City of Greater Geelong Planning Scheme Amendment C394

Land Subject to Inundation Overlay, LSIO2

Expert Witness Statement of Dr David Goldie Provis

February 2020

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APPENDICES

APPENDIX A Curriculum Vitae of Dr. D. G. Provis

1. INTRODUCTION

1.1 Name and Address

Dr David Goldie Provis
Cardno
Level 4, 501 Swanston Street
Melbourne VIC 3000

1.2 Qualifications and Experience

Academic Qualifications

BSc (1st Hons), Flinders University of SA, 1972
PhD University of Essex (UK), 1975
Grad Dip Business Admin Swinburne University of Technology 1992

Professional Associations

Senior Principal, Cardno Group
American Geophysical Union
American Meteorological Society
Comp IE Aust
Member, National Committee on Coastal and Ocean Engineering, Engineers Australia 2005-2017, Corresponding member 2017-present
Research Professor, Swinburne University of Technology 2015-2017(part-time)
Member, Victorian Coastal Council 2015-2018
Chair Science Panel, Victorian Coastal Council, 2017-2018
Member, Science Panel, Victorian Marine and Coastal Council

1.3 Statement of Professional Expertise

Design and execution of oceanographic field work.
Development of instrumentation for measurements in the ocean, including coastal processes.
Oceanographic instrumentation, including selection, deployment, mooring, design and ship-board operations.
Coastal oceanography.
Analysis and presentation of oceanographic data.
Analysis of sea level including tidal analysis and sea-level variability.
Use of numerical models in oceanography.
Development of criteria for marine operations and design.

Familiarity with dredging operations and monitoring of environmental impacts.

Development of techniques for the assessment of coastal vulnerability to climate change.

A copy of my Curriculum Vitae is provided in Appendix A.

1.4 Instructions and Information

I was engaged by City of Greater Geelong to provide advice in relation to the City of Greater Geelong Planning Scheme Amendment C394, Land Subject to Inundation Overlay (LSIO2), in particular the use of material from the Inundation Report, Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment. The engagement included

- The preparation of an expert witness statement, and
- Appearance at the Independent Panel Hearing in Geelong as an expert witness.

The following documents were available:

C394LandSubjectToInundationOverlay-mainclause.
C394CouncilAgenda26November2019 *(includes submissions and response)*
GreaterGeelongC394ggee44_04s2_ggeeExhibitionFinal
From City website:
https://www.geelongaustralia.com.au/amendments/item/8d6fe3cb76c04fa.aspx

Cardno, (2015). Inundation Report, Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment. Report prepared for City of Greater Geelong and Stakeholders, report NA49913529_R04, published by OurCoast (2016)
http://www.ourcoast.org.au/resources/Final_Inundation_BellarineCorioLCHA_FINAL.pdf

CCMA Submission C394 28 February 2020 DRAFT_V1 supplied by Corangamite Catchment Authority via CoGG

DELWP, 2018. LSIO_Coastal_Update_background.

Hansen Partnership (2019) *MAV Greater Geelong Planning Response to Sea Level Rise Plan 2019*

IPCC, (2019): *Technical Summary* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, E. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.- O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)].

Keaney and Kirsch (2017) *Bellarine Peninsula Corio Bay LCHA Implementation Final Report*, published by OurCoast.

McInnes, K.L., Macadam, I. and O'Grady, J. (2009). *The Effect of Climate Change on Extreme Sea Levels along Victoria's Coast*. CSIRO Marine and Atmospheric Research.

Victorian Coastal Strategy 2014.

2. BACKGROUND

2.1 Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment

Cardno was commissioned by the City of Greater Geelong (CoGG), the Department of Sustainability and Environment (DSE) (now the Department of Environment and Land, Water and Planning (DELWP), the Corangamite Catchment Management Authority (CCMA), the Department of Planning and Community Development (now part of DELWP) and the Borough of Queenscliffe (BoQ) to undertake the Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment (Bellarine Peninsula – Corio Bay LCHA). This study was one of four Local Coastal Hazard Assessments undertaken in Victoria through collaborative partnerships with local stakeholder agencies and was initiated through DSE (now DELWP) Future Coasts Program.

I was the Project Manager and Lead Investigator for Cardno on this project.

The Bellarine Peninsula – Corio Bay LCHA study area includes the entire Bellarine Peninsula and the northern side of Corio Bay, from Point Wilson in the north, to Breamlea in the south. The key aim of this study was to provide a comprehensive understanding of the extent of coastal hazards and the impacts on the coastal environments within the study area. This was done by addressing coastal, estuarine/riverine and climate-change challenges by defining the possible magnitudes and extents of the hazards in a considered and robust manner. One of the outputs of this study was the Inundation Report (Cardno, 2015) which was published through the OurCoast project (OurCoast, 2016) and formed the basis for the definition of the LSIO2.

2.2 Project Methodology

A schematic outline of the project methodology is shown in Figure 1. This shows three concurrent, interlinked streams, although all the cross-linkages are not shown. On the left is the project management and reporting stream, in the centre the geomorphology and history and, on the right, the modelling. The final two stages, the Risk Assessments and Adaptation Responses are not part of the Hazard Assessment and form bodies of work for following investigations which include the development of the LSIO2.

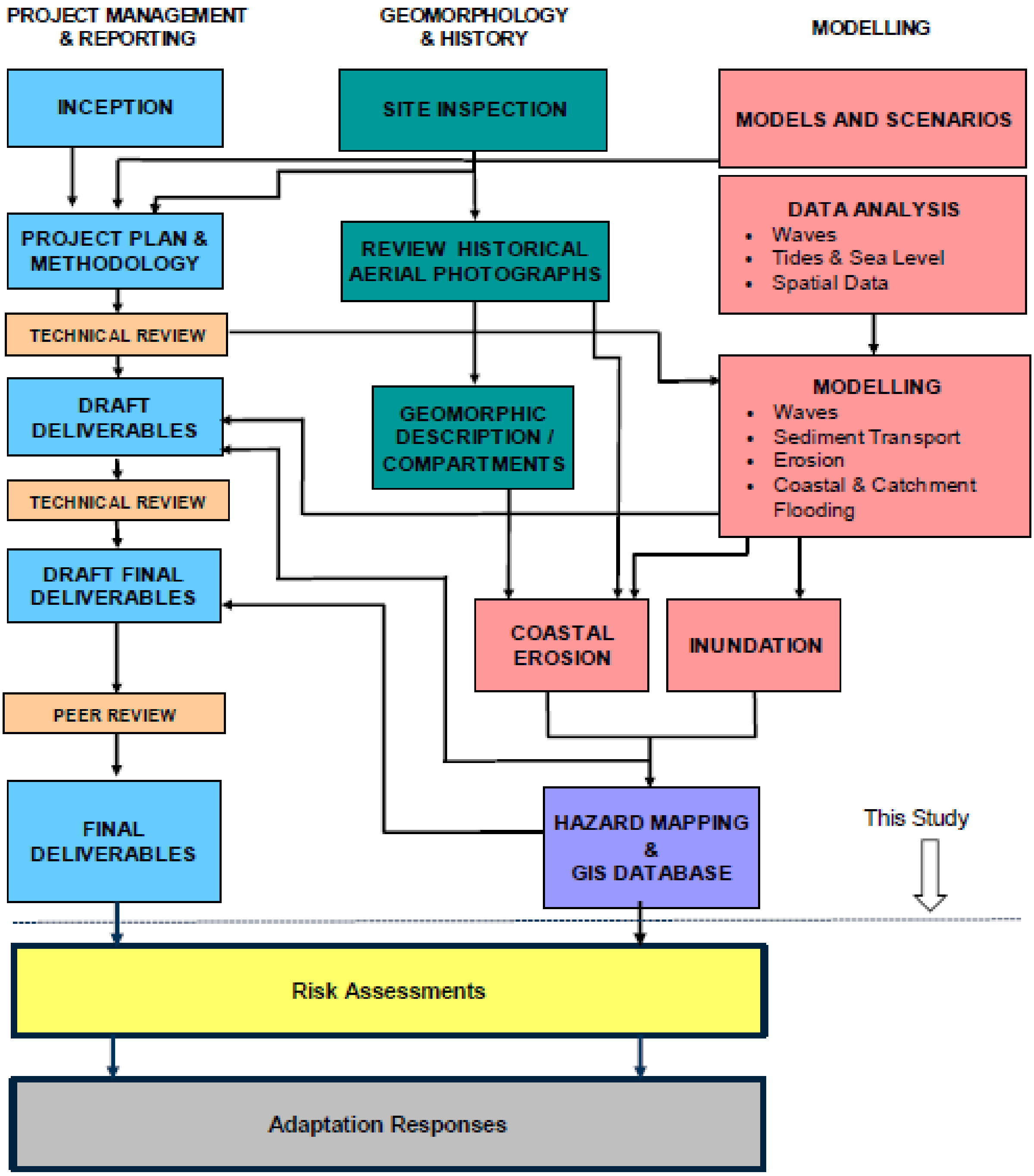

Figure 1 Schematic outline of the project methodology for the LCHA, from Cardno (2015)

2.3 Modelling

Details of the modelling are provided in Cardno (2015) but, in summary, the modelling was carried out using a mixture of static (“bathtub”) and dynamic modelling.

In static modelling, the relevant sea-level, normally the 1% AEP storm tide plus the relevant sea-level rise, is applied to the topography and any area with a land-surface elevation less than the applied sea level is considered as inundated. This is a conservative approach in that it will overestimate the extent of inundation. Static modelling does not include consideration of whether or not water is able to flow from the ocean into a given locality and does not always include consideration of features such levees. It also does not consider the time it might take for sufficient water to flow into an area to reach the same level as the ocean. For these reasons, static modelling should only be applied in situations where the inundation is hydraulically simple, the topography is not complicated and the flow paths are short. Where possible, in the LCHA, any topographic constraints to water flow were included in the static modelling through manual editing.

Dynamic modelling simulates the movement of water through the environment by accounting for the flow paths, friction of various surfaces and the time variation of sea-level and river flows. The dynamic methods are applied to the higher priority locations and where flow paths are more complex. In this study the SOBEK model from Deltares (formerly Delft Hydraulics) was used for dynamic modelling, this is an industry-standard model for flooding and inundation and includes detailed wetting and drying routines, allows for pipe networks and flow over weirs and embankments as well as variable bottom-friction to reflect surface roughness.

An example of the difference in outcome from the two methods is shown in figure 2.

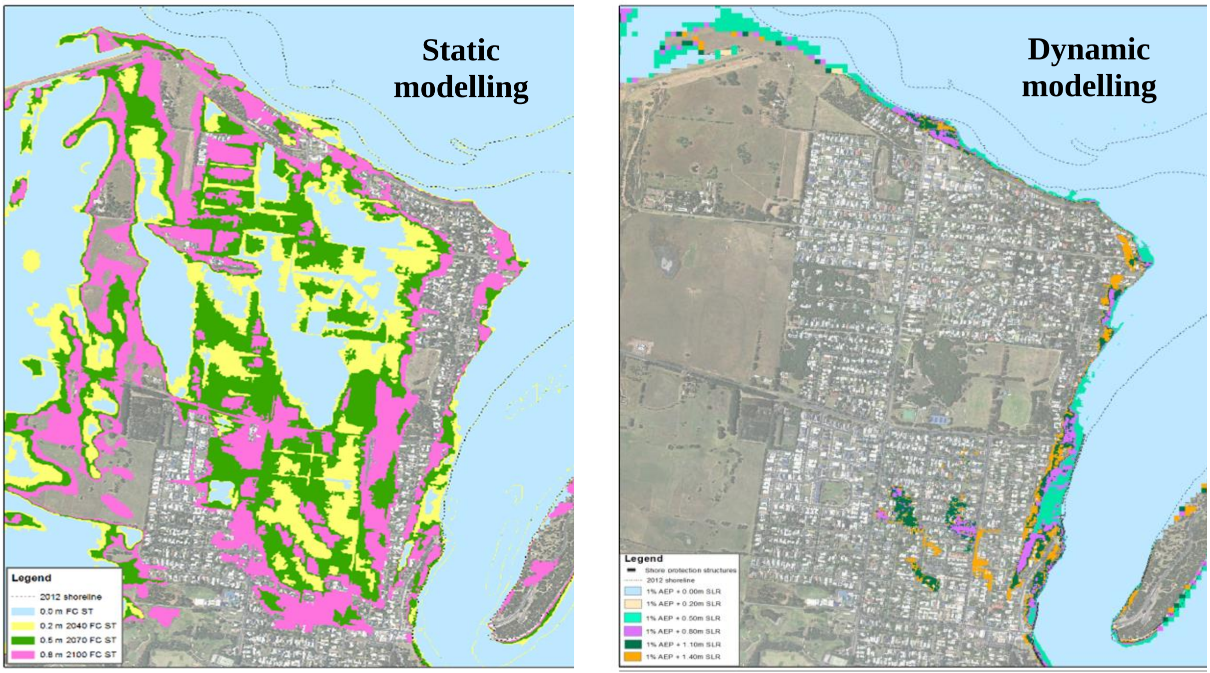

Figure 2. Difference between static modelling and dynamic modelling for the same case.

The modelling on the left of Figure 2, the static modelling, is from the “second-pass assessment” of coastal inundation undertaken for the Future Coasts program and is available on line at http://mapshare.maps.vic.gov.au/gvh270hydra/ . The results on the right are from Cardno (2015) and includes the values used to develop LSIO2. This is referred to as a “third-pass assessment”.

Crucial to the accuracy of the inundation modelling is the accuracy and validity of the underlying topographic and bathymetric data as well as the stormwater drainage pipe network. The topographic and bathymetric data used to generate the models was based primarily on the airborne-laser survey undertaken as part of the Future Coasts program of DES (now DELWP).

The topography data set was the LiDAR (2007) and the bathymetry the LADS (2009). The accuracy and implications for the project of using these data sets are discussed in more detail below. Information on the stormwater drainage pipe network was provided by the relevant local council.

Details of the various models, their spatial coverage, grid sizes and inputs are contained Cardno (2015).

2.4 Uncertainty

The type of assessment undertaken in this project has some inherent uncertainties that must be considered when using the information to inform subsequent applications. Each assessment has its own uncertainty and there are some generalised project-related uncertainties which are noted in Table 1. This type of assessment uses the best scientific practice to produce the best outcomes possible with the information available. The results are fit for a defined purpose, but are not to a level of detail to facilitate detailed design. The purpose of this study is to inform strategic flood and erosion management decisions and provide an insight into what may happen in future. The LSIO2 is an appropriate use, however the application of the LSIO2 must take account of these uncertainties.

Table 1 Sources and implications of project uncertainties (from Cardno, 2015)

	Type	Information	Implications	How overcome
DATA	Topographic LiDAR	The most recent LiDAR available was flown in 2007. The data are available at 1 m horizontal resolution, and were re-processed from the original level 2 classification into level 3 for input to a higher accuracy Intergovernmental Committee on Surveying & Mapping (ICSM) Level 3 classification.	The horizontal accuracy of the LiDAR data is +/- 35 cm, the vertical accuracy +/- 10 cm (RMSE 68% conf.). The implications of this are that the height of any given point *could* on average be approximately 10 cm above or below the height stated in the dataset. The implication is that, potentially, cross-shores profiles extracted based on the LiDAR could be incorrect, and flood and erosion extents could be over or underestimated. - Locations that have been significantly modified through works since the data were collected (e.g. Queenscliff marina) will not show within the LiDAR data.	Elevations were checked against survey data or construction drawings (where available) for vertical accuracy and manually checked and modified where possible for horizontal alignment.
DATA	Bathymetric data	The most recent bathymetric (LADS) data was collected in 2009 / 2010. The data set has some gaps within the study area, these are largely due to turbidity of the water during data capture (the LADS laser could not penetrate the water to the seabed).	The horizontal resolution of the data is 2.5 m, the horizontal accuracy is +/- 1.62 m, the vertical accuracy is +/- 0.26 m at 68% confidence, or better. The implications of the data are similar to those documented for the Topographic LIDAR data. The depth and slope for the nearshore zone has an effect on the wave modelling outputs, and therefore has an effect on the	Some hydrographic data exists for the offshore areas, however this is rather old and relatively uncertain in itself. The bathymetric data was given consistency checks, and where data was missing, profiles were checked against hydrographic charts (where possible) or

	Type	Information	Implications	How overcome
			erosion modelling. A deeper or steeper bathymetry would mean wave conditions would be underestimated, and modelled erosion extents could possibly be further inland than presented. The data gaps are quite extensive in the nearshore zone, particularly in zones of wave breaking.	profiles linearly interpolated to fill data gaps.
DATA	Waves	Measured wave data is available for two locations: - Point Nepean has 10 years of relatively continuous Wave buoy data (PoMC) - 1 year of measured wave height information was gathered using a pressure gauge near Portarlington (Water Technology, 2008).	There is very little data to validate wave models and the time span is too short to obtain more certain extreme events. Pressure gauge wave data is relatively uncertain, and also has no associated directions. Data set not likely to be appropriate for validation of PPB model.	No additional data at nearby locations is available to validate / compare the local measured data.
DATA	Tidal	20+ years of tidal data exists for the main tidal stations.	The data record is insufficient to provide fully certain values for extreme storm-tides. The locations of some tide gauges can introduce some uncertainty, e.g. Point Lonsdale is behind a rock shelf within the PPB entrance therefore is not representative of the open coast conditions.	Extremes determined using the tidal data were compared to known storm-tide events for consistency. Point Lonsdale open coast STLs are based on tides at Rip Bank (i.e. outside the entrance) rather than the Point Lonsdale tide gauge.
DATA	Coastal protection structures	Coastal protection structures were captured by the DSE Future Coasts Program, using DSE aerial imagery. It was identified that some protection structures were not captured initially. This was most likely because they could not be identified on the available aerial photography. Structure crest elevation, residual life and general condition is also uncertain / unknown in some locations.	Missing structures or structures that are present but in poor condition (that is unknown) will affect the inundation modelling, possibly flooding areas unnecessarily, or not allowing areas to flood that in reality might. Uncertainty about elevation will have similar implications to the above.	Members of the project reference group assisted with adding additional information. Structures with no crest elevation information were check with LiDAR and local stakeholders.

	Type	Information	Implications	How overcome
	Aerial imagery	The most recent aerial imagery was flown in 2012. Historical imagery also exists for some areas from as early as the 1930s. The ortho-rectification process and digitising of shorelines can introduce error. The level of error depends on the accuracy of ortho-rectification and scale at which shorelines are digitised. Ortho-rectification quality depends to some extent on the number and quality of reference points	Depending on the degree of horizontal error, this has an effect on the position of the shoreline at the time of capture and therefore values used for calculating coastal change. It must also be noted that historical aerial images used in this study provide only a snapshot in time. Typically, it is not known if the image was taken during a calm or stormy period or before or after a coastal storm. This could lead to a false impression of a 'stable' shoreline.	Images were provided by the client (DELWP) and checked against existing information, and between images of different years. No significant issues could be identified and images were utilised as supplied.
DATA	Geology	Surface Geological Mapping is available at 1:250,000 scale for the entire Bellarine Peninsula.	The accuracy of the dataset and level of information available for sub-surface geology does not allow for a fully accurate assessment of the possible available erodible (sand) volume of the open coast dunes/cliffs.	All available information, such as reports containing more localised information (e.g., Rosengren, 2010) were utilised in the assessment. This included information about calcarenite along the open coast between Barwon Heads and Point Lonsdale.
DATA	Geotechnical information	A number of geotechnical assessments have been undertaken for the study area previously. The scope of these studies differs from the current study, therefore the information within has limited use as part of this assessment.	The studies have been carried out for the 'present day', no sea-level rise scenarios have been considered. It may be more appropriate to link future geotechnical hazards to inspection by professional engineers, once significant change is determined through regular impaction by land managers.	Geotechnical assessment is beyond the scope of this project, however where necessary it will be noted that future hazard and risk will be linked directly to engineer inspections.
MODELLING	SWAN Modelling Bass Strait	Modelling of waves in Bass Strait for relationship with Point Nepean measurements depended on bathymetry beyond the LADS coverage area and may not be accurate. Hindcast for extreme events has limited validation and only spans 33 years. There is 10 years measured wave data from Point Nepean.	There is moderate to high uncertainty in the extreme wave conditions, the limited data used could over or underestimate the extreme values calculated, which would have an effect on the erosion hazards determined. More data would increase confidence levels.	The values used were checked using the limited measured data, but this has too short a span to provide high certainty. There are no data to validate the modelled relationships with the Point Nepean measurements and the study area. Both remain sources of uncertainty.

	Type	Information	Implications	How overcome
	SWAN Modelling Port Phillip Bay	No detailed data for directional waves available to validate modelling. Hindcasting has been used to obtain extreme events, but that is limited since there are only 22 years of wind fields available at Point Wilson.	Waves are fetch limited, but effects of bottom friction and depth-limited wave breaking provide significant uncertainty. Therefore, the extreme conditions could be over or underestimated in individual locations, which would have an effect on the erosion hazards determined.	Consistency checked (not validated) against Water Technology (2008) measured waves at Portarlington.
	Inundation Modelling (Static)	Depends on the accuracy of the LiDAR DEM and potential flow paths. Depends on accuracy of design water levels.	Results likely to be conservative (overestimate inundation) for given water levels, as overland flow etc. are not considered.	Manual checking where possible of elevations and extents, cross-referenced against anecdotal information.
	Inundation Modelling (Dynamic)	Depends on the accuracy of the LiDAR DEM and structure information. Requires friction factors for overland flow. Depends on accuracy of design water levels.	Results likely to be less conservative than the static model method.	Manual checking where possible, cross-referencing against anecdotal information. Timing of inundation is a good addition of information to aid in subsequent risk assessments.
	Storm events	Only one AEP event has been considered as the design scenario (a 1% AEP). This is a rare and significant event. More frequent events with a lesser impact are likely to occur, however, the implications of these, although possibly also significant, are not presented.	More frequent events, although smaller in magnitude have the potential to have a significant effect, especially in very low-lying or exposed areas. The concentration on a large infrequent event limits the amount of information available for short term management planning.	Where there is significant impact under a 1% AEP event with 0.0 m SLR, it may be necessary to assess more frequent return periods in subsequent assessments, especially where consequential risk may be significant.
Mapping	Inundation hazard maps (static)	The inundation layers present the maximum extent based on the LiDAR topography, the detail of this is limited by the background data as well as the processing of data. Where areas of inundated land at relevant elevations are located but not connected (flood path), these are edited out, however not at a resolution to remove all. Only large significant areas were removed.	Some low-lying areas not connected could appear to be flooded with no connection to the ocean. In reality, these may be filled with runoff, so the significance is potentially low, but an uncertainty nonetheless.	Maps are checked for connectivity, large obvious unconnected inundated areas are removed.

	Type	Information	Implications	How overcome
	Inundation hazard maps (hydro-dynamic)	The areas are gridded to cells; therefore the extent is based on a series of grid-sized square cells.	May be some slight elevation differences within the gridded cells, however only significant for the lower resolution models with larger grid cell sizes.	A prioritising exercise was undertaken early in the project, where the more detailed areas were targeted for a higher resolution model assessment (smaller grid cells).

3. ASSESSMENT

3.1 Basis of the LSIO2

The definition of the LSIO2 is based on the mapping from Cardno (2015) for the 1% AEP storm event with 0.8 m sea-level rise. As stated in the agenda for the Council Meeting of 26 November 2019, some minor changes were incorporated in the mapping. These include the removal of some isolated areas of flooding where there is not an overland flowpath from the ocean and the flooding is due to backflow up the stormwater drainage system. Council are committed to installing backflow-preventing valves on these pipes and hence this flood will be prevented.

3.2 Response to submissions

I have reviewed the submissions and Council responses as set out in the agenda for the Council Meeting of 26 November 2019. I agree with and support City's response to the submissions.

I note the response to submissions raised in paragraph 68 which relates to the timeframe of the predicted inundation. In Cardno (2015), the rise in sea level is not tied to a specific timeframe, but rather presents the inundation which would be expected if sea level rises by 0.8 m. In paragraph 71, City quote the "Normal" design life for new buildings of 50 years. This raises issues of a risk-based approach to planning in relation to the use of the LSIO2. This matter is discussed below.

4. OTHER CONSIDERATIONS

It is recognised that Government has decided to use the LSIO for planning for coastal inundation. I accept that, however feel it is appropriate to make some comments on the use of the overlay at this time. These comments do not question the use of LSIO2, however may be relevant when considering its application in specific cases when assessing applications for a planning permit.

There is a need to delineate between riverine flooding and coastal inundation. The present policy appears to be to apply the same methods, tools and understanding to the planning response for both phenomena. There are a number of significant differences in the physical processes.

1. One of the most important differences between riverine flooding and coastal inundation is the issue of stationarity. For planning purposes, riverine flooding is treated as a stationary process, that is, from a statistical point of view, the natural processes are not changing in time. The 1% AEP (Annual Exceedance Probability) flood level is considered as constant over time. Coastal inundation is changing due to sea-level rise and thus a given event, say the 1% AEP level, changes (i.e. increases) with time as evidenced by the "0.2 m sea-level rise by 2040 and 0.8 m by 2100" . This means that the "exposure probability", the likelihood of a structure experiencing an event changes over time. If, as noted above from the City's response to submissions, the normal life of a building is about 50 years, imposing the LSIO2 is very conservative and the risk of

inundation is well below the 1% annual exceedance probability. This factor needs to be considered in the application of the LSIO2.

2. Another difference is the duration of flooding or inundation. Riverine flooding may last for many hours, even days or weeks. The water level rises and recedes relatively slowly in most cases. Coastal inundation is caused by the combination of the astronomical tide and storm surge and the duration will be controlled by the astronomical tide and the timing of high tide. Thus the water level will be within say, 0.15 m, of its peak level for a time unlikely to exceed three hours. The elevated water will often not last long enough for flood waters to flow inland. Also the reduction in water level as the tide falls allows the water to flow back into the sea, opening access routes. This means that the consequences of inundation will be different from that normally occurring in riverine flooding and the means of protection or mitigation can also differ from those used for riverine flooding.

   The time scales associated with coastal inundation are illustrated in figure 3 which shows the measured sea-level from Lorne during a storm (blue line) along with the non-tidal sea-level or storm surge (red line). Note that the fine vertical lines are at 3 hourly intervals. The storm surge lasts for about 2 days, but the peak water levels are much shorter, approximately 2-3 hours. The time scale of riverine flooding is typically much closer to that of the storm surge.

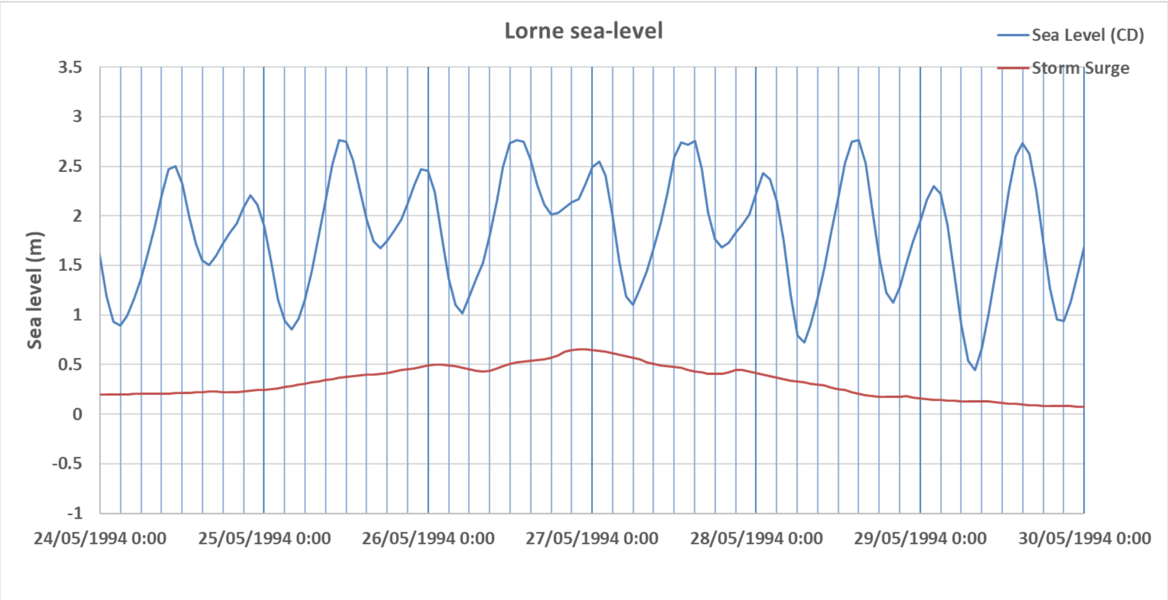

Figure 3 Measured sea-level at Lorne during a storm surge.

Riverine flooding has been studied for many years and the phenomena and behavior are well understood. Coastal inundation is not as well studied and understood in Victoria, and there are complex relationships with processes such as coastal erosion which need to be included in the analysis and response.

4.1 The Land Subject to Inundation Overlay

The LSIO2 deals with the non-stationarity of coastal inundation by assuming values for sea-level 0.8 m by 2100. This is in response to the State Planning Policy Framework, Clause 13.01-2S (31/07/2018) which includes the following strategies, among others:

- *Plan for possible sea level rise of 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, coastal processes and local conditions such as topography and geology when assessing risks and coastal impacts associated with climate change.*

  It also states

- *In planning for possible sea level rise, an increase of 0.2 metres over current 1 in 100 year flood levels by 2040 may be used for new development in close proximity to existing development (urban infill).*

The non-stationarity of coastal inundation means that land which is subject to the LSIO may not be subject to inundation at present, or indeed for many years to come. Thus, the risk of inundation is a future risk, not applicable at the present day. This is demonstrated in Figure 4 which shows the projections for the extreme storm-tide at Lorne which is representative of the sea-level along the Bass Strait coast of the Bellarine Peninsula.

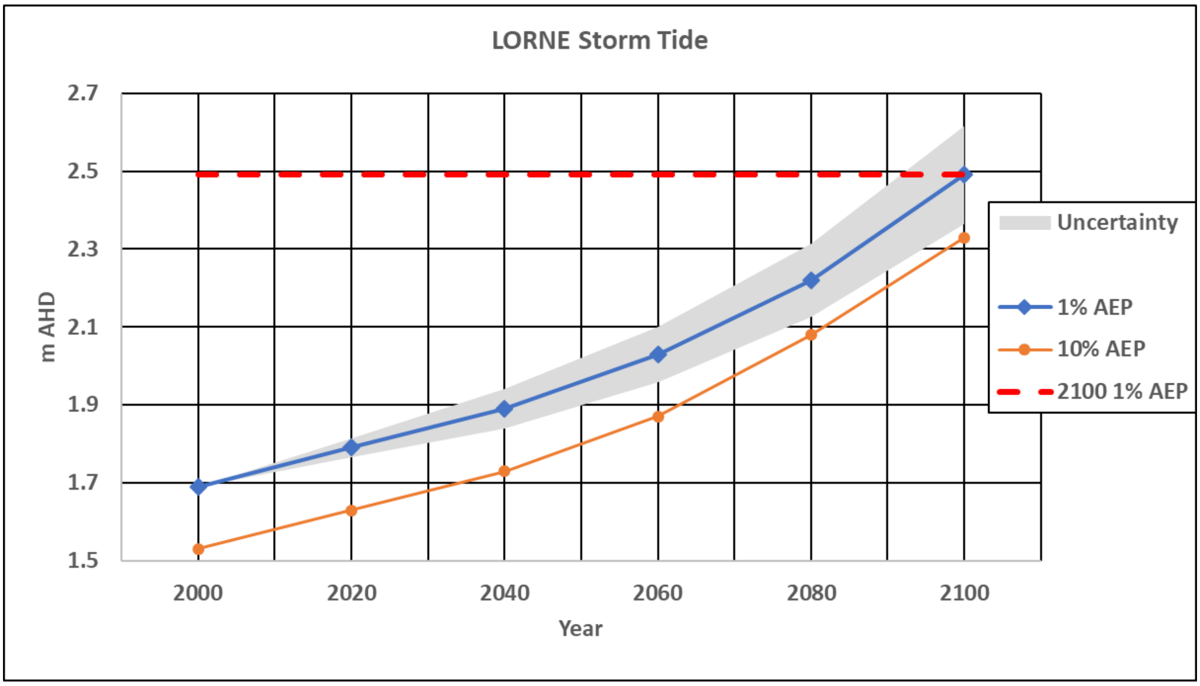

Figure 4 Projected extreme storm-tide levels at Lorne showing the 1% and 10% AEP and the uncertainty in sea-level rise applied to the 1% AEP, also highlights the 1% AEP level in 2100.

Figure 4 highlights some of the issues with using an LSIO for coastal inundation. The greyed are indicates the projected range of the 1% AEP sea-level based on the State Planning Policy Framework, McInnes (2009) and IPCC (2019). For reference, the 10% AEP sea-level, from Appendix A of Cardno (2015), is included to provide some measure of the increase in storm-tide for an order of magnitude (10 fold) change in risk of exceedance. The level set in the LSIO2, the

1%AEP level in 2100, i.e. with 0.8 m sea-level rise, is highlighted. It can be seen that even with the upper range of uncertainty, storm-tide levels are not projected to reach the LSIO2 level until after 2090 and hence the land within the LSIO2 is not "subject to inundation" for a significant length of time.

I acknowledge that the Corangamite Catchment Authority has made some allowance for these factors in their proposed assessment criteria as set out in their submission to this Panel, and I support the aims of these criteria, however it is still a conservative approach.

Whilst the LSIO is the best available planning tool at present for providing guidance in dealing with coastal inundation and the effects of climate change, I do not believe it is the best possible tool. I believe the risks associated with coastal inundation and coastal erosion would be better dealt with by means of a separate overlay, for example a "Coastal Management Overlay"

There are a number of the Decision Guidelines in section 44.04-8 (24/01/2020) which need to be considered differently in coastal inundation compared with riverine flooding. These include:

> *The potential flood risk to life, health and safety associated with the development. Flood risk factors to consider include:*
>
> - *The frequency, duration, extent, depth and velocity of flooding of the site and accessway.*
> - *The flood warning time available.*
> - *The danger to the occupants of the development, other floodplain residents and emergency personnel if the site or accessway is flooded.*

Due to the short duration of coastal inundation, the safest option in many cases for residents will be to remain in-situ and allow the inundation to recede, which it is known will occur within hours due to the tidal timescales of the inundation. Also due to the short timescale of the inundation, in many cases it is possible to provide defence at a local or property scale. Impervious fences and temporary barriers are readily able to resist the flow of water sufficiently to provide protection for the few hours required to allow the inundation to recede. There are many examples of such defences being employed in other locations. It is also important to note that it is possible and practical to predict the timing and magnitude of storm tides with high accuracy and lead times of days and with increasing accuracy as the event approaches. The Bureau of Meteorology generates forecasts of storm surge and section 5.4.1 of Cardno (2015) presents methodology for predicting storm tides with high accuracy. The predictability of the inundation also reduces the risks associated with sheltering in-situ and not evacuating and/or using local scale protection.

These factors should all be considered in the application of the LSIO2 when assessing planning applications.

The LSIO2 has been selected as the mechanism for planning controls to deal with coastal hazards, and the application of the LSIO2 by responsible authorities should consider the factors outlined above when assessing individual applications.

5. CONCLUSIONS

5.1 Conclusions

The Inundation Report, Bellarine Peninsula - Corio Bay Local Coastal Hazard Assessment, uses dynamic modelling and appropriate inputs to compute the inundation under a 1% AEP storm tide and appropriate river flows where applicable.

- The LSIO2 uses slightly modified inundation extents from Cardno (2105) to define the land areas liable to inundation under the 1%AEP storm-tide event under a 0.8 m sea-level rise relative to 1990 levels. The modifications are the removal of localised areas of inundation caused by backflow in the stormwater drainage system which will be prevented by the installation of backflow-prevention valves. Council are committed to installing these valves. The modifications are reasonable and valid
- The LSIO2 also excludes the area of inundation in Point Lonsdale due to ongoing works and development in this area. I am familiar with the development and support this exclusion from the LSIO2.
- The LSIO2 is not a perfect tool for dealing with the planning issues associated with coastal hazards, however some of its shortcomings can be dealt with by the discretion available to authorities in decision making when assessing applications.

5.2 Declaration

I formally adopt these conclusions and the information and reasoning I have presented in support.

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.

David Goldie Provis

21 February 2020

Appendices

APPENDIX A Curriculum Vitae of Dr. D. G. Provis

Dr David Provis

Current Position
Senior Principal/Oceanographer

Profession
Oceanographer

Years' Experience
37

Joined Cardno
January 1995

Education
BSc(1st Hons)
PhD
Grad Dip Business Admin

Professional Registrations
Comp IEAust

Affiliations
AGU, AMS, IEAust

Research Professor Swinburne University of Technology 2015-2017 (part-time)

Member, National Committee on Coastal and Ocean Engineering. IEAust (2005-2017), Corresponding Member

Member, Victorian Coastal Council 2015-2018

Summary of Experience

David is a Senior Principal of Cardno with more than 35 years' experience in coastal oceanography including the design and execution of oceanographic field work, data analysis and numerical modelling. He is a corresponding member of the National Committee on Coastal and Ocean Engineering, of Engineers Australia and a former member of the Victorian Coastal Council. David is the technical lead in the Cardno Melbourne-based team in Coast, Ocean and the Environment. His experience includes marine meteorology and the application of measured data in numerical modelling. He has expertise in coastal oceanographic phenomena including dispersion and fate modelling in the coastal environment as well as coastal processes. His diverse experience across a range of specialty areas includes:

> Oceanographic instrumentation selection, deployment, mooring, design and ship - board operations;
> Analysis, interpretation and presentation of oceanographic data including tide and sea level analysis and application in climate-change scenarios;
> Use of numerical models in oceanography;
> Use of oceanographic data and models to support planning and sea-level rise assessments;
> Preparation of environmental assessments on marine and related topics;
> Expert witness and peer reviewer on coastal and marine issues;
> Interpretation and modelling of sediment movement; and
> Conceptual design of coastal protection structures.

Significant Projects

> Bellarine Peninsula Corio Bay Local Coastal Hazard Assessment
> Port of Darwin, assessment of emergency moorings during tropical cyclones.
> Port Phillip Bay wave climate and sea-levels for coastal process studies
> Channel Deepening Project, for Port of Melbourne Corporation: Project Manager and principal investigator for the Hydrodynamics, Sediment Transport and Water Quality Modelling and Coastal Engineering.
> BassGas Project, for Origin Energy Resources: Development of design criteria and marine, coastal and surface water input into the environmental impact assessment for offshore platform in Bass Strait and subsea pipeline to Victoria.
> Hampton and Sandringham beach renourishment including groyne assessment and design
> Victorian Desalination Project: Team leader for oceanographic and dispersion modelling including functional design of the diffusers.
> Manager of data processing and management, Ichthys LNG Project Nearshore Environmental Monitoring Program for INPEX in Darwin.
> Development of methodology for Coastal Hazard Vulnerability Assessment under climate change scenarios.