State Significant Development: Flood Study Report

Dicker Data Warehouse and Distribution Centre

Prepared for DCI Projects 12 September 2018 Revision B

171516 CAAB

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Revision Control

Revision	Date	Description		Prepared by	Checked by	Approved by
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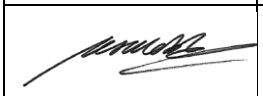
			Signature			
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Contents

1.0 Introduction

This Flood Study has been prepared in accordance with Sutherland Shire Council's Development Control Plan and associated policies to support the development of an industrial warehouse in Kurnell.

The scope of this report includes a comprehensive assessment of the existing flow regimes before evaluating the effects of the proposed development on flood behaviour. Following the pre and post development comparison, recommended flood planning levels will be discussed as well as various other flood planning considerations.

A review of the following flood related documentation available at Sutherland Shire Council's website was undertaken in the preparation of this assessment:

- Secretary's Environmental Assessment Requirements (SEARs dated 18 Jan 2018)
- Concept civil engineering sketches by TTW;
- Concept Architectural Plans by WMK Architecture;
- Sutherland Shire Council Development Control Plan (2015);
- "Australian Rainfall and Runoff – A Guide to Flood Estimation", Institute of Engineers, Australia (2016);
- NSW Floodplain Development Manual (2005);
- Georges River Floodplain Risk Management Study and Plan (May 2004);
- Kurnell Township Flood Study (May 2009);
- Sutherland Shire Council Sea Level Rise Policy (November 2016)

The increase in impervious areas and alteration of the natural topography due to land development has the potential to increase and concentrate peak storm flows. This has the potential to impact on flood regimes and cause erosion of the downstream drainage network and associated waterways. To avoid any adverse impact on the downstream drainage systems, the site must be designed to ensure the safe conveyance of flows within the capacity of the downstream trunk drainage systems in a healthy environmental state for Ecological Sustainable Development.

1.1 Flood Impacts

This report indicates the flood management strategy to prevent adverse changes in the existing flow regimes for the development of the project. The measures outlined in this report extend beyond the traditional management measures to consider the overall impact of the development on the surrounding areas and wider catchment.

As outlined in this report, the flood management strategy will ensure the site and surrounding properties have limited change in overall flooding due to the proposed development and the proposed development is flood free in rare storm events.

2.0 Site Background

2.1 Existing Flood Conditions

Flooding on the site is currently limited to surface runoff from impervious areas due to rainfall events. Due to the high hydraulic conductivity of the sandy soils, storm events up to the 1% AEP permeate into the ground without significant ponding or overland flow. There is no overland flow that enters the site from upstream catchments and there is no coastal flooding onto the site including for allowance for future sea level rise. Pre-development flood extents for the 1% AEP is shown in **Section 3.5.**

2.2 Locality

The site is located at 238-258 Captain Cook Drive, Kurnell which is within the Sutherland local government area (LGA). It is bound by a large warehouse to the north-east, Captain Cook Drive to the north-west, bushland to south-east and an unnamed gravel road to the south-west. The site currently is currently occupied by an industrial warehouse.

Figure 1 - Aerial photo of the proposed site (Source: https://maps.six.nsw.gov.au)

The proposed development includes the redevelopment of the site including construction of a new warehouse, carpark, stormwater infrastructure, earthworks including site filling, and associated utility services.

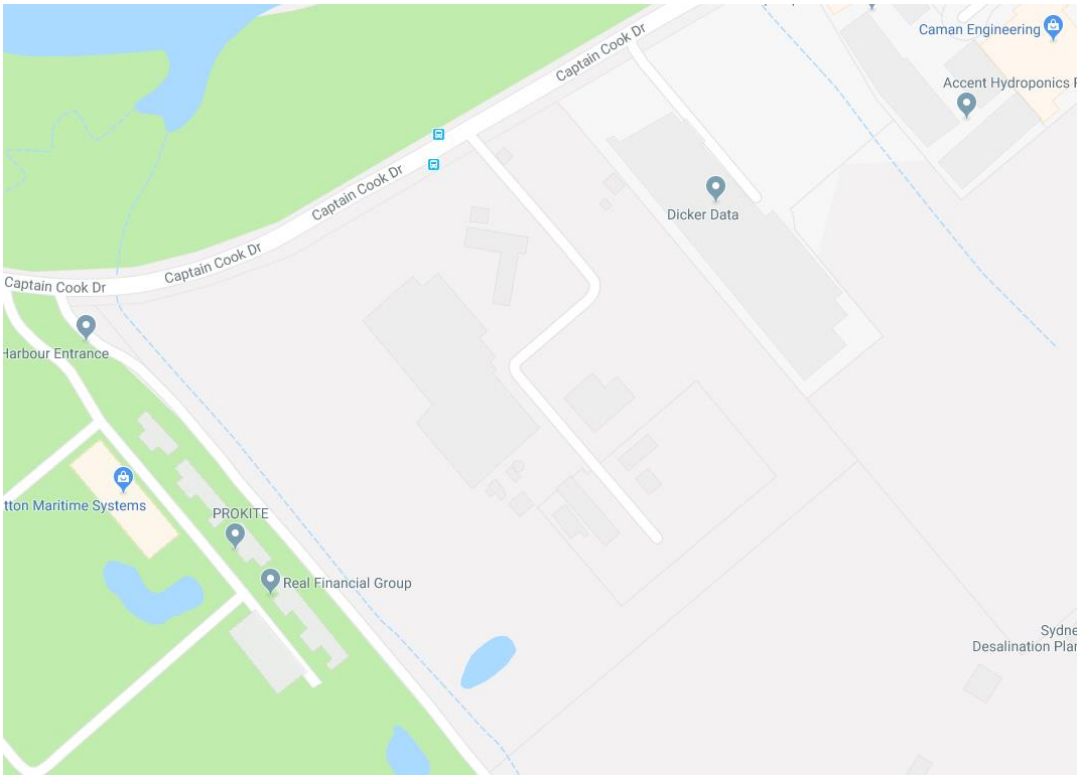

Figure 2 – Dicker Data Warehouse locality (Source: www.google.com.au/maps)

2.3 Key Issues

The key issues to be addressed in this report is:

- Review existing flood characteristics and behaviour with the combined effects of coastal inundation and overland flow from upstream catchments, with allowance for future sea level rise.
- Review the potential impacts to flood characteristics and behaviour as a result of the proposed development.
- Review the flood levels, depths and hazard within the site to confirm Flood Planning Levels for the development.
- Stormwater Management for the site is addressed in a separate report by TTW; *State Significant Development: Stormwater Management Plan 03.09.18.*

3.0 Flood Modelling

3.1 Study Catchment Area

The local catchment area for the development site was determined using a combination of LiDAR data, survey information, site inspection and interrogation of available contour maps.

The figure below indicates a conservative estimate of the 100 hectare catchment draining towards the low points within Captain Cook Drive. The catchment extents are shown by a dashed magenta line with the subject site outlined in a red polygon.

The catchment was conservatively estimated to be 50% pervious based on the combination of industrial development surrounded by dense vegetation. Overland flow across the subject site typically occurs in a South to North direction as sheet flow.

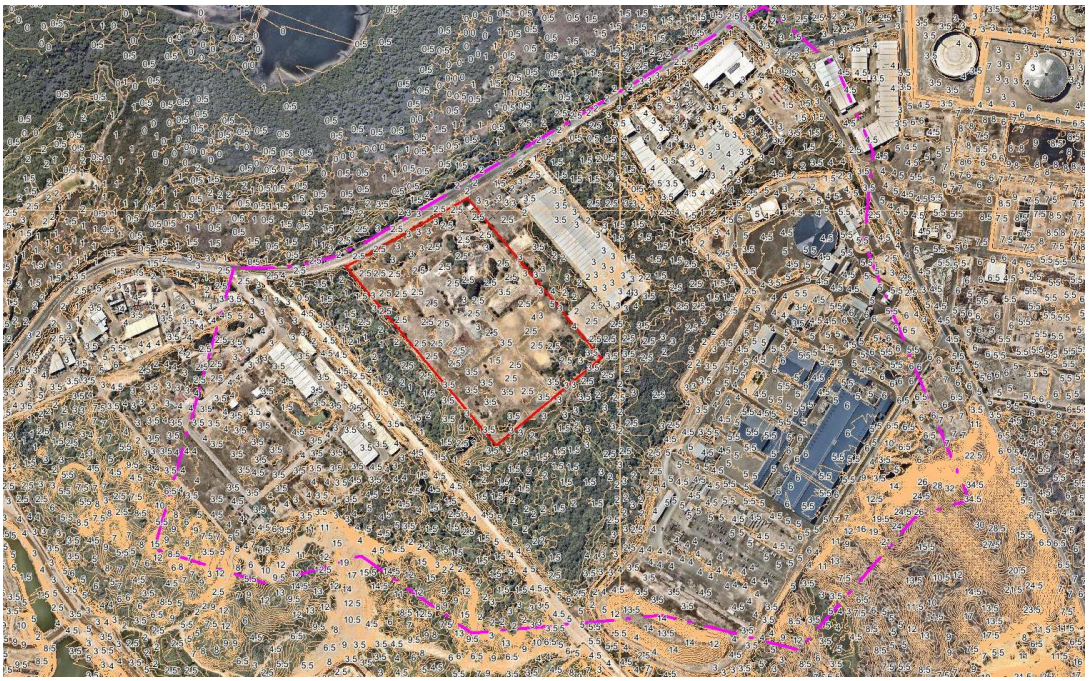

Figure 3 – Flood Study Catchment Area

3.2 DRAINS Assumptions – 1% AEP

A DRAINS model was used in determining the 1% Annual Exceedance Probability storm event using the following assumptions:

- Bureau of Meteorology's 2016 Intensity Frequency Duration data for rainfall run off rates and Australian Rainfall Runoff 2016 HUB initial/continuing loss modelling procedures and guidelines.
- A local catchment area of 100 hectares with an imperviousness ratio of 51%;
- Kinematic wave retardance factors of 0.016 for industrial impervious areas and 0.20 for pervious areas to reflect the densely vegetated shrub;
- Flow path length and slope calculated was based on the catchment area.

The above data was input into the model and run for all durations to determine the design storm for the 1% Annual Exceedance Probability event.

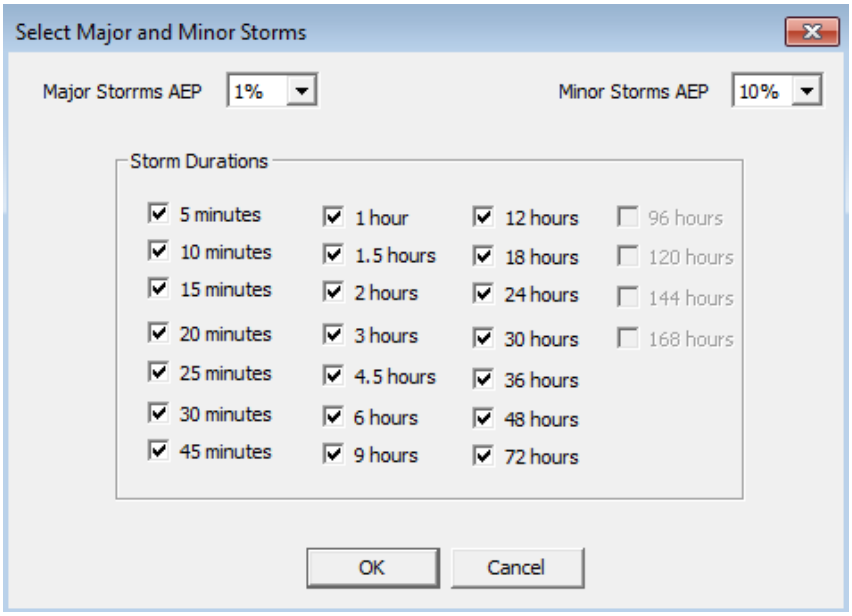

Figure 4 - Storm Durations Modelled in DRAINS

The critical storm based on the DRAINS modelling was found to be 23.951m^3/s in the 1% AEP, 15 minute burst, Storm 8. To evaluate the effects of volume rather than flow rate as well as accommodate for variances in catchment size, grade and flow path length two additional storms were considered for input into the TUFLOW model; 30 minute and 90 minute duration. Peak flood levels in the TUFLOW model were found to occur in the **30 minute storm**, indicating that a combination of tailwater level and volume of runoff are also contributing factors to flooding in Kurnell. The summary of the peak flows is attached to this report as Appendix A.

Storm	Peak Flow (cu.m/s)	
1% AEP, 15 min burst, Storm 1	23.956	
1% AEP, 15 min burst, Storm 2	23.945	
1% AEP, 15 min burst, Storm 3	23.939	
1% AEP, 15 min burst, Storm 4	23.939	
1% AEP, 15 min burst, Storm 5	23.950	
1% AEP, 15 min burst, Storm 6	23.945	
1% AEP, 15 min burst, Storm 7	23.957	
1% AEP, 15 min burst, Storm 8	23.951	Critical Storm for this AEP and Burst Duration
1% AEP, 15 min burst, Storm 9	23.968	
1% AEP, 15 min burst, Storm 10	23.962	
1% AEP, 30 min burst, Storm 1	23.419	
1% AEP, 30 min burst, Storm 2	18.131	
1% AEP, 30 min burst, Storm 3	20.618	
1% AEP, 30 min burst, Storm 4	21.629	
1% AEP, 30 min burst, Storm 5	20.066	
1% AEP, 30 min burst, Storm 6	17.819	
1% AEP, 30 min burst, Storm 7	23.492	
1% AEP, 30 min burst, Storm 8	18.486	
1% AEP, 30 min burst, Storm 9	21.438	Critical Storm for this AEP and Burst Duration
1% AEP, 30 min burst, Storm 10	22.575	
1% AEP, 1.5 hour burst, Storm 1	16.434	
1% AEP, 1.5 hour burst, Storm 2	17.231	
1% AEP, 1.5 hour burst, Storm 3	14.129	
1% AEP, 1.5 hour burst, Storm 4	12.324	
1% AEP, 1.5 hour burst, Storm 5	13.143	
1% AEP, 1.5 hour burst, Storm 6	19.075	
1% AEP, 1.5 hour burst, Storm 7	18.455	
1% AEP, 1.5 hour burst, Storm 8	16.230	Critical Storm for this AEP and Burst Duration
1% AEP, 1.5 hour burst, Storm 9	14.395	
1% AEP, 1.5 hour burst, Storm 10	13.886	

Figure 5 - Design Storms for TUFLOW

3.3 XP RAFTS Assumptions – PMP

XP RAFTS was utilised to estimate the PMP and peak flow hydrographs. The catchment characteristics were input into the model and ran for a range of durations ranging from 15 minutes to 6 hours which is the limit under the General Short Duration Method for calculating the Possible Maximum Precipitation (PMP). The peak flowrate based on the PMP for the given catchment area was found to be 124.729m^3/s in the 15 minute storm duration. To evaluate the effects of potential variance in catchment attributes and run off volume during the PMP event, the 30, 90 and 120 minute duration were also modelled. The Peak flood flows for the PMF were found to be the 90 minute duration.

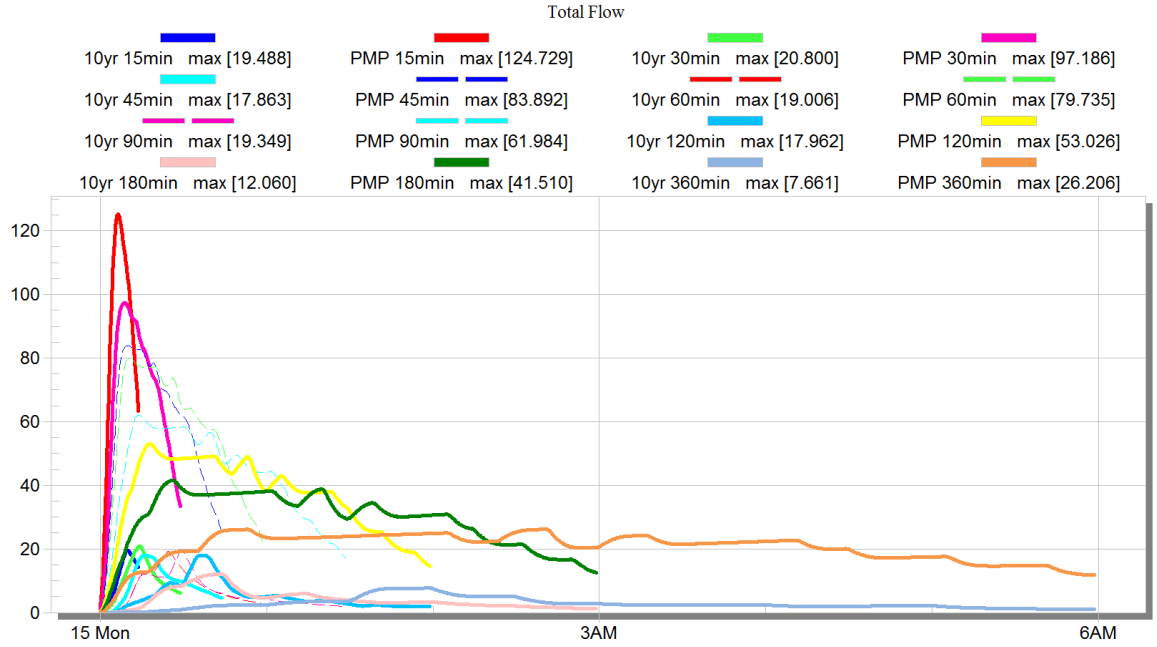

Figure 6 - XP RAFTS Results

3.4 TUFLOW Assumptions

The following design attributes were assumed for the purpose of a creating a pre development flood model:

- The direct rainfall (rainfall on grid) method was used in TUFLOW by applying the rainfall hyetograph generated from Drains (1% AEP) and XP-RAFTS (PMF) across the digital elevation model obtained from Lidar data.

- Roughness values applied to the external and site catchment are outlined in the ID table below and the figures attached to this report as Appendix B. The unshaded areas of the catchment were allocated a Manning's roughness of 0.025 to represent the sandy nature of Kurnell (ID5). The polygons shown in the post development breakdown were used to overwrite the cells in the pre-development scenario.

Material ID	Manning's n	Infiltration Parameters	! Description
1	0.018	1.5, 0.0	!road carriageways
2	0.02	1.5, 0.0	!driveways and car parks
3	0.03, 0.02, 0.1, 3.00	0.0, 0.0	!buildings
4	0.04	5.0, 3.0	!open space & long grass
5	0.025	1.5, 0.0	!urban space & paved
6	0.06	2.5, 1.0	!residential blocks
7	0.04	1.5, 0.0	!industrial/commercial blocks
8	0.25	5.0, 3.0	!mangroves, wetlands & dense vegetation
9	0.03	1.5, 0.0	!water
10	0.03, 0.04, 0.1, 0.06	5.0, 3.0	!long grass pasture
11	0.07	5.0, 3.0	!channel; weedy reaches, deep pools
12	0.035	5.0, 3.0	!channel; grass swale
13	0.07	5.0, 3.0	!brush
14	0.04	2.5, 1.0	!railway embankments
15	0.08	0.0, 0.0	!special use
16	0.03, 0.10, 0.1, 0.04	5.0, 3.0	!lawns/grass/playingfields

Table 1 - Manning's Roughness Values

- Buildings within the catchment were modelled with varying Manning's roughness value. For depths of flow less than 30mm the adopted Manning's was 0.02 to simulate the effects of roof sheet flow. For depths of flow in excess of 100mm the Manning's value was increased to 3 as a means of reflecting any existing freeboard provisions preventing the ingress of floodwater and storages in the model.

- A downstream boundary condition of 1.32m AHD was assumed as the tailwater level for the design storm. This allows for a level of 0.6m for high tide (Kurnell Township Flood Study 2009 by WMA) and an additional increase of 0.72m due to future sea level rise (Sutherland Shire Council's Sea Level Rise Policy, November 2016).

- Rainfall losses for impervious areas were set to IL = 1.5, CL = 0 and losses for pervious areas were set to IL = 5.0, CL = 3.0. These losses are conservative given that the ARR 2016 data hub for Tarren Point (the closest location to the site) was 32mm/hr continuing loss.

- To represent the sandy soils within Kurnell, infiltration losses were set to IL = 0, CL = 385mm/hr ($1.07x10^{-4}$ m/s). This infiltration rate is based 50% of the lowest rate as confirmed by geotechnical testing on site. Actual test rates vary from $2.14x10^{-4}$ m/s to $1.2x10^{-2}$ m/s. This infiltration rate was not applied to developed areas or open bodies of water. The initial ground water level was set at 1.4m (above the downstream tailwater level).

Figure 7 - External Catchment Breakdown

Figure 8 - Pre-Development Catchment Breakdown

Figure 9 - Post Development Catchment Breakdown

3.5 Pre-Development 1% AEP Results with Sea Level Rise

The design storms were applied to the catchment in TUFLOW using the direct rainfall method using a time versus rainfall depth hyetograph. The results in figure 10 show the pre-development flood depths for the 1% AEP, 30 minute storm with allowance for sea level rise.

The results confirm that there is no overland flooding from upstream catchments and no coastal inundation of the site. The only flood depth within the site is associated with surface water runoff from impervious areas within the development site.

Figure 10 – Pre Development 1% AEP Depths

3.6 Post Development 1% AEP Results With Sea Level Rise

Modifications were made to reflect the new building, external landscaping and changes to pervious and impervious surfaces. The results in figure 11 show the post-development flood depths for the 1% AEP, 30 minute storm with allowance for sea level rise.

The results confirm that there is no overland flooding from upstream catchments and no coastal inundation of the site. The only flood depth within the site is associated with surface water runoff from the roof and impervious areas within the development site. The proposed model does not include the pit and pipe stormwater network which would remove the flood depths around the perimeter of the building.

The proposed development does not exacerbate existing flooding. The only potential impact to offsite flooding is from stormwater runoff from the development site. However, the stormwater concept and strategy ensures that there is no increase in runoff from the development site up to and including the 1% AEP, refer to the separate Stormwater Management Plan by TTW ref; *171516 CAAA 03.09.18 revision A.*

Based on the flood modelling, the peak flood level within the infiltration basins is RL 3.20m AHD. The Flood Planning Level is therefore of 3.70m AHD with the proposed building floor level set at 3.80m AHD. Car parking levels will be set above the top of the infiltration basins.

Sensitivity checks have been carried out with different soil infiltration rates. The lowest infiltration rate measured on site through geotechnical testing is 2.14×10^{-4} m/s (770 mm/hr). Infiltration rates as low as 1.5×10^{-6} m/s (5.4 mm/hr) were modelled which resulted in approximately 100mm increase in flood levels on the site. The peak rainfall intensity for the 1% AEP 30-minute storm is 106 mm/hr. The confirmed soil infiltration rate is over seven times higher than this rainfall, and fluctuations in soil infiltration rates across the catchment would not have a significant impact on flooding.

Figure 11 - Post Development 1% AEP Depths & Flood Contours

3.7 Post Development PMF Results With Sea Level Rise

The 15, 30 and 90-minute storms were analysed to determine the effects of flowrate vs volume on peak flood levels. The 90-minute storm resulted in the highest peak flood levels. The results in figure 12 show the post-development flood depths for the PMF, 90-minute storm with allowance for sea level rise. The results show that the maximum PMF level is 3.40m AHD which is below the Flood planning level and the proposed building floor level of 3.80m AHD.

Figure 12 – Post Development PMF Depth

3.8 Tidal Flooding + Sea Level Rise

In addition to the above modelling the effects of tidal flooding and impact of sea level rise was considered. The design flood levels for tidal flooding taken from the Kurnell Township Flood Study (May 2009) Page 51 are listed to be RL 1.70m AHD for the 1% AEP event. With a projected sea level rise of RL 0.72m the estimated design flood level due to tidal flooding would be RL 2.42m AHD by 2100. As there is no overland flow entering the site from upstream catchments, the effects of sea level rise and tidal flooding would not affect the development as existing site levels are generally above the tidal flood level . Furthermore, the finished floor level of the development is proposed to be RL 3.80m AHD which is 1.37m above the tidal flood level.

3.9 1% AEP Afflux Comparison

An afflux comparison map (figure 16) was plotted to compare the change in peak 1% AEP flood levels as a result of the development. The contours and thematic mapping indicate that there will be negligible changes to flood levels (less than 10mm offsite) with the only changes within the development site. The changes in flood levels within the site are due to changes to the building layout, external ground levels and infiltration basins. The results confirm that the development has no impact to flooding to offsite properties

Figure 13 - Pre vs Post 1% AEP Afflux

3.10 Post Development 1% AEP Flood Hazard

Due to the flat, low lying nature of the catchment, dense vegetation and flooding mechanism driven by volume and tide rather than peak flow rate, the velocity of overland flow remains low. Figure 18 shows the post development flood hazard in accordance with NSW Floodplain Management Manual (2005). The majority of the site is shown to be low hazard with existing channels and the infiltration basins shown to be areas of high hazard, due to the increased depth of ponding and higher flow velocities.

Figure 14 - Post Development 1% AEP NSW Floodplain Hazard

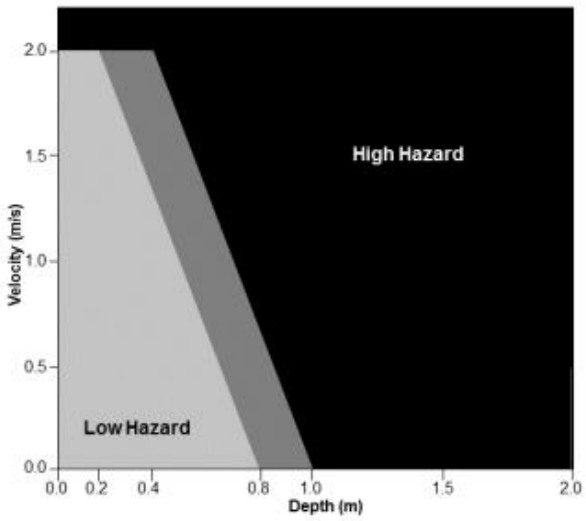

Figure 15 - NSW Floodplain Development Manual VD Chart

4.0 Flood Planning Levels

Based on the 1% AEP post development results, a peak flood level of RL 3.20m AHD is observed to within the infiltration basins. The Flood Planning Level for the site is 3.70m AHD, which allows for 500mm freeboard above the 1% AEP flood level. The proposed floor level of the habitable areas and warehouse is 3.80m AHD and satisfies Council's requirement.

Carparking areas are set above the top of the infiltration basin which will also be above the 1% AEP flood level of 3.20m AHD

Proposed Use	1% AEP design storm flood level	Required Freeboard above 1% AEP	Flood Planning Level
Habitable/ warehouse	RL 3.20m AHD	+500mm	RL 3.70m AHD
Driveway/ car park	RL 3.20m AHD	+0.00mm	RL 3.20m AHD

Table 2 - Flood Planning Levels

Note: In addition to the above table the proposed substation will be set on a plinth to achieve the 500mm freeboard requirement above the adjacent 1% AEP flood level.

5.0 Emergency Evacuation Plan

Due to the relatively short times of concentration and flooding nature of urban catchments it is likely that evacuation of properties will occur as a response to storm intensity rather than a preventative action in anticipation of approaching floodwater. Due to the hap hazard response to flooding and nature of the catchment being on a peninsula, it would be difficult to effectively organise the transportation of persons to areas outside of the flood affected zones.

The catchment characteristics result in flooding due to a combination of volume rather than flow rate, high tide levels and overland flow. As a result, changes to flood flows, depths and overland flow paths do not exponentially increase with the rarer storm events which is shown in the PMF scenario results. For this reason flood affectation in this catchment does not necessarily mean that properties need to be evacuated as a large majority of sites are not exposed to a high hazard nor would they be considered within the 'floodway' hydraulic category.

Although occupants may still able to escape either on foot or by vehicle along roadways in the 1% AEP even if evacuation is left late, due to the low lying nature of the catchment and flooding mechanism it is likely that most buildings will become flood islands in the PMF event. For these reasons it is recommended that occupants remain inside the building and take refuge as the finished floor level of the development is above the probable maximum flood level.

5.1 Site Emergency Response Flood Plan

A site emergency response flood plan detailing the flood inundation and mitigation measures as well as the proposed relocation of people to a safe location should be implemented by operations and management. The staff employed at the new development will be required to be trained for typical emergency situations such as fires. In addition to this generalised training the management of a flood event can also be incorporated into the responsibility of staff members. It is recommended that a flood plan address the following items:

- The training and action required for the management of a flood event including the deployment of any flood mitigation measures and relocation of persons.
- Similarly to fire wardens, flood wardens can be appointed and made responsible for managing the evacuation procedures. Flood evacuation drills can also be scheduled to ensure all persons are aware of the correct procedure.
- The maintenance and operation schedules of any alarm and warning systems implemented. E.g. a ball float alarm system can in installed within the lower lying pits which would then sound and activate alarms and any flood mitigation measures.
- Locations of the appropriate flood warning signage.

6.0 Conclusion and Recommendations:

The key findings and to be implemented for the development include the following:

- The site is not subject to flooding from coastal inundation or overland flow up to the 1% AEP storm.
- The site is affected by overland flow for the extreme Probable Maximum Flood.
- Localised ponding within the site is caused by the stormwater runoff from within the development site.
- The Flood Planning Level of 3.70m AHD is required with the current proposed floor level of 3.80m AHD. The proposed floor level will be above the PMF level.
- The development shall incorporate the flood planning considerations outlined in Section 4 above.
- Stormwater management measures will be implemented to ensure that there is no increase in surface water runoff from the site up to the 1% AEP. Refer to TTW report; *State Significant Development: Stormwater Management Plan 03.09.18.*
- An alarm warning system, flood warning and evacuation route signage is recommended to be incorporated as part of the development. Flood warning signage shall also be erected within the car park.

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Appendix A

DRAINS 1% AEP Results

Peak Flows for CAT_PRE

Storm	Peak Flow (cu.m/s)	
1% AEP, 5 min burst, Storm 1	13.394	Critical Storm for this AEP and Burst Duration
1% AEP, 10 min burst, Storm 1	20.282	
1% AEP, 10 min burst, Storm 2	20.282	
1% AEP, 10 min burst, Storm 3	20.288	Critical Storm for this AEP and Burst Duration
1% AEP, 10 min burst, Storm 4	20.288	
1% AEP, 10 min burst, Storm 5	20.294	
1% AEP, 10 min burst, Storm 6	20.282	
1% AEP, 10 min burst, Storm 7	20.288	
1% AEP, 10 min burst, Storm 8	20.282	
1% AEP, 10 min burst, Storm 9	20.294	
1% AEP, 10 min burst, Storm 10	20.294	
1% AEP, 15 min burst, Storm 1	23.956	
1% AEP, 15 min burst, Storm 2	23.945	
1% AEP, 15 min burst, Storm 3	23.939	
1% AEP, 15 min burst, Storm 4	23.939	
1% AEP, 15 min burst, Storm 5	23.95	
1% AEP, 15 min burst, Storm 6	23.945	
1% AEP, 15 min burst, Storm 7	23.957	
1% AEP, 15 min burst, Storm 8	23.951	Critical Storm for this AEP and Burst Duration
1% AEP, 15 min burst, Storm 9	23.968	
1% AEP, 15 min burst, Storm 10	23.962	
1% AEP, 20 min burst, Storm 1	24.187	
1% AEP, 20 min burst, Storm 2	23.08	
1% AEP, 20 min burst, Storm 3	19.996	
1% AEP, 20 min burst, Storm 4	23.839	
1% AEP, 20 min burst, Storm 5	20.814	
1% AEP, 20 min burst, Storm 6	22.445	
1% AEP, 20 min burst, Storm 7	23.903	
1% AEP, 20 min burst, Storm 8	22.079	
1% AEP, 20 min burst, Storm 9	21.785	
1% AEP, 20 min burst, Storm 10	22.94	Critical Storm for this AEP and Burst Duration
1% AEP, 25 min burst, Storm 1	21.276	Critical Storm for this AEP and Burst Duration
1% AEP, 25 min burst, Storm 2	20.282	
1% AEP, 25 min burst, Storm 3	22.186	
1% AEP, 25 min burst, Storm 4	21.111	
1% AEP, 25 min burst, Storm 5	21.918	
1% AEP, 25 min burst, Storm 6	20.797	
1% AEP, 25 min burst, Storm 7	23.267	
1% AEP, 25 min burst, Storm 8	20.174	
1% AEP, 25 min burst, Storm 9	20.584	
1% AEP, 25 min burst, Storm 10	23.917	

1% AEP, 30 min burst, Storm 1	23.419	
1% AEP, 30 min burst, Storm 2	18.131	
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1% AEP, 45 min burst, Storm 1	20.576	
1% AEP, 45 min burst, Storm 2	19.942	
1% AEP, 45 min burst, Storm 3	20.487	
1% AEP, 45 min burst, Storm 4	18.899	
1% AEP, 45 min burst, Storm 5	18.76	
1% AEP, 45 min burst, Storm 6	18.601	
1% AEP, 45 min burst, Storm 7	16.497	
1% AEP, 45 min burst, Storm 8	17.261	
1% AEP, 45 min burst, Storm 9	19.352	Critical Storm for this AEP and Burst Duration
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1% AEP, 1 hour burst, Storm 1	22.774	
1% AEP, 1 hour burst, Storm 2	15.666	
1% AEP, 1 hour burst, Storm 3	19.642	
1% AEP, 1 hour burst, Storm 4	15.343	
1% AEP, 1 hour burst, Storm 5	17.964	Critical Storm for this AEP and Burst Duration
1% AEP, 1 hour burst, Storm 6	19.074	
1% AEP, 1 hour burst, Storm 7	15.051	
1% AEP, 1 hour burst, Storm 8	16.894	
1% AEP, 1 hour burst, Storm 9	14.22	
1% AEP, 1 hour burst, Storm 10	20.378	
1% AEP, 1.5 hour burst, Storm 1	16.434	
1% AEP, 1.5 hour burst, Storm 2	17.231	
1% AEP, 1.5 hour burst, Storm 3	14.129	
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1% AEP, 1.5 hour burst, Storm 9	14.395	
1% AEP, 1.5 hour burst, Storm 10	13.886	
1% AEP, 2 hour burst, Storm 1	16.739	Critical Storm for this AEP and Burst Duration
1% AEP, 2 hour burst, Storm 2	17.373	
1% AEP, 2 hour burst, Storm 3	11.259	
1% AEP, 2 hour burst, Storm 4	19.629	
1% AEP, 2 hour burst, Storm 5	15.763	
1% AEP, 2 hour burst, Storm 6	17.749	

1% AEP, 2 hour burst, Storm 7	11.906	
1% AEP, 2 hour burst, Storm 8	16.946	
1% AEP, 2 hour burst, Storm 9	13.986	
1% AEP, 2 hour burst, Storm 10	16.293	
1% AEP, 3 hour burst, Storm 1	12.036	
1% AEP, 3 hour burst, Storm 2	15.136	
1% AEP, 3 hour burst, Storm 3	15.686	
1% AEP, 3 hour burst, Storm 4	16.432	
1% AEP, 3 hour burst, Storm 5	10.458	
1% AEP, 3 hour burst, Storm 6	12.517	
1% AEP, 3 hour burst, Storm 7	13.959	Critical Storm for this AEP and Burst Duration
1% AEP, 3 hour burst, Storm 8	12.842	
1% AEP, 3 hour burst, Storm 9	12.272	
1% AEP, 3 hour burst, Storm 10	14.993	
1% AEP, 4.5 hour burst, Storm 1	9.625	
1% AEP, 4.5 hour burst, Storm 2	13.874	
1% AEP, 4.5 hour burst, Storm 3	10.634	
1% AEP, 4.5 hour burst, Storm 4	14.371	
1% AEP, 4.5 hour burst, Storm 5	12.536	
1% AEP, 4.5 hour burst, Storm 6	13.725	
1% AEP, 4.5 hour burst, Storm 7	9.335	
1% AEP, 4.5 hour burst, Storm 8	11.769	
1% AEP, 4.5 hour burst, Storm 9	15.598	
1% AEP, 4.5 hour burst, Storm 10	12.68	Critical Storm for this AEP and Burst Duration
1% AEP, 6 hour burst, Storm 1	11.93	
1% AEP, 6 hour burst, Storm 2	12.871	
1% AEP, 6 hour burst, Storm 3	11.964	
1% AEP, 6 hour burst, Storm 4	8.806	
1% AEP, 6 hour burst, Storm 5	12.231	Critical Storm for this AEP and Burst Duration
1% AEP, 6 hour burst, Storm 6	14.016	
1% AEP, 6 hour burst, Storm 7	11.483	
1% AEP, 6 hour burst, Storm 8	10.13	
1% AEP, 6 hour burst, Storm 9	13.774	
1% AEP, 6 hour burst, Storm 10	14.094	
1% AEP, 9 hour burst, Storm 1	12.294	
1% AEP, 9 hour burst, Storm 2	11.313	
1% AEP, 9 hour burst, Storm 3	7.925	
1% AEP, 9 hour burst, Storm 4	11.983	
1% AEP, 9 hour burst, Storm 5	10.139	Critical Storm for this AEP and Burst Duration
1% AEP, 9 hour burst, Storm 6	7.722	
1% AEP, 9 hour burst, Storm 7	8.517	
1% AEP, 9 hour burst, Storm 8	7.953	
1% AEP, 9 hour burst, Storm 9	13.847	
1% AEP, 9 hour burst, Storm 10	8.78	
1% AEP, 12 hour burst, Storm 1	11.206	Critical Storm for this AEP and Burst Duration

1% AEP, 12 hour burst, Storm 2	10.15	
1% AEP, 12 hour burst, Storm 3	13.404	
1% AEP, 12 hour burst, Storm 4	7.598	
1% AEP, 12 hour burst, Storm 5	14.829	
1% AEP, 12 hour burst, Storm 6	14.643	
1% AEP, 12 hour burst, Storm 7	7.64	
1% AEP, 12 hour burst, Storm 8	10.519	
1% AEP, 12 hour burst, Storm 9	14.251	
1% AEP, 12 hour burst, Storm 10	8.457	
1% AEP, 18 hour burst, Storm 1	8.869	
1% AEP, 18 hour burst, Storm 2	6.898	
1% AEP, 18 hour burst, Storm 3	7.475	Critical Storm for this AEP and Burst Duration
1% AEP, 18 hour burst, Storm 4	5.57	
1% AEP, 18 hour burst, Storm 5	7.65	
1% AEP, 18 hour burst, Storm 6	9.857	
1% AEP, 18 hour burst, Storm 7	7.43	
1% AEP, 18 hour burst, Storm 8	4.683	
1% AEP, 18 hour burst, Storm 9	9.175	
1% AEP, 18 hour burst, Storm 10	5.834	
1% AEP, 24 hour burst, Storm 1	8.632	
1% AEP, 24 hour burst, Storm 2	10.638	
1% AEP, 24 hour burst, Storm 3	6.609	Critical Storm for this AEP and Burst Duration
1% AEP, 24 hour burst, Storm 4	7.402	
1% AEP, 24 hour burst, Storm 5	5.646	
1% AEP, 24 hour burst, Storm 6	6.977	
1% AEP, 24 hour burst, Storm 7	5.994	
1% AEP, 24 hour burst, Storm 8	6.519	
1% AEP, 24 hour burst, Storm 9	6.175	
1% AEP, 24 hour burst, Storm 10	5.332	
1% AEP, 30 hour burst, Storm 1	4.394	
1% AEP, 30 hour burst, Storm 2	8.62	
1% AEP, 30 hour burst, Storm 3	5.555	
1% AEP, 30 hour burst, Storm 4	7.055	
1% AEP, 30 hour burst, Storm 5	4.591	
1% AEP, 30 hour burst, Storm 6	4.509	
1% AEP, 30 hour burst, Storm 7	7.479	
1% AEP, 30 hour burst, Storm 8	5.189	Critical Storm for this AEP and Burst Duration
1% AEP, 30 hour burst, Storm 9	4.809	
1% AEP, 30 hour burst, Storm 10	3.373	
1% AEP, 36 hour burst, Storm 1	4.035	
1% AEP, 36 hour burst, Storm 2	7.073	
1% AEP, 36 hour burst, Storm 3	4.504	
1% AEP, 36 hour burst, Storm 4	6.685	
1% AEP, 36 hour burst, Storm 5	6.736	Critical Storm for this AEP and Burst Duration
1% AEP, 36 hour burst, Storm 6	5.5	
1% AEP, 36 hour burst, Storm 7	3.23	

1% AEP, 36 hour burst, Storm 8	7.543	
1% AEP, 36 hour burst, Storm 9	8.588	
1% AEP, 36 hour burst, Storm 10	6.812	
1% AEP, 48 hour burst, Storm 1	4.11	
1% AEP, 48 hour burst, Storm 2	5.109	Critical Storm for this AEP and Burst Duration
1% AEP, 48 hour burst, Storm 3	3.901	
1% AEP, 48 hour burst, Storm 4	6.45	
1% AEP, 48 hour burst, Storm 5	4.088	
1% AEP, 48 hour burst, Storm 6	6.379	
1% AEP, 48 hour burst, Storm 7	4.865	
1% AEP, 48 hour burst, Storm 8	2.838	
1% AEP, 48 hour burst, Storm 9	6.696	
1% AEP, 48 hour burst, Storm 10	6.674	
1% AEP, 72 hour burst, Storm 1	3.795	
1% AEP, 72 hour burst, Storm 2	2.662	
1% AEP, 72 hour burst, Storm 3	6.008	
1% AEP, 72 hour burst, Storm 4	3.792	
1% AEP, 72 hour burst, Storm 5	3.205	
1% AEP, 72 hour burst, Storm 6	4.74	Critical Storm for this AEP and Burst Duration
1% AEP, 72 hour burst, Storm 7	5.906	
1% AEP, 72 hour burst, Storm 8	4.402	
1% AEP, 72 hour burst, Storm 9	5.176	
1% AEP, 72 hour burst, Storm 10	4.946	

Appendix B

Catchment Manning's Roughness

PRE DEVELOPMENT: EXTERNAL CATCHMENT MANNINGS ROUGHNESS

0 0.2000
kilometres
Scale: 1:5,000

PRE DEVELOPMENT:
SITE CATCHMENT
MANNINGS ROUGHNESS

0 0.1000
kilometres
Scale: 1:2,500

POST DEVELOPMENT:
SITE CATCHMENT
MANNINGS ROUGHNESS

Appendix C

Compiled Flood Mapping Results

1% AEP - Existing Flood Depth

1% AEP - Proposed Flood Depth

1% AEP - Change in Peak Flood Level


1% AEP - Flood Hazard
PEAK FLOOD HAZARD
High
Medium
Low

PMF - Proposed Flood Depth