2020 DIGITAL FLOODPLAIN MANAGEMENT AUSTRALIA NATIONAL CONFERENCE

A Flood Resilient Australia: transforming vision into action

PROGRAM & ABSTRACT BOOK

Wednesday 20th and Thursday 21st May 2020

www.floodplainconference.com

FMA FLOODPLAIN MANAGEMENT AUSTRALIA

TOOWOOMBA REGION

HOSTED BY

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Contents

Welcome from Floodplain Management Australia

Since 1961 Floodplain Management Australia (FMA) has served the interests of Local Government Councils, floodplain management authorities, government agencies, consultants, businesses and other professionals involved in the important work of managing Australia's flood risks.

The highlight of each year is the National Conference, and this year we were scheduled to travel to Toowoomba in the nation's north to convene our annual event. However, as this is no longer possible we have made the decision with the support of our Members and presenters to transition the Conference to an online platform. Throughout this challenging and difficult time, we felt it was imperative to still offer you the key learnings so important to the professional development of our Members, and provide a means for us to get together, even though we can't be in Toowoomba.

While this Conference may feel somewhat different to usual, it still retains much of our planned in-person program, with Live Stream Presentations incorporating Q&A Sessions, and Pre-Recorded Narrated Presentations covering an array of informative FRM topics.

I wish to thank the many people who have contributed to the success of this event, especially Toowoomba Regional Council representatives, the Steering Committee members, the National Conference Program Advisory Committee, presenters, sponsors and supporters, and East Coast Conferences' staff who have worked over the last 18 months to ensure that this Conference delivers the very best in contemporary flood risk management.

On behalf of FMA, it is my great pleasure to welcome you to our first ever Digital Conference, to join virtually with colleagues from across Australia and also overseas in discussion, debate and policy development to help reduce the risks and impact of flooding in our communities.

And if you or your organisation are not yet an FMA Member, please visit **floods.org.au/membership** to find out more about joining Australia's leading network of flood professionals.

Kind regards

Ian Dinham
President
Floodplain Management Australia

Floodplain Management Australia

Floodplain Management Australia (FMA) is committed to promoting wise floodplain development and helping reduce the risks of flooding to life and property.

FMA was established after the disastrous NSW floods of the 1950s to support and promote best practice in floodplain management. We have grown to be a network of trusted flood professionals dedicated to working with all states and territories to raise flood awareness and the priority of flooding.

Our membership includes over 160 Local Government Councils, catchment authorities, government agencies, consultants, businesses and individuals involved in flood risk management in NSW, Queensland, Victoria, ACT, Tasmania, South Australia and the USA.

We promote wise land use planning principles which proactively guide appropriate development in floodplain areas. We support programs which manage flood risks and the impacts of flooding, to reduce private and public flood losses.

We represent Members' interests at State and Commonwealth government levels, promote public awareness of flood issues, support flood education programs and improve the knowledge and skills of floodplain management practitioners.

We provide opportunities for continuing professional development throughout the industry at FMA Meetings and Workshops, training courses and the annual FMA Conference.

In 2009, in partnership with the NSW Office of Environment and Heritage and the University of Technology Sydney, we initiated Australia's only industry based flood risk management course tailored to the needs of technical and land use planning staff and elected Council representatives. The course is continually evolving, and the material is applicable Australia wide.

If you or your organisation are not yet a Member, please talk to the FMA team about the benefits.

find us online + stay connected

floods.org.au

Young Floodplain Managers
Floodplain Management Australia

The FMA Young Floodplain Managers (YFM) network exists to represent, engage, and inspire young floodplain management professionals across Australia.

The objectives of the YFM are to:

- collaborate and share knowledge through networking opportunities, mentorships with industry leaders, professional development workshops and events, and social media platforms and forums where YFMs can discuss key issues and share innovative ideas
- inspire and empower YFMs to share new ideas and engage in industry discussions
- connect YFMs from across the public and private sectors as well as other young professional groups; and
- promote gender equality and diversity in all YFM activities and the broader industry.

Any floodplain manager is welcome to apply if committed to the objectives of the YFM. Whilst the YFM's mission is to represent, engage, support and inspire young floodplain management professionals across the nation, anyone who supports this objective is welcome to apply for membership of the YFM and engage in the group's actions, irrespective of their age or level of experience.

You can find out more about the network at **floods.org.au/yfm**

Sponsors and Supporters

Without the valuable support of our sponsors and exhibitors it would be impossible to hold the Floodplain Management Australia National Conferences. We would like to take this opportunity to thank all our sponsors, past and present, for their support.

We would also like to acknowledge the continuing support of the sponsors and exhibitors who have confirmed for the 2021 FMA National Conference in Sydney.

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For technical support throughout the online conference please contact:

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Tim Bolger
Bax Audio Visual
M | 0478 881 455|
P (02) 4322 1455 |
E av@baxav.com.au

Delegate Support:
Michael Blyde
Bax Audio Visual
Ph: 02 6441 8801

General Information

Conference Managers
Please direct any enquiries to the 2020 Digital Floodplain Management Australia National Conference Managers:

East Coast Conferences

Amy McIntosh, Jayne Hindle, Jasmine Durbidge
M: 0408 220 188 T: (02) 6650 9800
E: amy@eastcoastconferences.com.au
www.eastcoastconferences.com.au
ABN: 56 515 955 798

Website and Conference Papers
Following the conference, copies of full papers where they have been provided by the authors will be available in the Members' Section of the FMA website www.floods.org.au for 12 months and will then be available in the public section of the FMA website.

The information, opinions and recommendations contained in conference papers and presentations are those of the authors, and are not necessarily endorsed by Floodplain Management Australia (FMA). FMA makes no claims as to the accuracy of information contained in conference papers and presentations. Readers must excise their own judgement as to the suitability of the material for their purposes, and should contact the authors if clarification is required.

For further information on any particular paper or presentation, please contact the author/presenter directly.

CONFERENCE PROGRAM

(correct at 17/05/2020)

Wednesday 20th May 2020	
	Live Presentations with Q & A
10.00am	**MC Welcome & Acknowledgment of Country, Gerry Gannon**
10.05am	**Welcome from Floodplain Management Australia** **Ian Dinham**, President, Floodplain Management Australia
10.15am	**Welcome from Toowoomba Regional Council** **Mayor Paul Antonio,** Toowoomba Regional Council
10.25am	**MC updates on How the Day will run, Gerry Gannon**
10.30am	**Session Sponsored by "Queensland Reconstruction Authority"** Delivering on the Brisbane River Strategic Floodplain Management Plan **Graeme Milligan,** Queensland Reconstruction Authority Q&A Session
11.00am	Working Together for the Best Possible Flood Warnings in Queensland **Graeme Milligan,** Queensland Reconstruction Authority Q&A Session
11.30am	How Much is It Worth? Economic Values for Floodplain Management **Rhys Thomson,** Rhelm Q&A Session
12.00pm	Real-time Flood Forecasting and Dam Operations for the Ross River **Phillip Jordan,** HARC Q&A Session
12.30pm	The Only Way Is Up – Flood Evacuation in Parramatta CBD **Josh Nadiroglu,** BG&E Q&A Session
1.00pm – 2.00pm	**Lunch Break**
2.00pm	Young Floodplain Managers Address **Josh Eggleton,** Young Floodplain Managers Committee
2.15pm	TC Debbie Flood Studies - Lessons Learnt **Robyn Birkett,** Mackay Regional Council Short Q&A Session
2.30pm	AI Flash Flood Alert System **Timothy Kallady,** Piccard AI, **Paul Rasmussen,** Melbourne Water Q&A Session
3.00pm	Saving Lives from Floods **Shayne Baker & Adrian Mayhew,** International Life Saving Federation (ILS)

	Q&A Session
3.30pm	Don't Get in a Bog with Your RoG **Ben Tate,** Water Technology Q&A Session
4.00pm	**CLOSE OF DAY ONE LIVE PRESENTATIONS** **PRE RECORDED PRESENTATIONS AVAILABLE FROM 10.30AM WEDNESDAY – 11.59PM FRIDAY**
5.25pm	**YFM Virtual Trivia Social Event**

Thursday 21st May 2020	
	Live Presentations with Q & A
10.00am	**MC Welcome, Gerry Gannon**
10.05am	**FMA Conference 2021 Presentation** **Glenn Evans**, Executive Officer, Floodplain Management Australia, **Dominique Jovanovic**, Project and Services Manager, Floodplain Management Australia
10.15am	Flood Mitigation on Large Scale Infrastructure – Challenges and a Way Forward **Ben Mason,** Jacobs Short Q&A Session
10.30am	Time Out – Flood Emergency Response for a Major Sports Venue **Steven Molino,** Molino Stewart Q&A Session
11.00am	Purchase or Move? Lessons Learnt from Historic Property-based Floodplain Management Schemes **Alana Mosely** Q&A Session
11.30am	Hunter Valley Flood Mitigation Scheme – Wallalong Levee, Aberdeen Levee and Wallis Creek Floodgates Upgrade Works **Ben Patterson,** Royal HaskoningDHV Q&A Session
12.00pm	Raising Warragamba Dam: A Contingent Valuation Study of Flood Mitigation Versus Conservation **Joel Dalberger** Q&A Session
12.30pm	Both Flood and Community Engagement Specialists Working Together for Flood-informed Communities **Stephen Yeo,** Infrastructure NSW, **Holly Langler,** Infrastructure NSW Q&A Session
1.00pm – 2.00pm	**Lunch Break**

2.00pm	Towards Zero Lives Lost Using Ensemble Flood Forecasts **Adam Smith,** Bureau of Meteorology Q&A Session
2.30pm	Planes, Trains and Automalls – A Dutch Innovation for Climate Change in Brisbane **David Cox,** SMEC Q&A Session
2.55pm	Conference Wrap Up
	CLOSE OF DAY TWO LIVE PRESENTATIONS **PRE RECORDED PRESENTATIONS AVAILABLE FROM 10.30AM WEDNESDAY – 11.59PM FRIDAY**

Pre-Recorded FMA Online Presentations

Non-Worsening Criteria: When Best Practice Isn't Resilient
Laurence Allan, Allan & Dennis

Ross River Dam, February 2019 – Successful Mitigation of Five Larger Peak Flows
Teegan Burke, BMT

Planning to Action: Enabling Communities to Manage Flood Risk.
Rebecca Dick, Department of Environment Land Water and Planning

Toowoomba's Evolution in Flood Modelling and Floodplain Management
Zita Dore, BMT

Resilient Queensland: Perspectives of Community and Flood Resilience from Bauple to Boulia
Steve Dredge, Queensland Reconstruction Authority

A Framework for Resilient Development on Floodplains
Mike Edwards, Department of Environment, Land, Water and Planning (VIC)

Using Flood Data for Strategic Purposes
Shaun Epe, NSW State Emergency Services

Compounding Flood Disasters
Andrew Gissing, Risk Frontiers

Development of a Best Practice Flood Warning System
Allan Herring, Brisbane City Council

A Flood Resilient Victoria: Using Technology to Provide Multiple Benefits
Kedar Kumthekar, Department of Environment, Land, Water and Planning

Tasmanian Statewide Strategic Flood Mapping: Challenges and Uncertainties
Audrey Lau, Tasmania SES

Strategic Management of Flood Risk for Communities
Duncan McLuckie, Department of Planning, Industry and Environment

A Flood Resilient Bruce Highway for North Queensland: Haughton River Floodplain Upgrade
Tina O'Connell, HDR Pty Ltd

Flooding Impacts of Regional Farm Dams on Lowes Creek Maryland Precinct Development
Maria Pinto, Camden Council

In-situ Soil Moisture Monitoring in South Australia to Improve Flash Flood Forecasts
Dinesh Ratnayake, University of South Australia

Flood Considerations for Road Managers
Danny Rose, Tweed Shire Council

ARR2019 Quirks and How to Deal with Them
Chris Ryan, Catchment Simulation Solutions, **Oscar Garratt,** Wollongong City of Innovation

The Assessment of Flood Vulnerability Using Socio-economic Indices
Alireza Sadeghi Pouya, Townsville City Council

Flood Emergency Planning for Disaster Resilience
Katelyn Samson, Australian Institute for Disaster Resilience

Lessons from SA's Largest Expansion of Flood Warning Services in 20 Years
Belinda Skilton, Department for Environment and Water

Back to Basics – Testing the Validity of Wollongong Local Guidance for ARR2019
Heath Sommerville, Rhelm

Storm Tide Inundation Modelling for Flood Database
Cara van Megchelen, Cardno, **Chris Scraggs,** Cardno

Innovative 3D Data Collection to Inform Farm Dam Failure Response Planning
Tania Wilson, South Australian State Emergency Service

Live Presentation Abstracts (Alphabetical by Presenting Author)

Saving Lives from Floods

S Baker[1], A Mayhew[1]
[1]International Life Saving Federation, Darling Heights, QLD

There are 360000 drownings every year identified by World Health Organisation (WHO) and this doesn't include non-disaster data. All indications suggest that the impact of increased and more intense weather events will increase the threat in the future. Another contributing concern is that with over 600 million people living less than 10 metres above sea level the expectation is that population will increase and be impacted by extreme storms. As such, the likelihood of aquatic disasters impacting communities and individuals will increase as will the potential for increased drownings.

There is no doubting the capacity of multi-agency response is strong in Higher Income Countries (HIC) as evidenced by the collaborative strategies with other agencies in the UK, USA and Europe. Locally we have the potential to call on and use the capability that exists with the thousands of Australians involved in lifesaving that is still yet to be developed fully.

At the recent World Conference on Drowning Prevention 2019 in Durban South Africa the presenters facilitated a pre-conference workshop for participants from several countries to learn and explore the four phases of flooding: planning and preparation; flash flooding; flood expansion and flood recovery.
The outcomes supported the need for working collaboratively with other agencies to enhance understanding and effective communication in an aquatic emergency. Lifesavers bring competencies in first aid and emergency care, aquatic rescue, use of rescue boats, radio communication, rescue and recovery with a genuine desire to prevent drowning.

There is an opportunity to develop strategies from Durban that can help inform and educate the wider community through lifesaving organisations and to develop lifesaver awareness as well as prepare active lifesavers to be able to respond in a flood emergency.

Irrespective of the amount of rescue services available, there will always be a requirement for more – let's explore.

TC Debbie Flood Studies – Lessons Learnt

R Birkett[1], T Corney[2]
[1]Mackay Regional Council, Mackay, QLD
[2]AECOM, Mackay, QLD

Several rural catchments in Mackay were significantly impacted by flooding from the Tropical Cyclone (TC) Debbie event in March 2017. Three flood studies have been completed for Sandy Creek, Rocky Dam Creek and Funnel Creek to understand the flood risk and improve planning, emergency management and disaster preparedness.

In these catchments, the flooding from TC Debbie was reported as being the worst flooding experienced in residents' living memory. The community provided valuable information on the flooding experienced during community surveys. Residents provided a variety of useful information including rainfall data, photos, videos and flood flow direction and depth. The information provided by residents was used to calibrate the models used in the flood study. Some of these levels/extents could be replicated however data quality limited matching in some areas.

The flood studies were prepared for council by engineering consultants AECOM using the latest Australian Rainfall and Runoff (ARR) guidelines. The TC Debbie event was found to be a rare to very rare event. Several lessons were learnt to guide future flood studies in rural areas. These include surveying all key hydraulic structures, new LiDAR with appropriate rigor relating to vegetation removal especially in high intensity agricultural areas, understanding cane density and the state of the cane (laying over or upright) at the time of or during the event and additional rainfall and river height gauges.

Planes, Trains and Automalls – A Dutch innovation for Climate Change in Brisbane

D Cox[1], I Varley[1]
[1]SMEC, Brisbane, QLD

In a world of rising sea levels and increased rainfall intensities we are starting to design for the future. SMEC was awarded the detailed design of Australia's first Automall precinct adjacent the Brisbane Airport with a racetrack designed by Mark Skaife and luxury car showrooms. The finished levels sit below external flooding and is influenced by three mechanisms including Coastal, Fluvial and Pluvial inundation. Over 4km of external roads and flood gates will protect the 50ha site from external flooding. The difficult question is, how high will the water get next to that new Holden or Porsche GT?

The complexities of the project have been further amplified by the adoption of the latest ARR19 methodologies including joint probability analysis, rainfall ensembles, pre-burst rainfall and designing for climate change. The design solution includes automated flood gates with multiple redundancies along with pumps to ensure strict design specification are met. This paper and presentation will examine several aspects of the design and explore the following key questions:

- Why wasn't the site filled above external flood levels like the Airport?
- How do you design a robust and redundant flood gate system that can't fail when you need it most?
- How do you design the internal site drainage to function in a closed system that is dictated by gate closures and trapped tailwaters?
- How do you deal with a sinking site due to settlement and rising flood levels due to climate change?
- What duration should pre-burst rainfall be applied?
- What is an appropriate design life considering we all be driving electric cars and scooters in 50 years?

The project is currently in tender phase after completion of the bulk earthworks and detailed design. The final construction will commence shortly.

References:
Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019

Raising Warragamba Dam: A Contingent Valuation Study of Flood Mitigation Versus Conservation

J Dalberger[1], S Hasan[2], J Smart[2]
[1]McGregor Coxall, Sydney, NSW
[2]Austrlian Rivers Institute at Griffith University, Nathan, QLD

At the core of many infrastructure projects is conflict between conservation of the natural environment and the economic benefits derived from infrastructure expansion to accommodate the needs of growing populations. This is highlighted in the case of Warragamba dam, where it is proposed to increase the height of the dam wall for flood mitigation in the downstream floodplain. While the proposed dam raising project will reduce flood risk in towns and urban growth centres of western Sydney, it will also result in negative impacts for areas upstream of the dam. This study implemented a two-way contingent valuation (CV) survey to investigate societal preferences and willingness to pay (WTP) for environmental and indigenous heritage conservation versus flood mitigation across a study area of greater Sydney. The study found 43% of respondents have a preference for raising the dam for flood mitigation, 47% hold a preference for alternate flood mitigation measures that retain the existing height of the dam, and 10% of respondents indicate “no preference / don’t care”. Based on the data obtained, a mean WTP of $23.60 per person per year was calculated for the respondents who had a preference for raising the dam, and $10.90 per person per year for those who had a preference for maintaining the existing height of the dam. The results show that these non-market valuations have strong influence on the cost benefit analysis previously completed, and published, for the proposed dam raising project. From an Integrated Water Management perspective seeking to balance social, environmental and economic outcomes, the study highlights a divided population, with an underlying discourse of individuals grappling with what can be categorised as a philosophically challenging question of personal and public safety from a rare flood event versus conservation of the environment and indigenous heritage sites for bequest and altruistic value.

Flood Words: How can we Communicate them more Effectively to the Public?

N Dufty[1]
[1]Molino Stewart Pty Ltd, Parramatta, NSW

'Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia' (Australian Institute for Disaster Resilience 2017, page 5) states that "public consultation is an important element of understanding and managing flood risk". To conduct consultation effectively with at-risk communities it is imperative that the technical words and concepts used by floodplain risk managers are communicated so that the public can understand and respond.

There has been a large amount of research in Australia and around the world into effective flood communication related to other parts of the disaster management cycle, particularly for early warning messaging. In comparison, the translation of technical terms for the 'mitigation' phase of the cycle is poorly researched.
Recent research has shown that even Australian floodplain risk managers have differing definitions of apparently simple terms such as 'floodwaters' and that it could be useful to have agreed national or state-wide non-technical definitions of these terms for public use.

This paper explores simple definitions of commonly used flood risk technical words and concepts that could support public consultations especially related to flood studies and floodplain management plans. It also identifies other ways of communicating technical terms including by using graphics (e.g. maps, photographs, diagrams), analogies and anecdotes.

The paper concludes with a discussion of ways to communicate technical flood risk terms in culturally and linguistically diverse (CALD) communities which are prevalent across flood prone areas of Australia's large cities.

References

Australian Institute for Disaster Resilience (2017) *Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*, Australian Disaster Resilience Handbook 7, Australian Government Attorney-General's Department.

Real-time Flood Forecasting and Dam Operations for the Ross River

P Jordan[1], J Woolley[1], D Stephens[1], A Astorquia[2], C Druery[3], Z Ahmed[2]
[1]HARC, Blackburn, VIC
[2]Townsville City Council, Townsville, QLD
[3]Advisian, Sydney, NSW

Townsville City Council (TCC) are the owners of Ross River Dam (RRD). RRD plays a significant role in the operational management of floods in the Townsville region, as a result of the gated spillway which enhances its flood mitigation potential. During a major flood, which occurred in January and February 2019, flood operations resulted in the peak inflow of 4,400 m^3/s being mitigated to a peak outflow less than 1,900 m^3/s (IGEM, 2019).

TCC are now fully responsible for determining gate operations to be undertaken during flood events. HARC and Advisian set up and commissioned a real-time flood operations system for RRD and the downstream Ross River floodplain. The flood operations system was implemented in waterRIDE™ and the RORB hydrological model. A customised version of RORB was created that implemented the specific gate-operations procedures for RRD, as set out in the RRD Emergency Action Plan.

Flood forecasts and operations are implemented completely in waterRIDE™, which:

- imports rainfall and river gauging data from TCC's real-time network,
- imports gridded 7-day rainfall forecasts from the Bureau of Meteorology,
- runs the RORB model, incorporating flood gate operations,
- ingests the RORB results into waterRIDE™,
- maps the forecast peak flood extents and depths on the Ross River flood-plain, downstream of RRD,
- automates reports of forecast road closures,
- automates reports of forecast properties flooded above floor level.

TCC staff were provided with practical training in the operation of the system, simulating the 2019 flood and three synthetic events. A separate incident management exercise was run, where TCC staff ran the forecasting system for a synthetic event and interacted with the Local Disaster Management Group.
This project demonstrated how a local government can be empowered, via appropriate tools and training, to manage the complicated flood situation downstream of a large gated dam.

References:
Queensland Inspector General of Emergency Management (IGEM) (2019) Monsoon Trough Rainfall and Flood Review, Report 3, Final, 15 July 2019.

AI Flash Flood Alert System

T Kallady[1], P Rasmussen[2]
[1]Piccard AI, Melbourne, VIC
[2]Melbourne Water, Melbourne, VIC

Flooding is the most expensive natural disaster in Australia. The vast majority of damage is caused by flash flooding in urban drainage networks.
Despite this, predictive flood warning systems are generally only available for riverine floods.

There are two main challenges that have prevented flash flood forecasting to date. The first is the rapid development of flash floods. In many cases storm events are short duration and high intensity, with flooding occurring shortly after rainfall, leaving insufficient time for developing forecasts and issuing warnings. The second challenge is the complex nature of urban catchments, which are very difficult to model accurately with traditional hydrological methods.

Piccard AI, in collaboration with Melbourne Water, have developed an innovative Artificial Intelligence based system to overcome these challenges and deliver real time flash flood forecasts and automated alerts 1-2 hours before the onset of flooding. The system incorporates the latest in BoM nowcasting and real time water level and rainfall monitoring, and continuously learns from previous events to improve its accuracy.

Tens of thousands of properties in Melbourne are at risk of flash flood, due to being built in areas developed prior to introduction of planning controls in 1975. As the catchment management authority for the Melbourne metropolitan area, Melbourne Water is responsible for mitigating the impacts of floods. In some cases, structural mitigation e.g. drainage upgrades will not work, or are prohibitively expensive. Authorities must rely on non-structural mitigation solutions such as flood warning systems.

Melbourne Water identifies flash flood warning as a crucial step in protecting communities, and commissioned a trial of the AI system at three key flood affected areas in Melbourne: Elwood Canal, Laburnum Station and Brushy Creek. The results to date have been very promising, the system has received positive feedback from councils and SES.

Flood mitigation on Large Scale Infrastructure – Challenges and a way Forward

B Mason[1], M South[1]
[1]Jacobs, Melbourne, VIC

The east coast of Australia is currently experiencing an unprecedented investment in road and rail infrastructure. This presents many challenges for flood practitioners who are engaged to assess the flood impacts of proposed infrastructure and cater for the many project requirements of the road and rail authorities. In turn, challenges are also faced by floodplain management authorities who are responsible for assessing and guiding large infrastructure projects into considering and catering for requirements associated with the management of their floodplains.

The current industry framework of bidding for tenders requires flood practitioners to take significant risks on what will be designed and costed for from a flood mitigation perspective. Limited land availability and clashes with other key infrastructure components often places flood management requirements as task that will be dealt with in detailed design. This is often exacerbated by limited investment and time during concept and reference design stages to understand the floodplain impacts of the proposed infrastructure. All this often results in projects which are awarded with minimal consideration of changes to the floodplain.

This presentation will look at the many challenges faced by flood practitioners in dealing with large scale infrastructure projects. An alternative approach will also be discussed which shifts flood mitigation requirements into a risk – cost - benefit framework where all authorities involved agree to key project outcomes during the conceptual and reference design phase of a project. The aim of this approach is to minimise the risk of a project causing detrimental and costly floodplain impacts.

Delivering on the Brisbane River Strategic Floodplain Management Plan

G Milligan[1]
[1]Queensland Reconstruction Authority, Brisbane, QLD

In April 2019, the *Brisbane River Strategic Floodplain Management Plan* (the Strategic Plan) was released, and it set a new standard for whole-of-catchment floodplain management. A year on, the Queensland Government, Seqwater and the four local governments of Brisbane, Ipswich, Somerset and Lockyer Valley continue to work together towards delivery of the 52 recommendations of the long-term Strategic Plan.

The 52 recommendations will help achieve the nine desired outcomes to manage the impact of future floods and enhance community safety and resilience in the Brisbane River floodplain. These actions will build on the extensive work already delivered since 2011 to improve flood resilience in the catchment.
Living with flooding is a part of life in the Brisbane River Catchment, and while we can't prevent flooding from occurring, we can definitely take steps to strengthen our resilience to floods. Actions underway in the implementation phase relate to structural mitigation, land use planning, building guidance, community resilience, disaster management and landscape management.

The Queensland Government is responsible for leading 34 of the 52 recommended actions, and importantly 17 of the 52 actions have statewide application to support the flood resilience of all Queensland communities both now and into the future.
The four respective local governments used the Strategic Plan to inform Local Floodplain Management Plans (LFMPs) to apply regionally consistent approaches to increase flood resilience in their communities. LFMPs build on the Strategic Plan to establish more detailed floodplain management approaches within each council area. The LFMPs are key deliverables of the final phase of the Brisbane River Catchment Flood Studies.

The $2.4 million Strategic Plan was jointly funded by the Queensland Government, partner councils and Seqwater, with the Australian Government providing $375,000 through the Natural Disaster Resilience Program.

Working Together for the Best Possible Flood Warnings in Queensland

G Milligan[1]
[1]Queensland Reconstruction Authority, Brisbane, QLD

The Queensland Reconstruction Authority (QRA) is working with the owners of flood warning infrastructure to ensure Queenslanders get the best possible warnings of floods. Our challenges include having more than 3000 rainfall and river gauges statewide with multiple owners and operators, and stakeholders from state and local government, the private sector, and the Bureau of Meteorology.

The Fitzroy Regional Resilience Strategy Framework pilot project was delivered in 2019 by QRA in partnership with member councils of the Central Queensland Regional Organisation of Councils. The resulting shared understanding of catchment flood issues is supported by an asset management and action plan linked to funding opportunities to build future resilience. It supports coordinated regional implementation of a best practice flood warning gauge network and this model has learnings for future regional resilience strategies.

QRA is also delivering a Flood Warning Infrastructure Network (FWIN) project using a locally led and regionally coordinated catchment approach with councils and stakeholders affected by the 2019 North and Far North Queensland Monsoon Trough. The FWIN project is jointly funded by the Australian and Queensland Governments under the Disaster Recovery Funding Arrangements (DRFA) extraordinary assistance package. The FWIN project aims to deliver suitable flood warning infrastructure upgrades in the most appropriate locations; improvements to Bureau services to support primary producers and communities; and a range of assets to support better information being made available including the use of flood cameras at strategic locations.

FWIN project actions and workshops have created situational awareness of flood warning infrastructure, and incorporated existing initiatives into a common operating picture for stakeholders. Upgrade initiatives to existing infrastructure have been analysed against identified risk areas and gaps to support identification of network priorities, prioritisation principles, and support for procurement within established or emerging governance arrangements.

Time Out – Flood Emergency Response for a Major Sports Venue

S Molino[1], F Dall'Osso[1]
[1]Molino Stewart Pty Ltd, Parramatta, NSW

The new Bankwest Stadium in Parramatta is next to the Parramatta River and is able to seat up to 30,000 spectators, but during large concerts it may accommodate up to 45,000 patrons. Most people are expected to reach the site by public transport but there are large at grade car parks between the river and stadium. It includes five levels of premium, corporate and function spaces, as well as a range of food and beverage outlets. Before operations could commence on 14 April 2019, a FERP Plan had to be completed and implemented as a condition of the development approval. Molino Stewart prepared a FERP that addressed evacuation, emergency access, flood warning and awareness, and refuge requirements.

The challenges included:

- keeping up to 45,000 patrons safe in the full range of potential floods ranging from the 5% AEP which could affect some of the car parks to the PMF which could be metres deep within the stadium
- working within a flash flood environment where Council's the new flood warning system can provide advanced notification in the order of only two hours
- managing evacuation logistics where the public transport hubs are on the other side of the river to the stadium
- finding an appropriate balance between the risk of calling unnecessary event cancellations and the risk of having large numbers of people stranded by flooding

These were addressed by generating a multi-staged plan, with escalating alert modes and multiple response triggers. Given the sensitivity of the development, due to its location and the number of people potentially involved in a flood response exercise, the FERP was prepared in consultation with the Council, the NSW State Emergency Services and NSW Fire and Rescue.

Purchase or Move? Lessons Learnt from Historic Property-Based Floodplain Management Schemes

A Mosely[1]
[1]Jacobs, Brisbane, QLD

Globally, many house buy-back and relocation schemes have been devised to reduce risk-to-life and property damage during a flood event. However, property-based floodplain management can be both a technically and socially complex undertaking. Numerous "lessons learnt" have hence been gained by those overseeing these projects.

As part of this project, research was undertaken to analyse voluntary and compulsory property purchase schemes within Australia and around the world. The key objectives of this task were to:

- Understand the legislative and regulatory context of existing schemes;
- Determine the key scheme components, particularly around criteria used to determine property eligibility;
- Consider key social issues that can arise and how they are managed; and
- Determine applicable success factors and lessons learnt.

The research was also extended to land-swap schemes and house improvement schemes (including both 'wet proofing' and house raising). The project method entailed review of online data, as well as in-person and phone discussions with professionals involved in developing and delivering various schemes.

In considering the numerous case studies together, a number of common "success factors" and "lessons learnt" were identified. Key success factors included sound community engagement, giving homeowners options, enabling tight-knit communities to remain together, and having the "right team". Also notably was that the experience of a recent disaster served as impetus, encouraging greater uptake of voluntary schemes.

Lessons Learnt included consideration of a useful purpose for vacated land, sound management of the media, housing booms, and the need to 'keep it simple' when describing eligibility criteria. Additionally, the difficulties of relocations for the elderly and economically challenged arose in various examples.

The Only Way Is Up – Flood Evacuation in Parramatta CBD

J Nadiroglu[1], L Baxter[1], A Vincevicius[1], B Stinton[2]
[1]BG&E Pty Limited, Sydney, NSW
[2]BG&E Pty Limited, Perth, WA

A Case Study: Flood evacuation of mixed-use tower blocks in a flood prone area
Over the last few years Parramatta CBD (Central Business District) area has experienced an enormous scale of transformation including redevelopment of main square area and building new towers.

The transformation of CBD area is ongoing and still planning further development in public spaces and infrastructure. The Parramatta Square development area sits in historical swamp and is affected by riverine and overland flooding. BG&E's flood engineers were involved in solving some of the key challenges associated with overland flooding of new tower buildings (3, 4, 6 and 8 PS) and Parramatta Square public space.

This presentation will consider:
- Case study using flood doors and barriers where there is little effective warning and evacuation time;
- Evacuation challenges when the site is affected by flooding from different sources (riverine[3] and local catchment[4]);
- Complexities of flood evacuation where a super basement connects more than one building;
- Shelter-in-place solution when the surrounding area is subject to high hazard flooding.
- Benefits and risks associated with a shelter-in-place approach;
- Theory VS practicality selecting the ideal location for flood alarm sensors.

A case study will be presented based on BG&E experience and lessons learnt in the Parramatta CBD and how this may relate to similar flood prone development land in other areas.

References:
[3] – Lower Parramatta River Floodplain Risk Management Study and Plan (SKM, 2005)
[4] – Parramatta Square Flood Risk Assessment (BG&E, 2016)

Hunter Valley Flood Mitigation Scheme – Wallalong Levee, Aberdeen Levee and Wallis Creek Floodgates – Upgrade Works

B Patterson[1], A McIntyre[2], A Jackaman[3]
[1]Royal HaskoningDHV, Newcastle, NSW
[2]Department of Planning, Industry and Environment, Newcastle, NSW
[3]JK Geotechnics, Sydney, NSW

The Hunter Valley Flood Mitigation Scheme was built after the huge Hunter River floods of 1955 which devastated the entire lower Hunter Valley. The scheme is an integrated system of levees, spillways, drains and floodgates on the Hunter, Paterson and Williams rivers. It is operated and maintained by the Department of Planning, Industry and Environment (the Department) with support from Hunter Local Land Services (HLLS).

The scheme does not provide complete flood protection. It is designed to mitigate or reduce flood damage, typically in events up to the 5-20 year ARI event. Scheme assets provide minor flood protection for rural land and moderate flood protection for Maitland, Lorn, Raymond Terrace, Singleton and Aberdeen.

There are more than 2000 individual scheme assets maintained along the rivers and floodplains. The scheme is valued at close to $1 Billion.

Parts of the scheme have been operating now for over 50 years, and are showing signs of degradation. Routine maintenance is carried out by officers of the Department and HLLC.

Royal HaskoningDHV have recently undertaken the investigation (including survey, monitoring, modelling, ground investigations), concept and detailed design documentation of a series of asset mitigation works, including flood levee and flood gate rehabilitation and upgrade works.

This paper outlines three case studies (Wallalong Levee, Aberdeen Levee and the Wallis Creek Flood Gates) for flood asset upgrade and rehabilitation works, detailing some of issues raised, particularly emphasizing the need for adequate design and consultation with the communities that currently benefit from the scheme, and some of the innovative investigation and design solutions that have been developed.

A review of the Hunter Valley Flood Alleviation Scheme offers a unique insight into the relative life of flood defense assets and provides valuable lessons learnt for flood scheme asset designers and operators.

Towards Zero Lives lost using Ensemble Flood Forecasts

J Robinson[1], **A Smith[2],** P Fuller [3], C Robinson[1], W Wang[1] and A Boronkay[1]
[1] Bureau of Meteorology, Sydney, NSW
[2] Bureau of Meteorology, Melbourne, Victoria
[3] Infrastructure NSW, Sydney, NSW

Floods in the Hawkesbury Nepean Valley pose a significant risk to life and property. The Insurance Council of Australia considers the Valley to have the highest single flood exposure in New South Wales, if not Australia. Infrastructure NSW have been leading the implementation of a comprehensive multi-faceted strategy to reduce flood risk in the Valley. The Bureau of Meteorology (BoM) has the responsibility to deliver Outcome 6 of the strategy, which is to provide improved weather and flood predictions to enable impacted communities more time to safely evacuate.

To meet the challenge of providing extended lead time flood forecasts requires the use of ensemble rainfall forecasts. This means flood forecasts provide a range of possibilities instead of a single outcome. Producing these forecasts is a technical challenge and a challenge for decision makers. The use of ensemble forecasts requires a paradigm shift in the type of services the BoM provides and how they are used when making decisions.

With its partners, the BoM piloted a tailored flood forecasting service for the Valley. The service utilises specialised rainfall forecasts that combine automated radar nowcasting blended with high-resolution numerical weather prediction forecasts. The rainfall forecasts are used with an updated flood forecasting model to produce co-designed flood forecasting products that are aligned with the decision-making needs of emergency services.

The service provides forecasts with an extended lead time out towards 36 hours and provides insight into the uncertainties of forecasts which are linked to flood intelligence. It enables emergency services to make informed decisions on the evacuation of impacted communities.

This paper explores the lessons learned, insights, innovations and challenges in developing a co-designed flood forecasting service that provides the next generation of flood forecasting and warning services to the Australian Community.

Don’t get in a Bog with your RoG

B Tate[1], S Hof[1]
[1]Water Technology Pty Ltd, VIC

The Australian Rainfall and Runoff 2019 update has significantly improved the approach to design hydrology. This has been well studied and documented, being the focus of many conference presentations. One of the most significant changes has been the use of 10 temporal patterns for every design event, based on real storms as opposed to a single synthetic temporal pattern. This approach is known as the Ensemble approach. Most rainfall-runoff models have updated software to easily incorporate the Ensemble approach. Although this change to the Ensemble approach was intended for rainfall-runoff modelling, practitioners have started to use aspects of this approach in direct rainfall on grid modelling too. This imposes a large demand for additional computing resources, both hardware and software.
This paper presents findings from recent projects that have considered the sensitivity of direct rainfall on grid flood modelling results to different temporal patterns, losses, roughness and other modelling assumptions. The findings show that by using some common sense judgement and an understanding of what drives peak flood levels for your floodplain, you may not need to run hundreds of scenarios to develop appropriate flood mapping, saving you time, money and computer resources.

How Much is it Worth? Economic Values for Floodplain Management

R Thomson[1], D McLuckie[2], L Drynan[1], A Toniato[2]
[1]Rhelm, Sydney, NSW
[2]NSW Department of Planning, Industry and Environment, Newcastle, NSW

Within the NSW Floodplain Risk Management Process (as outlined in the Floodplain development Manual (2005), the prioritisation and selection of mitigation options is undertaken within the Floodplain Risk Management Study and Plan phases1. This is typically undertaken through a combination of economic analysis and multi-criteria assessment (MCA).

To date, economic cost benefit analysis (CBA) for NSW flood projects has largely focused on the quantification (in dollar terms) of expected property related flood damages and, in some cases, factors for intangible damages. Other impacts of flooding, such as environmental impacts or social impacts, are typically considered qualitatively or assessed through qualitative indices within multi-criteria assessments.

A review was undertaken on the current approaches adopted locally and internationally. The review focused on two components:

- The development of a draft framework to guide economic assessment in floodplain management projects (including the level of detail, the timing of when assessment are undertaken etc). This is summarised in Thomson et al (2019).
- The second component of the work involved a review of potential "rapid" assessment techniques for non-direct property related damages. This includes potential quantification of social and environmental impacts, such as risk to life, impacts on social infrastructure etc.

This paper focuses on the second component of the work. This involved reviews of both local and international guidelines and research to provide a summary of the available information that current exists, and some general guidance on some appropriate techniques. While this is just a start point, it provides a comprehensive collation of available information in this area to assist in the development of future guidance. This paper provides a summary of this information to assist the industry moving forward.

References:
NSW Government (2005). Floodplain Development Manual
Thomson R, McLuckie D, Toniato A, Drynan L and Kularatne T (2019). A Penny for your Flood – Quantifying the Impact, Floodplain Management Authorities Conference, Canberra.

Both flood and Community Engagement Specialists Working together for Flood-Informed Communities

S Yeo[1], S Ribbons[1], **H Langler**[1], A White[1], M Abood[1]
[1]Infrastructure NSW, Sydney, NSW

A flood study is completed. How can the outputs of that study be made accessible to stakeholders and communities? How can flood information be used to build people's readiness ahead of the next flood?

The NSW Government's *Hawkesbury-Nepean Valley Flood Risk Management Strategy* has had the commitment and resources to maximise value from the flood study process. Two of the nine outcomes of the Flood Strategy are:

- Accessible contemporary flood risk information
- An aware, prepared, and responsive community.

The *Hawkesbury-Nepean Valley Regional Flood Study* was finalised in July 2019, supported by a plain English Flood Study Overview. This new flood information provided the foundation for a range of products and activities seeking to elevate community awareness, preparedness and responsiveness.

A 'Get Ready for Flood Hawkesbury-Nepean' was launched in September 2019 using flood mapping on-line, animations, direct mail, digital messaging and billboards. The flood mapping and data is also supporting a range of targeted projects to build resilience amongst the most vulnerable sectors of the floodplain community, including workshops and briefings for the aged, disabled, social housing and early childhood sectors.

The delivery of these outcomes has involved a collaboration between flood and communications specialists, across Government stakeholders and in partnership with local councils. The input of communications and engagement professionals helped to share flood information widely and to translate it into digestible pieces. Flood specialists provided oversight, ensuring the integrity of the information released. Both skill sets are required to maximise the reach and accuracy of flood information for improved community understanding and resilience.

Ideas as to how to facilitate partnerships between flood and communications specialists at more typical council-led flood study scales are discussed.

Pre-Recorded Presentation Abstracts
(Alphabetical by Presenting Author)

Non-Worsening Criteria: When Best Practice Isn't Resilient

L Allan[1]
[1]Allan & Dennis, Brisbane, QLD

Urban development modifies the natural or existing ground surface, generally resulting in changes to the rainfall run-off volume, flow rate, velocity and duration of inundation of the site and surrounding areas.

Local Government Area's (LGA) across Australia generally require new developments situated within flood plains and overland flow paths to prepare a Flood Impact Assessments (FIA) demonstrating compliance with a non-worsening criteria, whereby the development must not:

- Increase peak flood levels external to the site;
- Increase peak flood discharge;
- Increase frequency or duration of inundation;
- Impact upon flood behaviour and therefore have an adverse impact elsewhere in the community; and
- Result adverse impact to surrounding properties.

This paper will explore the definitions of relevant terms such as:

- Adverse Impact; and
- Actionable Nuisance.

And will further explore other aspects that may influence flood impacts and nuisance including:

- Numerical noise in flood modelling software and what is considered acceptable noise;
- Assumptions of numerical modelling that may influence a flood impact assessment;
- Discussion of the limitation of some commercially available software packages / computation engines;
- Real damage to premises – flood damage curves with respect to model noise; and
- The impact of other elements such as wind effects and wave action on the free water surface.

Ross River Dam, February 2019 – Successful Mitigation of Five Larger Peak Flows

T Burke[1], B Caddis[1]
[1]BMT, Brisbane, QLD

In February 2019, the Ross River catchment experienced an extreme rainfall event, resulting in widespread flooding in Townsville.

Discharge from the Ross River Dam was managed during the event via automatic and manual gate operations. Substantial public scrutiny of the dam operations followed this event, including concerns that the dam was operated incorrectly and worsened flood conditions.

Post-event hydrologic and hydraulic modelling was undertaken by BMT on behalf of the Inspector-General Emergency Management to assess the performance of the Ross River Dam during the flood event and quantify the impact the dam's operations had on flooding downstream of the dam.

The dam was operated in accordance with flexible implementation of the dam's Emergency Action Plan (EAP), with four periods of manual gate operation. BMT's analysis quantified the impact of deviating from the automatic gate operations. The analysis also assessed how the operation of the dam mitigated flooding in downstream locations.

Our findings indicated that the dam provided significant mitigation benefits. During the event, managed outflow from the Ross River Dam peaked at 1,888 m^3/s. BMT's analysis demonstrated that the dam mitigated and delayed five flood peak discharges larger than this over a five day period – two of which were more than double the peak discharge that actually occurred.

Communication of these findings to the public helped to alleviate concerns that dam releases were the primary cause of flooding. Transparent communication about the dam operations undertaken is critical for public confidence. However, framing the operational information in the context of the full mitigation benefit of the dam may assist with greater understanding of the scale of the event and the benefits of the dam. Discussion of overall mitigation can help the community to understand how an appropriately managed dam can reduce peak flood levels when compared to a no-dam scenario.

Planning to Action: Enabling Communities to Manage Flood Risk

R Dick[1], D Wilkie[1]
[1]Department Environment Land Water and Planning, Swan Hill, VIC

This paper will describe the approach adopted in Victoria of engaging local communities in understanding their flood risks and developing strategies that do the most to reduce those risks.

The aim of flood mitigation is to narrow the gap between the existing risk and the community's tolerance for the risk - not to eliminate the risk.
The Victorian Floodplain Management Strategy (VFMS) incorporates lessons learnt from the 2010, 2011 and 2012 floods and sets the direction for flood mitigation in Victoria. The VFMS clarifies the roles and responsibilities of government, agencies and authorities in floodplain management.

Following the release of the VFMS, Regional Catchment Management Authorities (CMAs) led a state-wide systematic assessment of flood mitigation through development of the Regional Floodplain Management Strategies (RFMS). The RFMS involved stakeholders and the community to assess the risks and set the priorities for each community at a regional scale.

Locals know their area best. They can assess risks and determine what they are willing to invest in and can afford to maintain and then set mitigation priorities for their own communities.

Donald, a small town in the Buloke Shire of North-Western Victoria experienced record flooding in the 2011 floods. Their story showcases this process from devastation of floods to investing in actions the community wants and can afford.

References:
DELWP (2016). Victorian Floodplain Management Strategy. Melbourne: Department of Environment, Land, Water and Planning.

Toowoomba's Evolution in Flood Modelling and Floodplain Management

Z Dore[1], K Bashar[2], G Bebington[2], A Kolega[1], M Martin[1]
[1]BMT, Brisbane, QLD
[2]Toowoomba Regional Council, Toowoomba, QLD

The Toowoomba region experienced a catastrophic flood event in 2011, prompting Toowoomba Regional Council (TRC) to commence an ambitious project to prepare flood mapping for more than 30 towns which influenced the Flood Risk Assessment, Planning Evaluation and Planning Scheme Amendment (FRAPESA) Project. This project won the Flood Risk Management Project of the Year at Floodplain Management Australia's 2018 conference .

Following the completion of this project, Council identified that an understanding of flood behaviour for the remainder of the TRC area (i.e. rural areas between towns) should be mapped. The TRC - wide Regional Flood Study project was commenced in 2017 and aimed to develop rapid, low-cost flood extent mapping for the 1% AEP design flood event covering the TRC area in its entirety. In 2019, these regional models were updated to provide more comprehensive and accurate flood mapping, understanding of hazard, immunity and flood behaviour.

The model update involved including major structures and calibration to two historic events. Australian Rainfall and Runoff 2019 (ARR2019) was adopted for design event modelling and a full range of flood events from the 50% AEP event to the Probable Maximum Flood (PMF) were simulated.

The models provide a number of advantages and information sources for Council to better inform FRAPESA but also other Council activities such as planning for future roadworks, bridges and major culvert upgrading projects. These rural areas previously relied on historic flood information or topographic-based assessments and would require site-specific flood models for major infrastructure or developments. Now, Council, developers and the broader community have an improved understanding of flood risk across the region.

There were a number of challenges to achieving such an ambitious scope of works but the innovative solutions developed clearly demonstrated the potential for LGA-wide mapping which provides comprehensive mapping beyond major town centers.

Resilient Queensland: Perspectives of community and flood resilience from Bauple to Boulia

G Milligan[1], **S Dredge[1]**, L Gannon[1]
[1]Queensland Reconstruction Authority, Brisbane, QLD

Resilient Queensland has delivered pilot project regional resilience strategies that highlight the dynamic and the contrasting perceptions and the systems-based challenges of community and flood resilience. The case studies of the Central West Queensland and the Mary River regional resilience strategies demonstrate this across urban and rural / remote contexts in different regions across Queensland.

The Central West Regional Resilience Strategy in partnership with the local governments of Blackall-Tambo, Barcaldine, Longreach, Barcoo, Winton, Boulia and Diamantina, covers 23 per cent of Queensland. This area is characterised by desert uplands, Mitchell Grass Downs Country and Channel Country, with the Cooper Creek, Diamantina and Georgina River catchments draining to Kati Thanda-Lake Eyre. Gripped by years of persistent drought, the resilience of remote outback communities is intrinsically connected to the boom and bust cycles of the climate and landscape. Floodwaters are valued, even if it sometimes comes at a cost. These perceptions set a unique contrast to how flood is perceived by urban communities, such as that of the Mary River region.

The Mary River region finds its headwaters around the Conondale Ranges, traversing north over 300 kilometres through major urban centres such as Gympie and Maryborough before discharging to the Great Sandy Strait. This region is no stranger to major flooding, leading to community inundation, isolation, property and infrastructure damage, and placing life at risk. A great deal of focus on the human and social aspects of resilience has been the priority of the four local governments of the Mary (Sunshine Coast, Noosa, Gympie and Fraser Coast), resulting in highly innovative approaches to develop an atmosphere of community-led resilience.

References:
Resilient Queensland, 2018, Queensland Government, Available online at: https://www.qra.qld.gov.au/resilient-queensland
Central West Regional Resilience Strategy, 2019, RAPAD and Queensland Government, Available online at: https://www.qra.qld.gov.au/our-work-resilience-regional-resilience-plans/central-west-queensland-regional-resilience-strategy
Mary Regional Resilience Strategy, 2020, WBBROC, Sunshine Coast Regional Council, Noosa Shire Council and Queensland Government, Available online at: https://www.qra.qld.gov.au/our-work-resilience-regional-resilience-plans/mary-river-regional-resilience-strategy

A Framework for Resilient Development on Floodplains

M Edwards[1]
[1]Department of Environment, Land, Water and Planning, East Melbourne, VIC

Land use planning and development controls have often been accepted as an efficient and effective tool to prevent or reduce the likelihood of flood risk. The tricky bit is to have them in a form that is acceptable to decision makers and fair to developers. This can be difficult as developers and planners do not often understand the complexities of the flood studies that engineers utilise for understanding the flood hazard. Equally, land use planners are not engineers, and must consider a range of economic, social and environmental factors when making decisions about the use and development of land.

This paper considers what might be the desirable parts of a land use and development system, without judging the approaches taken by different jurisdictions. It examines guidance available from the ADR handbook 7 series on how information on flood risk can be packaged more readily to inform land use planning. It reviews, at a high level, what different flood controls are applied in different parts of Australia, and some of the issues that help explain the differences.

Based on the outcomes of this review, suggestions are made on a flexible and adaptable framework for land use planning and development controls.

Using Flood Data for Strategic Purposes

S Epe[1], A Frazer[2]
[1]State Emergency Service, NSW
[2]Department of Planning Industry and Environment, NSW

The NSW Flood Data Portal is a joint initiative with NSW SES and NSW Department of Planning, Industry and Environment. The portal is used by local and state government to share data and reports on flooding in NSW. The information consolidated in the NSW Flood Data Portal provides a great first step at looking at historical and recent information on flooding in an area.
GIS layers and systems uploaded to the portal are exported into an ArcGIS flood database, with potential to show gaps in knowledge and in areas. This can be used a useful and powerful tool to show the area of information and links not previously seen. This data has been further incorporated into the Geospatial Emergency Mapping System (GEMS), a valuable resource for using flood data for strategic and day to day purposes.

Analysis of Compound Flood Disasters

A Gissing[1,2,3]**,** M Timms[1], R Crompton[1], L Coates[1,2,3]
[1] Risk Frontiers, St Leonards, NSW, Australia
[2] Macquarie University, NSW, Australia
[3] Bushfire and Natural Hazards Cooperative Research Centre

Traditional risk management methodologies assess risk based on the assumption that hazards and their consequences occur discretely. Such events may have cascading consequences that occur as a chain reaction following their occurrence, similar to the toppling of dominos. These types of disasters, referred to as 'cascading events', arise sequentially and their consequences are dependent on each other.

Events that are independent of each other but occur sequentially or simultaneously further amplify complexity and demand for emergency response and recovery resources. These events are referred to as 'compound events'. An example of this type occurred during the 2010/11 Australian spring and summer and was comprised of a series of flood, tropical cyclone, bushfire and heatwave events that stretched the capacity of emergency services nationwide.

Utilising Risk Frontiers' PerilAUS database which records the impacts of disaster events in Australia comprehensively since 1900, Risk Frontiers undertook an analysis to identify the frequency of compound events in Australia. This presentation will provide an overview of the analysis and provide recommendations to enhance emergency risk management methodologies to account for compound events.

Development of a Best Practice Flood Warning System

J Charalambous[1], **A Herring[1]**
[1]Brisbane City Council, Brisbane, QLD

In Australia, the Bureau of Meteorology (BoM) has a mandate to issue flood warnings. For the Brisbane River, official BoM forecasts are issued in close collaboration with SEQWater (Wivenhoe and Somerset Dam releases) and potentially affected councils. For each of these agencies, flood warnings and flood intelligence, serves a different purpose.

The 2010 – 2011 season was one of the wettest on record in eastern Australia, with widespread flooding, firstly in central and western Queensland, followed by S.E. Queensland (including the Brisbane River). The interaction of moisture laden ex-tropical air flow with low pressure cells in SE Australia then resulted in major flooding in southern NSW and Victoria.

More recently, similar weather patterns in NW United States delivered heavy winter snow loads resulting in record snowmelt and major flooding and dam failures in the Mississippi River Basin.

Prior to the 2011 flood, Brisbane City Council developed an Access database which interpolated a predicted flood surface in 1D. Later, a customised system was developed to interpolate between a library of pre-mapped 2D flood surfaces using the WaterRIDE software package.

With support from the Queensland Reconstruction Authority and other users, this system has undergone a series of enhancements to widen its usefulness to other authorities. This work is expected to evolve further to suit new technology and changes in public expectations.

The first steps were taken recently toward developing a state-of-the-art Flood Warning System for the Brisbane River Valley. This project now begs the question: How good and how effective should a warning system be to be fit for purpose? Will such a warning and intelligence system ever be accurate enough or good enough?

A Flood Resilient Victoria: Using Technology to Provide Multiple Benefits

K Kumthekar[1]
[1]Department of Environment, Land, Water and Planning, Melbourne, VIC

Flood Intelligence Platform Originated out of the Neil Comrie review of 2010-2011 Victorian floods. It has not only met its purpose of being one source of truth for flood related data but has added value by providing appropriate information to assist other users. For example, FloodZoom supports;

- the Catchment Management Authorities to fulfil their statutory planning referral function and
- the water corporations to meet their statutory obligation to report activities for Algal Blooms, Dams safety and emerging Corporate and emergency Risk.

The Victorian Flood Intelligence Platform incorporates FloodZoom and is a warehouse of information that is scalable to deliver multiple flood management and water related benefits. Spatial data which includes current and historic flood extents and rasters not only assists in managing a response before, during and after a flood event but also provides insights in making informed decision when it comes to investing in flood mitigation strategies and ensuring communities are flood resilient.

The unique set up of the platform ensures spatial data collected for and during an event is best available and provides central and seamless access to all the personnel that can be called upon during an emergency.

The platform is a working example of cross border collaboration as it incorporates and display's real time and historic information from gauges installed on both sides of the Murray river.

Tasmanian Statewide Strategic Flood Mapping: Challenges and Uncertainties

A Lau[1], L Roberts[1], T Rigby[2], C Mazengarb[3], C Kain[3]
[1]Tasmania State Emergency Service, Hobart, Tasmania
[2]Rienco Consulting, Sorell, Tasmania
[3]Mineral Resources Tasmania, Hobart, Tasmania

In June and July 2016 extreme rainfall caused significant flooding across Tasmania, resulting in several deaths, and major damage to property and infrastructure. In response to an independent review into the floods, the Australian and Tasmanian Governments allocated $3 million for the State Emergency Service to deliver the Tasmanian Flood Mapping Project. The objective of the project is to produce statewide strategic flood maps to inform land-use, building, and emergency management planning. This presentation explores the challenges and uncertainties of developing statewide data sets to support a strategic flood model, including data capture and preparation, and changes to business process, focusing on;

- Capturing Light inferred Detection and Ranging (LiDAR) data to improve base-level information for the assessment of how river systems function (storage, channel, fringe areas);
- Developing a new state Digital Elevation Model (DEM), Manning's 'n' roughness for surface runoff layer, and soil moisture layer;
- Undertaking historical flood events reconstructions; and
- Compiling and assessing infrastructure, stormwater and flood data from State and Local Governments.

The project will deliver a flood data library that contains all of the modelling data; statewide strategic flood map with hazard categories across the landscape; a library of detailed flood studies available to emergency managers for use during community protection planning and events; and event reconstruction tools and models. All studies and data created during the modelling will be made publically available. The State Emergency Service is currently taking the lead in Tasmania to resolve the challenges of improving
flood intelligence and planning outcomes, and endeavoring to reduce uncertainties in flood modelling to improve land-use, building, and emergency management planning.

Strategic Management of Flood Risk for Communities

D McLuckie[1], A Toniato[1]
[1]New South Wales, Department of Planning Industry and Environment, Newcastle, NSW

The strategic flood risk management for communities requires a multi-disciplinary approach informed be an effective understanding of the full range of flood behaviour. This approach can lead to management of flooding through activities across the spectrum of prevention, preparation, response and recovery. It is led by government and may involve actions by a range of government and non-government entities and members of the community and can be undertaken at a range of scales.

Broad direction is generally provided through policy and legislation from higher levels of government, such as through the NSW Flood Prone Land Policy and Floodplain Development Manual. This direction can in turn, when considered within the context of a local community, inform approaches that are suitable for informing and supporting the management of flood risk for local communities.

This paper discusses the changing flood risk management guidance in New South Wales and its application for strategic management of flood risks to communities through a risk-based management framework. It examines how it can facilitation the understanding of flood risk and how this can link into decision making in government and across flood risk management, land use planning, and emergency management. It considered decisions that can influences the risk to the existing community and the growing risk from flooding as communities expand.

In doing so it considers the various end users of flood information and their contrasting information needs and draws on current and emerging practices in New South Wales as part of the update of the Floodplain Development Manual and associated guidance.

A Flood Resilient Bruce Highway for North Queensland: Haughton River Floodplain Upgrade

T O'Connell[1]
[1]HDR Pty Limited, Brisbane, QLD

FLOODS. A fact of life in North Queensland.

This project, on the Bruce Highway 50 kilometres south of Townsville, is on one of Australia's most complex floodplains. The Bruce Highway spans two major waterways and two lagoons, as well as cane tramways and local intersections. The Haughton River has a considerable wet tropics catchment, is naturally perched, has irrigation levees on both banks and weirs both upstream and downstream of the existing road crossing.

The floodplain sees regular inundation of the road. During the 2019 Monsoon Trough, the Bruce Highway within the project area was underwater for a total of six days. This closure disrupted locals, tourists, emergency services, transport operators and other motorists; and effectively cut off North and Far North Queensland road transport system. On average, this section of highway is closed for 3.5 days per year due to flooding.

Replacing a series of sub-standard crossings to effectively remove the flood vulnerability of the Bruce Highway across the Haughton River floodplain is a challenge of daunting proportions. Once the upgrade project is complete, the severity and frequency of closures will be greatly reduced, from an annual average submergence of 160 hours to just one hour – a massive improvement.

Utilising world-first technologies (the software package TUFLOW HPC) and innovative engineering solutions the Arup | HDR Joint Venture has delivered the design of this exciting project, currently being constructed by The Infrastructure Group on behalf of Queensland Department of Transport and Main Roads.

In a fast-paced competitive tender environment, a comfortable pathway would have been to proceed without delay with the model provided. The actual pathway led to substantially more runs of various options to optimise flooding infrastructure design elements. This has delivered enormous benefits in terms of cost and effectiveness – saving the need for over 2,000 linear metres of bridges.

References: AHJV (2019) *Bruce Highway | Haughton River Floodplain Upgrade | Global – Hydraulic Analysis Design Report* (prepared for TIG and DTMR).

Flooding Impacts of Regional Farm Dams on Lowes Creek Maryland Precinct Development

M Pinto[1]
[1]Camden Council, Oran Park, NSW

The Upper South Creek (USC) catchment in Camden Local Government Area is a fast developing area in Sydney South West with flood risks. This entire USC catchment with an area of 71 km^2 is transforming from rural to urban land use within the next 15 years. Seven large regional farm dams are present within the catchment that contribute to flood mitigation require future reconfiguration / filling through Priority Growth Area precinct development with the provision of compensatory flood storage. Past practice has been to remove the farm dams, but the scale of the dams is such that they need to be maintained in some form, generating the need for compensatory flood storage for man-made structures constructed about 40 years ago.

The Lowes Creek Maryland Precinct is located within the USC catchment, with an area of approximately 531 ha. Two large regional farm dams with the surface areas of approximately 18.1 ha and 19.1 ha lie within this Precinct. The total active storage of the two farm dams is approximately 283,140 m^3. The active storage refers to the storage above the full supply level up to embankment crest level of the dam. The removal of two farm dams would have adverse impacts on downstream flooding. To address the impacts of removal of farm dams, compensatory flood storages equivalent to the active storages of farm dams during 1% AEP, which is approximately 202,300 m^3 are required in addition to the detention storage required to mitigate the impacts of development.

A key component of precinct planning is to identify and address flood impacts of the precinct under the Water Cycle Management Strategy. The Lowes Creek Maryland Precinct Water Cycle Management Strategy is based on ARR 2016, using RAFTS hydrologic and TUFLOW hydraulic models.

References:
Cardno (NSW/ACT). (2019). Water Cycle Management, Lowes Creek Maryland Precinct.

In-situ Soil Moisture Monitoring in South Australia to improve Flash Flood Forecasts

D Ratnayake[1], G Hewa[1]
[1]University of South Australia, Adelaide, SA

The risk of flash flooding of small watercourses is a significant problem in several urban catchments in South Australia (SA). The FloodMon system has been introduced to forecasts the flash flood. However, catchment specific losses are not available for urban catchments, and these values are critical to getting reliable flash flood forecasts. To find loss values, the initial soil moisture content before an event is essential.

Availability of in-situ soil moisture data is limited within Australian for hydrological applications, mainly due to the cost involved and other challenges. Instead, the Australian Water Resources Assessment Landscape (AWRA-L) and some other satellite-based methods have been used to get estimated soil moisture data. However, some limitations and accuracy issues of the urban estimated soil moisture data set have been discussed. The accuracy of the data set can be improved by calibrating these values using catchment specific in-situ soil moisture data.

A portable soil water monitoring device, Diviner 2000, is used to measure soil moisture at 10cm intervals down to the route zone (1m depth) in 18 locations from two unregulated catchments, Dry Creek and Brownhill Creek in the Adelaide metropolitan region in SA. Field calibration of soil profiles at each site was conducted according to the Diviner 2000 manual. The data collection was done weekly from April 2018 to May 2019 to cover a full cycle of weather pattern within a year. This paper focuses on presenting the procedures adopted to calibrate the sensor for different soil profiles and the challenges faced during the data collection process. The observed patterns of the data and the comparison of the in-situ data against the estimated soil moisture data from AWRA-L and other satellite-based methods are also discussed.

Flood Considerations for Road Managers

D Rose[1]
[1]Tweed Shire Council, Murwillumbah, NSW

Local government Councils not only have a central role in floodplain management, they are also responsible for extensive networks of sealed and unsealed roads and related infrastructure assets (bridges, causeways, culverts etc.). The highest proportion of flood deaths in Australia are road related, with people attempting to cross flooded roadways (Haynes, 2015).

In 2017 Tweed Shire on the New South Wales Far North Coast experienced record flooding as a result of ex-tropical cyclone Debbie. Tragically three local community members lost their lives in a motor vehicle crash on a flood affected local road under Council's management. A coronial inquest was held into these deaths in 2019. During this inquest Council's management of road closures, communication to the public, and actions to ensure road user safety were scrutinised, with a number of recommendations being handed down.

This presentation will discuss these recommendations and their implications for road managers in Councils and other relevant agencies when flood events occur.

This presentation will also be used as content for the proposed pre-conference workshop on human behaviour in floods.

References:
Haynes K etal, 2015: An analysis of human fatalities from flood hazards in Australia 190

ARR2019 Quirks and How to Deal with Them

C Ryan[1], O Garratt[2]
[1]Catchment Simulation Solutions Pty Ltd, Sydney, NSW
[2]Wollongong City of Innovation, Wollongong, NSW

ARR2019 has introduced significant changes to the way practitioners develop and use design rainfall estimates in their work. The basics of the ensemble approach is now well understood, however, there are still elements that are often overlooked. This paper will discuss several issues that are not commonly considered and can have significant impacts on rainfall estimates. These include embedded burst detection and smoothing, the use of multiple bins in an ensemble and verification of BOM IFD data with at-site analysis.

An embedded burst occurs when a part of the storm burst has a rarer AEP than the whole burst. Embedded bursts are occurring in ARR2019 due to the large number of temporal patterns and the inability to detect embedded bursts until after the combination of rainfall depth and temporal pattern. We will examine some of the embedded bursts in ARR2019 temporal patterns and how key ensemble metrics can be influenced when embedded bursts are smoothed.

ARR2019 also notes that inconsistent results can sometimes occur where the 'bin' that temporal patterns are drawn from changes (ie., frequent, intermediate or rare). The problem is most pronounced between frequent and intermediate bins and in drier regions where rainfall losses absorb a large proportion of the rainfall. We will take a look at a case study where this occurs and how it can be overcome using larger ensembles.

The BOM IFD estimates are generated based on broadscale analysis and have been found to be inaccurate in some areas, particularly in some coastal NSW areas where orographic effects can be significant. Many flood studies in NSW are now requesting that BOM IFD data be verified by an at-site IFD analysis before use. We will show how this analysis can be done and demonstrate a case study where results vary from BOM data.

The Assessment of Flood Vulnerability Using Socio-economic Indices

A Sadeghi-Pouya[1]
[1]Townsville City Council, Townsville, QLD

Flood disasters have been extremely severe in recent decades, and they account for about one third of all natural catastrophes throughout the world. Societies living in flood-prone areas are vulnerable to floods due to three main factors: exposure, susceptibility and resilience. More specifically in the case of floods, a system is susceptible to floods due to exposure in conjunction with its capacity/incapacity to be resilient, to cope, recover or adapt to the extent. While deterministic modelling uses physically based modelling approaches to estimate flood probability, and are coupled with damage assessment models which estimate economic consequence, parametric approaches aim to use readily available data of information to build a picture of the vulnerability of an area.

This paper represents a set of socio-economic indices developed for the assessment of vulnerability toward riverine flooding. The developed indices assess the vulnerability through identification and evaluation of effective criteria by scoring technique leading to a vulnerability score. The method uses the ArcView GIS software with Spatial Analyst in order to describe the spatial verity of the vulnerability across the study area. The method was applied in a case study located in the southern margin of Caspian Sea (the largest closed sea of the world) and different maps were produced showing spatial verity of the socio-economic indices and the vulnerability across the study area.

The obtained results showed that the method leads to a relative sense and an overall picture of the vulnerability toward floods. The sensitivity analysis was also carried out in this study aimed at studying the effect of the indices on the relative vulnerability score. The result of the sensitivity analysis testified and approved the method potential of prediction the zones with the serious vulnerability and the assessment method developed in this study.

References

Balica, S. F., Douben, N., & Wright, N. G. (2009). Flood vulnerability indices at varying spatial scales. *Water science and Technology*, *60*(10), 2571-2580. Balica, S. F., Popescu, I., Beevers, L., & Wright, N. G. (2013). Parametric and physically based modelling techniques for flood risk and vulnerability assessment: a comparison. *Environmental modelling & software*, *41*, 84-92. Balica, S. F., Wright, N. G., & van der Meulen, F. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural hazards*, *64*(1), 73-105. Sadeghi-Pouya, A., Nouri, J., Mansouri, N., & Kia-Lashaki, A. (2017). An indexing approach to assess flood vulnerability in the western coastal cities of Mazandaran, Iran. International journal of disaster risk reduction, 22, 304-316. Sadeghi-Pouya, A., Nouri, J., Mansouri, N., & Kia-Lashaki, A. (2017). Developing an index model for flood risk assessment in the western coastal region of Mazandaran, Iran. Journal of Hydrology and Hydromechanics, 65(2), 134-145. Wang, S., & Huang, G. H. (2013). A two-stage mixed-integer fuzzy programming with interval-valued membership functions approach for flood-diversion planning. *Journal of environmental management*, *117*, 208-218.

Flood Emergency Planning for Disaster Resilience

K Samson[1]
[1]Australian Institute for Disaster Resilience, East Melbourne, VIC

The Australian Institute for Disaster Resilience (AIDR) is due to publish the much-*anticipated Flood Emergency Planning for Disaster Resilience* Handbook. The Handbook is part of the Australian Disaster Resilience Handbook Collection and fulfills a critical role in national resilience under the policy framework established by the National Strategy for Disaster Resilience (2011).

The Handbook reflects increasing national and international focus on reducing disaster risk and building disaster resilient communities, as considered in the National Disaster Risk Reduction Framework (Australian Government 2018) and Profiling Australia's Vulnerability (Australian Government 2018). It provides guidance to those that play an important role in flood emergency planning including community organistions, emergency managers, local government officials, and functional-area representatives.

This session will present flood emergency planning as an important measure for preventing and mitigating future vulnerabilities and losses as a result of flooding; and emergency management of flooding as a shared responsibility that requires investment in partnering with communities to develop flood emergency plans. It will highlight key concepts from the handbook, including a set of nationally agreed principles and guidance for flood emergency planning.

Lessons from SA's Largest Expansion of Flood Warning Services in 20 years

B Skilton[1], A Cornish[2]
[1]Department for Environment and Water, SA
[2]The Bureau of Meteorology, SA

The Light Gilbert and Wakefield Rivers Flood Warning (LGWFW) Project is the largest expansion of flood warning services in South Australia (SA) in the last 20 years and will provide improved flood warning services to 11 townships and their surrounding communities.

The Light, Gilbert and Wakefield Rivers are major ephemeral rivers in South Australia's Mid North with a history of causing widespread flooding. Floods in 2016 renewed efforts between the Bureau of Meteorology (the Bureau), state agencies and local councils to address the lack of data to enable better flood warning services being established. In 2017 four councils supported by the Department of Environment and Water (DEW) applied for funding from the Natural Disaster Resilience Program (NDRP) to develop a flood warning network. The LGWFW Project successfully received $196,000 of grant funding. The four councils contributed $84,000 with significant in-kind contributions from the Bureau and DEW.

The Project has constructed 10 new water level monitoring sites and 7 new rain gauges. Network design considered the needs of flood prone communities, the scope of the Bureau's riverine flood warning services, and the interaction between the Bureau's service and that of the developing South Australian State Emergency Service (SA SES) flash flood warning service. The ambiguity in flood warning infrastructure responsibilities in South Australia meant this project drew local political attention which had a significant impact on the implementation of design and construct phases of the LGWFW Project.

The LGWFW project is now progressing with flood warning classification, development of flood warning models and gathering impact intelligence to inform messaging. There are some key lessons learnt from the LGWFW project that will influence the approach to managing flood warning infrastructure and services going forward across Australia.

Back to Basics – Testing the Validity of Wollongong Local Guidance for ARR2019

H Sommerville[1], R Thomson[1], S Srbinovski[2], O Garratt-Symes[2] & I Ghetti[2]
[1]Rhelm, Sydney, NSW
[2]Wollongong City Council, Wollongong, NSW

The Wollongong Local Government Area (LGA) is characterised by a steep escarpment located next to a narrow area of coastal plains adjacent to the Pacific Ocean. This topography provides for some unique localised hydrological effects, which have proved challenging in the application of the Australian Rainfall and Runoff 2019 (ARR2019) (Ball et al, 2019) standard approaches and standard IFDs from the Bureau of Meteorology.

Ghetti et al (2019) provided an overview of some of the key challenges and localised guidance that was developed for Wollongong, including updated IFDs, research and guidance on revised preburst and losses (also discussed in Thomson et al, 2019) and various other considerations. Following this work, Council has been undertaking testing on a number of their catchments to understand the overall influence of these updated parameters, and comparing these against observed historical flood levels and estimates from ARR87. However, the key challenge has been the absence of reliable flow gauges to adequately test the hydrological techniques.

This paper explores the Mullet Creek catchment, and the adaptation of a water level gauge to provide a flow estimate and an estimated Flood Frequency Analysis (FFA). This FFA provides a unique opportunity to examine and assess the IFD rainfall suitability to the catchment using calibrated WBNM hydrological models and accompanying TUFLOW model. Investigation from IFD testing, pre burst rainfalls, varying temporal patterns, regional specific IFD rainfall, escarpment influenced rainfall and enveloped IFDs has been included in this assessment. This paper discusses the assessment process and will present the outcomes of the study. Overlaying this with the wider testing in other catchments, it has assisted Council in developing guidance for the wider LGA in the application of ARR2019.

Storm Tide Inundation Modelling for Flood Database

C van Megchelen[1], C Scraggs[2], P Comino[1], E Wong[1]
[1]Cardno, Fortitude Valley, QLD
[2]Cardno, Sydney, NSW

Note: the site location cannot be identified at this point in time. However, the study presented is one of the most detailed storm tide inundation modelling studies to be completed along Queensland's coastline.

Recently, Cardno has completed Storm Tide Inundation Modelling (STIM) on behalf of a council located along Queensland's extensive coastline. The models developed identified coastline and low-lying areas subject to Tidal and Storm Tide inundation under both present day and future climate / sea level rise scenarios.

To predict the Storm Tide inundation extent, a comprehensive numerical modelling system was applied which dynamically modelled storm tide and waves, including offshore waves and nearshore waves. Storm Tide Inundation Modelling was undertaken using Delft3D hydraulic modelling software that incorporated, among other conditions, spatial and time varying wind stress boundary conditions and wave stress boundary conditions. It also incorporated 1D and 2D hydraulic structures representing stormwater networks and other topographical features in coastal and inland areas subject to inundation.

Seven storm tide inundation models were developed as part of this study with areas ranging from 13 km^2 to 167 km^2. All of the modelling was undertaken with Delft3D software.

Several challenges were faced during this study with regards to flooding and drainage, such as converting multiple drainage data sets into one concise Delft3D drainage layer and complex tidal behaviour in the large estuaries.

The aim of this presentation is to present our modelling methodologies including key data inputs, challenges faced and how we overcame these challenges. Throughout the presentation insights into the modelling methodology will be provided. Discussion on potential future improvements will also be provided.

Innovative 3D Data Collection to Inform Farm Dam Failure Response Planning

T Wilson[1], S Pulford[1], J Moreland[1]
[1]South Australian State Emergency Service, Adelaide, SA

The South Australian State Emergency Service (SASES) is the Control Agency for extreme weather. During the significant 2016 storm event in South Australia several large-scale farm dam walls failed, or threatened to fail, placing downstream communities at risk.

As a consequence the SASES, in collaboration with Location SA and Esri Australia, have undertaken a project utilising Remotely Piloted Aircraft (RPA or drones) and propriety Esri Drone2Map software to gather intelligence to inform flood planning and emergency response in the event of farm dam failures.

Preliminary drone imagery captured over a near-empty flood mitigation dam, combined with bathymetric and LIDAR data, have been processed and draped over digital elevation modelling to produce 2D and 3D mapping products for the area immediately surrounding this infrastructure. Development of these 3D products has enabled dam storage volume calculations to be undertaken for a number of scenarios and will support the development of response plans and operational briefing tools.

The application of the methodologies developed during this first phase of the project will enable the SASES to collect accurate farm dam volumes for significant structures. This information will greatly assist in the estimate of potential impacts to downstream communities in the event of a dam failure. As a result, the SASES is in an advantageous position to develop highly accurate flood response plans and better serve the community of South Australia.