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REASERCH AND CASE STUDIES ON WATER LOSSES IN DISTRIBUTION NETWORKS AND THEIR EFFECT ON THE GROUNDWATER

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ABSTRACT: *The current paper approaches the possibility of using the devices owned by the Company I work for, namely the G.P.R., U.A.V., thermal imaging camera, for the purpose of loss detection both on drinking water distribution and transportation pipes. The paper comprises a series of cases we actually encountered on site and successfully identified using the G.P.R. and pre-encountered with the thermal cameras and drones. The cases are explained, illustrated with on-site images and have been confirmed by visual inspection in the respective areas and by other devices on Mobile Laboratory for Loss Detection and by conducting surveys (mechanized excavation) at those specific points. In conclusion, the methods used in the field to identify water losses can have good results as a secondary procedure for leak detection.*

Key word: *best practices; case studies; water losses;*

1. Introduction

Let's start with a short presentation of the County Company APASERV SA Neamt, this being the regional operator of the Public Water Supply and Sewerage Service from Neamt County, according to the delegation contract no. 13144 of 10.08.2009.

The main activities of the company are water abstraction, treating, transporting, storing and distributing drinking water, as well as collecting, transporting and treating wastewater. Currently, the company provides services of drinking in; 2 municipalities: Piatra Neamt, Roman, 3 cities: Targu Neamt, Bicaz, Roznov, 26 communities: Alexandru cel Bun, Dumbrava Rosie, Dragomiresti, Savinesti, Garcina, Girov, Dochia, Zanesti, Bodesti, Dobreni, Stefan cel Mare, Tasca, Horia, Tamaseni, Sabaoani, Cordun, Bara, Raucesti, Grumazesti, Vanatori, Baltatesti, Agapia, Pastraveni, Timisesti, Brusturi, Ruginoasa.

The supply of drinking water is made for a total number of 46101 users, through the approximately 1204 km of drinking water network.

Water losses in distribution networks is a major concern for the management of our company.

Water leaks represent the amount of water introduced into the water supply system but does not end up being used for the purpose for which it was intended.

Water losses can also be defined as the difference between the volume of water entering the water supply system and the volume of water consumed and billed to users. Water losses can be classified into two categories, namely: physical or real losses and commercial or apparent losses.

Physical losses consist of: leaks from the transmission and distribution pipes, leaks and discharges from overflowing tanks (reservoirs), leaks from the connecting pipes to the user's metering unit. Apparent losses represent the amount of water consumed but not paid by consumers.

Within the company APA SERV SA there is a team specialized in water loss detection which is dedicated only to this activity and which acts within the NRW

Bureau.

The activities carried out within the detection office are the mapping of the water network together with the GIS Office; checking consumers with contract and identifying consumers without one; determining network losses; installation and monitoring of sensors to determine losses on established sectors; monitoring pressure fluctuations in network pipes; monitoring the decrease of flows in the measuring areas; calculation of the amount of water lost in each measurement area.

2. Equipment used

All the activities mention earlier are carried out within the company with the help of the loss detection van equipped with the following devices: CORRELUX P250, SEBALOG N3, FM 880B, ULTRAFLOW METTER AC 600, HYDROLUX HL7000, VLOK PRO 2, GEORADAR DUO, GPR STREAM EM, thermal imaging camera FLIR, UAV – drone.

Apaserv has been making shy investments since 2004 in the purchase of specialized equipment for water loss detection. On 31st October 2013 County Company APASERV S.A. NEAMT purchased two geo-radar systems to identify fraudulent consumers connected to the drinking water distribution network.

2.1 G.P.R. - georadar

We all know what a geo-radar namely G .R .P. (Ground Penetrating Radar) is a signal-based technology via electromagnetic radio wave.

G.P.R. allows the harmless investigation of the pedological soil structure and underground installations (fig. 1).

The system the NRW office uses consists of a data recording unit and two antennas, for low and high frequency, representing a transmitter and a receiver.

Thus, high conductivity regions (> 10-7 S / m) cause disturbances that can be easily identified in geo-radar scanned graphs, therefore when using the geo – radar to scan the soil one should pay attention to what the device displays in the case of clay soil, any type of saltwater infiltration and generally any soil consisting of very fine grained particles or high water concentration which may be misleading.

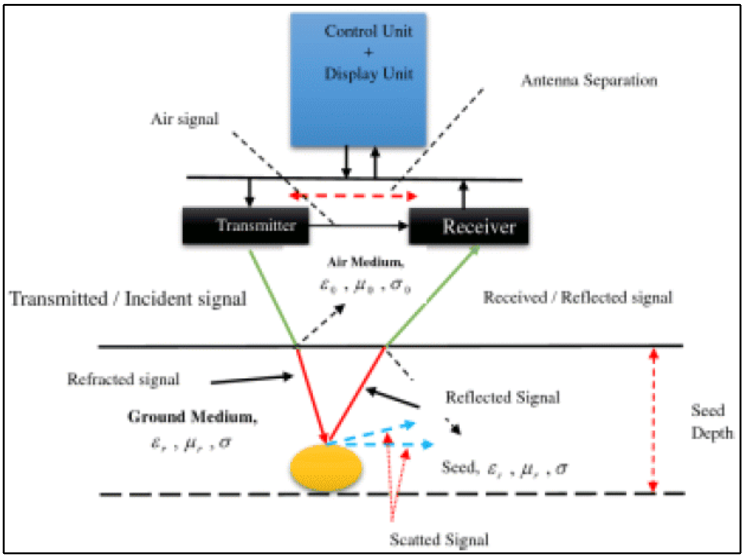

Fig. 1. Ground penetrating radar working principle

GPR could, in principle, identify leaks in buried water pipes either by detecting underground voids created by the leaking water as it erodes the material around the pipe, or by detecting anomalous change in the properties of the material around pipes due to water saturation. Unlike acoustic methods, application of ground penetrating radar for leak detection is independent of the pipe type (e.g., metal or plastic). Therefore, GPR could have a higher potential of avoiding difficulties encountered with commonly used acoustic leak detection methods as it applies to plastic pipes.

One case in which such equipment was used successfully was in the village of Borca. The main problem of this village was the water level in the main 3000 m^3 tank which fell very quickly. Several days of trying to determine the water losses on a 4 km - long polyethylene network failed to reveal any damage. The problem was discovered in the main tank area when geo-radar scans were performed.

Thus the full water volume from the water abstraction plant was lost along the main pipeline and did not reach the distribution network.

As it can be seen from the pictures (Fig. 2), around the DN 110 HDPE pipe there was a gap where water missed the pipe and went back to the underground water it originally came from.

In this situation where underground water level was quite high, thus increasing the earth conductivity and consequently making it impossible not only to identify the pipeline but also to determine pipeline damage (see Fig. 3), we relied on the fact that the water losses was very high, which made the soil conductivity much higher than normal around the damage, so it could be easily identified by geo-radar.

2.2 Flir T650sc thermal imaging camera

Another equipment used for leak detection (prevention) is the use of thermal cameras, the county company APASERV acquiring 4 thermal cameras Flir T650sc.

Thermal vision offers incredible solutions for a growing number of applications: maintenance, construction, transportation, medicine, research, surveillance, etc.

A thermal image can provide us with new information about the scanned object with the help of the infrared camera, information that is not obtained by simply viewing with

Fig. 2. Conducting surveys - mechanized excavation onsite

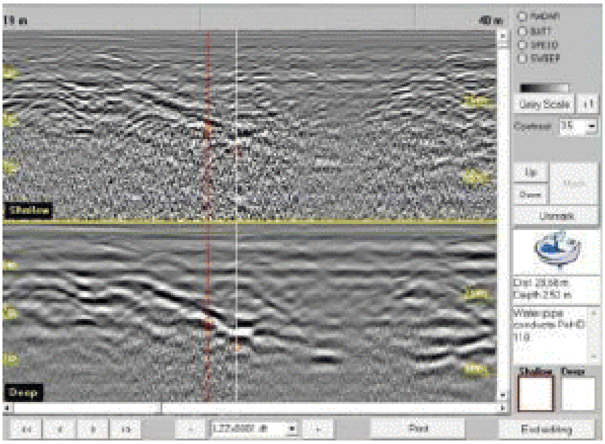

Fig. 3. Radar scan with markings of pipes and water losses

the naked eye or by other non-destructive investigation methods.

The thermal imaging camera does not measure the TEMPERATURE but the RADIATION emitted by the surface of the measured object. The radiation emitted depends first of all on the temperature of the object but also on its property of emitting radiation depending on the type of material, the quality of the surface, the visual angle , the geometry of the surface, the spectrum, the temperature of the object and the wavelength of the instrument with which the measurement is made.

The NRW office uses the thermal camera provided for various activities: in the identification of metallic sewer covered with asphalt (only provided that on the respective sewerage route there is circulation to observe the temperature difference), in general maintenance, for example in tanks (the body of the tank), when identifying the electrical installations from walls or apparently mounted, of the electrical panels, the operation of the electric motors, the server installations within the company as well as the identification of failures under certain conditions.

On the loss detection side delimitation was attempted for identifying water damage without using the conventional loss detection with equipment like Hydrolux, Correlux and GPR, only by the thermal scanning method. Fig. 4.

Also, the thermal method was used to identify problems inside houses caused by water losses on the part of buried pipes as well as to identify losses on the thermal side where the thermal method can be successfully used even in the buried heating and hot water pipes.

As can be seen in the pictures, the thermal camera can be used when the water reaches the lower limit of asphalt or concrete, thus oversaturating the groundwater, and the water creates a temperature difference from the outer one and the problem can be seen on the thermal imaging camera.

They are very often used for buried pipes in walls, on district heating networks given the fact that the temperature difference is larger and more pronounced.

For the two cases encountered, it was the location of the problem in an area with traffic at night, and the other was a case in winter where, it was easy to see the difference between outside temperature, snow temperature and water temperature in the pipe, coming to the surface.

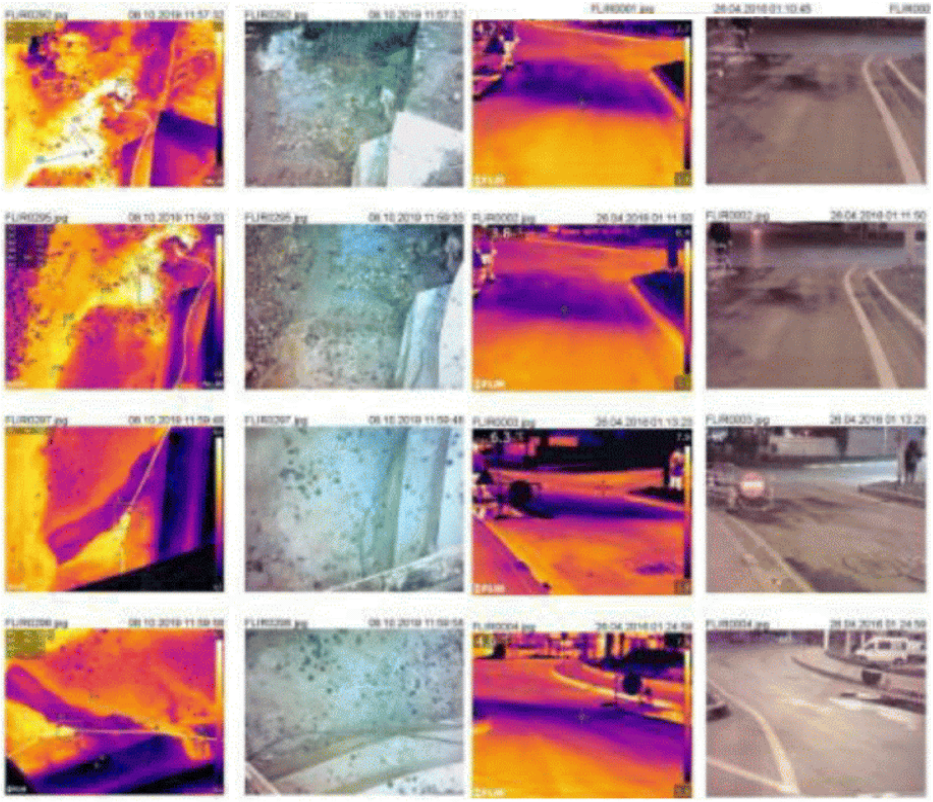

Fig. 4 Thermal scans beside normal picture

It is recommended that the use of thermal imaging camera be done by an authorized level 1 thermography operator in order to be able to distinguish between false signals emitted by glossy surfaces by using the correct emissivity table.

2.3 U.A.V. - unmanned aerial vehicle

The unmanned aerial vehicle (UAV), also known as drone, is an aircraft with no human pilot, being guided by a digital automatic pilot on board, or by a remote control from a control center on the ground or located in another piloted aircraft.The system owned by the company is purchased from SenseFLY, being an Ebee RTK (real-time kinematic) used mainly for geodetic mapping.

The system performs aerial photographic capture to produce orthomosaics (a single image made of multiple georeferenced pictures) and 3D models with an absolute precision of up to 3 cm - without ground control.

The NRW Office uses the UAV system for various works and carries forward various requests from outside the company such as fraudulent consumer identification, water damage pre-identification, and monitoring.

As a result of the on-the-spot checks, the presence of some anomalies in the field confirmed the damage to the water network.

Such a situation was in Târgu Neamţ where the orthophoto map of the main pipeline was carried out in the field and a detailed analysis revealed an anomaly as a rich vegetation grown in one place although it was a period of drought.

The verification indicated a damage near the existing main valve chamber. (Fig. 5).

3. Software being used

The software of the equipment used, can be acquisition and processing data such as: FLIR TOOLS, Gred HD, One Vision, DUO Detector, uNext, Overture, can be used both in the field and in the office.

For the UAV system is provided with two softwares, one for collecting flight data, with flight planning functions, telemetry tracking and one for data processing, which can create the 3D and orthomosaic model. Analysis can also be made, such as distance measurements, cross-sections and extraction of volume data can be done using software such as Pix4Dmapper, Global Mapper, Agisoft, Quick Terrain, MicroStation, ccViewer. The export data can also be done to ancillary software in order to add GIS data or create customized maps in programs such as ESRI, ArcGIS, QGIS, StereoCAD, AutoDESK, Maptek.

The orthophotoplan was obtained by processing the 83 images captured by the drone on 5 parallel paths (Fig. 6). The analysis can go further through the processing software where you can get different information such as green index, volume calculation, if you change the camera module with a thermal one you can do thermographic analysis, also NIR camera modules (near infrared) used especially in agriculture.

The settings used for thermal analysis in the Flir tools software were, 0.95 emissivity, the reflected temperature being 80°C, the measuring distance being 10 m, the relative humidity being 50%.

4. Results

The methods presented, through the encountered cases, can be used successfully if the necessary conditions for the use of this equipment in the field are met and can be used in cases where those methods do not give expected results, such as the influence of external noises, lack of intermediate manholes or lack pipe access, extremes temperature.

5. Conclusions

In conclusion, this paper analyzes the use of less atypical methods for identifying losses compared to conventional ones (using the method of listening with dedicated

Fig. 5 Confirmation onsite of the water loss

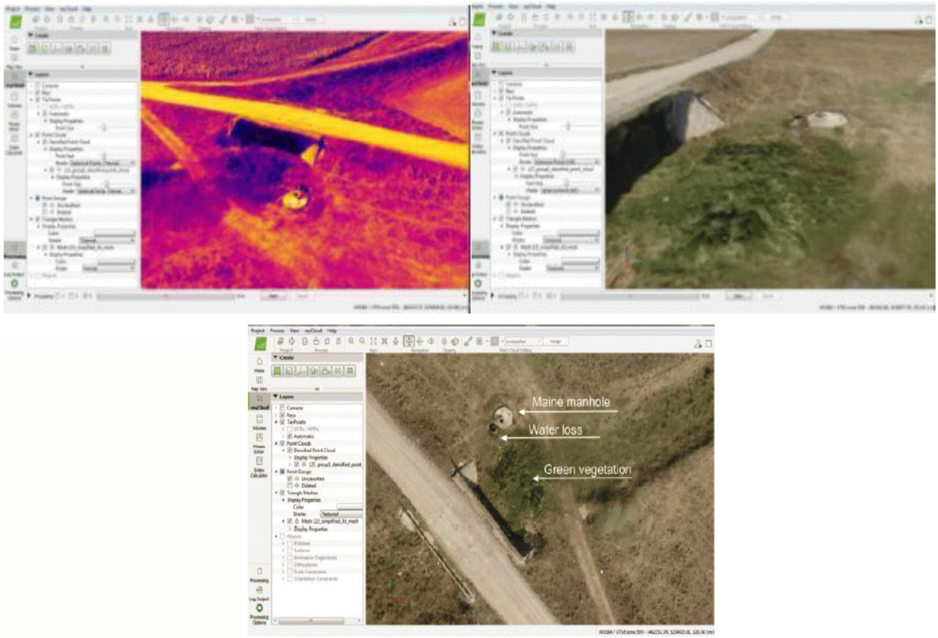

Fig. 6. Software processing and analysis of the acquisition data

equipment) and should not be perceived as universal replacement of all the so far existing devices, as they are complementary devices on certain loss detection segments.

The influence of water losses, whether they are from the drinking water distribution pipe or from the domestic and rainwater sewers, on the surface layer also called the groundwater can be observed both by chemical laboratory analyzes and by the use (in some cases) of the GPR.

Thus, it can be observed through the radar analysis software from what depth the groundwater starts to be observed and from here (through subsequent analyzes depending on the area) conclusions can be drawn as to whether there are damages to the water pipes, sewer pipes or rainwater pipes, there is a risk that the groundwater could be contaminated.

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