Satellite Leak detection Project in Mitrovica, Kosovo

ABSTRACT
The article is focused on using the modern technology in finding leakages in water supply system of Mitrovica, Kosovo, financed by Lux Dev (Luxembourg Agency for Development Cooperation) and implemented by Aquasave Ltd Skopje, with cooperation of Israeli company Utilis. This is the first project of this kind in the Balkan and wider region. The services under the project were set up to achieve the following objectives:

- Assessment of the network in whole and deliver locations of leaks displayed on several user-friendly GIS interfaces to MRWC (Mitrovica Regional Water Company).
- Check/confirm presence of leaks in some of the buffers defined by the particular leak Sheet in predefined period by means of different leak detection equipment.
- Improve i.e. enhance the capacity of MRWC in implementation of own leak detection activities and its capacity to continue with confirmation of leaks within the buffer defined in the Leak Sheets which have not yet been visited and checked the Consultant.

The project has been divided in two tasks:

- Task 1 - Leak detection by analysing spectral images from satellites
- Task 2 - Leak detection - verification of the leaks on the field, including training of the RWC Mitrovica NRW staff

INTRODUCTION
The specific objective of the Lux Dev project, under which the satellite leak detection project was carried out is to contribute to the achievement of a reliable and sustainable water supply to the population served by the Mitrovica Regional Water Company. One of the key areas of improvement is the reduction of non-revenue water (NRW). It is considered that there is significant room for improving on this indicator, as the NRW at approximately 75% is one of the highest in Kosovo.

The carried out satellite based leak detection project was expected to identify many possible leaks in the water supply system, with additional on-the-job support to the MRWC staff in using leak detection equipment, aimed at marking the leaks that the satellite leak detection project has identified.

AREA OF INTEREST
The area of interest of the services under this project is limited to the water supply system of the RWC Mitrovica, all investigation, measurement, water audit leak detection and calculation have been concentrated to the area under responsibility of RWC Mitrovica (Mitrovica - exclude Nort Mitrovica, Vushtrri and Skenderaj).

TASK 1 - LEAK DETECTION BY ANALYSING SPECTRAL IMAGES FROM SATELLITES

Background
The first task of the project was carried out by Utilis, an Israeli based company. Utilis developed a unique technology for leak detection in urban fresh-water distribution networks. Using technology that is used to look for water on other planets, Utilis analyses satellite imagery to detect leaks. The result? Leak detection that covers thousands of square kilometres at once, and that can identify a saving significant resources associated with finding leaks with current methods.

Utilis uses spectral aerial imaging – taken from satellite mounted sensors – to spot leakage in subterranean treated water networks. Treated water is detected, by looking for the particular spectral signature typical to treated water. Eventually, the user is presented with a leak report overlaid on a map with streets and pipes.

In cooperation with Aquasave Ltd. Macedonia and LuxDev Project, Utilis has provided a leak report for Mitrovica water utility that also includes Skenderaj and Vushtrri.

Production of the leakage report (Images to be seen below):

The Consultant Production Stages:

1. Satellite spectral image acquisition: raw images of the area taken based on AOI (area of interest) received from client (Choose with the end-user the area of interest (AOI)).
2. Radiometric corrections: The Consultant takes the raw data and prepares it for analysis, by filtering bounce from buildings and other manmade objects, vegetation hydrologic objects, etc. (Acquire satellite imagery of AOI).
3. Algorithmic analysis: using the Consultant advanced algorithmic analysis to track the spectral
"signature" of treated water and its interaction with the soil. A corrected microwave image is then analyzed, with fresh water leaks identified. The size of the leaks is estimated by cross referencing the algorithm’s output against local infrastructure (Overlay of pipe layer (GIS)).

4. Delivery: Normalized data is presented graphically with findings (leaks) displayed on a GIS web-based application. Field teams on the ground receive ‘Leak sheets’ generated by the Consultant system, to confirm and repair the leaks (Supply suspected leakage locations).

Delivery

Based on the output of the algorithm the following suspected leakage sites were chosen for field verification of an acoustic team.

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very High</th>
<th>no. Findings (Total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitrovica</td>
<td>6</td>
<td>22</td>
<td>19</td>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>Vushtri</td>
<td>2</td>
<td>18</td>
<td>12</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td>Skenderaj</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>

*the color coding indicates probability of finding the leak. The calculations of this legend are based on local parameters.
TASK 2 - LEAK DETECTION - VERIFICATION OF THE LEAKS ON THE FIELD, INCLUDING TRAINING OF THE RWC MITROVICA NRW STAFF

The Task 2 of the project refers to the verification of probable leaks in the respective Leak Sheets, provided by Utilis, and delivered under the Task 1. The Consultant Aquasave carried out comprehensive leak detection activities according to the given Leak Sheet with its leak detection and monitoring equipment and the professional staff. In addition, those activities have been used for training purposes of the MRWC Leak-Detection (NRW) team. This approach has the advantage that during the intervention of the Consultant on site, MRWC staff received training on the job, by using, apart from the Aquasave’s equipment, their own leak detection equipment. The consultant’s inputs for Task 2 has been defined for three weeks (15 working days), from 04.09.2017 until 22.09.2017.

Taking into account the limited time frame given under the Contract, the services have been organised and carried out with a maximum flexibility, to visit/check as many areas/Leak Sheets as possible, particularly emphasizing the systematic examination of the networks and finding all existing leaks in the buffer defined by particular Leak Sheet, instead of focusing and being satisfied with only one finding per Leak Sheet.

Methodology and equipment used for flow monitoring and leak detection

Daily preparation and activities

Prior to start of the activities, the “leak sheets” provided by Utilis have been printed out and each copy has been distributed to Aquasave and to the RWC Mitrovica leak detection team. In addition, Aquasave team has downloaded the GIS Cloud map for the field verification on mobile devices (smart phones).

Each day the both teams have instructed their teams to answer the following questions:

- Which sites will be visited on that particular day?
- What are the materials of the pipes?
- What are the characteristics of the area? (mountainous/flat/residential/industrial)?

Upon arriving at the Utilis suspected location, leak sheets and GIS Cloud app were used in order to decide which pipes need to be checked. As a rule of thumb, both teams have checked every access point: valves, hydrants, private connections, yard taps, water meter boxes, etc. using all acoustic tools and recorded every water movement on the ground. All the findings have been notified into the Leak Sheets and photos and videos have been taken on each finding in particular Leak Sheet. The collected information was put in the predefined Utilis data collection report format (Data Form) whereas the project Team Leader was periodically briefed.

Flow measurements

The activities in the Project started with the effective metering at the inlet of the pipeline for Skenderaj and Vushtrri, as an essential feature of network management, particularly for continuous flow monitoring for more than 24 hours by means of clamp-on ultrasonic flow meters with possibility to log flow data. Aquasave utilised the very latest technology in ultrasound flow measuring to accurately measure the flow in the existing pipelines for the client. The measurement was carried out from the outside wall of the pipe and without direct contact with the water column. There was no need to enter into the piping system or to interrupt the supply. The mobile ultrasound flow measuring device used in the project is UDM 200, SebaKMT-Germany.

The graphs from flow monitoring, including data statistics for Vushtrri and Skenderaj are shown below:

According to the graphs, the maximum flow for Vushtrri reaches more than 180 l/s during the night hours (supplied by Shipol Water Treatment plant), whereas during the day the average flow is around 15 l/s. In case of Skenderaj, the maximum daily flow has been recorded to more than 100 l/s and minimum night flow amounts to less than 50 l/s (including the legal night consumption and reservoirs inflow).

Leak localization

Sounding survey

Upon detection of the potential leakage problem in a network, the “Sounding” exercise has been undertaken. Sounding of a particular water distribution system is undertaken using a Listening Stick-Contact Microphone, which is placed against all possible valves, hydrants and service connection or other accessible points on active piping, to detect noise emitting from possible leaks.
The objective is to detect the contact points where leaks can be heard and eliminate the contact points where leak sounds are not heard. The listening stick used in the services is a highly sophisticated electronic device that has many useful features to help the operator to find and pre-point the leaks. This approach would not identify the position of the leak but would normally indicate if there is a leak on a certain section of pipe. A sounding survey was carried out as the follow-up stage to a leak detection exercise, sounding on all accessible fittings.

Leak Location

The leak location was carried out using the following pieces of equipment:
- Ground Microphone;
- Leak Noise Correlator.

Ground Microphone

The ground microphone is used to search for leaks along the pipeline between fittings. The technique involves placing the microphone on the ground at small intervals along the line of the pipe and recording the changes in the sound amplification as the microphone nears the leak position. The leak is pinpointed at the position of greatest noise intensity as detected by the ground microphone.

Leak Noise Correlator

The leak noise correlator is the most sophisticated of the acoustic leak location instruments. Instead of depending on the noise level of the leak for its location, it analyses leak sounds (including those inaudible to the human ear) and relies on the velocity of sound made by the leak as it travels through the water column and along the pipe wall towards each of two microphones placed on conveniently spaced fittings. The instrument is portable and it has the capability for frequency selection and filtering.

The correlator method is used instead of or as verification of the ground-microphone method. To use the leak correlator, the leak sound must be detectable at two or more contact points, and certain information must be entered into the correlator, including the linear pipe distance between the contact points, the water pipe material and size (diameter) of the pipeline.

Two electronically amplified microphones, connected to and powered by portable electronic preamplifier outstations, are attached to the selected contact points. The leak sound picked up by the microphones and amplified by the outstations is then transmitted to the correlator by a radio housed within the outstation.

FIELD VERIFICATION SUMMARY REPORT

Detection success rate

Over a period of three weeks the acoustic team of Aquasave along with the representatives of RWC visited 44 Utilis locations-Leak Sheets from 93 in total (from which 10 are located in North Mitrovica), 38 of them were positive and in total more than 60 leaks were detected in the field.

<table>
<thead>
<tr>
<th>Total leaks detected</th>
<th>62</th>
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<tbody>
<tr>
<td>Total suspected</td>
<td>0</td>
</tr>
<tr>
<td>Total quiets</td>
<td>6</td>
</tr>
<tr>
<td>Total visited findings</td>
<td>44</td>
</tr>
<tr>
<td>Total verified findings</td>
<td>38</td>
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<tr>
<td>Detection success rate</td>
<td>86%</td>
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Project Progress

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<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Total findings delivered</td>
<td>93</td>
</tr>
<tr>
<td>Total findings verified</td>
<td>44</td>
</tr>
<tr>
<td>Total findings unverified</td>
<td>49</td>
</tr>
</tbody>
</table>

All the findings located in particular Leak Sheet are well presented by photos and videos and disruption in the supplying to this report are part of the Data Form and electronic folders. In addition, a map with all findings has been prepared to visualize the findings in the area covered in this project.

NRW Training to RWC Mitrovica Staff

General Notes

It is acknowledged that Water Loss Management is a multi-disciplinary activity that practically involves all operational and functional aspects of water distribution. Water losses could successfully be managed through a series of comprehensive activities covering many issues such as real and apparent losses, speed and quality of repairs, asset management, pressure management, employees’ education, use of appropriate technology etc.

A key element in providing the right solution is to have capable water utility employees and without proper training, coordination and assistance it is extremely hard to expect positive results. A high level of continuous commitment, capabilities and active integration/application with appropriate knowledge is required from the water utility staff.

Therefore, the training of staff in skills and techniques features is very important in developing and implementing a leakage management strategy and for ensuring sustainability. It encompasses the motivation of staff, transfer of skills in the techniques and technology of leakage management as well as system operation and maintenance. There is a need to address the tasks, the problems and the constraints associated with introducing a leakage management programme at all levels within the company.

In order to further build the capacity of the MRWC staff in NRW Management, continuous training was carried out during the services. A classroom training given as a PowerPoint presentation provided an overview on the fundamentals of NRW management and strategy and dealt with the background and definitions of terminologies recommended by IWA and used in water loss management (non-revenue water, unavoidable annual real losses), performance indicators (ILI), with different approaches for real loss and apparent loss control and state of the art techniques and equipment used in leakage detection and control in the distribution system.

The training was continuous, during the entire duration of the services; it was organised as on-the-job training led by an expert from IWA Water Loss Specialist Group (Mr. Bojan Ristovski-Aquasave) and trained personnel from the Aquasave team, including use of various monitoring, tracing and leak detection equipment owned by Aquasave and MRWC.

Although the trained technical staff has shown good capabilities, it seems that they need more training days, especially when considering the exercises in the already established DMA’s.

In any case, managers should consider establishing full equipped and trained team (consisting of, at least, two Leak Detection technicians and a plumber) who will be engaged only in everyday leak detection activities, with separate vehicle and support from the purchasing department in supplying the necessary batteries for the equipment on regular periods.

Conclusion and Recommendations

Since in the Project no exact requirement or obligation was given to the consultant to visit/check all given Leak Sheets, significant efforts have been made in respect with the analysed and checked leak status of the buffer and of as many as possible Leak Sheets, whereas the MRWC staff was trained on NRW Management, with the intention of raising awareness to promote actions by the MRWC to address the problem.

Moreover, since full check/leak detection of all leak sheets was not really achievable within the timescales of the current project, this should further encourage the MRWC to continue checking the remaining leak sheets according to the experience gathered in the period of three weeks. Since NRW training has been provided to the MRWC, the next real step is to move towards implementing the methodology and techniques provided on training with respect of various leak detection activities on site.

Non-Revenue Water cannot be reduced unless there is a firm commitment within the MRWC to undertake a “Pro Active Policy” towards leakage detection activities. The establishment of an active Leak Detection Department and identification of an appropriate number of staff to work as part of a NRW action team is an absolute requirement in the first instance. There is a clear need to address the problems and constraints associated with introducing a NRW reduction programme within the MRWC. Tackling NRW requires a dedicated core of highly motivated and trained specialist personnel using own “state of the art equipment” and techniques. The use of local knowledge with an understanding of the day-to-day operation of the distribution system and water demand patterns is also essential.

Conclusions

- Over a period of three weeks, the acoustic team of Aquasave along with the representatives of RWC visited 44 Utilities locations-Leak Sheets from 93 in total (from which 10 are located in North Mitrovica). 38 of them were positive with more than 60 leaks, in total, detected in the field. Statistically speaking, on average, it is possible in RWC to detect four leaks per day which is four times more efficient than the industry average of one leak per day,
- The largest number of leaks is located on connections, which correspond with the world statistics and practices,
• During the visiting of the sites, a lot of water meter boxes/chambers has been found filled with water.

• Most of the visited water meter chambers were without water meter or the already installed water meter was not functional. This means that there are a huge percentage of illegal customers without water meter or non-functional water meter, comparing with the number of visited sites.

• MRWC staff was trained on leak detection and NRW Management and enabled to use their own leak detection and monitoring equipment.

• The existing leak detection and monitoring equipment is generally in good condition, but it still needs to be upgraded in order to perform all required services.

• The existing flow and pressure monitoring DMA system is not operational. There were no possibilities to get all necessary information to evaluate the systems under responsibility of the company from the aspect of real losses.

• The GIS map provided by MRWC is not updated.

• According to the findings, we could conclude that the methodology is functional and that the project could be evaluated as successful.

Recommendations

• All detected and notified leaks must be repaired immediately.

• The MRWC team should continue visiting the remain Leak Sheets with the existing equipment, notifying all detected leaks, taking photos and videos of all findings and filling the Data Form.

• Although the MRWC team is well trained, it still needs additional training, supervised and gained by experienced NRW engineer.

• To establish a full equipped and trained Leak Detection Team (consisting of, at least, two Leak Detection technicians and plumber) which will be engaged only in everyday leak detection activities, with separate vehicle and support from the purchasing department in supplying the necessary batteries for the equipment on regular periods,

• To equip the LDT with the necessary equipment,

• Availability of company funds for NRW activities

• Systematic field investigations for illegal connections on distribution pipes and possible bypass of water meters; Rotation of water meters/controllers should be consider,

• Seriously tackling commercial losses by updating the customer data base and replacing the water meters,

• Put the DMA monitoring system under operation—at utmost importance in order MRWC to be capable for data collection and analysis on the technical aspects of NRW. With operational DMA monitoring system, the flow consumption on each DMA, could be monitored in order to better interpret the current leak status of each DMA and the system, as a whole. The fully operational DMA monitoring system could prioritize DMA’s/networks with higher real water losses,

• Check if DMA is really DMA! Based on the information received, it seems that there are interconnections between the already established DMA’s. Apparently, the DMA’s are not fully isolated,

• In order to facilitate the DMA examination MRWC should update and complete their consumer data base in a way that all registered consumers can be located precisely on the ground, and thus their metered water consumption can be put into relation with the night flow measurement results, received by DMA monitoring system,

• Compile a quick top-down water audit for the fiscal year 2016 using the Free Water Audit Software package (which can be downloaded from the following web site- http://www.liemberger.cc/)

This will quickly and easily provide a preliminary assessment of water loss standing, cost impacts and serve as a basis for comparisons with other water utilities,

• Once a preliminary water audit exists in the software, the methods explained in the training can be followed to form a NRW team, develop a more detailed worksheet and start bottom-up activities and interventions to more accurately quantify and control apparent and real losses;

• Update the GIS maps with related attributes,

• Develop and maintain Leak Location and Frequency Database/ Maps

• Visual inspection of entire water and sewerage pipelines is necessary.

• Repair additional leaks that could be found through visual inspection and additional leak detection on the remaining network indicated on the Leak Sheets. Repairing visible and reported leaks (preferably within 24 hours of being reported) is without doubt one of the most obvious and basic interventions that should be implemented as a top priority;

• Replacement of old and bad-condition pipes and galvanized iron service connections will assist in reducing Real water losses/Non-Revenue Water;

• Install pressure reduction valves on some critical locations in order to reduce the pressure and reduce variations during the day and night. See the possibilities to upgrade the existing DMA’s to PMA by installing pressure reducing valve into the same chamber. Detailed pressure measurement at critical points should be carried out before.

• Develop a strategy and/or Action Plan for reduction of Non-Revenue Water;

• Further satellite based leak detection service should be offered on a multi-annual basis.