**

  There is also a second type of client machines that are used as a GIS thin client in the internet browser, which will perform the functions of WebAPP. In this case it is only necessary to have installed Google Chrome itself.

  The development is only certified and validated with the use of the Google Chrome browser and any other browser - Mozilla Firefox, Opera or Internet Explorer may have some dysfunctions and its usage is not recommended.

2. INSTALATION AND START UP

In this second section of the user's guide you will find all the necessary steps that must be done before starting working in the Giswater environment, from the pre-installation requirements of the software's configuration, through the creation of new projects (real or example), to testing the functionalities of Giswater.

2.1 Installation prerequisites.

In relation to section 1.3, where the suggested system's architecture was presented, in this part the details of the tree servers, of which the system is composed, will be commented

On the data server side, the performance depends mostly on the number of users and the volume of data.

As an order of magnitude and for companies with one or two people who edit data and between five to eight who consult, with a relatively small network data volume respect the volume of dedicated staff, a machine with four cores and a minimum of 32 GB of RAM has to be enough. Regarding hard drive, the two elements to keep in mind are capacity and speed.

In the case of larger organizations, it would be necessary to analyze the available server technology and the type of virtualizations that are used in order to adjust the needs to the reality of the service and verify whether the system is sufficient or needs to be resized.

If the machine is only used as a PostgreSQL server (and the basic functions of OS), the disk space consumed by the database is not very high. It is also important to know that the hard disk is used for more functions than just to store the PostgreSQL data in a binary format. Specifically, this use also includes

1. Basic functions of OS support.
2. Help through temporary files to PostgreSQL processes.
3. Storage of specific Giswater files.

It is recommened to initially allocate about 100 GB for storage. Regarding the access speed of the disk, which is a particularly relevant issue, the fact of having a solid hard drive (SSD) can greatly favor the benefits to end users with a controller that guarantees the fastest possible access to data.

On the side of the **web server**, less features are required and therefore, always taking into account the size of the company mentioned above, with a two-core machine (recommended having four) and a minimum of 16 GB of RAM would be sufficient. In any case, this will depend on the concurrence and the use on the web side.

What should be highlighted in this case is the importance of a disk to store the field photographs, which are made and than managed by a MongoDB database. For this purpose, the size of the disk which does not need to be solid, should be adjusted to the usage of daily capture of photographs on the web.

On the **file serve**r side and regarding the storage of specific Giswater files, it is recommended to use the same PostgreSQL machine to host a folder, read only, with shared network access for normal users in which they could find a *plugin* repositor, the original QGIS projects and also the primal installation files.

In this GIS directory the templates of the QGIS projects (subfolder templates) will be stored. This directory will also be configured as a path for QGIS client plugins (subfolder plugins) which will be installed on the client's machines. In the plugin's subfolder will be installes all those add-ons that are of interest to the organization.

About other data types (QGIS projects, cartography base layers, attached documents, etc.) It's not recommended to use the same machine. The best option is to use the shared network unit with which the data is usually worked (to take advantage of the organized backup system).

Configuring this folder with the plugins on all client users with read-only permissions ensures that all QGIS users have the same plugins installed and makes it much easier to update them.

On the **client** side the machines must have some processing capacity (i7 processors are recommended) with a minimum of 18 GB of memory. The operating system must be Windows 7 or higher. In case you want to carry out an intensive resource consumption with the generation of high-intensity geoprocesses, it is recommended to use a client machine with greater features such as a multicuore of 16-32 GB of RAM and a solid hard disk.

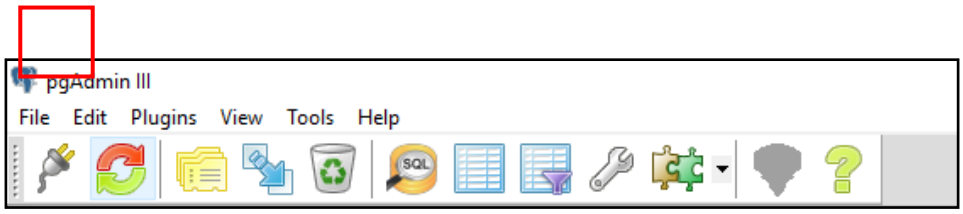
2.2 Download and configuration of PostgreSQL

PostgreSQL is an open source database with enormous potential, which will be used to store all the data with which Giswater works. Thanks to its geospatial extension PostGIS allows a very comfortable relation with GIS, especially QGIS. This extension contains of over 1000 geospatial functions, which maks it one of the most powerful GIS software available, although PostgreSQL is not a specific GIS program.

There are different versions of PostgreSQL available for download. To work with Giswater it is recommended to download any versión higher than 9.5, with which the programs are 100% compatible.

The download and installation are very simple and can be done from https://www.postgresql.org/download. Together with the database, a database administration program is installed, pgAdmin (https://www.pgadmin.org/download/ to download it), which will be used to manage the database in a visually way, easy for user. Using pgAdmin it's possible to modify the tables, views and rules of the database, as well as consult all the information and manage it.

Once both programs are installed, after opening pgAdmin the first thing that needs to be done is adding a new connection.

It's 

necessary to fill in the listed fields in order to créate a new connection:

- **Name**: connection name
- **Host**: it can be a localhost or a connection with another server
- **Port**: port
- **Service**: related to a service configured in a file pg_service.conf. (Opcional)
- **Maintenance DB**: existing database to which the new connection is related
- **Username**: user's name. The first user should be 'postgres'
- **Password**: password, which for a postgres user is also 'postgres'.

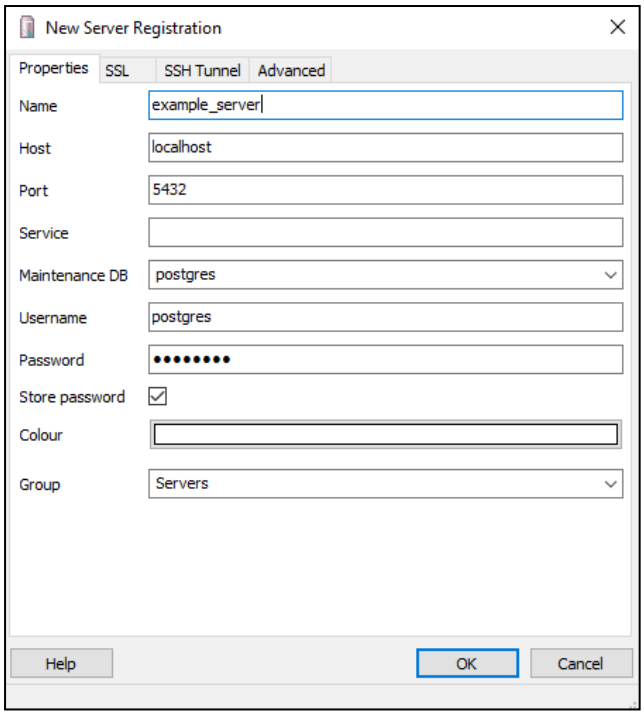


Image 4: Add new connection to Postgres using pgAdmin.

Once the new connection is created, the first 'public' scheme is automatically created in a database. Next, the PostGIS extension must be added, in order to have all the GIS functionalities available, as well as the pgRouting extension, which adds routing and network analysis functions to the database. pgRouting is essential for some of the Giswater tools such as the cutting polygon and the longitudinal profiles.

By clicking the SQL command button, we can write our first *query* → 


```
CREATE EXTENSION postgis;
CREATE EXTENSION pgrouting;
```

2.3 Download and configuration of Giswater.

Giswater is composed by an application, which acts as a driver used for the configuration, creation and management of the different projects in the database, and a plugin based on QGIS for the exploitation of network elements.

- To download Giswater use the link: https://www.giswater.org/downloads/?lang=en

The website of Giswater has available to download the latest version 3.0 as well as previous versions of the program.

Apart from the download tab, on the website you can also consult information about the product, the benefits of open source programs, the community of experts that develop Giswater or obtain materials and tutorials to learn how to use it.

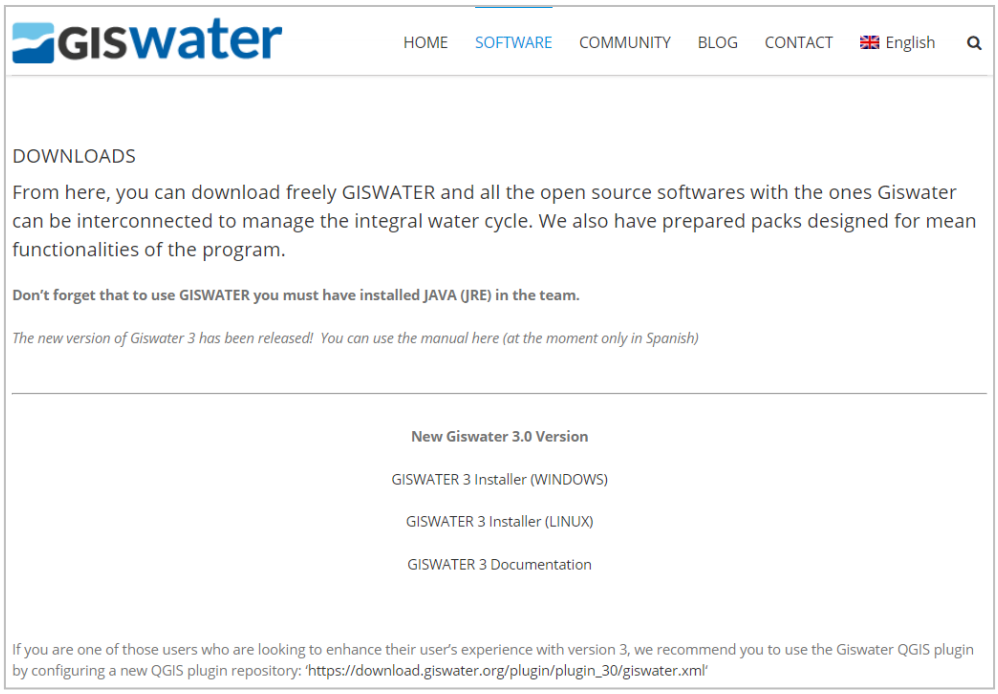


Image 5: Giswater website, where you can download both Giswater software and QGIS plugin. Previos versions are also available.

Once installed, open Giswater and start the configuration and creation of the new project.

2.3.1 Toolbar of the main menu.

Toolbar of the main menu of Giswater consists of the following submenús continuación:

- **File**: Allows to manage the configuration preferences defined by user and save or restore the database schema.
- **Project example**: Automatic creation of sample projects included in Giswater.
- **Tools**: Tools realte to the database:
  - Database administrator: Allows to open the database management program.
  - SQL file launcher: Allows to execute SQL scripts in the database.
  - Developer toolbox: Allows to update a database schema.
- **Configuration**: Allows to manage different parameters of the program.
- **About**: Relatied to other aspects of Giswater, like welcome, community or license.

2.3.2 Giswater configuration

It's possible to parametrize the basic options of the program using the menu ***Configuration***, such as:

Open INP files: Allows to configurate when the INP files are opened.

Open RPT files: Allows to configurate when the RPT files are opened.

Data Project update: Allows automatic updated in case of bugs.

Import result autom.: Allows automatic import of the simulation results.

Overwrite INP files: Allows to overwrite the INP files.

Overwrite RPT files: Allows to overwrite the RPT files.

Overwrite Result: Allows to store more than one result in a database (it's recommended to enable the option).

Check updates: Allows to check whether new versions of software are available (it's recommended to enable the option).

Choose language: Allows to choose the language of the project and user's interface.

Log folder size: Escoger la capacidad de la carpeta log.

DB Admin: Configuration of the path where the executable file of 'pgAdmin' is located in order to access the database.

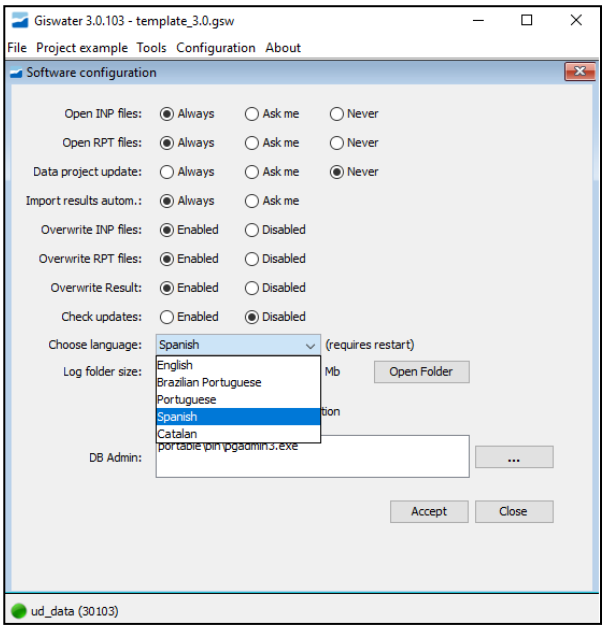


Image 6: Initial configuration of the software.

2.3.3 Connection configuration.

As a first step with Giswater, before creation of the data schema, is creation of the connection to the database on which all the data will be stored. To do this, in the 'Project preferences' menu, in the 'Connetion Parameters' section, the parameters of the connection needs to be configured:

Driver: Driver versión of the database connection.

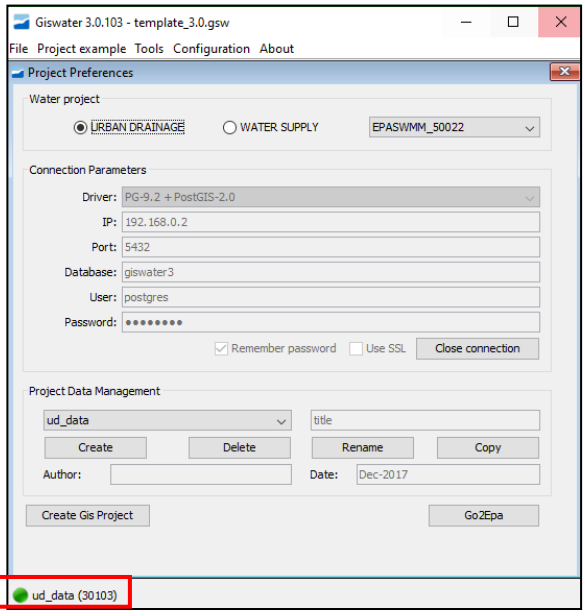
IP: IP address of the connection (may be localhost)

Port: Port enabled to access the connection.

Database: Name of the database.

User: Database user's name.

Password: User's password.



Green color indicates that the connection is correct

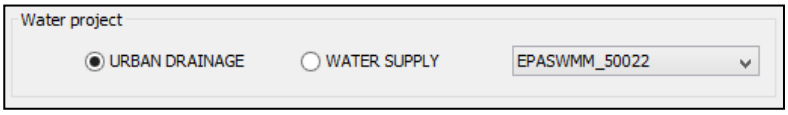
Image 7: Project preferences and management.

2.3.4 Creation of Giswater project template in a database

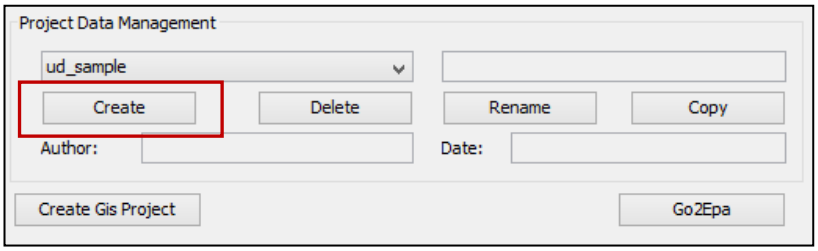
Once the connection to the database is configured, everything is ready to create a working scheme with the predefined template of all the tables, views and functions that act in the database. This template is the basic element of Giswater, because it represents the logical skeleton of the project and all the relationships that allow its correct operation. Within the template there are some tables with the data incorporated by default (system) and other tables and views with different data for each project.

So as to create the template the following steps have to be executed:

a) Select the project type (Urban Drainage o Water Suply)



b) In the menu Project Data Management, click the button ***'Create'***, in order to créate a new data schema (template of tables, views, functions, etc.).



Project name: Name of database schema.

Project title: Project title.

Author: Author of the project.

Date: Creat date.

Select SRID: Selector of Spatial Reference ID.

Import data: Allows to import a file with project creation parameters.

Once the data project has been created, it can be deleted, renamed or a copied using the buttons of Giswate. It's possible to verify if it has been created correctly by opening pgAdmin and the corresponding schema (manual_ud for this example). There must exists all the tables related to Giswater, although most of them empty.

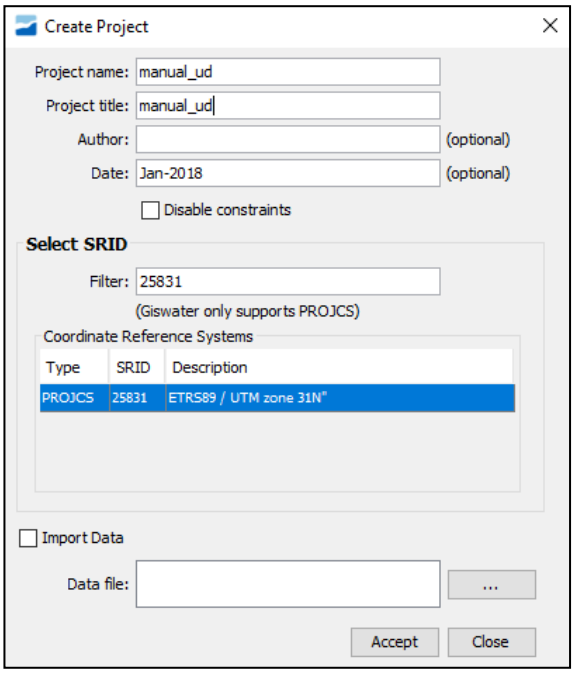


Image 8: Creation of a project in a database.

2.3.5 Basic configuration of a project template

There are many types of tables within all those created in the previous section. There are some that are already filled by default, others that will be filled in as elements of the network are created and there are tables that can be customized by the users, depending on their needs and those of their network.

The basic tables that match the main generic elements of any Giswater project are of great importance and must be taken into account in order to explain this section. They are the following:

- **Arc**
- **Node**
- **Connec**
- **Gully** (only for UD)

These four tables are empty and will only be filled when the project has geospatial elements of the corresponding type. The important thing is that they have many restrictions and relationships with other tables that must be fulfilled.

Below are the tables that, from the beginning, should be filled in by the user so that Giswater works correctly.

1- Creation of new, personalized network elements

cat_feature

node_type

arc_type

connec_type

gully_type (only for UD)

These tables are used as an intermediate catalog for all the elements of the different types.

Each element that is created must necessarily be part of an element type (feature_type), which can be node, arc, connec or gully, and in addition to another type within each of the above, specified in the table sys_feature_type (no modifiable by users). There are 24 records for water supply projects (ws) and 17 for sanitation (ud).

Each user can customize the *cat_feature* table with specific elements that are necessary for their network, provided they are related to one of the *sys_feature_type* fields (for example, TANK or FOUNTAIN) and one of the existing *feature_type* (for example, NODE or CONNEC).

The following tables that must be filled in are those of element types related to only one feature_type (*node_type, arc_type, connec_type and gully_type*). The id of the *cat_feature* table must match the id of * *_type* tables, which, obviously, will only have elements of their specific type. The * *_type* tables connect with the individual management tables of each element type, as well as with those that act on the hydraulic models (inp).

To finish the hierarchy of the tables that determine the existing elements, the catalog tables must be filled in by relating each new element, with name to the user's liking, with any of the *types* specified in the higher hierarchy tables (see section **4.2.1.1**).

2- Custom value domains

man_type_category

man_type_fluid

man_type_function

man_type_location

In these tables the specific information about the type of category, fluid, function or location related to the different types of basic elements (arc, node connec, gully) is defined. Each of the tables has the following fields:

id	serial	Automatic id (primary key)
*_type	varchar (50)	Field to put in the information that will be used in arc/node/connec/gully table
feature_type	varchar (30)	Element type to which the value is assigned
featurecat_id	varchar (30)	Allows to detail to which kind of element is assigned the value
observ	varchar (150)	Field for additional information

*category/fluid/function/location

To give an example of the use of these tables, we could define a domain catalog of custom values for a *tank* in addition to what would correspond to it by *node*.

These fields are managed by the database through foreign keys to guarantee the consistency and uniqueness of the information. The foreign key has special characteristics to govern this system of different values depending on the source table. One of the most important properties is the duplicity of the foreign key. This means, that to give an example for the node table, and regarding the type of fluid, the double key is managed so that only those values of *fluid_type* in the table *man_fluid_type* that meet the condition of having the field *feature_type* = 'NODE' will be available in the *node.fluid_type* field.

The double foreign key guarantees that the information is consistent at all times, avoiding insertions that do not comply with this criterion and spreading changes in case of renewing or eliminating value domains.

3- Verification values

value_verified

This table is used to customize the *verified* field that is present in all the tables of the basic elements. Each user, depending on their needs, can add verification values in order to improve the accuracy of their data.

Some examples of verification values could be: to review, verified, pending confirmation, etc.

4- Condiguration of tables embed in forms

config_client_forms

This table is used to customize the visibility of all the tables embedded in the forms and aims to customize which fields are visible, how wide they are and which is the alias of the column.

The relation shoulf be configurated and its appearance is detailed in the attached table

project_type	location_type	table
utils	basic toolbar	v_ui_workcat_x_feature_end
utils	basic toolbar	v_ui_workcat_x_feature
utils	om toolbar	v_ui_om_visit
utils	om toolbar	om_psector
utils	edit toolbar	doc
utils	edit toolbar	element
utils	epa toolbar	v_ui_rpt_cat_result
utils	plan toolbar	plan_psector
utils	plan toolbar	v_ui_om_result_cat
utils	node form	v_ui_scada_x_node
utils	node form	v_ui_scada_x_node_values
utils	node form	v_ui_element_x_node
utils	node form	v_ui_om_visit_x_node
utils	node form	v_ui_doc_x_node
utils	arc form	v_ui_element_x_arc
utils	arc form	v_ui_om_visit_x_arc
utils	arc form	v_ui_doc_x_arc
utils	connec form	v_ui_doc_x_connec
utils	connec form	v_ui_element_x_connec
utils	connec form	v_ui_om_visit_x_connec
utils	connec form	v_rtc_hydrometer_x_connec
ws	om toolbar	v_ui_anl_mincut_result_cat
ws	node form	v_ui_node_x_relations
ws	connec form	v_ui_mincut_hydrometer
ud	node form	v_ui_node_x_connection_downstream
ud	node form	v_ui_node_x_connection_upstream
ud	gully form	v_ui_doc_x_gully
ud	gully form	v_ui_om_visit_x_gully
ud	gully form	v_ui_element_x_gully

On the other hand, the configuration table has the listed columns:

id serial, location_type, project_type, table_id, column_id, column_index, status, width, alias, dev1_status, dev2_status, dev3_status, dev_alias, donde para la configuración del cliente QGIS solo se debe actuar sobre los campos:

status: true/false if it would be show or not in the forms

alias: the name of the columna shown in the

width: the width of the shown field

Fields *dev1_status, dev2_status, dev3_status and dev_alias* are created for users using mobile devices.

5- Creation of personalized attributes

man_addfields_parameter

This table, as its name indicates, is intended to add fields to any project element that are not created by default in Giswater. This allows users to customize the fields according to the requirements of each user. In this way if at any time there is a neccessity of linking any type of information to an element it's possible to do it through this table.

There are three more tables related to *man_addfields_parameter*:

- *man_addfields_cat_datatype*: catalog of data types *(integer, text, boolean ...)*

- *man_addfields_cat_widgettype*: catalog of widget types displayed in the form *(QCheckBox, QComboBox, QTextEdit ...)*

- *man_addfields_value*: table where the values are stored for each type of parameter added by the user.

The information contained in the fields of these tables can not be displayed in the attribute table of the element, but it will be seen in the corresponding form and in the addfields tables.

6- Configuration of visit, inspection and planification functionalities.

om_visit_parameter

The table *om_visit_parameter* allows to add fields for each type of inspection that can be done in the water network. Any type of visit can be defined (for example, inspection or rehabilitation) to meet the needs of the user. However, the visit must also be related to an existing element type.

plan_psector

It's required to insert at least one planification sector before starting to work. This zone will work as default sector for new planified elements.

2.4. Creation of new example project (sample)

To facilitate the first steps with Giswater and have a complete data model that serves as a reference source, Giswater has incorporated two example schemes, for both urban drainage *'ud_sample'*, and water supply networks *'ws_sample'*.

Having a complete data model, apart from serving as a query source to see how the data is structured within each of the tables, will allow to start with an environment and practice with all the features that contains the Giswater plugin.

In order to créate the *sample* project click *Project example* on the main menu toolbar.

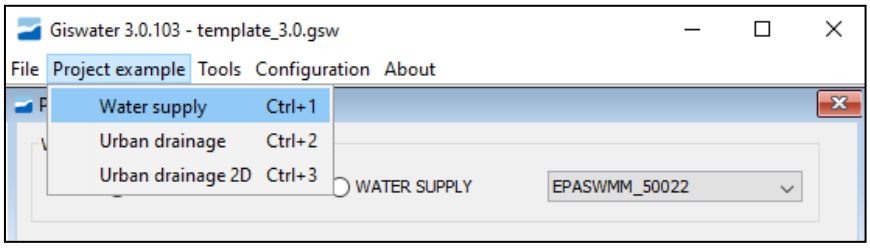
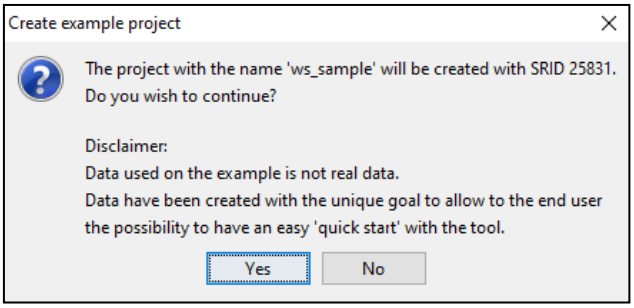


Image 9: With the database connection opened, it's posible to create a sample data schema to practise Giswater functionalities.

After clicking on selected type of project, the program warns about the characteristics of the example project and asks whether we wish to continue. Click **Yes** and the project will be created. In the case of having created the urban drainage example, a new scheme with the name *'ud_sample'* will appear in a database; If the created example is a water supply network, the created scheme will be called *'ws_sample'*.



Finally, create a new QGIS project to visualize and start working with the example data. When clicking OK button, the *sample* QGIS project will be created which will allow to start working with the sample data.

The generated project is specifically created to work with the tables of the database, as well as designed with a symbology that allows to visualize the project data in the most comfortable way possible.

2.5 Creation of project starting from scratch

If what we want is to start our project from scratch, with the real data of our network, we must take into account the vital layers so that at least the Giswater plugin would be activated once we are inside the QGIS project.

Si lo que queremos es empezar nuestro proyecto desde cero, con los datos reales de nuestra red, debemos tener en cuenta las capas vitales para que como mínimo se active el *plugin* de Giswater una vez estemos dentro del proyecto GIS.

The essential layers required by the *plugun* are the ones which call the views:

- **v_edit_arc** – view of all elements in table *arc*
- **v_edit_node** – view of all elements in table *node*
- **v_edit_connec** – view of all elements in table *connec*
- **v_edit_gully** (only UD) – view of all elements in table *gully*

Moreover, the listed tables have to be loaded:

- **version** – table that stores the information about different versions of programs (Giswater y PostgreSQL), schema creation date, the default language or EPSG.
- **exploitation** – value of exploitation to which belongs the network. There should be defined at least one exploitation so that the *plugin* activates itself. It's also neccessary to filter the data showed in a project using the *expl_id*

Once the information is in the tables of the created database (*manual_ud*), you can proceed to create a QGIS project to finally visualize the information in a specific software of Geographic Information Systems.

Within Project Preferences of Giswater and with the connection opened to manual_ud, click directly on the 'Create Gis Project' button. This will open the menu shown below where the following parameters are configured: Location where the QGIS file will be saved, file name, project type (choose between UD and WS) and the database schema with which it will be linked.

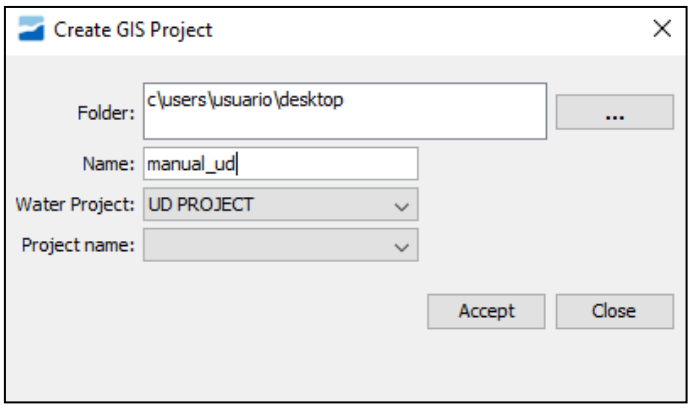


Image 10: It's posible to créate a QGIS project for an opened database connection using button *Create Gis Project*.

Once all the parameters have been defined, the project will be created. QGIS project links all the tables and views of the data template created in section 2.3.4 with the information filled in at the beginning of this section.

2.6 Configuration of QGIS

When opening the QGIS project for the first time, a series of parameters necessary to work with Giswater must be configured. These requirements are the following:

- Create a PostGIS connection to the database where the data schema is located
- To work comfortably and quickly with rasters, it's recommended to extend the cache memory of QGIS to 1GB and 1 year, through the menu 'Settings / Options / Network'.
- Choose open form if a single entity is selected
- Install plugins recommended to improve the QGIS user experience: Reloader, Table manager, Time manager
- Set two variables within the project properties (*Project / Project Properties / Variables*). To add variables to those that appear by default, there is the button 

    1. project_type ⟶ ud/ws (depending on the project type)
    2. expl_id ⟶ value of the *exploitation* with which the project works

How to configure the connection between QGIS and PostGIS

1) Open QGIS and click oni con **Add PostGIS layers** 

2) Click on button **New** and introduce the connection parameters.

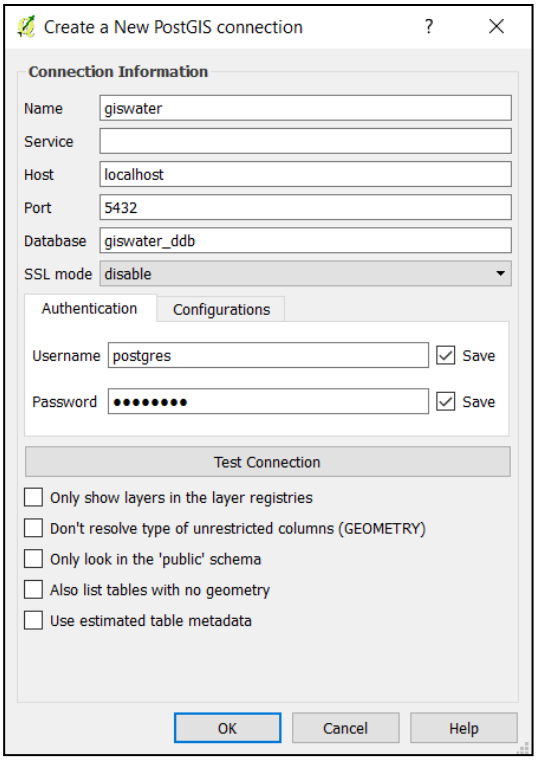
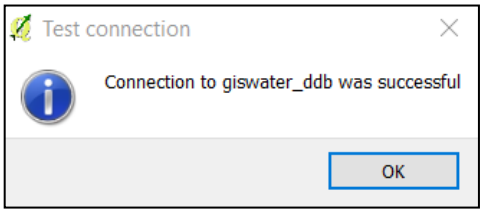


Image 11: Connection form between QGIS and PostGIS. Thanks to this it's posible to import layers from database.

3) Once the parameters have been entered, click on '**Test Connection**' button. If everything is correct the following message will be shown:



4) Click on **OK**. In this momento the connection is saved and will be available on the listo of connections. Once connected it's possible to see the list of all tables, with or without geometry, availables in the database and add it to the project if neccessary

3. BASIC WORK RULES

Once the software installation, the necessary configuration and the creation of data schemas and projects has been completed, the user must become familiar with the basic rules of working with Giswater. Apart from those already mentioned in the previous sections, which were indispensables for preparation process now it's time to make an approximation of the tool operation, its characteristics and capabilities, with special emphasis on the rules of how to work with the data in a safe way.

One of the main advantages of working combining a database with GIS is the great capacity that can be acquired in terms of robustness of the data thanks to the existence of primary and foreign keys, topological rules or the possibility of managing the data edition.

In this section the main rules and knowledge, which need to be taken into account while working with Giswater, will be presented.

3.1 Project types

There are two very different types of projects in the world of Giswater, which have great similarities in terms of the structurin and categorization of data, but which at the same time should not be confused by user. It's always important to know if you are working on:

- Water Supply

  Project related to the drinking **water supply** network of a territory. The data represent all the elements that are necessary for this type of network, starting with the pipes (arc elements) and following with the valves (node elements), that are found along the network among many other elements. Giswater aims to represent as accurately as possible the reality of a water supply system, so it covers all possibilities that may occur in the system.

  The main tools are used to regulate and manage water flows, pressures or planning supply to customers depending on the moment. In relation to this there are sets of tables that allow the monitoring of the flows thanks to SCADA systems or the management of real visits to the elements of the network.

- Urban Drainage

  Project related to the **sanitation and drainage** network of urban waters in a territory. As in WS projects, the aim is to represent the network in the most realistic way possible. Here the main elements are the conduits in which the wastewater circulates. There are elements that coincide with the wáter supply projects, but mosto of them are characteristic only for drainage networks, such as the gullies or the sewage treatment plants.

  Some of the most prominent tools of this type of project are related to the direction of wastewater circulation, either upstream or downstream. In this sense, Giswater allows to represent a profile of the conduits with relevant information about them,

This guide is unique for both types of project, although individualized manuals for each of them could perfectly exist. It has been worked to unify it in order to have all the information of Giswater in a single document, but the intention is that within this manual the user can quickly differentiate if the content of a section is specific to a WS project, a UD project or it is common section.

To accomplish this goal, all sections of the document that are specific to a project type will be marked with a color: blue for WS and yellow for UD. All the sections presented so far have been common, but from now on the differences between projects will be shown.

The following table compares some of the highlights of both types of projects:

	WS	UD
Existing elements	Node / Arc / Connec / Element	Node / Arc / Connec / Gully / Element
Parent nodes	Nodes can be related to a parent node	The option doesn't exist
Elements belonging to arc	Connec and unconnected nodes can belong to an arc	Connec and gullies can belong to an arc
Node type	The field doesn't exist in node table, it's controled by node catalog	Existe campo de gobierno de tipo de nodo
Arc Type	The field doesn't exist in *arc* table, it's controled by arc catalog	Existe campo de gobierno de tipo de arco
Connec Type	The field doesn't exist in *connec* table, it's controled by connec catalog	Existe campo de gobierno de tipo de connec, así como también de tipo de gully
Specific tools	Minimum cut (*mincut)*	Longitudinal profile, upstream and downstream
Topologic review	Incoherent nodes with arcs (T, X)	Sink nodes, possible flow regulators, high outlets, counter slope and intersected arcs.
Sector	Macrosector exists	Macrosector exists
Exploitation	Macroexploitation exists	Doesn't exist any superior entity
Elevation calculations and arc direction	The direction depends on digitalization	The direction of arcs depends on the geometric slopes, elevation calculated based on a dynamic decision tree
Structural inspection	Standard event	Specific events for structural inspection according to UNE-EN 13508-2

3.2 Available elements

One of the most attractive and representative features of Giswater is the large number of elements that can be represented in the work environment, a fact that allows a very tight representation of reality.

In this section the functionality of the main existing elements, which are visually represented in image 12, will be introduced. Most of the elements are represented here, although later we will see that there are more.

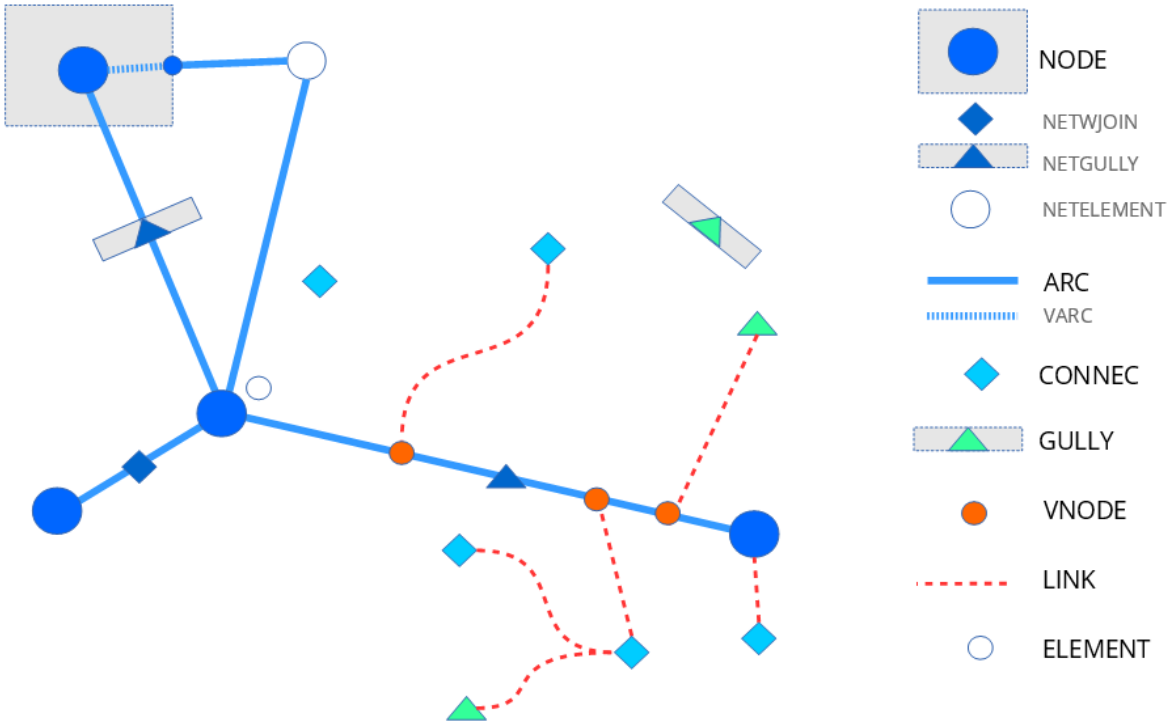


Image 12: Schematic representation of different elements in Giswater.

- Node

  One of the main element types of the network. It is always governed by topological rules. The node-type elements have been divided into a multitude of categories, differentiated for WS and UD projects. They are always represented as points, although some may have associated polygons that represent their real perimeter when needed.

  Nodes are always placed between two arcs; therefore, they break these arcs in different entities. Most elements exert specific functions to break (such as flow reductions or check valves), although there are nodes that would not normally break arcs, in some special cases they must exercise this function. They are those that are represented in the image:

  - Netwjoin: is a wáter connection (*connec*) that by its dimensions or other characteristics is a part of the network and is located on top of an arc.
  - Netgully: is a *gully* that by its dimensions or other characteristics is a part of the network and is located on top of an arc.
  - Netelement: is any element that does not usually connect to the network but due to its characteristics must be placed on top of an arc and cut into two.

- Arc

  Arcs, together with nodes, are the main elements of the network. They are located between two nodes and represent the conduits and pipes of the network. There are not as many types of arcs as there are of nodes, although they are also categorized and all their characteristics (such as diameter, material, roughness ...) can be added in their attribute table to differentiate them better.

  In the image the operation of a Varc (virtual arcs) is presented. They connect the network topologically between arcs and nodes when in reality an arc reaches a polygon and therefore does not really exist inside it as an arc. They are usually short stretches. This is necessary for the topology rules to work correctly in the Giswater network.

- Connec

  Connections, the elements that connect the network with buildings or other elements such as fountains. They are point elements, although to link the connections with the rest of the network, links and virtual nodes are used.

- Gully

  Gullies that are not placed on top of the arcs, but are located at a certain distance from the network. The ones located on top of arc are *netgullies* and are represented as nodes. They are also point elements, like connections, and can be related to the network through links and virtual nodes.

- Vnode

  Virtual nodes are nodes which, like the virtual arcs, do not exist in reality but must exist in the Giswater network so that it works correctly. Virtual nodes are always placed on top of arcs, but, unlike the nodes, they never divide the arcs into two parts.

  The function of these elements is to place on the network gullies and connections that are at a certain distance from arcs. They are point elements that, as has been said, are represented over the closest arc from the connec or gully

- Link

  Links are linear elements that relate gullies and connections with their virtual nodes located over the nearest arc, therefore, they exert the function of connecting the separated elements with the network.

- Element

  This category is available for other types of point elements not connected to the network, which the user can customize himself. It can be network accessories or any other element that is necessary for a representation with the highest possible degree of reality.

In addition to all these main elements, there are some other elements that do not have any topology but are interesting to visualize on the map:

- Address: within this group there are all those elements related to the representation of the territory of the network. The layers of street axis, municipal boundary, perimeter of buildings and portals are available.

- Pond / Pool: they represent the presence of pools and ponds in the territory. Although they are also related to the use of water, these elements do not connect with the network, but may be interesting as an additional source of information

- Dimensions: Finally, we must mention the layer that represents the dimensions. This table will only be filled when the user uses the specific tool to measure distances between elements. It's used as a complement to the network to see in detail the created dimensions.

3.3 General conditions of working with database

In order to work correctly with databases that contain a big amount of information, a series of basic rules must be followed so that the data has consistency and the usability of the database could be maximized.

Most of these rules have to do with the relationships between tables, which share a large number of columns and fields. In relation to this we must take into account foreign keys that allow the information of one table to be a part of another table.

In addition, it is also essential to understand the functionality of primary keys, the columns that restrict the repetition of fields.

```
CREATE TABLE manual_ud.sector
(
  sector_id serial NOT NULL,
  name character varying(50) NOT NULL,
  macrosector_id integer,
  descript text,
  undelete boolean,
  the_geom geometry(Polygon,25831),
  CONSTRAINT sector_pkey PRIMARY KEY (sector_id),
  CONSTRAINT sector_macrosector_id_fkey FOREIGN KEY (macrosector_id)
      REFERENCES manual_ud.macrosector (macrosector_id) MATCH SIMPLE
      ON UPDATE CASCADE ON DELETE RESTRICT
```

Image 13: Script of creation of a table *sector* with references of primary and foreign key.

Image 13 represents the creation script of the sector table, that the primary key of the table is sector_id, which means that the content of this column can not be repeated in any case. This table also has a foreign key, which refers to macrosector table and specifically to the macrosector_id field. What does this mean? That before inserting a value of macrosector_id in a table sector the same value must be created in the table macrosector. To give an example, if in the macrosector_id column of the macrosector table we only have data 1 and 2, to fill the same column in the sector table we can only choose one of these two numbers.

This makes the relationships between tables narrow and many fields have restrictions when adding information for it to be correct. Besides the use of keys, in some tables there are also restrictions of the check type, which limit the possibility of adding data in certain fields only with the established values. The check restrictions are only found where necessary, since they are tables that require specific values for the system to work correctly and therefore can not be modified.

As already mentioned in section **2.3.5**, the use of hierarchical catalogs to categorize the elements is very important and this functionality can only be developed through the use of foreign keys. To add elements in a catalog, they must always be related to some type of higher hierarchy element.

3.4 Map zones

To know how far the water supply and drainage networks reach, Giswater establishes different typr of zones that limit the territories. Each of these zones has specific characteristics and there are certain relationships between them, managed, as explained in the previous section, with foreign keys.

Image 14 allows to understand what is the role of each zone and with which other elements of the network is related to.

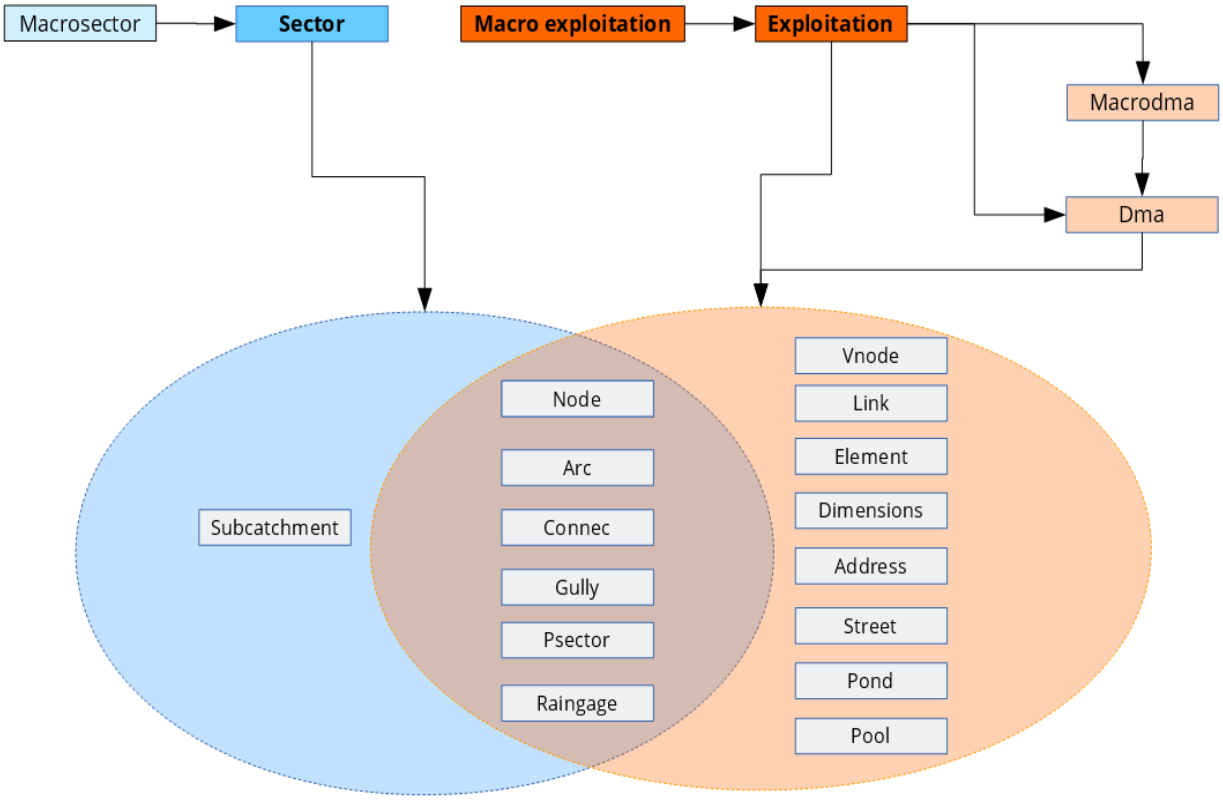


Image 14: Schema represents different zones and the elements of the network that are related to them.

The main zones are *Sector* and *Exploitation*, they act as heads of the rest of the map zones, each one within their activity. Sectors are delimited with hydraulic coherence as their only condition and may have large differences in the extension. A single sector can, for example, represent a single street or represent a whole municipality depending on the needs of each managing entity. The only indispensable thing is to have one or more water inlets and one or more water outlets in each sector. On the other hand, exploitations are more related to the territory and are formed by *macrodmas* and *dmas*.

All the main elements of the project must be located within sector and exploitation. As it is represented in the image, some elements are related just to exploitation and only *subcatchment* must be indispensable within a sector. In no case an element can be unrelated to any of the areas on the map.

3.5 Working in a corporative environment

In an administration department or a company dedicated to water management the employees never work on the same issues nor, usually, a single employee is in charge of the entire water management process. To allow working on different tasks at the same time Giswater environment can be categorized by different types of work depending on the tables or views that user usually needs. Both Giswater and PostgreSQL database

allow the introduction of different work roles, to facilitate the use of tools within a corporate environment where users work simultaneously.

The aim of roles is to improve security, preventing users without permission from modifying data likely to generate errors, as well as allowing a customization of some aspects of the project depending on each user with a different role.

The roles availables are:

Role type	ROLE NAME IN GISWATER	DESCRIPTION
Consult	role_basic	Allows to visualize and consult information without its modification
Operations and management	role_om	Allows to modify the data in tables related to visits and revisions
Edition	role_edit	Allows to edit data in most of the tables that has geometry
Hydraulic models	role_epa	Allows to modify data related to hydraulic models
Budget and planning	role_masterplan	Allows to modify data in tables related to budget and planning
Administrator	role_admin	Has all the permissions to edit data

All roles with a higher hierarchy automatically acquire lower role permissions, that's why they are sorted according to the importance and permissions they have.

3.6 Default values

Giswater has the option of adding default values to parameters that are mandatory or highly recommended. It facilitates the work of users at the process of inserting data in the different tables and views of the project. By means of different commands, when a new element is inserted and user has defined default values for the related fields, they are automatically filled in with that established value. The value set by default must always be of the same type as the field to be filled, otherwise the insertion will be erroneous.

3.6.1 User's values

User's default values are those that are managed through the *config_param_user* table. Usually these values are used during the data insertion process.

The corresponding parameters can be added within *config_param_user*. A clear example of the default value that can be used would be that of municipality, in case of having only one, the value of muni_id field could be automatically inserted.

The use of default values can be useful in the insertion of new elements. In the case of the map zones, it must be remembered that the default value prevails over the geometry of the area that Giswater automatically captures. For example, if a new element is to be inserted within the perimeter of a sector = 3,

the program will capture that the sector would be 3, but if we have a default value of sector = 2, the element will be inserted with sector = 2.

It's also possible to manage the default values using Giswater *plugin* **configuration** tool.

3.6.2 System values

The default system values are only modifiable by users with administration role. They are related to the configuration of tables and are usually used to manage the parameters of the different topological rules, which are described in the following section. Section **5.2.6** points out information with respect to the default system values, since they can be modifiable from the *plugin* **Configuration** tool.

3.7 Topology rules

The definition of geospatial topology says: "The topology expresses the spatial relationships between characteristics of vectors (points, polylines and polygons) connected or adjacent in GIS." Once the meaning is known, we will see some of the main topological characteristics that are important for the use of Giswater in its GIS branch.

3.7.1 Arc-node behavior

The relationship between arcs and nodes is probably the most important at the topological level within Giswater, partly because of the large number of elements that come into play. In order for the program to work properly, it is necessary to fulfill these topological rules. The program itself shows messages to the user when an important rule is about to be broken.

The Giswater *plugin* has a specific tool that allows detecting certain topological errors related to the arcs and nodes. Later we will see how this tool is used, but in this section, we will explain the topological rules that are emphasized:

- Orphan nodes: nodes that are not connected to any arc
- Duplicated nodes: nodes that are located exactly at the same place and that's why the produce the incoherence in the system
- Topological consistency of nodes: there are some specific topological rules of Giswater, which take into account the type of node. For example, there are types of nodes that must have connection with three different arcs, if not, they will be marked as erroneous.
- Arcs with the same start and end node: the arcs must always be placed between two different nodes (with different *id*), therefore, an arc that starts and ends at the same node is incorrect. This can be configured from the *config* table and the *samenode_init_end_control* field, where if we have the value *TRUE* the program will not allow arcs with the same start and end node; if we have FALSE, these arcs will be accepted.
- Arc without start or end node: Arcs disconnected from one of their ends.

3.7.2 Link-vnode behavior

Link is a graphical connection between elements of the map. The properties that it has are the direction of digitization, the node to which it belongs (*feature*) and the exit node (*exit*), as well as the userdefined_*geom* field (boolean value that allows to identify if the geometry is customized by the user or not) . In this sense, what a *link* does is to connect an input element with an output element, which can be directly the network (arc by node or by virtual node) or with an intermediate element (other connec or gully), that at its once they are directly connected to the network or to other connec or gully.

In case the output element is an arc or a node, the arc_id will be automatically assigned as the parent section of the link element, otherwise the arc_id will not be assigned automatically by the tool and the user must manually attribute the arc_id of the father stretch.

On the other hand, if the output element is neither *node*, nor *connec*, nor *gully*, a node called virtual node (Vnode) is created. In the case that vnode is close to an arc, by adhesion it is inserted over it.

Spetial features:
1) Regarding its *feature* node (which is upstream), the link acts as if it belongs to this feature, which means:

- The visibility of the map, ie link takes the value of dma, sector and exploitation from its feature.
- The default state value, when inserting a new link manually or automatically, is the same as feature's state.
- If the feature element (connec or gully) is deleted, the link is deleted too (feature is considered to be functioning as an integrated unit and not dissociated from its link).
- The attributes of the link, such as length, diameter or material, are represented and displayed in the data model of the feature to which it belongs.
- It is possible to have more than one link for a feature node (as they can have different states 0, 1 or 2, and user can modify it as he wishes).

2) Regarding the exit point *exit* (the one that is downstream), there is no more relevance but simply topology, which means that:
Respecto su punto de salida *exit* (el que se encuentra aguas abajo), ya no hay pertinencia sino simplemente topología, con lo cual:

- No status, nor visibility with the downstream elements is managed.
- Topology is managed (if the exit point moves, link moves as well).
- If an output element of a link is deleted, link will not be deleted until it's disconnected previously.
- If the output element is a connec or a gully, the arc_id value of the parent arc is copied from the exit element.
- If the vnode is updated to one arc or another, the arc_id field of the *feature* node is always updated. Attention: if the vnode update disconnects the link from arc, the arc_id of the feature node will automatically be NULL.

3) In case of using the tool of automatic connection of *connec* or *gully* to the network (connect_to_network):

- The tool will create, if necessary, a vnode. In case this vnode already exists, the same will be used to connect the link. The vnodes created by the tool have the value of vnode_type field AUTO. Those created by the user have the vnode_type of CUSTOM.

- The link created by the tool is always the shortest distance between the *connec* or *gully* and the network (using the layers v_edit_node, v_edit_arc, with which the state, exploitation and planning sectors decide what is shown in these two layers).
- Created link has as a default value of the field userdefined_geom set as FALSE. In case of a link drawn or updated by the user, the userdefined_geom field changes its value to TRUE.

- If the values of userdefined_geom is TRUE, the automatic tool won't redesign the link, preventing the 'destruction' of custom geometries.

4) As the link is an element that connects two other elements, if you want to update the geometry of it, for example, intermediate vertices, it is possible to do as long as the extreme vertices are not updated, in which case it will not be possible. If you want to reconnect different elements you must proceed with the deletion of the link and then creation of another.

3.7.3 Double geometry elements

Giswater makes use of double-geometric elements. This means that a single element is formed by two different geometries, in this case they are always points that belong to a polygon.

Only some of the elements of the network have this particularity. They are types of elements that can have much larger measurements than those that are represented with a simple point and therefore it's interesting to visualize them as a polygon around the point.

Double geometry elements for WS
▪ Tank, Register, Fountain
▪ Double geometry elements for UD
▪ Storage, Chamber, Wwtp, Netgully, Gully

When adding a new node of one of the listed types, a square polygon will be immediately created around the point element. The main topological rules of this relationship are:

- If the node is moved, the associated polygon will move to the new position of the node.
- If a new polygon is drawn, with the perimeter that the user wants and around a node of the same type, the new perimeter directly replaces the old one.
- It's impossible to draw a new polygon without a node of the same type being inside it
- If a node with double-geometry is deleted, the associated polygon will also be eliminated. On the other hand, if the polygon can be deleted without modifying the node.
- If a node with double-geometry is deleted, the associated polygon will also be eliminated. On the other hand, the polygon can be deleted without modifying the node.

To work with this type of double-geometric elements it's important to set a configuration that manages it. You can enable or disable this function in the *config* table, *insert_double_geometry* field. If it's enabled (recommended), the *buffer_value* field assigns a default value of the side length of the polygon square. As already said, this square can be edited to have a desired shape.

3.7.4 State's topology

To end the section of topological rules, we must also take into account some of the conditions in relation to the states of the elements. In the following table all types of modifications (insert or update) between arc and node elements are presented. It is worth reminding, that the available states are:

0 = Obsolete **1 = On Service** **2 = Planified**

From the element			Tot he element		Result	Comment
Type	TG_OP	State	Type	State		
NODE	INSERT/ UPDATE	0	Node	0,1,2	OK	State 0 doesn't have topology
			Arc	0,1,2	OK	State 0 doesn't have topology
		1	Node	0	OK	State 0 doesn't have topology
				1	KO	Only one node with state 1 can be located in the same place
				2	OK	It's possible to located node with state 1 over a node with state 2
		2	Node	0	OK	State 0 doesn't have topology
				1	OK	It's possible to located node with state 2 over a node with state 1
				2	KO	
ARC	INSERT/ UPDATE	0	Node	0,1,2	OK	
		1	Node	0	KO	
				1	OK	
				2	KO	
		2	Node	0	KO	
				1	OK	
				2	OK	If an arc belongs to the same psector as a node

The type of state that has the most restrictive conditions is the planned one. Operating with elements in state = 2 is only possible for users with the role of masterplan or higher and it must be kept in mind that the management of these elements can break the topology.

First of all, it's necessary to have at least one record in the *plan_psector* table, which is used to manage the planning. It is also essential to set a default value for psector. Arcs and nodes will be inserted with this default value in the specific tables: *plan_arc_x_psector* and *plan_node_x_psector*. It's important to check the *state* and *doable* fields.

All elements, whether nodes or arcs, which have *on service* state (1) and the user changes them manually to *Planified*, will be automatically introduced in the default psector that is currently available. Although this change is allowed by the topological rules, it should not be usual to pass a *On Service* element into *Planified*.

> **NOTE 01** ADDITIONAL TOPOLOGY INFORMATION: some of the parameters referred to the topology must be configured and customized according to the needs of the user. To perform such processes, you must use the *plugin* **Configuration** tool. The parameters related to the topology will be explained in detail in section **5.6.2** of the manual, as well as the operation of the tool.

3.8 Summary of work rules applied to the insertion of NODES

To finish this section of basic work rules, an example scheme is presented to summarize all the work rules that need to be followed in the process of inserting a new node element. In the diagram, the mandatory insertion fields are defined and arrows visualize the steps to follow in order to conduct the process correctly. The case in which the insertion is not possible is also presented.

Field *the_geom* is one of the most important fields and in this case the rules related to it are easy to understand. When inserting a new element, the geometry of it must be placed inside the geometry of a sector, dma and exploitation, otherwise the insertion will be erroneous.

If the state is 2, as mentioned recently, there must be at least one psector defined in a project, otherwise the insertion will be incorrect. For elements with status "on service" (1), the topological rules explained in section ***3.7.1*** must be fulfilled.

The other mandatory fields may have defined default values or being entered directly by the user. The hierarchies and keys for the catalogs of elements must be respected, which means that trying inserting a node that does not belong to the catalogs, we won't succeed.

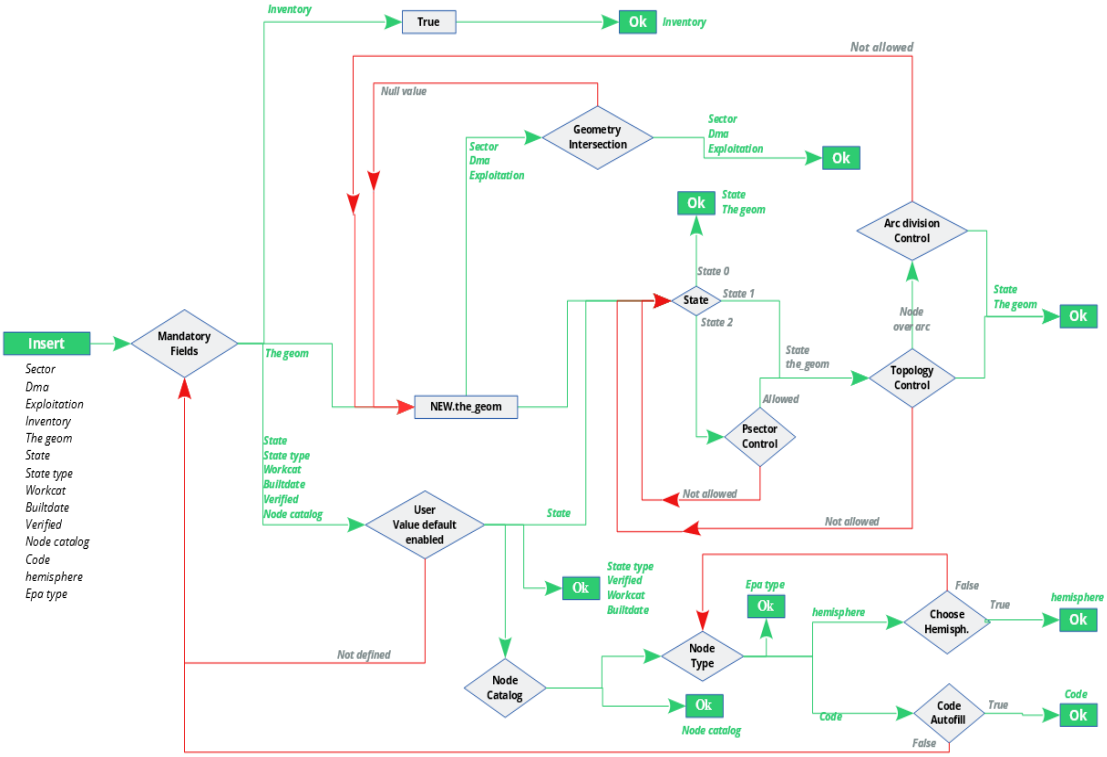


Image 15: Summary schema of the steps that need to be followed in the process of insertion of a node type element. The green lines represent successful steps; the red lines show the different scenarios in which the insertion will not be correct.

4. WORKING ENVIRONMENT IN QGIS

While all GIS systems are compatible with the Giswater tool, the same does not apply to the plugin, since it has been programmed as a complement to QGIS. Thus, all the available functionalities will be executed from the QGIS environment.

4.1 Graphic interface

Any user that requires the use of Giswater plugin must be familiar with geographic information systems (GIS).

Once the user has created a new data project, with the Giswater tool, as explained in sections **2.3.4**, **2.4** and **2.5**, he is already in a position to open the QGIS project and start working with it. In this manual the example project for water supply (ws_sample) will be used.

The main parts of the QGIS environment in relation to Giswater and its plugin are shown below.

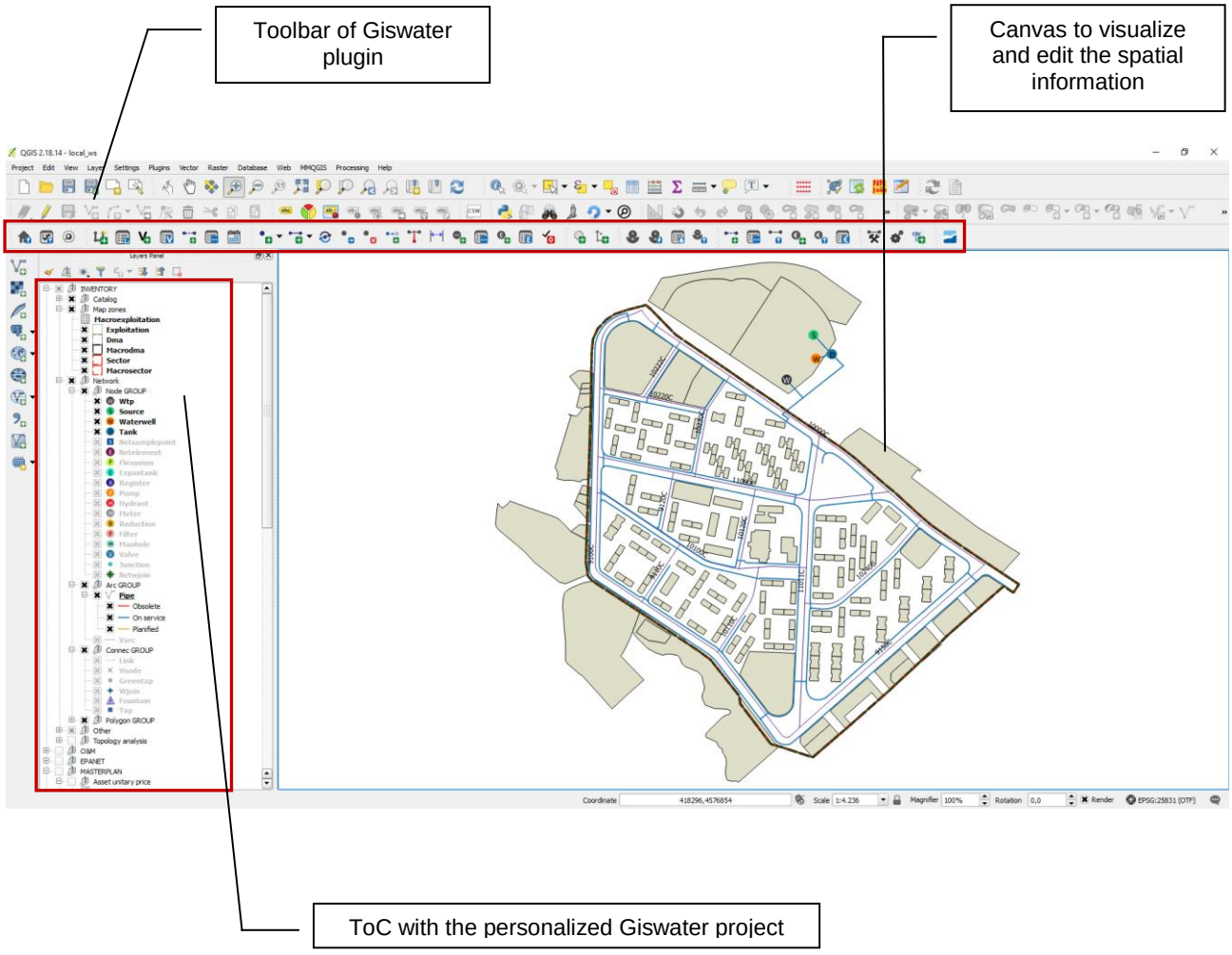


Image 16: General visualization of the screen with project of Giswater opened in QGIS. Note the complement toolbar and the customization of the table of contents.

4.2 Table of Contents

ToC (Table of Contents) is where all the necessary tables and views of the database are loaded. To have the information well structured, this topic has been divided into seven large groups that will also facilitate the management of roles (depending on the permissions, the user is be able to manage certain tables, which by default belong to a group). These groups are: Inventory of assets, Operations and maintenance, Analysis EPANET, Masterplan, System tables, Additional tables and Base maps.

In this section all the tables and views that are loaded in QGIS are described, in order to facilitate the user understanding of the complex network of tables that Giswater is composed of. Each table has a variable number of fields with information related to what the table represents. As the amount of information in this section would be very large, most of the definitions of tables and fields are presented in the annex of the manual. However, the user will find below enough information to understand the purpose of each group of tables.

> **NOTE 02** Usually the name that a layer receives inside the ToC is not exactly the same as it it in the database. Although in some cases it may coincide, it's important to know that they are mostly different. If inside QGIS the user has doubts about the table referenced by a layer, he can **place the mouse over** the name of the layer and the following information will appear:
>
> **dbname, host, port, user, sslmode, key, srid, type, table** (referring to the scheme and table)
>
> In the section **4.2** the layers are named by their name in QGIS and for greater understanding the name of the database table is added in parentheses.

4.2.1 Inventory of assets (INVENTORY)

This group contains the information about the network assets inventory and it's divided into five subgroups: Catalogs, Map zones, Network elements, Others and Topology analysis.

4.2.1.1 Catalogs

Working with catalogs is one of the main characteristics of Giswater, and it'is possible thanks to the database environment.

In fact, before starting working with the project it's necessary to fill in at least arc and node catalog to be able to introduce a simple record in the arc and node layers.

The function of catalogs is multiple. Among other characteristics, they allow to standardize inserted values, add economic value for every elemento of the network or characterize the properties of the elements for further use in the hydraulic model.

It's interesting to know that there are four types of catalogs:

- *Topological elements*: given that the network is based on the arc-node topology, the catalogs of elements are the most important ones (*node catalog and arc catalog*).
- *Other elements of the network:* The elements that complement the network sucha as *connecs* or *elements* which have their own catalogs.

- *Management:* As a complement to the network catalogs, there are other tables in the database that also act as catalogs, such as the catalogs of: soil, constructors, work records, owners, pavement.

- H*ydraulic model:* Catalogs that are necessary for the construction of a high quality hydraulic model. In this sense there is a *rugosities* catalog, which allows to differentiate roughness according to the age of the material.

List of the common catalogs (in brackets the name of the table in database)
- CATALOG OF NODE'S MATERIALS (cat_mat_node)
- CATALOG OF ARC'S MATERIALS (cat_mat_arc)
- CATALOG OF NODES (cat_node)
- CATALOG OF ARCS (cat_arc)
- CATALOG OF CONNECS (cat_connec)
- CATALOG OF ELEMENT'S MATERIALS (cat_mat_element)
- CATALOG OF ELEMENTS (cat_element)
- CATALOG OF OWNERS (cat_owner)
- CATALOG OF SOILS (cat_soil)
- CATALOG OF PAVEMENTS (cat_pavement)
- CATALOG OF WORK RECORDS (cat_work)
- CATALOG OF BUILDERS (cat_builder)

List of catalogs specifics for WS project
- CATALOG OF RUGOSITY (inp_cat_mat_roughness)
- CATALOG OF PRESSURE ZONES (cat_press_zone)

NOTE 03 Only for WS projects. When a new material is inserted in the catalog of materials for arcs, this new material is also automatically inserted as a record in the rugosity catalog (*inp_cat_mat_roughness*) but without period or roughness values.

List of catalogs specifics for UD project
- CATALOG OF ARC'S SHAPES (cat_arc_shape)
- CATALOG OF HYDROLOGY (cat_hydrology)
- CATALOG OF GULLIES (cat_grate)

Pre-dependencies

Before starting to work with catalogs, the system tables that typify the different elements of the network must be filled in (see section **2.3.5**):

node_type (in case of node catalog)
arc_type (in case of arc catalog)
connec_type (in case of connec catalog)
gully_type (in case of gullies catalog for UD)

Those tables are not present in the QGIS project, that's why they should be filled in directly in a database

Post-dependencies

The catalogs generate many dependencies, in fact, they must be filled before starting to work since their records will be requested in many system tables.

In addition, it should be noted that the catalogs also have dependencies between each other. In this sense, before filling the arc and node catalogs, the previous catalogs that are node materials and arc materials must be filled.

4.2.1.2 Map zones

The second group of layers of the assets inventory is the one related to the zones of the map. As its name very well indicates, this group of layers represents and delimits the different territorial zones of the map, already defined in section **3.4** of this manual.

All the layers in this group have polygonal geometry - except for macroexploitation, which only appears in a table format for WS projects. It's a very important group of layers, since one of the basic rules of the project is the necessity of every element of the network to be within one of the different zones.

Exploitation is essential to start any project. As mentioned before, it's highly recommended to add an exploitation value in the properties of the project, using a variable. Thus, the project will be directly related to an exploitation, the area of the map that, in general, will cover a larger area.

The map zones of Giswater are:

- Exploitation: exploitation area, usually related to a management area of one or more users.
- Macroexploitation: group of exploitations.
- Dma: in case of WS it's *district metering areas*, área used to register the water usage. For UD it's *district management areas*, management areas of sanitation network. In both cases they can be delimited according to the needs of the user and always with a coherence of use.
- Macrodma: group of dmas.
- Sector: sectors are related to the correct functioning of the hydraulic model and therefore they must be consistent with the water inlets and outlets of it. They are delimited according to this coherence as the user considers appropriate.
- Macrosector: group of sectores.

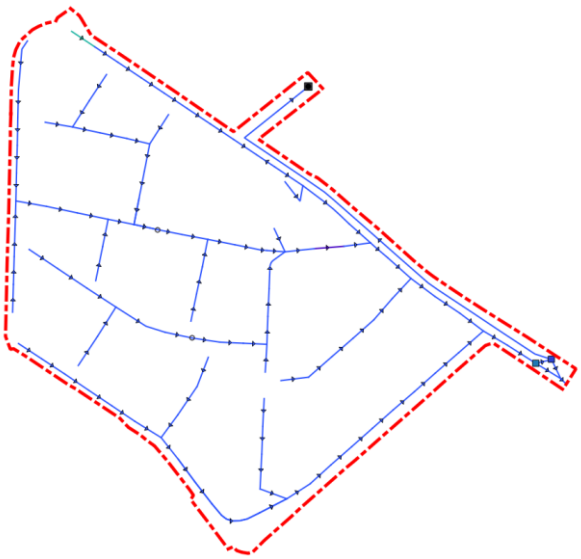


Image 17: Representation of one of the map zones, specifically of a *sector* that exists in the *ws*_sample project.

4.2.1.3 Network elements (Network)

This group contains of all those layers reffered to network elements which have geometry, that is, they are represented graphically on the map.

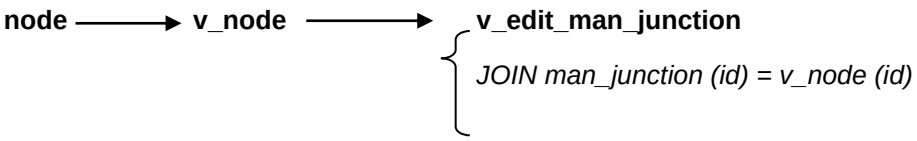
Once the corresponding catalogs have been completed, the construction of thr network can be started by editing these layers. Always following the order marked by the topological rules, as explained in section **3.7**.

The elements of the network are divided into four groups according to its category and geometry type:

- Group of elements *node*
- Group of elements *arc*
- Group of elements *connec* y *gully* (for ws only *connec*)
- Group of elements *polygon*

Each network element has its own editable view, which is what is visualized in QGIS. This editable view has attributes that come from the editable view of the corresponding element (node, arc, connec, gully).

The basic sequence of steps that make the data of each element is the following (example for *junction*):



To take advantage of the use of GIS, each element has its own associated style that is displayed in the graphical interface of QGIS. The styles are represented according to the specific type of element (to find out which are they consult the table *sys_feature_cat*).

In the case of network elements, the differences between project types are quite big. There are very few elements that coincide in both water supply and urban drainage; that is why no table in this group will be described as a common.

Table of all the elemnts present in UD project

Group	Element (*name of thetable*)	Description	Style
Node	Storage (*v_edit_man_storage*)	Storage	
	Chamber (*v_edit_man_chamber*)	Chamber	
	Wwtp (*v_edit_man_wwtp*)	Wastewater Treatment Plant	
	Netgully (*v_edit_man_netgully*)	Topological gully	
	Netelement (*v_edit_man_netelement*)	Topological element	
	Manhole (*v_edit_man_manhole*)	Manhole	
	Netinit (*v_edit_man_netinit*)	Network initiation	
	Wjump (*v_edit_man_wjump)*	Water jump	
	Junction (*v_edit_man_junction*)	Junction without register	
	Outfall (*v_edit_man_outfall*)	Outfall	
	Valve (*v_edit_man_valve*)	Valve	
Connec & Gully	Connec (*v_edit_man_connec*)	Connec	
	Gully (*v_edit_man_gully*)	Gully	
	Vnode (*v_edit _vnode*)	Connection to network	
	Link (*v_edit_link*)	Element of graphic connection	
Arc	Conduit (*v_edit_man_conduit*)	Conduit	
	Siphon (*v_edit_man_siphon*)	Siphon	
	Waccel (*v_edit_man_waccel*)	Water accelerator	
	Varc (*v_edit_man_varc*)	Fictional conduit	
Polygon	Gully polygon (*v_edit_man_gully_pol*)	Polygonal element for gully	

	Netgully polygon (*v_edit_man_netgully_pol*)	Polygonal element for topological gully	
	Wwtp polygon (*v_edit_man_wwtp_pol*)	Polygonal element for wastewater treatment plant	
	Chamber polygon (*v_edit_man_chamber_pol*)	Polygonal element for chamber	
	Storage polygon (*v_edit_man_storage_pol*)	Polygonal element for storage	

Table of all elements present in WS project

Group	Element (*name of the table*)	Description	Style
Node	Wtp (*v_edit_man_wtp*)	Water treatment plant	
	Source (*v_edit_man_source*)	Source	
	Waterwell (*v_edit_man_waterwell*)	Waterwell	
	Tank (*v_edit_man_tank*)	Tank	
	Netsamplepoint (*v_edit_man_netsamplepoint*)	Topological sample point	
	Netelement (*v_edit_man_netelement*)	Topological elemento	
	Flexunion (*v_edit_man_flexunion*)	Flexible union	
	Expantank (*v_edit_man_expansiontank*)	Expansion tank	
	Register (*v_edit_man_register*)	Register	
	Pump (*v_edit_man_pump*)	Pump station	
	Hydrant (*v_edit_man_hydrant*)	Hydrant	
	Manhole (*v_edit_man_manhole*)	Manhole	
	Meter (*v_edit_man_meter*)	Meter	
	Reduction (*v_edit_man_reduction*)	Reduction	

	Filter (*v_edit_man_filter*)	Filter	
	Junction (*v_edit_man_junction*)	Junction	
	Valve (*v_edit_man_valve*)	Valve	
	Netwjoin (*v_edit_man_netwjoin*)	Topological water connection	
Arc	Varc (*v_edit_man_varc*)	Fictional pipe	
	Pipe (*v_edit_man_pipe)*	Pipe	
Connec	Link (*v_edit_link)*	Element of graphical connection	
	Vnode (*v_edit_vnode)*	Connection to network	
	Greentap (*v_edit_man_greentap)*	Irrigation connection	
	Wjoin (*v_edit_man_wjoin)*	Water connection	
	Fountain (*v_edit_man_fountain)*	Fountain	
	Tap (*v_edit_man_tap)*	Tap	
Polygon	Fountain polygon (*v_edit_man_fountain_pol)*	Polygonal element for fountain	
	Register polygon (*v_edit_man_register_pol)*	Polygonal element for register	
	Tank polygon (*v_edit_man_tank_pol)*	Polygonal element for tank	

Forms of the elements

In addition to the visual style of each of the elements, they also have an associated form, designed one by one according to their specific fields. The forms are opened when the user clicks an item using the information button in QGIS and use different tabs to display the information according to their category:

- **Name of the elemento**: information related to the element's own attributes. In the tables located in the annex of the manual you can check the fields of each element, which are shown in this tab of the form. It's also distributed in different sections.
    - Numeric information: (***only for arc elements***) parameters related to geometries, dimensions, lengths, etc.
    - Basic information: basic information common between most of the elements, for example construction date, code, soil, elevation and depth, etc.

- Scecific information: information specific for each type of element
- Additional information: additional information. Contains the information about the address and other optionally information.
- Feature graphic design: Relatef to the visualization of the element. Position of the label, icon as *svg*.

- **Connections**: (***only for node type elements***) shows a table of all the elements connected to the node, distinguishing those which are upstream from the downstream
- **Relations**: shows a table of elements that are linked only to this element. They are usually not connected to the network, and the main element must be large enough to contain its related elements. The possible relationship, depending on the type of project and the type of element, is:
  - *Arc* can be related to *node* and *connec*
  - *Node* can be related to *node*
  - *Arc* can be related to *connec* and *gully*
- **Element**: in this tab other elements are shown, not connected to the network, which are linked to the element that we are visualizing. From the form itself you can link, unlink and add elements of this type.
- **Hydrometer**: (***only for connec type elements***) relates connections with hydrometers and can show their values, connect or unconnect them.
- **Document**: this tab shows the documents related to the visualized element. It's possible to link, unlink or créate a new document as well as filter them by date or document type.
- **O&M**: this tab shows the events related to the visualized element. Every event is a parto of a visit, which can be consulted using the button located in a form. It's also possible to add visit, show fotos and documents related to the events.
- **Scada**: (***only for node type elements***) tab show the values coming from the SCADA system.
- **Cost**: (***only for node and arc type elements***) allows to calculate the costo f the visualized element. For nodes, only two parameters come into play (price per unit or price per meter depth). For arc there are many more variables that are necessary at the time of calculating the price and all are specified in this last section of the form.

Sections of the form

In the following image the different parts of a form are presented. The reference is made to the different parts for each type of project, although the sample form is a *manhole* element of a UD project. The central part of the form, where the information that varies depending on the tab that is activated, is not described in the image, since in the previous section explains it in details.

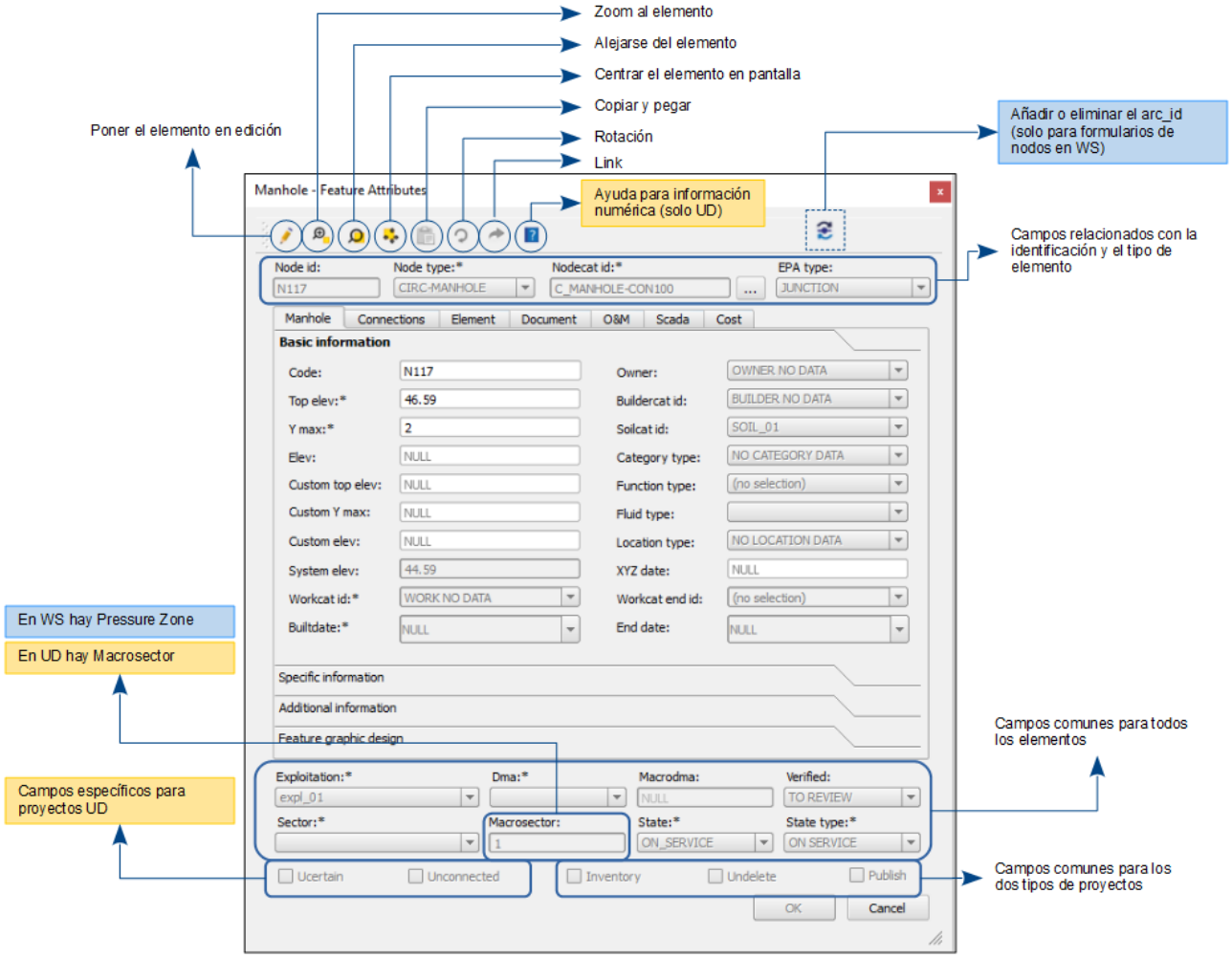
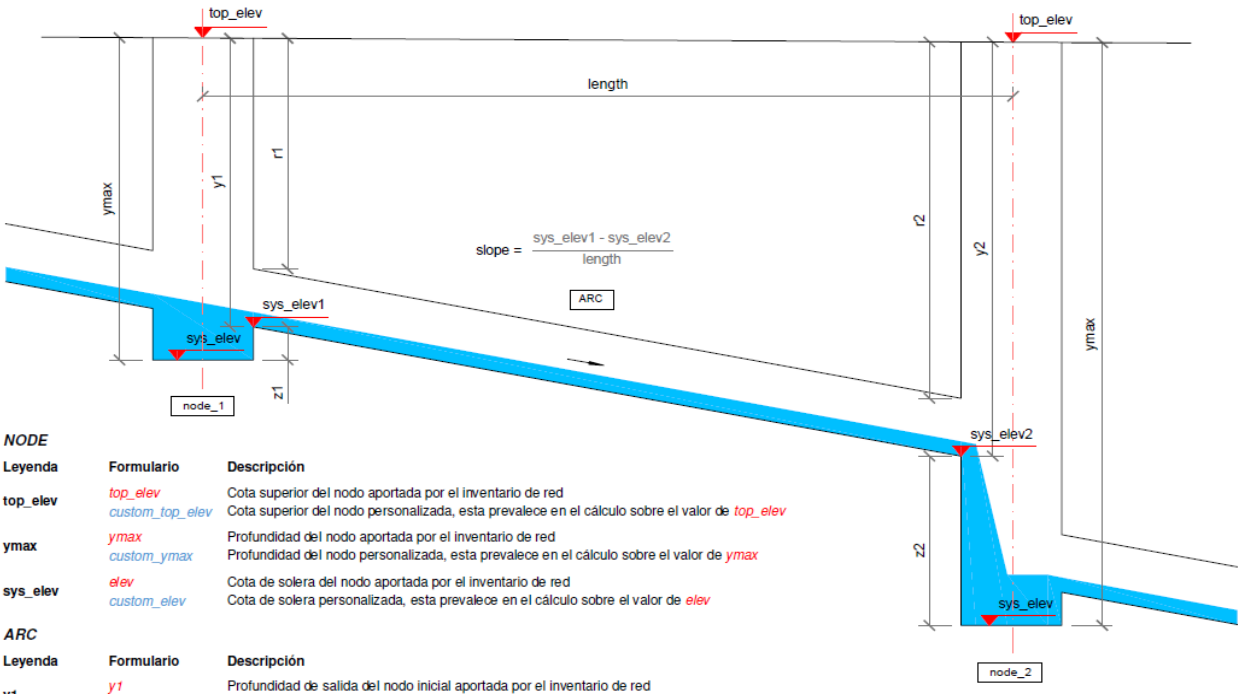


Imagen 18: Form of a node element, type *Manhole.* Most of the element's forms are similar to the presente done, which shows the distribution of the atributes and tabs.

In order to help users, understand some of the fields, the image 19 presents graphically the most important parameters like depth, dimensions and slope for the urban drainage project (UD).



NODE

Leyenda	Formulario	Descripción
top_elev	top_elev	Cota superior del nodo aportada por el inventario de red
	custom_top_elev	Cota superior del nodo personalizada, esta prevalece en el cálculo sobre el valor de top_elev
ymax	ymax	Profundidad del nodo aportada por el inventario de red
	custom_ymax	Profundidad del nodo personalizada, esta prevalece en el cálculo sobre el valor de ymax
sys_elev	elev	Cota de solera del nodo aportada por el inventario de red
	custom_elev	Cota de solera personalizada, esta prevalece en el cálculo sobre el valor de elev

ARC

Leyenda	Formulario	Descripción
y1	y1	Profundidad de salida del nodo inicial aportada por el inventario de red
	custom_y1	Profundidad de salida del nodo inicial personalizada, esta prevalece en el cálculo sobre el valor de y1
sys_elev1	elev1	Cota de salida del nodo inicial, se calcula automáticamente a partir de (top_elev - y1)
	elev1	Cota de salida del nodo inicial aportada por el inventario de red, prevalece en el cálculo sobre elev1
	custom_elev1	Cota de salida del nodo inicial personalizada, esta prevalece en el cálculo sobre el valor de elev1
y2	y2	Profundidad de entrada del nodo final aportada por el inventario de red
	custom_y2	Profundidad de entrada del nodo final personalizada, esta prevalece en el cálculo sobre el valor de y2
sys_elev2	elev2	Cota de entrada del nodo final, se calcula automáticamente a partir de (top_elev - y2)
	elev2	Cota de entrada del nodo final aportada por el inventario de red, prevalece en el cálculo sobre elev2
	custom_elev2	Cota de entrada del nodo final personalizada, esta prevalece en el cálculo sobre el valor de elev2

Image 19: Schema helps understand the information that should be put in the fields related to elevation, dimensions, depth of node and arc elements of urban drainage projects (UD).

4.2.1.4 Others

The elements that are not strictly a part of the water supply or sanitation network, but do have a visual representation on the QGIS map, which means they have geometry, are in this group. The data of these elements is not indispensable for the use of the hydraulic models incorporated Giswater, but its an information that can have interest in other aspects, and, therefore, it's also necessary to get to know its characteristics.

Common elements

- **Dimensioning** *(v_edit_dimensions)*: this table is filled in when the user uses the plugin tool that allows to calculate distances and dimensions between different points within the QGIS map. The distance is represented by a line and a label with the numerical information in meters. It also shows the depth in case of associating a value of it.
- **Samplepoint** *(v_edit_samplepoint)*: layer with information about sample points. These are the points where the water quality is analyzed. It has a field that relates the sampling point with a laboratory
- **Element** *(v_edit_element)*: can be any other type of element that needs to be defined first in the element catalog. These may or may not be linked with other network elements. They allow to add extra information in relation to some characteristic.

Specific elements of WS project

- **Pond** *(v_edit_pond)*: represents ponds located in the exploitation
- **Pool** *(v_edit_pool)*: represents pools located in the exploitation

4.2.1.5 Topology analysis

This last group of layers in the asset inventory represent the tables that are filled when the user uses topology tools, which are located in the *Toolbox*. 

Most types of topological analysis have a specific layer to represent their results on the map, since it's not possible to have elements with different geometries in the same layer.

Because of that, the following layers are present in the QGIS project, each with a different symbology and depending on the type of project:

Common layers of the topologic analysis:

- **Arc with same start-end node** *(v_anl_arc_point)* : point layer that represents nodes which are the result of arc with the same start and end node analysis
- **Arc without start-end node** *(v_anl_arc_x_node_point)* : point layer that represents nodes which are the result of arc without start or end node analysis
- **Arc without start-end node** *(v_anl_arc_x_node)* : line layer that represents arcs which are the result of arc without start or end node analysis
- **Connec analysis** *(v_anl_connec)* : view that represents the results of different topologic analysis related to *connec.*

Layers of topologic analysis related to UD projects:

- **Arc analysis** *(v_anl_arc)*: view that represents the results of different topologic analysis related to *arc.* It has a field *context* which allows to symbolize it in function of the conducted process:
  - Arc insersection
  - Arc inverted
  - Arc with same start-end nodes
- **Node analysis** *(v_anl_node)*: view that represents the results of different topologic analysis related to *node.* It has a field *context* which allows to symbolize it in function of the conducted process:
  - Node duplicated
  - Node orphan
  - Node topological consistency
  - Node exit upper intro

- Node flow regulator
- Node sink

Layers of topologic analysis related to WS project

- **Arc with same start-end nodes** *(v_anl_arc)* : line layer that represents the results of the analysis of arcs with the same start and end node
- **Node analysis** *(v_anl_node)*: view that represents the results of different topologic analysis related to *node.* It has a field *context* which allows to symbolize it in function of the conducted process:
  - Node duplicated
  - Node orphan
  - Node topological consistency

4.2.2 Operations and management (O&M)

The second group of layers in the ToC of the QGIS Giswater projectis the operations and management (O&M). Unlike the previous group (inventory of assets), which has a large number of layers, this one is reduced to a simple group of 2 or 3 layers depending on the type of project and the inventory of visits, common fot both types of projects.

The layers of operations and management are:

Visits (v_edit_om_visit)

In this layer all the completed visits made to the network are found and visualized by means of specific elements on the map. Each visit has a start and end date, as well as an identifier of the user who made the visit. Each visit can contain different events and in the same way each event can have several photographs to illustrate the event. Events are not found in this same layer, but they are related to visits with foreign keys.

Minimum cut process (*mincut*)

The mincut layers propose to the users the valves that should be closed in case of wanting to do some type of operation on any element of the network. Based on the different states and attributes of the elements, the cutting polygon will be different. There are several parameters that come into play when using this tool. Mainly we must take into account the state (state) and exploitation (exploitation) of the elements that are displayed on the screen, because the tool will use only the visible elements.

> **NOTE 04** It is important to remember that the mother tables of the project (*node, arc, connec*) contain all the information of elements of each type, but these elements are visualized in QGIS using views (*v_edit_node, v_edit_arc, v_edit_connec*), which performs a filter in function of which the item appears on the screen or not. If the user decides that he does not want to see the obsolete elements (using the status selector), the view will not contain the information of the obsolete elements, but the information is still in mother tables.

Since obsolete elements don't have topology (they are not connected to the network), it's recommended that they are not visible when the tool is used. The elements with state 'on service' can be used without any problems to make the cutting polygon. Also, the planned elements can be a part of a mincut polygon but it's necessary to be careful with those elements as they can be placed on top of other elements on service and cause errors in the process.

The layers that are loaded in the QGIS map are those related to the results of the mincut polygon according to its geometry and type of element, with its own symbology:

- **Mincut result valve** *(v_anl_mincut_result_valve)*: Results of the minimum cut polygon representing valves. The *proposed* field establishes whether a valve should be closed or not.
- **Mincut result arc** *(v_anl_mincut_result_arc)*: Results of the minimum cut polygon representing arcs.
- **Mincut result node** *(v_anl_mincut_result_node)*: Results of the minimum cut polygon representing nodes.
- **Mincut result connec** *(v_anl_mincut_result_connec)*: Results of the minimum cut polygon representing connecs.

Flowtrace

The *flowtrace* layers show elements of the network that are upstream or downstream from the selected element. The layer updates its fields each time user performs a new operation to know the affected elements and these are represented on the map, using a specific symbology, so they can be easily consulted. As in the tool of the mincut, also in this case all the elements that are visible on the map come into play (they are within the editable views of node, arc, connec).

The **use** of this tool is relevant in two different cases:

- Data structuring: if there are arcs that go in the wrong direction, it's easy to detect them using flowtrace process, because they will cut the network in an unusual point so its direction can be modified and thus correct the error.
- Consulting: it allows to visualize all the elements that are upstream or downstream of a specific element.

There are 2 layers and 4 different symbologies:

- **Flowtrace arc** *(v_anl_flow_arc):* represents the arc type elements for the flow tracking tool. It shows arcs that are upstream (*flow trace*) or downstream (*flow exit*) from the selected element.
    - Flow exit
    - Flow trace
- **Flowtrace node** *(v_anl_flow_node)*: represents the node type elements for the flow tracking tool. It shows nodes that are upstream (*flow trace*) or downstream (*flow exit*) from the selected element.
    - Flow exit 
    - Flow trace 

In the section ***5.2.2*** the details of using this tool with *plugin* is explained.

Giswater database contains many other tables related to the section O&M, but these are not found in the homonymous group of QGIS, as they are used in other ToC groups or for various program processes. The purpose of the operations and management tables is to do an inventory and schedule the visits made by technicians to the real supply or sanitation network in order to control, calculate or do any type of rehabilitation or repair in the network.

4.2.3 EPANET

The third group of layers found in the ToC is the one related to the hydraulic model (EPANET). The behavior of this group is based on the program with the same name, public domain and developed by the United States Environmental Protection Agency (EPA).

This is an exclusive group for water supply projects (WS), however, the sanitation projects have their exclusive group with similar characteristics (SWMM), which will be described in section **4.2.4**.

> **NOTE 05** EPANET performs simulations of hydraulic behavior and water quality in pressure distribution networks. EPANET determines the flow that circulates through the pipes, the pressure of each node, the water levels in the tanks and the concentrations of different chemical components that are in the network during a determined period of time. It can be used for a multitude of applications in analysis of distribution systems. The EPANET parameters found within Giswater are the same as those of the EPANET program itself; to have more information you can consult the user manual of this program.

The layers of the EPANET group are divided into two groups:

- **Input data:** all the layers with data necessary for correct work of hydraulic model. There are different groups within Input data according to the nature of the data and the type of geometry:
  - Node: formed by geometric layers of node type and related tables.
  - Arc: formed by geometric layers of arc type and related tables.
  - Controls & Rules: tables of different rules and contols related to data.
  - Options: tables of options related to hydraulic model.
  - Tags y Labels
- **Output result:** these are all the layers that store the results, once the hydraulic model has been done. They allow the results to be quickly visualized within the QGIS map and compared with older results. The results (tables with the prefix rpt) are divided into:
  - Node minimum values
  - Node maximum values
  - Arc maximum values
  - Energy usage y Hydraulic status

In chapter **7** of this manual it's shown how to implement the hydraulic model of the network through the layers and tables that that are part of this group.

4.2.4 SWMM

Storm Water Management Model (SWMM) is the third group of layers that can be found in the ToC of urbain drainage project (UD). It is the "brother" of EPANET, also developed by the EPA, but whose use and applications are obviously different.

> **NOTE 06** The SWMM water management model is a rainfall simulator, which can be used for a single event or to carry out a continuous simulation in an extended period. The program allows to simulate both the quantity and the quality of the evacuated water, especially urban sewers. It can be divided into the **runoff module**, catchment areas where the rain falls, and **transport module**, the route of these waters through the system of the network. Its main function is to estimate the quality of the water, its precipitated quantities and show the different results over time. The EPANET parameters found within Giswater are the same as those of the EPANET program itself; to have more information you can consult the user manual of this program.

The layers of SWMM are structured, like EPANET, in layers and tables of entry and exit, adding an intermediate group that will allow the user to establish which sectors and hydrological basins come into play when making the hydraulic model:

- **Input data**: input data for SWMM model. As there are a lot of parameters, they are grouped according to their nature:
  - Climatology: in this group data related to the weather, that may influence the water flow before it reaches the network, can be introduced.
  - Hydrology: referred to data related to water flow that enters naturally into network (runoff), such as rainfall, aquifers, infiltrations or thaw. There are two layers with geometry:

    Raingage: represents rain gauges as point elements

    Subcatchment: represents subcatchments as polygons
  - Hydraulics: in this group there are different elements of the network that are necessary to make the model. They are divided into nodes and arcs, each of them related to other tables without geometry that contain additional information.

    Node: elments such as *Junction, Outfall, Divider* y *Storage.* The additional tables refer to external contributions of flow that goes directly to the network. There are three types od them:

    - Inflows – series of flow values that go directly into the nodes defined by the user. They are used in case of absence of runoff data.
    - Dwf (Dry weather inflows) – continuous flow inputs that reflect the contributions that sewage flow makes to the network. They can be considered as reference flows of conduits.
    - RDII (Rainfall-Derived Infiltration/Inflow) –flows from rainwater that are introduced into the network due to direct contributions in the connections with the wells, collectors of pumps or in case of breaks in pipes or bad connections of the elements.

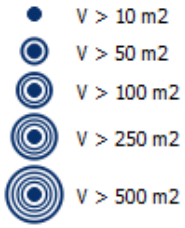
Arc: elements such as *Conduit* and *Virtual arc*. There are tables referring to the cross sections, which describe how the bottom level of a pipe varies and flow regulators which are devices used to control and derive the flows within the system. The *orifices*, *weirs*, *outlets* and *pumps* can exert the regulation function.

- Quality: this group of tables, without geometry, allows to introduce data related to land uses and pollutants present in the water. Land uses are only used to consider the phenomena of accumulation and carry-over of pollutants in the catchments.
- Curves & Timeseries: **Curves** allow to establish the relationship between two quantities (in a similar way to a graph) so that this data is easily introduced into the network by assigning curves to the elements of the system. **Time series** are used to describe certain properties of some project objects that vary over time.

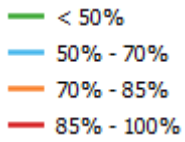
- **Input selected feature**: this group is used, in case of having several sectors or hydrological catchments, to select with which of them the user wants to work. This is one of the tools that Giswater adds to the own uses of the SWMM program. If specific zone to make the hydraulic model is selected, in this group of layers will be shown node and arc elements that come into play, which will be all those that are within the selected area.
- **Output result**: group of model results allows to visualize through elements symbolized on the map and data tables, the results of the SWMM hydraulic model. As in EPANET, it's also possible to compare results with another model previously made.

  The possible results of the model, ordered in the same way as the QGIS ToC as described below:

  - Node flooding: it shows all the water that overflows a node, during the time it has been overflowed, the maximum flow during the flood, as well as the different volumes of water on m^2. It is represented in QGIS in this way:

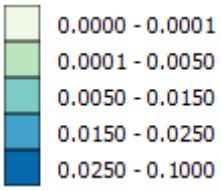


  - Node surcharge: overload occurs when water rises above the crown of the highest conduit. It shows the data referred to hours of overload and maximum and minimum values.
  - Node inflow: represents the total flow input, both laterally and through links. Shows total, temporary and maximum values.
  - Node depth: average and maximum depth of water. Maximum hydraulic height (HGL) and maximum depth time.
  - Arc flow: this layer represents the percentages of water flow in the network conduits. They are symbolized in QGIS as follows:



  - Conduit surcharge: in this layer the overload of conduits is represented. Only those arcs with one or more non-zero entries can be displayed. A conduit will be considered overloaded when the slope of the HGL exceeds the slope of the conduit. Data about overload times will be shown in one or both nodes linked to the arc.
  - Pumping summary: different data referred to the operation of the pumps, such as maximum and average flow pumped, energy consumed, percentages of operation times, etc.
  - Flow class: classification of different categories of flows related to the arcs, for example, if they are dry in one of their nodes or if the level of flow is critical
  - Arc pollutant load: relationship between arcs and pollutants

- Outfall flow/load: flows of outfall. Percentage of discharge time, maximum and average discharge flow, total discharge volume, etc.
- Subcatchment runoff: total values of precipitation, evaporation, infiltration, depth and volume of the escape of the subcatchment. It's represented by a break coefficient.



- Storage volume: data reffered to the deposit. Maximum and average volume in the installation, percentage used, times of use and maximum outflow of the deposit
- Subcatchment washoff: total mass of each pollutant that leaves the subcatchemnt
- LID performance: They are the performances that have been obtained through the application of LID (Low Impact Development) techniques.

The rest of the tables found in this group do not have geometry, but they also provide data related to results of the hydraulic model such as quality and quantity of infiltration, instability indexes, surface water values, among others.

4.2.5 Masterplan

This fourth group of tables and layers found in QGIS ToC is used to perform budget calculations of the network. It's one of the main tools of Giswater that has big potential, since its use allows to realize in a very simple way different valorization of the water network and allows to systematize this process so that once all the necessary data is available the calculation is be practically automatic. This means a considerable saving of time and work for the users responsible for carrying out such calculations.

For both WS and UD projects, the group structure is the same, but the data has some differences, since the nature of the projects is different. As throughout the manual, when any of the explanations is exclusive for a type of project, its membership will be specified.

There are two clearly differentiated parts within the *Masterplan* group:

- Calculation of the **heritage value** of the elements: in these layers the price is calculated for each element of every state (obsolete, on service or planned). All data is inserted into two views (*v_plan_result_node* and *v_plan_result_arc*) depending on the type of element.
- Calculation of values of the **planning sectors** (psector): prices are calculated only for the planned elements. Each group of elements planned for a network modification must be inserted into a planned sector or *psector*. The objective of this group is to know the price a planned operation on the network before carrying it out

The first step of all is to assign **prices** to the elements of the network, to the materials, to the possible combinations of variables and, in short, to all the parameters that may have cost to create the budget. In the catalogs there are many of these values, which are transferred directly to the elements. The rest of the prices should be included in the three tables of the *Asset unitary price* group:

- Simple price: in this table the simple prices for each parameter are shown. Most of these are imported from the database and calculations of ITeC (Institute of Construction Technology). The *unit* field specifies the way to calculate the price (per unit, per cubic meter, etc.)
- Compost price: shows variable prices, since the price of certain elements can not be calculated with a simple price, as it's made up of more than one part. Here we describe what the price refers to and the its id is related to the following table.

- Value compost price: contains the id's of the two previous tables. The compost_id can be repeated, since a composite element will consist of more than one simple element (simple_id). The column value represents the percentage of simple element that composes the compound element. By relating these fields it is possible to calculate the total prices.

NOTE 07 The elements can be assessed in cubic meters (m^3), units (u) or meters (m). The cost_unit field governs whether an item is valued in one way or another and it can be found in the different catalogs. It's important to know what types of element are specific for each form of valorization and what is the other field that gives the information to respect.

For UD (unit / element / measurement field)

-m^3 / Storage y Chamber / man_storage y man_chamber.max_volume

- m / any other / node.ymax

- u / any other / el propio elemento

For WS (unit / element / measurement field)

-m^3 / Tank / man_tank.vmax

- u / Pump / man_pump.pump_number

- m / any other / node.depth

- u / any other / el propio elemento

To calculate the heritage value, there is only one table inside the group of *input data:*

- Arc_x_pavement: this table has, as its only objective, to establish the percentages of types of pavement that has a evry arc. Obviously, an arc can have 100% of its length in the same pavement, but in oposite case when they vary along the arc, this table will be used to specify what percentage covers each type. As the pavements - which are found in the pavement catalog (*cat_pavement*) - have different prices per square meter, the fact of knowing the percentages used in each arc of the network will finally allow to establish very precisely the heritage values.

  ATTENTION: When you insert a new arc, the records are automatically inserted in the plan_arc_x_pavement table, without pavement values and percentages, but in this way all the arcs will be prepared to add the values of pavements.

Once the price and pavement tables have all the necessary data, it's time to fill in the tables of results of the patrimonial value. The importance of having complete data must be taken into account. Some data are taken from different tables. Some come directly from the tables of the elements (arc, node) and must be correctly filled in for a right calculation. All columns are required and all parameters are necessary.

There are two tables that has the results of the calculation of the heritage value. Remember that it's possible to display the data related to elements in **any state type**, whether it's obsolete, on service or planned:

- Plan result node: contains the data of the calculation of the heritage value of each node and is represented in QGIS as a punctual element with colors depending on the final value.
- Plan result arc: contains the data of the calculation of the heritage value of each arc and is represented in QGIS as a line element with colors depending on the final value.

4.2.5.1 Planification sectors (psectors)

Psectors, planification sectors, are areas with planned actions that affect different elements represented in the QGIS map. Obviously, if they are planned elements, their state must be planified (2).

The importance of this group of tables and layers is that it's usually difficult to calculate the value and price of operations of adding new elements to the network. Through these planning sectors it is be possible to obtain the execution price of the entire work, as well as the detailed prices of each element.

Tables and layers that are part of the section are detailed below:

- **Input data**
    - **Plan psector** *(v_edit_plan_psector)*: geometrically represents the existing planning sectors. It contains additional data, such as priority or some fields of percentages such as *gexpenses* (added contract costs) and *vat* (VAT cost).
- **Output data**
    - **Plan psector cost** *(v_plan_psector)*: has the same geometry as the previous layer, but the result of all cost calculations for the elements, that make up each planning sector is added. In this layer the final values of the different prices can be found:
        - € **pem ----------** material execution price
        - € **pec ----------** contract execution price (pam + gexpenses)
        - € **pec_vat ----------** pec + VAT
        - € **pca ----------** price for administration
    - **Plan psector x node cost** *(v_plan_psector_x_node)*: this layer represents the node-type elements of the planning sectors. The total cost of each element appears in its attribute table. It can be symbolized according to the cost.
    - **Plan psector x node arc** *(v_plan_psector_x_arc):* this layer represents the arc-type elements of the planning sectors. The total cost of each element appears in its attribute table. It can be symbolized according to the cost.
    - **Plan psector x other** *(v_plan_psector_x_other):* in this table, without geometry, the prices of other parameters that also participate in the planning are added.

4.2.5.2 Managing prices of network elements

In masterplan, in addition to planning the network sectors, two types of prices that the network can have are also managed. There are prices of reconstruction and rehabilitation.

To be able to have a reconstruction price assigned, it is necessary to have completely filled the fields of the catalogs provided for it, so the first thing to do is to fill them in. Figure 20 shows a pipeline with its respective measurements, specifying all the parameters that come into play when calculating prices.

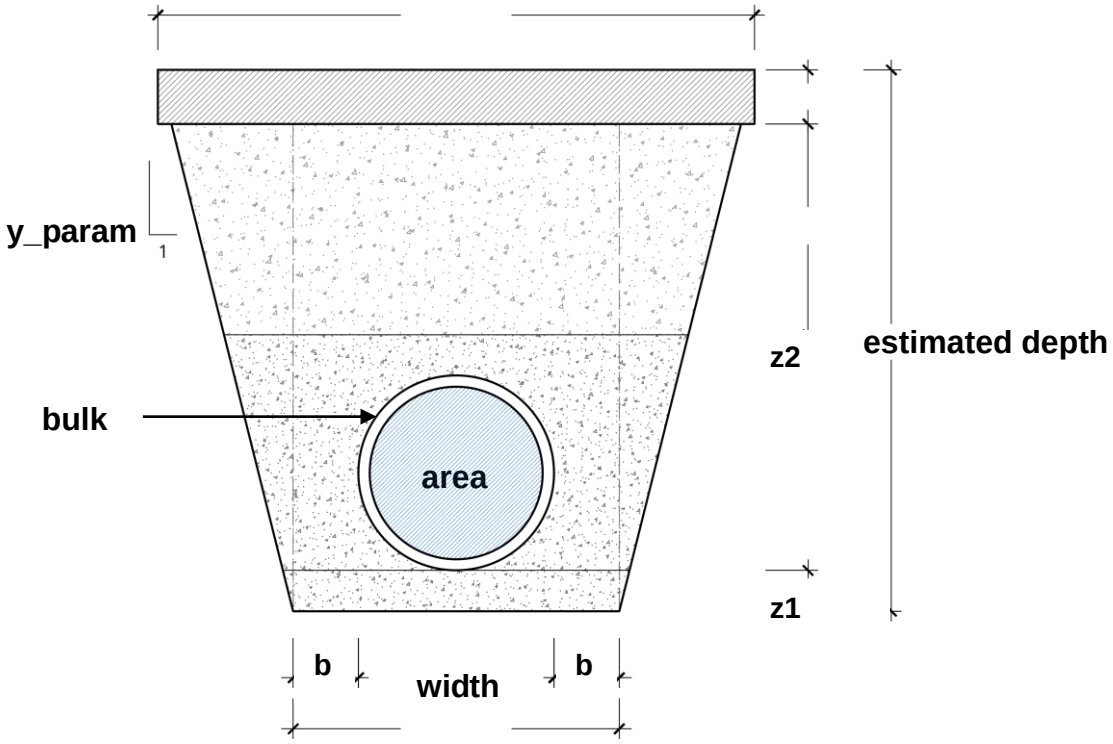


Image 20: Conduit's section with its measurement parameters.

The fields that affect the calculation of patrimonial value are:

From arc catalog (*cat_arc*):

z1 (m)
z2 (m)
width (m) – Total width. Width + bulk*2
area (m^2)
estimated_depth (m)
bulk (UD (m) WS (mm)) - thickness of the conduit's wall
cost_unit – Measurement units
cost - Price of the type of arc. Related with price tables.
m2bottom_cost - Price of the type of soil. Related with price tables.
m3protec_cost - Price of protection. Related with price tables.

From pavement catalog (*cat_pavement*)

thickness (m) – thickness of the pavement
m2_cost - Price of the square meter of the pavement. Related with price tables.

From soil catalog (*cat_soil*)

y_param – Inclination of the slope of the trench
b (m) - Distance between the Conduit and the trench limit
trenchlining (%) - Percentage of intivation of the soil type
m3exc_cost - Excavation price. Related with price tables.
m3fill_cost – Filling Price. Related with price tables.

m3excess_cost - Excess transportation price. Related with price tables.
m2trenchl_cost – Intivation price. Related with price tables.

From node catalog (*cat_node*):

estimated_y
cost_unit – Measurement units
cost – Price of the node type. Related with price tables.

Once the work is done, the only part left is to link the elements with its catalogs:
ARC in: cat_arc (arc.arccat_id), cat_pavement (plan_arc_x_pavement) y cat_soil (arc.soilcat_id)
NODE in: cat_node (node.nodecat_id)

On the other hand, in order to assign a rehabilitation price, given the disparity of costs and cases, each operator must build its own rehabilitation algorithm, with which the option is ready, but is disabled as a series value.

4.2.6 System

The tables of system ARE TABLES THAT SHOULD BE MANIPULATED BY EXPERT PERSONNEL since changes of the in this tables can cause that the system will stop working. In those tables the information that is necessary for the correct functioning of Giswater is located, but they will rarely have to be viewed directly, since there are tables with information that is shown in other places of the project. Even so, it's important to know its existence, objectives and usability.

Unlike the previous version of Giswater, now the group of system layers has a large number of tables with different types of information, which are divided into subgroups according to the type of role they are adjusted to.

- **Basic**

  This group contains some of the most important layers of the project, because if they are not within the ToC the program won't work. These are the editable views of node, arc, connec and gully elements (the last one only in UD projects). Through these views the rest of the layers that contain the geometric elements can be seen, therefore there are considered as "mother" views of the project. Its symbology coincides with that of each type of element in the group of network elements (section **4.2.1.3**).

  In addition to these views, the Basic subgroup also contains tables with information regarding hydrometers and *scada* data and catalogs or other external tables.

- **Edit**

  This subgroup also has relevant information stored in the tables, all without geometry. Some of them contain data with values that will be used in different Giswater tools, but there are others that deserve a more detailed explanation of their behavior:

  - **Project version** *(version)*: This table is **the most important** of Giswater project. It is used for a multitude of system tasks and it must be kept in mind that in the QGIS project there must always be one and only one for the plugin to activate.
  - **Node type** *(node_type):* The table characterizes the different types of node that the project can have. The list of types of nodes that the system permits - field *type*, from now on *'system node type*' - is not modifiable or extensible. What user can do is create as many node type elements as he wants – field *id*, from now on *'custom node type*' - with the same *system node type* attribute, as long as this attribute is in the system.

It’s important to know, that:

- Each *'system node type'* has a defined data model, different from the others. If user wants to create a new record of node type, he must first analyze which of the different data models implemented in the system nodes is more adjusted to the new '*node custom type*'.
- For each *'custom node type'* a default value of type of element in the hydraulic model can be defined. This default value is REQUIRED, but for each network element can be modified at any time by hydraulic engineers.
- *'Custom node type'* allows to customize the names of the elements in the selected language. This allows that, although the system always works with the *'system node type*' this will always be transparent for the user who will never see the *'system node type*' but will always work with the *'custom node type*'.

- **Arc type** *(arc_type)*: The table *arc_type* La tabla arc_type characterizes the different types of arc that are present in the project.

  Exactly as for node_type, It's important to know, that:

  - Each *'system arc type'* can have a defined data model, different than the others.
  - For each *'custom arc type'* a default value of type of element in the hydraulic model can be defined. This default value is REQUIRED, but for each network element can be modified at any time by hydraulic engineers.
  - *'Custom arc type'* allows to customize the names of the elements in the selected language. This allows that, although the system always works with the *'system arc type*' this will always be transparent for the user who will never see the *'system arc type*' but will always work with the *'custom arc type*'.

- **Connec type** *(connec_type)*: the table characterizes the different types of connec that the project can have. The list of types of connecs that the system permits - field *type*, from now on *'system connec type*' - is not modifiable or extensible. What user can do is create as many connec type elements as he wants – field *id*, from now on *'custom connec type*' - with the same *system connec type* attribute, as long as this attribute is in the system.

  It's important to know, that:

  - Each *'system connec type'* has a defined data model, different from the others. If user wants to create a new record of connec type, he must first analyze which of the different data models implemented in the system connec is more adjusted to the new '*connec custom type*'.
  - For each *'custom connec type'* a default value of type of element in the hydraulic model can be defined. This default value is REQUIRED, but for each network element can be modified at any time by hydraulic engineers.
  - *'Custom connec type'* allows to customize the names of the elements in the selected language. This allows that, although the system always works with the *'system connec type*' this will always be transparent for the user who will never see the *'system connec type*' but will always work with the *'custom connec type*'.

- **Gully type** *(gully_type)*: the table characterizes the different types of gully that the project can have. The list of types of gullies that the system permits - field *type*, from now on *'system gully type*' - is not modifiable or extensible. What user can do is create as many gully type elements as he wants – field *id*, from now on *'custom gully type*' - with the same *system gully type* attribute, as long as this attribute is in the system.

  It's important to know, that:

  - Each *'system gully type'* has a defined data model, different from the others. If user wants to create a new record of gully type, he must first analyze which of the different data models implemented in the system gully is more adjusted to the new '*gully custom type*'.
  - For each *'custom gully type'* a default value of type of element in the hydraulic model can be defined. This default value is REQUIRED, but for each network element can be modified at any time by hydraulic engineers.
  - *'Custom gully type'* allows to customize the names of the elements in the selected language. This allows that, although the system always works with the *'system gully*

type' this will always be transparent for the user who will never see the *'system gully type*' but will always work with the *'custom gully type*'.

It is important to know the functioning of the catalogs, their relations through foreign keys and other restrictions in order to maintain consistency of the project. In image 21, the **hierarchy** of elements' catalogs is represented.

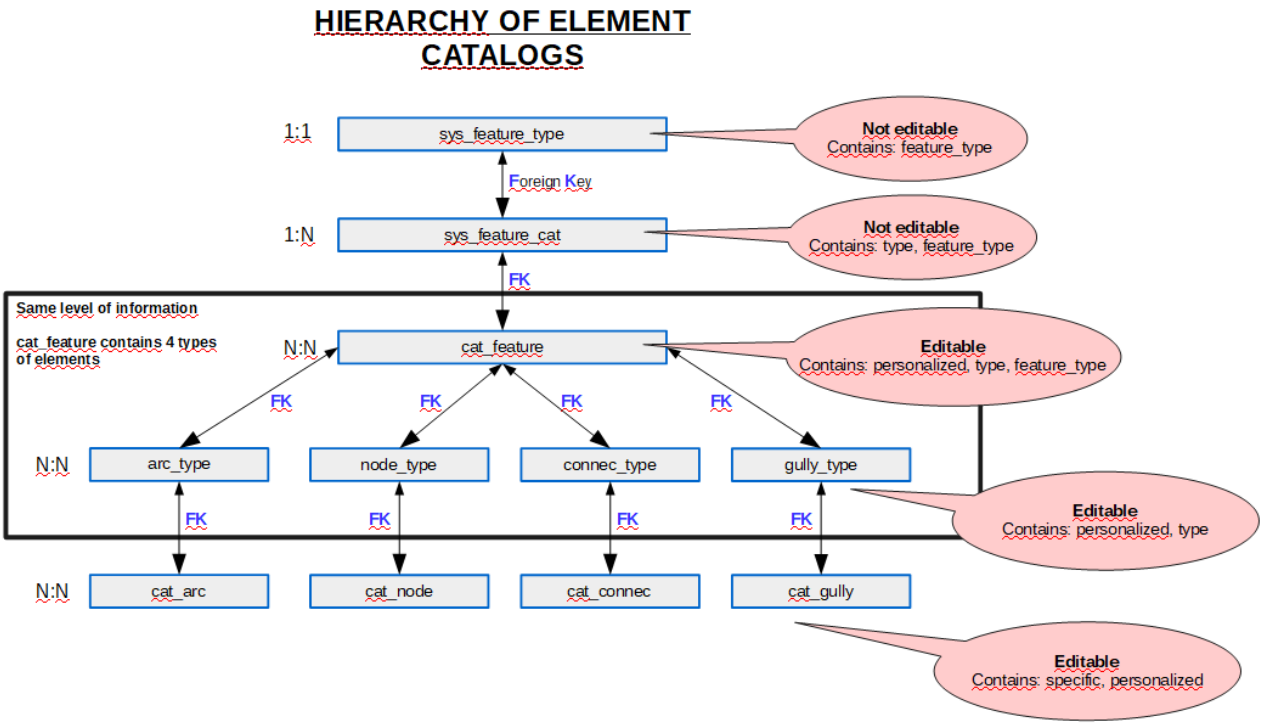


Image 21: Schema representing the hierarchy of tables related to principal elements of Giswater.

In addition to all the tables described, in the *Edit* subgroup there are tables:

- *man_type_function*
- *man_type_location*
- *man_type_category*
- *man_type_fluid*

These four tables are used to add specific information for each element. Its use is explained in point 2 of section **2.3.5.**

O&M

This subgroup contains tables with additional information about the operations and management group, such as visit parameters or types of visits. There is also the layer with polygonal geometry that represents the planning sector related to the *om* that is selected at the moment (*current*).

EPA Y SWMM
This subgroup contains tables with additional information related to the EPANET and SWMM layers. Most are containers of values that will be used during the calculations of the hydraulic model. Its data comes by default with the creation of the working scheme with Giswater, that is why those are tables that should not be modified by the user.

Masterplan
Contains tables related to the Masterplan section. There is a table with the relation of the different types of price units (m3, u, kg ...) and another one with the polygonal geometry that represents the planning sector that is selected at the moment (*current*).

Utils
The last subgroup aims to store other system tables that do not have any specific relationship with other subgroups. Here there is located *audit_cat_table*, a table that is used in some Giswater functionality and that at the same time can help the user to understand the rest of the tables of the entire project. *Audit_cat_table* contains the following information for **each of the tables** and views in the database schema:

- Id
- Context
- Description
- Role and criticality in the system
- Number of rows that the table must have in the system
- Role and criticality in QGIS (different than the one from the system)
- Message in QGIS
- Numeric sequence that filles in the field *id*.

This audit information can be very helpful when the user has doubts about the nature of a table and also about its need to be loaded in QGIS or in the system (database). In this sense, the criticality field represents this need. It has values from 0 to 3, with 3 being the maximum criticality, because if a table with criticality 3 is not loaded in the database or in QGIS (depending on which one has that criticality), the project will not be able to work or it will not work correctly.

The criticality 3 for QGIS is only present in four tables:

- Version
- v_edit_arc
- v_edit_node
- v_edit_connec

With these tables the program could begin to be used, although with some possibilities well below the real ones. Layers with criticality of QGIS = 2 are highly recommended to be loaded in the program, since their presence is important and if they are not found many of the features of Giswater could not be used. Layers with criticality of QGIS = 1 must also be loaded for proper functioning of all tools, although their non-existence in the project would not be especially tragic either. If any experienced user knows that any of these layers will not affect his use of the program, he could eliminate it from the ToC. Finally, the tables with criticality of QGIS = 0 should not be loaded in the project, as their presence is not necessary for the uses of Giswater. That table should not be eliminated from the system, even if ll the tables have been created with a specific objective and function.

4.2.7 Basemap

The last group of layers of the ToC of Giswater is the one with base maps, which is the cartography that can be used as reference for the rest of the elements and that represents some part of the territory. The incorporation of these layers to the project is very important, since it adds information that most users is used to see and therefore, they find it easier to identify to work with it. The base cartography is composed of:

- **Municipality** *(ext_municipality)* : polygon layer that marks the limits of municipality
- **Address** *(v_ext_address)* : punctual layer that represents the portals, each one with its number and relationship with the street to which it belongs
- **Streetaxis** *(v_ext_streetaxis)* : linear layer that represents the street axes within the municipality
- **Plot** *(v_ext_plot)* : polygonal layer that represents the different areas of the buildings and constructions that exist in the municipality.

There are different foreign keys between the street tables that give consistency to the data and restrict possible errors. The ext_address table has field *muni*_id which is relates it to ext_*municipality* table and field *streetaxis*_id relates it to *ext*_streetaxis table. At the same time, the ext_*streetaxis* is also related to municipality by the field *muni_id*. In case of existing many municipalities, each streetaxis can be related only to one municipality.

The origin of the data referring to base cartography has nothing to do with Giswater, but must come from other sources, hence the prefix ext in the layers, such as cadastral data. These layers, depite their external origin, are completely integrated into Giswater project and have more functionalities besides the simple cartographic representation of the elements. They must have specific structure, which can be seen in the annex of this manual. These functionalities will be reflected in section **5.2**, but its most important function is searching the specific location.

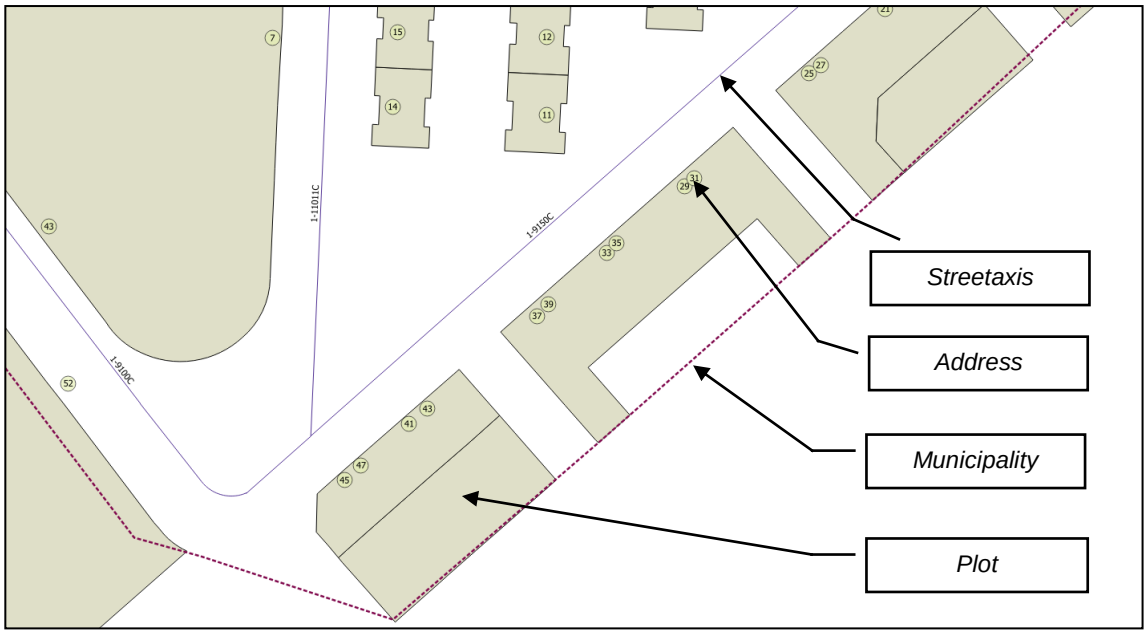


Image 22: Example of the elements that are present in the Basemap group.

In the same way, if a user wishes to, more external layers related to the base map of the area can be added into the group to visualize other elements or anything that one wants to represent. In this case, any layer that is added will be completely external to Giswater and will have no relationship with other tables. Examples of layers that can be added are a topography raster or an orthophoto.

5. GISWATER PLUGIN

5.1 Installation and configuration of Giswater plugin

In order to install and connect Giswater plugin with QGIS, it's necessary to configure a new repository, which

1. Open QGIS and access plugins' repository (Plugins > Mange and install plugins).
2. Enter the tab '*Settings'* and add a new repositoryo.
   'https://download.giswater.org/plugin/giswater.xml'

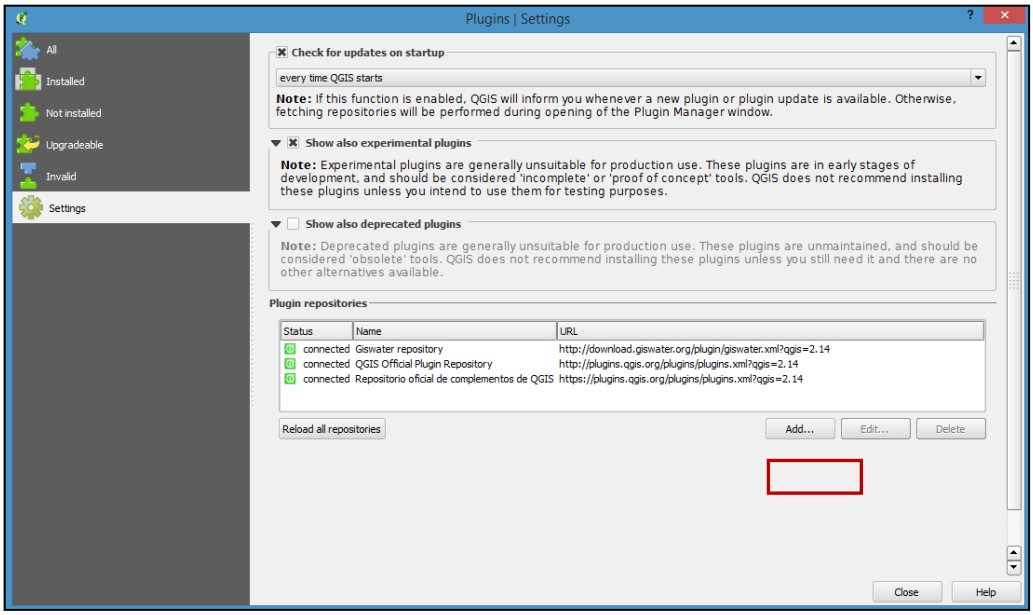


Image 23: To add the *plugin* of Giswater to QGIS it needs to be shown on the list of plugin repositories.

3. Introduce the name that will identify the repository and the URL.

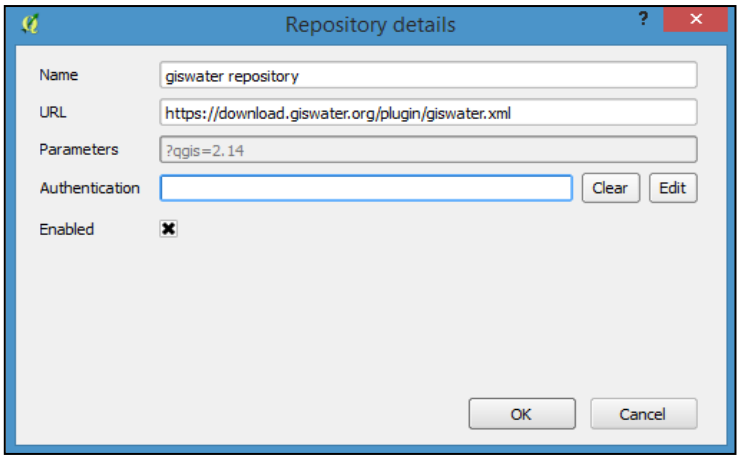


Image 24: The repository is added manually, using a URL.

4. Find and install Giswater plugin, from tab 'All'.

Warning: So that the Giswater plugin starts to work user must previously create a connection to the database, where the data schema is located, using PostGIS.

If after installing plugin and establishing the connection to the database, it doesn't appear directly in the toolbar, access the menu 'View / Toolbars' and add it.

In case of having more than one QGIS project open, the behavior of the plugin may present instabilities, so it's recommended not to use the plugin with more than one open QGIS project at a time.

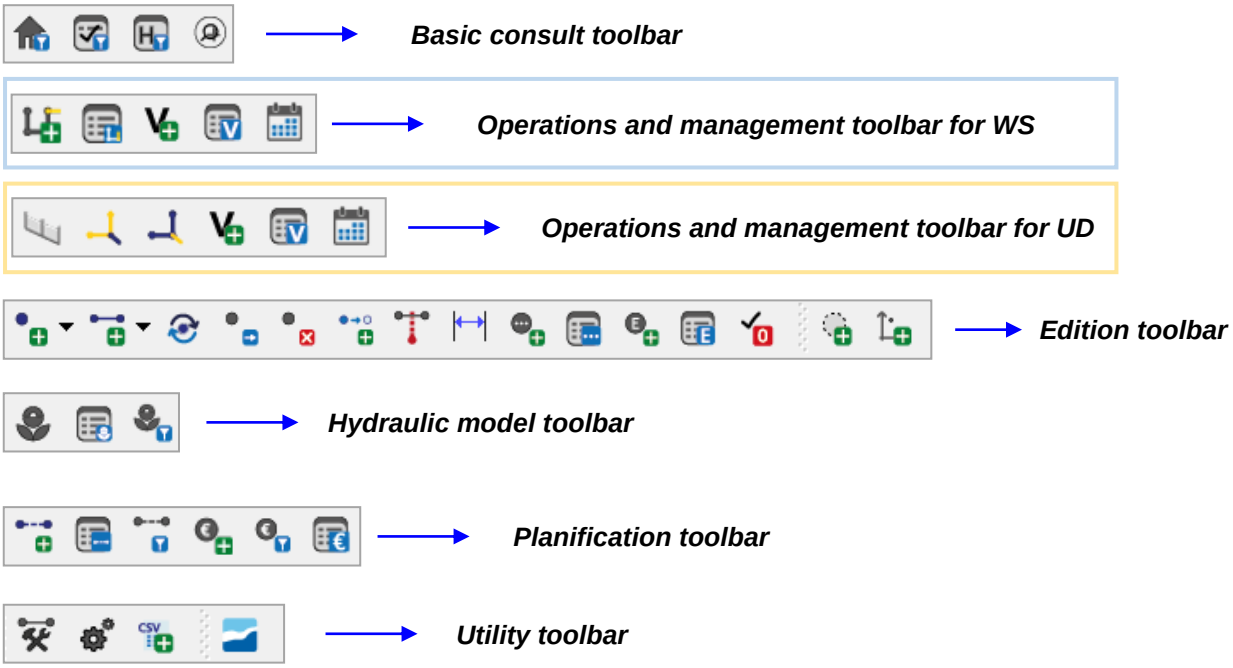
5.2 Toolbars of a plugin

One of the biggest and most notable improvements of the 3rd versión of Giswater can be found in the plugin tools. Not only the new capabilities have been added, but also the existing tools have been improved.

Giswater plugin is a part of the software with which the user should become more familiar, since most of the actions that he wants to carry out can be done using the tools available in the plugin.

Giswater currently has up to **38 tools** available, divided into different toolbars that must be associated with the six roles that exist in Giswater.

Those toolbars are:



Later on, the functionality and the objective that each one of the tools has is detailed.

5.2.1 Basics

This group of three consulting tools is related to the basic role of Giswater. They are tools that allow to select and consult the data, but still without the capacity to modify it. Even so, its use is very important, since the fact of selecting one or another parameter, for example, the states of the elements, will modify the behavior of other tools.

	Exploitation selector *Allows to visualize or not different exploitations – role_basic*

The exploitation selector, as its name indicates, is a tool that allows to choose the exploitation that will be visualized. When we talk about visualization it doesn't mean that the data of the exploitations that are hidden are eliminated, they are simply not visible in the graphical interface of QGIS.

The use of this tool is very simple: in the form appear two lists which contain the exploitations of the network. Those that are placed on the list on the left won't be displayed and those on the right will. To move an exploitation from one list to another it has to be selected by clicking on it and moved from one side to the other using the arrows, that are located between the two lists.

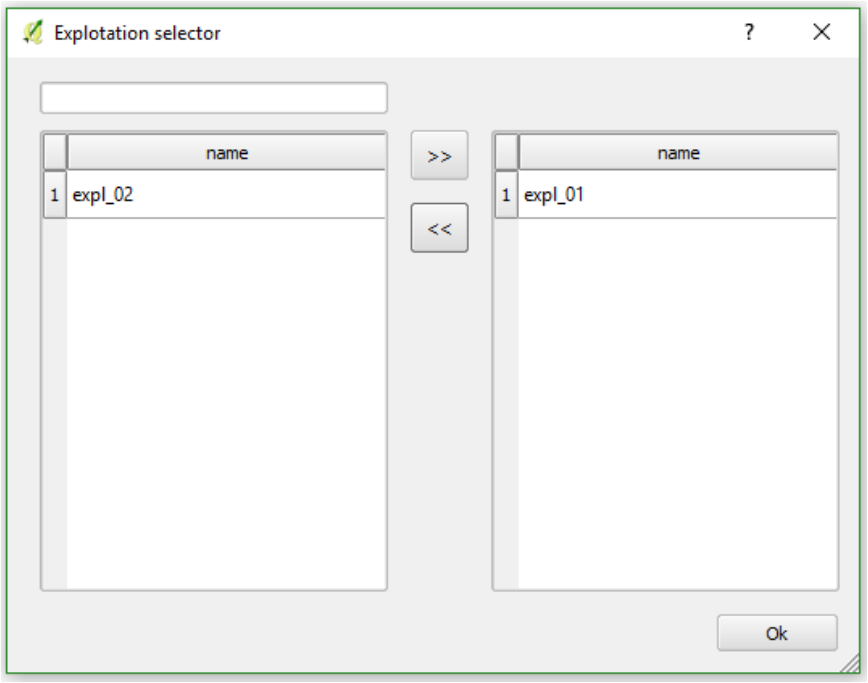


Image 25: Form of exploitation selector tool. On the left there are listed those that won't be visualized, on the right those that will be visible on the map.

In the form in image 25, exploitation 1 (expl_01) and all its data would be displayed in QGIS, unlike the data of expl_02, which will be hidden until the values of selector are modified again.

The box that is located above the list on the left allows to search among the different exploitations that are not visible.

ATTENTION: When an exploitation is selected in the selector, all the sectors that intersect that exploitation are displayed automatically.

	State selector *Allows to visualize the elements in function of their state – role_basic*

In the same way as the exploitation selector, the state selector allows to visualize the elements of the network depending on their state. The states have been previously defined and those are: OBSOLETE, ON SERVICE and PLANNIFIED.

This tool has the same performance as the previous one, the different states can be moved between two lists using the arrows located between them.

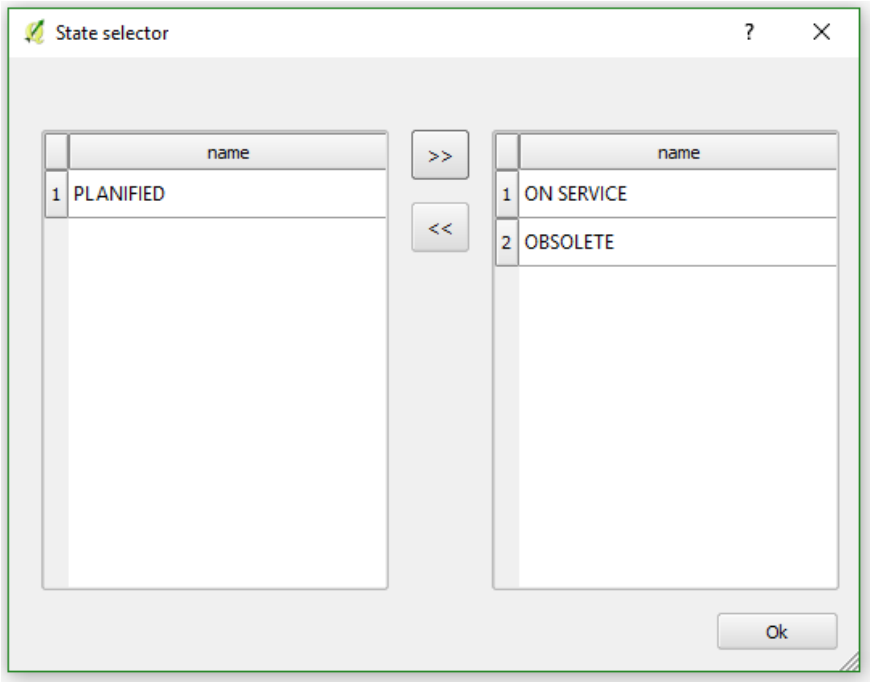


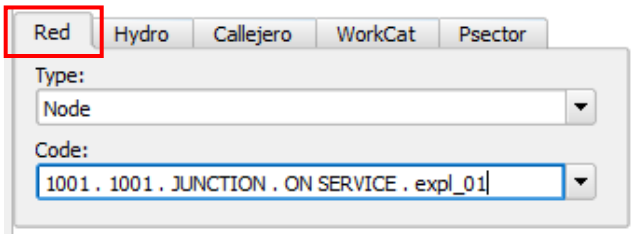
Image 26: Form of state selector tool. On the left there are listed states that won't be visualized, on the right those that will be visible on the map.

In the form of the image 26, the elements with state on service and obsolete have been selected and will be visible for the user. The plannified elements will be hidden. When using this tool, it must be beared in mind, that the elements that are displayed on the map will be the same and only ones that will be used by other tools that require those elements of the network.

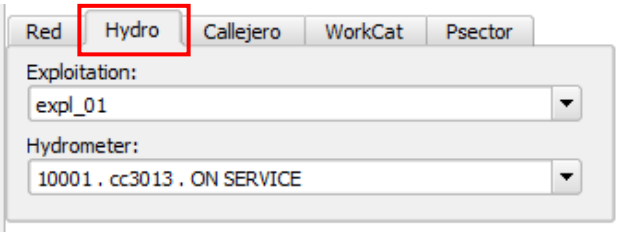
	Searcher *Allows to search for the elements of the network and addresses – role_basic*

The Giswater search engine allows to search and select elements of the network or the address. There are five different tabs within the search engine, each with different seeking parameters.

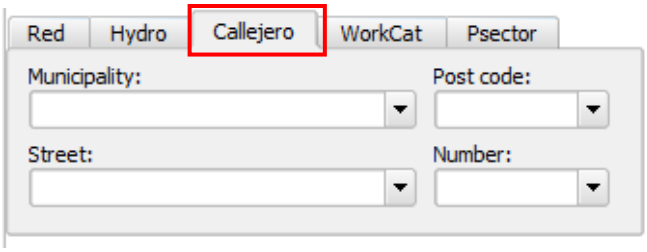
We will see tab by tab the use of the searcher:



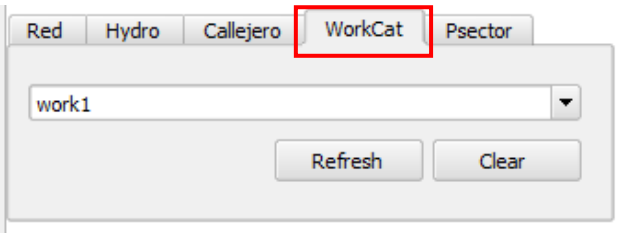
- **Network***:* allows to search for specific elements of the network. First the type of element must be selected, later in the drop-down list, all the available ones will be filtered showing their *code*, *id*, *type*, *state* and *exploitation*. When selecting one of them, the element will be zoomed and centered in the middle of the screen. Searcher acts with the project system layers, which is a reason to have them always loaded in the project.



- **Hydrometer:** it allows to search for hydrometers, which must always be related to connecs. In the first drop-down list the exploitation must be selected. Then, it's posible to search among all the hydrometers of that exploitation. The *hydrometer_customer_code*, *connec_customer_code* and hydrometer *state* will be displayed. When selecting a record, the tool will automatically open the hydrometer form and zoom in to the corresponding connec. All the parameters that are used in this browser tab are customizable by the user in the *config_param_system* table.



- **Address**: the third tab of searcher is related to the street map, loaded in the last group of Giswater layers (base map). It allows to search for municipalities, streets or specific portal numbers. To use it, the fields of the *ext_municipality*, *ext_streetaxis* and *ext_address* tables must be correctly filled out. After opening the Municipality drop-down list, and choosing municipality the map will be automatically zoomed in to its limits. It is also possible to make a similar selection by postal code. Next step, is choosing a street of the municipality in the *Street* drop-down list. By selecting a street, the map will zoom in to its extension. Finally, with the street selected, the street number may be chosen from a *Number* drop-down list. By clicking on a specific number the map will zoom in to the selected element, centering it on the screen.



- **WorkCat** *(work records):* it allows to filter the elements of type node, arc, connec, gully and element according to the work record to which they belong. In the drop down list user can choose a record and after clicking on it, a window containing two tables will automatically open. On the left side the elements that have assigned the selected record as a start work (installation of an element) will appear. In the table on the right, those which have it as an end work record will be displayed. Clicking on any row of the table will open the specific form of the element. In the lower part of each table a summary of the table is presented, showing the total number of elements of the same type as well as the total length of the arcs that are part of the selected work file.
- In addition, in this window it's possible to export the information presented in the tables into csv file. To do it's necessary to set the save path and click *Export to csv* button.

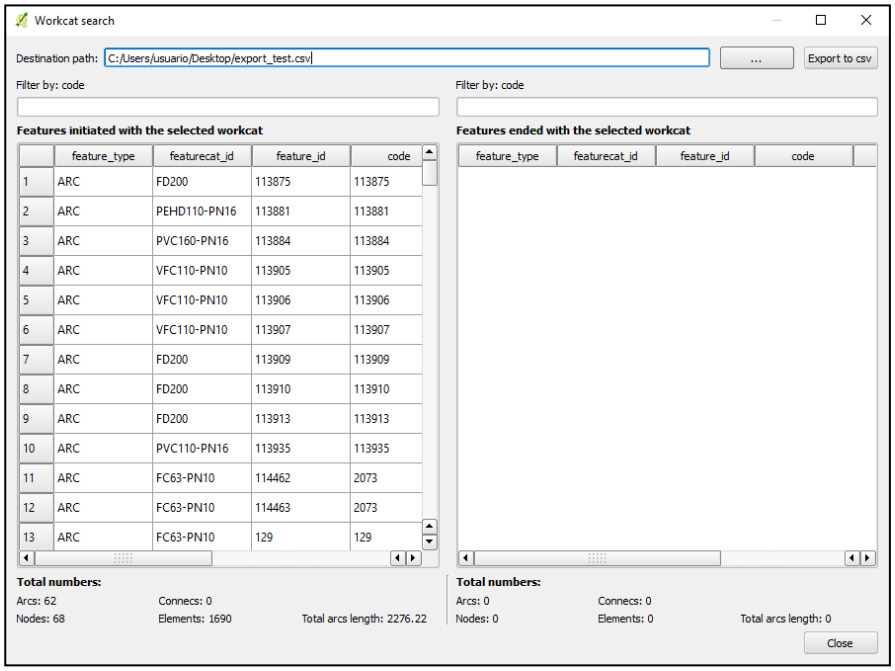
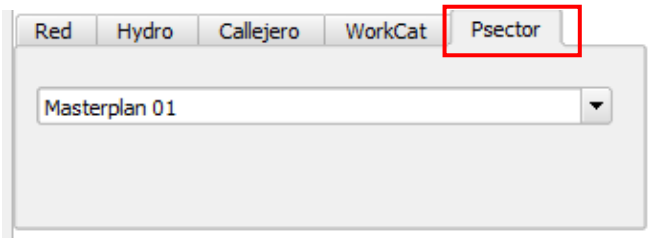


Image 27: Form of searching by work record (workcat_id). Allows to export the information into csv file.

In QGIS project there is loaded a layer (v_ui_workcat_polygon), which as the name implies, has polygonal geometry. This polygon is drawn dynamically around the elements of the map that have a specific work record. After selecting one of them using WorkCat search tool, the map will zoom in to the polygon of the work record. It allows to see how big area was covered by this action.

Below the drop-down list that allows to find the work record there are two buttons, *Refresh* and *Clear*. The first one is used to refresh the information of a work record, so in case of adding a new element with a specific workcat_id it must be clicked in order to regenerate the polygon and add to it the geometry of the new element. The second button, *Clear*, allows to eliminate the visualization of a polygon from the QGIS interface, simply so that it does not obstruct the use and representation of the rest of the elements. To visualize it again it's necessary to use again the searcher.



- **Psector**: The last tab of the search engine allows to look for the different planification sectors generated in the project. The use is very simple: select one of the psectores from the drop-down list. When clicking, the form associated with the corresponding psector will open automatically, there will be the possibility to edit the information, see the linked elements, add prices or documents, etc. The search engine also zooms to the geometry of the specific psector.

	Hydrometer's state selector *Allows to visualize or not the hydrometers in function of its state – role_basic*

The last tool of the basic bar is used to select the hydrometers according to their state. Like the spatial elements, the hydrometers also have a state, which the user defines and manages from the tables ext_rtc_hydrometer_state (to define new states) and ext_rtc_hydrometer (to add a certain state to the selected hydrometer).

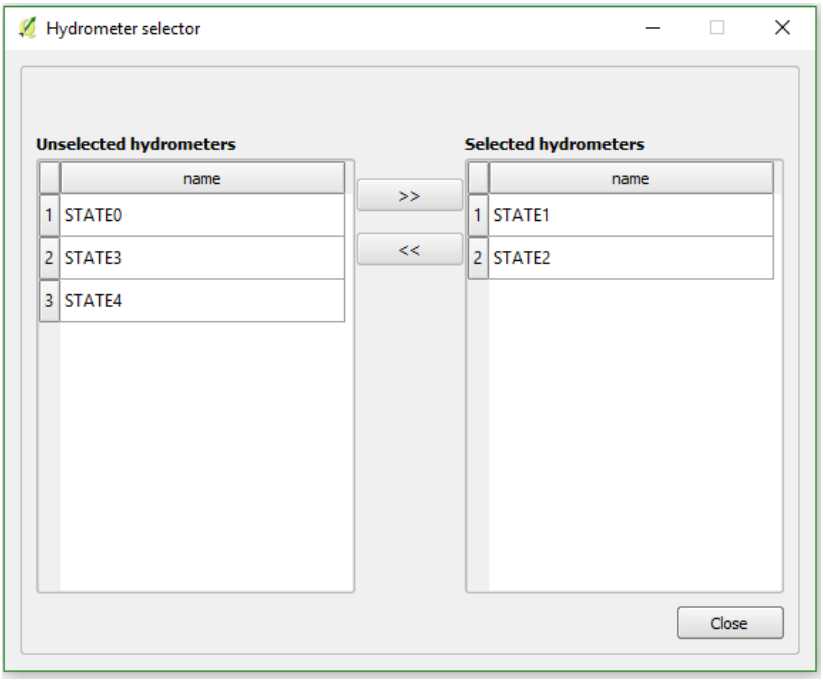


Image 28: Selected states are showed in the columna on the right.

The method of use of this tool is the same as that of exploitation and state selectors presented before. Remember that the hydrometers are shown in a tab of the *connec* or *gully* type elements to which they are linked to.

Using this tool will only show the information related to the hydrometers that have the selected states. This will happen in the tabs of the elements' forms and in the hydrometer seeker.

The objective of this selector is to facilitate the management of hydrometers, since it's a table that can have a huge amount of data and therefore its management can be dificult.

5.2.2 Operations and management

This group of tools is designed to perform or simulate actions on the actual network of water supply or urbain drainage. Some of them will be used directly from the location of the element in the field, to report information on its status, others from the office. One way or another they are focused on the actual use of the elements.

This O&M toolbar of the plugin is the only one where there are big differences between WS and UD projects. There are some tools that are only for water supply and others that are exclusive for urban drainage. As usual, a clear distinction will be made when detailing the operations.

However, there are several common tools in this toolbar, such as those related to the management of visits and events. The visits to elements are made by a worker in the field, who can add the information directly to the tables specially designed for this function through a mobile device.

Minimum cut polygon

Allows to create a new mincut polygon – role_om

Mincut polygon functionality is surely one of the most important functionalities that a drinking water network manager needs to operate with day to day. In this section it will be explained how the internal work logic of the database is developed.

The mincut polygon propagates flows from the elements that supply water to the network and then proposes the valves that should be closed in case of wanting to leave a specific point without water supply.

First of all, there are several **previous aspects** about the data that are strictly necessary for the tool to work correctly:

1. *Pgrouting* library is used for this process.
2. All *nodes* and *arcs* must have filled in fields *state* and *state_type*. The type of state must be one that is in use. This can be seen in the *value_state_type* table in the *is_operative* field, which must be TRUE. In case of FALSE the element will not enter into the process of the mincut polygon.
3. The network traceability is made from the node_1 and node_2 of the elements type arc, that's why the network must have topology.
4. The identifiers *(id*) of arcs and nodes must be integer.
5. Table *man_valve* should have values in fields *closed* y *broken*, which by default have value *FALSE*.
6. Mincut polygon works in the context of the exploitation system defined by the user in the table *anl_mincut_inlet_x_exploitation*. In this table the nodes that contribute water to the system (usually they are *source* or *tank*) together with the information to which exploitation they belong must defined.
7. The type of valves that participate in the mincut polygon must be configured. This can be done from the table *anl_mincut_selector_valve* or using the *plugin*. Usually they are only the *shutoff valves*.

8. For mincut there are three different types of states (not to be confused with the states of the elements of the network). These are defined in the table *anl_mincut_cat_state* and are:

    - **Planified** id=0
    - **In Progress** id=1
    - **Finished** id=2

Once all the mentioned aspects are controlled the tool can be used. Clicking on the button opens the mincut form, where, in the first place pay attention to the top menu. Here it's possible to distinguish the *mincut* types and the configuration of the tool. In the configuration the types of valves that enter into process can be selected.

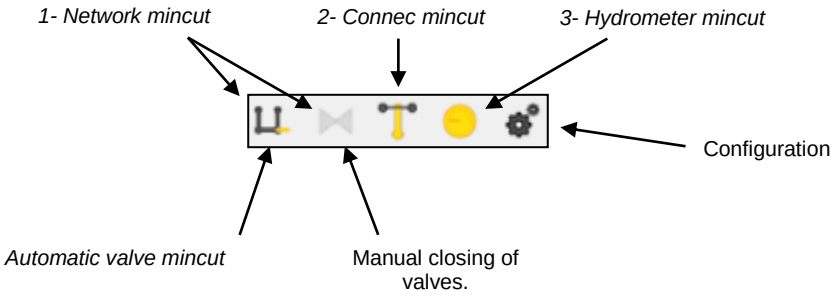


Image 29: Toolbar of mincut form. It's posible to select the type of proccess that will be performed.

As shoed in image 28 there are three types of mincut polygon. The one with the most developed functionality is number 1, which proposes the valves to be closed in order to leave a specific location without water supply

How to use the tree types of mincut:

- ***Network mincut – Class* 1**

    To make a mincut polygon of type 1 the form must be filled (image 30) with the parameters:

    - Work order: work record (optional).
    - Location: location of the point that won't have (made from fields municipality, post code, street and number).
    - Type: may be demo, real or test, depending on whether the water cut is actually going to take place or is just a test to see what would be the results
    - Cause: Accidental o plannified.
    - Start and end date: forecast dates of the process
    - User: name of the user assigned to this task.
    - Description: additional information in text format for the specific case.

    Now the state of mincut polygon will be Planified. The state is automatically modified depending on the process. At this moment it's time to click the button that will allow to choose the point of the network where the water will be cut. 

The cursor must be placed over the desired point, which can be located either on an arc or a node. When clicking, the mincut polygon will be automatically made, showing the valves that will have to be closed and all the elements that will be affected (sections, nodes and connections).

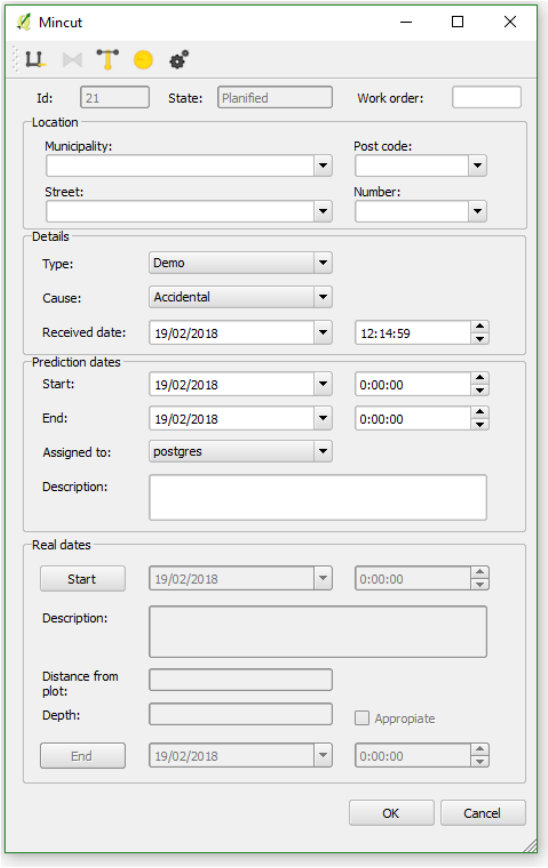


Image 30: Form of mincut polygon, same for all the mincut types. It has different functions and fields that are activated depending on the state of the process.

To offer this information *mincut* has different tables where the results are stored depending on the type of element:

- **Mincut result valve:** represents all valves of the network depending on whether they should be opened or closed → Open / Closed
- **Mincut result connec:** represents all the connecs of the network that will be affected by the mincut
- **Mincut result node:** represents all the nodes of the network that will be affected by the mincut
- **Mincut result arc:** represents all the arcs of the network that will be affected by the mincut

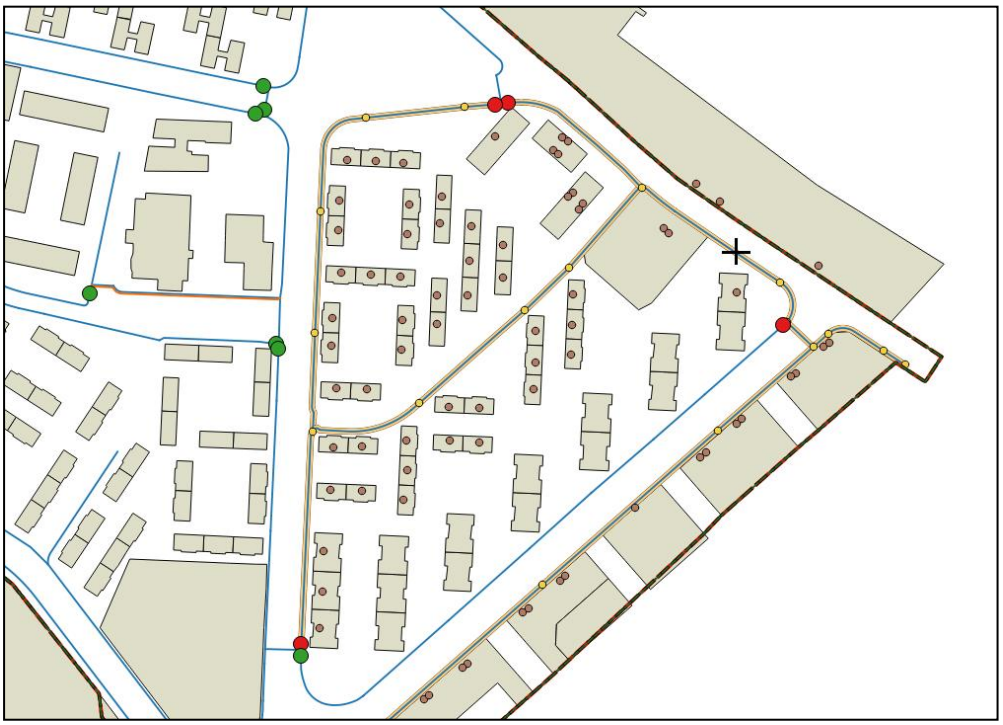


Image 31: View of the map showing the results of the mincut process. The symbology shows the valves to close, as well as arcs, nodes and connecs affected by it.

All these tables store the information of the element and the identifier of the mincut polygon and allow to clearly visualize on the map the affectation of the process, as shown in image 30.

At this moment the second button of the mincut toolbar is activated, which will allow, optionally, to choose a valve that for whatever reason will not be able to be closed. It can be done by clicking on the button and choosing the valve. After that the results of the process will be recalculated taking into account the modification. 

With the completed polygon and knowing that all the marked valves can be effectively closed, it's time for the second part of the form, which is called *Real dates*. When clicking on *Start*, the rest of the fields will be activated, the start date and time will be set automatically and the status of the process will change into *In Progress*. It's possible to add an additional description of the process and fiil in the other fields such as building distance or depth.

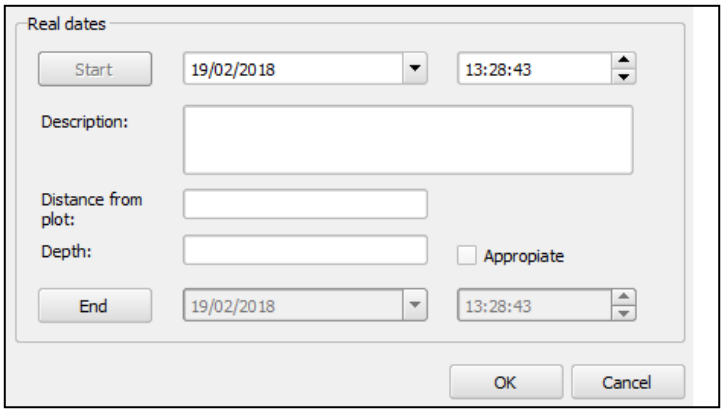


Image 32: Fields of form are activated when the true process of field work starts.

If it's a test *mincut* usually the duration will be very short, as the important part is the range of theprocess. On the other hand, if the mincut is real, the steps are clicking *OK* and leaving the process in this state until, when the time comes, clicking *End* to finish and change the state to *Finished*. Clicking End opens another small form to specify, if necessary, the location and dates of the process. By clicking OK in this last form, this cutting polygon will be permanently closed and stored without the possibility of editing it again.

Connec mincut – Class 2

To perform a type 2 mincut, in the same way as in 1, the form must be filled in with the location, dates and mincut details. Then, clickin the button will start the process:

At this moment a small form is opened that will allow to select the connections to which the water supply will be cut (Imagen 32).

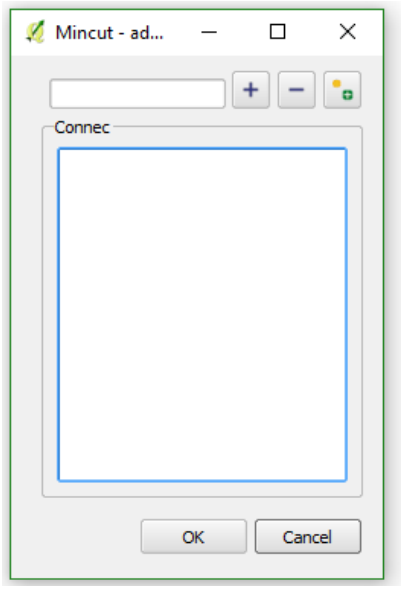


Imagen 33: Form to choose the connecs that will be affected by the mincut process.

There are two ways of selection:

- With the button  the connection can be added through its connec_id, which will be filtered in the container of values that are in the form.
- With the button  many connections can be added at the same time. All the connections that are inside the rectangle that is drawn on the map are going to be inserted in the *mincut*.

Button (-) allows to unselect the connections.

Once selected, by clicking OK these elements will be stored as connections to be cut for the *mincut* that is in process and they will be able to be visualized in the map through the *Mincut result connec* layer.

In the same way as for the *Network mincut*, at this moment the state may be modified. It can be left as planned, it can be started and left as in progress or finished.

Although this type of mincut polygon does not provide as much information as type 1, it is also important when planning network operations in cases where valves do not have to be closed, but the connecs will be.

- ***Hydrometer mincut – Class* 3**

  This last type of mincut polygon is very similar to the previous one, but with an added level of detail. In this case, the hydrometers that are going to be closed are identified. It is useful for cases in which not all the hydrometers of a connection must be closed.

  The flow of use is the same as in the previous case, but in this case the selection form has two filters: one for connecs and another for the hydrometers that are related to the connecs.

  Since the hydrometers do not have geometry, it will not be possible to visualize the results on the map, but they will be stored in the *Mincut result hydrometer* table.

	Mincut manager *Allows to manage the existing mincut polygons – role_om*

The mincut polygon manager complements the *mincut* tool. The objective of this tool is to store the different mincut polygons made in the project and allow to recover and visualize again the data refelated to the existing polygons.

After clicking the button a form opens. In the part there is a table where the polygons already made are displayed in rows, whatever their state (plannified, in process or completed). Each row presents the mincut polygon information: type, dates, street, cause, start element, etc. The capabilities of the tool are the following:

- Filter by *id*
- Filter by mincut state
- Delete selected *mincut*
- Open selected *mincut* → When opening a micut polygon first the form will be shown and in case when it's not finalized, it is possible edit the data. At the same time, the results tables of *mincut* will be updated with the data of the selected process and therefore it will possible to see them again on the map.
- *Mincut* selector → Next to the filter by *mincut_id* button there is a button that opens the mincut selector. After clicking, a selector will appear, allowing to see on the screen different mincut polygons at the same time. Important thing is that having different polygons in the selector, the tables where the data is stored will also have more information differentiated by the *mincut_id*.

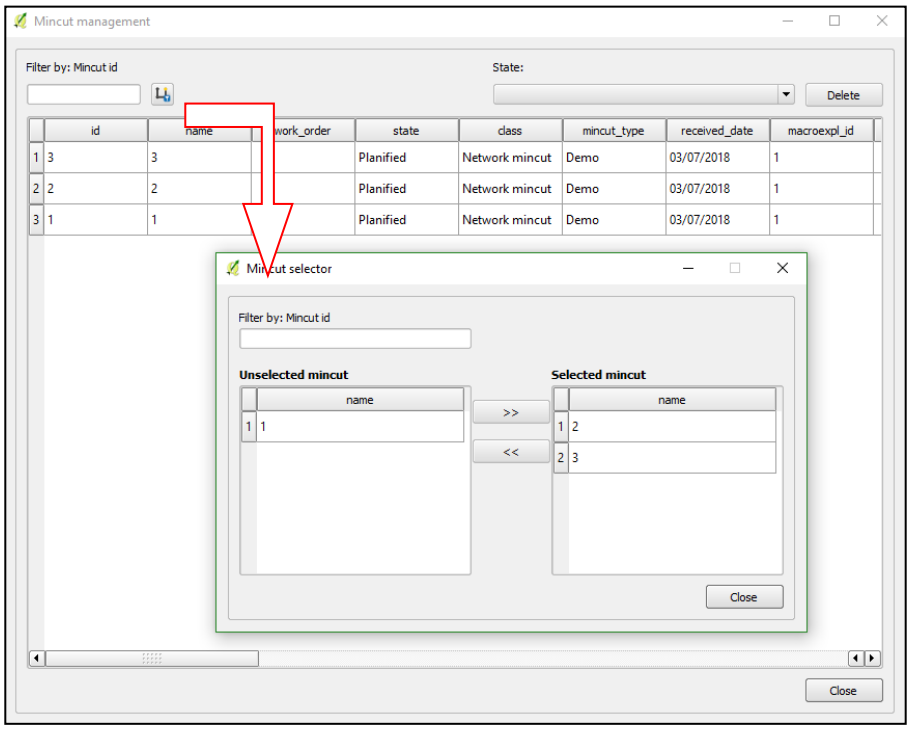


Image 34: For of mincut menager with opened mincut selector form.

Longitudinal profile

Allows to draw or load longitudinal profile – role_om

The longitudinal profiles are technical representations of a part of the urban water drainage system. This tool automatically creates longitudinal profiles of the area that user wants. To choose which elements should be represented, the user must select a start node and a final node. The longitudinal profile will represent all the arcs and nodes that are between these two nodes (including themselves). In addition, there is an option of selecting an additional node which, in case the initial and final nodes have two possible routes, will mark the direction by which the profile should be drawn.

Clicking the button that starts the tool will open a form like the one in image 34. Here the user must establish a profile id, as well as the start and end nodes. With the [+] button it can be choosen from the map by placing the cursor over the desired node. Once values of these nodes are set, by clicking *Exec profile*, the arcs that are inside the selection will appear automatically in the list on the right. Next step is clicking Draw button to create the desired longitudinal profile. The *Clear profile* button deletes selected data.

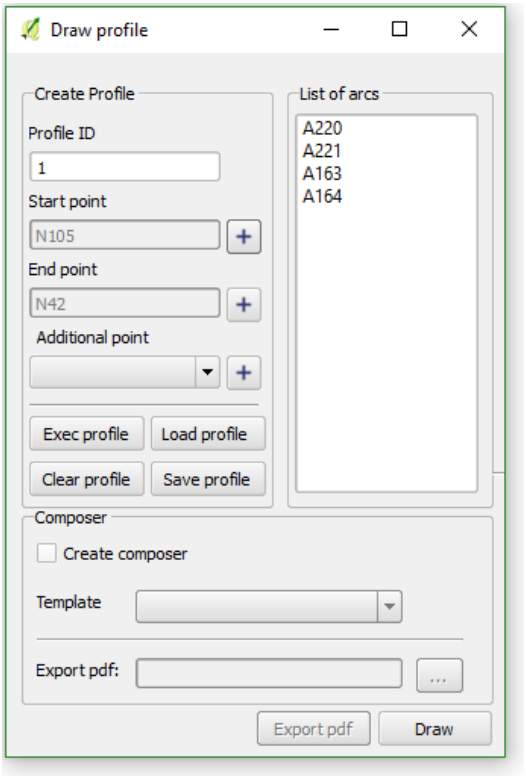


Image 35: Form to créate a longitudinal profile. Allows to select start and en nodes and draw a complete profile.

The example longitudinal profile shows the nodes and arcs that are between nodes N105 and N42. The representation is a graphic type with a table of dimensions in the lower part. It shows the following data:

- Elevation and maximum elevation of node
- Y max of node
- Diameter, slope and length of arc

This is a very useful tool to obtain a graphic representation of the network in a very simple way. It should be remembered that if any of the essential fields for drawing the profile is empty, the tool has customizable default values in the *config_param_system* table. These values are:

- *top_elev (node) / sys_elev (node)*
- *ymax (node)*
- *geom1 (cat_arc)*
- *z1 / z2 (cat_arc)*
- *cat_geom1(cat_node)*
- *sys_elev1 / sys_elev2 (arc)*
- *y1 / y2 (arc)*
- *slope (arc)*

In addition to drawing a new longitudinal profile, the tool allows to load an existing one. In order to keep a profile in a database it must be saved using *Save* profile button. All that is saved can be displayed again by clicking *Load profile* in a main form of a tool.

In order to prepare the profile to print it or export to pdf mark *Create Composer*, select one of the *templates* that are incorporated with Giswater and click Draw. The *Composer* of QGIS will be opened with the longitudinal profile represented in a personalized style. In addition to the longitudinal profile, the part of the map with the elements that make up the profile are shown, a general situation map and additional profile information: start and end nodes, length, scale and date (Image 36).

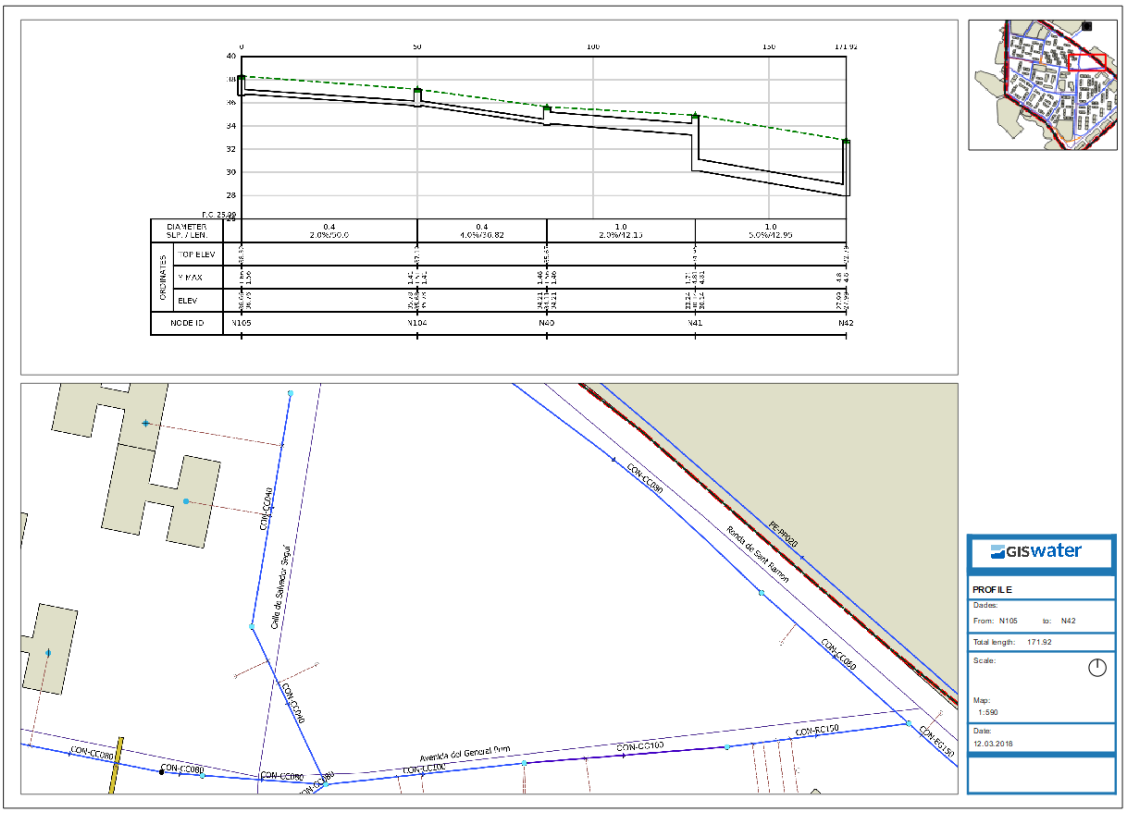


Image 36: Example of a QGIS personalized composer, that shows a longitudinal profile together with a map of its location.

Upstream

Shows the elements located upstream – role_om

This tool, specific for sanitation projects, allows to select a specific node of the network and show all the elements that are upstream of the chosen **node**. To show these elements, the tool selects all of them (by painting yellow) and it is possible to visualize them both in the graphical interface and in the attribute tables (where they are also selected).

Image 37: Elements located upstream from the selected node. On the right the error is show, because of the inverse direction of one of the arcs and that's why it's not detected as upstream.

Downstream

Shows the elements located downstream – role_om

This is the same process as the previous tool (upstream), but this time selected elements are located downstream from the selected node.
In order to make this selection, the tool searches in the nodes contiguous with the selected one checking its maximum height and in case when it is higher (for upstream) or lower (for downstream) it selects it and continues the search until the end of the network. One of the objectives of this tool is to help find errors in the network, since the elements upstream or downstream must have a coherence of heights so that water flows through the conduits. If the top_elev field of a node that should be upstream is smaller than its predecessor, the tool will stop and the node will not be selected. This can be understood more easily in image 37. On the right the section that should be upstream is not selected, therefore, there might be a problem with heights. In the one on the left all data is correcte and all the network elements are selected.

Add multiple visit

Allows creating a new visit and its relations – role_om

The visits with which Giswater works aim to make an inventory of the different moments in which some element or section of the network has been visited in reality. Keep in mind that a *visit* is the superior of a series of related parameters: a *visit* may contain multiple *events*, which, in turn, may contain multiple *documents*

After clicking *Add visit* tool, a form with four different tabs appears. In the first one there is a place to fill in the data of the new visit that is going to be created. Before doing that, it is necessary to have at least one value in the visits catalog (*om_visit_cat*), since each visit must be related to a value in this table. Only visits in *active* status will be available. When inserting start and end dates, there is a possibility to link the *selector_date* table to automatically obtain the dates that are inserted (Image 38).

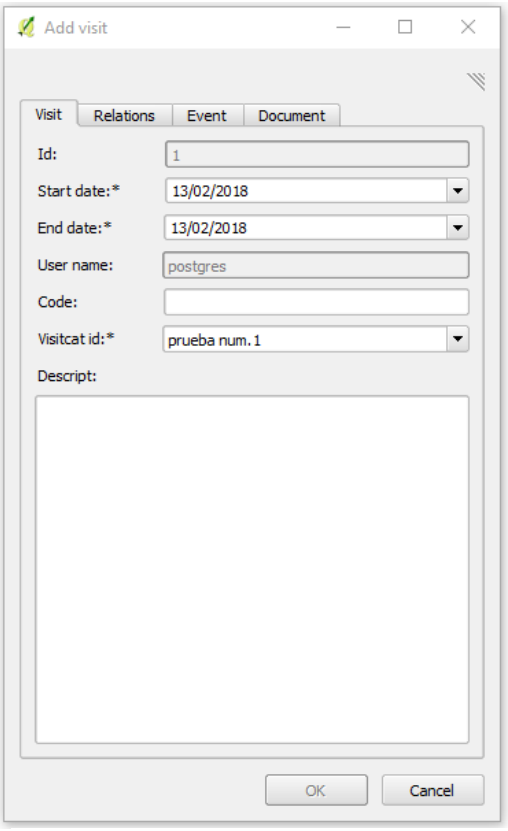


Image 38: For of creating a new visit. In the first tab all the basic data is located.

The second tab of the form refers to the relationships between elements and the visit. The link between creating visit and new elements can be added using the tools in this tab. It allows to select the type of element and add it by using id or by selecting directly from the map. (Image 39).

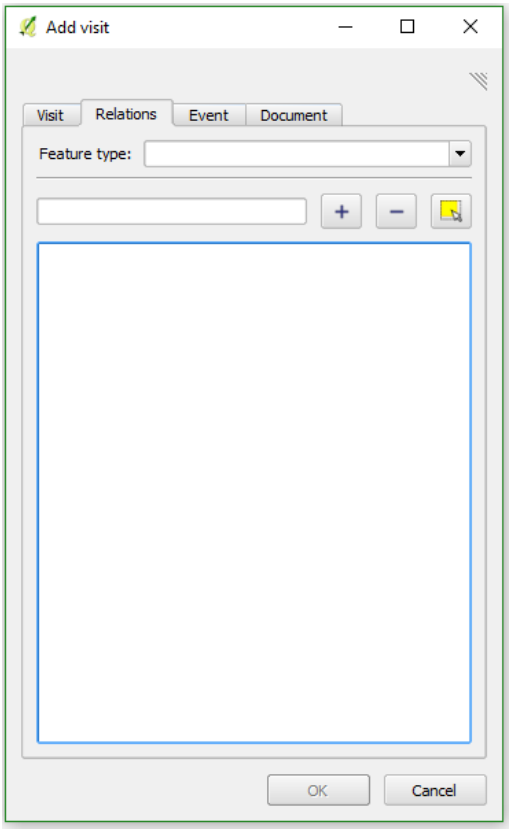


Image 39: Form of creating a visit. In the second tab the relation between visit and elements of the network is created. It is filtered by *feature_type*.

The third tab relates the visit with events (Image 40). As has been said, different events can be part of the same visit. These could be defined as actions taken during the visit, such as repairing a crack or cleaning a section of pipe. To insert an event at least one value in the parameter tables must be present (in the database they are called *om_visit_parameter* and *om_visit_paramter_type*). The parameters depend on the type of event and the type of element on which it is carried out. There are three types of events by default:

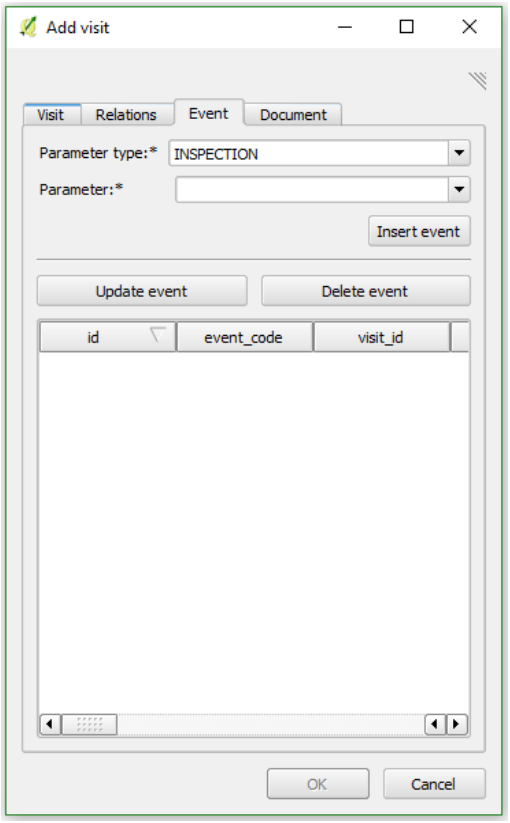


Image 40: Form of inserting the visit. The third tab relates events with the visit.

Standard events (*event_standard*) has fields like parameter, value and comment (optional text field).

Standard events of urban drainage (*event_ud_arc_standard*), have two fields more to manage the position inside the arc at which the event takes place.

Rehabilitation events of urban drainage (*event_ud_arc_rehabit*), especially indicated to identify structural pathologies that must be rehabilitated.

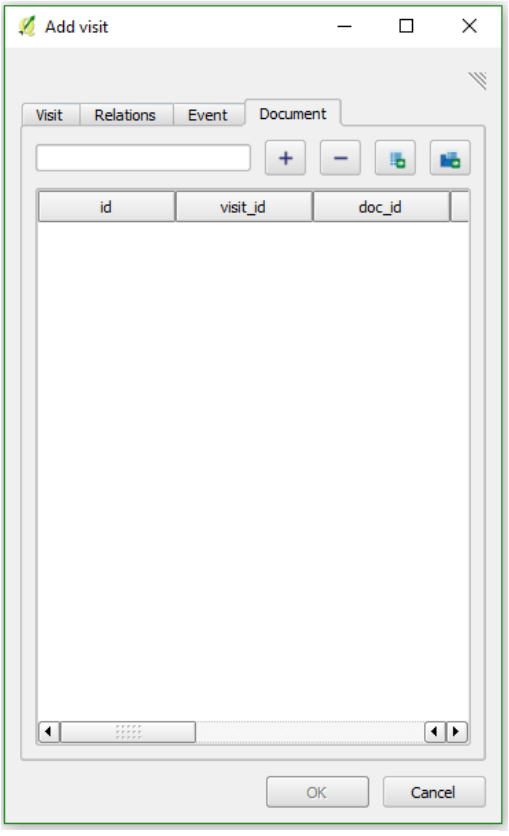


Imagen 41: The last tab that allows to related documents to the visit.

All generic element forms have the ability to add an image to the event or view the gallery of available images. In the case of **multiple visits**, this option will not be operative since it is not possible to add or view photographs in a multiple visit.

Finally, in the last tab of the form, visits can be related to documents (Image 41). These are external documents in 'common' formats such as *pdf, doc* or *csv*. In the text space it is possible to filter existing documents and link them to the visit. In case the user wishes to add a new document at this moment, it is possible to do so by clicking the button: 

This performs the same function as the *Add Document* plugin tool, which will be explained later.

The other button allows to open the URL of the selected document.

	Visit manager *Allows to manage the existing visits – role_om*

When opening the *visit manager*, a form with a table containing all the visits made and some of their data is shown. This tool allows to select a visit and open or delete it. The user is also allowed to filter visits by date

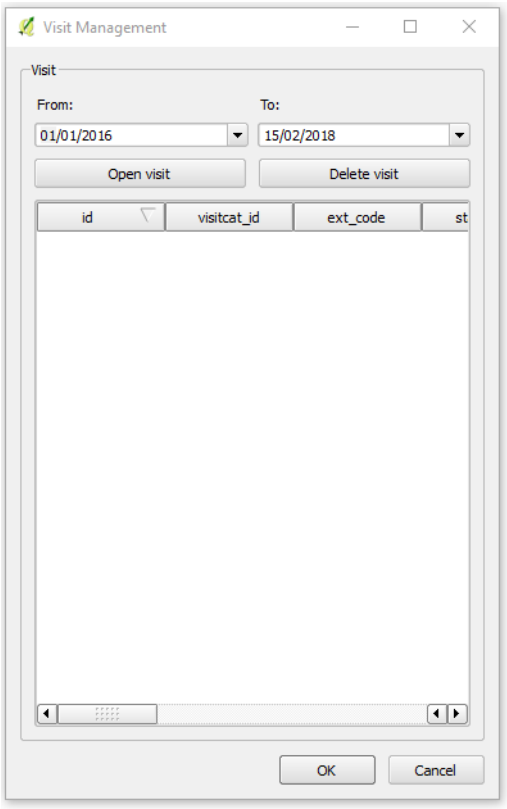


Image 42: Form of visit manager. Here all the available visits are shown and might be filtered by date.

	Date selector *Allows to set the dates– role_om*

This tool allows to establish the values for the dates of operations and management.

After clicking on it, a small form opens where it's possible to select a start date and a final date, which will be used later for other processes. This information is stored in the *selector_date* table and will be replaced as the user uses this tool and modify the values. The table allows only one set of date type values for each user, so that the same user can not have several dates available.

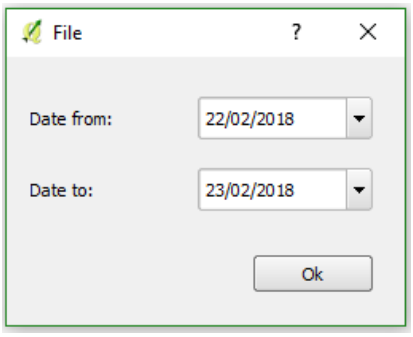


Imagen 43: Date selector. Dates inserted in this form will be used to set the dates of other processes.

The purpose of this tool is to simplify the use of dates of visits. If a user wants to create a view related to operations and management, he can filter the date fields using those in the *selector_date* table, and it will be very easy to update the values and use them as default dates. It is designed to establish values such as the following month or this week and use them in different scenarios.

To give an example of the usability of the tool, a query that generates a customized view that can be updated from the date selector is presented below. This view shows the valves, their geometry and their construction date:

```
CREATE VIEW SCHEMA_NAME.custom_view_name AS
SELECT node_id, the_geom, builtdate FROM SCHEMA_NAME.v_edit_man_valve, SCHEMA_NAME.selector_date
WHERE (builtdate, builtdate) OVERLAPS (from_date, to_date) AND cur_user=current_user;
```

To visualize the result thos view must be loaded in QGIS project. This view will be filtered automatically depending on the value that is put in the date selector. For example, if selected dates are from the beginning of 2010 until the present year, the view will only show the valves with a date of registration (field builtdate) between these dates.

To sum up, any table that has date values can be filtered through this tool, thus achieving a very simple method of representing information according to the needs of the user, who can customize the view.

5.2.3 Edition

The toolbar related to editing the network is the largest one. These tools are intended to facilitate the insertion, elimination or modification of existing data, especially in relation to geospatial elements. This includes basic tools for adding nodes or arcs, moving elements or connecting them together, as well as another block of tools to establish relationships with documents or additional elements.

. 	**Insert node** *Allows to insert a new node element – role_edit*

It's a basic tool that allows to add a new node-type element to the network, both for water supply and sanitation projects. To perform the insertion there are two options:

1. Click on an arrow on the side of a button and select from the list an element to insert.
2. Use the keyboard shortcut to select the element type to insert. The shortcuts must be previously configured in order to use this function. To do so, it's necessary to fill in the *shortcut_key* field of the *sys_feature_cat* table with a letter.

Once the node type is selected the next step is to place the element on a map by clicking the desired location. It is important to remember that many times a node will be inserted on top of an arc or another existing node. *Snapping* makes this task easy, but the important thing is that when inserting a node on top of an arc it will be broken in two parts to maintain the topological coherence of the network. Here the rules of the state topology come back into play (***3.7.4***): if the state of the arc is the same as the state of a node (except for obsolete elements), the node will be inserted and the arc will be divided; if the states of the elements are different, the node will be inserted, but without breaking the arc.

Clicking on the place of nodes insertation will automatically open the form related to it. Here the information referring to the new element can be added. Fields with (*) are mandatory and therefore must always be filled in; however, to facilitate the fast insertion of elements, some of these fields can be filled in automatically thanks to the functionality of Giswater. The exploitation, dma and sector of the new element will be captured directly in case the new element is situated within the limits of these zone layers.

The rest of the fields must be filled in manually or using some of the default values, which must have been previously configured.

Finally clicking OK will finish the edition and the new element will be inserted.

	Insert arc *Allows to insert new arc element – role_edit*

This tool allows add a new arc to the network. The flow of using it is exactly the same as of insertion of a node, with the exception that in the case of arcs it must be drawn between two nodes. In case of not doing so, the insertion will be erroneous, since the topological rules says that an arc has to have nodes at its ends. To draw an arc the first step is to click on the starting point and then draw different sections in desired direction until clicking again with the right button to finish the arc.

Once the insertion form of the arc opens it's important to know the differences that exist in some fields, since the arcs have specific attributes such as the length or the codes of the nodes. The other mandatory fields have the same usability as in the case of nodes.

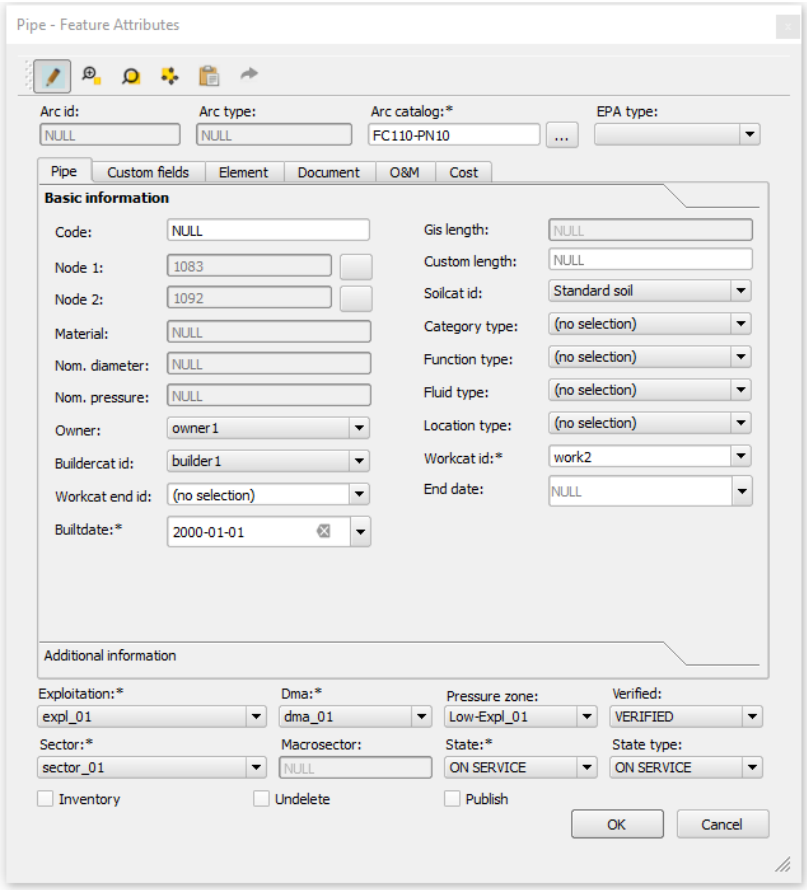


Image 44: General arc form, arc type *Pipe.* Most of the forms of elements are very similar, with some of the presented diferrences.

Finally, by clicking OK the edition is closed and arc is inserted.

	Replace node *Replaces an node with a new one and changes its state – role_edit*

The replace node tool aims to change an existing node to a new one. To do this, Giswater changes the state of existing node to obsolete and replaces it with a new node with the state on service. User can choose the type of node with which he wants to replace the previous one as well as modify its data.

When the tool button is clicked the cursor changes its appearance and allows to select the node that is about to be replaced. Once clicked on the item, a form opens where the work record of the elimination and creation of the elements must be chosen. If the work record doesn't exist in the *cat_work* table, there is a possibility to generate one directly from this tool by clicking the button […].

In the second part of the form there are the parameters of a node; here the current node type is displayed. At this time the new node type must be selected together with its specific catalog (a drop-down list that refers to the *cat_node* table). If *Keep elements* checkbox is marked, the elements and documents related to the old node will be saved for the new one.

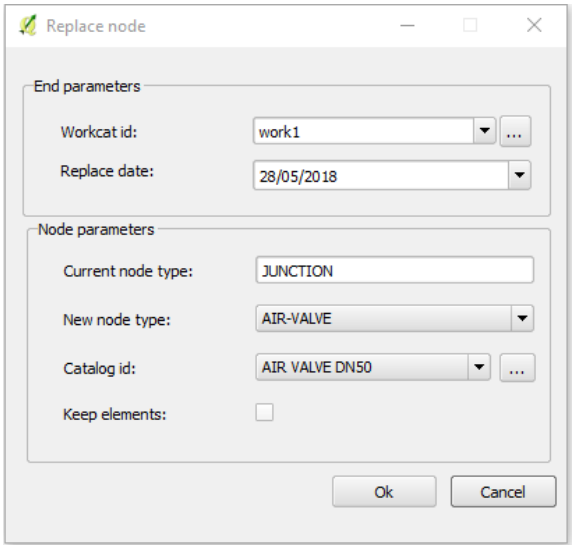


Image 45: Form of replace node tool. In this example a filter is replaced by the air valve.

In order to check the result of this tool, it can be done using state selector. That will allow to see one node in a state on service (1) and another in an obsolete state (0).

This is a very useful tool because it facilitates the process of replacing elements in the network, without having to worry about the topology since its position is exactly the same.

	Divide arc *Allows to divide an arc into two by placing a node over it – role_edit*

This tool allows to place nodes that are disconnected from the network on top of arcs. In this process the arc will be divided into two parts, which inherit the data from the old arc, but with new identifiers. It can only be done one by one.

The image 46 represents an arc that is a part of a network and a disconnected node. To move this node and place it over the arc, so that it becomes a part of the network, this tool must be used.

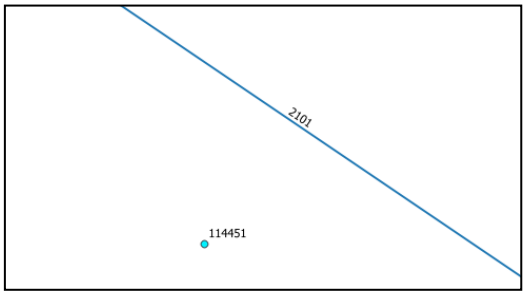


Image 46: Node 114451 is disconnected from the network and can be connected using *divide arc* tool.

Clicking the tool button and selecting the node 114451. Gives the possibility to draw an imaginary line to the arc that will be broken and where node will be placed. (Image 47)

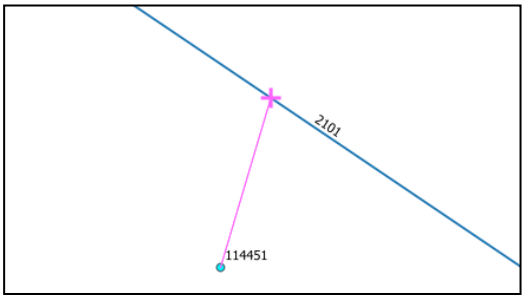


Image 47: The tool allows to move the node over the arc.

Finally, in image 48, node 114451 has been moved towards the arc and had divided it into two parts, one with id 114536 and the other 114537. The old arc with id 2101 has been removed.

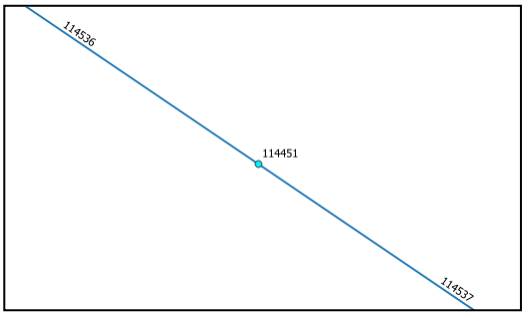


Image 48: Node connected to the network.

	**Arc fusion** *Allows to join two arcs in one, eliminationg the existing node – role_edit*

This tool does exactly the opposite of the previous one; It allows eliminate a node that divides pipes and thus join two arcs into one.

One of the requirements of this tool is that the arcs must be of the same type and belong to the same catalog, that is, the *arccat_id* attribute must be the same to be able to join them. The node can only be related to two arcs so that the process performs correctly.

It's important to keep in mind that if the node to eliminate has a *TRUE* value in the *undelete* field, it won't be possible to eliminate it. To do so this value needs to be changed to *FALSE*.

Knowing this, the flow of the tool is very simple: with the active tool cursor needs to be placed over the node that is going to be removed and after clicking it, a window will open warning about the elimination of the node. In case of accepting this node will be deleted and the two arcs with which it was related will automatically join in one with new *id*.

	Change node type *Allows to change the type of existing node – role_edit*

The change node type tool allows to select an existing node and automatically modify its type and catalog.

To use this tool, click its button and then select the node which will be changed. After selecting, the modification form will open, where the current node type is shown and whereit's possible to select the type by which it will be changed (Image 49). The catalog of nodes will filter according to the selected type of node. After clicking *OK*, the change will be made, without modifying the rest of the element's data

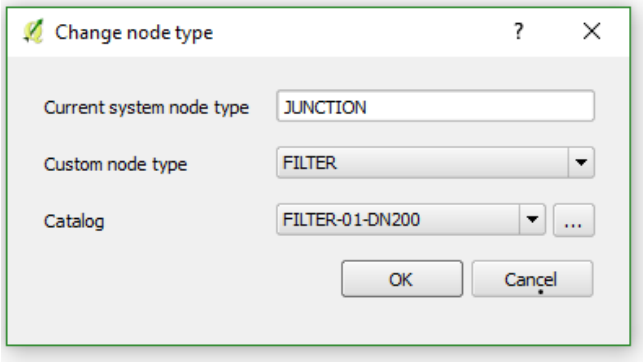


Imagen 49: Form of the change node type tool.

The usefulness of this tool lies in the fact that it allows modifying the type of node, a parameter that in the forms of the elements is not editable, in a very simple, convenient and fast way; without the need even to put into edition the selected node.

The Replace node tool and Change node type are very similar. Replace node deletes the old element and inserts one again, with a new identifier. In contrast to Change node type which maintains the identifier and does not deregister any element, it simply modifies its type.

	Connect to network *Allows to connect one or many connecs to the network – role_edit*

As we already mentioned, the connections are related with the network, specifically to the arcs, by means of links, which draw a straight line between the connec and the nearest network arc, where a virtual union node is located. The tool connect to network automates the process of creating these links and vnodes.

The objective of the tool is to connect to the network all connections that have no link. The tool allows to insert during one process as many links as the userwants, which makes it a very powerful tool and very easy to use.

By clicking the button to start the tool, the cursor changes its appearance and allows to draw a rectangle, within which the connections we want to connect to the network must be placed (Image 50).

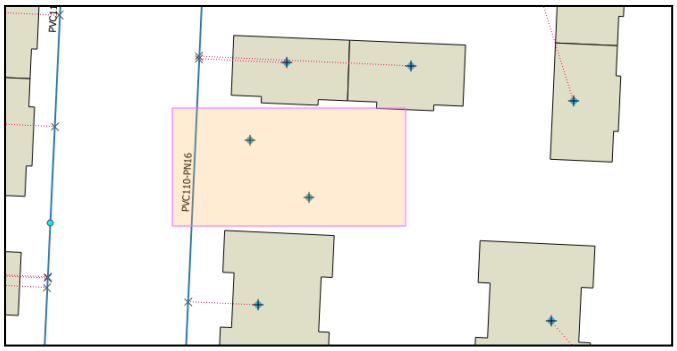


Image 50: Only the connecs inside the selection rectangle will be connected.

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At this moment the connecs will be painted yellow (selected), but it's still possible to draw another rectangle to select more connecs if needed, because those that are already selected will not be lost. It's important to know that to deselect connecs shortcut of *Shift* + *Ctrl* keys can be used together with drawing a rectangle that will act in the opposite way to the selection. Once all the connections are selected, clicking on the **right** button of the mouse will start the process. First a message will appear indicating the number of selected connections. After clicking *OK*, links will be automatically drawn from the connections to the network and at the intersection point the virtual nodes will be inserted (Image 51).

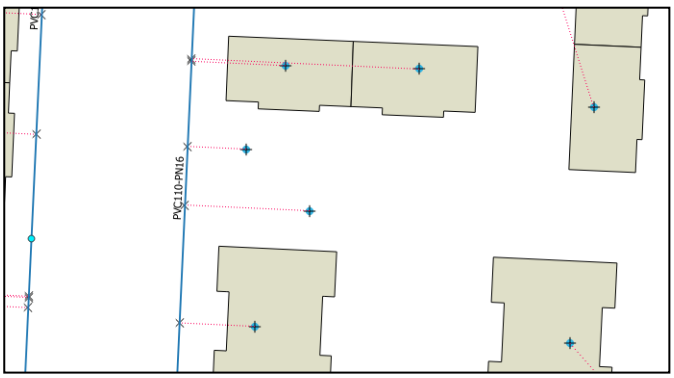

Image 51: Connecs already connected to the network with a link.

	Dimensioning *Allows to calculate and show the distance between elements – role_edit*

The purpose of the dimensioning tool is to offer the possibility of calculating distances within the map, either in relation to elements of the network or with elements of the base map. It is also possible to use the tool in spaces of the map where there is no layer.

As has been already said in previous sections, the dimensions are a linear geometry layer that is represented on the map by means of a view (v_edit_dimensions). This allows that the stored values can be represented on the map, offering additional information which may be valuable for networks with a particularly accurate digitization

How to use this tool? Clicking the button activates it and mouse cursor changes. The dimension is drawn as any other line, beggining by clicking on the point where it's supposed to start, finishing by clicking at the end point and terminating the process using right button of the mouse. In case of making dimension with more than one segment, drawing lines can be continued by clicking the left button.

Once the line is finished, the form opens, where more data may be introduced.

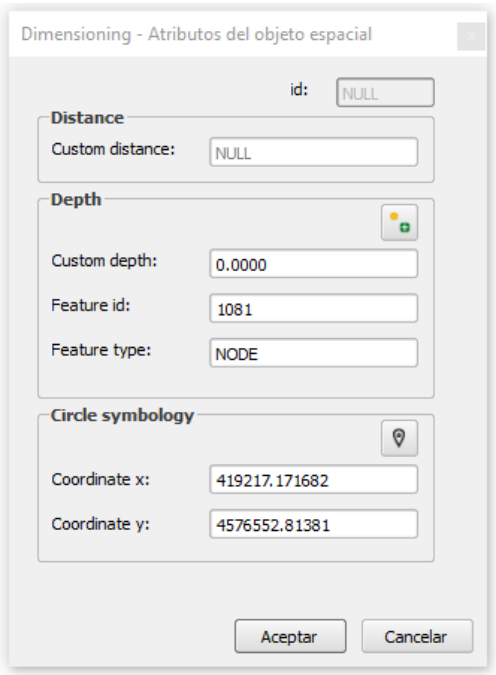

Image 52: Form of dimensioning, where data related to depth and distance may be introduced together with the coordinates of a circle symbology.

If the distance of the created dimension is known to the user, it can be introduced into *Custom distance* field, in case of leaving it blank the tool will calculate the distance from the map. If the depth of created dimensioning is known, field *Custom depth* should be filled. Otherwise, there is an option of selecting a node or connec and using its depth. In addition, the tool stores the *id* and the selected element *type*.

The tool offers different symbologies depending on the zoom of the project. The dimension data can be displayed as a label of a line or in a circle. Using the button below the coordinates of the circle location can be captured.

In images 53 and 54 the examples of the different types of dimensioning symbology according to the project's zoom is presented.

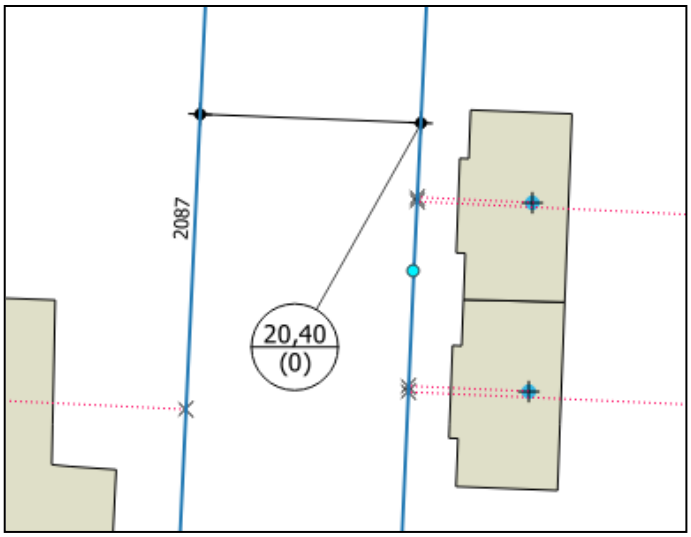

Image 53: Example of circle symbology. In the top part of the circle the distance is shown, above the depth. This type of symbology is programmed for small scales.

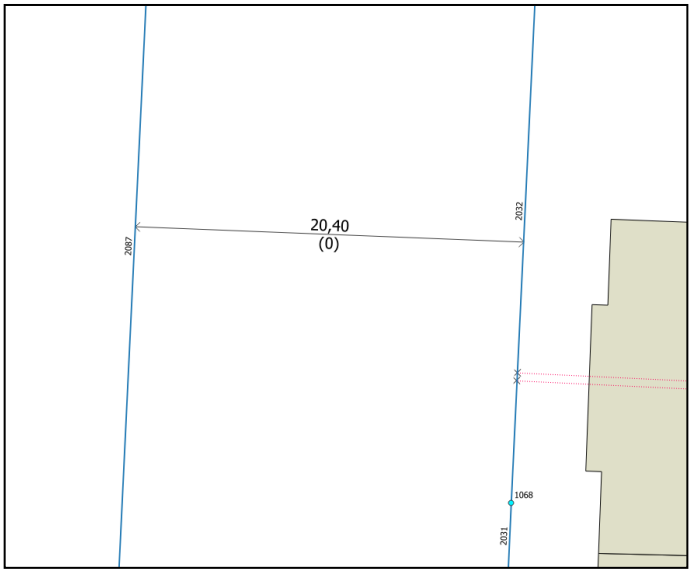

Image 54: Example of line symbology of the dimension (same case as in image 55). This type of symbology is programmed for big scales.

	Add document *Allows to relate a document with network elements– role_edit*

Many times, the elements of the network will be able to have linked information stored in external documents. As presented in other sections, this is possible with Giswater, since the element forms have a specific tab where a document can be created and linked with it.

This tool aims to link documents with one or more elements of the network, which can be opened and visible directly from the *plugin* and its forms.

Clicking on the tool button automatically opens the form to add a new document (Image 56). Here the data of the document: id, type, observations and the link with the path to the file or website must be enter.

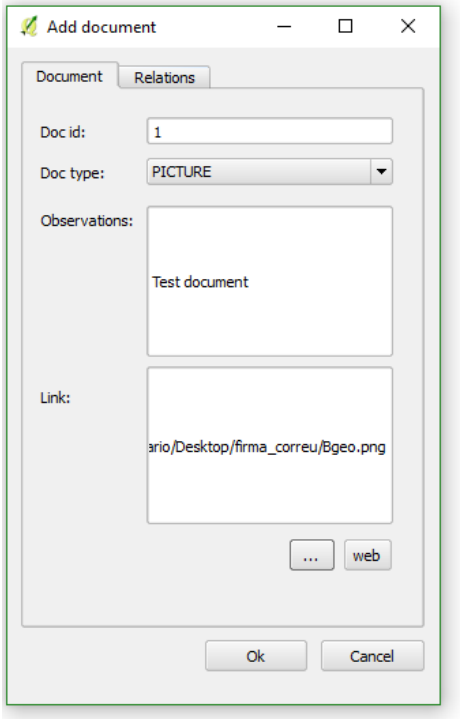

Image 55: First tab of creat document tool where the basic information is added.

Next, in the *Relations* tab, all the elements with which the new document will be related can be selected. Nodes, arcs and connecs must be added separately. They can be selected in the usual ways: with the buttons (+) and (-) they are added and deleted in the list of elements, by means of the *id*, or using the selector on the map, creating a rectangle to select different elements at the same time.

In the example of the image 56, the document that is being added in this process is linked to the node with *node_id* 1019.

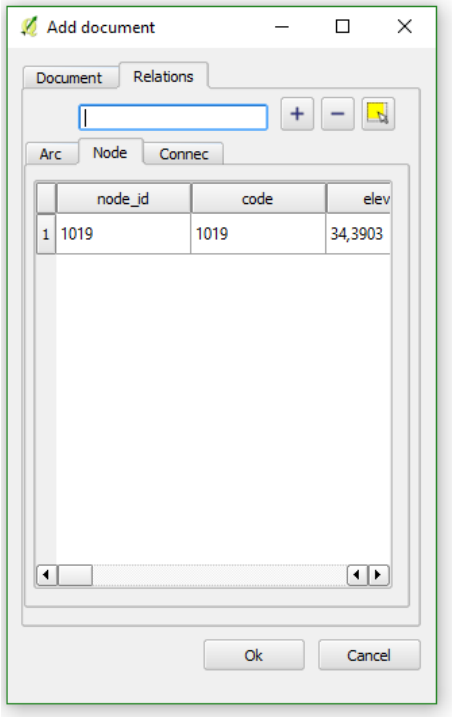

Imagen 56: Second tab of the tool form, where document is being linked to the elements of the network.

To verify the correct linkage of the document with the node, the form of the *Junction (node_id* 1019) can be opened, where, in the *Document* tab, the linked document with *doc_id* 1 should be present. The document may be opened by double clicking on the row (Image 57).

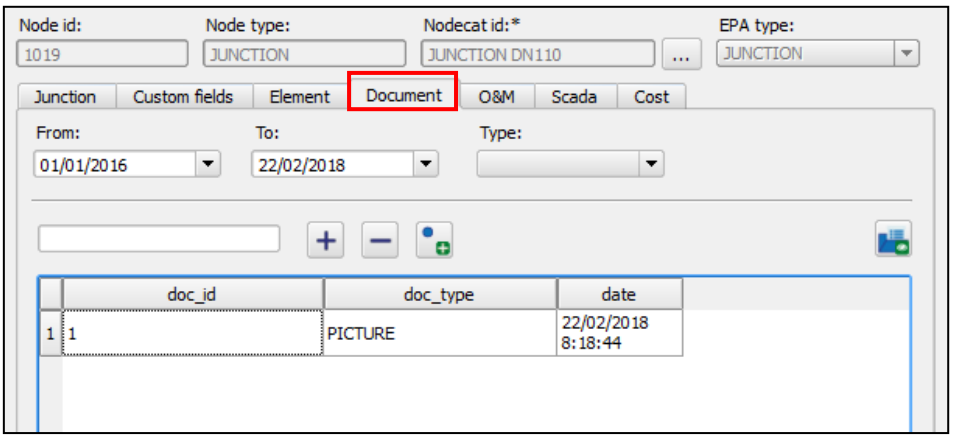

Imagen 57: Form of element to which a document was added. It's possible to check whether the link is correct.

This example showed relation to only one element, but the proces of relating it to many is the same.

	Document manager *Allows to see all the documents related to the network– role_edit*

The document manager is a tool used to inventory, visualize, filter and delete all the documents that have been linked to any element of the network.

In the form that opens after clicking on the tool a table with all the available documents is displayed. The table shows the following data:

- Id
- Document type
- Path
- Observations
- Date
- User that added the document

A document may be oppened using a double click on a row.

In the top section of a form a filter is located, which allows to list the documents in function of its *id*. On the right from the filter there is a button that allows to eliminate a selected document.

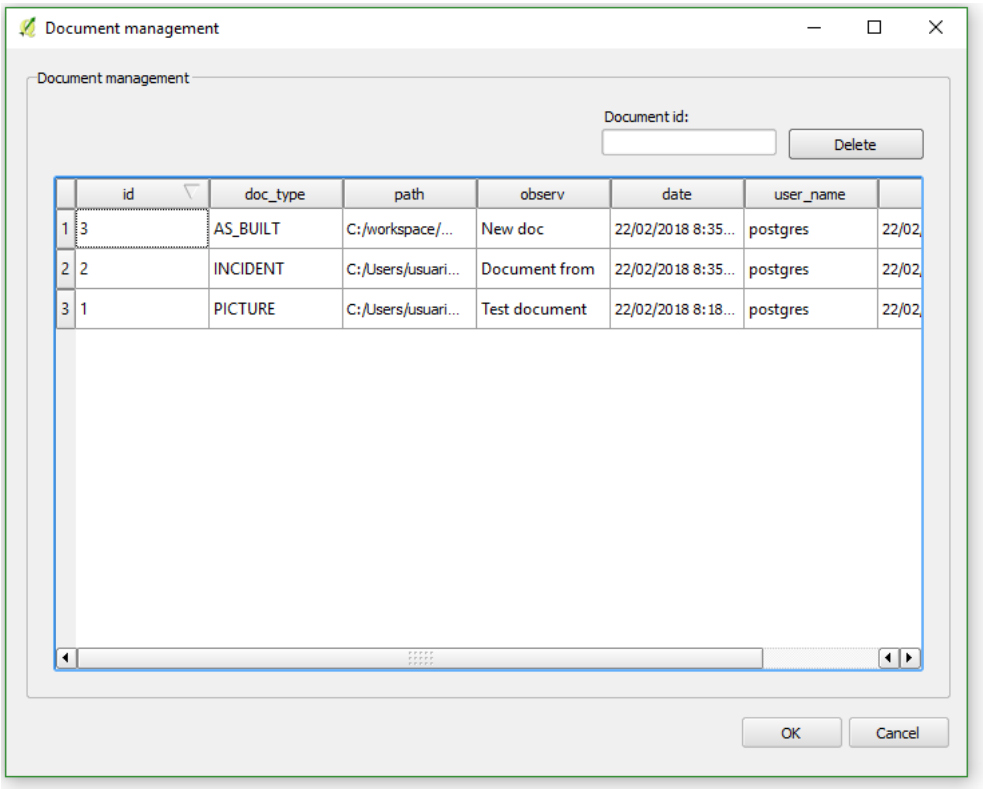

Image 58: Form of document manager. Here all the documents related to the network are visible. Form allows to filter, show and delete them.

	Add element *Allows to relate an element with other network elements – role_edit*

This tool is very similar to *Add document*, since they share the same objective of linking something with the elements of the network. The difference in this case is found in the type of object that is related; If an external document has been added before, now other elements will be linked with the elements of the network. In section **3.2** has been defined what elements are and that they have their own catalog, therefore, if a new element is added it must be related to any of those defined in the catalog of elements (*cat_element*).

Clicking on the button to start the tool will open the form to add a new element (Image 59). Here the data of the new element must be entered. Many fields are selectable in different drop-down lists. There is also a possibility to add the geometry of the element

Once the data is entered, in the *Relations* tab, new element must be linekd with the other elements of the network (arc, node, connec). To do this exactly the same steps as those of the *Add Document* tool must be followed.

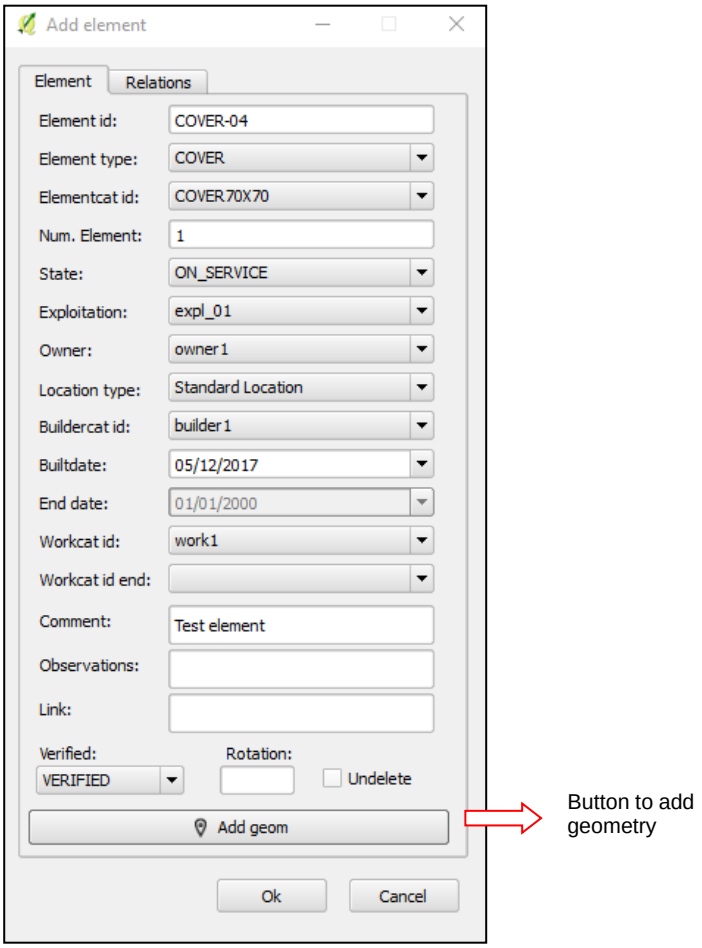

Image 59: Form of adding a new elementa and relating it to an existing elemento f the network.

	Element manager *Allows to see all the elements related to the network – role_edit*

The element manager, like all the management tools presented before, serves as an inventory of the elements found in the project. It allows to see all these elements and their attributes.

Double clicking on a selected item opens its specific form. In addition, there is an option to filter by the *element_id* field and delete elements with the *Delete* button.

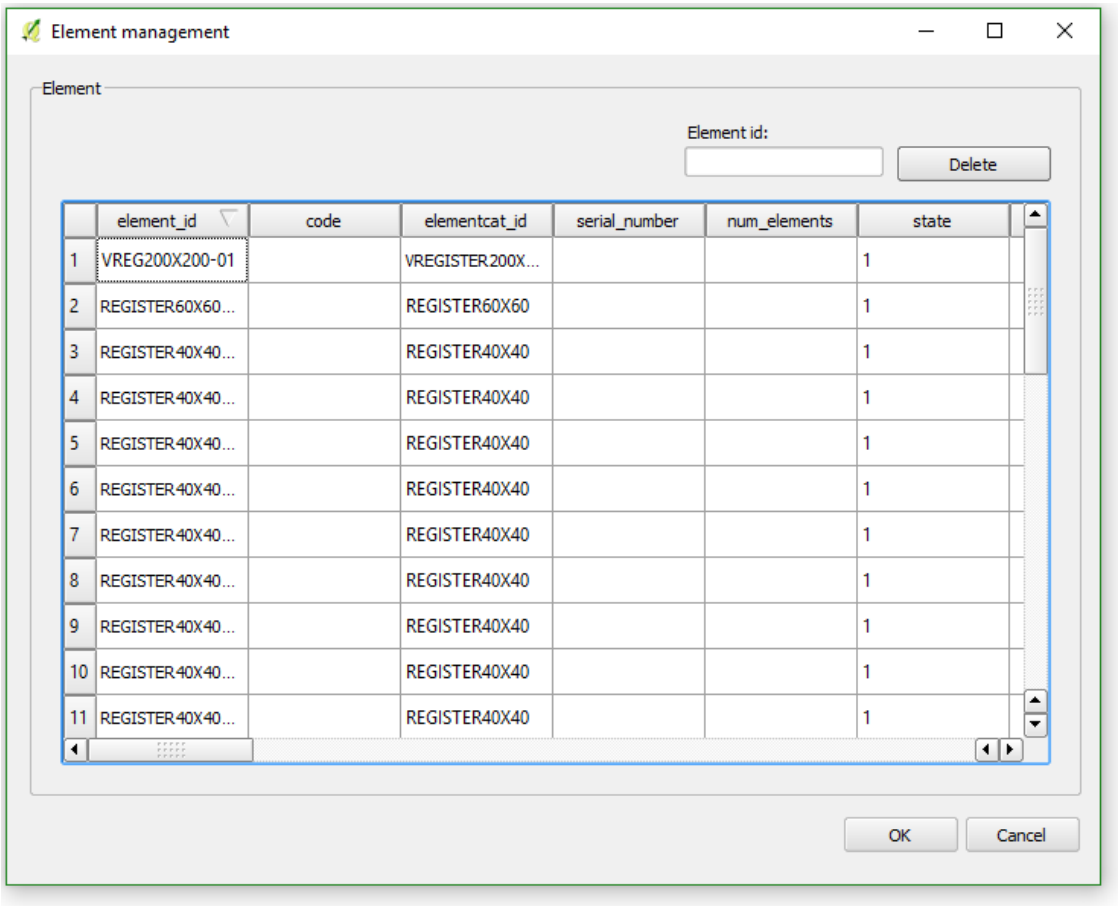

Image 60: Form of element manager. Allows to filter, show and delete elements.

	End feature *Changes state to obsolete – role_edit*

This tool aims to remove elements from the network, that is, change its status to obsolete. To do this, the elements must be on service. It is also necessary to take into account the topology rules when deleting elements, since it will not be possible to do so if, for example, the selected node is connected to other arcs. To 'end' the element it must be disconnected from the network.

In this case, Giswater permits an exception. Users are allowed to disconnect arcs that have associated connec-type elements, so that the arc will be disengaged and the related connecs will lose their link with the arc. This allows to facilitate the editing of the network in cases where it's necessary to cancel an arc and losing the relationship with the connec is not important. By way of prevention, the program will always show a list of all the elements that will be disconnected before proceeding.

When clicking on the tool button, the form to remove the item will open. First, it's necessary to fill in some data of the 'end', such as the date or the work record (a new one can be created at this point). The next step is to relate the 'end' with one or more elements. In the Relations tab all the elements that will be canceled should be selected. Once chosen, clicking OK will carry out the state change.

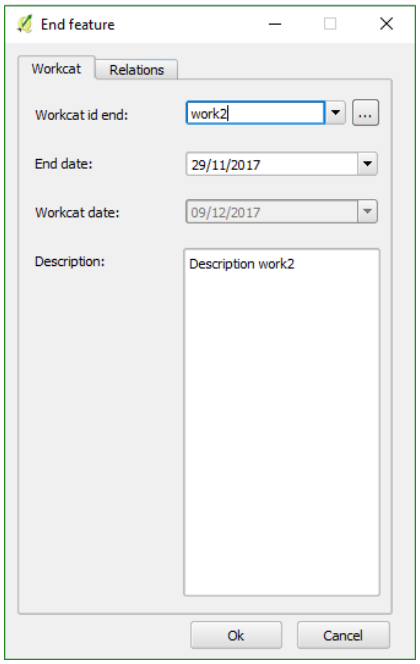

Image 61: Form of end feature. In the tab Relations it's posible to link one or many elements that will have their state changed to 0.

It's important to remember that the 'ended' elements will become obsolete, which does not mean that they will be eliminated. These will be equally visible if the obsolete elements are visible in the state selector.

	Create a circle *Allows to draw a circle in selected position – role_edit*

Draw a circle is the first of the two CAD tools that Giswater has. There are grouped within editing role, although they are in a small bar separated from the rest of the editing tools.

The objective of this tool is to draw a circle around a specific point with a radius set by the user. This circle should serve to draw support points when digitizing the network.

To facilitate the use of this tool it's neccessary to have configured the snapping of QGIS, since it will only be possible to draw circles using as reference elements configured in the *snapping*

After clicking the tool button will change the cursor shape. That's the moment of choosing the location of the center of a circle on the map. Next, the program will show the option to set a radius for this circle. Once entered the value and clicked *Accept* the circle will be created automatically.

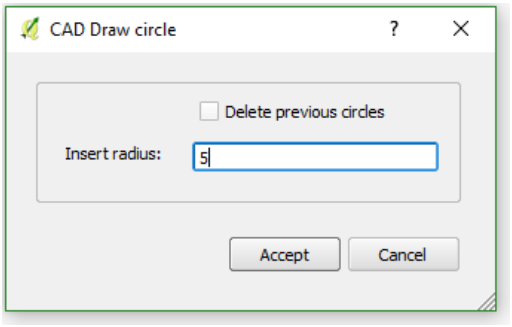

Image 62: Form in which the radius of a circle should be entered.

This circle and the rest of the elements that are generated with the tool will be stored in an auxiliary view of the database (*v_edit_cad_auxcircle*). If the view already contains too many unnecessary elements it's possible to eliminate them by clicking *Delete previous circles* checkbox and the view will empty at the end of the insertion of the new circle.

Knowing the radius of the circle and using its geometry as a reference, thanks to the *snapping*, inserting reference points that help drawing new elements in exact locations is possible.

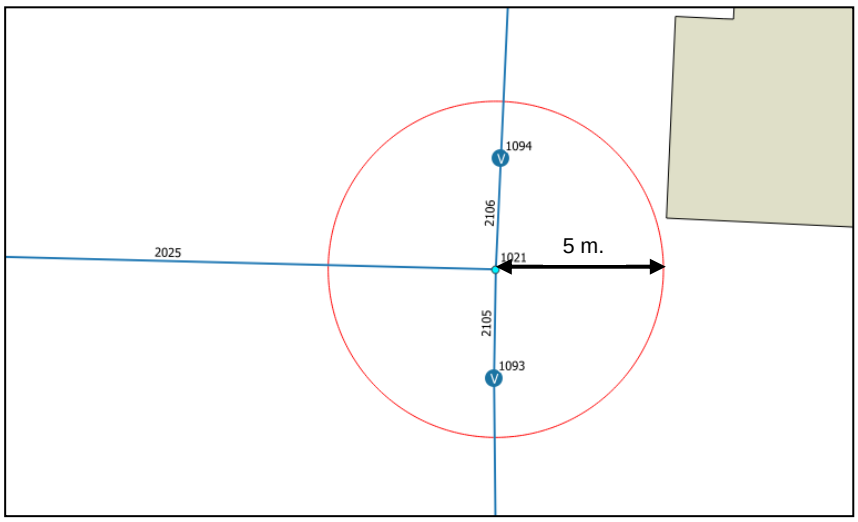

Image 63: Example of a circle generated with the tool. In the form, showed on the previous image, the value radius 5 was introduced.

	Add point using relative coordinates *Allows to draw a point in defined distance from another element – role_edit*

The second CAD tool of the Giswater *plugin* is the one that allows inserting a point element at a distance (x, y) relative to another point on the map. The point of support generated should serve as a reference to draw new arcs and nodes of the network.

To add a new relative point using this tool, after clicking the button first step is to mark two points on the map, either above other elements or in empty points. The imaginary line joining these two points will serve as a reference to introduce the relative point. Once selected, a form will open whith the fields to set the distances.

The X distance is the position where the support point will be located respecting the x coordinate of the beginning of the imaginary line. The Y distance is the position where the support point will be located respecting the y coordinate of the beginning of the imaginary line. Using the two distances the element will be placed. Both values admit negative numbers, because only then placing points in all direction is possible.

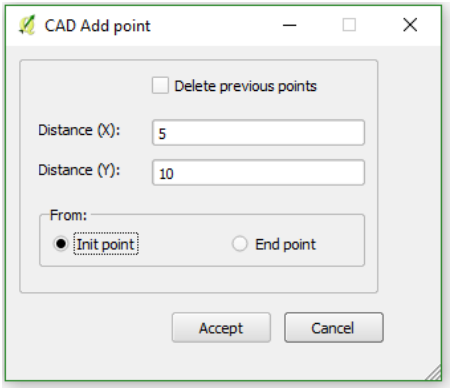

Image 64: Form of adding point using relative coordinates.

In the section *From* there are two options available: *Init point* the distances will be taken from the point which was clicked as first and *End point*, the distances will be relative to the second selected point.

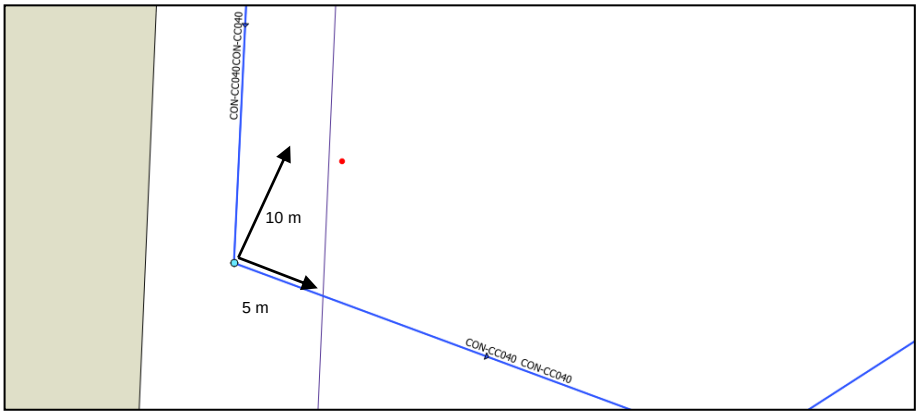

Image 65: Example of a relativo point located 5 meters of x distance and 10 meters of y distance from the *Junction* node. That's where the first click was made, the second one was made above, on the horizontal arc in order to follow the same direction.

All the support points created in a project are stored in an auxiliary view, in the same way as in the other CAD tool. In this case the view is called *v_edit_cad_auxpoin*t and itt can be found in the *BASEMAP* group of the ToC.

5.2.4 Hydraulic model

The group of tools related to the hydraulic model is the one used by users specialized in the management of hydraulic behavior in the distribution or sanitation networks. In addition to knowing the use of the four tools that make up the group, users should also be very clear about the data that is necessary for the models to work properly. These data are described in sections **4.2.3** and **4.2.4**. The characteristics and specific operations of the hydraulic model are explained in detail in section **7** of this manual.

	Go 2 EPA *Allows to export and import hydraulic model of the network – role_epa*

Go 2 EPA is the group's main tool for exporting the hydraulic model. Its objective is to obtain the results of this model, by filling in the corresponding tables and views, so that they can be automatically visualized in QGIS through a specific symbology.

Before using the tool, it is necessary to enter the mandatory data in the tables of EPANET (WS) or SWMM (UD) group, depending on the type of project. The tool has many similarities between both types, although there are parameters that are only specific for one type or another.

The process will be done in **two parts**, since the first one is done with the *plugin* and there are differences between both types of project, and the second with the Giswater *driver*, this being the same for both water supply and urban drainage projects.

FIRST PART - SPECIFIC

The operation of the tool in WS projects

When clicking the tool, main form opens, which has four buttons, designed to define parameters prior to the process (Image 66). First, there is the sector selector, which allows to choose which sector / s will or will not be a part of the hydraulic model that will be carried out

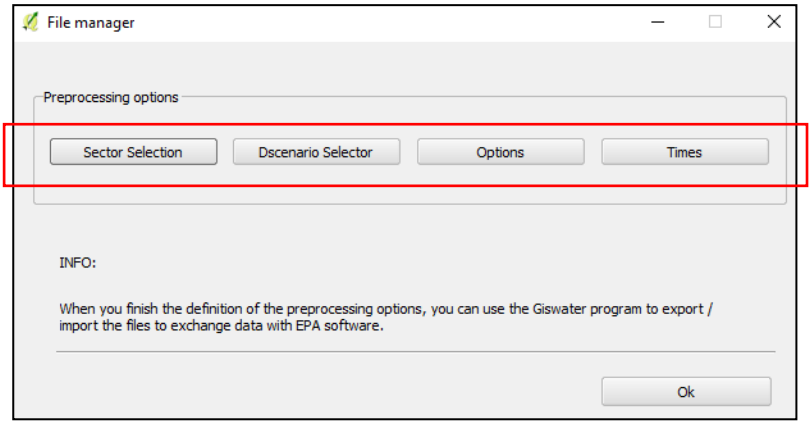

Imagen 66: Main form of Go 2 EPA tool with the options prior tothe process maked in red.

The second button is the selector of demand scenarios (**7.1.1.2**), which allows selecting a specific demand scenario, previously defined, to act on the exportation of the model. The performance is the same in all tools of 'selector' type, allowing to move different scenarios from one column to another.

The *Options* button, the third one, is where the user can define different variables related to the hydraulic model.

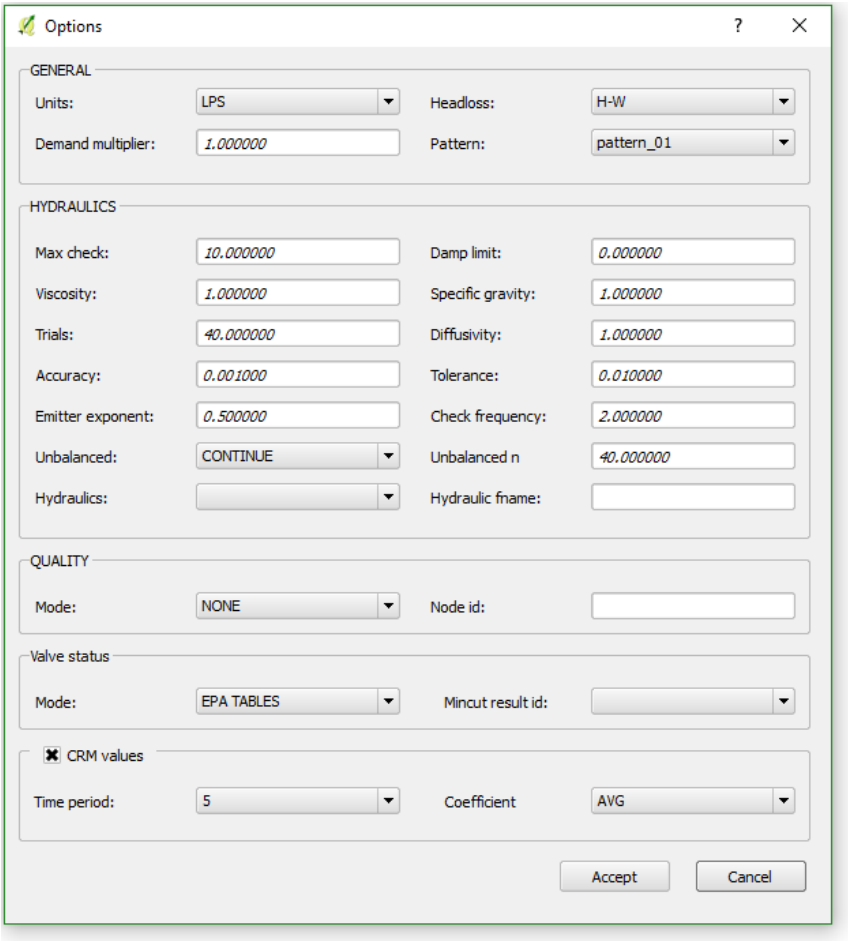

Image 67: Form of Options section of Go 2 EPA tool. All the data and configuration of the model should be introduced here.

All these fields are very similar to those used by EPANET program, therefore, the user in charge of this process, knowing the hydraulic operation, should already know how to fill in or modify the data.

Finally, with the *Times* button parameters related to the temporary variables can be defined.

The operation of the tool in UD project:

The tool is considered the same for both WS and UD, but, as already mentioned, the data, processes and results are different. If the project is related to urban drainage, then the form of the tool will be a little different. In the options buttons prior to the process, instead of the demand scenarios selector, there is a hydrology selector, defined in the table *cat_hydrology*.

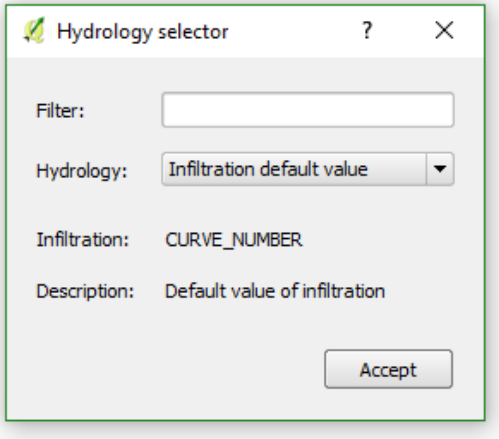

Image 68: Hydrology selector, which has the information related to the infiltration.

In reference to the *Options*, these are very similar to those of the SWMM program, therefore, knowing these, it's easy to fill in the form correctly. The *Times* tab, like in WS, allows to establish certain values of the time variables, which will be specific for the drainage data, much more related to the climatology.

SECOND PART - COMMON

The second part of the export / import process of the hydraulic model is carried out after the first one, that is, once the database has the hydraulic data and the options of the specific part correctly configured.

At this time, it is necessary to reuse the Giswater program, where *Go2Epa* button is located.

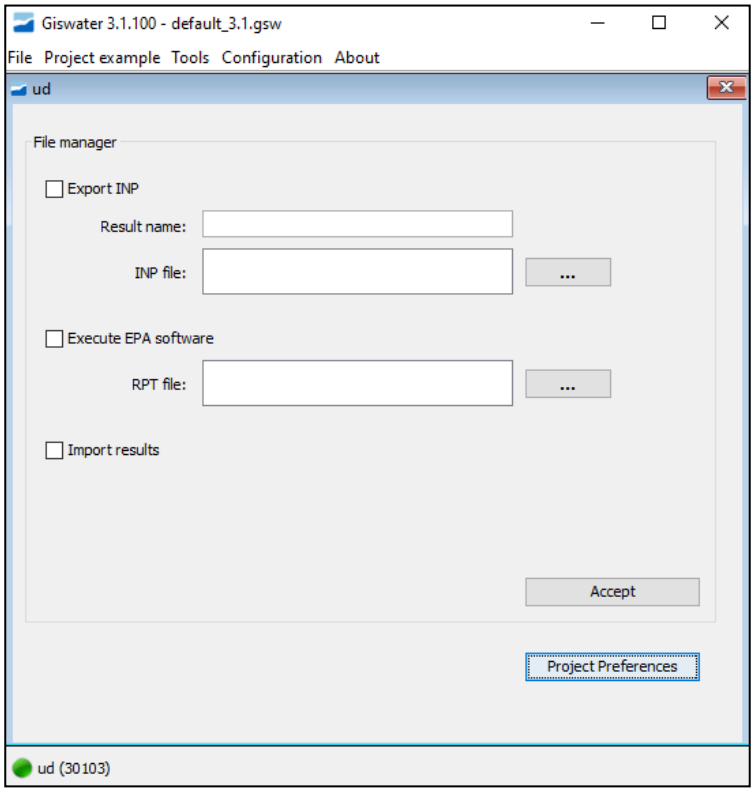

Image 69: *Driver* of Giswater allows to establish the paths where the files related to hydraulic model will be saved. In order to go to this page, click *Go2Epa* button located in Project preferences.

In the page that will open after clicking the button, the name for the corresponding export must be defined. It's also necessary to establish the routes in the computer where the *inp* and *rpt* files, generated at the end of the process, will be stored.

	Epa result manager *Allows to manage all the different results of carried out models– role_epa*

The *EPA Result Manager* tool allows to visualize the data of the different results of the import and export processes of the hydraulic model.

The form of the tool shows, for each row, different data of each one of the model's results. As always, filtering based on the result_id field is possible and rows can be eliminated using a *Delete* button.

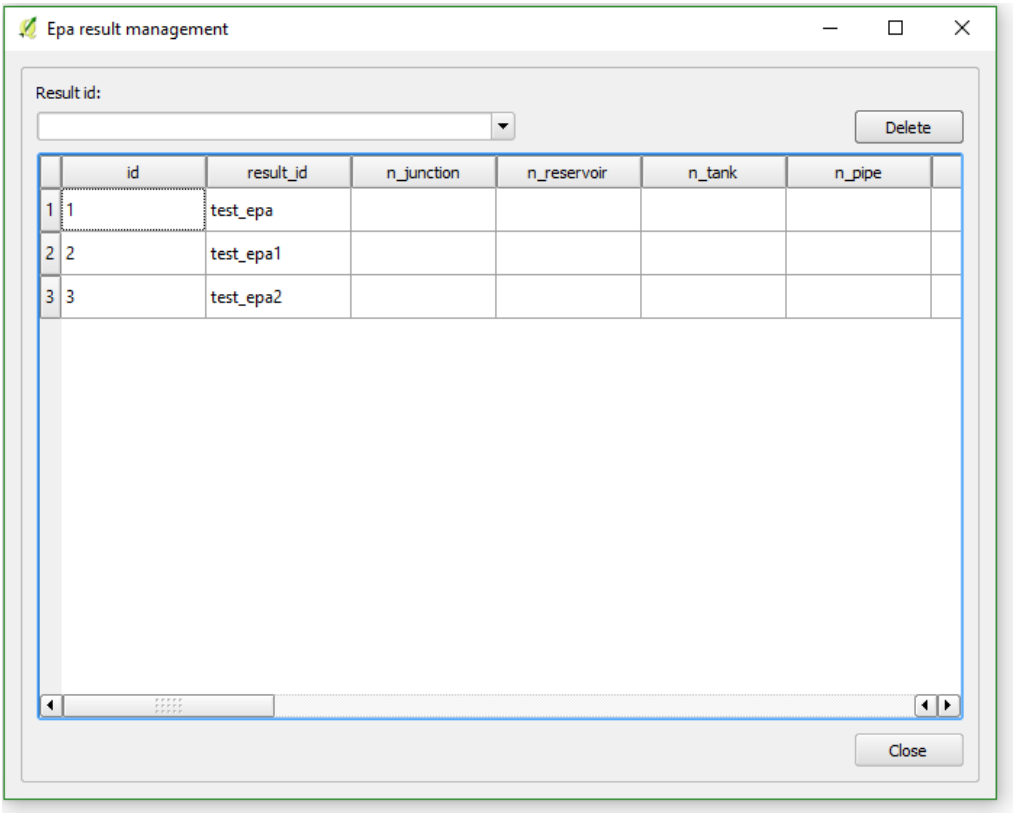

Image 70: Form of the EPA result manager. All the resutts of the exportation of hydraulic model are shown in the table. They can be filtered, showed and deleted.

	EPA Result selector *Allows to choose the results to visualize them in QGIS – role_epa*

This tool is used to establish the results of the hydraulic model that will be displayed in QGIS at that particular moment. The data of the chosen result will be the ones that fill in the different views present in the project, so that it is possible to see results of old processes, sectors or specific scenarios.

One of the highlights of the information management regarding the hydraulic model that Giswater does is the possibility of using data from two different results at the same time; first main one and another that serves to compare and visualize the existing differences.

With this tool it is also possible to select the result with which the main one will be compared, so that the data will appear in the comparison tables. These results will have the same style as the main ones, therefore, it will be possible to play with both groups and compare results.

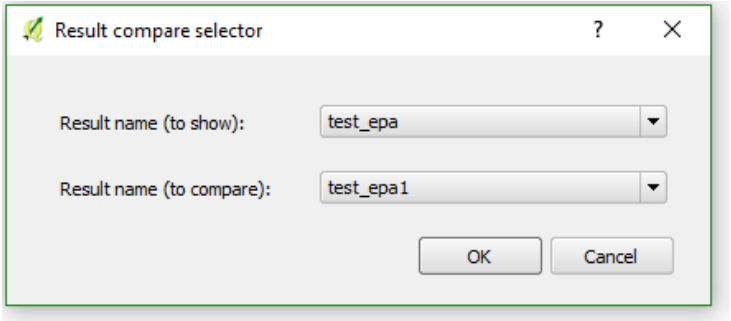

Image 71: Form of EPA result selector tool with two simple filters. First is a list of main results, that will be displayed in the QGIS layers created for this purpose. Second are the result for comparing, which also have its layers in the QGIS and are easy to visualize and compare.

The functioning of this tool is very simple: select the main result in the first *combo box*, which will show all available results. In the second *combo box* select the result that will serve as a comparison. Clicking the *OK* button will update the data and can be used.

5.2.5 Masterplan

The planning tools are specially designed for users in charge of issues related to budgets (both at the level of individual elements and of actions with multiple effects) and the management of planned sectors of the network. For the correct functioning of this group of tools, the project and its data must be specially configured and with great accuracy.

As already explained in section **4.2.5**, referring to the tables related to planning, the first step of all is to fill in the price data of the elements. Prices should be inserted in the *Simple Price*, *Compost Price* and *Value Compost Price* tables and these will be linked to the elements present in the results tables of their category:

- *Plan result node*
- *Plan result arc*
- *Plan psector x node cost*
- *Plan psector x arc cost*

If in the planning operations an economic planning will be carried out, it is necessary to fill all the prices of the fields of the tables that are related to it. For more information, see section **4.2.5**.

The different tools that make up the masterplan group are be explained below:

	**New psector** *Allows to créate a new sector of planification – role_master*

This tool aims to permit user to create a new planning sector and assign the elements with which it will be related, as well as show the cost details of the set of operations that would be necessary to carry out the project.

First, when the tool starts, the *psector* form appears (Image 72). This form is similar to the one that each specific element of the network has, but referring to an entire sector of the map and therefore to several elements.

In the initial tab the basic data of the *psector* must be enterd: name, priority, exploitation and sector to which it belongs, type and other observations.

At the moment, after clicking OK, the planning sector will be created. At the beginning it will appear without geometry, but at the moment it begins to have relations with elements, a polygonal, rectangular geometry will be automatically generated around the linked elements

.

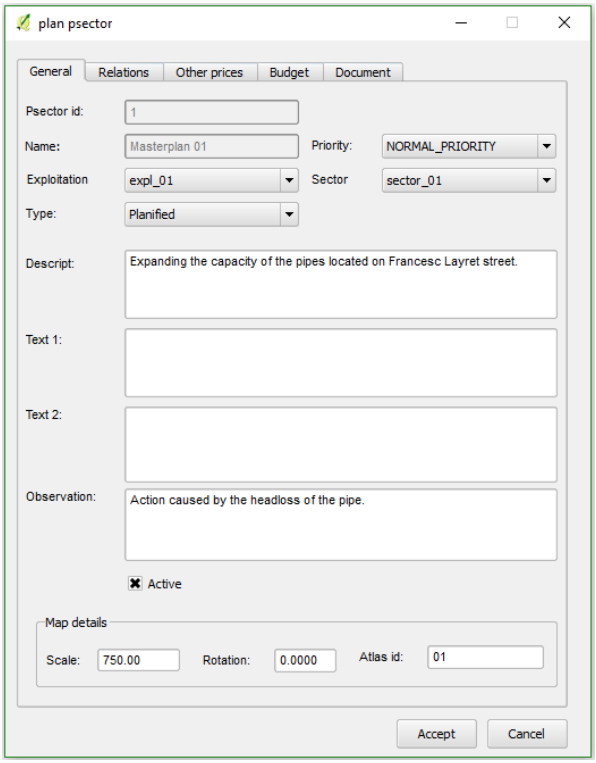

Image 72: Form to add a new planification sector. In the first tab all basic data can be added.

> **NOTE 08** It is very important to always generate at least one planning sector when user starts working with Giswater, since all elements with a planned state must belong to one. Without any planning sector it will not be possible to work with these elements and the program may show errors.

In order to link the network elements with a *psector* there are two ways:

- When inserting a new item with planned status. It will be directly linked to the planning sector that is selected as default at the time.
- Using the *Relations* tab of the form (Image 73) elements (arc and node) that will be part of the *psector* can be selected.

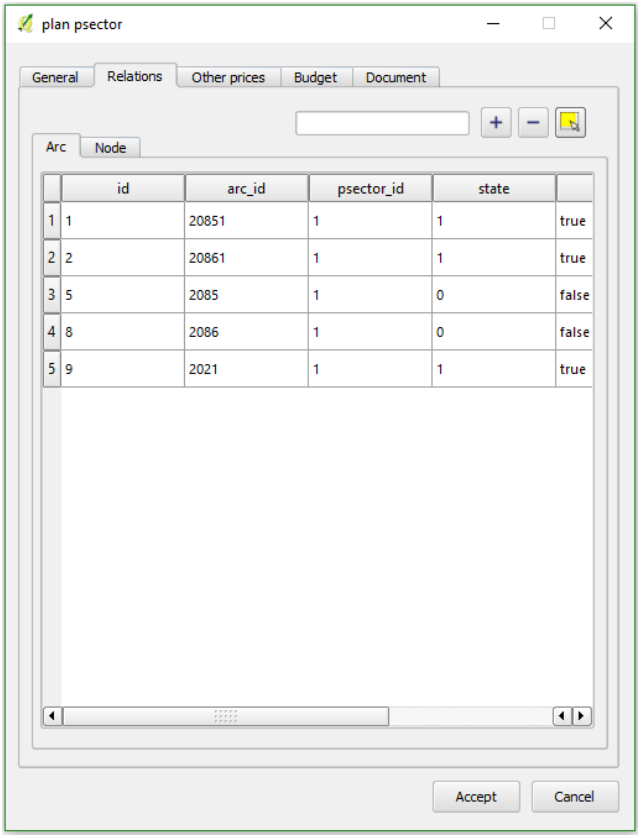

Image 73: The second tab of form is used to relate the elements of the network to the planification sector. They are located in two subtabs – arc and node.

In this tab the information of the related elements will appear. It is **important** to look at the **state and doable** fields. State refers to the state within the *psector*, it is not the state of the element in the network. Elements with state 1 will be displayed and those with state = 0 won't. *Doable* is used to establish whether or not the item will enter into budget calculations: TRUE will enter, FALSE will not enter. In many cases, the planning sectors need to incorporate existing elements in the network, which should not be used to calculate the price. The objective of this field is to allow such calculations. Those two fields will be filled automatically depending on the *state_type* of the linked element.

The third tab of the form is used to add to the budget of the planning sector the prices of any other parameters that are required to develop the work, apart from the value of the elements of the network. For example, the user can add prices for the transport of waste, excavation or any work that is necessary.

Selecting any of the prices and linking it with the total budget of the planning sector can be done by clicking on the lower part of the form with name ADD PRICES. The prices available in the *price_compost* table are shown here. All prices that are necessary for this budget can be added from here.

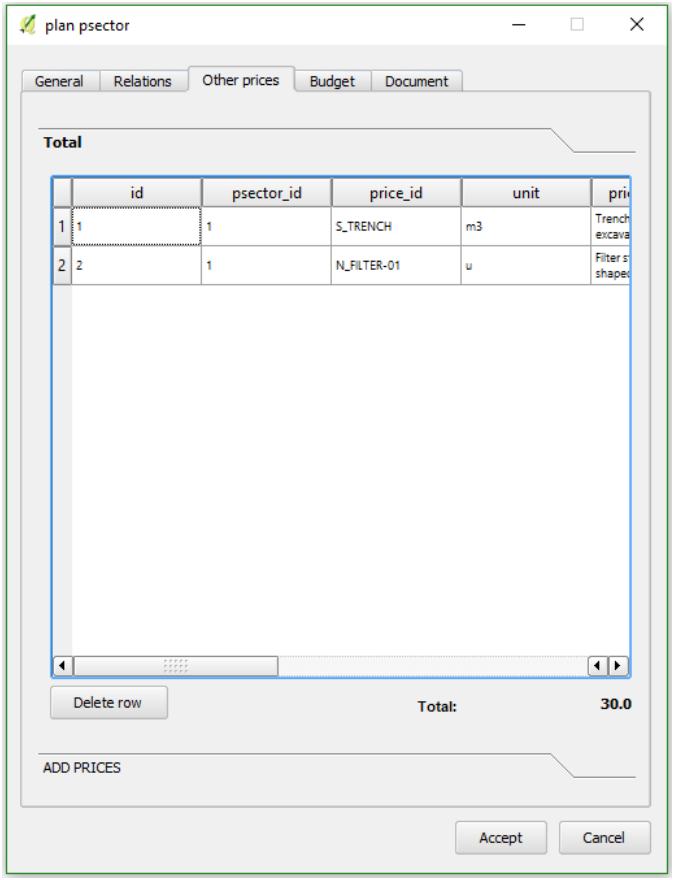

Image 74: Tab *Other prices* allows to link the costs not related directly with the network elements to the planification sector.

Tab *Budget* allows to see a budget summary of the planning sector. Here, the prices of the planned operations are detailed and presented in groups:

- Total value of arcos
- Total value of nodos
- Total value of other parameters
- General expenses (+19%)
- VAT (+21%)
- Others

With the sum of all these groups of prices the **total budget** of the project is generated.

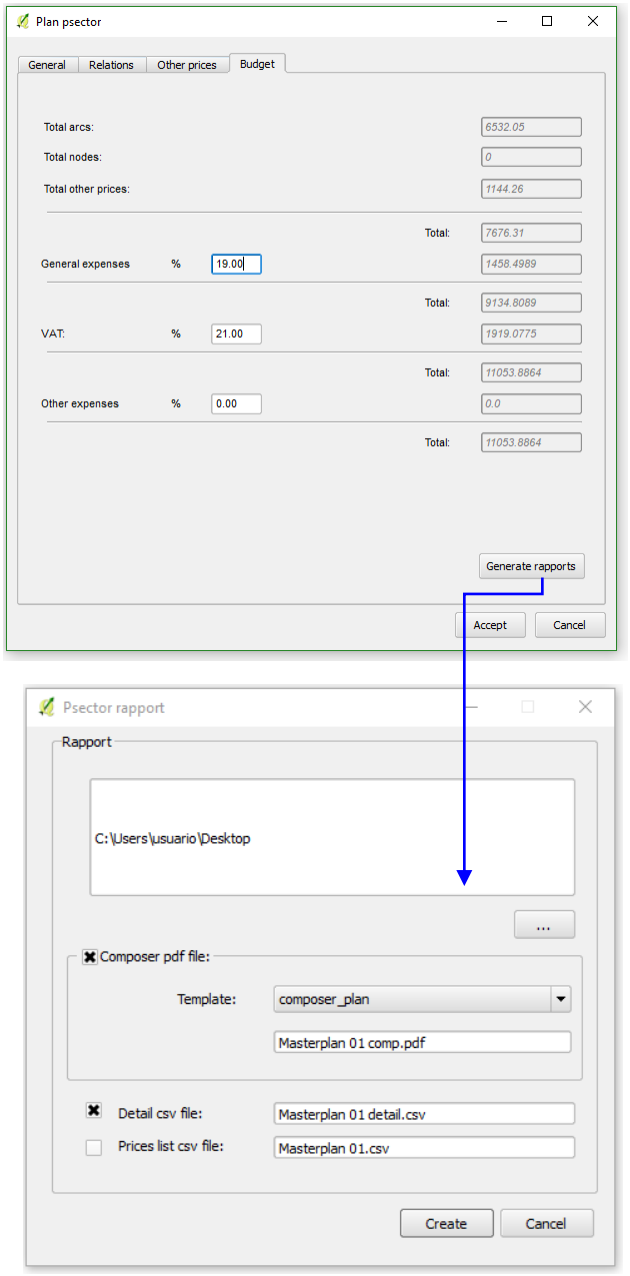

Image 75: The last tab of the form shows the total Budget of the psector. It's possible to create personalized reports with the data of psectors using the *Generate rapports*.

In the lower part of the form there is the *Generate rapports* button, which allows creating external files with the information about *psector*. There are three options to generate reports, each of them individually selectable based on the interest of user. The file in pdf format that can be generated by the QGIS composer can use templates that the user loaded into the project. Keep in mind that the template must be well configured so that the process could work properly.

The last tab, added in version 3.1 of the *plugin*, allows to link documents to a psector. These can be created from the existing form or link.

	Psector manager *Allows to manager the planification sectors– role_master*

The planning sector manager is a tool that allows to inventory, visualize, filter and eliminate existing psectors. In addition, it shows the planning sector which is selected as default at the moment and allows to change it by another one. The default psector is an important parameter, since all the planified elements that are inserted will be linked to it.

In the form, that opens after clicking on the tool button, a table with all the existing sectors and its data is presented.

It is possible to open the selected psector form with double click on the row. Unlike other Giswater management tools, this is the **only way to open the psector form**, therefore, it's very important to remember that while working on planification.

In the upper part of the form there is a filter, current default psector, button for changing the default psector and button to deleting the planification

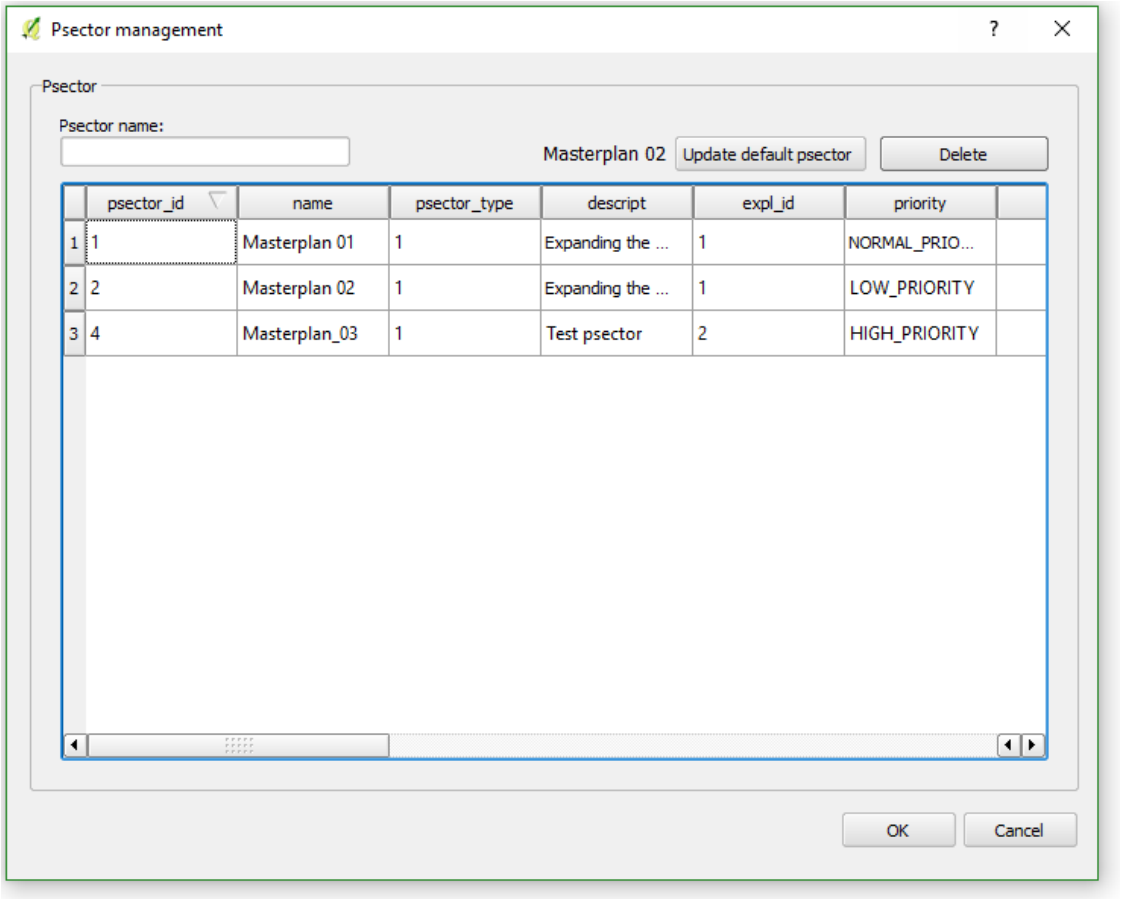

Image 76: Form of psector manager. All existing psectors in the project are displayed here. The tool allows you to filter according to the identifier, update the psector that will be used as default, delete data or open a specific form, where the user can view the related elements and associated budgets

	Psector selector *Allows to visualize or not the selected planification sectors– role_master*

This tool, like the others of the type 'Selector', allows to choose which sectors of planning will be seen on the screen at the moment. It aims to facilitate the management of these *psectors*, since seeing all their geometries at the same time can be inconvenient for user.

NOTE 09 The use of this tool coincides, in part, with the state selector. Users who have the right to use both tools should know that, even if the planned elements are desactivated in the state selector, with this tool the planned ones of the selected *psectors* will be displayed. In a contrary way, even if they do not have a selected *psector*, the planned elements can be viewed from the status selector. The difference is found in the fact that with the selector of *psector* the elements with state on service linked to the specific *psector* are hidden to show only the planned ones.

The usage of the tool is very simple. With the form opened, all the planning sectors that are on the right side will be visualized. The sectors that are not going to be displayed at this time should be on the list on the left. The change of columns is done by the arrows that are between them.

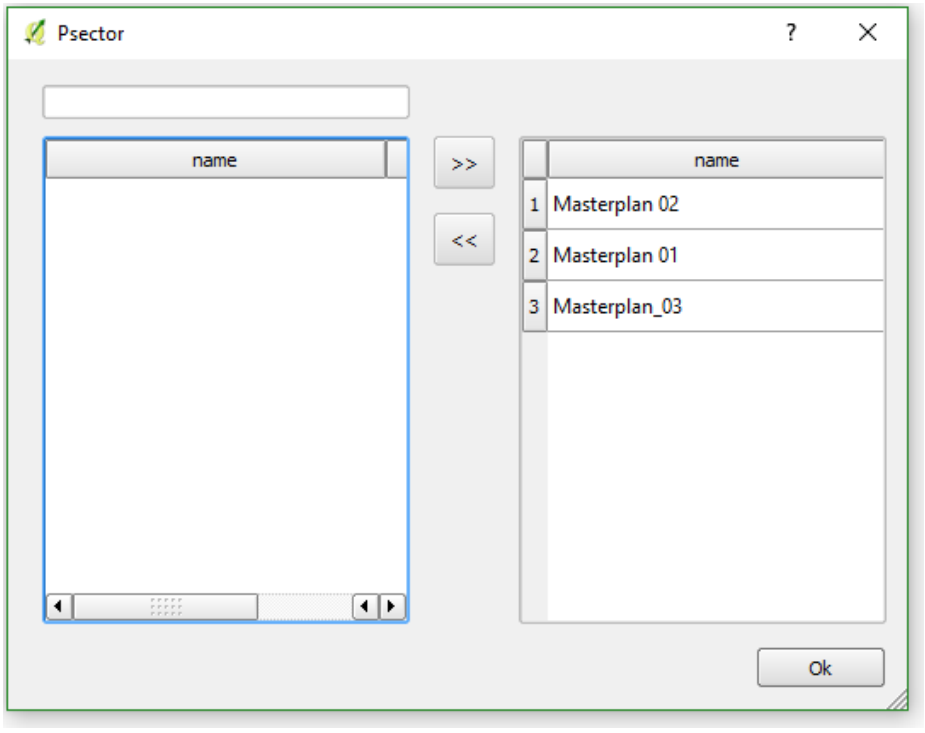

Image 77: Form of planification sector selector.

	New network cost *Allows to generate new costs of the network – role_master*

This tool allows to generate cost calculations of the network elements that are active (state = 1).

The only process that is carried out is establishing a new link between the active elements (state = 1), which already have their prices listed in the catalogs, and the current price base. There are two types of prices - rehabilitation and reconstruction.

The only thing to comment about the form are that prices that can have a multiplying coefficient, depending on what the report is intended for.

The form also supports a text field for any kind of observations.

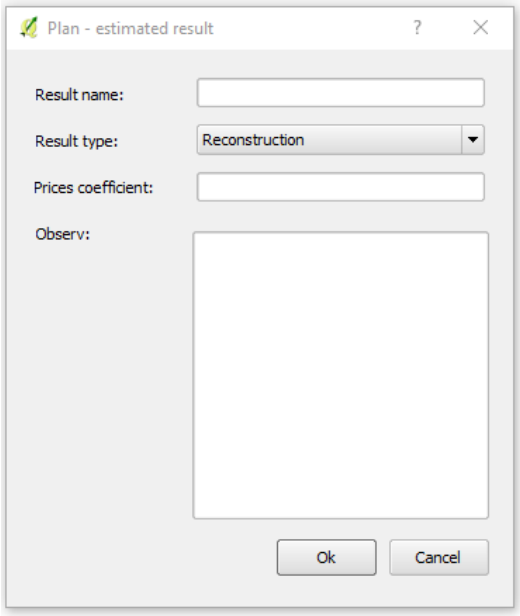

Image 78: Form to add a new cost of the network.

	Estimate result selector *Allows to select the result and work with it – role_master*

This tool, like the others of the type 'Selector', allows to choose which network cost calculation results (only those of rehabilitation type) will be displayed on the screen at the moment.

Selecting the network cost result as active result is used to replace the value shown in the views of *'v_plan_result_node*' and '*v_plan_result_arc*'. This value of interest is the one that will be displayed in the QGIS interface.

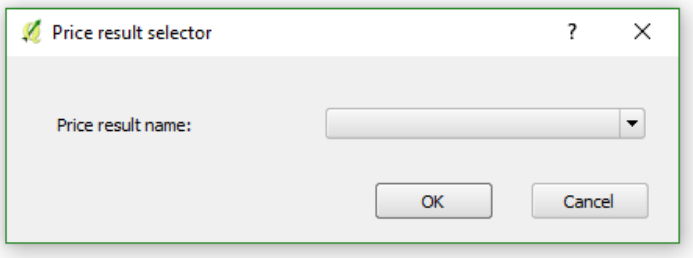

Image 79: Estimate result selector. The selection can be made using drop-down list.

	Network cost manager *Allows to manage different results of the costs– role_master*

Network cost manager is a tool that allows to inventory, visualize, filter and eliminate the different calculated network costs.

In the form that opens after clicking the tool button ther table with all the results is presented. It shows the data of each of the results.

It is possible to open the information relatef to the selected result by double clicking on the row.

In the upper part of the form it can be filtered according to the result identifier.

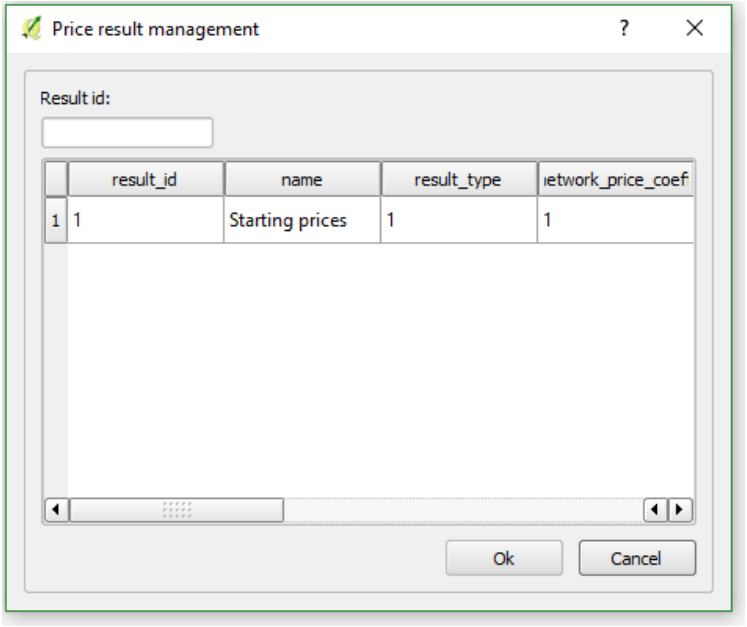

Image 80: Form of network cost manager. All the costs are showed here and can be filtered or opened.

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5.2.6 Administration

This last group of tools of the Giswater plugin is formed by tools that can be used for project management tasks. It is a heterogeneous group, with very different functionalities focused on general processes, unlike the rest of the toolbars that had much more specific role. Here there are tools that allow control, topology check, value management, data import and also Giswater's structural functionalities.

	**Topo tools** *Allows to use different tools of control and topology – role_admin*

The toolbox aims to offer a multitude of functions that may be useful when checking if the certain parameters of the project are correct. The different functions offer different answers: some insert data in tables and others represent new geometries within a layer.

The tool is divided into three tabs:

- **Edit**
  - Check Project /data: two functions. The first reads the layers loaded in the project and warns if doesn't find important layers that must be loaded. The second controls that the default values defined by user are consistent, which means, that the inserted values can be used in the required field and won't generate errors.
  - Topology: these functions analyze different topological rules of the network. When activating any of these parameters, if there are elements that do not comply with the rules, their values will be inserted in the corresponding layers of the *Topology analysis* group.
  - Check mincut data: checks if all the data related to mincut polygon are correct. Solo para WS.
  - Check profile tool: checks if all the data related to longitudinal profile are correct. Solo para UD.
- **Master**
  - Prices: two functions. One controls that the data needed to calculate reconstruction prices is complete and the other does the same for rehabilitations. The result is shown in the table *audit_check_data*.
  - Advanced topology review: are advanced topology functions, designed for the realization of revisions of the network. They allow to visualize possible errors respect the topological rules.
- **Admin**
  - Check data: function that controls the number of rows that each table of the project should have. It reads all the tables and its number of rows and compares it with the values that are defined as the minimum. The results are stored in the table *audit_check_project* and show the number of rows each

table should have and the actual number it has; in case the number is correct the enabled field will be TRUE, otherwise it will be FALSE.

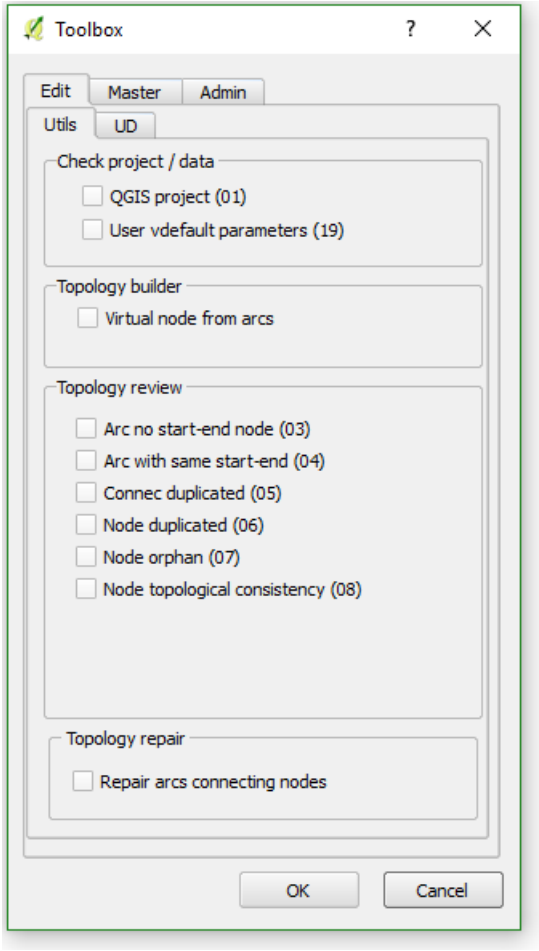


Image 81: Topo tools has many options divided into tabs. Both projects have their specific subtabs - WS and UD which appear depending on the type of the project.

	Config *Allows to define default values of the project – role_admin*

Configuration assistant for the behavior of the *plugin*. It allows to define different parameters that are used in other tools and processes of the project. It is a tool of enormous importance and the one that all users should know well, since its use is recurrent and essential for the operation of Giswater.

The form of the tool is divided into six different tabs. Within the tabs there is another subdivision depending on whether the parameters are common (Utils) or specific for WS or UD projects.

The operation is the same for all the tabs: each parameter has a *checkbox* next to its value. The user can set the value he considers appropriate, following the filters that each parameter has. If the *checkbox* is checked, the value of the parameter will be active and stored in one of the database configuration tables. If the *checkbox* is not checked, the value of the parameter will not be used anywhere.

Within the toolbox both default values configurable by the user and system values can be found. They can be modified or chosen by the user in the way that has been explained in the section **3.6.** Many of the values that can be configurable with the tool are easily recognizable, for example, those of the *Edit* tab. On the other hand, there are some that are more complex and require an explanation, such as those referring to topology:

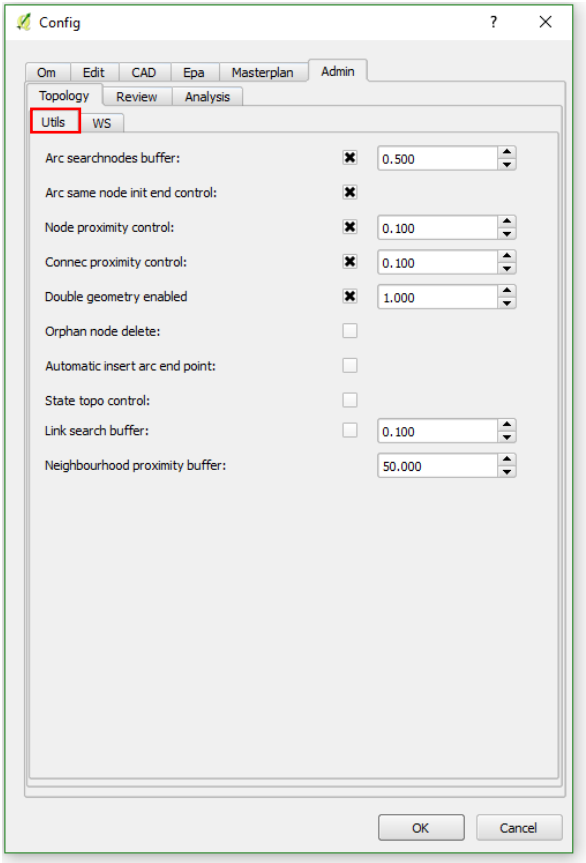


Image 82: Form of config, topology tab.

Arc searchnodes buffer: sets the tolerance when connecting ends of the arc to the nearest node.

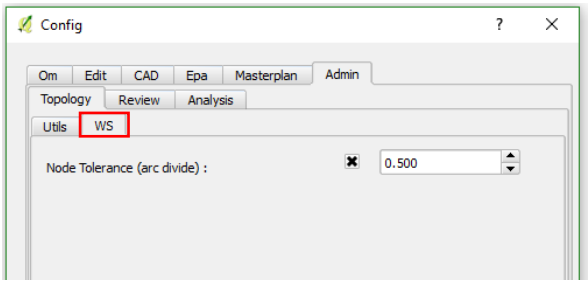
Arc same node init end control: Controls the arcs with the same start and end node.

Node/connec proximity control: allows or not the insertion of very close nodes / connecs, with defined tolerance value

Double geometry enabled: allows the automatic insertion of double geometry elements and controls the area that the generated polygon will occupy.

Orphan node delete: Deletes unconnected nodes

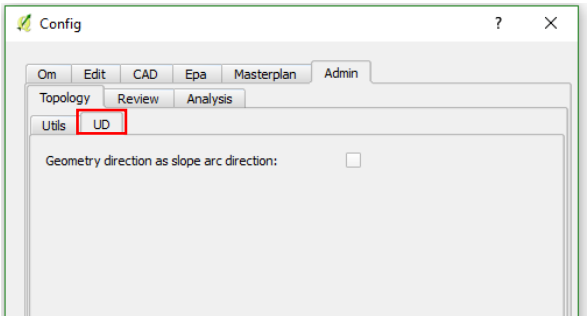
Automatic insert arc end point: Insert a node automatically at the end of the created arc. It's possible to choose the type of the inserted node.



State topocontrol: Activate or desactivate state topology control

Link serach buffer: allows to establish a tolerance to perform a *buffer* relative to a link.

Neighbourhood proximity buffer: allows to establish a tolerance when making a *buffer* that looks for elements considered as neighbors.



Node tolerance (arc divide): establishes a tolerance at the moment of breaking arcs.

Geometry direction as slope arc direction: controls whether the direction of the geometry is the same as the slope of the section.

In the tab related to the configuration of the CAD tools there is just one parameter, which allows choosing which of the ToC layers will be used as the base layer. This layer is the only one that QGIS will allow to snap while drawing. In case of not having this parameter set, the management of the layers that will allow the snapping will be managed from the own configuration of QGIS.

	Import CSV *Allows to importa n external csv file into database - role_admin*

It's very common to have data related to the network that is in table format, such as xls or csv. Giswater incorporates this tool in its *plugin* to provide the possibility of directly importing the data in a csv file into the schema tables.

To show the functionality of the tool, an example of importing a price table, which will be incorporated directly into the *price_simple* table will be presented. The program has a specially designed function to perform such a process. It's important to know that each type of csv import files must have a specific function.

How the tool is used to incorporate new simple prices into our database:

1- A .csv must be ready to import. This means that it must meet the requirements of the tool and the Giswater function, otherwise the data will not be incorporated correctly. These requirements can be checked by opening the tool and, at the top, selecting an *Import type*, in this case it's *Import db prices*.

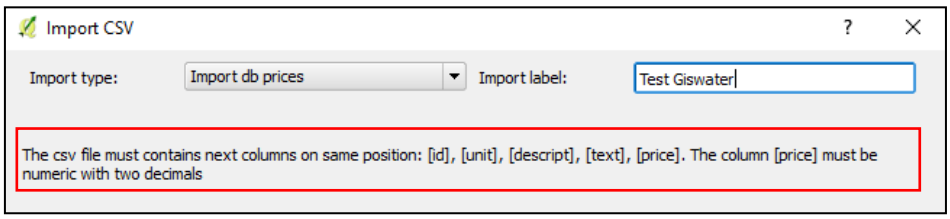
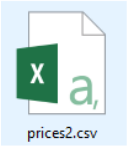


Image 83: The form of import csv explains how the csv file should be prepared in order to import it. In this case the name of all the imported prices will be Test Giswater.

The forms show the position and order of the fields: **id, unit, description, text, price (numeric with two decimals)**.



2- Within the form, with *Import db prices* selected, set a value for Import label, which will be the name that will receive the prices of the import and will be included in the catalog of simple prices (*Price_cat_simple*). For this example, it will be: **Test Giswater**.

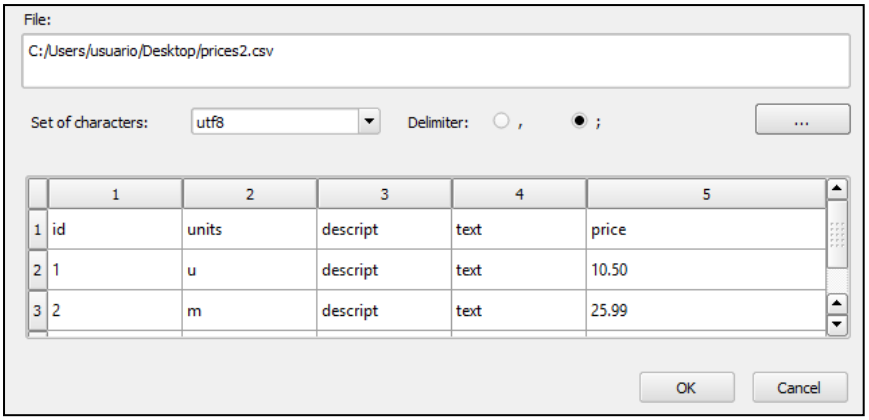
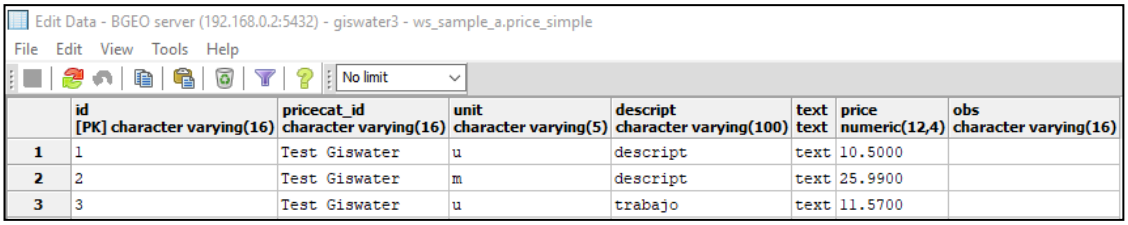


Image 84: With the file path added, the table will show a preview of the data.

3- Add the file path, here *prices2.csv* and select the encoding and the delimiter, which can be 'comma' or 'semicolon'. The table below shows a preview of how the data will be inserted (Image 84).

4- Click *OK* to start the process.

5- The function is parameterized so that the data of the correctly structured file could be incorporated directly into the *price_simple* table, so that the columns of this table coincide with those of the import. As presented on image 85, the data is perfectly added to the table, with all its records and with the price catalog (*pricecat_id*) as **Test Giswater**, which is selected from the *price_cat_simple* table where it was just added.



	id [PK] character varying(16)	pricecat_id character varying(16)	unit character varying(5)	descript character varying(100)	text text	price numeric(12,4)	obs character varying(16)
1	1	Test Giswater	u	descript	text	10.5000	
2	2	Test Giswater	m	descript	text	25.9900	
3	3	Test Giswater	u	trabajo	text	11.5700	

Image 85: The data from csv file inserted into the *Price_simple* table. The inserted values can be used in other functions of Giswater.

As the result of the process, the information from .csv file is inserted into specific tables of the database. The data located in the *price_simple* table are available for use in other Giswater tools and processes, for example while making budget calculations with Masterplan operations.

Apart from linking the price tables, the tool includes other specific functionalities to import csv files that refer to:

- **Import addfields:** to link custom fields directly to the *man_addfields_value* table. To do so, the table must have id of the element, the parameter (referring to the custom field) and the value to assign.

- **Import elements:** useful for linking elements associated with arcs, nodes or connecs. To perform an import a specific table for each type of element is required. That means, in order to link elements with nodes a csv that has only the information about node type elements in neccessary. The table should contain the id of the topological element, the catalog of the associated element, observations, additional comments and number of elements. When performing the operation, the *element* and *element_x_ * tables, which link the elements associated with the topological elements (node, arc, connec), are automatically filled in.

- **Import visit table:** useful to link visits to any type of network element. There are specific functionalities in the *Import type* drop-down list, for each type of element, so the visits can be linked only to nodes, arcs or connecs depending on the selected type and the csv file.

	Giswater *Shows the information about Fiswater and allows to open the software driver – role_admin*

The last tool of Giswater plugin is the one that provides information about the versions of the different drivers from which the whole project is supported:

- The *plugin* itself
- Giswater
- PostgreSQL
- PostGIS

Apart from this information, the tool also allows to run the Giswater driver in the same way that it could be done from the icon located on the computer. In this way all the functionality (section **2.3**) of Giswater (creation of new schemes, configuration of connections, renaming projects, etc.) is incorporated into the QGIS *plugin* itself.

The last function of this tool is a link to visit a website of Giswater.

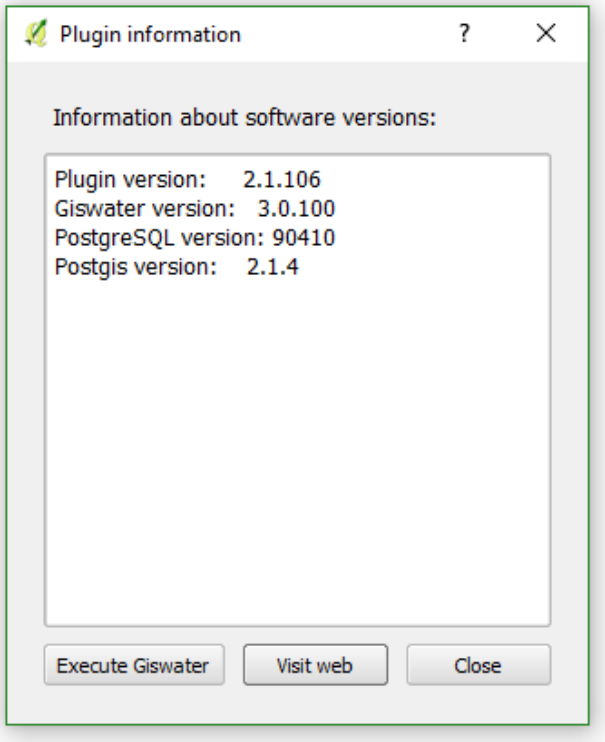


Image 86: Form of Giswater tool. From here the software driver or Giswater website can be opened.

6. HOW TO DIGITALIZE THE NETWORK

Once all the tools of the Giswater *plugin* are known, it's timeto use the full potential of the program and start working with the water network. It is considered appropriate and interesting to dedicate a section to present the correct steps to digitize the parts of the network, because it's one of the most common processes for those in charge of managing it.

Users who are more experienced in the use of GIS may not need to read this section, but it can also serve them as a small guide to develop a task of great precision.

To digitize, the *plugin* tools can be used, especially those associated with *role_edit*, but other parameters must be taken into account so that the insertion of new elements is correct and accurate. Next, it will be explained in detail which are the steps that must be followed, in chronological or to digitize new elements, both linear and punctual:

- **Example of digitalization of a new arc**

  By means of a practical example, carried out in one of the sample projects of Giswater, it will be explained how a new section of the network can be generated. It will consist of the insertion of 5 new nodes and 4 arcs. All these new elements must be placed in a specific position, as represented in the image 87, simulating a real work.

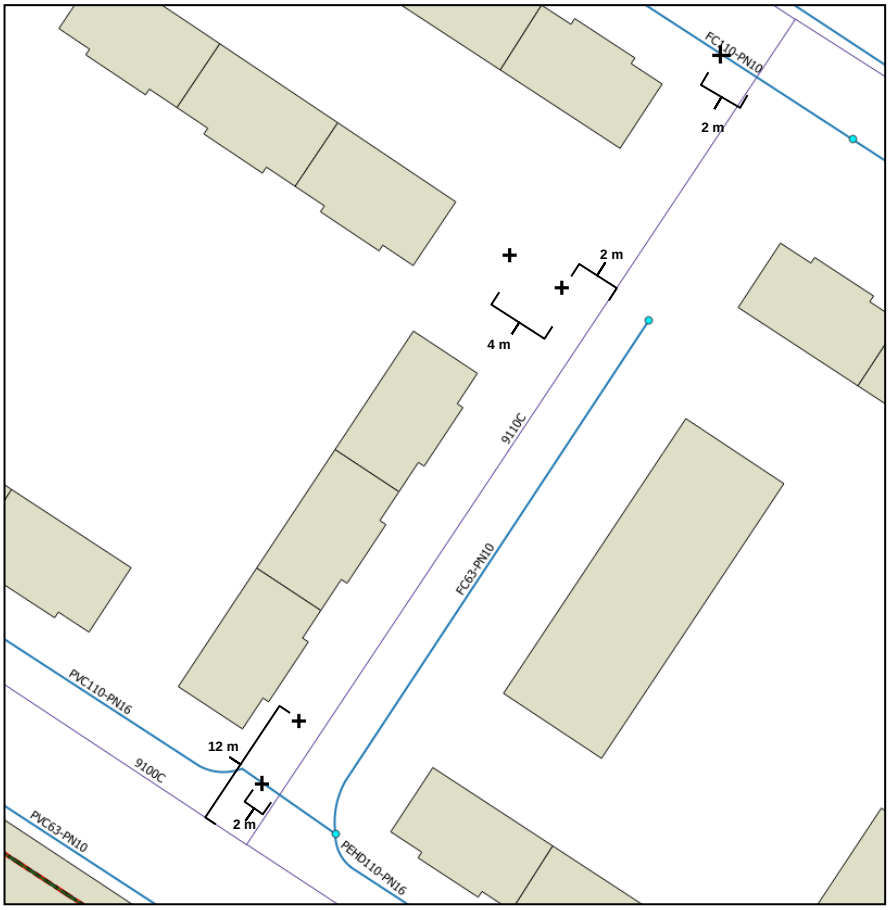


Image 87: The elements that will be inserted in this example should be located in the places showed in the image, where the distance between the elements is determined.

The elements represented in the image refer to the nodes, which will consist of 3 junctions (*Junction*), located at the intersections of arcs, a valve and a hydrant. The arcs will be all pipes (*Pipe*), which will be drawn in a straight line connecting the nodes.

Process

1. Before creating any element, it is very important to know what are the **mandatory** fields for each type of element, so that, if they are not filled in during insertion, it will not be completed. The following table specifies these fields and how they can be filled in, since Giswater offers different methods to facilitate the insertion of data. In the form itself the mandatory fields are marked with a *.

Field	¿In case in leaving it *NULL* (empty), how is it filled in?
Node/Arc catalog	Default value (one for each element)
Municipality	Default value, if not the value is captured from geometry
Exploitation	Default value, if not the value is captured from geometry
Dma	Value is captured from geometry, if not it uses default value
Sector	Value is captured from geometry, if not it uses default value
State	Default value, if not the first value from *value_state* table

2. It is important to configure default values, since many times the insertions of new elements will be made in the same municipality, exploitation, dma and sector. The default values will allow to work faster. For this example, using the configuration tool, the default values for Hydrant catalog, Junction catalog, Valve catalog, Verified (field not mandatory but recommended), Exploitation, Municipality, Sector and Dma will be set. The state will be entered manually each time.

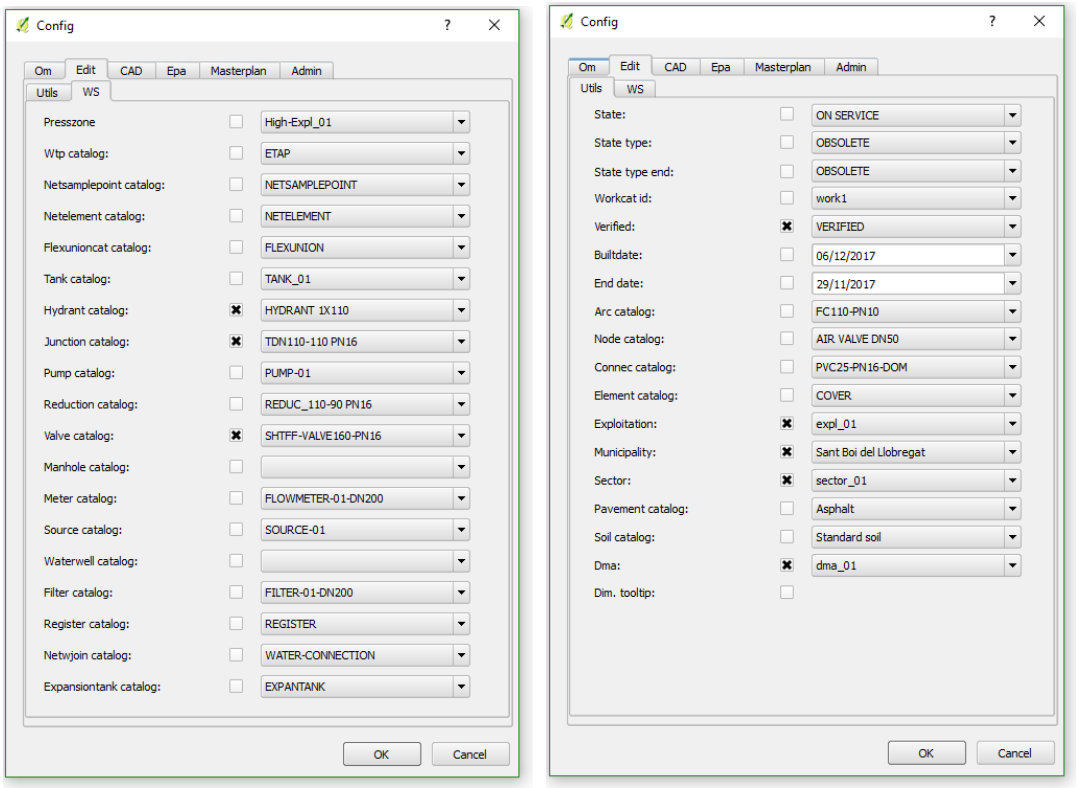


Image 88: In the form of Configuration the value default for this example are marked. They can be updated as many times as user wants.

3. To digitize with a higher degree of precision, as in the case of this example, before entering any element it's important to draw support points which will help with placing the nodes in the specific

location. To draw these support points there are different options: the CAD tools of the Giswater *plugin* or other tools incorporated into QGIS, such as the 'advanced digitization tools'.

4. To draw the first support point, which must be 2 meters from the intersection between the street 9110C and arc PVC110-PN16, the 'Create Circle' plugin tool will be used. With the snapping activated, place the cursor over the intersection and click. The radius of the circle must be 2 meters

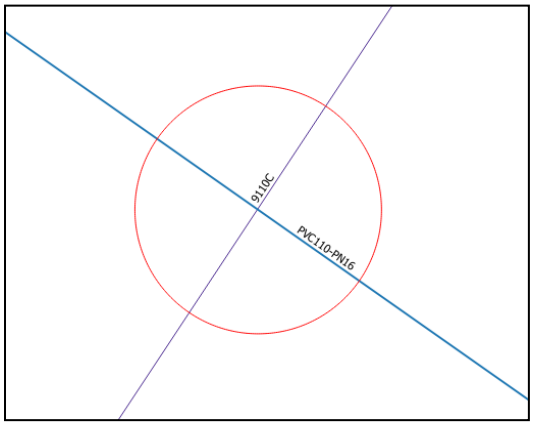


Image 89: The circle of 2 meters radius will be used to place the node in the exact location.

5. At the intersection of the circle line with the *Pipe* layer is where the first *Junction* element is going to be placed. Using the keyboard shortcut (J) the new element just above the intersection can be inserted. If the process is correct, the program should show a window telling that this node is about to break an arc. Since many values are established as default, the only thing that needs to be indicated in the form is *state*. In this case, *ON SERVICE*, together with the *status type* as *ON SERVICE.*

6. With the first element already introduced, the second support point needs to be placed. It will serve to mark the location of a new valve. This should be 12 meters from the beginning of the street 9110C and 2 meters to the left.

7. With the tool 'Add relative point', mark the first point at the beginning of 9110C street of the Streetaxis layer and another at a certain distance on the same line. That's how a point 12 meters from the beginning (x) and 2 meters towards the outside (y) can be drawn.

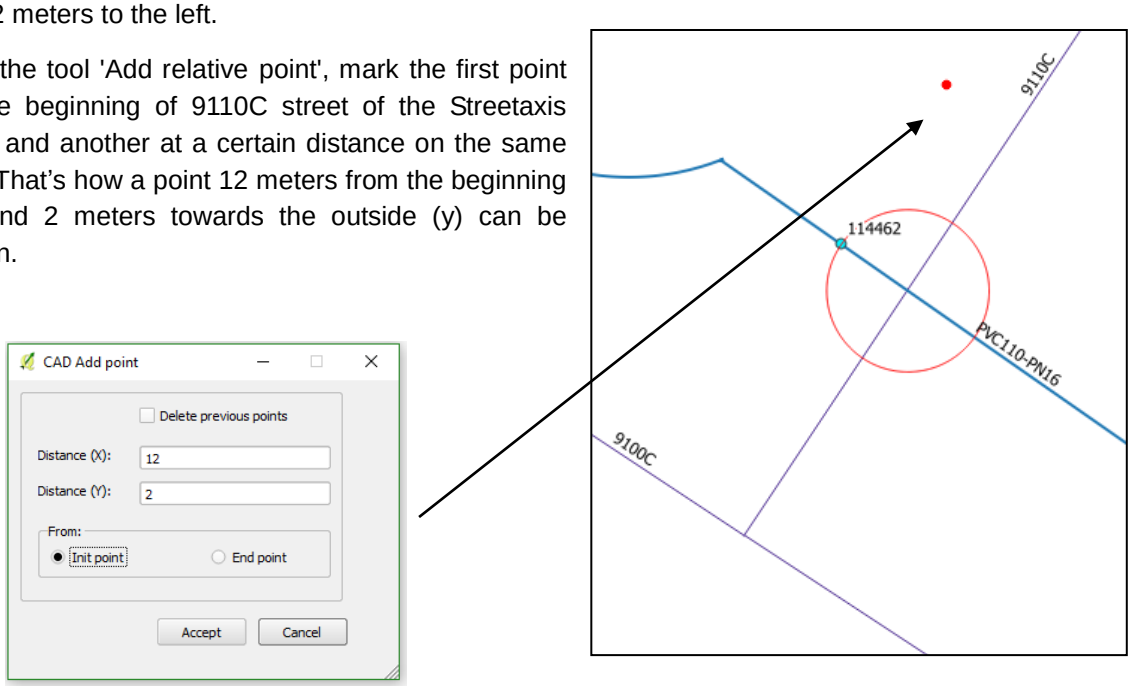


Image 90: The second node is located over the red point, generated using *'Add relative point'*.

8. Just over this support point is where the new valve should be placed. As before, the only values that need to be filled in manually are the state and type of state. The rest are configured by default.

9. To draw the next support point (in this case it will be a line), use the QGIS tools. With the **advanced digitizing panel,** it is possible to draw a line perpendicular to node 1072 and which, at the same time, is 2 meters from the street 9110C.

10. The first step is to generate a new temporary scratch layer (Image 90). It must be a linear layer, with the same EPSG as the project has. Once created, put the layer in edition and click on 'Add spatial object'.

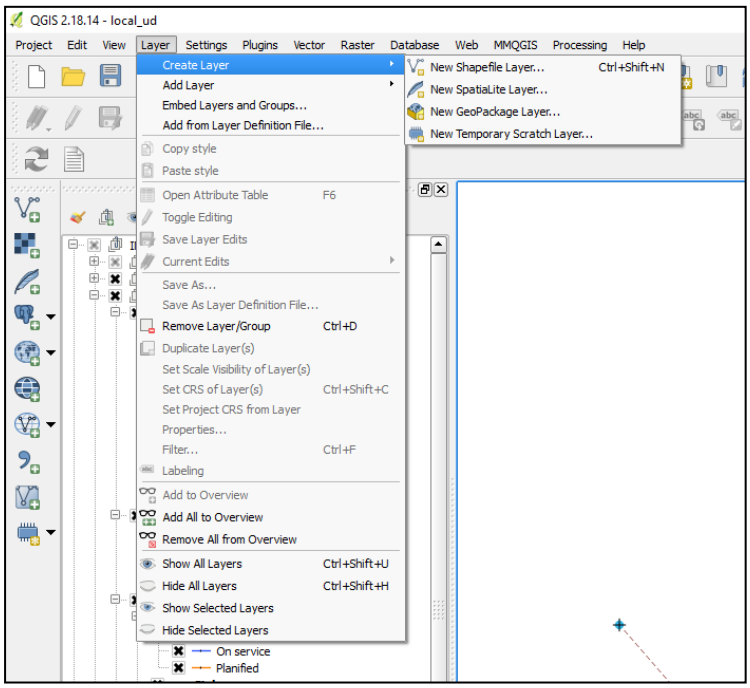


Image 91: From *Layer* in main menu a temporary scratch layer can be added.

11. With the advanced digitizing panel active, first select the node from which the new line should start. Then click on the 'Perpendicular' button and select the arc that will serve as a reference to draw the perpendicular line, in this case the Pipe showed in image 92. That thin auxiliary line is drawn perpendicular to the desired node. Now, click on the street axis, thus establishing the first part of the line. Without stopping the edition, establish a radius of 2 meters in the field where it says 'd', taking into account that the cursor must be located above the axis of the street. Click again on the auxiliary line, now just above the intersection with the 2 meter circle generated. Once the red line reaches where the desired point, click the right button of the mouse to finish the support line.

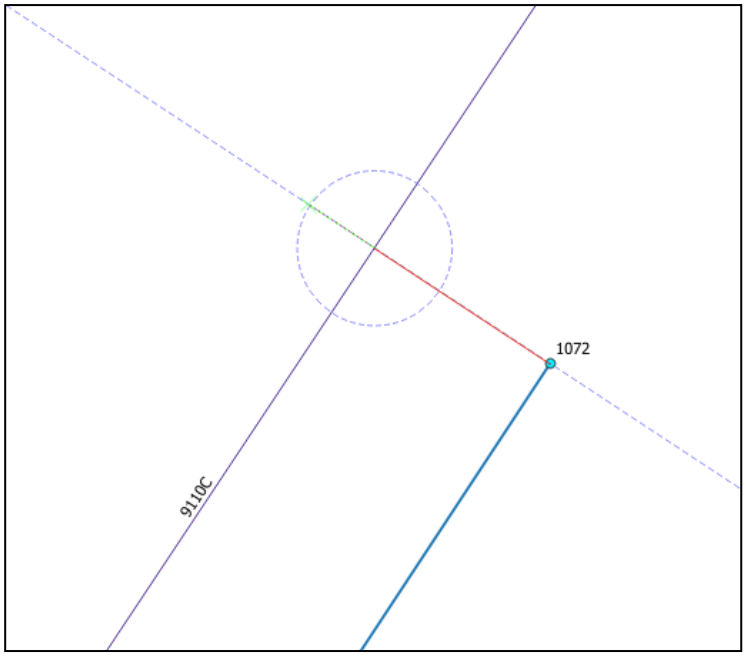


Image 92: Using the panel of advanced digitizing posible to draw a perpedicular line to another element at the desired distance. The red line represents an arc that will be saved in the temporal table. The left side of the circle also has the line slightly painted red.

12. Using this line, the third node of the example can be placed. In this case a union of type 'T'. In the same way as in previous cases, insert the new element just at the limit of the support line, knowing that it is exactly where it should be: two meters from the street axis, perpendicular to the other pipeline and at the same height as the union that ends this pipe.
13. The next step is tolocate the hydrant, which must be 4 meters from the union that was just generated and at the same height. Since the support line is still visible on the map, use it again to locate the new support point. Knowing that this must be at the same height as the line, introduce a point of support using tool 'Add relative point'.
14. With this tool mark a point on the node 114470 and another one on the support line of the temporal layer. The 'x' must be -4 and 'y' must be 0. In section from select the *Init point* as the start point of the relative element.

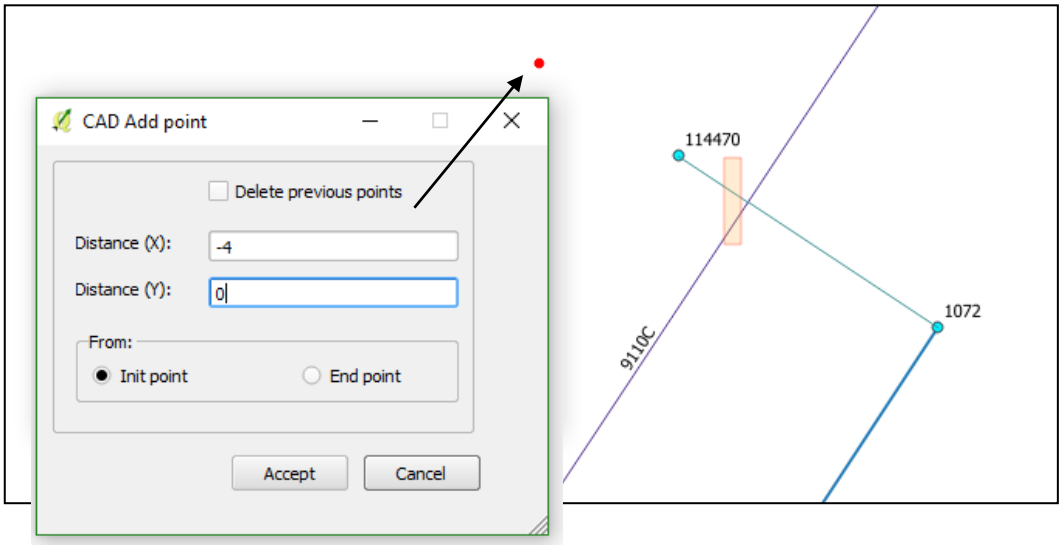


Image 93: the tool *Add relative point* can be used to place the point as the determined distance from another element. The temporal line is selected by the rectangle for its better visualization.

15. Place the hydrant just over the added support point. As always, with the default values configured, only the status of the node must be added.
16. Now, four out of five nodes that were planned at the beginning of the example are added. To insert the last union, which will break the arc FC110-PN10, use the same method as in the first union of the example: draw a circle with a radius of 2 meters at the intersection of the arc and the street axis.
17. Insert a unión element, checking that the arc was divided into two.
18. Drawing nodes is finishef. At this moment those nodes need to be connect using arcs. The insertion process is very simple.
19. At the beginning of the example, only the default values for node-type elements were established. Now it's important to add the default value for the arc catalog as well, in this case FC110-PN10, so the insertion will be faster.
20. To add the first pipe, using the keyboard shortcut 'P', choose the start node and the final node, clicking with the left mouse button to set it and with the right button to finish the line.

21. Repeat the process of inserting pipeline elements to join all the nodes created during this example, so that the network connects from one side to the other. The final result can be seen in image 94

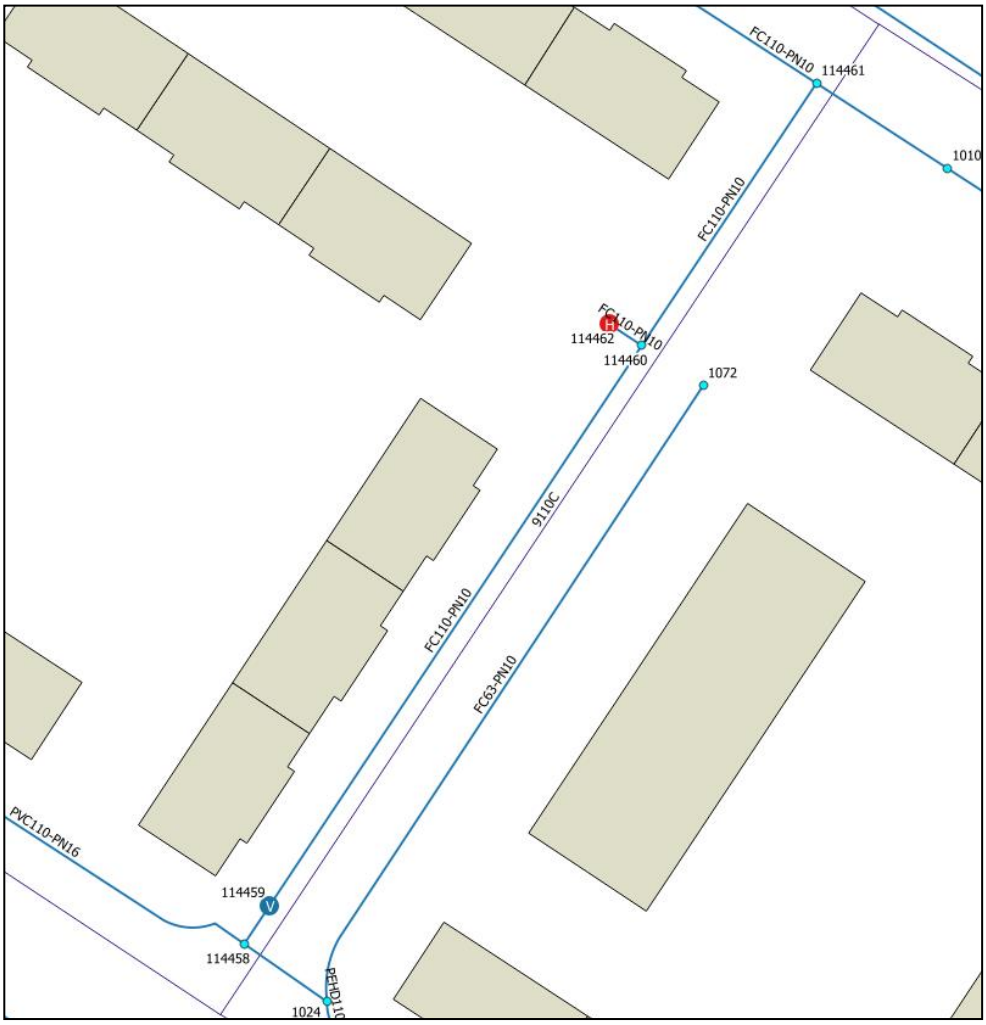


Image 94: The new network section, planned in image 87. Inserted nodes and arcs connect the already existing sections of the network with the new ones. The new elements are placed exactly where it was planned, so that the representation of the real network has the maximum possible precision.

7. EXPORT – IMPORT OF THE HYDRAULIC MODEL

7.1 Process characteristics

The process of export-import of a hydraulic model is done almost exactly as in version 1.1 of Giswater (the driver remains intact) but have introduced a number of improvements, which are list below:

1. The elements can be sent to a model according to their status (STATE) that can be on service, obsolete or plannified, with the only condition that they have hydraulic coherence. For example, the case that's not possible to happen, *in a sector there is only a deposit with on service state, and only planned elements are sent to hydraulic model.*
2. In case of WS projects it is possible to configure the roughness according to the age of the pipe. To do so, use the inp_cat_roughness table and assign the age to the element. If the construction date is not assigned to the element, it will be considered new for the purpose of capturing the roughness value.
3. In case of WS, a new concept of elements appeared that is called nodarcos. Nodarcos are those elements that in inventory management are flow regulating nodes, such as valves or pumps, but in the hydraulic model they must be arcs, since a flow regulator is always a conceptual element 'arc' that regulates flow between two different nodes.

7.1.1 Main characteristics for watter supply networks (WS)

In order to perform the hydraulic model, it's necessary to have complete and accurate data for each of the elements and parameters of the model. To understand everything required in each of the hydraulic model tables, the EPANET manual is available. It specifies in a very exact and detailed way all those necessary concepts.

7.1.1.1 Working by sectors

The work by sectors allows to filter and send to the hydraulic model only those elements that belong to a specific sector, or send several sectors at the same time. As specified in section **4.2.1.2** of this manual, the field *'sector_id'* stores the data of the hydraulic sector to which the element belongs, and subsequently through the table 'inp_selector_sector' filters those elements that belong to the selected sectors.

It should be noted that the sectors selected for export to the hydraulic model must have hydraulic coherence, that is, for WS there must be a water reserve, which supplies the system (RESERVOIR, TANK) and at least one point of consumption.

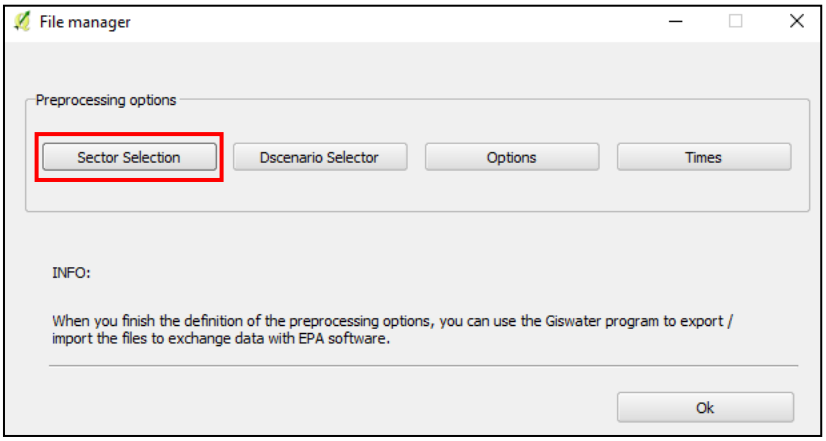


Image 95: It's possible to open the sector selector from the form of the tool Go2EP.

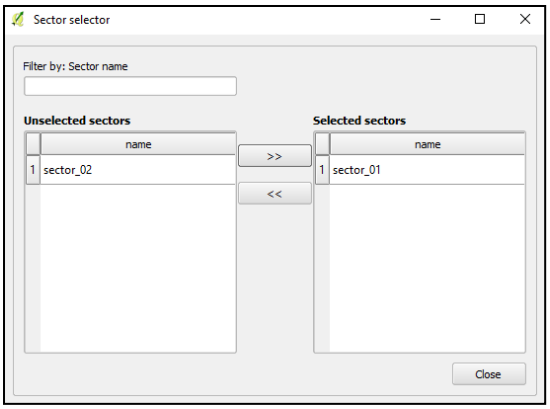


Image 96: Sector selector for hydraulic model.

7.1.1.2 Demand scenarios

In case of WS networks, exist demand scenarios. The demand scenarios allow to define different demand hypotheses on the consumption elements (JUNCTION).

In a normal case, the relationship between consumption point and demand value is 1: 1 and the main value of *demand*, together with the consumption pattern *'pattern_id'* are defined in the table *'inp_junction'*, as it is shown in the following image.

	node_id	elevation	depth	nodecat_id	sector_id	state	annotation	demand	pattern_id	macrosector_id
1	1012	47.5702	0.0000	HYDRANT 1X110	sector_01	ON SERVICE		16.000000	pattern_03	macrosector_01
2	113961	33.2100	0.0000	HYDRANT 1X110	sector_02	ON SERVICE		16.000000	pattern_03	macrosector_02
3	1009	45.0000	0.0000	HYDRANT 1X110	sector_01	ON SERVICE		16.000000	pattern_hydrant	macrosector_01

Using the *'inp_demand'* table user can apply an alternative demand to the main demand of the consumption node and change the demand pattern. First of all, the new scenario is created in the catalog table *'cat_scenario'* and later the node element is linked to the new demand and to the scenario to which it belongs, as shown below.

id	node_id	demand	pattern_id	deman_type	dscenario_id
1	1009	8.000000	pattern_hydrant		Hydrants_50%
2	1012	8.000000	pattern_03		Hydrants_50%

7.1.1.3 Transformation of nodes into arcs

Giswater solves this duality using the elements called *'nodarco'*. Elements that by their characteristics in the inventory are nodes, but due to their behavior of flow regulator in the hydraulic model must be arcs. This *'nodarco'* element is defined on user‘s demand in the system table (*node_type*).

All those elements that are labeled as SHORTIPE / VALVE / PUMP, are *'nodarco'* type elements, and therefore their model information is stored in the tables:

- inp_shortpipe
- inp_valve

- inp_pump

For a 'nodarco' element to be valid, it must comply with the rule of having 1 or 2 extreme arcs, otherwise the node will not be valid and will not become an arc.

The transformation process from NODE to ARC:

- A new ARC type geometry of 0.5 meters legth or less is generated (suffix _n2a)
- Two new JUNCTION nodes are generated (suffixes n2a1 'initial node' and n2a2 'final node')
- The arc geometries of the existing arcs are 'trimmed' and reconnected to the new nodes to accommodate the new arch
- The attributes of the JUNCTION elements are inherited from the parent node.
- The attributes of the ARC elements are inherited from one of the two extreme arcs (material, diameter, etc.)

7.1.1.4 Possibility of multipump

When representing a pump inside Giswater, there is a possibility that the relation between the element and its behavior in the hydraulic model is not 1:1, but that it contains more than one pump and therefore generates a 1: n relation with the element,

Every flow regulator labeled as PUMP stores its information in the *'inp_pump'* table, which must be completed with the parameters that regulate the operation of that pump, thus, by default, the relationship that is generated between the node and the number of pumps is 1: 1.

Using the *'inp_pump_additional*' table, Giswater allows to manage more than one pump for a single pump element. In this table the id of the parent node, the pump number defined in that node, respecting the total number of additional pumps and the working parameters of each of the additional pumps must be indicated, as shown in the following example:

id	node_id	order_id	power	curve_id	speed	pattern	status
1	1105	1		PUMP_02	*NULL*		OPEN
2	1105	2		PUMP_01	*NULL*		OPEN

The example shows two additional pumps of the node '1105'. It means that this node, when exported to the hydraulic model, will be transformed into three pump-type arcs each with their own working parameters.

7.1.1.5 Using different state types of valves

The management of the valve status in a supply network is usually dynamic, depending on the needs of the user its' state may be one or another to perform the hydraulic simulation of the model. This change in the status is due to changes in the inventory (broken valve, valve out of service, etc ...) or specific changes in their status when generating a mincut polygon.

Thus, it can be said that the valves may have different status depending on the table in which the data is stored: *'inp_shorpipe', 'man_valve'* or *'anl_result_mincut_valve'.*

Using the button 'Options' inside the form of export to the hydraulic model, user can choose the state of the valves that will be used in said simulation.

Image 97: Part of the form related to the state of valves.

- EPA TABLE: Those, which state is ‘On service’ o ‘Plannified’ in the layer *‘inp_shortpipe’*
- INVENTORY VALUES: Those, which state is ‘On service’ o ‘Plannified’ in the layer *‘man_valve’*
- MINCUT RESULT: Those valves that have been affected depending on the results generated by the mincut polygon. At the same time, user will be able to choose, using the 'Mincut result id' drop-down list, the results of the mincut polygon that he wishes to model.

7.1.2 Main characteristics for urban drainage networks (UD)

In order to perform the hydraulic model, it’s necessary to have complete and accurate data for each of the elements and parameters of the model. To understand everything required in each of the hydraulic model tables, the SWMM manual is available. It specifies in a very exact and detailed way all those necessary concepts.

7.1.2.1 Working by sectors

The work by sectors allows to filter and send to the hydraulic model only those elements that belong to a specific sector, or send several sectors at the same time. As specified in section **4.2.1.2** of this manual, the field *'sector_id*' stores the data of the hydraulic sector to which the element belongs, and subsequently through the table *'inp_selector_sector'* filters those elements belonging to the selected sectors.

It should be noted that the sector or sectors selected for export to the hydraulic model must have hydraulic coherence. For UD networks the minimum requirements would be an entry point of water into the system, either rain, through the application of a rain in the SUBCATCHMENTS or, through wastewater (DWF), and a point of exit of the system (OUTFALL).

7.1.2.2 Management of hydrology scenarios

In case of UD networks, exist hydrology scenarios. The hydrology scenarios allow to define different hypotheses about the method of infiltration, surface runoff, groundwater, de-icing, etc... applied to the drainage sub-basins (SUBCATCHMENTS).

Using the catalog *'cat_hydrology*' it’s possible to define a catalog element referring to the data of water flows that enter naturally into the system, indicating the identifier, a name and the infiltration method.

The infiltration methods recognizable by SWMM are: *curve number, Green-Ampt* or *Horton equation*.

Once the hydrology catalog is defined, each subcatchment needs to be related to the hydrology catalog to which it belongs, through the *inp_subcatchment* table, fields *hydrology_id*..

	conduct	initdef	curveno	conduct_2	drytime_2	sector_id	hydrology_id
ULL	NULL	NULL	83.0000	0.0000	10.0000	sector_01	1
ULL	NULL	NULL	83.0000	0.0000	10.0000	sector_01	1
ULL	NULL	NULL	83.0000	0.0000	10.0000	sector_01	1

This relation allows calculation of different hypotheses applied to the same subcatchment and allows, using the hydrology selector, to select those that should be used for the simulation.

It is important to note that the filled fields that refer to the infiltration method in the inp_subcatchment table must be recognizable by the hydrology catalog that is imputed to them.

7.1.2.3 Integration of the standard form catalog of SWMM

Giswater integrates in its system a variety of geometric sections accepted by SWMM. There are available in a conduits catalog of UD network. Using the arc catalog table, the different types of conduits are defined, filling in the following obligatory fields: *id, matcat_id, shape* and *geom* fields, necessary to define the shape of an arc.

In order to know what data should be put in these fields, consult the catalog of SWMM sections. It-s also important to know how this catalog and the domain table of values of normalized sections work (cat_arc_shape).

The table cat_arc_shape is composed by the following fields:

- **Id**: name of the form (in selected language) of the catalog (it's the value that acts as domain values of the cat_arc_shape field).
- **Epa:** name that receives the form in SWMM (see section catalog of SWMM).
- **tsect_id:** in case of open irregular shapes, label of the set of values in the inp_transects table that define the irregular geometry according to the HEC format.
- **curve_id:** in case of forms not included in the catalog of the attached document, name of the curve defined in the inp_curve table that defines the pairs of values that make up the detail of form of this section.
- **image**: system field with the name of the png file that is stored in the Giswater plugin folder (plugins / giswater / png) and that is called when an info is done on an arc type element and the cost tab is clicked.
- **descript**: auxiliary field the description of the section.
- **active**: boolean field that allows to control if the form is active in the catalog or has been unsubscribed and is not selectable

Taking into account the previous information and consulting the SWMM section catalog, the geom* fields can be filled in depending on the choosen form.

Two examples of the relation between the cat_arc_shape table and the arc catalog cat_arc are presen ted below:

In case of creating circular conduits, called, as 'Round' this translates into:

For the table cat_arc_shape,

cat_arc_shape.id = Round

cat_arc_shape.epa = 'CIRCULAR'

cat_arc_shape.image = 'ud_section_circular.png'

And in the table cat_arc,

cat_arc.shape = 'Round'

cat_arc.geom1 = Value of the internal diameter of arc expressed in meters.

In case of creating rectangular conduits, called, as 'Rectangular' this translates into:

For the table cat_arc_shape,

cat_arc_shape.id = 'Rectangular'

cat_arc_shape.epa = 'RECT_CLOSED'

cat_arc_shape.image = 'ud_section_rect_closed.png'

And in the table cat_arc,

cat_arc.shape = 'Rectangular'

cat_arc.geom1 = Value of the vertical dimension of arc expressed in meters

cat_arc.geom2 = Value of the horizontal dimension of arc expressed in meters

In reality the table *cat_arc_shape* is already filled in with all the standardized forms of SWMM, so expanding this catalog according to the needs of user is quite easy to understand and proceed.

THREE BASIC RULES need to be fulfilled:

1) The value of cat_arc_shape.id can be customized by user, but the value of cat_arc_shape.epa **must always be normalized** to one of the values of the SWMM section catalog.

2) All the measurements (cat_arc.geom*) **are interior** and should be expressed in **meters**.

3) Values of cat_arc.geom1 always correspond to the vertical dimension of the element, just as the values of cat_arc.geom2 always correspond to the horizontal dimension of the element

For the other cases, consult the SWMM section catalog.

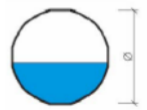
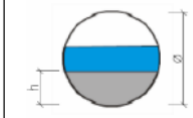
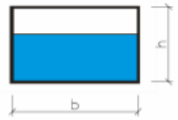
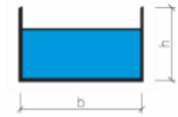
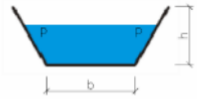
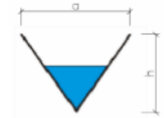
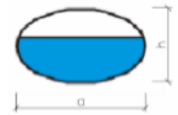
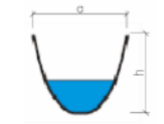
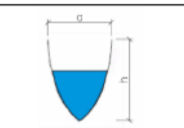
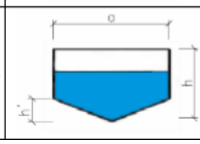
Shape	Schema	geom 1	geom 2	geom 3	geom 4	Shape	Schema	geom 1	geom 2	geom 3	geom 4
CIRCULAR		Ø (m)				FILLED_CIRCULAR		Ø (m)	h		
RECT_CLOSED		h	b			RECT_OPEN		h	b		
TRAPEZOIDAL		h	b	p	p'	TRIANGULAR		h	a		
HORIZ_ELLIPSE		h	a			VERT_ELLIPSE		h	a		
ARCH		h	a			PARABOLIC		h	a		
POWER		h	a			RECT_TRIANGULAR		h	a	h'	

Image 98: Table with different SWMM sections available in Giswater as a method of arc shape inventory.

7.1.2.4 Flow regulators

For the management of different flow controllers, version 3.0 of Giswater maintains the same logic as the previous versions where virtual arcs can be assigned to an EPA element.

In this sense, there are two types of virtual arcs, those that enter into the node (which would be the prolongation of the driving that precedes it) and those that leave the node (which would be the flow regulators).

In the first case, the **virtual** arc is simply a flow propagator, which apart from the characteristics of the element must have indicated the direction it drains (node 2). In this way, when carrying out the export to the hydraulic model, what Giswater does is joining this virtual arc with its predecessor, converting the two into a single one.

At the same time, if the *add_length* field value is *true*, the length of the virtual arc will be added at the time of merging, but if we have it in false, the length of that element will not be added

In a practical case, the virtual arcs which are propagators of flow, would be applied to nodes of big dimensions like deposits or cameras. Its arcs arrive to them but do not connect with the center, but remain at its perimeter. The connection section between these two points would be a **virtual_arc**.

In the second case the **virtual** arc behaves as a flow regulator. The flow regulators are structures or devices used to control and derive the flows within the transportation system. The flow control elements that SWMM can model are the ones listed below, together with the information in which tables there are stored:

- Orifice, tabla: inp_flwreg_orifice
- Weirs, tabla: inp_flwreg_weir
- Outlets, tabla: inp_flwreg_outlet
- Pump, table: inp_flwreg_pump

At the moment of introducing a new flow regulator, the following parameters must be defined in the tables mentioned above: source node, target arc, ordinal regulation (in case of introducing more than one regulator between that node and that arc with that type of regulation), and finally the different parameters that control that regulator.

In the particular case when there is a virtual arc just after the node, the field *exit_conduit* must not be the arc_id of the virtual arc but must be the arc_id of the conduit that receives the flow, since the operation of merging the virtual arcs with the conduit is coupled with the arc_id of the conduit.

If more than one regulator coexists between a given node and arc, at the time of export, the system draws for SWMM as many arcs as regulators.

Important aspects related to flw_length parameter:

- The parameter flw_length is the length of the flow regulator.
- If there is more than one flow regulator between the node and arc, the system will take the maximum value.
- The length of the flow regulator is important in case of orifices or weirs and refers to the distance downstream of it, in which normal flow conditions in the pipeline can not be assumed, ie it is an ineffective length of the pipeline. downstream conduit.

8. REAL-TIME MATHEMATICAL MODEL (RTC) FOR WS

Giswater 3 is pre-configured to simulate flow data in real time for the water supply projects (WS). It allows to calibrate with real data the obtained model results. For this purpose, the working workflow of real drinking water network data is as follows:

First thing to comment is that the commercial management system should be integrated into the GIS and that can be done using this table proposal:

```
CREATE TABLE hydrometer(
  id bigint PRIMARY KEY,
  code text,
  connec_id integer,
  muni_id integer,
  plot_code integer,
  priority_id integer,
  catalog_id integer,
  category_id integer,
  state_id integer,
  hydro_number text,
  hydro_man_date date,
  crm_number text,
  customer_name text,
  address1 text,
  address2 text,
  address3 text,
  address2_1 text,
  address2_2 text,
  address2_3 text,
  m3_volume integer,
  start_date date,
  end_date date,
  update_date date);

CREATE TABLE hydrometer_x_data (
"id" bigserial PRIMARY KEY,
"hydrometer_id" bigserial NOT NULL,
"m3value" float,
"value_date" date,
"period_id" integer);

CREATE TABLE hydro_cat_catalog(
"id" int8 PRIMARY KEY,
"code" character varying(16),
"hydro_type" character varying(100),
"madeby" character varying(100),
"class" character varying(100),
"flow" character varying(100),
"dnom" character varying(100),
"observ" text);


CREATE TABLE hydro_cat_type(
"id" integer PRIMARY KEY,
"code" character varying(16) NOT NULL,
"observ" character varying(100));
```

```
CREATE TABLE hydro_cat_category(
"id" integer PRIMARY KEY,
"code" character varying(16) NOT NULL,
"observ" character varying(100));

CREATE TABLE hydro_val_state(
"id" integer PRIMARY KEY,
"code" character varying(16) NOT NULL,
"observ" character varying(100));

CREATE TABLE hydro_cat_period(
"id" integer PRIMARY KEY,
"code" character varying(16) NOT NULL,
"observ" character varying(100));

CREATE TABLE hydro_cat_priority(
"id" integer PRIMARY KEY,
"code" character varying(16) NOT NULL,
"observ" character varying(100));
```

Using a script for connecting to the CRM, these tables can be filled either with the real time data, or with data obtained through process of loading and updating during the night. Once the tables are filled in, it's neccessary to relate that information using the tables and views of Giswater rtc_ * with their corresponding correlation.

LAYERS NECESSARY FOR REAL TIME MAPPING OF SCADA VALUES
ext_rtc_hydrometer_x_value: shows the current value of hydrometers (for remote reading)
ext_rtc_scada_x_value: shows the current value of scada

LAYERS FOR INFORMATIONAL ONLY
ext_cat_scada: scada catalog, optional
rtc_scada_x_dma: Scada x dma with the flow sign, optional
rtc_scada_x_sector: Scada x sector with the flow sign, optional
ext_rtc_scada_x_data: Valores hitorical values of scada (deprecated)

Hydrometers:
rtc_hydrometer: commercial table of inserted hydrometers
rtc_hydrometer_x_connec: table with the relation between hydrometers and connecs

Scada:
ext_rtc_scada: Tableof all registered SCADAS
rtc_scada_node: table with relation between scada and nodes

RTC Calculation:
ext_cat_period: Period catalog
IMPORTANT: periods of SCADA should be the same as COMMERCIAL periods

ext_rtc_hydrometer_x_data: Hydrometers' values used for the real time calculation
IMPORTANT: periods of SCADA should be the same as COMMERCIAL periods

ext_rtc_dma_period: Total values of dma per period
IMPORTANT: periods of SCADA should be the same as COMMERCIAL periods

IMPORTANT: The minimum, maximum, average values refer to the measurement interval (5 minutes, 10 minutes, etc), but the same for all three tables. These values will allow to calculate the maximum, minimum and loss values.
On the other hand, the total period value can be compared with the total value of the hydrometers period and establish the loss ratio for the dma.

Image 99: Part of the form of the tool Go 2 EPA, which incorporates the values of CRM.

The calculation options are available in the options form (CRM group VALUES) where it is necessary to activate the option of CRM (check box of CRM values enabled). From there it's possible to select the calculation period from among all available (Time period) and the coefficient, maximum, minimum, average value, with which it is intended to simulate within this calculation period (Coefficient)

To show in GIS:
All SCADA field data (flow rate & pressures) of the DMCs can be consulted using *rtc_scada_value*.

The information of the commercial data bank of monthly hydrometers' consumption of can be consulted using *rtc_hydrometer_value*.

In order to make an EPANET calculation:
In the table *ext_cat_period* different periods are defined and stored, from which an aggregate query of all the data of the SCADA and the HYDROMETER can be made.

With the information of specific period defined in *rtc_period*, the values for the different DMAs are recorded in the table *ext_rtc_dma_period*, thus obtaining for a given period:
- Contour flows: maximum, minimum and average (difference between the incoming and outgoing flows measured by the macro-meters)
- Total monthly flow.

These data are compared with the aggregate values of all consumers within the DMA for a given period of time (*cat_period*) and also with the previous ones to establish the loss coefficient. Based on the coefficient of losses and the maximum / minimum factors based on the values of *ext_rtc_dma_period*, the compensated values can be sent to EPANET:

Note: The aggregation of flow values for each hydrometer is done in the following way:

1- The reading of the total hydrometer value of the selected period is made
2- The coefficient of losses that is recorded in the DMA is applied
3- The maximum / minimum coefficient is applied, depending on user's choice
4- The different hydrometer values of a single connec are added
5- The different values of all the connec for a single arc are added
6- The 50% division of the flow values for a given arc between its extreme nodes is performed.
7- The sum of all values received by each node from its different arcs is calculated.
8- The information is sent to the hydraulic model, overwriting the estimated values that the nodes have.
In case that a node has an estimated value, but has no real value, the model will be made using the estimated value.

9. OTHER CONSIDERATIONS

9.1 Good practice

- Rendering

1) Only the visible information is being renderized:

It's important to study the performance and take the decision (activate).

It's crucial in order to gain the speed of the project.

>5000 only arcs

<5000 tanks

<2000 everything

<1500 connecs

<1000 links

<500 virtuals

2) Good QGIS configuration

Open: *Settings* > *Options* > *Rendering.* The configuration that is displayed in image 100 would be a correct example for layer rendering.

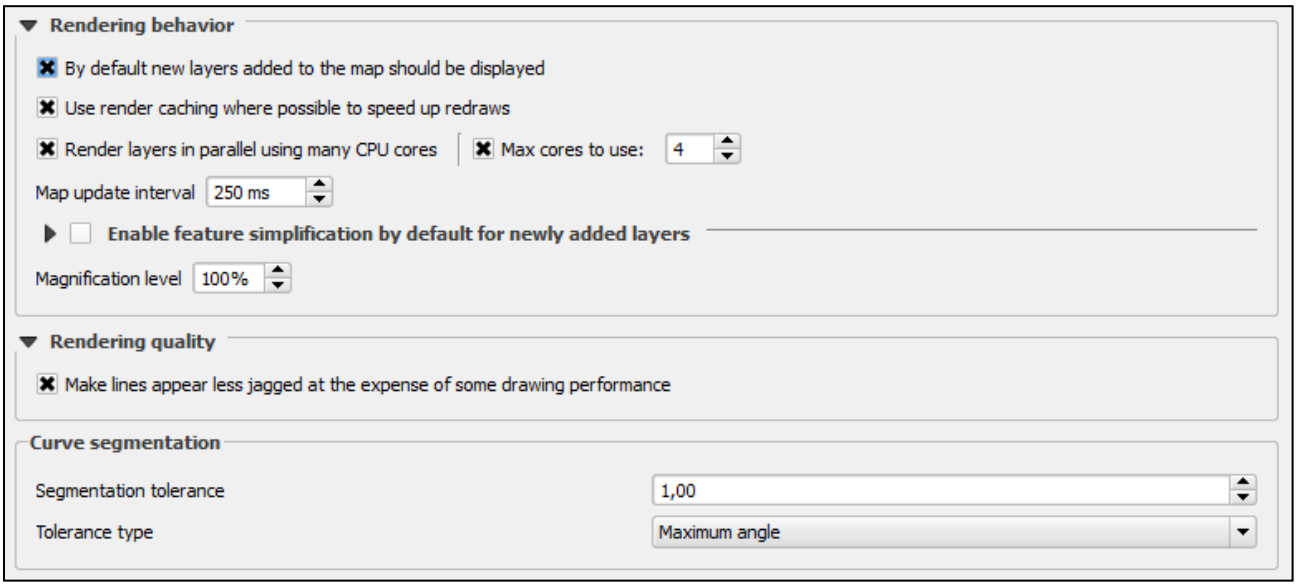


Image 100: Example of the configuration neccessary to good performance of rendering.

Each layer also should be controlled: *Layer propertie* > *Style* > *Layer rendering*

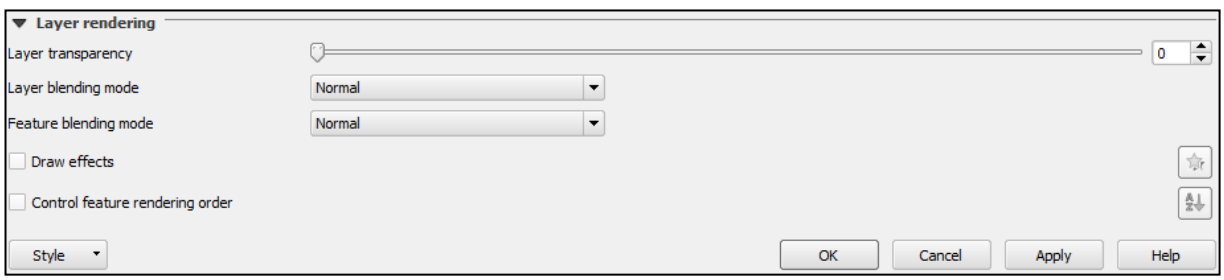


Image 101: Correct settings of layer rendering

9.2 Management and use of the QGIS composer

Giswater offers different templates to generate plans and maps of some part of the project. As already mentioned in previous sections, some of the tools directly incorporate the generation of plans using the *composer* templates. As examples, the tools of the longitudinal profile, the mincut polygon or the planning sectors generate plans directly

The Giswater *plugin* folder has a subfolder called *templates* that contains several *qpt* files, QGIS templates, that the user can call from the composer manager and add them to the project. Initially in this folder there are templates to make plans of the longitudinal profile, mincut polygon and the planning sectors (om and plan) for both A3 and A4 format.

However, each user can generate their own templates for the *composer*, so that any generated plan can have the desired appearance. For less experienced users, a good way to generate your own template is to copy some of the existing ones in Giswater and modify some of its parts.

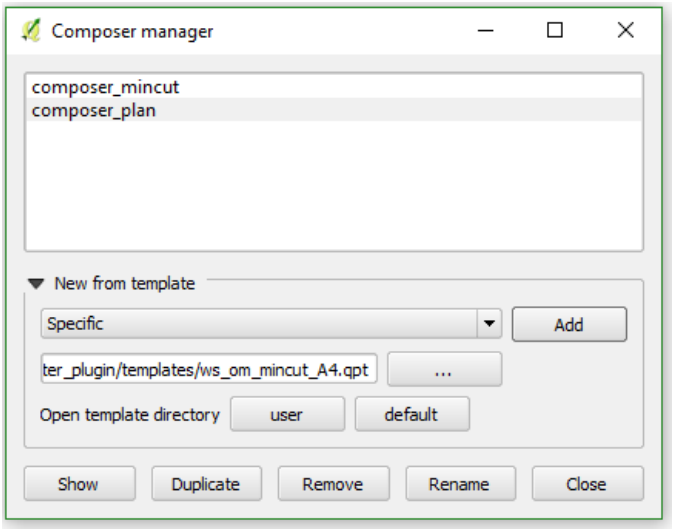


Image 102: Composers management form. Those linked to the QGIS project are represented here. In the templates folder there are more templates unlinked with the project

9.3 Control and verification of projects and schemas

As seen throughout the manual, the Giswater data schemas are complex and have a large number of tables, views and layers with dependencies between them, which can be difficult to understand at the beginning.

All Giswater data schema incorporates a "group" of tables and functions that allow the user to control different parameters, perform certain actions or verify processes, always in relation to the management of tables and the data they contain. The purpose of these audit tables is to provide users with help tools in the management and editing processes of Giswater.

- ***Audit check project***

Shows in QGIS if the project is missing some important layer to load.

Description: This function reads the tables present in QGIS project and compares them with the existing ones in the table *audit_cat_table*. Those that in this table have the field *qgis_criticity* greater than 0 should be loaded in the project, because their presence is necessary for the proper functioning of the tools of Giswater.

How it's used: It's activated alone. Each time the QGIS project is opened, the function reads the loaded layers and, in case of finding any with criticality greater than 0 that is not loaded, warnes the user showing the list of missing layers.

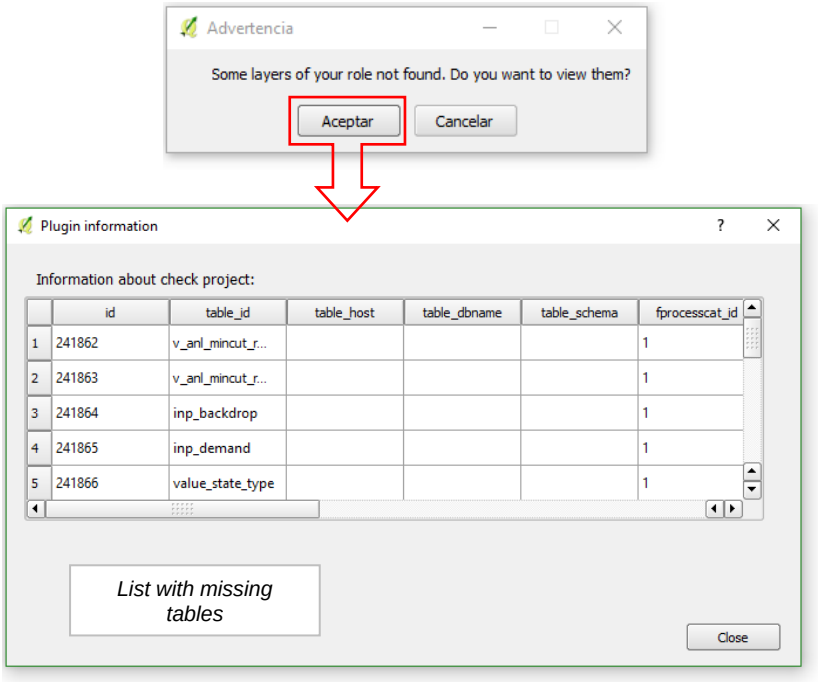


Image 103: The function *audit_check_project* acts every time the project is opened. In case of finding the layers that should be loaded, but are not, shows the list of those layers.

- ***Audit check data***

It informs if there are important fields for budget that have value null

Description: shows if some of the important columns for budget planning are empty. Acts on the following tables:

- *fprocesscat_id* = 15 – For the processes in which the value NULL affects the calculation of **reconstruction** results:
  - **Table:** *cat_arc* **Columns:** *active, cost, m2bottom_cost, m3protec_cost*
  - **Table:** *cat_node* **Columns:** *active, cost, cost_unit, estimated_depth, estimated_depth, estimated_y*
  - **Table:** *cat_connec* **Columns:** *active, cost_m1, cost_m3*
  - **Table:** *cat_pavement* **Columns:** *thickness, m2_cost*
  - **Table:** *cat_soil* **Columns:** *y_param, b, m3exc_cost, m3fill_cost, m3excess_cost, m2trenchl_cost*
  - **Table:** *cat_grate* **Columns:** *active, cost_ut*
  - **Table:** *arc* **Columns:** (compares arcs in state other than obsolete with the registers in table *plan_arc_x_pavement*)
  - **Table:** *plan_arc_x_pavement* **Columnas:** *pavcat_id*
- *fprocesscat_id* = 16 - For the processes in which the value NULL affects the calculation of **rehabilitation** results

For each of these tables, the function counts all the active rows and, at the same time, the rows for the particular columns that are not null. If when comparing both values there are less rows of the concrete column than of total active rows, it means that there will be NULL values in the column.

Finally, the function stores in the table *audit_check_data* a row with information regarding the table, the column and the number of rows with NULL values that it has found.

How it's used: the functionality can be activated the *Toolbox* tool all writing the following SQL *query* in Postgres:

```
SELECT 'SCHEMA_NAME'.gw_fct_plan_audit_check_data(1);

SELECT 'SCHEMA_NAME'.gw_fct_plan_audit_check_data(2);
```

This will automatically fill in the table *audit_check_data* showing rows with null values related to the column and specific table. The final objective of this function is to provide the user with the necessary information if he has all the data filled in order to perform the reconstruction (15) or rehabilitation (16) calculations.

Reconstruction

Rehabilitation

fprocesscat_id smallint	result_id character varying(30)	table_id text	column_id text	criticity smallint	enabled boolean	error_message text
15	0	cat_node	cost	2	FALSE	There are 3 row(s) without values on cost column
15	0	cat_grate	pavcat_id	2	FALSE	There are 266 row(s) without values on pavcat_id column

- ***Audit log feature***

Saves in a table all the modifications made to the data of the

Description: this function allows managing changes, both deletion and modification of data, for all types of project elements: node, arc, connec, gully and element. In this way it's possible to control all changes and rectify them in case of commiting an error. The table of the database *audit_log_feature* stores in rows every change made in the data, differentiating through a column if it is an UPDATE or DELETE operation.

How it's used: this functionality is disabled by default, because it stores a large amount of data for no reason. It can be activated using the following SQL *query* in Postgres:

```
SELECT 'SCHEMA_NAME'.gw_fct_audit_log_feature('ACTIVATE');
```

At this moment all the neccessary *triggers* and the function will be activa. It's possible to desactivate it using the folowing *query*:

```
SELECT 'SCHEMA_NAME'.gw_fct_audit_log_feature('DISABLE')
```

If the *triggers* have already been created and have been deactivated once, they must not be created again to reactivate them. They can be reactivated using the following *query*:

```
SELECT 'SCHEMA_NAME'.gw_fct_audit_log_feature('ENABLE');
```

If the function is active, with each modification made in the data of an element, a new row will be stored in the table *audit_log_feature* with all the information of the element before the modification. For example, if the *code* field of a node is changed from 2100 to 2150, the *code* 2100 will be saved, since the 2150 will be the one that will remain in the element's table.

id [PK] serial	fprocesscat_id smallint	feature_type character varying(16)	log_message text	feature_id character varying(16)	code character varying(30)
1	17	NODE	UPDATED	44443317	44443317
5	17	ARC	UPDATED	44443297	2100
9	17	NODE	UPDATED	44443321	44443321

- ***Audit schema check***

It allows to compare the information of two different schemes by creating views

Description: This function aims to offer all the necessary information in order to compare two different data schemas. This can be functional in cases where modifications have been made and it is not known exactly what they were. If there is a scheme that is known to be correctly filled in, comparing both schemes can be useful to obtain information about the modifications made in one of the two.

To show such information, the function generates different views in the scheme where it is called, what we will call the *original* scheme. The other will be the *comparison* scheme. The views generated are the following:

- *v_audit_schema_column*: reads all the columns of the tables and views of the original schema
- *v_audit_schema_table*: reads all the tables and views of the original schema
- *v_audit_schema_catalog_compare_table*: shos the tables of the original schema that are not present in the audit_cat_table.
- *v_audit_schema_foreign_column*: reads all the columns of the tables and views of the comparison schema
- *v_audit_schema_foreign_compare_column*: shows all the columns present in one schema but not in the other
- *v_audit_schema_foreign_compare_table*: shows all the tables present in one schema but not in the other

With all the information of the views, the user can easily know what are the differences in the architecture of the schemes, not the data itself, and can act accordingly.

How it's used: the use of this function is very simple and must be done through a query in the database by writing the name of the original scheme in front of the function and the name of the comparison scheme below, as follows:

```
SELECT 'ORIGINAL_SCHEMA'.gw_fct_audit_schema_check('COMPARE_SCHEMA');
```

ATTENTION: the original scheme and the comparison one must be in the same database so that the function can compare its information.

- ***Audit schema repair***

Allows to repair a scheme with the information from another one

Description: This tool can be used to repair a scheme based on the information of another scheme. Unlike the *audit_schema_check* function, this directly modifies the working scheme by adding tables, columns and different inherited rules of the scheme with which it is compared.

How it's used: the function must be called directly with a *query* in the database, basically in the same way as the previous function, only changing the name of the function.

```
SELECT 'ORIGINAL_SCHEMA'.gw_fct_audit_schema_repair('COMPARE_SCHEMA');
```