Australasian Hydrographer

April 2019

AUSTRALIAN HYDROGRAPHERS ASSOCIATION

Contents

AHA

Australian Hydrographers Association
National Office
02 6296 2795
services@aha.net.au
PO Box 1006
Mawson ACT 2607
Australia

Journal Editor and Advertising

Jacquie Bellhouse
journal@aha.net.au

Design

ByFriday
1300 BYFRIDAY (1300 293 793)
design@byfriday.com.au
www.byfriday.com.au

Material Submitted

JACQUIE BELLHOUSE

Editor’s Introduction

Wow a quarter of our year has gone already and what a quarter it has been!

During January Australia had its warmest January on record, with a series of heatwaves unprecedented in their scale and duration and overall rainfall was 38% below average. Tasmania had its driest January on record.

Conversely parts of Queensland saw record rainfall late January and early February as a result of a monsoonal trough. According to the Bureau of Meteorology the town of Townsville received one year’s rainfall in the space of nine days! This resulted in flooding and the evacuation of hundreds of people, the flood risks continuing through to early February.

On 5 February, the Bureau of Meteorology issued yet another flood warning for the Upper Burdekin River in Queensland. “We have done the calculations and the flow moving past Macrossan Bridge is enough to fill about 2.6 Sydney Harbours every day and still increasing!!!” Are there any action shots out amongst our readers for this one? As a West Aussie, with very little experience with floods of this magnitude, I would love to see them!

Elsewhere in February rainfall was the lowest on record for a number of stations including, New South Wales, Western Australia, and the Northern Territory. This means that large swathes of eastern Australia have been in drought for periods ranging from a year to seven years.

Providing some drought relief (but also a wild ride) Cyclone Veronica passed over the Pilbara coast in late March. Interesting side note; Veronica had her own Facebook page check it out if you feel like a bit of a giggle http://facebook.com/cycloneVeronica. In celebration of Veronica’s visit I have included a paper from the Manly Hydraulics Laboratory (MHL) on their experiences with her counterpart Cyclone Debbie.

With all these extremes the role of suitably qualified hydrographers, in collecting fit for purpose data according to Industry Best Practice and National Standards, has become even more vital. In support the Water Monitoring Standardisation Technical Committee (WaMSTeC) recently led the first periodic review of the guidelines, five years since they were published. Recently the revised guidelines were published on the Bureau of Meteorology website http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml. For more details on these standards and how they differ from the draft Flood Warning Infrastructure Standard (FWIS) please check out Kemachandra Ranatunga’s paper “The value of consistent hydrometric monitoring practices”.

Because our readers should have the chance to share their stories outside the conference, every quarter we send out a call for papers. This quarter Paul Wilson kindly sent through his paper from the 38th Hydrology and Water Resources Symposium, “Making it real - the delivery of real time water data in Victoria”. Thanks Paul I am sure our readers will find your paper very interesting.

And last but not least, I have included Jennifer Leslie’s paper ‘Stormwater Pond Surveying: “Why probe when you can ping”. Jennifer’s paper is a great example of the resulting benefits of our longstanding collaboration with our fellow Hydrographers across the ditch.

Jacquie Bellhouse
Journal Editor

BILL BARRATT

From the President

Collaboration is our future.

AHA has taken and is taking conscious steps to work with others in our industry sector.

We have now identified kindred organisations and the AHA National Office is making contact to introduce ourselves to them and to see how we can work together. Training, material, information and representation head the areas we can all benefit from, and we hope to announce new arrangements before my next message.

AHA is also collaborating with Federal and State bodies, acting on behalf of members to secure work for qualified members. We are also being approached for training, as our suite of subjects and levels grows.

AHA is also engaging with industry providers and will shortly set up a Think-Tank to present the AHA 2020 Onward training system for review and comment. Each of these bodies is equally important to ensure that AHA stays current and relevant.

However, it's the members who need to reap the benefits of the planning and work being done by the Office.

In the near future, all members and partners will receive an invitation to log in to the AHA site and upload personal and business details. This is the first time we have been able to have personal control of information and choice in engaging with AHA.

The system will have an important element for Certified Hydrographers. Those on the list will be able to upload information and make it publicly searchable.

This will be of particular interest to suitably qualified CPH members who qualify to work with NSW Dept. of Industry in installing, validating or maintaining meters under the new scheme that commences on 1 April.

We see collaboration as the way forward and aim to have the system in place for 2020 onward.

Bill Barratt
AHA President

The Value of Consistent Hydrometric Monitoring Practices

Kemachandra Ranatunga, Linton Johnston, Alex Cornish, Philip Douglas, Carla Mooney and Soori Sooriyakumaran, Bureau of Meteorology, Australia.
Paper presented to 21th Australian Hydrographers Association Conference Canberra. 12-15 November 2018.

Abstract

Standardisation provides significant benefits to the water monitoring industry including national and state organisations. The Bureau of Meteorology, under the Commonwealth Water Act 2007 functions, promotes standardised practices in hydrometric monitoring across Australia, in collaboration with organisations that collect water information.

Two areas, where the Bureau relies heavily on data from diverse sources, are in assembling consistent and transparent national water information, and in protecting the community through flood forecasting and warning. In both these areas, the Bureau is promoting standardisation of data networks through the National Industry Guidelines for Hydrometric Monitoring (NIGLs) and through the Flood Warning Infrastructure Standard (FWIS – currently in draft), respectively.

Initially published by the Bureau in 2013 and updated in 2019 the NIGLs present recommended Australian industry practices for hydrometric monitoring. They have recently been reviewed to ensure that they remain up-to-date with technological advancements. Concurrently, the Bureau is leading the development of FWIS, which is part of a set of measures intended to place flood warning services on a sustainable and robust footing for the long term. It will address the key issues of fit-for-purpose development of flood warning infrastructure, and the need for national consistency and coordination for risk based investment in these networks. Performance based FWIS will be recommended for endorsement in April 2019.

Those responsible for hydrometric monitoring need to be aware of both the NIGLs and the upcoming FWIS, and understand the implications of bringing them into practice. The paper will outline the relationship between the standards and discuss the areas of commonality and difference. It will also explore how together they will help achieve the goals of consistent practices and interoperable data.

Background

Under the Commonwealth *Water Act 2007* the Bureau of Meteorology (the Bureau) has key functions for the collection, collation, analysis and dissemination of information about water resources and the use and management of water in Australia. The Act also allows the Bureau to issue National Water Information standards. These are in addition to its functions under the *Meteorology Act 1955*.

Water monitoring and measurement is undertaken by nearly 200 organisations around the nation who supply the data to the Bureau. The Bureau's flood forecasting and warning services rely on over 100 different organisations for rainfall and river level data. These organisations generate the data for a range of purposes to satisfy a spectrum of business needs, often in addition to flood warning.

Uniformity in hydrometric monitoring practice and interoperability facilitates the use of data with known quality by a wide range of users. This can only be achieved when all parties, including the Bureau, incorporate common standards throughout their practices and procedures (Johnston and Robinson, 2012). Standard monitoring practices provide significant benefits including efficient integration of data from diverse sources, improved interoperability, interpretation and understanding of water information, better assessment of the fitness for purpose of the data, and reduced duplication in effort by monitoring organisations to develop practices and procedures. In many cases, information used for flood warning comes from sites installed primarily for other purposes such as water resource management or compliance monitoring. This has led to issues, including lack of interoperability between instruments and data transfer technologies, inappropriate siting for flood forecasting purposes and inadequate redundancy for critical infrastructure (BoM, 2018).

In response to the identified need for standardisation, the Water Information Standards Business Forum, with membership of relevant stakeholders on water information, developed and endorsed a series of ten National Industry Guidelines for hydrometric monitoring (NIGL) in 2013. The NIGLs largely adapt existing Australian Standards and ISO standards including relevant options to be implemented. The NIGLs apply to hydrometric water resource monitoring activities and include aspects related to surface water level, discharge and water quality, groundwater level and water quality, and rainfall. They present recommended Australian industry practice and combine practical guidance on site establishment, instrument systems, data management and training through to specific recommendations such as for application of acoustic Doppler instrumentation.

The intended benefits of these guidelines are described in a Basis for Endorsement document, published with the guidelines on the Bureau web pages (http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml).

The majority of key organisations involved in the collection, analysis and reporting of hydrometric information across the country have adopted a high proportion of the NIGLs (Ranatunga *et al.*, 2014). Organisations recognise the role of these non-mandatory guidelines in reducing exposure to risk associated with the development and maintenance of monitoring programs, and providing clear, high-level guidance and targets to mitigate under-performance of monitoring networks. The Water Monitoring Standardisation Technical Committee (WaMSTeC) recently led the first periodic review of the guidelines, five years since they were published, and were published in 2019 (BoM, 2019) (refer to *Table 1* for a list of the guidelines). The review ensures they remain up-to-date with technological advancements, and included additional guidance in relation to groundwater site establishment and monitoring.

Table 1. Monitoring application of the NIGL for Hydrometric Monitoring

Guideline number	Guideline name	Application			
		Surface water	Groundwater	Precipitation	Water quality
NIGL100.00–2019	Part 0: Glossary	✓	✓	✓	✓
NIGL100.01–2019	Part 1: Primary Measured Data	✓	✓	✓	✓
NIGL100.02–2019	Part 2: Site Establishment and Operations	✓	✓	✓	✓
NIGL100.03–2019	Part 3: Instrument and Measurement Systems Management	✓	✓	✓	✓
NIGL100.04–2019	Part 4: Gauging (stationary velocity-area method)	✓			
NIGL100.05–2019	Part 5: Data Editing, Estimation and Management	✓	✓	✓	✓
NIGL100.06–2019	Part 6: Stream Discharge Relationship Development and Maintenance	✓			
NIGL100.07–2019	Part 7: Training	✓	✓	✓	✓
NIGL100.08–2019	Part 8: Application of Acoustic Doppler Current Profilers to Measure Discharge in Open Channels	✓			
NIGL100.09–2019	Part 9: Application of in-situ Point Acoustic Doppler Velocity Meters for Determining Velocity in Open Channels	✓			
NIGL100.10–2019	Part 10: Application of Point Acoustic Doppler Velocity Meters for Determining Discharge in Open Channels	✓			

The Bureau, as the lead national agency in flood forecasting and warning, with representatives from relevant State and Territory emergency services agencies and water authorities, is leading development of the Flood Warning Infrastructure Standard (FWIS) as part of a series of standardisation activities being advanced by the Australia-New Zealand Emergency Management Committee (ANZEMC).

The FWIS will detail performance requirements for flood warning infrastructure from field instruments and communications equipment, through to data ingestion for receiving, storing and displaying real-time flood data. Performance requirements define the minimum permissible standard of capability of the flood warning infrastructure in terms of the flood warning service level to be achieved. This relationship between infrastructure performance and service level ensures that the data collected is fit-for-purpose for the application of flood forecasting and warning.

The FWIS will be non-mandatory and performance based and will apply to new and existing infrastructure required for riverine and flash flooding. The FWIS will be recommended for endorsement in April 2019 following extensive public and industry consultation (BoM, 2018).

Water and flood warning information

The *Meteorology Act 1955* includes the functions for the Bureau to issue warning of weather conditions likely to give rise to floods. By definition, the flood warning information is also part of water information under the Commonwealth *Water Act 2007*. The water data sharing driven by the *Water Act* and data sharing arrangements for flood forecasting and warning are carefully developed to work effectively with each other to meet different reporting requirements. A spirit of collaboration and working co-operatively underpin these arrangements (*Figure 1*).

Currently the Bureau collects stream flow information from more than 5,000 sites, out of which around 3,300 sites provide flood warning information (*Figure 2*). Hydrographers from many organisations monitor streamflow and rainfall, for multiple purposes. The Bureau collates this information regardless of the initial purpose and makes it widely available for secondary users. The Bureau also uses this information in a range of products and services, and one key service is flood forecasting and warning.

NIGLs apply to all water monitoring sites for which data are provided to the Bureau. However, to deliver a robust flood forecasting and warning service now and in the future, the flood sites need to meet certain criteria outlined by FWIS, such as specific conditions around frequency of reporting and reliability. Hence for these sites, both standards apply.

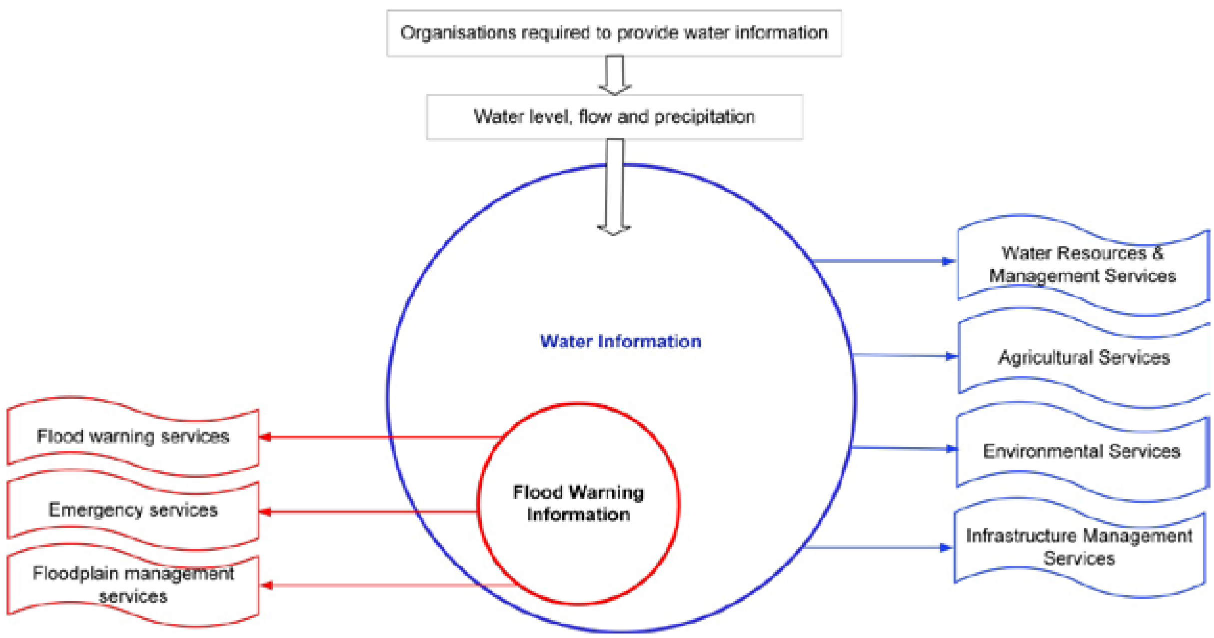


Figure 1. Flood information within the umbrella of water information and their services.

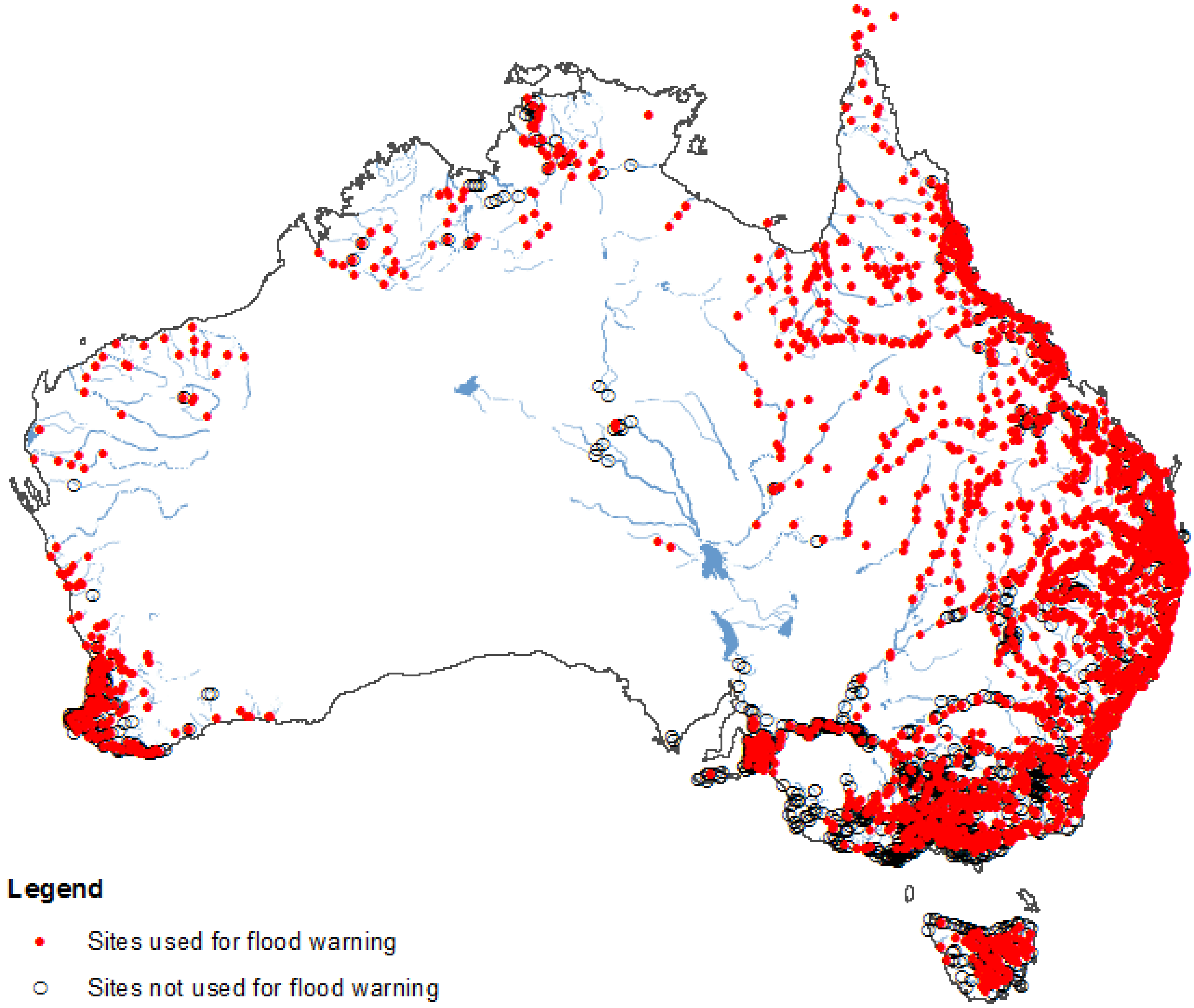


Figure 2. Streamflow sites in Australia.

Two standards: how do they fit together?

The NIGLs describe how the best practice of measuring the presence, flow and quality of water in rivers, lakes and groundwater should be achieved, given the available/current technology. Their stated purpose is to ensure data gathered from hydrometric monitoring sites will be suitable for its intended primary purpose. Hence, the NIGLs set a practitioner framework outlining the activities and procedures that the hydrographer needs to undertake, document and consider in order to achieve the intended purpose based on customer requirements. These customer requirements dictate that further benchmarks and measures are required for specific applications. The NIGL does not (and cannot) set those additional measures, because they will be many and varied according to the purpose and service requirement for which the information is required.

The FWIS expresses requirements specific to the purposes of flood forecasting and warning and identifies the level of performance (the standard) of what should be achieved. In other words, it describes the particular flood forecasting and warning customer requirements. Requirements are defined in terms of the function to be performed and the minimum performance level to be achieved for specified attributes.

The relationship between the NIGL and the FWIS including the flood warning service and water monitoring technology is presented in *Figure 3*.

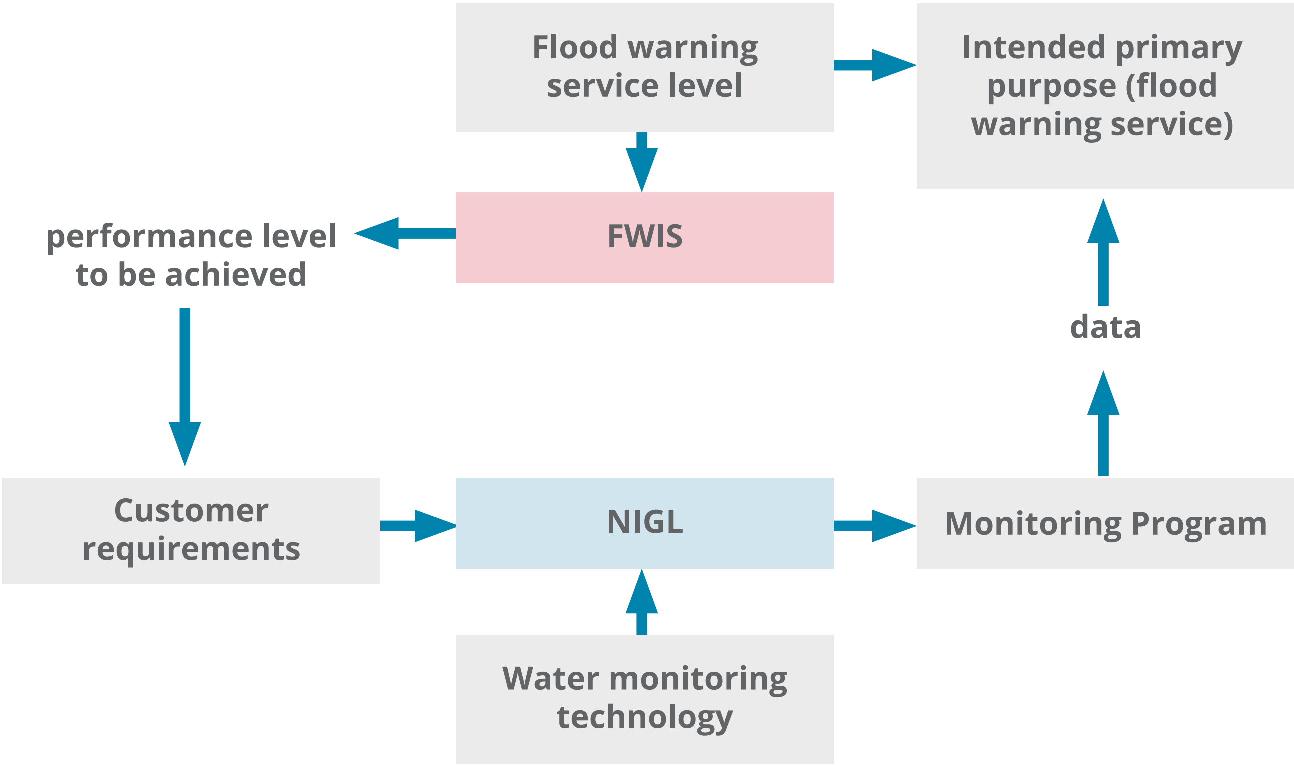


Figure 3. Relationship between the NIGL and FWIS.

The FWIS uses a performance matrix to group together various infrastructure components, i.e. site, data sensing (rainfall, water level and flow), data transfer and data use (ingest, storage and display) against infrastructure attributes; that is, collectability, interpretability, availability and assurability.

Performance attributes are listed as follows:

- The collectability attributes describe the time taken and constraints of providing data to the end user; that is, Bureau. This consists of latency of reporting, interoperability and data transfer information.
- The interpretability attributes relate to how indicative the flood data are to represent the catchment conditions and consist of data range, accuracy, sampling and data resolution (how often data collected and transferred) and metadata.
- The availability attributes relate to the ability of flood warning infrastructure to operate under adverse flood conditions and their maintenance regime, asset replacement and metadata latency.
- The assurability attributes relate to the degree of confidence of data as observed. They include compliance, contextual information and performance indicators.

Each element in the performance matrix connects a particular attribute to the component of the infrastructure. For example, the accuracy of data (the attribute) of the rainfall sensor component is one such element in the matrix. There will be a functional requirement for each element. Continuing the example of rainfall/accuracy element, the functional requirement for that element would be described in terms of the uncertainty:

The uncertainty of the rainfall measurement shall be sufficiently small to satisfy the design or service level requirement.

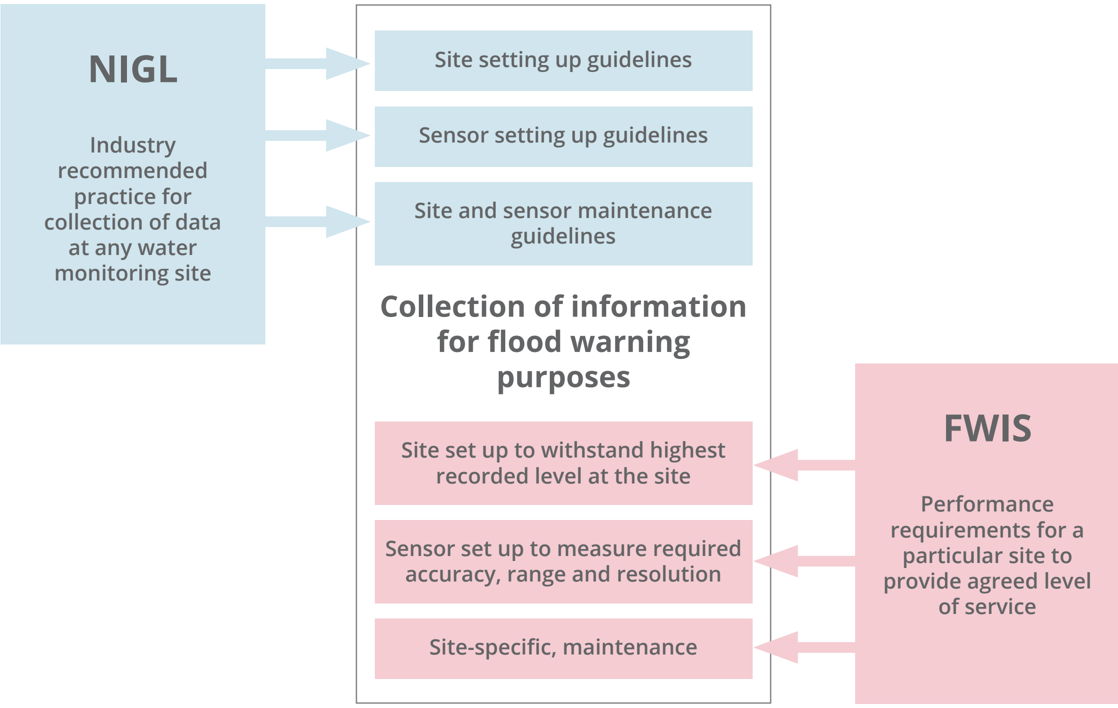


Figure 4. Relationship between prescriptive and performance-based standards shown by specific examples.

For a particular site, there will be a performance requirement for each element that matches the service expectation. In this way, each element of the matrix, which is appropriate for the infrastructure, will have a functional requirement and for each site, there will be a performance requirement. The FWIS contains a full set of functional requirements and describes a range of performance requirements for a range of service levels expected.

Therefore, the FWIS describes what should be achieved in terms of performance; that is, outcomes to be achieved (Standards Australia 2016) for sites which are to be used for the purposes of flood forecasting and warning. This also includes verification requirements so that consistency can be demonstrated across different technical solutions.

Performance based standards are flexible, promote innovation and mitigate the risks of anti-competitive influence by describing solutions which do not preference particular products or brands (Foliente 2000). Performance based standards allow flexibility, however they can be difficult to implement. Users may find applying the standard burdensome since they must interpret the requirements and develop their own solutions. In some cases, performance standards are supported by some form of prescriptive standard, which is described as a 'deemed to comply' solution (Standards Australia 2016).

This highlights the relationship between performance and prescriptive standards (Figure 4). From the outset, the FWIS development process adopted the principle that existing relevant prescriptive standards would be identified or 'called up' to support the verification component.

Examples of how they can be applied concurrently

Table 2 compares the different nature of requirements contained in both the NIGLs and the FWIS, which a hydrographer needs to consider when establishing and operating a monitoring site for the purposes of flood forecasting and warning.

The examples explore requirements and considerations relating to:

1. Water level measurement range;
2. Rainfall data capture sampling resolution; and
3. Water level accuracy.

Table 2. Examples of how both standards can apply concurrently

National Industry Guidelines requirements	Flood Warning Infrastructure Standard requirements
1. Water level measurement range	
The guidelines recommend hydrographers consider various factors when selecting a surface water monitoring site, to ensure it is suitable for its intended primary purpose. One of these factors to consider is measurement range. The guidelines go on to recommend that: • it should be possible to get an accurate stage reading from the gauge over the designed range; and • effective channel control should exist at medium to high flow ranges.	The standard sets the range of water levels (defined by upper and lower limits) which the instrumentation at a flood warning site must be capable of recording. The lower limit: • needs to be sufficiently low to detect initial water level rises in response to rainfall, to allow time before thresholds of interest are reached. The upper limit: • needs to be equal to or greater than the maximum known flood levels, or those levels for which forecasters will be required to issue warnings; • as a minimum, must be equal to the 1% AEP (Annual Exceedance Probability) flood level, plus a specified freeboard height; • must also be above the highest known water level and the major flood level, whichever is greater.
2. Rainfall data capture sampling resolution	
The guidelines impose a high-level requirement on organisations to define and document appropriate triggers for data capture, such that they meet customer requirements. The guidelines note that these triggers may be based on data exceedance criteria or fixed time logging. They do not specify these criteria or fixed intervals between sampling—those are the subject of particular customer requirements.	The standard sets maximum sampling intervals for rainfall measurements used in flood warning. Size and response time of the catchment in which the rain gauge is located are the key determining factors in deciding what the maximum sampling interval must be. To arrive at the required sampling interval, the hydrographer must categorise the catchment response by determining • the area of the catchment upstream of the location of interest (typically the next downstream forecast point); and/or • the time of concentration (time taken for water to flow from the most remote point in a catchment to the catchment outlet), or time to peak for the resultant hydrograph (the time from the centre of mass of the rainfall excess to the peak of the hydrograph). The standard contains a look-up table with maximum allowable sampling intervals for given catchment areas and times of concentration/time to peak.

National Industry Guidelines requirements	Flood Warning Infrastructure Standard requirements
3. Water level accuracy	
The guidelines require hydrographers make efforts to reduce or eliminate as many sources of error as is realistic, and undertake investigations to identify and eliminate sources of error in cases where overall uncertainty exceeds customer requirements. The guidelines contain numerous requirements and recommendations, which affect water level accuracy, but they do not specify absolute uncertainty limits for water level measurements. For example, the guidelines: • set criteria related to measurement structures and their influence on the accurate measurement of water level; • set requirements for routine checks and service visits to minimise the drift from acceptable tolerances for parameters measured; • require that organisations state and document the tolerance achieved for each parameter measured; • require that gauge plates be calibrated and adjusted where errors greater than ± 3 mm are found; • note that wave action may increase measurement uncertainty, and refer to the use of dampening tubes/boxes to dampen wave action.	The standard sets maximum levels of uncertainty in water level measurements at sites used for flood warning. In setting maximum levels of uncertainty, the standard requires hydrographers refer to the design thresholds for the flood warning site. These are typically the minor, moderate or major flood levels. The water level measurements must be of sufficient accuracy to resolve changes around these threshold levels, to be confident that they have or have not been exceeded for example. As such, the standard requires that overall water level measurement uncertainty must be • equal to or less than half the least significant figure of the flood threshold. The standard notes that there may be cases where a more stringent design requirement sets the uncertainty limits lower than those derived from the criteria relating to design thresholds. The standard does not explicitly describe how to achieve the maximum levels of uncertainty, but refers to methods prescribed in recognised best practice, such as Australian Standards or ISO standards.

Conclusion and way forward

The National Industry Guidelines for hydrometric monitoring (NIGL) present recommended Australian best practice for all aspects of hydrometric monitoring. It is about the "how" and is dependent on the technology. When technology changes the NIGLs change accordingly. Therefore, after five years of endorsement, they have recently been revised ensuring that they remain up-to-date with technological advancements. The application of NIGLs will continue to improve levels of consistency and comparability of data between collecting and user organisations, improving data quality and reducing duplication of effort for water monitoring.

The NIGL provides the means by which different standards or fitness's of data can be achieved whereas the Flood Warning Infrastructure Standard (FWIS) will provide the specific range of standards or performance levels relevant for flood forecasting and warning applications. The FWIS is not dependent on technology but on the required flood forecasting and warning service levels. The FWIS will improve transparency in data accuracy, interoperability, resilience and latency, and help reduce life cycle costs.

The two non-mandatory standards are similar to the extent that they are both designed to ensure that data collection is adequate to satisfy the intended purpose. The NIGLs prescribe actions in relation to measurement and need to provide specific guidelines for each technological solution. In contrast, the FWIS by being non-prescriptive on the technological solution encourages flexibility and innovation allowing the user to decide how to achieve performance.

The differences between the two documents are that the NIGL provides a level of technical detail that is commonly understood and expected by the hydrometric community. In contrast, the challenge of implementation is a live one for the FWIS because its requirements are expressed as broad performance expectations. The scope of the FWIS is also broader than the NIGL because it includes performance requirements for measurements. This implementation challenge is recognised and supported by the identification of technical standards in the verification component of the standard. The specific issue of the level of detail in the FWIS has been raised in the industry consultation phase and the need for tools to support implementation identified.

With the introduction of the FWIS in 2019, significant effort is required to build confidence in the integrity across both the water and flood information, and to demonstrate that data collection is undertaken to agreed industry processes and methodologies as guided by both standards. It will be important over time to map the interactions between the two to ensure that FWIS is maximally called up in the NIGLs, the Australian and ISO Standards.

Therefore, a combination of both standards will produce the best result for the practitioners of water monitoring for flood forecasting and warning purposes and allow supporting industries to identify and service common needs with greater confidence.

It is important to recognise that the standards are living documents and will remain open to review and continuous improvement. The full value of these standards will only be realised if the standards are adopted widely. Effective adoption of these standards by all water monitoring organisations will achieve maximum benefits for both water and flood management across Australia.

References

BoM (2018) Flood Warning Infrastructure Standard, Bureau of Meteorology, Australia. http://www.bom.gov.au/water/standards/floodwarning.shtml (Accessed 01/08/2018).

BoM (2019) National Industry Guidelines for hydrometric monitoring, Bureau of Meteorology, Australia. http://www.bom.gov.au/water/standards/niGuidelinesHyd.shtml (Accessed 21/03/2018).

Foliente, G. C. (2000) Developments in performance-based building codes and standards, Forest Products Journal, Vol. 50, No.7/8.

Johnston, L. and Robinson, G. (2012) *A national approach to water information standards*. Paper presented to 16th Australian Hydrographers Association Conference, Melbourne. 21-23 August 2012.

Ranatunga, K. Johnston, L. Torrible, L. and Malone, D. (2014) National Industry Guidelines for hydrometric monitoring - adoption at a national level. Paper presented to 17th Australian Hydrographers Association Conference, Sydney. 28-31 October 2014.

Standards Australia (2016) SG-003: Standards and Other Publications. Standards Australia.

Acknowledgements

The authors wish to thank members of the WaMSTeC review subcommittees and the National Flood Warning Infrastructure Standards Technical Advisory Group for their technical contributions and guidance in developing and reviewing these standards.

Making it Real — The Delivery of Real Time Water Data in Victoria

Paul J Wilson, Jasjit Chaggar, DELWP, Melbourne, Australia; paul.wilson@delwp.vic.gov.au

Paper presented to 38th Hydrology and Water Resources Symposium, Melbourne, 3-8 December 2018.

Introduction

The water information team at DELWP (Department of Environment, Land, Water and Planning) publishes surface water and groundwater data on a public website—the Water Management Information System (WMIS). WMIS contains data on water levels, water flow and water quality for all the Regional Water Monitoring Partnership (RWMP) monitoring sites across Victoria (850 surface water flow and level sites, 1,400 groundwater level sites and 180 water quality sites). The RWMP is a collection of 45 agencies (water corporations, CMAs, local/ state/ commonwealth government) that come together to share the costs of water data acquisition and collect all data to a common standard. The collective 'buying power' of the partnership results in reduced monitoring costs and less duplication of effort for partner organisations.

Generally, data is collected in two ways: it can either be collected manually in the field or be transferred via telemetry. Field data is collected monthly for surface water and quarterly for groundwater, and by the time this data is verified and published on WMIS it can be 2–3 months old. DELWP currently has approximately 900 telemetered sites collecting continuous data, but currently, has no capacity to receive or publish this data in real time on WMIS.

The solution

An 18 month program, implemented by DELWP on behalf of the RWMP, is now nearing completion. The program will allow real time data to be published on WMIS. This data will be less than one hour old.

DELWP decided on a cloud hosting solution and a staged approach for deployment. A cloud hosting solution was sought in order to move the hosting of WMIS out of the government hosting environment, where a Service Level Agreement (SLA) is not possible. An SLA is an essential requirement for delivering real time data.

The staged approach involved the deployment of eight key stages: (1) detailed business requirements; and solution design documents, (2) Proof of Concept; (3) formal Request for Quote and evaluation process for cloud hosting and support services; (4) build the environments and infrastructure; (5) System Integration Testing (SIT), and User Acceptance Testing (UAT); (6) developing an operations plan, cutover/implementation plan; (7) a limited field trial; and (8) a staged roll out to transfer all 900 telemetered sites to the new infrastructure and environments.

The detailed business requirements document is a key document that clearly outlines the business requirements of the solution to be built. The solution design documents outline the technical specifications of the build. Both these documents form the basis of the tender documents, how the solution is designed, priced and built. If these documents are not correct or comprehensive, then this will have (potentially major) implications later in the project—especially in the build phase. It will certainly result in increased build costs if the business requirements and solution design document are not correct.

The Proof of Concept (PoC) stage was a vital phase as we needed to be sure that the proposed solution would overcome the design problems and performance issues experienced by other interstate jurisdictions when their telemetry systems are under load. Most state water agencies use the Hydstra platform to manage their time series water data. The Hydstra developers were proposing a unique solution to address the known performance concerns, and this solution had not been trialled elsewhere. The aim of the PoC was to mitigate the risk of the new design and infrastructure performance in the cloud hosting solution. Essentially, we could try before we buy. It was hoped that all the design issues were tested and resolved during the PoC stage. They would be tested again during the Systems Integration Testing (SIT) and User Acceptance Testing (UAT) phases.

Being a government department, DELWP had to go through a very formal tender and evaluation process. All tenderers built their quotes and proposed solution around the business requirements and solution design documents. What we found is that it was very difficult to compare the different proposed solutions and associated costs. To overcome this, tenderers were asked to resubmit given a very defined list of requirements – this would ensure that we could compare like with like.

The build phase involved building three identical environments—development, test and production—and involved 24 servers. Being in the AWS (Amazon Web Services) environment meant that they offer 99.99% reliability on all servers. We increased this reliability on the ftp servers to 100% by having two ftp servers in 'high availability' in the production environment, which means there can be no loss of incoming data to the ftp server. If one server fails, the other ftp server automatically takes over.

SIT and UAT are key stages that test all aspects of the infrastructure, software and environment to make sure that everything is working as it was intended. Any defect identified through this process was logged and needed to be rectified before moving forward.

It was important that we were able to resolve the performance issues that other jurisdictions have had, especially when the system is under load (i.e. during flood, when many people are trying to access and download data). The solution was to produce all standard reports as static content and to have all large non-standard reports and data download as 'dynamic content' (i.e. produced on the fly) and located on a separate server.

Stage 6 involved planning for deployment and how you move from the existing arrangements to the new arrangements. Stage 7 involved a limited field trial to transfer 13 sites with different logger programs into the new environment. This stage will test that everything is working before the transfer of the full suite of sites into the new environment. The final stage (stage 8) involves transferring all remaining sites into the new environment. This stage could take up to 3 months, as it involves reprogramming individual loggers in the field.

Lessons learnt

Out of this staged approach, there are ten key lessons that can be applied to similar projects:

a. Make sure your business requirements document is correct and comprehensive. This should be written by a business requirements document specialist. If this document is wrong/ missing elements, then your solution will be wrong and you will incur additional costs to cover the missing requirements.

b. For a project of this size a good project manager is essential. While project managers can be expensive, they are worth their weight in gold—it is a fulltime position, you will not be able to deliver a project like this on a part time basis.

c. Do not cut corners in the planning. Cutting corners will derail the project at some point and will result in cost and time over runs. IT projects do not run to schedule!

d. There will be resourcing issues as faults are identified (especially in SIT and UAT). Daily triage meetings with service providers are required to prioritise and rectify faults in a timely way. All issues should be escalated as soon as possible to get them resolved. As the client you need to demonstrate you will not put up with substandard service from service providers.

e. Need to remain adaptive and find solutions/ work arounds as problems arise.

f. Lean to speak the language. You need to be an informed buyer. If you are not, you will be paying for things that you do not need, or you will not be aware of the options available.

g. A cloud solution does not work the same way as a normal server solution. Do not assume anything, ask questions. Depending on how your environments are structured, you may not be able to 'lift and shift' to another environment. This means that each environment will need to be built from scratch. It is also worthwhile for cloud projects to have access to a cloud architect. This will assist with being an informed buyer.

h. In a cloud environment, security is a big deal and your solution will be tightly locked down. This will present access problems that need to be resolved.

i. A proof of concept is a good step to go through. But remember it will not prove everything, so there will be surprises. The POC will help to reduce the number of surprises.

j. Communication is key. Need to keep everyone in the loop—internal users and all service providers. This is especially relevant if you are using off-site service providers.

Conclusion

The new cloud hosting environment for the delivery and management of real time water data will result in greatly reduced time lines for publishing water data. Telemetered data will be published every hour. It will also mean that DELWP will take control of its water data and this represents a significant change to business as normal.

An Evaluation of Real-Time Water Measurement

Dejan Subaric, Department of Natural Resources, Mines and Energy (DNRME), Brisbane, Queensland.
Paper presented to 19th Australian Hydrographers Association Conference Canberra. 12-15 November 2018.

Abstract

DNRME operate and maintain a network of more than four hundred primary stream or surface water gauging sites around the state of Queensland. These sites are telemetered and as such are expected to provide 24/7 access to water monitoring data.

During extreme events the reliability of our network can be compromised due to telemetry outages. In order to address this and provide timely, reliable and accurate data the team at the Hydrographic Support Unit (HSU) have carried out several development activities. This work has been underpinned with internal modernisation and external communications network changes.

To improve rate of change measurements, HSU has undertaken a bench and field evaluation of several commercially available continuous bubblers, which are summarised in this paper.

Pivotel is shutting down the Queensland Globalstar gateway in June 2019. To avoid losing telemetry data at satellite coverage pluviograph sites, we successfully evaluated and deployed a new satellite telemetry instrument.

During Cyclone Debbie in 2017 a significant portion of DNRME monitoring network was cut off partially due to infrastructure damage within the Telstra mobile network. In light of this network failure a decision was made to challenge the market to provide a robust, turnkey redundant telemetry platform. This work has resulted in the largest monitoring network change for Queensland in fifteen years.

Rate of Change

As the existing OTT CBS bubbler systems currently in use by DNRME have provided many years of dependable service in the field, it was decided to evaluate other similar systems for compatibility and also to gauge the advancements in modern technology. The HSU has performed an evaluation of four industry leading bubbler systems including field testing in North QLD. The bubbler systems we evaluated were the following:

- Sutron Compact Constant Flow bubbler (Sutron)
- FTS bubbler (FTS)
- Xylem Amazon bubbler (Amazon)
- HyQuest Solutions Air Force Compact bubbler (AFC)

In preparation for extreme events, we wished to upgrade our bubbler network to continuous bubble systems capable of performing quick measurements during fast rising water heights at sites with long capillary lengths (up to 300 m).

The evaluation involved testing at our HSU test pond followed by a real-world installation over a four to six-week field trial in North Queensland. The test setup at HSU comprised of identical length (21 m) capillary tubing from a common manifold mounted to the bottom of a 2.2 m high column of water controlled via a pump.

Figure 1 is a plot of the bubbler responses over approximately 35 mins of continuous rising conditions. All bubblers performed well in this condition and it would seem they are all suitable for our response requirements.

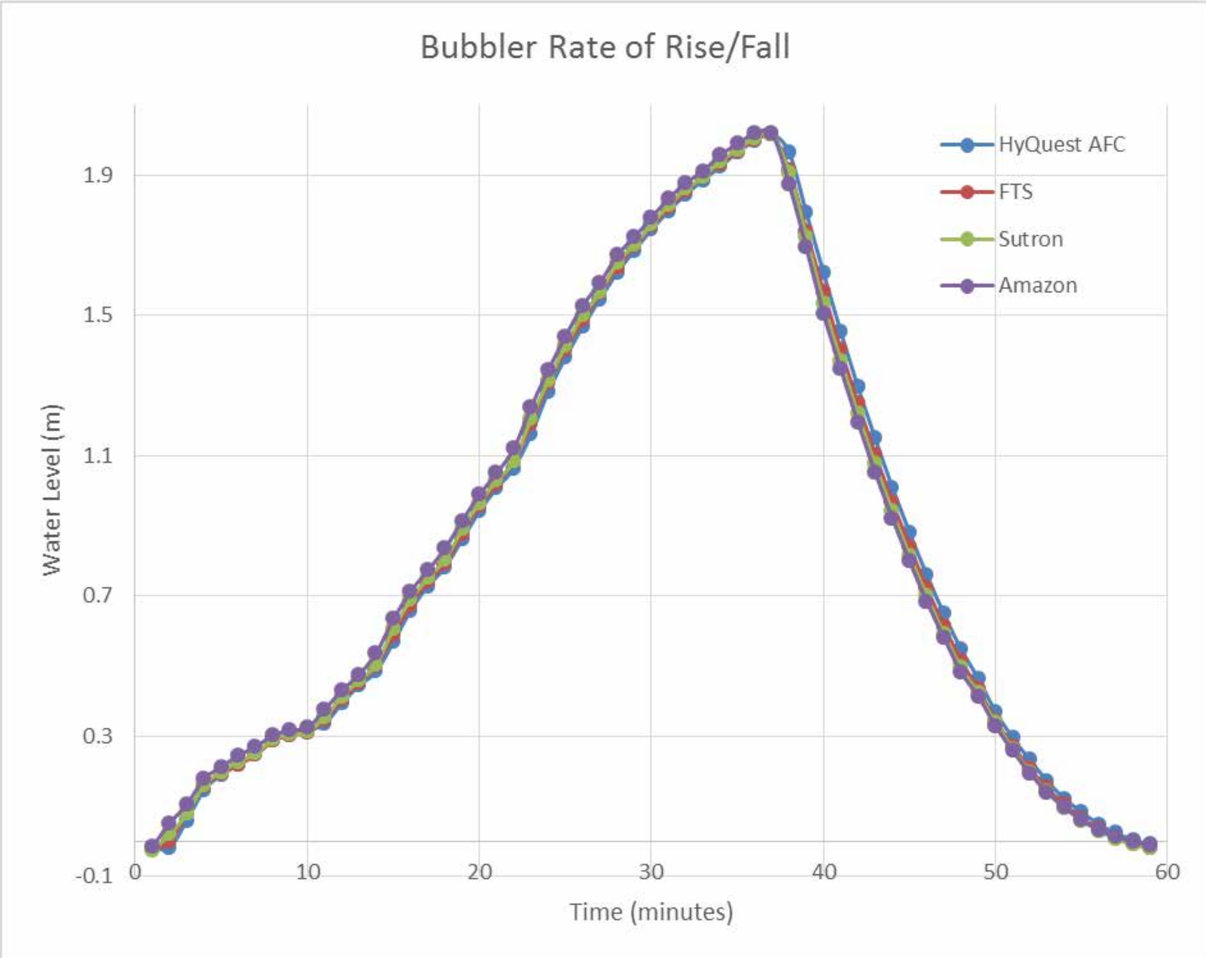


Figure 1. Recorded graphical data for rising water level measurement.

In the above results, the bubblers were set to identical settings to ensure a fair comparison. The following settings were used in this test:

- All bubblers set to 45 bubbles/min (AFC maximum)
- All bubblers set to 12 second sample averaging (AFC minimum)
- All bubblers calibrated to the same max height (2.24 m)

Figure 2 is a plot of the bubbler response when faced with an extreme rise in water level in a short period of time (2.2 m in 30 seconds). This case is extremely rare and would imply there is a large wall of water suddenly flooding the measurement zone. Impressively, all but the AFC bubbler are able to accurately respond to the height surge within a couple of minutes. The AFC steadily manages to catch up however the unit also exhibits some overshoot in the final height before settling to the correct value. The AFC is manufactured to operate at up to 8 m/h rise conditions.

400+ LOCATIONS

65+ COUNTRIES

12,000+ EMPLOYEES

ALS is one of the world's largest and most diversified testing, inspection and certification companies.

Globally, ALS is focussed on delivering superior testing and analysis, field sampling, training, environmental monitoring and specialist hydrology and meteorology expertise and services, across a wide range of industries including mining, water, oil and gas and construction – underpinned by globally recognised and certified safety, quality and environmental management systems.

Our Hydrographics services specialise in the supply and operation of a wide range of monitoring systems for long term, continuous monitoring of many environmental parameters including water, weather and air quality using state-of-the-art customised instrumentation, telemetry and data management solutions.

Right Solutions · Right Partner
www.alsglobal.com

ISO 9001 Quality Management · AS/NZS 4801:2001 Occupational Health and Safety Management · OHSAS 18001 Occupational Health and Safety Management · ISO 14001 Environmental Management

ENQUIRIES

ALS would be pleased to discuss your environmental monitoring needs:

www.alsglobal.com/hydrographics
hydrographics@alsglobal.com

Brisbane
P +61 7 3243 7222
2 Byth St, Stafford QLD 4053

Canberra
P +61 2 6202 5419
16B Lithgow St, Fyshwick ACT 2609

Mackay
P +61 7 4944 0177
78 Harbour Rd, Mackay QLD 4740

Melbourne
P +61 3 8756 8000
22 Dalmore Dr, Scoresby VIC 3179

Rockhampton
P +61 7 4936 3388
Unit 2/11 Sturt St, Rockhampton QLD 4702

Sydney
P +61 2 4721 3477
24A Lemko Pl, Penrith NSW 2750

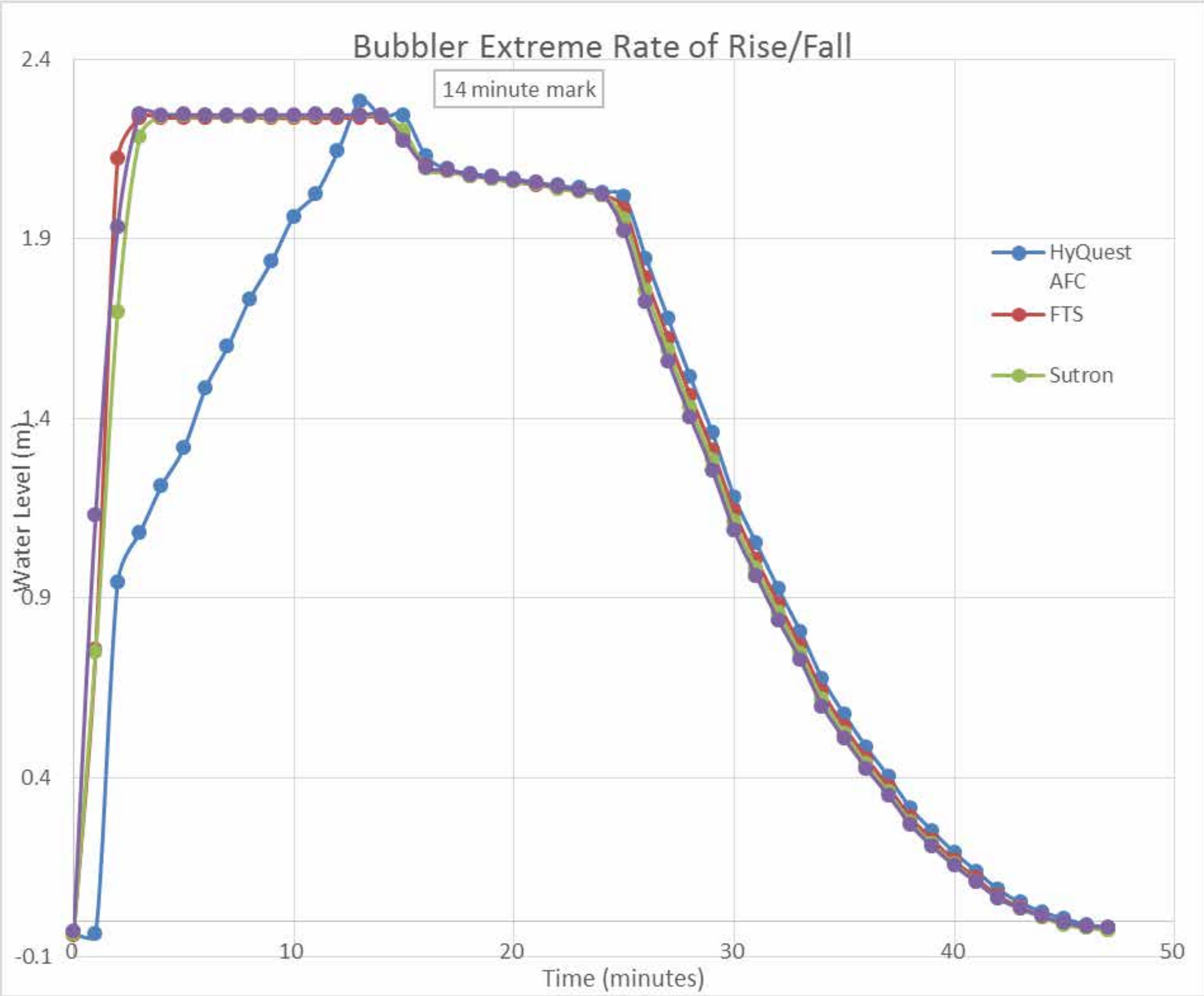


Figure 2. Recorded graphical data for extreme rising water level measurement.

In the above results, the bubblers were set to identical settings to ensure a fair comparison. The following settings were used in this test:

- All bubblers set to 45 bubbles/min (AFC maximum)
- All bubblers set to 12 second sample averaging (AFC minimum)
- All bubblers calibrated to the same max height (2.24 m)
- Actual fill time takes approximately 30 s
- Actual drain time takes approximately 30 min
- Drain was started once all four bubblers were reading the full height (14 min mark)

All four (4) bubbler system types were sent to the North Queensland region for field trials where they were installed at several bore water gauging stations. A lot of feedback was received regarding the installation process, the feedback has been summarised into *Table 1* as Strengths and Limitations.

All the bubblers worked well despite some initial challenges in the installation process. A higher power consumption was noticed compared to current OTT CBS instrumentation.

Table 1. Bubbler performance evaluation

Sutron Strengths	Sutron Limitations
Built-in data logger – SD card data download.	External desiccant module but high capacity.
Easy installation – ergonomic unit.	Two-line display screen navigation.
Dual orifice feature optional upgrade.	
Feature rich.	
Good ingress protection.	
FTS Strengths	**FTS Limitations**
Easy installation – ergonomic unit.	External desiccant module but high capacity.
Feature rich – display navigation.	Fiberglass enclosure – handling hazard.
Good ingress protection.	Limited range – 21 m.
Built-in service data logger – SD card.	
Anti-congestion manifold design.	
Amazon Strengths	**Amazon Limitations**
Easy installation – ergonomic unit.	External desiccant module but high capacity.
Feature rich – Wi-Fi, colour touchscreen, ranges.	Higher power usage – Wi-Fi.
Good ingress protection.	Steeper learning curve due to features.
Built in data logger –USB ports.	Sleep state/calibration issues.
Many extra features – future proof.	
AFC Strengths	**AFC Limitations**
Built-in air dryer – no desiccant.	Bulky enclosure – difficult installation.
Higher range limit – 50 m.	Slow response in extreme rate of rise.
Australian manufacturer – local support.	Not sealed – modification for ingress protection.
High quality ARB compressor/Festo tank.	Power consumption – separate fused wiring.
	Prone to user error due to manual valves.
	No built-in data logger.
	Limited features/settings.

To conclude this evaluation, it became clear that there was not a single bubbler best suited for all of our sites, however the Sutron stood out as the best replacement for most situations tested. The AFC doesn't require a desiccator and can measure up to 50 m, which is useful at some sites. The critical outcome was to ensure a high capacity desiccator is used and limit automatic purging.

Standalone Rainfall

With the Queensland Globalstar gateway shut down scheduled for June 2019, DNRME needs to upgrade all satellite telemetry sites to alternative providers. Our pluviography (pluvio) only sites are expensive to setup and maintain, furthermore the existing satellite telemetry solution experiences data loss due to the one way communication setup. The vision is to resolve all of these issues with a standalone product; the SatVUE (manufactured by Pacific Data Systems) is this product, identified to best meet the department's needs.

SatVUE contains a built-in data logger and battery along with a 5 W solar panel, all housed in a compact weather sealed pole mount standalone unit *(Figure 3)*.

Figure 3. SatVUE pole mounted in the field.

DNRME conducted a three-month field evaluation of two SatVUE units with great success in early 2018. The data we telemetered hourly was:

- Rainfall
- Voltage
- Temperature
- Signal Strength

A custom pole mount was fabricated to allow easy integration onto our existing infrastructure. Only 14 stations in our network are satellite pluviography sites, so it was not a large scale roll-out. The SatVUE web portal gives complete control of each field unit allowing over the air (OTA) configuration changes and complete reprogramming of operation.

The field installation switch from Globalstar to SatVUE was straightforward as shown in *Figures 4 and 5*. The SatVUE only requires a two wire cable from the Tipping Bucket Rain Gauge (TBRG).

[1] Notice provided by Pivotel via email alert on 30th June 2017.

Figures 4 and 5. Before and after installation of SatVUE at Globalstar telemetry site.

By switching to SatVUE our existing gauging shelters become obsolete. During the trials we left the existing field logger to retain data redundancy and to use it to verify the SatVUE data. Future installations at new sites would not require the shelter with the power and logger hardware as the SatVUE is a standalone unit. A pole with two arms would be sufficient to mount a TBRG and a SatVUE as a satellite telemetry pluviography station.

During the field trials, we noticed the telemetered data packets were quite large when rainfall was recorded. The SatVUE units were reprogrammed (OTA) with optimised code and this drastically reduced the data packet sizes.

The verification of the data occurred following a second field trip where the data log from both the SatVUE and the existing field logger were compared to the telemetered data. One site experienced zero discrepancy between all three data sources. The second site seemed to not have telemetered one bucket tip (1mm) over the three months. Whilst this was already a huge improvement over the existing Globalstar telemetry, we analysed why we saw a 1mm discrepancy.

It was found to be due to the bucket tip occurring during the delay between the hourly transmission and the satellite signal reception. The solution was a simple addition to the code and the new program was sent to the units via telemetry. The new code functionality was tested at HSU by replicating the issue found in the field, this verified that the unit performed as expected.

The SatVUE solution will evolve as development work is in progress to design a cellular version along with SDI-12 sensor compatibility and increased internal memory.

Telemetry Redundancy

DNRME must provide a modern, fit for purpose network for the provision of timely, reliable and accurate data. Extreme events have a habit of affecting our cellular network as we rely on Telstra towers at many sites. It was decided to challenge the market to provide a dual telemetry data collection platform. Halytech was able to provide not only the necessary level of project engagement but also the most fit for purpose solution.

Halytech was also able to provide this solution within our budgetary constraints and strict timeframe. The microSpider XQ logger was custom developed for Queensland in both hardware and software capabilities. For ease of field install, the enclosure was designed based on our existing data collection platform. The gland plate is a similar layout so that the switchover in the field is plug and play *(Figure 6)*.

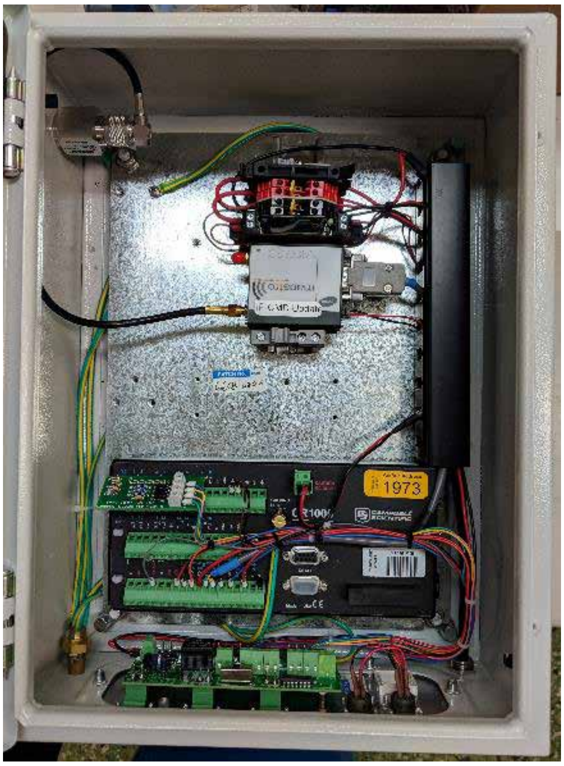
Figure 6. Old logger enclosure on the left, new XQ on the right.

Our previous data collection platform was based on a Campbell Scientific CR1000 logger however did not contain dual telemetry redundancy. The XQ logger has both cellular and satellite telemetry built-in which we configure to operate as a redundant failover platform. If the cellular NextG (Telstra) network fails, the XQ logger automatically switches to satellite transmissions via the Iridium satellite network.

The satellite communications occur via an Iridium Edge module which is mounted to the outside of our shelters and huts on a custom bracket (*Figure 7*).

Figure 7. Iridium Edge module mounted on a 2" pole.

The logger hardware is much simpler inside the new enclosure (*Figures 8 and 9*) which helps with reliability; there is also space for future expansion.



Figures 8 and 9. Old logger on the left, new XQ on the right.

Over the course of several months, we worked closely with Halytech to custom design the firmware and configuration we required for our monitoring network. During this time the XQ logger was put through extensive testing at the HSU test hut. We tested every feature again with every firmware update and switched between cellular and satellite telemetry many times to ensure it operated flawlessly. Work is ongoing to ensure data packets are optimised and ingested within the department's water information system.

We have full confidence that this new logger will exceed the needs of DNRME and have already started the upgrade process at Northern Queensland sites where access is difficult or impossible during the wet season. The next extreme event will be a true test whether we have accomplished what we set out to achieve—a robust monitoring network delivering key data during the worst of weather.

Summary

In summary, DNRME has prepared for future extreme events by investing in new technology. The efforts of extensively trialling new bubblers will hopefully pay off when the next fast rising event is recorded earlier than before. The satellite telemetry network solution brings future proofed data redundancy across the state. By learning from past extreme events, we strive to improve Queensland's water monitoring network for the future.

Extreme Events Push Data Quality Assurance to The Limits – The Experience of Cyclone Debbie

Bernard Tse, Manly Hydraulics Laboratory, Sydney, NSW
Sarah Dakin, Manly Hydraulics Laboratory, Sydney, NSW
Paper presented to 19th Australian Hydrographers Association Conference Canberra. 12-15 November 2018

Abstract

In March 2017, tropical cyclone Debbie brought widespread rainfall and flooding to the far north coast of New South Wales (NSW) including the Tweed, Lismore, Byron, Richmond Valley, Kyogle and Ballina local government areas. Five hundred SES flood rescues were carried out and in NSW six people lost their lives as a result of the flooding. In support of NSW emergency services, Manly Hydraulics Laboratory (MHL) deployed a field team to the flood affected area to obtain flood status checks for stations owned by the NSW Office of Environment and Heritage (OEH) during the event. This was followed up after the event to determine post flood status checks and debris line surveys.

There is often a high demand for water level and rainfall data during and immediately following a major flood event. This raw data is used for emergency planning, preparation and response; and it is often confirmed in field as the event unfolds by emergency personnel. The limitations of data which has not been quality controlled should be understood before being applied to other purposes such as modelling.

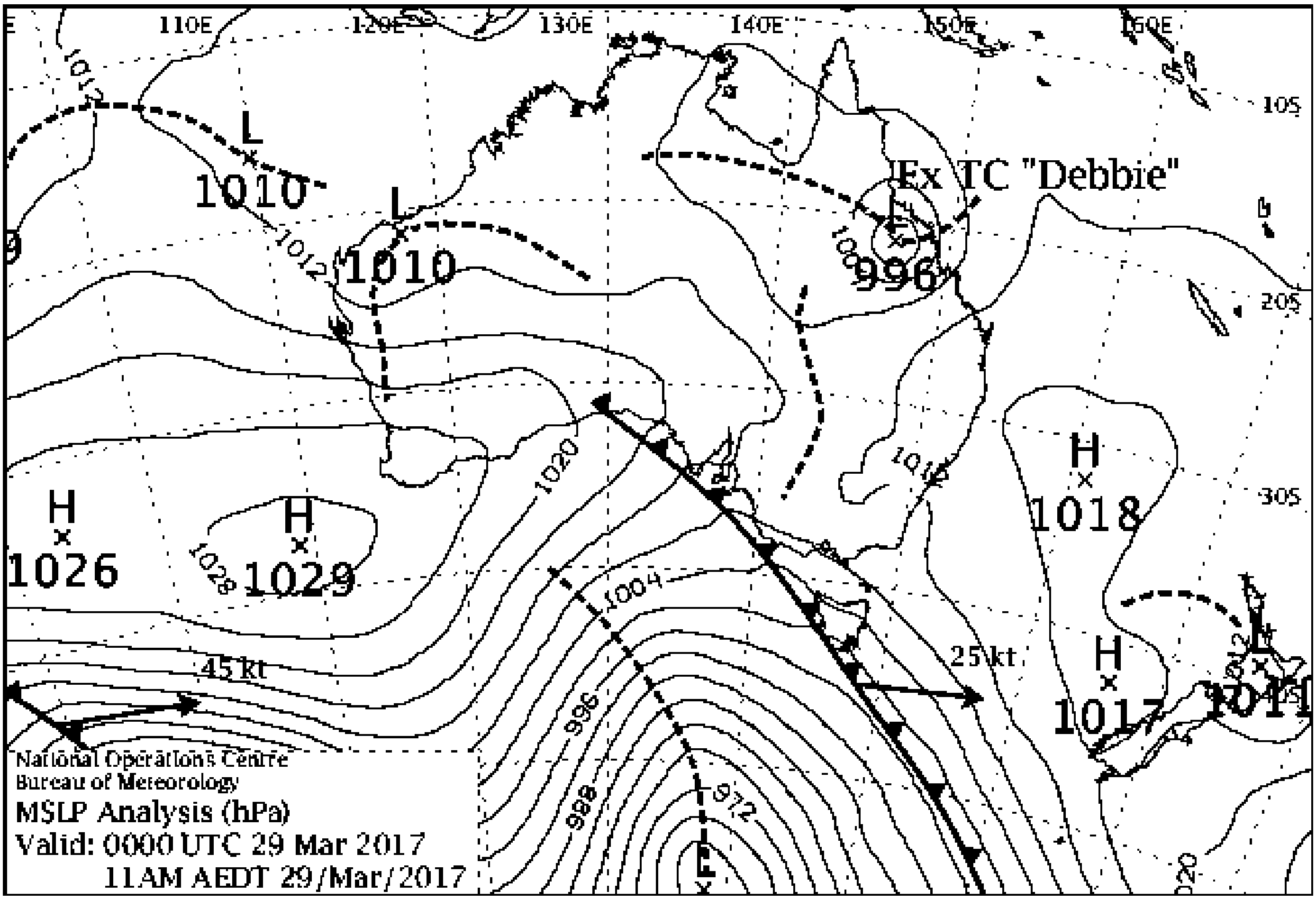
This paper identifies examples from the March 2017 Cyclone Debbie where the raw data was corrected for issues associated with an extreme flooding event. The magnitude of level adjustments can be significant, in the order of ±0.100 metres to more than 3 metres.

MHL applies a process of quality control and quality coding to its flood, estuary, ocean tide and rainfall monitoring stations that expresses the factors including uncertainty of the collected data. Understanding the differences between quality controlled and raw data during extreme events is critical to inform users of water data. The cost of getting data wrong can be substantial.

The event

On the morning of 25 March 2017, a low pressure system off the Queensland coast developed into a tropical cyclone and was given the name "Debbie", making landfall on the 28 March 2017 (refer to *Figure 1* for mean sea level pressure and radar images for 29 March 2017). Cyclone Debbie moved south across the NSW border by 30 March 2017, causing widespread rainfall and flooding to the far north coast of NSW including the Tweed, Lismore, Byron, Richmond Valley, Kyogle and Ballina local government areas (BoM, 2017). Almost five hundred SES flood rescues were carried out (ABC, 2017) and in NSW six people lost their lives because of the flooding (SBS, 2017). During this time, flood peaks observed at North Murwillumbah (AWRC No: 20120) was the highest in the 25 years of continuous digital record and Tumbulgum (201432) highest in the 32 years of continuous digital record. Refer to Figure 2 for a photograph taken downstream of Tumbulgum station on 31 March 2017 that depicts widespread flooding.

In support of NSW emergency services, MHL deployed a field team to the flood affected area to assess the status of the equipment and to collect field measurements for verification purposes. Access to many of the automatic water level monitoring stations was limited during this time due to inundation of roadways. Once the floodwaters had begun receding and access restored, the MHL team was able to complete a limited number of flood status checks. In the months following the event, post flood status checks and debris line surveys were undertaken to estimate the extent of the flooding.



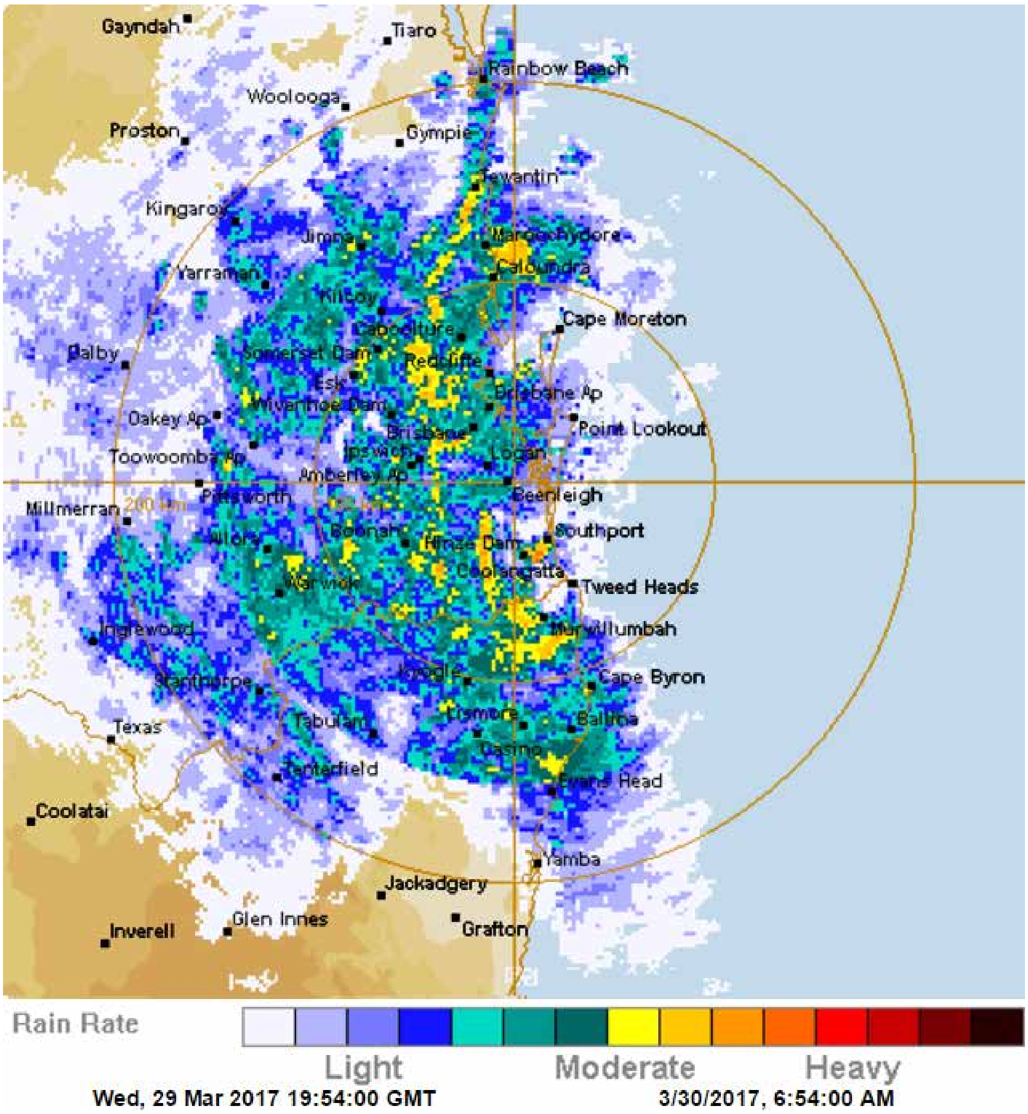


Figure 1. Mean sea level pressure and radar images on 29 March 2017 and 30 March 2017 respectively (images courtesy of BoM).

Figure 2. Tweed River downstream of Tumbulgum 1.59 pm 31 March 2017 3.31 m AHD.

Organisations collecting data during the event

Near real time raw data from various agencies was published on the Bureau of Meteorology's (BoM) website during the March 2017 event. A NSW north coast flood summary report (post event) was commissioned by OEH and the catchments that are the focus of the flood summary report include Tweed, Brunswick, Richmond and Wilsons River (MHL, 2017). Within these catchments the agencies that collect hydrological data of interest included:

- OEH
- BoM
- WaterNSW
- Tweed Shire Council
- Byron Shire Council
- North Byron Parklands
- Lismore City Council
- Rous County Council
- Ballina Shire Council

The number of station types within the catchments identified is shown in Table 1.

Table 1. Station type

Station type	No of stations
Water level	69
Rainfall	76
Wave	1

Dissemination of data

The first of many formal public requests received by MHL for flood data came on 9 April 2017. This came a day after the flood influence had diminished to where water level appeared to have returned to a regular tidal trace. The demand for data collected during the flood event occurs before the data quality control measures can be implemented. Quality control is undertaken by confirming or adjusting to field observer readings. At the time of the event, only raw or "un-coded" data of unknown accuracy could be provided until field visits for the NSW northern coastal region could be undertaken. At this stage, the only verification which can be done are comparisons with raw data from nearby stations and the long term operational history of the station. Generally, the target uncertainty for quality controlled data for water level stations maintained by MHL is "fair" data at ±0.020 m. Even with these caveats raw data is accepted by third parties, and in some cases used for secondary analysis and modelling (BMT WBM, 2018).

The quality assurance process

Following the completion of onsite verification readings, the data undergoes a quality control process. The purpose of the field measurements taken post-flood is to relate the actual conditions at each location. The flood peak should be in the order of the flood debris marks created by the floodwaters. Sensors should be factory calibrated before initial deployment and field calibration should occur every two years against a range of water levels far in excess of maximum flood heights. During and post flood statuses provide for a reliable verification of their performances during flooding. Comparisons between locations on the same river system are also used to compare the shape and height of the flood hydrograph.

Example extreme event differences between raw and quality controlled data

The majority of water level and rainfall stations performed well during the Cyclone Debbie event (94% overall average data capture across all organisations (MHL, 2017)). However, the following examples illustrate that during extreme events, raw data can be impacted by a number of factors including technology limitations, station and site environs damage and localised hydraulic affects.

North Murwillumbah water level station

The North Murwillumbah water level station is positioned downstream of Murwillumbah Bridge on the Tweed River at Murwillumbah on the northern bank. Prior to the cyclone Debbie event this station had suffered from scouring of the bank. A full inspection of the sensor could not be performed at the time as it required a dive team due to the steepness of the bank.

Following the event, another inspection was undertaken and found that the difference between recorded and actual level had increased to 0.175 m. This was confirmed with a comparison to the nearby Murwillumbah Bridge station during the rising limb of the flood event. Once the flood waters reached the bridge deck, the bridge acted as a barrier between the two stations, which meant that comparison between the two stations was no longer possible. *Figure 3* show the raw data as the red trace and the quality controlled data as the blue trace, the false increase in the flood peak of the raw data is due to bank scour causing the orifice to drop in the water column. This station was removed from web viewing during the flood event and this was communicated to BoM.

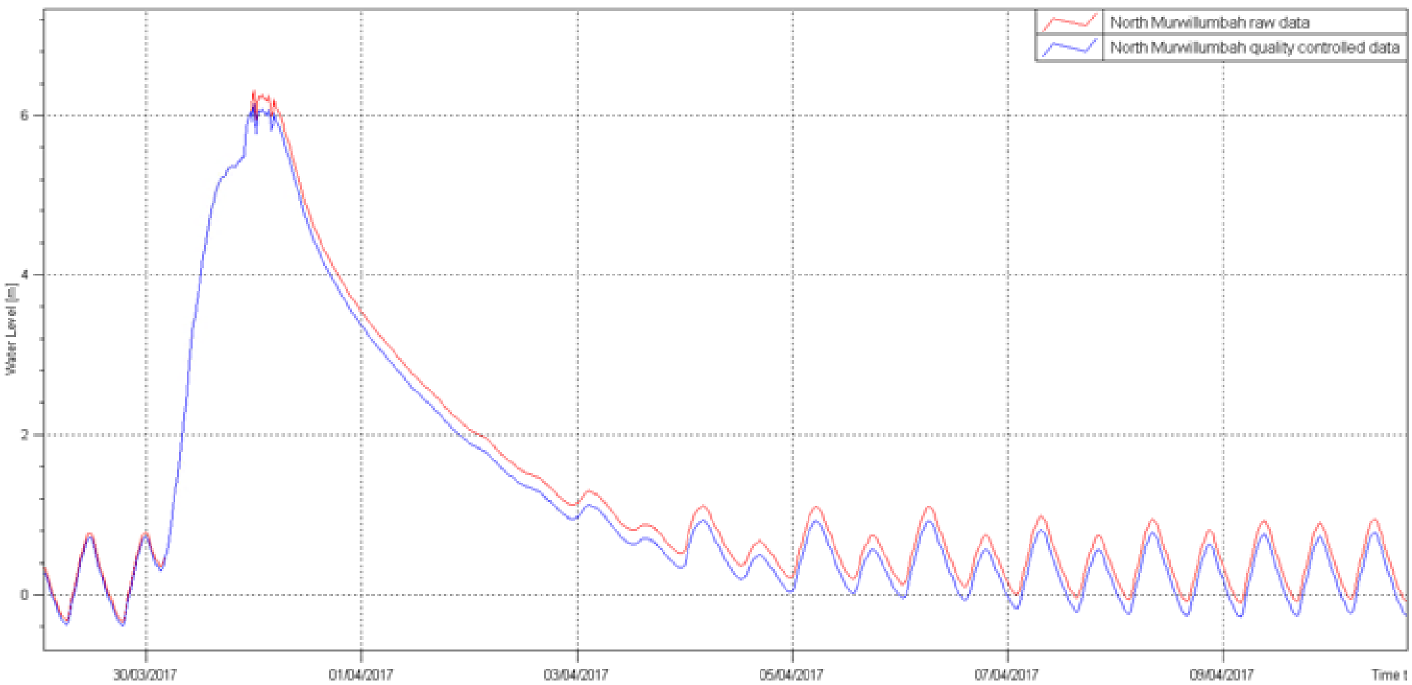


Figure 3. North Murwillumbah—suspect flood peak due to bank scour causing the orifice to drop in the water column.

Letitia 2A water level station

During the peak of the flood, level data from the primary submersible pressure transducer at Letitia 2A appeared suspect. Compared with the Tweed Entrance South ocean tide station, the water level was less uniform and significantly lower than it should be. The secondary floatwell water level sensor at this station, which is reliable when the water level is above 0.5 m AHD, provided more accurate data during the peak of the flood (*Figure 4*). The difference between the raw and quality controlled flood peak is 0.190 m.

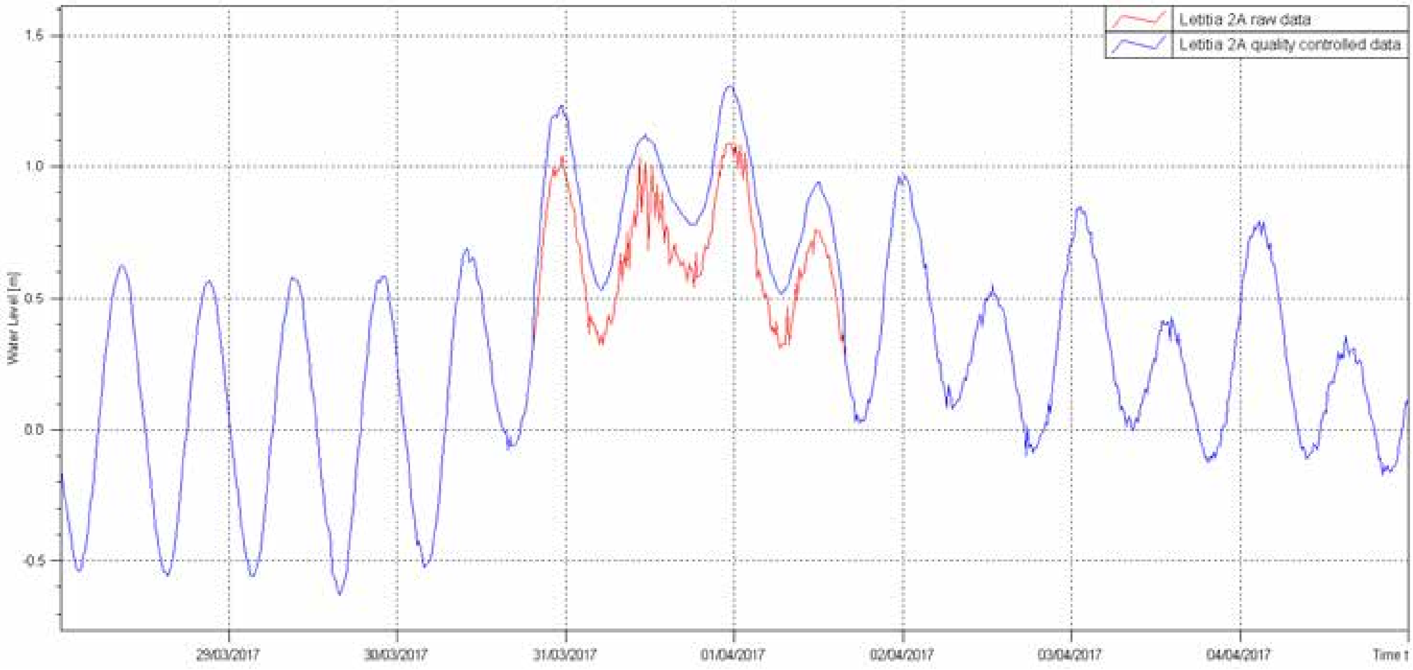


Figure 4. Letitia 2A—flood peak data from secondary floatwell sensor was more reliable during the event and replaced the primary submersible pressure transducer data.

Dry Dock water level station

An issue with the floatwell causing a significant step in the water level data was identified prior to the flood event. This fault was identified in the shaft encoder which required repair of the internal components. The suspect period was replaced with data from the backup submersible pressure transducer (*Figure 5*). The issue with the shaft encoder was resolved at the next maintenance visit.

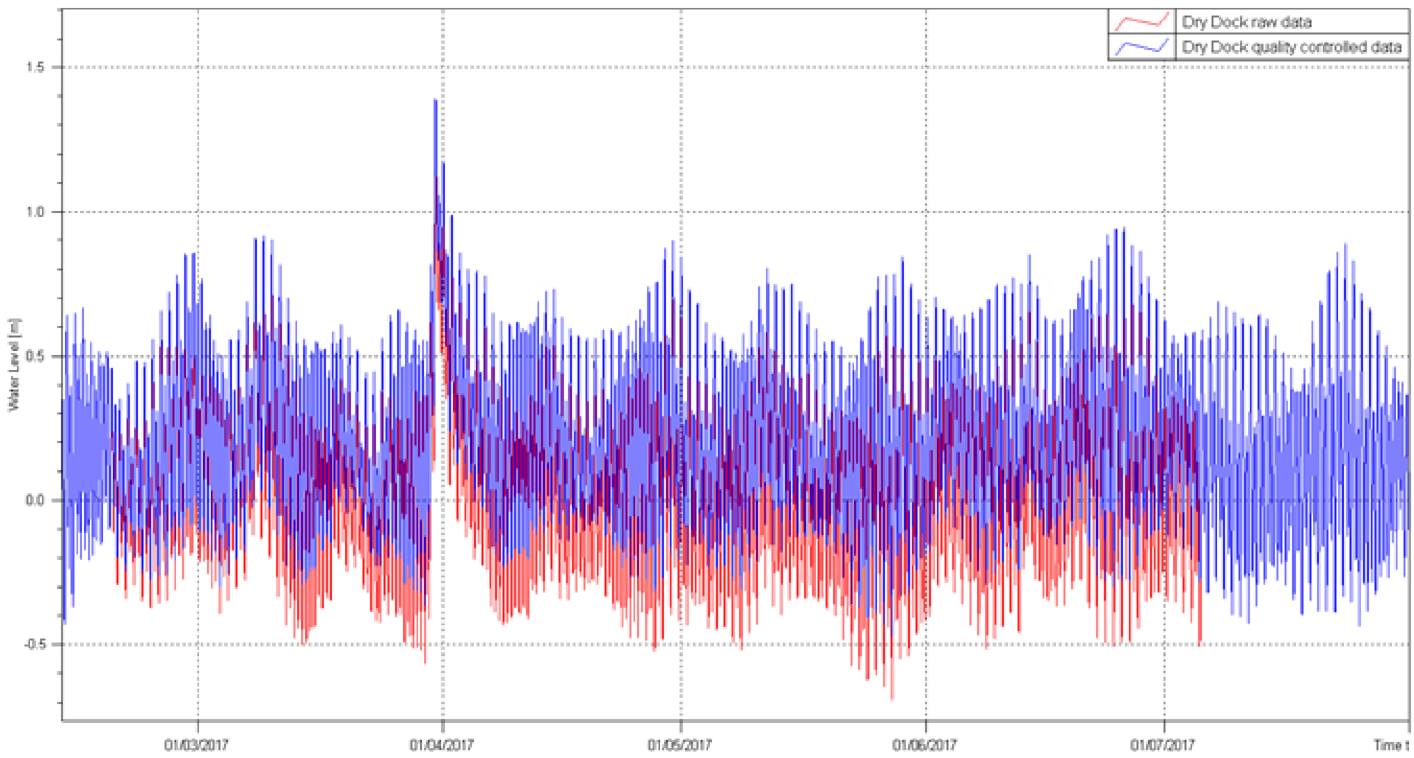


Figure 5. Dry Dock—issue with the shaft encoder occurred prior to the flood event. Backup submersible pressure transducer data has been used.

Kynnumboon water level station

The flood peak exceeded the false echo suppression zone of the radar water level station located at Kynnumboon causing a sudden drop off in the water level. An inspection of the station following the event identified flood debris marks indicating the floodwaters reach 5.24 m AHD on the downstream side of the bridge with no marks on the upstream side where the station is positioned. This observation indicated that, during the flood peak, floodwaters were held back by the bridge structure restricting the peak on the downstream side. Therefore, the debris line survey could not be used as a firm indicator of the flood peak. The suspect data is corrected with an offset of 1.66 m and removal of spikes in the data and then confirmed by comparison with the flood behaviour at stations downstream of Kynnumboon (*Figure 6*).

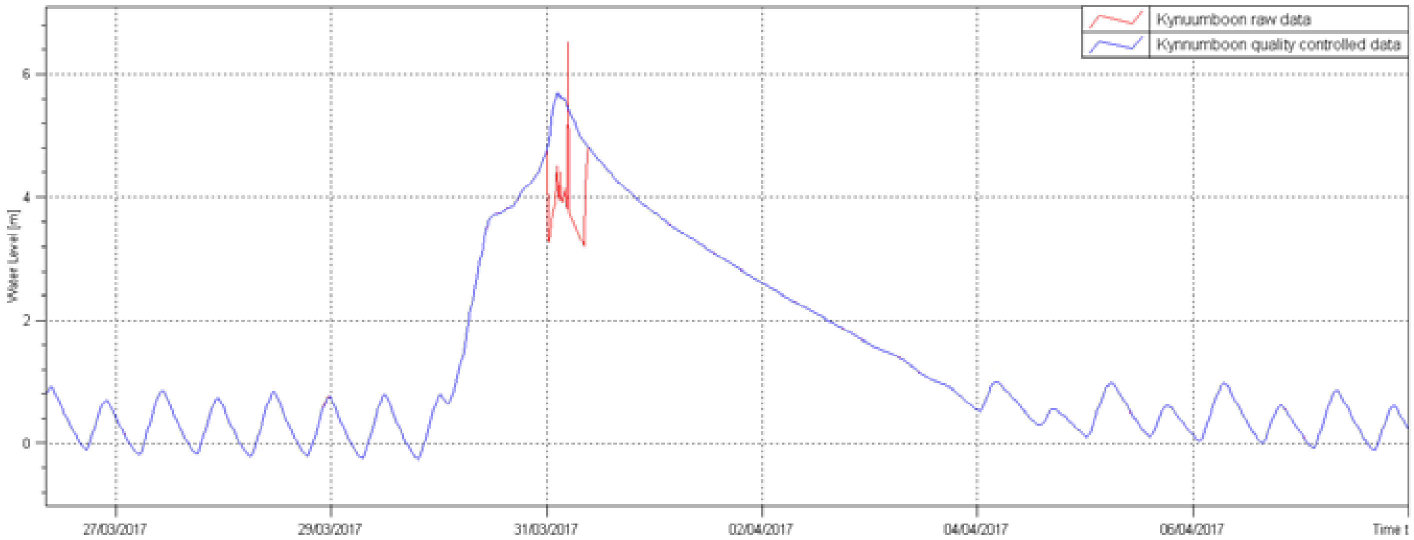


Figure 6. Kynnumboon—floodwaters exceeded the false echo suppression zone the radar.

Mullumbimby water level station

During status readings at Mullumbimby the logged values were shown to out by varying amounts over an 8-month period. At first, these differences can be mistaken for drift and thought to be resolved by linear transformation but once status checks were performed over the full tidal range, a lag in the tidal phasing and suppression of the tidal amplitude was identified. The lag was caused by a restriction of flow between the floatwell and the river due to a blockage in the floatwell feeder pipe that was caused by silt deposited during the March 2017 flood event. A tidal prediction was calculated for Mullumbimby with the difference between the tidal prediction and the raw data showing that the uncertainty on average was 0.250 m and in some isolated cases was over one metre difference. *Figure 7* shows the tidal prediction as the aqua trace, the raw data as the red trace and the crosses indicate observer readings. Once the feeder pipe was cleared on 20 December 2017 there is marked improvement in correlation between the raw data and the observer readings. The data affected by the blockage was removed from the quality controlled data set as it does not represent the actual conditions within an acceptable range (*Figure 8*).

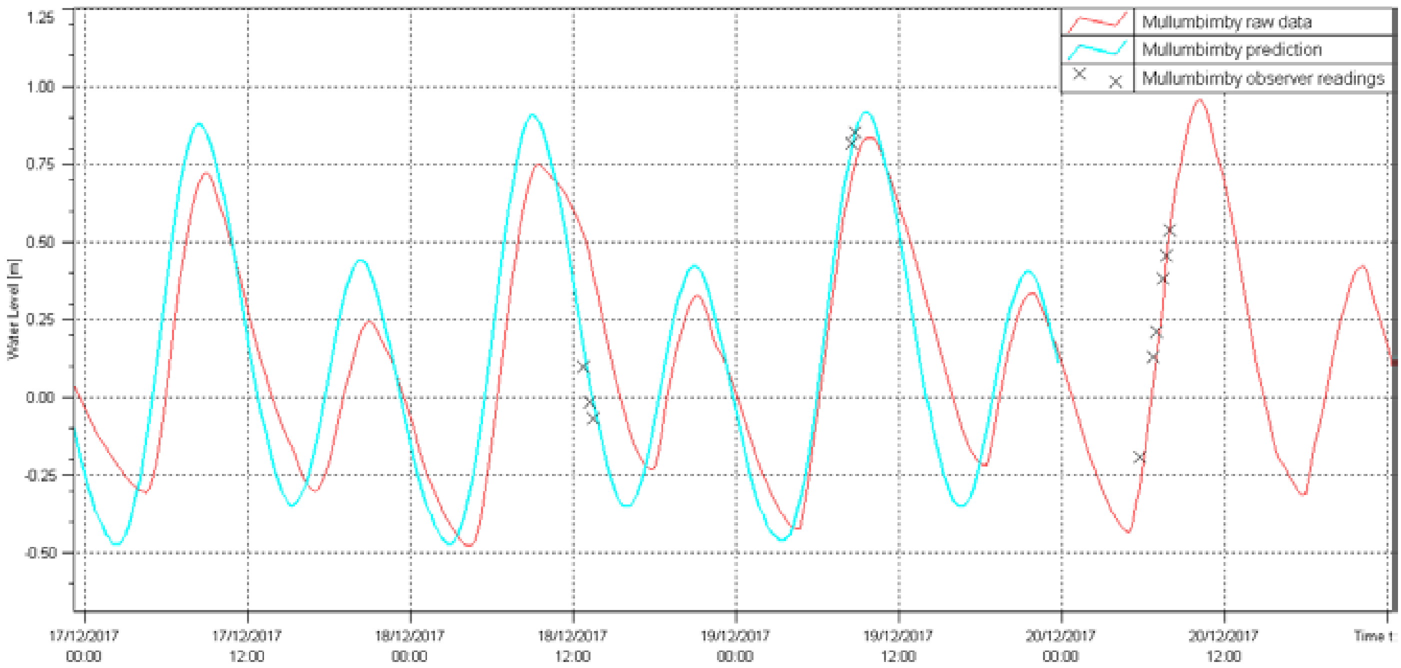


Figure 7. Mullumbimby—tidal prediction vs raw data with observer readings over plotted.

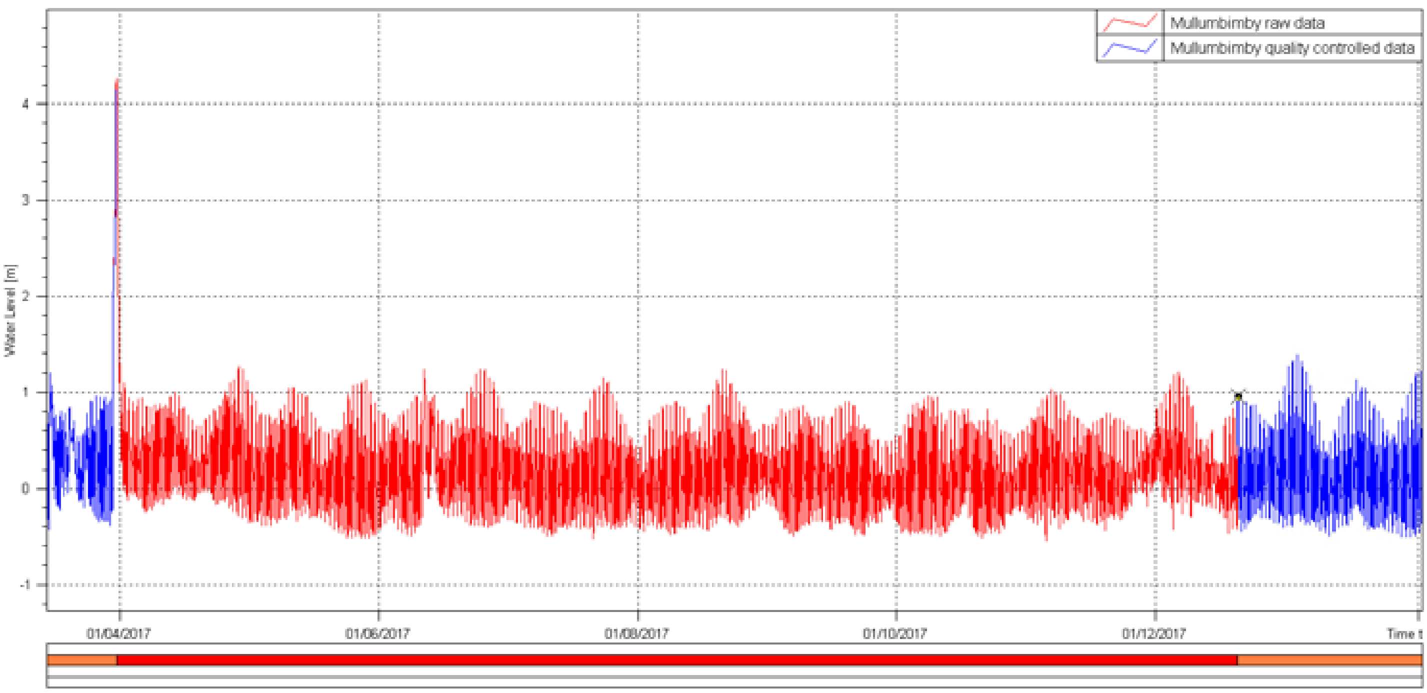


Figure 8. Mullumbimby—data was removed from the quality controlled data set.

Rocky Mouth Creek water level station

In the two weeks prior to the March 2017 event, a 0.110 m step in the submersible pressure transducer data was identified at the Rocky Mouth Creek station. This was corrected once a post flood station inspection observer reading was taken in June 2017 (*Figure 9*).

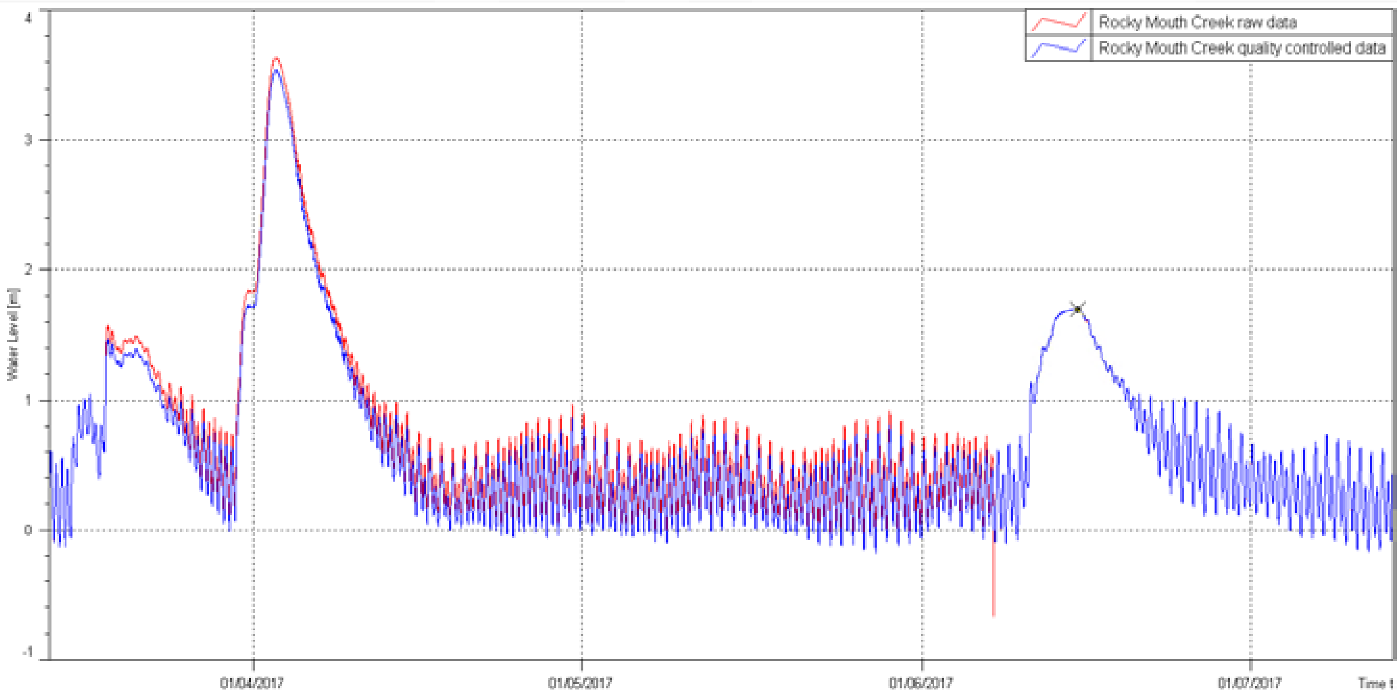


Figure 9. Rocky Mouth Creek—data collected from the submersible pressure transducer was offset by -0.110 m.

Woodlawn College water level station

The Woodlawn College station sensor is a dry (compressed gas) pressure transducer. During the flood peak, the gas pressure which the sensor was set to could not keep up with the rising water level. The flood peak was not captured as a result. The flood peak was later interpolated by comparison with the shape of the flood hydrograph identified from the downstream East Gundurimba station and a single peak water level observer reading was derived from a debris line survey (*Figure 10*). The difference between the raw and quality controlled flood peak is 3.9 m, which is a very significant difference. *Figure 11* is a photographed example of a debris line mark at Wilsons River that can be surveyed to verify flood peaks.

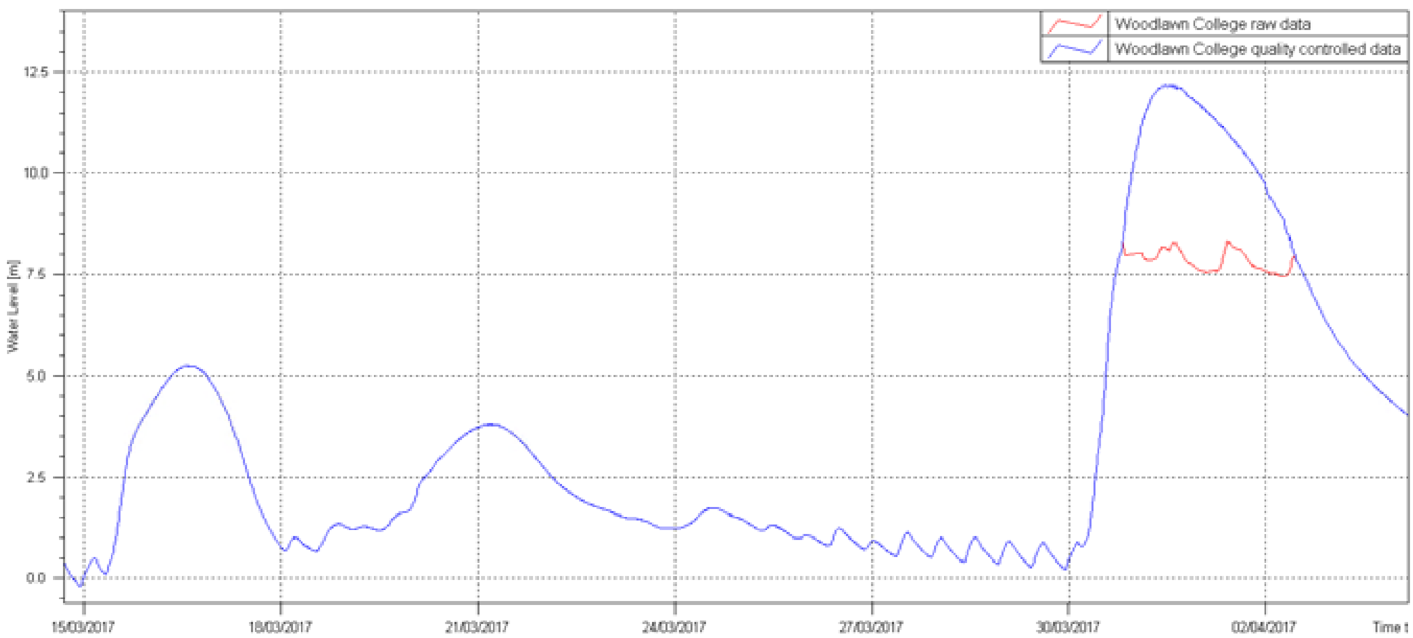


Figure 10. Woodlawn College—the red trace depicts the raw data and the blue trace is post quality control. The difference between the raw and quality controlled flood peak is 3.9 m.

Figure 11. Wilsons River, Winterton Parade North Lismore 12.39 pm 4 April 2017 debris line on bridge.

Modelling – the challenges

Henonin *et al*. (2013) describes the hydrological data input to a flood model as the foundation, and that even a well-designed house (the model) must lie on good foundations (data inputs). The quality of rainfall and water level inputs is a major issue to consider in the development of flood models and in assessing the outputs.

Raw water level and rainfall data from multiple sources were used to facilitate the quick commencement of an event based model for the NSW north coast. Allowances were required for issues associated with different data sources including: different datums between stations; the change from daylight saving time to eastern standard time during the flood study period; and, the lack of guidance on which organisation's data is more reliable and accurate to use when there is an overlap of stations in a locality (BMT WBM 2018a and 2018b, personal communication, 7 September 2018).

There can be political and public pressure for modelling to be undertaken quickly and action taken based on these results following a severe flood event where there have been damage and community impacts. Time constraint is a major factor as to whether raw or quality-controlled data is used in flood modelling and can cause modellers to undertake their own quality control based on limited information. The organisation collecting the data is best placed to undertake quality control and coding of data. In the case of the Cyclone Debbie event modelling; the data quality control activities were occurring in parallel with model event confirmation activities. The previous examples of post event data correction and coding illustrates the need for modellers to recognise the limitations of raw data in model development, be prepared for model modification as raw data is quality controlled, and ensure users of model outputs also understand the limitations of model development based on raw extreme event data.

Conclusion

Near-real time "raw" data will continue to be critical for flood warning and emergency operations during a flood event. There can be significant differences between raw data and the true water level values experienced during a flood event. The quality control process identifies, and in some cases, corrects the data to represent the actual flood values.

There needs to be recognition that the quality control process after an event takes time when balancing the need to demonstrate action by all layers of government soon after a flood event that has caused significant destruction and loss of life. Ideally, data shall be quality coded when provided to modellers so that the uncertainty associated with every data point is clearly defined within a finite range so that the uncertainty can be translated into the next stage of the model use.

Acknowledgements

Thank you to Ben Caddis of BMT WBM and Martin Rose of NSW Office of Environment and Heritage for sharing their experiences of the modelling phase of the March 2017 NSW north coast flood event.

References

ABC (2017). *Cyclone Debbie: SES volunteers quit in disgust after vile abuse and assaults.* Australian Broadcasting Corporation. http://www.abc.net.au/news/2017-08-07/ses-volunteers-quitting-after-abuse/8780198 accessed 4 June 2018.

BMT WBM (2018a). *Post Event Flood Behaviour Analysis and Review of Flood Intelligence – Lismore Final Report,* BMT WBM.

BMT WBM (2018b). *Post Event Flood Behaviour Analysis and Review of Flood Intelligence – Tweed River Final Report*, BMT WBM.

BoM (2017). Tropical Cyclone Debbie. Bureau of Meteorology. http://www.bom.gov.au/cyclone/history/debbie17.shtml accessed 31 August 2018.

Hénonin, J., Russo, B., Mark, O. and Gourbesville, P. (2013). *Real-time urban flood forecasting and modelling — A state of the art*. Journal of Hydroinformatics. pp 717 – 736.

MHL (2017). *OEH NSW North Coast Flood Summary March 2017*, Manly Hydraulics Laboratory, Report No. 2535 ISBN 978-0-646-97085-1.

SBS (2017). *Cyclone Debbie: The overall cost*. Special Broadcasting Service. https://www.sbs.com.au/news/cyclone-debbie-the-overall-cost accessed 4 June 2018.


EnvironMine
Data Services
Environmental Monitoring Specialists
Providing an environmental monitoring service to mining, industry, & government sectors.
Surface Water
Ground Water
Soil
Contaminated Waste
Data Management
Data Reporting
Water Quality
Water Level & Flow
Air Quality
Weather
Dust
SAMPLING | AUTOMATIC MONITORING | DATA MANAGEMENT
Gladstone - (07) 4973 7296 - Mobile 0448 666 487
www.environmine.com.au

Stormwater Pond Surveying: Why Probe When You Can Ping

Jennifer Leslie, Pattle Delamore Partners, Auckland, New Zealand, H Easton, Pattle Delamore Partners, Auckland, New Zealand, S Speed, Auckland Council, Auckland, New Zealand.

Paper presented to 19th Australian Hydrographers Association Conference Canberra. 12-15 November 2018.

Abstract

A new method of surveying stormwater ponds is saving time, increasing data quality and reducing health and safety risks. It involves a remotely-controlled Oceanscience Q-Boat 1800D (Q-Boat) deployed with a SonTek HydroSurveyor M9 Acoustic Doppler Current Profiler (ADCP) collecting accurate bathymetric and position data, which can be used for multiple applications.

Auckland Council manages nearly 500 stormwater ponds across the Auckland region, so stormwater pond maintenance works present a significant cost. To prioritise pond maintenance, Pattle Delamore Partners (PDP) and Auckland Council are using this new methodology to calculate sediment accumulation volumes, by comparing the ADCP bathymetry results to the as-built drawings of the ponds. This information is used to determine whether the stormwater pond is functioning efficiently, whether dredging maintenance is required and where the greatest deposition of sediment is occurring within the pond. Having an estimate of the sediment volume that requires removal, can also assist with obtaining an indication of dredging costs.

There are numerous advantages that the Q-Boat and ADCP methodology has over the traditional manual probe surveying method including faster data collection, greater data accuracy and reduced health and safety risks. In addition, comparative evidence between the two methods suggests that the manual probe surveying method may actually be compromising the integrity of the ponds.

The field techniques used to collect and process the data will be detailed and the potential uses of the data outputs explored. The benefits and shortfalls of this new method compared to the traditional manual probe surveying method will be evaluated, using examples. Case studies of other projects where the new methodology has been applied will be presented, including a bathymetric survey of an estuary and a marine port.

Introduction

Auckland Council currently own 487 stormwater treatment ponds within the Auckland region, made up of 342 wet ponds/wetlands and 145 dry ponds (Auckland Council, 2014). Approximately every 20 to 30 years, stormwater treatment ponds require major renewal works; normally to remove sediment captured as part of their water treating function.

To prioritise ponds that are nearing remedial works, Auckland Council requires bathymetric surveys to be undertaken to assess the volume of sediment accumulated. The method that has been used by Auckland Council to obtain this information in the past is the manual probe method.

A new methodology using an ADCP mounted within a Q-Boat was proposed by Pattle Delamore Partners (PDP) and trialled as part of this project. The method had previously been used successfully by PDP in 2015.

The ADCP works by transmitting "pings" of sound at a constant known frequency into the water, which are reflected back by particles in the water column. The ADCP uses the return signal to calculate the depth of the pond. The depth profile of the pond is then plotted and compared to as-built bathymetry to calculate the volume of sediment that has accumulated.

The trial of the methodology was successful and the method is currently being used to carry out further stormwater pond surveys for Auckland Council. The field techniques used to collect and process the data will be detailed and the potential uses and applications of the data explored. The benefits, and shortfalls of this new method compared to the traditional manual probe surveying method will be evaluated.

Two case studies where the new methodology has been applied in different circumstances will be presented, highlighting how it can be a valuable tool in planning for extreme events and designing stormwater devices and catchment models accordingly.

2. Method

2.1 Field Procedure

The field procedure is the highlight of the methodology, as this is where most of the new method's advantages over the alternative methods are realised. The field procedure is efficient, accurate and safer for the field staff operating the equipment. An overview of the steps involved in set-up and data collection are outlined in this section, along with some of the common problems that arise and how they are overcome.

2.1.1 Equipment

The set up required to undertake pond surveys consists of an Oceanscience Q-Boat 1800D (Q-Boat) and remote control, SonTek HydroSurveyor M9 (ADCP) and GPS, as well as a laptop or tablet. Similar equipment from other manufacturers could be substituted based on preference and availability.

The Q-Boat used in this project is a remotely-operated electric boat designed to make safe, unmanned bathymetric measurements with an ADCP (Oceanscience, 2011). It can be customised with different types of environmental equipment, depending on the intended monitoring purpose.

The ADCP is a system designed to collect bathymetric, water column velocity profile and acoustic bottom tracking data as part of a hydrographic survey. The two key components of the system are the HydroSurveyor Acoustic Doppler Profiler platform, and the data collection software called "HydroSurveyor" (SonTek, 2012). The ADCP is used to measure bathymetry in this methodology. A GPS is also attached to the Q-Boat and connected wirelessly to the laptop, allowing the location of each measurement to be recorded.

2.1.2 Assembly

Once arriving on site, set up is relatively quick. The best place to park and the best point to launch the boat is scoped on foot. This is usually provided by maintenance access ways which are pathways built into pond designs to allow machinery to access the pond for dredging.

The Q-Boat is assembled near the launch point into the pond. This requires attaching the propellers to the rear of the boat, connecting and strapping in the batteries, positioning the ADCP into the holder in the centre of the boat and connecting the cables to the Program Control Module (PCM), radio and GPS. Once set up, the boat can be heavy to lift and requires two people to carry it. *Figure 1* below shows the assembled and deployed Q-Boat.

Figure 1: Q-Boat set up and ready to survey.

2.1.3 Calibration and Connection

Calibration of the compass is carried out at each pond using RiverSurveyor software on the laptop or tablet. This should be done away from any magnetic interference such as a bridge or steel posts (Mueller, 2012). Two 360-degree rotations of the boat are made, while simulating the pitch and roll of the boat that is expected while surveying the pond.

Once the compass calibration has been passed, HydroSurveyor software is used to undertake the survey of the pond. A new project is created for each new pond surveyed and the survey area added onto the appropriate point on the map. The first time a survey is carried out, the appropriate measurements and offsets in relation to a Central Reference Point (CRP) need to be entered to ensure the correct boat set up is provided to HydroSurveyor. However, for subsequent surveys, previous surveys can be used as a template to save time.

Both the ADCP and GPS must be connected to HydroSurveyor before surveying can commence and remain so during the survey.

2.1.4 Collecting Data

The boat is then lifted and placed into the water near the edge of the pond. The remote control is turned on, the lid of the boat is opened and the ignition turned on. The Q-Boat propellers are now operational.

In HydroSurveyor, data collection is started, and the boat is driven around the pond using the remote control. On the laptop, the path the boat has taken will be shown, alongside the depth soundings and the interpolated bathymetry. Although the boat can travel at speeds of up to 1.8 m/s, driving the boat at full speed is not ideal while surveying. A sounding is obtained every second, therefore the quicker the boat is driven, the less data is collected.

A methodical path should be taken to cover the pond, starting with the perimeter of the pond, and then filling in the centre with vertical and horizontal lines. Post survey data processing will interpolate between the points and fill in any gaps that were not surveyed, so it is not essential to cover the entire pond surface. An example of acceptable coverage of a pond is shown in *Figure 2* below. The blue lines represent the Q-Boat path.

Figure 2: Q-Boat track during a stormwater pond survey, showing the coverage required to achieve a good bathymetric profile.

Along with the ADCP survey, pond water level measurements are taken at the time of surveying. This is important because depth measurements are taken relative to the water level, as that is the height at which the boat sits. Pond inlets or outlets provide the best reference points to measure water level against, as they tend to remain constant and elevation details are often available for them on the as-built drawings. ADCP pond surveying is best carried out during fine weather, when water levels are stable.

2.1.5 Field Troubleshooting

The most common issues faced during the field procedure include being unable to connect to devices, batteries running low and propellers getting clogged.

There can be difficulty in getting the laptop to recognise and connect with different devices. This can be resolved by double checking the settings and cable connections.

There is a range limit between the devices and the laptop of 200 m; however, this is rarely exceeded as most ponds are not large enough. If the connection between the boat and the laptop is impaired the overall boat status will flash red, instead of green, on the laptop. To overcome this, the person operating the laptop needs to move along the pond bank nearer to the boat until the status lights flash green.

As all components of the equipment set up rely on battery power, there can be issues with power consumption when surveying several ponds in one day. Spare batteries and/or chargers should be taken into the field to avoid data loss mid survey.

Ponds can have surface weed which gets tangled in the propeller as the boat drives over it. *Figure 3* below shows a propeller clogged with pond weed. After turning off the Q-Boat ignition the weed can be untangled from the propellers using a screwdriver or scissors. Continuing to operate the boat while the propeller is clogged can put strain on the Q-Boat motor and cause the batteries to overheat.

Figure 3: Q-Boat propeller clogged with weed.

Ponds that contain extensive weed are not considered suitable for the ADCP methodology. The propellers would become clogged very quickly in the example shown in *Figure 4*. Given the size of some ponds, untangling and re-deploying each time the propeller become clogged would not be feasible. The density of weed growth beneath the surface can also cause sound waves to be blocked, resulting in spikes in the depth measurements. For pond such as the one below, the ADCP method is not recommended and a manual survey should be carried out.

Figure 4: Auckland stormwater pond with extensive weed growth.

2.1.6 Data Processing

The data is processed using Surfer software. The data is exported from HydroSurveyor as an Excel file containing X, Y and Z coordinates. The X and Y being the Eastings and Northings from the GPS and Z the elevation in metres from the water level to the base of the pond, as measured by the ADCP.

The Z coordinates are converted to Reduced Level (RL) using the recorded inlet and outlet water level measurements, if the as-built drawings supplied for the pond contain the Reduced Levels (RL's) of the inlets and outlets.

The survey data is plotted in Surfer and various calculations performed. If the aim is to calculate sediment accumulation since the last as-built was produced, the as-built will be digitised and plotted in Surfer. The two layers (both now in RL) can then be compared, to identify areas of cut and fill and produce an overall volume of sediment accumulation or erosion.

Pre and post dredging surveys are only comparable if the water levels were recorded for each survey. The volume of sediment removed is calculated by subtracting the post dredging surveys from the pre-dredging surveys.

3. Discussion

3.1 Applications of Data

The bathymetry data is applied in several different ways. The most common use of the data is to calculate the quantity and location of sediment deposition since an as-built was last produced (i.e. when the pond was built or last maintained). This is useful in assessing the function and performance of a pond, to determine whether redesign is required.

The other way data is commonly used is for pre and post dredging surveys, to establish the quantity of sediment removed.

There are many other uses of bathymetry data collected using this method in stormwater ponds, such as calculating treatment volumes, providing information about a pond where no as-built is available and assessing pond function and performance for redesign purposes. The methodology can also be applied to features other than stormwater ponds (refer to Section 3.4 Case Study 1).

3.2 Utilisation by Auckland Council

The Auckland Council has and continues to utilise the data collected in several ways. The main aim at the start of the project was to create a priority list of ponds urgently requiring maintenance. Due to the number of stormwater ponds in Auckland, it is critical to understand which ponds need to be prioritised verses those that do not require maintenance. By using the ADCP method over the manual probe method, Auckland Council can more efficiently obtain accurate data about the state of their assets.

Calculating the amount of sediment that has accumulated since a pond was last maintained is useful in determining how well the pond is functioning. If a pond was recently maintained but has high sediment build up, then consideration can be given to the pond design.

Auckland Council is also using sediment accumulation volumes to estimate the expected cost of pond dredging, as the cost of this is based on the volume of sediment that will be removed. The survey can also be used for audit purposes, as the difference between the pre and post dredging surveys can be compared to the volume of sediment the contractor has invoiced as having removed.

3.3 Comparison to Manual Probe Method

The most commonly used alternative method to measure sediment build up in ponds in New Zealand is the manual probing method. There are variations of this; however the basic principle is that the operator moves around the pond in a boat or kayak taking manual readings of the depth using a rod or staff at various points. A measurement is taken where the rod first feels resistance, which is assumed to be the top of the sediment layer. The rod is pushed further into the sediment until the base of the pond is reached.

There are several issues with this methodology. Safety of the operators is one of the biggest concerns, as it necessitates a staffed boat or kayak moving around the pond (NZTA, 2010). It is possible for the operator to lose balance while taking depth measurements and fall into the pond. The health and safety risks are elevated in ponds that are very deep in parts, filled with weed and contain thick sediment. In comparison, the Q-Boat and HydroSurveyor methodology does not require the operator to enter the pond at all; all measurements are taken from the safety of the pond bank. The greatest safety risk posed by the ADCP method is that of the moving propellers on the Q-Boat. However, by following the appropriate method, with the ignition of the boat only being turned on once the Q-Boat is in the water, the risk of injury occurring is low.

The accuracy of the manual probe method is also an issue. Sediment build-up readings are inconsistent and unreliable as it is difficult to feel exactly where the top of the sediment begins. Pushing the rod deep into the sediment to determine the base of the pond is an estimate only (NZTA, 2010). Several case studies were carried out during the trial phase of the project, with ponds being surveyed using both methods for comparison. There was a 15-37% difference between the calculated sediment accumulation volumes, with the manual probing method consistently overestimating the sediment volume. This is a significant issue as a dredge operator could be expecting more sediment than what is present, increasing the risk of impairment to the pond lining.

Human error impacts measurements made using the manual probe method. This is because the manual method is based on the amount of pressure that comes from pushing the rod into the sediment. Each person will differ in their judgement, so different pressure will be applied to determine sediment depth. This error is likely the reason why the manual survey overestimated sediment accumulation compared to the ADCP survey methodology.

A further concern with the manual probe method is that it can cause damage to the pond itself. While pushing the survey rod down to reach the base of the pond the operator may push too far and go beyond the as-built level of the pond, causing an overestimation of sediment accumulation and impair the pond lining. Breaching the lining would compromise the integrity of the pond and potentially release contaminated sediment and water into the underlying soil and groundwater aquifers.

The manual probe method is also very slow and time consuming. It is faster to set up than the Q-Boat, however, obtaining data takes significantly more time. The manual method can provide approximately 30 to 60 data points per pond, with coverage of 150 m^2 per data point. The ADCP records around 10,000 data points in a small pond, providing a depth measurement every second (approximately). This equates to around five data points per 1 m^2, providing a more accurate overview of the pond's bathymetry.

The manual probing method does serve a purpose and provides an alternative for ponds where the Q-Boat and HydroSurveyor methodology is not appropriate (i.e. very weedy ponds). It is still considered to be a suitable method of providing an estimate of sediment build up within storm water ponds, however where possible it is recommended that the Q-boat method be used in order to enhance accuracy, improve efficiency and reduce health and safety risks for operators.

3.4 Case Study 1: Drury Creek

To enhance the accuracy of catchment modelling for flood mapping purposes, the methodology was adapted to an estuarine environment. Auckland Council developed a hydraulic model of the Hingaia Stream catchment in South Auckland. The purpose of the model was to support local development, including the upgrade of State Highway 1. However, within the model there were uncertainties around the bottom boundary condition of the catchment. A detailed bathymetric survey of the Drury Creek was used to inform the model and enable a more accurate flood prediction, improving the planning outcomes.

The method was fundamentally the same as that used for stormwater ponds, with only a few adjustments. The survey area was so large that the Q-boat could not be driven from the shore as connection between the remote and the PCM would be lost. Instead, a motorised dinghy was used to transport the two field staff, one driving the dinghy and one operating the Q-boat with the remote control.

Having staff members in the dinghy allowed a Castaway CTD (Conductivity Temperature Depth) unit to be deployed every 15 minutes at various areas of the creek. A Castaway measures conductivity, temperature and depth, at different depths to provide a profile. This information is useful as the presence of saline water within the estuarine environment affects the speed that sound waves travel through water. Thus, to ensure accurate results, CTD data is used to adjust the readings collected from the M9.

Within an estuarine environment the water level is constantly changing, as it is affected by tides. As the M9 takes readings from the surface of the water down, to ensure the depth readings are accurate, any change in water level needs to be accounted for. To enable this, a water level pressure transducer was installed the day prior to surveying at a known elevation and retrieved and downloaded after the survey was completed. As each water level was time stamped this record was able to be used to adjust the data collected from the M9.

Timing of the survey was also important as areas of the reef are exposed at low tide. To ensure the whole area was accurately captured surveying was only carried out two hours either side of high tide.

Auckland Council had an independent surveyor validate the data collected by PDP following the completion of the project. They confirmed the depth elevations in the output were accurate. The information obtained in the survey has been used to strengthen the Hingaia Stream model and allow for more accurate predictions of flood flows and extents.

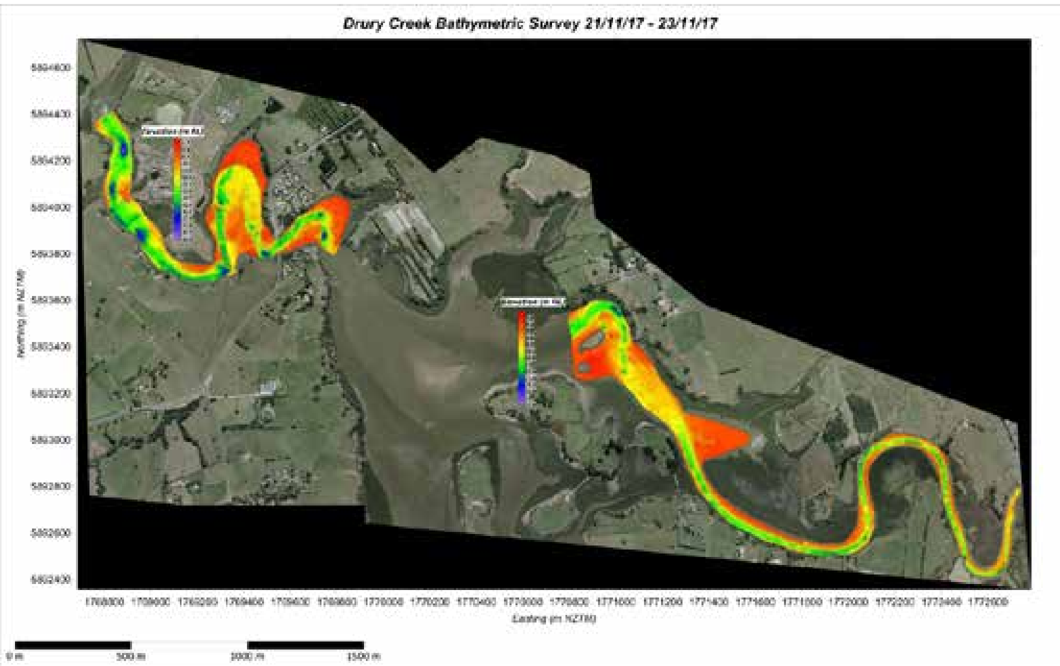


Figure 5: Output of the Drury Creek bathymetric survey.

3.5 Case Study 2: Brigham Street Wharf

A bathymetric survey of an area of sea bed between the North Wharf and Brigham Road in downtown Auckland was requested by Auckland Council. The area was too small and full of obstructions for a larger boat; however, the Q-Boat and M9 method were a perfect fit. The purpose of the survey was to provide detailed measurements of the sea floor to inform the design of a stormwater outfall extension—part of the scheduled infrastructure upgrades to prepare Auckland for hosting the 2021 America's Cup.

The methodology was like that of Drury Creek, with a pressure transducer installed the day prior to surveying, attached to a secure long metal pole attached to the wharf. This allowed for a change in tide during the survey. The Q-Boat was driven by remote control from the wharf edge, while a second staff member was deployed in a kayak to take Castaway measurements allowing the results to be adjusted for changes in salinity.

The weather played a role in this survey thwarting surveying efforts on several occasions, as large swells pose the potential of inaccurate depth data being collected. This was a problem that hadn't arisen previously, due to the lesser effect that wind has on stormwater ponds and estuarine environments. Despite these challenges, the survey was successful and provided a solution in a niche situation, where other more traditional methods were unsuitable.

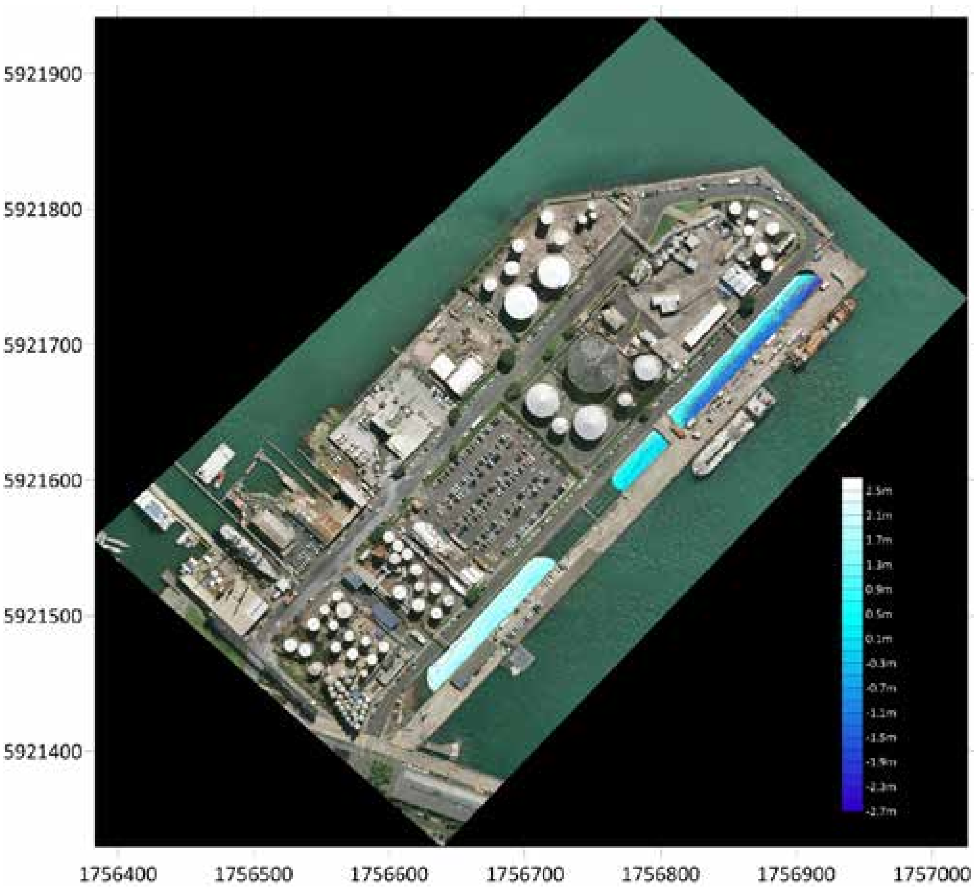


Figure 6: Output of the Brigham Street wharf bathymetric survey.

4. Conclusions

The Q-Boat and ADCP method is proving to be an excellent way to obtain data about stormwater ponds. The manual probing method comes with many limitations and safety risks which are overcome by the new method. Field staff can survey ponds from the safety of the bank and are able to collect more data points with greater accuracy in a reduced amount of time.

The method has provided Auckland Council with valuable information about its stormwater assets, allowing for prioritisation of maintenance works. The method is currently being used by Auckland Council to determine whether maintenance of a pond is required and to calculate the volume of sediment removed, through comparison of pre and post dredging surveys.

The data can potentially be applied to calculate treatment volumes, to provide information about a pond where no as-built drawings are available and to assess pond function and performance for redesign.

Since the methodology was developed, it has been used in other situations such as to inform flood mapping and catchment models in an estuarine environment, as well as providing seabed information for the construction of stormwater infrastructure.

It really does raise the question, why probe when you can ping?

References

Auckland Council Stormwater Department. (2014). *Auckland Council Stormwater Department Strategic Direction*. Auckland Council Internal report.

Mueller, D.S. (2012) *Best Practice for Calibrating SonTek RiverSurveyor M9/S5 Compass*. Online: https://hydroacoustics.usgs.gov/movingboat/pdfs/Best_Practice_for_Calibrating_SonTek_RiverSurveyor.pdf accessed 20 February 2017.

NZTA (2010) *Sediment Accumulation Monitoring Techniques*. Auckland Motorways, New Zealand Transport Agency, NZ.

Oceanscience (2011) *The Oceanscience Group: Q Boat 1800 User Guide*. V2.1.0. Teledyne Oceanscience.

SonTek (2012) *SonTek FAQ Guide: HydroSurveyor System*. Online: http://ysi.actonsoftware.com/acton/attachment/1253/f-00a7/1/-/-/-/-/HydroSurveyor%20FAQs.pdf accessed 21 February 2017.

AUSTRALIAN
HYDROGRAPHERS
ASSOCIATION