Proposed South Gippsland Planning Scheme Amendment C109 and Permit Application No 2016/180 relating to the Subdivision of Existing Lots at Venus Bay

Report for
Planning Panels Victoria Hearing
Scheduled for 28th & 29th November 2017

This report has been prepared for the
West Gippsland Catchment Management Authority

Instruction was received from

- Mr Adam Dunn, Statutory Planning Manager,
  West Gippsland Catchment Management Authority

Prepared by:

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1. Introduction

1.1 Report Purpose

I have been requested by the West Gippsland Catchment Management Authority (WGCMA) to provide expert evidence on flood hazard and risk in relation to:

- Proposed Planning Scheme Amendment C109 which seeks to rezone Lot 1 PS800516 being 143B Inlet View Road, Venus Bay, Lot 2 PS648056 and Lot 1 TP172550 being 113A Jupiter Boulevard, Venus Bay and Lot 1 PS648056 being 4 Ockenga Close, Venus Bay; and
- Permit Application 2016/180 concerning the subdivision of land into nine lots and the removal of native vegetation on Lot PS800516 being 143B Inlet View Road, Venus Bay and Lot 2 PS648056 and Lot 1 TP172550 being 113A Jupiter Boulevard, Venus Bay.

The purpose of this report is to provide expert witness evidence relating to flood hazard and risk associated with the proposed amendment and subdivision under 1% AEP flood and storm surge conditions in the context of existing and future climate change conditions and to provide an opinion on whether flood risk can be managed appropriately.

1.2 Report Structure and Content

This report examines the issue of flood hazard and risk associated with the proposed amendment and subdivision. Concluding remarks and a list of relevant references complete the report.

1.3 Certification

This report has been prepared by Mr. Michael Cawood, Principal of Michael Cawood & Associates Pty Ltd on the basis of information provided by the WGCMA coupled with independent research. While the site was not visited as part of that research, aerial photographs as well as GoogleEarth and StreetView images along with available information and professional experience were used as a basis for the opinions expressed in this report.

An abridged copy of Michael Cawood's Curriculum Vitae is located in Appendix A.

Prior to preparing this report, the author obtained a copy of the undated Planning Panels Victoria - Guide to Expert Evidence. The document was read and considered prior to preparation of this report.

1.4 Credentials: name, address, qualifications, experience and area of expertise

Expert:	Michael Cawood
Address:	Michael Cawood & Associates Pty Ltd 8 Stanley Street Chirnside Park Vic 3116
Qualifications:	B. Tech. Civil Engineering, South Australian Institute of Technology, 1978 Graduate Course in Hydrology, University of New South Wales, 1981 Master of Engineering Science, Monash University, 1988 Counter Disaster Planning, AEMI, 1993 Introduction to AIIMS course Chartered Professional Engineer (CPEng) National Engineering Register (NER)
Affiliations:	Fellow, Institution of Engineers, Australia Member of the College of Civil Engineers, Institution of Engineers, Australia Member, Floodplain Management Australia Member, Australian Water Association Inc Member, Hydrological Society of South Australia Member, International Association of Hydrological Sciences

Relevant Area of Expertise:	My principle area of expertise lies in emergency and flood risk management. This expertise has been built over a professional career of more than 39 years through a number of positions in both the public and private sectors. Of particular note is my involvement in flood forecast and warning activities for almost 30 years: from leader of the group within the Bureau of Meteorology that provides flood forecast and warning services for Victorian communities to a current role providing specialist technical consulting to VICSES during periods of severe flooding. I have also contributed, by invitation, to both the original development and subsequent reviews and updates of Australian national best practice manuals on *Flood Preparedness, Flood Warning* and *Flood Response*. Additional details outlining my expertise are provided in the attached CV.

1.5 Statement of Expertise to Prepare Report

I have a strong flood operations and management background with more than 39 years professional experience in the broad areas of flood hydrology and emergency and flood risk management. This experience has been built up through a career that has spanned both State and Commonwealth Government agencies as well as large, medium and small consulting companies.

Since establishing my own consultancy in August 2003, I have undertaken a variety of project management, policy and specialist technical, strategic and review orientated emergency risk management, flood, floodplain and dam safety assignments. I have provided flood related advice on a good number of projects and have assisted the development of a flood risk assessment tool. I have also had input on the flood mitigation and flood intelligence aspects of many flood studies across the State. In 2010, I was the first consultant invited by VICSES to provide on-going specialist operational flood advice within an Incident Control Centre and was the only consultant invited to provide expert technical flood management advice and input to the Comrie-led Victorian Floods Review in 2011. I also assisted in development of the Victorian Floodplain Management Strategy released in 2016 and am the only flood consultant actively assisting with the development of FloodZoom.

1.6 Instructions that Define the Scope of this Report

I was instructed verbally by Mr Adam Dunn of the West Gippsland Catchment Management Authority to provide expert advice in relation to flood hazard and risk associated with the proposed Planning Scheme Amendment and Permit Application at Venus Bay

In providing that advice I have had regard to accepted good floodplain management practice as discussed in detail in Handbook 7: Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017) and related documents. I have also referred to the Victorian Floodplain Management Strategy (DELWP, 2016), the Service Level Specification for Flood Warning Services for Victoria (BoM, 2015), the South Gippsland Shire Flood Emergency Plan (SGSC & VICSES, 2013) and various technical reports. The Tarwin Lower Flood Study report and companion flood mapping (WT, 2007) has provided much of the data (via WGCMA) on which this evidence report relies.

2. Summary of Opinion

It is my opinion, based on a consideration of flood hazard and risk, that in relation to the proposed Planning Scheme Amendment and Permit Application at Venus Bay:

- Creation of the additional lots will give rise to an increase in flood risk. This is contrary to current policy and accepted good floodplain management practice wherein the growth in flood risk is prevented by limiting the frequency of exposure of new development and its inhabitants to hazardous flood situations;
- The flood risk associated with access to and egress from Venus Bay cannot be adequately managed;
- An extreme flood hazard category is appropriate; and
- Subdivision should not occur.

3. Context and Key Flood Issue

The lower reach of the Tarwin River flows through a large area of coastal river flats as it passes Tarwin Lower and into Andersons Inlet, a shallow estuary connected to Bass Strait. High flows cause flooding of many local roads including the Inverloch-Venus Bay Road to the north east (upstream) and west (downstream) of Tarwin Lower. The lower reaches of the Tarwin River and its floodplain can be affected by tides and storm surges originating in Bass Strait. There are many levees across the lower floodplain constructed over a long period with the aim of controlling nuisance riverine and storm surge flooding.

It is evident from the Tarwin Lower Flood Study (WT, 2007) that flooding on the southern side of the river results from river flood water or storm surge spilling over levees / roads that have a relatively low crest level. At the western end of Tarwin Lower, the Inverloch-Venus Bay Road has a minimum crest level around 2.0mAHD[1]. Flood levels in excess of this spill out of the river and flow in a generally southerly direction. Further downstream towards Venus Bay, the crest of the Inverloch-Venus Bay Road drops to as low as 1.7mAHD to 1.8mAHD and storm surges in excess of this elevation spill over into the southern floodplain area. In both instances, access to and from Venus Bay is threatened. Access is lost with further rises.

The key flooding concern with the proposed Planning Scheme Amendment and subdivision covered by the Permit Application is in relation to egress from and access to Venus Bay and not with the site itself. This is because the only access road, the Inverloch-Venus Bay Road, is subject to deep, extensive and long lasting riverine and storm surge flooding (WT, 2007): it runs close to the Tarwin River for a distance of around 3.3km as it crosses the southern floodplain between Tarwin Lower and Venus Bay. Under future climate conditions, the road could be expected to be subject to more frequent and deeper flooding. This presents an extreme hazard to vehicles and a lesser hazard to pedestrians. See Figures 1 & 2.

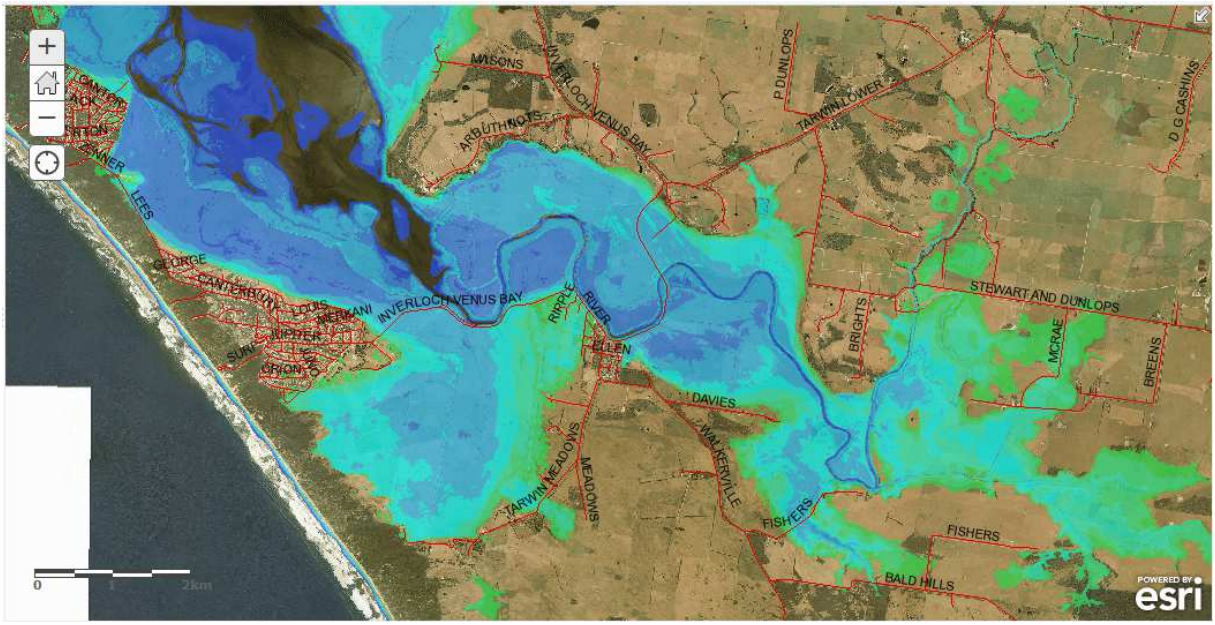

Figure 1: Combined 1% AEP riverine and storm surge flooding on the Lower Tarwin River floodplain
Derived from Water Technology, 2007

[1] WT (2007) quote a minimum crest level of around 1.6mAHD.

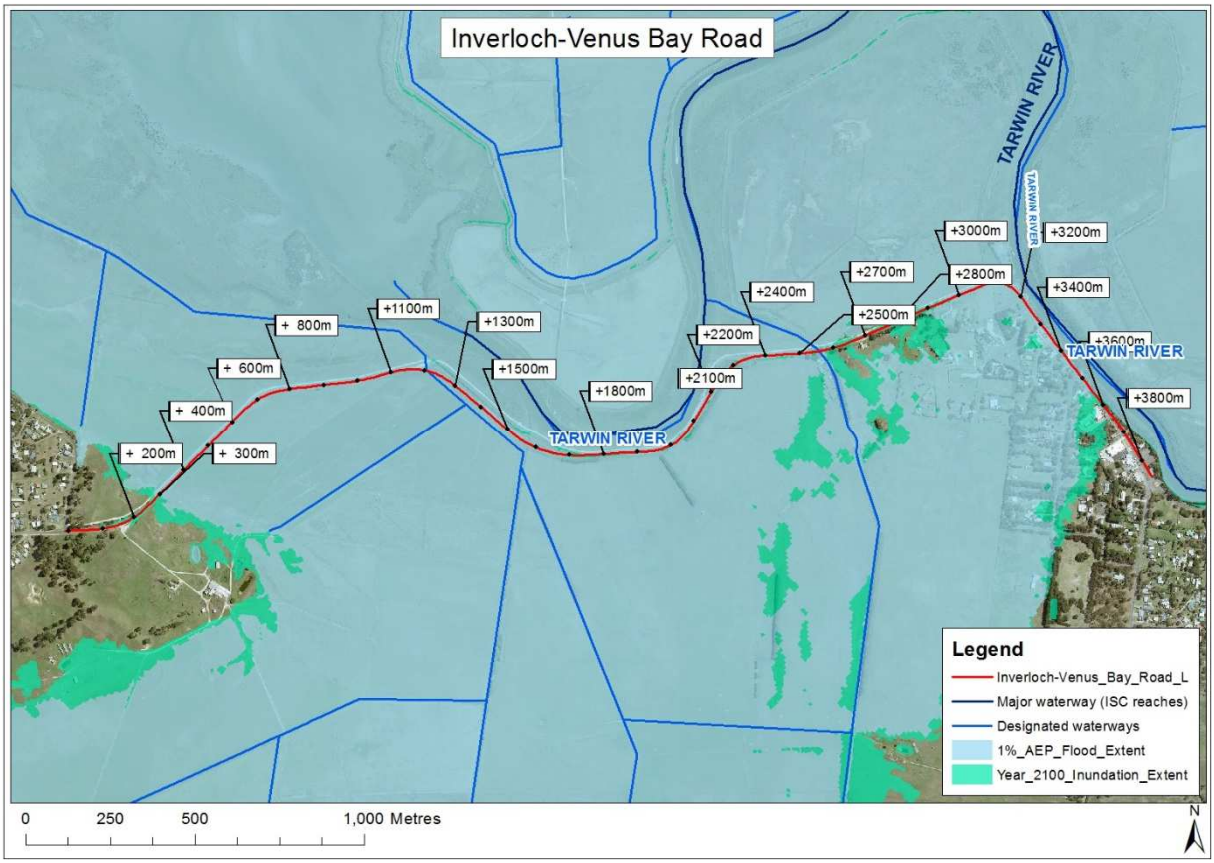

Figure 2: Zoomed-in view of the Inverloch-Venus Bay Road between Tarwin Lower and Venus Bay

The LSIO between Tarwin Lower and Venus Bay as delineated in the South Gippsland Planning Scheme is shown in Figure 3 below.

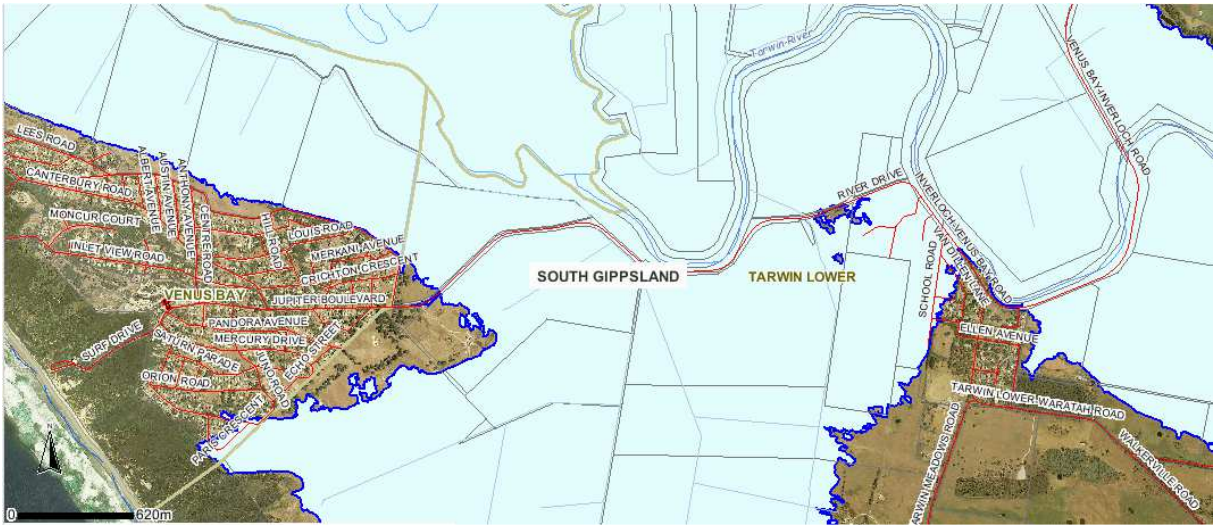

Figure 3: Extent of the LSIO between Tarwin Lower and Venus Bay

4. Flood Hazard

Floods create hazardous conditions to which humans are particularly vulnerable. The hazard varies with flood severity and, for the same flood event, location within the floodplain: the rarer the flood the more severe the hazard (AIDR, 2017).

A number of factors are considered in determining flood hazard. Both velocity and depth are critical factors, particularly in terms of personal safety along evacuation or access routes. For example, high-

velocity, low-depth flood water and lower-velocity, deeper water can destabilise people and sweep them off their feet, carry vehicles away and cause damage to structures. Vehicles become unstable at very low depths.

The most hazardous time during a flood may occur not at peak flow or peak level but as flood water rises. However, as data on flood behaviour within the Lower Tarwin River area is limited to what is available from the Tarwin Lower Flood Study (WT, 2007), the consideration herein must be limited to peak level conditions. A consequence of this is a possible underestimation of the hazard.

It is noted that in delineating floodway areas as part of the Tarwin Lower Flood Study (WT, 2007), Water Technology followed a process developed by the Floodplain Management Unit of the then DNRE (DNRE, 1998). This involved, amongst other things, analysing the depths and velocities associated with the 1% AEP flood and storm surge events and identifying high hazard zones within the floodplain. The resulting delineation (i.e. high hazard zones - see Figure 4 below) covers, in aggregate, around 2km of the approx. 3.3km long Inverloch-Venus Bay Road.

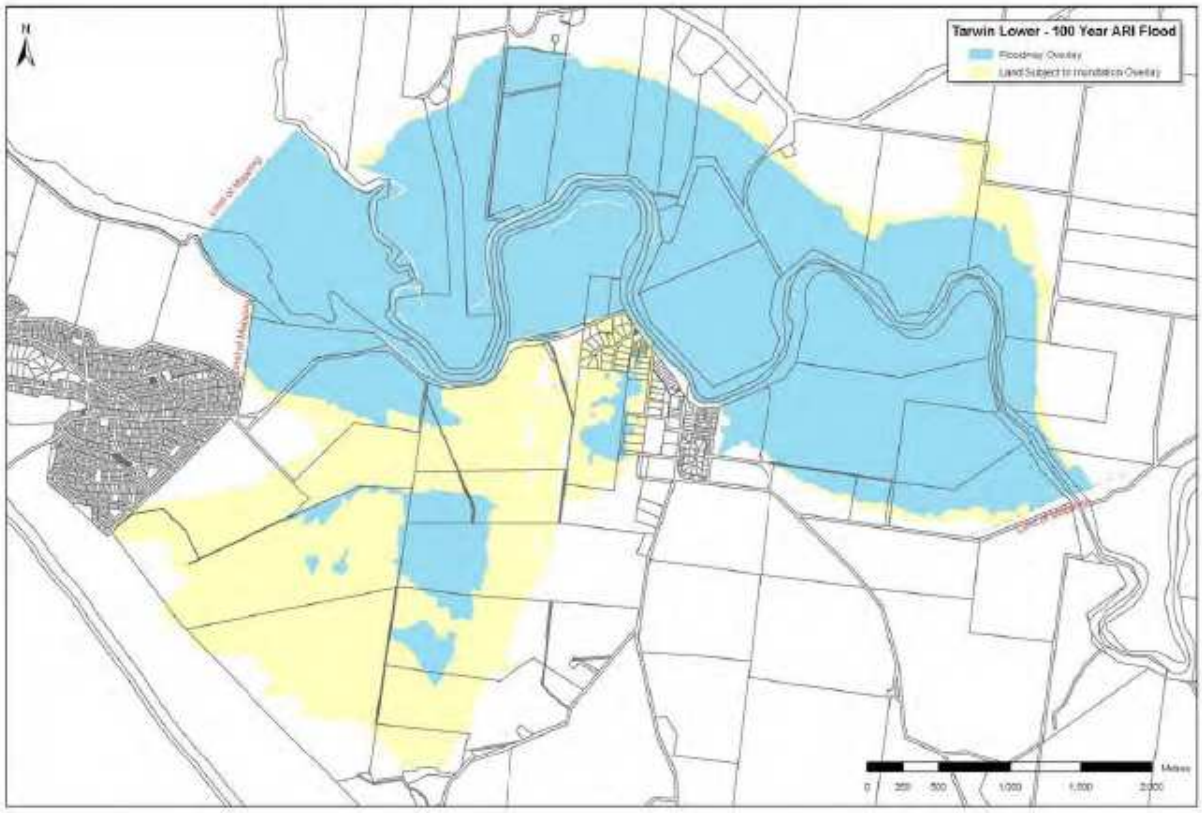

Figure 4: Tarwin River floodway at Tarwin Lower (extracted from WT, 2007)

Based on a consideration limited to flood severity and flood water depths and velocities and with due regard for AIDR (2017), I assess the single access route as being subject to an extreme flood hazard under both existing and future climate conditions. Consideration of other factors does not change the assessment.

5. Flood Risk

5.1 Introduction

A risk is caused by the interaction of a hazard and human activity. Thus in addition to consideration of flood depths and velocities, regard for flood risk in this case could include consideration of:

- Flood severity;
- Extent and depth of flooding;

- Rate of rise of flood water;
- Duration of flooding;
- Flood warning time;
- Character of evacuation or access routes – whether single or multiple routes, route distance, ability for children and elderly people to wade to safety with little difficulty and for sedan-type motor vehicles to travel the route safely;
- Potential for additional load on emergency services; and
- Potential for isolation or disconnection from medical or shopping facilities or from community and social services.

The Inverloch-Venus Bay Road between Tarwin Lower and Venus Bay runs close to the Tarwin River for a distance of around 3.3km as it crosses the southern floodplain. The floodplain and road, the latter even though it is raised above natural surface, are subject to both riverine and storm surge flooding under current conditions (WT, 2007). Under 1% AEP conditions, the flooding is deep, extensive and long lasting and poses a risk to vehicles and pedestrians.

Under future climate conditions (i.e. at 2100 with an estimated mean sea level rise of 800mm), flooding will be more severe and the risk to access, vehicles and pedestrians more acute.

5.2 Flood Severity

Floods do occur from time to time within the Tarwin River. While there are no river gauges in the lower reaches, a number of surveyed historic flood levels of unknown origin and date are available for the northern side of the floodplain and upstream of Tarwin Lower. These data were documented as part of the Flood Data Transfer project (DNRE, 2000) and were used by Water Technology to inform the Tarwin Lower Flood Study (WT, 2007).

There is a river gauge on the Tarwin River at Meeniyan. The record at that gauge suggests that while the August 2001 flood has been characterised as a moderate flood in the lower floodplain (WT, 2007), both the April 2011 and June 2012 events were larger with the June 2012 event the largest on record (SGSC & VICSES, 2013). Events larger than the August 2001 event were also recorded in August 1956, September 1959, May 1960, July 1977 and September 1993.

The aerial survey undertaken by WGCMA several hours after the peak of the August 2001 event indicates that the Inverloch-Venus Bay Road was either just wetted or very close to being wetted at low points. As Water Technology (WT, 2007) used this as a calibration event, the study provides an approximate flow rate at which the road would begin to be wetted. When applied to the 1% AEP flood hydrograph, this provides an indication of the length of time during which the road could be expected to be inundated during the 1% AEP Tarwin River flood. This suggests that the road will be wetted for around 120 hours (i.e. 5 days) and flooded to a depth of more than about 300mm at the low points for roughly 75 hours (i.e. 3 days) or perhaps longer.

The lower floodplain is also subject to flooding from storm surge as demonstrated in the Tarwin Lower Flood Study report (WT, 2007). Using the 1% AEP storm surge elevation graph from the report and a similar approach to that used above in the knowledge that as the tide oscillates the floodplain will continue to fill, as water pushed over the southern levee and road crest will not fully drain due to limited culverts and other water return structures. The net result of this is that while there may be an expectation that the road will become dry during the tide cycle associated with the 1% AEP storm surge, it is unlikely to occur. This suggests that the road will be substantially wetted for around 48 hours (i.e. 2 days) and flooded to a depth of more than 1m for a few hours every 12 hours or so.

Expected sea level rise within Bass Strait and Andersons Inlet associated with climate change is estimated to cause more severe flooding, raising levels by up to 800mm during the 1% AEP event. This will extend the time that the Inverloch-Venus Bay Road is un-trafficable.

It is not a matter of if, but when, the next flood, either riverine, storm induced or a combination, will occur

on the Lower Tarwin floodplain, inundating the Inverloch-Venus Bay Road and isolating Venus Bay.

Under existing 1% AEP flood conditions, the access road presents as high hazard.

5.3 Extent and Depth of Flooding

Deep flood water can be dangerous because it can destabilise people and vehicles resulting in injuries and fatalities. If flow velocity increases or individuals have any physical limitations, they can be destabilised by much lower water depths.

Under 1% AEP flood conditions, it is expected that the Inverloch-Venus Bay Road between Tarwin Lower and Venus Bay will be inundated in two locations: the first immediately to the west of Tarwin Lower, extending for more than $^1/_2$km and taking in the right angle bend in the road and the second a further $^1/_2$km or so further on but only extending for around 100m. Through the first stretch, flood water will be around 500mm to 680mm deep for around 100m and generally around 300mm to 400mm deep for the remaining distance. Depths through the second stretch will be somewhat lower with a maximum of around 270mm. Flood depths along the road are shown plotted in blue on Figures 5 & 6. The distances along the x-axis match the distances shown on Figure 2.

Under storm surge conditions, flooding of the Inverloch-Venus Bay Road will be more extensive and deeper. Inundation is expected to occur at five locations. The most severe flooding will occur immediately to the east of Venus Bay and extend for a distance of around 1.3km with depths generally around 500mm to 700mm but extending up to a little over 1m at the lowest point in the road. Flooding at the other locations will be shallower at around 100mm to 300mm and extend along the road for a maximum distance of up to around 300m. Flood depths along the road are shown plotted in green on Figures 5 & 6. As mentioned above, the distances along the x-axis match the distances shown on Figure 2.

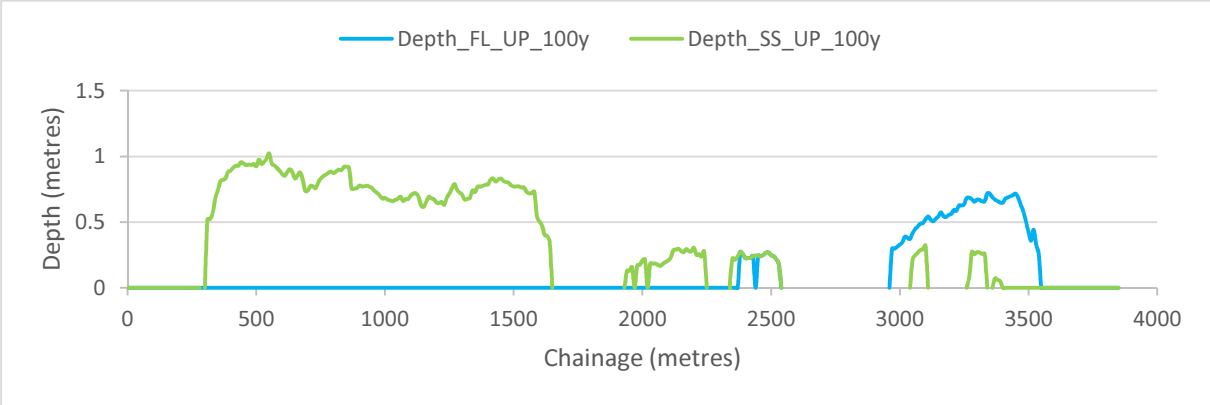

Figure 5: Upper limit of 1% AEP flooding depths along the Inverloch-Venus Bay Road

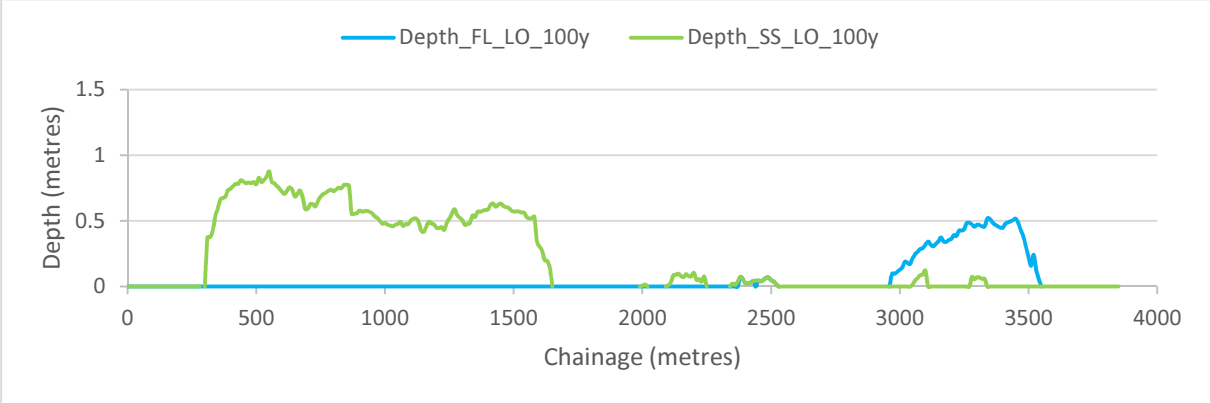

Figure 6: Lower limit of 1% AEP flooding depths along the Inverloch-Venus Bay Road

The above is consistent with the South Gippsland Flood Emergency Plan (SGSC & VICSES, 2013)

which identifies the Tarwin Lower Road (aka the Inverloch-Venus Bay Road) as being vulnerable to flooding and flooded during a 1% AEP event to a depth of 250mm to 500mm from just west of the Riverview Hotel at Tarwin Lower though to Venus Bay. The Plan categories the road as a major closure and Venus Bay as an isolated community under 1% AEP flood and storm surge conditions.

A worst case scenario of coincident 1% AEP riverine and storm surge flooding would result in a substantial portion of the Inverloch-Venus Bay Road being inundated to depths well in excess of a metre. However, the Tarwin Lower Flood Study report (WT, 2007) argues that coincident 1% AEP flooding is unlikely to occur as the synoptic drivers for each type of flooding are different. Maximum storm surge requires west to north-westerly winds while significant flooding in the catchment is typically associated with east coast lows (south-easterly winds) or south to south-westerly wind condition. While some combination of riverine and storm surge flooding is feasible, data to enable an assessment of flood levels and risk are not available. Consideration of flooding depths and extents herein must therefore be limited to individual flooding types. A consequence of this is a possible underestimation of the hazard.

In summary, it is determined that the one and only access route is subject to flooding to significant depth. Under existing 1% AEP flood conditions, this presents as high hazard.

5.4 Flood Velocities

Fast-flowing shallow water or slow-flowing deep water can unbalance people and vehicles resulting in possible injury or death.

Flow velocities on the Lower Tarwin river flats are generally low (WT, 2007), typically around 0.2m/s or less. However, over the road surface during both the rise and fall of the flood or storm surge, velocities could be expected to be higher due to what might be loosely termed “the weir effect”. What drives this is the difference in water levels either side of the road. Determination of those velocities with any degree of confidence is not a trivial matter and would require access to the hydraulic model developed for the Tarwin Lower Flood Study. As that model is not available to the WGCMA consideration herein must be limited to available information. A consequence of only considering the floodplain velocities rather than over-road velocities is a possible underestimation of the hazard

A consideration of available velocity information without regard for other matters indicates a low hazard.

5.5 Vehicle and People Safety

Many flood fatalities result from the interactions of people, often in vehicles, with flood water. Any situation that increases a person’s need to cross flood water increases the likelihood of an injury or fatality. Haynes et al (2016) in reporting on an analysis of flood related deaths in Australia since 1900, noted that the majority of deaths occurred in minor to moderate flood events, that 58% died within 20km of their home, that many were returning home when they died, and that the highest proportion of all those in a vehicle perished at night or during twilight when visibility was poor.

Research by the University of NSW Water Research Laboratory on how small and large cars behave when they encounter floods was reported widely during June 2016 (see for example http://www.wrl.unsw.edu.au/news/floodwaters-can-turn-cars-into-death-traps). Cars become vulnerable once flood water reaches the floor of the vehicle. A small car will be moved by water that is only 150mm deep and flowing at 1m/s. It will float away in 600mm of water. A large 4WD will become unstable in 450mm of low velocity water and will float when the water reaches a depth of 950mm. As can be seen from Figures 5 and 6, the depths at which vehicles become unstable are exceeded by some margin along the Inverloch-Venus Bay Road during 1% AEP flood and storm surge conditions. When coupled with some velocity, the safety of both vehicles and occupants becomes problematic.

AIDR (2017) provides guidance on the hazard associated with various combinations of flood depth and velocity for vehicles and pedestrians. Consideration of the conditions along the Inverloch-Venus Bay Road during 1% AEP riverine and storm surge flooding indicate a low hazard rating for wading adults but an extreme hazard rating for children and vehicles.

The above rating does not have regard for a range of other matters that impact on the hazard posed by wading through flood water. For example, flood water is notoriously polluted and skin infections post exposure can be severe and difficult to control, unexpected trips and falls due to unseen submerged objects and holes add to the risk, attempting to wade at night is more difficult than if done during daylight hours, and so on.

It is also noted that the sharp curve in the road immediately to the west of Tarwin Lower will be underwater and potentially not visible during a flood. This will be particularly so outside daylight hours. Further, the road is elevated to some extent with swales and drop-offs either side, limiting the opportunity to turn around and travel out of rapidly deepening flood water that extends for significant distances. These factors serve to reinforce the hazard rating as extreme.

The behaviours promoted around the world and more particularly by the various SES' within Australia that echo the VICSES messaging of "*Don't walk, ride or drive through floodwater*" are all aimed, for good reason, at encouraging people to keep out of flood water.

5.6 Flood Duration and Rate of Rise

Situations where flood waters rise rapidly are potentially more dangerous and damaging than in cases where levels increase slowly. Similarly, the situation where an area is isolated by flood water for extended periods is more dangerous than one where an evacuation route remains serviceable (e.g. need to access services, employment, family members, food, etc).

Due to the size and physical nature of the Lower Tarwin River and floodplain, flood waters rise and fall relatively slowly. Flooding therefore encroaches on normally dry land relatively slowly and during large floods could be expected to persist for up to 8 days or so with some oscillation due to tidal and other ocean driven phenomena.

It is not suggested that Venus Bay residents should evacuate or relocate when flooding is likely. Rather, it is likely that residents would remain in-situ with limited opportunity to leave the town other than through rescue or perhaps by boat, albeit that might well be a high risk journey. During a large flood, it is estimated that residents would be isolated for around 5 days or so.

While the rate of rise by itself does not suggest a high risk, when considered in concert with the extended duration of flooding and associated lengthy period of displacement or isolation, the risk remains high.

In summary, it is determined that under current 1% AEP flood conditions, access presents as extreme hazard while the period of isolation presents as high hazard.

5.7 Flood Warning Time

In general, the more time a community has available in the lead up to likely or assured flooding in which to prepare for the protection of goods and possible evacuation (i.e. the more lead time available) the less hazardous the flood will be to those affected and the lower the risk to life and property. The key is warning lead time.

Flood warning lead time is usually related to the rate of rise and fall of a flood. Slow rising floods offer an opportunity to forecast the rise, peak and fall of flood waters some days in advance. While floods tend to develop over a good number of hours in the Lower Tarwin, a flood forecast and warning service does not operate for the Tarwin River (BoM, 2015) although a couple of the basic elements do exist. While there is no or very limited rain and river level data available in near real-time to the Tarwin Lower and Venus Bay communities, the South Gippsland Flood Emergency Plan (SGSC & VICSES, 2013) does make reference to Venus Bay and access, and a Local Flood Guide does exist for the Tarwin River at Tarwin Lower and Venus Bay.

In view of the gap between flood risk and Total Flood Warning System service level (a reflection of the absence of Total Flood Warning System elements – WGCMA, 2017), the situation is rated as extreme hazard.

5.8 Impact on Emergency Services Personnel

As indicated in the previous sections, any person in Venus Bay requiring medical or other attention during a large flood would need to be evacuated. This would place a load on the emergency services and their resources.

Similarly, a person deciding to self-evacuate or to attempt to drive along the Inverloch-Venus Bay Road while it was flooded to depth, would place both themselves and their rescuers in danger. This danger would be heightened if they attempted to turn around in the flood water or missed one of the turns along the road and came off the roadway into deeper water alongside.

A hazard already exists in relation to access to and egress from Venus Bay during a flood. Creating additional lots will increase the potential dangers to occupants and emergency services personnel while also potentially increasing additional costs to the community associated with a period of out–of-home support in the event of an evacuation or an inability to return home.

6. Summary of Opinion

It is my opinion that the flood risk associated with the proposed subdivision cannot be adequately managed and should not occur. This opinion is based on consideration of:

- An extreme hazard rating assessment for the single low level access road under both existing and future climate conditions as determined using good practice floodplain management metrics;
- An increase in future flood risk as a result of exposure of the inhabitants of the proposed new lots to a hazardous flood situation contrary to good floodplain management practice; and
- In the event of a flood:
  - The potential for an increase in reliance on emergency services for personal safety and support, contrary to good practice; and
  - The potential for additional community costs associated with a period of out–of-home support in the event of an evacuation or inability to return home.

Further, it is my opinion that subdivision would in fact increase future flood risk as there would be;

- An increase in the number of people exposed to extreme flood hazard;
- A potential increase in the burden on emergency and related services;
- Compromise on the safety of individuals occupying one of the new lots; and
- A potential net increase in risk to the life and health of individuals living at Venus Bay.

7. Declaration

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have to my knowledge been withheld from the Panel.

8. References

Australian Institute of Disaster Resilience (AIDR) (2017)[2]: *Australian Disaster Resilience Handbook Collection - Handbook 7. Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia.* Australian Government Attorney-General's Department, 2017.

Bureau of Meteorology (BoM) (2015): *Service Level Specification for Flood Forecasting and Warning Services for Victoria – Version 2.0*. September 2015.

[2] This handbook and its supporting flood risk management guidelines replace *Manual 19: Managing the Floodplain* (EMA, 1999a), *Floodplain Management in Australia: Best Practice Principles and Guidelines* (SCARM, 2000).

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

Department of Natural Resources and Environment (DNRE) (1998): *Advisory Notes for Delineating Floodways.*[3]

Department of Natural Resources and Environment (DNRE) (2000): *Flood Mapping Report: Shire of South Gippsland*. 24 October 2000

Haynes, K., Coates, L., Dimer de Oliveira, F., Gissing, A., Bird, D. van der Honert, R., Radford, D., D'Arcy, R. and Smith, C. (2016): *An analysis of human fatalities from flood hazards in Australia, 1900-2015.* Paper presented at the 56th Floodplain Management Association Conference in Nowra, May 2016.

South Gippsland Shire and Victoria State Emergency Service (2013): *East Gippsland Shire Flood Emergency Plan – A Sub Plan of the MEMP – Version 1.4 April 2013.*

Water Technology (WT) (2007): *Tarwin Lower Flood Study.* Report No. J155/R01, January 2007.

West Gippsland Catchment Management Authority (WGCMA) (2017): *West Gippsland Floodplain Management Strategy*.

[3] These notes were developed to support the Flood Data Transfer Project. Michael Cawood managed the project on behalf of DNRE.

Appendix A
Michael Cawood's CV

Michael Cawood - Principal

Michael has more than 39 years professional experience in the broad areas of emergency and flood risk management, working across both the public and private sectors. He also has a strong flood operations and management background as well as mature project management and high order interpersonal and facilitation skills.

Michael is an experienced flood risk management practitioners and a contributing author to the Emergency Management Australia Best Practice Manuals relating to flooding and floodplain management. He also contributed (the only consultant to do so) to both the Comrie Review following the 2010-11 floods in Victoria and to the development of the Victorian Floodplain Management Strategy released in 2016.

Michael has been actively involved in the investigation and strategic assessment of a wide range of flood and floodplain management projects as well as in the development and real-time operation of all elements of flood forecast and warning systems in Australia and overseas. He has a strong flood operations and management background and extensive experience in dam safety and other emergency planning and exercising, in stakeholder consultation and in hydrometeorological instrumentation and networks and their management. He is experienced in planning tasks, allocating resources and working to budget within tight resource constraints.

Since establishing his own consultancy in August 2003, Michael has undertaken a variety of project management, policy and specialist technical, strategic and review orientated emergency risk management, flood, floodplain and dam safety assignments. While the majority of this work has been based in Australia, assignments have included in-country Team Leader for the flood warning capacity building component of the Asian Development Bank's "Strengthening Flood Management Sustainability in Hunan Province" project in China as well as specialist contribution over a seven year period to the World Bank as an STT on a Nile Basin flood preparedness and early warning project spanning Ethiopia, Sudan and Egypt.

During nearly seven years with the former Geo-Eng Pty Ltd and the GHD Group, Michael as a Principal Engineer, was involved in a range of consultancies focussing on flood and catchment planning and management supported by hydrologic, hydraulic and related analyses. Projects extended from flood risk management studies, hydrologic and hydraulic assessments and flood and floodplain management studies through to technical input to and management of the Victorian Department of Natural Resources and Environment's $4.5m Flood Data Transfer project. This project uploaded the State's flood related data to GIS and is the basis for the current Victorian Flood Database (VFD) and FloodZoom.

Earlier in his career, Michael worked for the Australian Government and prior to that for the South Australian State Government.

Michael is a nationally registered Chartered Professional Engineer (NER and CPEng) and a Fellow of the Institution of Engineers Australia (FIEAust).

Key Strengths

- High order interpersonal, consultation and facilitation skills with experience and proven ability to successfully work with a diverse range of stakeholders with varied perspectives and backgrounds.
- Mature project management skills with experience in participatory project preparation, planning tasks, allocating resources and working to budget within tight time and other constraints.
- Proven ability to prepare easy to read "plain English" technical reports and related material.
- Demonstrated ability to operate at a strategic level as both a team player and as an individual
- Well practiced and knowledgeable in incident management and AIIMS.
- Skilled in the application of risk management principles to emergency management, dams, floods and floodplains in the context of national standards and current good practices.
- Strong appreciation of the practices, principles and practicalities of emergency risk management, flood risk management and floodplain management.
- Experienced in operational and surface water hydrology.
- Knowledgeable and practiced on all facets of flood warning system conceptualisation, development and operation.

Overview of Experience

- More than 39 years professional experience in a wide variety of specialist technical, strategic and review orientated

investigations and assessments relating to flood, floodplain management, dam safety and emergency risk management in both the public and private sectors.

- All aspects of flood warning including risk, preparedness, intelligence, forecasting, response and recovery as well as total system assessment, design, development and operation.
- Operational and surface water hydrology and hydraulics.
- Incident management and AIIMS.
- Training, consultation and facilitation.

Relevant National Experience

1. Flood Risk and Floodplain Management

- As an independent member of various flood and floodplain management study teams, provided specialist advice and written input on flood risk management measures including non-structural elements covering preparedness, warning, response, community education and land use planning.
- Developed Floodplain Management Plans for a number of locations in Victoria. The Plans provide guidance for the management of existing and future development on the floodplain and aim to reduce future flood risk and contain residual risk.
- As project leader and technical specialist, developed a comprehensive suite of flood risk reduction strategies for Charleville and Augathella based on a methodology drawn down from AS/NZS 4360:1995 – Risk Management, and involving engineering assessments as well as substantial community and agency consultation. *This work represented the first ever application of the Risk Management Standard in an emergency management context and is recognised and referenced in the Australian National "Emergency Risk Management Applications Guide".*
- As part of a small multi-disciplinary team, developed a 10-year horizon Floodplain Management Strategy for a hydraulically steep region of Victoria subject to risk from high volume, high velocity rapidly developing flood events.
- Led a diverse team in the development of (draft) guidelines for the preparation of Total Management Plans (TMP) for floodplain and stormwater management in Queensland with regard for then current best practice, TMP processes and legislative and other arrangements, and underpinned by substantial consultation with stakeholder agencies and a Technical Steering Committee.
- Assisted architects and builders resolve flood risk issues associated with a range of minor and major commercial, municipal and residential developments. This has included the development of more than thirty (30) Flood Response Plans, with associated infrastructure and processes, aimed at reducing flood risk in line with statutory and development approval requirements
- Prepared the Flood Response Plan for the Lower Darebin Creek Trail shared pathway and assisted development of the functional specification for the flood warning and access control system.
- Provided expert witness services to a number of clients on flood risk, hydrologic and drainage related matters including the presentation of expert evidence at VCAT hearings.
- Developed a Flood Hazard assessment tool and a "Guideline for Development in Floodplain Areas" for a CMA.
- Developed project briefs and successful funding applications for flood, floodplain management and related studies.
- Assisted clients in briefing potential tenderers and in assessing proposals for flood related projects.

2. Flood Preparedness and Flood Warning

- Developed an early warning system for a large high consequence dam in NSW. *(in progress)*
- Developed a risk based assessment tool to inform SES of the need for evacuation during flood. *(in progress)*
- Developed the TFWS Assessment Tool and applied it across Victoria. The tool guides the determination of flood warning system development priorities for locations and river reaches through joint consideration of flood risk and a service level based assessment of the state of development of each TFWS element. Assessment results have informed development of Regional Floodplain Management Strategies across the State.
- Guided the development of a (total) flash flood warning system in an urban area with around 1 hour lead time.
- Developed Flood Management Plan and Flood Emergency Plan templates in consultation with VICSES and Melbourne Water and assisted their application to local governments. Both templates are now widely used.
- Assembled flood intelligence (including mapping) and delivered Municipal Flood Emergency Plans for more than fifty (50) areas across Victoria.

- Led a multi-disciplinary team that successfully implemented all flood warning system components of the Nathalia Floodplain Management Plan. The system was tested during the record flood of March 2012 and performed above expectations. *The State Floodplain Management Strategy references this system as "best practice".*
- Involved in the development and delivery of a State-wide Strategic Flood Intelligence report for VICSES in 2012.
- Worked with a Victorian Council on the development of an on-going flash flood awareness raising program. This included a review and recommendation on alerting procedures and processes and the preparation of material suitable for upload to Council's webpage as well as for print and distribution within the target community.
- Undertook comprehensive reviews of TFWS development priorities across Victoria and South Australia including delivery of robust assessment tools and procedures. The reviews were supported by extensive consultation programs. Recommendations are acting as drivers to a number of active State-based projects.
- Prepared reports on noteworthy flood events in order to document the event as well as the impacts and data collected.
- Investigated and reviewed operation of the Patawalonga-Barcoo Outlet System for the South Australian Government following severe flooding at Glenelg (a suburb of Adelaide) on 27 June 2003, as a sub-consultant to GHD Pty Ltd. More than 200 houses and public assets were flooded when the Lake control system prevented flood flows from adjacent hills catchments discharging to sea. Initial damage estimates exceeded A$20m. Input also included review of and recommendations on operational and flood preparedness activities with regard for existing institutional and contractual arrangements. Expert opinion was provided in a subsequent damages action.
- By invitation, actively involved in both the original development and more recent reviews and updates of Australian national best practice manuals on Flood Preparedness, Flood Warning and Flood Response. The invitations are evidence of peer recognition of Michael's substantial and highly regarded skills and experience in flood risk and incident management matters.

3. Incident and Emergency Management

- Provide specialist operational hydrologic, flood warning, response and related support services to the Victoria State Emergency Service (VICSES) during periods of flooding. This requires an active knowledge of AIIMS (Australasian Inter-service Incident Management System) and associated incident management processes and procedures as well as high order technical skills. *(on-going)*
- Provided independent review services in relation to fitness-for-purpose for emergency response planning and operations for an ACT client on flood extent and related mapping datasets and deliverables.
- Planned, developed, built, delivered / facilitated and reported on a wide range of AIIMS-based training and all-hazards all-agencies incident management exercises (desktop, functional, distributed, single, multi-agency, multi-site) and debriefs for a number of clients across eastern Australia with due regard for technical and statutory matters as well as for linkages to Corporate and applicable State emergency management frameworks. A tool kit was developed to assist a client become self-sufficient. Clients have included various water authorities / corporations and dam owners within Victoria, NSW and Queensland, VICSES, the Victorian State Control Centre (SCC), EPA Victoria and Melbourne Water. Examples include:
  - A member of the Writing, Control and Assessment teams for a 2-day 4-shift AIIMS–based functional exercise of a fully operational Incident Control Centre (ICC).
  - As part of a joint CFA and VICSES team, developed and delivered a series of five (5) 3-day introduction to and use of AIIMS in a flood response planning and management environment training courses for VICSES. This was followed by independent preparation and delivery of a series of stand-alone flood preparedness and planning workshops for VICSES.
  - Development and delivery a two-part State Flood Response Plan training exercise for VICSES.
  - Build, delivery and reporting on a number of statutory Part 6 exercises within Victoria.
  - Conceptualisation, delivery and reporting on a series of three (3) workshops and exercises for a Victorian water authority as an introduction to AIIMS and their AIIMS-based Corporate Incident Management Plan.
  - Development, build, delivery and reporting on a desktop emergency exercise on hazardous materials management for a Victorian water authority.
  - Facilitation of a wastewater innovation workshop with contributions from all sectors of the community and related agencies for an area severely damaged by wildfire and susceptible to landslip.

- During 2011/12, reworked Flood Incident Management Plans (FIMPs) and dam safety emergency plans (DSEPs) for twenty-one (21) dams under the control of a Victorian water authority using an adaptive AIIMS compatible template developed as part of this work and supported by an inclusive consultation process. An aim of the project was to ensure seamless escalation of an incident within the organisation as well as seamless engagement with Corporate Incident Management processes and the wider emergency management community.
- Developed a Security Risk Management Plan for an essential service operator in response to the requirements of the Terrorism (Security Protection) Act 2003.
- Undertook strategic and technical reviews of emergency management arrangements for a Council in Tasmania and another in Victoria, with particular attention to flood management and response.
- Developed the incident management components of the Regional Floodplain Management Strategies for two Victorian based Catchment Management Authorities.
- Responsible for the debrief, review and reporting on a number of State level incidents that included identification of lessons learnt and delivery of suggestions for improvement. These included the 2011-12 Blue-Green Algae bloom in the Gippsland Lakes and the period of VICSES operations that spanned the bush fires of Black Saturday in 2009.
- Drafted comprehensive position descriptions for selected AIIMS–based roles within ICCs and the SCC.

4. Policy and Strategy

- Undertook a review and proposed a framework for State and Local institutional and other arrangements associated with the identification and delivery of total flood warning system (TFWS) services for locations at risk from riverine and flash flooding as input to the development of State policy and the Victorian Floodplain Management Strategy.
- Provided expert technical flood management advice and input to the Comrie-led Victorian Floods Review. Michael was the only Consultant invited to provide assistance to the review. Input is acknowledged in the report. Recommendations from the report are now influencing the rework State policies and strategies.
- As a feed-in to the State's response to the Comrie-led Victorian Floods Review and to Regional Floodplain Management Strategies, reworked and expanded the TFWS Assessment Tool initially developed by Michael. The tool guides the determination of flood warning system development priorities for locations and river reaches through joint consideration of flood risk and a service level based assessment of the state of development of each TFWS element. See above. *Paper delivered to the 2016 Flood Management Association Conference.*

5. Data Networks and Equipment

- Closely assisted project co-operators on technical aspects of the specification and implementation of data collection networks utilising a range of technologies to support flood forecast and warning activities in more than ten (10) Victorian catchments. Specifications also developed for field equipment tendering and for long term maintenance of field sites and equipment.
- While still with the Bureau of Meteorology, worked cooperatively with an Australian company to successfully develop a domestic ERTS equipment manufacturing capability to meet Australasian-Pacific area needs.

6. Dam Safety Investigations and Emergency Management Planning

- Developed and delivered an emergency management exercise Tool Kit for Sydney Catchment Authority. Work has also included the planning, build, delivery and reporting on five (5) desktop and combined desktop and field based multi-agency exercises to test Dam Safety Emergency Plans for eleven (11) Sydney Water Corporation (SWC) storages and two (2) SCA storages, some within the Sydney metropolitan area for twelve of Sydney Water Corporation's reservoirs / dams.
- Planned, delivered/facilitated and reported on a full day desktop emergency management exercise and debrief for Goulburn Valley Water that presented a number of physical hazards and risks across the business and addressed issues of dam and site safety, security of supply of water and sewerage services and Corporate Emergency Management arrangements.
- Scenario developer and facilitator for a number of Dam Safety Emergency Management Planning exercises (desktop, field, distributed, single and multi-agency) involving single and multiple storages for variously Goulburn-Murray Water, Southern Rural Water and South West Water in Victoria, Sydney Catchment Authority and Sydney Water in NSW and SunWater and the Department of Energy and Water Supply in Queensland. In all cases, Michael's role included exercise formulation, planning and delivery as well as debrief and critique on dam safety emergency practices, procedures, related activities, communications (internal and external) and linkages to the

relevant State-wide emergency management frameworks. See for example the paper by *Evans, Cawood and Reid* presented at the Fremantle ANCOLD Conference in 2005.

- Involved in the preparation and review of DSEPs for a number of other dam owners and operators in Victoria and NSW, including local governments. This necessitates detailed knowledge of local and wider emergency management plans and procedures and in NSW, close cooperation with the State Emergency Service and Dam Safety Committee.
- Determined the hazard rating for Torrumbarry Weir following assessment of downstream incremental impacts under sunny day and flood failure conditions in support of an assessment of the need to upgrade the navigation lock for seismic shock.
- Provided technical direction and review of hydrologic and dam break studies for a number of storages within Victoria (e.g. Hazelwood Cooling Ponds and High Level Storage, Loy Yang storages, Lake Mokoan, etc).

7. *Hydrologic and Related Investigations*

- As a sub-consultant to the design team, undertook a strategic risk review of hydrologic and hydraulic investigations associated with East Link and advised on related matters.
- Hydrologic and hydraulic assessments and studies in support of a range of projects involving construction, water re-use, water harvesting / yield, drainage upgrades and downstream impacts, EIS processes, etc.
- Provided services to the Principal Loss Adjustor of a major international insurance company.
- Evaluation of surface and groundwater resources in the context of bulk entitlements/licensed abstractions, and assessment of impact of MDBC Cap on water resources management issues in North East Victoria.

8. *Project Management*

- Appointed as Engineers Australia's Technical Project Manager for the Australian Rainfall & Runoff (ARR) update project for a 20 month period ending late September 2011.
- Provided stop-gap Project Manager services for the IFD Revision project as part of the ARR update project.
- Oversaw the collection, collation and upload of new and revised flood related data to the VFD datasets on behalf of the Dataset Manager with due regard for update processes and protocols.
- As Project Manager, oversaw the efficient and accurate collection and collation, in GIS format, of State-wide flood data for NRE. Tasks included establishment of project metadata (17 themes) and QA procedures, preparation of specifications and supporting definition documents, establishment of contracts, technical and 'sensibility' checks on captured and interpreted data/information, program and budget control, and preparation of final reports and technical specs. Presentations were made to CMAs and Municipalities as part of output delivery as well as to other agencies (e.g. DoI, NRE, etc). Work also included investigation and recommendation on long-term management and growth of the resulting VFD datasets in the context of the VGIS and RDN, as well as the conduct of hands-on training sessions for CMA and RDN staff. *This project was the winner of the 2001 Australian Safer Communities Award, Pre-disaster Category, Combined Stream.*
- Managed start-up of the GTSM-PMP review project and the first 15-months of this 3-year State (WA, Qld & NSW) - ANCOLD - Commonwealth project. Work also involved mentoring the lead technical specialist in project management activities, skills and processes and effecting a seamless handover of project responsibilities.
- As manager of GHD-GE's component of the Victorian Water Industry Assets Inventory project, responsible for ensuring that a suitable data model was developed and then asset and related data from Victoria's 24 water businesses was collected, collated and loaded to the purpose built database ready for analysis by other team members.
- While with GHD, provided the key point of contact within the GHD-URS alliance for surface water and catchment related matters associated with the Victorian Government Technical Services Contract, a 3-year 4-Panel contract with DSE for a wide range of technical services. Also provided the primary point of contact from within GHD to the Principal's Representative on all Contract, Panel, project and related matters.

9. *Participative Consultation*

- Experienced in the successful conduct of participative consultation and facilitation processes at both community and agency level across a range of stakeholders with varied perspectives and backgrounds in open and closed forums in both operational and study settings. Examples of this work include:
  - Facilitation of a wide variety of dam safety and incident / emergency management exercises;

- Facilitation of forums in support of the development of a Council's Community Environmental Plan;
- Adoption of a lead role in the conduct of multi-stage community and agency consultation programs implemented as part of various flood and related studies;
- Conduct of a series of facilitated workshops with staff from flood warning system stakeholder entities at fourteen (14) locations across Victoria and South Australia as part of the reviews of FWS upgrade priorities;
- Interactive presentations at a large number of workshops and training activities, including in China and Africa.

Relevant International Experience

10. Emergency Management, Flood Preparedness and Flood Warning

- In-country Team Leader for the flood warning capacity building component of the Asian Development Bank's "Strengthening Flood Management Sustainability in Hunan Province" project in China. Report available.
- Undertook an in-country desktop rapid assessment of flood damages for the Blue and Main Nile rivers in Sudan in May 2005 for the World Bank as a feed into two major regional projects: the Flood Preparedness and Early Warning (FPEW) Project and the Multi-Purpose Project Program.
- Provided strategic advice and technical input on a significant Flood Preparedness and Early Warning project for the Blue and Main Nile rivers in Ethiopia, Sudan and Egypt for the World Bank. Inputs covered flood and mapping studies involving field survey as well as hydrologic and hydraulic analyses, flood mitigation planning, flood risk assessment, flood warning and forecasting, emergency preparedness and response in the context of existing and developing institutional arrangements, and community driven flood planning and capacity building. ToRs were developed and refined following in-country discussions during 2004. Involvement which included home office based mentoring on technical matters, guiding input to technical specifications for work packages, assessment of and recommendation on international team responses to various ToRs, and participation as a member of WB's periodic in-country FPEW project Inception, Preparation and Supervision teams continued up until the completion of Phase 1 work at the end of 2010. The project is effectively now on hold due to a range of in-country political and stability issues.

Qualifications and Affiliations

- Introduction to AIIMS course
- Counter Disaster Planning Course, Australian Emergency Management Institute, 1993
- Master of Engineering Science, Monash University, 1988
- Graduate Course in Hydrology, University of New South Wales, 1981
- B. Tech. Civil Engineering, South Australian Institute of Technology, 1978
- Fellow, Institution of Engineers Australia, Member of the IEA College of Civil Engineers, CPEng, NER
- Member, Floodplain Management Australia
- Member, Australian Water Association Inc
- Member, Hydrological Society of South Australia
- Member, International Association of Hydrological Sciences

Papers and Publications

Michael has co-authored and formally reviewed a good number of papers on flood, dam and related matters. He is a co-author on three papers currently waiting on abstract acceptance by recognised professional Journals and conference organisers.