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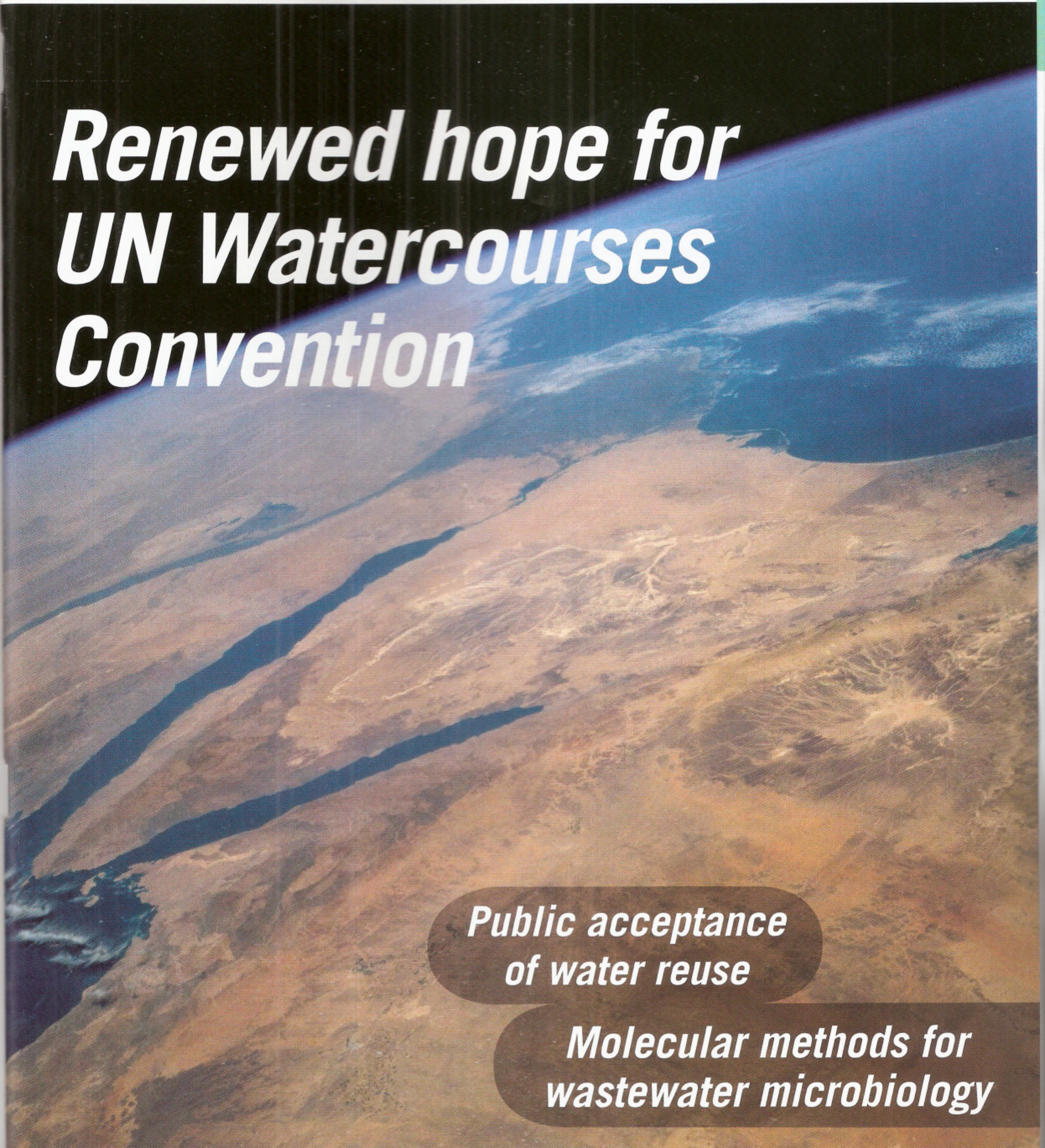

Renewed hope for UN Watercourses Convention

Public acceptance of water reuse

Molecular methods for wastewater microbiology

A multi-parameter first for integrated leakage monitoring in potable water networks

Early and accurate detection of leakage is critical to both the operational and economic performance of a water utility. **PETER MARTINEK** provides an overview and early trial results of a system able to support monitoring of entire distribution systems.

Around the globe, the issues of freshwater security and availability are attracting considerable attention, and the quest for answers has sparked an inter-national search for ways to overcome this fast-growing problem.

Press reports that suggest over 50% of carefully-treated water put into distribution is lost on its way to the tap are certainly cause for alarm. Because of the high figures involved, this lost water is often called 'the second water source', and it is now time to make use of it.

Alongside the well-known existing leak detection and applied water loss analysis tools, there is a need for a tool able to observe and monitor the whole pipe network to enable sustainable water loss management. Indeed, long term water loss reduction projects should only be started if the activities can be recorded and controlled via a monitoring system.

Now a technology based around a sensor able to measure water flow (bi-directional), pressure, noise and, optionally, temperature has been proving itself in practical applications for accurately investigating leakage in distribution systems.

In an attempt to reduce the volume of water lost from their distribution networks, locations including the city of Tallinn in Estonia, and Chemnitz and Crailsheim in Germany, and recently the city of Riga in Latvia, have turned to a new system to better identify where leakage is occurring.

The need for clear detection

As well as water supply management, water loss management, mainly in the reticulation network, is gaining increasing importance. An immediate and reliable record of water losses and clear identification of leak zones through permanent monitoring provide huge potential for savings, as these actions would minimise the duration of water loss and considerably reduce the effort required to detect leaks.

Nevertheless, security of supply must be the top priority. Over the short term, measures such as pressure reduction can provide fast, positive results. But such actions eliminate symptoms, rather than the ultimate causes, and are recommended only as a temporary solution.

The hydraulic operation of a water supply network is extremely complex. The WLM-System is an innovative, efficient and integral measuring system that actively supports monitoring of entire distribution systems.

The system measures and analyses, using Multiparameter-Sensors, which enables clear identification of any leaks that occur (Figure 1). These parameters are measured simultaneously at each position in the network and compared against a reference value. If a reference boundary value is breached, an alarm is raised.

The interaction between the parameters and the automatically-calculated boundary values produces a very accurate picture of where leakage is occurring. The boundary values can move only in the direction of improvement following each leak repair. The desired minimum or maximum values, for instance for minimum night flow, are individually remote-controlled by the Aqualys software – an application specifically designed for water loss management and diagnosis in distribution networks.

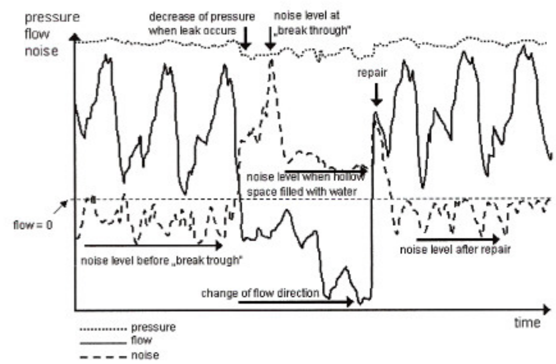

Figure 1: Growth of a leak – with Multiparameter measurement (Kölbl, 2009; ÖVGW-W63-2009)

Through optimal positioning of a number of sensors throughout the network and support from the Aqualys software, a water loss occurrence can be speedily isolated. For networks that are not divided into DMAs (district meter areas) in particular, this multi-parameter measurement is truly a state-of-the-art technology. Sensors are installed at key positions and create their own zones – that is, virtual zones (Figure 2). The installation is independent of material type and pipe size, which can be from 80mm diameter to over 1m.

Networks already divided into DMAs offer ideal conditions, but with virtual DMAs a separation into physical zones is not necessary and the advantage of an open network is retained. Comparison measurements for all parameters to values from the day before, with a synchronised time, trigger an alarm at a certain level of change and identify the leak zone.

The measured values are converted in the sensors' CPU (Central Processing Unit) to digital values, and are logged and transferred via an RS 232 interface by GSM (global system for mobile communications), cable or radio to a central computer. This data transfer is automatically controlled. As soon as the operator starts the Aqualys software (for instance, in the morning) they can see at a glance whether there has been a change in the network – that is, if a new leak has occurred.

On the main map (either a GIS (Geographic Information System) map

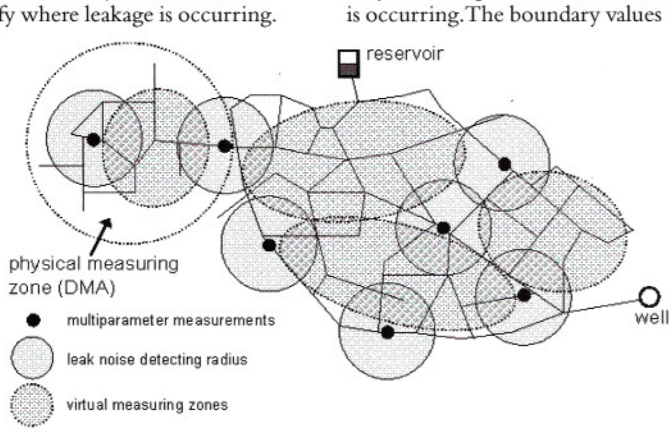

Figure 2: Measuring zones virtually and noise overlapping, (Koelb; Martinek; 2009)

or ordinary street map) each sensor is geographically positioned and marked with symbols for flow, pressure, noise and battery charging level. These symbols change from green to red in the event of an alarm situation. The Aqualys software also offers a number of comparisons and retrieval options. Automatic .csv file export and import is also possible, as is integration with SCADA (Supervisory Control and Data Acquisition) systems (see box).

The magnetic inductive flow sensor is designed to measure very low flow speeds (0.01m/sec with a resolution of 0.001m). Accurate measurements are possible, but for this application not really necessary. It is important to focus on comparing the measurements from the current day with previous values. Even a small deviation in flow can be identified.

The integrated piezo-ceramic pressure sensor has a range from 0 to 200m, and measures the dynamic pressure in the network as well as performing relevant data acquisition for analysis.

A highly-sensitive microphone is integrated into the WLM-Sensor, which performs a similar function to a noise logger. The key advantage is its positioning, in an area well protected from surrounding noise and with direct connection to the water in the pipe. This allows relatively good detection of typical leak noise not only via the pipe material but also through the water column. The flow noise recording can provide valuable data for analysis.

At this stage we recommend the strategic use of noise loggers. If a sensor highlights a flow alarm and no indication of leak noise, it is probably out of the noise detection radius of the sensor (see Figure 1). In general, for pinpointing a leak, the traditional methods should still be applied.

The hydraulic parameters are meaningful of course in evaluating the capacity, that is, the condition of the pipe network. At times of peak consumption, measurements can be performed to determine the carrying capacity of the whole or part of the network. The diagnostic feature is another key aspect of the WLM-Sensors' installation (see Chemnitz report).

The installation is fairly simple, similar to that for a house connection, via a pipe saddle with a shutter, valve gate or the special Sensor-Schacht module (see Figures 3 and 4). A good, coordinated WLM-System installation will enable a fast return on investment. Most importantly, the system is sustainable as it creates permanent monitoring of the important hydraulic parameters and other key measures, enabling an immediate reaction based on facts and measurements and not on estimates.

About the WLM-System

The system's features and advantages include:

- Electromagnetic insertion. The bidirectional flow sensor can detect flows from 0.01m/s to 10m/s with a resolution of 1mm
- Single flow sensor combined with integrated pressure and noise sensor and optional temperature sensor (Multiparameter Sensor), fits a wide range of diameters from 80 to > 1000mm.
- Output to RS 232 interface – opt 4 to 20 mA
- Hot tapping via an ordinary pipe saddle, sluice valve or special sensor chamber. This is a substitute for solid chamber construction and is a low cost solution
- Very robust and watertight (to IP 68) and maintenance free
- Many measurement options: all known major units; water loss amount; GSM transmission signal quality
- Designed to operate to individual cycles, night flows, minimum flow, access flow etc.
- Automatic .csv file export and import
- Remote control and remote update
- Power supply is 12V DC; or a mains supply preferably from street lights; or a solar panel
- Ideal for feasibility studies (checks must be made before starting any kind of activity) by using three major physical parameters: flow, pressure and noise
- Diagnostic tool for distribution systems

Figure 4: Sensor installed with special Schacht module

Figure 3: Sensor installed on pipe saddle

Case studies

Tallinn waterworks purchased its first six WLM-Systems in 2005. After three months of operation the utility had achieved its return on investment. The city has 51 sensors, with a further 60 units to be installed over the next few years to ensure the water supply for the entire city is completely under control. The complete case study can be downloaded from www.martinek.org.

Around two weeks after the installation in Chemnitz, the company received the following message – the company had submitted advice on some irregularities, as it provides guidance to the customer for around a month after installation: 'Dear colleagues, we have followed the advice about a possible burst on the pipe between Zwickauerstrasse and Goethering and tried to detect a leak. Result: there was no burst! We did however find the source of the noise responsible for the noise change and the change in pressure that we were detecting. In the pipe from Goethestrasse to Kassberg there is a strongly-throttled valve (this cannot be opened to its 'normal' state, otherwise there would be a significant increase in pressure in the Kassberg area). At this valve a technician had undertaken a routine check and turned it to the wrong position, which created an effect like a leak.

'Even though we couldn't detect a leak, the experience showed that this new technology reports even small changes to ordinary service, and it confirms the expected function of this measuring device.'

The Crailsheim water supply

Crailsheim is at the centre of the north east of the state of Baden-Württemberg in Germany, lying within Schwäbisch Hall county. The catchment area contains around 80,000 people, while Crailsheim itself has some 17,000 residents.

The water supply is carried via 121km of pipes (see Figure 5). In 2003 the network supplied 2.34M.m^3 of potable water, at least 70% of which came from neighbouring springs through the Jagst Group Water Supply Cooperative. The remainder, over 700,000m^3 in 2006, comes from the Northeast Württemberg Water Supply Cooperative.

The STW (stadtwerke, or public utility company) service area is sited from 401m to 466m above sea level (asl), with an average elevation of approximately 420m asl. Normal water pressure therefore varies considerably between 1.67 and 6.47 bar.

Most of the network was built using large nominal diameter conduit of between DN40 and DN300 in diameter. The preferred material is PVC (found in around 66% of all pipes). PE (polyethylene) pipe is also used extensively (around a quarter of all pipes), and the remaining pipes are metal. The average age of the conduit network is minimal.

The focal point of the service area is the two largest zones in the network, which mainly comprise plastic conduits. If a leak is detected and identified by zone metering, comprehensive and complicated location work is needed to find the leak and repair it.

The WLM sensor technology, sold in Germany by RBS wave, a subsidiary of EnBW (Energy Baden-Württemberg AG), is helping here. As explained above, the sensor technology is based on measuring probes that are installed directly into the conduit network and monitor flow through pressure and noise levels during non-peak (night) hours.

The sensor technology detects leakage very early. Even minimal flow velocities of less than 1cm/sec can be reliably recorded. The technology enables high-resolution monitoring of the entire supply network without physically disconnecting zones, which is hydraulically disadvantageous. This greatly reduces the effort involved in locating leaks.

Furthermore, the sensor technology enables the amount of leakage to be quantified when the leak is identified, so that a reliable estimate of its economic impact can be obtained.

With the installation of WLM sensors, the utility was able on one hand to have timely information about the occurrence of leakage and, on the other, to sustainably reduce the cost of leak location.

Multi-parameter measurement gives a much better picture of a particular control zone than one parameter alone – to give a musical comparison, one instrument is pleasant to listen to, but more instruments create a concert! ●

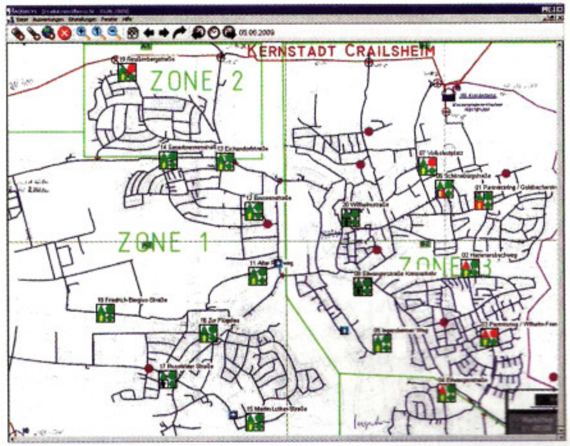

Figure 5: Conduit network overview

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