


Report

10-12 Boondah Road, Warriewood - Water Management Report

Prepared for Henroth Group

2 June 2022

Calibre Professional Services Pty Ltd
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Turning Knowledge Into Value

QUALITY ASSURANCE STATEMENT

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DOCUMENT CONTROL

ISSUE	DATE	ISSUE DETAILS	AUTHOR	CHECKED	APPROVED
Rev00	18/02/22	Rezoning Application	MC	TE	TE
Rev01	23/03/22	Additional Lots	MC	TE	TE
Rev02	21/04/22	Evacuation Strategy Updated	MC	TE	TE
Rev03	12/05/22	Updated as per clients' comments	MC	TE	TE
Rev04	02/06/22	Flood Evacuation strategy updated	MC	TE	TE
Rev05	14/05/24	Revised for Nursery Development	DKH	TE	TE

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Project Description

10 – 12 Boondah Road is located within the Northern Beaches Council. Situated within the infrastructure and rural region, the site comprises a total of 2.04 Ha, and is currently used for agricultural purposes.

Upon project completion, the transformation of the site will accommodate a nursery and garden centre with a children's playground, walkways, as shown in Figure 1.

1. Introduction

This Water Management Report has been prepared to inform the development application proposal for the site at 10-12 Boondah Road, Warriewood. This report summarises the investigations into the flooding resulting from the local waterways, the ocean, and the impacts of climate change. This report also provides commentary on future water quality and quantity measures that may be implemented as part of the nursery development, to be further documented and designed at the construction certificate stage. An objective is to preserve as much of the natural ecology as practically possible.

1.1 Objective and Purpose of this report

The objective of this report is to present the strategy for management of flooding for the site. Brief comment is provided regarding future water quality and quantity strategies for the site but is subject to future documentation and design at the construction certificate stage.

The strategy outlined in this report has been developed using an integrated approach to flood risk management, incorporating changes to the landscape within the development site, whilst seeking to maintain existing flood impacts and behaviour in the surrounding environment. Recommendations have been proposed for consideration with Northern Beaches Council.

1.2 Site Location and Project Area

10 – 12 Boondah Road is located immediately south of No. 14 – 18 Boondah road, which is an existing set of apartment blocks, zoned as medium density residential. Boondah road and Spine Bill Drive is located to the east and north of the property, respectively. On the other side of Boondah road, away from the property boundary sits Narrabeen Creek, which conveys flows from the crest of the local hill. On the western and southern property boundary sits Warriewood wetlands, which backs onto Mullet Creek. Warriewood Wetlands serves as a ponding area for the creek during storm events. Refer to Figure 1 for the site locality.

The site is comprised of dense vegetation, and currently house building materials and refuse. The materials will be removed to facilitate the future development. Most of the vegetation will be removed, with some of the threatened vegetation preserved as it is. The site peaks in No.12 near its northern boundary, sloping gently towards Boondah Road and its southern boundary at grades of 3%. The site slopes sharply to the wetland at slopes of 15%.

1.3 Landscape plan

The landscape plan prepared by JCA Landscape Architects as part of the development application process. An image of the current landscape plan dated 15/05/24 is shown in Figure 1.

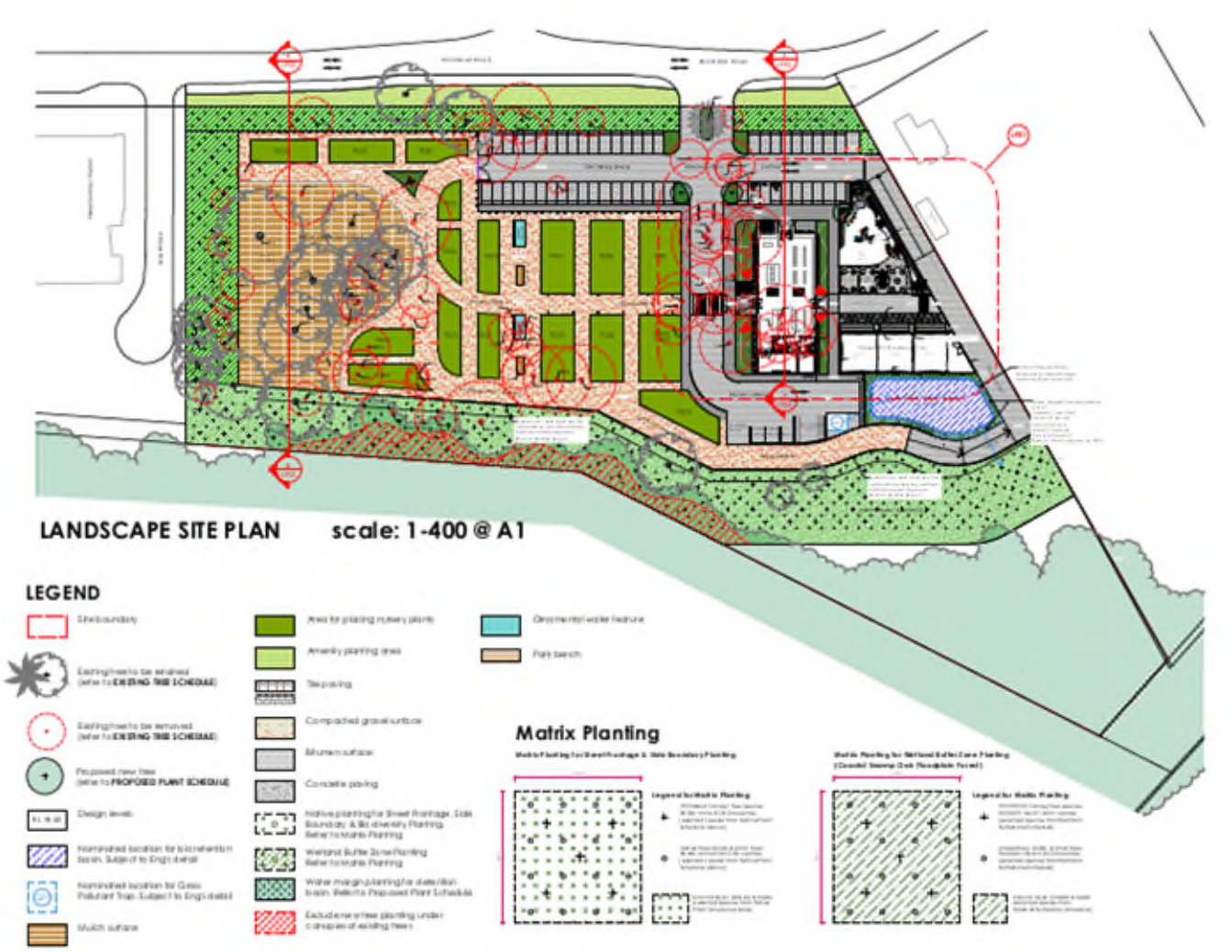

Figure 1 – Nursery and Garden Centre Landscape Plan

The garden centre and nursery are positioned to sit within the higher regions of the existing site. The pathways and propagation area to the east of the site are positioned in the lower areas of the proposed development. In this way, the latter areas will experience the impact of flooding, with the prior areas being higher than the 100-year event.

2. Legislative and Planning Context

This section outlines the relevant state local legislation and framework that is applicable to the planning and design of the flood management strategy.

2.1 Relevant Legislation

This section introduces the legislation applicable to the project, providing explanations of how each Act relates to the development, including the relevant approvals required.

2.1.1 NSW Environmental Planning and Assessment Act 1979 (as amended)

This Act is the primary piece of land use and planning legislation in New South Wales. It allows for the creation, at various levels of government, of environmental planning instruments to control land use and planning. State environmental planning policies (SEPPs), regional environmental plans, Local Environment Plans (LEPs), development control plans (DCPs), and council codes and policies can all be established under Part 4 the Act. The development of land as part of the development application is defined under Part 4 of the Act.

2.1.2 Biodiversity Conservation Act 2016

This Act replaces the Threatened Species Conservation Act and lists threatened species, populations, and ecological communities in NSW. If a threatened species, population or ecological community or its habitat, is likely to occur in any area which may be affected by a development proposal, then a 'seven-part test' in accordance with Section 5A of the EP&A Act must be conducted to determine whether the proposal could have a significant impact. If it is concluded that there is likely to be a significant impact, then a Species Impact Statement (SIS) must be prepared, and the proposed activity would then be subject to approval from the Chief Executive of the Office of Environment and Heritage (OEH).

Where an activity is proposed on protected Existing Native Vegetation on certified land, compliance with the conditions of the biodiversity certification order is required.

2.1.3 Water Act 1912 / Water Management Act 2000

The objectives of the Acts aim to provide for the sustainable and integrated management of the water sources and to apply the principles of ecologically sustainable development. The Acts set guidelines for the preparation of water management plans and direct the Water NSW in decision making. Water NSW is a separate entity within the NSW Department of Primary Industries. It is responsible for the management of the State's surface water and groundwater resources. The Office reports to the NSW Government for water policy and the administration of key water management legislation, including the Water Act 1912 and Water Management Act 2000.

2.1.4 Water Management Amendment (Controlled Activities) Regulation 2008

This Regulation of the Water Management Act 2000 replaces the Rivers and Foreshores Improvement Act 1948 from 4 Feb 2008. Under this Regulation a Controlled Activity Approval (CAA) is required from the Water NSW for works within 40 metres of top of bank. This permit application is developed at the detailed design stage of these proposals and needs to outline:

- A map of the area depicting the site to be affected by the works in relation to the waterway
- Plans indicating works to be undertaken including elevations
- Existing condition and values of the adjoining intertidal and aquatic environment (such as seagrass, rock platforms, and sandy beaches)
- Recent photographs of the site (preferably from the water).
- Details of excavations, earthworks and/or filling, including the type of materials to be affected, i.e., soil and rock

- The potential for disturbance of acid sulphate soils
- The potential for disturbance of contaminated material
- Stability assessment
- Location of existing drainage and any alteration to drainage
- A description of the construction methods to be used (including plant and equipment) and methods to be used to access the site
- Vegetation and landscape plans (including details of vegetation to be retained, removed and/or planted; numbers of each species to be planted; general indication of the location of plantings)
- Methods to be employed to manage potential environmental impacts such as erosion and sediment control plans, and remedial action plans

2.1.5 Local Land Services Act 2013

This Act establish a statutory corporation, Local Land Services, with responsibility for management and delivery of local land services in the social, economic, and environmental interests of the State in accordance with State priorities. The Act establishes local boards for the purpose of devolving operational management and planning functions to regional levels to facilitate targeted local delivery of programs and services. This Act commenced on 1 January 2014 and replaced the Catchment Management Authorities Act 2003 which established catchment management authorities and committees to achieve coordinated, sustainable management of natural resources on a water catchment basis.

2.1.6 Local Government Act 1993

Creates local governments and grants them the power necessary to perform their functions, among which are the management, development, protection, restoration, enhancement, and conservation of the environment of the area the local government is responsible for, in a manner that is consistent with and promotes the principles of ecologically sustainable development. The Local Government (Ecologically Sustainable Development) Act 1997 amended the Local Government Act so that ecologically sustainable development, including the sustainable use of resources, is now a guiding operational principle.

The NSW Floodplain Development Manual: the management of flood liable land relates to the management of flood liable land in accordance with Section 733 of the Local Government Act.

2.1.7 Environment Protection and Biodiversity Conservation Act 1999

This Act requires the approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Communities for actions that have, or are likely to have, an impact on matters of National Environmental Significance, including matters of national environmental significance including:

- Ramsar wetlands.
- National threatened species and ecological communities.
- Migratory species.
- Water resources regarding coal seam gas development and/or large-scale coal mining development.

Under the EPBC Act, Commonwealth approval is required for any controlled action being a project or development that would have, or that would be likely to have, a significant impact on a matter of national environmental significance. Under the legislation, this action must be referred to the Commonwealth Minister for the Environment.

2.2 Planning Framework

This section introduces the planning documents that are applicable to the stormwater infrastructure.

2.2.1 State Environmental Planning Policy (Transport and Infrastructure) 2021

State Environmental Planning Policy (Transport and Infrastructure) 2021 (Infrastructure SEPP) is intended to facilitate the efficient delivery of infrastructure projects and activities by public authorities such as Council.

Clause 2.56 of the Infrastructure SEPP provides that development for the purpose of a flood mitigation work may be carried out by or on behalf of a public authority (which includes Council) without consent on any land. This includes construction, routine maintenance works and environmental management works (clause 2.56).

Clause 2.137 of the Infrastructure SEPP provides that development for the purposes of a stormwater management facility may be carried out by, or on behalf of a public authority (which includes Council), without consent on any land. This includes construction, routine maintenance works and environmental management works (clause 2.137).

2.2.2 Pittwater Local Environmental Plan 2014

This the current version of this plan to date. This plan aims to make local environmental planning provisions for land in Pittwater in accordance with the relevant standard environmental planning instrument under Section 3.20 of the Act. The aims of the plan include encouraging a range of housing in appropriate locations that provide for the needs of the community both now and in the future and minimise risks to the community in areas subject to environmental hazards including climate change.

This LEP has been used to define the flood planning level (FPL) as the level of a 1% AEP flood event plus 0.5m freeboard.

2.3 Northern Beaches Requirements

This section introduces the local requirements that are applicable to the flooding strategy.

2.3.1 Pittwater Development Control Plan 21

This plan provides best practice standards for development. The plan sets controls specific to the flood risk level in a development (in this case, a mix from Low – High; refer to Figure 2).

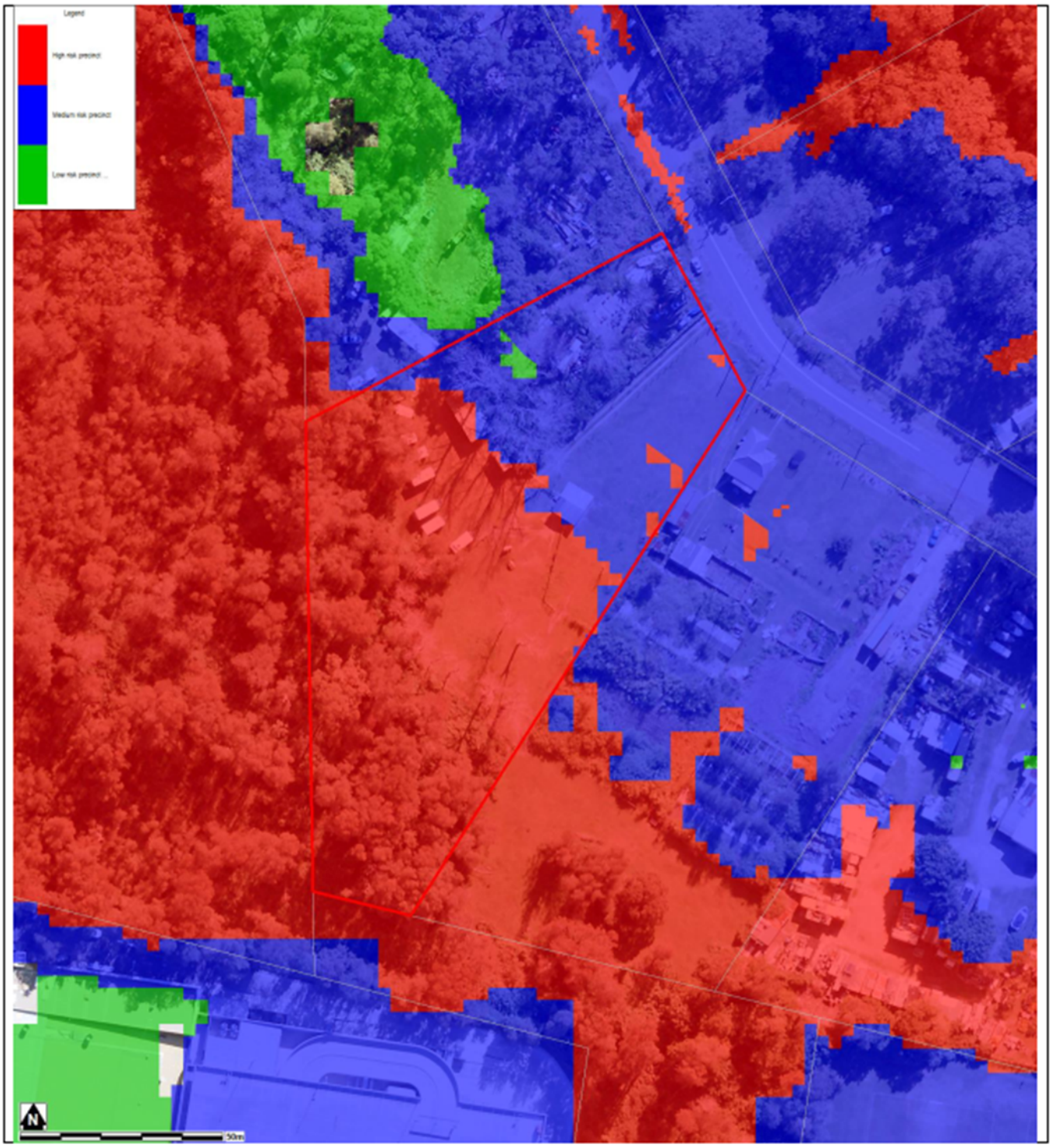

Figure 2 – Flood Risk Precinct Map

The flood controls for medium and high risk are the same for Business and industrial developments. Such controls include:

- New floor levels shall be at or above the flood planning level.
- Demonstration that there are no adverse impacts on flood levels or velocities caused by alterations to the flood conveyance.
- Demonstration that there is no additional adverse flood impact on the subject and surrounding properties and flooding processes for any flood event up to the PMF event including climate change impacts.

An impact is not defined as adverse if it;

- Will have no loss in flood storage or flood way in the 1% AEP and/or;
- Will result in less than 0.02m increase in the 50% - 1% AEP
- Will result in less than a 0.05m increase in the PMF
- Will result in less than a 10% increase in PMF peak velocity

The development will be focused in the low – medium hazard areas of the flood map, with the high hazard areas to contain earthworks balance cuts or remain as is.

2.3.2 Warriewood Valley Urban Land Release (Water Management Specification) 2001

This document has been prepared to ensure that the development of the Warriewood Valley is carried out in an ecologically sustainable manner within the realm of the water environment. The document aims to achieve this by providing Applicants and Council with tools to guide the Applicants preparation of water-related documentation in all stages of development.

The Specification provides recommended devices for stormwater quantity and quality purposes. These have been assessed against the current development application.

The Specification provides further flood planning levels to be adopted for various storm events. For this development, the walkways, cycleways, and water quality structures need to be above the 20% AEP level.

2.4 Northern Beaches Flood Studies

This section summarises the flood studies done within this development area, with how they have informed this stormwater strategy.

2.4.1 Ingleside, Elanora, and Warriewood Overland Flow Flood Study (June 2019)

The Ingleside, Elanora and Warriewood Overland Flow Flood Study catchment area is within the Northern Beaches Council (NBC) local government area (LGA) and includes the suburbs of North Narrabeen, Warriewood, Elanora Heights, and part of Ingleside. The catchment is located north of Narrabeen Lagoon and drains to the ocean, with an entrance at Narrabeen Head. The study area covers an area of approximately 1,650 hectares (16.5 km^2).

Flooding in this catchment can occur together with or independently from flooding of Narrabeen Lagoon. The results produced from this study are for Ingleside, Elanora, and Warriewood local overland flow events only. Peak flood levels from Narrabeen Lagoon have been modelled and documented in the Narrabeen Flood Study (2013).

The flood modelling produced for this study has provided peak flood depths and extents, velocities, hydraulic hazard, and categorisation for the PMF, 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10% and 20% AEP events. The results produced in the 2019 Council study is used to inform the flood levels and flood planning level for the site as this is the updated study adopted by Council. Calibre's flood modelling in Section 5 used the more conservative flood 2013 flood study for the purpose of the impact assessment.

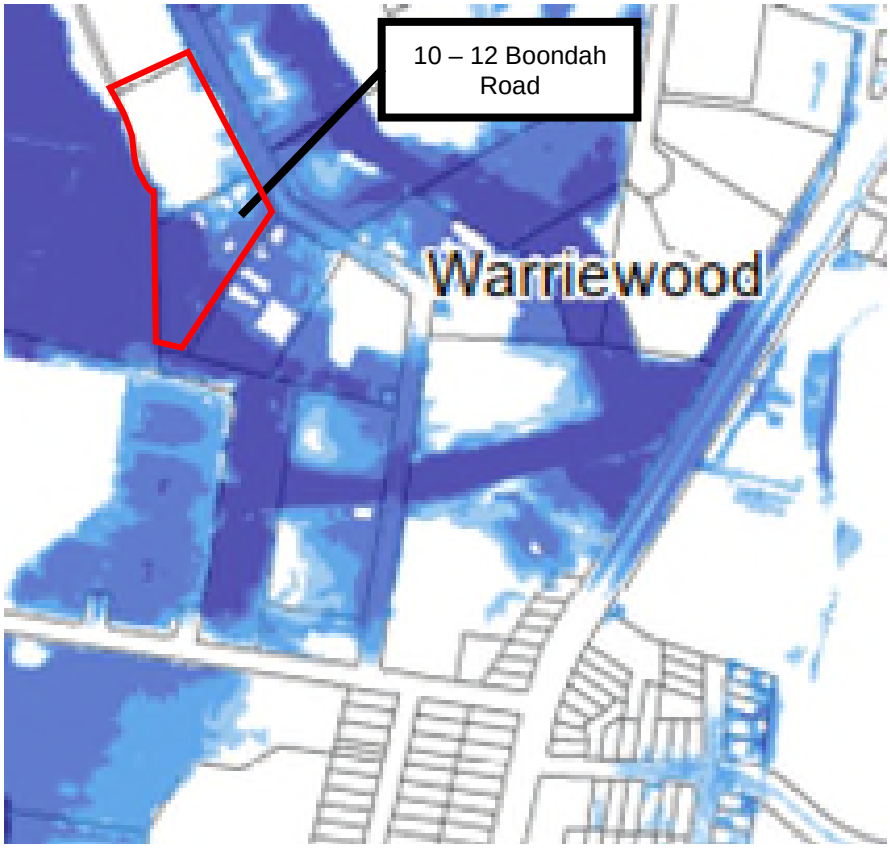

Figure 3 – 1% AEP peak flood depth (Ingleside, Elanora, and Warriewood Overland Flow Flood Study June 2019)

2.4.2 Narrabeen Lagoon Flood Study (September 2013)

The Narrabeen Lagoon Flood Study has been prepared for Warringah and Pittwater Councils to define the existing flood behaviour in the Narrabeen Lagoon catchment and establish the basis for subsequent floodplain management activities. The Narrabeen Lagoon catchment is located on the northern edge of the Warringah LGA and the south-eastern edge of Pittwater LGA on Sydney's northern beaches. The catchment occupies a total area of approximately 55km^2 and drains to the Tasman Sea through a narrow channel to the lagoon entrance at North Narrabeen Beach.

The primary objective of this Flood Study is to define the flood behaviour under historical, existing, and future conditions (incorporating potential impacts of climate change) in the Narrabeen Lagoon catchment for a full range of design flood events. The study provides information on flood levels and depths, velocities, flows, hydraulic categories, and provisional hazard categories for the PMF, 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, 10%, 20% and 50% AEP events.

Council has provided a copy of the Tuflow modelling for this 2013 study to Calibre for the purposes of determining the impact the development at 10 – 12 Boondah Road will have on the flood behaviour for the PMF, 1%, 20% and 50% AEP events with climate change. This 2013 study provides greater flood extents and hazards in the area where the development is placed. While the 2019 study is the current one for this LGA, Calibre will be using the more conservative 2013 study to demonstrate that this development will comply with Council's legislation for flood impact.

3. Stormwater Quantity Strategy

Urbanisation has the potential to impact the hydrology and hydraulics within the development site, downstream areas, and watercourses. Urban stormwater is predominantly runoff from impervious areas such as roads, roofs, footpaths, and car parks. Runoff from pervious areas such as gardens, lawns and vegetated open spaces contribute additional stormwater runoff during higher intensity rainfall events.

Urbanised catchments are characterised with increased impervious areas which are smoother and allow stormwater to flow and concentrate faster. As a result, post-development catchments discharge greater stormwater volumes at higher flow rates leading to more frequent high flow events when stormwater runoff is not managed. The potential impacts of increased stormwater runoff quantity include:

- Increases in channel forming flows. The increased frequency of high flow events changes the channel forming flow and affects channel shape. This may damage or destroy important in-stream and bank habitats
- Increases in peak flows. Increased peak flows increase downstream flood risks and place greater pressure on downstream drainage infrastructure
- Increases in flood levels. Higher flood levels may pose risks to public safety and subdivision assets

As a result, a stormwater quantity management strategy is required to mitigate the risks and consequences of urbanisation on the existing catchments.

3.1 Objectives

The objective of any stormwater quantity control is to limit post-development peak flowrates to the same level as pre-development peak flowrates. Pre-development peak flow rates are defined as those from a ‘rural’ land use or a combination of ‘rural’ and ‘forest’ land use.

Stormwater quantity management is to be provided by both detention and retention.

Detention can be provided in the following ways:

- On-site detention systems on a lot-by-lot basis for the short duration storms.
- Detention basins (either local groupings of lots or larger-scale basins); and/or
- Additional storage in Water Quality Control Ponds.

Retention measures include:

- Seepage techniques
- Stormwater Reuse.

3.2 Strategy

If there are regional detention structures active for this area, then the development can connect to the council system and pay the contributions required for its use.

If there are no regional detention structures for this area, but one is intended, then the development may fashion a temporary detention basin within the revegetated land in its boundaries. This would be subject to further investigation in the CC process.

If there are no regional detention structures intended for this area, then based on the current plan layout shown in Figure 1, OSD systems via basins would seem appropriate for this development. They may be situated within the extents of the nursery, which is placed above the 1% AEP at the FPL. This could cater to the higher impervious areas associated with any hardstand or road paving. The rainwater tanks may also serve as retention structures to recycle stormwater runoff for toilet, and landscaping uses.

The remainder of the development is largely vegetated land (either comprised of the TEC or revegetated areas). These areas will contribute little in the way of increased stormwater runoff and may therefore be permitted to bypass the detention structures.

4. Stormwater Quality Strategy

The presence of an urbanised environment will also produce an increase in pollutant runoff into the local river systems, due to the increased impervious area and local population. Hence pollutant control measures will have to be established at points prior to discharge into the river systems.

4.1 Objectives

It is considered essential that any water management system be ecologically based and consistent with sound engineering practice. The aim is to create an effective but unobtrusive stormwater management system that enhances, rather than reduces the values of the area and ensures minimal impact on downstream sites.

There is to be at least no degradation in existing water quality and habitat values as development proceeds, followed by a movement towards a long-term objective of progressive improvement in water quality and habitat restoration. As a minimum, a 'no-worsening' of existing runoff quality is required. Emphasis is placed on sector-based controls rather than large-scale treatment and control measures, as this approach is deemed more readily applicable to the area given the anticipated patterns of development.

Controls for water quality treatment may be provided within individual lots, private property, or public land. Such controls include, but is not limited to:

- Ponds/wetlands
- Filter strips
- Devices

4.2 Strategy

If there are nearby controls located on public land available for connection, then the development can connect to the pipe system and pay the contributions required for its use.

If there are no controls via public land currently available, but are intended in the future, then the development could fashion a temporary pond/wetland within the revegetated land or play area. This structure may be located within a detention basin if that is required also. The pond/wetland would be located above the 20% AEP storm event, and hence would only be impacted by major storms. This would be subject to further investigation in the CC process.

If there are no controls in public land intended for future use, then based on the proposed development shown in Figure 1, water quality devices could be placed within the stormwater network. Gross pollutant traps (GPTs) or baskets for the screening of rubbish could be placed within the pits, and treatment devices for other pollutants would be placed in the south east corner of the site.

The portions of the development which consist of revegetated, or TEC land may be excluded from the strategy, as that area is being restored to a natural condition. This approach is in keeping with the objectives set by WaterNSW.

5. Flood Study

10 – 12 Boondah Road sits within flood prone land. As part of the development, earthworks will be required to ensure the various uses of the land may function as intended. Earthworks within this development may have an impact on flood behaviour in the surrounding environment, hence a flood study is required to determine their severity. Calibre has acquired the Narrabeen Lagoon Flood Study TUFLOW model (2013) from Northern Beach Council to undertake a flood study analysis specifically for this development.

The latest study prepared for this LGA was the adopted Ingleside, Elanora, and Warriewood Overland flood study (2019), but the 2013 study provides more conservative flood extents for this development area. Comparison shall be made to the 2019 study regarding results where appropriate, using the 2013 Tuflow model to demonstrate that the development shall comply with the conservative results from that time.

5.1 Objectives

The various controls required for consideration in the flood study are given in Section 2 and in Table 1. Of significance to this development are the following:

- New floor levels shall be at or above the flood planning level.
- Demonstration that there are no adverse impacts on flood levels or velocities caused by alterations to the flood conveyance.
- The impacts of climate change are to be considered in the assessment, for both flood levels and FPLs.
- The level of walkways and cycleways adjacent to the creeks are to be above the 20% AEP flood level.
- Boondah Road fronting the development needs to be raised to the 1% AEP plus climate change.
- The filling of land will only be permitted where it can be demonstrated within the Water Management Report that there is no additional adverse flood impact on the subject and surrounding properties and flooding processes for any flood event up to the PMF event including climate change impacts.

An impact is not defined as adverse if it;

- Will have no loss in flood storage or flood way in the 1% AEP and/or;
- Will result in less than 0.02m increase in the 50% - 1% AEP
- Will result in less than a 0.05m increase in the PMF
- Will result in less than a 10% increase in PMF peak velocity.

These objectives form the basis for the flood study and strategy for the development at 10 – 12 Boondah Road, Warriewood. Northern Beaches Council has provided climate change event runs for the 5% AEP and 1% AEP only. Calibre has created a climate change scenario for the critical PMF event with a raised ocean boundary, as per discussions with Council. As no climate change events exist for the 50% and 20% AEPs, these have not been done.

5.2 Strategy and Data Sources

The Narrabeen Lagoon Flood Study TUFLOW model provides the basis for the flood study conducted by Calibre. The modelling parameters used by the model have been adopted by Calibre for their assessment. Some amendments have been made to the modelling to determine the effect the development would have on flood behaviour, and the provision of new information relevant to the area; these amendments are listed under Section 5.3. Some of the amendments have also included bug fixes.

The storm events modelled with TUFLOW were taken directly from the Council model, using the critical durations associated with each storm intensity. The storm events with climate change (1% AEP) had a maximum storm duration of 540mins, the PMF had a maximum duration of 360mins. All other storm events had a maximum duration of 1440mins.

5.2.1 Existing

The existing conditions of the flood area has been updated with current survey and the latest Light Detection and Ranging Systems Technology (LIDAR) which encompasses the subject site. The LIDAR data captured the terrain of the site area as measured from June 2020. The survey data captured the terrain of the site area (up to the extents of the vegetation) as measured from May 2019. The survey data was overlaid on the LIDAR data as it has greater accuracy.

5.2.2 Developed

The developed conditions of the flood area have been updated with the current survey and latest LIDAR data as above. On top of those, the earthworks intent for the development has been overlaid in the TUFLOW model as a 3d TIN surface.

For the purposes of the flood strategy, the landscape plan as shown in Figure 1 has been taken as the basis for design. The civil engineering program *12d* was used to create and shape the earthworks, to match with the landscape plan. Refer to Figure 4.

Figure 4 – Proposed Nursery Earthworks

The coloured hill shade indicates the extent of the proposed earthworks for the nursery.

For the purposes of this development application, the earthworks areas have been modelled based on spot levels in the proposed landscape plan.

5.3 Amendments To Narrabeen Lakes Study

Some amendments were required to provide adequate modelling conditions for the existing and developed scenario. The amendments are listed below.

5.3.1 Topographic Data

Any edits to the topographic data were read in on top of the z points, and underneath the z shapes in the Narrabeen Lakes model.

5.3.1.1 LIDAR

Calibre has imported LIDAR data dated from June 2020 (the latest available as from the date of this document). The extent of the LIDAR data imported is limited to a single tile which encompasses the development site, and part of the surrounding area, including the wetlands and river on the other side of Boondah Road. The LIDAR data update serves to incorporate any amendments to the surrounding topography from the time the flood study for Narrabeen Lakes was done.

5.3.1.2 Survey

The developer obtained a survey of the site dated from May 2019. The extent of the survey includes all features within 10-12 Boondah Road (up to the fringe of the dense vegetation), the intersection of Boondah Road and MacPherson Street, and Warriewood Valley Sports Court. The extent of the survey is shown by the red dots, overlaid on top of the raster image in Figure 5.

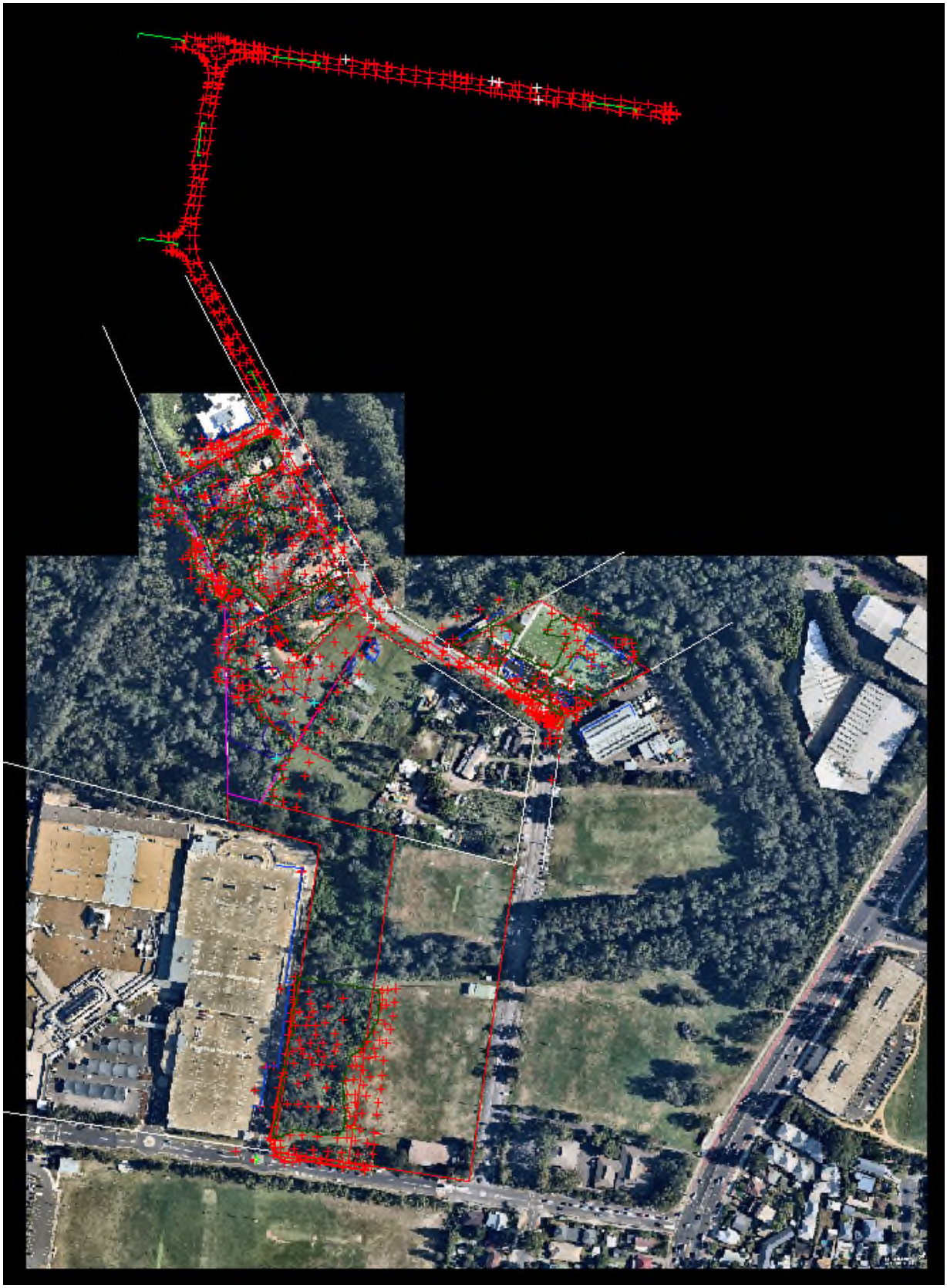

Figure 5 – Survey Extents

This survey data was read in on top of the LIDAR.

5.3.1.3 12d Tins

12d was used to shape the earthworks for the proposed design surface for the development. The extent and shape is as shown in Figure 4. The tin were exported from *12d* as 12da file and was read in on top of the LIDAR and survey data. Multiple runs of the TUFLOW software were done to determine the flood levels that correspond with each corresponding storm event.

As per the confirmation from council dated 27.04.21, Boondah road fronting the development has been raised to the 1% AEP + CC, which is RL 3.9. The Warriewood Valley Contributions Plan identifies the reconstruction of Boondah Road from the subject site to Jacksons Road intersection planned for construction to commence in 2023/24 however not being to the 1%AEP as it did not contemplate development occurring along this section of Boondah Road that would require road levels lifted to the 1% AEP. The evacuation strategy treats Boondah road from the southeast corner of No. 10 as if it were raised to the required RL.

5.3.2 MIF files

Some of the original Z Shape MIF files in the model contained overlapping geometry points that produced errors when attempting to run. The files were saved as .shp files in QGIS, redrawn with the same attributes and read into the control files. The amended files were.

- 2d_zsh_NL_Bridge_Structure_Roads_Final_002
- 2d_zsh_NL_CC_Bund_2100

5.3.3 TUFLOW version

Calibre's TUFLOW runs were done using the latest available version of TUFLOW (2020-10-AA\TUFLOW_iSP_w.64.exe). It is not known what version of TUFLOW was used for the Narrabeen Lakes model, but it would have been an older version. Calibre has used the same version of the TUFLOW for the existing and developed runs to ensure consistency and has calibrated the modelling to be consistent with a given event in one of Council's runs.

Calibre has also used the High-Performance Computing (HPC) solution scheme and Graphics Processing Units (GPU) hardware options for each run, to reduce the runtime for each event. The accuracy of the results with these options was tested against a run of the same name which did not use HPC and GPU and found that the results were the same.

5.3.4 Morphology Program

One of the commands in all the TUFLOW run files references a morphology control file. The morphology control file is present in the TUFLOW folders but is not responsive to attempts to use it. The morphology control file requires use of a program owned by BMT WBM which Calibre does not have access to. The program is undocumented and cannot be accessed via the TUFLOW website.

It is understood that the program mimics the effect of coastal erosion. The control file selects shapes and limits to apply the program to, which then changes the elevation of the shapes over a given time step. The control file specific to this TUFLOW model applies the program to three shapes at the entrance to the ocean. The behaviour of these shapes will therefore affect the flooding behaviour upstream.

Calibre cannot access the morphology program to run this file as it is seemingly exclusive to BMT WBM. Therefore, Calibre has amended the shapes at the entrance to the ocean to align with a given set of results from Council. As part of the flood modelling package, Council provided a flood information report for No. 10 Boondah Road Warriewood, which provided flood levels of RL 3.9 for a 1% AEP climate change scenario of 30% Rainfall Intensity and 0.9m Sea level rise.

Calibre ran the two events associated with these criteria without the morphology control and found that the water levels were 70mm higher. It was found that one of the structures at the ocean boundary had an elevation attribute. The elevation of the structure was therefore dropped till the water level results for Calibre's test run aligned with the results provided by Council. Hence, Calibre has adopted the impacts of the morphology control by dropping the elevation of the structure at the ocean boundary. This amended structure has been included in all other runs done by Calibre. Council has been informed on this approach to having the model run without the morphology control program.

5.4 Results and Mapping

Calibre has observed that the water elevation across the bulk of the Warriewood area remains level. This would suggest that the outlet to the ocean chokes the floodwater, causing it to pond back up the rivers and wetlands. This behaviour is consistent in each storm intensity and is confirmed with an increase with a longer storm duration and increase in ocean boundary. Therefore, the results summarised below represent the storm durations which produce the greatest flooding extent.

5.4.1 Existing Flood Behaviour

As stated above, the water elevation across the region builds as the storm duration increases. Regarding the development site, water builds up in Warriewood wetland and Narrabeen Creek. A comparison is provided with Figure 6 to Figure 10 for the existing 1% AEP 1440min storm for reference.

Figure 6 – 1% AEP Storm at 0min

In Figure 6 the water extents are present in Narrabeen Creek and Warriewood Wetlands. The water extents at 8 hours are shown below in Figure 7.

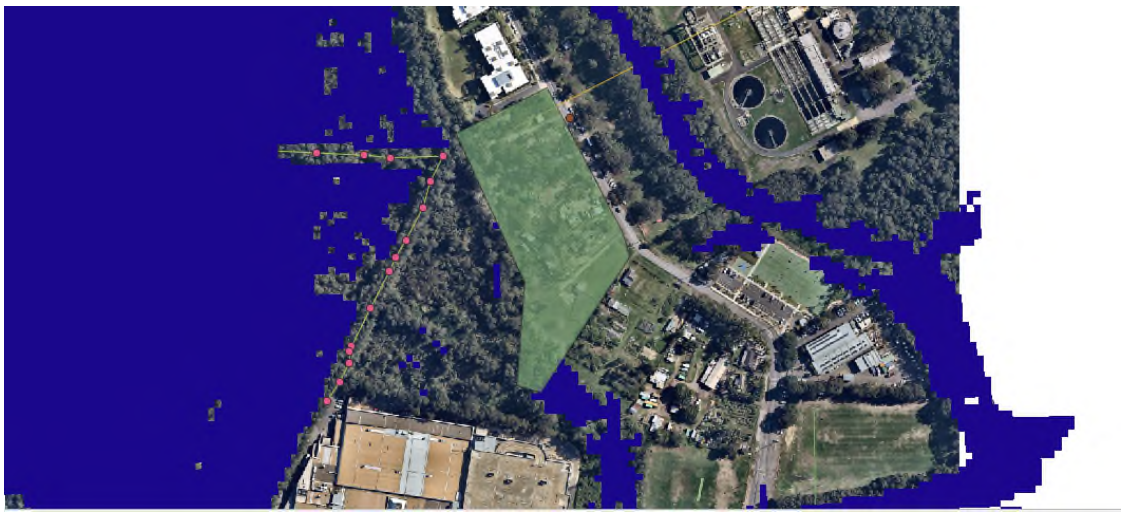

Figure 7 – 1% AEP Storm at 8 hours

Figure 7 indicates that water is building south, west, and east of the site. The flows remain within the wetland and creek but are gradually choking back towards the development boundaries.

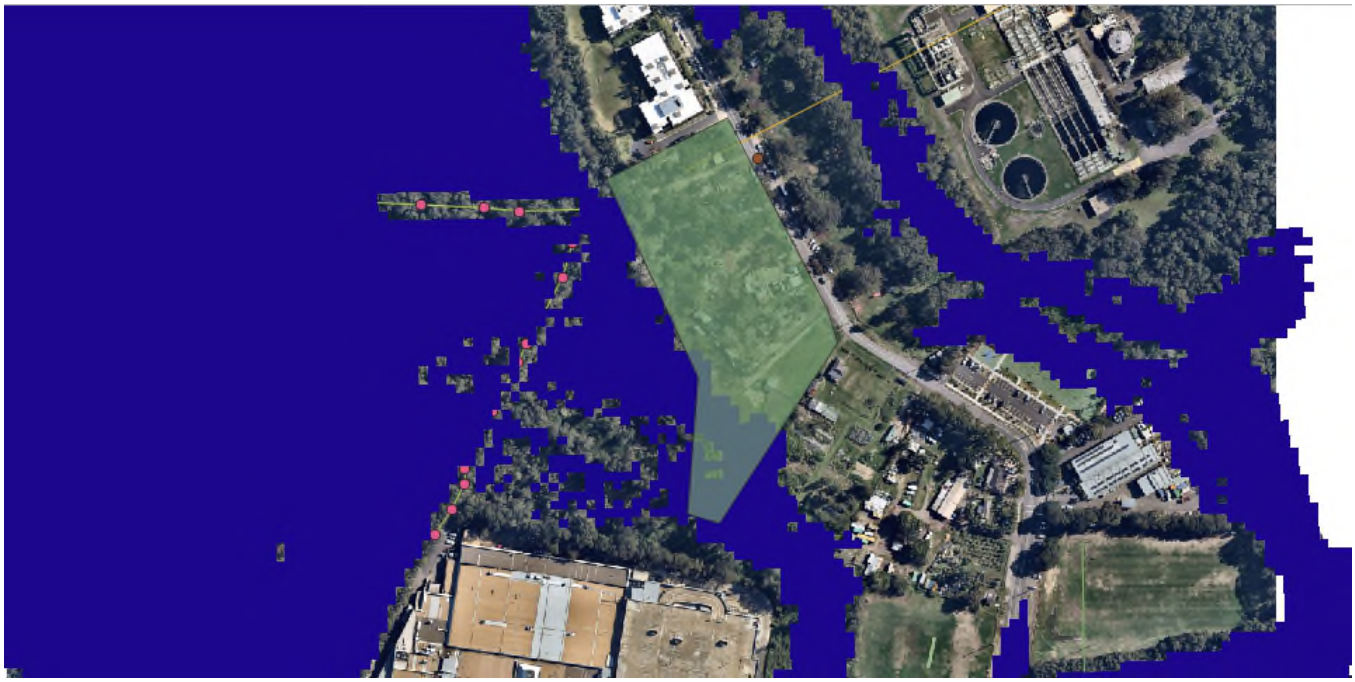

Figure 8 – 1% AEP Storm at 10 hours 30mins

Figure 8 indicates that the water building south of the site spills over and joins with the water in the wetland. This portion of the site is remaining undeveloped and hence will be able to operate as per existing conditions. The water in Narrabeen creek is ponding further and starting to break the banks of the river.

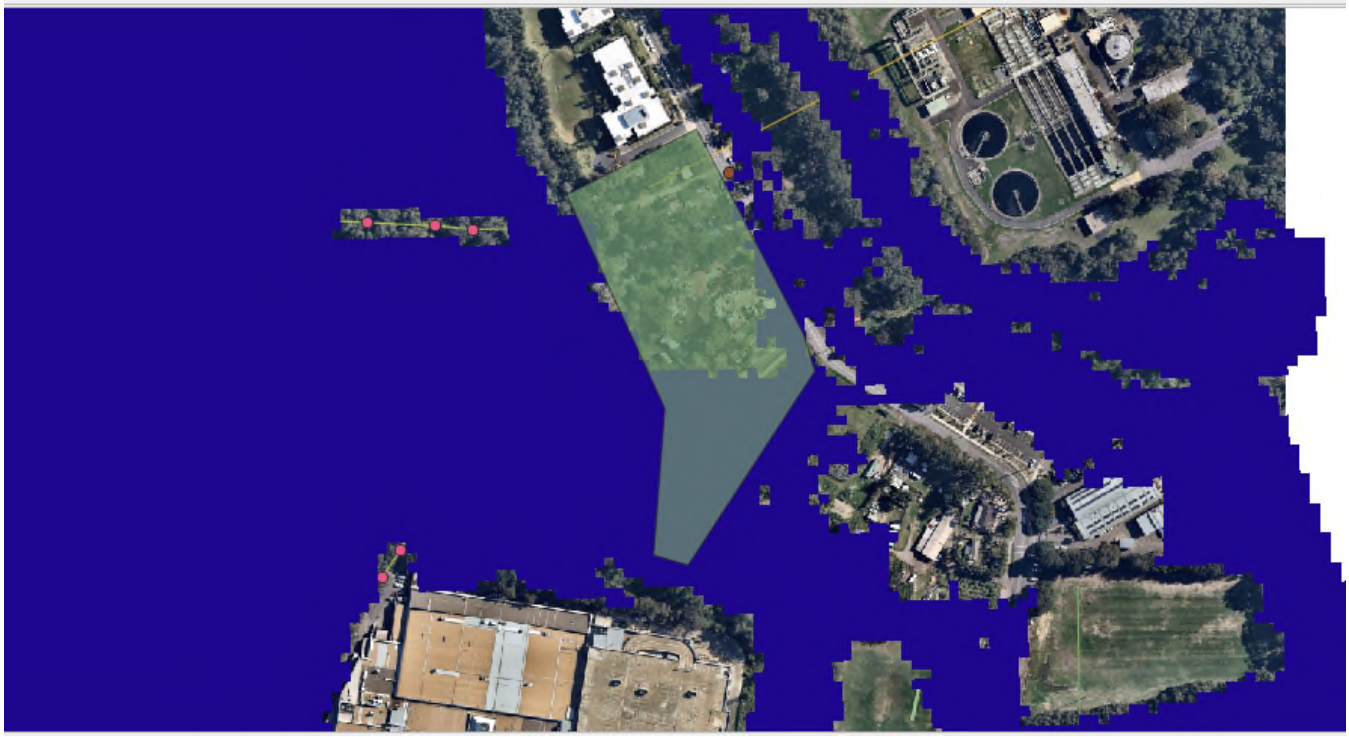

Figure 9 – 1% AEP Storm at 12 hours

Figure 9 indicates that water has continued to build in the southern half of the site, but the northern half remains dry. The water from Narrabeen Creek has broken the banks completely and is now flowing into the development site along the eastern boundary, down to join the ponding in the south. Thus, a flow path is formed along the eastern boundary of this development.

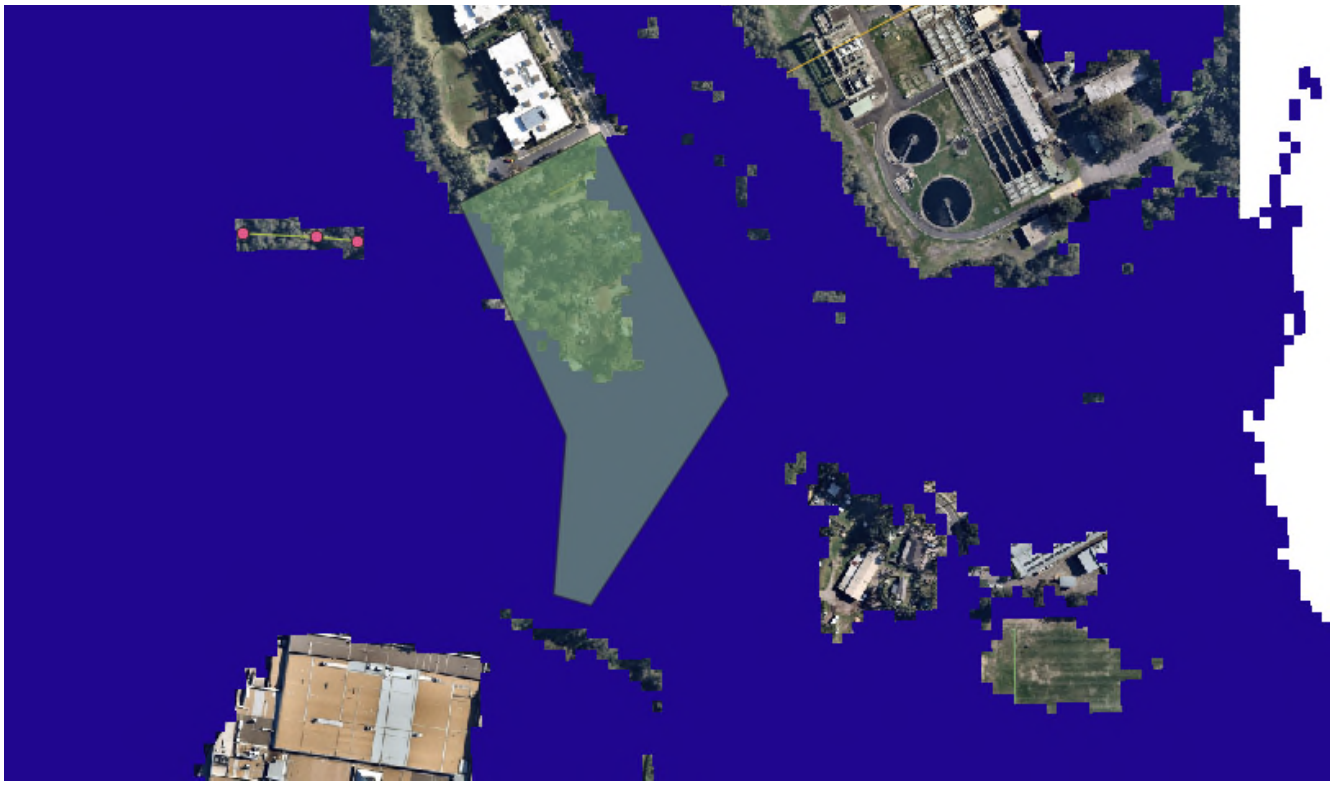

Figure 10 – 1% AEP Storm at 18 hours

Figure 10 represents the approximate peak of the storm event. The water has broken the banks of Narrabeen creek north of the site but continues to flow along the eastern boundary. Water continues to pond and flow in the southern half of the site.

5.4.1.1 Flow Paths

Based on figures provided above, the flows paths for this development manifest in the southern half of the site and along the eastern boundary. Most of the earthworks raising is concentrated in the northern half of the development, which is in keeping with the natural conditions. As the EEC areas are to be preserved, this will allow major storm events up to ten hours in duration to flow as per existing conditions.

The pathways along the western boundary are being raised to the 20% AEP, but as that area is subject to little inundation, it is not expected to have a significant impact. As the nursery is being built to the eastern boundary, and Boondah road fronting the development is being raised, the flooding extents on that front will be pushed back towards Narrabeen creek in a major storm event 12 hours or greater. It is expected then any noteworthy afflux will occur in that area. Sections 5.4.2 - 5.4.11 display the results of the development earthworks on the surrounding flood behaviour for those specific storm events.

The acceptable afflux for events up to the 1% AEP is 20mm. The acceptable afflux for events beyond that to the PMF are 50mm. An increase in 10% PMF peak velocity is acceptable. The nursery earthworks has been overlaid into each figure for reference.

5.4.2 Afflux – 50% AEP 1440min

The afflux for the critical storm for the 50% AEP is shown in Figure 11. A legend is provided for the figure.

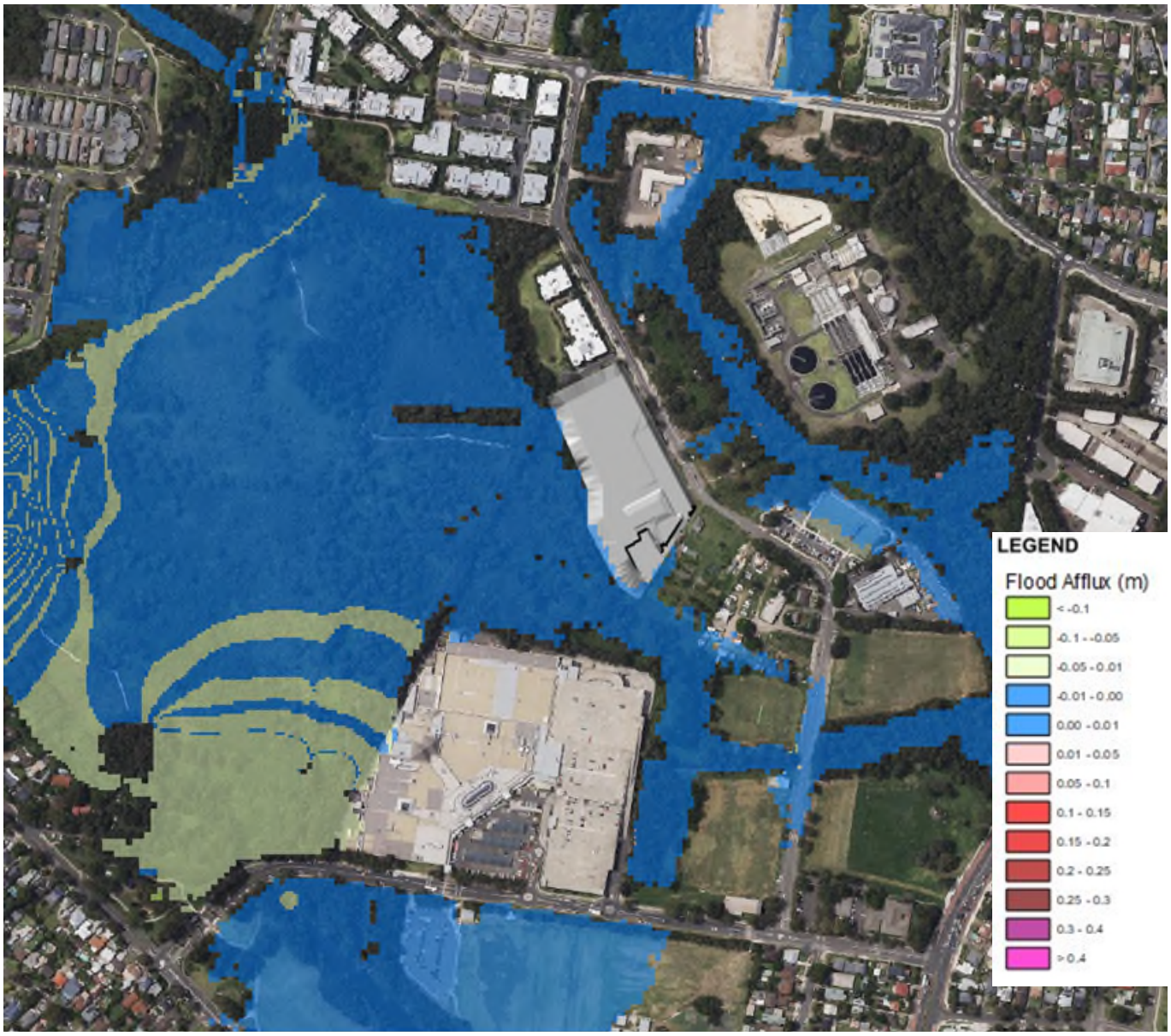

Figure 11 – 50% AEP 1440min Afflux

Figure 11 indicates that afflux within the site will be within the tolerances for Northern Beaches Council. The undisturbed areas have been filled in with water.

5.4.3 Afflux – 20% AEP 1440min

The afflux for the critical storm for the 20% AEP is shown in Figure 12.

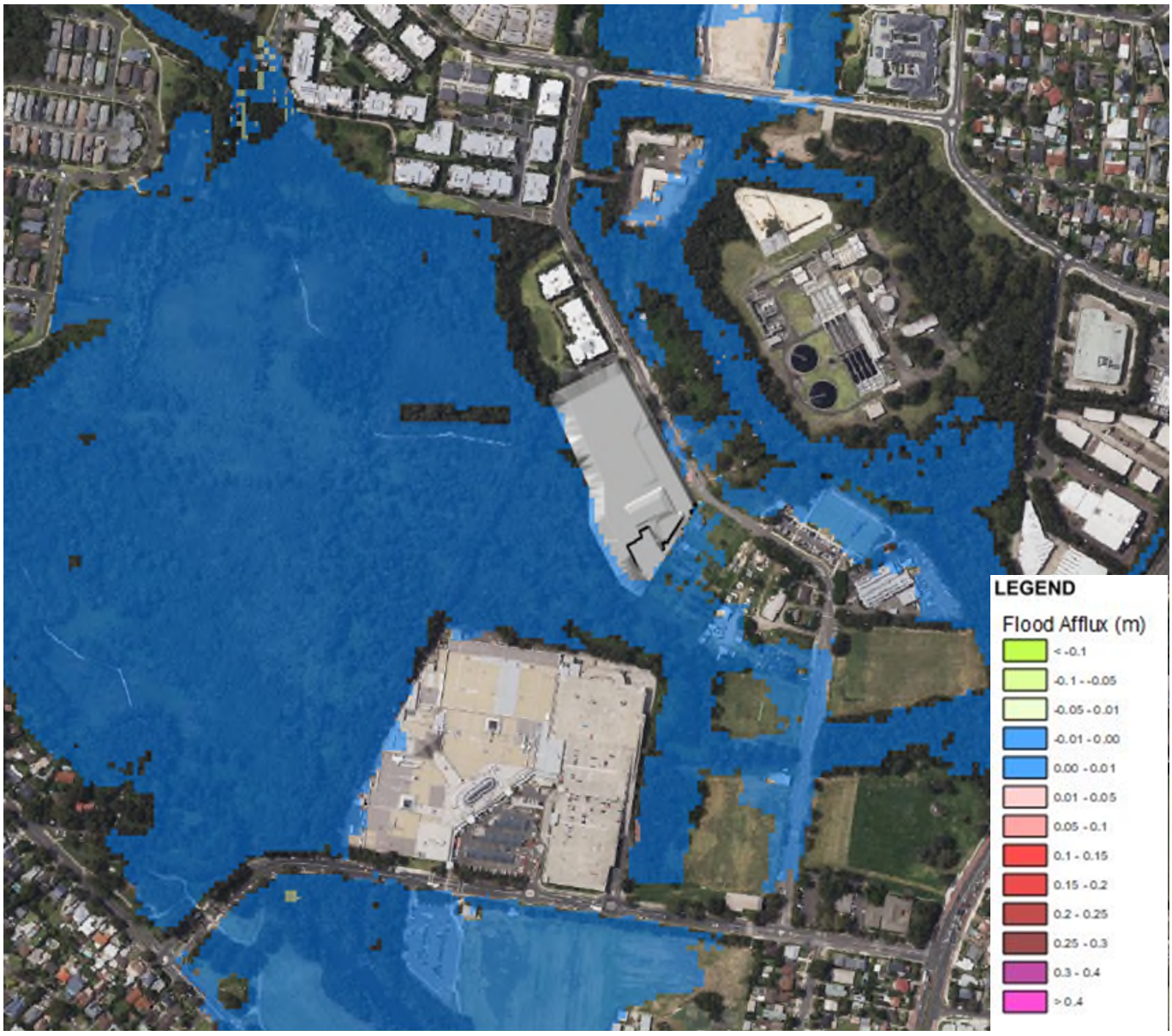

Figure 12 – 20% AEP 1440min Afflux

Figure 12 indicates that afflux within the site will be within the tolerances for Northern Beaches Council. The playground and walkways remain above the water levels as per the landscape plan, while the undisturbed areas are filled in with water. The 2019 study demonstrates similar behaviour for the 20% AEP, with flood water occupying the EEC area as well.

5.4.4 Afflux – 1% AEP 1440min

The afflux for the critical storm for the 1% AEP is shown in Figure 13.

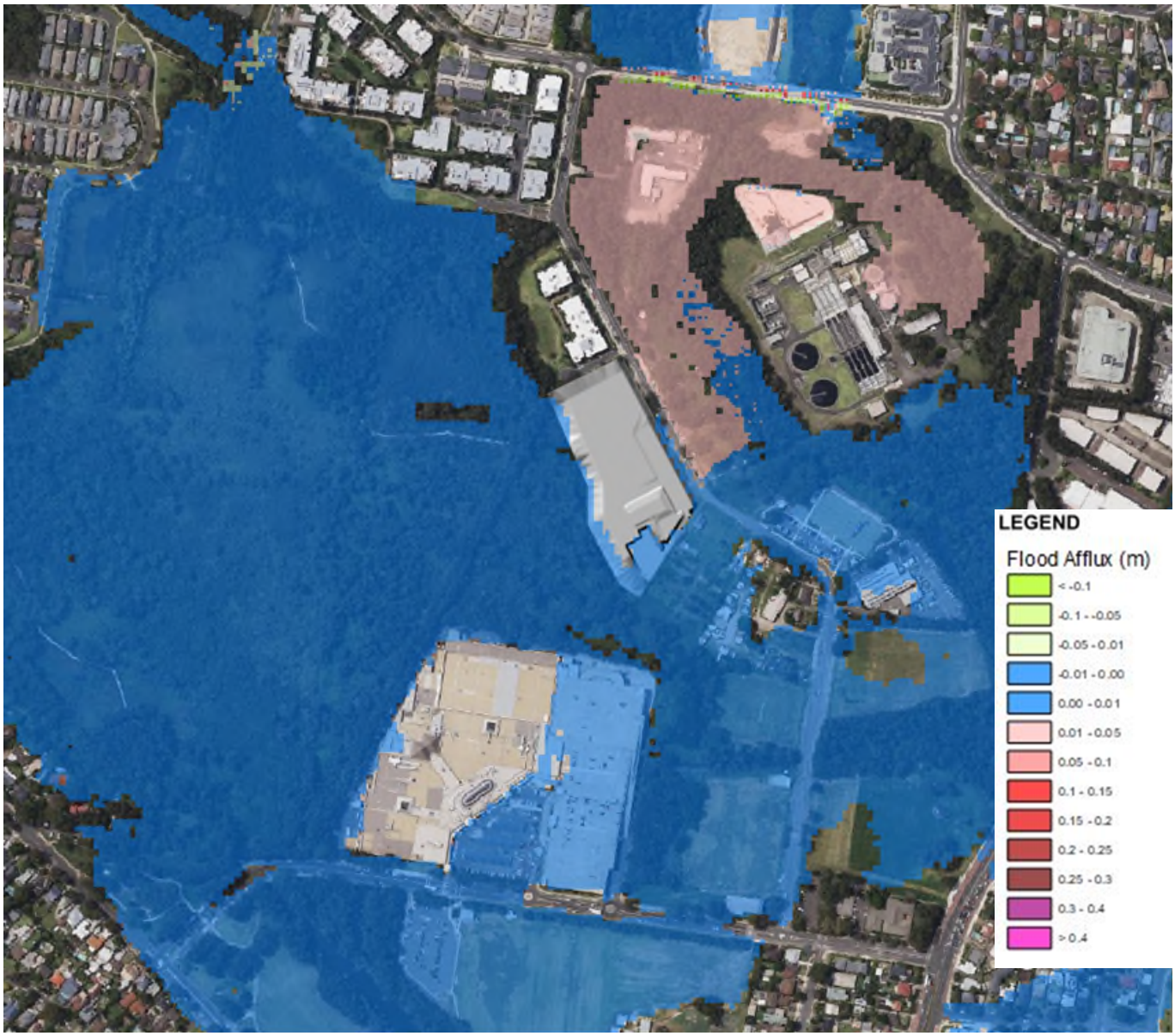

Figure 13 – 1% AEP 1440min Afflux

Figure 13 indicates that afflux within the 0.01 – 0.05 range will occur to the northeast of the site. The remainder of the area remains within the tolerances needed. The 2019 study demonstrates similar flood extents regarding the property, with water inundating most of No. 10, and infringing onto the property boundaries of No.12. A closer breakdown is provided in Figure 14.

The crest of the proposed raised Boondah Road is clear during the 1% AEP event. The modelling shows that there is a narrow strip of ponding between the proposed development landform and the proposed road form this is within the road verge area and will not impact the ability of people within the site from using the site or Boondah Road.

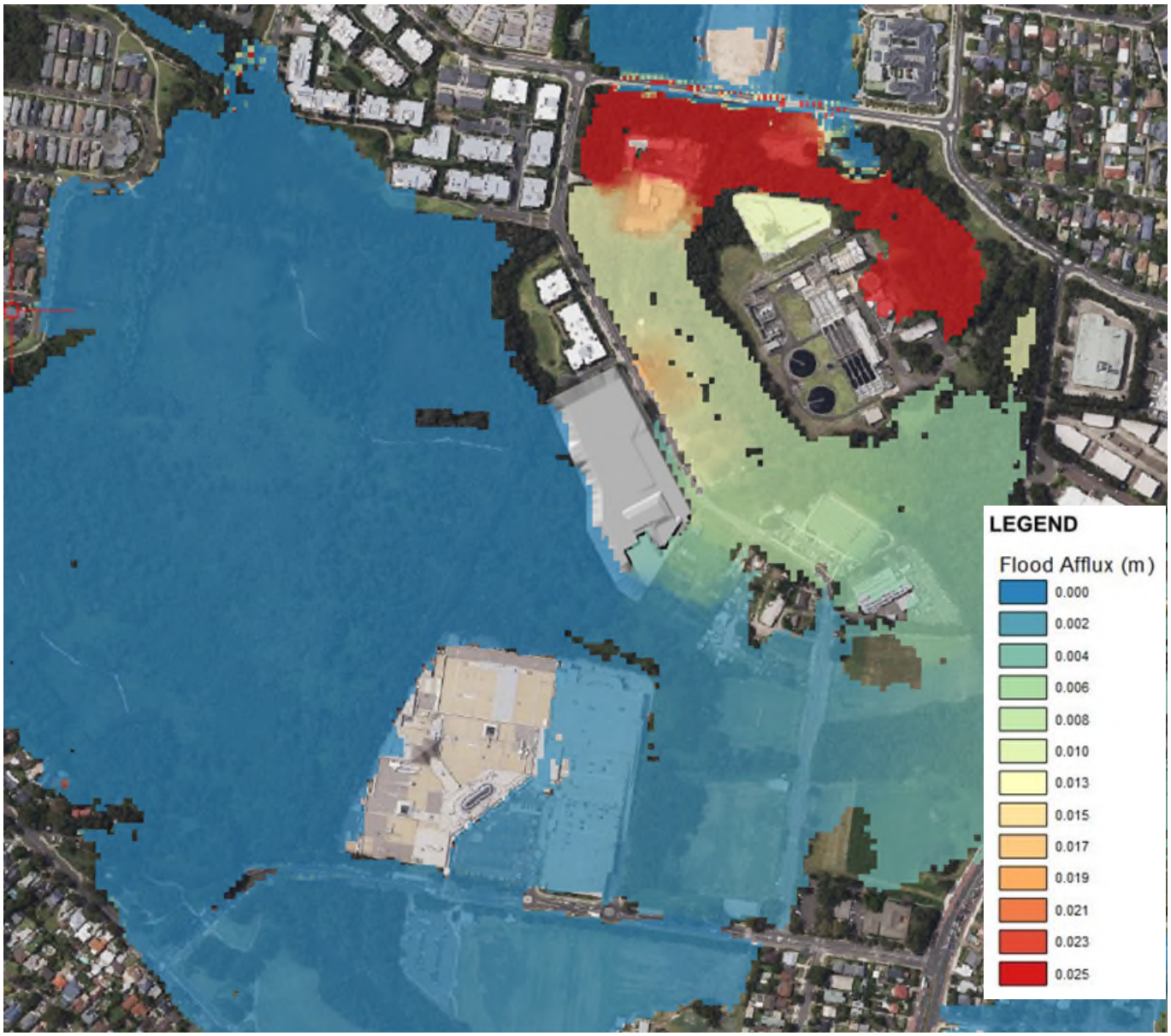

Figure 14 – 1% AEP 1440min Narrabeen Afflux

Figure 14 indicates that the severest parts of the afflux occur upstream of Narrabeen Creek in the Sydney water facility. The afflux peaks there at 25mm. The afflux elsewhere is within council's tolerances.

The afflux which exceeds the 20mm threshold is placed within an industrial wastewater treatment plant area, which does not house any residents. Therefore, the impact posed by this afflux increase is not dire, as it will not be densely staffed during the day, and people will not be present there at night.

The pattern of the afflux increase suggests that the Boondah Road raising is responsible for the sudden increase, as the water is ponding in front of transition slopes to the south. This would suggest that the water ponds on Boondah Road in the existing condition, and the road raising has driven it back into Narrabeen Creek, causing the water levels upstream to rise.

Calibre has done a TUFLOW run with no Boondah Road raising, as shown in Figure 15.

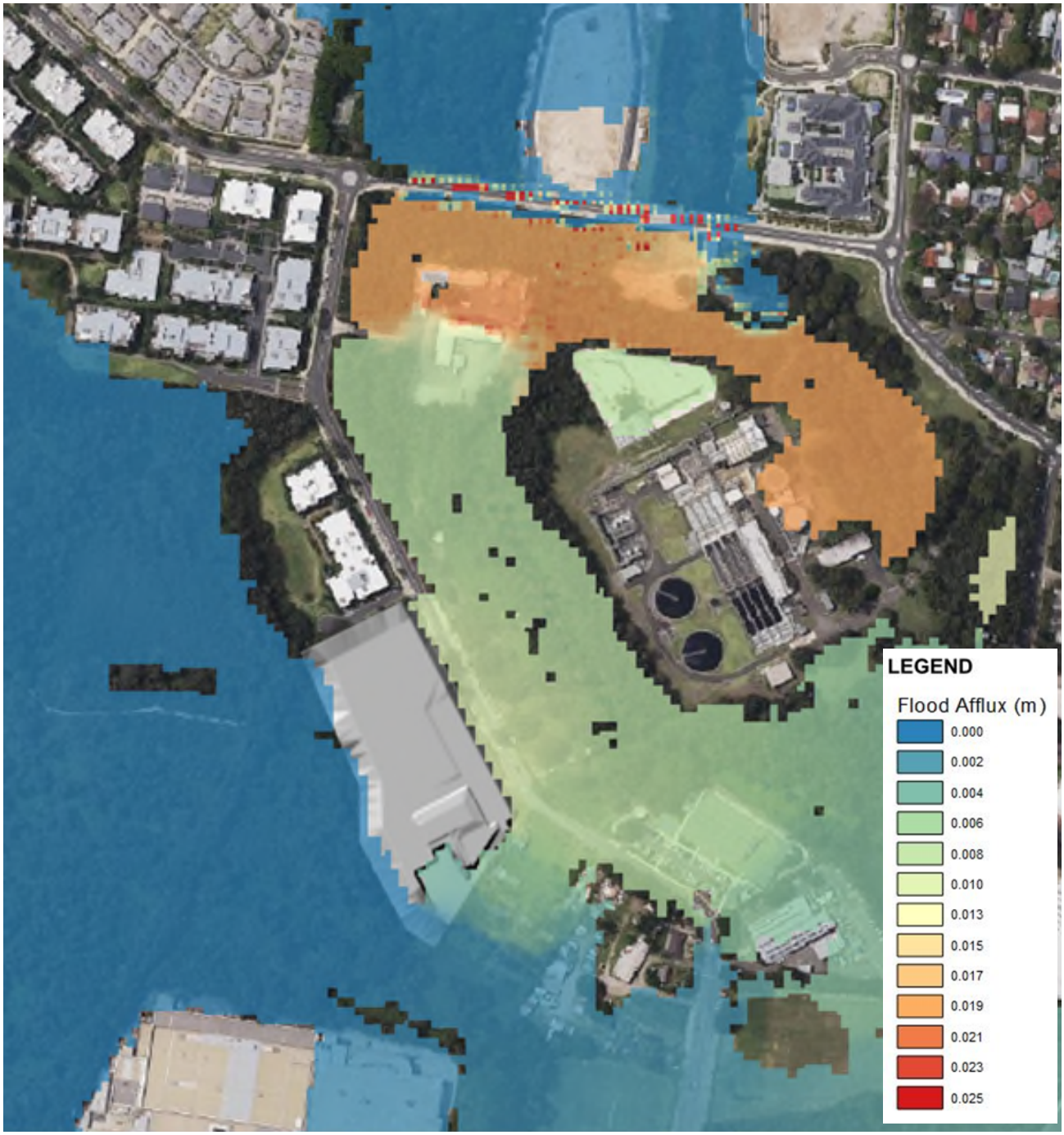

Figure 15 – 1% AEP 1440min Afflux without Boondah Road

The flood modelling for the 1% AEP without the Boondah Road raising gave a maximum afflux value of 0.017m. The earthworks within the property boundaries will be within Council's specification for tolerable afflux. Calibre has examined the behaviour of the 1% AEP 1440min storm and found that there is a difference in water levels between the eastern and western boundaries of the property of 20mm, with the higher levels in the creek reserve. The placement of pipes or culverts under the raised Boondah Road to allow the water to drain under the embankment to the south or eastern boundaries of site, should drop the afflux in Narrabeen Reserve to levels observed in Figure 15. Alternatively, such pipes or culverts could be used to provide the volume lost by the raised Boondah Road. The sizing and position of such structures can be confirmed at the construction certificate stage.

5.4.5 Afflux – 1% AEP 540min with climate change

The afflux for the critical storm for the 1% AEP with climate change is shown in Figure 16. The critical storm for climate change is determined to be the maximum duration storm, with a 30% rainfall increase and a 0.9m ocean boundary increase. The rainfall and ocean boundary increase produces a water elevation increase in the 1% AEP results of 800mm across the Warriewood region.

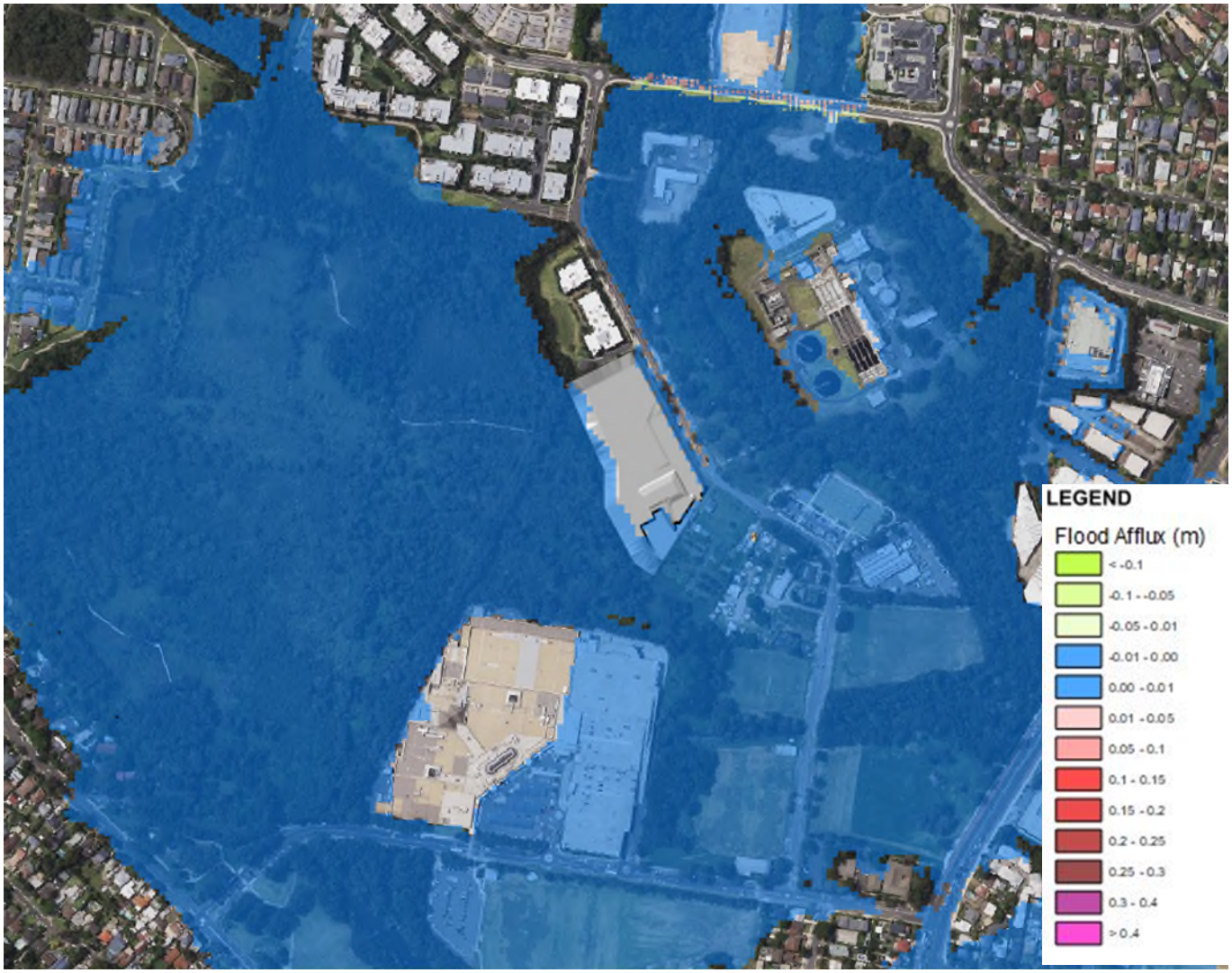

Figure 16 – 1% AEP 540min + CC Afflux

Figure 16 indicates that afflux within the site will be within the tolerances for Northern Beaches Council. The water submerges the walkways and lower areas within the development. The evacuation route to Firetail Drive and MacPherson Street remains clear. The severity of the afflux is less than the 1% AEP 1440min storm as the raising of Boondah Road has an insignificant effect on the overall flood levels within the area.

The 2019 study demonstrates similar flood extents regarding the property, with water inundating most of No. 10, and infringing onto the property boundaries of No.12. This is also shown in the council flood report. However, in Figure 16, the floodwater reaches further into No.12. However, the afflux threshold remains met for this storm.

The crest of the proposed raised Boondah Road is clear during the 1% AEP plus climate change event. The modelling shows that there is a narrow strip of ponding between the proposed development landform and the proposed road form this is within the road verge area and will not impact the ability of people within the site from using the site or Boondah Road.

5.4.6 Velocities – 1% AEP 1440min

The existing and developed velocities of the 1% AEP are given in Figure 17 and Figure 18. Council requires velocity mapping of the 1% AEP, but have not stated what tolerances are required, hence both existing and developed are provided for comparison.

5.4.6.1 Existing

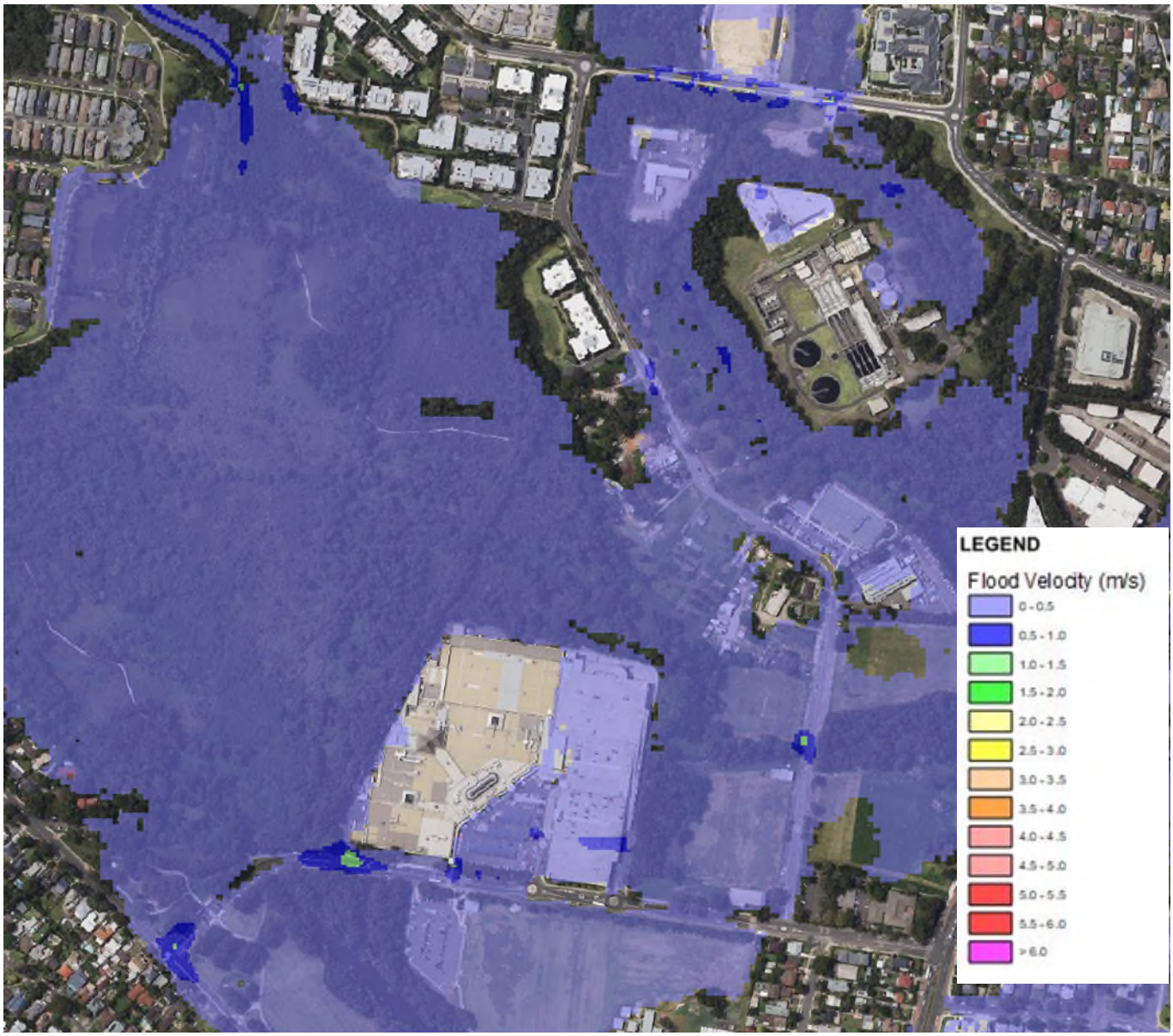

Figure 17 – 1% AEP 1440min Existing Velocities

In Figure 17, most of the velocity across the region is in the range of 0 – 0.5m/s, which is consistent with Calibre's assumption that stormwater flows pond in this area, rather than freely flow. Areas of higher velocity (up to 2m/s) are in roadways close to creeks, which are not being amended for this development. The 2019 study shows greater extents of velocities in the range of 0.5 – 1m/s across the region, though this can be attributed to the nature of the modelling of overland flows, rather than ponding as in this model.

5.4.6.2 Developed

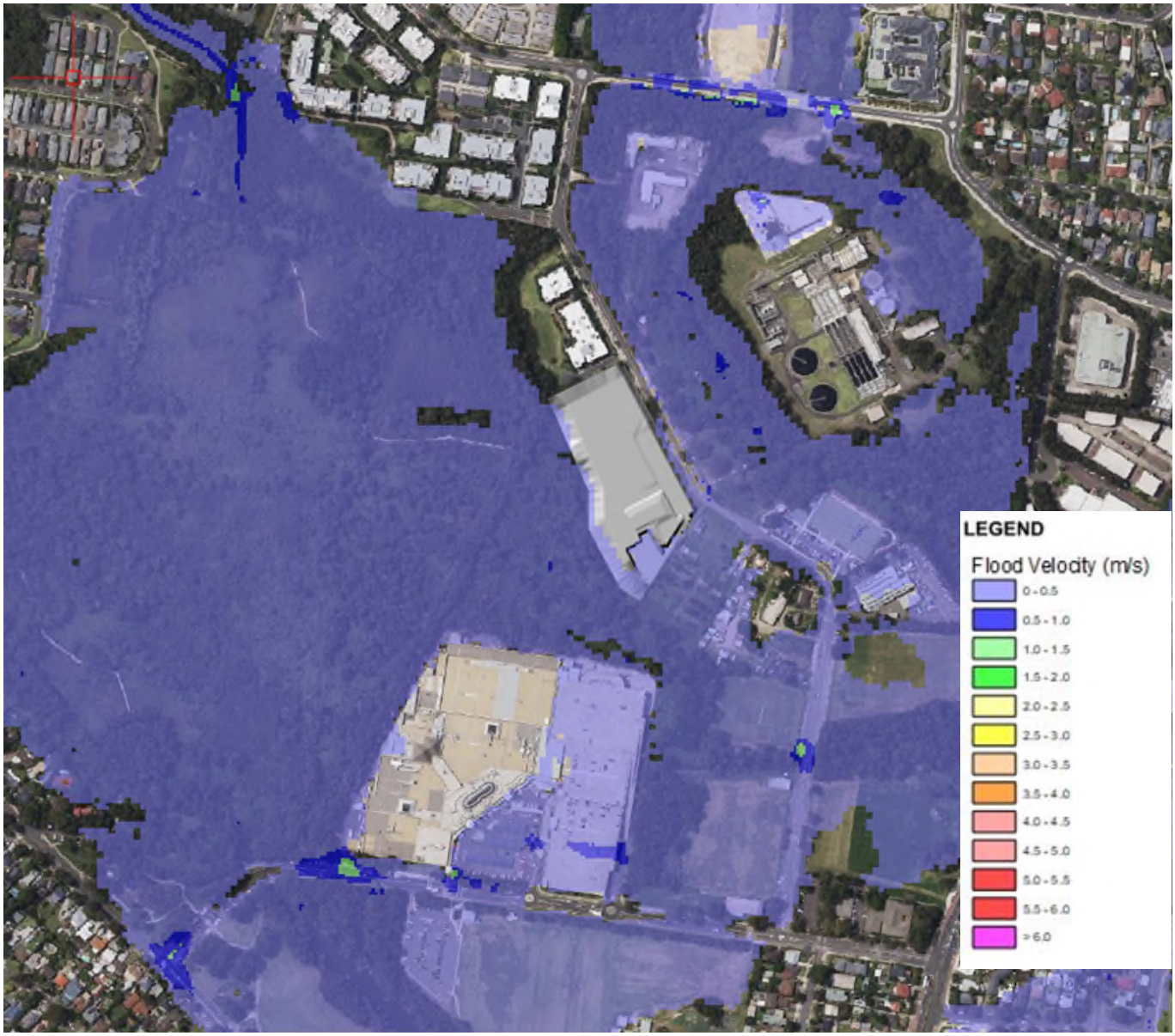

Figure 18 – 1% AEP 1440min Developed Velocities

In Figure 18, the velocity pattern in the developed case is very similar to the existing, with some very minor differences in Boondah Road fronting the development. Calibre considers that the impacts of the development on the 1% AEP velocity are negligible, as the static ponding behaviour of the flooding remains consistent.

5.4.7 Velocities – 1% AEP 540min with climate change

The existing and developed velocities of the 1% AEP with climate change are given in Figure 19 and Figure 20.

5.4.7.1 Existing

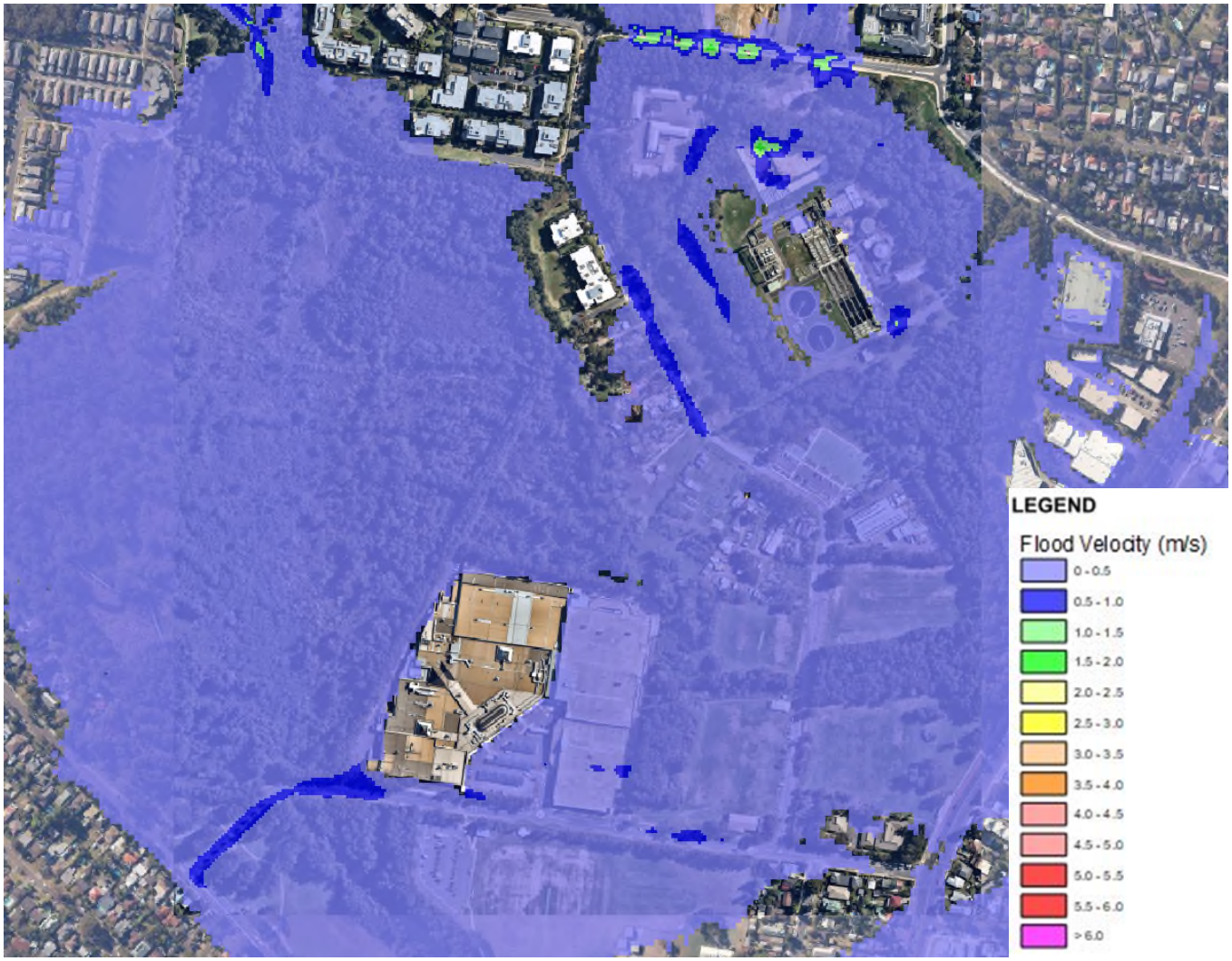

Figure 19 – 1% AEP 540min + CC Existing Velocities

In Figure 19, most of the velocity across the region is in the range of 0 – 0.5m/s, but the areas of 0.5 – 1m/s have increased. These are largely contained to the roadways. The 2019 study shows greater extents of velocities in the range of 0.5 – 1m/s across the region, though this can be attributed to the nature of the modelling of overland flows, rather than ponding as in this model.

5.4.7.2 Developed

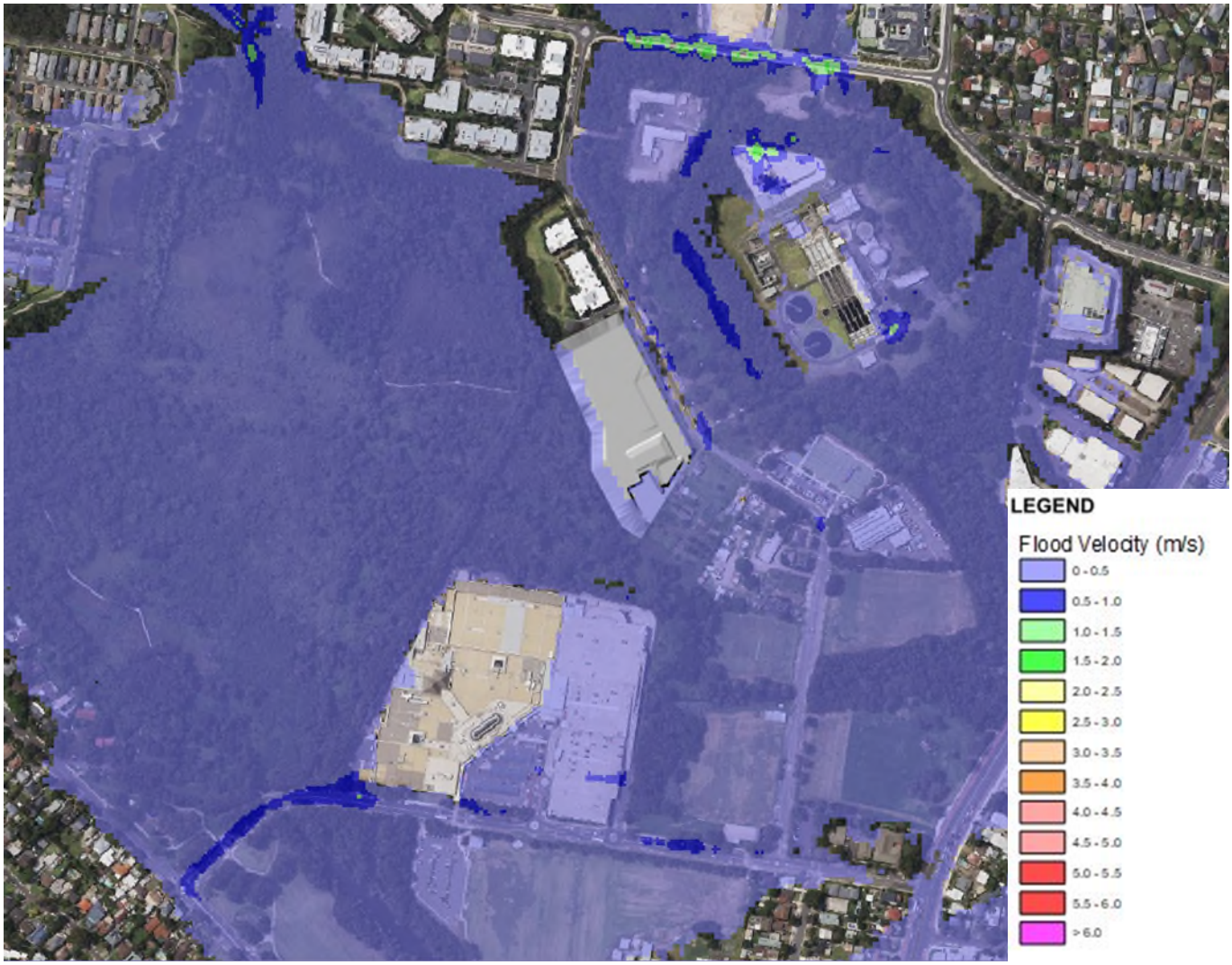

Figure 20 – 1% AEP 540min + CC Developed Velocities

In Figure 20, the velocity pattern in the developed case is very similar to the existing, with some differences in Boondah Road fronting the development. It is evident that the development earthworks and road raising are pushing water back into the creek extents, which is increasing flows with the creek, but then reducing the velocities in the roadway. Calibre considers that the impacts of the development on the 1% AEP velocity are negligible, as the static ponding behaviour of the flooding remains consistent.

5.4.8 Afflux – PMF 360min

The afflux for the critical storm for the PMF is shown in Figure 21.

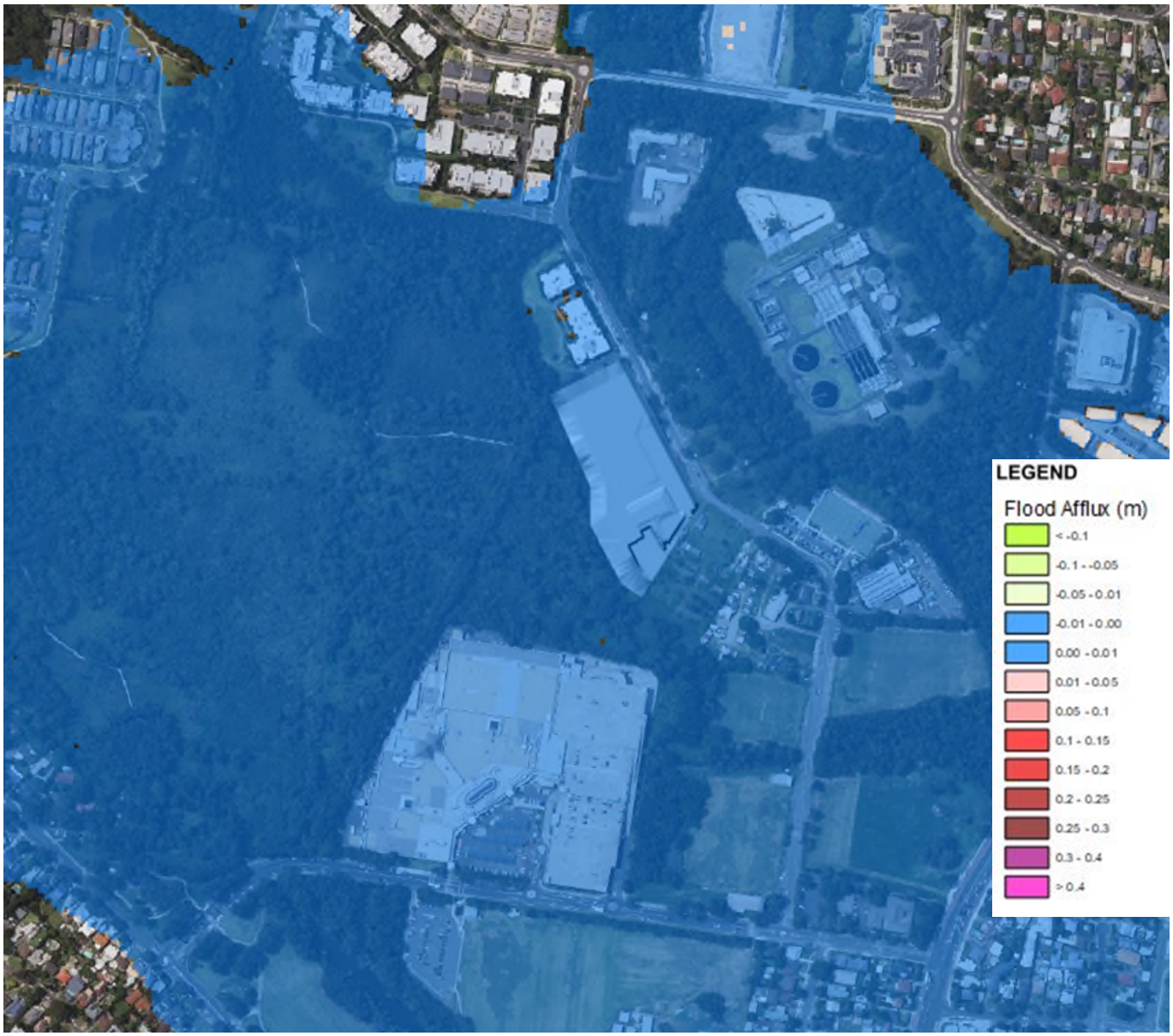

Figure 21 – PMF 360min Afflux

Figure 21 shows no increase in afflux across the Warriewood region, hence the earthworks proposed for this development will have no have effect on the PMF flood. The intersection of Macpherson Street and Boondah Road remains clear, hence that may serve as an evacuation point.

The 2019 study shows a smaller PMF extent around the development site. The flood depths in both the 2019 study and the 2013 study with the development show around 1m of flood depth within the property boundaries. The evacuation point from the development remains consistent between the 2013 and 2019 study.

5.4.9 Afflux – PMF 360min with climate change

The afflux for the critical storm with the PMF with climate change impact is shown in Figure 22. For this storm event, it is not reasonable to apply a rainfall increase, hence the ocean boundary has been raised by 900mm, as for the other critical climate change events.

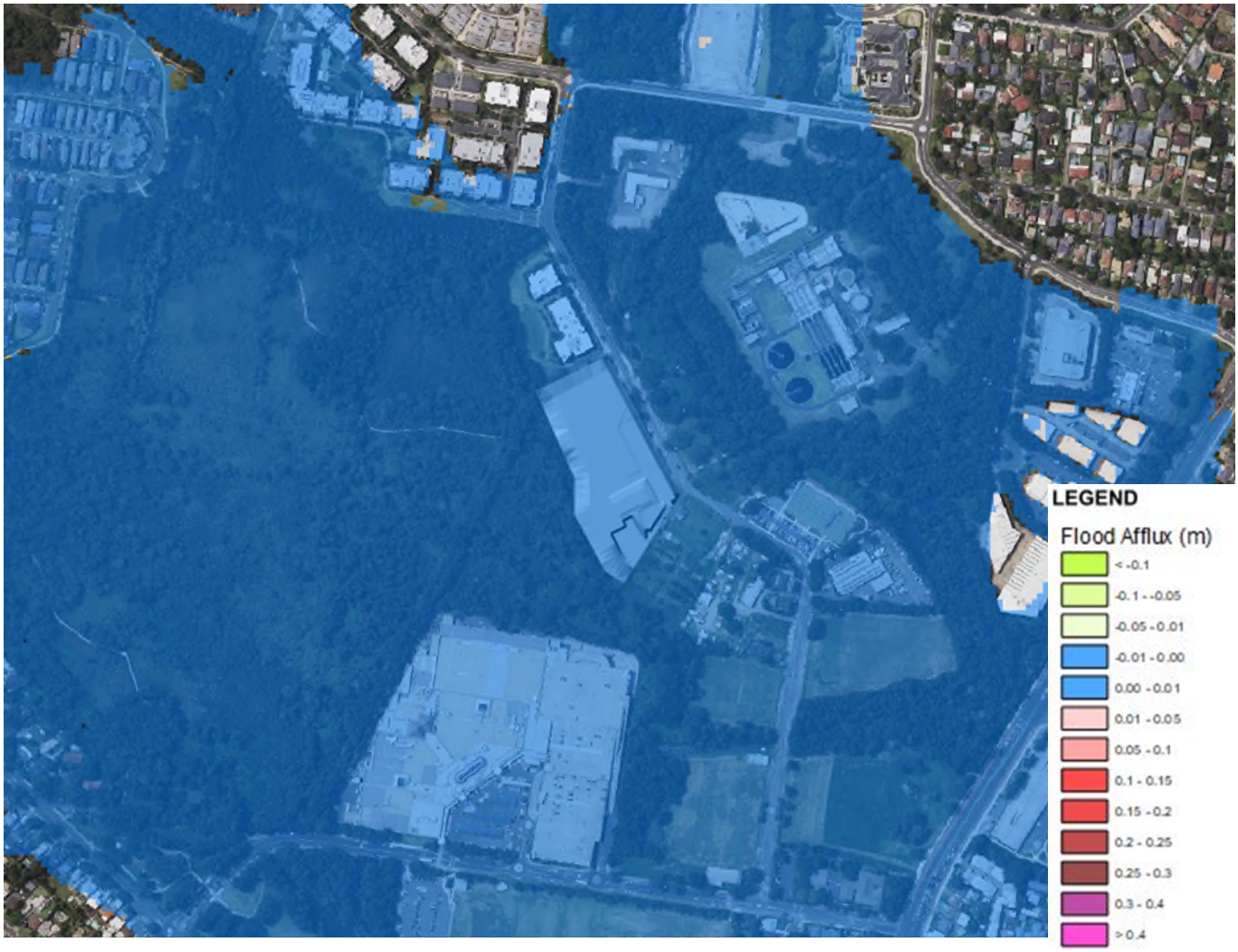

Figure 22 – PMF 360min + CC Afflux

The afflux for the PMF is within councils' tolerance of 50mm. MacPherson Street remains a suitable evacuation point. In the 2019 study, the flood extents have increased, when compared to the same study without climate change. The evacuation point remains the same.

5.4.10 Velocities – PMF 360min

The velocity comparison between the developed and existing scenario for the critical storm for the PMF is shown in Figure 23. Council requires that the development produces an increase of no more than 10% in PMF velocity.

Figure 23 – PMF 360min Velocity % Afflux

Figure 23 indicates that velocity percentage increases do exceed 10% but are small, localised zones across the area. These spots of sudden increases in areas downstream of the property, though, would not be due to the development at 10 – 12 Boondah Road. Neither the 2013 nor 2019 studies map the velocity afflux.

5.4.11 Velocities – PMF 360min with climate change

The velocity comparison between the developed and existing scenario for the PMF with climate change is shown in Figure 24.

Figure 24 – PMF 360min + CC Velocity % Afflux

Figure 24 has results like that of Figure 23, but to a reduced extent within the paths and walkway areas. It should also be noted that most flood velocities across the region are within 0 – 0.5m/s, even in the areas where large percentage increases occur. Refer to Figure 25.

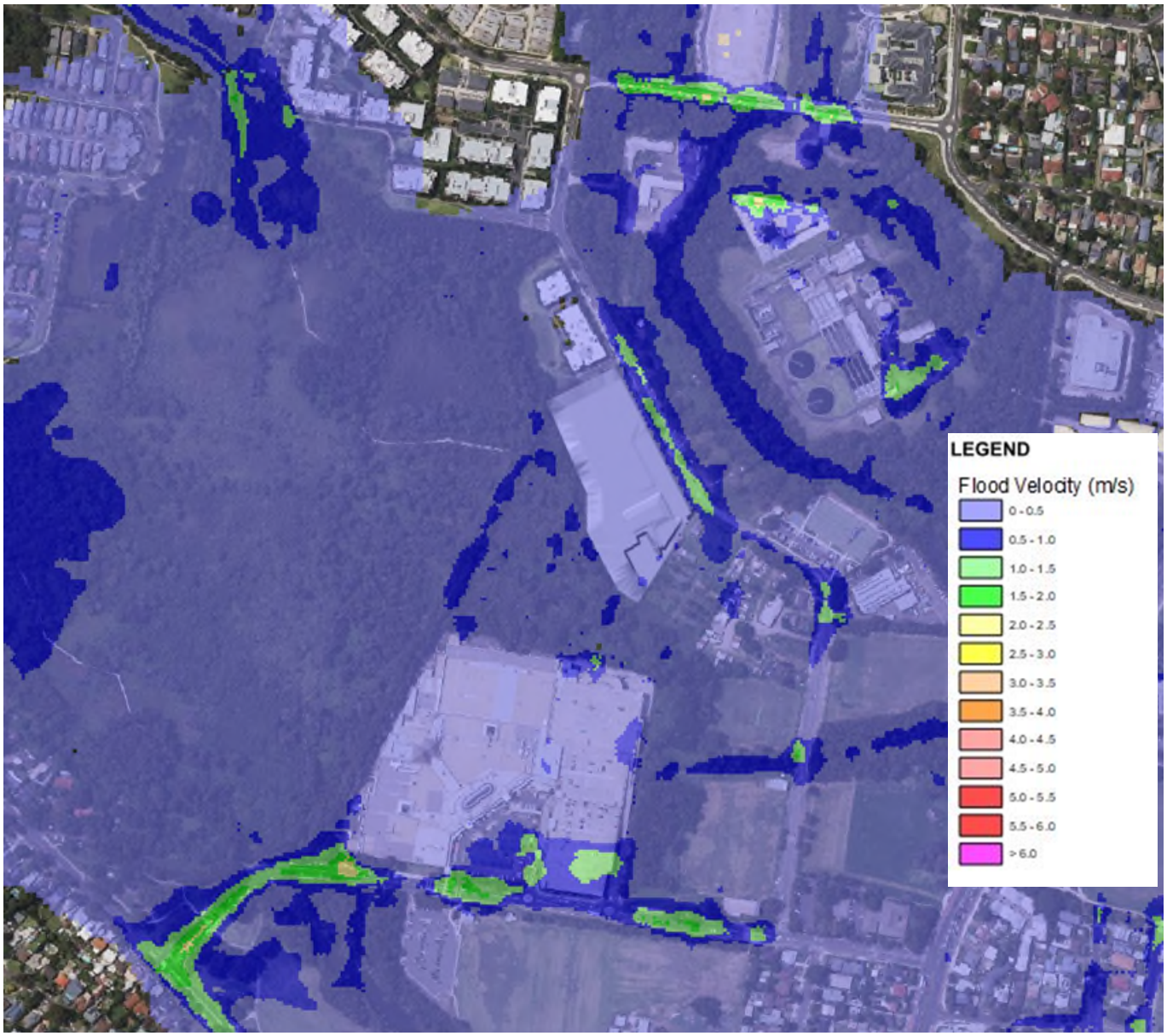

Figure 25 – PMF 360min Developed Velocities

Figure 25 indicates that within the paths and walkway areas where the high percentage increase occurs, the flood water remains reasonably static (within 0 – 0.5m/s), as per the existing condition of flood behaviour. Hence the earthworks cut in those areas is negligible on the PMF flood velocities. 0 – 0.5m/s is considered acceptable for most soil types and areas. The 2019 study shows greater extents of velocities in the range of 0.5 – 1m/s across the region. This can be attributed to the nature of the modelling of overland flows, rather than ponding as in this model.

5.4.12 Hazard Rating – Flood Risk Precinct Mapping

Council has provided Flood Information Reports for 10 – 12 Boondah Road, which contain a flood risk precinct map, based on the 2013 and 2019 studies. The map for No. 10 is shown in Figure 2, which shows the flood risk precinct mapping for the undeveloped site. An expanded map is shown again in Figure 26 to provide reference for the hazard rating. Flood Risk Precincts are categorised as low, medium, and high. They are divided based on the level of expected risk to persons and property due to flooding. The flood map is available from Northern Beaches Council website for flood hazards. 10 – 12 Boondah Road is shown outlined in yellow. The developable area nominated for the planning proposal is shown outlined in black. The area is equal to 1.32 Ha.

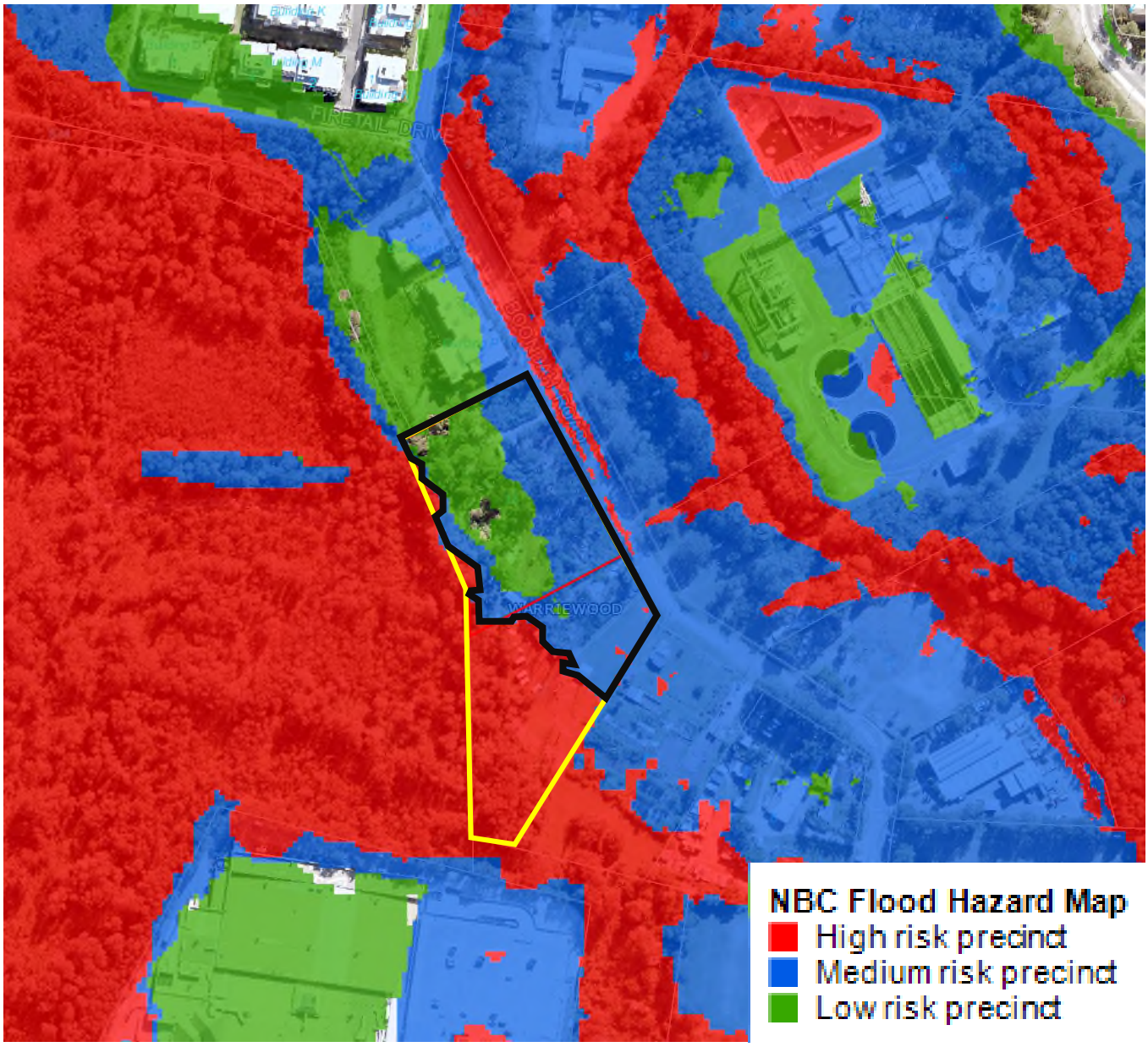

Figure 26 – Flood Risk Precinct Map

Council classifies the flood risk precincts as such:

- **Low Flood Risk precinct:** all flood prone land not identified within the High or Medium flood risk precincts (shown as green).
- **Medium Flood Risk precinct**: all flood prone land that is (a) within the 1% AEP Flood Planning Area; and (b) is not within the high flood risk precinct (shown as blue).

- **High Flood Risk precinct:** all flood prone land (a) within the 1% AEP Flood Planning Area; and (b) is either subject to a high hydraulic hazard, within the floodway or subject to significant evacuation difficulties (H5 or H6 Life Hazard Classification). (shown as red).

The extent of the hazard mapping represents the 1% AEP flood event with 500mm freeboard. It does not include the effect of climate change and presents the state of the area as currently shown (at present, undeveloped).

The Warriewood Valley Strategic Review report (WVSR) endorsed by Council in June 2013 recommends a maximum density of 32 dwellings per developable hectare. Calibre nominates that the developable land is a minimum of 1.32 Ha in size, as shown in Figure 26, defined as the land within the low and medium hazard zones.

The high flood risk area within Figure 26 (shown in red) is subject to significant hazard risks, requiring at a minimum special engineering construction and design (H5), or otherwise not suitable for people, vehicles, or buildings (H6). The medium and low flood risk areas are not subject to such conditions, and as such, are considered suitable for development, provided the development controls for flooding as given in Councils DCP are met. Calibre's modelling with the conservative 2013 Tuflow model in Sections 5.4.2 - 5.4.11 has demonstrated that the development can be built to within the tolerances provided by Council's DCP for low and medium hazard land. Refer to Table 1 for a complete summary of the DCP and other control conditions that have been met for this proposal.

The 2019 flood study with climate change also supports the provision of approximately 1.32 Ha of developable land for 10 – 12 Boondah Road. Figure D1 of the study (shown below as Figure 27) shows the flood extents of the 1% AEP with climate change (30% rainfall increase with 0.9m raised ocean boundary). The areas of high depth (as shown by dark blue) are consistent with the high hazard areas mapped in council's flood information report, as seen in Figure 26. The areas of lower depth are consistent with the medium and low hazard areas.

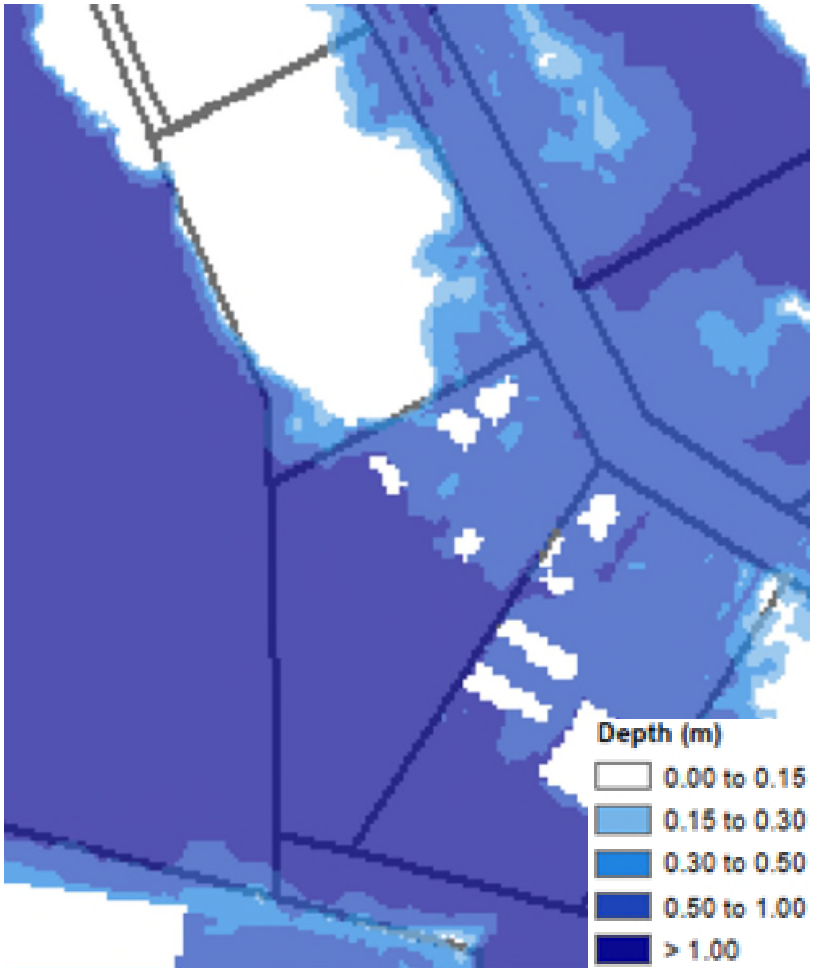

Figure 27 – 1% AEP flood extents with climate change (2019)

5.4.13 Hazard Rating – Flood Category and Hazard

In accordance with Clause C6.1 of the DCP, flood category and hazard classification as per clause A1.9 of the DCP with climate change needs to be obtained for this development. Flood Hazard is classified as Low or High (with an intermediate zone between them) like the Flood Risk Precinct, but it is determined according to the variable 'Z1', which is a quantitative factor derived from the graph below.

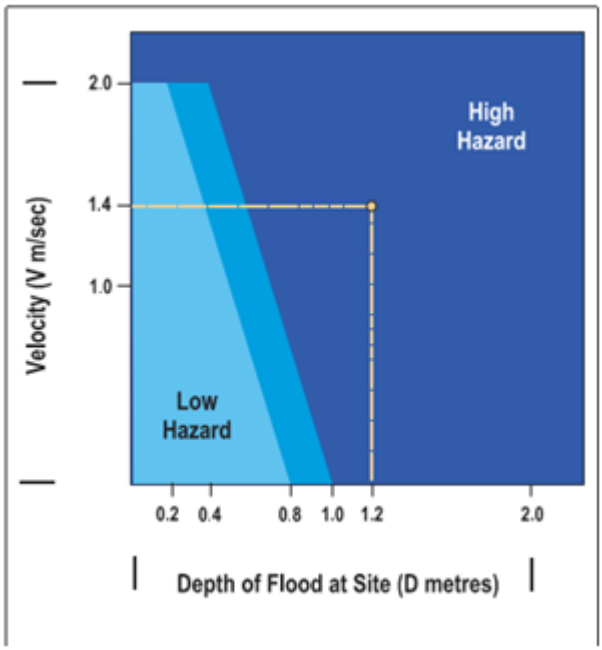

Figure 28 – Flood Hazard 'Z1' Graph

Calibre has run the 1% AEP with climate change (like the precinct planning) for the variable 'Z1' to determine the surrounding flood hazard against the development, in accordance with the DCP. The climate change considered is 30% rainfall intensity with a 900mm ocean boundary increase. The resulting hazard is shown in Figure 29.

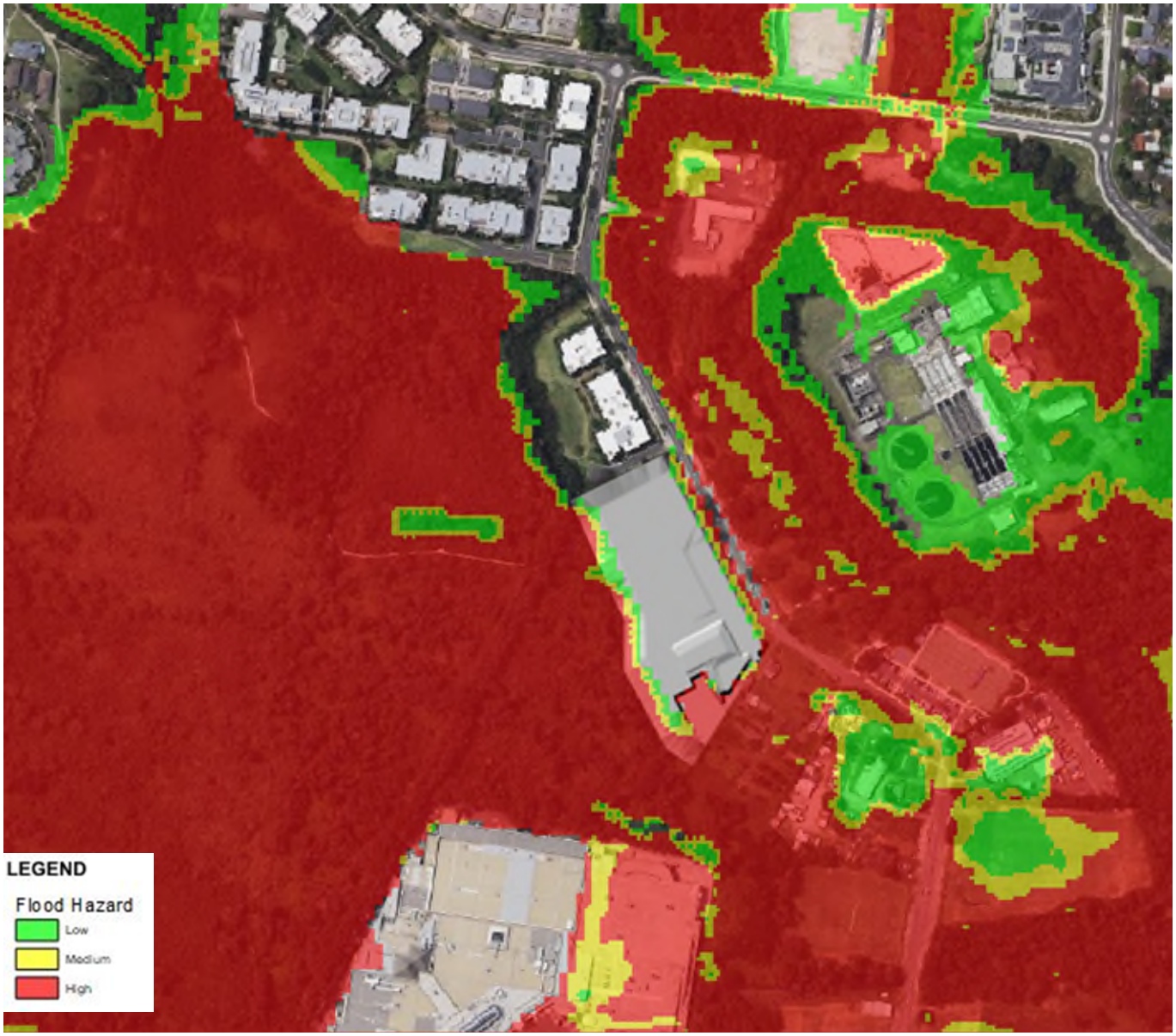

Figure 29 – 1% AEP with CC Flood Hazard

Figure 29 indicates that the earthworks proposed for this development will keep clear the development areas and the access ways to the evacuation route clear of any flood hazard in the worst case 1% AEP event. The evacuation route remains clear of any flood hazard in this event. This is consistent with Calibre's strategy to place the development at or above the FPL, and the 1% AEP with climate change.

5.4.14 Hazard Rating – PMF Flood Life Hazard

Part E1 of Clause B3.11 in the DCP states regarding medium and high hazard, if a property is affected by a Flood Life Hazard of H6, then development is not permitted unless it can be demonstrated that the risk level on the property is or can be reduced to a level below H6 or its equivalent. Calibre has modelled the variable 'ZAEM1' which categories flood life hazard H1 – H6. The results of this modelling for the PMF 360min (being the rarest storm event possible), is shown in Figure 30.

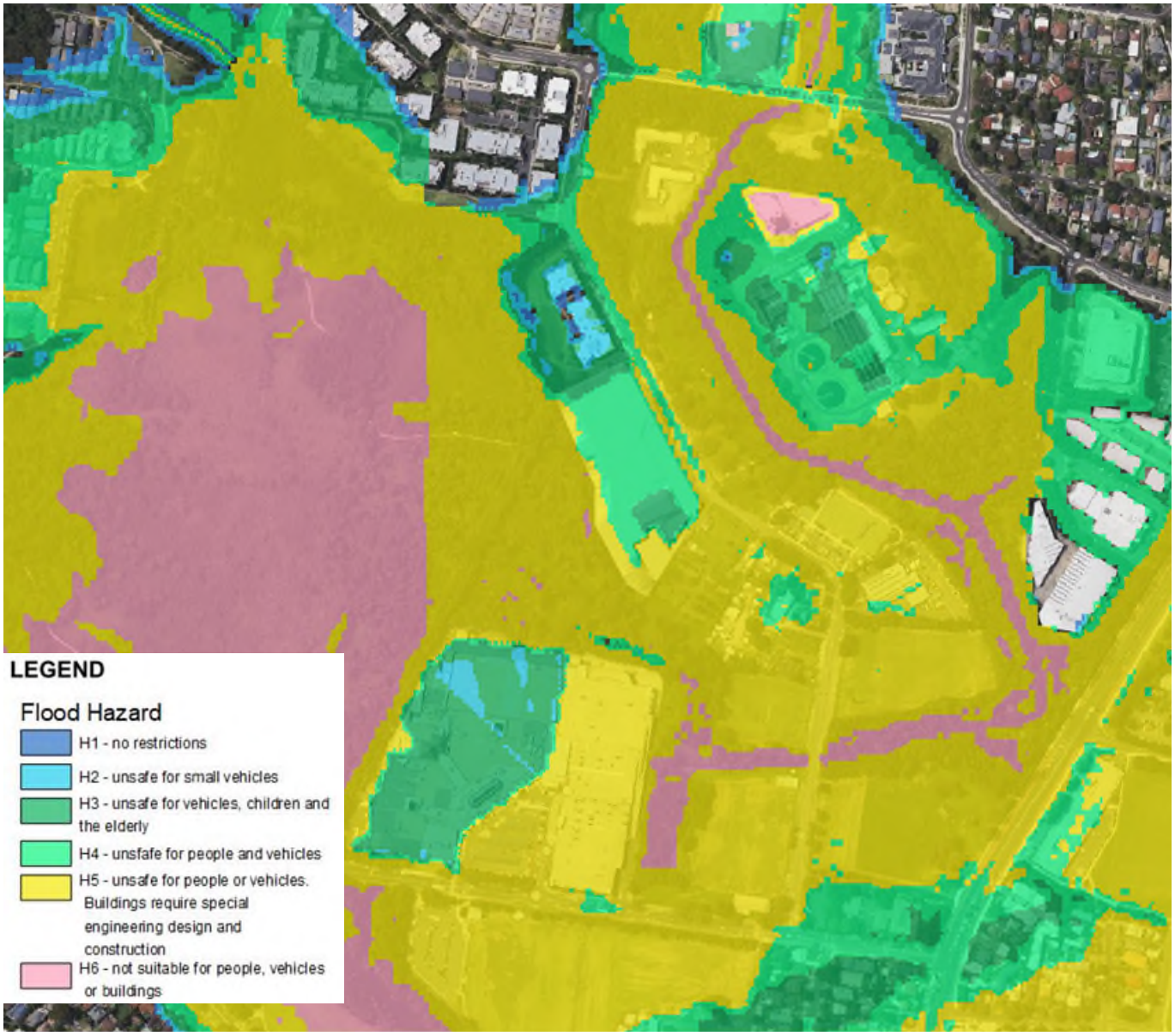

Figure 30 – PMF 360min Developed ZAEM1 Hazard Rating

The hazard mapping using the ZAEM1 variable shows that the rating within the nursery is H3 and H4. H3 is considered unsafe for children, while H4 is considered unsafe for people and vehicles, this is acceptable in this development as any workers or customers (and their children) will have already evacuated prior to the height of the PMF event to MacPherson Street above. In addition the evacuation route complies during the 1% AEP level.

Hence this development will comply with Part E1 of Clause B3.11 of the DCP.

5.5 Evacuation Plan

The evacuation plan for 10 – 12 Boondah Road is evacuation via Boondah Road for very rare storm events, exceeding the 1% AEP with the effects of climate change. This strategy also applies up to the exceedingly rare PMF storm events.

5.5.1 Evacuation Route

As per the Pittwater DCP, a medium-risk flood area requires evacuation or shelter in place for the PMF flood event (as per Figure 2). Calibre has determined that a flood evacuation route would have to run from the front of the development to MacPherson Street. The route is shown in Figure 31. As shown in Figure 22, the intersection of Boondah Road and MacPherson Street will be above the PMF event with climate change impacts.

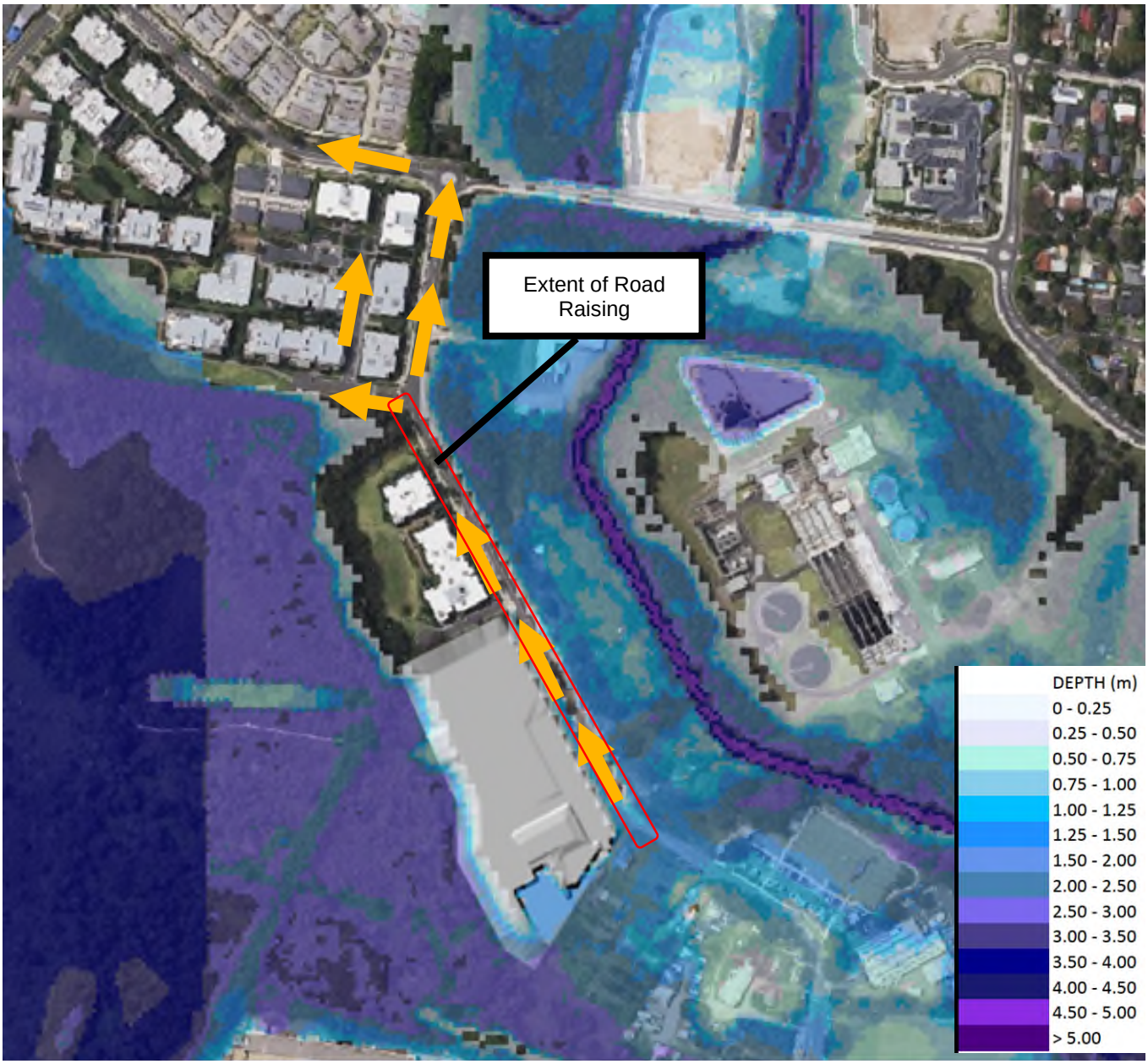

Figure 31 – Flood Evacuation Route in the 1% AEP + CC

The route has been modelled in TUFLOW, as a raised road corridor from the southernmost exit from 10-12 Boondah Road to the existing surface level at RL 3.9, located at Firetail Drive. Based on the flood modelling done by Calibre and

the 2019 study, the bridge over Narrabeen Creek is not going to be clear of the PMF event, hence it may not be used for evacuation purposes once inundated.

The crest of the proposed raised Boondah Road is clear during the 1% AEP and 1% AEP plus climate change storm events. The modelling shows that there is a narrow strip of ponding between the proposed development landform and the proposed road form this is within the road verge area and will not impact the ability of people within the site from using Boondah Road as an evacuation route.

5.5.2 Evacuation Timing

As stated under Section 5.4.1, the water elevation in a storm event builds across the region as the duration increases (refer to Figure 6 - Figure 10). Calibre has examined the behaviour of the PMF 360min duration storm (in accordance with the DCP), to determine the warning times and triggers available for evacuation. These flood extents represent the developed scenario. The hazard mapping system using ZAEM1 has been used to depict the evacuation timing, to determine at what point flood water becomes impassable.

5.5.2.1 Evacuation

This section details the timing of the rising floodwaters in the PMF storm, regarding the evacuation of 10 – 12 Boondah Road.

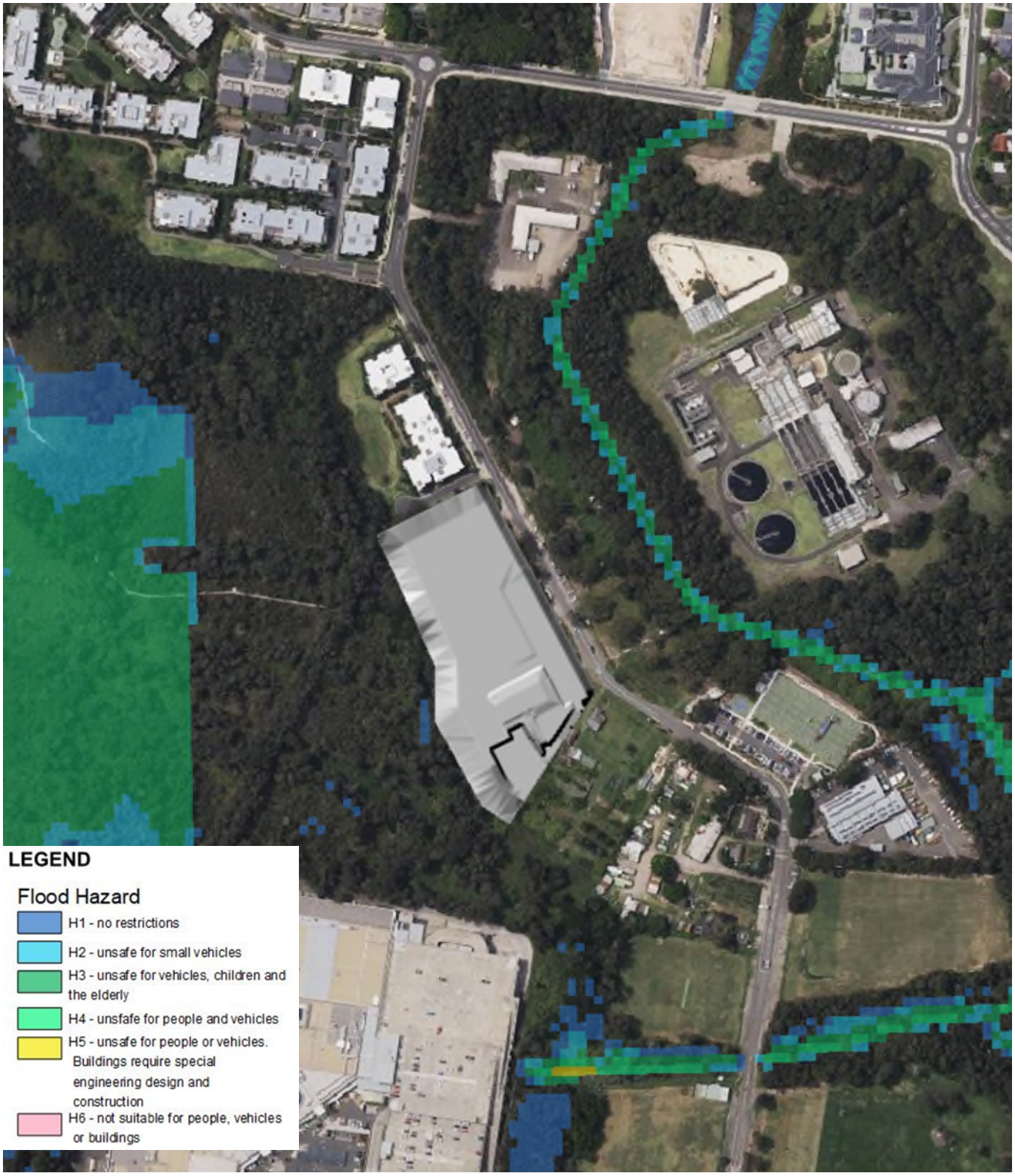

Figure 32 – PMF Storm at 0min

In Figure 32 the initial water levels in the model place water within the creek extents and wetland. The site remains unaffected.

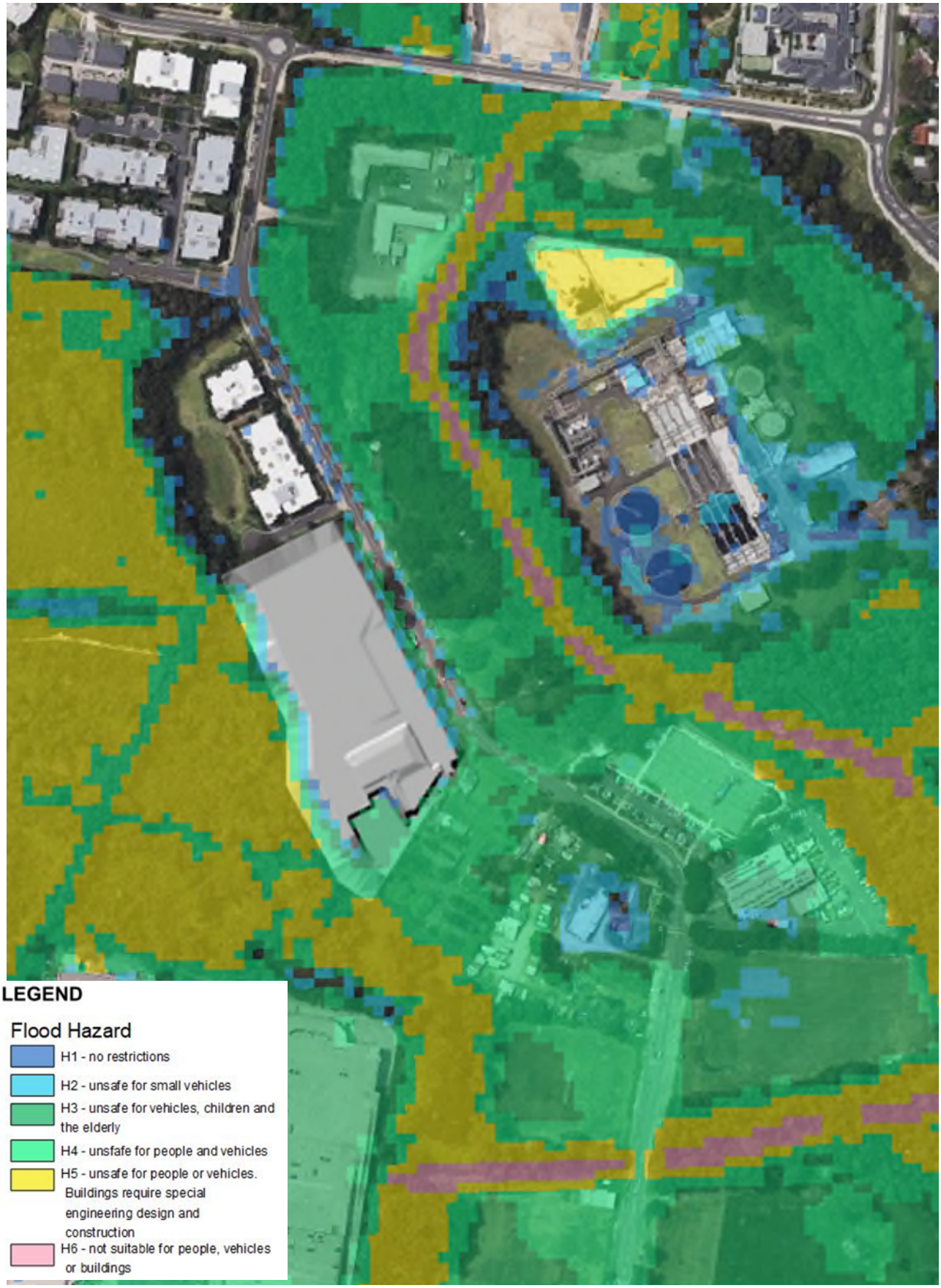

Figure 33 – PMF Storm at 75mins

Figure 33 indicates that water has built in Narrabeen Creek reserve but has not broken over the raised Boondah Road section, hence the evacuation route remains clear. The floodwater has built within the wetland, and to the south of the site to the extent that it has broken over into the lower areas and walkways, but as low hazard water. This will indicate to the workers that the storm event is greater than a 20% AEP flood. For reference, it takes 3 hours for a 1% AEP storm with increased rainfall intensity and raised ocean boundary to break into the lower areas and walkways, where the water reaches RL 2.57. For the PMF, the peak water level within the site boundary will be RL 2.77 at the 75-minute duration.

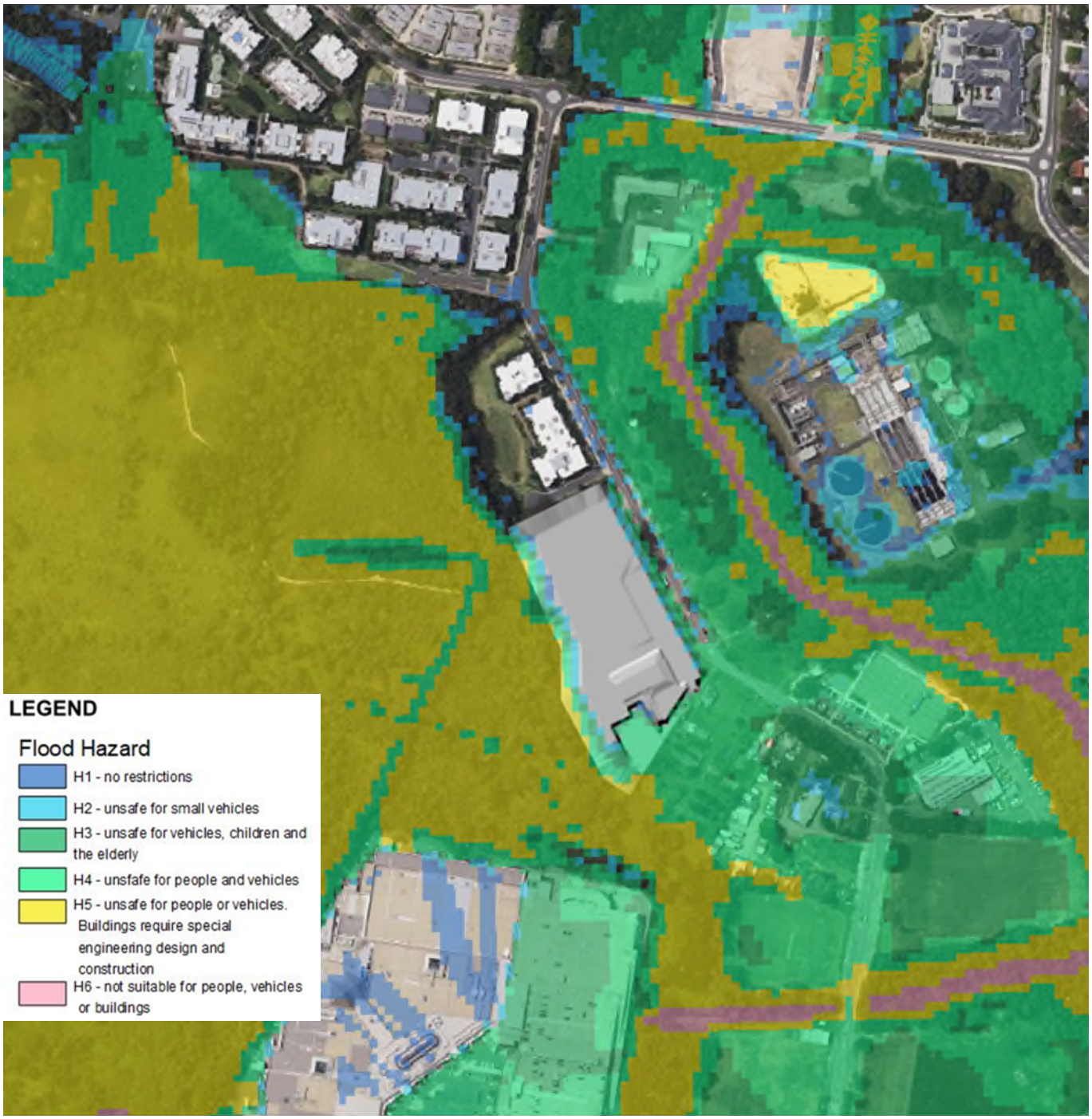

Figure 34 – PMF Storm at 165 mins

Figure 34 indicates that the PMF flood will overtop Boondah Road at 165 minutes from the start of the storm duration. The water does not yet overtop into the site. The flood hazard across the road remains H1, which imposes no restrictions, hence vehicles will still be able to travel to the evacuation point.

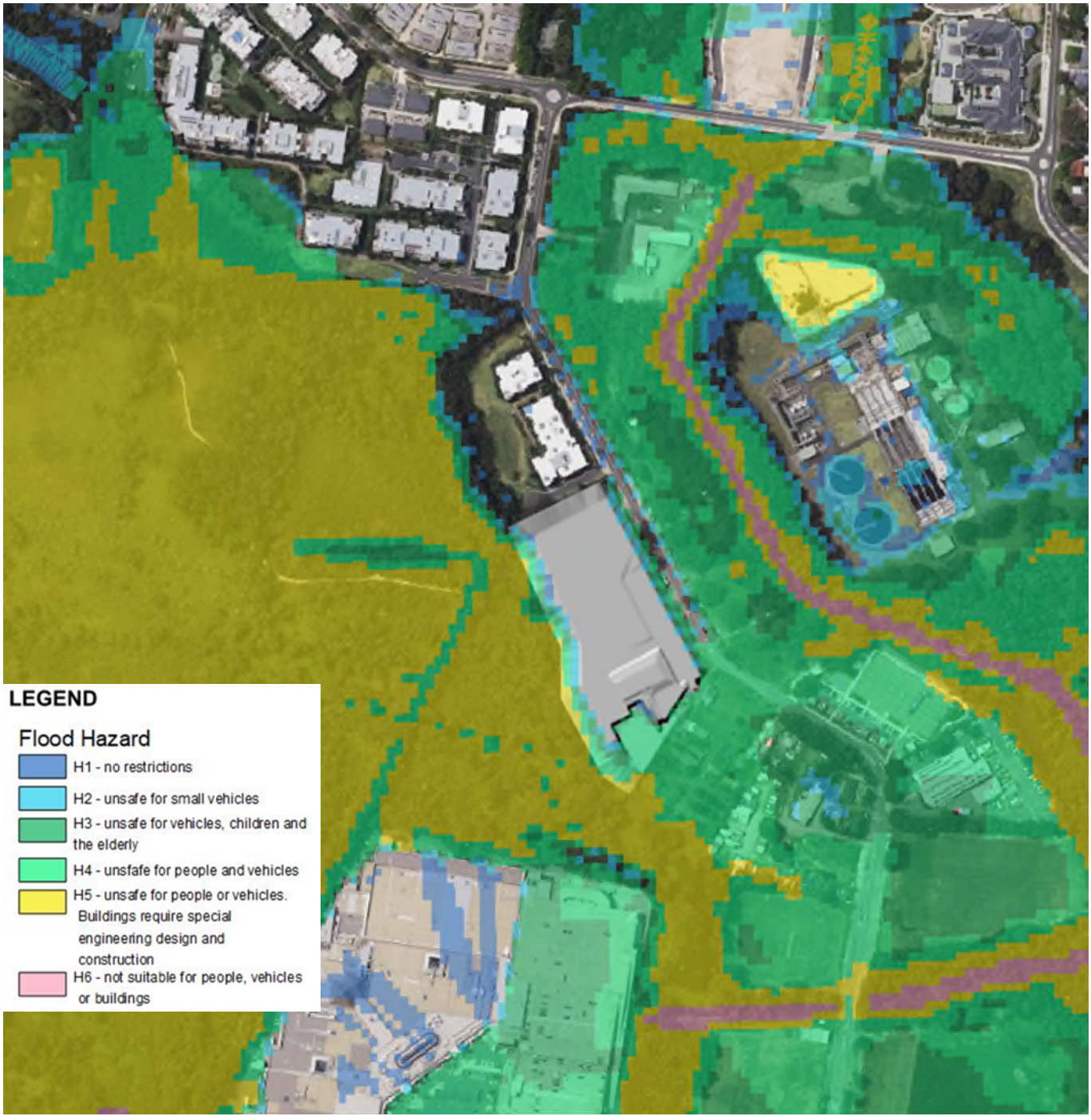

Figure 35 – PMF Storm at 180 mins

Figure 35 indicates that the PMF ponds into the site at the 3-hour mark. The water also ponds over the evacuation route. The hazard rating on the internal roads remains H1, and thus no restrictions to persons or vehicles in that place. The evacuation route is largely H1 but has spots of higher hazard rating. The presence of floodwater in the site will indicate to the workers that an event greater than the 1% AEP with climate change is occurring, and they must leave and it is advised they do so immediately (ideally in a large vehicle).

Figure 35 demonstrates that any PMF event shorter than 180 minutes will not flood the site. The following Figure 36 demonstrates a maximum period of 120 minutes between which the lower areas of the site are inundated to when the evacuation route becomes unsafe to small vehicles (H2). Figure 37 demonstrates a maximum period of 135 minutes between which the lower areas of the site are inundated to when the evacuation route becomes unsafe to large vehicles (H3).

5.5.2.2 Shelter in Place

Given that the proposed nursery is a single story low structure, a shelter in place policy is not advised for this development and that all workers and customers within the site are to leave prior to Boodah Road becoming impassable.

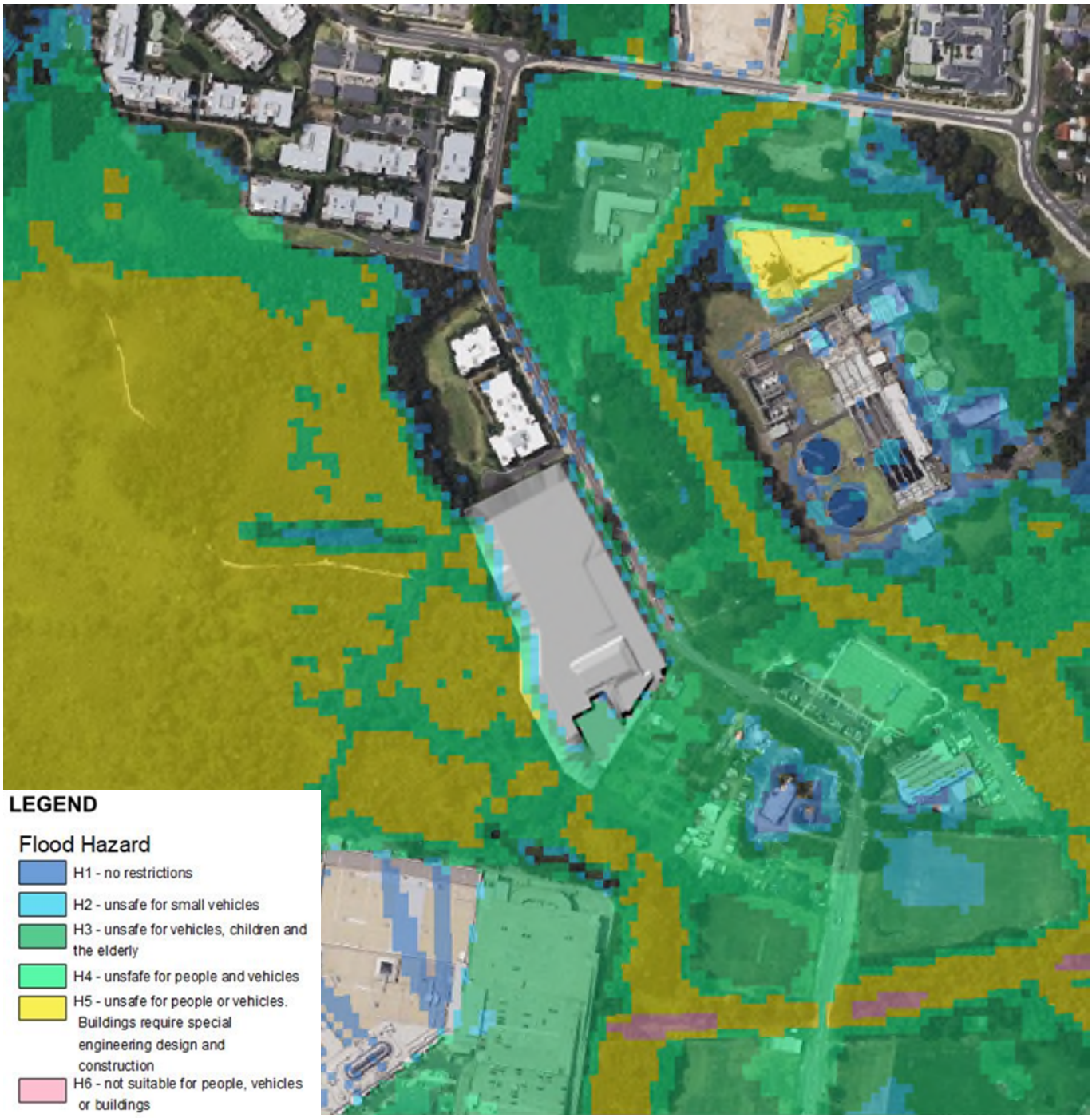

Figure 36 – PMF Storm at 195 mins

At 195 mins the water level within the carpark has risen to 4.33, which is just below the FPL for this development. For the PMF 360-minute storm then, there is an approximate half an hour lapse between water filling the carpark and touching the structure.

The minimum hazard rating in Boondah Road currently is H2, which is unsafe for small vehicles. It is still feasible for large vehicles to access Boondah road.

The following Figure 37 demonstrates a maximum period of 135 minutes between which the lower areas are inundated to when the evacuation route becomes unsafe for vehicles, as the minimum hazard rating on Boondah Road becomes 3.

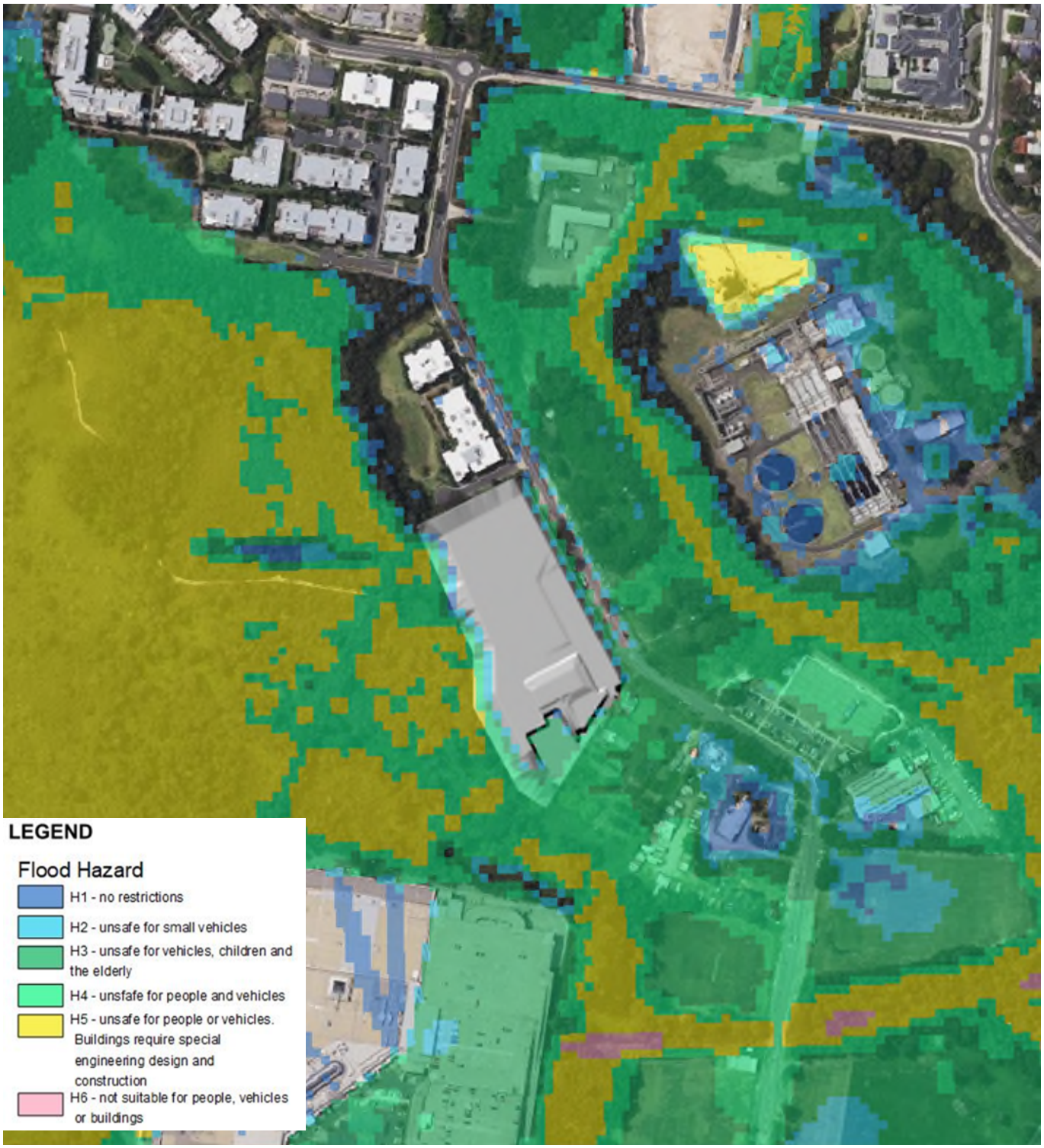

Figure 37 – PMF Storm at 210 mins

At 210 mins the water level within the carpark has risen to 4.54, which will enter structure. Calibre's TUFLOW modelling maps a peak PMF water level of RL 5.27 at 5 hours and 30 minutes into the PMF 360min duration storm.

5.5.3 Warning System

There are commercially available products which are designed to normally provide flood evacuation signals for sites and structures within proposed developments. Even though this site is not going to have anyone permanently residing on the site, this sort of system may still be used on developments such as this to detect flooding and help indicate when evacuation may be required, especially if the site is used at night or other times of low visibility. An example of these style of sensors is provided in Figure 38.

Figure 38 – Flood Sensor Products

Figure 38 indicates that a variety of flood sensor sizes are available for use. The sensor is in the metal casing at the end of the rod, called a ‘float’. The use of the sensor is shown in Figure 39.

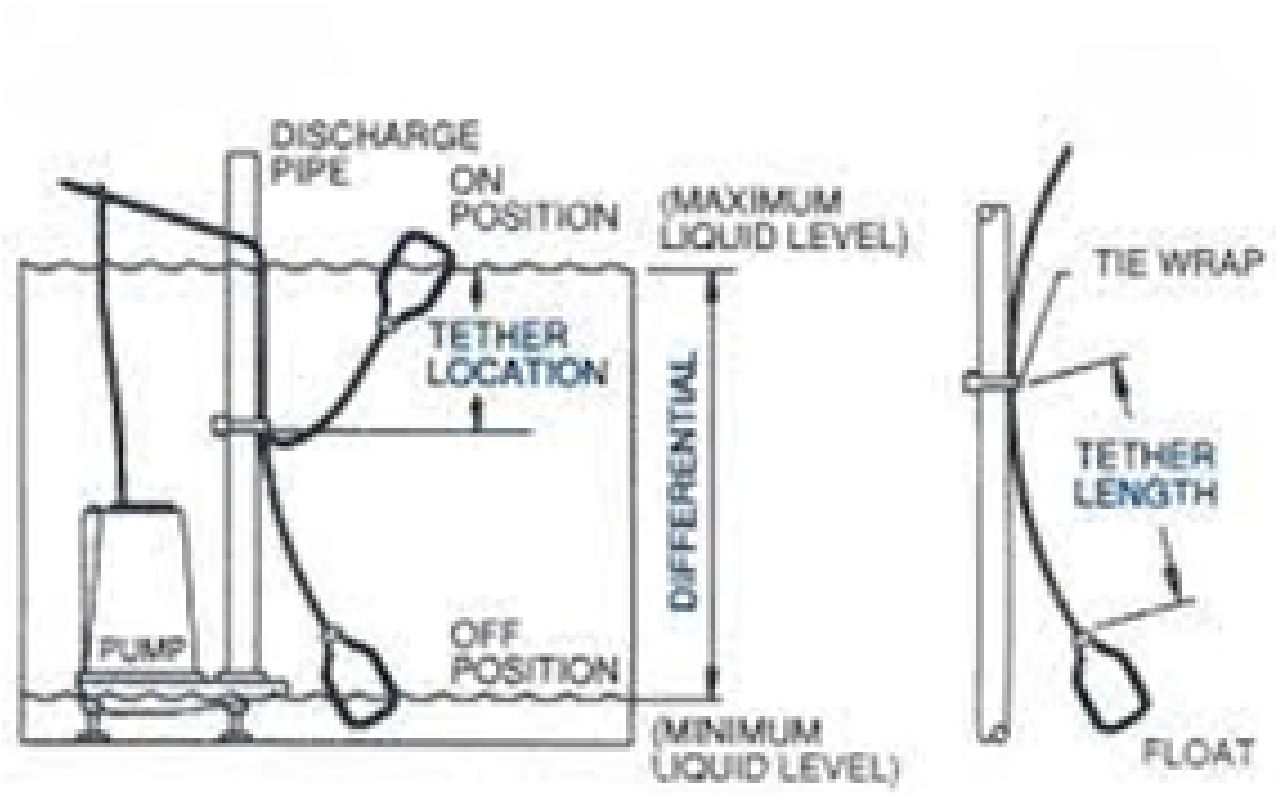

Figure 39 – Flood Sensor Operation

The flood sensor as shown in Figure 38 can be suspended from a steel rod, or within a perforated steel pipe (which will allow rainfall to drain out) at a determined RL. When water ponds around the flood sensor, the float will rise with it. At a determined height, a sensor within the float will fall to its rear, sending a signal via cable or radio to a control box, which contains a siren and warning light, as shown in Figure 40.

Figure 40 – Flood Warning Light and Box

A warning message and description of use may be attached to the boxes to advise workers and customers of its function. The siren and warning light (yellow) will go off once the sensor is tripped, which will occur when the float reaches the determined RL. For this development, the sensors set inside the steel poles could be set to trip at RL 2.75 (between 75 – 90 minutes into the PMF 360minute storm), which would provide around 75 minutes for workers to shut down, pack and get all customers to leave the premises along the determined evacuation route with them to follow. As it will take approximately a minute for vehicles reach the evacuation point, the workers and customers should have sufficient time to prepare and move.

The poles housing the flood sensors could be placed within the lower areas to the south of the site, such that they are free of exposed to flood waters but not intruding upon the daily operation and movement within the site. The warning light box may be placed at a spot within building near any cashier station for maximum effect.

The warning times and sensor locations may be revised upon more detailed design of the property. This system would ensure that people within the site are able to leave at the appropriate time in a rare storm event, even at night-time when they are not able to observe the flood water behaviour in the surrounding area.

5.5.3.1 Evacuation Duration

Calibre's TUFLOW modelling maps a peak PMF water level of RL 5.27 at 5 hours and 30 minutes into the PMF 360min duration storm. The simulation goes to 16 hours. Calibre has determined that the flood water drops away from the evacuation route to permit safe travel back to 10 – 12 Boondah Road 10 hours 30mins after the PMF 360-minute storm starts, using one lane.

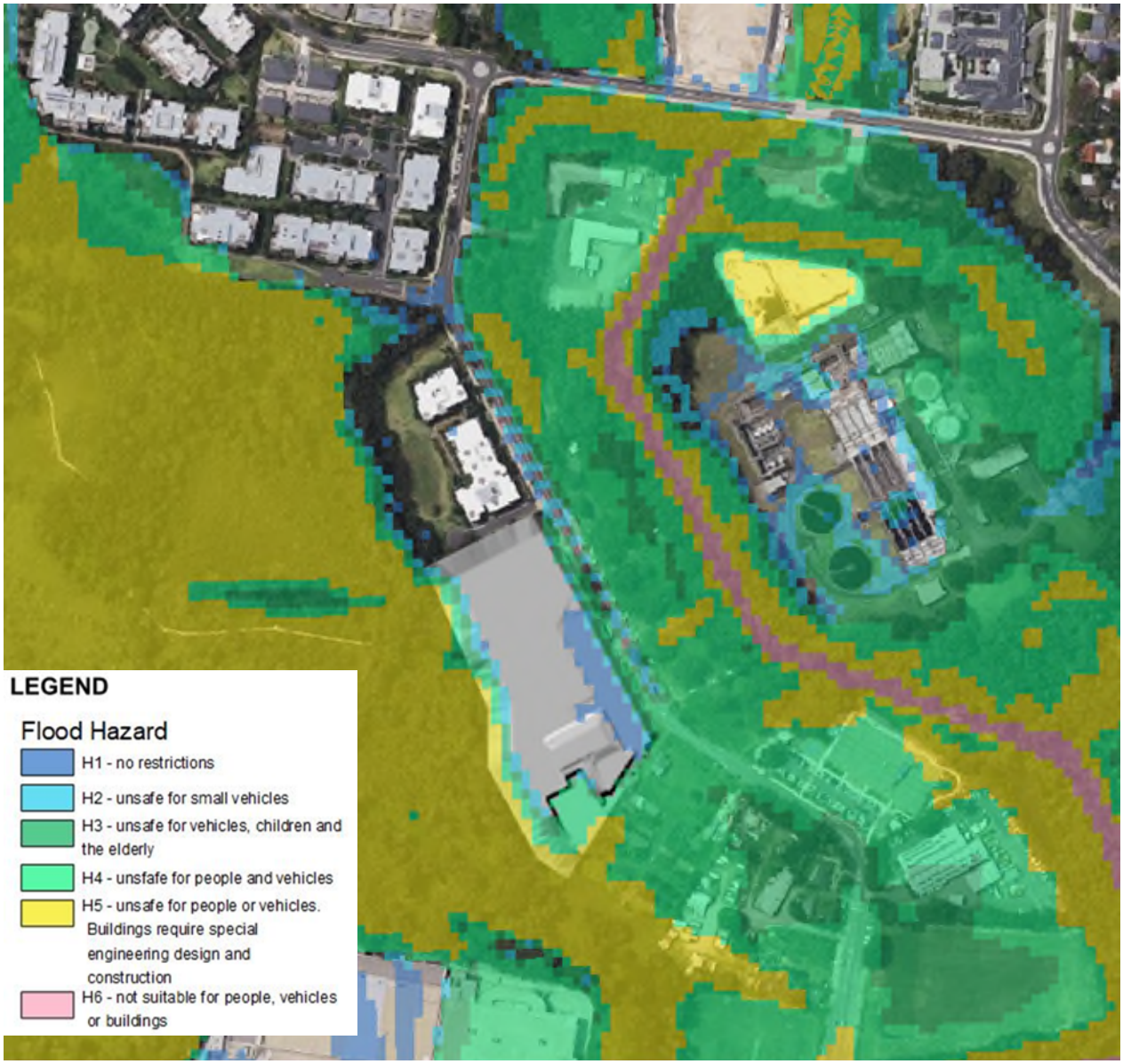

Figure 41 – PMF Storm at 10 hours 30 mins

The hazard across the site and at the entrance is 1, and thus is acceptable for people to drive through. Should the workers evacuate from the development 75 minutes after the PMF storm has started, then they will remain outside the development for approximately 9 hours and 15 minutes, from the time they evacuate to the time they may return.

The flood extents of the PMF cross MacPherson Street at No. 144 and the bridge over Narrabeen Creek at the 1-hour mark, from when the storm starts. They become impassable at 1 hour and 15 minutes. Hence the evacuees from 10-12 Boondah Road are restricted in movement to the roadway shown in Figure 42.

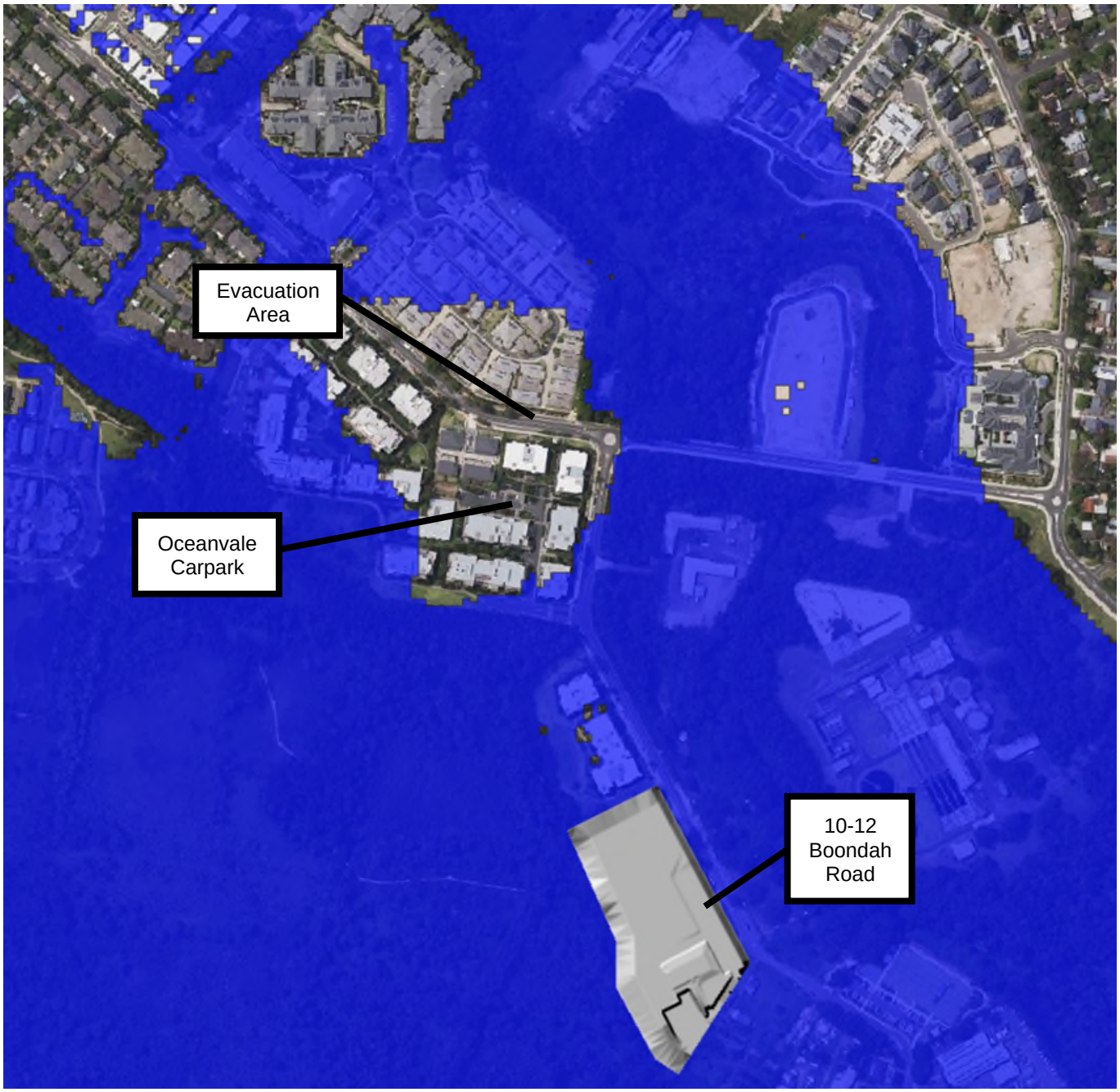

Figure 42 – PMF flood extents for evacuation

There are approximately 26 carparking spaces in the evacuation area on Macpherson Street. As there may be an unknown number of vehicles on site, some vehicles will be required to park within the Ocean vale area by following the rising grade of Firetail Drive. There are 19 marked visitor carparking spaces there, which would allow some people to park there for rest and shelter. Hence there will be sufficient space for any people to move their vehicles out of the floodwater.

Within the section of MacPherson Street that is clear of the flood extents, there is multi storey buildings on the south side and single storey housing on the north. There are walkways within the multi-storey housing that will allow evacuees to get out and have assistance rendered to them. Shelter could be found within the surrounding multi-storey housing for the 13 hours outside the site, if required.

These flood extents presented correspond with the worst-case scenario of an exceedingly rare storm event that allows for climate change effects (900mm sea level rise).

5.6 Discussion Points, Compliance and Recommendations

Further results may be presented for other storm durations, but the results selected above are the critical events for each storm intensity. It has been demonstrated for all events up to the 1% AEP that afflux is within tolerable levels within and without the site. The 25mm afflux occurs as the water is unable to break over Boondah Road in that instance, hence water ponds behind in Narrabeen Creek reserve to the Sydney Water Industrial Area. Calibre recommends that drainage structures in the form of a culvert or pipe be provided to pass water under the road embankment to the wetland or southern boundary, that the afflux may be brought to tolerable levels. Figure 15 indicates that if the raised Boondah Road is removed, then the afflux is brought back to tolerable levels. The proposed pipes or culverts may provide the required storage volume to mimic this.

The PMF velocity does exceed 10% in the flood cut area of the property, but this is not habitable. In the developed scenario, these areas of high percentage increases remain within 0 – 0.5m/s, which is acceptable for most areas. Hence the 10% increase in velocity will not yield any significant damage to that part of the property.

A summary of the conditions to be met and the strategies compliance with them is provided in Table 1.

Table 1 – Compliance Summary Table

Condition	Summary	Compliance
Pittwater LEP (2014) – 5.21 Flood Risk Management	(1) The objectives of this clause are as follows— (a) to minimise the flood risk to life and property associated with the use of land, (b) to allow development on land that is compatible with the flood function and behaviour on the land, taking into account projected changes as a result of climate change, (c) to avoid adverse or cumulative impacts on flood behaviour and the environment, (d) to enable the safe occupation and efficient evacuation of people in the event of a flood plan.	The development is compatible with the flood behaviour of the site and method for the evacuation of people in a safe manor has been documented. The development will have no adverse impacts that will affect the capacity of emergency response facilities.
Pittwater LEP (2014) – 5.22 Special Considerations	(2) This clause applies to— (a) for sensitive and hazardous development—land between the flood planning area and the probable maximum flood, and (b) for development that is not sensitive and hazardous development—land the consent authority considers to be land that, in the event of a flood, may— (i) cause a particular risk to life, and (ii) require the evacuation of people or other safety considerations.	This development is not considered a sensitive and hazardous development under this section. There are no particular risks to life for this site as it will be evacuated prior to any regional flooding occurring within the area.
Pittwater LEP (2014) – 7.3 Flood Planning	(Repealed)	N/A
Pittwater LEP (2014) – 7.4 Flood Risk Management	(Repealed)	N/A
Pittwater 21 DCP (2014) –	**This development sits within the Low and Medium Flood Risk Precinct according to the Flood Information Report and 2019**	

B3.11 Flood Prone Land	**study and is subject to multiple conditions under this clause. The conditions are laid out individually below.**	
	A1 Development shall not be approved unless it can be demonstrated in a Flood Management Report that it has been designed and can be constructed so that in all events up to the 1% AEP event: (a) There are no adverse impacts on flood levels or velocities caused by alterations to the flood conveyance; and (b) There are no adverse impacts on surrounding properties; and (c) It is sited to minimise exposure to flood hazard. Major developments and developments likely to have a significant impact on the PMF flood regime will need to demonstrate that there are no adverse impacts in the Probable Maximum Flood.	The 50% and 20% AEP events do not demonstrate any adverse impacts. The 1% AEP event does demonstrate afflux above the specified threshold, but in an area with no residential dwellings. This afflux can be reduced by the provision of drainage structures, to be further documented and designed at the construction certificate stage. Calibre has done preliminary modelling to confirm that the inclusion of such structures will accomplish this. The PMF event does demonstrate increases of velocity above 10%, but these are in small, discrete areas without residential dwelling, and remain within the 0 – 0.5m/s range, which is acceptable for nearly all material types.
	A2 Development shall not be approved unless it can be demonstrated in a Flood Management Report that in all events up to the 1% AEP event there is no net loss of flood storage. Consideration may be given for exempting the volume of standard piers from flood storage calculations. If Compensatory Works are proposed to balance the loss of flood storage from the development, the Flood Management Report shall include detailed calculations to demonstrate how this is achieved.	N/A – the pre-lodgement notes allow for either no additional adverse flood impact (as provided under A1), or no net decrease in flood storage up to the 1% AEP and PMF event. Calibre is following the former approach.
	B1 All buildings shall be designed and constructed with flood compatible materials in accordance with “Reducing Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas”, Hawkesbury-Nepean Floodplain Management Steering Committee (2006).	The velocities within the development are in the range of 0 – 0.5m/s up to the PMF event, which is acceptable to nearly all material types. Material selection can be detailed at a later stage.
	B2 All new development must be designed and constructed to ensure structural integrity up to the Flood Planning Level, considering the forces of floodwater, wave action, flowing water with debris, buoyancy, and immersion. Where shelter-in-place refuge is required, the structural integrity for the refuge is to be up to the Probable Maximum Flood level. Structural certification shall be provided confirming the above.	The velocities within the development are in the range of 0 – 0.5m/s up to the PMF event, which is acceptable to nearly all material types. Structural design can be detailed at a later stage.
	B3 All new electrical equipment, power points, wiring, fuel lines, sewerage systems or any other service pipes and connections must be waterproofed and/or located above the Flood Planning Level. All existing electrical equipment and power points located below the Flood Planning Level within the subject structure must have residual current	The floor level of any structures will be placed at the FPL. Any electrical equipment below this

devices installed that turn off all electricity supply to the property when flood waters are detected.	point (such as the flood sensors) shall be designed accordingly.
C1 New floor levels within the development shall be at or above the Flood Planning Level.	The floor level of any structures will be placed at the FPL.
C3 All new development must be designed and constructed so as not to impede the floodway or flood conveyance on the site, as well as ensuring no net loss of flood storage in all events up to the 1% AEP event. For suspended pier/pile footings: (a) The underfloor area of the dwelling below the 1% AEP flood level is to be designed and constructed to allow clear passage of floodwaters, considering the potential for small openings to block; and (b) At least 50% of the perimeter of the underfloor area is of an open design from the natural ground level up to the 1% AEP flood level; and (c) No solid areas of the perimeter of the underfloor area would be permitted in a floodway	Flood modelling has demonstrated that the area within the property boundary does not act as a floodway, due to the ponding nature of the storms based on the 2013 flood model. The EEC area within the property boundaries will be left alone, which will allow major storm events (up to the 1% AEP at ten hours), to flow as per existing conditions. There are no proposed pier/pile footings.
C4 A one-off addition or alteration below the Flood Planning Level of less than 30 square metres (in total, including walls) may be considered only where: (a) it is an extension to an existing room; and (b) the Flood Planning Level is incompatible with the floor levels of the existing room; and (c) out of the 30 square metres, not more than 10 square metres is below the 1% AEP flood level. This control will not be permitted if this provision has previously been utilised since the making of this Plan. The structure must be floodproofed to the Flood Planning Level, and the Flood Management Report must demonstrate that there is no net loss of flood storage in all events up to the 1% AEP event.	No such additions or alterations are proposed.
C6 Consideration may be given to the retention of an existing floor level below the Flood Planning Level when undertaking a first-floor addition provided that: (a) it is not located within a floodway; and (b) the original foundations are sufficient to support the proposed final structure above them. The Flood Management Report must include photos and the structural certification required as per Control B2 must consider whether the existing foundations are adequate or should be replaced; and (c) none of the structural supports/framing of existing external walls of are to be removed unless the building is to be extended in that location; and (d) the ground floor is floodproofed.	There are no existing floor levels below the FPL.
D1 Open carpark areas and carports shall not be located within a floodway.	There are no carpark spaces provided within flood ways.

D2 The lowest floor level of open carparks and carports shall be constructed no lower than the natural ground levels unless it can be shown that the carpark or carport is free draining with a grade greater than 1% and that flood depths are not increased.	The open carpark is free draining. This carpark caters for visitors only.
D3 Carports must be of open design, with at least 2 sides completely open such that flow is not obstructed up to the 1% AEP flood level. Otherwise, it will be enclosed. When undertaking a like-for-like replacement and the existing garage/carport is located on the street boundary and ramping is infeasible, consideration may be given for dry floodproofing up to the 1% AEP flood level.	There are no carports proposed for this development.
D4 Where there is more than 300mm depth of flooding in a car park or carport during a 1% AEP flood event, vehicle barriers or restraints are to be provided to prevent floating vehicles leaving the site. Protection must be provided for all events up to the 1% AEP flood event	The carpark does not have flooding greater than 300mm in the 1% event.
D5 Enclosed Garages must be located at or above the 1% AEP level	There are no enclosed garages proposed for this development.
D6 All enclosed car parks (including basement carparks) must be protected from inundation up to the Flood Planning Level. All access, ventilation, driveway crests and any other potential water entry points to any enclosed car parking shall be above the Flood Planning Level. Where a driveway is required to be raised it must be demonstrated that there is no net loss to available flood storage in any event up to the 1% AEP flood event and no impact on flood conveyance through the site. Council will not accept any options that rely on electrical, mechanical, or manual exclusion of the floodwaters from entering the enclosed carpark	There are no enclosed carparks proposed for this development.
E1 If the property is affected by a Flood Life Hazard Category of H3 or higher, then Control E1 applies, and a Flood Emergency Assessment must be included in the Flood Management Report. If the property is affected by a Flood Life Hazard Category of H6, then development is not permitted unless it can be demonstrated to the satisfaction of the consent authority that the risk level on the property is or can be reduced to a level below H6 or its equivalent. If the property is flood affected but the Flood Life Hazard Category has not been mapped by Council, then calculations for its determination must be shown in the Flood Management Report, in accordance with the “Technical Flood Risk Management Guideline: Flood Hazard”, Australian Institute for Disaster Resilience (2012). Where flood-free evacuation above the Probable Maximum Flood level is not possible, new development must provide a shelter-in-place refuge where: a) The floor level is at or above the Probable Maximum Flood level; and b) The floor space provides at least $2m^2$ per person where the flood duration is long (6 or more hours) in the Probable Maximum Flood event, or $1m^2$ per person for less than 6 hours;	The development is affected by a Flood Life Hazard Category H3. The flood evacuation strategy has been provided in this report, which provides for a route.

	c) It is intrinsically accessible to all people on the site, plainly evident, and self-directing, with sufficient capacity of access routes for all occupants without reliance on an elevator; and d) It must contain as a minimum: sufficient clean water for all occupants; portable radio with spare batteries; torch with spare batteries; and a first aid kit. Class 10 classified buildings and structures (as defined in the Building Codes of Australia) are excluded from this control. In the case of change of use or internal alterations to an existing building, a variation to this control may be considered if justified appropriately by a suitably qualified professional. Note that in the event of a flood, occupants would be required to evacuate if ordered by Emergency Services personnel regardless of the availability of a shelter-in-place refuge.	
	F1 Fencing, (including pool fencing, boundary fencing, balcony balustrades and accessway balustrades) shall be designed so as not to impede the flow of flood waters and not to increase flood affectation on surrounding land. At least 50% of the fence must be of an open design from the natural ground level up to the 1% AEP flood level. Less than 50% of the perimeter fence would be permitted to be solid. Openings should be a minimum of 75 mm x 75mm.	Future fencing on this site shall be designed to comply with this requirement.
	G1 Hazardous or potentially polluting materials shall not be stored below the Flood Planning Level unless adequately protected from floodwaters in accordance with industry standards.	Hazardous materials shall be located outside of the flood planning
	H1 Pools located within the 1% AEP flood extent are to be in-ground, with coping flush with natural ground level. Where it is not possible to have pool coping flush with natural ground level, it must be demonstrated that the development will result in no net loss of flood storage and no impact on flood conveyance on or from the site. All electrical equipment associated with the pool (including pool pumps) is to be waterproofed and/or located at or above the Flood Planning Level. All chemicals associated with the pool are to be stored at or above the Flood Planning Level.	There are no pools proposed for this development.
Pittwater 21 DCP (2014) – B3.12 Climate Change	For land identified within the Warriewood Valley Land Release Area involving development to which this control applies, a climate change assessment shall be incorporated in the Water Management Report as required by Clause C6.4 Flood - Warriewood Valley Residential Sectors, Buffer Areas or Development Sites, Clause C6.5 Flood - Warriewood Valley Employment Generating Sectors, Buffer Areas or Development Sites and in accordance with Council's Warriewood Valley Urban Land Release Water Management Specification (February 2001 or as amended). The climate change assessment shall include the impacts of climate change on the property over the life of the development and the adaptive measures to be incorporated in the design of the project. The following climate change scenarios shall be considered: Scenario 1: Impacts of sea level rise only	Calibre has modelled Scenario 2 only, as that presents the worst-case events regarding the effects of climate change on the flood extents. Modelling Scenario 1 will present flood extents smaller than Scenario 2, which will not be helpful in determining what measures need to be applied to the development.

	Scenario 2: Impacts of sea level rise combined with increased rainfall volume	
Water Management Spec	**Flood Planning Levels**	
	- 50%AEP flow to be carried in-bank	There are no 50% AEP flows across the development; they remain within the wetlands and creek extents.
	- The level of walkways and cycleways adjacent to the creeks are to be above the 20%AEP flood level except under special circumstances (and exposed for only short duration's) - Water quality control ponds, filter strips and structures are to be above the 20%AEP flood level and can be below the 1%AEP flood level but must lie within the private buffer area as outlined in Section 4.3.2.	The lower areas of the development will be set at the 20% AEP flood level. Placement of water quality control structures to be confirmed at a later stage upon confirmation of the regional strategy.
	- 1%AEP flows are to be carried within the public space corridors, and are to be further designed such that floodplain management and hazard management guidelines are accommodated to minimise risk to life - Flood extent to be mapped - Floor levels for properties adjacent to the creek are to be set at least 0.5 m above the 1%AEP level - Obverts of bridge decks of evacuation routes are to be set at least 0.5 m above the 1%AEP level	1% AEP flows will pass over the lower areas accessible to the public. The main area of the site will remain outside the 1% AEP. The flood extents have been mapped. The floor levels for the development have been set 0.5m above the 1% AEP with climate change. There are no bridge decks proposed for this development.
	PMF - Evacuation Planning - Flood hazards and risk to life - Flood extent to be mapped	The PMF flood extent and behaviour has been used to set the evacuation point, warning times and mechanisms, period of isolation and risk to life.

6. Conclusion

Calibre has prepared this Water Management Report to inform the development application proposal for the site at 10-12 Boondah Road, Warriewood. The investigations into the flooding resulting from the proposed earthworks indicates that council's requirements regarding flood controls have been met for all scenarios, except for:

- afflux for the 1% AEP 1440min storm which will peak at 25mm (5mm above the accepted increase). The 25mm peak will occur in a non-residential area (a mix of industrial and drainage reserve), thus no dwellings will be affected. This afflux may be reduced to tolerable levels by providing pipes or culverts under the raised Boondah Road embankment, which will allow water to drain to the wetlands on the western boundary. These pipes or culverts may provide additional storage volume to compensate.
- the PMF storm increase in velocities which will exceed 10%. These increases over 10% are purposefully introduced due to the earthwork's cuts proposed along the western boundary of the property, to provide the walkways, cycleways, play areas and regions of flood storage. These increases are also isolated to this earthwork cut, where no residences are proposed. Calibre's modelling of the development has also shown that the resulting velocities in that area remain between 0 – 0.5m/s, which is acceptable for most materials and hence

will not produce significant damage in that area. The PMF storm is also an exceedingly rare storm event, and hence highly unlikely to occur.

Calibre has provided suggestions of water quality and quantity measures which may suit the landscape plan layout and land use. These options may be further documented and designed at the construction certificate stage. The objective to preserve as much of the natural ecology as possible has been adhered to in this landscape plan design.

Appendix A No. 10 Flood Information Report

Appendix B No. 12 Flood Information Report

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