Mapping coastal zone inundation vulnerability at Lakes Entrance, Victoria, Australia

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Introduction

The inundation of low-lying coastal land/water interface areas adjacent to coastal lagoons, tidal inlets or estuaries constitutes an ever-present threat. Many such areas have been settled with high-value real-estate. Inundation conditions in such coastal areas often become apparent during the convergence of environmental 'forcings', primarily comprising of high influent catchment streamflows (caused by periods of extreme catchment rainfall), high coastal tidal and sea levels, and strong regional wind-effects which act to temporarily raise water levels in down-fetch lake or estuary areas. Inundation may also be sustained by extreme storm events, which can generate local or regional elevated sea level conditions known commonly as storm surges, and augmentation by highest astronomical tides (HAT) often exacerbates this problem. The Gippsland Lakes (situated in East Gippsland, Victoria, Australia) (refer **figure 1**) is one such extensive coastal lagoon system whose shores harbour extensive low-lying areas subject to periodic inundation. At the Lakes Entrance township (refer **figure 2**), urban development extends over an area that is currently classed as 'land subject to inundation'. Estimates of the 1:20, 1:50 and 1:100 year flood events for Lakes Entrance (respectively 1.3m, 1.6m and 1.8m AHD) (Grayson *et al*. 2004) have been deployed in this case study in support of digital inundation modelling of the Lakes Entrance township area, to provide accurate determination of the estimated maximum extents of any possible future inundation scenario.

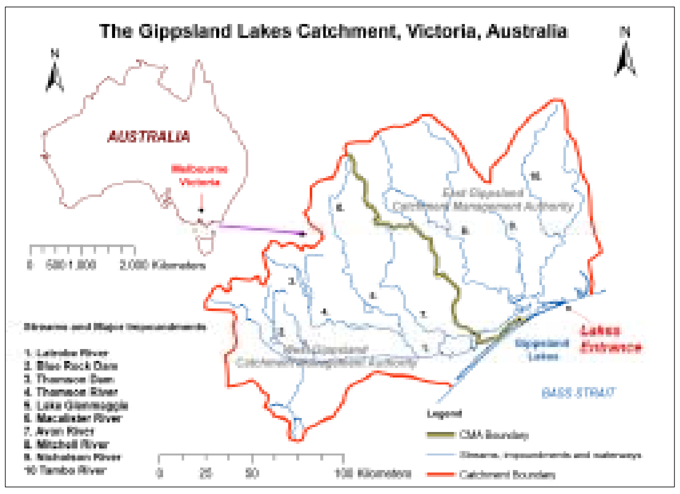

Figure 1: The Gippsland Lakes catchment, Victoria, Australia

Figure 2: The Lakes Entrance township, Victoria

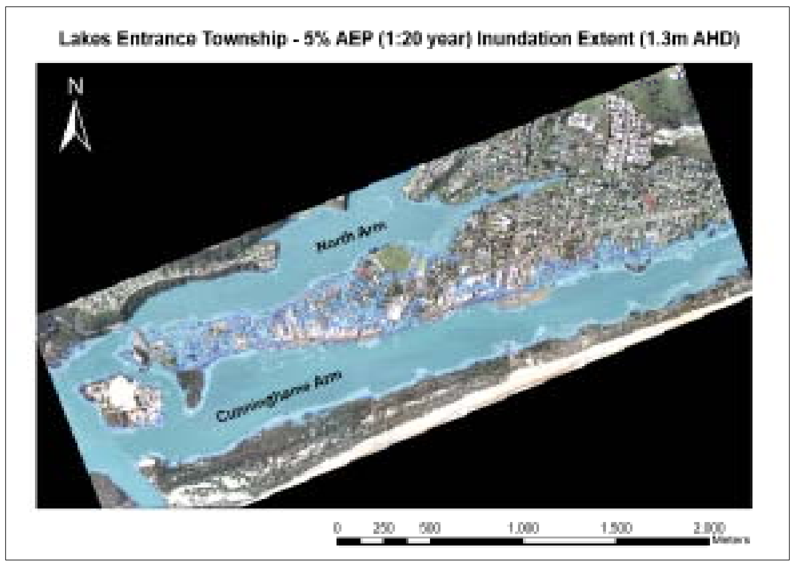

Figure 3: Derived estimated 5% Annual Exceedence Probability (AEP) (1:20 year) inundation extent for Lakes Entrance ***(+1.3m AHD)***

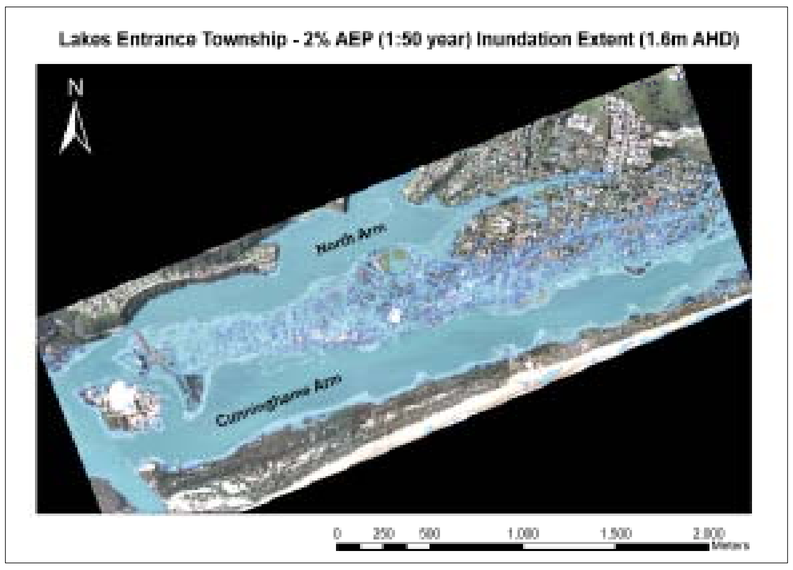

Figure 4: Derived estimated 2% Annual Exceedence Probability (AEP) (1:50 year) inundation extent for Lakes Entrance ***(+1.6m AHD)***

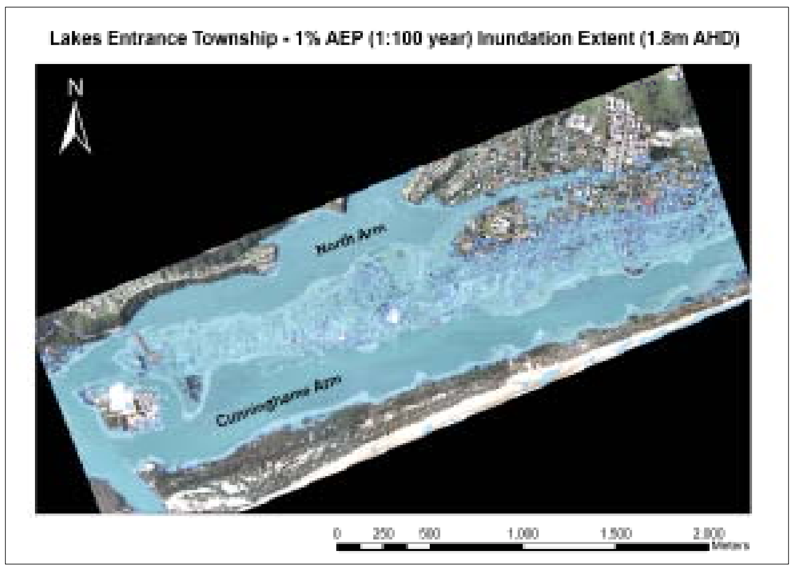

Figure 5: Derived estimated 1% Annual Exceedence Probability (AEP) (1:100 year) inundation extent for Lakes Entrance ***(+1.8m AHD)***

Methodology

This case study uses stereo aerial photography, real time kinetic (RTK) GPS survey data (Trimble R8), and digital photogrammetry methods (using Leica LPS software) for digital elevation model (DEM) extraction. Subsequent high-resolution 2D and 3D inundation event scenario modelling and spatial analysis for the Lakes Entrance townscape was completed using a GIS (ESRI ArcGIS 9.1). Model accuracy validation was carried out via manual survey methods.

Application of the DEM

This type of inundation modelling refers to a uniform elevation of water heights in the waterways surrounding the Lakes Entrance township, to the level of the recommended inundation scenarios. Thus, the derived inundation extent data for each scenario would represent the probable maximum inundation extent (or probable maximum flood – PMF). Practical model applications refer mostly to urban area planning and include: a) possible future inundation extent estimation/prediction with individual land parcel resolution; b) current and future land-use planning; c) integration into local emergency services information systems and contingency planning; d) provision of rapid stakeholder 'mental map' stabilisation; e) promotion of public and private stakeholder consensus-building, and f) for immediate assessment (including land parcel attribute documentation and geographical partitioning) of the relative inundation risk implications for insurance purposes. Scenario visualisation (refer **figure 3**) shows that large areas of the western end of the township would be more affected by a 1.3m AHD inundation scenario than would the eastern areas of the township. As the modelled horizontal inundation extent increases in response to vertical flood height increases (from 1.3m AHD to 1.6m AHD, and beyond to 1.8m AHD; refer **figures 4 and 5**), analysis shows that both the relatively lower-lying roads network and the stormwater pipe network acts as a 'conduit' for floodwater inundation of inner townscape areas. Significantly, detailed spatial analysis shows that the inundation of many township areas would firstly take place via floodwater discharge from stormwater inlet grates and kerbside inlets, prior to the overtopping of seawalls and/or the breaching of shorelines by floodwaters. 'At-risk' land parcels and assets, such as unsealed sewer manholes, are identifiable by simple overlay of vector asset class layers and derived inundation data layers in 2D or 3D (refer **figure 6**).

Conclusions

The relative estimated inundation extents for inundation scenarios at Lakes Entrance can be seen as exemplifying the deployment of GIS technologies in support of Integrated Coastal Zone Management (ICZM) initiatives. Within the overall context of ICZM, it is clear that GIS has the potential to act as an important tool not only for coastal inundation risk assessment, but also in support of many coastal planning and management issues and problems. In this case, the 2D and 3D inundation visualisation generation capacity can be used to provide relevant 'user-defined' information to all coastal zone stakeholders. Detailed mapping of inundation extents is a pre-requisite for land parcel inundation hazard assignment, for example, as a probable maximum flood (PMF) mapping system for flood-risk appraisal with land-parcel resolution; for inclusion in LGA planning schemes for use in future land-use planning; and for stormwater pipe network re-design to remove the estuarine flooding risk that is currently posed to areas of the Lakes Entrance township. Additionally, potential uses of such information refer to stakeholder flood awareness and education, and for emergency services contingency planning. At Lakes Entrance, it is clear that public and private stakeholder integration and consensus will be increasingly required in the future, to plan for the combined effects of climate change, estimated storm surge/tide, and flood inundation scenarios. Such coastal zone challenges provide future incentives for spatial database construction, analysis, maintenance, and data sharing by agencies tasked with ICZM in Victoria.

Figure 6: Vector overlay in 2D or 3D (1.3m inundation scenario, cadastral, roads, sewer and stormwater layers visualised here) can be used to identify 'at risk' land parcels and assets during inundation events

References

Grayson, R., Candy, R., Tan, K.S., McMaster, M., Chiew, F., Provis, D, and Zhou, S. (2004) *Gippsland Lakes Flood Level Monitoring Project: Final Report 01/04*. Centre for Environmental Applied Hydrology, The University of Melbourne.

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