Australasian Hydrographer

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AUSTRALIAN HYDROGRAPHERS ASSOCIATION

AHA

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JACQUIE BELLHOUSE

Editor's Introduction

Welcome to the August 2017 issue of the AHA Journal.

It has been pretty crazy quarter for me with a lot of interstate and intrastate travel for work. On the plus side I am racking up the frequent flyer miles and collecting some great photos of my home state (WA). On the downside there has been a lot of down-time in impersonal hotel rooms.

Dusk at Hearson Cove, Burrup Western Australia.

One of my recent trips took me to the Bureau of Meteorology's offices in Adelaide for the inaugural meeting of the Groundwater Monitoring Guideline subcommittee. The subcommittee one of two, recruited by WaMSTeC's Paul Rasmussen, have been tasked with improving the groundwater monitoring content of the published guidelines. The committee, made up of representatives from a range of backgrounds and states and agencies, have a significant bit of work ahead to supplement and extend the existing *National Industry Guidelines for hydrometric monitoring* (the existing guidelines) with more detailed guidance focused on groundwater monitoring.

In conjunction there is a second subcommittee, tasked with reviewing the ADCP guidelines. I have no doubt they are making great progress no doubt aided by the data and information collected during the recent 2017 ADCP Regatta and 2017 NZHS Technical Workshop.

With all this activity going on it is not surprising that I have chosen three articles that are a great reflection from where we have come and how we are all working together to move even further forward.

I have also included a great profile for one of our most recent Diploma of Water Operations graduates. Temistocle (Temi) Li Vigni is a great example of how Hydrography can really take you places, his profile makes for a great read.

Regards
Jacquie Bellhouse
Journal Editor

BILL BARRATT

From the President

Extreme sports, extreme bands, extreme medical services, extreme dialogue … we see the term extreme all over!

Extreme events have an impact on our industry as well. As an example, on 25 July, CSIRO reported “the frequency of extreme *El Niño* events is projected to increase for a further century after global mean temperature is stabilised.” The report goes on to say “currently the risk of extreme *El Niño* events is around 5 in 100 years…this doubles to approximately 10 events per 100 years by 2050”, and continues to increase. (CSIRO 2017)

How are we as hydrographers going to respond to these extreme events?

AHA’s role is to equip hydrographers to assist in managing extreme events:

- Before the event by having a better understanding of modelling, predictions and forecasting;
- During, by assisting in disaster relief and monitoring levels; and
- After by managing and monitoring the impact and devastation caused by the event.

The skill sets to manage events is broadening. Hydrographers need to understand the level, flow and quality of ground and surface water, as well as keeping up with changing technology and data management requirements.

AHA sees extreme events as having a growing impact on the profession and is updating its training offerings through:

- The AHA conference;
- The AHA *Introduction to Hydrography* course, and
- Subjects that will prepare you to complete the *Diploma of Water Industry Operations (Hydrography)*. The first of these new courses will be available in September.

AHA is also monitoring and influencing national training outcomes. AHA is represented by John Skinner on the *National Water Training Package Project Technical Advisory Committee* convened by Australian Industry Standards to ensure that training meets emerging professional requirements.

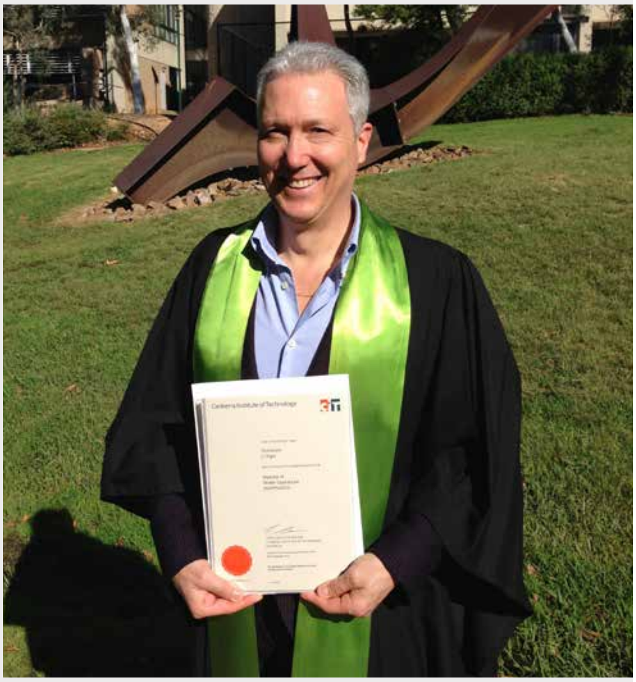
To ensure that national guidelines address surface and ground water, address flow and level and water quality, especially affecting extreme events, AHA is represented on the Water Monitoring Standards Technical Committee (WaMSTeC) convened by the Bureau of Meteorology. WaMSTeC chair (and AHA Member) Paul Rasmussen has recruited two WaMSTeC sub committees to review the ADCP guidelines and add groundwater specific content.

Finally, AHA is tuning its certification requirements to provide clear recognition to current and prospective employers that hydrographers are continuing to develop their skill set to address the requirements of not only routine hydrography, but also of extreme events.

Regards
Bill Barratt
AHA President

AHA Member Profile - Temistocle (Temi) Li Vigni

What hydrographic or other qualifications - relevant to your role - do you have?



- Diploma of Water Operations (*CIT*)
- Postgraduate Diploma in Science (PGDipSc)
- Bachelor of Geology (BGeolSc)

The AHA has also recognised me as a *Certified Practising Hydrographer*

What are your major career achievements? *from the oldest to the most recent*

- Drilling Site Geotechnical Engineer with "Intervento Geotecnico s.r.l." (Italy);
- Consultant Geologist with Associazione Professionale
- Geo Office (Italy);
- Assistant Scientific Officer (Hydrogeologist) with the Fluid Processes Group of the British Geological Survey (UK);
- Professional Diver with CNS Cooperativa Nazionale Sommozzatori (Tunisia);
- Hydrogeologist with the Italian Ministry of Foreign Affairs (Eritrea);
- General Manager with GEOservices Geological Supplies and Product Consulting
- Senior Hydrogeologist with Il Nuovo Castoro (INC) (Libya);
- System Specialist and Field Hydrographer with a number of Italian and foreign Government Agencies (Ethiopia, Uganda, Zimbabwe, Malawi and Sierra Leone);
- Lecturer at a number of Italian universities on the theory and practice of the use of ADCPs and ADVs;
- Sole Director and *Certified Practising Hydrographer* with GEOSPHERA Hi-tech Supplies Srl;

Where has hydrography taken you in the world?

Tunisia, Eritrea, Libya, Ethiopia, Uganda, Sierra Leone, Zimbabwe, Malawi, USA, Australia and Tajikistan.

How did your career related to hydrography commence?

I originally started as an agent of Hydrological Services Pty Ltd (now HyQuest Solutions), SonTek/YSI and Hydstra Pty Ltd (now Kisters) to promote and distribute their products in Italy.

Was there anyone who had a major influence on your career?

There were more than one but, Bill Steen (Kisters), Mike Lysaght (HyQuest Solutions) and Lee Pimble (SonTek) had the major influence on my decision to dedicate all efforts of mine to Hydrography.

What has been the most memorable experience in your career?

It was the first time I measured a large river as a system specialist and staff trainer. I was in Ethiopia in 2009 where Salini-Impregilo Spa (an Italian construction company) was building the GIBE III, one of the highest dams in the world. I was contracted to supply a RiverSurveyor M9 GPS RTK, provide training sessions and undertake discharge measurements upstream and downstream the cofferdam on the OMO River.

What makes hydrography interesting?

There are several reasons some of which are still unknown to me, but I always think to the next opportunity to travel to a new country, navigate a new river and meet special people.

What do you do when you are not at work?

I spend my time with my wife and my son Christian. He is 13 and he is a bowman in the 420 category.

Where do you see hydrography in 10 years?

Because of climatic changes and draught phases that are affecting our world, hydrography should be considered a strategic asset at global scale. Like blood in the human body, rivers, lakes and oceans represent the vital strength of our planet. Hydrography is the tool to preserve it.

Has "the means become the end" of data collection

Glenn McDermott, Enviromon, Sydney, NSW
Paper presented to 18th Australian Hydrographers Association Conference Canberra. 24-27 October 2016

Abstract

The old saying is "the end justifies the means" by Machiavelli in the 16th century. In the hydrometric business the "end" has in the past been to provide accurate flow and level and other data, with certified and experienced hydrographers, following national standards and/or best practice methods as "the means".

With the advent and increasing use of SCADA telemetry systems, users and clients are more and more requiring the availability of this data real-time, to make operational decisions.

At first this was only at sites where some operational control could be exercised by the operator. In several large water authorities, however, this thinking is being extended to include all monitoring sites, including those used for long term planning and reporting — with strong questioning of the need for continuing any non-operational sites.

This is now leading to questioning of the frequency of site visits and the cost of accurate calibration checks, which are not done for similar SCADA sites. These business reviews go hand in hand with budget cuts. So what is basically the "means" of collecting data (i.e. real time telemetry) is now becoming "the end" in questioning the accuracy maintenance practices and costs of the hydrometric industry.

In effect there is a growing risk that future hydrometric work will be done by electricians and not hydrographers. This paper presents the history of this issue as observed in Sydney Water and the NSW Department of Primary Industries. Its purpose is to raise the issue, with the hope that a way of working together can be found which benefits both the hydrometric industry and the electrical engineering industry (i.e. SCADA aspects), going forward.

1. Approach adopted

The approach proposed and followed here is to "know the past to understand the present and plan for the future". In particular concentrating on "knowing the past" so it is possible then to "understand the present".

There are three aspects to "knowing the past" which will be discussed in this paper:

- From whose point of view (which industry)? Hydrographic measurement industry, or the SCADA data telemetry and system control industry?
- On what sort of systems?
  - o Urban (such as Sydney) to suit operation, maintenance and improvement planning on sewerage and treatment systems - such as the NSOOS[1] and North Head STP[2];
  - o Non-urban (rural) — such as on regulated river systems — e.g. for the Murrumbidgee river operation, control maintenance and improvement planning.
- For which client(s)?

1. Northern Suburbs Ocean Outfall Sewer
2. Sewage Treatment Plant

2. Hydrographic Monitoring Systems

The general meaning of hydrography is "measurement of water". Its aim is to deliver data of a known, reliable and provable accuracy, to suit the requirements of the various data users. Below is an attempt to show the timeline of events and developments, that has influenced hydrography as practiced today in Australia.

2.1. Important events in development timeline

Year (circa)	Event
Pre 1900s	Daily reading of staff gauge posts by local landholders on large rivers. Data communicated back to state water departments by posting the monthly data returns, and paying the landholder a small fee.
Early 1900s - all analogue	• The first automatic level monitoring stations established, usually at or near the sites where large storage dams were planned. Level was measured via a float in a stilling well, connected to the bed of the river via an inlet pipe. The level of the float was translated to movement on a paper chart, and the ink trace on the chart would show the river level behaviour. The charts would require replacement every 4 to 6 weeks, and important events debris levels would be surveyed and noted on the paper charts - as a sanity check. • Flow gaugings were done on every site visit, and during flood flows whenever possible. All gaugings were recorded in log books for the site, and plotted on the site rating curve (usually an A-0 scale sheet on log-log grid). • Annual site surveys were done, and the movement in gauge posts levels checked and corrected. Inlet pipes were cleared, and various instrumentation checks done. • Some of the issues noted during this period: data accessibility was poor, as it was all on paper charts stored in a compactus; site safety management during flood gaugings was poor; stilling well inlet pipes would frequently block–causing underestimation of event peaks, and lagging of hydrographs. • Standards of practice were not formalised, but based generally on those developed to suit USGS needs for USA hydrographers, or UK needs for their hydrographers o The Snowy scheme developed its own training scheme to suit it's needs for skilled hydrographers.
1970s - Hydrography certificate & gas bubbler technology & digital begins	• Hydrography certificate course was developed and began, with many experienced hydrographers doing the course, along with new trainees. o For example in NSW this was done within the TAFE system. • Gas bubbler technology enters the scene as an alternative to stilling well level measurement. • This was a "great leap forward" for sewer level monitoring, to replace the stilling well approach which was a failure in sewers due to grease build up "trapping" the float. • Digital recording technology arrives as an alternative to the paper chart, and conversion from paper chart to digital began—shifting the knowledge required away from mechanical clockwork towards DC electrics and electronics. • Communicating levels at important sites (e.g. along large rivers during flood times) was not as yet automated, but usually involved the local landholder phoning in the staff gauge level. • Several ISOs are published in the late 1970s as a world standard for hydrographic practice—after collaboration with UK, US, European and Australian hydrographers and engineers—such as ISO 5168 (measurement uncertainty); ISO 748 (Current meter gaugings); ISO 2425 (Measure flow in tidal channels).

Year (circa)	Event
1980s- Enter digital & HYDSYS	• More ISO standards are published and made available for practising hydrographers, such as: ISO 1100 for establishment of gauging stations (Part 1) and Establishment of stage discharge relations (Part 2). • Digital data initially had no choice but to be stored on various early computer systems, which linked to the sensor manufacturers download software. • HYDSYS arrives on the scene in the early 1980s, and each major water authority moves towards its adoption as the time series data storage standard. • Digitisation projects commenced to convert important paper chart records to HYDSYS.
1990s- Enter private enterprise	• Many ISO standards are "copied" to form the AS3778 set of standards, and published as Australian Standards. These proved useful for: o Training staff and performance reviews; o Service agreements with clients, as traceable standards, which can define the measurement uncertainty (data accuracy) being delivered. • Phone line connectivity to most data loggers was enabled, allowing both data collection (without site visit) and real time signal availability to interested operators. • Velocity and depth sensors entered the market, and became the preferred technology for sewer gauging stations. • The largest sewer gauging contract in the world saw 500 sites established in Sydney, and responsibility transferred to a private company specialising in sewer gauging networks (ADS). Auditing their performance revealed several inadequacies in AS3778 applicability to this flow media, such as: o Current meter gaugings consisted of only 5 verticals at most, and only 15 seconds exposure time at most—making theoretical uncertainty of audit and calibration checks to be ±50%. • The "boil water alert" in Sydney in August 1998 resulted in the creation of Sydney Catchment Authority, and the subsequent letting of the largest hydrographic contract to private hydrographic interests (initially Thiess, and now ALS and MHL) covering all dams and rivers in the greater Sydney area. o Current meter exposure time "standards" were lowered from the previous 3 minute standard down to a 40 second standard to reduce costs (time) of gaugings. • This period also saw the growth in remote site telemetry for flood warning systems, either via phone lines or via dedicated radio networks (such as Radtel). • Water quality sensors and sensing were added to many flow gauging stations, such as for salinity, DO[3], turbidity and temperature to enable investigation of the many emerging environmental concerns. o There were some concerns that with this additional work load, and the tight per site operational prices, this might reduce the number or frequency of flow gaugings—and it did.

Year (circa)	Event
2000s- BOM[4] & new standards	• HYDSTRA (formerly HYDSYS) is well established as the National Standard for hydrographic data base storage, management and reporting. • Many river and rain gauging stations have data collected daily or weekly, in data packets via modem to HYDSTRA, with less frequent site visits needed. • ADCP use for flow gaugings as an alternative to current meter gauging, gains credibility and popularity—with the potential to be much safer, and take less time. • Long drought results in Federal Government funding the "National Water Initiative", paying for various instrumentation and data transfer improvements, resulting in all authorities transferring copies of their data to BOM for national archive, as well as writing new national practice guidelines for hydrography, such as: o Primary Measured Data; o Site Establishment and Operations; o Instrument and Measurement Systems Management; o Gauging (Velocity Area Method); o Data Editing, Estimation and Management; o Stream Discharge Relationship Development and Maintenance; o Training; o Application of Acoustic Doppler Current Profilers to Measure Discharge in Open Channels; o Application of In-situ Point Acoustic Doppler Velocity Meters for Determining Velocity in Open Channels; o Application of Point Acoustic Doppler Velocity Meters for Determining Discharge in Open Channels; • National Water Initiative pays for many water savings identification projects, managed via "Water for Rivers", as part of which large scale replacement of irrigation "billing" meters were funded, and included funding of Non-urban metering standards: o Based on "pattern approved meters"- i.e. not requiring hydrographic field validation checks; o Set precise targets for measurement uncertainty of "valid meters"; o Created a huge number of extra stations for data management - in HYDSTRA, or in SCADA? o The majority of sites do not conform with "all" pattern approval requirements, and so should require field verification of accuracy, with data management of these field checks by hydrographers, and storage in HYDSTRA?
2010s- Organisation changes	• The hydrographic monitoring service groups in several organisations, are made to come under the SCADA real time operations group(s), causing concerns about: o Lowering of data accuracy maintenance standards, and traceability to national standards; o "Planning" and "modelling" clients, who are equally data owners along with river and system operators, not having a strong enough voice to demand data quality be maintained as per hydrographic standards; o Time series data currently sent to HYDSTRA, now might be stored in the SCADA historic database; o Hydrography might become redundant, and replaced by SCADA electrical technicians.

3. Dissolved Oxygen
4. Bureau of Meteorology

2.2. Overview on hydrographic work "focus"

One overview point to note is that although hydrographic work has now come to include pressure pipe flow and water quality monitoring, the core of hydrographic work is open channel flow monitoring. The main difference being the added elements of extreme weather flow variability (e.g. river heights from 0.5 m in normal times to 25 m up the valley walls in large floods), and the fact that velocity distributions are anything but "regular". To do this work well requires an understanding and feel for the individual site hydraulics.

3. SCADA Systems

3.1. Historical timeline of SCADA development

The following text has been taken from a variety of sources, but principally the paper by David Bailey and Edwin Wright (2003)[5].

SCADA (supervisory control and data acquisition) has been around as long as there have been control systems, and has many ISO standards covering various aspects (see selected references in section 7). SCADA refers to the combination of telemetry and data acquisition. SCADA encompasses the collecting of the information, transferring it back to the central site, carrying out any necessary analysis and control and then displaying that information on a number of operator screens or displays. The required control actions are then conveyed back to the process.

1900–1970- The second industrial revolution- mass production powered by electricity

1932 – The concept of "negative feedback" was understood and was incorporated into new control theory concepts and design of control systems.
1950s – Machine tools were automated using Numerical Control (NC) using punched paper tape.
1959 – First use of distributed control throughout a large industrial plant.
1968 – First design concept of a Programmable Controller (PC).
1969 – Modicum 084 the first Programmable Controller (PC) implemented. (Modicum stood for Modular Digital Controller).

The first 'SCADA' systems utilized data acquisition by means of panels of meters, lights and strip chart recorders. The operator manually operating various control knobs exercised supervisory control. These devices were and still are used to do supervisory control and data acquisition on plants, factories and power generating facilities. The following figure shows a sensor to panel system.

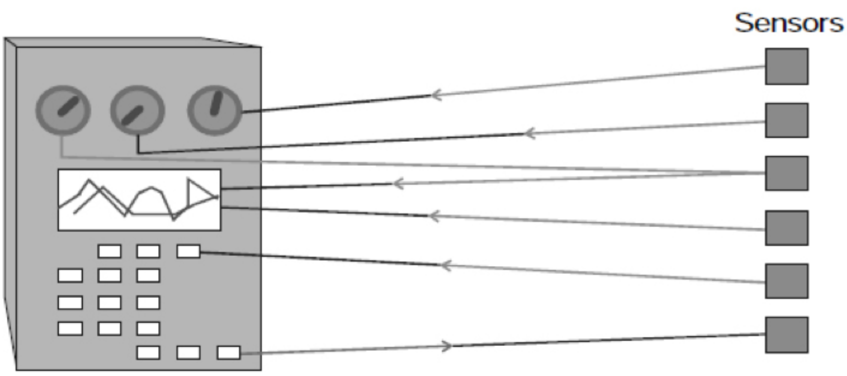


Figure 3.1 - Early SCADA system- all hard-wired direct from sensors to control panel.

This early sensor to panel type of SCADA system has the following advantages:
- It is simple, no CPUs, RAM, ROM or software programming needed;
- The sensors are connected directly to the meters, switches and lights on the panel;
- It could be (in most circumstances) easy and cheap to add a simple device like a switch or indicator.

[5] David Bailey and Edwin Wright. (2003) *Practical SCADA for Industry*. Oxford, Burlington: Newnes, 2003. ISBN 7506 58053. https://www.fer.unizg.hr/_download/repository/Practical_SCADA_for_Industry.pdf accessed 2017-08-31

The disadvantages of a direct panel to sensor system are:

- The amount of wire becomes unmanageable after the installation of hundreds of sensors;
- The quantity and type of data are minimal and rudimentary;
- Installation of additional sensors becomes progressively harder as the system grows;
- Re-configuration of the system becomes extremely difficult;
- Simulation using real data is not possible;
- Storage of data is minimal and difficult to manage;
- No off site monitoring of data or alarms;
- Someone has to watch the dials and meters 24 hours a day.

1970- 2000s- The third industrial revolution- automation of production by electronics

1971 – Allen-Bradley designed and named the Bulletin 1774 PLC and coined the term "Programmable Logic Controller".
1973 – Modbus introduced to allow PLCs to talk with one another.
1976 – Introduces remote I/O.
1986 – PLCs are linked to PCs as illustrated below.

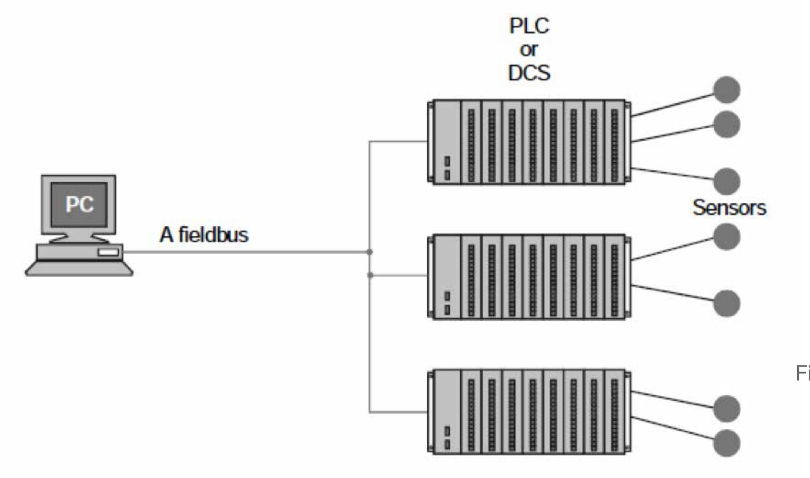


Figure 3.2 - PC to PLC with a fieldbus and sensors.

1990s – Fieldbus protocols to include ControlNet, DeviceNet, Profibus, Fieldbus Foundation.

The advantages of the PLC / DCS SCADA system are:

- The computer can record and store a very large amount of data;
- The data can be displayed in any way the user requires;
- Thousands of sensors over a wide area can be connected to the system;
- The operator can incorporate real data simulations into the system;
- Many types of data can be collected from the RTUs (remote terminal units);
- The data can be viewed from anywhere, not just on site.

The disadvantages are:

- The system is more complicated than the sensor to panel type;
- Different operating skills are required, such as system analysts and programmer;
- With thousands of sensors there is still a lot of wire to deal with;
- The operator can see only as far as the PLC.

1992 – Ethernet and TCP/IP connectivity for PLCs.
2003 – First controllers with embedded web server.

As the requirement for smaller and smarter systems grew, sensors were designed with the intelligence of PLCs and DCSs. These devices are known as IEDs (intelligent electronic devices). The IEDs are connected on a fieldbus, such as Profibus, Devicenet or Foundation Fieldbus to the PC. They include enough intelligence to acquire data, communicate to other devices, and hold their part of the overall program. Each of these super smart sensors can have more than one sensor on-board. Typically, an IED could combine an analogue input sensor, analogue output, PID control, communication system and program memory in one device.

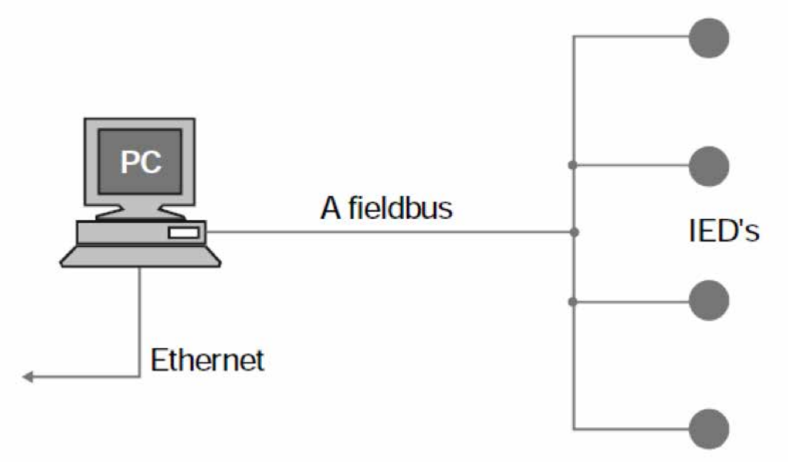


Figure 3.3 - PC to IED using a fieldbus.

The advantages of the PC to IED fieldbus system are:
- Minimal wiring is needed;
- The operator can see down to the sensor level;
- The data received from the device can include information such as serial numbers, model numbers, when it was installed and by whom;
- All devices are plug and play, so installation and replacement is easy;
- Smaller devices means less physical space for the data acquisition system.

The disadvantages of a PC to IED system are:
- More sophisticated system requires better trained employees;
- Sensor prices are higher (but this is offset somewhat by the lack of PLCs);
- The IEDs rely more on the communication system.

3.2. The modern SCADA system

Looking at the overall structure of a SCADA system, there are four distinct levels within SCADA, these being;

I. Field instrumentation,
II. PLCs and / or RTUs,
III. Communications networks and
IV. SCADA host software.

Figure 3.4 presents these, and the text below discusses each of these levels in detail, describing their function, how SCADA has changed over the past 30 years and the impact of security requirements and regulatory compliance on SCADA system operations.

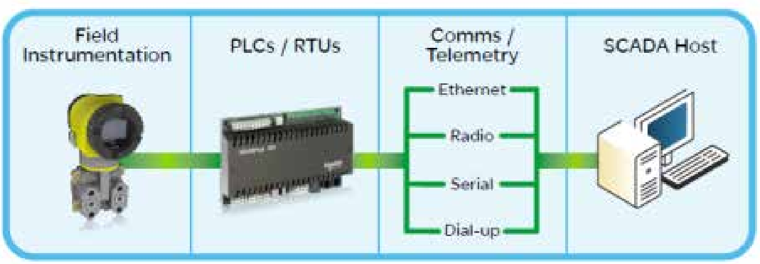


Figure 3.4 - Basic SCADA components.

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Field Instrumentation

"You can't control what you don't measure" is an old adage, meaning that instrumentation is a key component of a safe and optimised control system. Traditionally, pumps and their corresponding operational values would have been manually controlled i.e. an operator would start/stop pumps locally and valves would have been opened/closed by hand. Slowly over time, these instruments would have been fitted with feedback sensors, such as limit switches, providing connectivity for these wired devices into a local PLC or RTU, to relay data to the SCADA host software.

	Early instrumentation	Feedback sensors	Add Actuators
Pro	Installation is cost-effective	Central view	Central control
Con	Expensive to operate	Still expensive to operate	Higher technical requirements

Figure 3.5 - Developments in field instrumentation.

Although today's instrumentation technician requires more technical knowledge and the ability to design, install and maintain equipment, than in the past, this is mitigated by the reduced cost in automating processes and higher technical skills held by personnel. Today, most field devices such as valves have been fitted with actuators, enabling a PLC or RTU to control the device rather than relying on manual manipulation. This capability means the control system can react more quickly to optimise production or shutdown under abnormal events.

In terms of regulatory compliance, instrumentation for the oil and gas industry has had to comply with hazardous class, division and group classifications. The requirement is that the instrument must be designed for the location or area in which it has been placed, e.g. an environment where the existence of explosive vapours during normal operating conditions, or during abnormal conditions, are known.

In many cases the instrument is also required to function in harsh environments. Many types of instrumentation are designed for extremes of hot and cold. If the instrumentation is not designed for these temperatures, an artificial environment within a cabinet or some sort of building is required. This comes at an extra cost not just in initial design but also for ongoing maintenance.

Instrumentation must also comply with any EMC (electromagnetic compatibility) standards which may be in place, to ensure that an electrical device does not have any undesirable effects upon its environment or other electrical devices within its environment.

RTUs and PLCs

Programmable Logic Controllers (PLCs) and Remote Telemetry Units (RTUs) used to be distinctly different devices but over time they are now almost the same. This has been a convergence of technology as manufacturers of these devices expanded their capabilities to meet market demands.

If we go back 30 years, an RTU was a 'dumb' telemetry box for connecting field instruments. The RTU would 'relay' the data from the instruments to the SCADA host without any processing or control but had well-developed communication interfaces or telemetry. In the 1990s control programming was added to the RTU so it operated more like a PLC. PLCs on the other hand could always do the control program but lacked communication interfaces and data logging capability, which has been added to some extent over the past decade.

A further development of devices in the field is to offer a specific application that could incorporate a number of instruments and devices with an RTU/PLC, incorporating technology sets to provide an 'off the shelf' approach to common process requirements, e.g. gas well production that includes elements of monitoring, flow measurement and control that would extend as an asset into the SCADA Host.

In terms of environmental and regulatory compliance, PLCs and RTUs have the same type of requirements as instrumentation in that they operate in the same environment. However, PLCs have traditionally not been as environmentally compliant as RTUs. This is mainly due to the fact that PLCs were designed to operate in areas, such as factory floors, where the environment was already conditioned to some degree.

Remote Communications networks

The remote communication network is necessary to relay data from remote RTU/PLCs, which are out in the field or along the pipeline, to the SCADA host located at the field office or central control centre. With assets distributed over a large geographical area, communication is the glue or the linking part of a SCADA system and essential to its operation. How well a SCADA system can manage communication to remote assets is fundamental to how successful the SCADA system is.

Twenty years ago the communication network would have been leased lines or dial-up modems which were very expensive to install and maintain, but in the last 10-15 years many users have switched to radio or satellite communications to reduce costs and eliminate the problematic cabling issues. More recently, other communication types have been made available that include cellular communications and improved radio devices that can support greater communication rates and better diagnostics. However, the fact that these types of communication media are still prone to failure is a major issue for modern, distributed SCADA systems.

At the same time as the communication medium changed so too did the protocols. Protocols are electronic languages that PLCs and RTUs use to exchange data, either with other PLCs and RTUs or SCADA Host platforms. Traditionally, protocols have been proprietary and the product of a single manufacturer. As a further development, many manufacturers gravitated to a single protocol, MODBUS, but added on proprietary elements to meet specific functionality requirements. For the oil and gas industry there are a number of variants of MODBUS, including but not limited to, MODBUS ASCII, MODBUS RTU, Enron MODBUS and MODBUS/TCP. This provided a communication standard for the retrieval of flow or process data from a particular RTU or PLC.

This incremental development in using MODBUS protocol variants was seen as an improvement, but it still tied a customer to a particular manufacturer, which is very much the case today. A good example is how historical flow data is retrieved from a RTU/PLC by a SCADA Host. However, the advancement of SCADA Host software, and in some cases the sharing of protocol languages, has meant that many of the issues with proprietary elements have been further resolved.

In recent years, protocols have appeared that are truly non-proprietary, such as DNP (Distributed Network Protocol). These protocols have been created independently of any single manufacturer and are more of an industry standard; many individuals and manufacturers have subscribed to these protocols and contributed to their development. The diagram below illustrates the advantage of DNP.

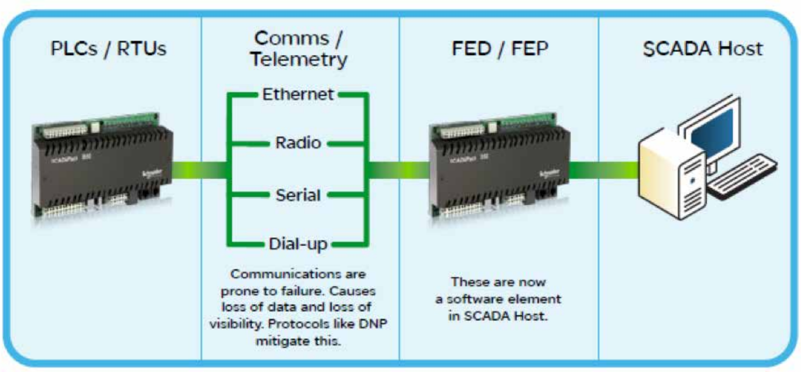

Figure 3.6 - Wide area network SCADA.

SCADA Host Software

Traditionally, SCADA Host software has been the mechanism to view graphical displays, alarms and trends. Control from the SCADA Host itself only became available when control elements for remote instruments were developed.

These systems were isolated from the outside world and were the domain of operators, technicians and engineers. Their responsibility was to monitor, maintain and engineer processes and SCADA elements. With advancements in Information Technology (IT) this is no longer the case. Many different stake holders now require real time access to the data that the SCADA Host software generates, as illustrated in Figure 3.6.

Accounting, maintenance management and material purchasing requirements are preformed or partly preformed from data derived from the SCADA system. Consequently, there is a drive for the SCADA Host to be an Enterprise entity providing data to a number of different users and processes.

This has encouraged SCADA Host software development to adopt standards and mechanisms to support interfacing to these systems. It also means that IT, traditionally separated from SCADA systems, is now involved in helping to maintain networks, database interfacing and user access to data.

Many of the initial SCADA Host products were developed specifically for the manufacturing environment where a SCADA system resided within a single building or complex, and did not possess many of the telemetry communication features required by SCADA systems for geographically distributed assets.

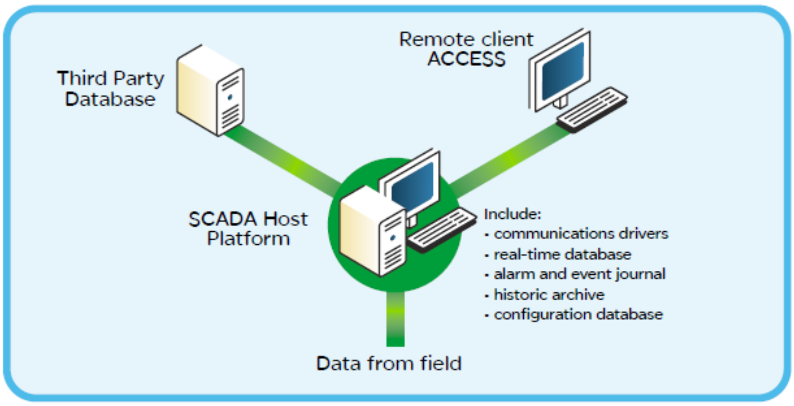

Figure 3.7 - SCADA host platform.

These types of 1st-generation SCADA Hosts often required a hybrid PLC or RTU, called a Front End Driver (FED) or Front End Processor (FEP), to be used for handling communications with remote devices. This resulted in a number of disadvantages as it required specialised programming, external to the SCADA Host platform, and created a communications bottleneck. Although multiple FED or FEP devices resolved some of this, there were extra costs and difficulties in creating and maintaining them due to their specialised nature. Modern SCADA software that encapsulates telemetry functionality no longer requires these types of hybrid PLCs for communications.

They now use software programs called ‘drivers’ that are integrated into the SCADA Host itself. Software drivers contain the different types of protocols to communicate with remote devices such as RTUs and PLCs.

As technology developed, SCADA Host software platforms were able to take advantage of many new features. These included the development of integral databases specifically designed for SCADA Host software requirements, being able to handle thousands of changes a second, for really large systems, yet still conform to standard database interfacing such as Open Database Connectivity (ODBC) and Object linking and Embedding for Databases (OLE DB). These standards are required so that third-party databases can access data from the SCADA Host software. Remote client access to the SCADA Host is another technology that has enabled users to operate and monitor SCADA systems while on the move between or at other locations.

There is a drive towards operational safety for SCADA Host systems within the oil and gas industry. 49 CFR 195.446 Control Room Management regulations look at SCADA Host software and how it functions in terms of operations, maintenance and management. It also covers the degree of integration of the SCADA system itself and its use of open architecture and standards.

Security

Security for SCADA systems has in recent years become an important and hotly debated topic. Traditionally SCADA systems were isolated entities that were the realm of operators, engineers and technicians. This has meant that SCADA Host platforms were not necessarily developed to have protected connections to public networks. This left many SCADA host platforms open to attack as they did not have the tools necessary to protect themselves.

In terms of remote assets communicating back to a SCADA Host, security has been an issue for many years with numerous documented attacks on SCADA systems. However, it's only been in recent years that an open standard has been produced to provide secure encrypted and authenticated data exchanges between remote assets and a SCADA Host platform.

Solutions for remote asset and SCADA host communication security have very different requirements. Security has to also be viewed overall, and not just in terms of the SCADA system itself. For example, if somebody wanted to disrupt production, they would not necessarily need to access the SCADA system to do this. If a gas wellhead site or a monitoring point on a gas pipeline is remotely situated, it could be easily compromised by a trespasser. If the asset is critically important, other solutions that may or may not form part of the SCADA system itself would have to be considered, e.g. camera surveillance security.

A large number of unauthorised accesses to a SCADA system come not from or at the remote assets themselves but through the SCADA Host or computers used to access the SCADA system for diagnostic or maintenance purposes. For example, the recent attack using the Stuxnet virus was introduced via a thumb drive on a computer used to access a SCADA system.

There are a number of standards available that describe how to secure a SCADA system, not just in terms of the technology employed, but in terms of practices and procedures. This is very important since the security solution to SCADA is not a technological silver bullet, but a series of practices and procedures in conjunction with technological solutions. These practices and procedures would include items of training, SCADA Host access and procedures to follow when SCADA security has been compromised. In modern SCADA systems IT departments are integral to implementing and maintaining SCADA security for an organisation and should be included in setting up practices, procedures and implementing technologies.

3.3. Overview of SCADA system drivers

As the name SCADA implies, the main aim of a SCADA system is to communicate sensed parameters (levels, flows, water quality) back to a central control point, and as far as possible to have programmed automatic control responses to changes, as well as enabling real time modelling of "what if" optimisation runs, for the information of the operator to make decisions on. The central focus is on communication, control and reliability and security of information, and on data "up-time".

Note that for open channel work, data accuracy appears to be related solely to manufacturer's claims rather than the hydraulic understanding of the open channel as would apply if AS3778 practices or the new BOM national guidelines were used.

Also note the gradual expansion of SCADA from its early beginnings at single location facilities, such as at dam operations rooms and sewage treatment plant control rooms, to now covering whole systems with remote sensing, including local control rooms and all their information, such as: NSOOS and North Head STP, and Murrumbidgee from upstream inflow stations to dams, to dam controls, to mid-section weir and gate controls, level and flowrate measurement points all the way down the river.

4. City hydrography example

The example here is focussed on the NSOOS and North Head sewer and treatment system. Figures 4.1 and 4.2 shows a map of the system in 1997, when the number of carrier gauges were in the process of being rationalised.

Figure 4.1 - Map of lower NSOOS to North Head STP.

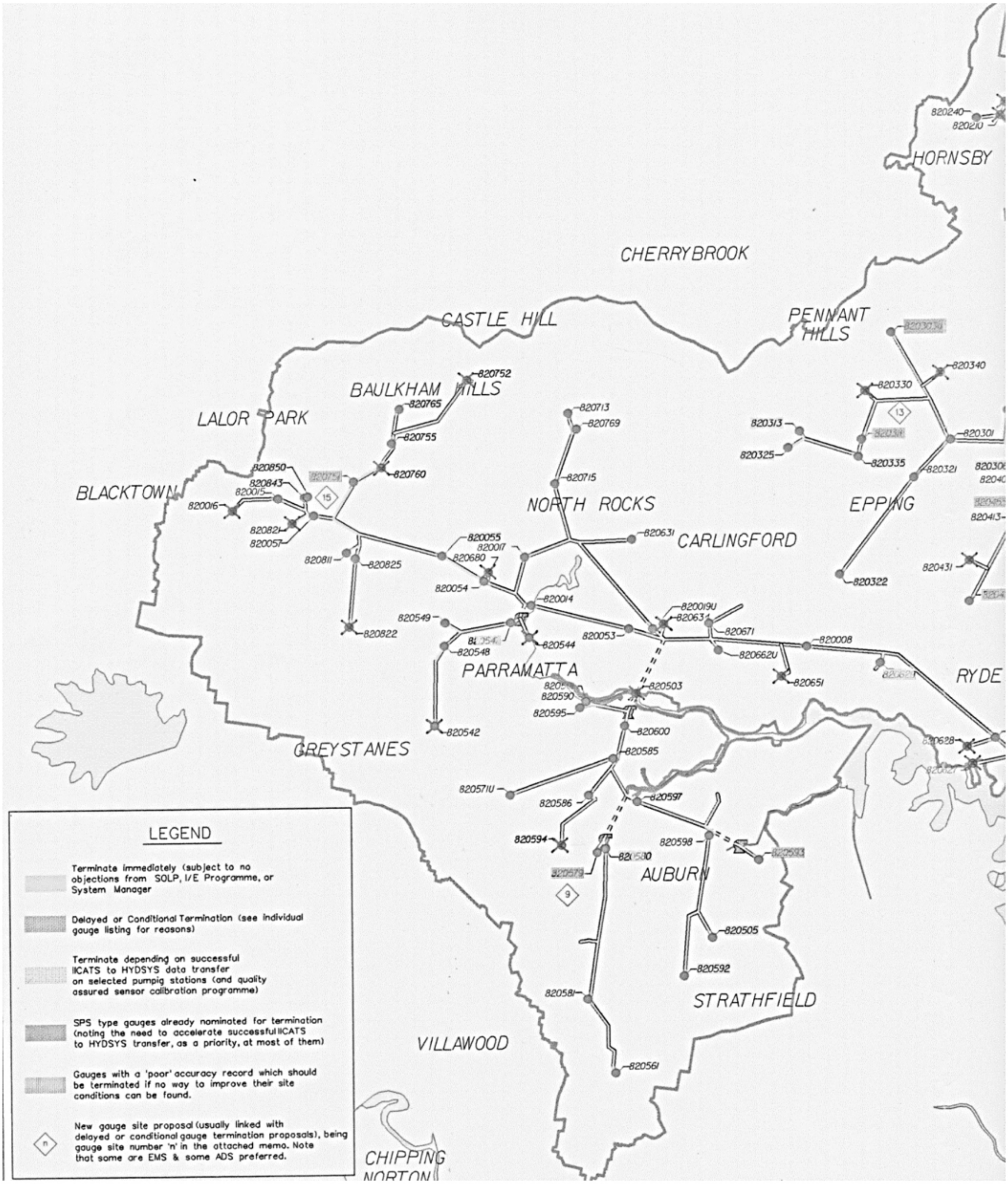

Figure 4.2 - Map of upper NSOOS.

4.1. Historical timeline of hydrographic developments

The history timeline table below is focussed on the NSOOS and North Head system, but covers general influencing factors as well.

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
1916–1930	Northern suburbs ocean outfall sewer constructed, with cliff face discharge-capacity estimates based on "estimated" future population. System included several large "capacity relief" overflow structures.	None.
1958	First edition of Australian Rainfall and runoff guidelines produced- covering how to design stormwater capacities based on rainfall intensity-frequency methods. Editor: Mr McIllwraith, MWS&DB engineer & surveyor.	Gauging Sub-Branch's Mr. Mort "invents" the Mort rain gauge, and establishes network of rain gauges (about 3 on the NSOOS).
1950s and 1960s	Post-war population explosion- much more than planned for in 1916, causing frequent wet weather overflow activation- especially at the "chocolate butterfly" near a popular TV game show host's luxury house.	None- except occasional use of rain gauge records for storm intensity definition- and to investigate sewage surcharge and overflow complaints.
1967	Brown and Caldwell consulting engineers (USA) report on the likely future NSOOS overflow frequency, and design of monitoring system so that this could be investigated using hydraulic and hydrologic models.	2 or 3 temporary flow and overflow monitoring stations installed for Brown & Caldwell work, who used this data, along with recorded rainfall, to define unit-hydrographs of wet weather inflow to the NSOOS, and model overflow frequency.
1972–1984	Construction of North Head sewage treatment plant lifting flow 60 m to ground level, and treatment, with cliff face discharge.	Large effluent flume designed by Gauging Sub-branch, and level (and discharge) monitoring began circa 1984 including upstream NSOOS level and flow monitoring stations immediately u/s in Manly and another further u/s at Clontarf.
1970–now	Trade waste licence agreements with major industrial companies discharging to NSOOS after local treatment.	Continuous flow measurement using small flumes or weirs- as billing meters. Designed and installed by hydrographers.
1972	NSW Clean Water Act becomes law which formed the basis of formation for the EPA.	Major overflow points monitored (about 3 in NSOOS), as well as some intermediate flow gauging stations, as per Brown and Caldwell's recommendations.

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
1972- 1984	Public outcry about level of sewage pollution on Sydney's beaches leading to decision to plan and build ocean outfalls.	A programme of monitoring current patterns off-shore, using drones- so that dispersion plumes and frequency of beach impacts could be investigated.
1984- 1990	Deep water ocean outfalls constructed at North Head, Malabar and Bondi.	
1987, 1988	Several very large storms cause repeated and highly visible raw sewage overflows to waterways, and became front page news- causing government focus on the issue, with much criticism and accusations of collusion between Sydney Water and EPA- e.g. publication of "Sewer Surfing" by Dr Sharon Beder.	
1989- 1990	NSOOS Pollution Abatement planning project commences.	Gauging Sub-Branch had by now been renamed Hydrographic Services, and established more than 12 new gauging stations on the NSOOS and major carriers- to suit the project's modelling input needs.
1991	• $40 million Clean Waterways Programme given to a joint venture between Montgomery (US), Sinclair Knight, and Willing and Partners- to model and review sewer systems and wet weather sewage overflows, and come up with solutions. • $40 million sewer gauging network establishment and operation contract let to ADS. • These were the largest Consultancy and monitoring contracts Sydney Water had ever outsourced, with the monitoring contract being the largest of its kind in the world, with 500 sites to be established.	Hydrographic Services, were placed in the position of having to hand over their carefully maintained long term depth and rating table gauging stations, for replacement with ADS's depth and velocity sensors, but retained their network of rain gauges and STP inflow, outflow and bypass gauges.
1991- 1996	Clean Water Consultants finalise their Overflow Abatement Plans for the NSOOS and other systems, with total costs ranging from "far too much" for the 100 year storm containment, down to a mere $ 4 billion to contain the 3 month storm.	ADS installed 500 gauges and collected data to HYDSYS from all 500 sites, which had all been telemetered using new land-lines laid to each data logger- and used for weekly data collection Hydrographic installed rain gauges in coverage gaps, doubling the network, and formed the sewer audit group- who performed regular field and office audit checks on ADS performance.

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
1997-1999	• EPA and Sydney Water negotiate practical and affordable O/F containment standards (e.g. 3 months to most waterways and 1 year to sensitive waterways). • Sydney Water commences Sewerage Overflow Licencing Programme to form the basis of detailed system & treatment licences with the EPA, with improvement plan schedules and costs. • Olympics in 2 years- decision made to “clean up Sydney Harbour” so approval given to build North Side Sewage Overflow tunnel, intercepting all major overflows along the NSOOS.	
1998	Boil water alert after Cryptosporidium and Giardia detected in drinking water leading to a royal commission and the subsequent decision to split the bulk water and treatment functions out of Sydney Water to Sydney Catchment Authority.	Hydrographic group “handover” their long term river, dam and water quality monitoring network to Thiess, when SCA decide to outsource this service.
1998~ 2008	Formation of AWT as a separate entity from Sydney Water such that groups in AWT could compete for external work. AWT “closed” ~ 2008.	Hydrographic win several external hydrographic work contracts as part of AWT, as well as looking after their portion of the sewer gauging networks, and auditing of all sewer gauging contractors. Note also that several long term sewer flow and overflow monitoring sites were “taken over” and made part of the North Side Storage tunnel operational SCADA control.
~2005	Sydney Water commenced annual environmental licence reports to EPA, fulfilling that licence condition, along with annual update of the overflow abatement plans for the system- which included proof of model calibration to gauge data from HYDSYS, as well as external audit of this, and use of models to “estimate” annual overflow volumes. Note that most of the annual licence fees for each system were based on these model estimated overflow volumes (i.e. $/ML). Also there was commencement of detailed SCAMP models and temporary gauging; covering all pipes up to 300 mm to 225 mm- to better model overflows. This roll-out of projects took until circa 2012 to complete.	Hydrographic continue to look after STP monitoring, and production of monthly and annual volume reports- for the operator’s licence reports to the EPA. Hydrographic did some of the earlier Scamp temporary gauging contracts, but ended up focussing more on auditing ADS and MHL doing the SCAMP works.

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
2000–Now	Water distribution system flow and pressure monitoring improvement to suit more sophisticated and interlinked modelling needs for planning and operational purposes.	Hydrographic Services now include management of the specialist electrical technicians who field check flowmeter accuracies, install flowmeters, and do commissioning tests on flowmeters.
2012–now	Hydrographic Services (now called Monitoring Services) successfully makes the business case to transfer back the sewer gauging stations network to it for operation and maintenance (i.e. from ADS and MHL). Also a change in management policy allows Monitoring Services to bid on external monitoring contracts.	Monitoring Services takes on new staff to deal with the much increased work load. Gives support to development of Diploma of Hydrography, but with focus on pipe flow gauging works to suit sewer network management, with NSW TAFE.
2016	Monitoring Services group placed under Real time monitoring and control group (IICATS).	IICATS management insist on replacement of field data loggers with standard IICATS RTUs, and also question why store data in HYDSTRA, when it can be perfectly well stored in their real time operational database. IICATS management question the need to be following hydrographic accuracy practices at monitoring sites, and indicate a preference for cheaper monitoring solutions.

4.2. Monitoring equipment and data storage changes

The hydrographic monitoring equipment refinement which took place, which accompanied the above events timeline, in general terms:

- 1940 to 1977—the "analogue period"—all level (pressure) sensors going to paper chart and ink recorders, powered by clockwork (requiring regular winding, and replacement of paper charts):
  - No (or minimal) telemetry;
  - Office hydrographers review each chart, extract and summarise key information to log books (such as O/F start and finish times), and store charts in secure and accessible storage (e.g. compactus);
  - Field flow gaugings summarised and stored in log books, and rating curves plotted on A0 size paper, with regular review by senior hydrographer;
  - Hydrographs of interest were calculated point by point, manually, and sent to internal clients on office files.

- 1977 to 1984—the "change to digital" period- various digital transducers now in use, to convert analogue pressure signal to a 4–20 mA digital signal, for recording on punch paper tape or early versions of silicon chips;
  - Rechargeable DC batteries used as the power source for the loggers;
  - At sites which needed real time signals for the operator, a phone line was connected direct to the new digital data logger, e.g. signal from NSOOS at Eustace St to North Head STP operations;
  - Various database storage media used to store data digitally such as HP minicomputer; Kaypro; CompaQ; Perkin Elmer computer, etc.
  - Monthly STP flows report automated (as much as possible) on HP computer.
- Also 1977 to 1984—the development of an Australian Doppler velocity sensor (with depth sensor as well) by MACE, and testing and use of these in small sewers.
- 1982 to 1986—Decision to adopt HYDSYS as the preferred (and unified) time series data storage software- along with conversion (gradually) of digital records held on earlier media.
- Circa 1986—first transit-time velocity sensing arrangement installed and operating on the NSOOS at Eustace St in Manly, as this was recognised as superior to the Doppler for this wide and deep channel
  - This sensor pair worked well with minimal maintenance up until it's removal circa 2004.
- 1990—ADS arrive in Sydney to demonstrate their "new to us" finger-sized velocity sensor, and their quad redundant (from the roof) ultrasonic depth sensing arrangement;
  - Including phone line hook-up facility- for data collection over the phone, to reduce field visits (and costs);
  - Some early questions raised about the Doppler velocity sensor's penetration under different silt distributions (e.g. dry weather versus wet weather).
- 1991–2012 extensive use of HYDSTRA as the "go to" database for rain and sewer and STP flow data, as well as design and use of regular reports required by clients (e.g. monthly STP report to STP operational management)
  - Protocols established for external parties to add data to HYDSTRA, and for quality coding such data.
- 2000 to now—increasing use of mobile phone modems and SIM cards to provide telemetry data collection from gauging sites, without the need for phone line creation and connection
  - Creation of near real time data reports for specific gauges and events:
    - Overflow report- 24 hours after the event;
    - Beach-watch and Harbour watch rainfall reports.
- 2003 to now —transit time velocity sensor pairs slowly replace Dopplers at several large trunk sewer sites, and show better reliability and substantially less "noise"
  - The more precise velocity allowed the daily "loop rating" behaviour of all trunk sewer gauges to be "discovered"
    - This explained the scatter of early gaugings compared with their site rating curves.
- Circa 2008—removal of local SCADA level sensor in flume at STP (i.e. recognising unnecessary redundancy), and giving of monitoring and signal provision responsibility to Monitoring Services, level sensor, data logger, and provision of depth and discharge signal to STP operator's SCADA, as well as records on HYDSTRA for planning clients.
- 2016 to now—replace sewer flow and rainfall dataloggers and telemetry with IICATS RTUs (remote telemetry units):
  - Rain gauge logger replacement in progress—but note the still existent risk of "a backwards step" switching away from event time recording to 5 minute total recording instead (to suit RTU limitations).
  - STP gauge loggers replacement deferred until precision of transducer can to better than ±20 mm.
  - Continued use of HYDSTRA being questioned as an unnecessary cost in view of the existence of the IICATS business intelligence historical data storage and access facility.

5. River hydrography- an example

The example here is the Murrumbidgee regulated river system, with its two large dams upstream (Blowering and Burrinjuck), its various competing water users, and the present move to place regional hydrographers under the system operator's control. A schematic diagram of the system is presented in Figure 5.1 and 5.2.

Please note that there are experienced hydrographers who could/would have done a better informed job on this example, but in the time available, only the basic level presented here has been possible.

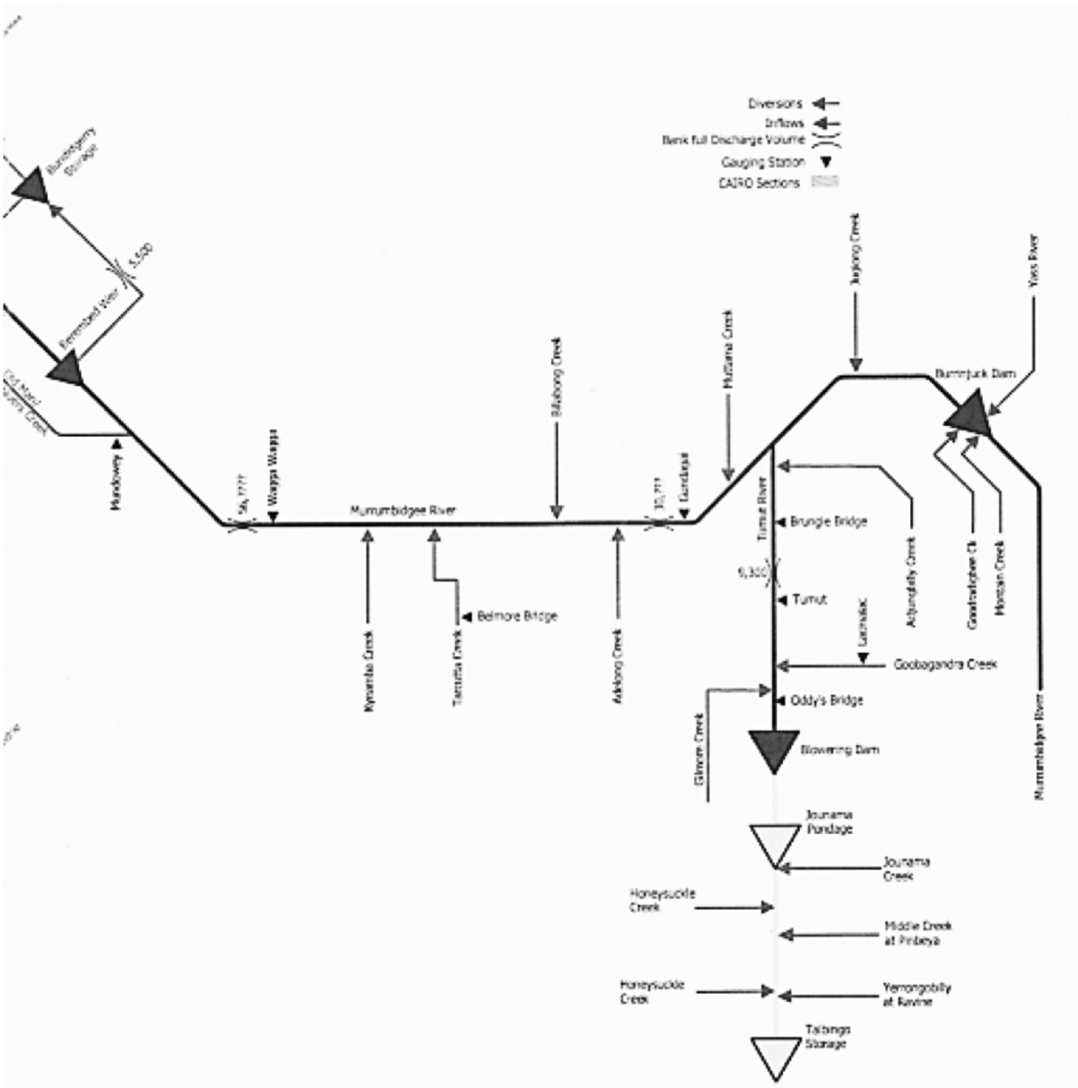

Figure 5.1- Schematic of Upper Murrumbidgee.

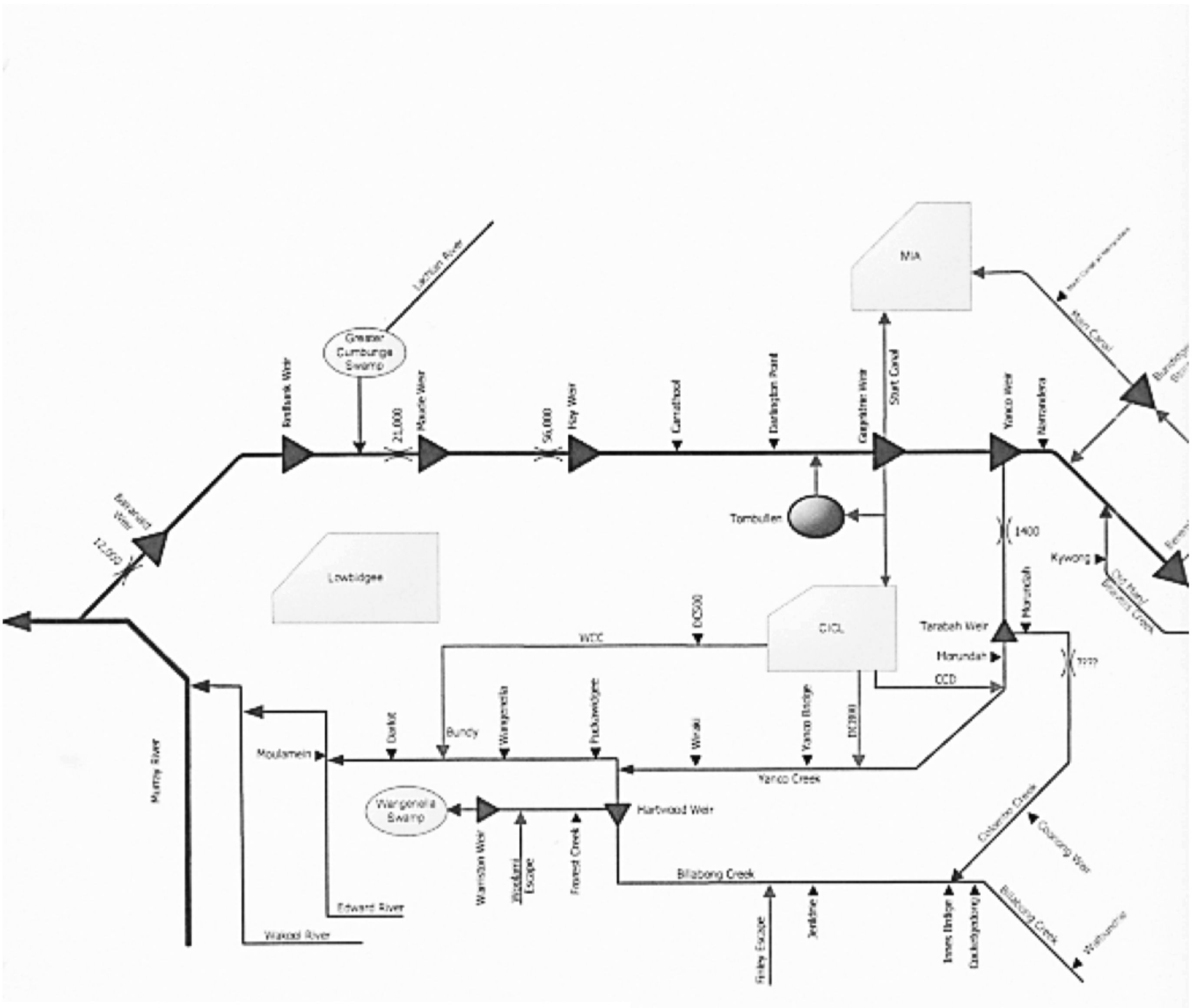

Figure 5.2- Schematic of Lower Murrumbidgee.

A timeline of important events on the system and their effects on the hydrographic network and/or hydrographic procedures and personnel, is given in the table below.

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
Prior to 1907	Basic monitoring network to suit planning for Burrinjuck dam.	Daily readings of levels at major monitoring points in the river and its tributaries, as well as current meter gaugings(?) and rating curve definitions. Flood warnings done by local property owners phoning in river levels.

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
1907 to 1928	Burrinjuck Dam constructed, with commissioning for water release in 1912 (to MIA). Cotter Dam constructed 1912 for ACT water supply.	Some river gauging sites upgraded to paper chart recorders using stilling wells and floats. New flow gauging stations established to suit regulated water delivery needs, and future planning of improvements and control infrastructure (like Berembed weir). Flood warnings still via phone call from local landholders.
1928 to 1964	Snowy Mountains Authority and Engineering Corporation formed, and design and construction of several dams, turbines, and large pipelines in the Snowy Scheme. Burrinjuck Dam upgraded 1957. Cotter Dam upgraded 1949-1951. Large floods in 1950s.	Expansion of flow gauging network by Snowy Authority- in upper catchment, including development of hydrographic training course. Expansion of hydrographic monitoring network to suit ACT water supply management needs, as well as regulated river water supply to irrigators downstream of Burrinjuck Dam.
1964 to 1968	Blowering Dam constructed for the Snowy Authority.	
1969 to 1990	Large floods in 1974. Increase in salinity issues and limited water for environmental purposes and for South Australia's water use needs- ongoing political debate.	Gradual conversion from analogue chart recording to digital silicon chip recording. Some major gauging stations had phone connections added, for real time access by the system operator at Leeton. Salinity and temperature monitoring added at many long term gauging stations.
1993/94	Long drought results in blue-green algae growths and water quality and environmental concerns in the Darling River-.	

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
1995 to 2000	Drought period persists leading to declaration of a CAP on water licences and development of water sharing plans, with extensive IQQM[6] modelling of all river systems in the Murray-Darling mega-catchment.	Some increased interest in low flow accuracy at gauging stations, as well as noting the ongoing "clash" of philosophies between the operator and hydrographic practice: so that when there has been a rating change at a site, it is only confirmed to the operator after 4 more gaugings (i.e. 8 months past the first gauging) confirm the change, then the rating is changed. Whereas the operator wants to know "now" that there has been a change, and how to change the rating accordingly, to know they are not wasting water by oversupply, or laying themselves open to poor management complaints for under-supply.
2000 to 2008	National Water Initiative funds various water saving projects and investigations, including upgrade of hydrographic instrumentation at many monitoring sites. Rubicon develops various new flowmeters, and it's Total Channel control system- as applied to Victorian bulk water systems.	Remote telemetry of water levels now mostly successful, and all gauging stations now digital. A copy of all data collected now provided to BOM for national archive.
2008 to now	Irrigation "billing" flowmeters replaced with more accurate magflow meters, with each one now telemetered, back to HYDSTRA? CORS real time optimisation model "construction" and calibration, to suit optimal operation of the regulated water supplies. Murray-Darling basin plan water sharing plan changes announced, causing strong public reaction against it by towns and irrigators, leading to revision and re-issue of the plan.	Potentially huge additional data storage and management task in HYDSTRA for additional billing meter time series data. Pilot study at 5 sites using in-situ side looking velocity sensors, to test practicality for real time indication of rating table changes, which would suit operational and flood warning improvement needs. State Water separates "CORS" optimisation model from the telemetry data supply, and has completed development (?)

6. Integrated Quantity and Quality Model by NSW

Year (circa)	Major Capital Work Or Investigation	Hydrographic Works
Now	Hydrographic monitoring services group all “summarily” transferred to State Water from Office of water, and now coming under the management control of the real-time (SCADA) group in State Water.	State Water SCADA engineers are questioning the need for: • HYDSTRA; • Frequent site visits and flow gaugings and level accuracy checks; • The need to follow best practice hydrographic standards.

The changes in equipment and instrumentation on the Murrumbidgee system can be taken as following the same lines as illustrated earlier in section 2.1.

6. Concluding Remarks

6.1. Philosophical differences

The hydrographic aim is to collect accurate flow and level data, traceable to national standards, and provide access to this data via HYDSTRA to data users. Telemetry access has been added at many sites, some for lower cost data collection and some for use by system operators. The data users started out as mainly policy and planning (i.e. modelling) for the water authority, but have expanded to include system operators.

The SCADA engineer’s aim is to collect sufficiently accurate sensor information from the facility to be controlled to enable control of the facility (such as Dams, treatment works, control gates, etc.). The main “client” for this data has been the operator. In recent times however “what if” optimisation and modelling capability has been added to SCADA facilities, causing a blending of the role of the operator and the SCADA engineer, because the operator now needs those modelling skills to effectively operate the system, particularly geographically diverse systems such as the Murrumbidgee regulated river system.

Modellers now working in policy and planning groups, such as IQQM modellers in NOW[7] and MOUSE modellers in Sydney Water, who have been the policy and planning group “clients” for hydrographic data usage, may now find a role in the introduction of modelling and optimisation runs in real time SCADA systems. In the past such “modellers” have had the “luxury” of not having to “fight” for data accuracy, as they have trusted the data and been content to accept that data they use out of HYDSTRA has been collected following hydrographic best practice, and has accuracy traceable and definable using Australian Standards (like AS3778).

The SCADA engineer makes every effort to assure 100% uptime of all data in the control system. The key performance indicator is system and data uptime and successful telemetry of data to the control room. Sensor data accuracy is of secondary concern. Whereas the hydrographer will make every effort to get the level sensor working accurately and reliably and the rating curve as up to date as possible, and as a secondary function have the data telemetered out.

6.2. Concerns about transition to SCADA philosophy

1. Replacing HYDSTRA with the SCADA’s historic database:
    - If data is less than a year old, it will probably be as accessible to planners and other users, as it is now through HYDSTRA, but will not offer the data analysis and reporting tools.
        - o Data analysis and reporting tools could be developed and added to the SCADA database, but why develop these for each SCADA system, when there is already a National Standard with already paid for an developed facilities of this type.
    - Older data (e.g. more than 1 year old) although SCADA engineers say it is accessible, experience so far is that it is only accessible after much effort and time, to pull it out of secure SCADA archive, with special arrangements having to be made each time.
    - No quality coding of data.
    - No facility to store flow gaugings and level checks (i.e. one-off events), or to “edit” data, such as adjusting for level sensor drift.

7. NSW Office of Water

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2. Replacing all data loggers with SCADA RTUs:
   - Rainfall records may be forced to be delivered in terms of 5 minute totals instead of event times, making hyetograph definition less accurate than those from event times.
   - Precision and resolution of some RTUs are coarser than the sensed data, for example a level sensor may have an uncertainty of ±5 mm, but the RTU may only be capable of rounding up or down to the nearest ±20 mm, thus creating poorer measurement uncertainty in level, and any subsequent use of that level to define discharge from a rating table.
3. Saving costs by reducing field visits, gaugings and bench top calibration checks:
   - Unless the following two aspects are formulated, there is no possible defence of the value of current practices:
     - o Planning clients need to be informed of the measurement uncertainty (traceable to AS3778) of their data, and need to state that this is the data accuracy they need to do their work (presuming that they do need that accuracy);
     - o Hydrographers need to formulate how measurement uncertainty of the data increases versus reduced frequency of site visits and reduced frequency of flow gaugings and benchtop pressure sensor calibrations.

Hydrographers transition to Electrical Instrument technicians?

- Unless some of the above concerns are dealt with and worked out with the SCADA engineering groups, policy and planning groups and executive management, it is not unlikely that emphasis will come off understanding the hydraulics of the site (etc.), and towards being classified as an instrument technician.
- On the other hand there may now be the opportunity to raise the integrity of the SCADA data and SCADA system reputation, by applying hydrographic levels of service to the SCADA sensors and their flow calibration curve maintenance.
  - o Including a more determined effort to get river velocity sensing up and running at key sites to suit operator's needs

6.3. Some past experiences for consideration

These are events in addition to those already mentioned previously.

Date (circa) and Subject	Description of event
1996– Time series of inflows to new Rouse Hill STP	The new STP had to go on by-pass each medium to large rainfall event. The best gauge data for investigating the cause was the total flow bypassed and out of the STP, which were both weirs and both had level sensors. Normally these data would have been available through HYDSYS, but in this case the Executive management had decided to design and build the STP as a turn-key, and data users were told they could get any historic data out of the SCADA's long term data base. Unfortunately nobody involved could be found who knew where and how to extract the last 5 years of data. Eventually we managed to find a SCADA software writer from another company, who managed to "salvage" enough of the data to be useful. This outcome delayed the investigation, and cost extra, as well as delaying the eventual remedial actions- which involved repairing every single upstream MH.
1998– Winmalee STP	As part of overflow abatement licensing planning for this system, to determine scope of works to meet targets, inflow data was not available as Winmalee had been constructed as a turnkey job, and we were told that the operator could get the historic data out for us. Again, like Rouse Hill, no data. Again a SCADA software specialist had to be found and engaged. He eventually salvaged what he could of the historic data, but every day of the record had 7 hours missing, sometimes during the peak of an event of interest, sometimes not. This was due to a mistake in the SCADA programming, which of course was not picked up because nobody was looking at the historic data.

Date (circa) and Subject	Description of event
2005– Now, SCADA engineers engage Hydrographers to check calibrate their many level sensors	IICATS provided monitoring services with an annual budget to field calibration check “X” of their SCADA level sensors, in reservoirs and pumping stations- and provide a calibration check certificate for each. Many were found to be substantially out and required adjustment This is a good example of “win win” co-operation.
2006– Murrumbidgee river gauge accuracy audit	This was a *Water for Rivers* project which audited each gauging station in the Murrumbidgee river system, and characterised its measurement uncertainty. One of the key findings was the philosophical dilemma the field hydrographer was faced with when a flow gauging showed a change had occurred (from the rating), and his/her knowledge of the site identified the likely cause (e.g. a tree fallen across the stream just downstream). The operator wants to know about this change straight away, and be issued with the new rating curve ASAP. Whereas to follow hydrographic practice, only change the rating after at least 3 more gaugings at different flowrates to the one just gauged- which may take 6 months. Meanwhile the operator, in a sense, has to be his own hydrographer, and mentally allow for the changed rating, in fulfilling that days water orders.
2008–2010 Murrumbidgee Trial of side looking Sontek velocity sensors	Five long established river gauging stations were fitted with side looking Sontek Doppler velocity sensors. One of the purposes was to calculate discharge from the continuity equation rather than from the rating, so that any change in rating would be accommodated without making the operator wait for a new rating. Another purpose was to improve the accuracy of real time flood flowrate estimation (in the absence of on the spot gauging crews). Although the aim(s) were clear- the success of this pilot study is unknown. Note that this is the sort of project that would be of interest for SCADA control improvement.
2010–2015: Various Sydney Water STPs	Hydrographic Monitoring Services have for many years looked after inflow, outflow and bypass flow gauges at all Sydney Water STPs. Many of the monitoring points had a second level sensor (and a rating presumably) which went back to the SCADA control room. The hydrographic data records (which all went to HYDSTRA) were used by the operator to report “accurate” flows to the EPA, as part of monthly and annual licence reporting. The SCADA records were used by the operator to check if treatment units were behaving or needed adjustment, with not so great a focus on data accuracy. Why have two level sensors in the one flume?, was an often asked question. In recent years, thanks to a co-operative effort between hydrographic and SCADA engineers (IICATS) the SCADA sensors have been removed in most locations and reliance now for operation and reporting on the level sensors maintained by Hydrographics, and rating table calibration checks and change management by Hydrographics.

6.4. Where to from here?

The only word that comes to mind is "dialogue". Focussed meetings with planning-modelling clients, as well as with SCADA engineers. These meetings should include presenting the accuracy currently being achieved, and ask the clients to consider is this sufficient for their purposes. It should also include how much that accuracy reduces if site visit "flow calibration" frequencies are lengthened, or the sensing technology is changed to a cheaper or less accurate type.

The other question to ask is how, in the long term, can this marriage be a "win win" event, like some of the examples in 6.3? Over to you for your consideration.

7. Selected SCADA related References

AS/NZS ISO 9001:2016 - *Quality management systems – Requirements*

AS/NZS ISO 14001:2016 CP - *Environmental management systems - Requirements with guidance for use*

EN ISO 10628 - *Diagrams for The Chemical and Petrochemical Industry* – various parts, 2015

ISO 81346 - *Industrial systems, installations and equipment and industrial products - Structuring principles and reference designation* – various parts, 2015

ISO/IEC 7498 - *Information technology - Open Systems Interconnection* – various parts, 1994

ISO 22400 - *Automation systems and integration -- Key performance indicators (KPIs) for manufacturing operations management* – various parts, 2014

ISO 16100 - *Industrial automation systems and integration -- Manufacturing software capability profiling for interoperability* – various parts, 2009

ISO 22745 - *Industrial automation systems and integration -- Open technical dictionaries and their application to master data* – various parts, 2010

ISO 23750 - *Industrial automation systems and integration -- Distributed installation in industrial applications* – various parts, 2005


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Australian ADCP Regatta, March 16-17 2017

Anthony Skinner,
NSW Operations Manager, ALS Hydrographics Australia

Abstract

On the 16 and 17 of March the Snowy Mountains hosted the Australian ADCP Regatta 2017.

The Regatta consisted of a field day on the Thredbo River at Paddys Corner, followed by a short session on bathymetry techniques on the Murrumbidgee in Cooma before wrapping up with a discussion session at the Snowy Hydro Discovery Centre, Cooma. The even gave participants a great opportunity to explore a range of objectives.

Overall the Regatta was attended by fifty four participants, representing five states and territories, along with a representative from New Zealand's Marlborough District Council. Overall the participating organisations represented a good mix of private and public hydrometric service providers, consultants and vendors.

Participating Organisations were:
- *ALS Hydrographics;*
- *Bureau of Metrology;*
- *Department of Environment, Land, Water and Planning (DELWP);*
- *Department of Water WA (now Department of Water and Environmental Regulation);*
- *Manly Hydraulics Lab;*
- *Marlborough District Council, New Zealand;*
- *Onyx ECS;*
- *Snowy Hydro Limited;*
- *Ventia;*
- *Water NSW;*

Vendors' onsite included:
- *HyQuest Solutions;*
- *Xylem Analytics; and*
- *Blue Zone Group.*

This article is a summary of the events, results and outcomes from the regatta with recommendations and suggestions for future events.

Regatta Objectives

As per the 2015 Regatta the even aimed to:
- Provide an opportunity for practitioners/organisations to 'pressure test' and discuss the application of ADCP discharge measurement techniques and processes against the National Industry Guidelines for hydrometric monitoring, Part 8[8],
- Enable opportunity for continuous improvement discussions between practitioners and suppliers with regards to the effectiveness/practicalities of the Guideline, application of techniques and instrument and gauging hardware applications.
- Validate ADCP performance by conducting comparison measurements and provide information to enable assessment of repeatability of data outputs.

8. https://aha.net.au/article/part-8-application-of-adcp-wisbf-gl-100-08-2013/ accessed 2017-08-31

- Provide opportunities to compare and share knowledge on data collection techniques, procedures, instruments and application in a potential variety of field conditions amongst practitioners and peers.
- Compile a report on results and outcomes for knowledge sharing amongst the national hydrometric industry.

In addition the 2017 Regatta identified two additional areas for further exploration in line with recommendations made following the 2015 Regatta:

- Location: Challenge processes/SOP's and technology with a mix of good and bad sections;
- Guidelines: Test more aspects of *National Industry Guidelines for hydrometric monitoring, Part 8, Application of Acoustic Doppler Current Profilers to Measure Discharge in Open Channels* under a wider range of conditions;

The potential to have a session on basic bathymetry applications (Bathymetry 101) with off the shelf products was also explored as a part of the two day program.

Regatta Format

The Regatta comprised of a mix of onsite tasks followed by an information and/or discussion session on the previous day's results.

Prior to the event a survey was sent to all the registered participants, in order to collect background information in relation to the organizations represented.

The participants were also asked to complete a post regatta survey, providing feedback on the workshop, content covered, topics for future consideration and the usefulness of such an event. Participants were also asked to provide their thoughts on future events and workshops.

The workshop was run by ALS Global under the mentorship of Snowy Hydro, who conducted the first regatta n 2015. This concept of the incumbent providing guidance to the next host worked well and should be consisted for any future events.

Regatta Location

The regatta was held on the Thredbo River near Jindabyne. The area was considered suitable as it contained:

- A channel stretch of approx. 30 m to 40 m wide with sections of fast moving shallow water on a rocky bed transitioning to a large sandy pool with distinct flow patterns due to its location on a bend;
- Natural hazards such as an island upstream and several riffle sections, creating a range of hydraulic conditions;
- A permanent SHL[9] traveller line, set up in the main body of the channel, and an SHL hydrographer onsite to assist with site knowledge;
- Natural flows in the 2-10 cumecs range. These were recognised as safe wading flows at this site.

An aerial view of the Regatta reach.

[9] SHL: Snowy Hydro Limited

The view downstream through the Regatta reach.

Regatta Process and Results

Deployment on the day saw SHL setup five dedicated taglines. These five sites represented the five different types of sections observed at this location, and providing a range of challenges from island in centre to large backwater sections.

The Snowy Hydro rating for site indicated an expected flow of 1.07 cumecs. This represented an extremely low flow and necessitated serious consideration as to the methods and procedures to apply in order to produce repeatable data collection. Due to the volume of attendees, many groups elected to “choose their own adventure” both upstream and downstream of the dedicated sections. These sections were identified as “Other”.

Some Statistics collected during the day:

- 54 Participants/Observers;
- 7 organisations from five states (NSW, Vic, SA, WA, Tas);
- ADCPs used included S5, M9, RiverRay, River Pro, Stream Pro;
- Other technology used - Oss B, FlowTracker;
- 47 measurements were collected;
- Methods used – Stationary 23, Moving 18, Wading 6;
- Mean Q = 1.086 cumecs (mean of all measures);
- Rated Q = 1.07 cumecs;
- 5 Set sections 18–25 m wide – 28 measures;
- Choose your own adventure – 19 measures;
- Wading gaugings sites were conducted downstream of the control;
- No moving boats were attempted in site 1

All participants conducted measurements based on their own organisational requirements and procedures. The required information was collected from each gauging, and tabulated to form the basis of the reporting, based on the following information:

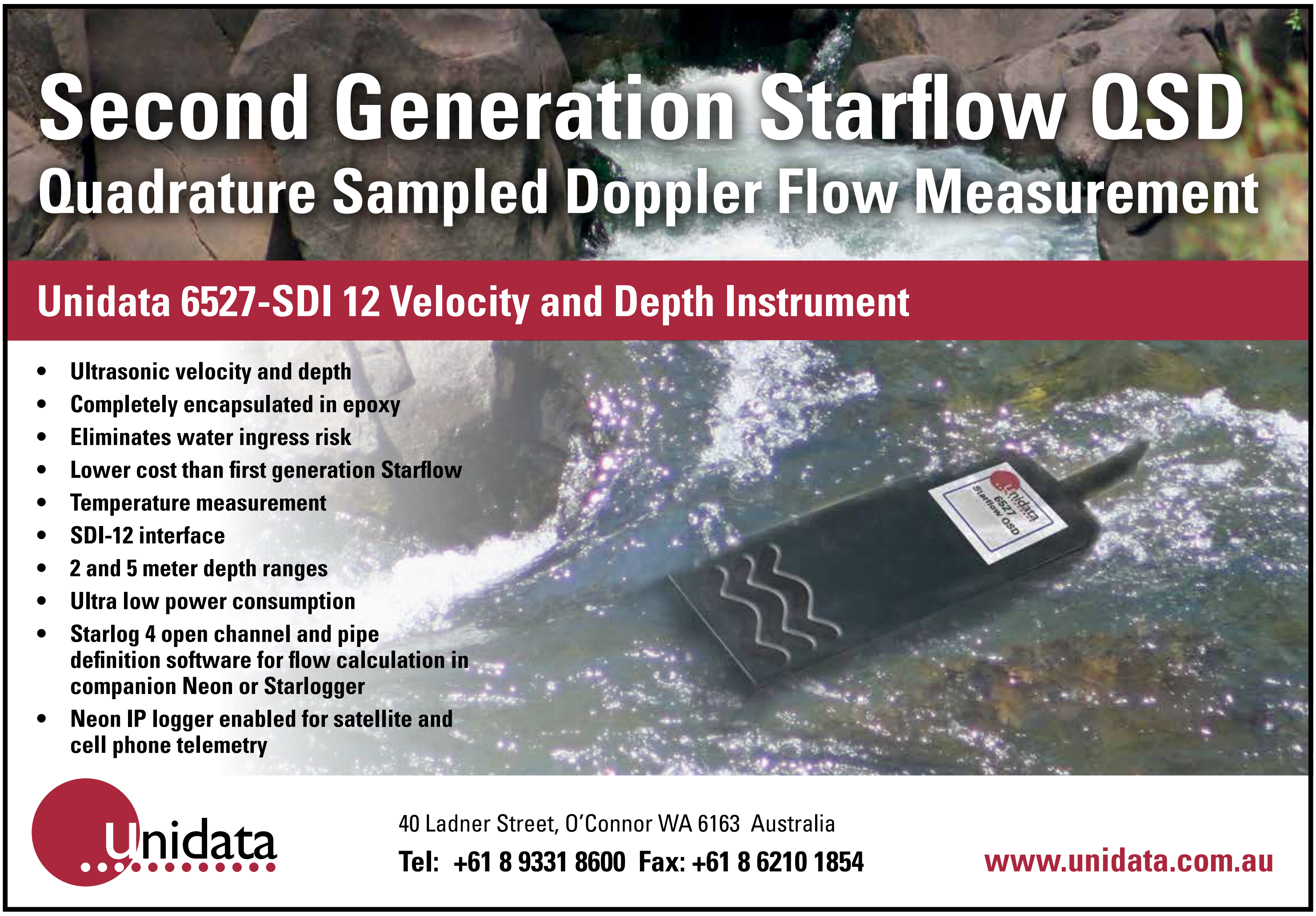
- Equipment / Model
- Method
- Moving Boat Test
- Q Raw
- Area
- Width
- Sensor Head Depth
- Exposure Time (secs)
- Duration
- Comments

Post processing techniques were not applied to any data collected, it is suggested they should be considered and discussed at future regattas.

Sontek and RDI equipment was used on the day with a larger percentage of organisations using the Sontek M9 equipment.

Discharge Results

The adopted mean has been taken from all flow gaugings performed. Overall results show a 1.086 cumec with the breakdown from moving boat, stationary and wading indicated in the following plot.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Pollution
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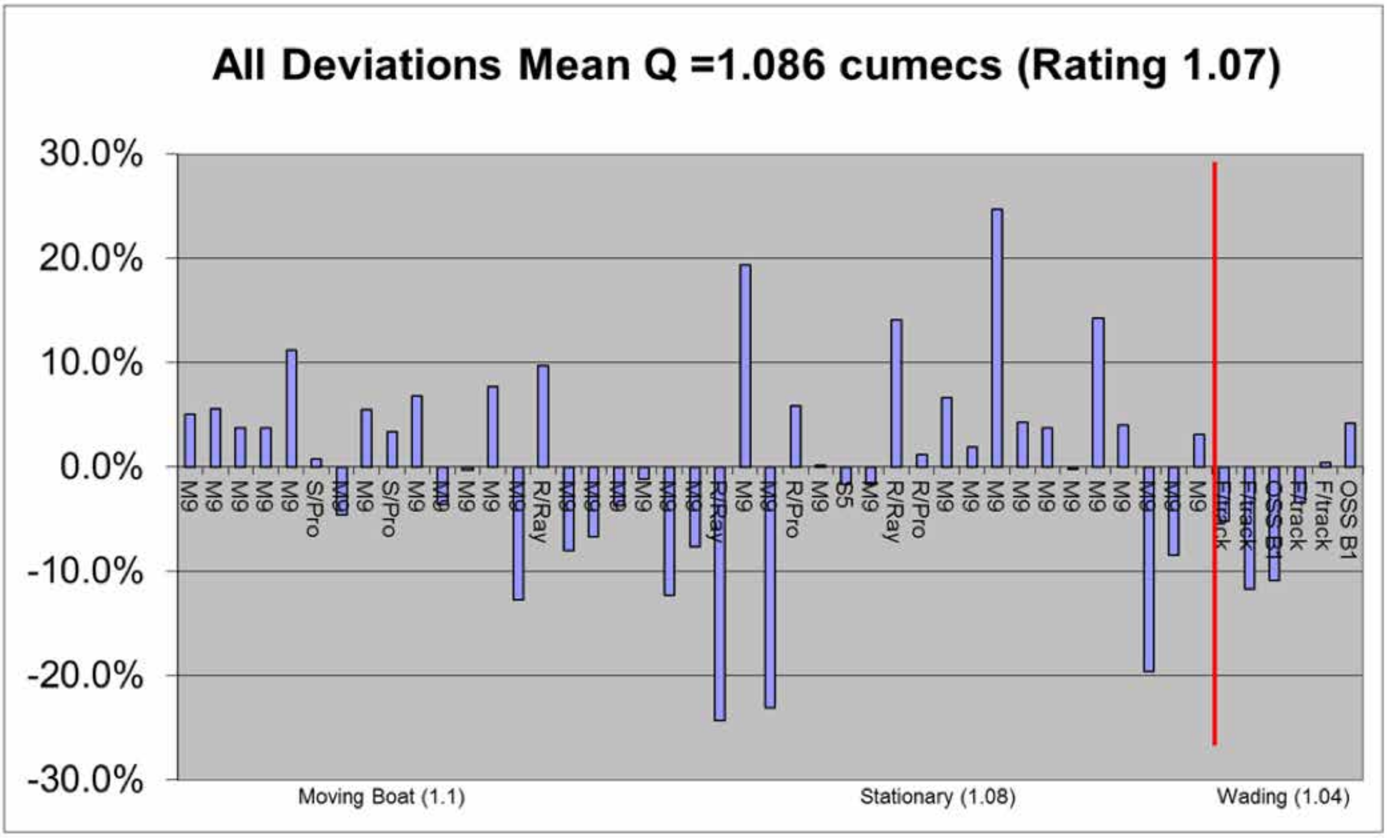


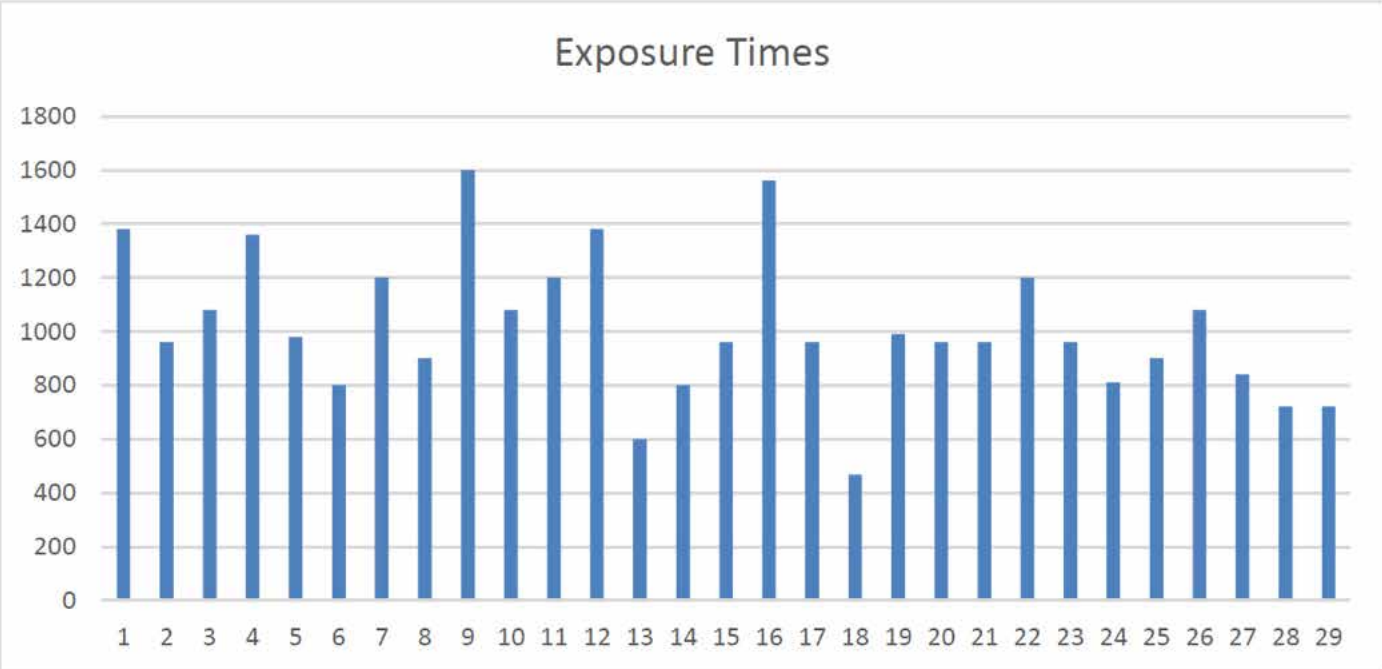
Observations/commentary on the results:

- Some large scatter in the deviation. These outliers could be easily explained with comments provided on the field sheets. Many organizations trailing various methods in the low flow conditions to prove that results can vary.
- The low Q on day contributed to the scatter—larger flows at a uniform site in theory should see the scatter reduced (as demonstrated at 2015 Regatta).
- During the regatta participants were experimented with the operational limits of ADCP equipment. Some of the larger scatters may be result of participants experimenting with different modes/techniques, as well as testing ADCPs in conditions where they would not normally operate effectively.
- An instance of 2 ADCPs being tethered together (side by side) yielded exactly same result. In this instance it is not clear if frequency overlap/receiving issues contributed to this result. The participant organisation will investigate the results further.
- Large scatter occurred around measurements at Section 1. This was to be expected as it was considered the poorest section with depths encroaching on blanking distance, estimates required at shallow sections, etc.
  It should be noted that no moving boat measurements were attempted at this section!
- Measurement scatter from Regatta Mean by section:
  Section 1: +20% to -24%
  Section 2: +14% to -2%
  Section 3: +7% to -3.5%
  Section 4: +24% to -13%
  Section 5: +3.5% to -12.5%
  Alternate sections: +14% to -20%

Exposure Time

The minimum acceptable time of exposure for ADCPS gaugings, outlined in the quality assessment guide in the National Guidelines, is set at 800 seconds. This is further broken into Stationary and Moving boat. Stationary being for the sum of the times at each vertical and Moving Boat is the sum of the exposure times for the accepted transect used to calculate the final discharge. An exposure time of less than 800 seconds should incur a downgrade in the quality ranking.

Exposure times were not provided for all gauging's completed, however, from those that were provided the average exposure time was 1015.



The exposure comparison between moving boat and stationary indicate that there is very little advantage in either method in regards to time saved. This was also evident in the 2015 Regatta.

Some other notes from the 2015 Regatta that participants agreed were still relevant, in regards to exposure time:

Moving Boat

- It is important to keep the boat speed at less than the water speed. As a result extended sections of slower flows resulted in reduced boat speeds;
- Some larger times in the results would likely be due to visiting groups being unfamiliar with the section and flow conditions. It was found that as they became familiar with their transects, they became more efficient.

Stationary

- It became apparent during the general discussion that 40 sec minimums were being used at each vertical with some using 60 sec.
- The number of verticals measured in the cross section can vary with stream width (aligning with aspects of AS3778);
- Spacing of the verticals through the section was done such that the participants could define the stream bed (rather than using fixed spacing).

Post Regatta Discussion

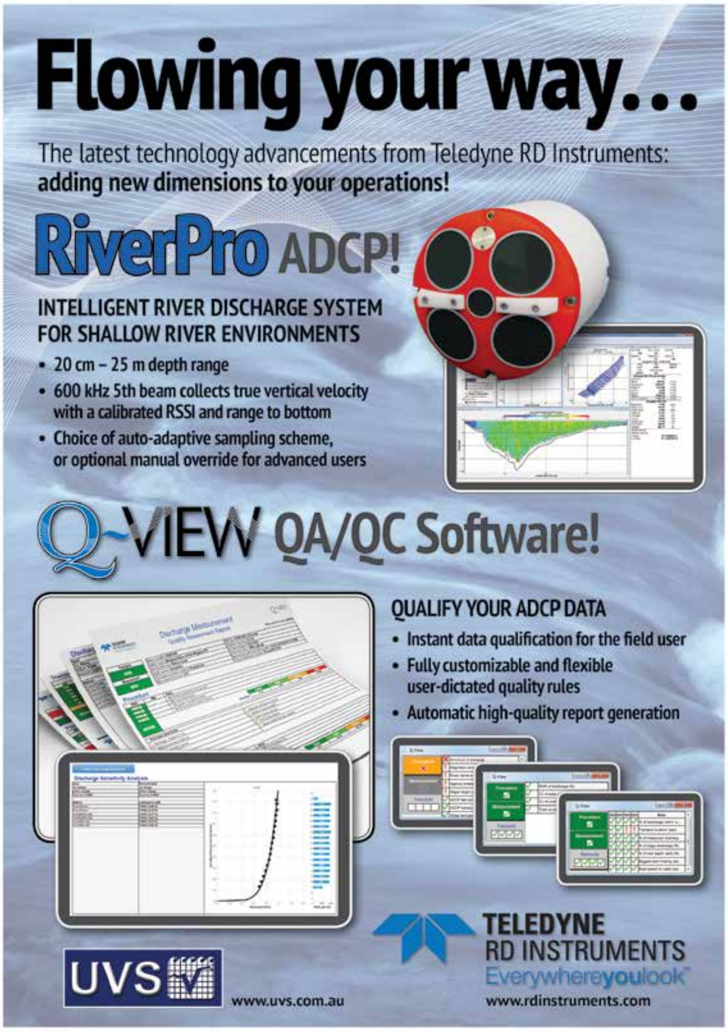
Some general observations:

- The Bureau of Meteorology *National Industry Guidelines for hydrometric monitoring, Parts 8 to 10* are due for renewal;
- JRGWI[10] and/or the Bureau of Meteorology have been asked to provide a list of who is on this committee. Each of the agencies/participants should push information and queries through to them via the WaMSTeC[11] processes and/or their state JRGWI representatives;
- Technical Reference Group AHA (ADCP) – Contact is Simon Cruickshank (AHA committee);
- It was suggested that Google Drive could be used for the sharing of docs between organizations. Further feedback on this suggestion is sought;
- Regattas are a great way to QA/QC your device against other units. This is a similar observation to those noted at the New Zealand Regattas.

Challenges:

- The site selected proved challenging due to the low velocities, most agreed this was a good test of equipment capabilities;
- While site selection is key in normal gauging processes participants thought it may not have been the largest contributor to the scatter in the resultant data but rather the low flow conditions pushed the operational limits of equipment;
- There were too many crews to work within the five designated sites. This resulted in many gaugings taken at alternate locations;
- The site was difficult compared to the first Regatta, however the ability to alter and control flows at future Regattas would be an advantage;
- Does it matter that the regatta site has an existing rating—most agree yes;
- Post processing of data, a session on this and the changes it makes to dataset would be good for "classroom discussion".
- Bathymetry, requires more in depth discussion and perhaps a regatta on its own.

10. Joint Reference Group Water Information — consists of Bureau of Meteorology and State representatives
11. Water Monitoring Standards TEchnical Committee — national group convened by Bureau of Meteorology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2017 NZHS Technical Workshop, Dunedin, New Zealand, April 3-6 2017

Mic Clayton,
Team Leader Hydrographic, Snowy Hydro Limited

Abstract

Under the theme ***"Are you making a difference in field hydrology?"****, The New Zealand Hydrological Society Technical Workshop was held over 4 days in early April in Dunedin.*

The Workshop was hosted by the teams from Otago Regional Council and NIWA, Dunedin, with support from the NZHS and was attended by over 100 participants including presenters from the US, Canada, Europe and Australia.

The four day format ran as follows:

Day 1 – ADCP Quality Assurance

Kevin Oberg (USGS[12]) led a workshop on:

- USGS quality assurance tools for ADCP gaugings;
- the development of QRev; and
- understanding what QRev is telling you about your ADCP measurement.

During the session the workshop then worked through example problems, provided by participants for review, using the QRev package.

The following days Regatta logistics were finalised prior to the session finishing for the day.

Day 2 – ADCP Regatta and dilution gauging demonstrations

Held on the Waipori River, in the lower Waipori Gorge south west of Dunedin over 90 participants worked with a 10 cumec flow, courtesy of the Trust Power Generation team in the region.

12. United States Geological Survey

The view downstream through the Regatta reach in the Waipori Valley.

Aerial view of the Regatta reach.

All manner of deployments from remote control ADCPs and kayak mounted units, through to an ADCP rig affectionately dubbed "The Ironing Board" worked with eight rigged lines. Participants were asked to focus on three of these sections when gathering measurement data in order to provide a good statistical data set for analysis.

The regatta also gave participants the opportunity to undertake quality assurance processes, stream side, using the improved knowledge gained from the previous day's workshop on QRev. This enabled measurers to review and assess outputs in line with NEMS (National Environmental Monitoring Standards) which is being applied throughout the field hydrology sphere in New Zealand.

https://www.lawa.org.nz/learn/factsheets/(nems)-national-environmental-monitoring-standards/

The lads from Otago also put their culinary skills on show with a very fine sausage sizzle for lunch!

Sausages cooked safely!

During the regatta Christoph Sommer and Mike Lysaght (HyQuest) undertook a fluorescein dilution gauging. While the river became that brilliant green some of us are familiar with, at the injection point, the dilution within stream soon made it invisible to the eye. The dye however was picked up on the Sommer sensor system deployed in the river.

Flourescein tracer injection upstream of the regatta reach.

Tracer detection sensors in the regatta reach.

Further salt dilution gauging demonstrations were undertaken on Mill Creek, a tributary downstream of the regatta reach, later in the day by Christoff and Gabe Sentlinger (Fathom Scientific) where small flows of approximately 86 litres/sec were measured (previously confirmed by wading gaugings earlier in the day).

Gabe Sentlinger, Fathom Scientific, prepares sensors for salt dilution gauging at Mill Creek.

More images and footage from the Regatta can be found at https://www.youtube.com/watch?v=LbZqg1UmIUE and https://www.facebook.com/pg/hydrologyaus/photos/?tab=album&album_id=1632501213431505

Day 3 and 4 – Formal Workshop Presentations

Held in the Dunedin Centre in the historic Octagon precinct of Dunedin, the workshop was formally opened by Mayor David Cull. In his opening speech the Mayor outlined the history of Dunedin and the importance of water in its development. A major centre in New Zealand, Dunedin has historically relied on water and the rivers for everything from gold mining and agriculture right through to the harbour where they exported their products and wealth to New Zealand and the rest of the Empire.

The conference venue – reflects the wealth of a past era and the clock tower helped keep the conference proceedings on time!

Before presentations began the group received a report on the tragic death of Hawkes Bay team member, Mike Taylor, who was involved in a fatal vehicle accident on departure from a hydrometric site on Friday March 24. While still under Worksafe New Zealand investigation, it is believed that the accident occurred on a 'safe' section of farm track leaving the site. Mike had contacted the office as he was departing the site, however the alarm was raised when he did not arrive back at base in a reasonable time and the vehicle tracking device indicated that the vehicle had not moved.

This accident has impacted many who knew Mike, in particular those he worked with. They feared something had gone wrong, but were unable to communicate anything until rescue services and police could confirm what had happened. This sobering event highlights how a workplace accident can impact a wider community beyond our immediate family and friends. With official investigations into the incident, the sense of loss of a friend and colleague, for many, will continue for some time.

The workshop presentations were widely varied, reflecting the diversity of work that New Zealand field hydrologists are involved in. Interspersed through the program were updates on the latest NEMS activities and New Zealand Health and Safety laws and how they are impacting the activities of organisations undertaking field hydrology. Information on the latter item was also collated during break-out sessions.

International presentations added great scientific value to the knowledge being shared with all. These presentations included uncertainties of recent flow monitoring techniques, exposure to new ways of considering how to do things through explanations of projects, developments in areas of dilution gauging techniques and non-contact gauging techniques, including imagery and radar techniques, for flood situations.

Results from the Day 2 Regatta were presented as well as from the recent Australian Regatta.

Forsyth Barr Stadium, home of the Otago Highlanders, was the venue for the workshop dinner and excellent Southland fare was enjoyed by all.

Editor's Note: Mic has kindly provided abstracts from the presentations in the Appendix of his original workshop summary. While we have not included them in the journal if you would like to peruse them please feel free to contact me at journal@aha.net.au for the full version of his article with the Appendices.

The Workshop becomes Real Time!

In the weeks previous to the workshop Cyclone Debbie had wreaked havoc and damage in Australia. After leaving Australia and wandering across the Tasman "she" met up with a cold front and intensified into a severe low. This impacted New Zealand's North Island and northern parts of the South Island, particularly those areas impacted by the 2016 Kaikōura earthquakes. The area was then further impacted by the remnants of Cyclone Cook just over a week later.

The town of Edgecumbe in the Bay of Plenty, was a focal point during the workshop as the flood protection works embankment failed, devastating much of the town, with live footage of the breach occurring.

Earthquake dam water levels were viewed in real time data streams from recently installed monitoring sites, particularly at the site of the Hapuku Dam, as the rainfall from ex cyclone Debbie impacted the area in the north of the South Island around Kaikōura. http://harvestalarms.com/w.cgi?cmd=gph&hsn=12135&typ=4&date=20170310110000

Over 200 landslide dams were formed following the earthquake in November 2016 blocking valleys and creating potentially hazardous situations for downstream populations in the event of sudden collapse of these dams. Level monitoring was installed on a number of these sites to monitor when these dams would overtop. Overtopping can trigger erosion, weakening the deposited dams and potentially leading to catastrophic failure.
https://www.ecan.govt.nz/get-involved/news-and-events/2017/how-the-rain-has-dealt-with-the-landslide-dams/

While these areas were probably too hazardous to undertake discharge measurements in the midst of the flood emergency the hydrology teams from affected areas were itching to get back to their regions. This resulted in the alteration of the workshop programming in order to accommodate the changing situation.

What is QRev?

The USGS developed QRev as a post processing tool for moving boat ADCP measurements. The USGS identified that the algorithms between manufacturers of ADCP equipment, in the computational functions, were different. In short – if you took the raw acoustic data from one brand and ran it through the algorithm processing of a competing brand you would most likely obtain a different discharge result!

The following is an extract from the Introduction of the Q Rev V2.8 user manual published in 2016 by the USGS (D.S. Mueller, https://pubs.usgs.gov/of/2016/1052/ofr20161052.pdf)

The use of acoustic Doppler current profilers (ADCPs) from a moving boat is a commonly used method for measuring streamflow. These measurements have been reviewed and post-processed using manufacturer supplied software and the user's knowledge and experience to interpret the quality of the measurement, correctly configure discharge processing settings, and set appropriate thresholds to screen out erroneous data. This dependency on the software supplied by the manufacturer has created two problems for the U.S. Geological Survey (USGS).

1. *The software programs supplied by the different manufacturers have limited automated quality assessment features, and graphics and tables for user review are inconsistent among the manufacturers. Consequently, data quality assessment is not independent of the instrument used to make the measurement but rather is dependent on the capabilities of the manufacture supplied software to review and assess the data quality. The lack of automated quality assessment features leaves the assessment to the knowledge and experience of the user and may result in inconsistent assessments of data quality.*
2. *Software programs from different manufacturers use different algorithms for various aspects of the data processing and discharge computation. Consequently, if the same dataset could be processed by each manufacturer's software, the resulting discharges could be different.*

Development of common and consistent computational algorithms combined with automated filtering and quality assessment of the data will provide significant improvements in quality and efficiency of streamflow measurements. This development will ensure that USGS streamflow measurements made using ADCPs are consistent, accurate, and independent of the manufacturer of the instrument used to make the measurement.

The USGS Office of Surface Water developed a computer program, QRev. The program can be used to compute the discharge from a moving-boat ADCP measurement using data collected with any of the Teledyne RD Instrument (TRDI) or SonTek bottom tracking ADCPs. QRev applies consistent algorithms for the computation of discharge independent of the manufacturer of the ADCP. In addition, QRev automates filtering and quality checking of the collected data and provides feedback to the user of potential quality issues with the measurement. Various statistics and characteristics of the measurement, in addition to a simple uncertainty assessment, are provided to users to assist them in properly rating the measurement. QRev saves an extensible mark-up language (XML) file that can be imported into databases or electronic field notes software, such as, SVMobile.

Wrap Up

The sombre discussions around the loss of a colleague while at work, brought home to us all that while we arguably have the best job in the world, it is not without its hazards, even in what might be the most benign of situations. Looking after ourselves and our mates at work, so we can get home safely at the end of the day, is our priority when we are out there doing the job we love.

This year's NZHS Technical Workshop provided a great practical and collegiate environment for field hydrologists and hydrographers, with its structure flowing through to support activities in the following sessions.

The ADCP QA workshop improved the knowledge and expertise of participants in the area of field reviewing ADCP gaugings conducted at the Regatta the next day, with outcomes and exercises from the Regatta becoming points of reference in presentations in the following workshop presentation days!

Other presentations served to highlight areas of emerging technologies and techniques in the monitoring worlds that field hydrologists become involved. The networking arising from these interactions can only serve to improve the skills and knowledge of field practitioners.

Finally

I would like to take this opportunity to thank Snowy Hydro Limited (SHL) for supporting my participation in this year's Workshop.

Thanks also to Evan Baddock (NIWA, Dunedin) for encouraging SHL to permit me to present at the workshop on our Cloud Seeding monitoring program and Anthony Skinner (ALS Hydrographics, Penrith) for providing preliminary data from the Australian ADCP Regatta held a couple of weeks previously for presentation (on his behalf) alongside the NZ Regatta preliminary presentation of results.

Next year's Technical Workshop is programmed for Tauranga on the North Island. If this year's workshop is any indication the bar has been set reasonably high for next year!

Standing alone from the annual New Zealand Hydrological Society Annual Conference, these workshops focus on the technical and field side of hydrological monitoring in New Zealand. The Workshops swap annually between the North and the South Islands and regional councils are encouraged to host the event with the assistance of the NZHS. Successful workshops have previously been held in the smaller centres of Gisborne and Greymouth, having evolved from being a small component of LAEMG (Local Authority Environmental Monitoring Group) activities in New Zealand in previous years.

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