METERING QUEENSLAND – DEVELOPMENTS IN MEASURING TECHNOLOGIES

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Abstract

Currently, the Queensland Department of Natural Resources and Water (NRW) is undertaking the installation of water meters on ground and surface water entitlements (generally excepting stock and domestic purposes). Although most of the developed works pump water through a fully charged conduit, Queensland also has the challenge of measuring water taken through gravity-fed partially full pipes and water collected in storages from overland flow.

With the vast range of methods used to take water across the state, some novel solutions have been developed to measure the volume of water taken. These include trials of meters designed for partial pipe and open channel flow, to the development of both a buoy-based system for measuring on-farm storages and dataloggers with customised output for proprietary databases.

The metering process has been instigated to enhance water resource management across the state. To value-add to manual readings of water meters, the decision has been made to install dataloggers on every installation, giving an enhanced dataset of both time and rate of take. Practical implementation of this decision has demanded the development of dataloggers to suit the purpose

This paper discusses the development and testing of various technologies applied to the measurement of water allocations within Queensland.

Introduction

In line with the National Water Initiative, the Queensland Department of Natural Resources and Water (NRW) has been implementing a water meter installation program since 2003. The program involves installing an estimated 10,000 to 16,000 water meters across 49 regional areas of Queensland costing an estimated $100 - 180 million dollars. The majority of meters will be rolled out over the next six to seven years, in accordance with regional and planning priorities. The program targets unsupplemented water allocations with the general exception of those for stock and domestic supply.

NRW's *Metering Water Extractions Policy* was endorsed in May 2005 to cover the metering of unsupplemented water extractions managed by NRW and supplemented water extractions managed by Water Service Providers (WSPs). Under this policy, which was developed to ensure consistent metering practices across the state, meters are supplied and owned by NRW and installed, maintained and read by manufacturer certified contractors engaged by NRW. Water users pay an annual charge which recovers the cost of the metering process.

Queensland is in the unique position of having already made the decision to meter water entitlements prior to the start of the development of national standards for irrigation water meters. NRW has been developing procedures, meter standards and installation specifications to ensure that we align with the national objectives. These procedures are documented in the *Metering*

Process Manual. It is due to this that Queensland is perhaps further through the process, and also the problem solving, than other state jurisdictions.

While the majority of meters to be installed are of the small diameter (50 to 450mm) closed conduit type, there are also large diameter (>450mm to 1800mm) closed conduit, large diameter (up to 1.5m) partially filled pipes and measurement of storage volumes to monitor take from overland flow. Each of these situations has presented its own unique problems. The sites are diversified in location and quality of installation. Water quality at the sites is also variable from clean groundwater supplies to heavily sediment laden waters.

While the meters are owned and maintained by NRW, the costs are recovered from the entitlement holder and so there is an additional motivation for cost effective results. The solutions devised to meet these problems are presented here as the focus of this paper.

Closed Conduit Trials

The Queensland State Government purchasing policy dictates that to maintain fairness and equity, purchases of large volumes of an item which are spread over time should be conducted through a Standing Offer Agreement (SOA). Through this process, suitable suppliers of closed conduit water meters were identified and the offered products were assessed against the guidelines set down by the purchasing program.

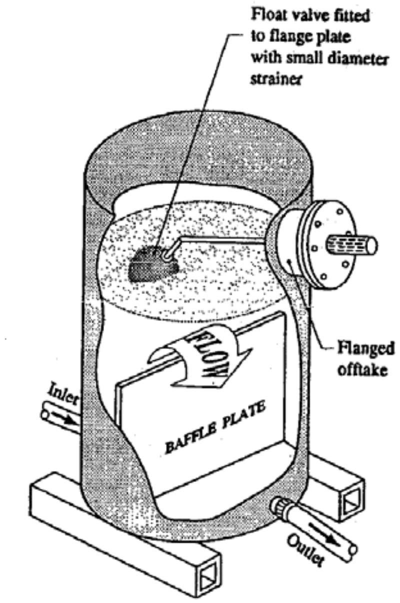
As a further confirmation of meter suitability for our program, it was decided to buy one of each type of meter offered from each supplier and conduct an in situ test over time to assess the performance and gauge the reliability of each product.

The Lockyer Valley, west of Brisbane was chosen for the test due to its proximity to Brisbane and the range of pumping issues presented. The major water source in the valley is groundwater and currently levels are dropping with the result that some of the bores are pumping sand and air. There are also issues with deteriorating water quality. The meters were installed on random sites, unless a particular water quality issue was being tested on a particular type of meter. The meters were visited on at least a quarterly basis with checks being made to ascertain the meters performance in that particular situation.

Most of the meters performed well, however the occasional stoppage of mechanical meters caused by pumped sand particles led to underestimation in metered water usage. It also increased maintenance costs for that style of meter thereby reducing the gap in whole of life costs between the lower initial cost mechanical meter and the more expensive initial cost non-mechanical meter.

Over pumping of some bores causing cavitation in the pump as well as aeration of the water delivery is common in the Lockyer Valley. The aerated deliveries led to overestimation of the actual water usage in mechanical types of meters and underestimation in non-mechanical meters. A gas separation tank was trialled at the borehead to remove the air from the delivery before it passed through the meter. This type of device is currently used on discharge systems from bores in the Great Artesian Basin and is shown in Figure 1. The graph in Figure 2 shows how erratic the flowrate was prior to the fitting of the gas separation device. The mechanical meter had been overreading the flowrate by 75%. Non-mechanical meters have a tendency to under read the flowrate due to failure to account for the ‘pockets’ of air. The gas separation tank also had the benefit of removing sand particles from the water delivery.

The main difficulty that is facing the Department in its implementation of its metering program is the huge variety of conditions that require metering, the lack of information at each of these sites required to make the correct meter choice, and the need to choose a common meter type across an area to minimize maintenance costs.



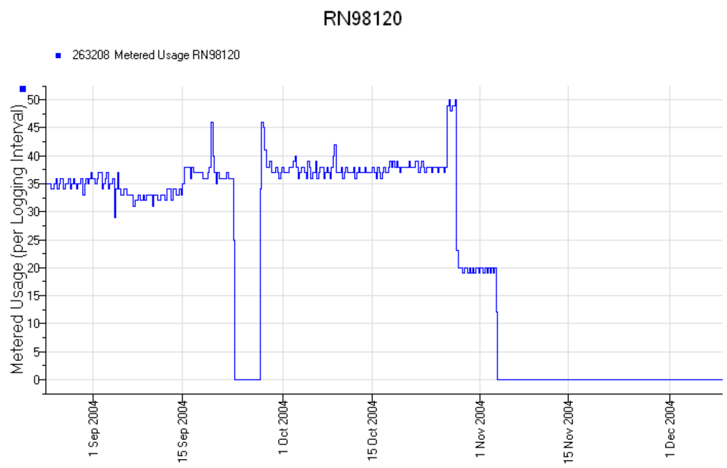


Figure 1: Gas Separation Tank

Figure 2: Measured Flowrate

Manifolding

As previously stated, entitlement holders pay an annual charge which recovers the cost of the metering service. This annual charge is payable for each meter installed and on some properties that have multiple points of take, this can result in a very expensive exercise. In the situation where the points of take are in close proximity and under the same entitlement, it has been possible to link the pipework together (or manifold) so the take by the entitlement holder is able to go through one meter thereby reducing his annual charge.

We are in the process of conducting a trial to determine the accuracy of such an installation. The property that has been chosen has three bores that discharge through 3 individual 50mm meters. Downstream of the individual meters, the discharges are manifolded together which then discharges through a 100mm meter into a surface storage. The operation of the bores is independent of each other and so it is possible to have just one bore discharging through the 100mm meter, well below the normal operating flowrate of the meter. The 100mm meter must also be capable of measuring the flow when all bores are pumping together.

All meters are fitted with dataloggers and the data will be reviewed at the end of the current irrigation period to determine the effectiveness of using a single larger meter.

Insitu Testing

In order to check the accuracy of in service meter installations, a trial of in situ testing was conducted at one of the closed conduit trial sites in the Lockyer Valley. The site was chosen for the ease of adapting existing pipework to accept the additional test meter that was to be installed. An electromagnetic test meter, with a theoretical accuracy of 0.2%, was flow tested at Brisbane Water's Water Meter Testing Facility (BWMTF) to obtain the laboratory accuracy of the meter prior to installation in the field so this could be used to adjust the results obtained. The test meter was installed inline with the meter under test 40 diameters downstream of any bend or obstruction and 20 diameters upstream of any connection back into the existing pipework.

After installation, readings were taken from both meters and then again after at least 14 days of use. The service meter was then removed and flow tested at the BWMTF so we could ascertain what error was associated with the meter and what error was associated with the meter installation. While the service meter was at the BWMTF, a replacement meter was installed, which allowed the entitlement holder to maintain business as usual, but also gave us the opportunity to test a different type of meter in the same pipework configuration. Results are shown in table 1.

Meter Type being tested	Error due to meter	Error due to installation	Total error
Electromagnetic	-0.21	-0.10	-0.31
Mechanical paddlewheel	0.63	3.59	4.22

Table 1: Difference in errors associated with different meter installed in the same pipework

Iron Related Bacteria

The presence of the iron related bacteria (IRB), of which *Gallionella ferruginea* is the most recognised species, is of particular concern due to the build-up produced in the pipe work and meter body. Initially this build-up, in the case of mechanical meters will ultimately stop them, reduces the internal diameter causing the meter to over read. All water meters used for rural applications, whether mechanical or electronic, measure the velocity and coverts that velocity into a volume by multiplying it by the cross sectional area and integrating that over time. A graphical illustration of the resultant error is given in figure 3. It can be seen that even small variations in the internal diameter can cause errors in the installation to be greater than 5%.

The build-up of IRB in the pipe is largely attributed to the bacteria producing a polysaccharide which enables it to stick to the pipe's inner surface. To gain energy out of the oxidation and fixation of iron, they must live in a specific environment that contains "reduced iron, the right amount of oxygen and sufficient amounts of carbon, phosphorus and nitrogen" (Halbach et al, 2001)

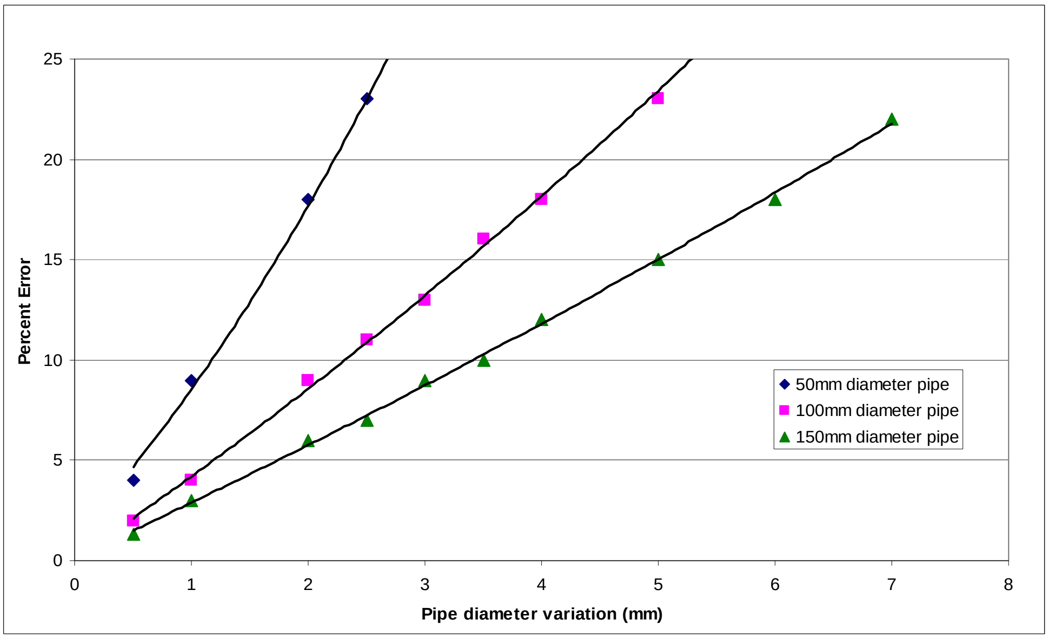


Figure 3: Percent reduction in flow for reductions in pipe diameter

As each site has a different rate of build-up, depending on such things as the population size of the bacteria, flow velocity, pipe material and condition, the cost effectiveness of mitigating strategies is a complex calculation.

Costing exercises have been completed on various cleaning strategies and methodologies in order to provide a basis for the correct assessment of when it is cost effective to install more expensive pipe work and meters to expedite the cleansing process.

We conducted trials of both two and three meters inline to ascertain rates of build-up and the resultant effect on various types of meters. As a result of these tests, and in conjunction with our colleagues at the Department of Water in Western Australia, we have designed installation plans to assist in the routine removal of IRB build-up that have minimum added head loss and cost implications over those previously adopted.

Overland Flow

The passing of the *Water Act 2000* has allowed Queensland to regulate the taking of, or interference with, overland flow water for the first time. Previously there was no legislative basis for regulating the taking of overland flow water, leaving the security and reliability of downstream water entitlements vulnerable to diversions within the upper catchment.

With the regulation of overland flow comes the need to measure the take. Where the take is active, such as through a sump, pump, drain or pipes, the measurement can be easily done by metering. But where the take is passive, such as diversion and collection in a surface storage, the decision to measure take has presented its own unique problems.

Conventional methods for the measurement of storages involve the fixing of a pressure transducer to a solid structure within the storage and running conduit to shield the data cables that run from the transducer to the surface data display unit. This can be a lengthy and difficult process.

In order to come up with a more cost effective solution to the monitoring of storage water levels, the Department has undertaken the development of a buoy based system of measuring storage level depth and transmitting that data back to a receiver situated on the bank of the storage. The buoy system which is known as ERIC was initially based on commercially available floats and used radio based dataloggers. The floats proved bulky to deploy and the interrogation of the system required the use of a laptop to gather information.

Working with a local company, a small lightweight float was developed that was cast to house the transmitter and battery in a tough plastic enclosure. The buoy is approximately 400mm in diameter and because of its compact size and weight, it is easily deployed. Working with Hydrological Services in Sydney, a more user friendly transmitter and receiver were developed. The buoy-mounted transmitter is configurable using dip switches to set the radio frequencies and transmission times. The bank-mounted receiver collects the transmitted depth information and has the ability to convert the depth information into a volume for that storage. Touch buttons are used to set up the receiver and input the depth - volume relationship for the storage. The display also uses touch buttons to toggle through the different information screens, giving the entitlement holder local access to the data. The receiver has an analogue output to enable the information to be logged against time. Figure 4 shows the on-bank receiver with a datalogger fitted. ERIC has a range of 1km between the transmitter and receiver. Figure 5 shows the buoy deployed in an offstream storage in outback Queensland. Figure 6 shows typical data that is recorded by the ERIC buoy system.

Figure 4: On Bank Receiver and Datalogger

Figure 5: Deployed Buoy

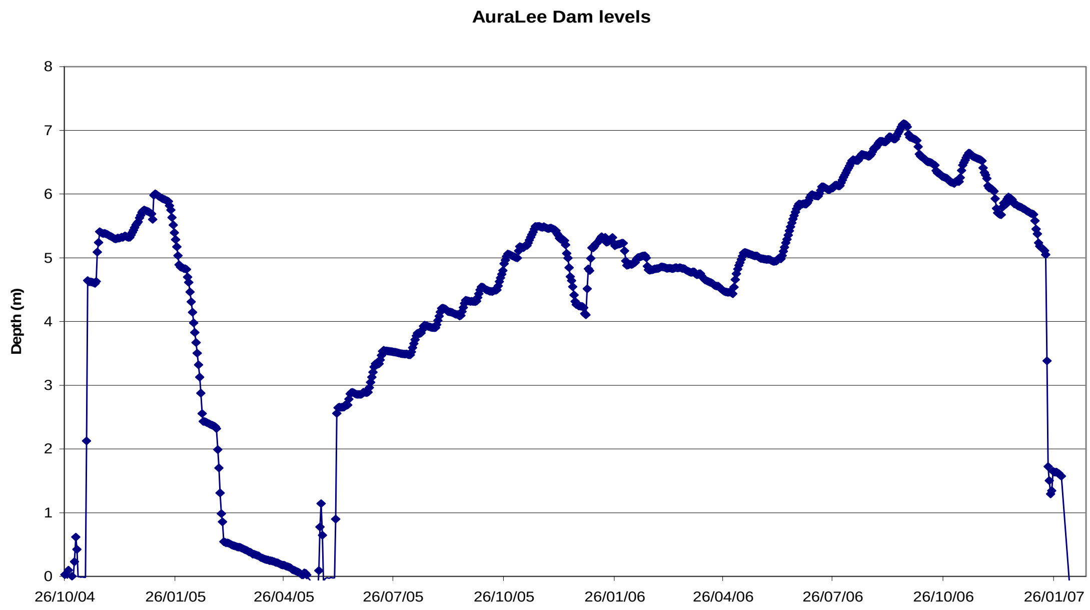


Figure 6: Recorded Water Levels

Partial Pipe

Most of the meter installations required in Queensland are closed conduit applications. However, there are many gravity diversions through large diameter pipes that often operate under partially filled conditions. These installations present particular problems, as there is a need to measure the depth as well as the velocity of the water.

A trial site was chosen at Nindigully, south of St George in western Queensland, to test various “off the shelf” technologies designed for measuring partially filled pipe applications. Four such devices were installed, two in each of two “sister” pipes that divert streamflow from the Moonie River into a network of storage dams and channels on the property.

Two of the devices, a Marsh McBirney FloDar and an ADS 3600, have been designed to monitor sewer flows and so have sensors that are mainly mounted at the top of the pipe to keep them out of the flow most of the time. The other two devices, the Unidata Starflow and MACE FloPro have been designed to measure open channel situations.

In both pipes, sensors in the flow itself were installed using expanding stainless steel bands to which the sensors were attached at an appropriate distance from the bottom of the pipe to keep them out of any silt build-up that may occur.

The ADS 3600 has separate Doppler velocity and ultrasonic depth sensors. The ADS Quadredundant depth sensor was mounted into a hole cut in the top of the pipe and measures the distance to the water by averaging pairs of measurement from each of the four ultrasonic sensors onboard. The separate velocity sensor is mounted in the flow. A battery that lasts approximately one year and which can be trickle charged via solar panel if required, powers the system. There is no display available for this system.

The MACE FloPro has Doppler velocity sensors and a top mounted ceramic pressure transducer mounted in an integrated submersible unit. It is provided with a remote display which houses the electronics and a battery which is trickle charged via solar power.

The Marsh McBirney FloDar has all sensors mounted in a single unit. The unit is mounted in a proprietary bracket, above the flow in a hole cut in the top of the pipe. An ultrasonic sensor measures depth and velocity is measured by RADAR aimed at the surface of the water. Recognised assumptions made to convert this into a mean velocity for the flow area.

The Unidata Starflow has the Doppler velocity sensors, pressure transducer and electronics all mounted in an integrated submersible unit. Power is provided by 12-volt battery with solar panel back-up. A display was later retrofitted to the existing infrastructure.

The ADS 3600 and the Unidata Starflow were installed in one pipe and the Marsh McBirney FloDar and the MACE FloPro in the other.

To gain an independent measure of velocity, a 150mm diameter port was installed into the top of the pipe on the upstream side at a distance far enough away that there would be no disturbance of the Doppler signal while independent readings were being taken. An opportunity arose in February 2008 to measure the velocity of flow independently to the readings provided by the installed instruments. During the flow event, a Sontek Flowtracker was inserted down through the 150mm portal and the velocities recorded. It can be seen in figure 7 that there are reasonable correlations between the Flowtracker velocities and those reported by the installed instruments. The different averaging times of the instruments and the fact that the velocities recorded are at the lower end of the measuring limitations of the installed devices, account for some, if not all, of the differences in velocities recorded. Further in situ tests are planned, as it is important to gain this type of independent measurement for verification purposes.

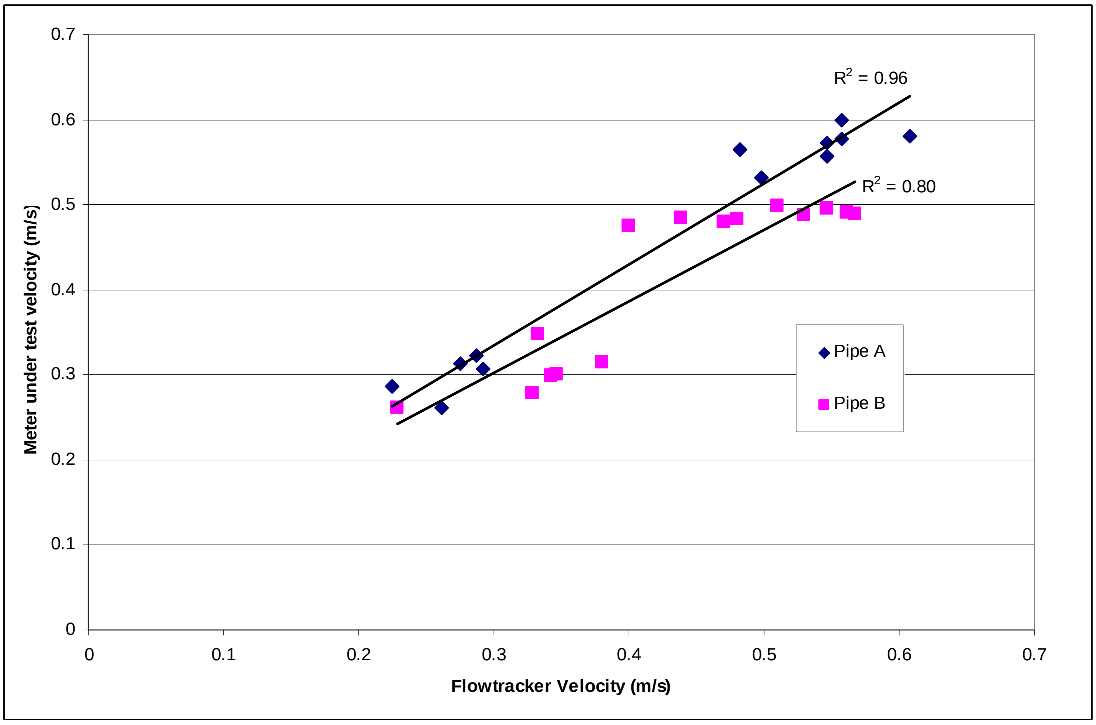


Figure 7: Correlation of velocities between independent measurements and in situ meters

From the graph in figure 8, it can be seen that the depths of each of the instruments are in agreement with each other. The height difference between the two pipes can be seen, together with the depths from the pressure transducers mounted at each end of each of the pipes.

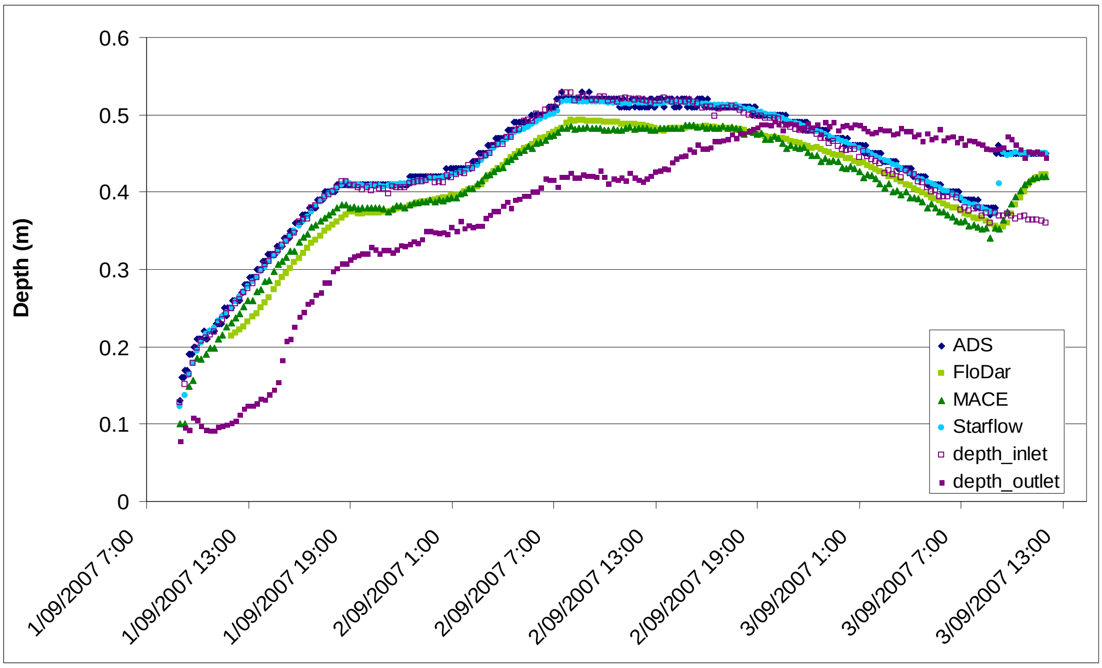


Figure 8: Depth from various instruments on partial pipe trial Sept. 07

For the purpose for which these instruments will be used, it is important to have the instrument display the correct cumulative total, as well as other parameters. Therefore post-processing of downloaded data after the event is not considered an acceptable method of arriving at the totalised value. To provide an error estimate produced by each device, the total flow was calculated independently, from the logged values of depth and velocity from each instrument. Where missing data and obvious outliers were found, these values were replaced by values calculated by using the Manning equation from the values recorded adjacent to the invalid data point.

So far, during the 18 months of the trial, floating debris has wrapped around ultrasonic sensors, impeding their measurements and dislodging sensors and their cables.

Due to site characteristics, hostile environmental conditions and inherent problems with Doppler velocity measurements, correctly measuring volumes through a partial pipe is challenging to say the least.

Dataloggers

The Department is in the process of installing water meters on works that take unsupplemented water throughout the State and a decision has been made that all meters will be equipped with electronic data loggers. The information from the dataloggers will be used for planning, monitoring water harvesting events and compliance. As a result, when combined with existing meters, there will be approximately 13,000 to 19,000 loggers which will be read once or twice a year.

Various single channel dataloggers were sourced from the market place and trialled. But due to the requirement that any information from dataloggers attached to the meters had to be input into the Department's database, it was decided that a custom-built datalogger should be sourced.

As with all metering in the state, the solution had to be simple and cost effective so as to limit the costs to users. The data loggers were required to be single channel and to use a hybrid period/event recording format that checks hourly for a cumulative reading, but only records a reading if an event has occurred. As null values are not being recorded, this reduces the volume of data stored on the logger and hence improves the data logger's capacity (while not significantly reducing the value of the data), as well as reducing data download times. The output from the logger was required to be a simple string that could be read directly into the Department's database.

Two suppliers (Hydrological Services of Sydney and Environmental Data Services of Nerang) have developed this hybrid logger for our needs and we are currently working with these suppliers to develop a download system using a PDA as opposed to a laptop.

Telemetry

The reading of the existing meters is currently being undertaken by a contractor and is done on a manual basis. With the large increase in the number of meters across the State, telemetry rather than manual reading of the meters may be an option. To determine the effectiveness of such a telemetry system, a trial of different types of telemetry systems was undertaken in priority areas across the State during 2004 to 2006.

The trial investigated many of the products available on the market at that time and determined their suitability for use. It is difficult to nominate one method as a single solution because the location of water meters across the State is so diversified. The spread of the various carrier systems is equally diversified and doesn't always align with the location of the meters. Technology is also constantly changing as was witnessed during the trial (e.g. the replacement of CDMA with NextG), so the range of technology available in each situation must be assessed to obtain the most cost effective solution.

For the trial, commercial suppliers were invited to supply telemetry solutions so that all types of telemetry were considered:

- Novaris (a Telstra development company) installed a CDMA based system that used SMS messaging delivery to a remote server. The system was upgraded to broadband delivery as this service became available to the trial area, which greatly reduced transmission costs. Transmissions were also generated by events which also led to a reduction in operating costs.
- HydroTasmania developed their Ajenti system during the trial which was a simple datalogger and modem system. The benefit of this system was that it could also be linked to radios to send information back to central hubs, thereby reducing transmission costs.
- Greenspan utilised more sophisticated datalogging at site and CDMA data transmission
- MACE (Measuring & Control Equipment) chose to use individual web addresses at hubs at each site with radio connection of remote sites back to the hub. CDMA and Satellite modems were trialled for transmission options.
- JOCOM (a subsidiary of AWMA) were asked to trial a short range drive-by radio system that would allow data transmission to a local vehicle without incurring carrier costs. JOCOM also provided a radio hub to Next G modem site.

The cost to implement a telemetered site is made up of three cost components;

- *Capital cost of the equipment at the site*,

Metered use data can be easily gathered by accumulating pulses from the meter. A lot of the systems that were available at the beginning of the trial had greater capabilities than what was required and so were more expensive. Networking multiple sites into hubs also contributed to lower capital costs.

- *Carrier costs for the transmission of the data to the database system*

The modems for the trial were put onto the network without any bargaining of the costs. If a system was implemented, there would be opportunities to negotiate better rates with the proposed size of the network. Transmission costs could also be reduced with constant access systems. Radio hubbing of sites could also greatly reduce the cost of data transmission.

- *Administration cost* ,

A large proportion of the trial cost (29%) was for the internal administration costs. Again this cost could be greatly reduced because of the simple nature of the telecommunication. Ongoing maintenance would also be required to be considered in the long term operation of any telemetry system.

The trial demonstrated that the cost of setting up and operating a telemetry system for the reading of water meters far exceeds the cost of obtaining the same water meter readings by manual methods. The component of the cost that is difficult to quantify is the value of the timeliness of the data. This is particularly the case for water harvesting events where the water usage information currently is not verified for considerable periods after the event.

References

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