



Flood Assessment

for

7-15 Columbia Way, Norwest

for GTL Properties Pty Ltd

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Acronyms

AEP	Annual Exceedance Probability
ARR1987	Australian Rainfall and Runoff 1987
ARR2019	Australian Rainfall and Runoff 2019
BoM	Bureau of Meteorology
CC	Climate Change
DCP	Development Control Plan
DRAINS	A 1D hydrologic and hydraulic modelling software
DEM	Digital Elevation Model
FPL	Flood Planning Level
FPL1	THSC Flood Planning Level 1 - 20 Year ARI
FPL2	THSC Flood Planning Level 2 - 100 Year ARI
FPL3	THSC Flood Planning Level 3 - 100 Year ARI + 0.5m Freeboard
FPL4	PMF
ha	Hectares – Measure of Area
IFD	Intensity-Frequency-Duration Rainfall Chart
LGA	Local Government Area
LiDAR	Light Detection and Ranging Terrain Data (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)
THSC	The Hills Shire Council
TUFLOW	A 1D and 2D hydraulic modelling software

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Introduction

Northrop Consulting Engineers have been engaged by GTL Properties Pty Ltd to prepare a Flood Assessment to support the Planning Proposal at 7-15 Columbia Way, Norwest, herein referred to as the subject site. The subject site locality is presented in **Figure 1** overleaf.


This study has been prepared in response to a Council's Request for Information (RFI) with respect to submission of the planning proposal for the subject site (REF: 3/2022/PLP). Liaison with The Hills Shire Council (THSC) representatives suggests flood information at the subject site is limited and as such, a two-dimensional flood study has been prepared herein.

This flood assessment aims to outline the flood behaviour at the subject site and review the Planning Proposal with respect to the NSW Ministerial Direction and Council's Local Environmental Plan (LEP), and Development Control Plan (DCP).

This assessment has been prepared with the consideration of the following documents and guidelines:

- Australian Rainfall and Runoff 1987 Guidelines (AR&R 1987).
- Australian Rainfall and Runoff 2019 Guidelines (AR&R 2019).
- NSW Floodplain Development Manual (NSW Government 2005).
- The NSW Government Ministerial Local Planning Direction 4.1 – Flooding.
- NSW Government Guideline “Considering Flooding in Land Use Planning” dated July 2021.
- Australian Rainfall and Runoff Guidelines – Project 15 – Two-dimensional Modelling in Urban and Rural Floodplains, dated November 2012.
- The Hills Shire Council Local Environmental Plan (LEP) 2019.
- The Hills Shire Council Development Control Plan (DCP) 2012, in particular Part C, Section 6 – Flood Controlled Land.
- The Hills Shire Council Guideline “TUFLOW Modelling Criteria for Single Lot/ Small Development in Urban Environments”.
- The Hills Shire Council Guideline “Requirements for TUFLOW Models and Associated Data from Consultants: Input and Output Files”.
- The Hills Shire Council Guideline “Waterways Drainage Design Requirements”.
- The Hills Shire Council Checklist “TUFLOW Modelling Checklist for Submission”.



Legend
 Site Boundary

0 100 200 Metres
 1:10,000

Figure 1 [A]
Subject Site Locality

7-15 Columbia Way
 Norwest



Methodology

This flood assessment has been prepared generally using the following procedure:

- Desktop review of available previous investigations and information including design plans, LiDAR, survey data and land use classifications.
- Preparation of a one-dimensional DRAINS hydrological model to quantify peak flows approaching the subject site.
- Preparation of an Existing Case two-dimensional TUFLOW hydraulic model to quantify the existing flood behaviour across the subject site and vicinity.
- Modification of the Existing Case TUFLOW hydraulic model to include an anticipated maximum developed case yield, creating the Developed Case scenario.
- Comparison of the existing and developed case results to review the worst case impact the proposed development has on the existing flood behaviour, both on-site and in adjacent properties.
- Review of the anticipated site flood conditions with respect to the relevant planning policies.
- Review and recommend future flood mitigation and control measures for the subject site based on Council's flood related Development Controls.

The one-dimensional DRAINS model has been prepared to generate inflows to be passed onto the two-dimensional model and to assist with determining the critical duration for the investigation, thus reducing the time it takes for design run iterations.

This study has been prepared with consideration to the following plans and documents.

- Planning proposal prepared by Sutherland and Associates.
- Architectural drawings prepared by Turner Architects and dated the 12 of July 2022.
- Detailed survey prepared by Chadwickcheng Consulting Surveyors and dated the 10th of December 2020.

Subject Site and Proposed Development

Subject Site

The subject site is located within the Hills Shire Council (THSC) Local Government Area (LGA) at Norwest and includes the parcel of land at 7-15 Columbia Way, otherwise known as Lot 200 in DP877496 and Lot 2015 in DP857960.

The subject site has an area of approximately 3.0 hectares with elevations ranging from approximately 85 m AHD in the south-western corner to 99m AHD in the north-eastern corner.

The subject site generally falls in a south-westerly direction with grades along Columbia Way of approximately 3%. Grades immediately adjacent to Spurway Drive are relatively steep with a retaining wall, which varies in height from approximately 1-3m, located along the majority northern boundary. A retaining wall also exists between Lot 200 DP877496 and Lot 2015 DP857960. This wall ranges from approximately, 1-2.5m in height.

The existing site land use includes commercial facilities and a childcare centre. Vehicular and pedestrian access is largely via Columbia Way. The characteristics of the area are presented in Photos 1 and 2 below.



Photo 1 – Looking north along Columbia Way (©Google Maps, 2020)



Photo 2 – Looking south along Spurway Drive (©Google Maps, 2020)

Proposed Development

The planning proposal (REF: 3/2022/PLP) seeks to amend THSC LEP 2019 to facilitate a higher density commercial office space and to enhance the employment capacity of the subject site to support future growth in the Norwest precinct. This involves modification of the THSC LEP 2019 to permit an increased building height from 116 meters to 155.85 and to amend the Floor Space Ratio from 1:1 to 2.36:1. A concept site plan and layout has been prepared by Turner architects which demonstrates the proposal seeks to construct:

- Multiple Commercial Towers up to 15 storeys' high.
- Five levels of Basement Carparking (including podium levels).
- Enhanced public domain and open space areas.

The proposed commercial towers are expected to include commercial, retail, and childcare facilities.

Due to the high-level phase of this assessment (i.e. planning proposal) a “worst case” developed scenario with respect to flooding has been assessed, whereby future landscaping and buildings fully block any flow paths. It is anticipated the development extent will be further reviewed at Development Application phase as more information becomes available (i.e. civil and landscape plans). Additional information as to how this was modelled is presented in the Model Parameters Section of this report.

It is noted that the adjacent Spurway Drive and Columbia Way have been earmarked for future road upgrades. These upgrades have not been included as part of the Planning Proposal, and as such what is presented herein may be considered an interim scenario. It is anticipated future design of these road upgrades have the potential to improve the flood conditions presented herein.

Additional information with respect to the proposed development layout and the roads earmarked for upgrades are presented in the concept design plans prepared by Turner architects.

Council Requirements

The modelling and results presented herein have been prepared generally in accordance with THSC TUFLOW modelling criteria for single lot / small developments. These guidelines have been provided by THSC for the purposes of this assessment.

The requirements set out in THSC TUFLOW modelling criteria for single lot/ small developments guidelines are summarised in the below Table 1. Note that, further assessment of the planning proposal with respect to the flooding related THSC LEP, DCP and the NSW Ministerial Directions requirements are presented in the Discussion section of this report.

Table 1 – THSC TUFLOW Modelling Requirements

Requirement	Response
TUFLOW Version Where possible the latest version of TUFLOW model to be used.	The latest TUFLOW version 2020-10-AD with HPC GPU module has been used.
Digital Elevation Model (DEM) DEM for the study area to be developed using ALS data and/or site survey data.	Sub-Catchment Boundaries have been prepared using NSW LPI LiDAR elevation data as presented in Figure 2. A combination of the NSW LPI LiDAR and Detailed Survey prepared by Chadwickcheng Consulting Surveyors has been included in the TUFLOW model. Additional information is provided in the Hydraulic Model Parameters Section of this report.
Grid Size Model grid size to represent the flow behaviour in an urban environment, with consideration of narrow overland flowpaths, such as between and permanent obstructions. One meter grid size is recommended unless a larger grid size justified.	The modelled Grid Size is discussed in the Hydraulic Model Parameters Section of this report.
Flow Path Obstruction and Constrictions Obstructions across a flow path, such as buildings, sheds, fences and road embankments etc, are to be appropriately incorporated in the model with reference to the recent physical modelling undertaken as part of Australian Rainfall & Runoff – Revision Projects and Document Updating Project 15 – Two-Dimensional (2D) Modelling in Urban Areas.	Land use representation and surface roughness has been prepared generally in accordance with these guidelines. Additional information is discussed in the Hydraulic Model Parameters Section of this report.
Downstream Boundary Downstream boundary conditions in TUFLOW model may be defined using one of flowing approaches: Assigning a water level versus flow curve (HQ Curve); or	Water Level versus Time (HT) has been adopted for this investigation. The TUFLOW model has been extended downstream far enough so that backwater effects from the boundary conditions have minimal impact on predicted flood behaviour.

Requirement	Response
<p>Assigning a water level versus time curve (HT Curve).</p> <p>The available hydraulic models from previous studies may be used to obtain these relationships for the drainage catchments.</p> <p>Where possible, model boundary should be extended sufficiently downstream of the study area boundary so that backwater effects from the boundary condition have minimal impact on predicted flood behaviour.</p>	<p>Additional information is provided in the Hydraulic Model Parameters Section of this report.</p>
<p>Upstream Flow Boundary</p> <p>For single lot development hydrograph generated using standard procedure at the downstream site, boundary has to be applied as upstream flow boundary.</p>	<p>Inflows have been generated using DRAINS software. Inflow locations are presented in Figure 3.</p> <p>Additional information on boundary conditions is discussed in the Hydraulic Model Parameters Section of this Report.</p>
<p>Initial Water Level (IWL)</p> <p>A constant water level can be set as the IWL. Allocated IWL is to be commensurate with the starting water level of downstream water level boundaries.</p>	<p>A constant water level of 70m AHD has been set in the TUFLOW model and is adopted as Initial water level of the downstream boundary. Additional information on boundary conditions is discussed in the Hydraulic Model Parameters Section of this Report.</p>
<p>Design Events</p> <p>Minimum 100 yr ARI event to be run for both the existing and the developed catchment conditions. Simulation of more frequent events, such as, 10 and 20 ARI design storms may also be required. Please consult with Councils Waterways Team for further advice.</p>	<p>The 1% AEP and 1% AEP Climate Change design storm events have been considered for the purposes of this study. These events are expected to be required to satisfy the requirements of the LEP, DCP and NSW Ministerial Directions.</p> <p>More frequent events have not been included herein.</p>
<p>Critical Duration</p> <p>Developed model shall be run for a range of storm durations sufficient to identify the critical duration.</p>	<p>A range of storm durations has been considered by the two-dimensional TUFLOW model.</p> <p>Selection of the critical duration has been discussed in the results section of this report.</p>
<p>Cumulative Mass Error</p> <p>All three Cumulative Mass Error percentage values such as for the overall model, for all the 2D domains and for any 1D domains should be within a +3% limit.</p>	<p>The results of all the three Cumulative Mass Error percentage values are within the +3% limit.</p> <p>Typically using the HPC GPU solver, a CME of 0% is observed for all durations.</p>
<p>Flood / Overland Flow Path Mapping</p> <p>Cut off depth of 0.1m to be used for mapping flood extents are.</p> <p>At least 0.2m contour intervals to be used in flood level and flood depth mapping</p>	<p>A cut off depth of 0.1m and 0.2m contour intervals have been adopted for all figures in this report.</p>

Model Parameters

Detailed two-dimensional hydraulic modelling was undertaken using the TUFLOW hydrodynamic modelling software. DRAINS software has been used to generate inflows for the TUFLOW model. The hydrological and hydraulic model parameters are presented below.

Hydrological Model

The hydrological model used for the assessment is the DRAINS one-dimensional software. As per THSC Waterways Drainage Design Requirements for flood estimation the ARR 1987 guidelines were adopted for this study. Use of the ARR 1987 hydrology has been confirmed verbally with THSC officers.

The input data for the DRAINS model used in this study includes sub-catchment data, design rainfall data and the ILSAX/ HORTON losses. These are summarized below.

Sub-Catchment Properties

Sub-catchment boundaries have been digitised using a combination of LiDAR, aerial imagery, cadastral boundaries, and detailed survey. A typical impervious percentage of 90% was adopted over road reserves while, due to the commercial nature of the surrounding lots, a typical 80% impervious fraction was adopted elsewhere. The following Table 2 presents the sub-catchment properties while, the catchment extents are presented in Figure 2 overleaf.

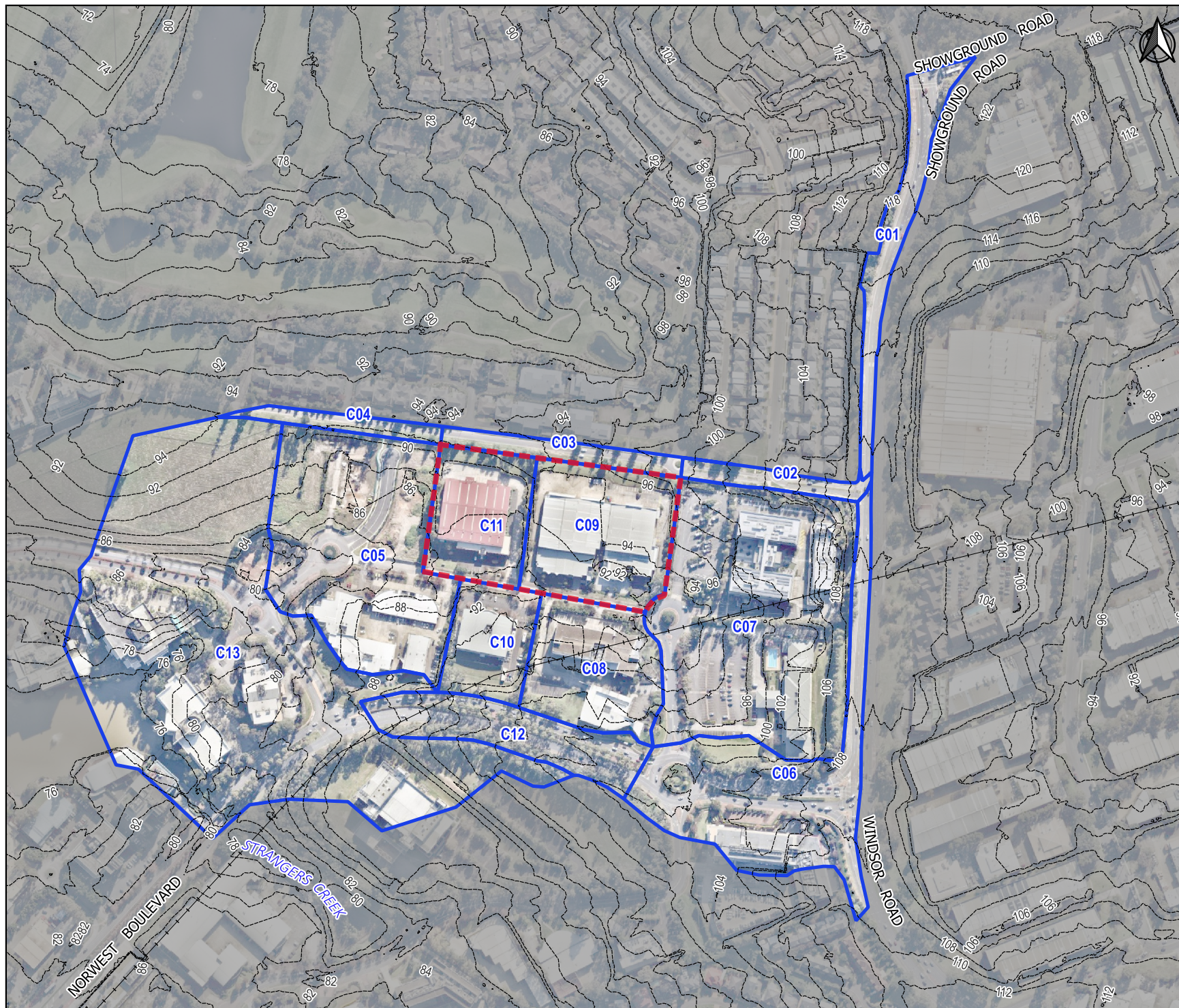
Table 2 - Sub-Catchment Properties (Refer to Figure 2)

Catchment Reference	Area (ha)	Impervious (%)	Catchment Reference	Area (ha)	Impervious (%)
C01	0.89	90	C08	1.51	80
C02	0.34	90	C09	1.83	80
C03	0.44	90	C10	0.89	80
C04	0.31	90	C11	1.20	80
C05	3.48	80	C12	1.21	90
C06	2.74	90	C13	8.91	80
C07	4.59	80			

Rainfall

Rainfall intensities have been obtained from the Bureau of Meteorology (BoM) website for a location over the catchment centroid. The following Table 3 presents the Intensity-Duration-Frequency (IFD) used for the study.

Rainfall intensities for the Climate Change scenario have been increased based on the worst-case Representative Concentration Pathway (RCP) of 8.5 and year 2090. The ARR Data Hub suggests during this worst-case scenario, a predicted increase in rainfall depths of up to 19.7% can be expected.



- Legend**
- ▬ Sub-Catchments
 - ▬ Site Boundary
 - Terrain Contours (mAHD)

0 80 160 Metres
1:5,000

Figure 2 [A]
**Sub-Catchment
Boundaries**

7-15 Columbia Way
Norwest



Table 3 - IFD Rainfall Intensities

Duration (mins)	1% AEP (mm/hr)	1% AEP CC (mm/hr)
5	220.0	263.3
10	169.0	202.3
20	122.0	146.0
30	98.6	118.4
60	67.7	81.0
120	45.8	54.8
180	36.4	43.6

Losses

The Horton/ ILSAX hydrological model has been used in combination with the ARR 1987 rainfall intensities. A summary of the adopted depression storage depths is summarised in the below Table 5.

Table 5 – Horton/ ILSAX Depression Storage Values

Land use	Depression Storage (mm)
Paved/ Impervious Area	1
Supplementary Area	1
Grassed Area	5

In addition to the above, an antecedent catchment soil condition of 3 was adopted representing a catchment with a “slow infiltration rate” and wet antecedent conditions.

Hydraulic Model

The hydraulic model used for this study is the two-dimensional (2D) TUFLOW hydrodynamic software. For this study, the latest TUFLOW version 2020-10-AD with HPC GPU module has been used.

Two-Dimensional Grid Extent and Size

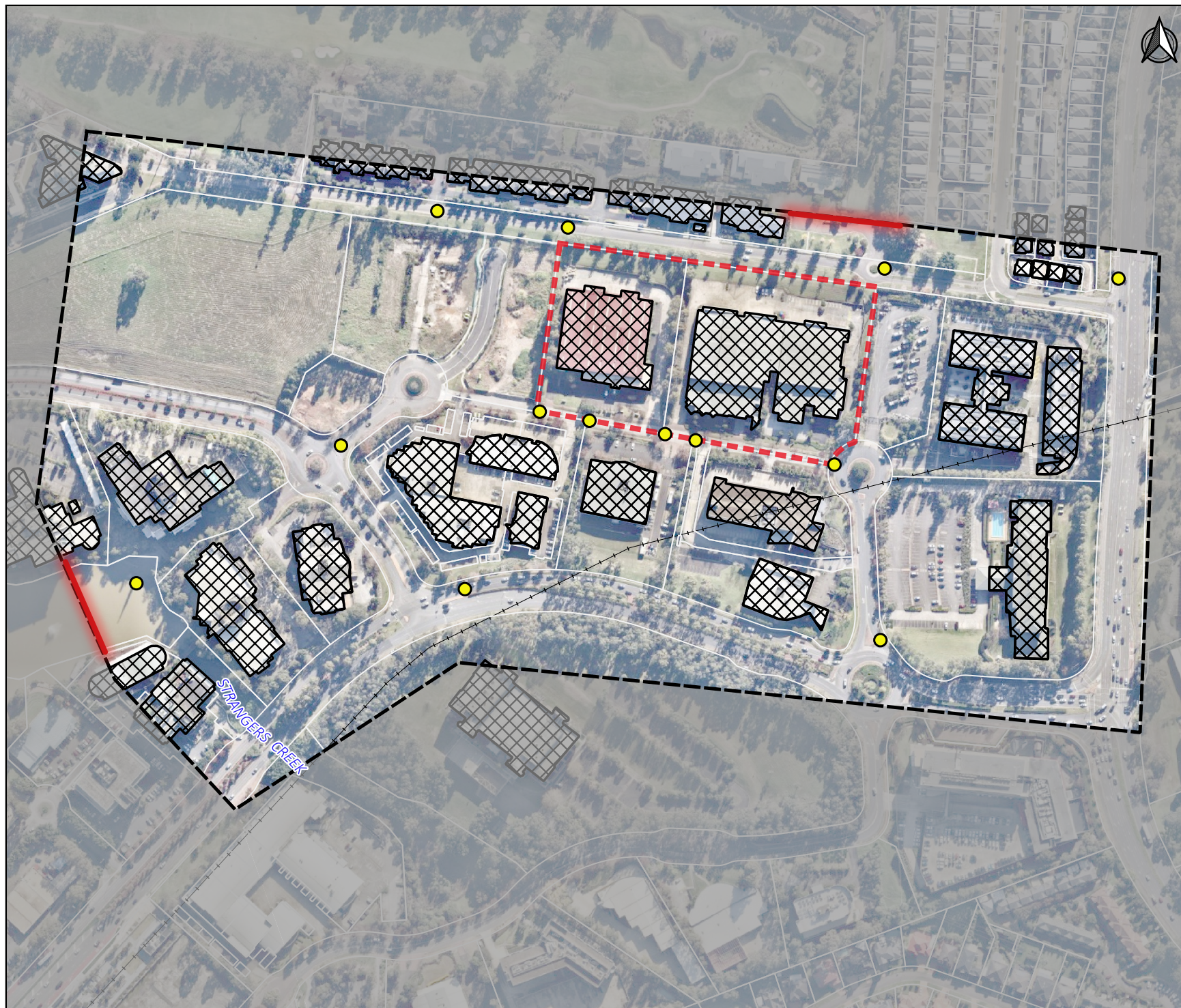
A grid size of 0.5m was adopted for the two-dimensional model to adequately represent flows through the road carriageway, across the site and through overland flow paths.

The two-dimensional grid extent is shown in **Figure 3** overleaf. The grid extends to approximately Norwest Boulevard to the south, Longview place to the north, Windsor Road to the east and Strangers Creek to the southwest.






Boundary Conditions

The model boundary conditions are presented in **Figure 3** overleaf. Flows derived by the DRAINS model have been applied directly to the two-dimensional grid via a series of one-dimensional polygons.

An outlet head boundary has been entered into the two-dimensional model at two locations: One approximately 370m downstream of the subject site at Strangers Creek, and a second to the north of Spurway Drive, approximately 20m north of the subject site. These boundaries have been added to the model as a HT curve in accordance with Council's guidelines.



Legend

-  Buildings
-  Model Extent
-  Site Boundary
-  Downstream Boundary
-  Inflow Locations

0 60 120 Metres
1:3,800

Figure 3 [A]
2D Model Setup

7-15 Columbia Way
Norwest



The outlet boundary at Stranger Creek has been sited at an elevation of 70m AHD, assuming free outfall tailwater conditions. With RL of 70m AHD, tailwater levels at Stranger Creek are not expected to influence flood levels or the flood impact results at the subject site as the subject site is sited approximately 15m above this level. Similarly, the outlet boundary north of Spurway Drive is located downstream of Spurway Drive and is intended to capture flows that fall away from the site.

Catchment Roughness

Catchment roughness was based on a review of hydraulic literature (including ARR 2019 – Project 15), aerial imagery and observations made during the site visit. It is noted that buildings have been fully blocked out, representing 100% flow obstructions.

Figure 4 and **Figure 5** presented overleaf show the land use type for the existing and developed case scenarios respectively. The following Table 4 presents the surface roughness values adopted for each land use.

Table 4 - Land use Roughness (Manning's)

Land use	Roughness (Manning's)
Grassland/ Low Vegetation	0.040
Water	0.020
Road/ Hardstand Area	0.020
Thick Vegetation	0.080

As previously mentioned, for the purposes of the Planning Proposal, the majority of the subject site has been blocked out for the developed case, to review a maximum yield scenario. The majority of the site has been blocked out with the exception of the extent of the easement for Columbia Way which is not expected to be significantly altered for the proposal.

It is noted that additional development setbacks have not been considered with the block out extending to the edge of the eastern, western and northern site boundaries. In doing so, the block out represents both the flood impact of the proposed buildings as well as any potential modifications to landscaping.

This modelling methodology is expected to be a “worst case” scenario with respect to flooding, whereby future landscaping and buildings fully block any flow paths. It is anticipated the development extent will be further reviewed at Development Application phase as more information becomes available (i.e. civil and landscape plans).

Terrain

Terrain data used in the development of the model includes a combination of LiDAR elevation data and detailed survey. Additional manual amendments have been made with a 150mm kerb and gutter burnt into the detailed survey surface following review that the survey surface captures the top of kerb only.

Terrain data used for both the Existing and Developed case scenarios is presented in **Figure 6**.

Infrastructure

Due to limited available information, the magnitude of the events considered, and to remain conservative for the purposes of this assessment, below ground infrastructure has not been included in the hydraulic model.



Legend

- Buildings
- Site Boundary
- Model Extent

Land use

- Low Vegetation
- Water
- Hardstand Area
- Thick Vegetation

0 70 140 Metres
1:4,000

Figure 4 [A]
Existing Case
2D Model Land Use

7-15 Columbia Way
Norwest





Legend

- Buildings
- Developed Blockout
- Site Boundary
- Model Extent

Land use

- Low Vegetation
- Water
- Hardstand Area
- Thick Vegetation

0 70 140 Metres
1:4,000

Figure 5 [A]
Developed Case
2D Model Land Use

7-15 Columbia Way
Norwest





Legend

- Buildings
- Dev Extent
- Site Boundary
- Model Extent
- Kerbs

Elevation (mAHD)

- <= 74.0
- 74.0 - 78.0
- 78.0 - 82.0
- 82.0 - 86.0
- 86.0 - 90.0
- 90.0 - 94.0
- 94.0 - 98.0
- 98.0 - 102.0
- 102.0 - 106.0

0 70 140 Metres

1:4,000

Figure 6 [A]

2D Model Terrain

7-15 Columbia Way
Norwest

Results

Critical Duration

All design storm durations ranging from the 5-minute to 4.5-hour were entered into the two-dimensional model to determine the critical storm duration for the 1% AEP design storm event.

The two-dimensional TUFLOW modelling indicates that generally the 15-minute and 25-minute storm durations were critical across the subject site and vicinity.

Existing Case Behaviour

Maximum modelled water depth and elevation contours for the 1% AEP design storm event are presented in **Figure A1** of Appendix A. The results presented in Figure A1 suggests the majority of flow in Spurway Drive are contained within the road carriageway, with the exception of a small portion of flows that spill along the western boundary of the subject site.

Figure A1 of Appendix A also shows flows through Columbia Way breaching the capacity of the road carriageway and spilling into the subject site and adjacent properties with depths in excess of 300mm observed in some areas.

Flood hazard conditions have been assessed based on the latest AR&R 2019 hazard categories as presented in **Figure 7** below. Flood hazard conditions for the 1% AEP design storm events are presented in **Figure A2** of Appendix A.

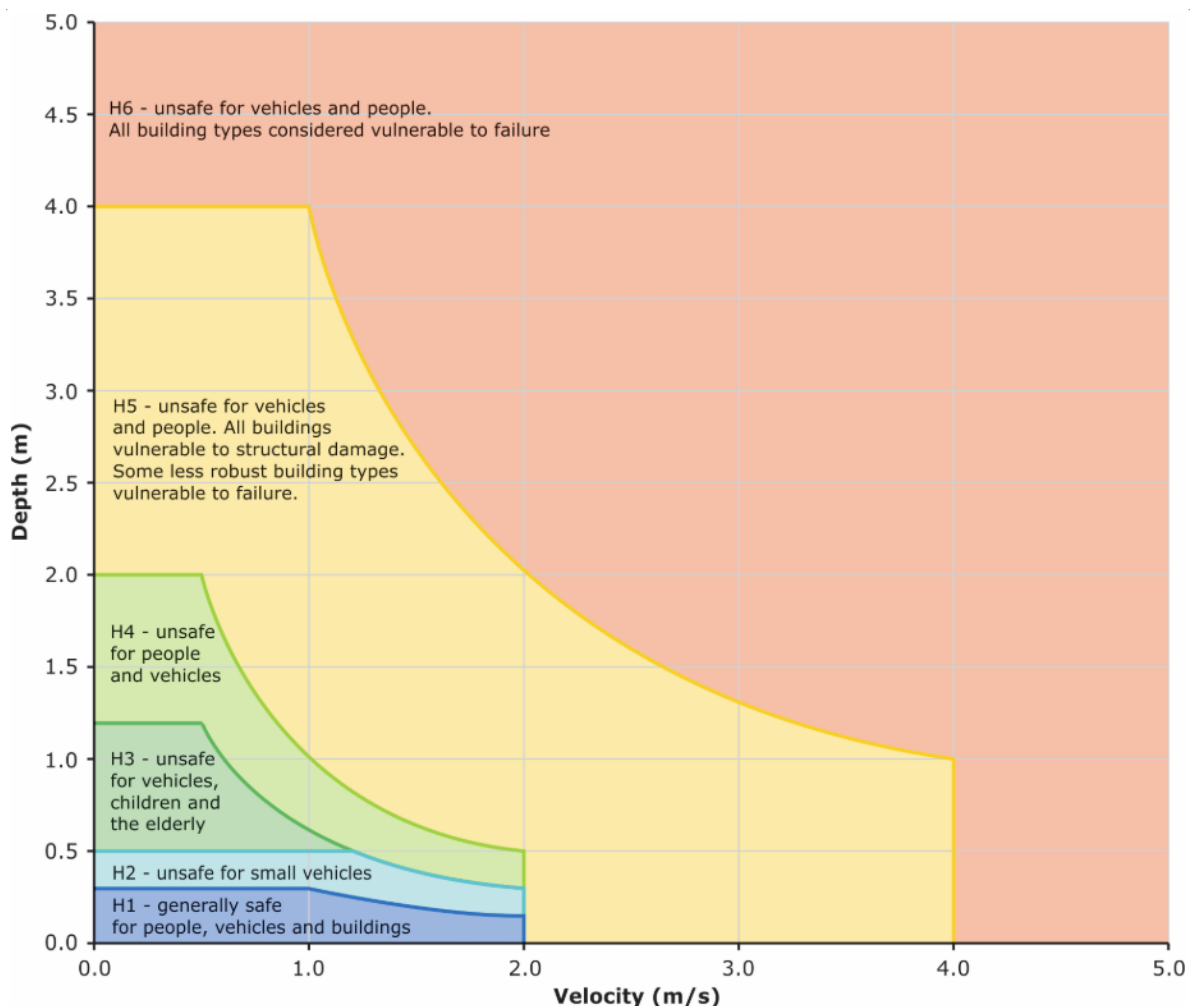


Figure 7 - Australian Rainfall and Runoff (2019) Hazard Categories

Flood hazard conditions across the subject site, during the 1% AEP design storm event, are generally low with the exception of flows in Columbia Way with Figure A2 of Appendix A showing up to H5 hazard conditions are observed in the road carriageway.

The flood hydraulic categories are also presented in Figure A3 of Appendix A and are based on the following criteria:

- Floodway is defined as areas where:
 - The peak value of velocity multiplied by depth ($V \times D$) > $0.25\text{m}^2/\text{s}$, AND peak velocity > 0.25m/s , OR
 - Peak velocity > 0.6 m/s AND peak depth > 0.3m .
- Flood Storage comprises areas outside the floodway where peak depth > 0.5m .
- Flood Fringe comprises areas outside the Floodway where peak depth < 0.5m .

The results for the 1% AEP design storm event are presented in **Figure A3** of Appendix A. Generally, Flood Fringe is observed across the site, however floodway conditions are observed in the Columbia Way road carriageway.

Developed Flood Behaviour

Figures presenting the developed case scenario for the 1% AEP design storm flood events are presented in **Figures B1- B3** of Appendix A.

A review of the results presented in **Figures B1- B3** suggests the existing case flood behaviour in both Spurway Drive and Columbia Way remains generally un-changed during 1% AEP design storm event following the introduction of the proposed development.

Flood Effects

Flood effects created by the theoretical maximum development extent during the 1% AEP design storm event are presented in **Figure C1** of Appendix A. The results suggest isolated increases of up to approximately 90mm are possible in Columbia Way, however generally less than 30mm is observed during the 1% AEP design storm event.

It is anticipated flood impacts will be further reviewed at Development Application phase as more information (such as a civil design surface) becomes available. During Development Application Phase, it is recommended the landscaping adjacent to Columbia Way be sympathetic to the existing flood conditions and graded so as to not create a significant adverse impact in adjacent and downstream properties.

Climate Change Sensitivity

The impact of climate change during the 1% AEP developed case scenario has been reviewed using the latest ARR 2019 guidelines. Given the location of the subject site, with terrain levels ranging between 85-99m AHD, Sea Level Rise has not been considered as part of this investigation.

There is, however, the potential for increased rainfall depths due to climate change with the worst-case Representative Concentration Pathway (RCP) of 8.5 and year 2090 considered for this study. The ARR Data Hub suggests during this worst-case scenario, a predicted increase in rainfall depths of up to 19.7% can be expected.

The results presented in Figure D1 of Appendix A suggests increases in flood depth in Spurway Drive of generally less than 10mm while, an increase generally less than 25mm is also observed in Columbia Way along the north-western boundary of the subject site. These increases are considered only minor and are not expected to significantly alter development of the subject site.

Discussion

Flood Mitigation Measures and Development Controls

As discussed in the Flood Effects section of this report, it is recommended at Development Application phase that landscaping along Columbia Way be sympathetic to the existing flood conditions in the area and graded so as to not create a significant adverse impact in adjacent and downstream properties.

Additional Development Controls are outlined in the Hills Shire Council Development Control Plan (DCP), in particular Part C, Section 6 – Flood Controlled Land – Part 2 – Objectives and Development Controls.

THSC DCP presents the following Flood Planning Level (FPL) thresholds for the purposes of defining development controls:

- FPL1 = Flood Planning Level 1 – 5% AEP
- FPL2 = Flood Planning Level 2 – 1% AEP
- FPL3 = THSC Flood Planning Level 3 – 1% AEP + 0.5m Freeboard
- FPL4 = PMF

The majority of the proposed development is expected to fall under the commercial / industrial categorisation with the exception of the childcare facilities which are categorised by Schedule A of the DCP as “Residential”. Development Controls applicable for these land uses are covered under both Sections 2.5 and 2.6 of the DCP. Additional General Controls are also outlined in Section 2.2 of the DCP.

A review of the Development Controls applicable for the subject site are summarised in Table 6 below. It is recommended future development of the subject site consider these controls and adopt as necessary.

Table 6 – DCP requirements

Item	Requirement	Response
General Controls – Section 2.2		
2.2 (a)	<p>The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to:</p> <ul style="list-style-type: none"> I. Loss of flood storage. II. Changes in flood levels and velocities caused by alterations to the flood conveyance, including the effects of fencing styles. III. The cumulative impact of multiple potential developments in the floodplain. 	<p>A “worst case” flood impact assessment has been prepared herein to assess the sensitivity of the subject site to flood impacts.</p> <p>Following review of the results, adverse flood impacts are expected to be able to be managed through sympathetic grading and design along the Columbia Way frontage. It is anticipated this will be further reviewed at Development Application Phase as more information becomes available.</p>
2.2 (c)	The design materials and construction of the proposed development shall comply	This is expected to be feasible for the subject site and will be further

Item	Requirement	Response
	with the principles set out in the publication "Reducing Vulnerability of Buildings to Flood Damage – Guidance on Building in Flood Prone Areas", published by the NSW Government.	investigated at Development Application and Construction Certificate phase.
Industrial, Commercial and Residential – Sections 2.5 and 2.6		
2.5 (b) & 2.6 (a)	No development is to occur in or over a floodway area, a flow path or a high hazard area (as defined in the FDM) generated by flooding up to FPL2 unless justified by a site-specific assessment.	With the presence of the easement over Columbia Way, the proposed development is not expected to be located within a floodway area, a major flow path or a high hazard area. It is anticipated that a site-specific flood study will be prepared at Development Application phase to review flood impacts and site grading in the vicinity of Columbia Way.
2.5 (b) & 2.6 (b)	Habitable floor levels are to be at FPL3 or higher	Placement of habitable floors at the 1% AEP + 500mm is not expected to be a significant development constraint. It is anticipated this will be further reviewed at Development Application phase.
2.5 (c) & 2.6 (c)	Non-habitable floor levels to be equal to or greater than FPL3 where possible, or otherwise no lower than FPL1 unless justified by a site-specific assessment.	Placement of non-habitable floors no lower than the 5% AEP is not expected to be a significant development constraint. It is anticipated this will be further reviewed at Development Application phase.
2.5 (d)	A restriction is to be placed on the title of the land, pursuant to S.88B of the Conveyancing Act, where the lowest habitable floor area is elevated above finished ground level, confirming that the undercroft area is not to be enclosed, where Council considers this may potentially occur.	This is expected to be feasible for the proposed development and will be further investigated at Development Application phase.
2.5 (e) & 2.6 (d)	All structures to have flood-compatible building components below FPL3.	Flood compatible materials below the 1% AEP + 500mm is not expected to be a significant development constraint. It is anticipated this will be further reviewed at Development Application phase.
2.5 (f) & 2.6 (e)	Applicant to demonstrate that the structure can withstand the forces of floodwater debris and buoyancy up to and including FPL3, or FPL4 if required	There is an opportunity to construct and design a robust building with the capacity to withstand flood forces during future development phases.

Item	Requirement	Response
	to satisfy evacuation criteria (i.e. use as a refuge area) An engineer's report may be required.	It is recommended the capacity of any proposed buildings be confirmed by a structural engineer to withstand flood forces to prior to Construction Certificate.
2.5 (g) & 2.6 (f)	The flood impact of the development to be considered to ensure that the development will not increase flood effects elsewhere, having regard to: I. Loss of flood storage; II. Changes in flood levels and velocities caused by alterations to the flood conveyance, including the effects of fencing styles; and III. The cumulative impact of multiple potential developments in the floodplain. An engineer's report may be required.	A "worst case" flood impact assessment has been prepared herein to assess the sensitivity of the subject site to flood impacts. Following review of the results, adverse flood impacts are expected to be able to be managed through sympathetic grading and design along the Columbia Way frontage. It is anticipated this will be further reviewed at Development Application Phase as more information becomes available.
2.5 (h) & 2.6 (g)	The minimum surface level of open car parking spaces or carports shall be as high as practical, and not below FPL1.	This is expected to be feasible for the proposed development and will be further investigated at Development Application phase.
2.5 (i) & 2.6 (h)	Garages or enclosed car parking must be protected from inundation by flood waters up to FPL2. Where 20 or more vehicles are potentially at risk, protection shall be provided to FPL3.	This is considered feasible for the proposed development and will be further investigated at Development Application phase.
2.5 (j) & 2.6 (i)	Where the level of the driveway providing access between the road and parking space is lower than 0.3m below FPL2, the following conditions must be satisfied- when the flood level reach FPL2, the depth of inundation on the driveway shall not exceed: I. The depth at the road; or II. The depth at the car parking space. A lesser standard may be accepted for single detached dwelling houses where it can be demonstrated that risk to human life would not be compromised.	This is expected to be feasible for the proposed development and will be further investigated at Development Application phase.
2.5 (k) & 2.6 (j)	All service conduits located below FPL3 are to be made fully flood compatible and suitable for continuous underwater immersion. Conduits are to be self-draining if subject to flooding	This is expected to be feasible for the proposed development and will be further investigated at Development Application phase.
2.6 (k)	Applicant to demonstrate that area is available to store goods above FPL3	This is expected to be feasible for the subject site and will be further

Item	Requirement	Response
		investigated at Development Application phase.
2.6 (l)	No external storage of materials below FPL3 which may cause pollution or be potentially hazardous during any flood.	This is expected to be feasible for the proposed development and will be further investigated at Development Application phase.
2.5 (l) & 2.6 (m)	<p>A Site Flood Emergency Response Plan is required when elements of the development, including vehicular and pedestrian access, are below FPL3.</p> <p>The site Flood Emergency Response Plan should relate to the land use and site conditions in conjunction with flood behaviour up to FPL2 expected to be experienced at the site. The plan should consider the following specific actions:</p> <ul style="list-style-type: none"> • Preparing for a flood; • Responding when a flood is likely; • Responding during a flood; and • Recovery after a flood. <p>The flood plan should be consistent with the relevant NSW SES "FloodSafe Guide.</p>	This is expected to be feasible, however, will be further investigated at Development Application phase.

The Hills Shire Council Local Environmental Plan (2019)

A portion of the subject site is expected to be located within the Flood Planning Area and as such, the provisions outlined in the THSC LEP (2019), in particular Section 5.21 – Flood Planning are applicable. These items are summarised in Table 5 below.

For the purposes of this investigation, the Flood Planning Area is defined as the 1% AEP + 500mm. This is generally consistent with the Floodplain Development Manual as required in the THSC LEP (2019).

Table 5 - THSC LEP (2019) Assessment

Reference	Local Environmental Plan Item	Response
5.21 (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 the capacity to enable vertical evacuation and on-site refuge and as such, is not expected to increase the risk to life on the subject site.
(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	The flood affected portions of the subject site are largely located along and adjacent to Columbia Way. This area is covered by an easement with generally flood fringe observed elsewhere. The proposed development extent is located outside of the floodway and as such

Reference	Local Environmental Plan Item	Response
		<p>is considered compatible with the flood function of the land.</p> <p>Climate Change has been considered herein with projected increases in flood depth generally less than 25mm expected. This is considered a minor reduction in freeboard requirements and as such, future climate conditions are not expected to drive or significantly alter the design of any required future flood mitigation measures.</p> <p>Additional information is presented in the Climate Change Sensitivity section of this report.</p>
(c)	to avoid adverse or cumulative impacts on flood behaviour and the environment	<p>As recommended in the Flood Effects section of this report, grading and levels adjacent to Columbia Way should be designed to be sympathetic to flood effects.</p> <p>Grading, site levels and flood impacts are expected to be reviewed further at Development Application phase as more detailed information becomes available.</p>
(d)	to enable the safe occupation and efficient evacuation of people in the event of a flood	<p>The proposed development has capacity to enable vertical evacuation and on-site refuge therefore, enabling safe occupation and efficient evacuation.</p>
5.21 (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	<p>The flood affected portions of the subject site are largely located along and adjacent to Columbia Way. This area is covered by an easement with generally flood fringe observed elsewhere across the subject site.</p> <p>The proposed development extent is located outside of the floodway and as such, the proposal is considered compatible with the flood function of the land.</p>
(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	<p>As recommended in the Flood Effects section of this report, grading and levels adjacent to Columbia Way should be designed to be sympathetic to flood effects.</p> <p>Grading, site levels and flood impacts are expected to be reviewed further at Development Application phase as more detailed information becomes available.</p>

Reference	Local Environmental Plan Item	Response
(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	The proposed development has capacity to enable vertical evacuation and on-site refuge, therefore limiting any impacts on existing evacuation routes for the surrounding area.
(d)	incorporates appropriate measures to manage risk to life in the event of a flood.	Flood mitigation measures and controls outlined in the THSC DCP are expected to be feasible. Additional information is presented in the Flood Mitigation Measures and Development Controls Section of this report.
(e)	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 subject site is not located directly adjacent to any defined watercourses. Additional on-site stormwater quantity and quality control measures, required to limit environmental impacts, are expected to be reviewed at Development Application Phase.
5.21 (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.	Climate Change has been considered herein with projected increases in flood depth generally less than 25mm expected. This is considered a minor reduction in freeboard requirements and as such, future climate conditions are not expected to drive or significantly alter the design of any required future flood mitigation measures. Additional information is presented in the Climate Change Sensitivity section of this report.
(b)	the intended design and scale of buildings resulting from the development.	As recommended in the Flood Effects section of this report, grading and levels adjacent to Columbia Way should be designed to be sympathetic to flood effects. Grading, site levels and flood impacts are expected to be reviewed further at Development Application phase as more detailed information becomes available.
(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.	The proposed development has capacity to enable vertical evacuation and on-site refuge therefore enabling safe occupation and efficient evacuation. Flood mitigation measures and controls outlined in the THSC DCP are expected to be feasible. Additional information is presented in

Reference	Local Environmental Plan Item	Response
		the Flood Mitigation Measures and Development Controls Section of this report.
(d)	the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.	Anticipated flood behaviour is presented herein. Flood mitigation measures and controls outlined in the THSC DCP are expected to be feasible, limiting the requirement to modify, relocate or remove proposed future buildings.

NSW Ministerial Direction 4.1 - Flooding

The subject site has been assessed based on the NSW Ministerial Direction, in particular Direction 4.1 – Flooding. These items are summarised in the following Table 6.

Table 6 - NSW Ministerial Direction 4.1 – Flooding Requirements and Response

Item	Development Control	Response
4.1.1	A planning proposal must include provisions that give effect to and are consistent with:	
(a)	The NSW Flood Prone Land Policy	<p>Part of the subject site is located within the Flood Planning Area and as such, the provisions of the NSW Flood Prone Land Policy and Floodplain Development Manual are applicable.</p> <p>The principles of the NSW Flood Prone Land Policy are expected to be satisfied through adoption of appropriate flood mitigation and controls.</p> <p>Review of THSC DCP requirements suggest these controls are expected to be feasible for the proposed development and are expected to be further assessed at Development Application phase.</p>
(b)	The principles of the Floodplain Development Manual 2005.	<p>The principles of the Floodplain Development Manual (2005) are expected to be achievable through the implementation of the necessary development controls outlined in THSC DCP.</p> <p>This is expected to be further reviewed at Development Application Phase.</p>
(c)	The Considering Flooding in Land Use Planning Guideline 2021	<p>The recommendations contained within this guideline are captured under the THSC LEP 2019.</p> <p>It is noted, THSC have not captured any additional “Special Flood Considerations” outlined by this guideline.</p>

Item	Development Control	Response
		<p>Key flood constraints outlined in this guideline are summarised as;</p> <ul style="list-style-type: none"> • Flood Function • Flood Hazard • Flood Extent and Behaviour; and • Risk to Life <p>These elements have all been discussed in this assessment.</p>
(d)	Any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council	<p>Liaison with THSC representatives suggest an existing flood study / floodplain risk management plan is not available for the subject site.</p> <p>This study in lieu of these studies and has been prepared generally in accordance with the principles of the NSW Floodplain Development Manual 2005 and Councils TUFLOW modelling guidelines.</p>
4.1.2	A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Business, Industrial or Special Purpose Zones.	The planning proposal does not propose to rezone Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Business, Industrial or Special Purpose Zone.
4.1.3	A planning proposal must not contain provisions that apply to the flood planning area which:	
(a)	Permit development in floodway areas	<p>The results presented in Figures B3 and C3 of Appendix A suggests the majority of the site affected by the 1% AEP is largely flood fringe.</p> <p>Floodway behaviour is however, observed in Columbia Way. This area is covered by an existing easement which restricts development. As such, development within floodway areas is not expected as part of the proposal.</p>
(b)	Permit development that will result in significant flood impacts to other properties,	<p>As recommended in the Flood Effects section of this report, grading and levels adjacent to Columbia Way should be designed to be sympathetic to flood effects.</p> <p>Grading, site levels and flood impacts are expected to be reviewed further at Development Application phase as more detailed information becomes available.</p>

Item	Development Control	Response
(c)	Permit development for the purposes of residential accommodation in high hazard areas	Residential development is not included as part of the planning proposal. Furthermore, high hazard flood behaviour during the 1% AEP is not observed over the developable area.
(d)	Permit a significant increase in the development and/or dwelling density of that land	The majority of the subject site is located outside the extent of the 1% AEP with opportunity for the planning proposal and future development to incorporate necessary flood mitigation measures to limit risk to life on the subject site.
(e)	Permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate.	Childcare facilities are expected to be proposed on the subject site. Flood hazard conditions in Spurway Drive are expected to be safe for all events up to and including the 1% AEP design storm event, enabling evacuation if required. Furthermore, vertical evacuation within the subject site is expected to be available in the upper levels of the facility during extreme events, if required.
(f)	Permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent	Not applicable.
(g)	Are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities	The proposed development is expected to have capacity to provide on-site vertical evacuation, limiting off-site evacuation requirements and infrastructure upgrades off-site. As such, significant additional government spending for the purposes of flood mitigation, and emergency response measures is not expected.
(h)	Permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event	The proposed development is expected to have capacity to store any hazardous materials above flood prone land.
4.1.5	For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as	In the absence of an existing Flood Study or Flood Risk Management Study for the subject site, the Flood Planning Area is defined by the results presented herein and review of the relevant planning policies.

Item	Development Control	Response
	otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.	Based on the proposed development, and the definition of Flood Planning Area in THSC LEP (2019) to remain consistent with the NSW Floodplain Development Manual (2005), the Flood Planning Area for the subject site is expected to be defined as the 1% AEP + 500mm.

Conclusion

Northrop Consulting Engineers were engaged by GTL Properties Pty Ltd to prepare a Flood Assessment for the Planning proposal submission at 7-15 Columbia Way, Norwest.

A flood study has been prepared generally in accordance with THSC TUFLOW modelling guidelines. The results of the study are presented herein.

Development of the subject site has been reviewed with respect to the flooding related NSW Ministerial Directions, THSC LEP and DCP. The assessment concludes development of the subject site is expected to be feasible generally in accordance with the requirements outlined in these planning policies.

It is anticipated the proposed development will be further assessed at Development Application Phase as more information becomes available.

Limitation Statement

Northrop Consulting Engineers Pty Ltd (Northrop) has been retained to prepare this report based on specific instructions, scope of work and purpose pursuant to a contract with its client. It has been prepared in accordance with the usual care and thoroughness of the consulting profession for the use by GTL Properties Pty Ltd. The report is based on generally accepted practices and standards applicable to the scope of work at the time it was prepared. No other warranty, express or implied, is made as to the professional advice included in this report.

Except where expressly permitted in writing or required by law, no third party may use or rely on this report unless otherwise agreed in writing by Northrop.

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The report was prepared on the dates shown and is based on the conditions and information received at the time of preparation.

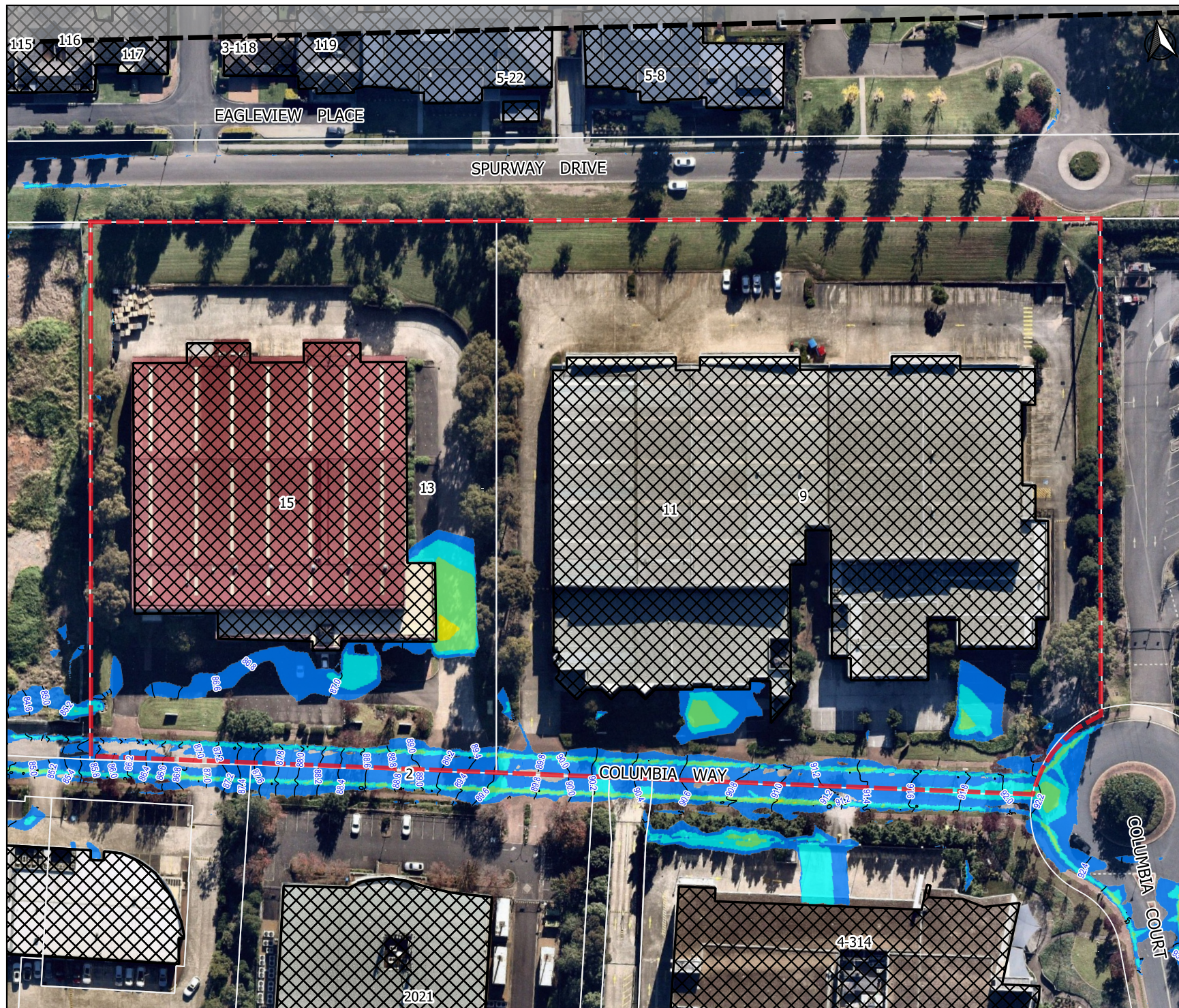
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Document Register

Rev	Status	Prepared	Approved	Date
1	DRAFT	DJ	LG	11/07/2022
A	FINAL	DJ	LG	13/07/2022

Appendix A – Flood Figures



Legend

- Buildings
- Site Boundary
- Model Extent

Flood Contour (mAHD)

Depth (m)

- <= 0.1 (Not Shown)
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

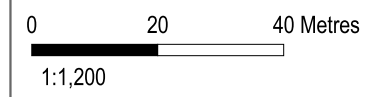
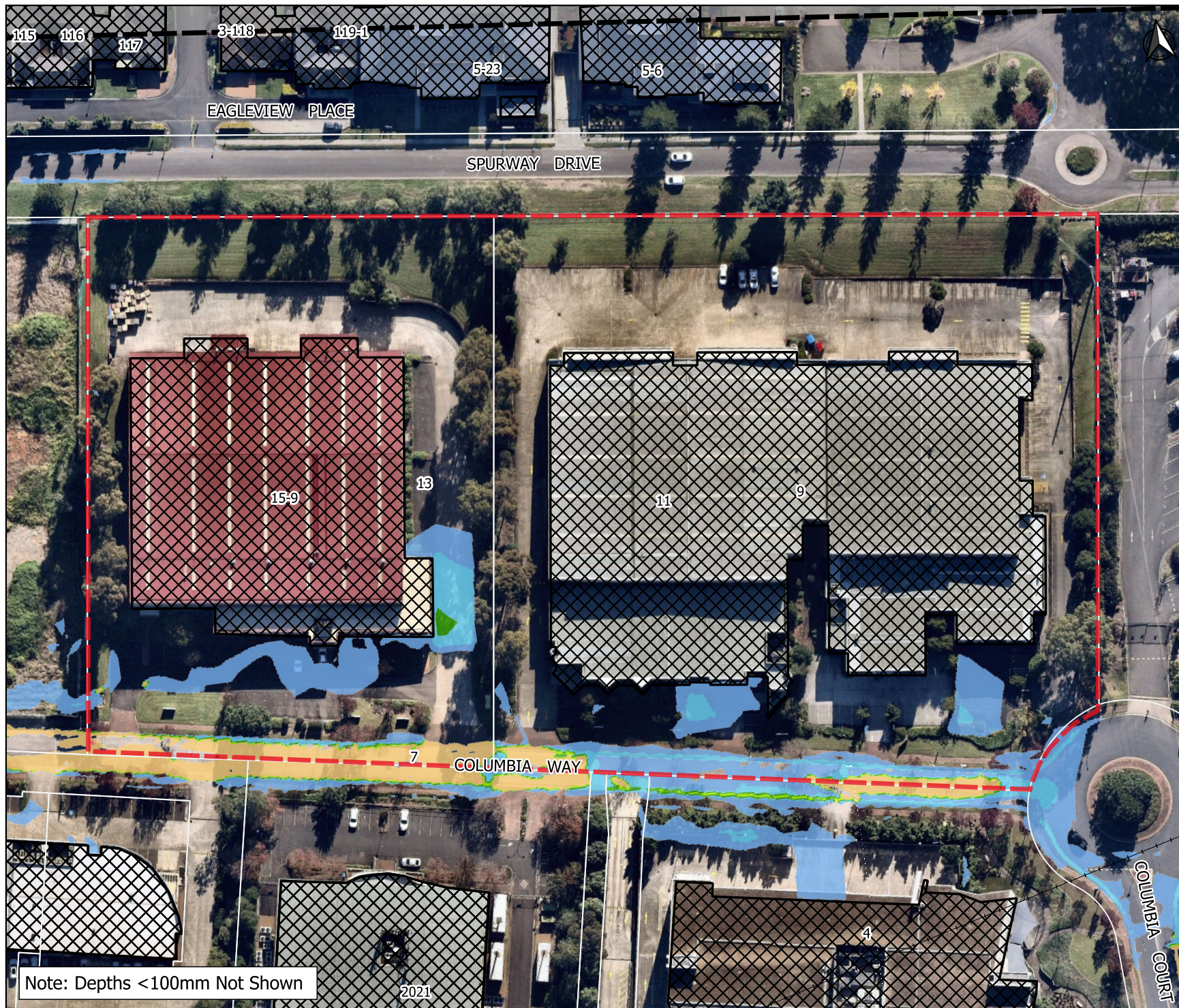


Figure A1 [A]

Existing Case
1% AEP Flood Depth
and Elevation

7-15 Columbia Way
 Norwest





Legend

- Buildings
- Site Boundary
- Model Extent

Hazard Category

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

0 20 40 Metres

1:1,200

Figure A2 [A]
Existing Case
1% AEP Flood Hazard

7-15 Columbia Way
 Norwest





Legend

- Buildings
- Site Boundary
- Model Extent
- Site Boundary

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe

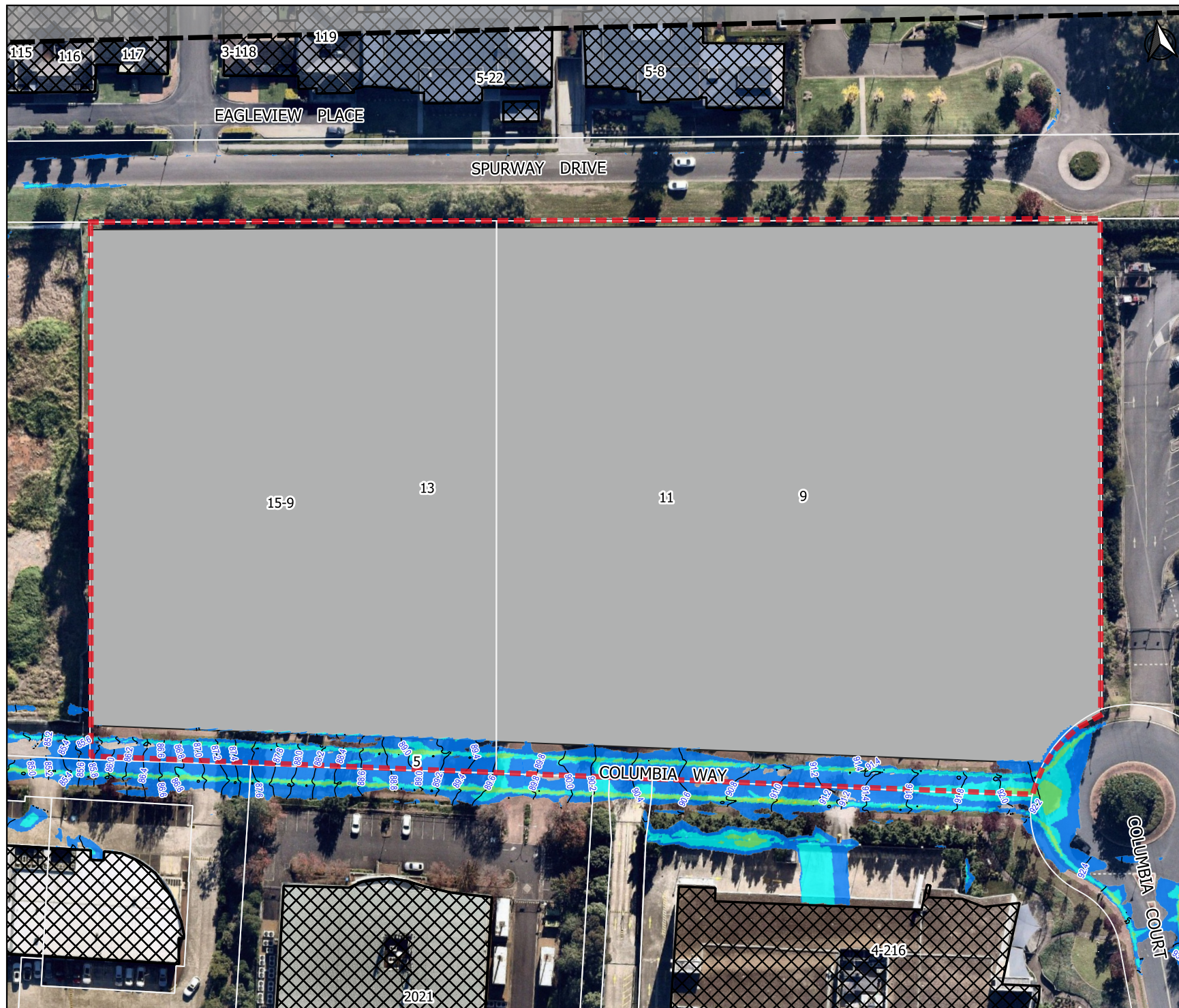
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Figure A3 [A]

Existing Case
1% AEP Flood Hydraulic
Categories

7-15 Columbia Way
Norwest





Legend

- Buildings
- Site Boundary
- Model Extent
- Proposed Development
- Flood Contour (mAHD)

Depth (m)

- ≤ 0.1 (Not Shown)
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- Greater than 2.0

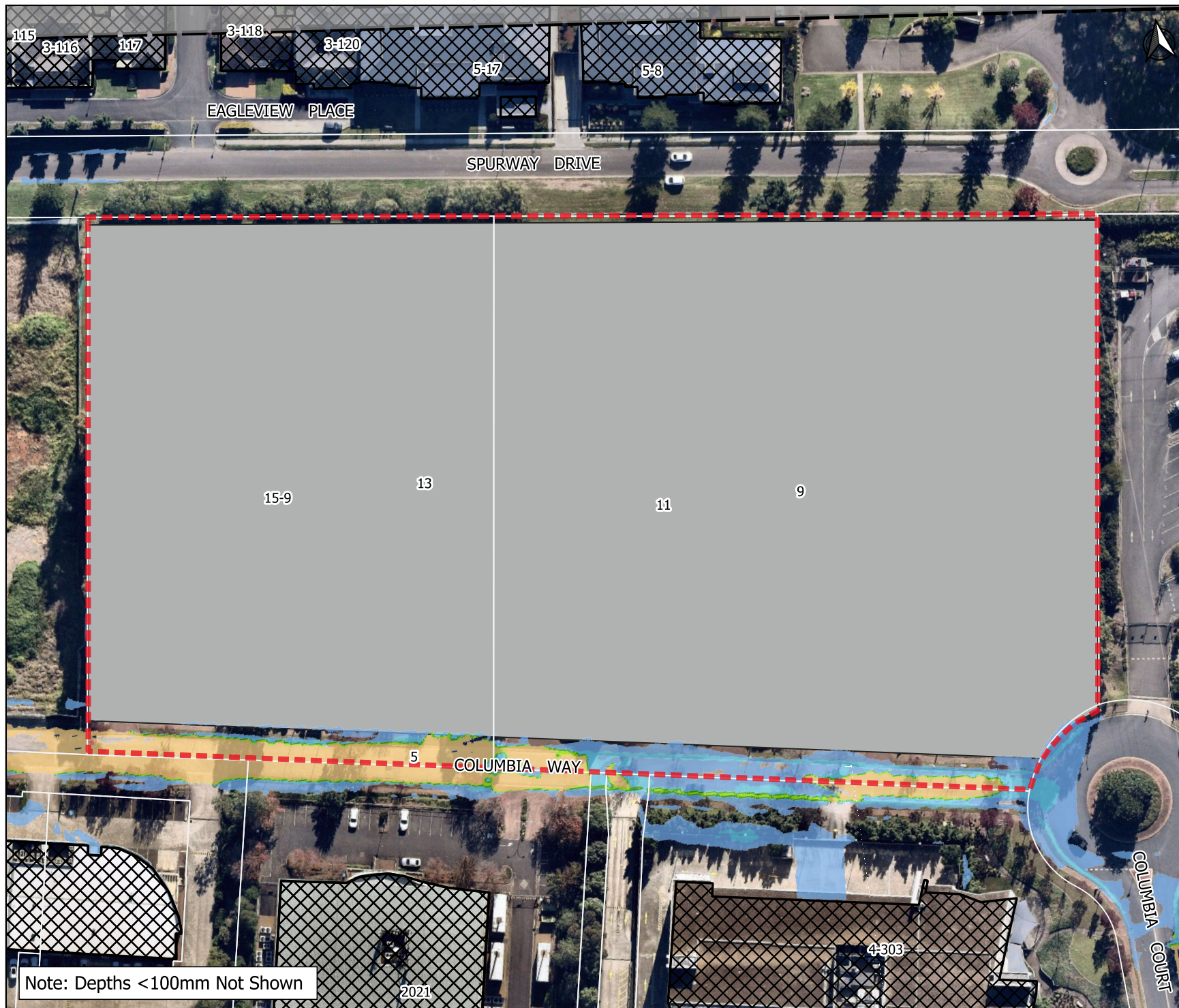
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Figure B1 [A]

**Developed Case
1% AEP Flood Depth
and Elevation**

7-15 Columbia Way
Norwest





Legend

- Buildings
- Site Boundary
- Model Extent
- Proposed Development

Hazard Category

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

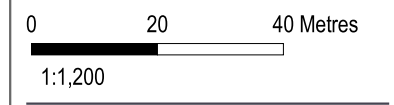


Figure B2 [A]
Developed Case
1% AEP Flood Hazard

7-15 Columbia Way
 Norwest





Legend

- Buildings
- Model Extent
- Site Boundary
- Proposed Development

Hydraulic Categories

- Floodway
- Flood Storage
- Flood Fringe

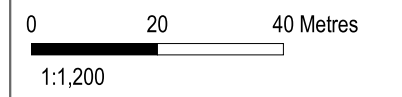
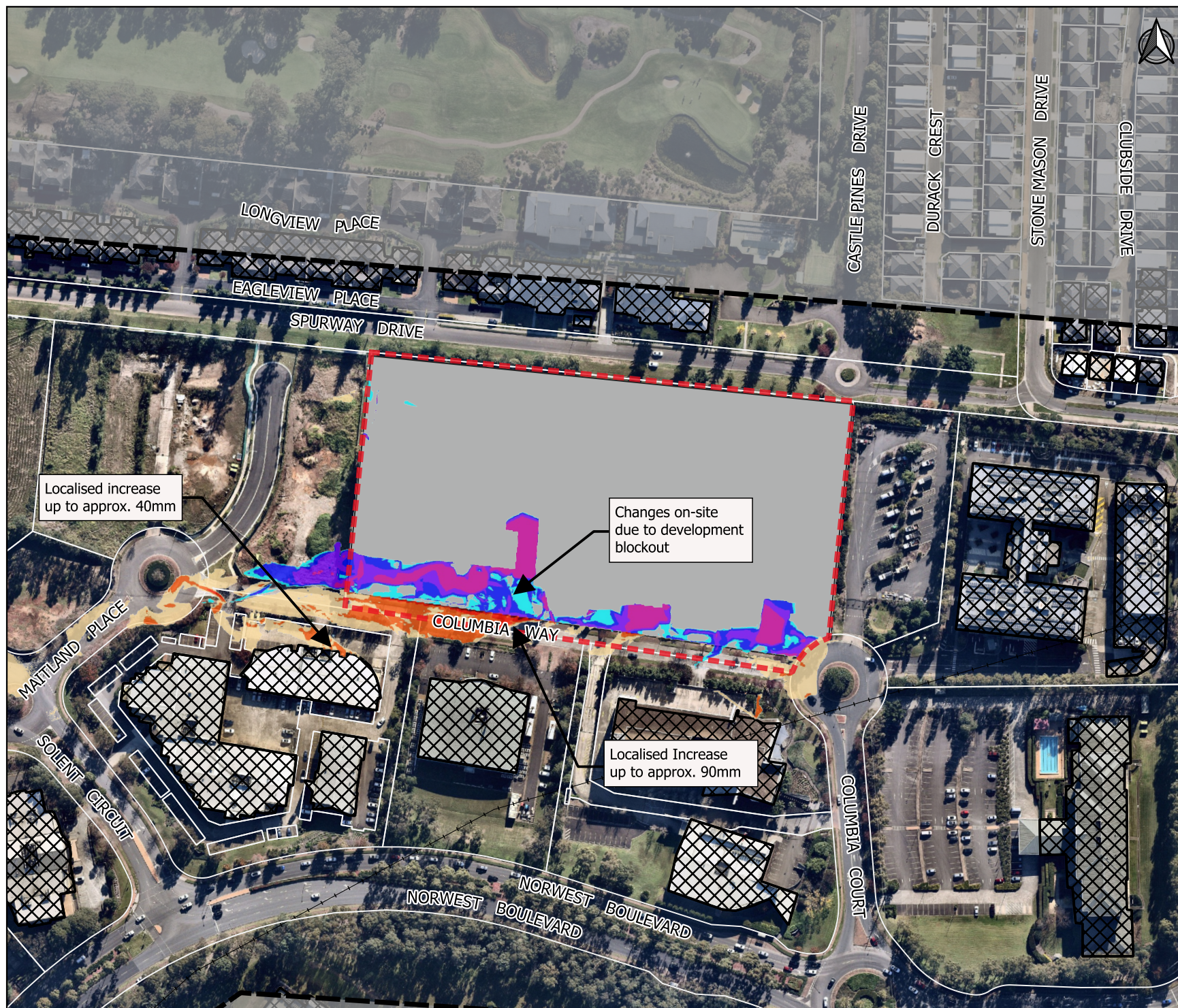


Figure B3 [A]
Developed Case
1% AEP Flood Hydraulic
Categories

7-15 Columbia Way
 Norwest



Note: Depths <100mm Not Shown



Legend

- Site Boundary
- Buildings
- Model Extent
- Proposed Development

Depth Difference (m)

- ≤ -0.100
- 0.050 - -0.100
- 0.025 - -0.050
- 0.010 - -0.025
- 0.010 - 0.010
- 0.010 - 0.025
- 0.025 - 0.050
- 0.050 - 0.100
- Greater than 0.100

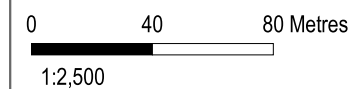






Figure C1 [A]
Pre-to-Post Comparison
1% AEP Event
Flood Depth Difference

7-15 Columbia Way
 Norwest










Legend

-  Site Boundary
-  Buildings
-  Model Extent
-  Proposed Development

Difference (m)

-  ≤ 0.001 (Not Shown)
-  0.001 - 0.010
-  0.010 - 0.025
-  0.025 - 0.050
-  0.050 - 0.100

0 40 80 Metres
1:2,500

Figure D1 [A]

**Climate Change Sensitivity
Developed Case
1% AEP Event**

7-15 Columbia Way
Norwest

