ACCURATE MEASUREMENT OF MINIMUM NIGHT FLOWS FOR WATER LOSS ANALYSIS

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ABSTRACT

Continuous monitoring of night flows into water supply zones or district metered areas is an important operational tool for identifying water loss within a reticulation network. There are a number of points that must be taken into account when designing and installing a metering solution for monitoring minimum night flows. Meters must be sized correctly to strike a balance between accuracy at low flows and head loss at high flows. Care must be taken during installation to ensure that flows are accurately measured and that the electrical connections, including power supply, are all correct. Another important consideration is programming of the meter to give desired outputs and how data is collected, viewed and analysed. Most meters have both analogue and digital outputs and may be logged using telemetry-based dataloggers or connected to an existing SCADA / telemetry system. By ensuring metering is accurate and the results are interpreted correctly, local water utilities will have the tools in place to manage water loss in their systems and achieve sustainability of savings through ongoing monitoring.

KEY WORDS

Water loss; minimum night flow; magflow meters

1.0 INTRODUCTION

Continuous monitoring of night flows into water supply zones or district metered areas (DMAs) is an important operational tool for identifying water loss within a reticulation network. Under the Water Loss Management Program (WLMP), a joint initiative of the NSW Water Directorate and Local Government and Shires Associations of NSW with funding from the Australian Government's 'Water for the Future' Program, over 200 magflow meters have been or will be installed by local water utilities (LWUs) in NSW for the purpose of monitoring flows into DMAs, with particular attention paid to night flows for water loss assessment.

The average minimum night flow data gathered from these meters is used to determine whether or not it is warranted to undertake an active leak detection survey of the pipe network. It is input to the WLMP's proprietary District Metered Area Analysis software along with network details (such as kilometres of mains, system pressure, pipe details and number of connections) and industry standards for unavoidable background leakage to come up with a prediction of water loss in megalitres (ML) per year. From this prediction, an economic analysis can be undertaken to determine if the volume of water that could be saved via leak detection and repairs justifies the expense of an active leak detection survey. Funding of up to 33% of project costs is available through the WLMP.

The metering solutions put in place by LWUs during the program are intended to be an ongoing tool for system management that will ensure sustainable water savings result from the funding provided by the Australian Government.

To date, 3,500 megalitres (ML) of water have been saved across 75 participating utilities as a result of the metering, leak detection and pressure management works, with significant additional savings expected by the end of the project in June 2011. This paper examines some of the issues that have arisen during the metering works undertaken by LWUs, and outlines the key points to take into consideration when designing a metering system for accurate measurement of night flows.

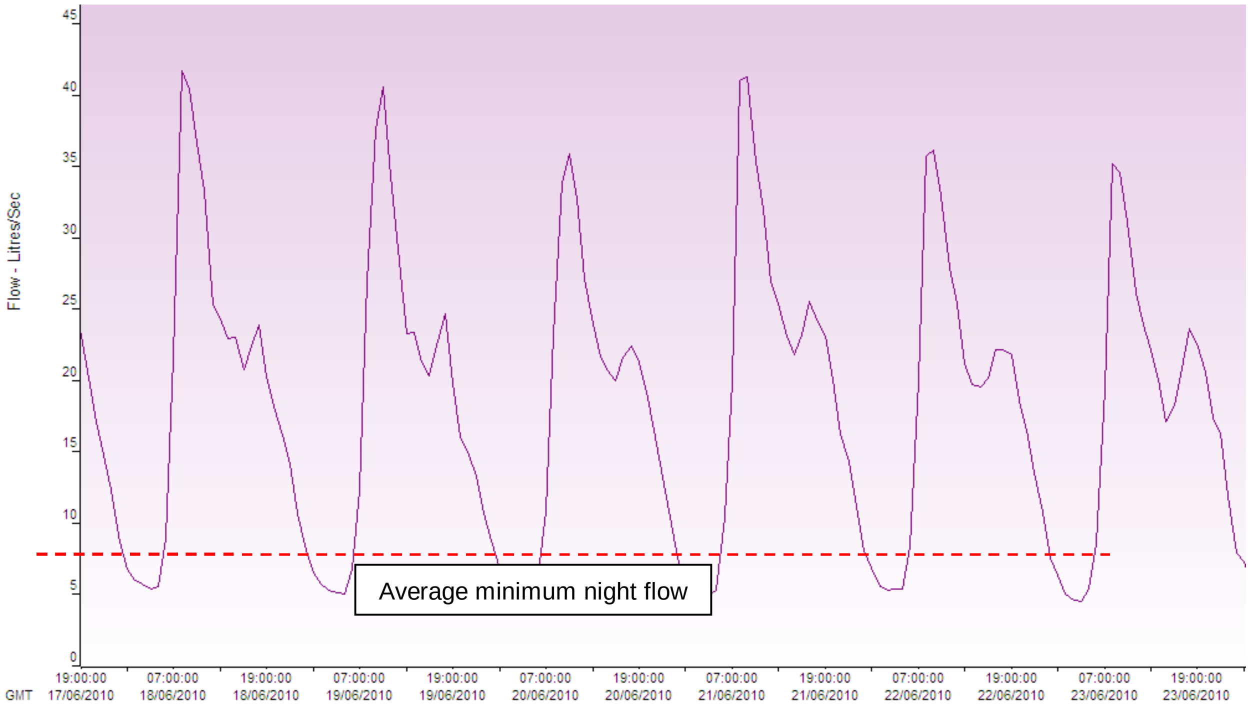
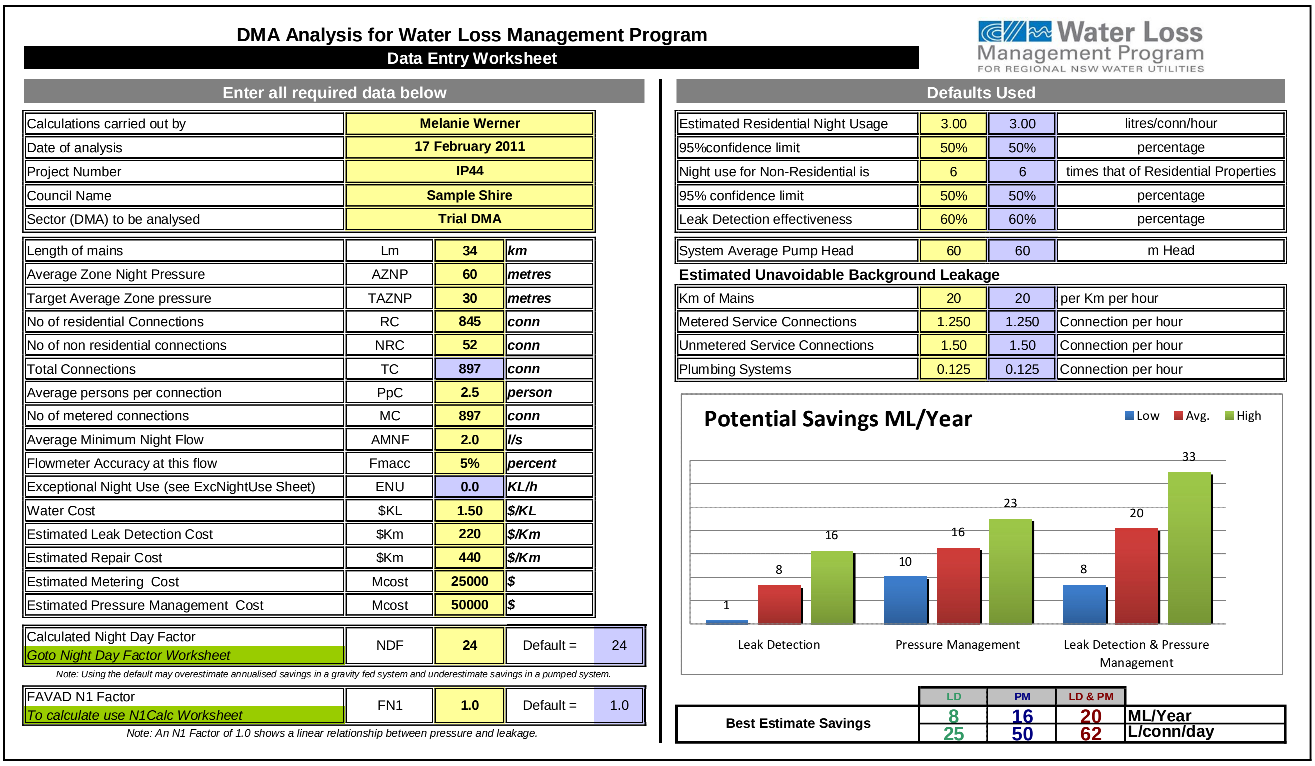


Figure 1: ***Typical diurnal flow trace into a District Metered Area (DMA)***



DMA Analysis for Water Loss Management Program

Data Entry Worksheet

Water Loss Management Program FOR REGIONAL NSW WATER UTILITIES

Enter all required data below

Calculations carried out by	Melanie Werner		
Date of analysis	17 February 2011		
Project Number	IP44		
Council Name	Sample Shire		
Sector (DMA) to be analysed	Trial DMA		
Length of mains	Lm	34	km
Average Zone Night Pressure	AZNP	60	metres
Target Average Zone pressure	TAZNP	30	metres
No of residential Connections	RC	845	conn
No of non residential connections	NRC	52	conn
Total Connections	TC	897	conn
Average persons per connection	PpC	2.5	person
No of metered connections	MC	897	conn
Average Minimum Night Flow	AMNF	2.0	l/s
Flowmeter Accuracy at this flow	Fmacc	5%	percent
Exceptional Night Use (see ExcNightUse Sheet)	ENU	0.0	KL/h
Water Cost	$KL	1.50	$/KL
Estimated Leak Detection Cost	$Km	220	$/Km
Estimated Repair Cost	$Km	440	$/Km
Estimated Metering Cost	Mcost	25000	$
Estimated Pressure Management Cost	Mcost	50000	$

Calculated Night Day Factor / Goto Night Day Factor Worksheet	NDF	24	Default =	24

Note: Using the default may overestimate annualised savings in a gravity fed system and underestimate savings in a pumped system.

FAVAD N1 Factor / To calculate use N1Calc Worksheet	FN1	1.0	Default =	1.0

Note: An N1 Factor of 1.0 shows a linear relationship between pressure and leakage.

Defaults Used

Estimated Residential Night Usage	3.00	3.00	litres/conn/hour
95%confidence limit	50%	50%	percentage
Night use for Non-Residential is	6	6	times that of Residential Properties
95% confidence limit	50%	50%	percentage
Leak Detection effectiveness	60%	60%	percentage
System Average Pump Head	60	60	m Head

Estimated Unavoidable Background Leakage

Km of Mains	20	20	per Km per hour
Metered Service Connections	1.250	1.250	Connection per hour
Unmetered Service Connections	1.50	1.50	Connection per hour
Plumbing Systems	0.125	0.125	Connection per hour

	LD	PM	LD & PM	
Best Estimate Savings	8	16	20	ML/Year
	25	50	62	L/conn/day

Figure 2: ***WLMP DMA Analysis Tool***

2.0 DESIGN, LOCATION AND INSTALLATION OF METERS

The night flows into a zone should ideally be measured with an accuracy of better than ±10% of calculated theoretical minimum night flows. This is the minimum flow that would be expected in a zone with no recoverable leakage (i.e. only unavoidable background leakage). It is a conservative estimate and flows do not normally get to those levels. Meter accuracy will therefore improve as flows increase above the calculated minimum.

To achieve the required flow velocity for a magflow to measure with the desired accuracy, the meter often needs to be smaller than the pipe feeding the area (e.g. a reservoir outlet pipe). This reduction in size can be achieved by 'tapering down' to a smaller meter but a balance must be achieved so as to not create excessive head loss. Meter sizing tools or advice available from manufacturers should be utilised to achieve this balance.

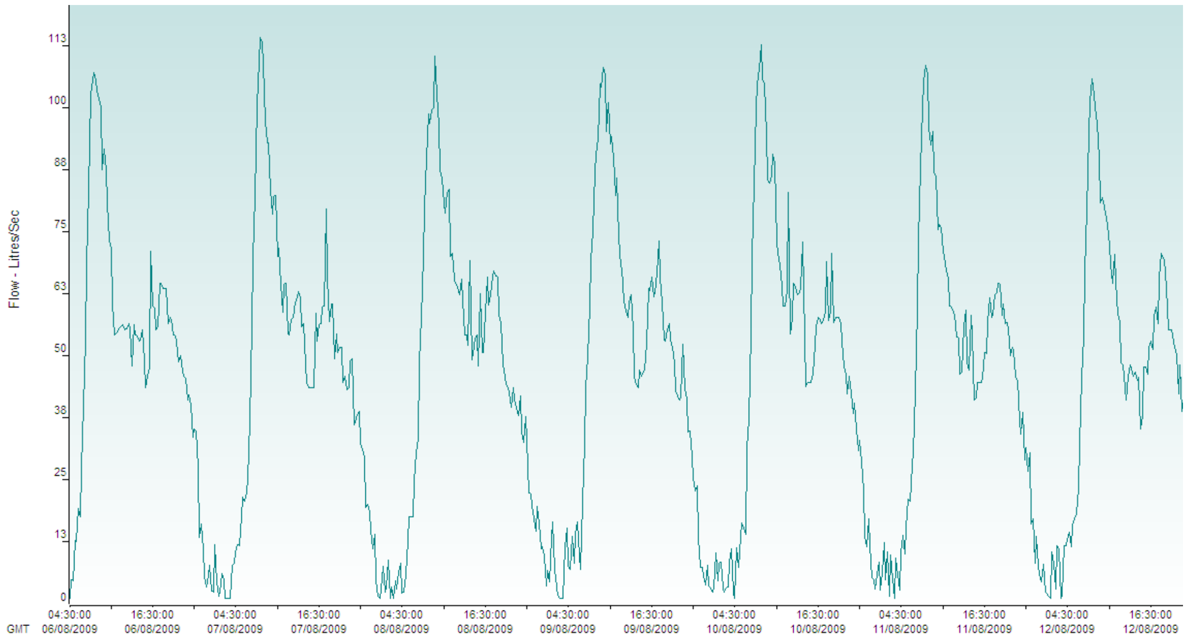


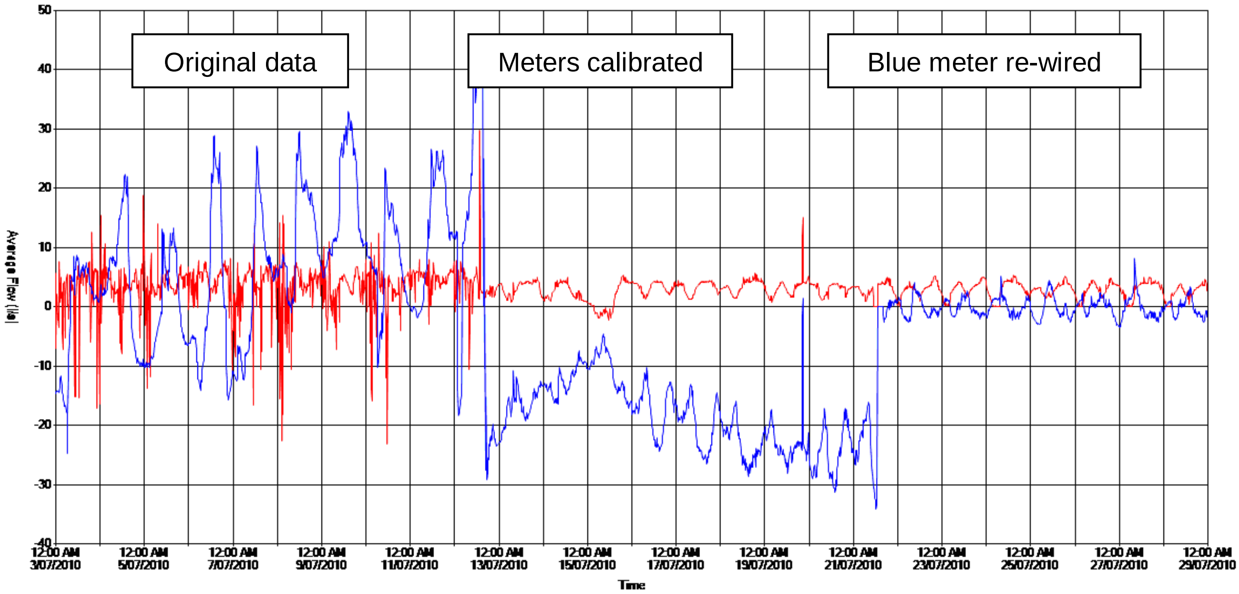
Figure 3: ***Oversize meter measuring with low accuracy at minimum night flows***

The location/s of meters must also be given careful consideration. All feeds into a zone need to be captured. Changes to reticulation operation may be needed to minimise the number of meters required. Alternatively, the use of in-reservoir metering can be considered and may be cost-effective if the alternative is multiple meters on lines outside the reservoir.

When installing the meter, manufacturers' specifications should be closely adhered to. Thought must be given to how both the meter flow tube (sensor) and transmitter (or converter) will be protected. For the sensor, options include direct burying or installation in a concrete pit with a lid, a simple sewer manhole or a hydrant box for protection. For the transmitter, access is a higher priority so that programming, meter readings and regular verification can be carried out. These units are often best placed with dataloggers or telemetry systems in an electrical cabinet above ground that is protected from the elements and can be easily accessed. Water ingress can be a major problem for meter electronics and 'potting' the connections at both the transmitter and sensor will protect against this.
Power supply is another important consideration. Mains, battery or solar power are the main options. Whilst mains power may be perceived as more reliable, there are very accurate battery powered flow meters now available with a battery life of up to 5 years.

These can be combined with battery powered loggers to give a totally battery supplied solution for metering and logging, which can save on the expense of connecting mains power to a site. It does however require programmed maintenance of battery replacement. The service life of batteries is getting better all the time, and may increase to 10-20 years in the foreseeable future.

Connections from the sensor flow tube to the transmitter are also critical. The work must be carried out by a suitably qualified technician to ensure the wiring is correct and the appropriate materials used. The graph in Figure 4 shows the outputs obtained from two reservoir outlet meters feeding into a common zone where the meters had not been calibrated since installation and unshielded wire had been used to connect the sensor to the transmitter, resulting in interference and inaccurate readings.



<u>Figure 4:</u> ***Logged outputs of meters which were out of calibration and incorrectly wired***

3.0 METER OUTPUTS AND MONITORING

Magflow meters are typically capable of giving an analogue (4-20mA) and digital pulse (corresponding to a specified volume) outputs. For night flow monitoring, the standard unit of data collected is 15 minute average flow calculated from the pulse outputs. To reduce the influence of short-term fluctuations in flow, this data is converted to hourly averages when calculating average minimum night flows. If 15 minute data were used for those calculations the MNF will be lower, more conservative and more sensitive to fluctuations, potentially indicating there is not a project worth pursuing when hourly data will suggest there is. Logging flows with a frequency less than 15 minutes will generate excessive data that is not required.

The complexity of monitoring is increased when forward and reverse flow are both required, and/or there is more than one meter measuring flows into a zone. The data must be processed appropriately to ensure that net inflow to a zone can be clearly displayed on a graph for simple visual checks of minimum night flow. Programming of magflow meters must also be undertaken carefully to ensure that the desired outputs are obtained. Common issues include specifying pulse lengths which result in missing pulses, being over-generous with analogue scaling leading to poor resolution, setting minimum flow cut-offs which create the illusion of zero night flows (as shown in Figure 5 and so on.

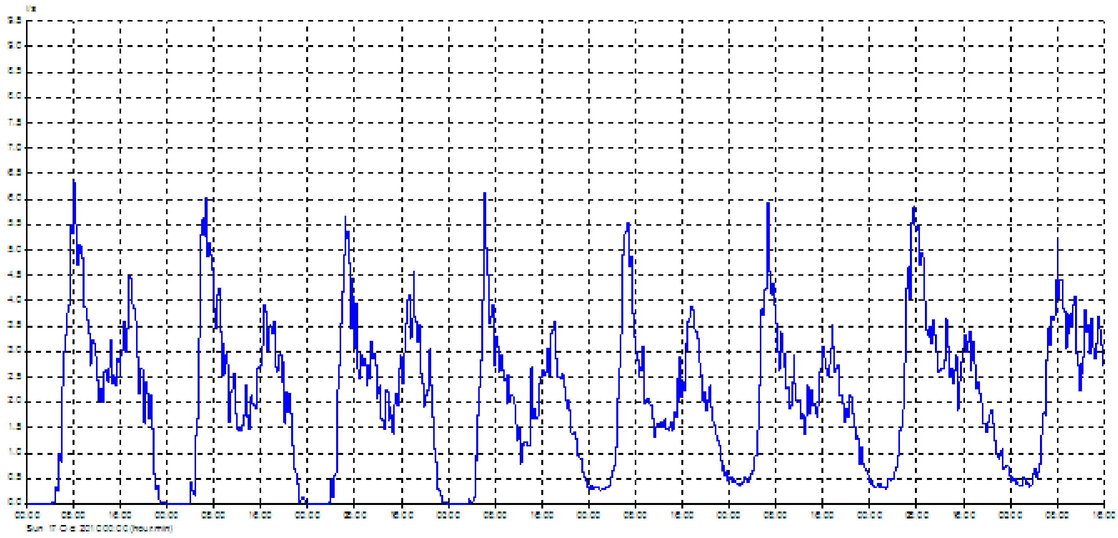


Figure 5: ***Change in night flow once low flow cut-off was removed from meter programming***

3.1 Monitoring Systems

The three main choices for monitoring flow data are as follows:

- A telemetry datalogger system designed specifically for use with district meters
- An existing SCADA system with capacity for flow monitoring
- Online monitoring via a website with data uploaded from GPRS dataloggers.

The relative advantages and disadvantages of these three options are shown in Table 1.

Table 1: ***Advantages and disadvantages of different monitoring systems***

System	Advantages	Disadvantages
Telemetry dataloggers	Designed for district metering purposes – hardware and software Robust and reliable battery-powered dataloggers Low ongoing cost (~$5/month) and can be lower capital cost than SCADA upgrade	Software must be installed on all users' PCs Host PC must always be on for data to be collected Can have reception issues if installed in pits
SCADA system	Flow data is integrated with other aspects of water supply No new software required Can be cost-effective if there is existing capacity for additional inputs at sites	Systems generally not designed for monitoring minimum night flows Monitoring digital pulse outputs may require hardware upgrades Difficult to collect and add / subtract multiple data points at time based intervals. Only new systems will allow.
Web-based monitoring	Data is accessible anywhere there is an internet connection Basic data processing can be done via website	Dataloggers are still being developed Currently ongoing costs are higher than for alternatives ($20-30/month) Can have reception issues if installed in pits

The availability of telemetry dataloggers which use the DMP3 protocol can enable them to be used in conjunction with legacy SCADA systems for flow monitoring in 15 minute or hourly periods. This can overcome the issue SCADA systems have with time stamped rather than interval data so is another alternative for LWUs to consider.

4.0 DISCUSSION

Accurately measuring the night flows in a zone is not simply a matter of matching meter and inlet pipe size and hoping for the best. Careful consideration must be given to the following issues:

- Sizing the meter appropriately for accuracy at low flows / minimal head loss at high flows
- Locating the meter/s so that all inflows to a zone are captured in a cost-effective manner
- Installing the flowmeter sensor and transmitter in accordance with manufacturers' instructions so that they are capable of accurate measurement and protected from the elements or suitably sealed
- Checking all electrical connections and suitability of power supply
- Programming the meter to give the desired outputs
- Scheduling any required maintenance for the meter and monitoring system such as meter verification or battery replacement.
- Selecting the most appropriate tool for monitoring meter outputs on an ongoing basis for sustainable water loss management.

5.0 CONCLUSIONS

The WLMP will, during its lifetime, assist 75 local water utilities to install over 200 magflow meters for flow monitoring. The experience gained from this process has highlighted a number of issues that require consideration when designing and installing a metering and monitoring solution. By paying attention to these issues and obtaining specialist advice where necessary, LWUs can ensure that they develop a solution appropriate to their needs and resources which will allow them to monitor water loss in their reticulation network for years to come. This will guarantee that any water savings achieved as a result of active leak detection and repairs are sustained over the years, and that capacity is built within LWUs for sustainable water loss management.

6.0 ACKNOWLEDGEMENTS

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