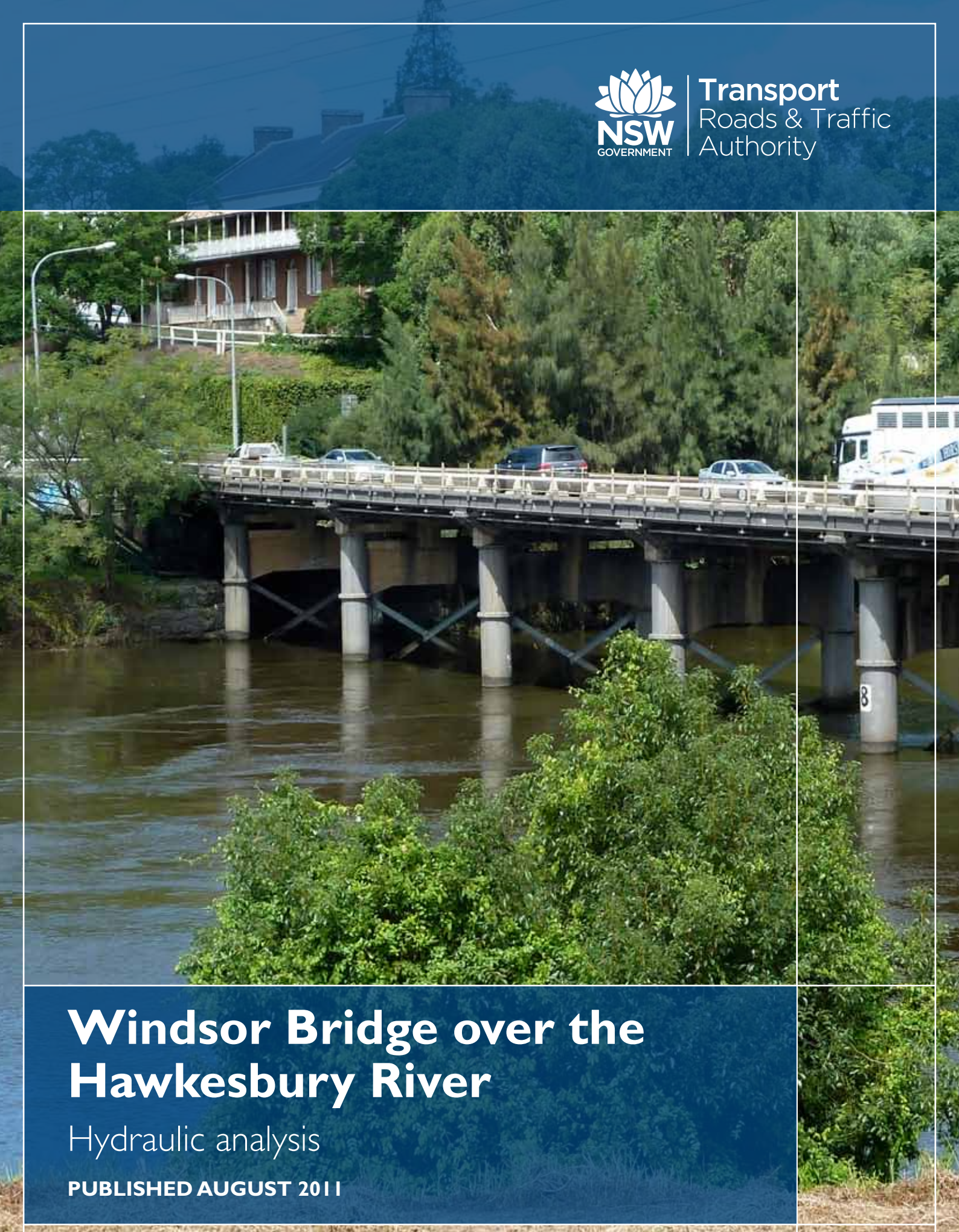

Transport
Roads & Traffic
Authority

NSW GOVERNMENT

Windsor Bridge over the Hawkesbury River

Hydraulic analysis

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Roads and Traffic Authority of NSW

Hydraulic Analysis

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Roads and Traffic Authority
PO Box 973
Parramatta NSW 2124

110019/L101019_RTA

1 August 2011

Attention: Phanta Khamphounvong

Dear Phanta,

Re: Proposed Replacement of Windsor Bridge
Hydraulic Assessment

BACKGROUND

WMAwater have been commissioned to assess the potential hydraulic impacts of two options for the replacement of the existing Windsor Bridge. Option 1 for the proposed bridge replacement will cross the Hawkesbury – Nepean River approximately 50 metres downstream of the existing Windsor Bridge, Option 6 will cross South Creek approximately 300 metres downstream of the existing Fitzroy Bridge, continuing on to cross the Hawkesbury – Nepean River approximately 400 metres downstream of the existing Windsor Bridge. Both options have design levels at approximately the 1 in 5 year ARI level, therefore providing flood immunity during that event.

Both bridge replacement options will be constructed while the existing Windsor Bridge is in place. The existing bridge will be removed on completion of the new bridge.

FLOOD BEHAVIOUR

The Hawkesbury-Nepean catchment covers an area of approximately 22,000 km^2 and extends from Goulburn in the south to the mouth of the Hawkesbury River at Broken Bay. It includes major tributaries which drain from several high rainfall areas creating a unique flooding environment. The topography of the Hawkesbury-Nepean valley significantly effects flooding in the valley coming from a narrow gorge to downstream of Wallacia where the valley widens to form the floodplain between Penrith and Castlereagh and at Yarramundi the valley opens to form a further major floodplain in the area of North Richmond, Richmond, Windsor and Wilberforce.

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Outflow from the system is controlled by a gorge downstream of Wilberforce, in severe flood events inflow of floodwaters from the Hawkesbury-Nepean and its tributaries exceeds the outflow through the gorge resulting in extensive flooding of significant depth across the valley. Characterised by rapidly rising floodwaters which can totally and partially inundate a number of towns including Richmond, Windsor, South Windsor, Bligh Park, McGraths Hill, Pitt Town, Penrith, Emu Plains, North Richmond, Wilberforce and Riverstone.

South Creek a tributary to the Hawkesbury – Nepean River can be affected by flooding from two possible mechanisms. The first involves backwater flooding from the Hawkesbury – Nepean River, and the second results from flooding of the local South Creek catchment. The Hawkesbury - Nepean Flood Study has shown that backwater flooding is the dominant flood mechanism in the lower reaches of South Creek. During a typical Hawkesbury River flood event the lower reaches of South Creek experience three separate stages of flooding. Initially, floodwaters from the local South Creek catchment, which has a shorter response time, flow down South Creek towards the Hawkesbury – Nepean River at Windsor. As flooding increases in the main river, the floodwaters back up and the flow direction reverses along South Creek to fill the floodplain. Once the peak level in the Hawkesbury – Nepean River has been reached and floodwaters begin to recede, the flow reverses again and the third stage occurs as the floodplain storage drains back out of South Creek to the main river.

A summary of design flood levels at each bridge crossing are provided in Table 1.

Table 1 Design Flood Levels

Event (Year ARI)	Design Flood Level (m AHD)		
	Option 1	Option 6 – Hawkesbury River	Option 6 – South Creek
5	11.05	11.04	10.99
100	17.29	17.29	17.27

MODELLING APPROACH

The existing RUBICON hydraulic model of the Hawkesbury – Nepean River, has been adopted for use in this assessment. The RUBICON model was originally established for the Warragamba Dam Auxiliary Spillway EIS Flood Study (1996). Results from the hydrologic (RORB) model from that study have been adopted as is, providing inflows to the RUBICON model.

The impact of the proposed bridge options were investigated using a combination of HEC-RAS and RUBICON hydraulic models. The HEC-RAS model contains extensive options for simulating the effects of bridges within the floodplain allowing better quantification of the headloss through the proposed bridge structure. Headlosses determined during the HEC-RAS modelling have been transferred directly to the RUBICON model. This allowed the effects of the bridge to be determined beyond the immediate vicinity of the structure. This process was carried out for each bridge option and each waterway crossing, that is one crossing of the Hawkesbury River for Option 1 and two crossings, of both the Hawkesbury River and South Creek for Option 6.

Three scenarios were considered:

1. Existing Conditions (including existing Windsor Road bridge),
2. Bridge Option 1, and
3. Bridge Option 6,

Each scenario was analysed for the 5 year and 100 year ARI design events.

Initially, to properly assess the impacts of the piers, embankments and deck of each option a localised HEC-RAS model to represent the existing (Windsor Road) and proposed bridges was established. The HEC-RAS model was used to determine the potential head losses due to the proposed bridges. A number of conservative assumptions were made, including:

- the railing of both the existing and proposed bridges was assumed to be fully enclosed,
- the area obstructed by the bridge abutment was removed from the cross section,
- the area obstructed by the piers was also removed from the cross section and was based on long section diagrams provided by the RTA.

The models were run for a series of different flow and tailwater level combinations with the results then being used to define a structure suitable for inclusion in the RUBICON model.

The existing RUBICON model was then updated and refined in the area of the proposed crossings and modified to include the structure details. Any afflux determined from the HEC-RAS model were transferred to RUBICON to allow an assessment of impacts in the wider catchment to be made. The potential hydraulic impacts associated with the proposed bridges were determined at the site and at relevant locations upstream and downstream of the site.

RESULTS

Option 1

The HEC-RAS model showed that for 5 and 100 year ARI peak flood level and flow combinations, Option 1 produced very little afflux.

This was confirmed by the RUBICON model with the maximum impact occurring in the 5 year ARI event immediately upstream of the proposed bridge. The maximum impact was 0.05 m. This impact is reduced to less than 0.01 m upstream of Devlins Road. The impact does not generally extent over the wider floodplain, however there is some propagation of the impact into the overland areas located between Penrith and Windsor, this is a maximum of 0.04 m at Bakers Lagoon. This increase in flood level translates to a slight reduction in peak flood level immediately downstream of the proposed bridge of the order of 0.01 m. This reduction extends into the floodplain surrounding South and Eastern Creeks. The impact of Option 1 during the 100 year ARI is less than 0.01 m and is localised to immediately upstream of the proposed bridge site.

The hydraulic impacts (change in peak flood levels relative to existing conditions) of Option 1 are summarised in Table 2.

Option 6

Option 6 crosses both South Creek and the Hawkesbury River and therefore consideration has been given to the impact of both structures. The HEC-RAS model showed that for the 5 and 100 year ARI peak flood level and flow combinations Option 6 - Hawkesbury River Bridge and Option 6 – South Creek Bridge produced very little afflux. The HEC-RAS model showed that for the higher range of flow and flood level combinations Option 6 – South Creek Bridge produced minor afflux. These higher flood levels and flows represent the events in which Hawkesbury River flooding is dominant, that is backwater flooding.

The RUBICON model confirmed that little afflux occurs as a result of Option 6 – Hawkesbury River Bridge, a maximum impact of 0.06 m occurs during the 5 year ARI event. This is slightly greater than Option 1 but also dissipates to less than 0.01 m at Devlins Road. The impact is generally contained to the main river except some overland areas between Penrith and Windsor, the maximum impact of 0.05 m occurs in Bakers Lagoon. There is also a slight reduction in peak flood levels immediately downstream of the proposed bridge of the order of 0.02 m, this impact also extends into the floodplain of South and Eastern Creeks. The impact of Option 6 – Hawkesbury River Bridge during the 100 year ARI is less than 0.01 m and is localised to immediately upstream of the proposed bridge site.

The RUBICON model showed that although backwater flooding from the Hawkesbury River produces the highest flow through the bridge (Option 6 – South Creek Bridge), velocities are low and subsequently the proposed bridge has no measurable impact on peak flood levels. The maximum impact along South Creek was less than 0.01 m for both the 5 and 100 year ARI event. Impacts less than this are within the accuracy limits of the model.

While Hawkesbury – Nepean River flooding is the dominant and more likely flooding mechanism at the site it should be noted that the bridge is likely to have a greater impact for a flood produced by the local South Creek catchment only, given that the proposed bridge will obstruct the waterway area. Note however this combination of flooding is unlikely to occur without any flooding within the Hawkesbury – Nepean River and would result in peak flood levels significantly lower than the levels from flooding of the Hawkesbury – Nepean River (of the order of 5 to 7 m lower).

The hydraulic impacts (change in peak flood levels relative to existing conditions) of Option 6 are summarised in Table 2.

Table 2 Hydraulic Impacts of Proposed Bridge Options (m)

Location	Option 1		Option 6 (Hawkesbury River and South Creek Crossing)	
Hawkesbury River	**5 Year ARI**	**100 Year ARI**	**5 Year ARI**	**100 Year ARI**
DS Penrith Weir	0.00	0.00	0.00	0.00
Devlins Road	0.01	0.00	0.01	0.00
Yarramundi	0.02	0.00	0.02	0.00
North Richmond	0.02	0.00	0.03	0.00
Hibberts Lane	0.04	0.00	0.05	0.00
Windsor Bridge	0.05	0.01	0.06	0.01
South Creek Junction	-0.01	0.00	-0.01	0.00
Wilberforce	-0.01	0.00	-0.01	0.00
Sackville	-0.01	0.00	-0.01	0.00
Floodplain				
Fitzroy Bridge	-0.01	0.00	-0.01	0.00
Junction South Creek and Eastern Creek	-0.01	0.00	-0.01	0.00
Agnes Banks	0.01	0.00	0.02	0.00
Richmond	0.00	0.00	0.00	0.00
Bakers Lagoon	0.04	0.00	0.05	0.00

Average cross section velocity increases slightly between the existing and proposed scenarios (both Option 1 and Option 6), Table 3 summarises peak flood velocity.

Table 3 Average Cross Section Velocity Comparison (Upstream of Proposed Bridge) (m/s)

	Existing				Proposed			
	Velocity at Peak Flood Level		Peak Flood Velocity		Velocity at Peak Flood Level		Peak Flood Velocity	
Location	**5 Year ARI**	**100 Year ARI**	**5 Year ARI**	**100 Year ARI**	**5 Year ARI**	**100 Year ARI**	**5 Year ARI**	**100 Year ARI**
Option 1	1.8	0.6	2.2	3.5	1.8	0.6	2.3	3.5
Option 6 – Hawkesbury River	1.6	0.6	1.8	3.0	1.6	0.5	1.8	2.9
Option 6 – South Creek	<0.1	<0.1	-1.6	-2.4	<0.1	<0.1	-1.5	-2.4

The hydraulic assessment of the proposed bridge indicates that either bridge option (Option 1 and Option 6) will have minimal impact on flood levels for both the 5 and 100 year ARI Hawkesbury – Nepean River flooding.

We trust that the above meets your requirement, should you require further information please do not hesitate to contact the undersigned.

Yours faithfully,
WMAwater

E J Askew
Associate