RISK MANAGEMENT IN STORMWATER AND FLOODING
IEAUST — AWWA — SIA 28 FEBRUARY 1996

FLOOD DAMAGE, FLOOD STANDARD AND ECONOMIC RISKS ... JUST ONE PIECE OF THE PUZZLE!

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Summary

The Blacktown Floodplain Management Study, which concentrates on the Eastern Creek Catchment of the Hawkesbury–Nepean Valley, is nearing completion. The lowermost reach of Eastern Creek, referred to as the Eastern Creek North precinct, is under the influence of flooding from the Hawkesbury River. In this precinct, the probable maximum flood has been calculated to be more than 11m higher than the 100 year average recurrence interval flood. Therefore it is important to quantify not only the existing flood risk through a flood damage assessment, but also to address the possible future risks from planned urban development. These additional future risks will depend on the adopted flood standard — a flood standard that is too low may incur unacceptably high risks in the future, while a flood standard that is too high may place unnecessarily severe constraints on development and may necessitate a rethink of some regional planning issues.

This paper concentrates on quantifying these future flood risks in economic terms and shows that this is just one component of a much larger macro-economic/social/political analysis needed to select an appropriate flood standard. The adoption of the flood standard cannot simply consider the immediate floodplain of Eastern Creek North precinct — the decision has impacts even further afield than local government boundaries or even the Hawkesbury–Nepean Valley itself.

1. HOW IS 'FLOOD RISK' QUANTIFIED? — THE FLOOD DAMAGE ASSESSMENT

The assessment of flood damages is generally the method used to quantify flood risk in a particular floodplain area. The flood damage assessment quantifies the potential cost of flooding to the community — it does not determine who should pay for the effects of floods, rather, it treats the entire community in one overall cost.

1.1 Existing Flood Risk

The total potential damage bill for a particular sized flood is divided into a number of components. The definitions and methodologies used in estimating flood damage have been established by a number of previous investigations. **Figure 1** summarises the types of flood damages that are generally considered. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and hence are much more difficult to quantify.

The flood damage assessment generally refers to the 'existing flood risk'. Flood mitigation options are assessed by how well they could potentially reduce this risk. In the economic appraisal process, the 'benefits' of a particular option refer to the amount by which the predicted flood damage would be avoided.

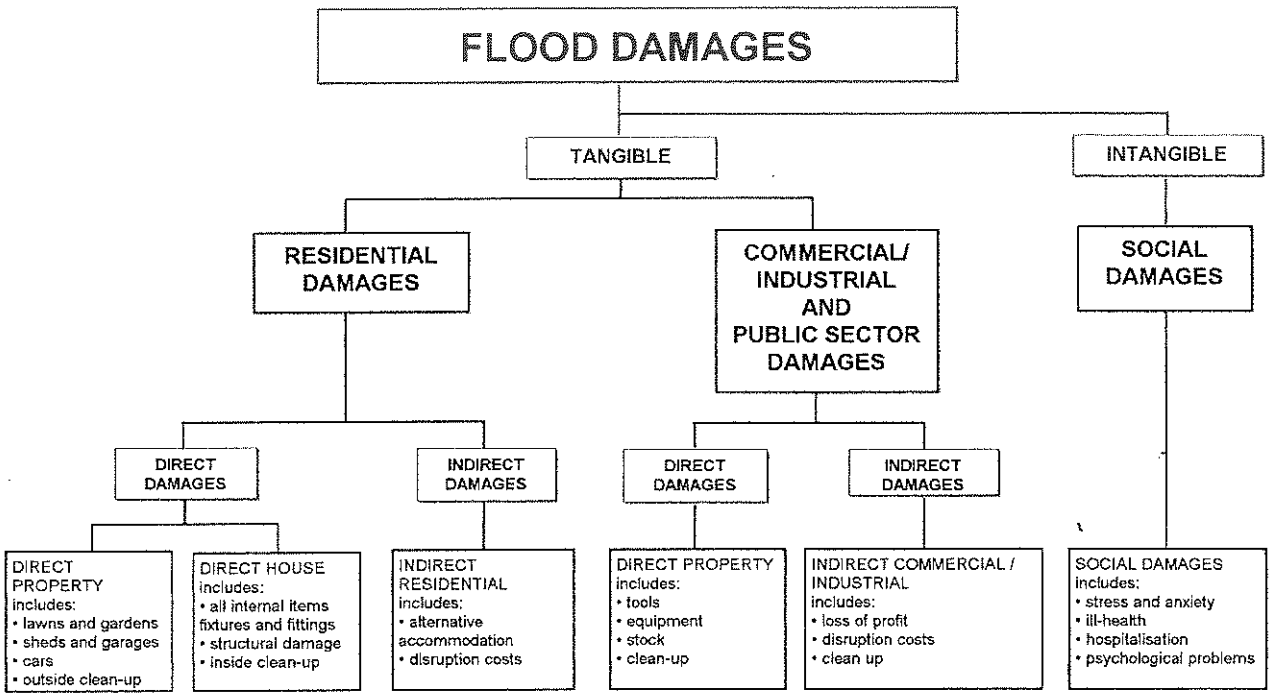

Figure 1: Types of flood damage
Source: Bewsher Consulting (1996a)

1.2 Future Additional Flood Risk

What the flood damage assessment should also consider is the possible future flood risk from additional development in the floodplain. This future potential damage is dependent on the amount of development potential there is between a particular flood standard and the probable maximum flood (PMF) event. It should be noted that the selection of a particular flood standard does not change anything in the past, only in the future. Regardless of the flood standard adopted (and assuming no flood mitigation measures are undertaken), the existing flood damage would not be reduced — only future flood damage from additional development can be prevented.

2. THE EASTERN CREEK NORTH PRECINCT

Eastern Creek is a large tributary of the Hawkesbury–Nepean catchment that flows into the Hawkesbury River near Windsor. As part of the Blacktown Floodplain Management Study (Bewsher Consulting, 1996b) the lowermost reach of Eastern Creek within the Blacktown City local government area (generally north of the Castlereagh Freeway road reserve) has been referred to as the 'Eastern Creek North precinct'. **Figure 2** shows that the Eastern Creek North precinct is only one very small pocket of Hawkesbury–Nepean floodplain.

The Eastern Creek North precinct would suffer backwater flooding from the Hawkesbury River in a 20 year ARI flood and larger, when flood levels in the area are generally influenced by those at Windsor. Flood levels for events smaller than the 20 year ARI flood are more generally influenced by local catchment rainfall. **Figure 3** shows a representation of the large differences in flood levels for different sized floods in the Eastern Creek North precinct. Key points from this figure are as follows:

- the PMF level (which includes a failure of the Warragamba Dam wall) would be more than 11m higher than the 100 year ARI flood level;

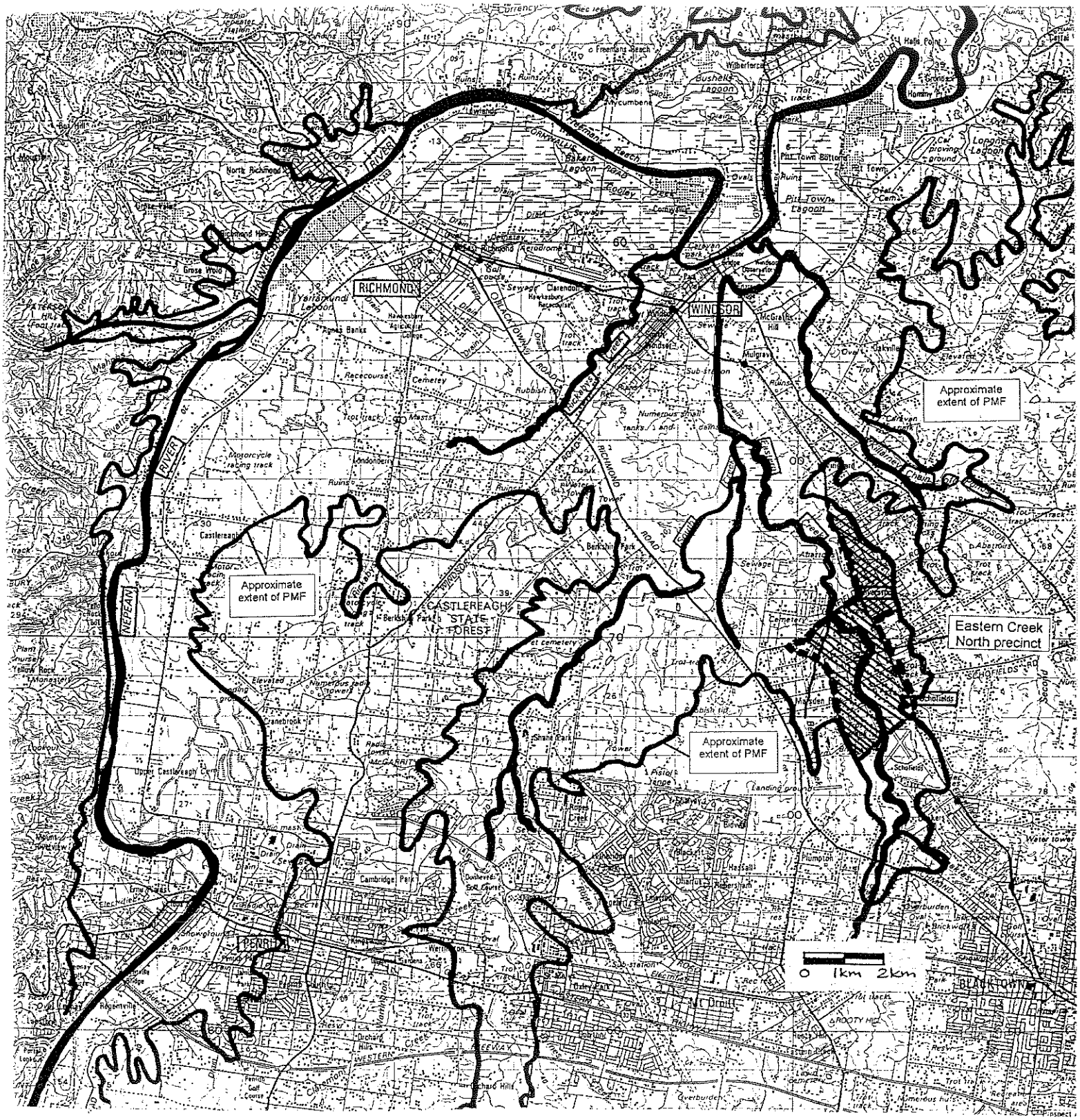

Figure 2: The Hawkesbury–Nepean floodplain

Approximate extent of probable maximum flood event (Source: ERM Mitchell McCotter, 1995)
Note that the flood extents shown are indicative only and the reader should refer to ERM Mitchell McCotter for more information

- the 1,000 year ARI flood level would be 4m higher than the 100 year ARI flood level;
- even the 1867 flood, which is the largest flood in the Hawkesbury–Nepean Valley since white settlement, would have been 2.4m above the 100 year ARI flood level. It had a recurrence interval of 300–400 years.

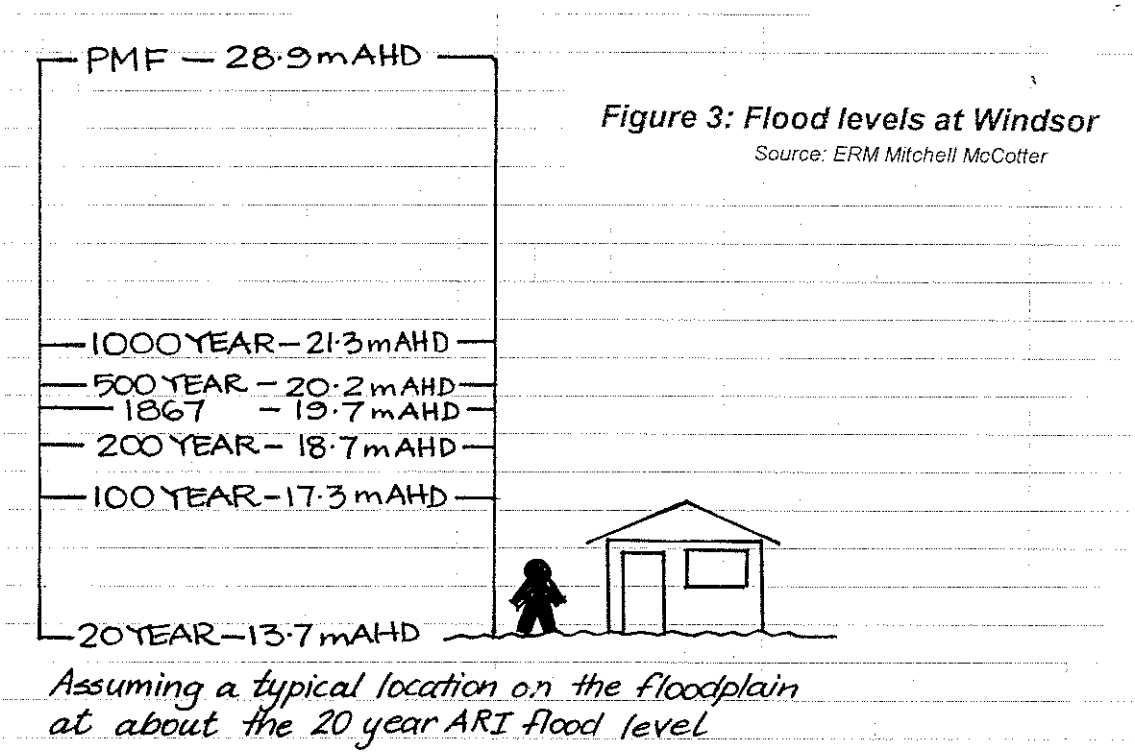

Figure 3: Flood levels at Windsor

Source: ERM Mitchell McCotter

2.1 Existing Flood Risk in Eastern Creek North

Table 1 summarises the potential damage bill from flooding that could be expected in the Eastern Creek North precinct in a 20 year ARI, 100 year ARI, 1,000 year ARI and PMF flood events. The number of residential and business properties that would be inundated above floor level have also been included in this table. Note that the expected damage bill for a PMF would be about 20 times that of the 100 year ARI flood, while a 1,000 year ARI flood would be about 5–10 times as severe. Based on this analysis, the damage bill for 'an 1867 flood' would be about $40–$50 million.

TABLE 1: EXISTING FLOOD RISK IN EASTERN CREEK NORTH PRECINCT

FLOOD	RESIDENTIAL PROPERTIES		BUSINESS AND INFRASTRUCTURE PROPERTIES		SOCIAL DAMAGE	TOTAL POTENTIAL DAMAGE BILL*
	No. floors Inundated*	Potential Damage Bill*	No. Floors Inundated*	Potential Damage Bill*	Potential Damage Bill*	
PMF	1,440	$70 million	120	$170 million	$10 million	$250 million
1,000	660	$30 million	60	$70 million	$6 million	$110 million
100	180	$6 million	30	$5 million	$2 million	$13 million
20	20	$0.6 million	<5	$0.3 million	$0.1 million	$1.0 million
Average Annual Damage **	—	$410,000	—	$450,000	$160,000	$1.0 million
Present Value of Flood Damage***	—	$4 million	—	$5 million	$2 million	$11 million

Source: Bewsher Consulting (1996a)

* *Values have been rounded to provide an indication of magnitude for this paper.*

** *Average annual damage (AAD) — the cost of flood damage that could be expected each year by the community, on average.*

*** *Present value of flood damage — the equivalent value of flood damage if brought back to present day, assuming a discount rate of 7% over a period of 20 years.*

Table 2 puts the Eastern Creek North precinct into context by summarising the existing flood risk for the entire Hawkesbury–Nepean valley. Based on this information, the damage bill in the valley for 'an 1867 flood' would be about $1.5–$2.5 billion. By comparing 'Total potential damage bill' columns in **Tables 1** and **2**, it can be seen that the Eastern Creek North precinct represents only about 2%–3% of the total flood risk for the entire Hawkesbury–Nepean valley.

TABLE 2: EXISTING FLOOD RISK IN HAWKESBURY–NEPEAN VALLEY

FLOOD	NO. PROPERTIES INUNDATED		TOTAL POTENTIAL DAMAGE BILL*
	Residential*	Business*	
PMF	17,000	3,500	$9.5 billion
1,000	12,000	2,700	$3.5 billion
100	5,000	1,000	$800 million
20	1,000	100	$150 million
Average Annual Damage**	—	—	$38 million

Source: ERM Mitchell McCotter (1995)

* *Values have been rounded to provide an indication of magnitude for this paper.*

** *Average annual damage (AAD) — the cost of flood damage that could be expected each year by the community, on average.*

2.2 Possible future flood risk in Eastern Creek North precinct

As discussed previously, the PMF level has been assessed to be more than 11m higher than the 100 year ARI flood in the Eastern Creek North precinct. Because the Eastern Creek floodplain is quite flat, this relatively large difference in flood height results in a large area of land — up to about 1km — being affected between the 100 year ARI flood and the PMF.

Compared to other areas of similar terrain, where the difference between the 100 year ARI flood and the PMF is more commonly about 1m–3m, the potentially affected area in the Eastern Creek North precinct is in the order of 5 times greater than in more 'typical' floodplains.

Don Fox Planning (1996) have examined the potential for development over the next 20 years between the 100 year ARI flood and the PMF for the Eastern Creek North precinct both within the current zonings as well as within planned future release areas.

In the Blacktown study area, it is unlikely that a flood standard less than the existing 100 year ARI flood standard would be adopted.

Within current zonings, there appears to be little potential for development between the 100 year ARI flood and the PMF. Most of the possible future development between the 100 year ARI flood and the PMF would be included in the large scale urban development strategy known as the Rouse Hill Urban Release Area (Sydney Regional Environmental Plan No. 19).

Table 3 shows the number of potentially flood affected properties (residential and commercial/industrial flooded above surrounding ground level) both for existing and future conditions for the following flood sizes:

- less than 100 year ARI flood;
- between the 100 and 1,000 year ARI floods;
- between the 1,000 year ARI flood and the PMF.

TABLE 3: POSSIBLE FUTURE FLOOD RISK IN EASTERN CREEK NORTH PRECINCT

FLOOD (ARI)	NO. OF FLOOD-AFFECTED RESIDENTIAL PROPERTIES				NO. OF FLOOD AFFECTED COMMERCIAL/INDUSTRIAL PROPERTIES			
	EXISTING	POSSIBLE FUTURE	INCREASE		EXISTING	POSSIBLE FUTURE	INCREASE	
			NO.	%			No.	%
<100 year	250	250	nil	0	30	30	nil	0
100-1,000 year	410	450	40	10%	30	80	50	170%
1,000 year - PMF	770	960	190	25%	60	95	35	60%

Table 3 shows, for example, that if a 100 year ARI flood standard was adopted:

- there would continue to be 250 residential and 30 commercial/industrial properties flood-affected in a 100 year ARI flood event;
- in a 1,000 year ARI flood event, there would be 40 additional residential (total of 700) and 50 additional commercial/industrial properties (total of 110) that would be flood affected;
- in a PMF event there would be 230 additional residential (total of 1,660) and 85 additional commercial/industrial properties (total of 205) flood affected.

Don Fox Planning have used the term 'Outer Floodplain Area' to describe the area between the level of the adopted flood standard and the PMF.

Using the possible future increase in development between the 100 year ARI and PMF level, the potential future flood 'risk' was quantified using flood damage assessment methodology. As shown in **Figure 4**, three different flood standards were considered:

- 100 year ARI;
- 1,000 year ARI;
- PMF.

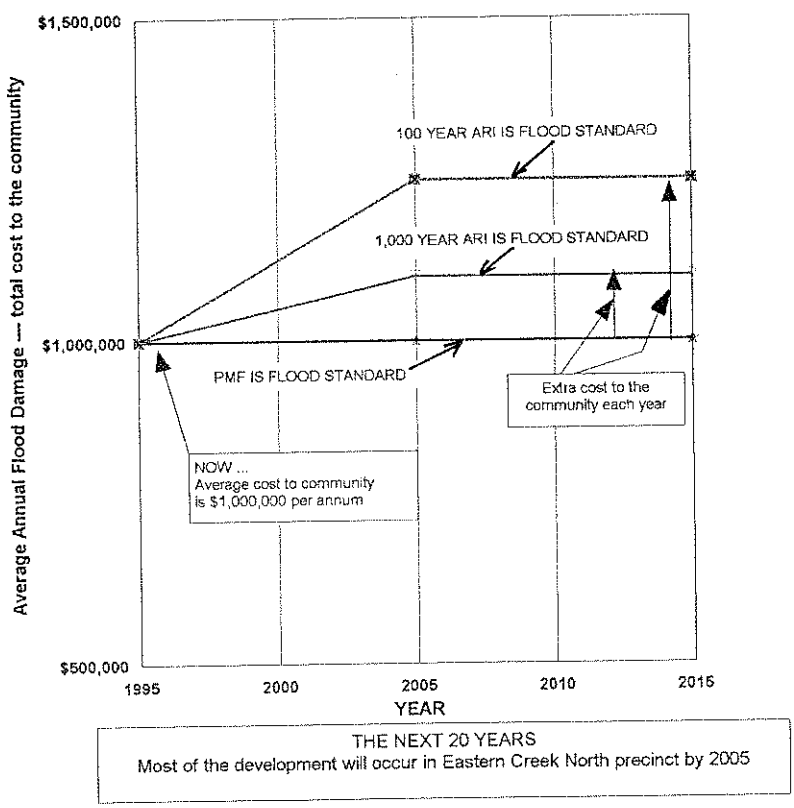

Figure 4: Future flood damage

If a 100 year ARI level was adopted as the flood standard for all future development, the average annual damage results showed that there would be a:

- 2% increase over present levels of residential damage;
- 25% increase over present levels of commercial/industrial damage;
- 12% increase over present levels (about $150,000 every year) in total flood damage to the community.

Similarly, if a 1,000 year ARI level was adopted as the flood standard for all future development, the average annual damage results showed that there would be a:

- less than 1% increase over present levels of residential damage;
- 5% increase over present levels of commercial/industrial damage;
- 2% increase over present levels (about $40,000 every year) in total flood damage to the community.

The results showed that if a PMF was adopted as the flood standard there would be no increase in flood risk over the next 20 years. **Figure 4** shows these results diagrammatically.

From a purely flood damage perspective, these results show that a flood standard somewhere between the 100 year ARI and 1,000 year ARI may be appropriate.

These results also show that, for this particular area, the most increase in total flood damage to the community would be attributed to the commercial/industrial sector, regardless of flood standard. This appears to be contrary to many Council's policies that allow commercial/industrial properties to develop at a lower flood standard than in residential areas.

ERM Mitchell McCotter (1995) suggest that the average annual damage for the Hawkesbury–Nepean Valley will increase from $38 million to $100 million over the next 50 years – an increase of more than 2½ times — should a 100 year ARI flood standard be adopted for the valley.

It should be emphasised that the possible future flood damage cost is only one input to the macro-economic analysis needed to determine an appropriate flood standard. This will determine whether these additional costs to the community would be offset by other (non-flooding) factors.

3. WHAT ARE THE ISSUES AFFECTING SELECTION OF A PARTICULAR FLOOD STANDARD?

The flood standard (or designated flood) is the flood level selected for planning purposes, and will directly determine the area of land that should be subject to flood-related building and development controls (Public Works Department, 1986).

Selection of the flood standard is one of the most critical decisions in floodplain management, and is not an easy one. It should be based on an understanding of the flood behaviour, together with the balancing of the social, economic and environmental consequences of flooding, including the potential for property damage and the risk to human life. Selection of the flood standard will also need to balance short-term gains against long-term problems, for example:

- if the flood standard is too low — large areas may suffer quite frequent inundation with corresponding high flood damage bills. As more and more development occurs, damage bills will get higher and higher over time;

- if the flood standard is too high — large land areas that would be rarely flooded may be subjected to unnecessarily restrictive development and building controls.

The issues affecting the selection of a flood standard are numerous, with the implications often extending beyond the immediate floodplain area, or even the particular local government area. Issues and factors that need to be considered include the following:

- flood behaviour including flood depths and velocities;
- the existing flood standard (from Council's Interim Flood Policy, for example);
- flood standards in neighbouring local government areas;
- existing and potential land use;
- the availability of land for future development;
- the impact of future development on existing development;
- the impact on the future development itself;
- the proximity of land suitable for future development to existing services and transport routes;
- the increase in potential flood damage as a result of choosing a particular flood standard;
- the consequences of floods larger than the flood standard;
- the flood awareness of the community;
- the possibility of creating a false sense of security if the flood standard is too low;
- flood warning, evacuation and emergency response implications;
- change in land values and other social equity issues;
- the risk of loss of life;
- other social impacts including disruption, anxiety and stress;
- 'infill' development policies;
- Council's duty of care;
- the environmental impact on the riverine corridor;

3.1 What if the PMF was adopted as the flood standard in the Eastern Creek North Precinct?

If the PMF was adopted as the flood standard in the Eastern Creek North precinct, the flood damage analysis has shown that the flood risk to the community would not get any worse. It is also acknowledged that such a flood standard would result in significant environmental improvements to the riverine corridor. However, there are several foreseeable planning and social problems associated with such a decision.

As can be seen on **Figure 2**, the Eastern Creek floodplain is divided by the main Blacktown–Richmond Railway Line — a strategically vital transport link for the Rouse Hill Urban Release Area. The railway line and its immediate corridor are located at approximately the 100 year ARI flood extent. The extent of the PMF is about 1km away. Given the importance of the land surrounding the railway stations (particularly Riverstone), the consequences of precluding development in this vicinity may have far reaching impacts on the urban release area. The cost of moving the railway line or conversely, creating a link across the floodplain to the station, may far outweigh the avoided flood damages.

The impacts on infill development or adjacent development within existing zoning would also be high — would it really be practical to construct a house 11m higher than those nearby?

3.2 What if the 1867 flood was adopted as the flood standard for the Eastern Creek North Precinct?

The flood damage analysis has shown that a flood standard somewhere between the 100 year and 1,000 year ARI flood may significantly reduce the future additional damages bill and may result in a more 'acceptable' increase in flood risk than if the 100 year ARI was adopted. One option may be to adopt the 1867 flood as the flood standard for the Eastern Creek North precinct. This 300–400 year ARI flood standard would have the following advantages:

- it is a real event that is well documented and is (almost) in living memory;
- the level of the 1867 flood is about 2.4m above the 100 year ARI flood level — 2.4m represents one storey of a house, which would be much more visually acceptable if floor levels were based on this value.

3.3 The need to consider the 'Outer Floodplain Area'

Whatever the ultimately adopted flood standard (assuming it is below the PMF) it is likely that it will also be important to consider the 'Outer Floodplain Area', that is, the area between the level of the flood standard and the PMF. Even if the 1867 (plus freeboard) was adopted for floor level control, the PMF would still be 7m higher than the 1867 level. It may not necessarily be appropriate to apply floor level controls in the 'Outer Floodplain Area', however the following considerations could be applied to this area;

- the structural design of the building could consider that total covering by water could occur:
- the use of flood compatible building materials could be suggested in the Local Environmental Plan (LEP);
- all communities (residential and business) could be targeted for flood awareness programs and/or evacuation procedures;
- major and/or critical public infrastructure could be located outside the area (for example, railway lines, freeways, other important transport linkages, hospitals, community facilities used for evacuation of citizens and State Emergency Services' bases):
- other measures to ensure that properties in the outer floodplain area are not regarded as 'flood-free' — this could be as drastic as an appropriate notation on the property's Section 149 planning certificate.

3.4 What about the rest of the Hawkesbury–Nepean Valley?

The flood damage assessment (Bewsher Consulting, 1996a) and planning study (Don Fox Planning, 1996) carried out as part of the Blacktown Floodplain Management Study (Bewsher Consulting, 1996b) has concluded it may be appropriate to adopt a flood standard greater than the 100 year ARI flood in areas under the influence of backwater flooding from the Hawkesbury River. However, such a decision is likely to impact upon other localities within the Hawkesbury–Nepean floodplain.

It should be noted that 'flood standards' (or 'planning levels') are already different in this area of Blacktown and adjacent areas in the Hawkesbury Local Government area. The following planning levels are those used to show whether land has a 'flood affectation' on its Section 149 certificate:

- 'flood standard' for Blacktown City Council — 17.0m AHD
- 'flood standard' for Hawkesbury Council — 16.0m AHD
- 100 year ARI flood level at Windsor — 17.3m AHD.

These differences already cause confusion in the community such as:

- most people don't understand that these are 'planning levels' and not (necessarily) flood levels;
- most people wonder why 'the flood level is 1m higher across the road' near the boundary between the two Council areas;
- most people have a false sense of security that the 'planning level' is the biggest flood that could occur (in fact, it would be 11m–12m higher);
- in both cases, the 'planning levels' ignore the fact that bigger floods can and have occurred.

Conversely, there is likely to be considerable social (and political) impact if the 'planning level' in the Windsor area was lifted to the same as Blacktown, such as:

- additional construction costs associated with having higher building floor levels as well as the use of flood compatible materials;
- additional development approval and supervision costs incurred by Council as a result of the extra area of land affected by flood-related controls;
- the potential loss of property values for properties previously considered to be 'flood-free';
- the potential increase in property values 1km from the railway line!

These impacts would intensify if a planning level such as the 1867, flood or even higher, was adopted throughout the Hawkesbury– Nepean Valley.

4. CONCLUDING REMARKS

This paper has examined the quantifying of flood risk in dollar terms using the assessment of flood damages in the Eastern Creek North precinct of the Hawkesbury–Nepean valley. Although flood damage assessment generally refers to the 'existing flood risk', the possible additional future risk from flooding have also been assessed for this pocket of the Hawkesbury–Nepean valley. The possible additional risk from flooding depends on the flood standard adopted and the amount of development potential between the flood standard and the PMF.

Whatever flood standard is adopted, existing flood risk would not be reduced – only future additional flood damage can be prevented. However, the quantifying of additional flood risk is only one component of a much larger macro-economic/social/political analysis needed to select an appropriate flood standard.

If a PMF is adopted there would be no increase in future flood risk but large areas of land are likely to be affected by planning and development controls. There would also be serious implications for the Rouse

Hill Urban Release Area as the strategically vital Blacktown—Richmond Railway line would be located up to 1km away from the limit of development.

Over the past 10–20 years, communities have become 'comfortable' with the 100 year ARI flood as their flood standard or planning level. However, this has led to a false sense of security that bigger floods are not possible. This is particularly important in the Hawkesbury–Nepean valley where:

- the PMF is more than 11m higher than the 100 year ARI flood;
- bigger floods have occurred in the past — the 1867 flood (300–400 year ARI) would be about 2.4m above the 100 year ARI flood level.

Calculations have shown that a 100 year ARI flood standard in the Hawkesbury–Nepean valley would cause average annual flood damages to increase by 2½ times over the next 50 years.

The 1867 flood may be an appropriate flood standard for the Eastern Creek North precinct (as well as the whole Hawkesbury–Nepean valley). However, the area between the flood standard and the PMF (referred to as the Outer Floodplain Area) should still be considered in a planning sense. This could include appropriate notation on property certificates, flood awareness and evacuation programs, together with the preclusion of critical major infrastructure.

One important step to determine the flood standard is to ask 'what level of flood risk is acceptable to the community?' It is, after all, the community's decision — hopefully a decision they will own when making planning decisions for the floodplain. However, for the community to make that decision they need to be aware and understand all the issues. Otherwise when the big flood eventually comes, engineers and planners will (yet again) bear the wrath of the community. The challenge for engineers and planners is to come to terms with all the issues and relay (in understandable terms) this to the decision makers and the community — only then is the community going to be in a position to make informed decisions about the level of flood risk they are willing to accept.

5. REFERENCES

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6. ACKNOWLEDGEMENTS

The input from Paul Grech from Don Fox Planning through many discussions about 'flood standard and planning implications' is gratefully acknowledged.

Brian Chapman of Blacktown City Council gave his permission for some of the early findings of the Blacktown Floodplain Management Study (Bewsher Consulting, 1996a) to be presented in this paper. It is noted that many of these findings are tentative and at the time of publication of this paper, these findings were still under review and had not been formally adopted by Council.

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Sue Ribbons has a Civil Engineering Degree with 1st Class Honours from the University of Technology, Sydney. She worked with the (then) Department of Water Resources (NSW) for 6 years, where she was involved in a number of facets of water resources, operations and irrigation. Sue is now in her 9th year of consulting in the water engineering industry — concentrating on hydrology, hydraulics, flood mitigation works, floodplain management, urban stormwater management, stormwater quality control and environmental impact assessment.