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AHA
**AUSTRALIAN
HYDROGRAPHERS
ASSOCIATION**

Material Submitted

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Contents

JACQUIE BELLHOUSE

Editor's Introduction

It has been fairly busy quarter for me, between putting together this issue, seeing the review of Guidelines go out for consultation and a flight over to Melbourne to hear the latest update on the products now available from the Bureau of Meteorology.

Whilst I have been a little under the pump I have also landed back in Perth inspired. After hearing about the range of really great work being done all around our great nation I felt this issue should reflect some of the topics of conversation.

Leading off is Richard Hillhouse's article on skills development for hydrographers, a very topical subject given the recent developments in the delivery of the Diploma of Water Industry Operations (Hydrography) with our business partner TAFE NSW.

I have also included some great articles on the *Water Quality Metadata Guidelines* by Rob De Hayr, the *Application of Acoustic Doppler Technology in Sediment Transport* by Daniel Wagenaar and *Removing Tidal Aliasing in Estuarine Discharge Data* by Justin Stockley.

Each is a brilliant read in four very different hydrographic areas.

A change in direction

As indicated last quarter the AHA has gradually been changing the way it communicates with members.

In our last issue, I indicated how have been working on improving the presentation of the *Australasian Hydrographer*, the AHA journal.

Further to this, as of this issue, we recommenced the tradition of sending out a reminder pre-release of the journal. As a result we are getting a good flow of article ideas in, which you should see published in the coming months.

We now also have a publishing schedule in place to the end of 2019. As a consequence we are now flagging the future publication dates and due dates for articles on the AHA Webpage. See https://aha.net.au/journals/ for further detail.

Please feel free to take note and send me anything you think might be of interest to our members.

Regards
Jacquie Bellhouse
Journal Editor

BILL BARRATT

From the President

United We Stand

I am pleased to advise that the Committee met recently for a day and revised the AHA Governance Plan. It is now available will soon be on the AHA website for those who are interested.

In the past few years we have deliberately focused on creating transparent systems, ease of access for members and defining our way forward.

As a Committee I can report that we stand united in delivering for our members over the coming year.

One aspect that became evident is that collaboration in the non-profit sector is vital.

- INTERNATIONALLY - We seek like-minded organisations and opportunities to offer our services.
- NATIONALLY - We seek like-minded organisations to share resources, information and skills.
- MEMBERS - We seek input to use the experience and knowledge from our members.
- INDUSTRY - We seek input for industry requirements, so that AHA can assist in meeting industry needs.

Our aim is to seek assistance from each of these identified areas. That assistance can come in the form of material, training, advice, mentoring, volunteering and more.

We also aim to be relevant both to members and the sector. So our focus is to develop opportunities, products and services that are needed.

So in the coming months, I hope you see this aspiration turn into reality. As much as we seek to offer, we also look to industry, Government bodies and individuals to contribute to the valuable profession by offering to work together; to add resources to the national resource pool and to be open to collaborating with other bodies.

I have no doubt that, by working together, we can make better use of the skills, knowledge and resources that are sometimes under-utilised.

AHA is committed to working with and on behalf of the sector, and we hope you agree that this approach is the best way forward. If we can help - please ask. If you can contribute - just let us know.

In the end... United We Stand.

Regards
Bill Barratt
AHA President

Skills Development for Hydrographers – a Strategic Approach

Richard Hillhouse, WaterNSW, East Maitland, NSW.
Paper presented to 18th Australian Hydrographers Association Conference Canberra. 24-27 October 2016.

Abstract

Technology and associated techniques have changed significantly in the hydrometric industry throughout our generation. At the same time, there has been a growing expectation that new hydrographers will hold tertiary qualifications. In reality though, a classroom education does little to equip someone with the specific skills needed to be a proficient hydrographer in the 21st century.

Consequently most hydrometric skill development occurs 'on the job'. Whilst this should ensure that training is practical and relevant; there are potential risks that may include a lack of structure, poorly defined goals, potential for incorrect techniques to be passed on and no objective mechanism for measuring success. An unstructured approach, combined with a reliance on experienced hydrographers (who may not necessarily be effective trainers), can result in significant individual or systemic skills gaps.

Over the past 2 years WaterNSW have taken a strategic approach to hydrometric skills development. This paper will outline the inception, development and implementation of a hydrometric skills matrix and a skills assessment process. It will describe the results, as well as the lessons learned and the follow up activities that have been initiated in response to the outcomes.

It is anticipated that this paper will motivate other hydrometric organisations to consider a strategic approach to skills development and allow them the benefit of learning from WaterNSW's experiences.

Motivations

There were three triggers that coincided in late 2014 to initiate the development of the Hydrometric Skills Mapping Process.

Management

In WaterNSW the State Hydrometric Manager has responsibility for almost 60 hydrographers in 14 locations scattered throughout the state. These range from new recruits to veterans of the industry with 4 decades of experience. The State Hydrometric Manager was routinely required to outline the corporate capability to stakeholders, but had little empirical evidence of current skill sets to support his anecdotal claims and presumptions.

External Audit

WaterNSW operates under a certified ISO9001 Quality System which is periodically audited for compliance. To support this the unit has a comprehensive suite of procedures and a register of staff qualifications; however external auditors continued to question the lack of documented evidence showing staff could demonstrate the skills required to perform the tasks as described in the procedures.

Personal Pathway

With nearly 60 hydrographers in the organisation and three grades of seniority/pay, that many hydrographers aspire to progress through, it would seem imperative that the unit has a clearly defined pathway for skill development. Unfortunately, this was not the case, and skill development had been a largely ad hoc process dependent on a number of local variables. It was recognised that there was a need to define the skills that correspond with each grade of hydrographer. The intent that new recruits (and existing staff) could see what learning opportunities were ahead of them and supervisors could structure training around these pathways.

Approach

The initial approach was to develop a competency framework and to review what was already available including:

- Statements contained in the Units of Competency for the Hydrography Diploma.
- The Water Industry Occupation and Competency Framework that had just been released for comment by Government Skills Australia and included levels of hydrography that matched quite neatly with our three grades.
- Our organisation's Position Profiles for the three grades of hydrometric officer.
- Relevant references to training and/or competency in our corporate Operating Procedures.
- A set of competency statements from another hydrometric organisation.

There was a lot of synchronicity between all of these sources, however not much that was pragmatic enough, or specific enough, to address our needs. At this point it was recognised that WaterNSW would be better served by moving away from competencies to focus on skills. Competency can be considered as 'possessing the attributes that allow someone to perform a task well'. Competency can be demonstrated but is not really measureable, making it very difficult to objectively quantify.

Skill, on the other hand, can be defined as 'the ability to do a specific task well'. By focussing on specific skills, there is an opportunity to measure and quantify corporate capacity to perform tasks that clients were paying for. During the research examples were found of other industries creating a 'Skills Map' to report a range of skill sets for a group of workers. Typically the end result was a fairly simple graph or table. A useful outcome was determined to be a system that allowed WaterNSW to:

- See what skills hydrographers did have that were deemed important,
- See what skills hydrographers did not yet have, but which were deemed important, and
- Build a picture (map) of skills from which systemic deficiencies, regional differences or other trends could be recognised so that training resources could be applied strategically to generate the best return on investment.

With a clear picture in mind of a useful end point (**Skills Map**); it was simply a case of working backwards to develop a mechanism for measuring specific skills (**Skills Assessments**) and further back, to clearly define those specific skills that would be applicable for each grade of hydrographer (**Skills Matrix**).

Skills Matrix

Surprisingly, developing the Skills Matrix was perhaps the most difficult part of the process. It was not to be a stocktake of all the skills contained within our organisation, but rather a set of core target skills for each grade. There is not an expectation that hydrographers will be able to demonstrate all skills applicable to their grade at the time of assessment, but rather an expectation that all hydrographers will develop those skills in time and this is the responsibility of their supervisor/manager.

It was difficult because each defined skill needed to be objectively measureable. There are a large number of skills utilised in hydrography that are not easily measured, or that would require subjective assessment. For example, it would not be possible to objectively and repeatedly measure whether staff could demonstrate a skill that was defined as: "select a good gauging section". Firstly because the determination of what is 'good' is subjective; and secondly

because during a site visit to assess the hydrographer, the available sections might be either all 'good' or all 'not good'; in which case the selection of a 'good' section cannot be demonstrated in a way that could be compared with other candidates that are assessed at different sites.

Consequently an initial very long list was gradually reduced to 63 core skills in four categories – surveying, data processing, gauging and ratings. Some skills apply universally to hydrography and some relate specifically to the equipment and techniques we use in our organisation.

Each of the skills was then identified as a target skill for a grade of hydrographer. That is, basic skills were identified as targets for all grades of hydrographers while more advanced skills were identified as targets for only grade 2 or 3 hydrographers. Because the list of skills currently contained in the Skills Matrix are 'core' skills, there are not yet any specialist skills that apply only to grade 3 hydrographers. However this matrix was designed to allow for possible future expansion. A sample of some of the rating skills is shown below in Figure 1.

4.11	Describe a Section control and Channel control	x	
4.12	Identify what information is required to produce a theoretical rating at a site with a channel control	x	
4.13	Identify what information is required to extrapolate (extend) an existing rating	x	
4.14	Apply quality codes to a rating according to WaterNSW procedures	x	
4.15	Identify what (and where) comments/calculations should be recorded for each rating	x	
4.16	Print a rating in table and plot views	x	
4.17	Use formulae to create a theoretical rating (e.g. weir formula/Manning/Chezy)		x
4.18	Use HYCHANNEL to create a theoretical rating where sufficient survey data is available		x
4.19	Extrapolate a rating using the logarithmic method		x
4.20	Extrapolate a rating using the Area*Velocity method		

Figure 1. A sample of the Hydrometric Skills Matrix.

Skills Assessment

Each of the individual skills is defined so that a hydrographer can be asked to demonstrate it, and an objective determination can be made as to whether or not the skill was successfully demonstrated. The majority are practical tasks (or discrete components of a larger task) but some require the candidate to demonstrate their knowledge with a verbal response.

The 63 skills were compiled into a series of Skills Assessments that allow for an assessor to work through each skill with a hydrographer using questions, routine work tasks or simulated exercises. The outcome is a record of whether each skill has been 'demonstrated' or 'not yet demonstrated' (NYD). Reasons for an 'NYD' result could be that the candidate has never been exposed to the skill, they use it infrequently and have forgotten, they perform the task incorrectly or they lack confidence and therefore request an NYD result so that the need for further training will be flagged in the system. Instructions are included in the assessment to guide people through the process.

The complete assessment should take 2 days per person to complete – one day of field based tasks and one day of office work. The duration varies depending on the distance to field locations, the rate at which the hydrographer completes the tasks and whether or not all skills are assessed. So far six skills for which WaterNSW are still finalising new procedures have not been included, so most assessments have taken one and a half days.

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Hydrometric Skills Map Procedure

A written procedure accompanies the matrix, assessments and map. The procedure describes the purpose and scope of the process and details how it is to be implemented. It also includes a description of roles and responsibilities, issues around confidentiality of the results and dispute resolution processes.

The procedure states that the Hydrometric Skills Map process is intended to:

- Identify and map the current skills base across the hydrometric unit.
- Identify and map training priorities across the hydrometric unit.
- Allow hydrographers to identify and highlight their personal priorities in training and professional development.
- Allow managers to strategically direct resources to achieve the best training and professional development outcomes.
- Provide evidence to external quality auditors that the hydrometric unit has an adequate skills base to perform its functions and has a system that identifies training needs.

Skills Map

With nearly 60 hydrographers across multiple grades operating in 6 regions and being assessed in 63 unique skills; there is a significant amount of data produced as a result of this process. It was very important that we didn't simply record that data, but that it could be used to report individual results, highlight trends and provide a justification for strategic decision making.

The principle of gap analysis formed the basis for reporting results. That is, where is the organisation compared to where it would like to be? This is represented mathematically for each hydrographer as a percentage of target skills demonstrated relative to the total number of target skills applicable to their grade.

Various filters can be applied to look at percentages demonstrated by an individual hydrographer, a region, grade, skill set, individual skill or any combination of these variables.

Outcomes

At the time of developing this paper, thirty two WaterNSW hydrometric staff members had participated in the assessments. Results can be identified on a range of levels; some obvious and expected, others more subtle. Below are examples of key learnings in regards to the skill levels of staff, as well as some of the actions taken in response.

Rating skills

The most significant result (expected but not previously quantified) was that collective stage-discharge rating skills were not where the organisation would like them to be. The overall result for the ratings skill set is currently 78% (of target skills demonstrated) compared to overall results of 98% (Surveying), 90% (Data Processing) and 95% (Gauging). It is worth noting that these numbers aren't necessarily directly comparable with each other as the skills included in each set may vary in complexity. For example, at this stage ADCP gauging skills have not been assessed and only basic surveying tasks have been included in the matrix, whereas the ratings component includes more technical tasks. However, the result confirmed that more work was needed in developing rating skills identified as being critical to the delivery of consistent, high quality flow data to our clients.

Figure 2 (below) shows the overall results for each individual skill that has been assessed so far. It is clear that rating results (purple) show there is room for further development. By breaking the results into individual skills, it is easy to identify which specific rating tasks people are comfortable with and which ones need a greater training focus.

Figure 2. WaterNSW Hydrometric Skills Map results by individual skills.

It is worth noting that most WaterNSW hydrographers had completed the 3 day face-to-face AHA ratings course 2-4 years ago. The Skills Map assessment process highlighted that the training had been effective in introducing rating skills, but it was also apparent that most staff had not retained the skills (and/or confidence) developed during that training. The organisation therefore needs to manage the ongoing development and retention of rating skills better – particularly theoretical skills and advanced techniques that may be used infrequently.

Individual training needs

Unsurprisingly there is significant variability in the skills of individual hydrographers in the organisation. Figure 3 (below) shows the results for each individual hydrographer assessed so far. This paper is not the place to discuss individual cases, but the results are a useful tool to help supervisors understand the current status and training needs of their staff. Many staff work from offices that are geographically isolated from their supervisor and have limited opportunity for interaction with colleagues. Skills Map results allow supervisors to provide targeted instruction, modified workloads or appropriate mentoring partnerships in order to encourage skill development.

These results should not be directly compared to one another without understanding that each assessment is only a snapshot in time; and that these assessments have been conducted over 18 months. Consequently it would be expected that more recent participants should have benefited from actions that were implemented in response to early results.
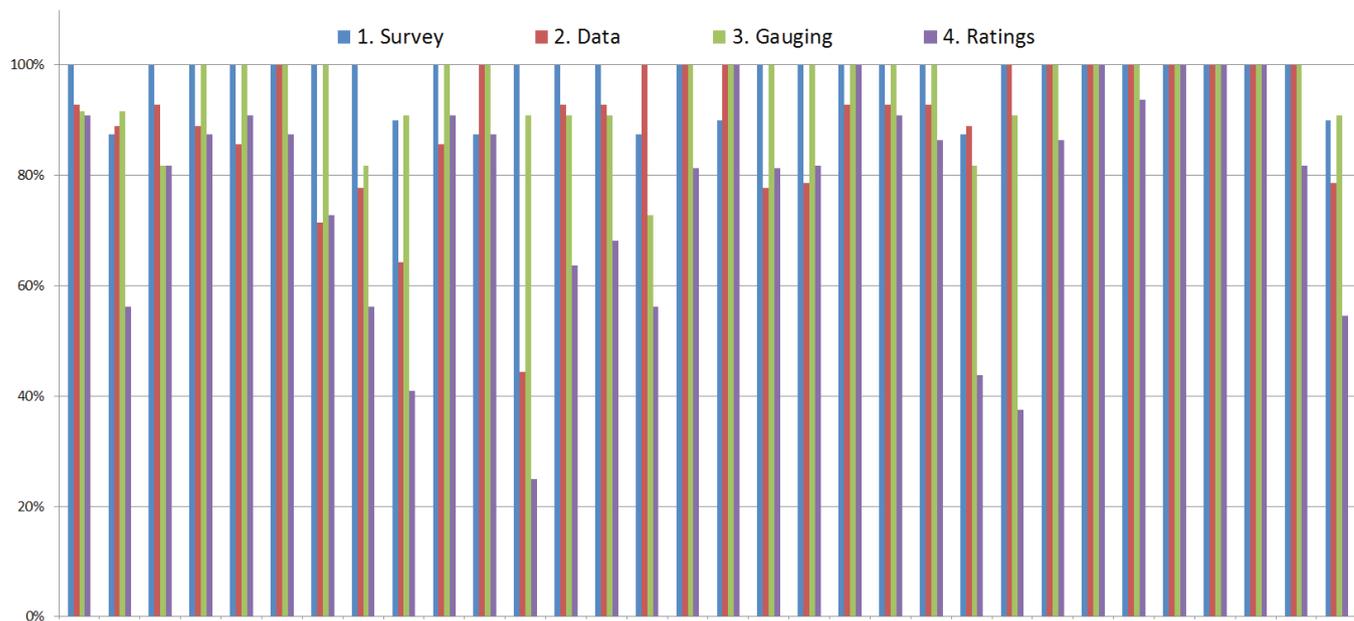
Figure 3. WaterNSW Hydrometric Skills Map results by individual hydrographer.

Knowledge transfer

The Skills Map process also illuminated an interesting trend related to knowledge transfer from experienced hydrographers to their less experienced colleagues. Grade 1 and 2 hydrographers were generally able to demonstrate task-based skills very competently, but were less likely to effectively demonstrate knowledge-based skills that were designed to assess their understanding of streamflow and hydraulic theory.

The conclusion drawn from this trend is that the organisation is quite effective in training new staff how to use equipment; but less effective in teaching them the underlying principles that govern the work. This shortcoming limits their ability to understand more complex tasks and make informed choices about which techniques are compatible with certain circumstances. For example, only 56% of our Grade 1 and 2 hydrographers could describe the difference between a section control and a channel control; knowledge that is a critical precursor to the selection of formulae and techniques for theoretical flow calculation. In contrast, 88% of Grade 3 hydrographers could describe the difference.

Improved procedures

The results have also fed back into the continuous improvement of the quality system. For example the two lowest results in Figure 1 identified deficiencies in procedures. The Data skill with the lowest result highlighted a task involving new equipment and software that staff had not been trained in and procedures yet to be developed for. The lowest rating overall involved an existing procedure that was not supported and/or well understood by many staff who, as a result, elected not to attempt the task. This procedure obviously needs to be reviewed.

Identifying local practices

The assessment process also identified a variety of local practices that were inconsistent with other regions. Some of these were legacy issues passed down from predecessors that needed to be resolved; while others were improvements or shortcuts that could be shared to benefit other hydrographers.

Actions

There are three levels on which action has been taken in response to these results.

Firstly, individual hydrographers are able to respond to their results. Examples of responses include: enrolment in the Diploma, reviewing previous training notes, seeking opportunities to expand responsibilities, making time to practise skills and improved communication with experienced colleagues.

Secondly, supervisors have the most opportunity to influence skill development within their teams by utilising the skills of their more experienced and competent staff. Examples include: running a local workshop to share skills and collectively work on complex tasks, restructuring teams so that people can benefit from working with colleagues with a different skill set and encouraging informal mentoring on a local level.

Thirdly, is a corporate level response. Procedures have been reviewed or amended in response to some results. Most significantly the organisation has purchased rapid eLearning development software and has commenced producing eLearning resources that specifically target the greatest areas of need. Initially this involved a module that addressed the five poorest skill results (that didn't require procedural changes) and then a series of rating related modules (two of four proposed modules have been released so far).

These resources are web-accessible and allow hydrographers to learn or revisit these skills when convenient and/or necessary. The eLearning platform allows for content to be communicated in an interactive format and includes video demonstrations of the software used for many of our tasks. A few brief videos are also available on the web to share some of the useful ideas and shortcuts that have been picked up during the assessment process.

Reflections

Below is some commentary about the WaterNSW process, how it has been implemented and things learnt along the way.

Potential expansion

Ever since the Hydrometric Skills Map process was first proposed the management team has seen the potential benefits and suggested that it could be expanded to include the roles of hydrometric coordinators and instrumentation officers. The primary hurdle is identifying skills relevant to these positions that are objectively measureable. Many of their responsibilities revolve around management and/or reactive problem solving; tasks that usually have unique variables that couldn't be accurately captured in a simulated exercise or series of specific skill statements.

Even for hydrographers, there are many aspects of their routine work that are not yet covered by the current skills matrix and are probably unsuited to this type of mapping process.

Cost

There are four significant costs associated with this process.

- The cost (in time) for someone to develop, implement and administer the process. This will vary according to the scope of the process and how familiar this person is with the skill sets involved.

- The cost (in time and travel) for the assessor/s to conduct the assessments. Typically in the organisation, which is spread across NSW, an assessor completes two assessments in a week by travelling to a location on Monday, completing the 2 assessments and travelling home Thursday evening or Friday.

- The cost (in time away from routine work) for the hydrographer to participate. It could be argued that this aspect of the process is cost neutral. Hydrographers are encouraged to complete the field component of the assessment at sites that require the work, i.e. surveys and gauging. Much of the office component involves processing data which would need to occur anyway. Anecdotally 50% of the assessment is routine work and 50% is simulated exercises. Considering that the assessor works as the 'offsider' for the field component, other local hydrographers are not required in the field and are therefore free to do other routine work. Consequently there is no net cost to the local area as a result of the assessment process.

- The potential cost (non-monetary) to staff morale and goodwill. If handled poorly this process could lead to workers feeling anxious or insecure.

Diplomacy

Implementing the process and conducting the assessments with hydrographers does involve a significant amount of diplomacy. The goal is for this process to assist each hydrographer to develop skills and confidence that will enhance their own sense of professional pride; whilst also improving corporate capability. There can be a fine line between drawing attention to someone's deficiencies on one hand; and helping them to recognise opportunities for professional development on the other.

The emphasis is that this process is more about finding how to do things better, rather than finding where the organisation is falling short. That has largely been accepted by hydrographers who have been willing to use the process to highlight areas in which they have not been given adequate opportunities to develop skills, and to provide them with some leverage to request those opportunities from their supervisor. Inevitably there have been some participants that have not embraced it enthusiastically, but all have still participated willingly and acknowledged the intent.

As an assessor (and probably because of personal responsibility as the creator of the process) the author has found some assessments emotionally exhausting – particularly with candidates that have worked in the industry for a long time but are having difficulty demonstrating many of the skills. It can be a complex task to complete the assessment accurately and objectively whilst reassuring and motivating the participant.

Follow up

As previously mentioned, the skills map provides only a single snapshot in time of individual and corporate capability. Theoretically it would be nice to use this as a benchmark and repeat the process in 3 years to measure improvement. However there is little value in repeating the entire assessment. WaterNSW has identified ratings as an area that needs more investment: the rating assessments should be repeated in 3 years to quantify any improvements made in that area.

Management should support any individual hydrographers that requested a re-assessment in order to validate their own progress.

When new procedures for the use of ADCPs are finalised and released, and 6-12 months has been allowed for people to familiarise themselves with those procedures; new assessments should be made on a representative sample of hydrographers (perhaps 6-10) to measure how effectively those skills have been adopted and retained.

The skills matrix will continue to provide a pathway of skill development for new staff entering the organisation and they should participate in the assessment process within 2 years of commencing employment with WaterNSW.

Driving skill development

The Hydrometric Skills Map process can define measure and map core skills. It doesn't provide a mechanism to train staff. This is perhaps the single biggest shortcoming in our system. Without a dedicated training role in the structure, responsibility for staff skill development rests primarily with Hydrometric Coordinators who are generally busy enough with other administrative and operational tasks, and have varying levels of qualifications, skills, experience, aptitude and personal interest in training and professional development.

As a result, current organisational structure at the moment is not well suited to having a consistent culture of skill development driven from a single source. This legacy led to identifying the need for a skills mapping process; but now limits the extent to which proactively response to the collected information can occur.

Conclusion

For other hydrometric organisations considering adopting a strategic approach to skills development, there are three critical questions that should be considered.

Do you have the right system?

Start from your desired end point and work back to ensure that you develop a system that will deliver what you want. This will almost inevitably mean a narrower scope than what you would like; but it is better to start with a narrow scope in a system that works, than to develop a system with a broad scope that doesn't deliver useful outputs.

Do you have the right people?

The potential risk to goodwill among the workers means that it is important that assessors are sensitive to balancing the needs of people against task-oriented goals. Managers and supervisors must also buy into the system and be proactive in promoting the benefits to the individuals, as well as the benefits to the organisation as a whole.

Do you have the right structure?

Ideally you will anticipate the organisational elements you need in place to best respond to the outcomes of a skills mapping process, and can establish them at the outset. This may involve appointment of staff to specific roles or equipping supervisors and/or managers with the necessary skills and resources to drive consistent professional development. To gain maximum benefit across the organisation, actions may need to be driven from, or at least coordinated by, a single source.

Towards Better Management of Water Quality Data: Metadata Guidelines to Improve Application to The Real World

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Paper presented to 18th Australian Hydrographers Association Conference.

Abstract

The National Industry Guideline for water quality metadata was published in May 2016. It provides a nationally recommended and consistent approach to describing metadata for the collection, storage and analysis of water quality data. Metadata is structured information that describes or provides context for data and is essential for understanding data and its limitations.

This guideline provides guidance about mandatory and optional metadata elements and describes data entities (or groupings) that are meaningful and pragmatic for hydrographical, laboratory and hydrologic practitioners.

The guideline is applicable to both automated continuous water quality monitoring (e.g. using in-situ sensors or probes), tests performed in the field and grab samples sent for laboratory testing.

Implementation of the guideline will facilitate consistent collection of metadata, and will improve the interoperability, quality and future usefulness of water quality data.

The guideline was developed with Bureau of Meteorology (the Bureau) funding and led by the former Queensland Department of Environment and Resource Management. The authors collaborated with national industry experts and practitioners to produce current guidance appropriate to Australian conditions, and were cognisant of the range of relevant national and international standards.

Extensive industry input and consultation has been a feature of the development and review processes for the guideline. A Technical Reference Group significantly contributed to final review and redrafting of the guideline which was subsequently endorsed by the Water Monitoring Standardisation Technical Committee (WaMSTeC) and published by the Bureau.

National Industry Guidelines can be considered as living documents. The status of endorsed guidelines is periodically reviewed by WaMSTeC at intervals of no greater than five years.

Background

Under the Commonwealth *Water Act 2007*, the Bureau of Meteorology (the Bureau) has responsibility to collect, hold, manage, interpret and disseminate water information, including water quality information, at a national level. There is a considerable range of standards, practices and procedures employed by organisations collecting water quality data which leads to differences in the quality and extent of metadata which organisations record. The Bureau and other data users are faced with the challenge of interpreting data and metadata from diverse sources in a consistent fashion.

Metadata is essential for correct interpretation and understanding of data. It is structured information that describes, explains, locates, or otherwise makes it easier to retrieve, use, or manage an information resource (National Information Standards Organisation, 2004). For water resource management the metadata associated with water quality monitoring provides contextual information about sample location, sample procedures, storage of data, description of laboratory analysis and results of the analysis. The need for complete and consistent metadata is heightened when there is a separation between data collectors and data users either by distance or time.

An industry needs analysis of water information standards, commissioned by the Bureau in 2010, identified metadata standards as a priority area for development (GHD 2010). The report concluded that there are strong drivers for common metadata standards from the perspective of both the Bureau and data collecting organisations.

At present there is little consistency in the way organisations code information about the collection, analysis and storage of water quality data. The codes used in the analysis of water samples also differ between laboratories, even though they may apply the same technical references and instrumentation. This inconsistency restricts the interoperability of data sets between organisations, and severely constrains the longer term goals of the Bureau to collate water quality data from multiple agencies.

Initial projects toward water quality metadata standardisation

Between 2009 and 2011 the Queensland lead water agency (then the Department of Environment and Resource Management) was funded through the Bureau administered Modernisation and Extension of Hydrometric Monitoring Systems program to conduct a number of water quality metadata projects (Bureau of Meteorology 2011). The aim of the projects was to identify the range of water quality information captured by the various agencies, government bodies, councils and water authorities across Australia, and to develop a nationally standardised approach to water quality metadata.

The initial project in 2009-2010 delivered a report *Scoping Information Management Protocols for Water Quality Monitoring in Queensland* (Ryan et al. 2010) which developed a framework for water quality information management and identified an initial metadata list that could improve consistency across different organisations. The project involved representatives from several Queensland state agencies and a representative of the then NSW Office of Water.

A second project in 2010-2011 featured extensive consultation with and input from 28 water agencies throughout the country and included a workshop in Brisbane in February 2011 attended by representatives from all states and the Commonwealth. The project produced a series of three reports published in July 2011 (Ryan *et al*. 2011, van Willigen *et al*. 2011b and 2011c). The key recommendation from this project was that the Bureau should consider incorporating a proposed list of metadata as the required water quality metadata component of the Australian Water Resources Information System (AWRIS). AWRIS is an information system built by the Bureau capable of receiving, standardising, organising and interpreting water data from across the nation. It was envisaged that the identified water quality metadata would be supplied by water entities to the Bureau on a regular basis for loading into AWRIS. These project outputs and recommendations laid the foundations for the National Industry Guideline.

Development of the guideline

The national water quality metadata guideline was brought into focus through the Water Monitoring Standardisation Technical Committee (WaMSTeC). WaMSTeC was convened in 2014 as a national water industry committee to continue the work of the Water Information Standards Business Forum, coordinating and fostering water monitoring standards and guideline development. WaMSTeC supports the Bureau in its function to set water information standards and to consult with the States as set out in the *Water Act 2007 (Cwlth)*.

The process to develop the National Industry Guideline for water quality metadata followed the *Guidelines and Standards Endorsement Process* (WaMSTeC 2015) which was adopted and published by the Bureau (refer to Figure 1 for an outline of the endorsement process). To support this process, a Technical Reference Group (TRG) was formed to oversee the drafting and review of the guideline, and to facilitate the industry consultation phases. The TRG included members with appropriate training or expertise in the field of activities specific to the guidelines, namely, data collection, laboratories, data management and water quality assessment and had 17 representatives from all jurisdictions. The primary role of the TRG was to review and edit guideline drafts under an agreed Terms of Reference and ensure the final guideline represents current industry recommended practice.

To assist in the process of industry consultation and the review of the draft guideline, the Australian Water Association (AWA) agreed to support the TRG as an industry representative body. The role of the industry body is discussed in the *Guidelines and Standards Endorsement Process* (WaMSTeC 2015).
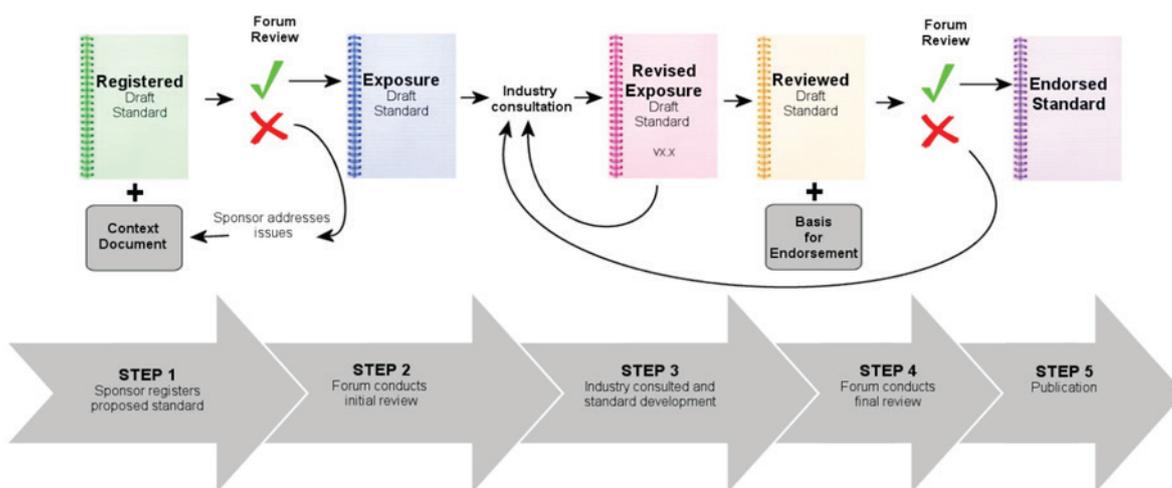
Figure 1. Process for developing and endorsing standards.

The first draft of the guideline, based on initial project work described in the previous section, was reviewed by TRG members early in 2014 and revised later that year in preparation for broader industry consultation. This open consultation period occurred between August and September 2014 when WaMSTeC's predecessor (the Water Information Standards Business Forum) published the draft guideline on the Bureau's web pages and sought input from all practitioners involved in water quality information. The invitation to comment was promoted widely, including through AHA and AWA networks. The TRG considered all input received through the consultation phase and agreed a final list of metadata elements in early 2015. Comments made in a submission by the CSIRO were addressed through a separate focus group and the TRG presented a final draft of the guideline to WaMSTeC in October 2015.

WaMSTeC endorsed the National Industry Guideline for water quality metadata in November 2015 and it was published in 2016 (Bureau of Meteorology 2016). Endorsement signifies that the guideline aligns with industry recommended practice and is in step with relevant Australian and international standards.

What the guideline delivers

The guideline has been developed in the context of the Bureau's 'Improving Water Information' program and should be adopted as best practice for water quality data collected and being supplied to the Bureau under the *Water Regulations 2008* (Cwlth) by persons named in the Regulations. It pertains specifically to the following water quality data parameters identified in the Regulations:

- Electrical conductivity of surface water and groundwater.

- pH of surface water and groundwater.

- Total suspended solids concentration of surface water.

- Turbidity of surface water.

- Total phosphorus and total nitrogen concentration of a surface water sample.

- Temperature of surface water.

While these parameters represent only a small selection of physio-chemical variables used for environmental assessment, in practice the guidelines can be applied to all other water quality parameters and programs including those external to the Water Regulations reporting requirements.

- The guideline describes 58 separate metadata elements that are meaningful and pragmatic for hydrographical, laboratory and hydrologic practitioners. The elements are grouped into entity classes which reflect the entire data lifecycle from collection to analysis and reporting. These high-level metadata groupings are:

- Metadata to describe where samples are taken. Elements in this group capture details about the site and monitoring point name, ID and location.

- Metadata to describe the sample. This group captures metadata needed to provide information about surface water and groundwater samples used in both lab-based and field-based analysis, including in situ probes. It includes metadata to clarify sample set memberships, such as particular monitoring projects or hydrological events. Knowledge of these sample sets can provide insight into the background circumstances of the sample and help identify related samples or possible future samples that could be anticipated from ongoing monitoring operations.

- Metadata to describe the result. These elements relate to the actual reportable result of the water quality observation. They include elements such as the result date/time, minimum and maximum practical quantitation limits, measurement units and measurement uncertainty.

- Metadata to describe the determinand. This group of elements clearly identifies the determinand (also known as parameter, variable or analyte) and links to the relevant technical references governing the production of values.

- Metadata to describe the technical references. These elements identify relevant technical references describing methods and standards which govern the collection and management of samples or the production of results for a determinand.

Typical associations and links between the groups are shown in the simplified entity relationship diagram at Figure 2.
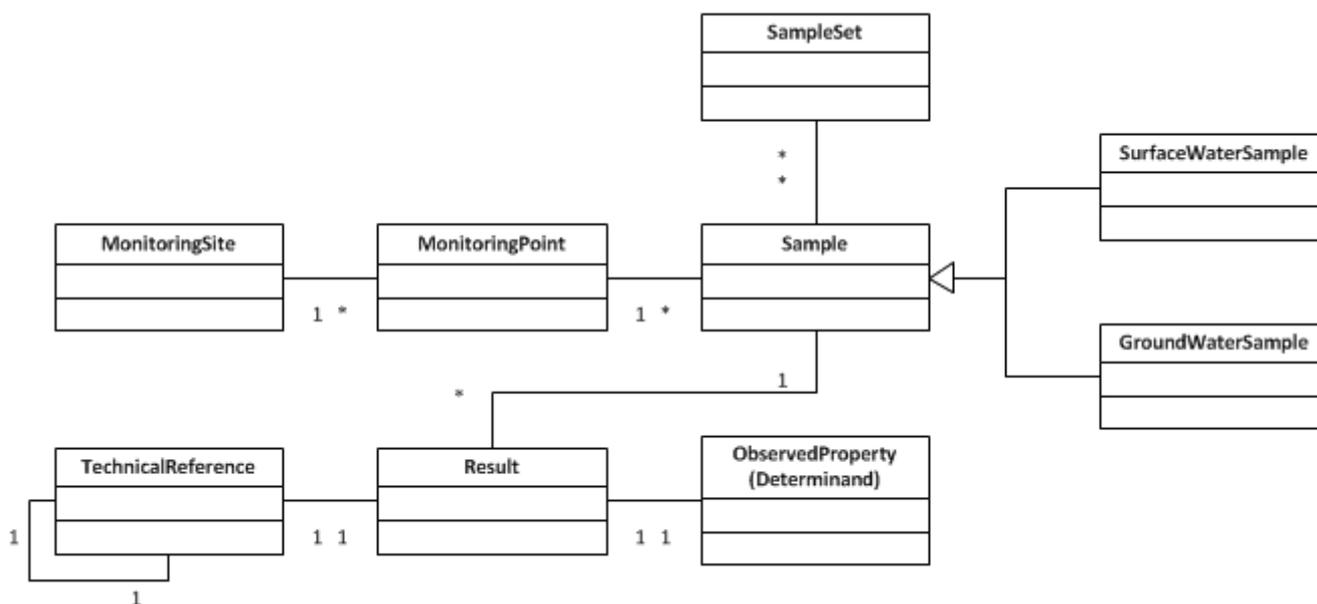
Figure 2. Simplified metadata entity relationship diagram

Benefits of adoption

Whilst adherence to the guideline is voluntary, national adoption will deliver benefits to both data producers and data users.

A common understanding of metadata requirements will benefit data producers as they realise efficiencies and cost savings in shared systems and procedures. The water quality metadata guideline will deliver value to data producers by:

- reducing costs to develop and share systems, software and procedures based on standardised data requirements;

- enhancing interpretative capacity of information through improved consistency and reduced uncertainty about data;

- extending value of the initial investments of water monitoring programs through improved confidence in using the data beyond the original objective e.g. for model calibration and validation; benchmarking water quality condition assessments; and statistical analyses;

- increasing the ability to collate and compare data from a wider range of water monitoring organisations; and

- increasing opportunities for building relationships and networks with other jurisdictions working in water quality data collection and management.

Users of water quality data, including scientists and natural resource managers, will benefit through an increased ability to correctly interpret data, assess data quality and determine whether data are fit for purpose. National adoption of the guideline will deliver value to the Bureau and other national agencies by:

- increasing the quality and completeness of metadata provided with water quality monitoring observations;

- increasing the consistency of data and metadata across multiple data sets;

- enabling more efficient development of systems that can collate, compare, store and manage data in an effective manner from multiple jurisdictional data sources;

- focusing and directing the development of standardised coding for water quality metadata in data management systems and data transfer formats;

- allowing more effective environmental assessments and better water management decisions as a result of increased availability of comparable and relevant data; and

- increasing the longevity of data as, over time, undocumented or inadequately described data may become redundant or misleading.

As one example, the analysis of salinity across the Murray-Darling basin conducted by Jolly *et al*. (2001) would have been dramatically enhanced by the existence of this guideline. In that study, the CSIRO led team (including one author of this paper) had to collate inconsistent salinity data with hydrographic data from four jurisdictions before analysing and reporting on basin trends. Many hours were spent by CSIRO and three state monitoring organisations collating disparate data from 87 stream gauging stations throughout the 26 major sub-stations over four states. Lack of available metadata meant that there was no clarity that data from different states were compatible. Even within states, there was no consistent metadata available to demonstrate that data were produced to the same standards over time. Had this guideline existed and been followed, together with the National Industry Guidelines for hydrometric monitoring, better scientific analysis, would have resulted, removing assumptions and giving more confidence in the environmental and resource management outcomes. The guideline will also offer benefits to the range of instrument manufacturers and data management system suppliers by articulating national recommendations. This will allow supporting industries to identify and service common needs with greater confidence.

Another example was with the initial analysis of legacy water quality data collected in Great Barrier Reef (GBR) catchments by a number of agencies over many years. A considerable amount of total nutrient data that would have cost millions of dollars to collect had to be disregarded due to the lack of metadata. Different laboratory analytical methods for nutrients are available but these may not give similar results for all types of water samples. There is considerable evidence that using alkaline peroxodisufate digestion on water samples with medium to high concentrations (>50 mg/L) of suspended sediments or dominated by organics leads to underestimation of total nitrogen and phosphorus concentrations, when compared with analysis using Kjeldahl digestion (Maher *et al*. 2002). Around 50-60 % of all data available either did not have information as to whether the samples were taken in high flow or ambient conditions or accurate locations and in some cases the method of analysis was not clearly identified.

Monitoring for water quality in large catchments is both labour-intensive and very expensive. Sampling across flood hydrographs is conducted under difficult physical conditions but without rigorous sampling, sample handling protocols and an understanding of the conditions at the time of sampling further analysis of data is of little value.

Realistic comparisons of water quality from source to sea within GBR catchments, across different catchments and from year to year, require consistent sampling protocols, analytical methods and importantly, appropriate metadata. This approach is essential also for evaluation of improved or degraded water quality arising from changed land management practices.

Each of these benefits will only be realised if the guideline is broadly adopted. It is intended that the guideline can be readily adopted by organisations by mapping their current information to the recommended metadata requirements. Now that the guideline is published, an increased adoption rate of its recommendations is expected.

Future directions

Owing to the wide range of disciplines that are associated with the different activities required to produce and utilise water quality data, there is not one all-encompassing industry body. Hence, it may be necessary in the future to recruit other organisations to expand promotion of the guideline and ensure reach to all members of the Australian industry.

The National Industry Guideline for water quality metadata should be considered as a living document. WaMSTeC, with the support of the Bureau, is responsible for ongoing governance of the guideline which will be subject to review at least every five years, giving consideration to any issues or requests for changes raised by industry. The review process will ensure the guidelines remain technically sound and up to date with technological advancements. We encourage users to send their feedback to regulations@bom.gov.au.

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Application of Acoustic Doppler Technology in Sediment Transport

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Paper presented to 18th Australian Hydrographers Association Conference
Canberra. 24-27 October 2016.

Abstract

The application of acoustic Doppler instruments has expanded into various facets of catchment hydrology and water engineering. This paper not only aims to demonstrate the successful integration of the technology within catchment hydrology but also show the significant improvement in existing practices and development of more reliable techniques in determining:

- *Suspended-sediment concentration;*

- *Bathymetry and Velocity Mapping;*

The traditional methodology that was applied over the past century in defining these key parameters had number of limitations due to the available technology and resources required to perform field measurements. This often resulted in insufficient and unreliable data sets for model development and yield calculations.

This paper will also review research done by the USGS and U.S. Army Corps of Engineers to identify the most effective surrogate for suspended-sediment concentration (SSC), and software that is built on the current acoustic Doppler current profiler (ADCP) platform. This software enables the user to perform depth measurements and velocity measurements simultaneously for bathymetry and velocity mapping.

Introduction

The application of acoustic Doppler instruments has over time expanded into various facets of catchment hydrology and water engineering. The traditional methodology, applied over the past century in defining these key parameters, had a number of limitations due to the available technology and resources required to perform field measurements. This often resulted in insufficient and unreliable data sets for model development and yield calculations.

Research has since been undertaken by the USGS and U.S. Army Corps of Engineers to identify the most effective surrogate for suspended-sediment concentration (SCS). The methodologies that were identified for the study consisted of turbidity, laser diffraction and acoustic backscatter principles. During the initial investigation it was found that the most promising technique is the measurement of acoustic backscatter strength with an acoustic doppler velocity meter (ADVM). A surrogate model was developed based on the SSC samples taken over a two year period in both the Clearwater and Snake Rivers from 2008 -2010. ADVM measurements were performed during the same period and the acoustic backscatter surrogate displayed the best relation with the measured SSC during the development of the model. The acoustic surrogate model provides improved estimation of SSC and load than the traditional sediment-transport curves based on discharge during different time scales when sediment concentration is variable (Wood and Teasdale 2013).

The technology available for bathymetric surveys is limited to the measurement of bed profiles and the incorporation of velocity and or river classification along the channel with bathymetry surveys information is a complex process. SonTek has developed HydroSurveyor software that is built on the current RiverSurveyor

acoustic doppler current profiler (ADCP) platform that enable the user to perform depth measurements and velocity measurements simultaneously for bathymetry and velocity mapping. The ability to create a complete elevation grid of the surveyed area, i.e. a digital elevation model (DEM), based on ADCP bathymetry and Lidar topography and then combine this with a 3D velocity grid of the survey area over several flow conditions gives the user a numeric solution and graphical presentation of flow conditions in the river based on 3D velocity and depth. This data can then be used to improve hydrodynamic river models, identify changes in river flow conditions, improve velocity-index equations, etc. The graphical presentation of field measurements extends the scope of application to wider scientific audience within catchment hydrology. An intensive depth and velocity study was conducted by Idaho Power Corporation (IPC) on the Snake River just below CJ Strike Hydroelectric Dam in February 2015 to understand the influences of different turbine combinations on a nearby velocity index gauging station and the results are included in this paper.

Methods

Suspended-Sediment Concentration

Sediment Sample Collection

Suspended-sediment samples were collect by the USGS and U.S. Army Corps of Engineers based on the equal-width-increment (EWI) sampling method (U.S. Geological Survey, 2006). The sampling was targeted at three different areas during the hydrograph, rising limb, peak and falling limb for each river. A total of thirty three suspended-sediment samples were collected during the period at each site in the Clearwater and Snake Rivers from 2008 -2010 (Wood and Teasdale 2013).

Surrogate Instrument Data Corrections

The acoustic backscatter data or signal-to-noise ratio (SNR) measured by the ADVM cannot be applied directly for determining the SSC and need to be corrected into a more appropriate estimator of SSC. The acoustic backscatter of each cell measured by the ADVM was corrected for the following losses:

• Beam spreading;

• Transmission losses owing to absorption by water;

• Absorption or attenuation by sediment.

The methodology used for correcting acoustic backscatter data during this study are documented in Wood and Teasdale (2013) report and are not further discussed in this paper. The different steps involved for correcting acoustic backscatter data for each measurement cell from the ADVM is graphically presented in Figure 1 (Wood and Teasdale 2013).
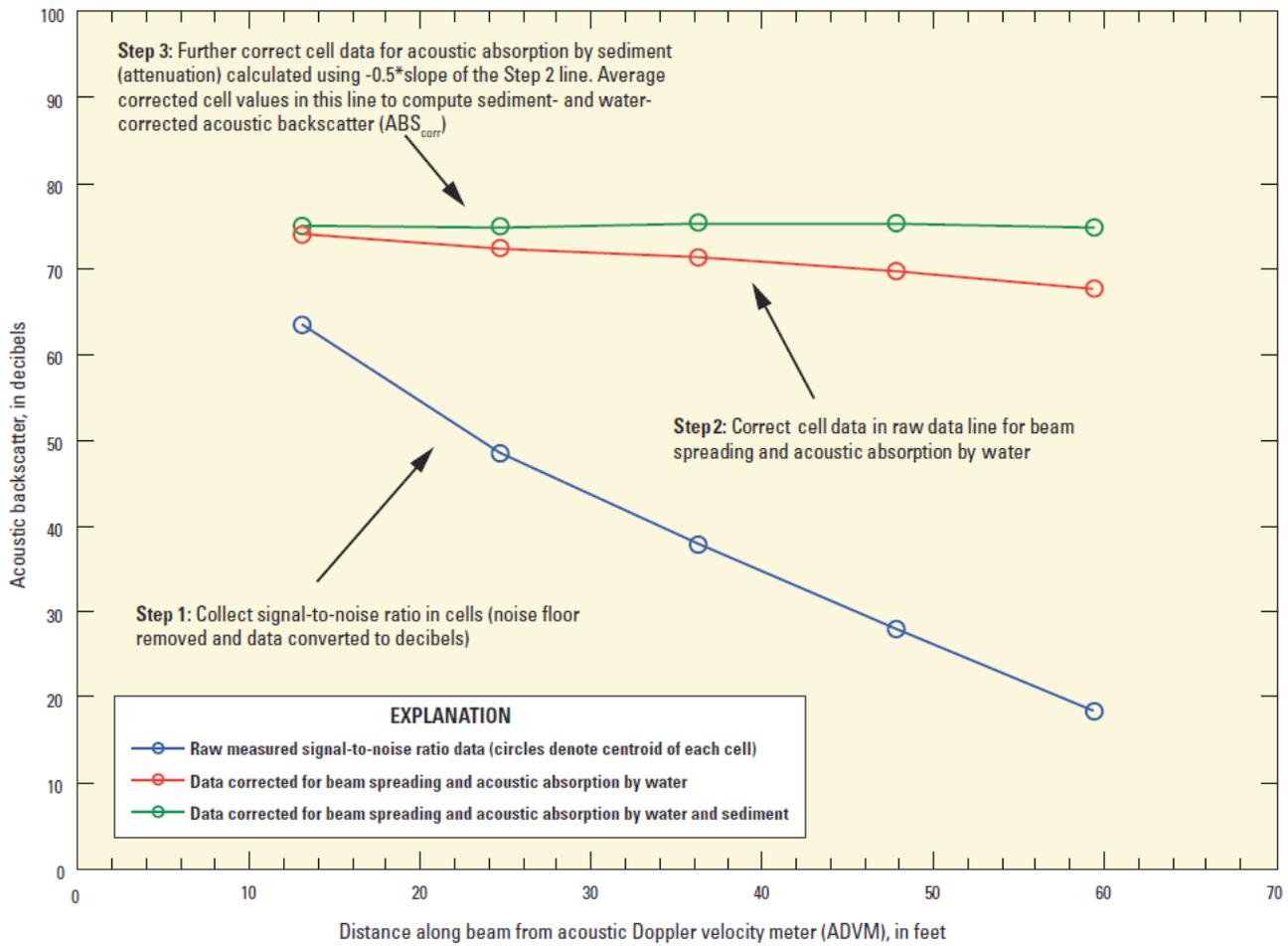
Figure 1. Process for calculation of range-normalized acoustic backscatter corrected for two-way transmission losses in the Clearwater River, Idaho, and Snake River, Washington.

Surrogate Model Development

The samples collected at each site in the Clearwater and Snake Rivers from 2008 – 2010 were used to develop surrogate models with the acoustic backscatter data during the same period. The acoustic backscatter data was averaged in 1-hour time frames to overlap the suspended-samples that were analysed.

Models were developed for each site in the Clearwater and Snake Rivers between SSC and acoustic backscatter data using stepwise ordinary least squares regression techniques. Regression models were selected based on statistical significance (measured by p values) of explanatory variables and various regression statistics, such as high coefficient of determination (R2), low standard error, constant variance and random patterns in residuals plots, and low relative percent difference. Surrogate regression models for total suspended sediment, sand, and fines concentrations based on acoustic backscatter are graphically presented in Figure 2 (Wood and Teasdale 2013).
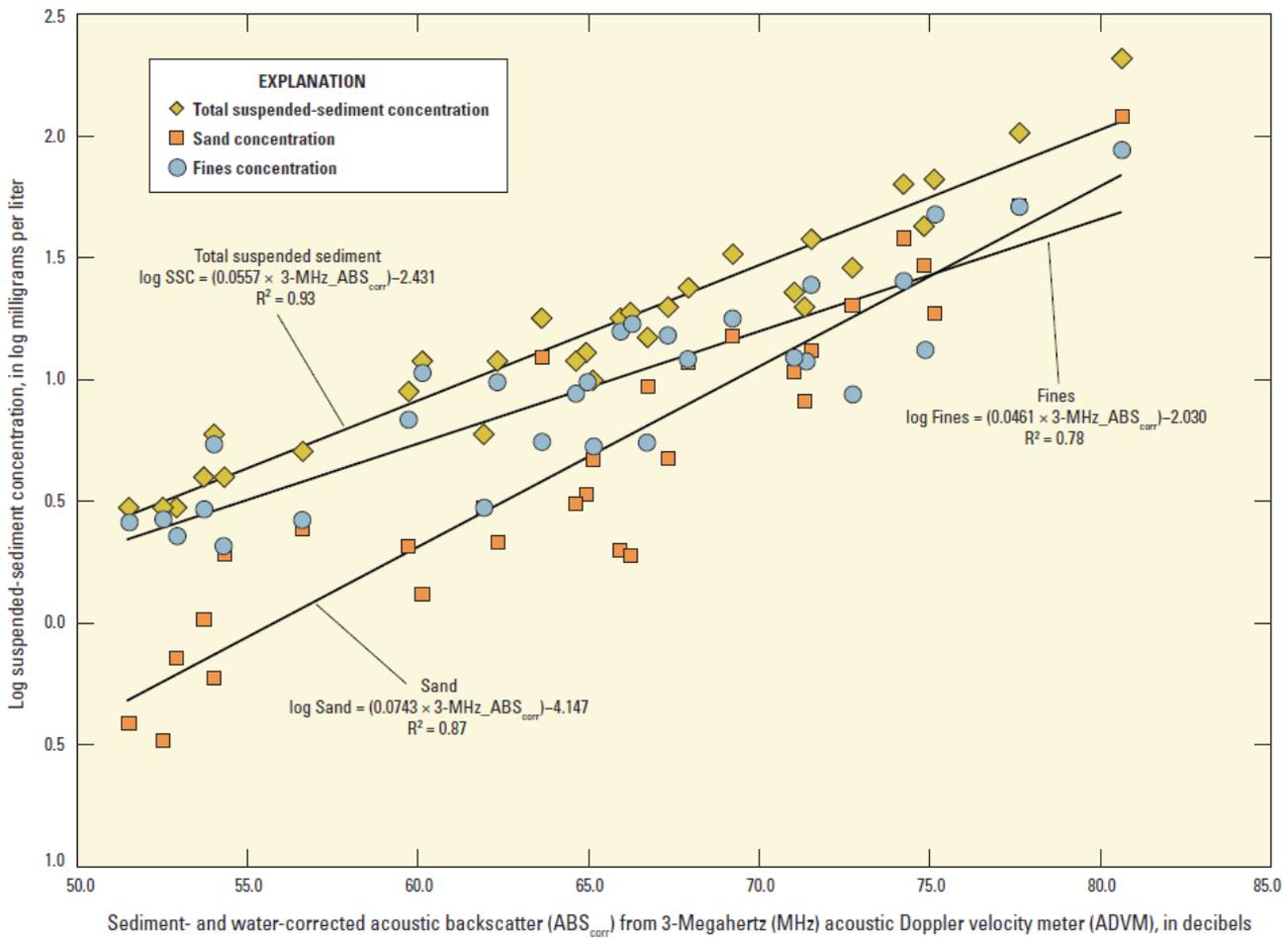
Figure 2. Surrogate regression models for total suspended sediment, sand, and fines concentrations based on acoustic backscatter for the Clearwater River near Spalding, Idaho.

Bathymetric and Velocity Mapping

Field data collection, data processing and visualization of results

Acoustic Doppler measurements were performed on the Snake River below CJ Strike Dam near Boise, ID on February 19th, 2015. An aerial photo of the survey section along with the multiple M9 ADCP track lines is presented in Figure 3.

Figure 3. Survey Section on the Snake River below CJ Strike Dam showing ADCP survey track lines (courtesy of WaterCube, LLC).

The data collection process consisted of running parallel track lines in a downstream direction along a 1 km section of the channel reach along with a section of cross-track lines (above the bridge near the location of the velocity index gauging station) using the following platforms for measurements:

- 3 x Kayaks.
- 1 x Jet Boat (to transport kayaks back to start of survey section).
- 1 x Ocean Science high-speed remote-controlled survey boat for accessing difficult areas of the river reach and conducting high-precision cross-track measurements upstream of bridge.

All of the measurement platforms used for the bathymetric and velocity mapping survey were equipped with a SonTek RiverSurveyor M9 with integrated DGPS 2G-PCMs for high-precision position, telemetry, and power. The measurements performed with the SonTek RiverSurveyor are captured in RiverSurveyor Live software with the following main parameters:

- 3D water-velocity profile of water column.
- Total water depth (from each of the 5-depth beams).
- Bed profile depth.
- GPS position and elevation.
- Signal to noise ratio (SNR).
- Pitch and roll.
- Track distance.
- Heading.

These parameters are recorded every second during the measurement, resulting in a high resolution of measured depth and 3D water-velocity profile data. Graphical views of the data collections results processed by WaterCube, LLC using the M9 RiverSurveyor are shown in figure 4.
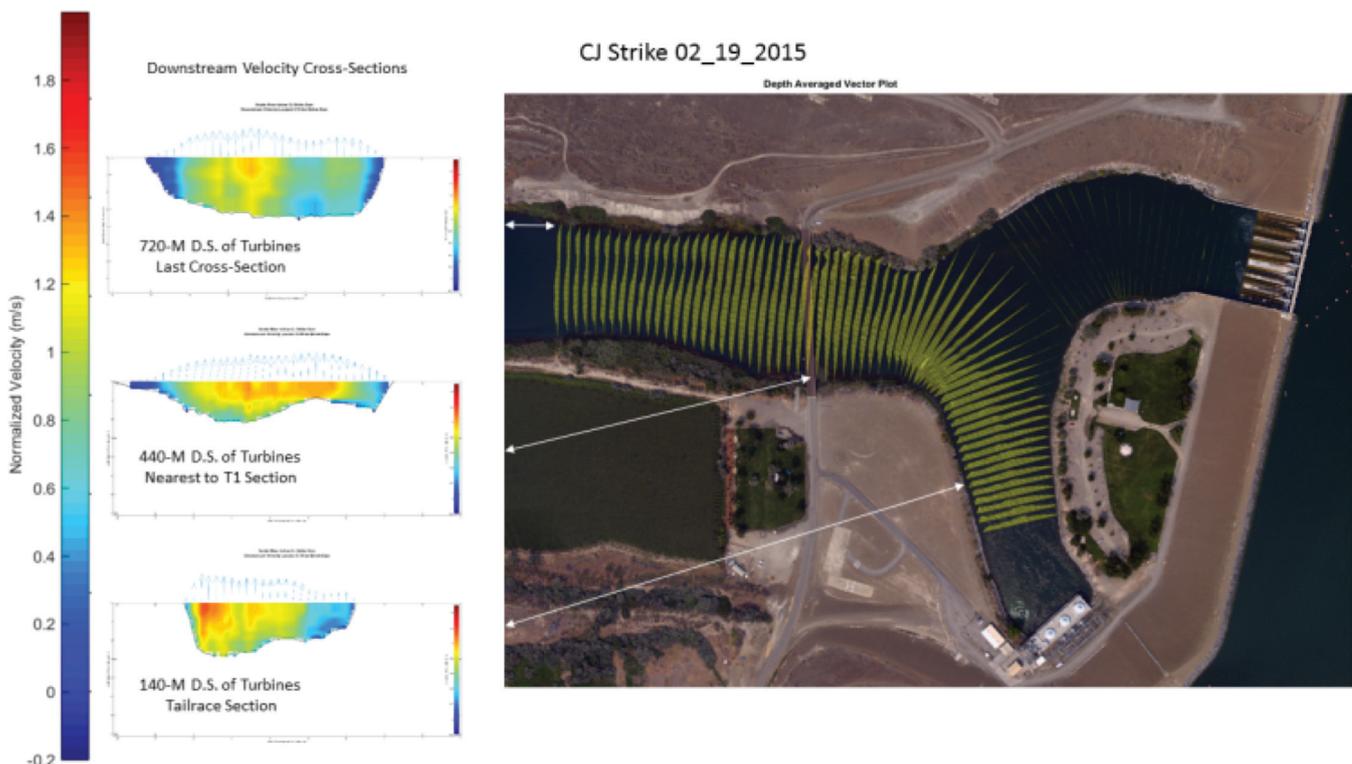
Figure 4. Aerial view of the Snake River below CJ Strike Dam showing multiple cross-sections of depth-averaged velocity vectors and corresponding cross-sections of downstream water velocity profiles (courtesy of WaterCube, LLC).

M9 ADCP Data processing with WaterCube

M9 ADCP data sets collected during the river survey on the Snake River were quickly combined, linked, and gridded using a software processing engine developed by WaterCube, LLC. WaterCube processing develops high-resolution grids of depth and 3D velocity in the channel reach for a single or multiple flow events. This process involves an advanced data screening procedure to ensure the highest quality of data possible for processing. The M9 ADCP 5 beam depth and 3D water-velocity profile data were linked with LiDAR topography data to develop a complete digital elevation model (DEM) and 3D velocity water-profiles grid of the study area. This type of analysis provides improved definition of the water-edge and above water topography for flood flow and analysis and hydraulic analysis (www.watercubedata.com). A 3D graphical view showing the water-velocity profile grid arranged in equal-interval cross-sections linked to the DEM (created by linking ADCP depth data with LiDAR topography) is shown in figure 5.
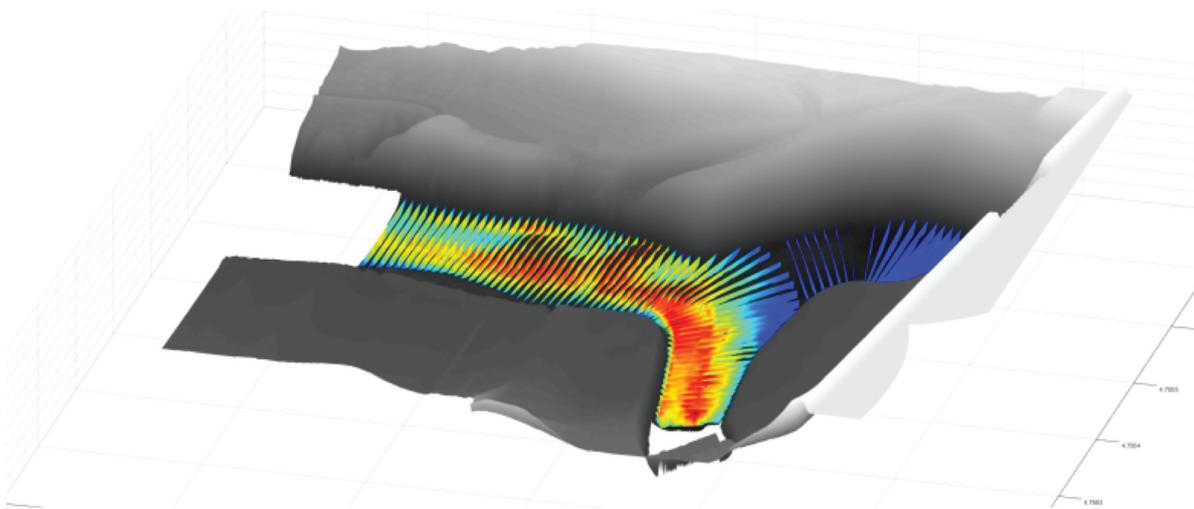
Figure 5. 3D view of equal-interval cross-sections of downstream velocity linked to a DEM developed using Aerial LiDAR data linked to ADCP bathymetry (courtesy of WaterCube, LLC).

Findings

Suspended-Sediment Concentration

The acoustic Doppler velocity meters (ADVM) demonstrated during the acoustic surrogate model development the robustness of the technology. The study results also highlighted that a higher frequency instrument showed the best estimation of SSC of all technologies.

The acoustic surrogate model based on the 3 MHz acoustic backscatter represented 93% of the variability in the SSC and 8.6% average between measured and estimated SSC. The standard error and variance for the 3 MHz acoustic surrogate model was lower and more consistent than all the other models. The 3 MHz acoustic surrogate model results with sediment transport curves and physical samples are graphical presented in Figure 6.
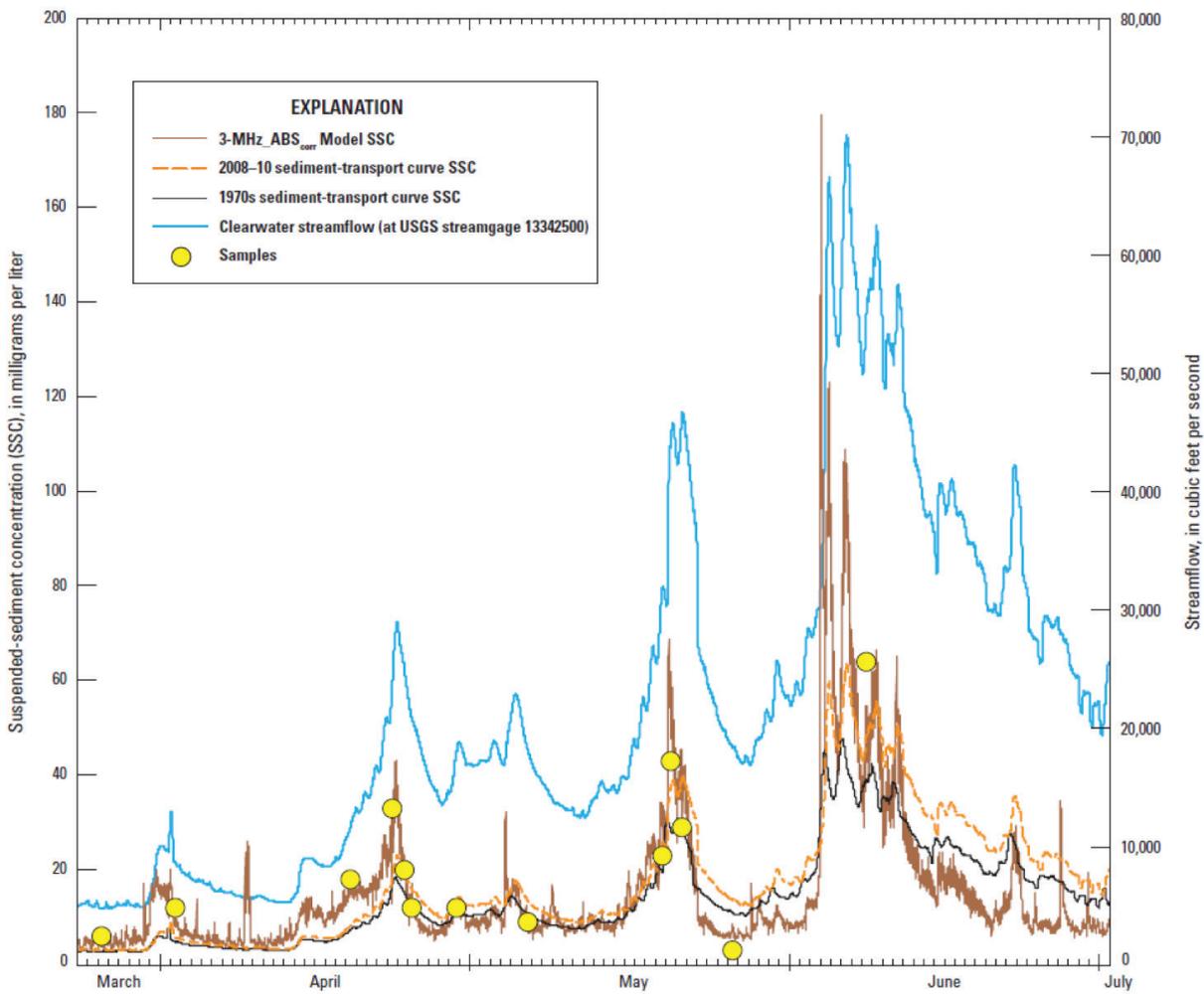
Figure 6. 3 MHz acoustic surrogate model results with sediment transport curves and physical samples.

Conclusion

The application of acoustic Doppler technology in catchment hydrology is becoming an important criterion in the application of the various spheres of hydrology. Information has never in the past been so accessible or cost effective than now with the use of acoustic Doppler technology.

The use of Geographic Information Systems (GIS), Digital Elevation Models (DEM) or Hydrological Models requires significant amounts of data to enable the user to develop a model based on the catchment characteristics and the hydrological processes involved. The individual measurements performed on an ad hoc basis are not sufficient for these purposes and a more comprehensive monitoring program is required.

The acoustic Doppler range used enables the user to perform a range of monitoring techniques with the following methods defined:

- Instantaneous point velocity measurement;
- Continuous point velocity measurement;
- Instantaneous velocity measurements at a cross section;
- Continuous velocity measurements at a cross section;
- Bathymetry and velocity mapping of a channel reach.

There are continuous developments being achieved with both technology and methodology for the application in catchment hydrology. Acoustic Doppler technology will have a much larger role in the science and management of catchment hydrology in the future.

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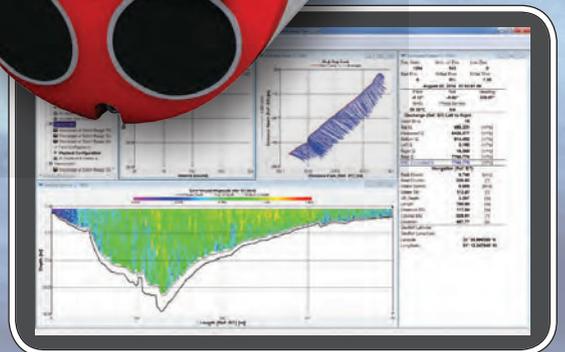
Removing Tidal Aliasing in Estuarine Discharge Data; The Big Reveal

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Paper presented to 18th Australian Hydrographers Association Conference Canberra. 24-27 October 2016.

Abstract

A major waterworks in South Malaysia draws its source water from the lower reaches of the Johor River. During high tides and in dry seasons, a salt water wedge pushes far enough upstream, causing saline raw water to affect water supply operations. A dam was constructed such that the upstream water could be regulated and selectively released to manage this issue, however with the development of the surrounding area it was recognised that there was a need to have a better understanding of the existing baseline flows along the major rivers. An expected outcome of this study was to determine travel times of released dam water to the water works in order to optimise dam operations.

A series of gauging stations was established along the river which measured water level and velocity. The peak discharge from the dam release was clearly tracked through the first two stations. The third station was affected by tidal flux and as such the movement of the peak discharge was effectively masked. This paper looks at the methods employed to collect the information as well as the subsequent analysis of the data to assist the operation of the dam and waterworks. In particular, the use of a low pass digital filter to remove tidal aliasing is demonstrated and a broader context comment on the handling of discharge data subjected to tidal influences is discussed referencing current USGS policy.

1. Introduction

A major waterworks in South Malaysia draws its source water from the lower reaches of the Johor River. During high tides and in dry seasons, a salt water wedge pushes far enough upstream, causing saline raw water to affect water supply operations. An upstream dam selectively releases water to manage this issue, however with continued development of the surrounding area and pressures on water use there was a need to have a better understanding of the existing baseline flows along the major rivers. One expected outcome was to determine travel times of released dam water to the water works in order to optimise dam operations.

Discharge was continuously measured at three points between the dam and the water intake for a period of three months. The dam releases were clearly seen in the upstream two station hydrographs. However, the third station was affected by tidal flux and as such the movement of the peak discharge was effectively masked. This prompted research into removing the tidal flux from time series discharge data using numerical filters.

There exists a lot of literature on the use of filters in oceanographic applications where they are often required to remove background sea-level fluctuations to isolate the effects of tsunamis and storm surges. The term "de-tided" refers to records from which tide components have been removed.

Their use in tidally affected river discharge data is less prolific.

Fortunately, in 2010, the United States Geological Survey (USGS) had recognised that there was an increasing amount of coastal discharge data being collected and that they had no comprehensive policy to guide the handling of data subjected to tidal influences. They subsequently published a technical memorandum (Office of Surface Water Technical Memorandum No 2010.08) which described the process for classifying time series discharge data as tidally affected as well as the methodology for its processing and archiving. Of particular interest was the prescribed use of a Godin Low Pass Filtering program to remove tidal influence. The use of this filter is the basis for this paper.

2. Measurement stations

Three stations were established in 2010 to report continuous discharge along the river from the reservoir to the water intake.
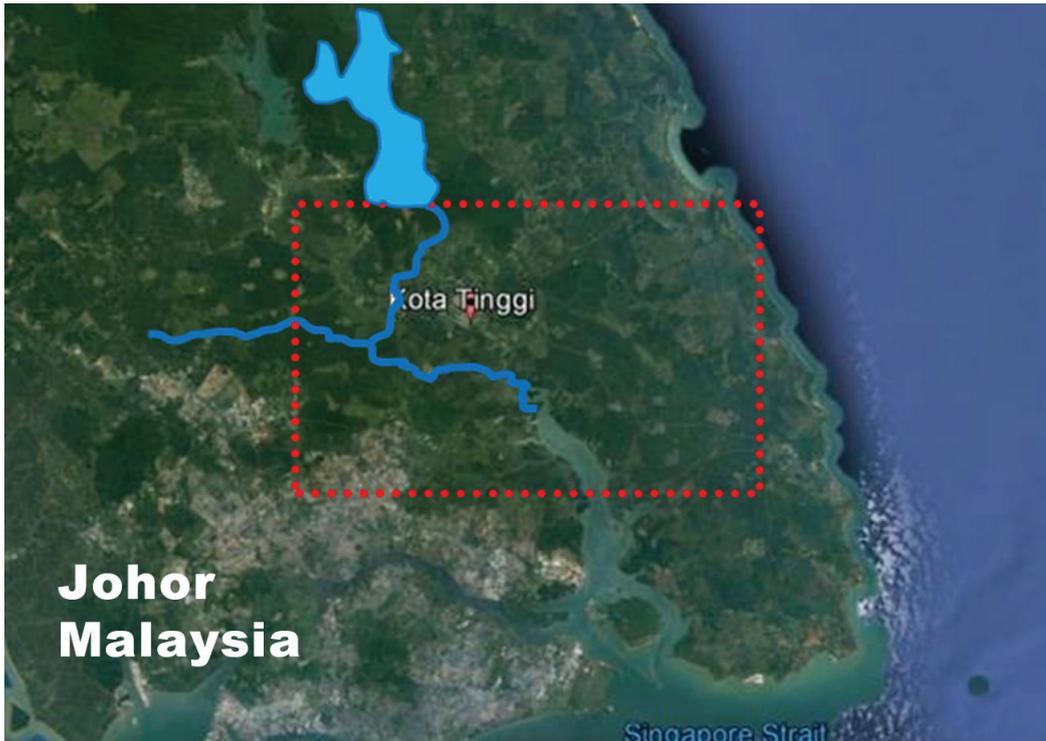
Image 1: Area location.

Image 2: Distances to stations.

Image 3: Station 1. Approximately 20 m wide.

Image 4: Station 2. Approximately 30 m wide.

Image 5: Station 3. Approximately 40 m wide.

The station commissioning was undertaken using the below typical sequence:

1. Site investigation and selection.
2. Installation of Side Looking Level/Velocity Sensor on pole.
3. Measurement of station cross section to develop level to area rating table.
4. Discharge measurements during normal flow and planned releases from dam to develop velocity index.
5. Monthly maintenance and data download.

Installed instrumentation photos are provided below (Image 6).

Image 6.1: Station installation.
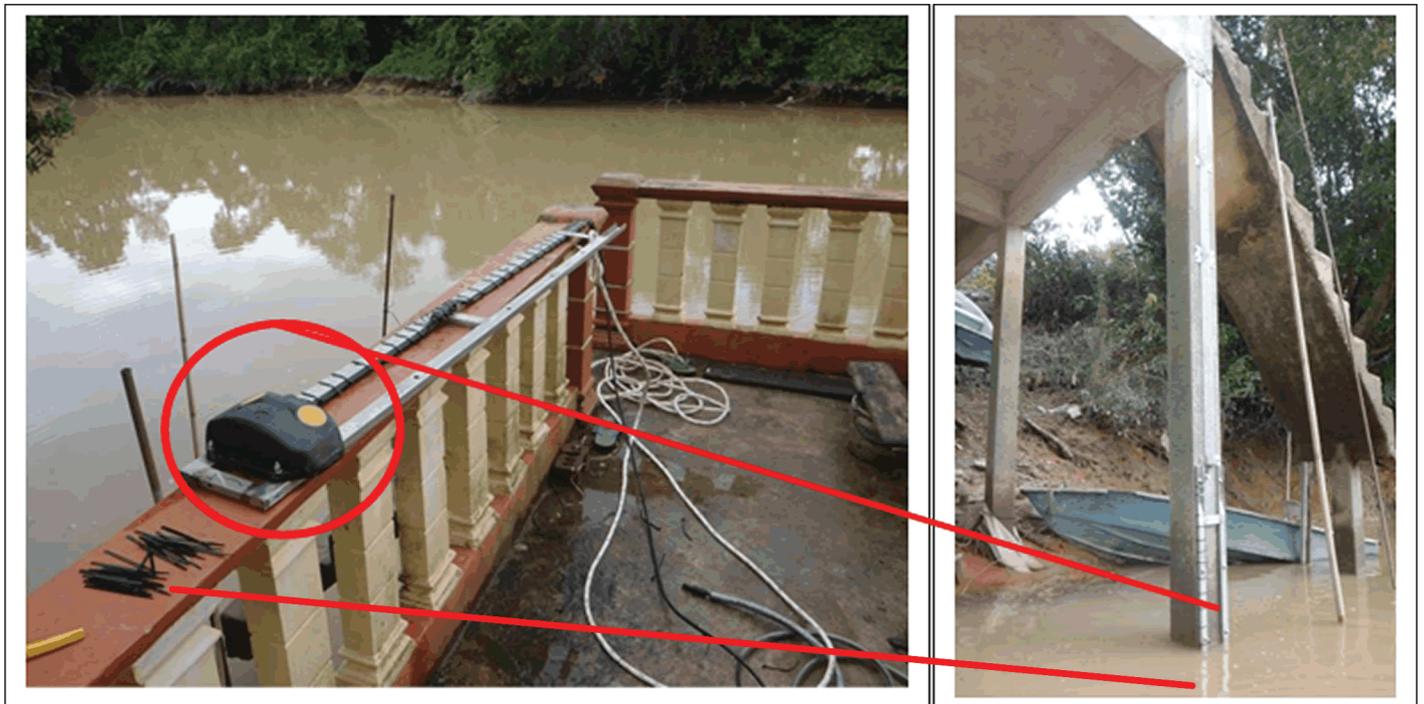
Image 6.2: Side looking Acoustic Doppler current meter measuring stage and velocity.

3. Collected Data

Data was collected from the three locations as detailed below:

Station 1

HYPLOT V130 Output 25/06/2010

Period 48 Day   Plot Start00:00_26/04/2010   2010
Interval2 Hour   Plot End 00:00_13/06/2010
Site   SG_LINGGIU Sungai Linggiu, Upstream of Road Bridge
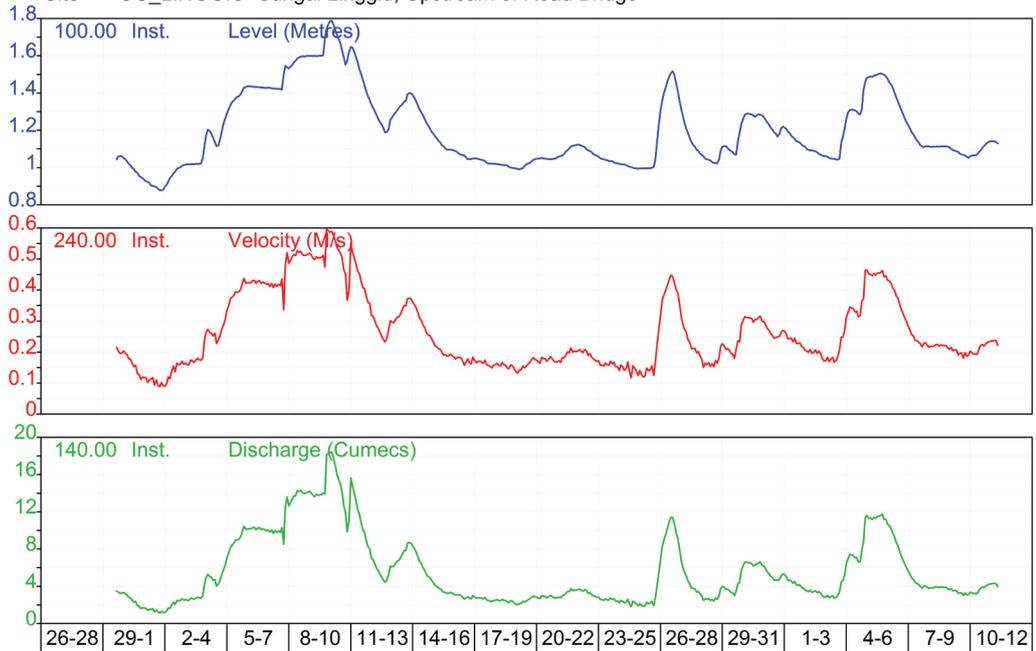
Station 1

HYPLOTXY V93 Output 16/06/2010

Axis	Transform	Site	Type		Variable
X (ind)	(None)	SG_LINGGIU	Inst.	100.00	Level (Metres)
Y (dep)	(None)	SG_LINGGIU	Inst.	140.00	Discharge (Cumecs)
Interval	2 Minute		Equation		Y = 18.621 * X - 16.754
Start	00:00_20/04/2010		Correlation Coefficient		0.985
End	00:00_12/06/2010		Standard Error of Estimate	0.640	
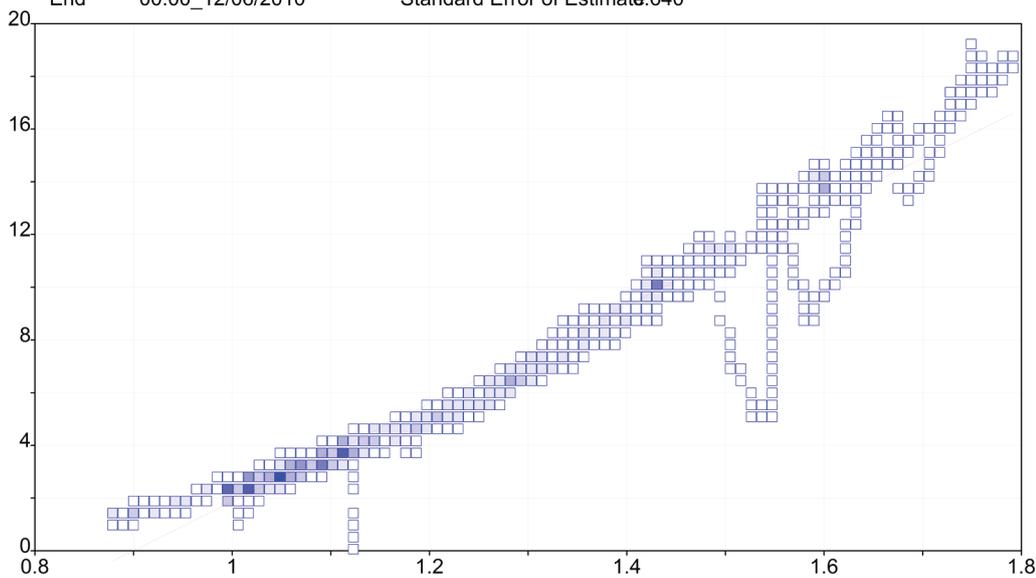
Good stage to discharge relationship. Dips in rating attributed to build up of debris on downstream bridge which was subsequently washed away. This was confirmed through with onsite observation.
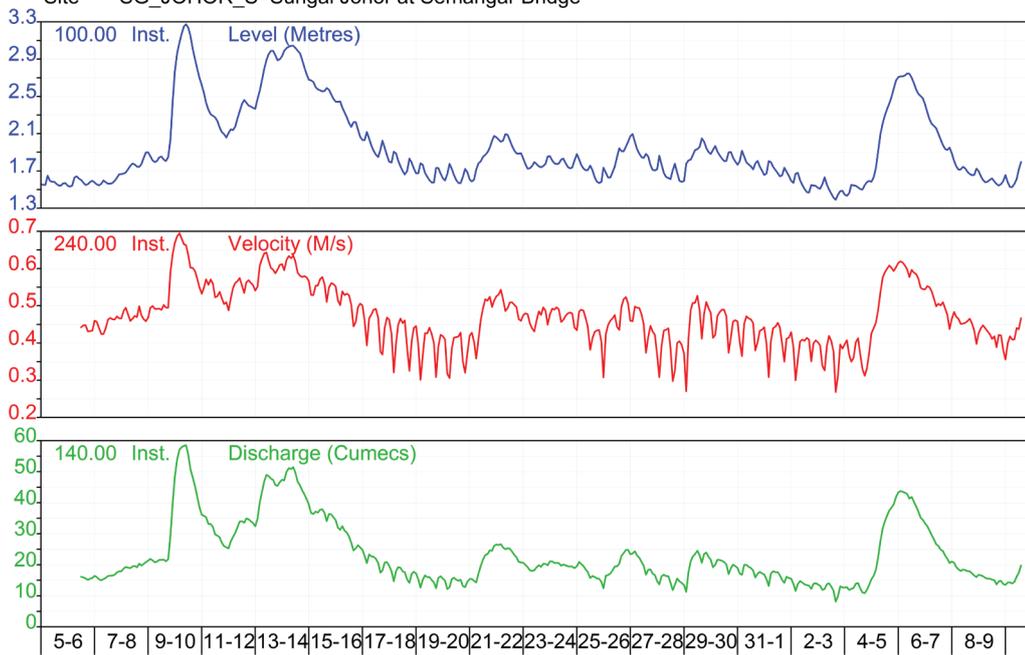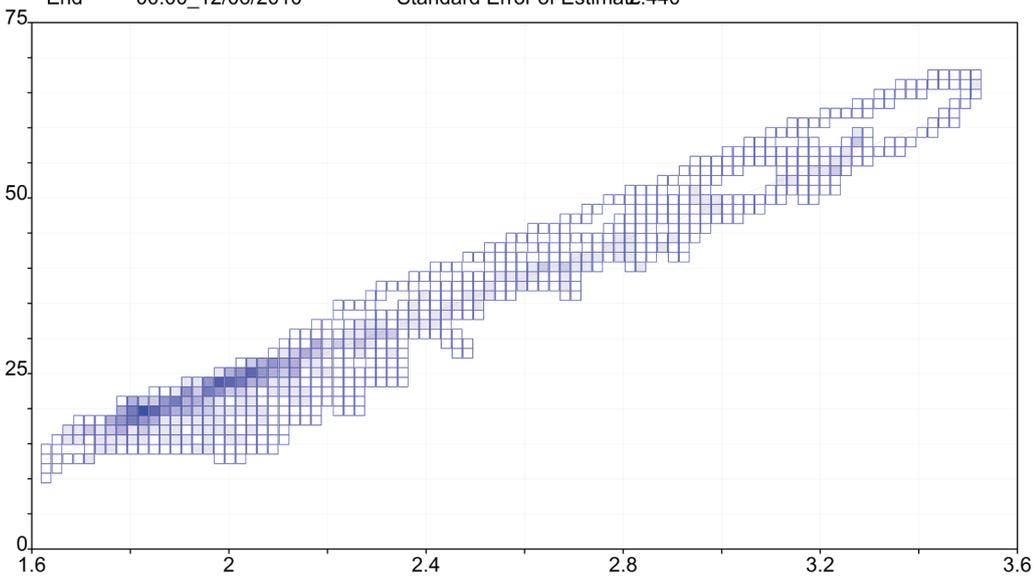
Station 2

Period 37 Day   Plot Start 00:00_05/05/2010   2010
Interval 2 Hour   Plot End 00:00_11/06/2010
Site   SG_JOHOR_S Sungai Johor at Semangar Bridge

Station 2

Axis	Transform	Site	Type		Variable
X (ind)	(None)	SG_JOHOR_S	Inst.	100.00	Level (Metres)
Y (dep)	(None)	SG_JOHOR_S	Inst.	140.00	Discharge (Cumecs)
Interval	2 Minute		Equation		Y = 26.742 * X - 30.831
Start	00:00_20/04/2010		Correlation Coefficient	0.977	
End	00:00_12/06/2010		Standard Error of Estimate	2.440	

Station 2 was the middle station but exhibited tidal affects to the stage and discharge data during periods of low base flows. The tidal influence is quite significant and surprising given this station was a significant distance inland from the coast.

Station 3

Period 42 Day   Plot Start 00:00_30/04/2010   2010
Interval 2 Hour   Plot End 00:00_11/06/2010
Site   SG_JOHOR_P   Sungai Johor upstream of PUB Intake

Station 3

Axis	Transform	Site	Type	Variable
X (ind)	(None)	SG_JOHOR_P	Inst.	100.00 Level (Metres)
Y (dep)	(None)	SG_JOHOR_P	Inst.	140.00 Discharge (Cumecs)
Interval	2 Minute		Equation	Y = -24.527 * X + 128.038
Start	00:00_20/04/2010		Correlation Coefficient	-0.279
End	00:00_12/06/2010		Standard Error of Estimate	58.286
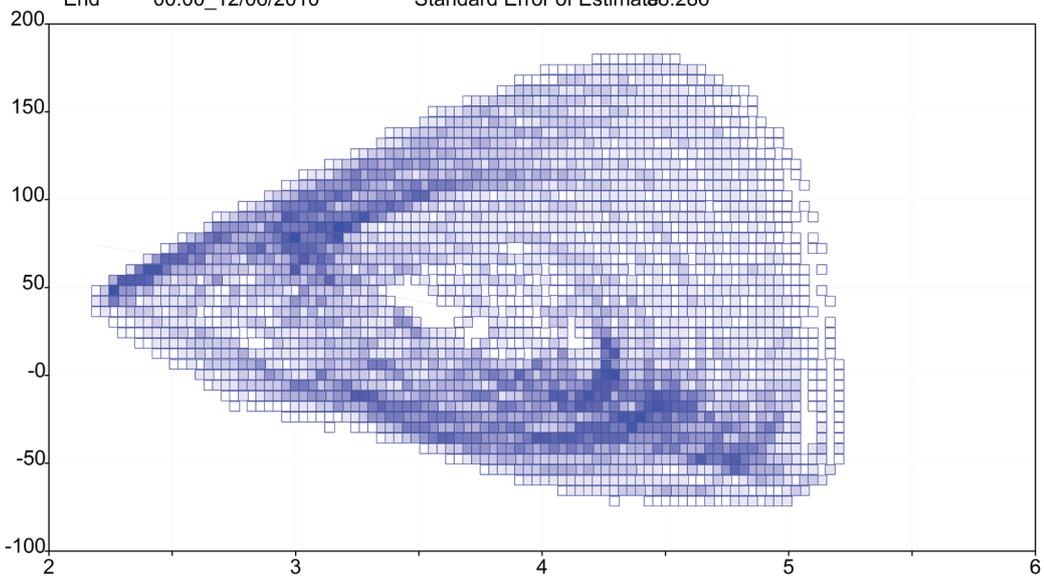
Station 3 was located just upstream of the water intake point. The discharge data is heavily tidally influenced. The releases from the dam are effectively masked and cannot be discerned from the hydrograph.

4. The USGS perspective

As mentioned, the USGS recognised that there was an increasing amount of coastal discharge data being collected and they required a documented policy to identify, process and archive tidally influenced discharge data. They subsequently released the document: USGS Office of Surface Water Technical Memorandum No 2010.08 *Processing and Publication of Discharge and Stage Data Collected in Tidally-Influenced Areas.*

The primary issue that was addressed in the released document relates to a phenomenon called tidal aliasing. "The solar day computation interval (24 hours) used by Automated Data Processing System (ADAPS) is less than a lunar day (24.84 hours) resulting in an apparent oscillation within the computed daily value time series that is unrelated to physical conditions or runoff events in the upstream basin" (USGS TM NO. 2010.08).

The document also recognises that "often the quantity of real interest to a user is net (or seaward) freshwater discharge or basin yield, and organisations are asked to present this quantity in data and interpretive publications. Net discharge cannot be determined from the maximum and minimum statistics nor, for reasons related to the aliasing issues described above, can it be inferred or determined from daily (24-hour) averaging. Thus, other approaches must be utilized. One way to obtain net flows is to remove the effects of tidal components through the application of a low-pass filter to the unit-value time series".

The key components of the process in the document are summarised below:

1. The required processing and publication of tidal data will depend on the appropriate classification of the data-collection site. Sound hydrologic judgment will be needed to classify sites as (a) affected significantly by tides, (b) not affected significantly by tides, or (c) indeterminate. A decision tree diagram and a program that produces statistics and graphical plots are provided (in Appendix C) to help make that decision.

2. The publication of 24-hour means for discharge at sites influenced significantly by tidal dynamics will no longer be allowed unless the data are first filtered to remove tide signals.

3. A Godin low-pass filtering program is provided to remove tidal signals from discharge records. The program does not filter stage data. The Godin filter is a good general-purpose filter, but any documented filter may be used to remove tidal signals from the discharge or stage data if the process and software are documented and archived properly, respectively.

USGS recommended filter tool details

The filter tool used by the USGS for tidally affected discharge data is the *Godin Filter (Godin, 1972)*. This is used for filtering the tidal influence out of water data. This filter resamples the data series to hourly increments, and then applies three passes (from USGS TM NO. 2010.08):

1. 12-1-11 hour moving average, using a 24-hour span with the averaged value written back to the 13th point of the span.

2. The second pass takes the output of the first and applies an 11-1-12 hour moving average, using a 24 hour span with the averaged value written back to the 12th point of the span.

3. The third pass is a 12-1-12 hour moving average, using a 25 hour span with the averaged value written back to the 13th point of the span.

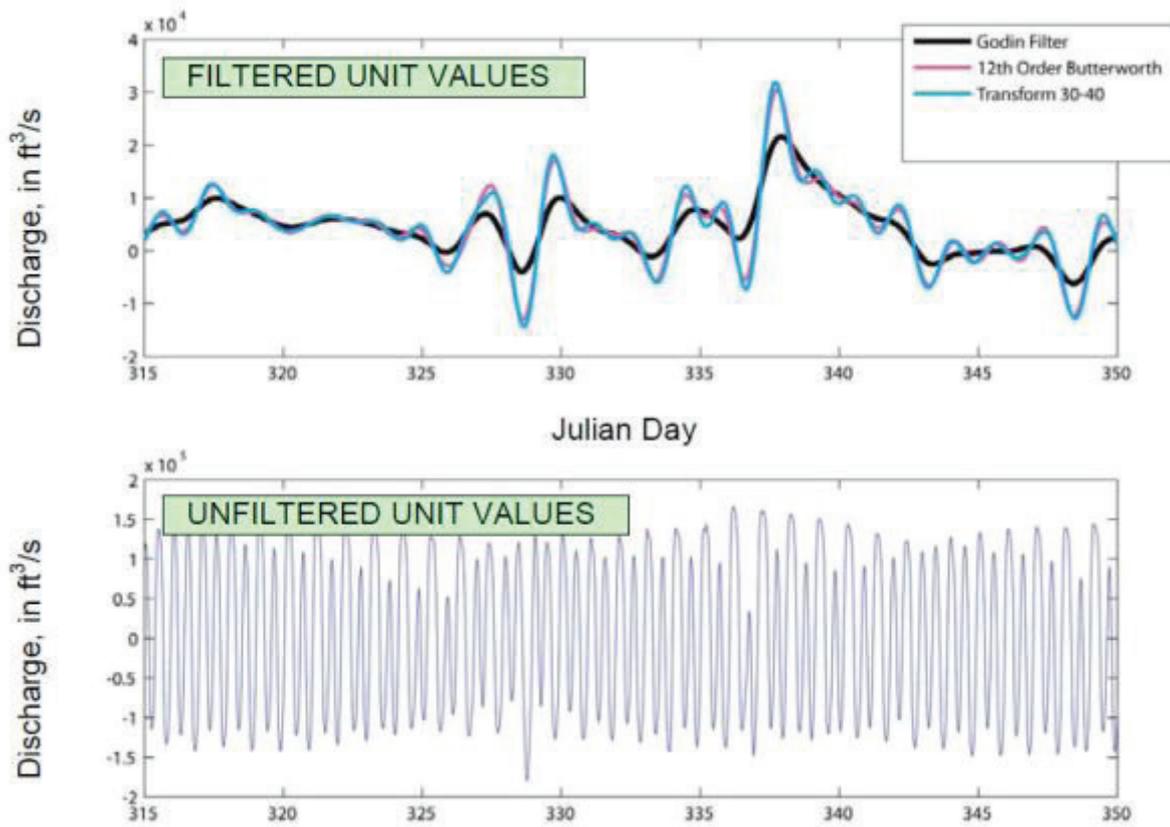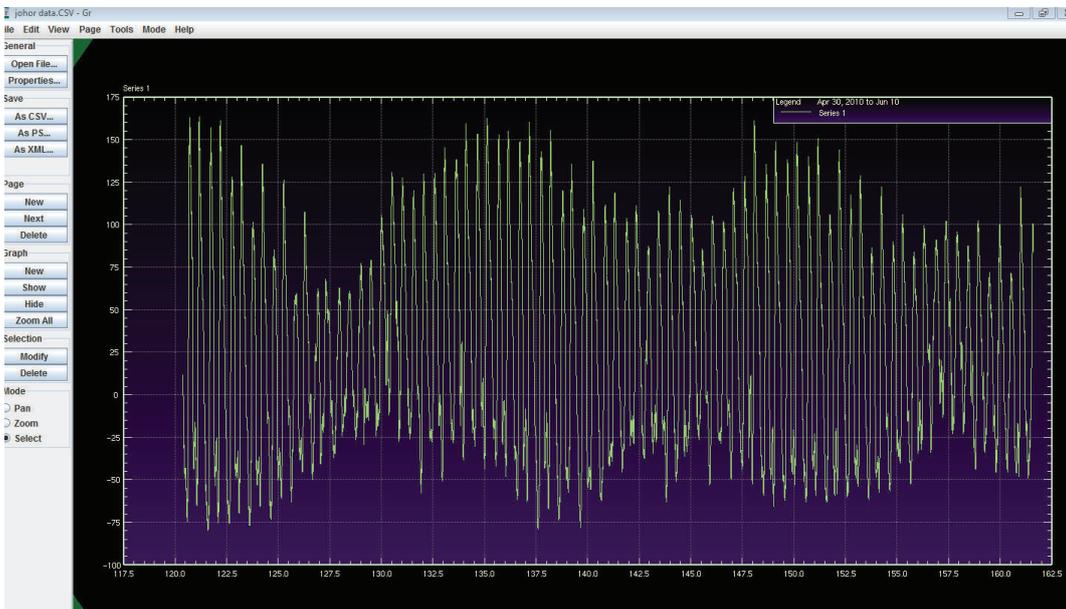Approximately 1.5 days of data will be deleted from both ends of the data series.

Image 7: Sample of Dataset showing unfiltered and filtered data values.

5. Application of the Low Pass Filter

The filtering program that applies the Godin filter as described in Section 4 was used for the discharge data collected at Station 3.

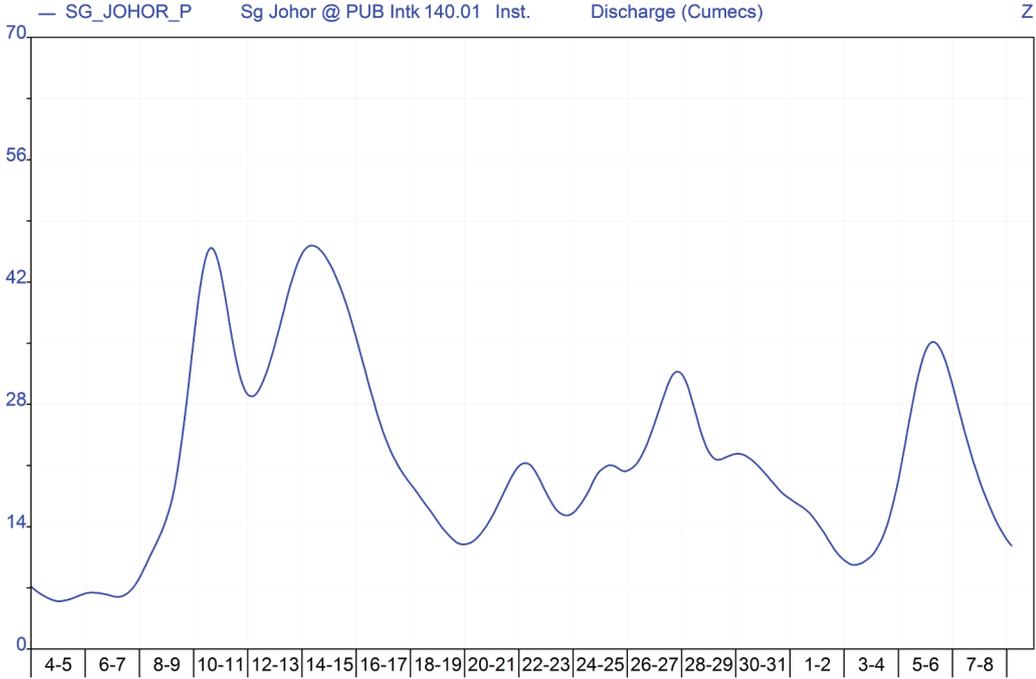## Input Discharge Data from Station 3

Resultant Data after application of Low Pass Filter

Station 3

HYPLOT V130 Output 24/12/2010

Period 37 Day Plot Start 00:00_04/05/2010   2010
Interval 2 Hour Plot End 00:00_10/06/2010

— SG_JOHOR_P   Sg Johor @ PUB Intk 140.01 Inst.   Discharge (Cumecs)   Z

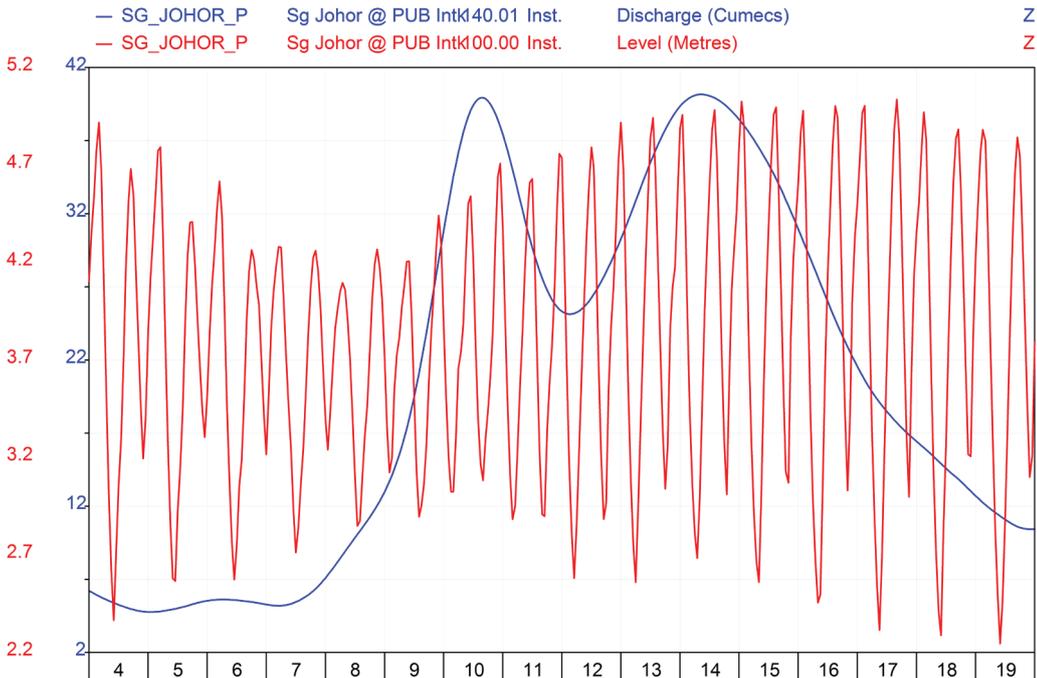## Station 3: Stage versus Filtered Discharge Plot

HYPLOT   V130   Output   24/12/2010

Station 3

HYPLOT V130 Output 24/12/2010

Period 16 Day Plot Start 00:00_04/05/2010   2010
Interval 1 Hour Plot End 00:00_20/05/2010

— SG_JOHOR_P   Sg Johor @ PUB Intk 140.01 Inst.   Discharge (Cumecs)   Z
— SG_JOHOR_P   Sg Johor @ PUB Intk 100.00 Inst.   Level (Metres)   Z

Discharge Comparison between Downstream and Upstream Stations   HYPLOT V130 Output 24/12/2010

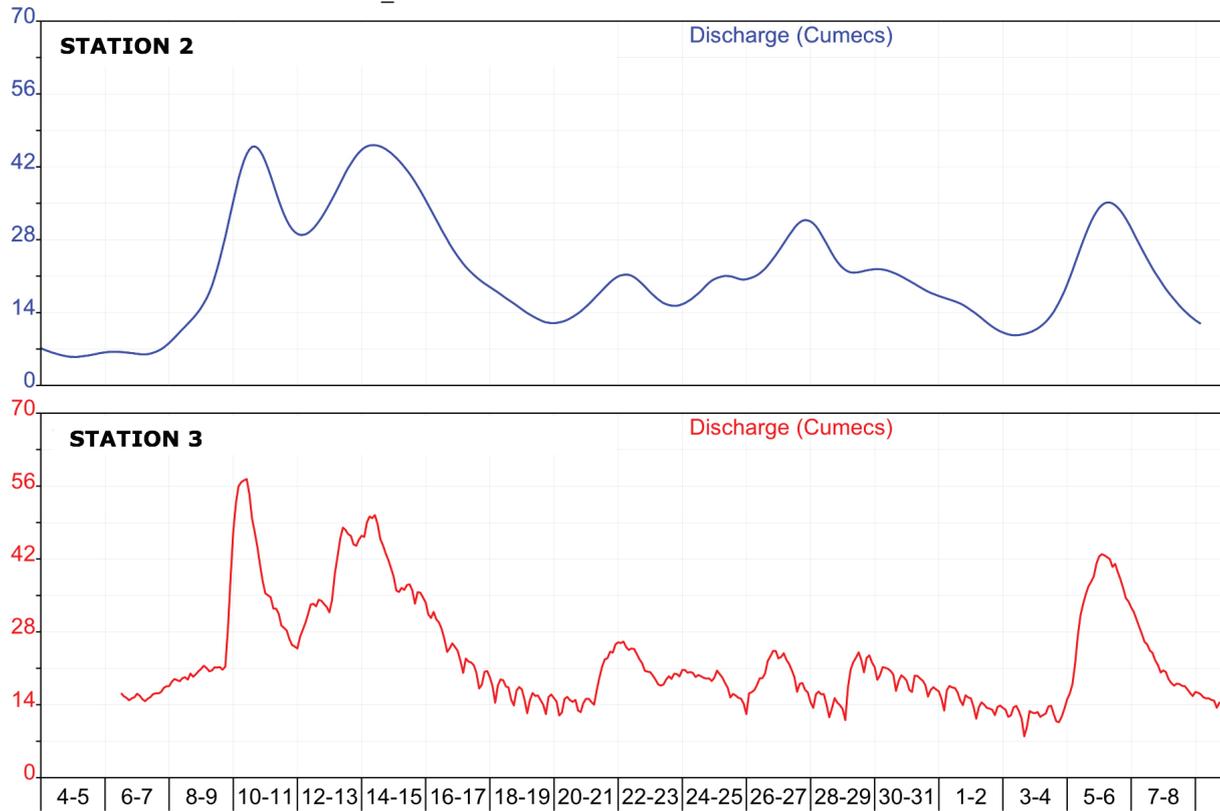Period   37 Day   Plot Start 00:00_04/05/2010   2010
Interval 2 Hour   Plot End   00:00_10/06/2010

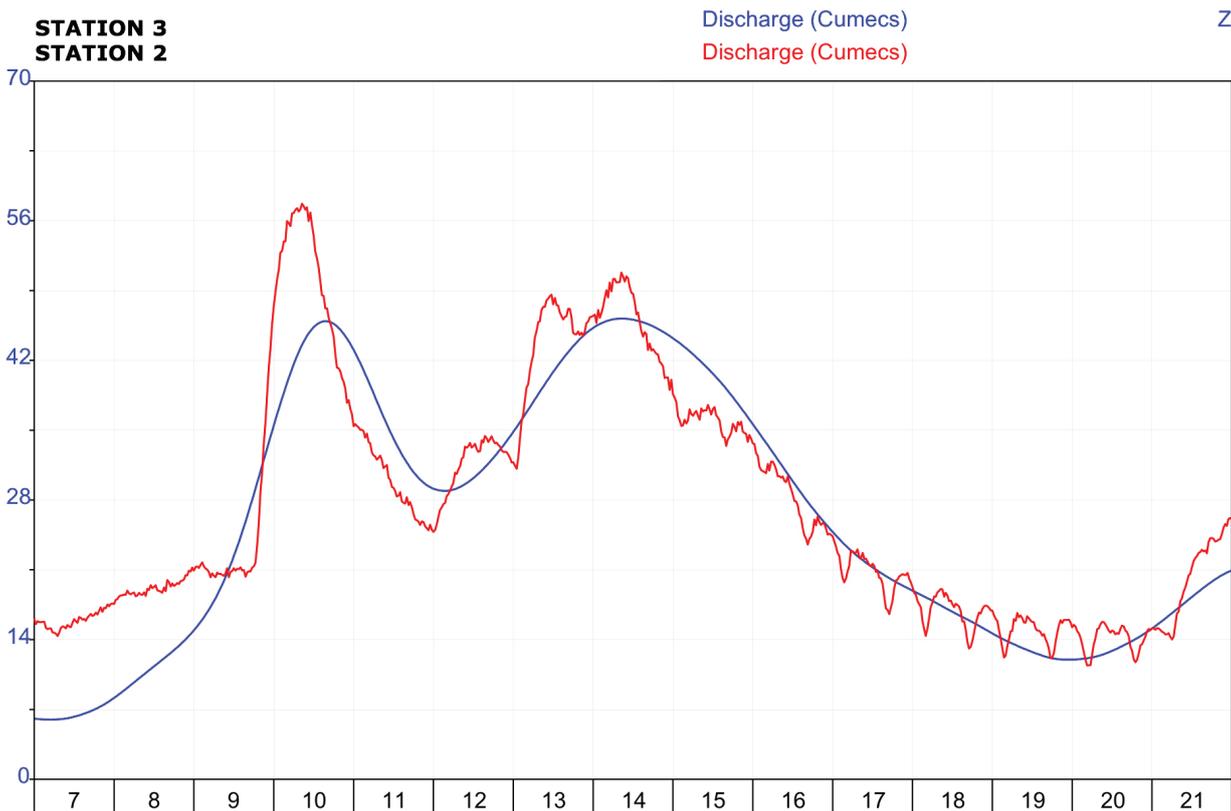Discharge Comparison between Downstream and Upstream Stations during dam release

Period   15 Day   Plot Start 00:00_07/05/2010   2010
Interval 30 Minute Plot End   00:00_22/05/2010

6. Conclusions

As more coastal discharge is collected it is important to understand the impacts of tidal influences both obvious and not so obvious as well as techniques that can be used to make data sets more meaningful.

In the case above, the travel time of the peak release from the dam was able to be determined from the filtered data. Using the "raw" discharge data this would not have been possible at all.
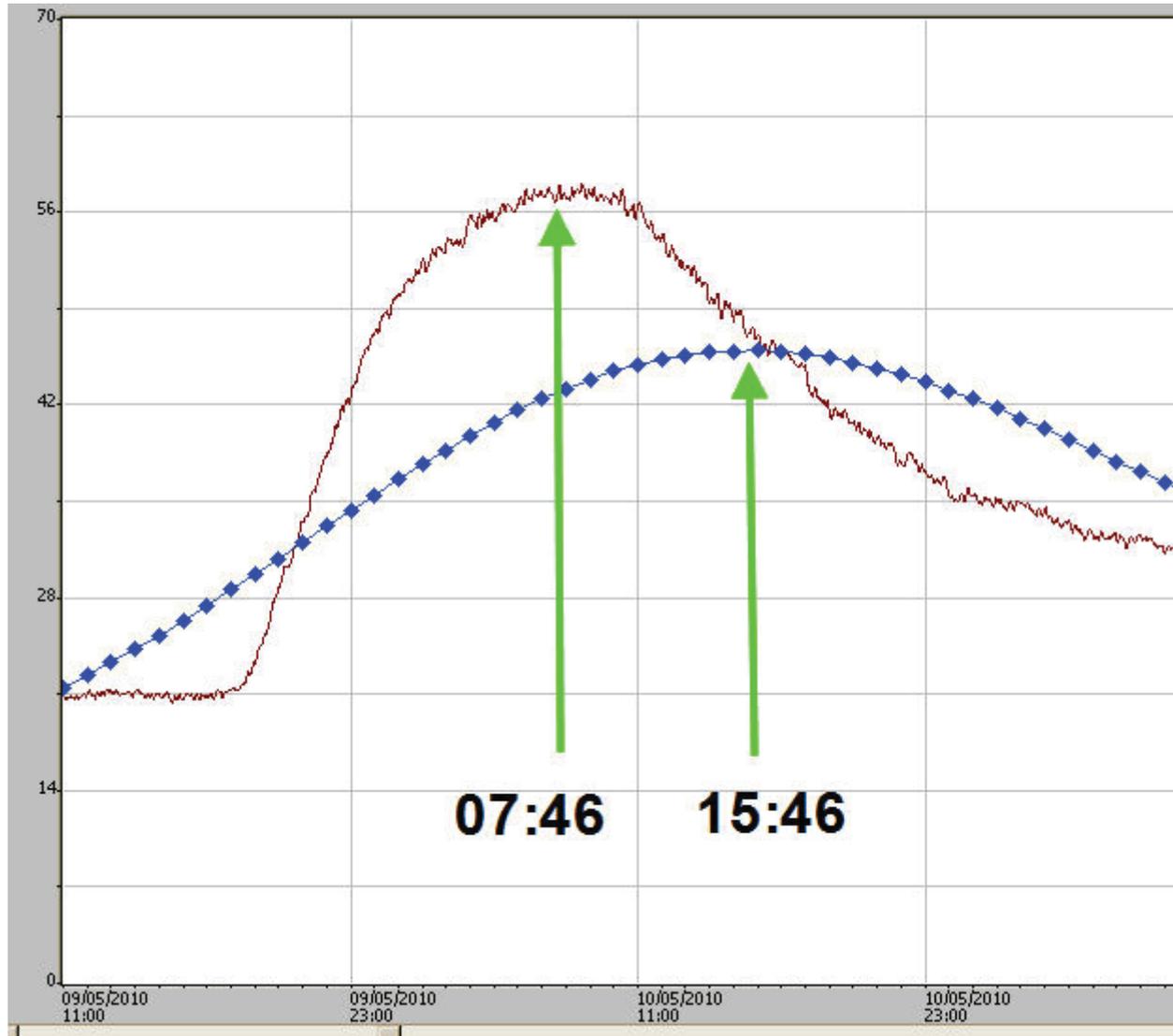
Travel time from Station 2 to Station 3: Approximately 8 hours.

7. Acknowledgement

The author acknowledges Greenspan Technology Pty Ltd for the support and authorisation to publish photos and plots as part of this paper.

8. References

USGS Office of Surface Water Technical Memorandum No. 2010.0: *Processing and Publication of Discharge and Stage Data Collected in Tidally-Influenced Areas* August 27, 2010 (revised September 22, 2011).

Godin, G., 1972, *The Analysis of Tides*, University of Toronto Press, Buffalo.

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