Proposal of an autonomous system with sensors for the calibration and distribution of water in the Bela Vista Community - Amazonas - Brazil

Ismael Tomé Souza da Conceição
ismaelsouzatc@gmail.com
Centro Universitário FAMETRO – Amazonas – Brasil

Fabiana Rocha Pinto
fabiana.floresta@gmail.com
Coordenação de Engenharia Centro Universitário FAMETRO - Manaus - Brasil

David Barbosa de Alencar (Corresponding author)
david002870@hotmail.com
Instituto de Tecnologia e Educação Galileo da Amazonia – ITEGAM - Brasil

Igor Felipe Oliveira Bezerra
igorfelipe.dss@hotmail.com
Universidade Nillton Lins - UNINILTON LINS – Manaus - Brasil

Abstract

Water consumption has increased exponentially in recent years on the planet, due to the large demographic growth that has made urban areas very dense, and with tasks that increasingly require water use, making the problem of water scarcity a reason. of growing concern. The present work aimed to analyze the water supply system of the community Bela Vista Manaus-AM. Field observation, documentary research and data evaluation allowed the identification of the main factors that make the current system present in the community inefficient. The supply system suffers from constant leaks due to high pressure in some sections, while in others, low pressure occurs, causing some consumers to stop receiving water frequently in their homes, as well as failures in supply selectivity, which is made manually. The result of the survey carried out in the community showed a high rate of disapproval of the services provided by the company that operates the local supply system, where 88% were dissatisfied with the service provided, while in the overall evaluation of the service, 62% considered it to be unsatisfactory. poor quality, 38% said it was good and no one rated the service as excellent. With all this information, it is advocated the conscious use of water and the importance of sectorization as a way to obtain better control over the supply system. In this way a system automation proposal is outlined with the replacement of some equipment with others with more specific operation accuracy and inclusion of others, as well as basically simple changes to make the current system efficient, safe, more productive and with lower operating cost.

Keywords: Water distribution system; Sectorization; Automation;

1. Introduction

Water, an essential element for sustaining life on planet Earth, is used in various segments and for various purposes, such as power generation, irrigation in agriculture, in the manufacture of products and food, and for consumption, in survival conditions [1].

Water consumption on the planet has increased exponentially in recent years, due to the large demographic growth that has made urban settlements very dense, and with tasks increasingly demanding the use of water, and consequently, the growth of industries and agriculture. , these last two factors together account for 92% of all water consumed in the world [2].

Lack of planning for the deployment and expansion of water distribution networks causes leaks, further aggravating the problem of scarcity [3]. And the great distances from the consuming centers of the springs is one of the deficiencies found in the urban water supply in Brazil [4]. Given the awareness that this is an exhaustible resource arises the need for more efficient management of this asset.

Distribution systems are composed of reservoirs and distribution networks, and the water mains are responsible for the water path from the extraction sources to the distribution networks, which in turn takes the water to the reservoirs (water tanks) or directly to the end consumer, being the system stage where the majority of leakage and theft losses occur [5].

Through technology, the most efficient use of this good is sought, since a large percentage of the water produced for urban consumption is lost in the supply systems from its collection to distribution to the final consumer. In developed countries these losses are around 8%, while in developing nations it reaches 45% [6]. In Brazil, wastewater from treated water reaches 30% according to the National Sanitation Information System - SNIS [7].

For Sousa [8], sectorization would be a solution to these problems, which consists of separating the supply system by sectors, making it easier to control and distribute efficiently, using technology as an ally to control pressure, flow, points. among others, making it even easier to maintain and repair the network, since the shutdown would be done only in the zone that presents the problem.

In areas far from springs artesian wells, together with technology, come to intervene by means of sensors, water pumps, plumbing and other components in the problem of rural or urban water supply deficiency [9]. With knowledge of signals and systems, one can envisage the calibration and control of a water supply system.

Automation can be defined as a set of techniques designed to automate, that is, automating a given process without the use of human, muscular or mental energy, replacing them with computer-controlled electronics, and their benefits to processes. They are clearly visible: efficiency, safety, higher productivity, lower cost [10], examples of automated processes: washing machine, electronic door, elevator and multifunctional robots.

The main components used in automation are: sensors, which are devices sensitive to some form of energy, light, thermal, kinetic; or in relation to physical quantities, such as temperature, pressure, velocity, current, acceleration, position and others; the actuators, which are the components that produce movements; frequency inverters, responsible for varying the voltage and frequency supplied to the motor; the valves and logic controllers - PLC [11].

Valves are components that have the function of establishing, controlling and stopping the flow in a pipeline, and are important fittings that need to be sized correctly to avoid unnecessary expense as they are expensive but indispensable devices without which the piping would be useless [12]. According to [13], valve sizing is a very important point to be addressed, as it will determine how sensitive the valve will change the flow rate of the fluid. For this it is necessary to know the flow, which is how much fluid passes through a hole in a given time, considering the loss of a pressure bar, characteristic loss of the valves. For fluids in liquid state there is a simple equation:

$$CV = 1{,}16\ Q\ \sqrt{(\rho/\Delta P)} \quad \text{eq. 1}$$

Where: CV = coefficient of flow per gallon per minute (gpm); Q = mass flow in m^3 / h; ΔP = Upstream pressure - Downstream pressure (bar); ρ = density (kg / dm^3).

Programmable Logic Controllers - PLCs, this equipment is similar to a programmable computer to perform various control functions, reducing the uses of wires, complex circuits and relays, as well as ease of programming, installation, speed control, network compatibility, verification. of defects and test convenience and high reliability [14].

The main reasons for justifying the use of automation in the water supply system are: greater control via real-time monitoring, reduction in operating cost and control of physical losses in the system. Electrical commands issued through a command center, control supply, locate network failures in real time, and remotely troubleshoot with repair time optimization. An efficient water supply system, while preserving a finite asset by eliminating leaking waste, prevents accidents that can cause everything from material loss to death in the most extreme cases.

Thus, this study aims to demonstrate the importance of automation in water distribution more efficiently, with the purpose of qualitatively analyzing the supply system of a community of Manaus, exposing its failures and causes, looking for technology provides solutions to the problems observed.

2. Material and Method

2.1. Study area

The Bela Vista community is located in the Puraquequara neighborhood, located in the east of Manaus / AM, on the shores of Puraquequara Lake. The community lives basically from family farming, through the planting and harvesting of food needed to support the family, and the use of fishing in Puraquequara Lake to supplement the food.

With 20 years of existence has 28 roads, between streets and avenues, which began to receive earthmoving, drainage and asphalting in November 2017, gradually starting at Rua Beira Rio, one of the main access roads to the community, followed by other main ones, Princess Dayana, Dom Jackson, Maria Raquel and Tim Maia, until they reach all the routes that were finalized at the end of the following year.

The Bela Vista Community has a school and municipal day care centers, as well as a soccer field, has about 300 families with approximately 1480 people, but does not have an efficient water distribution system and is not interconnected with the city's water supply system.

2.2. Kind of study

The approach used in the research was the qualitative method, which according to [15], this method explains the reason for things, specifying what needs to be done to solve a problem without worrying about the proof, because it uses various means of approaches. Regarding the research objective it was based on exploratory and descriptive. Exploratory research seeks to make the subject explicit or construct hypotheses, involving bibliographic survey, while in the descriptive researcher needs to gather various information about what he wants to research, seeking to describe facts and phenomena of a reality [16].

Documentary analysis was also observed, which requires a little more care, since it is the identification, verification and appreciation of documents that maintain a close relationship with the object investigated and that had no analytical or systematized treatment [16].

2.3. Data collect

Data were collected for this work through community visits that took place about twice a month since the beginning of the research. Residents, distribution system workers and community president were observed in order to seek satisfaction information and difficulties in the operation of the system, using the exploratory research method.

A survey of the vulnerabilities of the water distribution system was performed using the descriptive research method and the qualitative approach specified the problem of the inefficient Bela Vista Community system, to be solved.

In addition to a documentary analysis of the documents existing at the headquarters of the community secretariat with data on the implementation, and operation of the current water supply system, as well as a satisfaction survey of the services provided by the cooperative managing services performed by the Social and Educational Center of the Aleixo Lake - CSELA.

2.4. Collection Instruments

Through a pre-designed questionnaire, an analysis of the residents' satisfaction with the current water supply system was carried out, taking care to obtain a significant sampling of residents by street, with the purpose of making the result as close as possible. possible from the reality of the majority.

Also the employees, who sought to observe the difficulties encountered in their day to day, in carrying out their work activities and the most frequent defects that occur in the system.

The cooperative that manages the extraction and distribution of water in the community provided some documents regarding the implementation and distribution of the system, a list of devices and project components, as well as the results of a satisfaction survey conducted by CSELA, requested by the operators themselves cooperative.

2.4.1 Community Water Supply System

In the evaluation of the community supply system, two steps were adopted:

a) Step 1 - Satisfaction with community residents and employees of the company that manages the supply system was analyzed.

b) Step 2 - the survey of the equipment currently used in the system and existing documentation was

performed.

2.4.1.1 Step 1: Satisfaction Survey

A survey was conducted with the community residents with the intention of knowing the level of water quality assessment they are receiving, if the supply time is being sufficient and if the flow meets their needs, where Figure 1 shows the spreadsheet model. of evaluation observed in the research.

Satisfaction Survey of Water Distribution System in Bela Vista Community							
Date	Street	House Number	Sufficient water receipt time, yes or not?	Received water pressure, strong, weak or regular?	Does the street face or has it ever had problems with leaks, yes or not?	Satisfied with the supply service, yes or not?	Evaluation of the service provided: great, good or bad.

Figure 1. Evaluation model observed in the satisfaction survey.
Source: Author.

With the cooperative employees, it was raised about the difficulties in operating the system and the most frequent problems encountered to serve the community efficiently, as well as information about the difficulties in operation.

2.4.1.2 Step 2: Equipment Survey and Documentation

The cooperative was asked to list the equipment that makes up the current water extraction and distribution system, brands, models and specifications, with the aim of studying the system's extraction capacity, pressure and flow.

Of the mentioned equipment, it is worth mentioning the water pumps used in the system, which are Schneider brand IP55 Multi-stage 380 / 660V, model ME-34500 C167 and 50 HP power, and the wafer hand butterfly valves.

The cooperative also granted some documents regarding the implementation and operation of the system, such as a community map showing the points where the main and secondary pipelines pass, the location of the points where the control and flow valves are located, as well as the headquarters of groundwater extraction.

The results of the satisfaction survey carried out by the Lago do Aleixo Social and Educational Center, requested by the cooperative with the consumers of the service provided in order to know about the quality, quantity, time of reception and pressure of the water received by the water supply system. distribution.

3. Results and Discussion

We sought to detail the result of the satisfaction survey conducted with residents separated by streets in the Community, where the amount and sample of the survey was obtained considering the length of the street and locality, ie, in the longest roads there was a larger number of people. observed taking care to cover the

entire length of the space, respecting the sampling location (table 1).

During the survey, 225 residences distributed in 27 streets of the Community were visited, as shown in table 1, Princesa Dayana Street was where there was the largest number of respondents, explained by being the main and longest way and the smallest number in Pará Street. for the opposite reason.

Table 1 - Satisfaction survey of the water distribution service in the Bela Vista Manaus Community - AM.

Streets→		Airton Sena	Anselmo Duarte	Daniela Peres|Padre Calério	Denner	Dom Jackson	Dr. Alcion	Dr. Celso	Florentina Pereira	Frei Damião	Frei Tomaz	Hilário Calheiro	Irmã Dulce	Irmã Helena	Jacamin	João Paulo	José Lindoso	Júlio Damião	Luiz Gonzaga	Madre Tereza de Calcutá	Mané Garrincha	Maria Aparecida	Maria Raquel	Padre Ludovico	Pará	Princesa Dayana	Rio Unai	Tim Maia	Total	Average	%
Satisfaction questionnaire	-	10	10	7	7	9	5	10	10	8	8	5	6	8	9	10	10	9	6	10	10	7	10	5	4	15	8	9	225	-	-
Sufficient water receipt time?	yes	5	9	4	0	5	0	1	8	4	3	2	2	1	2	6	2	5	1	2	9	1	2	0	0	12	2	3	91	3,4	40%
	Not	5	1	3	7	4	5	9	2	4	5	3	4	7	7	4	8	4	5	8	1	6	8	5	4	3	6	6	134	5	60%
Received water pressure?	strong	3	5	0	0	1	0	2	4	1	0	0	0	0	1	2	2	3	0	0	4	0	2	0	0	10	0	1	41	1,5	18%
	weak	4	3	5	7	6	5	6	4	6	6	4	4	5	7	3	6	1	5	3	3	6	6	4	4	3	7	7	130	4,8	58%
	Regular	3	2	2	0	2	0	2	2	1	2	1	2	3	1	5	2	5	1	7	3	1	2	1	0	2	1	1	54	2	24%
Does the street face or has it ever had problems with leaks?	yes	9	10	6	7	9	5	8	10	8	8	5	4	8	9	10	8	9	6	10	10	7	9	5	4	2	8	9	203	7,5	90%
	Not	1	0	1	0	0	0	2	0	0	0	0	2	0	0	0	2	0	0	0	0	0	1	0	0	13	0	0	22	0,8	10%
Satisfied with the supply service?	yes	2	1	0	1	2	0	0	1	0	0	0	0	0	0	1	0	0	0	3	4	0	2	0	0	6	1	3	27	1	12%
	Not	8	9	7	6	7	5	10	9	8	8	5	6	8	9	9	10	9	6	7	6	7	8	5	4	9	7	6	198	7,3	88%
Evaluation of the service provided:	great	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0%
	good	4	5	5	2	6	0	4	6	1	3	1	2	2	2	5	3	4	0	2	5	6	4	1	0	10	1	2	86	3,2	38%
	bad	6	5	2	5	3	5	6	4	7	5	4	4	6	7	5	7	5	6	8	5	1	6	4	4	5	7	7	139	5,1	62%

Source: Author

Each road receives 4 h of daily supply, in which the time of water reception was observed. The result showed that 40% of the population indicated that it was sufficient, justifying that correctly stored water and used consciously, meets the daily need. While 60% were dissatisfied with the supply time, indicating the need for more time.

Under the pressure on which water is received, 18% think it is strong, 24% weak, while 58% of people observed indicate that it is below expectations. Analyzing the results separately by street and household position, positive responses are noted for people residing in the streets closest to the underground water catchment centers and houses at the beginning of the road. As the extraction centers move away, the pressure tends to decrease.

From Figure 2, referring to the last three observations, 90% of people say they have already seen some type of water leakage in the distribution pipes in their streets, where the other 10% indicate no occurrence. It is also noticed that these residents are present at the beginning of the observed streets and it can be concluded that the leaks mostly occur at the end of the pipes.

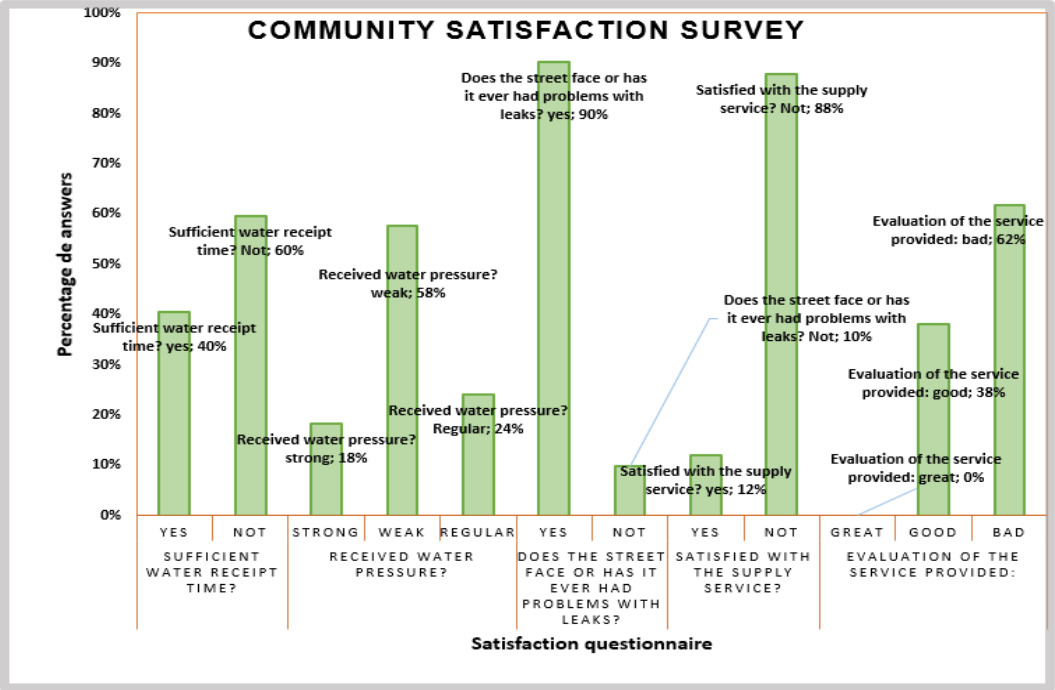

Figure 2. Result of the community satisfaction survey.
Source: Author

Of the 225 analyzed, 88% are not satisfied with the service provided in the community, and 12% say they are satisfied thinking that five (5) years ago (when the system started operating), did not have any supply system of water, each resident had to have his artesian well, either ask from a neighbor who had a little water well or travel a considerable distance carrying water from Lake Puraquequara. Overall, 62% said the service was poor, 38% said it was good and no one rated the service excellent.

The negative assessment in this case is justified because, according to [17], the operational performance and the quality of water received is essential in the evaluation of the provision of water supply services, in addition to the type of provider and size of the system.

In analyzing the results carried out by the Lago do Aleixo Social and Educational Center, requested by the cooperative with the service's consumers to expose in accountability with the municipality and justify the investment given, and comparing with the results obtained above it is possible to notice major controversies, with 73% of respondents say they receive water with strong pressure, 17% say they arrive with regular pressure and 10% weak, and overall service rating 63% of respondents rate excellent service, 30% regular and only 2 % bad.

Regarding the difficulties in the operation of the system and the most frequent problems faced to provide an efficient service to the community, the cooperative collaborators stated that the team is composed of four operators for eight water catchment and distribution bases by artesian wells. move between them to start and stop the water pumps at predefined times, and are located far from each other.

The water pumps used are brand and model that stands out among the best in the market, with pressures supplied ranging from 1 to 4 stages, allowing you to program the stage depending on the need for pressure. The difficulty of the operators in this regard is the need for manually direct pressure and flow control at the pump so that there is no shortage of supply to the last street dwellers due to low pressure and not causing

the pipes to rupture with the high.

Manual control becomes this “gambling” manual control, because if the operator releases a low pressure and all the people on the street open their taps, the latter will not be supplied, however if he releases a high pressure and few others. If they do, the pipes may not support and break.

In addition to the difficulty of distribution valves with manual valves, manual supply has to be released to a given street at predefined times.

The operator has to travel to the valves located at the beginning of the street connected to the central adductor, shown in a design drawing made in autocad in figure 3, where the red points are the locations of the flow release valves and the yellow points are. water extraction bases, which causes forgetfulness of supply release for some often.

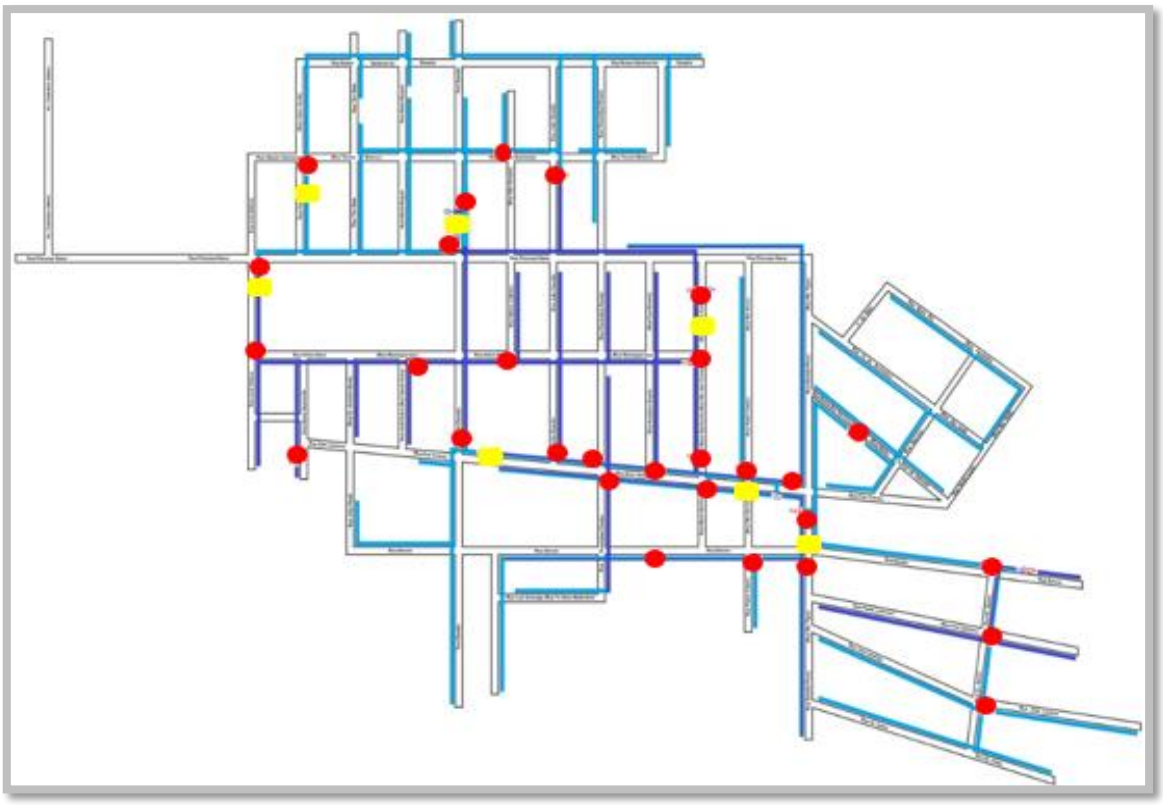

Figure 3 - Schematic drawing of flow release valves and extraction bases made by autocad.
Source: Cooperative that manages the supply system, modified by the author.

Therefore there is a need to create an autonomous system with sensors for calibration and water distribution in this community. The successful implementation and operation of this can be as a "showcase of observation" to accept the need to implement sectorization in the city's supply system. In this Community, being part of the City of Manaus, it can be concluded that this System will be as a sectorization of a larger system.

Thus, according to what was said by Sousa [8], a distribution system divided by smaller sectors with the aid of technology makes it easier to control pressure, flow flow and network leakage, making the system more efficient and reducing losses. well, that's the water.

By means of pressure sensors, monitor this physical quantity of water inside the pipelines by sending a

signal to a logic controller installed in the extraction bases, which will increase or decrease the pressure stage of the water pump as the system needs, avoiding that the pipeline will rupture in the event of too high a pressure, or if homes farther from the distribution center are no longer receiving water due to low flow pressure.

In addition to replacing the current manual valves, the electrically operated valves and commands sent by the logic controller (PLC), causing them to open or close the passage of water at predefined times for each community route, making the selectivity of the supply automatically.

Thus, we want to show that an automated system, as the one defended by [4], basically simple distribution and control of water pressure is able to replace the current and inefficient system of the Bela Vista Community, Puraquequara, Manaus - AM.

According to [18], it is common to observe many campaigns aimed at consumers for the conscious use of water, but there are actions for efficient use that do not depend on user behavior, occurring due to failures of design, execution and operation in the supply system. . Therefore the use of technology can be applied to solve these failures, promoting economy in the use of this good, avoiding waste and promoting sustainability.

An efficient water supply system has as its essential parameter the loss rate of this well, since leaks are directly related to pressure and flow losses, influencing the volume of water distributed to the population [17]. As a result of the implementation of automation in the water distribution system in the Bela Vista community, we seek to reduce the use of this feature.

In addition to generating savings, avoiding unnecessary costs with premature replacement of equipment, number of operators and inefficient use of electricity from equipment adjustment failures, equipment power oversizing, lack or failure of operational control [19].

Starting from the very concept of [10], with the action of automating the water supply system, the Bela Vista Community can obtain visible benefits using this process, such as: efficiency, safety, higher productivity and lower cost.

4. Conclusion

This work has shown the importance of separating water supply systems from large cities into smaller sectors, facilitating efficient control and distribution, using technology as an ally to control pressure and flow, and identifying and correcting water points. failures more easily.

The water supply system of the Bela Vista community was analyzed, indicating that it is an inefficient system, causing 88% of consumers dissatisfaction with the service provided, due to constant leaks in the distribution system, frequent lack of supply in some homes, forgetfulness in the selectivity, made manually by the valves installed between the main water mains connections and the secondary piping that leads water to the homes.

It was also observed that the water pumps used in its eight community-distributed water extraction bases are of a brand and model of excellent performance having four pressure stages, where it would be enough to install a logic controller - PLC in each one of them. pressure sensors inside the pipes and replace manual valves with electrically operated valves, as well as peripherals to automate the system.

The sensors will therefore measure the pressure inside the pipes, informing the logic controllers that the required pressure stage of the pump will be activated, the system will automatically selectivity at predetermined times, sending signals to the valves.

Thus, it is concluded that the automation of the Bela Vista Manaus-AM community water supply system will solve the current problems bringing efficiency, safety, higher productivity and lower operating costs.

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