Australasian Hydrographer

August 2013

Kelvin Baldock performing neutron probe soil moisture measurements. (Yule River bore field, near Port Hedland, WA)

Is groundwater monitoring the "forgotten" aspect of the AHA? (Photograph courtesy of the WA Water Corporation)

AUSTRALIAN HYDROGRAPHERS ASSOCIATION

AHA

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BILL STEEN

Chairman's Report to AHA AGM

Development of the Diploma Course has been a key focus of the AHA committee. The committee approved the expenditure to have the first unit, rating tables, to be developed for "face to face" training. The model for expenditure was to recoup the investment through the running of the course. This has been achieved with Paul Langshaw delivering the first of three ratings courses with other courses in the pipeline.

The committee has also discussed and approved the second training material development for a "face to face" course in Hydraulics.

The 2012 AHA conference was a major financial success for the AHA generating approximately $80,000. This financial windfall was primarily due to an increase in trade booths and corporate sponsorships. In terms of participants, 2012 numbers were lower than 2010 however, the new "workshop" style seemed to be well accepted and the AHA gained positive feedback.

The 2014 conference organisation has commenced with NSW water agencies forming the conference convenors.

The AHA has been extremely active with the BoM Water Information Standards Business Forum. The AHA formed several Technical Reference Groups to address guidelines relating to ADCP, Data, Training, and Field procedures. At the last forum meeting several guidelines were approved by the forum and these have now been published.

The two projects were:

- *A series of hydrometric guidelines covering the range of hydrometric practice managed by Grant Robinson from the NSW Office of Water (NOW)*
- *A series of standards covering use of Acoustic Doppler technology led by Mark Randall of Qld Department of Natural Resources and Mines (DNRM)*

KRYSTAL HOULT

Secretarial Update

Much of the content below extents from the Association's Annual General Meeting held on the 28 August in Canberra. The formal AGM minutes and reports will be emailed directly to all financial members of the Association. The AHA Committee would like to thank those who took the time to attend the AGM. Your presence and input was greatly appreciated.

Committee Meetings and Journals

Since the last Annual General Meeting held during the conference in August 2012 the AHA Committee has met four times, split 50:50 between teleconference (12 December 2012 and 7 February) and majority in person meetings (12 April and 28 August prior to the AGM).

Two journals have also been published during that time, in November 2012 and April 2013. Frank Davies is to remain in his role as journal editor for the Association in the interim despite the appointment of a Publicity Officer. However, as Frank has indicated a desire to stand down at the end of the year, expressions of interest for the role are being called for.

Member Database

For the 2012/13 financial year the Association had 309 members. A comparison with membership numbers in previous years is still to be finalised, but will be circulated once complete.

For the 2013/14 financial year we have already had 117 members renew via our new online membership database. Membership for the current financial year is technically due by the end of August. However, this due date is likely to be extended till the end of September due to the timing of the renewal emails sent out to members. If you cannot locate the email containing your renewal link please email membership [at] aha [dot] net [dot] au.

We have received $16,841 in membership funds this financial year thus far (as at 27 August).

Membership with the Association has always intended to be continuous. This will become more transparent due to the inherent nature of the new online system not allowing for intermittent renewal.

National Promotions is now managing memberships for the Association. This means that they are now the contact for receiving membership payments rather than AHA. i.e. who membership cheques for the Association are made out to, where membership cheques need to be sent and the bank account that membership funds need to be deposited into has changed. Please ensure that you note the new details for your preferred payment method on your membership invoice.

Further options and flexibility are being looked into in regards to payment for membership registration including the ability to allow for bulk payment of certification and membership fees and multi-year advance payments.

Public Officer

The AHA is incorporated under the NSW Associations Incorporation Act 1984. This Act requires an association to have a public officer who lives in NSW and is over 18 years of age. John Skinner has held the position of

Public Officer for the Association since it was initially incorporated in 1990. John Skinner recently advised the Committee of his wish to resign from the position of Public Officer for the Association pending the election of a new Public Officer by the AHA Committee. The AHA would like to thank John for his efforts in this role on behalf of the Association for the last 23 years. Grant Robinson was appointed as the new Public Officer by the AHA Committee at our recent committee meeting held prior to the AGM on the 28 August.

Publicity Officer

At the February AHA Committee meeting Grant Robinson, our AHA Webmaster, volunteered to take on the vacant role of Publicity Officer for the Association. This appointment was voted on and accepted by the Committee as an interim measure. Grant was formally elected by the membership into the position of Publicity Officer at the recent AGM. Grant has brought the seemingly tireless and relentless energy that he brings to all tasks that he takes on to the role of Publicity Officer. This has had a clear impact in the visibility of the Association in terms of the eNews and our LinkedIn page in particular.

Constitution

At the recent AGM a new constitution for the Association was put forward by Grant Robinson and accepted by the meeting. This is based on the model constitution from the NSW Associations Incorporations Regulation 2010, with some modifications to meet our specific requirements. The new constitution and a summary of the changes were provided to financial members within the required timeframe prior to the AGM for comment (21 days). The new constitution is available on the AHA website - AHA Constitution.

2014 Conference Update

We are pleased to announce that the Convening Committee, venue and dates of the 2014 Australian Hydrographers Association Conference have been confirmed.

Thank you to each of our 2014 Convenors and their respective organisations for their commitment. Your support is greatly appreciated by the AHA.

Following extensive analysis, numerous discussions and venue visits we have now confirmed ANZ Stadium at Sydney Olympic Park as the venue for the 2014 Australian Hydrographers Association Conference. The Conference will be held from Tuesday 11 to Friday 14 November 2014.

ANZ Stadium has a similar setup to the AHA 2012 Melbourne Conference in terms of floor space and an interconnected conference room and trade area. The location (Homebush) has several accommodation options and everyone is effectively housed within the one complex. Transport can be direct from the airport via a taxi, regular trains from the city and there is ample car parking.

A Convening Committee inception meeting was held via teleconference on the 12 August, during which Natalie Noakes from Sydney Water was nominated and elected by the AHA 2014 Convenors as Chairperson. Those of you who attended last year's conference will recall that Natalie won the Alex Miller Award for best conference presentation, as voted by the floor, for her stellar presentation "A Hydrographic Journey along the Hawkesbury Nepean System."

AHA 2014 Convenors

Natalie Noakes, Sydney Water (Chairperson)
Grant Robinson (Secretary)
Ray Boyton, NSW Office of Water
Graham Parsons, NSW Office of Water
John Hayes, NSW Office of Water
Lee Garnham, NSW Office of Water
Tony Polchleb, Sydney Water
Sarah Darvill, Manly Hydraulics Laboratory

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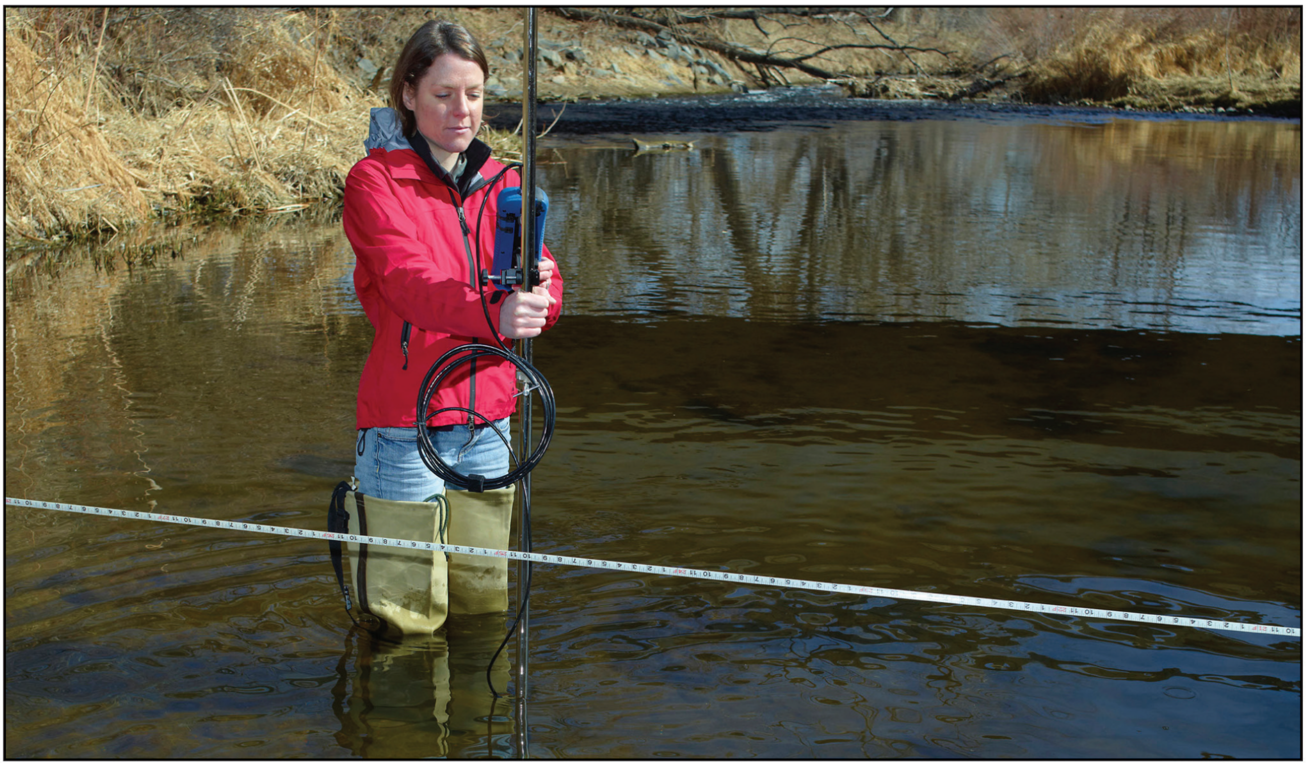

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OTT Hydromet

Hydrometric Standards TRG Update

Jacquie Bellhouse
(Incoming) Chair of Hydrometric Standards TRG

If you attended the AHA 2010 Perth conference, the AHA 2012 Melbourne conference, or have been enthusiastically reading the AHA's recent Monthly Update bulletins and Journals you will be full bottle on the National Hydrometric Standards recently endorsed by the Bureau of Meteorology's Water Information Standards Business Forum. The guidelines are available via the Bureau of Meteorology Water Information Standards website (http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml).

These guidelines began as two separate projects funded by the Bureau of Meteorology's Modernisation and Extension of Hydrologic Monitoring Systems program, funded from the federal water package following the passage of the Water Act 2007 (Cwlth). Their development and final endorsement is thanks to of the enthusiasm and commitment of AHA Technical Reference Groups chaired by Simon Cruickshank (Acoustic Doppler Parts 8 to 10) and Grant Robinson (Hydrometric Guidelines Parts 1 to 7). The glossaries from both projects form Part 0 and will be added to the Bureau's Australian Water Information Dictionary (www.bom.gov.au/water/awid).

Moving forward, the guidelines are intended to be living documents. Reviews will be coordinated by the Water Information Standards Business Forum (www.bom.gov.au/water/standards/sbforum) and involve industry expertise, including the AHA. The guidelines will be reviewed at no less than three yearly intervals to:

1. Ensure they remain current relative to other published standards and guidelines;
2. Incorporate ongoing feedback from industry; and
3. Ensure they are up to date with technological developments.

The endorsement of the Hydrometric Guidelines does not indicate intent for the TRG to disappear or fade into the background. The TRG is proud of the proactive role it has been able to take in developing a quality product but acknowledges the guidelines are in an establishment phase. The TRG is committed to supporting the Forum in the ongoing revision of these guidelines and development of additional ones (see following article "Groundwater Monitoring and the AHA").

It is with regret that the Hydrometric Standards TRG recently accepted the resignation of its chair Grant Robinson. Grant recently retired from NSW Public Service after 42 years of service. The TRG would like to thank Grant for his considerable passion, organisation and drive over the past four years, without which we would not have these guidelines.

On Grant's departure I have agreed to take up the role as chair. By way of introduction, I am currently a Water Services Strategy Adviser with Western Australia's Water Corporation with extensive experience in hydrography (including groundwater monitoring), water source compliance, water resource planning, and a passion for all things eco-hydrological. I have a Bachelor of Science from Edith Cowan University, a Certificate IV in Hydrography from NSW TAFE and almost twenty years' experience in the hydrographic and water resources industry.

My first priorities as the inbound chair will be to review the items placed in the "Parking Lot" during earlier discussions, and the TRG's Terms of Reference to ensure they accurately reflect its ongoing commitment to the maintenance of the guidelines. I will also investigate how the TRG might establish an improvement log for all ongoing industry feedback. I am happy to hear from anyone who wishes to remain or become involved. I am available via LinkedIn (http://www.linkedin.com/profile/view?id=224122141) or trg.hydrographic.chair [at] aha [dot] net [dot] au

Groundwater Monitoring and the AHA

Jacquie Bellhouse
Western Australia's Water Corporation

As discussed above, over three years effort by many across the nation paid off when the Water Information Standards Business Forum endorsed the series of ten Hydrometric Monitoring Guidelines.

The AHA should rightfully be proud of the proactive role it has taken to support BoM in delivering a quality product.

During May's Water Information Standards Business Forum it was acknowledged that whilst the guidelines were a giant and positive step forward, further guidance was sought in regards to the effective collection of groundwater data.

Groundwater is becoming a critically important resource around Australia and its allocation and conservation is a hot topic. Effective monitoring of groundwater is required to support resource investigations, compliance monitoring and research activities. Hand in hand is the recognition that there is a growing need for more comprehensive standards to guide the collection activities.

In response, the Northern Territory's Simon Cruickshank and I have volunteered to undertake a gap analysis into the availability of guidelines and standards for a range of groundwater related data collection activities on behalf of the Forum.

Initially we have been busy comparing individual assessments in reference to their respective agencies and have identified similar needs. Whilst there appear to be standards and guides available from various state and national bodies they are quite diverse and do not appear to cover all aspects. It is suspected that these findings may be mirrored by other agencies/jurisdictions around Australia.

We are therefore keen to hear from anyone who has an interest or desire to see further industry guidance in the area of groundwater data collection.

Recently there has also been a discussion underway on LinkedIn regarding the inclusion and recognition of industry members involved in groundwater monitoring. Historically the AHA has not formally involved professionals responsible for groundwater data collection. However with the recent expansion of groundwater time series data collection, there are increasing similarities between the disciplines as groundwater monitoring adopts equipment, data systems and procedures similar to those implemented by surface water technicians.

As water allocation plans are developed, there is a growing requirement to manage and undertake groundwater and surface water monitoring in a more holistic and coordinated fashion.

In response some agencies around Australia have developed Monitoring or Data Management Divisions that amalgamate personnel responsible for the collection and management of data in various fields such as hydrographic, groundwater, water quality, regulation and in some instances GIS. This amalgamation / diversification results in an increased knowledge base and skill sets throughout the division and of each hydrographer.

Where establishing entire data collection divisions is not practicable, hydrographers are individually diversifying into the water quality, and groundwater monitoring spheres in addition to the more traditional surface water components.

With the change in the traditional “hydrographic” working environment it has been asked “Does the AHA need to adapt to incorporate the changed working environment and broaden its membership base to incorporate specialist operators such as groundwater technicians and water quality officers?” Furthermore, should the AHA be more proactive in promoting and catering for groundwater monitoring?

What do you think?
Are you seeing these trends in your region?
If you are a groundwater technician, what representation and support would you like to see the AHA provide?
Is there a wider industry need for further national guidelines for the collection of groundwater data?

If you wish to join in on the discussion, both Simon and I can be contacted via the AHA and/or its LinkedIn Forum “AHA at a crossroad?”

High Flows - How Accurate, How Soon?

Glenn McDermott
Enviromon P/L, NSW

This article is focussed on high flows (i.e. flood flows), from a client’s perspective of wanting to know “how accurate, how soon?” The intent for writing the article is both to inform and to stimulate thought and discussion on this topic - particularly when talking about new sites, and the technology and method choices available, and how they will give different answers to this question.

Traditional Rating Tables

The most common type of river and creek flow monitoring site is that with a single level sensor at the site, monitoring levels continuously (or at set intervals, such as 15 minutes), and converting these levels to flow rate estimates using a “calibrated” rating table. The rating table is established from field gaugings. At any time during the “life” of the monitoring site a rating curve “line-of-best-fit” is drawn through the plotted gaugings, and extrapolated up into the highest flow range using any one of a number of simple extrapolation models.

Field gaugings can generally achieve a flow rate accuracy (measurement uncertainty) of ±7% or better. Flow rates “looked up” using the rating table IN THE GAUGED RANGE can achieve slightly better than the gauging accuracy, and typically can achieve ±5% uncertainty, depending on the degree of scatter about the curve. Above the gauged range, in the “extrapolated” part of the rating table, the uncertainty increases along with the extent of extrapolation. For example if the highest field gauging had a gauge height of 1 m, but the highest peak flow level of interest was 10 m, then a flow rate estimation uncertainty of ±50% should be expected.

If a more sophisticated hydraulic model is used to define the rating extrapolation (such as HECRAS or MIKE11) then ±30% flow rate uncertainty should be achievable at the same 10 m level.

So, a traditional site generally goes through the following rating table accuracy stages to reach maturity over time using a simple Manning’s n extrapolation model (assuming the site has a reliable low and high flow hydraulic control, such as a rock bar or similar):

- Stage 1 = ±50%; - at the beginning, say in the first year of operation, with the only gaugings being of low flows, and using a simple Manning’s “n” extrapolation to flood flow levels
- Stage 2 = ±30%; - after some years of operation eventually “captures” field gaugings for middle range flows
- Stage 3 = ±10%; - after capturing field gaugings during the second biggest flood on record, needing only a short extrapolation to the highest flood on record

The time gap between stages 1 and 3 can be anything from two to twenty years, or "never" if it is a low priority site. A typical relationship between time in the life of a site and gradual improvement in high flow discharge measurement uncertainty is presented below in Figure 1, based on a gradual decrease in rating table extrapolation to estimate flow rate at the highest flow rate on record. Also shown is the lower uncertainty curve achievable if a more sophisticated hydraulic model is used to do the rating extrapolation.

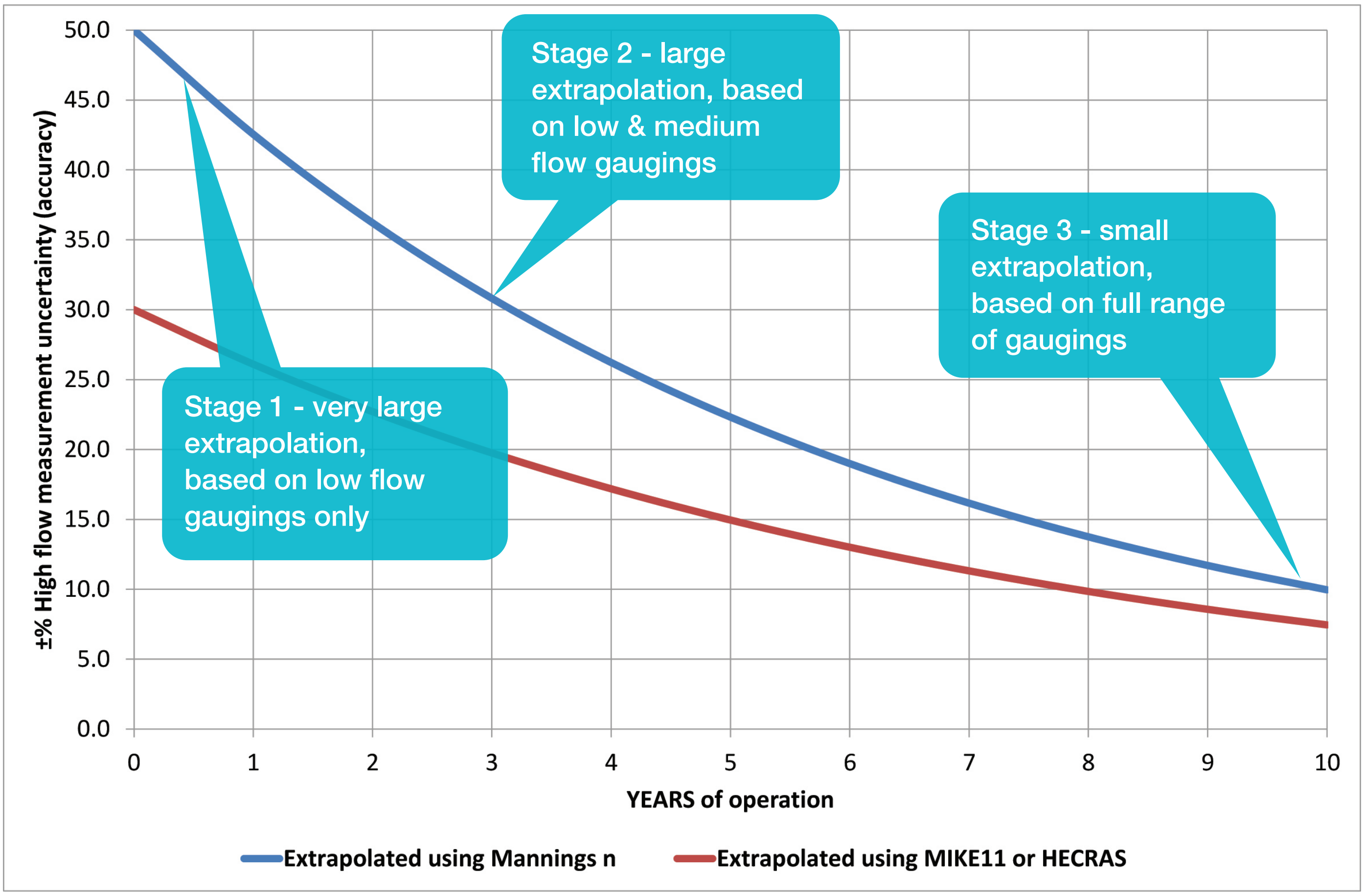


Figure 1. Typical improvement in high flow accuracy over the life of a traditional monitoring site.

One of the most commonly asked "client" questions is "How accurate is the data?" As can be appreciated from the above "typical" station life, the answer to this question changes over time, as the degree of calibration of the rating table becomes more and more complete.
Some clients are not interested how long the journey to greater accuracy takes, such as those interested in long term water supply and climate change investigation considerations. Others, however will ask if there is a way to get better accuracy "sooner" rather than later, such as for a network of sites for a flood warning system.

The simple answer is "yes", if you are willing to pay extra for a velocity sensor to be added to the site. The next section looks at that.

Using Additional Velocity Sensors

How much sooner can ±10% be achieved with additional velocity sensing?

Given a site with good quality and well placed velocity sensor(s) installed for the purpose, the sensors' sensing zone velocities will be captured during every flood fresh event. Although this is not as complete as field gaugings during such high flow events, it is a significant "head start" compared with "no field gaugings captured" during such events.

Flow rates (Q) for high flow events are calculated using the continuity equation "Q=vA", where "v" is average cross section velocity, and "A" is cross section area at that level. No current technology can measure the overall average cross section velocity, but instead relies on a velocity index factor (VIF) to convert the velocity recorded in the limited sensing zone "vs" to an estimate of average velocity over the whole cross section, such that "Q=VIF*vs*A".

Field gaugings remain vital for calibrating the relationship between velocity index factor "VIF" and either level or sensed velocity or both. To keep it simple here, assume the VIF rating referred to here is versus level only.

The simplest form of VIF extrapolation model is to extend the line of best fit through the level versus VIF values calculated from field gaugings, as suggested by sensor manufacturers. The larger this extrapolation then the higher the uncertainty in VIF, and hence the higher the uncertainty in flow rate calculated.

Just as for the traditional site and flow rating curve extrapolation, the use of a more sophisticated velocity pattern model for the purpose of better defining the level versus VIF rating, yields greater accuracy (lower uncertainty) sooner rather than later, such as models by Maghrebi and Ball (2006), and McDermott (VisvelPro 2008).

This introduces the same "rating table calibration" journey as for a traditional site, but in this case it is now the VIF versus level rating table, and goes through the same stages as before, but with overall better accuracy (reduced uncertainty) of flow rate estimate from the start, due to the improved information recorded during every event:

- Stage 1 = ±30%; - at the beginning, say in the first year of operation, with the only gaugings being of low flows, and using a simple "line of best fit" extrapolation to flood flow levels
- Stage 2 = ±20%; - after some years of operation eventually "captures" field gaugings for middle range flows
- Stage 3 = ±7%; - after capturing field gaugings during the second biggest flood on record, needing only a short extrapolation to the highest flood on record

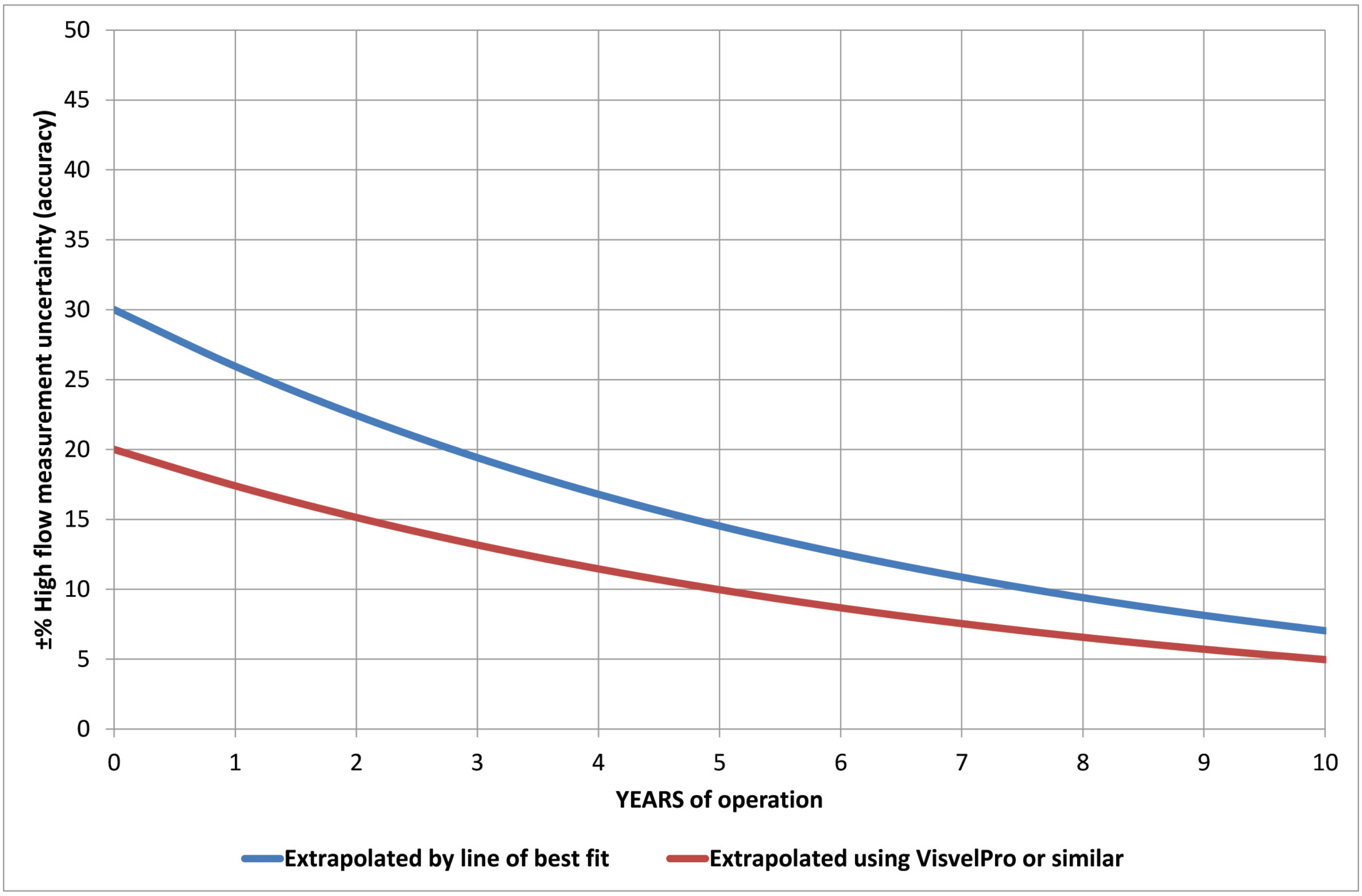


Figure 2. Typical improvement in high flow accuracy over the life of a velocity and depth monitoring site

A typical relationship between time in the life of a site and gradual improvement in high flow discharge measurement uncertainty is presented in Figure 2, based on gradual decrease in the VIF rating table extrapolation to estimate flow rate at the highest flow rate on record. Also shown is the lower uncertainty curve achievable if a more sophisticated hydraulic model is used to do the rating extrapolation (such as VisvelPro).

Comparing Figure 1 with Figure 2 shows how much sooner any particular accuracy of interest can be achieved by the velocity and level sensing site versus the traditional “level only” site.

What About Non-Ideal Sites?

The most common sort of “non-ideal” aspects are:

- Shifting control - with erosion and deposition cycles on bed and banks, changing the level to flow rate rating each time
- Intermittent backwater effects from some downstream intermittent control, such as dam gate operation, or the confluence of two large rivers, causing the steady flow rating to be irrelevant
- Hysteresis or loop rating effects, due to relatively flat bed slopes- causing the singular steady flow rating to be irrelevant, with each event having its own unique loop rating

The effect of these non-ideal aspects on “how accurate how soon” is that the two sets of uncertainty curves (i.e. Figures 1 and 2) move up, and show greater uncertainties.

Note however that by adding a velocity sensor to the monitoring site, although this does not help with “shifting control” sites, it does allow significantly better informed flow rate calculation at sites with backwater and/or hysteresis issues. High flow accuracy at these sites will however be a little worse than at, say, a site with neither of these effects and a good control.

References

Maghrebi, M.F. and Ball, J.E. *New method of Estimation of Discharge*, ASCE Journal of Hydraulic Engineering, October 2006

McDermott, G.E. *Velocity index factor sensitivity to velocity distribution in open channels*, Institution of Engineers Australia - Australian Water Resources Journal, December 2008

Life Beneath the Waves

Dr Andrew Skinner
Engineering Director, MEA, SA

Introduction

Back when I was doing my doctorate in Adelaide University's Department of Civil and Environmental Engineering in the early 2000s, another doctoral student in the same department asked Measurement Engineering Australia (MEA) to build some rafts with temperature strings and a weather station on them to measure the thermal stratification in one of our local reservoirs.

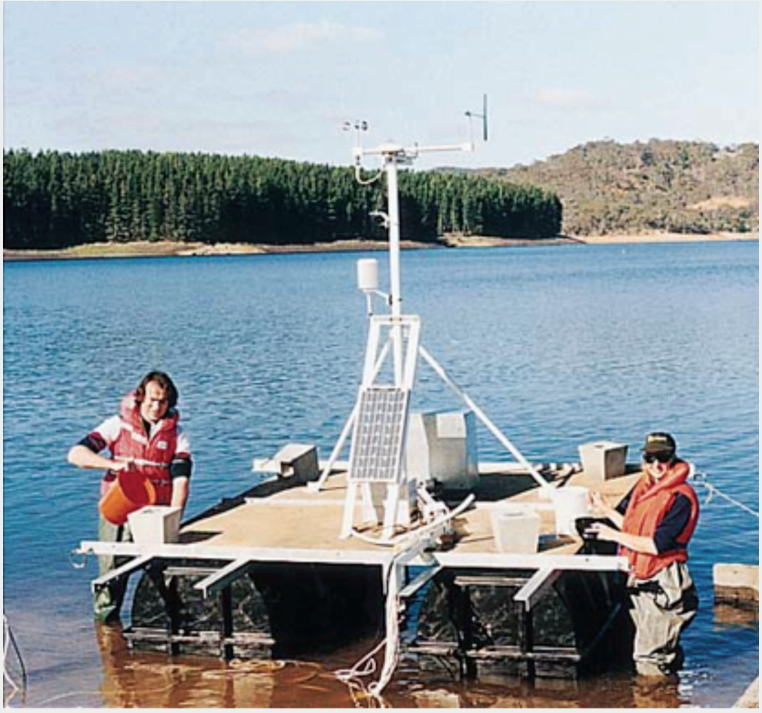


Figure 1. David Lewis (on the left) of the University of Adelaide installing an early raft-based stratification system in the Myponga Reservoir in South Australia. The multi-channel ADC electronics is installed in the enclosure at the rear of the raft. The multiple individual thermistors can be seen hanging over the front of the raft (white cables). Cormorants (shags) roosted on the raft and turned the surface into a nasty-smelling slippery place to carry out service work.

Round about then, I'd been messing about with ways to extend a dumb data logger's ability to read lots of temperature channels with very high resolution, so I figured I could mix the two jobs together and come up with a neat solution. That story was to evolve over more than a decade, squander a bucketful of MEA's R&D dollars and leave me with some fascinating insights into life beneath the waves.

The science behind all these temperature and salinity measurements is called 'physical limnology', no doubt to distinguish it from 'biological limnology' which covers all those living organisms that consider electronics lowered into their watery domain to be either a new home or something to chew on.

I was also a bit slow figuring out the difference between scientists – those guys who discover cute stuff and publish papers to advance their careers – and engineers, those guys whose career advances only if they can come up with saleable sensors that gain their employers the minimum of grief and the maximum of kudos.

Those first temperature strings were horrible – each one had typically twenty individual thermistor temperature sensors on its own cable. These inevitably leaked before twisting themselves into a broken rats-nest covered with slime and barnacles that rubbed against the mooring cable until electrical faults developed such that the whole ugly mess had to be hauled up and repaired.

What developed out of all these early tribulations were robust smart sensors (Figure 2) strung along a single heavy-duty rubber cable up to 100 m long. These temperature sensors operated on everybody's favourite data logger via the one-wire SDI-12 bus, could resolve temperature to 0.001°C and were matched to within ±0.006°C of each other (Figure 4). The latter business was important because some of the temperature gradients in well-mixed reservoirs are pretty weak. The sensors also had to handle the enormous pressures down at 100 m depth and be calibrated against a traceable temperature standard.

Figure 2. An MEA temperature sensor string bundled together for two-point in-field calibration at the Torrens Lake in Adelaide South Australia. Lots of effort went into keeping water out. Sensors are large so that their thermal mass acts to filter out turbulence-induced temperature variations at a five minute logging rate.

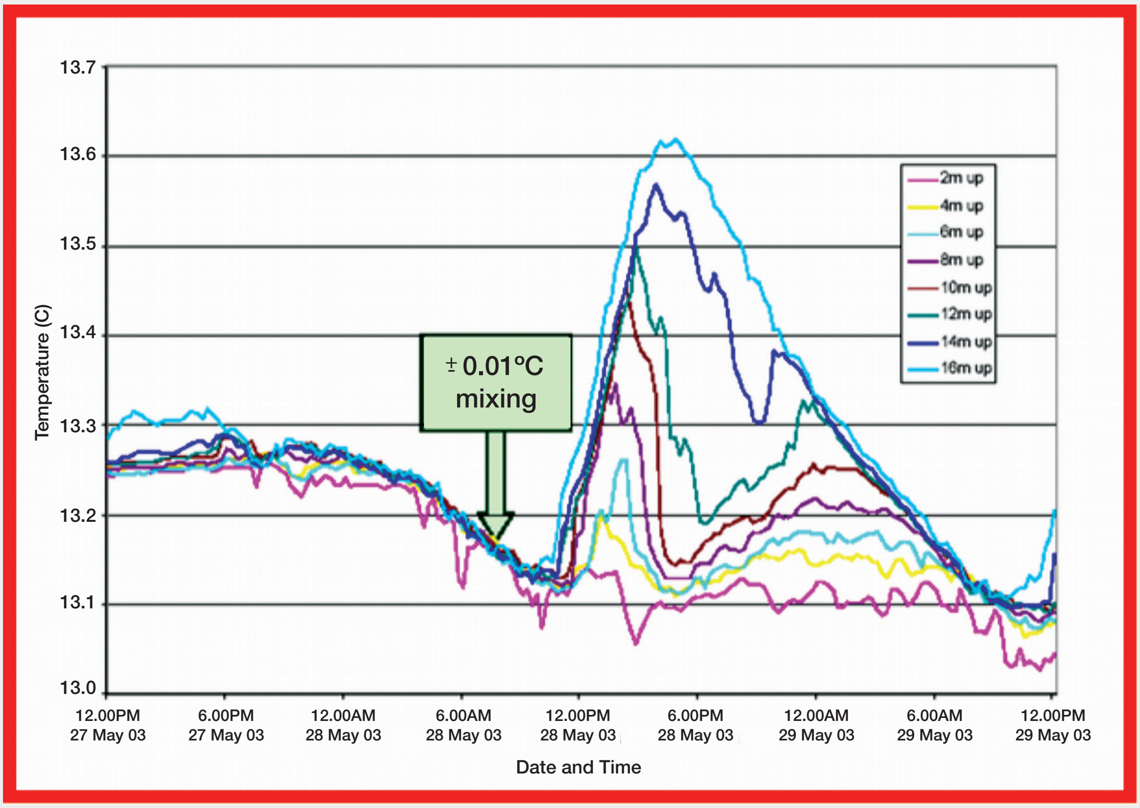


Figure 4. Evidence of 'sensor calibration consistency' in a 16m water column. Data prior to sunrise on the 28th May 2003 indicated that the top 14m of the water column mixed to within ±0.01°C, vindicating the level of matching (±0.006°C) attained during design and calibration. Systems deployed in the Murray River in June 2009 demonstrated matching over similar depths to within ±0.004°C.

What is all this Stratification Stuff?

What happens in large water bodies such as lakes, reservoirs and stagnant sections of rivers is that, during calm hot weather, they break apart into two separate water bodies having two very different water qualities.

The top layer warms up and so becomes less dense, floating on the colder denser layer below. So a sharp temperature and density change occurs somewhere below the surface at the junction between these two water bodies – it's called the 'thermocline' or 'metalimnion'. This thermocline acts like a glass plate, stopping the movement of nutrients, oxygen and small organisms between the two worlds. The top layer (the 'epilimnion') gets all the sunlight and oxygen, so algae and other organisms do well up here. In the dark waters below (the 'hypolimnion') conditions become 'anoxic' because the dissolved oxygen mixed into the top layer by wind and waves doesn't penetrate down through the thermocline. Nasty things start to happen, with heavy metals popping out of the sediments as the chemistry changes and with creatures dying for want of something to breathe.

It's not altogether true that no mixing between these two layers happens across the thermocline.

When strong winds blow steadily along the length of a reservoir, they bank up the surface water downwind and the heavier bottom water is pushed back upwind. When the wind stops, this banked-up water relaxes and the whole water body sloshes backwards and forwards in the reservoir basin with a steady rhythm, the lighter top layer swinging out-of-phase with the denser bottom layer. This causes 'seiching' (Figure 3), an internal wave develops along the thermocline, and these waves 'break' underwater where the thermocline meets gently sloping banks. Mixing happens.

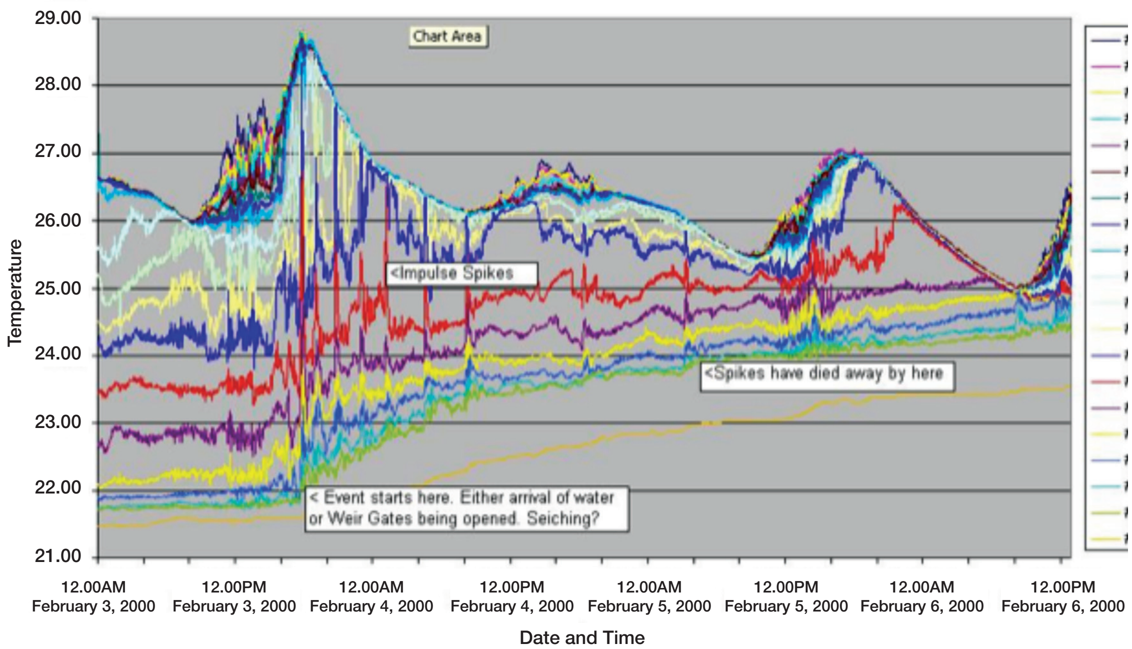


Figure 3. Evidence of 'seiching' in the Torrens Lake during a lake-flushing exercise designed to clear blue-green algae from this recreational lake in Adelaide's centre. An expensive volume of water was released from Kangaroo Creek dam and rushed down the Torrens River Valley to flush the lake. The inflow hit the dam wall (which failed to open), creating reflections and sloshing in the basin of the Torrens Lake.

Other weird things happen.

If there is a rain storm over the catchment of a reservoir, the creeks fill with cold dense water which rushes into the inlet of the warm reservoir and promptly sinks to the bottom, pushing across the sediments through the hypolimnion and short-circuiting the usual slow mixing (Figure 6). If water is being drawn from the reservoir at some depth, seiching and short-circuits can play havoc with the downstream water treatment plant; water quality switches rapidly between the two types of water sloshing into the inlet pipes.

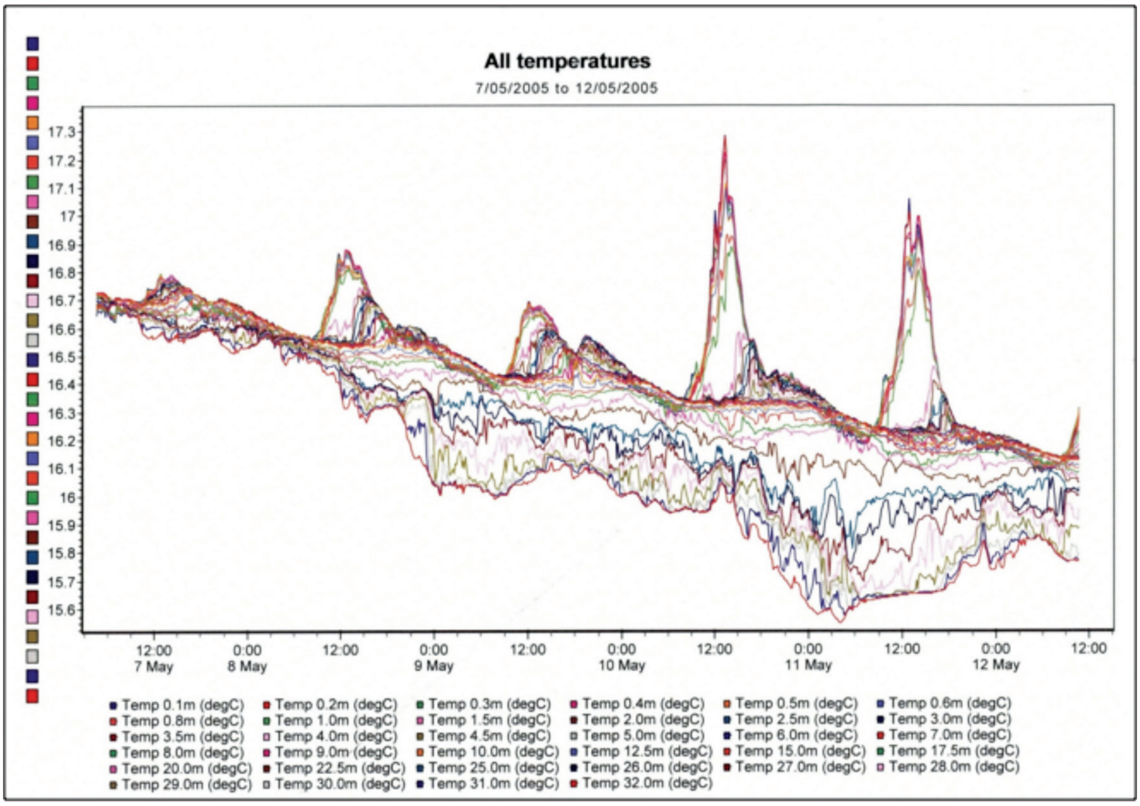


Figure 6. Evidence of a cold-water in-rush event from the catchment 'short-circuiting' the Happy Valley Reservoir by under-flowing the main water body. The 'curtain effect' of cooler waters at depth can be seen in the data on the sensors between 25 m and 32 m from midday on the 8th May 2005, reaching a peak around midnight on the 11th May 2005.

Finally, weather can also cause fascinating things to happen.

The warm surface layer that develops over summer gradually cools down as autumn sets in. At some point it can get cooler and heavier than the bottom layer. Suddenly, millions of tonnes of water sink through the now warmer bottom layers. This 'over-turning' process (Figure 5) mixes the reservoir once again, and operators need to anticipate the likely shift in water quality by watching the rate of thermocline collapse as the surface cools.

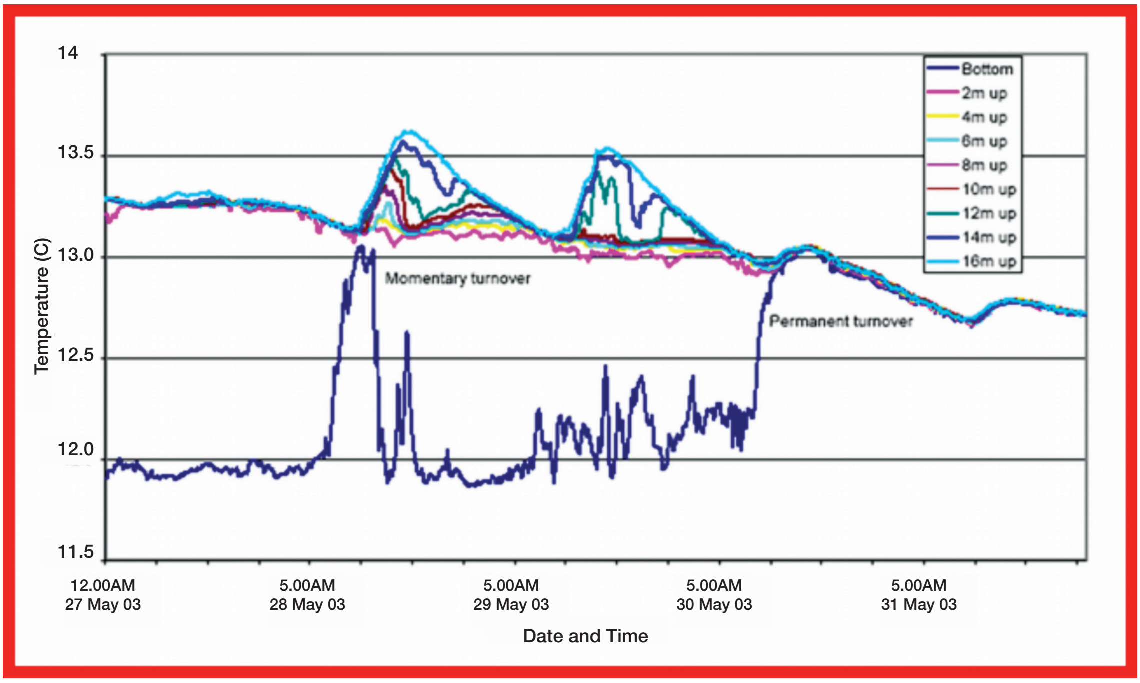


Figure 5. A 'turn-over' event in early autumn at the White Swan Reservoir in Ballarat Victoria. The bottom two metres of the water column is over 1°C cooler than the 14 metre water column above it. As the surface layers cool, their density increases and the water column becomes unstable, leading to complete mixing around dawn on the 30th May 2003.

Other cute things happen at river mouths, such as density separation between salt and fresh water layers in estuarine environments; a 'halocline' forms. The same thing can happen when saline groundwater seeps into the bottom layers of a river system and just sits there getting heavier and saltier in invisible puddles. But that's a story for another day…

Along the journey towards smarter sensors, MEA built various rafts and sensor string platforms, with varying degrees of success (Figure 1, Figure 7, Figure 8 and Figure 9). These days, other folk just buy our temperature sensor strings and attach them however they wish to their own logging systems. We're OK with that – we had all our fun getting the best out of simple temperature measurements in a new underwater environment.

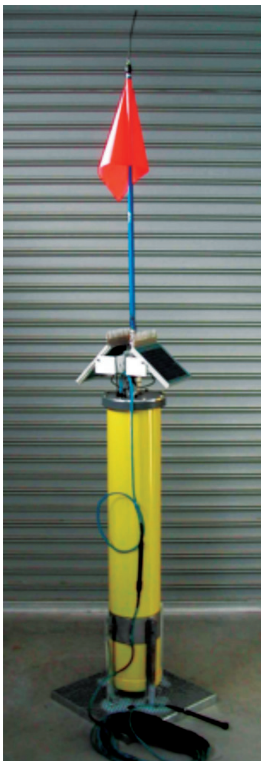


Figure 7. A simple radio linked ship-to-shore buoy supporting a SDI-12 thermistor string. No data logging occurs on the buoy; instead, all data is transmitted immediately after each 15-minute measurement.
This buoy got caught in a storm against the lee of a steel cable strung across the reservoir surface; it turned-turtle and sank.

Figure 8. This Sealite buoy supports a full MEA logging system, an integrated weather station capsule (Vaisala WXT-510) for air temperature, relative humidity, (drum-head) rainfall sensor, barometric pressure, ultrasonic wind speed and direction and separate global solar and net radiation sensors. All of these sensors are SDI-12 compatible, as is the MEA electronic compass (seen through the instrument door) developed to give a local reference direction for the wind direction sensor.
The data logger reads only SDI-12 sensors, and includes Next-G cellular-phone telemetry for remote data collection.

Figure 9. A MEA spar-buoy supporting three separate thermistor strings having different anchoring arrangements to allow stratification monitoring in the epilimnion (surface layer), metalimnion (thermocline layer) and hypolimnion (bottom layer) of a reservoir, no matter how the water level changes. The perforated plate at the bottom of the buoy acts as a hydraulic damper to prevent the buoy 'bobbing' in rough water. The length of the chain wrapped around this damper plate is adjusted to change the flotation depth of the spar buoy, which sits low in the water (bottom, right) to allow correct operation of the net radiometer. The latter is part of the weather station cluster mounted on the buoy to monitor wind and solar energy. The station uses cellular phone long-haul telemetry and VHF ship-to-shore SCADA radio systems.

Waterways – 2011/12 Fact sheet

Melbourne Water is the caretaker of river health in the Port Phillip and Westernport region. In this role we manage:

- 8,400 kilometres of rivers and creeks
- 1,473 kilometres of drains
- 344 constructed waterway treatment systems and wetlands
- 300 monitoring stations on waterways and drains
- 157 urban lakes.

Key achievements 2011/12

- $26.2M invested in streamside works to protect and improve river health - removing weeds across 1,310 km, revegetating 281 km of land along waterways, and stabilising eight sites subject to erosion
- $2.56M provided under our Stream Frontage Management Program to support a record 725 projects on private property – constructing 107km of fencing along waterways to exclude livestock, and planting more than 246,000 native seedlings
- Funded 125 Community Grant waterway management projects totalling $590,000 and supported public land managers through 114 Corridors of Green projects totalling $969,000
- Met a 70% target for total community satisfaction with waterways (scoring 77%)
- Released full environmental water entitlements to rivers including 11 billion litres for the Thomson River and 5 billion litres for the Yarra River
- Yarra River was runner-up in the prestigious International River Prize
- Completed construction of a new weir at Dights Falls on the Yarra River
- Completed consultation on drafts of the Healthy Waterways Strategy (2013-18) that will be used as a guide to protect the environmental health of our waterways and the amenity they provide, making Melbourne a better place to live Total reservoir storage level increased by 14.2% – rising from 55.8% at 1 July 2011 to 70% at 30 June 2012 (first time storages have reached 70% since January 1998)

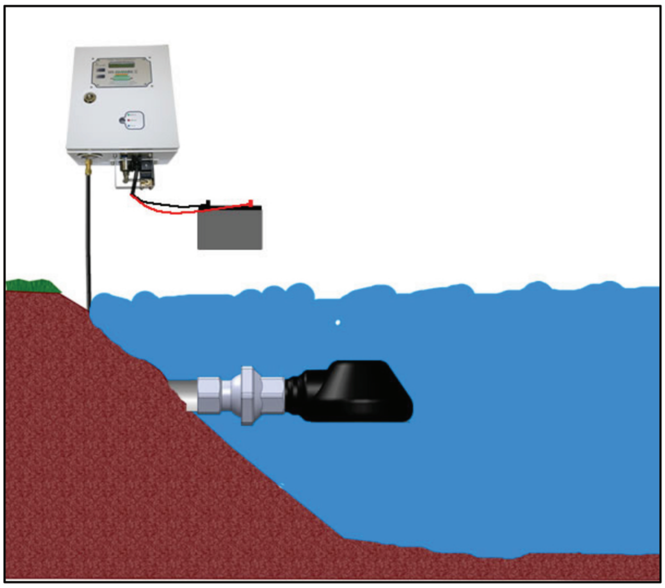
Melbourne Water also manages water supply catchments, treats and supplies drinking and recycled water, and removes and treats most of Melbourne's sewage.

NEW FROM HYDROLOGICAL SERVICES

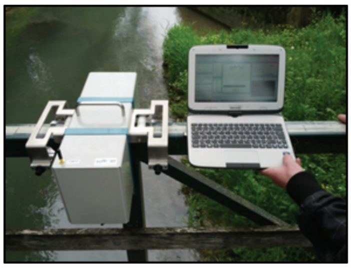
HS-30V Mk II 'Trident' Bubbler System

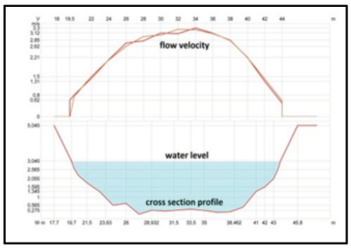
The HS-30V Mark II bubbler is Hydrological Services latest innovation, when used in conjunction with the GCO1P/SS (supplied with the system), the HS-30V Mark II forms a complete Bubbler Level Sensor for measuring water level in dams, rivers, canals and tanks with up to 30 mH2O (100 ft) with 200m (650ft) river-line length. Features include:

- *Large volume Gas Chamber Orifice*
- *In-built accurate WL3100 pressure transducer (with full temperature compensation)*
- *Compact design (380 x 260 x 190mm)*
- *'Ultra' low power consumption (22.4mA avg—lake): (40mA avg–1m (3.3ft) tidal)*
- *New 'auto-purge' maintenance free stainless steel air dryer system (no desiccant required)*



'Non-Contact' Stream Discharge Measurement Technology





The RP-30 is a radar velocity profiler, which allows accurate measurement of surface velocity in rivers, canals and streams, during flood conditions. The RP-30 is a proven alternative to conventional 'contact' measurement with mechanical current meters or ADCP technology with the added advantage of keeping the field team in a safe position, away from fast flowing water.

The RP-30 is a portable radar velocity sensor and can be safely operated from a bridge rail or from an existing cableway.

The velocity spectrum is automatically transmitted via Bluetooth from the RP-30 to a standard laptop which runs the modelling software "RP Commander" supplied. Using the theory of the Manning and Strickler methods, total discharge can be calculated from section mean velocity (estimated from the measured surface velocity), using an existing cross section, bank/bed roughness coefficients and prevailing water level.

The portable RP-30 radar velocity profiler is the ideal tool for field hydrographers to quickly determine the discharge of rivers or canals. With the ability to measure the velocity in turbulent and high flow situations the RP-30 is a reliable alternative to conventional 'contact' technology.

For more information please contact Mike Lysaght (T: 02 9601 2022 - Email: mikel@hydrologicalservices.com)

Remote Response

Mic Clayton
Team Leader Hydrographic Services, Snowy Hydro Limited

When you go to the pub and the bloke with a couple of beers under his belt next to you asks "What do you do mate?" you obviously answer proudly, "I'm a hydrographer and I work in a wide variety of remote locations."

The bloke with a couple of beers under his belt wants to ask you "What's a hydrographer?" but has trouble pronouncing it, let alone remembering the word past the first syllable but can relate to the word 'remote'.

His eyes become teary - he's been to that place called Remote in his youth, out there somewhere near that big lake in the centre of Australia where his jacked up 4 - wheel drive got bogged in the mud after the rain, or was it that time gazing across the expanse of the Southern Ocean from a beach on the west coast of Tasmania while he worked out how he was going to get his jacked up 4 - wheel drive out of the soft sand it was bogged in before the tide came back in, or was it the time in that really steep river valley when he and his mates in their jacked up 4 - wheel drives got stuck in a stream that was a bit more bouldery and deeper than they thought?

Notice a theme in these romantic remembrances?

That's right! The real answer is that being 'remote' could mean anywhere!

Hydrographers often work in small teams, or on occasions alone, and very regularly in what are termed 'remote' locations, those romantic locations that our mate in the pub remembers.

What does 'remote' really mean though? A bit of research from *Webster's New World Dictionary and Thesaurus, 1996* provides us with:

Re mote (ri mōt')adj.- [< L, remotus, removed] 1 distant in space or time 2 distant in connection, relation, etc.

Going back to our mate in the pub, distance is obviously the first definition that easily comes to mind for remote, but an equally important dimension is time. How do we interpret this dimension in the word remote that we often use in our job descriptions? Do we consider where we are working in regards to time as well?

Time from when I fall over just around the bend on the track from my work mate working in the gauging hut to when he realises that I haven't come back with the tool we left in the truck.

Time from when he realises I haven't come back yet to when he thinks to come and see what I am only doing but only after he finishes that bit of a data download from the logger.

Time when he walks back up the track and finds me unconscious on the track.

Time to get the call out for help – if you can get the call out.

Time for someone to acknowledge and respond to the situation.

Time.

Think how long it might take to get help in an emergency - even in the big smoke. This is the time dimension of 'remote'.

For those of us not working in the big smoke the reduced availability of emergency services is a big consideration in maintaining a safe work process for our staff particularly when working in environments where the definition of remote can change dramatically with rapidly changing weather or operating conditions.

In Australia's Alpine areas hydrographic teams at Snowy Hydro undertake training that is specific to our areas of operation, in particular Alpine Survival training that enables us to understand and be better prepared for those situations we hope will never occur in our working day in the snow. It doesn't have to be a snowy winter day in the Alps – even in summer rapidly cooling weather conditions are common and having the right equipment, PPE and knowledge of our working environment are critical for individuals to work safely in a variety of climate conditions.

During winter the time aspect of remote greatly increases. Roads and tracks become impassable for normal vehicles because of snow and there is a reduced ability to operate aircraft if a situation arose where field parties required assistance.

Our hydrographic field parties use mobile phones (voice and text messages), satellite phones and our own radio network for communications with office staff to maintain some sort of safety call-in process. In an emergency we even have little silver buttons in our vehicles that we can push to send an alarm over the radio network.
In our packs we carry Personal Locator Beacons (PLB).

Obviously plenty of methods to communicate a desire for assistance but what if…

I'm in that valley where we know we have a radio black spot.
I have to stand next to that special gum tree to get a text message out.
My satellite phone can't see the satellites even though I'm sitting on the roof of Australia!
I can't get to my PLB because it is in the pack in the vehicle only a hundred metres away and my broken leg won't co-operate to get me back to the safety of the vehicle.
No-one was at their desk in the office to take my call…

Many of you will have experienced these scenarios at one time or another!

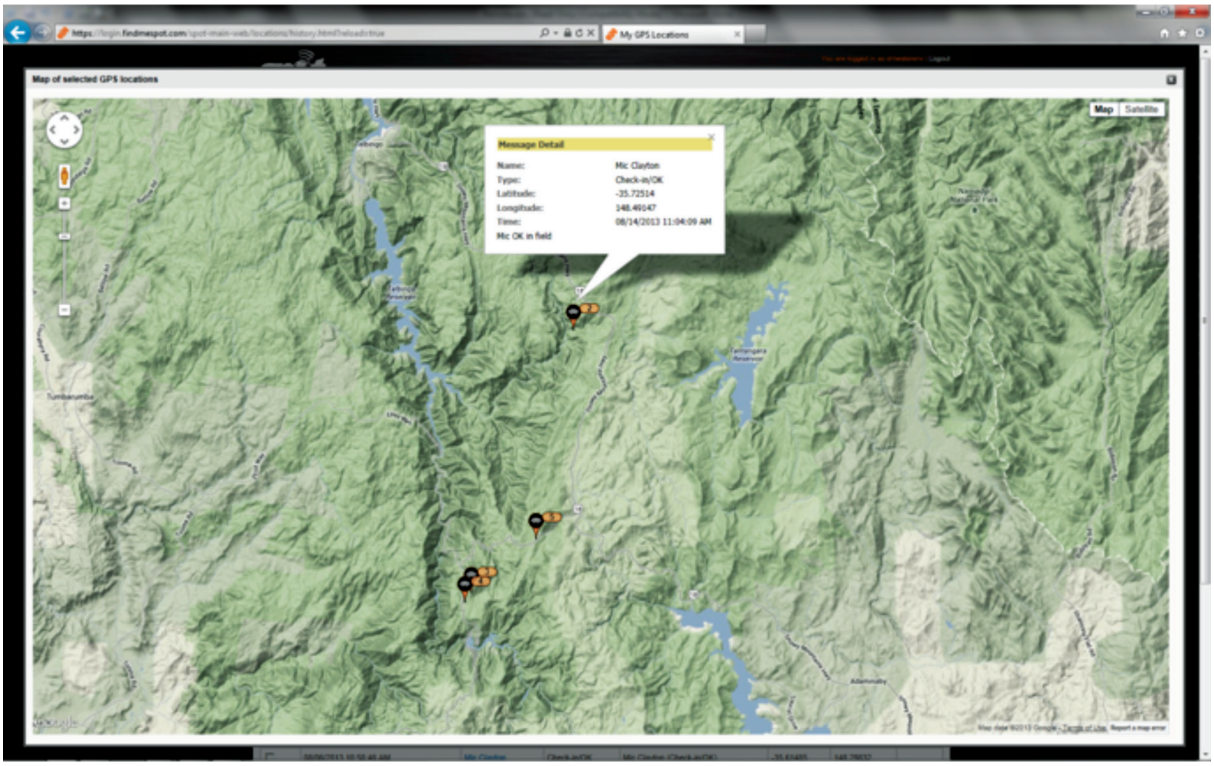
Late last year we got a couple of Spot GPS trackers to try out. People had a play with them occasionally but forgot to turn them off, let the batteries go flat, or forgot they were there to try out. Yep the concept just floated along.

Then just before Christmas I spent some time with Phil Downes and his Environment Canterbury crew working out of Christchurch in New Zealand. Off we went on a helicopter trip, stood in some rivers up the east coast from Christchurch and then it rained a bit and there was some jet boat gauging to be done. In this time I noticed Spot trackers, just like our couple of play ones back in Cooma, being put to proper use, particularly on our jet boat gauging trip.

When driving, the Spot sat on the dash of Phil's vehicle and was activated manually to send an "I'm OK message" at agreed intervals. Coupled with an agreed phone-in protocol, when reception was available (sound familiar?), this gave the field team a measure of safety call-in processes through the day, but it was the jet boat gauging day that flicked the light on for me.

We wore the Spot trackers.

Left: Preparing equipment for the jet boat gauging run in New Zealand – note the Spot tracker being worn on the left arm.
Right: Spot tracker unit.



Example of map interface for the Spot system.

They weren't hidden in our packs in the storage section of the boat or left in the vehicle 10 km away at the boat launch spot while we were on the river that was flowing at 300 cumecs doing the gauging. They were with us and activated. Each team member wore one and used it.

Back in Snowy Land I decided that my team would utilise the Spot technology as yet another important part of our safety processes.

The Spots are now utilised as part of the safety call-in processes of the teams, which also includes phone and radio messages through the day to nominated call-in persons. The call-in person is not necessarily bound to the desk as the Spot system enables text messages and emails to be directed as appropriate. These messages contain GPS co-ordinates of the personnel activating the Spot and the time the Spot was activated. The Spot information can also be viewed in Google Maps, and so on.

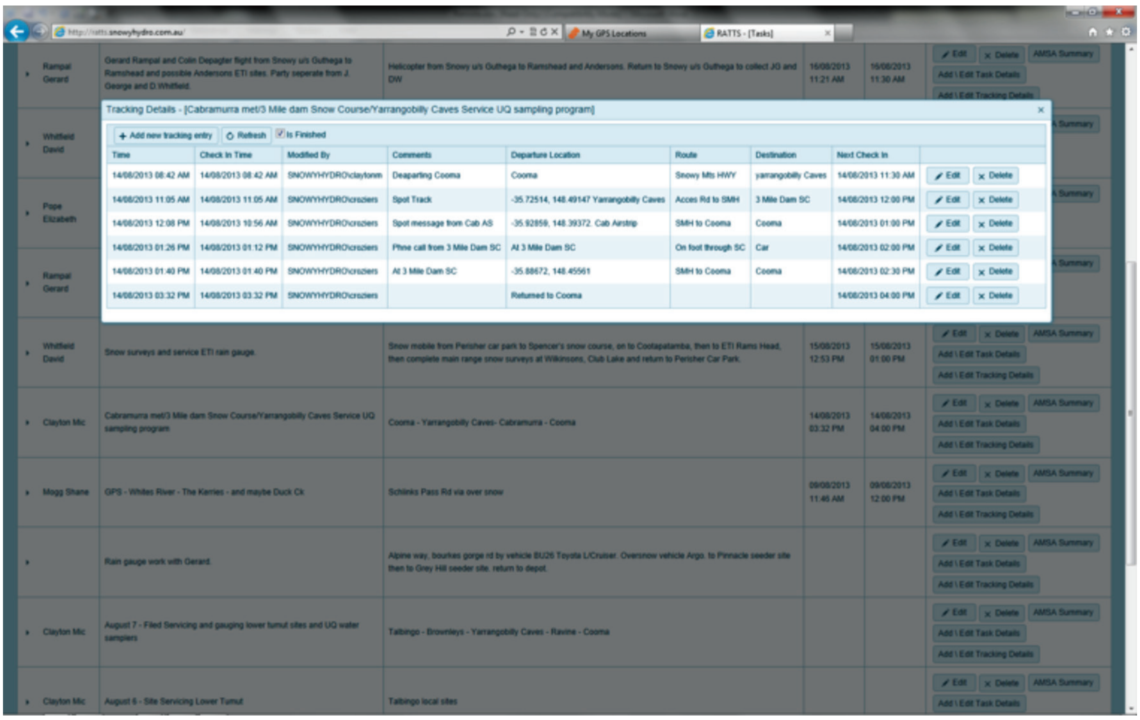
While the Spot units can be set to continuous track mode, the policy for our teams is that a physical pressing of the OK button is the primary method of use. Why? If you operate the Spot purely on track mode it only tells you where the Spot is. It doesn't indicate that the person it is meant to be attached to is OK. The same applies to vehicle tracking systems that only tell you where the vehicle is. They don't tell you where or how well the hydrographers is fairing if they are wandering through the bush away from the vehicle.

As our teams moved into Spots as a permanent attachment to us in the field, the SHL Emergency Manager came to us requesting hydrographic input into the company's emergency response plans, given the remote nature of much of the work we undertake.

This interaction was beneficial and timely and as a result as in the last few months a system known as the Remote Area Task Tracking System (RATTS) has evolved.

We now have a system into which we log the Spot messages and the important location information we are receiving from our field teams. This provides a transparent interface for other SHL safety personnel to access in the event of an emergency situation. Another advantage of RATTS is that it contains the allocation of PLB units to staff in the event that one is activated. Activation also causes an Australian Marine and Safety Authority response.

The RATTS system also contains specific details of team members (male/female/known medical conditions), what vehicle is being used (the rescue party is looking for a white Hilux), supplies and provisions the team is carrying (they have a tent and 24 hours food) and so on – all information that will help assistance to the field team to be tailored if a situation arises.



Example of a RATTS information page

So what does this combination of technology, safety processes and reporting system mean to us? *Time.*

Reducing the time taken in getting assistance to a team in an emergency increases the likelihood of a good welfare outcome for staff.

Having recent location information if assistance is required *reduces the time* response teams need to work out where you are, let alone find you. Assistance can get to you quicker.

Time is not wasted trying to work out who is where or who they are with. When an emergency response is initiated, the information contained within the central RATTS system can be quickly provided to emergency response authorities tasked for the assistance. The company's emergency response team doesn't have to use valuable time trying to locate the supervisor or team leader to advise them who is supposedly in the field. The additional Spot activity recorded in RATTS provides recent movements of the field party for the emergency response teams.

Employers are bound to provide a safe working environment for their employees. Being aware of a hydrographic team's location and welfare is part of this safe system of work. The system of safety discussed briefly in this article encompasses a combination of technologies and systems.

While the Spot units have been embraced by our teams, they are only part of the safety system we utilise. Like the other technologies (mobile phone, radio) it is important to be aware of their capabilities and limitations. Having a variety of available communications for field operations provides flexibility within the system for maintaining a safety process.

The safety process described here may not suit every organisation, but that is not an excuse for not having a safety system for your people.

Is Your Site's Datum Stable?

Frank Davies
Department of Water WA

Department of Water, WA Practices

The recommended practice for gauging station operation in the Department of Water, WA is to establish a single survey reference point at the site to act as the primary Bench Mark (BM). Obviously, this point must be very carefully selected and installed to ensure that it is stable since all level data collected is referenced to it. The level of the BM is also tied into Australian Height Datum, primarily to facilitate the preparation of flood warning information.

Annual Station Level Checks (SLC) are performed to confirm the stability of the station and its features. Key features are the cease to flow (CTF), any secondary survey reference points that are called Reference Marks (RMs), level check devices such as staff gauge plates and Peak Level Indicators (PLIs), and float well inlet inverts or the orifice for gas pressure systems. RMs are generally permanent points used to confirm the stability of artificial weirs (the RMs are installed on the concrete wing walls). They also offer survey "short-cuts" to quickly confirm the levels of locations such as the orifice. However, SLCs should always commence at the station's BM.

For convenience, the BM and gauging station data are operated on a local datum which is called Standard Level (of Elevation - SL). Again, for simplicity, at station commissioning an initial station survey establishes the level of the BM value in SL by allocating a nominal level of 10 m SL to the CTF, and then deriving the BM level from this. Subsequently, the BM SL value should never change (unless it is physically moved), but the CTF value can change should the river bed erode, the weir change, etc.

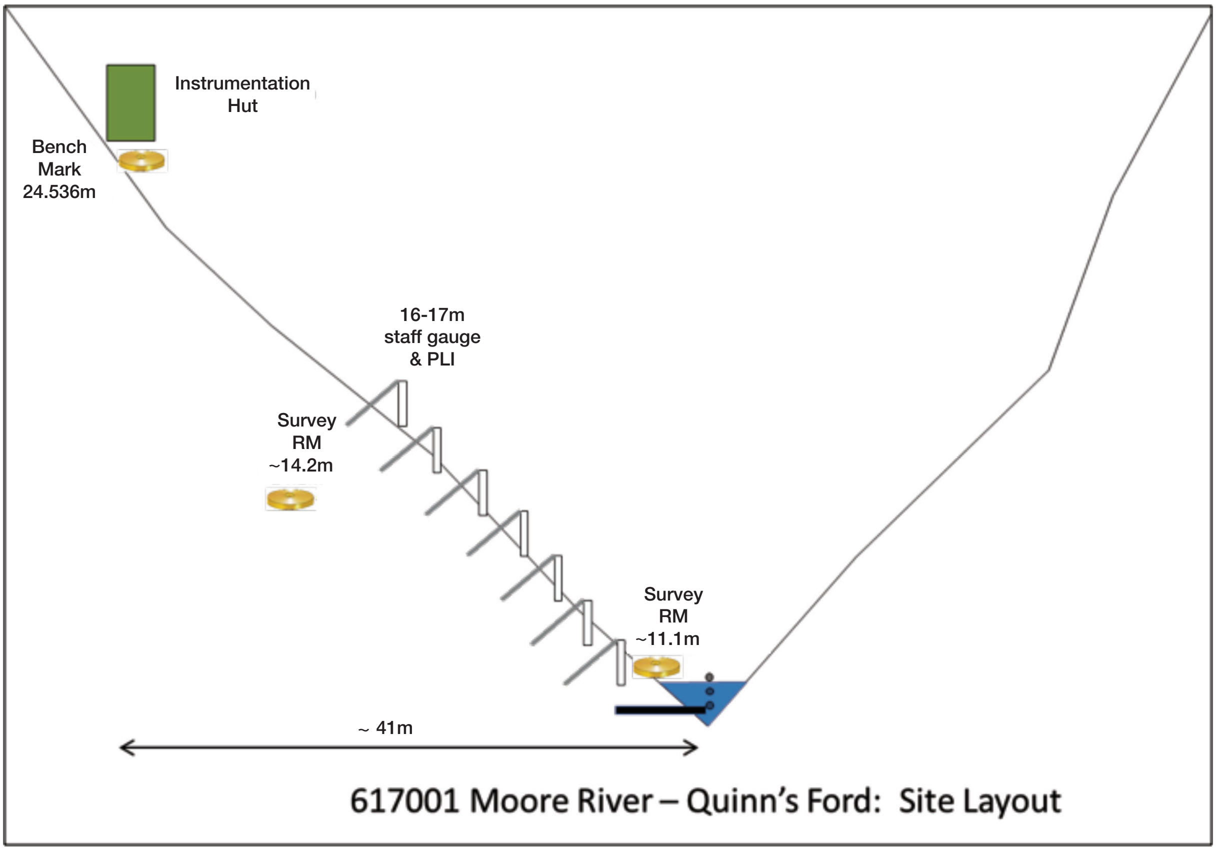
These practices have proven to be a reliable method of station operation for over half a century. However, problems can arise if there is doubt in the stability of the BM, and operating practices become unreliable.

An Unstable Station

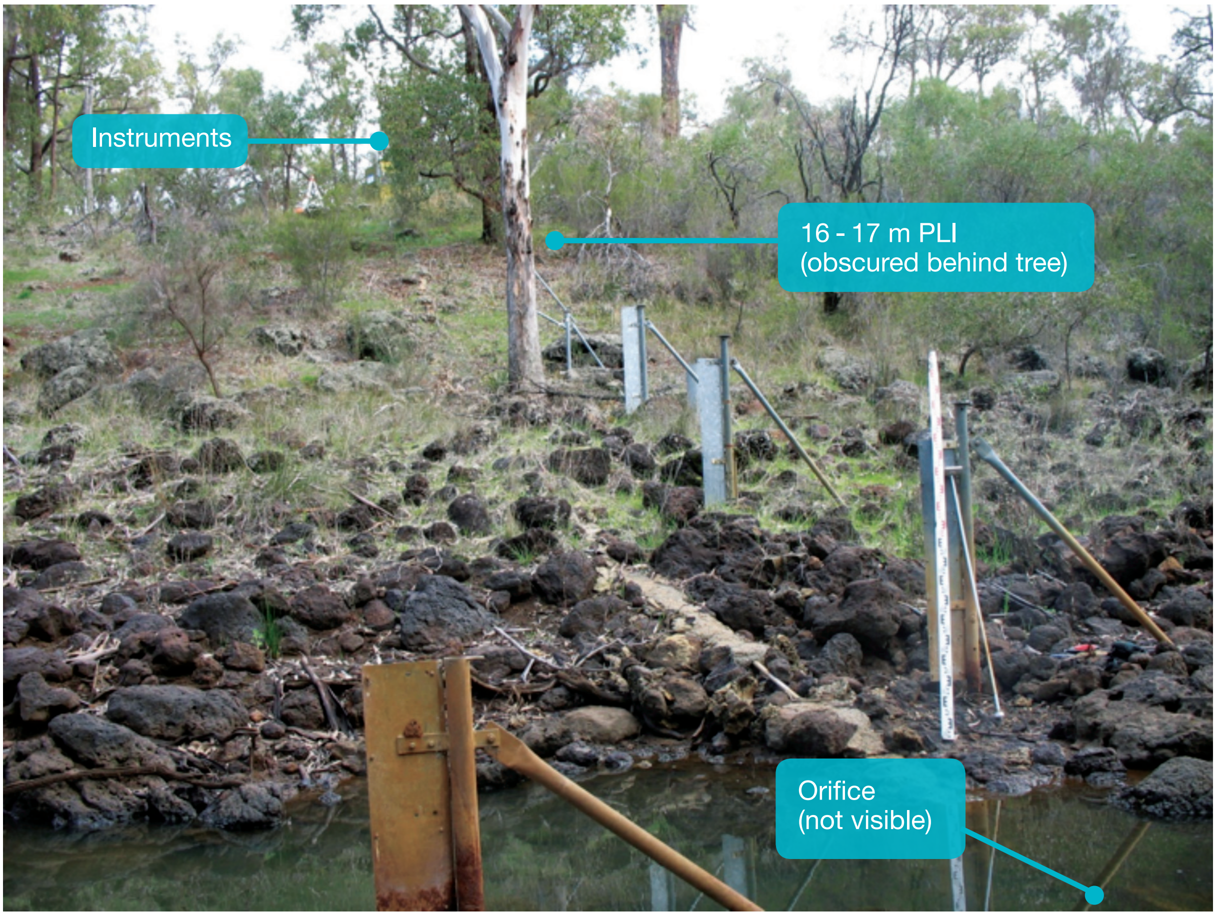
Station 617001 Moore River - Quinn's Ford has been in operation for over 40 years. However, in recent years the results of SLCs were producing confusing results, with the orifice returning values in the order of 100 mm different to previous surveys. Obviously, the orifice level is crucial to defining the datum applied to the pressure instrument to ensure that the correct stage is being recorded.

Was the orifice actually moving?
Were the surveys poorly executed?
How should the level data be verified?
How does this affect the rating?

The station is located in a steeply incised valley, as shown schematically in the following diagram. The instrument shelter is located half way up the valley, but well above the highest recorded stage of 15.4 m (450 m3/s) in March 1999. SLCs should ideally include all of the features displayed; commencing with the BM and including the two RMs, the orifice and seven PLIs. Checks of the CTF value are generally not possible as the stage is rarely low enough to clearly identify it.



(You might ask why the instrumentation is over 10 metres above the maximum recorded flow. I also wondered whether that is appropriate. But if you were investigating the 12,400 km2 catchment back in 1968 you might have also have put it in the same place, particularly given the deeply incised valley.)



Looking up the valley from the orifice.

Investigation of the SLCs through the site's history revealed that surveying practices were not consistently complying with the standard practices. Some surveys used the BM as the level reference whilst others used one of the RMs down towards the river. This was associated with a recommendation in 1986 that the BM was actually moving, but this recommendation was never fully adhered to. In addition, the checks were being completed sporadically, with many years where no surveys occurred and others where the quality control of the survey was unsatisfactory. This partly reflected the staffing levels, varying degrees of hydrographic expertise and management changes that had occurred over time.

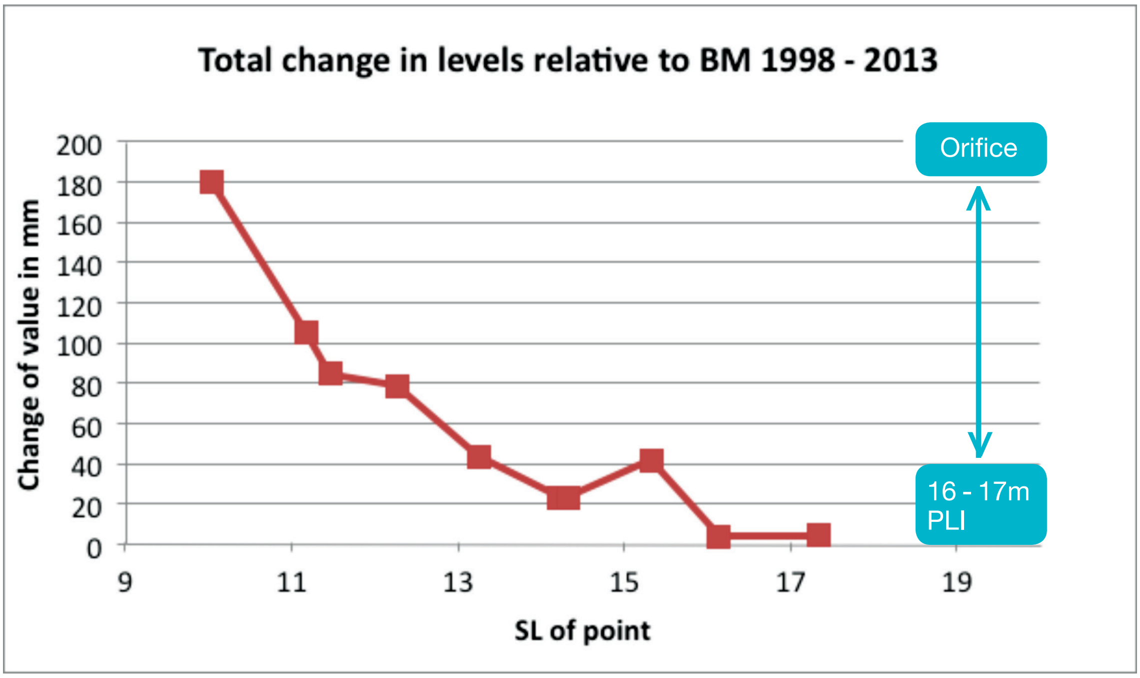
More uncertainty was added due to the fact that some of the surveyed features had been replaced or repaired over time. The orifice had been replaced three times, and the lower PLI possibly several, as it was prone to damage during higher flows.

Despite these short-comings there was a large volume of surveying evidence available from the 27 or so SLCs that were observed. From this data it was possible to plot historical trends of the levels of each of the surveyed features at the site. The only problem was to choose a single datum reference point and hope that it was stable.

Somewhat fortuitously the original station BM was chosen as the datum in preference to the other two RMs that could also have been used to isolate any site movement. Plots of the data showed some clear trends. The highest PLI (used to mount the 16-17 m staff gauge) showed virtually no change in level since 1984, presumably when it was first installed. Since there was no apparent movement between the BM and the PLI then it was reasonable to assume that the BM was stable (unless both features were moving – an unlikely scenario as they are about 20 metres apart horizontally and 8 metres vertically.

Moving down the bank to the other features, a progression was evident; the closer to the river the greater the change in levels. This provided a reasonable understanding of how the change was occurring, although it didn't explain why, but that's not central to this story.

The outcome of this research is best displayed in the plot of relative movement of the features.



Interestingly, a rating review in 2007 identified that the minimum annual flow levels had also been rising in steps over the years. The site is perennial, but most flows result from winter rainfall, meaning that the annual minimum level occurs during late summer to autumn. The ratings were subsequently adjusted by the inferred trend with progressively higher CTF values. No specific causes were offered and it is unlikely that flow regime changes associated with climatic change could explain this effect. It does however support the conclusion that the river bed near the orifice line was rising similarly to the channel near the orifice approximately 50 metres upstream.

Why is the Movement Occurring?

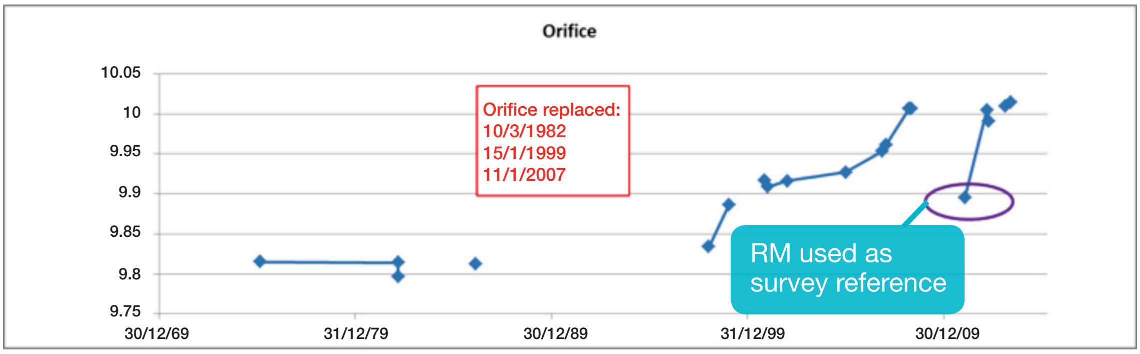
Understanding why the movement is occurring would most likely require knowledge of the hydrogeology of the area. However, it is possible to speculate.

The most extreme period of movement correlates with the high flows in 1999 (see the graph of orifice levels below). So, it is possible that this was associated with swelling of clays that may lie underneath the gravelly rock bars that occupy the channel. As the graph above shows, the two PLIs above the 15.4 m flow level both show minimal movement. But there have been earlier flows above 14 m, so why didn't the movement occur then?

Managing the Situation

At first, radical thoughts came to mind. Perhaps relocate the site and start again? The cost of this would be prohibitive and would cause a discontinuity in the record, even if a suitable site could be found.

Understanding what was happening with the orifice was the most important matter. The changes look quite dramatic when presented in a graphical form. However, year to year the change in orifice level has generally not been large. There appeared to be just two periods where a significant change occurred.



Surveyed levels of the orifice.

The present recommendation is to continue operation, but to tighten up operating practices by ensuring annual SLCs are completed and carefully analysed. Whenever the orifice is determined to have moved then the stage record could be adjusted to compensate. Also, at the time of the annual check of the datum of the pressure instrument, an adjustment of this value will be made if a new orifice value is identified.

Some Final Points

1. Survey bench marks for gauging stations need to be carefully installed to ensure they are stable.
2. Regular, quality assured site stability surveys are important.
3. Survey results should be carefully analysed to monitor station stability.
4. A site needs more than one stable survey reference point to isolate any problems of site instability. Just one will lead you to insanity if you have a similar problem and try to work out what parts are moving.
5. Be aware of potential peripheral effects associated with extreme flow events. Whilst not conclusive, the data for this site shows signs that the movement was associated with high flows.

Footnote

I suspect that some of the practices in this article may be a little foreign to many journal readers.
However, I'd hope that it arouses some thoughts about the way you operate your gauging stations.
The outcome of the research described has also surprised many WA hydrographers, so hopefully it will make you aware of potential issues at your sites.

Technology Cross-Over

Peter Collings, Paul Crogan, Ryan Bramwell and Frank Davies
This article is courtesy of the Department of Water, WA

The Meadow St gauging station is located in the Swan Estuary, the exit for the Avon River before it flows into the Indian Ocean. Its information assists emergency staff in the management of flood situations for Perth. Perth hasn't had many floods of late, as we all know, but it is still important to ensure that the gauging station is dutifully performing its function.

In recent times the heavily tidally influenced hydrograph had shown signs of inlet blockage. The usual answer in this case is a well flush; plug the inlets, fill the well with water, remove the caps and let the head of water "clean out the pipes". This initially appeared to improve the trace, but the effect was not enduring. So, what was causing the inlets to block?

We had been aware for some time that our groundwater monitoring compatriots had obtained a "down-the-hole" camera to assist them with bore maintenance such as clearing blockages, inspecting casing condition, etc. The camera sits on the end of a long cable, has a light, and is very compact, as you would expect to provide images down bores. So, a float well inlet is simply a bore casing sitting in the horizontal rather than the vertical, isn't it?

Access to the inlets is not easy as they sit well below the water surface so the selected day had to be on a low tide. Then it was off to estuary with a wetsuit and the camera equipment.

Bore hole camera being fed into inlet.

After some "duck-diving" the camera returned some very murky, but useful images revealing the cause of the inlet problems as muscles and barnacles attached to in the inside of the pipe, which was suspected after a previous attempt to scrape the inlets clear. In this image from the camera's movie you may just be able to make out the inside of the inlet pipe and a barnacle attached on the left.

Removing the barnacles turned out easier than we had thought. We had only just purchased some new inlet scrapers which were perfect for the job; bouyant and very flexible. It just requred some more duck-diving which the locals seemed keen to join in on.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Improving Water Information

Seasonal Streamflow Forecasts
Information about likely streamflow conditions at 70 locations around Australia
www.bom.gov.au/water/ssf

Australian Water Resources Assessment
Report on the status of our nation's water resources
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National Water Account
A set of water accounting reports for nine significant water-use regions in Australia
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Intensity–Frequency–Duration Design Rainfalls
Rainfall estimates used to design water and stormwater infrastructure
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Australian Government
Bureau of Meteorology

HIGH LEVEL QUALITY ANALYSIS

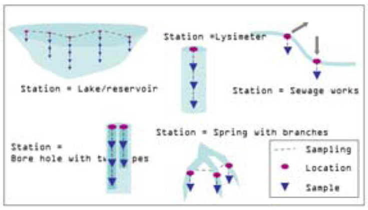
Water Management Tasks

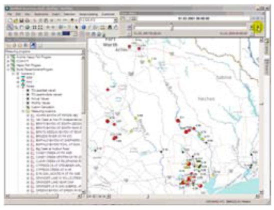
Government agencies and water management companies face complex tasks in the wake of the amended legal conditions. Water quality data on all bodies of water must be collected, managed and evaluated, and both qualitative and quantitative data must be combined in the data analysis to provide a meaningful data set. The actual quality of bodies of water can only be adequately assessed on the basis of this complex data. Finally, the collected data and analysis results must be presentable as graphs in order to present findings to the general public.

Features of The KISTERS Water Quality Module

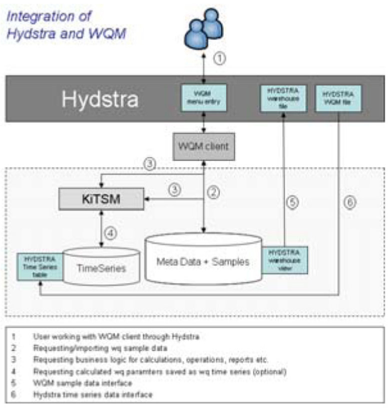
The **KISTERS Water Quality Module (KiWQM)** was added to the KISTERS water management information systems in order to measure up to an integrative approach capable of handling the variety of tasks at hand. The module allows expert users to organise and directly link water quality data and hydrological information (e.g. for load calculations) in a relational database. This has made the combination of qualitative and quantitative data on bodies of water possible.

Data import from Excel and LIMS - Sample data can be imported both automatically and manually. Import comprises not only measured and analytical values, but also verbal descriptions of the sample. Automatic import is carried out through a highly configurable importer. This tool allows the import of files created in spreadsheet programs, the standard format for sample data. An XML interface supports automatic imports of sample data from Laboratory Information Management Systems (LIMS).





Configuring measured data - The module also supports the definition of measurement programs as well as substance and comparison lists, based on which sample data can be evaluated efficiently. Water quality measurement stations are assigned to these measurement programs, which in turn appear in the KISTERS Explorer in display mode. Display mode provides access to the sample data, e.g. all descriptive, measured, or analysed data of a sample at each station. Extensive KISTERS tools are available for evaluations in graph and table format. The Water Quality Module additionally represents the basis for spatial data evaluation, for example through the generation of water quality maps via the KISTERS ArcGIS extension.



Contact KISTERS for further information
Email: support@kisters.com.au
Phone: 02 6154 5200

KISTERS

Alternative Staff Gauge Installation

Mike Lysaght

In this photograph you'll notice a range of very stable staff gauge 'plates'. They are on a stream near the capital of Thimpu in the country of Bhutan (on the edge if the Himalayas). The only problem I can see is that a meticulous re-paint would be required if they are found to be in error by a few millimetres following a survey as part of the site's annual inspection?

AUSTRALIAN HYDROGRAPHERS ASSOCIATION