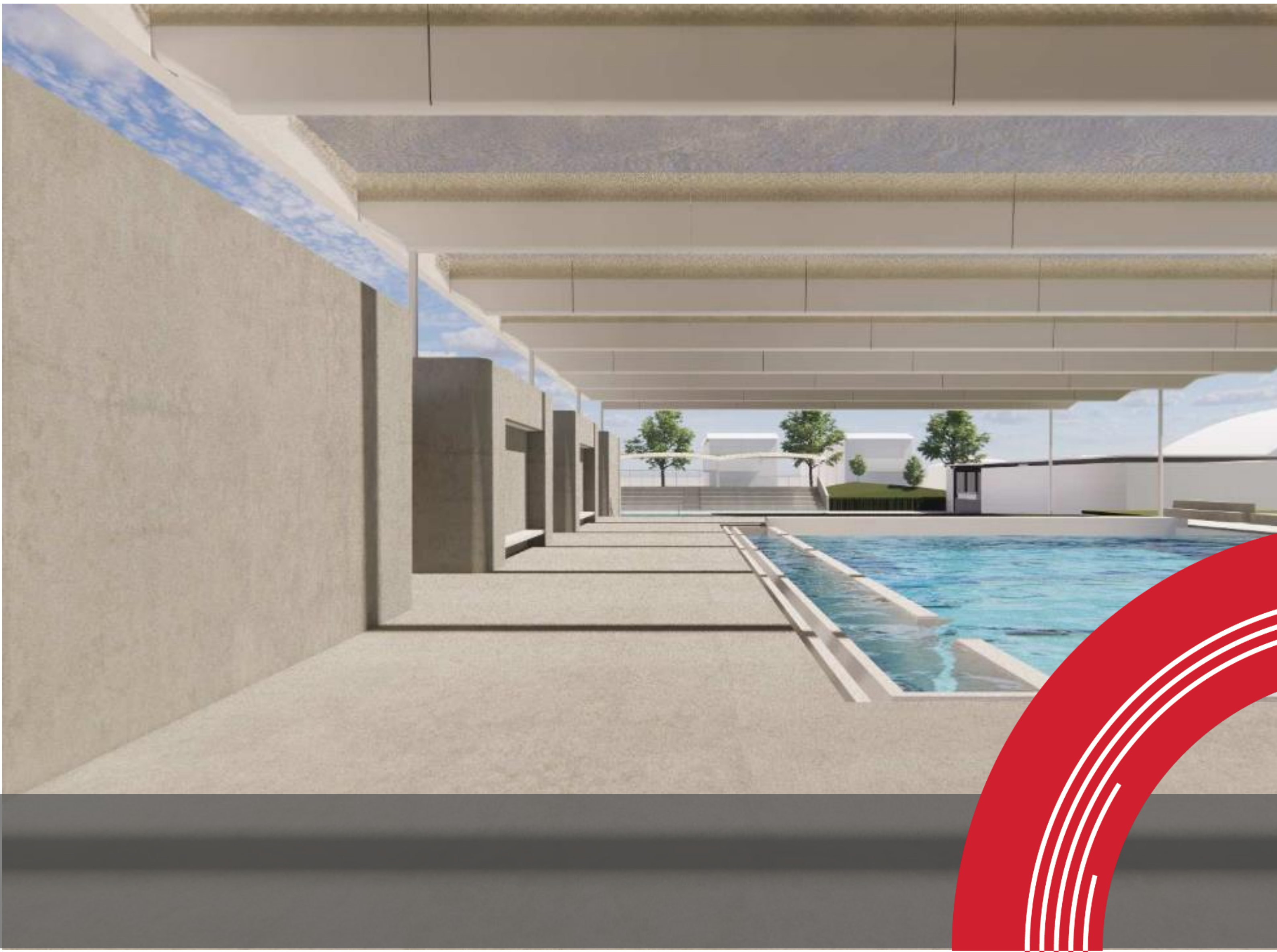

Port Macquarie Aquatic Facility

Gordon Street, Port Macquarie NSW 2444

Flood Impact and Risk Assessment

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Abbreviations

AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff 2019
BoM	Bureau of Meteorology
DCP	Development Control Plan
DRAINS	One dimensional rainfall runoff and hydraulic modelling software
FPL	Flood Planning Level
LGA	Local Government Area
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging (also see ALS)
m	Measure of length / height / distance (metres)
m AHD	Meters above Australian High Datum
m/s	Measure of velocity (metres per second)
m^3/s	Measure of flow rate (cubic metres per second)
PMF	Probable Maximum Flood

Terminology

The information presented in the following report uses the terminology as specified in the Australian Rainfall and Runoff 2019 guidelines. The following presents the conversion between the previous terminology, as used with the Wrights Creek Flood Study, and the latest version which has been used throughout this report.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
Extreme	0.0005	0.05	2000	2000
	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

Introduction

Northrop Consulting Engineers Pty Ltd (Northrop) have been engaged by CO-OP STUDIO, on the behalf of Port Macquarie-Hastings Council, to prepare a Flood Impact and Flood Risk Assessment for the proposed Aquatic Facility located along Gordon Street in Port Macquarie, herein referred to as 'the subject site'. The purpose of the study is to review the impact the proposed development has on the existing flood behaviour within the subject site and adjacent properties.

This assessment aims to determine the existing flood conditions on the site, from the local and regional catchment, investigate the feasibility of the development layout, and review the impact of the proposed development.

Site Description

The subject site is Macquarie Park, otherwise known as Lots 5, 6, 7, 8, 9, 14, 15, 16, 17, 18, 19, 20, Section 16 DP758852 and Lot 2 DP 808449. The site is approximately 2.9ha and is located within the Wrights Creek catchment in the Port Macquarie Hastings Council (PMHC). The site is bounded by Gordon Street to the North, Wrights Creek to the South, Grant Street to the East and Munster Street to the West. The subject site is shown in Figure A1 of Appendix A. Survey of the subject site shows elevations ranging from 5.2m AHD at the Gordon Street Frontage, to 2.6m AHD in the south-western corner.

The site is subject to flooding from the local and regional upstream catchments. Stormwater through the subject site falls westerly, with flows exceeding the capacity of the road stormwater network along Gordon Street and Grant Street. These flows traverse the subject site in a south-westerly direction, discharging into Wrights Creek. Regional flows from the upstream Wrights Creek catchment impact the site, with the existing subject site providing flood storage. This occurs in most rainfall events due to the location of the subject site, at the bottom of the contributing catchment.

Proposed Development

CO-OP Studio, on behalf of the Port Macquarie Hastings Council, are seeking to construct an Aquatic Centre along Gordon Street, Port Macquarie (existing location of Macquarie Park). The proposed development will consist of a multi-stage construction, with an overview of the final development shown in Figure 1 overleaf.

Stage 1 of the development involves the facilities buildings, with the reception/administration, gym, café, club room and amenities included. The first stage also contains the construction of the 50-metre outdoor pool, 25 metre indoor pool, programme pool and 135 car spaces, to adjoin Munster Street to the northwest of the subject site. The carpark is also accessible via Gordon Street, with a one-way road to allow bus accessibility for event drop offs.

Following the completion of Stage 1, further works for Stage 2 will commence and include an additional 35 car spaces, gym extension, the outdoor leisure area, slides, and splash zone.

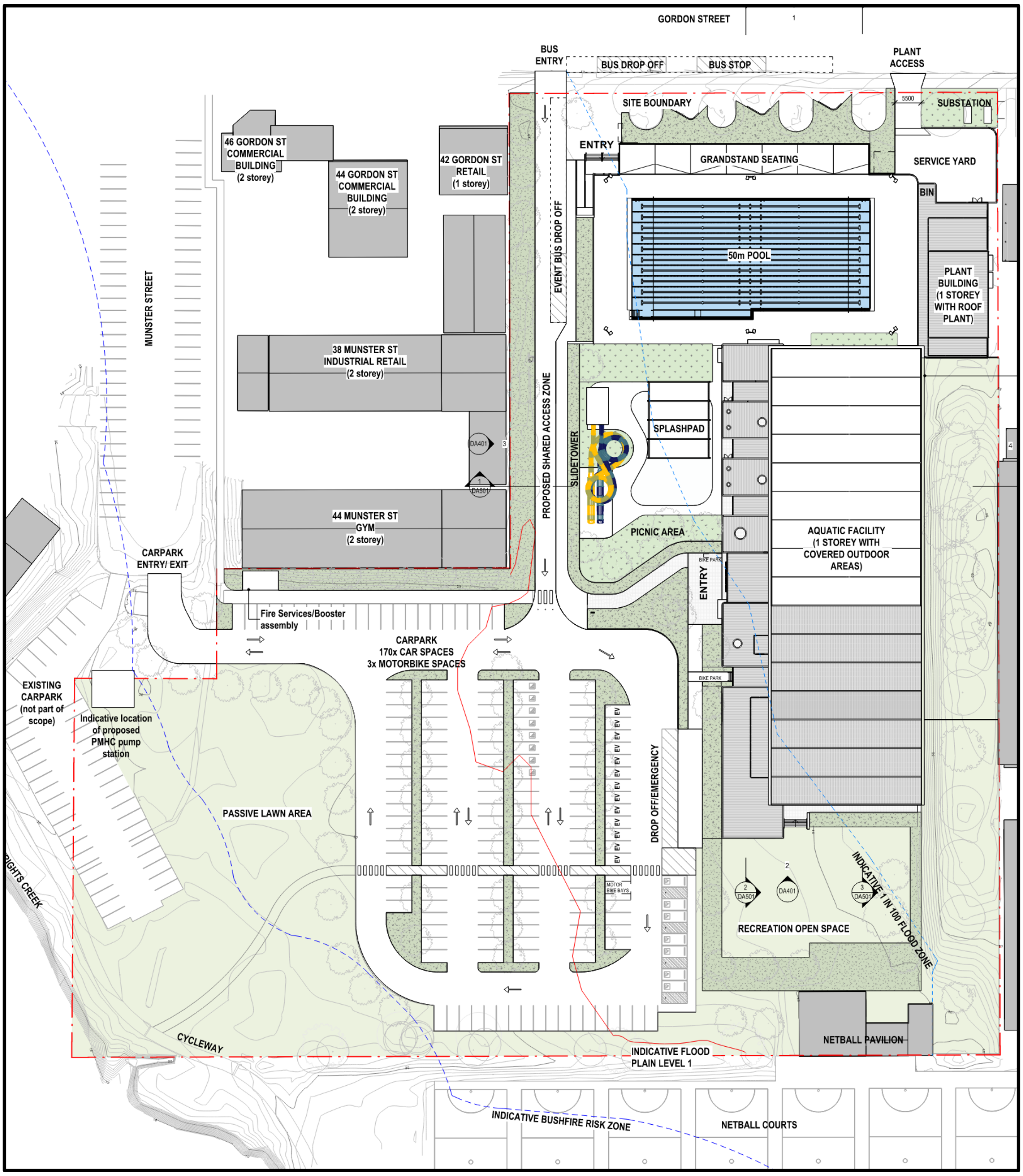

Figure 1 – Proposed Development Layout

Previous Studies

Wrights Creek Flood Study Update (2018)

The Wrights Creek Flood Study, conducted in 2018, was undertaken to understand the flood behaviour of the Wrights Creek catchment and develop a feasible management plan for future flood events. The previous flood study, completed in 2007 by Patterson Britton and Partners, forms the basis of the study. Updated modelling has been prepared in XPRAFTS and TUFLOW to better represent the catchment characteristics and use updated hydrological processes. This includes updated survey of the ground levels, culverts, and bridge structures.

As part of the study, local 1D inflows were applied across the 2D model grid, with the main pipe trunk drainage and channels included. The tailwater conditions were set to the neap tide level at 0.45m AHD, as the 2007 Flood Study determine the coincident flooding between Wrights Creek and Hastings River, downstream of the subject site, is unlikely. This was adopted in the site specific TUFLOW model.

The results from the updated study indicated a maximum water level of approximately 3.9m AHD across the subject site in the 1% AEP and 6.0m AHD in the PMF. This is shown in Figure 2 and Figure 3 of the updated flood study, with maximum depths in excess of 1 metre and 3 metres across the subject site for the 1% AEP and PMF, respectively.

Within the study, key reporting locations were recorded, with design flood levels upstream and downstream of the subject site summarised in Table 1 - Design Flood Levels (WMAwater, 2018).

Table 1 - Design Flood Levels (WMAwater, 2018)

Key Reporting Location	18% AEP	5% AEP	1% AEP	PMF
Grant Street on Wrights Creek	4.05	4.53	4.82	6.27
Crossing of Stormwater Pipe upstream of Lake Road on Wrights Creek	2.51	3.07	3.76	5.72

The hydraulic categorisation was undertaken using a combined flow percentage and encroachment analysis for the 1% AEP and 1% AEP with climate change (a rainfall increases of 10% and sea level rise of 900mm). The proposed development is located partially within the floodway, as shown in Figure 4, in the lower reaches of the Wrights Creek catchment. The remaining extent of the subject site is made up of flood fridge and flood storage, with the north-eastern corner flood free within the 1% AEP flood event.

The hazard categorisation for the 1% AEP event is shown in Figure 5. The subject site is classified as Low Hazard through the middle of the site, and increases from medium to High Risk, the closer the site is located relative to Wrights Creek.

The hazard categorization does not significantly change between the 1% AEP and climate change Scenario 1. High hazard occurs on the floodplain over Munster Street and immediate vicinity, to the west of the subject site.

Figure 2 – 1% AEP Peak flood depths and levels from Wrights Creek Flood Study (WMAwater, 2018)

Figure 3 – PMF Peak flood depths and levels from Wrights Creek Flood Study (WMAwater, 2018)

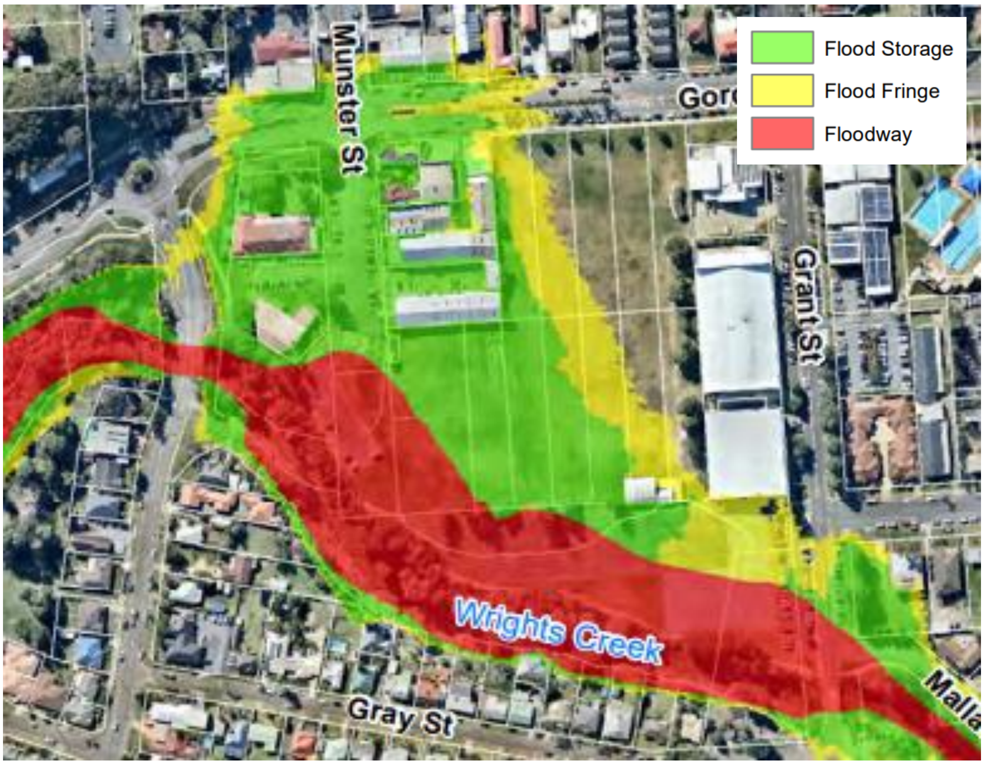

Figure 4 - Hydraulic Categorisation 1% AEP Event from Wrights Creek Flood Study (WMAwater, 2018)

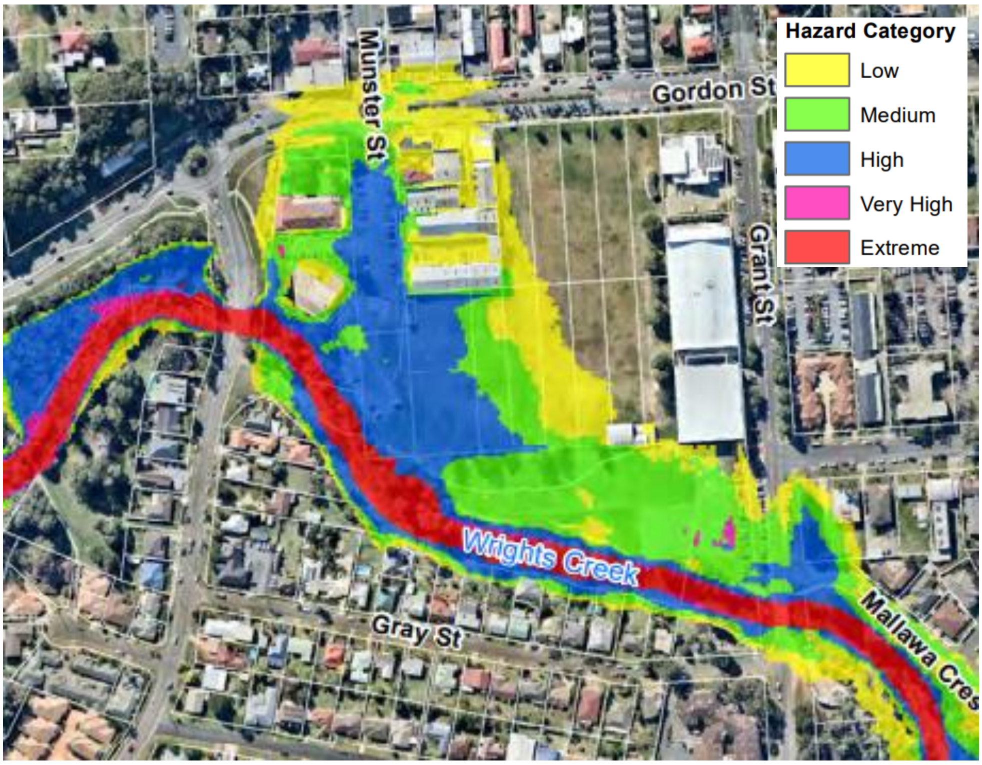

Figure 5 - Hazard Categorisation 1% AEP Event from Wrights Creek Flood Study (WMAwater, 2018)

Methodology

This assessment has been undertaken through the following methodology:

- Desktop review of previous investigation including the Wrights Creek Flood Study Update (WMAwater, 2018), LiDAR elevation data, aerial photography and the stormwater data provided within Council models.
- Delineate the local contributing catchment to the outlet of the proposed development, located in Wrights Creek.
- Site visit to review the existing topography, nearby stormwater infrastructure, land-uses, and surface roughness.
- Analysis of the Council DRAINS model to assess the flows expected through and around the subject site. Modifications to the stormwater data to represent the existing case scenario, using the details of the DRAINS model to provide a guide for further modelling.
- Preparation of a Rainfall on Grid (RoG) existing case two-dimensional TUFLOW hydraulic model to represent the flow behaviour through the subject site using detailed survey, LiDAR elevation data and an estimation of surface roughness using aerial photography.
- Run the Existing Case Model for the 10% AEP, 5% AEP, 1% AEP, 1 in 200 AEP and PMF design storm events.
- Modification of the TUFLOW model to include the proposed layout for the development. Additional amendments to the proposed development to provide mitigation of flood impacts have been included in the design.
- Run the Developed Case Model for the 10% AEP, 5% AEP, 1% AEP, 1 in 200 AEP (considered as a proxy for climate change) and PMF design storm events.
- Run the Existing and Developed Case Models for the 5% AEP, 1% AEP, 1 in 200 AEP and PMF design storm events within the Wrights Creek TUFLOW model to represent the flood behaviour from regional flooding.
- Envelope the local and regional flood behaviour for each of the design storm events modelled, for the existing and developed case scenarios.
- Comparison of the two-dimensional flood depths to review the effects of the proposed development on the flood behaviour within the subject site and in adjacent properties.

A description of the modelling parameters and assumptions, presentation of the results and discussion with respect to compliance with Council's Development Control Plan are presented herein.

TUFLOW Model Parameters

Detailed two-dimensional hydraulic modelling was undertaken using the TUFLOW hydrodynamic modelling software. TUFLOW version 2020-10-AD with HPC GPU solver was used for the assessment. The modelling undertaken to assess a flood behaviour for the 10% AEP, 5% AEP, 1% AEP and 1 in 200 AEP (climate change) and PMF flood events.

Presented below are the hydrological and hydraulic model parameters used to prepare the TUFLOW model.

Hydrological Parameters

The hydrology approach adopted for this assessment is Direct Rainfall on Grid (RoG). Applying rainfall directly to the two-dimensional grid is expected to provide the most realistic representation of the distributed nature of the terrain when compared to traditional one-dimensional approaches.

As per the latest AR&R 2019 guidelines, initial loss, continuing loss, pre-burst, and storm burst rainfall portions of the entire storm event have been considered as part of this study as shown in the below Figure 6.

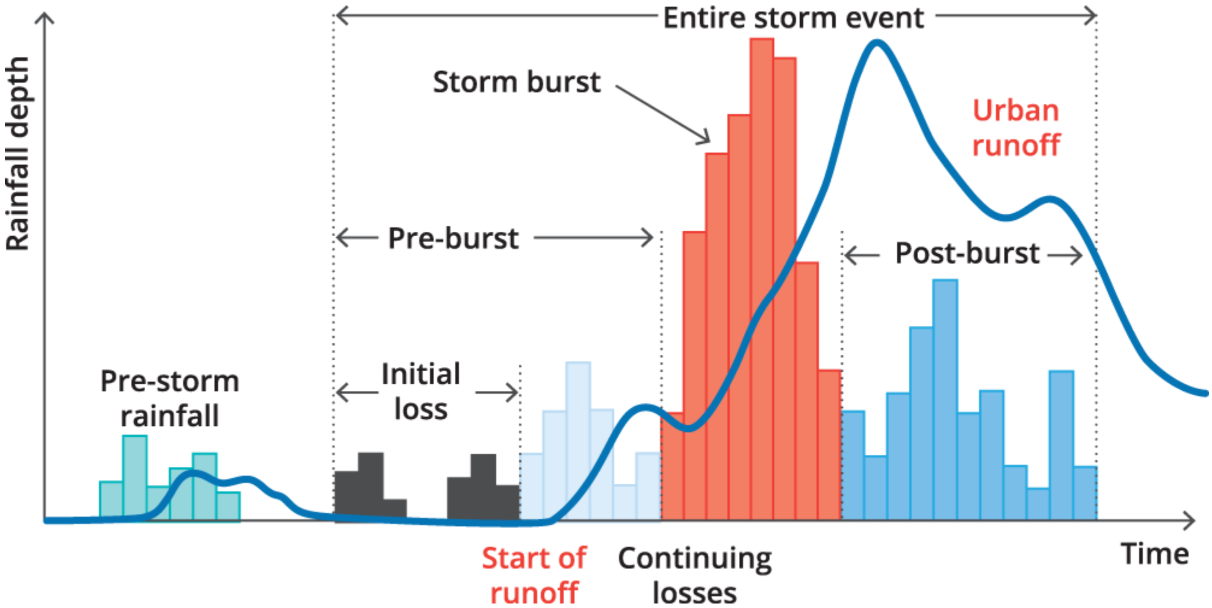

Figure 6 - Rainfall Runoff Processes in Urban Catchments

Burst Rainfall Data

Rainfall Intensity-Frequency–Duration (IFD) depths for the ARR 2019 have been obtained from the Bureau of Meteorology (BOM) for the study area.

AR&R 2019 recommends the use of the storm ensemble method using 10 temporal patterns for each storm duration. For this investigation, storm durations ranging from the 15 minute through to 180-minute events were assessed in the hydrological model for the 10% AEP, 5% AEP, 1% AEP and 1 in 200 AEP design storm events. Similarly, durations ranging from the 15-minute to 6-hour durations were reviewed for the PMF.

A summary of the burst rainfall depths is listed in Table 2 overleaf.

Table 2 - IFD Rainfall Depths

Duration	10% AEP (mm)	5% AEP (mm)	1% AEP (mm)	1 in 200 AEP (mm)	PMF (mm)
10-minute	26.3	30.4	40.2	45.3	-
15-minute	33.1	38.2	50.4	56.7	170
20-minute	38.2	44.2	58.5	65.8	-
25-minute	42.5	49.2	65.3	73.5	-
30-minute	46	53.4	71.1	80.1	250
45-minute	54.5	63.5	85.4	96	320
60-minute	61	71.2	96.5	109	370
90-minute	71.1	83.3	114	128	460
120-minute	79.2	92.9	127	143	540
180-minute	92.3	108	149	168	640
240-minute	-	-	-	-	720
300-minute	-	-	-	-	800
360-minute	-	-	-	-	840

Pre-Burst Rainfall Data

The latest NSW Specific Transformational pre-burst depths have been added from the AR&R Data Hub to the design rainfall events and distributed evenly over the timesteps prior to the burst of the design storm events. The model was run for a range of storm events over a duration between 10 minutes and 3 hours. Modelled pre-burst rainfall depths are outlined in Table 3 below.

Note that pre-burst rainfall for the 1 in 200 AEP and PMF design storm events were not considered. This is considered a conservative approach as initial losses are also excluded from the analysis. This assumes a saturated catchment prior to the application of the full burst depth and therefore a higher peak flow was expected.

Table 3 - Transformational Pre-Burst

Duration	10% AEP (mm)	5% AEP (mm)	1% AEP (mm)
60-minute	25.1	26	30.5
90-minute	23.6	24.1	31.6
120-minute	24.4	25.9	32.5
180-minute	24.9	26.9	32.5

Rainfall Losses

The below Table 4 and Table 5 present the Initial and Continuing losses used for the study. The latest Probability Neutral Burst Initial Losses were obtained from the ARR data hub. Similarly, the latest Office of Environment and Heritage (OEH) guidelines recommend reducing the continuing loss values provided by the ARR Data Hub, by a factor 0.4 for un-calibrated models within NSW. As such, the modelled continuing losses have been reduced accordingly, as the subject site is not located within the extents of a calibrated model.

Table 4 – Infiltration Loss Parameters

Parameter	Initial Loss (mm)	Continuing Loss (mm/hr)
Rural Catchment (ARR Data Hub)	38.0	5.70
Pervious (Modelled)*	Variable	2.30*
Pervious – 1 in 200 AEP and PMF (Modelled)	0	0
Impervious (Modelled)	1.0	0

*Factored by 0.4 from ARR Data Hub Values

Table 5 – Probability Neutral Burst Initial Loss

Storm Duration	10% AEP (mm)	5% AEP (mm)	1% AEP (mm)
10-minute	12.5	11.6	7.1
15-minute	12.5	11.6	7.1
20-minute	12.5	11.6	7.1
25-minute	12.5	11.6	7.1
30-minute	12.5	11.6	7.1
45-minute	12.5	11.6	7.1
60-minute	12.5	11.6	7.1
90-minute	14.0	13.5	6.0
120-minute	13.2	11.7	5.1
180-minute	12.7	10.7	5.1

Two-Dimensional Grid Extent and Timestep

All events were modelled with a grid size of 1m x 1m for the two-dimensional model to represent flows around the buildings and through overland flow paths. The grid extends over an area of 75.5ha from Pacific Drive in the east, to Lake Road in the west. The grid was also extended south to include a greater extent of Wrights Creek. This was undertaken to allow peak flows from the Wrights Creek Flood Study to be applied upstream of the subject site.

TUFLOW HPC Solver (version 2020-01-AA) was used for the analysis with a corresponding minimum timestep of 0.1 second adopted.

Terrain

A combination of detailed survey and LiDAR elevation data has been used to generate the model terrain. The detailed survey was primarily used in the model with LiDAR covering the outer extents of the model and survey of Wrights Creek from Council's model overlayed to show the creek profile. The topography of TUFLOW model is shown in Figure A2.

Across the proposed development, the surface elevation has been modified to represent the design intent. The finished floor levels for each of the buildings within the subject site have been set at 5m AHD in accordance with Council's guidelines. The flood model has represented likely levels through the outdoor areas to facilitate pedestrian accessibility and carparking grades.

The terrain levels through the site were also raised for the proposed carpark to be set at the 5% AEP flood level specified in the Wrights Creek model. As such, the south-western corner of the carpark is at approximately 3.7m AHD, with levels increasing towards the entry of the proposed facility.

Boundary Conditions

Inflows into the two-dimensional model were produced through the Rainfall on Grid hydrology. Rainfall was applied directly to the two-dimensional grid with rainfall losses removed from the model based on the land use assigned to each grid cell.

An outlet head boundary has been entered downstream of the subject site with a static tailwater elevation of 0.45m AHD. This level is based on the information presented in Wrights Creek Flood Study and represents neap tide conditions.

In the developed case model, an additional inflow for the total area through the site, has been applied within the new stormwater network proposed along the eastern boundary of the site, assuming all flows on the roof of the development would be captured. As such, the development extent was represented in DRAINS, and the flows for each of the modelled events were extracted.

Catchment Roughness

To represent the surface roughness within the model, the Manning's 'n' values from the Wrights Creek Flood Study were adopted. These are presented in Table 6.

Table 6 – Mannings 'n' Surface Roughness

Land use Type	Mannings 'n' Value
Grassed Area	0.035
Wrights Creek	0.030
Roads and Hardstand	0.015
Gravel	0.025
Residential (Landscaping Beneath Buildings)	0.070

All buildings in the catchment, external to the subject site, were represented by elevating the surface level by five metres. This allowed rainfall to enter the grid, as opposed to blocking out each of the buildings. This has been done to better represent the flow paths between buildings whilst maintaining the quantity of inflow.

For the proposed development, the building extents are represented as block outs, removing the rainfall applied to those areas of the grid. To ensure the quantity of flows for the site were not under-estimated, a hydrograph for the total blocked area was applied to the stormwater network within the eastern boundary swale.

Hydraulic Structures

The pit and pipe network in the 2D model consists of a variety of stormwater inlet pits, pipes, and culverts. The information used in the model was extracted from the local catchment DRAINS model received from Council, in addition to observations made during the site investigation. These are shown in Figure A3.

The developed case pipes have been designed to capture those flows approaching the site, and discharge directly into Wrights Creek to the south-west of the site. Two additional networks have been added to capture those flows entering the site from Gordon Street and Grant Street. All pipes added to the developed case model are equal to or less than a 600mm diameter pipe, to allow sufficient cover and longitudinal fall through the network.

A swale has also been proposed along the eastern boundary to allow the flows captured across the proposed roof to be discharged freely into, along with a secondary measure to convey approaching flows. The swale capacity has been estimated to convey the 1% AEP flows entering from Grant Street, in assistance with the pit and pipe network. This will be refined at detailed design.

The developed case stormwater infrastructure is shown in Figure A4.

Results

The following is a summary of the flood results for the existing and developed case scenarios, along with the pre to post comparison of the flood behaviour.

Critical Event

To determine the critical storm event for the study focus area, the latest methodology outlined in the AR&R 2019 guidelines was used. This involved the classification of the median value of the ten temporal patterns for each storm duration. From the median values, the duration and temporal pattern that produced the maximum median value for the return period was documented.

Using the DRAINS model, storm durations ranging from 10 minutes to 3 hours were reviewed to determine the critical durations for each of the 10%, 5%, 1%, and 1 in 200 AEP design storm events. The PMF was also reviewed from 15-minutes to 180-minutes. From the model the following critical events were determined for the study area:

- 10% AEP – 30 minutes – Temporal Pattern 10
- 5% AEP – 30 minutes – Temporal Pattern 10
- 1% AEP – 45 minutes – Temporal Patterns 8
- 1 in 200 AEP – 45 minutes – Temporal Pattern 8
- PMF – 45 minutes

These durations were used for both the existing and developed case scenarios presented herein.

Peak Flows

The peak flows for the subject site and the surrounding catchment are presented in Table 7. The location of the flow lines which these have been extracted is shown in Figure A5.

Table 7 – 1% AEP Peak Flows

Location	1% AEP Flow (m^3/s)	
	Existing	Developed
Gordon Street (Upstream of Subject Site)	7.62	7.62
Grant Street	1.87	1.87
Munster Street	13.20	12.72
Subject Site (Frontage to Gordon Street)	1.76	0.34
Subject Site (Traversing the Site)	3.06	1.16
Gordon Street (Downstream of Subject Site)	7.46	7.07
Through Buildings West of Subject Site	0.09	-

Existing Flood Behaviour

The existing case flood depth and elevation contours during the 10% AEP, 5% AEP, 1% AEP and the PMF are presented in Figures B1, B2, B4, B6 and B7 of Appendix A.

The results show overland flow entering the subject site via Grant Street in the east, and Gordon Street to the north, which occurs when the stormwater infrastructure within the road network reaches capacity and overtops the kerb. These flows traverse the site in a south-westerly direction before discharging into Wrights Creek.

Figure B1 represents the local catchment flood behaviour for the 10% AEP flood event. This shows the subject site is inundated by depths up to 65mm in the northern corner of the site and reaches depths up to 330mm in the south-western corner.

For the remaining events, an envelope of the local and regional model results was used to represent the 'worst case' flood behaviour across the site. Whilst it is unlikely that these events occur concurrently, the full extent of flooding for the subject site was examined.

During the 5% AEP and 1% AEP event, the flood level across the site is in the order of 3.4 to 5.2m AHD and 3.9 to 5.3m AHD with a maximum flood depth of approximately 1.0m and 1.5m observed in the south-western corner of the site. These values were taken outside of the Wrights Creek extent, as the south-west corner of the site is located within the floodway. Within the PMF, the site is inundated by depths up to 3.3m, resulting in the flood elevation across the site at approximately 5.9m AHD.

Flood hazard figures for the 5% AEP and 1% AEP, and PMF design storm events are presented in Figures B3, B5 and B8 of Appendix A. Flood hazard is based on the latest Australian Rainfall and Runoff Guidelines with the hydraulic behaviour and pedestrian, vehicle and building thresholds summarised for each category below in Figure 7.

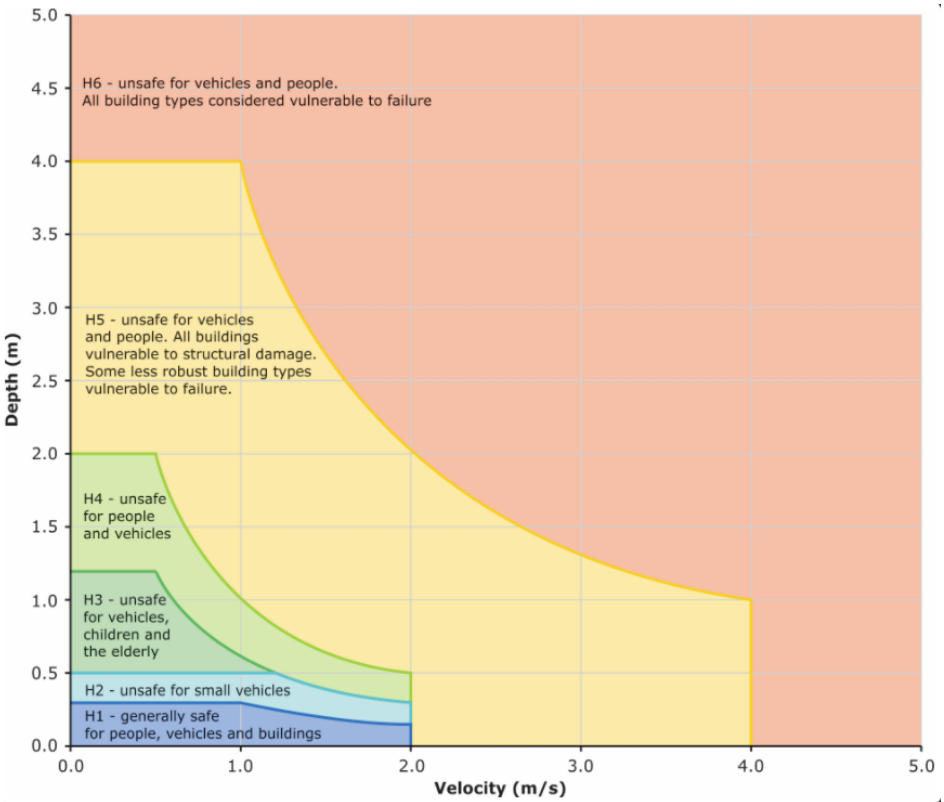

Figure 7 – Australian Rainfall and Runoff (2019) Hazard Categories

The 5% AEP flood hazard for the subject site ranges from H1 in the north-east, to H3 in the south-west. Munster Street and Gordon Street are both shown as hazard H3, and above which provides no evacuation route from the existing subject site via vehicle.

Similarly for the 1% AEP, the site is predominantly H1 with increases to H4 and H5 in the south-west corner. These hazards indicate the frontage along Gordon Street is safe for pedestrian use, however access via Munster Street is unavailable. In the PMF, the existing case flood hazards ranges from H3 to H6 across the site with the hazard severity increasing in the proximity of Wrights Creek. This is unsafe for pedestrians and vehicles.

Developed Flood Behaviour

The developed case scenario contains Stage 1 and 2 of the proposed facility. The model incorporates each of the hydraulic structures discussed in the previous section of the report, in addition to a 600mm retaining wall along the plant access perimeter in the north-east corner. Swales have been used along the east and northern boundaries to convey flows entering the subject site, and a designated flood storage area to the south-east of the site has also been modelled. To ensure the existing netball building to the south of the site is not impacted by increased flood levels through the southern area of the site, a small bund has been included in the model.

Figures presenting the flood depth, elevation and hazard are included in Figures C1 to C8 of Appendix A. The development is proposed to be set at a level above the 1% AEP plus 500mm freeboard, in accordance with Council requirements. As such, each of the proposed buildings within the subject site are blocked out, and all facilities and adjoining areas at set at 5m AHD.

Overland flows entering from Grant Street to the east has been captured within a proposed swale and is discharged into the open space south of Stage 2. This was integrated in the developed case model to reduce the potential for adverse flood impacts in adjacent public and private properties.

For flows entering the site from Gordon Street, the proposed stormwater infrastructure in the landscaped area captures the flows which traversed the site in the existing case model. In addition to the proposed stormwater infrastructure, a shallow swale has also been proposed along the northern boundary, capturing additional flows.

During the 10% AEP flood event, the subject site is inundated by depths up to 130mm in the northern corner of the site and reaches depths up to 315mm in the south-western corner. An increased depth is shown in the northern corner, as flows have been captured in the proposed swale along the Gordon Street Frontage. The flood elevation across the site ranges from 2.4m AHD to 5.1m AHD. This is presented in Figure C1.

During the 5% AEP and 1% AEP event, the maximum flood behaviour is similar to the existing case model, with the flood level across the site is in the order of 3.4 to 5.1m AHD and 4.0m to 5.2m AHD. A summary of the developed case 1% AEP flood behaviour is summarised in Table 8 overleaf. Figure A5 shows the locations of the information presented. Within the PMF, the site is inundated by depths up to 3.4m. The flood elevation within the PMF ranges from 5.8 to 6.0m AHD throughout the site.

Through the subject site the extent of flooding is reduced as the flows entering the site are captured and conveyed within the proposed stormwater network. This reduces the likelihood of having impacts on the surrounding properties.

Flood hazard figures for the 5% AEP, 1% AEP, and PMF design storm for the developed case scenario are presented in Figures C3, C5 and C8 of Appendix A.

The 5% AEP and 1% AEP flood hazard for the subject site ranges from H1 in the north-east, to H3 in the south-west. The majority of the proposed carpark location is located above H2 remaining safe for pedestrians and vehicles however, whilst vehicles would be safe if located onsite, an evacuation route is not available with Munster Street and Gordon Street showing hazards in excess of H2, as shown in the existing case model. The hydraulic hazard across the subject site ranges from H3 to H5 in the PMF, with hazard severity increases in the proximity of Wrights Creek, similar to the existing case model.

Table 8 – 1% AEP Flood Behaviour Developed Case

	Location	Flood Depth (m)	Flood Elevation (m AHD)	Flood Hazard
1	North-east Corner - Substations	0.13	5.29	H1
2	Service Yard Entry	0.01	5.00	H1
3	50m Pool Entry	0.68	4.24	H1
4	Gordon Street Bus Entry	0.17	4.08	H1
5	Munster Street Entry Road	1.25	3.95	H4
6	Swale along Eastern Boundary	0.58	5.30	H3
7	Main Entry	-	-	-

Flood Impacts

Pre to Post Comparison – Flood Elevation

A comparison of the 10%, 5%, 1% and 1 in 200 AEP existing case scenario with the developed case option has been completed for the site specific TUFLOW model. This was undertaken to determine the extent of the impacts for the pre to post development conditions and ensure the flood immunity to the surrounding properties is not impacted by the proposed development, in accordance with Council requirements. The result is presented in Figures D1, D3, D5 and D7 of Appendix A.

The 10% and 5% AEP flood events show an increase of 20mm and 14mm within Munster Street, and an increase of 18mm and 31mm in Wrights Creek, respectively. Any additional increases are contained within the subject site. Conversely, the proposed stormwater network reduces the flows across Gordon Street, with decreases up to 30mm and 35mm for the 10% and 5% AEP flood events pre to post.

Similarly, the 1% AEP pre to post flood elevation comparison shows decreases along Gordon Road, with the proposed swale capturing flows which enter the site and convey into the proposed stormwater network. There is a small area of increase on the property east of the development. Whilst the increase exceeds the 10mm commonly adopted by Council as “no change”, this does not impact the flood immunity of the development, with the increase contained at the foot of the ramp, and no entryways in the immediate vicinity of the increased flood level. An additional increase is shown within Munster Street, up to 14mm. The increase is contained within the road, with the proposed development reducing the flows over the western boundary into the existing buildings.

In the 1 in 200 AEP an increase of 10mm is shown within Munster Street, and an increase up to 17mm downstream of the site in Gordon Street. Additional flows are observed in Gordon Street as the proposed swale has been sized to convey the 1% AEP flood event, and therefore is not expected to capture all flows onto the site in the 1 in 200 AEP flood event.

All remaining increases are contained within the subject site, Wrights Creek, and road corridors, and ultimately do not increase the hydraulic hazards through this area. Through conveying more flow through the developed model, the impacts of the proposed development are mainly observed through the terrain modifications within the subject site, including the proposed swales and designated flood storage area, with the existing flow paths redirected.

Pre to Post Comparison – Flood Velocity

Similarly, a pre to post comparison of the 10%, 5%, 1% and 1 in 200 AEP flood velocity was undertaken and is presented in Figures D2, D4, D6 and D8. The variable relationship between depth and velocity is important in determining the associated hazard and safety criteria for the flood conditions.

Increases in the flood velocity for each of the flood events is largely reflected in the areas where terrain modifications have been made to create concentrated flow paths. In the existing case, Macquarie Park allows flows entering the subject site to sheet across the extent of the field. However, as flows are constricted to dedicated swales through the proposed development, higher velocities occur.

The impacted areas are consistent in each of the events modelled, with increases to the south of the proposed development, to the west of the proposed carpark, and in the kerb and gutter along Munster Street and Gordon Street. An increase greater than 1.0m/s is observed to the south of the proposed development due to the terrain modifications and the use of this area as a ‘vegetated swale’ to convey all flows entering the site from the east and traversing across to Wrights Creek. Despite this increase, the velocity magnitude is less than 1.5m/s which is lower than the erosive threshold for grass.

Climate Change Sensitivity

The 1 in 200 AEP was run as a proxy for the climate change assessment. A comparison of the 1% AEP and 1 in 200 AEP developed case flood depth was undertaken and shows increases in the vicinity of the subject site are generally less than 52mm upstream of the development and less than 180mm downstream of the subject site within the extents of Wrights Creek. The result of the proposed development is presented in Figures E1.

Discussion

Flooding Mechanisms

The site is subject to flooding from two mechanisms overland flow from the local catchment and mainstream flooding from Wrights Creek. The local catchment flows have been assessed by the Rainfall on Grid model, whilst the mainstream flood behaviour has been extracted from the Wrights Creek TUFLOW model undertaken by WMAwater for the Wrights Creek Flood Study (2018).

Whilst it is not expected that the peak events would occur concurrently, an envelope of the local and regional flood results has been undertaken to demonstrate the 'worst case' flood impacts across the subject site. This was conducted for the 5% AEP, 1% AEP, 1 in 200 AEP, and PMF flood events, and represents the peak flood behaviour for each event using the maximum value.

Evacuation Route

In both the existing and developed case flood models, is it evident that evacuation via Gordon Street and/or Munster Street are not feasible due to the flood hazard exceeding H1 in both scenarios. For each of the design events modelled, ranging from the 10% AEP to the PMF, evacuation via road is not achievable. If occupants become stranded on the site, there is potential for evacuation, by foot, via Grant Street in the east. This is shown as equal to or less than H2 in the 1% AEP which is safe for pedestrians.

To facilitate the use of Gordon Street as an evacuation route, the existing stormwater network would require upgrading.

Response to Pre-DA Advice

A summary of the pre-lodgement meeting advice, received on 1st May 2023, and how these have been addressed in regard to flooding on the proposed development, is provided in Table 9 below.

Table 9 – Pre-DA Advice

Requirement	Response
Planning	
Site is located within the flood planning area. Provisions of clause 7.3 of LEP 2011 to be addressed	Clause 7.3 of the Port Macquarie-Hastings LEP 2011 has been repealed. Further flooding provisions have been addressed in Table 16.
Flood	
A detailed Flood Impact Assessment (FIA) & Flood Risk Assessment (FRA) will be required for any development located within the floodplain. The FIA & FRA will need to demonstrate that the development is capable of compliance with the provisions of the Flood Policy (2018), or any subsequent versions adopted by Council.	This report includes a Flood Impact Assessment and Flood Risk Assessment in accordance with this requirement.
The FIA & FRA will need to be prepared by a suitably qualified flood engineer, as per the requirements of section 8.5 of the Flood Policy and be prepared in accordance with the	This report has been prepared and verified by a suitably qualified flood engineer.

Requirement	Response
requirements of section 8.3 & 8.4 of the Flood Policy.	
A large portion of the site is classified as a 'Floodway' under the Wrights Creek Flood Study (2018). This area should be avoided where possible for development as a result of the high-risk nature of this area of the floodplain. Certain 'open' developments (carparks, roads/ driveways, open space recreation etc) maybe permitted in this area subject to suitable analysis and demonstrating no off-site impacts and an acceptable level of risk	The proposed layout of the development has considered the flood extent of Wrights Creek, with a large portion of the development positioned outside the 1% AEP flood extent. The carpark and entry/exit roads have been raised according to the FPL1 (5% AEP Wrights Creek flood level). As such, the carpark has been set at 3.7m AHD, 240mm above the level specified by Council in December 2019.
Preliminary modelling indicates that whilst carparking is lifted to FPL1, that the area is unsafe during a 1% event. Further investigation and design is recommended to assess whether there are any feasible options available to modify this area so that hazard category is raised to H1?	The proposed carpark has been raised to reduce the extent of flooding which occurs in the 1% AEP flood event and limit the risk onsite during major flood events. As such, only a small portion of the carpark exceeds hazard category H1, with most of the carpark flood free or at H1. It is important to note that within the vicinity of the subject site, the proposed carpark provides the greatest area of refuge in the 1% AEP flood event, with both surrounding roads in excess of H1 and unsafe for both pedestrians and vehicles.
The proposed development results in filling of Flood Storage/Floodway - in accordance with Flood Policy Requirements, additional difference modelling required to confirm that the impact is less than 10mm on peak Flood levels, and less than 0.1m/sec on Flood velocities, over the full range of Floods up to the 200-year ARI, within/ at the property boundary. Current modelling focuses on depth only and the 1% event only.	As shown in Figures D1 to D8, an analysis of the flood elevation and velocities have been explored for events ranging from the 10% AEP to the 1 in 200 AEP (200-year ARI) flood event. Within these figures, the flood elevation increases exceed 10mm within Munster Street in each of the events modelled. However, these increases are mainly contained within the road reserve, and therefore are not expected to have adverse impacts on the flood immunity of surrounding properties. Additionally, increases are shown between the southern boundary and the existing netball courts. This has been nominated in the design to act as a vegetated swale and convey flows in major rainfall events. Therefore, this impact is considered negligible. The flood velocity also exceeds 0.1m/s for each of the events. This is shown in Gordon Street and Munster Street, however, is contained primarily within the kerb and gutter.

Flood Risk

Effective Warning Time

Effective warning time is the time available for people to undertake appropriate actions, such as evacuating. A reduced warning time increases the potential for the exposure of people to hazardous flood situations. The ability to deliver effective flood warning to communities can be limited by a range of factors, including the response time of the catchment and the availability of a total warning system for flooding for the area.

As the subject site is impacted by two flooding mechanisms, the effective warning time for the subject site can range from a few days in advance or may be significantly shorter depending on the alerts received from services such as the BOM. As the site is impacted by flash flooding from the upstream local catchment, there is a potential for floodwaters to rise quickly, and no effective warning time to be available.

Flood Readiness

The preparation of a Flood Emergency Response Plan (FERP) should be developed to provide the employees and visitors with information readily available in the event of a predicted major or extreme rainfall event. The FERP should outline the flood behaviour as presented in this report, warning notifications, and the evacuation limitations and emergency procedures to be followed.

Rate of Rise of Floodwaters

A rapid rate of rise can lead to people who are evacuating being overtaken or cut-off by rising floodwaters. It is often associated with high velocities, but it can be an issue if access routes are affected by flooding. Due to the nature of the catchment, the floodwaters will peak within hours of rainfall commencing, with the maximum rate of rise expected to be approximately 0.25m in 45 minutes for the 1% AEP and 0.5m in 25 minutes during the PMF critical events.

Duration of Flooding

Overland flooding in the study area is generally a result of intense short-duration rainfall events. As a result, the duration of inundation of roads and built areas is typically short, limited to up to 4 hours in up to the PMF event, specifically in flood storage locations.

Note that the duration of flooding for depths greater than 0.3m, at which stage floodwaters become impassable for most passenger vehicles, is generally limited to approximately 1.5-hour duration in most roads surrounding the proposed development.

Furthermore, a relatively short duration of inundation is also expected at the site with the local TUFLOW model indicating the duration of the event will occur in the order of 3 hours during the 1% AEP flood event. This is estimated as the time in which the flood depth and velocity return to a stable level corresponding to a H1 flood hazard. This hazard classification allows vehicles to safely return home.

Evacuation Issues

It is expected the facility would have limited occupants in the event of a major or extreme rainfall event, given the nature of the proposed development. However, in the event rainfall commences whilst personnel and visitors are onsite, the limited warning time and rate of rise in flood waters, heavily impacts the evacuation paths, as trafficable flood access is limited.

The hazard surrounding the site in all events modelled indicates the subject site access exceeds H2 in all events greater than the 10% AEP, via both Gordon Street and Munster Street. Whilst occupants could self-evacuate via foot, floodwaters surround the subject site.

A Flood Emergency Response Plan should be undertaken to provide information relative to the evacuation routes and onsite refuge.

Effective Flood Access

Flood access relies on the ability to predict flooding and warn occupants of the need to evacuate prior to a flood event.

It is noted that for the proposed development, pedestrian and vehicular access is available along the Gordon Street frontage within the isolated regional flood event, however, in the event of local catchment flooding, as represented in the site-specific flood model, vehicular access becomes unavailable for all events in excess of 5% AEP.

Type of Development

The proposed development is classified as recreational, as per the land use categorisation of the flood policy. The existing development in the floodplain is open space, with the surrounding lots largely residential, with some areas of commercial, industrial, and special land uses.

Flood Hazards

The flood hazard for the subject site has been quantified in the TUFLOW model, as reported within this report. The flood hazard is high in the vicinity of the subject site, with H5 hazard on both Munster Street and Gordon Street and Church Streets, in the existing 1% AEP event.

Existing Risk

The following potential risks from the flood hazard were identified in the existing condition and is presented below in **Table 10**. Whilst the existing subject site is an open space, there is an associated risk with the subject site. This has been determined in accordance with Chapter 6 of the Australian Disaster Resilience *Managing the Floodplain (2017)*.

Table 10 – Existing flood risk analysis

Item	Likelihood	Consequence	Risk Rating
Illness due to contact with contaminated floodwater	Rare to Very Rare	Moderate	Medium
Structural damage causing economic loss	Extremely rare	Insignificant	Very low
Loss of life	Extremely rare	Catastrophic	High

Developed and Residual Risk

Mitigation measures proposed in the design, and potential mitigation measures that could be implemented for the development are presented below in **Table 11**.

Table 11 - Mitigation Measures

Item	Mitigation Measures
Illness due to contact with contaminated floodwater	It is expected that floodwaters entering the site from Wrights Creek and the local stormwater collection from Gordon and Grant Street, will be largely confined to areas such as the carparks, entryway and landscaped areas. As such, the materials which are used through the proposed development flow paths are to be flood compatible to allow for easy cleaning following a flood event.
Structural damage causing economic loss	The proposed developed will be constructed on materials which can withstand the forces due to floodwater and debris impact. This will reduce the likelihood and consequence of structural damage in the developed case.
Loss of life	The likelihood of loss of life has the potential to be reduced through implementation of a Flood Emergency Response Plan. Principles of any response plan centres around - awareness, preparation, and appropriate response.

Following implementation of the proposed mitigation measures, the residual developed risk analysis is presented below in Table 12. A risk matrix showing the existing and residual risk comparison is presented in Table 13.

Table 12 – Developed residual risk analysis.

Item	Likelihood	Consequence	Risk Rating
Illness due to contact with contaminated floodwater	Rare to Very Rare	Moderate	Medium
Structural damage causing economic loss	Extremely rare	Moderate	Low
Loss of life	Extremely rare	Catastrophic	High

Table 13 - Risk matrix

Likelihood	AEP Range (%)	Consequence: Insignificant	Minor	Moderate	Major	Catastrophic
Likely	>10					
Unlikely	1 to 10					
Rare to very rare	0.01 to 1			Floodwater (E+D)		
Extremely rare	<0.01	Structural damage (E)		Structural damage (D)		Loss of life (E + D)

Note: Developed risk (D) Existing risk (E)

Risk: Very low Low Medium High Extreme

Compliance with Planning Controls

This section discusses the planning controls that apply to the proposed development.

Flood Policy

The Port Macquarie-Hastings Council's Flood Policy, effective December 2018, outlines the considerations to be made by Council in exercising its environmental assessment and planning functions in relation to development in the Port Macquarie Hastings Local Government Area. Using the information provided in the Floodplain Development Manual (2005), the flood risk to occupants can be managed and minimise the flood damages and impacts to adjacent properties.

Council specifies the different Flood Planning Level Categories, based on the land use of the proposed development. These are presented in Table 14 . The relevant FPLs for the development have also been included, as extracted from the Wrights Creek model (2018). The proposed development is classified as a commercial facility, and as such, the flood planning level is as follows:

"FPL2 with 25% of the ground floor plan area to be at or above FPL3. Consideration will be given to a lower floor level in limited circumstances where mobility access standards are to be met and where compatibility with existing street frontages is required. The absolute minimum floor level will be FPL1."

Table 14 - Flood Planning Level (FPL) Categories

Category	Proposed – FPL Category Description	Wrights Creek FPL (m AHD)
FPL1	5% AEP Flood level (No allowance for Climate Change, No Freeboard)	3.46
FPL2	1% AEP Flood level + Climate Change Allowance (No Freeboard)	4.10
FPL3*	1% AEP Flood level + Climate Change Allowance + 500mm Freeboard (FPA)	4.60
FPL4	Probable Maximum Flood (PMF) level	5.72

Within the Port Macquarie-Hastings Flood Policy, the FPL makes up one component of the prescriptive controls. These controls apply a particular Flood Risk for each type of development, with those applied to the aquatic facility summarised in Table 16 overleaf. The requirements vary depending on the hydraulic classification and flood hazard conditions on the property.

The flood policy provides an outline for the different hydraulic categories of the floodplain, including floodway, flood storage and flood fringe areas. It highlights the type and nature of development which is allowed according to the hydraulic classifications on the property. The policy states filling of flood storage is not encouraged however may be considered depending on the results of flood investigations showing no adverse impacts from adding in the proposed development.

The hazard category is categorised according to a combination of the flow velocity and the depth of floodwater and the degree of difficulty for pedestrians, vehicles and infrastructure. From the 2007 Wrights Creek Flood Study, and the updated study in 2018, the 1% AEP flood hazard was classified as high in the south-western corner and reduces to low through the proposed location of the carpark. The flood hazard categorisation system adopted in the flood policy and differed from the hazard categorisation system recommended in Australian Rainfall and Runoff 2019. The flood hazard mapping prepared in the site-specific flood model follows the ARR 2019 system.

Given the predominant nature and the location of the subject, the controls for the subject site have been adopted as flood storage. This is supported by the 2007 Wrights Creek model. As such, the following Table 15 was adopted:

Table 15 – Prescriptive Controls for Development in Flood Storage Areas

Prescriptive Control	Requirements	Responses
Floor Levels	At least 25% of the ground floor level area for Commercial and Industrial Development must be at or above FPL3. The remaining 75% of the floor level area can be sited at or above FPL2. Where multiple units are proposed as part of an industrial or commercial Development, at least 25% of the ground floor level of each unit must be at or above FPL3. The application must demonstrate the feasibility of moving bulky or heavy items to the raised area.	The proposed development has been set at 5m AHD, which is above the 1% AEP flood level plus 500mm as documented in the Wright's Creek Flood Study
Flood Proofing	Flood Proofing must be provided to all aspects of the proposed Development up to FPL3	The proposed development has been set at a level higher than FPL3, as specified from the Wrights Creek Flood Study. The materials used for construction should be flood compatible.
Flood Impact on Other Properties	Where Development will take place in a designated Flood Storage Area, the applicant is required to demonstrate that the impact on peak 100-year ARI Flood levels is less than 10mm, and on peak 1% AEP flood velocities is less than 0.1m/sec, at the property boundary. Where practical, excavation and other works may be proposed to address this requirement, although this is unlikely in an urban environment. Any Development must ensure that existing overland flow paths are not impeded. Additional drainage infrastructure may be required to achieve this objective.	The proposed development involves filling in an existing flood storage area for major and extreme rainfall events. To compensate for the loss of storage a combination of stormwater infrastructure upgrades and a designated flood storage area has been integrated into the development. There is an increase up to 14mm in Munster Road, as shown in Figure D1 however, this is not expected to impact any of the surrounding lots.
Site Access and Flood	Council will only support Commercial/Industrial Development where Effective Warning Time and	Due to the nature of the local catchment, an effective warning time may not be feasible.

Prescriptive Control	Requirements	Responses
Evacuation Requirements	reliable access is available for evacuation. Developments will be required to demonstrate that evacuation through low hazard conditions during the early warning period of a Flood is achievable. A minimum 8-hour Effective Warning Time must be available to a particular site. The applicant is encouraged to liaise with Council to establish whether a Flood Risk Assessment is required for the proposed Development. Where available, the Flood Risk Assessment must consider evacuation times documented in Emergency Response Management Community Data Sheets. These are typically available in completed Floodplain Risk Management Study Reports. Safe Reliable Evacuation must be provided from the site to land above the PMF, preferably to an approved Flood Evacuation Centre. Evacuation must be assessed for stability in accordance with Australian Rainfall and Runoff (AR&R) Book 9, Chapter 6 - Safety Design Criteria (2013). Evacuation plans must be independent and not rely on others (SES) to ensure safe and reliable evacuation.	Whilst it is not available for the flash flooding catchment, the proposed development is set above the Wrights Creek catchment flood level.

Local Environment Plan

The Council LEP requirements have been addressed in Table 16 below.

Table 16 – Port Macquarie-Hastings Local Environmental Plan (2011)

Requirement	Response
5.21 Flood Planning	
(1) The objectives of this clause are as follows	
(a) to minimise the flood risk to life and property associated with the use of land,	The proposed development has been set at the floor levels in accordance with the FPL3, with respect to risk to property. Risk to life mitigation measures are discussed further in Items 2(c) and 2(d) below.
(b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change,	This is discussed in Item 2(a) below.
(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,	The proposed development is not expected to significantly impact other properties within the surrounding environment. Additional stormwater infrastructure has been implemented to capture the flows which traverse the site in the existing case. This minimises the impacts of the reduced flood storage across the subject site. On this basis we do not believe it will contribute to cumulative impacts.
(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.	The proposed development is subject to flash flooding and short flood durations. On-site refuge can be provided to wait out these events.
(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development	
(a) is compatible with the flood function and behaviour on the land, and	The site is not affected by a floodway however is located with the flood storage area for Wrights Creek. The flood storage through the site in events in excess of the 5% AEP is maintained through the positioning of the carpark along the south-western edge of the site. On this basis, the development is considered compatible with the flood function and behaviour.
(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and	As presented in the Flood Section of this report, the proposed development is not expected to adversely affect adjacent properties during the 1% AEP design storm event. The proposed development will integrate appropriate

Requirement	Response
	measures to limit the adverse impacts on surrounding developments/properties.
(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and	The proposed development is subject to flash flooding and short flood durations. On-site refuge can be provided to wait out these events.
(d) incorporates appropriate measures to manage risk to life in the event of a flood, and	Flood Planning Levels and flood protection for the proposed development are discussed with the report, as per the Flood policy. On-site refuge is provided within the subject site. The proposed development is expected to reduce flood inundation across the subject site during the developed case scenario, therefore reducing risk to life due to flooding. It is considered feasible to implement a Flood Emergency Response Plan as part of the development to increase the awareness of flood risks, identify persons responsible for emergency response, and recommend actions to prepare and respond to a flood emergency.
(c) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses.	The proposed development is located outside the extent of Wrights Creek, and therefore is not changing the existing conditions through the watercourse. The implementation of stormwater controls through the subject site will reduce concentrated flows traversing the site, limiting the erosion potential of the development. Therefore, the proposed development is not expected to cause any increases in erosion or siltation downstream, destruction of riparian vegetation, or reduction in the stability of riverbanks or watercourses.
(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters	
(a) the impact of the development on projected changes to flood behaviour as a result of climate change,	It is not expected that the proposed development will create significant adverse impacts on the flood behaviour for surrounding properties. The proposed development has been set above the FPL3 level, which considers the impacts of climate change. Therefore, the small change in the 1 in 200 AEP flood event, as shown in Figure D2, the impact is deemed negligible.
(b) the intended design and scale of buildings resulting from the development,	By others.

Requirement	Response
(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,	Onsite flood refuge is an appropriate measure to manage the risk to life. Furthermore, it is considered feasible to implement a Flood Emergency Response Plan as part of the development to increase the awareness of flood risks, identify persons responsible for emergency response, and recommend actions to prepare and respond to a flood emergency
(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.	Given the context of the site it is unlikely to be significantly impacted by coastal erosion.
7.4 Floodplain risk management	
(1) The objectives of this clause are as follows	
(a) in relation to developments with particular evacuation or emergency response issues—to enable the evacuation of land subject to flooding above the flood planning level,	The subject site has been developed at the FPL specified within the Flood Policy. As such evacuation to an area above the FPL can be achieved safely.
(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.	The operational capacity of emergency response facilities would not be heavily impacted by the proposed development. The proposed aquatic facility would be expected to have minimal visitors onsite if significant rainfall is expected, and those remaining onsite once rainfall has started are located at the FPL. It is expected, any items required during this time, would be available onsite, limiting the impact on emergency response facilities
(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development incorporates appropriate measures to manage risk to life from flood—	
(a) caravan parks, (b) correctional facilities, (c) emergency services facilities, (d) group homes, (e) hospitals, (f) residential care facilities, (g) tourist and visitor accommodation.	Not applicable.

Development Control Plan

The Port Macquarie-Hastings Development Control Plan 2013 outlines the following objectives in Hazard Management B3 Section 19. These provisions must comply with the Floodplain Management Plan and Flood policies of the Port Macquarie-Hastings Council.

Table 17 - Port Macquarie-Hastings Development Control Plan (2011/2013)

Requirement	Response
To maintain the existing flood regime and flow conveyance capacity.	The proposed development has been designed to maintain the existing flow regime, with stormwater infrastructure proposed to capture the flows which previously traversed the site and discharge into Wrights Creek.
To enable evacuation of land subject to flooding	The proposed development will be set at the FPL indicated by the Flood Policy and is expected to provide onsite refuge when necessary. Therefore, evacuation from the site should not be required in the event of a flood. The development is to have a Flood Emergency Response Flood Plan prepared for the site to ensure flood risk is managed appropriately.
To avoid significant adverse impacts on flood behaviour.	The proposed developed is not expected to create adverse impacts on surrounding properties. Increases are shown to the south of the development, as additional flows are conveyed however, this is not expected to impact any properties.
To avoid significant adverse effects on the environment that would cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of the riverbanks or watercourses	The proposed development layout has been designed within the north-eastern section of the site, as far from the Wrights Creek watercourse as possible, to limit the potential for erosion, siltation or destruction of the riparian corridor, as a result of the development.
To limit uses to those compatible with flow conveyance function and flood hazard.	The flow conveyance and flood hazard has been considered in the design of the proposed development.
To limit the cost of evacuation on the general public	The proposed development is not expected to have adverse impacts on the general public in the event of a major or extreme rainfall event. In the event of flooding from Wrights Creek, early evacuation can be achieved, and not impact the general public.

Conclusion

Northrop Consulting Engineers have been engaged to prepare a flood impact assessment and flood risk assessment for the proposed aquatic centre development at Macquarie Park, Port Macquarie.

This study has reviewed the existing flood extents across the subject site, the flood impact of the proposed development as well as the development compliance with Port Macquarie-Hastings Council Flood Management Controls. The model parameters and assumptions made throughout the model have been discussed, and the results for the 10% AEP, 5% AEP, 1% AEP, 1 in 200 AEP, and PMF design storm events have been presented in the above correspondence.

From this analysis, it was determined the proposed development has negligible impacts on the local and regional flood behaviour.

Should you have any queries, please feel free to contact the undersigned on (02) 4943 1777.

Prepared by:

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Appendix A – Flood Figures

Legend

Subject Site

0 100 200 Metres

1:7,500.000008

Figure A1 [A]

Subject Site Locality

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

24/10/2023 X:\PROJECTS\SYDNEY\2020 Jobs\SY202382 - Port Macquarie Aquatic Centre\spatial\FIGURES\QGIS Project\230823\230823_PMAF_Figures.qgz230823_PMAF_Figures.qgz

Data Source:

Legend

Subject Site

Topography (m AHD)

- <= 2.0
- 2.0 - 4.0
- 4.0 - 6.0
- 6.0 - 8.0
- 8.0 - 10.0
- 10.0 - 12.0
- 12.0 - 14.0
- 14.0 - 16.0
- 16.0 - 18.0
- 18.0 - 20.0
- 20.0 - 22.0
- 22.0 - 24.0
- 24.0 - 26.0
- 26.0 - 28.0
- > 28.0

0 70 140 Metres

1:4,000.000004

Figure A2 [A]

TUFLOW Model Topography

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

24/10/2023 X:\PROJECTS\SYDNEY\2020 Jobs\SY202382 - Port Macquarie Aquatic Centre\spatial\FIGURES\QGIS Project\230823\230823_PMAF_Figures.qgz230823_PMAF_Figures.qgz

Data Source:

Legend
- Subject Site
- Model Extent
- Existing Buildings
- 2D Outflows
- Existing Stormwater Pits

Existing Stormwater Pipes
- C
- R

Manning's Roughness
- Creek (0.030)
- Residential (0.070)
- Grassed Area (0.035)
- Roads (0.015)
- Hardstand (0.025)
- Overbank (0.100)

0 70 140 Metres

1:4,500.000005

Figure A3 [A]

Existing Case
TUFLOW Model Setup

Port Macquarie
Aquatic Centre
SY202382-01

NORTHROP

Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings
- 2D Outflows
- Existing Stormwater Pits
- Proposed Stormwater Pits

Existing Stormwater Pipes

- C
- R

Proposed Stormwater Pipes

- C
- R

Manning's Roughness

- Creek (0.030)
- Residential (0.070)
- Grassed Area (0.035)
- Roads (0.015)
- Hardstand (0.025)
- Overbank (0.100)

0 10 20 Metres

1:1,000

Figure A4 [A]

Developed Case
TUFLOW Model Setup

Port Macquarie
Aquatic Centre
SY202382-01

NORTHROP

Legend

Subject Site

Proposed Development

Flood Levels

Peak Flow Locations

1
2
3
4
5
6
7

0 10 20 Metres

1:1,000

Figure A5 [A]

Subject Site
Key Reporting Locations

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- 0.025 - 0.030 (Cut-Off Depth)
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure B1 [A]

Existing Case
10% AEP Flood Depth and Elevation
Local Catchment w/ Neap Tide Tailwater

Port Macquarie
Aquatic Centre
SY202382-01

NORTHROP

Legend

- Subject Site
- Model Extent
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- 0.025 - 0.030 (Cut-Off Depth)
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure B2 [A]

Existing Case
5% AEP Flood Depth and Elevation
Envelope of Local and Regional Flood Events

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Existing Buildings

Flood Hazard (ARR2019)

- H1
- H2
- H3
- H4
- H5
- H6

0 30 60 Metres

1:2,000.000002

Figure B3 [A]

Existing Case 5% AEP Flood Hazard Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

Legend

- Subject Site
- Model Extent
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- 0.025 - 0.030 (Cut-Off Depth)
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure B4 [A]

Existing Case 1% AEP Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Existing Buildings

Flood Hazard (ARR2019)

- H1
- H2
- H3
- H4
- H5
- H6

0 30 60 Metres

1:2,000.000002

Figure B5 [A]

Existing Case
1% AEP Flood Hazard
Envelope of Local and
Regional Flood Events

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend
- Subject Site
- Model Extent
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)
- 0.025 - 0.030 (Cut-Off Depth)
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure B6 [A]

Existing Case 1 in 200 AEP Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- 0.025 - 0.030 (Cut-Off Depth)
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure B7 [A]

Existing Case PMF Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

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Data Source:

Legend

Subject Site

Model Extent

Existing Buildings

Flood Hazard (ARR2019)

H1

H2

H3

H4

H5

H6

0 30 60 Metres

1:2,000.000002

Figure B8 [A]

Existing Case
PMF Flood Hazard
Envelope of Local and
Regional Flood Events

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- > 0.030
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure C1 [A]

Developed Case
10% AEP Flood Depth and Elevation
Local Catchment w/ Neap Tide Tailwater

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- > 0.030
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure C2 [A]

Developed Case 5% AEP Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings

Flood Hazard (ARR2019)

- H1
- H2
- H3
- H4
- H5
- H6

0 30 60 Metres

1:2,000.000002

Figure C3 [A]

Developed Case 5% AEP Flood Hazard Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre SY202382-01

NORTHROP

Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- > 0.030
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure C4 [A]

Developed Case 1% AEP Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings

Flood Hazard (ARR2019)

- H1
- H2
- H3
- H4
- H5
- H6

0 30 60 Metres

1:2,000.000002

Figure C5 [A]

Developed Case
1% AEP Flood Hazard
Envelope of Local and
Regional Flood Events

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- > 0.030
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure C6 [A]

Developed Case 1 in 200 AEP Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings
- Flood Elevation (0.5m)
- Flood Elevation (0.1m)

Flood Depth (m)

- > 0.030
- 0.030 - 0.050
- 0.050 - 0.075
- 0.075 - 0.100
- 0.100 - 0.250
- 0.250 - 0.500
- 0.500 - 0.750
- 0.750 - 1.000
- 1.000 - 1.500
- 1.500 - 2.000
- 2.000 - 2.500
- 2.500 - 5.000
- > 5.00

0 30 60 Metres

1:2,000.000002

Figure C7 [A]

Developed Case PMF Flood Depth and Elevation Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings

Flood Hazard (ARR2019)

- H1
- H2
- H3
- H4
- H5
- H6

0 30 60 Metres

1:2,000.000002

Figure C8 [A]

Developed Case PMF Flood Hazard Envelope of Local and Regional Flood Events

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Depth Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - -0.005
- -0.005 - 0.005
- 0.005 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 30 60 Metres

1:2,000

Figure D1 [A]

Pre to Post Comparison
10% AEP Flood Elevation
Local Catchment w/ Neap Tide Tailwater

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Figure D2 [A]

Pre to Post Comparison
10% AEP Flood Velocity
Local Catchment w/ Neap Tide Tailwater

Port Macquarie Aquatic Centre
SY202382-01

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Data Source:

Data Source:

Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Depth Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - -0.005
- -0.005 - 0.005
- 0.005 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 30 60 Metres

1:2,000

Figure D3 [A]

**Pre to Post Comparison
5% AEP Flood Elevation
Local Catchment w/ Neap
Tide Tailwater**

Port Macquarie
Aquatic Centre
SY202382-01

NORTHROP

Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Velocity Difference (m/s)

- <= -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- > 0.200

0 30 60 Metres

1:2,000

Figure D4 [A]

Pre to Post Comparison 5% AEP Flood Velocity Local Catchment w/ Neap Tide Tailwater

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Depth Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - -0.005
- -0.005 - 0.005
- 0.005 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 30 60 Metres

1:2,000

Figure D5 [A]

Pre to Post Comparison 1% AEP Flood Elevation Local Catchment w/ Neap Tide Tailwater

Port Macquarie Aquatic Centre SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Velocity Difference (m/s)

- <= -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- > 0.200

0 30 60 Metres

1:1

Figure D6 [A]

Pre to Post Comparison 1% AEP Flood Velocity Local Catchment w/ Neap Tide Tailwater

Port Macquarie Aquatic Centre SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Depth Difference (m)

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - -0.005
- -0.005 - 0.005
- 0.005 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 30 60 Metres

1:2,000

Figure D7 [A]

Pre to Post Comparison
1 in 200 AEP Flood Elevation
Local Catchment w/ Neap
Tide Tailwater

Port Macquarie
Aquatic Centre
SY202382-01

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Legend

- Subject Site
- Model Extent
- Propsoed Development
- Proposed Development
- Existing Buildings

Velocity Difference (m/s)

- <= -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- > 0.200

0 30 60 Metres

1:2,000

Figure D8 [A]

Pre to Post Comparison
1 in 200 AEP Flood Velocity
Local Catchment w/ Neap Tide Tailwater

Port Macquarie
Aquatic Centre
SY202382-01

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Data Source:

Legend

- Subject Site
- Model Extent
- Proposed Development
- Existing Buildings

Depth Difference

- <= -0.300
- -0.300 - -0.200
- -0.200 - -0.100
- -0.100 - -0.050
- -0.050 - -0.025
- -0.025 - -0.010
- -0.010 - -0.005
- -0.005 - 0.005
- 0.005 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- 0.100 - 0.200
- 0.200 - 0.300
- > 0.300

0 70 140 Metres

1:4,000

Figure E1 [A]

Climate Change Scenario
1 in 200 AEP minus 1% AEP
Flood Depth
Local Catchment w/ Neap Tide Tailwater

Port Macquarie Aquatic Centre
SY202382-01

NORTHROP

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