REPUBLIC OF MOLDOVA

APA CANAL CHISINAU

CHISINAU WATER SUPPLY & SEWAGE TREATMENT - FEASIBILITY STUDY

Contract No: C21156/ECWC-2010-01-01



Potable Water Supply Network
Model calibration and hydraulic diagnostic - FINAL

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LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Apa Canal Chişinău
EPA	Environmental Protection Agency
ND	Nominal Diameter
PS	Pumping Station
SAN	Water Treatment Plant in Vadul Lui Voda
WTP	Water Treatment Plant in Chişinău

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1. INTRODUCTION

This report presents the construction and the calibration of the hydraulic model. The construction of this hydraulic model was based on the data collected concerning the configuration of the network, the operation of the pumping station, the dimensions of the reservoirs... The quality of the model depends therefore on the quality of these collected data.

Once the model is built, the calibration process follows, in order to compel the model to reproduce reality. After the calibration stage, the model can be used as a tool:

- To analyse the current condition of the network and to propose a diagnostic of the network operation. The model shows:
    - The pipes where the velocity is high which leads to high linear head losses and higher risks connected to the effects of water hammer;
    - The points where the pressure is too small.
- To design the future extensions of the network and to design the pipes which are to be rehabilitated;
- To simulate different configurations considered for the future operation of the system;
- To simulate the quality of the water in the network and the residence time in the reservoirs;
- To view the problems created by the unavailability of a water source, a pipe, a pumping station;
- To optimize the investments and the operational costs.

This report will present the diagnostic of the current network.

2. CONSTRUCTION OF THE HYDRAULIC MODEL

2.1. PRESENTATION OF EPANET SOFTWARE

Developed by EPA's Water Supply and Water Resources Division, EPANET is a software that models water distribution piping systems. It is a Windows 95/98/NT/XP program that performs extended-period simulation of the hydraulic and water quality behaviour within pressurized pipe networks.

Pipe networks consist of pipes, nodes (pipe junctions), pumps, valves, and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of the water in each tank, and the concentration of a chemical species throughout the network during a simulation period. Chemical species, water age, source, and tracing can be simulated.

EPANET provides a graphical environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats. These include colour-coded network maps, data tables, time series graphs, and contour plots.

EPANET is public domain software that may be freely copied and distributed.

2.2. STUDY AREA

The network modelled concerns the complete drinking water network managed by Apa Canal Chişinău and connected to the network supplied by the water treatment plants of Chişinău and Nistru.

For example, the network of Ghidighici -as independent from the main network- and the networks of Coşerniţa and Maximovca -as not managed by ACC- have not been modelled.

As explained in the report of the measurement campaign (MD500E: Potable Water Supply Network Measurement Campaign – Summer 2011), the study area consists of 33 hydraulic entity: 17 independent hydraulic entities in Chişinău city and 16 in the suburbs.

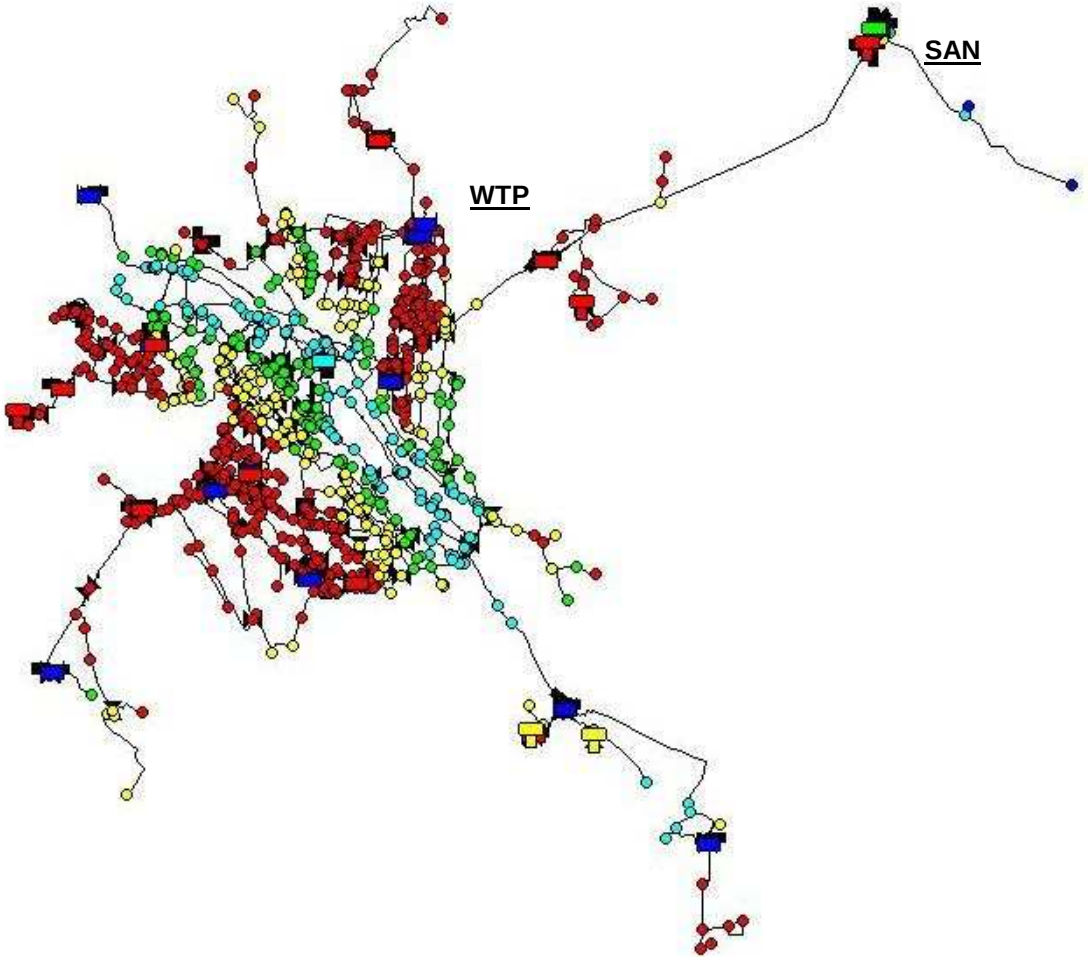


Figure 2.1: Study area

2.3. COMPONENTS OF THE MODEL

The components of the network that have been modelled are:

- **Production**: the operations of the water treatment plants of Chişinău and Nistru have not been modelled. The production of water is therefore represented by a reservoir (an infinite source of water).
- **Pumping stations**: All the functioning pumps have been modelled. The pump curve provided by ACC has been entered in Epanet software. When this curve did not reproduce well reality, the pump curve was created points by points to reproduce the operation of the pump on the reference day. The variable speed drives were modelled by a Pressure Reducing Valve (PRV). These valves force the downstream pressure on a set pressure.
- **Storage of the water**: the different reservoirs of Chişinău have been modelled using tanks. The important parameter for the tanks is the evolution of the volume of water depending on the height of the water in the tank. When the supply is performed by the top of the reservoir, the supply pipe is modelled by a Pressure Sustaining Valve (PSV) that forces the pressure upstream at a set pressure.
- **Transfer of the water**: Only the structural pipes have been modelled (not below 300mm except when it is a structural pipe). The source of the modelled network

is the autocad file provided by ACC. The parameters for the pipes are the diameter and the length.

- **Supply of the water**: The supply of the water is performed through the nodes of the model. To each node, the exact elevation –taken from the cadastre- has been entered.
- **Regulation systems**: Generally, the valves of the network are not modelled. The modelled valves are the ones generating a head loss. Epanet proposes several types of valves to model different phenomenon:
    - Pressure Reducing Valve (PRV): this valve stabilizes the downstream pressure. The valve generates the exact head loss to maintain the downstream pressure at the set pressure (the setting is in m).
    - Pressure Sustaining Valve (PSV): this valve stabilizes the upstream pressure. The valve generates the exact head loss to maintain the upstream pressure at the set pressure (the setting is in m).
    - Pressure Breaking Valve (PBV): this valve generates a set head loss (the setting is in m).
    - Flow Control Valve (FCV): this valve restricts the flow to a set value (the setting is in m^3/h)
    - Throttled Control Valve (TCV): this valve models a partially closed valve on the network. The setting (*K* without unit) corresponds to the friction factor and the head loss (*H* in m) generated is ruled by the classic equation:

$$H = K\frac{v^2}{2g}$$

2.4. DISTRIBUTION OF THE CONSUMPTION

One of the most critical steps of the model construction is to allocate properly the real consumption to each node, as well as the evolution of consumption throughout the day. To achieve this objective, two steps are involved:

- Allocating the average consumption to each node of the model and
- Then defining the daily variations.

2.4.1. GEOGRAPHICAL DISTRIBUTION

Thanks to the water demand study performed in the framework of this study, the geographical distribution of the average consumption of drinking water is known (see Figure 2.2). The study area has been divided in 190 small zones and the average consumption has been determined for each one of this zone.

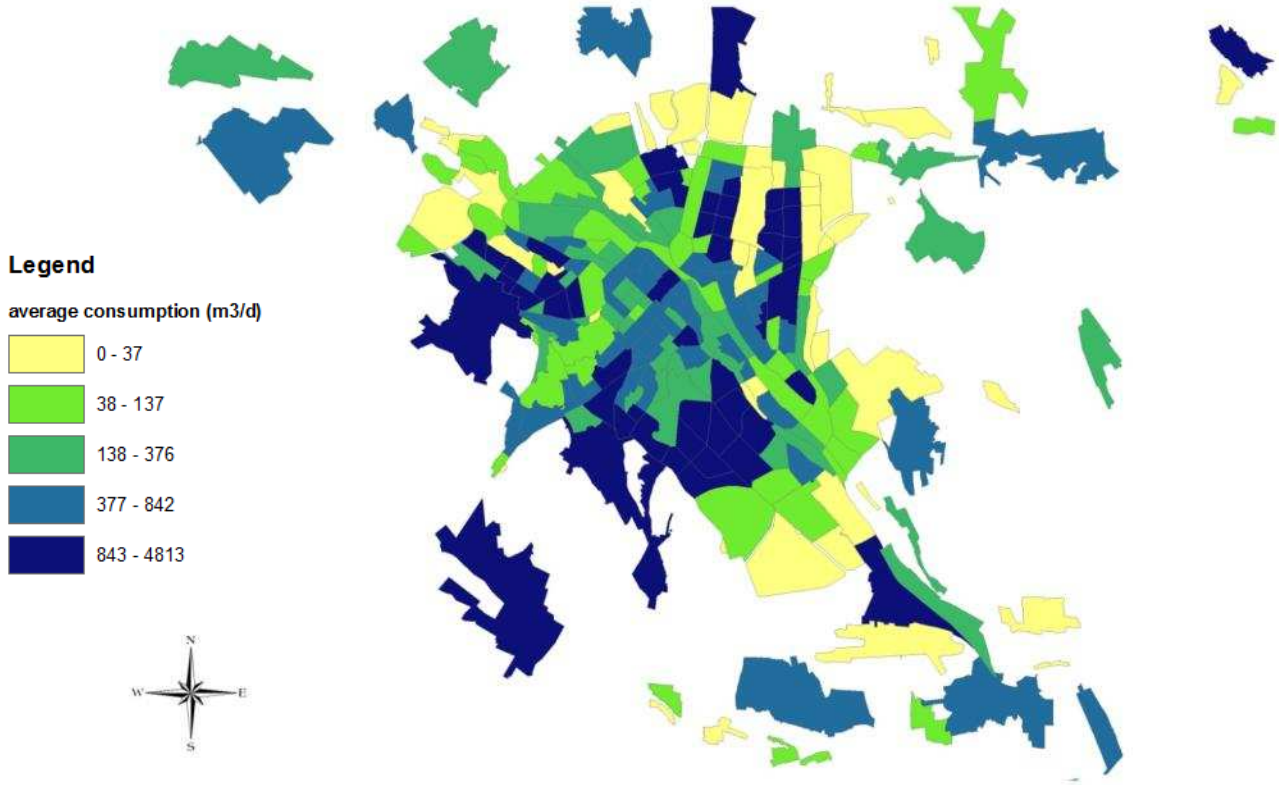


Figure 2.2: geographical distribution of the average water consumption in Chişinău and suburbs

For each zone, the total consumption has then been divided between the different nodes of the model falling within and an average consumption has hence been defined for each node of the model.

2.4.2. CONSUMPTION PATTERN

The consumption pattern is the way the consumption varies throughout the day. One consumption pattern has been defined for each hydraulic entity through the analyses of the results of the measurement campaign.

Depending on its affiliation to one hydraulic entity, the relevant consumption pattern has been attributed to each node.

3. CALIBRATION OF THE MODEL

3.1. CALIBRATION'S OBJECTIVES

Once the model has been built, he can calculate the flow and the pressure at each point (be it link or node) of the model. However, these calculations do not reflect reality as long as the model has not been calibrated. The main objective of the calibration is therefore to adjust the parameters of the model (as the head losses generated by the valves), in order to model reality.

The measurement campaign measured the flow and the pressure at key locations of the network as well as the water level in the reservoirs in order to perform the calibration. The results from the measurement campaign are then compared with the calculations of the model.

The Table 3.1 below presents the number of calibration points for each entity and the detailed list is provided in Annex 1.

Table 3.1: Number of calibration points for each hydraulic entity

Hydraulic entity	n° of calibration points for pressure	n° of calibration points for flow	Hydraulic entity	n° of calibration points for pressure	n° of calibration points for flow
Zone 1	11	2	Airport	2	2
Zone 2	9	3	Codru-Airport	2	
Zone 2 Doina	4		Codru-Sîngera	2	
Zone 2 Oţel	10		Coloniţa	2	1
Zone 3 Buicani	3	2	ContreReservoirs MDK	3	1
Zone 3 Ciocana	2	2	Coşerniţa	1	
Zone 3 Independenţa	3	2	Dobrogeah	3	
Zone 3 Rîscani	3		Durleşti-Cartuşa	4	1
Zone 3 U.A.	1		Durleşti-Gribov	3	2
Zone 3 Valea Dicescu	3		Ialoveni	5	
Zone 4 Buiucani	4	2	SAN to Tohatin	4	1
Zone 4 Ciocana	3	2	Sîngera		
Zone 4 Independenţa	3	2	Stauceni	3	2
Zone 4 Telecentru	2	2	Tohatin	2	
Zone 4A Botanica	1	2	Vadul Lui Voda	4	
Zone 4A Schinoasa	1		Vatra	1	
Zone 4A Telecentru	4	2			

The calibration process enables the localization of the head losses on the network, as well as the possible dysfunctions of the system. This step is an essential stage before any simulation can be carried out.

3.2. CALIBRATION METHODOLOGY

3.2.1. CONDITIONS OF THE REFERENCE DAYS

The calibration is performed separately for all hydraulic entities. Therefore, in the model, the different hydraulic entities are separated from each other, to be able to calibrate the whole network by small parts (and therefore on different days, corresponding to the different measurement campaigns performed).
The calibration is performed on one day –the reference day- chosen from the measurement campaign.

The **reference days** have been chosen as days where the operation of the network has not been disturbed and can be considered typical. The Table 3.2 summarizes the reference days for all hydraulic entities of the study area.

Once the reference days have been chosen, two items have to be determined and allocated to the nodes:

- The average consumption of this day (using the consumption coefficient obtained through the analysis of the measurement campaign) and
- The pattern of the supply volume for each entity. The consumption patterns used in the calibration of the model are presented in the Annex 2.

Moreover, the reference days enable the modelling of the time of operation of the pump, the set pressure of the variable speed drives driving the pumps on the network as well as the regulation of the valves upstream the reservoirs.

Table 3.2: Reference days for all the hydraulic entities

Hydraulic entity	day	Hydraulic entity	day
Zone 1	June 7th	Airport sector	July 8th
Zone 2 (Tohatin + Vostoc + Independenţa)	July 27th	Codru to Airport	July 8th
Zone 2 Doina	July 27th	Codru to Contrereservoir MDK	July 8th
Zone 2 Oţel	July 28th	Codru to Sîngera	July 12th
Zone 3 Buiucani	June 22nd	Coloniţa	September 3rd
Zone 3 Ciocana	June 22nd	Coşerniţa	August 24th
zone 3 Independenţa	June 22nd	Dobrogeah	July 5th
Zone 3 Rîscani	June 22nd	Durleşti Cartuşa	August 13th
Zone 3 UA	July 27th	Durleşti Gribov	August 13th
Zone 3 Valea Dicescu	June 17th	Ialoveni	July 5th
Zone 4 Buiucani	June 7th	SAN to Tohatin	August 24th
Zone 4 Ciocana	August 26th	Sîngera city	July 12th
Zone 4 Independenţa	August 9th	Stauceni	August 31st
Zone 4 Telecentru	August 9th	Tohatin	August 29th
Zone 4a Botanica	August 10th	Vadul Lui Voda	August 25th
Zone 4a Schinoasa	August 10th	Vatra	June 9th
Zone 4a Telecentru	August 10th		

3.3. CALIBRATION BY HYDRAULIC ENTITY

3.3.1. BOUNDARY CONDITIONS

As explained above, each hydraulic entity has been modelled separately. For each entity, boundary conditions have been defined. These boundary conditions enable the model to reproduce the conditions of the reference day. There are two types of boundary limits:

- At the inlet of the zones, the pressure (for example, suction pressure) is imposed and the flow is then calibrated. This limit is modelled through a reservoir with an imposed pattern (corresponding to the variation of the suction pressure or of the water level in the tank on the reference day).
- At the outlet of the zones (for example, when the water enters a pumping station), the flow is imposed and the pressure is calibrated. This limit is modelled through a point at which the demand corresponds to the flow entering the pumping station on the reference day.

Table 3.3: Boundary conditions for each hydraulic entity in Chişinău city

	Set values for Pressure	Set values for Flow
Zone 1	Water Level in the reservoirs of Ciocana, Balişevschi and Ghidighici	Inlet of Codru PS
Zone 2 Doina	Water Level in the reservoirs 1, 2, 3 and 4 of the WTP	Inlet of Buiucani and Universita Agrara PS
Zone 2 Oţel	Water Level in the reservoirs 1, 2, 3 and 4 of the WTP	Inlet of Buiucani PS and Balişevschi PS
Zone 2 Tohatin, Vostoc and Independenţa	Water Level in the reservoirs 1, 2, 3, 4 and 5 of the WTP	Inlet of Ciocana, Valea Dicescu and Independenţa PS
Zone 3 Buiucani	Suction pressure coming from the network in Buiucani PS	None
Zone 3 Independenţa	Suction pressure coming from the network in Independenţa PS	None
Zone 3 Valea Dicescu	Water Level in the reservoirs of Valea Dicescu	Inlet of Telecentru PS
Zone 3 Rîşcani	Water Level in the reservoirs 1, 2, 3 and 4 of the WTP	None
Zone 3 Ciocana	Water Level in the reservoirs 1, 2, 3 and 4 of the WTP	None
Zone 3 U.A.	Suction pressure in Universita Agrara PS	None
Zone 4 Buiucani	Water Level in the reservoirs of Buiucani PS and Suction pressure coming from the network in Buiucani PS	Inlet of Gribova Ps
Zone 4 Independenţa	Water Level in the reservoirs of Independenţa PS and Suction pressure coming from the network in Independenţa PS	Inlet of Botanica PS
Zone 4 Telecentru	Water Level in the reservoirs of Telecentru PS	None
Zone 4 Ciocana	Water Level in the reservoirs 1, 2, 3 and 4 of the WTP	Inlet of Stauceni PS
Zone 4a Telecentru	Water Level in the reservoirs of Telecentru PS	Inlet of Schinoasa PS
Zone 4a Botanica	Suction pressure in Botanica PS	None
Zone 4a Schinoasa	Water Level in the reservoirs of Schinoasa PS	None

Table 3.4: Boundary conditions for each hydraulic entity in the suburbs

	Set values for Pressure	Set values for Flow
Vadul Lui Voda	Water Level in the reservoirs of SAN	None
Coşerniţa	Water Level in the reservoir of SAN	None
SAN to Tohatin	Water Level in the reservoir of SAN	Inlet of Tohatin PS
Coloniţa	Water Level in the reservoirs of Tohatin PS	None
Tohatin	Water Level in the reservoirs of Tohatin PS	None
Stauceni	Water Level in the reservoir of Stauceni	None
Durlesti-Gribov	Water Level in the reservoir of Gribova PS	None
Durlesti-Cartusa	Water Level in the reservoir of Gribova PS	None
Ialoveni	Water Level in the reservoirs of Ialoveni	None
Codru to Sîngera	Water Level in the reservoir of Codru PS	Inlet of Sîngera PS
Codru to Airport	Water Level in the reservoir of Codru PS	Inlet of Airport PS
Codru to Contrereservoir MDK	Water Level in the reservoir of Codru PS	None
Sîngera	Water Level in the reservoirs of Sîngera PS	None
Dobrogeah	Water Level in the reservoirs of Sîngera PS	None
Airport	Water Level in the reservoirs of Airport PS	None
Vatra	None	Flow leaving Ghidighici PS toward Vatra village

3.3.2. CALIBRATION PARAMETERS

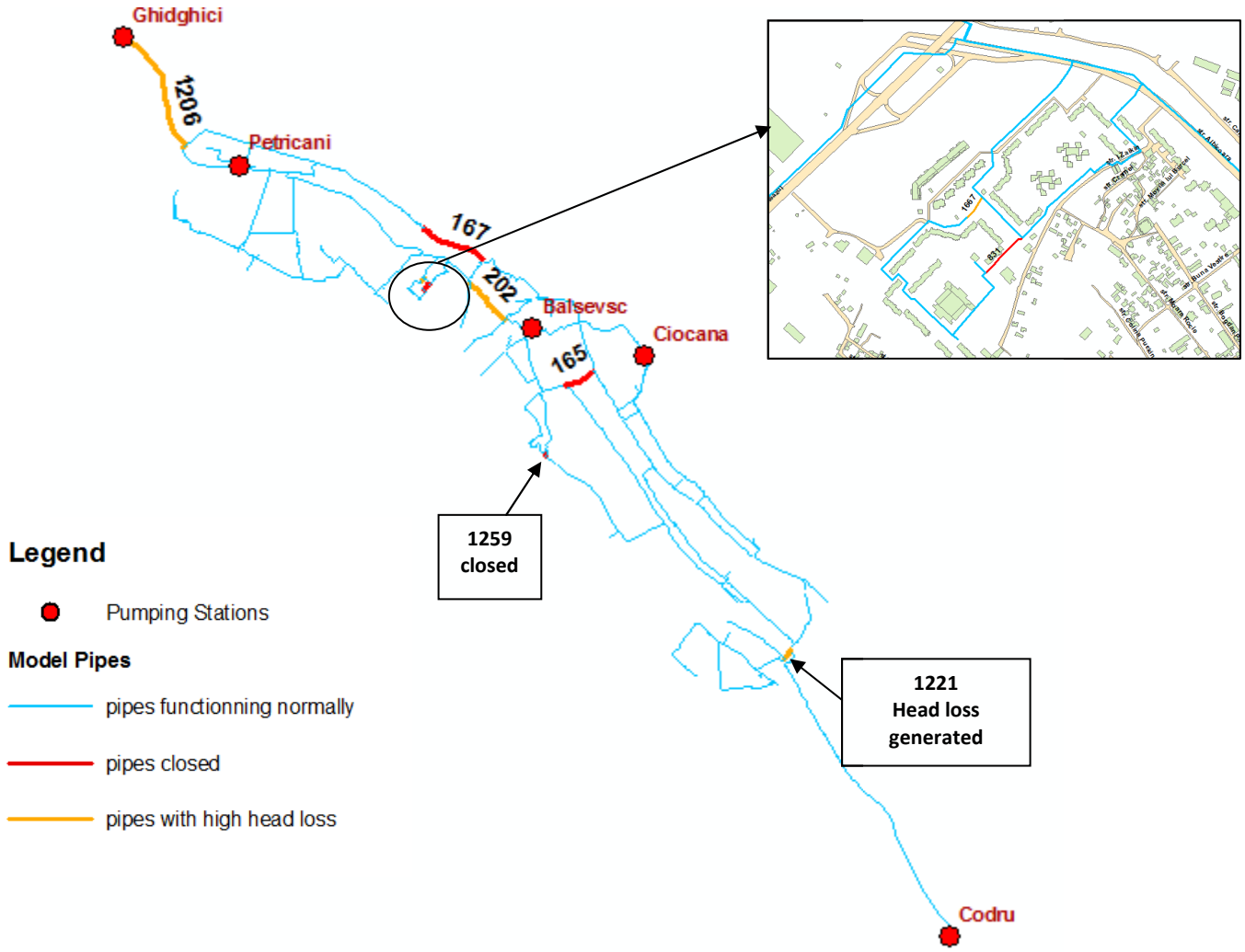
The calibration phase consists in reproducing the observed pressure. In order to do so, the singular and linear head losses are adjusted in each pipe.

3.3.2.1. Zone 1

During the calibration stage, in order for the model to recreate the flows and the pressures measured in reality, the following pipes had to be closed (see Figure 3.1):

- Pipe 165 (ND 600) located at Str. M. Lomonosov;
- Pipe 167 (ND 315) located at Str. Izmail;
- Pipe 831 (ND 300) located at Str. Independentei;
- Pipe 1259 (ND 250) located at Bd. I. Gagarin;

Figure 3.1: Zone 1-Closed pipes and pipes with a high head loss



The calibration of the zone 1 required the addition of a singular head loss in the following pipes (here are reported only the pipes where the maximum generated head loss is ≥ 2m):

- Pipe 1206 (ND 400), located at Şos Balcani, has a maximum singular head loss of 4.3m;
- Pipe 1221 (ND 400), located on the Street. Gradina Botanica, has a maximum singular head loss of 3.5m;
- Pipe 1667 (ND 300), located close to the intersection of the Streets Albişoara and Mihail Viteazul - maximum singular head loss of 3.2m;
- Pipe 184 (ND 200), located at Str. Feredeulu - maximum singular head loss of 2.4m;
- Pipe 202 (ND 500) , located at Str Albişoara - maximum singular head loss of 2.3m;

The Figure 3.1 shows on a map the pipes that were closed on the 8th of June, as well as the pipes where a high head loss was generated in order to recreate the measured data.

3.3.2.2. Zone 2

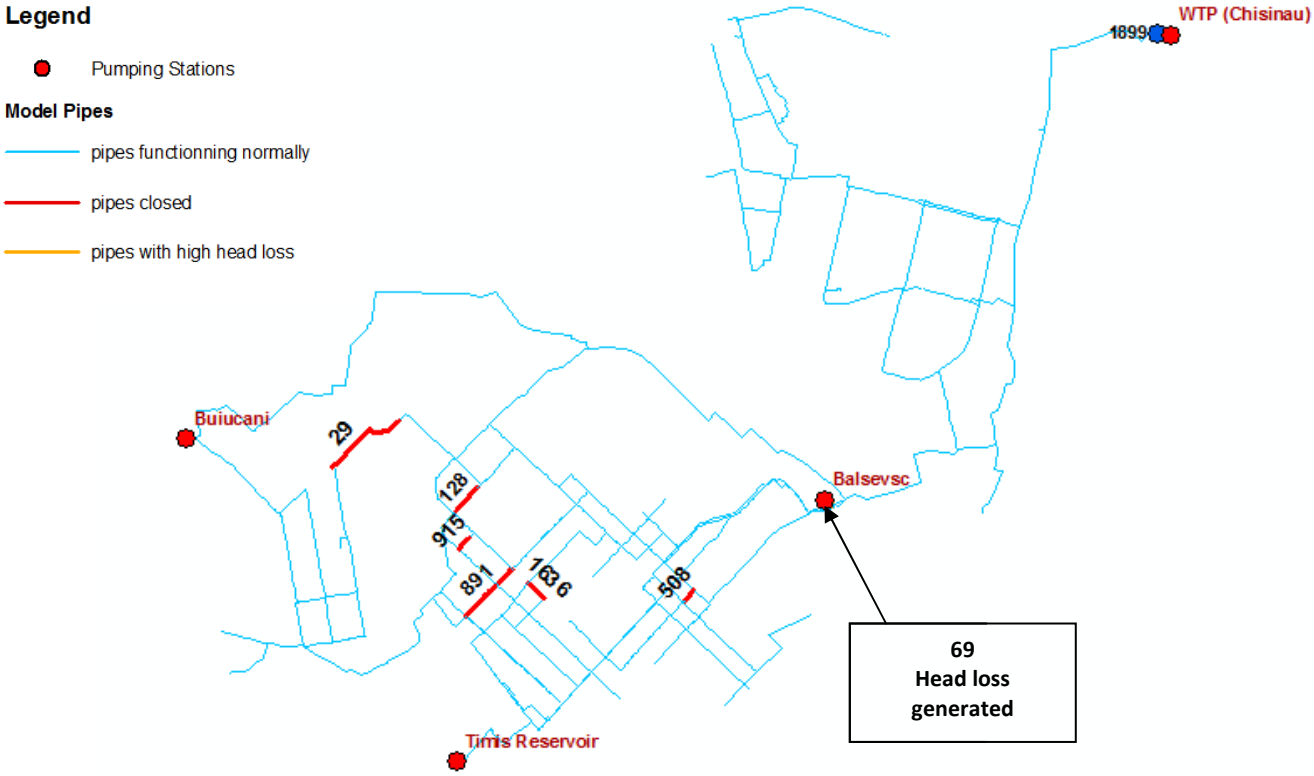
For the calibration of the zone 2 Oţel, the head loss had to be created in the following pipes:

- Pipe 69 (ND 200), located at the Street Feredeulu, has a maximum singular head loss of 3.6m;
- Valve 1899 (ND 1200) which regulates the pressure in the outlet Oţel at the Water Treatment Plant. This valve is regulated throughout the day and creates a head loss between 28.03m and 32.69m.

Moreover, the following pipes had to be closed:

- Pipe 29 (ND 600) located at Str. Ion Creanga;
- Pipe 128 (ND 600) located at Str. Toma Ciorbr;
- Pipe 508 (ND 500) located at Str Mihei Eminescu;
- Pipe 891 (ND 300) located at Str. Sfatul Țării;
- Pipe 915 (ND 250) located at Str. Mitropolit Petru Movilăl;
- Pipe 1636 (ND 250) located at Str. 31 August 1989

ating a high head loss



The zone 2 Tohatin, Vostoc and Independenţa corresponds to the area in Chişinău supplied by the outlets Vostoc and Independenţa from the Water Treatment Plant and by the pumping station of Tohatin. The calibration of this zone required the creation of singular head losses in the following pipes and valves (only the head loss ≥ 2m were considered):

- The pipe 1 (ND 1200), located close to the Street N. Milescu Spataru, has a maximum singular head loss of 2.0m;
- The pipe 23 (ND 1000), located at the Street Izmail, has a maximum singular head loss of 12.5m;

- The pipe 902 (ND 1000), located at the Street Pantelimon Halippa , has a maximum singular head loss of 3.9m;
- The pipe 1201 (ND 1200), located at the Street Industriala, has a maximum singular head loss of 19.2m;
- The valve 1805, located close to the intersection of the Streets Vadul-lui-Voda and Mircea cel Batrân, has a maximum singular head loss of 14.7m;

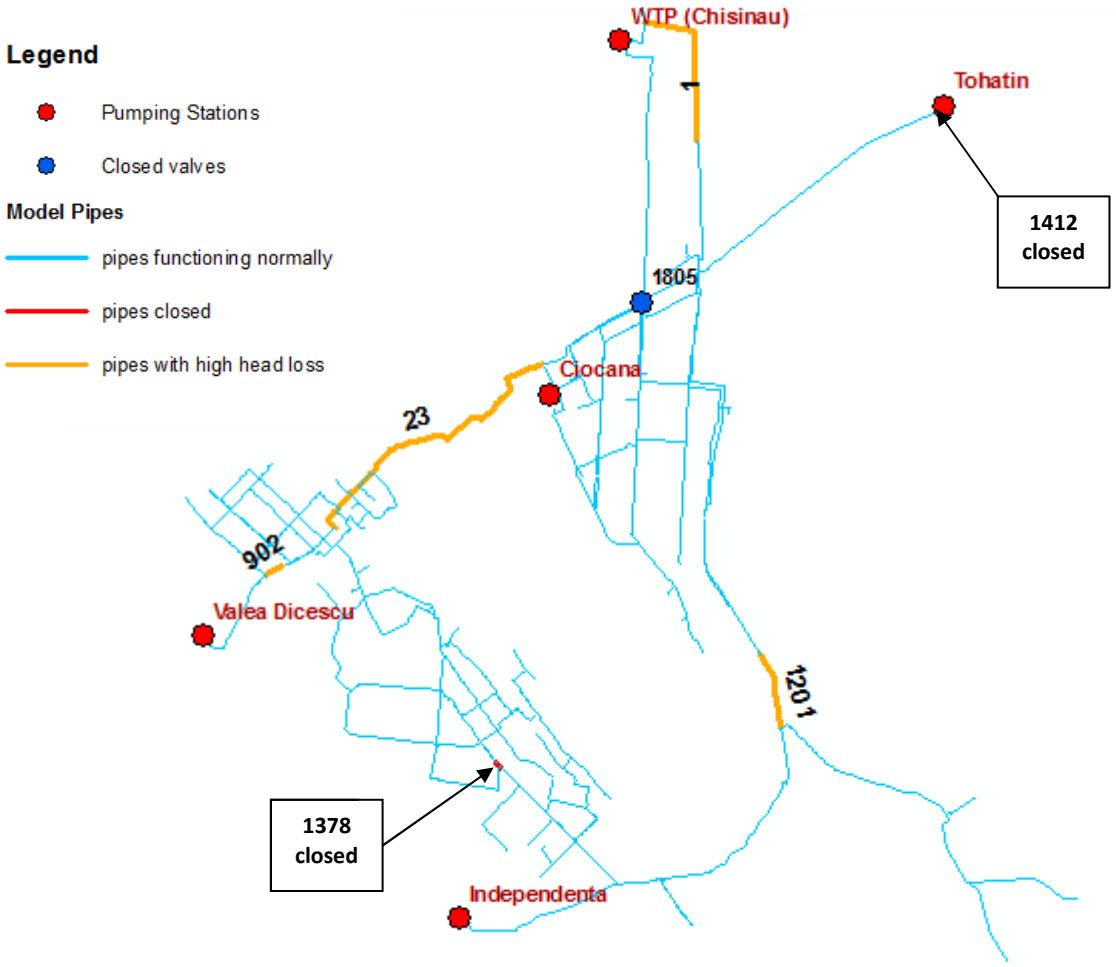
Moreover, for the calibration of the Zone, the following pipes had to be closed:

- Pipe 1378 (ND400) located at Str. Sarmizegetusa;
- Pipe 1412 (ND600) located in Tohatin Pumping Station.

The summary of the parameters allowing the calibration of the zone 2 are presented in the Figure 3.3.

For the calibration of the Zone 2 Doina, a head loss of 17m had to be generated by the valve 510, situated in the street Pogdorenilor (see Figure 3.4).

1 or generating a high head loss



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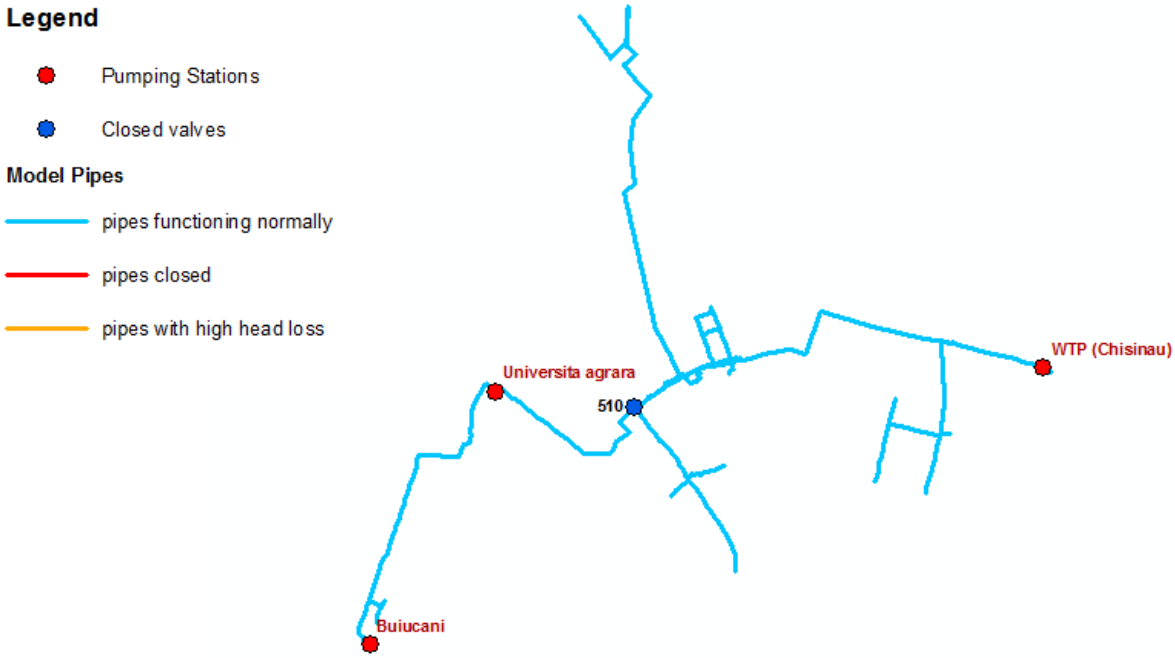
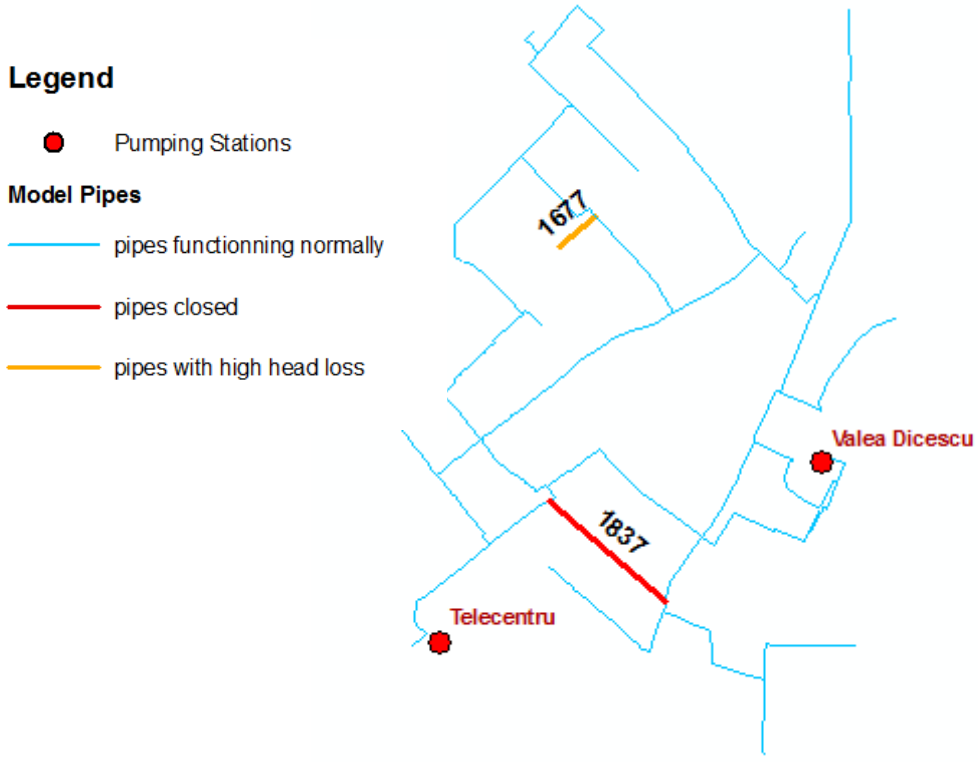


3.3.2.3. Zone 3

For the calibration of the Zone 3 Valea Dicescu, the pipe 1837 (ND 150), located Street Dokuceaev, had to be closed and a head loss had to be generated in the pipe 1677 (ND 150), located Street Drumul Viilor. The head loss is equivalent to 7.4m maximum and accentuates the pressure variations measured in the booster Drumul Viilor 28/4.

high head loss

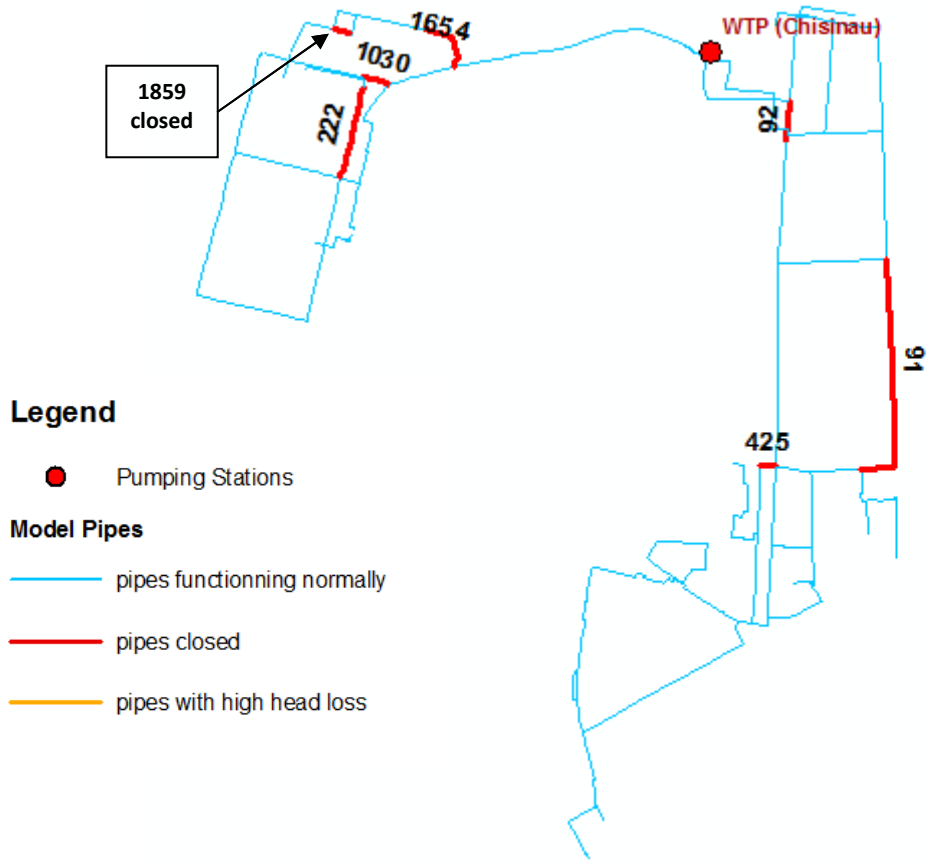


Regarding the calibration of the Zone 3 Rîscani the following pipes had to be closed in order to recreate exactly the flow and pressures observed:

- Pipe 222 (ND 500) located at Bd. Moskova;
- Pipe 1030 (ND 500) located at Str. Studenţilor
- Pipe 1654 (ND 250) located at Str. Studenţilor;
- Pipe 1859 (ND 250) is closed after 09:30 am located close to the Str. Studenţilor.

Similarly, for the Zone 3 Ciocana, the following pipes had to be closed (see Figure 3.6):

- Pipe 91 (ND 500) located at Str. Milescu Spataru;
- Pipe 92 (ND 300) located close to Str. Milescu Spataru;
- Pipe 425 (ND 700) located at Str. Pedru Zadnipru.



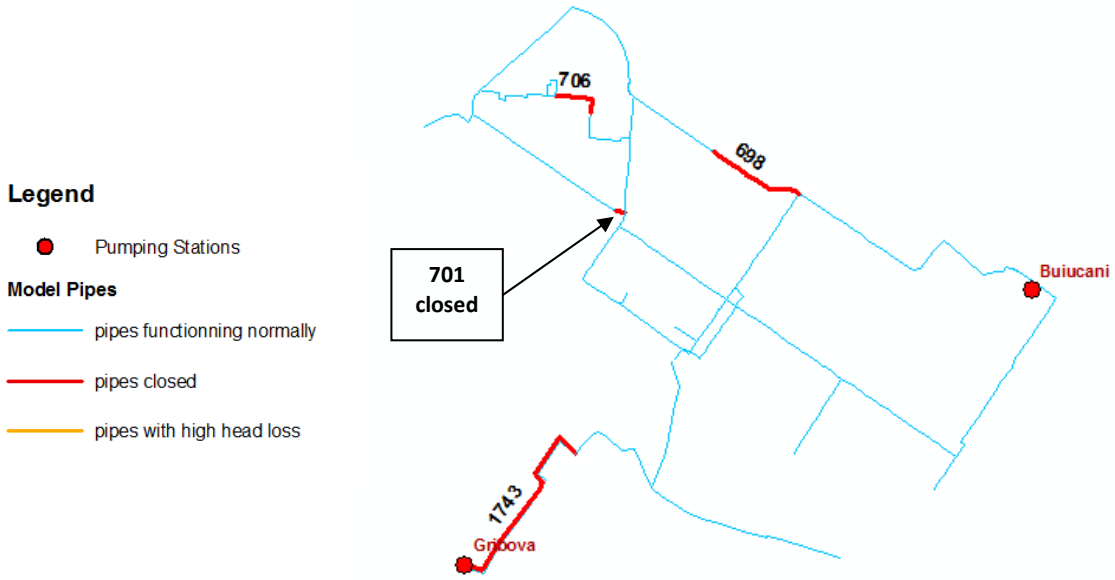
Finally, for the calibration of the Zone 3 Buiucani three pipes had to be closed:

- Pipe 726 (ND 300) located Street. Alba Iulia;
- Pipe 737 (ND 400) located close to the Street Nicloai Costin;
- Pipe 744 (ND 300) located Street Doina and Street Ion Aldea-Teodorovici.

3.3.2.4. Zone 4

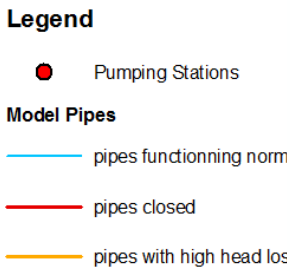
To calibrate the Zone 4 Buiucani, four pipes had to be closed:

- Pipe 698 (ND 400) located Street Nicloai Costin;
- Pipe 701 (ND 300) located Street Alba Iulia;
- Pipe 706 (ND 300), situated Street Liviu Deleanu;
- Pipe 1743 (ND 200) located close to the Street Onisifor Ghibu;



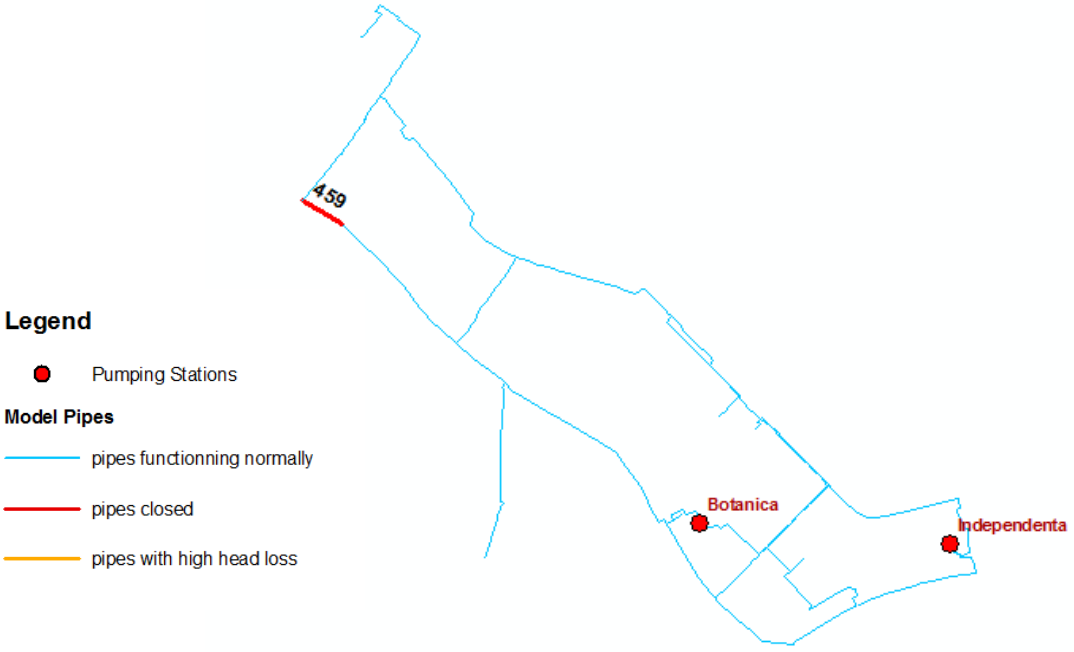
Similarly, for the calibration of the Zone 4 Ciocana, four pipes had to be closed:

- Pipe 85 (ND 500) that links the water treatment plant and the intersection of the streets I. Vieru and M. Sadoveanu;
- Pipe 544 (ND 400) located close to Bd. Mircea cel Batrîn;
- Pipe 552 (ND 400) located Street M. Sadoveanu;
- Pipe 571 (ND 500) located Bd Mircea cel Batrîn.

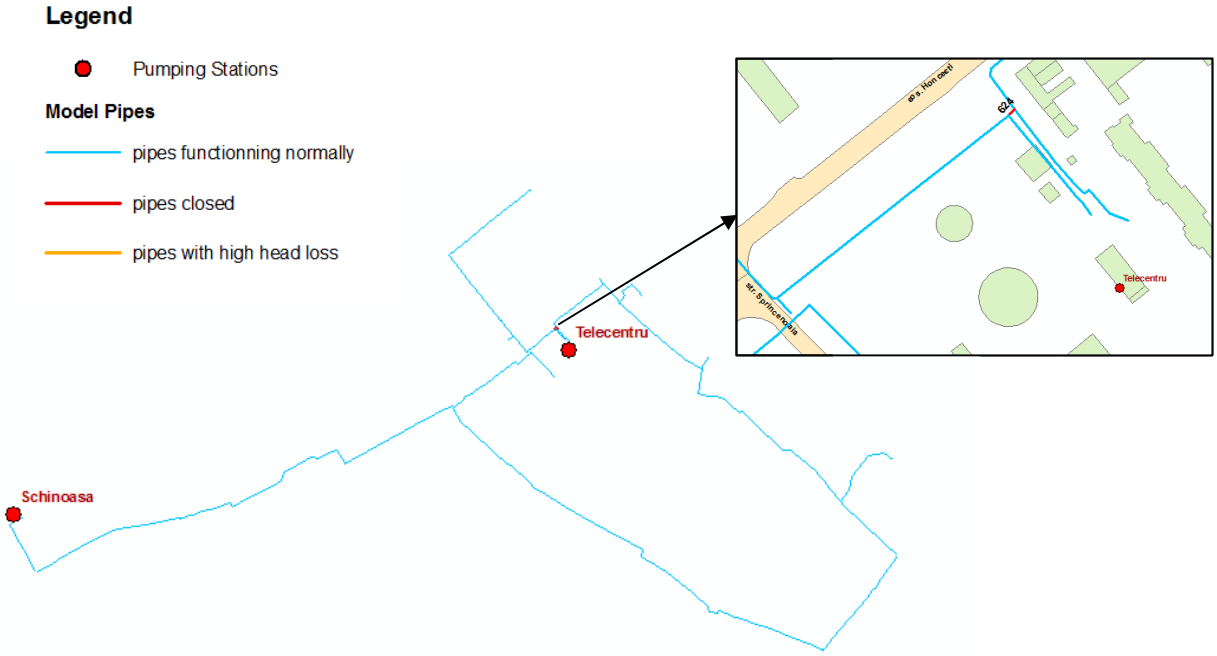


na- Closed pipes

Similarly, in order to calibrate the Zone 4 Independenţa, the pipe 459 (ND 600), located Street Grenoble, had to be closed.



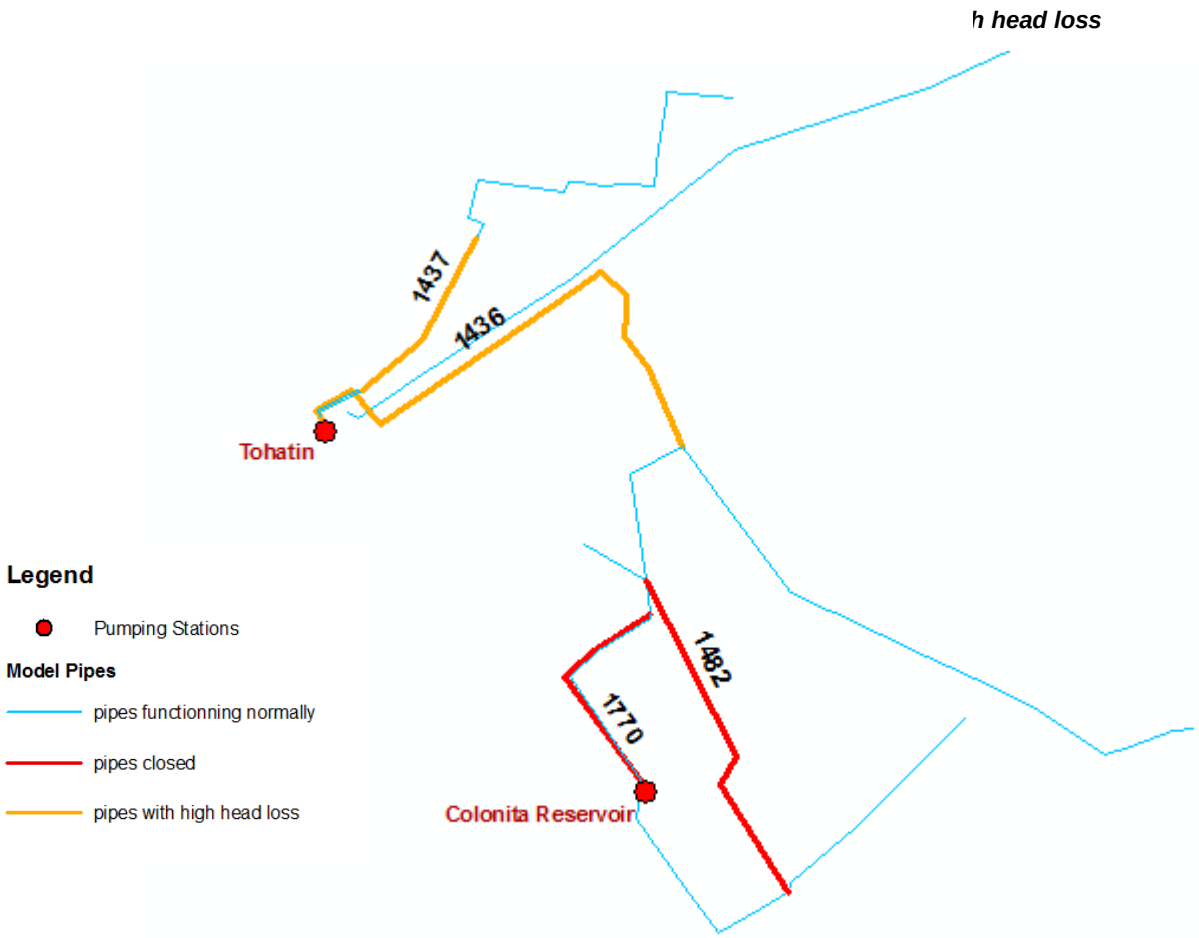
Finally, for the calibration of the Zone 4 Telecentru, the pipe 624 (ND 315), located Şos. Hîncesti, had to be closed.



3.3.2.5. Suburbs

In the suburbs of Chişinău, the calibration of the pressure zones “Coloniţa” and “Tohatin” (recreating the measured flows, pressures and the water level in the reservoir of Coloniţa) was obtained if two pipes had to be closed and high head losses had to be generated in two other pipes:

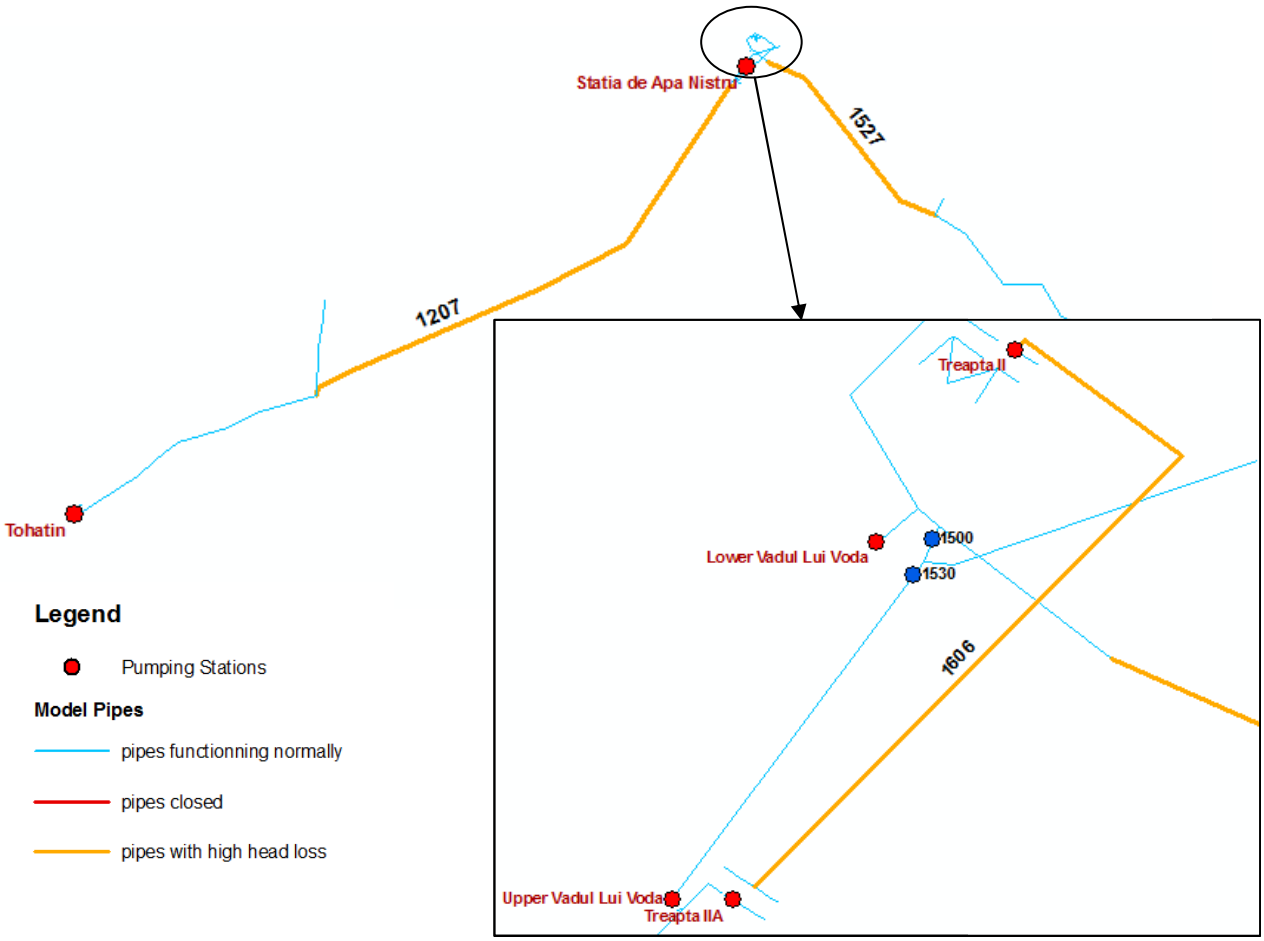
- Pipe 1482 (ND 250) located in the village of Coloniţa had to be closed. But on this street, two pipes connect the reservoir of Coloniţa to the pipe coming from Tohatin Pumping Station. Only one of them seems to remain functioning.
- Pipe 1770 (ND 250), located as well in the village of Coloniţa had to be closed;
- The pipe 1437 (ND 200), located in the pressure zone Tohatin, has a singular head loss of 2.3m;
- The pipe 1436 (ND 300), located in the pressure zone Coloniţa, has a singular head loss of 10.6m;



In order to calibrate the zones Vadul Lui Voda and SAN to Tohatin Pumping Station (modelling the measured flows and pressures and the water level in the reservoir of Upper Vadul Lui Voda), head losses had to be created in the following pipes and valves (only the head losses ≥ 2m were considered):

- Pipe 1207 (ND 800), connecting the pumping stations Treapta IIA and Tohatin, has a maximum singular head loss of 7.8m;
- Pipe 1606 (ND 700), connecting the pumping stations of Treapta II and Treapta IIA, has a maximum singular head loss of 4.3m;
- The pipe 1527 (ND 300), connecting the territory of SAN to the city of Vadul Lui Voda , has a maximum singular head loss of 29.4m;
- The valve 1500, throttled valve on the pipe supplying the city of Vadul Lui Voda, has a maximum singular head loss of 8.6m;
- The valve 1530, located on the territory of SAN, has a maximum singular head loss of 0.65m.

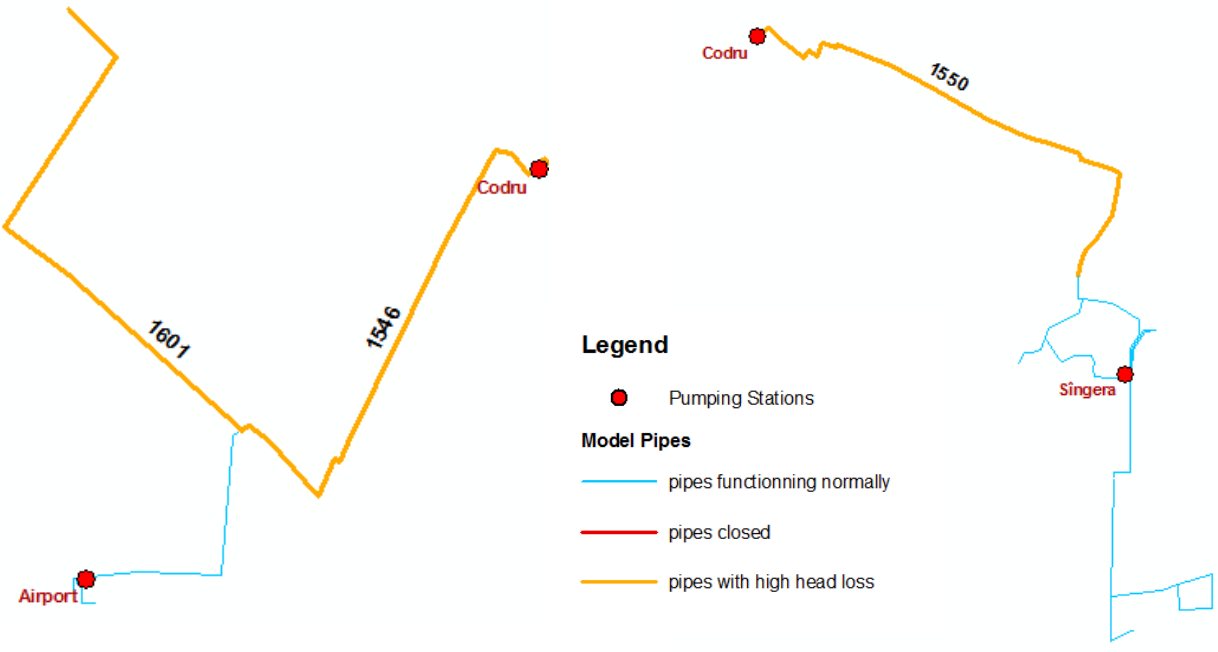
h head loss



The calibration parameters for the suburbs in the south of Chişinău are presented in the Figure 3.14 and the Figure 3.15. To calibrate the hydraulic entity “Codru to Airport”, a singular head loss had to be created in the following pipes:

- Pipe 1546 (ND 250), with a maximum head loss of 9.8m and
- Pipe 1601 (ND 200), with a maximum head loss of 3.5m.

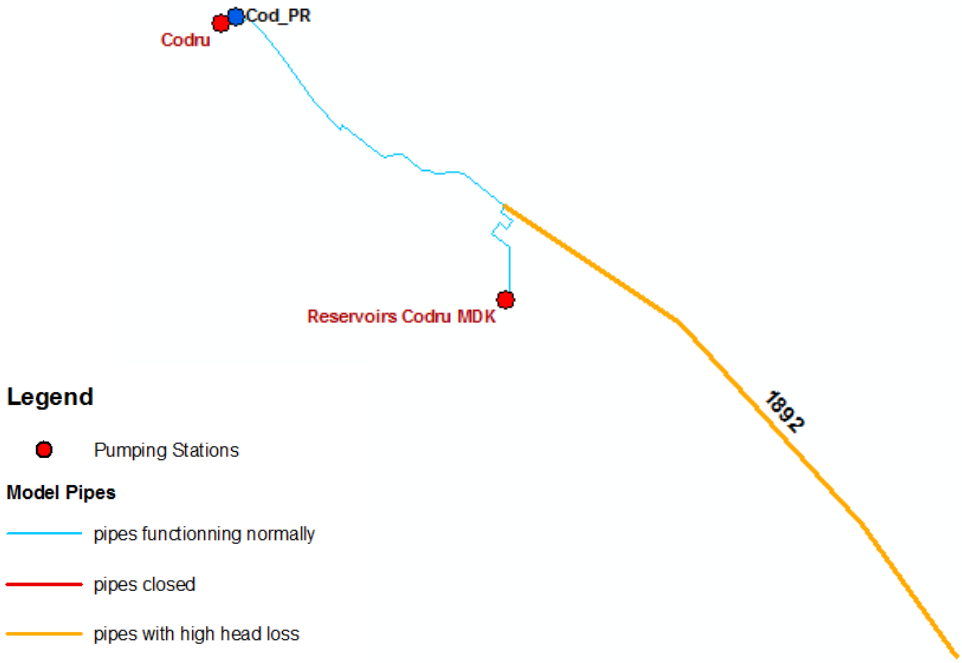
rge singular head losses



Similarly, in the zone “Codru to Sîngera”, the calibration of the entity required the creation of a maximum head loss equivalent to 11.3m in the pipe 1550 (ND 400).

For the pressure zone Codru MDK, the calibration has focused mainly on finding the water level of the Reservoir Cod_Res1. For this purpose, the head loss generated by the throttled valve in the pumping station of Codru (Valve Cod_PR) is revolving around 50m. And the calibration of the pressure in the zone supplied by the reservoir required the generation of a maximum 2.0m head loss in the pipe 1892 (ND 250).

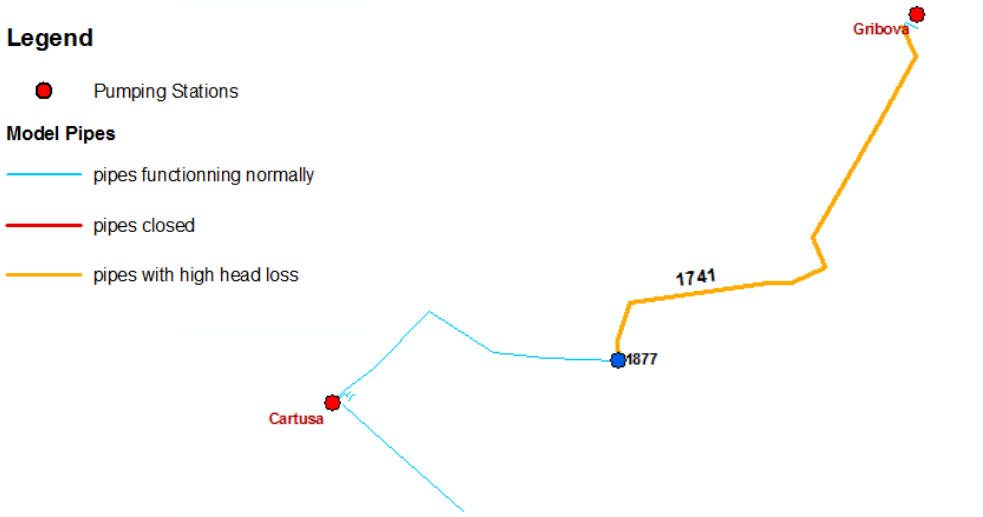
h head loss



In the city of the Durleşti, the calibration enabled to reproduce the measured flows, pressures and the measured water level in the reservoir of Cartuşa. For this purpose, singular head losses had to be generated in the following pipes and valves:

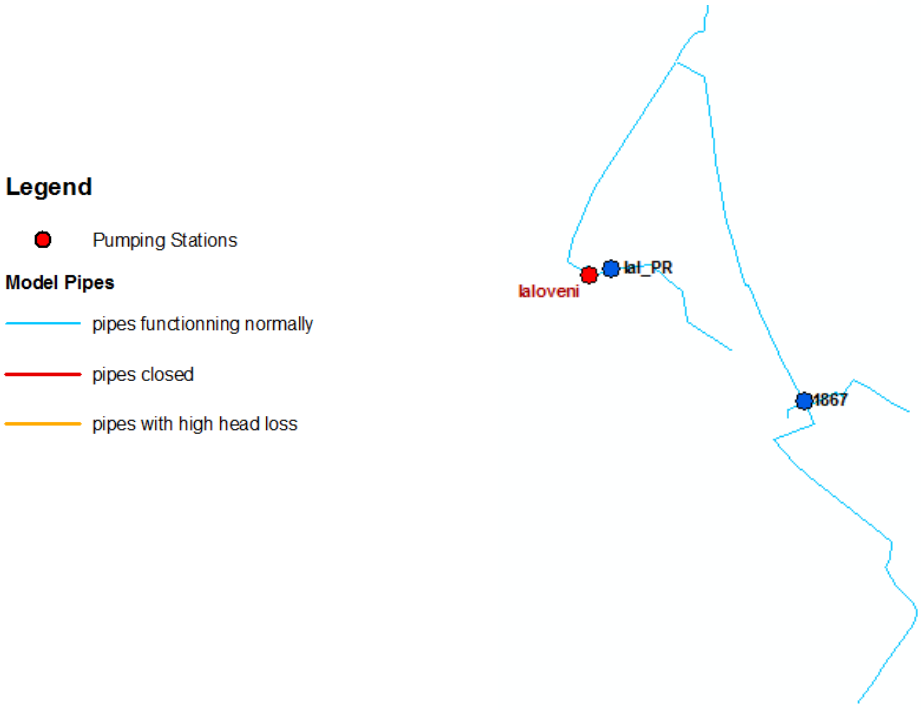
- The pipe 1741 (ND 150), connecting the pumping stations of Gribova and Cartuşa, has a maximum singular head loss of 14.1m;
- The valve 1877, located in Durleşti (between the pumping stations of Gribova and Cartuşa), has a maximum singular head loss of 24.2m.

ar head losses



Finally, for the calibration of the zone “Ialoveni”, the maximum singular head loss created in the valve Ial_PR (ND 150) is 12.3m (this valve modelling the pressure reducer in the pumping station of Ialoveni). A second valve (valve 1867), located on Alexandu Cel Bun creates a maximum head loss of 32m.

ses



3.4. RESULTS OF THE CALIBRATION

Epanet is able to compute tables and graphs illustrating the achievement of the calibration stage by comparing the results of the model with the measures taken on site.

As an example, the Figure 3.18 and the Table 3.5 present the results for the zone 3 Buiucani.

Figure 3.18: Graph of the comparisons between the model and the reality for the zone 3 Buiucani

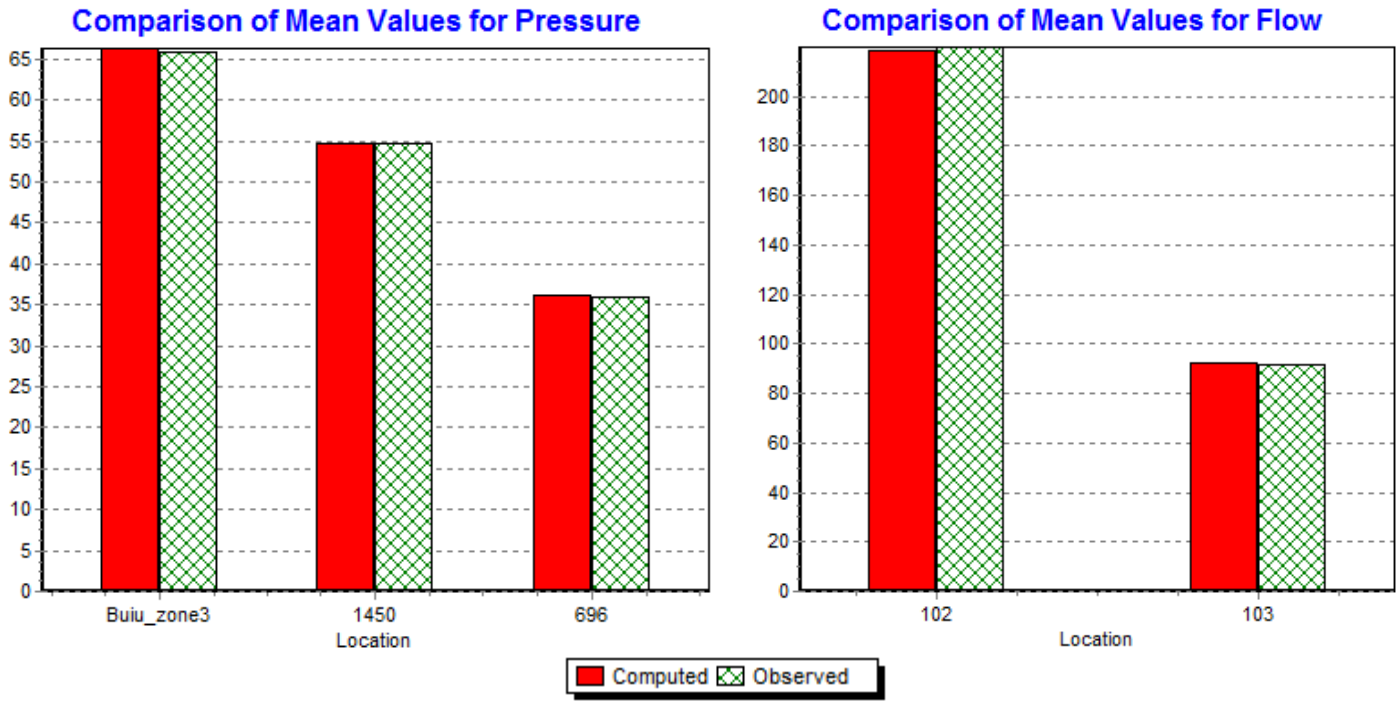


Table 3.5: Statistical differences between the computed and measured values on the zone 3 Buiucani

	Location	Observed mean	Computed mean	Mean Error (m)	RMS Error (m)
Pressure m	Buiu_zone3	65.93	66.32	0.394	0.448
	1450	54.74	54.69	0.266	0.332
	696	36.01	36.24	0.279	0.356
	Total	52.23	52.42	0.313	0.382
Flow m^3/h	102	219.98	218.76	1.818	2.322
	103	91.41	92.64	1.794	2.320
	Total	155.70	155.70	1.806	2.321

The **Mean Error** corresponds to the average of the absolute error between each measured and simulated value (see equation below where θ is a parameter)

$$Mean\ Error\ (m) = \frac{\sum(\theta_{measured} - \theta_{computed})}{143}$$

The **RMS Error** (Root Mean Square Error) corresponds to the square root of the mean of the squared errors between the observed and simulated values (see equation below)

$$RMS\ Error\ (m) = \sqrt{\frac{\sum(\theta_{measured} - \theta_{computed})^2}{143}}$$

The Table 3.5 shows that the flow points and the pressure points have been calibrated with an overall error of 1%.

The Table 3.6 and Table 3.7 give the results of the calibration for all hydraulic entities.

Table 3.6: Statistical results for the calibration of the flow

Hydraulic entity	number of calibration points	observed mean (m^3/h)	computed mean (m^3/h)	Mean Error m^3/h	RMS Error m^3/h	%
Zone 1	2	120.03	122.22	9.523	15.840	8%
Zone 2	3	1787.33	1787.09	48.360	64.485	3%
Zone 3 Buicani	2	155.70	155.70	1.806	2.321	1%
Zone 3 Ciocana	2	326.97	326.93	4.705	5.654	1%
Zone 3 Independenţa	2	321.71	317.84	5.549	7.028	2%
Zone 4 Buiucani	3	184.87	184.07	8.640	11.482	5%
Zone 4 Ciocana	2	120.55	118.29	2.324	2.783	2%
Zone 4 Independenţa	2	218.28	222.21	6.124	7.543	3%
Zone 4 Telecentru	2	71.17	71.19	5.597	7.917	8%
Zone 4A Botanica	2	18.59	18.59	0.680	0.912	4%
Zone 4A Telecentru	2	155.95	155.98	3.142	3.641	2%
Airport	2	7.91	7.90	1.062	1.415	***13%***
Coloniţa	1	52.73	54.34	2.624	5.620	5%
ContreReservoirs MDK	1	84.87	84.89	1.222	1.697	1%
Durleşti-Cartuşa	1	24.66	25.21	0.884	1.750	4%
Durleşti-Gribov	2	22.64	22.3	1.844	2.347	8%
SAN to Tohatin	1	1122.34	1122.36	6.774	8.417	1%
Stauceni	2	41.27	41.23	2.351	3.007	6%

Table 3.7: Statistical Results for the calibration of the pressure

Hydraulic entity	number of calibration points	observed mean (m)	computed mean (m)	Mean Error m	RMS Error m	%
Zone 1	11	59.13	59.42	0.657	0.846	1%
Zone 2	10	50.53	50.8	1.214	1.981	2%
Zone 2 Doina	4	57.39	57.51	0.458	0.705	1%
Zone 2 Oţel	9	55.74	55.82	0.491	0.723	1%
Zone 3 Buicani	3	52.23	54.42	0.313	0.382	1%
Zone 3 Ciocana	2	42.55	42.6	0.341	0.708	1%
Zone 3 Independenţa	3	57.17	57.26	0.351	0.515	1%
Zone 3 Rîscani	4	61.63	61.75	0.375	0.686	1%
Zone 3 U.A.	1	55.06	55	0.139	0.163	0%
Zone 3 Valea Dicescu	3	43.14	43.36	0.657	1.414	2%
Zone 4 Buiucani	4	55.52	55.31	0.79	1.337	1%
Zone 4 Ciocana	3	45.32	45.58	0.417	0.718	1%
Zone 4 Independenţa	3	60.49	60.59	0.282	0.362	0%
Zone 4 Telecentru	2	40.1	40.07	0.121	0.147	0%
Zone 4A Botanica	1	61.17	61.2	0.285	0.499	0%
Zone 4A Schinoasa	1	53.98	54.26	0.446	0.744	1%
Zone 4A Telecentru	4	45.72	45.87	0.377	0.48	1%
Airport	2	43.21	43.15	0.383	0.518	1%
Codru-Airport	3	54.63	54.43	1.022	1.508	2%
Codru-Sîngera	2	48.78	48.84	0.216	0.28	0%
Coloniţa	3	32.32	32.24	1.066	2.485	3%
ContreReservoirs MDK	3	27.54	27.63	0.252	0.366	1%
Coşerniţa	1	50.41	50.39	0.241	0.29	0%
Dobrogeah	3	49.86	49.87	0.215	0.271	0%
Durleşti-Cartuşa	4	19.21	18.73	0.599	0.983	3%
Durleşti-Gribov	3	57.19	57.59	4.035	5.781	7%
Ialoveni	5	64.38	64.47	0.732	1.265	1%
SAN to Tohatin	4	36.72	36.72	0.311	0.426	1%
Stauceni	3	45.31	45.53	0.684	1.149	2%
Tohatin	2	39.04	39.16	0.509	0.759	1%
Vadul Lui Voda	4	27.17	26.06	1.351	2.233	5%
Vatra	1	55.78	56.75	1.178	2.837	2%

As can be observed in these two tables, the calibration stage went smoothly and most of the measured pressure and flows were recreated with an acceptable error margin:

- An average difference of less than 5m for the pressure points;
- And a mean error representing less than 10% for the flow. At the exception of the airport where the network isn't known and therefore the calibration could not be efficient.

The detailed graphic and statistical results for the other hydraulic entities are presented in the Annex 3 and 4.

4. DIAGNOSTIC OF NETWORK OPERATION

Once the calibration has been performed, it is possible to use the model. As the model computes the pressure, the flow, the velocity and the head loss at each point of the network, a simulation provides therefore information leading to a diagnostic of the network operation. The diagnostic is performed for the reference days, therefore during the summer where the consumption of water is higher, as the calibration of the model enables us to obtain a "snapshot" of the condition of the network on these days.

In order to obtain a diagnostic, it is possible to perform "minimum" or "maximum" simulations, where the model provides for each item the minimum or maximum values of the days for all the parameters for. These special modes enable an easy description of the problem directly on Epanet's workplace.

It is then possible to locate the pipes with:

- High velocity (leading to an enhanced risk of water hammer in case of a sudden stop of the supply and to high head losses) by observing the maximal velocity of the pipes in each zone;
- Low velocity (possible sedimentation and long residence time) by observing the minimal velocity on each zone.
- High head losses (due to linear and singular head losses).

The results from the simulations show as well the locations in the city where the pressure is too low or too high. These results will enable the optimization of the pressure regulation for a better network operation.

In Chişinău city, the most widespread problem is the low velocity in the pipe: for most of the pipes, even the maximal velocity is below 0.2m/s. The maps showing the results that are not presented below can be found in Annex 5.

4.1. ZONE 1

The pressure Zone 1 is the lowest pressure zone of Chişinău, with a total head of about 105m, imposed by the reservoirs of Ciocana and the regulation valves downstream Ciocana tanks. The zone is situated alongside the river Bîc and, due to the topographical configuration, the pressure is really high in the central part of the zone while problems with low pressure might arise on the borders of the zone (see Figure 4.1):

1. The minimal pressure at this point is 17.5m. However, the houses supplied are located than this node and correspond to a residential area (without any high building).Therefore, this result is not worrying.
2. At the crossroad of Burebista and Cetatea Alba, the pressure is more than 35m but there is a building of 9 floors at this point (requiring a pressure of 46m). This part of the network could be supplied by the zone 2.

3. In the same way, at the crossroad between Calea Iesilor and the street Mesagerului, the pressure is around 50m and there is a building of 16 floors (requiring a pressure of 74m). Apa Canal does not operate any booster near this building but a private booster is highly probable.

4. Crossroad between bd Catemir and street Izmail, 2 buildings of 16 floors may be not connected to the boosters. If that is the case, problem of low pressure might arise.

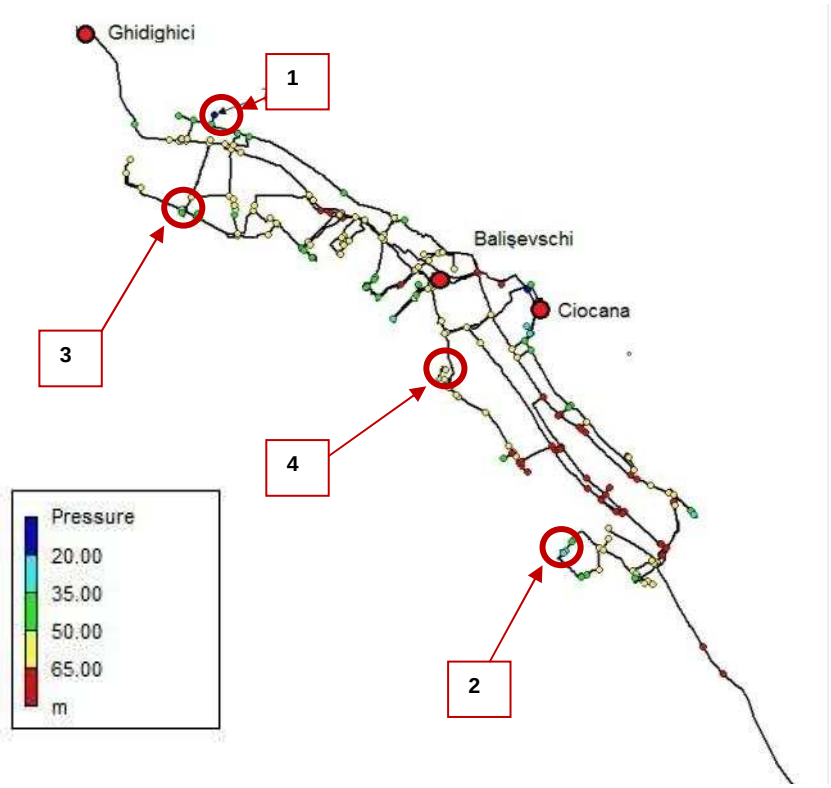


Figure 4.1: minimal pressure for the zone 1

However, these problems of low pressure do not arise due to a hydraulic problem or an undersizing of the pipes of the zone. Indeed, the velocity of the water in the zone is really low (for most of the pipes, below 0.2m/s) and the maximal head loss (except for a few pipes) is less than 1m/km. In the same way, the variations of pressure are not excessive (between 7m and 15m) and are due to the variations of level in the reservoirs of Ciocana, and most of all to the pressure regulation performed at the outlets of the reservoirs. This regulation allows air to enter the network and damages therefore the pipes.

In the Figure 4.2, it is possible to identify three pipes in which the head loss is more important:

- Pipe 184 (ND 200), with Δh=109.3 m/km, where 35 m/km are due to linear head loss; this pipe is undersized but the length is so short (30m) that the head loss created is negligible.
- Pipe 1221 (ND 400), with Δh=21.6m/km due to singular head loss;
- Pipe 1667 (ND 300), with Δh=49.8 m/km due to singular head loss.

The pipe 184 is the outlet of the pumping station of Balisevschi to the zone 1. The velocity in the pipe reaches the value of 1.78 m/s, which suggests that this section is undersized.

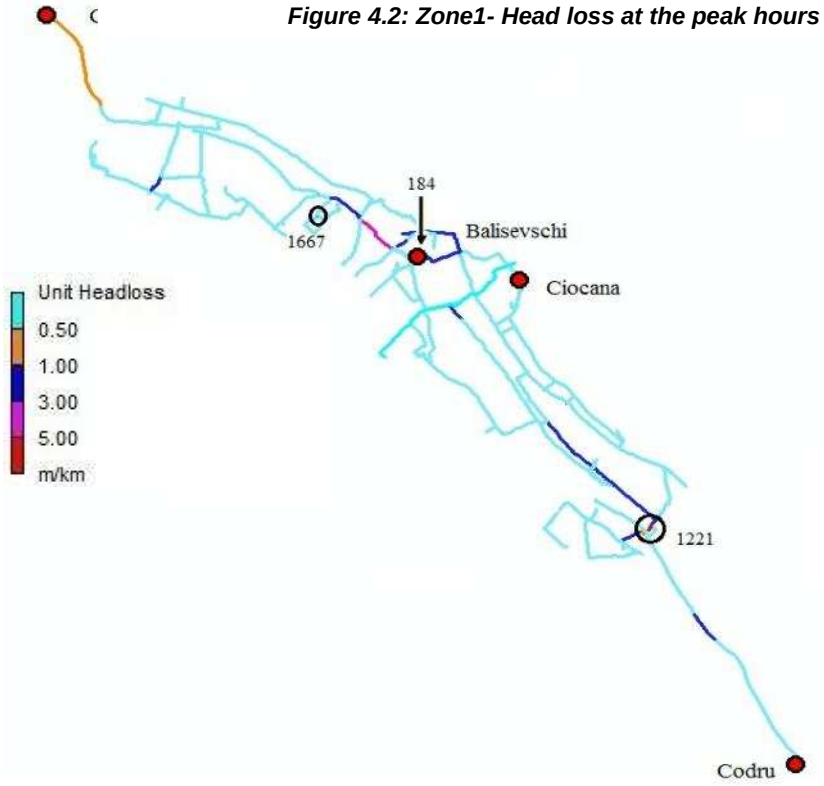


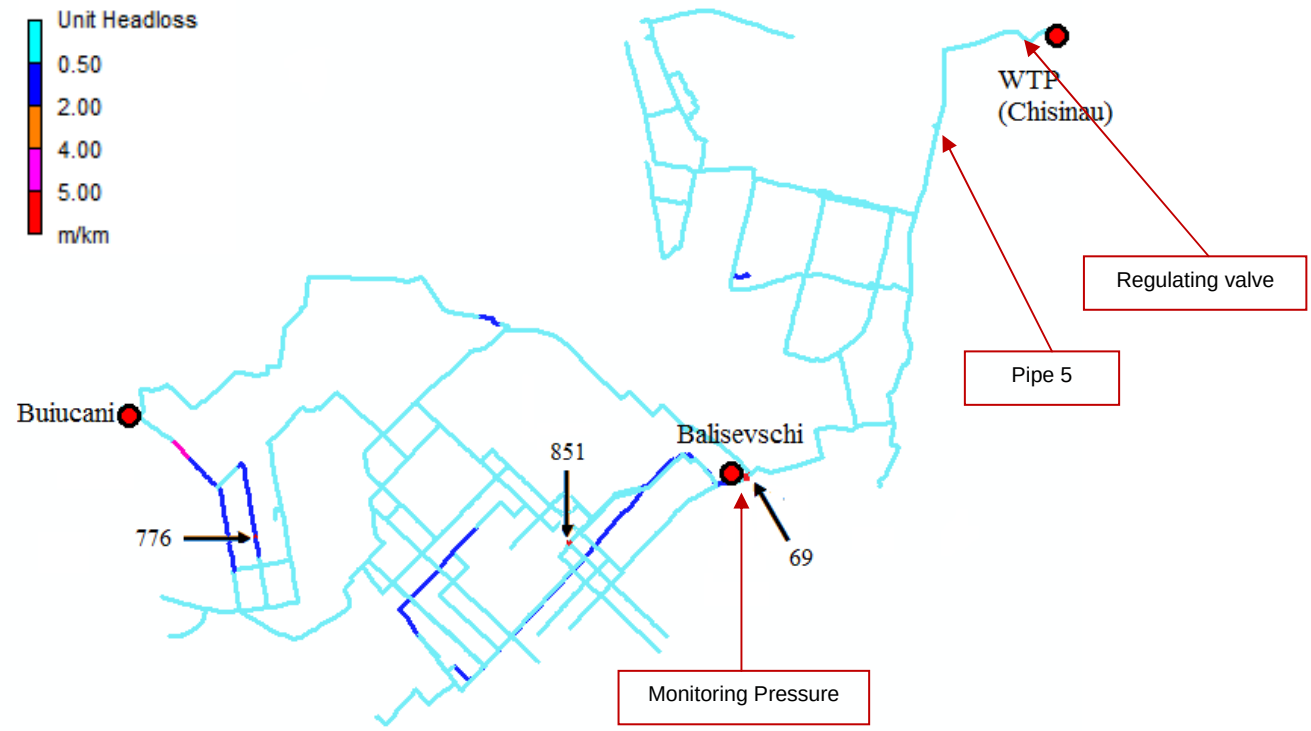
Figure 4.2: Zone1- Head loss at the peak hours

4.2. ZONES 2

4.2.1. ZONE 2 OȚEL

In this zone, the velocity and the head loss are really low (except for a few pipes), leading to the conclusion that this zone might be completely oversized and the risk of sedimentation or of long residence time is high. Three pipes have been found with an important head loss (see Figure 4.3):

- Pipe 69 (ND 200), with a head loss of 58.4 m/km, of which 16.2 m/km is due to linear head loss. This pipe is the one supplying the reservoir of Balişevschi and the pressure upstream the regulation valve is still 7 bars.
- Pipe 776 (ND 150), with a linear head loss of 5.4 m/km. The diameter of the pipe is 200mm but becomes 150mm for 33m.
- Pipe 851 (ND 125), with a linear head loss of 9.1 m/km. This pipe connects one 300mm pipe to a pipe which diameter is 250mm. It is undersized but the length is so short (15m) that the head loss created is negligible



However, no problem of really high pressure can be found in this zone, as the pressure is regulated at the outlet of the Water Treatment Plant. This regulation creates a high head loss (around 30m) and is monitored by the pressure in Balişevschi Pumping Station. Thanks to the close monitoring, the pressure variation in this zone does not exceed 6m, in spite of the regulation. However, because of the location of the regulation (the highest point of the zone), air enters the network and the steel pipe 5 (ND 1200) is therefore in a really poor state.

The pressure is closely monitored so no big problems appear in the zone. However, the pressure may be a bit low sometimes at the critical points (see Figure 4.4):

1. On Maatevici Street, the minimal pressure is 23m, sufficient to supply a 3-floors building but insufficient for the 5 floors buildings of the state university. The piezometry of the zone 2 Oţel should be monitored a bit higher to prevent any risk of low pressure at this location.

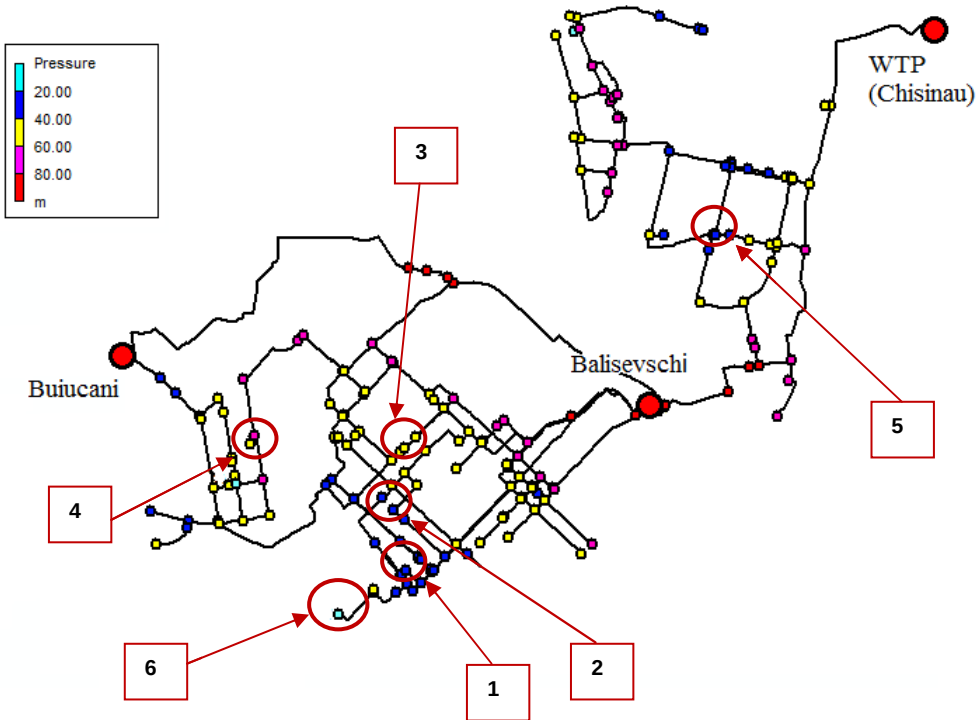
2. In the centre of the city, a building with 14 floors (on Strada Sciusev) should have a private booster (all the more as a 7-floors building near it is supplied through a booster).

3. In the same way a building with 17 floors on Strada Sfartul Ţarii would not be able to be supplied otherwise.

4. A building of 16 floors (Street E. Coca 19/1) is supplied with a pressure of 60m, while the pressure for this building should be 74m. A booster exists to supply this building but is currently not working.

5. At the crossroads of the streets A. Russo and Bogdan Voievod, a building of 17 floors can only be supplied if connected to a private booster (the pressure here is around 40m)

6. At the inlet of the Timiş reservoir, the pressure is below 20m. However, the houses around are not supplied by the zone 2 Oţel. This low pressure therefore does not have any negative effect.

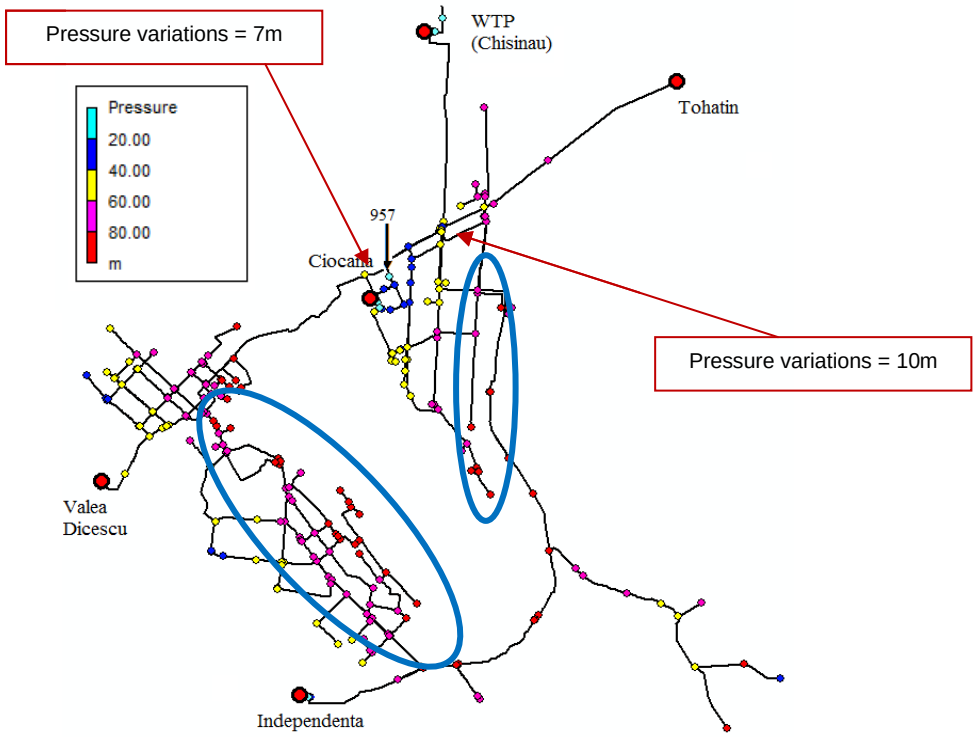


4.2.2. ZONE 2 TOHATIN, VOSTOC AND INDEPENDENŢA

In the Zone 2 supplied by the outlets Vostoc and Independenţa from the WTP and by the reservoirs of Tohatin, the biggest problem is the high pressure, especially for two zones: the industrial zone and the part of the zone 2 situated in the sector Botanica (zone defined by the blue circles in the Figure 4.5).

However, one point was found to have insufficient pressure: at the point 957 (below in the Figure 4.5), the buildings are 5 floors, while the minimal pressure was 20m. On the 27th and on the 28th of July, something happened on the network that made the pressure drop by 7m. The usual minimal pressure at this location should therefore by around 27m, with therefore a slight risk of low pressure.

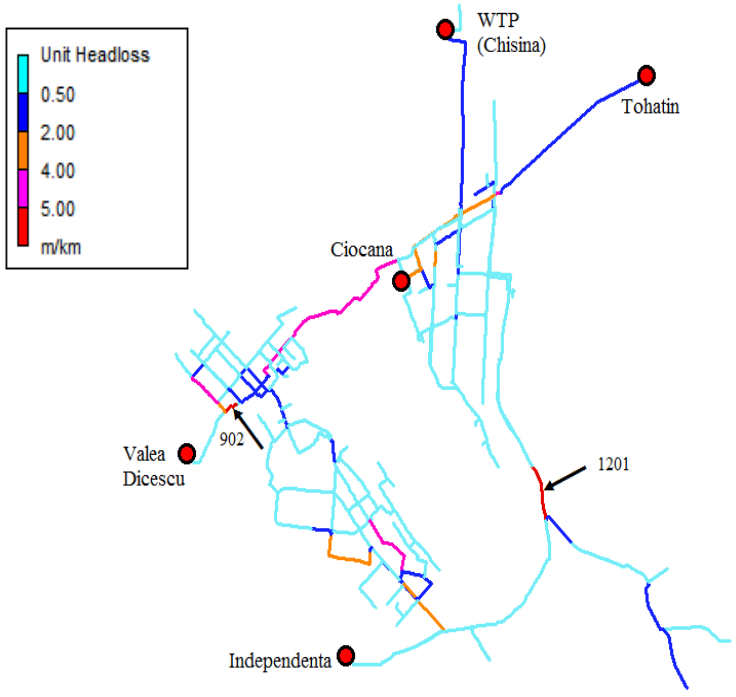
The pressure variations in the zone stay low except on the transfer from Tohatin Pumping station to Ciocana reservoirs (where the connection between the outlets from the WTP and Tohatin is made). The pressure variations are more important on this transfer than at the inlet of Ciocana's reservoir. This strange hydraulic behaviour could not be explained with the modelling (see Figure 4.5).



The high pressure in the zone corresponds to low velocities in the zone, without any regulation. It is however possible to identify in the zone 2, 2 pipes with an important head loss, created by a singular head loss (see Figure 4.6):

- Pipe 902 (ND1000), with a head loss of 17.3 m/km, due to a singularity.
- Pipe 1201 (ND1200), with a head loss of 9.1 m/km, due to a singularity

The pressure is



4.2.3. ZONE 2 DOINA

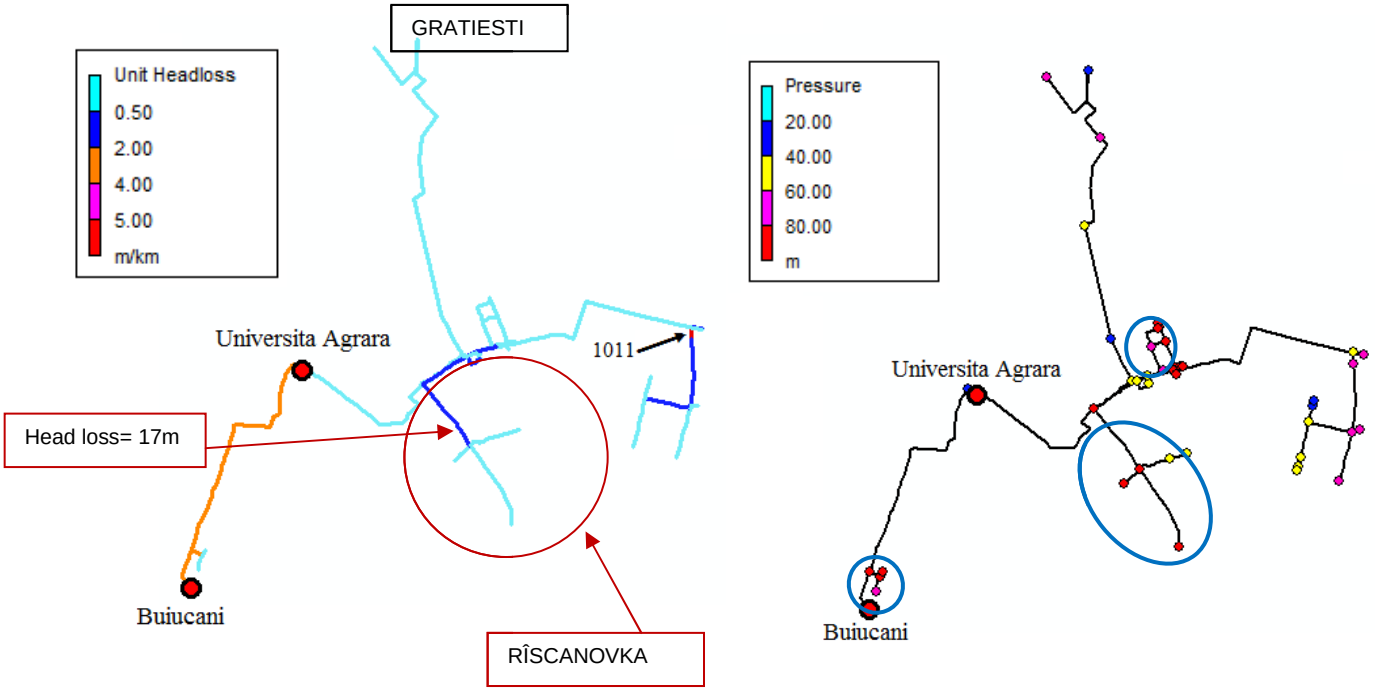
The Zone 2 Doina is mainly a transfer pipe from the Water Treatment Plant to the pumping stations of Buiucani and Universita Agrara and to the city of Gratieşti.

The velocity and the head loss in the pipes are really low except for two points:

- The pipe 1011 (ND 200) which has a maximal linear head loss of 11.1m/km due to a narrowing of the diameter of the pipe from 300mm to 200mm. This portion of pipe is clearly undersized (see Figure 4.7 below).
- On the street Pogdorenilor, a singularity (that should be a partially opened valve) creates a head loss of 17m. This fact could explain why ACC is not able anymore to supply the whole zone of Rîşcanovka only by the outlet Doina and has to bring water from the outlet Oţel.

Despite this high head loss, the pressure in Rîşcanovka is still too high for this residential area, as on several other part of the zone (see Figure 4.8)

2 Doina ***he zone 2 Doina***



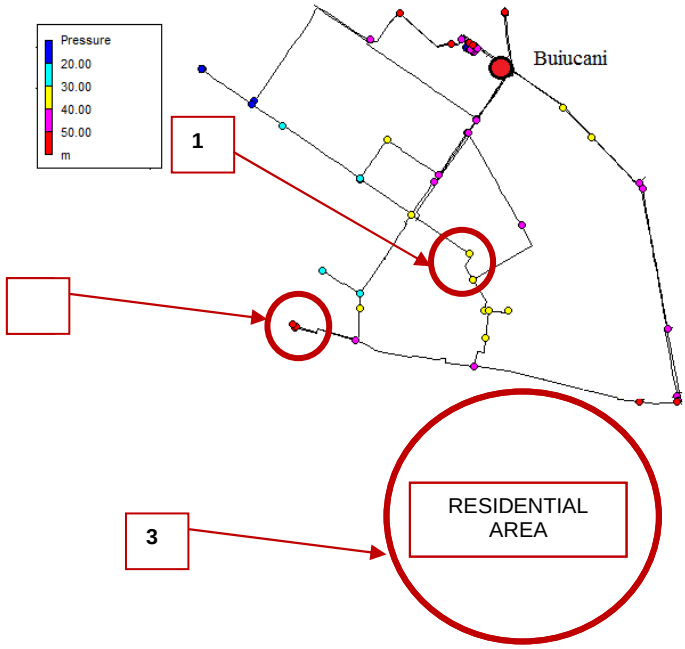
4.3. ZONES 3

4.3.1. ZONE 3 BUIUCANI

In the Zone 3 Buiucani, no problems of high head loss have been found and the velocity in all the pipes is really low. Therefore, the variations of pressure or problems of high and low pressure are due to regulation of the pressure in the pumping station of Buiucani. During the night, the pumps are bypassed and the piezometry is defined by the reservoir in the Water Treatment plant. Some problems of low pressure appear at this moment (Figure 4.9):

1. The pressure on the street Alba Iulia is 40m during the night, while buildings with 9 floors have to be supplied here (the minimal pressure should be 46m)
2. The pressure during the night is 25m at the street Ion Pelivan, while the buildings have 5 floors (minimal pressure should be 35m)
3. In the residential sector south of the street Vasile Lupu, there is no main pipe (all the pipes have a diameter smaller than 100mm) and the network was not modelled. But it is known that in summer, there are problems of pressure in this area and that the network is undersized.

Figure 4.9: Minimal pressure on Buiucani Zone 3

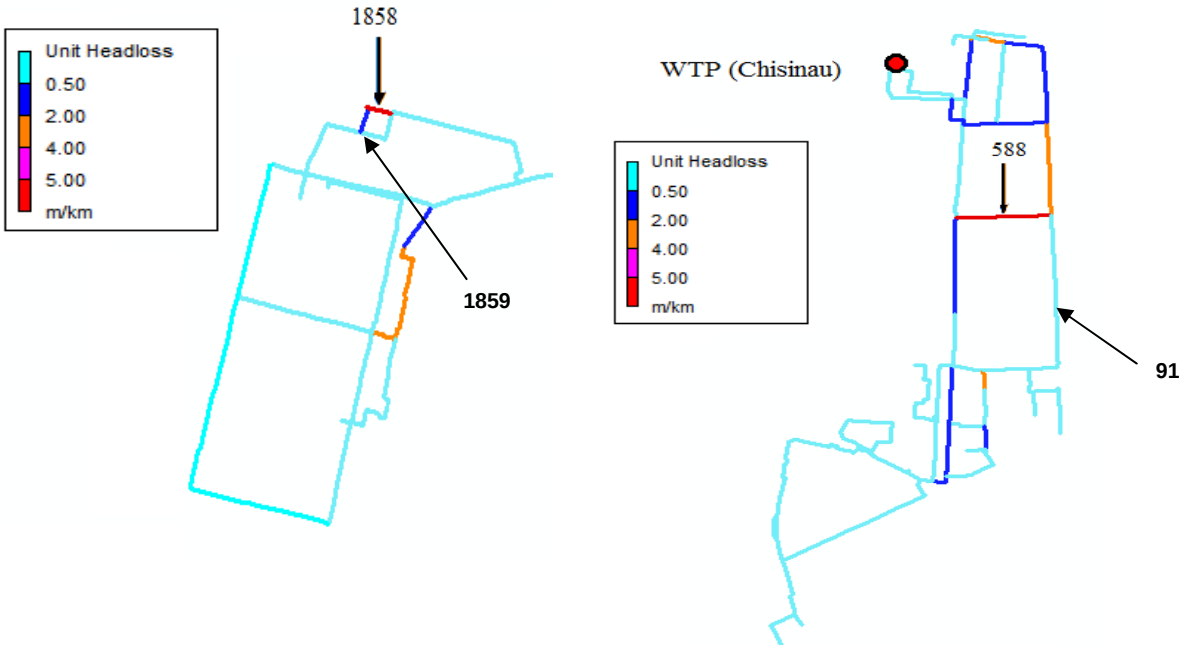


On the contrary, during the day, the pumps are working and the pressure is 10m too high in the zone. The set pressure in Buiucani Pumping station could be reduced if it does not create problems of low pressure in the residential area.

4.3.2. ZONE 3 CIOCANA AND RÎSCANI

The Zones 3 Ciocana and Rîscani are both supplied by the Pumping Station of the Water Treatment Plant. Most of the pipes of these zones have a very low velocity and a low head loss for the exception of two pipes:

- In the zone 3 Rîscani, the pipe 1858 (ND 90), which presents a really high head loss after 09:30 pm (the linear head loss is 59.1 km/m). Indeed, on the reference day, the pipe 1859 (ND 250) had to be closed at 09:30 pm, generating at this point a really high velocity in the smaller parallel pipe (otherwise almost unused) and creating a high head loss at this moment.
- In the Zone 3 Ciocana, the pipe 588 (ND 400), with a linear head loss of 7.0 m/km. This high head loss corresponds to a high velocity due to the fact that the pipe 91 had to be closed for the calibration of the reference day.



e peak hour

In the zone 3 Rîscani, the buildings are really high and the pressure is consequently high. The pressure for one building is however too low during the night. The building has 17 floors (see Figure 4.12) and the pressure during the night is 64m instead of 76m. This problem of pressure does not arise because of an important head loss on the network.

In the same way, in the zone 3 Ciocana, the pressure is high. As the difference in altitude is high in this zone (the altitude is lower in the west (see Figure 4.11), the pressure in a part of the zone is more than 40m higher than the objective.

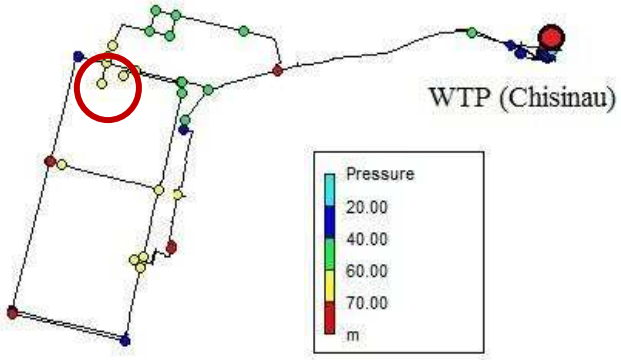


Figure 4.12: minimal pressure in the zone 3 Riscani

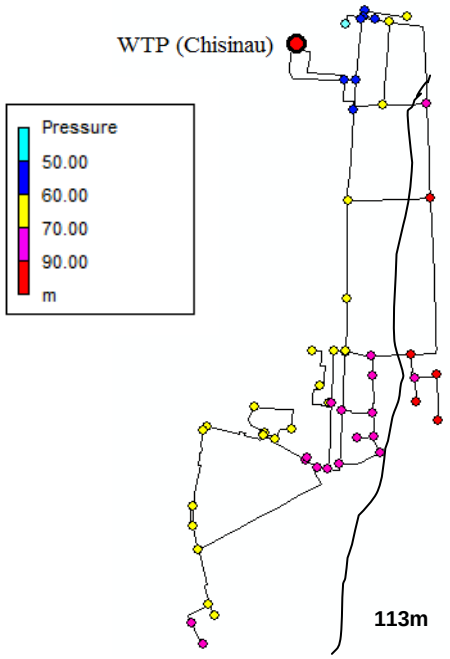


Figure 4.11: Maximal pressure in the zone 3 Ciocana

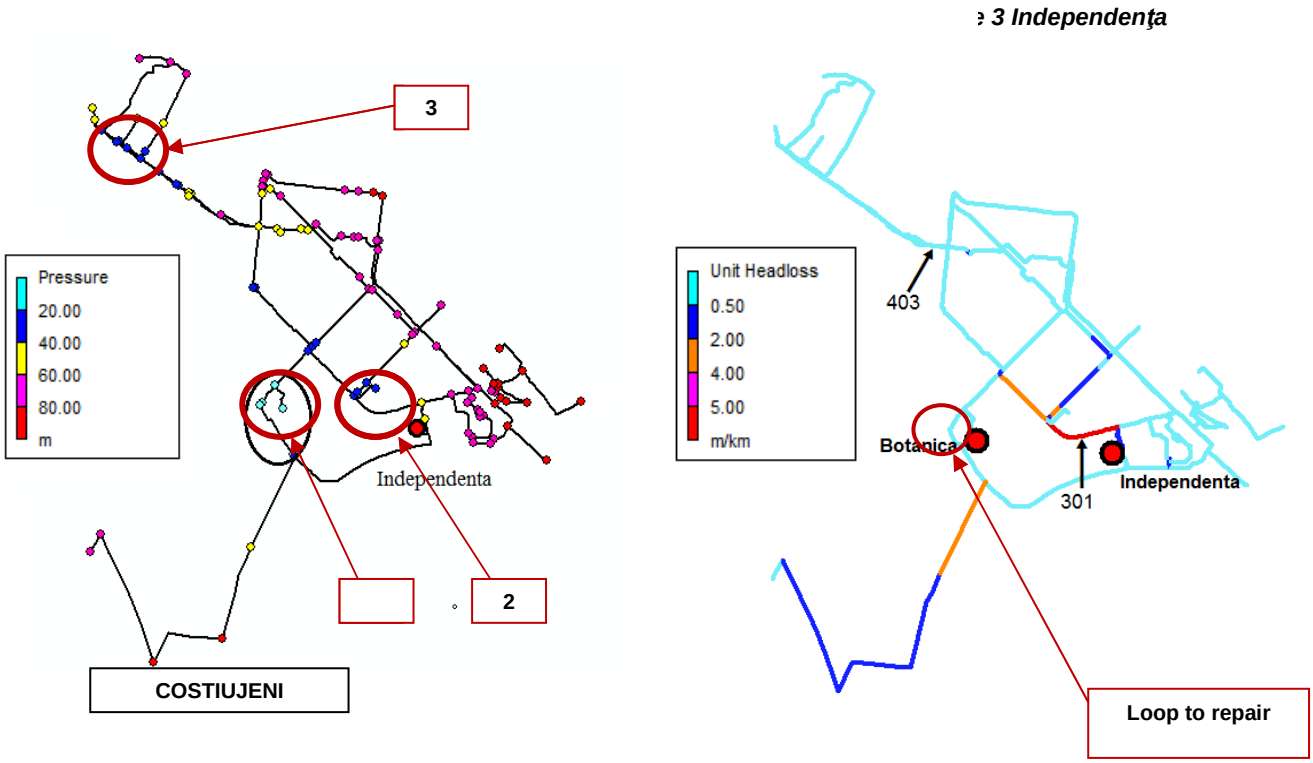
4.3.3. ZONE 3 INDEPENDENŢA

In the zone 3 Independenţa, a few problems arose. First, the pressure is low at several points of the zone:

1. The pressure is really low at one point where the elevation is the highest (see on the Figure 4.13). This result is not a problem if the pipe is only a transfer pipe at this point. However, the autocad file indicates that 9-floor buildings are supplied by the zone 3 at this point. As the pressure is around 10m, it seems slightly probable and these buildings are surely supplied by the zone 4 Independenţa (the two pipes are parallel) with a pressure of 40m.

2. The pressure is low during the night when the pumps are stopped in this area (crossroads between Independenţei street and Cuza Voda Bd), where the buildings have 9 floors.

3. Here, there is a building of 9 floors and the pressure is not enough -even during the day- to supply it (about 36m instead of 46m). This is because this place is far away from the pumping station of Independenţa and when the 600mm pipe connecting the pumping station of Valea Dicescu to this part of the network will be rehabilitated (the work has begun and it should be done current 2012), this problem of pressure will disappear.



Then, the pressure is really high in Costiujeni. However, ACC regulates the pressure in this zone with a pressure reducer and keeps the pressure at an acceptable level.

The low pressure at the crossroad Independenţei/ Cuza Voda (#2 above) is due to the high head loss in one of the pipe of the zone:

- The pipe 301 (ND 400) where the head loss reaches 7.3m/km during the peak hours. The velocity of the water in the pipe reaches 1.3m/s, leading to the conclusion that the pipe is undersized. A way to resolve this problem would be to repair the loop (see Figure 4.13) that has been abandoned a few years ago because of high leakages. To repair this loop of the network would relieve the pipe on Independenţei street (ND 400) and the pressure problem mentioned above would be eliminated (#2)
- In the pipe 403 (ND 400) a singular head loss of 8.9m is created.

4.3.4. ZONE 3 VALEA DICESCU

In the zone 3 Valea Dicescu, no high head loss is observed except at the entrance of the Booster Drumul Viilor 28/4. Indeed, the singular head loss is the only explanation to the high variations measured at the booster. No other high head loss has been observed in this zone and the velocity is really low in the whole zone outside of the transfer pipe from Valea Dicescu pumping station to Telecentru pumping station. The whole zone is therefore oversized. Moreover, the pressure is too high in the residential area compared to what should be observed.

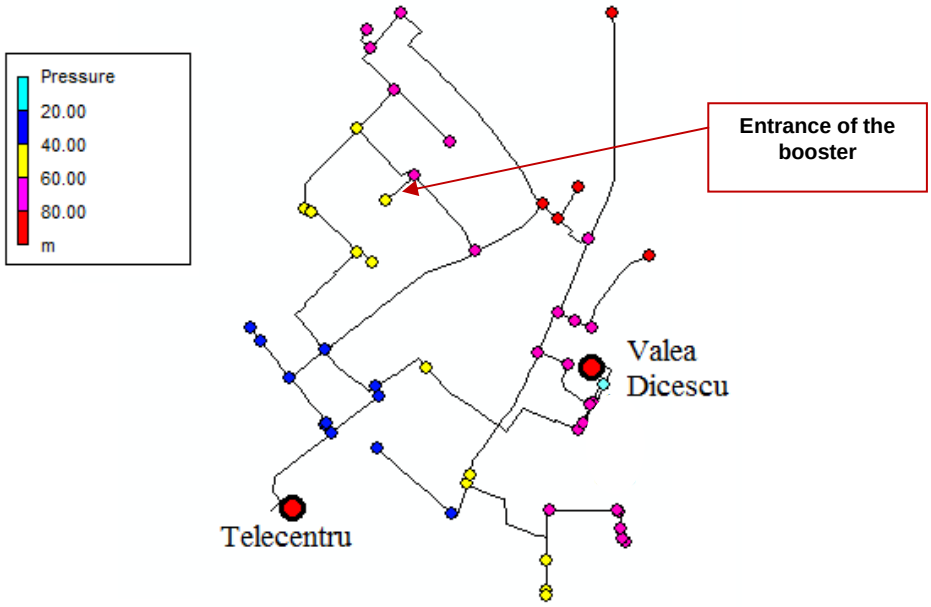


Figure 4.14: Pressure in the zone Valea Dicescu

4.4. ZONES 4

4.4.1. ZONE 4 TELECENTRU

In the zone 4 Telecentru, the maximal velocity is below 0.2m/s for all the pipes in the zone. The main pipes of this zone are highly oversized. Therefore, there is no problem of low pressure, even though the pressure in the transfer pipes might sometimes be low. And the pressure variations follow the set pressure in the pumping station, meaning, there is absolutely no variations of pressure on the network.
On the contrary, the pressure is often 10m higher than required on the zone, even though the pressure at the critical point reaches exactly the objective pressure

4.4.2. ZONE 4 CIOCANA

In the zone 4 Ciocana, the velocity is really low in the pipes and the head loss is consequently very low. Therefore, no problems of low pressure even during peak hours can be noticed. Hence, all the boosters are stopped, meaning that no problems of low pressure have been identified. However, on the eastern part of the zone (see Figure 4.15), the pressure during the night is around 35m, while the objective pressure is 46m as all the buildings around have 9 floors.

Moreover, the pressure on the transfer pipe to Stauceni is low (below 20m) and problems could arise if houses were built alongside the transfer.

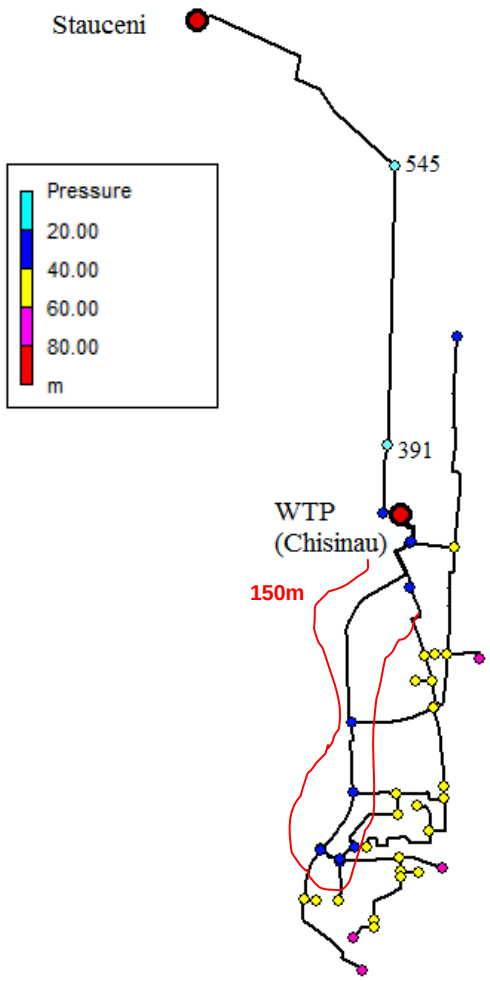


Figure 4.15: Minimal pressure in the zone 4 Ciocana

4.4.3. ZONE 4 INDEPENDENŢA

In the zone 4 Independenţa, the velocity in the pipes is really low (lower than 0.2m/s), suggesting that the pipes are oversized. Therefore at the two points (see Figure 4.16) where the pressure is a bit too low, the problem can be resolved by adjusting the set delivery pressure at the pumping station Independenţa during the night:

1. There is a 6-floor building and the minimal pressure (during the night) is 26m (instead of 34m). However, during the day, the pressure is 38m.
2. There is a 14-floors building with a minimal pressure (during the night) of 60m instead of 66m. However the pressure is 72m during the day.

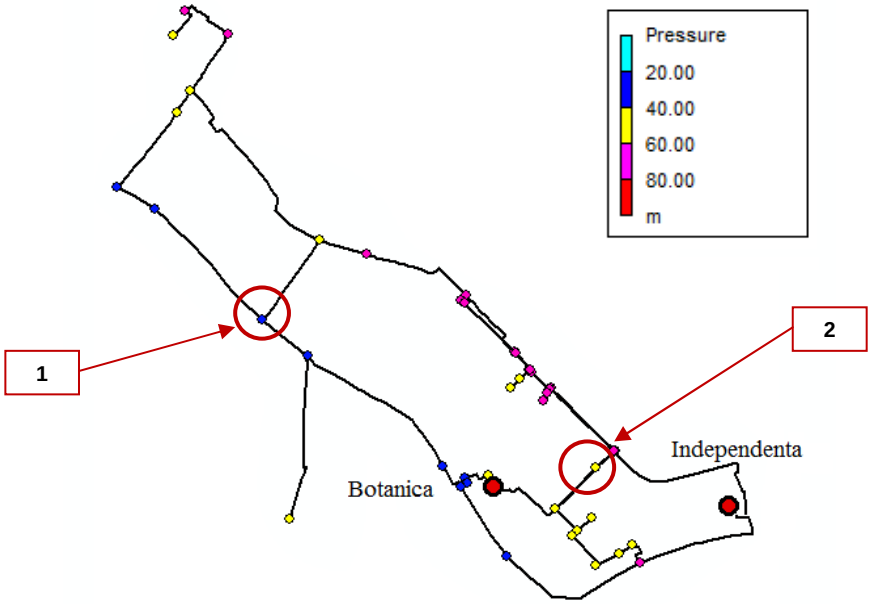


Figure 4.16: Minimal pressure in the zone 4 Independenta

4.4.4. ZONE 4 BUIUCANI

In the zone 4 Buiucani, most of the pipes generate a really low head loss. Only three pipes create a high head loss (see Figure 4.17):

- The pipe 710 (ND 200) with a linear head loss of 6.0 m/km. In order to calibrate the model, the pipe 706 (ND 300) was closed and if the pipe is reopened, a loop will be created and will allow to reduce the head loss in the pipe 710.
- The pipe 715 (ND 300) with a linear head loss of 5.9 m/km. In order to calibrate the model, the pipe 698 (ND 400) was closed and if the pipe is reopened, a loop will be created and will allow to reduce the head loss in the pipe 715.
- The pipe 1740 (ND 150) with a linear head loss of 21.3 m/km. The head loss generated is really high and explains why the pressure is low arriving at the pumping station of Gribova and why the pressure variations at this point are high (about 20m). A second pipe parallel (ND 150) to it seems to exist and would relieve the pipe 1740. In the future, however, with the supply of Durleşti through Schinoasa PS, the head loss created by this pipe will drop to 8m/km.

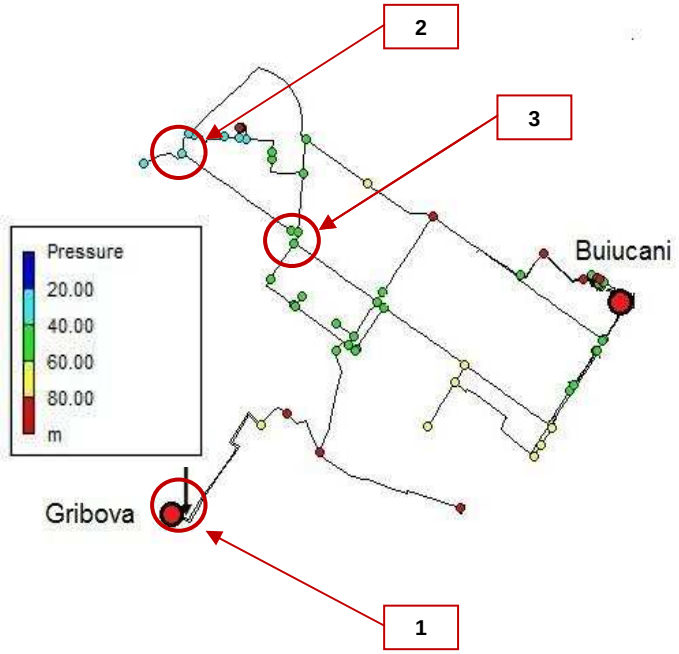
Independently from the high head loss in these three pipes, some spots with a low pressure can be found in the zone 4 Buiucani (see Figure 4.17):

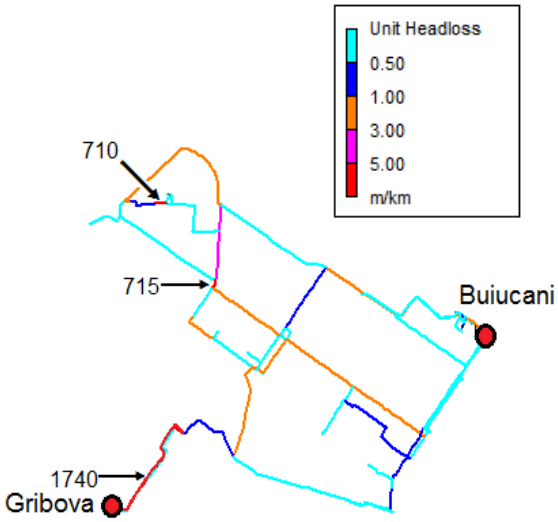
1. At the inlet of Gribova Pumping Station, the pressure is below 20m. At this point, when the reservoirs of Gribova are being filled, the pressure is not enough to supply even the residential houses around.

2. At the end of the Alba Iulia Street, some 9-floor buildings are not connected to boosters and the pressure is too low: 36m instead of 46m. Furthermore, during the peak hours, the pressure can drop even more.

3. At the crossroad of the streets Alba Iulia and O. Ghibu, there is a building of 16 floors that cannot be supplied if there is not a private booster

iiucani





4.5. ZONES 4A

4.5.1. ZONE 4A SCHINOASA

In the zone 4A Schinoasa, the head losses in the main pipes are at an acceptable level, except for the transfer pipes in the residential area (see Figure 4.18). The head loss reaches 60.8m/km in the portion of the pipe with a diameter of 100mm. The velocity in this portion is also high (maximal velocity is 2.4m/s), showing that this pipe is undersized. However, if the pumping station of Schinoasa is later supplied by Ialoveni pumping station, these pipes would be less used and the linear head loss would return to an acceptable level.
The variations of pressure after this pipe with a high head loss are therefore important (around 8m) even though the set pressure in Schinoasa Pumping Station is constant.

On another matter, the pressure is really high in the residential area, but it enables to maintain an acceptable pressure at the point near the valve between Chişinău and Ialoveni.

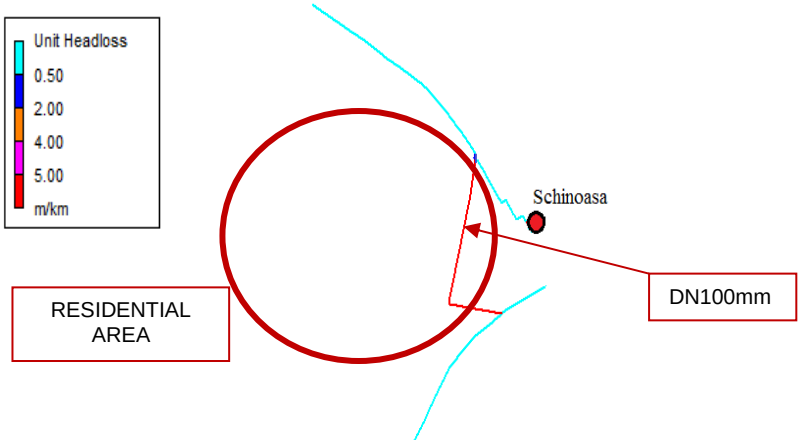


Figure 4.18: Maximal Head loss in the Zone 4A Schinoasa

4.5.1. ZONE 4A BOTANICA

The Zone 4A Botanica is a really small zone, where the maximal velocity in all pipes is below 0.2m/s.

The pumping station Botanica is operating to supply the high buildings around (17 floors) and acts more like a booster than a pumping station. Strangely, the pressure in the zone is too low compared to the height of the buildings: the pressure is 67m for two buildings of 17 floors (the pressure should be 78m).

4.5.2. ZONE 4A TELECENTRU

The head loss in the main pipes of the zone 4A Telecentru is really low at the exception of the pipe 1862 (see figure below) with a maximal linear head loss of 36.6 m/km. This high linear head loss is due to a narrowing of the diameter of the pipe from 300mm to 150mm. This portion of pipe is clearly undersized (while the rest of the network is oversized).

Therefore no problems of low pressure arise because of high head losses during the peak hours and the two problems of low pressure are due to the regulation in Telecentru Pumping Station (see Figure 4.19):

1. This pipe is a transfer pipe. However; some buildings are connected to it and the pressure is too low during the night to supply them (15m).
2. At this emplacement, the pressure is 22m during the night, not enough to supply the 5-floor buildings (however, the pressure during the day is enough)

As the altitude is much lower in the city of Codru than in the rest of the zone, three pressure reducers are installed on the network of the city Codru.

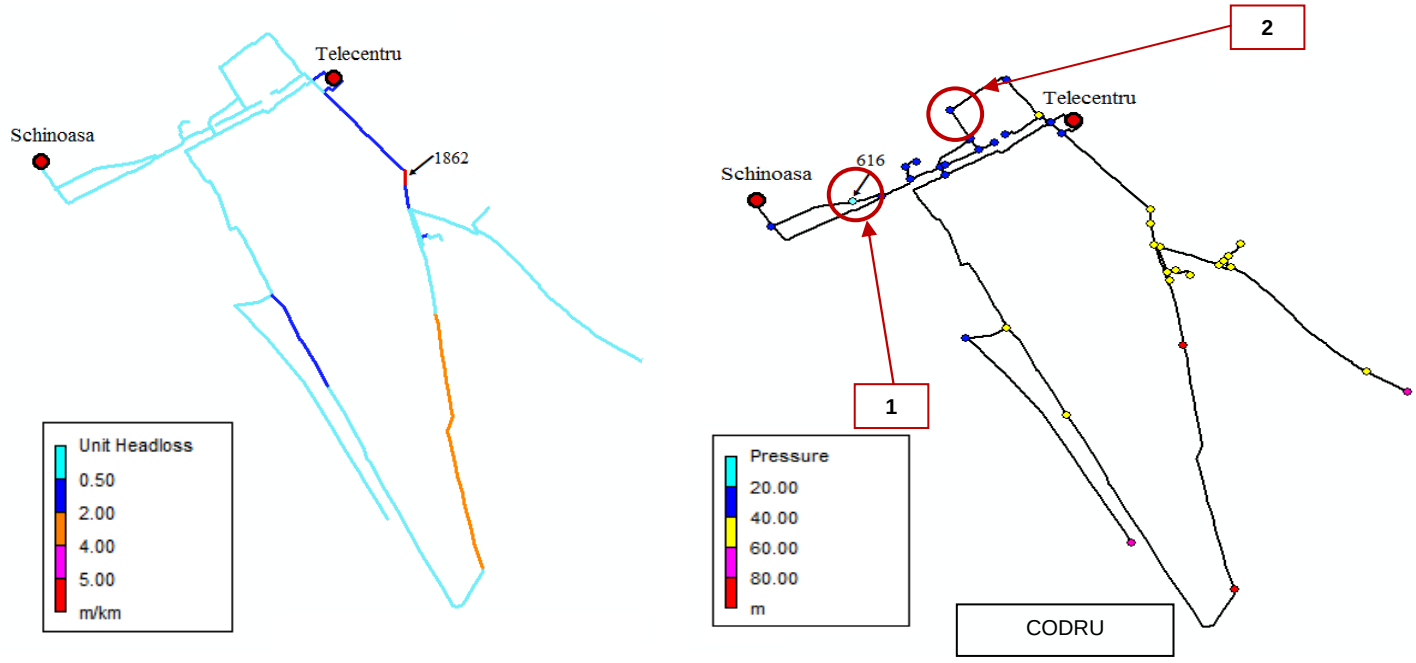


Figure 4.19: Maximal head loss and minimal pressure in the zone 4A Telecentru

4.6. SUBURBS

The modelling of the suburbs was really simplified and a real diagnostic is not possible. The following text will bring some information regarding high head loss generated in the cities and villages surrounding Chişinău.

4.6.1. DURLEŞTI

In Durlesti, part of the city is supplied successively by the pumping station of Gribova (generally during the night to fill the reservoirs of Cartusa) and by the pumping station of Cartusa. The pipes are therefore submitted to important constraints as the pump in Gribova is switched off every day. The daily pressure variations are therefore really important (more than 20m between the two pumping stations and about 10m in the part of the network supplied only by Cartuşa pumping station) and the pressure is too high or too low, depending on the pumping station that is working:

- When the pump of Gribova is working, the pressure is really high in the neighbourhood of the pumping station (the delivery pressure is 110m).
- When the pump in Gribova is switched off, the pressure becomes too low in part of Durleşti where the altitude is high.

The head loss when transferring the water from the pumping station of Gribova to the pumping station of Cartuşa is really high: around 50m of head loss at the peak flow (when the pump of Gribova is working) for 1750m of pipe, instead of the 5m that would be awaited from a well operating transfer. As the velocities are ranging from 0.1 to 1.1m/s,

the pipes do not seem to be particularly undersized (except for a portion with a diameter of 100mm) and the head losses are due to singularities -as a partially closed valve.

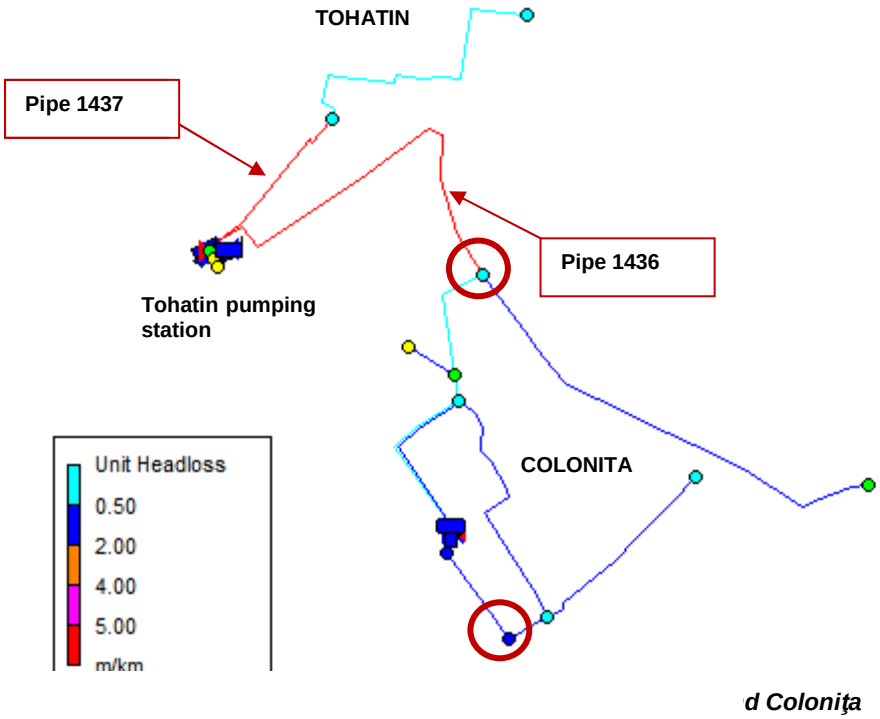
4.6.2. COLONIŢA AND TOHATIN

The two outlets from the pumping station of Tohatin present high head loss: due to a singularity for the pipe supplying Colonita (pipe 1436 (ND 300)) and due to linear head loss and a high roughness for the pipe supplying Tohatin (pipe 1437 (ND 200)).

Due to this high linear head loss in the pipe supplying Tohatin, the pressure variation is really high in the village of Tohatin and decreases at the peak hour till 13m: far too low. This was recorded every day during the measurement campaign.

In the village of Coloniţa, the water is successively supplied by the pumping station of Tohatin and gravitationally by the reservoir of Coloniţa. The pumps in Tohatin pumping station are switched off when the reservoirs are full. The variations of pressure are therefore high in the pipes situated on the transfer.

Even though the reservoirs are at the highest point of Coloniţa, the pressure is sometimes low at some point of the city (circled in red in the Figure 4.20 below)

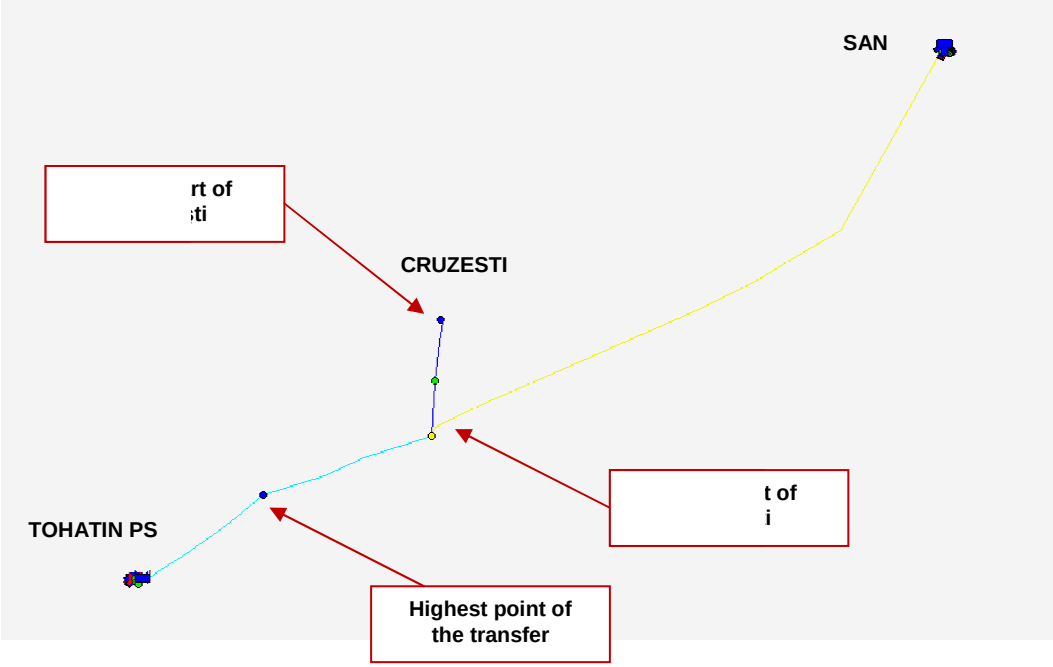


d Coloniţa

4.6.3. TRANSFER FROM SAN TO TOHATIN PS

No problems of high head loss are observed during the transfer of water from the Water Treatment Plant of Nistru (SAN) and the Pumping Station of Tohatin.

The Figure 4.21 shows the highest point of the transfer (where the pressure is really low (around 6m) and ACC has to be careful for the pressure not to be negative at this point. The figure shows as well that the pressure is really high in the low part of Cruzeşti, while in the upper part of Cruzeşti, the pressure is low (the pressure is about 20m before the booster). As the area is only residential, this pressure is enough.

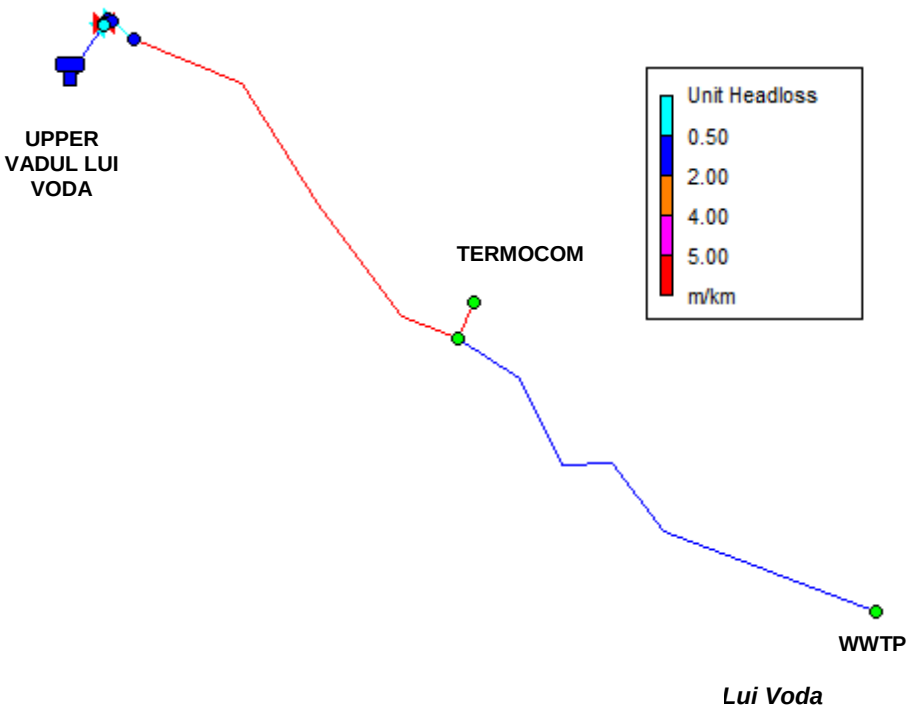


4.6.4. VADUL LUI VODA AND COŞERNIŢA

These two cities were supplied on the reference day gravitationally by the reservoir “Upper Vadul Lui Voda”. The pressure is then regulated by throttled valves on the territory of SAN.

The pipe that transfers the water from the reservoir of Upper Vadul Lui Voda (located on the territory of SAN) to the city of Vadul Lui Voda has a high head loss due to a singularity. This singularity creates at the peak hour a head loss of 30m. Therefore the variations of pressure in the city of Vadul Lui Voda are important (more than 25m)

There is however no problem with low pressure on the zone.



4.6.5. STAUCENI AND GOIANUL NOU

No problem is to be noted. However, due to the consumption in the village of Goianul Nou (see below the measures taken for the pressure in this village), the velocity reaches peaks that triggers high instantaneous linear head losses in the pipes of the transfer from Stauceni to Goianul Nou (especially the portion with a diameter of 110mm).

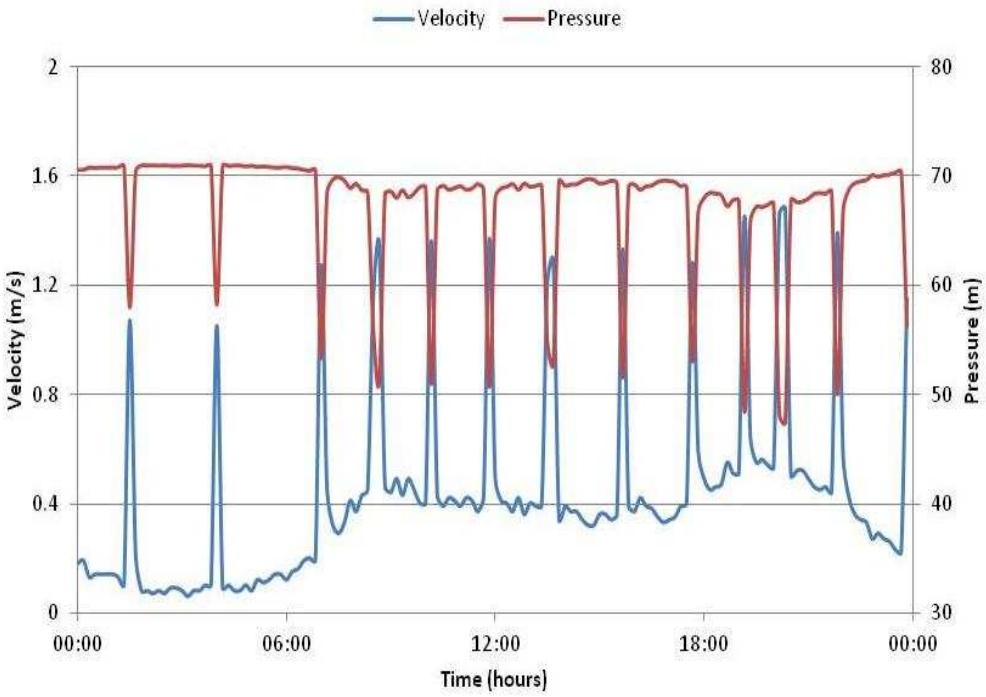
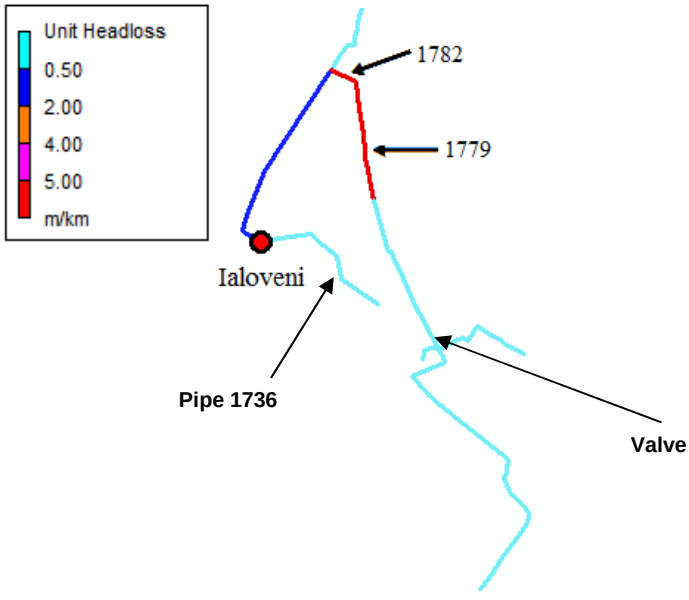


Figure 4.23: Pressure and velocity in the village of Goianul Nou on the 31st of August

On this transfer; the pressure might sometimes reach really low value (as the variations of pressure are over 20m).

4.6.6. IALOVENI

Figure 4.24: High Head loss in Ialoveni City



In the two pipes (DN 150) on the Figure 4.24, the linear head loss is high: 11.8m/km and 16m/km. These pipes may be undersized as the diameter of the pipe afterwards is 300mm (with a maximum linear head loss of 0.16m/km, suggesting that this pipe is fairly

oversized). This problem will not appear in the future if project on the supply in Ialoveni city is implemented (the supply will be performed through the pipe 1736).

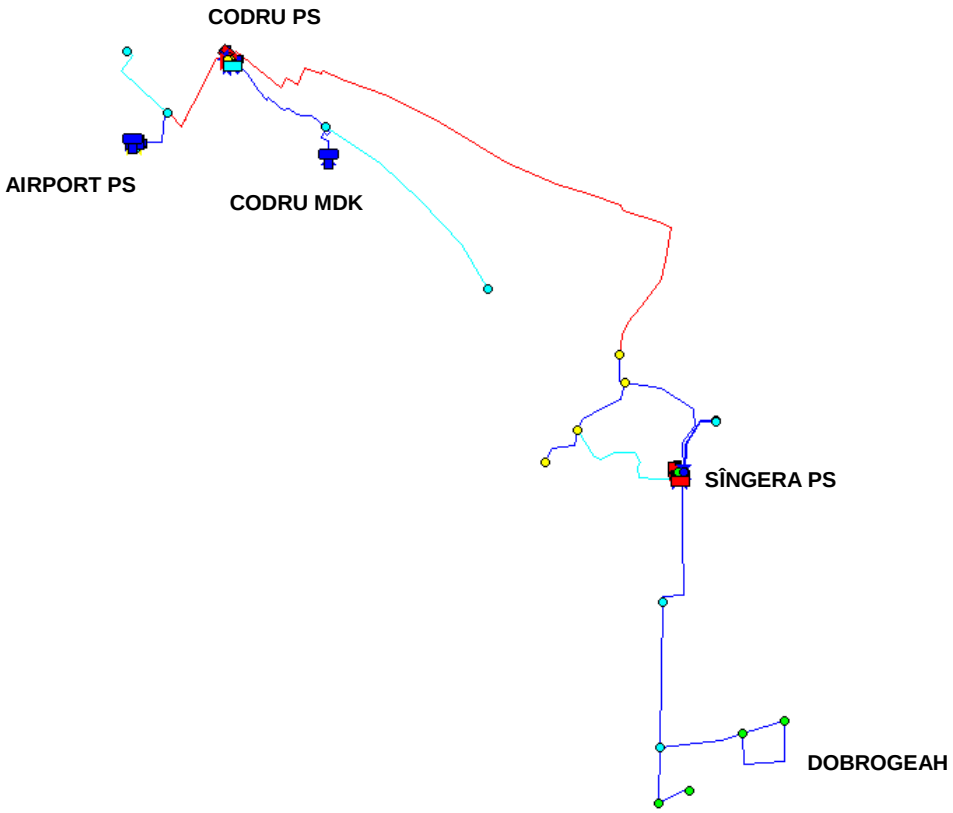
Moreover, a high head loss (32m) is generated by a pressure reducing valve or by a throttled valve on Alexandru Cel Bun Street.

4.6.7. SUBURBS DEPENDING ON CODRU PUMPING STATION

During the transfer of water from Codru Pumping Station to Airport Pumping Station, a high head loss is generated, certainly in Codru Pumping Station.

In the same way, the transfer of water from Codru Pumping Station to Sîngera Pumping Station generates a head loss probably in the pumping station of Codru

Figure 4.25: Suburbs in the south of the Chişinău



On the other hand, the outlets from Sîngera pumping station (the gravitational outlets or the delivery pipe towards Dobrogeah) are oversized and the head loss and the velocity are really low.

Due to the variations of altitude in the cities of Sîngera or Dobrogeah, the pressure might be too high in some part of the cities (as in Dobrogeah, some buildings have nine floors while most of the buildings are individual houses with two floors).

5. RECOMMENDATIONS

The model helped us to obtain an overview of the problems on the network of Chişinău city.

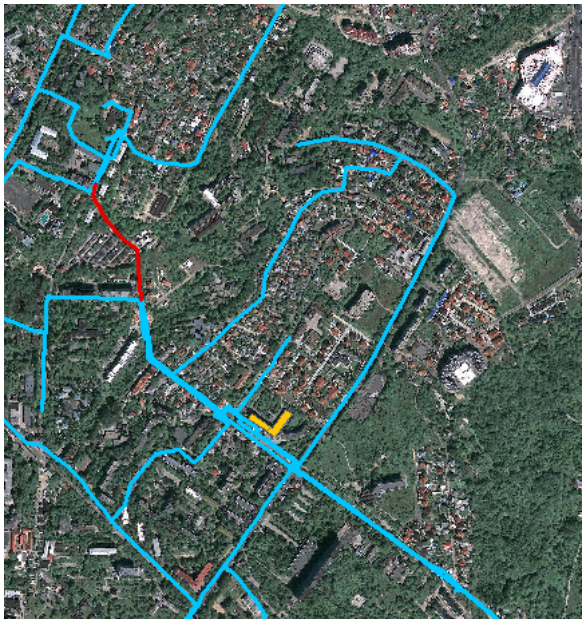
Some zones have very high pressure that ACC should try to reduce in the future. Moreover, the network is most of the time oversized and therefore there are not many problems of high head losses created and of locations with low pressure points. The few recommendations are described below and summarize in the figures below:

- The highlighted singularities in the pipes should be tracked down and removed as much as possible.

- The two biggest singularities to be tracked down should be the one on the street Pogdorenilor, that dissipates 17m and that forced ACC to change the configuration of the supply in Rîşcanovka (part of the zone is supplied by the outlet Oţel).

- In the same way, the singularities at the inlet of the booster Drumul Viilor 28/4 should be tracked down as it creates high pressure variations.

- Some rehabilitation of pipes can be done to relieve the network:

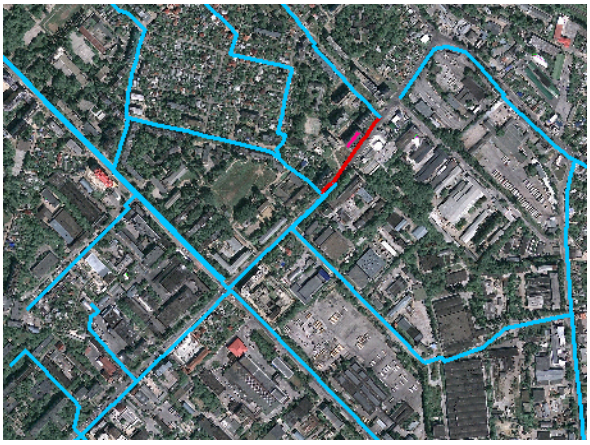


- Once the pipe on the street Limonov will be replaced, the north of the zone 3 Independenţa should be supplied by the pumping station Valea Dicescu.

- In the same way, the loop that has been disconnected on the zone 3 Independenţa (at the crossroad of the streets Grenoble and Trajan) should be rehabilitated in order to get rid of the problem of low pressure on the Bd Cuza-Voda.

In some zones, ACC took the decision to lower the pressure during the night and therefore the pressure is too low during the night (Zone 3 Buiucani, Zone 4 Ciocana and Zone 4 Independenţa) but the pressure is high enough during the day. Maybe it would be good to homogenize the system on the whole city.

- In some points in the city, risk of low pressure arose during the summer:

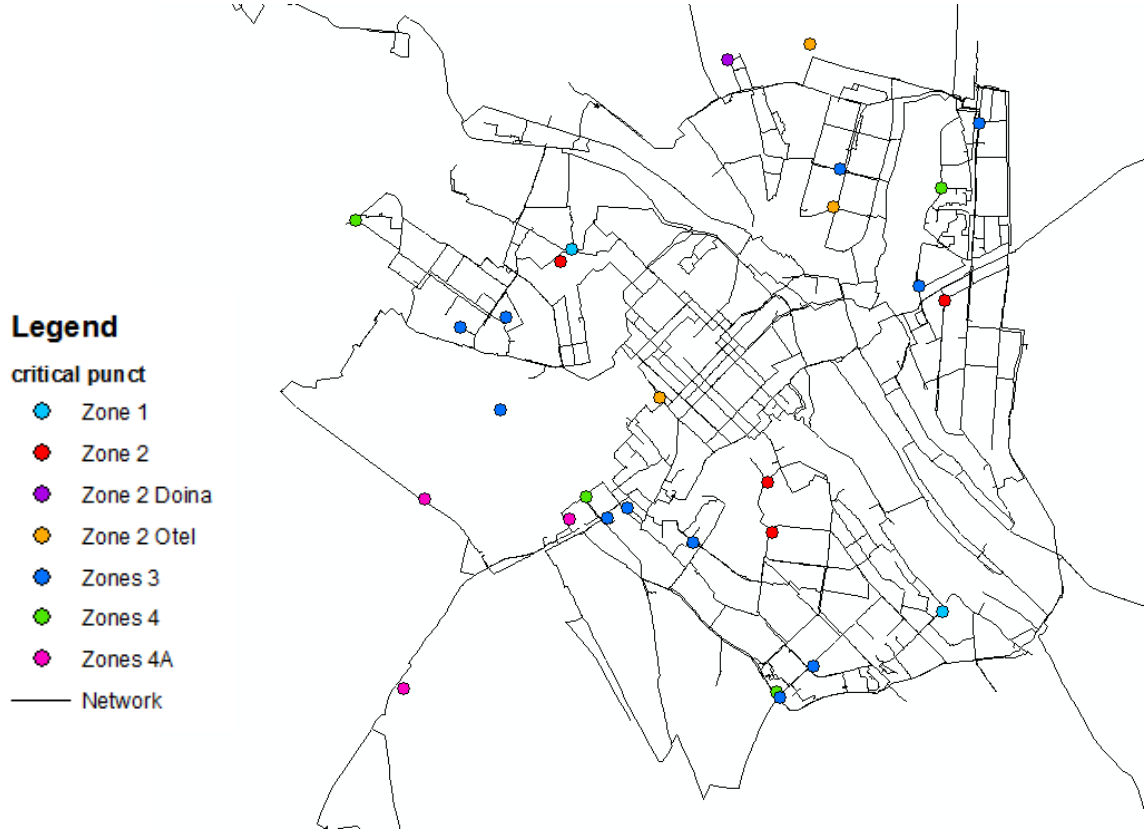


- On the zone 1 in Cetatea Alba, there is a building of 10 floors without a booster operated by ACC where there is a risk of low pressure. This part of the network should maybe be passed on the pressure zone 2 if the consumers complain.

- At the critical point of the Zone 4 Buiucani, the pressure is 10m too low during the day. ACC should either increase the set pressure at the outlet of the pumping station Buiucani or install a booster for the nine floors buildings.

Moreover, in the suburbs, the modelling was succinct. The measures showed that the concerned volumes were small and the modelling gave a hint on the problems encountered in the suburbs. However, ACC should continue to improve the knowledge of these networks, with exact maps of the network, of the closed valves etc.

The best way to avoid any problem of low pressure in the city remains the monitoring of the pressure at the critical points. The map of the critical points is shown below and telemetric pressure sensors should be installed at these points.



Annexes

Annex 1 List of the calibration points

Table of the pressure points for the calibration in Chisinau city (obtained through the measurement campaign)

Hydraulic entity	Localisation of the measure	Name	epanet node
Zone 1	Balişevschi, delivery pressure	Z1-P4	1227
	Ghidighici, delivery pressure	Z1-P5	1231
	Codru, inlet pressure	Z1-P6	1474
	Booster Muncesti 406/1	Z1-P7	1458
	Booster Muncesti 56/1	Z1-P8	1462
	Booster Gradinelor 60	Z1-P9	1443
	Booster Albişoara 82/7	Z1-P10	1444
	Booster Ieşilor 47/3	Z1-P11	1483
	Network Point at Doga/Aeromului	Z1-P12	1446
	Network Point at Uzinelor/ Volunterilor	Z1-P13	1459
	Network Point at Petru Rares/ Cosmonautilor	Z1-P14	770
Zone 2	Independenţa PS upstream regulating valve	Z2-P1	1131
	Valea Dicescu PS upstream regulating valve	Z2-P8	1165
	Ciocana PS upstream regulating valve	Z2-P9	965
	Booster n°43. Dragan 30/7	Z2-P13	1441
	Booster n°17 Cuza Voda 1/6	Z2-P14	180
	Booster n°4. Decebal 19/1	Z2-P15	1461
	Pressure reducer in Bîc	Z2-P19	1566
	Pressure control points on each side of the valve separating zone 2 Tohatin and zone 2 Vostoc	Z2-P23	158
		Z2-P24	1015
	Ciocana Transit pipe	Z2-P25	959
Zone 2 Doina	Buiucani PS Suction Pressure	Z2-P5	1189
	Booster n°53. Socolei 21/1	Z2-P16	254
	Pressure control Point Badiu/ Pogdorelinor	Z2-P20	869
	Universita agrara Suction Pressure	Z2-P4	1207
Zone 2 Otel	Downstream regulating valve Costin/Dimo	Z2-P3	105
	Buiucani PS upstream regulating valve	Z2-P6	1192
	Balişevschi PS upstream regulating valve	Z2-P7	319
	Pressure Control Point of the WTP's valve: Balişevschi	Z2-P11	320
	Booster n°59.Bogdan Voievod 10/2	Z2-P12	1438
	Booster n°32. Puskin 44/1	Z2-P17	360
	Booster n°36. Coca 19/1	Z2-P18	1448
	Pressure Control Point Studentilor/Florilor	Z2-P21	1396
	Pressure Control Point Maleevici/ Puskin	Z2-P22	1275
Zone 3.U.A	U.A. delivery pressure	Z2-P10	1214
Zone 3 Buiucani	Buiucani PS delivery pressure	Bui3-P2	Buiu_zone3
	Booster n°60. Constitutiei 8/1	Bui3-P3	1450
	Pressure Control Point Alba Iula/ Sucevioa	Bui3-P4	696
Zone 3 Rîscani	WTP PS, delivery pressure	Cio3-P2	847
	Booster n°48. Studenţilor 7/6	Cio3-P3	1297
	Booster n°50. Moscovei 11/6	Cio3-P4	1436
	Pressure Control Point Studenţilor/ Florilor	Cio3-P6	103

Hydraulic entity	Localisation of the measure	Name	epanet node
Zone 3 Ciocana	WTP PS, delivery pressure	Cio3-P2	847
	Booster n°58. Sadoveanu 2/6	Cio3-P5	950
Zone 3 Valea Dicescu	Valea Dicescu PS, delivery pressure	Cen3-P2	1173
	Telecentru PS, Upstream regulating valve	Cen3-P3	1155
	Booster n°40. Drumul Viilor 28/4	Cen3-P6	1453
Zone 3 Independenţa	Independenţa PS, delivery pressure	Cen3-P5	1206
	Booster n°1. Dacia 2	Cen3-P7	249
	Pressure Control Point Cuza Voda/ Independenţei	Cen3-P8	1484
Zone 4 Buiucani	Buiucani PS, delivery pipe	Bui4-P2	Buiu_zone4
	Gribov, inlet	Bui4Q3P3	1348
	Booster Alba Iulia 202	Bui4-P4	659
	Booster Nicolae Costin	Bui4-P5	1451
Zone 4 Telecentru	Telecentru PS, delivery pressure	Cen4-P1	tele_zone4
	Pressure Control Point Testemeanu/Grenoble (zone Telecentru)	Cen4-P9	110
Zone 4 Independenţa	Independenţa PS, delivery pressure	Cen4-P4	1205
	Botanica PS, suction pressure	Cen4-P5	1524
	Pressure Control Point Testemeanu/Grenoble (zone Independenţa)	Cen4-P10	109
Zone 4 Ciocana	Water Treatment plant, delivery pressure to zone 4	Cio4-P2	846
	Booster Zadnipru 2 (A. Russo 55/6)	Cio4-P5	536
	Booster I. Vieru 5/4	Cio4-P6	1440
Zone 4A Botanica	Botanica PS, Delivery pressure	Cen4-P6	1144
Zone 4A Telecentru	Telecentru PS, delivery pressure	Cen4a-P2	tele_zone4a
	Pressure Control Point Hîncesti/ Aurel Viacu	Cen4-P8	1352
	Schinoasa PS, upstream regulating valve	Cen4a-P3	1178
	Booster n°8. Drumul Schinoasei	Cen4a-P6	1456
Zone 4A Schinoasa	Schinoasa PS, delivery pressure	Cen4a-P4	1174
	Pressure Control Point Str Ialoveni 100	Cen4a-P7	622
	Pressure control Point Sf vineri/ Valea Radiului	Cen4a-P8	1402

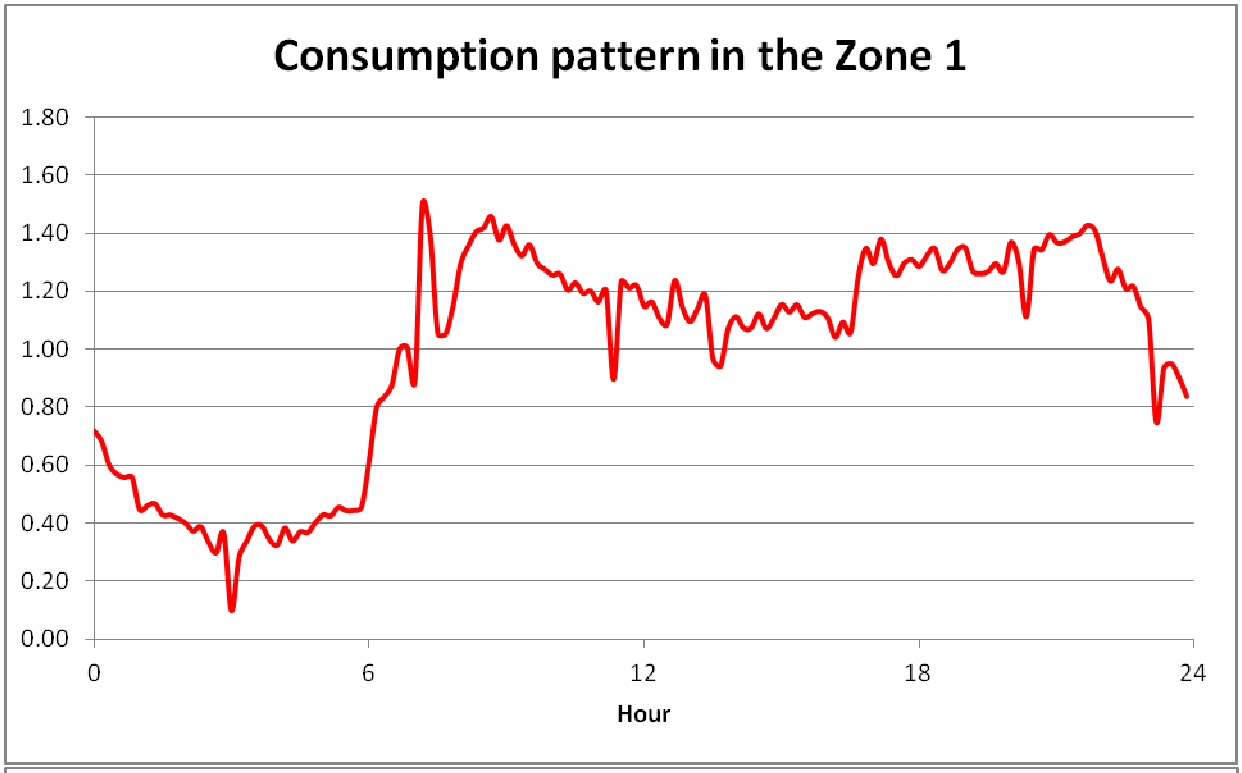
Table of the pressure points for the calibration in the suburbs (obtained through the measurement campaign)

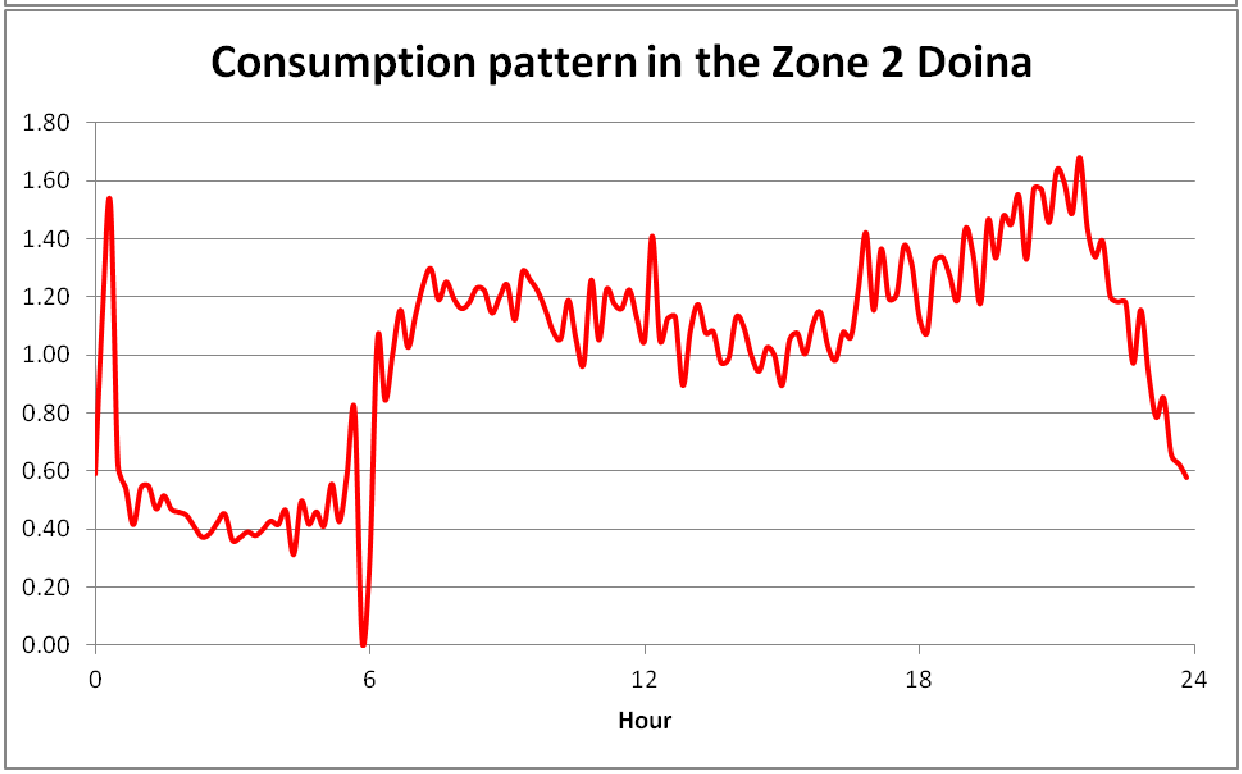
Hydraulic entity	Localisation of the measure	Name	epanet node
Stauceni & Goianul Nou	Stauceni PS, outlet in the temporary manhole	Cio4-Q6P4	1337
	Stauceni PS, outlet without the temporary manhole	Cio4-Q5P8	1337
	Goianul nou village (after Stauceni PS)	Cio4-P7	1630
Durleşti Gribov	Gribova PS, delivery pressure	Dur-P1	1347
	Gribova PS, Downstream partially open valve	Dur-P5	1353
	Cartuşa PS, Inlet before the loop	Dur-Q2P2	1359
	Pressure Control Point, Gribova sector	Dur-P7	1511
Durleşti Cartuşa	Cartuşa PS, Outlet before separations	Dur-Q3P3	1360
	Pressure Control Point, Cartuşa (Ostanovka)	Dur-P6	1520
	Cartuşa reservoir, Water Level	Dur-H2	Cartusa
SAN to Tohatin	Treapta II, delivery pressure	VLV-P1	1670
	Treapta IIA, suction pressure	VLV-P2	1381
	Treapta IIA, delivery pressure to Tohatin	VLV-P3	1668
	Booster Cruzeşti	VLV-P11	1593
Coloniţa	Tohatin PS, delivery pressure to Coloniţa	VLV-P9	1262
	Coloniţa Pressure Control Point	VLV-P10	1582
	Coloniţa Reservoir, Water Level	VLV-H5	Col_1
Tohatin	Tohatin PS, delivery pressure to Tohatin	VLV-P8	1261
	Tohatin city	VLV-P12	1624
Coşerniţa	SAN, chambre K8, outlet Coşerniţa	VLV-P5	1486
Vadul Lui Voda	SAN, chambre K8, outlet Vadul Lui Voda	VLV-P6	1485
	TERMOCOM in Vadul Lui Voda	VLV-P13	1631
	WWTP in Vadul Lui Voda	VLV-P14	1632
	Upper Vadul Lui Voda reservoir, Water Level	VLV-H2	Upper_VLV
Vatra	Ghidighici, delivery pressure	Z1-P5	1231
Codru to Sîngera	Codru PS, delivery pressure to Sîngera	Cod-P1	1228
	Sîngera PS, pressure before regulating valve	Cod-P4	1291
Codru to Airport	Codru PS, delivery pressure to Sîngera	Cod-P1	1228
	Airport PS, inlet before regulating valve	Cod-Q9P8	1272
	Pressure Control Point at Dacia 67/2	Cod-P15	746
Airport	Airport PS, outlet in the new pumping station	Cod-Q10P10	air_out1
	Airport PS, outlet in the old pumping station	Cod-Q11P11	air_out2
Dobrogeah	Sîngera PS, delivery pressure	Cod-P7	1290
	Pressure Control Point in Sîngera Tok	Cod-P13	1616
	Pressure Control Point in Dobrogeah	Cod-P14	1595
Codru MDK	Codru PS, delivery pressure to Codru Reservoirs	Cod-P3	963
	Booster Muncesti in Sîngera	Cod-P12	1685
	Codru MDK Reservoir, Water Level	Cod_H3	CodRes_1
Ialoveni	Ialoveni PS, delivery pressure to Ialoveni	Ial-P1	1322
	Ialoveni PS, delivery pressure to Moldova	Ial-P2	1323
	Valve between Ialoveni and Chisinau	Ial-P3	402
	Crossing of Izvoarilor and Basarabia (in Ialoveni)	Ial-P4	1550
	Alexandru Cel Bun (In Ialoveni)	Ial-P5	1549

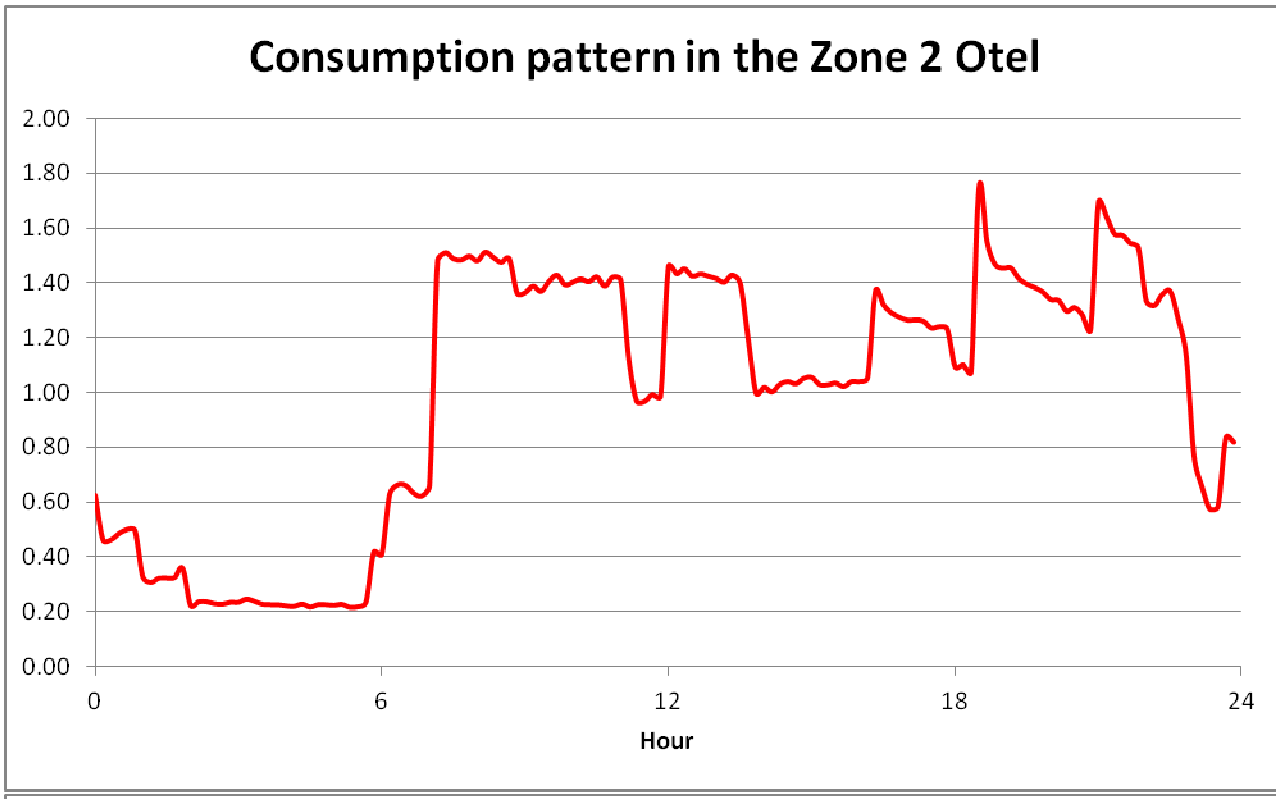
Table of the flows for the calibration in the study area (obtained through the measurement campaign)

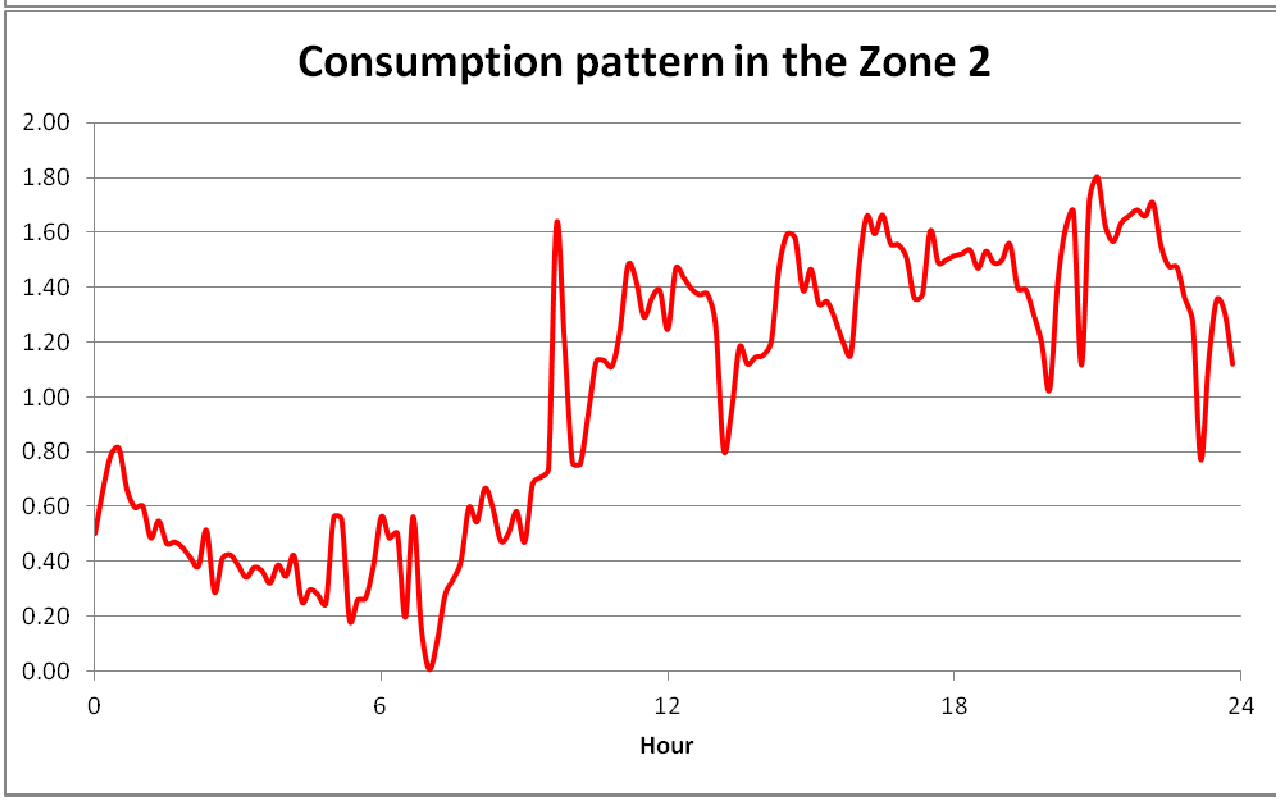
Hydraulic entity	Localisation of the measure	Name	epanet link
Zone 1	Balişevschi, outlet	Z1-Q4	184
	Ghidighici, outlet to Chisinau	Z1-Q5	1206
Zone 2	WTP PS, outlet Independenţa	Z2-Q1	1
	WTP PS, outlet Vostoc	Z2-Q12	6
	Tohatin PS, outlet K5 and K4	Z2-Q14 & Q15	1208
Zone 3 Buiucani	Buiucani PS, outlet 1	Bui3-Q1	102
	Buiucani PS, outlet 2	Bui3-Q2	103
Zone 3 Ciocana	WTP PS, Outlet CC	Cio3-Q1	87
	WTP PS, Outlet CC1	Cio3-Q2	89
Zone 3 Independenţa	Independenţa PS, outlet 1	Cen3-Q3	134
	Independenţa PS, outlet 2	Cen3-Q4	143
Zone 4 Buiucani	Buiucani Outlet Z4-1	Bui4-Q1	100
	Buiucani Outlet Z4-2	Bui4-Q2	58
Zone 4 Telecentru	Telecentru PS, outlet 1 zone 4	Cen4-Q1	623
	Telecentru PS, outlet 2 zone 4	Cen4-Q2	622
Zone 4 Independenţa	Independenţa PS, outlet 1	Cen4-Q3	112
	Independenţa PS, outlet 2	Cen4-Q4	43
Zone 4 Ciocana	WTP PS, outlet CC2	Cio4-Q2	81
	WTP PS, outlet CC3	Cio4-Q3	79
Zone 4A Telecentru	Telecentru PS, outlet 1 zone 4a	Cen4a-Q1	17
	Telecentru PS, outlet 2 zone 4a	Cen4a-Q2	16
Zone 4A Botanica	Botanica PS, outlet 1	Cen4-Q6	48
	Botanica PS, outlet 2	Cen4-Q7	173
Durleşti Gribov	Gribova PS, Outlet Cartuşa	Dur-Q1	1741
	Cartuşa PS, Inlet before the loop	Dur-Q2P2	1845
Durleşti Cartuşa	Cartuşa PS, Outlet before separations	Dur-Q3P3	1564
Stauceni	Stauceni PS, outlet in the temporary manhole	Cio4-Q6P4	814
	Stauceni PS, outlet without the temporary manhole	Cio4-Q5P8	815
SAN to Tohatin	SAN, Outlet to Tohatin	VLV-Q1	1869
Coloniţa	Tohatin PS, outlet Coloniţa and Maximovca	VLV-Q6	1436
Airport	Airport PS, outlet in the new pumping station	Cod-Q10P10	1464
	Airport PS, outlet in the old pumping station	Cod-Q11P11	1463
Codru MDK	Codru PS, outlet to the reservoir MDK	Cod-Q3	1499

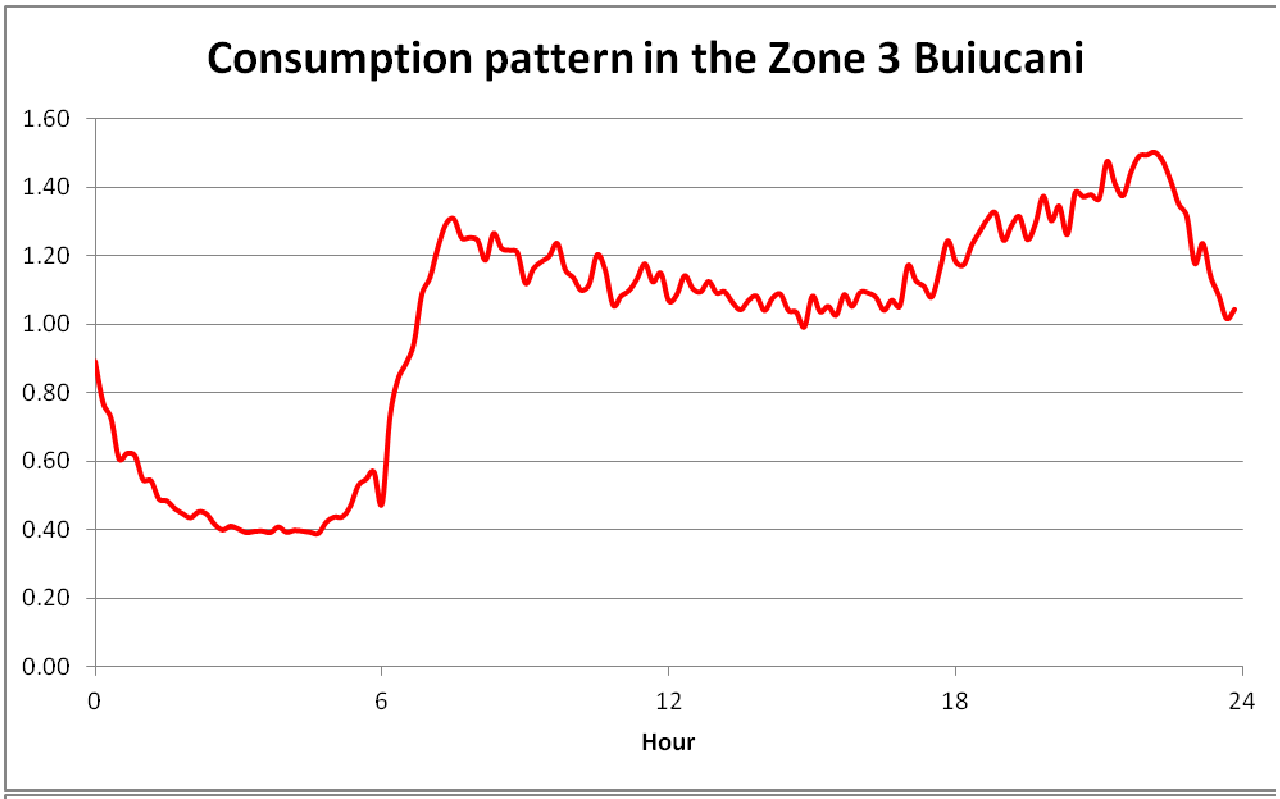
Annex 2 Consumption Patterns

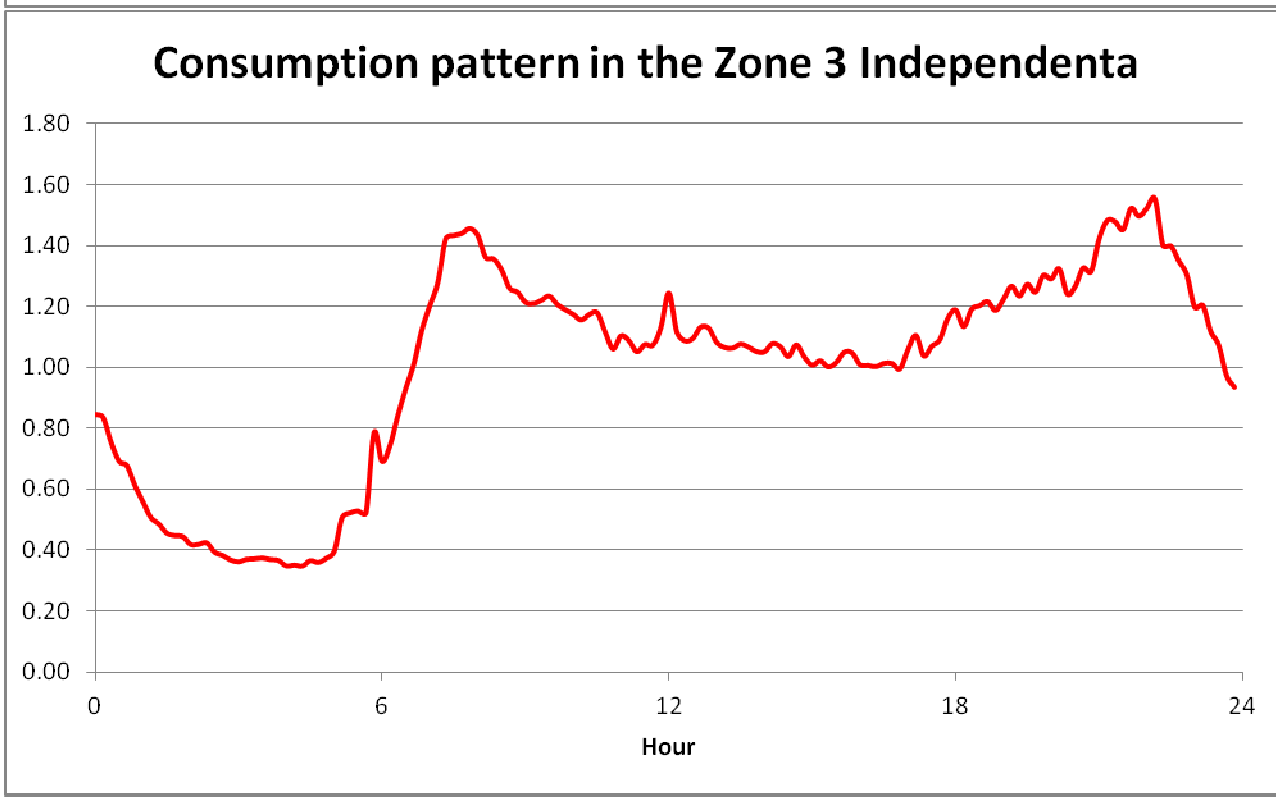

Consumption pattern in the Zone 1
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

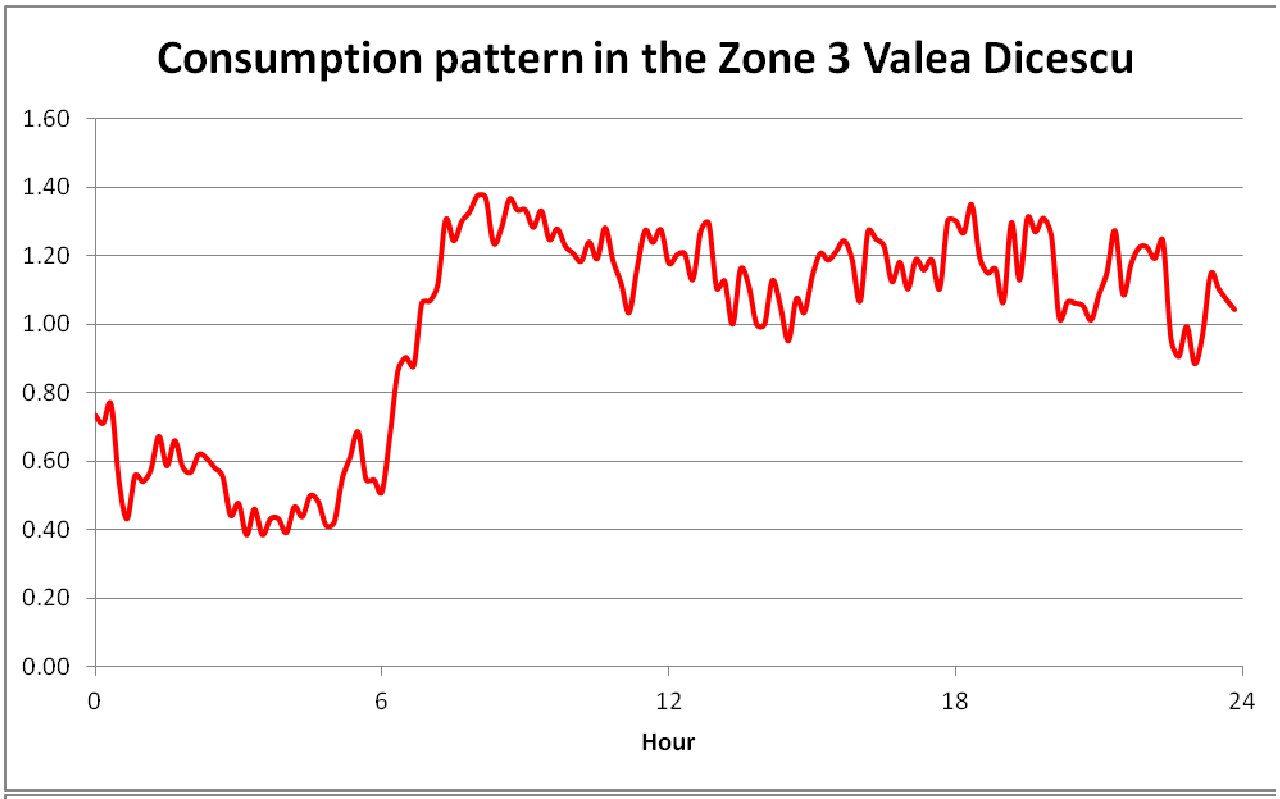

Consumption pattern in the Zone 2 Doina
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

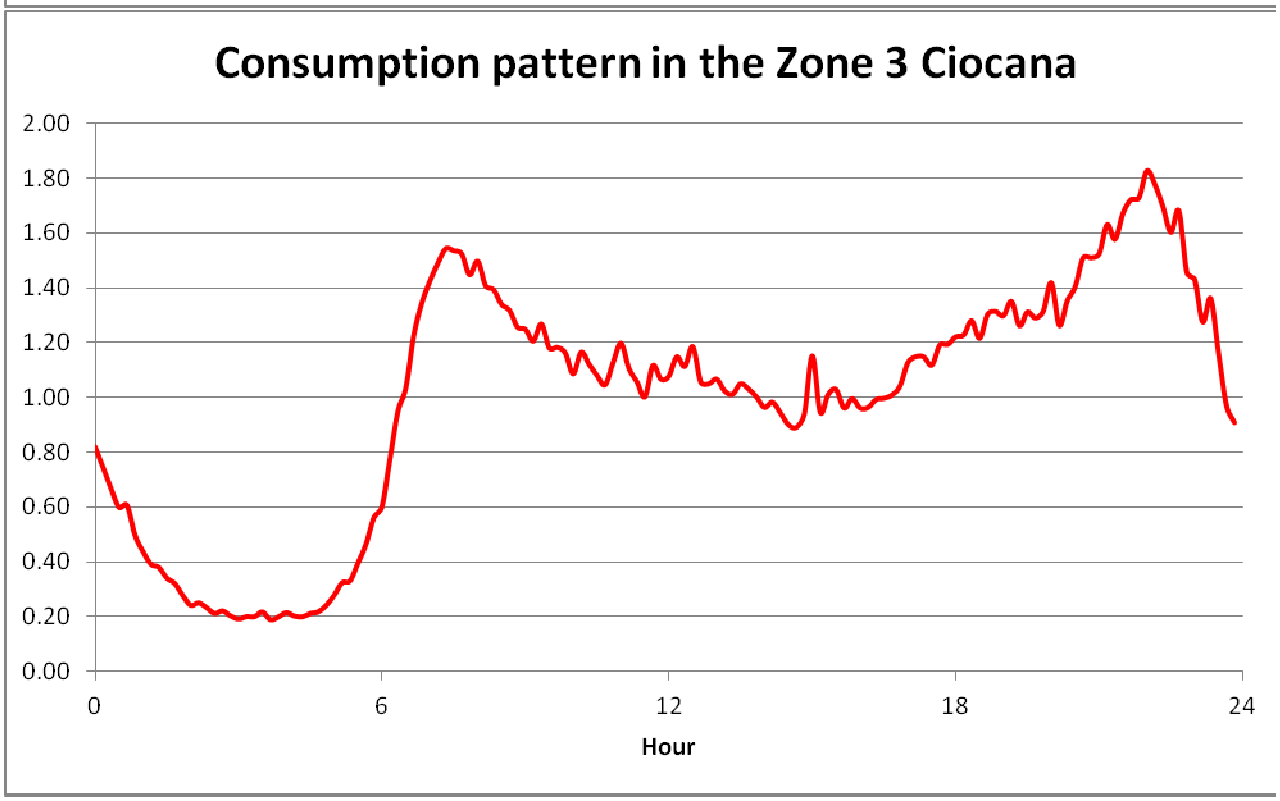

Consumption pattern in the Zone 2 Otel
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

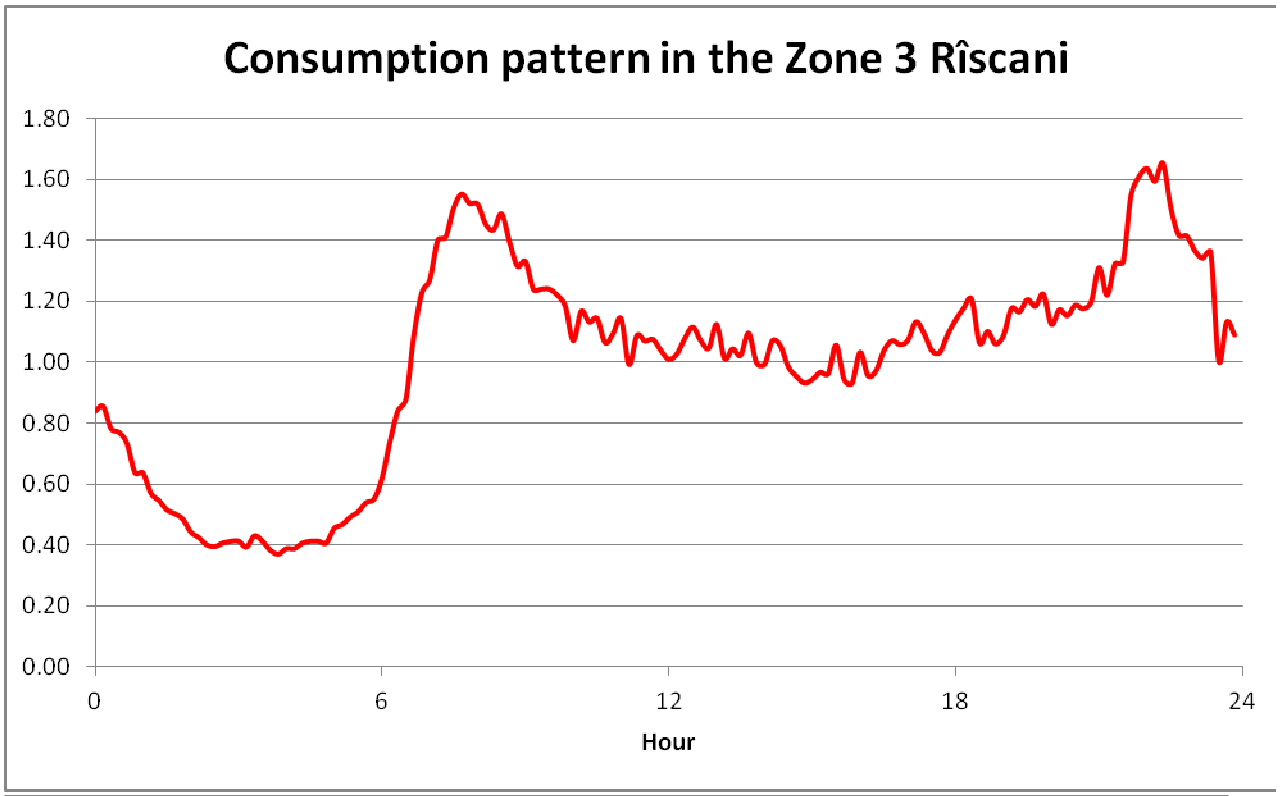

Consumption pattern in the Zone 2
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

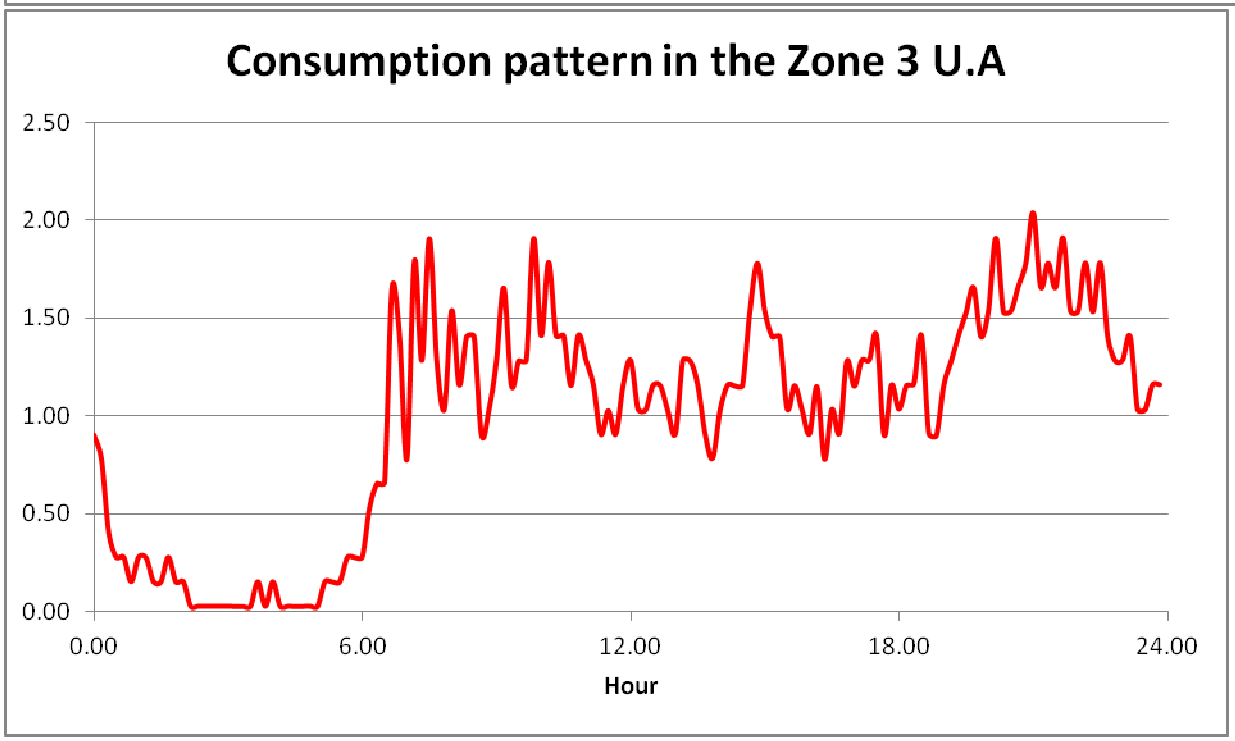

Consumption pattern in the Zone 3 Buiucani
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

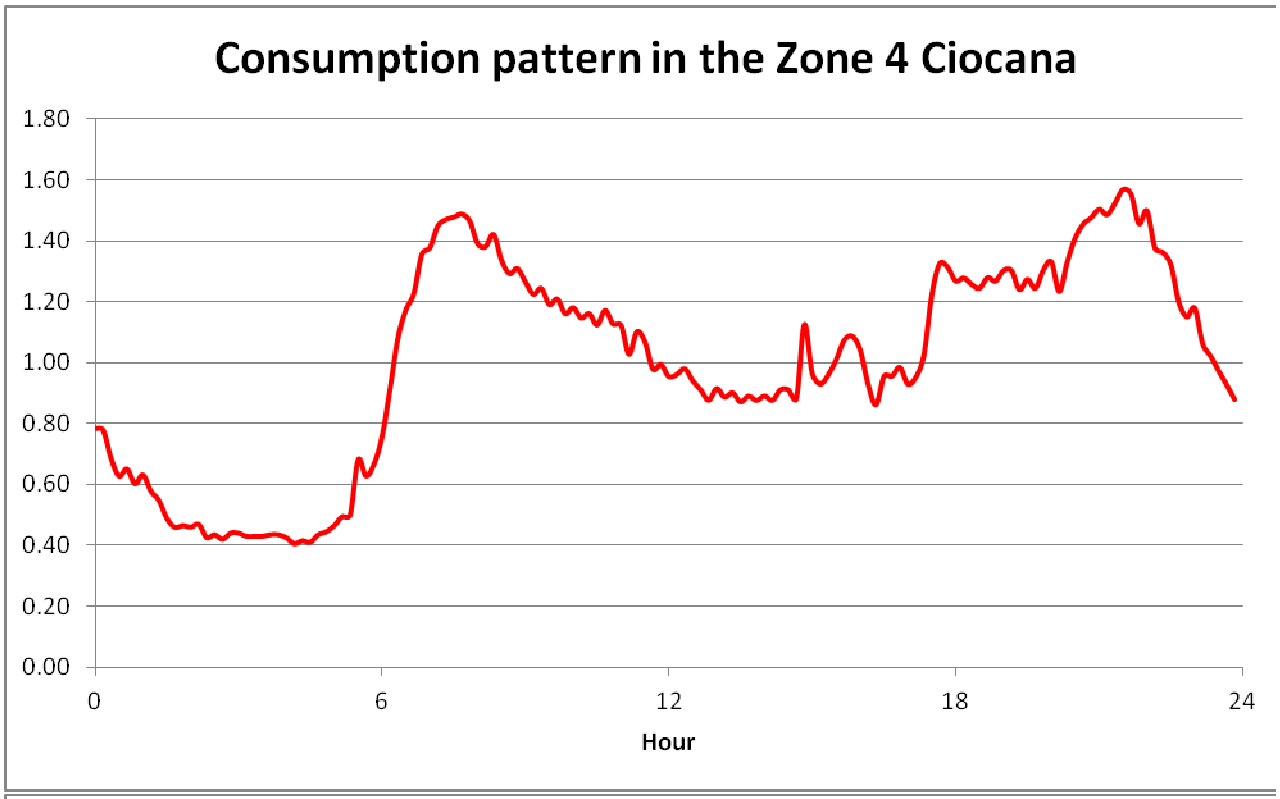

Consumption pattern in the Zone 3 Independenta
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

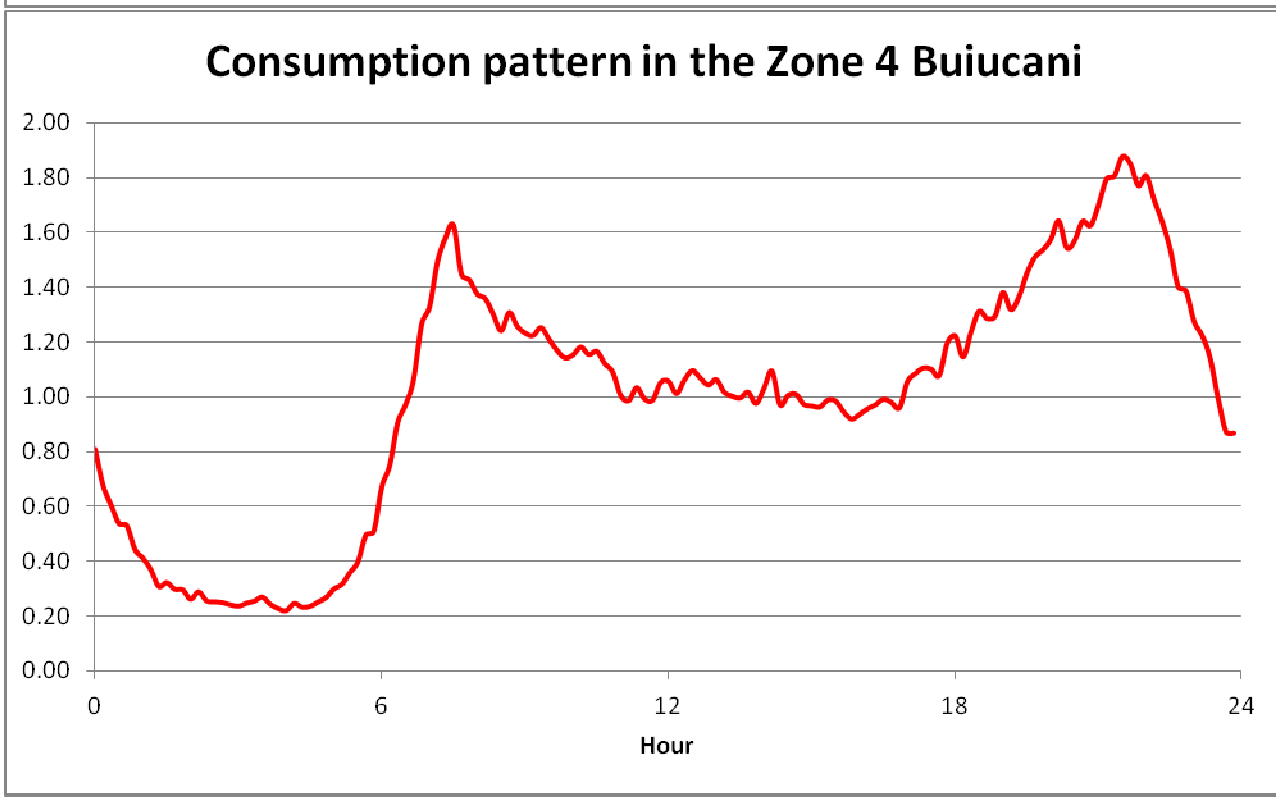

Consumption pattern in the Zone 3 Valea Dicescu
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

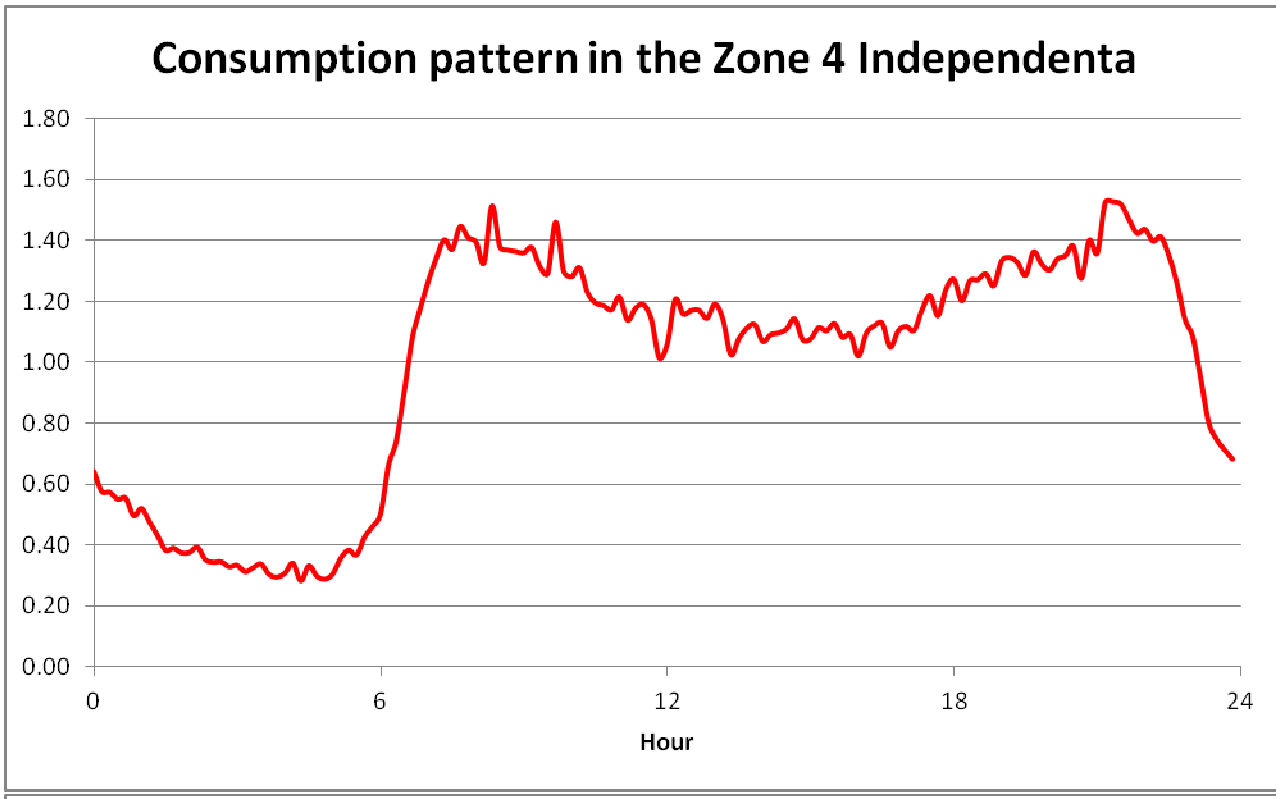

Consumption pattern in the Zone 3 Ciocana
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

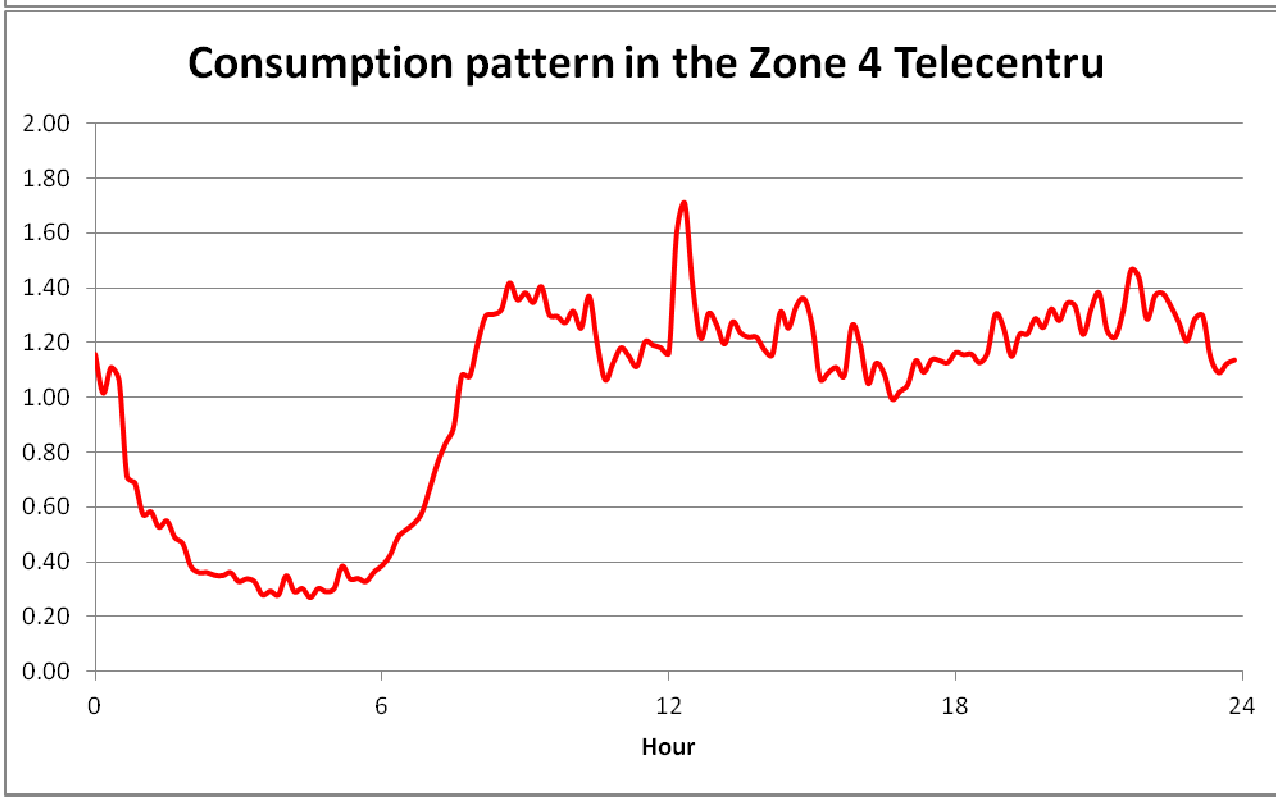

Consumption pattern in the Zone 3 Rîscani
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

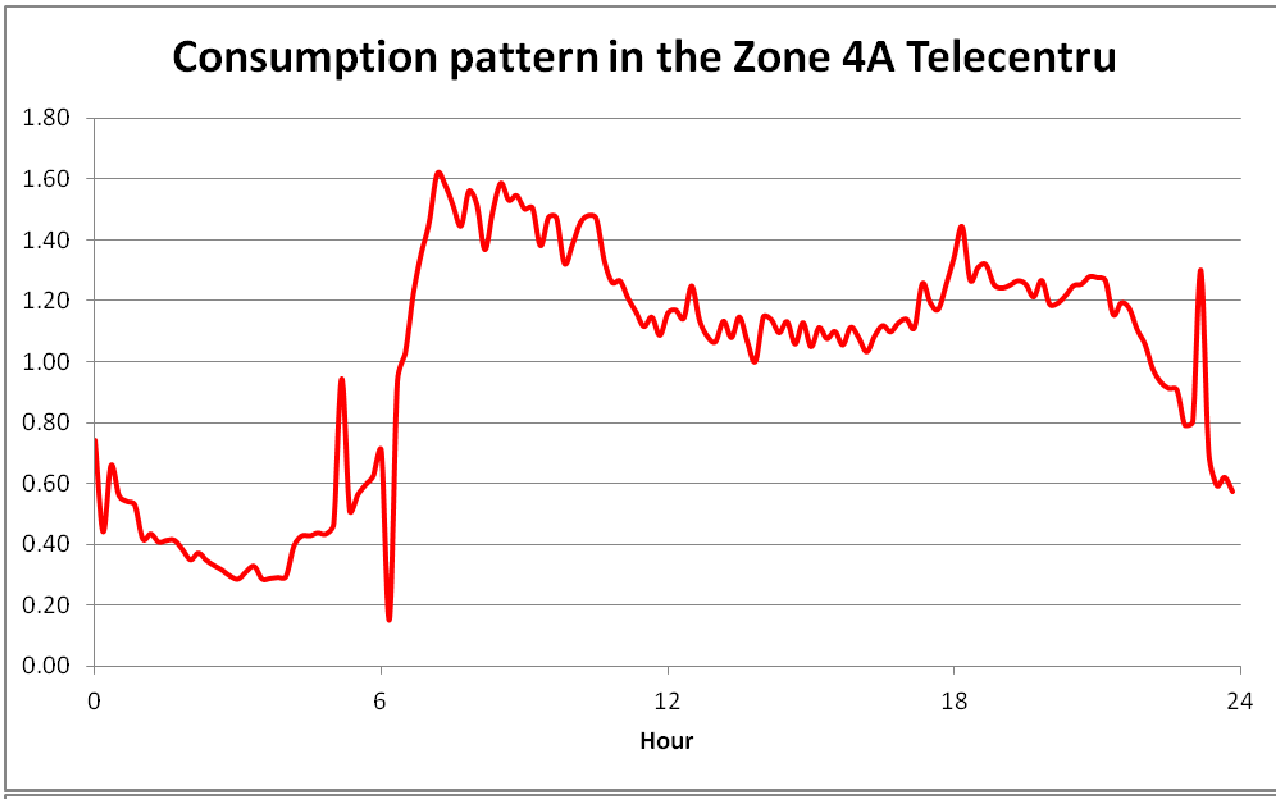

Consumption pattern in the Zone 3 U.A
2.50
2.00
1.50
1.00
0.50
0.00
0.00
6.00
12.00
18.00
24.00
Hour

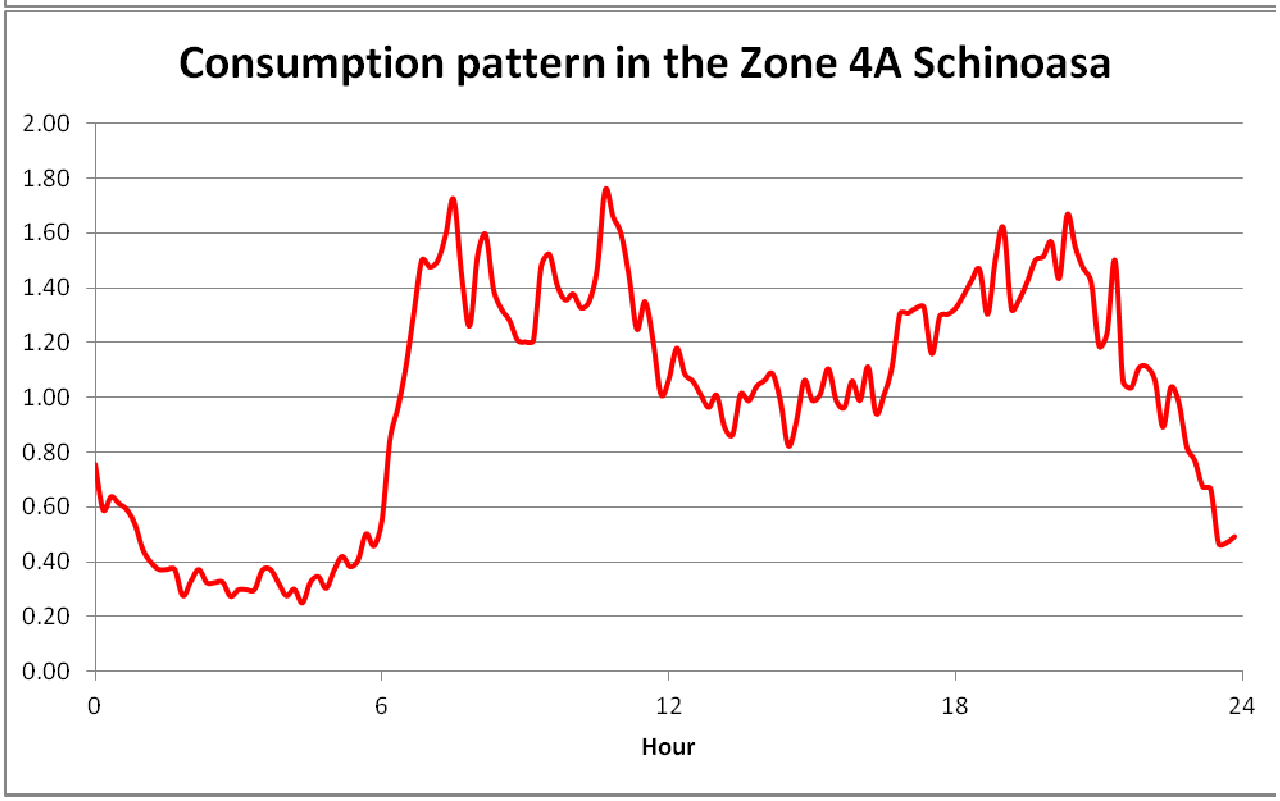

Consumption pattern in the Zone 4 Ciocana
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

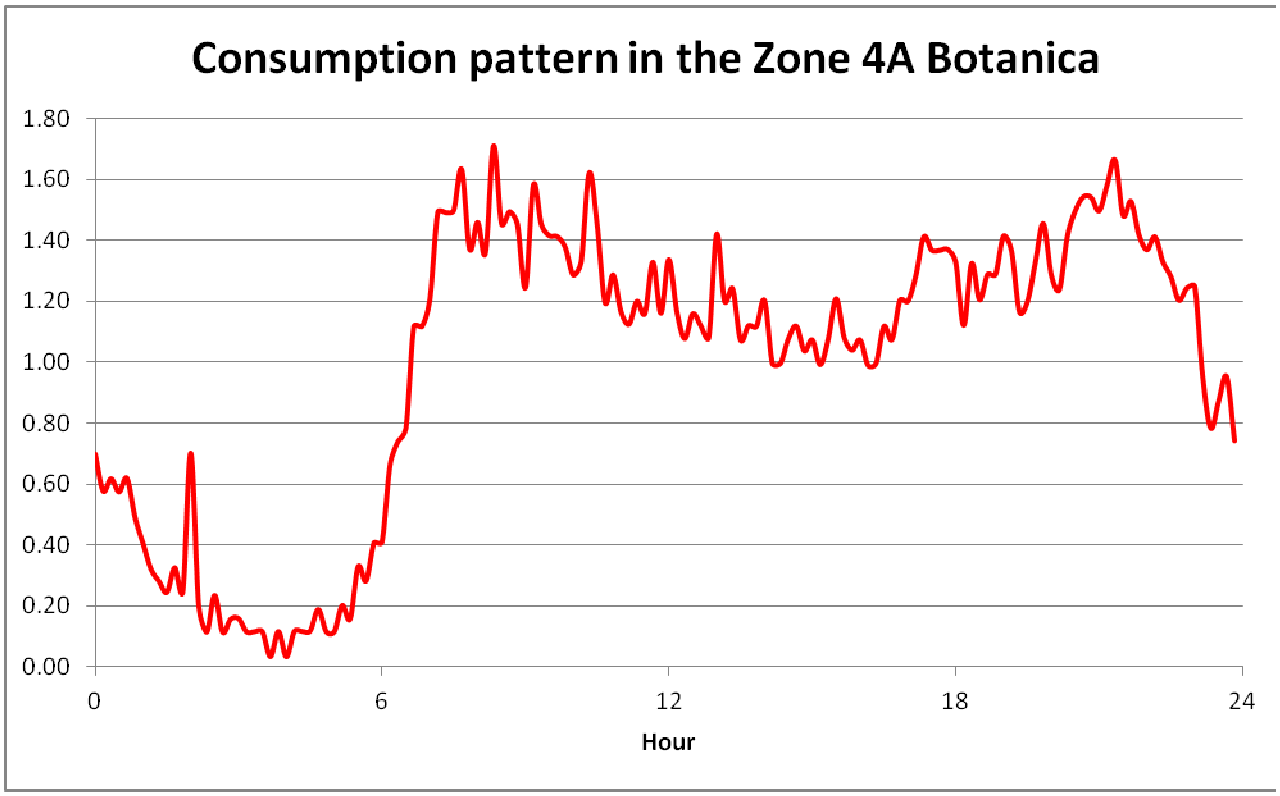

Consumption pattern in the Zone 4 Buiucani
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

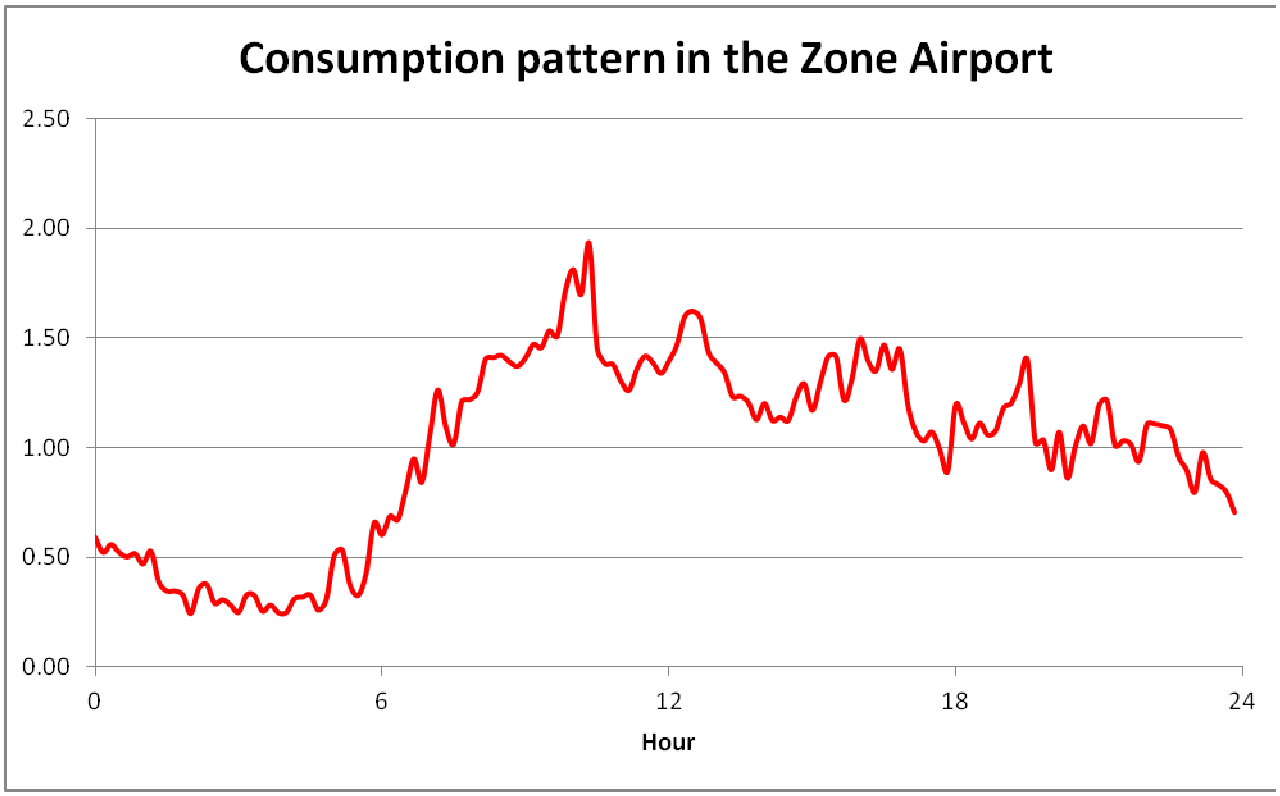

Consumption pattern in the Zone 4 Independenta
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

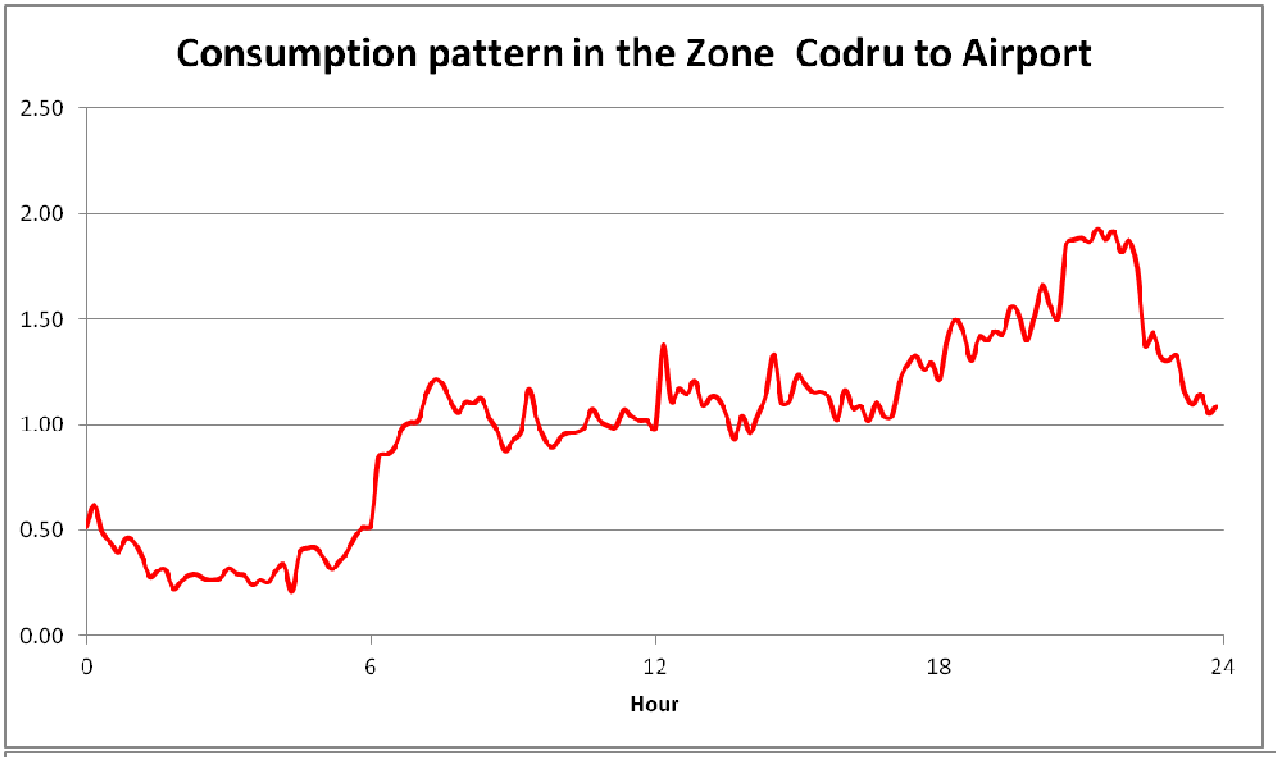

Consumption pattern in the Zone 4 Telecentru
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

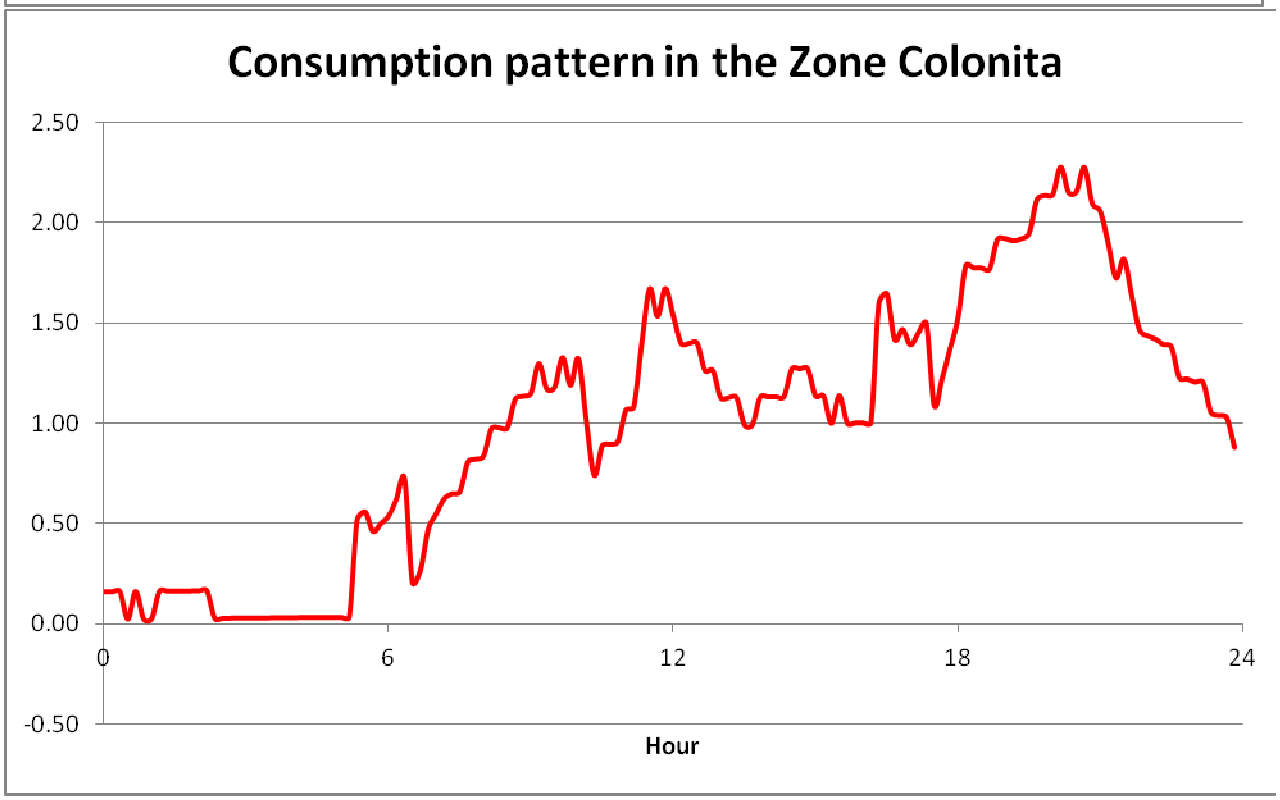

Consumption pattern in the Zone 4A Telecentru
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

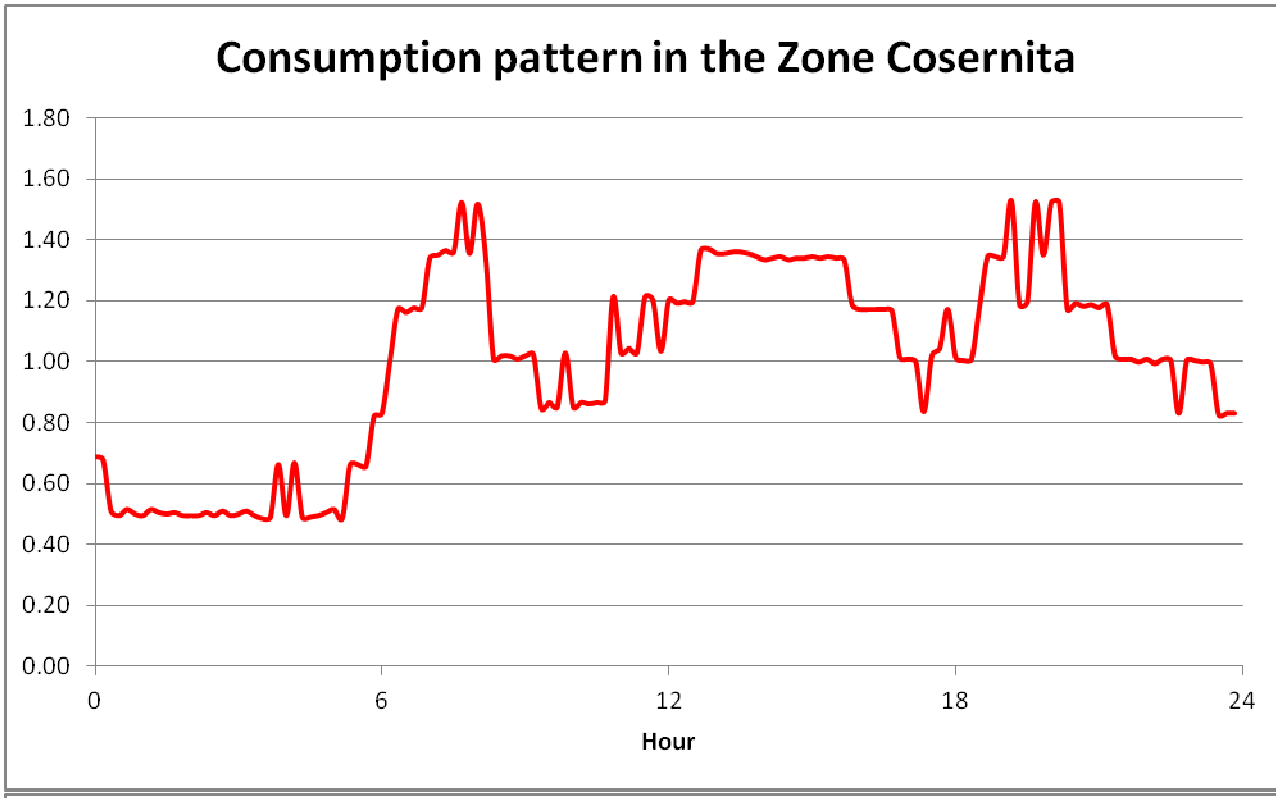

Consumption pattern in the Zone 4A Schinoasa
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

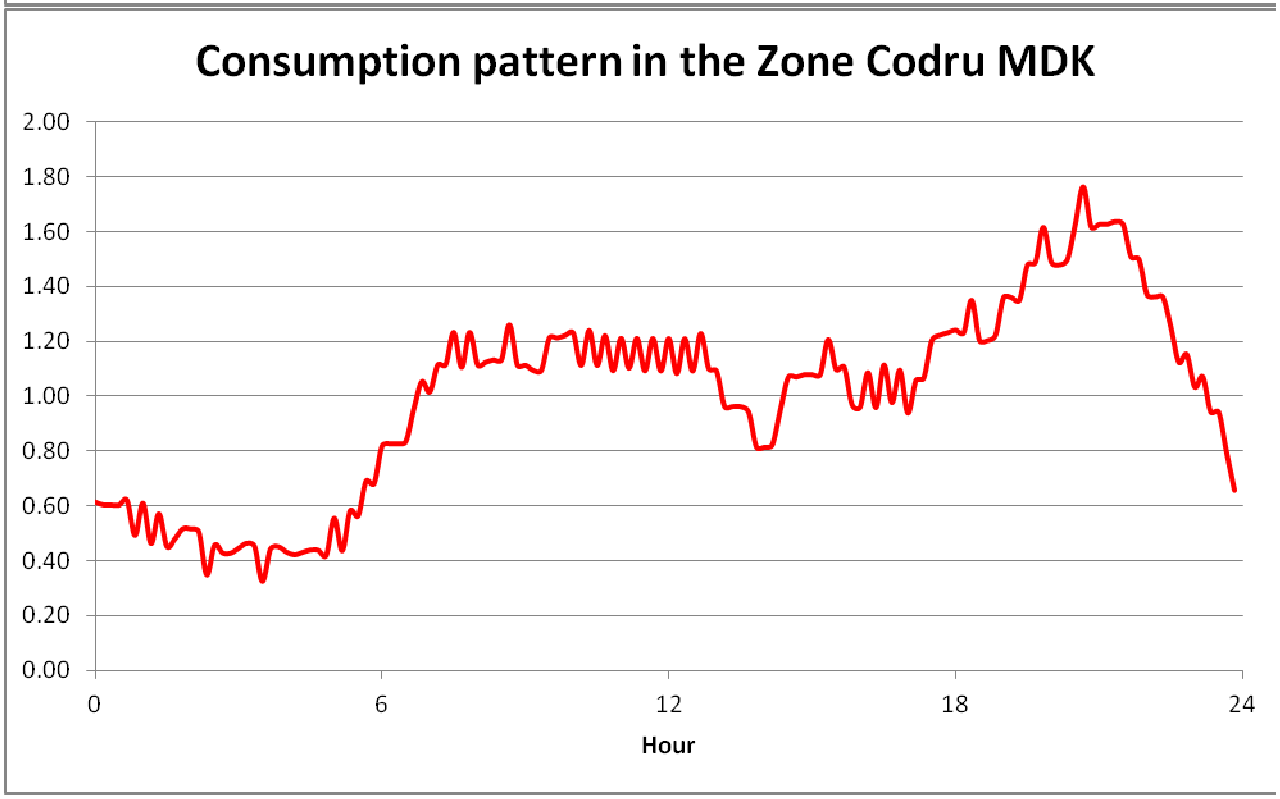

Consumption pattern in the Zone 4A Botanica
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour

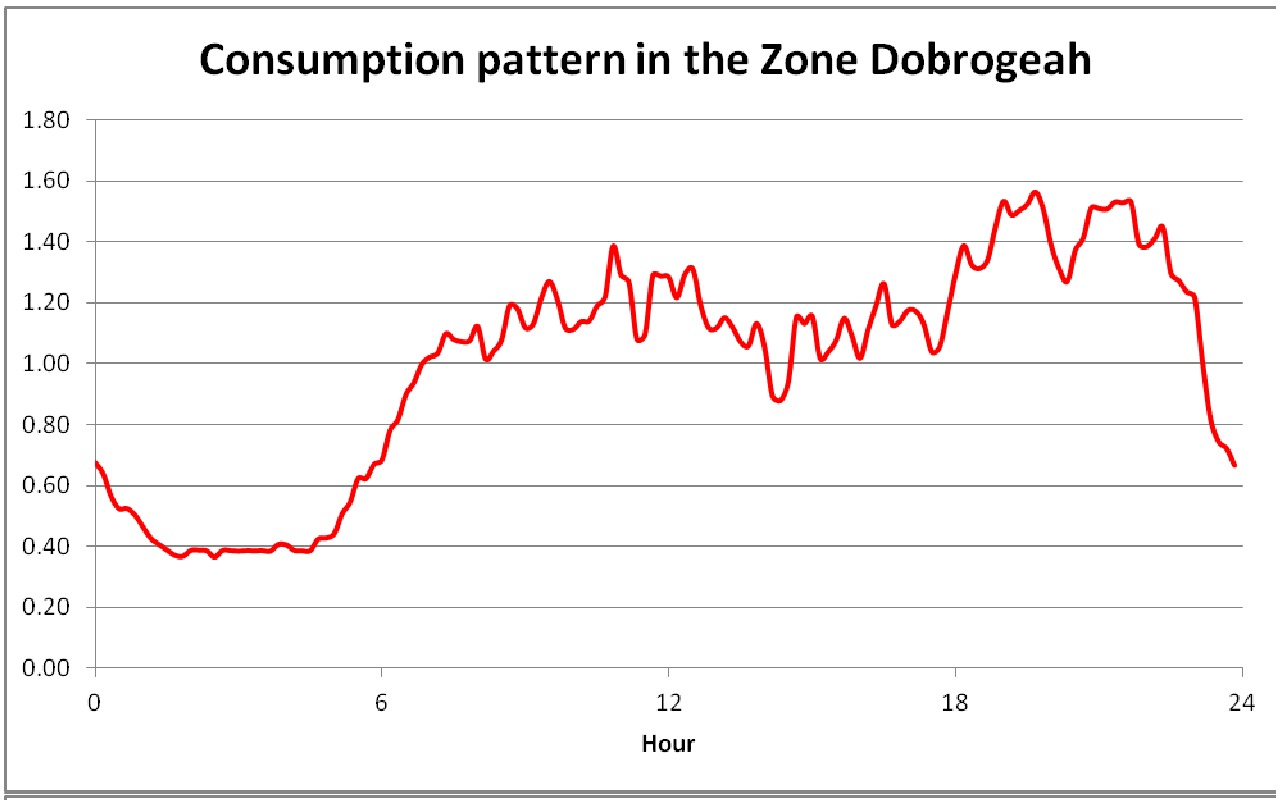

Consumption pattern in the Zone Airport
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour

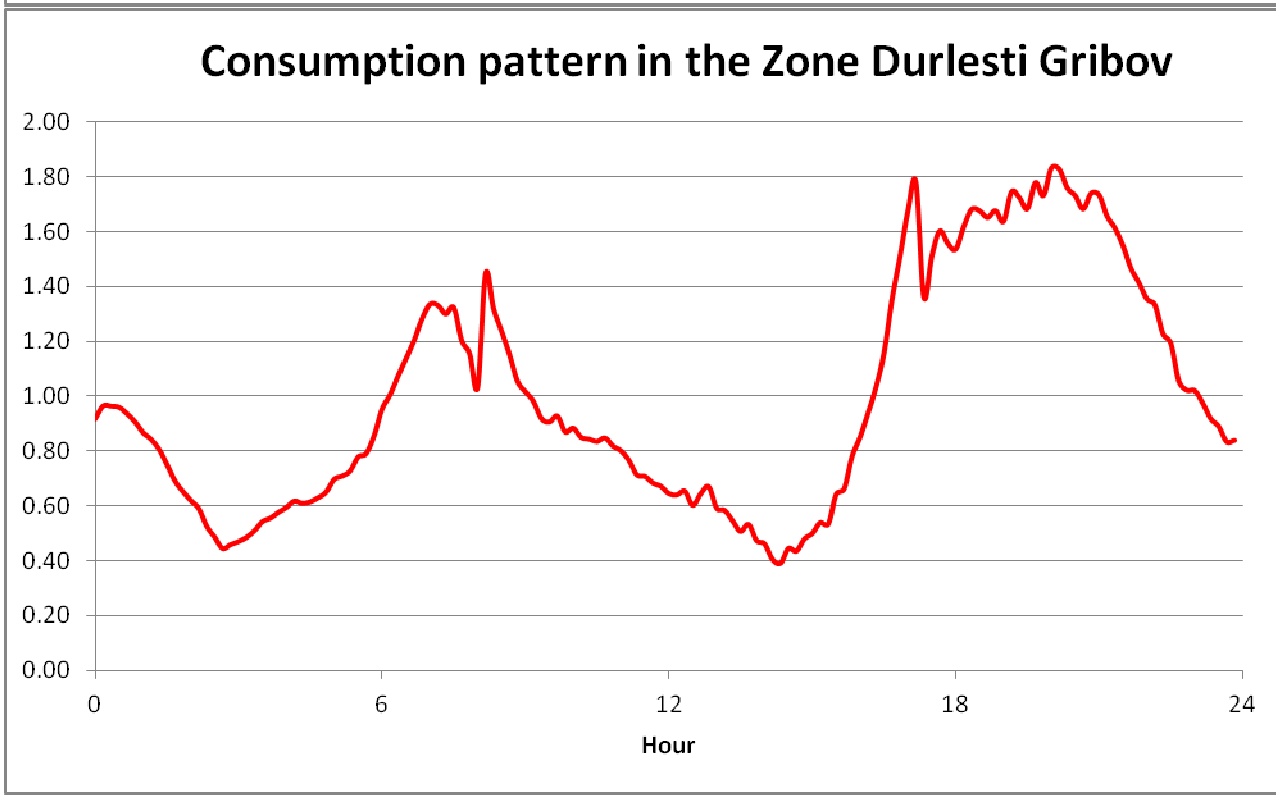

Consumption pattern in the Zone Codru to Airport
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour

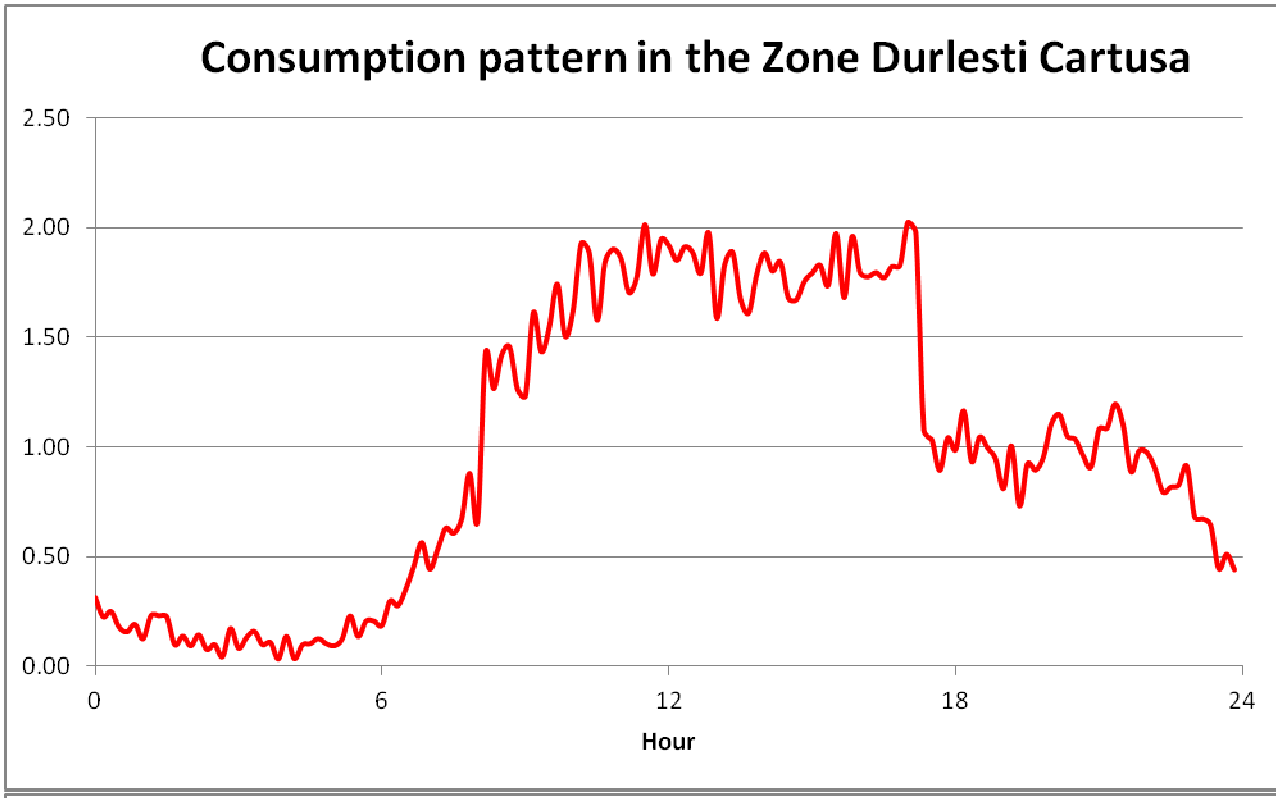

Consumption pattern in the Zone Colonita
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
0
6
12
18
24
Hour


Consumption pattern in the Zone Cosernita
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Codru MDK
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Dobrogeah
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Durlesti Gribov
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Durlesti Cartusa
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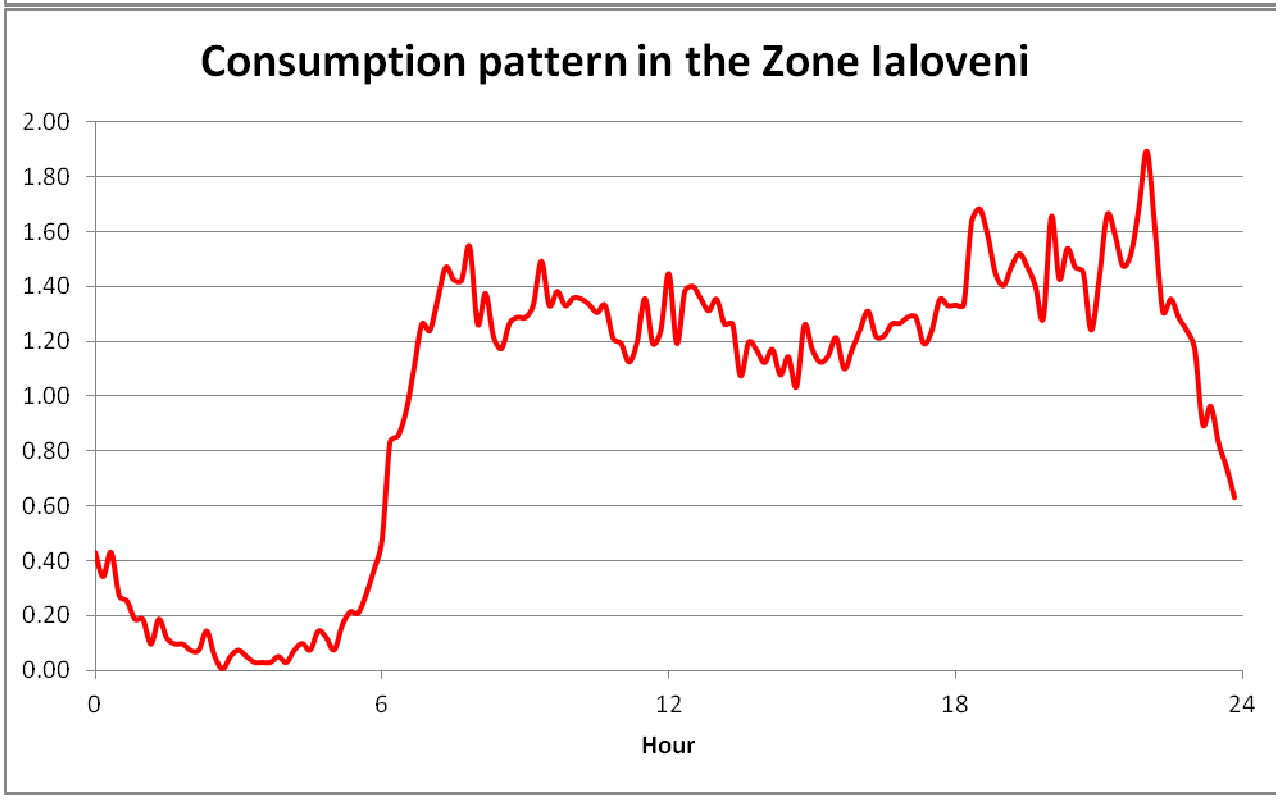
6
12
18
24
Hour


Consumption pattern in the Zone Ialoveni
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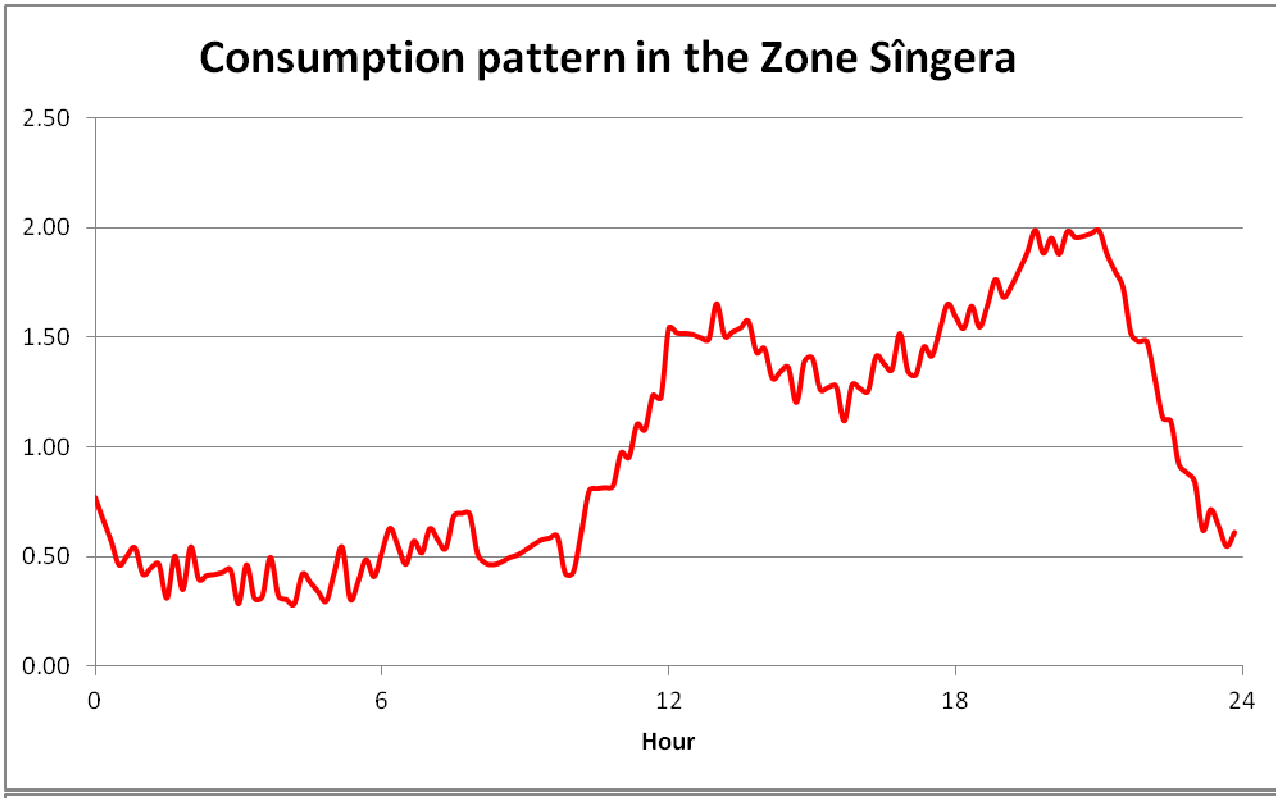
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Sîngera
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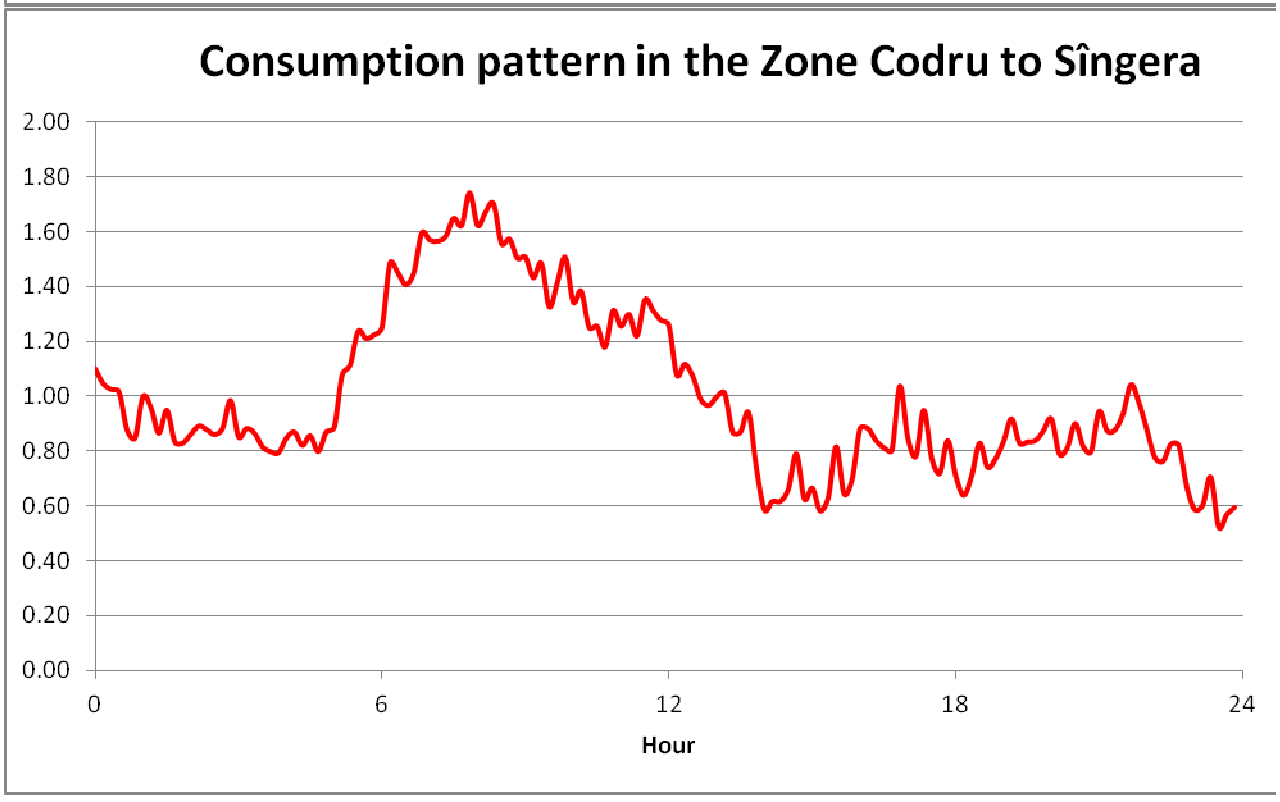
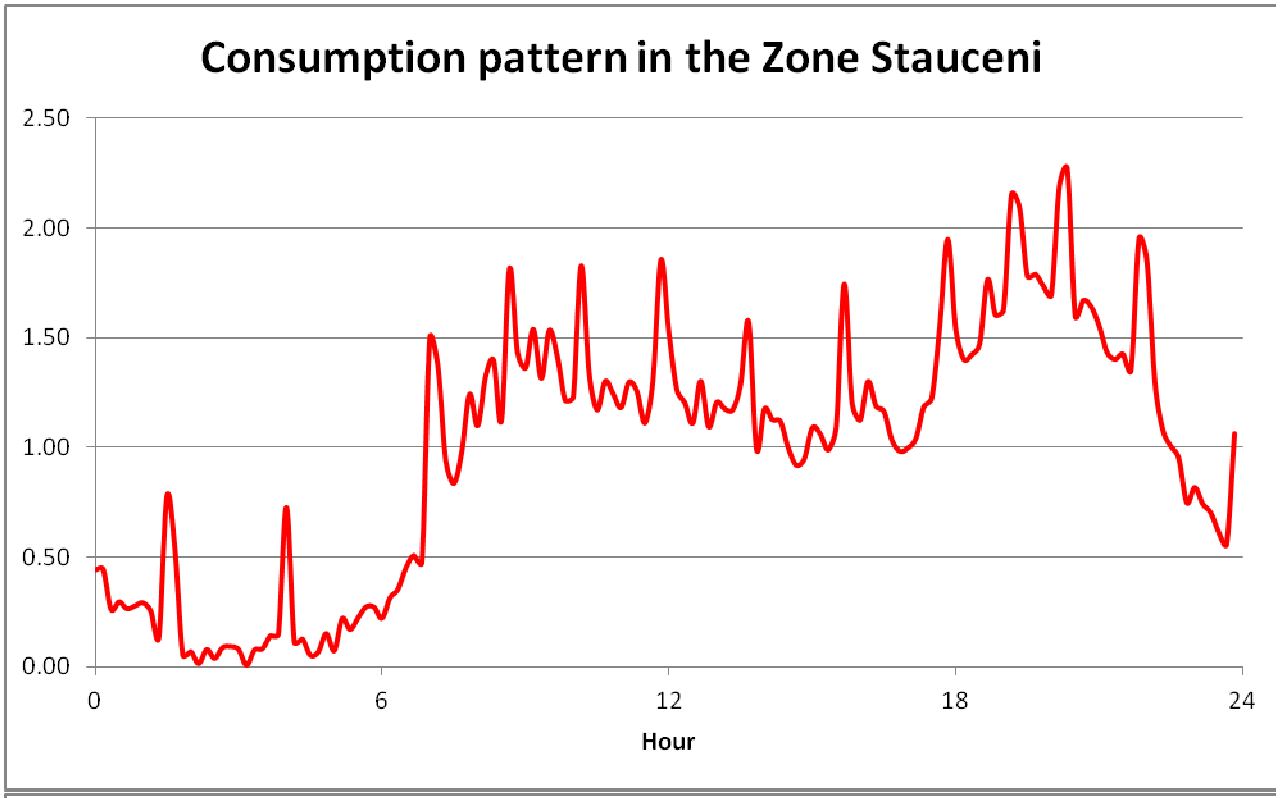
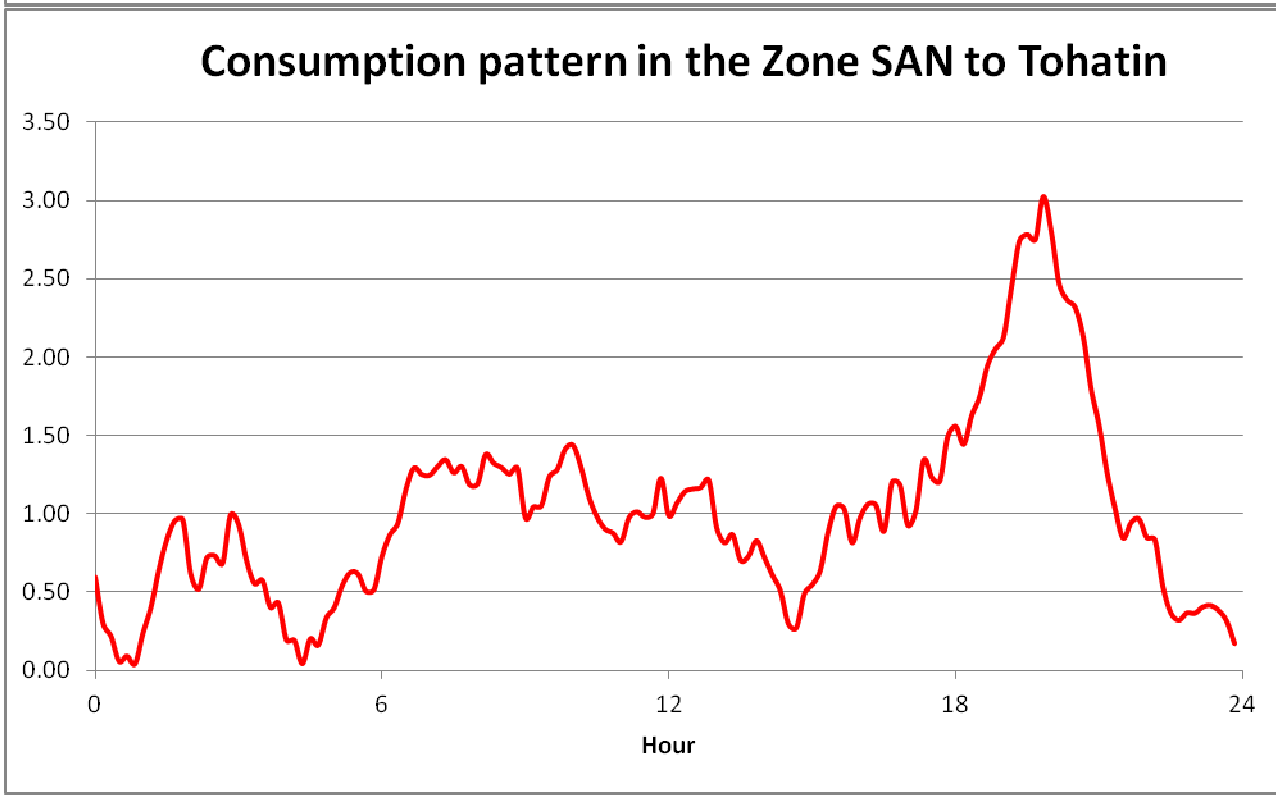
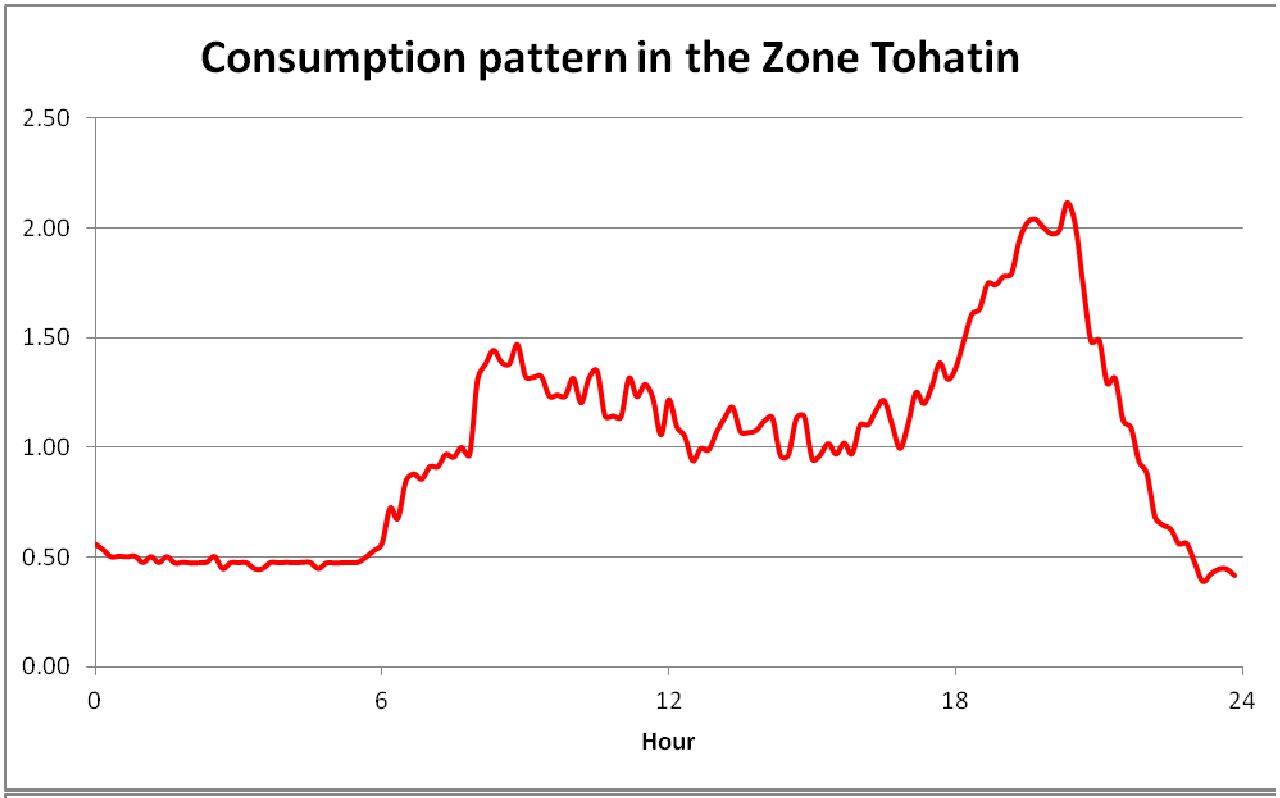
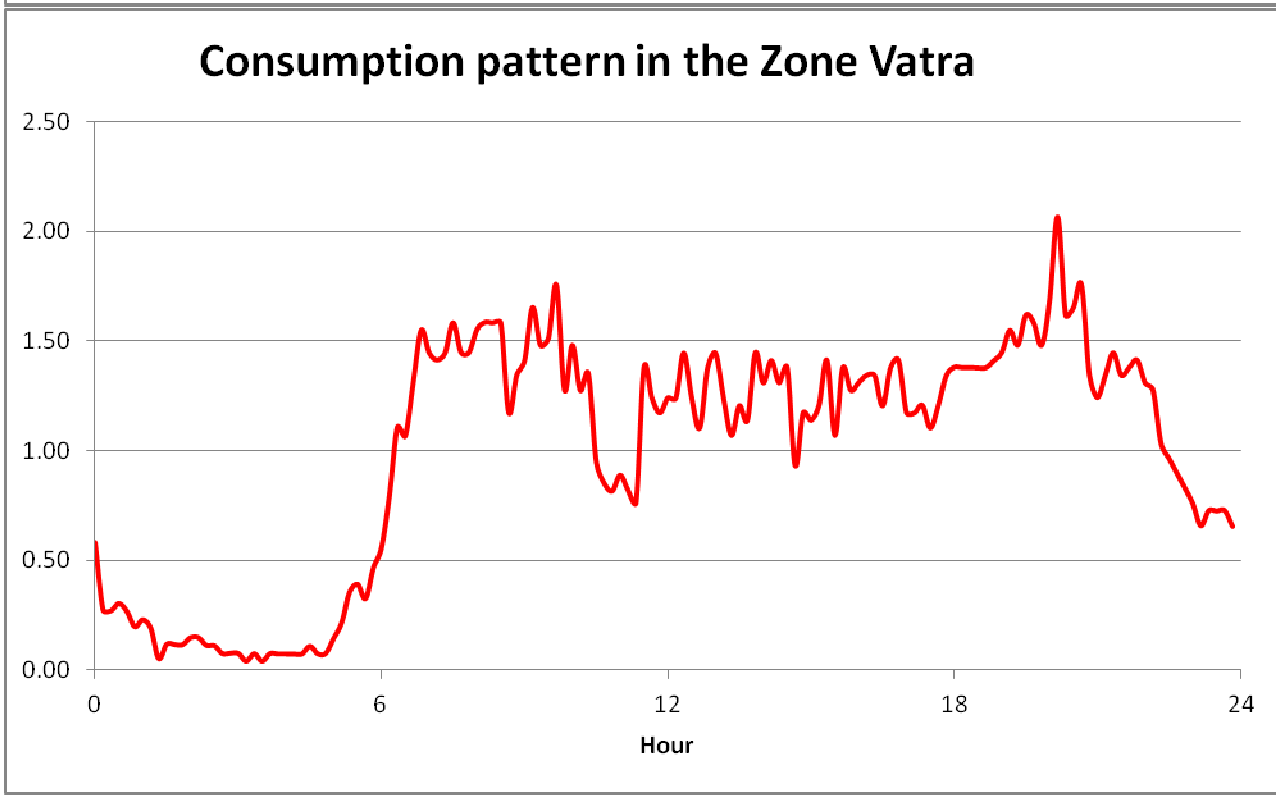
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour

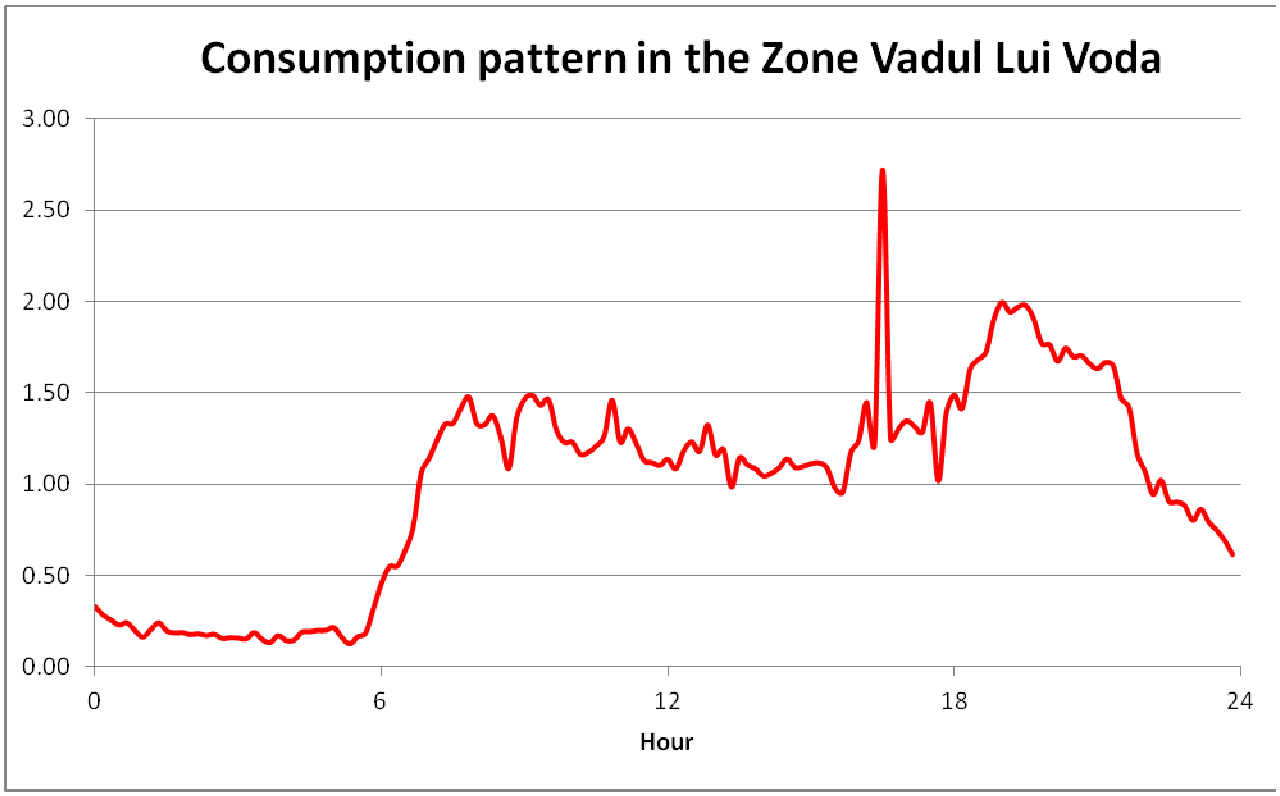

Consumption pattern in the Zone Codru to Sîngera
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Stauceni
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone SAN to Tohatin
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour


Consumption pattern in the Zone Tohatin
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour

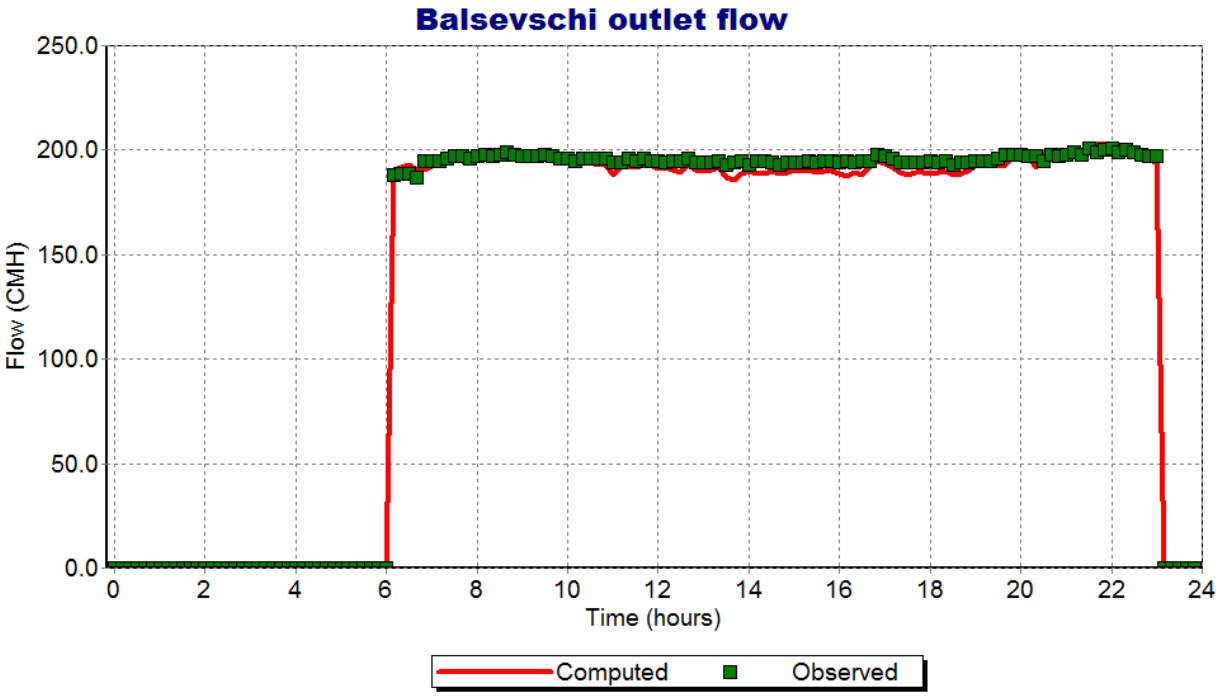

Consumption pattern in the Zone Vatra
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour

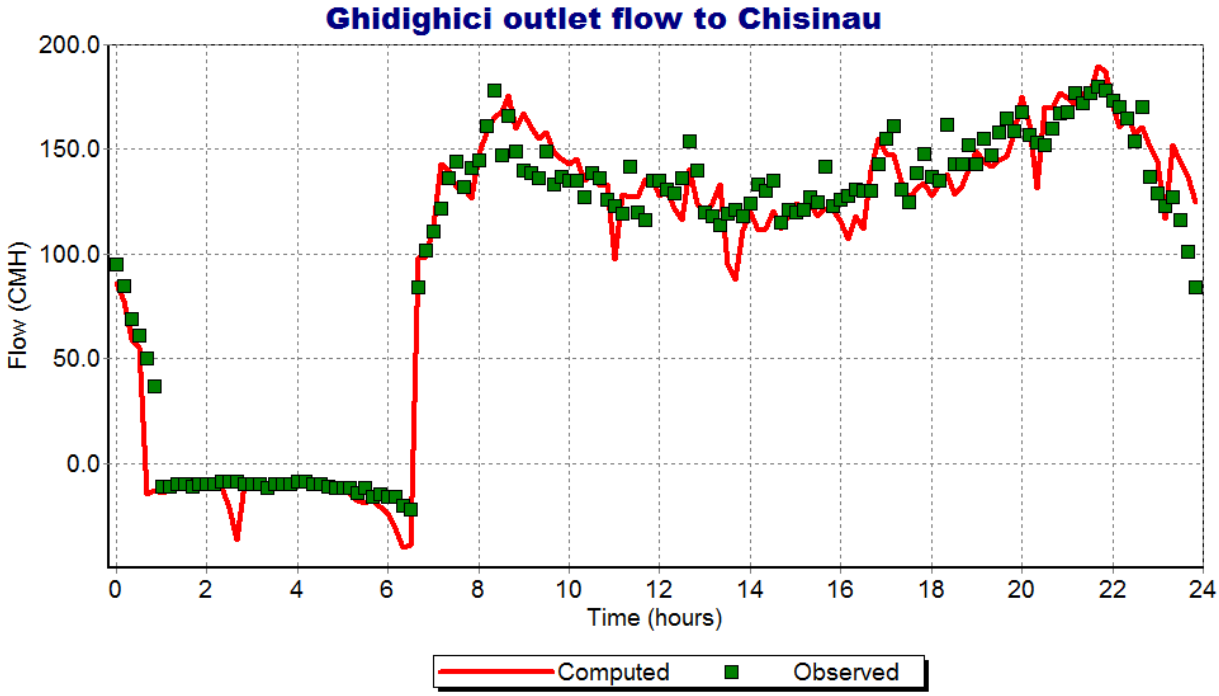

Consumption pattern in the Zone Vadul Lui Voda
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
6
12
18
24
Hour

Annex 3 Calibration graphs

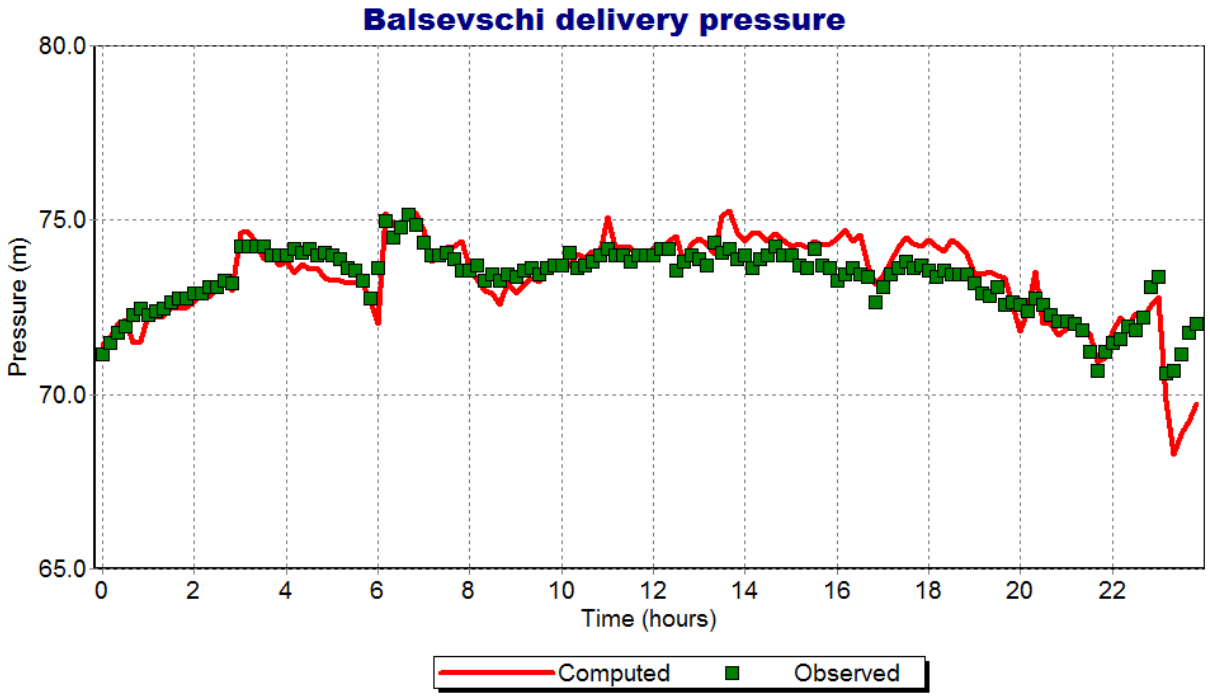
Zone 1

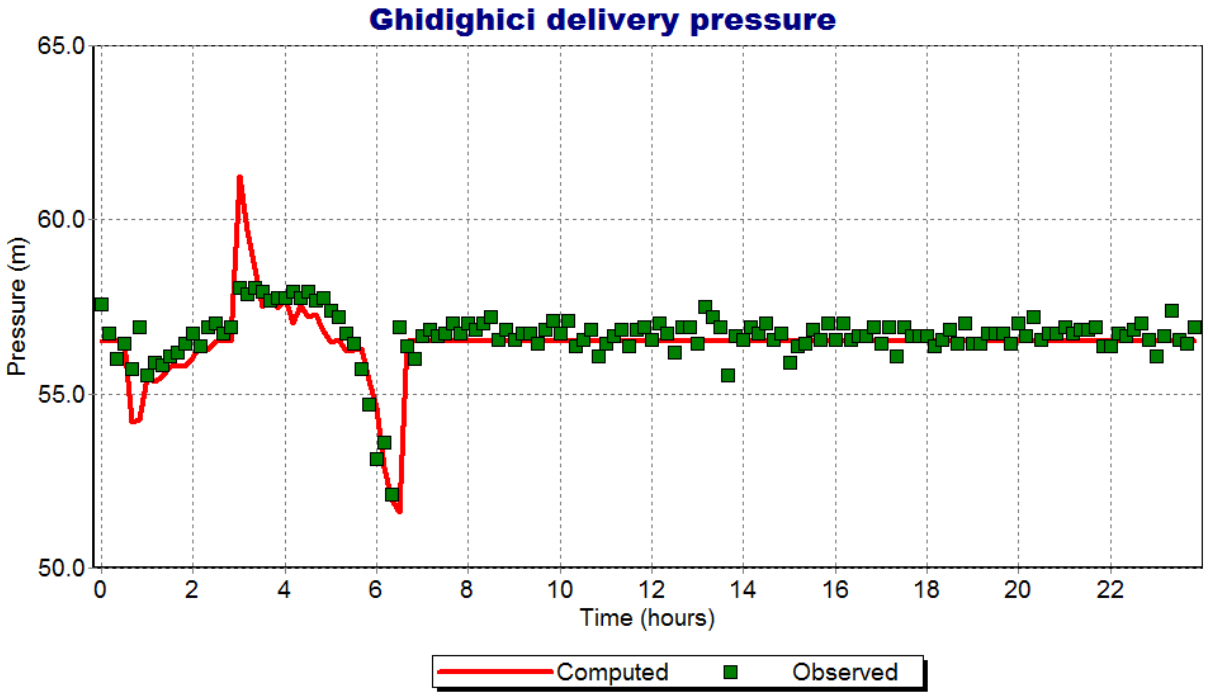
Flow in the Zone 1

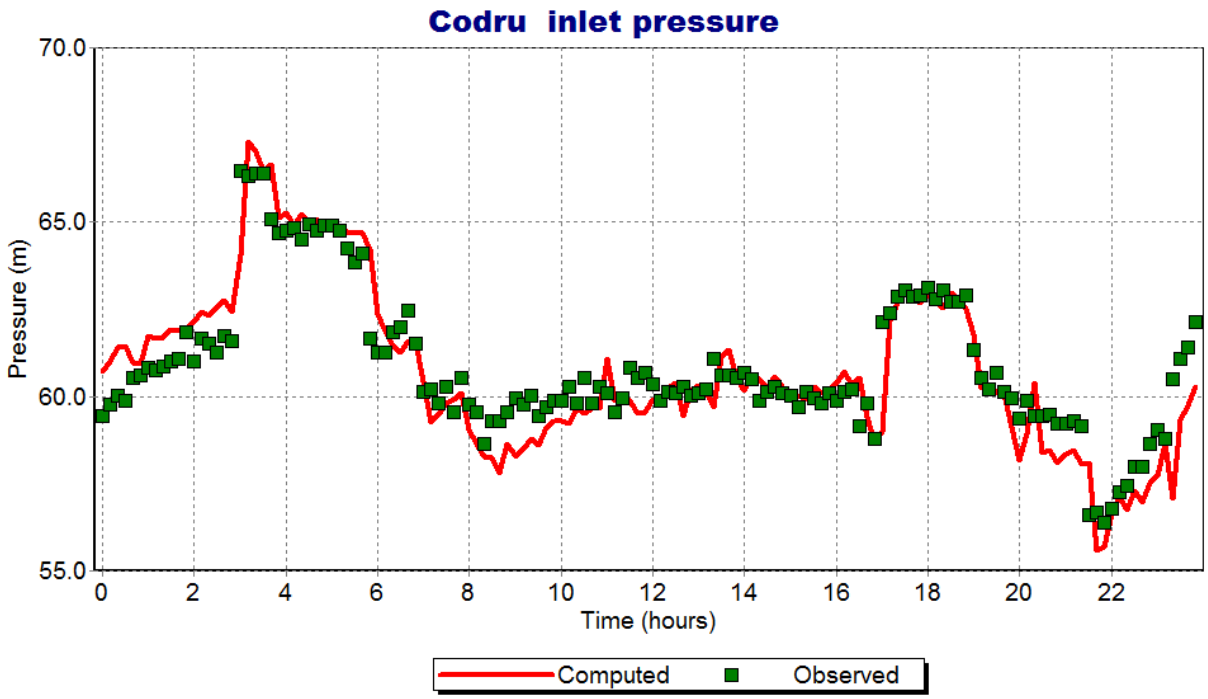


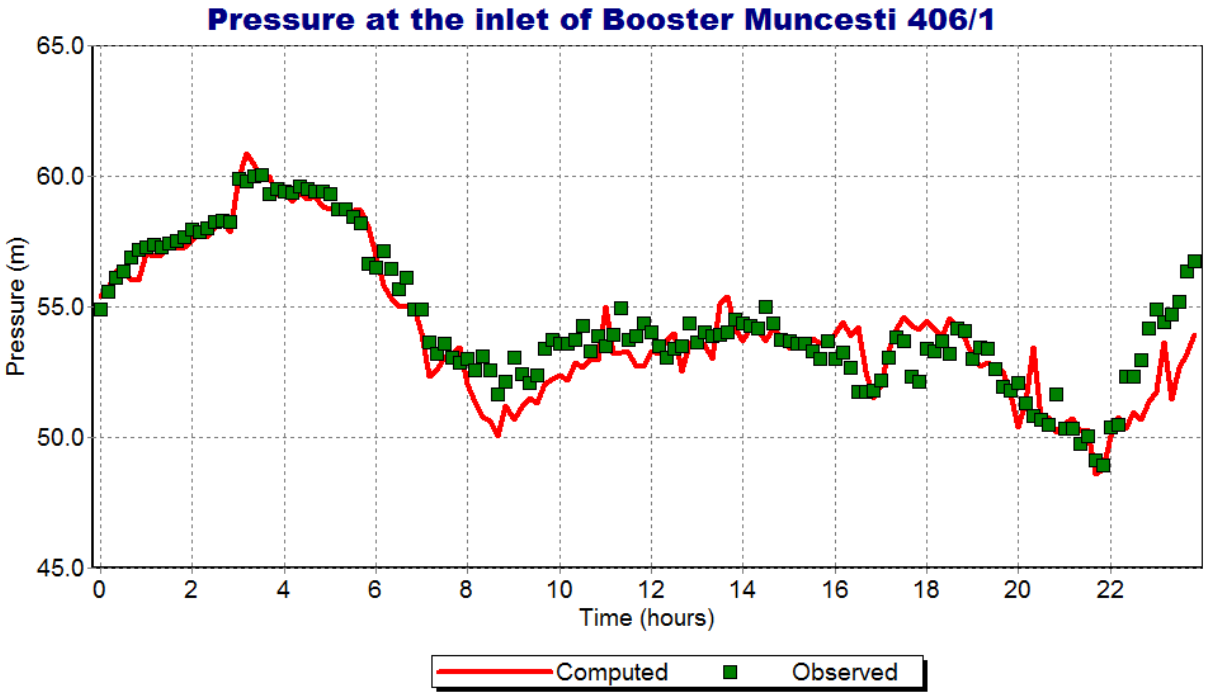


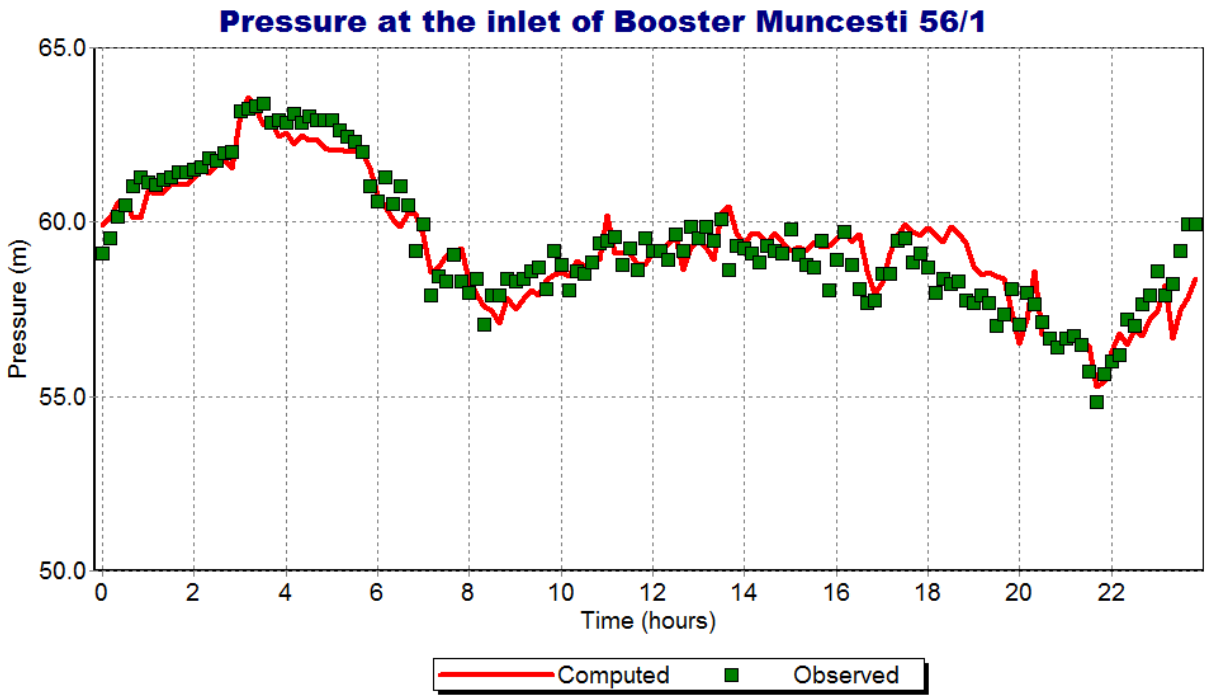
Pressure in the zone 1

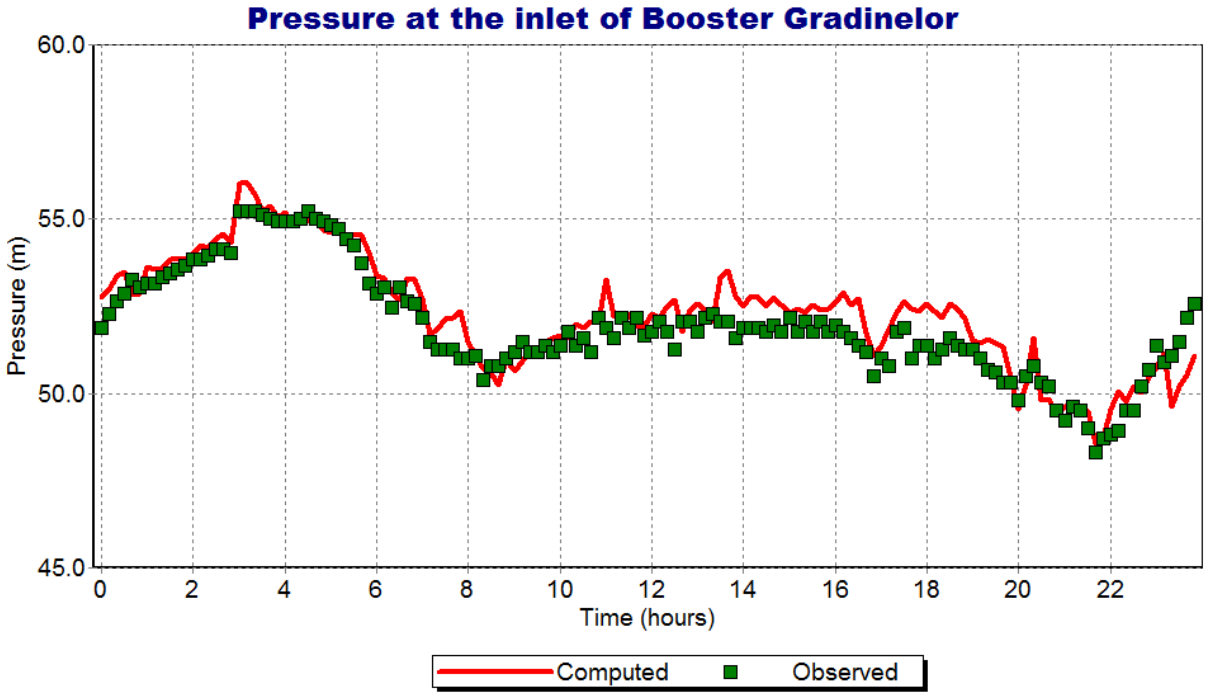


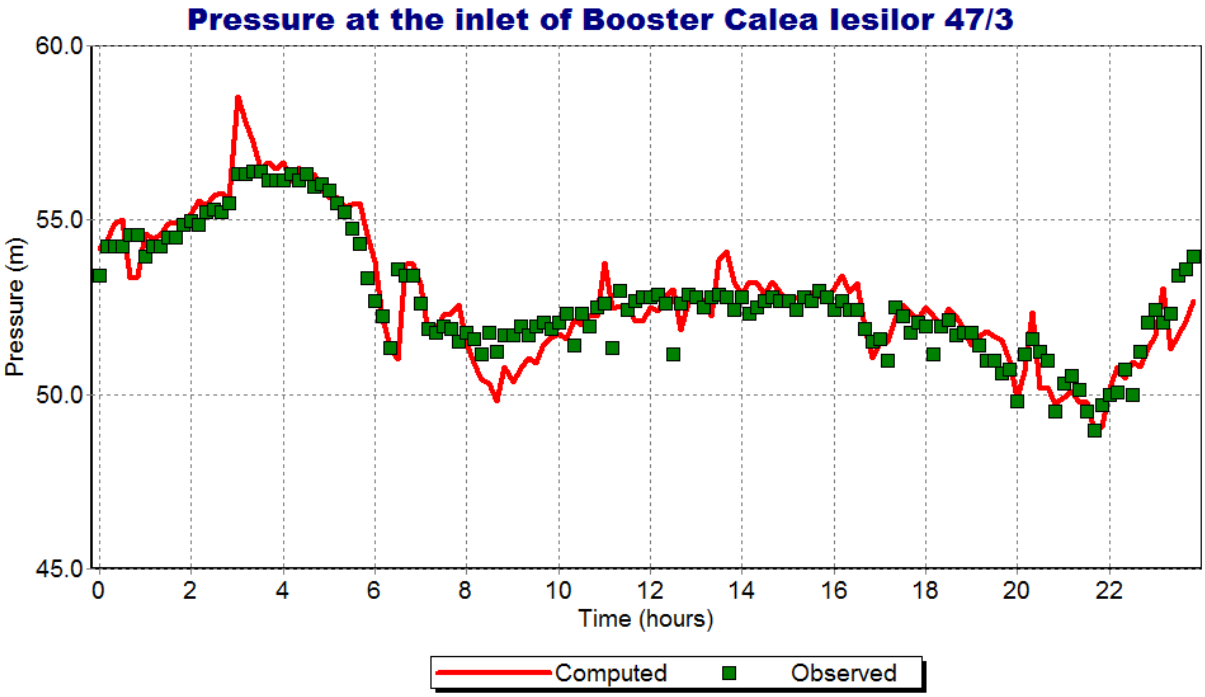


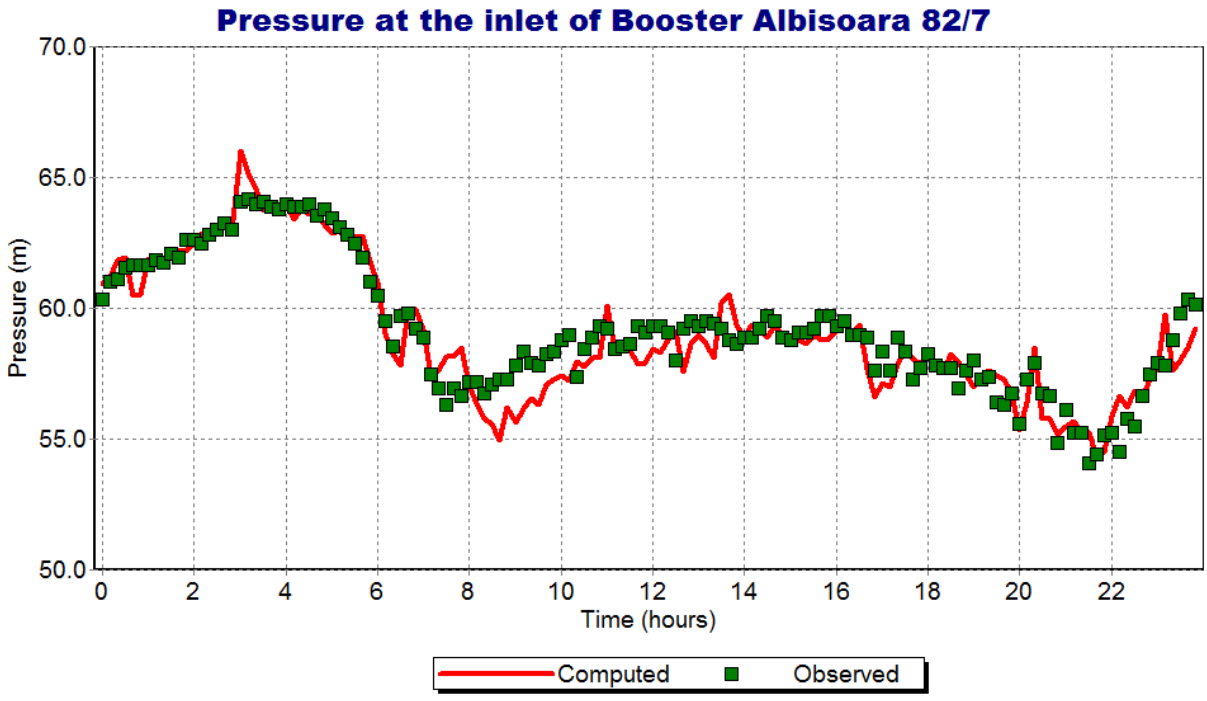

Codru inlet pressure
70.0
65.0
60.0
55.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

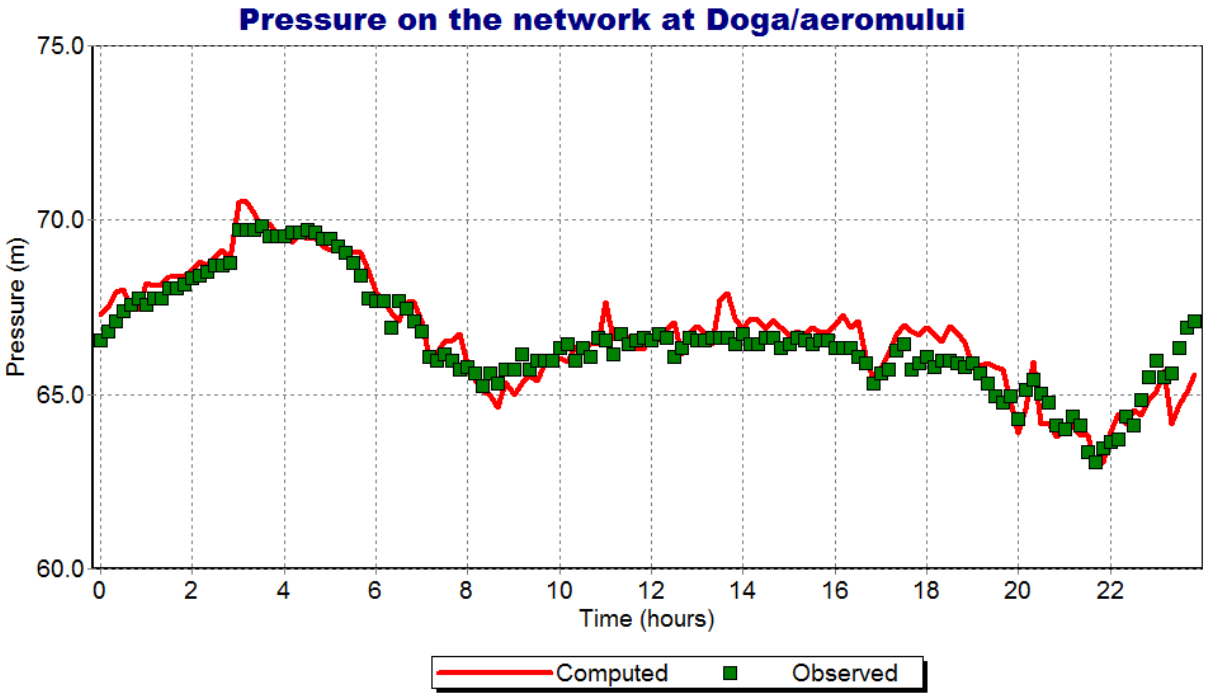

Pressure at the inlet of Booster Muncesti 406/1
65.0
60.0
55.0
50.0
45.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

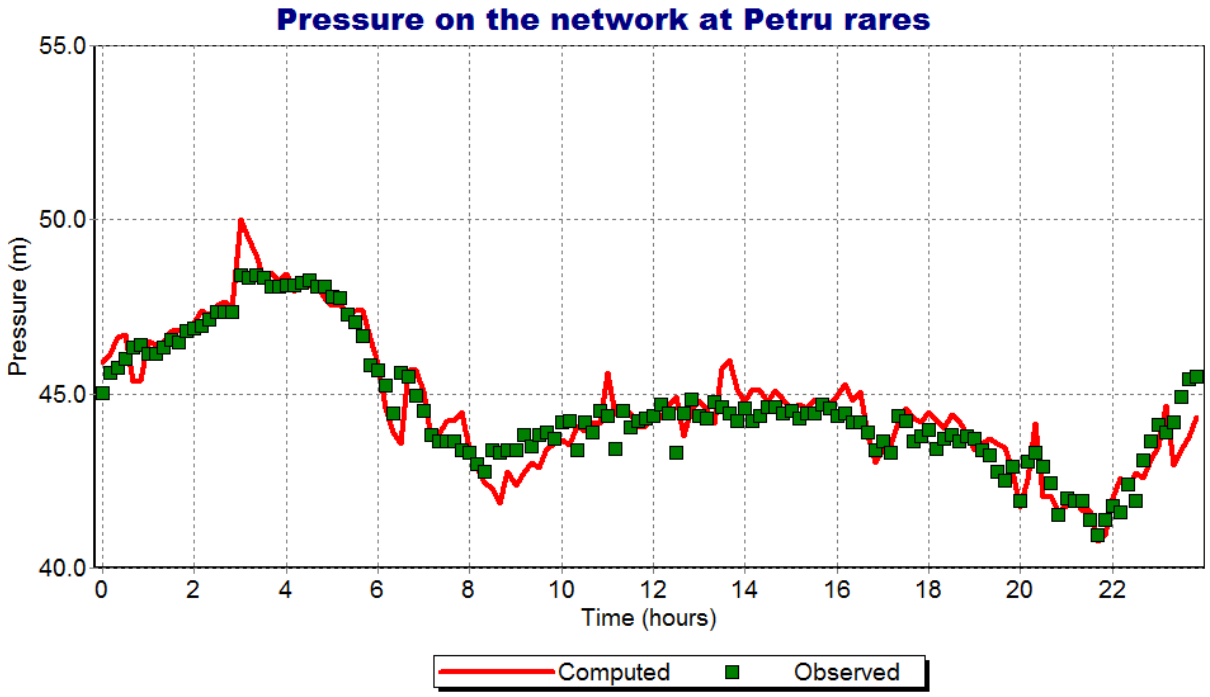

Pressure at the inlet of Booster Muncesti 56/1
65.0
60.0
55.0
50.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

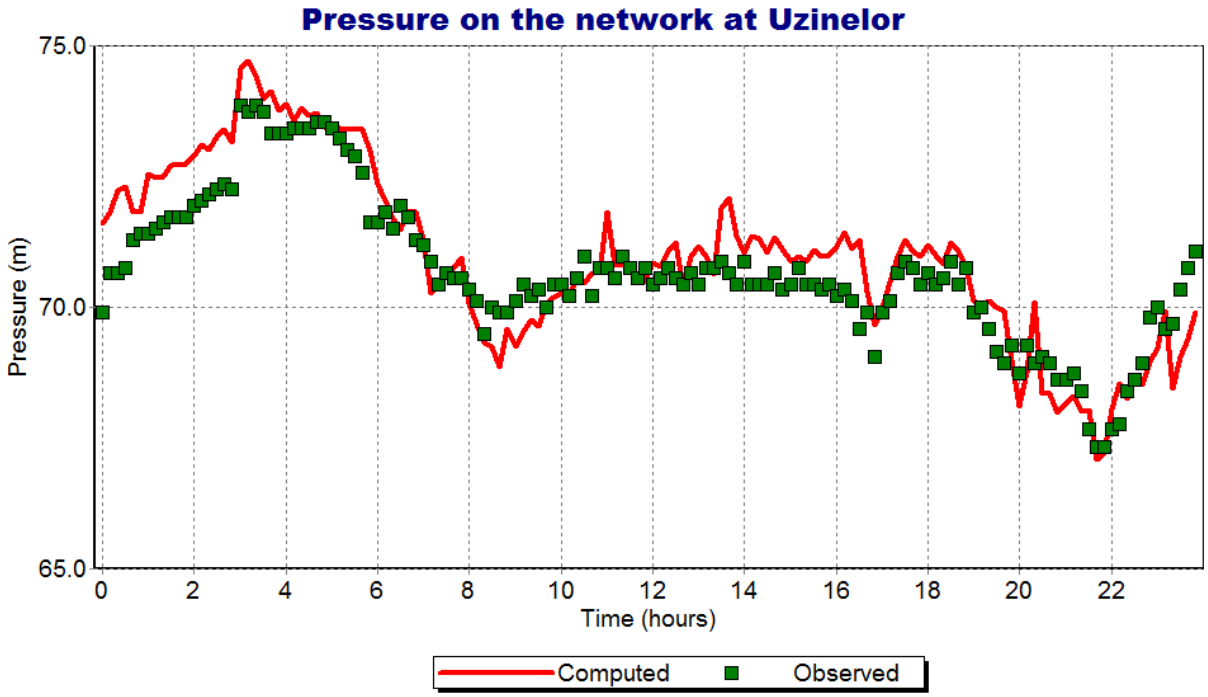

Pressure at the inlet of Booster Gradinelor
60.0
55.0
50.0
45.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed


Pressure at the inlet of Booster Calea Iesilor 47/3
60.0
55.0
50.0
45.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed


Pressure at the inlet of Booster Albisoara 82/7
70.0
65.0
60.0
55.0
50.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

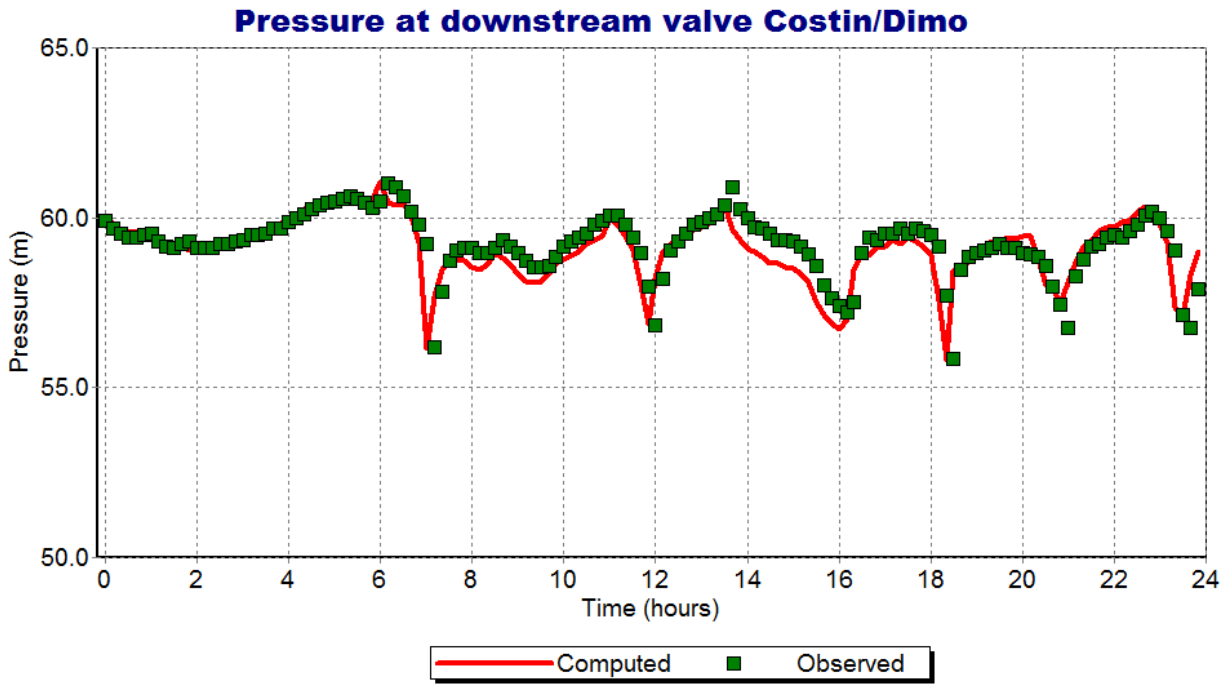

Pressure on the network at Doga/aeromului
75.0
70.0
65.0
60.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

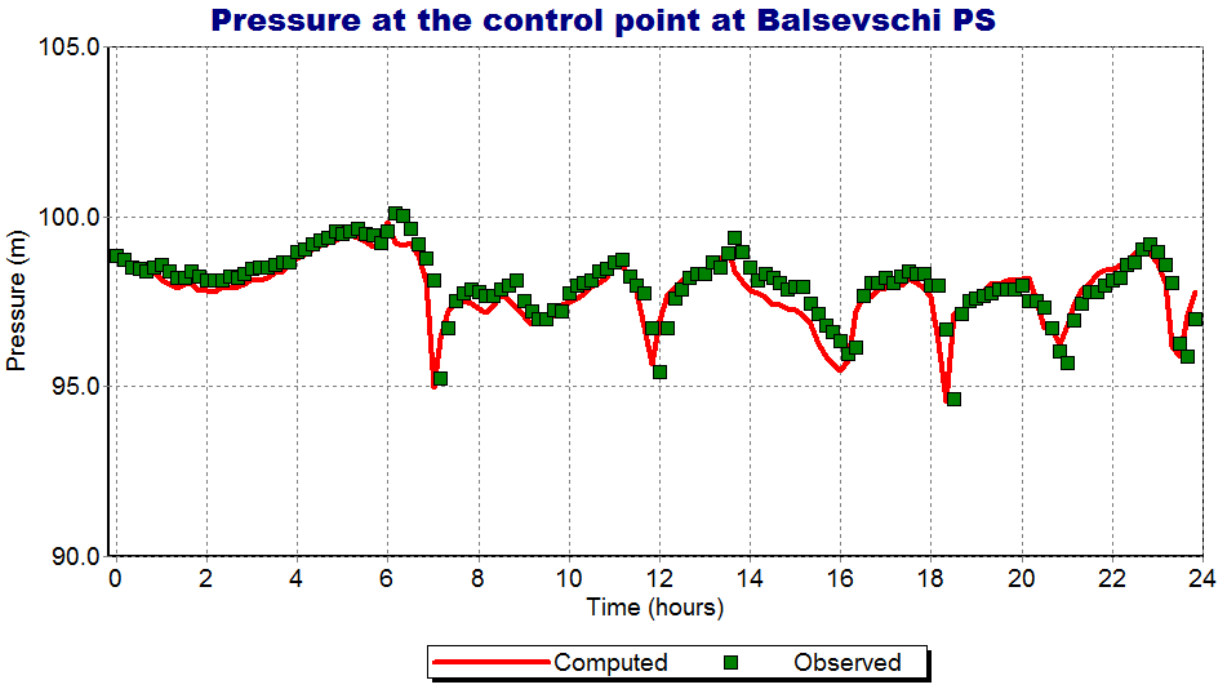

Pressure on the network at Petru rares
55.0
50.0
45.0
40.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

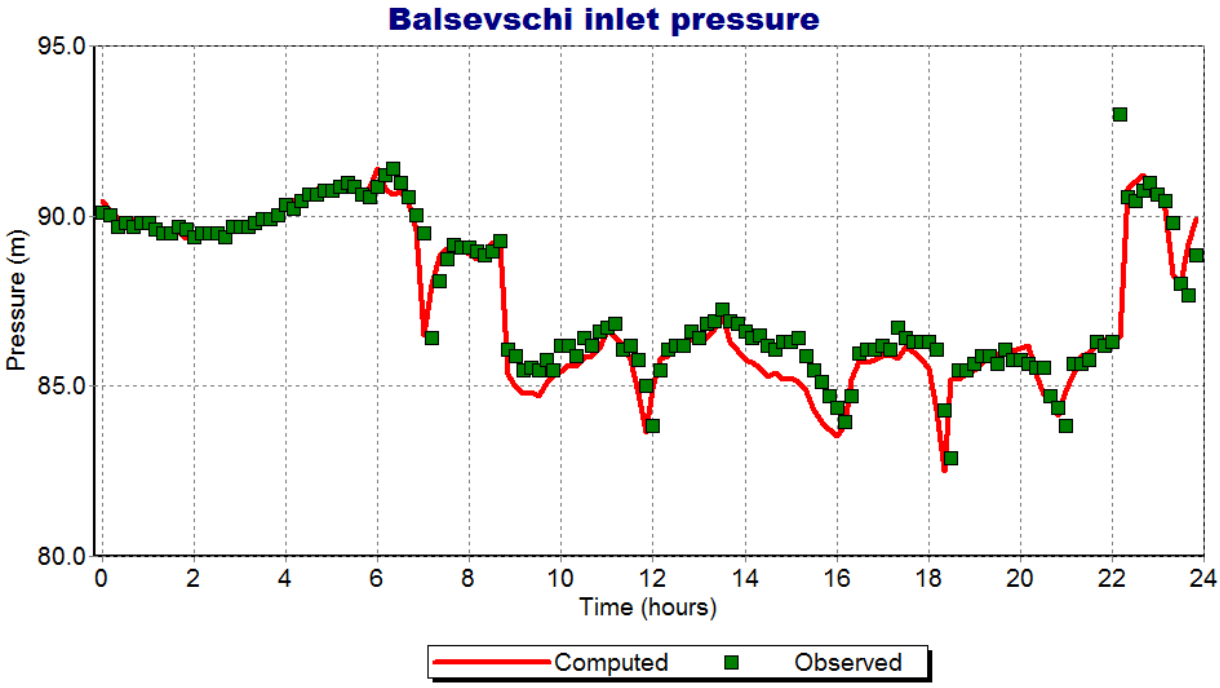


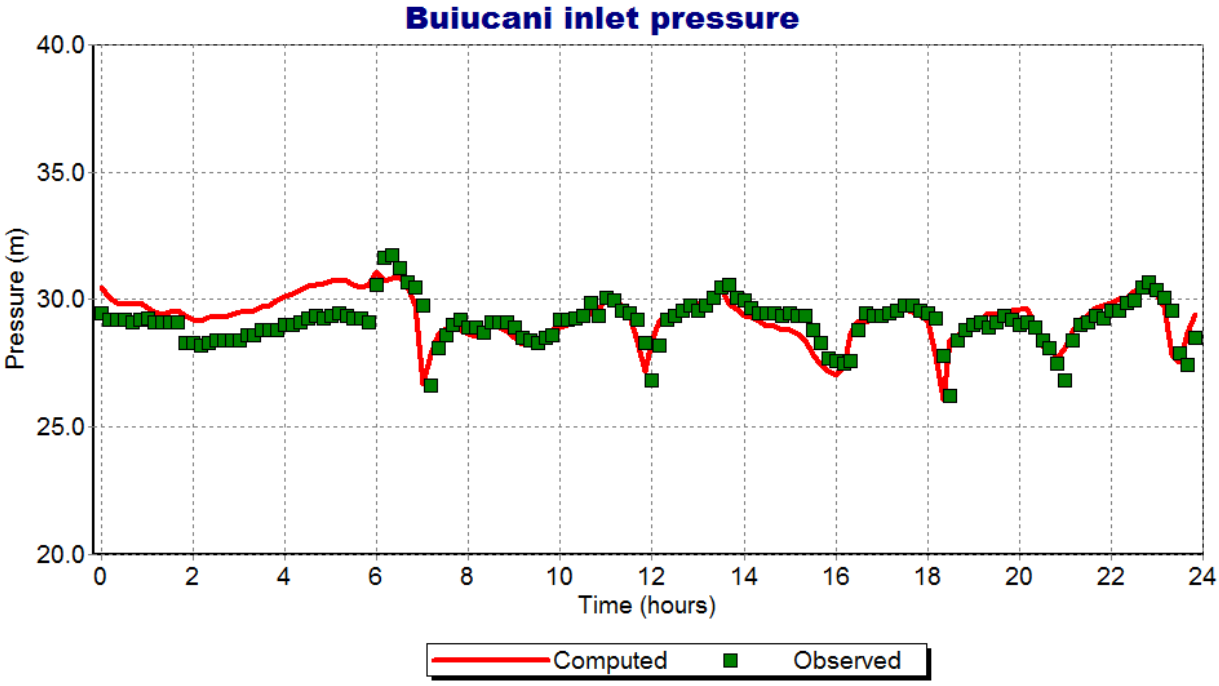
Zone 2 Oţel

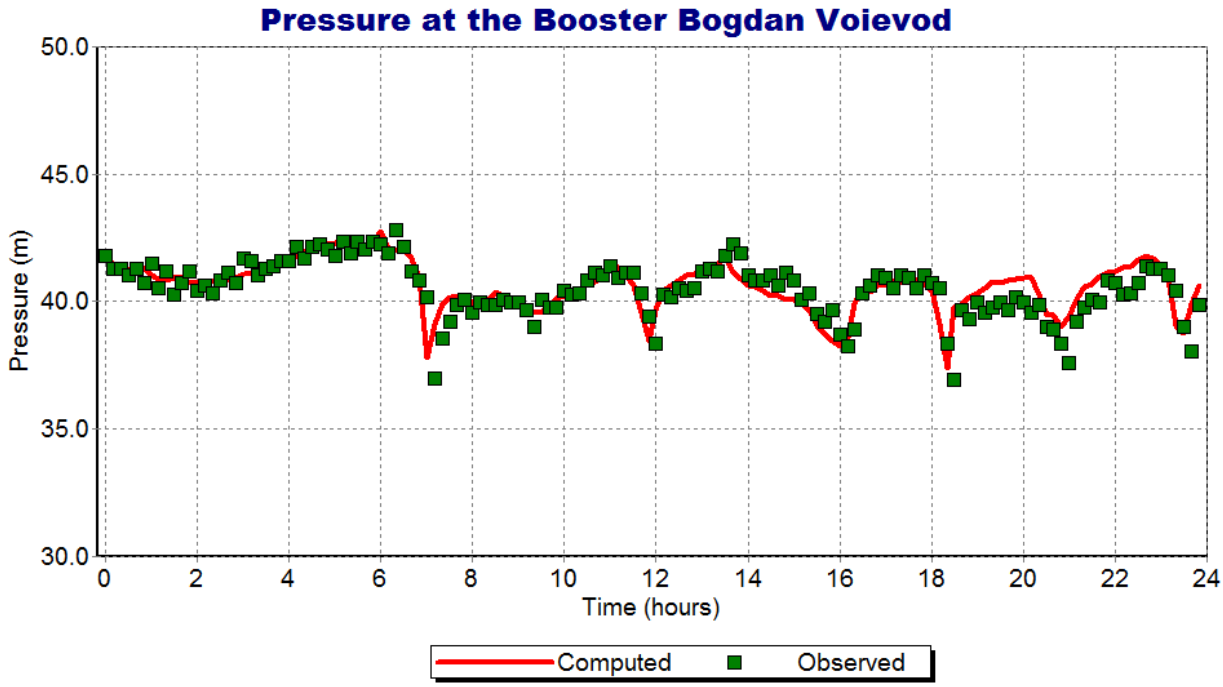
Pressure in the Zone 2 Oţel supplied by the outlet Oţel from the WTP

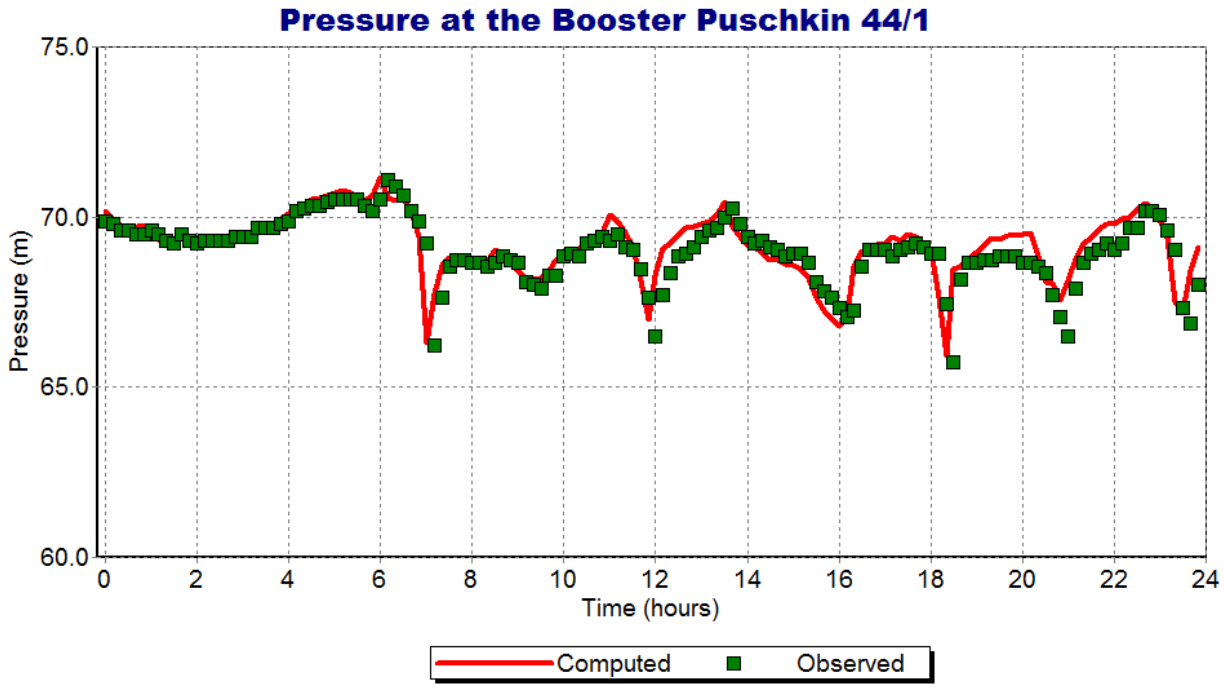


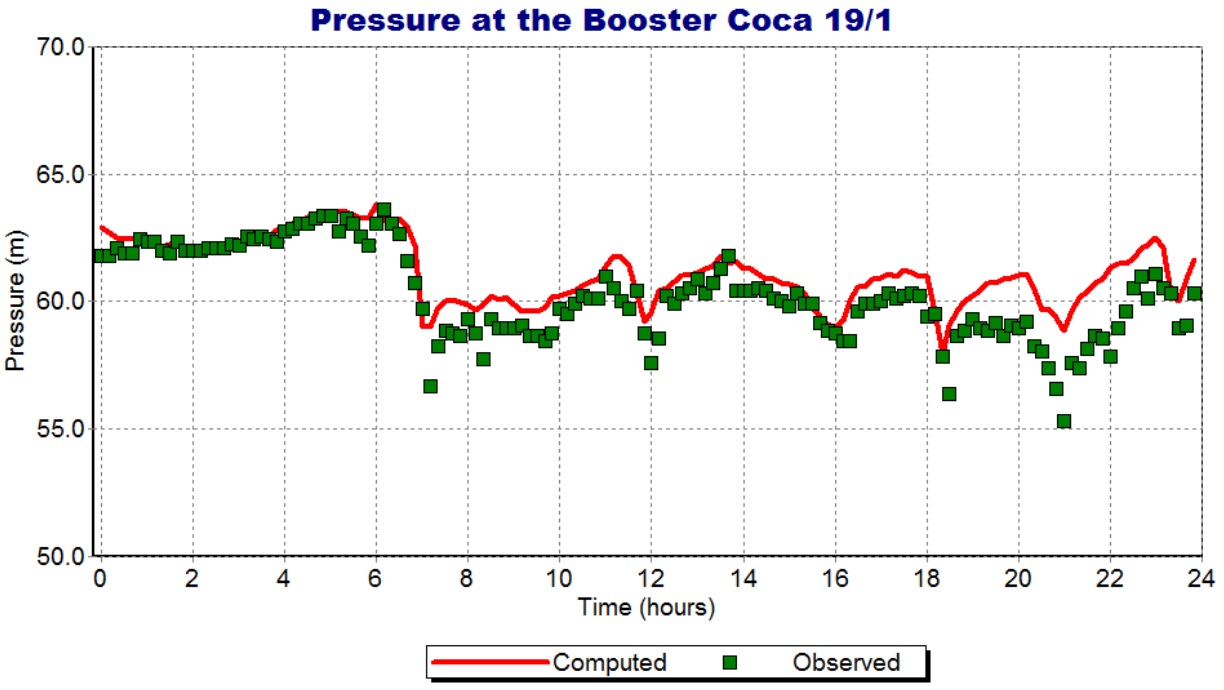

Pressure at the control point at Balsevschi PS
105.0
100.0
95.0
90.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

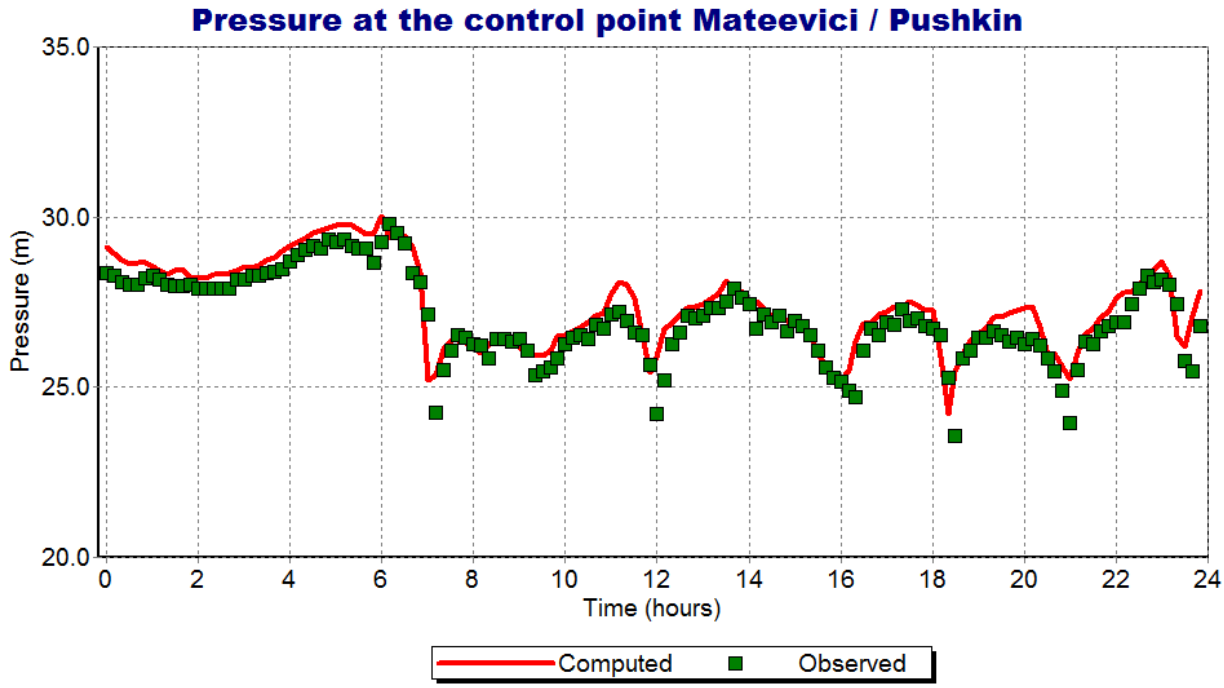

Balsevschi inlet pressure
95.0
90.0
85.0
80.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

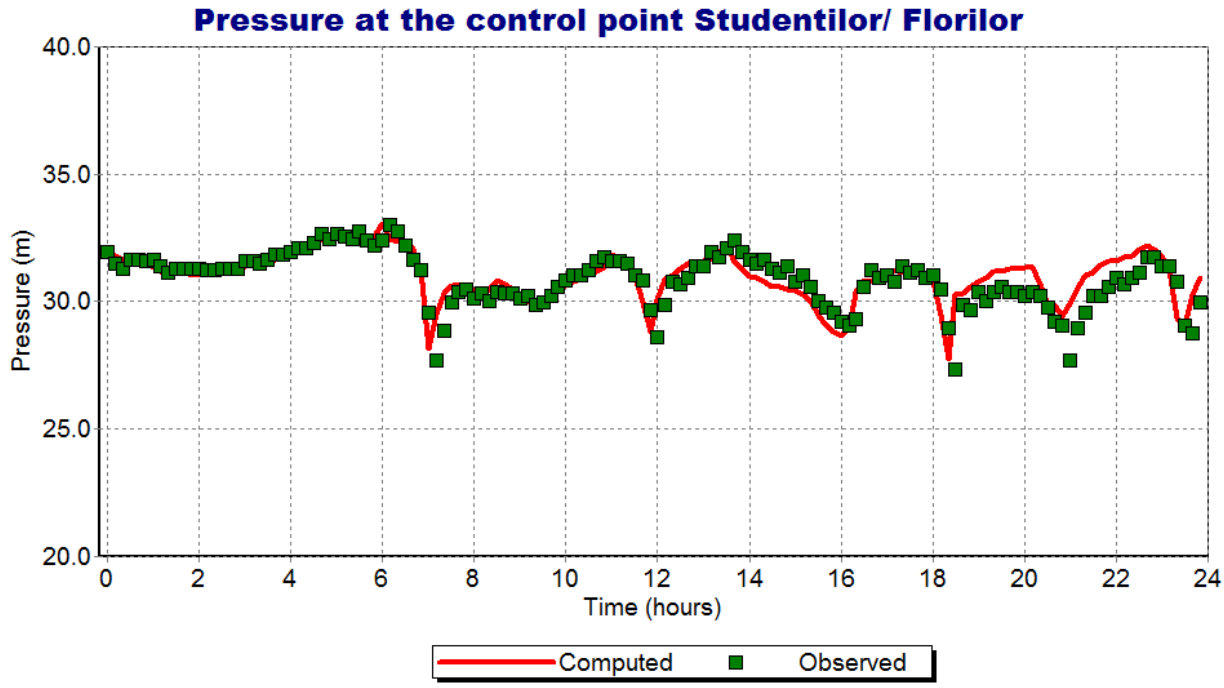

Buiucani inlet pressure
Pressure (m)
40.0
35.0
30.0
25.0
20.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the Booster Bogdan Voievod
Pressure (m)
50.0
45.0
40.0
35.0
30.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the Booster Puschkin 44/1
75.0
70.0
65.0
60.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

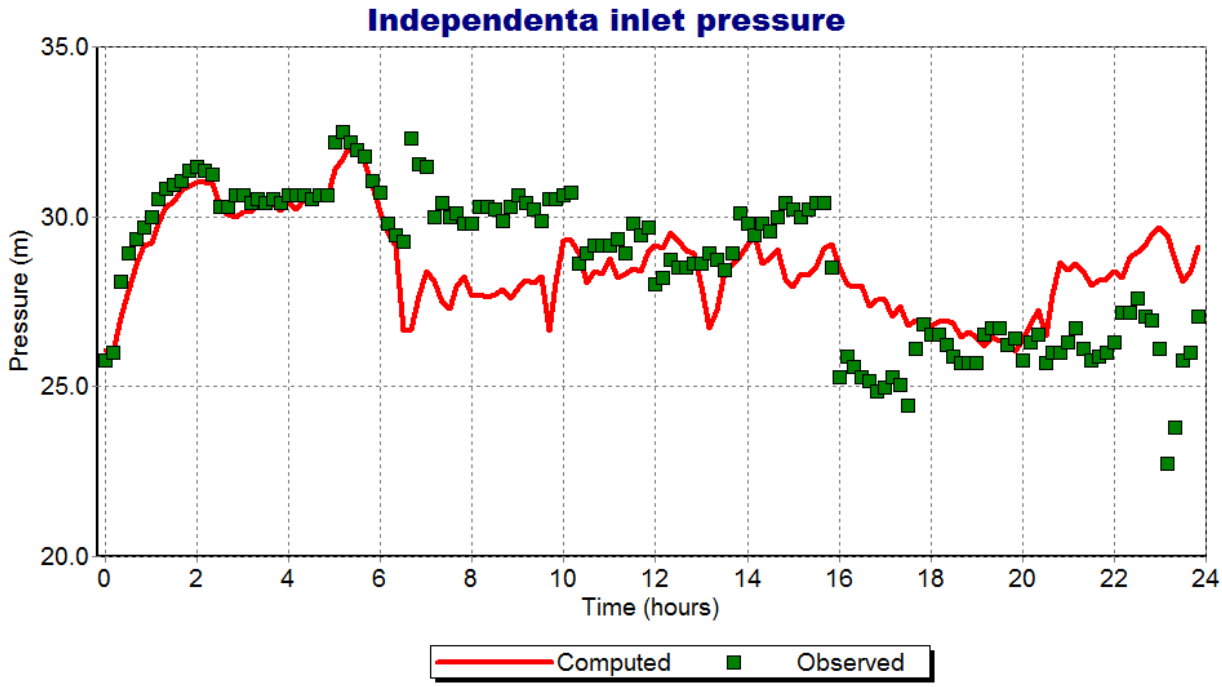

Pressure at the Booster Coca 19/1
70.0
65.0
60.0
55.0
50.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

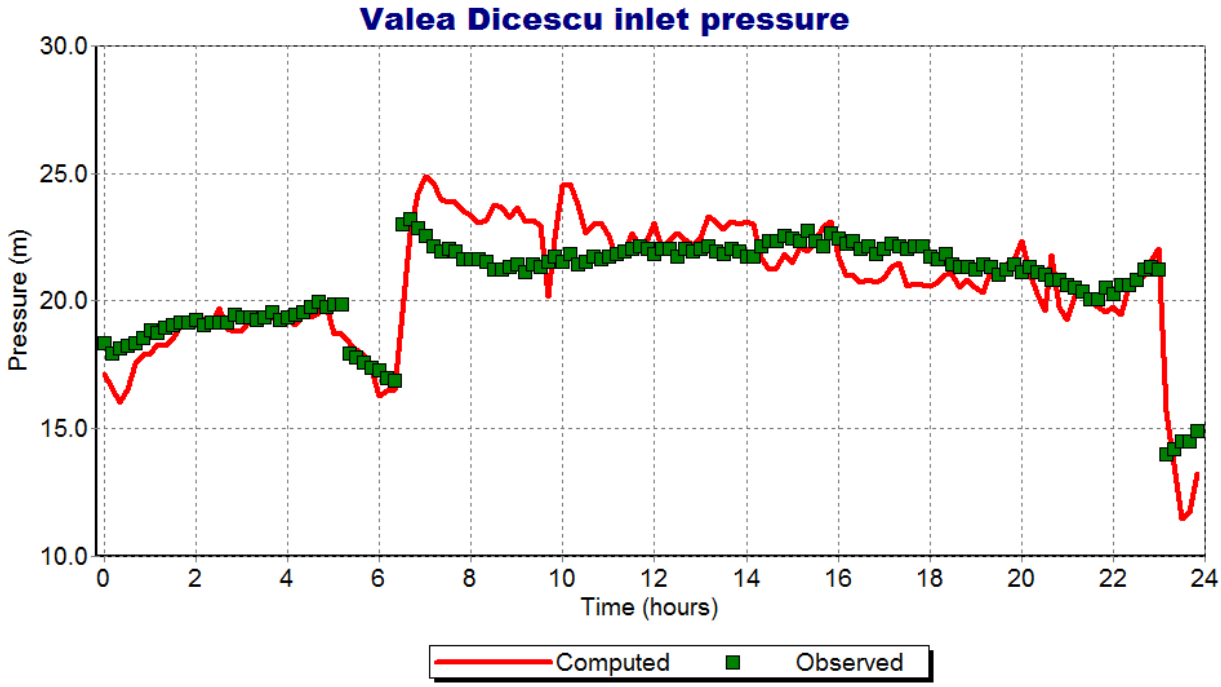

Pressure at the control point Mateevici / Pushkin
Pressure (m)
35.0
30.0
25.0
20.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

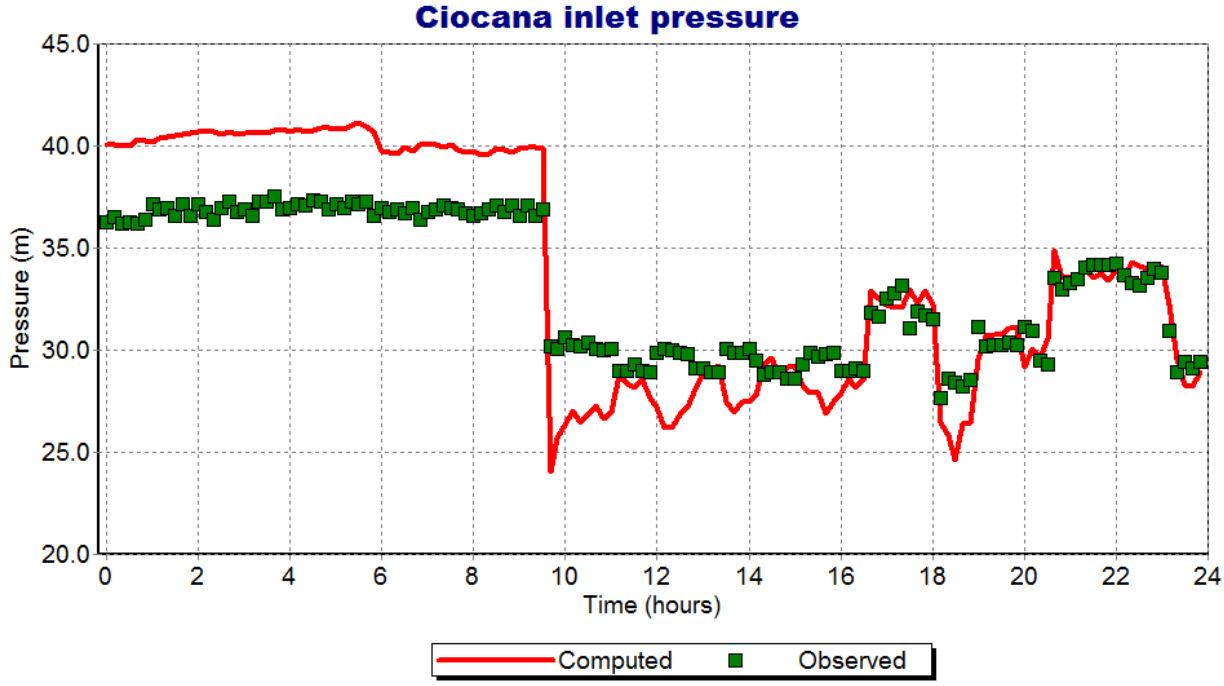

Pressure at the control point Studentilor/ Florilor
Pressure (m)
40.0
35.0
30.0
25.0
20.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

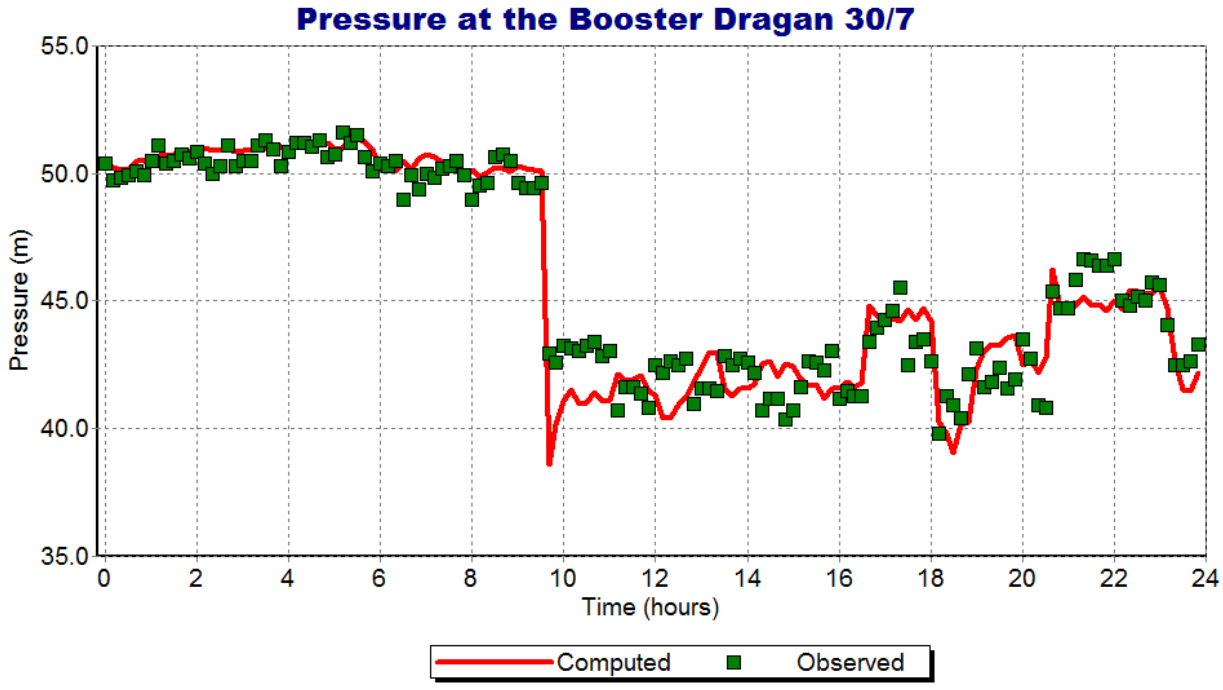
Zone 2 (Tohatin, Vostoc and Independenţa)

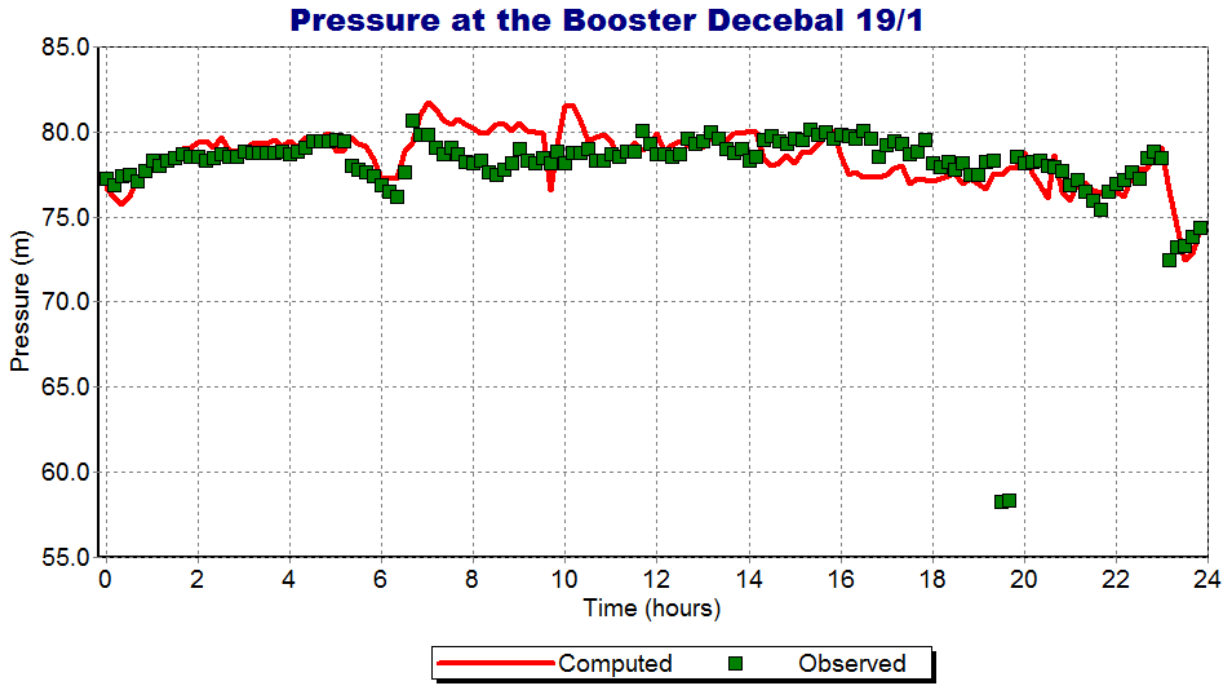
Pressure in the Zone 2 supplied by the outlets Vostoc and Independenţa from the WTP and by the Reservoirs of Tohatin PS

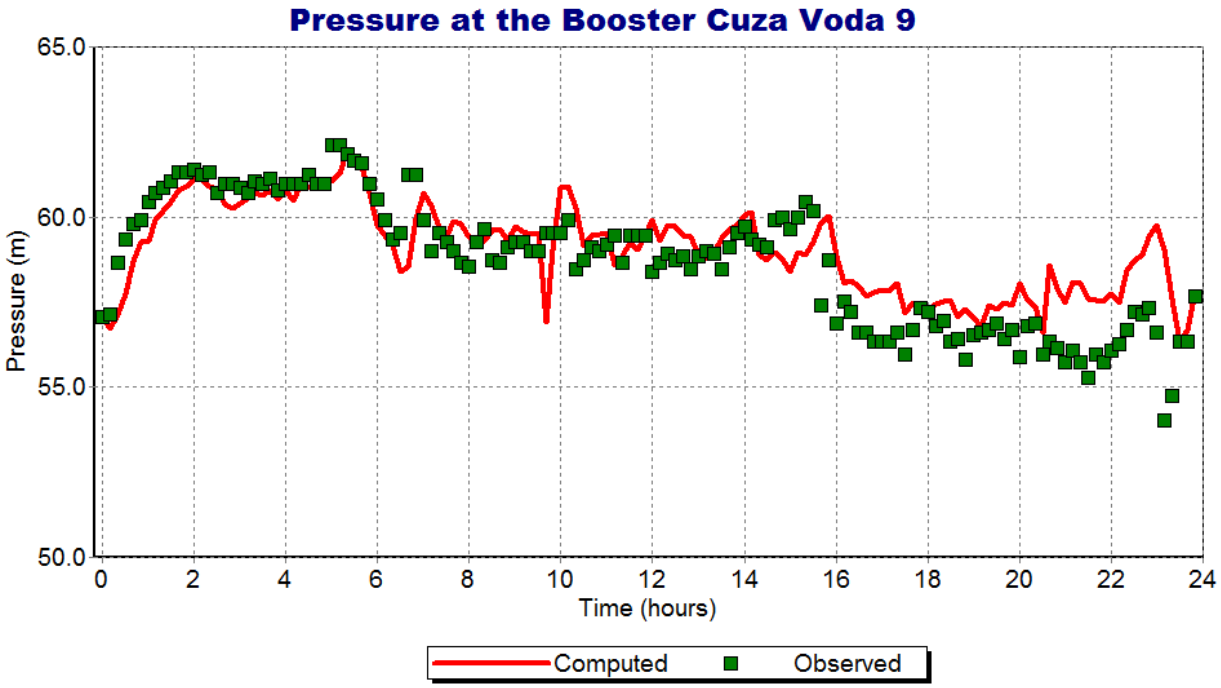


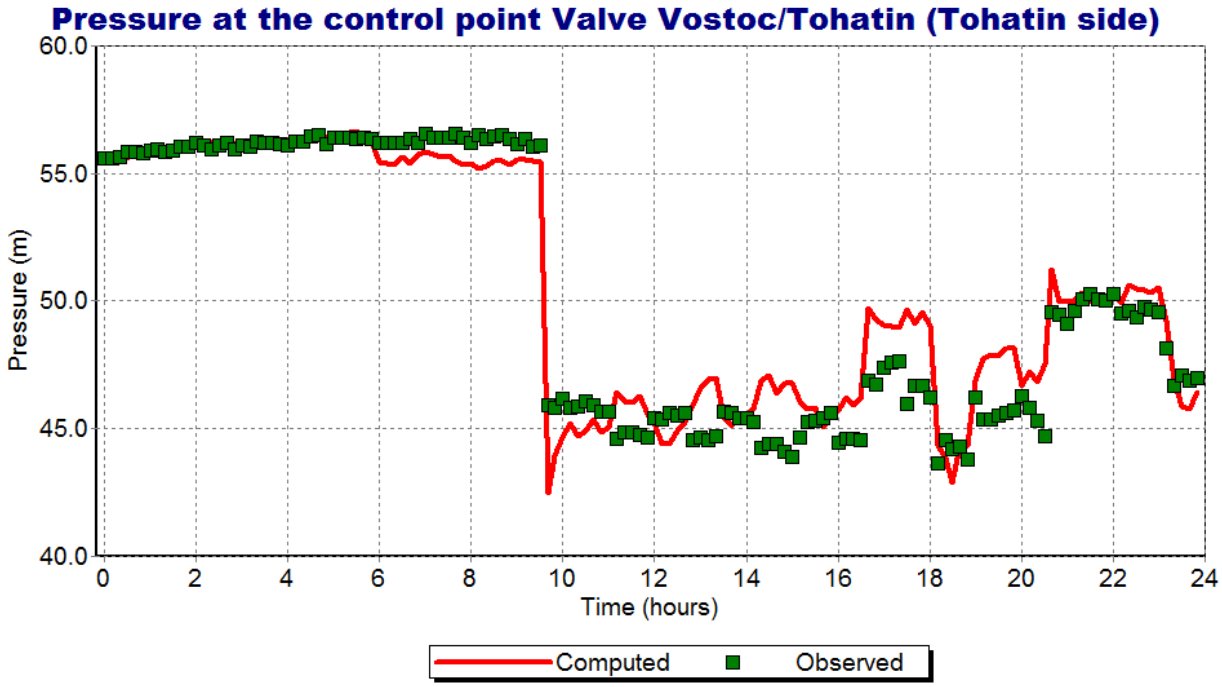


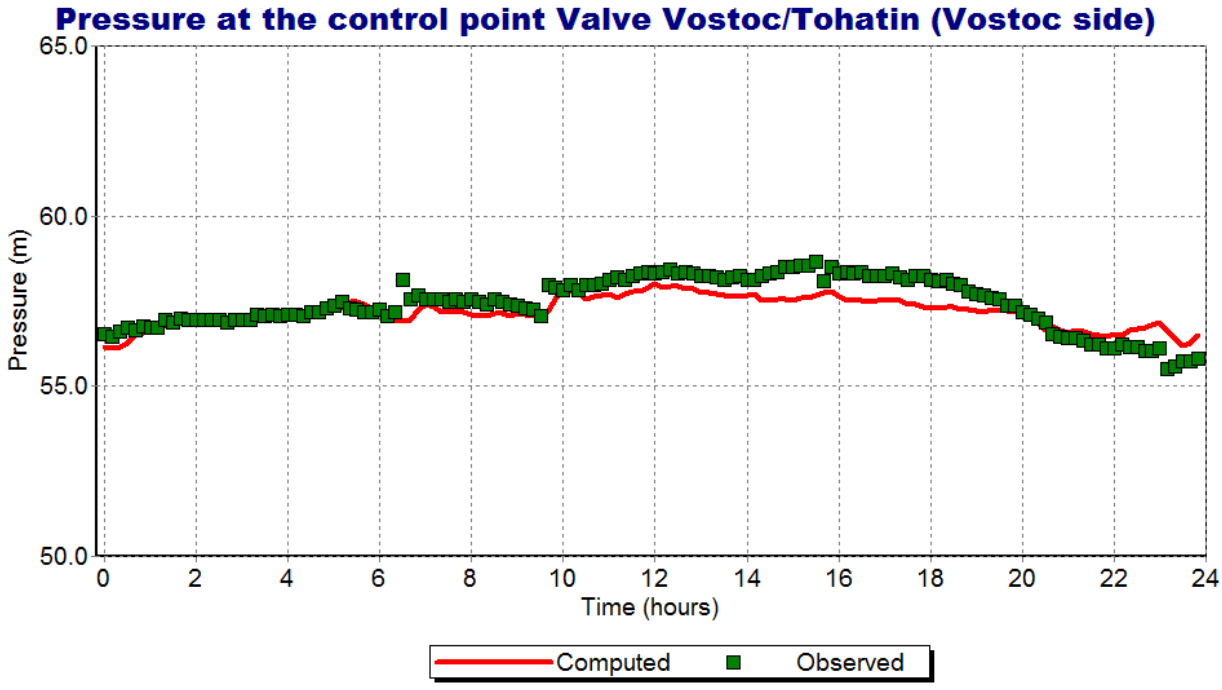

Ciocana inlet pressure
45.0
40.0
35.0
30.0
25.0
20.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

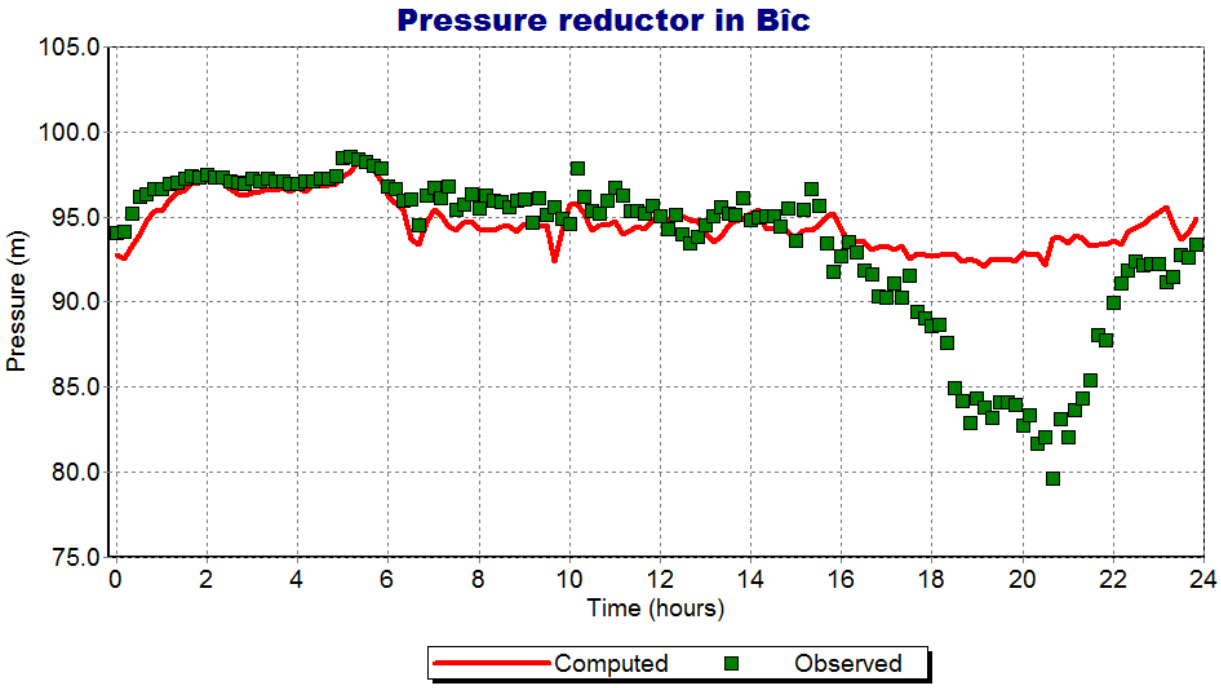

Pressure at the Booster Dragan 30/7
55.0
50.0
45.0
40.0
35.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

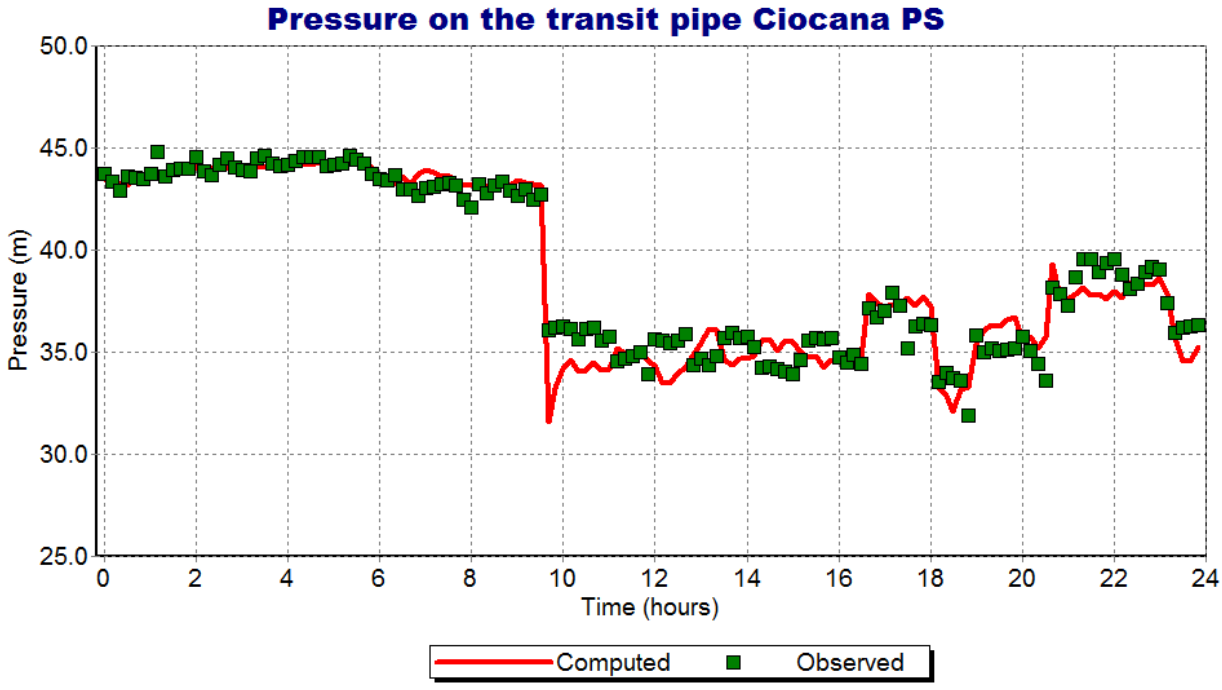

Pressure at the Booster Decebal 19/1
Pressure (m)
85.0
80.0
75.0
70.0
65.0
60.0
55.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the Booster Cuza Voda 9
Pressure (m)
65.0
60.0
55.0
50.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

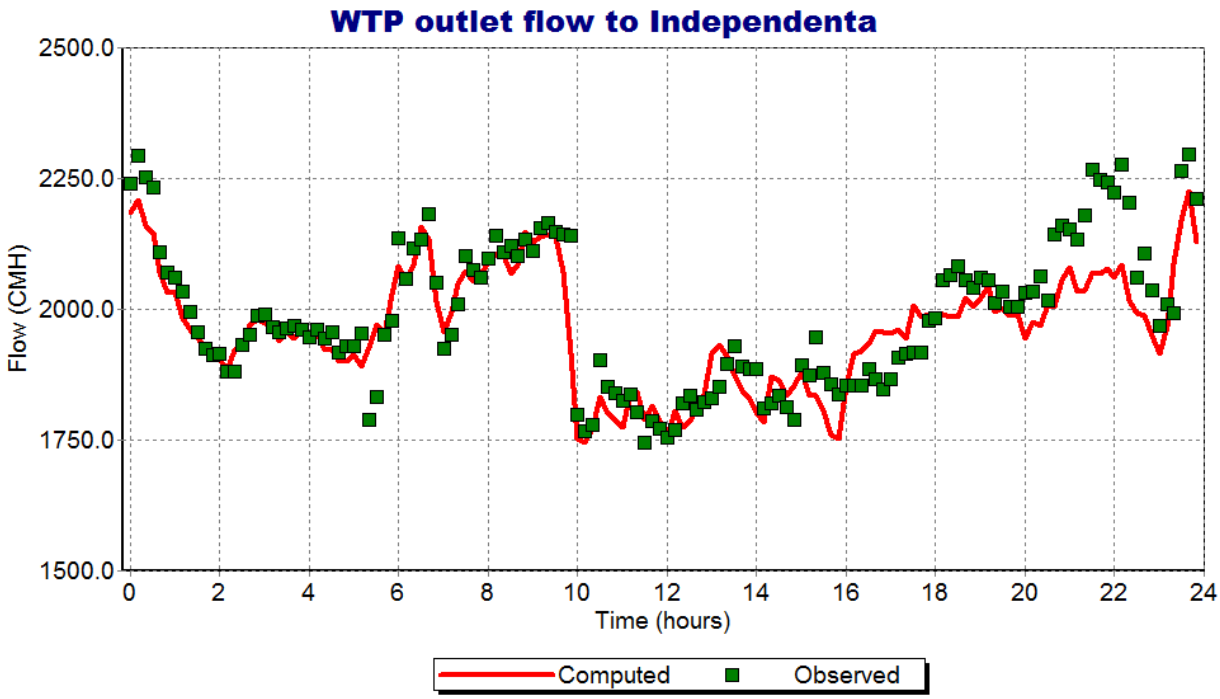

Pressure at the control point Valve Vostoc/Tohatin (Tohatin side)
60.0
55.0
50.0
45.0
40.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

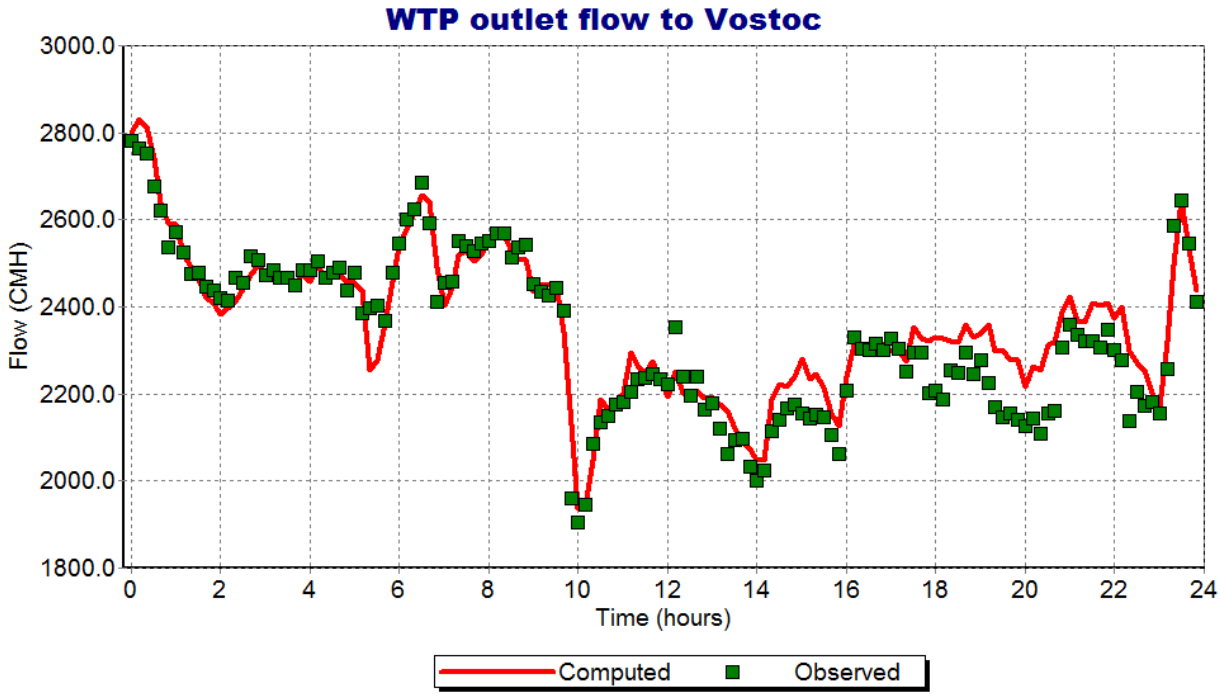

Pressure at the control point Valve Vostoc/Tohatin (Vostoc side)
65.0
60.0
55.0
50.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

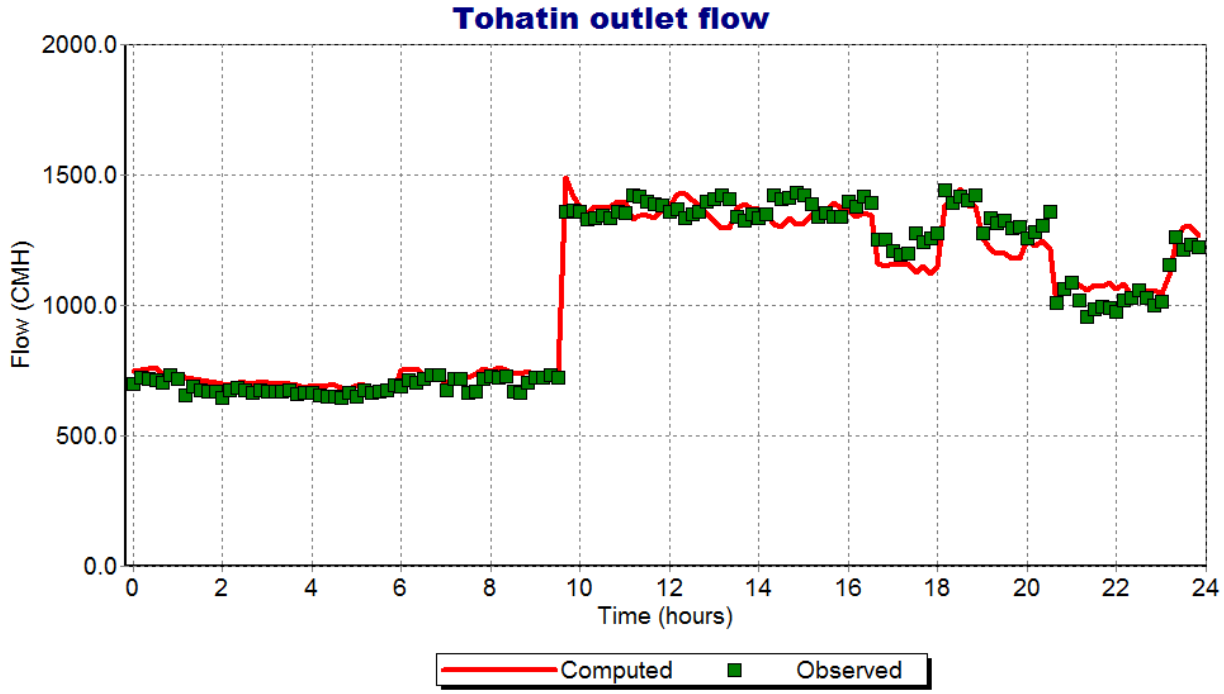

Pressure reductor in Bîc
105.0
100.0
95.0
90.0
85.0
80.0
75.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

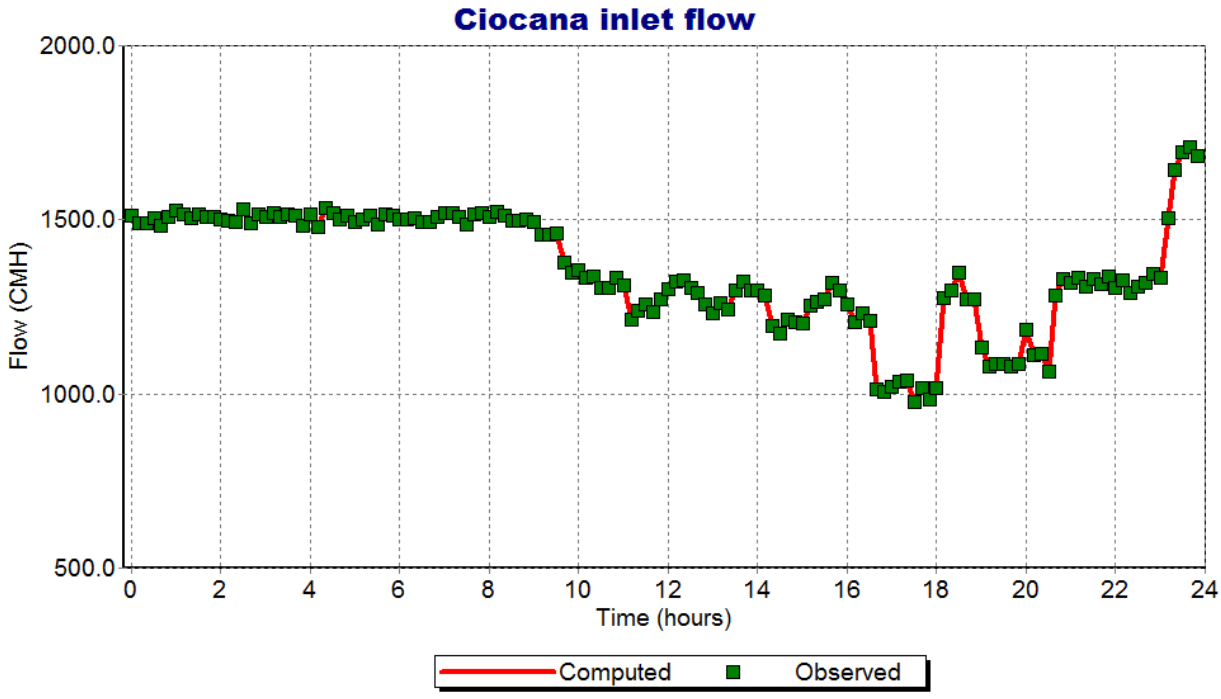

Pressure on the transit pipe Ciocana PS
50.0
45.0
40.0
35.0
30.0
25.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

Flow in the Zone 2 supplied by the outlets Vostoc and Independenţa from the WTP and by the Reservoirs of Tohatin PS



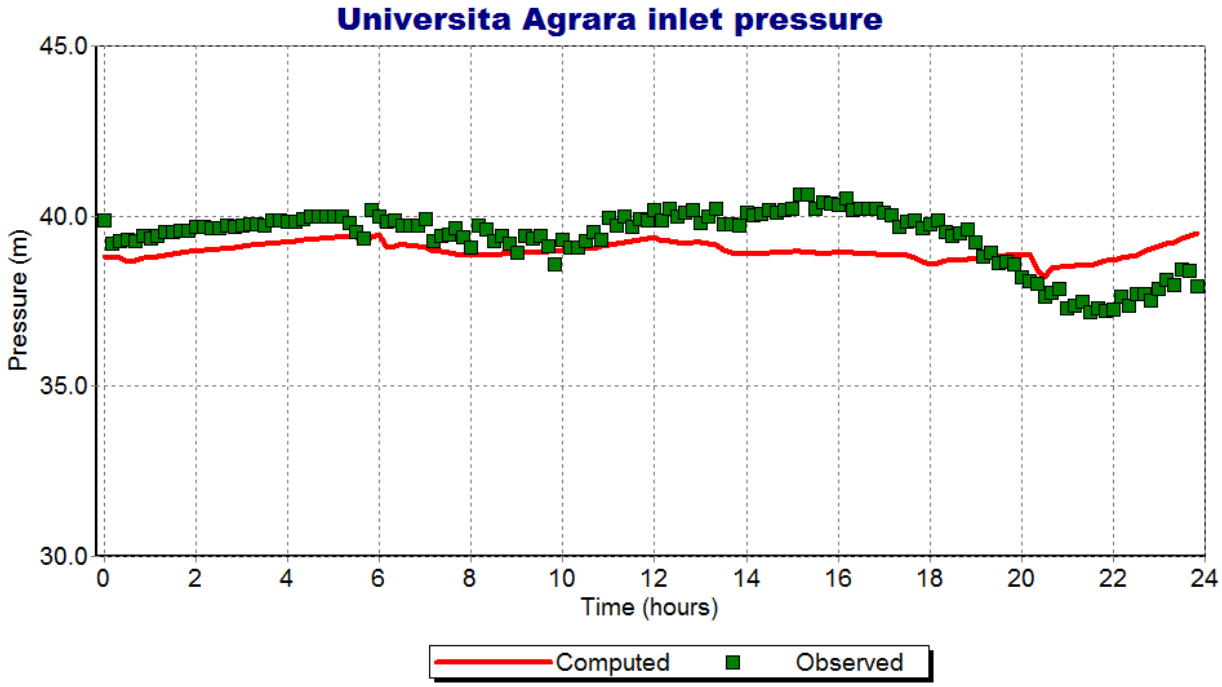


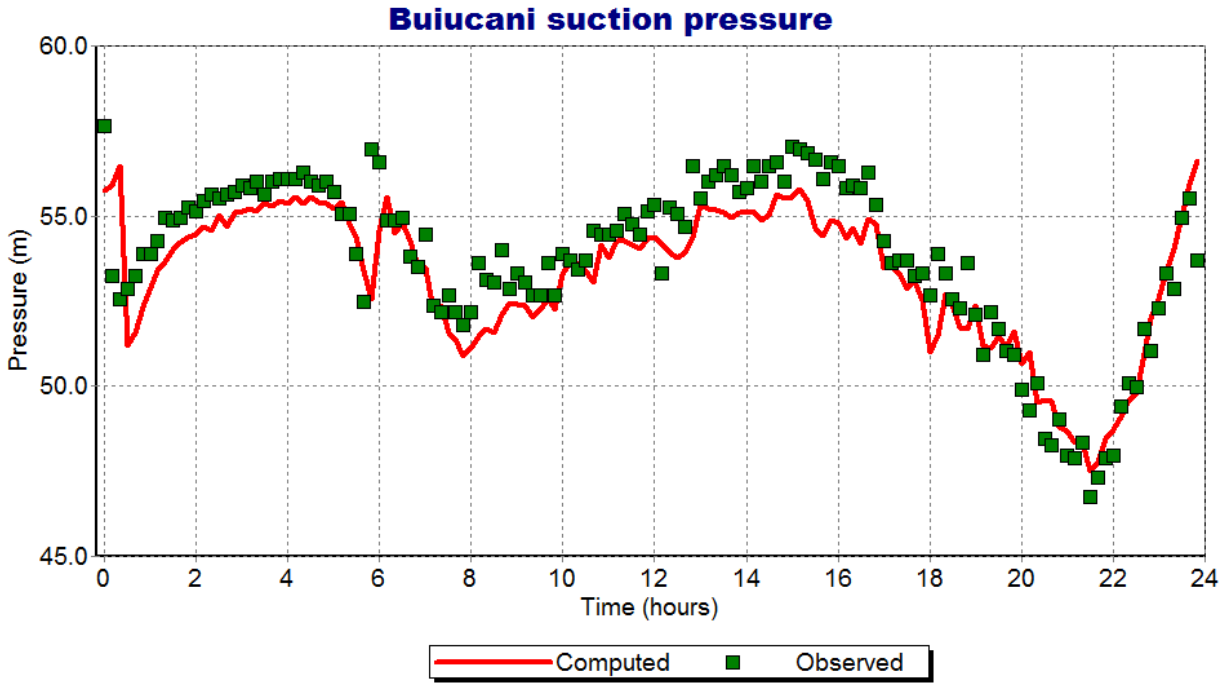

Tohatin outlet flow
2000.0
1500.0
1000.0
500.0
0.0
Flow (CMH)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

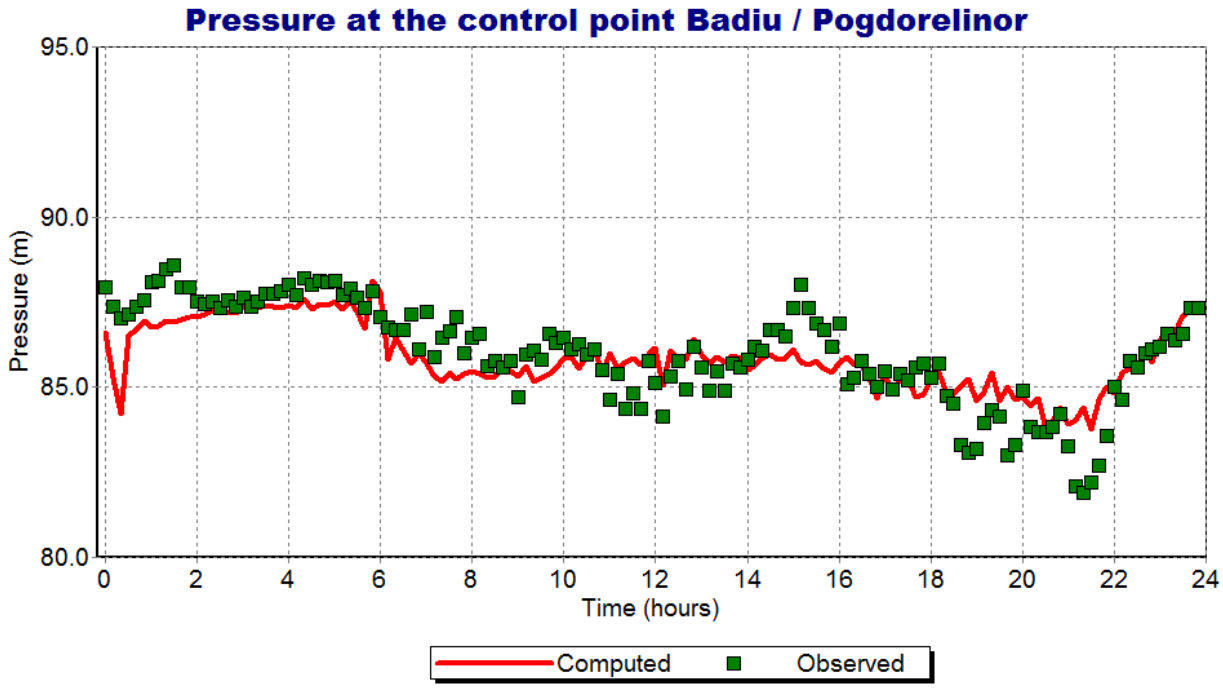

Ciocana inlet flow
2000.0
1500.0
1000.0
500.0
Flow (CMH)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

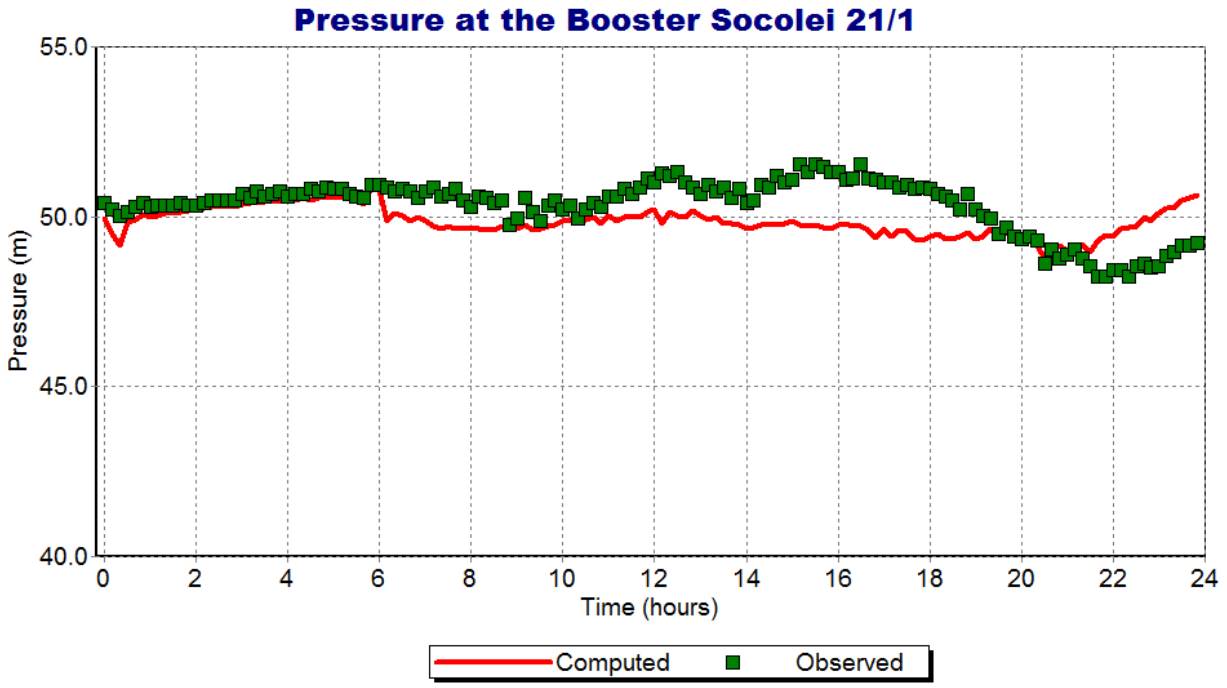
Zone 2 Doina

Pressure in the Zone 2 Doina supplied by the outlet Doina from the WTP



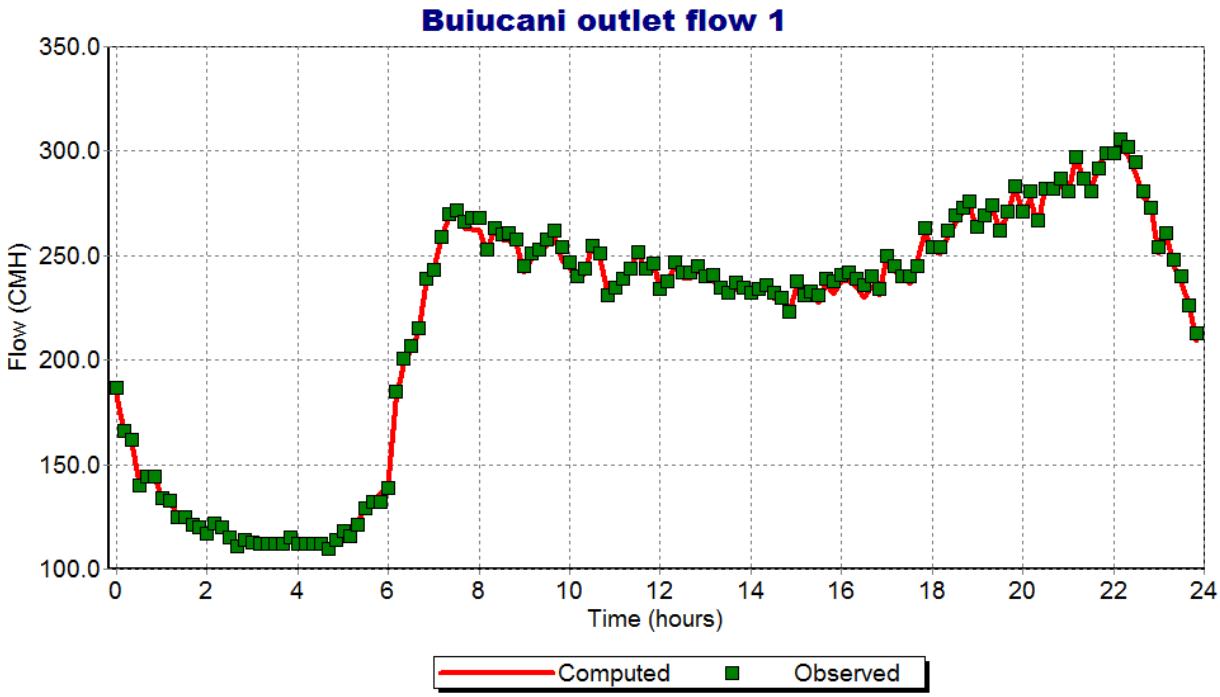


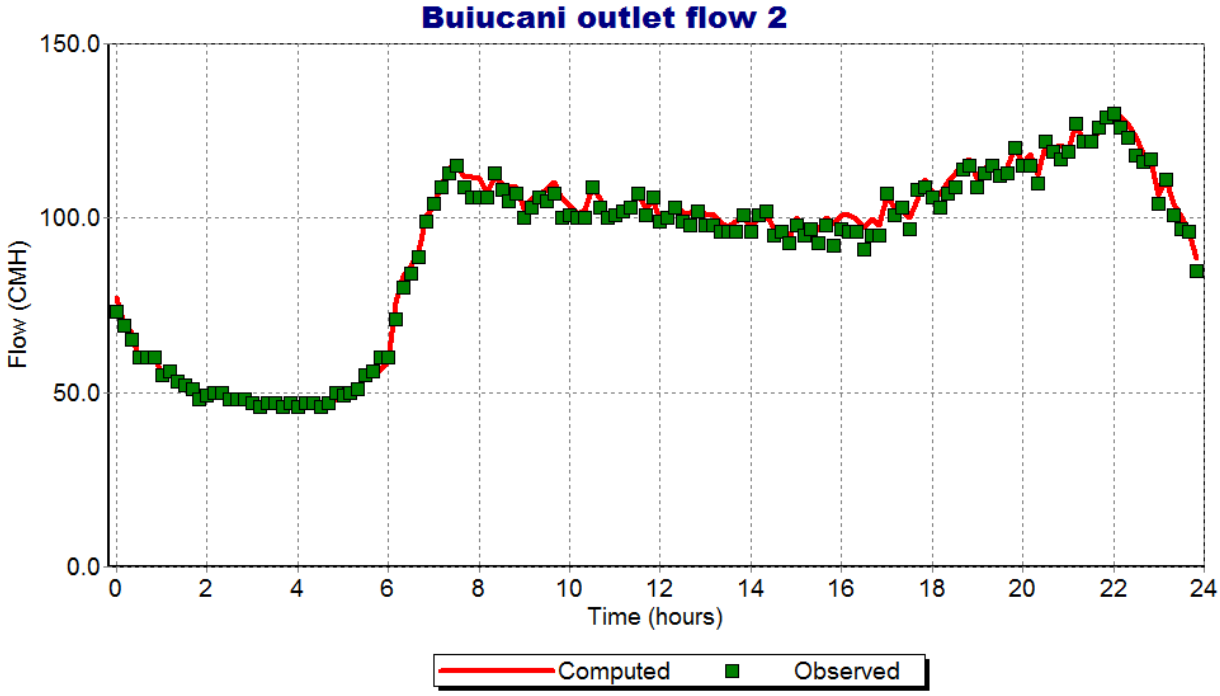

Pressure at the control point Badiu / Pogdorelinor
95.0
90.0
85.0
80.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the Booster Socolei 21/1
55.0
50.0
45.0
40.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

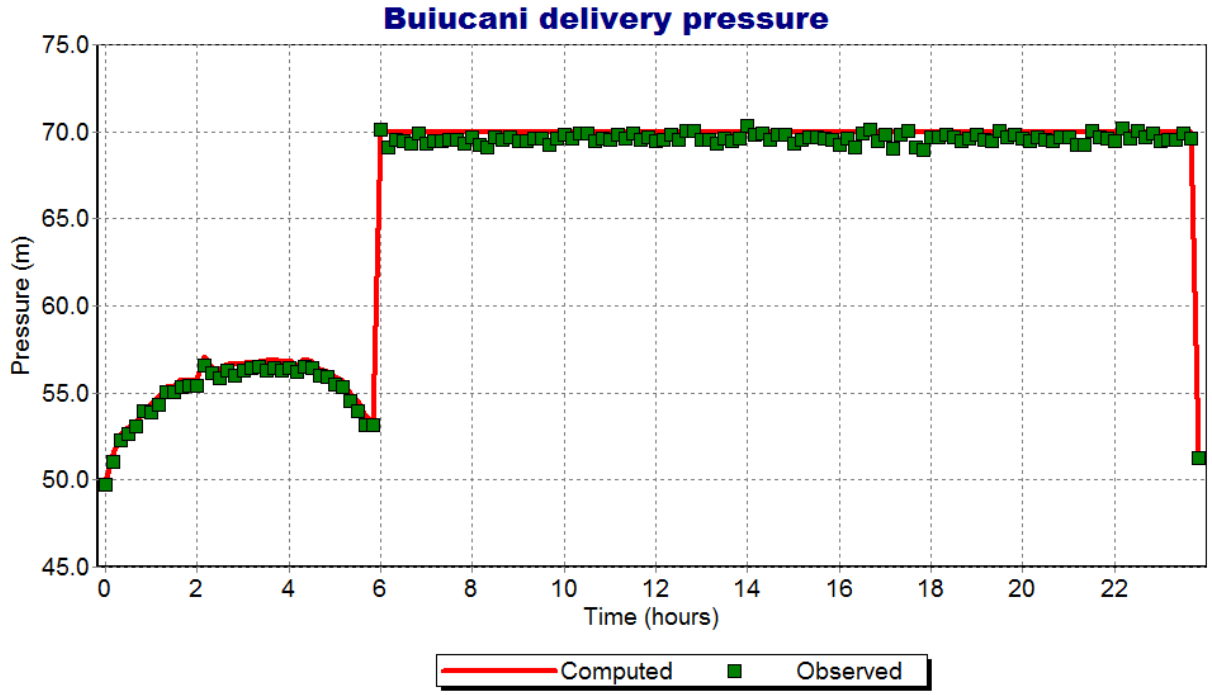
Zone 3 Buiucani

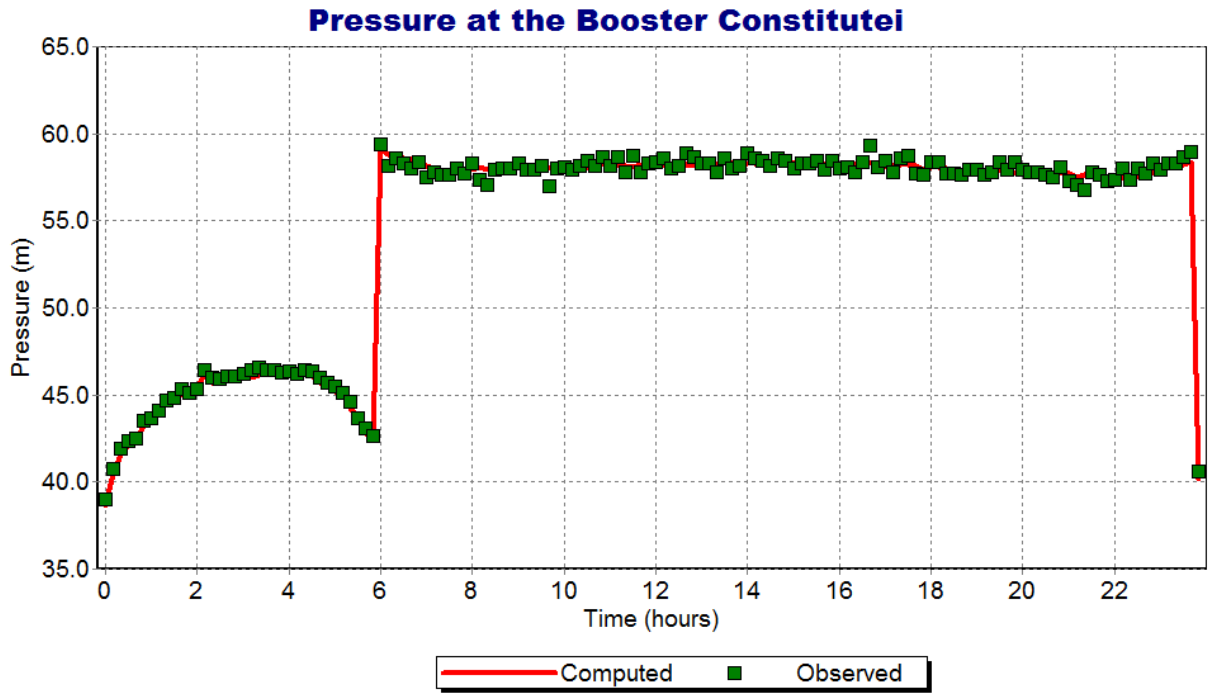
Flow in the Zone 3 Buiucani

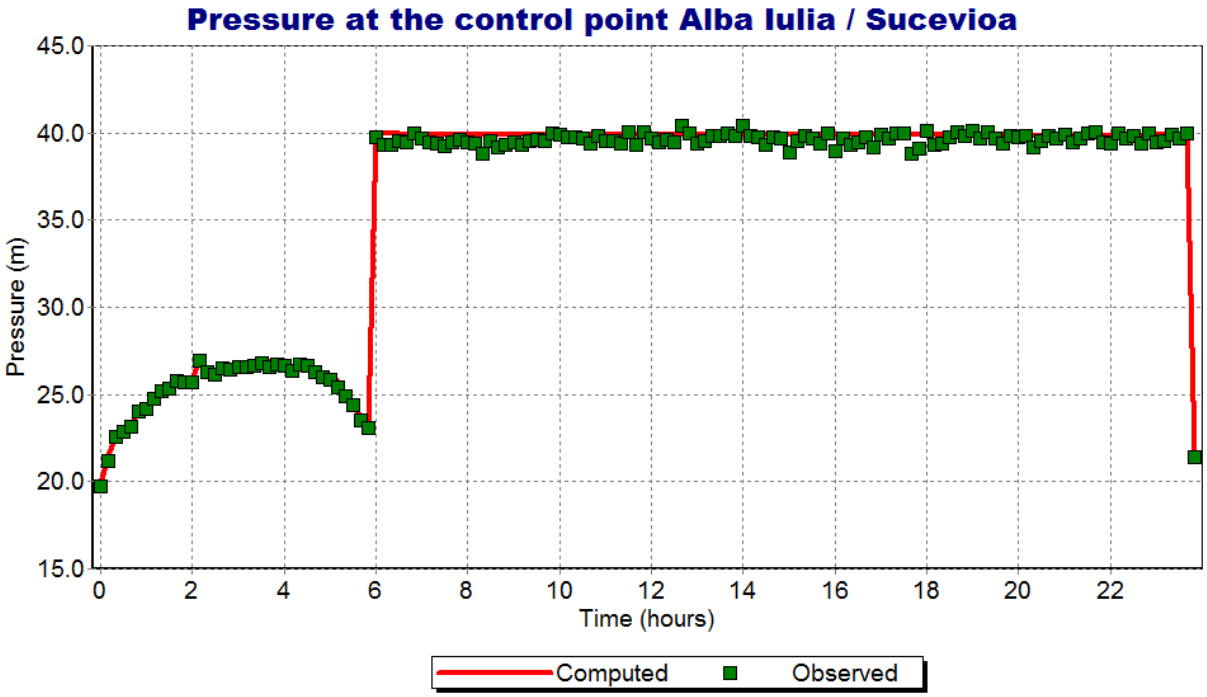




Pressure in the Zone 3 Buiucani

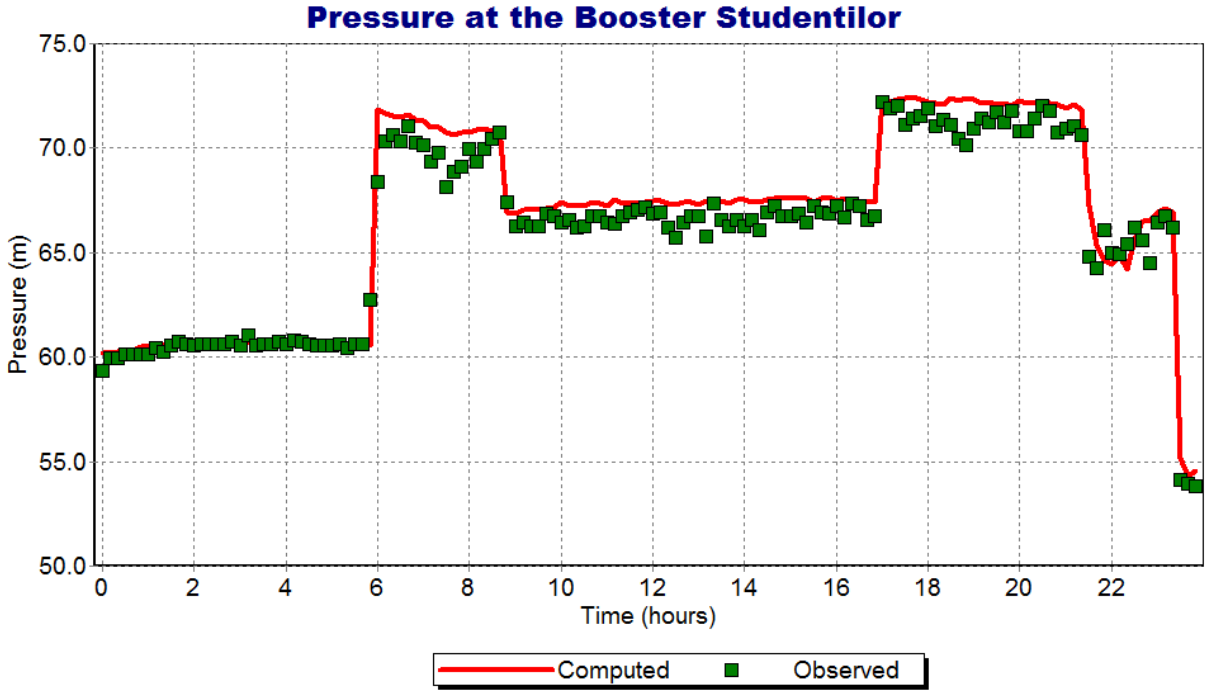


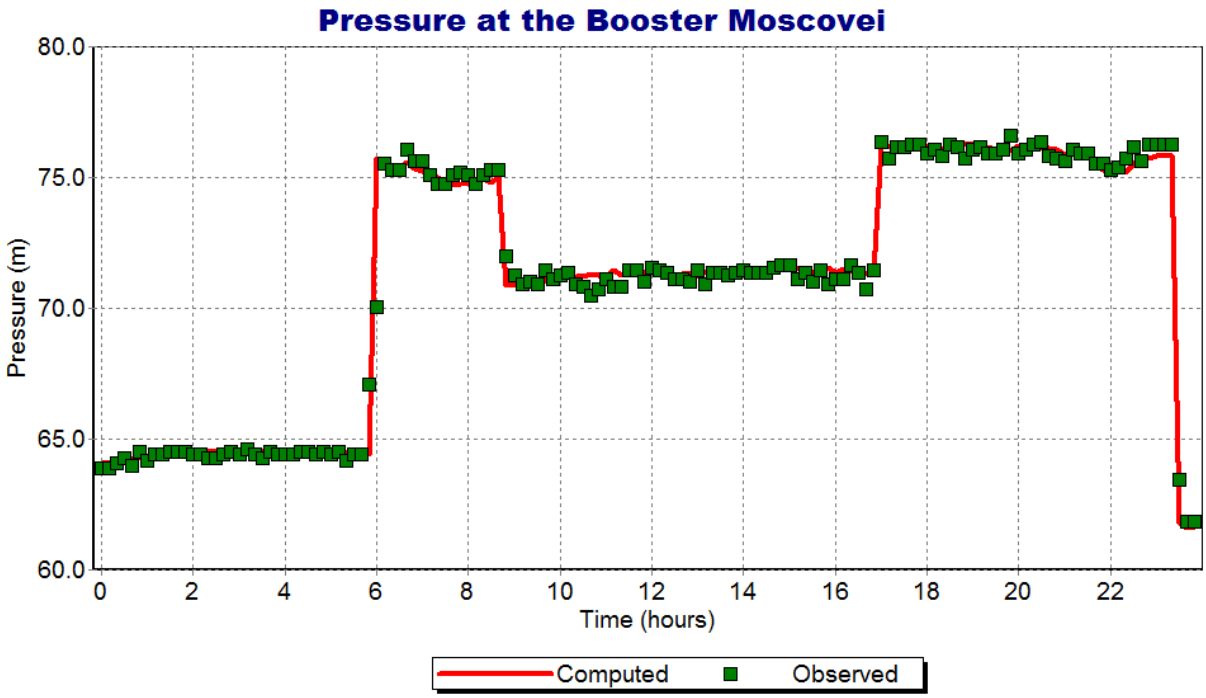


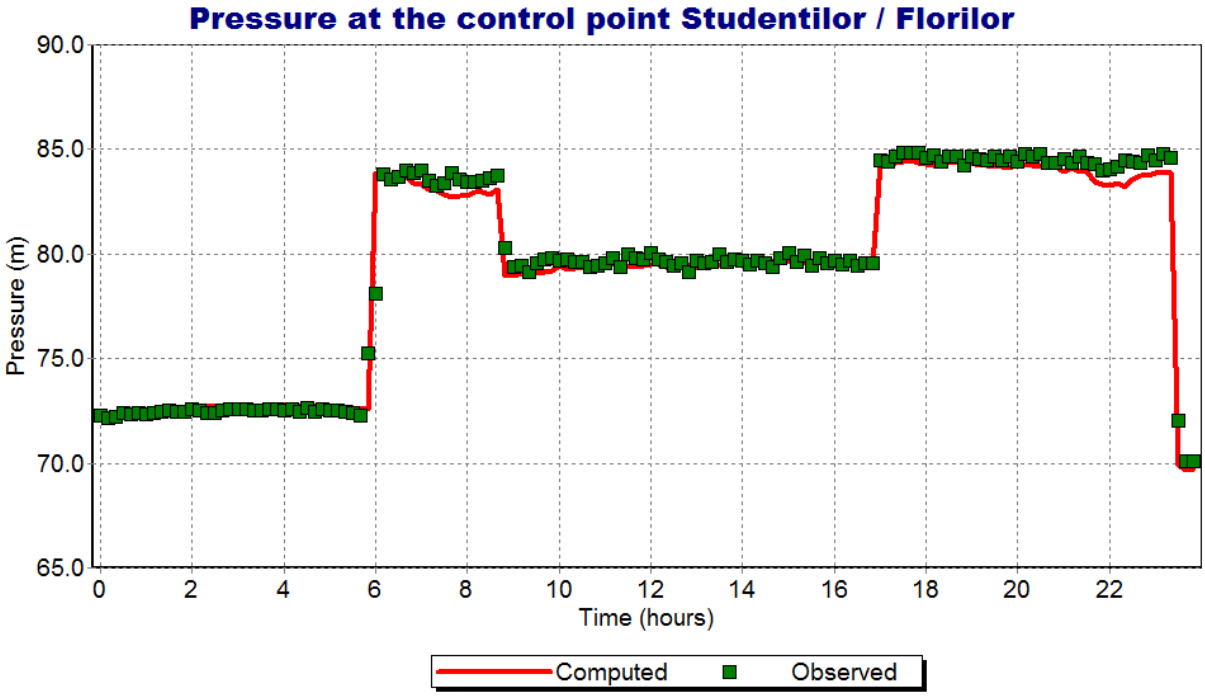


Zone 3 Rîscani

Pressure in the Zone 3 Rîscani

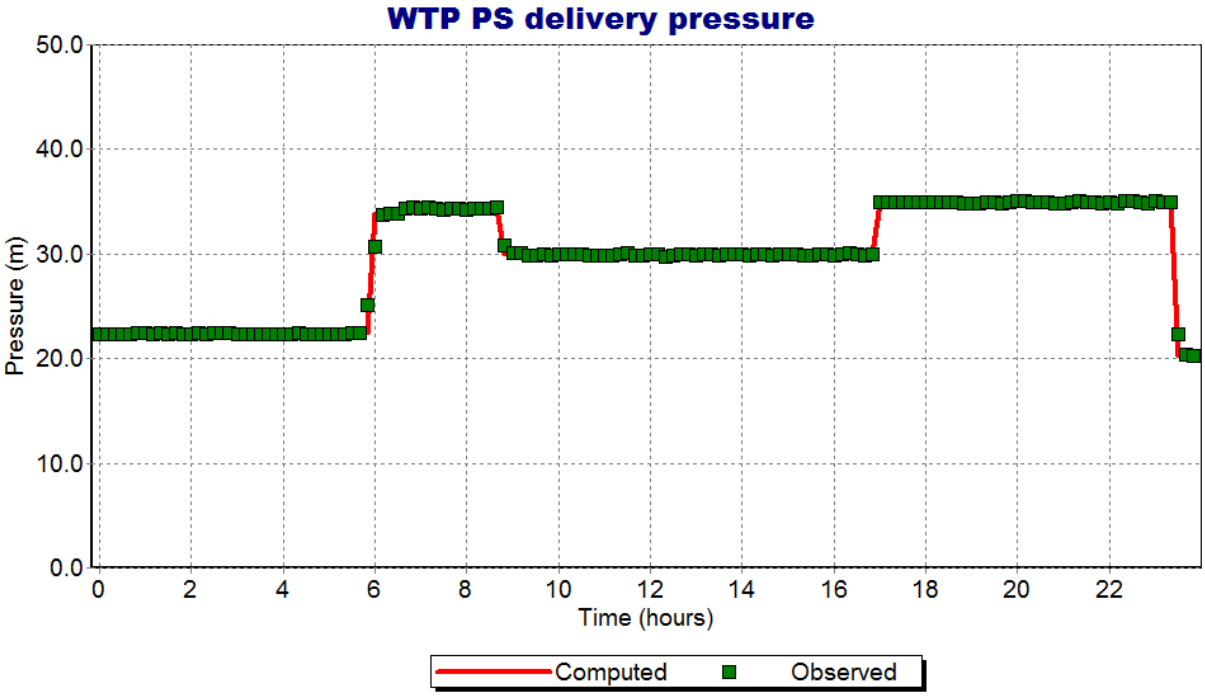


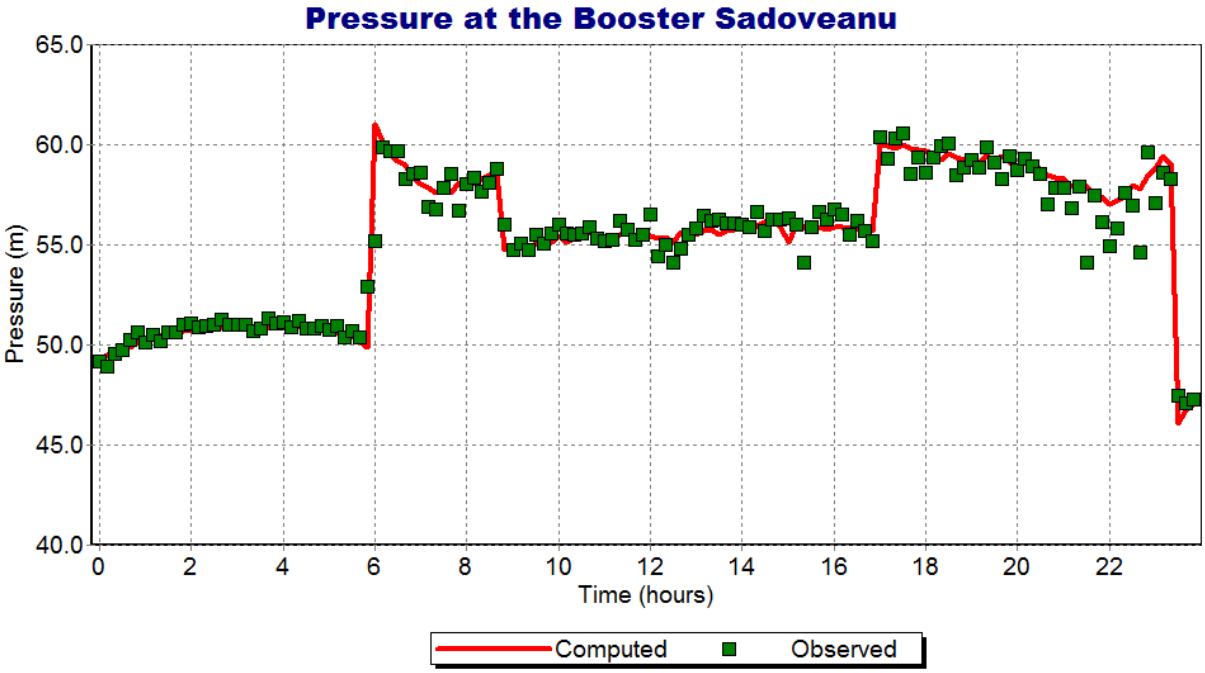

Pressure at the Booster Moscovei
Pressure (m)
80.0
75.0
70.0
65.0
60.0
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed


Pressure at the control point Studentilor / Florilor
Pressure (m)
90.0
85.0
80.0
75.0
70.0
65.0
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

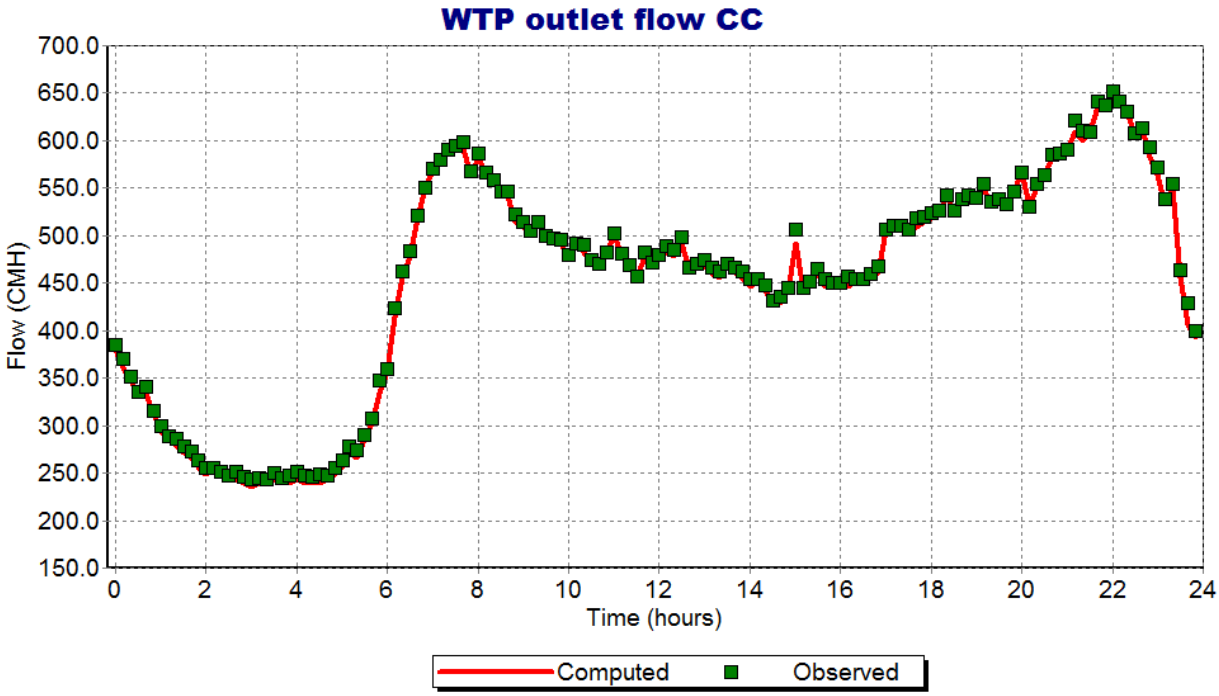
Zone 3 Ciocana

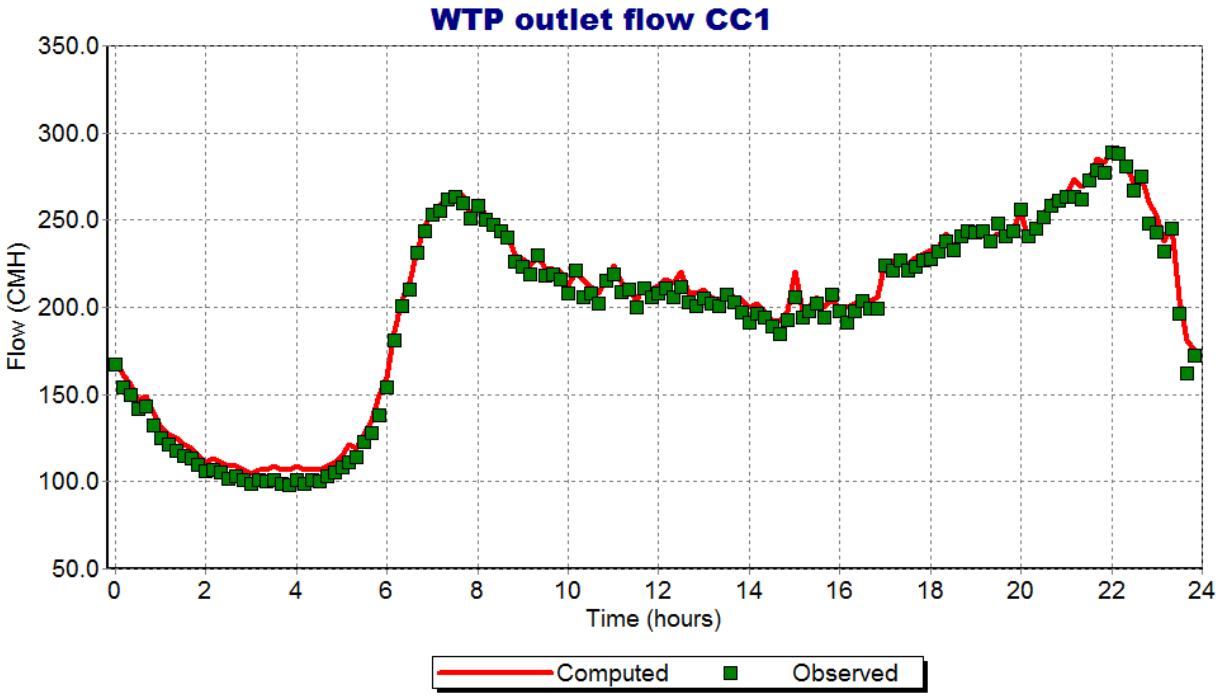
Pressure in the Zone 3 Ciocana





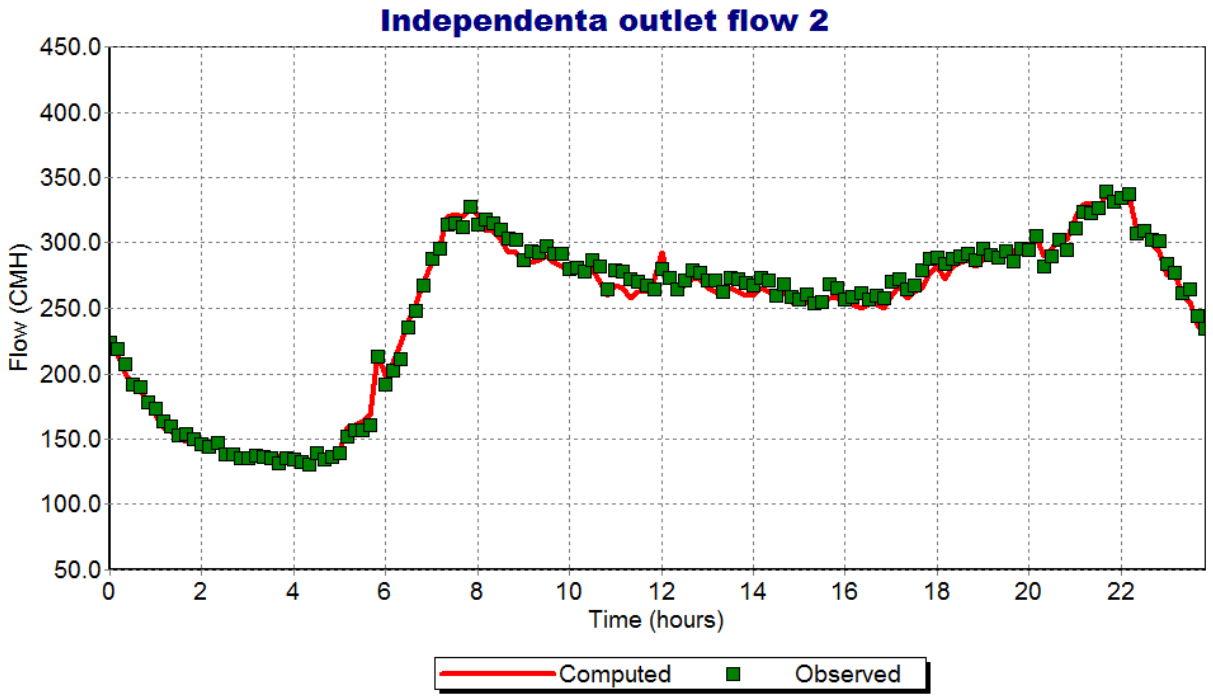
Flow in the Zone 3 Ciocana

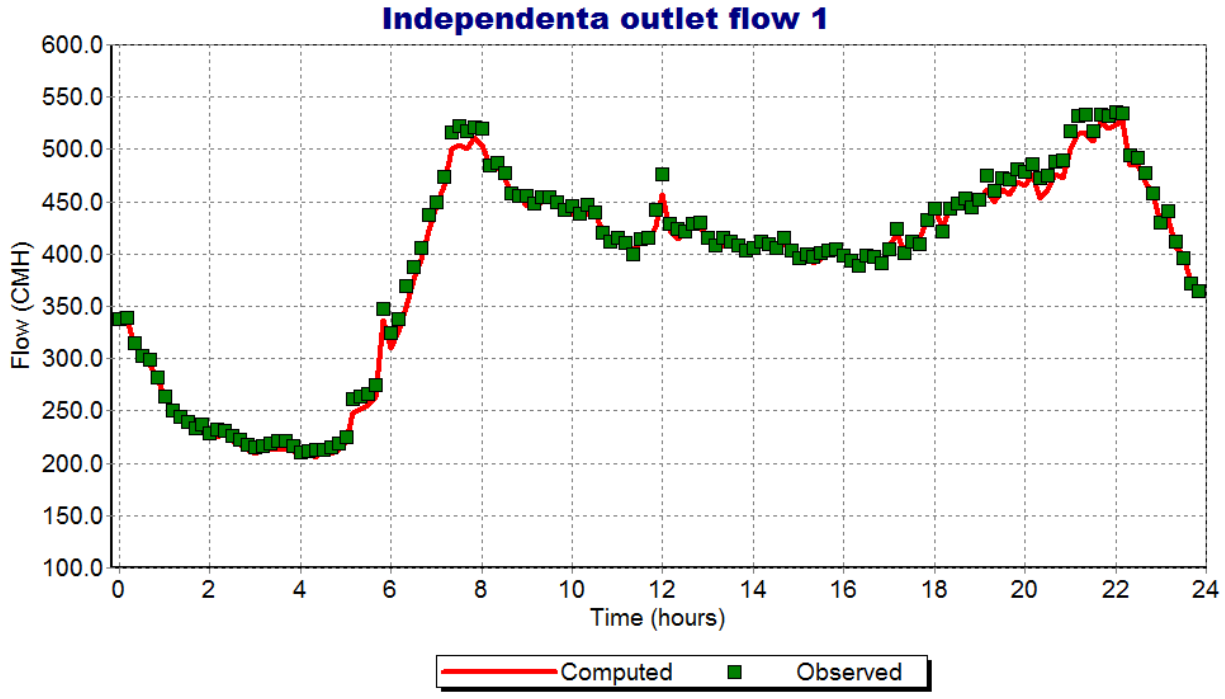




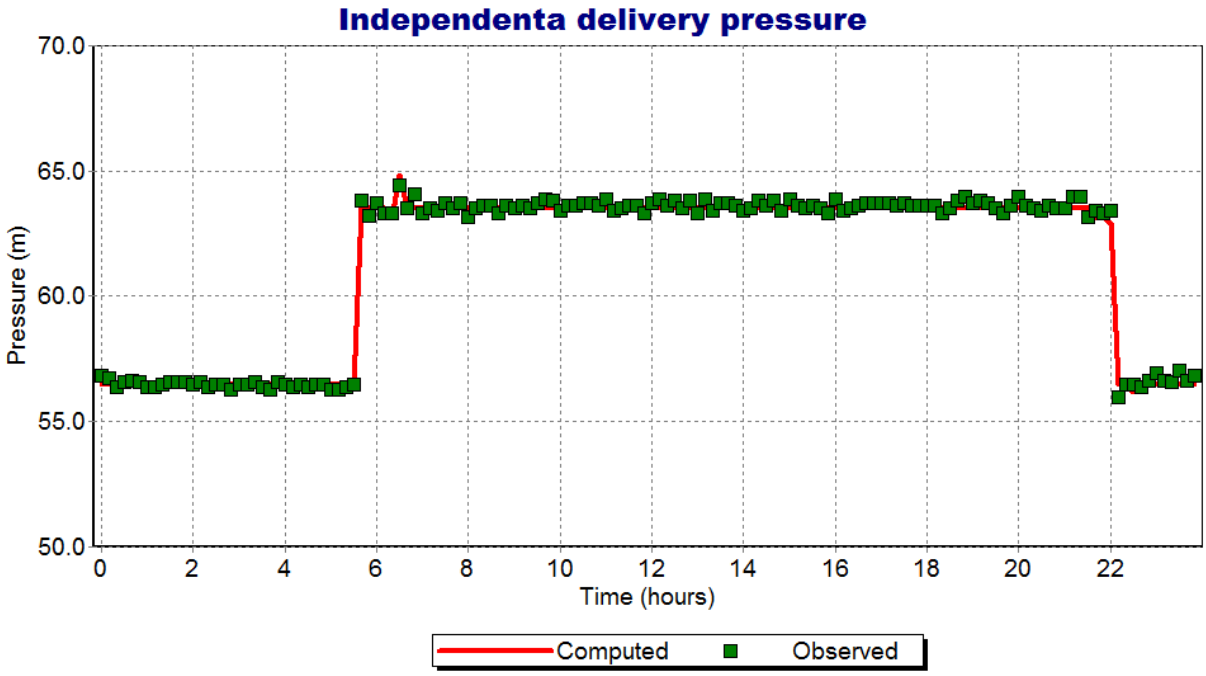
Zone 3 Independenţa

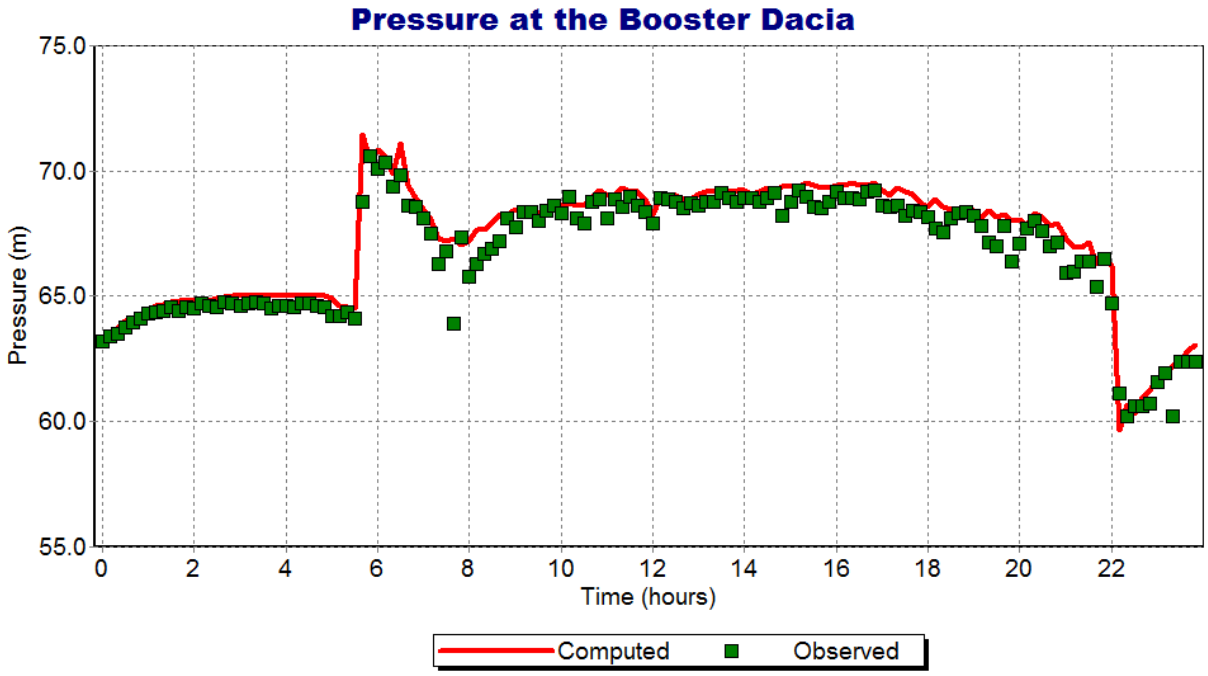
Flow in the Zone 3 Independenţa

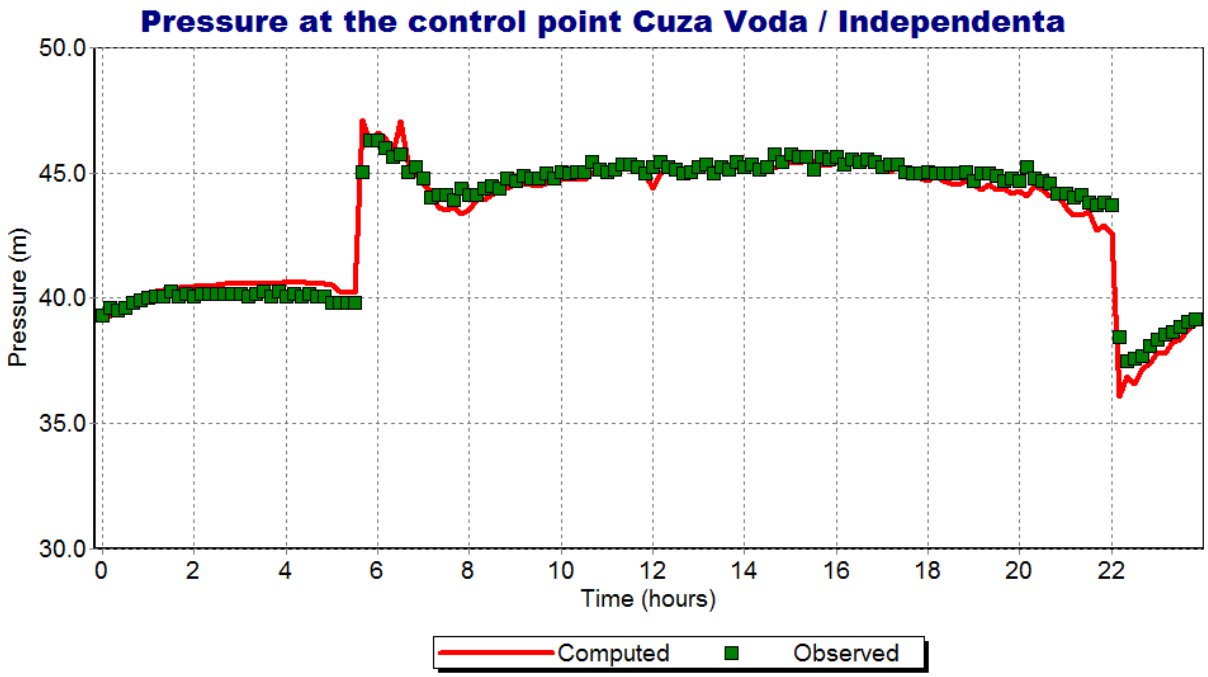




Pressure in the Zone 3 Independenţa

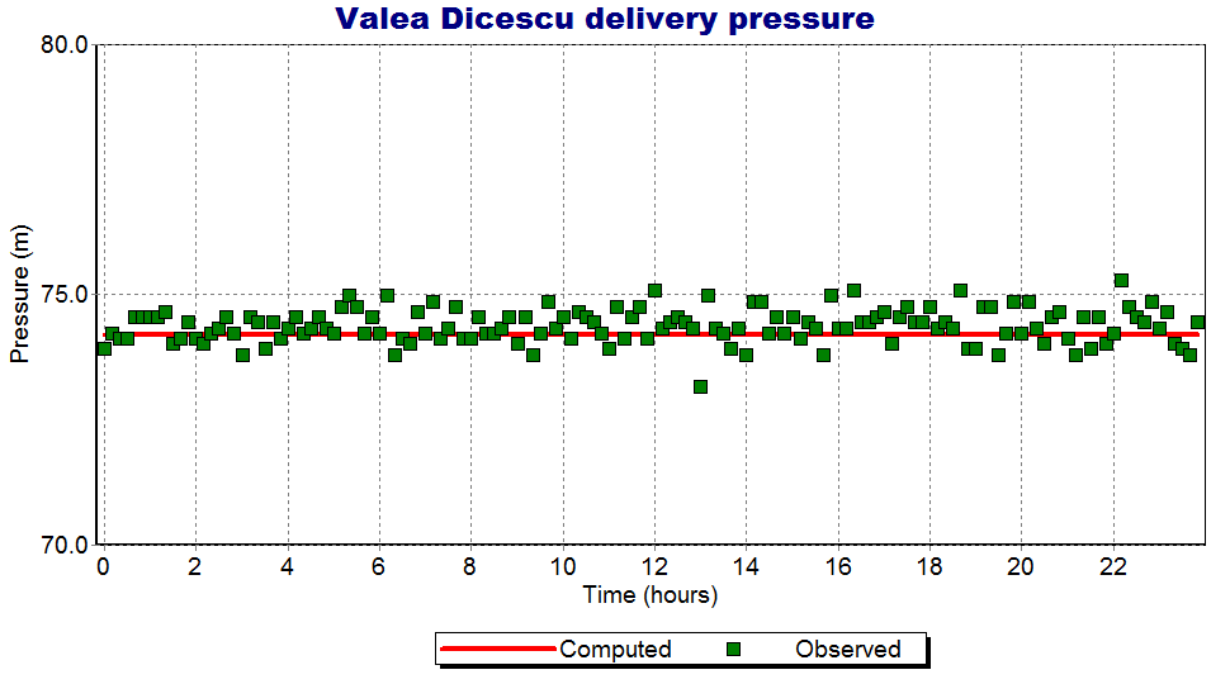


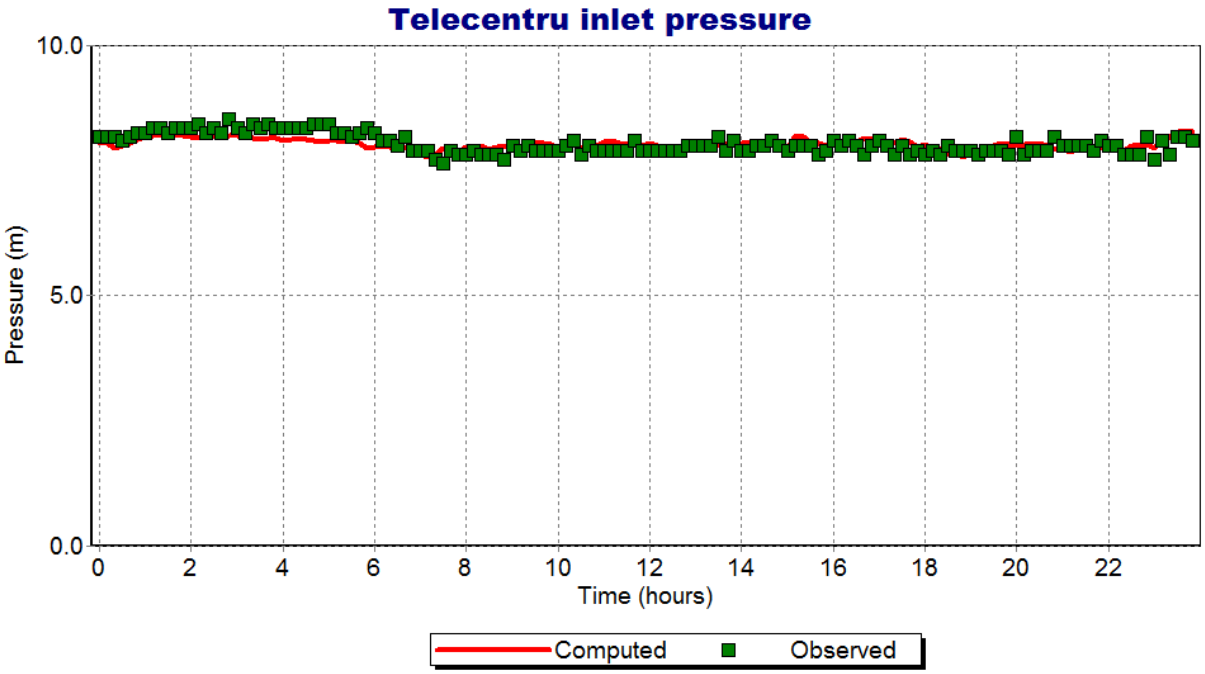


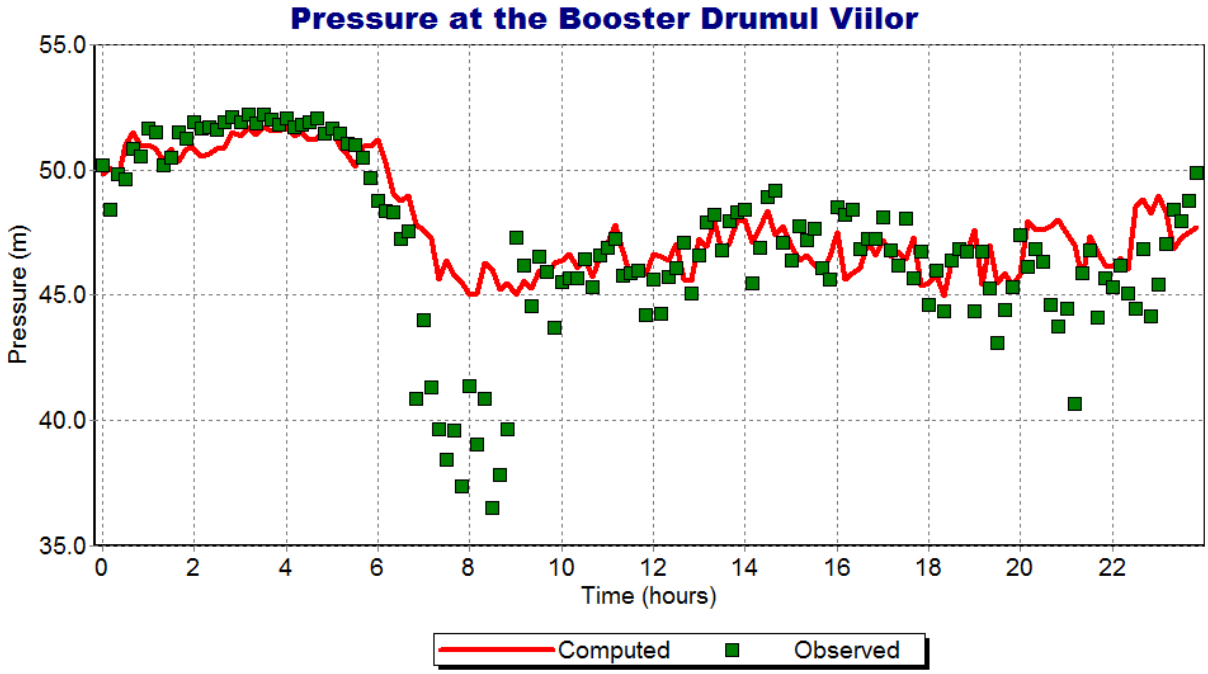


Zone 3 Valea Dicescu

Pressure in the Zone 3 Valea dicescu

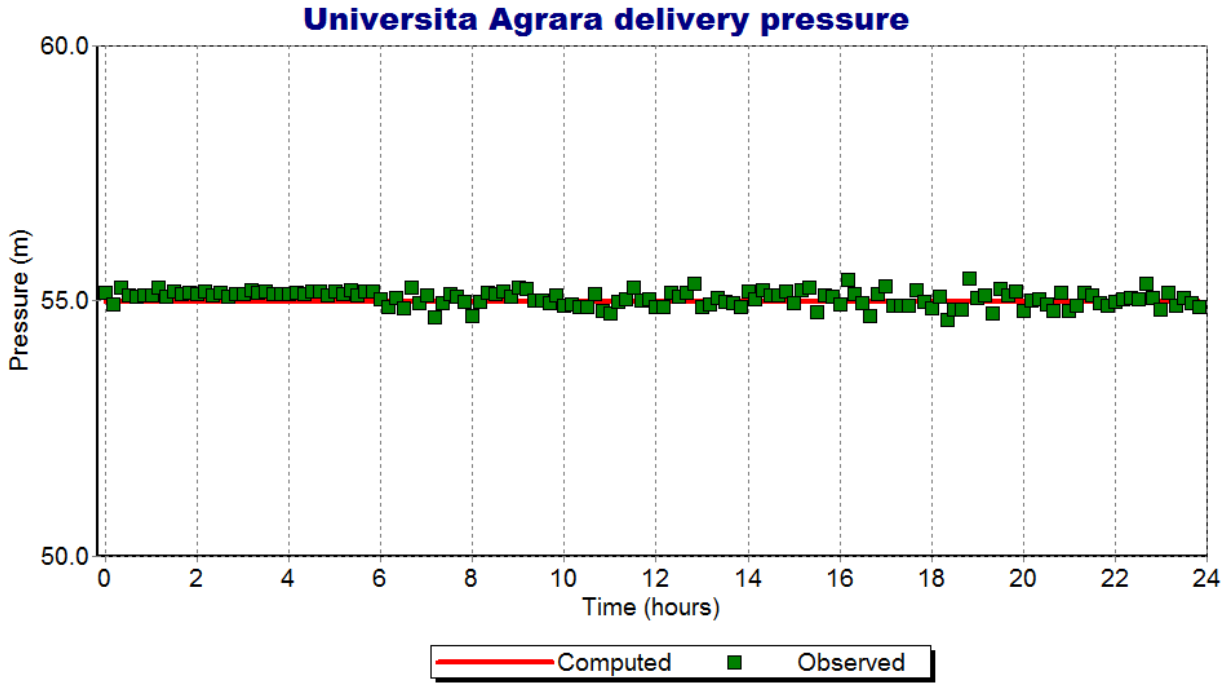



Telecentru inlet pressure
10.0
5.0
0.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed


Pressure at the Booster Drumul Viilor
55.0
50.0
45.0
40.0
35.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

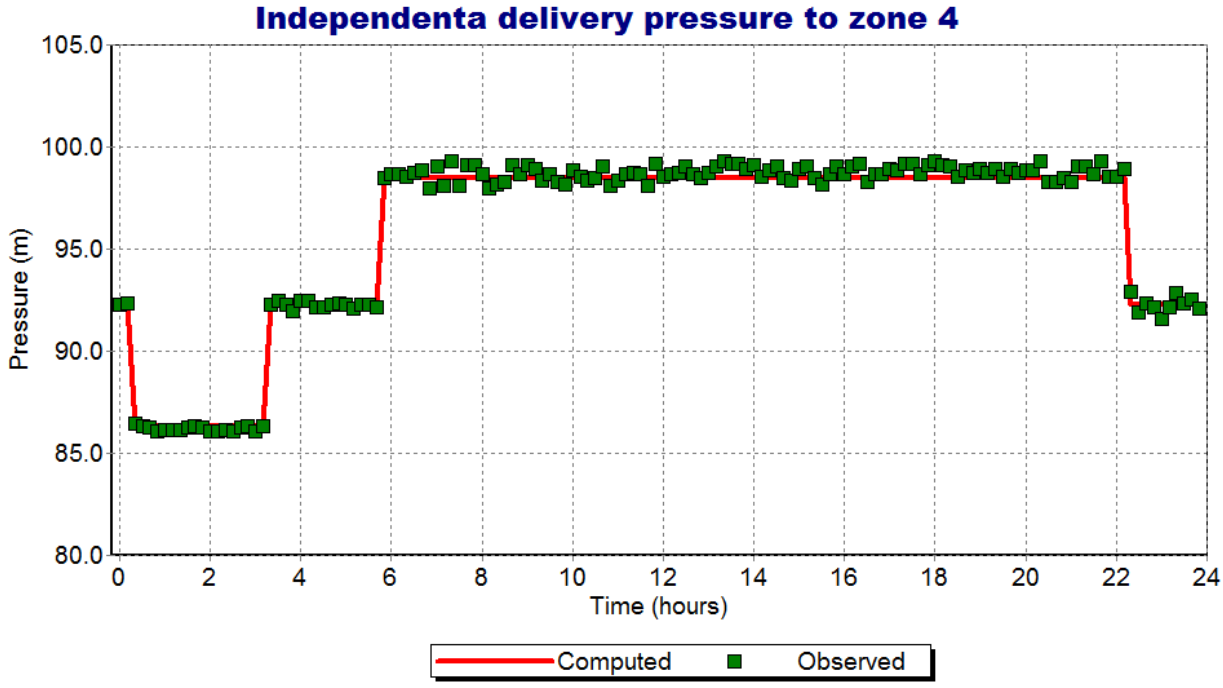
Zone 3 Universita Agrara

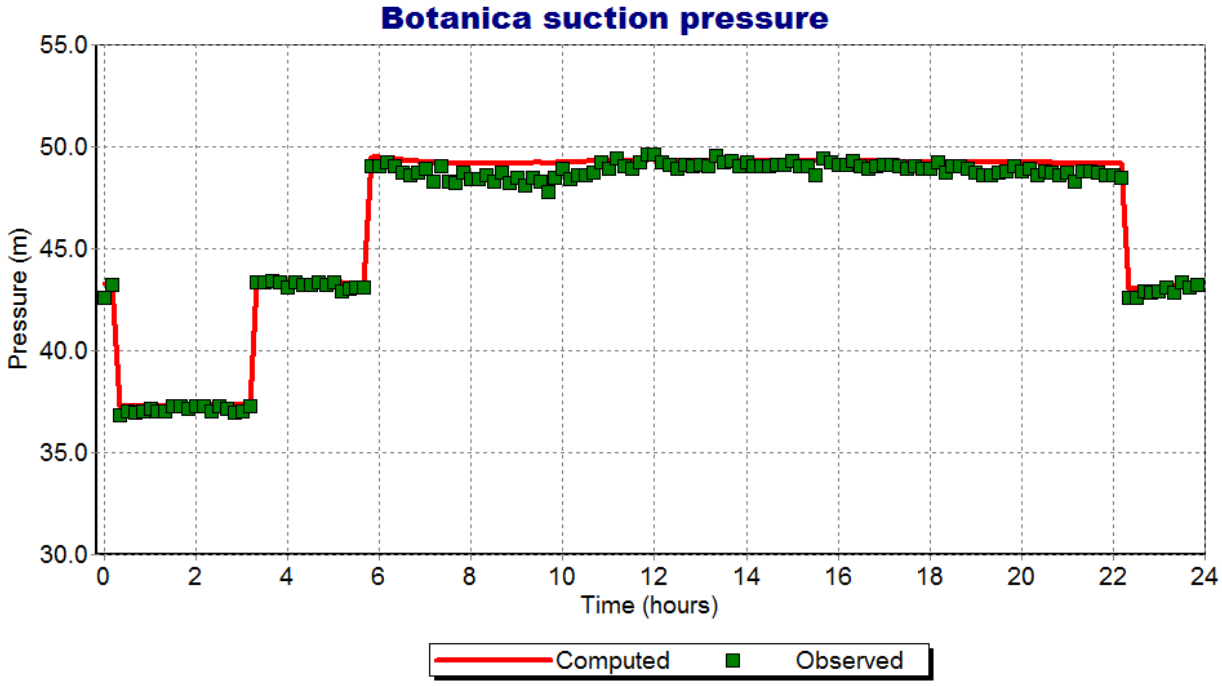
Pressure in the Zone 3 Universita agrara

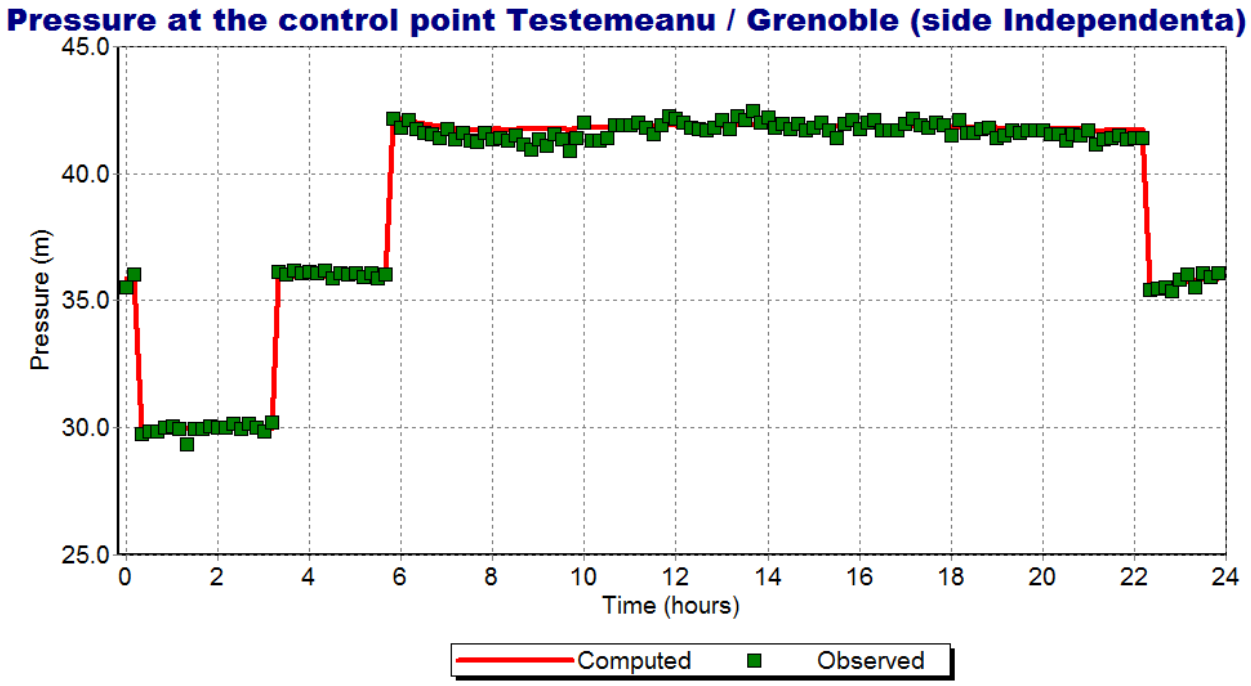


Zone 4 Independenţa

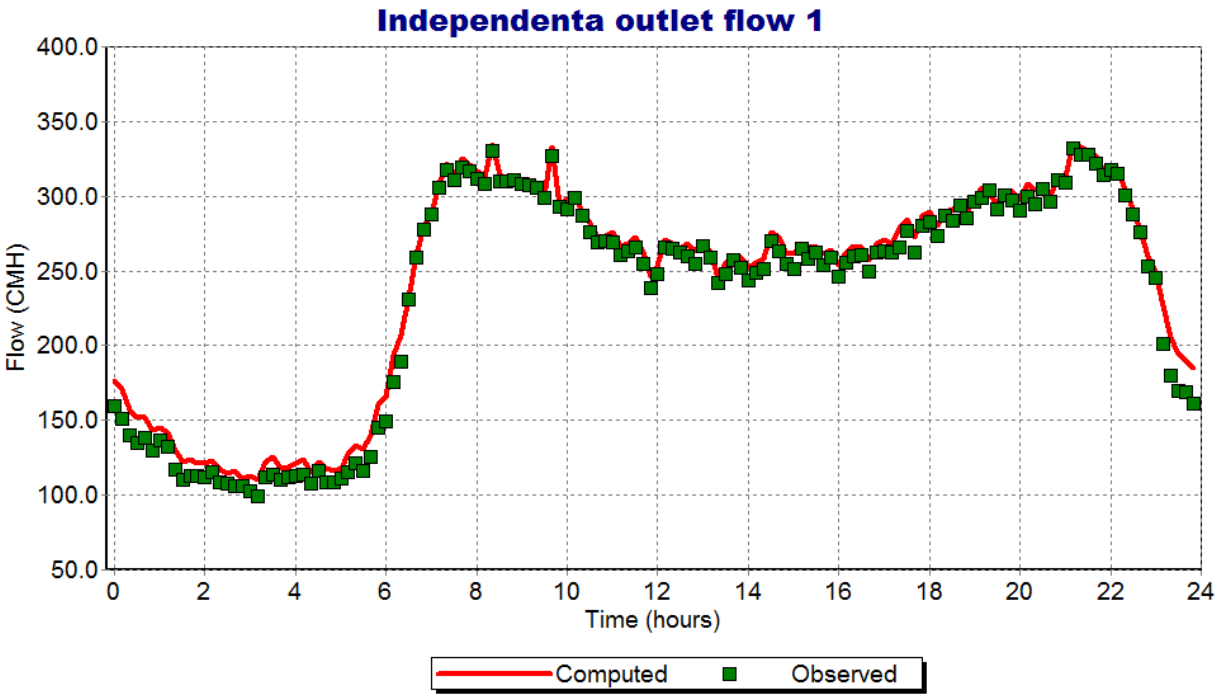
Pressure in the Zone 4 Independenţa

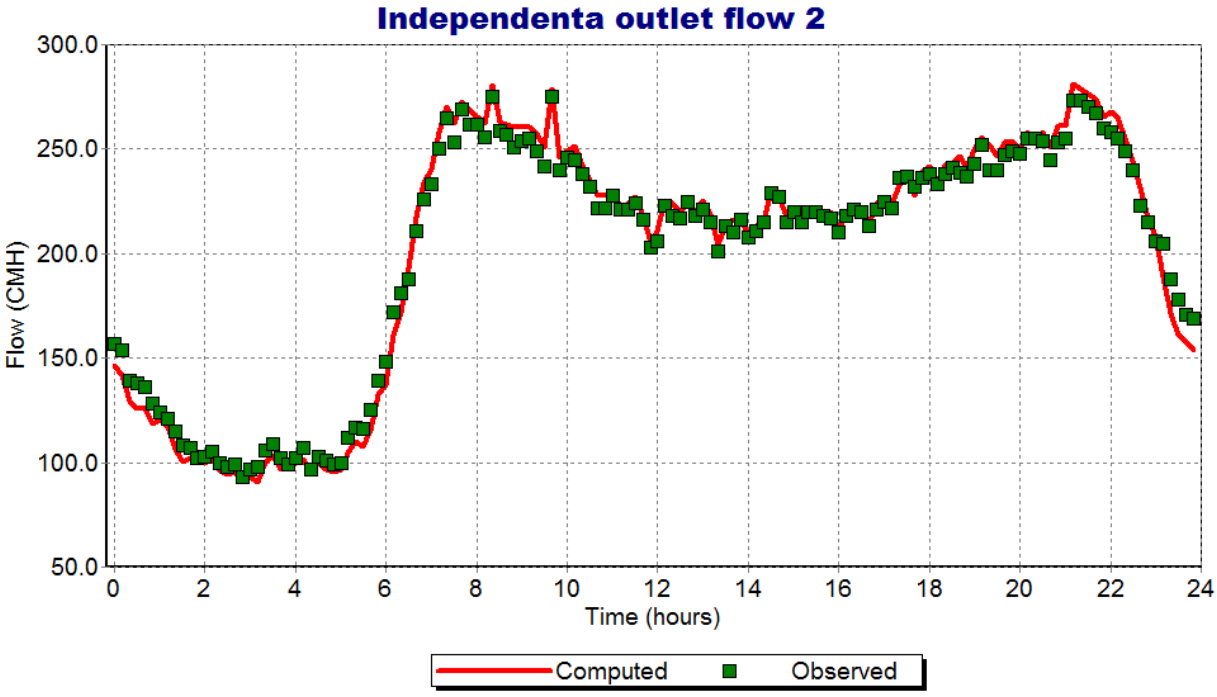



Botanica suction pressure
55.0
50.0
45.0
40.0
35.0
30.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the control point Testemeanu / Grenoble (side Independenta)
45.0
40.0
35.0
30.0
25.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

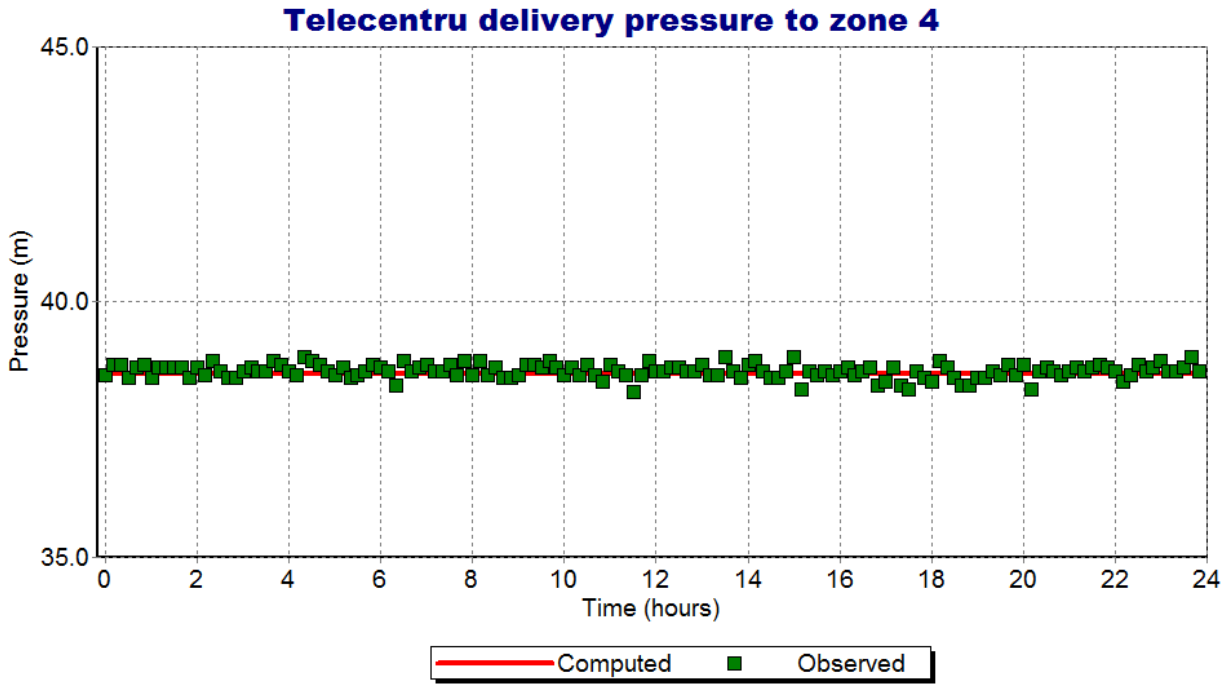
Flow in the Zone 4 Independenţa

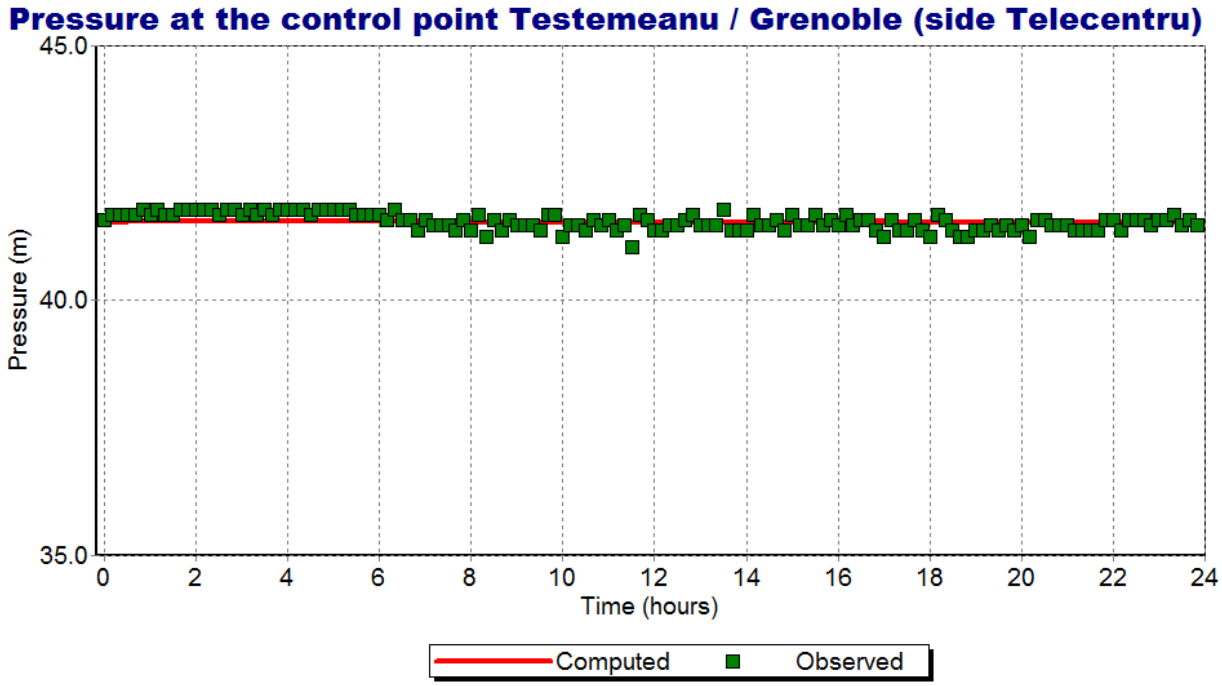




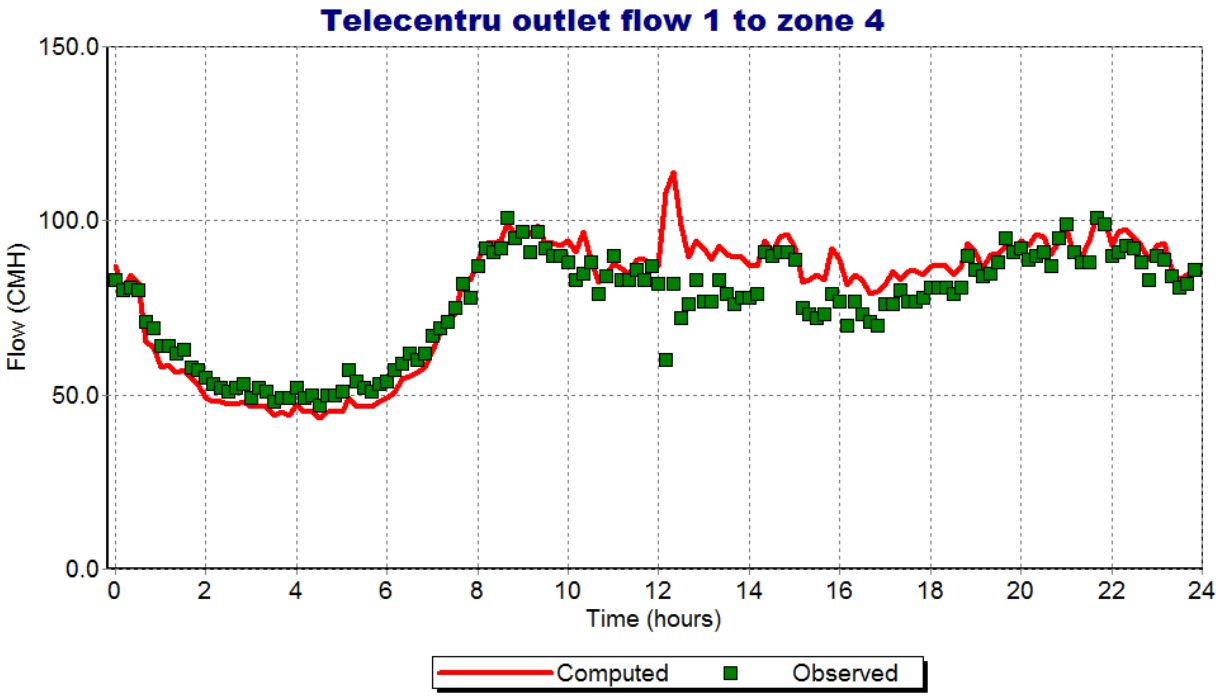
Zone 4 Telecentru

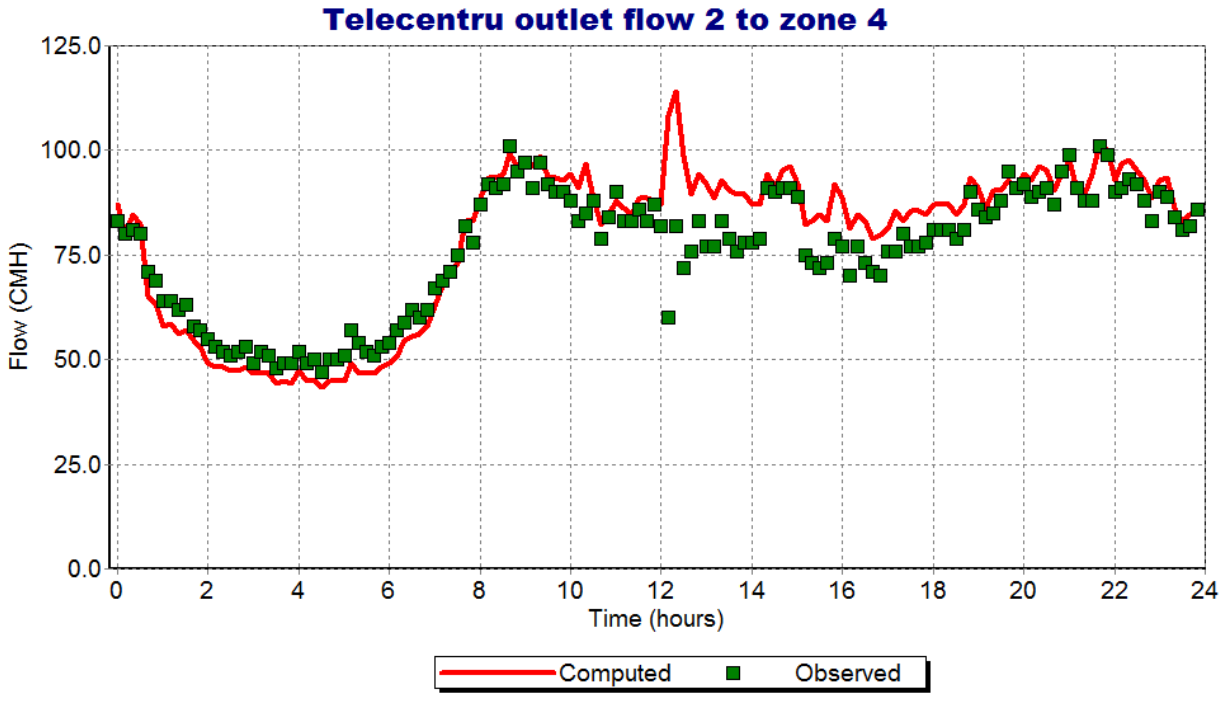
Pressure in the Zone 4 Telecentru





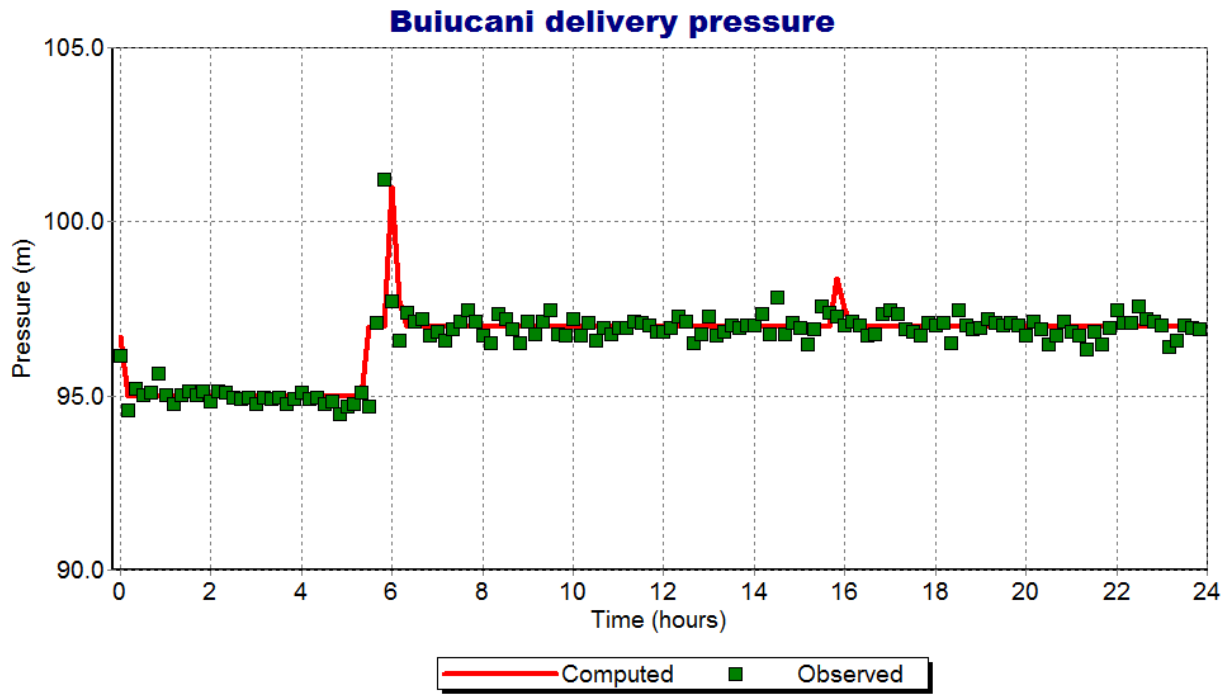
Flow in the Zone 4 Telecentru

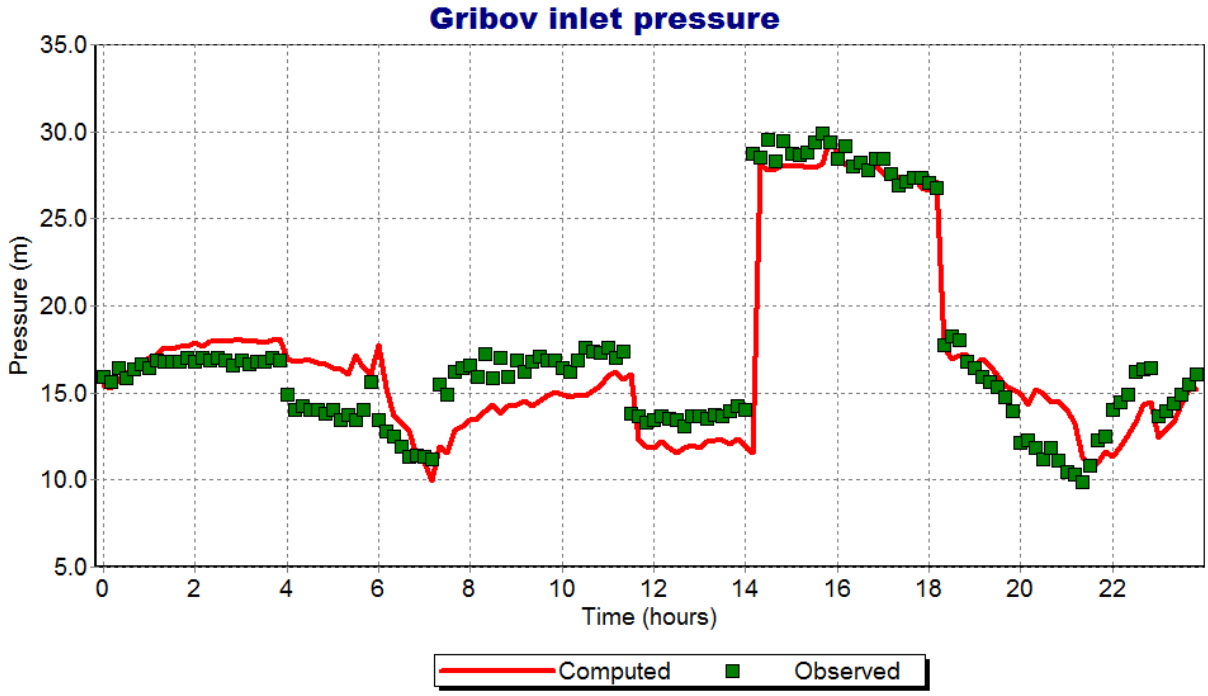


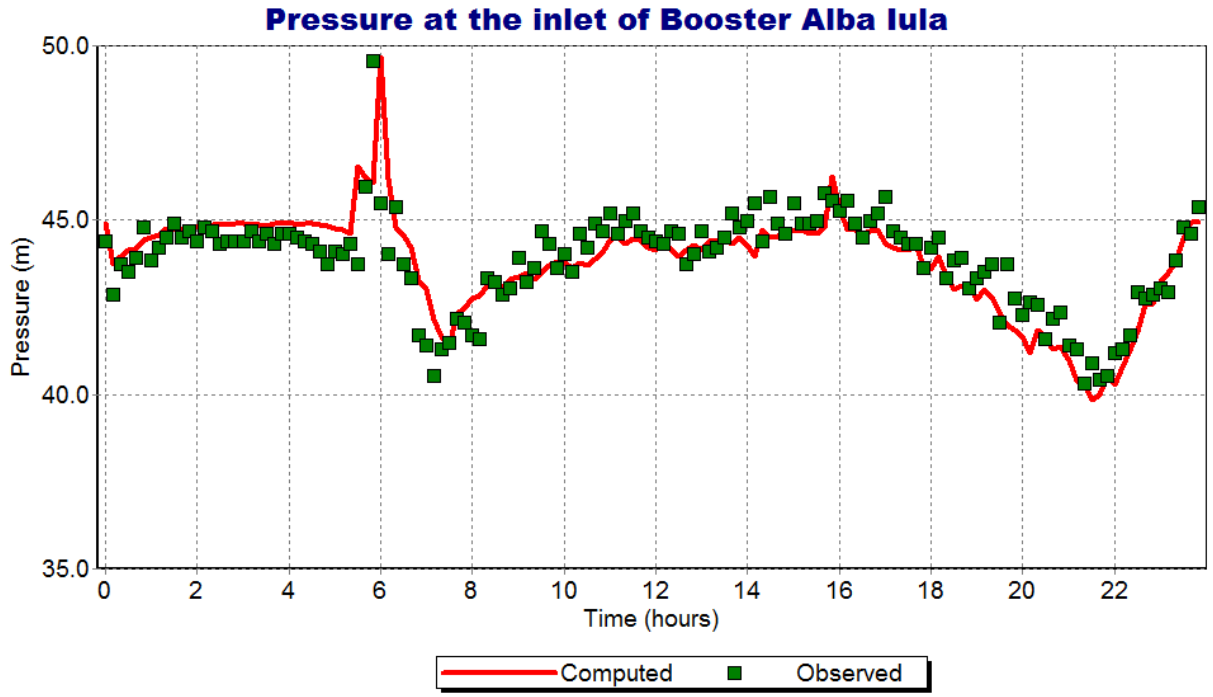


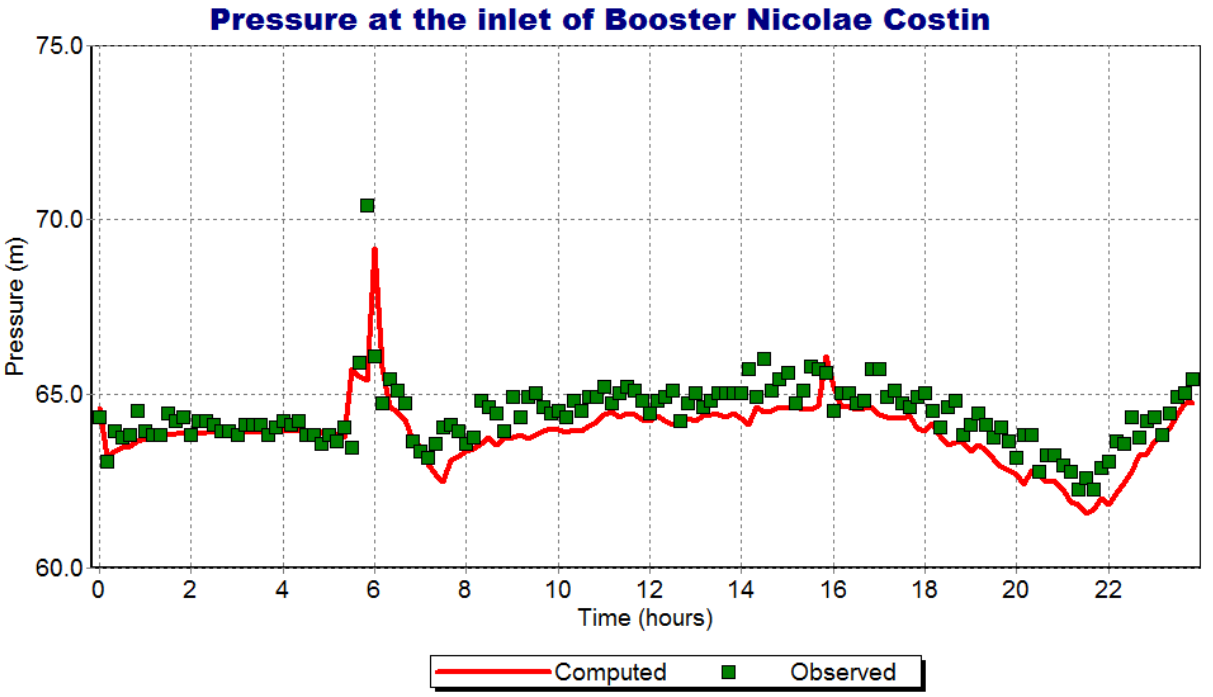
Zone 4 Buiucani

Pressure in the Zone 4 Buiucani

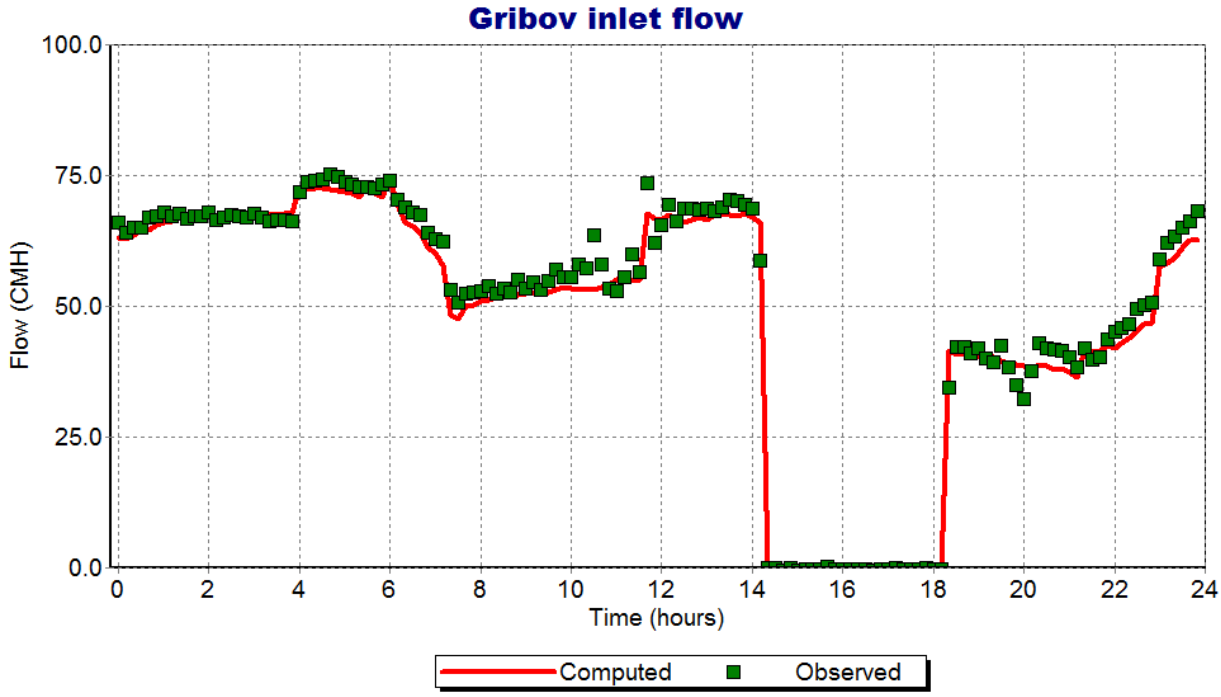


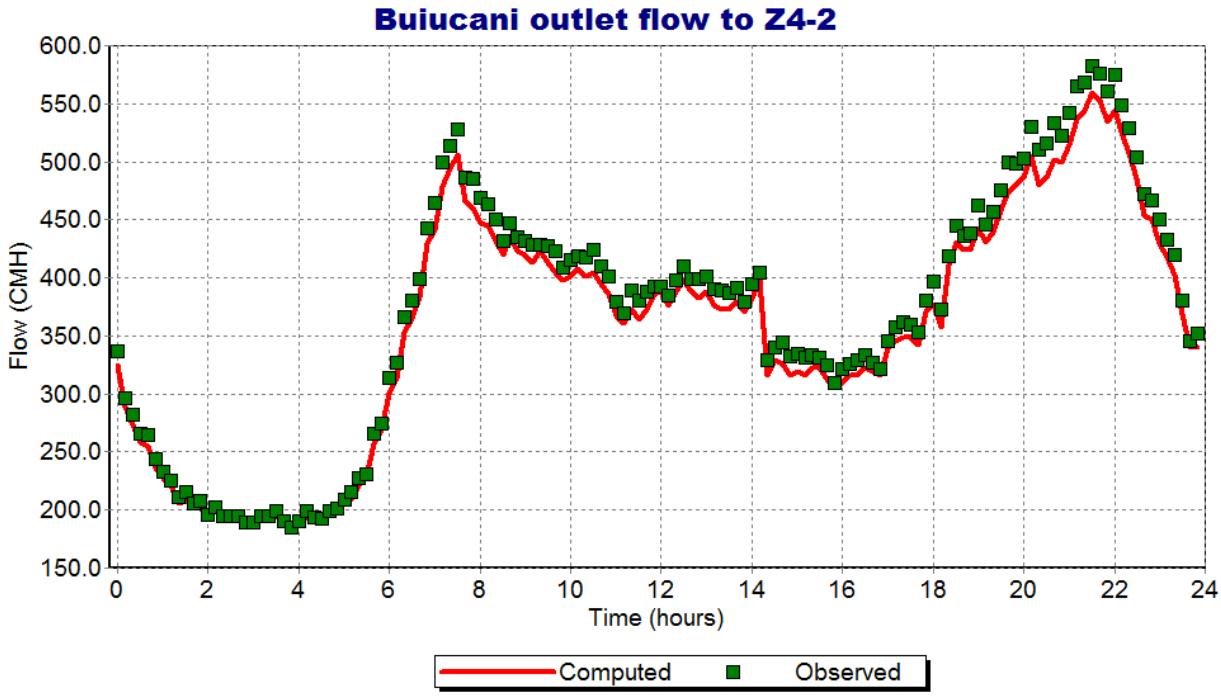


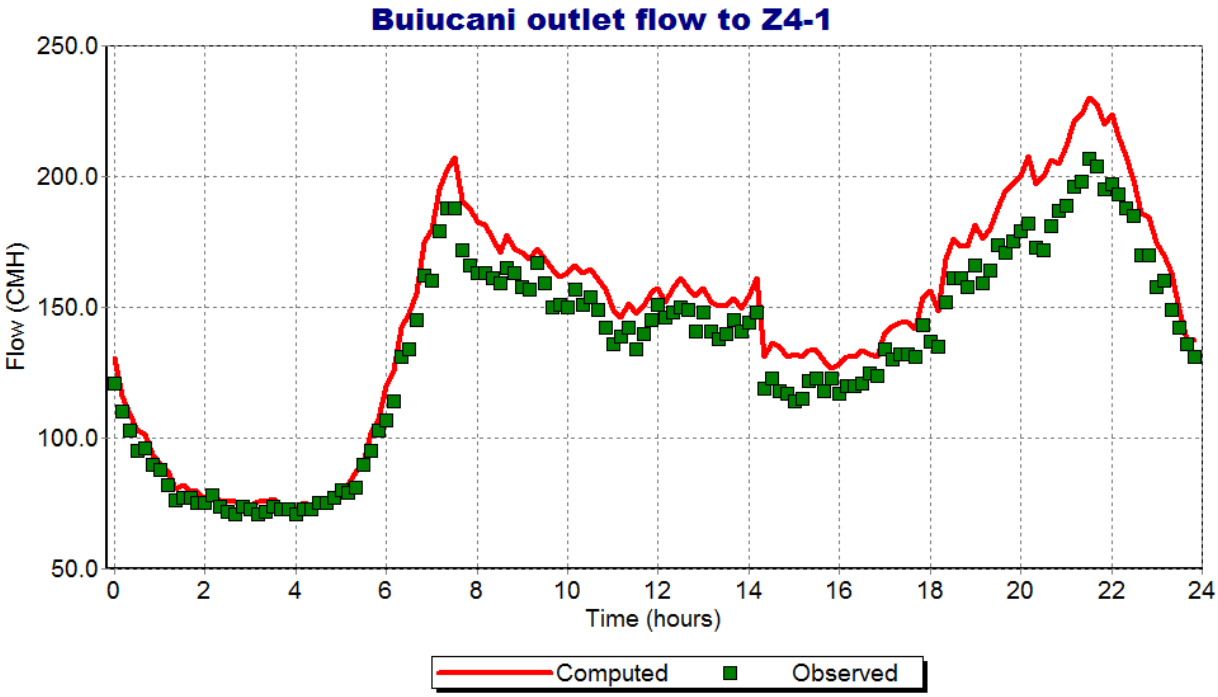

Pressure at the inlet of Booster Alba Iula
50.0
45.0
40.0
35.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed


Pressure at the inlet of Booster Nicolae Costin
75.0
70.0
65.0
60.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

Flow in the Zone 4 Buiucani

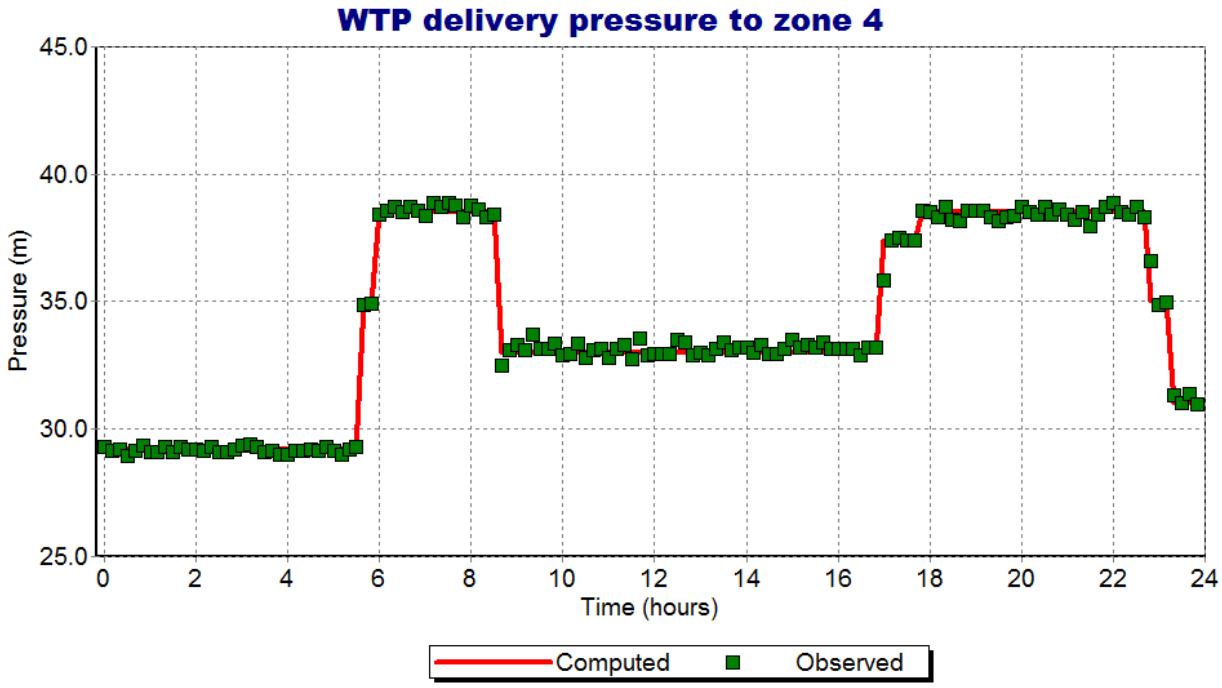


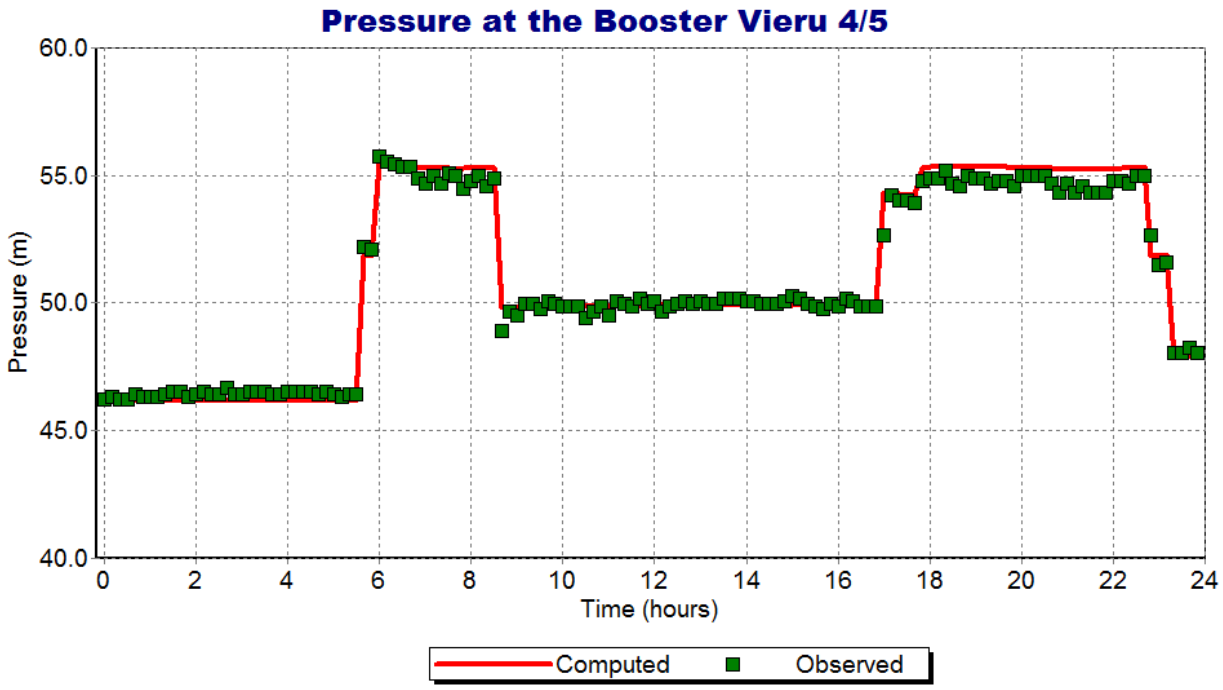


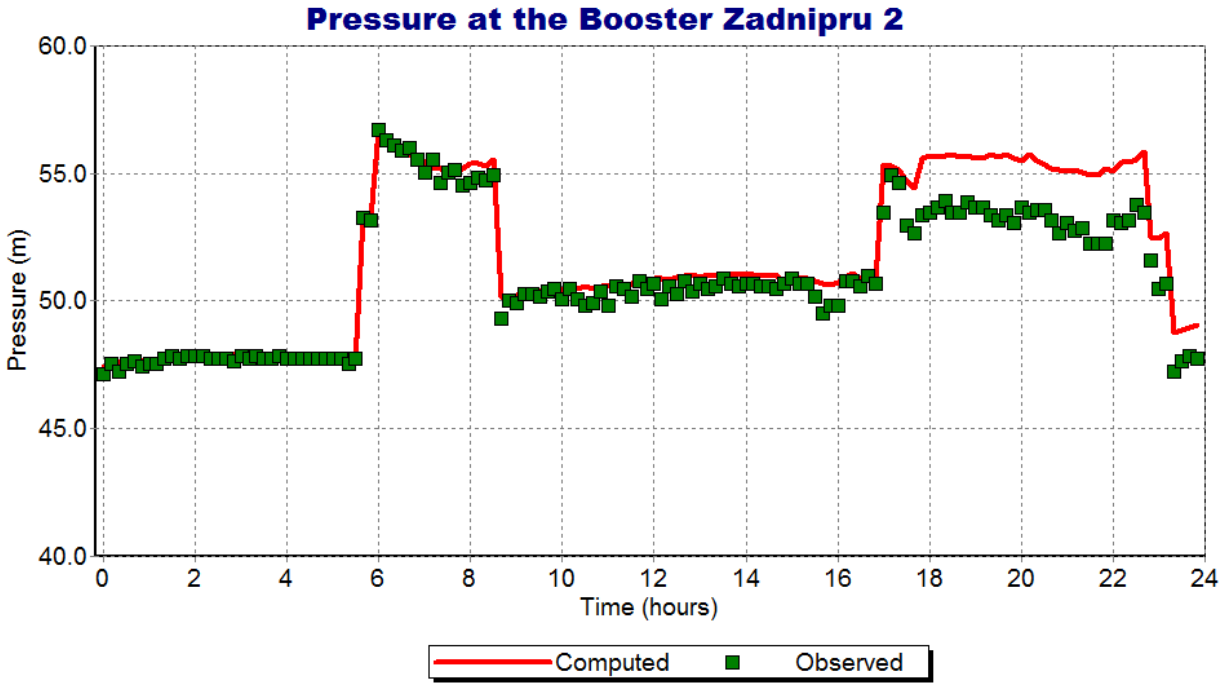


Zone 4 Ciocana

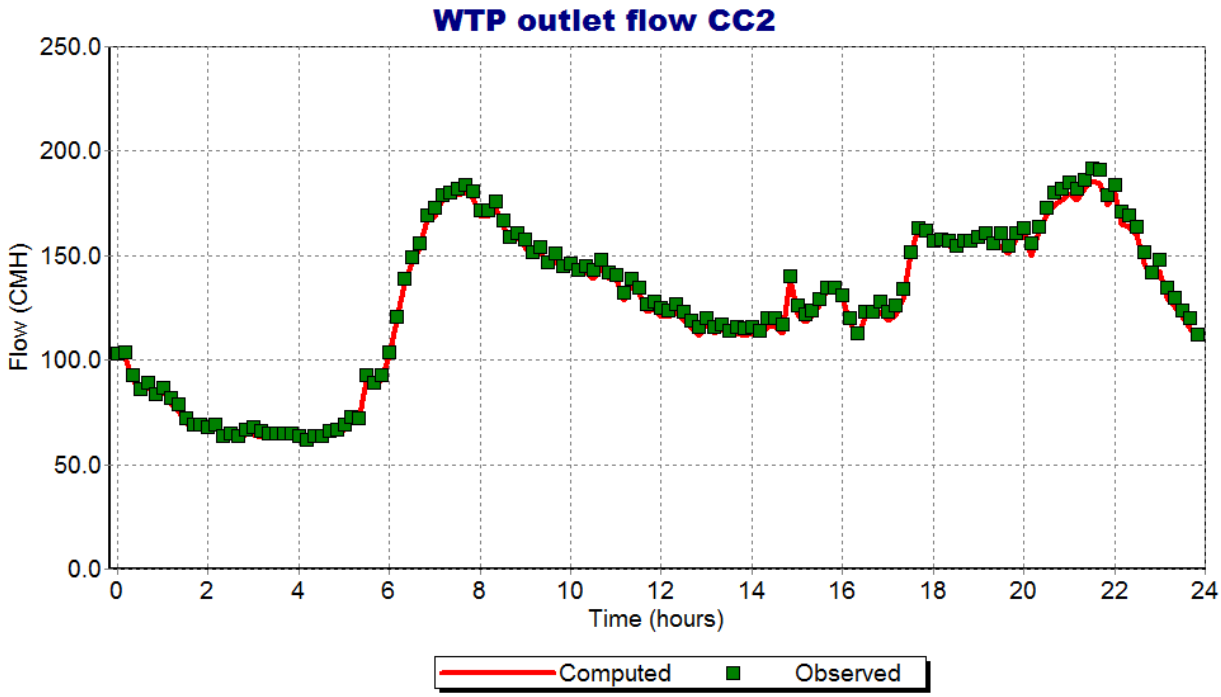
Pressure in the Zone 4 Ciocana

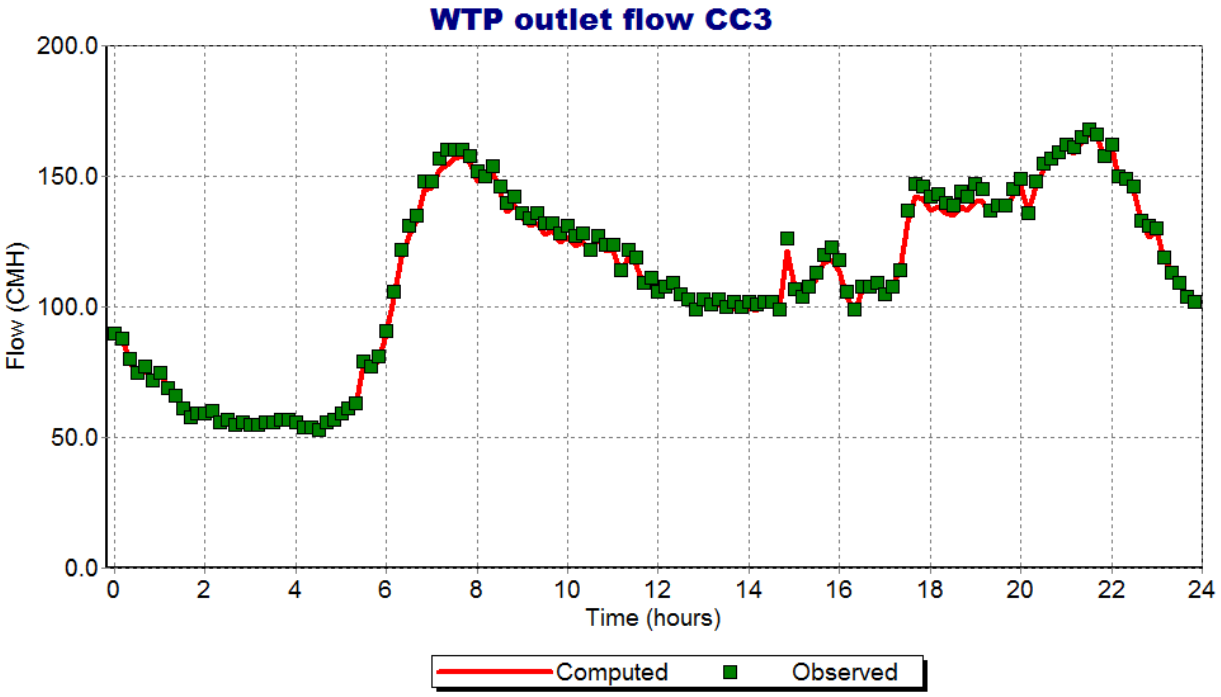



Pressure at the Booster Vieru 4/5
Pressure (m)
60.0
55.0
50.0
45.0
40.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the Booster Zadnipru 2
Pressure (m)
60.0
55.0
50.0
45.0
40.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

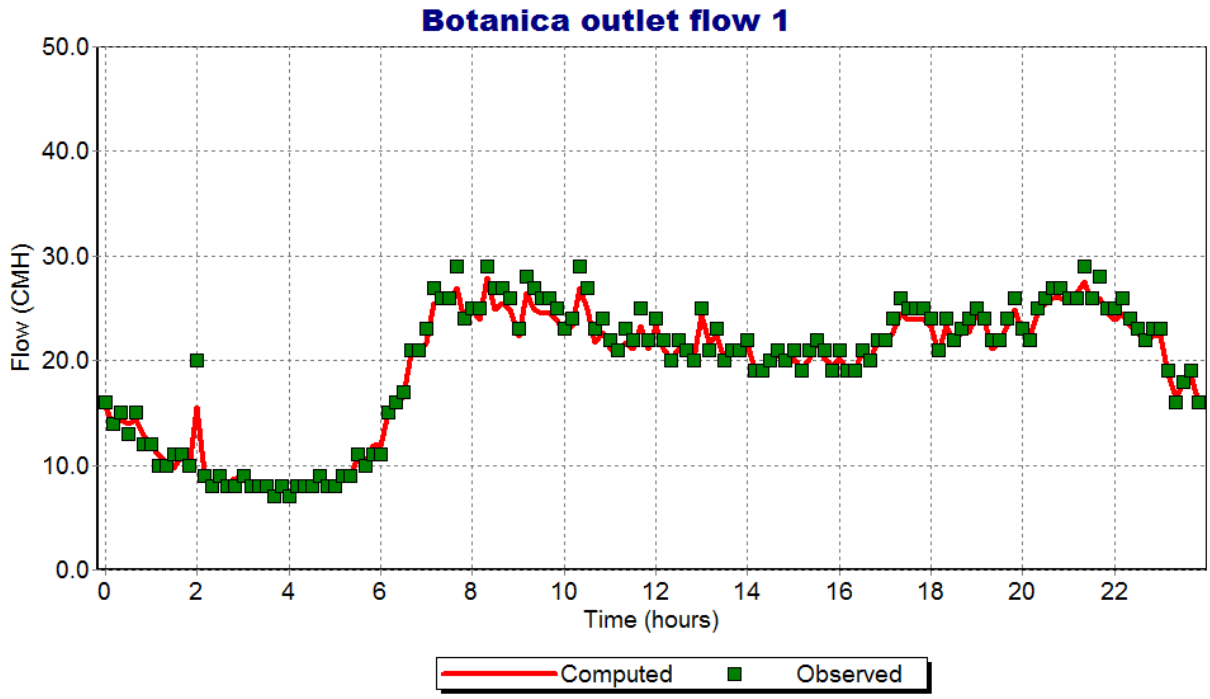
Flow in the Zone 4 Ciocana

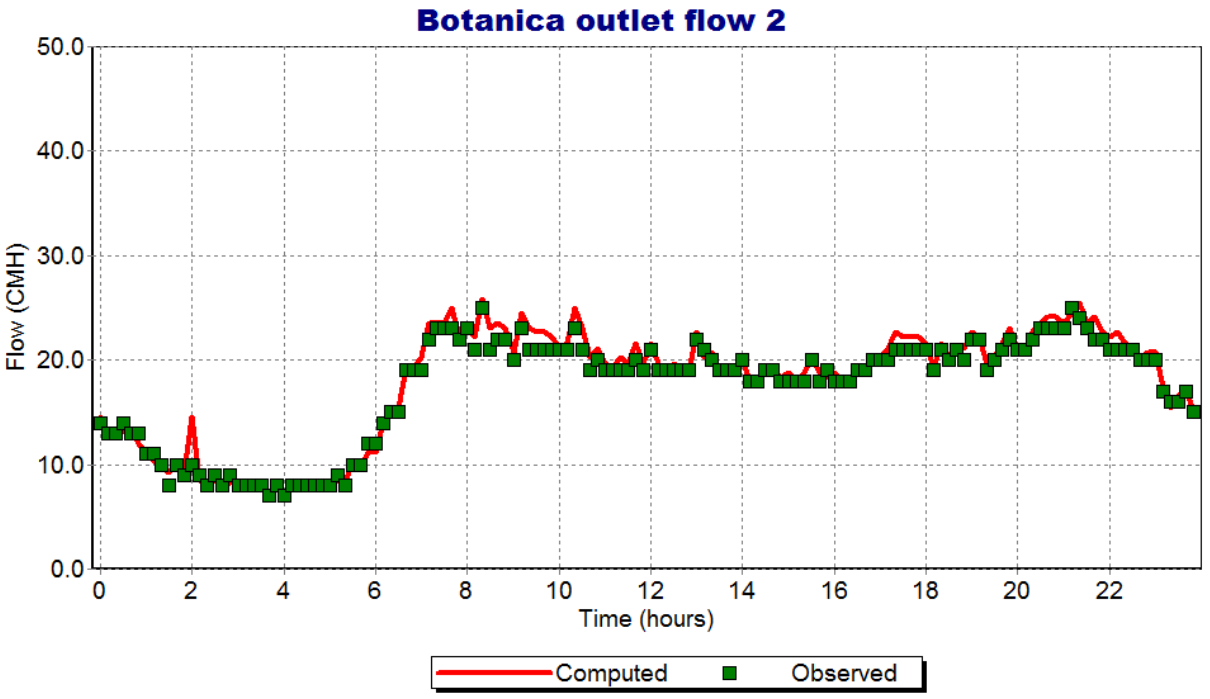




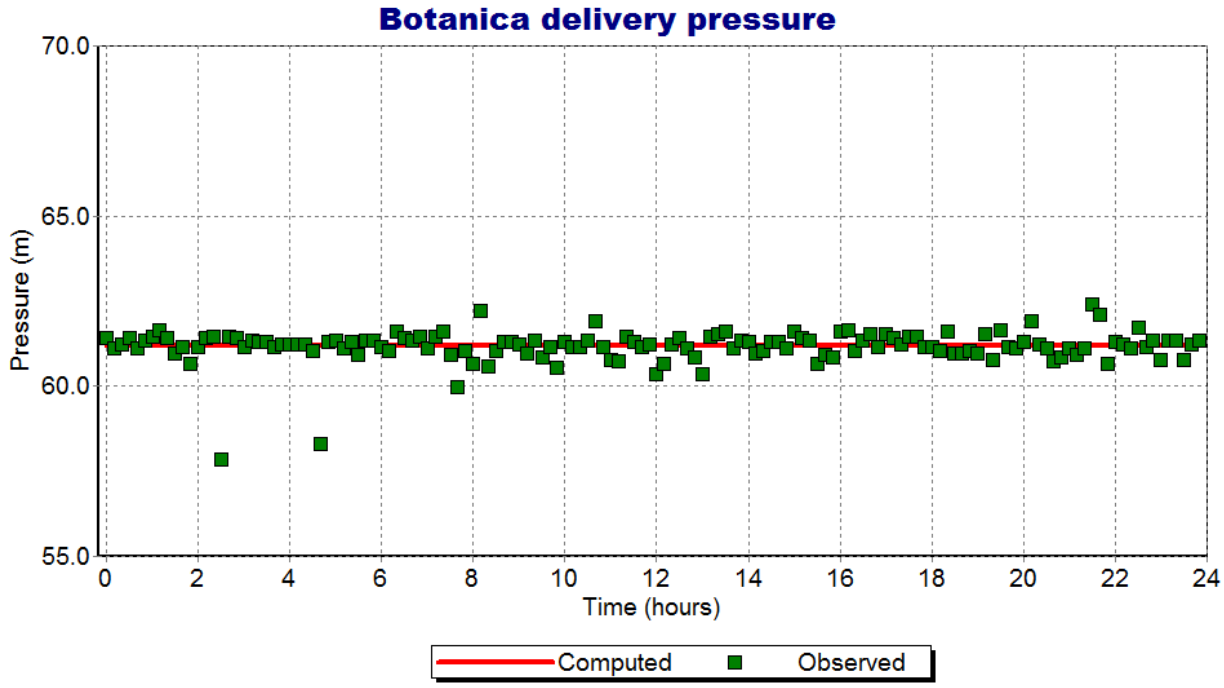
Zone 4A Botanica

Flow in the Zone 4A Botanica



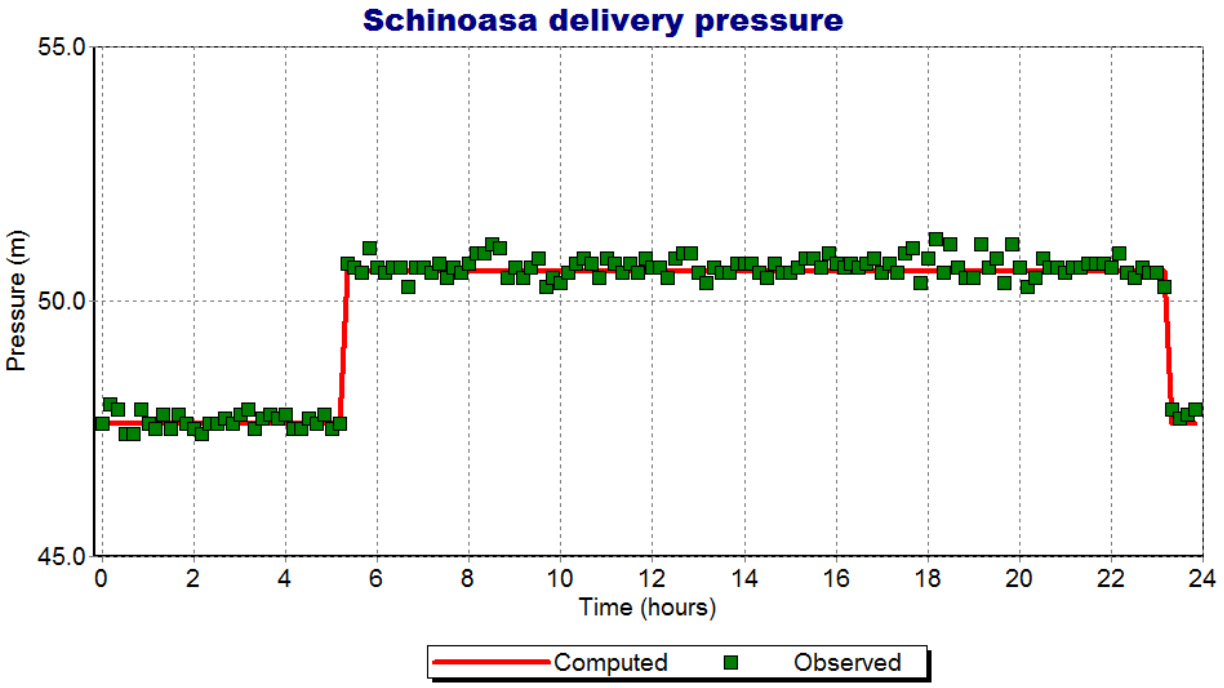


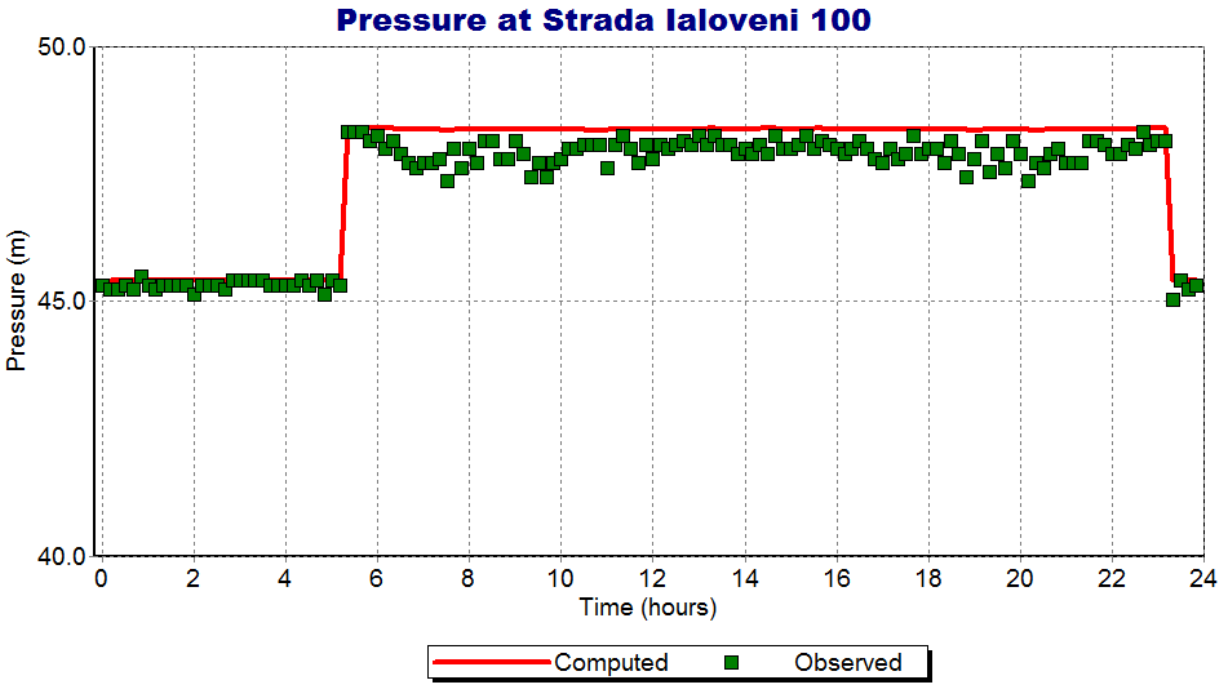
Pressure in the Zone 4A Botanica

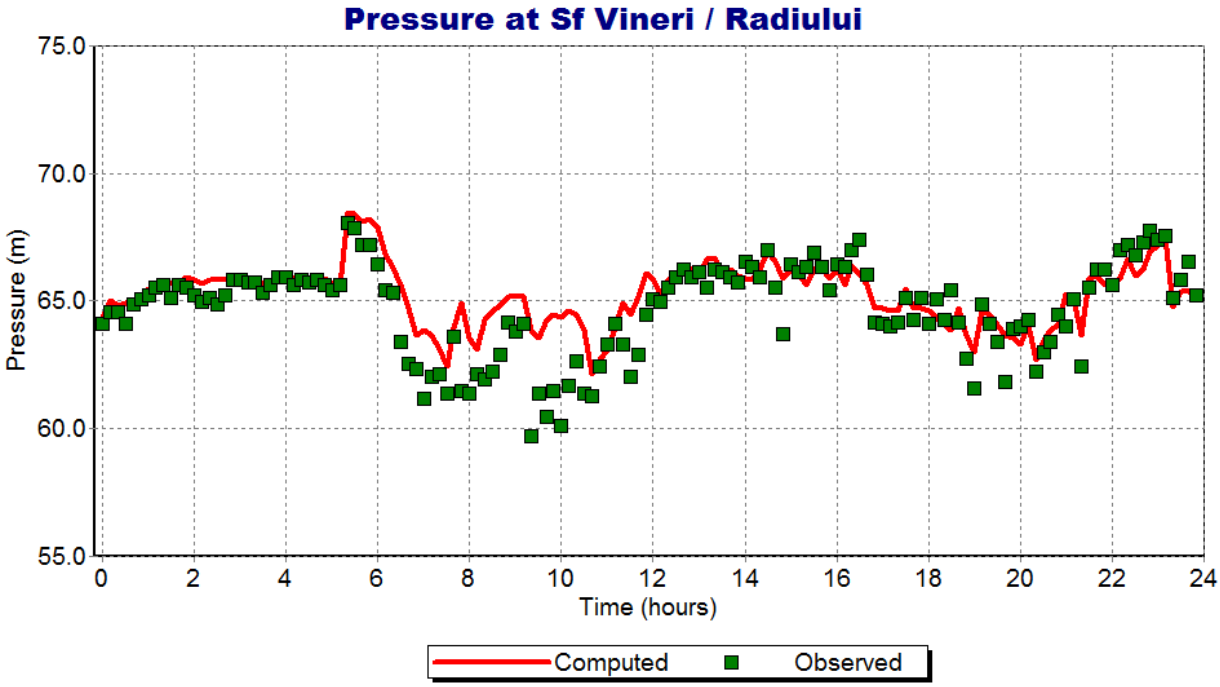


Zone 4A Schinoasa

Pressure in the Zone 4A Schinoasa

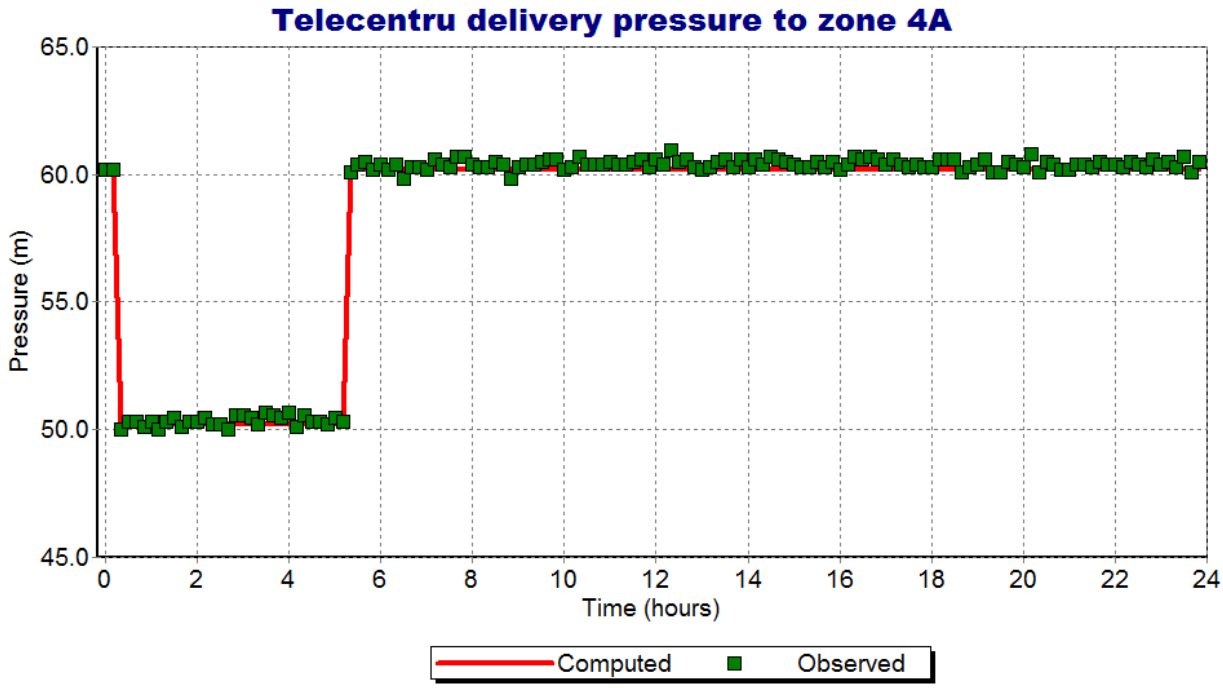


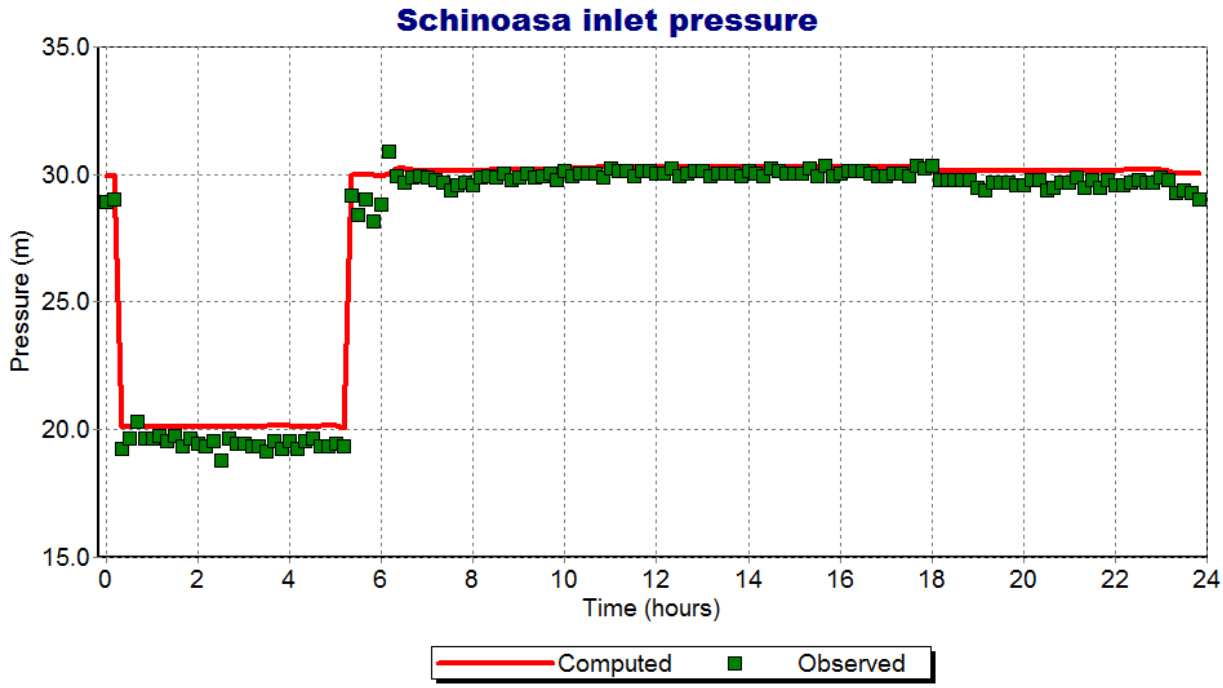

Pressure at Strada Ialoveni 100
50.0
45.0
40.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

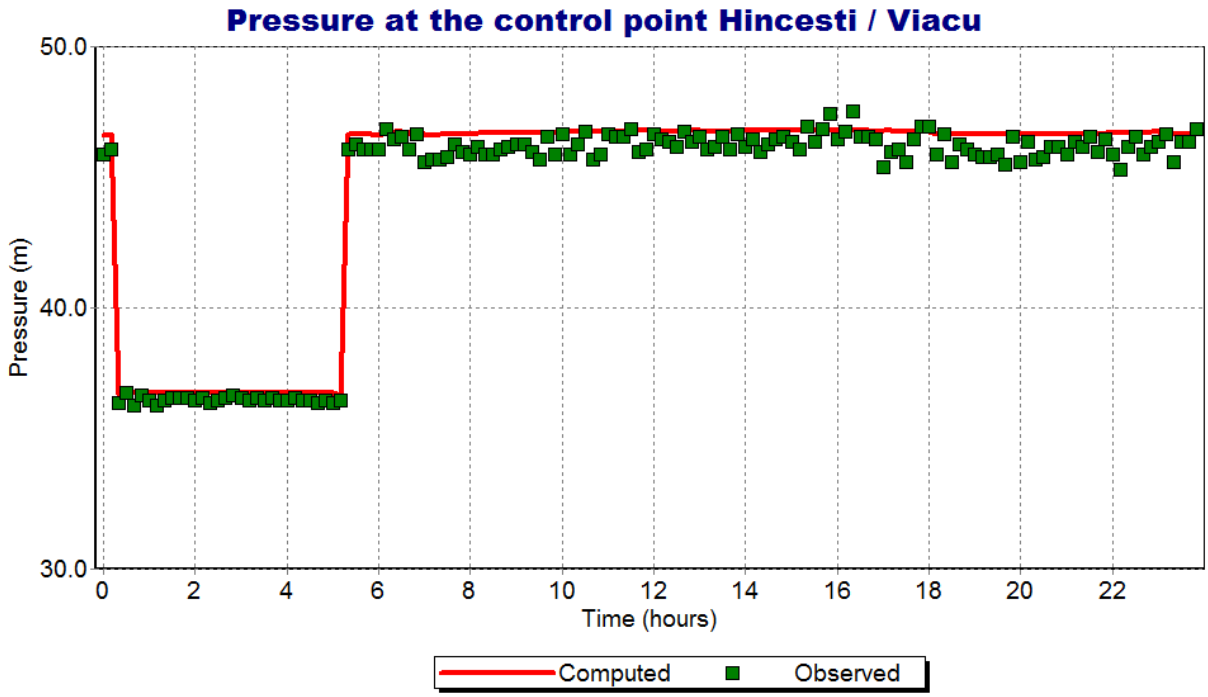

Pressure at Sf Vineri / Radiului
75.0
70.0
65.0
60.0
55.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

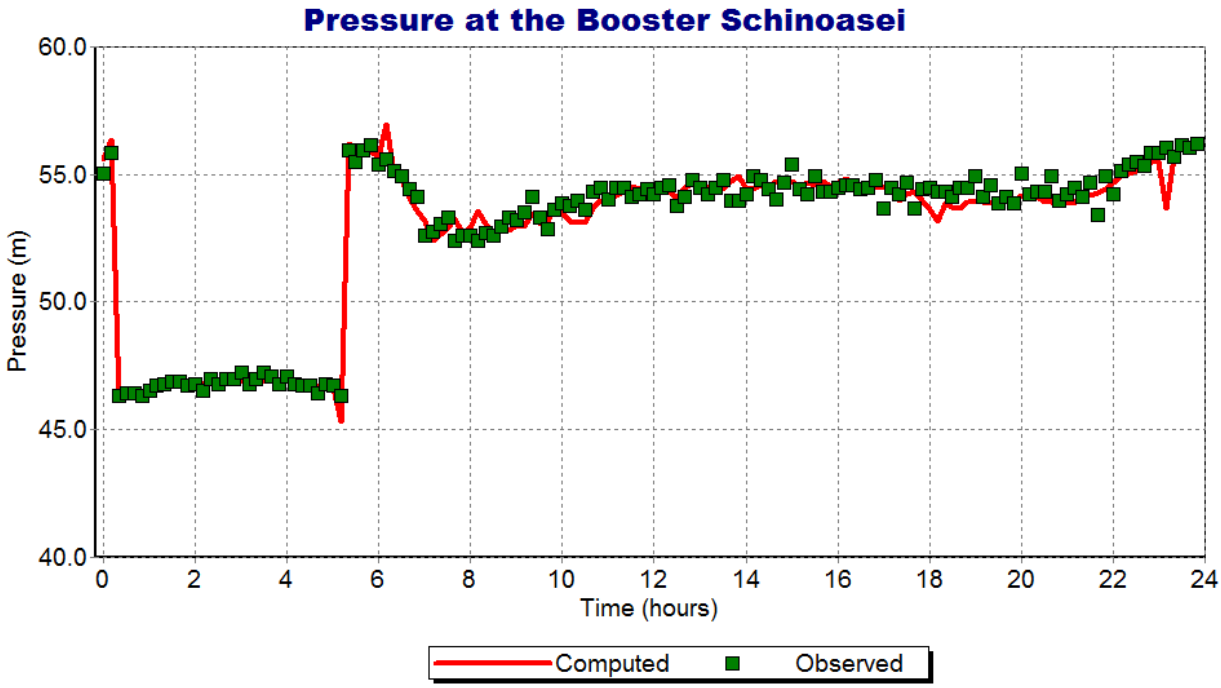
Zone 4A Telecentru

Pressure in the Zone 4A Telecentru

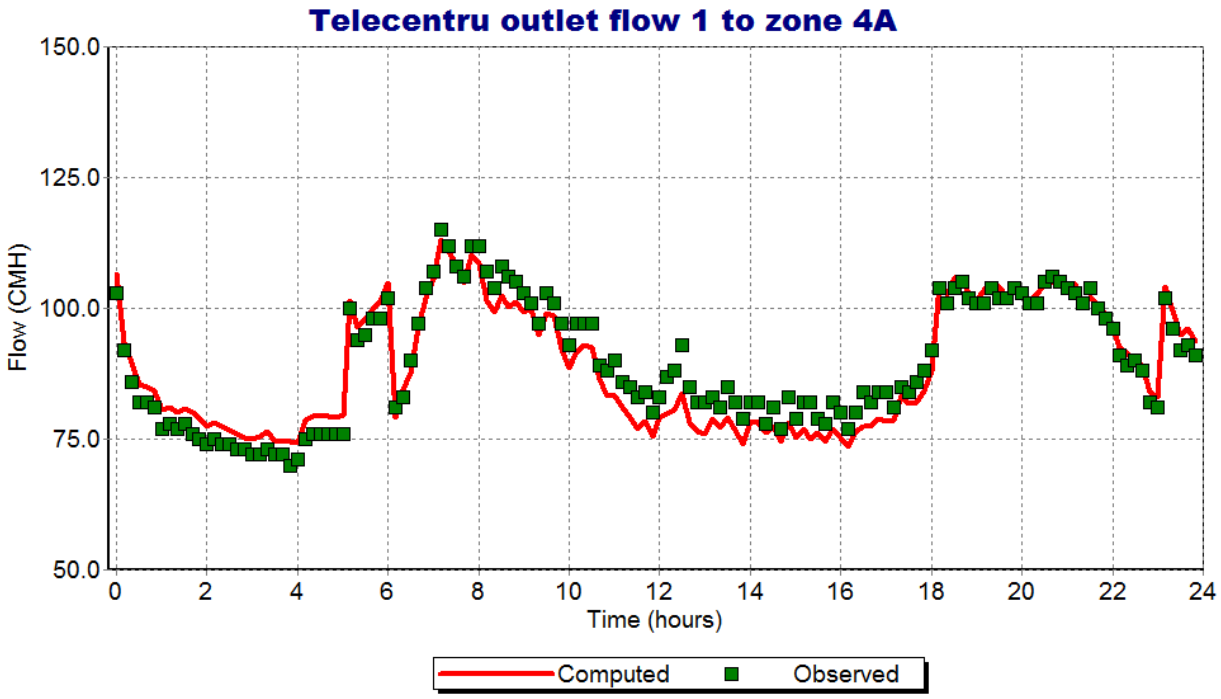


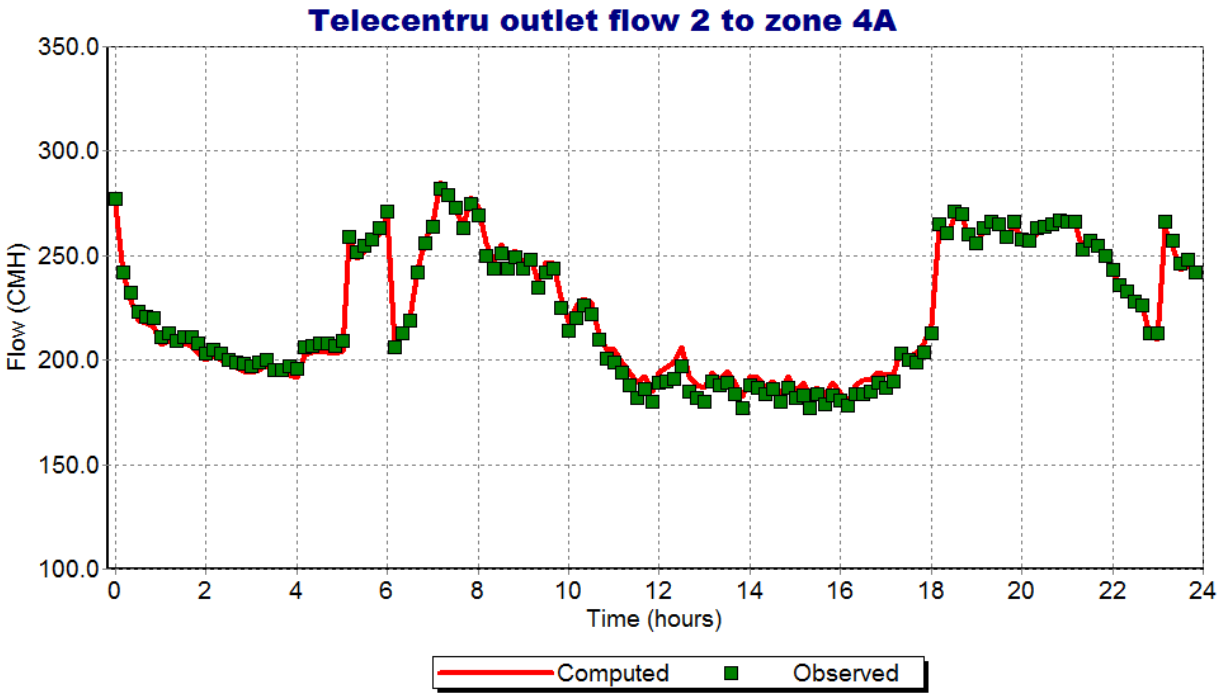



Pressure at the control point Hincesti / Viacu
50.0
40.0
30.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed


Pressure at the Booster Schinoasei
60.0
55.0
50.0
45.0
40.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

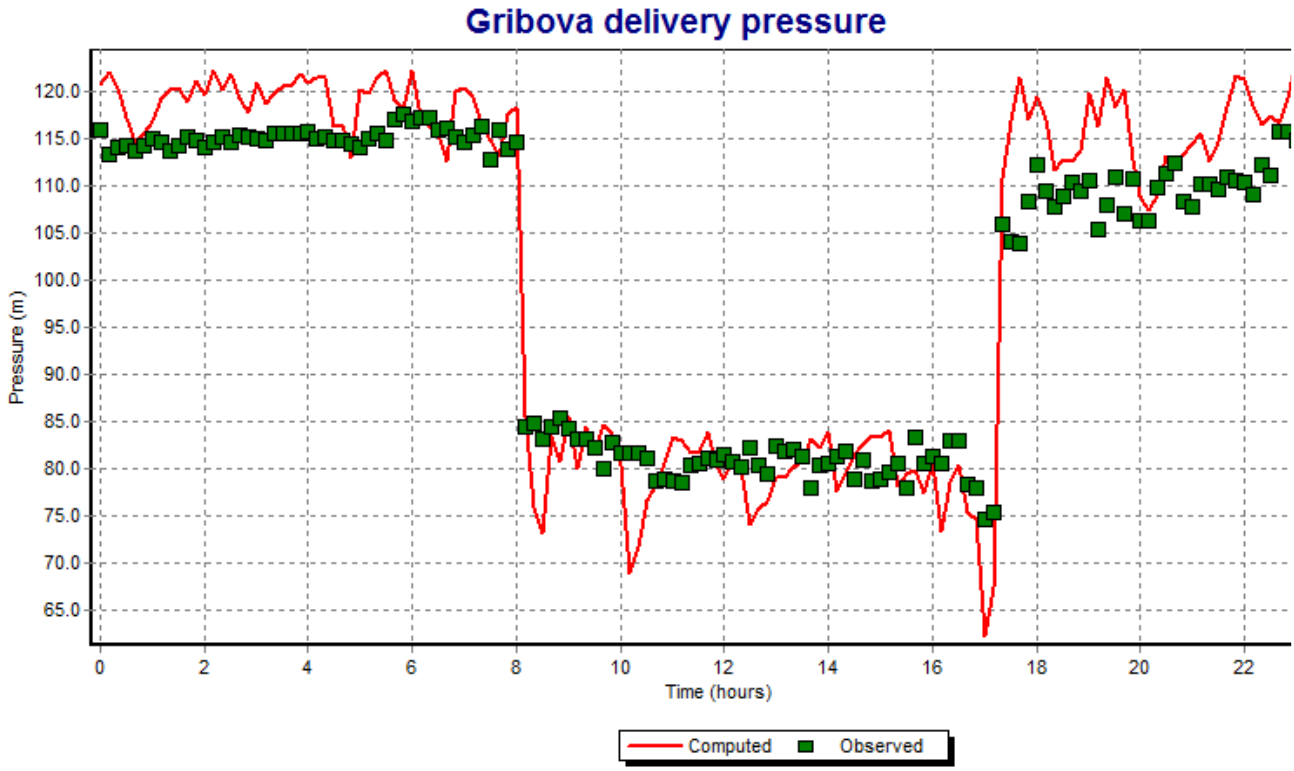
Flow in the Zone 4A Telecentru

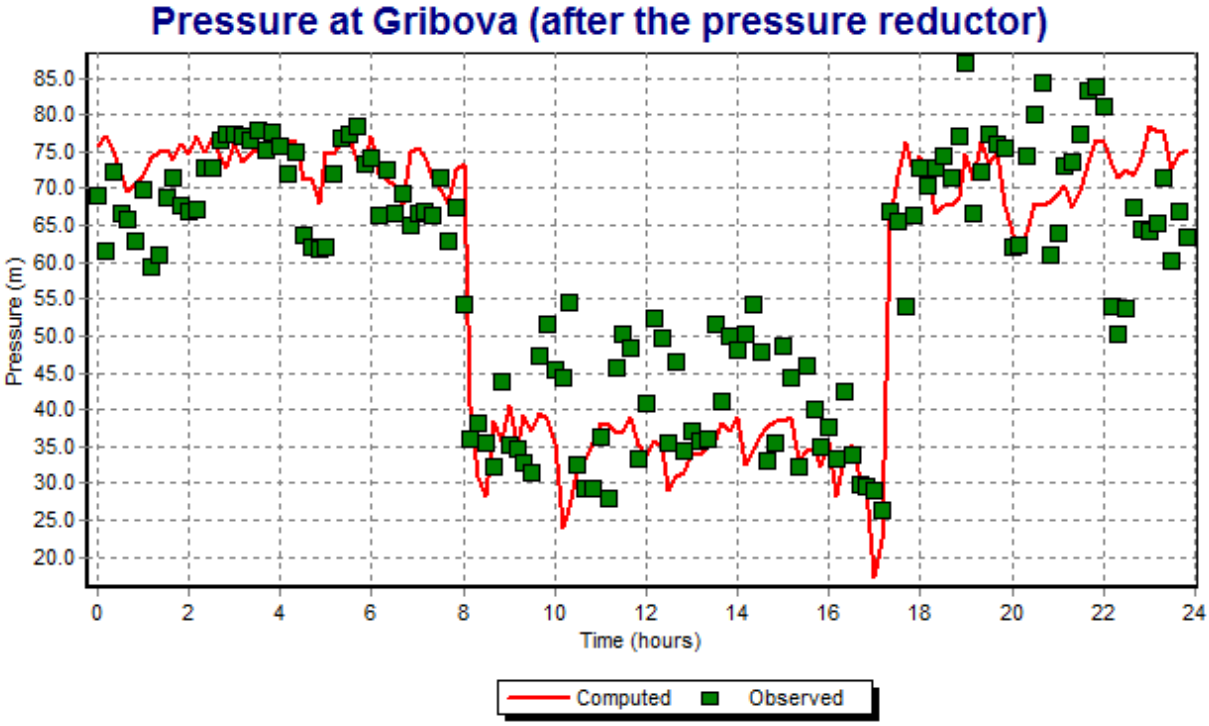


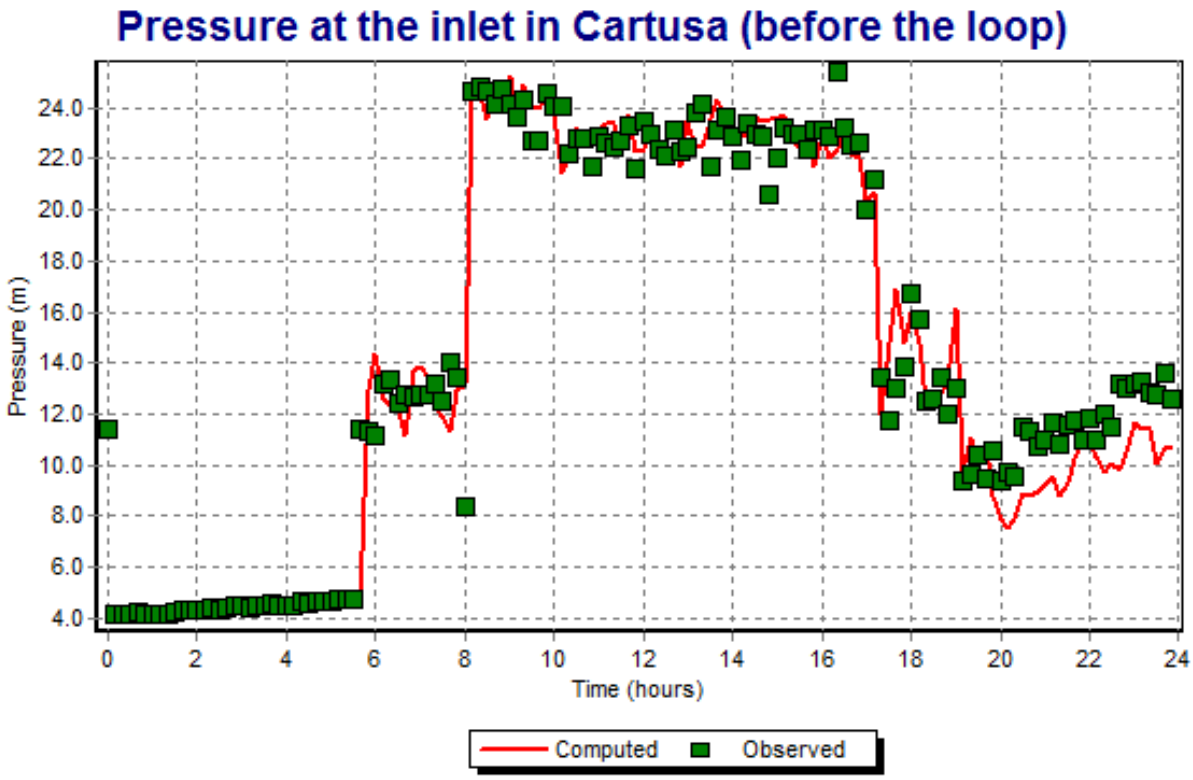


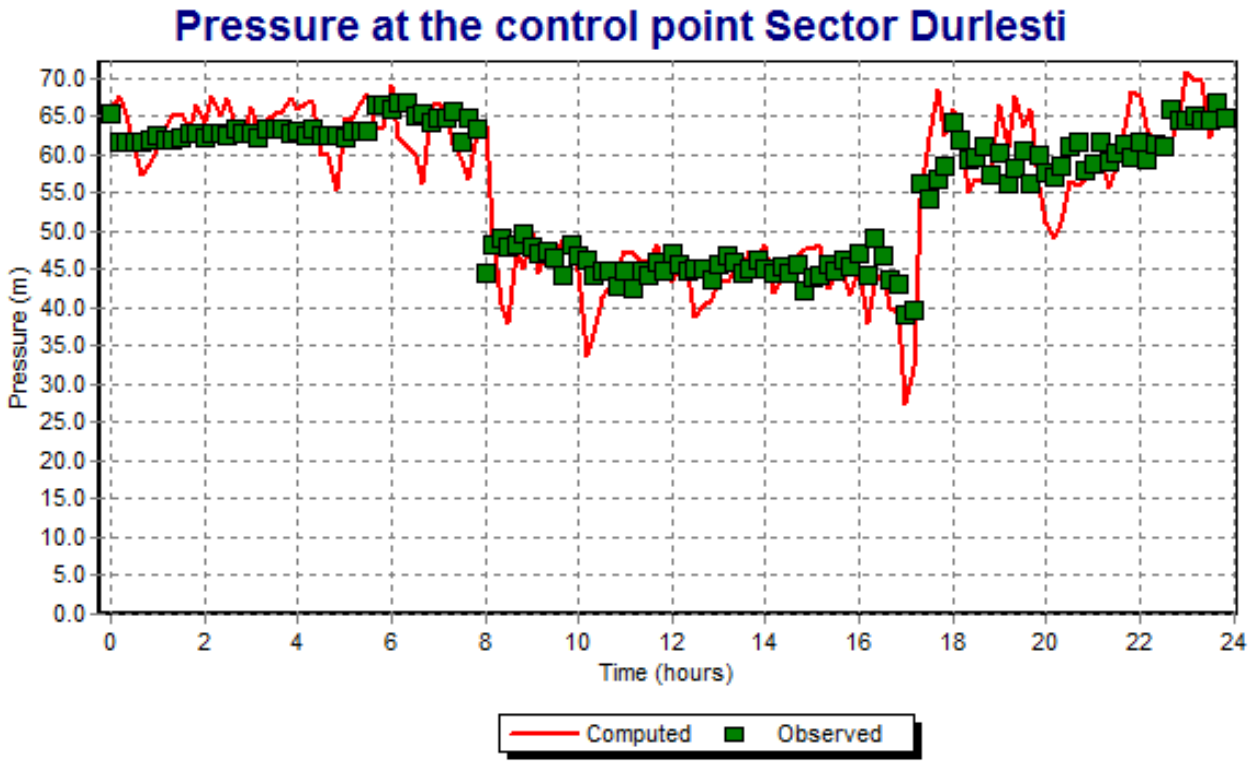
Durleşti Gribov

Pressure in the Zone Durleşti-Gribova, supplied by the pumping station of Gribova

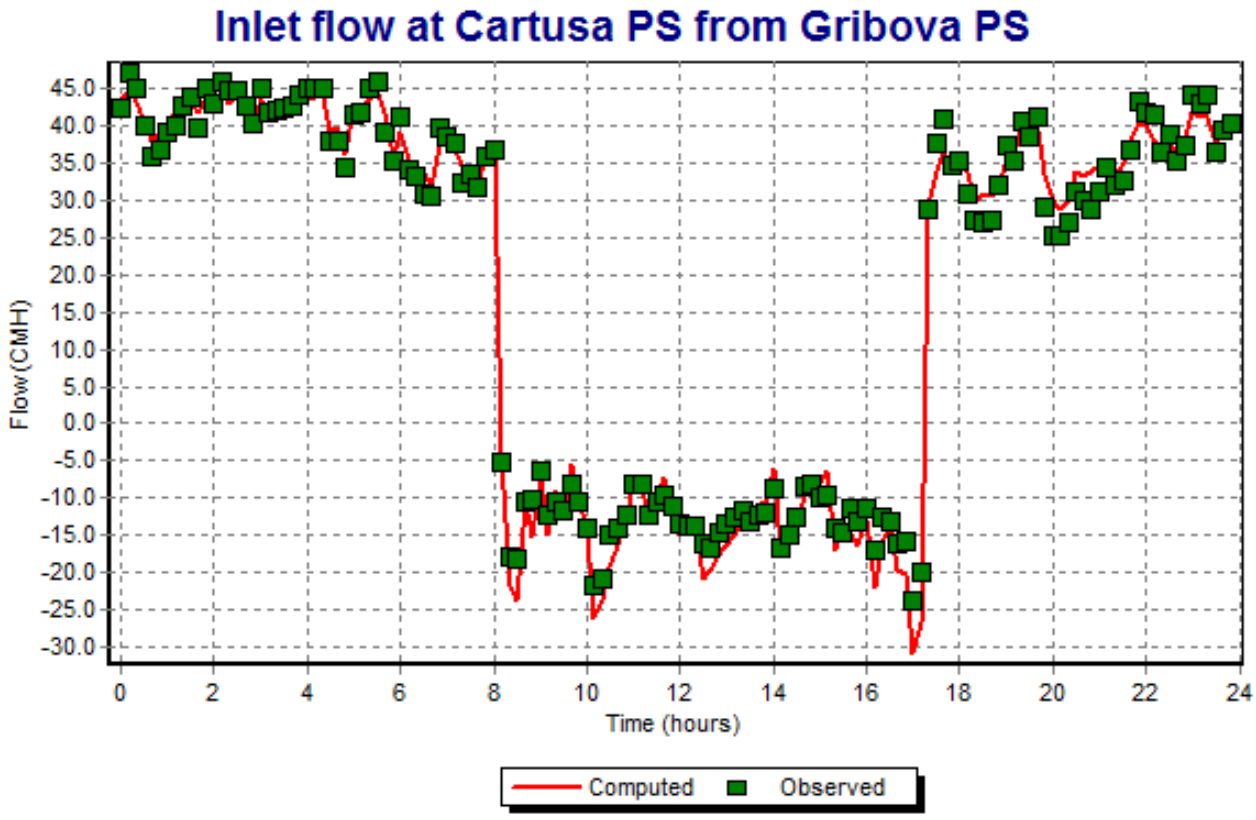


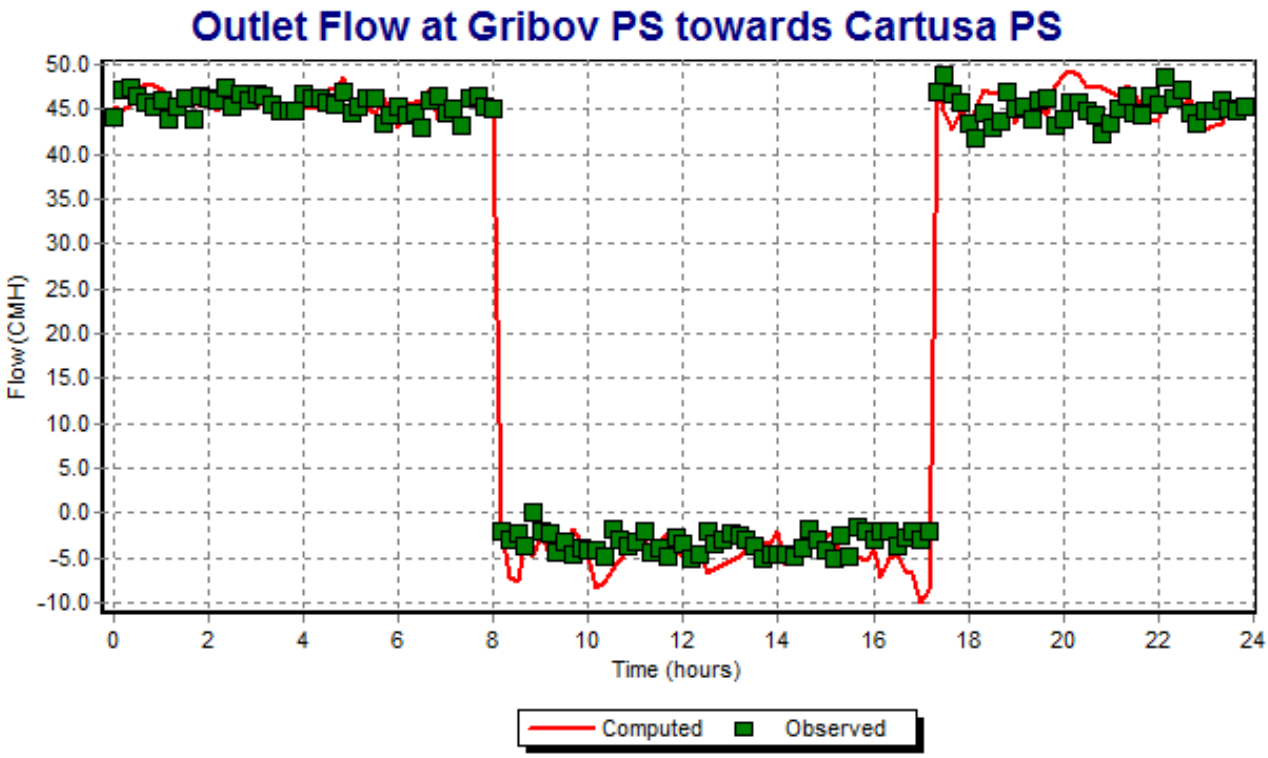



Pressure at the inlet in Cartusa (before the loop)
Pressure (m)
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the control point Sector Durlesti
Pressure (m)
70.0
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

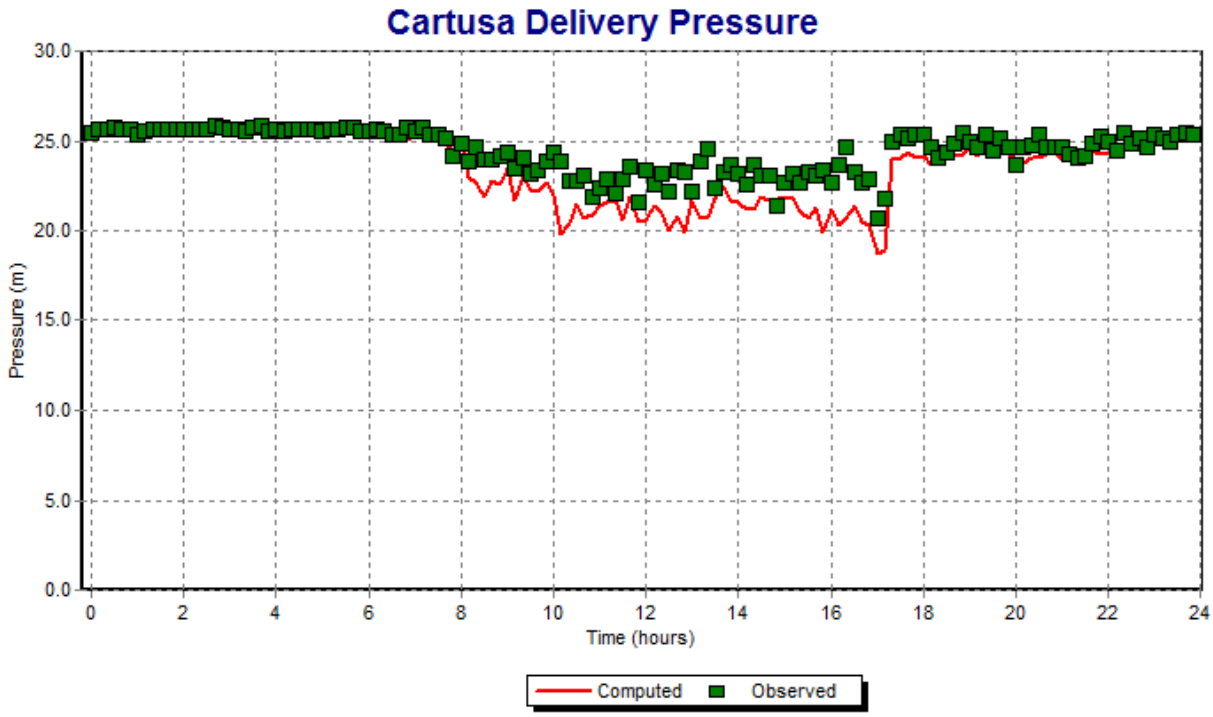
Flow in the Zone Durleşti-Gribova, supplied by the pumping station of Gribova

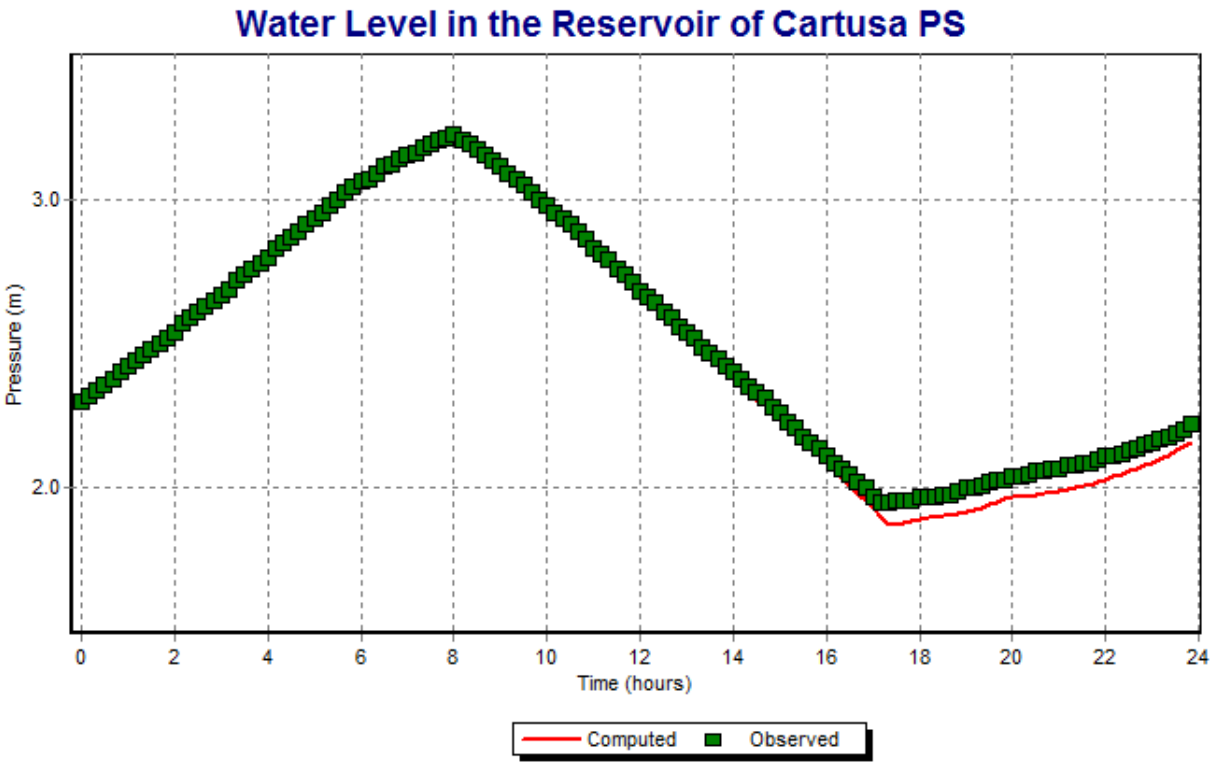


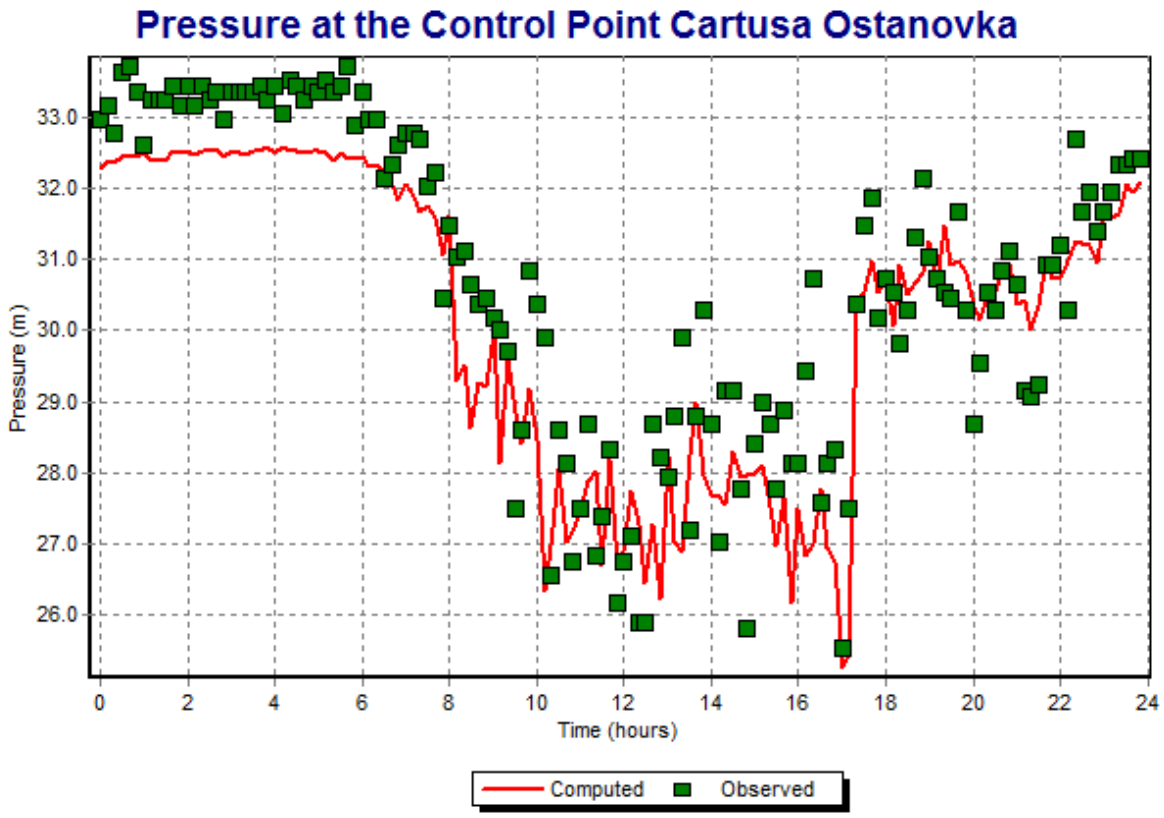


Durleşti Cartuşa

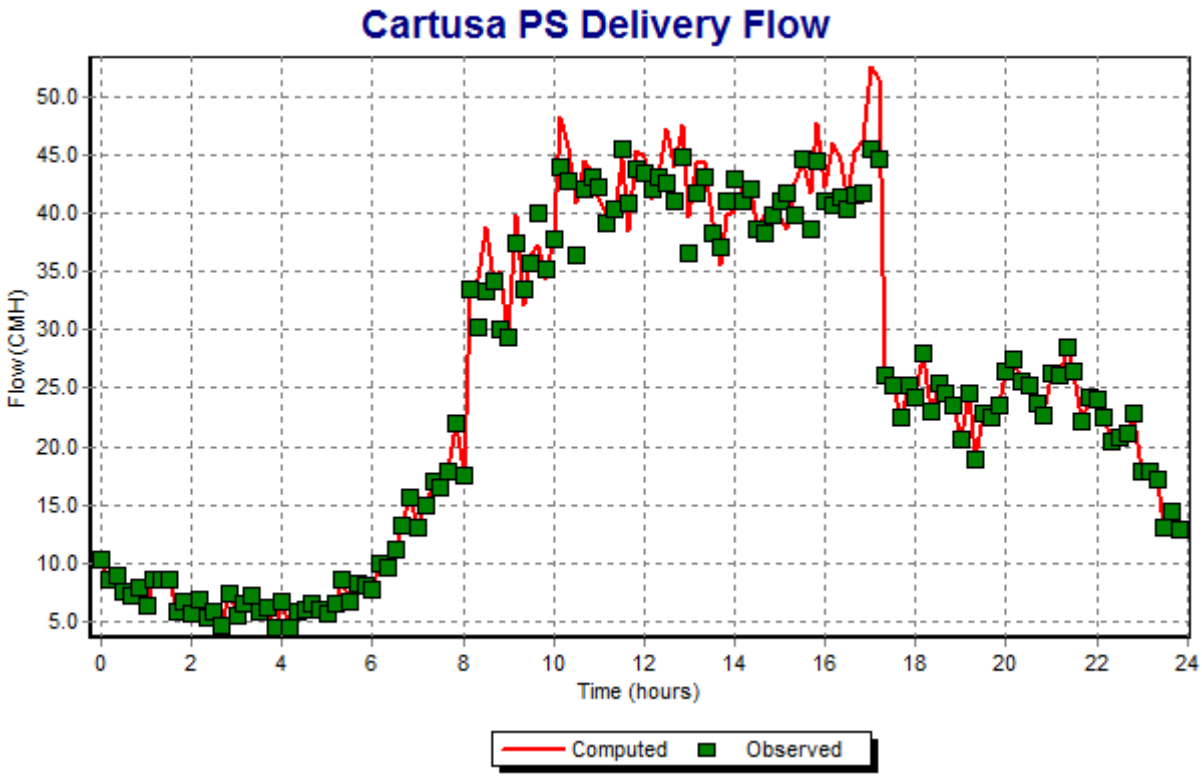
Pressure in the Zone Durleşti-Cartuşa, supplied by the pumping station of Cartuşa





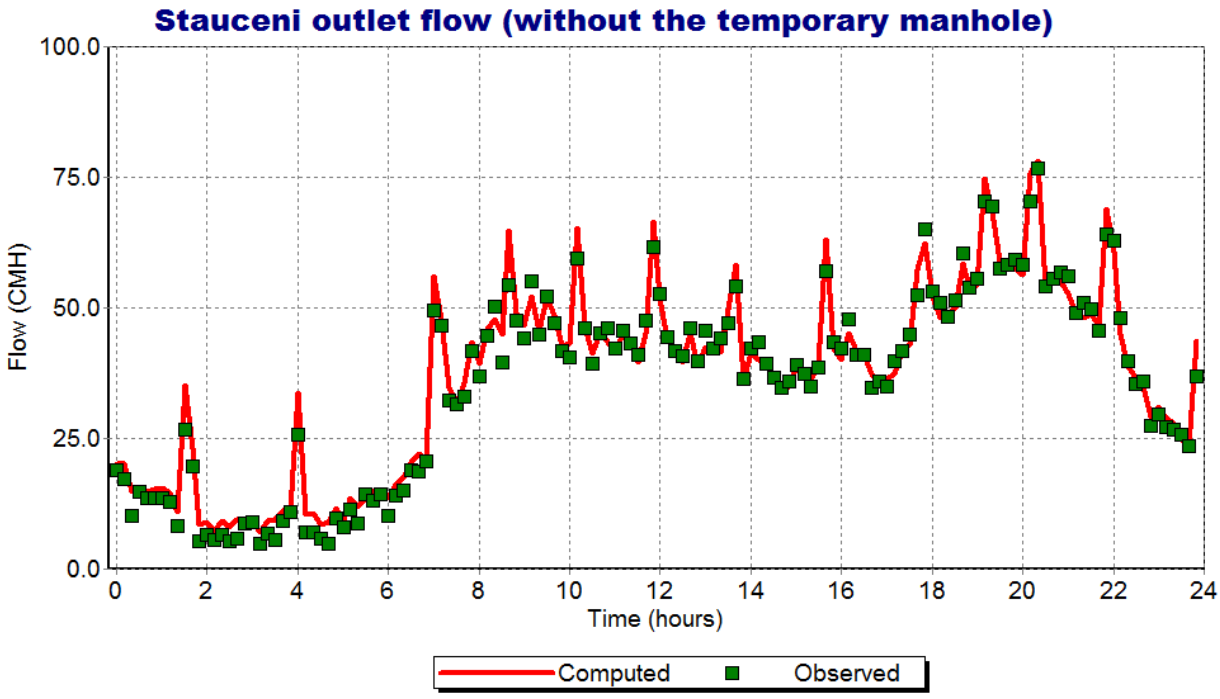


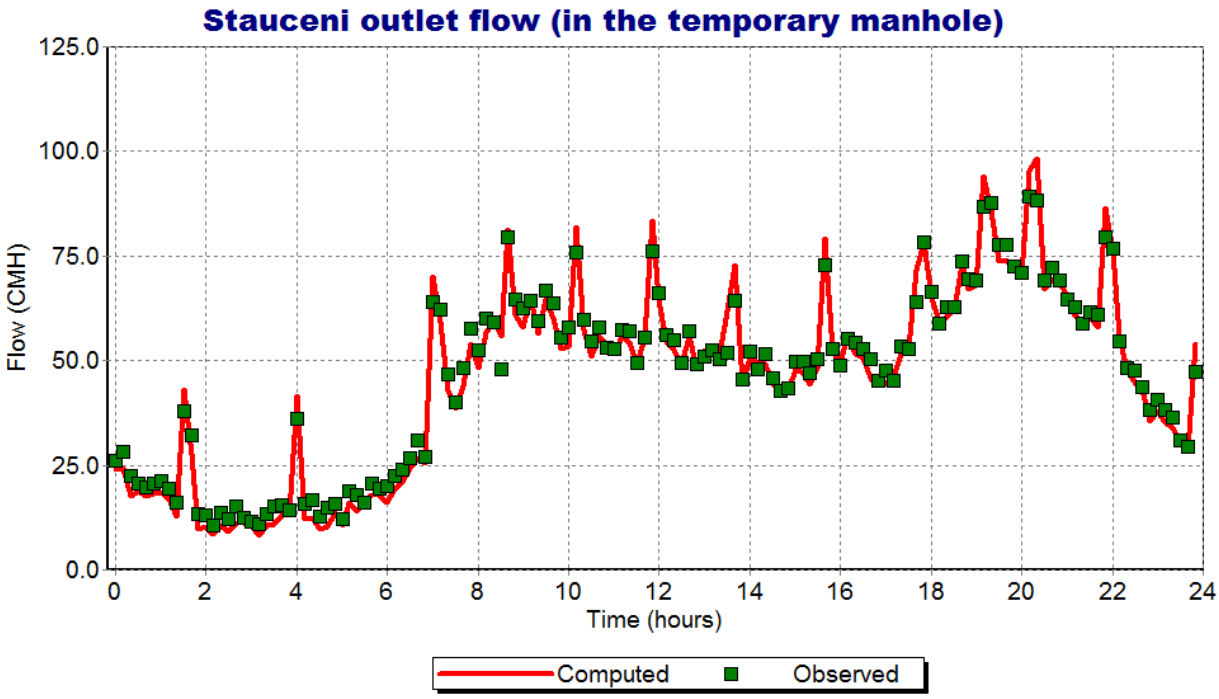
Flow in the Zone Durleşti-Cartuşa, supplied by the pumping station of Cartuşa



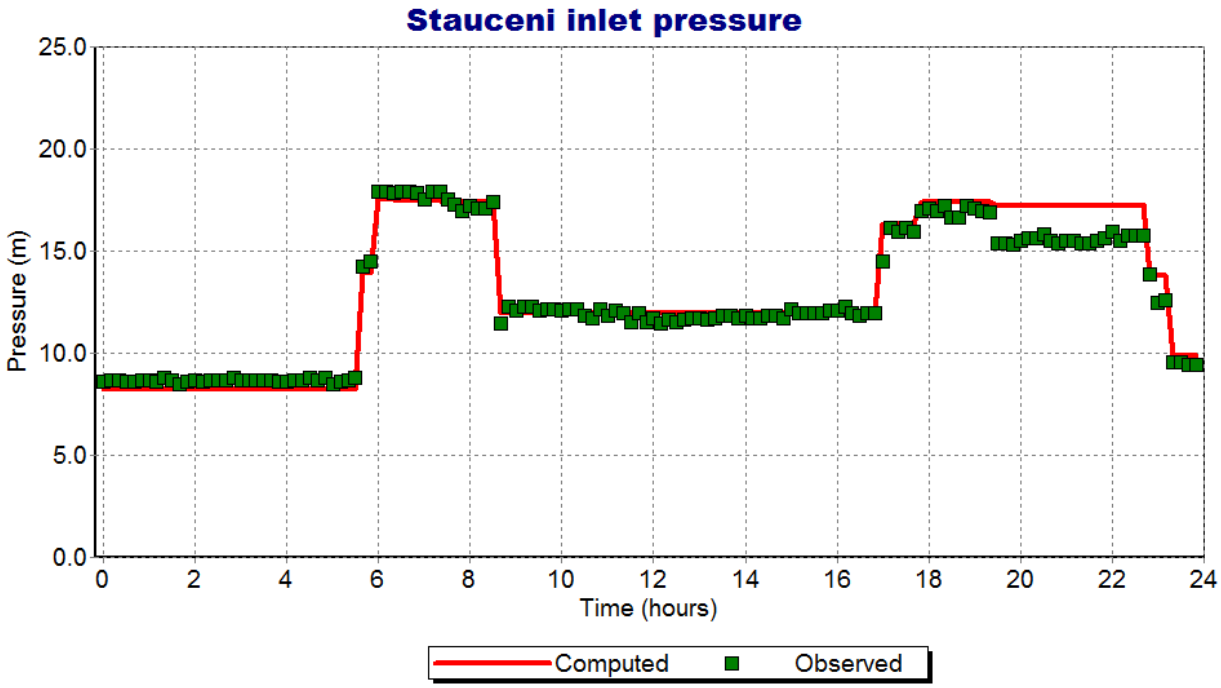
Stauceni

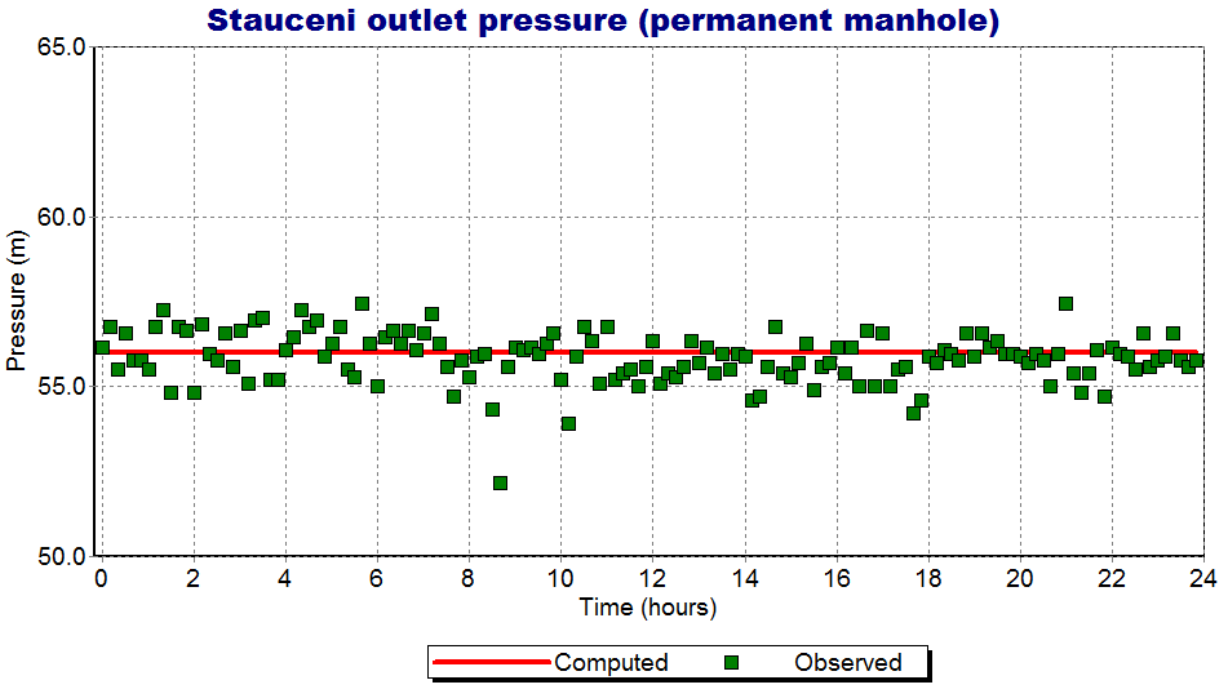
Flow in the Zone 4 Stauceni

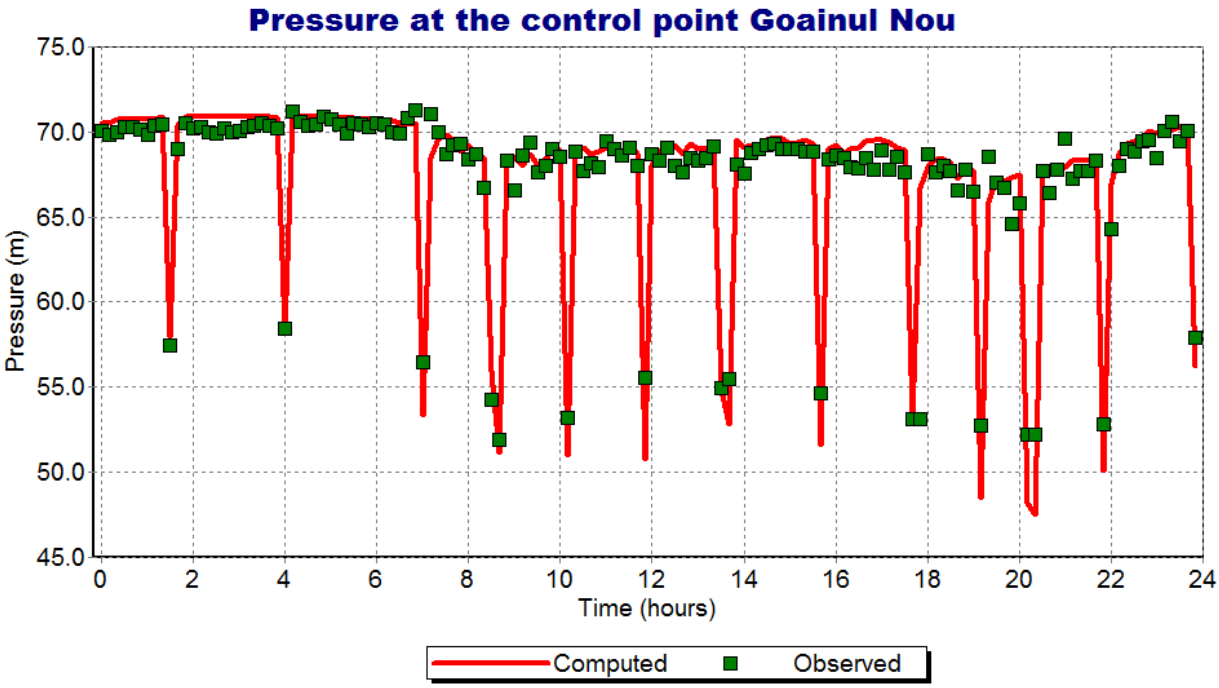




Pressure in the Zone 4 Stauceni

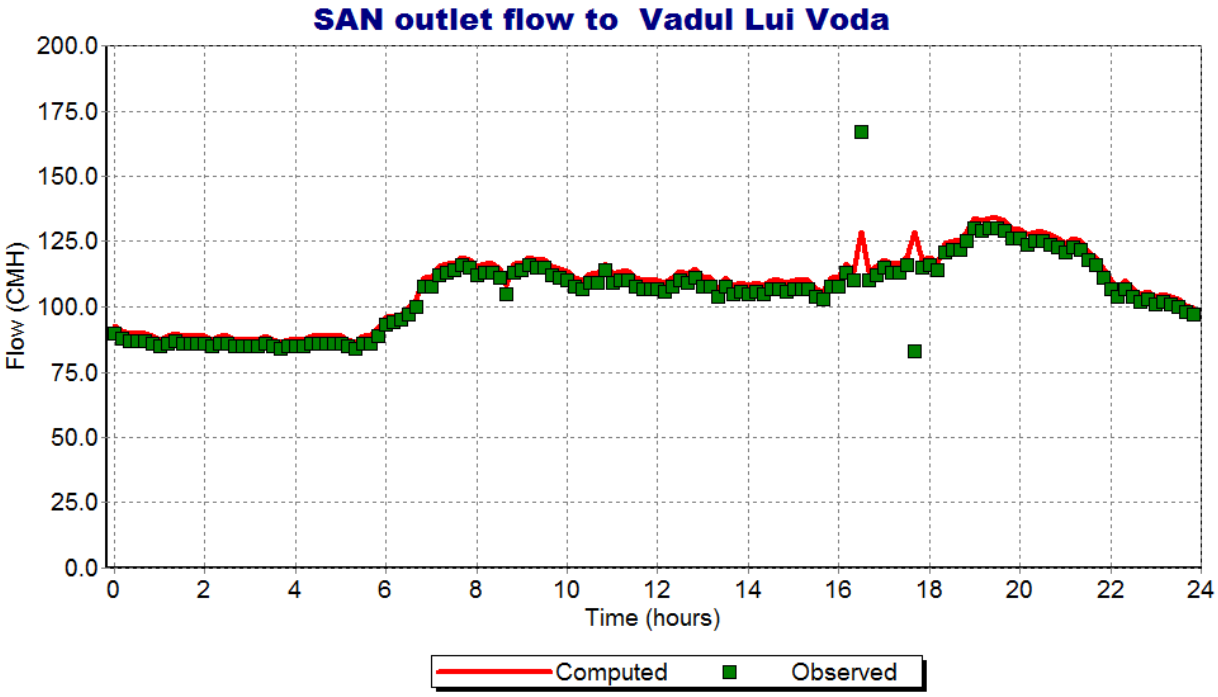




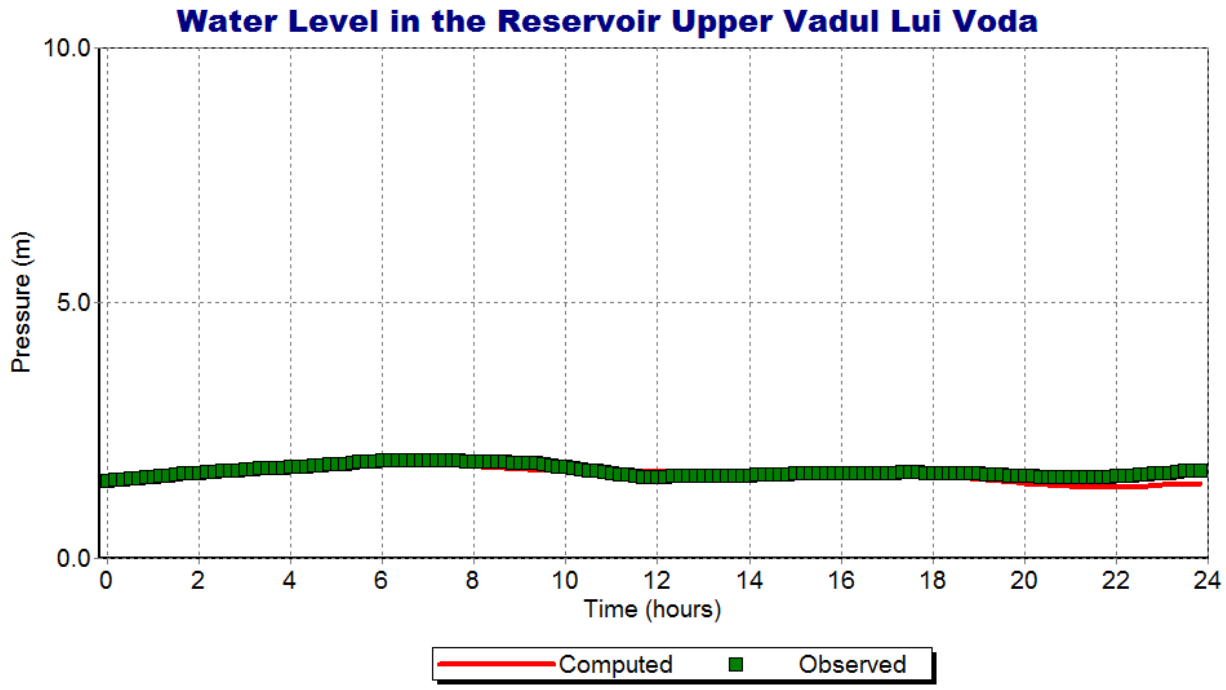


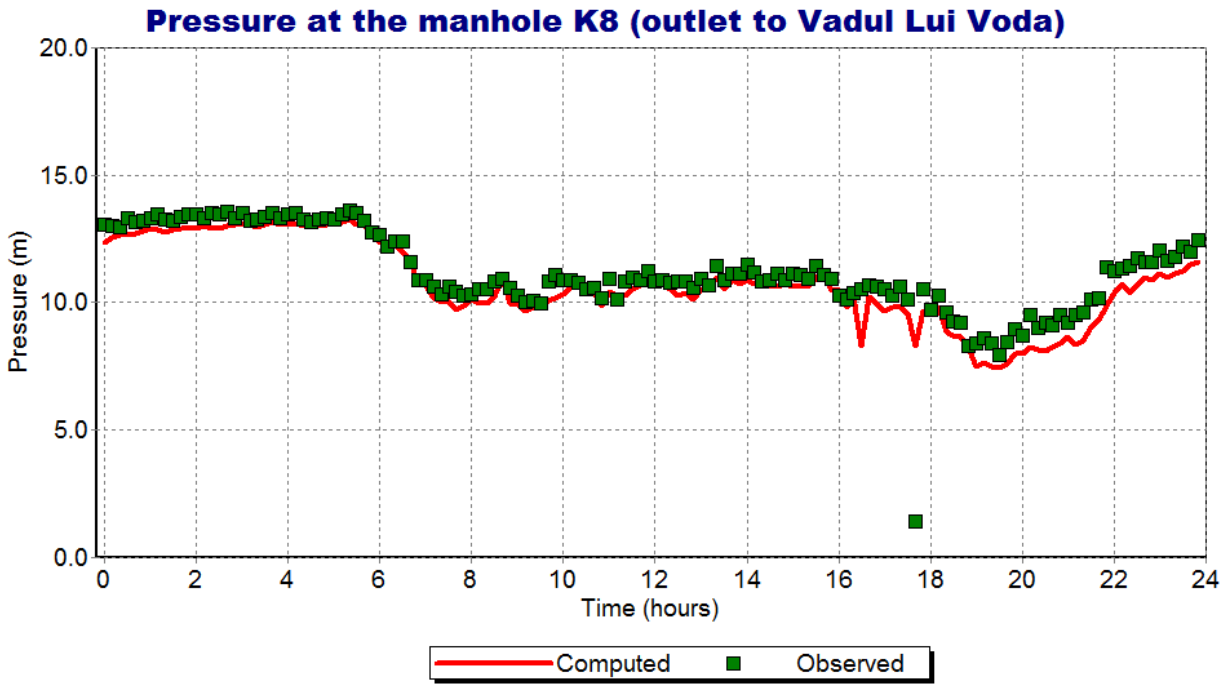
Vadul Lui Voda

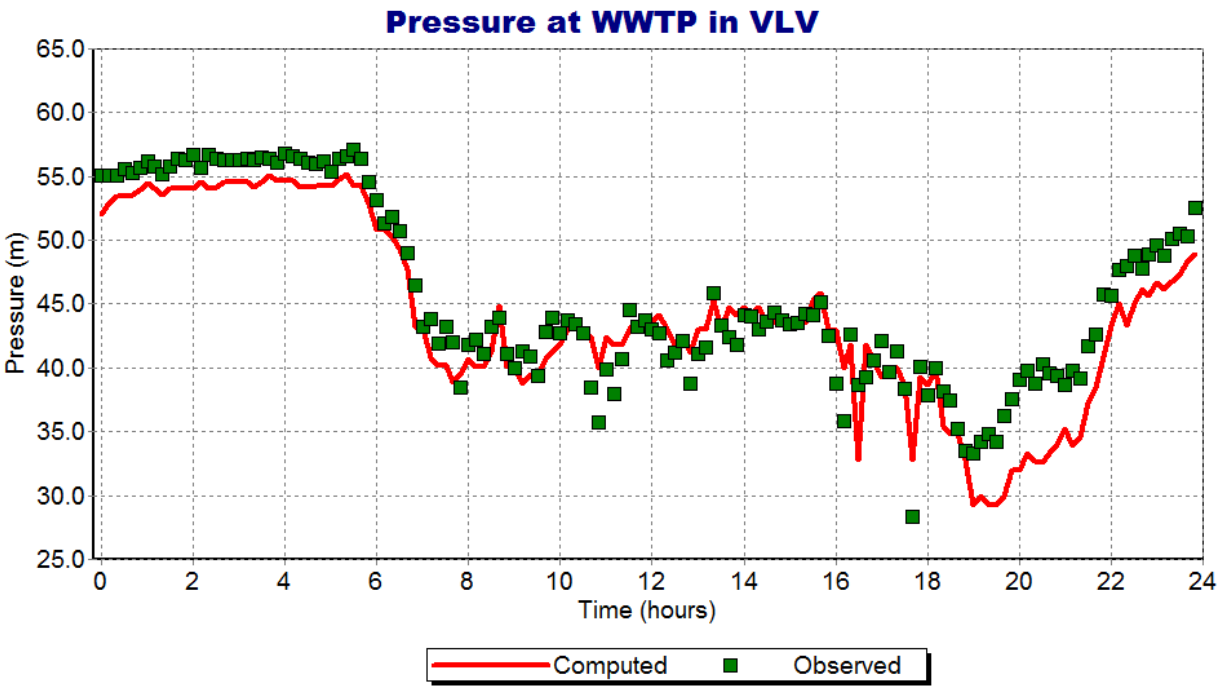
Flow in the Zone Vadul Lui Voda, supplied by the reservoir Upper Vadul Lui Voda

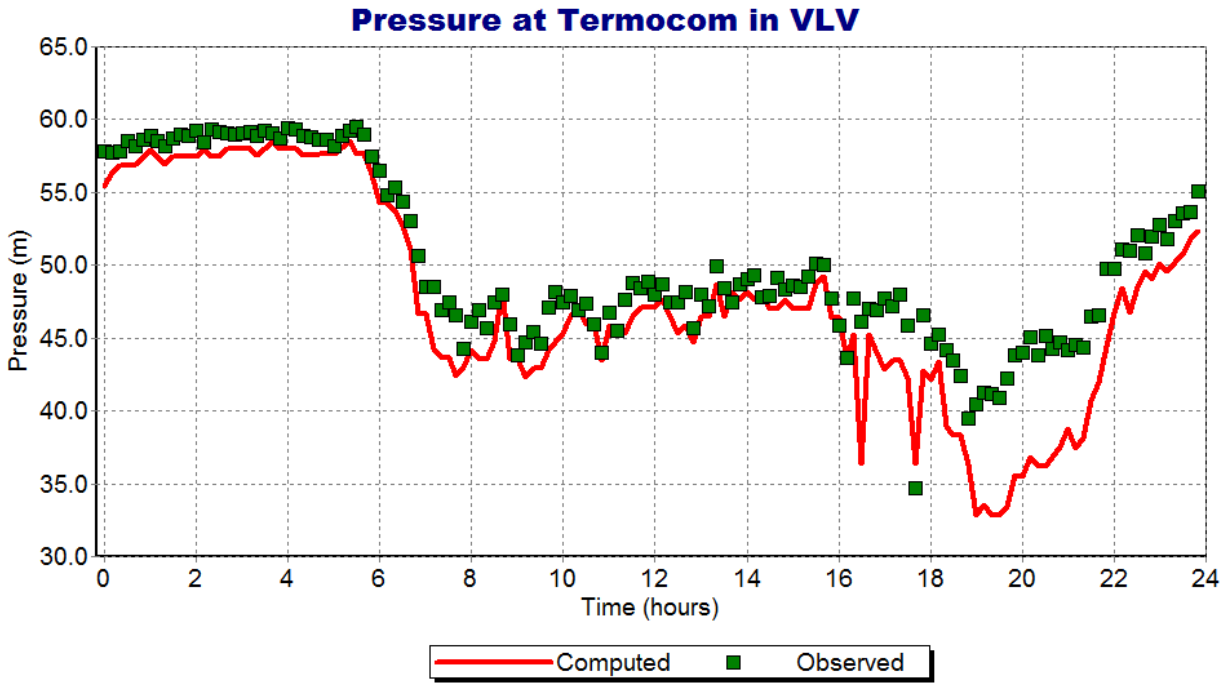


Pressure in the Zone Vadul Lui Voda, supplied by the reservoir Upper Vadul Lui Voda



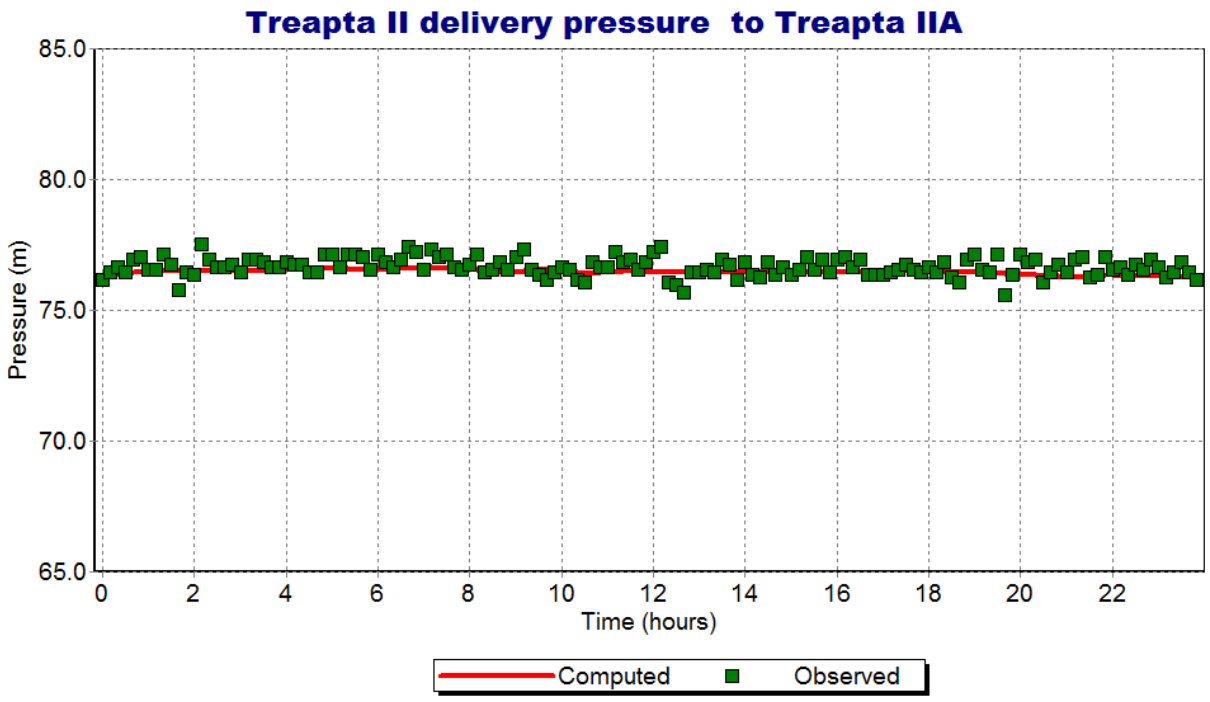


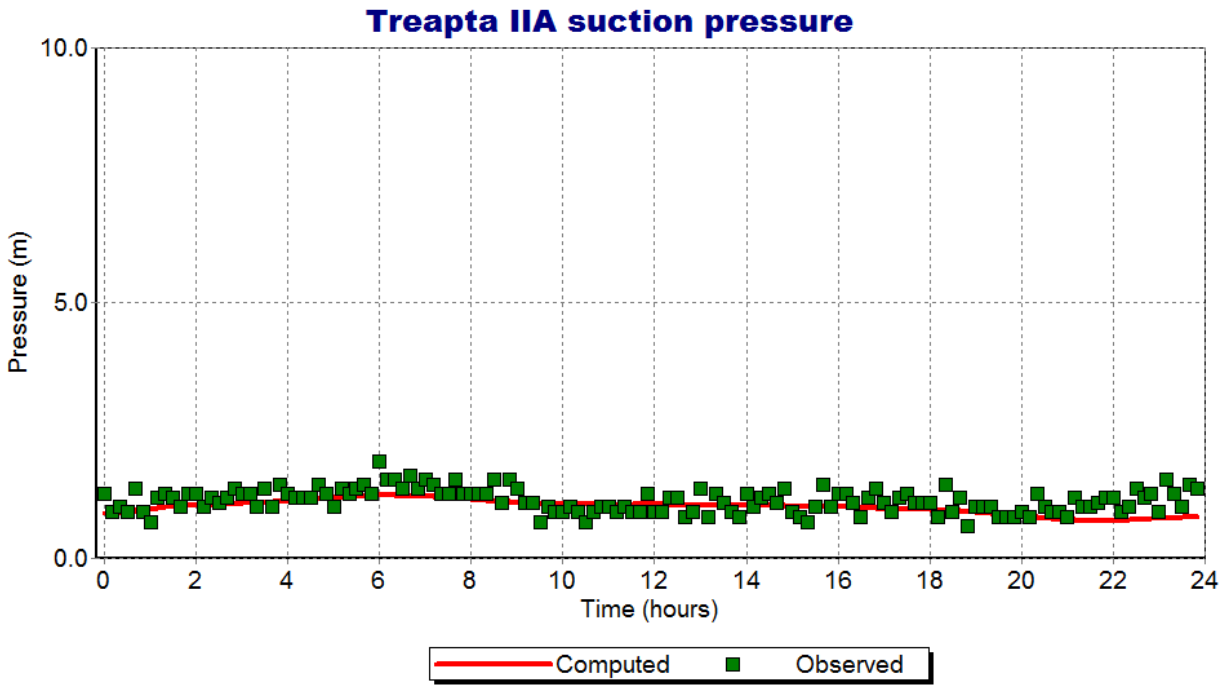

Pressure at WWTP in VLV
Pressure (m)
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
25.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

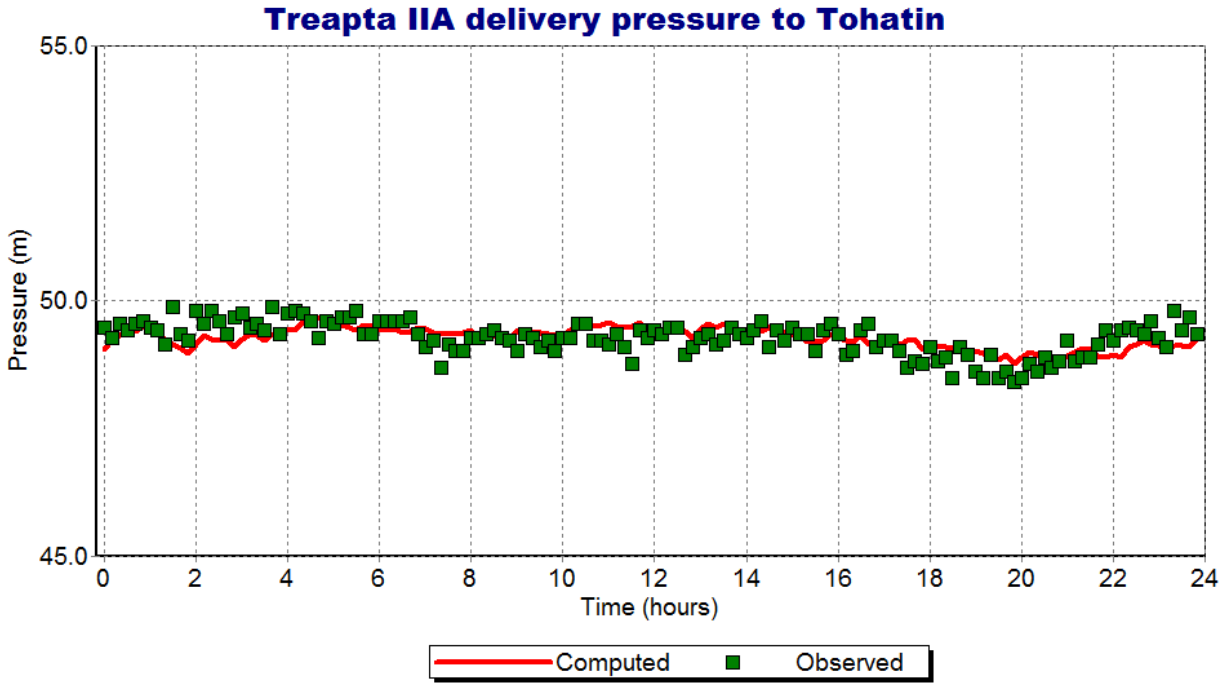

Pressure at Termocom in VLV
Pressure (m)
65.0
60.0
55.0
50.0
45.0
40.0
35.0
30.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

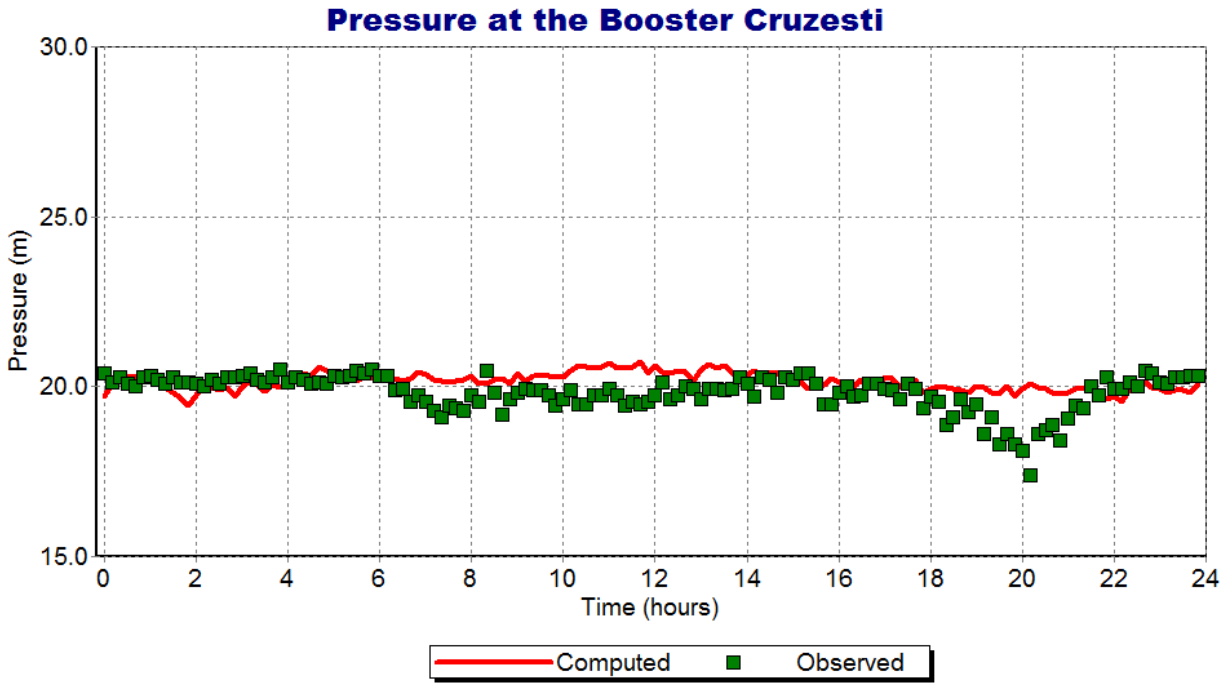
SAN to Tohatin

Pressure in the Zone between SAN and Tohatin pumping Station

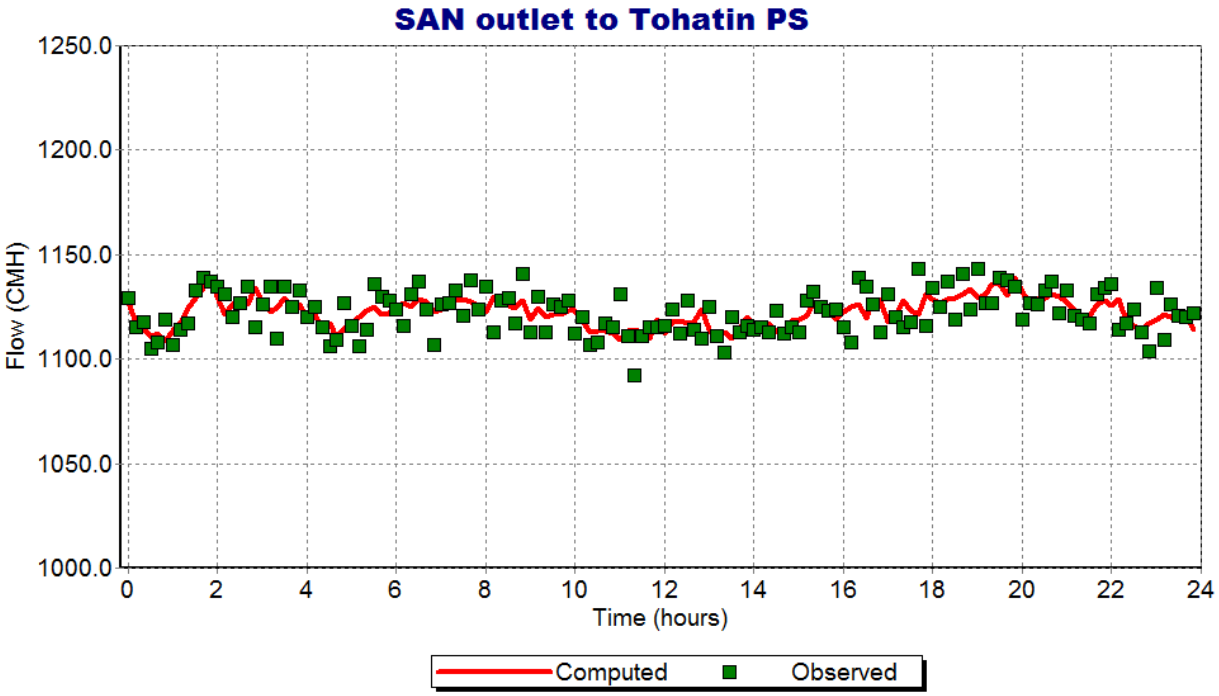


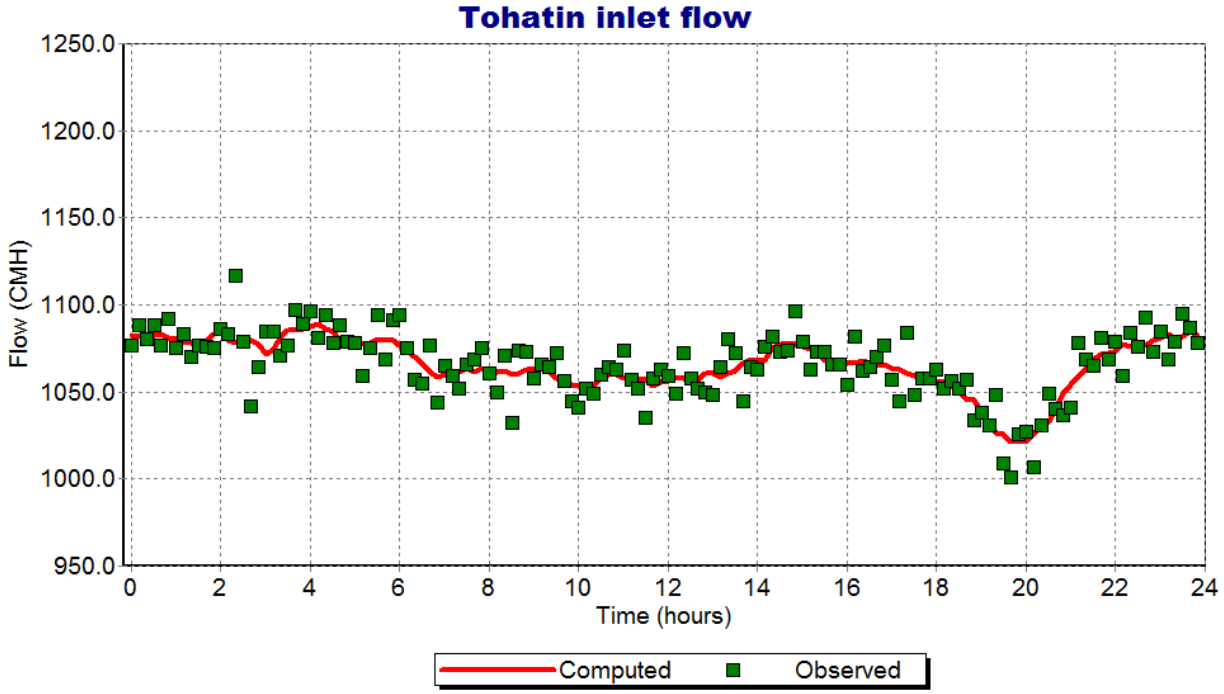



Treapta IIA delivery pressure to Tohatin
55.0
50.0
45.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the Booster Cruzesti
30.0
25.0
20.0
15.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

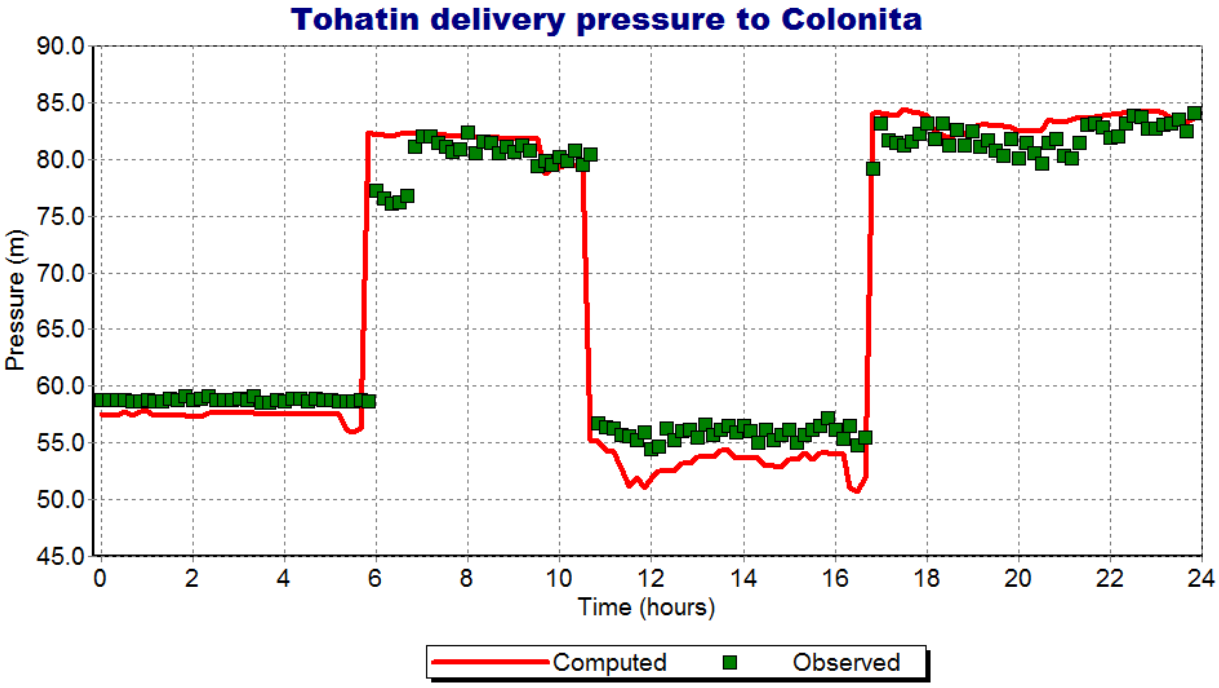
Flow in the Zone between SAN and Tohatin pumping Station

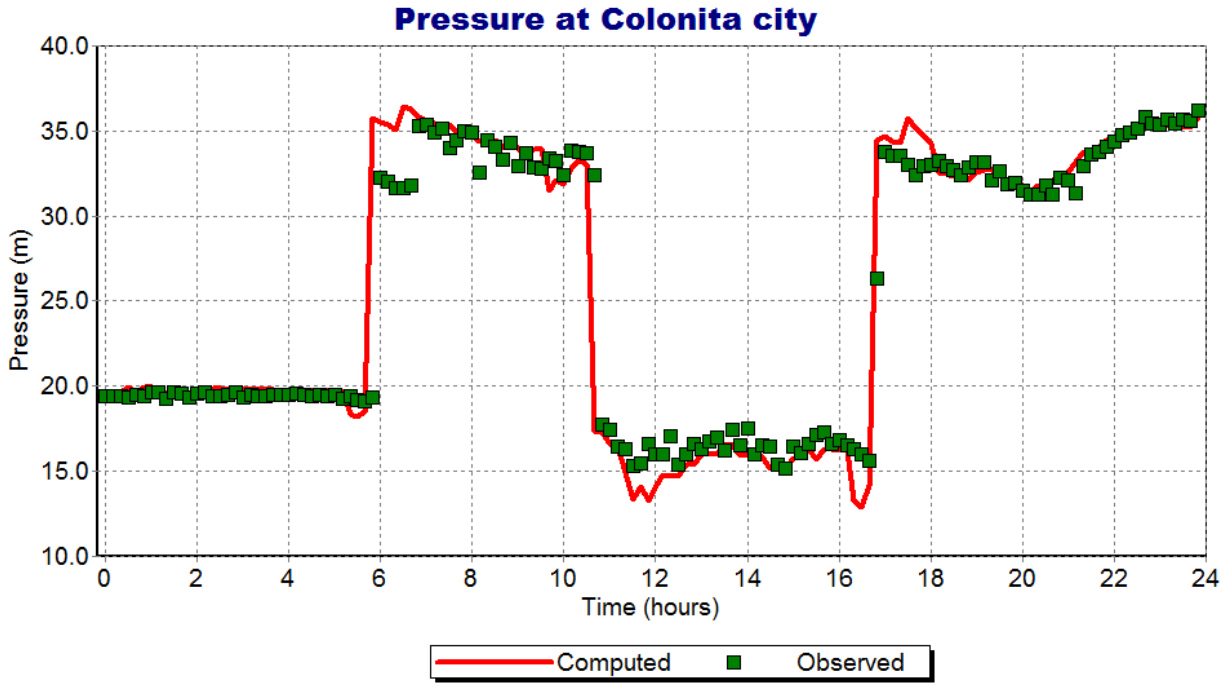


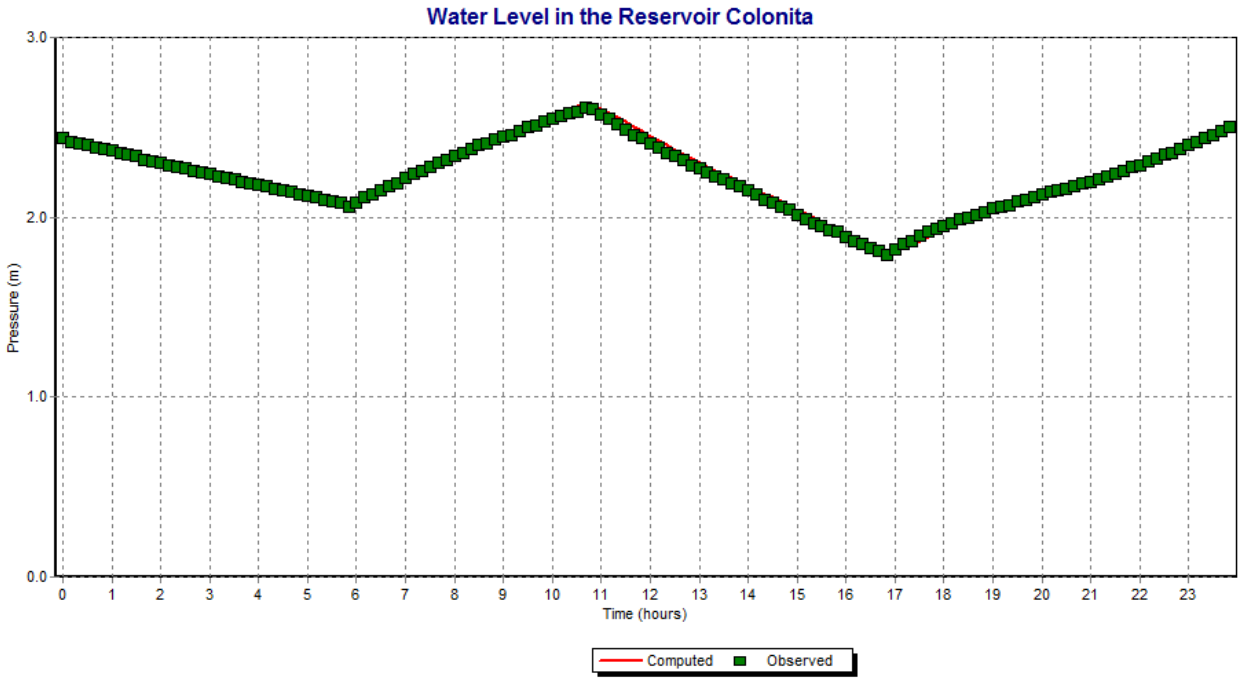


Coloniţa

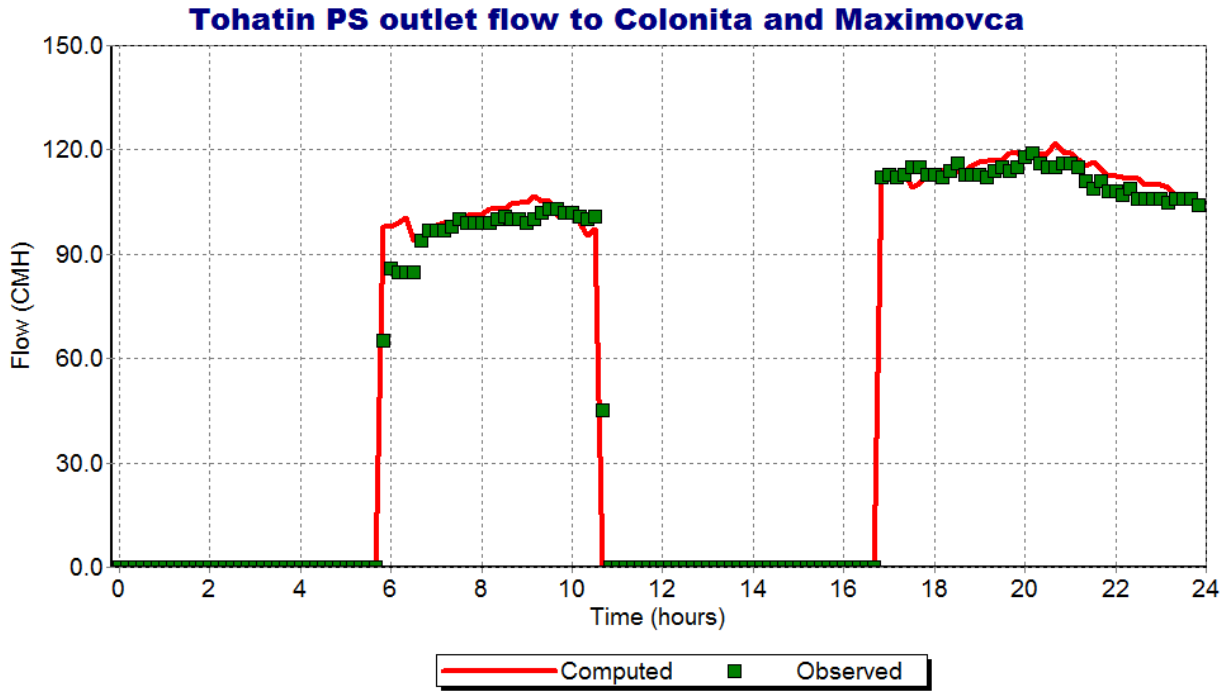
Pressure in the Zone Coloniţa, supplied by the pumping station of Tohatin





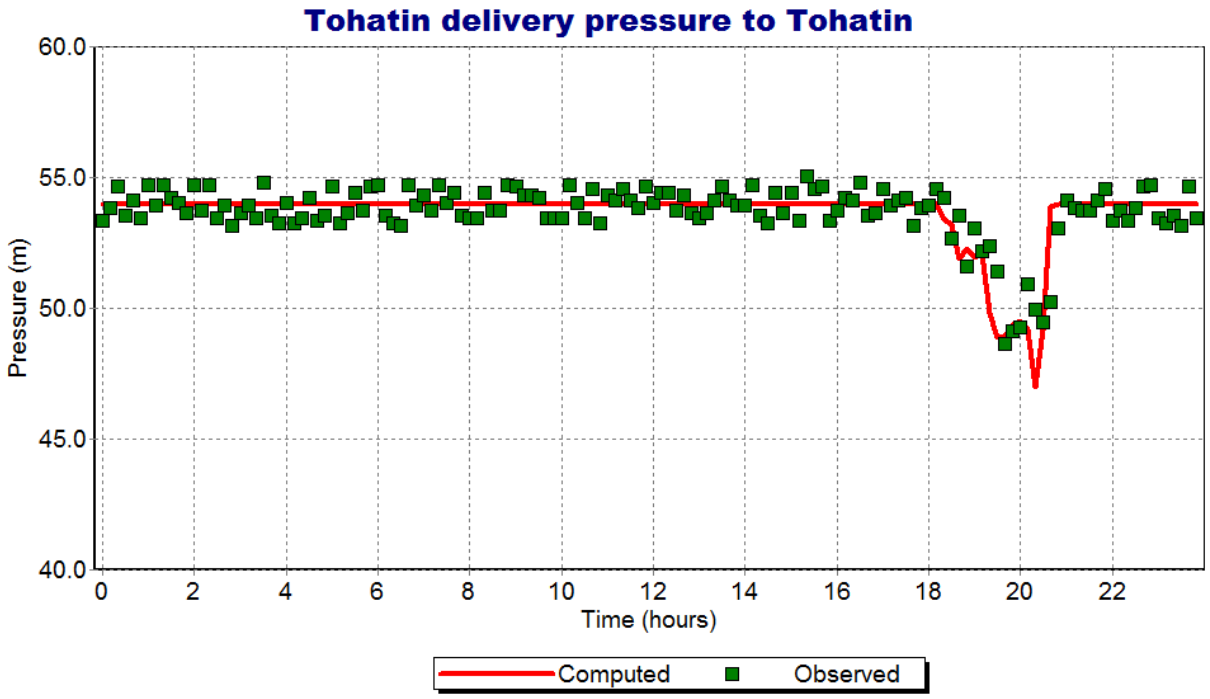


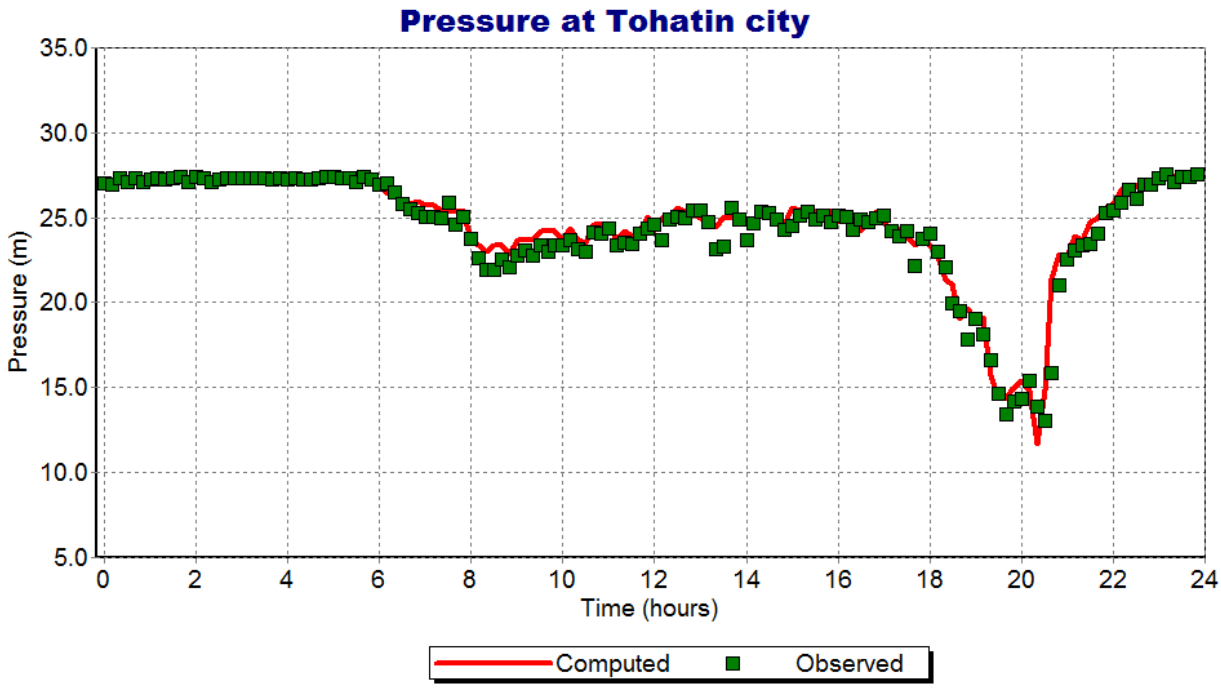
Flow in the Zone Coloniţa, supplied by the pumping station of Tohatin



Tohatin

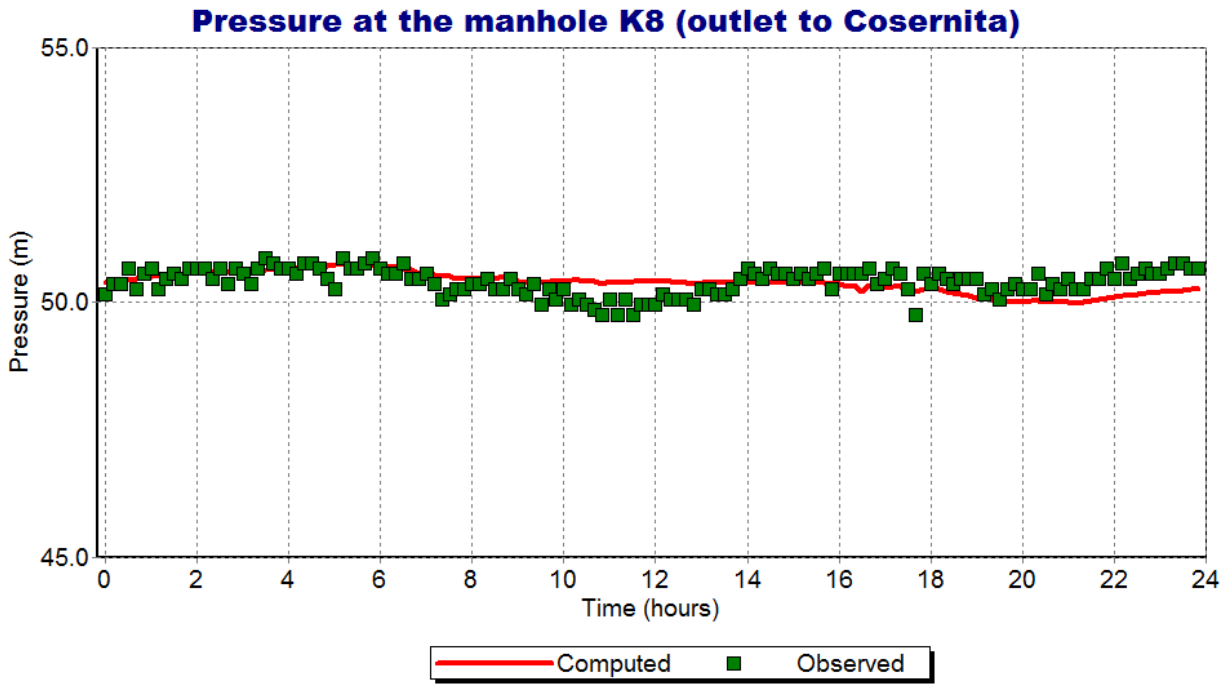
Pressure in the Zone Tohatin, supplied by the pumping station of Tohatin





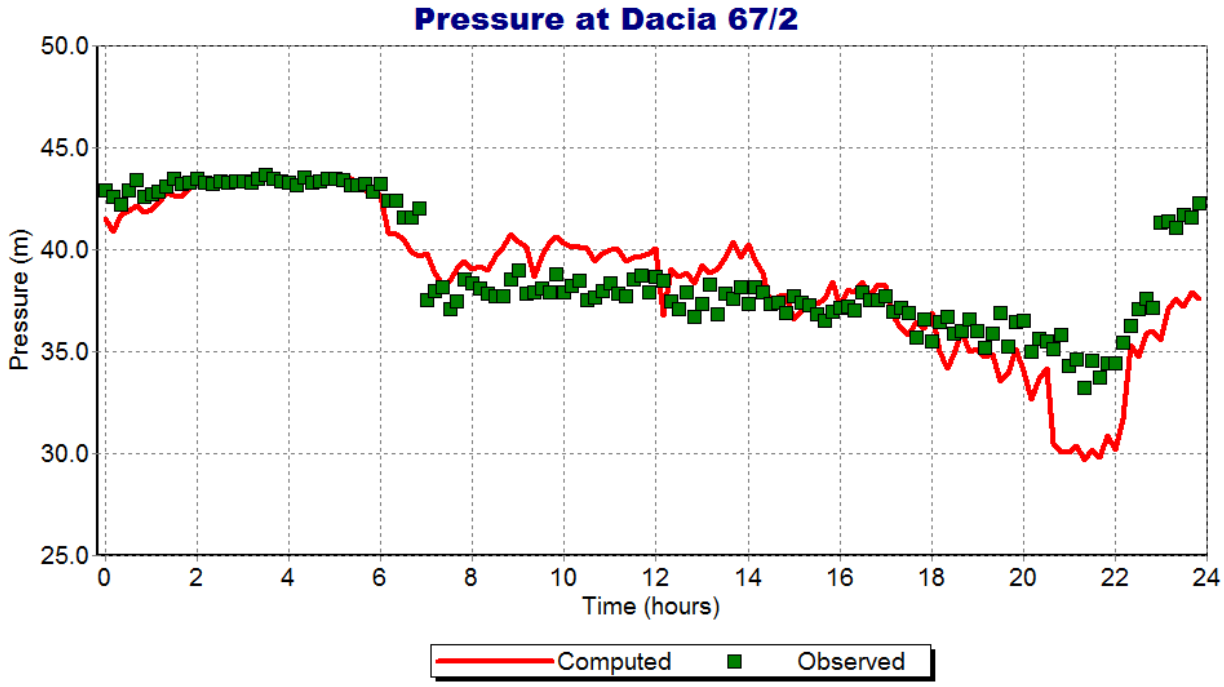
Coşerniţa

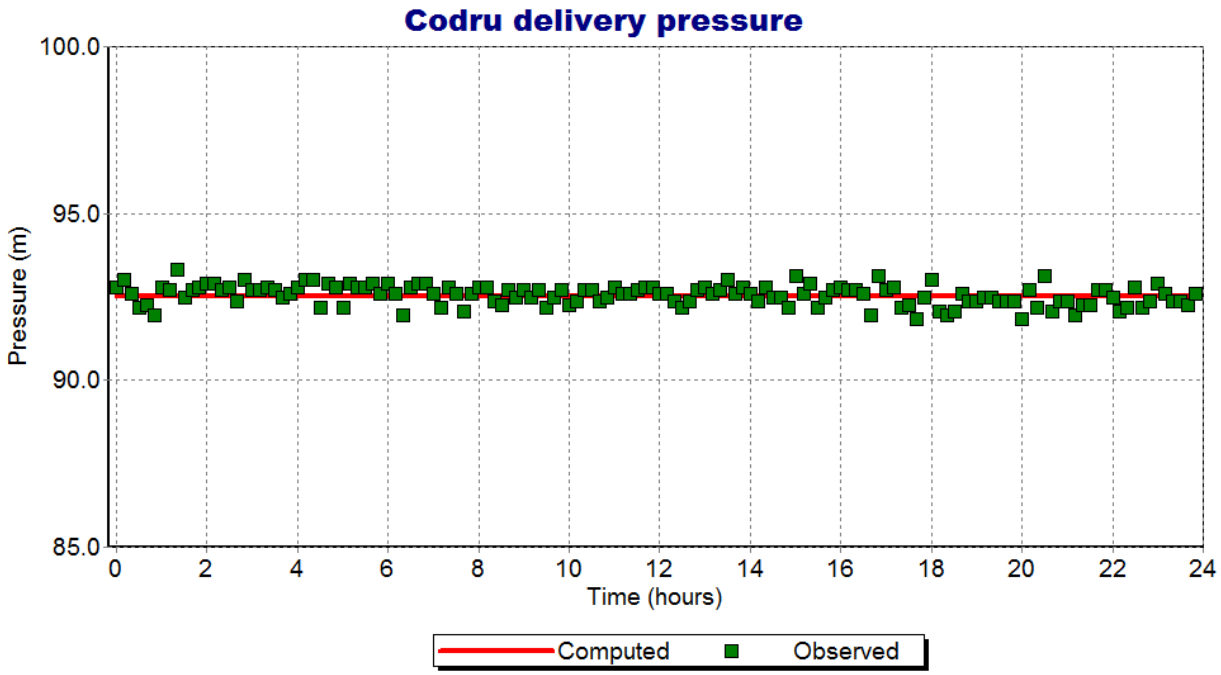
Pressure in the Zone Coşerniţa, supplied by the reservoir Upper Vadul Lui Voda

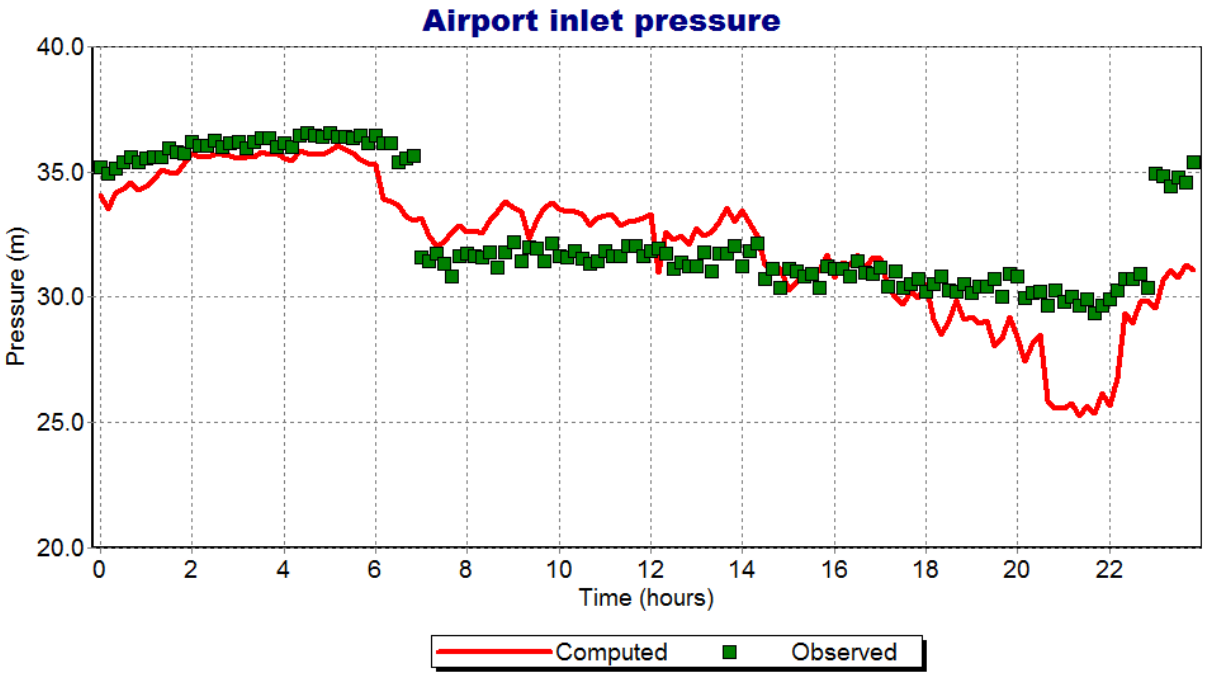


Codru to Airport

Pressure in the Zone between Codru PS and Airport PS

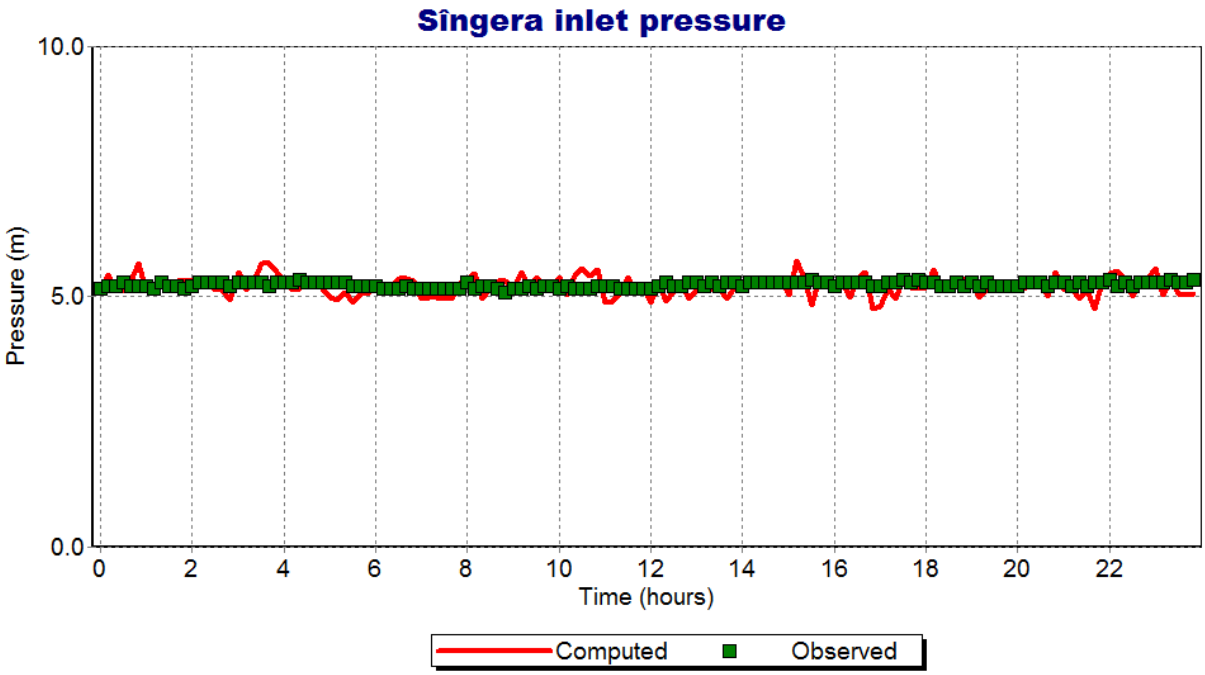


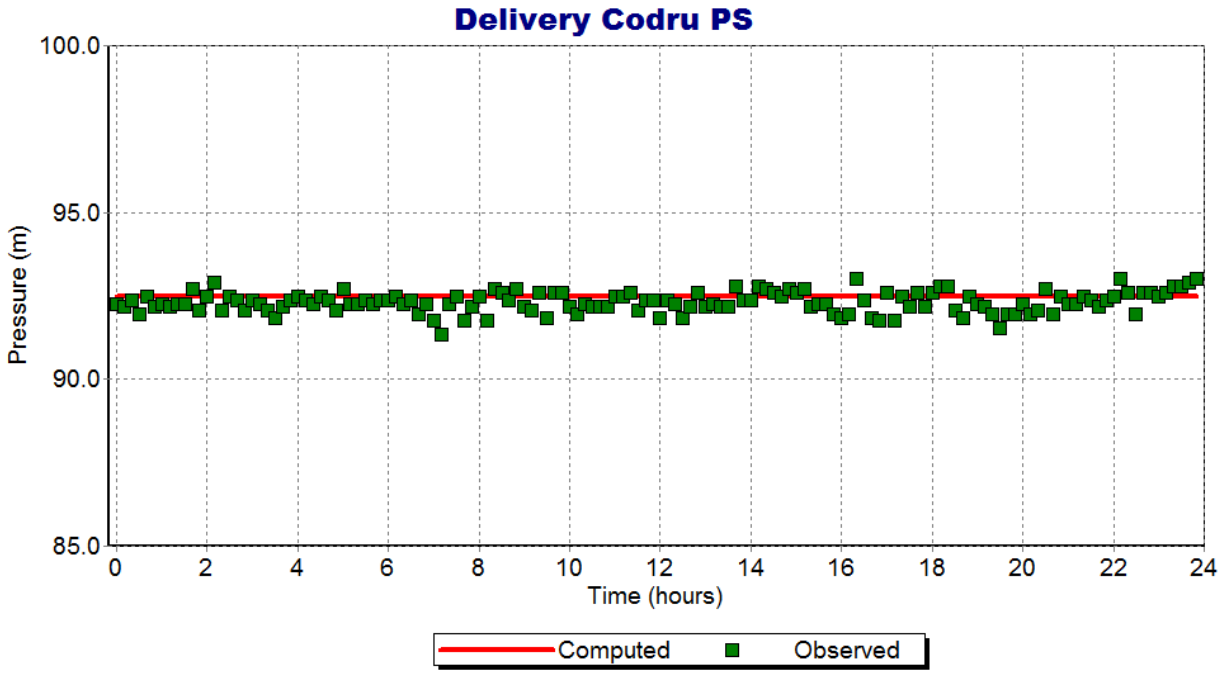

Codru delivery pressure
100.0
95.0
90.0
85.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Airport inlet pressure
40.0
35.0
30.0
25.0
20.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

Codru PS to Sîngera PS

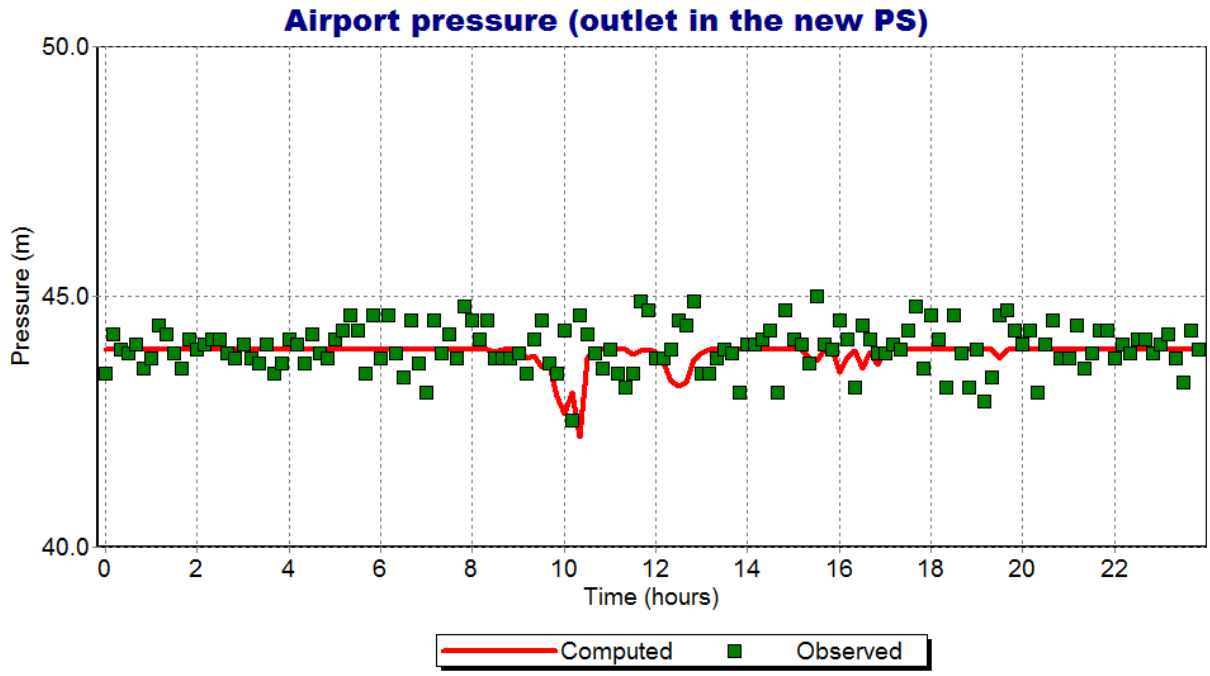
Pressure in the Zone between Codru PS and Sîngera PS

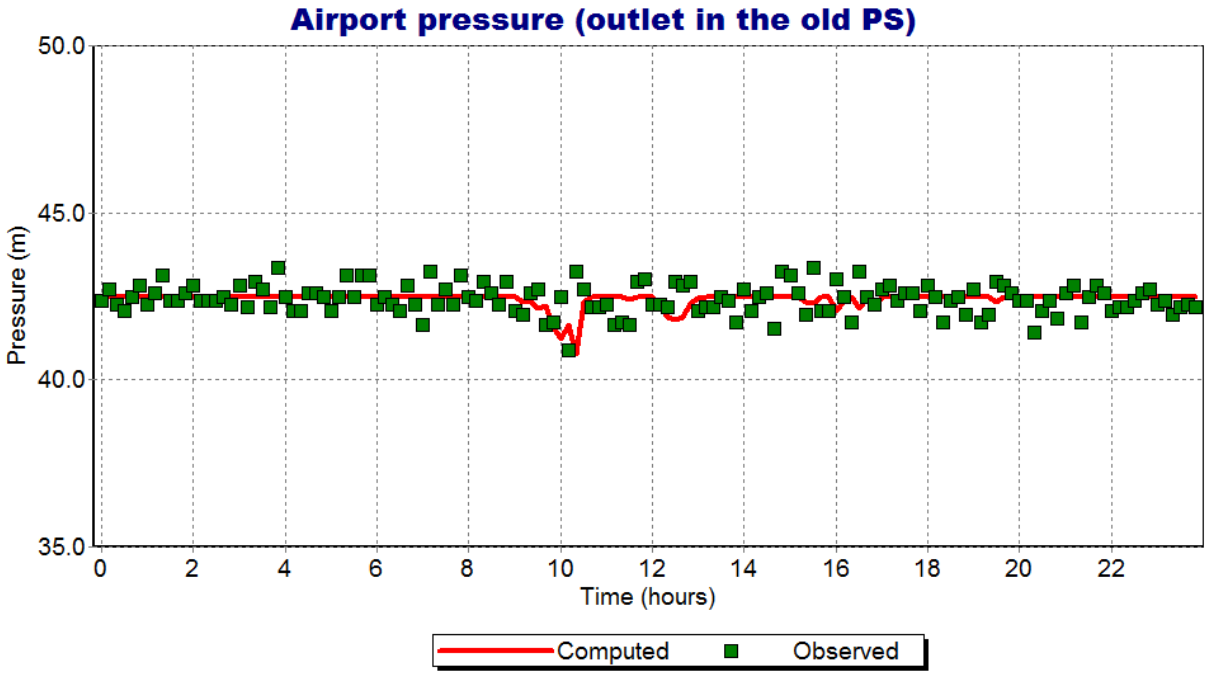




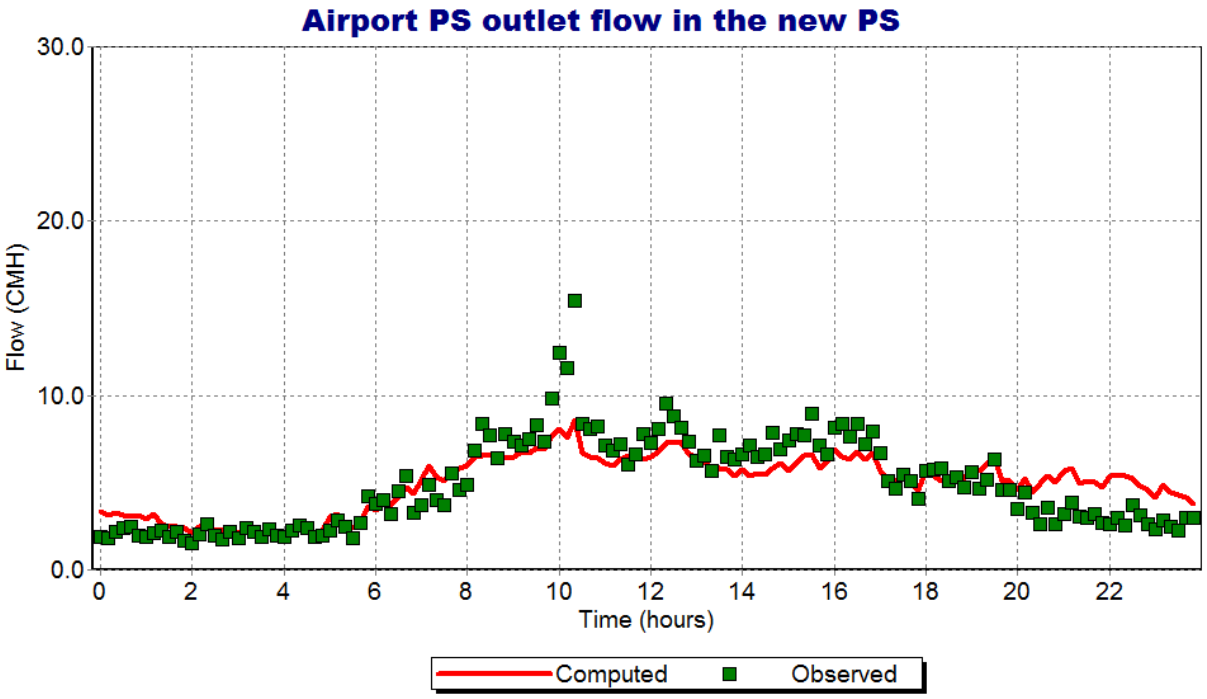
Airport

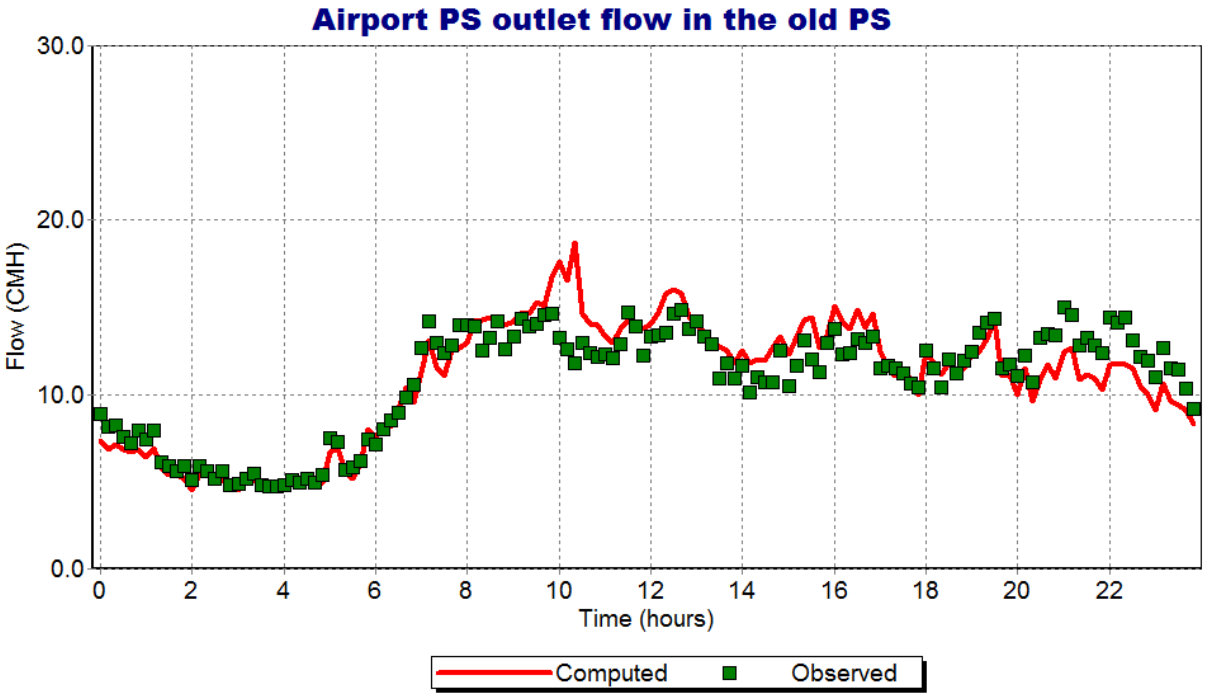
Pressure in the Zone of the Airport





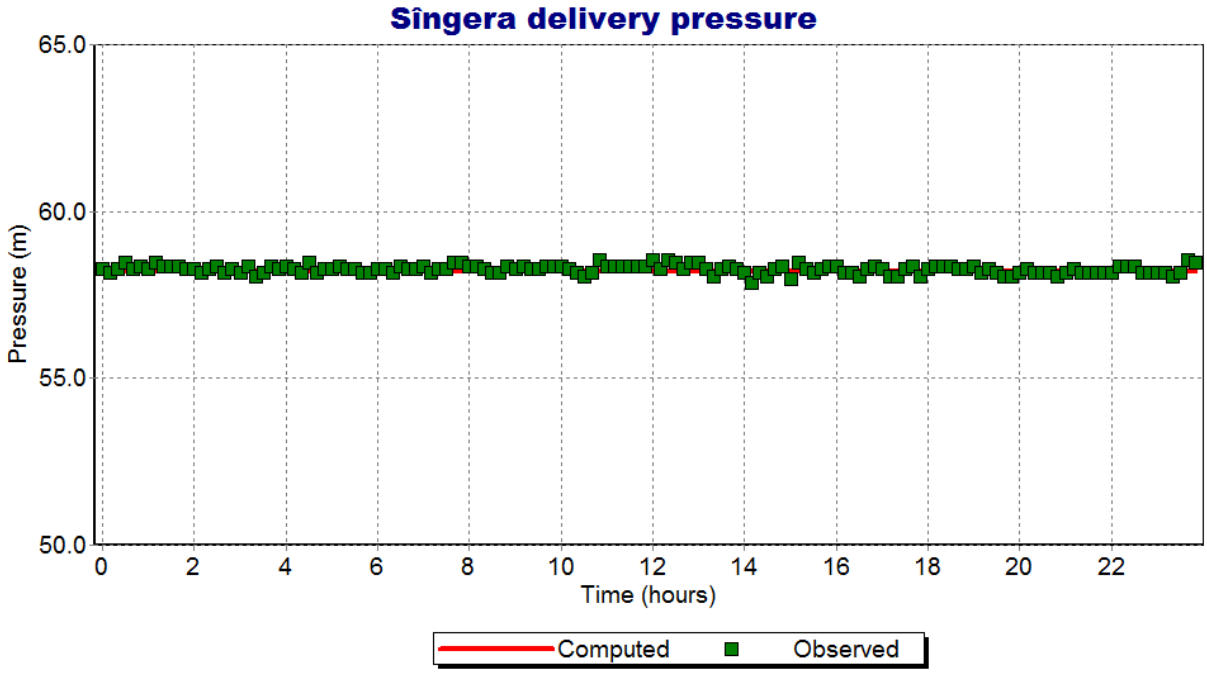
Flow in the Zone of the Airport

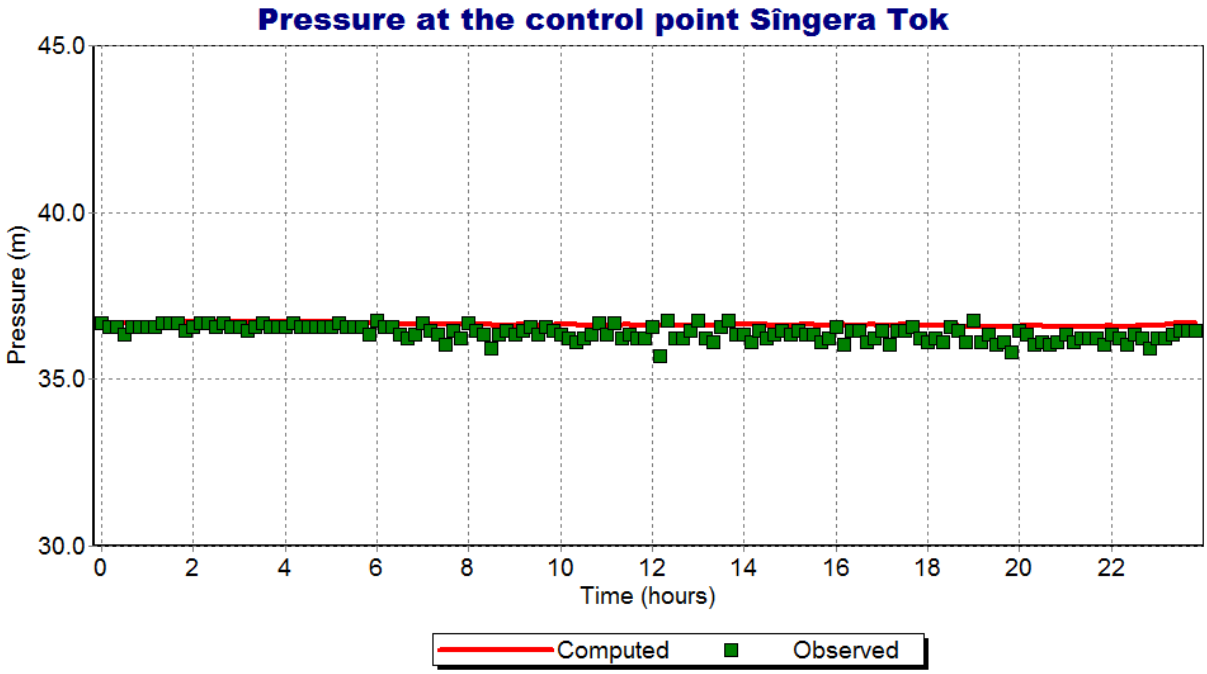


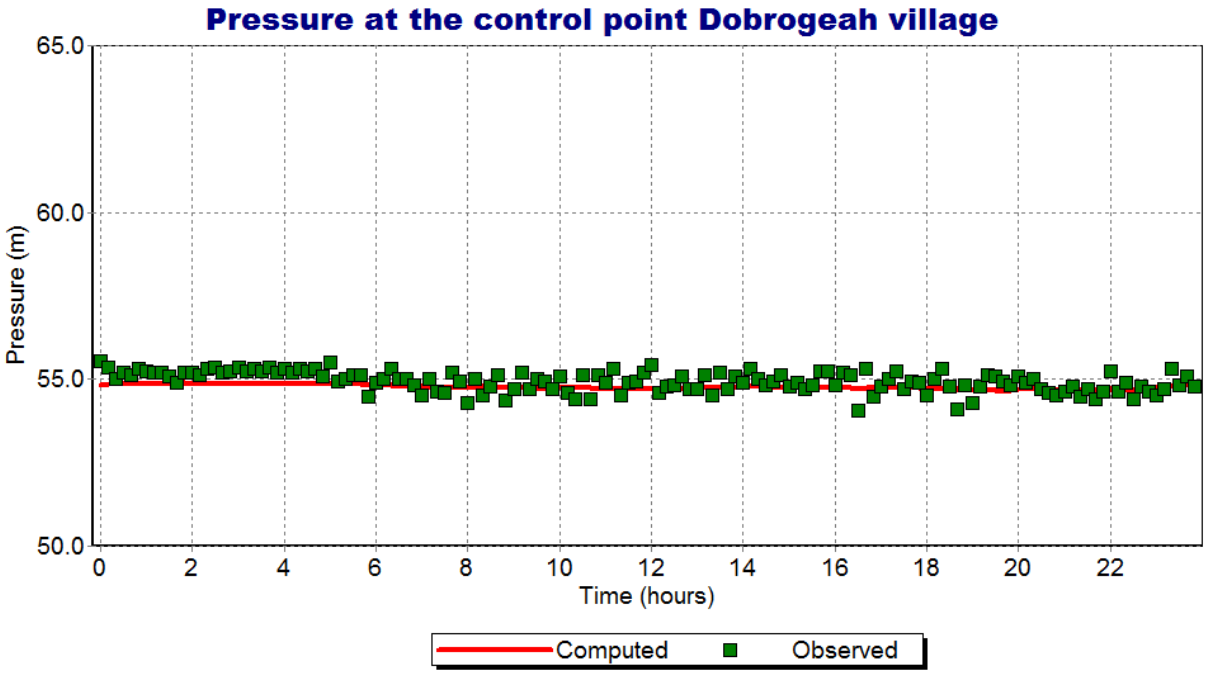


Dobrogeah

Pressure in the Zone Dobrogeah

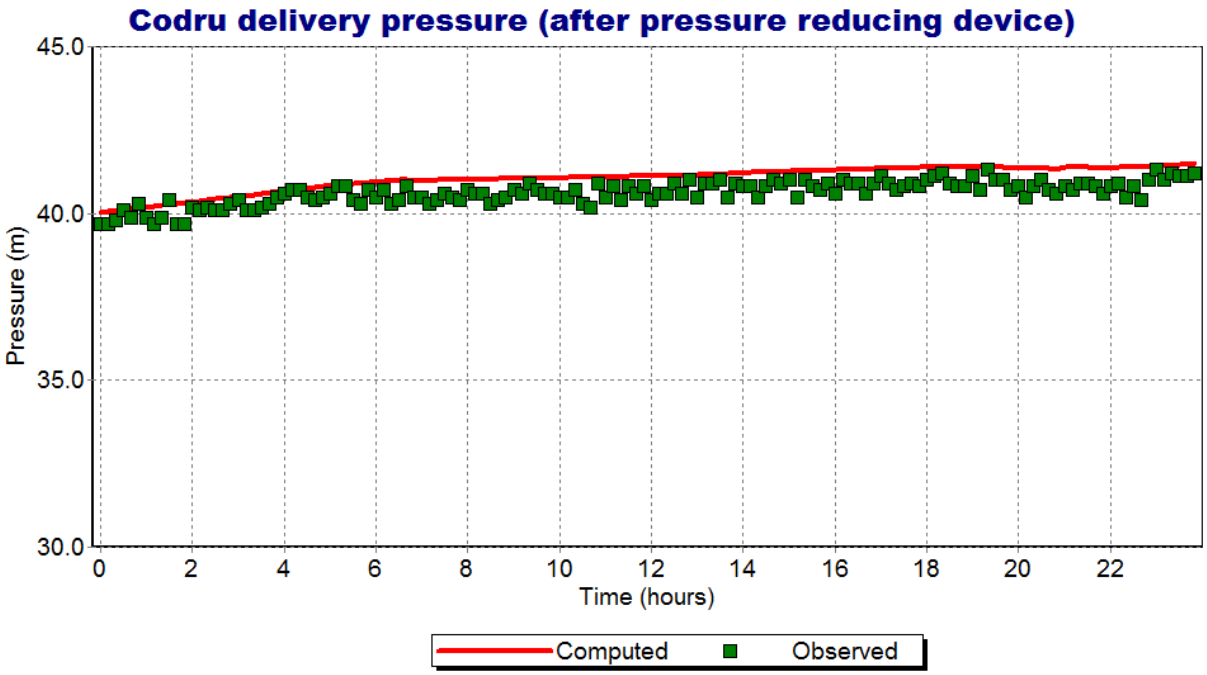


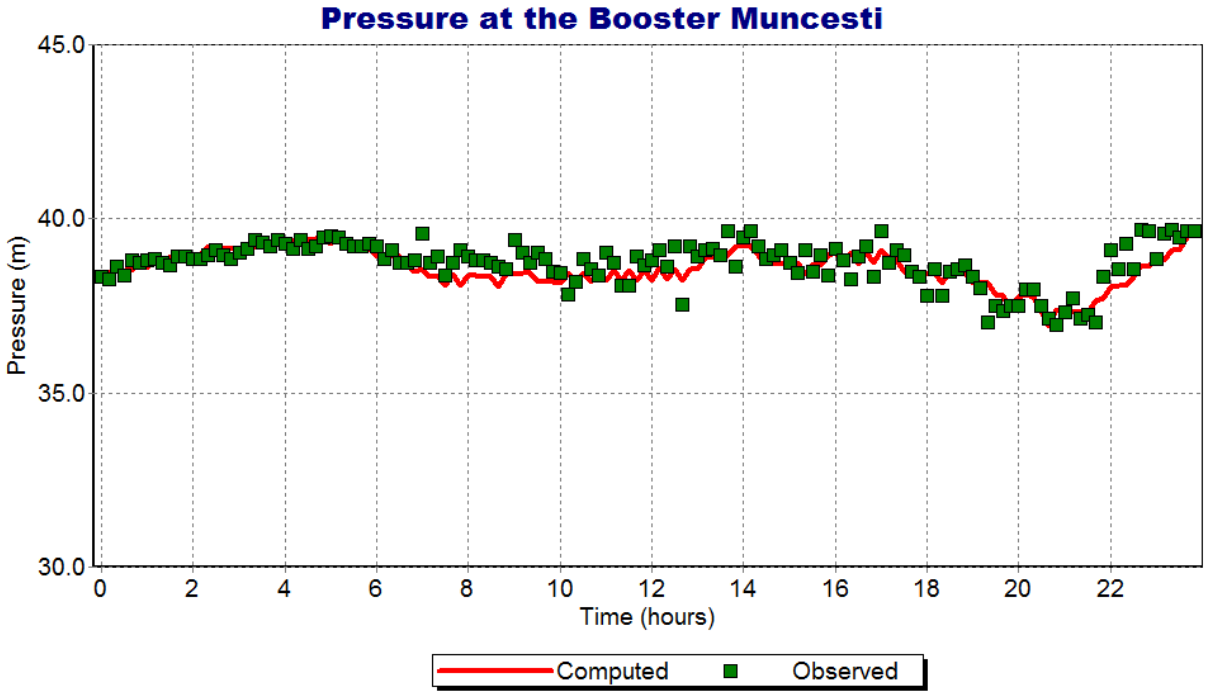


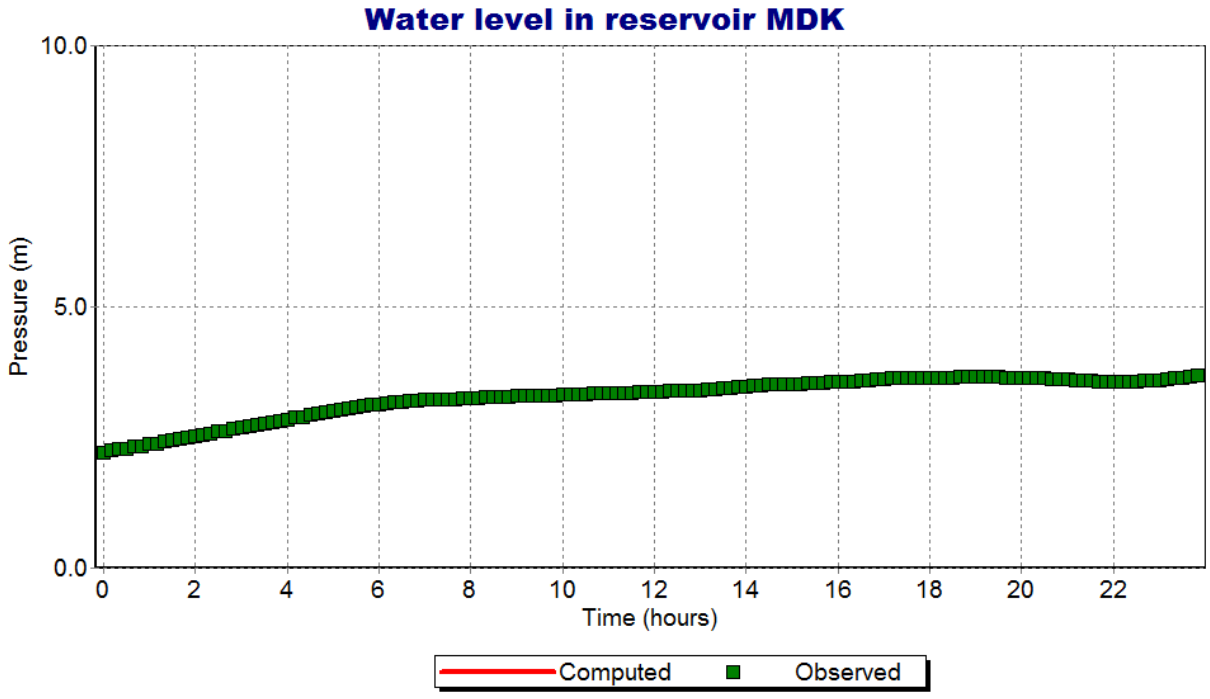


ContreReservoirs Codru MDK

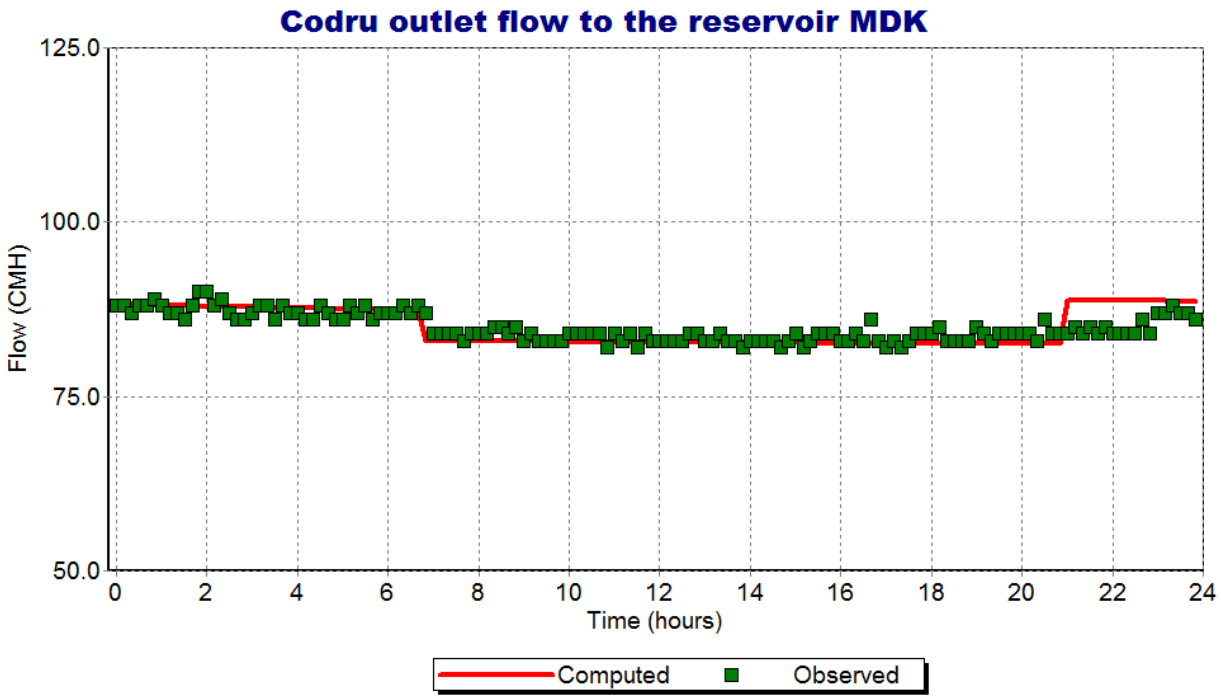
Pressure in the Zone Codru MDK




Pressure at the Booster Muncesti
45.0
40.0
35.0
30.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

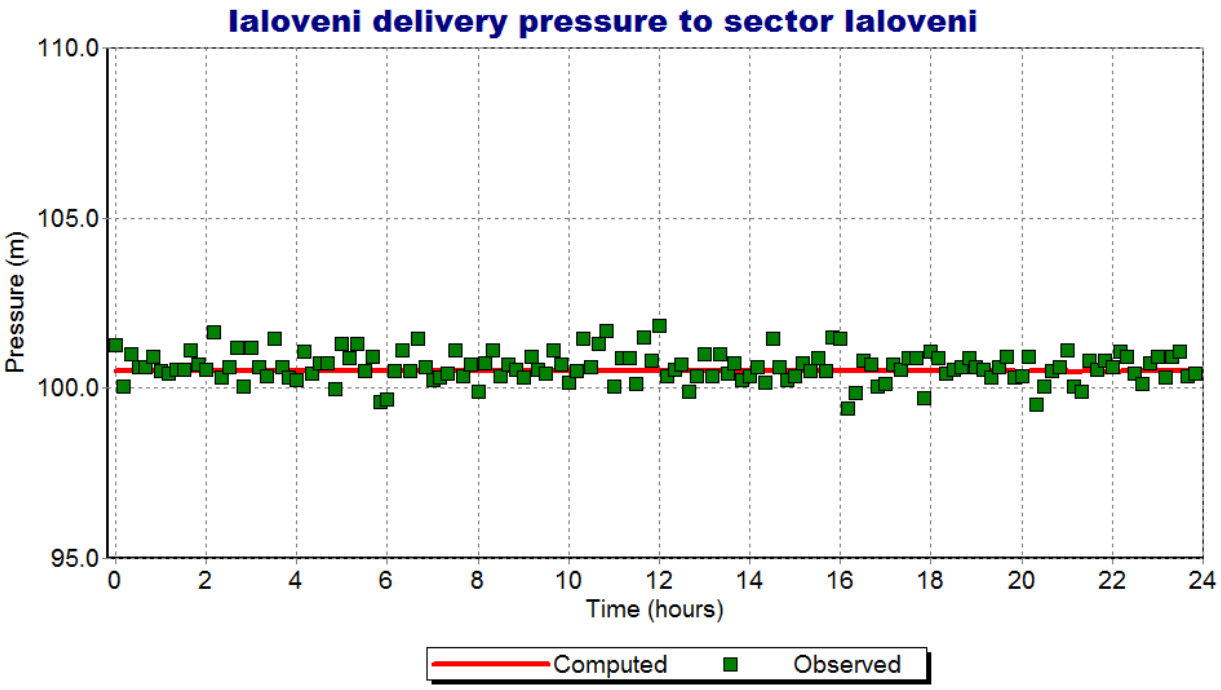

Water level in reservoir MDK
10.0
5.0
0.0
Pressure (m)
0
2
4
6
8
10
12
14
16
18
20
22
Time (hours)
Computed
Observed

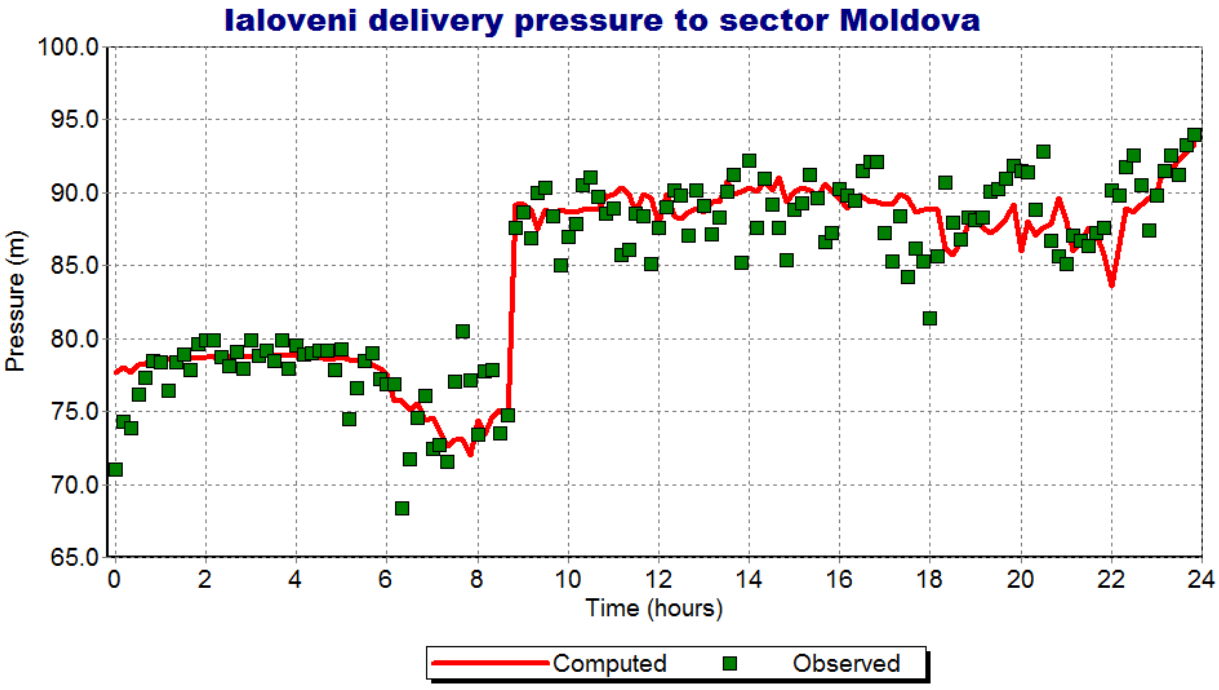
Flow in the Zone Codru MDK

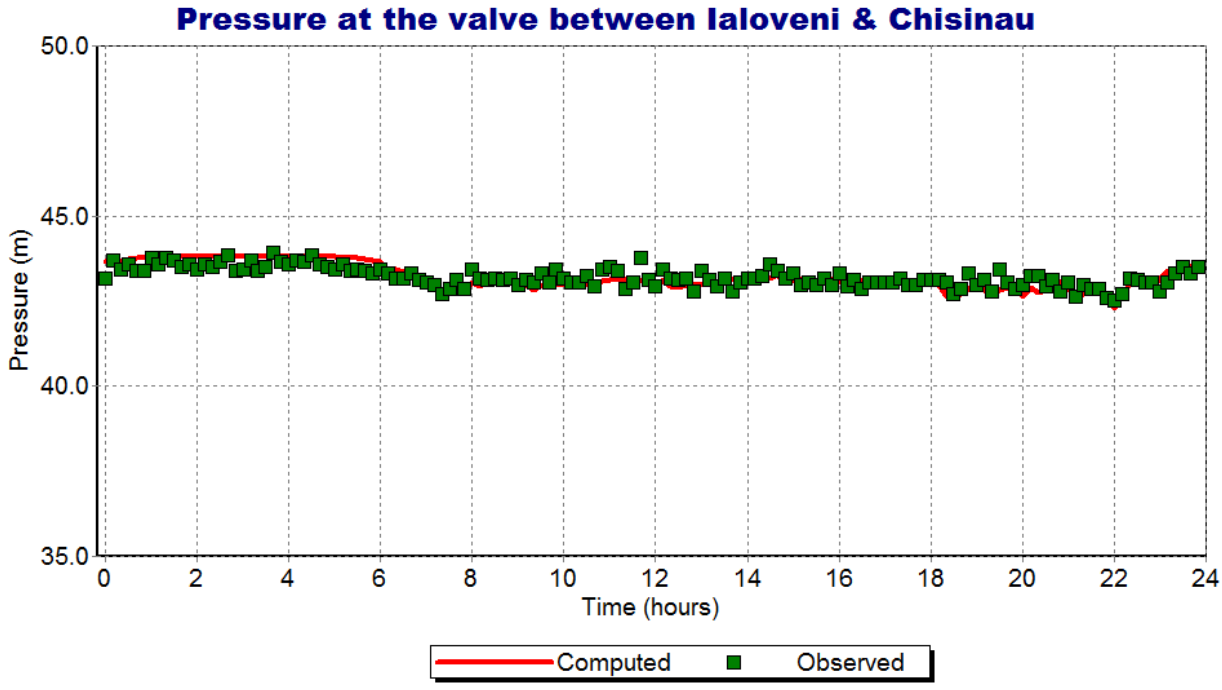


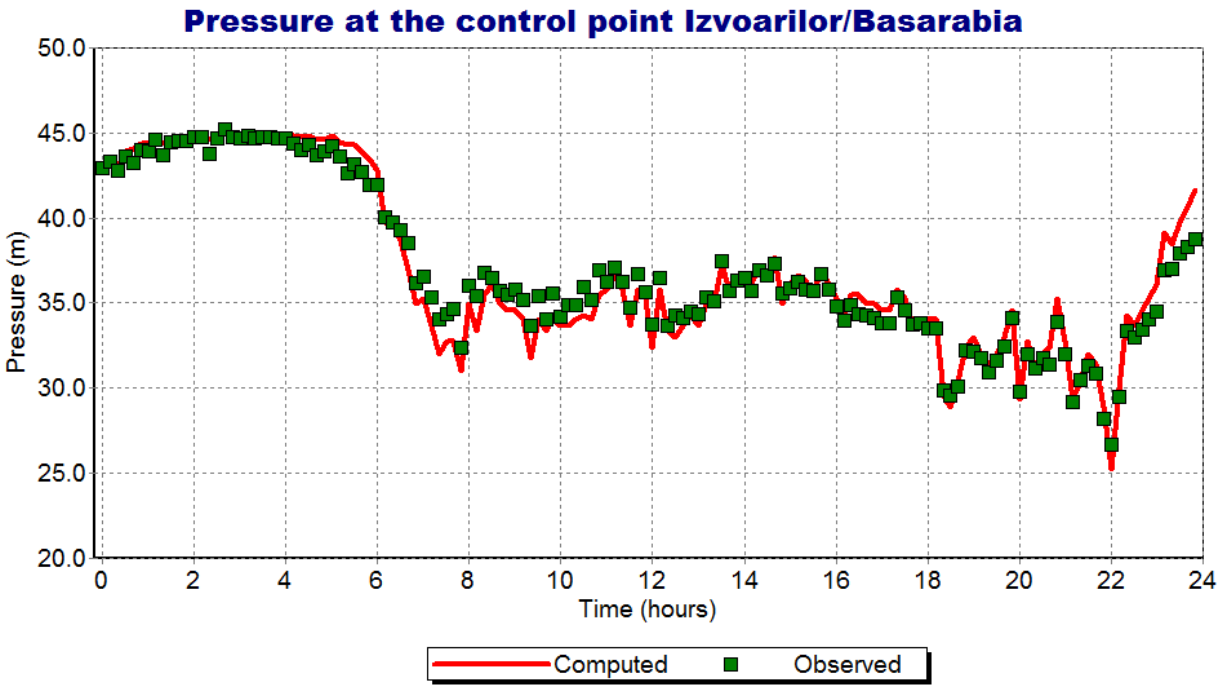
Ialoveni

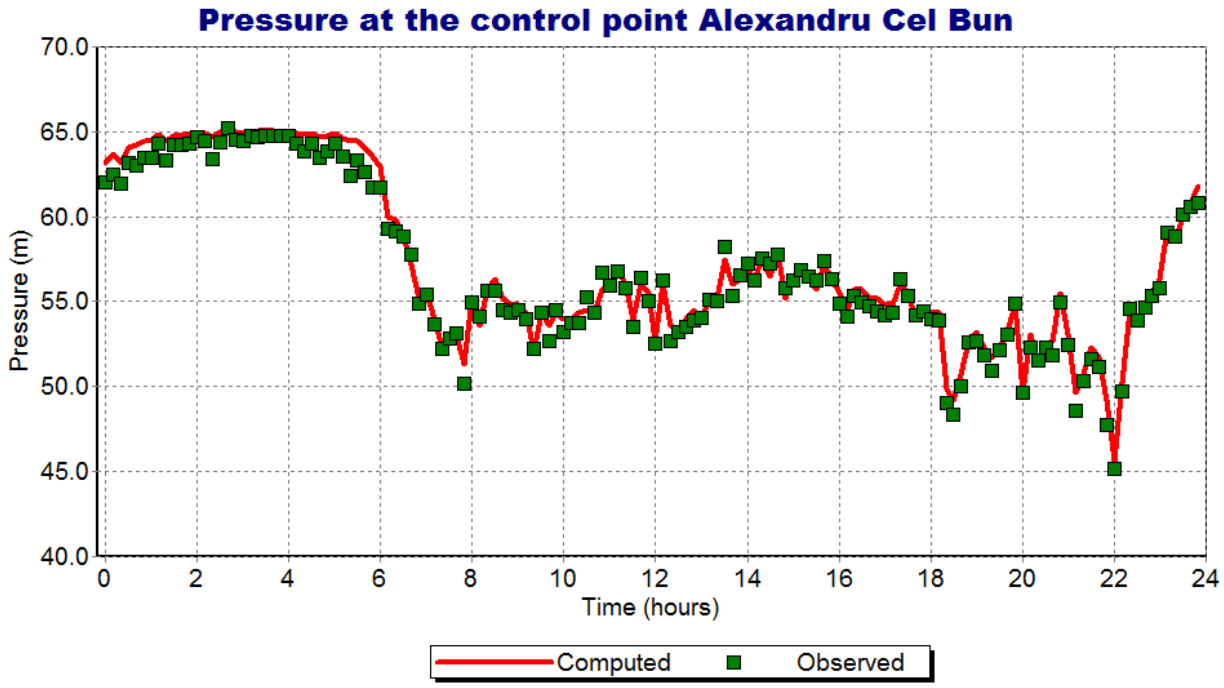
Pressure in the Zone Ialoveni




Ialoveni delivery pressure to sector Moldova
Pressure (m)
100.0
95.0
90.0
85.0
80.0
75.0
70.0
65.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

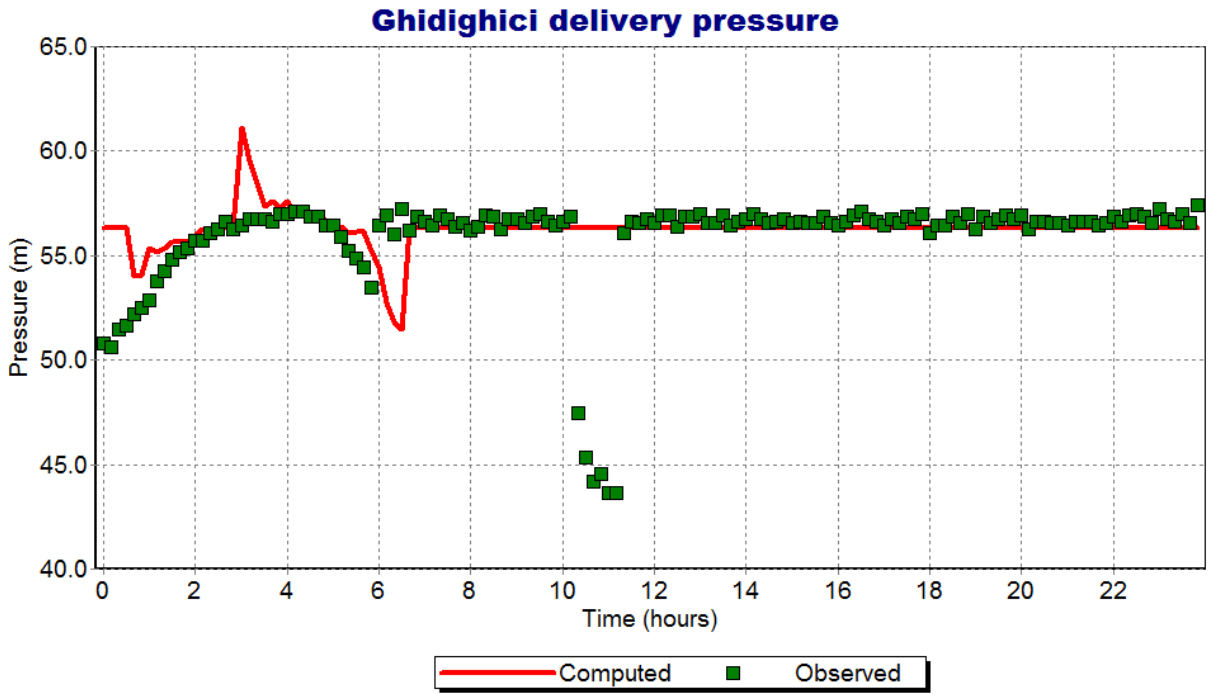

Pressure at the valve between Ialoveni & Chisinau
Pressure (m)
50.0
45.0
40.0
35.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the control point Izvoarilor/Basarabia
Pressure (m)
50.0
45.0
40.0
35.0
30.0
25.0
20.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed


Pressure at the control point Alexandru Cel Bun
Pressure (m)
70.0
65.0
60.0
55.0
50.0
45.0
40.0
0
2
4
6
8
10
12
14
16
18
20
22
24
Time (hours)
Computed
Observed

Vatra

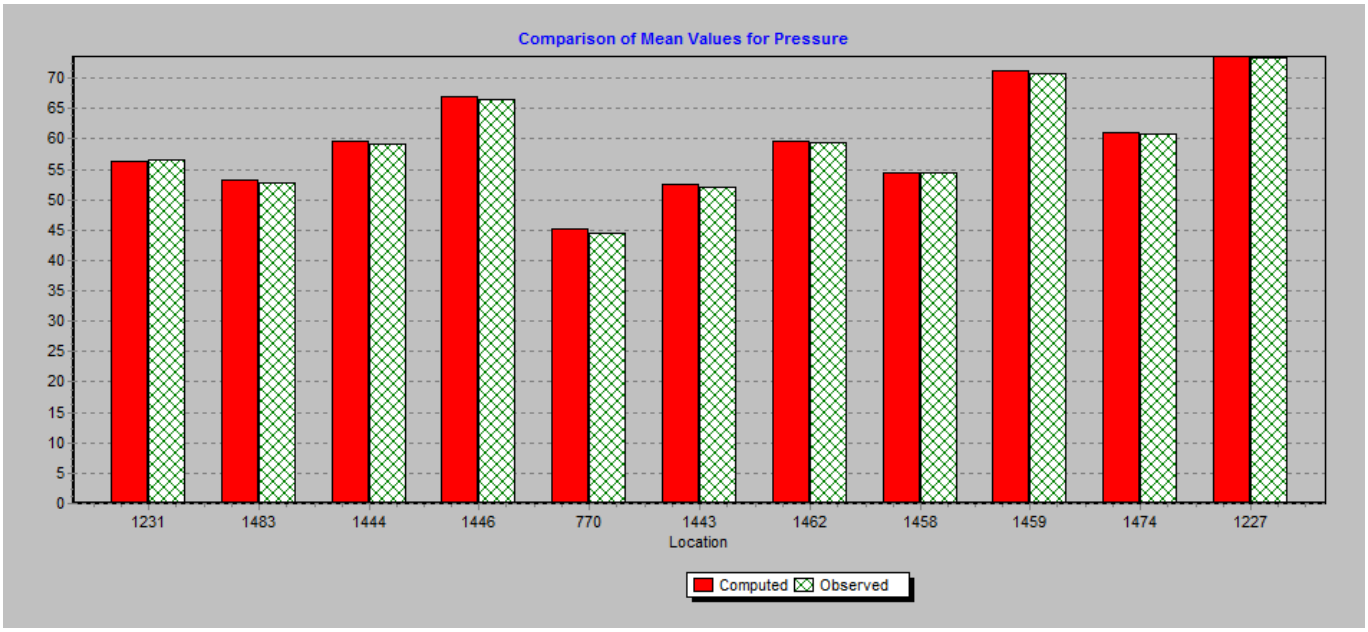
Pressure in the Zone Vatra



Annex 4 Calibration Results

Zone 1

Pressure

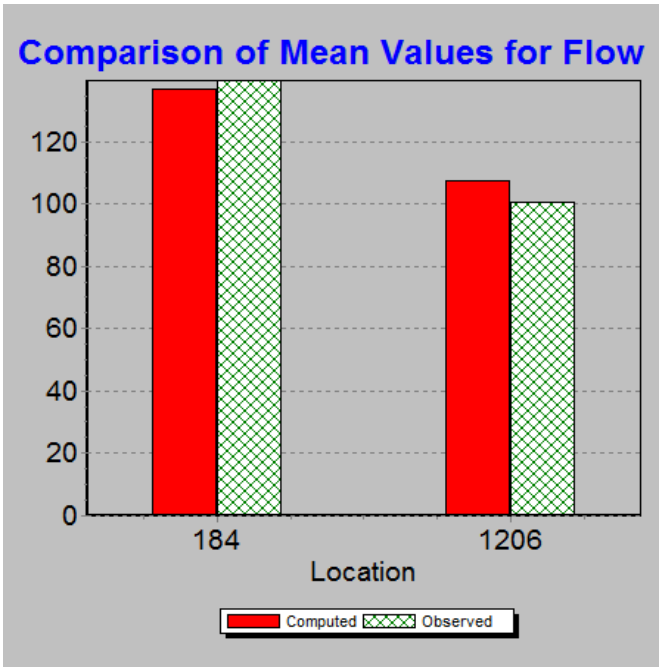


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1231	143	56.67	56.25	0.520	0.813
1483	143	52.72	53.31	0.750	0.912
1444	143	59.19	59.53	0.724	0.934
1446	143	66.58	66.99	0.545	0.673
770	143	44.61	45.26	0.771	0.928
1443	143	51.95	52.58	0.707	0.848
1462	143	59.35	59.59	0.611	0.771
1458	143	54.47	54.36	0.760	1.022
1459	143	70.69	71.18	0.631	0.766
1474	143	60.85	60.94	0.653	0.863
1227	143	73.30	73.60	0.558	0.710
Network	1573	59.13	59.42	0.657	0.846

Correlation Between Means: 0.999

Flow



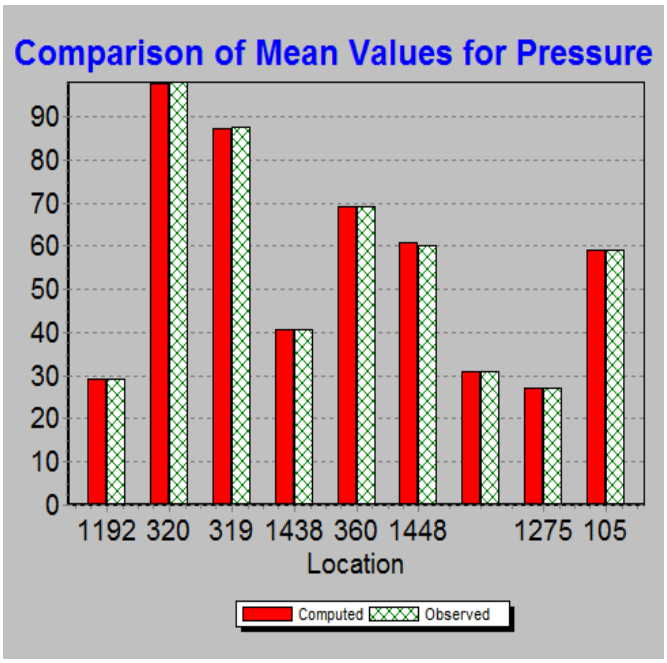
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
184	143	139.53	136.99	2.855	3.852
1206	143	100.52	107.45	16.191	22.068
Network	286	120.03	122.22	9.523	15.840

Correlation Between Means: 1.000

Zone 2 Oţel

Pressure



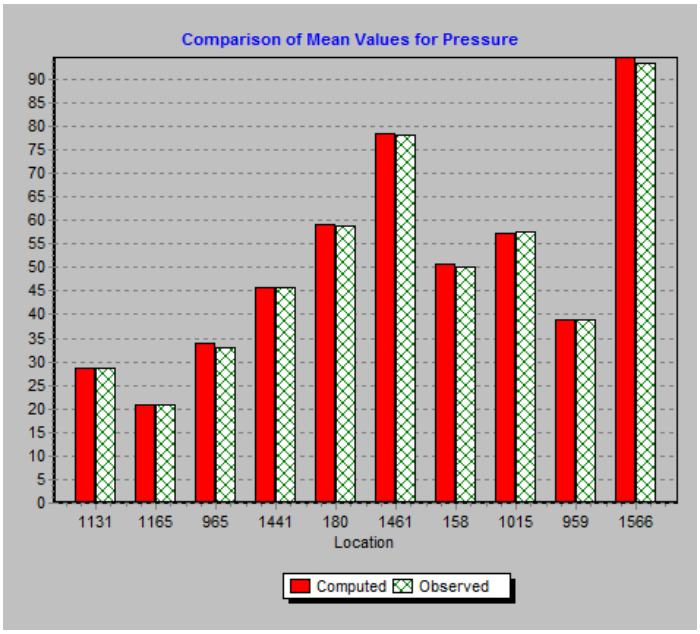
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1192	143	29.11	29.24	0.580	0.767
320	143	98.03	97.82	0.440	0.640
319	143	87.63	87.37	0.480	0.851
1438	143	40.51	40.63	0.496	0.691
360	143	69.02	69.16	0.406	0.616
1448	143	60.24	60.93	0.750	1.012
1396	143	30.88	31.01	0.475	0.676
1275	143	27.03	27.17	0.364	0.487
105	143	59.24	59.08	0.425	0.641
Network	1287	55.74	55.82	0.491	0.723

Correlation Between Means: 1.000

Zone 2

Pressure

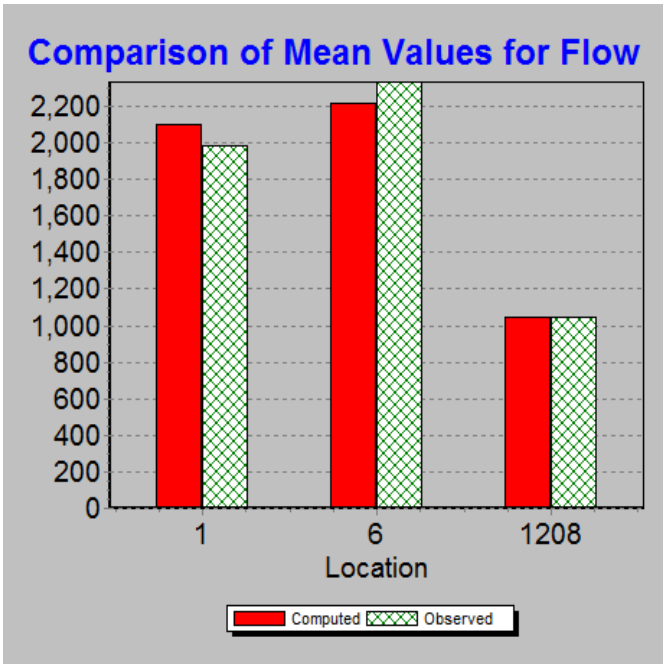


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1131	143	28.67	28.55	1.325	1.762
1165	143	20.71	20.72	0.929	1.187
965	143	33.12	33.93	2.263	2.664
1441	143	45.90	45.86	0.861	1.112
180	143	58.70	59.08	0.888	1.169
1461	143	78.08	78.51	1.299	2.620
158	143	50.26	50.62	0.919	1.258
1015	143	57.45	57.19	0.394	0.487
959	143	39.05	38.93	0.774	1.043
1566	143	93.34	94.62	2.490	3.907
Network	1430	50.53	50.80	1.214	1.981

Correlation Between Means: 1.000

Flow



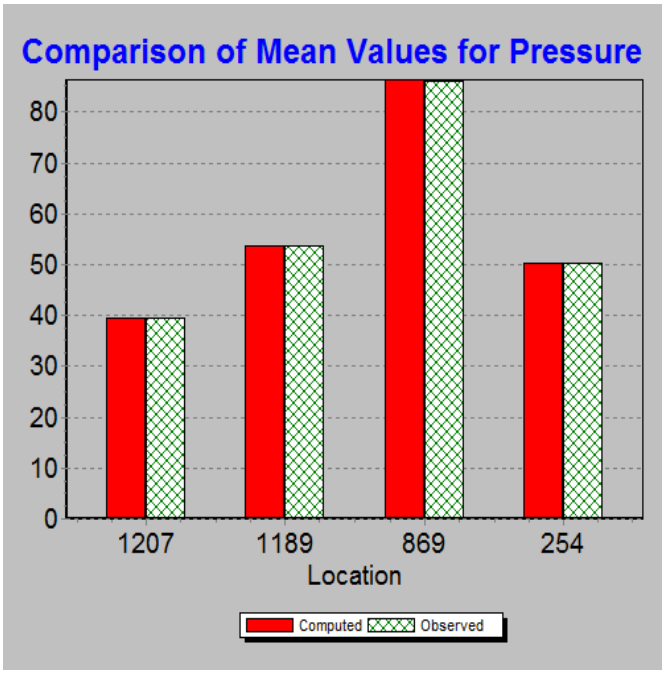
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1	143	1987.27	1962.73	51.305	68.749
6	143	2332.59	2360.63	48.189	64.653
1208	143	1042.12	1037.92	45.584	59.735
Network	429	1787.33	1787.09	48.360	64.485

Correlation Between Means: 0.999

Zone 2 Doina

Pressure



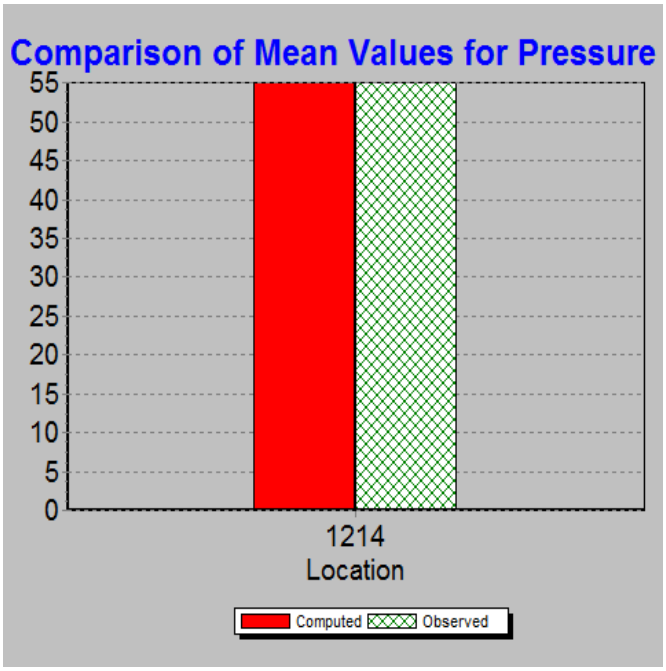
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1207	143	39.38	39.49	0.240	0.307
1189	143	53.83	53.79	0.596	0.887
869	143	86.01	86.39	0.803	1.027
254	143	50.34	50.37	0.195	0.228
Network	572	57.39	57.51	0.458	0.705

Correlation Between Means: 1.000

Zone 3- Universita Agrara

Pressure



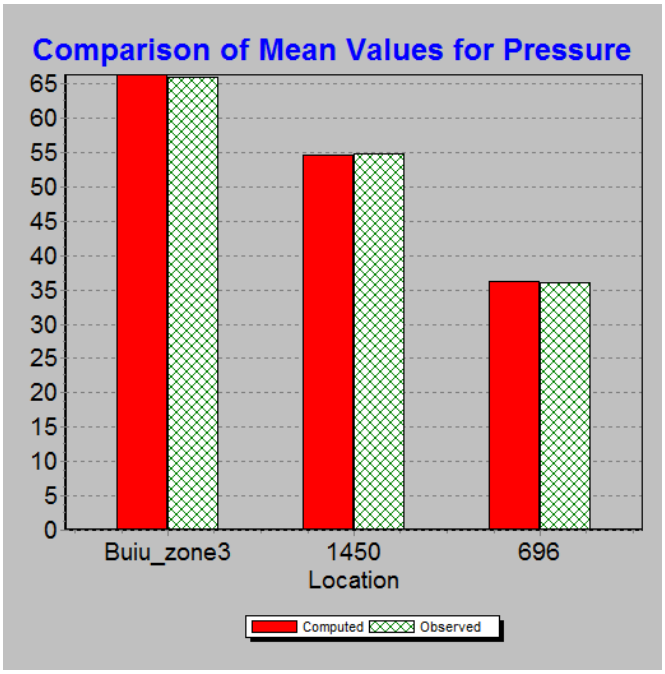
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1214	143	55.06	55.00	0.139	0.163
Network	143	55.06	55.00	0.139	0.163

Correlation Between Means: -0.211

Zone 3 Buiucani

Pressure

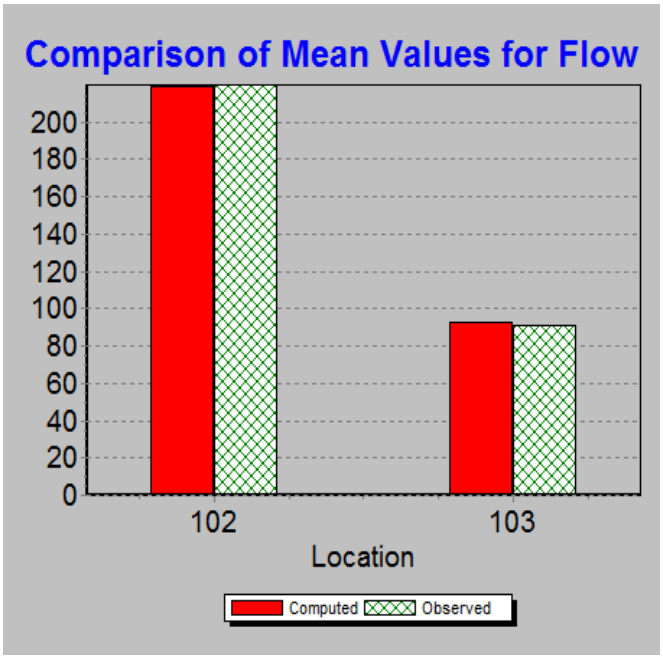


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
Buiu_zone3	143	65.93	66.32	0.394	0.448
1450	143	54.74	54.69	0.266	0.332
696	143	36.01	36.24	0.279	0.356
Network	429	52.23	52.42	0.313	0.382

Correlation Between Means: 1.000

Flow



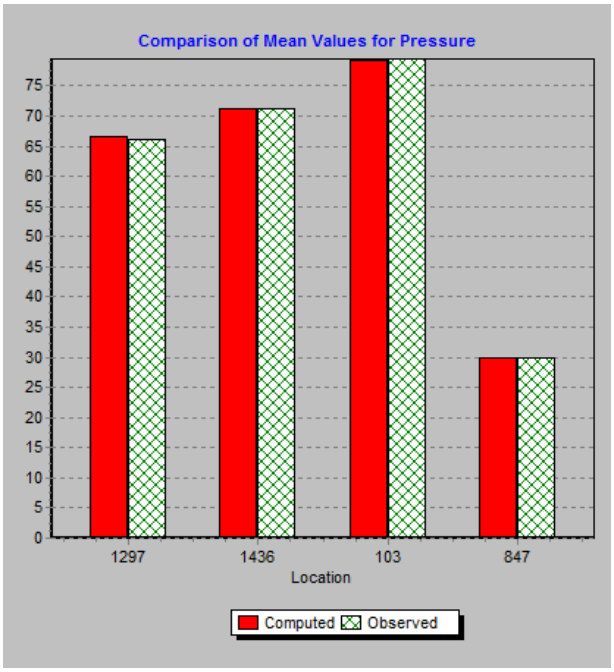
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
102	143	219.98	218.76	1.818	2.322
103	143	91.41	92.64	1.794	2.320
Network	286	155.70	155.70	1.806	2.321

Correlation Between Means: 1.000

Zone 3 Rîşcani

Pressure



Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1297	143	66.11	66.73	0.722	0.937
1436	143	71.14	71.17	0.268	0.605
103	143	79.50	79.28	0.380	0.692
847	143	29.79	29.81	0.130	0.403
Network	572	61.63	61.75	0.375	0.686

Correlation Between Means: 1.000

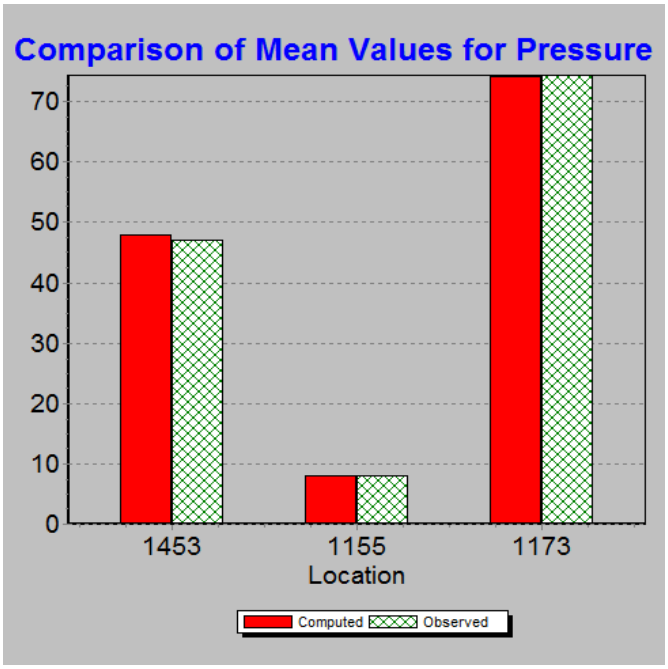
Zone 3 Valea Dicescu

Pressure

Calibration Statistics for Pressure

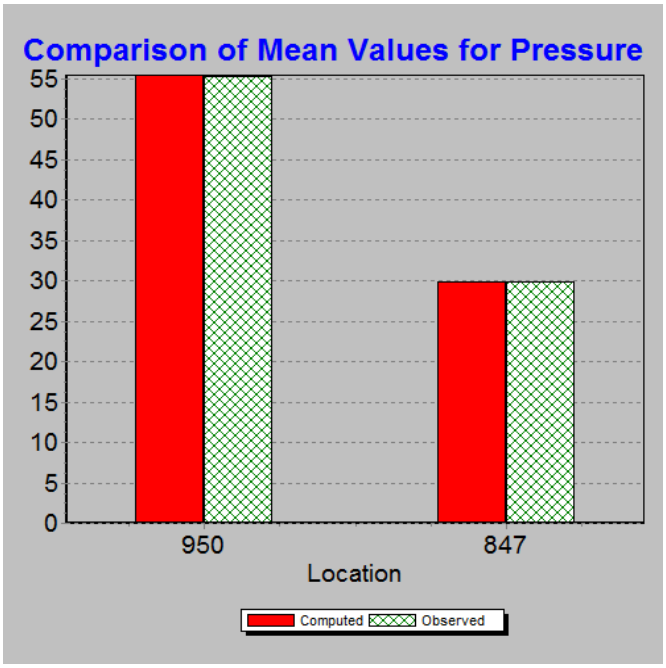
Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1453	143	46.99	47.84	1.537	2.414
1155	143	8.04	8.03	0.130	0.157
1173	143	74.38	74.20	0.304	0.383
Network	429	43.14	43.36	0.657	1.414

Correlation Between Means: 1.000


Comparison of Mean Values for Pressure
70
60
50
40
30
20
10
0
1453
1155
1173
Location
Computed
Observed

Zone 3 Ciocana

Pressure

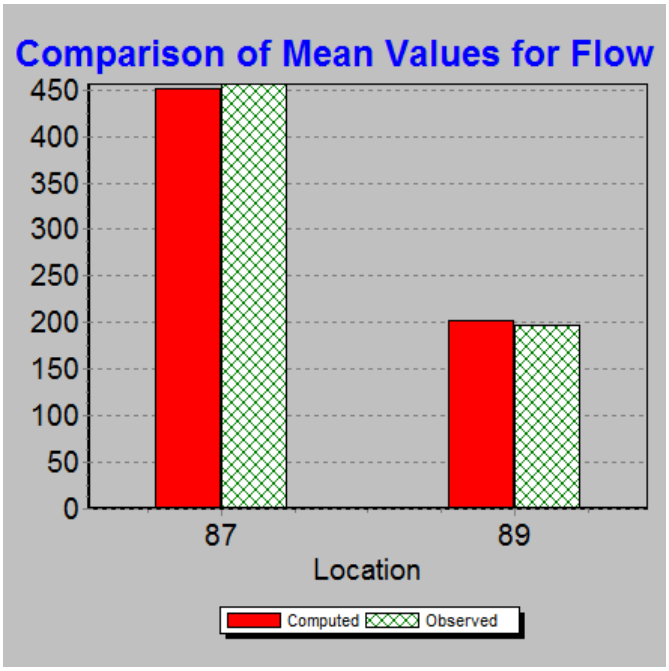


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
950	143	55.31	55.40	0.552	0.916
847	143	29.79	29.81	0.130	0.403
Network	286	42.55	42.60	0.341	0.708

Correlation Between Means: 1.000

Flow



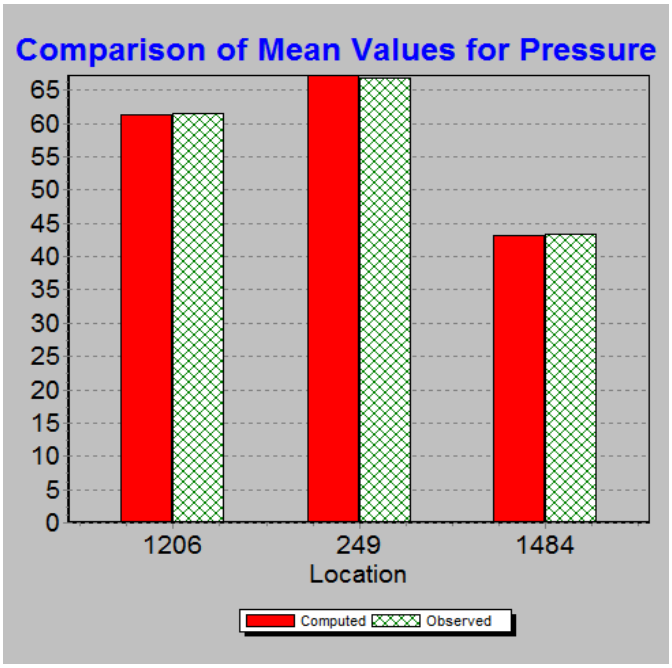
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
87	143	456.17	451.68	4.748	5.759
89	143	197.76	202.17	4.662	5.547
Network	286	326.97	326.93	4.705	5.654

Correlation Between Means: 1.000

Zone 3 Independența

Pressure

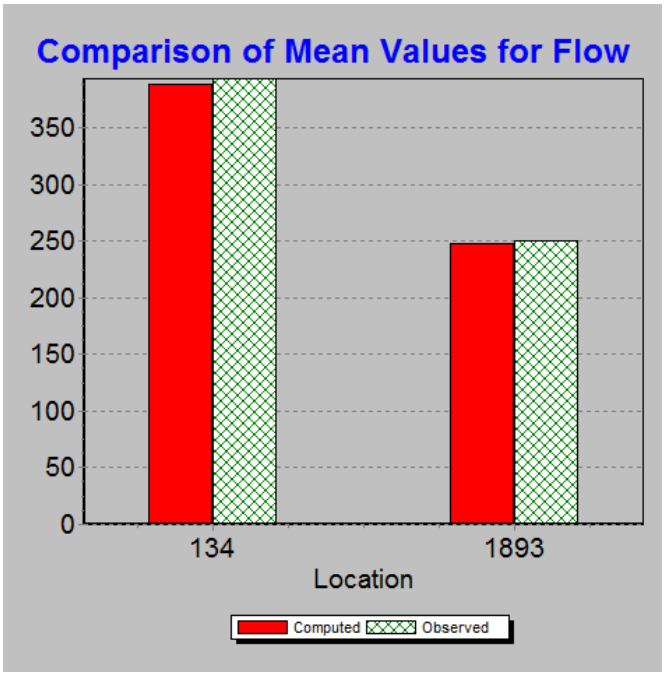


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1206	143	61.42	61.34	0.168	0.214
249	143	66.75	67.23	0.526	0.711
1484	143	43.34	43.22	0.359	0.496
Network	429	57.17	57.26	0.351	0.515

Correlation Between Means: 1.000

Flow



Calibration Statistics for Flow

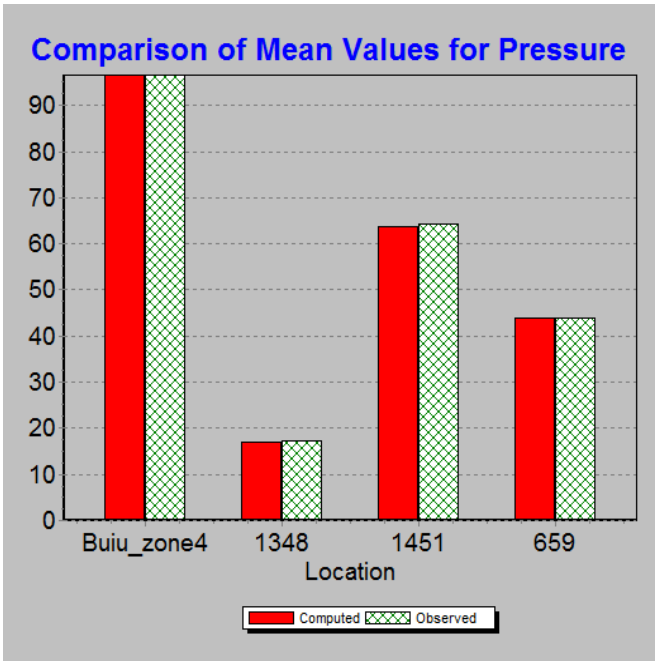
Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
134	143	393.19	388.54	5.705	7.535
1893	143	250.24	247.15	5.393	6.482
Network	286	321.71	317.84	5.549	7.028

Correlation Between Means: 1.000

.

Zone 4 Buiucani

Pressure

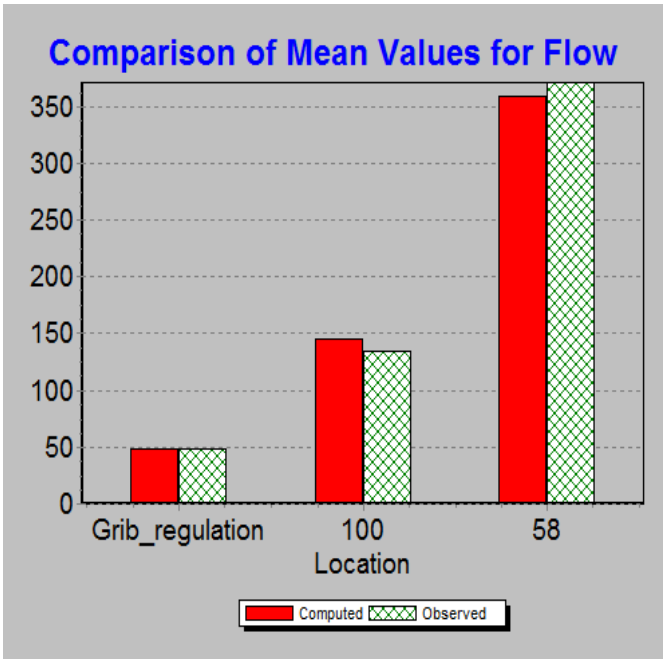


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
Buiu_zone4	143	96.55	96.60	0.290	0.571
1348	143	17.29	16.97	1.626	2.313
1451	143	64.40	63.87	0.652	0.877
659	143	43.87	43.81	0.592	0.836
Network	572	55.52	55.31	0.790	1.337

Correlation Between Means: 1.000

Flow



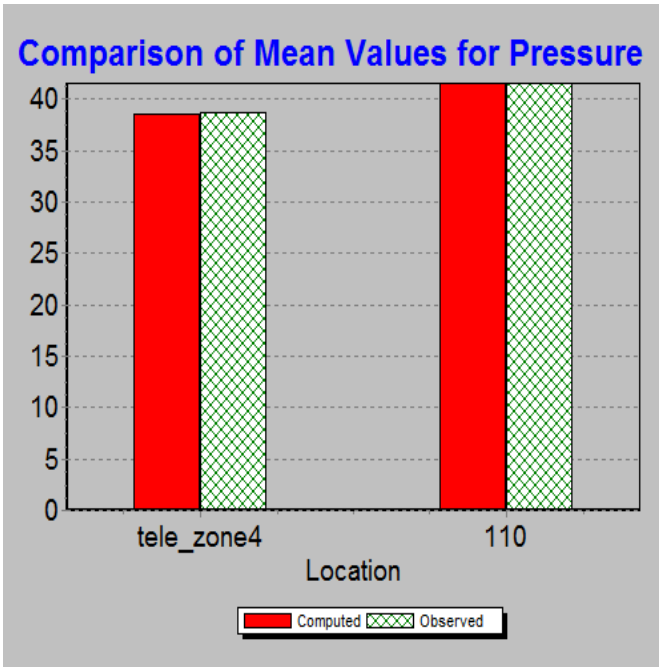
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
Grib_regulation	143	49.06	47.93	1.858	2.535
100	143	134.39	145.75	11.371	13.221
58	143	371.17	358.52	12.692	14.639
Network	429	184.87	184.07	8.640	11.482

Correlation Between Means: 0.999

Zone 4 Telecentru

Pressure

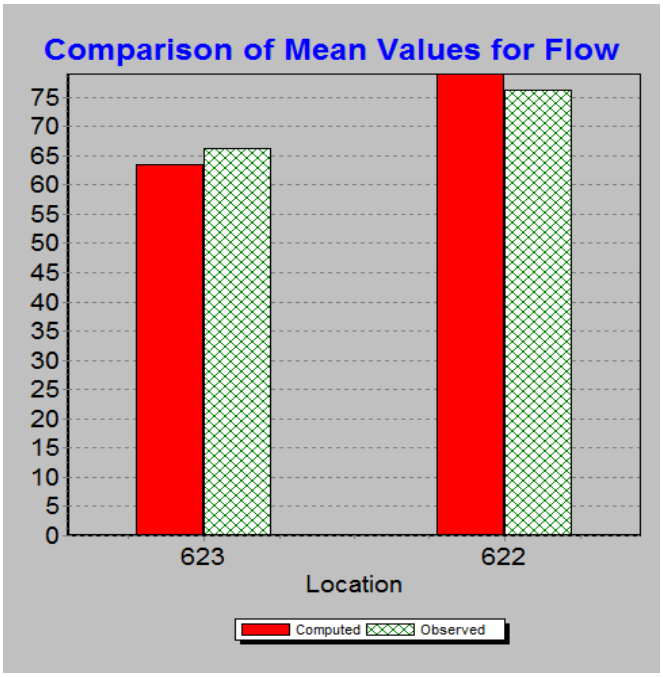


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
tele_zone4	143	38.65	38.60	0.114	0.144
110	143	41.55	41.55	0.129	0.150
Network	286	40.10	40.07	0.121	0.147

Correlation Between Means: 1.000

Flow



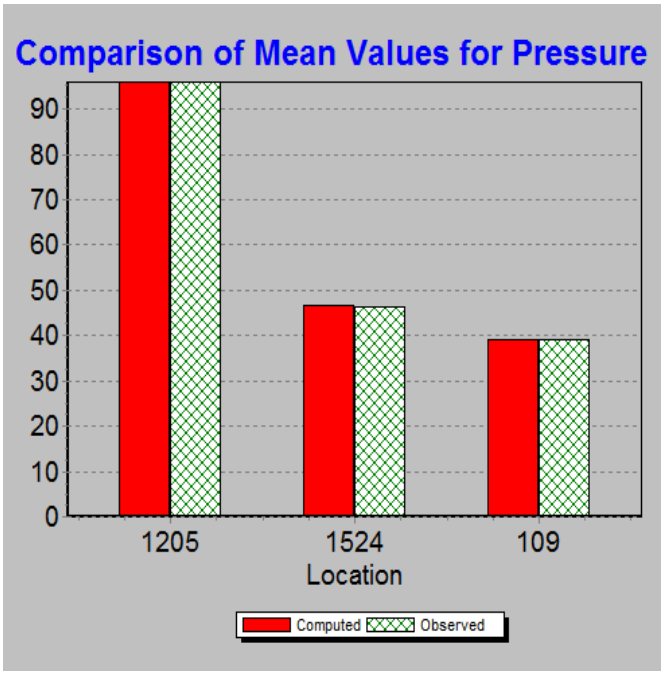
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
623	143	66.15	63.41	5.565	7.899
622	143	76.19	78.97	5.629	7.934
Network	286	71.17	71.19	5.597	7.917

Correlation Between Means: 1.000

Zone 4 Independența

Pressure

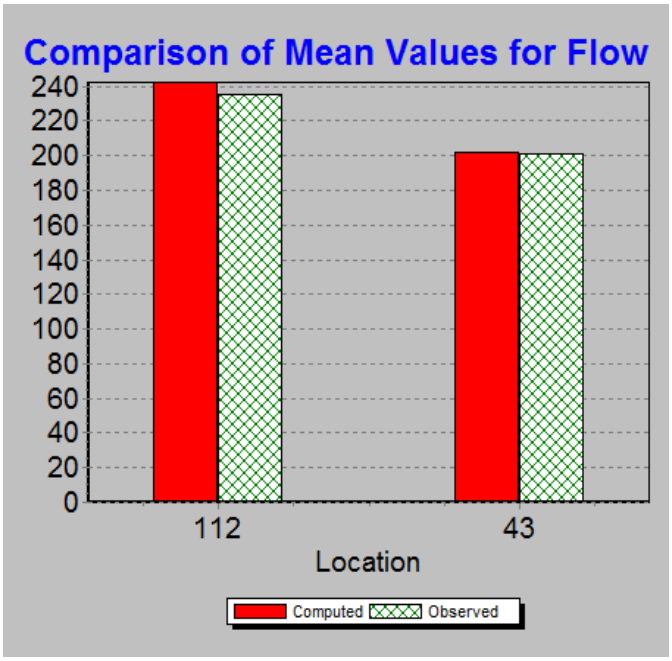


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1205	143	95.97	95.84	0.286	0.362
1524	143	46.34	46.67	0.354	0.441
109	143	39.17	39.26	0.206	0.262
Network	429	60.49	60.59	0.282	0.362

Correlation Between Means: 1.000

Flow



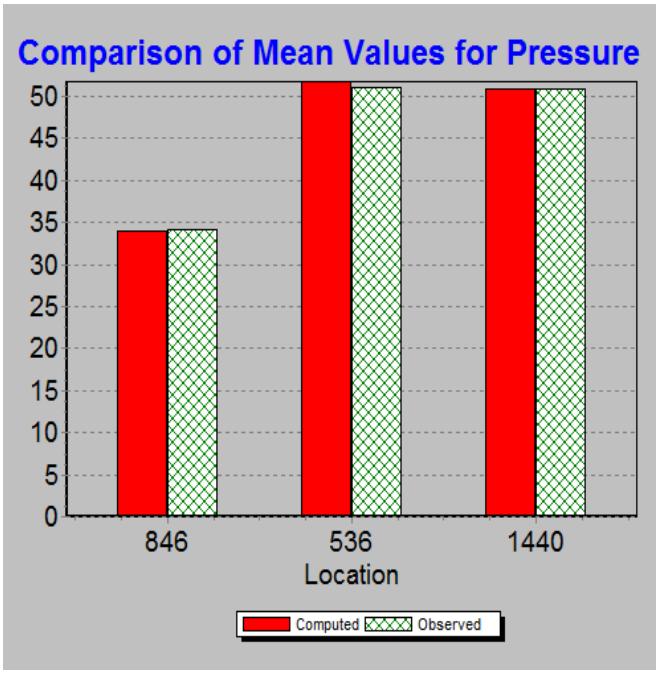
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
112	143	235.24	242.37	7.163	8.740
43	143	201.32	202.06	5.085	6.115
Network	286	218.28	222.21	6.124	7.543

Correlation Between Means: 1.000

Zone 4 Ciocana

Pressure

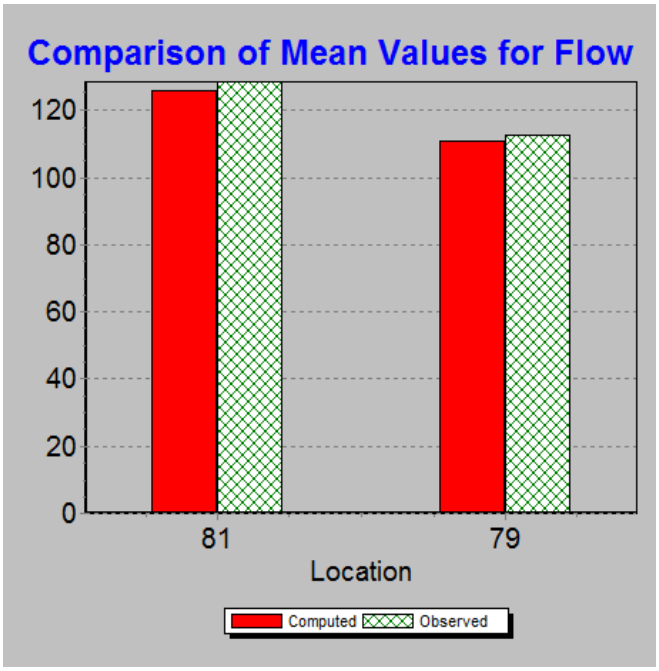


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
846	143	34.10	34.05	0.180	0.277
536	143	51.01	51.76	0.764	1.145
1440	143	50.85	50.93	0.307	0.397
Network	429	45.32	45.58	0.417	0.718

Correlation Between Means: 0.999

Flow



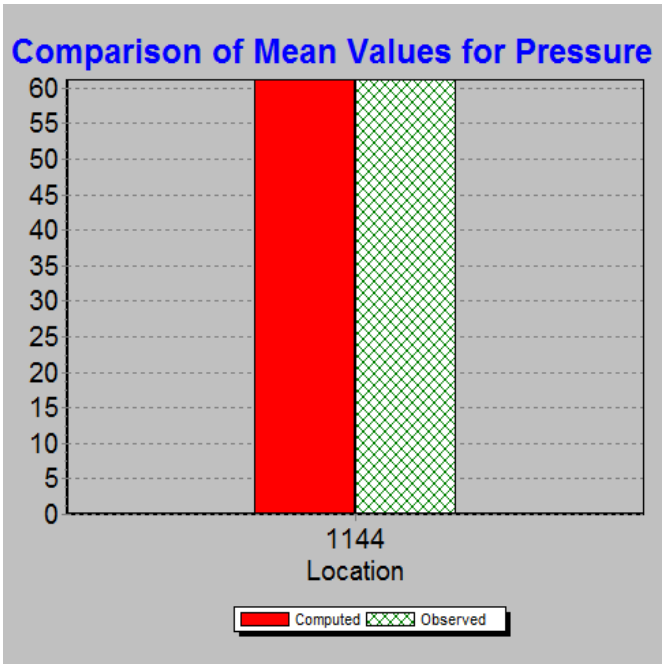
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
81	143	128.52	125.75	2.786	3.129
79	143	112.57	110.83	1.861	2.387
Network	286	120.55	118.29	2.324	2.783

Correlation Between Means: 1.000

Zone 4A Botanica

Pressure

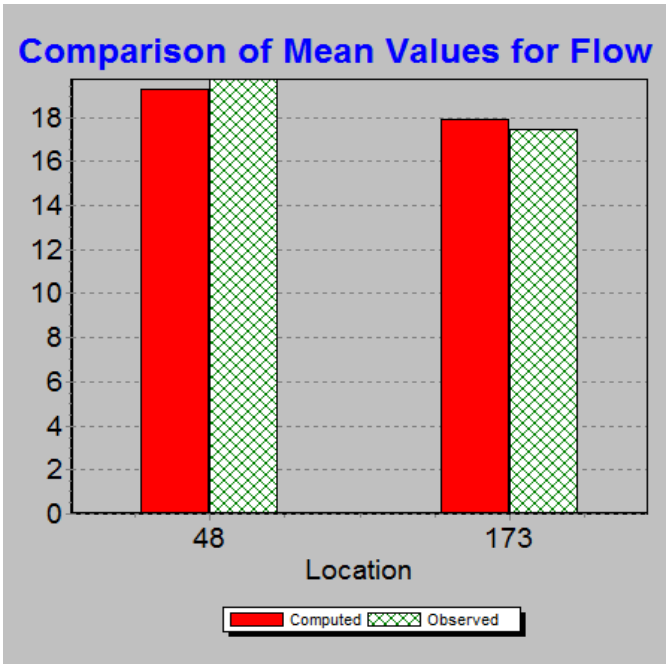


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1144	143	61.17	61.20	0.285	0.499
Network	143	61.17	61.20	0.285	0.499

Correlation Between Means: 2.182

Flow



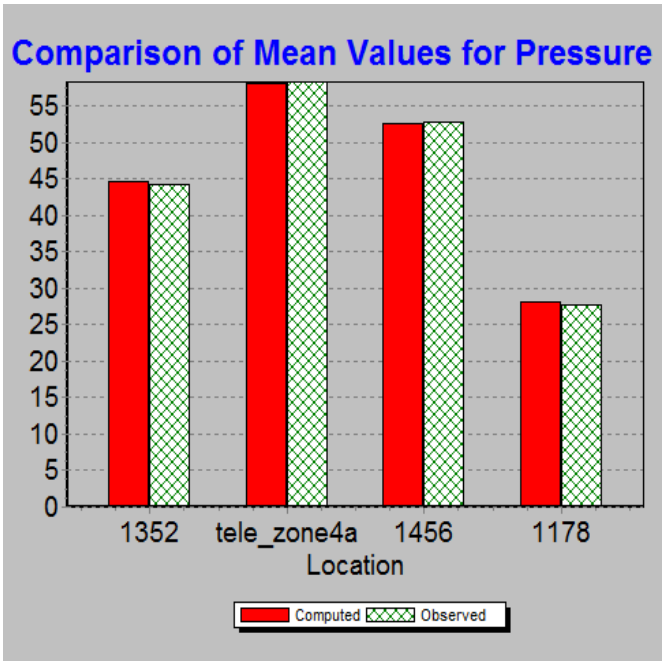
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
48	143	19.73	19.25	0.679	0.910
173	143	17.45	17.94	0.681	0.913
Network	286	18.59	18.59	0.680	0.912

Correlation Between Means: 1.000

Zone 4A Telecentru

Pressure

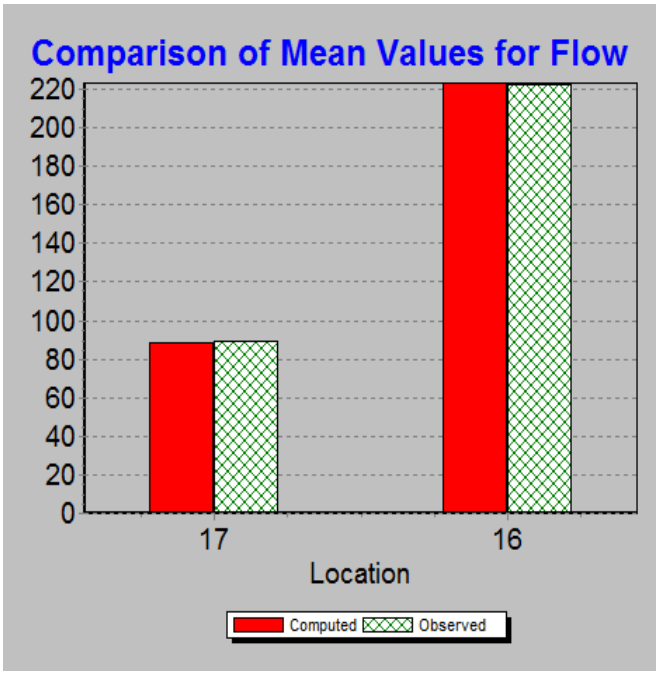


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1352	143	44.18	44.62	0.475	0.572
tele_zone4a	143	58.29	58.09	0.234	0.280
1456	143	52.77	52.67	0.352	0.481
1178	143	27.66	28.09	0.446	0.535
Network	572	45.72	45.87	0.377	0.480

Correlation Between Means: 1.000

Flow



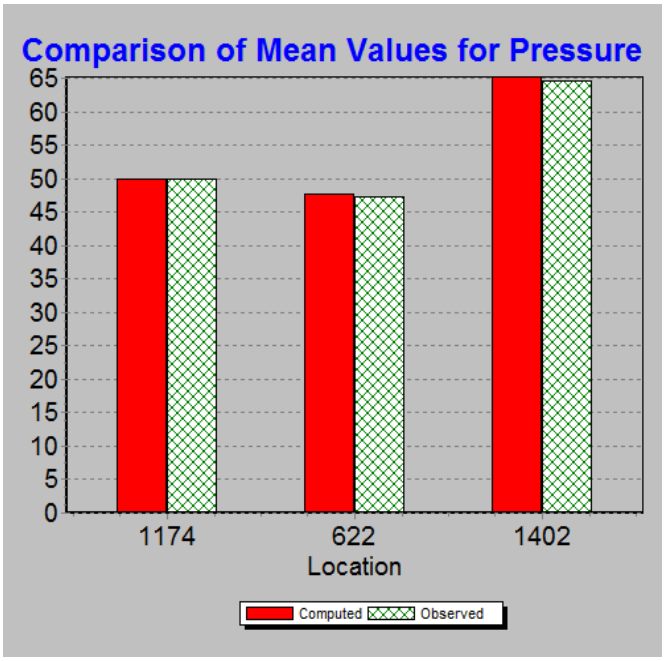
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
17	143	89.69	88.72	3.145	3.613
16	143	222.22	223.25	3.138	3.669
Network	286	155.95	155.98	3.142	3.641

Correlation Between Means: 1.000

Zone 4A Schinoasa

Pressure



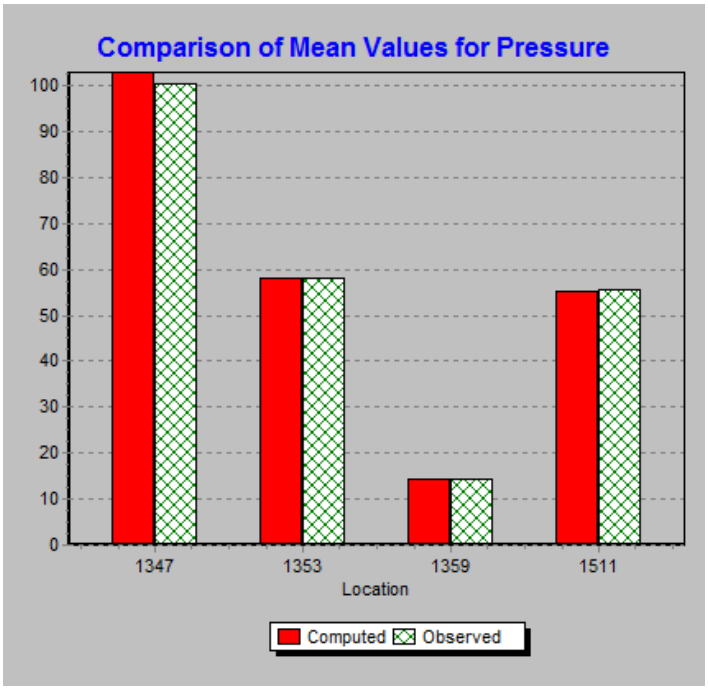
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1174	143	49.94	49.87	0.157	0.203
622	143	47.31	47.66	0.351	0.423
1402	143	64.69	65.25	0.831	1.201
Network	429	53.98	54.26	0.446	0.744

Correlation Between Means: 1.000

Durleşti-Gribov

Pressure



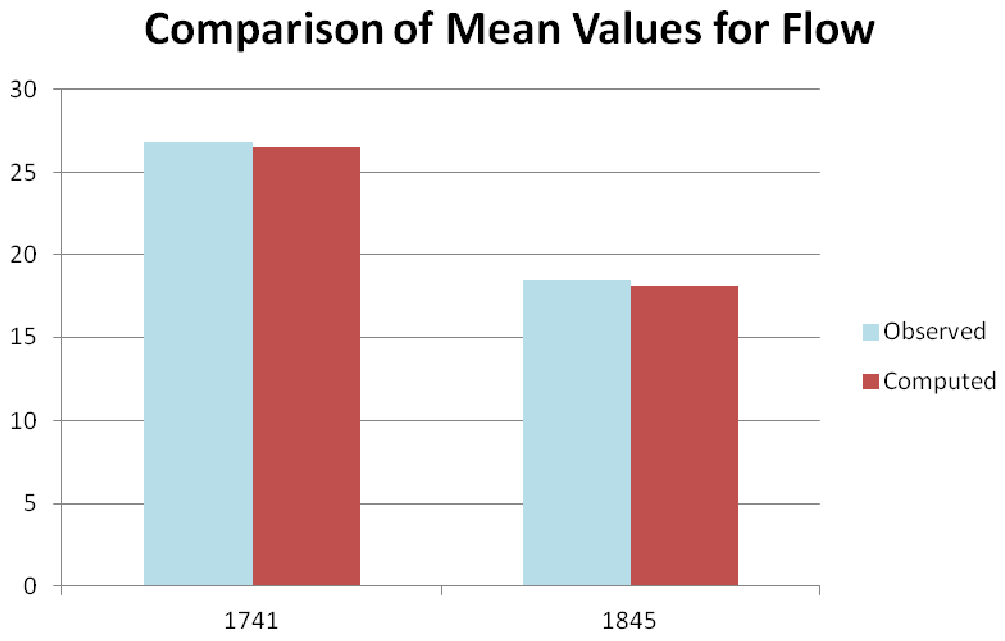
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1347	143	100.57	102.94	4.488	5.547
1353	143	58.18	57.94	6.982	8.878
1359	143	14.50	14.17	1.034	1.574
1511	143	55.50	55.32	3.634	4.651
Network	572	57.19	57.59	4.035	5.781

Correlation Between Means: 1.000

Flow

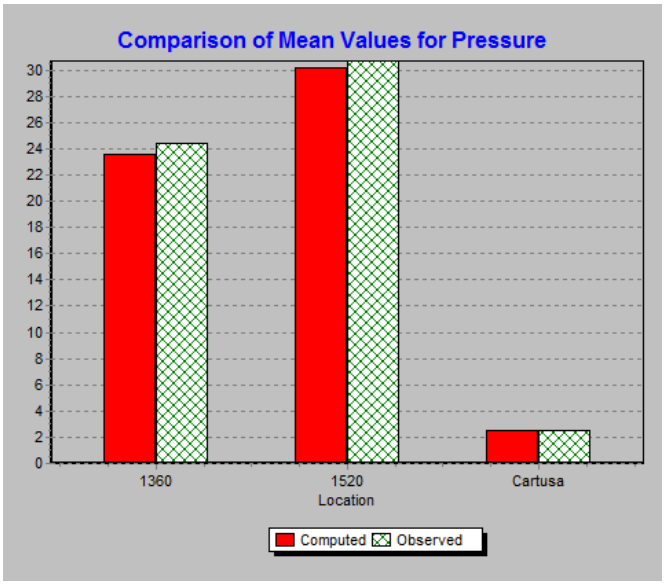
Epanet is not able to automatically compute statistical comparison for negative flow:



Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error	%
1845	143	18.45	18.11	1.846	2.349	10%
1741	143	26.83	26.49	1.843	2.346	7%
Network	286	22.64	22.30	1.844	2.347	8%

Durleşti-Cartuşa

Pressure

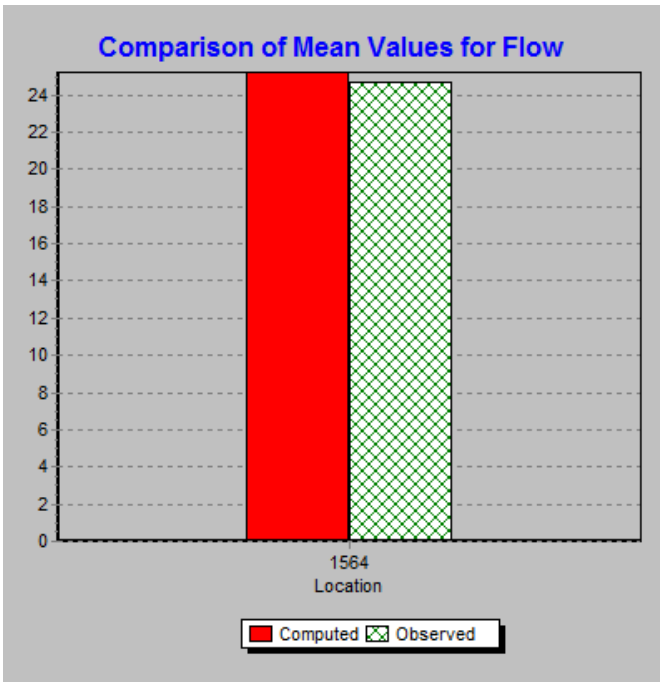


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1360	143	24.43	23.55	0.909	1.316
1520	143	30.69	30.14	0.860	1.078
Cartusa	143	2.51	2.49	0.028	0.041
Network	429	19.21	18.73	0.599	0.983

Correlation Between Means: 1.000

Flow



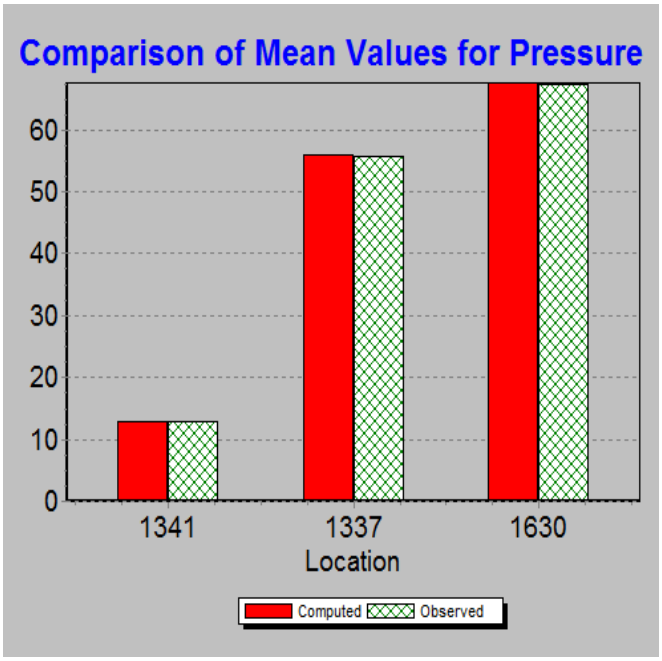
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1564	143	24.66	25.21	0.884	1.750
Network	143	24.66	25.21	0.884	1.750

Correlation Between Means: 13.835

Stauceni

Pressure

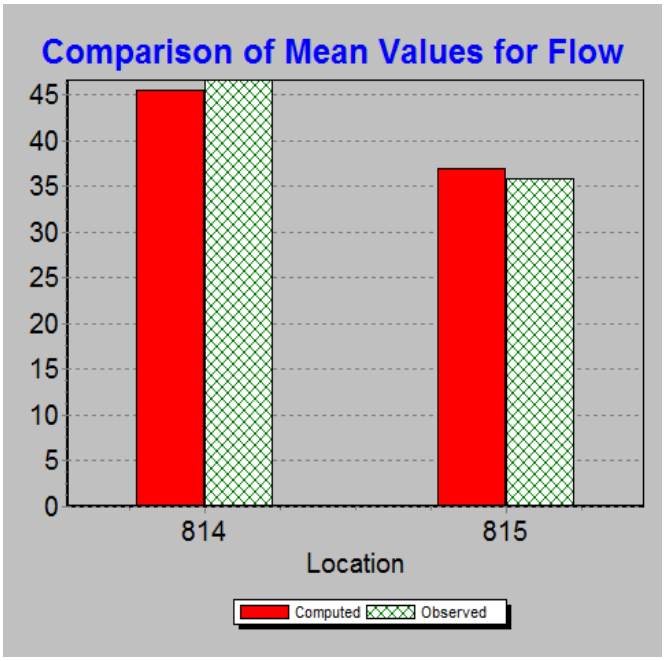


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1341	143	12.78	13.00	0.522	0.738
1337	143	55.84	56.00	0.577	0.760
1630	143	67.31	67.61	0.953	1.685
Network	429	45.31	45.53	0.684	1.149

Correlation Between Means: 1.000

Flow



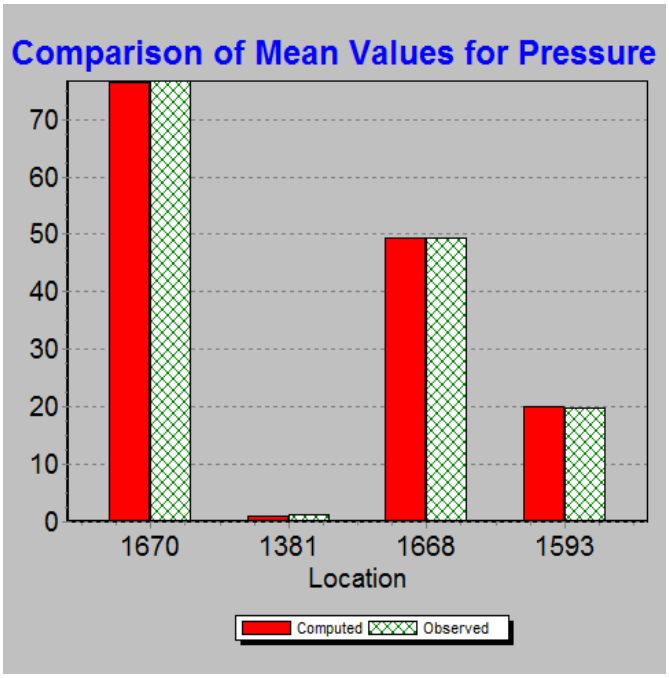
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
814	143	46.63	45.56	2.660	3.305
815	143	35.92	36.90	2.042	2.676
Network	286	41.27	41.23	2.351	3.007

Correlation Between Means: 1.000

SAN to Tohatin

Pressure

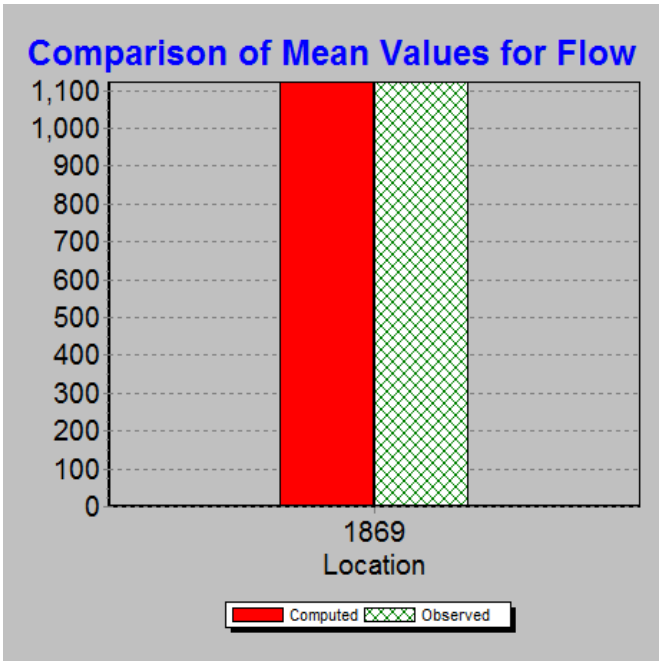


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1670	143	76.67	76.47	0.305	0.388
1381	143	1.13	1.01	0.197	0.246
1668	143	49.27	49.28	0.232	0.289
1593	143	19.81	20.15	0.510	0.656
Network	572	36.72	36.72	0.311	0.426

Correlation Between Means: 1.000

Flow



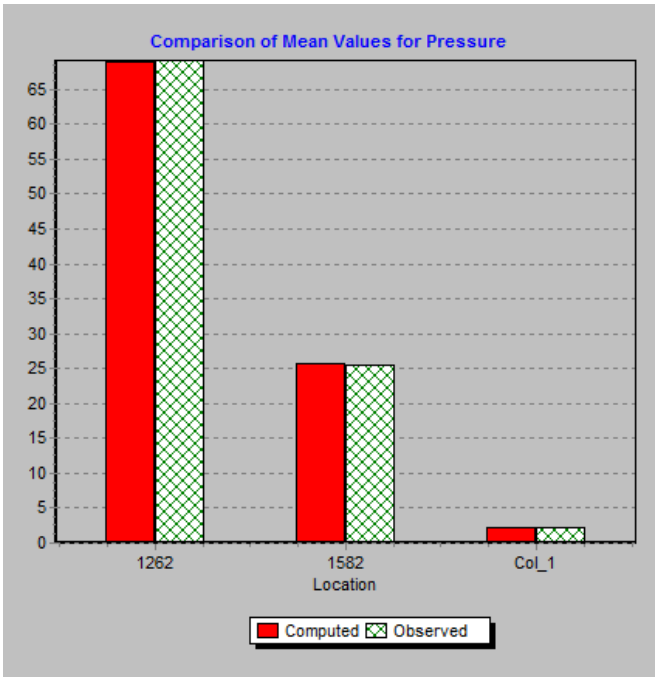
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1869	143	1122.34	1122.36	6.774	8.417
Network	143	1122.34	1122.36	6.774	8.417

Correlation Between Means: 1.466

Colonița

Pressure

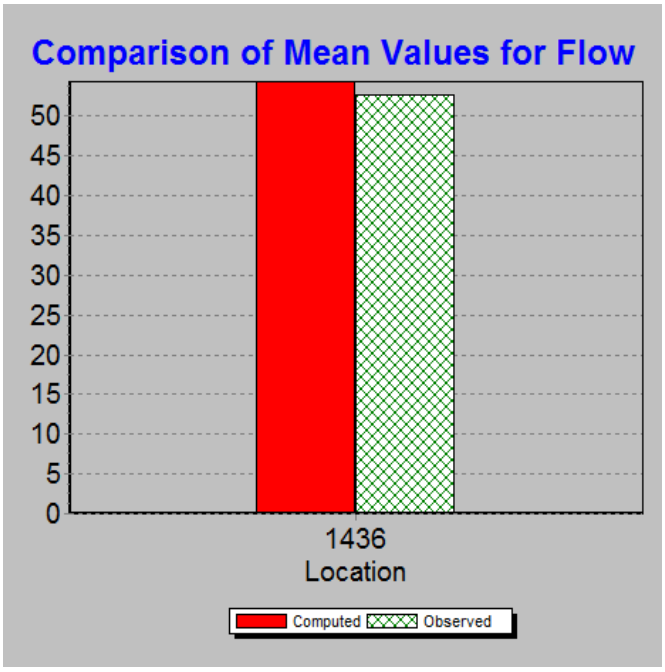


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1262	143	69.15	68.84	2.146	3.635
1582	143	25.57	25.66	1.038	2.304
Col_1	143	2.23	2.23	0.014	0.018
Network	429	32.32	32.24	1.066	2.485

Correlation Between Means: 1.000

Flow



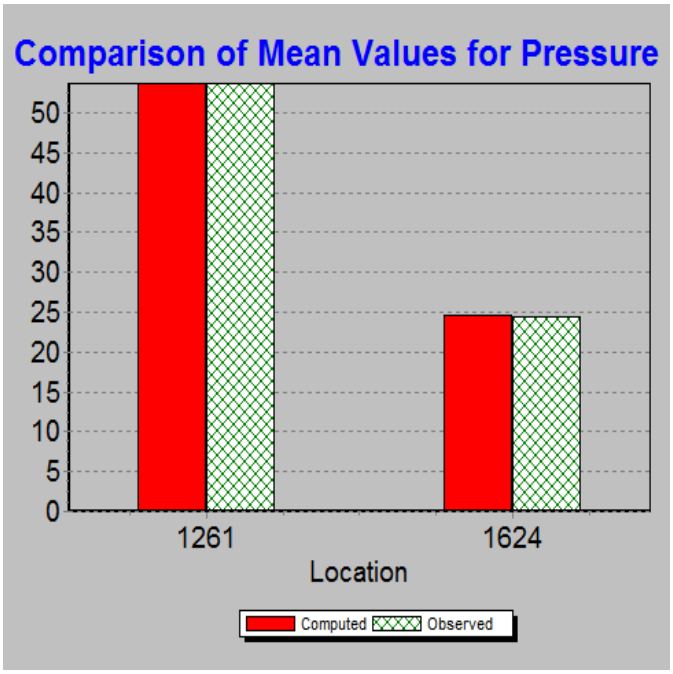
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1436	143	52.73	54.34	2.624	5.620
Network	143	52.73	54.34	2.624	5.620

Correlation Between Means: 0.000

Tohatin

Pressure



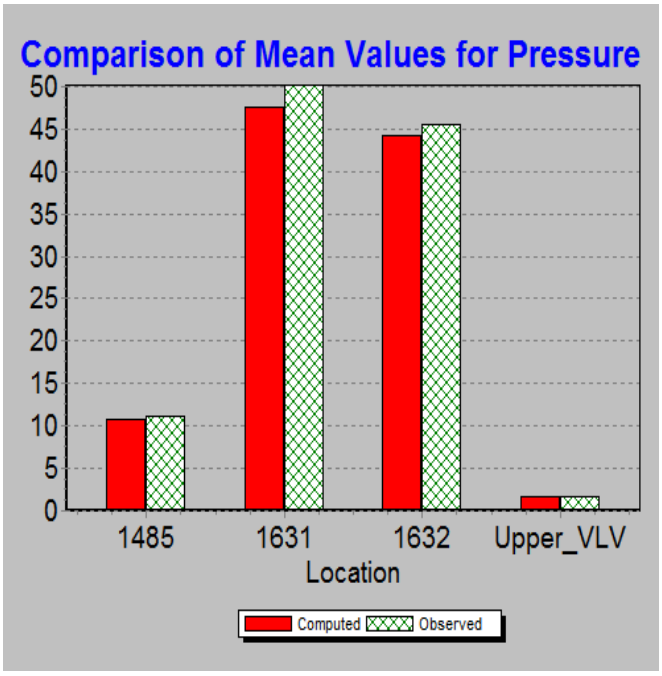
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1261	143	53.70	53.65	0.531	0.731
1624	143	24.37	24.66	0.486	0.786
Network	286	39.04	39.16	0.509	0.759

Correlation Between Means: 1.000

Vadul Lui Voda

Pressure



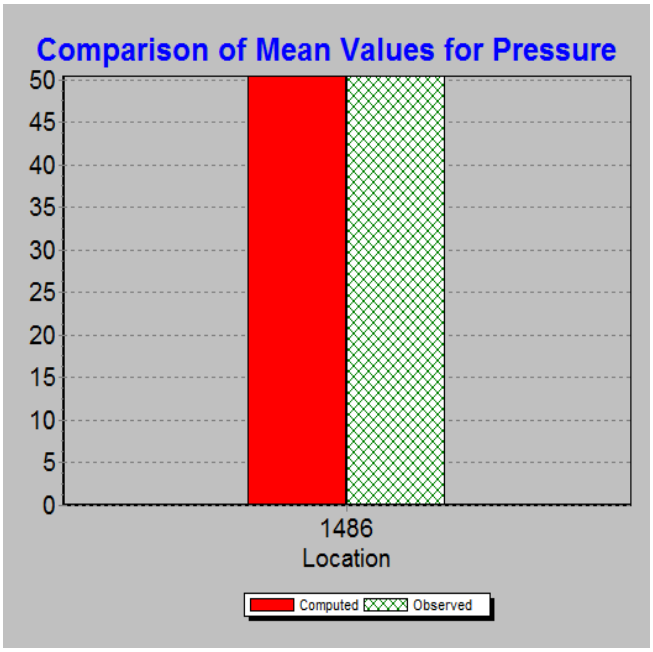
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1485	143	11.19	10.76	0.543	0.825
1631	143	50.16	47.64	2.578	3.409
1632	143	45.60	44.18	2.203	2.762
Upper_VLV	143	1.71	1.66	0.078	0.105
Network	572	27.17	26.06	1.351	2.233

Correlation Between Means: 1.000

Coşernița

Pressure



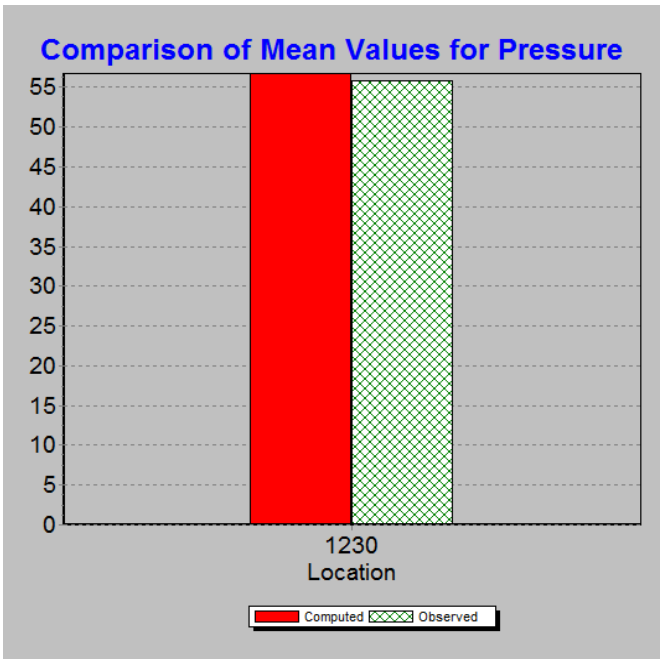
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1486	143	50.41	50.39	0.241	0.290
Network	143	50.41	50.39	0.241	0.290

Correlation Between Means: 0.000

Vatra

Pressure



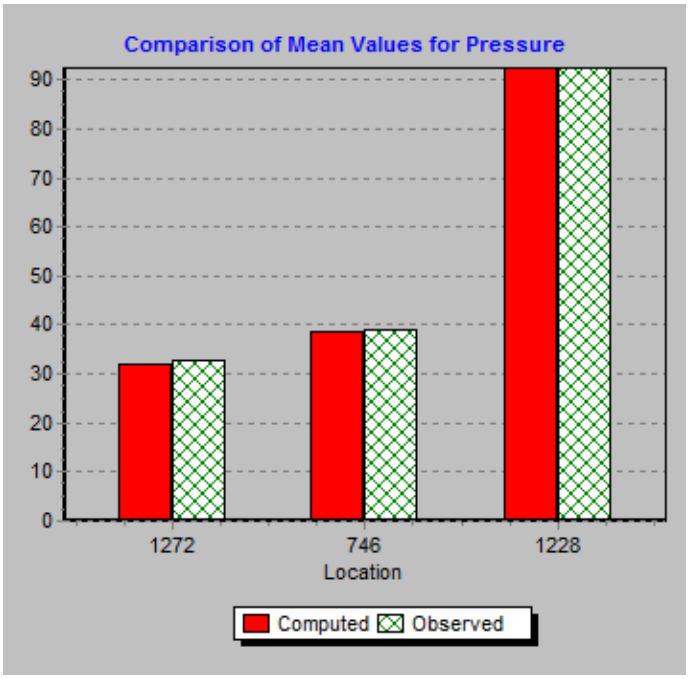
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1230	143	55.78	56.75	1.178	2.837
Network	143	55.78	56.75	1.178	2.837

Correlation Between Means: -0.381

Codru PS to Airport PS

Pressure



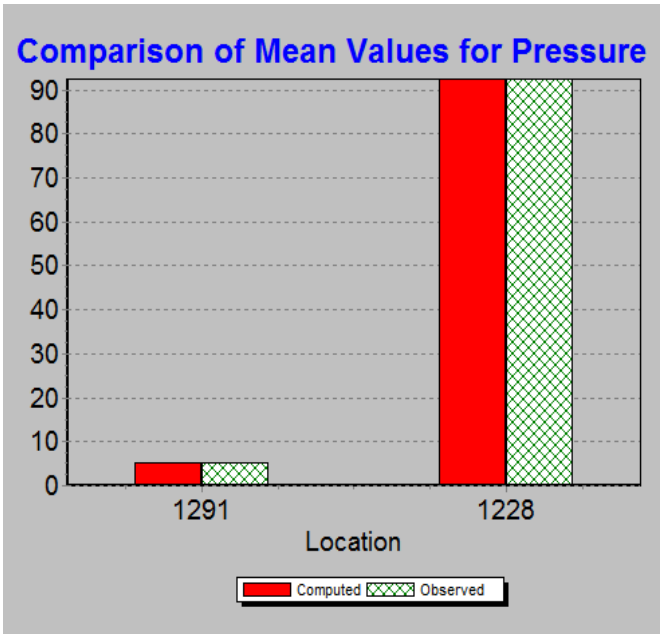
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1272	143	32.62	32.13	1.380	1.772
746	143	38.97	38.70	1.417	1.889
1228	143	92.31	92.47	0.269	0.341
Network	429	54.63	54.43	1.022	1.508

Correlation Between Means: 1.000

Codru PS to Sîngera PS

Pressure



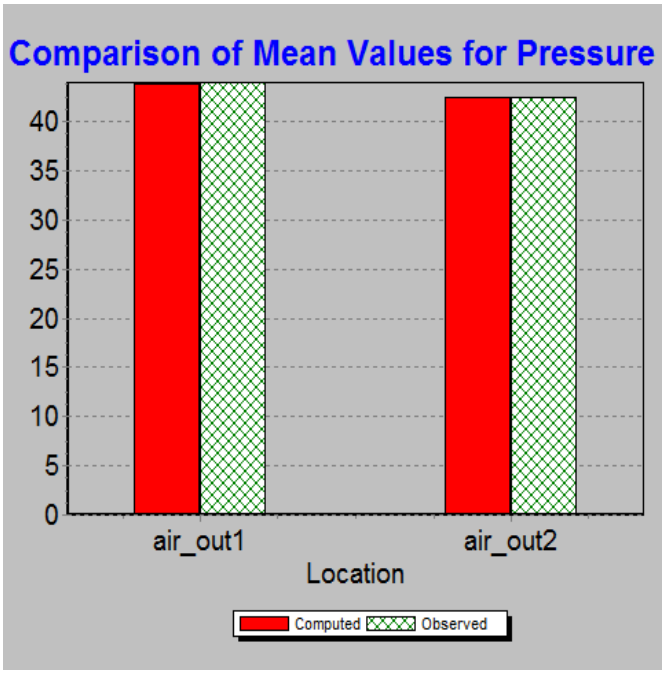
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1291	143	5.24	5.22	0.163	0.202
1228	143	92.31	92.47	0.269	0.341
Network	286	48.78	48.84	0.216	0.280

Correlation Between Means: 1.000

Airport

Pressure

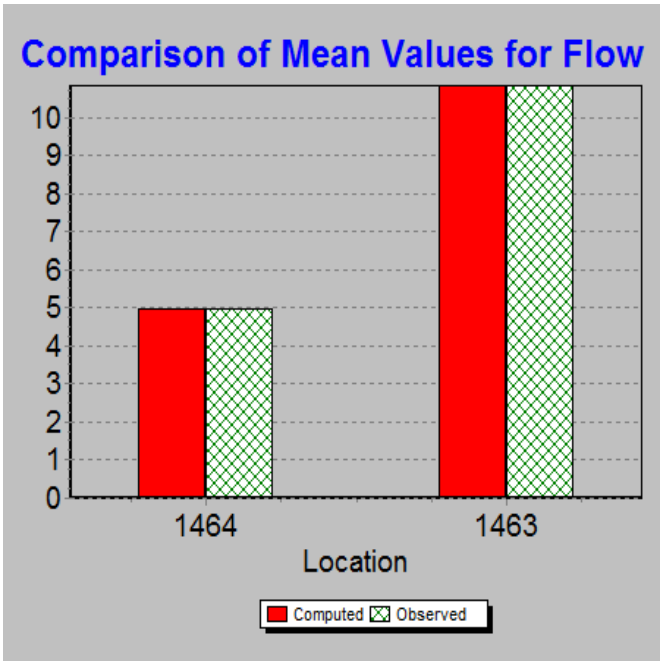


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
air_out1	143	43.99	43.87	0.397	0.538
air_out2	143	42.42	42.43	0.370	0.498
Network	286	43.21	43.15	0.383	0.518

Correlation Between Means: 1.000

Flow



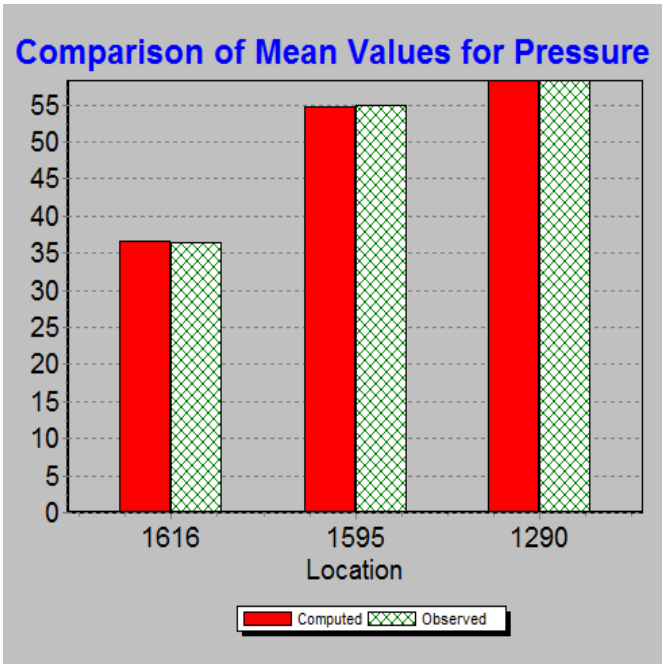
Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1464	143	4.98	4.97	1.061	1.412
1463	143	10.83	10.84	1.062	1.417
Network	286	7.91	7.91	1.062	1.415

Correlation Between Means: 1.000

Dobrogeah

Pressure



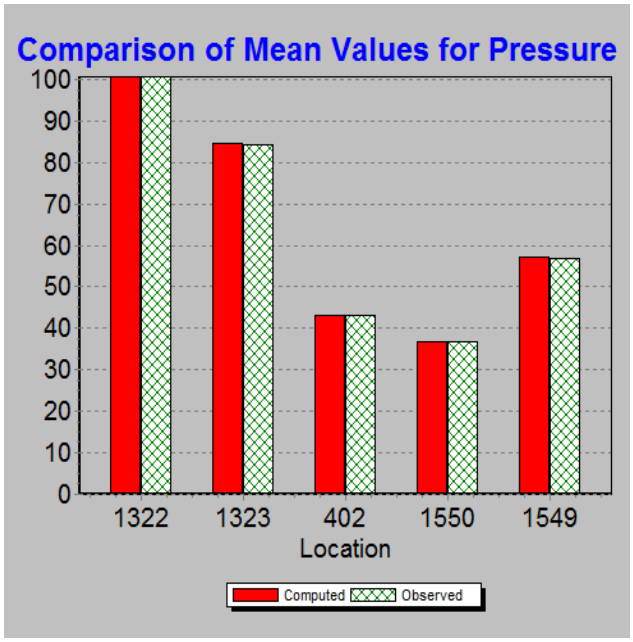
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1616	143	36.39	36.64	0.265	0.316
1595	143	54.94	54.77	0.271	0.321
1290	143	58.26	58.20	0.108	0.133
Network	429	49.86	49.87	0.215	0.271

Correlation Between Means: 1.000

Ialoveni

Pressure



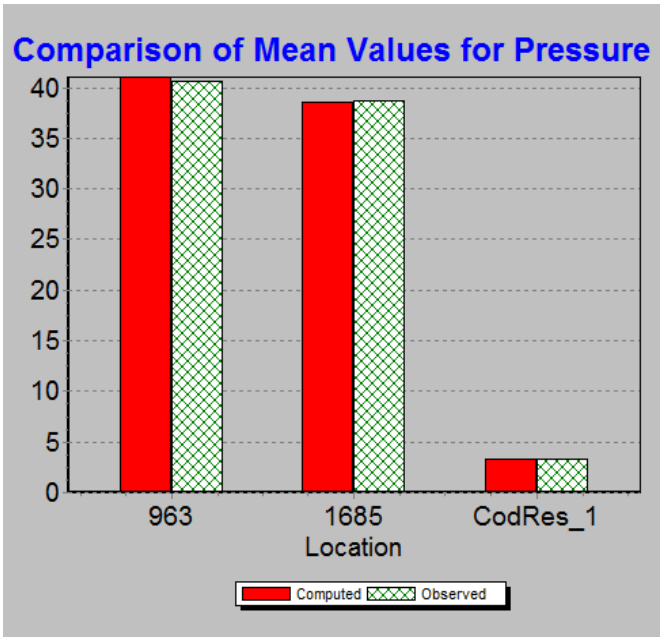
Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1322	143	100.63	100.49	0.360	0.467
1323	143	84.37	84.58	1.906	2.556
402	143	43.21	43.21	0.186	0.234
1550	143	36.92	36.94	0.705	0.882
1549	143	56.77	57.15	0.505	0.640
Network	715	64.38	64.47	0.732	1.265

Correlation Between Means: 1.000

Codru PS to Contre Reservoirs MDK

Pressure

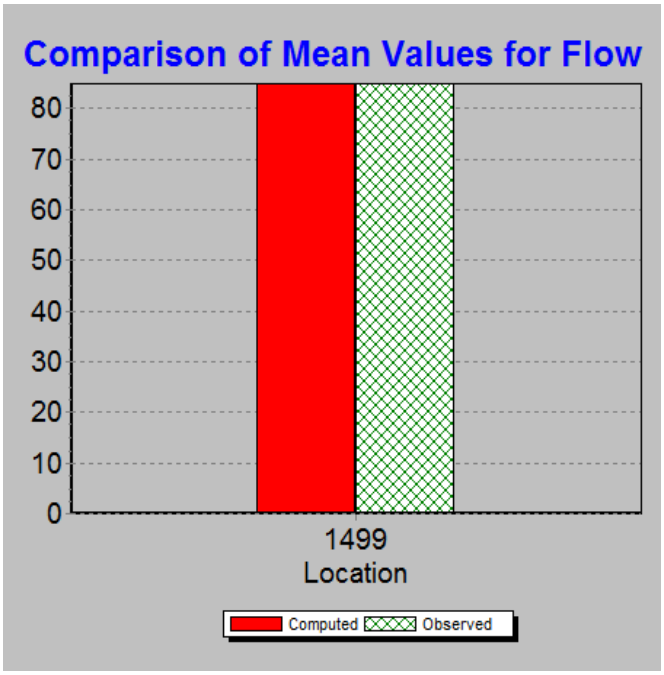


Calibration Statistics for Pressure

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
963	143	40.62	41.04	0.426	0.473
1685	143	38.72	38.58	0.322	0.422
CodRes_1	143	3.27	3.27	0.009	0.010
Network	429	27.54	27.63	0.252	0.366

Correlation Between Means: 1.000

Flow



Calibration Statistics for Flow

Location	Num Obs	Observed Mean	Computed Mean	Mean Error	RMS Error
1499	143	84.87	84.89	1.222	1.697
Network	143	84.87	84.89	1.222	1.697

Correlation Between Means: 0.000

Annex 5 Diagnostic of the network

Pressure variations

Figure 1: Zone 1

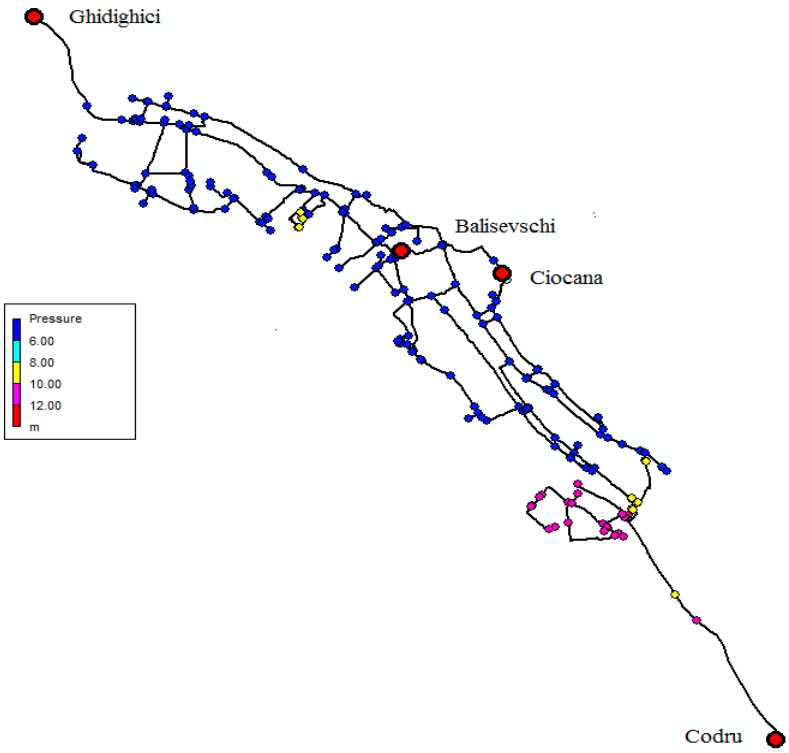


Figure 2: Zone 2 Doina

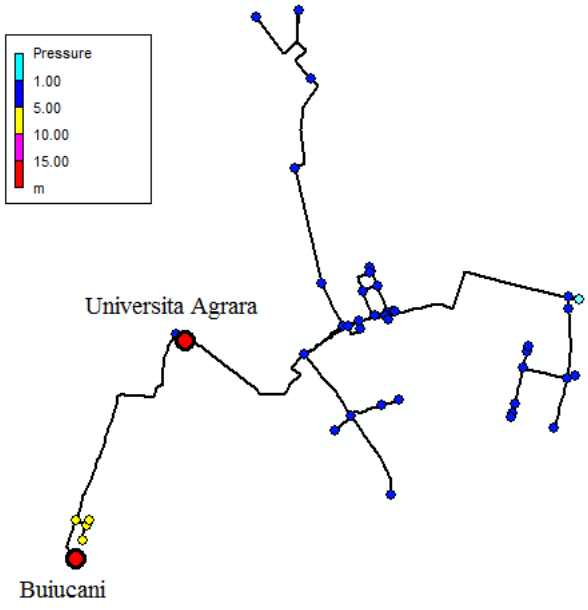


Figure 3: Zone 3 Rîscani

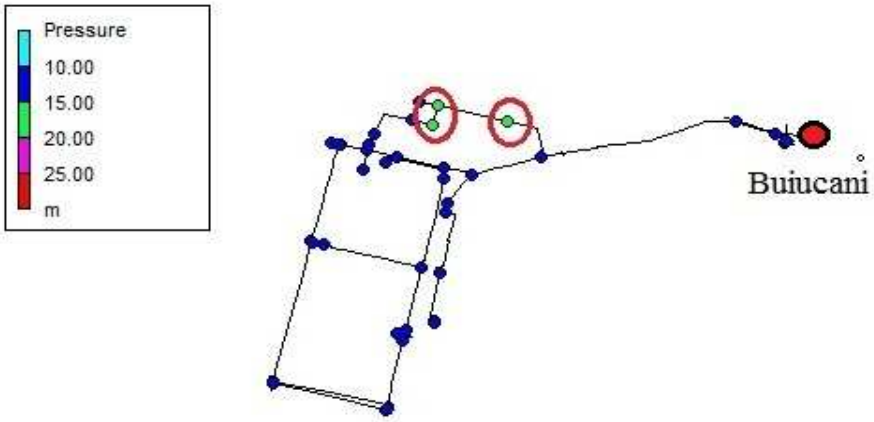


Figure 4: zone 3 Independenţa

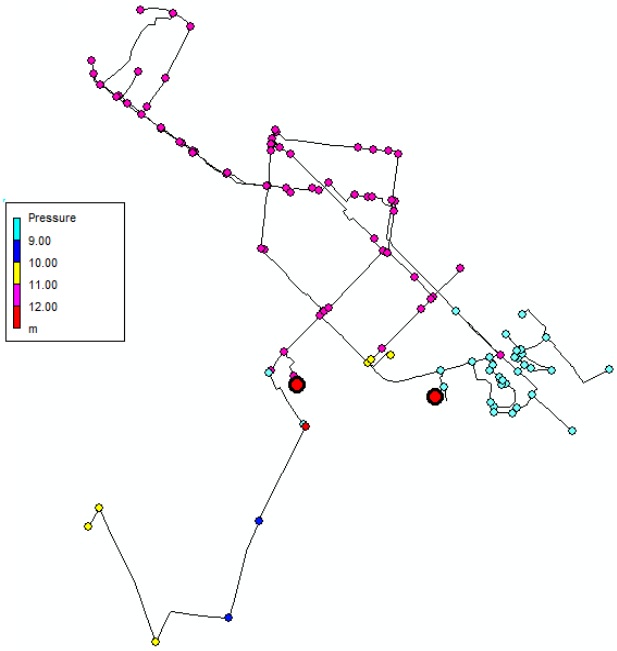


Figure 5: Zone 3 Valea Dicescu

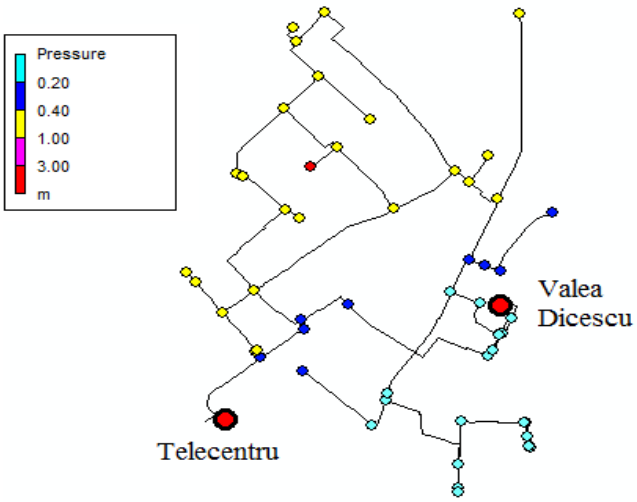


Figure 6: Zone 4 Buiucani

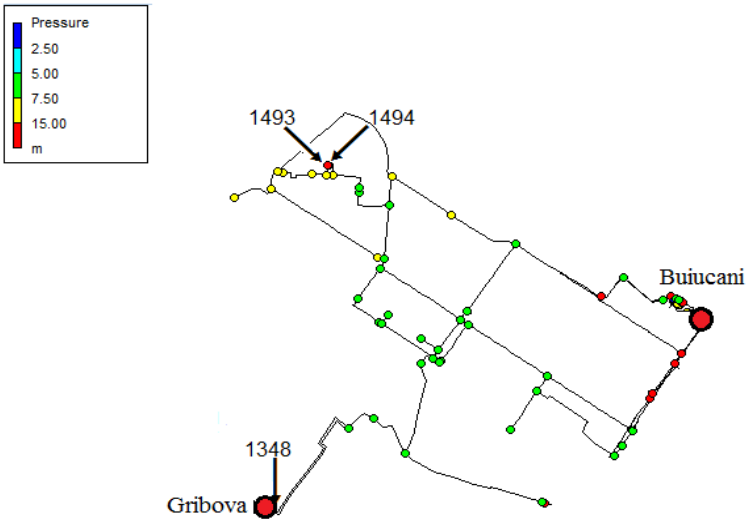


Figure 7: Zone 4A Botanica

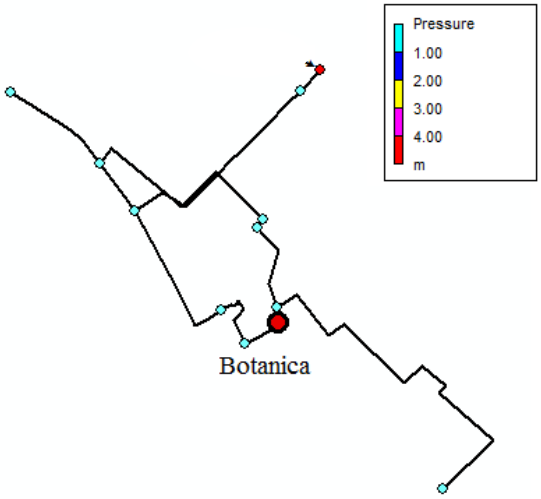


Figure 8: Zone 4A Schinoasa

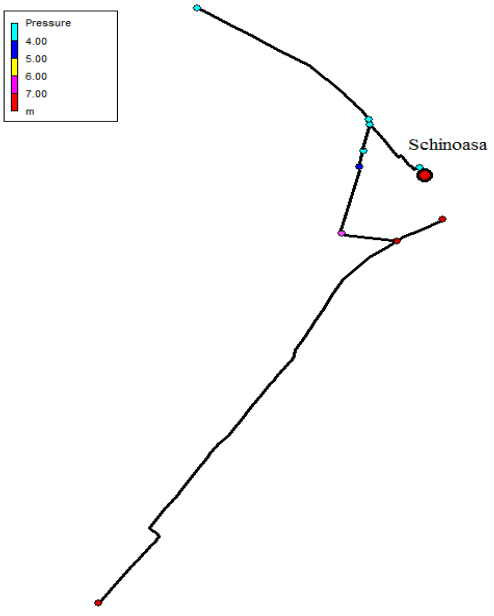


Figure 9: Zone between Codru Ps and Sîngera PS

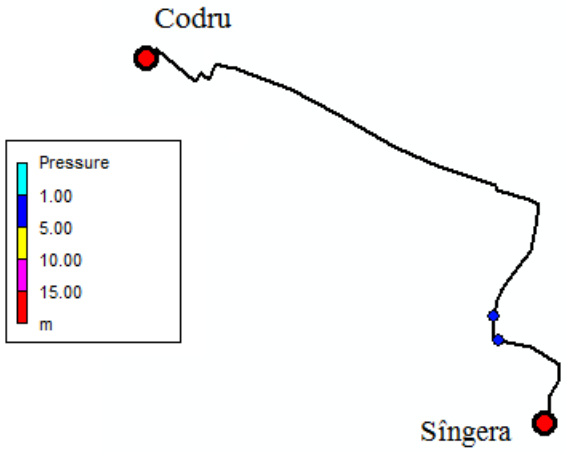


Figure 10: Sîngera

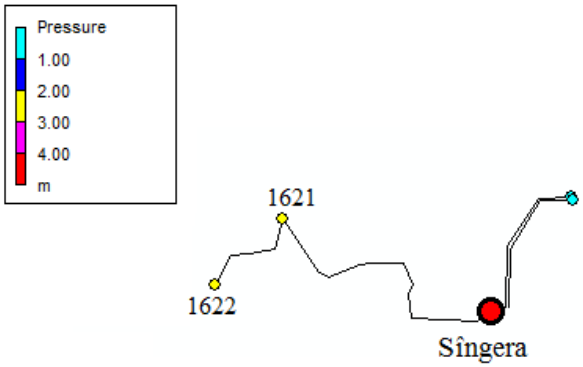


Figure 11: Codru MDK

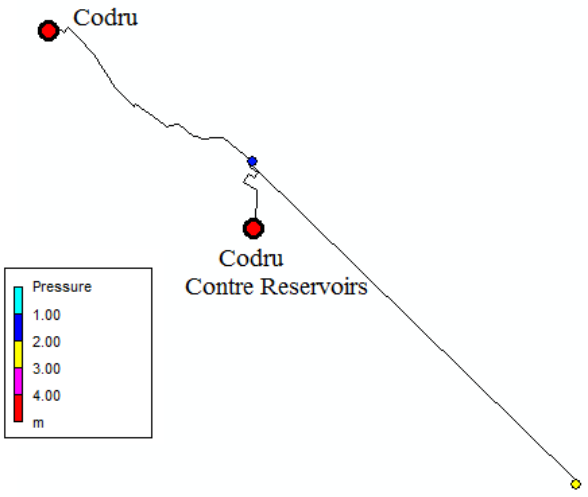


Figure 12: Zone Durleşti-Gribov

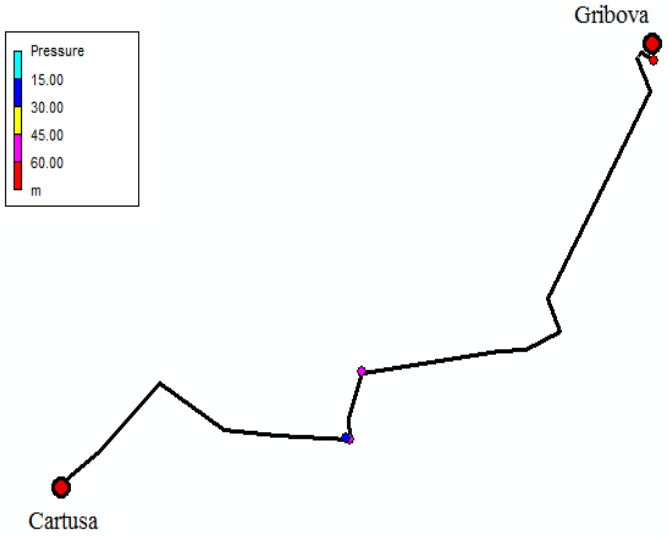


Figure 13: Stauceni and Goianul Nou

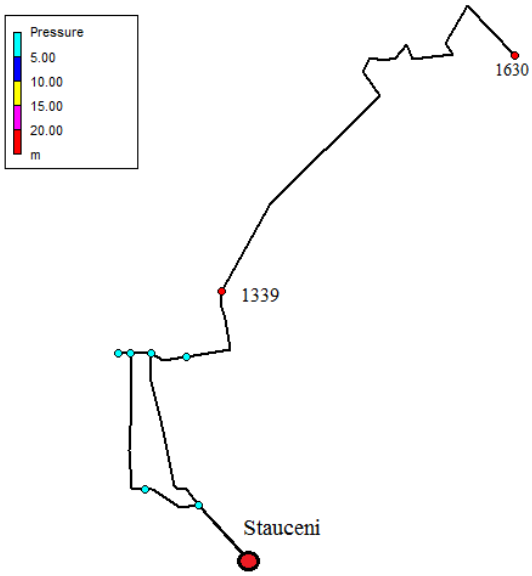


Figure 14: Tohatin

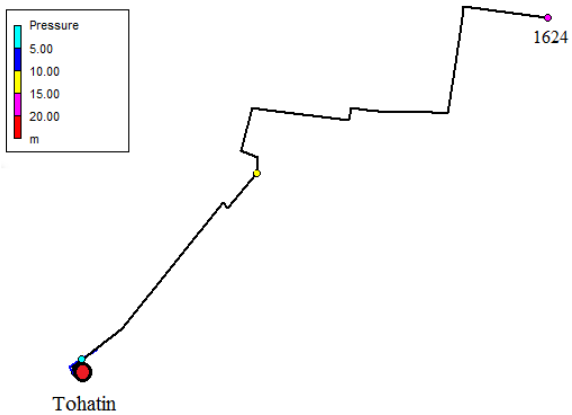


Figure 15: Coloniţa

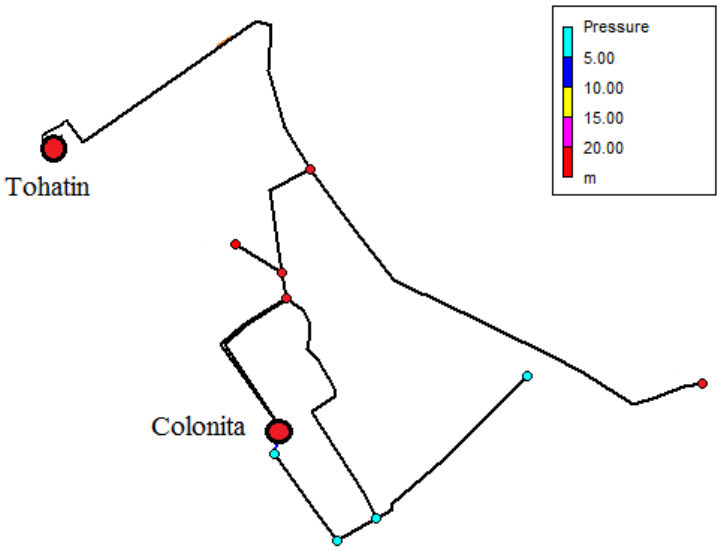
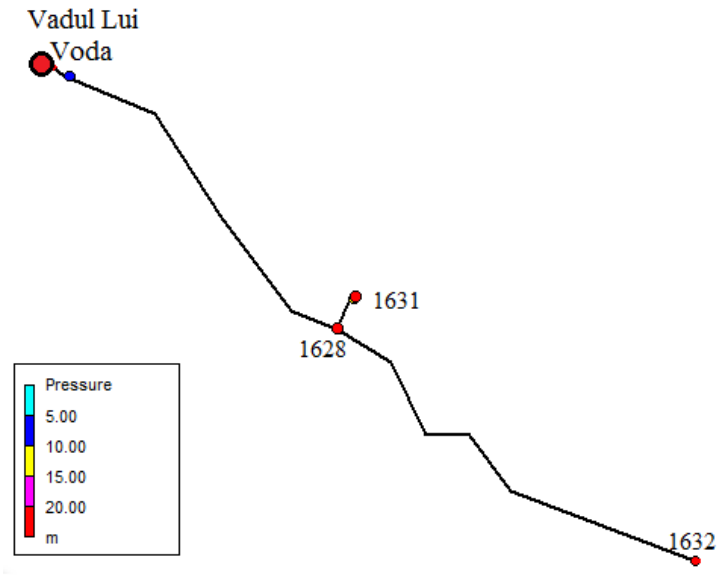


Figure 16: Vadul Lui Voda



Maximum Pressure

Figure 17: Zone 1

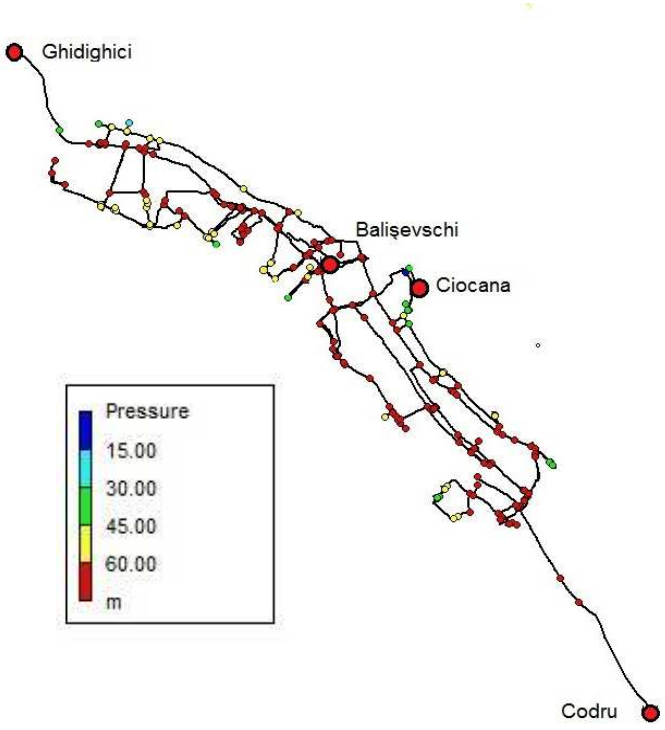


Figure 18: Zone 2 Oţel

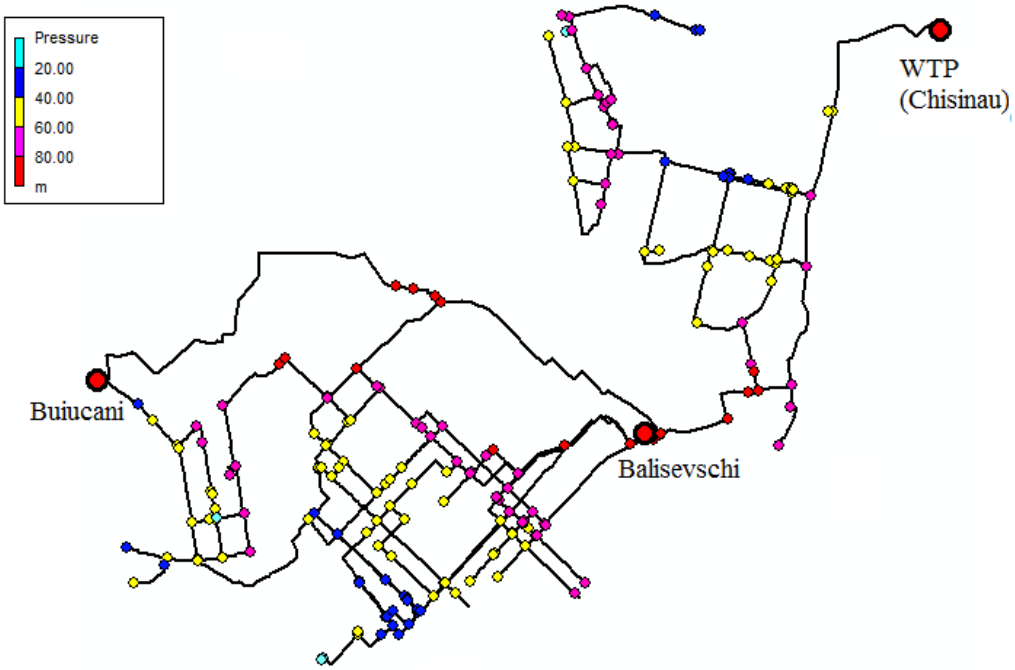


Figure 19: Zone 2 Doina

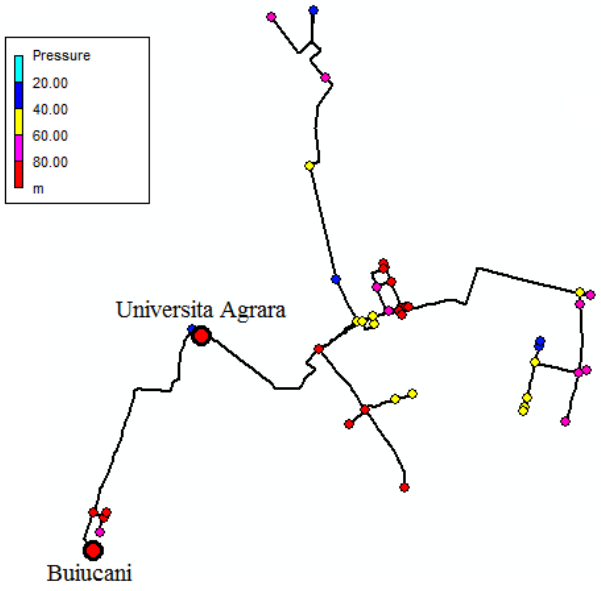


Figure 20: Zone 3 Buiucani

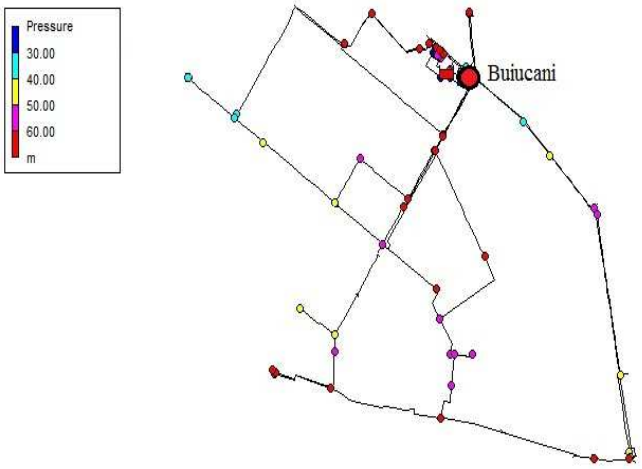


Figure 21: Zone 3 Rîscani

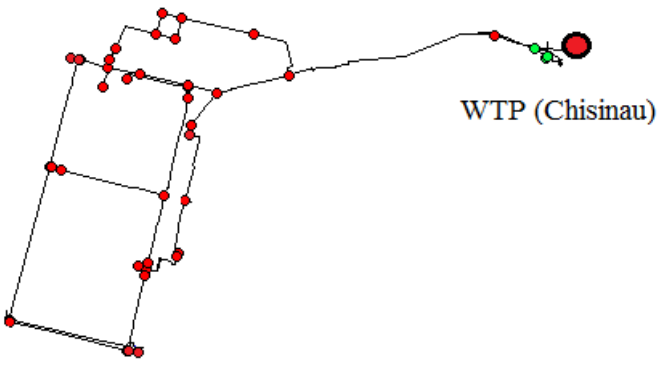


Figure 22: Zone 3 Independenţa

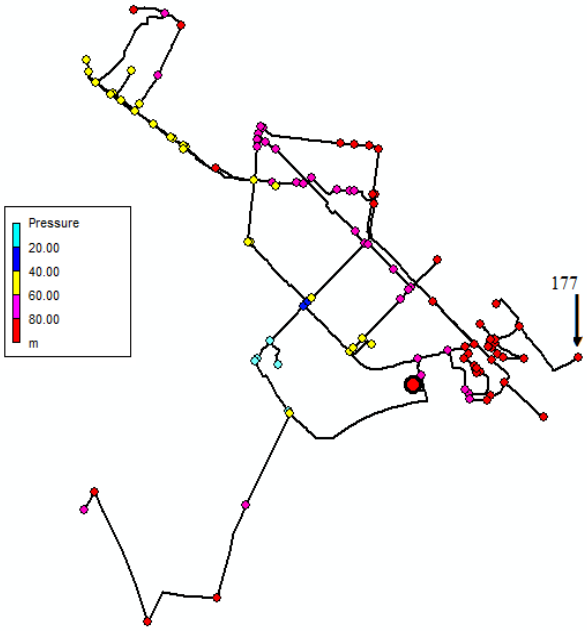


Figure 23: Zone 3 Valea Dicescu

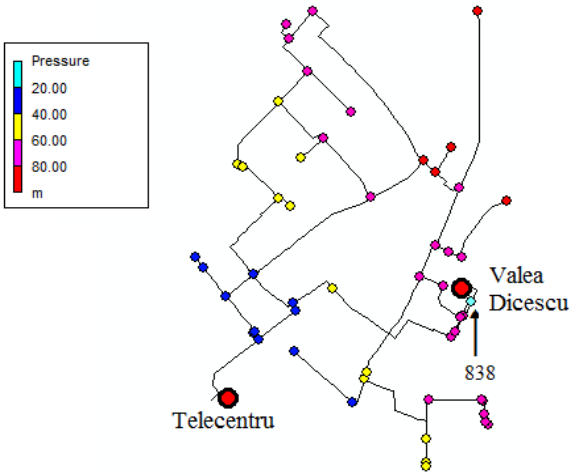


Figure 24: Zone 3 Universita agrara

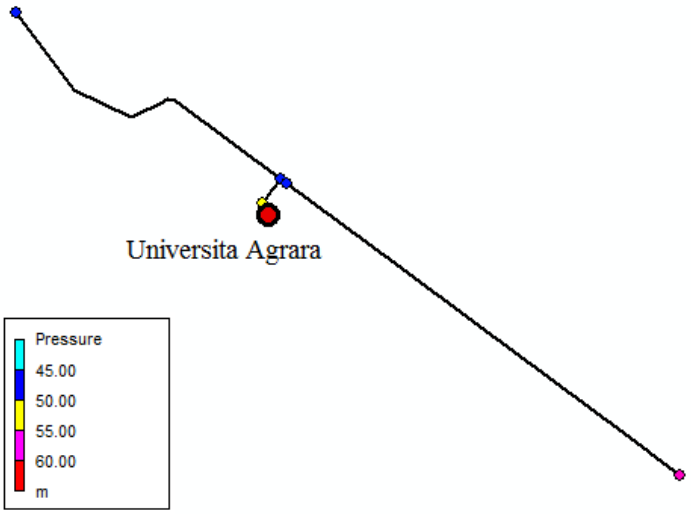


Figure 25: Zone 4 Independenţa

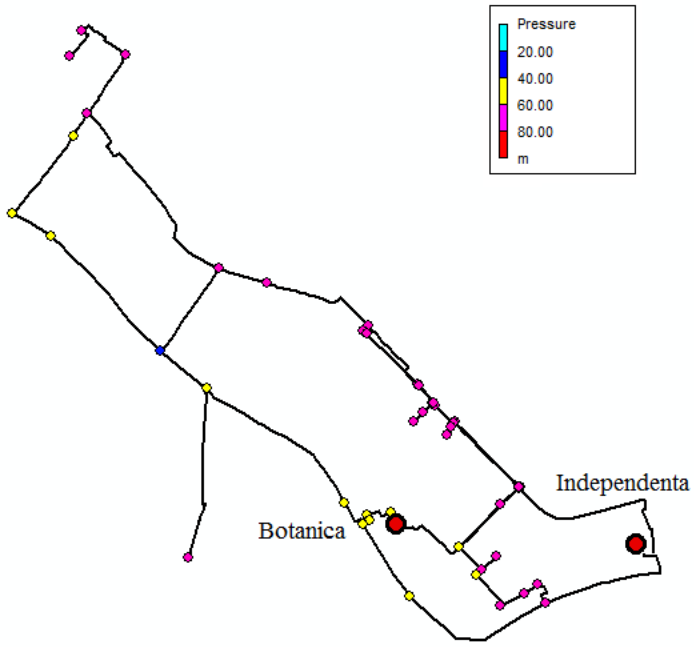


Figure 26: Zone 4 Ciocana

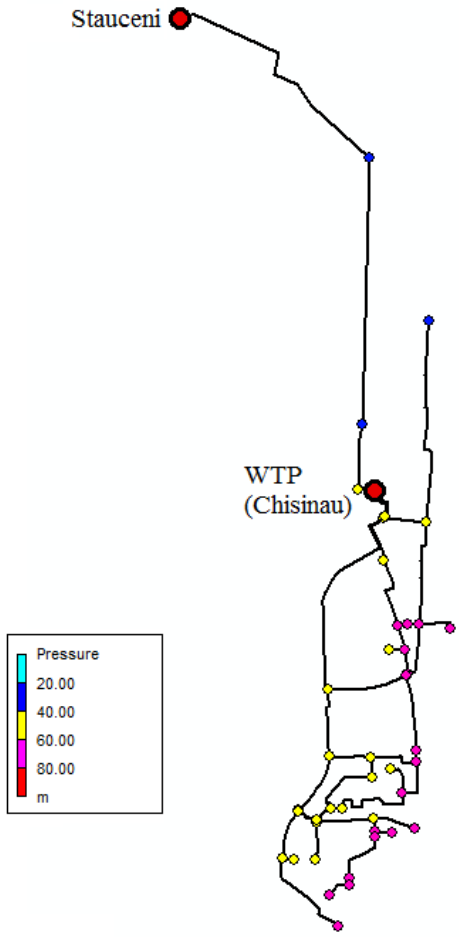


Figure 27: Zone 4 Buiucani

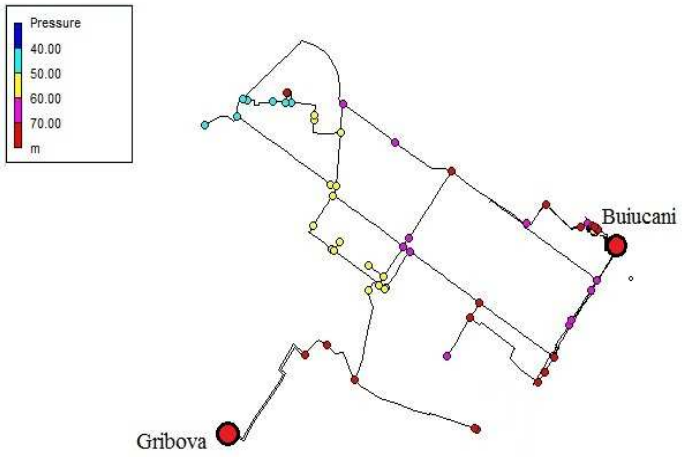


Figure 28: Zone 4A Telecentru

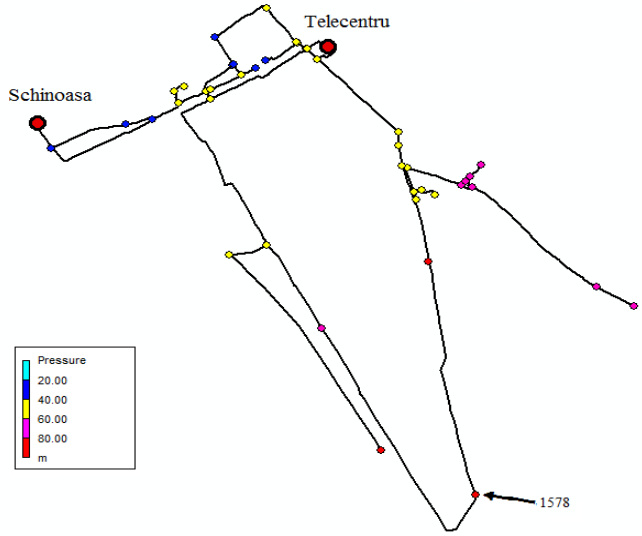


Figure 29: Zone 4A Schinoasa

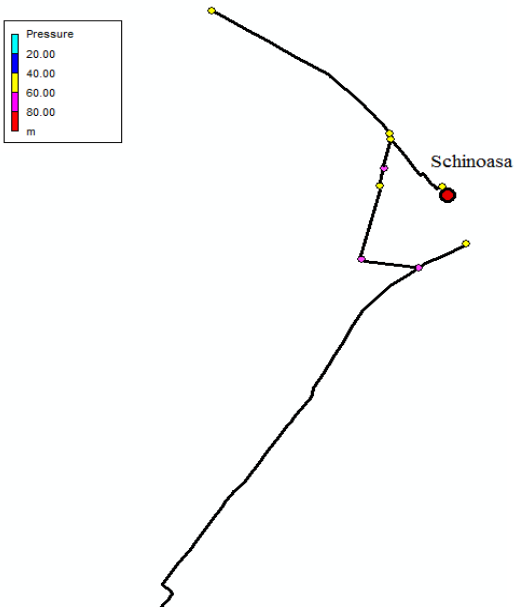


Figure 30: Zone between Codru PS and airport PS

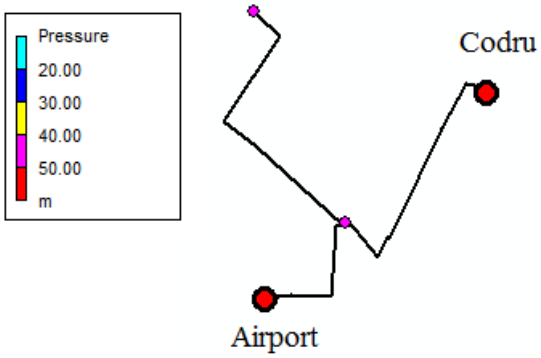


Figure 31: Zone between Codru PS and Sîngera PS

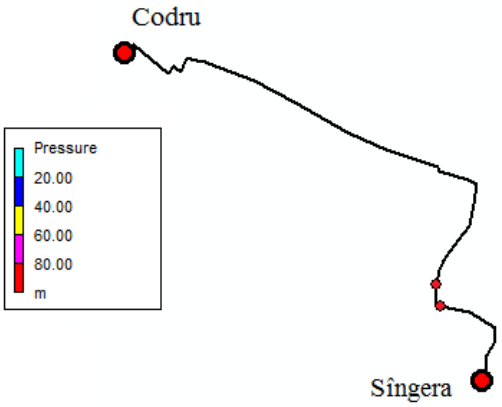


Figure 32: Dobrogeah

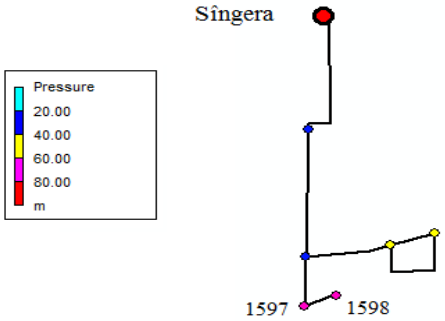


Figure 33: Sîngera

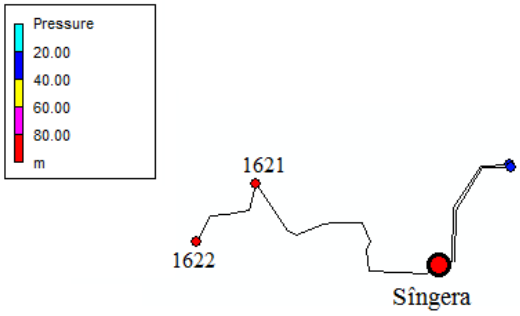


Figure 34: Codru MDK

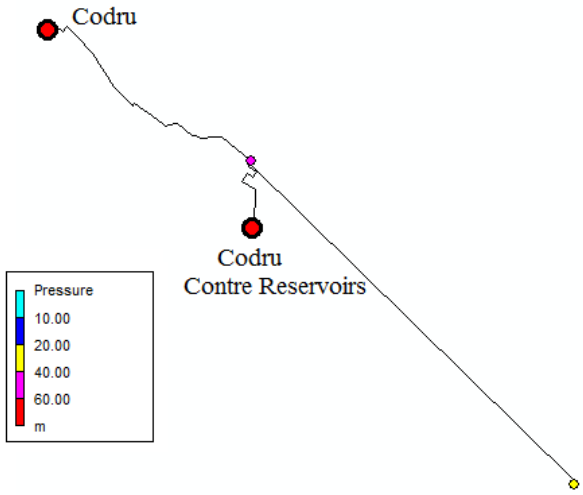


Figure 35: Ialoveni

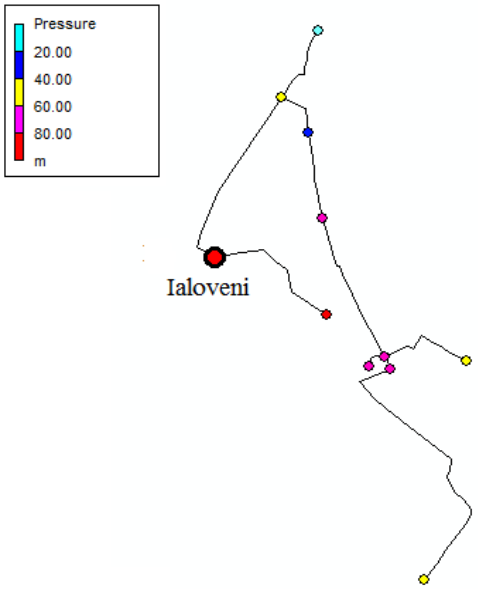


Figure 36: Zone Durleşti-Cartuşa

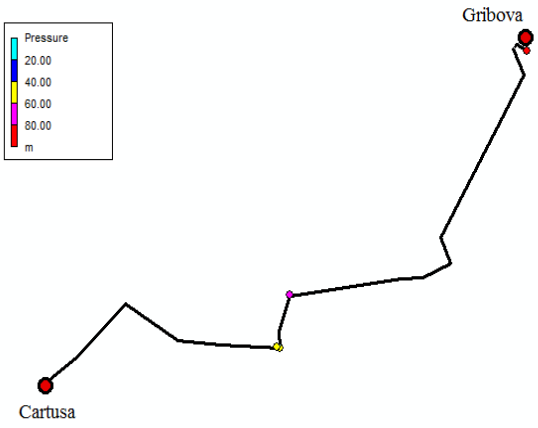


Figure 37: Stauceni and Goianul Nou

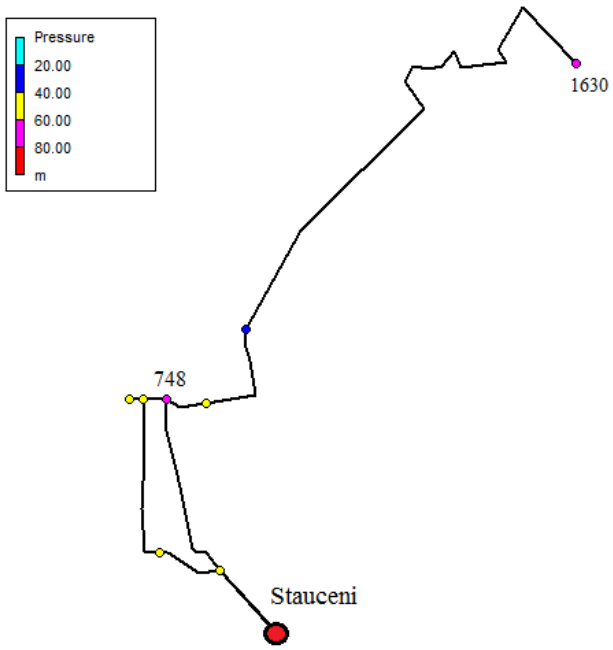


Figure 38: Zone between SAN and Tohatin PS

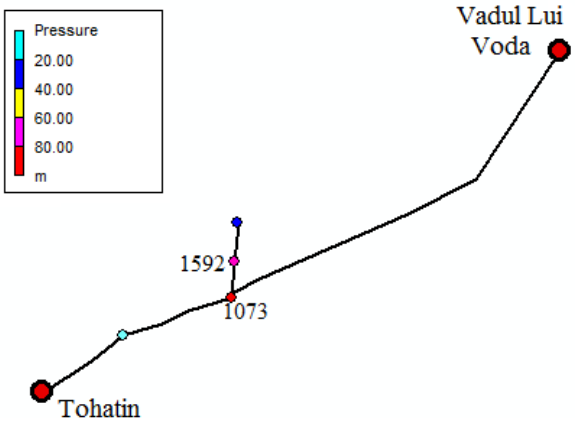


Figure 39: Tohatin

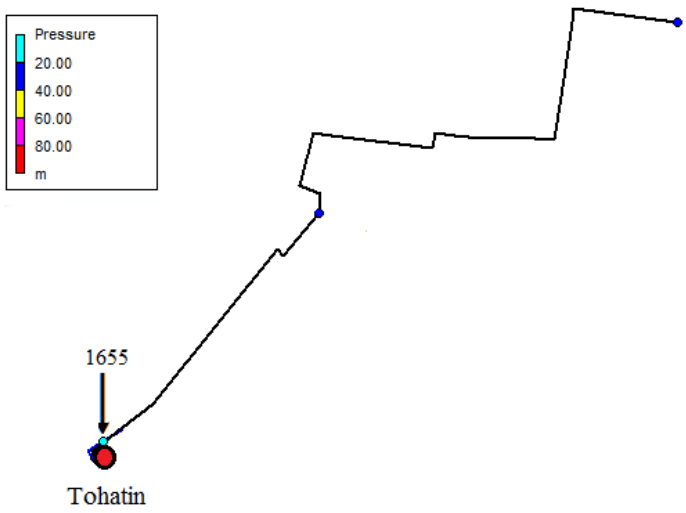


Figure 40: Coloniţa

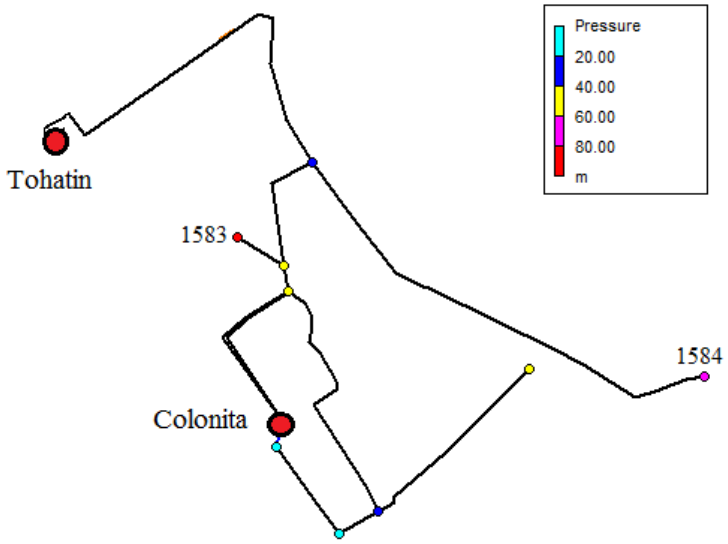
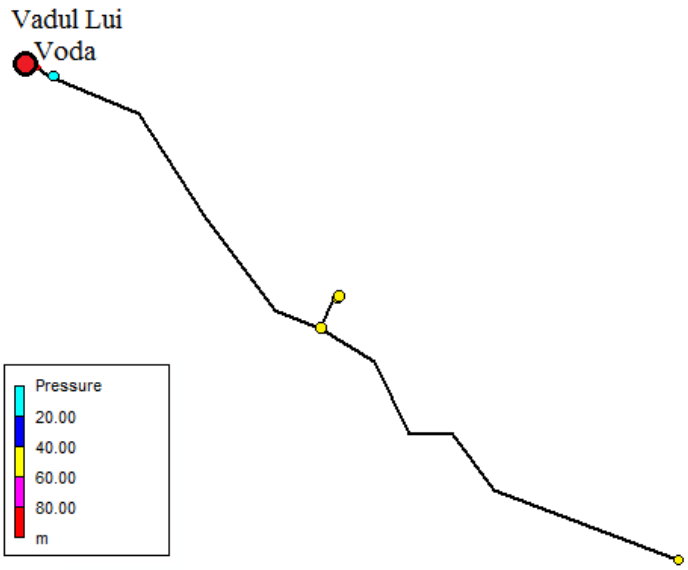


Figure 41: Vadul Lui Voda



Minimum Pressure

Figure 42: Zone 3 Ciocana

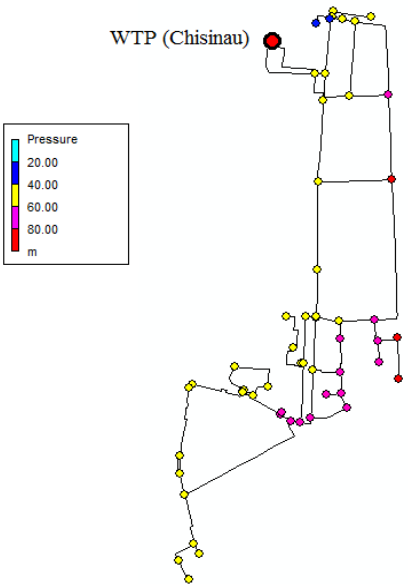


Figure 43: Zone 4 Telecentru

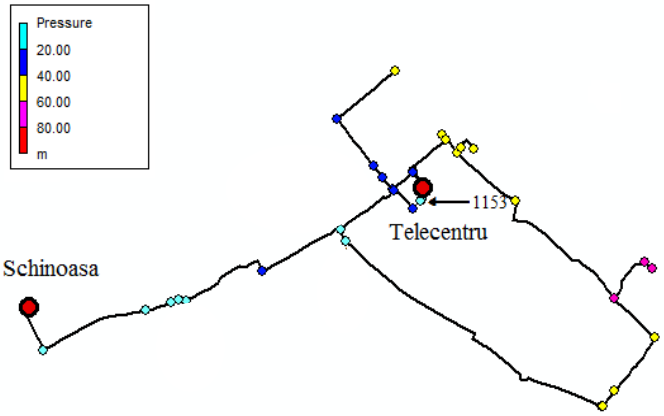


Figure 44: Zone 4A Schinoasa

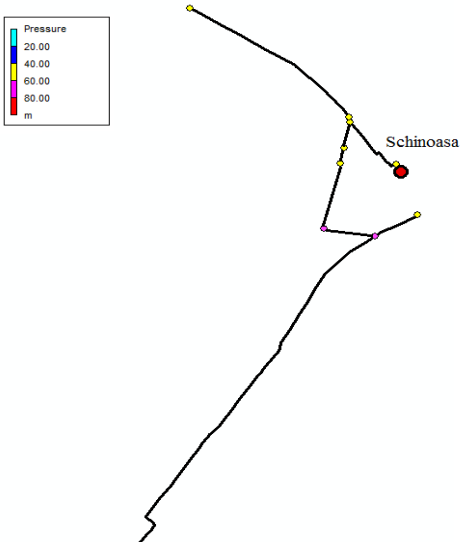


Figure 45: Zone between Codru PS and airport PS

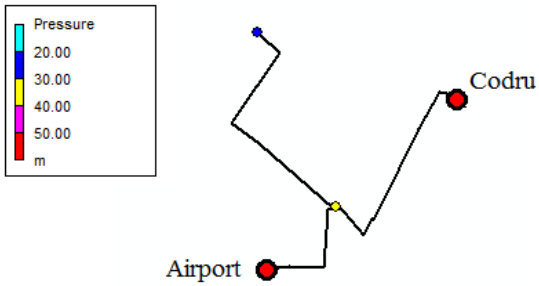


Figure 46: Ialoveni

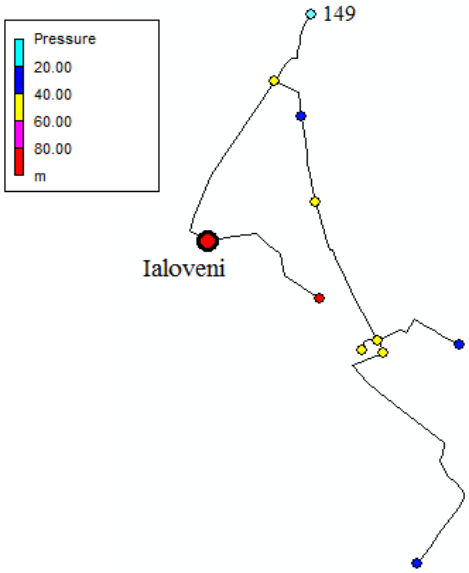


Figure 47: Tohatin

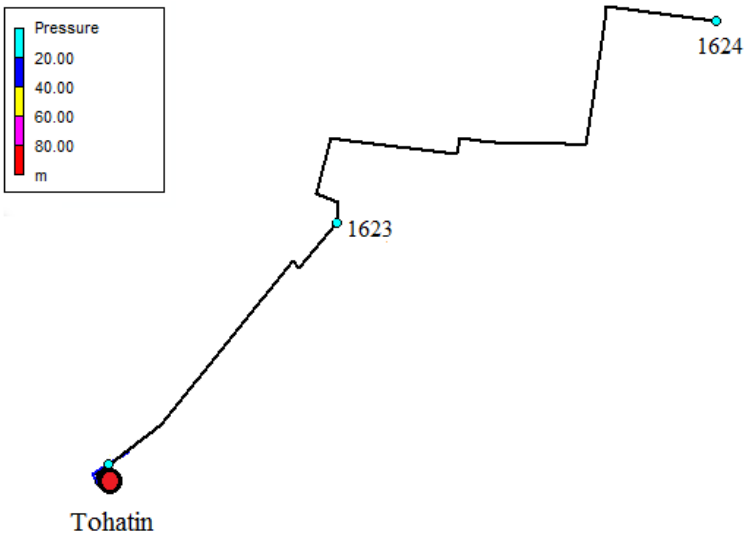


Figure 48: Coloniţa

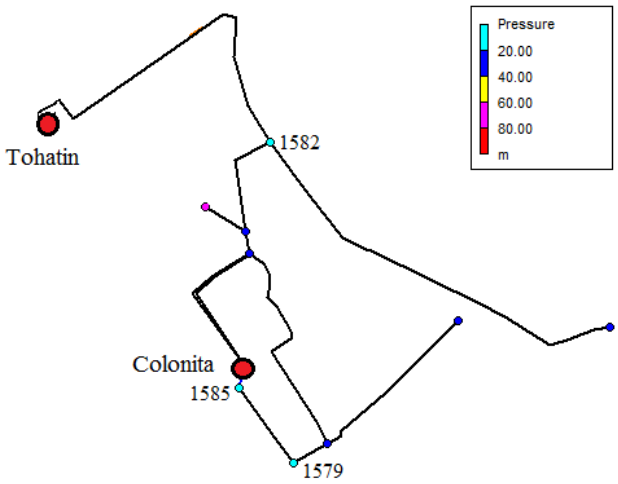


Figure 49: Zone Durleşti-Gribov

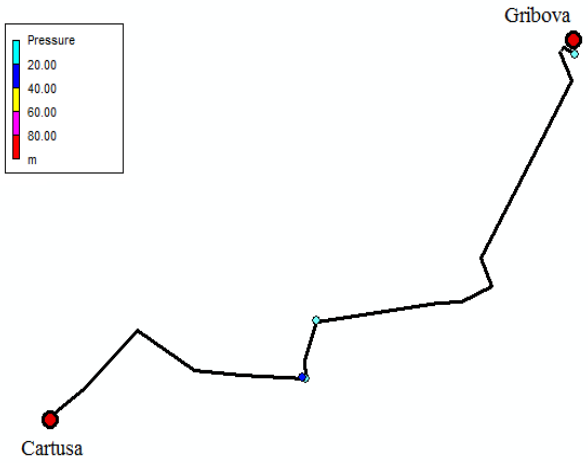


Figure 50: Stauceni and Goianul Nou

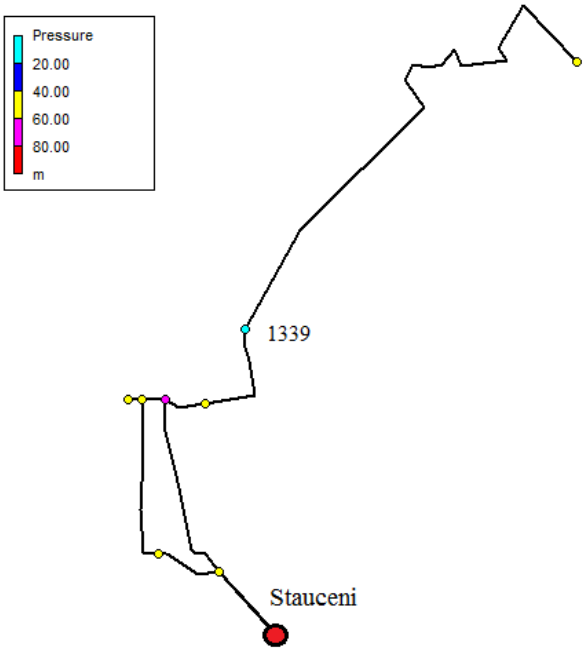
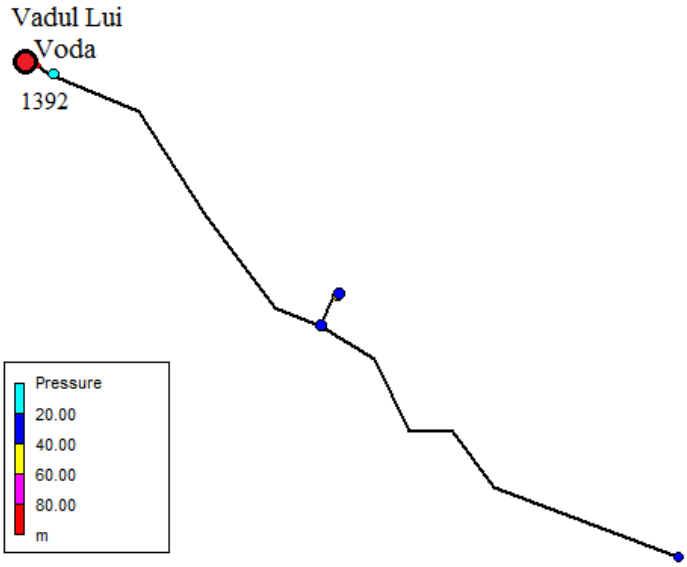


Figure 51: Vadul Lui Voda



Maximum Velocity

Figure 52: Zone 1

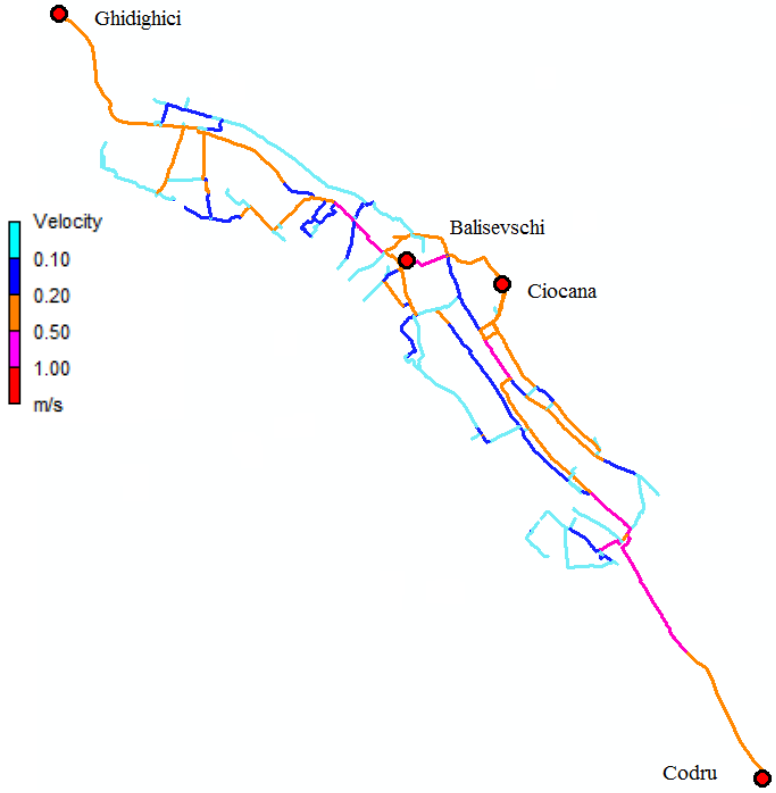


Figure 53: Zone 2 Oţel

Figure 54: Zone 2

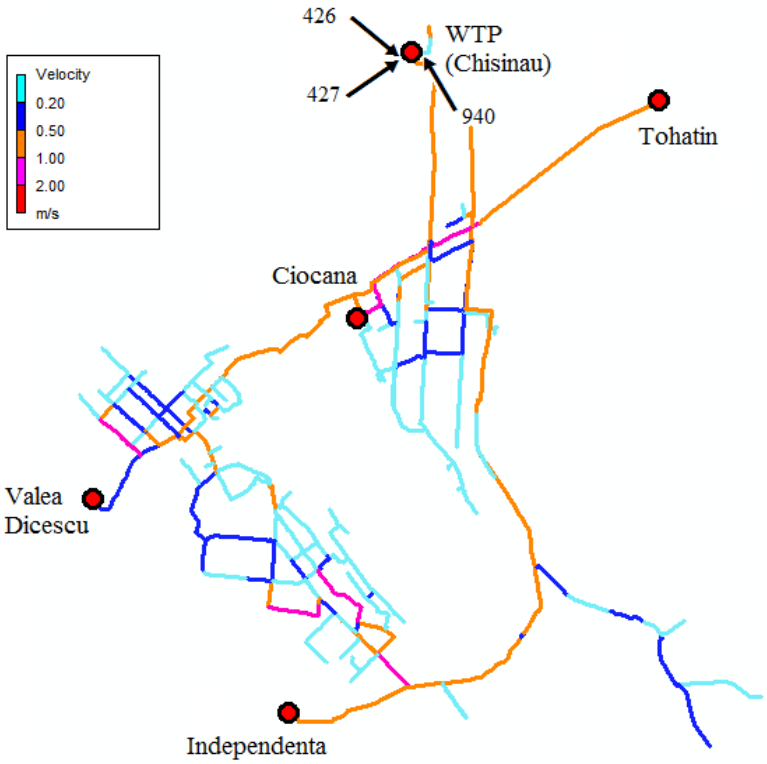


Figure 55: Zone 2 Doina

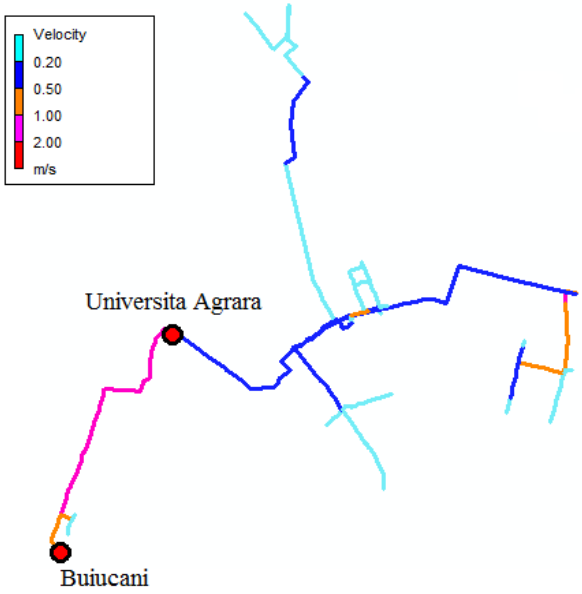


Figure 56: Zone 3 Buiucani

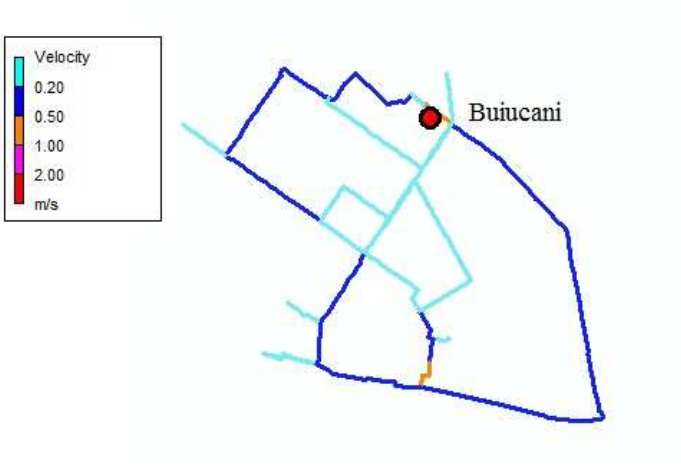


Figure 57: Zone 3 Ciocana

Figure 58: Zone 3 Rîscani

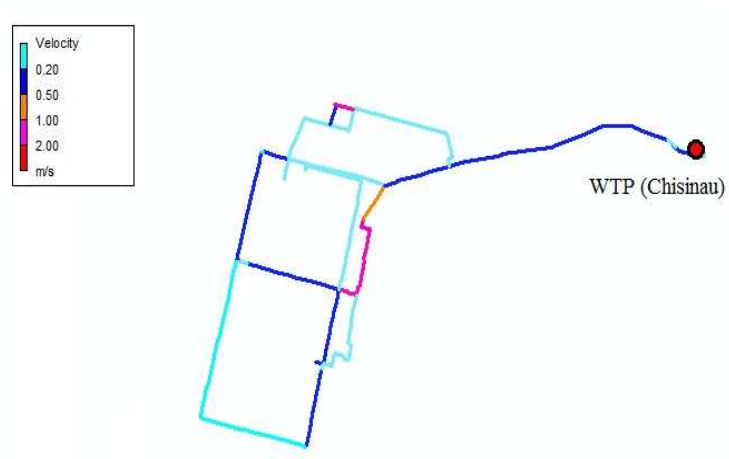


Figure 59: Independenţa Zone 3

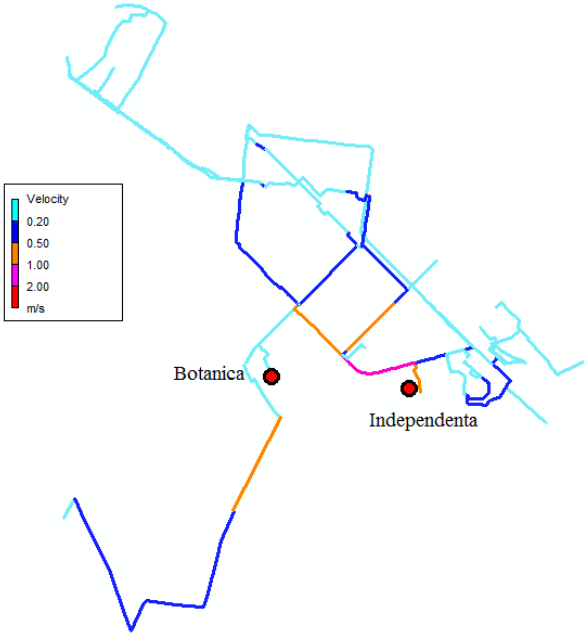


Figure 60: Valea Dicescu Zone 3

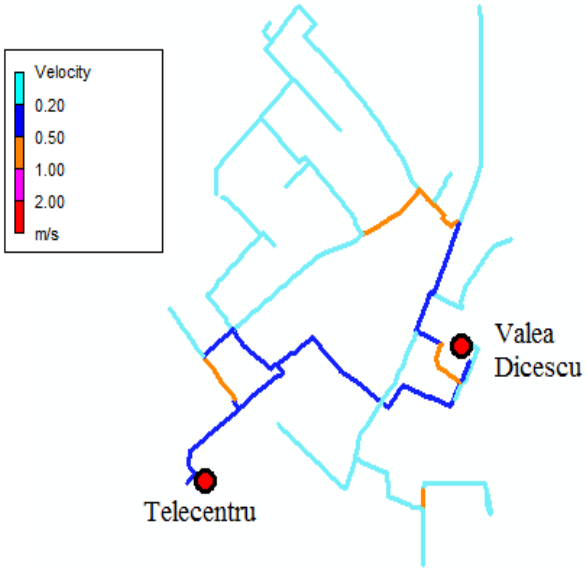


Figure 61: Zone 4 Buiucani

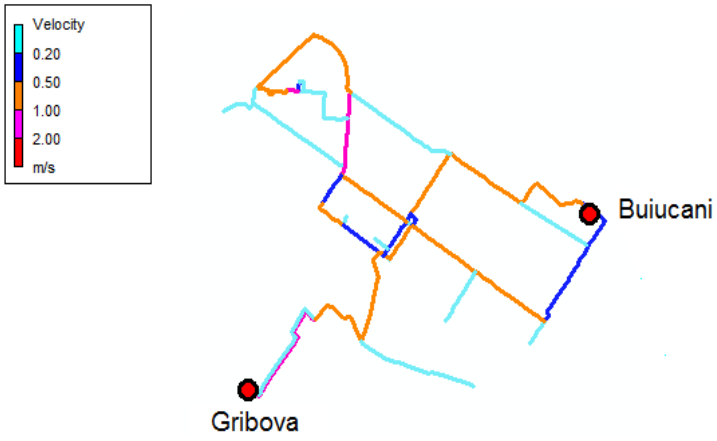


Figure 62: Zone 4 Telecentru

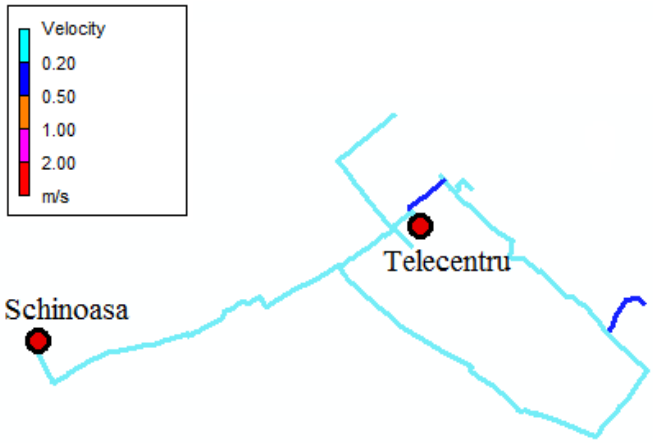


Figure 63: Zone 4 Independenţa

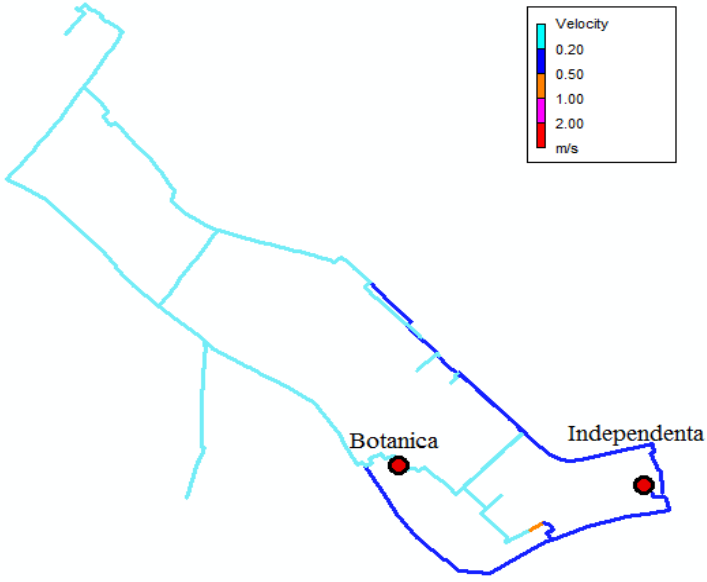


Figure 64: Zone 4 Ciocana

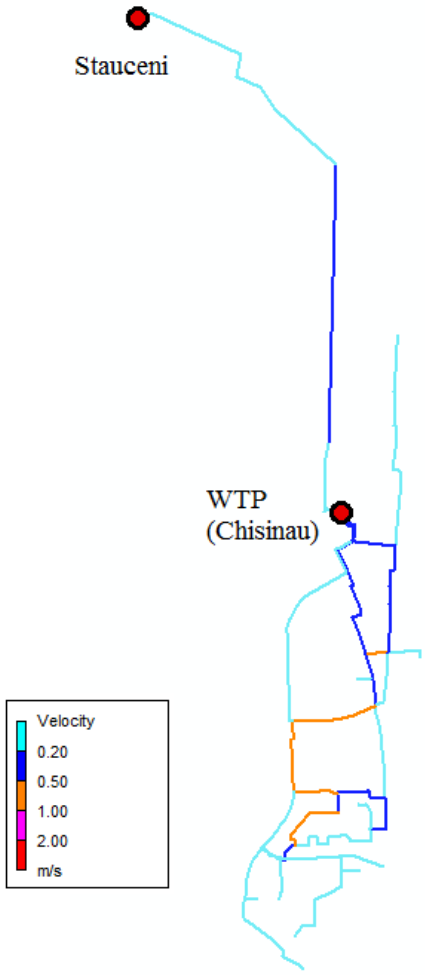


Figure 65: Zone 4A Telecentru

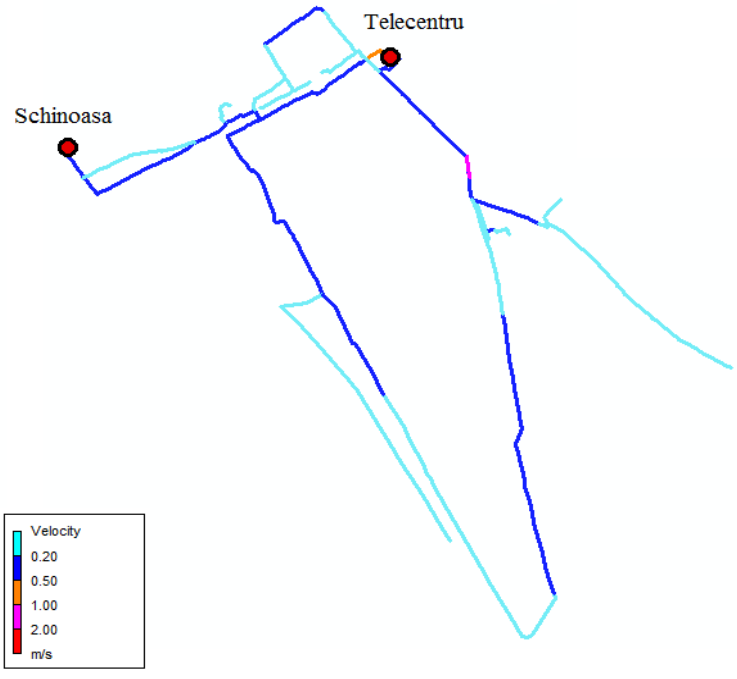


Figure 66: Zone 4A Schinoasa

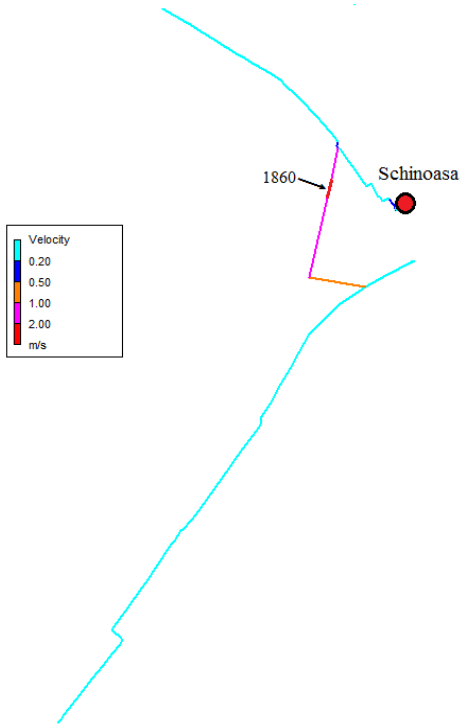


Figure 67: Zone between Codru PS and airport PS

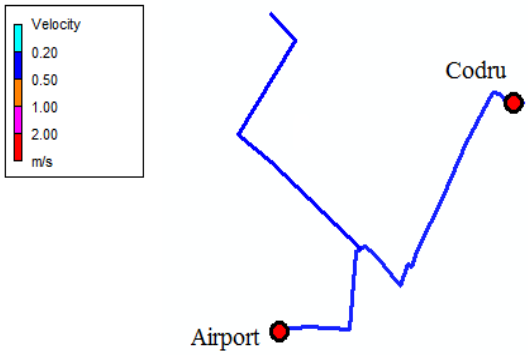


Figure 68: Zone between Codru PS and Sîngera PS

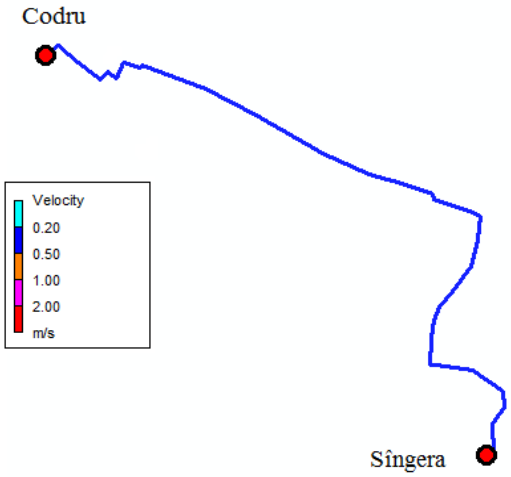


Figure 69: Dobrogeah

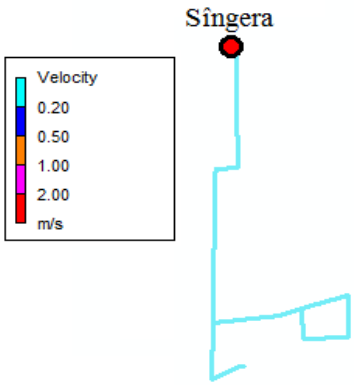


Figure 70: Sîngera

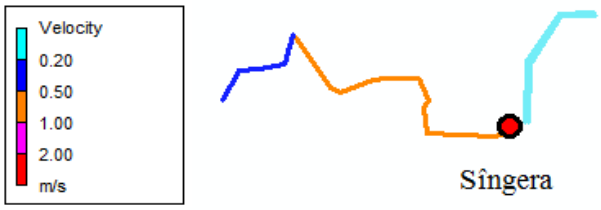


Figure 71: Codru MDK

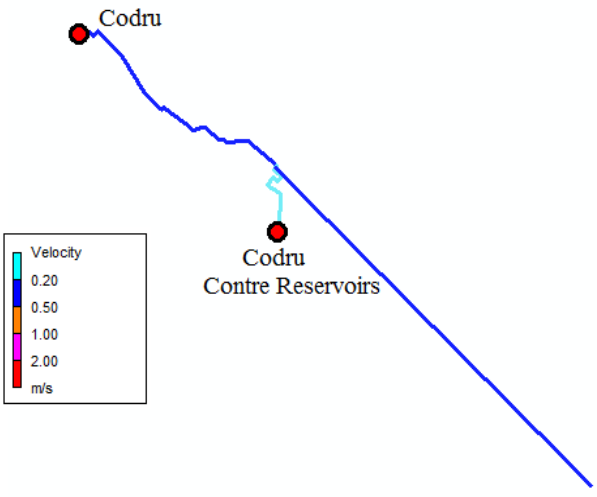


Figure 72: Ialoveni city

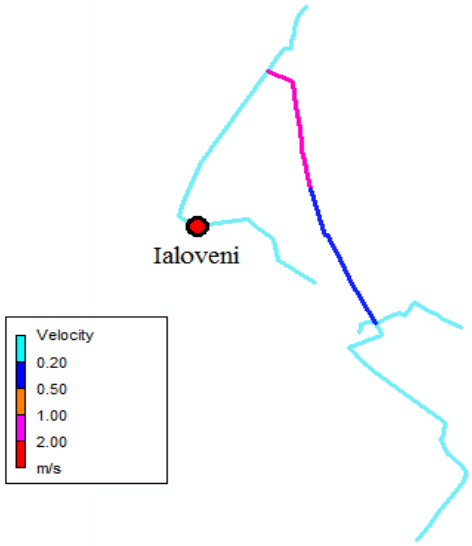


Figure 73: Durleşti

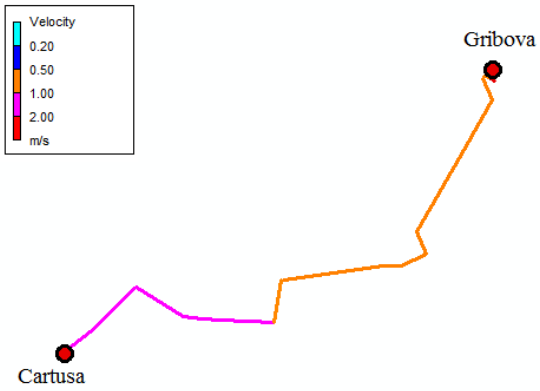


Figure 74: Stauceni and Goianul Nou

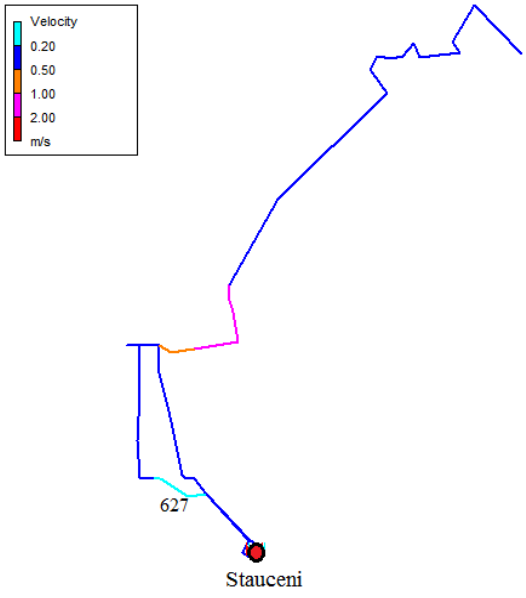


Figure 75: Zone between SAN and Tohatin PS

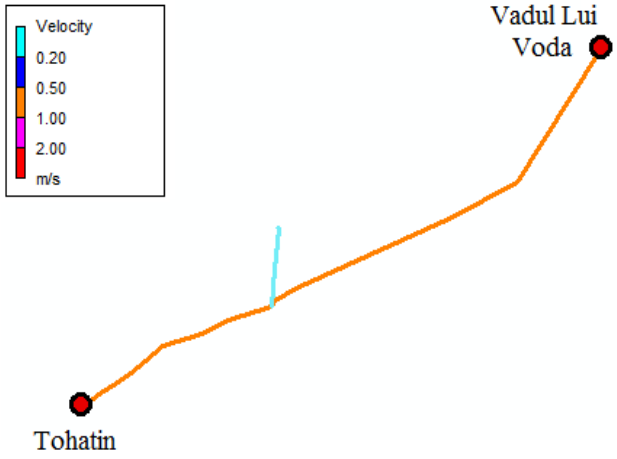


Figure 76: Coloniţa

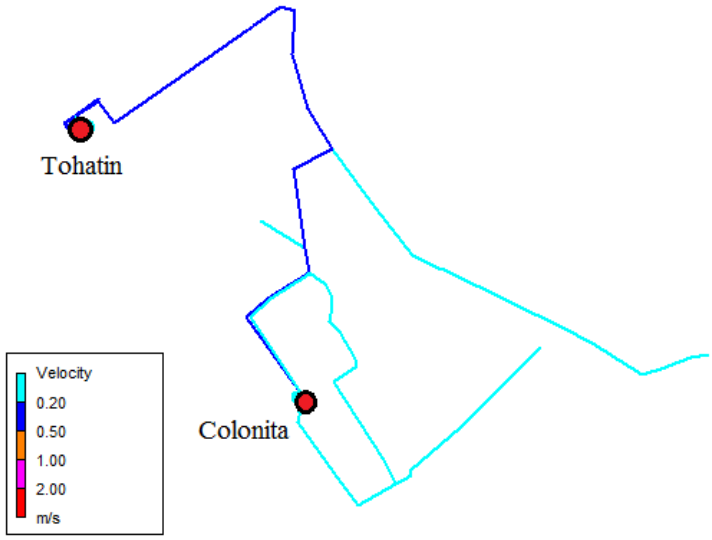


Figure 77: Tohatin

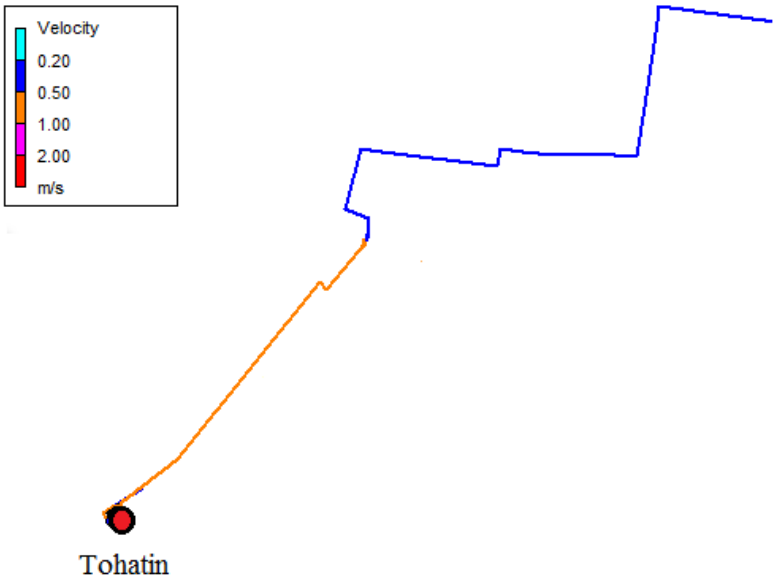
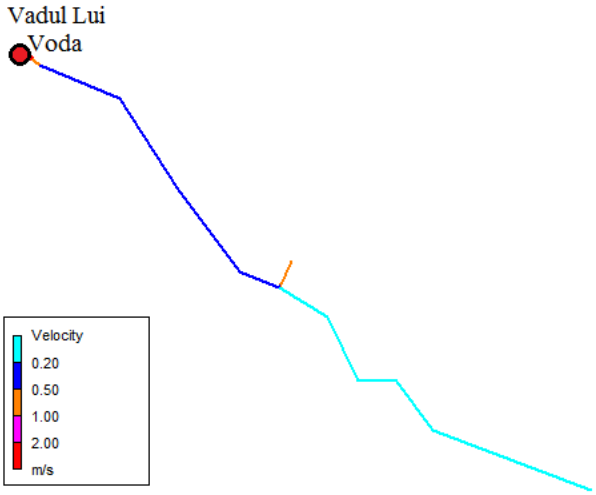


Figure 78: Vadul Lui Voda



Maximum Head Loss

Figure 79: Zone 3 Buiucani

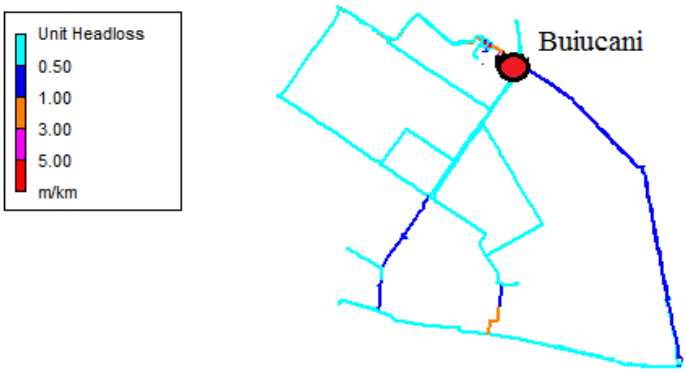


Figure 80: Zone 3 Valea Dicescu

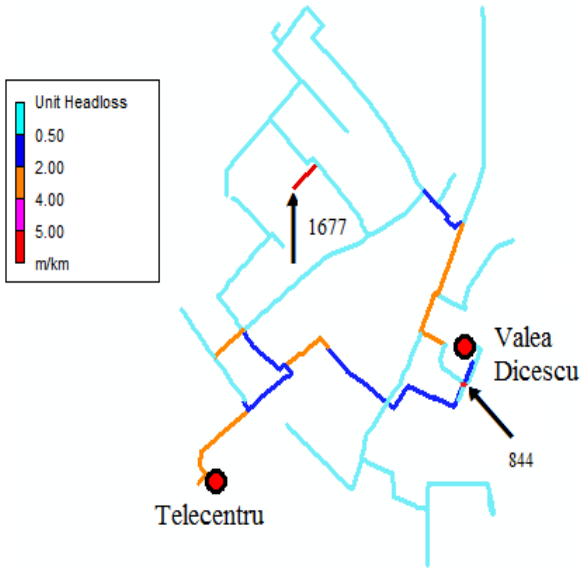


Figure 81: Zone 4 Telecentru

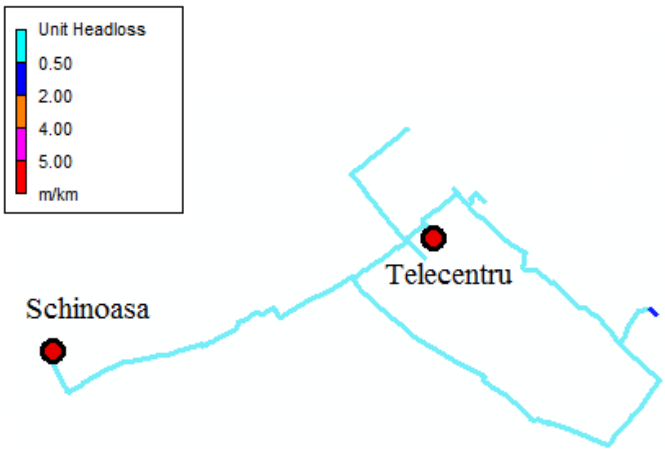


Figure 82: Zone 4 Independenţa

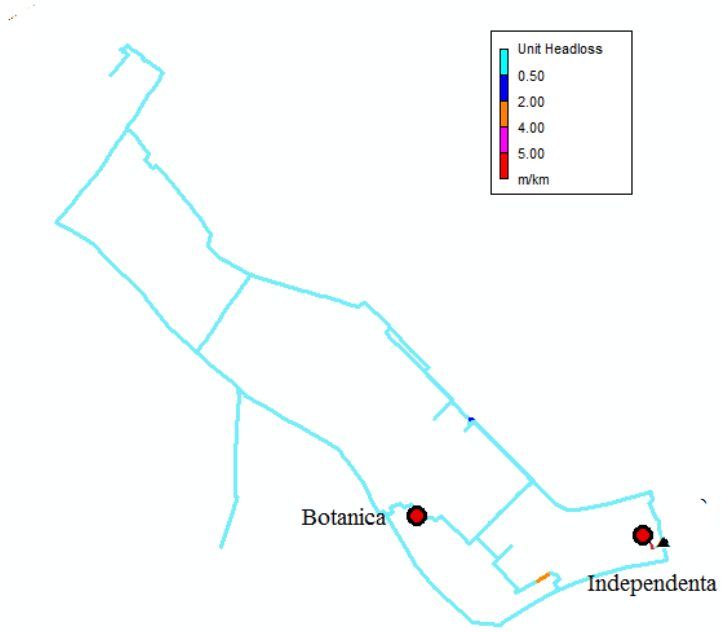


Figure 83: Zone 4 Ciocana

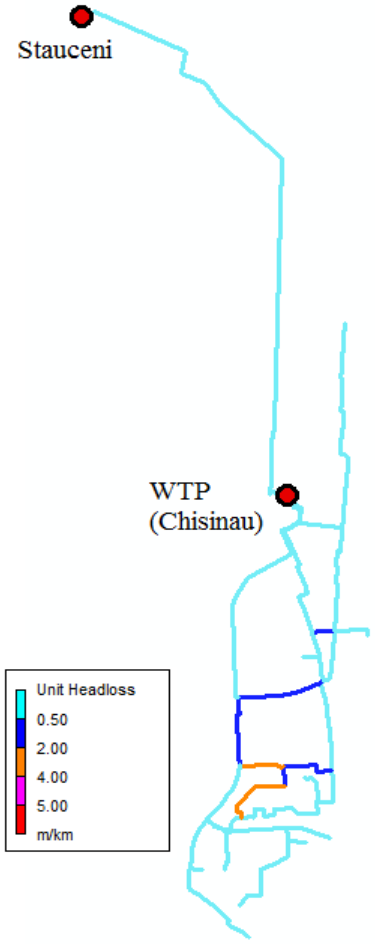


Figure 84: Zone between Codru PS and airport PS

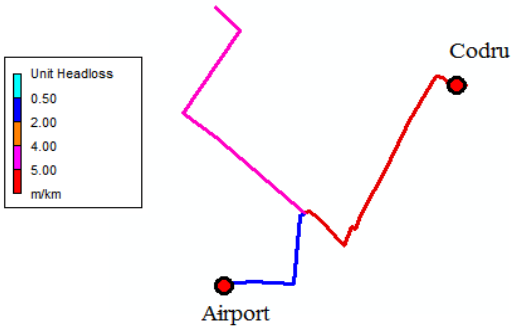


Figure 85: Zone between Codru PS and Sîngera PS

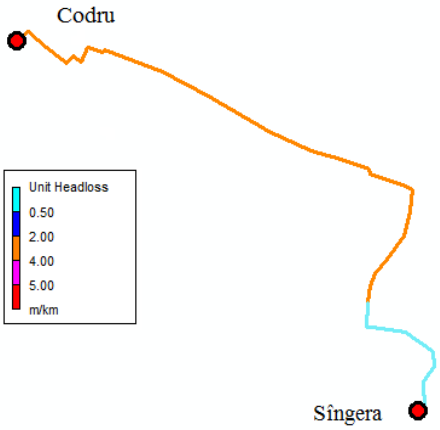


Figure 86: Dobrogeah

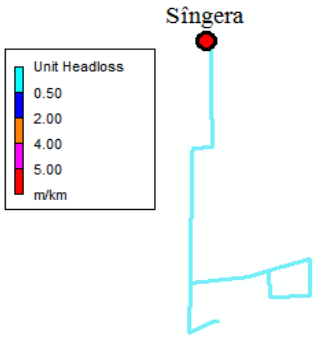


Figure 87: Sîngera

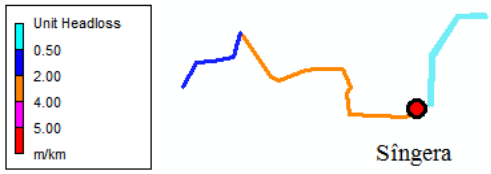


Figure 88: Codru MDK

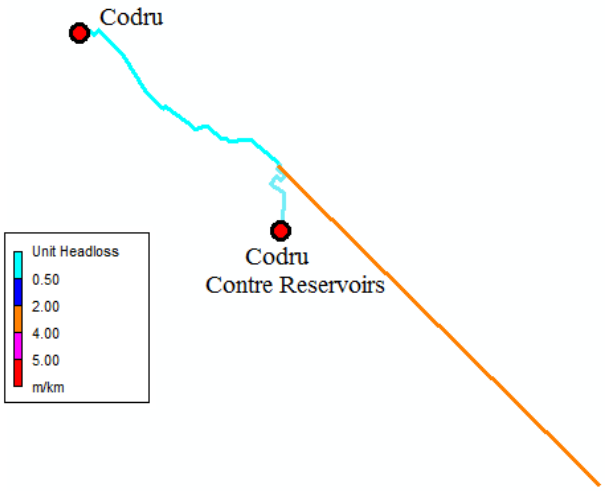


Figure 89: Durleşti

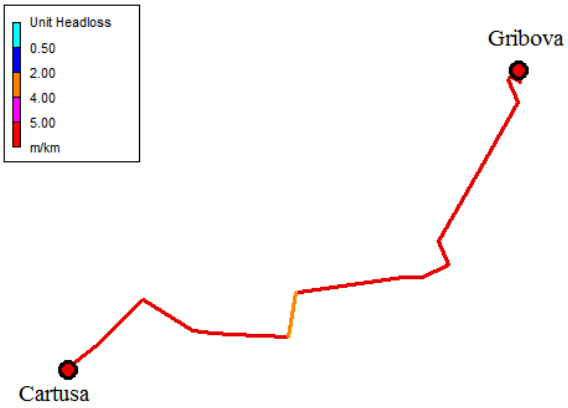


Figure 90: Stauceni and Goianul Nou

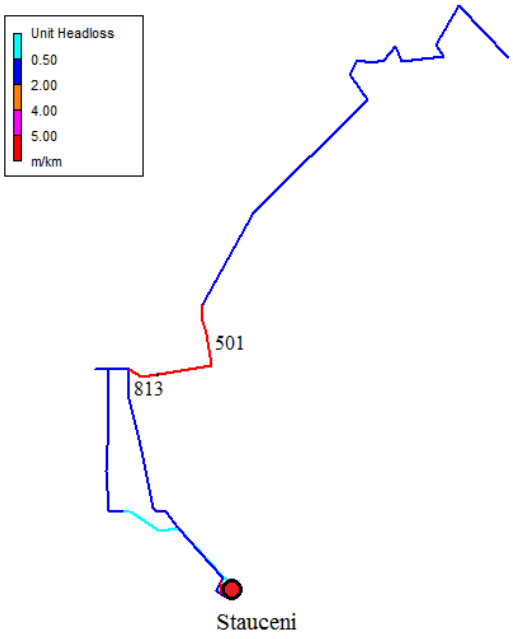


Figure 91: Zone between SAN and Tohatin PS

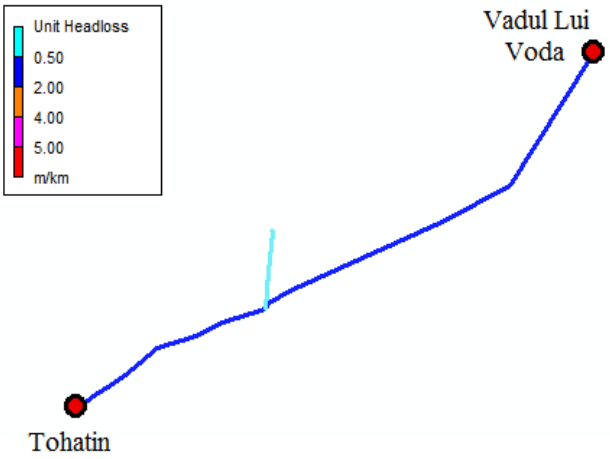


Figure 92: Coloniţa

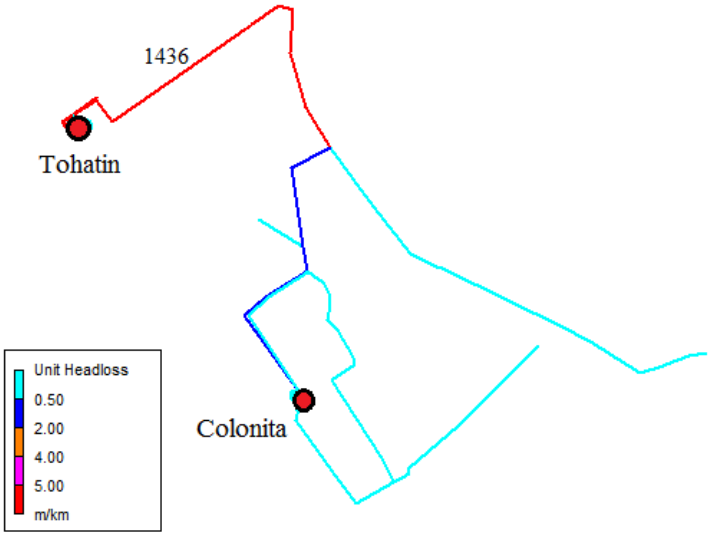


Figure 93: Tohatin

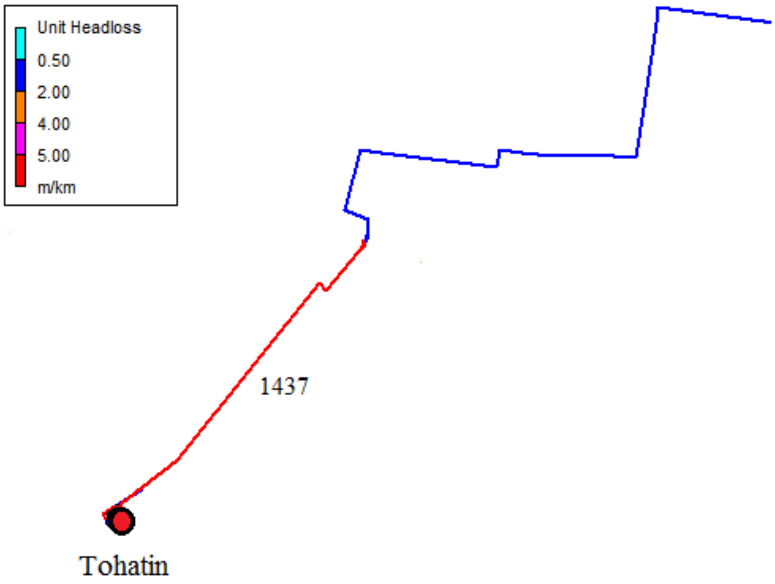


Figure 94: Vadul Lui Voda