Oak Tree Maude Development

2A Maude Street, Belmont NSW 2280

Stormwater and Flood Management Assessment prepared for Oak Tree Group

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Table of Contents

Introduction

Northrop Consulting Engineers have been engaged to undertake a Stormwater and Flood Assessment for Oak Tree Retirement Villages Group for the proposed development at 2A Maude Street, Belmont NSW 2280. This report has been prepared for development application submission to Lake Macquarie City Council (LMCC) to convey the philosophy adopted throughout the management plan.

This study has been prepared to review the existing flood extents across the subject site, review the flood impact of the proposed development and compliance of the proposed development with Council's flood related Development Controls. Additionally, the stormwater management strategies implemented into the proposed development have also been outlined, in accordance with the LMCC Development Control Plan (DCP).

Site Description

The subject site is located within the Lake Macquarie City Council (LMCC) at Lot 202 of DP1236307. The site has a total area of approximately 0.9 hectares and is generally flat, ranging from 4.0m AHD to 6.0m AHD from west to east with an approximate slope of two percent. Under the Lake Macquarie Local Environmental Plan 2013, the site is zoned as Private Recreation (RE2), and currently consists of the Belmont Sporties Club building.

The site is located approximately 250m east of the Pacific Highway, with frontage to both Maude Street to the north and Glover Street to the south. Pat Cahill Oval adjoins the site to the north, and Miller Field adjoins the site to the east. To the west is Lot 201 of DP 236307 which contains an empty lot, following the excavation of the former bowling greens of the Sporties Club. A Child Care Centre and a Residential Dwelling is located to the south and south-west of the subject site.

The subject site is not classified as flood prone land, however there are sections of the site which are impacted by overland flow path, as flow travels from west to east across the site. An easement is located along the southern extent of the subject site.

Figure 1: Site Locality

Proposed Development

Oak Tree Retirement Villages Group are seeking to establish a Residential Seniors Living Facility at 2A Maude Street, Belmont. The proposed development includes approximately 75 self-contained units split over two multi-storey buildings. A sub-ground carpark is proposed, with consideration required to the existing easement which runs beneath the site.

The proposal will provide a mixture of dwelling formats between one and three bedrooms in order to accommodate a diverse range in housing needs. In addition, communal facilities, including kitchen and dining facilities. The common areas included in the proposed development consists of a gym and lounge/library, along with a courtyard and pool which separates the two buildings.

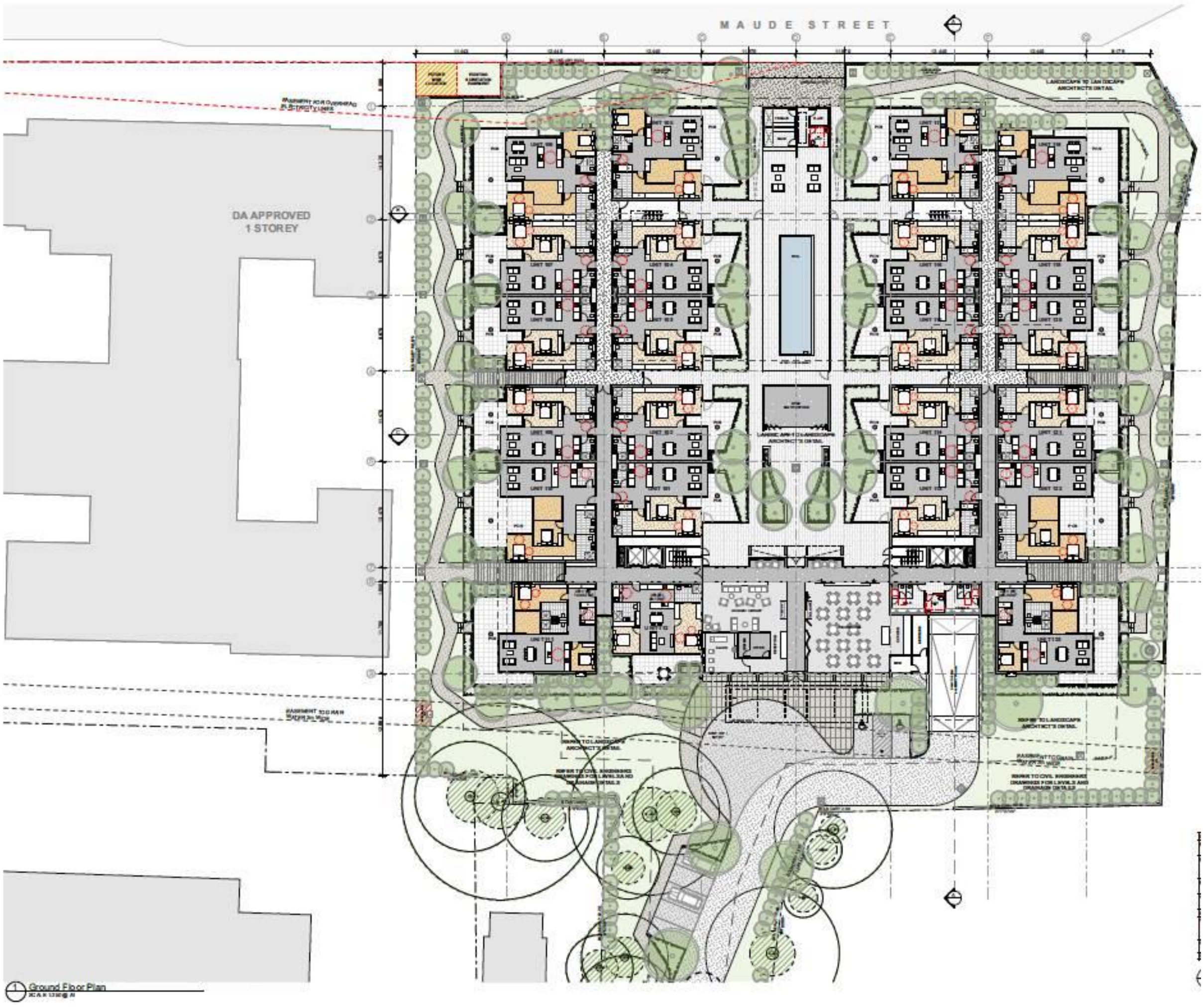


Figure 2: Proposed Development Layout

Review of Council Requirements

Stormwater Assessment

The proposed stormwater management system adopted on site has been designed generally in accordance with the Lake Macquarie Development Control Plan (LMDCP) 2014 Section 2.8. In addition, consideration is to be given to the following guidelines:

- Water Cycle Management Guidelines.
- NSW MUSIC Modelling Guidelines (WMAwater, 2015)
- Stormwater Quality Improvement Devices Guidelines.
- Drainage Design Guidelines.

Section 5.4.1 of the Water Cycle Management Guidelines states the stormwater management targets for total suspended solids, total phosphorus, and total nitrogen. In order to meet these reduction targets, stormwater treatment devices have been incorporated into the design of the development.

Section 2.1.1 of the Drainage Design Guidelines states the requirements for onsite stormwater detention. A development may require onsite stormwater detention to reduce the post-developed flow rates, thereby limiting the impact on downstream ecosystems.

Table 1: LMCC Stormwater Control Requirements

Council Requirement	Our Response
A Water Cycle Management Plan must be submitted for all development except single dwelling houses and dual-occupancy developments. The Water Cycle Management Plan must provide details of the management of stormwater, and the measures proposed to mitigate the effects of stormwater on adjoining or downstream sites in accordance with Council's Water Cycle Management Guidelines.	The water cycle management plan is provided in this report and is illustrated on civil drawing NL183048 DAC03.01.
A Site Stormwater Drainage Plan must be submitted for all single dwelling houses and dual occupancy development proposals. The Site Stormwater Drainage Plan must be prepared in accordance with Council's Water Cycle Management Guidelines.	This is not applicable for this development.
On-site measures must be implemented to maintain water quality, and to minimise the volume of stormwater run-off and the rate at which stormwater leaves the site	A treatment train is proposed as part of this development to manage water quality. This includes a rainwater reuse tank capturing runoff from the roof and being used to irrigate the majority of the landscaped areas. Pit inserts treat runoff from the hardstand areas. Runoff captured by the eastern drainage line and overflow from the tank is directed through a Stormfilter prior to

Council Requirement	Our Response
	discharging into the trunk drainage line running through the stormwater easement.
A maximum of 10% of run-off from built impermeable surfaces may be discharged directly to the drainage system. The remaining 90% of run-off must be captured for reuse or managed through infiltration and retention measures prior to being discharged to the drainage system.	Bypass flow adjacent to Glover Street and Maude Street does not exceed 10%. The remaining 90% is treated through the treatment train described herein prior to discharge.
Stormwater management systems should be visually unobtrusive and integrated within site landscaping, car parks or building structures	Proprietary stormwater treatment systems are proposed and concealed within drainage pits and underground. This is visually unobtrusive for the proposed development.
All developments (except dwelling house or dual occupancy) that involve the re-use of stormwater or the use of recycled water must demonstrate compliance with the Australian Guidelines for Water Recycling and the licensing requirements of the Water industry Competition Act 2006.	Re-use of stormwater is proposed for external irrigation only.
Stormwater management systems must be designed in accordance with the Water Cycle Management Guidelines	Consideration has been given to the Water Cycle Management Guidelines through the preparation of the stormwater management system.

Flooding Assessment

This report has been prepared generally in accordance with the Lake Macquarie City Council Development Control Plan in particular Section 2.9.

Table 2: LMCC Flooding Control Requirements

Council Requirement	Our Response
Development must be consistent with the current version of the NSW Floodplain Development Manual, and any relevant local flood study, floodplain management study or plan applying to the land that has been endorsed by Council	A DRAINS model has been prepared for the local catchment to determine peak flows from design rainfall. A TUFLOW model has also been prepared to assess the flow behaviour in the vicinity of the subject site.
The proposed development must consider and respond to flooding hazards. It must also mitigate risks to life and/or property through design and positioning of development.	The flooding risks have been considered in the development proposal. This includes setting the floor level above the 1% AEP plus 500mm freeboard or approximately at the PMF. The crest of the basement carpark has been set at the 1% AEP plus 500mm freeboard. An overland flow path is provided along the western boundary to the north which provides additional capacity compared to the existing case eastern flow path.

Council Requirement	Our Response
Buildings must not be located in an identified floodway.	The building is not located within an identified floodway and fundamentally replaces an existing building.
Buildings and other structures, including fences, must be designed so as not to impede the flow of floodwaters or entrap debris.	Consideration has been given to fencing type and palisade fencing is proposed for boundaries that convey significant flow in extreme events.
Habitable rooms and commercial development must have a finished floor height at least 500mm above the 100-year ARI (1% AEP) event, or is to have equivalent measures in place to mitigate flood damage (e.g. flood barrier system with evacuation plan). Where probability flood levels are not available, habitable rooms must have a finished floor height at least 500mm above the highest observed flood level for the development site.	The finished floor level has been set above the 1% AEP plus 500mm freeboard. Consideration has also been given to the PMF due to the sensitive proposed use. The PMF calculated is approximately at the same level as the proposed finished floor levels.
Fill is not permitted within core riparian zones, within the Lakefront Development Area or the Foreshore Development Area, or within the extent of the 100-year probable ARI (1% AEP) flood event.	Fill is proposed to achieve the desired development outcome. To offset this, a significant stormwater infrastructure upgrade is proposed through the easement through the subject site and downstream through Miller Field. This conveys the 1% AEP through the subject site and lowers levels at the western boundary providing a benefit for the subject site, neighbouring property at 2B Maude Street and existing developments on Glover Street. This is considered an overall reduction in flood risk.
Lesser provisions may be acceptable where the applicant can demonstrate that the type of development or the proposed use poses no significant risk to life or property by flooding.	As described above measures to minimise the risk to property and life have been incorporated in the development proposal.
Any use of fill associated with development must not substantially impede the flow of floodwater and must not contribute to flooding or ponding of water on any other property.	Fill has been incorporated as part of the development proposal to achieve level access from Glover Street. To counteract the impact of this fill, a significant stormwater infrastructure upgrade has been proposed through the subject site easement and Miller Field. This lowers the flood level adjacent to the developments in Maude Street and Glover Street and increases the flood levels on recreational land downstream which is considered an overall reduction in flood risk.
Development on designated flood prone land should incorporate the floodplain risk management measures, as recommended by a local flood study, floodplain	The property is not designated flood prone land. It is subject to overland flow from the local upstream catchment. Measures are included in the development proposal to minimise risk to property

Council Requirement	Our Response
management study or plan, which identifies and addresses appropriate actions in the event of flooding.	and life. This includes setting of floor levels above the 1% AEP plus 500mm freeboard or approximately the PMF level, provision of an overland flow path along the western boundary for events rarer than the 1% AEP and the ability for residents and visitors to seek refuge onsite in extreme events.
Development on land subject to flooding must use flood compatible materials that will minimise damage by flooding.	The development proposes robust construction and flood compatible materials to withstand damage from flooding.
Development on lots adjoining areas affected by a 100-year probable ARI event will be subject to floor height requirements, even when the site may not be subject to flooding from the 100 year probable ARI event. This requirement is not applicable for land higher than 500mm above the 100-year probable ARI, as calculated for the relevant site.	This has been considered as part of the development proposal and floor levels are set above the 1% AEP plus freeboard.

Stormwater Management Strategy

This section of the report outlines the stormwater management strategy for the proposed development. The strategy has been developed in accordance with Lake Macquarie City Council guidelines and involved an investigation of the flooding behaviour of the development and surrounding catchment.

Stormwater Drainage

The subject site is impacted by overland flooding originating from the upstream local catchment. During the existing case, regional flows from Ernest Street to the west of the subject site exceed the capacity of the stormwater network and continue across the subject site before flowing across the sporting ovals and into a vegetated channel in the east.

Whilst there is a decrease in the impervious area from approximately 79.6% in the pre-developed state to 62.9% in the post developed state, the location of the development, and extent of the buildings has the potential to impact the peak flow and volume of stormwater runoff from the site.

To review the impact the proposed development has on the existing flow regime, an investigation has been prepared using a TUFLOW hydraulic model for the subject site and contributing catchments. The LMCC objectives, with respect to water quantity, outlined in the Council Requirements section of this report, have been reviewed as part of this investigation.

Methodology

This assessment has been undertaken through the following methodology:

- Desktop review of available information including the proposed development, LiDAR elevation, aerial photography and the stormwater data provided by Lake Macquarie City Council.
- Delineate the contributing catchments to the outlet of the proposed development, east of Miller Field.
- Site visit to review the existing topography, nearby stormwater infrastructure, land-use and surface roughness.
- Construction of a DRAINS model to estimate the local catchment peak flows surrounding the subject site. Flood hydrographs were generated for the 1% and 1 in 200 AEP (Annual Exceedance Probability) and PMF (Probable Maximum Flood) events.
- Comparison of the peak flow derived by the pre and post developed catchments during the 1% AEP, 1 in 200 AEP and PMF design storm events at the site discharge points.
- Preparation of an existing case two-dimensional TUFLOW hydraulic model to represent the flow behaviour through the subject site. Flood Hydrographs for the DRAINS model have been included in the TUFLOW two-dimensional model, as well as the downstream tailwater levels from the Lake Waterway Flood Study.
- Modification of the TUFLOW model to include the proposed development. Additional amendments to the proposed development to provide mitigation methods in the design.
- Comparison of the two-dimensional flood depths to review the effects of the proposed development on the flood behaviour within the subject site and in adjacent properties.

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

DRAINS Model Parameters

Stormwater runoff inflows for the existing catchment conditions has been modelled using the DRAINS software package. The DRAINS model included 11 sub-catchments which have been mapped based on 1m LiDAR survey across the subject site and surrounding vicinity. The model was used to create the flow boundary conditions for input into a two-dimensional TUFLOW model. Parameters which were adopted in the DRAINS model are discussed below.

It is noted that the latest Australian Rainfall and Runoff Guidelines (2019) have been used in the preparation of the study.

Catchment Data

Sub-catchments have been determined using a combination of detailed survey, LiDAR, aerial imagery, onsite observations, and cadastral data. The sub-catchments used in the DRAINS model are shown in Figure 3. The time of concentration was determined for each of the catchments, with the kinematic equation applied to determine the overland flow path time for the catchments which were pervious.

Storm Losses

Storm losses used for this investigation have been obtained from the ARR Data Hub. Storm losses provided by the ARR Data Hub are intended for rural catchments. As the proposed development is located in an urbanised area, additional reductions to the pervious initial losses have been applied as shown in the below Table 3.

The pervious losses have been reduced by a factor of 0.7, as recommended in the latest ARR 2019 guidelines. Similarly, modelled continuing losses have been reduced by a factor of 0.4 in accordance with the advice provided in the latest Department of Primary Industry and Environment (DPIE) guidelines.

Table 3: Adopted DRAINS Rainfall Loss Rates

Land-Use	Initial Loss (mm)	Continuing Loss (mm/hr)
Rural Pervious (ARR Data Hub)	21.0	2.4
Urban Pervious (Modelled)	14.7	0.96
Urban Impervious (Modelled)	1.5	0

Burst Rainfall Data

Rainfall Intensity-Frequency–Duration (IFD) depths for the ARR 2019 have been obtained from the Bureau of Meteorology (BOM) for a location over the catchment centroid.

The “East-Coast South” temporal patterns have been adopted for the ARR 2019 hydrology. These temporal patterns were applied to 1% AEP and 1 in 200 AEP design storm depths. The Generalised Short Duration Method (GSDM) and procedures outlined in the Publication *“The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method”* (BOM, 2003) were used to develop design storm depths and patterns for the Probable Maximum Flood (PMF).

Pre-Burst Rainfall Data

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

TUFLOW Model Parameters

Two-Dimensional Grid Extent and Timestep

All events were modelled with a grid size of 1m x 1m for the two-dimensional model to accurately represent flows around the buildings and through overland flow paths. The grid extends over an area of 20.5ha from the Pacific Highway in the west to a vegetated channel east of Miller Oval.

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

Terrain

A combination of detailed survey and LiDAR elevation data has been used to generate the model terrain. As the latest LiDAR for the subject site was collected in 2014, the site visit presented various features which were not illustrated by the LiDAR. As such, manual changes were added into the model to better represent the terrain and flow paths which were present on the subject site.

Boundary Conditions

Inflow hydrographs have been entered for each of the catchments within the model, as extracted from the DRAINS model. These were applied to the model via the pit locations, and to the lowest point within those sub-catchments without pits. These represent the maximum of the median for each quantile, median storm for each ensemble duration as recommended in Clause 5.9.2, Book 2 of the AR&R2019 Guidelines. Peak flows expected at the proposed development location are outlined in the results section.

An outlet head boundary has been entered downstream of the subject site with a tailwater elevation of 1.5m AHD. These levels are based on the flood elevation rasters in the Lake Waterway Flood Study.

Catchment Roughness

The modelled surface roughness is presented in Table 4 below.

Table 4: Mannings 'n' Surface Roughness

Land use Type	Roughness (Manning's)
Grass	0.035
Residential (Landscaping Beneath Buildings)	0.060
Creek	0.080
Roads and Hardstand	0.015
Gravel	0.025

All buildings in the catchment were represented as 100% impervious obstructions. This has been performed in an attempt to better represent the flow between the buildings.

Pit and Pipe Network

The pit and pipe network in the 2D model consists of a variety of stormwater inlet pits, pipes and culverts. The information used in the model is a combination of detailed survey data, visual observations, and Council files.

A detailed survey of the pipe alignment was conducted to ensure the stormwater network in the model accurately represented the development site. As such, various changes were made to the model, with some pipes realigned to undocumented junction pits, and other pipes removed as the survey was unable to locate the pipes.

DRAINS Peak Flow

The peak discharge of the catchment consisting of the subject site was determined for the 10% AEP, 1% AEP, 1 in 200 AEP and the PMF events. These are summarised in Table 5.

Table 5: Rainfall Events and Critical Durations

Event	Peak Discharge (m^3/s)
10% AEP	0.51
1% AEP	0.90
1 in 200 AEP	1.02
PMF	3.05

Existing Flood Behaviour

The existing stormwater infrastructure upstream of the subject site are generally small pipes, with limited cover. As such, the site is subject to flooding from overland flow, due to the insufficient capacity of the pipeline. This flow path follows generally in the same location as the existing stormwater line. Flows from Glover Street to the south of the subject site, connect with overland flow from Ernest Street directly upstream of the development boundary. The existing site conditions provide a 2-metre overland flow path to the south, between the existing building and fenced site boundary.

Results of the 10% AEP indicate the flow which is entering from the west of the development site, is not captured within the sag inlet pit. As such, overland flow from Glover Street flows back to the west and joins overland flow from 8-10 Ernest Street, in addition to the flow path down the western boundary and to the south of the building.

During the 1% AEP event, the flood level across the site is in the order of 4.9m AHD with a maximum flood depth of approximately 0.35m observed in the south-western corner of the site. Velocities are generally lower than 0.2m/s, with peaks in excess of 1.3m/s in the north-eastern corner of the site. Within the PMF, the site is inundated by depths up to 0.5m, resulting in an elevation of 5.05m AHD.

Flood hazard is based on the latest Australian Rainfall and Runoff Guidelines with the hydraulic behaviour and pedestrian, vehicle and building thresholds summarised for each category in the below Figure 3. Hazard categories for the development site are generally H1 with few H2 categories within the 1% AEP and increases to have H3 on the western boundary as well as H6 in the north-eastern corner in the PMF. The H6 hazard can be attributed to a surface inlet pit to the north of the subject site.

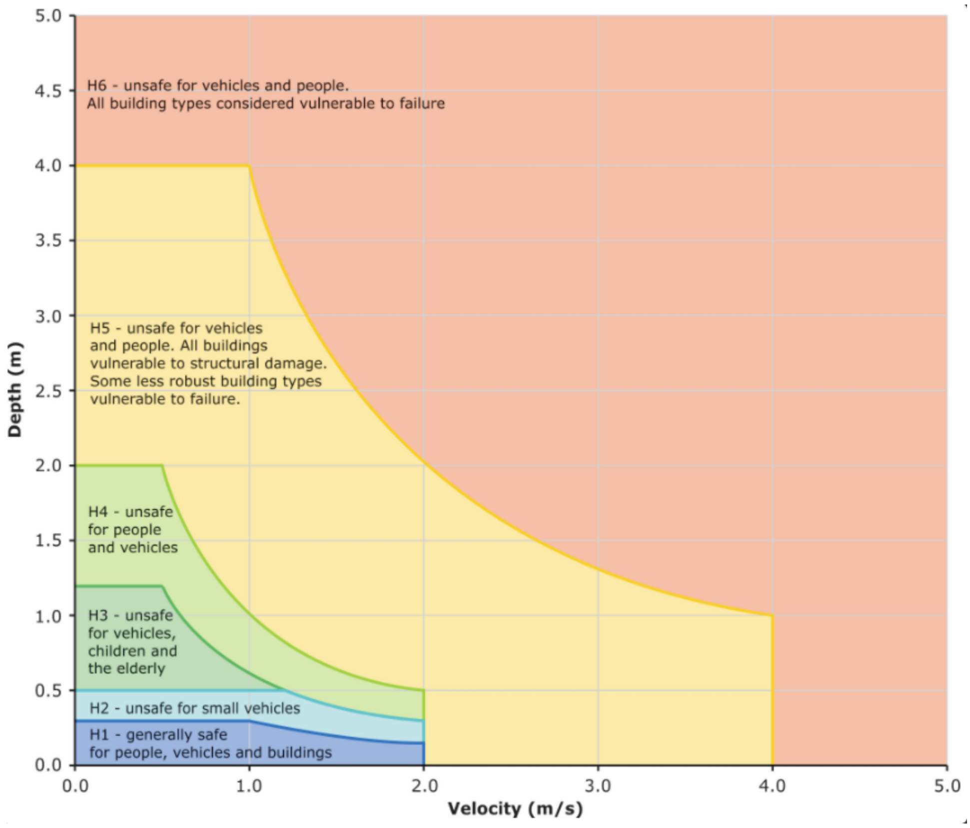


Figure 3: Australian Rainfall and Runoff (2019) Hazard Categories

The 1% AEP flood behaviour for various locations around the site were investigated. These included immediately upstream, at 2B Maude Street, the main overland flow route, Maude Street, and at the outlet of the site in the north-east corner. This is summarised within the following table, Table 6.

Table 6: 1% AEP Flood Behaviour - Existing

Event	2B	Maude Street	2A
Flood Level (m AHD)	4.89	4.61	4.88
Flood Depth (m)	0.58	0.10	0.35
Flood Hazard	H3	H2	H2

The existing case flood depth and elevation figures for the 1% AEP, 1 in 200 AEP and PMF are presented in Figures C1, C3 and C4 of Appendix A, respectively. Similarly, the flood hazard for the 1% AEP and PMF flood events are presented in Figures C2 and C5.

Developed Flood Behaviour

In the model, it was determined that an upgrade was required for the stormwater network from Ernest Street through to 2A Maude Street to convey the 10% AEP requirement for the site. As such, the existing stormwater network through the site was removed and made use of the Council easement.

The proposed three metre easement contains a 2.0m x 0.6m culvert and is accessed via the surface inlet pit in the sag point directly upstream of the development site. The surface inlet pit has been upgraded to a 1.8m x 1.8m grate from the existing to allow more flow to be captured. At the outlet of the site, a vegetated swale has been proposed, following the boundary line of the baseball pitch on Miller Field. This swale joins the existing outlet, which discharges into a wetland.

The existing stormwater pipeline from 8-10 Ernest Street to the western boundary of the subject site was also upgraded as part of the development, in addition to the proposed development on 2B Maude Street. These changes were included in the development and were expected to have a significant impact on the flood behaviour as the existing surface is an overland flow path for the major to extreme events.

During the 1% AEP the maximum flood elevation is 4.68m AHD, at 4.78m AHD in the 1 in 200 AEP event and 5.34m AHD in the PMF. Whilst the flow in the developed case is similar to that of the existing case with flows entering the subject site from the west, flow now predominately travels north along the western boundary in the 1 in 200 AEP and PMF event. From raising the levels through the development, the west to east overland flow path is reduced and only activated in the PMF. Additionally, the PMF level is increased as a result of the major flow path through 2B Maude Street becoming developed. This means increased flow is expected to be bypass via Maude Street and run through the overland flow path to the west of the site.

The 1% AEP hazard categories in the developed case have been reduced to H1 in a small portion of the site. Through upgrading the stormwater network, majority of the 1% AEP event is captured and conveyed underground. In the PMF, the hazard category reaches H3 along the western boundary. This is the main overland flow path for the development, so greater flow is expected along the boundary than in the existing case.

The 1% AEP flood behaviour has been investigated at 2B, the main overland flow route, and at the outlet of the site in the south-east corner. This is summarised within the following table, Table 7.

Table 7: 1% AEP Flood Behaviour - Developed

Event	2B	Maude Street	2A
Flood Level (m AHD)	4.68	4.44	4.28
Flood Depth (m)	0.37	0.20	0.1
Flood Hazard	H2	H1	H1

Developed case flood depth and elevation contours during the 1% AEP, 1 in 200 AEP and PMF are presented in Figures D1, D4 and D5 of Appendix A. Figure D3 presents the 1% AEP velocity of the developed case, and Figures D2 and D6 represent the flood hazard categories across the subject site and vicinity during the 1% AEP and PMF design storm events.

Comparison of Flood Behaviour

A comparison between the 1% AEP and 1 in 200 AEP existing and developed case scenarios using the site-specific TUFLOW model is presented in Figures E1 and E2. From the comparison, a decrease is evident in the water levels observed in the upstream properties, as well as along Glover Road and Maude Street. Through conveying more flow through the developed model, the increase in depth is mainly observed through the swale.

Stormwater Quality Management Strategy

Stormwater Quality Philosophy and Targets

The proposed development has the potential to impacts the stormwater runoff from the site. In order to minimise any adverse impacts on the downstream watercourses; stormwater treatment devices have been incorporated into the design of the development. Council's Water Cycle Management Guidelines (2013) identifies the level of stormwater quality treatment to be provided for the proposed development. These are outlined in Table 8 below.

Table 8: LMCC Water Quality Targets

Pollutant	Reduction Target
Total Suspended Solids (TSS)	80%
Total Phosphorus (TP)	45%
Total Nitrogen (TN)	45%
Gross Pollutants	70%

Stormwater Quality Improvement Devices (SQIDs) have been incorporated throughout the development to ensure runoff is treated in line with the above Council requirements.

To review the performance of the proposed SQIDs, a MUSIC model has been prepared for the proposed development. The MUSIC model setup, including the parameters and assumptions used are summarised below.

MUSIC - Treatment Train Assessment

To determine the effectiveness of the proposed water quality control measures, stormwater quality modelling was undertaken using the Model for Urban Stormwater Improvement and Conceptualisation (MUSIC) V6.3.0. The model used LMCC rainfall and PET data from 1999-2008 with a 6-minute timestep for the north region.

Modelling was completed in accordance with the "NSW MUSIC Modelling Guidelines" (BMT WBM, 2015). The MUSIC model was developed using recommended parameters presented in the NSW MUSIC Guidelines (BMT WBM, 2015) and the LMCC's MUSIC Link. A schematic of the MUSIC model can be seen in Figure 4.

Catchment Summary

A summary of the catchments modelled in are summarised below.

- Total Site Area = 9,575 m^2
- Pre-developed Impervious Fraction = 79.6%
- Post-developed Impervious Fraction = 62.6%
  - Roof Area = 4245.6 m^2 (100% impervious)
  - Driveway = 841.8 m^2 (100% impervious)
  - Hardstand = 2404 m^2 (85% impervious)
  - Landscaped Area = 3283 m^2 (0% impervious

Modelling was prepared in accordance with the "NSW MUSIC Modelling Guidelines" (BMT WBM, 2015). The MUSIC model was developed using recommended parameters presented in the NSW MUSIC Guidelines (BMT WBM, 2015), the LMCC's MUSIC Link and the LMCC standard drawings.

A schematic of the MUSIC model is presented in the below Figure 4. The source nodes adopted to represent the development were Urban Roof, Urban Sealed Road, and Urban Mixed. Urban Mixed was used to represent the landscaped areas and varied in impervious percentage depending on the locations within the development.

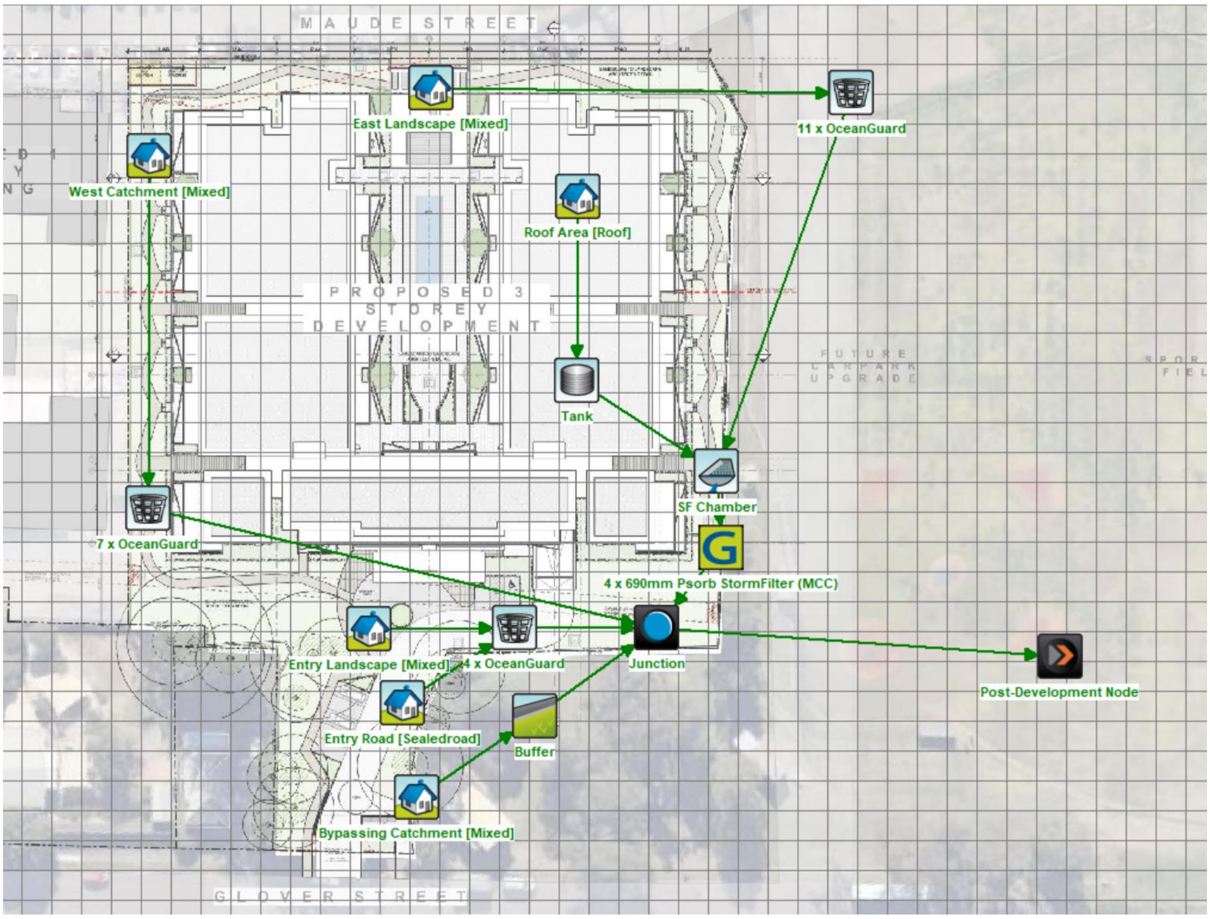


Figure 4: MUSIC Model Layout Schematic

Treatment Train Strategy

The proposed treatment train incorporates the following:

- A rainwater tank is proposed to collect runoff from all roof areas,
- OceanGuard pit inserts (or approved equivalent) are proposed throughout all grated inlet pits in the landscaped areas and entry road.
- StormFilter chamber is located near the outlet of the site, before discharging into the vegetated swale
- The bypassing catchment areas are to drain across a buffer area.

Treatment nodes were created within the MUSIC model to represent the water quality treatment devices. A description of each of these measures are included overpage.

Rainwater Tank

Runoff from the roof areas is to be collected and diverted to a 100kL rainwater tank. All downpipes connected to the tank are proposed to be connected to a first flush device located prior to the tank inlet. The first flush device will provide treatment acting to remove leaf litter sediment before entering the tank. The high flow bypass for the reuse tank was modelled to capture 100% of the flow on the roof. As such, a maximum of 100m^3/s was adopted for the inlet of the tank.

The re-use demand adopted in the MUSIC model included external re-use for irrigation of the landscaped areas. External reuse was estimated using the SEQ MUSIC Modelling Guidelines.

An annual irrigation rate of 548mm/m^2 (daily rate of approximately 1.5mm/m^2) has been assumed based on the guidelines which is expected to be distributed across pervious landscaped areas of the development. These areas equate to an approximate area of 2641m^2. As a result, an annual external re-use demand of 1447kL was calculated. External re-use was modelled using the annual demand scaled by daily PET-Rain as per the NSW MUSIC Modelling Guidelines (BMT WBM, 2015). The below Table 9 provides a summary of the contributing roof areas, the external re-use demand and volume of the proposed tank, and the percentage of re-use demand met.

Due to spatial constraints and the proposed rainwater tank size, the re-use storage will be situated underground adjacent to the basement carpark, where adequate space is available.

Table 9: Re-use Tank Parameters

Roof Area (ha)	Annual External Re-use Demand (kL)	Tank Volume (kL)	% Re-use Demand Met
0.435	1447	100	80.3

A maximum drawdown capacity of 80% was assumed with the bottom 20% of the tank expected to be “topped up” with potable water to ensure demand is met during dry periods.

Overflow from the rainwater tank will be directed to the StormFilter before exiting the site via the proposed stormwater network.

Pit Inserts

Pit inserts are to be used for all proposed grated pits through the driveway and landscaped areas of the site. A total of 22 OceanGuard pit inserts were included in the MUSIC model, representing each of the inlet pits proposed in the development.

The landscaped areas were divided into three contributing areas: west, east and entry landscape. A high flow bypass of 0.14m^3/s, 0.22m^3/s and 0.08m^3/s, respectively, was calculated based on a peak treatment flow rate of 0.02m^3/s per unit in accordance with the manufacturers specifications.

Buffers

A buffer was included in the MUSIC model to simulate the interaction between the hardstand landscaped areas and the adjacent pervious areas. For the proposed development, the percentage of upstream area contributing to each of the buffer nodes was modelled, with 50% of the defined impervious area buffered as per the NSW MUSIC Modelling Guidelines (BMT WBM, 2015).

Proprietary Treatment Device

An Ocean Protect StormFilter is proposed in the south-eastern corner of the catchment. Flow reaching the filter chamber is derived from the rainwater tank overflow as well as the landscaped areas along the eastern boundary. The StormFilter treats stormwater runoff from the proposed development, before discharging the treated stormwater into the existing stormwater network downstream of the site.

The StormFilter has been modelled based on the details the manufacturers have specified. This is based on the chamber consisting of four 690mm filters, proposed to be located within a manhole. Using these values, and the depth allowance of 1.4m, the StormFilter was added into the model to meet the requirements set out by the LMCC.

MUSIC Modelling Results

The results from the MUSIC modelling are presented in Table 10.

Table 10: MUSIC Model Result Summary (Outlet Node)

	Source Load (kg/yr)	Residual Loads (kg/yr)	Percentage Reduction	Target Objectives
Total Suspended Solids (TSS)	610	116	**81%**	80 %
Total Phosphorous (TP)	1.45	0.70	**51.8%**	45 %
Total Nitrogen (TN)	13.7	7.4	**45.9%**	45 %
Gross Pollutants	174	3.56	**98%**	90 %

Table 10 shows that the proposed stormwater management strategy effectively achieves the load reduction targets set out in the LMCC DCP 2013, as estimated by MUSIC. A MUSIC-link report has been included in Appendix B. The MUSIC model can be provided upon request.

A reuse demand efficiency for the proposed 100kL reuse tank was determined to be approximately 80.3% reuse, in accordance with the LMCC requirement. To review the performance of the proposed 100kL reuse tank, the following was prepared which demonstrates the impact which the different tank volumes has on the reuse demand requirement met, relative to the roof area and capture available.

Figure 5 suggests a benefit of only 4% is achieved by increasing the tank volume another 20kL. Similarly, a reduction of 20kL would result in a reduction in the tank efficiency of approximately 8%. As a result, a tank size of 100kL proposed herein is considered the most cost-effective size while still providing a reasonable benefit with respect to the external reuse demand.

Ongoing maintenance of the implemented treatment devices will be required to ensure they continue to operate as intended.

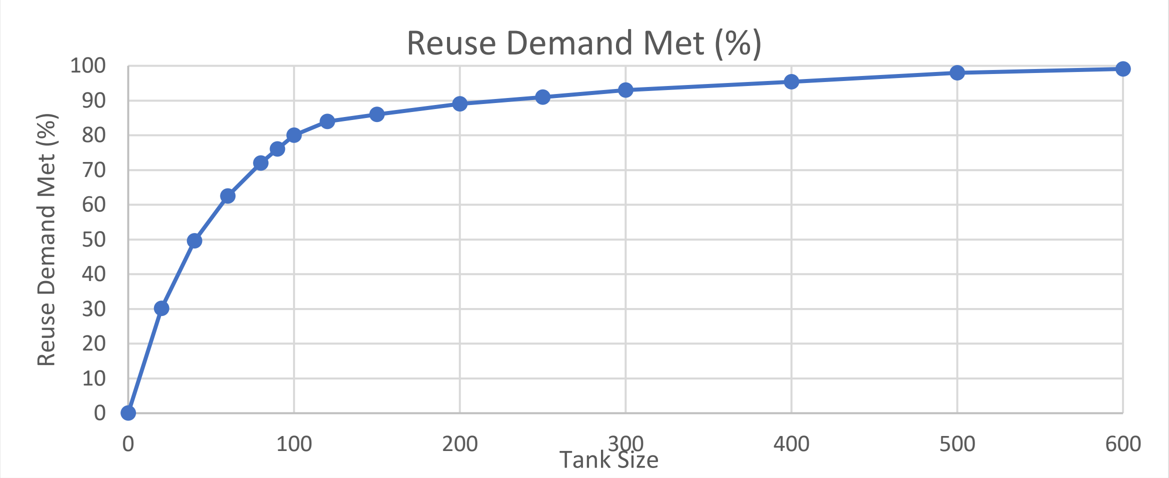


Figure 5: Rainwater Tank Re-use Demand

Construction Phase

In accordance with LMCC's Erosion and Sediment Control Guideline a Concept Erosion and Sediment Control Plan has been prepared for the site. The plan is intended to ensure appropriate management of soil disturbance and stormwater runoff throughout the construction phase of the project. In accordance with Council requirements the plan has been developed with primary refence to Landcom's 2004 publication *'Managing Urban Stormwater – Soils and Construction'.*

Conclusion

Northrop Consulting Engineers have been engaged to prepare a flood impact assessment and stormwater management plan for the proposed development at 2A Maude Street, Belmont.

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

The investigation concluded that:

- The flows from the upstream catchment and proposed developed are not considered to create a significant flood impact on the downstream catchment and the area surrounding the site.
- Measures implemented as part of the development provide mitigation of flooding risk to property and life.
- The proposed development generally complies with the requirements of LMDCP 2014 Section 2.8 with respect to stormwater management.
- The proposed development generally complies with the requirements of LMDCP 2014 Section 2.9 with respect to floodplain management.

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

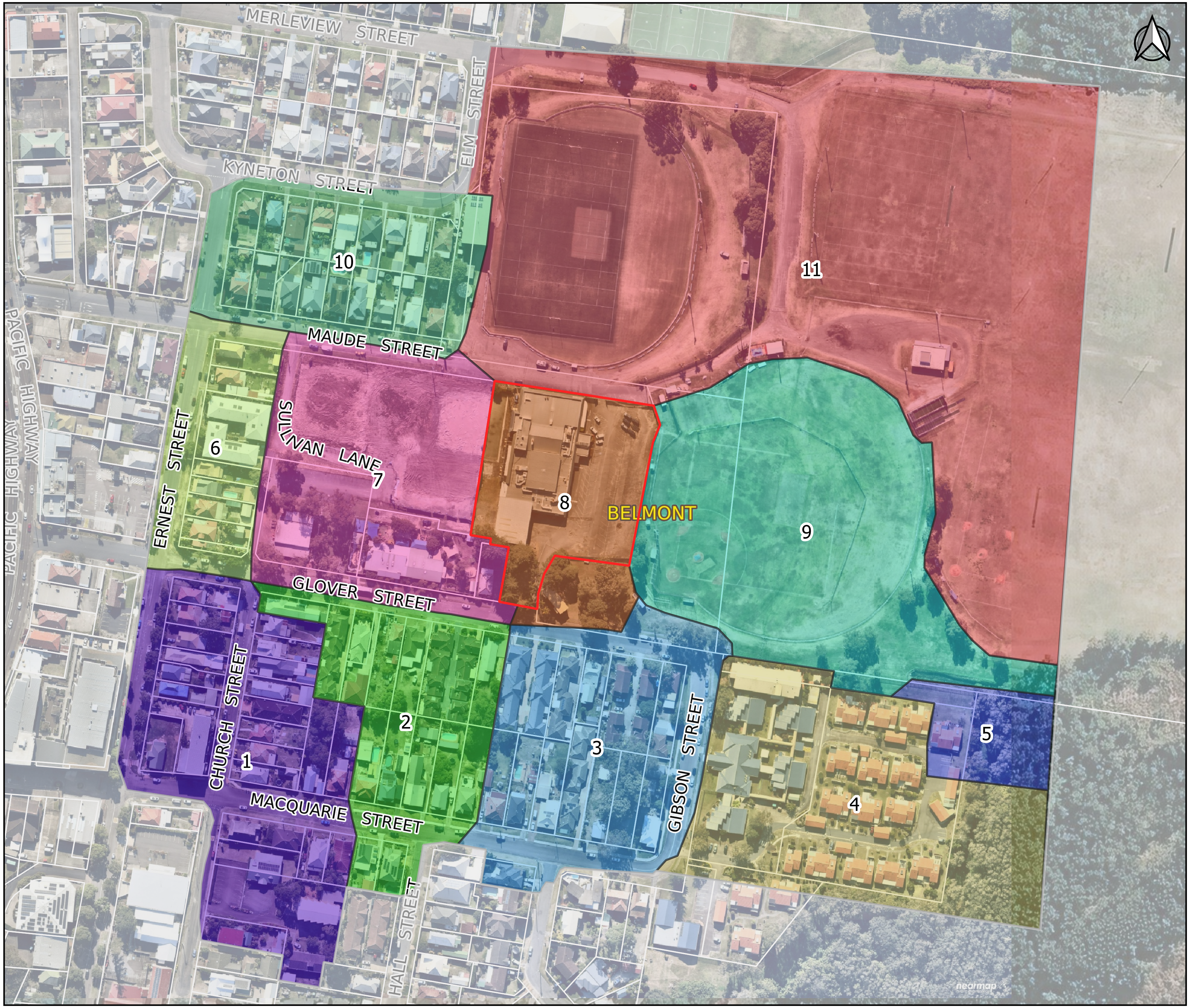
Prepared by:

Danielle Nicol
Civil and Flooding Engineer
BEng (Environmental)

Reviewed by:

Angus Brien
Principal Engineer
BEng (Civil) MIEAust CPEng RPEQ

Appendix A



Legend

Subject Site

Model Extent

Cadastre

0 50 100 Metres

1:3,000

Figure A1

Study Terrain and Catchments

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

2/9/2021 Y:\YEAR 2018 Jobs\NL183048-01 - 2A Maude Street, Belmont\O - Drawings\QGIS\Figures\210902_NL183048-01_Figures.qgz

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Legend

- Subject Site
- Model Extent
- Developed Buildings
- Developed Surface(mAHD)

Developed Mannings

- 0.015
- 0.035
- 0.06
- 0.025

0 50 100 Metres

1:3,000

Figure A2

Existing Case Roughness and Model Setup

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

3/9/2021 Y:\YEAR 2018 Jobs\NL183048-01 - 2A Maude Street, Belmont\O - Drawings\QGIS\Figures\210902_NL183048-01_Figures.qgz

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Legend

- Subject Site
- Model Extent
- Developed Buildings
- Developed Surface(mAHD)

Developed Mannings

- 0.015
- 0.035
- 0.06
- 0.025

0 50 100 Metres

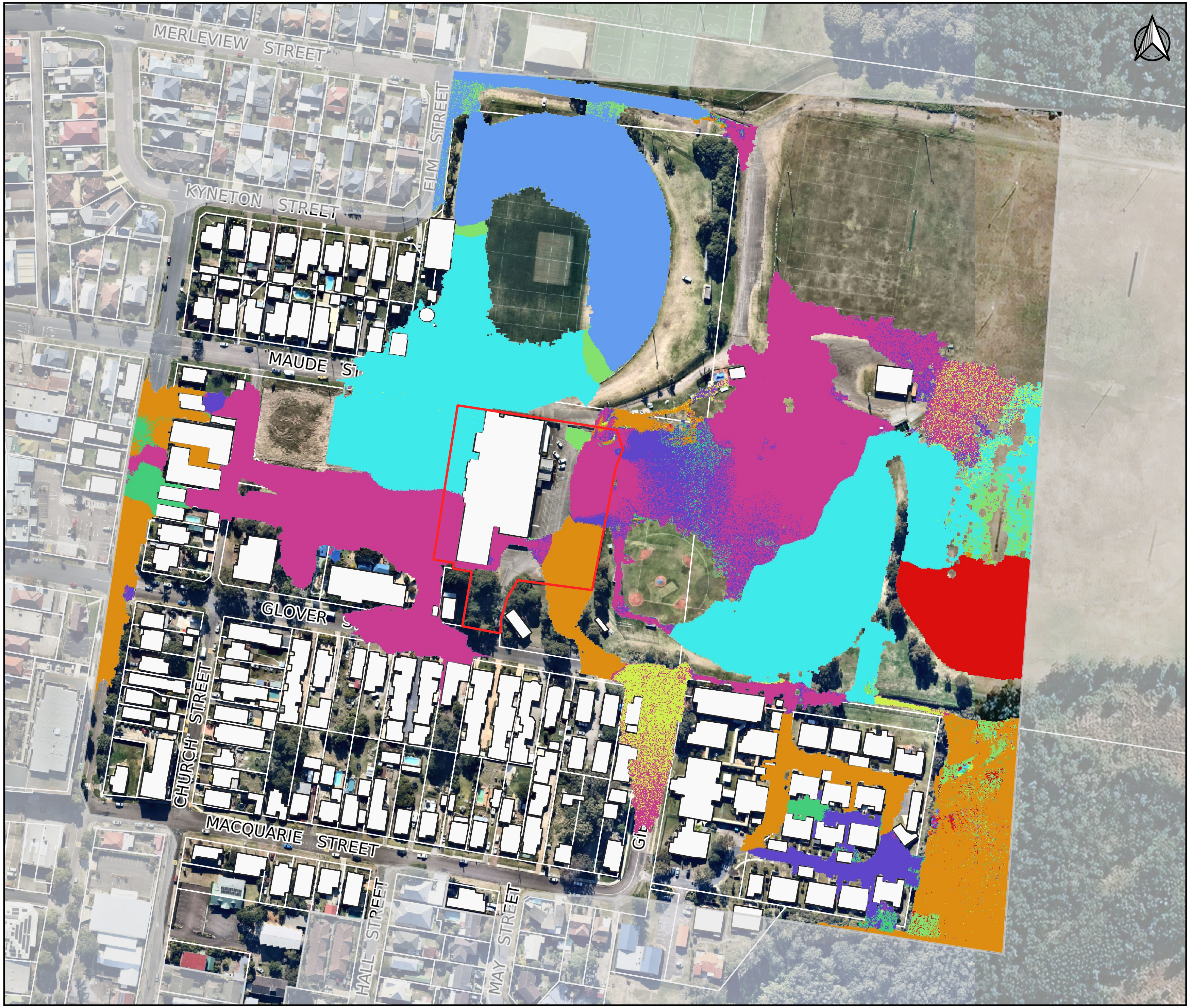
1:3,000

Figure A3

Developed Case Roughness and Model Setup

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP



Legend

- Subject Site
- Model Extent
- Existing Buildings

Critical Event Durations

- 10min
- 120min
- 15min
- 180min
- 20min
- 25min
- 30min
- 45min
- 60min
- 90min

0 50 100 Metres

1:3,000

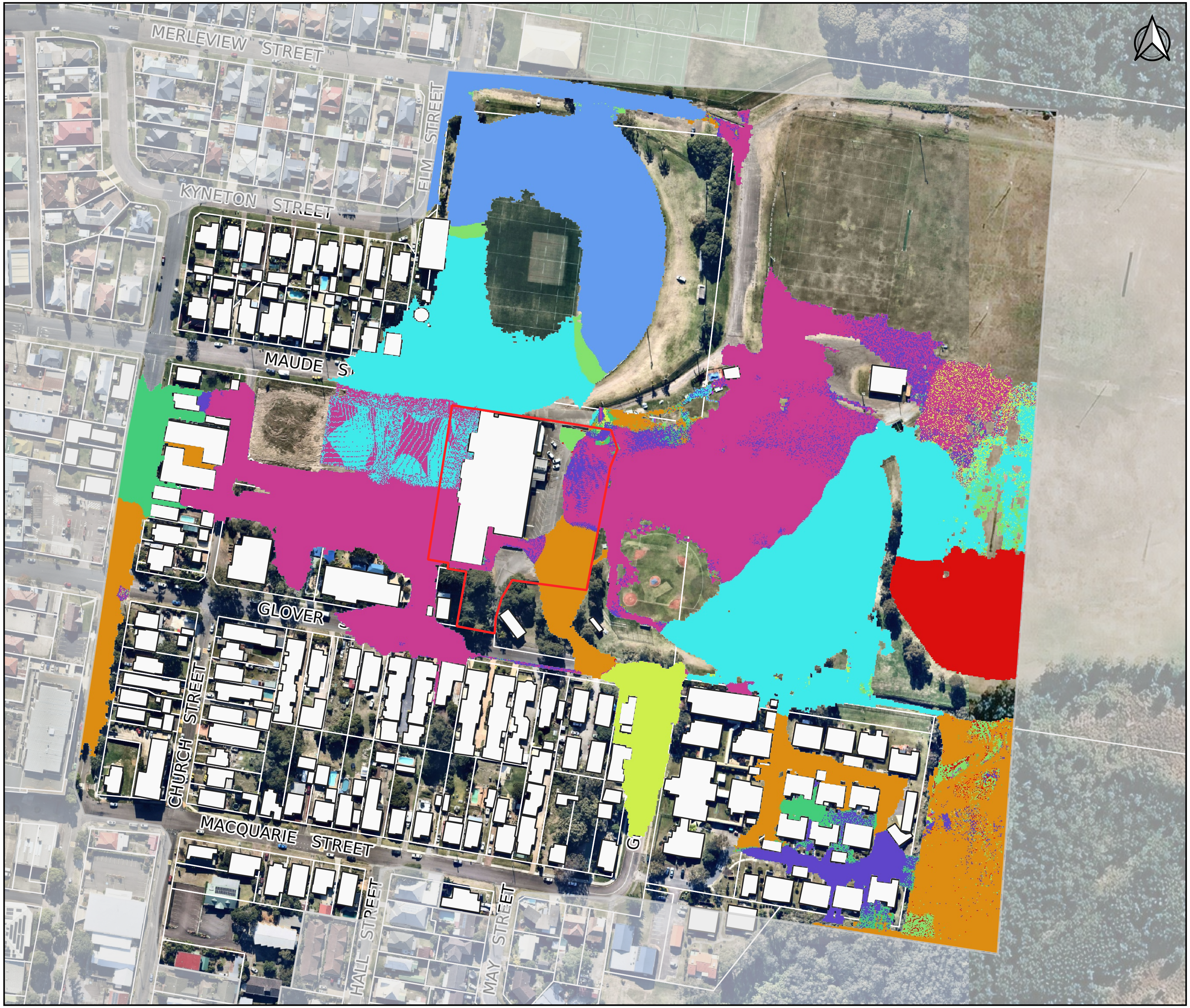
Figure B1

Existing Case
1% AEP Critical Event

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Existing Buildings

Critical Event Durations

- 10min
- 120min
- 15min
- 180min
- 20min
- 25min
- 30min
- 45min
- 60min
- 90min

0 50 100 Metres

1:3,000

Figure B2

Existing Case
1 in 200 AEP Critical Event

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Legend

- Subject Site
- Model Extent
- Existing Buildings

Critical Event Durations

- 120min
- 150min
- 15min
- 180min
- 30min
- 45min
- 60min
- 90min

0 50 100 Metres

1:3,000

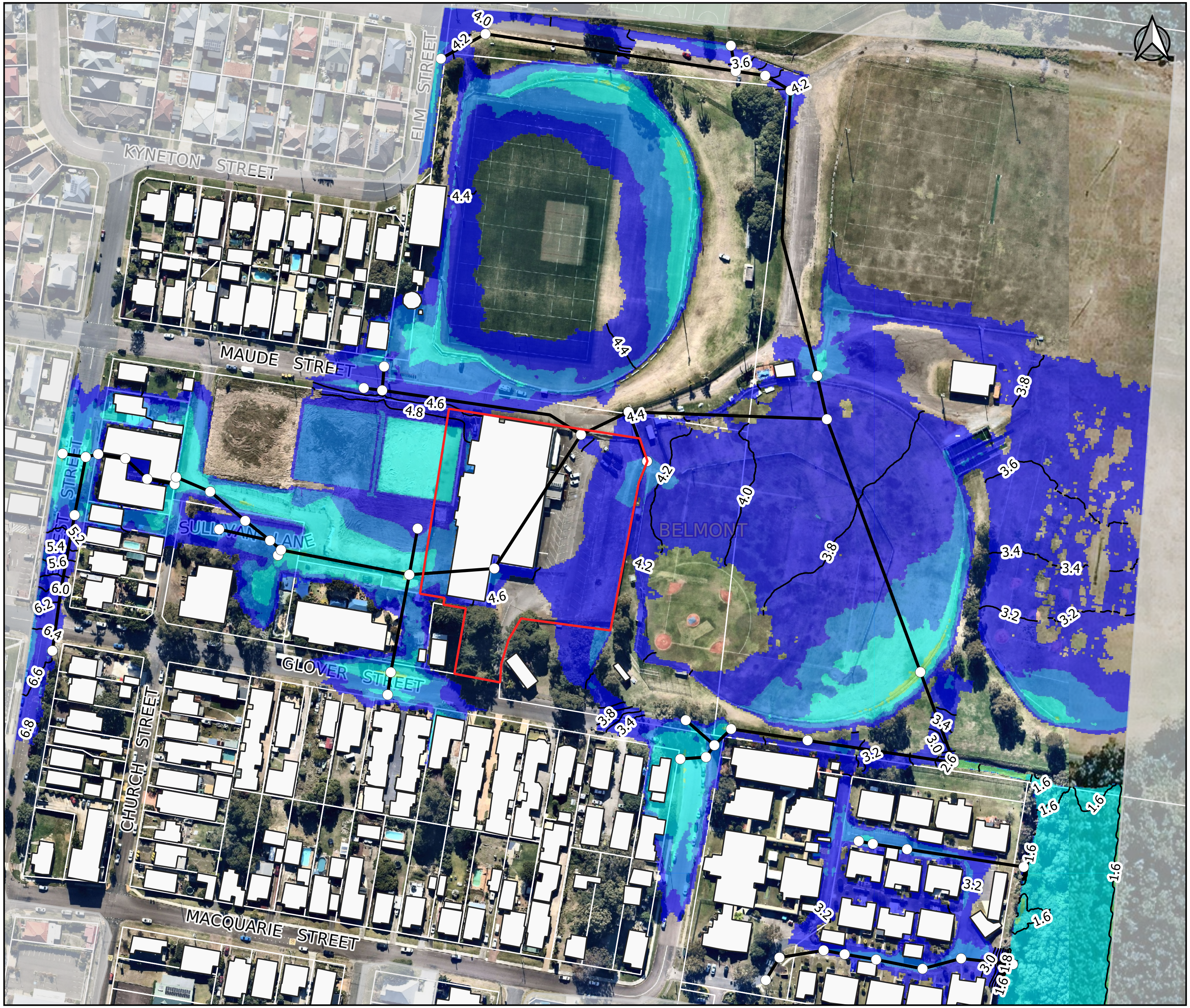
Figure B3

Existing Case
PMF Critical Event

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Existing Buildings
- Existing Pits
- Existing Pipes
- 0.2m Elevation Contours

Flood Depth (m)

- Less than 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- Greater than 1.2

0 40 80 Metres

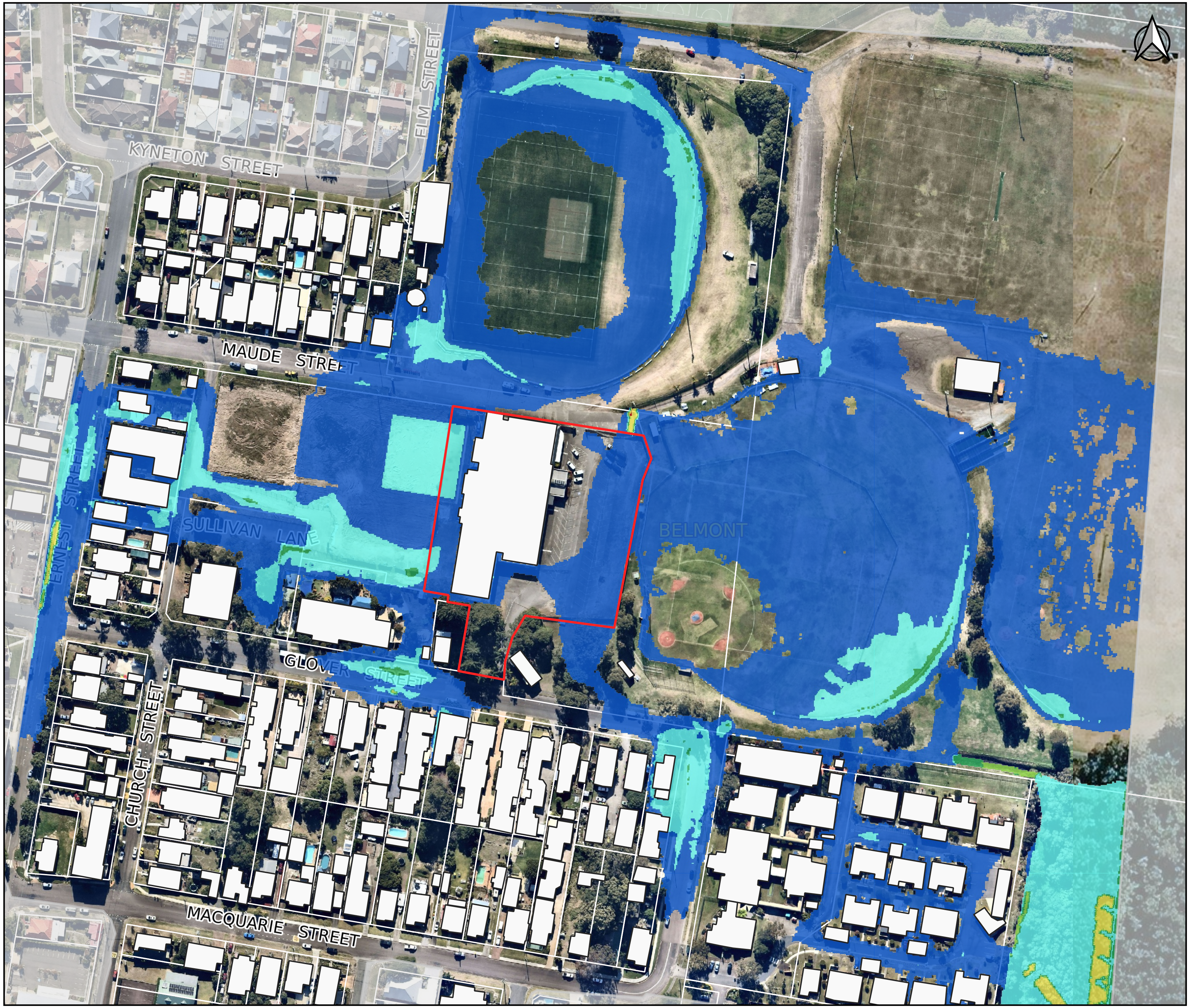
1:2,500

Figure C1

Existing Case
1% AEP Flood Depth and Elevation Contours

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP



Legend

- Subject Site
- Model Extent
- Existing Buildings

Hazard Category (ARR2019)

- 1
- 2
- 3
- 4
- 5
- 6

0 40 80 Metres

1:2,500

Figure C2

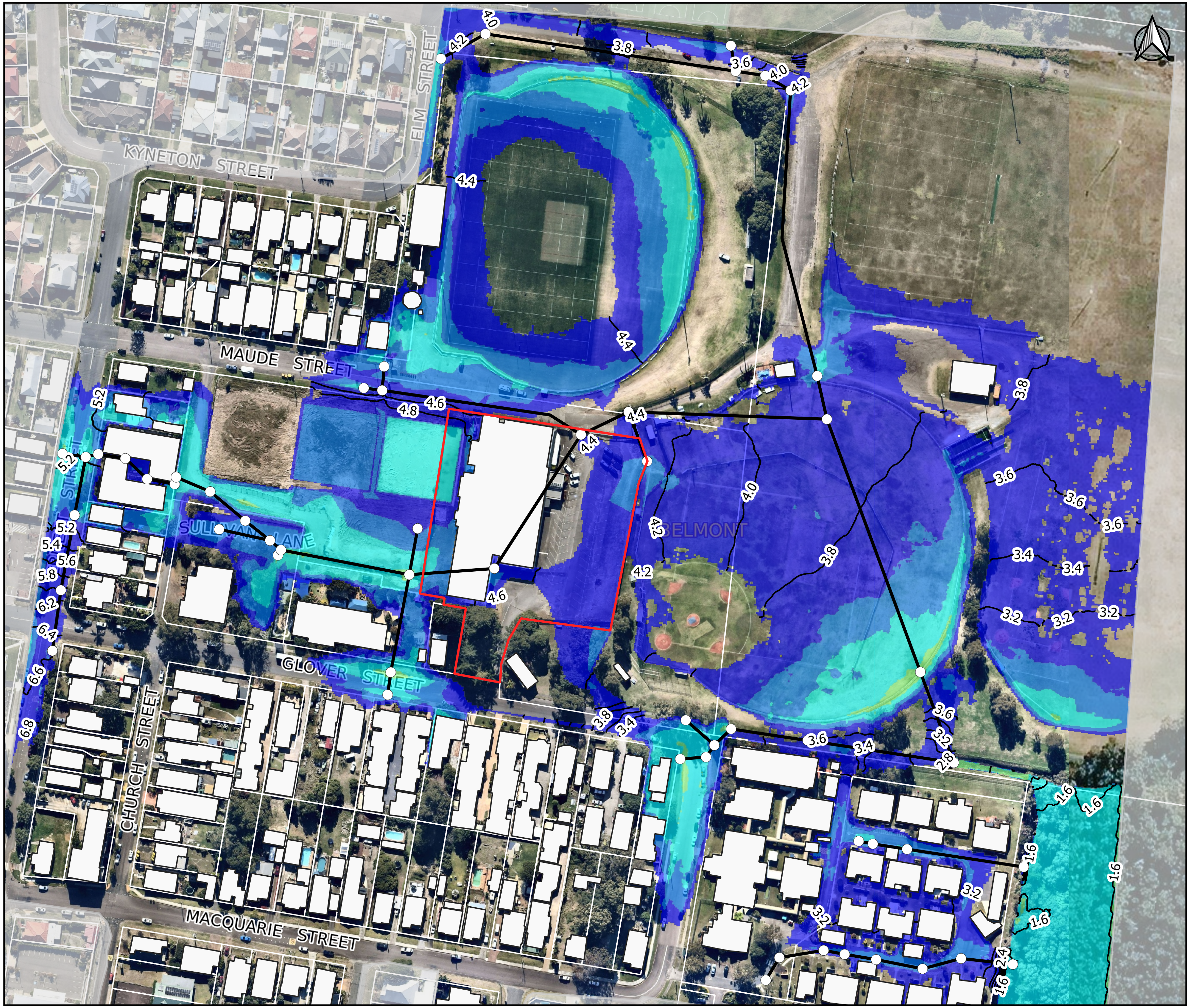
Existing Case
1% AEP Flood Hazard

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

3/9/2021 Y:\YEAR 2018 Jobs\NL183048-01 - 2A Maude Street, Belmont\O - Drawings\QGIS\Figures\210902_NL183048-01_Figures.qgz

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Existing Buildings
- Existing Pits
- Existing Pipes
- 0.2m Elevation Contours

Flood Depth (m)

- Less than 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- Greater than 1.2

0 40 80 Metres

1:2,500

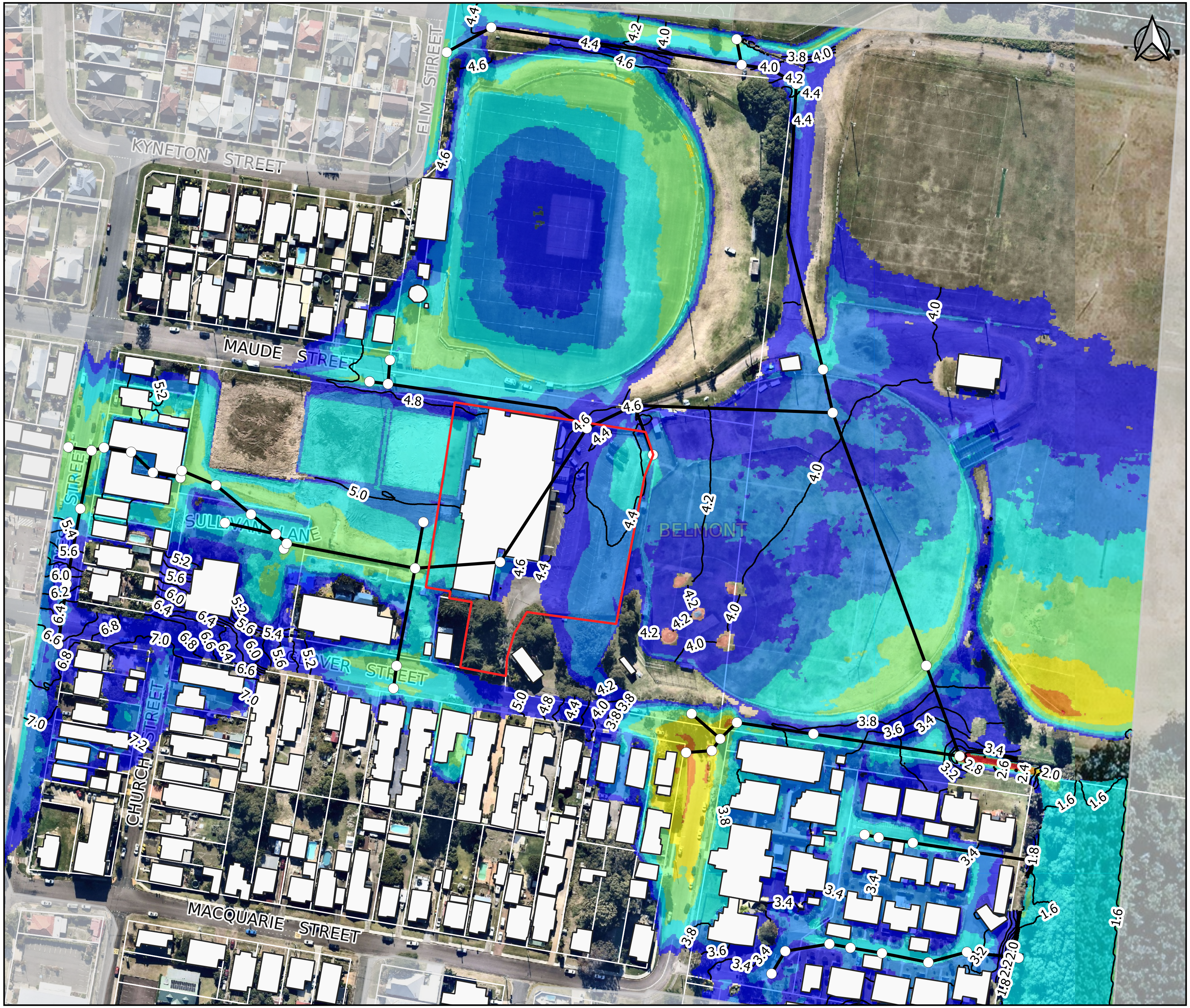
Figure C3

Existing Case
1 in 200 year Flood Depth and Elevation Contours

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Existing Buildings
- Existing Pits
- Existing Pipes
- 0.2m Elevation Contours

Flood Depth (m)

- Less than 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- Greater than 1.2

0 40 80 Metres

1:2,500

Figure C4

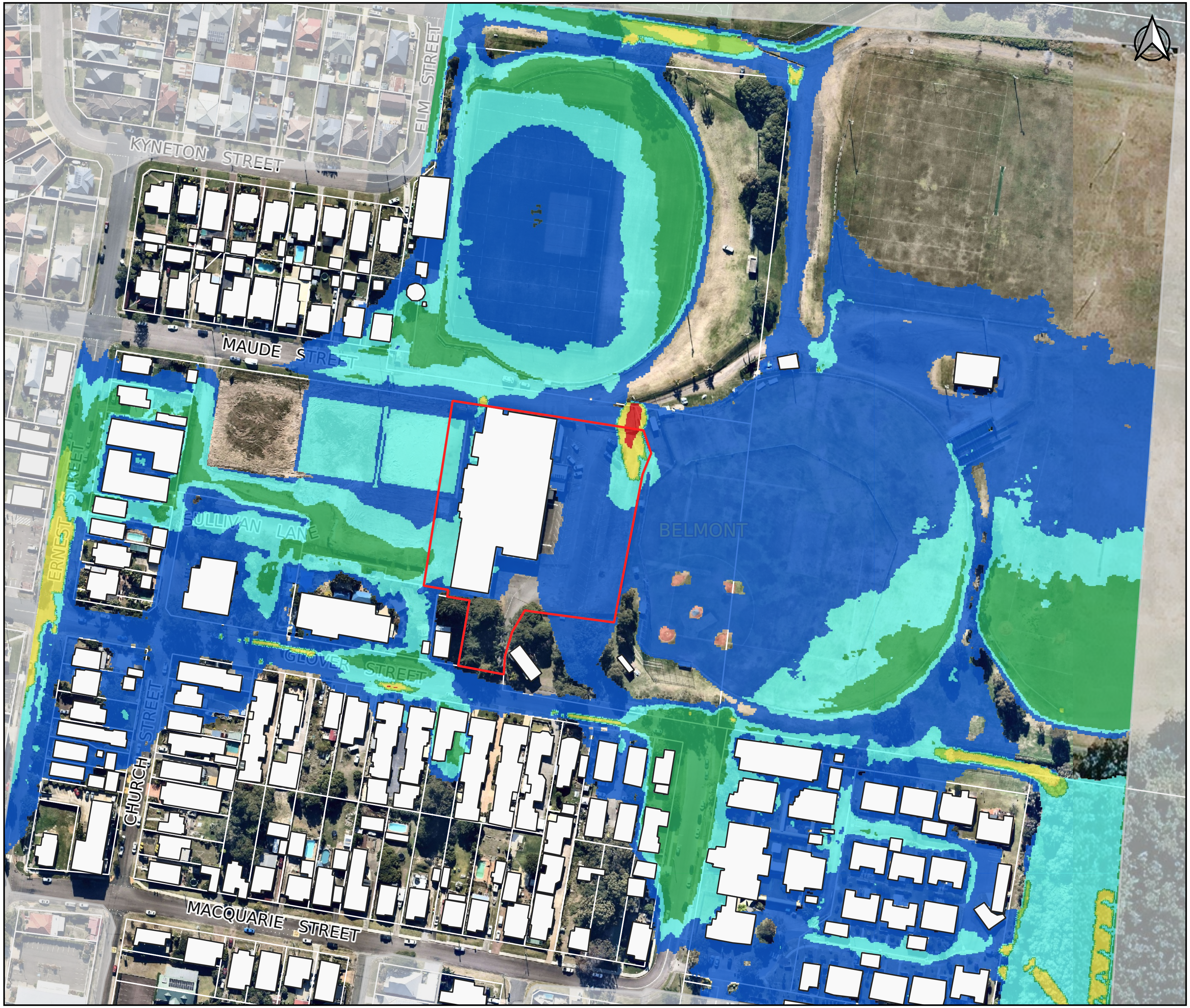
Existing Case PMF Flood Depth and Elevation Contours

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

3/9/2021 Y:\YEAR 2018 Jobs\NL183048-01 - 2A Maude Street, Belmont\O - Drawings\QGIS\Figures\210902_NL183048-01_Figures.qgz

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

Subject Site
Model Extent
Existing Buildings

Hazard Category (ARR2019)

1
2
3
4
5
6

0 40 80 Metres

1:2,500

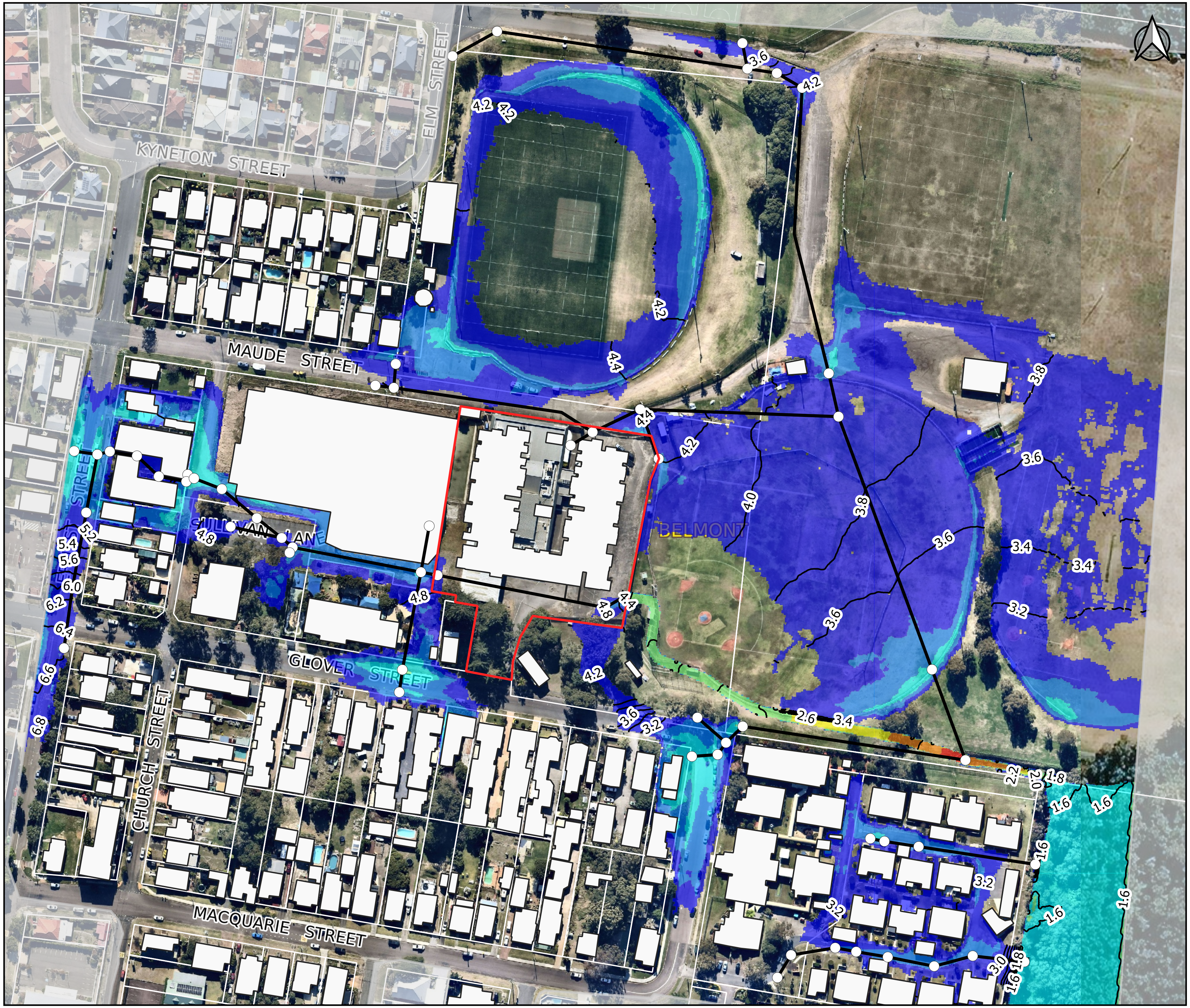
Figure C5

Existing Case
PMF Flood Hazard

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Developed Buildings
- Developed Pits
- Developed Pipes
- 0.2m Elevation Contours

Flood Depth (m)

- Less than 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- Greater than 1.2

0 40 80 Metres

1:2,500

Figure D1

Developed Case 1% AEP Flood Depth and Elevation Contours

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

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Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Legend

- Subject Site
- Model Extent
- Developed Buildings

Hazard Category (ARR2019)

- 1
- 2
- 3
- 4
- 5
- 6

0 40 80 Metres

1:2,500

Figure D2

Developed Case
1% AEP Flood Hazard

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Legend
Subject Site
Model Extent
Developed Buildings
Flood Velocity (m/s)
2.5
0

0 40 80 Metres
1:2,500

Figure D3

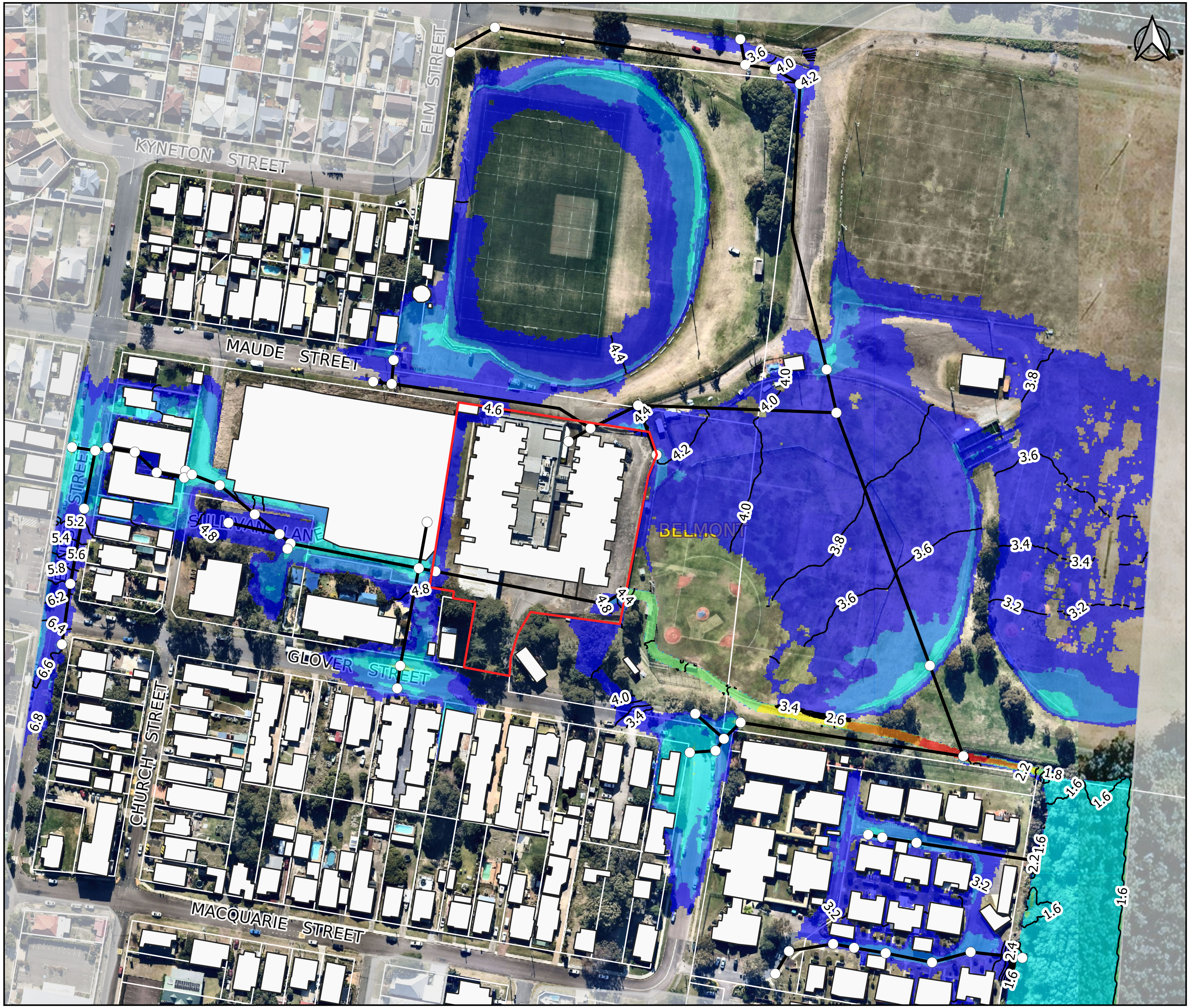
Developed Case 1% AEP Flood Peak Velocity

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

3/9/2021 Y:\YEAR 2018 Jobs\NL183048-01 - 2A Maude Street, Belmont\O - Drawings\QGIS\Figures\210902_NL183048-01_Figures.qgz

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Developed Buildings
- Developed Pits
- Developed Pipes
- 0.2m Elevation Contours

Flood Depth (m)

- Less than 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- Greater than 1.2

0 40 80 Metres

1:2,500

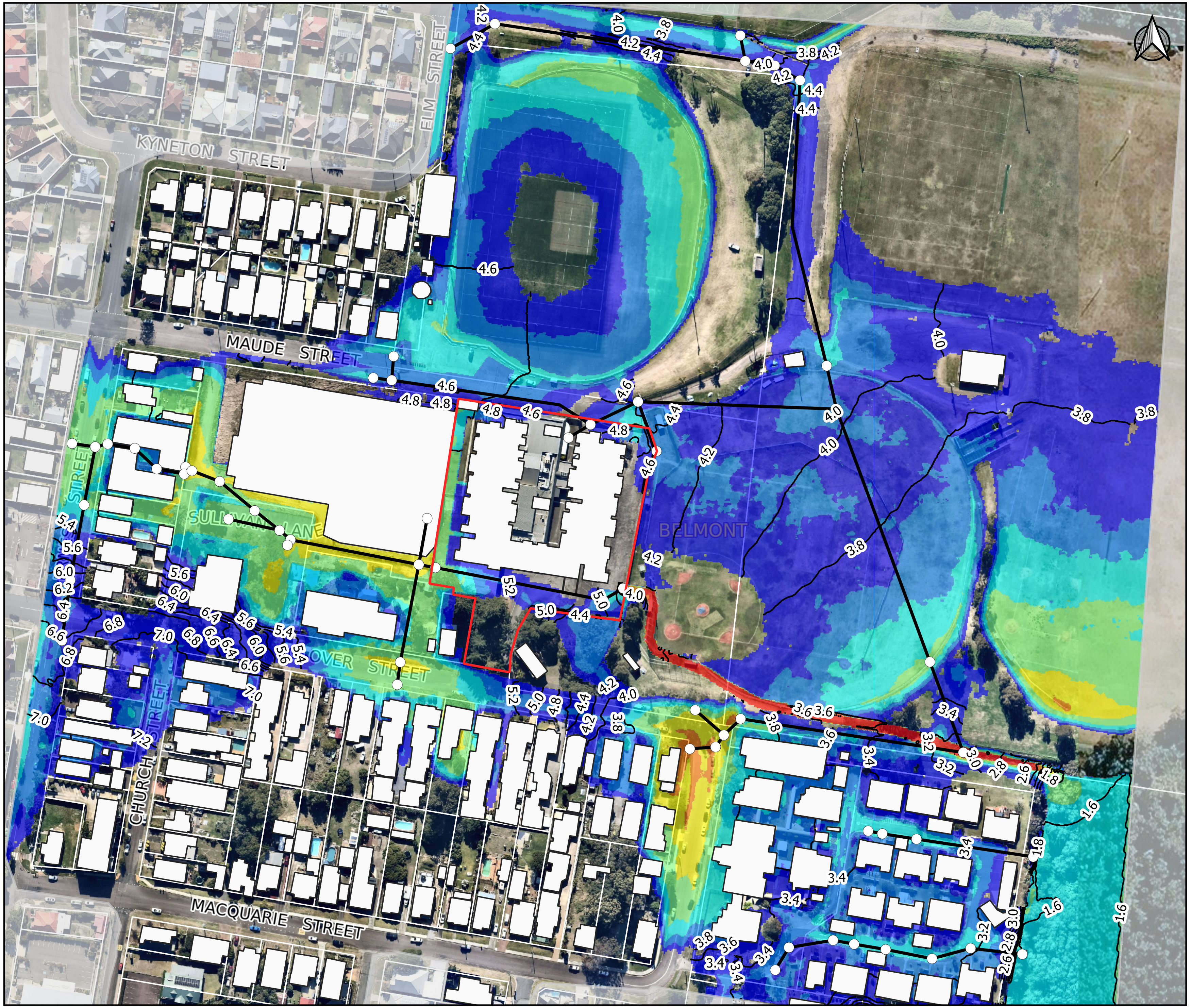
Figure D4

Developed Case 1 in 200 AEP Flood Depth and Elevation Contours

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Developed Buildings
- Developed Pits
- Developed Pipes
- 0.2m Elevation Contours

Flood Depth (m)

- Less than 0.15
- 0.15 - 0.3
- 0.3 - 0.5
- 0.5 - 0.8
- 0.8 - 1.0
- 1.0 - 1.2
- Greater than 1.2

0 40 80 Metres

1:2,500

Figure D5

Developed Case PMF Flood Depth and Elevation Contours

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

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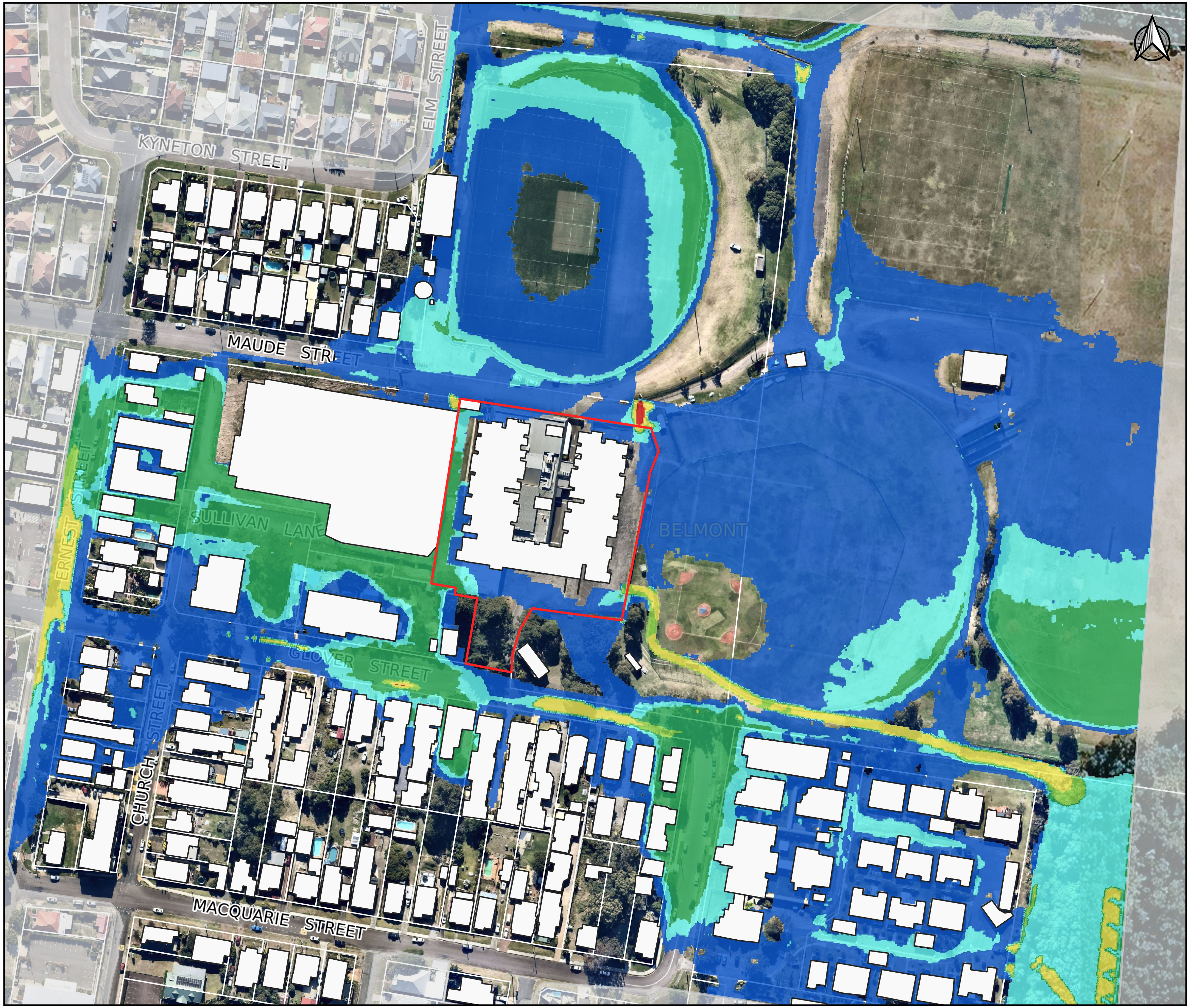
Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)



Legend

- Subject Site
- Model Extent
- Developed Buildings

Hazard Catgory (ARR2019)

- 1
- 2
- 3
- 4
- 5
- 6

0 40 80 Metres

1:2,500

Figure D6

Developed Case
PMF Flood Hazard

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

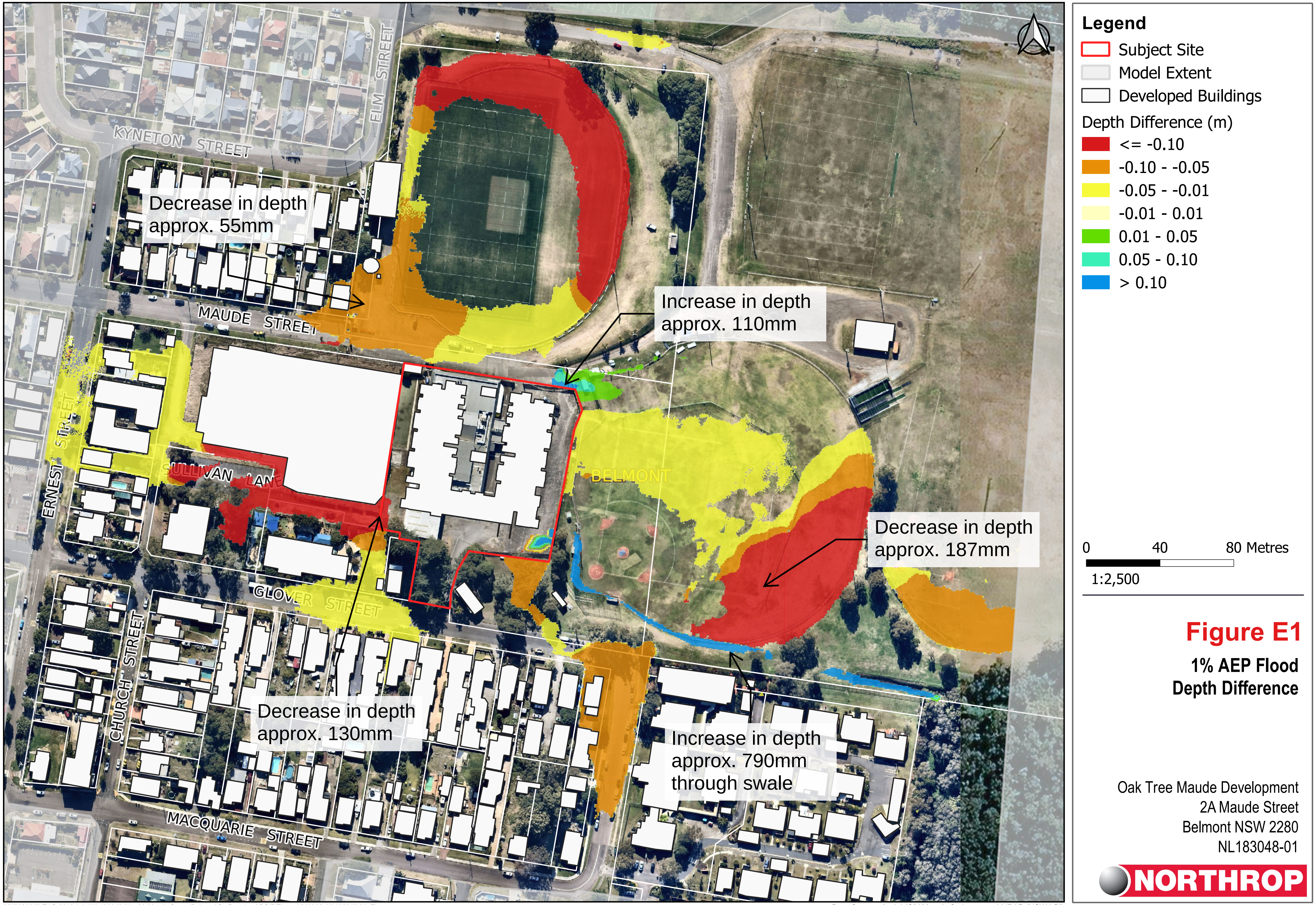


Figure E1

1% AEP Flood Depth Difference

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Legend

- Subject Site
- Model Extent
- Developed Buildings

Depth Difference (m)

- <= -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 40 80 Metres

1:2,500

Figure E2

1 in 200 year Flood Depth Difference

Oak Tree Maude Development
2A Maude Street
Belmont NSW 2280
NL183048-01

NORTHROP

Data Source: Aerial (SIX Maps), Cadastre and LiDAR (NSW LPI)

Appendix B

MUSIC-*link* Report

Project Details		Company Details	
Project:	Oak Tree Maude Developmnt	**Company:**	Northrop Consulting Engineers
Report Export Date:	31/08/2021	**Contact:**	Danielle Nicol
Catchment Name:	NL183048-01	**Address:**	Level 1, 215 Pacific Highway Charlestown NSW 2290
Catchment Area:	0.968ha	**Phone:**	(02) 4943 1777
Impervious Area*:	70.53%	**Email:**	DNicol@northrop.com.au
Rainfall Station:			
Modelling Time-step:	6 Minutes		
Modelling Period:	1/01/1999 - 31/12/2008 11:54:00 PM		
Mean Annual Rainfall:	902mm		
Evapotranspiration:	1408mm		
MUSIC Version:	6.3.0		
MUSIC-link data Version:	6.34		
Study Area:	North Region		
Scenario:	North Region		

* takes into account area from all source nodes that link to the chosen reporting node, excluding Import Data Nodes

Treatment Train Effectiveness		Treatment Nodes		Source Nodes	
Node: Post-Development Node	**Reduction**	**Node Type**	**Number**	**Node Type**	**Number**
Flow	18.3%	Rain Water Tank Node	1	Urban Source Node	6
TSS	81%	Sedimentation Basin Node	1		
TP	51.8%	Buffer Node	1		
TN	45.9%	GPT Node	3		
GP	98%	Generic Node	1		

Comments

Notional Detention Time unable to be modifed.

Passing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Buffer	Buffer	Proportion of upstream impervious area treated	None	None	0.5
GPT	11 x OceanGuard	Hi-flow bypass rate (cum/sec)	None	None	0.22
GPT	4 x OceanGuard	Hi-flow bypass rate (cum/sec)	None	None	0.08
GPT	7 x OceanGuard	Hi-flow bypass rate (cum/sec)	None	None	0.14
Post	Post-Development Node	% Load Reduction	None	None	18.3
Post	Post-Development Node	GP % Load Reduction	70	None	98
Post	Post-Development Node	TN % Load Reduction	45	None	45.9
Post	Post-Development Node	TP % Load Reduction	45	None	51.8
Post	Post-Development Node	TSS % Load Reduction	80	None	81
Rain	Tank	% Reuse Demand Met	80	None	80.2889
Sedimentation	SF Chamber	% Reuse Demand Met	None	None	0
Sedimentation	SF Chamber	High Flow Bypass Out (ML/yr)	None	None	0
Urban	Bypassing Catchment	Area Impervious (ha)	None	None	0.011
Urban	Bypassing Catchment	Area Pervious (ha)	None	None	0.011
Urban	Bypassing Catchment	Total Area (ha)	None	None	0.023
Urban	East Landscape	Area Impervious (ha)	None	None	0.132
Urban	East Landscape	Area Pervious (ha)	None	None	0.113
Urban	East Landscape	Total Area (ha)	None	None	0.246
Urban	Entry Landscape	Area Impervious (ha)	None	None	0
Urban	Entry Landscape	Area Pervious (ha)	None	None	0.075
Urban	Entry Landscape	Total Area (ha)	None	None	0.075
Urban	Entry Road	Area Impervious (ha)	None	None	0.075
Urban	Entry Road	Area Pervious (ha)	None	None	0
Urban	Entry Road	Total Area (ha)	None	None	0.075
Urban	Roof Area	Area Impervious (ha)	None	None	0.435
Urban	Roof Area	Area Pervious (ha)	None	None	0
Urban	Roof Area	Total Area (ha)	None	None	0.435
Urban	West Catchment	Area Impervious (ha)	None	None	0.027
Urban	West Catchment	Area Pervious (ha)	None	None	0.086
Urban	West Catchment	Total Area (ha)	None	None	0.114

Only certain parameters are reported when they pass validation

Failing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Sedimentation	SF Chamber	Notional Detention Time (hrs)	8	12	0.0379

Only certain parameters are reported when they pass validation

Contact Us

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