Flood Impact and Risk Assessment Report

Morgan Road, Belrose

For Metropolitan Local Aboriginal Land Council

July 2024

Prepared by: Leo Zhou

Contents

Issue	Date	Author	Approved
A	02/06/22	Leo Zhou	Minh Vu
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1 Introduction

1.1 Background

Colliers Engineering & Design (CED) (formerly Craig & Rhodes) has been engaged to prepare a Flood Impact and Risk Assessment (FIRA) for the Morgan Road, Belrose site on behalf of the Metropolitan Local Aboriginal Land Council.

The purpose of this report is to assist in establishing the feasibility of the rezoning in the proposed layout plan prepared by COX Architecture. The Plan has been developed to correspond to the broad level design outcomes required by Council and the Department of Planning and Environment (DoPE).

The overall strategy comprises key waterway measures for flooding, water quality and ecological management within the study area. A concept design has also been performed for the key flood management and water quality measures proposed for the site to support the planning proposal and to ensure that there are no adverse impacts on the downstream environment.

This report should be read in conjunction with the *Stormwater Management Plan* (2022) prepared for the site by CED.

1.2 Site Location

The site is located in the suburb of Belrose in Sydney's northern beaches area, bounded by Forest Way and Morgan Road, shown in Figure 1. The downstream receiving waters are Middle Creek and Narrabeen Lagoon.

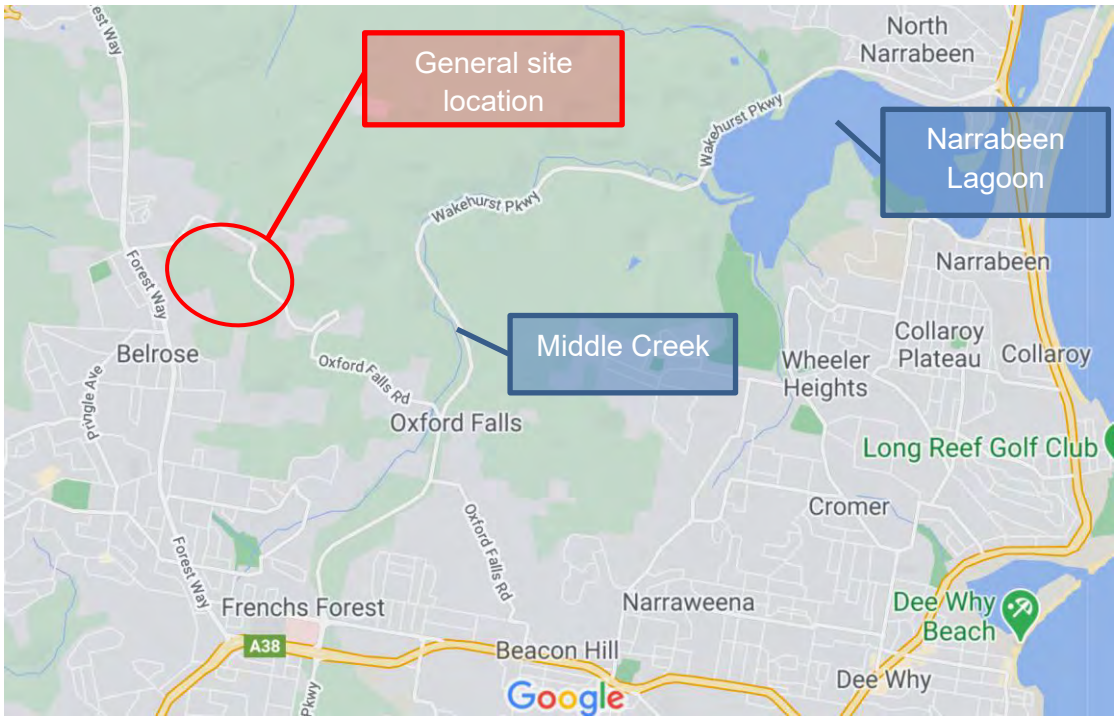

Figure 1 General Site location

A detailed site location is provided in Figure 2, showing the location of Snake Creek and Middle Creek.

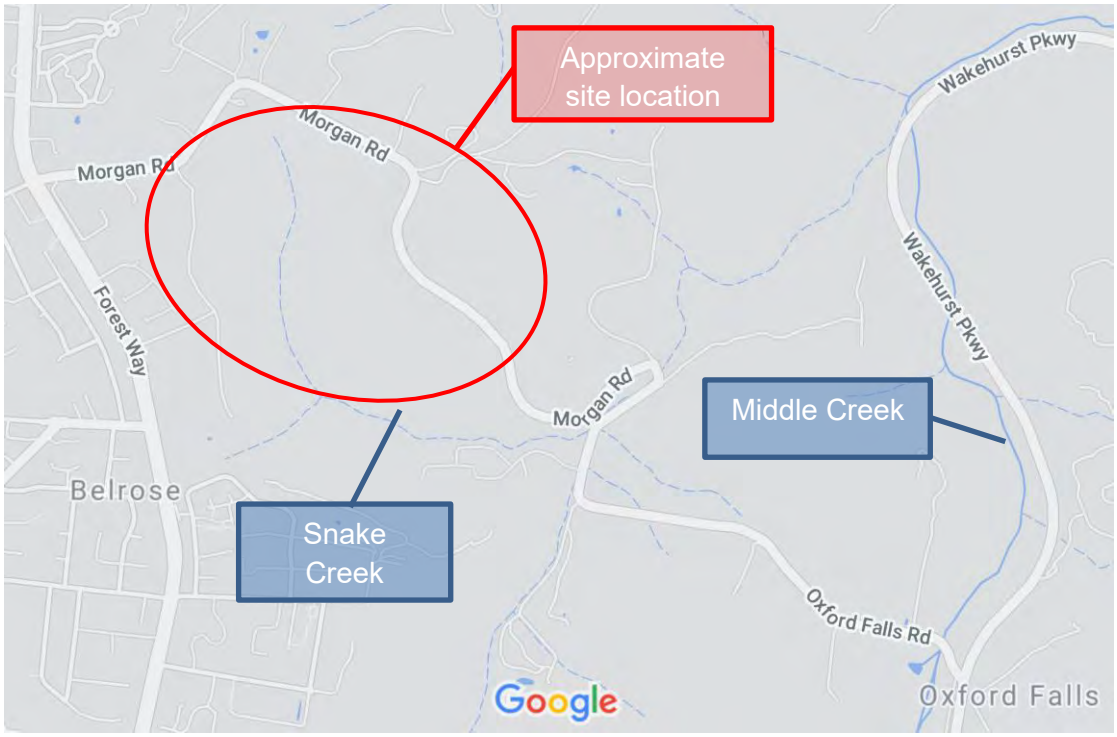

Figure 2 Site location

1.3 Proposed Development

The proposed development extents are shown in Figure 3 below in the context of Morgan Rd and Forest Way.

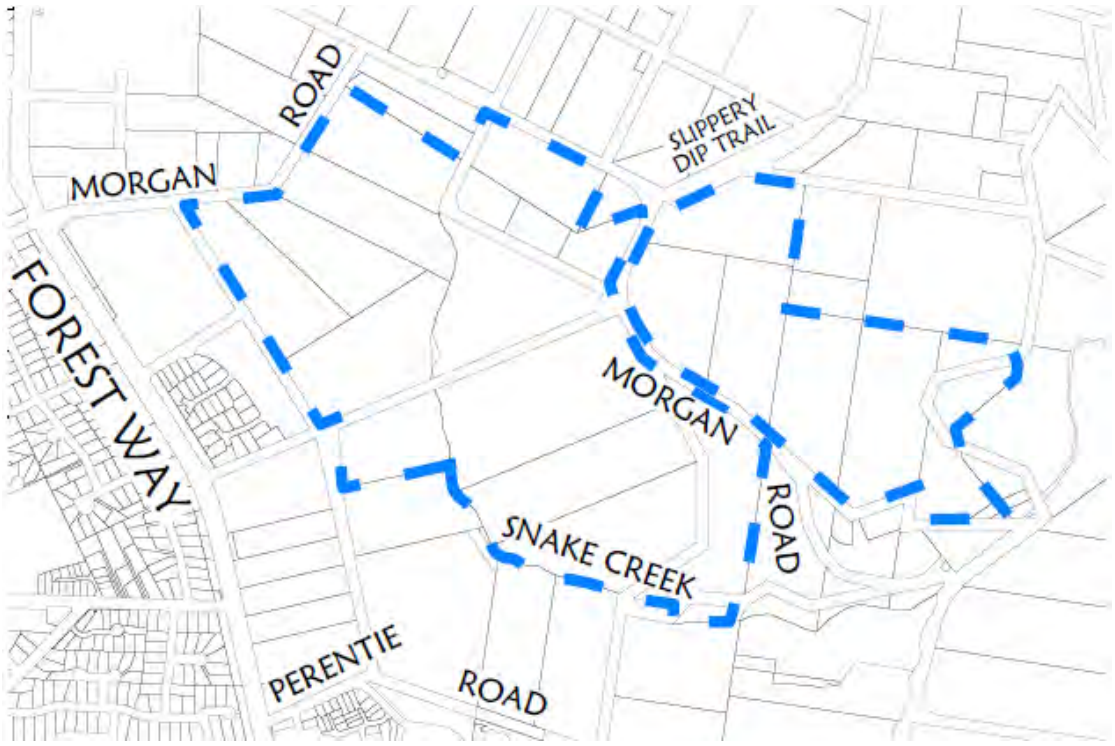

Figure 3 Proposed Subdivision Extent

The draft structure plan of this area is shown in Figure 4. The pink shaded areas denote potential residential areas, and the green shaded areas represent various reserved areas for conservation, bushfire management, parklands, riparian corridor, and stormwater treatment.

Figure 4 Draft Structure Plan by Cox

1.4 Objective

The purpose of this report is to:

- Review existing Northern Beaches Council (Council) flood modelling data and planning requirements;
- Identify flood behaviour for the proposed development for the specified 5%, 1%, 0.5%, 0.2% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events;
- Undertake a Flood Impact and Risk Assessment for the proposed draft layout plan in accordance with the Department of Planning and Environment (DoPE) Local Environment Plan Making Guidelines;

1.5 Scope of Work

This report addresses the flood impact and risk assessment requirements for the Morgan Road, Belrose site. It serves to facilitate the enhancement and conservation of biodiversity and ecological health within the existing riparian corridors and provide an integrated natural resource for the community.

The scope as understood by CED is;

- Adopt the hydrologic XP-RAFTS model from the previous *Stormwater Management Plan* prepared by CED, with amendments to the catchment setup and parameters where appropriate
- Undertake hydrologic and hydraulic assessment of the site as an integrated approach to flood risk and water cycle management;
- Undertake preliminary concept earthworks design grading to inform the post-developed flood assessment;
- Develop a two-dimensional TUFLOW hydraulic flood model for the site and assess the above-mentioned storm events under both pre- and post-development conditions;
- Assess different development scenarios within the hydraulic model to determine the potential impact of the development on the flood regime and the impacts of flooding on the development, through an iterative process;
- Prepare preliminary flood maps for the pre- and post-development conditions;
- Prepare a Flood Impact and Risk Assessment report to support the rezoning for the Precinct, detailing the investigations, findings, calculations, and design details.

It is noted that this is a high-level report undertaken primarily to assess the feasibility of the proposed masterplan layout and Planning Proposal. It is acknowledged that further detailing and refinement of the various flood, water quantity and quality management elements proposed for the area would be necessary at the Development Application stage, and as part of the design process.

1.6 NSW Agency Comments

Revision B of this report and the other associated documentation was submitted for the Patyegarang Planning Proposal, Morgan Road, Belrose (PP-2022-3802, dated 22 December 2022) which has previously been reviewed by the Biodiversity, Conservation and Science Group (BCS), a department sitting within the Environment and Heritage group of the NSW Department of Climate Change, Energy, the Environment and Water. On 21 November 2023, BCS provided flooding and stormwater related commentary on the Planning Proposal, which was then reviewed by Colliers Engineering & Design and a response to the key issues was provided on 16 January 2024. BCS has then reviewed this response and provided a detailed advice letter on 3 April 2024. CED have taken this advice into consideration and undergone updated hydrologic and hydraulic modelling in response as documented in Revision C of this report. CED's written response to BCS' advice has also been provided in Section 8.

2 Background

2.1 Study Area

2.1.1 Topography

The site is located in a relatively steep and elevated area, with slope gradients reaching upwards of 35%, with rock cliffs and ledges scattered throughout. There are a number of ridge lines separating the site into sub-catchments, however overall the entire site falls to Snake Creek which runs in a north to southeast direction through the site. The upper boundary of the site is lined by Morgan Road, which also functions as a ridge line that runs through the site. As the site is high in elevation, there is expected to be no oceanic influences on flood behaviour.

2.1.2 Land Use

The existing area of Belrose which encompasses the site is largely undeveloped and is not currently zoned for any purposes. The site is largely vacant, with a number of rural residential properties adjacent. The land west of the site adjacent to Forest Road contains the urban areas of Belrose and retirement villages.

2.1.3 Waterways

The site encompasses the headwaters of Snake Creek that drains into Middle Creek and Narrabeen Lagoon. There are stormwater culverts under Morgan Rd that direct upstream urban runoff into Snake Creek at the headwaters. The higher reaches of Snake Creek within the proposed development area are deeply incised in a sandstone terrain as shown in Plates 1 and 2.

Plate 1: General view of Snake Creek

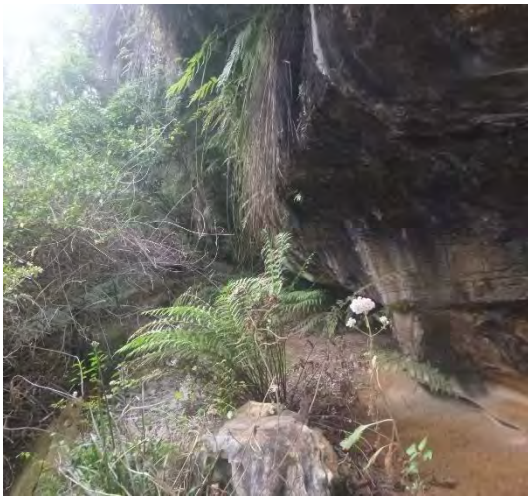

Plate 2: Example of escarpment profile

The creek is characterised as a seasonal stream, with intermittent creek flows throughout the year. The site geology and soil profile is conducive to a stable creek. Baseflow for an extended period of time after a rain event.

The creek bed is very stable, being predominantly bedrock. An example is shown in Plate 3 below.

Plate 3: Exposed bedrock

The *Warringah Creek Management Study* (2004) classifies Snake Creek and Oxford Creek as Class B acknowledging some degradation in the upper reaches.

Council uses the Strahler System of Stream Order (1957) in their *Policy for Protection of Waterways and Riparian Land (PL 740)* to classify waterways and riparian corridor widths.

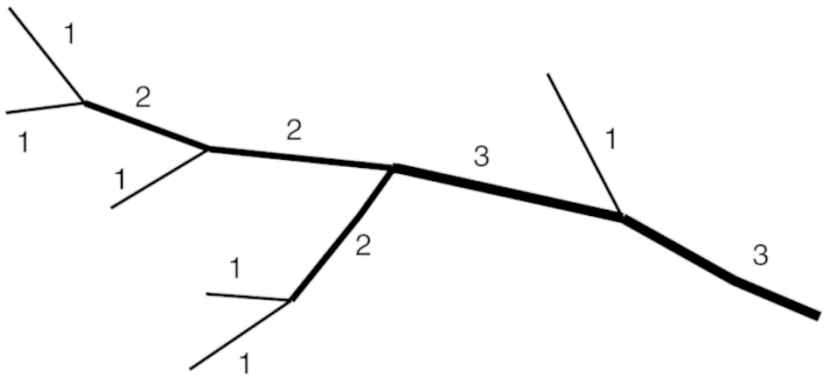

Figure 5 Strahler Stream Order System (extracted from Protection of Waterways and Riparian Land)

Figure 6 shows the extent of 1st order and 2nd order streams within the site extent. Most of the development is adjacent to 1st order with the south-east extremity being 2nd order.

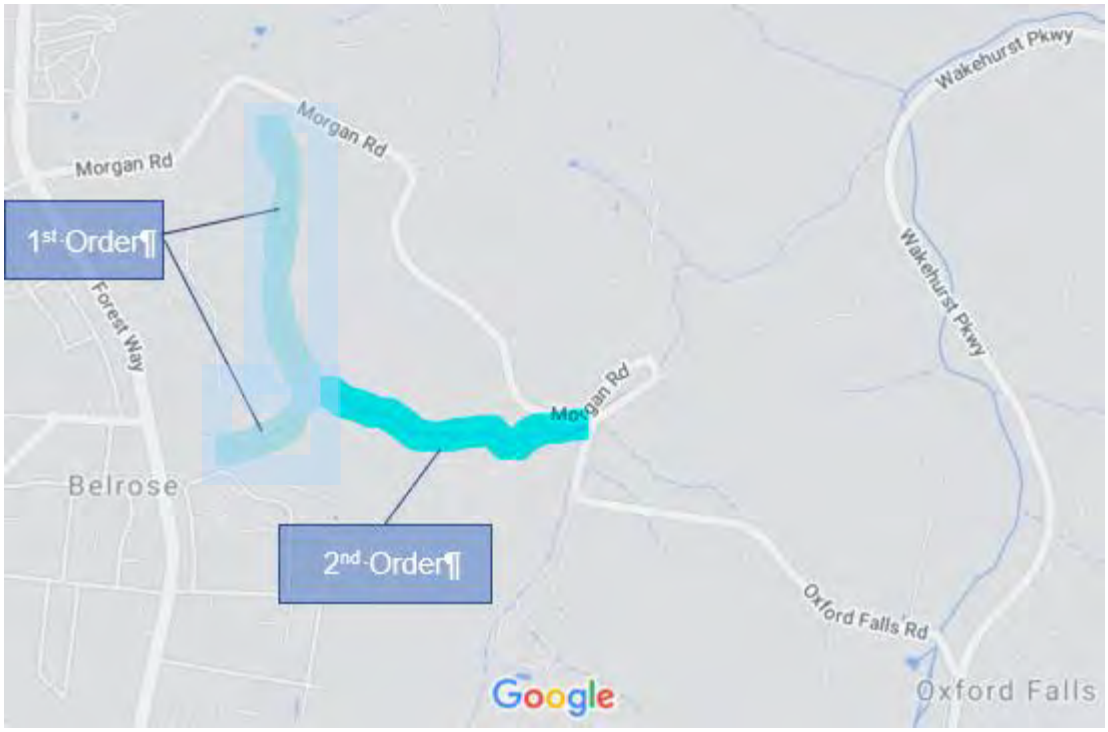

Figure 6 Stream Order definition according to Strahler System

2.1.4 Catchments

The site is located near the upper reaches of Snake Creek and as such the catchments draining through the site are not relatively small in scale. The full site itself encompasses an area of approximately 72.9 hectares, with the proposed total developable land in this area comprising of 32.2 hectares. There are external catchments draining through the site and into Snake Creek largely from the north and west of the site. The general external catchment map is shown in Figure 7 below.

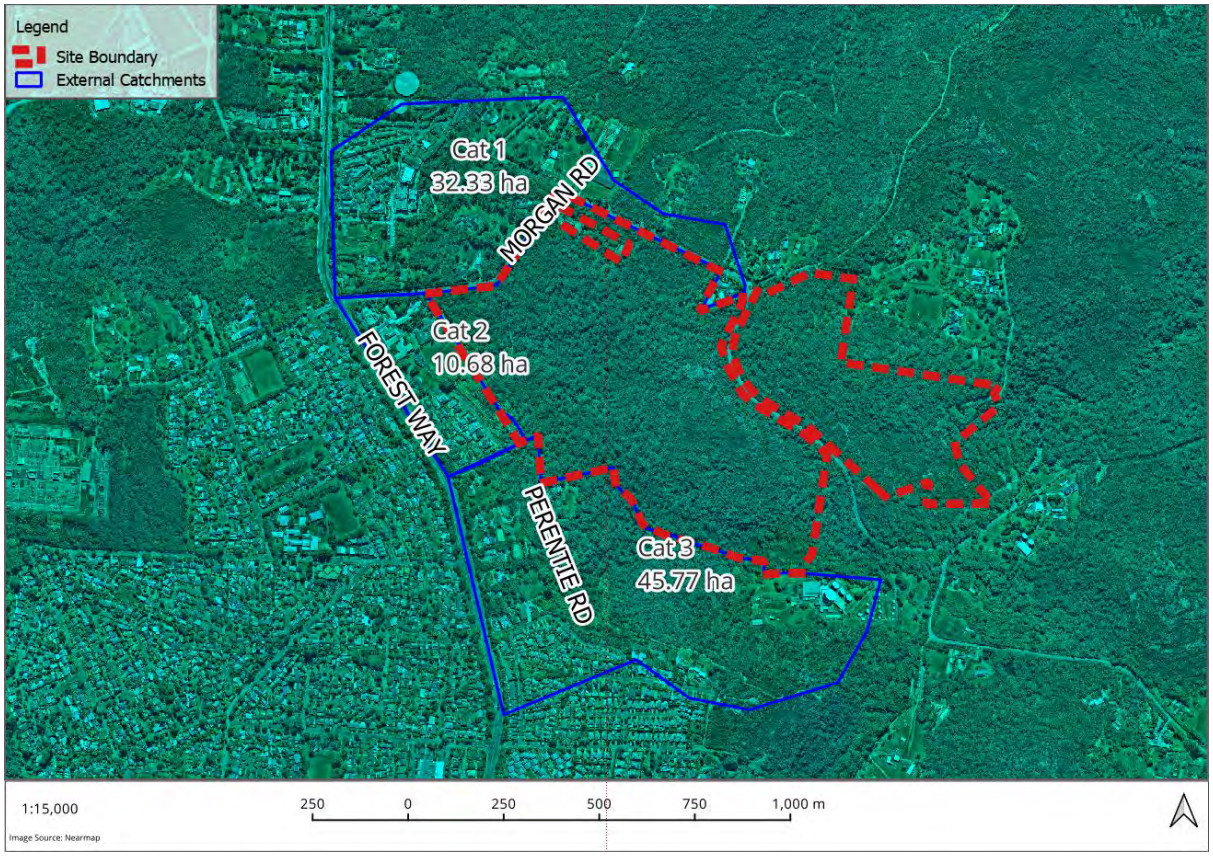

Figure 7 General catchment map

2.1.5 Soils

The precinct is mapped by various soil landscapes, including Gymea, Oxford Falls, Hawkesbury and Lambert. The site is underlain by the Hawkesbury Sandstone formation of the Wianamatta group. The Hawkesbury sandstone formation typically comprises of course-grained quartz sandstone with minor shale and laminate lenses. These are overlain by podzolic soils with shallow to moderately deep siliceous sands along drainage lines.

The precinct is considered to have a high susceptibility to erosion due to the characteristics of the colluvial and erosional soil-landscape combine with the high rainfall intensity resulting in soil loss conditions. Soil depths will vary depending on the bedrock, with typical depths of 0.5m. It is expected that gullies will have a greater depth of soil cover up to 2m. It is expected that the hydraulic conductivity of the soil would vary from 60-120 mm/hr due to the variety of soil textures.

2.2 Known Flood Behaviour

The site is situated near the top of a catchment that ultimately discharges to Narrabeen Lagoon, with the only well-defined overland flow path being Snake Creek. The site is primarily affected by overland flows from the rainfall runoff across the site area and upstream catchments, as well as mainstream flooding from Snake Creek.

Due to the steep topography, the site is largely unaffected by mainstream flooding, as the mainstream flood waters are concentrated within Snake Creek with a flood level that is much lower than the majority of the site. Also owing to the site topography and the absence of any drainage structures and other hydrologic/hydraulic controls which could have an effect on

flooding, the flood behaviour through the site is characterised by shallow but high velocity flows, apart from Snake Creek itself in which the flood behaviour would consist of deep and high velocity flows. There are no known existing flood problems on the site. Additionally, in consideration of the catchment properties, specifically the high elevation conditions as well as the bushland environment, there is limited available information on the history of overland flooding in the study area. There is also no flow gauging or monitoring for the catchment that we are aware of.

The closest tributary is Oxford Creek which joins up with Snake Creek roughly at the eastern boundary of the site but is located approximately 600 m downstream of the proposed development area and is also approximately 55 m lower in elevation that the proposed development. Therefore, the tributary is not expected to have an impact on the flood behaviour within the site. Further downstream there is a road crossing over the creek where Oxford Falls Road intersects with Morgan Road. This low-lying bridge crossing was known to be frequently flood affected. However, as of March 2024 according to Northern Beaches Council's information, the bridge has now been reconstructed as a two-lane vehicle bridge with designated pedestrian access to improve access and safety in the area. The community engagement report for the bridge upgrade indicates that the new bridge has been designed to be above the 1% AEP flood level, which would improve safety and access to Morgan Road and the site from this location.

2.3 Emergency Management

The regional emergency response procedures are generally outlined in Emergency Management Plans (EMPLANs) and associated sub-plans. The NSW State EMPLAN outlines the general approach to emergency management and the roles and responsibilities of the respective agencies, with the NSW State Emergency Services (SES) being in charge of flood emergencies.

The Northern Beaches Local Emergency Management Plan (EMPLAN) was authorised in March 2021, followed by the Northern Beaches Flood Emergency Sub Plan which was authorised in April 2021 as a sub plan to the Northern Beaches Local EMPLAN. These plans detail general strategies for flood emergency management, as well as identify types of flooding risks and areas that are highly susceptible to flooding which would require emergency response procedures. Overall, the Morgan Road, Belrose site is not deemed as an area which is at risk of either flash flooding or lagoon flooding.

There are no evacuation plans prepared for the area, however it is expected that in the event that evacuation is required (likely for a medical emergency), evacuation should be determined by access to the nearest medical emergency centre which would be Northern Beaches Hospital located approximately 3 km south of the site. The major road through this area, Forest Way, is assumed to be the regional evacuation route for the suburb of Belrose.

3 Review of Available Information

3.1 Structure Plan/Masterplan

The plan prepared by COX Architecture as shown in **Appendix A** shows the proposed layout of the development, including roads, superlots and parks/reserves conservation areas. This plan encompasses the recommendations for:

- Bushfire management
- Flora and fauna
- Infrastructure requirements to service the development
- Conservation areas, including the riparian zone

This plan has been relied upon for the development of the stormwater management Plan as detailed in the previous *Stormwater Management Plan* (2022) report by CED.

3.2 Topographic Data

1-metre LiDAR data (2020) has been sourced from ELVIS for the purposes of this assessment. Although a full detailed survey of the site has been commissioned, the data was not yet available for this study.

3.3 Historic Flood Data

A number of previous studies have been undertaken in the vicinity of the site, including the following:

- Frenchs Creek Flood Study (DHI Water & Environment, 2010)
- Narrabeen Lagoon Flood Study (BMT WBM, 2013)
- Narrabeen Lagoon Floodplain Risk Management Study (Cardno, 2019)
- Pittwater Overland Flow Flood Study (Cardno, 2013)

Although Snake Creek and Oxford Creek which pass through the site are tributaries of Middle Creek which discharges to Narrabeen Lagoon, the extents of the flood studies do not cover the site. However, the Narrabeen Lagoon Floodplain Risk Management Study (Cardno, 2019) has been used to inform the design parameters for the hydrologic and hydraulic model where possible.

4 Flood Related Requirements

4.1 Relevant Development Controls and Guidelines

Available guidelines reviewed and considered or adopted for the study include the following.

4.1.1 Flood Impact and Risk Assessment Flood Risk Management Guide [LU01] (DoPE, 2022)

This guideline prepared by the DoPE provides advice on the scope and scale of a Flood Impact and Risk Assessment (FIRA). It outlines the report structure and output requirements of a typical FIRA, which has been used as the basis for this assessment.

4.1.2 Flood Risk Management Manual (DoPE, 2023)

The primary objective of this manual is to build on the success of FRM in NSW which focuses on the management of the consequences of flooding related to human occupation of the floodplain for urban development, agricultural production and other industries. The manual aims to guide Council's in the strategic management of flood risk to communities across their local government areas. This manual has been used to inform the design decisions and outcomes of this report, and largely supersedes the Floodplain Development Manual 2005.

4.1.3 Flood Hazard [FB03] (DoPE, 2023)

The Flood Hazard guidelines is an addition to the Flood Risk Management Manual and defines flood hazard information and managing flood risk. This guideline has been used in conjunction with the Australian Rainfall and Runoff (2019) information regarding flood hazards to assess the flood hazards for the site and the proposed development.

4.1.4 NSW Floodplain Development Manual (Department of Infrastructure, Planning and Natural Resources, 2005)

This guideline for development in flood affected areas has largely been superceded by the Flood Risk Management Manual (DoPE, 2023), however the objectives and definitions outlined in the guideline have still been considered in this assessment.

4.1.5 Incorporating 2016 Australian Rainfall and Runoff Into Studies [FB04] (DoPE, 2019)

This is a guideline on the use of Australian Rainfall and Runoff (for 2016/2019) within flood studies, and has been used in conjunction with Australian Rainfall and Runoff (2019) to develop the methodologies and parameters for the FIRA.

4.1.6 Warringah Development Control Plan (2011)

The overriding objective of the DCP is to create and maintain a high level of safety and environmental quality throughout Warringah. Development should result in an increased level of local amenity and environmental sustainability.

The DCP currently applies planning controls to land uses mapped in the Warringah LEP 2011. Section E11 outlines the controls for flood prone land. Although the site is not identified as being affected by flooding on Council's Flood Risk Precinct Map (refer to Figure 8), and hence

the development matrix does not have any controls that apply to the site, the flood precinct map is based on Council's information from publicly available flood studies and floodplain risk management plans of which there may be none available for the site. As the DCP controls are the best prescriptive controls available to CED, the planning controls in Section E11 of the DCP have been considered for the purposes of this assessment.

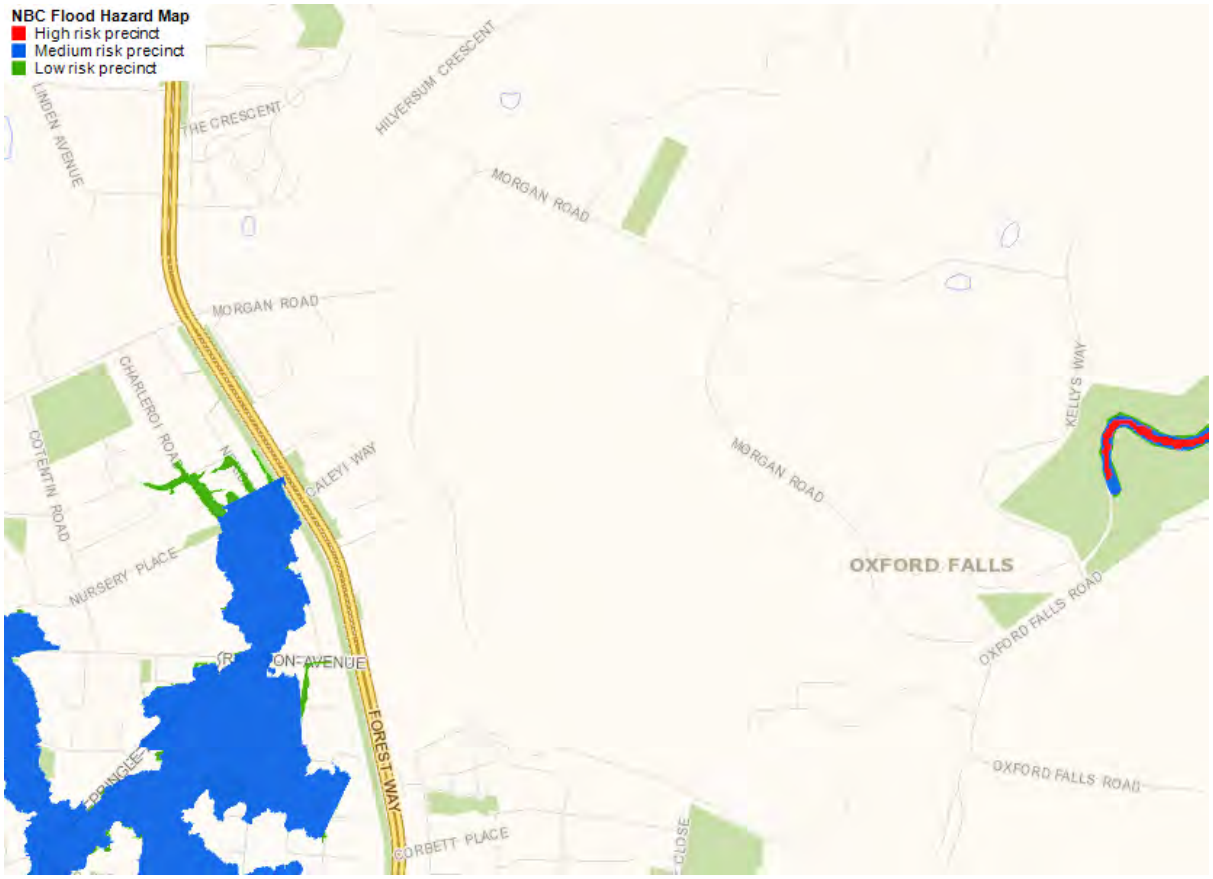

Figure 8 Extract from Northern Beaches Council flood risk precinct online map

4.1.7 Warringah Local Environmental Plan (2011)

The objective of the LEP is to make planning provisions for land in the Warringah area to create and maintain a high level of safety and environmental quality throughout Warringah. Section 5.21 of the LEP specifically relates to flood planning, and its general objectives aim to:

1. Minimise the flood risk to life and property associated with the use of land,
2. Allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change
3. Avoid adverse or cumulative impacts on flood behaviour and the environment,
4. Enable the safe occupation and efficient evacuation of people in the event of a flood.

5 Hydrology Assessment

This assessment undertook hydrologic modelling of the study area using XP-RAFTS (Version 2018.1.1) for the study area. XP-RAFTS is a widely used hydrological modelling tool for predicting the stormwater runoff for large catchments in pre- and post-development conditions. Modelling was undertaken using the Australian Rainfall & Runoff (2019) ensemble storm methodology for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF storm events under existing and developed conditions.

The adopted XP-RAFTS parameters and details have been refined and updated based on those provided in the *Stormwater Management Plan* (2024) by CED.

1. Sub-catchment delineations were adopted from the XP-RAFTS hydrologic model based on topographical features in the LiDAR (2020) data.
2. Intensity Frequency Duration (IFD) data and rainfall temporal patterns were based on the Bureau of Meteorology (BoM, 2022) data and the ARR Data Hub (2022).
3. Probable Maximum Precipitation (PMP) intensities and temporal patterns were determined using the BoM (2003) Generalised Short-Duration Method (GSDM).

5.1 Pre-Development Conditions

The XP-RAFTS model was prepared for the pre-development conditions to generate catchment rainfall-runoff hydrographs. The 'pre-development' scenario is defined as the proposed development site being in an undeveloped state. The subject site has been divided into six pre-development sub-catchments based on topographical features and representative overland flow paths with existing catchment parameters applied. (Refer to **Appendix B** for the full detail of XP-RAFTS catchment parameters).

The six site catchments were further divided into five additional sub-catchments representing the private roof, driveway, pervious and public open space, road areas to match post development catchment delineation, while adopting pre-development catchment parameters such as Manning's 'n' roughness and impervious percentage.

The upstream external catchments have been divided into six sub-catchments. The fraction imperviousness of the external catchments has been estimated by measuring existing developed areas from recent Nearmaps aerial imagery (April 2021). For catchments without any developed areas, particularly over the site, a fraction imperviousness of 5% has been adopted. The sub-catchment delineation for the site and its upstream catchments has been provided in Figure 9 below, with the XP-RAFTS layout for the pre-development scenario shown in Figure 10.

A review of the ARR data hub was undertaken to estimate the site losses. Existing initial loss values within the current ARR system have been found to have a significant bias toward default values. Considering this, a hierarchy approach to loss and pre-burst estimation is used. In this case, the more preferred options of using average calibration losses from other studies in the catchment or area if available.

A review of the existing Narrabeen Lagoon Floodplain Risk Management Study (Cardno, 2019) revealed that in their XP-RAFTS hydrology model they had adopted the rainfall loss values for impervious and pervious surfaces as listed in Table 1 below. As the site falls within the Narrabeen Lagoon catchment, the same rainfall loss values have been adopted within our XP-RAFTS model for all modelled scenarios and events. These values were also compared to the probability neutral burst initial loss values established in the WMAWater 2019 study and available through the ARR datahub within the area and for sites with similar geomorphic conditions. The review estimated the initial loss was approximately 5-7 mm/hr and that the continuing loss was 0.1-0.5 mm/hr, which was similar to the values adopted in the Narrabeen Lagoon Floodplain Risk Management Study.

Table 1 Rainfall Loss Values for Surface Types

Surface Type	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious	10	2.5
Impervious	2	0

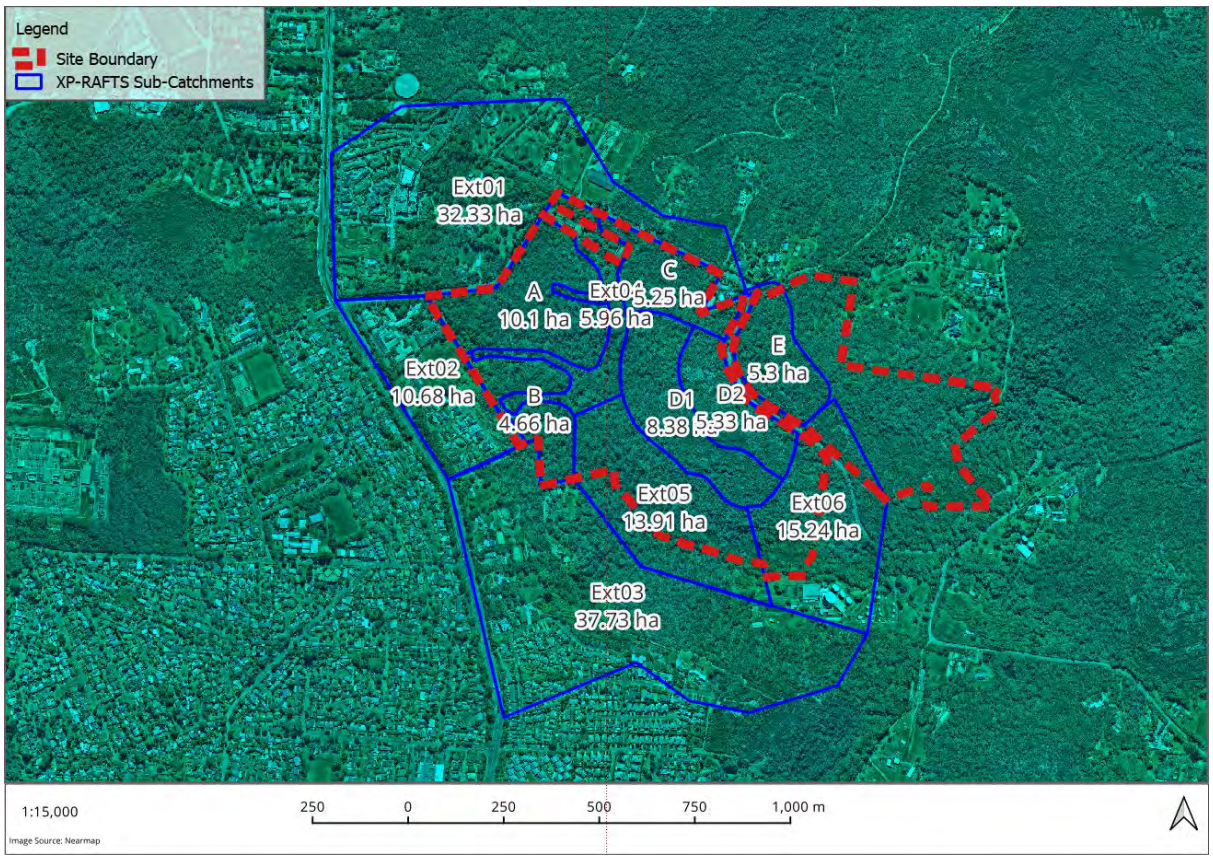

Figure 9 XP- RAFTS Catchment Map

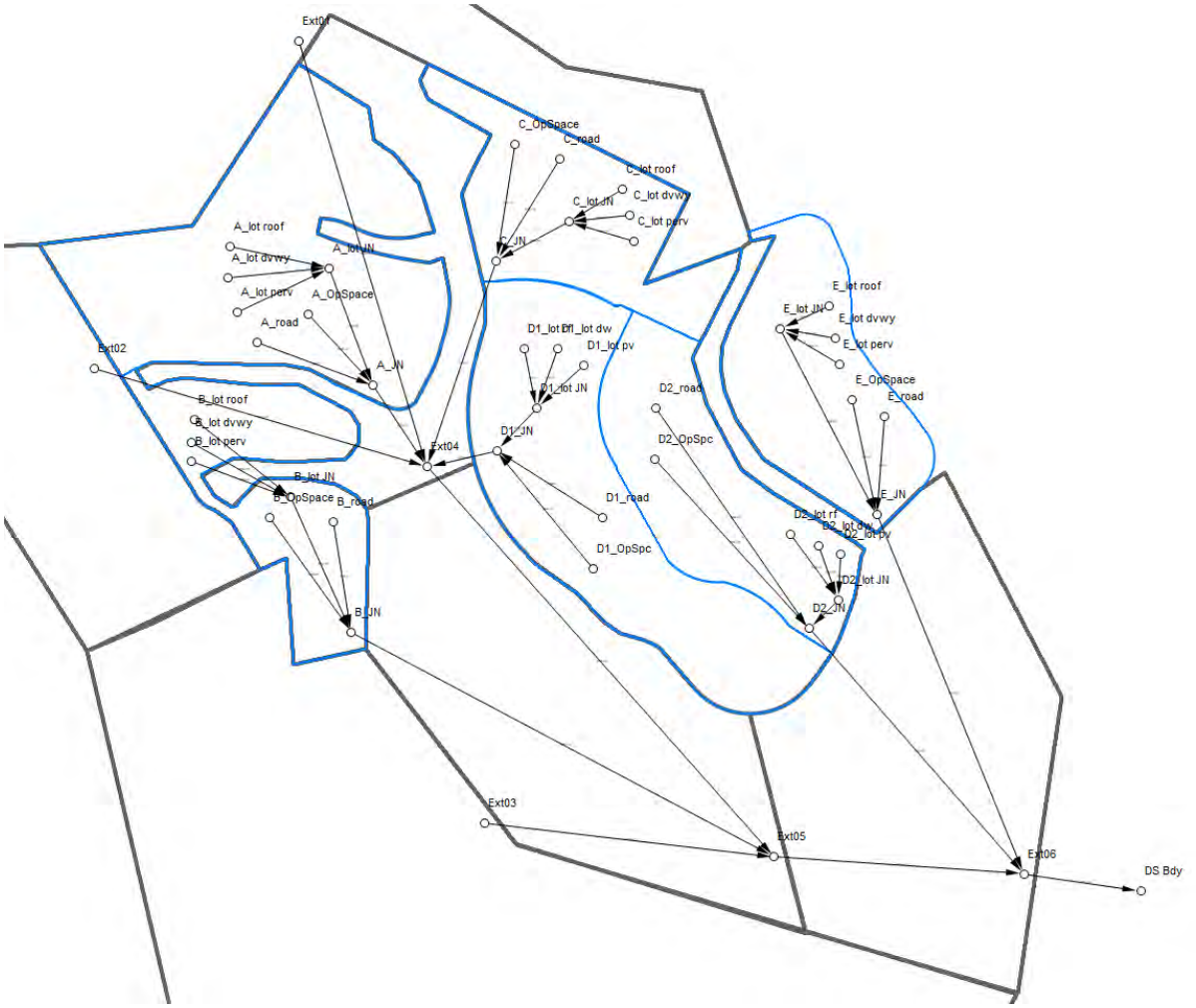

Figure 10 XP-RAFTS Pre-Development Scenario Model Layout

5.2 Post-Development Mitigated Conditions

The 'post-development mitigated' scenario is defined as the subject site in a developed state as per the Draft Structure Plan by COX Architecture (see **Appendix A**), with stormwater quantity and quality infrastructure operational. The developed state of the future development is represented by:

1. Increasing the impervious area of the internal site catchments. The adopted aggregate impervious % for each of the site sub-catchments is provided in Table 2.
2. Increasing the Manning's 'n' roughness of the internal site catchments
3. Reducing the vectored slope of the internal site catchments in anticipation of benching construction for the lots and roads.

Refer to **Appendix B** for full details of the XP-RAFTS catchment parameters.

Table 2 XP-RAFTS Sub-Catchment Overall Imperviousness

Catchment	Impervious %
A	61.3
B	60.0
C	60.6
D1	60.7
D2	20.7
E	62.4
Ext01	26.0
Ext02	57.0
Ext03	35.0
Ext04	5.0
Ext05	5.0
Ext06	15.0

The XP-RAFTS model was produced for the post-development scenario to generate catchment rainfall-runoff hydrographs. As the catchment delineation between the pre-development and post-development case remains consistent, the overall model layout uses the pre-development layout (as per Figure 10) as a base. The layout has then been modified for the post-development case to include the proposed stormwater detention within the site in the form of rainwater tanks on the lots and underground storage within the roads. The XP-RAFTS layout for the post-development scenario is shown in Figure 11.

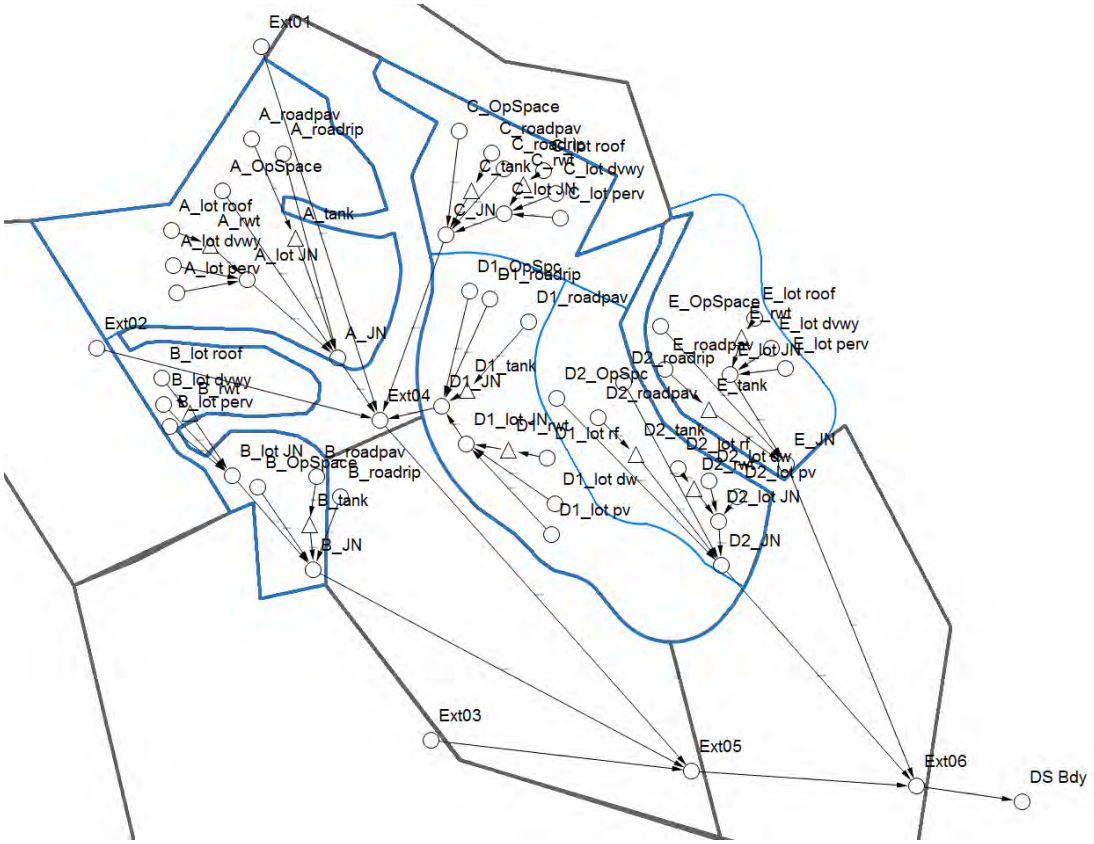

Figure 11 XP-RAFTS Post-Development Mitigated Scenario Model Layout

The proposed stormwater detention features, which comprise of on-lot rainwater tanks and sub-surface stormwater detention underneath the roads, have been modelled within each of the six proposed sub-catchment areas as combined detention using the Basin tool in XP-RAFTS. The parameters adopted for each of the combined stormwater detention features are provided in Table 3 below. It is noted that the infiltration systems proposed for the roads adjacent to riparian corridors has been excluded from modelling as these have been designed to attenuate the flows from rare flood events and thus are likely to have a negligible effect on reducing the peak flows from the catchments in the modelled events. This also results in a more conservative modelling outcome.

The proposed stormwater features are described in detail in CED' *Stormwater Management Plan* (2024) report. Two 5 kL rainwater tanks are proposed for each lot, one of which is for stormwater re-use. Half of this re-use tank has been assigned towards dedicated on-site stormwater detention (OSD) in addition to the entirety of the second tank. The road sub-surface storage has been nominated as 14 kL for every 1000 m^2 of road surface area, and this has been aggregated for the road surface area within each sub-catchment.

Table 3 XP-RAFTS Stormwater Detention Parameters

Catchment	Total Rainwater Tank Volume (m^3)	Rainwater Tank Outlet Diameter (mm/tank)	Total Sub-Surface Storage Volume (m^3)	Sub-Surface Storage Outlet Diameter* (mm)
A	1056	40	406	155
B	255	70	124	160
C	705	40	149	165
D1	540	70	271	160
D2	68	75	28	160
E	555	55	208	155

* Nominated outlet size for a representative 14 kL sub-surface storage per 1000 m^2 of road catchment

5.3 *Sensitivity Model (Post-Development Unmitigated Conditions)*

As per BCS' comments in their advice letter dated 23 May 2024, an additional hydrological scenario has been modelled of the site in its post-development conditions without any stormwater detention in place. This model will then be used to assess the isolated impacts of the proposed stormwater detention features. The overall model layout and catchment parameters remains the same as the post-development scenario as per Figure 11, but with the proposed stormwater detention features removed. The XP-RAFTS layout for the 'post-development unmitigated' scenario is shown in Figure 12.

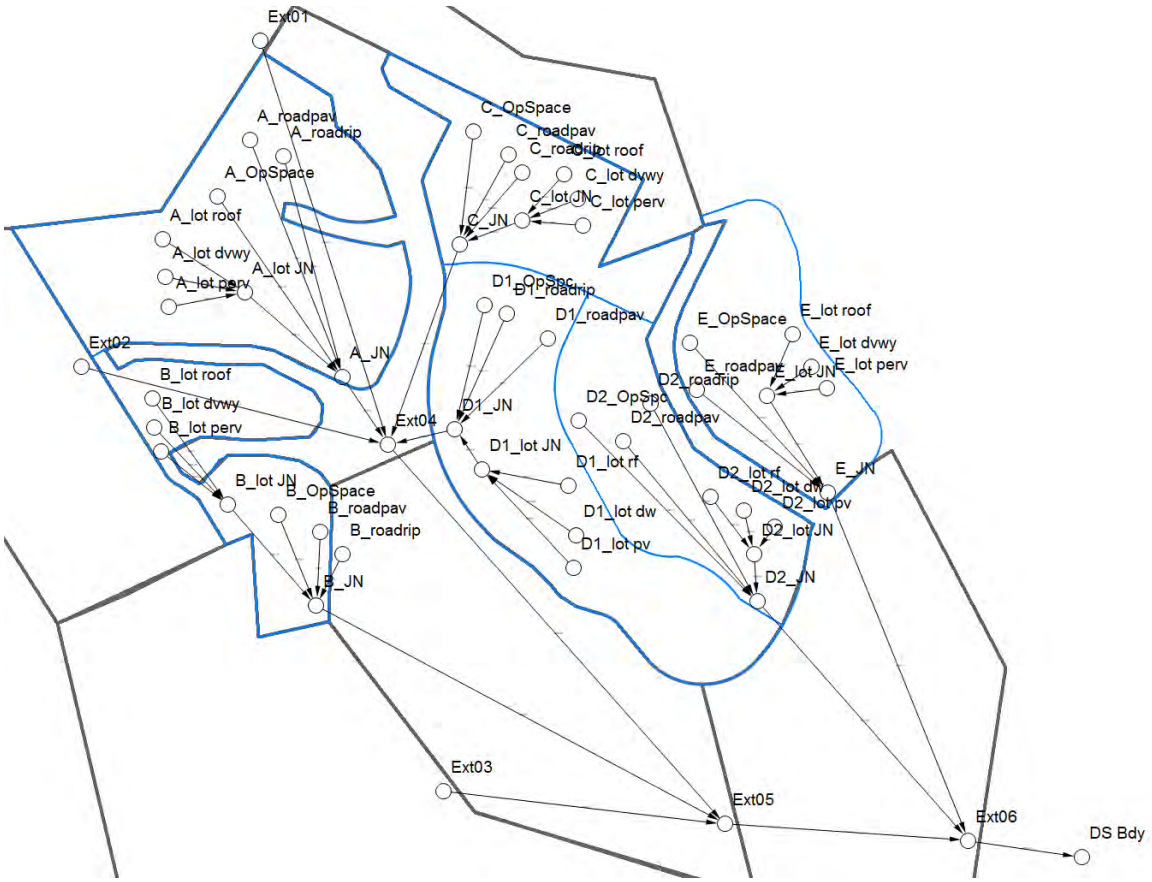

Figure 12 XP-RAFTS Post-Development Unmitigated Scenario Model Layout

5.4 *Hydrology Results*

The XP-RAFTS hydrology model was run for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design storm events for storm durations ranging from 15 minutes to 4 hours in order to determine the critical storm duration and median temporal patterns at the site downstream boundary. The critical storm duration was found to be 25 minutes for the 1% AEP, 0.5% AEP and 0.2% AEP events and 1 hour for the 5% AEP event. For the PMF event, the critical storm was 30 minutes based on the maximum for all durations run. For all other events for which the ensemble of storms was run, the median storm was selected as these generally resulted in more conservative peak flows than the mean storms. These results are shown in the ensemble statistics analysis from XP-RAFTS in Figure 13 below.

Ensemble Statistics Utility

Node: DS Bdy Result Type: Max Flow Total (m3 / s)

Ensemble Name	AEP	Mean	Mean Storm	Median	Median Storm
ECS_5pct_15min	5%	27.17900	ECS_5pct_15min_10	27.37250	ECS_5pct_15min_10
ECS_5pct_25min	5%	31.54390	ECS_5pct_25min_4	30.38600	ECS_5pct_25min_8
ECS_5pct_1hr	5%	31.76510	ECS_5pct_1hr_7	32.64750	ECS_5pct_1hr_3
ECS_5pct_2hr	5%	25.37080	ECS_5pct_2hr_4	25.88100	ECS_5pct_2hr_3
ECS_1pct_15min	1%	42.60270	ECS_1pct_15min_5	42.95950	ECS_1pct_15min_1
ECS_1pct_25min	1%	48.25040	ECS_1pct_25min_6	48.85600	ECS_1pct_25min_9
ECS_1pct_1hr	1%	43.66010	ECS_1pct_1hr_6	43.52100	ECS_1pct_1hr_5
ECS_1pct_2hr	1%	37.33950	ECS_1pct_2hr_8	39.03900	ECS_1pct_2hr_5
ECS_1in200_15min	1 in 200	47.20160	ECS_1in200_15min_5	47.72850	ECS_1in200_15min_1
ECS_1in200_25min	1 in 200	53.12890	ECS_1in200_25min_6	53.56850	ECS_1in200_25min_9
ECS_1in200_1hr	1 in 200	47.87180	ECS_1in200_1hr_5	47.93550	ECS_1in200_1hr_5
ECS_1in200_2hr	1 in 200	40.63370	ECS_1in200_2hr_8	42.58100	ECS_1in200_2hr_2
ECS_1in500_15min	1 in 500	55.81510	ECS_1in500_15min_5	56.26850	ECS_1in500_15min_1
ECS_1in500_25min	1 in 500	62.06930	ECS_1in500_25min_9	62.17850	ECS_1in500_25min_9
ECS_1in500_1hr	1 in 500	55.15550	ECS_1in500_1hr_5	55.55650	ECS_1in500_1hr_5
ECS_1in500_2hr	1 in 500	46.82280	ECS_1in500_2hr_8	48.77050	ECS_1in500_2hr_2

Ensemble Statistics Utility

Node: DS Bdy Result Type: Max Flow Total (m3 / s)

Ensemble Name	AEP	Mean	Mean Storm	Median	Median Storm	Min	Min Storm	Max	Max Storm
0	0	188.59900	PMP_1hr	203.94300	PMP_1hr	121.49600	PMP_4hr	226.94200	PMP_30m

Figure 13 XP-RAFTS Ensemble Statistics at Site Downstream Boundary

The peak flows of each sub-catchment for the site critical storm duration and temporal pattern are reported in Table 4 below for the three hydrological scenarios modelled: pre-development, post-development mitigated, and post-development unmitigated conditions.

Table 4 Peak Flows at Outlet of Each Sub-Catchment for Pre & Post Development

5% AEP	PRE-DEVELOPMENT	POST DEVELOPMENT (UNMITIGATED)	POST DEVELOPMENT (MITIGATED)
	Peak Flow (m^3/s)	Peak Flow (m^3/s)	Peak Flow (m^3/s)
Area A	2.68	3.02	2.52
Area B	1.25	1.40	1.30
Area C	1.36	1.51	1.20
Area D1	2.23	2.49	2.28
Area D2	1.40	1.44	1.42
Area E	1.40	1.57	1.35

1% AEP	PRE-DEVELOPMENT	POST DEVELOPMENT (UNMITIGATED)	POST DEVELOPMENT (MITIGATED)
	Peak Flow (m^3/s)	Peak Flow (m^3/s)	Peak Flow (m^3/s)
Area A	4.84	6.23	4.31
Area B	2.43	2.93	2.40
Area C	2.62	3.14	2.02
Area D1	4.13	5.15	4.01
Area D2	2.54	2.65	2.52
Area E	2.68	3.25	2.20

0.5% AEP	PRE-DEVELOPMENT	POST DEVELOPMENT (UNMITIGATED)	POST DEVELOPMENT (MITIGATED)
	Peak Flow (m^3/s)	Peak Flow (m^3/s)	Peak Flow (m^3/s)
Area A	5.28	6.74	4.65
Area B	2.65	3.16	2.58
Area C	2.85	3.40	2.18
Area D1	4.50	5.57	4.31
Area D2	2.77	2.89	2.75
Area E	2.92	3.52	2.43

0.2% AEP	PRE-DEVELOPMENT	POST DEVELOPMENT (UNMITIGATED)	POST DEVELOPMENT (MITIGATED)
	Peak Flow (m^3/s)	Peak Flow (m^3/s)	Peak Flow (m^3/s)
Area A	6.09	7.67	6.58
Area B	3.05	3.60	3.62
Area C	3.28	3.87	3.63

Area D1	5.19	6.34	5.87
Area D2	3.20	3.32	3.34
Area E	3.36	4.00	3.72

PMF	PRE-DEVELOPMENT	POST DEVELOPMENT (UNMITIGATED)	POST DEVELOPMENT (MITIGATED)
	Peak Flow (m^3/s)	Peak Flow (m^3/s)	Peak Flow (m^3/s)
Area A	18.57	19.20	19.09
Area B	8.80	9.13	9.11
Area C	9.57	9.71	9.69
Area D1	15.57	15.90	15.87
Area D2	9.60	9.65	9.67
Area E	9.90	10.04	10.02

The results show that proposed stormwater detention features proposed in the stormwater footprint methodology can manage the peak flows in the post-development scenario to be equal to or less than the peak flows in the pre-development condition in most of the modelled storm events. Although there are some proposed sub-catchment areas which show a slight increase in the post-development mitigated peak flows in the 5% AEP, these increases have largely been offset by reductions in peak flows in the other sub-catchment areas. The increases and reductions are balanced such that overall, there is a negligible increase in peak flow at the site outlet as shown in Section 5.5 below. The storm event was also modelled hydraulically in TUFLOW as per Section 6 to confirm that there are no downstream impacts.

The 0.2% AEP and PMF events are much rarer design events which the proposed stormwater features have not been designed to attenuate the runoff within each sub-catchment, hence it is expected that there is an increase in peak flows from each sub-catchment due to the development. However, as shown in Section 5.5 below, the there is no increase in the peak flow at the site outlet in the 0.2% AEP or PMF events, likely due to the timings of the runoff being affected by the proposed development, with catchment runoff being released into the waterways earlier than the external catchments.

5.5 Downstream Boundary Flow Comparison

The 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF storm durations were modelled for the downstream boundary for the existing and developed conditions. The peak flows and hydrographs downstream of the site for each storm event are provided in Table 5 below.

Table 5 Downstream Boundary Flow Comparison

AEP	PRE DEVELOPMENT		POST DEVELOPMENT	
	Peak Flow (m^3/s)	Critical Duration – Temporal Pattern	Peak Flow (m^3/s)	Critical Duration (Temporal Pattern)
5%	32.7	1hr - #3	32.8	1hr - #3
1%	48.9	25min - #9	48.7	25min - #9
0.5%	53.6	25min - #9	53.4	25min - #9
0.2%	62.2	25min - #9	62.0	25min - #9
PMF	226.9	30min	225.3	30min

Overall, the results indicate that that the stormwater management system proposed is effective in attenuating flow peaks and volumes to pre-development levels. Mild variations in the 5% AEP event was found, but this is due to the limitations of the modelling for the planning proposal. It is expected that in the detailed design stage, these stormwater features can be designed with the multi-stage discharge outlets for the proposed stormwater detention features in order to fully cater for both minor and major storm events. The stormwater detention features have currently been designed such that the 1% AEP to PMF events have been successfully attenuated. In the detailed design stage, the modelling will be further refined to design the system and its outlets more conservatively for the minor storms.

5.6 Hydrologic Validation

The results of the hydrologic validation are outlined in Table 6 below, with the results of the Regional Flood Frequency Estimation (FRRE) analysis in Figure 14 and Figure 15. It is noted that the calculation methods below are purely for comparison purposes as a sanity check to determine if the calculated peak flows are within the same range of values for different methodologies.

It is important to consider the limitations of the RFFE and Rational Method. For example, the RFFE estimates are based on data from the nearest gauged catchments in the region with the nearest one being located relatively far from the site (approximately 23 km). The ARR1987 Rational Method is a calculation of peak flow using the Bransby William/Adam's equation for the time of concentration. It is noted that the estimated time of concentration for the catchment from this method is within the order of one hour, which is greater than the critical duration of the storm derived from the XP-RAFTS model, therefore the Rational Method is expected to produce a lower peak flow than XP-RAFTS.

Taking the limitations of the calculation methods into account, the peak flow estimate from XP-RAFTS is greater than the peak flow calculated from Rational Method as expected, and it also falls within the confidence limits of the RFFE estimate.

Table 6 Hydrological Validation

Validation Location	Calculation Method	Peak Flow (m^3/s)
Snake Creek Outlet from Site Catchment	XP-RAFTS	48.9 (25 minute storm duration)
	RFFE	99.7 5% Confidence Limit =41.3 95% Confidence Limit = 244
	Rational Method	34.32

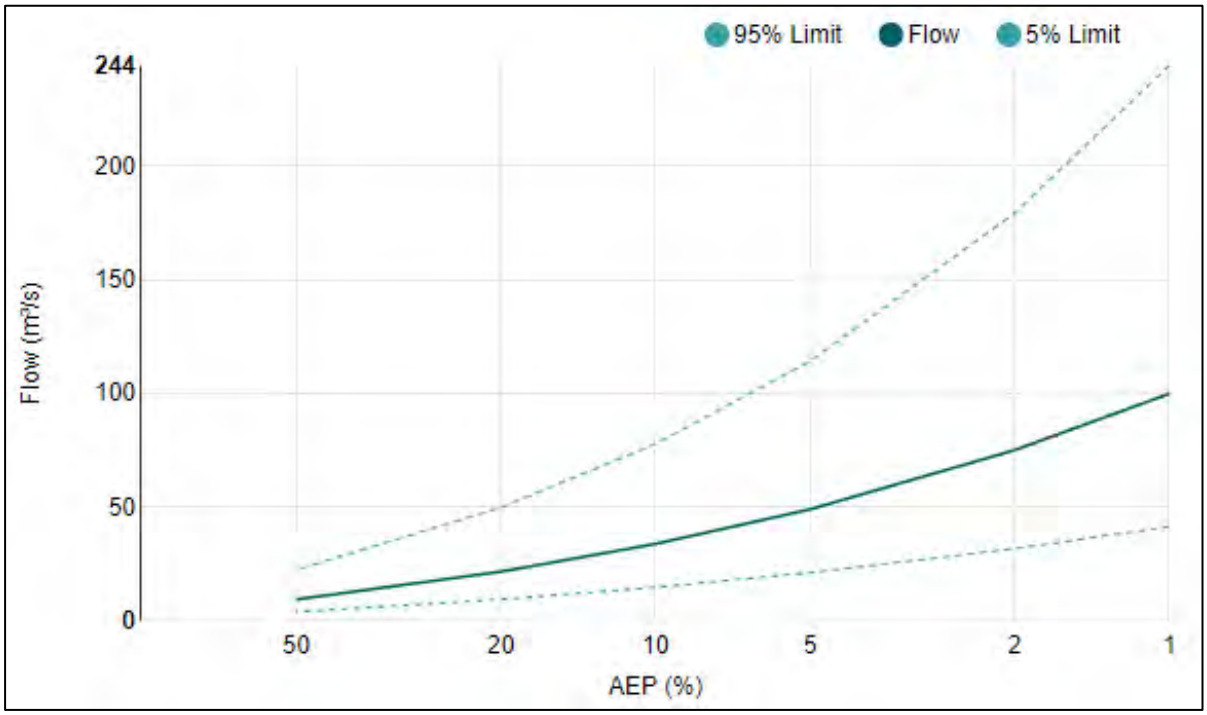

Figure 14 Regional Flood Frequency Estimation Graphical Results with 5% and 95% Confidence Limits

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	9.30	3.85	22.3
20	21.5	9.32	49.7
10	33.7	14.6	77.6
5	48.9	21.1	114
2	74.9	31.6	179
1	99.7	41.3	244

Figure 15 Regional Flood Frequency Estimation Analysis Tabulated Results

6 Hydraulic Assessment

6.1 Model Setup

The flood behaviour of the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design storm events under existing (pre-development) and post-development conditions at the site have been modelled using a two-dimensional TUFLOW hydraulic model. The TUFLOW model extends from Forest Way to just upstream of Oxford Falls Road at the downstream boundary.

The hydraulic modelling was undertaken with user defined inflows from the XP-RAFTS model to assess the existing flows and the potential flood impacts resulting from the proposed development.

Due to the limited availability of existing flow or water level data to calibrate to in the catchment, there was no validation to existing data performed.

A brief model summary highlighting key modelling assumptions and checks for the 1% AEP Post Developed (Mitigated) Scenario have been provided below. The model checks provided in this summary provide confidence in the stability of the model.

- 2D cell size: 2m
- 1D/2D connections: SX Lines
- 1D Timestep: 0.1 sec
- 2D Timestep: 0.25 sec
- Final Cumulative Mass Error (%): 0.00%
- Volume In: 69942m³
- Volume Out: 66520m³
- Negative Depths: 0

6.2 Pre-Development Scenarios

The TUFLOW modelling of the pre-development study area was undertaken using the following model parameters:

1. TUFLOW version 2023-03-AE was adopted, using the HPC GPU solution scheme.
2. A 2m topographic grid was used in the model construction based on the available LiDAR (2020) data sourced from ELVIS.
3. The model domain was defined approximately 500m north-west of Morgan Road and approximately 200m west of the site up to Forest Way. At the downstream end the domain has been set at approximately 350 m downstream of the proposed development, just upstream of Oxford Falls Road.
4. Source area (SA) inflow boundary conditions based on the critical duration hydrographs from the XP-RAFTS model for pre-development conditions were used to discharge runoff from the sub-catchments into the model.

5. Manning's n roughness values were specific for land use zones in the study area based on aerial photography (Nearmaps, 2022). The adopted values are specified in Table 7 below.
6. Existing buildings in the study area were modelled as flow obstructions.
7. PO lines were placed at the site downstream boundary and within the development to assess the flows leaving the site and flows contributing to the overall creek flow respectively.

Table 7 Manning's roughness coefficients

Material	Manning's n Values
Creeks and waterways	0.045
Open grassed space	0.04
Roads	0.02
Residential	0.05
Vegetation - dense	0.10
Vegetation - medium	0.08

6.3 Pre-Development Hydraulic Modelling Results

The pre-development TUFLOW modelling was undertaken to simulate the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF events. Peak flood depth, level, hazard and extent mapping for these results are presented in **Appendix C**.

The results of the pre-development conditions flood modelling are discussed below:

1. The primary flood mechanism on the site is mainstream flooding from Snake Creek and other overland flow paths. Runoff from the upstream catchment to the northwest flows past Morgan Road and into Snake Creek.
2. The peak flood depths and levels at the locations indicated in Figure 16 are summarised in Table 8 below.
3. Flood velocities in the creek are generally high, reaching above 5 m/s in all modelled storm events. This is largely due to the steep topography on site.
4. Subsequently flood hazards in the creek are also high, reaching up to H6 hazard in all modelled storm events.
5. As the site and its surroundings are currently bushland, there is negligible flood affectation of existing properties. There is an existing Telstra communications facility downstream of the site adjacent to Snake Creek which appears to be partially flood affected only in the PMF event.

Table 8 Peak existing flood depths and levels at observation locations

		Observation Location								
	AEP	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Peak Level (mAHD)	**5%**	128.7	118.1	105.8	101.8	140.2	139.8	87.3	102.6	55.2
	1%	128.9	118.2	106.0	102.0	140.4	139.8	87.6	102.8	55.5
	0.5%	128.9	118.3	106.0	102.0	140.5	139.8	87.7	102.8	55.6
	0.2%	128.9	118.3	106.1	102.1	140.5	139.8	87.8	102.8	55.8
	PMF	129.4	118.5	106.7	102.6	140.9	139.8	88.7	103.3	57.3
Peak Depth (m)	**5%**	1.3	1.1	1.2	0.6	0.3	0.1	1.0	0.4	1.4
	1%	1.4	1.3	1.4	0.7	0.5	0.1	1.3	0.6	1.7
	0.5%	1.4	1.3	1.4	0.7	0.5	0.1	1.3	0.6	1.8
	0.2%	1.5	1.4	1.5	0.8	0.5	0.1	1.4	0.6	1.9
	PMF	2.0	1.6	2.1	1.4	0.9	0.1	2.3	1.1	3.5

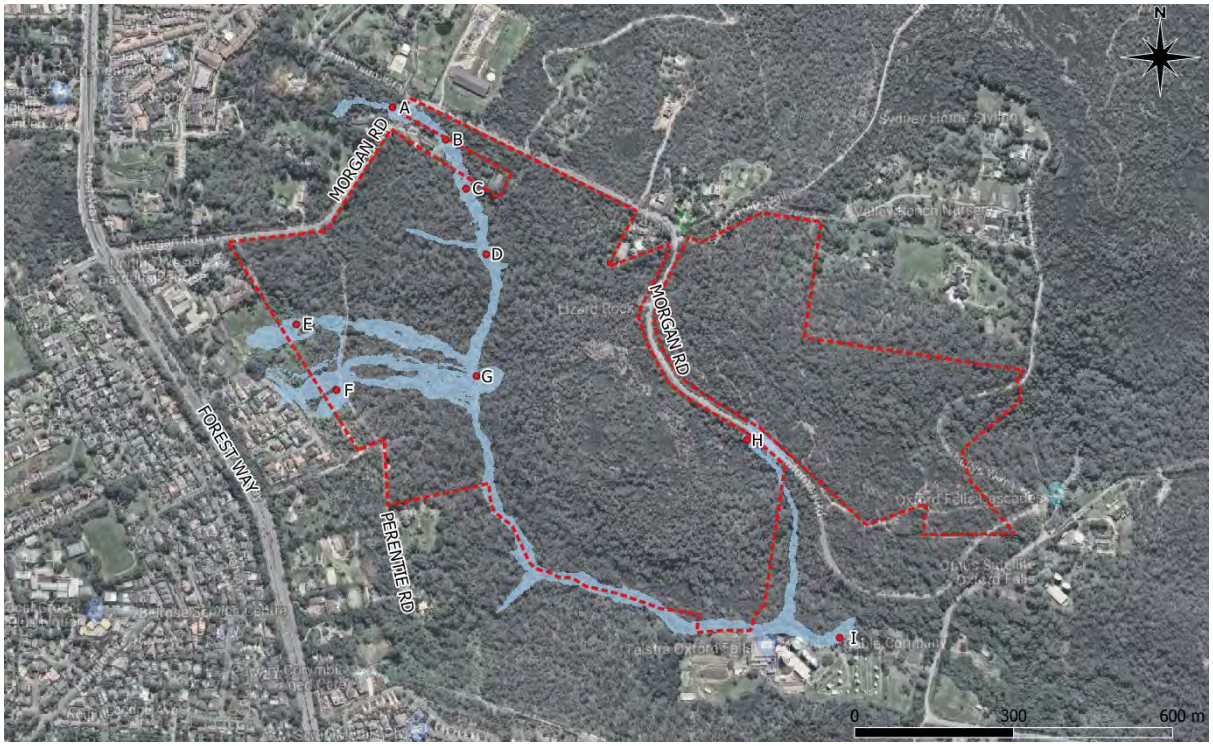

Figure 16 Key Observation Locations from TUFLOW Model

Along the western boundary of the development, adjacent observation wells E & F there is a trapped low point which results in water pooling at this location. Once the pool at the low point has reached capacity, water can be seen to overtop and enter the development.

Due to the location of this low point, both inflow points have been moved further west by approximately 50m in order to capture the interaction at the Site boundary. Having the inflow point too close to the boundary would result in an inaccurate representation of flow conveyance from the upstream catchment by bypassing the pool and only showing flow within the creek. The western boundary will need to be looked at more closely in the mitigated conditions scenario to model the interaction with upstream flows appropriately.

6.4 Post-Development (Mitigated) Scenarios

The post-development hydraulic model was prepared to account for the proposed changes in land use under post-development conditions as per the draft layout plan as well as mitigation measures. The following model elements were modified for proposed conditions:

- The site's Manning's roughness zones were updated to represent the proposed design surfaces as per the draft layout plan.
- The inflows for the SA boundary conditions for the proposed development sub-catchments were updated based on the XP-RAFTS model for post-development conditions, with implemented stormwater detention features.
- The inflows for the SA boundary conditions from the external catchment were located approximately 50m and 100m from the western and northern Site boundaries respectively.
- A series of pipes have been modelled along the western boundary of the development in order to convey breakout sheet flows from the external catchments which pool adjacent to the development pad and into the creek. Pipe sizing is currently nominal and is subject to change during the detailed design phase of the project.
- Preliminary concept earthworks grading pads for the proposed road and lot layout were modelled to raise the proposed development above the floodplain where necessary.

All other modelling elements remain unchanged from the pre-development model.

6.5 Post-Development (Mitigated) Hydraulic Modelling Results

The post-development TUFLOW modelling was undertaken to simulate the 5% AEP, 1% AEP, 0.2%, 0.5% and PMF events. Peak flood depth, level, hazard and extents mapping for these results are presented in **Appendix C**.

The results of the post-development conditions flood modelling are discussed below:

1. The post-development flood behaviour and conditions are largely unchanged from the pre-development conditions as the proposed development is largely outside of the flood extents in all modelled events.
    a. External flows entering the development from the west can be seen to differ slightly from pre-developed conditions. Sheet flow into the development has been redirected by managing flows pooling along the western boundary via pipes and minimal earthworks to grade in an overland flow path towards the existing creeks, which concentrates the flows into the creeks.
2. Runoff from the upstream external catchments is concentrated slightly towards the overland flow paths indicated in the draft layout plan, however Snake Creek is largely untouched.

3. Although a climate change scenario with increased rainfall intensity was not specifically run, the design 0.5% and 0.2% AEP events represent an increased rainfall intensity of approximately 8% and 22% from the design 1% AEP event respectively. The rise in water level in the creeks due to the increased rainfall intensity in these events do not cause additional flood inundation of the proposed development and therefore climate change is not considered to be a risk to the development.
4. The peak flood depths and levels at the locations indicated in Figure 16 are summarised in Table 9 below.

Table 9 Peak proposed flood depths and levels at observation locations

		Observation Location								
	AEP	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
Peak Level (mAHD)	**5%**	128.7	118.1	105.8	101.9	140.3	140.1	87.3	102.5	55.4
	1%	128.9	118.2	106.0	102.0	140.5	140.1	87.6	102.7	55.7
	0.5%	128.9	118.2	106.1	102.1	140.5	140.1	87.6	102.7	55.8
	0.2%	128.9	118.3	106.1	102.1	140.5	140.1	87.7	102.7	55.9
	PMF	129.5	118.4	106.8	102.7	141.0	140.1	88.5	103.2	57.5
Peak Depth (m)	**5%**	1.2	1.0	1.2	0.6	0.1	0.1	0.9	0.5	1.3
	1%	1.3	1.1	1.3	0.8	0.2	0.1	1.2	0.6	1.7
	0.5%	1.3	1.2	1.4	0.8	0.3	0.1	1.2	0.7	1.8
	0.2%	1.4	1.2	1.5	0.9	0.3	0.1	1.3	0.7	2.0
	PMF	1.9	1.6	2.1	1.5	0.7	0.2	2.2	1.2	3.5

Table 10 Peak Flow Comparison Downstream of Site

AEP	Pre-development Flow (m^3/s)	Post-Development (Unmitigated) Flow (m^3/s)	Post-Development (Mitigated) Flow (m^3/s)
5%	35.69	35.68	35.38
1%	53.47	56.54	51.96
0.5%	59.03	62.94	57.52
0.2%	69.41	74.43	69.42
PMF	255.47	252.75	253.25

6.6 Post-Development (Unmitigated) Scenario's

The post-development hydraulic model was prepared to account for the proposed changes in land use under post-development conditions as per the draft layout plan. The model follows the same assumptions and considerations as mentioned in the post-development

mitigated scenario with the exception of no mitigation measures when determining the hydrological inputs.

The flood extents which can be viewed in **Appendix C** highlights that the results from a lot impact perspective are very limited. The extents across both modelling scenarios are largely the same.

6.7 Flood Impacts of Mitigation Measures

Afflux results for all storm events have been provided in **Appendix C**, with the post-development mitigated results being compared to the pre-development results. The afflux results show some minor, localised water level increases directly adjacent to the proposed concept earthworks pad at locations where the pad is within the flood extents, particularly along the western boundary. This is due to the runoff from the western external catchment being concentrated from sheet flow into channelised flow within the creeks. However, these impacts are located within the creeks on site and do not extend upstream or downstream of the impacted area and onto neighbouring properties. These impacts also do not represent an increased risk to people or property; hence they are considered to be acceptable.

Although the peak flow from the post-development sub-catchments modelled by XP-RAFTS are slightly above pre-development peak flows in the 5% AEP, 0.2% AEP and PMF events (as outlined in Section 5.4) there is an overall reduction in the peak water level within Snake Creek. This shows that the 5% AEP event does not result in any downstream impacts due to the development and that the proposed stormwater detention features are sufficient. For the rarer storm events, it is likely that runoff from the developed catchments tend to discharge to the creek earlier than they would in the existing catchments. Therefore, the runoff from the development is conveyed through the site slightly before the peak of the runoff from the external catchments arrives.

Additionally, design flows downstream of the site and within the Site were compared under pre-development and post-development (Unmitigated) and post-development (Mitigated) conditions to assess the potential impact of the proposed development and the effectiveness of the flood management strategy. The location where the result comparisons were made are shown below in Figure 17, with flow hydrographs at the downstream location presented in Figure 18 to Figure 22**.** Internal flow hydrographs providing a comparison across each model scenario is shown in Figure 23 to Figure 25.

In Table 9 the results indicate that the network of proposed stormwater detention and treatment features in the post-development scenario are still adequate in attenuating the peak flow to pre-development levels in all modelled events even though the calculated peak flows from post-development XP-RAFTS model are slightly above pre-development flows in some cases. This shows that there is no overall impact to flood behaviour as a result of the proposed development. The flow hydrographs also further confirm that the timing of the catchment flows in the post-development scenario are shifted to be slightly earlier than those in the pre-development scenario.

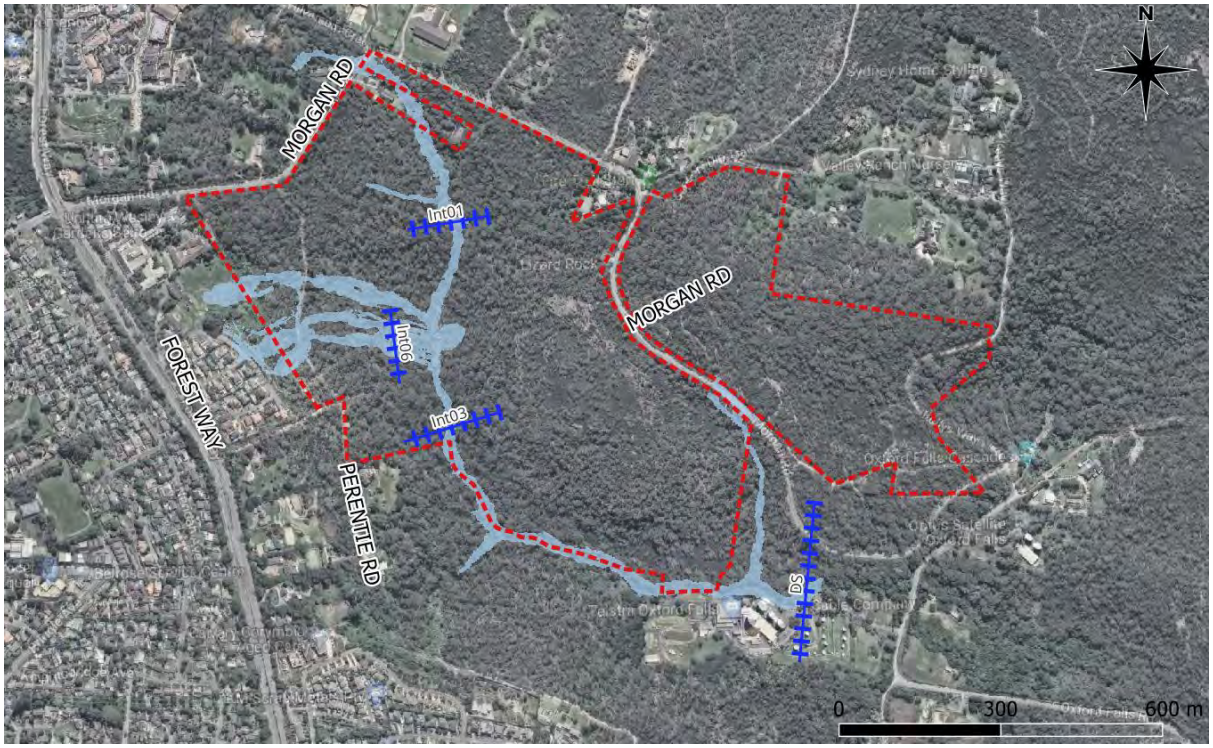

Figure 17 Downstream & Site Observation Locations from TUFLOW Model

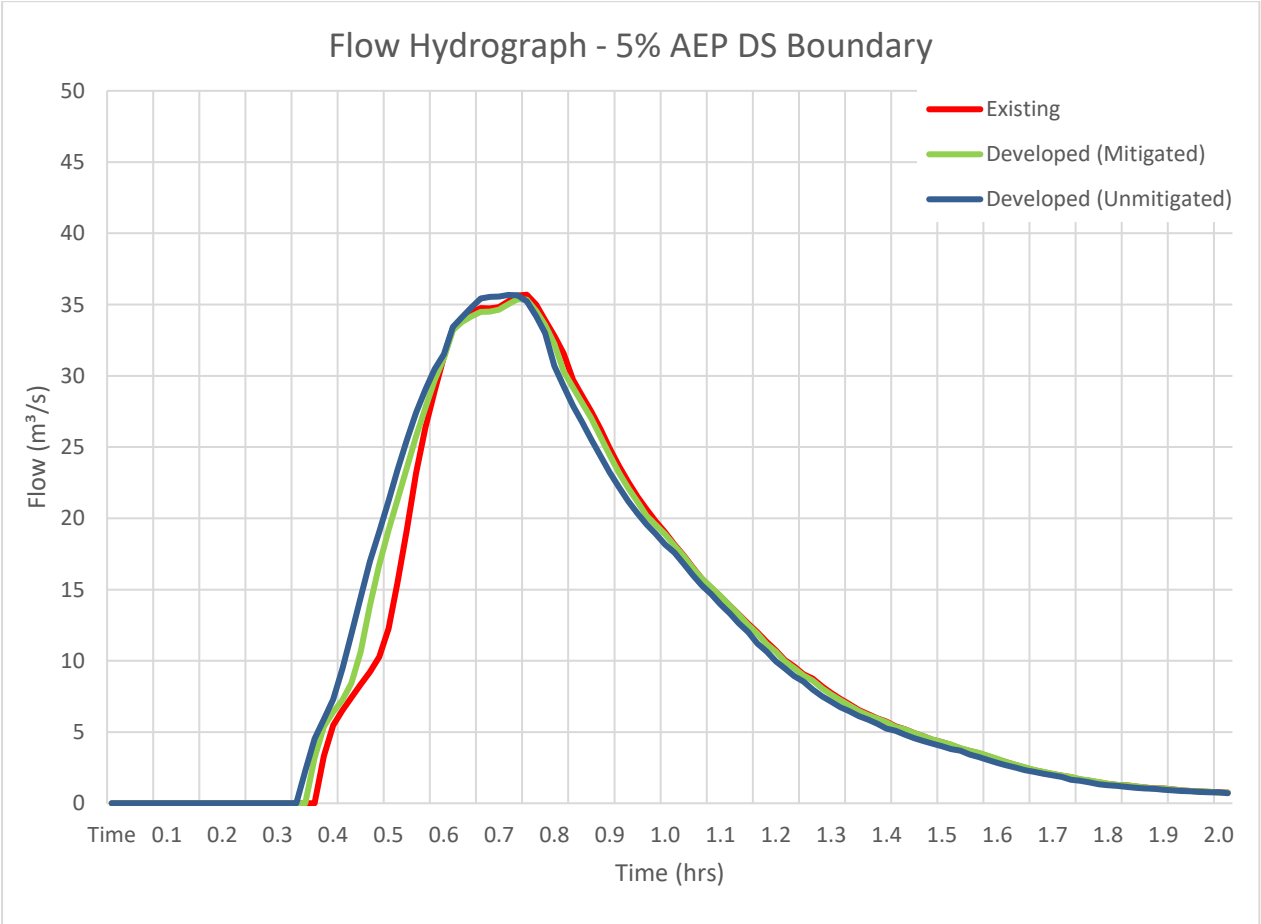

Figure 18 Flow Hydrograph Comparison Downstream of Site (5% AEP)

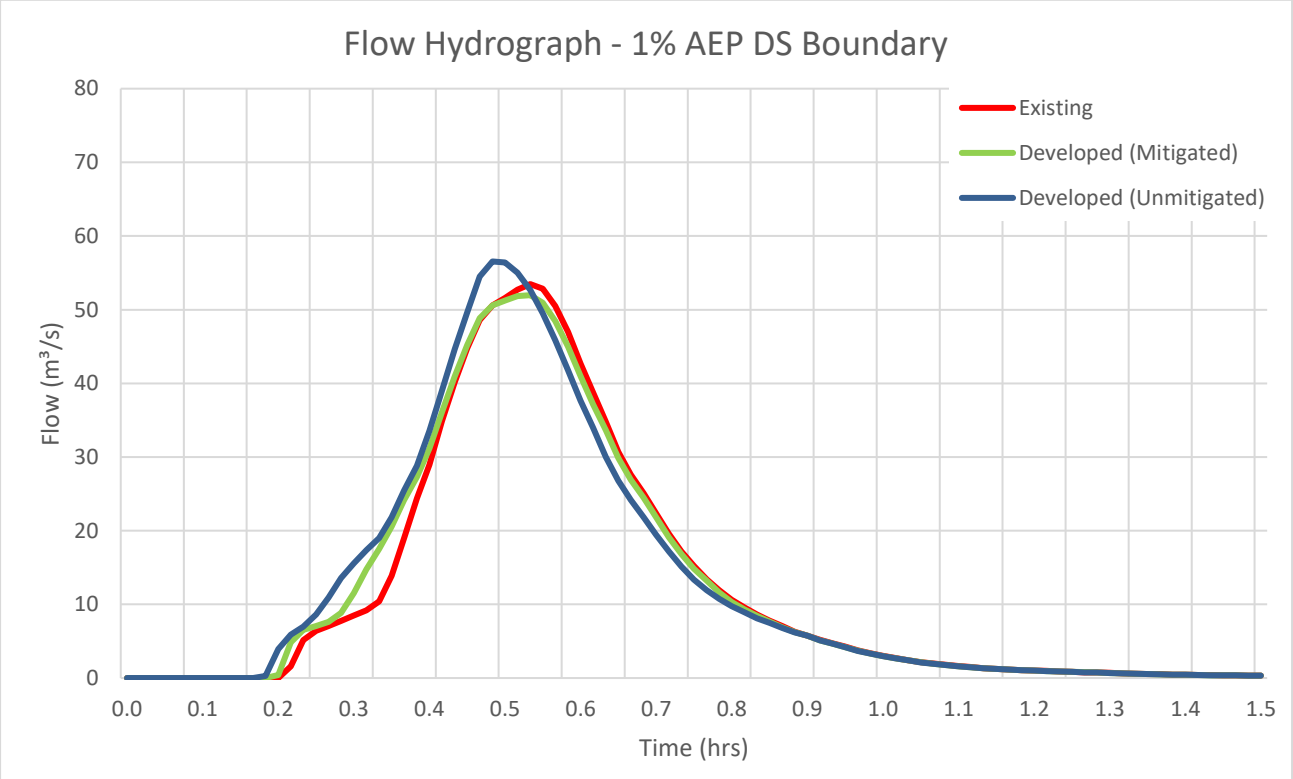

Figure 19 Flow Hydrograph Comparison Downstream of Site (1% AEP)

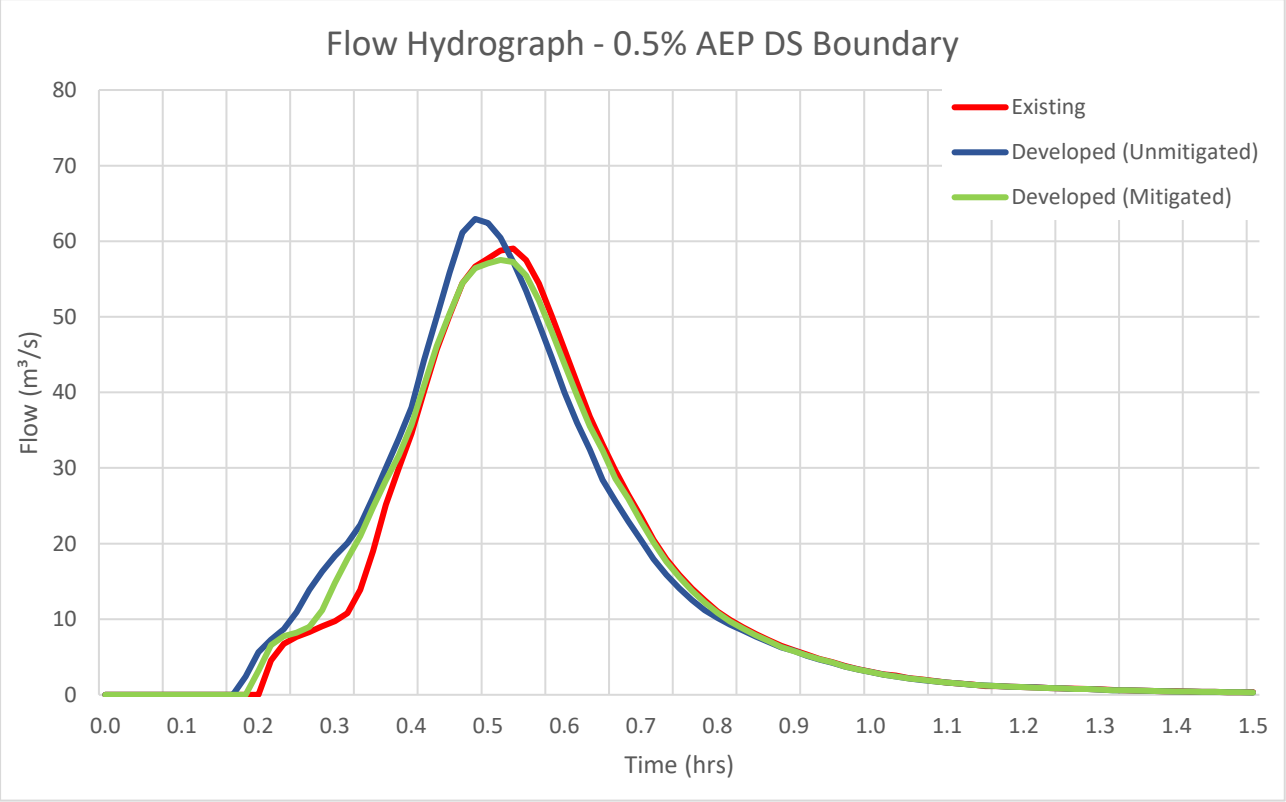

Figure 20 Flow Hydrograph Comparison Downstream of Site (0.5% AEP)

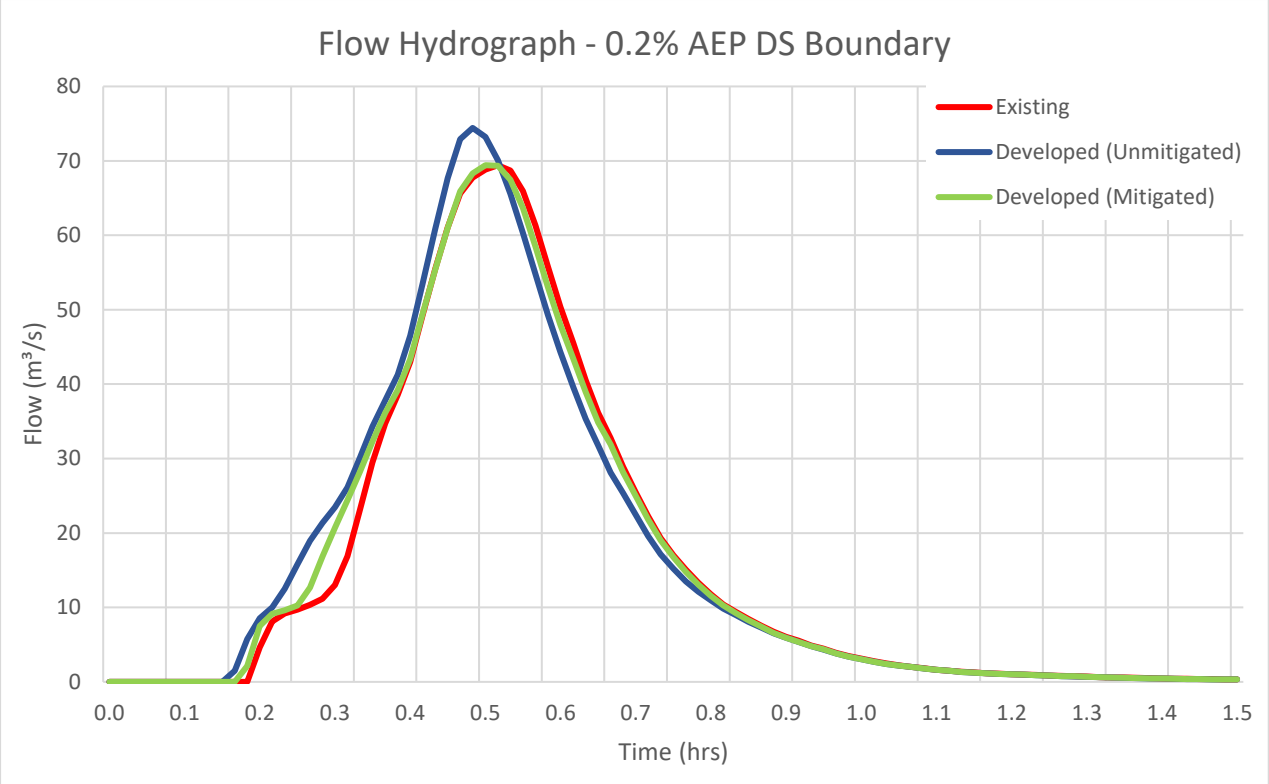

Figure 21 Flow Hydrograph Comparison Downstream of Site (0.2% AEP)

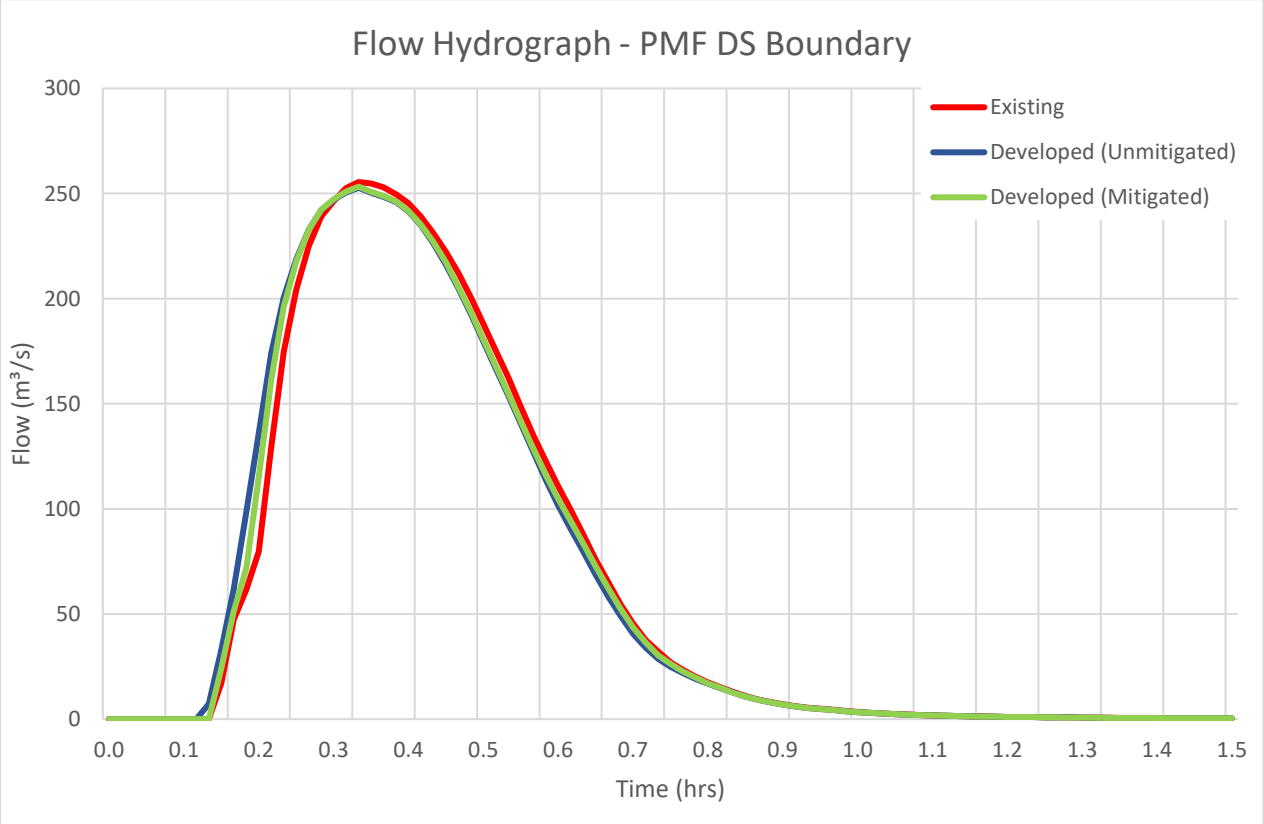

Figure 22 Flow Hydrograph Comparison Downstream of Site (PMF)

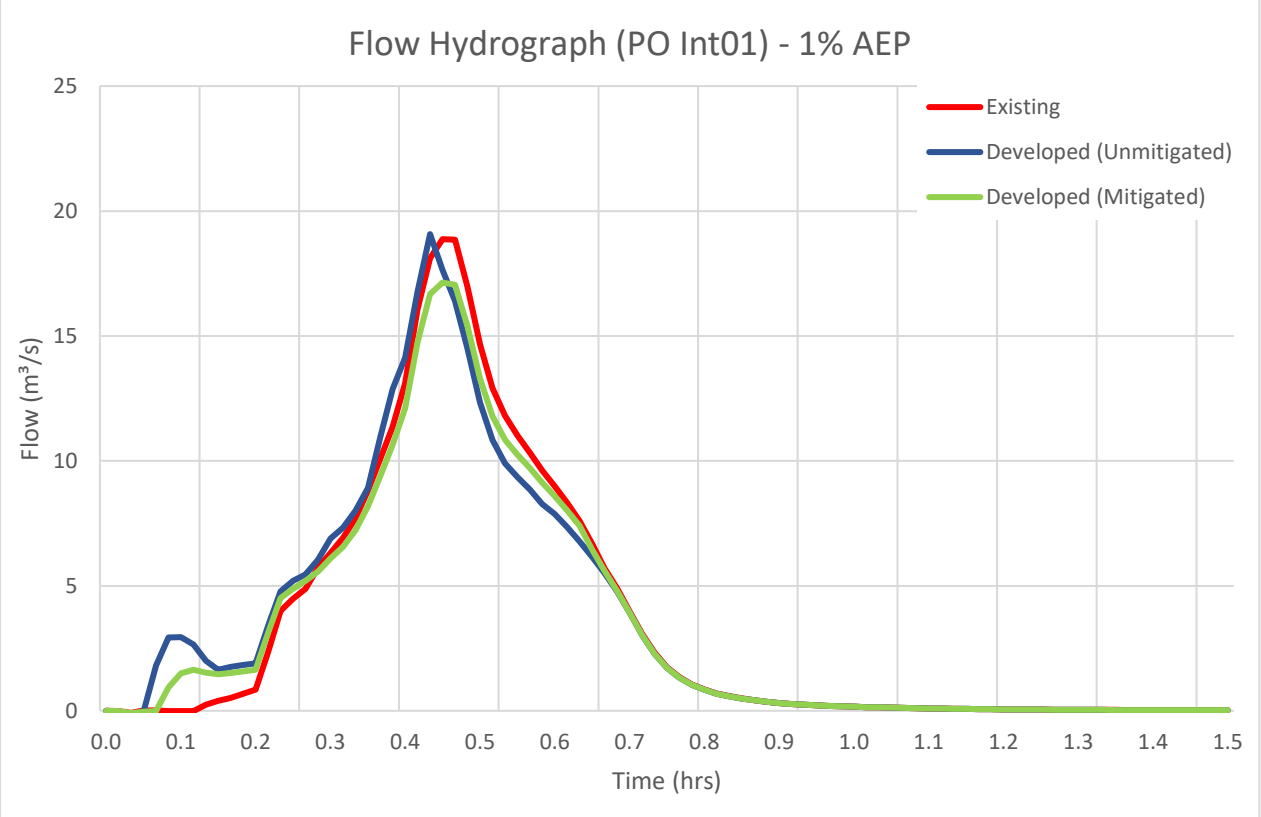

Figure 23 Flow Hydrograph Comparison of PO Line Int01 (1% AEP)

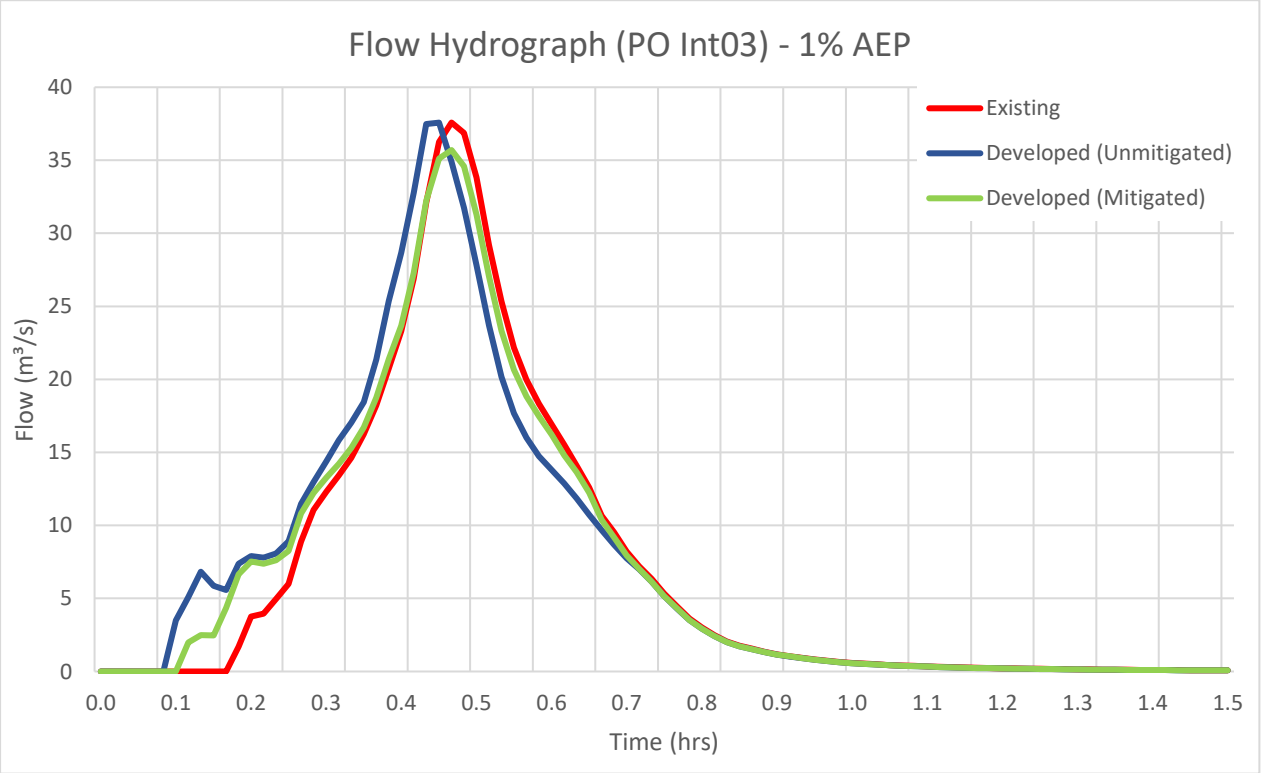

Figure 24 Flow Hydrograph Comparison of PO Line Int03 (1% AEP)

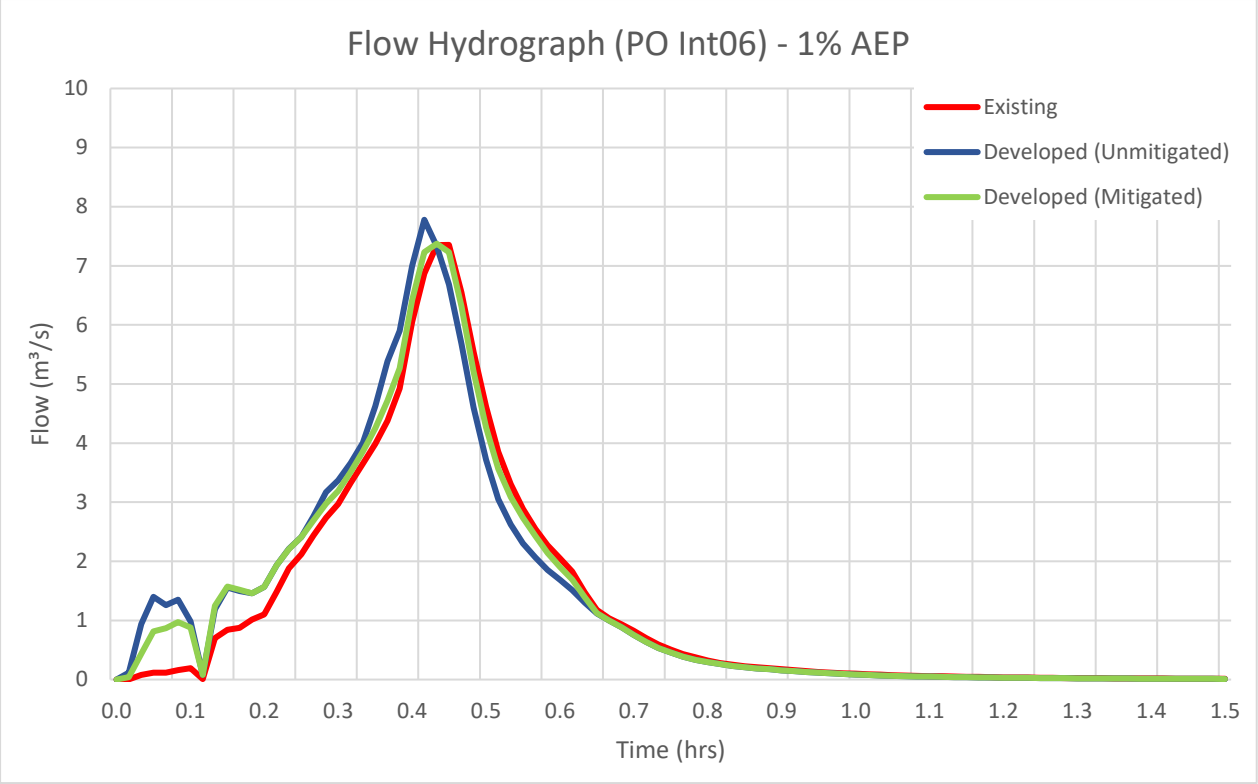

Figure 25 Flow Hydrograph Comparison of PO Line Int06 (1% AEP)

7 Key Findings and Recommendations

The key findings of the flood assessment and the proposed recommendations are discussed below:

1. The proposed layout plan is found to be compatible with the existing floodplain environment and is adequate to support the planning proposal from a flooding perspective. The flood assessment demonstrates the site can be developed in accordance with Council and DoPE's flood planning requirements without causing adverse offsite impacts to water levels and peak discharge downstream of the site.
2. The proposed stormwater detention features located within the lots and roads are able to manage the increase in catchment runoff due to the proposed development in storm events up to and including the 0.5% AEP event by reducing the post-development peak discharge from each sub-catchment to within a reasonable amount as pre-development.
3. Flood planning levels for the proposed developments are to be further considered in the detailed design stage. As previously mentioned, the Council DCP planning controls do not cover the site as it is not deemed to be in a flood affected precinct, however they have still been considered in this assessment. In Council planning controls it is required for residential developments in any flood risk precinct to have building floor levels at the flood planning level (FPL) which is defined as the 1% AEP flood level plus freeboard, typically 500mm. Based on the site topography and the current preliminary layout and concept earthworks grading, the development is largely above the FPL for the majority of the site without any further earthworks fill required. Along the western boundary where the overland flow paths are less defined, some local grading may be required to raise the lots and to convey the waters around the proposed development and into the drainage corridors. Within the development itself, it is expected that lot and road benching design will be implemented for usability and ease of construction for the site.
4. Any road crossings over floodways and overland flow paths will need to be designed as bridges or contain culverts to allow flood waters to be conveyed underneath. The culverts should ideally be adequately sized such that there are no upstream impacts due to a backwater effect, and so that any flood waters overtopping the crossing will not be hazardous for people or vehicles in the event that evacuation or emergency access is required. These hydraulic structures are subject to detailed design and modelling at a later stage along with proposed site grading.
5. The flood emergency response will need to be considered for the site. Currently the site topography in conjunction with the proposed concept earthworks grading for the site has been designed such that all proposed development areas and roads are outside the PMF extents. Although this isn't strictly required by the DCP, this design is easily accommodated by the natural topography of the site, and also reduces the need for evacuation in the event of a flood. Hence the majority of the proposed development including access roadways are not expected to be inundated for all storm events up to even the PMF event. This is evident in the post-development flood result maps presented in **Appendix C**, however it is subject to detailed site grading and stormwater design for the road crossings as mentioned above. Accordingly, shelter-in-place is the recommended emergency response for all future residents of the Morgan Road,

Belrose development as there is no risk of flood affectation for the project. In the event of a medical emergency, the site has enough fall to ensure that all lots will have rising road access out of the site. Further discussions and consultation with NSW State Emergency Services (SES) is recommended at a later stage.

8 Compliance with Agency Comments

As discussed in Section 1.6, BCS have reviewed the planning proposal and have provided commentary on flooding related issues in a letter dated 3 April 2024. CED have provided an amended FIRA (Revision C) in response to this advice and have responded to each comment in Table 11 below. In accordance with BCS' advice, CED have also provided a compliance table against the Ministerial Local Planning Direction 4.1 in Table 12 below, in the absence of Council flood mapping for the site.

Table 11 CED Response to BCS Comments

Issue	BCS Comment	CED Comment
Flood Risk Management	In summary, limited consideration has been given to the issues raised by BCS. An updated FIRA was not provided with the post-exhibition response.	An updated FIRA is being provided with Revision C of this report.
Consultant Qualifications	BCS acknowledges that the CV of Kylee Smith has been provided. However, several issues have not been adequately responded to, including in relation to the hydrological modelling methodology.	CED believes the issues have been adequately responded to with Revision C of this report.
Ministerial Direction 4.1 Flood Prone Land	2. The FIRA has confirmed that the site is flood prone. Flood mapping was removed from LEPs following release of the Flood Planning Package in 2021. Consistency with the Local Planning Directions must be demonstrated. 3. Per original advice on the planning proposal: The flood planning area will need to be established. This is to assess consistency with the local planning direction. The direction will no longer apply at the DA stage, so it would be too late to prepare this at the DA stage.	2. The updated FIRA is compliant with the Local Planning Directions. 3. The flood planning area map has been provided in Appendix C.
Flood Impact and Risk Assessment Report	4. BCS agrees that not every element of Table 5 and 6 is required but considers there are substantial elements lacking from the FIRA to make it suitable for the planning proposal stage. BCS has reviewed Tables 5 and 6 against the FIRA and recommends the following be included: a) FIRA requirements including local planning direction; and discussion of each item in the direction to demonstrate consistency b) Refer to the Flood Risk Management Manual 2023 and supporting guides (not only LU01) as informing the FIRA. eg FB04 Incorporating 2016 Australian Rainfall and Runoff in studies c) Follow guidance in FB04, including Section 3.7.1 on losses. This includes probability neutral burst losses and consideration of losses from calibrated studies eg Narrabeen Lagoon Flood Study d) Subcatchment map with scale and legend, preferably on an aerial photo, to ensure sufficient discretisation across the site that enables all relevant flow paths to be mapped. Subcatchments on the site may be too large e) Critical durations and temporal patterns – demonstrate selection is reasonable f) Model checks g) Mapping of depth, level, velocity and hazard for the 5% AEP and PMF events and one of the 0.5% AEP and 0.2% AEP events, for both existing and proposed conditions. Mapping to date has included only the 1 % AEP event h) Impacts: flood level difference mapping for 1% AEP, PMF; comparison of hazards pre to post development	4. a) Compliance to the Ministerial Local Planning Direction 4.1 has been discussed in Table 12. b) Relevant supporting guidelines have been reviewed as per Section 4. c) Losses from the Narrabeen Lagooon Floodplain Risk Management Study (Cardno, 2019) have been adopted for the updated modelling. d) Subcatchment maps have been provided in Appendix C, Map 01. e) Critical duration and temporal patterns statistics from XP-RAFTS has been discussed in Section 5.4. f) Model Checks including mass balance and Peak CME have been provided along with a summary of modelling parameters, refer to Section 6.1 g) Mapping for all modelled storm events is provided in Appendix C. h) Impacts for 1%, 0.5%, 0.2% and PMF events have been provided in Appendix C.

Issue	BCS Comment	CED Comment
	i) While BCS does not require FERCC mapping, demonstration of rising road access should be provided for all flood affected lots.	i) The proposed lots for the development are outside of the PMF extents. Additionally, the site has enough fall to ensure that there is rising road access away from the flood corridors for all lots.
	5. BCS is concerned at the methodology used and recommends that relevant industry guidance is followed, including Australian Rainfall and Runoff. Regardless of whether end of line treatment or dispersed treatment measures is adopted, the flood modelling methodology must appropriately reflect the hydrological changes under developed conditions, including changes to flow volume and timing. The original advice remains relevant: This is not considered an appropriate methodology for flood modelling nor stormwater detention modelling. The proposed measures to mitigate peak flow impacts, such as stormwater detention, must be explicitly modelled and not simply using an increased initial loss. The hydrographs shown in the report are not indicative of stormwater detention measure outflows and do not correctly show the likely impact of changes to site hydrology. Hydrographs should be presented of the existing case, developed case without detention measures and developed case with detention measures. If the proponent is unable to model the dispersed on-site detention, the post-development scenario may include increased imperviousness without any treatment measures. This would be a conservative representation but may be more accurate than the current modelling. BCS requests that hydrographs are provided further upstream, at locations where the impacts due to increased imperviousness can be seen. e.g. for site sub-catchments. BCS suggests an independent peer review of the hydrology may be necessary if the requested amendments cannot be made. 6. The stormwater strategy proposed has been in use for over 20 years. The stormwater strategy does not influence BCS advice on the requirements for flood risk management. 7. Per point 5, BCS advises that this approach does not appear to be generating accurate representations of post-developed flow behaviour. Whether or not the flows are contained within the waterways remains unclear as the post-development scenario modelling does not follow relevant guidance. BCS does not consider it necessary to incorporate any water quality or detention elements into TUFLOW provided that these are appropriately incorporated in the	5. The hydrologic model has been amended to include explicit modelling of the proposed stormwater detention features as per the advice. The attenuated catchment runoff hydrographs are then exported to TUFLOW to run the hydraulic models. 6. See comment 5. 7. See comment 5. 8. Fraction impervious for all sub-catchments as an aggregate has been provided in Table 2. An effective impervious fraction of 60% for developed lots is considered to be reasonable based on the methodology outlined in ARR 2019. We also note that the impervious fraction adopted for developed areas in the Narrabeen Lagoon Floodplain Risk Management Study is 50%. The impervious fraction for existing bushland areas has been lowered to 5%, taking into account BCS' advice. This is deemed to be reasonable considering that the site is also very rocky in nature, which is effectively considered as impervious material. 9. Hydrologic validation has been provided. Hydraulic validation is subject to flow or gauge monitoring, however as the catchment is not a complex urban catchment, there is little room for results to vary in a way that will impact the

Issue	BCS Comment	CED Comment
	hydrological model. BCS considers the DA stage too late to define flood behaviour. Flood constraints on the land must be established prior to rezoning. 8. Appendix B provides impervious fractions for over 30 individual subcatchments, which is difficult to interpret. BCS requests a summary table is presented that shows aggregated data for the catchments A, B, C etc. This will enable consideration of whether the overall impervious fractions are reasonable. BCS is concerned that the post-development hydrographs appear unrealistic as they do not show the impact of increased impervious surfaces. For rare and extreme events, the flood volumes are expected to increase even when on site detention reduces peak flows to match existing conditions. An impervious fractions of 60% for residential lots may be low for new development areas with lot sizes of 450-600 m2. BCS also queries the application of 10% imperviousness for the existing site. This is considered very high for what is essentially bushland and should be reconsidered. Inflating the impervious fraction for existing site conditions can disguise true impacts due to development. 9. Validation has been provided for the hydrological modelling only. Validation of the hydraulic model is still recommended. Sensitivity testing would be recommended if there are no suitable validation methods. 10. BCS recommends that the original advice is followed as it is highly relevant for the planning proposal stage. It is recommended that the hydraulic model is extended downstream to include Oxford Falls Road and that a suitable frequent event such as the 1 event per year is used to map flooding over the road. 11. BCS recommends that the original advice is followed as it is highly relevant for the planning proposal stage to understand the nature of potential for impacts caused by the development. Due to edge effects, the model boundary should never be the site boundary. The flood extents on the site may not be accurate at these inflow points. 12. Resolved.	proposed development. 10. As discussed in Section 2.2, Oxford Falls Road is sufficiently far enough from and lower in elevation than the proposed development area on site such that any impacts from the development would be minimal. Modelling to include Oxford Falls Road would require modelling of Oxford Creek as well which is not within the scope of works for this assessment. Whilst Oxford Falls Road is one of the access points to Morgan Road and the development site and thus can be assigned some degree of importance, the bridge crossing Oxford Creek has recently been upgraded to be above the 1% AEP flood level. Therefore, it would be safe to assume that day to day access and emergency access up to the 1% AEP event is adequate for this transport route. For this reason as well, it is deemed to be pointless to model smaller events for this bridge crossing. 11. The 2d_SA polygons for the upstream external catchments have been moved further away from the site boundary as per the advice to avoid edge effects. 12. N/A.
Flood Impacts	13. BCS notes that the flood impacts cannot be accurately assessed until the modelling issues above are resolved. BCS requests that information such as peak flows be provided for the post-development scenario both with and without treatment measures so that the changes due to the development and impact of treatment measures can be understood. This is requested due to the concern around the hydrological modelling.	13. Peak flows for all modelled scenarios, including the post-development scenario with and without stormwater detention, have been included in the updated FIRA for impact assessment.

Issue	BCS Comment	CED Comment
Frequent Flooding of Transport Route	14. BCS original comment is not specifically in relation to flood evacuation, but other emergencies such as bushfire and also day-to-day access. It is noted that fires and floods may occur concurrently. We request this comment be given due consideration and response. As requested above and in our original comments, the Flood Impact and Risk Assessment Report should model and map flood affectation at Oxford Creek, especially smaller events. BCS recommends the SES is consulted on any proposal to develop a Flood Emergency Response Plan. The lots appear to be largely unaffected by the PMF. As such evacuation due to flood emergencies may be unnecessary. 15. BCS requests that an explanation is provided in the FIRA regarding any information from the transport report that may be relevant to this issue.	14. See comment 10 above. 15. N/A.
Stormwater Management	16. BCS notes that the proposed strategy using distributed treatment measures has been in use for over 20 years. BCS also notes that water sensitive design measures are typically designed for the management of day-to-day rain events and do not reduce flood afflux caused by developments for larger events. As stated in the Flood Risk Management Measures guideline: The focus of FRM is on understanding and managing the rare to extreme flood events that have significant impacts on and risks to communities. These may be risks to people or may relate to damage to property and infrastructure. These events are typically of significantly longer duration than those that are relevant to WSUD. BCS reiterates that appropriate hydrological modelling has not been completed to demonstrate no impact to flows and recommends this is completed per above comments.	16. See comment 5 above.
Proposed Earthworks Strategy	17. Resolved. The earthworks strategy wording should be updated to reflect this. 18. Resolved. It should be confirmed that the updated flood modelling reflects this approach, noting that BCS does not suggest filling of lots to the 1% AEP plus freeboard would be necessary.	17. Earthworks strategy wording has been revised. 18. CED agrees that filling of lots for the majority of the site for the purposes of flooding freeboard is largely unnecessary, except for near the overland flow paths along the western boundary of the site. However, lot and road benching would be the preferred design for the development area due to the steepness of the site.

Table 12 Compliance Table with Ministerial Local Planning Direction 4.1

Direction 4.1	CED Comment
(1) A planning proposal must include provisions that give effect to and are consistent with: (a) the NSW Flood Prone Land Policy, (b) the principles of the Floodplain Development Manual 2005, (c) the Considering flooding in land use planning guideline 2021, and (d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.	1. a) The FIRA has been developed in accordance with achieving the outcomes of the NSW Flood Prone Land Policy with regards to reducing the impacts of flooding and flood liability on communities and owners of flood prone property. The proposed development is outside of any mainstream flood extents, with the local overland flooding from the western catchments largely being dealt with in the post-development scenario with proposed culverts and localized grading. This results in a flood free development area, with no material off-site impacts upstream or downstream of the site. b) The FIRA has been developed based on the principles and definitions outlined in the NSW Floodplain Development Manual (2005), though this has largely been superceded by the Flood Risk Management Manual (DoPE, 2023). c) The Considering flooding in land use planning guideline 2021 has been reviewed and considered in the development of the flood planning area and FPL for the site. d) As the site falls within the Narrabeen Lagoon catchment,the Narrabeen Lagoon Floodplain Risk Management Study (Cardno, 2019) has been reviewed and considered for this assessment, with modelling parameters being adopted where appropriate.
(2) A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones.	2. The flood planning area has been defined for the planning proposal based on the post-development scenario and shows that the development sits outside of the flood planning area extents. The concept masterplan for the planning proposal has considered the flood extents and riparian corridors and the proposed development is considered to be compatible with the floodplain as there are no areas proposed to be zoned as Residential within the flood planning area.
(3) A planning proposal must not contain provisions that apply to the flood planning area which: (a) permit development in floodway areas,	3. The proposed development does not contain any development within the post-development scenario flood planning area.

Direction 4.1	CED Comment
(b) permit development that will result in significant flood impacts to other properties, (c) permit development for the purposes of residential accommodation in high hazard areas, (d) permit a significant increase in the development and/or dwelling density of that land, (e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, (f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent, (g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or (h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.	
(4) A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which: (a) permit development in floodway areas, (b) permit development that will result in significant flood impacts to other properties, (c) permit a significant increase in the dwelling density of that land, (d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate, (e) are likely to affect the safe occupation of and efficient evacuation of the lot, or (f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.	3. The proposed development does not contain any development between the post-development scenario flood planning area and PMF extents.
(5) For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.	5. The flood planning area map for the post-development scenario has been prepared in accordance with the definitions in the Floodplain Development Manual 2005, and the Flood Risk Management Manual 2023 which supersedes it.

9 Conclusion

This FIRA study for the proposed masterplan layout & Planning Proposal for the Morgan Road, Belrose site has been undertaken in accordance with the requirements outlined in Council's LEP and DCP and the Department of Planning and Environment's policies.

Based on the results of the study, it is concluded that the management measures proposed for the site, including its network of stormwater quantity and quality features, are effective in ensuring that there would be no adverse impacts in the overall Snake Creek catchment as a result of the proposed development. Although there may be some minor localized impacts in areas of fill, these are negligible and do not have any widespread effects on people, property or the environment, hence they are considered to be immaterial. It is considered that opportunities exist after the rezoning stage to further refine and optimize the design grading to potentially alleviate these minor impacts.

Overall, the proposed layout plan is deemed sufficient to support the planning proposal from a flooding perspective.

10 References

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) *Australian Rainfall and Runoff: A Guide to Flood Estimation*, © Commonwealth of Australia (Geoscience Australia), 2019.

Bureau of Meteorology (2021), *Rainfall IFD Data System*

CED (2024), *Stormwater Management Plan*

Department of Infrastructure, Planning and Natural Resources (2005), *Floodplain Development Manual*

Department of Planning and Environment (2023), *Flood Hazard [FB03]*

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Department of Planning and Environment (2023), *Flood Risk Management Manual*

Department of Planning and Environment (2019), *Incorporating 2016 Australian Rainfall and Runoff Into Studies [FB04]*

Montgomery Watson Harza (MWH) (2004), *Warringah Creek Management Study.*

Northern Beaches Council (2011), *Protection of Waterways and Riparian Land Policy [PL 740]*.

Northern Beaches Council (2011), *Warringah Development Control Plan (DCP)*.

Northern Beaches Council (2011), *Warringah Local Environmental Plan (LEP)*.

Appendix A – Preliminary Concept Plans

Draft Structure Plan

0 50 100 200

September 14, 2022

Hydrology

Adopted Parameters per Land Type

Land Type	%Impervious	Pervious IL	Pervious CL (mm/hr)	Pervious 'n'	Impervious IL	Impervious CL (mm/hr)	Impervious 'n'
Existing	5	10	2.5	0.06	2	0	0.013
Lot – Roof	100	-	-	-	2	0	0.013
Lot – Driveway	100	-	-	-	2	0	0.013
Lot – Pervious	0	10	2.5	0.03	-	-	-
Public road	70	10	2.5	0.03	2	0	0.013
Open Space	10	10	2.5	0.03	2	0	0.013
External Catchment	Varies	10	2.5	Varies	2	0	0.013

Design storms

Design rainfalls have been obtained from 2016 BOM IFD at the site location. Temporal patterns have been obtained from ARR Datahub. The design rainfall and temporal hydrologic data have been used in the RAFTS modelling for both the pre and post development scenarios.

Catchment

Catchment delineation

Internal catchments have been delineated based on the site Draft Structure Plan, 29th April 2021 by Cox Architecture. External catchments have been delineated based on site topography using LIDAR data.

Vector Average slope

The catchment average slope has been calculated using lidar levels and representative flow paths for each catchment. For the post-development scenario, the average slope for the site catchments has adopted an assumed slope of 5% to account for the anticipated lot and road benching design that will be necessary for steep site such as this one.

Hydraulic routing

Existing and developed catchments has been routed based on existing site topography. Catchment lag times have been calculated based on the uniform flow velocity of 2m/s and measured flow path lengths between nodes.

EXISTING MODEL CATCHMENT PROPERTIES

Node ID	Total Area [ha]	%Imp	Vectored Slope [%]
A_lot dvwy	0.520	5	15
A_lot perv	2.080	5	15
A_lot roof	2.601	5	15
A_OpSpace	0.612	5	15
A_road	4.380	5	15
B_lot dvwy	0.228	5	15
B_lot perv	0.912	5	15
B_lot roof	1.140	5	15
B_OpSpace	0.407	5	15
B_road	2.025	5	15
C_lot dvwy	0.368	5	15
C_lot perv	1.474	5	15
C_lot roof	1.842	5	15
C_OpSpace	0.192	5	15
C_road	1.242	5	15
D1_lot dw	0.501	5	15
D1_lot pv	1.908	5	15
D1_lot rf	2.385	5	15
D1_OpSpc	0.506	5	15
D1_road	3.138	5	15
D2_lot dw	0.066	5	15
D2_lot pv	0.264	5	15
D2_lot rf	0.330	5	15
D2_OpSpc	4.279	5	15
D2_road	0.401	5	15
E_lot dvwy	0.376	5	15
E_lot perv	1.504	5	15
E_lot roof	1.880	5	15
E_OpSpace	0.048	5	15
E_road	1.488	5	15
Ext01	32.521	26	12.5
Ext02	10.741	57	12
Ext03	37.826	35	21
Ext04	5.906	5	7
Ext05	13.983	5	3
Ext06	15.245	15	15
Total	**155.3**		

DEVELOPED MODEL CATCHMENT PROPERTIES

Node ID	Total area [ha]	%Imp	Vectored Slope [%]
A_lot dvwy	0.521	0	5
A_lot perv	2.081	0	5
A_lot roof	2.602	0	5
A_OpSpace	0.612	10	5
A_roadpav	2.899	70	5
A_roadrip	1.481	70	5
B_lot dvwy	0.229	0	5
B_lot perv	0.913	0	5
B_lot roof	1.141	0	5
B_OpSpace	0.407	10	5
B_roadpav	0.887	70	5
B_roadrip	1.137	70	5
C_lot dvwy	0.369	0	5
C_lot perv	1.475	0	5
C_lot roof	1.843	0	5
C_OpSpace	0.192	10	5
C_roadpav	1.064	70	5
C_roadrip	0.178	70	5
D1_lot dw	0.478	0	5
D1_lot pv	1.909	0	5
D1_lot rf	2.386	0	5
D1_OpSpc	0.506	10	5
D1_roadpav	1.933	70	5
D1_roadrip	1.205	70	5
D2_lot dw	0.067	0	5
D2_lot pv	0.265	0	5
D2_lot rf	0.331	0	5
D2_OpSpc	4.279	10	5
D2_roadpav	0.200	70	5
D2_roadrip	0.200	70	5
E_lot dvwy	0.377	0	5
E_lot perv	1.505	0	5
E_lot roof	1.881	0	5
E_OpSpace	0.048	10	5
E_roadpav	1.488	70	5
Ext01	32.521	26	12.5
Ext02	10.741	57	12
Ext03	37.826	35	21

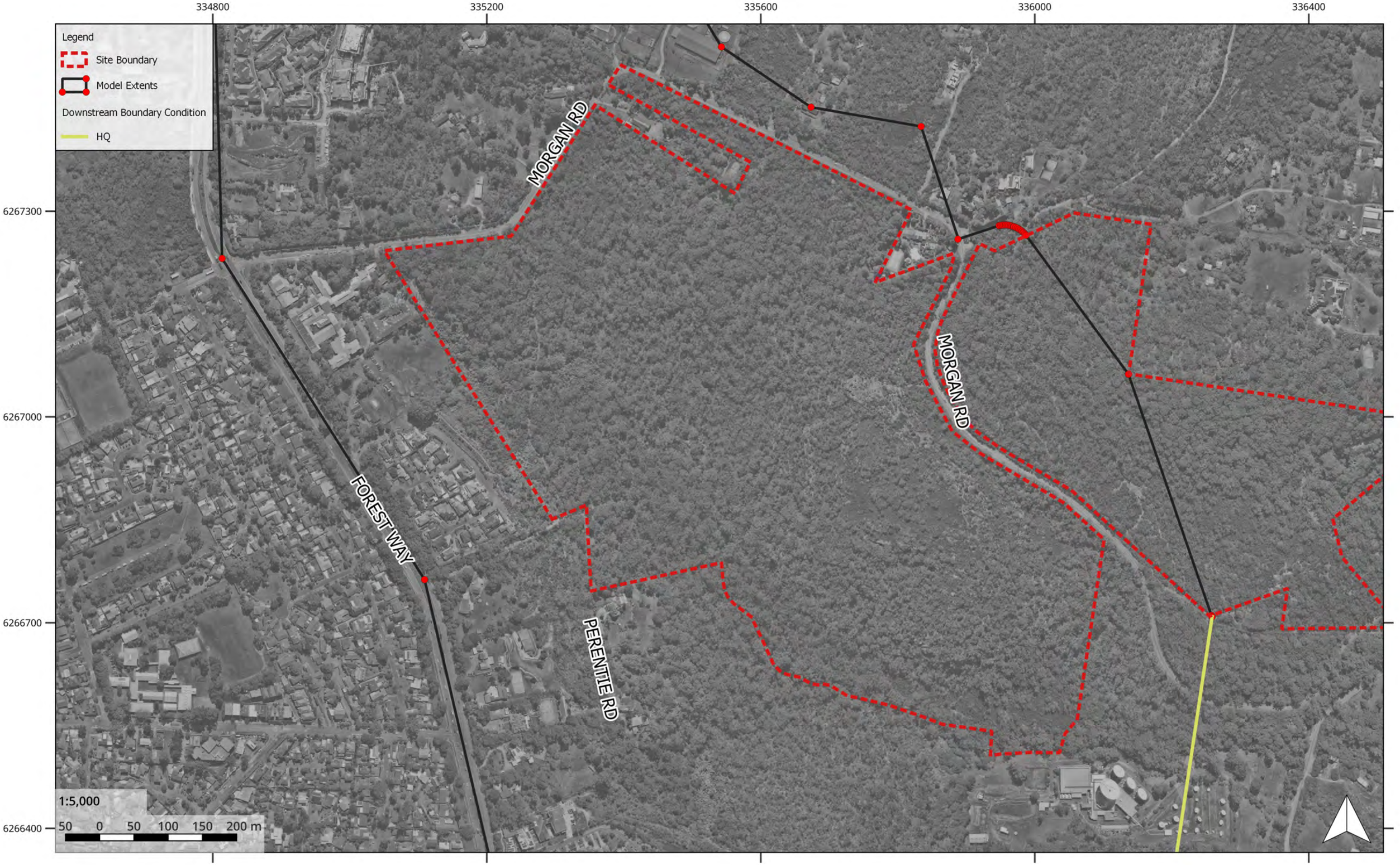
Ext04	5.906	5	7
Ext05	13.983	5	3
Ext06	15.245	15	15
Total	**155.3**		

Appendix C – Flood Maps

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 01: Catchment Map
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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Map 02: TUFLOW Model Setup
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

120.0 110.0 110.0 100.0 130.0 150.0 140.0 120.0 130.0 110.0 100.0 90.0 150.0 140.0 130.0 120.0 110.0 80.0 70.0 100.0 80.0 90.0 70.0 70.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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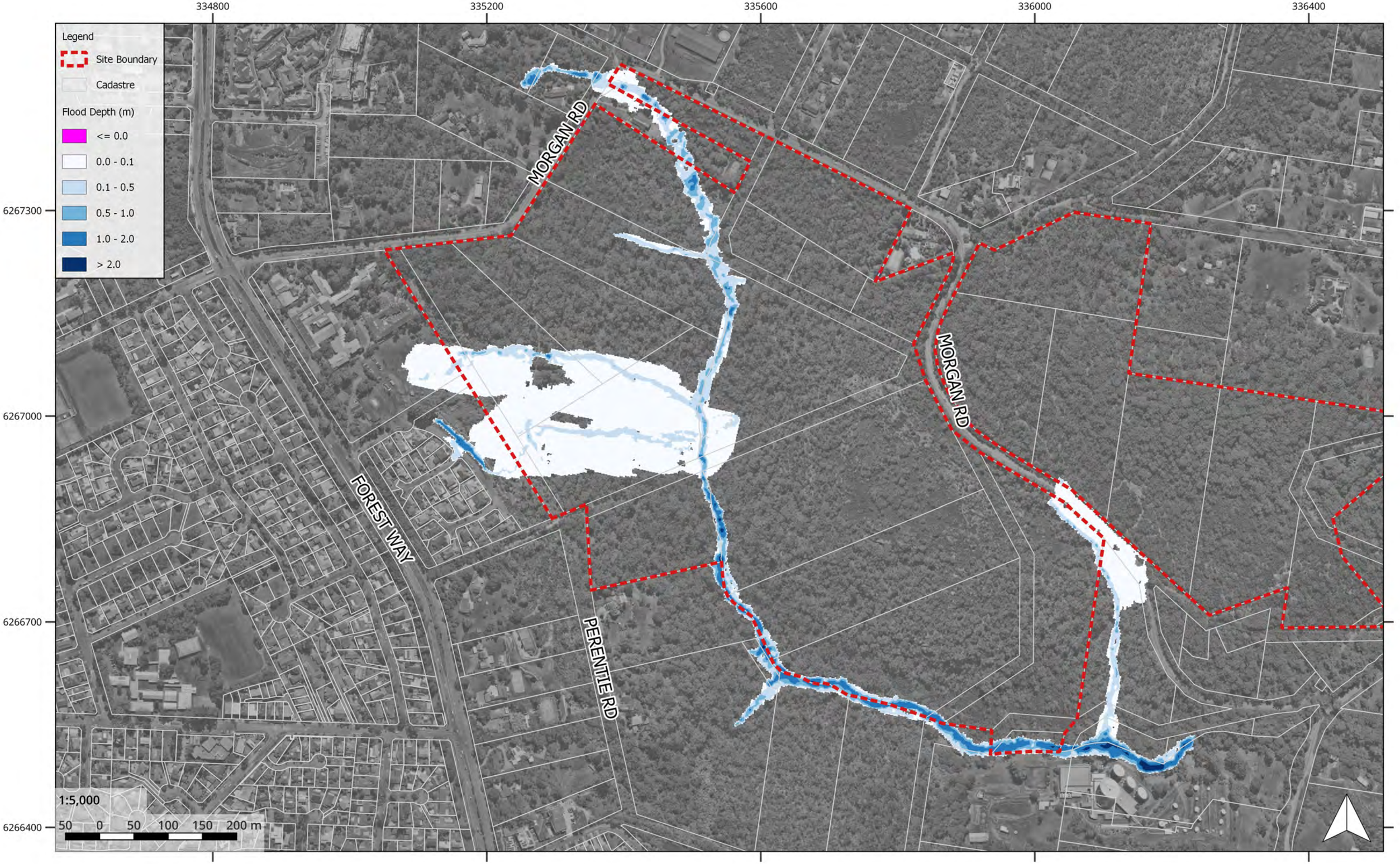
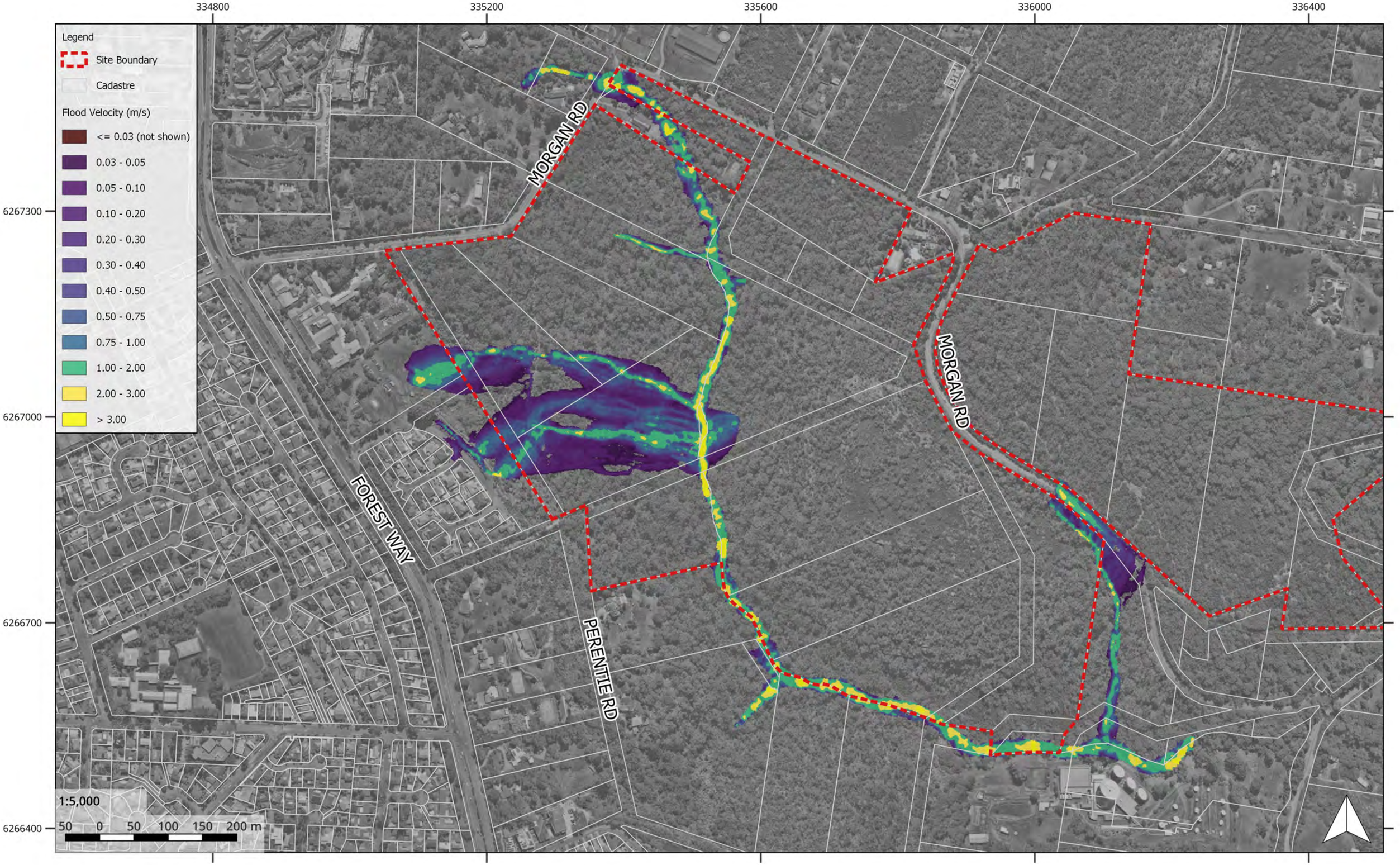
Map 03: 5% AEP Existing Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

Map 04: 5% AEP Existing Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 05: 5% AEP Existing Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Existing Flood Hazards

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 06: 5% AEP Existing Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

130.0 120.0 110.0 110.0 100.0 150.0 130.0 120.0 100.0 140.0 130.0 110.0 90.0 130.0 110.0 80.0 70.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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Map 07: 1% AEP Existing Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Depth (m)

<= 0.0

0.0 - 0.1

0.1 - 0.5

0.5 - 1.0

1.0 - 2.0

> 2.0

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 08: 1% AEP Existing Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Velocity (m/s)

- <= 0.03 (not shown)
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 09: 1% AEP Existing Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 010: 1% AEP Existing Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

130.0 120.0 110.0 110.0 100.0 150.0 130.0 120.0 100.0 130.0 140.0 110.0 90.0 130.0 110.0 80.0 70.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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Map 011: 0.5% AEP Existing Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Depth (m)

<= 0.0

0.0 - 0.1

0.1 - 0.5

0.5 - 1.0

1.0 - 2.0

> 2.0

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 012: 0.5% AEP Existing Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Velocity (m/s)

- <= 0.03 (not shown)
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 013: 0.5% AEP Existing Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 014: 0.5% AEP Existing Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

FOREST WAY

PERENTIE RD

MORGAN RD

130.0 120.0 110.0 110.0 100.0 130.0 120.0 130.0 140.0 150.0 130.0 110.0 100.0 90.0 110.0 80.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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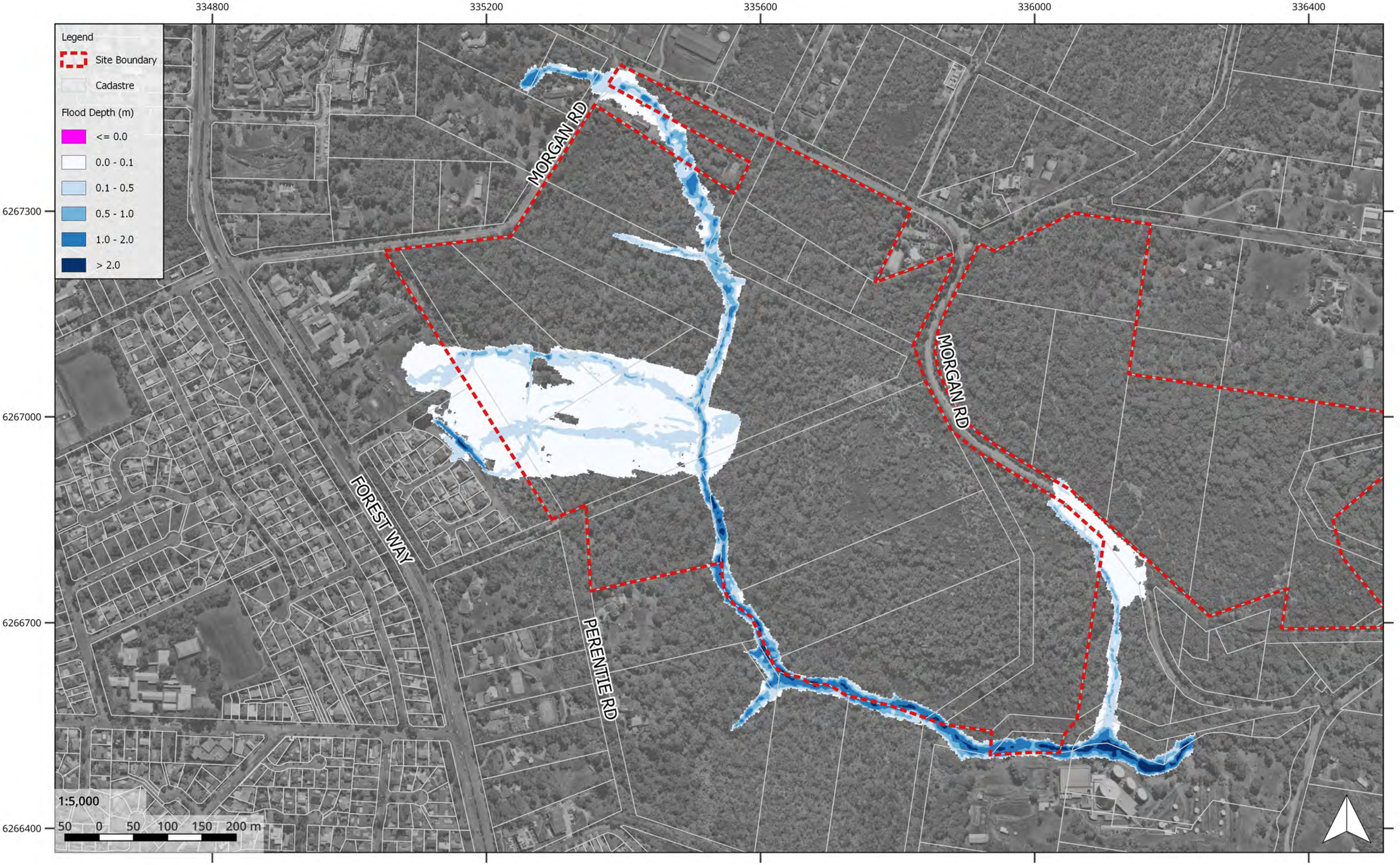
Map 015: 0.2% AEP Existing Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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Map 016: 0.2% AEP Existing Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Velocity (m/s)

- <= 0.03 (not shown)
- 0.03 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.30
- 0.30 - 0.40
- 0.40 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 2.00
- 2.00 - 3.00
- > 3.00

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 017: 0.2% AEP Existing Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 018: 0.2% AEP Existing Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

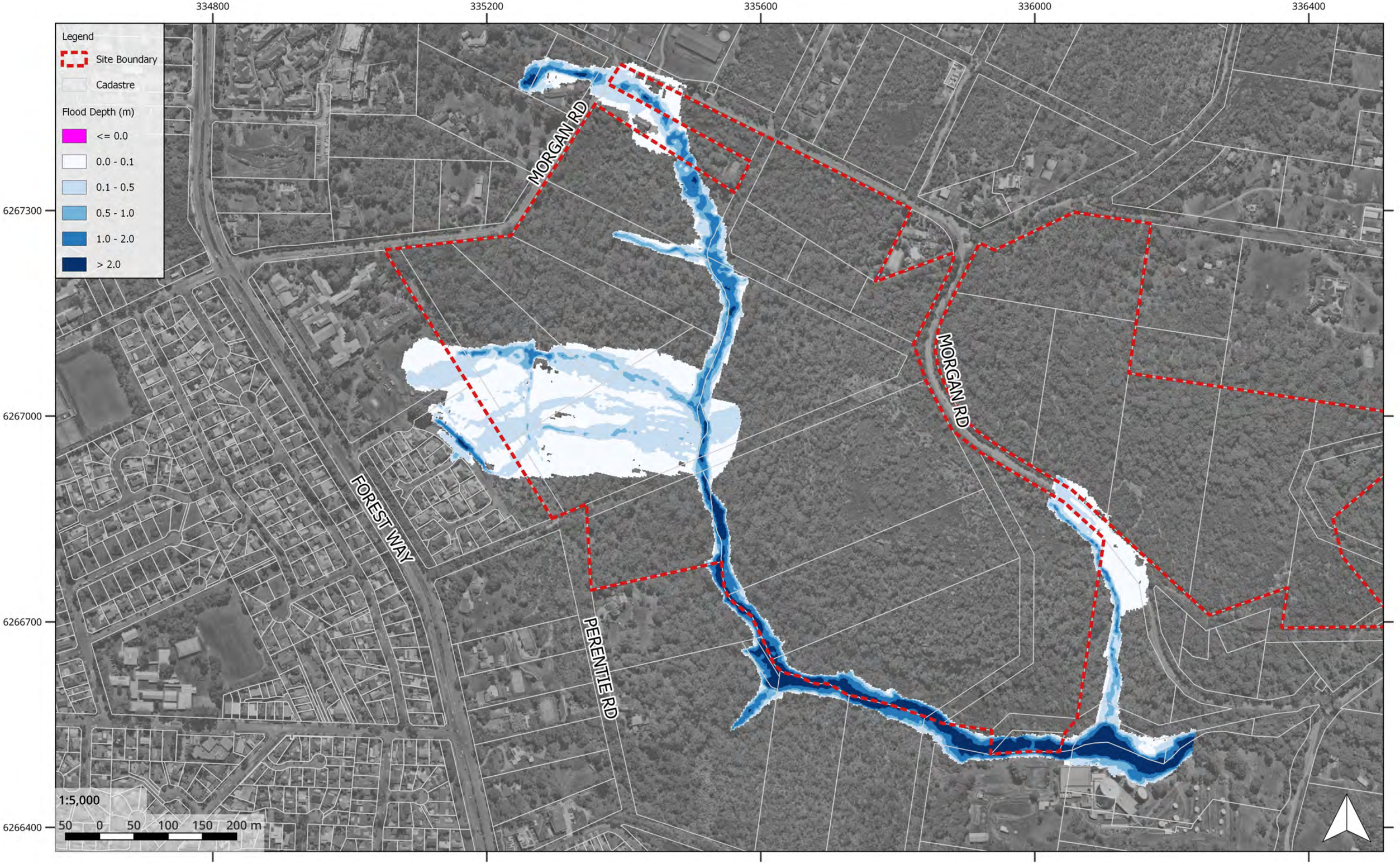
1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

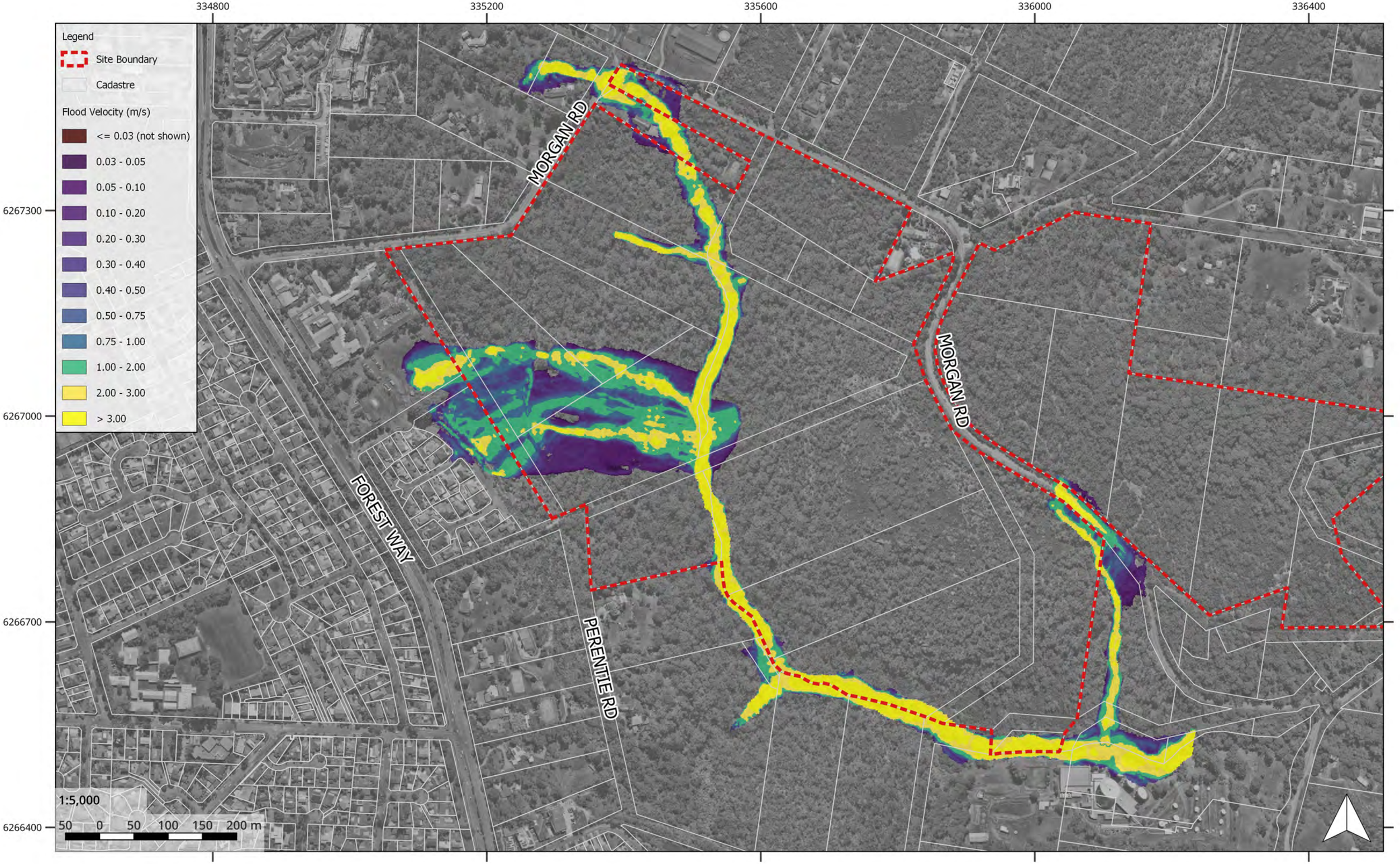
Map 019: PMF Existing Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 020: PMF Existing Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 021: PMF Existing Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 022: PMF Existing Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

120.0 110.0 110.0 100.0 140.0 130.0 120.0 110.0 100.0 150.0 90.0 130.0 120.0 110.0 100.0 150.0 140.0 80.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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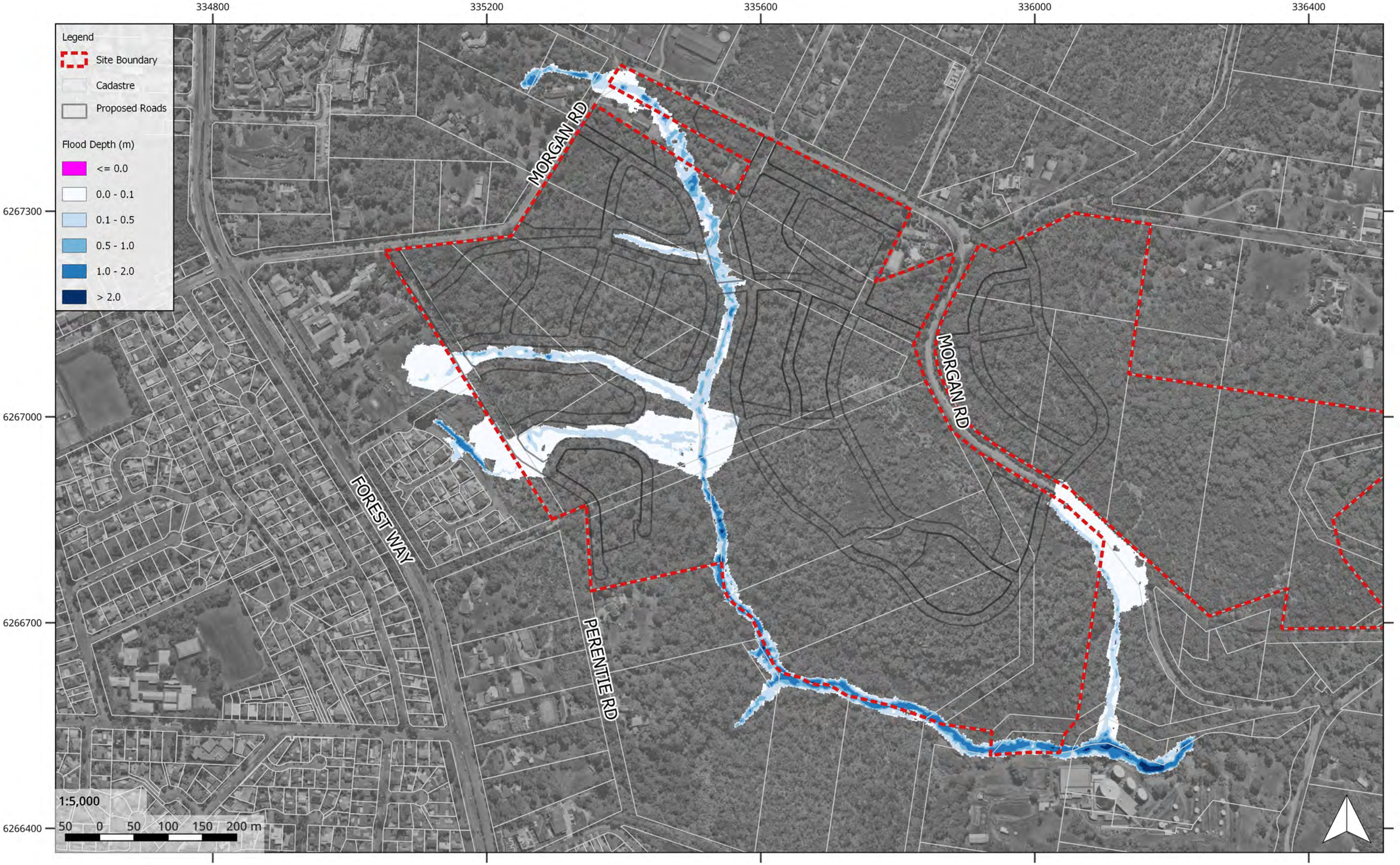
Map 030: 5% AEP Proposed Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 031: 5% AEP Proposed Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Velocity (m/s)

<= 0.03 (not shown)

0.03 - 0.05

0.05 - 0.10

0.10 - 0.20

0.20 - 0.30

0.30 - 0.40

0.40 - 0.50

0.50 - 0.75

0.75 - 1.00

1.00 - 2.00

2.00 - 3.00

> 3.00

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 032: 5% AEP Proposed Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 033: 5% AEP Proposed Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

FOREST WAY

PERENTIE RD

MORGAN RD

130.0 120.0 110.0 110.0 100.0 140.0 130.0 120.0 110.0 100.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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Map 034: 1% AEP Proposed Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Depth (m)

<= 0.0

0.0 - 0.1

0.1 - 0.5

0.5 - 1.0

1.0 - 2.0

> 2.0

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Colliers Engineering & Design (NSW) Pty Ltd endeavours to ensure that the information provided in this map is correct at the time of publication. Colliers Engineering & Design (NSW) Pty Ltd does not warrant, guarantee or make representations regarding the currency and accuracy of information contained within this map.

Map 035: 1% AEP Proposed Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

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Map 036: 1% AEP Proposed Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

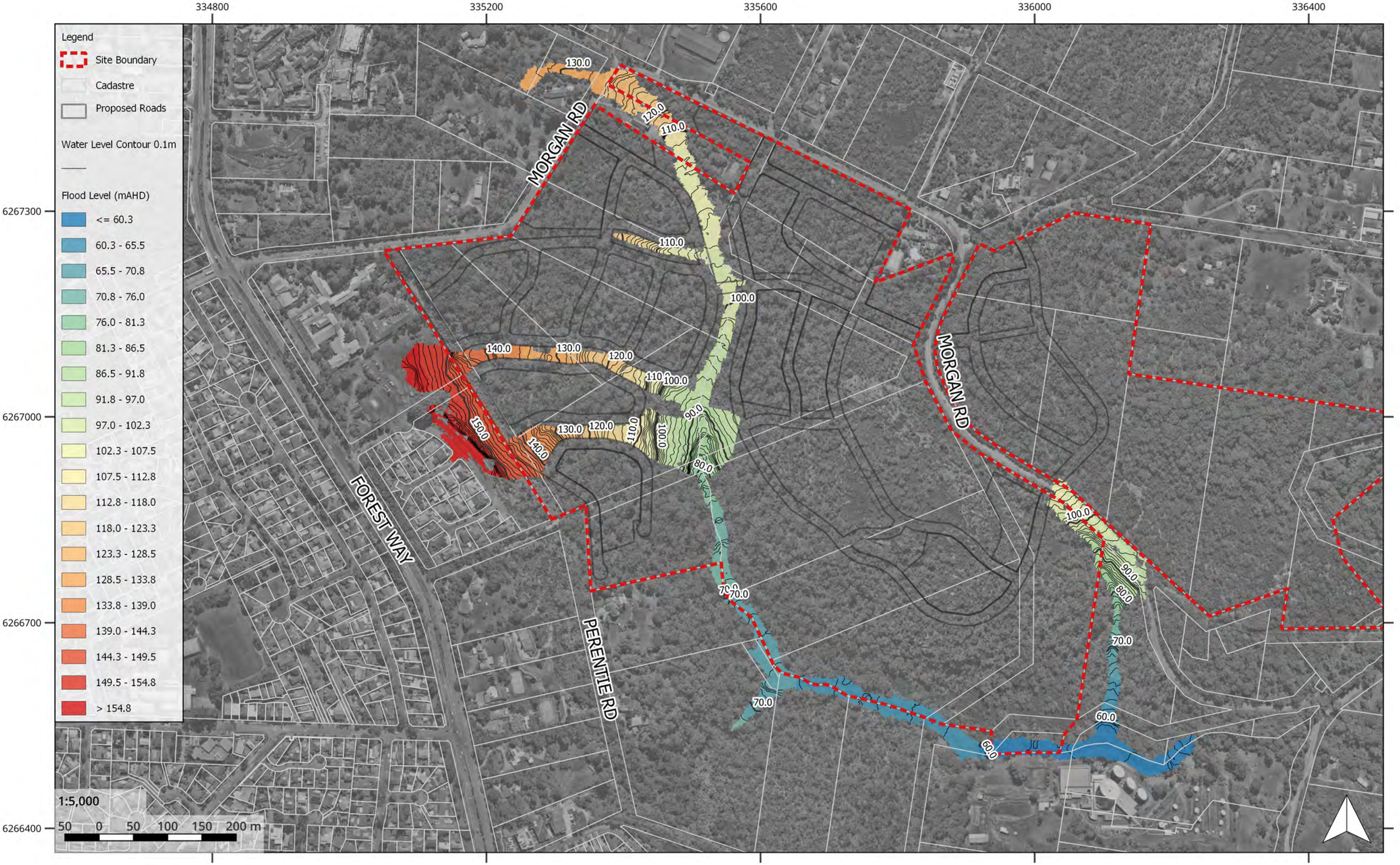
PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 037: 1% AEP Proposed Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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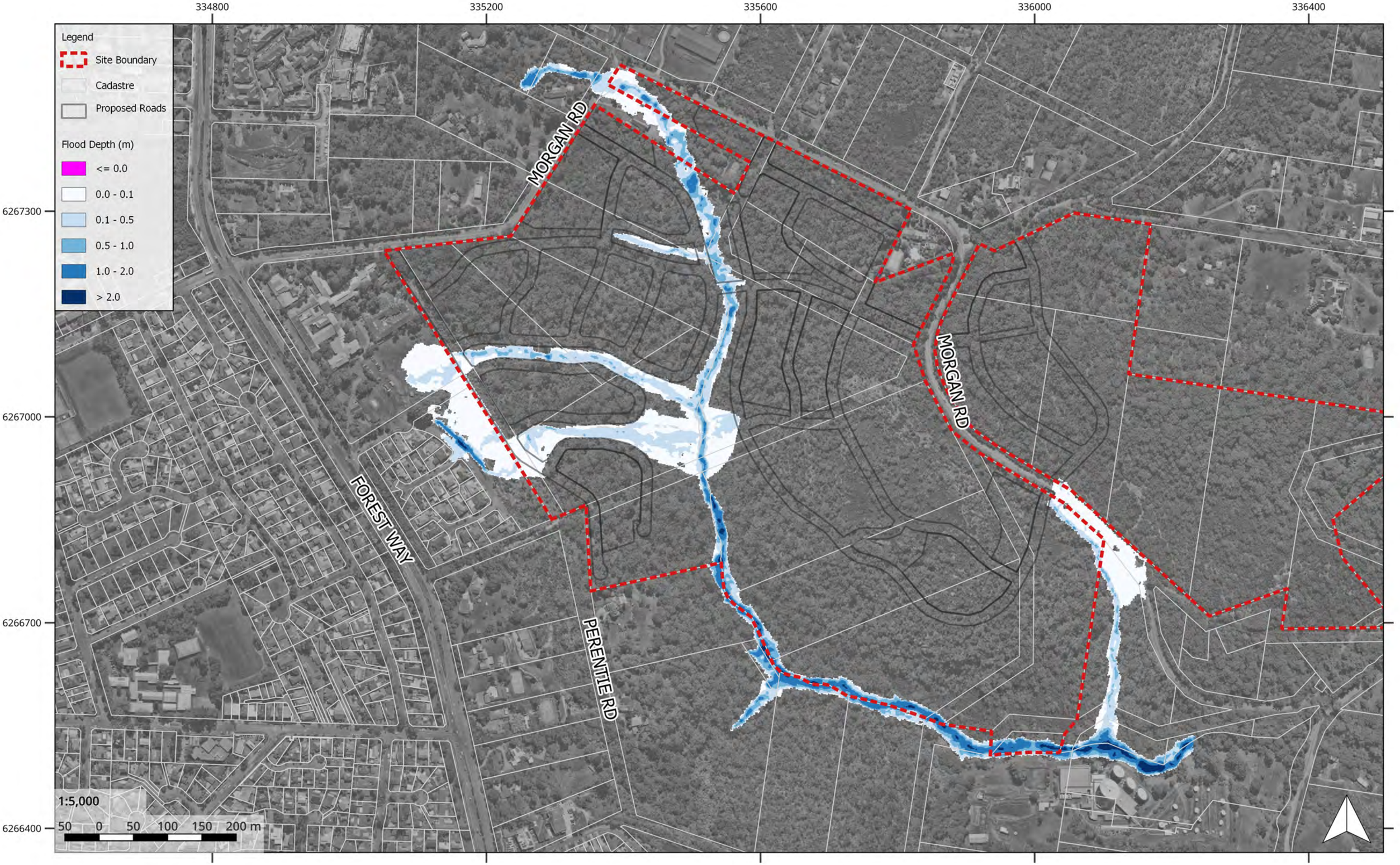
Map 038: 0.5% AEP Proposed Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



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Map 039: 0.5% AEP Proposed Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Velocity (m/s)

<= 0.03 (not shown)

0.03 - 0.05

0.05 - 0.10

0.10 - 0.20

0.20 - 0.30

0.30 - 0.40

0.40 - 0.50

0.50 - 0.75

0.75 - 1.00

1.00 - 2.00

2.00 - 3.00

> 3.00

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 040: 0.5% AEP Proposed Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 041: 0.5% AEP Proposed Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

FOREST WAY

PERENTIE RD

MORGAN RD

130.0 120.0 110.0 110.0 100.0 140.0 130.0 120.0 110.0 100.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Colliers

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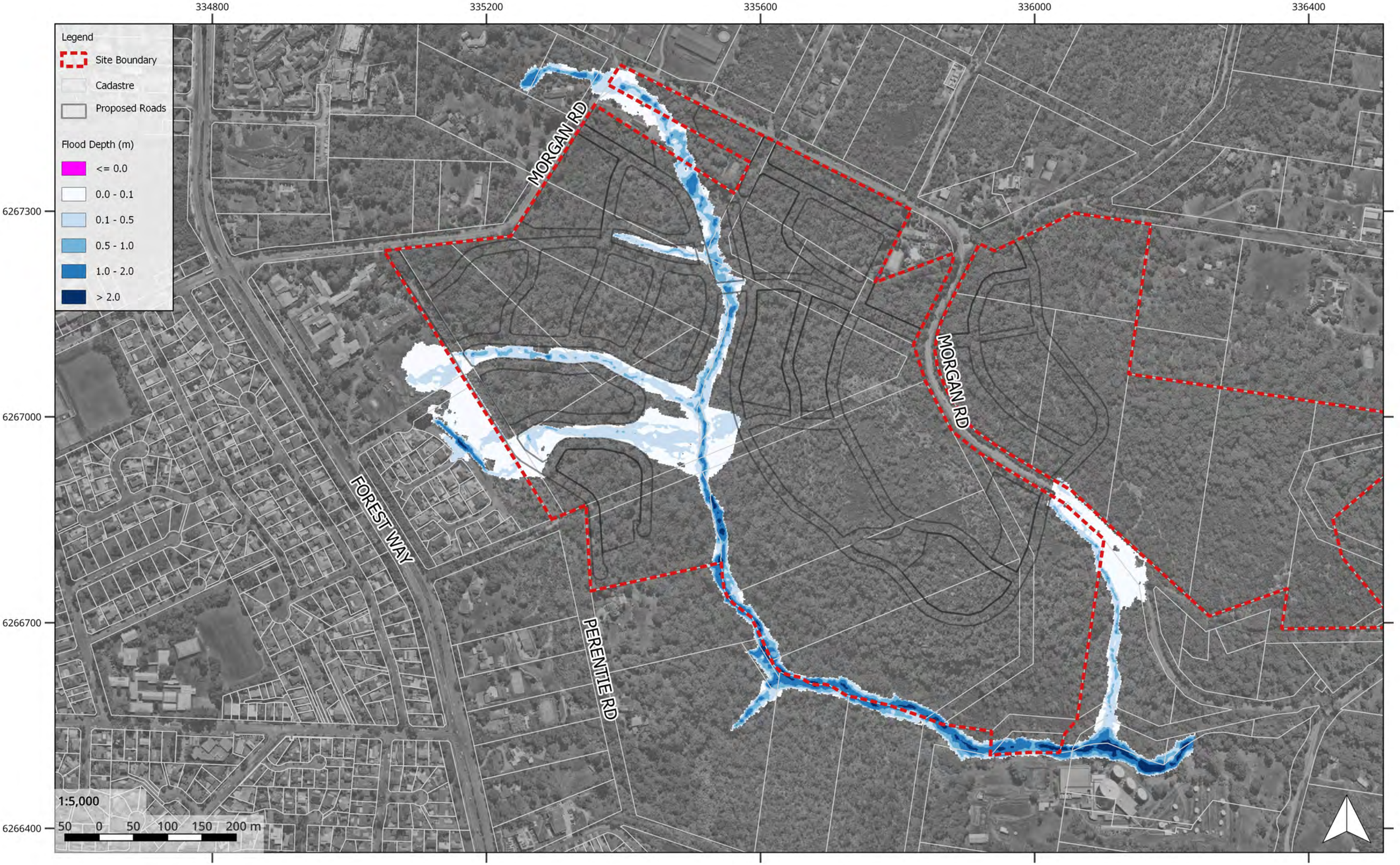
Map 042: 0.2% AEP Proposed Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



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Map 043: 0.2% AEP Proposed Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

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Map 044: 0.2% AEP Proposed Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 045: 0.2% AEP Proposed Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Water Level Contour 0.1m

Flood Level (mAHD)

- <= 60.3
- 60.3 - 65.5
- 65.5 - 70.8
- 70.8 - 76.0
- 76.0 - 81.3
- 81.3 - 86.5
- 86.5 - 91.8
- 91.8 - 97.0
- 97.0 - 102.3
- 102.3 - 107.5
- 107.5 - 112.8
- 112.8 - 118.0
- 118.0 - 123.3
- 123.3 - 128.5
- 128.5 - 133.8
- 133.8 - 139.0
- 139.0 - 144.3
- 144.3 - 149.5
- 149.5 - 154.8
- > 154.8

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

130.0 130.0 120.0 110.0 120.0 110.0 100.0 140.0 130.0 120.0 110.0 100.0 150.0 140.0 130.0 120.0 110.0 100.0 90.0 80.0 70.0 70.0 70.0 100.0 90.0 80.0 70.0 60.0 60.0 60.0

1:5,000

50 0 50 100 150 200 m

Map 046: PMF Proposed Flood Levels
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Depth (m)

<= 0.0

0.0 - 0.1

0.1 - 0.5

0.5 - 1.0

1.0 - 2.0

> 2.0

MORGAN RD

MORGAN RD

FOREST WAY

PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

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Map 047: PMF Proposed Flood Depth
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

Colliers

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Map 048: PMF Proposed Flood Velocity
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Cadastre

Proposed Roads

Flood Hazard Category

H1 - Generally Safe for people, vehicles and buildings

H2 - Unsafe for small vehicles

H3 - Unsafe for vehicles, children and the elderly

H4 - Unsafe for people and vehicles

H5 - Unsafe for vehicles and people.
All buildings vulnerable to structural damage.
Some less robust building types vulnerable to failure.

H6 - Unsafe for vehicles and people.
All building types considered vulnerable to failure.

MORGAN RD

MORGAN RD

FOREST WAY

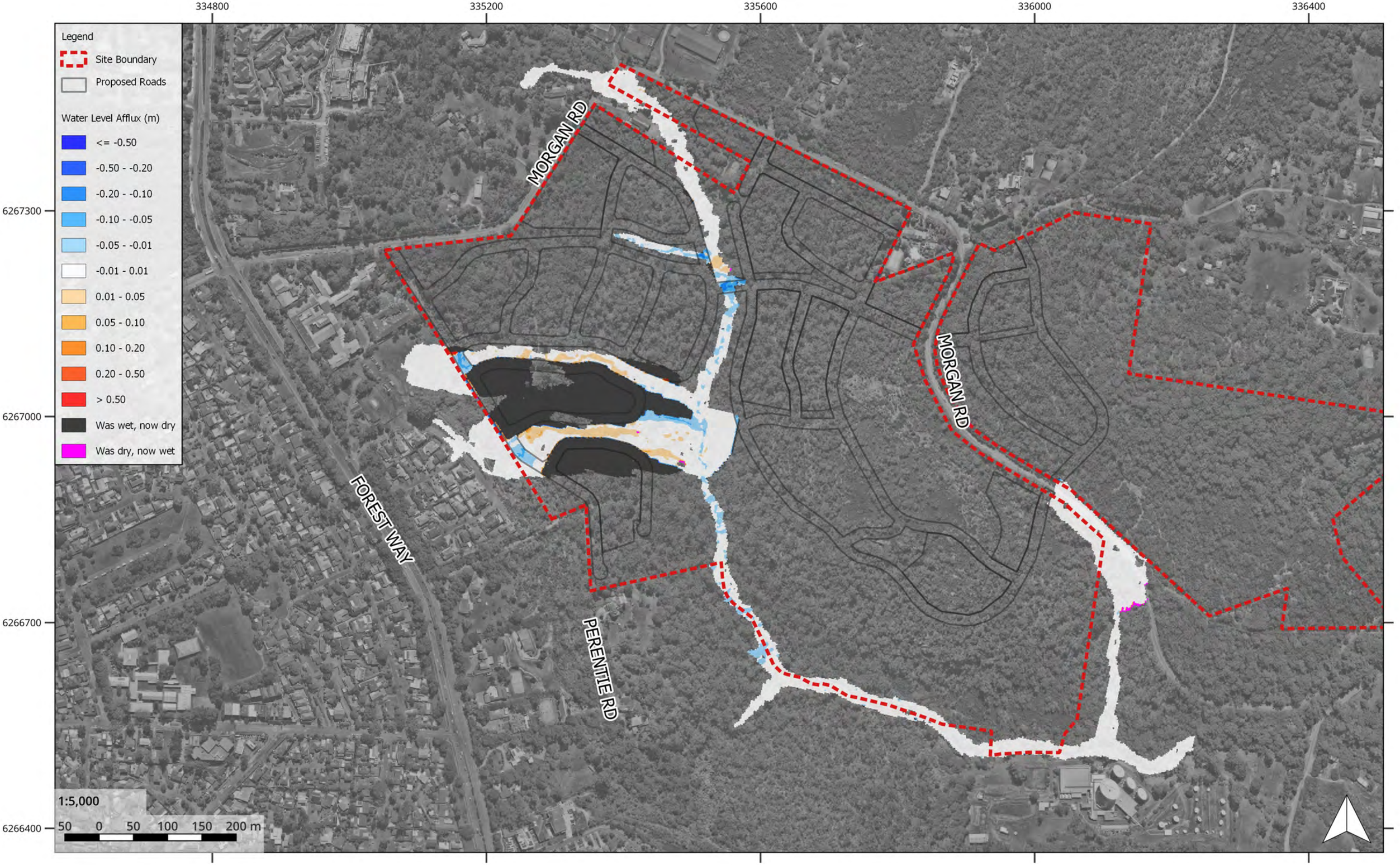
PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 049: PMF Proposed Flood Hazard
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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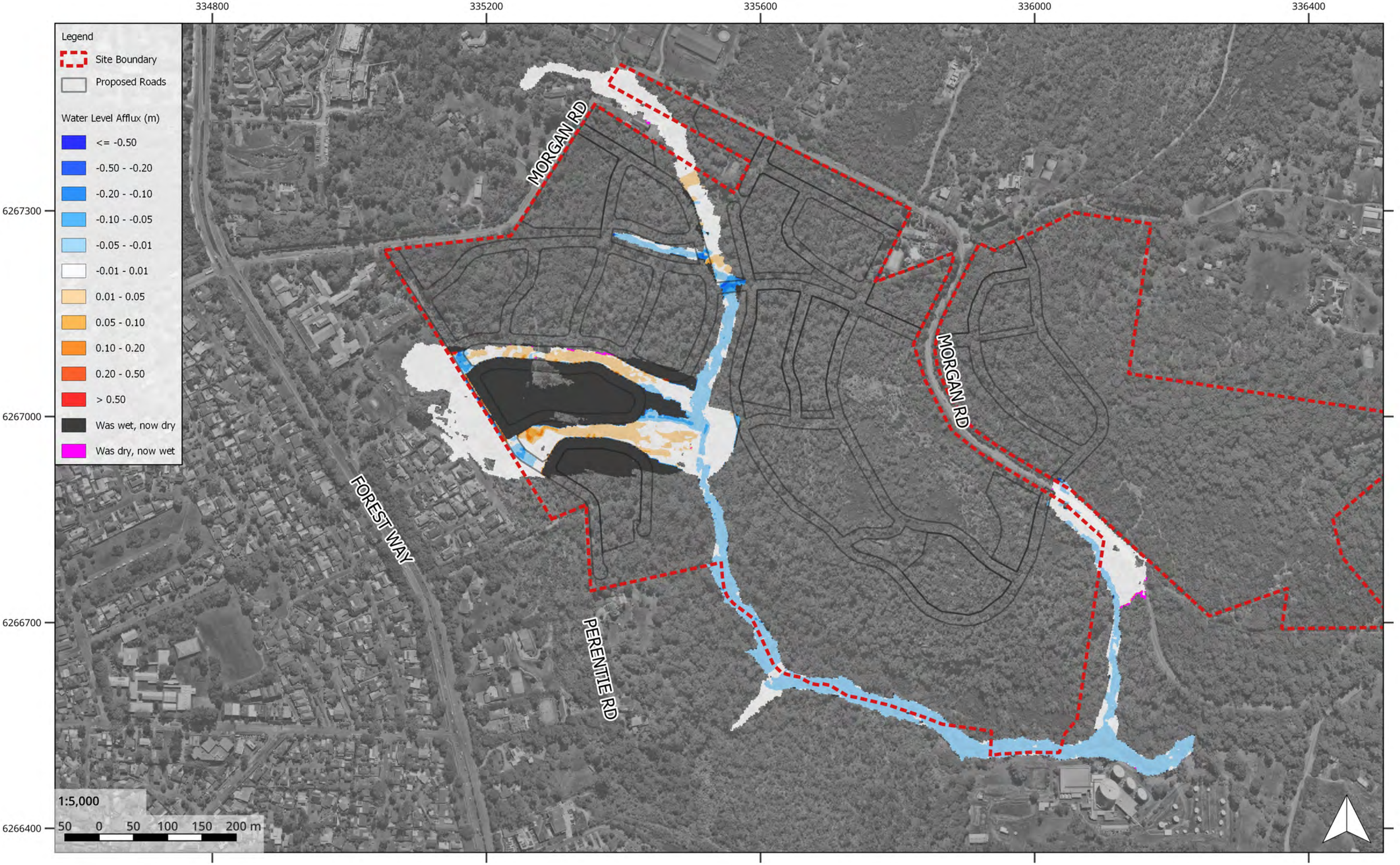
Map 070: 5% AEP Flood Afflux
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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Map 071: 0.5% AEP Flood Afflux (Climate Change)
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

Site Boundary

Proposed Roads

Water Level Afflux (m)

- <= -0.50
- -0.50 - -0.20
- -0.20 - -0.10
- -0.10 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.10
- 0.10 - 0.20
- 0.20 - 0.50
- > 0.50
- Was wet, now dry
- Was dry, now wet

MORGAN RD

MORGAN RD

FOREST WAY

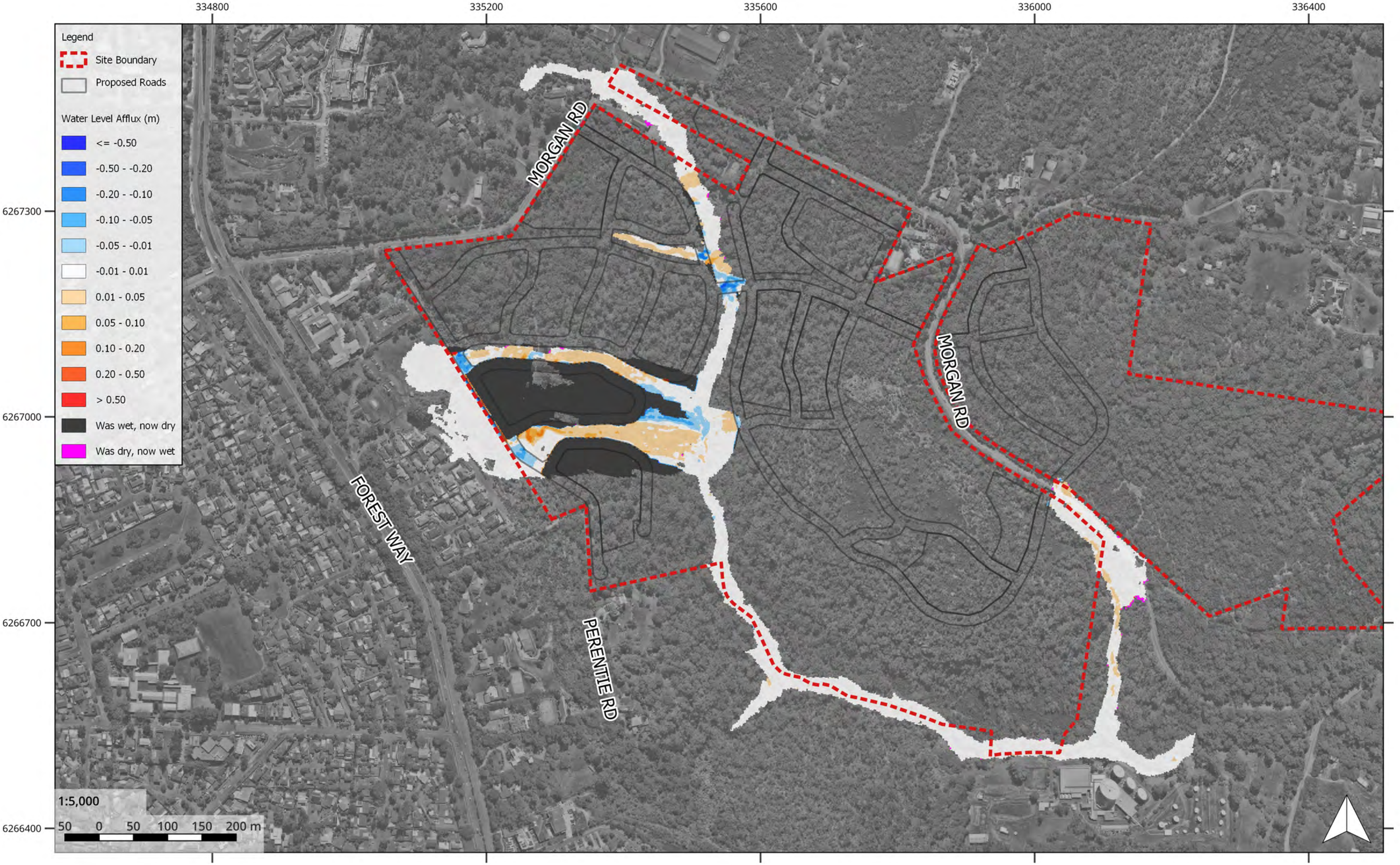
PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 071: 1% AEP Flood Afflux
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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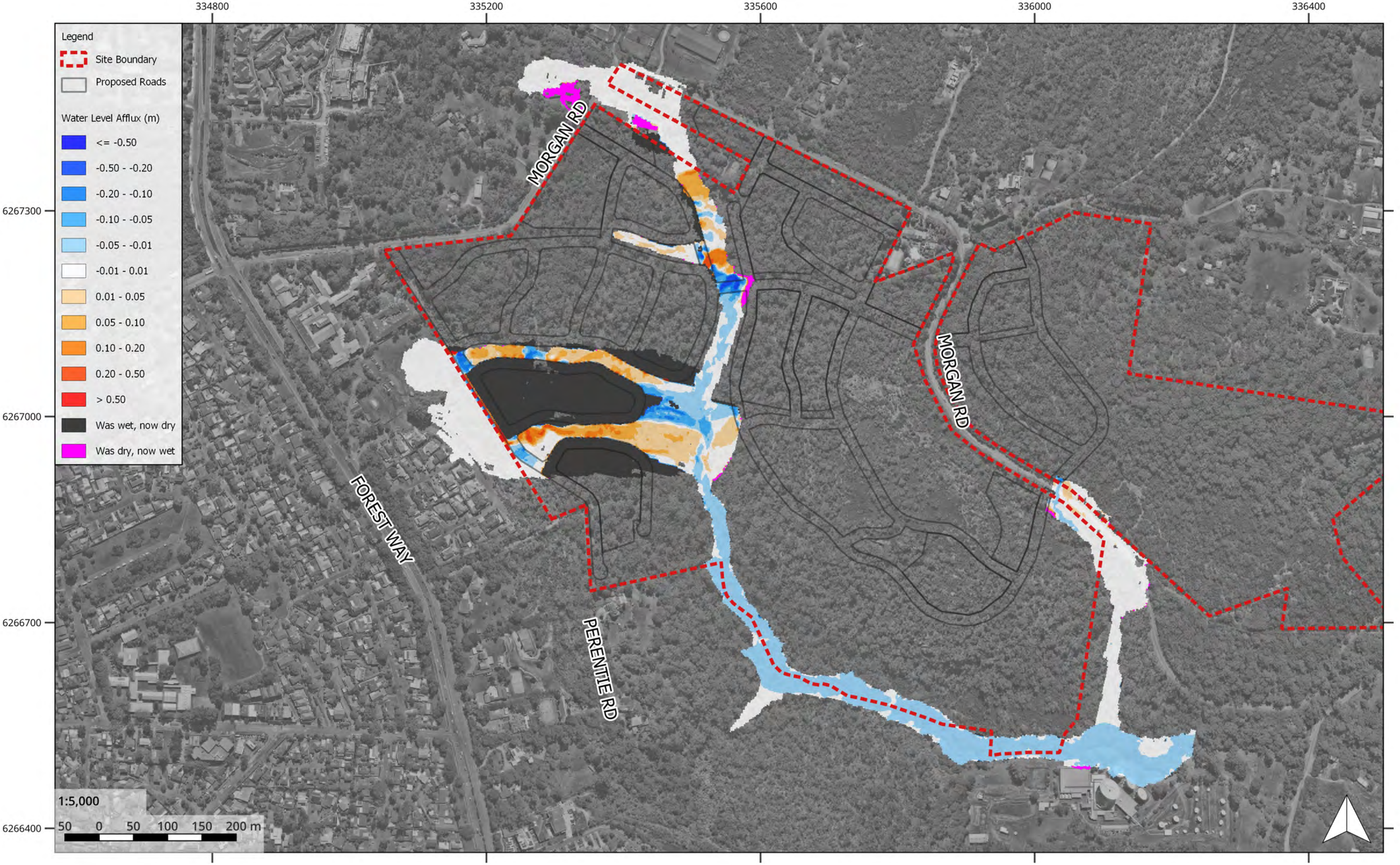
Map 073: 0.2% AEP Flood Afflux (Climate Change)
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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Map 074: PMF Flood Afflux
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

Colliers

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Map 080: 5% AEP Flood Extent Comparison
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

- Site Boundary
- Cadastre
- Proposed Roads
- Proposed Flood Extent
- Existing Flood Extent

MORGAN RD

MORGAN RD

FOREST WAY

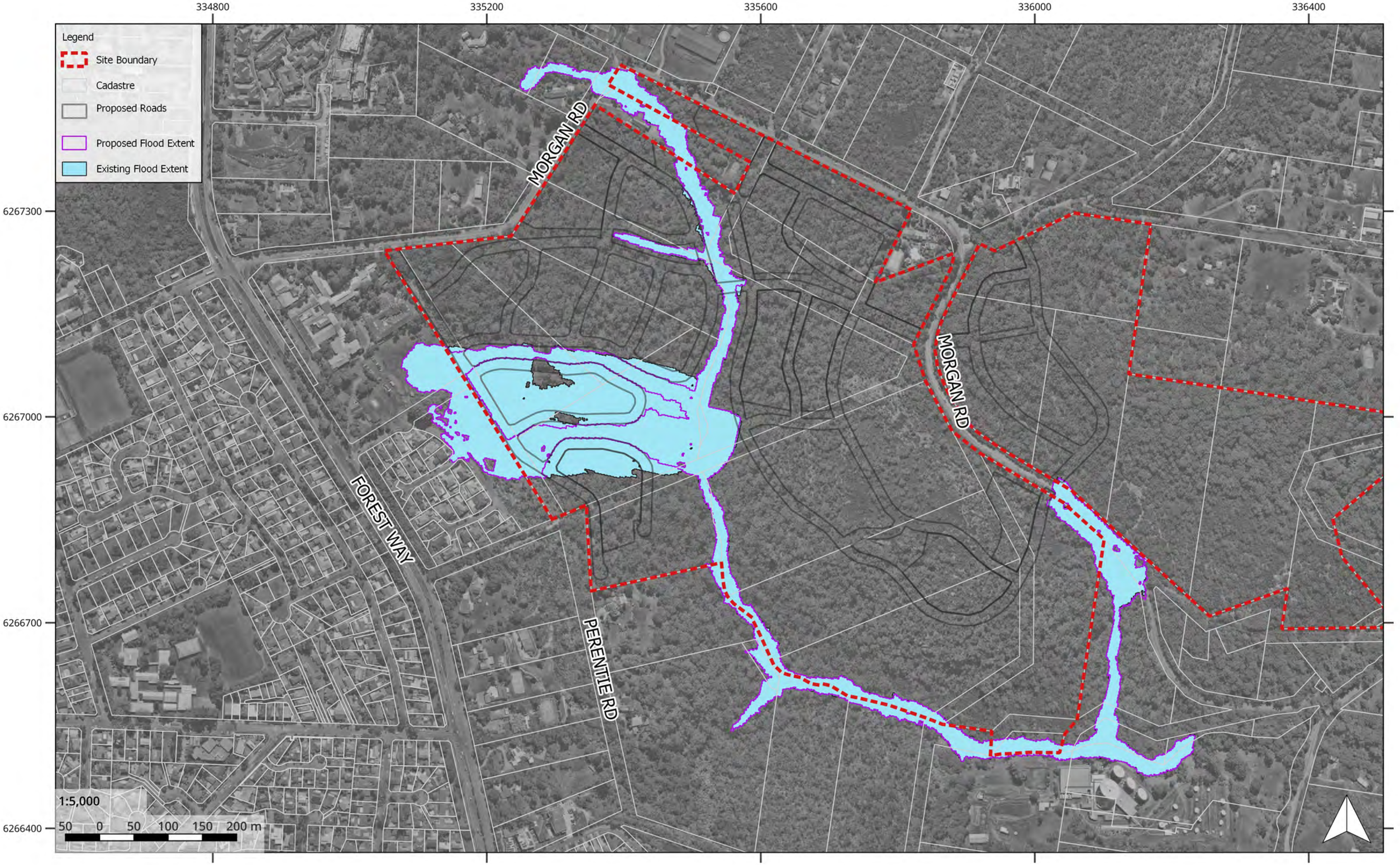
PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 081: 1% AEP Flood Extent Comparison
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

Map 082: 0.5% AEP Flood Extent Comparison
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

334800 335200 335600 336000 336400

6267300

6267000

6266700

6266400

Legend

- Site Boundary
- Cadastre
- Proposed Roads
- Proposed Flood Extent
- Existing Flood Extent

MORGAN RD

MORGAN RD

FOREST WAY

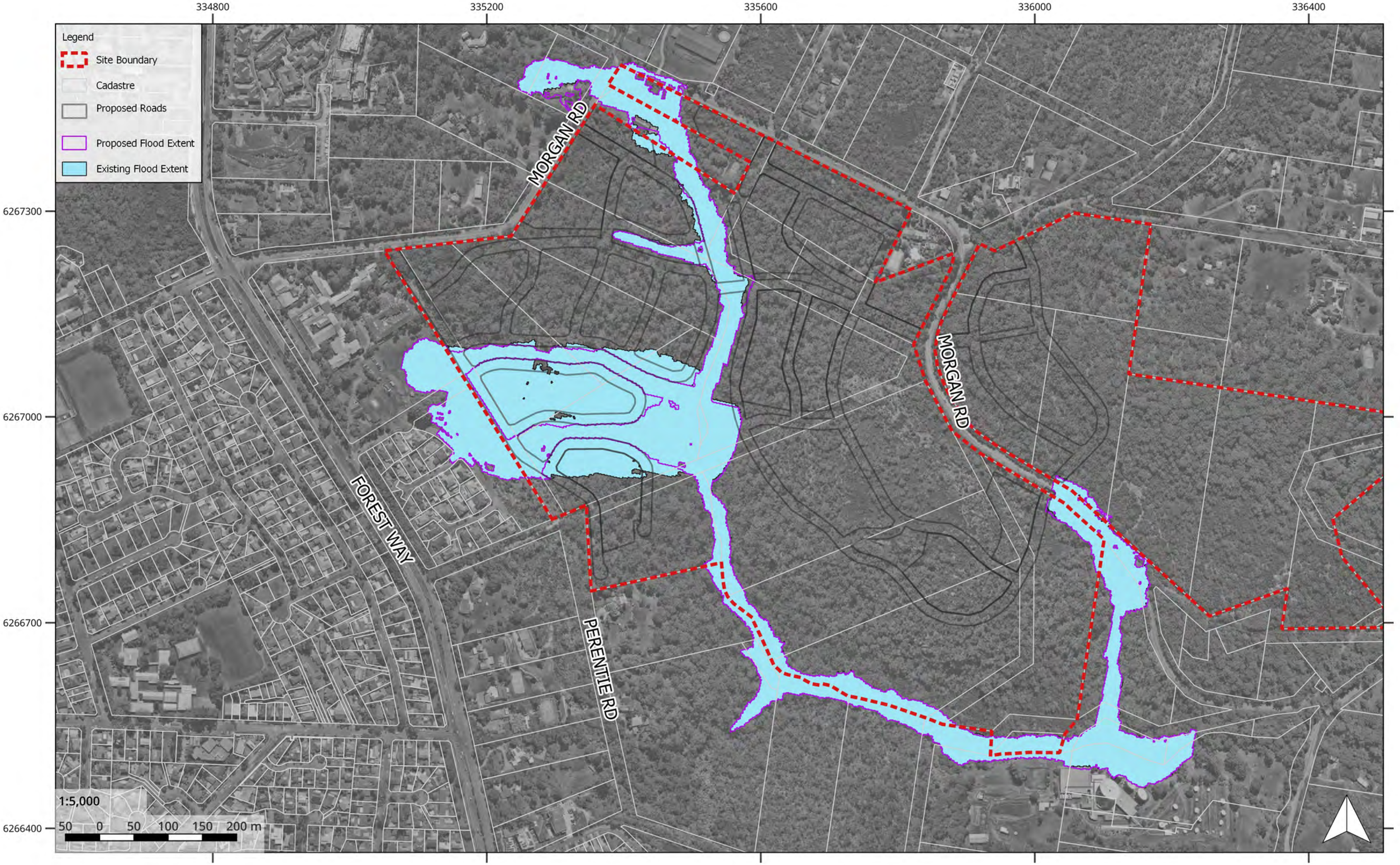
PERENTIE RD

1:5,000

50 0 50 100 150 200 m

Colliers

Map 083: 0.2% AEP Flood Extent Comparison
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council



Colliers

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Map 084: PMF Flood Extent Comparison
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

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Map 090: Flood Planning Area
Project: Planning Proposal (Morgan Road, Belrose)
Project Number: 096-16
Client: Metropolitan Local Aboriginal Land Council

Appendix D – CVs

Minh Vu

Director, Engineering | NSW
Engineering & Design

minh.vu@colliers.com
Main: (02) 9869 1855
colliers.com.au/ced

7/3 Rider Blvd,
Rhodes NSW 2138

Qualifications & Accreditations

Bachelor of Engineering (Civil)

Master's Degree in Project Management

Master's Degree in Engineering Science

Chartered Professional Engineer (CPEng,NER)
Fellow of the the Institution of Engineers Australia (FIEAust)

Registered Professional Engineer of Queensland (RPEQ)
Design & Building Practitioner (Fair Trading NSW)

Memberships & Affiliations

Fellow of the Institution of Engineers Australia (FIEAust)
APEC Engineer

Area of Expertise

Minh is a highly accomplished Chartered Professional Engineer (CPEng, NER, FIEAust) with over 18 years of industrial experience, currently leading Colliers' engineering team. In this role, he ensures the quality and timely delivery of engineering design projects. Minh possesses extensive expertise in civil engineering design, project management, master planning, and construction. At Colliers, Minh has successfully guided our engineering team in providing top-notch services to clients spanning the Sydney Metropolitan and Illawarra Region.

His skill set encompasses road design, bulk earthworks design, stormwater design, flood study, water-sensitive urban design, project management, and master planning. Minh's unwavering dedication to excellence and his diverse capabilities make him an asset at Colliers.

Professional Accomplishments

West Dapto, Wollongong NSW for Newquest Property

Civil Engineering design, surveying, superintendent, and project management to deliver several subdivisions (Sanctuary View & Lynden View) consists of approx. 500 lots from Neighbourhood Plan, DA, SWC and Subdivision Certificate.

Minh involved with utility services relocation, road design, earthwork, retaining wall, **Stormwater Design and Flooding including On-Site Detention & WSUD** and Construction Contract Management.

Ardeness, Edmondson Park Liverpool for Allam Homes

Civil Engineering design and project management to deliver a mix of residential and Strata subdivision consists of appox.450 lots from DA, SWC and Subdivision Certificate.

Minh involved with Rezoning, WIK, Transgrid approval, road design, earthwork, **Stormwater Design and Flood including regional On-Site Detention & WSUD** and Construction Contract Management.

Clemton Park Village, Bankstown-Canterbury NSW for Frasers Property

Minh was responsible for Civil Engineering Design to obtain WSC, Contract Management and Construction Coordination for the urban-infill mixed use development in Sydney's South-West comprising 800+ units, integrating design with proposed green spaces, commercial and residential dwellings. In addition, Minh was **responsible for the design and delivery of stormwater infrastructure including a significant under public road On-Site Detention system in satisfaction of the local authority.**

Cleveland Planning Proposal, Wollongong NSW for Newquest Property

Land Surveying, Master Planning and Civil Engineering designs for a Planning Proposal over multiple land holdings at Cleveland Road, Cleveland.

Minh involves with the rezoning & master planning of approx. 3,000 + medium and low-density dwellings integrating with schools, town centres, sporting fields, riparian corridors, **stormwater quality & quantity measures, flood mitigation,** major publics road (S 7.11), open spaces and Sydney Water infrastructures to support the proposed development.

Lowes Creek Maryland Planning Proposal, Camden NSW for Macarthur Developments

Lowes Creek Maryland is a new precinct planned for Sydney's Southwest Growth Area which spans over approximately 517 hectares roughly 8km south of the proposed Western Sydney Aerotropolis.

Minh involves with the water cycle management study & master planning of approx. 8,000 + medium and low-density dwellings integrating with town centres, sporting fields, riparian corridors, **stormwater quality & quantity measures, flood mitigation,** major publics road (S 7.11), open spaces and Sydney Water infrastructures to support the planning proposal.

Land Environmental Court – Stormwater Expert Witness

Case Number: 2022/00099956
Applicant: More Human Property No1. PTY LTD
Respondent: Campbelltown City Council

Minh was the stormwater expert witness for a proposed commercial development located at 192 Narellan Road, Campbelltown. The design includes stormwater pit and pipe networks, a stormwater wetland system involving floating grass panels for the purpose of stormwater treatment.

Land Environmental Court – Civil Engineering Expert Witness

Case Number: 2022/00303272
Applicant: Leda Holdings Pty Ltd
Respondent: Sutherland Shire Council

Minh was the civil engineering expert witness for a proposed industrial development located at 1A/1B/1C Box Road, Caringbah. The design includes road & drainage design, bulk earthworks, and industrial driveways.

Leo Zhou

Civil Engineer | NSW
Engineering & Design

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Main: (02) 9869 1855
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7/3 Rider Blvd,
Rhodes NSW 2138

Qualifications & Accreditations

Bachelor of Engineering (Civil Engineering, Honours Class 1)

Membership & Affiliations

Member of Engineers Australia with NER

Area of Expertise

Leo is a talented civil engineer who has been working for over 5 years in hydrology and flood modelling, boasting extensive experience in diverse projects encompassing subdivision developments, including residential, commercial, and industrial sectors, as well as regional precinct-level initiatives.

Proficient in tools such as TUFLOW, QGIS, DRAINS, XP-RAFTS and 12D, Leo plays a pivotal role in hydrology and flood modelling, contributing to effective flood management strategies. His expertise extends to encompass stormwater design and road geometric design, ensuring comprehensive and integrated solutions in his projects. Leo's wealth of experience positions him as a valuable asset in navigating the complexities of water-related challenges, making significant contributions to the success of

Professional Accomplishments

Catherine Field Planning Proposal

Concept stormwater detention basin, road and earthworks grading design for the Catherine Field Planning Proposal within the Catherine Field Precinct, as well as detailed and iterative flood modelling of the proposed options to produce an effective and working design.

Mt. Maryland Planning Proposal

Detailed flood modelling of the proposed earthworks and detention basins across the Mt. Maryland Precinct, including the hydrologic modelling, to produce an effective and working design.

Austral and Leppington Subdivision Projects

Lead civil designer and flood modeller for various subdivision projects in the Austral and Leppington area currently in the concept DA and SWC stage.

15 Nicholson Road, Woonona Residential Development

Major involvement with the earthworks, stormwater design and flood modelling for the proposed 26 multi-dwelling townhouses with associated basement car parking which is currently being assessed in the Land and Environment Court. Provided support and assistance with the modelling required for the court proceedings.

1 Bowtells Drive, Avoca Beach

Led the flood modelling (TUFLOW) for the development application of a caravan park adjacent to an intermittently closed and open coastal lagoon with complex hydraulic processes.

Culburra Beach

Mixed-Use State Significant Development. In charge of the estuary processes and pollutant transport modelling (TUFLOW AD) of the Crookhaven River for a proposed approximately 46 ha urban development west of the township of Culburra Beach.

Colliers International Engineering & Design (NSW) Pty Ltd | ABN 77 050 209 991
Level 7, 3 Rider Blvd Rhodes NSW 2138
Main: +61 2 9869 1855

Memo

Ref 096-16

To:	Department of Planning & Environment
From:	Colliers International Engineering & Design
Date:	12th December 2023
Subject:	Re: Planning Proposal – Patyegarang Morgan Rd Belrose – SES response

In response to letter by NSW State Emergency Services (SES) dated 22 November 2023 to Northern Beaches Council in relation to Planning Proposal at Morgan Rd Belrose know as Patyegarang we provide the following advice in relation to the matters raised by the SES as follows;

SES Statement

The consent authority will need to ensure that the planning proposal is considered against the relevant Ministerial Section 9.1 Directions, including 4.1 – Flooding and is consistent with the NSW Flood Prone Land Policy as set out in the Flood Risk Management Manual 2023 (the Manual) and supporting guidelines, including the Support for Emergency Management Planning. Key considerations are outlined in Attachment A.

CED Response

Noted and agreed.

SES Statement

Recommend ensuring that rising road access is available for all proposed dwellings on the site.

Recommend ensuring that the community is aware of the significant flood risk on nearby roads such as Oxford Falls Road and Wakehurst Parkway, for example, through appropriate signage.

Request flood modelling maps detailing the 1% AEP and PMF levels, as although these were requested by NSW SES during the meeting held on 12 October 2023, these were not provided to NSW SES prior to the writing of this response.

Note that the modelling demonstrates overall increases to peak flow for most post-development scenarios.

Note that the site has slope gradients reaching up to 35% and may therefore pose a risk of overland flow flooding on the site and therefore recommend this is assessed.

CED Response

In response to the matters raised by the SES, CED refer the SES to the Craig & Rhodes / CED FIRA Report dated July 2023 that contains detailed TUFLOW flood modelling and mapping that demonstrates the extent of flood behaviour within and adjoining the site. See attached report.

Further matters raised by the SES are addressed as follows;

SES Statement

Any proposed Emergency Management strategy for an area should be compatible with the evacuation strategies identified in the relevant local or state flood plan or by the NSW SES.

CED Response

Northern Beaches Flood Emergency Sub Plan April 2021 by the SES applies to the subject land.

SES Statement

Decisions relating to future development should be risk-based and ensure Emergency Management risks to the community of the full range of floods are effectively understood and managed.

The Flood Impact and Risk Assessment provided states that “the Morgan Road, Belrose site is not deemed as an area which is at risk of either flash flooding or lagoon flooding.”

However, we note that the modelling demonstrates overall increases to peak flow for most post-development scenarios, and that the site has slope gradients of up to 35% and may therefore pose risks of overland flooding.

If possible, we would recommend flood modelling to include the risk of flooding from overland flow, noting if any overland flow paths would overtop roads and put people at risk of isolation due to flooding.

We also note there is an existing flood risk on nearby roads, particularly Oxford Falls Road and Wakehurst Parkway, with several flood rescues attended by NSW SES in recent years.

We recommend that the flood risk on nearby roads and actions that should be undertaken to reduce the potential risk to life should be clearly communicated to all site users, for example through clear signage or active warning measures (e.g. lights/barricades etc).

CED Response

CED are of the view that the FIRA report prepared for the project has modelled the required frequency of storm events from the 5% to the PMF. These maps are contained in the appendix of the FIRA report.

- The 5%, 1%, 0.5% and 0.2% AEP, and the PMF storm events were all modelled, and results compared (see the snip from Section 5 of the report)

- Table 6 in the report demonstrates that in 3 of the 5 storm events (5%, 1%, and PMF) the flows leaving the model at the downstream end in developed conditions are lower than the flows leaving the model in existing conditions, and for the other 2 storm events (0.5% and 0.2% AEP) the flows leaving the model are the same – i.e. there is NO impact due to the development. The downstream location is shown in the third figure.

- Flood mapping was provided for the 1% AEP event only.

- Flood extents comparison between pre- and post- development was provided for all storm events. This demonstrates that flooding is better contained within the Riparian Corridors compared to existing, without impacting the downstream outfall from the site.

Figure 1: Section 5 from the report outlining the storm events modelled.

5 Hydraulic Assessment

5.1 Model Setup

The flood behaviour of the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design storm events under existing (pre-development) and post-development conditions at the site have been modelled using a two-dimensional TUFLOW hydraulic model. The TUFLOW model extends from Forest Way to just upstream of Oxford Falls Road at the downstream boundary.

Figure 2: Table 6 from the report demonstrating that outflows from the model are the same or reduced as a result of the development

Table 6 Peak Flow Comparison Downstream of Site

AEP	Pre-development Flow (m^3/s)	Post-Development Flow (m^3/s)
5%	36.55	35.89
1%	57.44	57.14
0.5%	63.31	63.32
0.2%	77.86	77.86
PMF	298.17	297.63

Figure 3: Illustrates the outflow reporting location for Table 6 above.

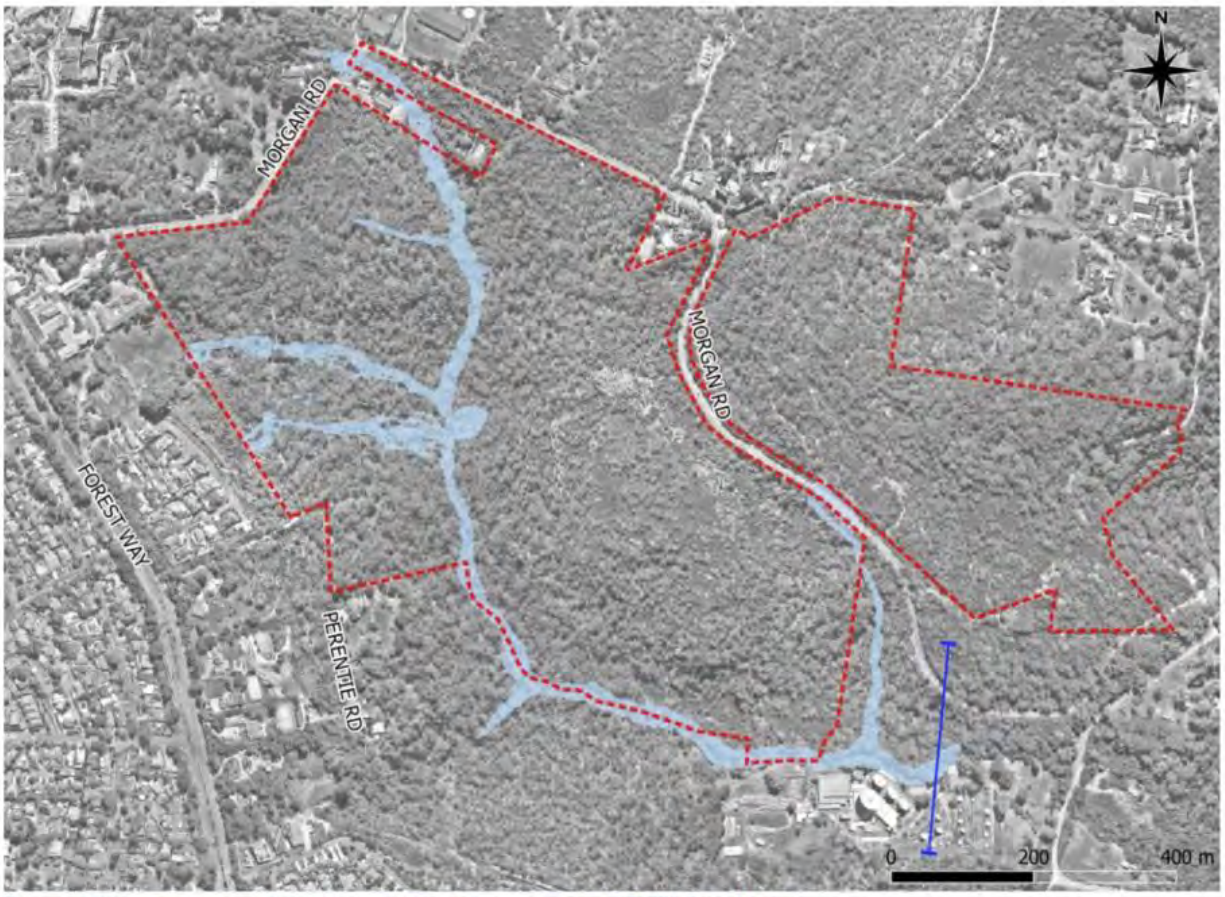

Figure 10 Downstream of Site Observation Location from TUFLOW Model

The flood modelling at the existing section of Morgan Rd where it crosses Snake Creek shows that there is no increase in flood levels as a result of the development in this location.

There is an existing flood risk in this location and this is identified by signage installed by Northern Beaches Council.

Local residents are aware of this risk.

SES Statement

The ability of the existing community to effectively respond (including self-evacuating) within the available timeframe on available infrastructure is to be maintained.

It is not to be impacted on by the cumulative impact of new development.

We recommend ensuring that rising road access is available for all new proposed dwellings, to ensure that people do not become trapped by floodwater, either from creek flooding or overland flow / ponding of water in low points along roads.

CED Response

CED are of the view that a Shelter in Place approach is best suited to this site.

Flood modelling shows that the 1% & PMF floods are contained and defined within the existing creeks and riparian flow paths on the site and they do not overtop in these events.

A shelter in place approach means that residents can safely stay in their dwellings during storm events without adding unnecessarily to already busy roads.

All new roads within the project will rise away from natural flow paths and this will allow a natural escape to higher ground with out the need to pass through flood waters.

SES Statement

The preferred Emergency Management approach is evacuation, where evacuation capacity and capability has been demonstrated as the most effective strategy to manage Emergency Management risks (i.e. a strategy that enables the users of development to self-evacuate to an area outside the floodplain that has adequate services to sustain the community in an orderly planned outcome).

This includes consideration of flood warning and evacuation demand on existing and future access/egress routes considering potential impacts of localised flooding. Where this is not possible any decision involving redevelopment, and in particular increasing population at risk, needs to consider the safety of the community.

This may include provisions such as effective flood warning, a practical safe refuge for the full range and behaviour of flooding (i.e. above the PMF and designed to withstand the associated forces of flooding), and provisions to be able to safely self-sustain for short duration flooding.

Managing these risks requires careful consideration of development type, likely users, and their ability respond to minimise their risks. This includes consideration of:

Isolation – There is no known safe period of isolation in a flood, the longer the period of isolation the greater the risk to occupants who are isolated.

Secondary risks – This includes fire and medical emergencies that can impact on the safety of people isolated by floodwater. The potential risk to occupants needs to be considered and managed in decision-making.

Consideration of human behaviour – The behaviour of individuals such as choosing not to remain isolated from their family or social network in a building on a floor above the PMF for an extended flood duration or attempting to return to a building during a flood, needs to be considered.

Any Emergency Management strategy needs to consider people visiting the area or using a development.

An effective flood warning strategy with clear and concise messaging understood by the community is key to providing the community an opportunity to respond to a flood threat in an appropriate and timely manner.

In terms of the current proposal, the flood risk at the site and actions that should be undertaken to reduce the potential risk to life should be clearly communicated to all site users, for example through signage.

CED Response

CED is aware of the potential risk of flooding & adjoining the site to residents and visitors to the site during flood events.

We are confident that our TUFLOW models show that the flood paths crossing the site are well defined and contained within creek banks and corridors so as to not present a risk from overtopping and sheet flows.

The site is located at the top of the drainage catchment and as such storm events are relatively short and unlikely to create riverine flooding.

In our opinion a SHELTER IN PLACE strategy is best suited to the location.

As the project is a Community Title development the Community Management Association can develop a Emergency Management Plan for all land owners and visitors that provides evacuation options in the event of a major storm event.

Company License No: A-55555

Yours truly,

Andrew Halmarick
NSW State Director CED

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Colliers International Engineering & Design (NSW) Pty Ltd
ABN 77 050 209 991

Department of Planning and Environment
4 Parramatta Square, 12 Darcy Street
Parramatta NSW 2150

16/01/2024
096-16

Attn: Lauren Templeman
Specialist Planning Officer

Dear Lauren,

Re: Response to Flooding Related Comments from Environment and Heritage Group (EHG) Regarding Planning Proposal Patyegarang (PP-2022-3802)

Colliers Engineering & Design (formerly Craig & Rhodes) have previously prepared a Flood Impact and Risk Assessment (FIRA) report and Stormwater Management Report to support the Patyegarang planning proposal at Morgan Road, Belrose. The planning proposal project was submitted by Gyde dated July 2023 and has been reviewed by the Environment and Heritage Group (EHG), who have provided detailed commentary on flood risk management issues. The commentary is attached to the letter from the Department of Planning and Environment dated 21 November 2023 (refer to Attachment A).

This document has been prepared to detail Colliers' response to EHG's comments regarding flood risk management issues. Further information or clarification regarding this work can be obtained by contacting the undersigned.

Sincerely,

Kylee Smith
Senior Civil Engineer
Colliers Engineering & Design NSW

RFI Response

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
Flood Risk Management	-
Summary The planning proposal seeks to alter a provision that affects flood prone land. EHG has reviewed the supporting information for the planning proposal and considers that insufficient information has been provided. Further information should be provided at this stage of the planning process prior to any decision on the planning proposal.	-
Consultant Qualifications It is recommended that a consultant specialised in floodplain management completes the required assessment. EHG refers to the requirements for consultant qualifications as stated in Section 1.4 of the Flood Risk and Impact Assessment (FIRA) Guideline. Those scoping, undertaking, and reviewing a FIRA should typically include an appropriately qualified professional engineer. They should have experience and advanced skills in catchment hydrology, floodplain hydraulics and have a good working knowledge of flood risk management practices and guidance in New South Wales. Flood risk management is a separate discipline to stormwater management. Experience with other similar	1. The flooding works completed as part of this FIRA has the full oversight and review by Kylee Smith, a degree qualified senior civil engineer at Colliers Engineering & Design with chartered status (CPEng, NER) and with over 13 years' experience in water resources and flood modelling.

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
projects suggests that a flood risk management specialist working for the applicant is critical to avoid a protracted assessment process.	
Ministerial Direction The Planning Proposal report Appendix 4 outlines consistency with the Ministerial Directions under Section 9.1 of the Environmental Planning and Assessment Act 1979. Regarding Direction 4.1 Flooding, the report states "The Site is not located within flood prone land. Accordingly, Direction 4.1 is not applicable." EHG notes that the Flood Impact and Risk Assessment Report shows the land as flood affected. Therefore, consistency with the Ministerial Directions must be demonstrated. The flood planning area will need to be established.	2. The site is not identified as "flood prone land" in Council's statutory mapping from the Local Environmental Plan (LEP). Notwithstanding, the site is affected by minor flooding which is mainly concentrated within the Snake Creek corridor and connecting overland flow paths. Whilst a site-specific flood planning area map was not produced for the planning proposal, the development was undertaken with consideration to the Local Planning Directions under Section 9.1(2) of the Environmental Planning and Assessment Act 1979 by the Minister for Planning (2022). 3. The DA Design will ensure that all lots are above the Flood Planning Level – 1% AEP + 0.5m and where necessary, road centrelines will be adjusted accordingly. Therefore, a map showing the flood planning area overlaid on the proposed layout will be prepared and provided at the time of DA submission.
Flood Impact and Risk Assessment Report A FIRA needs to be prepared in accordance with the NSW Government's Guideline Flood Impact and Risk Assessment Guideline to support this planning proposal. The content of	4. A flood impact and risk assessment (FIRA) report was prepared (Flood Impact and Risk Assessment Report Morgan Road, Belrose, September 2022) and submitted on July 2023 with consideration to the NSW

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
the FIRA should be in general accordance with Tables 5 and 6 of Attachment A of the guideline.	Government's Flood Impact and Risk Assessment Guideline (LU01) to support this planning proposal. At Planning Proposal stage, the analysis is necessarily high-level and therefore it is not possible to respond to every element of Table 5 and 6, however, as the project develops a full FIRA assessment in accordance with LU01 Tables 5 and 6 will be submitted for DA assessment.
Modelling Hydrological and hydraulic modelling has been undertaken of the 5% AEP, 1% AEP, 0.2% AEP, 0.5% AEP and PMF events for the pre and post development scenarios. However, EHG raises concerns over the accuracy of the modelling and notes that the methodology needs to be revised before EHG's advice can be provided. EHG recommends that a flood risk management specialist prepare the relevant modelling and reporting. The Flood Impact and Risk Assessment Report states that "The stormwater volume retention from the proposed water quality and quantity features was modelled by increasing the initial loss of the developed areas, and the site development area was represented by increasing the impervious area of these catchments." This is not considered an appropriate methodology for flood modelling nor stormwater detention	5. The flood modelling methodology described by EHG involves a typical development with stormwater detention basins to detain the stormwater runoff such that post-development flows are less than or equal to pre-development flows. As discussed in full detail within the Stormwater Management Plan (Stormwater Management Plan, Morgan Rd, Belrose, September 2022) and summarised in Point 16 below, Colliers considered the option of traditional end-of-line water quality treatment and detention, however due to the very steep and rocky nature of the terrain, a stormwater strategy involving detention basins at the bottom of each catchment was deemed to be unviable and incompatible with an effective and sustainable design. 6. The proposed stormwater strategy instead adopts a more innovative Stormwater Footprint Strategy which

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
modelling. The proposed measures to mitigate peak flow impacts, such as stormwater detention, must be explicitly modelled and not simply using an increased initial loss. The hydrographs shown in the report are not indicative of stormwater detention measure outflows and do not correctly show the likely impact of changes to site hydrology. Hydrographs should be presented of the existing case, developed case without detention measures and developed case with detention measures. Note that it is not generally considered relevant or necessary to model any water quality treatment measures in flood modelling. Further details are required, including the percentage imperviousness adopted in each catchment under existing and developed conditions. The flood impact mapping will need to be recalculated after reasonable modelling of the proposed development including stormwater detention measures has been completed. It is not considered appropriate for all area of allotments aside from the roof and driveway to be considered as pervious. The overall fraction impervious for the proposed residential areas must be calculated and presented to ensure it is reasonable. Given that there is no available flood study covering the site from Council and the lack of available calibration data, reasonable efforts must be made to validate the modelling.	involves introducing both stormwater storage and stormwater treatment throughout the development at an individual lot scale, street scale and precinct scale, rather than focusing on just a basin at the bottom of each catchment. A more detailed summary is provided in Point 16 below. 7. Within the flood modelling, a methodology was adopted whereby initial loss was increased as a simplified approach to simulating storage. This was adopted for the early stages of modelling for the Planning Proposal submission only to assess potential changes in flow regime due to the development. It is expected that due to most flows being contained within the waterway, there will be minimal change to the flooding outcomes by incorporating the detention elements once detailed. Nevertheless, the water quantity / detention elements will be incorporated into the TUFLOW model and an updated, complete set of mapping will be provided at DA Stage once the earthworks grading and detailed sizing of the stormwater detention elements are completed. Colliers Engineering & Design (NSW) is confident that the modelling undertaken within the Stormwater Management Strategy (2022) for the Stormwater Footprint is sufficient to demonstrate that there is no

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
This could include comparison with a rainfall on grid model. Relevant guidance should be followed in validating both hydrological and hydraulic modelling. It is recommended that the hydraulic model is extended downstream to include Oxford Falls Road and that a suitable frequent event such as the 1 event per year is used to map flooding over the road. It is further recommended that the hydraulic model is extended a suitable distance upstream of the site for the two flow paths at the west to enable a due comparison of flood behaviour and assessment of flood impacts. The eastern flow path appears to terminate around Morgan Road and should be extended to ensure the full extent of the flow path across the site has been mapped. Flow depths greater than 0.1m should be included on the mapping. The use of a roughness (Manning's n) value of 0.05 for residential areas needs further explanation and justification. It is unclear for which area this applies and if it is a composite value for buildings, yards and driveways.	adverse impact to the downstream waterway because of the development. 8. The impervious area of the catchments was provided in Appendix B of the FIRA report (2022). For the developed catchments, an impervious area of 60% was adopted for the residential lots, 70% for road reserves, and 10% for open space areas. For the existing catchments, an impervious area of 10% was adopted across the board, to represent the existing conditions vegetated open space. These values are typically consistent with, or more conservative than the values recommended in Council's AUS SPEC Engineering Specifications (2000). Additionally, the catchments external to the site were modelled as undeveloped in the existing conditions scenario and developed in the developed conditions scenario. 9. In regards to validation of the hydrologic and hydraulic models, given the lack of available calibration data, it is proposed to validate the results for the 1% AEP storm event against two peak flow methodologies – Regional Flood Frequency Estimation (RFFE) and the NSW Rational Method. This is an industry standard approach to peak flow comparison and the results are provided in Attachment B below.

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
	10. Whilst it may ultimately be useful to extend the hydraulic model further downstream to cover Oxford Falls Road at the crossing over Oxford Creek to ensure that the full extent of the flow path across the site is mapped. It is more appropriate to undertake this analysis at DA stage once the bulk earthworks design and detailed design of the stormwater elements is complete. At this stage, extension of the model will provide no additional information to assist assessment of the Planning Proposal. 11. Extending the model further upstream of the two western flow paths will have limited benefit as the flow regime is largely shallow sheet flow in the upper reaches of the catchment due to a lack of defined flow paths in the topography. This would not result in substantially increased peak flows at the location of the inflows currently adopted. In addition, prior to detailed site grading and stormwater drainage design being modelled, sheet flow from the upstream catchment would result in shallow sheet flooding across the development lots, which is not a realistic future scenario. 12. The Manning's roughness n value of 0.05 for the residential areas represents the composite value of the developed lot excluding the building itself.

Attachment 1 – EHG Comments on Planning Proposal Patyegarang (PP-2022-3802)	Colliers Response
	However, in this model the value is largely irrelevant given the lots themselves are not inundated, as it is not a rainfall on grid model.
Flood Impacts The Flood Impact and Risk Assessment Report has not adequately demonstrated the flood afflux of the pre and post development scenarios. Tables 1 and 2 of the Flood Impact and Risk Assessment Report both show the flows would increase, which is expected to lead to flood impacts. The flood impact mapping will need to be recalculated after reasonable modelling of the proposed development has been completed, including stormwater detention measures.	13. The flows reported in Table 1, 2 and 3 of the FIRA do show a marginal increase in the post-development peak flow, however the flood afflux result shows a negligible change in peak water level. This is due to a change in the timing of the peak of the hydrographs in the post-development scenario, as Figures 11-15 of the FIRA shows the extracted flow hydrographs downstream of the site from the TUFLOW modelling, where the peak of the hydrograph in the developed conditions scenario is approximately the same as in the existing conditions scenario, but slightly shifted to the left (i.e. the peak occurs slightly earlier). In addition, the Stormwater Strategy (2022) further demonstrated, through preparation of an XP RAFTS model, that peak flows could be managed by the Stormwater Footprint Methodology. The modelling demonstrated that peak flow in the critical duration increased by no more than 8% in post-development conditions for the critical duration and increased marginally at the downstream boundary for the critical duration in post-development conditions.

Frequent Flooding of Transport Route The route to Wakehurst Parkway via Oxford Falls Road is frequently flooded and impassable at both Oxford Creek and Middle Creek. This should be considered in traffic and transport investigations and any consideration of emergency evacuation. Ideally, the Flood Impact and Risk Assessment Report should model and map flood affectation at Oxford Creek, especially smaller events. Council may be able to provide information on the Middle Creek crossing.	14. For emergency evacuation, there is a rising flood-free egress route via Morgan Road headed in a north and western direction. This would be the recommended evacuation route as opposed to travelling downstream towards the road crossings over Oxford Creek and Middle Creek which are flood affected. This can be detailed in a Flood Emergency Response Plan for the development if PMF modelling results in flooded lots upon completion of detailed design, although it is considered that this will be unlikely. 15. Refer also to the Transport report prepared by JMT.
Stormwater management The provided stormwater management report is a very high-level document that does not demonstrate adequate consideration of a strategy to mitigate the impacts of development on stormwater and flood flows. Consideration should be given to the locations of stormwater detention basins, noting that bioretention swales and basins are unlikely to meet the requirement to reduce peak flows from all storm events. In particular, the larger events must be modelled in a suitable hydrologic software package.	16. The Stormwater Strategy for the proposed Belrose Development was prepared by Leaders in the field of Integrated Stormwater Management Design. It is proposed to act as an innovative industry benchmark, rather than adopt a traditional approach where the traditional approach is not viable due to the landform and topology. The strategy is designed to mimic natural stormwater flows by minimising impervious areas, reusing rainwater and stormwater, and providing treatment measures that replicate the natural water cycle as per Point 5 in the Council DCP. The approach results in management of flood afflux as well as water quality and ensures that there is no prompt for hydrogeological adjustments to the waterway due to negligible change in the hydrological regime. This minimises the need for hard engineering solutions and works within the constraints of the natural

	features and topography of the landscape where possible. The Stormwater Footprint approach considers stormwater volume as the key variable across various scales including lot, street, and neighbourhood. The Stormwater Footprint is the ratio of the average annual runoff from post-development to the average annual runoff from pre-development where a stormwater footprint target close to 1 is the desired outcome to ensure the downstream waterway will remain unaffected by the proposed development, the geomorphic conditions will remain unchanged and the stormwater quality will achieve a reasonable result. This approach is an innovative alternative that utilises distributed water quantity and quality treatments and adopts best practice management of stormwater. The results of which were demonstrated within the Stormwater Management Strategy (2022) utilising the industry standard software MUSIC and XP RAFTS to analyse water quality and quantity.
Proposed Earthworks Strategy The proposed earthworks strategy involves the following per the Flood Impact and Risk Assessment Report: • "slightly lowering the flow paths to channelise the overland flow", and • "all proposed development areas and roads would be filled to an elevation that is above the PMF event".	17. The bulk earthworks design is not yet complete. Colliers Engineering & Design notes the Department's preference to ensure suitable cross-sections with maintenance of vegetation. This preference will be considered throughout the development of the design. 18. Owing to the steep terrain on site, the proposed development areas adjacent to the waterways and overland flow paths are generally already above the

EHG queries this approach including the necessity of raising land above the PMF and the lowering of flow paths rather than provision of a suitable design cross section. EHG queries how this can be consistent with maintaining existing vegetation across the site.	PMF level, however Colliers agrees that raising the development above the PMF is not necessary and that raising to the 1% AEP + 0.5m freeboard is the preferred approach.

References

Craig & Rhodes (2022) *Flood Impact and Risk Assessment Report, Morgan Road, Belrose*

Storm Consulting (2022), *Stormwater Management Plan, Morgan Rd, Belrose*

Warringah Council (2000), *AUS-SPEC #1 Development Specification Series, Design*

Attachment A: Letter from Department of Planning

Department of Planning and Environment

Our ref: DOC23/891068
Your ref: PP-2022-3802

Lauren Templeman
Specialist Planning Officer
Planning Group
Department of Planning and Environment
4 Parramatta Square, 12 Darcy Street
PARRAMATTA NSW 2150

21 November 2023

Subject: Consultation and exhibition - Planning Proposal Patyegarang (PP-2022-3802)

Dear Lauren

I refer to the email received by the Environment and Heritage Group (EHG) via the planning portal on 25 September 2023 referring the Patyegarang planning proposal, Morgan Road, Belrose for consultation under section 3.34(2)(d) of the *Environmental Planning and Assessment, Act 1979*.

According to the Planning Proposal Patyegarang Project by Gyde Planning dated July 2023, the planning proposal seeks to:

- transfer the site from Warringah Local Environmental Plan 2000 to Warringah Local Environmental Plan 2011 and implement standard instrument zones
- secure dual occupancies as an additional permitted use within the R2 low density residential zone
- secure additional permitted uses within the RE2 Private Recreation zone to enable environmental management works, stormwater services, asset protection zones (APZs) and bushfire works, utilities and servicing works where required
- introduce maximum building heights (8.5 metres)
- introduce a range of small, medium to large residential lot sizes, and
- manage an appropriate number of dwellings based on the site capacity.

In its previous pre-lodgement comments to DPE Planning on this planning proposal dated 29 April 2022, EHG raised several issues including that "in its current form the proposal fails to adequately consider and avoid the biodiversity values that exist within the site". It is noted that the exhibited planning proposal does not reference EHG's pre-lodgement comments.

EHG has reviewed the exhibited planning proposal and provides detailed comments on biodiversity and flood risk management issues in Attachment 1.

Regarding biodiversity, EHG remains of the view that the planning proposal has failed to demonstrate application of the avoid and minimise framework established under the *Biodiversity Conservation Act 2016*. The Preliminary Biodiversity Development Assessment Report (BDAR) is an incomplete report and requires significant revision to provide a complete biodiversity assessment for the proposal. In this regard, the current BDAR should not be relied on for strategic planning

purposes until it is further informed by adequate investigation of impacts and further avoidance of the site's biodiversity values. Insufficient information has therefore been provided to support the planning proposal including the proposed zone boundaries and structure plan.

Regarding flood risk management, the planning proposal seeks to alter a provision that affects flood prone land. EHG considers that insufficient information has been provided for the planning proposal and further information should be provided at this stage of the planning process.

Considering the above, EHG does not support the planning proposal and recommends that the concerns and issues raised in this submission are addressed.

Please also note that given the identified deficiencies and inadequacies, EHG will not be commenting on the Patyegarang Project Draft Development Control Plan in this submission. Once the planning proposal has been revised to address the issues and concerns raised in this submission, EHG will review the draft DCP.

Should you have any queries regarding this matter, please contact Susan Harrison, Senior Team Leader Planning via Susan.Harrison@environment.nsw.gov.au.

Yours sincerely,

Louisa Clark
Director
Greater Sydney Branch
Biodiversity and Conservation

Attachment 1: EHG comments on Planning Proposal Patyegarang (PP-2022-3802)

Pre-lodgement consultation

On 29 April 2023, EHG provided DPE Planning detailed pre-lodgement comments on this planning proposal (Attachment 2). EHG's submission identified a range of issues with the proposal including that "in its current form the proposal fails to adequately consider and avoid the biodiversity values that exist within the site".

EHG notes that the Department's Gateway Determination Report PP-2022-3803 dated June 23 makes no reference to EHG's pre-lodgement comments and concerns about the draft planning proposal.

The exhibited planning proposal package including the Planning Proposal Patyegarang Project by Gyde Planning dated July 2023 (Planning Proposal report) also makes no reference to EHG's pre-lodgement comments. Instead, Section 6.4.2 and Appendix 5 in the Planning Proposal report advise that a project presentation was made to EHG on 14 September 2022. It should be noted that the briefing with EHG was held on 11 March 2022, not 14 September 2022.

Biodiversity

Preliminary Biodiversity Assessment Development Report

The following comments are provided in relation to the Preliminary Biodiversity Development Assessment Report (BDAR). These comments should be read in conjunction with EHG's previous submission the requirements of which have largely not been incorporated into the latest information.

- The operational and construction footprint and therefore the extent of the Subject Land, as defined in the Biodiversity Assessment Method (BAM), is likely to be an underestimation given the full extent of impacts from the proposal have not been considered.
- Given the extent of the proposed rezoning, there are likely to be indirect impacts beyond the footprint of the proposed R2 Low Density Residential and RE2 Public Recreation zone development boundaries. In this regard, the identification of the Subject Land, must be incorporate the full extent of both direct and indirect impacts.
- In Appendix C "Applying the description (2011 Determination)" table there are several rows which indicate that the characteristics of the Subject Land are such that the occurrence of Duffys Forest is possible. There is one section that strongly indicates that Duffys Forest occurs within the Subject Land given that the characteristics relate to the floristic and location specifications of the threatened ecological community (TEC). Reference to the Smith and Smith (2000) method does not provide significant assistance to determine whether the Duffys Forest TEC occurs on the Subject Land. The conclusions provided from the Smith and Smith method applied within the BDAR was created from 0.4ha plots which is not commensurate to the Smith and Smith (2000) method which uses larger sites. In regard to the identification of the community, the Final Determination states "Diagnostic species provide a guide to identification of the community, but care should be taken in the

application and interpretation of diagnostic plant species because of sampling limitations; the reduction in species diversity in degraded sites; and the fact that some species may only be present at a site at some times as a part of the soil seedbank or as dormant buds/tubers." In this regard, the use of the Smith and Smith (2000) diagnostic test may not result in an accurate understanding of the presence or absence of Duffys Forest within the Subject Land. The justification for the exclusion of Duffys Forest TEC is inadequate to conclude that it does not occur given the reliance on the Smith and Smith (2000) diagnostic method.

- The Smith and Smith (2000) report states "Compared with Sydney Sandstone Ridgetop Woodland, the normal vegetation community of Hawkesbury Sandstone ridges, stands of Duffy's Forest vegetation tend to have a taller, denser tree layer and a grassier understorey" and "No sites of low open-forest or open-woodland were found, although one area of low woodland was encountered on the TAFE land at Belrose, and one area of tall open-forest at Sir David Martin Reserve, South Turramurra (neither site was sampled by quadrats)" demonstrating some variation within the TEC which has not been accounted for within the justification in the BDAR for this TEC.
- The BDAR states that "Current regional vegetation maps (Sydney Metro Area, 2016; & SVTM_NSW_Extent_PCT, 2022) do not map any part of the subject property as a PCT associated with Duffys Forest EEC", however, Smith and Smith indicate that there are instances of Duffys Forest within Belrose and the SVTM also shows Duffys Forest within close proximity to the Subject Land indicating that, if the floristic composition and location aligns with that of the Final Determination for Duffys Forest then the likelihood of it occurring within the Subject Land is high.
- Discussion regarding the identification of Coastal Upland Swamp in the Sydney Basin Bioregion endangered ecological community (EEC) on the Subject Land lacks details which should be included to be able to determine whether the community is present on the site. Given Coastal Upland Swamps occur in areas where trees "may be present as scattered individuals or clumps of mallee or arborescent eucalypts", a map of the waterlogged portions of the site and descriptions of the trees present in this area would assist. The BDAR states that "Numerous small ephemeral drainage lines feed into Snake Creek, many of which support slow draining soaks, small pools, and hanging swamps." The justification for the assessment of the presence or absence of the Coastal Upland Swamp in the Sydney Basin Bioregion EEC is inadequate given the Subject Land characteristics and the descriptions within the Final Determination.
- Given the concerns raised over the identification of the plant community types (PCTs) on the Subject Land, the ecosystem credit species (ECS) and species credit species (SCS) may require updating in accordance with accurate identification of PCTs.
- Table 15 within the BDAR lists survey times required by the Threatened Biodiversity Data Collection (TBDC) for each threatened species. There are several threatened flora species which were not surveyed within the required survey period including *Camarophyllop sis kearneyi*, *Hygrocybe anomala* var *ianthinomarginata*, *Hygrocybe aurantipes*, *Hygrocybe austropratensis*, *Hygrocybe collucera*, *Hygrocybe griseoramosa*, *Hygrocybe lanecovensis*,

Hygrocybe reesiae and *Hygrocybe rubronivea*. The Department's webpage on Biodiversity experts | NSW Environment and Heritage states, *Surveys for species credit species need to be conducted at the optimum time for detection. Survey months for species are automatically populated in the Biodiversity Assessment Method Calculator (BAM-C) via the Threatened Biodiversity Data Collection (TBDC). These months were selected assuming 'average' conditions, and that the survey is undertaken using an appropriate method, time of day and conditions (based on relevant survey guidelines).*

You can adjust survey timing if, for example, natural disturbances or climatic events are likely to alter the months when the species is most likely to be found. Sometimes additional information about survey times is provided in the 'General Notes' field of the TBDC: for example, 'shoulder' months, differences in survey season during particular environmental conditions or across the species distribution.

Also available for flora-specific survey is the Flora Species with Specific Survey Requirements, which you can find on the BAM-C page. If you vary your survey time from those in the BAM-C make sure you document and justify this in the Biodiversity Assessment Report. For more information see page 38 of the Biodiversity Assessment Method Operational Manual – Stage 1."

Adequate justification for alteration to the survey times or a report from a recognised "expert" has not been provided.

- In addition to the above species surveyed outside of the required survey period, there are several species listed in Table 15 that were surveyed both within and outside of the required survey period. It is unclear from the BDAR which survey effort hours are within the correct survey period and so it cannot be determined if the survey effort within the correct time periods are adequate or if the survey was largely undertaken in the incorrect survey time periods. The surveys undertaken outside of the required survey period should be disregarded unless an appropriate justification can be provided. The BDAR should show the extent of the survey efforts within the correct time periods.
- Table 19 describes caves and crevices present on the Subject Land which may be used by microchiropteran bats such as the Little Bent-wing Bat and Eastern Bent-wing Bat and the Rosenberg's Goanna and Spotted-tailed Quoll. Adequate mapping and investigation of these habitat types and their potential impacts has not been provided within the BDAR.
- SCS surveys for the threatened amphibians Red-crowned Toadlet, Green and Golden Bell Frog and Giant Burrowing Frog were required to be undertaken. Appendix D within the BDAR shares details regarding survey methods. The dedicated amphibian surveys made assumptions regarding unsuitable habitat on portions of the site, but provided no justification as to why areas were unsuitable habitat for survey. Surveys are required to be undertaken in accordance with the NSW Survey Guide for Threatened Frogs.
- Section 7.1 of the BDAR describes how biodiversity values within the Subject Land were prioritised for avoidance. While the prioritisation describes avoiding known habitat for threatened flora and fauna, the proposal impacts on a significant amount of habitat. Impacts are proposed to known threatened species habitat widely across the Subject Land, however

there are avoidance measures proposed for some areas of threatened species habitat in the areas mapped as "Conservation Zone" (Figure 3 of the BDAR). EHG considers areas mapped as "retained vegetation" have not been avoided given the proposed R2 and RE2 zoning and associated permissible uses. Future construction and land use activities within or adjacent to these areas will have direct and indirect impacts affecting vegetation retention. It is considered that the proposal has not adequately accounted for Biodiversity Values within the Subject Land and has not adequately avoided and minimised those impacts. It should be noted that the use of the R2 and RE2 zones is also discussed below under the zoning regime section of this response.

- The proposed development layout indicates minimal buffers will be provided for riparian corridors. Avoidance of further impacts through increasing riparian buffers to provide more functional biodiversity corridors is required.
- It is difficult to understand how impacts have been calculated for the credit offset requirement and where full or partial loss have been calculated for offsets without adequate mapping showing where they have been applied. Asset Protection Zones (APZs) are not considered a compatible land use within conservation areas and should be wholly contained within development areas. In fully vegetated locations, the institution of APZs are likely to change the PCT integrity to the extent that it may not meet the benchmark requirements to be classified as the community. In this regard, future vegetation integrity scores of 0 must be applied to all proposed development areas, inclusive of APZs.
- The BDAR reports that there are uncertain impacts at this "high level planning stage" in section 8.5. There are further obvious impacts that have not been accounted for and for which can be readily identified. EHG expects consideration of all potential impacts arising from the future development. This includes impacts to all areas within the proposed RE2 and R2 zones including the "retained vegetation".
- Biodiversity impacts from infrastructure upgrades for surrounding services and road networks outside of the site boundaries must be considered in the biodiversity assessment for the proposal.
- The BDAR should consider whether there are likely to be indirect impacts to the proposed "Conservation Zone" (Figure 3) and how this land will be managed into the future considering the proposed increase in the intensity of use of the Subject Land. Not all impacts have been accounted for within the BDAR which makes it difficult to provide the required avoid and minimise measures required by the BAM. See section 8.5 and 10.2 in the BDAR. Details relating to the mechanisms that will be relied upon to conserve the areas proposed for conservation are required in addition to an understanding of the impacts. This is a relevant consideration based on the extent of development that will be facilitated by the proposal. EHG does not support the assumption that there will be no impacts to the "Conservation Zone".
- Given the concerns raised in relation to the identification of the correct PCTs and associated TECs on the Subject Land, the considerations of which Serious and Irreversible Impact (SAII)

entities may be present or utilising habitat within the Subject Land and hence any information provided in relation to the assessment of SAII may be incomplete.

- The ECS and SCS are likely to be underestimations given EHG's concerns with identifying direct, indirect and prescribed impacts as described above.

It is considered that in its current form the proposal has failed to demonstrate application of the *Biodiversity Conservation Act 2016* avoid and minimise framework.

The Subject Land is fully vegetated and contributes to larger ecological corridors beyond the Subject Land's boundaries. The native vegetation on Subject Land includes numerous records of threatened species and ecological communities, and their habitats. The BDAR has failed to adequately justify its assessment of the PCTs and any associated TECs which in turn undermines all threatened species assessments on the entirety of the Subject Land.

With consideration to the proposed structure plan and topography of the site, EHG expects all areas identified for potential development, including areas mapped as "retained vegetation" and APZs would need to be cleared or partially cleared of native vegetation to achieve the development outcomes as proposed. The BDAR does not reflect the full extent of the native vegetation removal required within the areas of retained vegetation which are proposed R2 and RE2 zones, and APZs.

EHG previously recommended that at a minimum, assessment of biodiversity values and impacts be undertaken through application of stage 1 and elements of stage 2 of the BAM. This approach will ensure biodiversity outcomes are optimised and future development can proceed with greater certainty. It will also allow EHG to adequately consider any proposed biodiversity impacts.

The planning proposal will allow for R2 and RE2 zones across the locality which will increase the intensity of the use over the Subject Land. Avoiding impacts on biodiversity values should not be deferred to the future development stage but should be addressed as part of the planning proposal to maximise the integration of conservation measures with other aspects of the planning proposal outcomes including the conservation of riparian corridors, planning of infrastructure and roads, flood management, and lot patterns.

The BDAR lacks adequate consideration of the full extent of impacts to native vegetation and Biodiversity Values across the Subject Land and as such does not provide the details necessary to be able to draw conclusions in relation to biodiversity impacts. Therefore, the BDAR does not provide the information necessary to develop a planning proposal responsive to these constraints.

The proposal does not adequately avoid and minimise impacts by appropriately locating and designing the proposal and reducing the scale of the development in accordance with Section 7 of the BAM.

Section 10.2 of the BDAR it states, "there are no impacts that do not require further assessment". The BDAR is an incomplete report and requires significant revision to complete a biodiversity assessment for the proposal. In this regard, it is recommended that the current BDAR should not be relied on for strategic planning purposes until it is further informed by adequate investigation of impacts and further avoidance of the sites Biodiversity Values.

Zoning regime

RE2 Private Recreation and R2 Low Density Residential

As discussed above, Figure 3 in the BDAR shows areas mapped as 'Retained vegetation' outside of the conservation zone. The Planning Proposal report draft Structure Plan (Figure 6) also identifies these areas of 'Retained vegetation' outside the proposed conservation area. The Planning Proposal report zoning map (Figure 26) shows these 'Retained vegetation' areas within the RE2 (with additional permitted uses) and R2 zones.

Regarding the use of the R2 and RE2 zone, the Planning Proposal report states:

> *The revised planning proposal applies an RE2 zone to the northwest portion of the Snake Creek riparian corridor and parts of its tributaries. This reflects the proponent's intention to retain vegetation within these areas and enable their ongoing management and enjoyment by future and existing residents. The planning proposal seeks to include Additional Permitted Uses (APU) within these areas to enable works to enable the servicing and utilities of the adjoining R2 Low Density Residential zone to occur within these areas. This provision is to purely ensure that the RE2 zone can be provided without disconnecting the R2 Low Density residential zones roads and servicing across these areas. Environmental management works, bushfire works and APZs and stormwater services are also sought as additional permitted uses within the RE2 zone. The majority of these works would be exempt development under the State Environmental Planning Policy (Transport and Infrastructure) 2021 if undertaken on or behalf of a public authority, i.e., Council and Sydney Water.*

EHG does not support the proposed approach of zoning the Snake Creek riparian corridor and its tributaries/ natural ephemeral flow paths, retained native vegetation and threatened species habitat to be protected as RE2 and R2. The broad range of permitted uses in the R2 and RE2 zones (including the additional permitted uses the planning proposal seeks to introduce) are inconsistent and incompatible with the retention of native vegetation and protection of the high biodiversity values present including threatened species habitat and the riparian corridor.

EHG recommends that the high biodiversity present on the Subject Land, including the entirety of the Snake Creek riparian corridor and its tributaries/ natural ephemeral flow paths as well as native vegetation and threated species habitat to be retained and protected should be zoned C2 Environmental Conservation to ensure the conservation of these areas. The objectives and permitted uses in the C2 zone in the Warringah LEP 2011 are considered compatible and consistent with the conservation of the high biodiversity values present and will afford long term protection.

C2 Environmental Conservation

EHG notes that the Planning Proposal report states that "The revised proposal makes no changes to the proposed C2 Environmental Conservation Area".

It is unclear how conservation lands will be protected in perpetuity, owned and managed. Details relating to the mechanisms that will be relied upon to conserve the proposed conservation land are required.

Perimeter roads or similar buffers should be provided between development and conservation zones. Furthermore, the pathways proposed in the conservation areas in Figure 23 Open Space Structure Plan in the Planning Proposal report is inconsistent with conservation outcomes.

Asset Protection Zones

The Planning Proposal Report states "The APZs are related to the residential development and are intended to be predominately provided within the R2 zoned land and boundaries of the proposed RE2 zones. The detailed requirements and extent of the APZs will not be finalised until the development application stage to respond to the subdivision and proposed building siting and use". As previously advised, the extent of APZs will be a significant factor in the level of vegetation removal and biodiversity impacts that occur. EHG expects that the full extent of impacts from the APZs will be included in the planning proposal.

Ministerial Direction

The Ministerial Direction 3.1 Conservation zones requires that "A planning proposal must include provisions that facilitate the protection and conservation of environmentally sensitive areas".

As discussed in this submission, EHG considers that the planning proposal contains an inadequate assessment of biodiversity values and in its current form the proposal has failed to demonstrate application of the avoid and minimise framework. Furthermore, the RE2 and R2 are not considered appropriate zones to retain, conserve and protect the high biodiversity values present given the broad range of uses permitted. EHG does not consider that the direction has been adequately addressed.

Flood Risk Management

Summary

The planning proposal seeks to alter a provision that affects flood prone land. EHG has reviewed the supporting information for the planning proposal and considers that insufficient information has been provided. Further information should be provided at this stage of the planning process prior to any decision on the planning proposal.

Consultant Qualifications

It is recommended that a consultant specialised in floodplain management completes the required assessment. EHG refers to the requirements for consultant qualifications as stated in Section 1.4 of the Flood Risk and Impact Assessment (FIRA) Guideline. Those scoping, undertaking, and reviewing a FIRA should typically include an appropriately qualified professional engineer. They should have experience and advanced skills in catchment hydrology, floodplain hydraulics and have a good working knowledge of flood risk management practices and guidance in New South Wales. Flood risk management is a separate discipline to stormwater management. Experience with other similar projects suggests that a flood risk management specialist working for the applicant is critical to avoid a protracted assessment process.

Ministerial Direction

The Planning Proposal report Appendix 4 outlines consistency with the Ministerial Directions under Section 9.1 of the *Environmental Planning and Assessment Act 1979*. Regarding Direction 4.1 Flooding, the report states "The Site is not located within flood prone land. Accordingly, Direction 4.1 is not applicable." EHG notes that the Flood Impact and Risk Assessment Report shows the land as flood affected. Therefore, consistency with the Ministerial Directions must be demonstrated. The flood planning area will need to be established.

Flood Impact and Risk Assessment Report

A FIRA needs to be prepared in accordance with the NSW Government's Guideline Flood Impact and Risk Assessment Guideline to support this planning proposal. The content of the FIRA should be in general accordance with Tables 5 and 6 of Attachment A of the guideline.

Modelling

Hydrological and hydraulic modelling has been undertaken of the 5% AEP, 1% AEP, 0.2% AEP, 0.5% AEP and PMF events for the pre and post development scenarios. However, EHG raises concerns over the accuracy of the modelling and notes that the methodology needs to be revised before EHG's advice can be provided. EHG recommends that a flood risk management specialist prepare the relevant modelling and reporting.

The Flood Impact and Risk Assessment Report states that "The stormwater volume retention from the proposed water quality and quantity features was modelled by increasing the initial loss of the developed areas, and the site development area was represented by increasing the impervious area of these catchments." This is not considered an appropriate methodology for flood modelling nor stormwater detention modelling. The proposed measures to mitigate peak flow impacts, such as stormwater detention, must be explicitly modelled and not simply using an increased initial loss. The hydrographs shown in the report are not indicative of stormwater detention measure outflows and do not correctly show the likely impact of changes to site hydrology. Hydrographs should be presented of the existing case, developed case without detention measures and developed case with detention measures. Note that it is not generally considered relevant or necessary to model any water quality treatment measures in flood modelling.

Further details are required, including the percentage imperviousness adopted in each catchment under existing and developed conditions. The flood impact mapping will need to be recalculated after reasonable modelling of the proposed development including stormwater detention measures has been completed. It is not considered appropriate for all area of allotments aside from the roof and driveway to be considered as pervious. The overall fraction impervious for the proposed residential areas must be calculated and presented to ensure it is reasonable.

Given that there is no available flood study covering the site from Council and the lack of available calibration data, reasonable efforts must be made to validate the modelling. This could include comparison with a rainfall on grid model. Relevant guidance should be followed in validating both hydrological and hydraulic modelling.

It is recommended that the hydraulic model is extended downstream to include Oxford Falls Road and that a suitable frequent event such as the 1 event per year is used to map flooding over the road. It is further recommended that the hydraulic model is extended a suitable distance upstream of the site for the two flow paths at the west to enable a due comparison of flood behaviour and assessment of flood impacts. The eastern flow path appears to terminate around Morgan Road and should be extended to ensure the full extent of the flow path across the site has been mapped. Flow depths greater than 0.1m should be included on the mapping.

The use of a roughness (Manning's n) value of 0.05 for residential areas needs further explanation and justification. It is unclear for which area this applies and if it is a composite value for buildings, yards and driveways.

Flood Impacts

The Flood Impact and Risk Assessment Report has not adequately demonstrated the flood afflux of the pre and post development scenarios. Tables 1 and 2 of the Flood Impact and Risk Assessment Report both show the flows would increase, which is expected to lead to flood impacts. The flood impact mapping will need to be recalculated after reasonable modelling of the proposed development has been completed, including stormwater detention measures.

Frequent Flooding of Transport Route

The route to Wakehurst Parkway via Oxford Falls Road is frequently flooded and impassable at both Oxford Creek and Middle Creek. This should be considered in traffic and transport investigations and any consideration of emergency evacuation. Ideally, the Flood Impact and Risk Assessment Report should model and map flood affectation at Oxford Creek, especially smaller events. Council may be able to provide information on the Middle Creek crossing.

Stormwater management

The provided stormwater management report is a very high-level document that does not demonstrate adequate consideration of a strategy to mitigate the impacts of development on stormwater and flood flows. Consideration should be given to the locations of stormwater detention basins, noting that bioretention swales and basins are unlikely to meet the requirement to reduce peak flows from all storm events. In particular, the larger events must be modelled in a suitable hydrologic software package.

Proposed Earthworks Strategy

The proposed earthworks strategy involves the following per the Flood Impact and Risk Assessment Report:

- "slightly lowering the flow paths to channelise the overland flow", and
- "all proposed development areas and roads would be filled to an elevation that is above the PMF event".

EHG queries this approach including the necessity of raising land above the PMF and the lowering of flow paths rather than provision of a suitable design cross section. EHG queries how this can be consistent with maintaining existing vegetation across the site.

End of Submission

Attachment B: Peak Flow Validation

The results of the validation are outlined in Table 1 below. It is noted that the calculation methods below are purely for comparison purposes as a sanity check to determine if the calculated peak flows are within the same range of values for different methodologies.

It is important to consider the limitations of the RFFE and Rational Method. For example, the RFFE estimates are based on data from the nearest gauged catchments in the region with the nearest one being located relatively far from the site (approximately 23 km). The ARR1987 Rational Method is a calculation of peak flow using the Bransby William/Adam's equation for the time of concentration. It is noted that the estimated time of concentration for the catchment from this method is within the order of one hour, which is greater than the critical duration of the storm derived from the XP-RAFTS model, therefore the Rational Method is expected to produce a lower peak flow than XP-RAFTS.

Taking the limitations of the calculation methods into account, the peak flow estimate from XP-RAFTS is greater than the peak flow calculated from Rational Method as expected, and it also falls well within the confidence limits of the RFFE estimate.

TABLE 1 HYDROLOGICAL VALIDATION (CL = CONFIDENCE LIMIT)

Validation Location	Calculation Method	Flow (m^3/s)
Snake Creek Outlet from Site Catchment	XP-RAFTS	71.7 (25 minute storm duration)
	RFFE	99.7 5% CL =41.3 95% CL = 244
	Rational Method	34.32

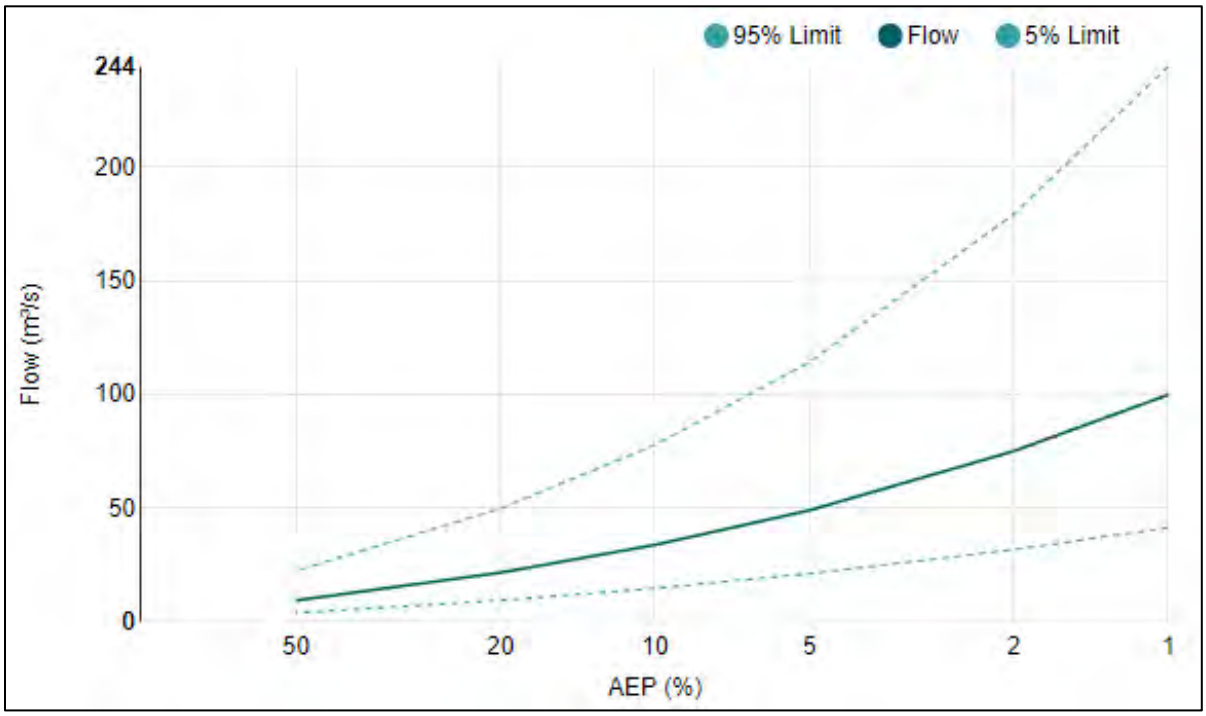

FIGURE 1 REGIONAL FLOOD FREQUENCY ESTIMATION GRAPHICAL RESULTS WITH 5% AND 95% CONFIDENCE LIMITS

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	9.30	3.85	22.3
20	21.5	9.32	49.7
10	33.7	14.6	77.6
5	48.9	21.1	114
2	74.9	31.6	179
1	99.7	41.3	244

FIGURE 2 REGIONAL FLOOD FREQUENCY ESTIMATION ANALYSIS TABULATED RESULTS

Attachment C: Kylee Smith CV

Kylee Smith

Senior Civil Engineer | VIC

Engineering & Design

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Qualifications & Accreditations

Bachelor of Civil & Infrastructure Engineering, (Hons 1st Class), Water Engineering

Memberships & Affiliations

Member of Engineers Australia with CPEng NER

Technical Skills

- Hydrologic & Hydraulic Modelling
- Floodplain Mapping & Mitigation
- Development Impact Assessments
- Floodplain & Catchment Management
- Dam breach & Consequence Assessments
- Flood Emergency Response Plans
- Water Cycle Management Plans for Large New Town Rezoning Applications
- Modelling Software TUFLOW 1D & 2D, HEC-RAS 1D & 2D, RORB, 12D, Map Info, QGIS, TUFLOW FLIKE, MUSIC (basic)
- Relevant Guidelines such as ARR2019, DEWLP Development in Flood Affected Areas, VicRoads Drainage Manual, NSW Flood Management Manual (2023)
- Peer Review of Modelling undertaken by both internal and external colleagues and consultants

Area of Expertise

Kylee is a Degree qualified Civil Engineer with Chartered Status (CPEng, NER) since 2016. She has been working within Water Resources and Flood Modelling for over 12 years and has developed expertise in Hydrology, Hydraulics, Flood Impact Analysis, Flood Risk Assessments, Catchment Management and Stakeholder Engagement.

Having represented Melbourne Water at panel hearings in Victoria, Kylee is well placed to provide expertise to the Panel Hearing regarding items relating to flooding.

Professional Accomplishments

McKinnon Creek Detention Basin – Project Manager

The submission had been assessed by DNRME in QLD and there was a requirement for additional information. Kylee reviewed the current report, liaised with both DNRME and the client to ensure that all requirements were thoroughly understood and engaged and managed a Project Engineer from within WMS to undertake the technical modelling of the Basin Failure. To better understand the geotechnical aspects of the impacts of failure on the basin, Kylee engaged an external dams expert to provide advice around the failure mechanisms and geotechnical aspects.

Joslin Valley Flood Mitigation Project – Project Manager and Hydraulic Engineer

Joslin Valley lies within the LGA of Norwood, Payneham & St Peters Council, South Australia. It contains significant overland flow paths that flood many properties throughout the valley. Kylee's role was to assess a legacy flood model and update it to the latest ARR2019 Guidelines for use in this project, produce a comprehensive existing conditions report, model a range of mitigation scenarios, undertake a damages assessment of existing and mitigated conditions, and produce mapping and reporting for Council to determine the best mitigation outcome to reduce the flooding impacts throughout the area.

Menangle Park Feasibility and Water Cycle Management Study

Kylee undertook the hydrology and hydraulic model build, flood mapping and associated reporting for inclusion into a Water Cycle Management Report for Menangle Park, a 1500 lot subdivision proposal located within Medhurst in Sydney's Outer Suburbs. The WCM Report forms part of a greater study undertaken by Colliers as a Planning Submission to rezone the site. Box Hill High Density Projects for Bathla Group

Pacific National Tasman Freight Terminal - Senior Engineer – Flood Modelling)

The Tasman Freight Terminal is a proposed Intermodal Rail Hub on a site in Melbourne's outer west. Initially, Kylee undertook flood modelling of the site for the purposes of a Due Diligence assessment. Design is being undertaken and the modelling is being updated to include the Concept Design and a report submitted to the client for a land rezoning application.