

# **GIS tools for water supply systems: an implementation using JGrassTools and gvSIG**

Franceschi Silvia & Antonello Andrea

*gvSIG Festival – May 2016*



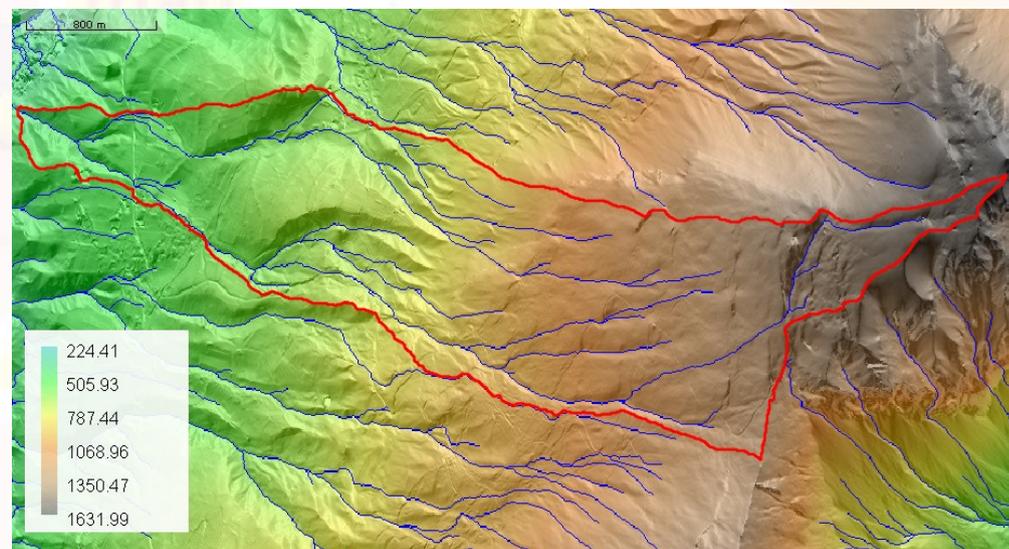
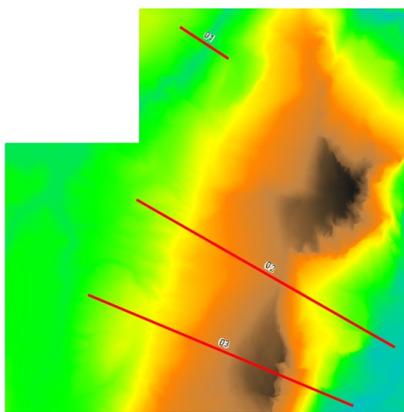
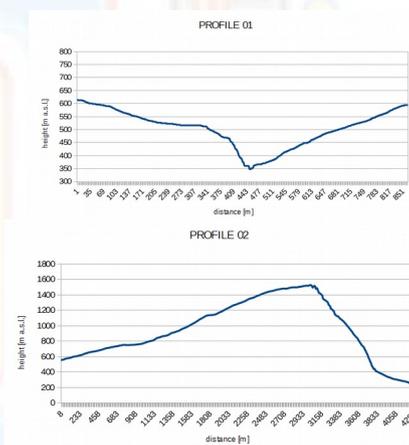
# WHO AM I?

- environmental engineer specialized in hydrology, hydraulics and geomorphology
- co-founder of HydroloGIS with Andrea Antonello
- developed scientific models contained in the JGrassTools library in the field of:
  - hydrology
  - hydraulics
  - forestry
- PhD student of Science and Technology at the Free University of Bolzano (Italy)
- OSGeo Charter Member

**HydroloGIS**  
Environmental Engineering

# JGRASSTOOLS

- geospatial Open Source library containing modules for:
  - vector and raster processing
  - geomorphology
  - forestry
  - mobile mapping connection
  - LiDAR data analysis



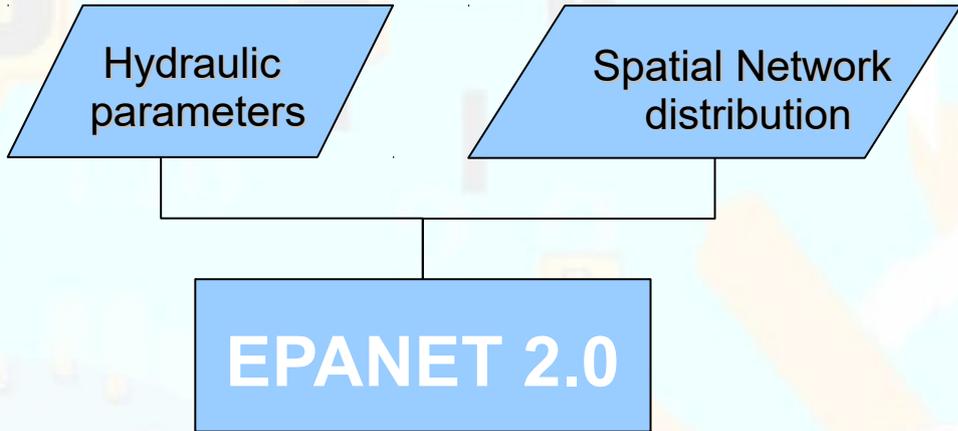


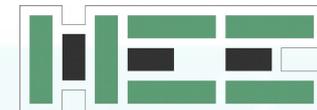
# EPANET

- a powerful and well known software for water supply system management (analysis) and design
- developed by EPA (United States Environmental Protection Agency)
- predicts the dynamic hydraulic and water quality behavior within a drinking water distribution system operating over an extended period of time
- research tool for improving the understanding of the movement (flow and direction) of the water within a distribution systems



# EPANET & GIS





# EPANET & GIS

Hydraulic parameters

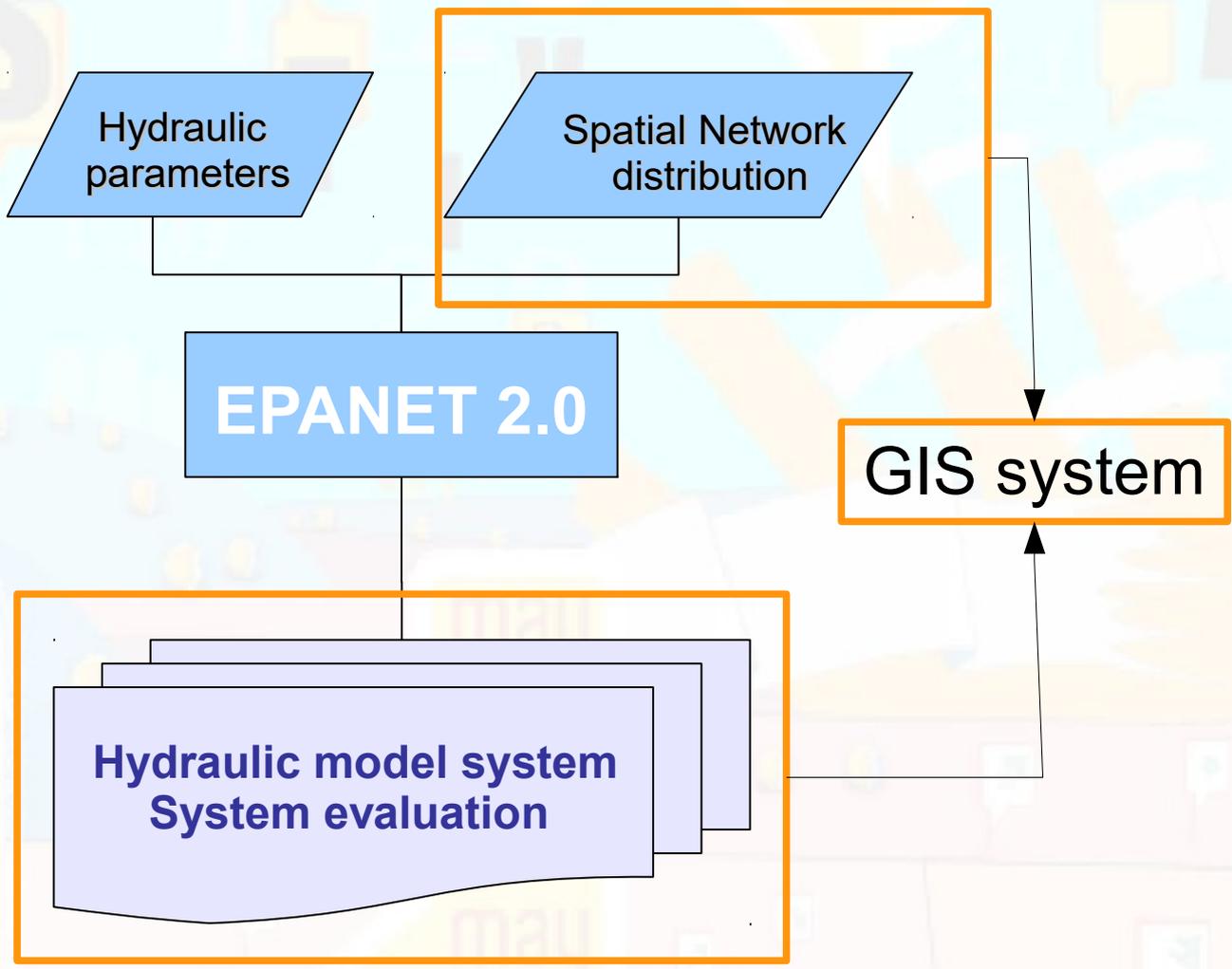
Spatial Network distribution

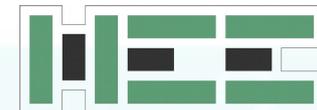
EPANET 2.0

Hydraulic model system  
System evaluation



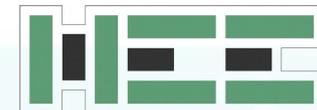
# EPANET & GIS





# EPANET & GIS

- the bindings to the original EPANET library are integrated as a module in the JGrassTools library



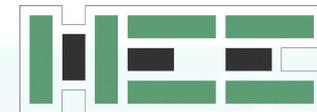
# EPANET & GIS

- the bindings to the original EPANET library are integrated as a module in the JGrassTools library
- a plugin in gvSIG is developed that supplies a graphical interface to prepare the data for EPANET in a GIS way



# EPANET & GIS

- the bindings to the original EPANET library are integrated as a module in the JGrassTools library
- a plugin in gvSIG is developed that supplies a graphical interface to prepare the data for EPANET in a GIS way
- this plugin provides all of EPANET → there is no need to install EPANET software itself, it comes automatically with the plugin



# EPANET & GIS

## 4 STEP SIMULATION RUN

1. generate new shape files: reservoirs, valves, pumps, pipes, tanks, junction



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1. generate new shape files: reservoirs, valves, pumps, pipes, tanks, junction
2. synchronize shape files attributes using other available geospatial data: DTM for elevation and pipes' 3D length evaluation



# EPANET & GIS

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3. run EPANET simulation: hydraulic parameters definition and insertion of other information to be added for the simulation



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3. run EPANET simulation: hydraulic parameters definition and insertion of other information to be added for the simulation
4. open the EPANET result viewer: visualization of the results, spatial maps and charts with the evolution of local variables in space and time

# EPANET & gvSIG

The tools are available from the menu:

**HydroloGIS** → Epanet

The screenshot displays the gvSIG interface with the HydroloGIS menu open. The menu items are:

- Epanet
- Geoparazzi
- Strumenti
- JGrasTools
- Create Project Files
- Sync Project Shapefiles
- Run Epanet
- View Results
- Style Layers

The main map area shows a network diagram overlaid on a topographic map of a town. The network consists of nodes (blue circles) and links (colored lines). Node J24 is highlighted. The map is labeled "CASTELLI DI RIEMMI".

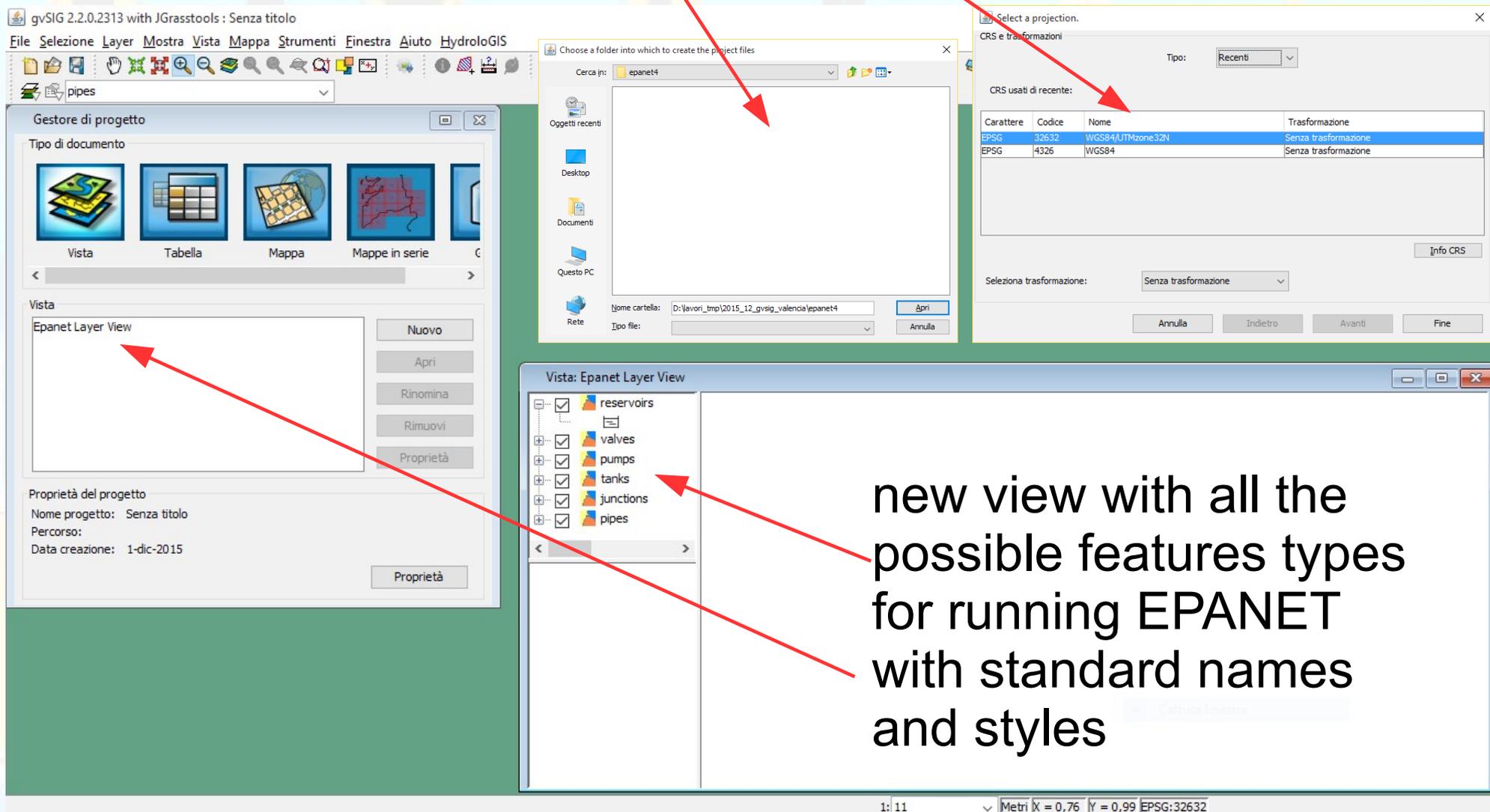
The "Gestore di progetto" window shows the results for node J24 in run 2. The graph plots PRESSURE (Y-axis, 47 to 51) against time (X-axis, 1970-01-01 00:00 to 1970-01-01 03:00). The pressure starts at approximately 48.1 at 00:00, rises to 50.0 at 01:00, and remains constant at 50.0 until 03:00.

The "Epanet Results Browser" window shows the following details:

- Epanet Runs: 2 - test02
- Title: test02
- Description: New Epanet Run Description
- User: hydrologis
- Timestamp: 2015-12-01 10:08:26
- Variables:
  - Node variable: PRESSURE
  - Link variable: FLOW
- Timeline:
  - Select time: 1970-01-01 02:00:00
- Plots:
  - Plot Node: J24
  - Plot Link: P51

# 1. CREATE PROJECT FILES

Select the folder and the projection of the project



The screenshot shows the gvSIG 2.2.0.2313 interface with the following components:

- Project Manager (Gestore di progetto):** Shows document types (Vista, Tabella, Mappa, Mappe in serie) and the selected 'Epanet Layer View' view. Properties include: Nome progetto: Senza titolo, Percorso: (empty), Data creazione: 1-dic-2015.
- Folder Selection Dialog:** Shows the selection of the 'epanet4' folder.
- Projection Selection Dialog:** Shows the selection of the 'Senza trasformazione' (No transformation) projection.
- Epanet Layer View Window:** Shows a list of feature types: reservoirs, valves, pumps, tanks, junctions, and pipes, all checked.

new view with all the possible features types for running EPANET with standard names and styles

1: 11 | Metri | X = 0,76 | Y = 0,99 | EPSG:32632



# 1. CREATE PROJECT FILES

Shapefiles attributes contain the required parameters for the features

gvSIG 2.2.0.2313 with JGrasTools : Senza titolo

File Modifica Selezione Mostra Tabella Vista Mappa Strumenti Finestra Aiuto HydroGIS

Vista: Epanet Layer View

- reservoirs
- valves
- tanks
- pumps
- junctions
- pipes

Tabella degli attributi: reservoirs

id	head	pattern_id
0 / 0 righe selezionate.		

Tabella degli attributi: valves

id	startnode	endnode	diam	type	setting	min_loss	status
0 / 0 righe selezionate.							

Tabella degli attributi: pumps

id	startnode	endnode	power	head_id	speed	pattern_id	price	pri_pat_id	effic_id
0 / 0 righe selezionate.									

Tabella degli attributi: tanks

id	elev	init_lev	min_lev	max_lev	diam	min_vol	vol_cur_id
0 / 0 righe selezionate.							

Tabella degli attributi: junctions

id	elev	DEPTH	demand	emitt_coef	pattern_id
0 / 0 righe selezionate.					

Tabella degli attributi: pipes

id	startnode	endnode	length	diam	rough	demand	pattern_id	leakcoeff	min_loss	status
0 / 0 righe selezionate.										

Metri X = 1,08 Y = 0,61 EPSG:32632

# 1. CREATE PROJECT FILES

GIS layers (orthophoto or technical maps) as background to draw/transform the main features of the aqueduct

gvSIG 2.2.0.2313 with JGrasTools : epanet\_castello3.gvsproj

File Selezione Layer Mostra Vista Mappa Vista portatile Strumenti Finestra Aiuto HydroloGIS

junctions

Vista: Epanet Layer View

- ☑ tanks
- ☑ junctions
- ☑ reservo
- ☑ pipes
- ☑ 044100
- ☐ CTP20

Inizia editazione

Rinomina

Tabella degli attributi

Proprietà

Zoom al layer

Rimuovi layer

Ricarica

Mostra errori

Porta in primo piano

Copia

Taglia

Incolla

Esporta...

Aggiungi layer

Tabella degli attributi: junctions

	id	elev	DEPTH	demand	emitt_coef	patte
1	J53	965,298	1,500	0,100	0,000	
2	J52	943,197	1,500	0,100	0,000	
3	J51	947,771	1,500	0,100	0,000	
4	J50	948,213	1,500	0,100	0,000	
5	J49	948,894	1,500	0,100	0,000	
6	J48	949,035	1,500	0,300	0,000	
7	J47	948,896	1,500	0,300	0,000	
8	J46	950,385	1,500	0,300	0,000	
9	J45	949,548	1,500	0,300	0,000	
10	J44	948,027	1,500	0,100	0,000	
11	J43	947,698	1,500	0,300	0,000	
12	J42	948,257	1,500	2,000	0,000	
13	J41	952,554	1,500	0,100	0,000	
14	J40	946,590	1,500	0,100	0,000	
15	J39	942,532	1,500	0,100	0,000	
16	J38	940,974	1,500	0,100	0,000	
17	J37	947,798	1,500	0,100	0,000	
18	J36	938,502	1,500	1,000	0,000	
19	J35	948,946	1,500	0,100	0,000	
20	J34	944,038	1,500	0,100	0,000	
21	J33	938,573	1,500	0,100	0,000	
22	J32	940,214	1,500	3,000	0,000	
23	J31	939,706	1,500	0,300	0,000	
24	J30	942,756	1,500	0,100	0,000	
25	J29	942,477	1,500	0,300	0,000	
26	J28	943,485	1,500	0,300	0,000	
27	J27	942,688	1,500	0,300	0,000	
28	J26	938,681	1,500	1,000	0,000	
29	J25	940,378	1,500	2,000	0,000	
30	J24	942,352	1,500	2,000	0,000	
31	J23	938,598	1,500	3,000	0,000	
32	J22	936,453	1,500	0,300	0,000	

1: 1.578    Metri X = 687.554,96 Y = 5.128.322,86 EPSG:32632

# 2. SYNCHRONIZE ATTRIBUTES

DTM for elevation and pipes' 3D length evaluation

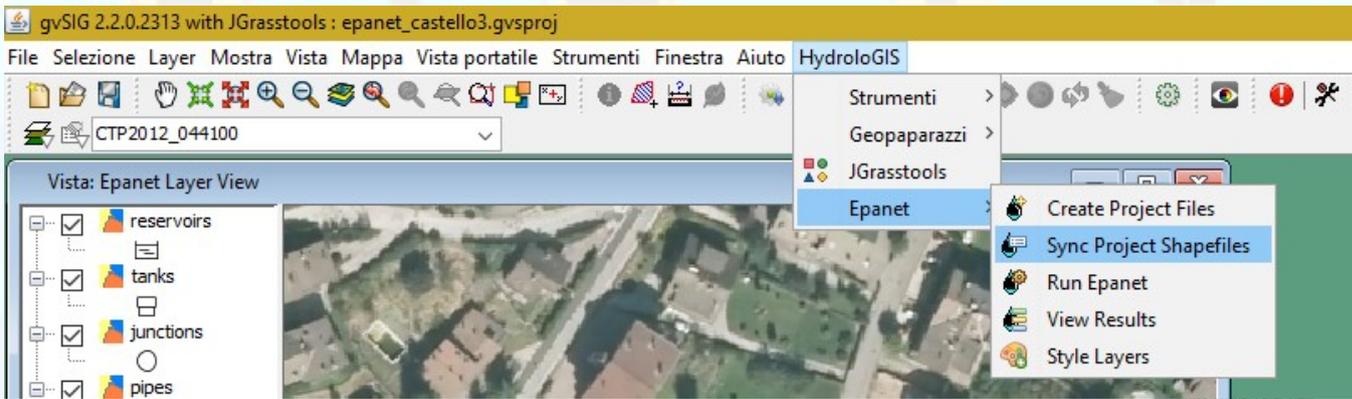
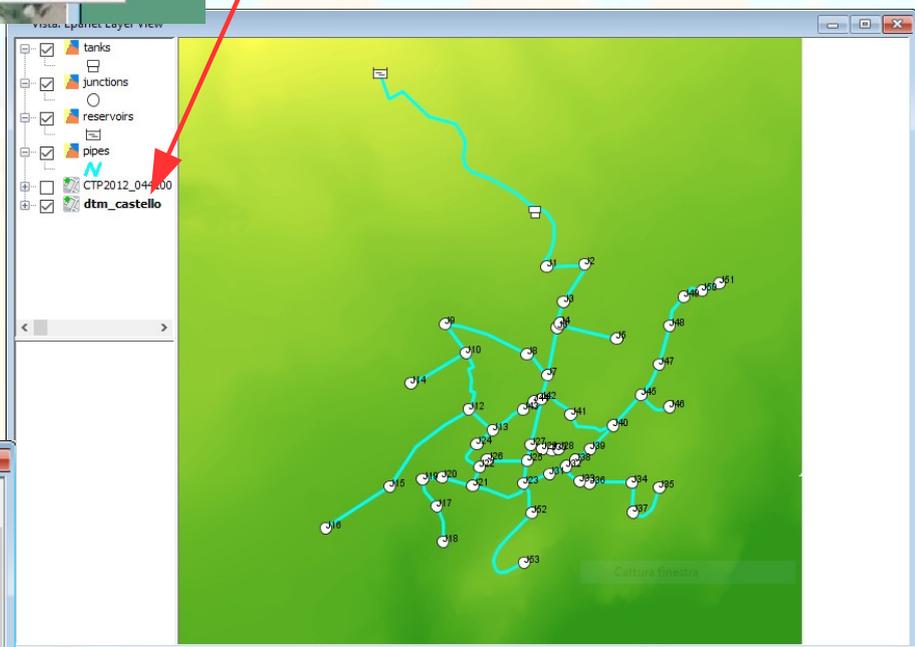


Tabella degli attributi: junctions

id	elev	DEPTH	demand	emitt_coef	pattern_id
1	965,298	1,500	0,100	0,000	
2	943,197	1,500	0,100	0,000	
3	947,771	1,500	0,100	0,000	
4	948,213	1,500	0,100	0,000	
5	948,894	1,500	0,100	0,000	
6	949,035	1,500	0,300	0,000	
7	948,896	1,500	0,300	0,000	
8	950,385	1,500	0,300	0,000	
9	949,548	1,500	0,300	0,000	
10	948,027	1,500	0,100	0,000	
11	947,698	1,500	0,300	0,000	
12	948,257	1,500	2,000	0,000	
13	952,554	1,500	0,100	0,000	
14	946,500	1,500	0,100	0,000	

Tabella degli attributi: pipes - 1

id	startnode	endnode	length	diam	rough	demand	pattern_id	leakcoeff	min_loss	status
P1	J8	J9	152,476	80,000	0,050	0,000		0,000	0,000	open
P2	J9	J10	62,127	80,000	0,050	0,000		0,000	0,000	open
P3	J10	J12	115,346	80,000	0,050	0,000		0,000	0,000	open
P4	J44	J43	23,922	100,000	0,050	0,000		0,000	0,000	open
P5	J43	J13	63,537	100,000	0,050	0,000		0,000	0,000	open
P6	J49	J48	57,502	80,000	0,050	0,000		0,000	0,000	open
P7	J48	J47	69,309	110,000	0,002	0,000		0,000	0,000	open
P8	J47	J45	61,931	110,000	0,002	0,000		0,000	0,000	open
P9	J45	J40	71,611	110,000	0,002	0,000		0,000	0,000	open
P10	J40	J39	56,718	100,000	0,050	0,000		0,000	0,000	open
P11	J39	J38	32,204	100,000	0,050	0,000		0,000	0,000	open



## 2. SYNCHRONIZE ATTRIBUTES

Warnings and errors messages from the tools are highlighted in a pop-up dialog.

The screenshot displays a GIS application window with the following components:

- Project Manager:** Shows the current project and layers.
- Console Log:** Contains the following text:
 

```

      Process SyncEpanetShapefilesExtension started at: 2015-11-30 17:01:22
      Reading input vector layers...
      Reading coverage: dtm_castello.asc
      Finished.
      ...
      Finished.
      Extracting elevations from dem...
      20%...
      40%...
      50%...
      70%...
      90%...
      100%...
      Finished.
      Extracting pipe-nodes links...
      10%...
      30%...
      50%...
      60%...
      80%...
      100%...
      Finished.
      Extracting pumps attributes...
      Finished.
      Extracting valves attributes...
      Finished.
      
```
- View: Epanet Layer View:** Shows a map with a color-coded elevation background (DTM) and a network of pipes and nodes. A legend on the left lists layers: reservoirs, junctions, tanks, pipes, and dtm\_castello. The dtm\_castello legend shows elevation values: 795.46, 903.03, 1010.59, 1118.16, 1225.73, and 1333.29.
- WARNING Dialog Box:** A red arrow points to a dialog box with the following text:
 

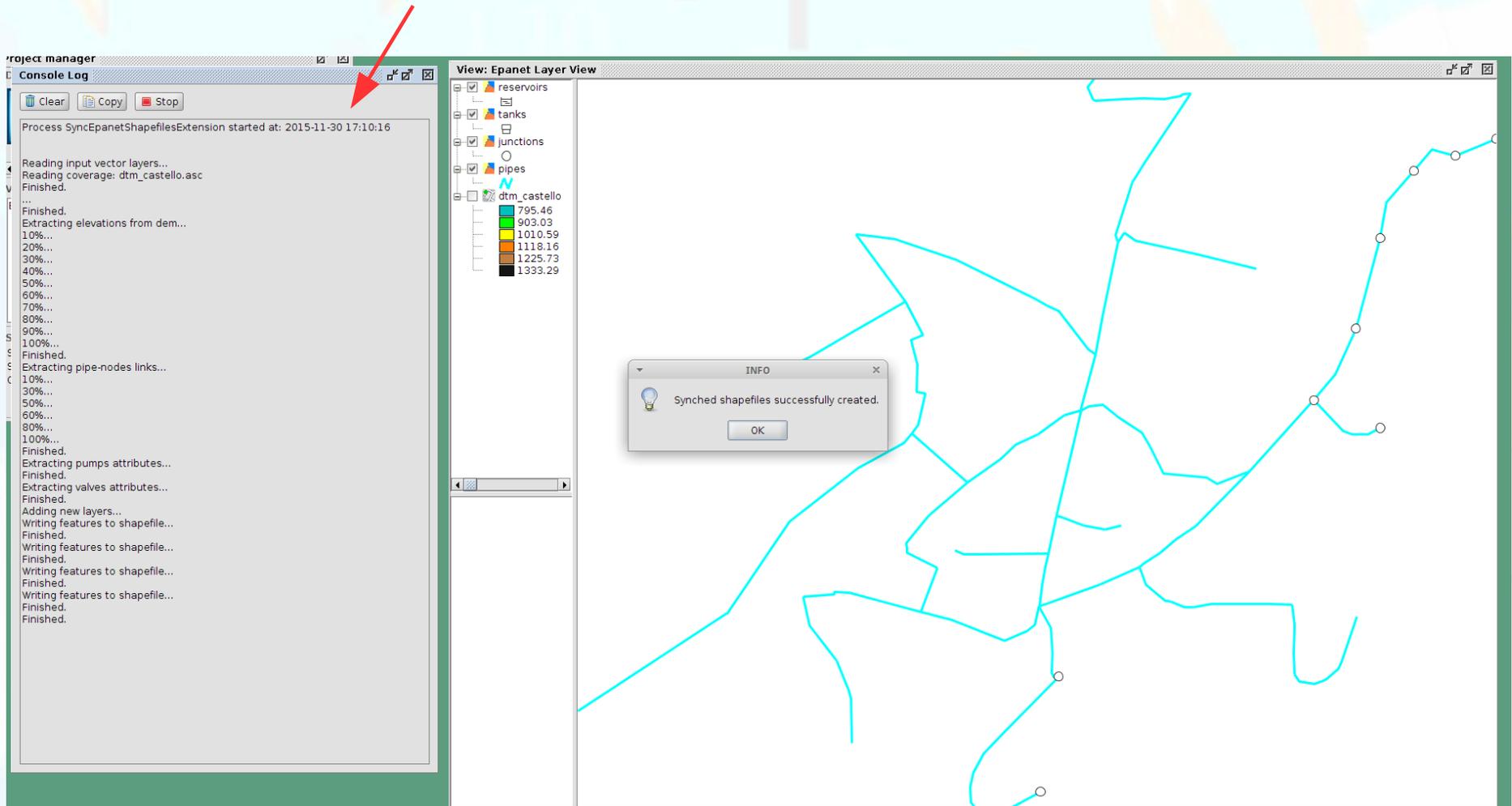
```

      WARNING
      Some of the features could not be synced:
      No end node found for pipe: P4
      No end node found for pipe: P14
      No start node found for pipe: P21
      No start node found for pipe: P27
      No start node found for pipe: P28
      No end node found for pipe: P41
      OK
      
```

The status bar at the bottom indicates the scale is 1:4,486 and the coordinates are Meters X = 686,922.95 Y = 5,128,317.32 EPSG:32632.

# 2. SYNCHRONIZE ATTRIBUTES

Progress state and general information are displayed in a dedicated Console



# 2. SYNCHRONIZE ATTRIBUTES

Complete all the required parameters for the features

gvSIG 2.2.0.2313 with JGrasTools : epanet\_castello3.gvsproj

File Modifica Selezione Mostra Tabella Vista Mappa Strumenti Finestra Aiuto HydroGIS

Vista: Epanet Layer View

- tanks
- junctions
- reservoirs
- pipes
- CTP2012\_044100
- [0.0, 1.0[
- [1.0]

Tabella degli attributi: tanks

tank	id	elev	init_lev	min_lev	max_lev	diam	min_vol	vol_cur_id
1	T1	999,538	4,000	2,000	6,000	7,000	0,000	

Tabella degli attributi: junctions

junc	id	elev	DEPTH	demand	emitt_coef	pattern_j
1	J53	965,298	1,500	0,100	0,000	
2	J52	943,197	1,500	0,100	0,000	
3	J51	947,771	1,500	0,100	0,000	
4	J50	948,213	1,500	0,100	0,000	
5	J49	948,894	1,500	0,100	0,000	
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9	J45	949,548	1,500	0,300	0,000	
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13	J41	952,554	1,500	0,100	0,000	
14	J40	946,590	1,500	0,100	0,000	
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25	J29	942,477	1,500	0,300	0,000	
26	J28	943,485	1,500	0,300	0,000	
27	J27	942,688	1,500	0,300	0,000	
28	J26	938,681	1,500	1,000	0,000	
29	J25	940,378	1,500	2,000	0,000	
30	J24	942,352	1,500	2,000	0,000	

Tabella degli attributi: reservoirs

reservoir	id	head	pattern_id
1	R1	1.085,000	

0 / 1 righe selezionate.

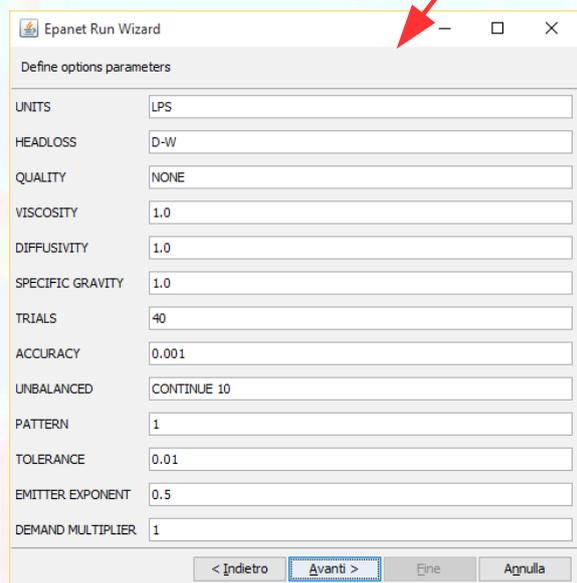
Tabella degli attributi: pipes - 1

pipe	id	startnode	endnode	length	diam	rough	demand	pattern_id	leakcoeff	min_loss	status
1	P1	J8	J9	152,476	80,000	0,050	0,000		0,000	0,000	open
2	P2	J9	J10	62,127	80,000	0,050	0,000		0,000	0,000	open
3	P3	J10	J12	115,346	80,000	0,050	0,000		0,000	0,000	open
4	P4	J44	J43	23,922	100,000	0,050	0,000		0,000	0,000	open
5	P5	J43	J13	63,537	100,000	0,050	0,000		0,000	0,000	open
6	P6	J49	J48	57,502	80,000	0,050	0,000		0,000	0,000	open
7	P7	J48	J47	69,309	110,000	0,002	0,000		0,000	0,000	open
8	P8	J47	J45	61,931	110,000	0,002	0,000		0,000	0,000	open
9	P9	J45	J40	71,611	110,000	0,002	0,000		0,000	0,000	open
10	P10	J40	J39	56,718	100,000	0,050	0,000		0,000	0,000	open
11	P11	J39	J38	32,204	100,000	0,050	0,000		0,000	0,000	open

Metri X = 687.905,24 Y = 5.128.058,53 EPSG:32632

# 3. RUN EPANET SIMULATION

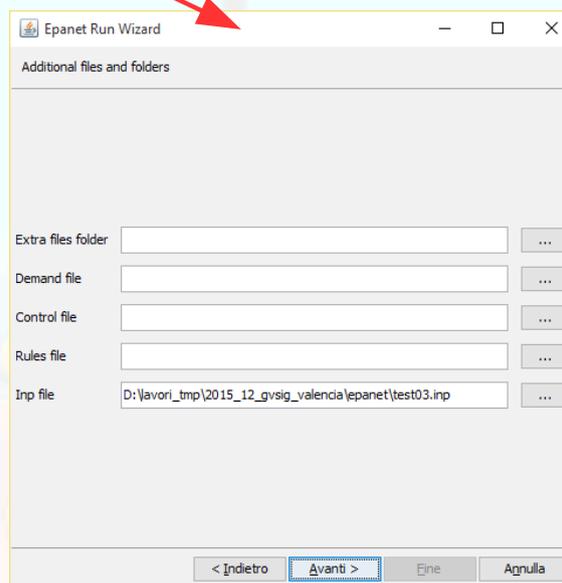
Simplified wizards help the user to fill in the main hydraulics parameters



Define options parameters

UNITS	LPS
HEADLOSS	D-W
QUALITY	NONE
VISCOSITY	1.0
DIFFUSIVITY	1.0
SPECIFIC GRAVITY	1.0
TRIALS	40
ACCURACY	0.001
UNBALANCED	CONTINUE 10
PATTERN	1
TOLERANCE	0.01
EMITTER EXPONENT	0.5
DEMAND MULTIPLIER	1

< Indietro **Avanti >** Fine Annulla



Additional files and folders

Extra files folder  ...

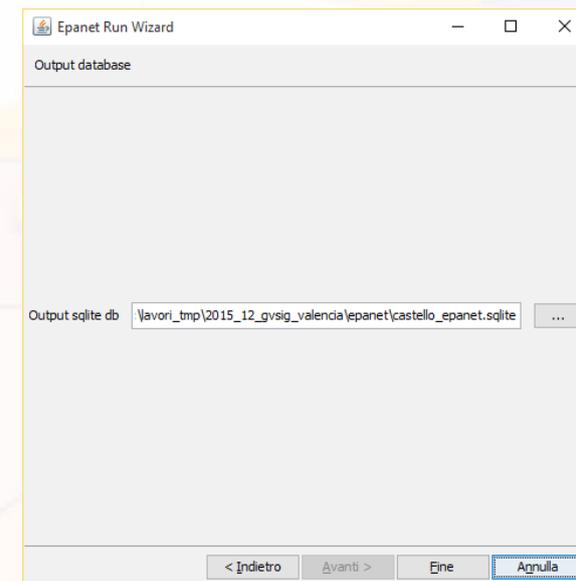
Demand file  ...

Control file  ...

Rules file  ...

Inp file  ...

< Indietro **Avanti >** Fine Annulla



Output database

Output sqlite db  ...

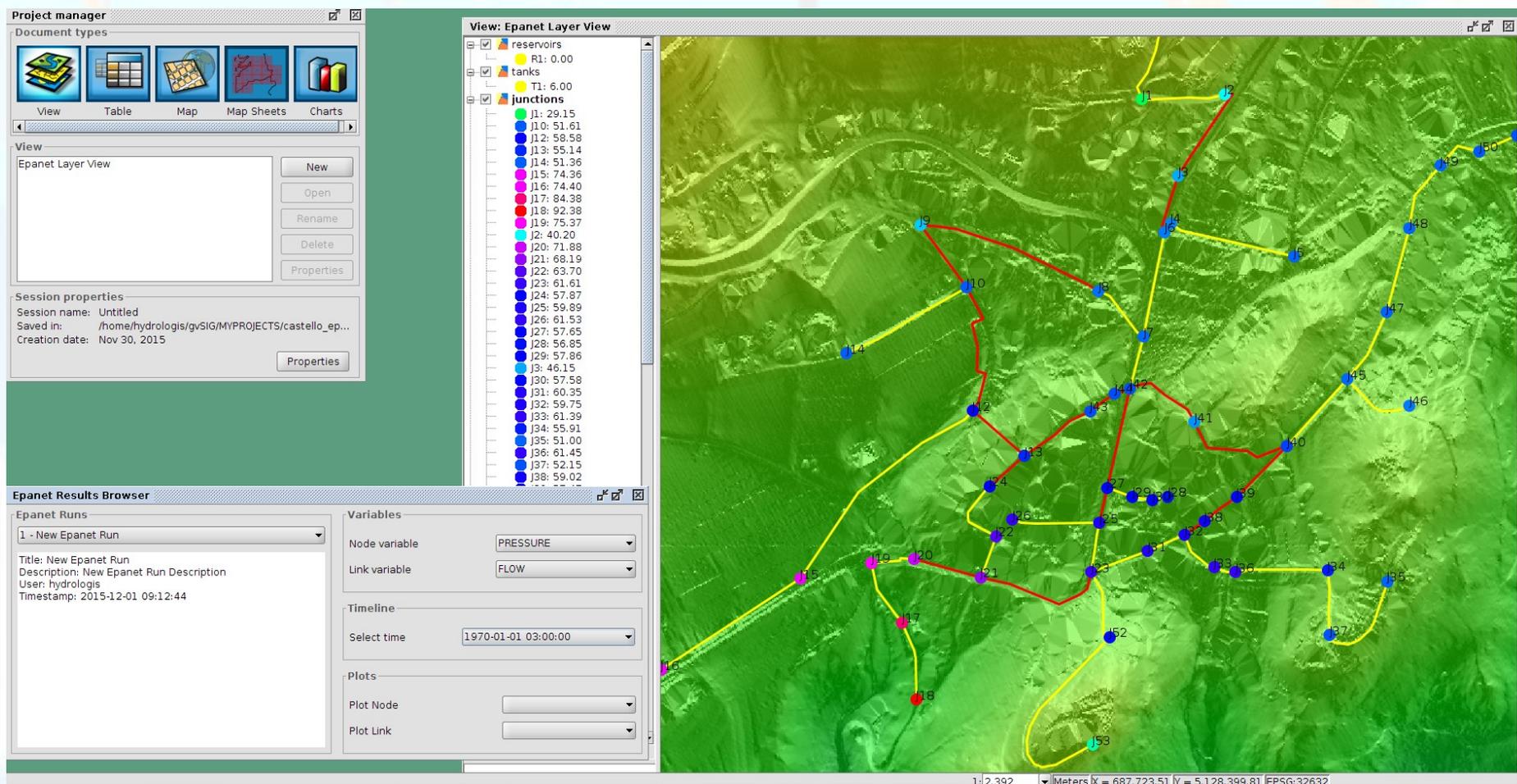
< Indietro **Avanti >** Fine **Annulla**

The results are stored in a local database (sqlite)



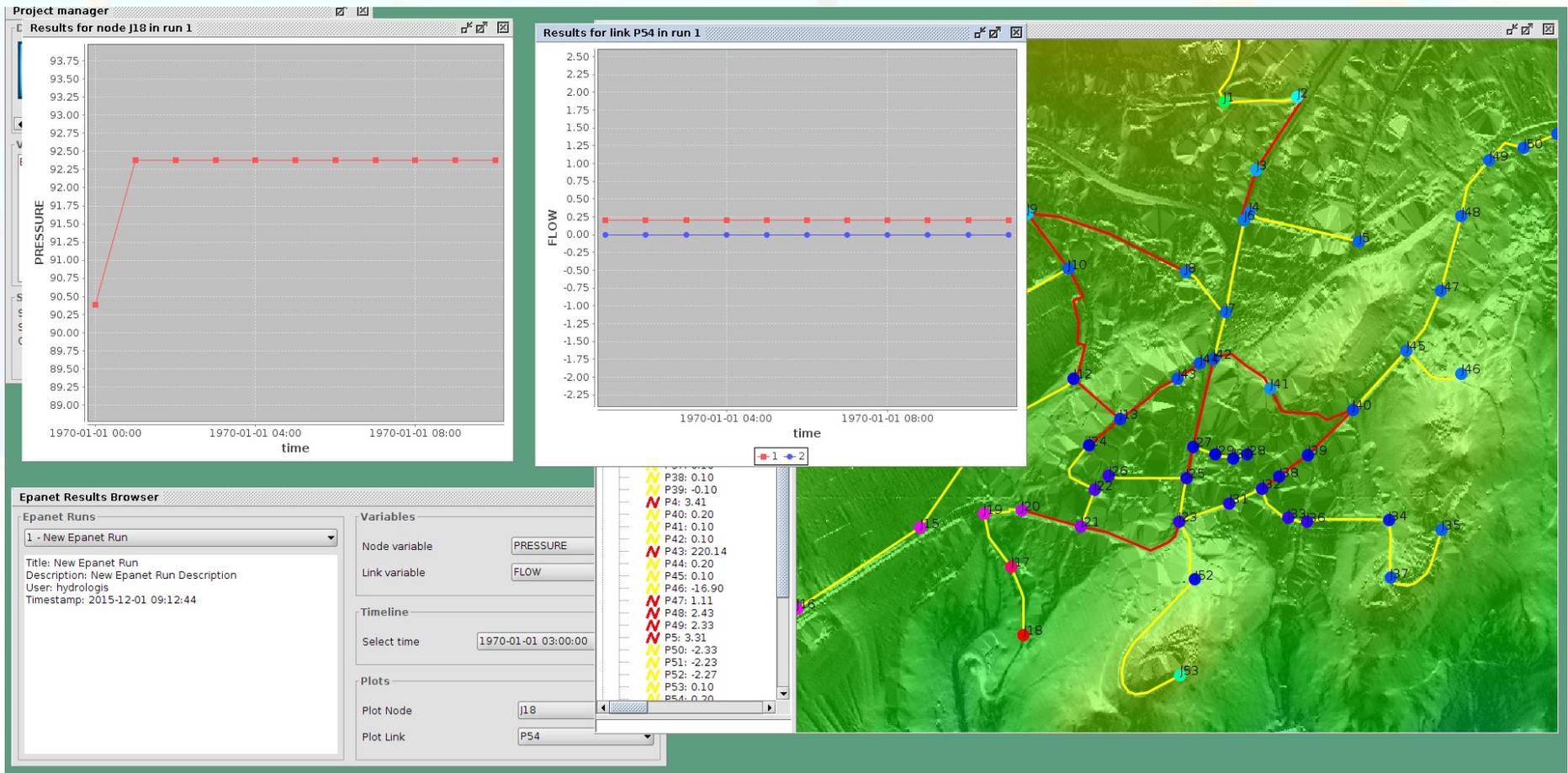
# 4. VISUALIZATION OF RESULTS

- selection of the timestep, variable and elements to visualize
- visualization of results on the map (pipes, junctions)



# 4. VISUALIZATION OF RESULTS

- selection of the timestep, variable and elements to visualize
- visualization of results on charts (nodes, pipes)





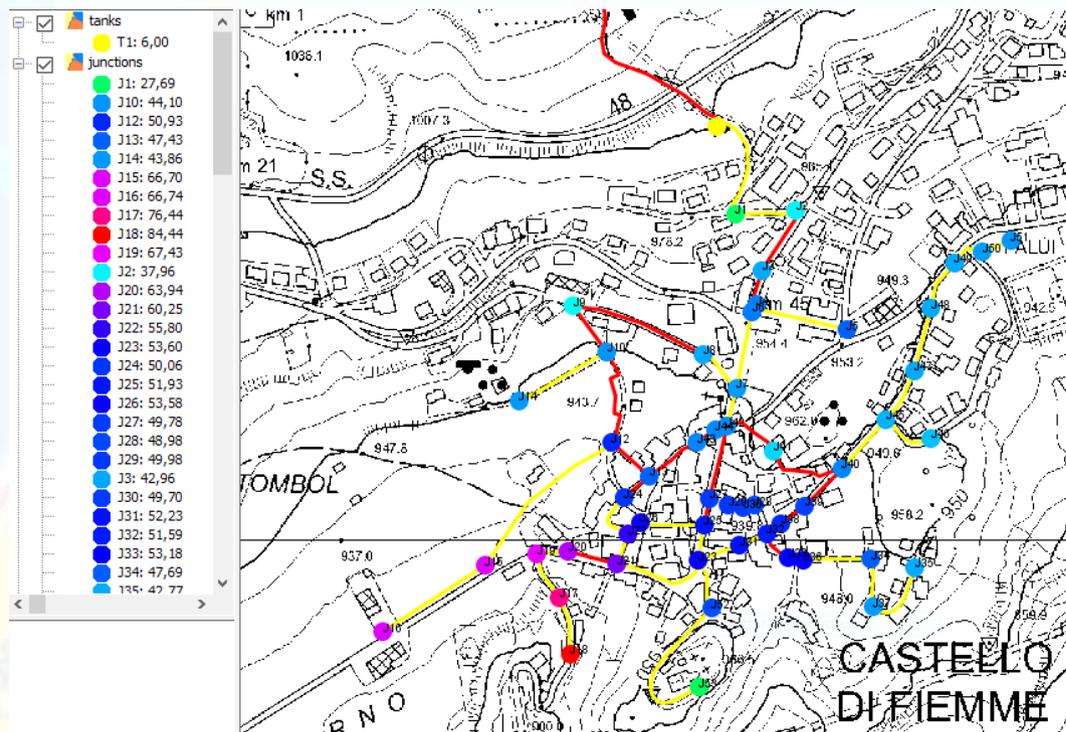
# EPANET & gvSIG

Can help assess alternative management strategies for improving the performance of the system by:

- altering source utilization within multiple source systems
- altering pumping and tank filling/emptying schedules
- targeted pipe cleaning and replacement
- pre-localization of leakages

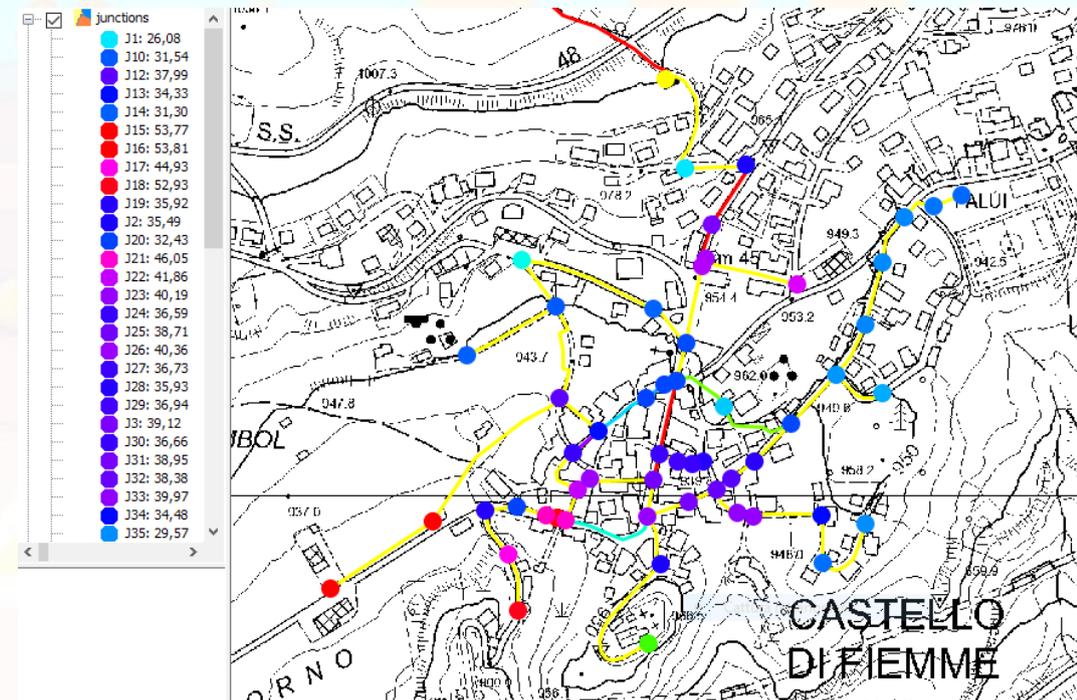
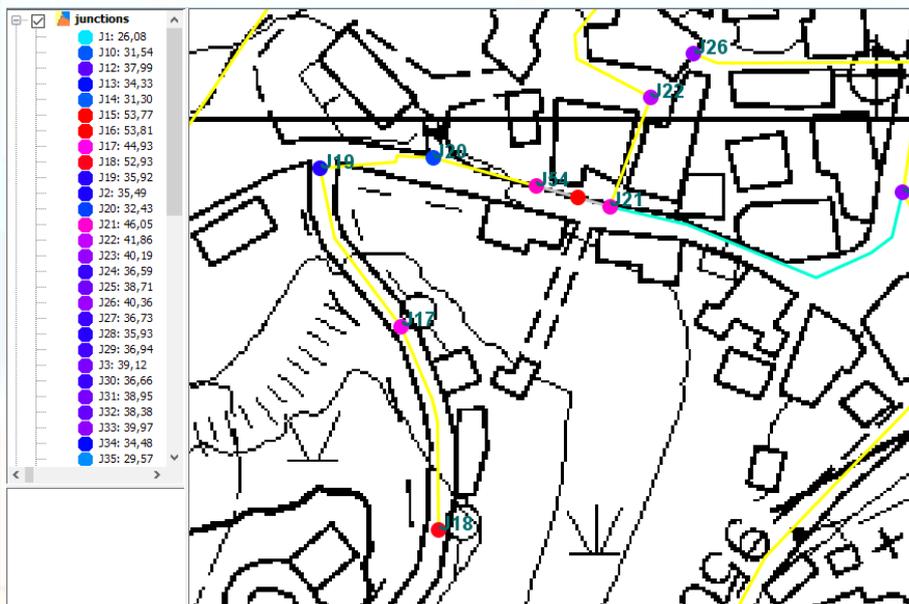
# EPANET & gvSIG

- problems are highlighted in the results
- test new design solutions: Pressure Reducing Valve



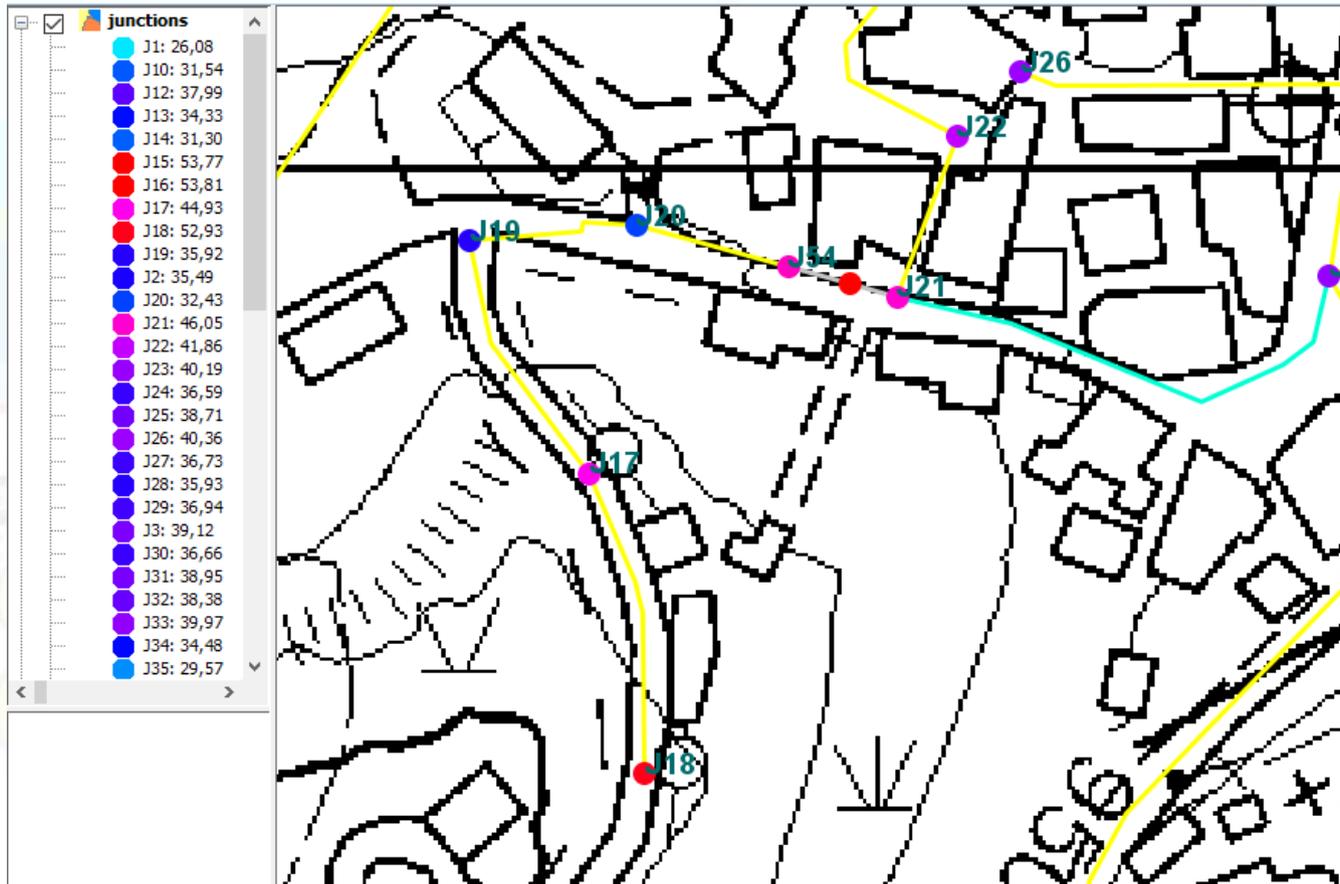
# EPANET & gvSIG

- problems are highlighted in the results
- test new design solutions: Pressure Reducing Valve



# EPANET & gvSIG

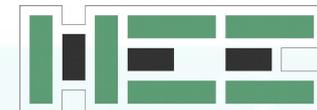
- problems are highlighted in the results
- test new design solutions: change volume of tank





# FUTURE PLANS

- finalize the implementation and testing of Epanet in gvSIG in different areas and scenarios
- integrate the support for simulation of the water quality in Epanet
- integrate a new model for design and verification of systems for collecting rain water and sewage in urban environments



**THANKS FOR THE ATTENTION!**

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