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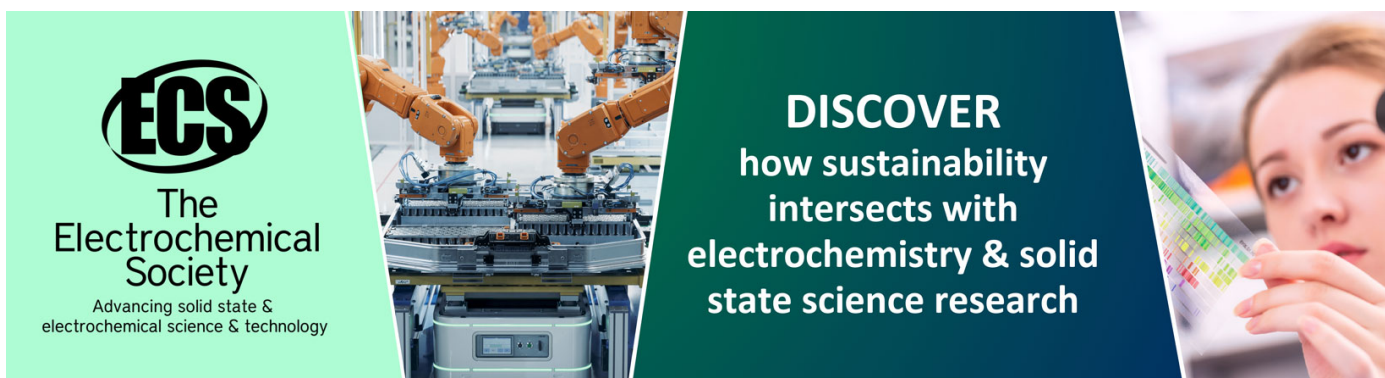
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Hydraulic Modelling of the Water Supply System of Năsăud City, Bistrița Năsăud County

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Abstract. The paper presents a study of hydraulic modelling of the drinking water and sewage distribution network in Năsăud City, Bistrița Năsăud County from Romania, which includes a calibrated simulation of the flow through networks (systems), and allows the elaboration of a future strategy of developing the networks of water and sewage. The need to develop hydraulic models as accurately as possible results from the fact that, by creating and calibrating the hydraulic model of a system, a variety of system problems can be identified, solutions can be mitigated to them by addressing the problem of rehabilitation, expansion or design of new systems, systematically with the exact observation of the influences that a certain operation has (modification) on the whole system. The calibrated hydraulic models allow this regardless of the complexity of the system (number of objects, nodes or pipes). The results can be tracked both at the scale of time, and in real time by simulating the functioning of the system at these time scales. We decided to approach the problems of sizing and verifying the network (system) using software solutions packages, in this case the MIKE URBAN calculation program, for pressure hydraulic systems and for free flow hydraulic systems. MIKE URBAN can import and export network data as ESRI ArcView shape files, allowing the network data to be directly imported and exported into and from ArcView. Thus, the network is completely resolved, the calculation of hydraulic sizing and verification of the network (system) being performed simultaneously on all sections of pipelines, and in all nodes of the network (system). The possible mismatches between the results obtained from the calculation, and the real values of the field, the rigour corrections can be made almost instantaneously in the nodes / sections, where this operation is required.

1. Introduction

The territory of Bistrița Năsăud County from Romania presents a varied and complex landscape, arranged in a form of a natural amphitheatre with steps opening to the Transylvanian Plain, outlining three landscape areas – mountain area, hill area, and meadow area (figure 1).



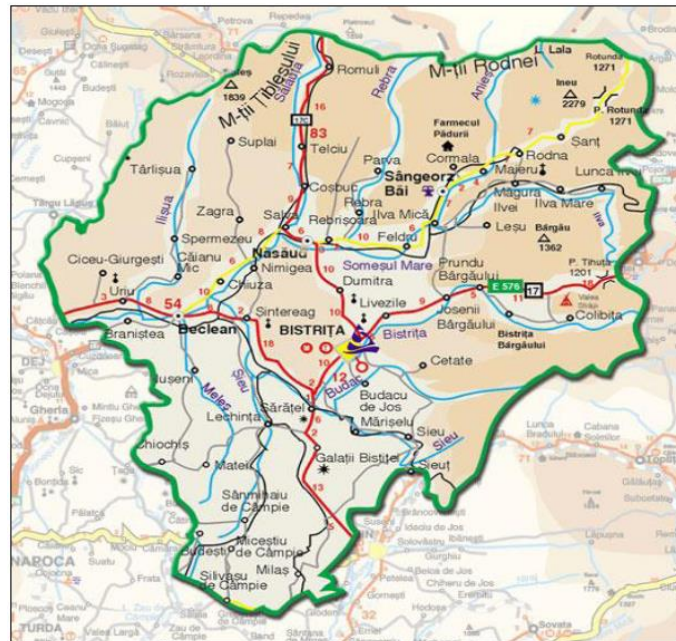


Figure 1. Bistrița Năsăud County, Romania

The design of drinking water supply and sewage systems has been greatly influenced by methods and calculation equipment available to engineers and designers. A network and/or system model is created to solve a network (system). Data from a basic set are required, and together to the software solution package they give the network model. The solution becomes very simple in terms of hydraulic parameters. There exists a close link between basic data, the software package, and the model.

Pipes and nodes are the basic elements of a model (network/system). The modelling process comprises four stages – data collection, network solution (the initial model), calibration and analysis. Data collection is necessary to perform the network, field measurements and data being necessary for a more accurate simulation of the system operation.

The network solution results when data are organized in a set that requires the choice of the solution package. This one is executed to calculate the values of the hydraulic parameters.

Calibration is the process of adjusting the required input data until the output data (results) reflect the field values. Analysis represents the process of identifying and planning operations in the work system, using or based on an already calibrated model.

The calibrated model can be used to determine the hydraulic parameters at all points and for all time intervals. These values can be determined for the points where their measuring devices cannot be implemented in the network / system.

The program used for networks dimensioning, and for creating a calibrated hydraulic model is an independent one. It is used separately for water supply systems, also for sewage networks. We also can use hydraulic modelling programs, that includes both components. In the second case, hydraulic calculus and running of calibrated models is done individually.

1.1. Current situation of the water supply system

1.1.1. Conceptual description. Technological flow. The water supply system of Năsăud has a capture and treatment capacity used at only 22% of current consumption, which has allowed and would allow in the future the expansion of the water services to other neighbours of Năsăud and nearby rural areas. The city has a storage capacity of 1600 mc, composed of 2 x 300 + 1000 mc tanks, made in stages of

1975, and 1983 years. At this moment, the 2 x 300 mc tanks are in conservation and only the capacity of 1000 mc is used for an area that includes five streets, located at a high level of the city (figure 2).



Figure 2. Drinking water storage tank

At the current consumption of 18 l/s this volume is enough to solve the operation of the system for 12 hours, according to the norms, but totally insufficient at the total capacity of 165 l/s, at which it could work in the future. The distribution network is relatively underdeveloped compared to the new urban configuration of Năsăud City and currently operates by direct pumping from the treatment plant, except for the area fed from the 1000 mc tank.

1.1.2 Establishing the functional parameters after running the model. The designing process of the basic model involves going through two stages – establishing the component objects of the considered system, and obtaining and/or interpreting data from data packets. For the design and construction of the basic hydraulic model it was necessary to process the data packages obtained from the existing technical documentation (GIS database), but also data from field measurements and the monitoring of the considered system. The statistical and numerical processing of these data was performed taking into account the already existing numerical data and their interpretation, but also by their numerical conversion for all sets and types of field data. Different types of media, computing consoles and editing programs were used to process the data sets, also CAD type programs for processing data obtained from topographical surveys, and 3D processing of the topographical surveys data (of system objects).

1.2 The GIS database

In order to use the GIS data package, it was necessary to systematize, prepare and convert them in order to be able to bring in the form and content of input data for the hydraulic modelling program. Within this activity there were systematized and broken down by categories of objects, parameters and value indices, all data suitable to be used in the hydraulic modelling activity.

Data extracted from GIS database has been converted to numeric tabular data for water supply system objects.

In order to achieve the hydraulic models for the considered system, it was completed the GIS database with additional measurements made in the field.

These measurements targeted those groups of objects related to water supply and sewerage systems located outside the built-up areas or at long distances.

The data obtained from field measurements were converted into tabular numerical data for the objects of the water supply system, as follows – data for the capture source and its characteristics / parameters, data for the characteristic points of the adduction pipes, data regarding the parameters of the supply pipes, regarding the physical – geometrical parameters of the tanks, the physical – geometrical parameters of the pumps, and the inflection points of the distribution network (table 1).

Table 1. Characteristic points of the adduction pipes

Node	X-Coord	Y-Coord
wNode_CR_Lusca	456295,095	642471,415
wNode_CR_Salva	453320,801	644290,020
wR_1000mc_Nasaud	455455,237	643457,630
wR_STAP_500mc_Rebra	460808,949	643678,582
wR_STAP_90mc_Rebra	460769,218	643662,151
wNode_CR_Rebrisoara	460028,451	643342,060
wR_544mc_Rebrisoara	458535,714	645316,900
wSursa_Rebra	461374,982	644647,898
wR_900mc_Feldru	469188,398	642702,263
wR_450mc_Nepos	464774,268	642796,242
wNode_CA_1	461.229.974	644.399.196
wNode_CA_2	461.199.731	: 644399.551

The imported data establish the operating system and network conditions for a given time interval.

The data set must be able to provide information at least on the system pipes, network characteristics, and water demand. They describe physical characteristics of the simulated system. Pipe length, diameters, roughness coefficients are as necessary as node dimensions and consumption data. The characteristic data system describes pressure and pumps flow, tank elevation, and settings for downstream pressure regulating valves.

2. Calibration of the hydraulic model

In order to obtain a calibrated hydraulic model, and also realistic results from a hydraulic – functional point of view following the simulation of the system operation, there were taken into account several important aspects – establishing the consumer categories and the specific consumption for each type, and preparation of the calculation briefs according to specific consumption by categories of consumers and specific to the area / locality (for water demand and requirement, hourly variation of consumption, necessary for the storage system, hourly variation of volumes/levels in tanks, the emptying / filling times of tanks and number of cycles in the considered interval, and sizing flows of the adductions and the distribution network), determining the water balance, monitoring of consumptions / flows taken from the source, establishing the bi-univocal relationship between the source flows and the requirement resulting from the calculation briefs, determining consumptions and their distribution on nodes, monitoring of hydraulic parameters and of their hourly variation in the representative consumption nodes, determining and closing the pressure rings, etc.

2.1. Hydraulic- functional diagnosis

Following the running of the calibrated hydraulic model and the simulation of the system operation, a series of functional parameters were obtained.

At the same time, it was possible to ascertain the state and behaviour of the system from a hydraulic – functional point of view.

The running of the calculation model was made in two hypotheses of operation of the water supply system – static regime, and dynamic regime.

The first one, the hypotheses of steady flow operation involves running the model and simulating the operation of the network neglecting the consumption of nodes. In this case, speeds and speeds transited on the network will be negligible.

Regarding the operation of the supply system of the Năsăud City in static regime, the following aspects can be specified – the distribution network is hydraulically balanced, the balancing being achieved from the first set of calculations, and the simulation was performed with all control and control valves in an open position.

The dynamic flow hypothesis involves running the model and simulating the network operation taking into account the nodes consumption and its hourly variation.

In this case, the speeds and flows transited on the pipes and implicitly the hydraulic pressure losses will influence the pressure regimes in the nodes (figure 3).

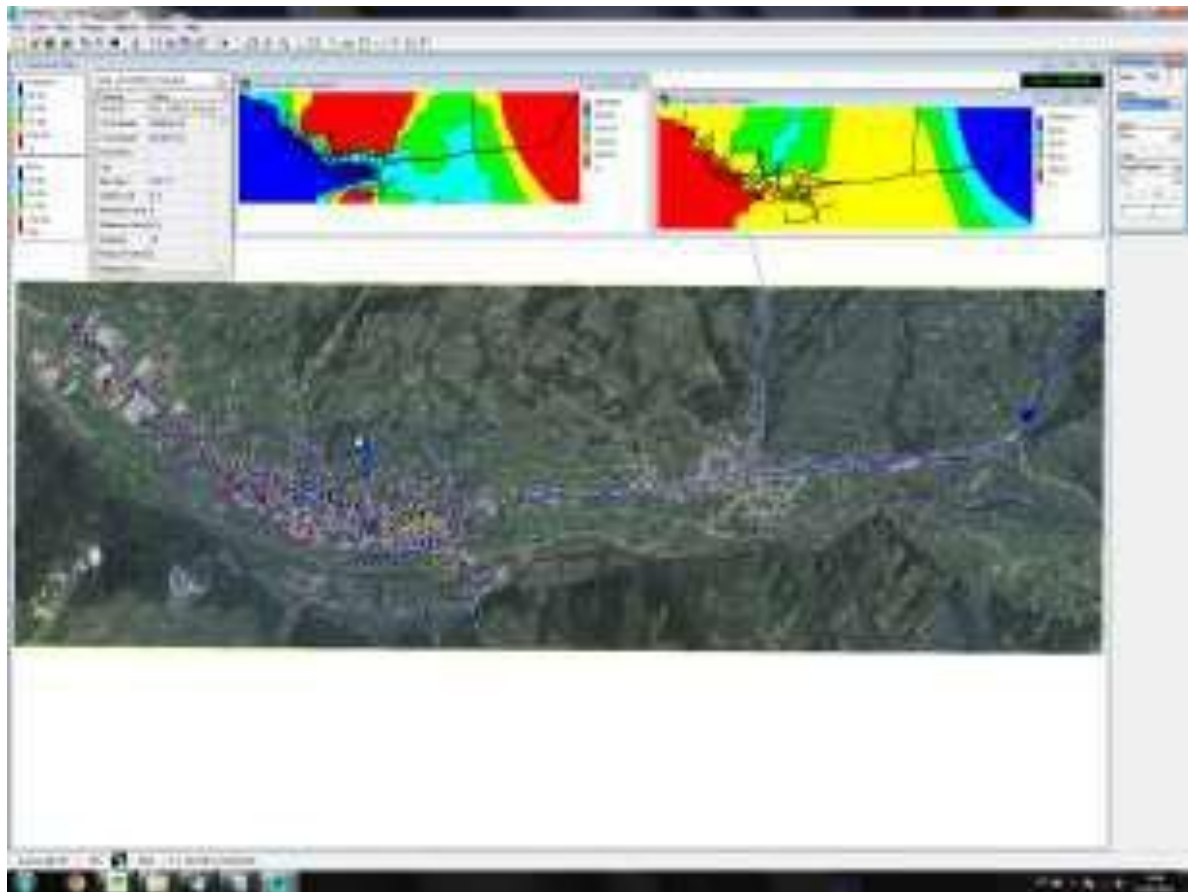


Figure 3. The Năsăud supply system – plan representation on the hydraulic model

It is mandatory to zoning the distribution network on equal pressure areas and to ensure a relatively constant regime with minimal variations in terms of available pressures, for each considered area (figure 4).

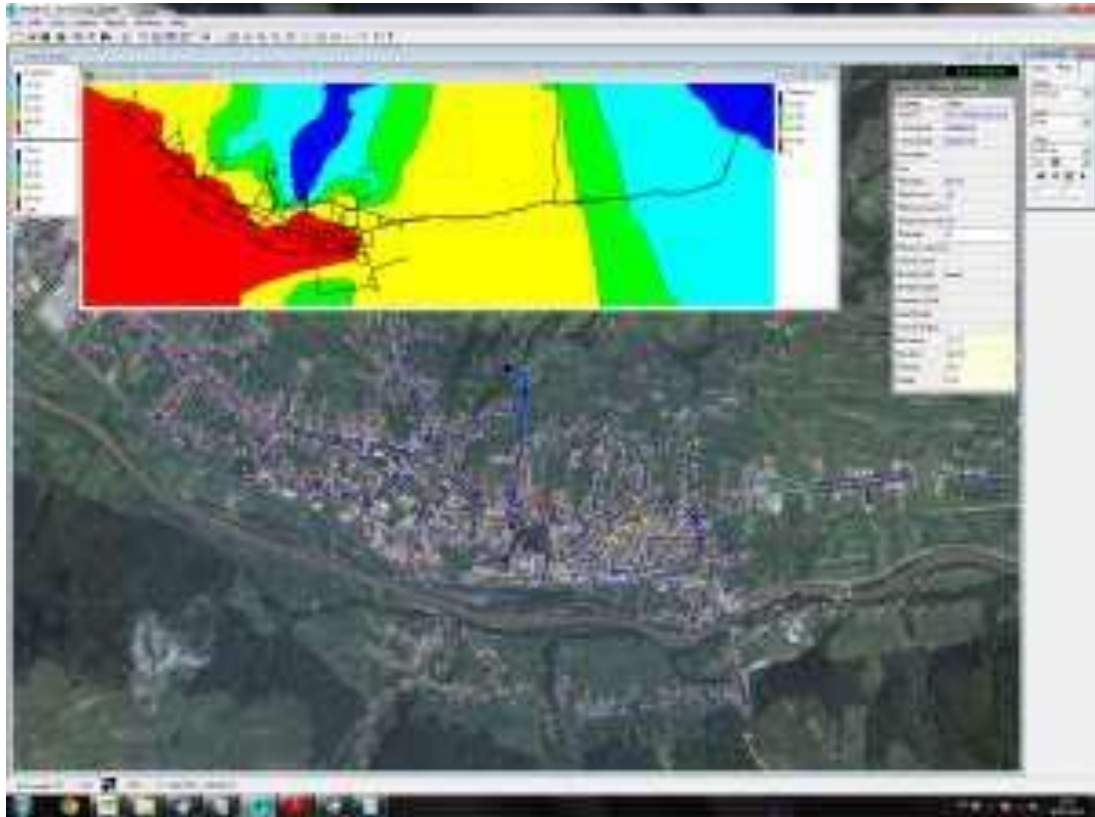


Figure 4. View of full system Năsăud plan on the hydraulic model

3. Conclusions and recommendations

The existing catchment at the Rebra River operates at an average capacity of 20 – 25% of its working capacity. It is recommended to supplement the storage capacity with an additional volume of approx. 800 – 1000 mc.

The pressure regime in the nodes falls within the vast majority of nodes within acceptable limits.

The network is predominantly annular, which leads to a relatively good balance from the hydraulic points of view.

It is necessary to avoid the branching of the network for extensions without taking measures to close / make equal pressure rings.

Also, it is recommended the automation of the operation for component objects, such as pumping stations, tanks, drinking water treatment plant, disinfection stations, etc.

Having available the calibrated hydraulic model for the considered hypotheses, there exists the problem of their use in the next period, but in perspective for the subsequent modifications in the network (system). The operator, the design engineer or the responsible person for monitoring and updating the model becomes a dispatcher of the system and a decision – maker in taken intervention measures on it.

There is necessary the periodic calibration of the model according to the changes occurred and the possible field monitoring of the pressures in the nodes and the flow regimes on the pipes. It is also recommended to diversify the calculation hypotheses, and operation of the considered supply system, depending on the current needs.

There exists, practically, no limitation of working steps/ hypotheses in this regard.

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