ACOUSTIC LOGGERS AS PART OF A COMPREHENSIVE WATER LOSS MANAGEMENT STRATEGY

Amyn Bhimani
President
Hetek Solutions Inc.
2085 Piper Lane
London, ON N5V 3S5
Email: amyn.bhimani@hetek.com
Phone: (226) 271-2016

ABSTRACT

The summer of 2015 has provided a stark reminder that water is one of our scarcest and most valuable resources. All across Western Canada, warm dry conditions have resulted in municipalities imposing water restrictions on their citizens. As the effects of climate change continue to impact our planet, warm and dry may be the new normal which means that there will be increased pressure on municipalities to minimize water losses.

A comprehensive water loss management strategy includes water audits, flow monitoring, and water leak detection. Traditionally water leak detection has been conducted using a ground microphone with a technician walking the distribution system and listening for leaks.

Water leak detection using acoustic loggers has several advantages over traditional leak detection methods:

- Several types of data are available including sound frequency and leak probability warnings;
- Data is delivered in a consistent manner without interpretation;
- Sound files can be easily shared;
- The marginal cost of data acquisition is zero;
- Logger installation locations can be geo-tagged;
- Data from any given logger deployment can be compared to data from previous deployments;
- Data can be collected and analyzed remotely; and
- Leaks can be correlated without deploying crews into the field.

Acoustic loggers may be deployed temporarily in “lift and shift” mode or permanently using “fixed network mode”. Data can be collected either from the loggers themselves, by patrolling the loggers, or remotely through the cellular network.

With the ease of collecting and analyzing data and the advantages over traditional leak detection methodologies, acoustic loggers have emerged as a transformative technology that can be used in conjunction with an overall water loss management program, including water audits and flow monitoring, to proactively find and repair water leaks in an effective and affordable manner.

INTRODUCTION

The summer of 2015 has provided a stark reminder that water is one of our scarcest and most valuable resources. All across Western Canada, warm dry conditions have resulted in municipalities imposing water restrictions on their citizens. As the effects of climate change continue to impact our planet, warm and dry may be the new normal which means that as stewards of our water resources, municipalities will need to become more diligent in combatting water loss.

Acoustic leak detection is one of the tools at the disposal of municipalities and with recent technological developments in the form of acoustic loggers, municipalities have the opportunity to integrate acoustic listening into their overall water loss management strategy in a much more proactive manner. This paper discusses traditional acoustic listening methodologies, the advent of acoustic loggers and how they can be used in conjunction with water audits and flow monitoring programs.

ACOUSTIC LISTENING – THE TRADITIONAL WAY

Traditionally, water distribution systems have been inspected for leaks using a ground microphone and digital correlator. A technician would walk along the pipeline with a ground microphone and listen along the pipeline, at valves, and at hydrants to determine if they could detect the sound of water escaping the pipe (see Figure 1). This method continues to be used by municipalities all across Canada and can be an effective method for finding water leaks. However, there are several limitations that can be overcome using more modern acoustic logging technology.

Figure 1

The primary limitation of traditional acoustic logging methods is that the human ear cannot be calibrated. As a result, each technician will hear and interpret the sounds that they are experiencing differently and report different results. Accordingly, leaks may be missed or be misinterpreted, resulting in false positives, depending on the technician's ability to accurately detect and differentiate between minute changes in tone and frequency.

In addition to data being reported inconsistently, traditional acoustic methods do not allow for effective logging of the data collected in the field. This manifests itself in a number of different ways. First, there is no record of the specific locations where a technician has stopped to listen for a leak. Second, when a technician returns to a particular location minutes, days, or months after they or another technician was at that location, they have no way of comparing the data that they are collecting to data previously collected at that location. Small changes in the frequency

of sound at a particular location may be an indication of water loss, but since there is no way of recalling what sound was detected at that location previously a small change may go undetected and the opportunity for catching a leak when it is small and easy to manage lost.

The third limitation around traditional acoustic methods is an issue of safety and cost. A leak by definition is represented by the lowest constant sound that can be detected along a particular length of pipe. In order to determine the lowest constant sound, it is most effective to collect data at periods of lowest flow, typically between 1 am and 5 am. Having individuals working at these hours in the dark raises a number of safety issues that must be mitigated in order to complete the survey safely. In addition, if additional data is desired from a specific location or area, the cost of acquiring that additional data is the same as the cost of acquiring the initial data, literally doubling the cost of the overall survey.

While traditional methods have these limitations, they have served the industry well for many years and may be sufficient for some municipalities with newer infrastructure or very low levels of nominal water loss. However for most Canadian municipalities the advent of acoustic loggers affords an opportunity to integrate their water leak detection program with their overall water loss management strategy and take a much more analytical and cost effective approach to finding and repairing water leaks early.

ACOUSTIC LOGGERS – AN OVERVIEW

Acoustic loggers are acoustic listening devices which are installed throughout the water distribution system, typically in valve boxes, on hydrants, or in manholes. The loggers are programmed to turn on early each morning when traffic noise and water use are at their lowest levels and collect acoustic data that can then be consolidated and analyzed to determine the probability of leaks. Figure 2 depicts a logger installed in a manhole.

Figure 2

Modes of Deployment

There are two modes of logger deployment: "lift and shift" mode and "fixed network" mode. In "lift and shift" mode, loggers are temporarily installed in a particular area with data collected over a period of time determined by the municipality. Once data for that area is collected, the loggers are "lifted" out of their installation locations and "shifted" to new locations in a different area and the process repeated. While the loggers are installed, the data can be collected as frequently as desired. If the municipality wishes to collect additional days of data from any given area, the marginal cost to do so is zero. This is a significant advantage over traditional methods where the marginal cost to collect one additional day of data is the same as the initial cost.

In “fixed network” mode the loggers are permanently installed in a given area which can be as large as the entire distribution system. This mode is typically recommended where the cost of distributing water is high or where there are specific areas that are deemed high risk due to age of infrastructure or other factors that warrant permanent monitoring. Data is collected and analyzed daily using one of a number of data collection methods.

Data Collection

Data from acoustic loggers can be collected in one of three ways. Loggers can store several days’ worth of data on the logger itself. When operating in “lift and shift” mode where the loggers are only going to be installed in a given area for a short period of time before being moved to a different location, the data can be collected directly from the loggers prior to them being shifted to a new location.

Where the loggers will be installed for an extended period of time or where the municipality wishes to analyze the data regularly, data can be collected by patrolling the loggers. This involves driving by each of the logger installation locations with a receiver that will communicate with the loggers as they are passed and receive the most recent data. Transmitted data can be stored and analyzed either on a computer or on a command unit designed to operate with the loggers.

In “fixed network” mode, data can be collected remotely using the cellular data network. Loggers are programmed to transmit data via a cellular network, through a series of repeaters, and to a GSM box which consolidates the data daily and transmits it to an FTP server. Once received by the server, data can be viewed and analyzed either through a web interface or using desktop software. Daily reports can also be emailed or sent via text to a number of individuals designated by the municipality so that any urgent matters can be quickly identified and responded to. Once the network is established, there are virtually no additional labour costs associated with collecting data.

Once the data is collected, the advantages of acoustic loggers over traditional methods becomes readily apparent.

DATA ANALYSIS USING ACOUSTIC LOGGERS

Acoustic loggers provide several advantages over traditional methods, most of which revolve around the ability to collect, store, and analyze data. The first advantage is in the types of data that can be stored.

Sound Frequency

One of the pieces of data reported by acoustic loggers is the frequency of the lowest constant sound detected. This is a numeric indication of the lowest constant sound and is not subject to interpretation by a technician. This mitigates one of the challenges with traditional methods, that being the inconsistency of data. Figure 3 depicts a history table which shows data from a small number of installations over several days.

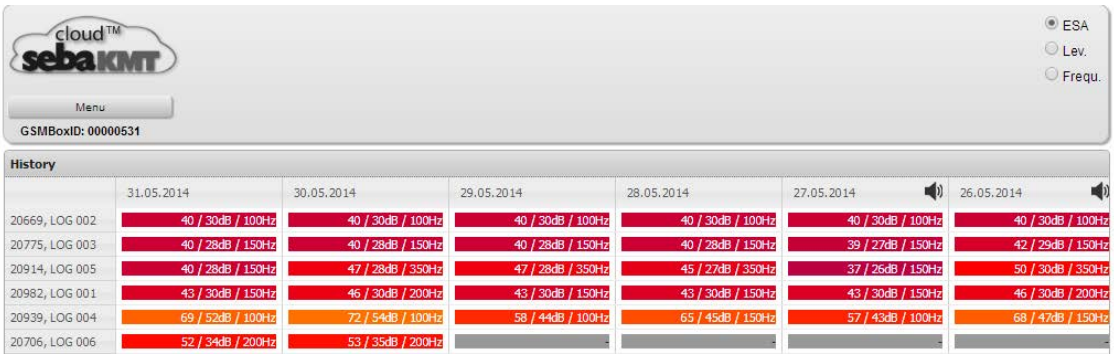

Figure 3

Sound Files

In addition to the numerical data, a sound file of the lowest constant sound can also be collected without having to attend the location with a ground microphone. This sound file can be shared electronically with all members of the project team to validate whether sounds detected by the loggers are in fact leaks. By being able to easily collect and share this data, the municipality can avoid deploying crews on false positives or at least mitigate the risk of doing so by having several individuals confirm the leak rather than relying on the interpretation of a single technician.

Geo-Position

The GPS location of each logger installation can be identified, logged, and overlaid on a map (see Figure 4). This allows data for any given location to be compared to data previously collected at that location with any changes being readily identified and investigated.

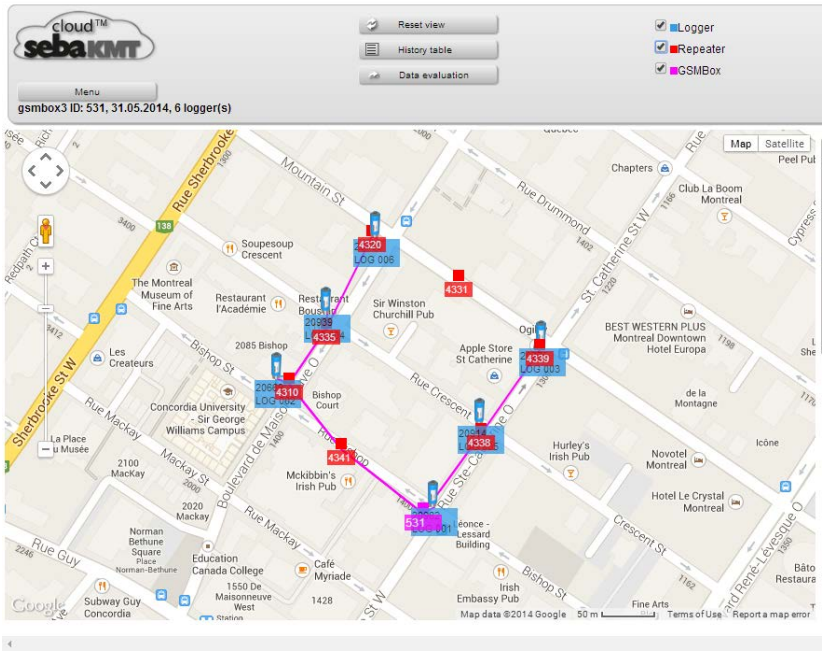

Figure 4

Figure 4 represents a small fixed network installation where the loggers are depicted in blue, repeaters depicted in red, and the GSM box depicted in purple. The lines connecting the items represent the communication path between the loggers, repeaters, and GSM box.

Leak Probability Indication

When the loggers are programmed, the municipality is able to indicate a frequency threshold where they wish to be notified of a probability of a leak. In "fixed network" mode, one of the valuable pieces of data is a colour coded indication of leak probability. In instances where a large number of loggers are deployed, this visual indication allows a user to focus on the highest risk areas first rather than sifting through the data from each logger to determine where there may be issues. Figure 3 provides an example of the colour coded probability of a leak for each of the depicted loggers.

Correlation Data

Whether deployed in "lift and shift" or "fixed network" mode, acoustic loggers are able to correlate leaks either in the field, online, or using desktop software. Correlating using acoustic loggers is similar to using a digital correlator in that the most accurate results will be obtained when the specific details of the pipe including material, diameter, and length can be accurately provided. Figure 5 depicts a sample online correlation using acoustic loggers in network mode. In this example, the leak is 901 feet from Logger #2 in the direction of Logger #4. It is recommended that a ground microphone be used to pinpoint the leak prior to initiating repair activities.

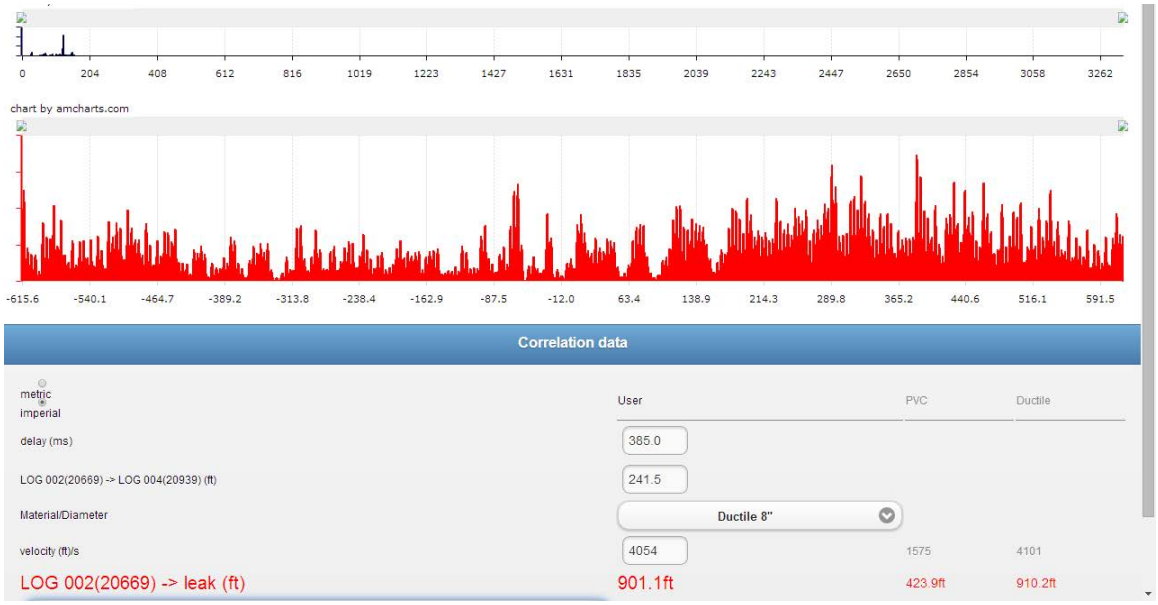

Figure 5

With their ability to collect and analyze several types of data and by being able to collect that data in a cost effective manner, acoustic loggers can be implemented into a comprehensive water loss management program.

WATER LOSS MANAGEMENT AND ACOUSTIC LOGGERS

Water Audit

The first step in any comprehensive water loss management program is the completion of a comprehensive water audit using AWWA Standard M36. It is recommended that prior to initiating an acoustic logger deployment, an audit be completed for two reasons. First, by completing the water audit the municipality will be able to confirm that water losses are in fact due to leakage and not some other factor. This information will allow the municipality to deploy their resources toward addressing the actual problem rather than running the risk of making a decision as to whether or not to embark on an acoustic logging program without knowing the amount and cause of water loss.

The second reason for completing a water audit is to determine the volume and cost of water lost through leakage. Once this is known, a cost / benefit analysis can be conducted to determine whether a comprehensive acoustic listening program will add value.

Flow Monitoring

An acoustic logging program provides a perfect complement for municipalities undertaking flow monitoring programs. One of the challenges with flow monitoring programs is while they identify areas where water loss is suspected and provide an estimate of the amount of water being lost, they are not proficient at pinpointing where in the distribution network leakage is occurring. Areas that have been identified as high risk through flow monitoring can be inspected using loggers in “lift and shift” mode relatively quickly to identify specific leak locations so that the amount of water loss can be minimized.

Whether used as part of a flow monitoring program or on their own, a water loss management strategy including the deployment of acoustic loggers will assist municipalities to proactively identify and repair leaks in their water distribution system.

Proactive Leak Detection

Municipalities in Canada have historically taken several approaches to water leak detection. In some cases, a reactive approach is preferred where water leaks are only considered when water starts exuding from the ground or when a customer complains that their basement is flooding. In other cases, a contractor is brought in periodically to perform a traditional water leak detection survey. Very few municipalities take an aggressive proactive approach to water leak detection and given the limitations of traditional methods this is understandable. However, as we have seen over the past several months with the number of water restrictions imposed throughout western Canada, proactively minimizing the amount of water lost through leakage will be critical in the years ahead. Figure 6 demonstrates the benefits of being able to identify and repair leaks early.

Leak Type	Water Loss per hour Liters	Water Loss per hour Imp Gallons	Water Loss per hour m3	Water Loss per day Liters	Water Loss per day Imp Gallons	Water Loss per day m3	Water Loss per year Imp Gallons	Water Loss per year m3	Estimated Annual Cost @ $0.50 per m3
Leaking Curb Box	500	109	0.5	12,000	2,639	12	963,464	4,380	**$2,190**
Leaking Valve	500	109	0.5	12,000	2,639	12	963,464	4,380	**$2,190**
Leaking Hydrant	750	164	0.75	18,000	3,959	18	1,445,197	6,570	**$3,285**
Leaking Service Pipe	3,000	659	3	72,000	15,837	72	5,780,789	26,280	**$13,140**
Leaking Main	5,000	1,099	5	120,000	26,396	120	9,634,649	43,800	**$21,900**
Mains Break	35,000	7,698	35	840,000	184,774	840	67,442,556	306,600	**$153,300**

Figure 6

With the advent of acoustic loggers, a proactive water leak detection strategy using sophisticated technology that allows for the collection and analysis of data in an effective and affordable manner is now possible. Simply deploying a small fleet of loggers in "lift and shift" mode in high risk areas is an easy way to start down the path of proactive leak detection for municipalities of all sizes. As data is collected, additional loggers can easily be added to increase the scale of the deployment as required.

CONCLUSION

Acoustic loggers offer several advantages over traditional water leak detection methods:

- Several types of data are available;
- Data is delivered in a consistent manner without subjective interpretation;
- Sound files can be easily shared;
- The marginal cost of data acquisition is zero;
- Logger installation locations can be geo-tagged;
- Data from any given logger deployment can be compared to data from previous deployments;
- Data can be collected and analyzed remotely; and
- Leaks can be correlated without deploying crews into the field.

Municipalities will come under increased pressure in the coming months and years to minimize water losses. Acoustic loggers, along with water audits and flow monitoring programs, will allow municipalities to proactively manage water losses in an efficient and affordable manner.