MACS Energy & Water GmbH

wSmart Manual: network optimization module

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Version: 1.0

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1. Introduction

The constant increase of economic and environmental regulations, demands, and complexity present unprecedented challenges for infrastructure projects. Analogic solutions are no longer sufficient to improve and optimize operations and costs. The situation is no different for water utilities.

The use of digital technologies has become essential, offering almost unlimited potential to transform the world's water systems, making utilities more resilient, innovative, and by extension building a stronger, ecological, sustainable, and economically feasible foundation for the future [1, 2].

Digitalization and automation of water services are inevitable and will create great opportunities for utilities ready to embrace them. MACS Energy & Water is ready to support its clients with consultancy and solutions in the digital water transformation.

WaterSmart (**wSmart**) is an award winner[1] state-of-the-art web-based software designed to support water professionals in the conception of networks, management, and operations of water supply systems. The application is modular, comprising network optimization and network management modules.

WaterSmart Network Optimization (**WSNO**) is a novel water distribution network assessment tool for rapid prototyping and identification of technically and economically optimal water network designs. The application is a multi-language expert system, which provides consultants and practitioners in the utility sector the possibility to easily simulate network performance and test different optimization strategies.

WaterSmart Network Administration (**WSNA**) is an intelligent, flexible, and customizable system for specialized control, data centralization, and management of water and sewage companies. This application is based on solid database architecture that provides a secure and reliable modular online administration system. In a single application, the user manages real-time data of customers, operations, and warehouse inventory.

This document presents information exclusively for the **Network Optimization module**. The following sections describe how to access and configure projects, run hydraulic simulations, automatically generate maps and reports, and export GIS data.

No software installation is required to use the application, the user only needs a stable internet connection and a web browser. For the current software's version, wSmart can be accessed through the link: http://46.4.196.90:8001.

[1] Seal of Excellence Certificate delivered by the European Commission, EU Framework Programme for Research and Innovation 2014-2020.

2. GUI environment

In this section, the software's main interface is described, such as the login page and how to work with the interactive project's map. In the following sections, the functionality and configuration of specific features are detailed.

2.1 Accessing projects

To use wSmart no software installation is required, the access is done through a regular link in any web browser. User login and password are previously given by MACS and additional accounts can be requested by contacting the support team.

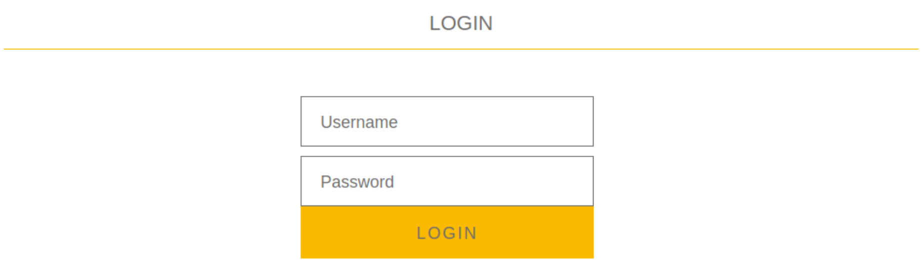


Fig. 1. wSmart's login page.

After login, the user has the option to create a new project or open an existing one, where only projects that are part of the user's group are displayed in the selection menu.

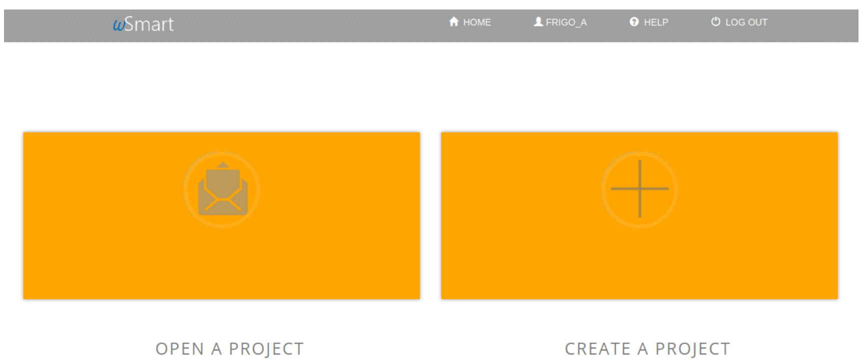


Fig. 2. Opening a project in wSmart.

2.2 Creating a new project

To create a new project, the user needs to specify some parameters that are used for the analysis of the hydraulic simulations and in the automatic reports generation.

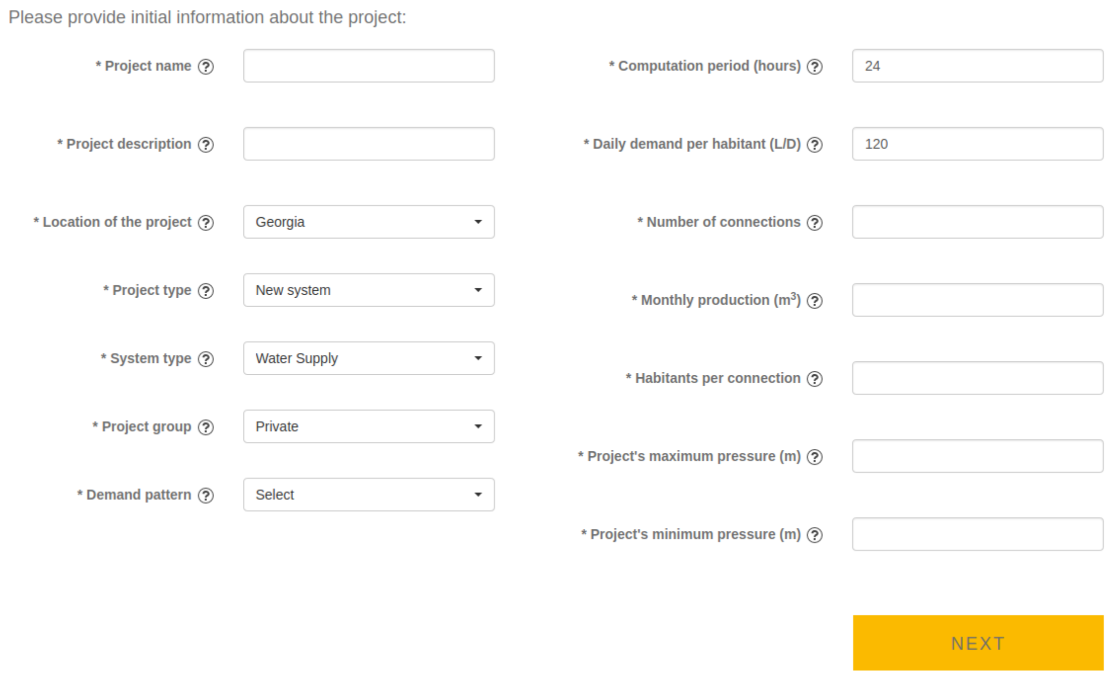


Fig. 3. Creating a new project.

Project name:

Standardized name for the project, e.g. "Waste Water - Region 1".

Project description:

A full description of the project.

Location of the project:

Country where the project is located and being developed.

Project type:

If is a new or already existing project.

System type:

If the project is a water supply or wastewater system.

Project group:

Define the group that can visualize the project.

Demand pattern:

Set the water consumption pattern in the project's region. Available patterns can be verified in: http://46.4.196.90:8001/demandPattern/.

Computation period:

Number of hours used in the simulation (24 hours is the default).

Daily demand:

The daily amount of water consumed per habitant (L/d).

Number of connections:

Expected number of active water connections (e.g. houses).

Monthly production:

Expected volume of water to be generated for the system (m^3)

Habitants per connection:

Average number of habitants in each connection.

Maximum design pressure:

Maximum designed/expected pressure to be achieved in the system.

Minimum design pressure:

Minimum designed/expected pressure to be achieved in the system.

2.3 Project edition page

After creating or opening a project, the user accesses the project's edit page. This page consists of an interactive map, hydraulic objects to design the network, simulation options, and, GIS tools.

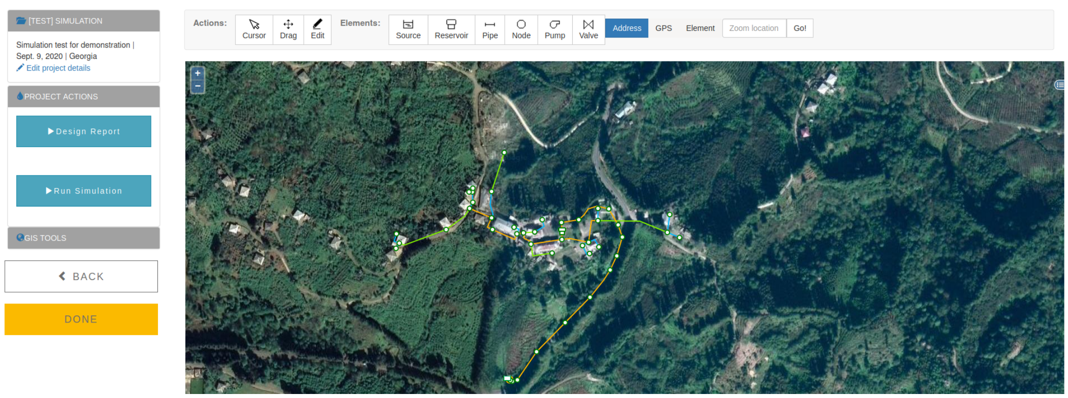


Fig. 4. Project edition page.

2.3.1 Interactive map

Similar to available map solutions, wSmart's also features an interactive satellite view. By left-clicking and holding, the user can navigate and visualize the project's area. It's also possible to change the zoom by using the mouse's scrolling or clicking on the zoom option (Fig. 5 - 1). The user can also select additional layers (Fig. 5 - 2) to display over the map, such as forest areas or a map of properties.

Fig. 5. Map zoom and layers.

2.3.2 Edit project details

The user can update or archive the current project by clicking on the hyperlink "Edit project details" on the left upper corner of the project edition page (Fig. 4). Then, the previously defined project's information is loaded and can be modified.

To **save** the latest changes, the user needs to click on the "Update project" button.

To **delete** the current project, click on the "Archive project" button.

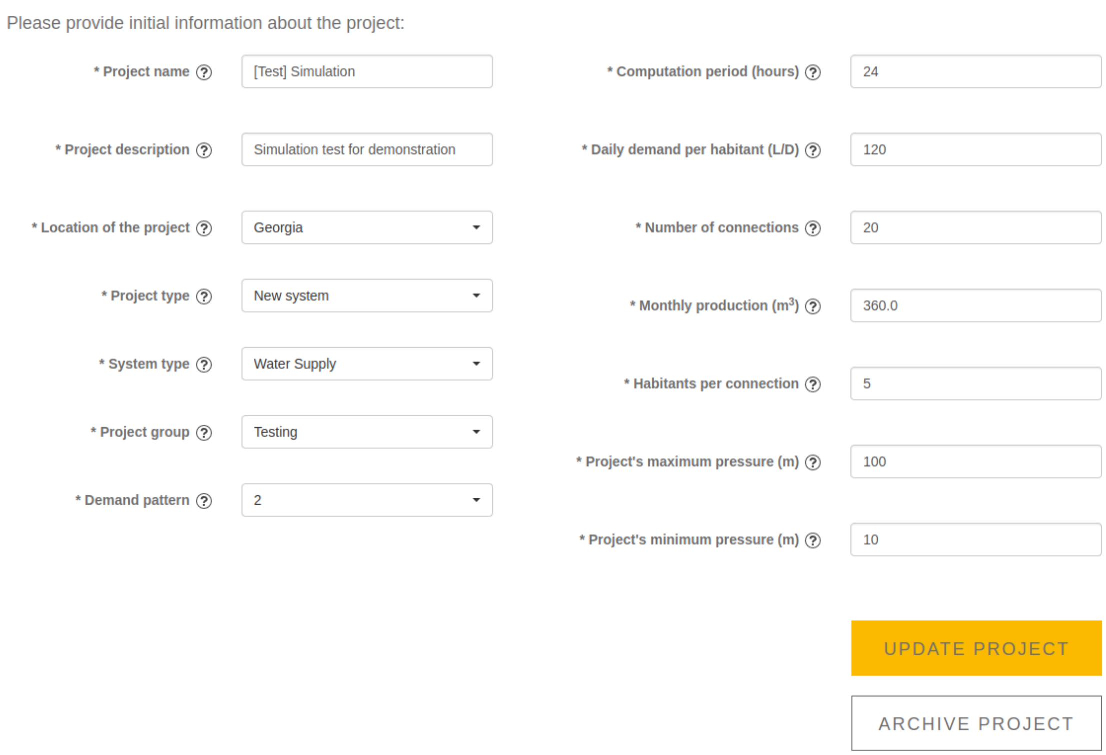


Fig. 6. Edit project detail page.

2.3.3 Hydraulic objects

The user designs the network by inserting and configuring hydraulic objects on the interactive map. To insert objects, the user has to click on hydraulic elements and then on the desired location. In the following sections, these objects are further detailed.

Fig. 7. Hydraulic objects.

2.3.4 Action tools

To interact with inserted hydraulic objects, the user needs to use action tools (Fig. 8). The **Cursor** option is used to move the map, **Drag** to change the location of an object (e.g. water tank or node), and **Edit** to configure the element's parameter.

Fig. 8. Object and map cursors.

The application also features an address, coordinate, and element location tool (Fig. 9). To locate an address, the user needs to describe it as specific as possible, as the system uses the Google engine to find the location. For the GPS, it's necessary to write the latitude and longitude, where these values are related to EPSG 3857 coordinate system. For the element search, the user needs to specify the element's identification code.

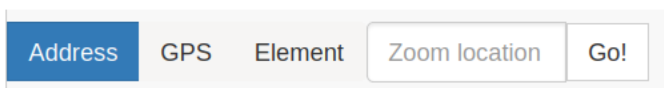


Fig. 9. Find location feature.

2.3.5 Project actions

The **Projects Actions** menu presents two button options: **Design Report** and **Run Simulation**.

The first button generates a design report, which is a PDF document that compiles the project's main characteristics. This report, however, does not contain results from the hydraulic simulation and is recommended to wastewater projects analysis[2] or when the network's performance results are not necessary.

The second option is the **Run Simulation** button. When the water system is correctly set, this option starts the hydraulic simulation for water supply projects. For more information about the hydraulic modeling process, please check section [3].

2.3.6 GIS Tools

This menu presents a set of tools designed to speed up the project's development regarding GIS analysis and files. It consists of reports, the option to export the project's data to specific file formats (DXF, KML, and Shapefiles), and import data to wSmart. In the following sections, these tools are detailed.

[2]wSmart's inbuilt hydraulic model is specific to water supply projects and currently does not model wastewater systems.

3. Hydraulic objects

As presented in Fig. 7, the user designs the network by selecting a hydraulic object and placing them on the interactive map. The description and configuration of these elements are described in the following.

3.1 Water source

Water sources are points where water initially enters the system, such as streams, rivers, lakes, or wells. For these hydraulic objects, **name** and **description** are parameters required to be manually inserted by the user. The application automatically assigns values for **id**, **head**, **latitude**, and **longitude**.

The hydraulic head information is filled based on the elevation of the selected water surface in meters, which is obtained from the Digital Elevation Model (DEM). Given that water levels cannot be accurately determined by a DEM, these values should only be used as references and for concept design projects (basic projects). The field is editable and the use of real elevation of the water surface is highly recommended when a detailed design is required. A diagram about the hydraulic head is shown in Fig. 11.

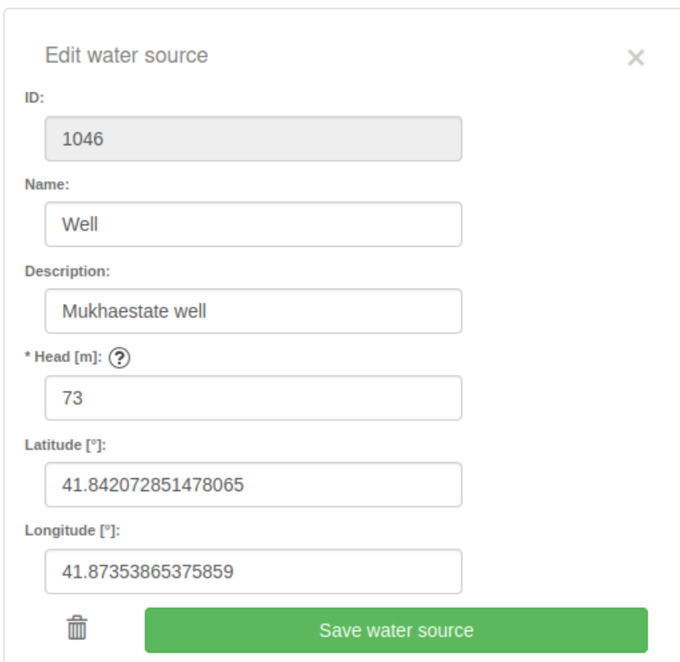


Fig. 10. Water source hydraulic object.

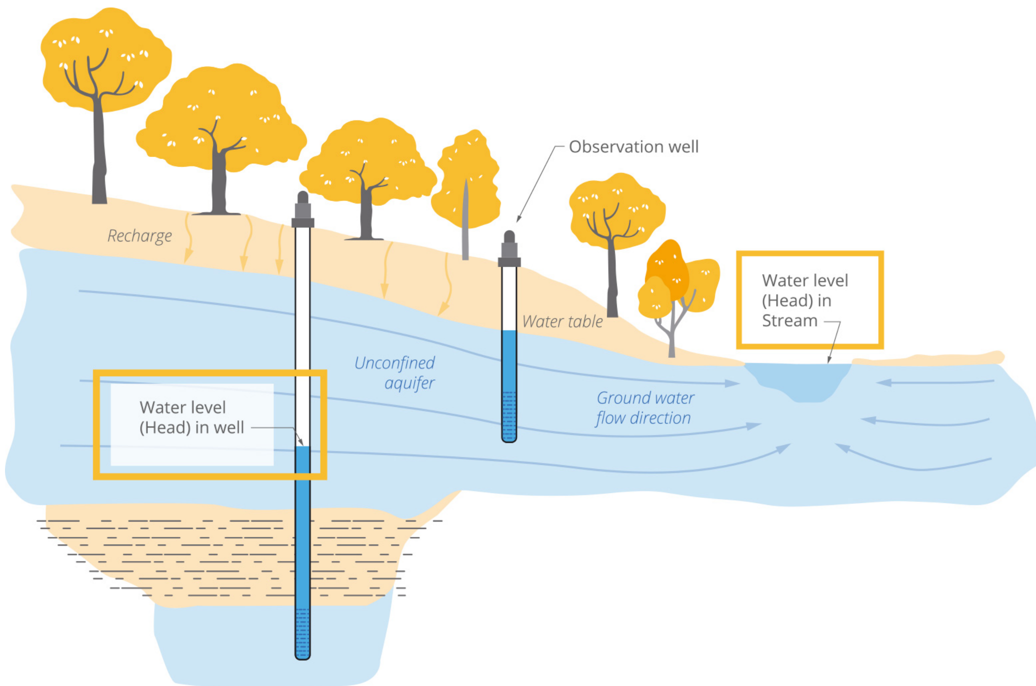


Fig. 11. Hydraulic head of water sources.

3.2 Reservoir

In wSmart reservoirs are tanks used to store water. This object receives automatically data for **latitude**, **longitude**, **id**, and **elevation**, where the latter can be edited. The user needs to manually insert the reservoir's **name**, **construction year**, **shape**, and dimensions (in meters), such as **type**, **length**, **width**, **diameter**, and **water level**. The tank's **volume** (m^3) is also automatically calculated based on **initial**, **minimum**, and **maximum levels** of the reservoir, which are referenced from ground elevation in meters (Fig. 13).

In practice, water levels never reach the top of the reservoir and neither do minimum levels reach the very bottom. Water pumping stops after a certain threshold. This is done to avoid pump cavitation or water losses due to overflows. This is why pumping rules were defined in the software underlying code. These rules determine that pumping will start if reservoir levels reach 0.5 meters above the minimum level and stop if they are 0.5 meters below the maximum level. Half a meter was picked as a reference recommended limit.

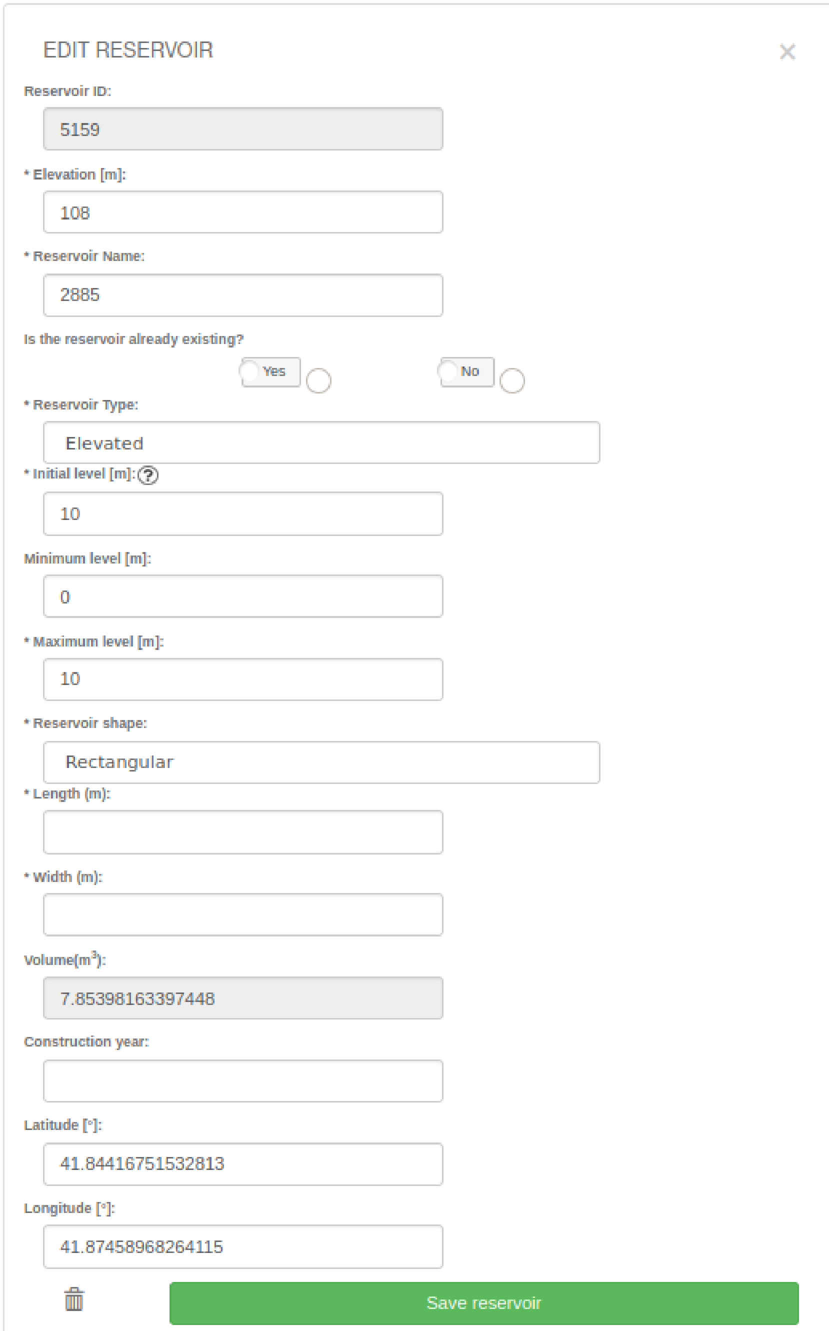


Fig. 12. Reservoirs configuration.

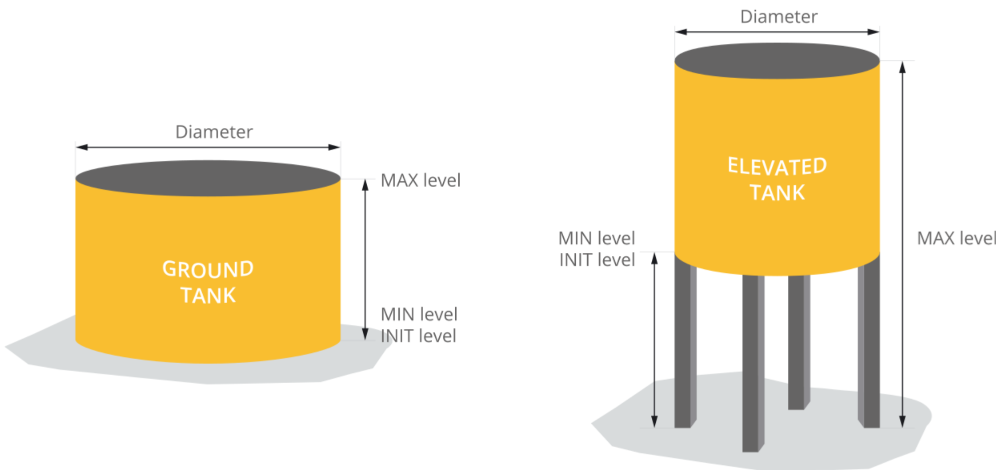


Fig. 13. Reservoirs water levels.

3.3 Nodes

Nodes or junctions are points where water flows in, out, or where pipes join. In wSmart, the only parameter required from the user for this element is the **water demand** specification, i.e., the amount of water consumed by this node in liters per second per day. The application provides all remaining parameters automatically, namely the **id**, **latitude**, and **longitude**.

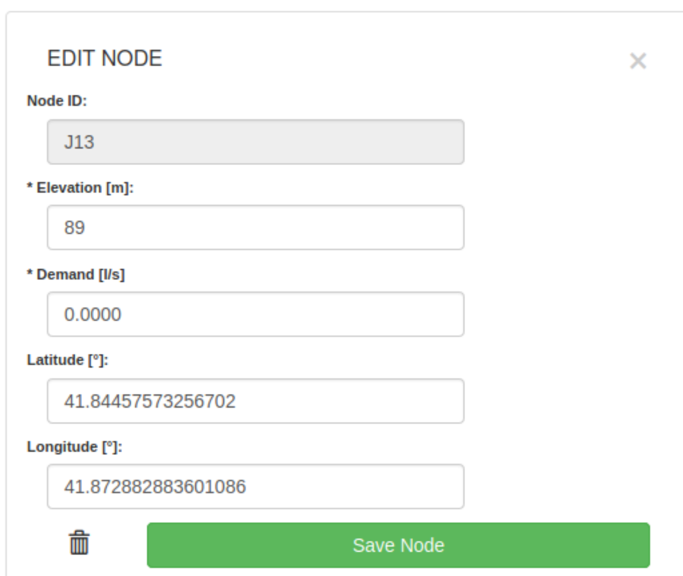


Fig. 14. Node hydraulic object.

3.4 Pipes

Pipes are hydraulic objects that are inserted between two nodes. After clicking on this element button, the user needs to select two nodes to connect. The system automatically calculates the pipe's **length**, the **status** can be set to either open or closed, and the **type** can be selected from a dropdown list containing pipe types with different diameters, materials, and nominal pressure (PN).

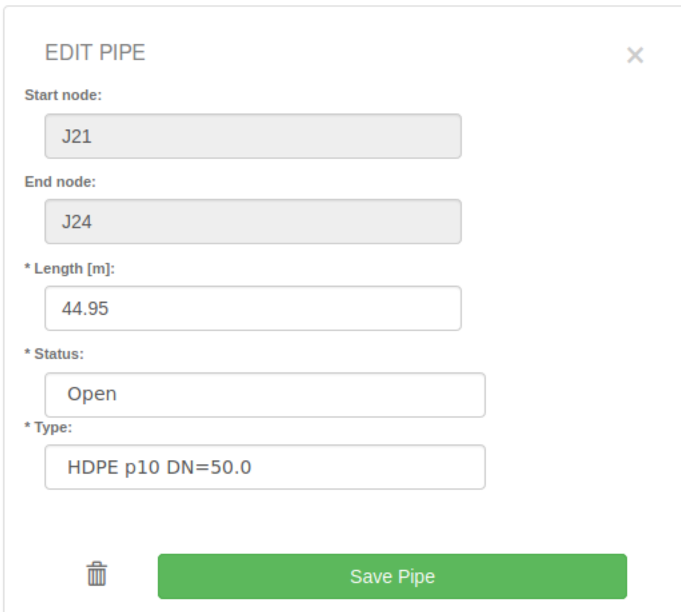


Fig. 15. Pipe hydraulic object.

3.5 Pumps

Pump objects are also inserted between two nodes. The only configuration required is to select a pump model from the **type** drop-down selection. This menu contains information on pump model and power (in hp), where each entry has a pump-curve attributed to it. These pump models and curves were previously researched and added to the database.

To simplify the modeling process, it's not possible to vary the pump's power, speed, or pattern, which are constant in simulations. The pressure increase applied by the pump is obtained by the instantaneous flow and the pump curve.

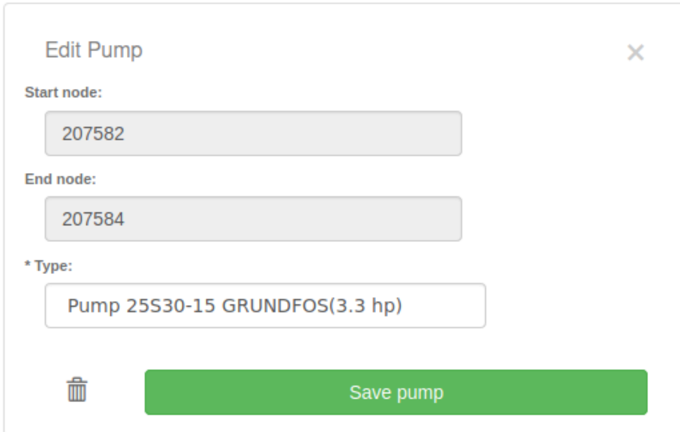


Fig. 16. Pump hydraulic object.

3.6 Valves

Valves are hydraulic objects used to control the pressure and flow in the network. The software features PRV and PBV valves with open or closed configurations.

PRVs valves limit pressure by closing when the pressure downstream is larger than the pressure upstream and by opening when the pressure setting on the downstream side is achieved. PBVs valves allow flow in both directions and they control pressure by defining a pressure loss. They are used to model cases where pressure drops occur, however they do not represent real physical elements.

The parameters for valves are the **diameter** (mm), the valve **type**, the **setting** pressure (m) and the minor coefficient. For PRV valves, the setting defines the maximum to be achieved in the system after the valve, where for PBV elements, the setting field specifies the amount of pressure lost downstream the valve in meters.

The minor loss field is a required input parameter. Minor loss refers to the minor loss coefficient, which is usually given by the valve manufacturer. Minor loss coefficients can also be found in tables with estimated values for each type of fitting. This information currently needs to be researched by the user.

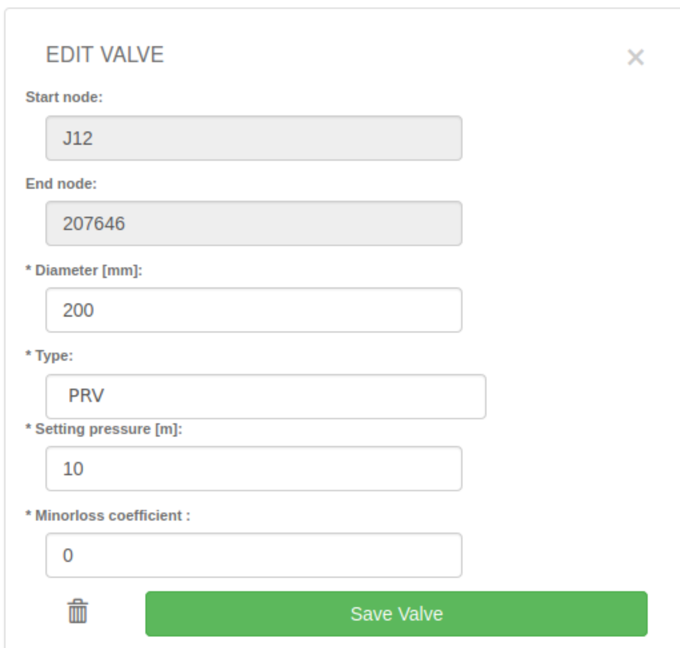


Fig. 17. Valve hydraulic object.

4. Project actions

This menu features the **Design report** and **Run simulation** actions, both described in the following.

Fig. 18. Project actions menu.

4.1 Design report

The **Design report** is a customizable PDF document that features all main characteristics of the water or wastewater network, such as the project's specifications and lists of all inserted hydraulic objects. It currently consists of four sections:

- System characterization: a summarized description of the project's characteristics, namely the data inserted when the project was created;
- Network schema: presents a draft of the network design, i.e. the position of all hydraulic objects;
- System elements description: lists of all inserted hydraulic objects and characteristics, for example, pipe types and their lengths;
- Summary investment costs of the project: a concise table presenting the total costs of products.

4.2 Run simulation

One of wSmart's main features is the possibility to run hydraulic simulations for water supply projects. Users can assess the network performance, providing relevant information about water pressure, flow, velocity, and quality in the entire system. Technicians can easily evaluate the impacts of even slight changes in design, such as adding new house connections or changing pipe diameters.

The hydraulic model used by wSmart is based on EPANET libraries, a long-term reference algorithm applied in water supply systems modeling worldwide. Detailed information of the model can be found in EPANET's manual [3].

The simulation is only possible if the network is correctly configured. If errors happen, the system shows warnings, as nodes that are not connected to the network or the occurrence of negative pressures. New features are available after successful simulations (Fig. 19).

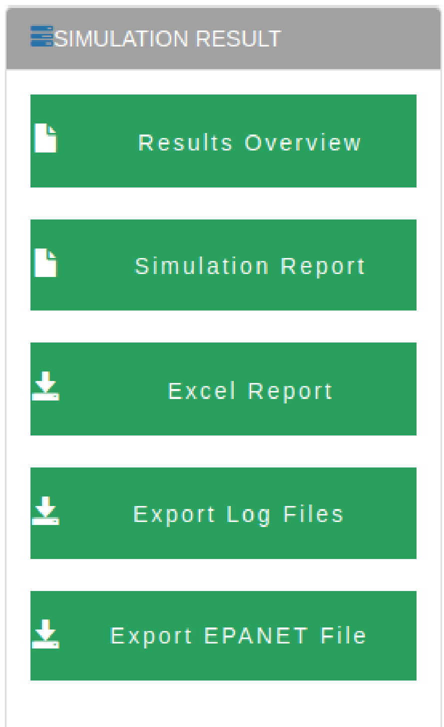


Fig. 19. Simulation results menu.

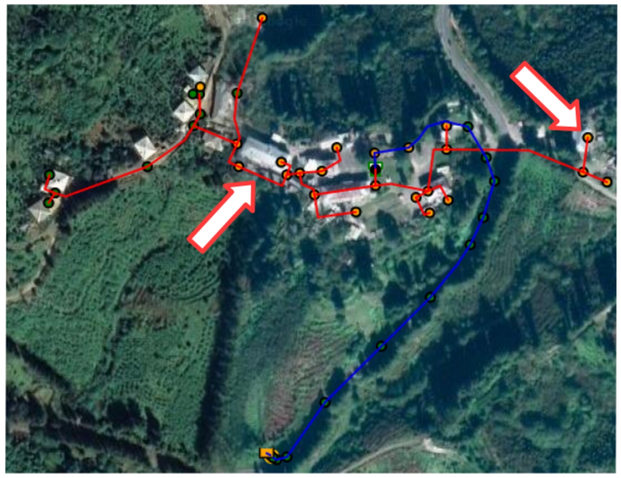
4.2.1 Map information

After the simulation, the project's map is updated, now featuring the network's hydraulic results. The displayed information can be used for fast and general analysis of the network performance. For more detailed results, the user can verify the **Results overview**, generate the **Simulation report** or **Excel reports**.

As presented in Fig. 20 (right), a color scheme is used to verify pressure in nodes and flow in pipes. The map is interactive and these verification parameters can be easily changed by the user and for each simulation's timestep. It's also possible to verify additional information by hovering the mouse over each inserted hydraulic object, as shown in Fig. 20 (left).

EPANET NODES: 207609	
result_demand	0.00875 (L/s)
result_head	110.144 (m)
result_pressure	6.144 (m)
result_quality	0.000 (ntu)
Time	18:00

EPANET PIPES: 119402	
result_flow	0.210 (L/s)
result_velocity	0.138 (m/s)
result_headloss	0.794 (m)
result_quality	0.000 (ntu)
Time	18:00



Pressure on nodes (m)	
●	< 0 – 0
●	0 – 15
●	15 – 100
●	> 100

Flow on pipes (L/s)	
—	0 – 0.2
—	0.2 – 0.6
—	0.6 – 1.0
—	1.0 – 1.4
—	> 1.4

Fig. 20. Simulation results map.

4.2.2 Results overview

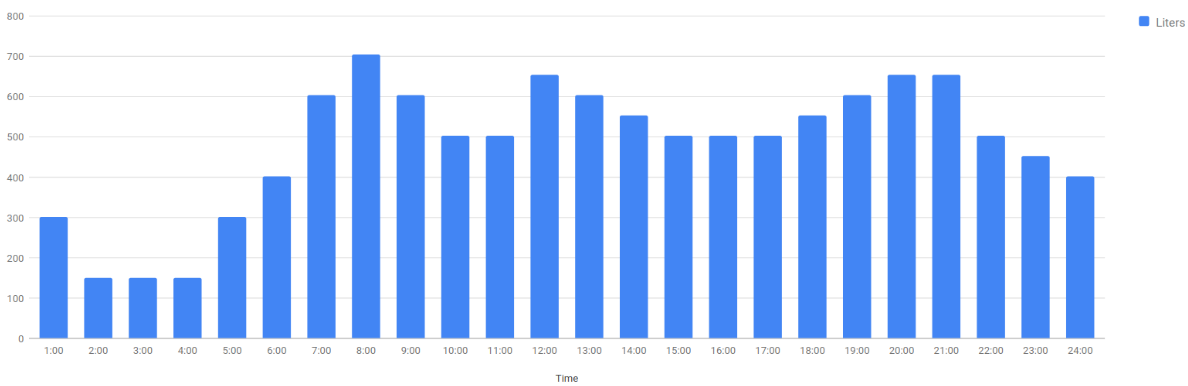
The software features a dashboard, where the user can quickly verify the network's hydraulic performance and main results. This tool is presented in a webpage-like environment and is fully customizable (Fig. 21). Currently, it displays information about the project's characteristics, achieved pressure and velocity in the system, and water demand.

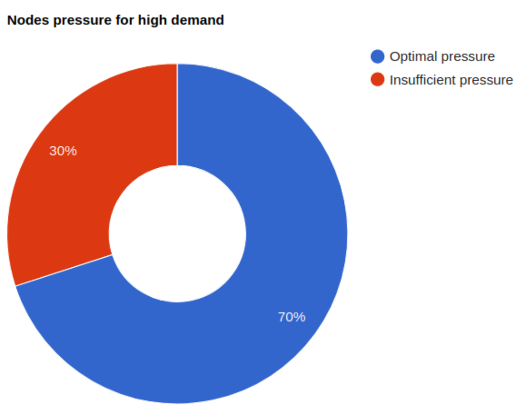
Water pressure is one of the most relevant parameters in water distribution systems, especially for the highest and lowest-demand periods. In the project setup (Section 2.2), the network's designer specified what are the minimum and maximum pressure that is desired in the system. With this information, the user can verify after each simulation the percentage and which nodes have optimal, insufficient, and excessive pressure in the network. For further simulation details, the user can generate PDF reports (section 4.2.3) or export Excel tables (section 4.2.4).

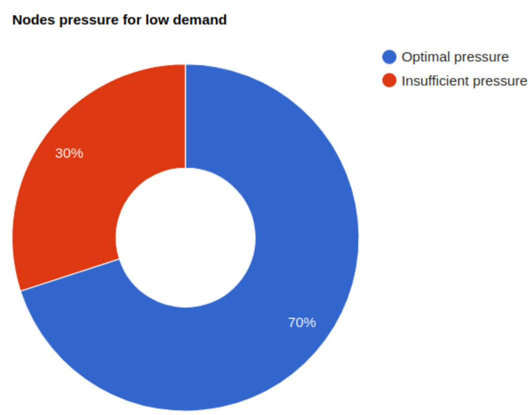
wSmart simulation results dashboard

Project	[Test] Simulation	**Number of people served**	100
Number of active connections	20	**Length of network**	1,393.5 m
Total daily production	12.0 m^3	**Total daily demand**	11.5 m^3
Maximum pressure on nodes	34.0 m	**Minimum pressure on nodes**	0.2 m
Maximum water velocity	1.606 m/s	**Average water velocity**	0.047 m/s

Network water demand per hour (L/H)







Nodes to check for high demand hour

Time	Id	Pressure
8	207590	5.7
8	J21	7.75
8	J19	7.75
8	J23	7.75
8	J20	7.74
8	J22	7.75

Nodes to check for low demand hour

Time	Id	Pressure
2	207590	7.61
2	J21	9.61
2	J19	9.61
2	J23	9.61
2	J20	9.61
2	J22	9.61

Fig. 21. wSmart results dashboard.

4.2.3 Simulation report

The software features a PDF document generation that compiles the project's main characteristics and hydraulic simulation results. It can be customized to present specific information required by the user, for example, the emission of automatic project reports for regulatory agencies.

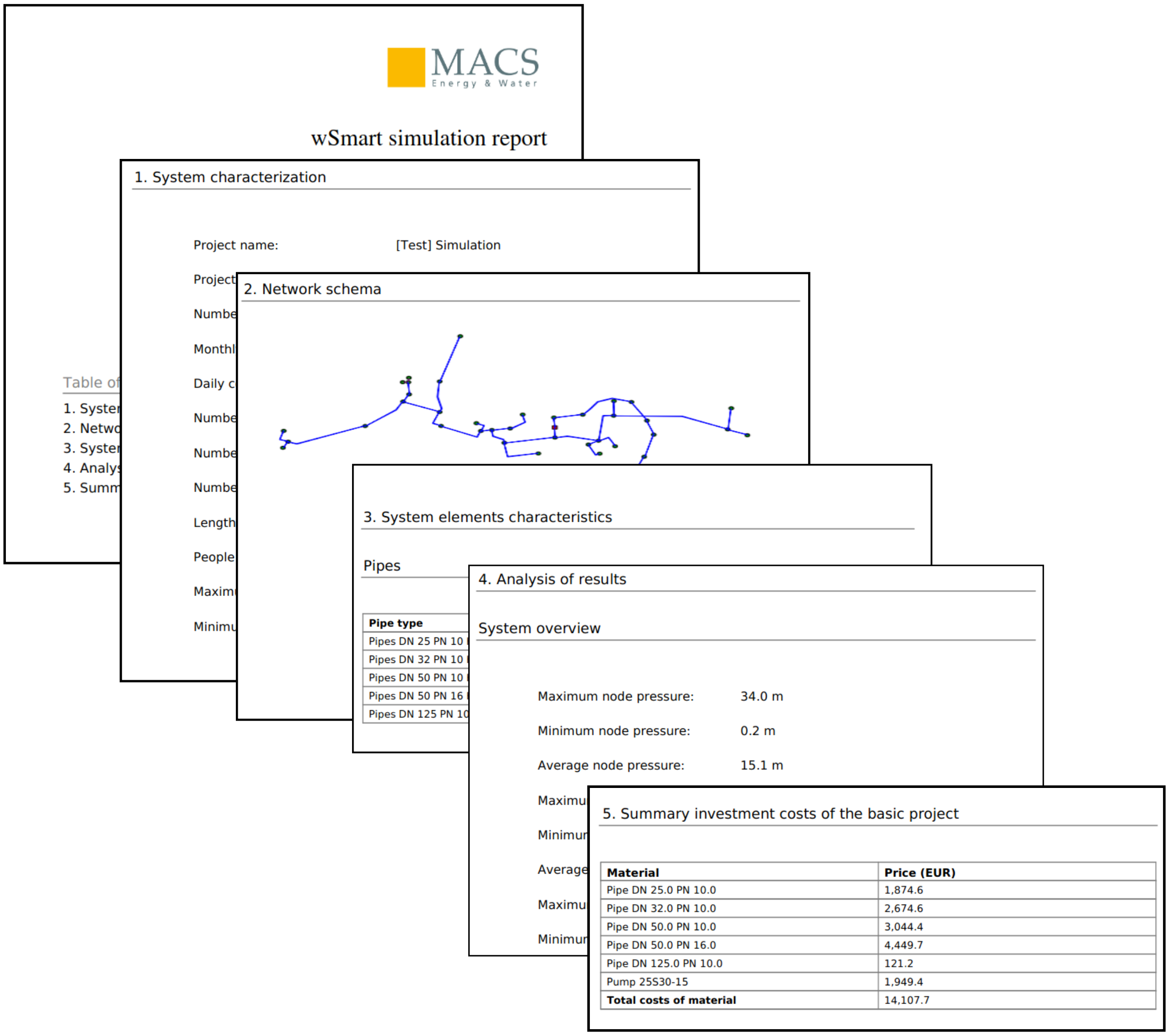


Fig. 22. Simulation report.

The report currently consists of five sections:

- System characterization: a summarized description of the project's characteristics, namely the data inserted when the project was created;
- Network schema: presents a draft of the network design, i.e. the position of all hydraulic objects;

- System elements description: lists of all inserted hydraulic objects and characteristics, for example, pipe types and their lengths;
- Analysis of results: presents the network's performance results for all hydraulic objects;
- Summary investment costs of the project: a concise table presenting the total costs of products.

4.2.4 Excel report

The application can automatically generate Excel tables, presenting detailed and raw data of the project. This feature is especially useful for technicians that are interested in further evaluating simulations and perform specific data analysis. Currently, it exports four Excel files:

- Project's costs: a summarized description of the project's expenses;
- Land ownership: description of all hydraulic objects that are placed within private properties;
- Simulation results for pipes: hydraulic results for pipes-related parameters;
- Simulation results for nodes: hydraulic results for nodes-related parameters.

4.2.5 Export log and EPANET files

Additional simulation's data can be obtained by exporting the simulation log and EPANET files:

- Log files: presents the simulation's adopted parameters and warnings;
- EPANET file: generates the project's EPANET input file.

5. GIS tools

This section of wSmart features a set of GIS-related tools designed to speed up water and wastewater project's development.

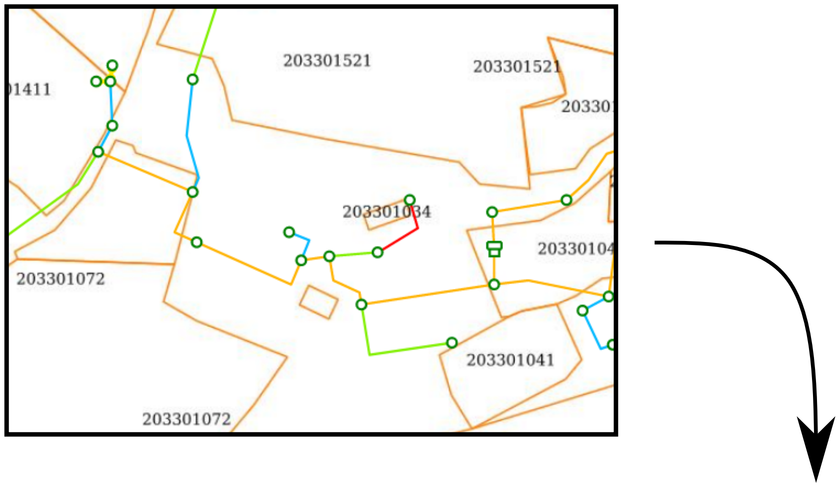
Fig. 23. Project GIS tools menu.

5.1 Ownership report

Besides technical and economic aspects, the implementation of water projects also depends on social and environmental obligations, such as obtaining licenses and permits. These documents usually require a considerable amount of complex and detailed information.

For populated villages, construction may be necessary within private properties. Thus, the **ownership report** automatically compiles information of all inserted hydraulic objects in the project and indicates if these elements are inside owned or public areas (Fig. 24).

It's also possible to export a PDF map to help the area assessment. Both the report and the map can be further customized.



WaterSmart	Ownership Report	Project: [Test] Simulation	Generation time: 2020-10-26 08:37:35				
STRUCTURE	WS ID	SPECIFICATION	LENGTH (m)	WIDTH (m)	AREA (m2)	CONTRACT TYPE	PARCEL ID
PIPE	119355	HDPE/25.0	1.6	1.0	1.6	SUPERFICIES	882012733060
PIPE	119358	HDPE/50.0	19.6	1.0	19.6	SUPERFICIES	882012733060
PIPE	119363	HDPE/32.0	17.2	1.0	17.2	SUPERFICIES	882011054196
PIPE	119365	HDPE/25.0	19.9	1.0	19.9	SUPERFICIES	882011054196
PIPE	119368	HDPE/50.0	20.9	1.0	20.9	SUPERFICIES	882011054271
PIPE	119368	HDPE/50.0	16.8	1.0	16.8	SUPERFICIES	882011054196

Fig. 24. Ownership report.

5.2 Export GIS data

The software has inbuilt features to export project's data for different formats, making it accessible to be used in other software. It may be required, for example, when environmental agencies need projects' Shapefiles for the emission of licenses or when engineers need to visualize data in AutoCAD for further detailed design.

Data for all hydraulic elements are exported, namely pipes, tanks, reservoirs, pumps, valves, and nodes. Currently, wSmart can export data to Shapefiles, DXF, and KML formats:

- Shapefile: ArcGIS, QGIS, PostGIS;
- DXF: AutoCAD, WaterCAD;
- KML: Google Earth, ArcGIS, QGIS.

Fig. 25. Data export and communication with other software.

5.3 Import data

WaterSmart can import external project's data using Shapefiles. The user needs to ensure that the names and structure of the files follow the instructions described below. Updated information can be obtained accessing: http://46.4.196.90:8001/shapesTables/.

5.3.1 Water supply projects

Nodes:

For water supply nodes, the Shapefiles should be named **nodes.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- nodeid: character field, is the given label for the node.
- demand: numeric field, node water consumption (liters / second).
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 1. Water supply nodes Shapefile example.

gid	nodeid	demand	geom
1	66317	0.02	1100F234ASDBH00
2	66323	0.00	1100FGSEASDBH00

Pipes

For water supply pipes, the Shapefiles should be named **pipes.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- label: character field, is the given label for the pipe.
- node1: character field, informs the node or junction where the pipe starts.
- node2: character field, informs the node or junction where the pipe ends.
- diameter: numeric field, is the pipe nominal diameter (mm).
- pn: numeric field, is the pipe PN value.
- material: character field, informs the pipe material.
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 2. Water supply pipes Shapefile example.

gid	name	node1	node2	diameter	pn	material	geom
1	60004	66381	66431	32	16	HDPE	1100F234ASDBH00
2	60005	66323	66423	32	10	HDPE	1100FGG4ASDBH02

Reservoirs

For water sources, the Shapefiles should be named **reservoirs.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- name: character field, is the given label for the tank.
- descr: character field, is the description for the tank.
- nodeid: character field, is the given label for the tank node.
- head: character field, is the head of the tank (m).
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 3. Water sources Shapefile example.

gid	name	descr	nodeid	head	geom
1	Reservoir1	50 m2	R1	2.0	1100F234ASDB4442
2	Reservoir2	30 m2	R2	3.0	1100F234ASDB4DR

Water tanks

For water tanks, the Shapefiles should be named **tanks.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- name: character field, is the given label for the tank.
- xlength: character field, is the length of the tank (m).
- xwidth: character field, is the width of the tank (m).
- volume: character field, is the volume of the tank (m^3).
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 4. Water tanks Shapefile example.

gid	name	xlength	xwidth	volume	geom
1	Tank1	2.0	2.5	10.0	1100F234ASDB4F0
2	Tank2	2.0	2.5	10.0	1100F234ASDB4XT

Pumps

For water pumps, the Shapefiles should be named **pumps.shp** and present the following table structure:

- integer field, automatically defined by the software that generated the Shapefile.
- name: character field, is the given label for the pump.
- node1: character field, informs the node or junction where the pump starts.

- node2: character field, informs the node or junction where the pump ends.
- pump_type_id: character field, informs the pump's type.
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 5. Water pump Shapefile example.

gid	name	node1	node2	pump_type_id	geom
1	Pump1	66381	66431	3	1100F234ASDBH00
2	Pump2	66383	66435	3	1100FGG4ASDBH02

Válvulas

For water valves, the Shapefiles should be named **valves.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- name: character field, is the given label for the valve.
- node1: character field, informs the node or junction where the valve starts.
- node2: character field, informs the node or junction where the valve ends.
- diameter: character field, is the valve nominal diameter (mm).
- type: character field, the valve type (PRV or PBV).
- setting: character field, informs the valve operational pressure (m) according to its type.
- minorloss: character field, informs the pressure loss (m).
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 6. Water valve Shapefile example.

gid	name	node1	node2	diameter	type	setting	minorloss	geom
1	Valve1	66381	66431	20	PBV	3	0	1100F234ASDBH00
2	Valve2	66323	66423	20	PRV	3	1.5	1100FGG4ASDBH02

5.3.2 Waste water projects

Manholes

For manholes, the Shapefiles should be named **manholes.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- nodeid: character field, is the given label for the manhole.
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 7. Manholes Shapefile example.

gid	nodeid	geom
1	66317	1100F234ASDBH00
2	66323	1100FGSEASDBH00

Pipes

For wastewater pipes, the Shapefiles should be named **pipes.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- label: character field, is the given label for the pipe.
- node1: character field, informs the node or junction where the pipe starts.
- node2: character field, informs the node or junction where the pipe ends.
- diameter: numeric field, is the pipe nominal diameter (mm).
- pn: numeric field, is the pipe PN value.

- material: character field, informs the pipe material.
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 8. Wastewater pipes Shapefile example.

gid	name	node1	node2	diameter	pn	material	geom
1	60004	66381	66431	32	16	HDPE	1100F234ASDBH00
2	60005	66323	66423	32	10	HDPE	1100FGG4ASDBH02

Septic tanks

For septic tanks, the Shapefiles should be named **septics.shp** and present the following table structure:

- gid: integer field, automatically defined by the software that generated the Shapefile.
- name: character field, is the given label for the tank.
- xlength: character field, is the length of the tank (m).
- xwidth: character field, is the width of the tank (m).
- volume: character field, is the volume of the tank (m^3).
- spec_1: character field, the user can insert specifications, as PAX.
- spec_2: character field, the user can insert specifications, as communal or individual.
- geom: geometry field, automatically defined by the software that generated the Shapefile.

Table 9. Septic tanks pipes Shapefile example.

gid	name	xlength	xwidth	volume	spec_1	spec_2	geom
1	Tank1	2.0	2.5	10.0	5 PAX	COMMUNAL	1100F234ASDB4F0
2	Tank2	2.0	2.5	10.0	5 PAX	COMMUNAL	1100F234ASDB4XT

6. Network design example

In this section, we describe a step-by-step network construction. Initially, we create a new project and insert the required information, as presented in Fig. 3. Then, using the interactive map we zoom in a region to start the network's configuration.

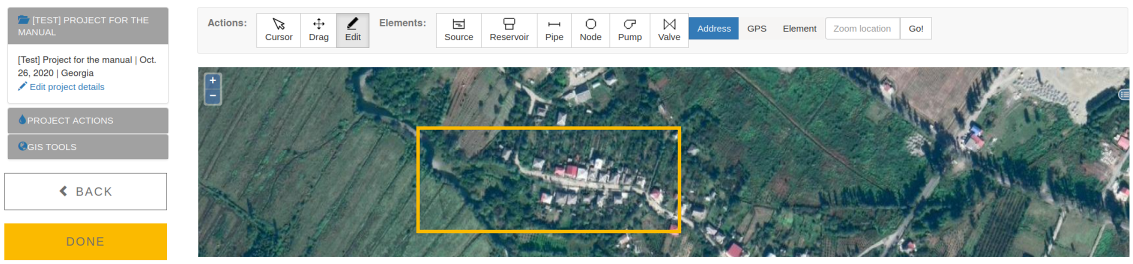


Fig. 26. Selecting an area to design a network.

1. Adding a water source

The network design starts with the project's water source, such as wells, lakes, or rivers. We click in the **source** object and then in the position where we want to insert it on the map.

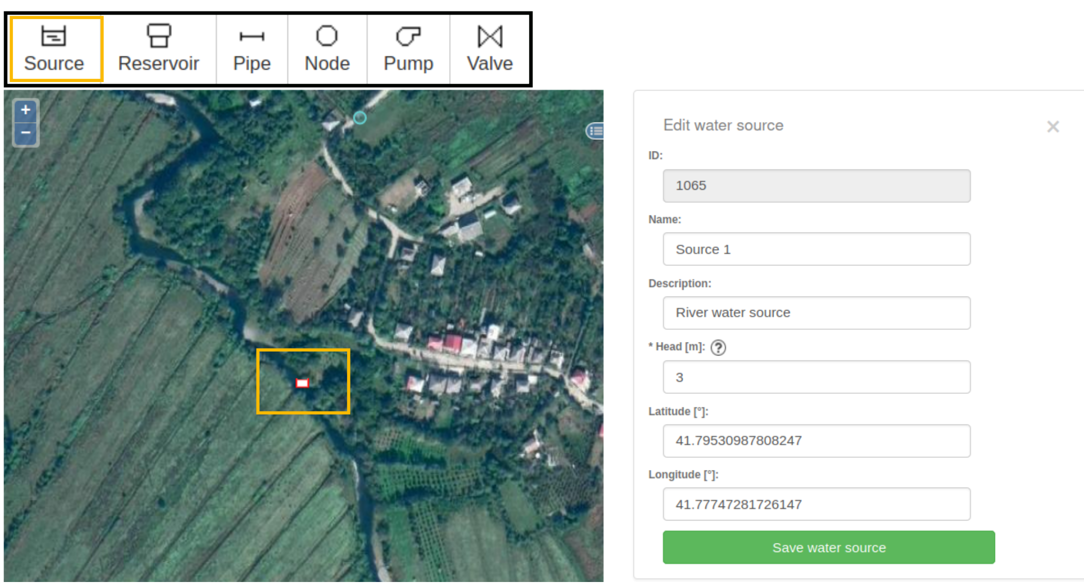


Fig. 27. Adding a water source in the project.

2. Adding nodes

Nodes are structures that connect pipes or where water enters or leaves the system. Whenever just connecting two pipe sections, the node works as a junction, and the water consumption must be zero. If the node leads to a house connection, we need to specify the daily demand in liters per second.

Supposing that a typical daily consumption (d_p) in the region is 120 liters per person (p) per day (d), and a house has on average five people, the node's demand is:

$$d_{hL/day} = d_p \times p = 120 \times 5 = 600[\mathrm{L/day}] \tag{1}$$

Since 1 day has 86400 seconds, to obtain the demand in liters per second for each house with 5 people:

$$d_{hL/s} = \frac{d_{hL/day}}{86400} = 0.007[\mathrm{L/s}] \tag{2}$$

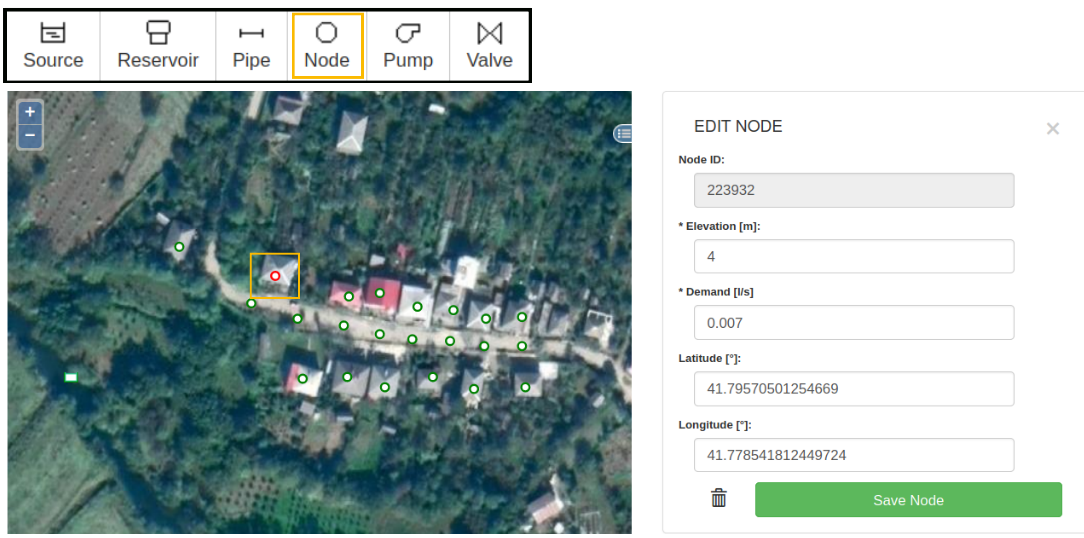


Fig. 28. Adding nodes in the project.

The water consumption for each node will automatically increase or decrease according to the selected demand pattern.

3. Adding water tanks

Water tanks or reservoirs are used to store water and support daily variations in water consumption. After placing the element on the map, the user needs to specify its characteristics, such as water level and dimensions.Figure 13 presents a schematic representation of the main input parameters of reservoirs.

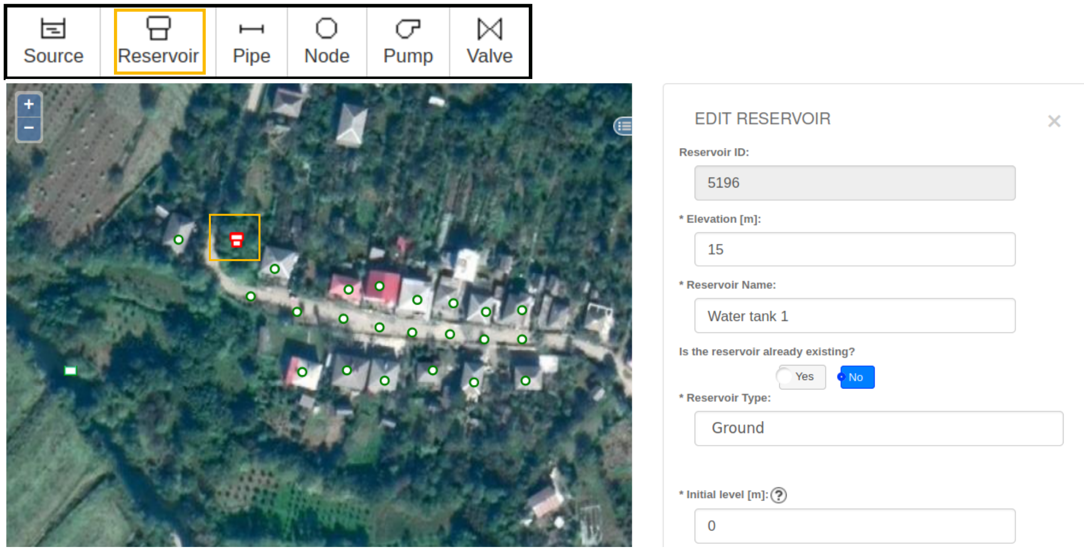


Fig. 29. Adding water tanks in the project.

4. Connecting pipes

Pipes must be inserted between elements, then the initial and final point of a pipe must be a node, a source, or a reservoir. The start node, end note, and length are automatically given by the software. The user needs to specify the pipe's status and type.

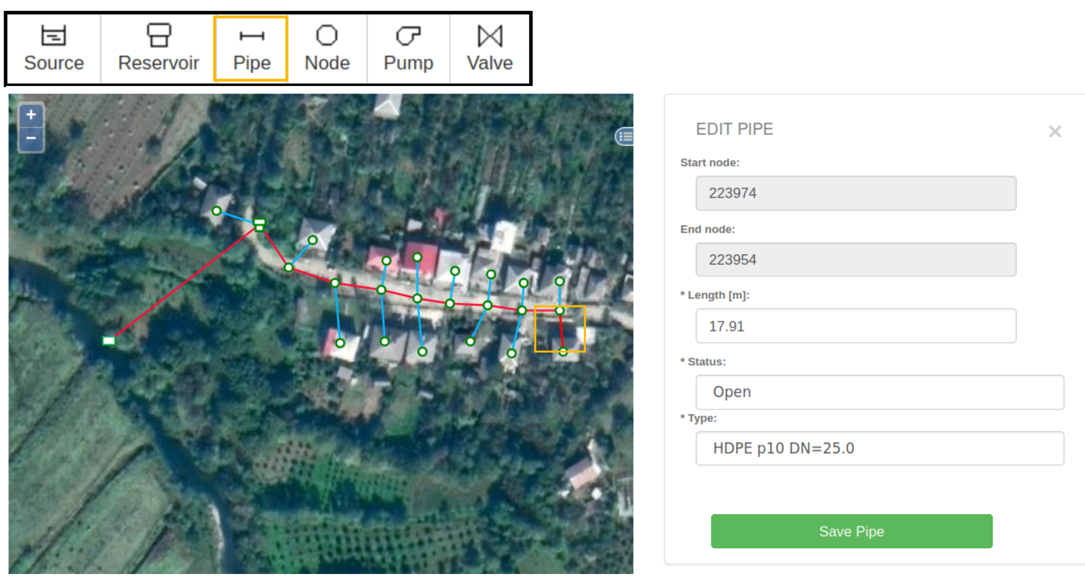


Fig. 30. Adding pipes in the project.

Pipes with different diameters have specific colors in wSmart. The user needs to take into account that each pipe has a different material and internal diameter, thus friction factors and head loss, which directly impact the water flow pressure and pressure.

5. Adding a pump

For the current project, we can observe in Figs. 27 and 29 that the water source elevation is lower than the tank's. Then, the gravity force is not sufficient to make water flow to the network, and it's necessary to use a pump to increase the system's head.

Pumps, just like pipes, must be inserted between nodes, sources, or reservoirs elements. To add the pump, we removed the pipe previously connecting the water source to the tank, added two additional junctions (no water demand), and a pump between them (Fig. 31). Now, the network has sufficient pressure to supply the water tank when the level drops below a certain threshold.

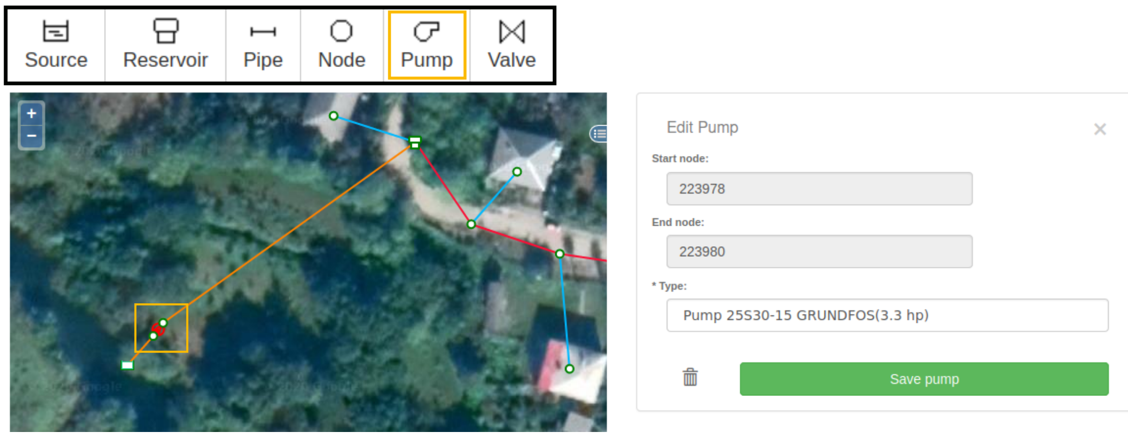


Fig. 31. Adding a pump in the project.

6. Adding a valve

Valves are hydraulic devices used whenever a reduction of water pressure to specific values is necessary. As presented in Fig.

Supposing that one specific node in the network should not have water pressure higher than 5 meters (Fig. 32), a PRV valve was inserted. We defined the **setting** parameter to 5 meters, thus the downstream pressure won't exceed this value.

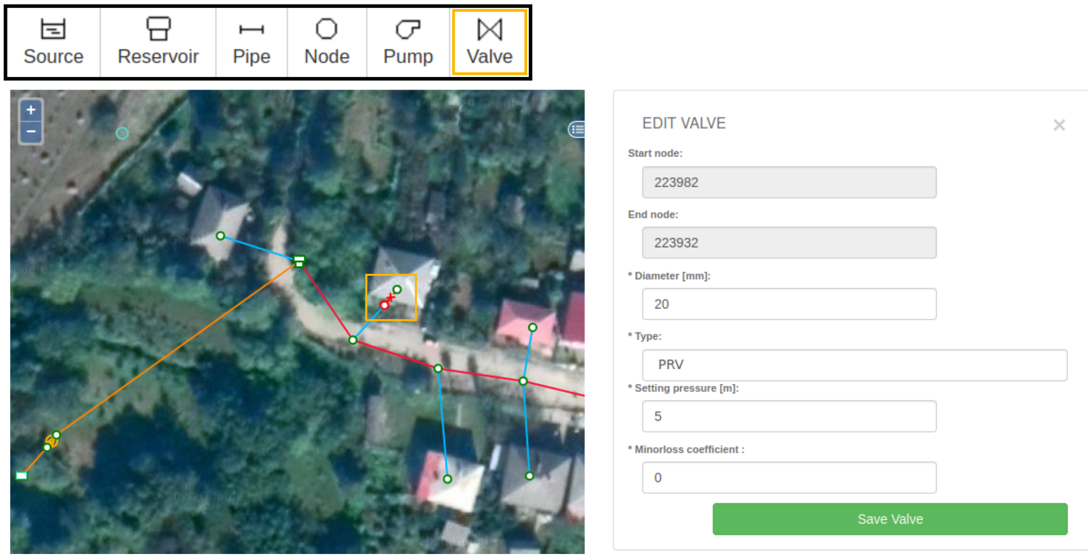


Fig. 32. Adding a valve in the project.

7. Running and checking simulations

After inserting and configuring all objects, we can start hydraulic simulations for water supply projects. When the simulation is successful, a pop-up log message appears and presents the used parameters (Fig. 33).

As shown in previous sections, we can evaluate the results directly on the map (Fig. 20), using the results dashboard (Fig. 21) or generating automatic PDF and Excel reports (Sections 4.2.3 and 4.2.4).

Project log information

```
****************************************************************
* E P A N E T *
* Hydraulic and Water Quality *
* Analysis for Pipe Networks *
* Version 2.00.12 *
****************************************************************

WaterSmart
Trial for WaterSmart

Input Data File ................... /var/www/WaterSmart/tmp/out_521.txt
Number of Junctions................ 25
Number of Reservoirs............... 1
Number of Tanks ................... 1
Number of Pipes ................... 24
Number of Pumps ................... 1
Number of Valves .................. 1
Headloss Formula .................. Darcy-Weisbach
Hydraulic Timestep ................ 1.00 hrs
Hydraulic Accuracy ................ 0.001000
Status Check Frequency ............ 2
Maximum Trials Checked ............ 10
Damping Limit Threshold ........... 0.000000
Maximum Trials .................... 40
Quality Analysis .................. None
Specific Gravity .................. 1.00
Relative Kinematic Viscosity ...... 1.00
Relative Chemical Diffusivity ..... 1.00
Demand Multiplier ................. 1.00
Total Duration .................... 24.00 hrs
Reporting Criteria:
No Nodes
No Links

Analysis begun Mon Oct 26 17:29:15 2020
```

Back to edit | Continue

Fig. 33. Simulation results analysis.

References

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[2] Will Sarni,Cassidy White,Randolf Webb,Katharine Cross,Raul Glotzbach (2019) Digital Water - Industry leaders chart the transformation journey (International Water Association),

[3] Rossman, L A (2000) EPANET 2 USERS MANUAL (U.S. Environmental Protection Agency, Washington, D.C.), EPA/600/R-00/057.