Flood Impact Analysis

16 Macpherson Street, Warriewood, NSW

Final Report

P2309661JR01V03

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Prepared for Investment Projects Management

environmental science & engineering

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Glossary of Terms

AEP	Annual exceedance probability: the probability of a flood event occurring within a year. A 1% AEP flood has a 1% chance of occurring in any given year.
BMP	Biodiversity Management Plan
CC	Climate Change
Council	Northern Beaches Council
DA	Development Application
PDCP	Pittwater Development Control Plan
PLEP	Pittwater Local Environmental Plan
FPL	Flood planning level
MA	Martens & Associates Pty Ltd
NBC	Northern Beaches Council
PMF	Probable maximum flood: the most extreme flood event possible for a certain location, typically with an approximate ARI of 100,000 to 10,000,000 years.
SIP	Shelter-in-place
WWMS	Warriewood Valley Urban Land Release Water Management Specification

1 Introduction

1.1 Overview

Martens & Associates Pty Ltd (**MA**) have prepared this Flood Impact Analysis (**FIA**) to support a development application (**DA**) to the Northen Beaches Council (**Council**) for a proposed residential subdivision (the **Proposal**) at 16 Macpherson Street, Warriewood, NSW (the **Site**). The Proposal is the subject of a Class 1 merits appeal to the NSW Land & Environment Court in proceedings 2023/00250329 (the **Proceedings**).

The FIA assesses the significance of flood impacts arising from works arising from the proposal and has been based on flood modelling documented in the following report prepared by Stantec:

- *Flood Impact and Risk Assessment: 16 Macpherson Street, Warriewood*, prepared by Stantec, dated 5 May 2023 (**Stantec Flood Report**).

1.2 Proposal

The Proposal consists of demolition of existing structures within the Site and construction of 28 dwellings, including ancillary infrastructure, roadworks, landscaping, community title subdivision and the dedication of the creek like corridor. The following is observed:

1. **Earthworks**: An overview of the Proposal, including proposed earthworks is provided at Figure 1,[1] indicating that most of the Site will be filled to achieve sufficient flood immunity levels for residential land. Areas of excavation occur close to Narrabeen Creek, including works associated with the stormwater basin, and regarding works within the 25 m creek dedication corridor.

2. **Drainage**: By reference to Figure 2,[2] Site drainage will be directed to a stormwater basin located outside of the 25 m land dedication adjacent to Narrabeen Creek. Basin discharge is directed to an outlet into Narrabeen Creek. The existing drainage system within Brands Lane adjacent to the Site will also be upgraded to an 1800x900 mm box culvert also directed to an outlet into Narrabeen Creek.

1.3 Site Inspection

A detailed inspection of the Site, local road and drainage system, and nearby Narrabeen Creek line was undertaken by Dr Daniel Martens and Mr Stanley Leung on 29 August 2023. Creek bed and bank conditions were viewed during the inspection.

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[1] Extracted from the Civil Works plans prepared by Craig & Rhodes, Drawing No. 048-22C-DA0051, dated 4 May 2023.

[2] Extracted from the Civil Works plans prepared by Craig & Rhodes, Drawing No. 048-22C-DA0102, dated 4 May 2023

1.4 DA Comments

Prior to commencement of the Proceedings, Council's had requested further information relating to flood impacts arising from the Proposal. These requests and our responses are provided in Table 1.

Table 1: Council's request for further information on flood impacts.

Request for Further Information	Response
If removal of the adverse impacts on private property is not possible, justification as to why not.	Detailed analysis and justification of impacts is provided at Section 3.3.
Mapping of the difference in Velocity x Depth product for the 1% AEP and PMF events.	VD product difference maps are provided at Map 6 and Map 12.
Specific confirmation on whether each of the requirements in Table 4.3 of the Warriewood Valley Urban Land Release Water Management Specification (2001) have been met.	Confirmation is provided at Table 12.

1.5 SOFACs

The Statement of Facts and Contentions (**SOFACs**) filed in the Proceedings, dated 12 October 2023, raises a number of issues in respect of flood impact. These and our responses are provided in Table 2.

Table 2: Flood contentions.

Council Comments	Response
5. *The proposed development should be refused because it will result in adverse flooding impacts on nearby private property.*	(see below)
a) *The proposal will result in adverse impacts on nearby private property in the 1% AEP and Probable Maximum Flood (PMF) events. In the 1% AEP event, flood levels would increase by more than the permitted tolerance of 0.02m and peak velocities would increase by more than the permitted tolerance of 10%. In the PMF event, flood levels would increase by more than the permitted tolerance of 0.05m and peak velocities would increase by more than the permitted tolerance of 10%.*	Whilst there are some exceedances of thresholds specified in the PDCP, these do not cause harm to the environment, public or private property or infrastructure, and do not result in material changes to flood risks within the floodplain. Refer to the detailed flood impact analysis provided in Section 3.
b) *The worst adverse impacts on private property are along the western boundary of 14 Macpherson St adjacent to Brands Lane and at the rear of 14 Macpherson St, but there are also scattered small patches of adverse impacts on the former 18 Macpherson St, 10 Macpherson St, across the road at 1 Fantail Ave & 2 Fantail Ave and east of Lorikeet Gr on the opposite side of the creek. In the PMF event, peak velocities are above 1m/s*	See response to contention 5(a). Peak velocities for the PMF event are provided at Map 9,

Council Comments	Response
(which may be of possible concern in relation to scour) but the actual values are not provided. These values should be provided.	
c) *Insufficient information has been submitted to demonstrate that the proposed development complies with the flood related requirements in Table 4.3 of the Warriewood Valley Urban Land Release Water Management Specification 2001. It appears from the mapping that not all of these requirements have been met, however it is difficult to determine this conclusively. Specific confirmation must be provided regarding whether each of the requirements have been met.*	An assessment and confirmation of compliance is provided in Section 3.7.

1.6 Guidelines

This report has been prepared in accordance with the following guidelines and policies:

1. *Australian Rainfall and Runoff – A Guide to Flood Estimation*. Commonwealth of Australia (2019) (**AR&R**).
2. *NSW Floodplain Development Manual*, Department of Infrastructure, Planning and Natural Resources (2005) (**FDM**).
3. Pittwater Local Environmental Plan 2014 (**PLEP**).
4. Pittwater Development Control Plan 21 (2007) (**PDCP**).
5. Warriewood Valley Urban Land Release Water Management Specification, Pittwater Council (2001) (**WWMS**).
6. *NSW Flood Impact and Risk Assessment – Flood Risk Management Guideline LU01*, prepared by the NSW Department of Planning and Environment (June 2023).

2 Environmental Setting

2.1 Existing Land Use

Existing Site land use consists of a two-storey dwelling presenting to Macpherson Street (refer to Figure 3) and a Plant Nursery presenting to Brands Lane (refer to Figure 4). Brands Lane is sealed for around 60 m after its intersection with Macpherson Street (refer to Figure 5) and is then unsealed for the remaining approximately 155 m to Narrabeen Creek (refer to Figure 6).

Zoning pursuant to PLEP is R3 Medium Density Residential (refer to Figure 7).

2.2 Adjoining Development

There is an existing senior's living estate development adjoining Brands Lane to the southeast at 14 Macpherson Street which includes a range of building types and basement car parking (refer to Figure 8). The estate fronts Narrabeen Creek to the northeast (refer to Figure 9).

2.3 Topography

By reference to Figure 10, the following observations are made in respect of topography:

1. Ground levels within the Site grade generally towards the southeast and range from approximately 5.0-5.5 along the northwestern boundary to 4.5-4.6 along the southeastern boundary.

2. Site grade is generally slight with falls of around 2-3 % towards the southeast.

3. The rear of the Site adjacent to Narrabeen Creek appears to be partly filled, this constricting the flow within Narrabeen Creek at that location. Creek channel width and capacity are significantly larger adjacent to 14 Macpherson Street downstream of the Site.

2.4 Riparian Corridor

2.4.1 Location and Extent

The riparian corridor of Narrabeen Creek adjoins the Site at the northeastern boundary. Narrabeen Creek is a perennial stream flowing in a generally south to southeastly direction from the Site for some 2.1 km before its confluence with Mullet Creek, which in turn flows to the northern shores of Narrabeen Lagoon around 730 m further downstream.

The riparian corridor at the Site is approximately 40-45 m wide and consists of the creek, creek bank vegetation, a pedestrian footpath and open grass areas. Immediately downstream of the Site, the corridor widens to around 60 m. In this area the right (southern) bank of the creek has been historically rehabilitated through earthworks and significant replanting of riparian vegetation. The Proposal includes the dedication of

around 25 m of land adjoining the existing riparian corridor so that the corridor width is increased to around a total of 65 m, this being consistent with the width immediately downstream.

2.4.2 Site Observations

A detailed inspection of the riparian corridor adjacent, upstream and downstream of the Site was undertaken during the view. By reference to Figure 11, the following observations are made in respect of specific areas within the riparian corridor:

1. **Area A** – This portion of the Site is proposed to be dedicated to Council as part of the riparian corridor. At present the area is used for parking, storage of nursery materials and other goods (refer to Figure 12, Figure 13 and Figure 14).

2. **Area B** – This area includes the riparian corridor adjacent to the Site as well as a portion of the corridor upslope of the Site. The creek channel in this reach is generally rectangular and shallow, with width approximately 2-3 m in lower sections (refer to Figure 15) and slightly narrower in the upper sections at approximately 1.5-2 m (refer to Figure 16). Notable features include a pedestrian footway and associated open grass areas located within the left bank corridor (refer to Figure 17), heavily vegetated creek banks (refer to Figure 18), and a stable creek channel (refer to Figure 18). Bed and bank materials appeared variably comprised of a silty sands, sandy silts and clays. A low bench or incipient floodplain was evident adjacent to both banks.

3. **Area C** – This portion of the riparian corridor includes the pedestrian bridge crossing over Narrabeen Creek (refer to Figure 19).

4. **Area D** – This area contains the bulk of the riparian corridor downstream of the Site, including the channel and significant parts of the left and right bank corridor. The right bank area is characterised by densely revegetated riparian land (refer to Figure 20) containing areas of recent shallow depth flood deposits in the process of becoming vegetated (Figure 21). Remnant tree protection sleeves emplaced during previous revegetation were observed at the base of numerous trees (refer to Figure 22). The channel in this area was wider than upstream of Area C.

5. **Area E** – This area comprised the interface land between the Area D right bank riparian corridor and private land within 14 Macpherson Street. Adjacent to Brands Lane the area is characterised by sloping grassed landscaping with a concrete footpath (refer to Figure 23). Landscaping width varies, becoming widest where there are larger gaps between buildings (refer to Figure 24 and Figure 25). Building ground floor levels in this area are significantly elevated (about 1 m) above ground levels (refer to Figure 26).

6. **Area F** – This portion of the left bank riparian corridor exists between Lorikeet Grove and the riparian corridor proper. It is characterised by various large retaining structures supporting Lorikeet Grove comprising of sandstone blocks (refer to Figure 27) and concrete block work (refer to Figure 28). In places the retaining structures are stepped (refer to Figure 29). Adjacent and to the

southeast of Area F was an area of undeveloped land characterised by grasses and scattered trees containing a south flowing overland flow path to the Creek (refer to Figure 30).

7. **Area G** – This area contains a number of artificial waterbodies forming part of the stormwater management system for land to the south and southeast of the Site (Figure 31). The final pond adjacent to the riparian corridor maintain a riprap reinforced overflow weir (refer to Figure 32).

2.5 Stantec Flood Report

2.5.1 Overview

The Stantec Flood Report details an assessment of flooding extent and behaviour at the Site and was prepared to support Site redevelopment. The following is noted from the report:

1. The Site is located in a predominantly Medium Risk flood precinct,[3] this being all flood prone land that is (a) within the 1% AEP Flood Planning Area (**FPA**) and (b) is not within the high flood risk precinct.

2. Flood modelling completed is based on the results of the 2019 Ingleside, Elanora and Warriewood Overland Flow Flood Study prepared by WMA Water which was completed prior to the approval and construction of the current housing development on 18 Macpherson Street Warriewood adjacent and to the northwest of the Site. Updates to the 2019 model included incorporating Site and 18 Macpherson Street survey, incorporation of new building footprints, and adjustments to roughness zones to accommodate new development and vegetated areas.

2.5.2 Existing Flood Conditions

The Stantec Flood Report provides a detailed analysis of existing (or 'benchmark') flood conditions at the Site for a range of storms including the critical 50% AEP, 20 %, 1% and PMF, each rainfall increased by 30% to account for climate change (**CC**). The report observes that the actual probability of these CC events occurring under current day conditions is significantly lower than what is suggested by the AEP of the event. For instance, the 1% AEP + CC event has an equivalent AEP in today's terms of 0.11 %, this being equivalent to a 1 in 871 year event.[4]

The following observations are made in respect of existing 1% AEP conditions, which have been assessed under no climate change and 30% CC scenarios:

1. **1% AEP Depths**: The existing 1% AEP and 1% AEP + 30% CC flood extents are copied at Figure 33 and Figure 34. In both cases, the 1% AEP flood does not extend over the entire Site. Under existing conditions, flood depths within the

[3] Refer to Stantec Flood Report at Figure 2, p 9.

[4] Refer to Stantec Flood Report at Section 4.2, pp 40-41.

Site are typically < 0.3 m. Under CC conditions, flood depths increase in the order of 15-20 cm within flood affected areas and flood extents are slightly increased. Depths > 1.5 m are typically confined to the Narrabeen Creek channel and to the right bank riparian corridor adjacent to the 14 Macpherson Street development where riparian rehabilitation has been undertaken such that the 1 % AEP flows are confined to the corridor.

2. **1% AEP Velocity**: The existing 1% AEP flood velocity has been reproduced at Figure 35, indicating that velocity within the Site is typically < 0.3 m/s except adjacent to the Creek where velocity ranges between 0.5-1.0 m/s. Velocities > 1.0 m/s adjacent to the Site and downstream, are experienced primarily within the creek channel and near channel overbank areas.

3. **1% AEP Flood Hazard:** The existing 1% AEP flood hazard has been reproduced at Figure 36, indicating that the Site is affected by H1, H2 and H3 hazards. Areas within the Narrabeen Creek channel reach up to H6 in a few locations, although the channel is typically H5.

2.5.3 Proposed Flood Conditions

The Stantec Flood Report provides a detailed analysis of proposed (or 'future') flood conditions at the Site for a range of storms including the critical 50% AEP, 20 %, 1% and PMF, each rainfall increased by 30% to account for CC. The following observations are made in respect of proposed conditions:

1. **1% AEP Depths**: The proposed 1% AEP and 1% AEP + 30% CC flood extents are copied at Figure 37 and Figure 38. In both cases, the 1% AEP flood does not extend into the residential areas.

2. **1% AEP Velocity**: The proposed 1% AEP flood velocity has been reproduced at Figure 39, indicating that flood flows are confined to land associated with the stormwater basin and riparian corridor dedication adjoining Narrabeen Creek.

3. **1% AEP Flood Hazard:** The existing 1% AEP flood hazard has been reproduced at Figure 40, indicating that flood hazard within the Site are confined to land associated with the stormwater basin and riparian corridor dedication adjoining Narrabeen Creek.

2.5.4 Flood Impacts

Flood impact plots are provided at Appendix C of the Stantec Flood Report, and include impact for the 50% AEP + CC, 20 % AEP + CC, 1 % AEP + CC and PMF + CC flood depths, as well as 1% AEP + CC and PMF + CC flood velocities. Stantec make the following comments in respect of flood impacts:

1. **Flood Depths**: The proposed development has a negligible adverse impact on 50%AEP + 30%CC, 20%AEP + 30%CC, 1%AEP + 30%CC and PMF + 30%CC flood levels, noting:

a. **1%AEP + 30% CC**: *There are local increases located within the creekline corridor adjacent to the property as well as a zone of local increases that are slightly greater than 0.02 m located within the creek corridor downstream of Brands Lane. There is also a small area of local increases greater than 0.05 m just downstream of Brands Lane. These local increase within the creek corridor do not adversely impact on any existing dwellings*.[5]

b. **PMF + 30% CC**: *There are local increases less than 0.05 m located within the creekline corridor downstream of Brands Lane as well as a zone of local increases that are slightly greater than 0.05 m within the creek corridor downstream of Brands Lane. As indicated in Table 4 these increases are around 0.06 – 0.07 m in the vicinity of existing dwellings. There is also a very small area of greater local increase downstream of Brands Lane. Given the probability of a PMF + 30%CC flood at this time (1 in 40,000,000 AEP) these local impacts of greater than 0.05 m within the creek corridor are considered to be negligible*.[6]

2. **Flood Velocity**: The proposed development does result in some increases in flow velocity, but these are considered acceptable for the following reasons:

a. **1% AEP + CC:** Velocity increases *exceed 10% primarily in Brands Lane and at the intersection with Macpherson Street with scattered impacts elsewhere. Figures E15 and F15 disclose that while the velocity increases in Brands Lane the peak velocity remains below 1 m/s. These velocity are not of concern in relation to scour*.[7]

b. **PMF + 30% CC:** Velocity increases *exceed 10% within the subject property and primarily in Brands Lane and within a section of Macpherson St with scattered impacts elsewhere.*

Figure E23 discloses that velocities exceed 1m/s extensively throughout the locality, including in the creek corridor, Macpherson Street and parts of Brands Lane under Benchmark Conditions. Figure F23 discloses that the area on Brands Lane where velocities exceed 1m/s increases under Future Conditions. While the increase in velocity to parts of Brands Lane may be of possible concern in relation to scour, it is no more so than elsewhere in the locality, including the creek corridor and Macpherson Street under both Benchmark and Future Conditions and for this reason the exceedances above the DCP impact criterion are considered minor and acceptable.[8]

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5 Stantec Flood Report Section 4.2.1, pp 43.

6 Stantec Flood Report Section 4.2.1, pp 43.

7 Stantec Flood Report Section 4.2.2, pp 43.

8 Stantec Flood Report Section 4.2.2, pp 43.

3 Flood Impact Analysis

3.1 Methodology

The following methodology was used to analyse the flood impacts documented in the Stantec Flood Report:

1. Complete a detailed review of the Stantec Flood Report.
2. Extract flooding mapping data from the flood model documented in the Stantec Flood Report, notably:
    a. Existing and proposed 1% AEP + 30% CC flood levels and impacts.
    b. Existing and proposed 1% AEP + 30% CC flood velocities and impacts.
    c. Existing and proposed 1% AEP + 30% CC flood VD products and impacts.
    d. Existing and proposed PMF + 30 % CC flood levels and impacts.
    e. Existing and proposed PMF + 30% CC flood velocities and impacts.
    f. Existing and proposed PMF + 30% CC flood VD products and impacts.
3. Identify locations where impacts exceed thresholds specified (if provided) in the PDCP.
4. Define issues to be considered to enable analysis of potential flood impacts.
5. Inspect identified locations where relevant.
6. Analyse the significance of any threshold exceedance based on risks to property, environment and safety.

3.2 Pittwater DCP

3.2.1 Objectives

The PDCP maintains the following objectives in respect of development on flood prone land:[9]

- Protection of people.
- Protection of the natural environment.
- Protection of private and public infrastructure and assets.

3.2.2 Controls

Pursuant to section B3.11 of the PDCP, the Site's classification as being located predominantly within a Medium Flood Risk precinct and the development being for

[9] PDCP Section B3.11.

residential purposes, controls A1 and A2 apply to the Proposal in respect of considering flood effects caused by development. These are provided in Table 3.

Table 3: PDCP s B3.11 residential development controls on flood effects.

Control	Desctiption
A1	*Development shall not be approved unless it can be demonstrated in a Flood Management Report that it has been designed and can be constructed so that in all events up to the 1% AEP event:* *(a) There are no adverse impacts on flood levels or velocities caused by alterations to the flood conveyance; and* *(b) There are no adverse impacts on surrounding properties; and* *(c) It is sited to minimise exposure to flood hazard.* *Major developments and developments likely to have a significant impact on the PMF flood regime will need to demonstrate that there are no adverse impacts in the Probable Maximum Flood.*
A2	*Development shall not be approved unless it can be demonstrated in a Flood Management Report that in all events up to the 1% AEP event there is no net loss of flood storage.* *Consideration may be given for exempting the volume of standard piers from flood storage calculations.* *If Compensatory Works are proposed to balance the loss of flood storage from the development, the Flood Management Report shall include detailed calculations to demonstrate how this is achieved*

The PDCP[10] defines 'adverse impacts' for the purpose of flood prone land referred to in control A1 as follows:

1. *Will result in less than 0.02m increase in the 1% AEP.*
2. Will result in less than a 0.05m increase in the PMF.
3. *Will result less than a 10% increase in PMF peak velocity.*
4. *Will have no loss in flood storage or flood way in the 1% AEP.*

We note that these definitions are at odds with the intent of control A1 and the flood prone land objectives, and we have therefore assumed therefore that for points 1-3 the word '*less*' should be read as '*greater*', and for point 4 the words '*have no*' should be read as '*result in a*'. Such a reading would be consistent with Council's SOFACs (refer to Table 2). Further, The definition of 'adverse impacts' in Control A1 refers only to the velocity change criteria for the PMF, but not to the 1% AEP flood as specified in Contention 5(a) of the SOFACs.

In addition to these controls, the following additional controls are noted which add climate change to the flood impact assessment process and modify the assessment criteria:

[10] Definitions are provided in Section A1.9 of the PDCP.

1. Pursuant to Section B3.12 of the PDCP, any proposed intensification of development on flood liable land within the Warriewood Valley Land Release Area should include the effect of climate change on flood behaviour and levels.

2. Pursuant to Section C6.1 of the PDCP, any development within a release area is to assess, and where required mitigate, flood impacts with the addition of climate change including changes to 50%, 20% 1% AEP and PMF flood levels, and changes to 1% AEP and PMF flow velocities.

   Section C6.1 asks that there is '*no additional adverse flood impact on the subject and surrounding properties and flooding processes for any flood event up to the PMF event including climate change impacts*'. By additively applying the definition of 'adverse impacts' given in Section A1.9,[11] this would therefore modify the Proposal's assessment criteria for adverse flood impacts for the climate change scenario to:

   a. *Will result in greater than 0.04m increase in the 1% AEP.*

   b. Will result in greater than a 0.10m increase in the PMF.

   c. Will result greater than a 20% increase in PMF peak velocity.

In summary, there is some ambiguity and uncertainty in the PDCP regarding how to identify areas where potential adverse flood impacts may occur, and there are assessment criteria differences between what is expressed in the SOFACs and the PDCP.

3.3 Analysis

3.3.1 Investigation Locations and Criteria

The flood impact analysis focused on specific investigation locations described in defined Table 4. Flood maps are provided in Attachment B and have been prepared based on the flood model documented in the Stantec Flood Report.

Table 4: Flood impact analysis investigation areas and criteria.

Variable	Reference	1% AEP	PMF
Flood level (mAHD)	Criteria	Afflux > 0.02 m	Afflux > 0.05 m
	Maps	1, 2	7, 8
Flow velocity (m/s)	Criteria	Increase > 10%	Increase > 10%
	Maps	3, 4	9, 10
Velocity x depth product (m^2/s)	Criteria	Increase > 10%	Increase > 10%
	Maps	5, 6	11, 12

The following is noted in respect of the adopted criteria:

[11] The impact criteria are doubled because C6.1 asks for 'additional' adverse impacts.

1. Flood level afflux investigation criteria are based on Section A1.9 of the PDCP and not the lower standard when CC is included.

2. Flow velocity investigation criteria includes a 10% increase threshold for the 1% AEP as requested in the SOFACs (not required by the PDCP).

3. Velocity x depth product plots have been included as these were previously requested by Council (but are not included in the SOFACs). The PDCP does not provide a threshold change criteria, hence a nominal 10% increase has been adopted to identify investigation locations to be consistent with the velocity increase investigation criteria.

3.3.2 Analysis Considerations

The impact of any flood impact threshold exceedances was analysed at each of the identified investigation locations by one or more considerations outlined in Table 5. These considerations were developed so that the significance of the flood impact could be evaluated.[12]

Table 5: Flood impact analysis considerations.

Variable	Considerations
Flood level afflux	1. Is vegetation inundation materially increased? 2. Will existing land-uses be impacted? 3. Will enjoyment or amenity of the land be degraded? 4. Will there be an increase in flood risk to life or property? 5. Are flood evacuation risks increased?
Velocity increases[1]	6. Will vegetation likely be impacted? 7. Will property or infrastructure be impacted? 8. Will soil erosion likely occur? 9. Will creek channel impacts occur?
VD product increases	10. Will risk to life or public safety increase? 11. Will the use of the land be detrimentally impacted?

Notes

1. Flow velocities of > 2 m are typically assumed to have potential to scour vegetated areas.[13]

[12] The adopted considerations are consistent with the approach and guidance provided in Section 3.3 Table 3 of the *NSW Flood Impact and Risk Assessment – Flood Risk Management Guideline LU01*, prepared by the NSW Department of Planning and Environment (June 2023).

[13] See for example Soil Conservation Guidelines for Queensland, Chapter 9 Waterways, Section 9.3, Table 9.1, p 10.

3.3.3 1% Event Analysis

3.3.3.1 Flood Levels

1% AEP + 30 % CC flood level increase investigation areas identified in Map 1 and Map 2 provided in Attachment B are described and analysed in Table 6. This finds that off-site flood level increases will not lead to any detrimental impacts on the existing riparian corridor of Narrabeen Creek, nor will the use, amenity or enjoyment of adjoining land to the northwest or southeast be detrimentally affected.

Table 6: Analysis of 1% AEP + 30% CC flood level changes.

Location	Description	Analysis
1	North of Site within and adjacent to riparian corridor	The identified flood level changes are acceptable because: • Maximum depth increases within the existing riparian corridor minor at < 20 cm. These will not impact on existing vegetation or Creek conditions as existing depths are up to 2 m or more. • Depth increases on adjoining land to the north are minor at < 20 cm and are located within vegetated land associated with the riparian corridor and land adjoining the stormwater basin. These changes will not affect the use and enjoyment of the land, will not affect amenity, and will not lead to an increase in risk to life or property. • Depth increases within Brands Lane minor at < 20 cm. These will not impact on existing vegetation or Creek conditions as existing depths are up to 2 m or more, and flood evacuation will not be affected because the impacted area is not an evacuation route.
2	Northeast of Site within riparian corridor and within landscaped area of 14 Macpherson St	The identified flood level changes are acceptable because: • Maximum depth increases within the existing riparian corridor minor at < 20 cm. These will not impact on existing vegetation or Creek conditions as existing depths are up to 2 m or more. • Depth increases on adjoining land to the landscaped area of 14 Macpherson St are minor, mostly < 5cm except a small area of up to 20 cm. These changes will not affect the use and enjoyment of the land, will not affect amenity, and will not lead to any material increased risk to life or property. This area is heavily vegetated (refer to Figure 9 and Figure 11 at Location E).

3.3.3.2 Flow Velocities

1% AEP + 30 % CC flow velocity increase investigation areas identified in Map 3 and Map 4 (Attachment B) are described and analysed in Table 7. This finds that off-site flood flow velocity increases will not lead to any detrimental impacts on the existing riparian corridor of Narrabeen Creek, nor will there be any likely impacts on existing vegetation, hardstand areas, property or infrastructure.

The analysis has found that there is a small location within Brands Lane in the riparian corridor (location 3) where peak flow velocity increases above 2 m/s following the Creek

regrading works. For this area we recommend any pervious areas are rapidly stabilised following completion of earthworks with biodegradable jute matting fixed into place and then hydro mulched to ensure rapid vegetative establishment. Routine inspections and maintenance during the vegetation establishment period will ensure that the risk of soil erosion and vegetation loss is appropriately mitigated.

Table 7: Analysis of 1% AEP + 30 % CC flow velocity changes.

Location	Description	Analysis
1	Minor scattered areas in the model domain	The identified flow velocity changes are acceptable because: • The identified areas are predominantly located in regions of low velocity of < 1m/s. Changes are minor and will not lead to impacts on property or infrastructure. • Where increases occur within vegetated areas, vegetation will not be impacted because velocities are not increased above 2 m/s.
2	Areas within Macpherson St and Brands Ln	The identified flow velocity changes are acceptable because: • Identified areas are located in regions where velocity ranges up to 1.5 m/s. Changes are minor and no impact on property or infrastructure will occur because increases are insufficient to cause damage. • Where increases occur within vegetated areas, vegetation will not be impacted because velocities are not increased above 2 m/s.
3	Within riparian corridor where creek bank is regraded	The identified flow velocity changes are acceptable because: • Velocity increases occur here because the creek regrading works increase the flow capacity of the channel at this location, directing increased flows across this part of the riparian corridor. • The small area which is identified as increasing above 2 m/s can be initially stabilised, where it is to be retained as pervious riparian area, with biodegradable jute matting fixed into place and then hydro mulched to ensure rapid vegetative cover following earthworks. Routine inspections and maintenance during the vegetation establishment period will ensure that the risk of soil erosion and vegetation loss is appropriately mitigated. • Any hardstand areas within this location will not be impacted by the velocity changes.
4	Within adjoining land to northwest	The identified flow velocity changes are acceptable because: • Velocity increases occur here because the Site creek regrading works increases flow rates due to increased floodplain drainage capacity in this area. • The area is localised near the boundary and occurs within vegetated stable land and impacts are therefore not anticipated. • No property or infrastructure is likely to be impacted.
5	Within the riparian corridor and landscaped	The identified flow velocity changes are acceptable because:

Location	Description	Analysis
	area of 14 Macpherson St northeast of Site	• This area is heavily vegetated (refer to Figure 9 and Figure 11 at Location E). • Velocity increases occur here because the Site creek regrading works increases flow rates due to increased floodplain drainage capacity in this area. • Velocities remain low at < 1.5 m/s and any increase will not lead to material risk of scour or loss of vegetation during a flood. • Increased soil erosion is not anticipated during a flood event given the well vegetated condition of the land. • Any hardstand areas within this location will not be impacted by the velocity changes. • No property or infrastructure is likely to be impacted.
6	Within drainage infrastructure northeast of 14 Macpherson St.	The identified flow velocity changes are acceptable because: • Velocity increases occur here because the Site creek regrading works increases flow rates due to increased floodplain drainage capacity in this area. • Velocities remain low at < 1.5 m/s and any increase will not lead to material risk of scour or loss of vegetation during a flood. • Increased soil erosion is not anticipated during a flood event given the well vegetated condition of the land. • Any hardstand areas within this location will not be impacted by the velocity changes. • No property or infrastructure is likely to be impacted by the changes.
7	Within left bank riparian corridor downstream of Site	The identified flow velocity changes are acceptable because: • Velocities remain low at < 1.5 m/s and any increase will not lead to material risk of scour or loss of vegetation during a flood. • Increased soil erosion is not anticipated during a flood event given the well vegetated condition of the land. • No property or infrastructure, including the retaining walls at this location, is likely to be impacted by the changes.
8	Within rural residential land east of Site	The identified flow velocity changes are acceptable because: • Velocities remain low at < 1.5 m/s and any increase will not lead to material risk of scour or loss of vegetation during a flood. • Increased soil erosion is not anticipated during a flood event given the well vegetated condition of the land. • No property or infrastructure is likely to be impacted by the changes.

3.3.3.3 VD Product

1% AEP + 30 % CC VD product increase investigation areas identified in Map 5 and Map 6 (Attachment B) are described and analysed in Table 8. This finds that off-site flood VD product increases will not lead to any detrimental impacts on road infrastructure, risks to public safety or affectations in the use of land.

Table 8: Analysis of 1% AEP + 30 % CC VD product changes.

Location	Description	Analysis
1	Minor scattered areas in the model domain	The identified VD product changes are acceptable because: • VD product increases are minor at < 0.25 m^2/d. • VD product remains low and safe at < 0.4 m^2/s.[14]
2	Areas within Macpherson St and Brands Ln	The identified VD product changes are acceptable because: • VD product remains generally low and safe at < 0.4 m^2/s except for the lower portion of Brands Ln beyond the entrance to 14 Macpherson St. • New residences within the Site adjoining Brands Ln where VD > 0.4 m^2/s can continue to have safe access via the new internal road within the Site.
3	Within riparian corridor where creek bank is regraded	The identified VD product changes are acceptable because: • Changes in VD product arise largely from the proposed Creek regrading which increase floodplain flow capacity at that location. • This location is within the riparian corridor which is otherwise unsafe during a flood and would not be used for public access during a flood.
4	Within adjoining land to northwest	The identified VD product changes are acceptable because: • Changes in VD product arise largely from the proposed Creek regrading which increase floodplain flow capacity at that location. • This location is within the riparian corridor which is otherwise unsafe during a flood and would not be used for public access during a flood.
5	Within the riparian corridor and landscaped area of 14 Macpherson St northeast of Site	The identified VD product changes are acceptable because: • VD product within the landscaped area of 14 Macpherson St remains low and safe at < 0.4 m^2/s. • Changes within the riparian corridor are otherwise unsafe during a flood and would not be used for public access during a flood.
6	Within drainage infrastructure northeast of 14 Macpherson St.	The identified VD product changes are acceptable because: • Changes are < 0.25 m^2/s and located within land used for drainage and riparian vegetation.

[14] For example, Blacktown Council's *WSUD Developer Handbook 2020* recommends at section 15.7.2 that VD product < 0.6 m^2/s are safe for pedestrians.

Location	Description	Analysis
7	Within left bank riparian corridor downstream of Site	The identified VD product changes are acceptable because: • Changes are minor and do not materially change the low risk rating of < 0.4 m^2/s. • Entry into the riparian corridor would be otherwise be considered unsafe during a flood and would not be used for public access during a flood.
8	Within rural residential land east of Site	The identified VD product changes are acceptable because: • VD product increases are minor at < 0.25 m^2/d. • VD product remains low and safe at < 0.4 m^2/s.

3.3.4 PMF Event Analysis

3.3.4.1 Flood Levels

PMF flood level increase investigation areas identified in Map 7 and Map 8 are described and analysed in Table 9. This finds that off-site flood level increases will not lead to any detrimental impacts on the use or safe evacuation of land, notably land within 14 Macpherson St to the southeast of the Site.

Table 9: Analysis of PMF + 30 % CC flood level changes.

Location	Description	Analysis
1	North of Site within and adjacent to riparian corridor	The identified flood level changes are acceptable because: • The increases are largely contained within the riparian corridor where flood depth changes are not material compared to existing depths. • Afflux on adjoining land to the northwest will not affect the use or safe evacuation of that land. • The extent of flood liable land is not materially altered.
2	Northeast of Site within riparian corridor and within landscaped area of 14 Macpherson St	The identified flood level changes are acceptable because: • The increases are largely contained within the riparian corridor where flood depth changes are not material compared to existing depths. • Afflux on adjoining land to the southeast on 14 Macpherson St will not affect the use or safe evacuation of that land. • The extent of flood liable land is not materially altered.

3.3.4.2 Flow Velocities

PMF + 30 % CC flow velocity increase investigation areas identified in Map 9 and Map 10 (Attachment B) are described and analysed in Table 10. This finds that off-site flood flow velocities will not be increased to rates inconsistent with those experienced elsewhere within the riparian corridor or road reserves, and will not likely detrimentally impact private land beyond any impacts likely to be experienced under extreme PMF flood conditions.

Table 10: Analysis of PMF + 30 % CC flow velocity changes.

Location	Description	Analysis
1	Minor scattered areas in the model domain	The identified flow velocity changes are acceptable because: • Increases are trivial and typically < 0.1 m/s.
2	Areas within Macpherson St and Brands Ln	The identified flow velocity changes are acceptable because: • Increases are largely confined to hardstand road areas which will not be materially affected by the increases. • There are some areas where velocity increases above 2m/s. However, the extent of these areas is minor and not inconsistent with higher flow velocities experienced within road corridors in the local area.
3	Within riparian corridor where creek bank is regraded	The identified flow velocity changes are acceptable because: • Velocity increases occur here because the creek regrading works increase the flow capacity of the channel at this location, directing increased flows across this part of the riparian corridor. • High velocities are experienced throughout the Narrabeen Creek corridor during the PMF, which is the worst case conceivable flood event where potential creek impacts would be anticipated in any case. The velocities in this location are not inconsistent with those experienced elsewhere within the local creek corridor.
4	Within adjoining land to northwest	The identified flow velocity changes are acceptable because: • Changes do not result in new areas of > 2m/s velocity. • No property or infrastructure is likely to be impacted because of the Proposal.
5	Within the riparian corridor and landscaped area of 14 Macpherson St southeast of Site	The identified flow velocity changes are acceptable because: • Velocities remain < 2m/s. • No property or infrastructure is likely to be impacted because of the Proposal.
6	Within drainage infrastructure southeast of 14 Macpherson St.	The identified flow velocity changes are acceptable because: • Increases are trivial and typically < 0.1 m/s.
7	Within left bank riparian corridor downstream of Site	The identified flow velocity changes are acceptable because: • High velocities are experienced throughout the Narrabeen Creek corridor during the PMF, which is the worst case conceivable flood event where potential creek impacts would be anticipated in any case. The velocities in this location are not inconsistent with those experienced elsewhere within the local creek corridor. • The area which experiences >2 m/s velocities is slightly increased, however, this is consistent with existing creek and overbank velocities experienced at this location, particularly under the Narrabeen Creek crossing.
8	Within rural residential land east of Site	The identified flow velocity changes are acceptable because: • Increases are trivial and typically < 0.2 m/s.

Location	Description	Analysis
9	Within right bank riparian corridor east of Site	The identified flow velocity changes are acceptable because: • Increases are trivial and typically < 0.1 m/s.

3.3.4.3 VD Product

PMF + 30 % CC VD product increase investigation areas identified in Map 11 and Map 12 (Attachment B) are described and analysed in Table 11. This finds that off-site flood VD product increases will not lead to any material risks to public safety, impacts on evacuation routes or significant affectations in the use of land.

Table 11: Analysis of PMF + 30 % CC VD product changes.

Location	Description	Analysis
1	Minor scattered areas in the model domain	The identified VD product changes are acceptable because: • VD product increases are minor at < 0.25 m^2/d. • VD product remains low and safe at < 0.4 m^2/s.
2	Areas within Macpherson St and Brands Ln	The identified VD product changes are acceptable because: • The localised increases do not impact the evacuation route along Macpherson Street because the route is otherwise impacted at numerous locations at peak flow conditions by VD product > 0.6 m^2.
3	Within riparian corridor where creek bank is regraded	The identified VD product changes are acceptable because: • Changes in VD product arise largely from the proposed Creek regrading which increase floodplain flow capacity at that location. • This location is within the riparian corridor which is otherwise unsafe during a flood and would not be used for public access during a flood.
4	Within adjoining land to northwest	The identified VD product changes are acceptable because: • Changes in VD product arise largely from the proposed Creek regrading which increase floodplain flow capacity at that location. • This location is largely within the riparian corridor which is otherwise unsafe during a flood and would not be accessed during a flood.
5	Within the riparian corridor and landscaped area of 14 Macpherson St southeast of Site	The identified VD product changes are acceptable because: • Changes within the riparian corridor and landscaped areas of 14 Macpherson St are of no consequence as these areas are otherwise unsafe during a flood and would not be accessed during a flood.
6	Within drainage infrastructure southeast of 14 Macpherson St.	The identified VD product changes are acceptable because: • Changes are minor at < 0.25 m^2/s and located within land used for drainage and riparian vegetation.
7	Within left bank riparian corridor downstream of Site	The identified VD product changes are acceptable because:

Location	Description	Analysis
		• Changes within the riparian corridor are of no consequence because these areas are unsafe under existing conditions and would not be accessed during a flood. • Changes within the road reserve are minor at < 0.25 m^2/s.
8	Within rural residential land east of Site	The identified VD product changes are acceptable because: • VD product increases are minor at < 0.25 m^2/d. • VD product remains generally low and safe at < 0.4 m^2/s.
9	Within right bank riparian corridor east of Site	The identified VD product changes are acceptable because: • Changes are minor at < 0.25 m^2/s and located within land used for drainage and riparian vegetation. • VD product remains generally low and safe at < 0.4 m^2/s.

3.4 Warriewood Valley Specification

A compliance assessment with Table 4.3 Flood Planning Levels in the *Warriewood Valley Urban Land Release Water Management Specification*, prepared by Pittwater Council (2001) (**WWMS**) is provided in **Error! Reference source not found.**.

Table 12: WWMS Table 4.3 compliance assessment.

Flood	Requirement	Assessment	Comply
50% AEP	• *50%AEP flow to be carried in-bank.*	• 50% AEP + 30% CC flows are carried in bank. Refer to Stantec Flood Report Figures F1-F4.	Y
20% AEP	• *The level of walkways and cycleways adjacent to the creeks are to be above the 20%AEP flood level except under special circumstances (and exposed for only short duration's).*	• No walkways or cycleways are proposed. • Existing cycleways not impacted by Proposal.	Y
	• *Water quality control ponds, filter strips and structures are to be above the 20%AEP flood level, and can be below the 1%AEP flood level but must lie within the private buffer area as outlined in Section 4.3.2.*	• Basin is located outside of 20% AEP + 30% CC flood extents (refer to Stantec Flood Report Figure F6). • Basin is located within private buffer area to creek.	Y
1% AEP	• *1%AEP flows are to be carried within the public space corridors, and are to be further designed such that floodplain management and hazard management guidelines are accommodated to minimise risk to life.*	• 1%AEP + 30% CC flood affectation occurs within the Site only adjacent to the creek corridor near to the basin and away from residential land (refer to Stantec Flood Report Figure F10). • Design has been completed to remove 1% AEP flood hazard from residential areas and minimise risk to life.	Y
	• *Flood extent to be mapped.*	• 1% AEP and 1% AEP + 30% CC flood extents are mapped in Stantec Flood	Y

Flood	Requirement	Assessment	Comply
		Report at Figures F9 and F13 respectively.	
	• *Floor levels for properties adjacent to the creek are to be set at least 0.5 m above the 1%AEP level.*	• Item C1 in Appendix D and Appendix F of the Stantec Flood Report confirms that all floor levels will be set at or above the 0.5m above the 1% AEP +CC event water level.	Y
	• *Obverts of bridge decks of evacuation routes are to be set at least 0.5 m above the 1%AEP level.*	• No bridges are proposed as part of the Proposal.	Y
PMF	• *Evacuation planning.*	• Dwellings will be two storey and offer a suitable refuge for all residents. Refer to discussion under item E1 in Appendix D of Stantec Flood Report.	Y
	• *Flood hazards and risk to life.*	• PMF hazards are mapped in Stantec Flood Report at Figure F24. • Within the proposed residential areas on the Site, flood hazards are acceptable at H1 and H2 in the PMF and H1, H2 and pockets of H3 in the PMF + 30% CC.	Y
	• *Flood extent to be mapped.*	• PMF + 30% CC flood extents are mapped in Stantec Flood Report at Figure F21.	Y

4 Summary and Conclusions

A detailed analysis of potential flood impacts arising from the development has been completed based on the flood modelling documented in the Stantec Flood Report. The analysis methodology included:

1. Extract flood data from the Stantec Flood Report flood model.
2. Identify locations where impacts exceed thresholds specified in the PDCP.
3. Define issues to be considered to enable analysis of potential flood impacts.
4. Inspect identified locations where relevant.
5. Analyse the significance of any adopted threshold exceedance (flood level, velocity and velocity x depth product) based on risks to property, environment and safety.

The analysis found that whilst there are some exceedances of thresholds specified in the PDCP, these do not cause harm to the environment, public or private property or infrastructure, and do not result in material changes to flood risks within the floodplain. Specifically:

1. Flood level impacts: Flood level increases will not lead to any detrimental impacts on the existing riparian corridor of Narrabeen Creek, nor will the use, amenity or enjoyment of adjoining land to the northwest or southeast be detrimentally affected.
2. Flow velocity impacts: Flood flow velocity increases will not lead to any detrimental impacts on the existing riparian corridor of Narrabeen Creek, nor will there be any likely impacts on existing vegetation, hardstand areas, property or infrastructure.

   The analysis has found that there is a small location within Brands Lane in the riparian corridor (location 3) where peak flow velocity increases above 2 m/s following the Creek regrading works. For this area we recommend any pervious areas are stabilised following completion of earthworks with biodegradable jute matting fixed into place and then hydro mulched to ensure rapid vegetative establishment. Routine inspections and maintenance during the vegetation establishment period will ensure that the risk of soil erosion and vegetation loss is appropriately mitigated.
3. Velocity x depth (VD) product impacts: Flood VD product increases will not lead to any detrimental impacts on road infrastructure, risks to public safety or affectations in the use of land.

Attachment A: Figures

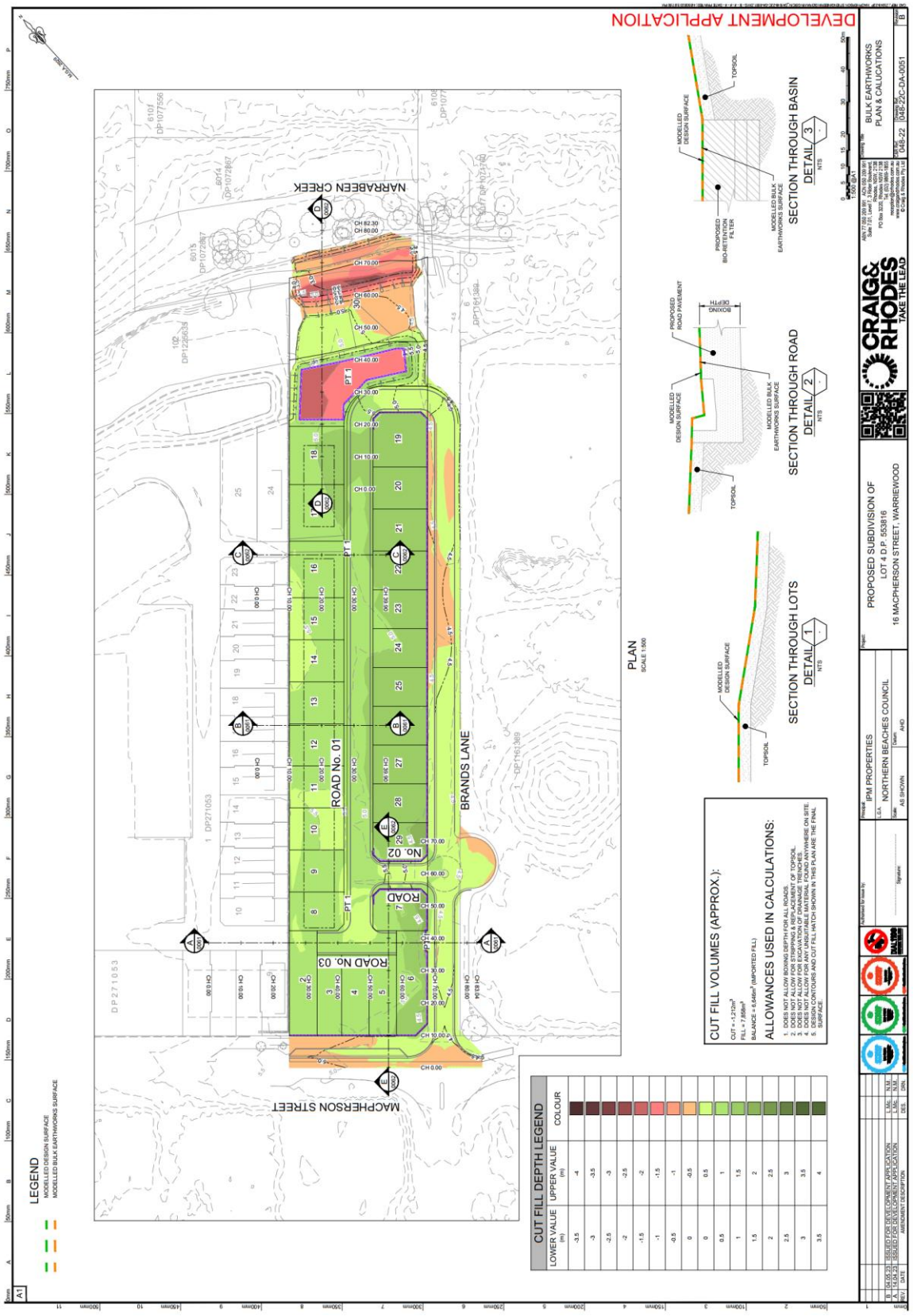

Figure 1: Proposal with earthworks.

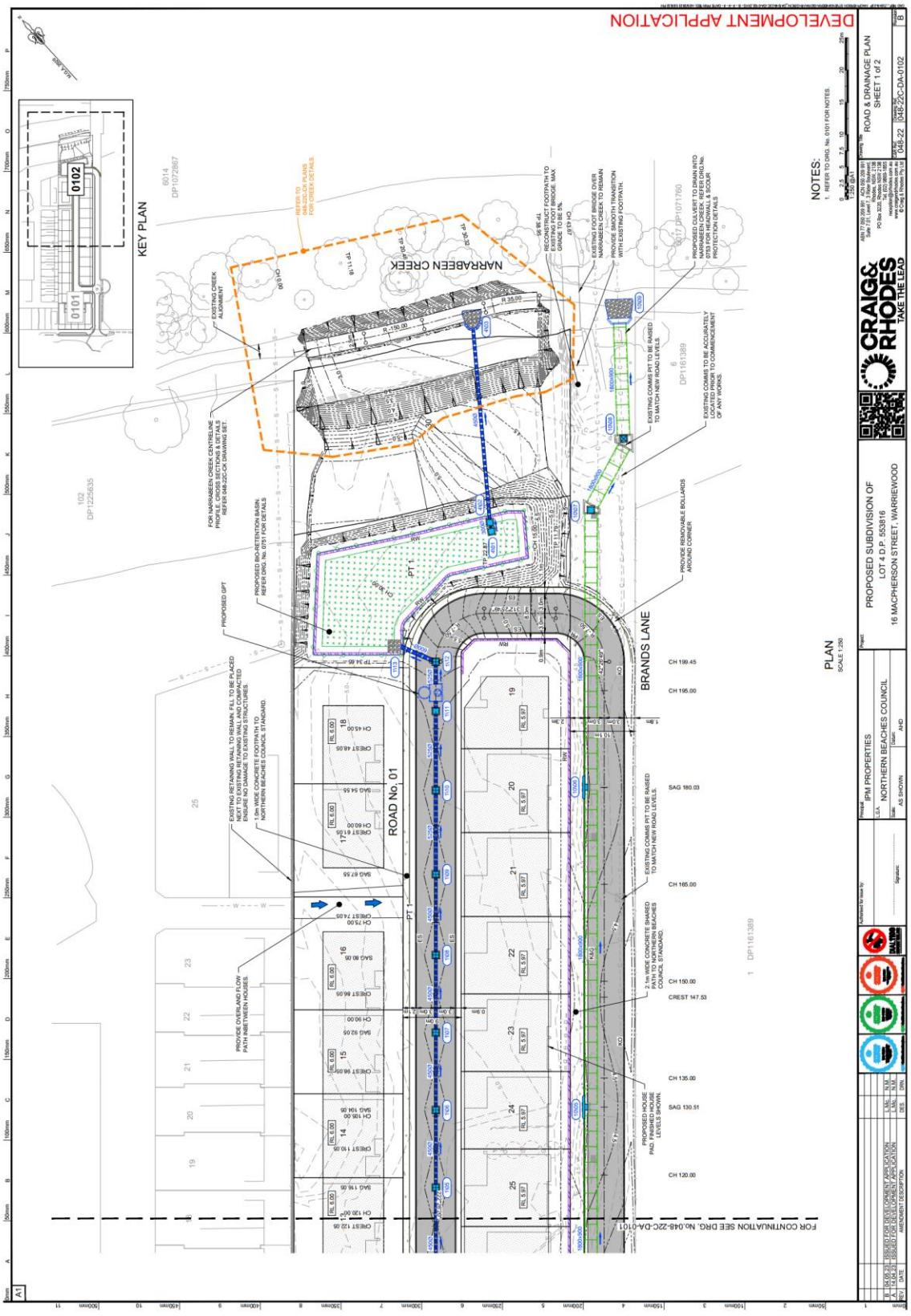

Figure 2: Proposal drainage adjacent to Narrabeen Creek.

Figure 3: Existing Site dwelling facing Macpherson Street.

Figure 4: Existing Site plant nursery.

Figure 5: Brands Ln looking SW towards Macpherson St.

Figure 6: Brands Ln looking NE towards Narrabeen Creek.

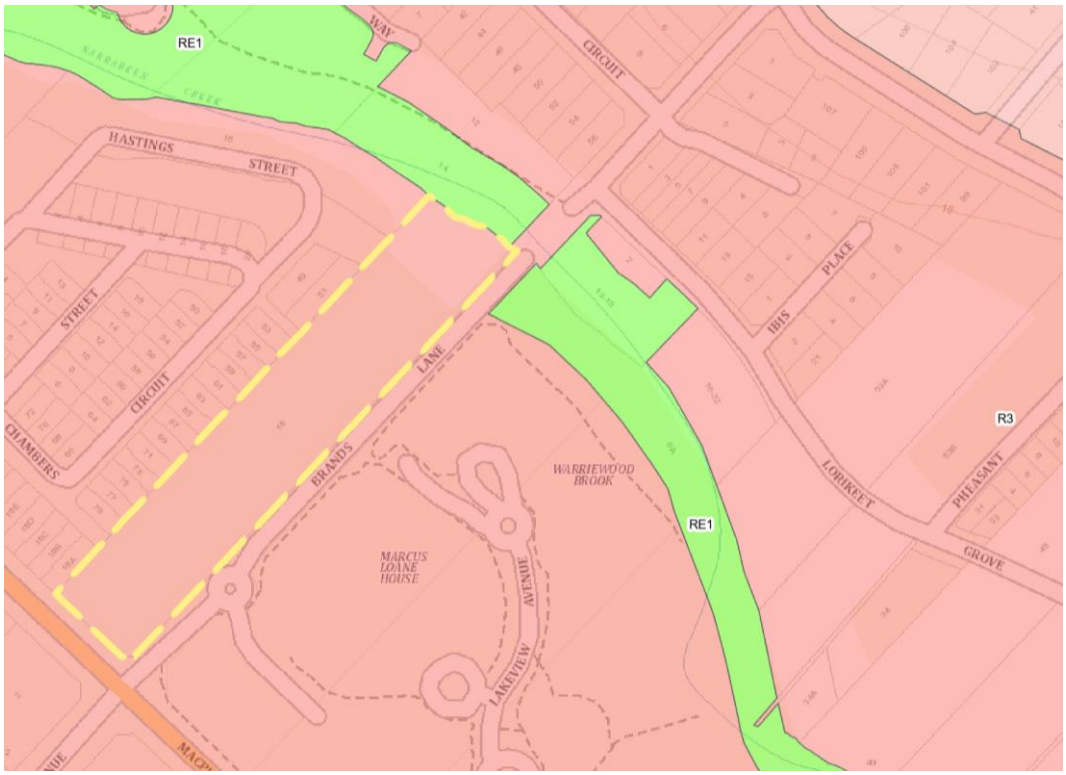

Figure 7: Site zoning.

Figure 8: Entrance to existing senior's living estate at Brands Lane.

Figure 9: Brands Ln senior's living estate frontage to Narrabeen Creek.

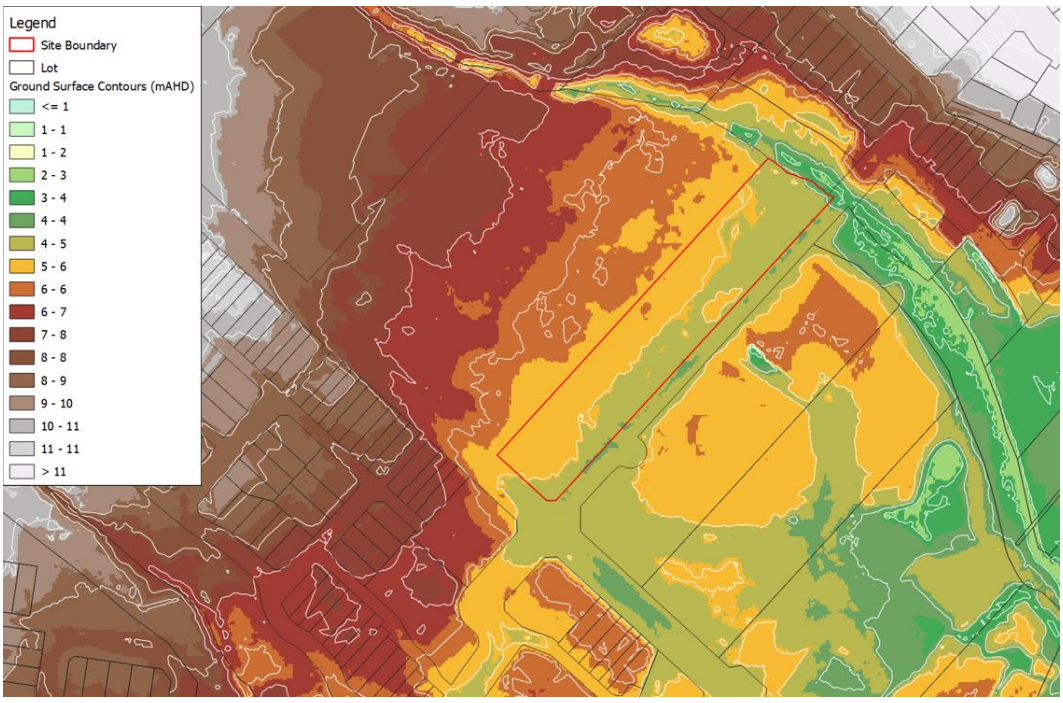

Figure 10: Local topography.

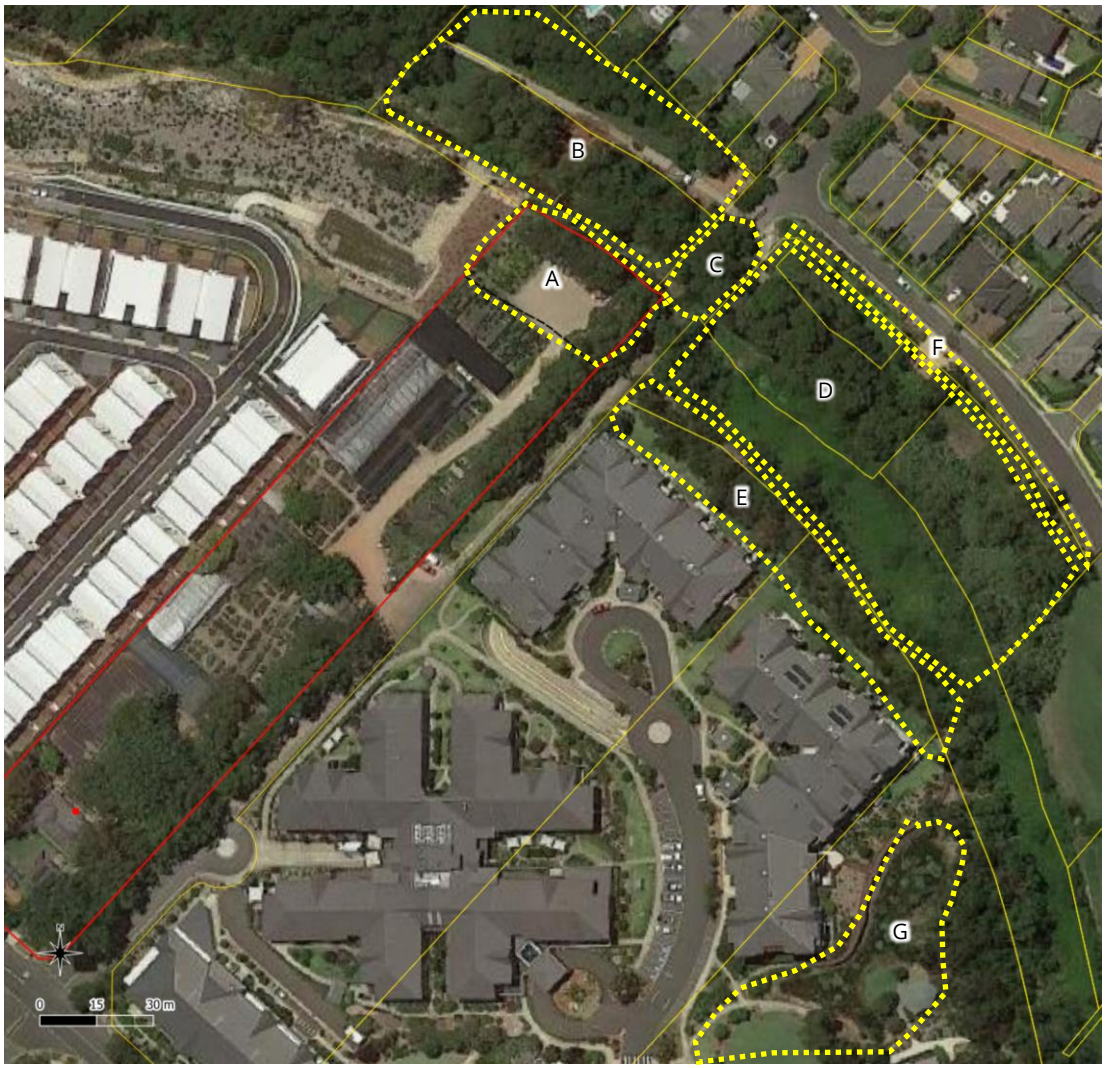

Figure 11: Site observation locations.

Figure 12: Area A nursery parking and materials storage.

Figure 13: Area A nursery parking and materials storage.

Figure 14: Area A nursery parking and materials storage.

Figure 15: Area B view looking downstream at lower section of creek channel.

Figure 16: Area B creek channel in upper reach.

Figure 17: Area B footway and open grass areas.

Figure 18: Area B heavily vegetated creek banks.

Figure 19: Area C pedestrian bridge crossing.

Figure 20: Area D right bank dense riparian vegetation.

Figure 21: Area D right bank recent shallow depth flood deposit.

Figure 22: Area D right bank remnant tree protection sleeves.

Figure 23: Area E right bank landscaping adjacent to Brands Ln.

Figure 24: Area E right bank landscaping adjacent to riparian corridor.

Figure 25: Area E right bank landscaping between buildings.

Figure 26: Area E right elevated buildings floor levels.

Figure 27: Area F sandstone block retaining wall in riparian corridor.

Figure 28: Area F concrete block retaining wall.

Figure 29: Area F stepped retaining structures.

Figure 30: Area downgradient of Area F.

Figure 31: Area G stormwater ponds.

Figure 32: Area G stormwater pond riprap overflow weir.

Figure 33: Existing 1% AEP flood depths (Stantec Figure E10).

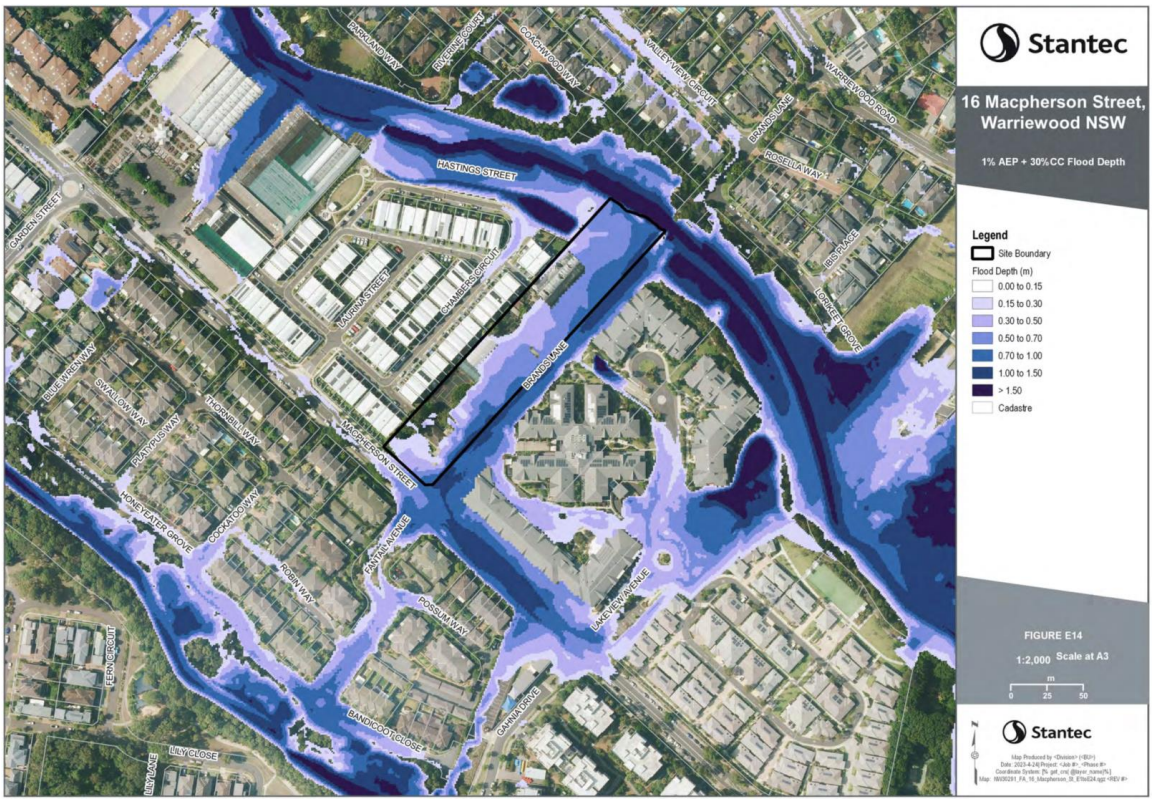

Figure 34: Existing 1% AEP + 30% CC flood depths (Stantec Figure E14).

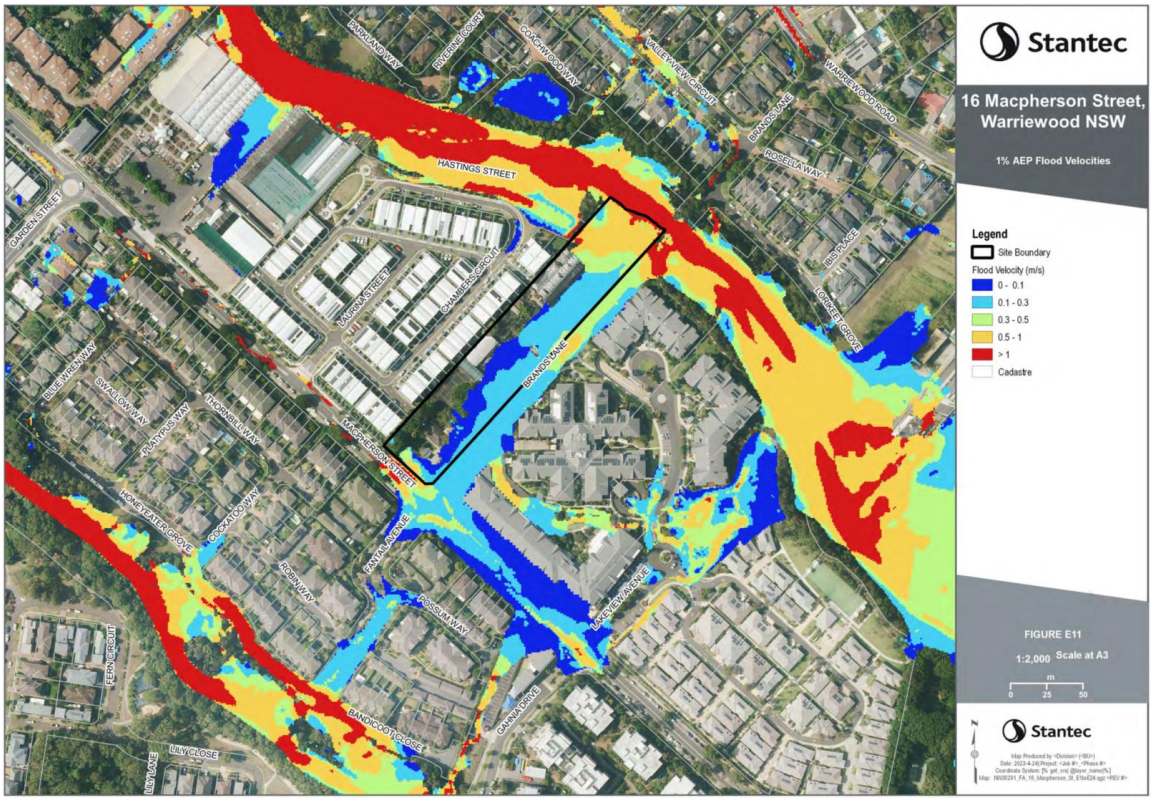

Figure 35: Existing 1% AEP flood velocity (Stantec Figure E11).

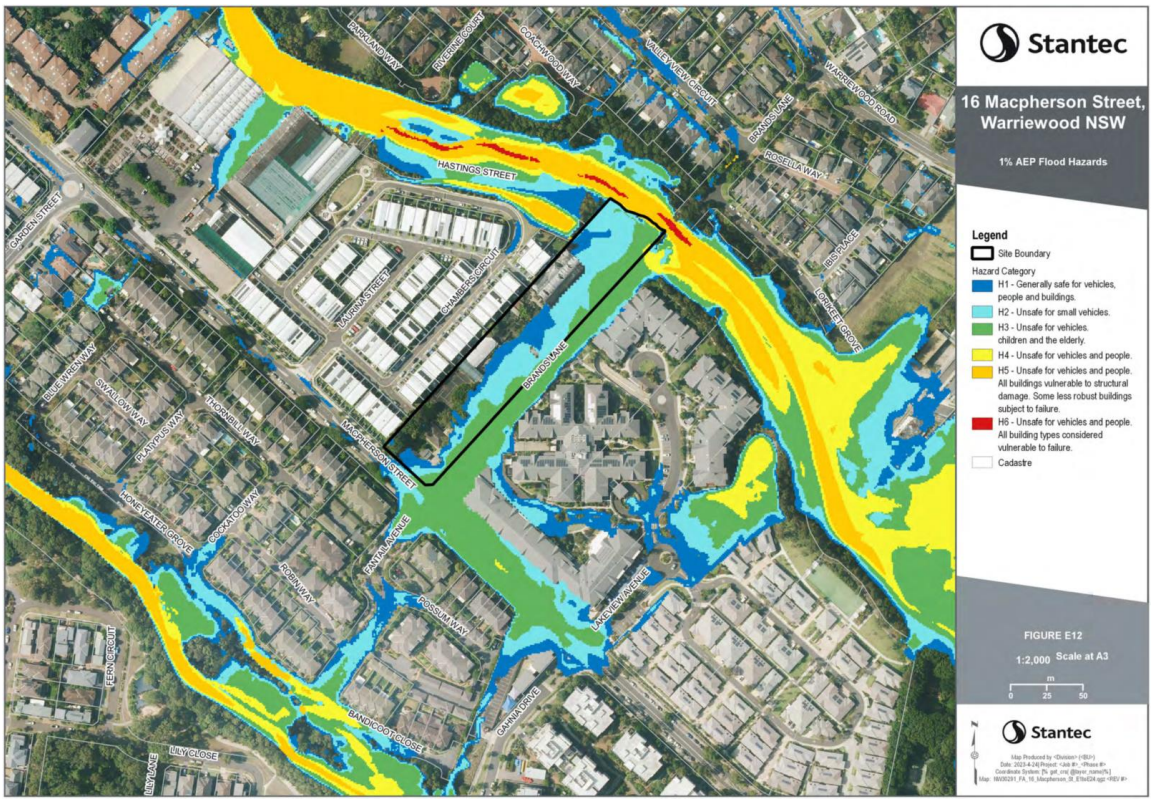

Figure 36: Existing 1% AEP flood hazard (Stantec Figure E12).

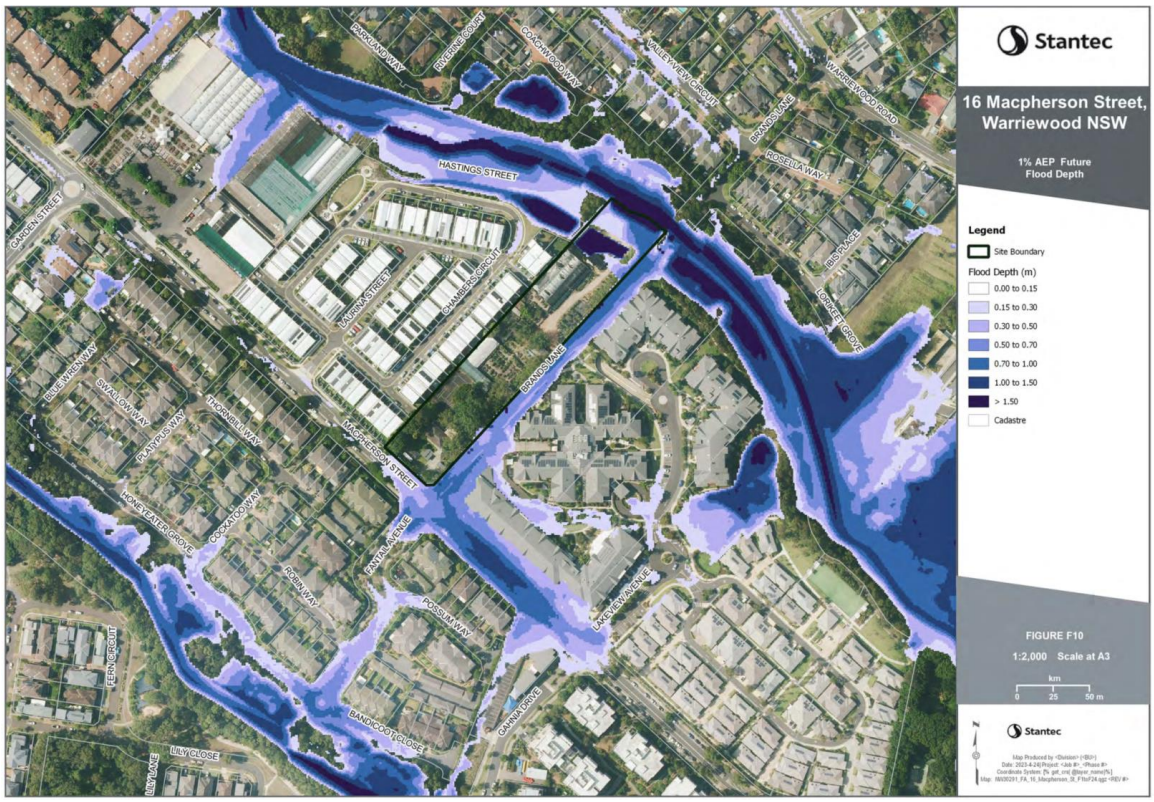

Figure 37: Proposed 1% AEP flood depths (Stantec Figure F10).

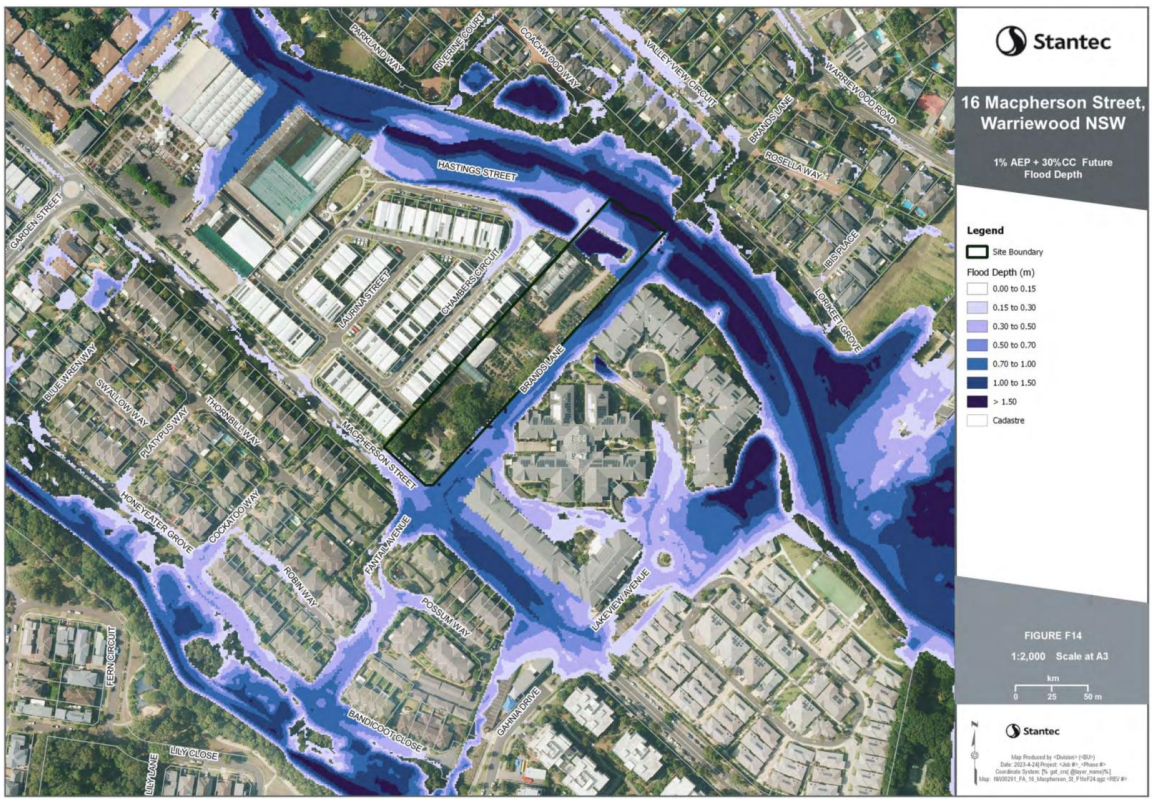

Figure 38: Proposed 1% AEP + 30% CC flood depths (Stantec Figure F14).

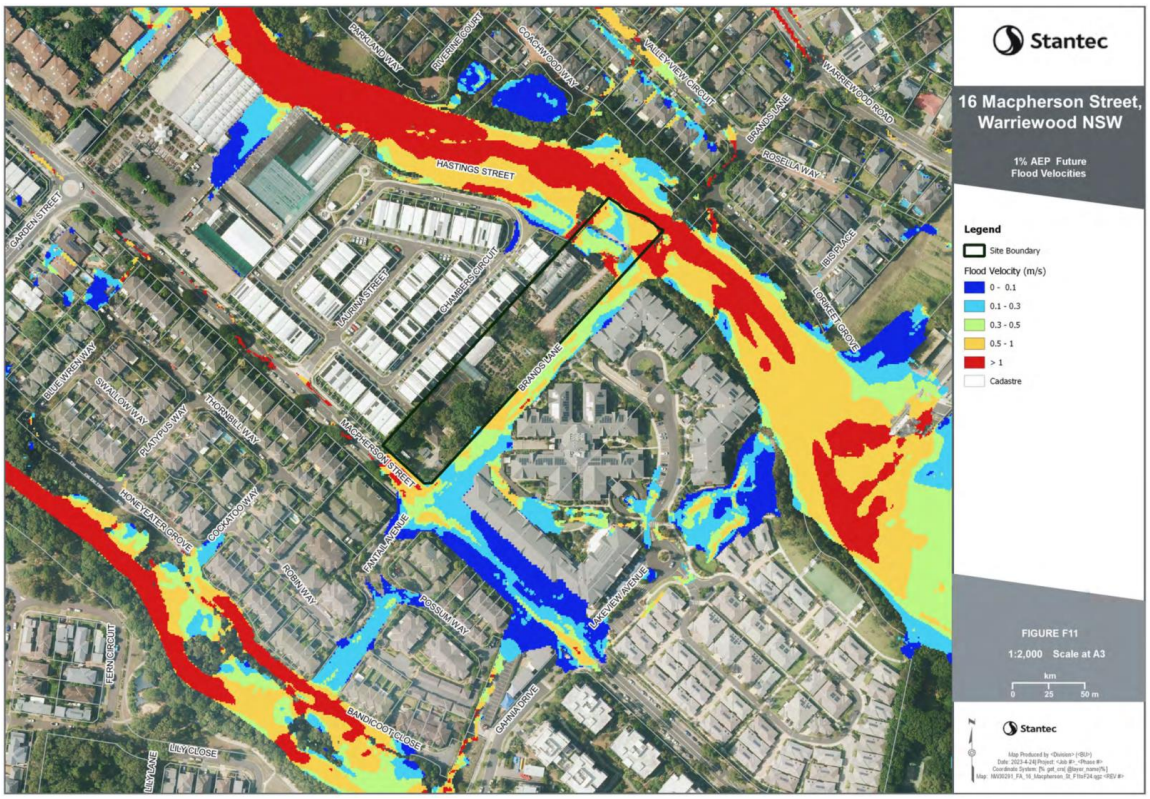

Figure 39: Proposed 1% AEP flood velocity (Stantec Figure F11).

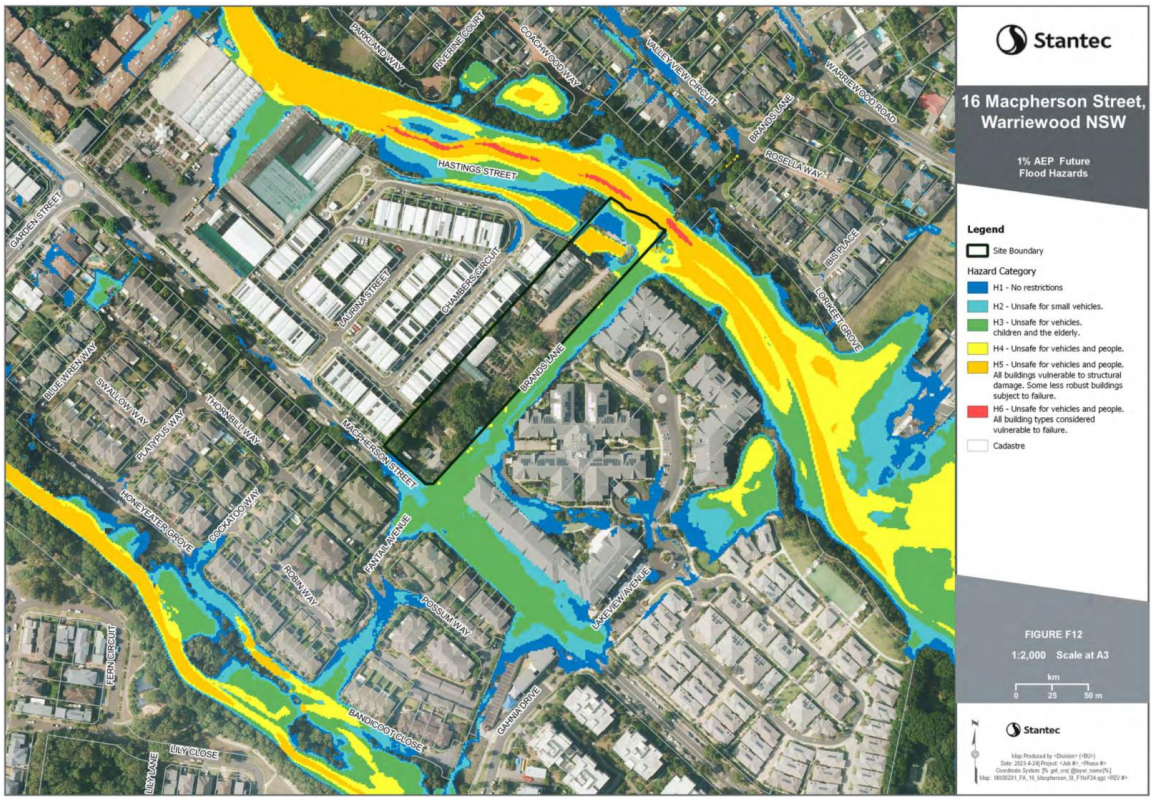

Figure 40: Proposed 1% AEP flood hazard (Stantec Figure F12).

Attachment B: Flood Maps

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Water Level Increase (m)

- > 0.02

Water Depth (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

1

2

0 20 40 60 80 100 m

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Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website

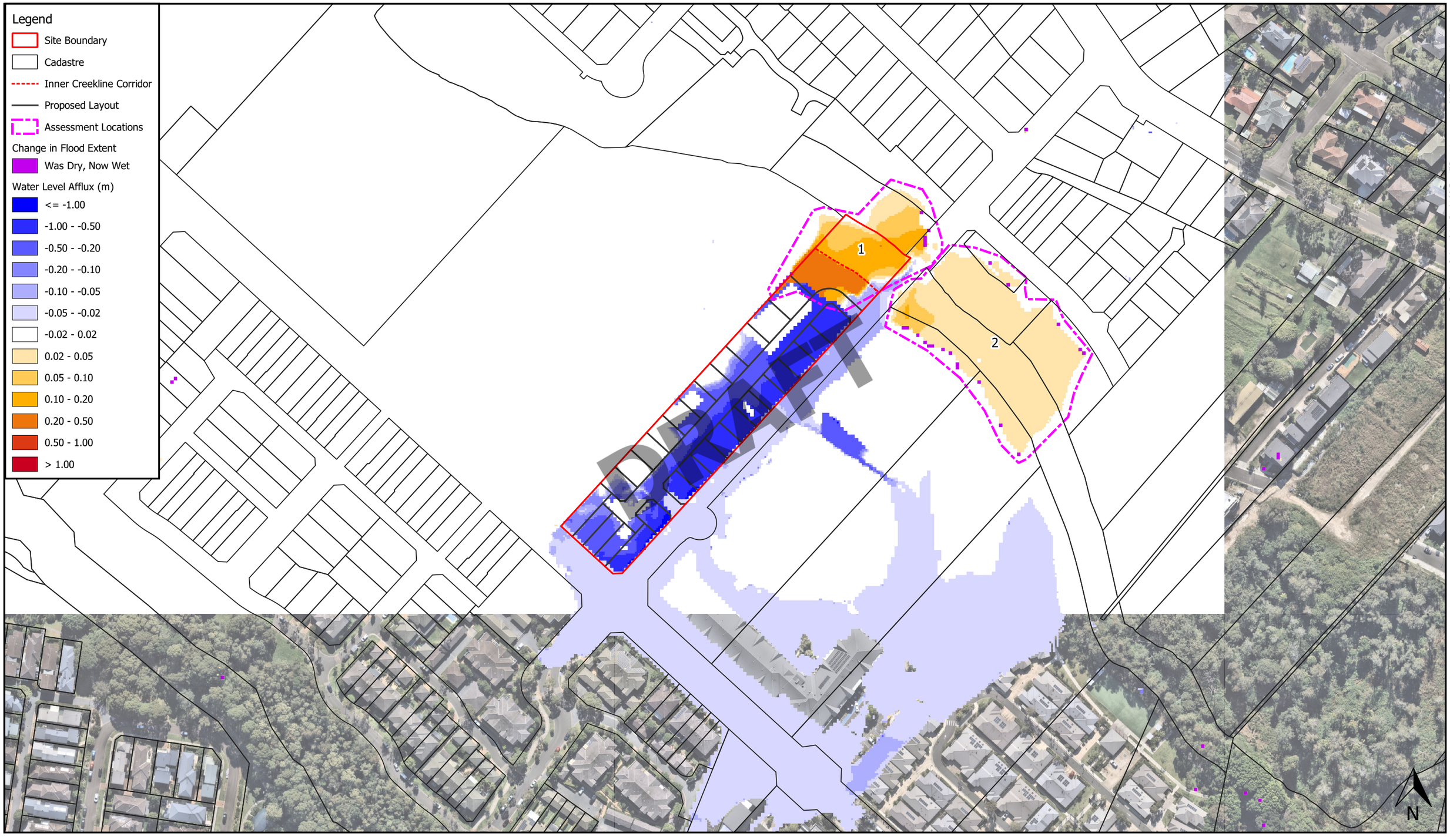
Environment | Water | Geotechnics | Civil | Projects

Map Title / Figure:

1% AEP + CC Proposed Conditions Maximum Water Level and Water Depth

Map 01	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356



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Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website
- Areas coloured blue represent water level decrease.
Areas coloured yellow/red represent water level increase.

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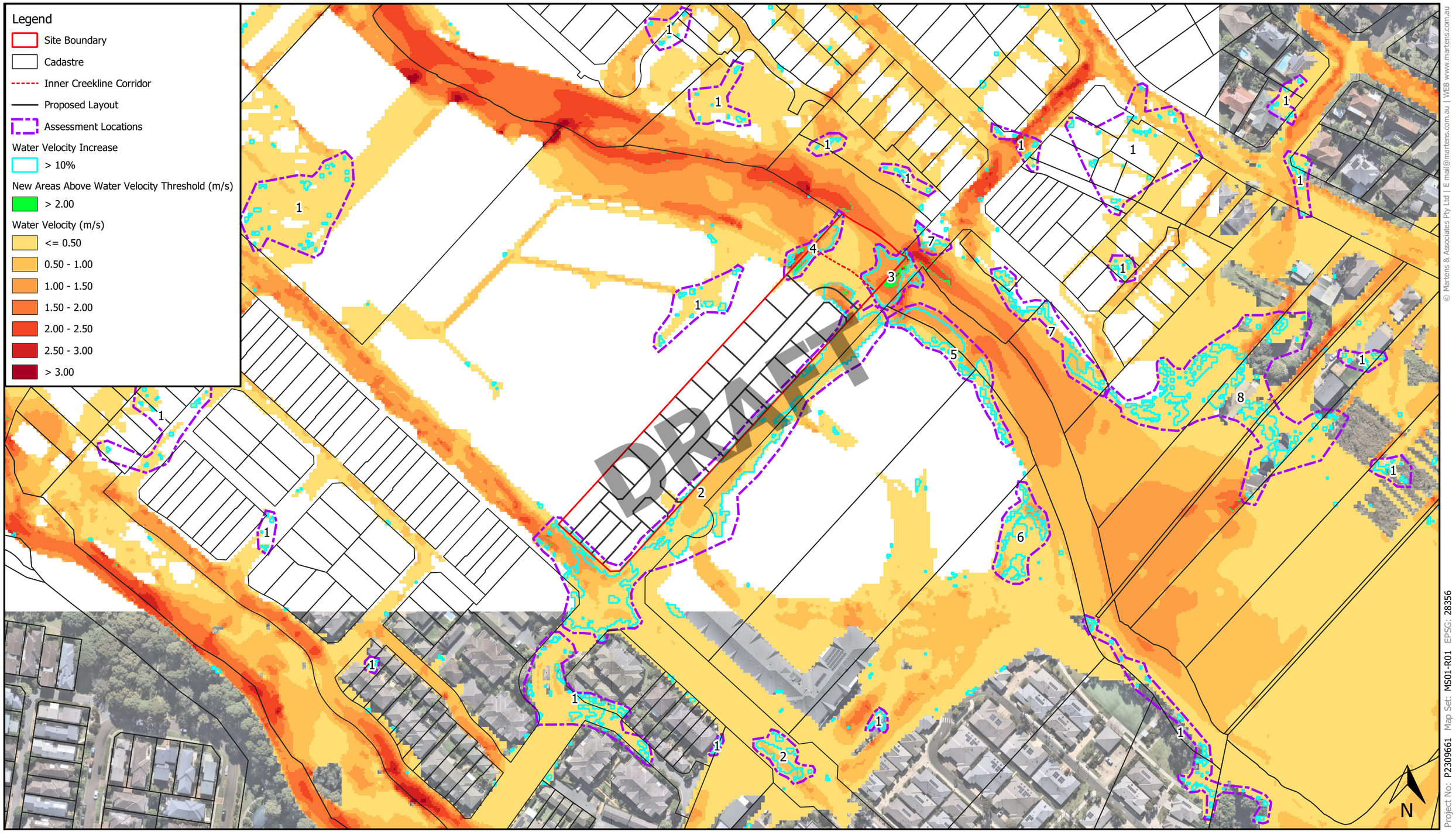
Map Title / Figure:

1% AEP + CC Proposed Conditions Water Level Afflux

Map 02	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356



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Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website

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Map Title / Figure:

1% AEP + CC Proposed Conditions Maximum Water Velocity

Map 03	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Water Velocity Increase

- > 10%

New Areas Above Water Velocity Threshold (m/s)

- > 2.00

Water Velocity Afflux (m/s)

- < -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- > 0.50

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

N

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Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website
- Areas coloured blue represent velocity decrease. Areas coloured yellow / red represent velocity increase.

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Map Title / Figure:

1% AEP + CC Proposed Conditions Water Velocity Afflux

Map 04	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Velocity Depth Product Increase

- > 10%

Velocity Depth Product (m²/s)

- 0.0 - 0.4
- 0.4 - 0.6
- > 0.6

DRAFT

0 20 40 60 80 100 m

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Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website

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Environment | Water | Geotechnics | Civil | Projects

Map Title / Figure:

1% AEP + CC Proposed Conditions Velocity Depth Product

Map 05	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Velocity Depth Product Increase

- > 10%

Velocity Depth Product Afflux (m²/s)

- <= -1.25
- -1.25 - -1.00
- -1.00 - -0.75
- -0.75 - -0.50
- -0.50 - -0.25
- -0.25 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- > 1.25

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

N

0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website
- Areas coloured blue represent velocity depth product decrease.
Areas coloured yellow/red represent velocity depth product.

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Map Title / Figure:

1% AEP + CC Proposed Conditions Velocity Depth Product Afflux

Map 06	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Water Level Increase (m)

- > 0.05

Water Depth (m)

- 0.0 - 0.1
- 0.1 - 0.2
- 0.2 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- > 5.0

1

2

0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website

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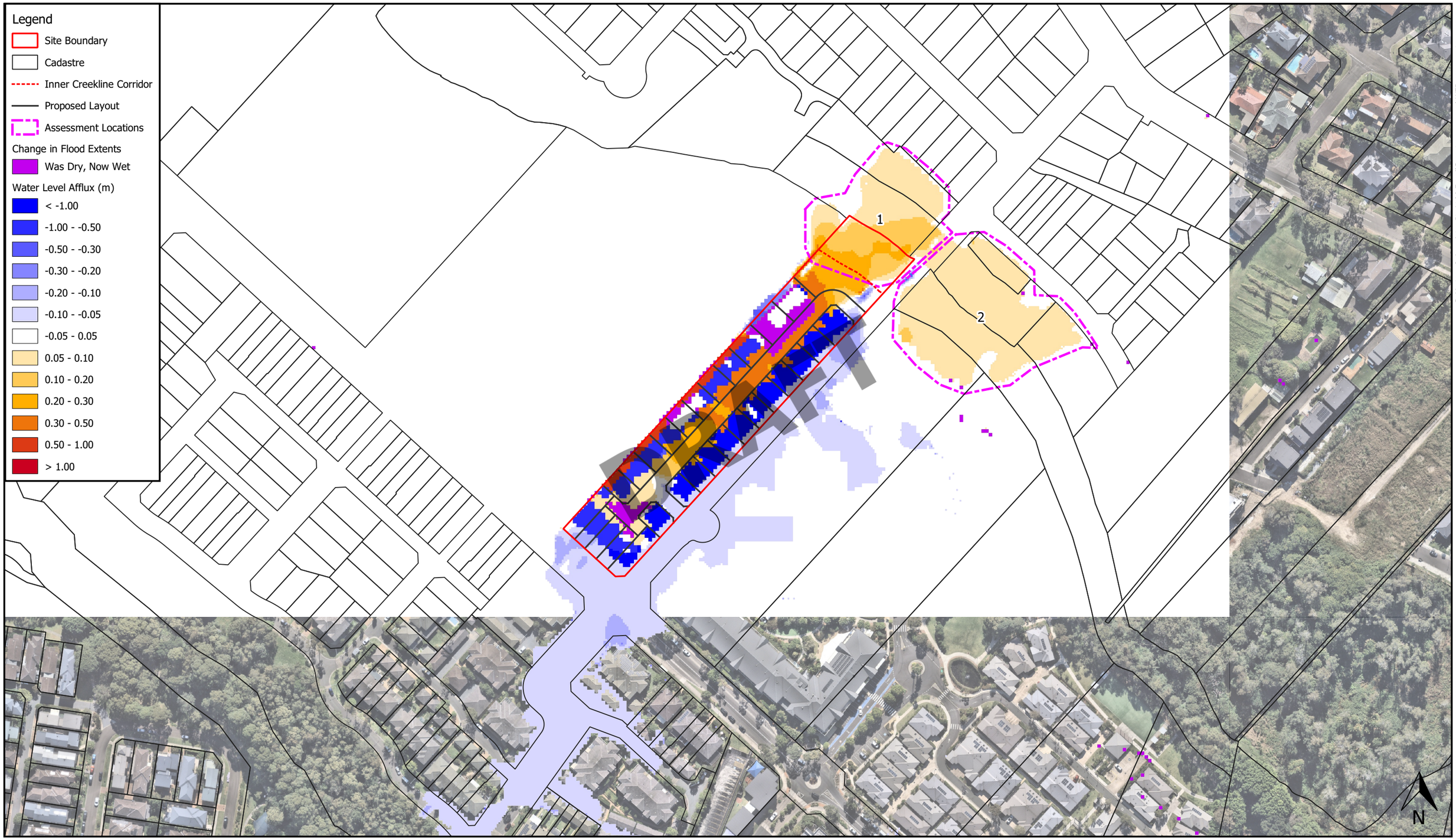
Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

Map Title / Figure:

PMF + CC Proposed Conditions
Maximum Water Level and Water Depth

Map 07	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date



0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website
- Areas coloured blue represent water level decrease.
Areas coloured yellow/red represent water level increase.

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Map Title / Figure:

PMF + CC Proposed Conditions Water Level Afflux

Map 08	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Water Velocity Increase

- > 10%

New Areas Above Water Velocity Threshold (m/s)

- > 2.00

Water Velocity (m/s)

- <= 0.50
- 0.50 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 2.50
- 2.50 - 3.00
- > 3.00

0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website

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Map Title / Figure:

PMF + CC Proposed Conditions Maximum Water Velocity

Map 09	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Water Velocity Increase

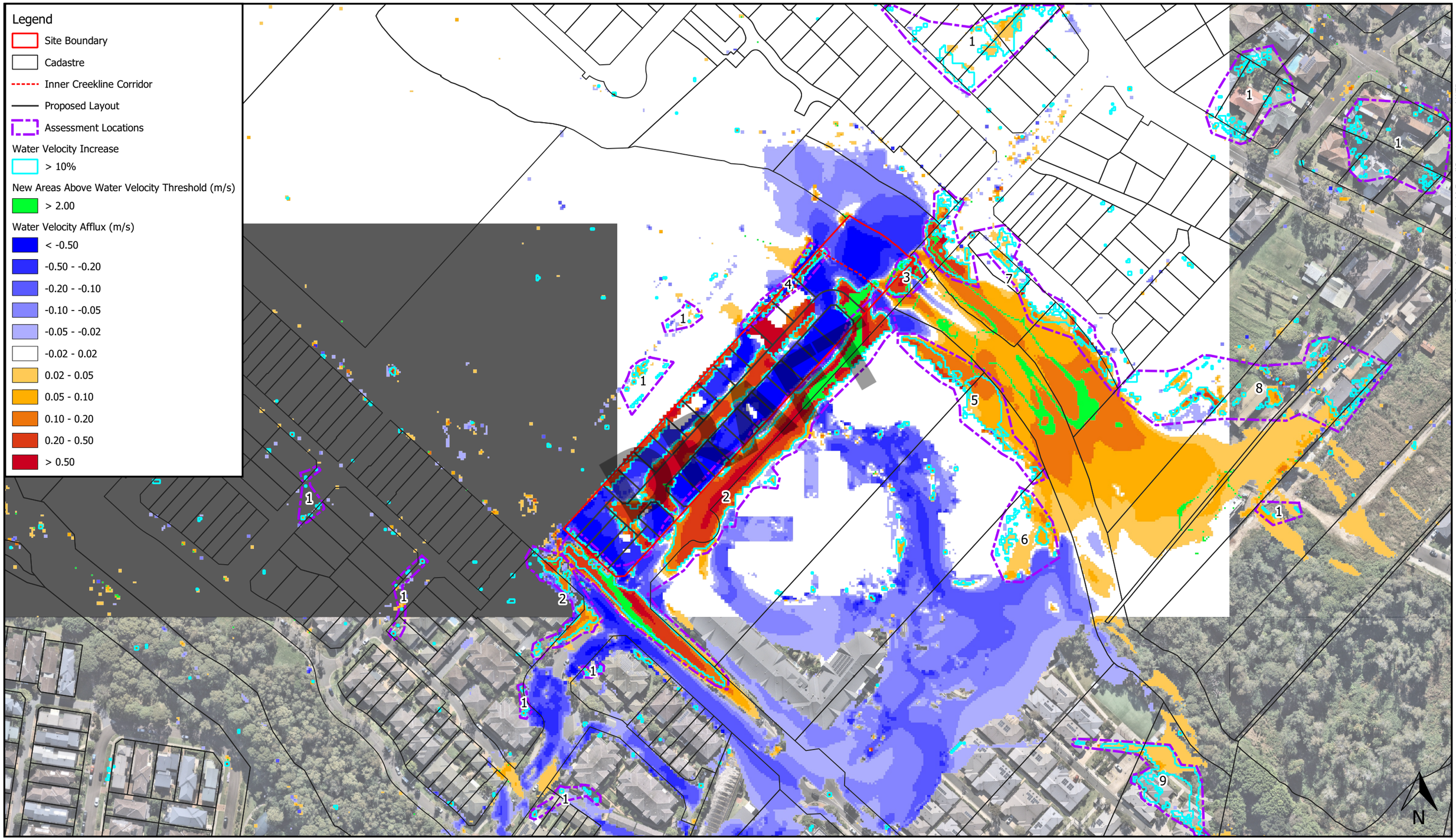
- > 10%

New Areas Above Water Velocity Threshold (m/s)

- > 2.00

Water Velocity Afflux (m/s)

- < -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.02
- -0.02 - 0.02
- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- > 0.50



0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website
- Areas coloured blue represent velocity decrease. Areas coloured yellow / red represent velocity increase.

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Map Title / Figure:

PMF + CC Proposed Conditions
Water Velocity Afflux

Map 10	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

Legend

- Site Boundary
- Cadastre
- Inner Creekline Corridor
- Proposed Layout
- Assessment Locations

Velocity Depth Product Increase

- > 10%

Velocity Depth Product (m²/s)

- 0.0 - 0.4
- 0.4 - 0.6
- > 0.6

N

0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website

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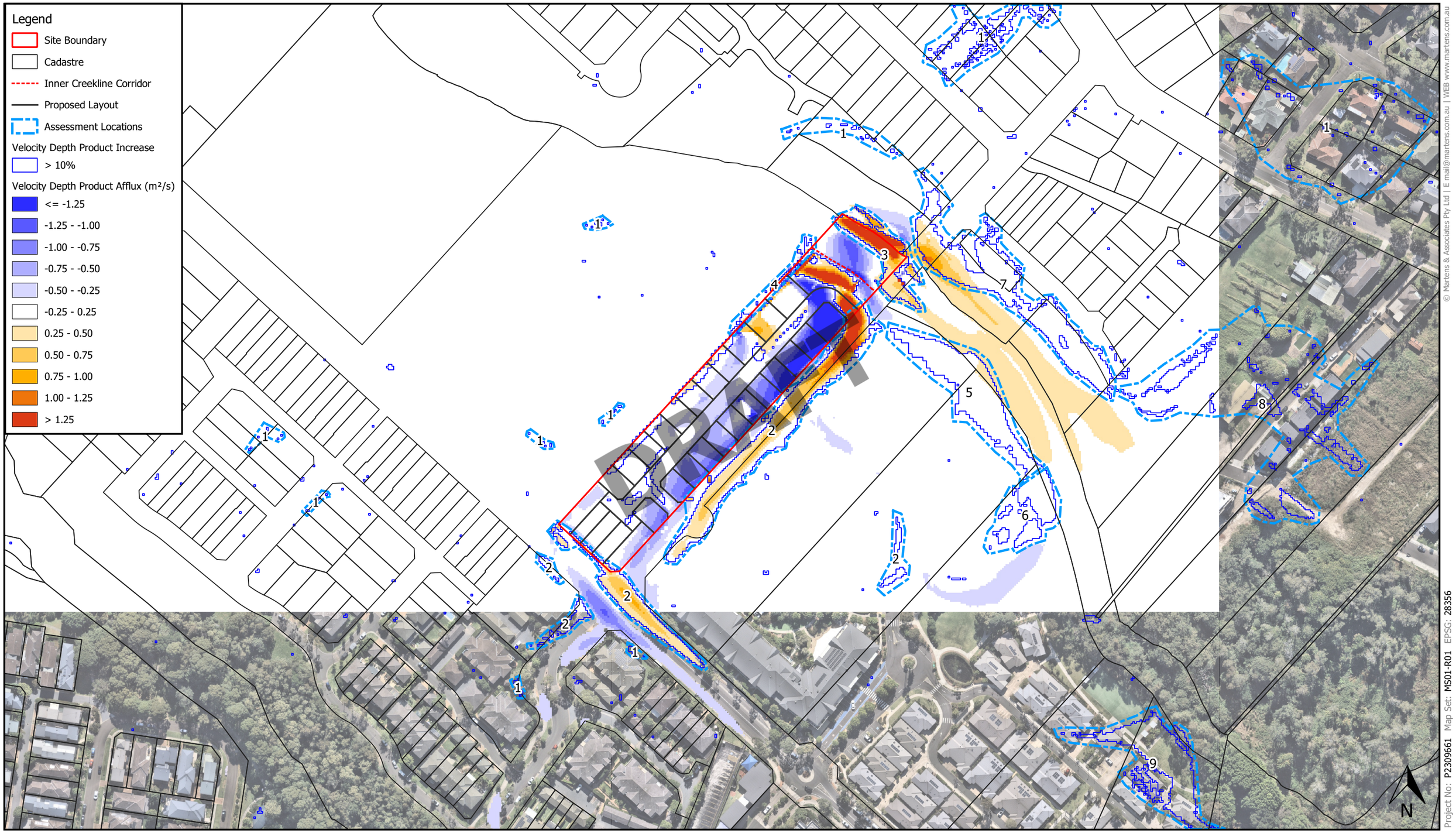
Map Title / Figure:

PMF + CC Proposed Conditions Velocity Depth Product

Map 11	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date

Project No: P2309661 Map Set: MS01-R01 EPSG: 28356



Project No: P2309661 Map Set: MS01-R01 EPSG: 28356

0 20 40 60 80 100 m

1:2000 @ A3

Viewport

Notes:
- Aerial from Nearmap (2023)
- Cadastre from NSW Spatial Services (2023) 'Clip & Ship' SIX Maps website
- Areas coloured blue represent velocity depth product decrease.
Areas coloured yellow/red represent velocity depth product.

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Map Title / Figure:

PMF + CC Proposed Conditions Velocity Depth Product Afflux

Map 12	Map
16 Macpherson Street, Warriewood, NSW	Site
Flood Impact Analysis	Project
Flood Assessment	Sub-Project
Investment Projects Management	Client
01/11/2023	Date