Our Ref: NW30290 - L04 :BCP/bcp
Contact: Dr Brett C. Phillips

17th November 2022

The Manager,
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Dear Kim,

FLOODING ADVICE FOR PROPOSED DEVELOPMENT OF BLOCK D, SITE 1 AND SITE 2 AT 224 – 240 PITT STREET, MERRYLANDS

We are pleased to submit our report summarising our flood assessment of the proposed development of Block D Site 1 and Site 2 (formerly known as Block A and Block B) at 224 - 240 Pitt Street, Merrylands. Our flooding advice addresses Council's DCP flood controls in relation to Block D of the development, including Flood Planning Levels (FPLs) for the development. The advice is informed by flood modelling to ascertain flood levels at the site in the 1% and 5% Annual Exceedance Probability (AEP) events and the Probable Maximum Flood (PMF).

1. BACKGROUND

1.1 Neil Street Precinct

As described, in part, by Holroyd City Council, 2015[1]:

> *This Urban Design Review has been prepared in support of a Planning Proposal for the amendment of the local plans related to Merrylands Neil Street Precinct (Neil Street Precinct) contained within the Holroyd Local Environmental Plan (LEP) 2013 and Holroyd Development Control Plan (DCP) 2013. …….*
>
> *This review focused on the delivery of sustainable buildings that respond to the local context and topography whilst minimising amenity impacts on existing and potential neighbouring development, the public domain and residential developments in and around the Neil Street Precinct. The improvement of pedestrian access to and from the Merrylands Train Station was also a focal point in the project which considered access and movement through the private and public domain. ….*

[1] Holroyd City Council (2015) "Merrylands Neil Street Precinct, Urban Design Review", Final Report, October

The Precinct

Neil Street Precinct is bounded by Pitt Street to the west and the Railway Corridor to the east. To the north of the Precinct is Holroyd Gardens and to the south is Merrylands Train Station (Refer Figure 1). The Northern boundary of the Precinct is within the 400m walking distance catchment of the Merrylands Train Station. …

Vision

The Precinct is envisioned to be characterised by a high-quality, well designed, safe and liveable environment within walking distance to Merrylands Railway Station, which is the main transport hub for the area. Properties along Pitt Street and the future development along New Road 1 will support a mix of retail, commercial office/business and residential functions.

The landscape vision for the site is to insert a new landscape layer that provides a meaningful and distinctive landscape that not only strengthens the character of Precinct but all of Merrylands Centre. The proposed landscape will build on the DCP 2013 public domain structure to form a comprehensive design. Landscaping and planting along the streets and between lots will provide another layer of landscape type accentuating the landscape setting created by Holroyd Gardens and will 'soften' the built environment. …….

Figure 1 Neil Street Precinct and Proposed Blocks (Source: Figure 23, Holroyd City Council, 2015)

Proposed Block D

As described, in part, by Holroyd City Council, 2015:

> *Block D is bounded by Neil Street to the north, the railway corridor (which runs northeast to southwest) to the east and south, Merrylands Train Station to the southwest and New Road 1 to the west with the overland flow path located to the east of New Road 1.*
>
> *Although the accessibility of Block D is enhanced by the proposed Road 1, it is also constrained by the existing Sydney water culvert which runs through the site. The flood flow path which is envisioned to form part of the public open network provides an opportunity for Block D to enhance the public domain of the area by incorporating a centrally located space - Neil Street Park for recreational purposes.*
>
> *Given the landscape setting, this Block is expected to accommodate secondary active uses (e.g. gymnasium, child care centre, corner shop, café) that support and enhance the liveability of the Precinct. The ground level activity within Block D will be focused along New Road 1.*
>
> *The detailed, site specific controls within this section will define the scale and character of development at the Pitt and Neil Streets intersection, providing development that create a positive image. …….*

1.2 Subject Site

The subject site is Block D (refer **Figure 1**).

The Precinct is located in the confluence of two overland flow paths, from the west and southwest, with a trunk drainage line owned by Sydney Water nearby. The trunk drainage line drains to A'Becketts Creek. Elevations generally range between 15 m AHD and 17 m AHD.

The site was shown to be affected in the 1% AEP, according to the Merrylands CBD Flood Study (Bewsher, 2002) and more recently in the Holroyd City LGA Overland Flood Study prepared in April 2017.

Council's Flood Advice for 2 Neil Street dated 19 October 2022 and 4 Terminal Place dated 20 October 2022 (attached in **Appendix A**) advise in part:

> *The above property is shown to **be affected** by the 1% Annual Exceedance Probability (AEP) flood, according to the information available to Council from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017.*

Council's Flood Advice for 4A Terminal Place dated 20 October 2022 (attached in **Appendix A**) advises in part:

> *The above property is shown to **be not affected** by the 1% Annual Exceedance Probability (AEP) flood, according to the information available to Council from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017. However, it is located within the floor level control area, in which the floor levels of the new buildings are required to be set with sufficient freeboard above the adjacent flood level.*

Hence, the site was identified as a Flood Control Lot by Cumberland City Council.

Figure 2 Proposed Ground Floor Layout for Building A, Block D Site 1

Figure 3 Proposed Ground Floor Layouts for Buildings B, C and D, Block D Site 2

1.3 Proposed Development

The proposed development site layout comprises a series of new buildings and associated driveways located in Sites 1 and 2.

A plan of the proposed Block D Site 1 development of is shown in **Figure 2**.

A plan of the proposed Block D Site 2 development of is shown in **Figure 3**.

2. OBJECTIVE

The objective of this study was to assess flooding across the subject site and to assess the impacts of the proposed development on flooding.

3. PREVIOUS STUDIES

As described by Lyall & Associates, 2015[2]:

> *A number of investigations have been carried out over the past three decades which deal with flood behaviour (both main stream and overland) in the study catchments. ….*
>
> *Note that reference is also made in this report to a companion study that was undertaken by Lyall & Associates (L&A) on behalf of HCC and SWC which used the same hydrologic and hydraulic models which were developed as part of the present investigation (L&A, 2014). The study involved a detailed investigation into flood risk management options that could be implemented as part of the future redevelopment of the Merrylands CBD, which is located in the A'Becketts Creek catchment.*

The listed studies were completed between March 1989 and December 2004.

Previous studies include the following:

- 2002 Merrylands CBD Flood Study undertaken by Bewsher Consulting
- 2015 Merrylands CBD Neil Street Precinct Flooding Investigation undertaken by Lyall & Associates
- 2017 Holroyd City LGA Overland Flood Study undertaken by Lyall & Associates
- 2015-2017 Hydrologic and Hydraulic Modelling undertaken by Cardno

These are outlined in **Appendix B**.

4. 2022 FLOOD ASSESSMENT

4.1 Update of 2017 Proposed Conditions

The hydrological and hydraulic modelling was based on the previous modelling undertaken by Cardno and described in Appendix B.4.

[2] Lyall & Associates (2015) "Merrylands CBD Neil Street Precinct Flooding Investigation", *Letter Report*, prepared for Holroyd City Council, September.

As described in Appendix A.4.3, precinct planning includes a new road between Terminal Place and Neil Street passing through the development site, an upgrade of the drainage network in the area and configuration of a new swale.

The 2017 design case scenario was developed through including the following components in the model:

- Proposed building block layouts;
- Proposed road design TIN for main roads prepared by SMEC Pty Ltd and provided to Cardno by AT&L;

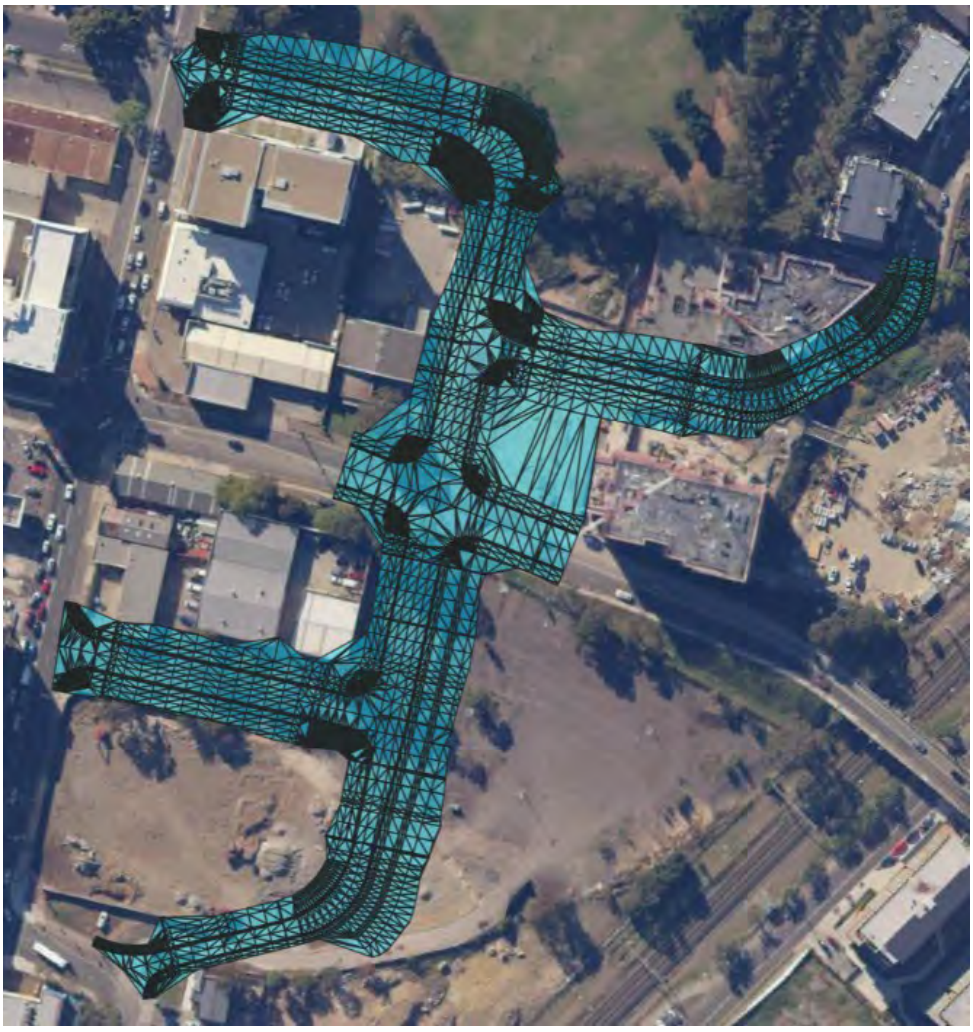


Figure 4 Updated Road design TIN provided by AT&L

- Proposed drainage network design prepared by SMEC Pty Ltd and provided to Cardno by AT&L; and
- Proposed internal road design TIN prepared by AT&L Pty Ltd and provided to Cardno.

The 2017 configuration was updated to incorporate an updated road TIN and updated drainage works provided by AT&L. The updated TIN is plotted in **Figure 4**.

The updated floodplain model was then re-run for the 1% and 5% AEP events and the PMF.

4.2 2022 Proposed Conditions

During design development for Block D a series of meetings were held with members of the project team and with Council to explore the opportunity to modify the previous adopted swale configuration and to enhance the open space and the frontage along the western side of Building A (refer **Figure 2**). This design development culminated in a modified swale configuration, re-grading of the local park and incorporation of a driveway crossing as set out in **Figure 5**. The proposed works include:

- A modified swale plan layout with a maximum 600 mm step on the edge of the swale;
- A 6 m wide driveway crossing with 6 x 600 mm (W) x 450 mm (H) RCBC

Figure 5 2022 Proposed Conditions

- Re-grading of the proposed new park
- Inclusion of a solid wall along the rear (eastern boundary) and wrapping around the northern and southern boundaries as far as needed to prevent 1% AEP overland flows from the rail corridor spilling into Block D and to provide not less than 500 mm freeboard above the 1% AEP flood levels in the rail corridor to protect any rear entries to Buildings B, C and D.

4.3 2022 Results

The flood behaviour under the 2022 proposed conditions was assessed for the 1% and 5% AEP events and the PMF.

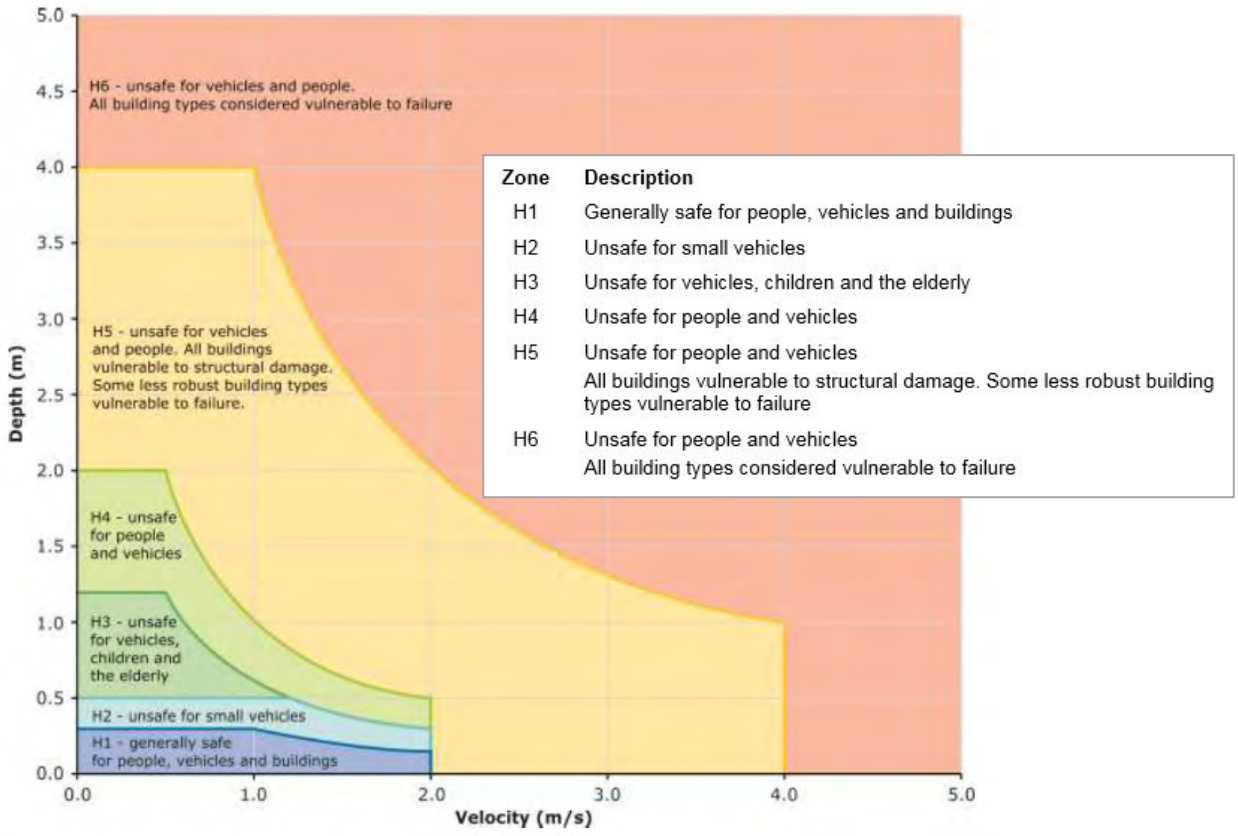
Flood Levels, Velocities Depths and Hazard

Based on the 2022 proposed conditions including the layouts for Buildings A (Site 1) and B, C and D

- 5% AEP, 1% AEP flood level contours and PMF level contours are mapped respectively in **Figures F1, F5** and **F9**.
- 5% AEP, 1% AEP flood depths and PMF depths are mapped respectively in **Figures F2, F6** and **F10**;
- 5% AEP, 1% AEP flood velocities and PMF velocities are mapped respectively in **Figures F3, F7** and **F11**;
- 5% AEP, 1% AEP flood hazard categories and PMF flood hazard categories (see criterion below) are mapped respectively in **Figures F4, F8** and **F12**;

Flood hazard vulnerability curves based on six categories H1 – H6 are as shown below.

It is noted that H1 conditions would be trafficable for small and large vehicles while H2 conditions would be trafficable for larger vehicles only.



4.4 Flood Warning Time

Due to the size of the catchment, flood warning times are limited at the site. The short warning times result in insufficient time to evacuate any residents and/or visitors from the site. Instead, residents and/or visitors would need to shelter in place. The expected time that visitors and/or residents would need to shelter in place would be less than 3 hours in a PMF. The available flood warning time would need be taken into consideration for flood emergency response planning.

4.5 Impact Assessment

Council has previously assessed the 100 yr ARI flood level impacts for various scenarios in its 2015 Merrylands CBD Neil Street Precinct Flooding Investigation. The 100 yr ARI flood level impacts are well known to Council. A comparison of the 100 yr ARI flood levels under 2022 proposed conditions are around 0.1 m to 0.2 m higher the 100 yr ARI flood levels reported in Council's flood certificate attached in **Appendix A**). The 100 yr ARI flood levels under 2022 proposed conditions are consistent with the 100 yr ARI post-development flood levels accepted by Council when granting approvals for Block B and Block C previously.

The impacts of the 2022 proposed conditions on 5% AEP, 1% AEP flood levels and PMF levels in comparison with flood levels under the updated 2017 conditions are mapped respectively in Figures D1, D2 and D3 which are attached in **Appendix C**. It is concluded that in the 2022 proposed conditions has negligible adverse impact.

5. COUNCIL FLOOD CONTROLS

The site of the proposed development lies within the former City of Holroyd, and the applicable flood-related development controls are given in the Holroyd Development Control Plan (DCP) 2013. Part A, Section 8.6 of the DCP relates to development on flood prone land, outlining flood related development controls. The development controls that are relevant depend on the level of flood risk at the site. The DCP defines the following flood risk precincts:

- *High Flood Risk Precinct - This has been defined as the area of land below the 1% AEP flood that is either subject to a high hydraulic hazard (in accordance with the provisional criteria outlined in the Floodplain Development Manual) or where there are potential evacuation difficulties. Development within this Precinct is extremely restricted, as it is very hard to ensure the safety and protection of both person and property during a critical storm event;*

- *Medium Flood Risk Precinct - This has been defined as land below the 1% AEP flood subject to low hydraulic hazard (in accordance with the provisional criteria outlined by the Floodplain Development Manual). Development within this Precinct is possible, however appropriate flood management measures must be implemented, to ensure the safety and protection of both person and property during a critical storm event; and,*

- *Low Flood Risk Precinct - This has been defined as all other land within the floodplain (i.e. within the extent of the probable maximum flood) but not identified as either a high flood risk precinct or medium flood risk precinct, where risk of damages are low for most land uses. Development within this Precinct is possible, however consideration for development is needed to ensure that property is protected.*

The application of these controls to the site is discussed in **Section 6**.

6. PROPOSED DEVELOPMENT

6.1 Flood Risk

Based on Buildings A, B, C and D being located in either a Medium Flood Risk precinct or a Low Flood Risk precinct, the following development controls for Medium Flood Risk apply:

Design Floor Level:

- Habitable floor levels shall be equal to or greater than the FPL (1% AEP flood plus freeboard); and,
- Floor levels of open car parking areas and garages shall be 150 mm above the 1% AEP flood. This may be achieved with a suspended floor which allows the continued passage of flood waters or filling if justified by a site specific assessment, (subject to "Flood Effects" and other controls below new line). Basement car parking must be protected from the 1% AEP flood plus freeboard of 500 mm, except where, in Council's view, it is impractical to do so, but freeboard shall not be less than 150 mm.

Building Components & Method:

- All structures to have flood compatible building components below or at the FPL (1% AEP flood level plus freeboard).

Structural Soundness:

- Engineers report to demonstrate and certify that any structure can withstand the forces of floodwater, debris & buoyancy up to & including the FPL (1% AEP flood plus freeboard).

Flood Effects:

- The impact of the development on flooding elsewhere shall be considered.

  Note: When assessing flood effects, the following must be considered:
  - *loss of storage area in the floodplain;*
  - *changes in flood levels & velocities caused by alteration of conveyance flood waters; and*
  - *cumulative impacts of the development.*

Evacuation:

- Reliable egress for pedestrians to the lowest habitable floor level is required from the building to an area refuge above the PMF level, either on-site or off-site; and,
- Applicant to demonstrate that the development is to be consistent with any relevant flood evacuation strategy or similar plan.

Management and Design:

- No external storage of materials below the FPL (1% flood plus freeboard) which may cause pollution or be potentially hazardous during any flood; for commercial development and,
- Applicant to demonstrate that area is available to store goods above the FPL (1% AEP flood plus freeboard) for residential development.

Figure 6 Proposed Ground Floor Layout for Building A, Block D Site 1

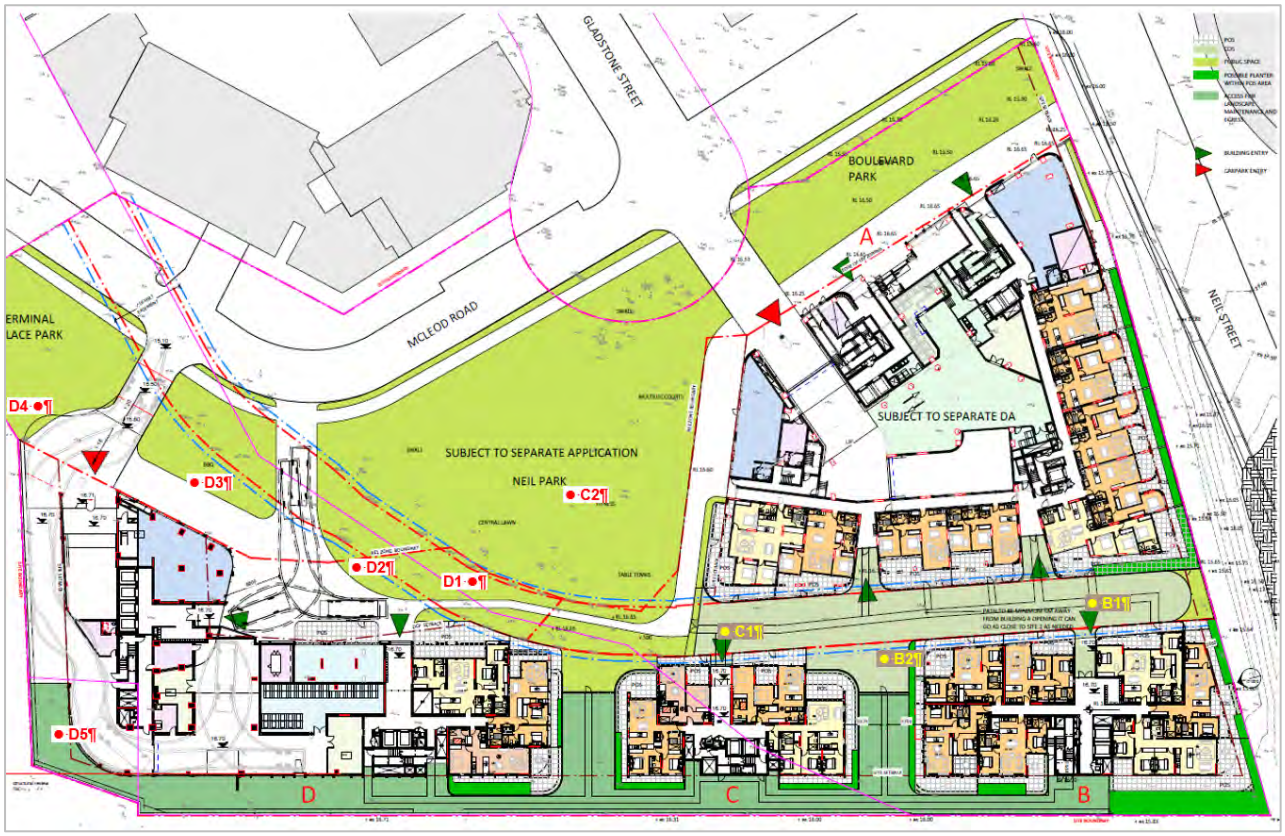


Figure 7 Proposed Ground Floor Layouts for Buildings B, C and D, Block D Site 2

6.2 Freeboard

As the upstream catchment area for the study area is greater than 16 ha, the freeboard required is 500 mm. The DCP permits lesser freeboards for developments with smaller upstream catchments.

6.3 Floor Levels

The Block D Ground Floor levels and reference flood levels are presented in **Table 1**. The reference flood levels locations are given in **Figures 6** and **7**.

The compliance of the ground floor level in combination with other measures is also assessed in **Table1**.

Table 1 Flood Planning Levels across Block D under 2022 Proposed Conditions

	1% AEP Flood Level (m AHD)	FPL (m AHD)	PMF Level (m AHD)	Proposed Level (m AHD)	Compliance against FPL
Building A					
A1	16.15		17.94	16.31	Internal driveway crest complies with mimimum requirent of 1% AEP flood level + 0.15 m
A2	16.13	16.63	17.67	16.7	Complies
A3	16.13	16.63	17.41	16.7	Complies (FPL extrapolated from A2)
A4	Dry	*16.63*	17.41	16.7	Complies (FPL extrapolated from A2)
A5	Dry	*16.63*	17.21	16.7	Complies (FPL extrapolated from A2)
A6	Dry	*16.63*	17.38	16.7	Complies (FPL extrapolated from A2)
A7	Dry	*16.66*	17.75	16.7	Complies (FPL extrapolated from C2)
A8	Dry	*16.66*	18.06	16.7	Complies (FPL extrapolated from C2)
A9	Dry	*16.66*	18.08	16.7	Complies (FPL extrapolated from C2)
A10	16.16	16.66	17.98	16.7	Complies
Building B					
B1	Dry	*16.66*	17.78	16.7	Complies (FPL extrapolated from C2)
B2	Dry	*16.66*	18.05	16.7	Protects rear of Buildings B and C
Building C					
C1	Dry	*16.66*	18.09	16.7	Complies (FPL extrapolated from C2)
C2	16.16	16.66	18.08	16.7	Protects rear of Buildings C and D
Building D					
D1	16.16	16.66	18.09	16.7	Complies
D2	16.16	16.66	18.09	16.7	Complies
D3	16.16	16.16	18.09	16.7	Complies
D4	16.16	16.66	18.12	16.7	Driveway crest complies with requirent of 1% AEP flood level + 0.5 m
D5	Dry	*16.66*	17.82	16.7	Loading dock complies (FPL extrapolated from D4)

When assessing the compliance of ground floor levels of any entry the following issues were considered:

(i) The floor level is at or above the 1% AEP flood level + 0.5 m or the proposed floor level is protected by other measures which ensure that a 0.5 m freeboard is achieved via any potential flowpath; and

(ii) Any proposed measures are not outflanked eg. the rear area of buildings is not outflanked by floodwaters discharging between buildings.

6.4 Driveway Crest Levels

The DCP states that basement car parking must be protected from the 1% AEP flood plus freeboard of 500mm, except where, in Council's view, it is impractical to do so, but freeboard shall not be less than 150mm.

The relevant 1% AEP flood level at the entry to Building A basement car parking levels is RL 16.16 m AHD. The proposed driveway crest level is 16.31 m AHD which is the minimum that Council can accept.

The relevant 1% AEP flood level at the basement car park entry to Buildings D, C and B is RL 16.16 m AHD. The proposed driveway crest level is 16.7 m AHD which provides 500 mm freeboard which complies with the DCP.

6.5 Evacuation and Safe Refuge

The DCP stipulates that reliable egress for pedestrians to the lowest habitable floor level is required from the building to an area refuge above the PMF level, either on-site or off-site.

Due to the limited flood warning times, there would be insufficient time to evacuate any residents, staff and/or visitors from the site. Residents, staff and/or visitors would need to shelter in place.

Reliable vertical access is required for pedestrians to reach an area of refuge above the PMF. The PMF level for Block D ranges from RL 17.21 to 18.12 m AHD (refer Table 1). The first floor of Buildings A, B, C and D are all above the PMF level and the first floor and higher levels would provide temporary refuge during flood emergencies.

A Flood Emergency Response Plan would need to be prepared prior to occupation of the buildings. The operational requirements of any flood warning system would need to be allowed for in building construction. The number of Persons at Risk (PAR) during the PMF would need to be estimated and an appropriate area of refuge provided in publically accessible areas of the buildings.

7. CONCLUSION

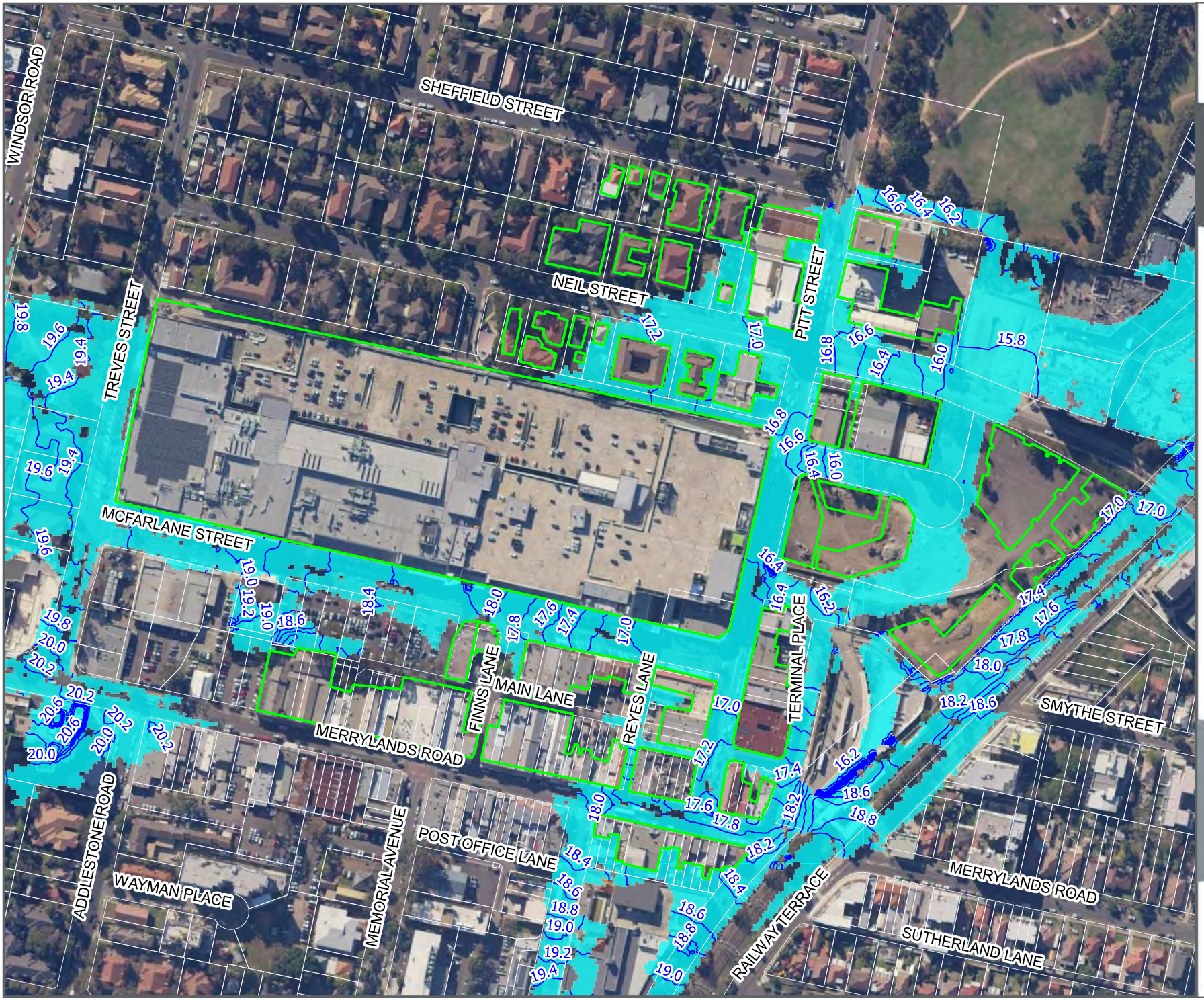
It is concluded that flood protection can be afforded to Block D Site 1 and Site 2 through the measures outlined in this letter.

Yours faithfully

Brett C. Phillips

……

Dr Brett C. Phillips
Senior Principal
for **Cardno now Stantec**



Flood Risk Assessment
Block D - Site 1 and Site 2

5% AEP
Flood Extents and Flood Levels

Legend

- Cadastre
- Proposed Buildings
- Flood Extent
- 0.2m Water Level Contour (mAHD)

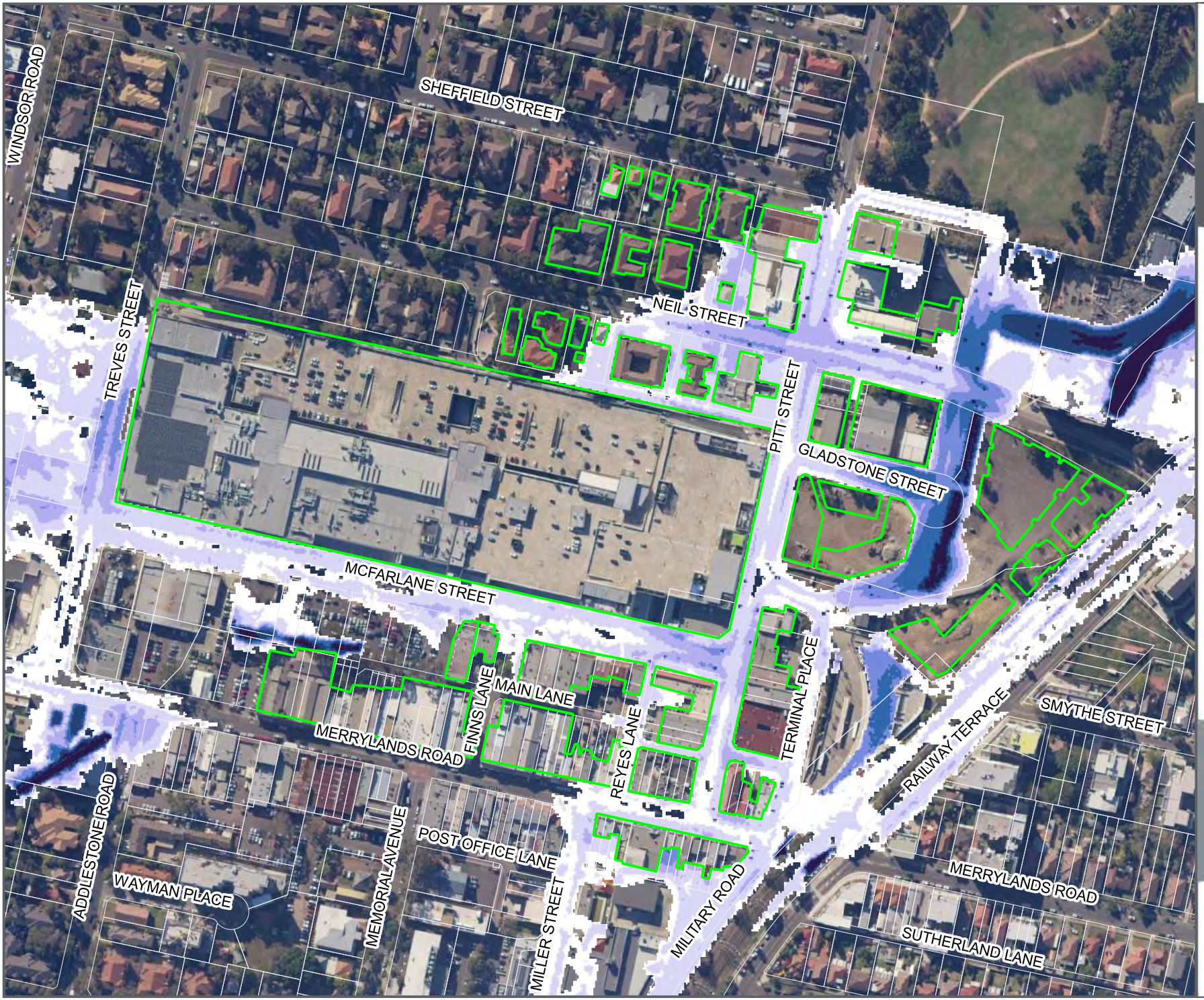
FIGURE F1

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1



Flood Risk Assessment
Block D - Site 1 and Site 2

5% AEP
Flood Depths

Legend

- Cadastre
- Proposed Buildings

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE F2

1:3,500 **Scale at A4**

0 20 40 60 m

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Map: 220913TinSmecwithswale.qgz Rev 1

Flood Risk Assessment
Block D - Site 1 and Site 2

5% AEP
Flood Velocities

Legend

- Cadastre
- Proposed Buildings

Velocity (m/s)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

FIGURE F3

1:3,500 **Scale at A4**

0 20 40 60 m

Cardno

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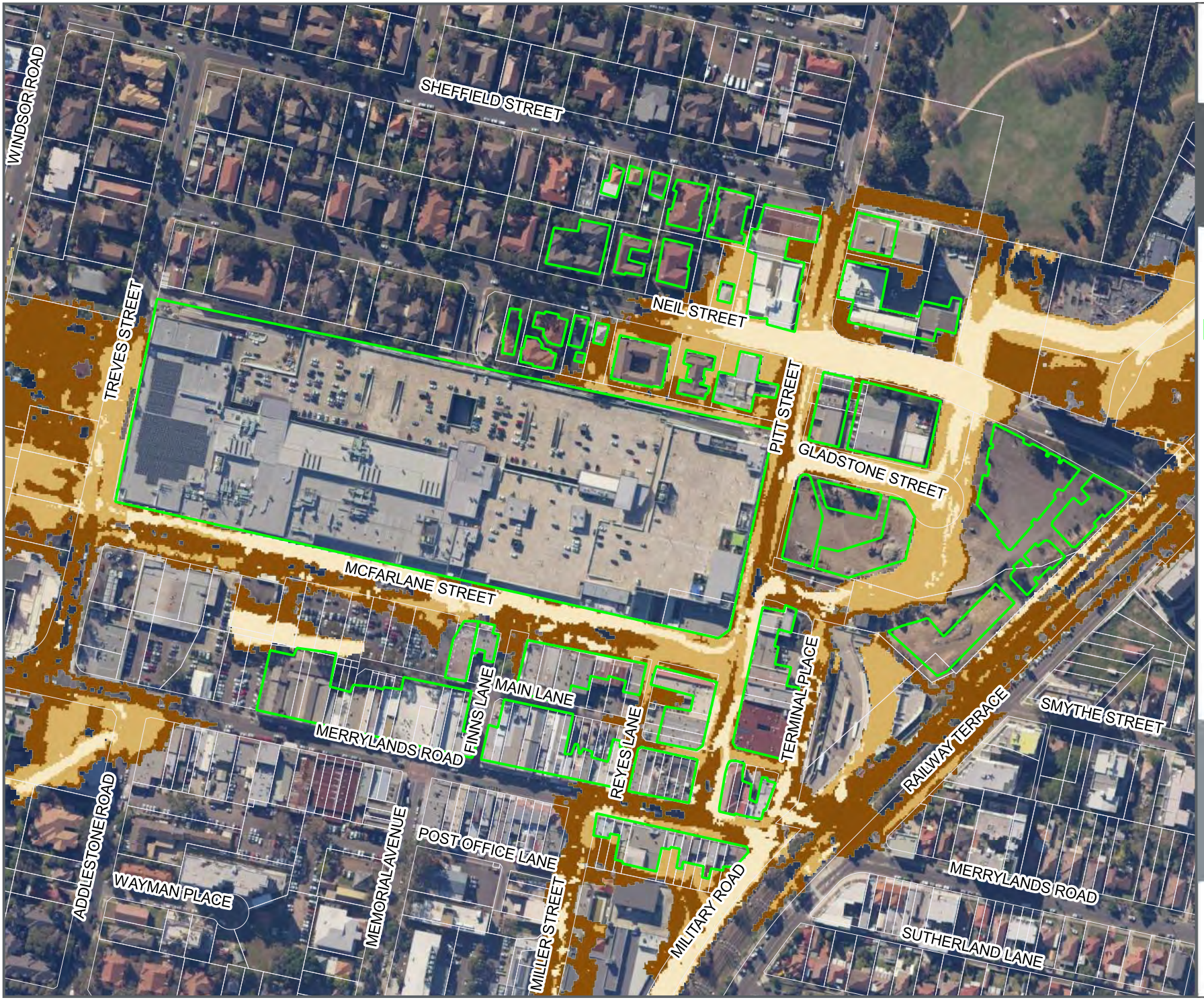

Flood Risk Assessment
Block D - Site 1 and Site 2

5% AEP
Flood Hazard Categories

Legend

- Cadastre
- Proposed Buildings

Hazard Categories

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE F4

1:3,500 Scale at A4

0 20 40 60 m

Cardno

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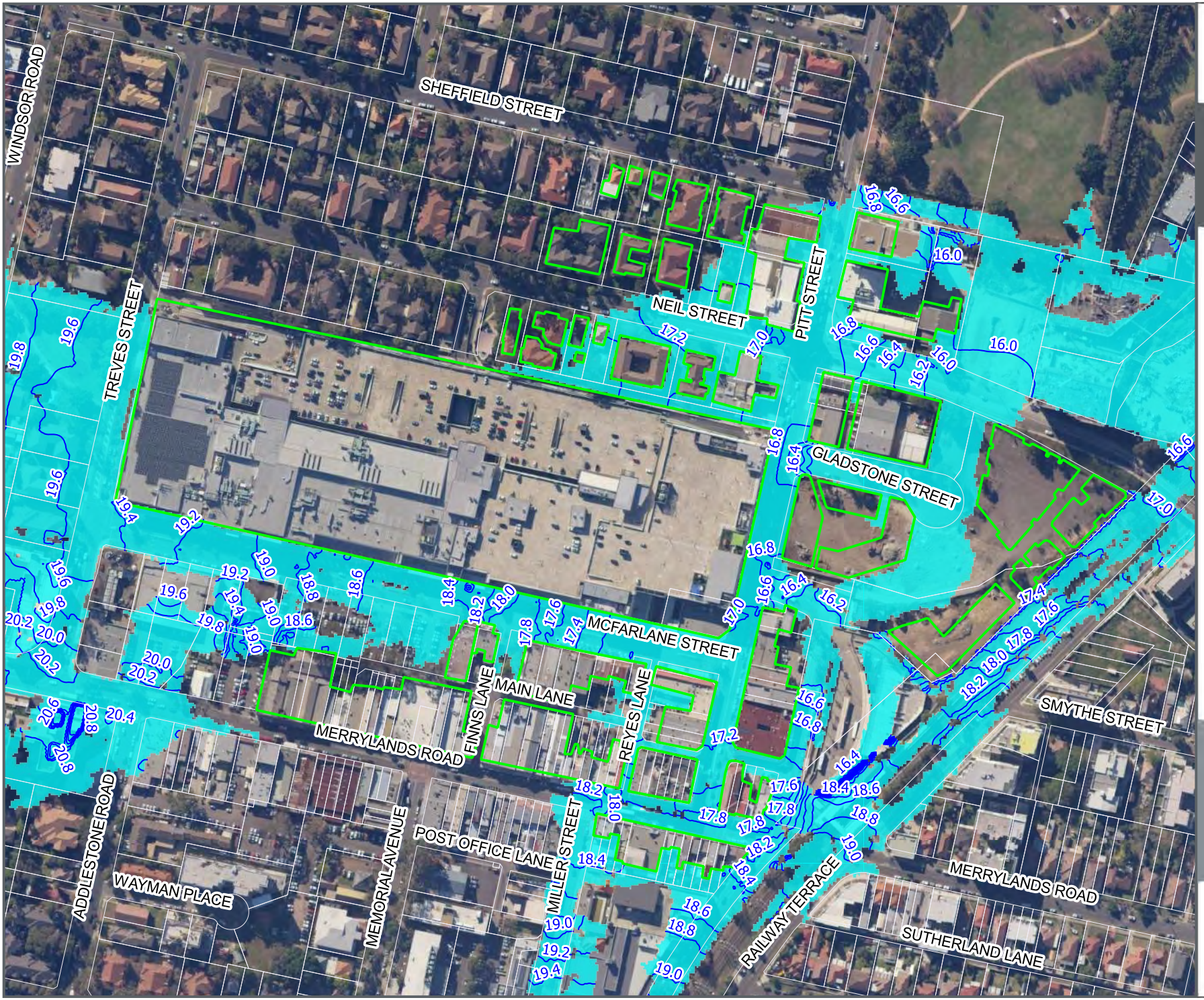

Flood Risk Assessment
Block D - Site 1 and Site 2

1% AEP
Flood Extents and Flood Levels

Legend

- Cadastre
- Proposed Buildings
- Flood Extent
- 0.2m Water Level Contour (mAHD)

FIGURE F5

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
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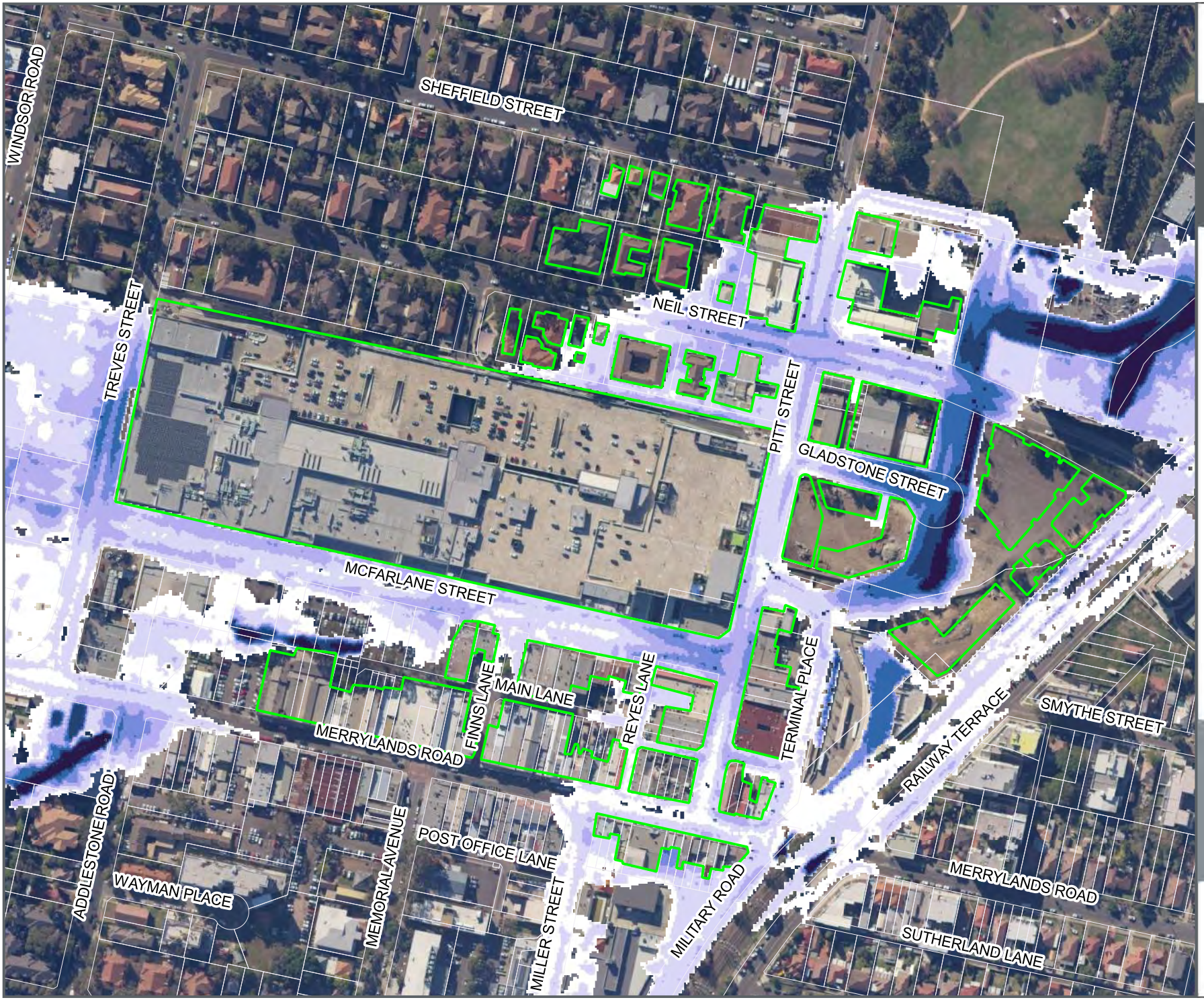

Flood Risk Assessment
Block D - Site 1 and Site 2

1% AEP
Flood Depths

Legend

- Cadastre
- Proposed Buildings

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE F6

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
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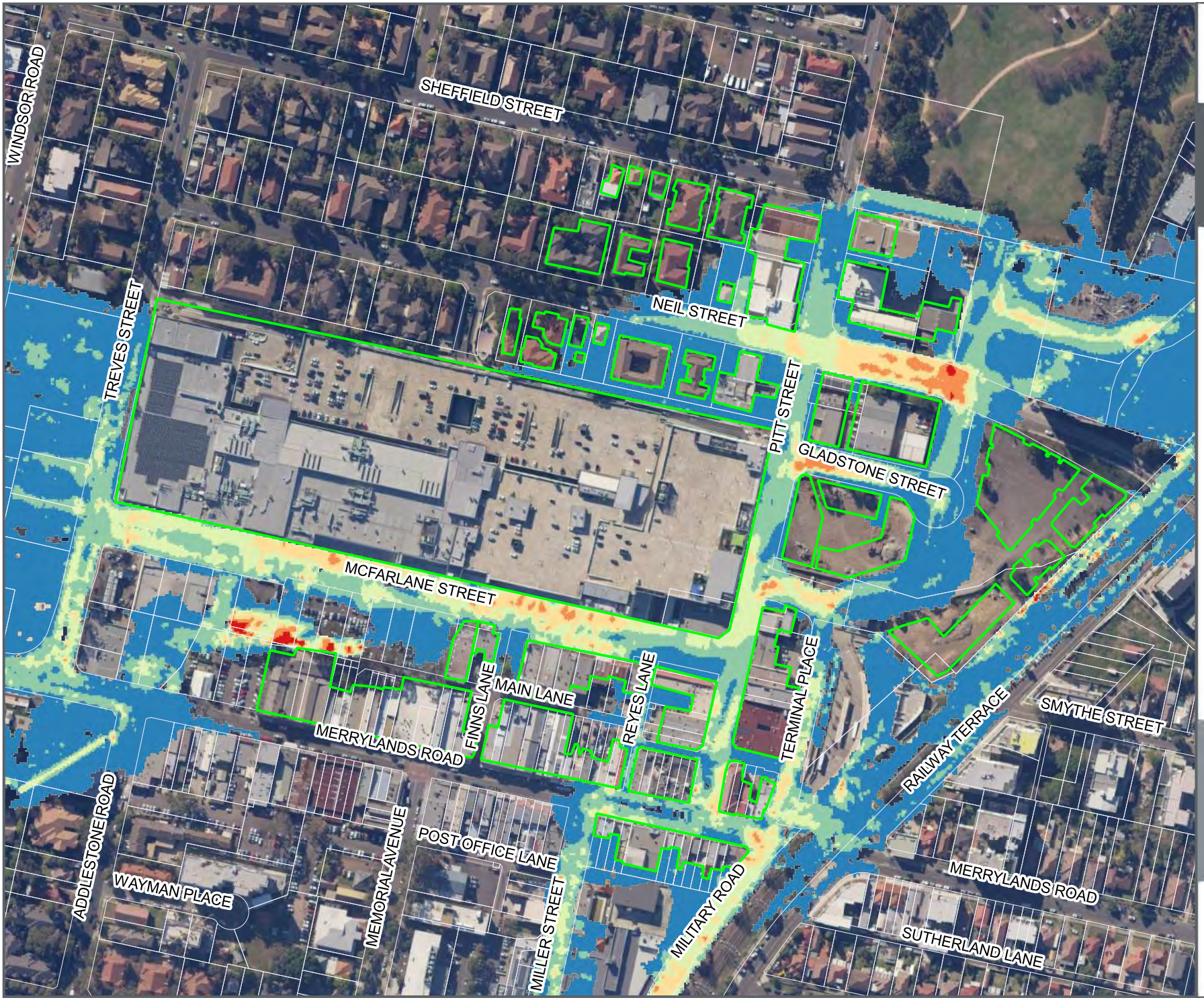

Flood Risk Assessment
Block D - Site 1 and Site 2

1% AEP
Flood Velocities

Legend

- Cadastre
- Proposed Buildings

Velocity (m/s)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

FIGURE F7

1:3,500 Scale at A4

0 20 40 60 m

Cardno

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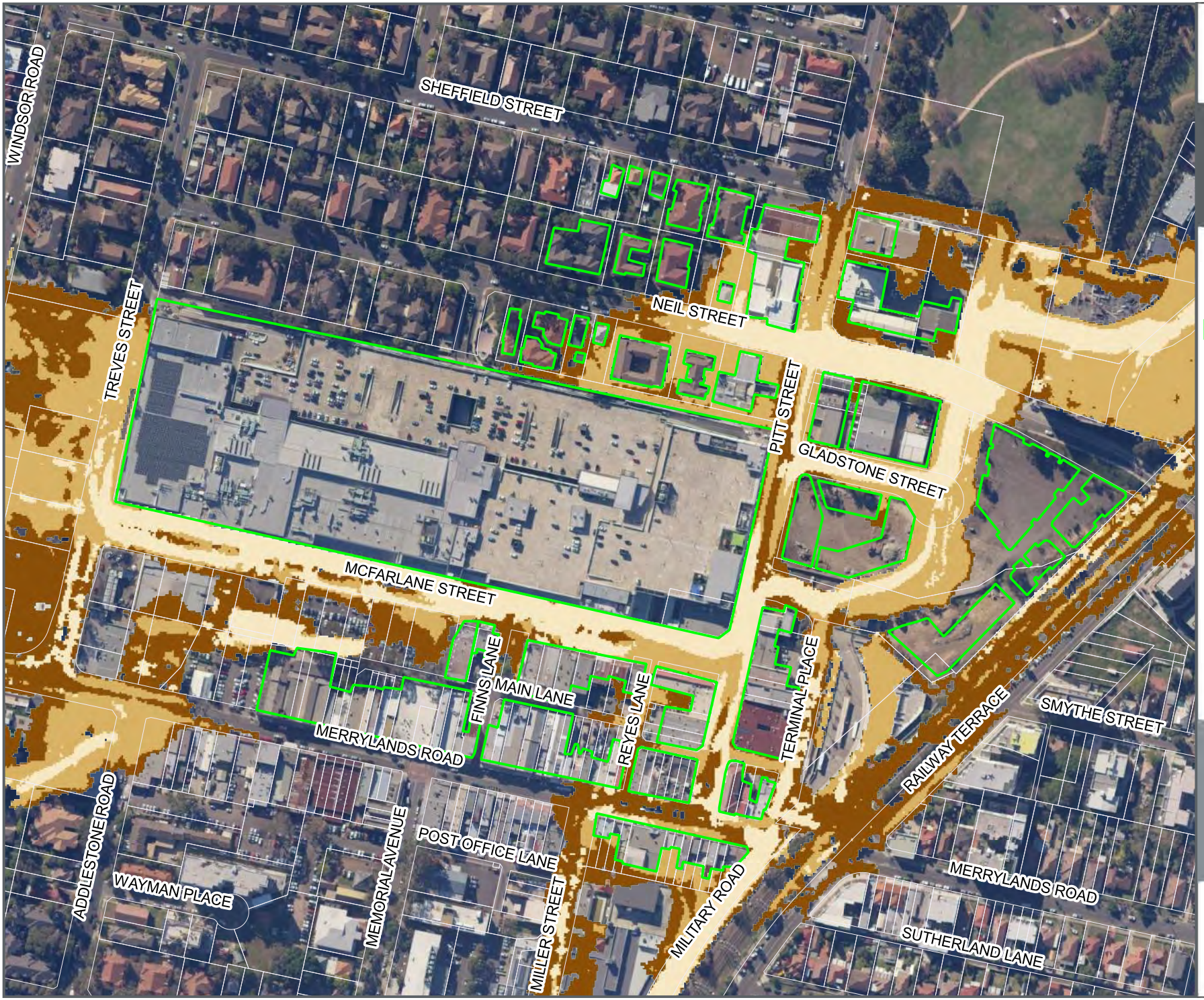


Flood Risk Assessment
Block D - Site 1 and Site 2

1% AEP
Flood Hazard Categories

Legend

- Cadastre
- Proposed Buildings

Hazard Categories

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

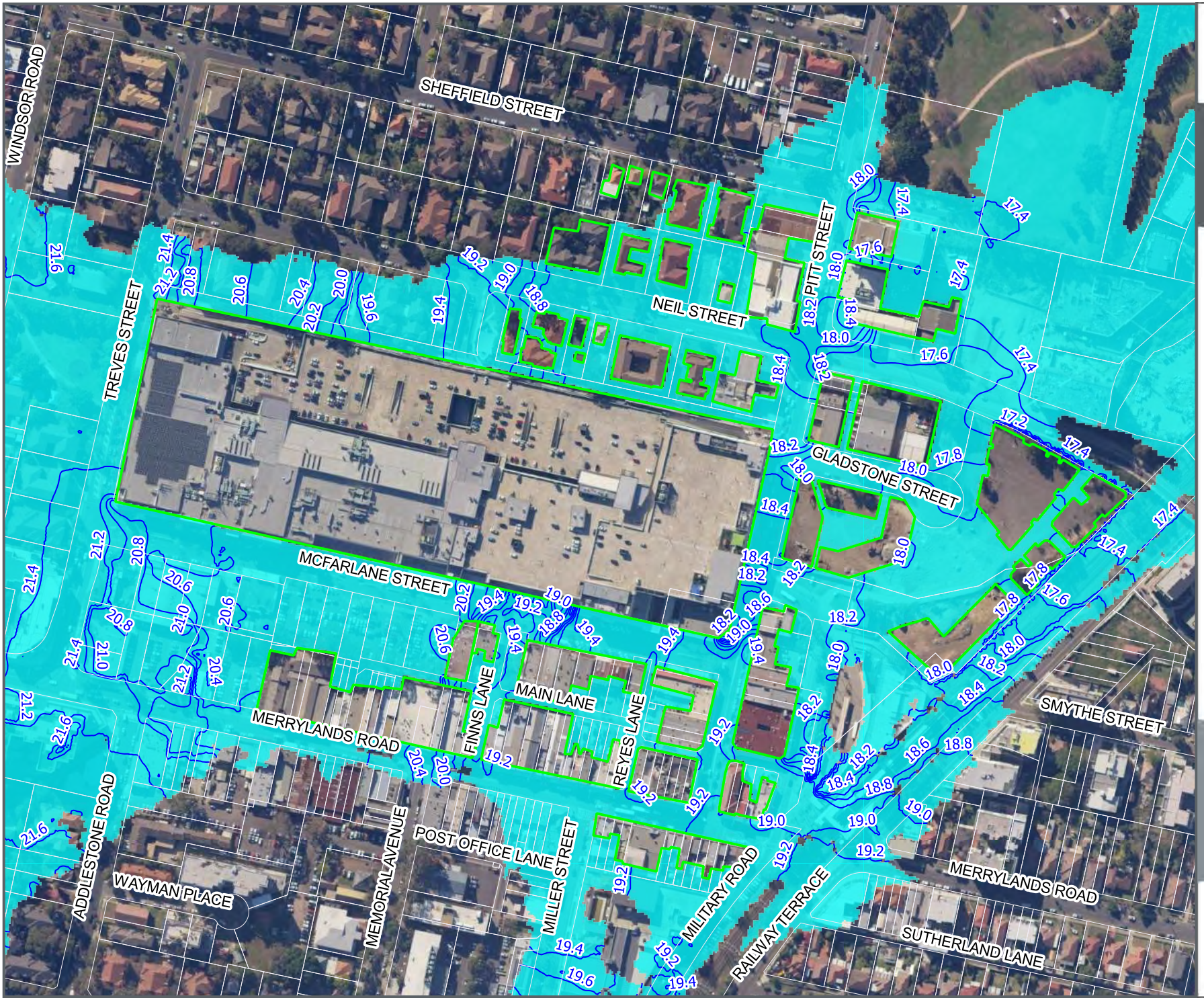
FIGURE F8

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1



Flood Risk Assessment
Block D - Site 1 and Site 2

PMF AEP
Flood Extents and Flood Levels

Legend

- Cadastre
- Proposed Buildings
- Flood Extent
- 0.2m Water Level Contour (mAHD)

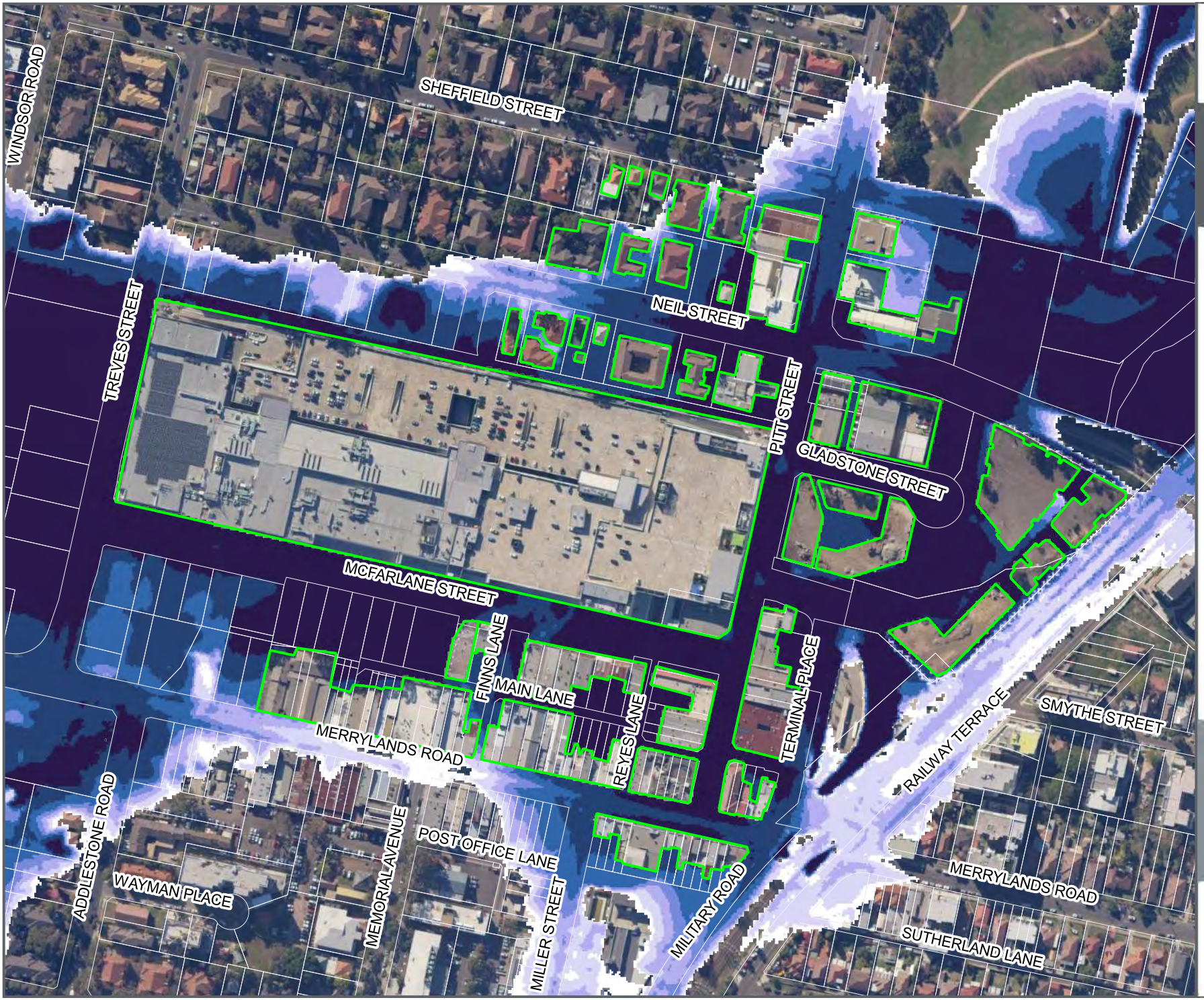
FIGURE F9

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1



Flood Risk Assessment
Block D - Site 1 and Site 2

PMF
Flood Depths

Legend

- Cadastre
- Proposed Buildings

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

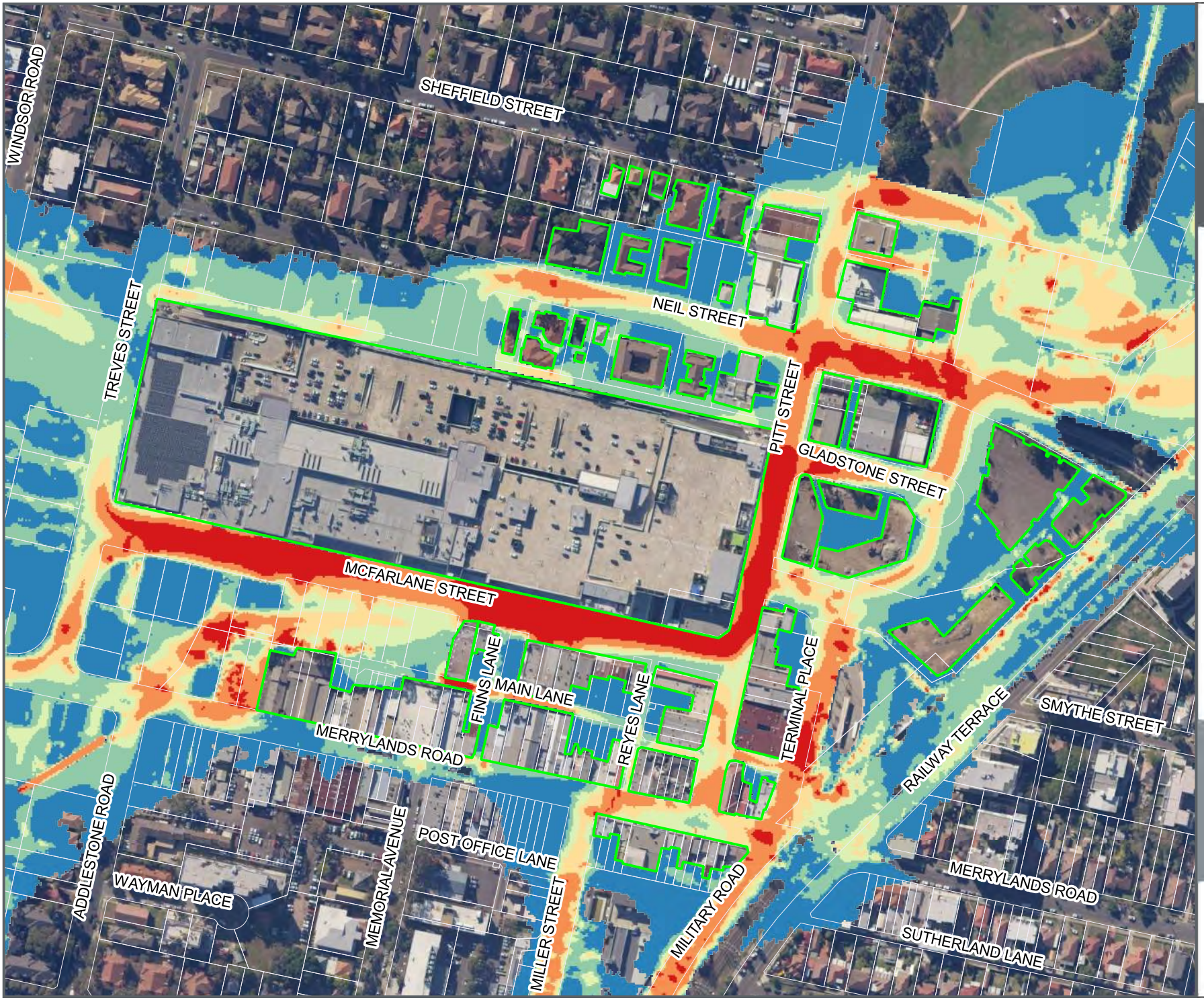
FIGURE F10

1:3,500 **Scale at A4**

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1



Flood Risk Assessment
Block D - Site 1 and Site 2

PMF
Flood Velocities

Legend

- Cadastre
- Proposed Buildings

Velocity (m/s)

- < 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 3.0
- > 3.0

FIGURE F11

1:3,500 **Scale at A4**

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1

Flood Risk Assessment
Block D - Site 1 and Site 2

PMF
Flood Hazard Categories

Legend

- Cadastre
- Proposed Buildings

Hazard Categories

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE F12

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1

Appendix A
Council Flood Advices

CUMBERLAND
CITY COUNCIL

Ref: EC2022/1022

19 October 2022

Aland
8 Gould Street
SOUTH STRATHFIELD NSW 2136

Dear Sir/Madam,

Subject: **Flood Levels at 2 Neil Street MERRYLANDS NSW 2160, Lot 2 DP 1217412**
Application No: **EC2022/1022**
Property: **2 Neil Street MERRYLANDS NSW 2160,**

Council refers to your request dated 26 September 2022 requesting flood information at the above property.

1% ANNUAL EXCEEDANCE PROBABILITY (AEP) FLOOD:
The above property is shown to be affected by the 1% Annual Exceedance Probability (AEP) flood, according to the information available to Council from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017.

The 1% AEP flood level refers to a flood which has a 1% chance of being equalled or exceeded in any one year and this site has been assessed as a high flood risk. It should be noted that a flood could occur that is more severe than the 1% AEP flood at any time.

The maximum 1% AEP flood level relevant to the subject property has been determined (see the attached plan) to Australian Height Datum (AHD) as follows:

1. At location A - 16.0 mAHD
2. At location B - 15.9 mAHD
3. At location C - 15.8 mAHD
4. At location D - 15.7 mAHD

The subject property has been identified as Flood Control lot. Under the SEPP (Exempt & Complying Development) 2008 Regulation 3.5(1), a Complying Development Certificate must not be issued for, "Development under this code must not be carried out on any part of a flood control lot, other than a part of the lot that the council or a professional engineer who specialises in hydraulic engineering has certified, for the purpose of the issue of the relevant complying development certificate, as not being any of the following:

a) a flood storage area,
b) a floodway area,
c) a flow path,
d) a high hazard area,
e) a high risk area."

Council has determined that part of the flood control lies in one of the five items above – **items A, B, C, D and E**; therefore, a CDC cannot be issued on this site. The identified flood items are represented by the darker area within the 1% AEP flood extent on the attached map. If the development is proposed within any part of this zone (dark blue area), a pre and post flood study must accompany the Development Application. Alternatively, if the development is proposed within the uncoloured and/or light blue areas (flood fringe zone), a CDC may be considered for this site. However, the surface flows must not be impeded (blocked) and the redevelopment shall allow the free movement of the flood around any proposed structure(s).

In all cases, flood level on adjacent properties shall not be increased. Supporting documentation is to accompany the development.

Minimum habitable floor levels shall be 0.5m above the flood level at the upstream side of the structure. Minimum non-habitable floor levels (garages, laundry, sheds, etc.) shall be 0.15m above the flood level at the upstream side of the structure. Interpolation between flood levels is allowed.

The relationship between these levels and the ground surface may be determined by a survey of the property undertaken by a Registered Surveyor.

It should be noted that where the development or redevelopment of the property is proposed, reference should be made to the relevant Development Control Plan with regard to flooding and drainage issues. Please include a copy of this letter and map with any Development Application that you may lodge with Council for the subject site.

For modelling purposes, the models (pre and post development flood study) shall be calibrated to Council's 1%AEP Flood levels (or interpolated levels) at least 10 metres upstream and downstream from the property boundaries.

Note:
The brown shaded area on the attached Map represents the flood waters with a depth of flow less than 100mm and does not attract any flood controls. It is presented on the flood map to show the continuity of flooding within the area. However, if development occurs within the brown areas, the structure shall not impede or divert flows to adjacent properties.

Flood levels are not static due to changing circumstances (e.g., revision of the flood model) and accordingly the above flood level is only valid for one year from the above date.

PROBABLE MAXIMUM FLOOD (PMF):
The above property is shown to be **affected** by the Probable Maximum Flood (PMF), according to the information available to Council.

The nearest PMF flood levels available from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017 shown in the Map attached are as follows:

1. At Location A - 18.9 mAHD
2. At Location B - 18.7 mAHD
3. At Location C - 18.0 mAHD
4. At Location D - 17.6 mAHD

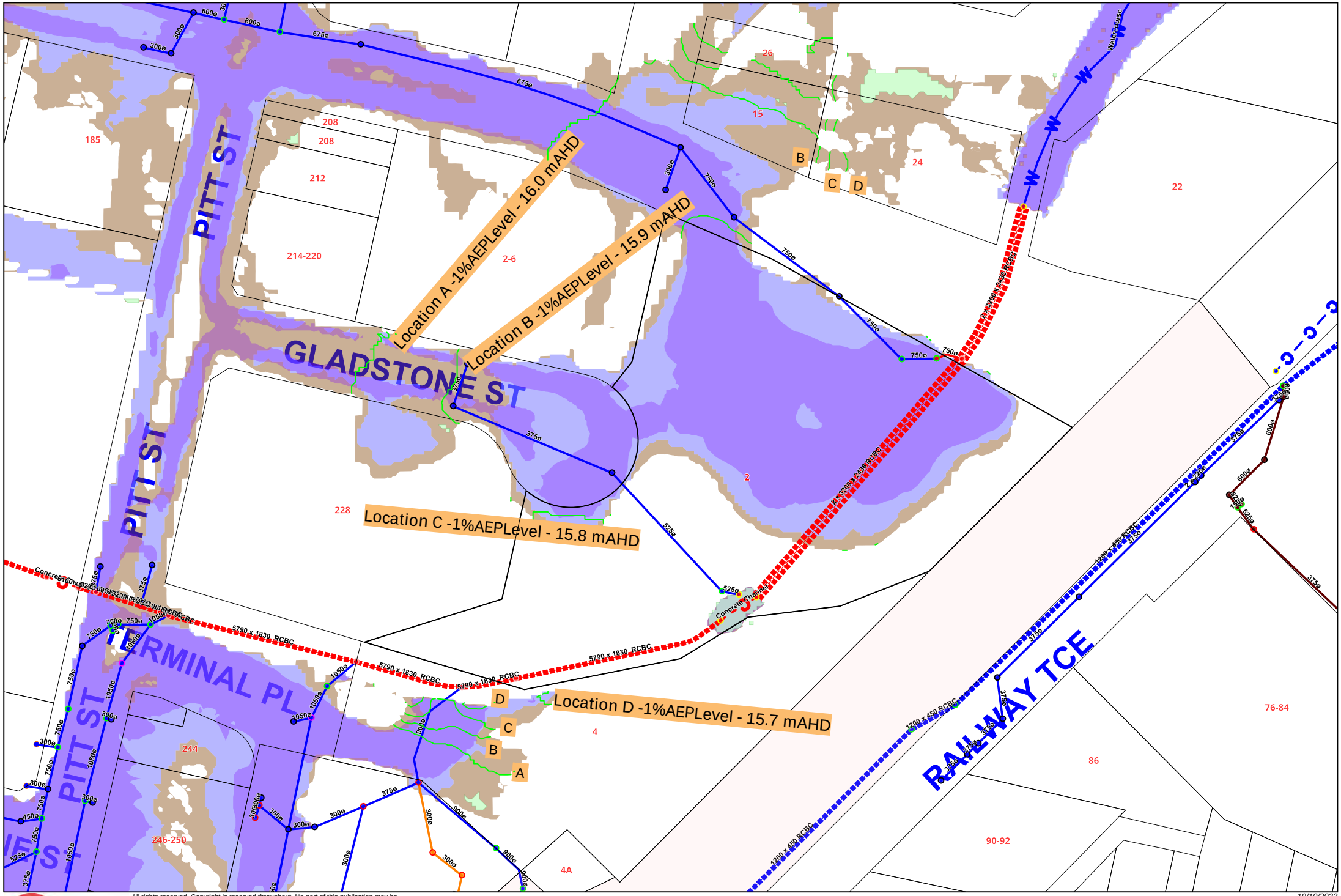
The coloured areas on the attached map represents the extent of the flood event. The light brown areas do not attract flood controls.

PMF levels are primarily used for evacuation purposes in the development of the property.

Should you have any further enquiries in this regard, please contact Luiza Atakulova, Planning Systems Support Officer during normal office hours, Monday to Friday on 8757 9955.

Yours sincerely,

Manisha Priya, Devarapalli
STORMWATER ENGINEER



19/10/2022

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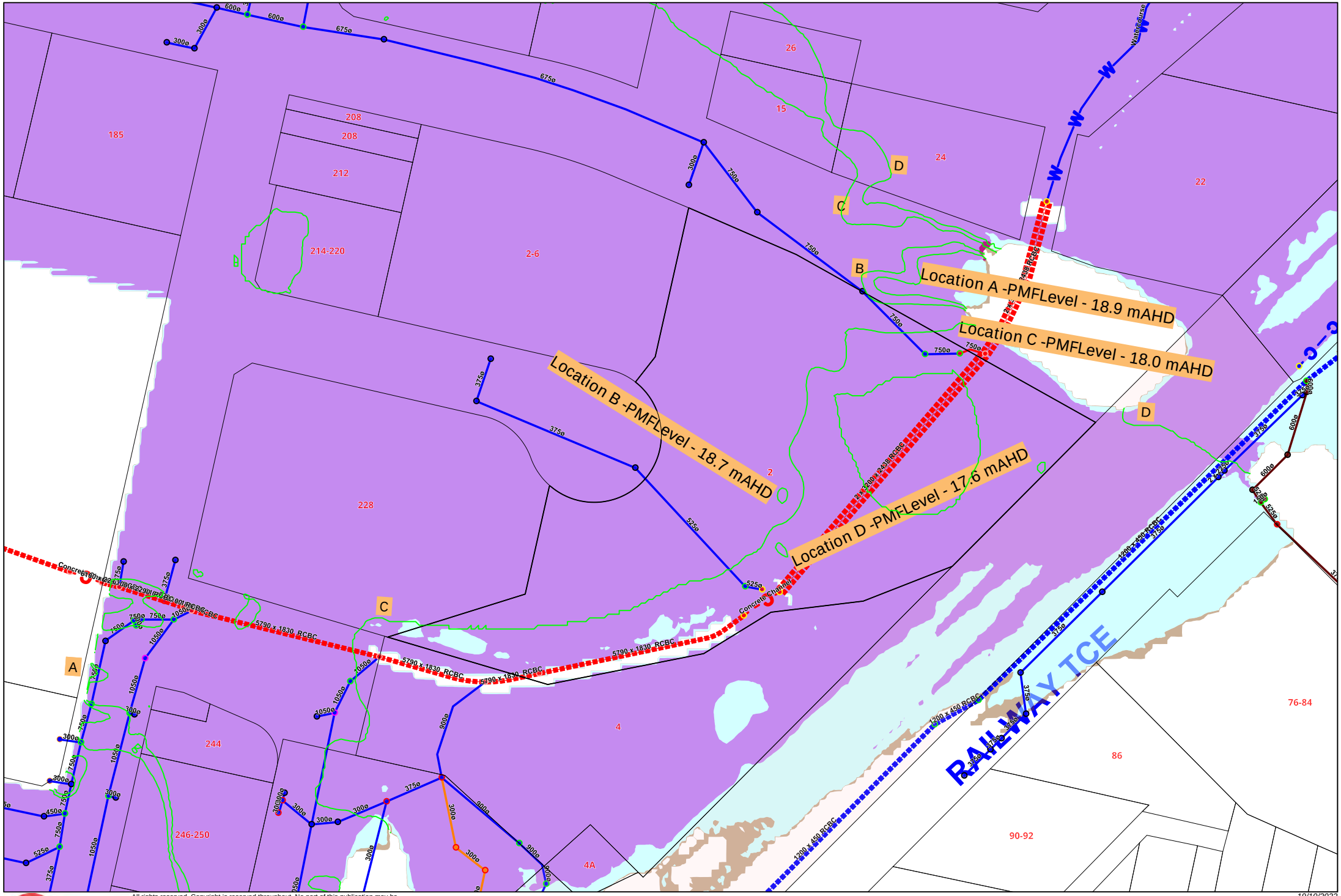
when printed at A3



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when printed at A3

CUMBERLAND
CITY COUNCIL

Ref: EC2022/1025

20 October 2022

Aland
8 Gould Street
SOUTH STRATHFIELD NSW 2136

Dear Sir/Madam,

Subject: **Flood Levels at 4 Terminal Place MERRYLANDS NSW 2160, Lot 1 DP 229589**
Application No: **EC2022/1025**
Property: **4 Terminal Place MERRYLANDS NSW 2160,**

Council refers to your request dated 26 September 2022 requesting flood information at the above property.

1% ANNUAL EXCEEDANCE PROBABILITY (AEP) FLOOD:
The above property is shown to be **affected** by the 1% Annual Exceedance Probability (AEP) flood, according to the information available to Council from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017.

The 1% AEP flood level refers to a flood which has a 1% chance of being equalled or exceeded in any one year and this site has been assessed as a high flood risk. It should be noted that a flood could occur that is more severe than the 1% AEP flood at any time.

The maximum 1% AEP flood level relevant to the subject property has been determined (see the attached plan) to Australian Height Datum (AHD) as follows:

1. At location A - 16.5 mAHD
2. At location B - 16.0 mAHD
3. At location C - 15.7 mAHD
4. At location D - 15.1 mAHD

The subject property has been identified as Flood Control lot. Under the SEPP (Exempt & Complying Development) 2008 Regulation 3.5(1), a Complying Development Certificate must not be issued for, "Development under this code must not be carried out on any part of a flood control lot, other than a part of the lot that the council or a professional engineer who specialises in hydraulic engineering has certified, for the purpose of the issue of the relevant complying development certificate, as not being any of the following:

a) a flood storage area,
b) a floodway area,
c) a flow path,
d) a high hazard area,
e) a high risk area."

Council has determined that part of the flood control lies in one of the five items above – **items B, C, D and E**; therefore, a CDC cannot be issued on this site. The identified flood items are represented by the darker area within the 1% AEP flood extent on the attached map. If the development is proposed within any part of this zone (dark blue area), a pre and post flood study must accompany the Development Application. Alternatively, if the development is proposed within the uncoloured and/or light blue areas (flood fringe zone), a CDC may be considered for this site. However, the surface flows must not be impeded (blocked) and the redevelopment shall allow the free movement of the flood around any proposed structure(s).

In all cases, flood level on adjacent properties shall not be increased. Supporting documentation is to accompany the development.

Minimum habitable floor levels shall be 0.5m above the flood level at the upstream side of the structure. Minimum non-habitable floor levels (garages, laundry, sheds, etc.) shall be 0.15m above the flood level at the upstream side of the structure. Interpolation between flood levels is allowed.

The relationship between these levels and the ground surface may be determined by a survey of the property undertaken by a Registered Surveyor.

It should be noted that where the development or redevelopment of the property is proposed, reference should be made to the relevant Development Control Plan with regard to flooding and drainage issues. Please include a copy of this letter and map with any Development Application that you may lodge with Council for the subject site.

For modelling purposes, the models (pre and post development flood study) shall be calibrated to Council's 1%AEP Flood levels (or interpolated levels) at least 10 metres upstream and downstream from the property boundaries.

Note:
The brown shaded area on the attached Map represents the flood waters with a depth of flow less than 100mm and does not attract any flood controls. It is presented on the flood map to show the continuity of flooding within the area. However, if development occurs within the brown areas, the structure shall not impede or divert flows to adjacent properties.

Flood levels are not static due to changing circumstances (e.g., revision of the flood model) and accordingly the above flood level is only valid for one year from the above date.

PROBABLE MAXIMUM FLOOD (PMF):
The above property is shown to be **affected** by the Probable Maximum Flood (PMF), according to the information available to Council.

The nearest PMF flood levels available from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017 shown in the Map attached are as follows:

1. At Location A - 18.0 mAHD
2. At Location B - 17.9 mAHD
3. At Location C - 17.8 mAHD
4. At Location D - 17.7 mAHD

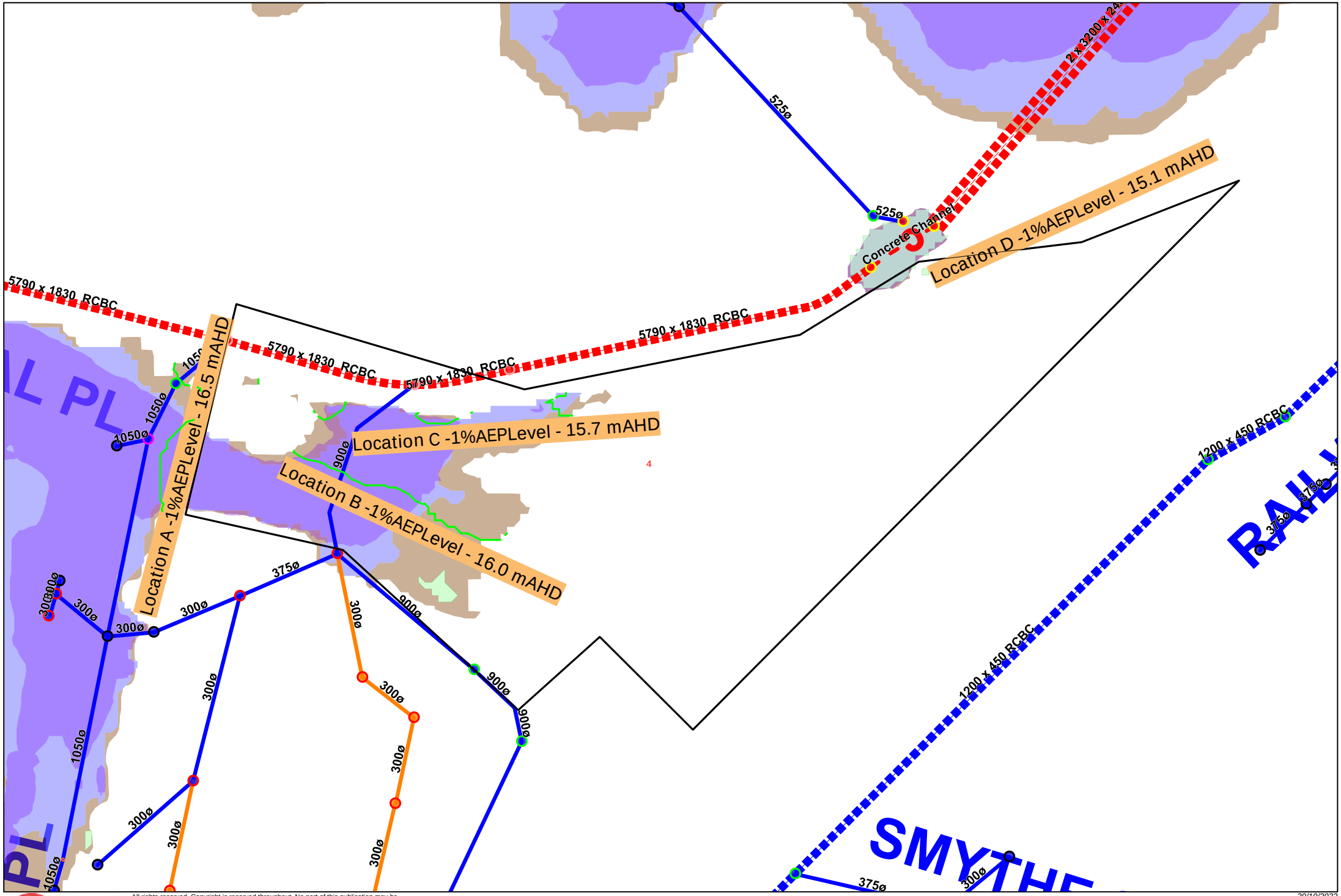
The coloured areas on the attached map represents the extent of the flood event. The light brown areas do not attract flood controls.

PMF levels are primarily used for evacuation purposes in the development of the property.

Should you have any further enquiries in this regard, please contact Luiza Atakulova, Planning Systems Support Officer during normal office hours, Monday to Friday on 8757 9955.

Yours sincerely,

Manisha Priya, Devarapalli
STORMWATER ENGINEER



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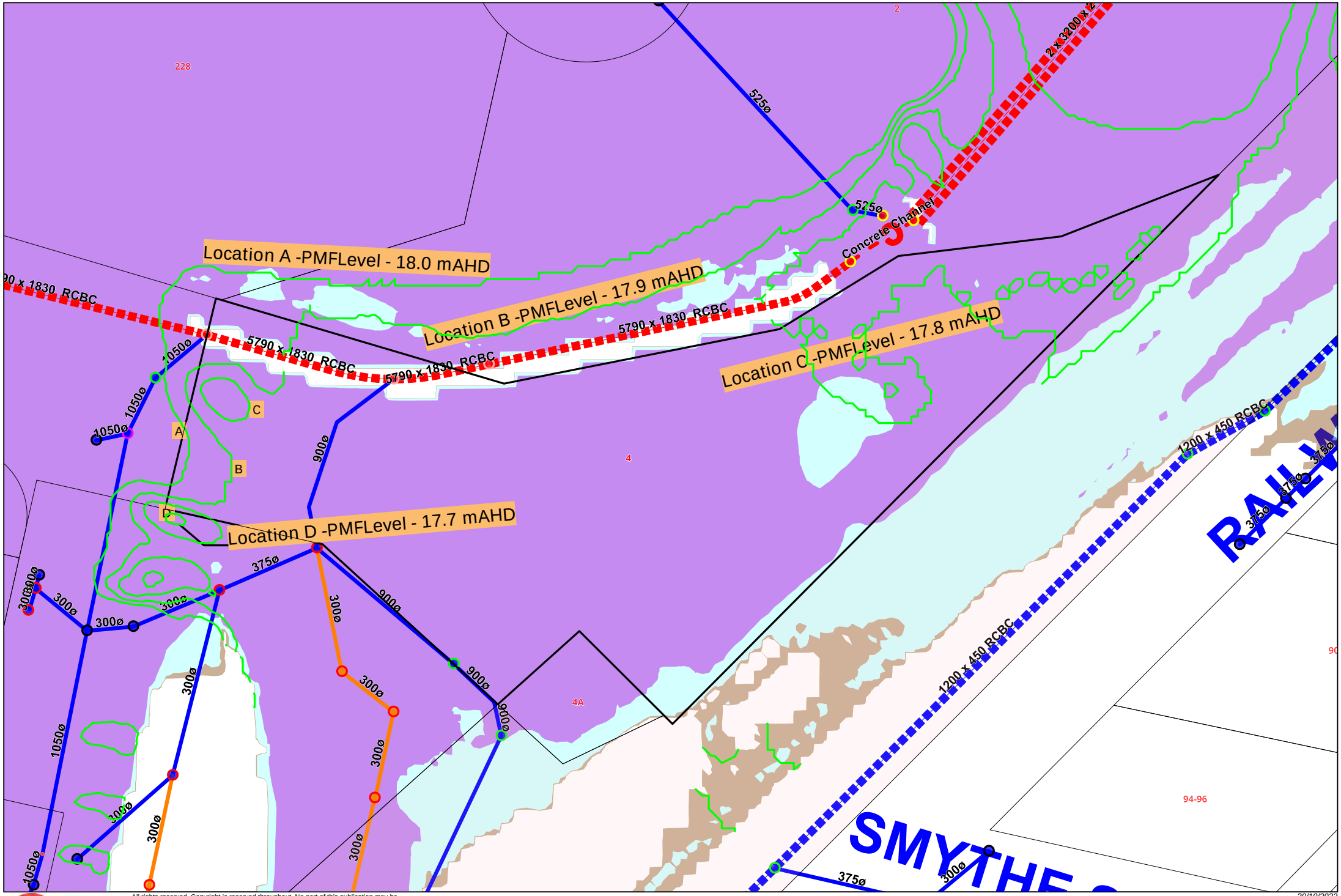

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Scale 1 : 500
when printed at A3

CUMBERLAND
CITY COUNCIL

Ref: EC2022/1026

20 October 2022

Aland
8 Gould Street
SOUTH STRATHFIELD NSW 2136

Dear Sir/Madam,

Subject:	**Flood Levels at 4A Terminal Place MERRYLANDS NSW 2160, Lot 1 DP 1173048**
Application No:	**EC2022/1026**
Property:	**4A Terminal Place MERRYLANDS NSW 2160,**

Council refers to your request dated 26 September 2022 requesting flood information at the above property.

1% ANNUAL EXCEEDANCE PROBABILITY (AEP) FLOOD:

The above property is shown to be **not affected** by the 1% Annual Exceedance Probability (AEP) flood, according to the information available to Council from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017. However, it is located within the floor level control area, in which the floor levels of the new buildings are required to be set with sufficient freeboard above the adjacent flood level.

The 1% AEP flood level refers to a flood which has a 1% chance of being equalled or exceeded in any one year. It should be noted that a flood could occur that is more severe than the 1% AEP flood at any time.

The maximum 1% AEP flood level relevant to the subject property has been determined (see the attached plan) to Australian Height Datum (AHD) as follows:

1. At location A - 16.1 mAHD
2. At location B - 16.0 mAHD
3. At location C - 15.7 mAHD

Minimum habitable floor levels shall be 0.5m above the flood level at the upstream side of the structure. Minimum non-habitable floor levels (garages, laundry, sheds, etc.) shall be 0.15m above the flood level at the upstream side of the structure. Interpolation between flood levels is allowed.

The relationship between these levels and the ground surface may be determined by a survey of the property undertaken by a Registered Surveyor.

It should be noted that where the development or redevelopment of the property is proposed, reference should be made to the relevant Development Control Plan with regard to flooding and

drainage issues. Please include a copy of this letter and map with any Development Application that you may lodge with Council for the subject site.

For modelling purposes, the models (pre and post development flood study) shall be calibrated to Council's 1%AEP Flood levels (or interpolated levels) at least 10 metres upstream and downstream from the property boundaries.

Note:
The brown shaded area on the attached Map represents the flood waters with a depth of flow less than 100mm and does not attract any flood controls. It is presented on the flood map to show the continuity of flooding within the area. However, if development occurs within the brown areas, the structure shall not impede or divert flows to adjacent properties.

Flood levels are not static due to changing circumstances (e.g., revision of the flood model) and accordingly the above flood level is only valid for one year from the above date.

PROBABLE MAXIMUM FLOOD (PMF):

The above property is shown to be **affected** by the Probable Maximum Flood (PMF), according to the information available to Council.

The nearest PMF flood levels available from the "A'Becketts Creek Overland Flood Study" prepared by Lyall & Associates Consulting Water Engineers in June 2017 shown in the Map attached are as follows:

1. At Location A - 18.1 mAHD
2. At Location B - 18.0 mAHD
3. At Location C - 17.9 mAHD

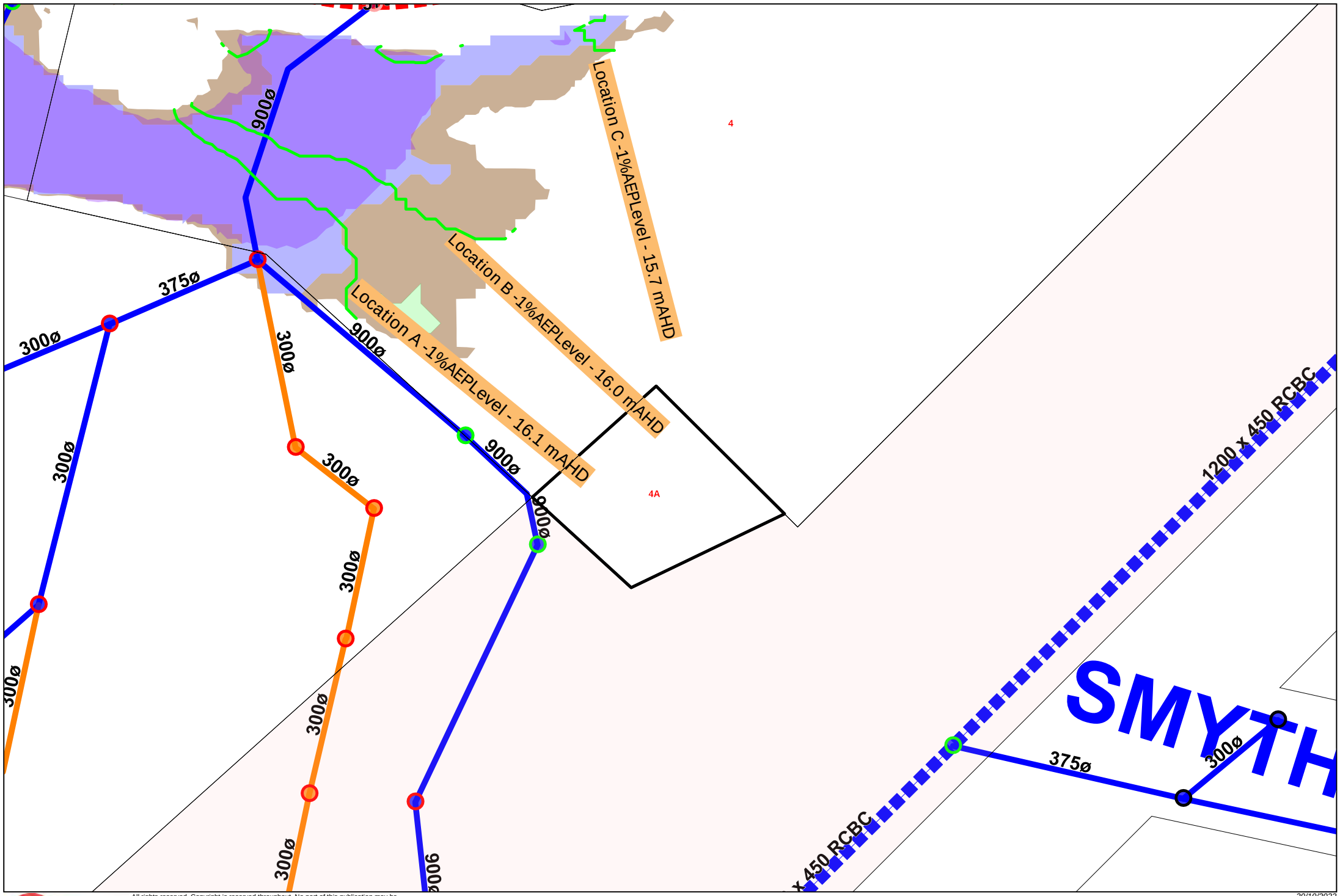
The coloured areas on the attached map represents the extent of the flood event. The light brown areas do not attract flood controls.

PMF levels are primarily used for evacuation purposes in the development of the property.

Should you have any further enquiries in this regard, please contact Luiza Atakulova, Planning Systems Support Officer during normal office hours, Monday to Friday on 8757 9955.

Yours sincerely,

Manisha Priya, Devarapalli
STORMWATER ENGINEER



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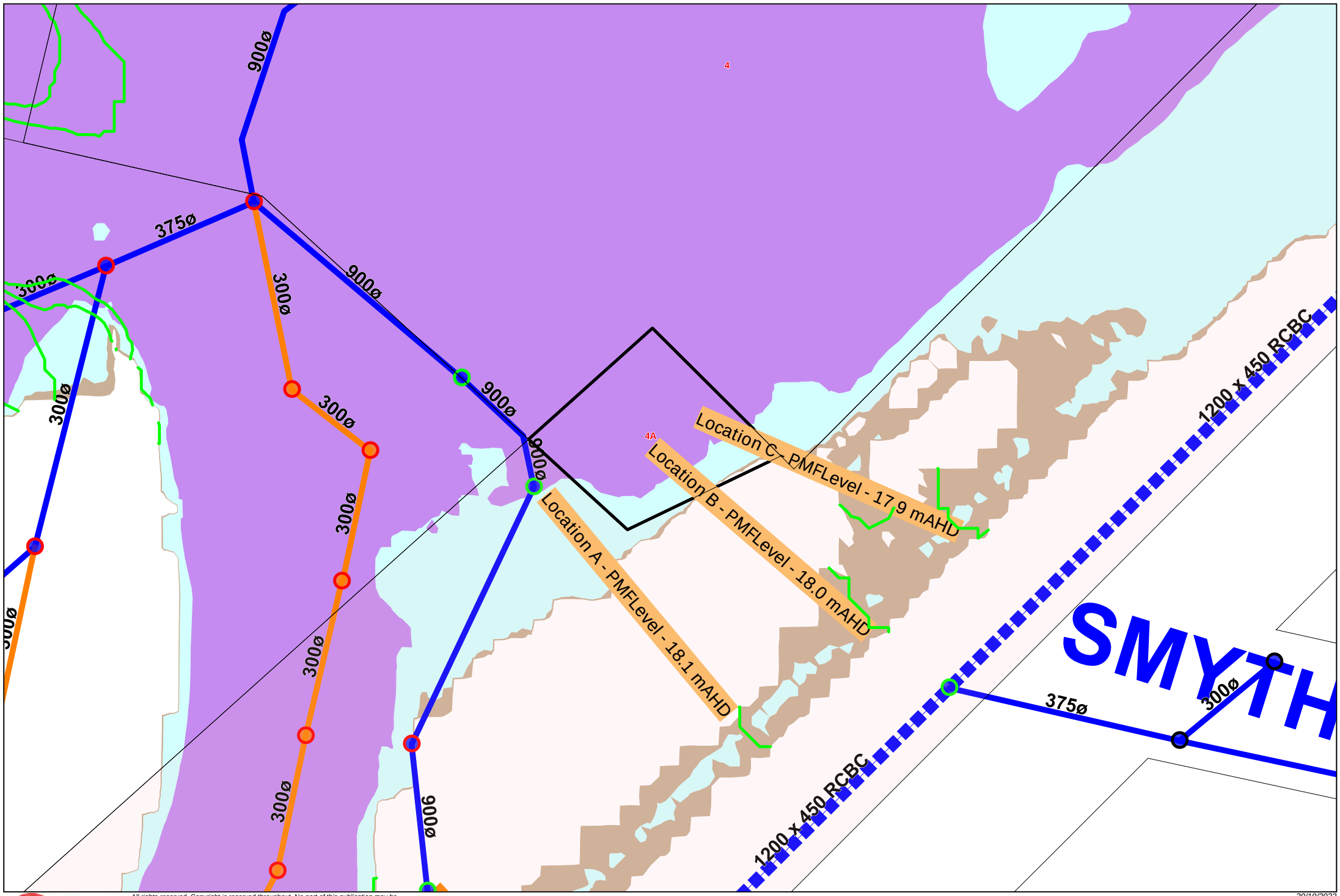

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Appendix B
Previous Studies

As described by Lyall & Associates, 2015[3]:

> *A number of investigations have been carried out over the past three decades which deal with flood behaviour (both main stream and overland) in the study catchments. ….*
>
> *Note that reference is also made in this report to a companion study that was undertaken by Lyall & Associates (L&A) on behalf of HCC and SWC which used the same hydrologic and hydraulic models which were developed as part of the present investigation (L&A, 2014). The study involved a detailed investigation into flood risk management options that could be implemented as part of the future redevelopment of the Merrylands CBD, which is located in the A'Becketts Creek catchment.*

The listed studies were completed between March 1989 and December 2004.

B.1 2002 Merrylands CBD Flood Study

In 2002 Bewsher prepared the Merrylands CBD Flood Study. The study was undertaken using HEC-RAS 1D modelling software to estimate flood levels. The 1% AEP flood levels from the 2002 floodplain model of the precinct are shown in **Figure B.1**.

The results showed that the site was flooded with water levels ranging from RL 17.0 m AHD to 17.4 m AHD.

Figure B.1 2002 1% AEP Flood Levels (Bewsher, 2002)

[3] Lyall & Associates (2015) "Merrylands CBD Neil Street Precinct Flooding Investigation", *Letter Report*, prepared for Holroyd City Council, September.

B.2 2015 Merrylands CBD Neil Street Precinct Flooding Investigation

As described by Lyall & Associates, 2015

This letter sets out the findings of an investigation which was undertaken to assess the impact a proposed amendment to the layout of the proposed buildings within the Neil Street Precinct component of the Merrylands Central Business District (CBD) will have on flooding behaviour and to assess whether additional measures are required to mitigate the impacts of the proposed changes on flooding behaviour.

1. Key Findings of Present Investigation

The key findings of the present investigation were as follows:

(i) Post-developed flooding patterns will be similar in nature to those assessed as part of a previous investigation which was undertaken into the impact future development within the CBD will have on flooding behaviour (refer Section 2 of this letter for background to previous study).

(ii) All of the elements comprising the preferred flood risk management scheme recommended as part of the previous investigation should be retained. However, a minor refinement to the previously proposed scheme is recommended which involves the partial closure of the existing reach of channel which is located on the northern (downstream) side of Neil Street.

(iii) While development could proceed within the Neil Street Precinct prior to the redevelopment of the remainder of the CBD, it will be necessary to construct the elements of the preferred flood risk management scheme which lie to the east of Stockland Mall as part of the precinct development, as otherwise adverse flooding conditions will arise in existing development which lies to the west (upstream) of Pitt Street when the remainder of the CBD is developed.

(iv) If the Neil Street Precinct is to be developed prior to the implementation of all of the elements comprising the preferred flood risk management scheme, then finished ground and floor levels will need to take into account the increased depths of flow which will be experienced in the new road network east of Stockland Mall.

(v) Care will need to be taken when setting finished ground levels in the Neil Street Precinct to ensure that overland flow is confined to the road and open-space areas and does not discharge in an uncontrolled manner between the proposed buildings (for example, flow will need to be prevented from discharging along the route of the existing trunk drainage line which generally follows the natural valley of the catchment east of Pitt Street)

(vi) While the impacts of development will generally be confined to the Neil Street Precinct, further design development will need to be undertaken which is aimed at improving the capture of overland flow at the location where the main arm of A'Becketts Creek crosses the northern boundary of the precinct. This will require a 3D model of the road network to be developed to enable a more accurate assessment of patterns of overland flow to be undertaken in this area.

(vii) Flow in the various overland flow paths for storms with average recurrence intervals (ARI's) up to 100 years would remain low hazard in nature should the Neil Street Precinct be developed prior to the implementation of the full range of measures comprising the preferred flood risk management scheme.

(viii) Climate change induced increases of up to 10 per cent in the intensity of 100 year ARI rainfall would only lead to an increase of between 10 and 100 mm in the depth of overland flow in the Neil Street Precinct.

B.3 2017 Holroyd City LGA Overland Flood Study

As described by Lyall & Associates, 2017[4]:

This report presents the findings of an investigation into the behaviour of overland flow within nine of the ten catchments (excluding the Pendle Creek catchment1) across the Holroyd City Local Government Area (LGA). Figure 1.1 shows the extent of the nine study catchments which comprised:

- *A'Becketts Creek*
- *Clay Cliff Creek*
- *Coopers Creek*
- *Domain Creek*
- *Duck Creek*
- *Finlaysons Creek*
- *Greystanes Creek*
- *Prospect Creek*
- *Westmead Creek*

The study objective was to define the nature of overland flow in terms of its depth, extent and velocity for design storms ranging between 5 and 100 year Average Recurrence Interval (ARI), as well as for the Probable Maximum Flood (PMF). The scope of the study included investigation of overland flow only, since a number of previous studies have investigated main stream flood behaviour along the major creeks within the LGA.

The hydrologic models were runoff-routing models based on the DRAINS software, whilst the hydraulic models were based on the TUFLOW software. A DRAINS model and corresponding TUFLOW model were developed for each study catchment.

.....

Incorporation of Work-As-Executed Plans Provided by SWC

Following completion of the model testing process, SWC provided details of its trunk stormwater drainage system in the vicinity of the Merrylands CBD in the A'Becketts Creek catchment. This comprised a series of Work-as-Executed (WAE) plans covering trunk drainage elements within the area bounded by Treves Street (to the west), Merrylands Road (to the south) and Neil Street (to the north).

Comparison of the SWC plans to HCC's asset database showed a number of inconsistencies in terms of dimensioning of the various open and covered channels and associated invert levels. Accordingly, the relevant one-dimensional model elements in the A'Becketts Creek catchment TUFLOW model were updated to reflect the SWC asset data.

…..

[4] Lyall & Associates (2017) "Holroyd City LGA Overland Flood Study", *Final Report*, Rev 1.3, 2 Vols, prepared for Holroyd City Council, April.

The procedures used to obtain temporally and spatially accurate and consistent Intensity-Frequency-Duration (IFD) design rainfall curves for the study catchments are presented in Book II of IEAust, 1998. Design storm rainfalls for frequencies of 5, 20, 50, 100, 200 and 500 year ARI were derived for storm durations ranging between 25 minutes and 6 hours.

The 100 yr ARI flood depths in the Neil Street Precinct mapped in the 2015 and 2017 Lyall & Associates studies are given in **Figures B.2** and **B.3** respectively.

It is noted that the flood extents within the precinct mapped in **Figures B.2** and **B.3** and in Council's flood advice (refer Appendix A) all reflect the buildings that were present within the precinct at the time of the assessments up until 2017. These buildings are no longer present and/or either have been or in the process of being replaced by approved development.

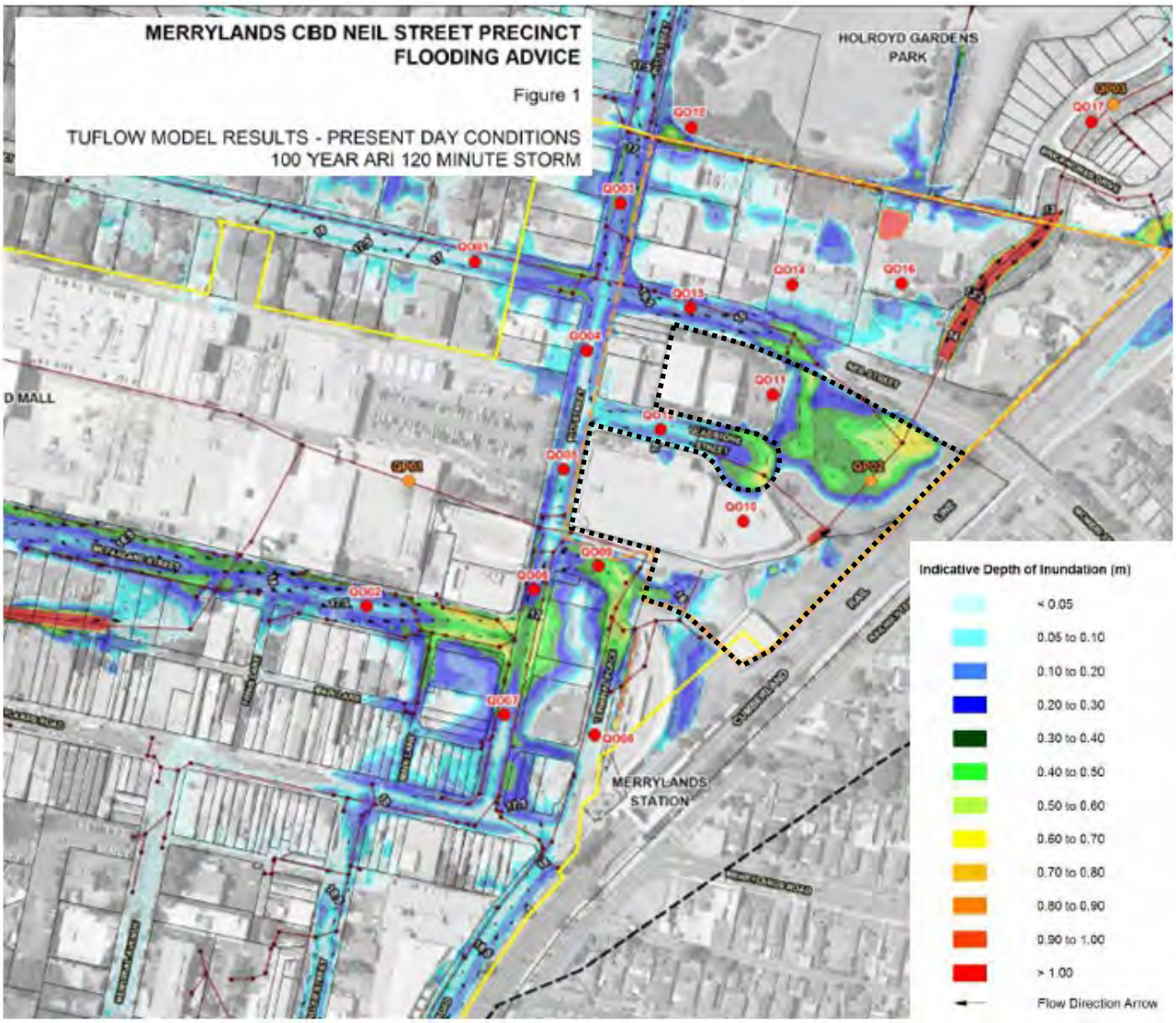

Figure B.2 2015 100 yr ARI Flood Depth (Lyall & Associates, 2015)

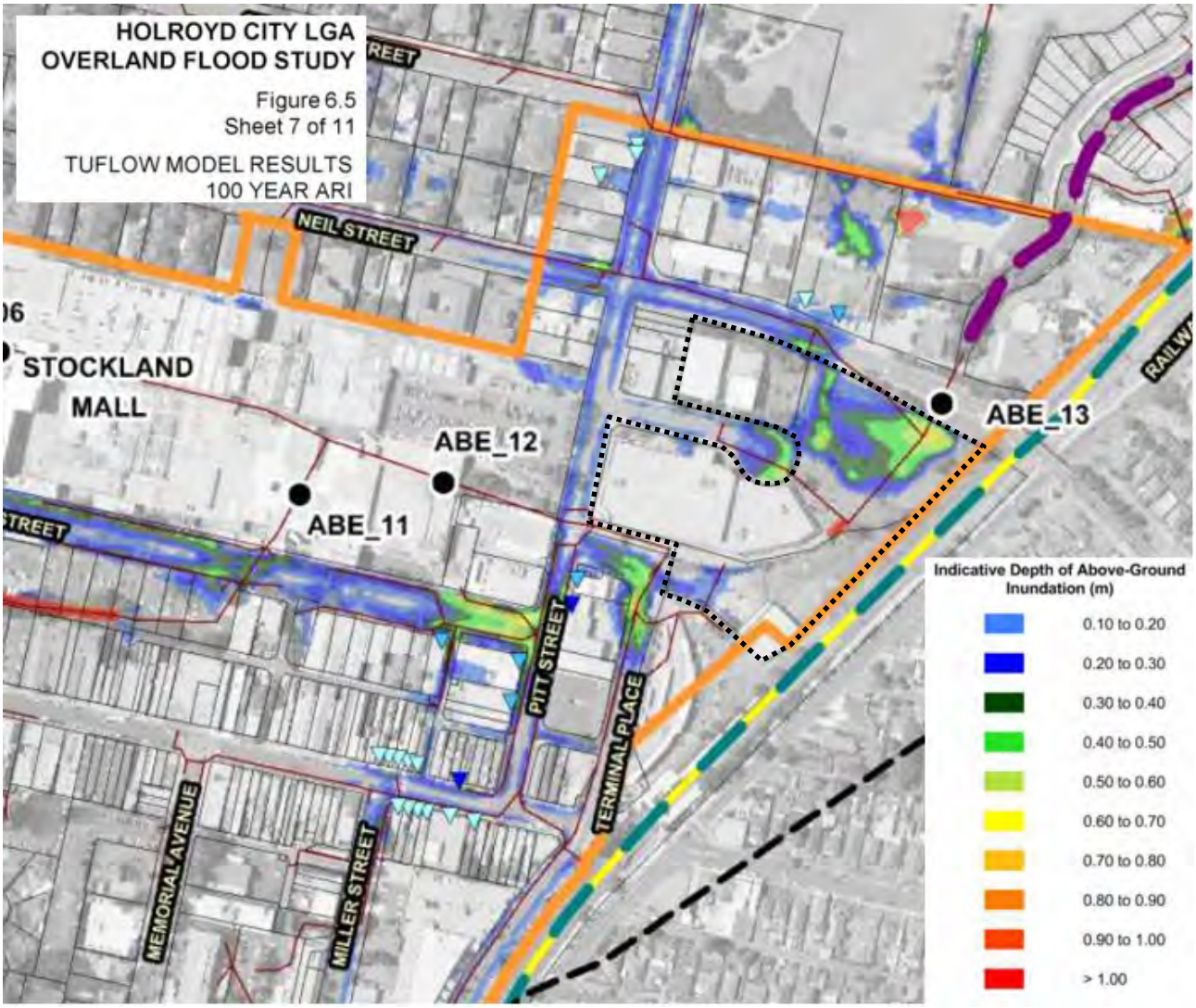

Figure B.3 2017 100 yr ARI Flood Depth (Lyall & Associates, 2017)

B.4 2015-2017 Hydrologic and Hydraulic Modelling

The hydrological and hydraulic modelling undertaken by Cardno is summarised as follows:

B.4.1 Available Data

The following data informed the modelling:

- LiDAR survey data was extracted from Cardno archives;
- Stormwater pit and pipe data for the catchment which was provided by Holroyd City Council;
- Hydraulic and Hydrologic model inputs from A'Becketts Creek Drainage Master Plan (GHD 2009);
- Detail Survey of existing site and surrounding roads prepared by SDG Land Development Solutions;
- Detail Survey of the trunk drainage system running through the site prepared by Land Partners;
- Aerial photography of the site recorded by Nearmap in 2015;
- Proposed architectural drawings of the site;

- 3D model of the proposed ground levels (TIN) prepared by AT&L;
- Drainage design drawings by SMEC in pdf format; and
- A detailed study by Lyall & Associates titled “Merrylands CBD Neil Street Precinct Flooding Investigation”.

B.4.2 Hydrological Modelling

Cardno had previously developed a hydrological model for the catchment using XP-RAFTS (2015). The catchment modelled is approximately 575 ha, and is shown in **Figure B.4**

Rainfall

The 1% AEP design storms were modelled using design temporal patterns and IFD data obtained from Australian Rainfall and Runoff (ARR1987). The design rainfall intensities were in line with those used for the A'Becketts Creek Drainage Master Plan (GHD 2009). Rainfall was assessed for a range of storms from 25 minute to 6 hour durations, with the 90 minute found to be critical at the site.

Rainfall Losses and Surface Roughness

Catchments were defined as 50% pervious and 50% impervious in the XP-RAFTS model. The losses and roughness values for each surface type is shown in **Table B.1** below.

Validation

The results from the hydrology model were validated against the XP-RAFTS model developed for the A'Becketts Creek Drainage Master Plan (GHD, 2009) for Parramatta City Council. Cardno compared the area and flow for a sub-catchment draining to Treves Street, upstream of the subject site. The validation of Cardno’s model is outlined in **Table B.2** below. The results show a good comparison.

Table B.1 Key Parameters adopted in the developed hydrology model (XP-RAFTS) (2015)

	Impervious	Pervious
Initial Loss (mm)	1	5
Continuing Loss (mm/hr)	0	2.5
Catchment Roughness	0.025	0.045
BX Factor	1.4	1.4

Table B.2 Hydrological Model Validation

Location	Catchment Area (ha)	Peak Flow (m^3/s)
Treves Street Node (GHD)	195.8	38
AE3 (Cardno)	196.6	39

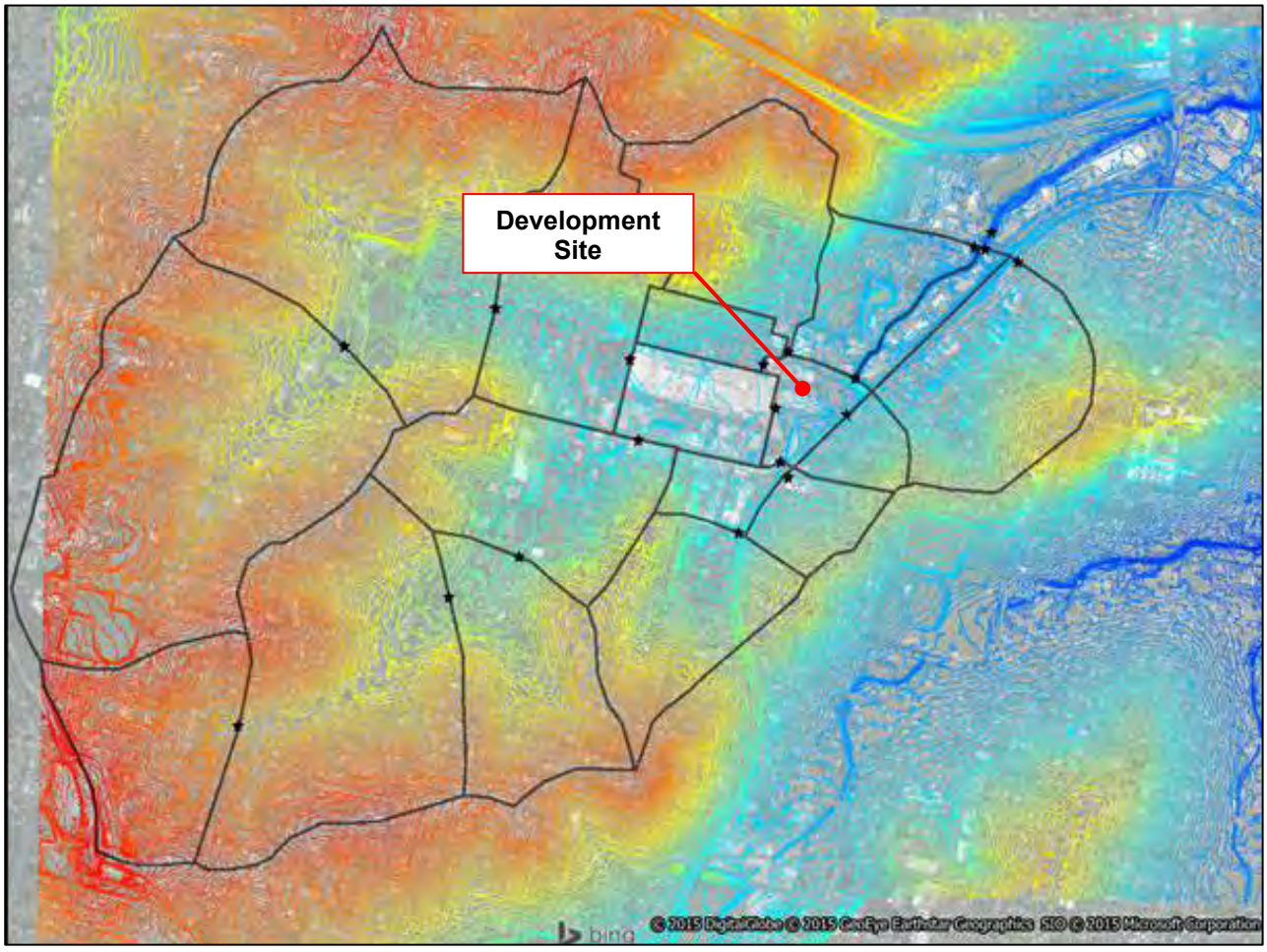

Figure B.4 Sub-catchment Map with Terrain Contours

Calibration

In 2015, Holroyd City Council engaged Lyall & Associates Consulting Water Engineers to undertake a study titled “Merrylands CBD Neil Street Precinct Flooding Investigation”. The study assessed the impacts of a proposed amendment to the layout of the buildings within the Neil Street Precinct component of the Merrylands CBD on flooding in the area and associated mitigation works including drainage upgrades. This study has been used by Council to inform design and for consultation purposes.

Cardno was not supplied with any hydrologic or hydraulic model developed by Lyall & Associates, nor any additional data beyond that available in the report. However, the outcomes of the study including flows presented in the report were able to be used. The XP-RAFTS model previously developed by Cardno was calibrated to better align with the flows reported in the Lyall & Associates report.

The impervious fraction was revised based on a more detailed assessment. The fraction increased to an average of 61%. **Table B.3** shows the key parameters adopted in the calibrated model.

The 2 hour storm was selected by Lyall & Associates as the critical duration for maximising peak flows in the CBD. Cardno’s hydrologic model showed that the 1.5 hour storm was critical at Node AA1 (downstream of Neil Street), however the flows in a 2 hour storm are very similar at this node. Therefore, in order to be consistent with the Lyall & Associates study, the 2 hour storm burst was selected for the 2015-2017 study.

Table B.3 Key Parameters adopted in the calibrated hydrology model (XP-RAFTS)

	Impervious	Pervious
Initial Loss (mm)	1	40
Continuing Loss (mm/hr)	0	5
Catchment Roughness	0.025	0.045
BX Factor	3.6	3.6

A calibration point (Node AA1 in the XP-RAFTS model) was selected just downstream of Neil Street. **Figure B.5** shows location of the calibration point. **Table B.4** lists the flows generated by the hydrologic model at this location, before and after calibration of the model.

Flows from the re-calibrated XP-RAFTS model were used as the input of the hydraulic (TUFLOW) model.

Flows in the hydraulic model (TUFLOW) at the calibration point are compared against the flows reported in the study by Lyall & Associates. The report did not provide flows from a hydrologic model and hence this section provides no comparison with flows reported by Lyall & Associates.

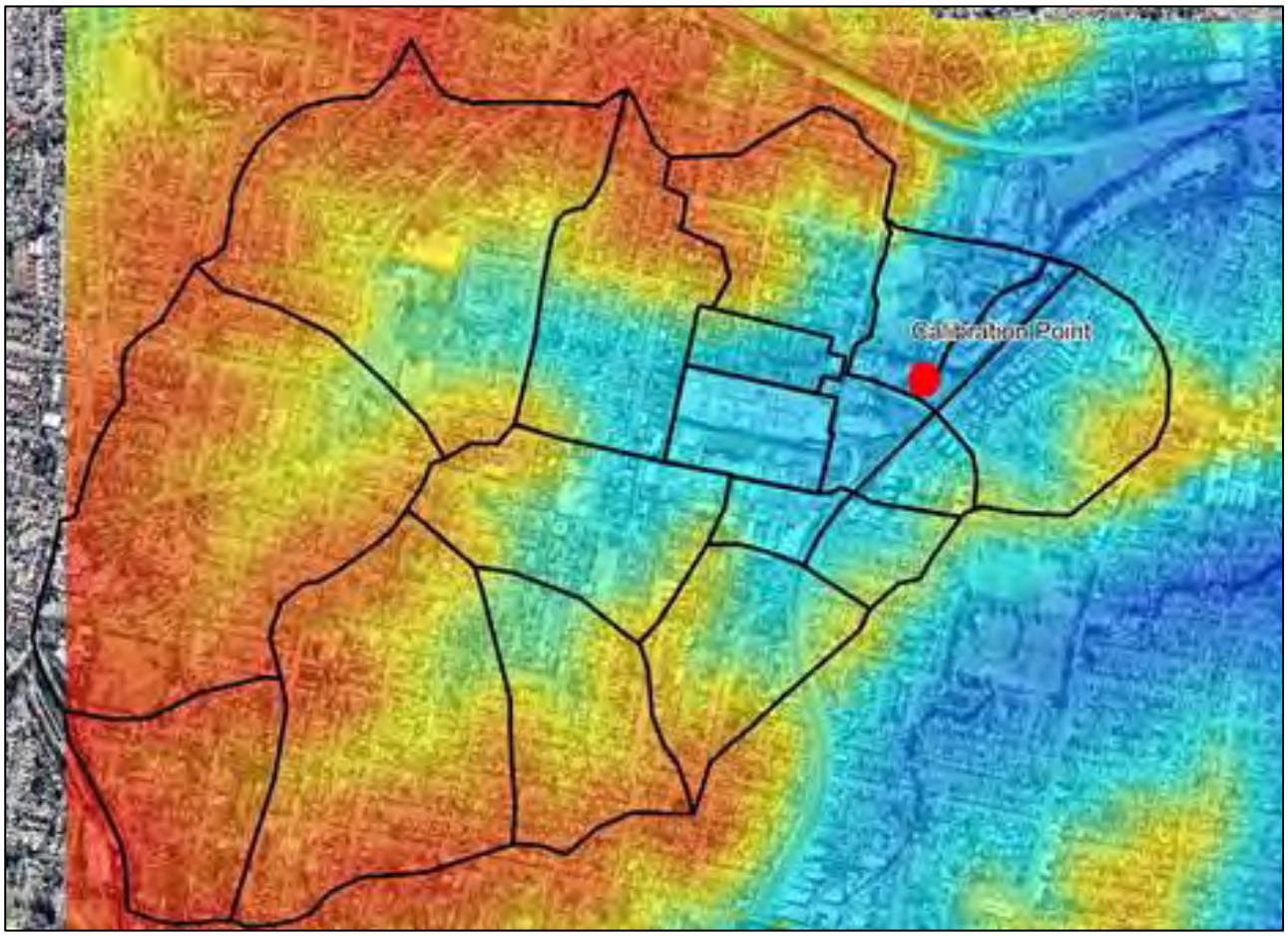

Figure B.5 Location of the Calibration Point

Table B.4 Hydrologic Model Flows at the Calibration Point Before and After Calibration

Model	Location (Node)	Peak Flow (m^3/s)
Prior to Calibration	AA1	88.5
Post Calibration	AA1	81.9

B.4.3 Hydraulic Modelling

In order to assess the flood behaviour of the site, Cardno's pre-existing TUFLOW 1D/2D floodplain model was extended downstream to include the development site for development applications in 2015.

Model Topography

The model terrain grid was developed from Cardno-owned LiDAR of the area (taken in 2013). The Vertical Mapper software package was used to interpolate the data to a 1m x 1m grid, creating a detailed 3D surface (digital terrain model) of the study area. The base terrain for the subject site and its surrounds is shown in **Figure B.6**.

Detailed ground survey undertaken by SDG Land Development Solutions dated February 2015 covers the site as well as Neil Street, Pitt Street, Gladstone Street and Terminal Place. This survey was used to update the model terrain.

Surface Roughness

Surface roughness has been modelled in the 2D TUFLOW model using spatially distributed roughness ("n") values. The values used in Cardno's pre-existing TUFLOW model were adopted and extended to include the area of interest.

1D Hydraulics

The stormwater pit and pipe network was modelled as 1D elements in the TUFLOW model. The stormwater pit and pipe data for the catchment was provided by Holroyd City Council previously. The model included 1D elements along the main trunk drainage paths. Small diameter pipes were not modelled.

A trunk drainage system traverses the site, as a 5.79 m x 1.85 m culvert entering the site at Pitt Street and then twin 3.2 m x 2.44 m culverts further downstream to Neil Street. Modelling of this system used the detail survey prepared by Land Partners. Invert levels of this large channel/culvert system were included as per the Detail Survey, while other 1D network element invert levels were estimated based on ground levels. The existing 1D network is shown in **Figure B.7**.

Boundary Conditions

Inflow hydrographs were adopted per the TUFLOW model previously prepared by Cardno and the XP-RAFTS model, but updated to the newly calibrated flows. A stage-discharge relationship was adopted for the downstream boundary condition.

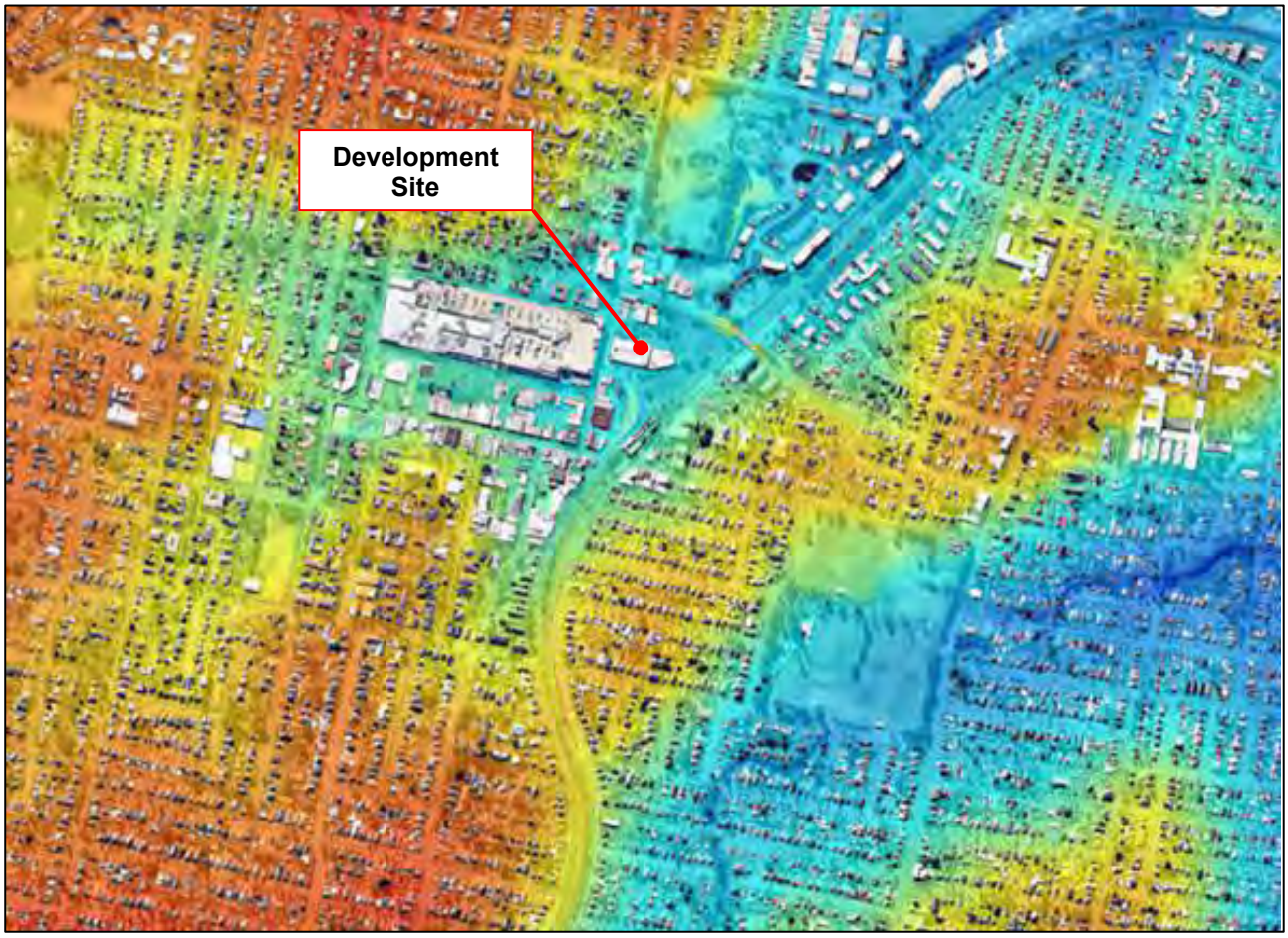

Figure B.6 Base Terrain for the Subject Site and Surrounds

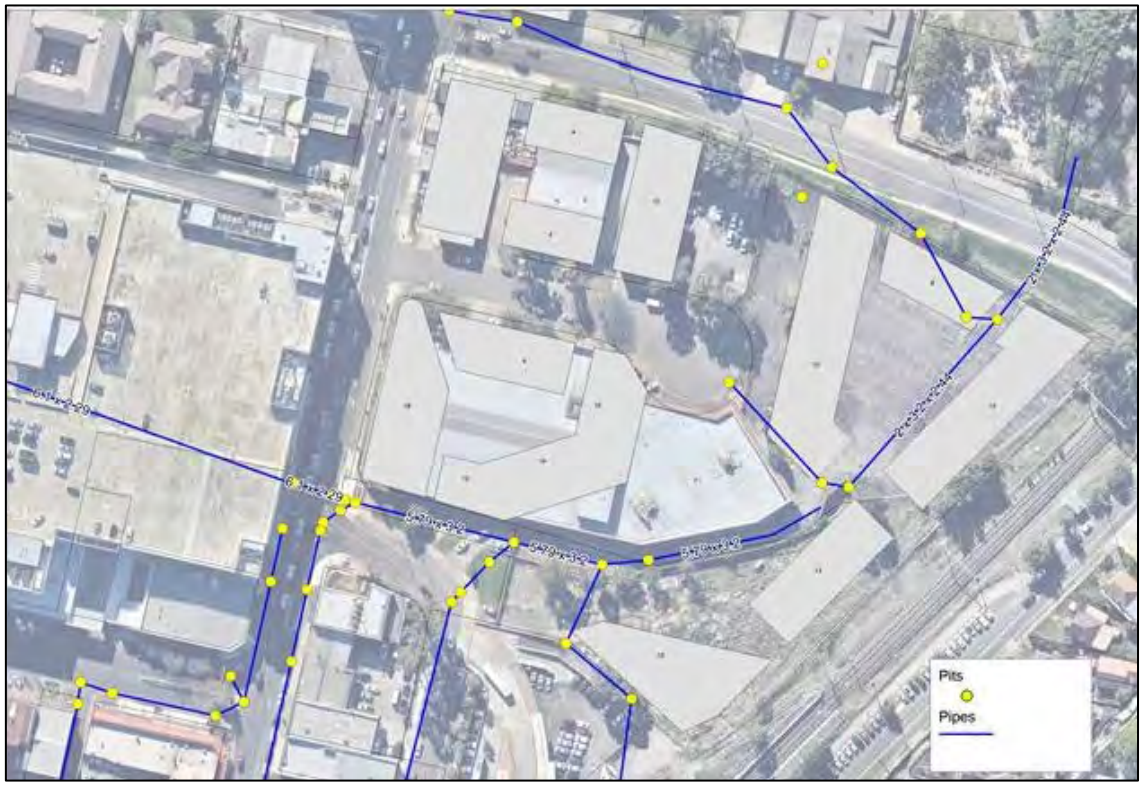

Figure B.7 Existing 1D Network

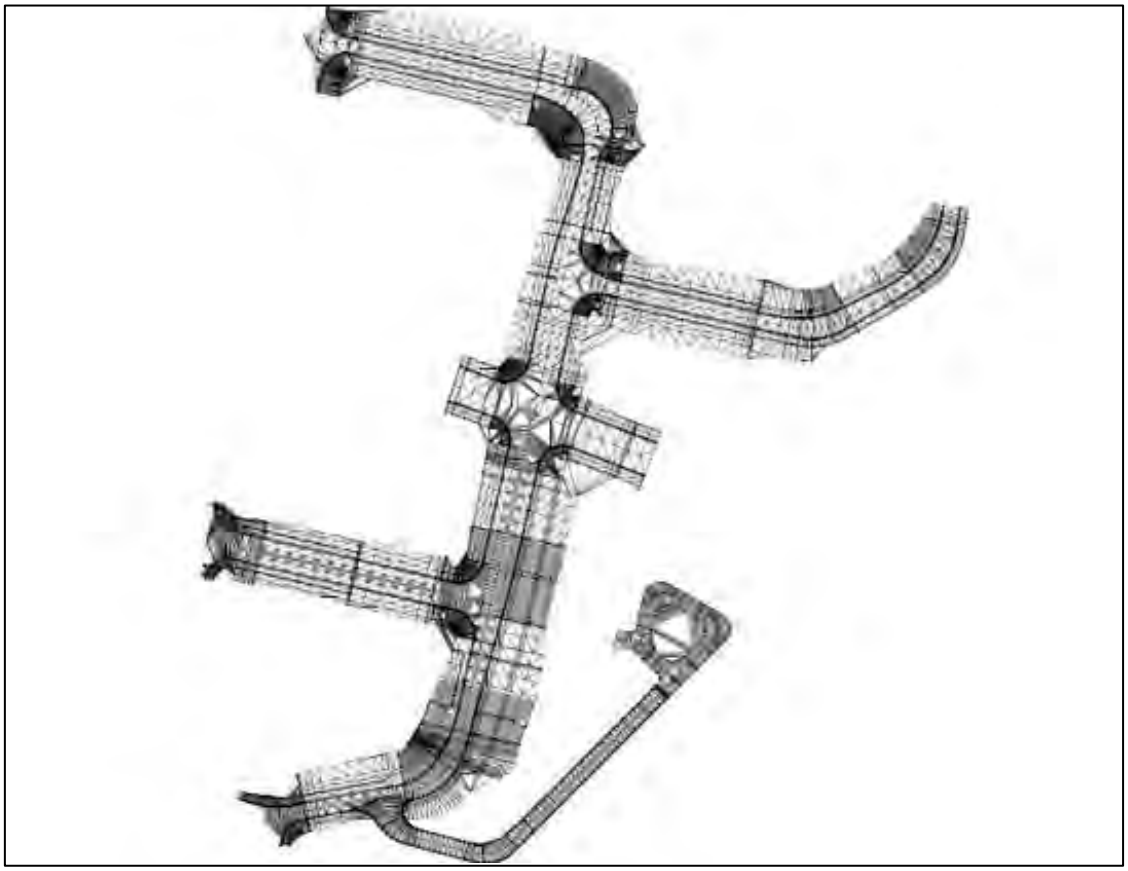

Figure B.8 Road design TIN prepared by SMEC and AT&L

Proposed Conditions

In addition to the proposed development at the site, a road is planned between Terminal Place and Neil Street passing through the development site. Precinct planning also includes an upgrade of the drainage network in the area and configuration of a new overland flow path. **Figures B.8** and **B.9** show details of the proposed road and pipe upgrade.

Cardno's pre-existing TUFLOW model was modified to mimic the future condition of the site. The design case scenario was developed through including the following components in the model:

- Proposed building block (Block D);
- Proposed road design TIN for main roads prepared by SMEC Pty Ltd and provided to Cardno by AT&L;
- Proposed drainage network design prepared by SMEC Pty Ltd and provided to Cardno by AT&L; and
- Proposed internal road design TIN prepared by AT&L Pty Ltd and provided to Cardno.

Results

Cardno assessed flood behaviour for the 1% and 5% AEP events and the PMF.

A comparison of flows from Cardno's hydraulic model with flows reported by Lyall & Associates at the calibration point downstream of Neil Street shows a good comparison between the two studies. **Table B.5** shows the details of this comparison.

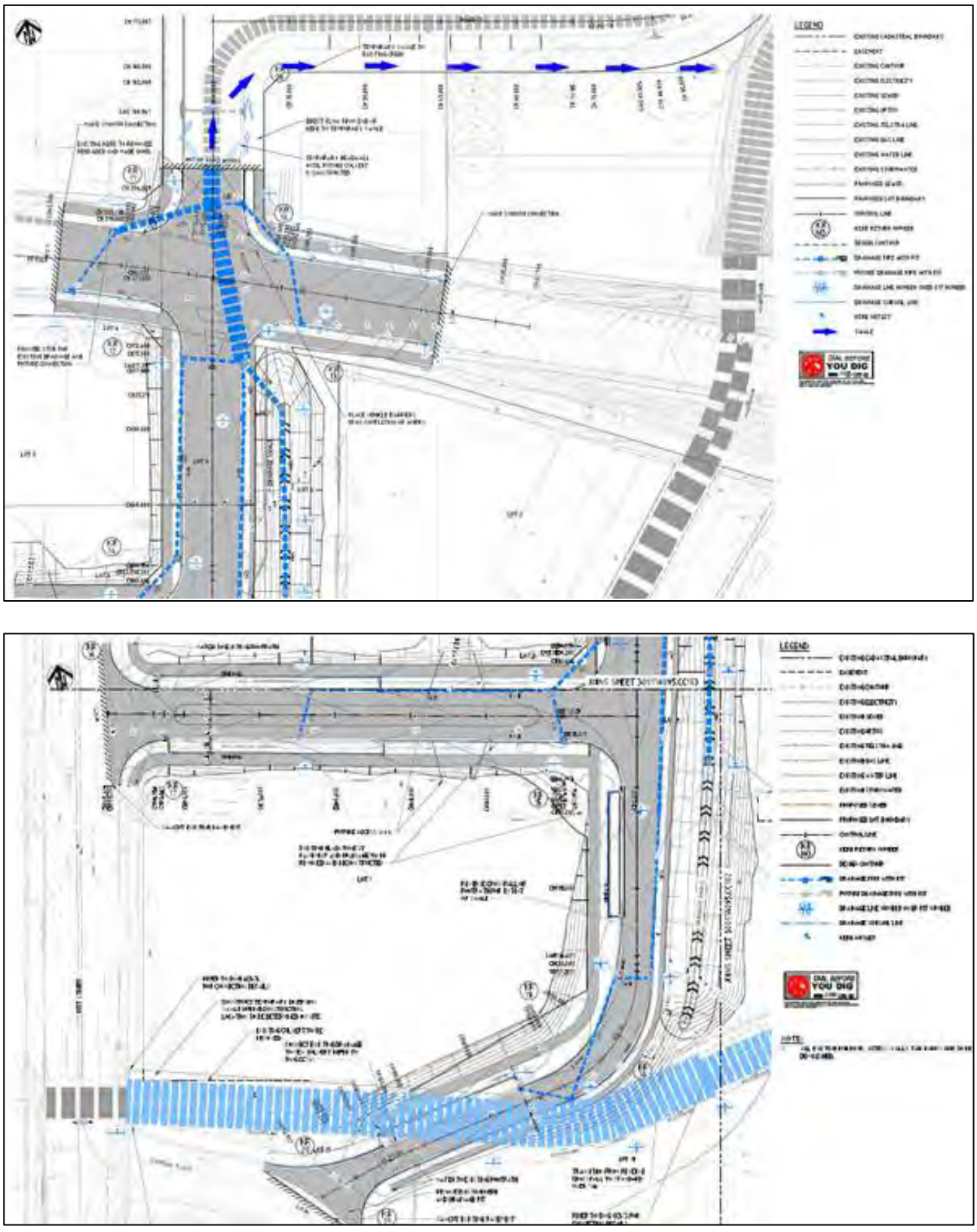

Figure B.9 Drainage network upgrade designed by SMEC and provided to Cardno by AT&L

Table B.5 Hydraulic Model Flow Comparison – Existing Conditions

Location	Peak Flow (m^3/s)
QP03 + QO17 (Lyall & Associates)	48.65
QO17 (Cardno)	47.9

Peak depths from the current study and the study by Lyall & Associates were compared for 1% AEP event at a few locations. Peak flood depth from both studies were comparable along McFarlane Street and upstream.

Depths predicted by Cardno are generally higher along Terminal Place and further downstream.

B.4.4 Flood Behaviour

Flood Behaviour under Existing Conditions

The flows from the calibrated XP-RAFTS model were used to model existing conditions. The result of this analysis showed that flood levels dropped significantly from previous estimates made by Cardno in 2015, which is a result of the lower flows.

Flood Behaviour under Proposed Conditions

Modelled results of the proposed development have been mapped for peak water levels and peak depths for the 1% and 5% AEP events and the PMF. The peak results from the proposed development show a decrease in comparison with the flood levels previously estimated by Cardno. This is due to the downstream works (north of the site) as included in the TIN by SMEC.

Appendix C

Impact of 2022 Swale Configuration

Flood Risk Assessment
Impact of Modified Swale

5% AEP
New Swale Minus Old Swale
Water Level Difference

Legend

- Cadastre
- Proposed Buildings

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Change in Flood Extents

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE D1

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1

Flood Risk Assessment
Impact of Modified Swale

1% AEP
New Swale Minus Old Swale
Water Level Difference

Legend

- Cadastre
- Proposed Buildings

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Change in Flood Extents

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE D2

1:3,500 Scale at A4

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1

Flood Risk Assessment
Impact of Modified Swale

PMF
New Swale Minus Old Swale
Water Level Difference

Legend

- Cadastre
- Proposed Buildings

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Change in Flood Extents

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE D3

1:3,500 **Scale at A4**

0 20 40 60 m

Cardno

Map Produced by W&E BU
Date: 2022-11-14| Project: NW30290
Coordinate System: GDA94 MGAZone56
Map: 220913TinSmecwithswale.qgz Rev 1