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Implementation of City Information Modeling (CIM) concepts in the process of management of the sewage system in Piumhi, Brazil

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Abstract. The municipality of Piumhi, Brazil, lives with sewage system problems. Currently the model used by the SAAE (local Water and Sewage Public Provider) only provides corrective actions. The combination of the concepts BIM and GIS will allow the movement towards the City Information Modeling, seen in a promising way for public management. The purpose of this research is to develop a management model for the sewage network that focus on preventive actions, allowing a decision-making process based on accurate information. Meetings were held with the municipal autarchy, enabling a diagnosis of the current situation and the determination of strategies for dices collect. 1731 wells were surveyed, with the following data collected: depths, geographic coordinates, diameter, pipe's material and flow direction in each section. The wells in the sewage network were 1291 visible, 316 unseen and 64 non-precision coordinates. The wells in the sewage interceptors were 56 visible and 4 unseen wells. Due to the high percentage of unseen wells (18,5%) many alignments of the sewage network were no determined, what is recommended to be done as maintenance occurs in the existing infrastructure. A web management tool for QGis and tutorials will be, allowing SAAE to carry out the preventive management of the sewage network. The development of a reliable database will allow the identification of problems and the comparison of the conditions and characteristics of the existing networks, allowing the SAAE to define assertive actions to improve infrastructure performance and generate savings in financial resources, equipment and manpower.

Keywords: Building Information Modeling, City Information Modeling, Geographic Information System.

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1. Introduction

A study carried out by the Treats Brazil Institute (Instituto Trata Brasil in Portuguese) in 2014 concluded that the country contains delays in sanitation when compared to international models. Universal access to basic sanitation services is still distant and with this, problems with the country's sewage, besides causing pathologies, also affect the economy and bring negative impacts to the environment. Still according to this study, "the relative delay of Brazil in the area of sanitation has a distant historical origin". Fifty years ago, only 33% of the population had sewage collected, and less than 5% of the total collected received treatment before final disposition.

With the improvement of these services, a better quality of life can be achieved, as well as the reduction of government spending to address such problems that affect the socioeconomic sphere also in the municipality of Piumhi - MG.

According to IBGE - Brazilian information body (2018), the estimated population for Piumhi for 2018 is 34456 inhabitants, its Municipal Human Development Index is 0.737 and the GDP is USD 5251,35 (referenced in November 26th of 2018). In 2010 Piumhi used to have 92.7% of its sewage system in adequate conditions and 30% of public roads were urbanized.

The municipality coexists with several problems related to the sewage system. The clandestine connections of rainwater in the sewage network and the solid waste discarded in the system that can obstruct the network, causing effluent return to the residences, in addition to the fact that the Sewage Treatment Plant (ETE) operates at higher flows than that designed.

Once the source of the problems related are hard of being identified, they have a high potential of affect the good condition of managing the system. It is hard to localize the irregular connections as well as the source of solid waste into the sewage network.

What SAAE does is fixing the problems as they happen, but proactive actions are not possible to be taken. In the same logic, SAAE use to take preventive actions based on individual knowledge about the system, what causes many investments mistakes, decreasing the gains and returns for the population. This also doesn’t allow to keep data and information about the system.

The City Information Modeling (CIM) can contribute to improve the management process, stablishing methods to keep, control and understanding data related to several areas of public management. To understand the concept of CIM is important to understand the concepts of Building Information Modeling (BIM) and Geographic Information System (GIS).

According to Amorim (2015), “CIM is analog to BIM in urbanism. It is a system of urbans components represented by symbols in a 2D space and inside a 3D space. This is also designed from the expansion of GIS 3D improved with views in several levels and multiple scales, design toolbox and inventory of 3D components with their relationship”.

Amorim (2015) conclude that CIM implementation can be a way to improve the urban management efficiency, because its concepts “look for the general effectiveness of the entire infrastructure system”.

A key point to the success of CIM is the construction of a unique data base, to which one the stakeholders involved in the decision-making process have access to that, allowing them to take good decision and operate the system. For this exist two relevant independent actions: the CityGML standard (OGC, 2012) and the Industry Foundation Classes, the IFC, developed by buildingSMART.

This research is divided in four parts: literature review; diagnosis of the sewage system; development of a plug-in to QGis software; and the development of tutorials or manuals. This paper shows the result for the first and second parts as the research is still on going.

The present project is justified by the offer of a contribution to a management method that aims to act in a preventive way in the maintenance and operation of the sewage system and increase the quality of the decision making. These benefits will contribute to reduce the problems of network management and to make more precise decisions in both Piumhi and municipalities with the same characteristics.

2. Methodology

The literature review was developed using reliable sources to gather knowledge and familiarity with the proposed theme and the required areas of knowledge. In this stage the researchers also understood the concepts of CIM, BIM, GIS and what has been developed around the world to improve data management in public services.

The second part, which is about the diagnosis of the sewage network, includes obtaining data about the existing infrastructure followed by the survey of all the wells available and its data relative to upstream and downstream pipes (diameters, depths, geographic coordinates (X, Y, Z), material and flow direction). A GPS GNSS RTK L1/L2 was used to develop the survey of around 140 kilometres of existing network and 1731 wells. The data obtained allowed to calculate other parameters such as the inclination and length of the pipe for each stretch.

Google Satellite images were georeferenced using QGis software and around 214 maps were printed to be used during the survey.

The wells surveyed were divided in five categories: (1) Wells in sewage interceptor and (2) Wells in sewage network, which concerns to the wells surveyed with high precision coordinates; (3) Unseen wells in sewage interceptors and (4) Unseen wells in sewage network, which concerns to assumed wells that were covered by something like asphalt, concrete or others; (5) Non-precision wells in the sewage network, which concerns to visible wells with low precision coordinates due to the field limitations.

After completing the survey, the data were sent in spreadsheet and through search tools, the information collected was associated with the coordinates of each point so that it could facilitate the data entry in the Georeferenced Information System software.

Then the sewage network was designed in AutoCAD Civil 3D and QGis to verify the incompatibilities, which has been done together the SAAE employees.

3. Results and discussions

The total amount of wells surveyed in Piumhi was 1731. 77,8% of the wells registered were surveyed with high precision as shown in the table 1.

Table 1. Survey conditions of the wells.

	Number of Occurrences	**Percentage of Occurrences**
Wells in sewage interceptor	56	3,2
Wells in sewage network	1291	74,6
Unseen wells in sewage interceptors	4	0,2
Unseen wells in sewage network	316	18,3
Non-precision wells in the sewage network	64	3,7
TOTAL	1731	100,0

During the survey several difficulties were noted in registering some wells, either because they were covered by asphalt or sand hills, or even because they were under an area covered by trees, where the GPS loses quality in communication with satellites. At the end of the survey, the points were presented on the city map, as shown in the figure 1.

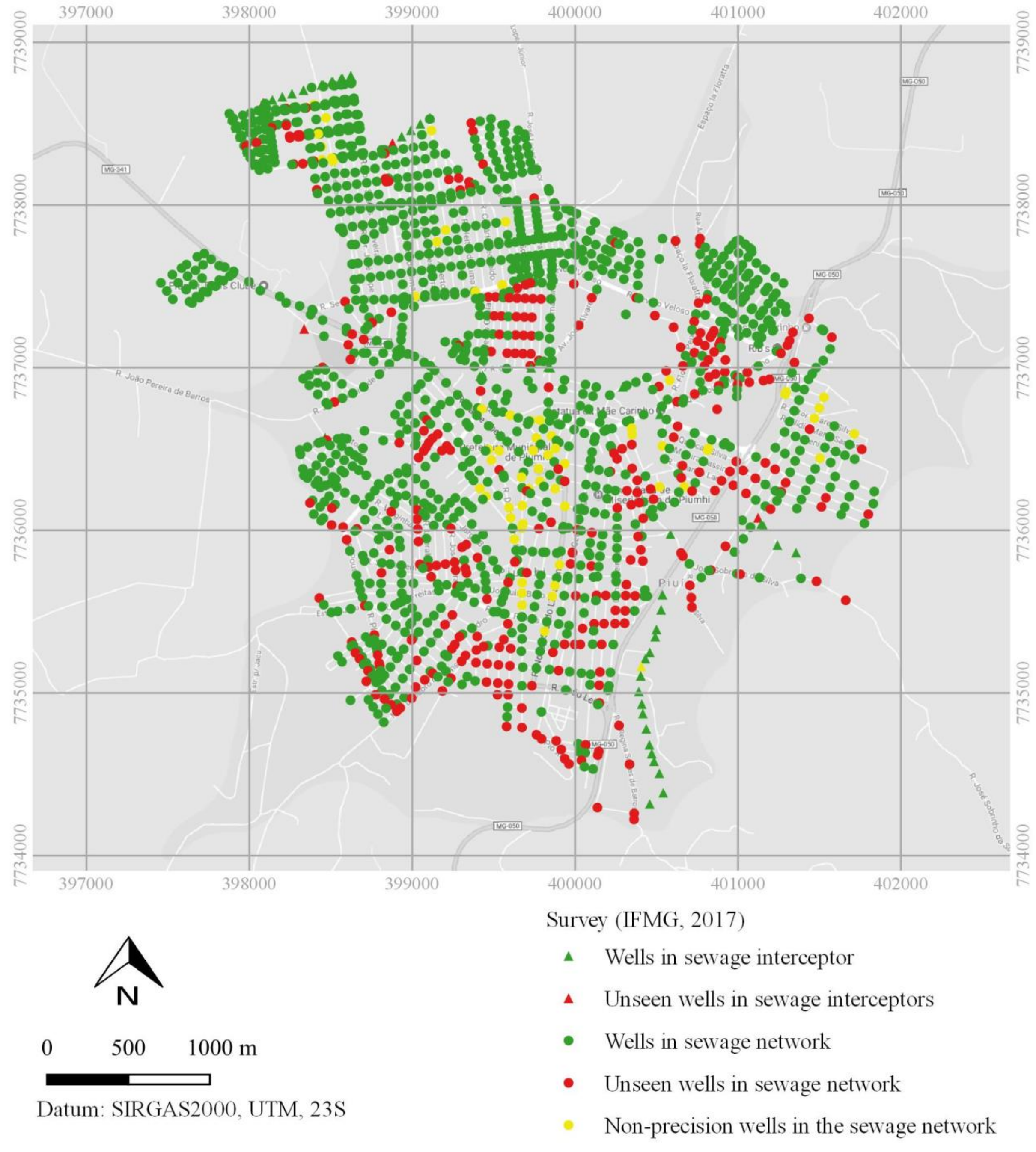

Figure 1. Wells surveyed.

In addition to the problems related above, some wells were clogged. The Figure 2 shows a sewage well with unobstructed passage with two pipes, one for upstream and other for downstream flow. In Figure 3, a well can be observed with obstructed passage, not being able to perform the measurement of the depth of the pipes and observation of material, diameter and direction of the flow.

Figure 2. Unobstructed well.

Figure 3. Well with clogged passage.

The lack of data from the unseen, from the non-precision survey and from the clogged wells limited the model developed, causing a lack of information about the sewage network in a significant part of the city, especially in regions with older occupations and where there is poor control about the activities developed by the public manager or even by the people.

The figure 4 is a cut out of the sewage system and shows several stretches with good information, but also shows some stretches with lack of information. For example, the stretch between wells 1010 and 973 has complete data, but the same cannot be assumed for the stretch between wells 989 and 1003, due to unseen well or between 945 and 969, due to clogged wells.

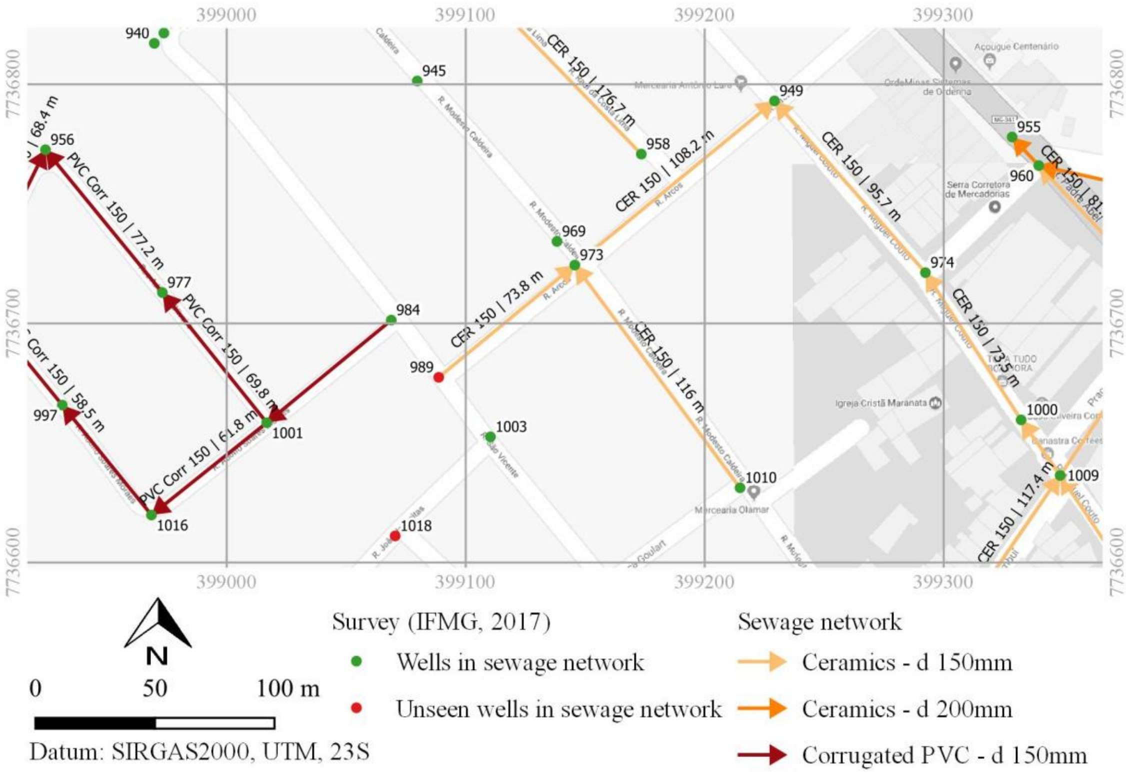

Figure 4. Sewage network with lack of information.

4. Conclusions

Several data were not obtained with high accuracy, what limits modeling information and consequently brings other challenges to the proposal of implementing concepts of BIM and GIS to achieve the concepts of CIM in the management of the sewage system by SAAE. It's remarkable how important is to keep the as built of the system to provide better information for public management decisions.

Although the work is still in progress, it is possible to conclude that access to the municipal sewage network is impaired due to the existence of unseen or clogged wells. This brings inaccuracies to the surveyed network.

However, the survey provided data to start modeling the sewage network and will contribute to supply the public managers with good information to make decisions related to the sewage network.

The implementation of BIM concepts looks like to be feasible, but some challenges shows up as, for example, the need of hardware, software and people trained to develop objects and to keep data updated and available to all those who are part of the system.

Information needed to design objects to be used in BIM can be extracted from the data surveyed. The georeferenced information, including data such as diameter, slope, material, length and other can be used to work in a BIM software like Autodesk Autocad Civil 3D to design or evaluate, for example, a project of a new infrastructure in the city.

The data provided up to now is important to continue this research and will be used to develop the next phases: the development of a plug-in to QGis software and the development of tutorials or manuals to help SAAE to implement and to continue developing concepts of GIS, BIM and CIM to improve its management model.

It is recommended that future works consider to evaluate how to integrate the model proposed to the people who are daily working evaluating the conditions of the sewage system and have the potential to obtain data to give feedback with more precise information.

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