JONES NICHOLSON
CONSULTING ENGINEERS

FLOOD ASSESSMENT

FOR

22 HOSPITAL ROAD, BULLI

PREPARED FOR

GILDA BARAKAT

DATE: 16 JUNE 2017

OUR REFERENCE: CRPT-20151420.01C

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REVISION HISTORY

REVISION	DATE	BY	CHECKED	COMMENTS
A	29/01/2016	BM	SMcM	Preliminary
B	28/09/2016	BM	SMcM	Updated for SEAR's
C	16/06/2017	BM	SMcM	Final amendments

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1 INTRODUCTION

Jones Nicholson have been engaged to provide a detailed flood study on the proposed Bulli Aged Care Centre of Excellence at 22 Hospital Road Bulli .

The subject site comprises of Pt Lot 1 DP165903 and Pt Lot 1 DP 175787 . The total area covered by the lot is 12,000m2 or (1.2 hectares) . Directly North of the site there is a water coarse which has been partly piped and converted into a dish drain . For the purposes of this report this water coarse will be referred to as Wharton's Creek .

Figure 1- Subject Site

2 CATCHMENT PROPERTIES

The catchment for this assessment was determined using SixMaps contours. Figure 2 shows a mark-up of the catchment area .

Wharton's Creek is fed by an elongated and largely developed catchment that extends eastwards from the escarpment towards Bulli and the subject site . After joining Wharton's Creek it passes into an open channel that drains towards Bulli Beach . The catchment is approximately 14.8ha.

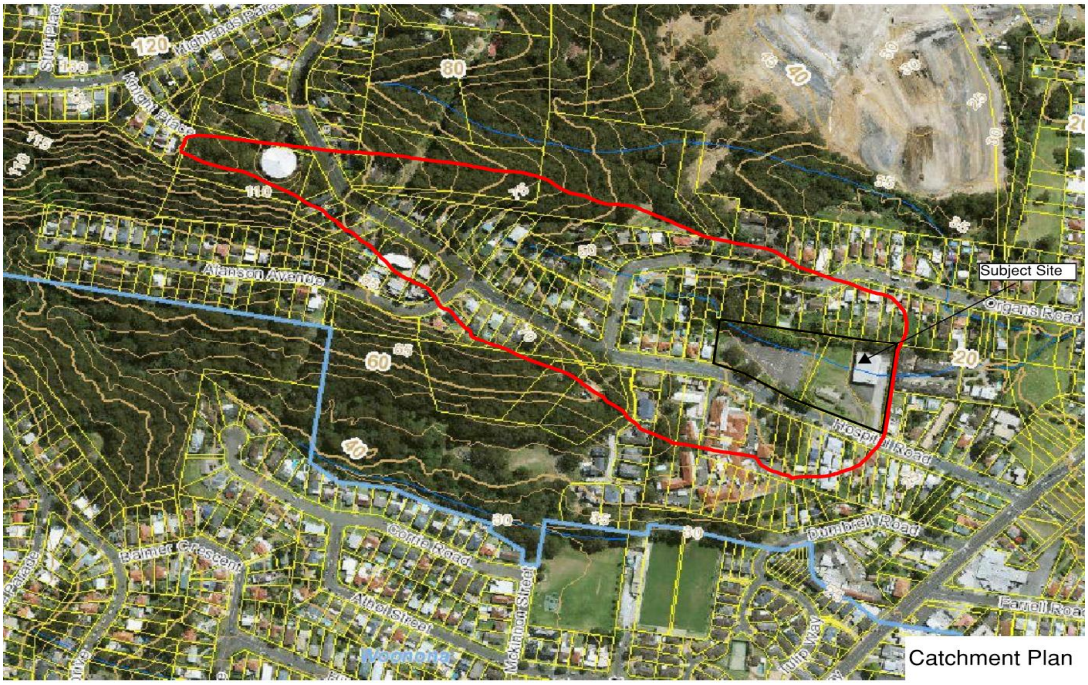

Figure 2 - Catchment Map

Figure 3 – Local Drainage Map

3 HYDROLOGIC MODELLING

Hydrological modelling was undertaken using iWBNM2010, an updated interface to the WBNM hydrological engine . WBNM ('Watershed Bounded Network Model' Boyd et al,2007) is an advanced storage-routing model that allows simulation of complex catchment behaviour .

A summary of the adopted modelling parameters is provided below .

- Lag Parameter : 1.60
- Stream Routing : 1.00
- Initial Loss : 0.00
- Continuing Loss Rate : 2.50
- Rain gauges : Woonona
- Impervious% : 50%
- Catchment Area : 14.8ha

The resulting overland flow during a 100 yr ,200yr and PMF AEP storm event affecting the subject site as a result of this catchment is:

Q_{100} = 8.652 m^3/s

Q_{200} = 9.764 m^3/s

PMF = 23.178 m^3/s

We have adopted the WBNM flowrates as model inputs for the hydraulic model described below.

4 CLIMATE CHANGE ANALYSIS

The DECC document "Practical Consideration of Climate Change" (October 2007) provides guidance on the likely impacts of climate change on both sea levels and rainfall intensities. Under worst-case scenario, this document specifies a sea level rise of 0.91m by the year 2100 and an increase in rainfall intensities of 30%.

We have adopted the same climate change scenario as typically detailed in councils Flood Risk Management studies. That is, the 100yr ARI rainfall intensities were increased by 20%. This 20% was applied to the WBNM rainfall hyetographs, the model re-run and the resulting peak flowrate used as input to the HECRAS model. The resulting climate change 100yr ARI flowrate at the bottom of the catchment increased from 8.652m^3/s to 10.51m^3/s (an increase of about 1.86 m^3/s)

5 SEA LEVEL RISE ANALYSIS

Due to the location of the site approximately 1.5km from any body of water affected by tidal waters any sea level rise will not impact on the site or the waterway running adjacent to the site.

6 RAINFALL INTENSITY ANALYSIS

To analyse the impact on increasing rainfall intensities we have adopted an increase of 20% and re run a WBNM model to get new flow rates. The resulting flowrate at the bottom of the catchment increased from 8.652m^3/s to 10.51m^3/s (an increase of about 1.86 m^3/s). We then used these new flow rates and input them into the HECRAS model to determine the impact on the water levels.

7 HYDRAULIC MODELLING

For the purpose of this hydraulic analysis we have a detailed model of the North Eastern section of Wharton's Creek that is closest to the subject site. Due to the lack or survey information a

conservative modelling approach was taken for the upstream section of Wharton's creek. It is clear however that the water levels are clearly lower then the site ground levels .

HECRAS is a 1-Dimensional river/channel analysis tool developed by the US Army Corps of Engineers and capable of steady and unsteady flow simulation. The model permits supercritical, sub-critical and mixed mode simulations, and includes graphics for checking and comparison of calculated flood profiles and levels. The flow obtained from the rational method was used in the HEC-RAS model to visually obtain the flood extents at selected cross-sections through the subject site.

Cross sections were generated along Wharton's Creek from the 3D survey information provided for the existing site only . The locations of the cross sections can be seen in Appendix B . Flow inputs are as described above.

A summary of the adopted model parameters is provided below:

- Expansion Coeff – Normal Transitions: 0.3 (watercoarse)
- Contraction Coeff – Normal Transitions: 0.1 (watercoarse)
- Upstream Boundary Cond: Normal Depth 6.5% slope
- Downstream Boundary Cond: Normal Depth 6.5% slope

Manning's n-values for the various material zones surrounding the site are as detailed below In Table 1.

Table 1 – Manning's n-values

Material Zone	Description	Manning's n
Gravel	Gravel Driveways etc	0.025
Concrete	Impervious areas	0.012
Road	Asphalt Roads	0.013
Mixed use	Trees, gravel, low shrubs	0.080
Ineffective	Used to model zero velocity	Varying
Buildings	Solid flow obstructions	-

7.1 LIMITATIONS

All data, observations and opinions contained in this report pertain to the hydraulic assessment of flood flows at or in the vicinity of the site. This report neither purports to be nor is an investigation into any other aspect of flooding within the site or surrounding catchment, or at any other site in the immediate vicinity.

This report and the results contained within are only as accurate as the survey information provided. Jones Nicholson Pty Ltd takes no responsibility or liability for incorrect survey information. The report is only valid for the development as proposed and detailed in this report and is not valid for any other use.

8 MODEL RESULTS

8.1 PRE-DEVELOPMENT SCENARIO

The existing (pre-developed) condition has been modelled and a flood plan prepared to illustrate the extent of flooding on the subject site. The water surface does not intersect with the natural surface on the left side of the cross-sections as the survey does not extend any further, however, the properties on this side of the site have high metal fences which would potentially restrict the flow in a way that is consistent with the cross sections used. However the HEC RAS restrictions at the extent of the survey information is considered to be a conservative approach .

Table 2 shows the pre-development water surface levels at each of the cross sections through the site. A plan showing the flood extent and the HEC-RAS cross-sections have been included in Appendix B.

Table 2 - Pre-development Water Surface Levels – 100 Yr ARI

CROSS SECTION	100 YEAR EXISTING
190	32.49
180	31.40
170	30.5
160	30.3
150	29.7
140	29.44
130	29.00
120	28.80
110	28.6
100	28.10
90	27.50
80	26.03
70	25.08
60	24.41
50	23.91
40	23.75
30	23.65
20	23.29
10	22.66

Table 3 - Pre-development Water Surface Levels – 200 Yr ARI

CROSS SECTION	200 YEAR EXISTING
190	32.52
180	31.89
170	31.49
160	31.21
150	30.98
140	30.36
130	29.50
120	29.37
110	29.11
100	28.64
90	27.79
80	26.41
70	25.19
60	24.47
50	24.16
40	24.02
30	23.69
20	23.33
10	22.69

Table 4 - Pre-development Water Surface Levels – PMF AEP

CROSS SECTION	PMF EXISTING
190	32.75
180	32.13
170	31.91
160	31.72
150	31.53
140	30.80
130	29.87
120	29.72
110	29.41
100	28.94
90	28.04
80	26.73
70	25.65
60	25.08
50	24.37
40	24.24
30	24.20
20	23.67
10	22.93

Table 5 - Pre-development Water Surface Levels – Increased Rainfall Intensities 100 Yr ARI

CROSS SECTION	CLIMATE CHANGE – RAINFALL INTENSITIES – 100 Yr ARI
190	32.54
180	31.90
170	31.52
160	31.24
150	31.02
140	30.39
130	29.52
120	29.39
110	29.13
100	28.66
90	27.81
80	26.43
70	25.22
60	24.51
50	24.19
40	24.05
30	23.72
20	23.35
10	22.71

8.2 POST-DEVELOPMENT SCENARIO

The post-development condition has been modelled and the results showed that the proposed buildings are not affected by the flood waters nor does it effect the flood levels in the vicinity of the site.

9 DISCUSSION

The pre-development results are generally consistent with the 1% AEP and the PMF flood levels provided in the Flood Information Report from Wollongong City Council.

Table 6 - Pre-development Water Surface Levels Comparison

CROSS SECTION	COUNCIL FLOOD LEVELS – 100 Yr	COUNCIL FLOOD LEVELS – PMF	MODEL FLOOD LEVELS - 100Yr ARI	MODEL FLOOD LEVELS - PMF
140	29.41	29.72	29.44	30.80
90	27.75	27.79	27.50	28.04
50	24.18	24.55	23.91	24.37

The council's floodplain risk management policy requires the flood planning level (FPL) to be 0.5m above the water surface level of the 1% AEP flood event and the PMF event. Council's flood matrix does not indicate a FPL for this type of development. As such a **FPL 29.94 m (Middle section of site - CH 140.0) and 28.00 m (North Eastern section of site – CH 90.0) AHD** may be adopted for the 100 year storm event. **FPL 31.30 m (Middle section of site - CH 140.0) and 28.54 m (North Eastern section of site – CH 90.0) AHD** can be adopted for the PMF event**.**

10 CONCLUSION

- The subject site is predominately flood free with a small area of flood risk along the Northern boundary which is clearly below the developable area of the subject site.
- HECRAS & WBNM programs were used to calculate the flood levels and impact on the flood waters in the surrounding area.
- The water levels calculated 29.44m (Middle section of site) - 27.50m (North Eastern section of site) are generally consistent with the 100 year flood levels provided in councils flood level information advice
- The water levels calculated 30.80m (Middle section of site) - 28.04m (North Eastern section of site) are slightly higher than the PMF flood levels provided in councils flood level information advice.
- During the PMF flood event the building is slightly effected by flood waters approximately 1-5mm in depth. The flood modeling showed that this did not have adverse effects on the flood waters on site and on adjoining properties. The FFL of this area is above the flood water levels.
- During a PMF flood event the building will not need to be evacuated. All escape routes from the building are above and clear of the PMF flood waters.
- The OSD located in the north eastern corner of the site will be suspended on piers to allow the natural flow of water.
- The proposed development does not impact the flood water levels on the site or the surrounding properties.