AMR for Water Distribution System Leak Detection

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Infrastructure Engineer
American Water
American Water

- Largest investor-owned water services provider in North America
- Serves 16.2 million people
- Operations in 32 states and Canada
- 7,000 employees
- Owns and operates or operates 789 water treatment plants and 56 wastewater treatment plants

- 308 individual service areas
- 44,000 miles of distribution mains
- 84 surface water treatment plants
- 624 groundwater treatment plants
- 913 wells
- 175,000 Fire Hydrants
Acoustic Monitoring Device

- Using a low-cost, waterproof sensor installed near the water meter
- Easily strapped to service pipe
- Can detect noise into system,
  - about 500 feet through metallic pipe
  - 300 feet through plastic pipe
- Maintenance-free, 10+ years (battery)
- Read through AMR communication interface or as independent radio unit

Graphics courtesy of Flow Metrix/Itron
AMR Fixed Network and Acoustic Monitoring

Schematic courtesy of Hexagram
Connellsville is located along the steep Youghiogheny River valley forty miles south of Pittsburgh.

System dates back to 1880’s. Mostly cast iron and galvanized steel but also AC, ductile, & plastic. About 38 of 57 miles of main are over 100 years old.

NRW was over 25% and the cost of water (purchased from an adjacent system) is $1.90 per thousand gallons.
How Does It Work?

- Monitor “listens” and identifies the minimum sound in 10 minute intervals between 12:30 and 4:30 AM when water use and other noise sources are minimal.

- The single nightly data point is broken down into a spectrum of sound associated with leak noise and shows low, medium and high frequencies as well as a sum of the leak noise frequencies for ferrous and plastic.

- The monitor also reports on the highest differential between the lowest noise and the highest (red).

- The software interprets changes and magnitude of sounds to rate the location as a possible source of a leak.
Snapshot of Leak Survey Data

The acoustic monitor data is organized and highlight the most likely candidates for leak noise to check.
Continuous Leak Survey Data

The software displays a history showing the noise level at each day.
Tracking Leak Sound History

An MLOG located near a cast iron main leak indicates a leak running April 1, 2006 until November 23, 2006.
Initial 2005 Connellsville Results

- 487 MLOG leak detecting sensors were installed in Connellsville in Spring 2005.

- Five one week correlation studies were conducted by Flow Metrix and American Water staff in June, July, August, October, December 2005. A total of 129 locations were visited in 2005.

- From June to December 2005 46 leaks were reported in Connellsville (18 the same period in 2003, 12 in 2004).

- 24 of the 46 leaks were identified by acoustic monitors and repaired in advance of surfacing. Another 10 were MLOG identified before surfacing but appeared before repair made. The remaining 12 surfaced and were repaired.

- With the reduction of blow-off flow and leaks, flow is consistently down about 255,000-285,000 gpd in 2006.
Finding the Leak that Never Surfaces

This leak was destined to flow to the nearby river or into the storm sewer above without coming to the surface for years. Found by acoustic monitoring.
Piloting Results 2006

- 19 of the 40 leaks were identified by acoustic monitors and repaired in advance of surfacing. Another 6 were MLOG identified before surfacing but appeared before repair made. The remaining 15 surfaced and were repaired.

- Link to water temperature became apparent in the fall.

We can actually anticipate leak starts occurring mostly after a water temperature drop in surface supply systems.
Piloting Results 2007

- In a year of very cold temperatures 18 of the 68 leaks were identified by acoustic monitors and repaired in advance of surfacing.

- Another 12 were MLOG identified before surfacing but appeared before repair made. The remaining 38 surfaced and were repaired including at least 18 breaks which are believed to have surfaced immediately and could not be detected before repair.

- Many of the immediate failures were splits and circumferential failures of cast iron pipe. The monitors continue to detect about half of the smaller pipe failures that are more likely to run for extended time though at lower flows.
Changing the Pattern of Leaks

This line shows typical cyclic pattern of leaks before MLOG

MLOG operational late Spring 2005
Not All Leaks Found by Acoustic Monitoring

- MLOGs have missed some long standing leaks in Connellsville for a variety of reasons:
  - MLOGs placed out of range of some leaks (more units will be added)
  - MLOG failures in meter pits (a more resilient model is being installed)
  - Pipe material (repair) transitions mask out sound
  - Background sounds hide leak noises
  - Potential for loss of contact with pipe

- AMR system continues to reliably transmit meter readings so communication network is intact but there can be incomplete data sent causing MLOG data to “skip.”
AMR Piloting at American Water

- Research in Connellsville.
  - AwwaRF AMR Project and AWWARF Cross Connection Project will examine AMR and “alarms” detecting metered backflow

- Other pilots with AMR fixed network system:
  - Itron in Irvington, NJ system – also part of the AwwaRF AMR Project with emphasis on identifying customer leaks
  - Hexagram/Gutermann with leak noise correlation in Metro Chicago
  - Future testing ahead for advanced systems from Datamatic, Neptune

- Evaluation of alternative acoustic monitoring compatible with mobile AMR.
  - Permalog systems active in PA and other states

- Radio MLOGs will be combined with mobile AMR.
Questions Being Answered

Leaks are detected usually up to 400 feet but have, on occasion been detected in the range of 1000 feet. Leak sound does dissipate over distance especially where pipe materials changes from metal to plastic and back.

User detection skills have improved with experience. Sound history and knowledge of background noise sources helps discern between leak and other noise.

Pinpointing leaks can be accomplished by one man and leak noise correlator in between 30-90 minutes. Correlators can be compromised by daytime noise. Mixed results from overnight correlation.

Definite higher noise in extremes of heat and cold. There are patterns. Optimum time for leak detection appears to be the fall.
Questions Answered in Assessing Continuous Leak Detection as an AM tool

- If the utility is performing this analysis, a weekly or biweekly analysis seems to be effective. The vendor is setting up a web site that could provide daily alerts on significant changes.

- It appears that about 50-75% of leaks start as small leaks. Splits and circumferential breaks are more likely to surface rapidly. Many of the cast iron pipe breaks are not readily detected slow evolving breaks.

-Leaks become surfacing bursts in a time range from immediate to months, maybe years. Drainage, surface conditions play a role.

- To date, leaks detected and repaired before surfacing cost 3/4 of other surfacing leaks (and even less compared to leaks we could have detected).
The AMR BOP – a three step process of evaluation for American Water

- Level 1 Screening – eliminates obvious locations where AMR change not practical.

- Level 2 Screening – provides each district an opportunity to gain reasonable view of potential of AMR in systems – to include mobile and fixed network and use of acoustic monitoring for leak detection.

- Level 3 Screening – more sophisticated economic analysis designed to set the table for making a business case for AMR.
Detailing Cost Savings Areas

- Meter reading labor, meter reading supplies, insurance.
- Customer service labor, reduced regulatory complaints.
- Reduced liability claims with breaks.
- Reduced NRW (savings in chemicals, electricity, etc.).
- Reduced cost of service and main repairs.
  - Scheduling repairs
  - Reduced damage
  - Improved system knowledge
  - No need for system wide leak surveys
Level 1 Screening Process

The deal killers. It makes no sense to look at AMR if billing is not going to be monthly or meter reading is highly efficient because it is the major (but not the only) economic driver.

**DON'T LOOK AT AMR IF**

- Reading is not monthly and there is **NO** intent to implement monthly reading
- The number of meters read by staff exceeds 500/day and estimated reads average below 1.5%
- There is already a successful (mobile) AMR system being started and is at least 20% complete
- A substantial meter changeout program has just been completed (50% in last 3 years)
Modeling Benefits versus Costs

- AMR equipment including encoder meter conversions.
- AMR end point (best performed with meter change-out) and collector installations.
- Acoustic monitoring equipment and installation.
- Software changes, training, troubleshooting expenses.
- Increased leak pinpointing expense.
- *Early repair of all leaks does not mean that the total cost of repair is reduced (more leaks to fix initially).*
  - Spending today’s dollars for leak repair may be more than spending tomorrow’s dollars plus cost of lost water.
- Potential depreciation loss and meter purchase costs to accelerate meter change-out to accommodate AMR.
Level 2 Cost Model

- Side by side comparison of mobile AMR and Fixed Network AMS.
- Minimal input from district or system under study.
- Relative value of options expressed in years for payback (less than 5 years is good, 5-8 years is reasonable and more than 8 years increasing less practical at the present time.

AFTER INPUT THIS QUICK SUMMARY PROVIDES A QUICK LOOK AT THE POTENTIAL PAYBACK AND COSTS INVOLVED

<table>
<thead>
<tr>
<th>QUICK SUMMARY</th>
<th>Simple payback time calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>for Fixed Network</td>
<td>8.54 years</td>
</tr>
<tr>
<td>for Mobile AMR</td>
<td>8.30 years</td>
</tr>
</tbody>
</table>
## Level 2 Cost Model - INPUTS

- Straight forward data entry.

### USER INPUTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>District Name/System</td>
<td>Northwest Indiana</td>
</tr>
<tr>
<td>Number of Customers to be Served by AMR</td>
<td>74,500</td>
</tr>
<tr>
<td>Two Letter Abbreviation of State</td>
<td>IN</td>
</tr>
<tr>
<td>Percentage of Meters in Pits</td>
<td>10%</td>
</tr>
<tr>
<td>Percent of Meters to be Changeout</td>
<td>25%</td>
</tr>
<tr>
<td>Number of Full-time Meter Readers</td>
<td>7.00</td>
</tr>
<tr>
<td>Number of Full-time Meter Readers to be Retained</td>
<td>1.00</td>
</tr>
<tr>
<td>Percent of Customers Served That is High Density</td>
<td>40%</td>
</tr>
<tr>
<td>Percent of Customers Served That is Medium Density</td>
<td>50%</td>
</tr>
<tr>
<td>Percent of Customers Served That is Low Density</td>
<td>10%</td>
</tr>
<tr>
<td>Average Day MGD</td>
<td>26.00</td>
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<tr>
<td>Cost to Produce Water</td>
<td>$0.50</td>
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<tr>
<td>Percentage of Non Revenue Water</td>
<td>18.0%</td>
</tr>
<tr>
<td>Annual Metered Income</td>
<td>$25,000,000</td>
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<tr>
<td>Number of Reads for Billing</td>
<td>12</td>
</tr>
<tr>
<td>Percent of Meters Already Part of a Mobile AMR System</td>
<td>0%</td>
</tr>
<tr>
<td>Time in Years to be Used to Install AMR Transmitters</td>
<td>4</td>
</tr>
</tbody>
</table>
Level 2 Cost Model - OUTPUTS

- Summarizes costs, provides for investment/payback profile

<table>
<thead>
<tr>
<th>COST SUMMARY</th>
<th>Fixed Network AMS</th>
<th>MOBILE AMR</th>
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</thead>
<tbody>
<tr>
<td>SUMMARY OF CAPITAL COSTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMR system</td>
<td>$5,831,688</td>
<td>$4,450,788</td>
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<tr>
<td>AMR installation</td>
<td>$1,160,338</td>
<td>$908,900</td>
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<tr>
<td>LEAK MONITORING system</td>
<td>$814,844</td>
<td>$801,806</td>
</tr>
<tr>
<td>LEAK MONITORING installation</td>
<td>$26,075</td>
<td>$18,578</td>
</tr>
<tr>
<td>TOTAL CAPITAL COSTS</td>
<td>$7,832,944</td>
<td>$6,180,072</td>
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<tr>
<td>SUMMARY OF ANNUAL OPERATING COSTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AMR operating and maintenance</td>
<td>$141,550</td>
<td>$25,330</td>
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<tr>
<td>LEAK MONITORING operating and maintenance</td>
<td>$15,319</td>
<td>$16,297</td>
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<td>SUBTOTAL ADDITIONAL OPERATING COSTS</td>
<td>$156,869</td>
<td>$41,627</td>
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<td>SUMMARY OF ANNUAL OPERATING SAVINGS</td>
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<tr>
<td>Meter Reading/Customer Service</td>
<td>$724,580</td>
<td>$505,783</td>
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<tr>
<td>LEAK MONITORING savings</td>
<td>$350,023</td>
<td>$279,996</td>
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<td>SUBTOTAL OPERATING SAVINGS</td>
<td>$1,074,603</td>
<td>$785,778</td>
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<tr>
<td>NET ANNUAL OPERATING SAVINGS</td>
<td>$917,734</td>
<td>$744,151</td>
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Payback 8.5 years and 8.3 years
AMR COST MODEL – Understanding and Building the Business Case

The model is flexible for Districts to input their own data as AMR costs vary between American systems as function of system size, density, staffing and location.

The comprehensive model assesses MLOG as savings from reduction of NRW will vary depending on cost of water, amount of NRW and effectiveness of MLOG.

Model will look at cash flow and depreciation in format for Finance and Capital Planning offices to analyze.

### SUMMARY OF ANNUAL OPERATING COSTS

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
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<tbody>
<tr>
<td>AMR operating and maintenance</td>
<td>$63,549</td>
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<td>MLOG operating and maintenance</td>
<td>$9,426</td>
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### SUMMARY OF ANNUAL OPERATING SAVINGS

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<thead>
<tr>
<th></th>
<th>Amount</th>
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<tbody>
<tr>
<td>Meter Reading</td>
<td>$886,791</td>
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<tr>
<td>Customer Service</td>
<td>$66,020</td>
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<tr>
<td>MLOG savings</td>
<td>$1,157,506</td>
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### NET ANNUAL OPERATING SAVINGS

<table>
<thead>
<tr>
<th></th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>simple payback time calculation</td>
<td>3.76 years</td>
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### AMR Annual Income Impacts

- Free cash flow
- Net income
Discussion: Leakage, AMR and Customer Service

Leaks on the customer side of the meter can be captured and confirmed quickly with the fixed network AMR, continuous flow sensing meters and/or acoustics. Alerts may occur well before bills are issued.

This provides the opportunity to notify the customer before that next bill of a leak and before the bill gets extremely large. American Water then becomes proactive rather than reactive defending high use and large customer bills.
Innovation Continues – creates issues related to best timing

Several AMR firms have developed mesh networks for water utilities:

- Mesh network permits AMR units to transmit between units and reduce the number of collector units – a major savings for AW.

- Mesh network allows for two way communication.

At least two firms have a working shutoff valve that is operated by fixed network and mobile AMR.

- Shutoff capability would have major impact on transfer of properties.
Innovative Continues

- New interfaces with other leak detection firms to offer other leak sensing options.
- An integrated transmitter inside a standard street valve box.
- A new pilot in Connellsville to detect backflow via meters will send an immediate alarms in the event of backflow as well as tampering and continuous metered flow.
Innovative Continues

- An AMI actuated shutoff valve being tested by PA American

- Some AMI vendors are introducing mesh technology that allows units to relay from one transmitter to another – reducing the number of data collectors

- Some AMI firms are working towards the single solution that migrates from touch pad to mobile to fixed network
Act or Await Innovation

- Mesh technology could provide a major cost reduction associated with data collectors and obtaining sites for collectors that might ordinarily be located on private property.

- Actuated valves could have serious cost implications for seasonal use meters and high rates of delinquent customers.

- Migrating from one technology to another allows for easy transition and an alternative approach in case of system breakdowns.

  - Utilities must decide whether to wait for the next improvement or jump in now and possibly miss an important development.