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Expert Opinion: Stability of People, Vehicles and Buildings in Flood Water

WRL Technical Report 2015/11
August 2015

By G P Smith

Water Research Laboratory
University of New South Wales
School of Civil and Environmental Engineering

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Project Details

Report Title	Expert Opinion: Stability of People, Vehicles and Buildings in Flood Water
Report Author(s)	G P Smith
Report No.	2015/11
Report Status	
Date of Issue	13 August 2015
WRL Project No.	2015057
Project Manager	G P Smith
Client Name	Grantham Floods Commission of Inquiry
Client Address	PO Box 15185 City East QLD 4002
Client Contact	Ms Joanne Paterson
Client Reference	DOC/15/133134

Document Status

Version	Reviewed By	Approved By	Date Issued
Final	W C Glamore	G P Smith	13 August 2015

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1. Introduction

This expert opinion on flood water hazard has been prepared by Grantley Smith of the University of New South Wales' Water Research Laboratory in response to the Letter of Instructions from the Grantham Floods Commission of Inquiry dated 13 August 2015 (ref: DOC/15/133134). The Letter of Instructions is attached to this report as Appendix A.

The Letter of Instructions sought expert opinion on the likely effects of fast flowing water on "*a rural town with a range of buildings of different structures (brick, wood and prefabricated), all one or two stories in height and where buildings are generally well spread out".*

The Letter of Instructions also sought opinion on the potential impacts on a rural township by flood flows with a range of flow speeds and depths including water flowing at 20 km/hour, 30 km/hour, 40 km/hour, 60 km/hour, and 80 km/hour in the following scenarios:

(i) water is 0.5 m deep, no debris in the water;
(ii) water is 0.5 m deep, substantial debris in the water;
(iii) water is 1.0 m deep, no debris;
(iv) water is 1.0 m deep, substantial debris in the water;
(v) water is 1.5 m deep, no debris;
(vi) water is 1.5 m deep, substantial debris in the water;
(vii) water is 2.0 m deep, no debris;
(viii) water is 2.0 m deep, substantial debris in the water;
(ix) water is 2.5 m deep, no debris;
(x) water is 2.5 m deep, substantial debris in the water;
(xi) water is 3.0 m deep, no debris;
(xii) water is 3.0 m deep, substantial debris in the water.

1.1 Resume – Grantley Smith BE Civil (Hons), MEngSc (Water Engineering), MIEAust, CPEng

I am the Principal Engineer and Manager of the Water Research Laboratory, Civil and Environmental Engineering at UNSW Australia.

I have extensive, experience in the fields of flood hydrology, flood flow hydraulics and floodplain management. This experience was gained working with industry and government, (local, state and federal) both within Australia and overseas.

Within these fields I have specialist skills and knowledge of the physical processes of flood flows, numerical and physical modelling of flood flows, and assessment of the vulnerability of communities and community assets and infrastructure during floods. My full CV is attached as Appendix B.

2. Flood Flows in Nature

Flood waters have the potential to cause great damage. When buildings, vehicles and people are in the path of flood waters they can be susceptible to being lifted, pushed and/or rolled along by the flood flows.

In the simplest terms, the damage and danger that flood waters might cause can be related to the force of the flood flows as they travel down a floodplain. The force of flood waters can be described by the depth and speed that the flows are travelling at. So it follows that deeper, faster flows can impart more force and cause more damage than slow, shallow flows.

The characteristics of naturally occurring flood flows are influenced by the shape, size and slope of the terrain that they are flowing through. In nature, flood flows are often moving fastest in the steep, upper reaches of a river catchment. Generally, in a large catchment like the Brisbane River catchment, flows move faster in the steeper tributary creeks and streams in the upper catchment and slow down as they pass onto the broader floodplain in the lower catchment.

The speed and depth of flow in any particular local part of the floodplain is also dependent on the volume of flow passing and the shape of the floodplain. Larger flows caused by extreme rainfall events over the catchment usually pass through a local floodplain area at higher depths and higher speeds than smaller flows from less intense storms.

Flood flows in nature always seek to move in the lowest energy condition, which is slow and deep rather than fast and shallow. So if the floodplain shape allows it, flows will preferentially spread out over the banks of the creek channel and onto the floodplain and flow at a slower speed.

However, if the floodplain is narrow and constrained, fast moving flood flows will seek a lower energy condition by scouring out the channel to make it bigger if the channel material allows it. Large, deep, fast flows are capable of moving huge amounts of sediment including soil and gravel from the creek or river banks and bed. When the banks are undermined, the flood flows pick up large amounts of debris and vegetation up to and including fully grown trees. In extreme cases, deep fast flood flows in river rapids have been known to move large boulders weighing several tonnes down the river channel.

3. Flow Speeds in Nature

The fastest flood flow speeds observed in nature are typically in the steepest river channels or at the base of large flow structures like dam spillways. Direct measurement of flow speeds in floods is difficult and dangerous, so examples of directly measured flow speeds are rare. However, flow speeds can be reasonably estimated where information about the flow rate and the dimensions of the river channel or flow structure are known. Some readily available examples of flow speeds in nature and at river structures are provided below.

3.1 Flow Speeds in Large River Rapids

In 2006, the United States Geological Survey sent a team to the Colorado River in Utah to measure river flow speeds in the Cataract Canyon rapids (Magirl et al., 2009). The river rapids at this location are well known for their fast and violent flows through the canyon. A picture showing Colorado River rapids is provided to illustrate this type of flow conditions in Plate 1 below. The peak flow speed measured in the river rapids was reported as 6 metres per second (m/s) which equates to approximately 22 kilometres per hour (km/h). Other estimates of flow speeds in the Colorado River rapids by experienced white water rafters put the flows at 25 to 35 miles per hour (http://www.teamsantafe.org/05newsletters/newsletter_2005_07.shtml, sourced 28 July 2015) which is approximately 40 to 55 km/h (11 to 15 m/s).

Figure 1: Colorado River Rapids

(source: http://www.teamsantafe.org/05newsletters/newsletter_2005_07.shtml, 28 July 2015)

3.2 Flow Over the Wivenhoe Dam Spillway in flood

In January 2011, with the Brisbane River catchment in major flood, Wivenhoe Dam spillway was activated with all five spillway gates opened. The peak flow rate over the spillway was 7,460 metres cubed per second (m^3/s). At this flow rate, the peak flow speed at the base of the spillway has been estimated by hydraulic specialists at the UNSW Water Research Laboratory at

21 m/s or 75 km/h. Large flip bucket spillways on major dams are typically designed for flow speeds in the order of 15 to 20 m/s (55 to 70 km/h).

Figure 2: Wivenhoe Dam Spillway

(source: http://www.couriermail.com.au/news/queensland/wivenhoe-put-under-pump-to-save-region/story-e6freoof-1226552717108)

3.3 Flow Speeds on a Typical Floodplain

Peak naturally occurring flow speeds can also be estimated by considering evidence of flood water level slopes or by the types of rock and soil material eroded by flows after floods have passed through a floodplain and the flood waters have subsided.

The flow speeds required to erode different types of river bed material have been measured in controlled tests. Information from these tests is often used to design construction works to stabilise river banks and channels. Information from the tests show that flow speeds of 16 km/h (4.4 m/s) would erode 0.2 m diameter rocks (Chow, 1959). Similarly, design guidelines aimed at providing rock protection for river banks recommend 0.5 tonne rock to remain in place in 16 km/h (4.5 m/s) flow speeds and 4 tonne rock to withstand flows of 22 km/h (6.0 m/s) (Main Roads Western Australia).

As a point of reference a 0.5 tonne basalt rock would typically be about 0.3m diameter, which is the size of a microwave oven. A 4 tonne basalt rock would be about the size of a single seater lounge chair.

Tests on soil erosion indicate that flows in the order of 7 to 11 km/h (2 to 3 m/s) (Chow, 1954) are fast enough to move large amounts of top soil, similar to the erosion that occurred in the Lockyer Valley in January 2011.

Based on this evidence, it would be rare for floodplain flow speeds to be greater than 20 km/h (5.5 m/s) on an alluvial floodplain.

3.4 Summary of Flow Speeds in Nature

In summary, the most extreme observed natural flows occur in steep, rock lined river channels or at large flow structures like dam spillways. In these extreme cases under large flow rates, flow speeds can peak at 75 km/h at the base of large dam spillways like Wivenhoe Dam. Flow speeds in river rapids have been measured at 22 km/h and have been reported by estimation as high as 55 km/h.

Flow speeds on an alluvial floodplain, like the Lockyer Creek floodplain where extreme erosion of vegetation and top soil has occurred might have experienced flow speeds up to 14 to18 km/h (4 to 5 m/s). Flow speeds on floodplains are rarely higher than 20 km/h, even in extreme cases.

4. Vulnerability of People, Vehicles and Buildings in Flood

The National Flood Risk Action Group, a committee formed by the Federal Attorney General's Department has recently completed a major revision of national best practice in floodplain management *(AEM Handbook 7, 2014)* (https://ema.infoservices.com.au/items/HB7-2ND). As part of this review, the UNSW Australia's Water Research Laboratory completed an extensive literature review aimed at determining the characteristics of flood flow that would expose people, vehicles and buildings to damage and danger in floods (Smith et al., 2014). This review, which included information from the floods in Grantham in January 2011 compiled the 'vulnerability curves' presented in Figure 3.

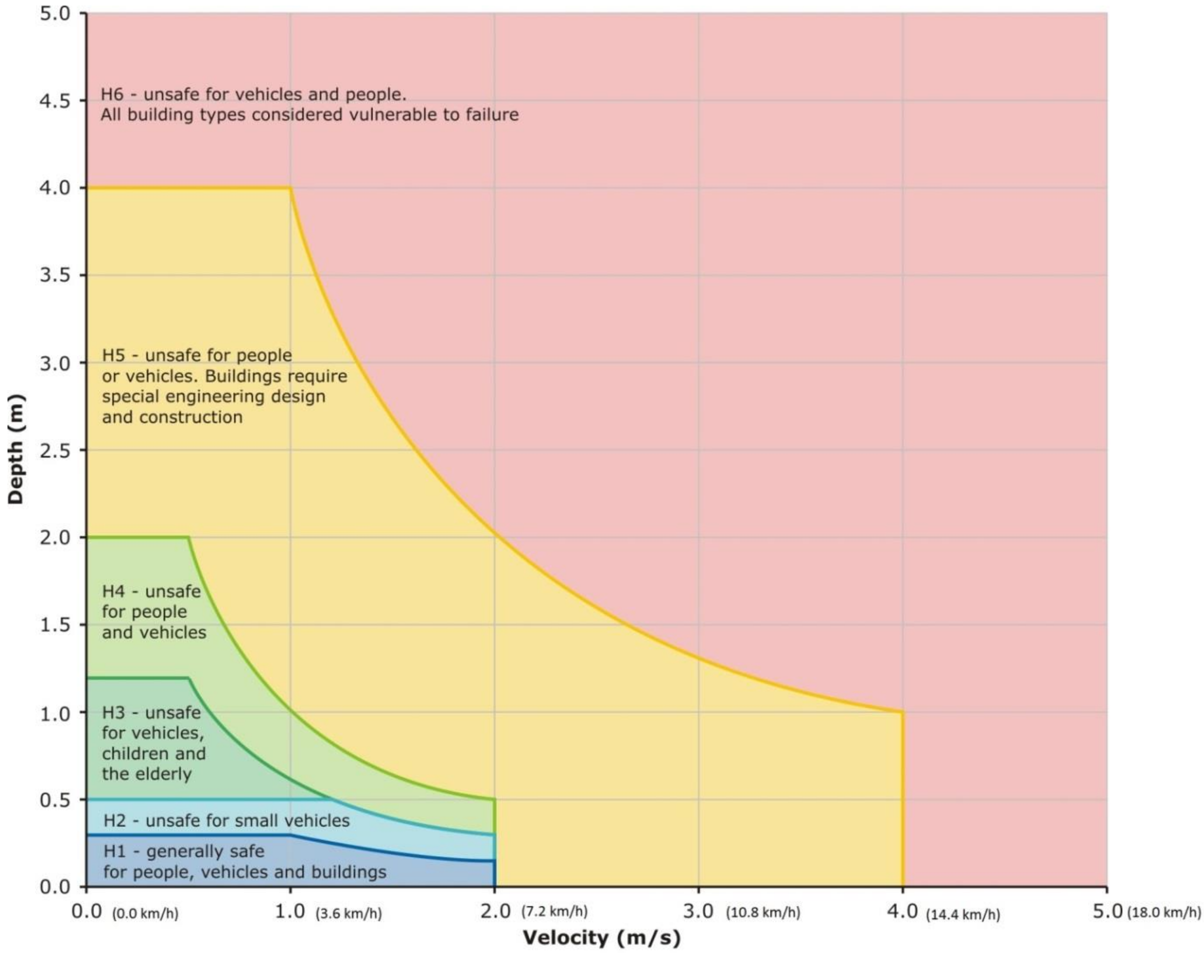

Figure 3: Flood Hazard Vulnerability Curves (AEM, 2014)

The review found that the level of danger and vulnerability of buildings, vehicles and people when exposed to flood waters is dependent on the force of the flood flows, which can be described in the simplest terms by the depth and speed that the flood waters are moving.

The level of danger and the potential to cause damage can also be increased by the rate of rise of the flood waters, the amount of debris and sediment carried by the flows and the warning time available prior to the flood occurring.

In summary, the review found that:

- People and vehicles can become unstable in relatively shallow and slow moving flows;
- In slow moving flows, small cars can become buoyant when flow depths exceed **0.3 m** and large four wheel drive vehicles can become unstable when flow depths are above **1.2 m**;
- Fit adults walking through floodwaters can become unstable when flow depths exceed **1.2 m.** Primary school age children and the elderly members of the community may become vulnerable to toppling over in flood waters deeper than **0.5 m**;
- Residential buildings are at risk of failure once flood flows are greater than **1.0 m** deep in combination with flow speeds greater than **3.6 km/h** (1 m/s).
- All building types including concrete reinforced industrial buildings are prone to failure once flood flows are greater than **2.0 m** deep in combination with flow speeds greater than **7.2 km/h** (2 m/s).

5. Assessment of Danger and Damage for Noted Flow Depth and Speed Combinations

When considering the amount of danger and damage that flood waters can cause, its helpful to have a frame of reference. Some simple examples are provided below:

- A swimmer in the Olympic final of the 100m freestyle swims at about **7.2 km/h** (2 m/s). It follows then, that if an average person fell into flood waters 1 or 2 metres deep travelling at 7.2. km/h they would have extreme difficulty saving themselves;

- Water is heavy. Each **one metre cube** of water weighs about **one tonne** (1000kg). If a house is exposed to a floodplain flow **2 m deep** and **20 m wide** travelling at **3.6 km/h** (1 m/s) it is exposed to a similar force to being hit by a **40 tonne semi-trailer** every 15 seconds.

So it can be seen that objects in the path of flood flows are often exposed to extremely large and dangerous forces, even when the water is moving quite slowly.

5.1 Water is 0.5 m Deep

At a flood flow depth of **0.5 m** small vehicles are likely to float at the rear end (i.e. away from the stabilising weight of the motor) and low flow speeds in the order of **3 km/h** will be enough to push these small cars off the road. If the road is on an elevated embankment, a small car washed off the embankment into deeper water is liable to sink putting the occupants lives in danger. At **0.5 m** deep, flow speeds in excess of **7.2 km/h** would push most larger cars and some four wheel drive vehicles off the road. When flow speeds velocities are greater than **7.2 km/h** in combination with flow depths greater than **0.5 m**, lighter construction, single story residential properties (e.g. fibro, cladded) are vulnerable to failure by the walls collapsing in from the weight and impact of the water. At flow speeds greater than about **11 km/h** larger brick or concrete buildings are liable to damage from erosion around the building foundations. If flow speeds increase to **15 km/h** even the most robustly constructed concrete reinforced buildings are likely to fail even in water depths as low as **0.5 m.**

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

5.2 Water is 1.0 m Deep

In flood flows of **1.0 m** depth most types of small and medium sized vehicles are vulnerable to being pushed off the road, even in slow moving flows. Once pushed off the road into deeper water they may sink, putting the occupants lives at risk. Once flow speeds are greater than about **4 km/h** in **1.0 m** deep water, most larger cars and four wheel drive vehicles will also be vulnerable to being washed away.

In flood flows of **1.0 m** depth flowing at speeds in excess of **4 km/h** lighter construction, single story residential properties (e.g. fibro, cladded) are vulnerable to failure by the walls being pushed in from the weight and impact of the water. If flow speeds increase to **7 to 8 km/h** most brick construction buildings would be liable to failure by the walls collapsing from the weight and impact of the water. If flow speeds increase to **15 km/h** even the most robustly constructed concrete reinforced buildings are likely to fail in water depths of **1.0** m by erosion undermining the building foundations**.**

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

5.3 Water is 1.5 m Deep

In flood flows **1.5 m** deep most types of small and medium sized vehicles are vulnerable to being pushed off the road, even in slow moving flows. Once pushed off the road into deeper water they may sink, putting the occupants lives at risk. If the flow speed increases to about **4 km/h** most larger cars and four wheel drive vehicles will also be vulnerable to being washed away. If flow speeds increase to **7 to 8 km/h** most brick construction buildings would be liable to failure due to the walls collapsing. If flow speeds increase to **10 to 12 km/h** even the most robustly constructed concrete reinforced buildings are likely to fail in water depths of **1.5 m** due to the foundations being undermined by scour.

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

In flows **1.5 m** and deeper, with flow speeds greater than **10 km/h** there is the potential for the flow to move large rocks which would have the impact of water borne projectiles, making the flows extremely dangerous. Individuals exposed to such flows are at extreme risk.

5.4 Water is 2.0 m Deep

In flood flows **2.0 m** deep all vehicles including small trucks are vulnerable to being pushed off the road, even in slow moving flows. Once pushed off the road into deeper water they may sink, putting the occupants lives at risk. Light framed buildings will be vulnerable to failure in flows **2.0 m** deep even if the flows are moving extremely slowly (e.g. **1 to 2 km/h**) as this depth of flow would subject the structure to large forces that could push the whole structure over. If Queenslander style homes on high stumps are not tied down to the stumps, they will be vulnerable to floating off the stumps and disintegrating at this flow depth. If flow speeds increase to **3 to 4 km/h** most brick construction buildings would be liable to failure due to wall collapse. If flow speeds increase to **7 to 8 km/h** even the most robustly constructed concrete reinforced buildings are vulnerable to failure due to erosion around the foundations or uplift forces on the building failing the walls and foundation slab.

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

In flows **1.5 m** and deeper, with flow speeds greater than **10 km/h** there is the potential for the flow to move large rocks and boulders which would have the impact of water borne projectiles, making the flows extremely dangerous. Individuals exposed to such flows are at extreme risk.

5.5 Water is 2.5 m Deep

In flood flows **2.5 m** deep all vehicles including small trucks are vulnerable to being pushed off the road, even in slow moving flows. Once pushed off the road into deeper water they may sink, putting the occupants lives at risk. Light framed buildings will be vulnerable to failure in flows **2.0 m** deep even if the flows are moving extremely slowly (e.g. **1 to 2 km/h**) as this depth of flow would subject the structure to large forces that could push the whole structure over. If Queenslander style homes on high stumps are not tied down to the stumps, they will be vulnerable to floating off the stumps and disintegrating at this flow depth. If flow speeds increase to **3 to 4 km/h** most brick construction buildings would be liable to failure would be liable to failure due to wall collapse. If flow speeds increase to **6 to 7 km/h** even the most robustly constructed concrete reinforced buildings are vulnerable to failure due to erosion around the foundations or uplift forces on the building failing the walls and foundation slab. Flow speeds greater than **11 km/h** at **2.5 m** depth have great force with the potential to clear the landscape of all buildings and vegetation.

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

In flows **1.5 m** and deeper, with flow speeds greater than **10 km/h** there is the potential for the flow to move large rocks and boulders which would have the impact of water borne projectiles, making the flows extremely dangerous. Individuals exposed to such flows are at extreme risk.

5.6 Water is 3.0 m Deep

In flood flows **3.0 m** deep all vehicles including large trucks are vulnerable to being pushed off the road, even in slow moving flows. Once pushed off the road into deeper water they may sink, putting the occupants lives at risk. Light framed buildings will be vulnerable to failure in flows **3.0 m** deep even if the flows are moving extremely slowly (e.g. **1 to 2 km/h**) as this depth of flow would subject the structure to large forces that could push the whole structure over. If Queenslander style homes on high stumps are not tied down to the stumps, they will be vulnerable to floating off the stumps and disintegrating at this flow depth. If flow speeds increase to **3 to 4 km/h** most brick construction buildings would be liable to failure due to the walls collapsing. If flow speeds increase to **5 to 6 km/h** even the most robustly constructed concrete reinforced buildings are vulnerable to failure are vulnerable to failure due to erosion around the foundations or uplift forces on the building failing the walls and foundation slab.

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

In flows **1.5 m** and deeper, with flow speeds greater than **10 km/h** there is the potential for the flow to move large rocks and boulders which would have the impact of water borne projectiles, making the flows extremely dangerous. Individuals exposed to such flows are at extreme risk.

5.7 Water is 4.0 m Deep

Flows above **4.0 m** deep are extremely dangerous irrespective of the flow velocity. Any vehicle caught in **4.0 m** deep water is in extreme danger. Flows of this depth have enormous force and have the potential to cause damage to even the most robust concrete structures. Flows greater than **4.0 m** deep travelling at greater than **10 km/h** would destroy most types of built infrastructure, pushing most buildings over.

Additional sediment or water borne debris like vegetation, tree trunks and fence posts will only serve to increase the impact of the flows, increasing the potential for damage and danger. In many cases, large individual pieces of debris will move more or less at the same speed as the flow, becoming projectiles in the flow. Heavy rafts of debris may also build up on buildings and other structures, adding to the load on the structure and increasing the likelihood of the structure failing.

In flows **1.5 m** and deeper, with flow speeds greater than **10 km/h** there is the potential for the flow to be moving large rocks and boulders which would have the impact of water borne projectiles, making the flows extremely dangerous. Individuals exposed to such flows are at extreme risk.

6. Summary

The information presented above shows that flood waters travelling at relatively slow flow speeds can move with great force. Evidence shows that:

- Small cars can become buoyant and be washed off roads in flows as shallow as **0.3 m**;
- Primary age children and the elderly can become unstable and lose their footing in flows as shallow as **0.5 m**;
- Large four wheel drive vehicles can become unstable when flow depths are above **1.2 m**;
- Fit adults walking through floodwaters can become unstable when flow depths exceed **1.2 m**;
- Residential buildings are at risk of failure once flood flows are greater than **1.0 m** deep in combination with flow speeds greater than **3.6 km/h** (1 m/s);
- All building types, including concrete reinforced industrial buildings, are prone to failure once flood flows are greater than **2.0 m** deep in combination with flow speeds greater than **7.2 km/h** (2 m/s).

Laboratory tests on rocks and analysis of scour and erosion after flood waters have receded show that vast amounts of soil, gravel and rocks can be moved by flows travelling at speeds of 7 to 11 km/h. On this basis, it would be rare for flood speeds on an alluvial floodplain, such as in the Lockyer Valley, to exceed 20 km/h. Flood speeds greater than 60 km/h are only seen at large man-made structures and are unlikely to ever occur in a natural floodplain.

6.1 Declaration

This report represents my expert opinion on flood water hazards prepared to address the Letter of Instructions (ref: DOC/15/133134) provided to me by the Grantham Floods Commission of Inquiry. In preparing this report, I have relied on the listed references and my knowledge of the subject gained over my 24 years of engineering practice.

Grantley Smith, 13 August 2015

7. References

AEM (2014) *Australian Emergency Management Handbook: Managing the floodplain: best practice in flood risk management in Australia (AEM Handbook 7, 2014)*. Available at: https://ema.infoservices.com.au/items/HB7-2ND.

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APPENDICES

A – Letter of Instructions
B – Grantley Smith Curriculum Vitae

Reference number: DOC/15/*133134*

Grantley Smith
Principal Engineer and Manage
Water Research Laboratory
UNSW
110 King St
Manly Vale NSW 2093,

Dear Grantley

GRANTHAM FLOODS COMMISSON OF INQUIRY – STABILITY OF PEOPLE, VEHICLES AND BUILDINGS IN FLOOD WATER – LETTER OF INSTRUCTIONS

Engagement as a water hazard expert for the Grantham Floods Commission

The Grantham Floods Commission of Inquiry (the Commission) has been established to make a full and careful inquiry with respect to the flooding of the Lockyer Creek between Helidon and Grantham on 10 January 2011.

The scope of the Commission's terms of reference includes an inquiry in relation to the Grantham quarry and the impact the existence or breach of that quarry had on the flooding at Grantham.

Scope of your engagement

The Commission confirms your engagement to provide an expert opinion as to the effect of fast flowing water on a town environment like Grantham i.e. a rural town with a range of buildings of different structures (brick, wood and prefabricated), all one or two stories in height and where buildings are generally well spread out.

Your opinon is also sought, in general terms, of the effect of moving water on (a) the type of buildings common in the Grantham area, and (b) people and vehicles where the water is flowing at 20km/hour, 30km/hour, 40km/hour, 60km/hour, and 80km/hour in the following scenarios:

(i) water is 0.5m deep, no debris in the water;
(ii) water is 0.5m deep, substantial debris in the water;
(iii) water is 1.0m deep, no debris;
(iv) water is 1.0m deep, substantial debris in the water;
(v) water is 1.5m deep, no debris;
(vi) water is 1.5m deep, substantial debris in the water;
(vii) water is 2.0m deep, no debris; and
(viii) water is 2.0m deep, substantial debris in the water.
(ix) water is 2.5m deep, no debris;
(x) water is 2.5m deep, substantial debris in the water;
(xi) water is 3.0m deep, no debris;
(xii) water is 3.0m deep, substantial debris in the water;

If it is possible to provide analogies to assist understanding of the force of the water in any of these scenarios please do so. Similarly, if you can, please provide information as to the comparison between velocities perceived on dry land as opposed to velocity in water (for example, a comparison between the velocity of a car travelling on a dry highway as opposed to the velocity of water (or debris travelling in that water) travelling along the same highway.

Finally, if there are physical limitations to the maximum speeds which water can reach. Please include this information in your advice.

Please provide your opinion in the form of an expert report addressed to the Commission and signed by you.

I look forward to receiving your expert report in due course.

Yours sincerely

Joanne Paterson
Director
Grantham Floods Commission of Inquiry

13 August 2015

Water Research Laboratory

Grantley Smith BE, MEngSc, CPEng
Manager and Principal Engineer

Never Stand Still | Faculty of Engineering | School of Civil and Environmental Engineering

Grantley Smith is Manager of the Water Research Laboratory (WRL) of the University of New South Wales. WRL is a leading international research and consulting laboratory utilising numerical modelling, physical modelling and field data collection to provide expert solutions in the areas of water, coastal and environmental engineering and groundwater. As Manager and Principal Engineer, Grantley is responsible for all commercial and applied research projects, financial operations, ongoing professional development of staff and the maintenance and development of WRL's facilities and techniques.

Grantley is an Australian expert in the fields of physical and numerical modelling of water. In his 22 years as a professional engineer, Grantley has developed his skills on a broad range of projects providing assessment and solutions for water engineering and water resources investigations. He has particular expertise in the selection and application of appropriate numerical models to support design solutions, planning and management across the water spectrum. Numerical modelling projects have been undertaken using 1D, 2D and 3D hydrodynamic and water quality models.

Grantley has specialist expertise in water resources management through a hands-on career investigating catchment processes. He is acknowledged by his peers as an expert in the application of numerical models to catchments and floodplains and was instrumental in the pioneering use of 2D hydrodynamic models for floodplain flow prediction and inundation mapping. His experience gained through direct participation in the evolution of floodplain modelling has provided him with an outstanding knowledge of the application and interpretation of appropriate numerical models to support environmental planning, management and forecasting for floodplains. Grantley is a lead author and key contributor to reports supporting the revision of Australian Rainfall and Runoff, most recently contributing to guidelines for appropriate use of 2D numerical models to floodplains. He is also a co-contributor to guidelines setting safety criteria for people and vehicles in floods.

Qualifications

BE Hons (Civil Engineering), UQ
MEngSc (Water Engineering), UNSW

Affiliations

CPEng (Chartered Professional Engineer)
NPER (National Professional Engineers Register, Australia)
Australia Water Association
Immediate Past Chair, Engineers Australia Sydney Water Panel
Chair, 34th Hydrology and Water Resources Symposium

Professional History

1990-1996 : Project Engineer - Lawson and Treloar, NSW
1997-1999 : Senior Engineer - Lawson and Treloar, NSW
1999-2000 : Computational Hydraulics Engineer - Danish Hydraulics Institute, Denmark
2000-2004 : Principal Engineer - DHI Water and Environment, Australia
2004-2009 : NSW State Manager - DHI Water and Environment, Australia
2009-2011 : Senior Project Engineer - WRL, UNSW
2012- : Manager and Principal Engineer - WRL, UNSW

Specialist Fields of Expertise

- Project management
- Flood studies and floodplain management
- Flood safety
- Hydrological processes and wetland hydrology
- Water resources management
- Surface water/groundwater interactions
- Flow forecasting
- Hydrodynamic and water quality modelling
- Environmental flow delivery
- Ocean outfalls
- Estuarine processes
- Hydraulics structures

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Relevant Experience

Rivers and Flooding
Newcastle City-Wide Floodplain Risk Management Plan, NSW
Lower Hunter River Floodplain, NSW
Ironbark Creek Floodplain, NSW
Middle Creek Flood and Sediments, NSW
Woy Woy Flooding, NSW
Darling River, Bourke - Louth, NSW
Dark Creek Flooding, NSW
River Murray Environmental Flow Easements, NSW
Haslam Creek Hydraulic Investigation, NSW
Frenchs Creek FPMS, NSW
Warrah Creek Flooding ,NSW
Blackman's Swamp Creek FS, NSW
Mawson Lakes Channel, SA
Flood Damage Assessment, Czech Republic
Bohle River Flood Study, QLD
Onion Creek, Texas, USA
Tenterfield Flood Study, NSW
Brickfield Creek Flood Study, NSW

Flood Hazard
Flood Fatalities Estimation
National Flood Hazard Guideline – AEM Handbook 7
Flood Hazard – Analysis Methods

Hydrology and Forecasting
Wollondilly/Wingecarribee, NSW
Shoalhaven (Tallowa Dam), NSW
SCA Real-Time Forecasting System Framework, NSW
Vistula River, Poland

Dams and Structures
Hume Dam Gate Operations, NSW
Copeton Dam Fuse Plug EIA, NSW
Tumut 3 Turbine Upgrade, NSW
Chaffey Dam Break, NSW
Bethungra Dam Break, NSW
Potts Hill Reservoir, NSW
Cordeaux Dam Break, NSW
Avon Dam Break, NSW
Nepean Dam Break, NSW

Water and Wastewater
Sydney Water Sewer Sediment Blockage Analysis, NSW
Maldon Odour Control, VIC
Sydney Water Two-Phase, Dynamic H2S Model Scoping, NSW
Industrial Waste Impacts, SWOOS, NSW
Balickera Pump Station Upgrade, NSW
Sydney Water SCAMPS, NSW
Northside Storage Tunnel, NSW
Shelly Beach H2S Assessment, NSW

Training and Lecturing
Numerical Modelling
Floodplain Hydraulics
Wetland Hydrology/Hydrodynamics

Panels and Review
VIC DEPI Flood Program – Peer Review
Australian Rainfall and Runoff
QLD Coal Seam Gas Surface Water Review
Ord River Irrigation Scheme Expansion
Lower Lakes Acid Sulphate Review
NSW Rivers Environmental Restoration Program, Hydraulic Modelling

Wetlands
Tomago Wetlands NSW
Yarrahappini Wetlands NSW
Chowilla Floodplain Baseline, SA
Chowilla Floodplain Options, SA
Koondrook Forest, NSW
Gunbower Forest, VIC
Macquarie Marshes, NSW

Coasts, Estuaries and Outfalls
Hunter River Water Quality Model, NSW
Sydney Desalination Plant Outfall Design and Commissioning, NSW
Newcastle Harbour Extreme Ocean Water Levels, NSW
Stockton Coastal Processes, NSW
Port Jackson Model, NSW
SWC SOLP Receiving Waters, NSW
Illawarra Outfall Commissioning, NSW
Illawarra Outfall Design, NSW
NSW Shelf Bathymetry, NSW
Danish Olympic Sailing Team - Port Jackson Forecasts, NSW
Navigation Channel Siltation, NSW
Dredge Plume Assessment, NSW
Cooks River Dispersion Study, NSW
Hunter River WWTW - Receiving Waters Assessment, NSW
Lake Illawarra Entrance, NSW
Tomago Aluminium Outfall, NSW
Kikori River Pipeline Stability, PNG

Project Summary

Year	Project	Position & Activities
2015	Newcastle Voluntary Purchase Assessment	Project Manager and Technical Expert. Analysis of design flood conditions on an urban overland flowpath in Newcastle NSW. Assessment of the vulnerability of buildings on the flowpath to failure during flood. Design and assessment of voluntary purchase scenarios to limit potential loss of life and residential damages during flood.
2015	Toowoomba Overland Flood Study	Expert Reviewer Expert advice and review of the proposed methodology for the Toowooomba Overland Flood Study.
2015	Flood Fatalities Literature Review	Lead Author Literature review for the Australian Government National Flood Risk Action Group (NFRAG) on methods to estimate fatalities during flood conditions.

2014	Flood Hazard Technical Guideline	Author, Flood Hazard Guideline. Preparation of technical guideline to support recently released national best practice manual for floodplain management
2014	Flood Hazard – background report	Project Manager and technical expert. Prepartion of a literature review and fundamental research into hazard on floodplains. Investigation of quanitifcation of flood hazard and recommendation of hazard vulnerability guidelines for people, vehicles, buildings and infrastructure on floodplains
2014	Temperate Peat Swamps on Sandstone	Expert Reviewer Literature review to investigate the impacts of long wall mining on temperate peat swamps os sandstone in Blue Mountains and Illawarra. Critical Analysis of Temperate Highland Peat Swamps on Sandstone Literature colaltion and Evaluation of Mitigation and Remediation Techniques.
2013	Coincidence of Catchment and Ocean Flooding Stage 2 - Recommendations and Guidance	Author and Principal Investigator Collation, analysis and development of guidance for the NSW Government on the joint occurrence of coastally driven and catchment driven flooding for design purposes.
2013	Safety Design Criteria for People and Vehicles	Author and Principal Investigator Report for Australian Rainfall and Runoff on floodplain safety criteria for people and vehicles in floods.
2013 - ongoing	VIC DELWP Flood Program	Expert review services for the Victorian Flood Program flood studies and flood mapping.
2012	Big Swamp Rehabilitation Project Hydrological Study	Expert Reviewer Development of a strategy for the rehabilitation of Big Swamp on the Manning River floodplain. Design of earthworks and hydraulic controls for controlled inundation of acid-sulfate affected floodplain.
2012	Joint Probability Assessment of NSW Extreme Waves and Water Levels	Expert reviewer Collation of offshore oceaographic data and statistical analysis of the joint probability of extreme waves and elevated ocean levels during extreme offshore storm events
2012	Throsby Creek Dredging: Flood Assessment	Principal Investigator Assessment of impacts of proposed dredging on flood levels in Throsby Creek, Newcastle. Numerical modelling, interpretation and reporting.
2011	Yarrahappini Wetland Restoration	Expert Reviewer, Modelling: Review of hydrodynamic and advection dispersion models of Yarrahappini Wetland on the Macleay River, NSW. Testing of gate opening options for tidal inundation to restore salt marsh and negate acid sulphate conditions.
2011	Sewer Sediment Blockage Assessment	Project Manager: Development of a controlled experiment to assess the flow velocity conditions required to self-cleanse consolidated cohesive sediments in sanitary sewers.
2011	QLD Coal Seam Gas, Surface Water Review	Expert Reviewer: Review of surface water aspects of development proposals for three coal seam gas development applications for the Federal Department of Sustainability, Environment, Water, Population and Communities. Assessment of impacts to matters of National Environmental Significance with respect to the EPBC Act.

2010	ARR Project 15, Floodplain Flow Blockages in Urban Areas	Lead Researcher and Project Manager: Development of detailed physical and numerical models of the Merewether floodplain in Newcastle NSW. Assessment of various 2D numerical modelling techniques to determine suitability and accuracy as applied for representation of urban floodplain flow behaviour.
2010	Hunter River Water Quality Model	Project Manager and Modelling Expert: Development of a hydrodynamic and advection dispersion model of the Hunter River tidal pool. Assessment of the influence and impact of adjusted wastewater treatment plant outflows to the river as part of the assessment of a catchment wide water re-use scheme for the Lower Hunter River valley.
2010	Ord River Irrigation Scheme	Expert Reviewer: Review of surface water aspects of a development proposal to expand the Ord River irrigation scheme for the Federal Department of Sustainability, Environment, Water, Population and Communities. Assessment of impacts to matters of National Environmental Significance with respect to the EPBC Act.
2009-2010	Newcastle City-Wide Floodplain Management Plan	Team Leader, Modelling: Review of floodplain models as the basis of flood planning levels. Coordination of models as tools for the assessment of flood mitigation structures. Advice to the committee regarding floodplain hydraulic performance.
2009	Gunbower Forest Review	Expert Reviewer: Provided due diligence review of numerical modelling inputs used as the basis for design of channels for environmental flow delivery in the Gunbower Forest.
2009	Chowilla Floodplain Review	Expert Reviewer: Provided expert review of the 2D numerical model assessment of the effectiveness of the proposed Chowilla Weir to control environmental flow inundation extents on the Chowilla Floodplain.
2009	Design Review of Odour Control Device	Expert Reviewer: Review of proposed adjustments to sanitary sewer designs in order to minimise odour generation at a site in Maldon, Victoria for Coliban Water.
2009	Sydney Desalination Plant Outfall	Project Manager: Physical model testing of the Sydney Desalination Plant outfall diffuser. Design advice to the Bluewater consortium to refine outfall design performance for both dilution and headloss.
2008	Analysis of Extreme Ocean Levels at the Hunter River Entrance	Project Director: Investigation to provide an assessment of the various extreme ocean phenomena which may induce an elevated ocean level and to quantify estimates of the component ocean water level anomalies that might combine to develop into an elevated ocean level or “storm surge” event in the extreme range in the Hunter River at Newcastle.
2008	Wallsend Plattsburg (Ironbark Creek) Flood Study	Project Director/Senior Technical Reviewer: Developing a coupled MIKE-FLOOD model to determine the flooding characteristics of the Wallsend-Plattsburg floodplain provision of GIS information to form part of council flood planning guidelines.

2008	Middle Creek Flood Study and Sediment Transport Study	Project Director: Development of a linked 1D/2D floodplain model to assess the impact of sand extraction on flow behaviour in a semi urban creek system.
2008	Woy Woy Flood Study	Project Director: Development of an integrated 2D surface water/3D groundwater model for the flood assessment of a sandy coastal floodplain on the NSW central coast.
2007	Expert Assistance - Hunter River Flood Emergency	Flood Forecasting Expert: Expert advice supplied to NSW State Emergency Service for Hunter River Flood Emergency. Analysis of real-time flood records "on the fly". Forecasting of flows and impact areas to determine potential requirement for evacuation. Go/no go advice for evacuation procedures.
2007-2008	Koondrook Perricoota Hydraulic Modelling	Project Director/Senior Technical Adviser: Analysing the hydraulic behaviour of the Koondrook forest using a MIKE-FLOOD model spanning 100km. The investigation focuses on maximising the advantages of hydraulic structures with environmental flows to inundate the forest for given criterion.
2007-2008	Darling River Flood Study - Bogan River Junction to Louth	Project Manager: Development and calibration of a 2D model of the Darling River floodplain near Bourke. Estimation of design flows by flood frequency analysis. Design floodplain behaviour estimation using a representative flow hydrograph derived from historical flood information.
2007	Balickera Pump Station, 3D Flow Model Analysis	Project Director: Development of a full 3D model description using DHI's computational fluid dynamics package NS3. Assessment of flow conditions in pump intake bay for upgrade of water supply offtake.
2007	Wollondilly/Wingecarribee Catchment Hydrological Assessment	Project Manager: Development and calibration of hydrological model for the upper portion of the Sydney Water supply catchment. Model development to be included in the SCA Floodwatch system as part of the upgrade of the system for use as a Spill Emergency DSS.
2007	Port Jackson Receiving Water Model - UTS Challenge Grant	Project Coordinator: Development and calibration of a 2D/3D receiving water model for Sydney Harbour to be used as a basis of University of Technology Sydney research of water quality including contaminated sediments.
2007	Wyong Employment Zone Flood Assessment	Development of hydrologic and flood models of the proposed Wyong Employment Zone in the headwaters of the Porter's Creek Wetland sub-catchment. Analysis of impact of likely development on flow regime.
2007	AMCOR Paper Mill - Upgrade Assessment	Project Manager: Assessment of impact of revised flow regime for paper mill outfall into SWOOS sewer main in Southern Sydney.
2007	Hume Dam Spillway Operations Analysis	Project Manager: Development of a MIKE-11 model to simulate operation of the gated spillway of Hume Dam. Logic tree development for spillway operation procedures. Calibration of model to storage level and flow release for a range of historical floods. Analysis of operations for extreme floods up to PMF.

2007	Sydney Water Sewer Overflow Licensing Project - Receiving Water Models	Project Manager: Re-calibration and extension of receiving water quality model for Port Jackson, Botany Bay/Georges River and Cooks River in Sydney NSW.
2007	SCA Flow Forecasting	Project Manager: Development of a real-time flow forecasting system for the Sydney Water Supply catchments. System is in daily use by operators with information published to SCA intranet.
2007	Koondrook Forest Modelling Assistance	Project Director: Providing training and assistance to Department of Natural Resources in building a 1D/2D hydraulic model for the investigation of regulatory structures.
2007	Dark Creek Flood Study	Project Director/Senior Technical Reviewer: Developing a coupled MIKE-FLOOD model to determine the flooding characteristics of Dark Creek and providing GIS information to form part of council guidelines.
2007	Black Creek Flood Study	Project Director/Senior Technical Reviewer: Undertaking community survey for historical information and collating existing material on flooding in Cessnock. Development of a hydrologic and a 1D/2D hydraulic model to investigate flooding characteristics in Cessnock.
2006	River Murray Hydraulic Modelling	Project Manager: Developing a 1D MIKE-11 model covering the River Murray from Hume Dam to Lake Mulwala. Development of inundation maps as basis for flow easement acquisition for environmental flow releases as part of Living Murray program.
2006	Copeton Dam Auxiliary Spillway Analysis	Project Manager: Coordinator of multi-disciplinary team for assessment of environmental impact for proposed auxiliary spillways for Copeton Dam upgrade. Team included terrestrial ecologists, geomorphologist, geologist and archaeologist.
2006	Haslam Creek Hydraulic Investigation	Project Engineer: Development of a 2D model for the analysis of design event floods for the building application for the new Tooheys Brewery site.
2006	Chowilla Floodplain Regulator Options Assessment	Project Manager and Technical Specialist: Project involved testing a range of regulator options in the Chowilla Floodplain hydraulic model aimed at improving wetland vegetation health, as part of the Living Murray program.
2006	Illawarra Outfall Commissioning	Project Manager: Design and execution of a range of experiments to confirm satisfactory operation of the Illawarra Waste Water System marine outfall. Coordination of onshore and offshore teams including plume measurement using rhodamine tracer and visual inspections by dive team.
2005	Upgrading of the Lower Hunter River Model at Hexham	Project Manager: Review of the 1D model developed for the Lower Hunter River flood study. Development of a nested 1D/2D model in the Hexham area to enable Newcastle City Council to make informed decisions in respect to flooding for development planning and control in the Hexham area.
2005	Thurgoona Flood Study	Project Director: Flood Study for the Thurgoona Catchment in Albury.

2005	Lavington Catchment Flood Study	Project Director: Flood Study for the Thurgoona Catchment in Albury.
2004-2005	French's Creek Floodplain Management Study and Plan	Project Manager: Development of a dynamically linked 2D overland flow/pipe network model for analysis of storm water flooding of an urban residential catchment in the Warringah Council Local Government Area. Community Consultation program to gain historical "local knowledge" perspective of flooding and also to engage community interest in the management of the floodplain. Model calibration and verification. Design flood predictions. Integration of study outcomes into Council's GIS planning system. Development and work shopping of flood mitigation options. Integration of mitigation options into a Floodplain Management Plan for the catchment.
2004-2005	Stockton Beach Coastal Processes Study	Project Director: Evaluation of sediment transport conditions at Stockton Beach, Newcastle NSW. Wave and sediment transport modelling to evaluate the coastal erosion issues occurring in the area. The study also includes the analysis of protection alternatives to minimise the impact of erosion on coastal property.
2004	Lake Hume Inundation Mapping	Project Manager: Mapping of flood extents in Lake Hume for a range of Lake levels. Maps prepared so that potential inundation around the township of Tallangatta could be assessed.
2004-2005	Chowilla Wetland Hydraulic Modelling	Project Manager: Setup and validated a 2D hydraulic model of the Chowilla Wetland ana-branch system using MIKE-FLOOD. Review of ALS sourced DEM. Several site inspections and preparation of advice for additional ground survey brief and flow gauging requirements. Calibration of model to historical flood events. Assessment of a range of options aimed at exaggerating the floodplain inundation of allocated environmental flows to enhance environmental outcomes.
2004	Poulton Park Flood Study	Project Manager: Development of a dynamically linked 2D overland flow/pipe network model for analysis of storm water flooding of a highly urbanised catchment in the Kogarah Council Local Government Area. Model calibration and verification. Design flood predictions. Integration of study outcomes into Council's GIS planning system.
2004	Warrah Creek Flood Study	Project Manager: The Warrah Creek Catchment is characterised by a steep upper catchment that drains to a low gently sloping floodplain. The lower catchment is an alluvial floodplain that has a series of interconnected ana-branches.
2004	Bethungra Dam Break Study	Project Manager: Development of a 1D model to assess flood impact due to hypothetical dam failure of the Bethungra Dam. Mapping of flood impacts for the downstream floodplain.

2004	Tumut 3 Turbine Upgrade - Head Race and Tail Race Channel Surge Ming	Project Manager: Tumut 3 power station, part of the Snowy Hydro Scheme is to have its 6 turbines up-rated. The up-rating of the turbines has the potential to change the operational regime of the power station in terms of maximum and minimum operational water levels in the head race and tail race channels. DHI were engaged to undertake detailed 3D numerical model analysis of the headrace and tailrace channels using the software package NS3, a full Navier Stokes solution for free surface flow. The NS3 model was successfully calibrated to measurements taken specifically for the study. The calibrated model was then used to predict surge levels in the head race and tail race channels for a range of station stoppage and start-up scenarios.
2004	Chaffey Dam Break Modelling	Project Manager: Development of a hydraulic model for hypothetical dam failure of Chaffey Dam in NSW. Preparation of flood impact mapping.
2003/2004	Illawarra Waste Water Strategy - Ocean Outfall Design	Project Manager: Design of Ocean outfall to meet stringent licensing criteria for near field and far field dilution over a wide range of flows for the consolidated Illawarra WWTW. Numerical and Physical modelling of outfall pipeline stability, outfall salt water purging and dilution analysis.
2003/2004	Elanora Heights overland flood study - Pittwater Council	Project Manager: Development of a dynamically linked 2D overland flow/pipe network model for analysis of storm water flooding of a highly urbanised catchment on Sydney's Northern Beaches. Model calibration and verification. Design flood predictions. Integration of study outcomes into Council's GIS planning system.
2003	Hydrological Modelling Hume Catchment - NSW Department of Sustainable Natural Resources/Murray Darling Basin Commission	Project Manager: Development of innovative approach to design flood prediction using a continuous hydrological model (NAM). Analysis of soil moisture time series for selection of design initial conditions. Comparison of model outputs with more traditional design flood modelling approaches.
2003	Hydrological Modelling Hume Catchment - NSW Department of Sustainable Natural Resources/Murray Darling Basin Commission	Project Manager: Development and calibration of NAM hydrologic model for three catchments in the Upper Murray River catchment. The model calibration was part of a larger study aimed at selecting the most appropriate hydrologic model for use in design flood estimation for the Hume Dam storage.
2003	Hydrological Model Statistics Software - NSW Department of Sustainable Natural Resources/Murray Darling Basin Commission	Project Manager: Design and drafting of a functional specification for a software tool to assist in the statistical comparison of hydrological model outputs with observed data. Supervision of programming team. Software alpha testing. Transfer of software to client and client training.
2003	Tenterfield Flood Study - Tenterfield Shire Council - Tenterfield NSW	Modelling Specialist: Responsible for technical supervision of the study team. Data acquisition, mapping and hydrological and hydraulic modelling of the Tenterfield City catchment.

2003	Hume Dam Hydrology - Drafting of Hydrological Method Statements - NSW Department of Sustainable Natural Resources/Murray Darling Basin Commission	Hydraulic Modelling Expert: An integral part of the Hydrologic Risk Assessment of the Hume Dam is the signed acceptance of the Murray Darling Basin Commission's Technical Review Committee of suitable methodologies to address each stage of the study. DHI staff were contracted to draft various prescriptive method statements designed to meet the objectives of the stated study outcomes.
2003	Hume Dam Hydraulic Model Scoping Study - NSW Department of Sustainable Natural Resources/Murray Darling Basin Commission	Project Manager: Assistance to the NSW Department of Sustainable Natural Resources to scope the survey data requirements for a MIKE-11 hydraulic model of the Hume Dam Catchment. Definition of model domain. Analysis of existing survey data. Development of a survey brief for remote sensing (Airborne Laser Survey) of the Upper Murray River and tributaries floodplain.
2002	Brickfield Creek Flood Study - Upper Parramatta River Catchment Trust	Project Manager: Detailed hydraulic modelling of the Brickfield Creek floodplain the Upper Parramatta River catchment. Compilation of survey and development of hydraulic models. Prediction of design flood levels and associated flood hazard levels. Flood mapping. Integration of model results into Upper Parramatta River Catchment Trust's greater catchment model and GIS decision support system.
2002	Potts Hill No1 Reservoir Dam Break - Sydney Catchment Authority	Project Manager: Development and simulation of a 2D model to assess hypothetical failure of the Potts Hill No 1 Reservoir at Yagoona in Sydney's south western suburbs. Assessment of dam flood inundation area, flow depth and velocity, and travel time. Estimation of likely loss of life. Recommendation of preliminary dam hazard rating.
2002	Mawsons Lakes Channel Design - Maunsell Australia Pty Ltd, Adelaide Australia	Project Manager: The Mawson Lakes development in the northern suburbs of Adelaide, South Australia. The development area is presently serviced by a network of leveed, man-made channels that cope adequately with smaller floods but contribute to a complex pattern of interacting flow paths when floodwaters pass over bank onto the wider floodplain. A number of channel deviations, hydraulic structures and roadway embankments also contribute to the complexity of the flood flow behaviour. DHI was engaged to provide advice to improve the hydraulic efficiency of the system. MIKE-FLOOD 2D floodplain model with detailed MIKE-11 hydraulic structures nested at sub-grid scale.
2002	Blackman's Swamp Creek Flood Study - Orange City Council	Project Manager: Detailed flood modelling of the Blackman's Swamp Creek catchments flowing through the Orange CBD. Compilation of hydrological and hydraulic models. Prediction of design flood levels and associated flood hazard levels. Flood mapping. Integration of model results into Council's GIS decision support system.
2002-2003	Illawarra Wastewater Strategy - Outfall Design and Construction. Walter-Vivendi Joint Venture	Project Manager: Manager of DHI's project team responsible for the timely technical input to the design and construction of the Illawarra STP shallow water ocean outfall. DHI's contributions included definition design of ocean wave and current climate, pipeline stability, pipeline scour, outfall pipeline hydraulics including purging and intrusion, near and far field plume dilution and physical modelling of outfall dynamics.

2001	Brownhill/Keswick 2D Flood Study, Hydro Tasmania, Adelaide, Australia	Hydraulics Expert: Responsible for specialist input for the design and operation of a complex two-dimensional urban floodplain model. The model included an innovative approach to the representation hydraulic structures by embedding 1D flow elements in the 2D model domain.
2001	NSW Shelf Bathymetry - NSW EPA, Sydney, Australia	Compilation and quality checking of available data in order to develop a detailed terrain model of the sea bed for the area offshore NSW between Port Stephens and Jervis Bay for use in numerical models.
2001	Mona Vale - Bayview Flood Study - Pittwater Council, Sydney, Australia	Detailed flood modelling of the Mona Vale and Bayview catchments on Sydney's Northern Beaches. Compilation of hydrological and hydraulic models. Prediction of design flood levels and associated flood hazard levels. Integration of model results into Council's GIS decision support system.
2000-2001	Wonga Beach Drainage Study - Douglas Shire Council, Mossman, QLD, Australia	Compilation and construction of hydrological and hydraulic (1D) models of the Wonga Beach area. Concept design, testing, and ranking of a range of structural and non-structural options designed to reduce the impact of flooding on the community. Development of a Drainage Management Strategy for implementation by Council.
2000	Bohle River 2D Modelling Study - Townsville, QLD, Australia	Development of a MIKE-21 2D model to predict the flood levels, flow patterns and velocity fields on the lower Bohle River floodplain. Verification of the model against historical flood data.
2000	Flood Damage Assessment - Morava Catchment, Czech Republic	Application of GIS based software designed to assess the economic impact of flooding on a flood-affected community. Assessment of direct, indirect and intangible damages. Assessment of the impact on flood damages of several flood mitigation scenarios as part of a benefit cost analysis of the options.
2000	Bohle River MIKE-11 GIS Flood Mapping - Townsville, QLD, Australia	Application of Arcview GIS based floodplain mapping software to the Bohle River floodplain to determine the extent of flood inundation for a range of flood risk levels determined using MIKE-11 1D flood models.
2000	Danish Olympic Sailing Team Current Predictions - Sydney, Australia	Prediction of fine scale, spatially resolved current predictions for Olympic Sailing Courses on Sydney Harbour and offshore during the Sydney Olympics.
2000	Northside Storage Tunnel Design - Shelly Beach Offtake - Sydney Water, Australia	Adjustment and simulation of the Northern Suburbs Ocean Outfall System MOUSE model to include the Northside Storage Tunnel. Assessment of the impact on tunnel operation of additional flow volume from the Shelly Beach area.
1999	Flood Management Model - R&D Project, Denmark	Research, planning and design of a GIS based floodplain management tool aimed at improving the quantification and management of the impact of flood behaviour on flood affected communities.
1999	WAMM Project, Tagliamento River, Italy	Calibration of a MIKE-11 1D model to historical flood levels. Additional calibration and comparison of M11 GIS flood extents with SAR satellite imagery of November 1996.
1999	Onion Creek, Texas, USA	Development of a 2D (MIKE-21) model of the Onion Creek floodplain in the City of Texas, USA. Calibration of model to overbank flood conditions. Assessments of possible impacts to existing flood behaviour by the raising of the William Cannon Drive Road Bridge and its approaches which cross the floodplain.

1999	Vistula River, Poland	Implementation of Floodwatch GIS flood monitoring system, including MIKE-11 fully dynamic FF module for realtime flood forecasting on the Vistula River, Poland.
1998-1999	Mona Vale Golf Course Water Quality Management Study, Australia	Review of water quality in golf course ponds, design of water quality management strategies, design of monitoring programme to define loads into the golf course. Modelling of long-term loads and evaluation of existing pond sizes to meet long-term course requirements. Setting of criteria and levels of compliance. Design of monitoring programs.
1998-1999	Careel Creek Flood Study, Australia	Detailed flood modelling of the Careel Creek catchment at Avalon on Sydney's Northern Beaches. Analysis of the reticulated stormwater drainage system using the fully dynamic MOUSE modelling system. Identification of stormwater overflows. Full integration of the MOUSE stormwater drainage model with a MIKE-11 model of surface drainage and open channel flows to determine flood depths. Integration of model results into Council's GIS decision support system.
1998-1999	Wallsend/Plattsburg High Definition Flood Study, Australia	Development and calibration of hydrologic and hydraulic models to include all flood affected areas in the Wallsend/Plattsburg catchment in western Newcastle. Definition of flood level, velocity and hazard on a property by property basis. Integration of flood model results with Council's GIS and databasing systems. Full documentation and transferral of models and GIS interface system to Council.
1998	Mona Vale Golf Course Water Quality Monitoring, Australia	Collection and analysis of stormwater flow parameters, CTD data and water quality samples. Range of wet weather storm events, average and dry weather conditions.
1998	Channel Stabilisation, Illawarra	Concept design of channel stabilisation and rehabilitation works for a reach of channel on the Illawarra Escarpment.
1998	Lidsdale Hydraulic Study - RTA, NSW	Development of hydraulic and hydrologic models of a small catchment at Lidsdale to describe existing flooding of the highway. Development of structural options designed to reduce the flood risk and hazard to highway traffic under flood conditions.
1997-1998	Clarence River Water Supply Augmentation Scheme Project, Australia	Development of hydraulic models using IQQM model inflows. Calibration of salinity in estuarine portion. Provision of hydraulic information based on offtake scenarios to ecology groups for environmental impact.
1996-1998	Allans Creek Floodplain Management Study, Australia	Extension and recalibration of hydraulic and hydrologic models to PMF levels. Simulation and reporting of design flood events. Flood hazard definition, flood damage calculations. Full interfacing of model results with Council's GIS system. Development of floodplain management options, model testing of structural options. Examination of social, cultural, heritage and environmental issues. Implementation of community participation program. Preparation of Floodplain Management Plan.
1997-1998	Warriewood Integrated Water Management Study, Australia	Development of integrated water quality and quantity management strategy for 110Ha urban release area on the Northern Beaches of Sydney. Long-term water quality analysis, setting of criteria and compliance reporting, riparian corridor design and vegetation requirements.
1997-1998	Narara Creek Floodplain Management Study, Australia	Development of flood mitigation options for an area of Gosford, flood damage assessment and evaluation of works associated with implementation of the plan.

1997	Dam Break Study of Woronora Dam, Australia	1D modelling of hypothetical failure of the Woronora Dam and the Woronora and Georges River floodplains. Prediction of inundation areas and floodwave travel times. Identification of infrastructure at risk. Estimation of population at risk and loss of life. Recommendation for dam hazard rating.
1997	Ingleside/Warriewood, Australia	Development of hydrologic and hydraulic models to establish the effects of urbanisation on flooding for several catchments on Sydney's Northern Beaches. Testing of several flood mitigation options.
1995-1997	Water Supply Reservoir Dambreaks, Australia	1D and 2D dambreak analysis on ten reservoirs in Sydney. Prediction of inundation areas and flood wave travel times. Calculation of likely damages, and estimation of loss of life.
1996	Dam Break Study of Avon Dam, Australia	1D modelling of hypothetical failure of the Avon Dam and the Hawkesbury/Nepean floodplain. Prediction of inundation areas and floodwave travel times. Identification of infrastructure at risk. Estimation of population at risk and loss of life. Recommendation for dam hazard rating.
1996	Dam Break Study of Cordeaux Dam, Australia	1D modelling of hypothetical failure of the Cordeaux Dam and the Hawkesbury/Nepean catchment floodplain. Prediction of inundation areas and floodwave travel times. Identification of infrastructure at risk. Estimation of population at risk and loss of life. Recommendation for dam hazard rating.
1996	Newcastle CBD and Honeysuckle Flood Strategy, Australia	Definition of flooding behaviour in the Newcastle CBD area to develop long-term sustainable strategies for urban development. Flood damage assessment and GIS implementation of strategies.
1996	Hydrodynamic and Transport Dispersion Models - Shoalhaven River, Australia	Compilation and calibration of MIKE-11 hydrodynamic and transport dispersion models to be used in study of breaching of Shoalhaven Heads during flood events and flushing of the same area under low flow conditions.
1993-1996	Tilligerry Creek Flood Study, Australia	Extension of the Lower Hunter River hydrologic and hydraulic models to include the Tilligerry Creek areas in Port Stephens Shire. Model calibration and Verification. Prediction of range of design flood profiles.
1995	Ironbark Creek Flood Management Strategy, Australia	Conversion of various flood models to common standard, development of flood damage estimates and evaluation of detention and channel improvement strategies for a heavily urbanised catchment in Newcastle. Development of flood management strategies in consultation with the Community and Council.
1995	Cooks River - Data Collection, Australia	Collection and analysis of CTD data profiles as part of a study of stratified flow in the Cooks River by the Sydney Water Board.
1995	Straits of Johor - Water Quality Investigations, Australia	To determine the impact of altering the condition of the causeway between Singapore and Malaysia. Incorporated catchment non-point pollutant export estimation, treatment plant and landfill leakage sources. Calibration of water quality models and prediction of impacts due to changes in the causeway openings.
1994	Millers Forest Drainage Investigation, Australia	Investigation of drainage problems in low lying farmlands on the Lower Hunter River floodplain. Identification of drainage "hotspots" using GIS technology to interrogate digital elevation model of terrain. Simulation of drainage times using 1D and 2D hydraulic models.

1994	Lake Illawarra Entrance Study, Australia	Hydrologic, hydrodynamic, transport-dispersion and sediment transport models - calibration of MIKE-11 model under both tidal and flood conditions. Investigation into likely effects of proposed lake entrance stabilisation.
1994	Hunter River Coliform Modelling, Australia	Two studies on the Lower Hunter River simulating the impacts of Coliforms.
1994	Raymond Terrace and Medowie WWTW Catchment Investigations Coliform Modelling, Australia	Simulation of bacterial fate for proposed treatment plant at Raymond Terrace under wet and dry weather flow conditions.
1993	Lower Hunter River Floodplain Management Study, Australia	Conceptualisation of flood mitigation options. Implementation of mitigation options in 1D model of Lower Hunter River floodplain. Interpretation of model results.
1990-1993	Lower Hunter River - Green Rocks to Newcastle, Australia	Calibration, verification of hydrologic and hydraulic models to the Hunter River, NSW for the Public Works Department. Several studies undertaken including tidal and flood calibration, local drainage management, floodplain management and geomorphology.
1993	Adamstown Overbridge Hydraulic Investigation, Australia	Design of bridge openings and flooding impacts for proposed road bridge over floodplain in Newcastle. Integration of 1D model results with GIS. Spatial representation and interrogation of model results in GIS environment.
1993	Hexham Light Industrial Area, Australia	Investigation of likely impacts to flood levels and velocities by proposed filling of areas in the Hunter River floodplain.
1993	Tomago Aluminium Outfall, Australia	Investigation of waste water plume dispersion for outfall in Hunter River, NSW.
1993	Hexham Swamp Inundation Study, Australia	1D and 2D modelling of Hexham Swamp as part of TCM project on Ironbark Creek to determine possible improvements to floodgate operation.
1993	Logan River, Australia	Calibration and verification of hydraulic and transport dispersion models of the Logan/Albert River system and southern Moreton Bay. Calibration of water quality models and prediction of impacts due to planned additional sewage treatment plants.
1992-1993	Hydrodynamic and Transport Dispersion Models - Ironbark Creek, Australia	Investigation of impact of floodgates on tidal penetration and salinity levels for a tributary creek of the Hunter River, NSW.
1992	Navigation Channel Siltation Study, Australia	Motion of ocean bed sediment under combined wave and current action was analysed to estimate the rate of infill of a navigation channel for a range of current directions and wave heights.
1992	Ironbark Creek - Data collection, Australia	Collection and analysis of stage, discharge and salinity data as part of the study into impact of floodgates on Ironbark Creek.
1992	Emu Plains Flood Study, Australia	Application of 2D model to urban floodplain in western Sydney. Definition of existing flood behaviour under a range of design events.
1992	Leneghans Drive, Australia	Investigation of likely afflux caused by proposed upgrade of the F4 freeway at Leneghans Flat on the Hunter River floodplain.

1991	Turbidity Plume Study, Australia	Investigation of the effect dredging for marine aggregates might have on turbidity levels in the ocean near the dredging unit.
1991	Cooks River Dispersion Study, Australia	Calibration of MIKE-11 hydrodynamic and transport dispersion models to recorded data on Cooks River, NSW.
1991	Dunbogan Canal Estate, Australia	Construction of a MIKE-11 model to aid in the investigation of tidally induced flushing and circulation of water through the design canal estate network.
1991	Kikori River, Papua New Guinea, Australia	Conversion of SYSTEM-11 flood model to MIKE-11 format. Calibration and verification of MIKE-11 model for low level discharges. Extraction of flow velocities for pipeline stability analysis.
1990	Lower Hunter River Oakhampton to Green Rocks, Australia	Conversion of SYSTEM-11 flood model to MIKE-11 UNIX format. Development of less detailed DOS flood routing model from more complex system to provide a simple model for the routing of floods through the area for flood frequency analysis without running the complex system.
1988	Water Resources Commission, QLD, Groundwater Division	Analysis of groundwater quality and storage levels on the Condamine River between Talgai Weir and Dalby, leading to a recommendation as to how much future irrigation by bore water should be allowed in the area.

Training Courses & Lecturing

2008	Associate, University of Technology, Sydney	Visiting Lecturer/Researcher: Provision of lectures, short courses, research collaboration, and Masters and PhD supervision.
1994-2008	DHI Software Training Courses	Tailored workshops from 2 days to several weeks on numerical modelling with practical problems and continuing education on use of modelling software. Assistance to various agencies and consultants in specialised applications of MOUSE, MIKE-11, MIKE-21, MIKE-FLOOD, MIKE-3, Temporal Analyst, MIKE-11 GIS and MIKE Flood Watch.

Committees/Panels

2012: Chair 34th Hydrology and Water Resources Symposium
2008: NSW Government Rivers Environmental Restoration Programme (RERP) Hydrodynamic Modelling Working Group
2003: 28th Hydrology and Water Resources Symposium
2002: Ongoing: Engineers Australia, Sydney Water Panel (Immediate Past Chair)

Languages

	English	**German**	**Danish**
Speaking:	5	2	1
Reading:	5	2	2
Writing:	5	1	1

(Excellent = 5; Average = 3-4; Poor = 1-2)

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Selected Publications

Smith, G. P. and McLuckie, D (2015). “Delineating Hazardous Flood Conditions to People and Property”. 2nd National Floodplain Management Association Conference, 19-22 May 2015, Brisbane

Toniato, A., Mcluckie, D. and **Smith, G.P.,** “Development of Practical Guidance for Coincidence of Catchment Flooding and Oceanic Inundation”. 54th Floodplain Management Association Conference, 20-13 May 2014, Denniliquin

Smith, G. P. and Mack, M. (2014). "Practical Considerations for Interpreting Flood Hazard". 35th Hydrology and Water Resources Symposium 24 - 27 February 2014, Perth.

Rahman, P., Sharma, A. and **Smith, G.** (2011) Estimating Design Floods for Gauged Urban Catchments under Climate Change Conditions Case Study: Cooks River, Sydney, *Proceedings – 34th IAHR World Congress,* 26 June – 1 July 2011, Brisbane, QLD Australia

Shand, T.D., **Smith G.P.**, Cox, R.J. and Blacka, M.J. (2010) Development of Appropriate Criteria for the Safety and Stability of Persons and Vehicles in Floods, *Proceedings – 34th IAHR World Congress,* 26 June – 1 July 2011, Brisbane, QLD Australia

Shand, T.D., Cox, R.J., **Smith G.P.** and Blacka, M.J. (2010) Appropriate Criteria for the Safety and Stability of People in Stormwater Design, *Proceedings – Stormwater 2010,* Stormwater Industry Association, 8 – 12 November 2010, Sydney NSW Australia

Van Kalken, T., Madsen, H., Skotner, C., Pedersen, C.B. and **Smith, G.** (2007) A functional decision support system for the optimisation of dam operations, NZSOLD 2007, *Dams - Securing water for our future*, 17-21 November 2007, Queenstown, NZ

Sakal A, **Smith, G.P.** and Klinting, A. (2006) Managing Catchment Inflows using Real-time Flow Forecasting. *30th Hydrology and Water Resources Symposium*, Launceston, Tasmania

Carr, R.S. and **Smith, G.P.** (2006) Linking of 2D and Pipe Hydraulic Models at Fine Spatial Scales [online]. *2006 7th International Conference on Urban Drainage Modelling and the 4th International Conference on Water Sensitive Urban Design*, Book of Proceedings, pages: 888 – 895

Smith, G.P. and Carr, R.S. (2005) Linked 2D overland and 1D Pipe System modelling for Urban Flooding. *Proceedings - NZWWA 4th South Pacific Conference on Stormwater and Aquatic Resource Protection*, Auckland

Green, J., **Smith, G.P.** and Varley, I. (2005) A Guide to Rainfall-Runoff-Routing Model Selection. *Proceedings - 29th International Hydrology and Water Resources Symposium*, Canberra

Smith, G.P. and Green, J. (2005) Design Flood Loss Estimation using a Continuous Modelling Approach. *Proceedings - 29th International Hydrology and Water Resources Symposium*, Canberra

Smith, G.P., Perrens, S. and Carr, R.S. (2003) Calibration of overlapping hydrologic and hydraulic flood models to limited historical data. *Australian Journal of Water Resources*, IEAust, 6(2):151 – 158

Smith, G.P., Wilson, G.E. and Jorgensen, G. (2001) MIKE Flood Watch - A Physically-Based, Real-time Flood Monitoring and Flood Forecasting System. *2nd Victorian Flood Management Conference*

Carr, R.S., **Smith, G.P.**, Lincoln Smith, M. and Jack, C. (1999) Linking of Hydraulic Models with Ecologic Assessments. *8th International Conference on Urban Storm Drainage*

Carr, R.S., **Smith, G.P.** and Bacon, P. (1999) A Time Series Modelling Approach for Assessment of Environmental Conditions. *8th International Conference on Urban Storm Drainage*

Smith, G.P., Lincoln Smith, M., Jack, C. and Carr, R.S. (1997) The Way Water Moves - Linking Hydrology and River Hydraulics with Ecology. *24th Hydrology and Water Resources Symposium*

Smith, G. (1994) A Comparison of One and Two-dimensional Models as Applied to a Floodplain - the Hexham Swamp Inundation Study [online]. *1994 International Conference on Hydraulics in Civil Engineering: ‘Hydraulics Working with the Environment’.* Preprints of Papers, p 25 – 30

Smith, G.P. (1993) A Practical Application of an Unsteady, Two Layered Model to Stratified Flow in an Estuary. *University of New South Wales, Australia, School of Civil Engineering, Civil Project Report*

Treloar, P.D., Roper, A.M. and **Smith, G.P.** (1993) Lake Illawarra - Numerical Modelling of Entrance Processes. *11th Australasian Conference on Coastal Engineering*