THE ART OF DEFINING TRUE FLOOD HAZARD – A CASE STUDY OF TWO FLOODPLAINS IN THE ILLAWARRA REGION

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ABSTRACT

Flood hazard can be defined as the risk to life and limb and damage caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain. The Floodplain Development Manual (NSW Government, 2005) describes various factors to be considered in determining the degree of hazard. These factors are:

- Size of Flood;
- Effective Warning Time;
- Flood Readiness;
- Rate of Rise of Floodwaters;
- Depth and Velocity of Floodwaters;
- Duration of Flooding;
- Evacuation Problems;
- Effective Flood Access; and
- Type of Development.

Provisional flood hazard is flood hazard categorisation based on hydraulic principles only (depth and velocity). Often provisional hazard only is used to define the flood hazard precincts in a Floodplain Risk Management Study. When provisional flood hazard is considered in conjunction with the above listed factors it provides a comprehensive analysis of flood hazard, known as “true hazard”.

Considering flood hazard in terms of all of the above listed factors is not always a straightforward task. As part of the floodplain risk management process (Floodplain Development Manual, 2005), true hazard was defined in two separate floodplains within the Wollongong and Shellharbour Local Government Areas: Lake Illawarra and Allans Creek.

The catchments and hence flooding mechanisms within the Lake Illawarra and Allans Creek Floodplains are significantly different. The difference between the two case study floodplains and flood mechanisms provided an opportunity to apply standard criteria for the flood hazard factors in significantly different situations.

This paper discusses the details of the methodology for deriving provisional hazard and the translation of the provisional to true flood hazard for the two subject floodplains.
INTRODUCTION

Flood hazard can be defined as the risk to life and limb and damage caused by a flood. The hazard caused by a flood varies both in time and place across the floodplain. The Floodplain Development Manual (NSW Government, 2005) describes various factors to be considered in determining the degree of hazard. These factors are:

1. Size of Flood;
2. Effective Warning Time;
3. Flood Readiness;
4. Rate of Rise of Floodwaters;
5. Depth and Velocity of Floodwaters;
6. Duration of Flooding;
7. Evacuation problems;
8. Effective Flood Access; and
9. Type of Development.

Hazard categorisation based on all of the above factors is part of establishing a Floodplain Risk Management Plan. Provisional flood hazard is flood hazard categorised based on hydraulic principles only (depth and velocity). When provisional flood hazard is considered in conjunction with the above listed factors it provides a comprehensive assessment of the flood hazard, known as the “true hazard”.

Not all of the above listed factors are applicable to all floodplains, in terms of affecting hazard definition. Similarly, the application of these factors is rarely consistent across all floodplains. As part of the floodplain risk management process (Floodplain Development Manual, 2005), true hazard was defined in two separate floodplains within the Wollongong and Shellharbour Local Government Areas: Lake Illawarra and Allans Creek. The catchments and floodplain of the two study areas are significantly different and hence the flooding behaviour within the floodplains is also different. These two case studies provided an opportunity to apply true hazard analysis in a consistent manner across two very different floodplains.

Allans Creek Catchment and Floodplain

The Allans Creek catchment, on the south-western side of Wollongong, drains a catchment area of approximately 42km² from the Illawarra Escarpment to the Port Kembla Inner Harbour. The western areas of the catchment near the Illawarra Escarpment are very steep and are predominantly forested. The middle reaches of the catchment are mainly rural with some forest and residential development, while closer to the coast the catchment floodplain is relatively flat with a blend of residential, industrial and commercial development.

There are five main tributaries draining the catchment. The result is a hydrologically complex system in the lower reaches, with the timing of the arrival of flows at different locations and the relative magnitude of flows resulting in complex flooding mechanisms.

The Allans Creek catchment and floodplain are shown below in Figure 1.
Lake Illawarra Catchment and Floodplain

Lake Illawarra is a shallow coastal lagoon located on the undulating coastal plain between the ocean and the cliffs of the Illawarra Escarpment. The catchment of approximately 23,500 hectares is characterised by a low coastal plain, dominated by the western backdrop of the Illawarra Escarpment. Generally, elevated areas of the catchment closer to the escarpment are rural or forested in character and slope steeply while the lower areas closer to the lake are flatter and have a mixture of residential, commercial and heavy industrial development. Two major transport links, the F6 freeway and the Illawarra railway line traverse the catchment from north to south.

Lake Illawarra itself has an area of approximately 35km² with fourteen contributing creeks. Recent entrance works (southern training wall, completed in 2001 and northern and southern breakwaters, completed in 2007) have fixed the mouth of the Lake to the north of Windang Island. The condition of the entrance channel is affected by ocean storms, wave action, floods and tides.

Rainfall runoff from the steeper western parts of the catchment flows eastward downslope to quickly reach the much flatter coastal floodplain. Here the flow gathers and slows markedly with resulting increased flood depths. Flood flows in the lower parts of the catchment are complicated by bridge and culvert crossings over the feeder creeks before entering the body of Lake Illawarra. Floodwaters within the lake body are characterised by slow velocities and a near horizontal water surface. Closer to the lake entrance inlet, the floodwaters accelerate into the entrance channel to pass under the Windang Road Bridge and out to the Tasman Sea.

The Lake Illawarra catchment and floodplain are shown below in Figure 2.
OBJECTIVES

The true hazard assessment was undertaken as part of the Floodplain Risk Management Study for Allans Creek (Cardno Lawson Treloar & Wollongong City Council, 2006) and the Lake Illawarra (Cardno Lawson Treloar, Wollongong City Council & Shellharbour City Council, in prep). The purpose of undertaking the assessment was to define the Flood Risk Precincts which control development in the floodplain (as defined in Wollongong and Shellharbour City Council’s relevant development controls).

The primary objective of undertaking the assessment in two very different floodplains simultaneously was to attempt to develop a systematic methodology for applying true hazard criteria across all floodplains. The contrasting flooding behaviour experienced in Allans Creek and Lake Illawarra provided an opportunity to do so.

METHODOLOGY

Provisional Flood Hazard

Provisional flood hazard is determined through a relationship between the depth and velocity of floodwaters (Appendix L, NSW Government, 2005). The Floodplain Development Manual (2005) defines two categories for provisional hazard – High and Low. Provisional hazard mapping was undertaken utilising the hydraulic model results for both floodplains determined as part of the flood studies for the two floodplains.
True Flood Hazard

Provisional flood hazard categorisation based around the initial hydraulic evaluations described above, does not consider a range of other factors that influence the “true” flood hazard. Therefore provisional hazard categorisation is assessed in conjunction with several factors which are discussed in detail below to determine the true hazard categories.

1. Size of Flood

The size of a flood and the damage it causes varies from one event to another. It was agreed between the relevant floodplain managers and stakeholders that the 100 Year ARI event was the appropriate event to categorise “true” high hazard for the Allans Creek and Lake Illawarra Floodplains.

2. Effective Warning Time

The effective warning time can also be described as the time for people to undertake flood response actions such as lift or transport belongings and/or evacuate. This time is generally always less than the total warning time available to emergency agencies. This is because of the time needed to alert people to the imminence of flooding and to have them begin effective property protection and/or evacuation procedures.

Lake Illawarra has a large catchment size and predominately flat, low lying lower catchment, resulting in a relatively longer critical duration flood event of 36 hours for the 100 Year ARI flood event. This results in a significant amount of time from when the flood waters start to rise until the peak of a flood event occurs.

Conversely, the Allans Creek catchment is relatively smaller and is dominated by the backdrop of the Illawarra Escarpment. The steep characteristics of the upper catchment result in a fairly short critical duration flood event at the 100 Year ARI of 2 hours in the upper reaches which increases to about 6 hours in the lower floodplain. This results in a very limited warning time available to residents and visitors in the catchment.

The SES Region responsible for the Lake Illawarra and Allans Creek floodplain does not currently have any predictive capabilities for flooding events to assist with the evaluation of warning time. Therefore, warning time as a true hazard factor was not determined to be applicable to the Lake Illawarra or Allans Creek floodplains and as such did not have an impact on flood hazard categorisation.

Effective warning time may be of some consequence on the peninsular at Windang (Lake Illawarra floodplain). Portions of this area flood to hazardous depths and this area becomes isolated by flood waters for an extended period of time. Evacuation from this area is limited by the inundation of the access roads, which occurs approximately 11 to 14 hours after the initial rise of flood waters. It is therefore possible for some people to evacuate from the Windang Area.

3. Flood Readiness

Flood readiness can greatly influence the time taken by flood-affected residents and visitors to respond in an effective fashion to flood warnings. In communities with a high degree of flood readiness, the response to flood warnings is can be prompt, efficient and
effective. Flood readiness is generally influenced by the time elapsed since the area last experienced severe flooding. The last major flood event in the Lake Illawarra Floodplain was in 1991. The event was approximately a 50 Year ARI flood event. However, the extent of floodwaters during this event was not significantly less than the 100 Year ARI design event (since the difference in flood levels between the events is of the order of 0.5 m). However, due to the time elapsed since the flood event it not considered appropriate to assume that the community is “flood ready”. As such, the flood hazard definition has not been altered to reflect flood readiness.

In the Allans Creek Floodplain, flooding occurred in 1998 and 1999. As these floods could be considered to be within recent memory there is likely to be a high degree of flood readiness amongst long term residents, even those not directly affected by the flood. However, since the two recent events had varying intensities across the catchment, it is difficult to quantify flood readiness on a spatial extent and therefore relate the implication to flood hazard mapping. It is impossible to adequately define one area to be more flood ready than another and it would be remiss to reduce flood hazard across the whole catchment based on a high degree of flood readiness and therefore, the flood hazard definition was not altered to reflect flood readiness.

4. Rate of Rise of Floodwaters

The rate of rise of floodwater affects the consequences of a flood. Situations where floodwaters rise rapidly are potentially far more dangerous and cause more damage than situations where flood levels increase slowly. The catchment and floodplain characteristics affect the rate of rise.

It was determined through the workshop proceedings that areas with a high rate of rise should be assessed for inclusion in the “true” high hazard extent. A combined rate of rise and depth criterion was adopted to define high hazard areas. High hazard areas were defined as those with a rate of rise of greater than 1m per hour and a flood depth of greater than 500mm. A 500mm flood depth is indicative of vehicles becoming unstable even with no velocity (NSW Government, 2005).

Within the Lake Illawarra floodplain the average rate of rise for the 100 year ARI event is approximately 0.1m/hour, which is considered to be a fairly low rate of rise. As such, the rate of rise in Lake Illawarra was not considered to be of an order of magnitude to affect flood hazard definition.

Due to the steep nature of the Allans Creek catchment and upper reaches of the floodplain, the Allans Creek floodplain has a very high rate of rise (up to 8m/hour in the 100 Year ARI event). Additional high hazard areas were defined in the Allans Creek floodplain as a result of the rate of rise criteria.

5. Depth and Velocity of Floodwaters

As outlined above provisional hazard mapping is determined from a relationship between velocity and depth. This was carried out for both floodplains at each cross section for maximum depth and velocity couplings. High hazard areas for the majority of the Lake Illawarra floodplain were largely dependant on depth. Conversely, high hazard areas for the majority of the upper reaches of the Allans Creek floodplain were largely dependant on velocity.
6. Duration of Flooding

The duration of flooding or length of time a community, town or single dwelling is cut off by floodwaters can have a significant impact on the costs and disruption associated with flooding. Through the workshop process it was agreed that 24 hours was the threshold duration of inundation which would identify a property to be classified as high hazard. It should also be noted that longer durations of flooding can occur from events more frequently than the 100 Year ARI.

As Lake Illawarra is a fairly large and flat floodplain, with low rates of rise, the duration of flooding is fairly long. The duration of flooding can be greater than 40 hours for properties along the immediate shoreline of the lake. Those areas in the Lake Illawarra floodplain which are inundated for greater than 24 hours are already classified as high hazard due to the depth of flooding at these locations. As such, no additional properties were classified as high hazard due to duration of flooding.

Due to the steep nature of the Allans Creek catchment and the high rates of rise already discussed, the duration of flooding within the floodplain is relatively short. The duration of flooding ranges from 2 hours in portions of the upper reaches of the floodplain to 12 hours in the lower, flatter areas of the floodplain. There are no locations which have a flooding duration greater than 24 hours. Therefore, the hazard mapping was not altered due to the "duration of flooding" criterion.

7. Evacuation Problems

The level of damage and disruption caused by a flood is also influenced by the difficulty of evacuating flood-affected people and property. Evacuation may be difficult because of a number of factors, including:

- The number of people requiring assistance;
- Mobility of people;
- Time of day; and
- Lack of suitable evacuation equipment.

Generally development types which would pose evacuation issues (such as aged care facilities, hospitals and schools) are not permitted within high risk precincts of Lake Illawarra and Allans Creek floodplains (as defined by the relevant development control plans). Wollongong City and Shellharbour City Councils’ flood policies (DCP54 and DCP: Floodplain Risk Management) provide full details of land use categories permissible within the floodplain.

Flood warning and the implementation of evacuation procedures as well as the development of Local Flood Plans by the State Emergency Service (SES), are widely used throughout NSW to reduce flood damages and the risk to life in locations of existing development. Private flood warning and evacuation plans are already in place for specific areas within the Lake Illawarra floodplain, primarily the caravan parks on the foreshore, in particular Oaklands, Lake Illawarra Village (now Jetty’s By The Lake), The Oasis and South Pacific. The warning systems established for these parks also serve to assist the Councils’ and the SES with emergency response activities.
Evacuation problems are an important factor in floodplain management and future planning controls. However, as a true hazard factor it was not considered to affect the hazard categorisation of the floodplain.

8. **Effective Flood Access**

The availability of effective access routes from flood prone areas can directly influence personal danger and potential damage reduction measures. Effective access means an exit route that remains trafficable for sufficient time to evacuate people and possessions. Through workshop proceedings effective access was determined to be a road which is flooded to a depth of less than 300mm of water. For the Lake Illawarra and Allans Creek floodplains a property was considered to have an access hazard issue if it had no effective access for at least 24 hours.

It should be noted, that while effective flood access at this stage has been assessed based on these criteria, discussions and workshopping with the SES and Council is currently being undertaken to re-evaluate the effective flood access criteria.

A separate hazard classification was mapped to define these areas at the 100 Year ARI. This area was defined as “Isolation Hazard”. Isolation hazard applies to both flood affected properties and properties which do not have flood inundation but where their access is affected. There were several low hazard properties in the Lake Illawarra floodplain which were defined as “Isolation Hazard”. As there are no areas which are flooded for more than 24 hours within the Allans Creek floodplain, this criteria does not apply.

Following detailed consideration of the manner in which this issue should be dealt with, workshop participants agreed that rather than incorporating the Isolation Hazard areas into the development controls for Lake Illawarra, the land use zoning of these areas should be modified to restrict the type and density of development that would be permitted in these areas. The rezoning will limit the type of development that can occur in Isolation Hazard areas and thereby endeavour to reduce the risk to life and damage to property incurred by flooding of access routes.

9. **Type of Development**

The degree of hazard to be managed is also a function of the type of development and resident mobility. This may alter the type of development considered appropriate in new development areas and modify management strategies in existing development areas. Both Wollongong and Shellharbour Councils currently have development control policies (DCP54 and DCP: Floodplain Risk Management respectively) which consider and manage development within floodplains. The DCPs define prohibited land uses for high, medium and low risk precincts. These flood risk precincts are defined by the hazard mapping that was undertaken as part of this assessment.

Through the workshop process it was determined that the hazard category of individual properties would not be altered due to current land use type. However, it was considered useful to identify any properties which are currently located within the floodplain which may require special consideration in terms of flood impacts such as schools, aged care facilities and community buildings. A preliminary assessment was undertaken to identify land use types within the floodplains (PMF extent).
OUTCOMES OF THE ASSESSMENTS

Due to the nature of flooding in the Lake Illawarra and Allans Creek floodplains many of the factors do not alter the provisional hazard mapping. A summary of the factors which affect flood hazard and the findings of the study are presented below in Table 1.

Table 1  Outcomes of the Assessments

<table>
<thead>
<tr>
<th>Factor</th>
<th>Outcome of Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lake Illawarra Floodplain</td>
<td>Allans Creek Floodplain</td>
</tr>
<tr>
<td>Size of Flood</td>
<td>True high hazard to be determined by 100 Year ARI</td>
</tr>
<tr>
<td>Effective Warning Time</td>
<td>The whole floodplain has a fairly long warning time and therefore, no particular areas would be subject to a higher or lower hazard category on the basis of this factor.</td>
</tr>
<tr>
<td>Flood Readiness</td>
<td>Due to the time elapsed since the last major flood event, flood readiness in the Lake Illawarra floodplain is not considered an appropriate factor to alter flood hazard categories.</td>
</tr>
<tr>
<td>Rate of Rise of Floodwaters</td>
<td>Rate of rise of flood waters in the Lake Illawarra floodplain is fairly low, as such no additional high hazard category areas have been included due to this factor.</td>
</tr>
<tr>
<td>Depth and Velocity of Floodwaters</td>
<td>Provisional Flood Hazard Mapping.</td>
</tr>
<tr>
<td>Duration of Flooding</td>
<td>All properties which are inundated for 24 hours or more are already classified as high hazard, under provisional categories.</td>
</tr>
<tr>
<td>Evacuation Problems</td>
<td>Due to the regulations on permissible development within the floodplain no additional properties were defined as high hazard due to evacuation problems.</td>
</tr>
<tr>
<td>Effective Flood Access</td>
<td>Macquarie Shores Estate at Albion Park Rail has been classified as Isolation It may be necessary to apply rezoning to some of this area.</td>
</tr>
<tr>
<td>Type of Development.</td>
<td>This does not affect hazard mapping extents, however this will be incorporated into the development controls.</td>
</tr>
</tbody>
</table>

TAKE HOME MESSAGES
True Hazard mapping has traditionally been viewed as a subjective process with a large degree of variability in its application across different floodplains. This project has seen the factors contributing to True Hazard mapping applied in two floodplains in a consistent manner using quantitative methods where applicable. The result was not only true hazard mapping for the two floodplains but also a systematic methodology which can be applied across a range of floodplains.

More and more Councils are attempting to apply true hazard factors to hazard mapping. Not only is hazard mapping critical in determining flood risk management measures during the preparation of Floodplain Risk Management Plans but is often used by agencies when prioritising funding for floodplain risk management measures. As such, it is important that there is consistency in the application of true hazard definitions. This process would be assisted greatly if a set of guidelines in applying true hazard definitions were available on a state-wide basis.

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REFERENCES


