WaterNetGen

Water Distribution Network Models Generator and Pipe Sizing

User's Manual

By

João Muranho (muranho@mail.telepac.pt)
Ana Ferreira (amferreira@ipcb.pt)
Joaquim Sousa (jjoseng@isec.pt)
Abel Gomes (agomes@di.ubi.pt)
Alfeu Sá Marques (jasm@dec.uc.pt)

Civil Engineering Department, Coimbra University, Rua Luís Reis Santos, Pinhal de Marrocos (Pólo 2), 3030-788 Coimbra

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(working version)

DISCLAIMER

This is a working version of the user's manual.

FOREWORD

CHAPTER 0 – GETTING START

WaterNetGen is an EPANET extension for automatically build Water Distribution Network (WDN) synthetic models, do pipe sizing, compute technical performance indicators, and allowed demand-driven and pressure-driven simulations.

The Figure 1 shows a general overview of the EPANET with WaterNetGen extension.

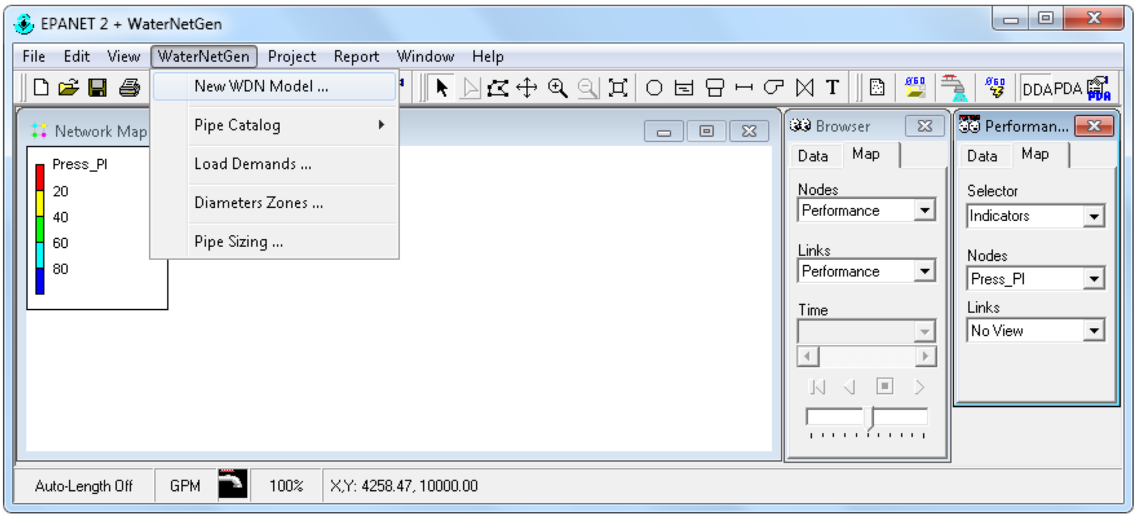


Figure 1 - General overview

Generate a new synthetic model & Pipe Sizing:

0) Generate a new model (WaterNetGen >> New WDN Model);
1) Create (WaterNetGen >> Pipe Catalog >> New), Edit the current catalogue (Create (WaterNetGen >> Pipe Catalog >> Edit) or import a pipe catalogue from a existing project (WaterNetGen >> Pipe Catalog >> Import);
2) Set demand (WaterNetGen >> Load Demands);
3) Do pipe sizing (WaterNetGen >> Pipe Sizing).

Network Performance:

1) Open an EPANET project;
2) Select the performance item in Project Browser;
3) Select the performance indicator in Performance Browser;
4) Run simulation.

Pressure-driven simulation:

1) Open an EPANET project;
2) Click on the PDA button;
3) Set the categories of pressure-driven demand;
4) Run simulation.

CHAPTER 1 – INTRODUCTION

WaterNetGen is an EPANET extension for automatically build Water Distribution Network (WDN) synthetic models, do pipe sizing, compute technical performance indicators, and allowed demand-driven and pressure-driven simulations.

1.1 Generation of synthetic models

1.2 Pipe Sizing

1.3 Technical performance indicators

1.4 Pressure-driven simulation

1.4 Typical use of WaterNetgen

To generate a new WDN synthetic model we select **WaterNetgen >> New WDN Model ...** from the menu bar to open the dialog form shown in Figure 2.

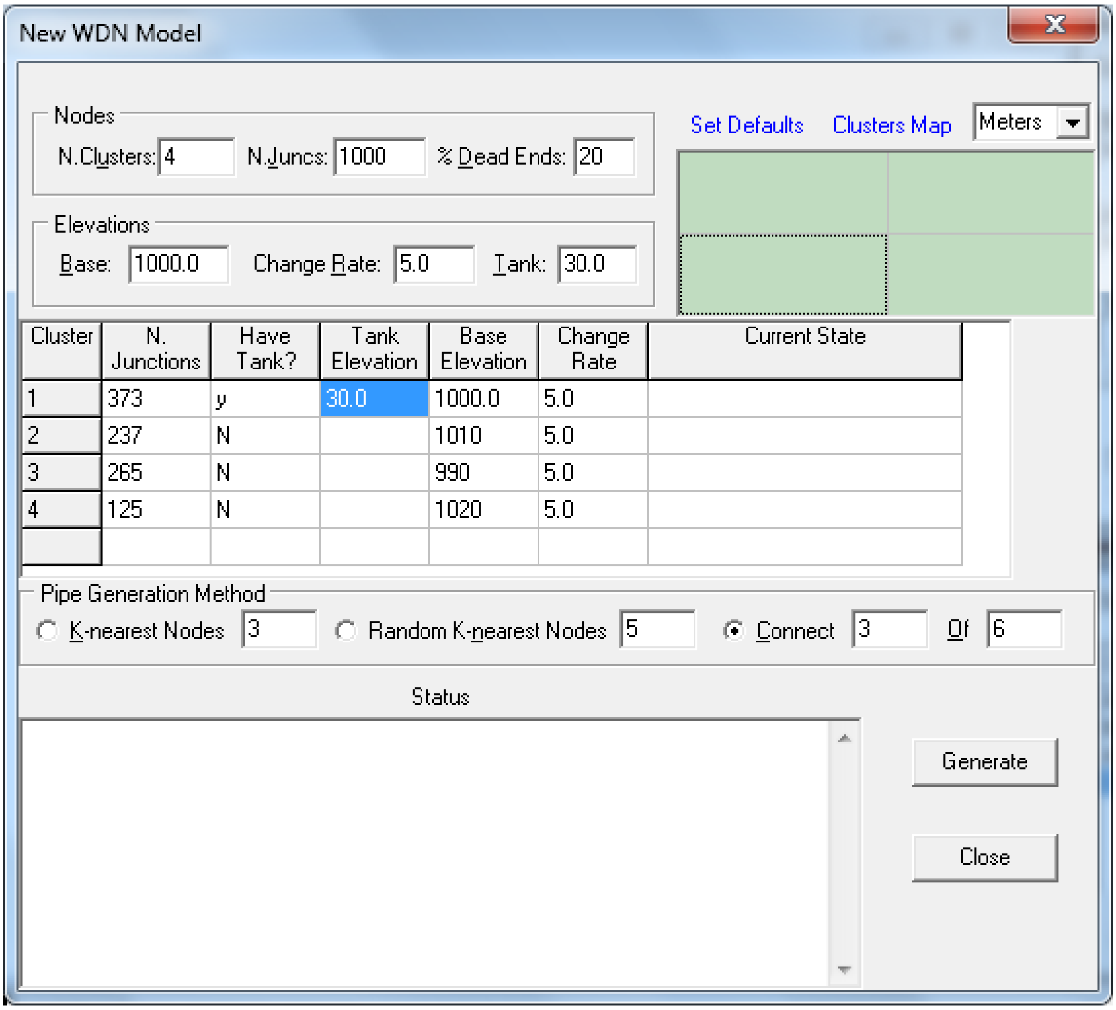


Figure 2 - Generate a new WDN model

We must specify the number of clusters and the number of junctions of our network. Initially the junctions are randomly distributed by the clusters. We can manually change the number of junctions of each cluster. The nodal elevations are generated on a cluster base taking into account two parameters: the base elevation and the elevation change rate. The elevation base is the starting point of the generation process and the elevation change rate is the allowed fluctuation (in [-change rate; +change rate]) between two connected junctions.

Each cluster can have its own tank. The node with highest elevation (in the network) is always connected with a tank.

We can choose the length units (meter or feet) in use in our network and also set the map dimensions clicking in the button **Cluster Map** (or double-click over the cluster map overview – blue rectangle in Figure 2).

To generate pipes for each cluster we need selected the generation method most appropriate for our needs. We can play with the different generation methods and parameters to get sensibility to the generated networks topology.

The inter-cluster connection is done by linking the two most closed junctions of neighbour clusters.

We must set the project defaults for the new model by clicking the button **Set Defaults**. The Figure 3 shows the relevant parameters for the generation process, namely, the number of storeys above ground, pipe demand coefficient, pipe demand pattern, pipe loss coefficient, and pipe loss pattern. The others properties represent formulas that play a paramount role in the network sizing process, as we will see later.

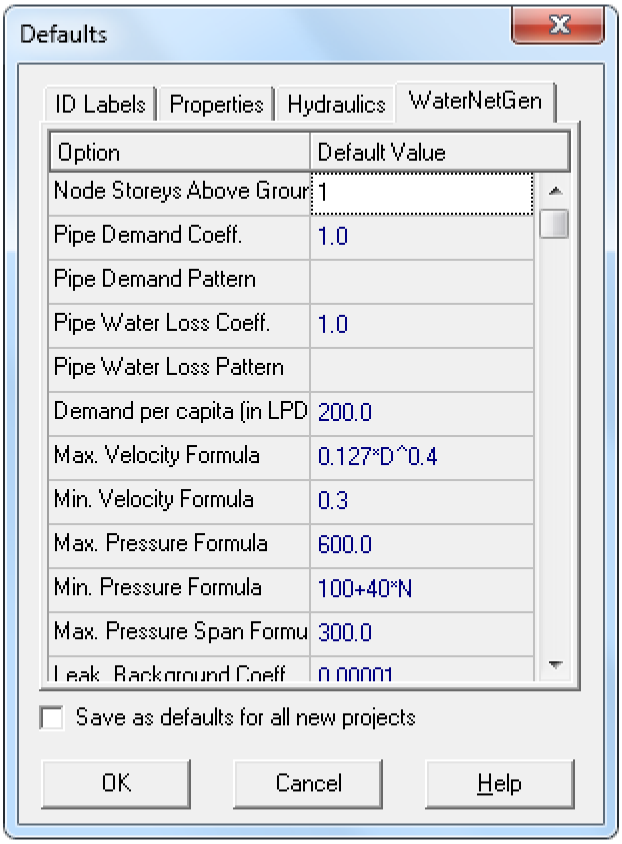


Figure 3 - WaterNetGen Project defaults

The number of storeys above ground of a node indicates the height of buildings supply by the pipes connected to this node. The pipe demand coefficient and pipe demand patterns characterized the water consumption associated with each pipe. Similarly, the pipe loss coefficient and pipe loss pattern represents the water losses in each pipe. The Figure 4 shows some of the junction and pipe new properties.

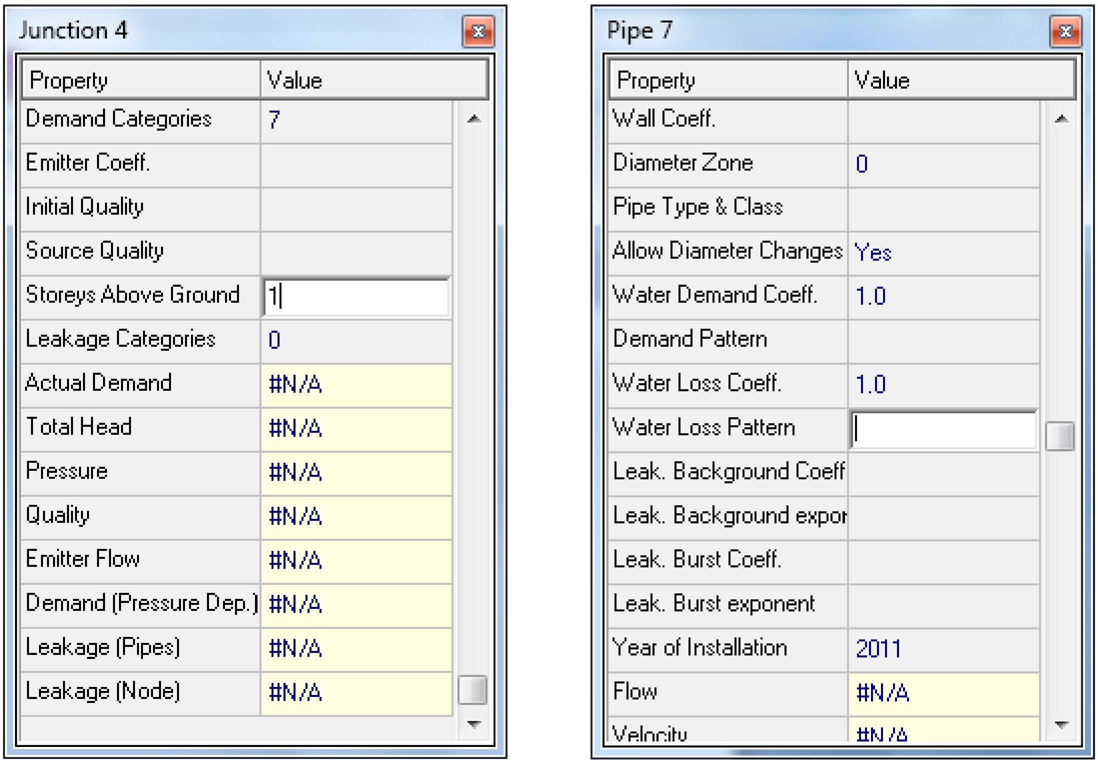


Figure 4 - New Junction & Pipe properties

The Figure 5 shows an example network (topology) automatically generated.

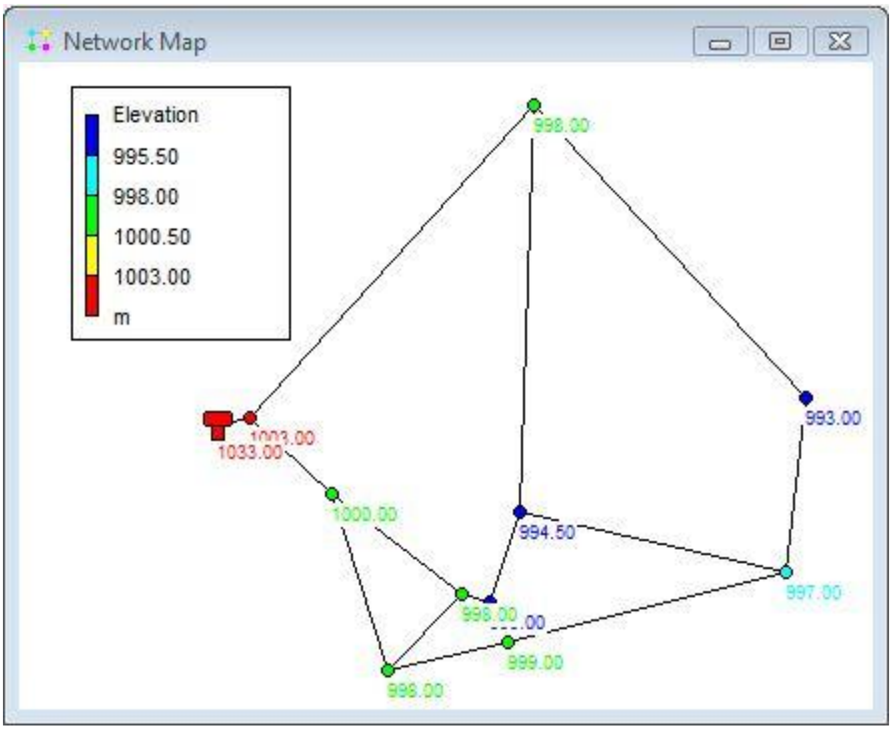


Figure 5 - WDN topologic example

CHAPTER 3 – PIPE CATALOGUE

The pipe catalog specifies the commercial available diameters for pipes. The diameters are specified in millimeters (for SI units) or in inches (for US units). For each pipe type it can be specified the roughness values for Hazen-Williams, Darcy-Weisbach, or Chezy-Manning formulas. The Figure 6 shows the dialog form to create/edit a pipe catalog.

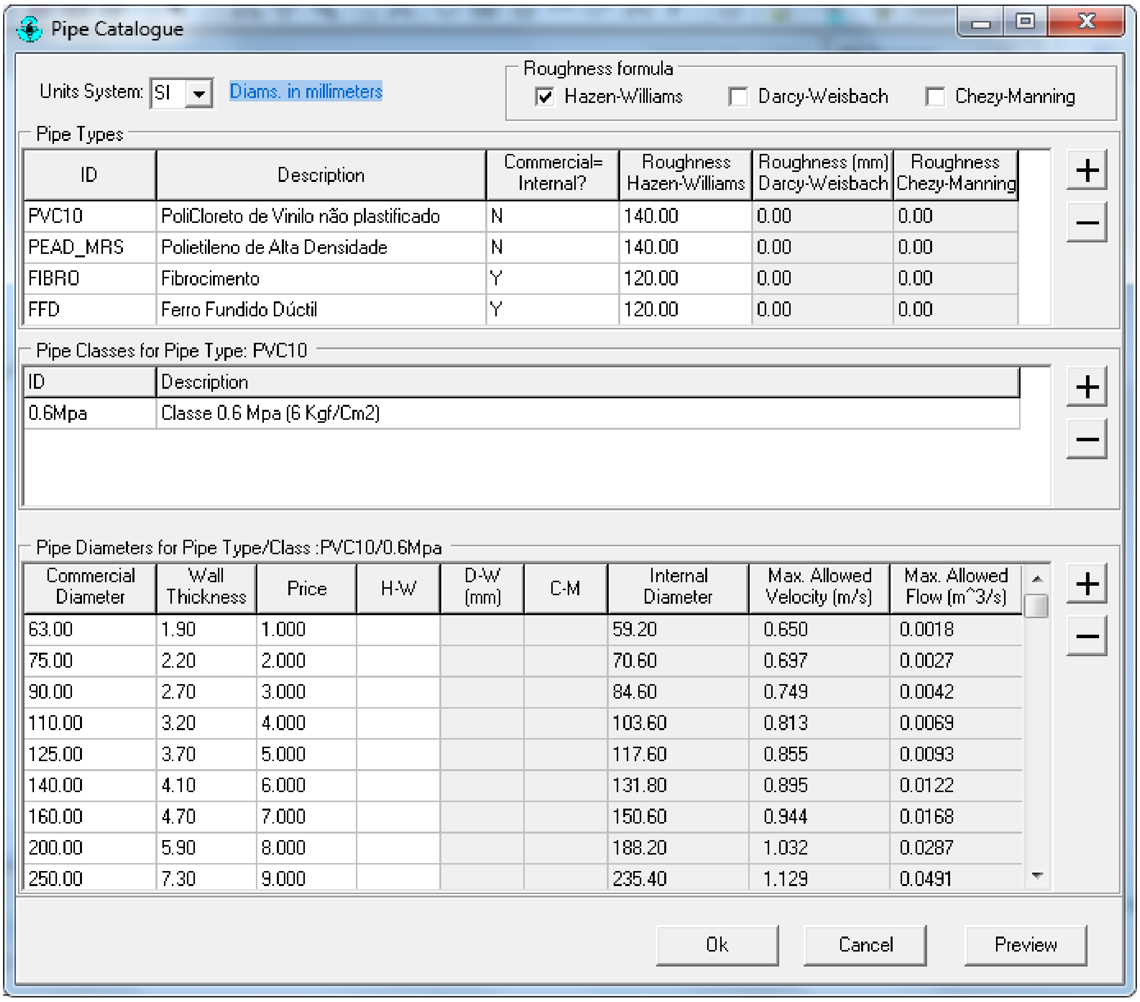


Figure 6 - Edit the list of commercial avalable pipe diameters and its properties.

In EPANET properties editor for pipes the user can set the pipe diamenter for the pipe being edit. This diameter value corresponds to the pipe *Internal Diameter*. The maximum velocity and maximum flow values are computed taking into account the user defined formulas presented in Figure 3, also accessible throught Options-Formulas from Data Browser (as shown in Figure 7 bellow).

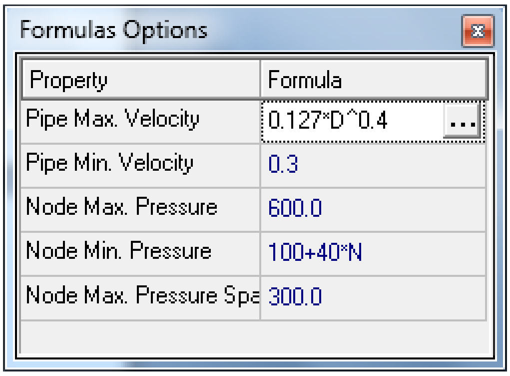


Figure 7 - Pressure and velocity formulas

CHAPTER 3 – PIPE SIZING

In order to start the sizing process it is necessary to associate a pipe type and a pipe class to each sizable pipe (that is, pipes object of the sizing process) and load the water consumptions to the network nodes.

Pipe Type and Class Assignment

The pipe material (type and class) assignment can be done for a single pipe or for set of pipes (select a rectangular region containing the pipes) or for all pipes at once (pressing *CTRL+A*). After select the pipes, we must click the right mouse-bottom, select the Pipe Type menu item from the pull-down menu, and choose the Pipe Type and Pipe Class (see Figure 8).

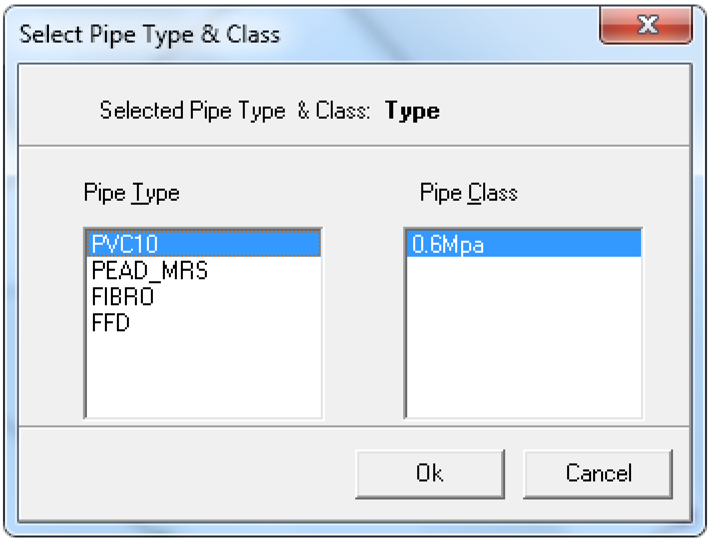


Figure 8 - Assign a Pipe Type and a Pipe Class to selected pipes

Demand Assignment

Water consumption is assigned to junctions as demand categories. For sizing purposes each pipe has a water distribution coefficient (and its pattern) and a loss distribution coefficient (and its pattern) – see Figure 4. The distribution coefficient represents the inhabitants' density that is served by the pipe.

The average demand is computed taking into account the inhabitants and the per capita demand. The Figure 9 shows the dialog form to assign water loads.

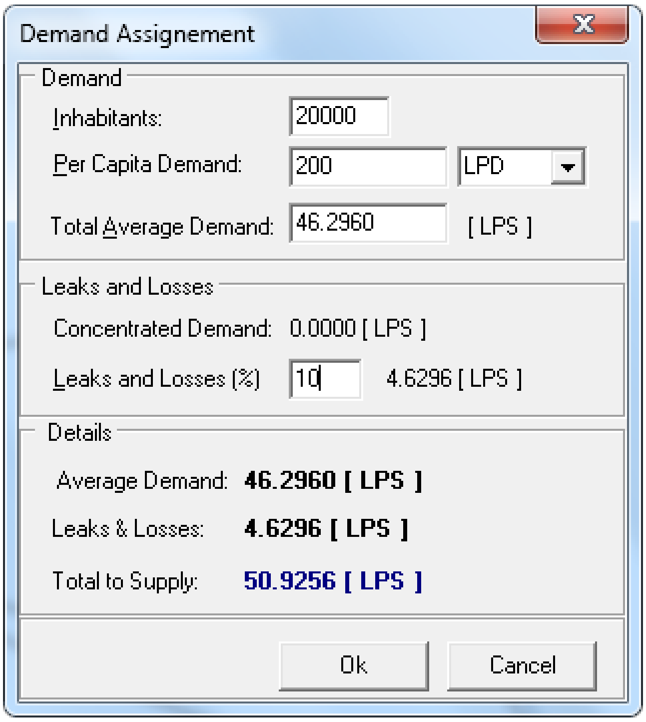


Figure 9 - Demand assignement

As been said, water is assigned to junctions as demand categories. The Figure 10 shows de demand categories for a junction, where there has been created “Pipe” and “Loss” categories for each pipe that connects to the junction. The Pressure Lower-Bound and Pressure Threshold fields shown in the figure is used for pressure-driven simulation.

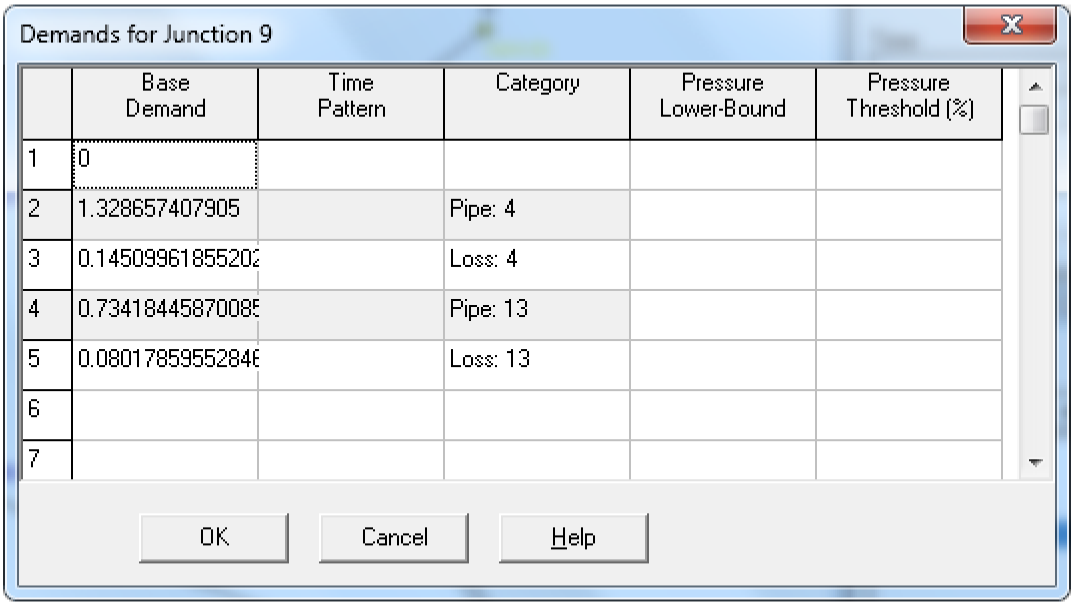
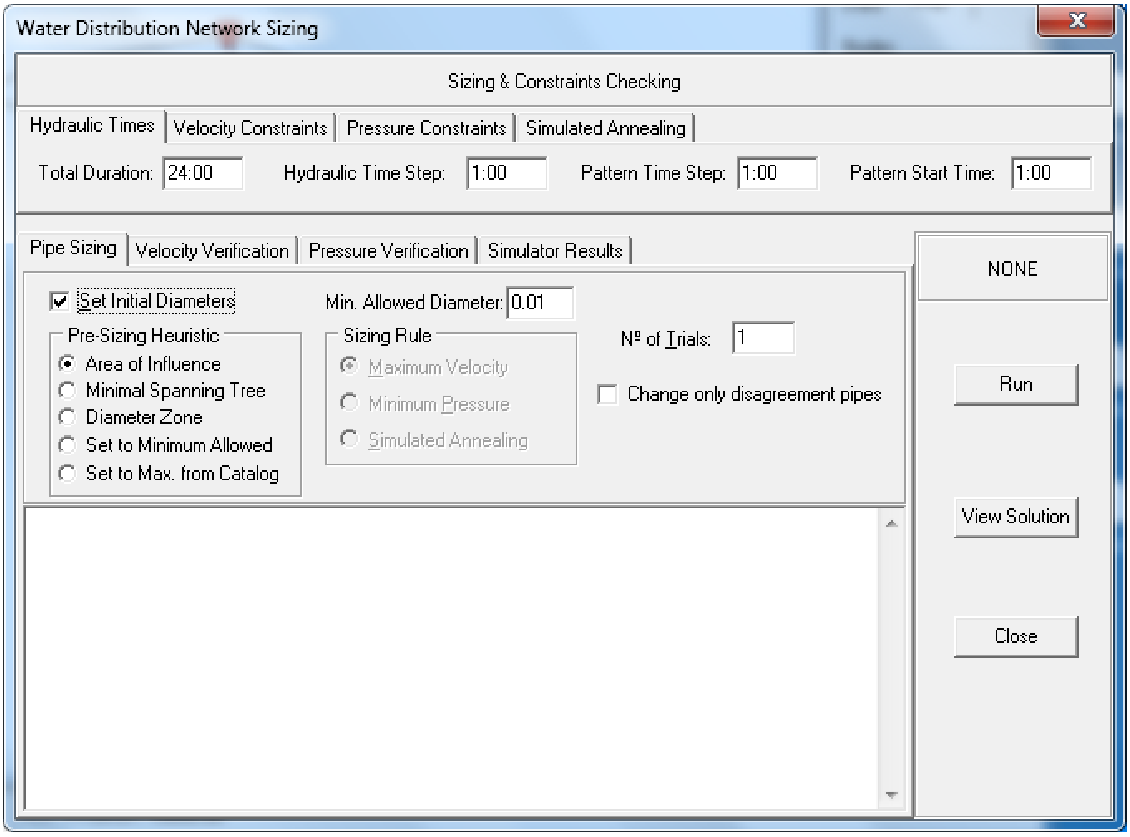


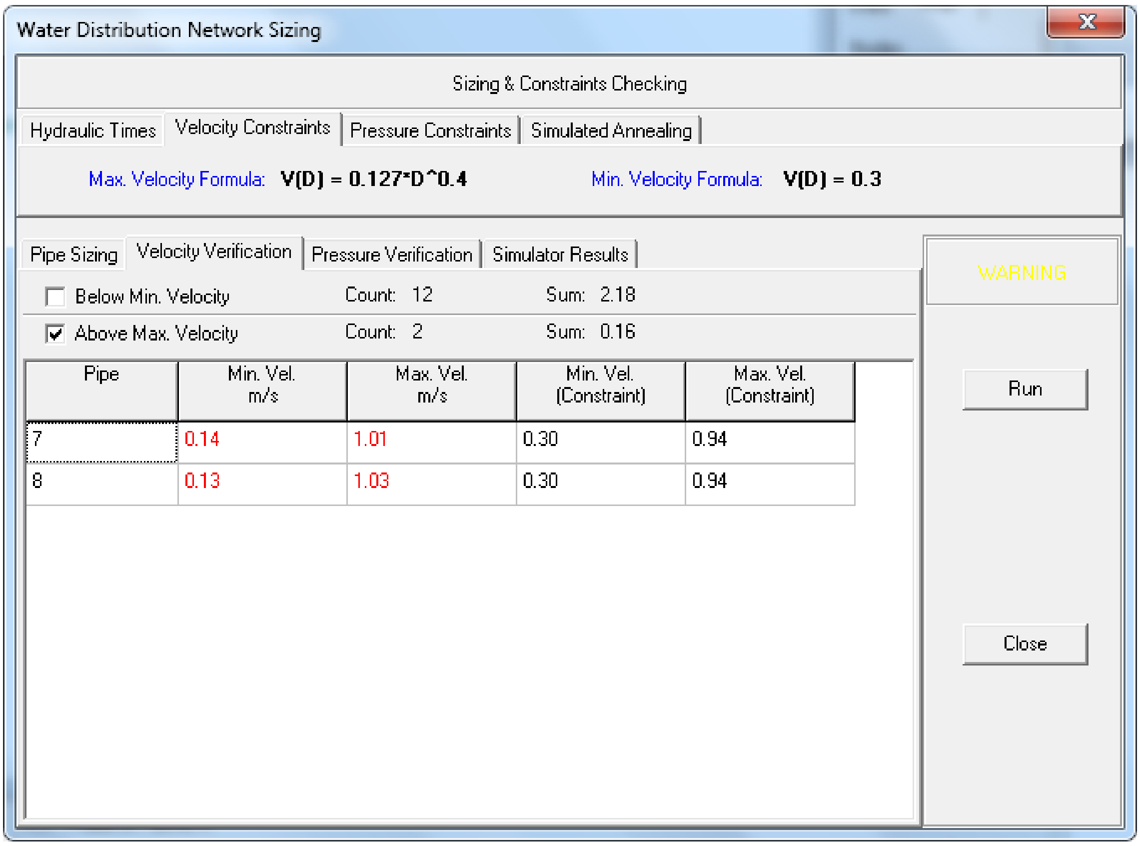
Figure 10 - Demand categories

Pipe Sizing

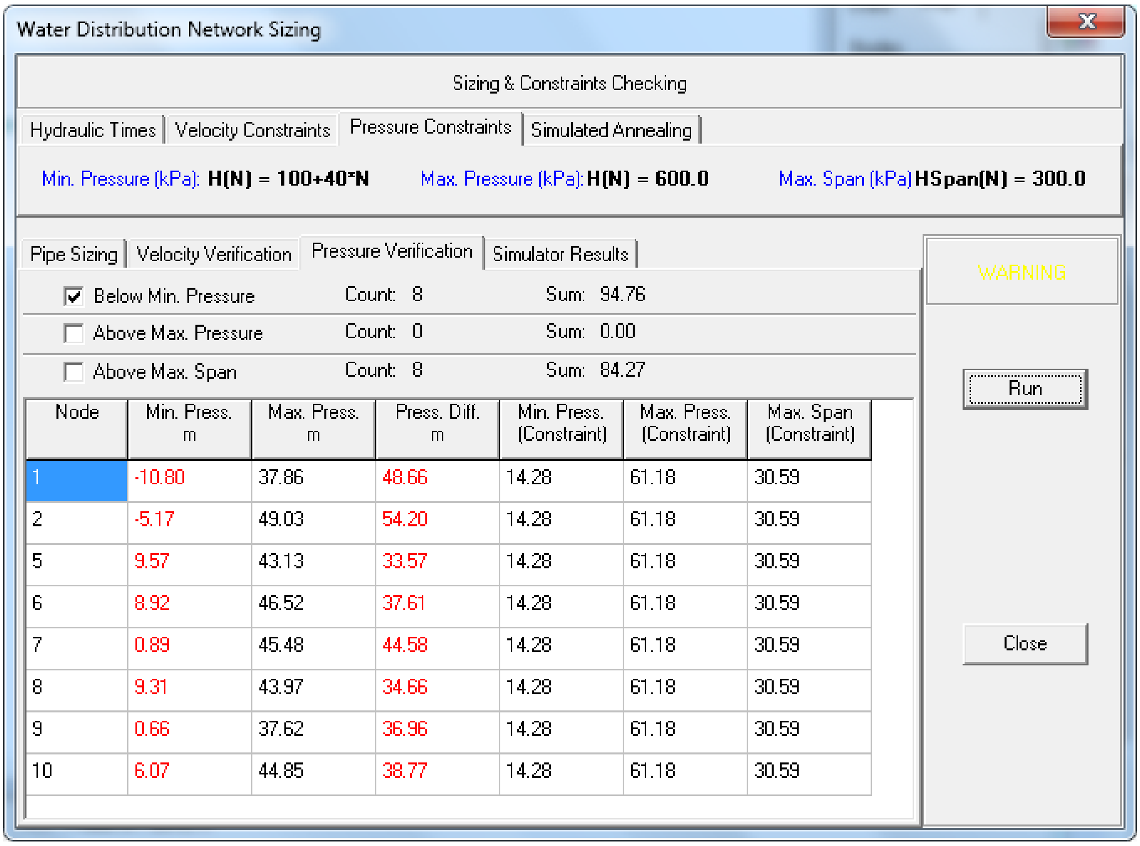
Pre-sizing



Velocity Verification

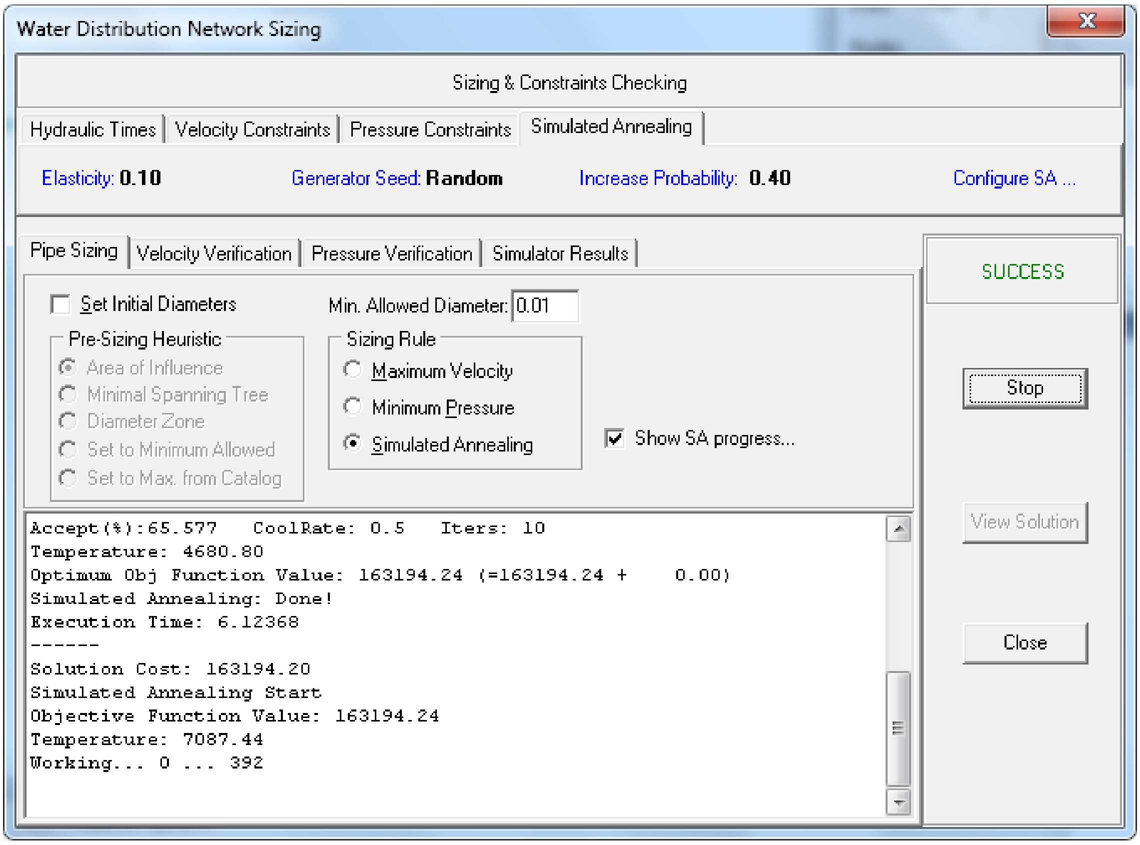


Pressure verification

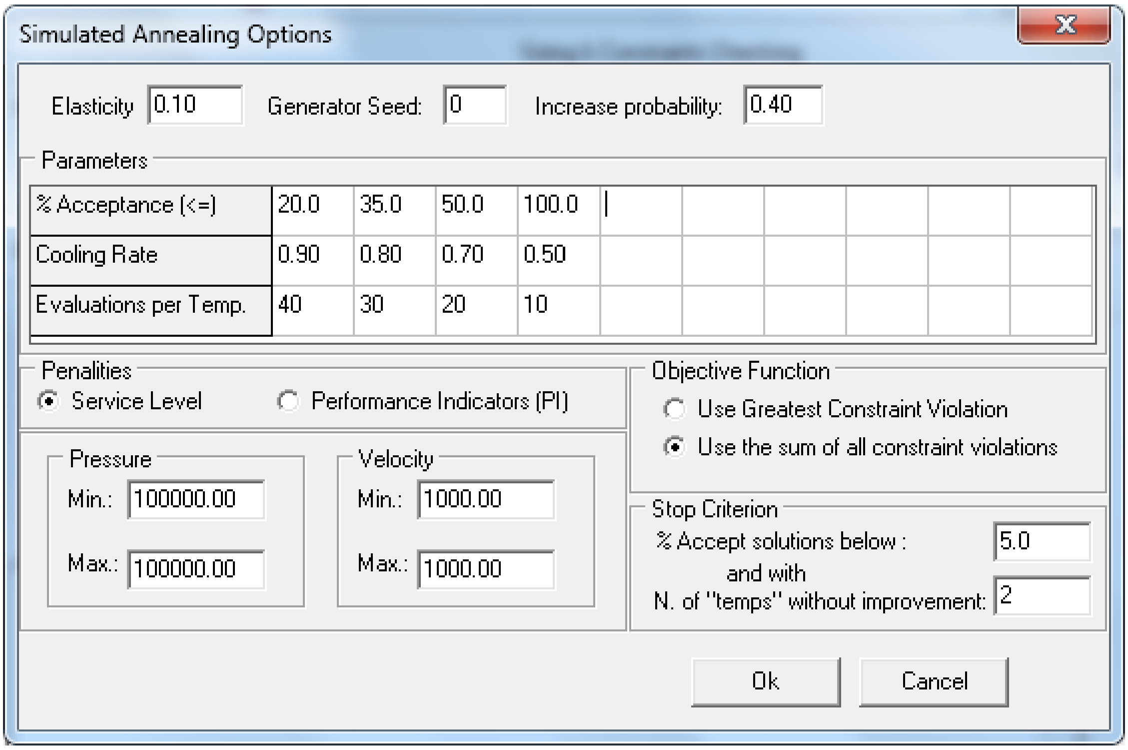


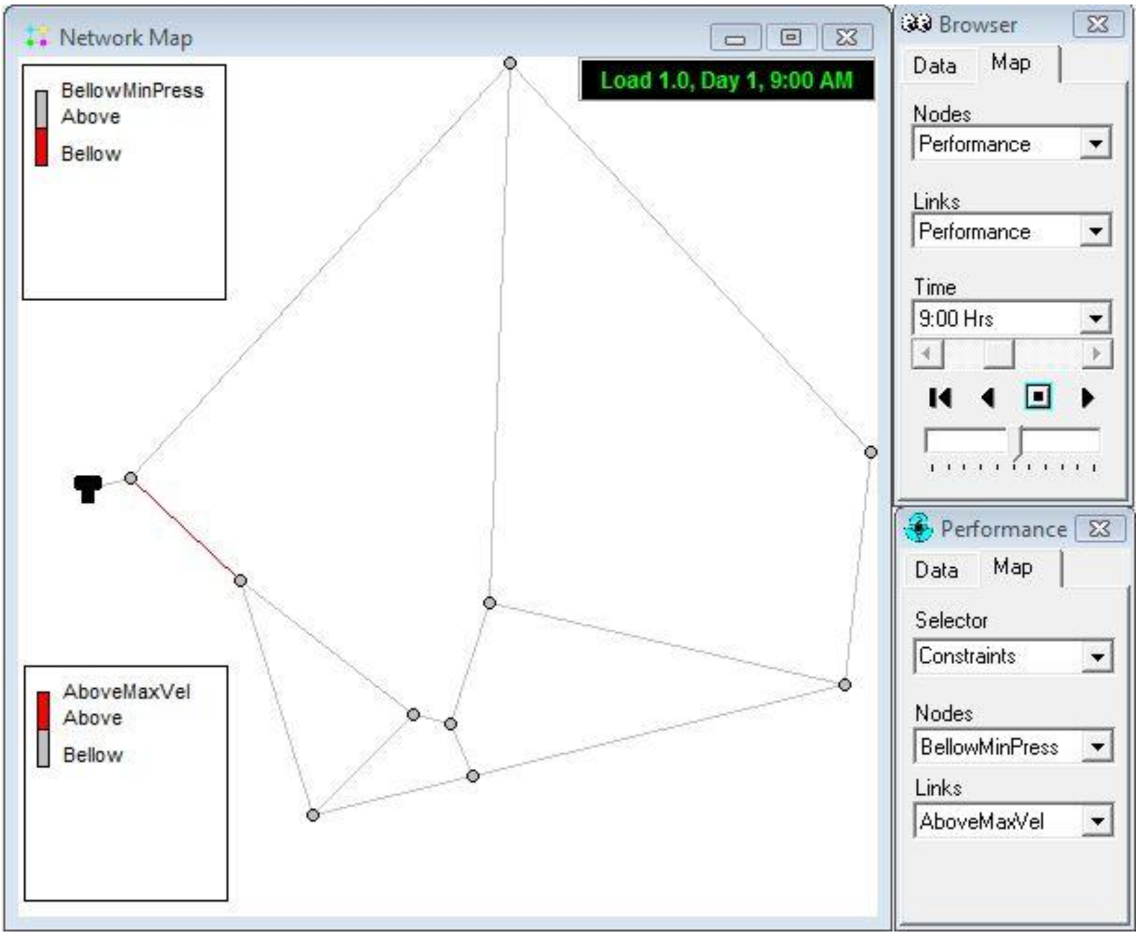
Node	Min. Press. m	Max. Press. m	Press. Diff. m	Min. Press. (Constraint)	Max. Press. (Constraint)	Max. Span (Constraint)
1	-10.80	37.86	48.66	14.28	61.18	30.59
2	-5.17	49.03	54.20	14.28	61.18	30.59
5	9.57	43.13	33.57	14.28	61.18	30.59
6	8.92	46.52	37.61	14.28	61.18	30.59
7	0.89	45.48	44.58	14.28	61.18	30.59
8	9.31	43.97	34.66	14.28	61.18	30.59
9	0.66	37.62	36.96	14.28	61.18	30.59
10	6.07	44.85	38.77	14.28	61.18	30.59

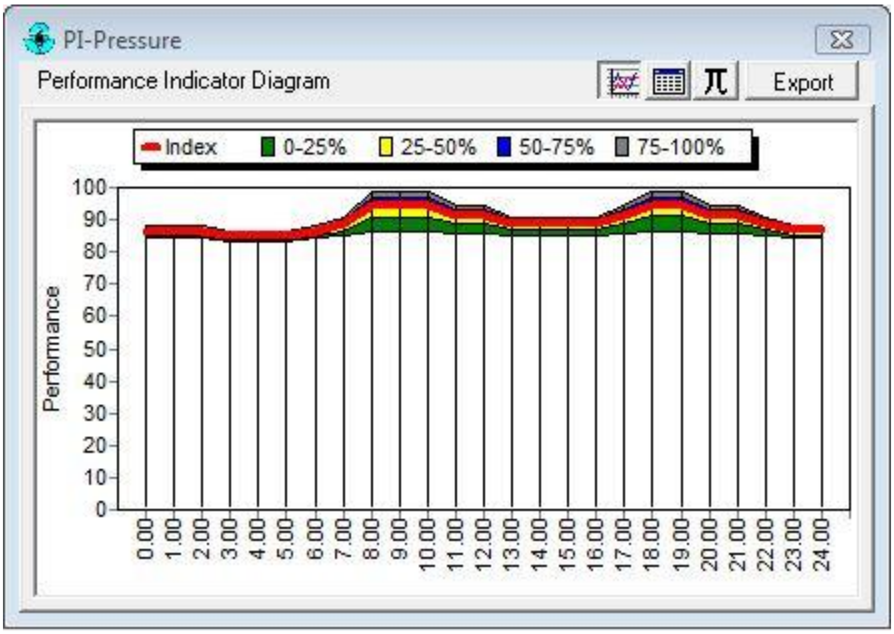
Optimized sizing


Water Distribution Network Sizing
Sizing & Constraints Checking
Hydraulic Times
Velocity Constraints
Pressure Constraints
Simulated Annealing
Elasticity: 0.10
Generator Seed: Random
Increase Probability: 0.40
Configure SA ...
Pipe Sizing
Velocity Verification
Pressure Verification
Simulator Results
SUCCESS
Set Initial Diameters
Min. Allowed Diameter: 0.01
Pre-Sizing Heuristic
Area of Influence
Minimal Spanning Tree
Diameter Zone
Set to Minimum Allowed
Set to Max. from Catalog
Sizing Rule
Maximum Velocity
Minimum Pressure
Simulated Annealing
Show SA progress...
Stop
View Solution
Close
Accept(%):65.577 CoolRate: 0.5 Iters: 10
Temperature: 4680.80
Optimum Obj Function Value: 163194.24 (=163194.24 + 0.00)
Simulated Annealing: Done!
Execution Time: 6.12368

Solution Cost: 163194.20
Simulated Annealing Start
Objective Function Value: 163194.24
Temperature: 7087.44
Working... 0 ... 392


Simulated Annealing Options
Elasticity 0.10
Generator Seed: 0
Increase probability: 0.40
Parameters
% Acceptance (<=) 20.0 35.0 50.0 100.0
Cooling Rate 0.90 0.80 0.70 0.50
Evaluations per Temp. 40 30 20 10
Penalities
Service Level
Performance Indicators (PI)
Objective Function
Use Greatest Constraint Violation
Use the sum of all constraint violations
Pressure
Min.: 100000.00
Max.: 100000.00
Velocity
Min.: 1000.00
Max.: 1000.00
Stop Criterion
% Accept solutions below : 5.0
and with
N. of "temps" without improvement: 2
Ok
Cancel


Network Map
BellowMinPress
Above
Bellow
Load 1.0, Day 1, 9:00 AM
AboveMaxVel
Above
Bellow
Browser
Data
Map
Nodes
Performance
Links
Performance
Time
9:00 Hrs
Performance
Data
Map
Selector
Constraints
Nodes
BellowMinPress
Links
AboveMaxVel


PI-Pressure
Performance Indicator Diagram
Export
Index
0-25%
25-50%
50-75%
75-100%
Performance
100
90
80
70
60
50
40
30
20
10
0
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
9.00
10.00
11.00
12.00
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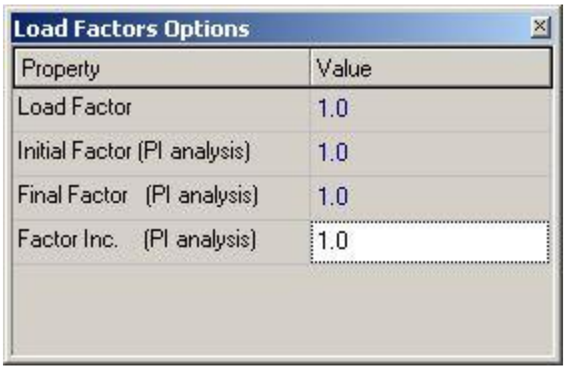

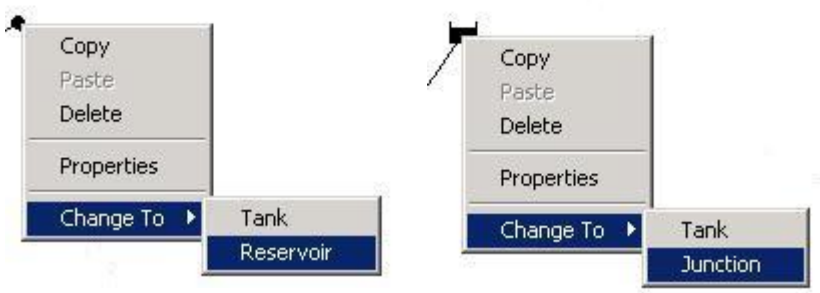

Figure 11. Popup menu to change node type (Junction/Tank/Reservoir)

$V_{max} = 0.127D^{0.4}$, onde D é o diâmetro em milímetros. O caudal máximo é calculado a partir da fórmula $D = \sqrt{\frac{4Q}{\pi V}}$, onde Q é o caudal (em $m^3 s^{-1}$), V a velocidade (máxima) e D o diâmetro (em *m*). Note-se que as unidades do caudal no EPANET são indicadas nas opções do projecto.

$$Node\ Demand = Base\ Demand + 0.5 * \sum_i L_i * C_i * Q_u$$

$$Average\ demand = Inhabitantes * Demand\ per\ capita\ [l/day]$$

$$Q_u = \frac{Average\ demand}{86400 * \sum_i L_i * C_i}\ [ls^{-1}m^{-1}]$$