

Flood Impact Assessment

Seniors Living Development

59915160



Prepared for
Waterbrook Bayview Pty Ltd

15 June 2019

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1 Background

Cardno (NSW/ACT) Pty Ltd (Cardno) was engaged by Waterbrook Bayview Pty Ltd to prepare flood impact assessments of the proposed Bayview Golf Course works and of the proposed seniors living development on an elevated portion of the existing Bayview Golf Course (Lot 1 DP 66920, Cabbage Tree Road, Bayview).

This Flood Impact Assessment has been prepared in support of an application for a Site Compatibility Certificate (SCC) for the Seniors Living Development which is described in Section 1.1 below.

1.1 Subject Site

Bayview Golf Course is an 18-hole course covering an area of 39.6 ha located in the suburb of Bayview in part of the Northern Beaches Local Government Area (LGA) that was formerly Pittwater LGA. The golf course is bounded on three sides by Pittwater Road to the east, Parkland Road to the south-west, and Cabbage Tree Road to the north. Cabbage Tree Road transects the golf course with four holes located in a parcel of land north of Cabbage Tree Road to the north-west.

The golf course is mostly surrounded by residential development, with Pittwater High School located on the eastern side of Pittwater Road. To the north-west of the golf course is mostly bushland in the elevated ridgelines of Bayview.

A 2 ha portion of the north-west parcel of the golf course (north of Cabbage Tree Road) is the subject of a proposal seniors living development by Waterbrook Bayview Pty Ltd. The location of the site within the Bayview Golf Course is shown in **Figure 1-1**.



Figure 1-1 – Location of Subject Site and Seniors Living Development (Source: Bing Aerial, 2015)

Works proposed as part of the Seniors Living Development are:

- Site preparation works;
- Provision of vehicular access to the development;
- Construction and occupation of seven (7) separate buildings of predominantly 3-4 storeys in height for the purposes of self-care dwellings with ancillary services and facilities;
- Basement level car parking;
- Associated landscaping and public domain improvements; and
- Extension and augmentation of physical infrastructure utilities as required.

The Seniors Living Development site is located in the centre of the north-west parcel of land for the Golf Course, at the existing location of Hole 4 and Hole 5. It is proposed to locate the new development along an existing ridgeline at a higher elevation than the low-lying portion of the golf course located on the southern side of Cabbage Tree Road. Levels across this portion of the site range from RL 5 to 27 m AHD, while the majority of the golf course lies below RL 2 m AHD.

1.2 Previous Submission for Site Compatibility Certificate Assessment (2014)

Waterbrook Bayview Pty Ltd submitted a Site Compatibility Certificate application on 11 August 2014 to the NSW Department of Planning and Environment (DPE). Subsequently DPE requested additional information relating to flora, fauna and flooding, which was provided on 16 September 2014.

A *Pre-Development Flood Assessment* was prepared for the proposed concept at the time (Martens Consulting Pty Ltd, August 2014) as part of the previous Site Compatibility Certificate Application submitted to the DPE.

The conclusions from the flood study assessment were:

- The site is not flood affected in the 1% Annual Exceedance Probability (AEP) event.
- The peak flood level in the Probable Maximum Flood (PMF) event for the site is RL 12.4m AHD.
- The site is partially affected by Category 3 – Overland Flow Path – Major.
- The site is subject to flood-related development controls as outlined within Section B3.22 of Pittwater Development Control Plan (DCP) 21.
- This requires the preparation of a Flood Risk Management Report to support any development application in accordance with Appendix 8 of the Pittwater DCP 21.
- As the development results in an “intensification of development” the site is also subject to Section B3.23 of Pittwater DCP 21, meaning that development must consider climate change impacts on flood behaviour.
- A flood emergency response of “shelter-in-place” is recommended for the site as opposed to flood evacuation. Although the Flooding Report prepared by Cardno in November 2015 had a section which discusses Flood Emergency Response, which is also included in this report, the discussion states that the site does not enquire any consideration of emergency response.

1.3 Determination for Initial Site Compatibility Certificate Assessment (2015)

The determination of the DPE assessment was noted within the “Recommendation for refusal statement and report to the Secretary regarding the Site Compatibility Statement Application under the SEPP SLHPD Bayview Golf Course”, Department of Planning & Environment File 14/14939, dated 5 January 2015. The DPE assessment recommended that the application should be refused for the following reasons:

1. The proposed height, scale and built form is inconsistent with the existing surrounding character of the area, which is predominantly two storey single detached housing in a heavily landscaped environment;
2. ***The site is classified as flood prone land and insufficient evidence has been provided to demonstrate development potential or to ensure there would be no adverse impact on surrounding land uses; and,***
3. The proposal would have significant environmental implications for existing threatened flora and fauna and the adjacent wildlife corridor. Limited evidence or consideration has been provided to address the potential direct and indirect impacts of development or mitigation measures.

The DPE referred the application to the former Pittwater Council as the site lies within the former Pittwater LGA. Council's advice on the application was contained in a letter sent to the DPE on 10 September 2014. Council objected to the development for the following reasons relevant to flooding (other objections were cited but they are not relevant to this study):

1. The applicants response to a PMF event is inconsistent with State Emergency Services policies that require access to be maintained to a seniors housing development at all times;
2. Lack of information outlining the flood evacuation strategy, structural integrity of the proposed buildings, and PMF / 1% AEP and climate change overland flowpaths through the site.

1.4 Revised Site Compatibility Certificate Application (2016)

Following this initial refusal, Cardno was engaged by Waterbrook to revise the development proposal in response to the reasons for refusal from the previous submission.

In response to the DPE's comment relating to environmental considerations and flora and fauna (Point 3 above), amendments to the lower golf course (south of Cabbage Tree Road) were proposed to recreate a more natural creek line through the golf course, with natural estuarine vegetation to line the creek, allowing for an improved fauna passage through the golf course. These proposed rehabilitation works were proposed to offset any tree removal works proposed within the seniors housing site.

These rehabilitation works would result in a significant change in landform in the floodplain. Detailed hydraulic modelling was undertaken of the creek rehabilitation works to assess the potential flood impacts of the works. This hydraulic modelling addressed DPE's concern that there was insufficient evidence to ensure there would be no adverse floodway impact on surrounding land uses from the proposed seniors housing development and golf course upgrades (Point 2 above).

Subsequent to the receipt of responses from Pittwater Council and the DPE on the 2016 Site Compatibility Certificate Application, Pittwater Council adopted the *Flood Emergency Response Planning for Development in Pittwater Policy (2015)*.

The policy was supported by a reference document titled *Pittwater LGA Flood Risk to Life Classification Study* (Cardno, 2015). It identifies development controls for all new development in the floodplain, and has been adopted and included in Section B3.25 of the DCP and in Appendix 15 of the DCP.

Pittwater Council's two comments related to flood emergency response provisions. Consequently the flood emergency response requirements of the proposed development were assessed in accordance with the details set out in the adopted policy for the revised site compatibility certificate application (2016).

1.5 Document Structure

This flood impact assessment, prepared in support of the proposed works described in Section 1.1, includes:

- A review of the existing flood affectation (**Section 2**);
- A flood impact assessment for the proposed Seniors Living Development (**Section 3**) and two addenda (**Section 4**);
- An assessment of flood risk for the proposed Seniors Living Development (**Section 5**); and
- A discussion of flood emergency response (**Section 6**).

2 Existing Conditions

2.1 2017 Flood Study

The relevant flood study for the site is the *Mona Vale, Bayview, and McCarrs Creek Flood Study Review*, prepared by Royal HaskoningDHV. Northern Beaches Council adopted this flood study in July 2017.

Figure 2-1 shows the Flood Planning Area (1% AEP flood level plus 500mm freeboard) from the *Mona Vale, Bayview, and McCarrs Creek Flood Study Review* (Royal HaskoningDHV, 2017). As can be observed, the majority of the low-lying portion of the Bayview Golf Course is inundated by mainstream flooding in the 1% AEP event. The PMF extents from the *Mona Vale, Bayview, and McCarrs Creek Flood Study Review* are shown in **Figure 2-2**. These Figures show that the seniors living site is impacted by minor overland flooding at the southeast corner of the site.

Six climate change scenarios were assessed by Royal HaskoningDHV in 2017. These scenarios are listed as follows:

Scenario	Rainfall	Tailwater
1	1% AEP Event + 10% Rainfall (simulated as 0.5% AEP Rainfall)	Current Conditions
2	1% AEP Event + 30% Rainfall (simulated as 0.2% AEP Rainfall)	Current Conditions
3	1% AEP Event	2050 Conditions
4	1% AEP Event	2100 Conditions
5	1% AEP Event + 30% Rainfall	2100 Conditions
6	PMF Event + 30% Rainfall	2100 Conditions

2.2 Update of 2017 Flood Model

The works proposed in the Bayview Golf Course to the south of Cabbage Tree Road require detailed hydraulic modelling to assess any flood impacts.

The existing flood model developed by Royal HaskoningDHV for the *Mona Vale, Bayview, and McCarrs Creek Flood Study Review* has been updated as part this assessment. While the overall model has been based on LiDAR data, the levels on the subject site were updated based on a detailed ground survey undertaken by Grinsell and Johns Pty Ltd (02/10/15, Drawing 9-01-15) which is provided in **Appendix A**.

Detail Survey of the Seniors Living development site and Cabbage Tree Road prepared by Bee and Lethbridge (Aug 2017, Drawing 18990a) is provided in **Appendix B**.

The ground survey was added to the existing model's Digital Elevation Model (DEM) which was a 1.5 m x 1.5 m grid based on LiDAR data.

The Mona Vale Road upgrade works were also represented in the model.

The updated model was re-run to establish benchmark flood levels under Existing Conditions. The climate change Scenario applied for this model is Scenario 5 based on the adopted scenario by the Northern Beaches Council. Plots of the water level and depth, velocity and provisional flood hazard in the 1% AEP, Scenario 5 and the PMF events under Existing Conditions are given in **Figures C1 to C10** in **Appendix C**.

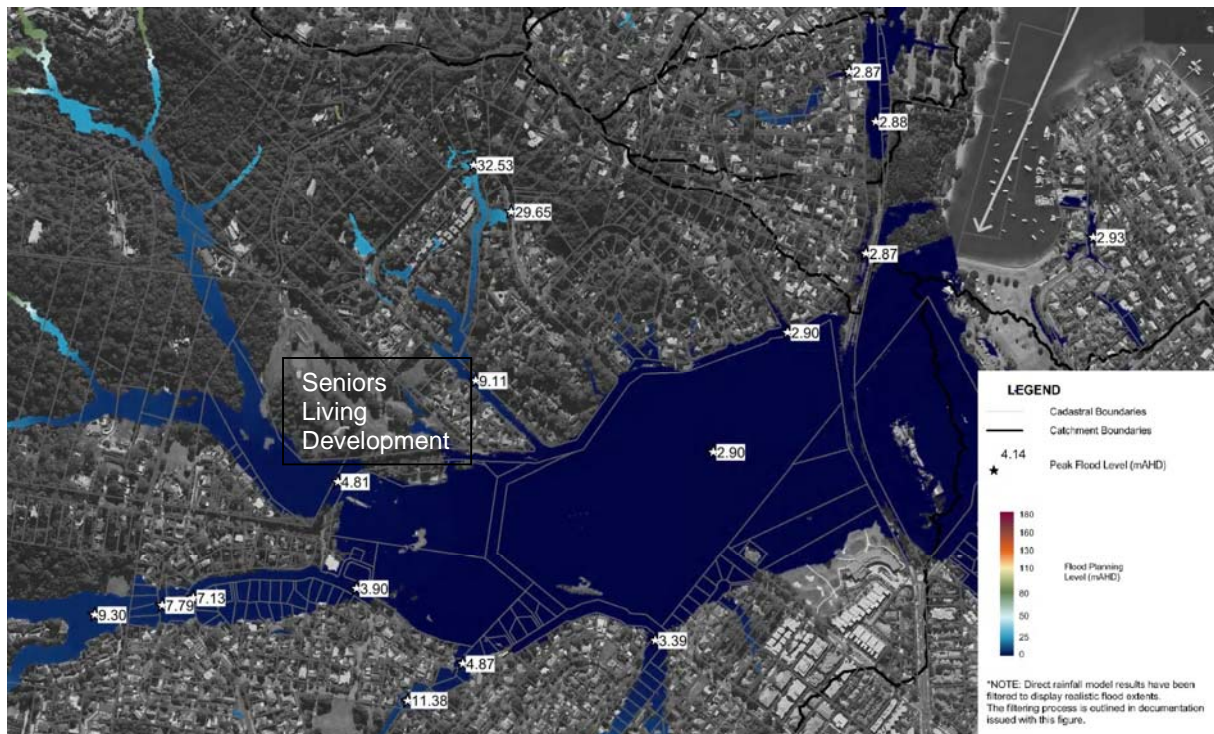


Figure 2-1 Flood Planning Area Map for the Seniors Living Development Site (Royal HaskoningDHV, 2017)

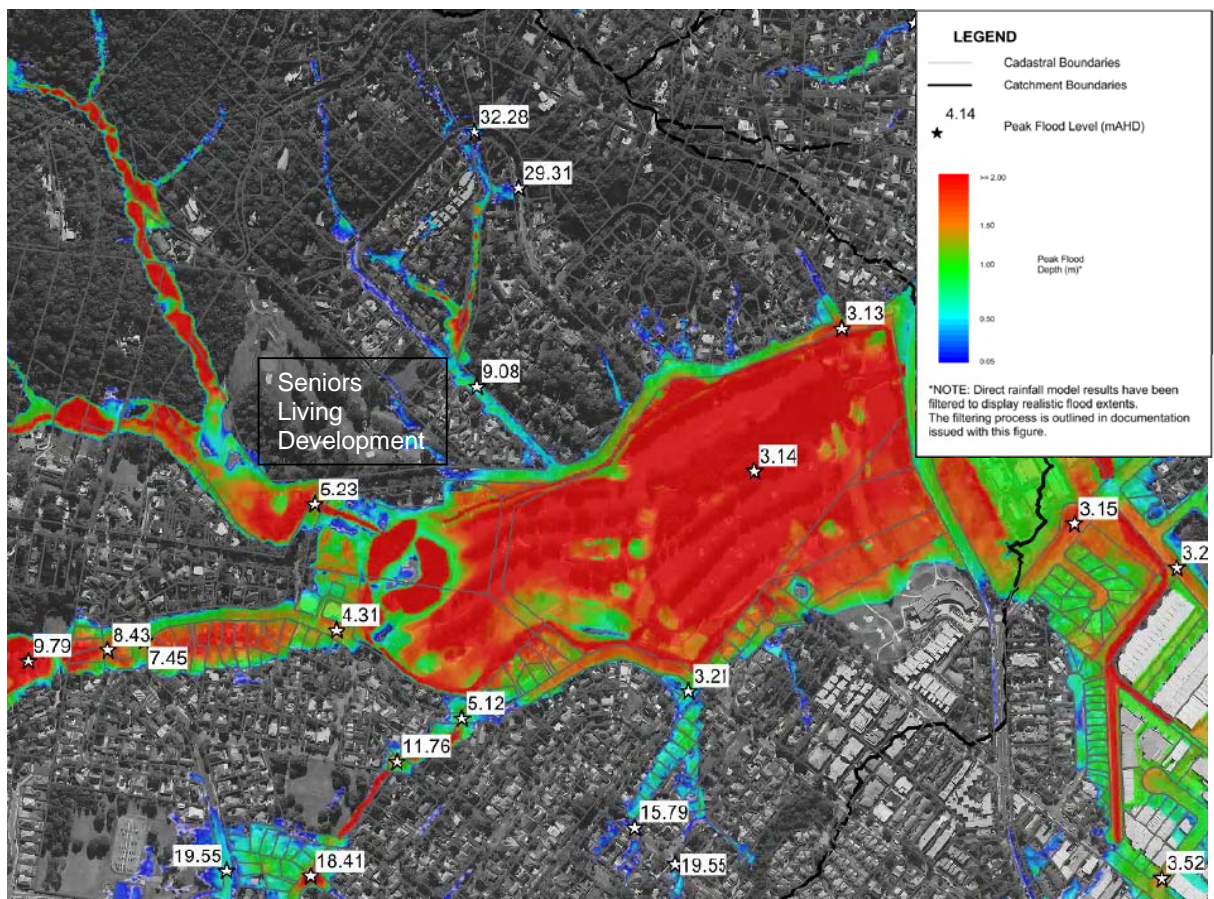


Figure 2-2 PMF Flood Levels for the Seniors Living Site (Royal HaskoningDHV, 2017)

3 Flood Impact Assessment

Works proposed as part of the Seniors Living Development include:

- Site preparation works;
- Provision of vehicular access to the development;
- Construction and occupation of seven (7) separate buildings of predominantly 3-4 storeys in height for the purposes of self-care dwellings with ancillary services and facilities;
- Basement level car parking;
- Associated landscaping and public domain improvements; and
- Extension and augmentation of physical infrastructure utilities as required.

While the Seniors Living Development lies on land free of flooding, a flood assessment has been carried out of the overland flowpath at the east of the site. The objective of the modelling was to confirm that the Seniors Living Development works could be undertaken to offer the improvements outlined above without having any adverse impacts.

3.1 Flood Impact Requirements

As per the DCP for Flood Prone Land, the following maximum flood impacts from development are considered allowable outside the Seniors Living Development site:

- Less than 0.02 m water level increase for the 1% Annual Exceedance Probability (AEP) event;
- Less than 0.05 m water level increase for the Probable Maximum Flood event; and
- Less than 10% increase in velocities for the PMF event.

Iterative modelling was undertaken to identify a Seniors Living Development configuration that best satisfied the DCP requirements.

3.2 Future Conditions

The existing floodplain model was updated to include the following proposed measures to be implemented as part of the Seniors Living development:

- Constructing a trapezoidal channel at the eastern side of the site to convey the overland flows into twin 750 mm circular pipes to convey the majority of the flow to a location upstream of the existing pipe under Cabbage Tree Road;
- Channel side slopes of 1V : 3H, with a base width of 3 m;
- Installation of 2 x 1.5 m (W) and 0.45 (H) culverts under the driveway in order to control and mitigate runoff from the proposed driveway; and
- Upgrade the existing pipe under Cabbage Tree Road to increase its capacity to locally lower flood levels and reduce flooding impacts at the southeast end corner of the site on Cabbage Tree Road.

The drainage works are detailed in Revision F of the following civil drawings prepared by Marchese Partners and dated 24 August 2018 as follows:

- DA-C-201 CIVIL WORKS CABBAGE TREE ROAD STORMWATER LAYOUT PLAN
- DA-C-202 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL PLAN
- DA-C-221 CIVIL WORKS CABBAGE TREE ROAD STORMWATER LONG SECTION

- DA-C-222 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 1
- DA-C-223 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 2

A comparison of the existing and proposed surface levels is presented in **Figure C24** in **Appendix C**.

3.3 Flood Events

As outlined in Section 3.1, the flood impact requirements necessitated the modelling of the 1% AEP and PMF events to confirm no adverse off-site flood impacts.

The 2017 Flood Study adopted a conservative combination of rainfall and receiving water levels ("tailwater" levels). Tailwater levels in the Pittwater Estuary were adopted using design storm surge events of the same probability as the corresponding design rainfall event, i.e the 1% AEP rainfall event was combined with the 1% AEP storm surge level. Due to the proximity of the Bayview Golf Course to the Pittwater Estuary to the north, the impacts of storm surge on flooding in the golf course are significant.

A summary of the design events which were modelled is included in **Table 3-1**. These events were modelled under both Existing and Future Conditions. For the Seniors Living Development, the critical storm burst duration for the 1% AEP event is 2 hours, while the 15 minute hour storm is critical in the PMF.

Table 3-1 Seniors Living Development Modelled Design Events

Design Event	Storm Burst Duration	Adopted Tailwater Level
1% AEP	2 hour	RL 1.49 m AHD (1% storm surge)
1% AEP with Climate Change	2 hour	RL 1.49 m AHD (1% storm surge)
PMF	15 mins	RL 1.75 m AHD (An extreme storm surge)

3.4 Filtering Criteria

When the adopted modelling approach is "rainfall on grid" then map filtering is a required component to produce realistic flood extents. The criteria given in **Figure 3-1** have been applied to the mapping of results for events up to the 1% AEP event and the criteria given in **Figure 3-2** for events greater than the 1% AEP Event.

Filtering Criteria	Justification
Depth $\geq 0.15\text{m}$	Depths above 0.15m are considered significant and contribute to the flood extent. Depths below 0.15m are only considered significant where flood waters have an associated significant velocity (refer below).
Depth below 0.15m with a velocity depth product $> 0.3\text{m}^2/\text{s}$	Includes significant flowpaths under 0.15m of depth in the mapping.
Depth below 0.15m with a velocity depth product between $0.025\text{m}^2/\text{s}$ and $0.3\text{m}^2/\text{s}$	These areas are considered local stormwater and were removed from the flood study mapping. The local stormwater extents were provided to Council for management through the stormwater clause of the DCP.
"Puddles" less than 100m^2 removed from the flood extents	Excludes insignificant "puddles" from direct rain model results.

Figure 3-1 Filtering Criteria up to the 1% AEP Event (after RoyalHaskoningDHV, 2017)

Filtering Criteria	Justification
Depth $\geq 0.15\text{m}$	Depths above 0.15m are considered significant and contribute to the flood extent.
"Puddles" less than 200m^2 removed from the flood extents	Excludes insignificant "puddles" from direct rain model results.

Figure 3-2 Filtering Criteria for events greater than the 1% AEP Event
(after RoyalHaskoningDHV,2017)

3.5 Results

Plots of the water level and depth, velocity and provisional flood hazard in the 1% AEP, 1 % AEP with Climate Change (Scenario 5) and the PMF events under Existing Conditions and Future Conditions are given in the Figures listed in **Table 3-2** below and attached in **Appendix C**.

Table 3-2 Seniors Living Development - Model Results Figure List for Appendix C

Figure	Title	Event	Type
C1	Existing Conditions (Seniors Living Site)	1% AEP 2h Duration	Depth and Water Level
C2	Existing Conditions (Seniors Living Site)	1% AEP 2h Duration	Velocity
C3	Existing Conditions (Seniors Living Site)	1% AEP 2h Duration	Hazard
C4	Existing Conditions (Seniors Living Site)	1% AEP 2h Duration	Floodway
C5	Existing Conditions (Seniors Living Site)	1% AEP+CC 2h Duration	Depth and Water Level
C6	Existing Conditions (Seniors Living Site)	1% AEP+CC 2h Duration	Velocity
C7	Existing Conditions (Seniors Living Site)	1% AEP+CC 2h Duration	Hazard
C8	Existing Conditions (Seniors Living Site)	PMF 15min Duration	Depth and Water Level
C9	Existing Conditions (Seniors Living Site)	PMF 15min Duration	Velocity
C10	Existing Conditions (Seniors Living Site)	PMF 15min Duration	Hazard
C11	Future Conditions (Seniors Living Site)	1% AEP 2h Duration	Depth and Water Level
C12	Future Conditions (Seniors Living Site)	1% AEP 2h Duration	Velocity
C13	Future Conditions (Seniors Living Site)	1% AEP 2h Duration	Hazard
C14	Future Conditions (Seniors Living Site)	1% AEP 2h Duration	Floodway
C15	Future Conditions (Seniors Living Site)	1% AEP+CC 2h Duration	Depth and Water Level
C16	Future Conditions (Seniors Living Site)	1% AEP+CC 2h Duration	Velocity

C17	Future Conditions (Seniors Living Site)	1% AEP+CC 2h Duration	Hazard
C18	Future Conditions (Seniors Living Site)	PMF 15min Duration	Depth and Water Level
C19	Future Conditions (Seniors Living Site)	PMF 15min Duration	Velocity
C20	Future Conditions (Seniors Living Site)	PMF 15min Duration	Hazard
C21	Future Less Existing Conditions (Seniors Living Site)	1 % AEP 2h Duration	Flood Level Differences
C22	Future Less Existing Conditions (Seniors Living Site)	PMF 15min Duration	Flood Level Differences
C23	Future Less Existing Conditions (Seniors Living Site)	1 % AEP 2h Duration	Velocity Differences
C24	Future Less Existing Conditions (Seniors Living Site)	PMF 15min Duration	Velocity Differences
C25	Future Less Existing Conditions (Seniors Living Site)	-	Terrain Differences

3.5.1 Peak Water Levels and Depths (Future Conditions)

The Seniors Living Development lies generally on flood free land, therefore the width and depth of flooding on the Seniors Living Development is not extensive. The peak water level and depth results under Future Conditions are presented in **Figures C11, C15 and C18**. The extent of Floodways which were mapped based on criteria adopted by Council is presented in **Figures C4 and C14**. The plots show the following:

- There is no flooding on the driveway in 1%AEP event or the PMF under Future Conditions;
- There is no flooding on Cabbage Tree Road in the vicinity of the entry in 1%AEP event under Future Conditions;
- Under Existing Conditions in a 1% AEP flood a floodway is mapped at the eastern edge of the subject site; and
- The proposed channel and twin pipes will convey the 1% AEP flow through the site such that the Floodway is no longer present on the site under Future Conditions.

3.5.2 Peak Velocities (Future Conditions)

The peak flood velocities which are plotted in **Figures C12, C16 and C19** disclose the following:

- In the 1% AEP event and PMF there is no flooding within the subject site;
- There is no flooding on Cabbage Tree Road in the vicinity of the entry in 1%AEP event under Future Conditions;
- Under Future Conditions Cabbage Tree Road is affected in the PMF with velocities not exceeding 1.0 m/s.

3.5.3 Flood Level Impacts

The impacts of the proposed works on flood levels are mapped in **Figures C21 and C22**. These plots disclose that:

- The proposed channel and drainage works will convey the 1% AEP flow through the site such that the flood level decreases by up to 2.0 m on the eastern side of the subject site;
- There are no adverse off-site impacts in the 1% AEP and the PMF events with reduced flood levels on Cabbage Tree Road in the vicinity of the driveway entry.

3.5.4 Velocity Impacts

The impacts of the proposed works on flood velocities are mapped in **Figures C23** and **C24**. These plots map the changes in flood velocities as a percentage of the velocities under Existing Conditions.

While **Figure C23** discloses small scattered areas of local increase in the 1% AEP velocity located within the site and locally on Cabbage Tree Road the greatest impacts are located within the golf course in the vicinity of the outfall of the proposed new drainage line (refer Drawing DA-C-201 Rev F).

Figure C24 likewise discloses small scattered areas of local increase in the PMF velocity located within the site, adjacent to Cabbage Tree Road and scattered within the golf course.

It is concluded that the off-site impacts on velocity in the 1% AEP and PMF events are not significant as they are small areas and mostly located on road reserve or the golf course and do not impact on surrounding private land. It is therefore concluded that Council's requirement relating to velocity impacts is satisfied.

4 Flood Impact Assessment Addenda

4.1 FIA Addendum – November 2018

On 19 December 2017, Waterbrook Bayview Pty Ltd lodged Development Application DA2017/1274 with Northern Beaches Council ("Council"). The amended DA sought consent for:

- (i) **Golf Course Upgrade**
The works involve significant regrading and reconfiguration of the 18-hole golf course and flood mitigation works, including raising sections of the golf course. The development also includes revegetation, providing new pathways, and the construction of a new maintenance shed for the storing of maintenance equipment to replace the existing shed.
- (ii) **Senior's Housing**
The proposal involves construction of seniors housing development to be located on the northern half of the golf course (being north-west of Cabbage Tree Road) comprising 85 'serviced self care housing' dwellings spread across seven separate buildings and associated landscaping works. The development also includes the construction of a new internal road to provide access into the proposed seniors housing development from Cabbage Tree Road, a round-about on Cabbage Tree Road (and associated pedestrian crossing), and construction of an access pathway from the site through to the bus stop on the eastern side of Annam Road

On 14 November 2018 a Statement of Facts and Contentions was lodged by Northern Beaches Council in relation to NSW Land and Environment Court Proceedings No. 2018/257108.

One of the contentions that the application must/ought be refused was flood impact on the basis that the flood study report was of insufficient detail to inform an assessment of flooding impacts and flood management.

The particulars of Council's contention are reproduced in **Appendix D**. Additional information that responded to each of the particulars was prepared and is included in **Appendix D**.

4.2 FIA Addendum – January 2019

In January 2019, an amended statement of facts and contentions identified a remaining flood impact issue 12a. This issue was stated as: *The flood study has not defined the overland flood risk associated with runoff from the golf course, through the development, particularly when local channels are surcharged (possibly after considering blockage). The development could redirect distributed overland flows with potential impact on Cabbage Tree Road or offsite. In addition, Block A and B could be at risk from surcharged overflow associated with the eastern drainage channel. Elaboration is required.*

It was identified that the primary driver of this concern was the presence of ponding water on the development site flood maps prepared, particularly near Block A and B. The presence of ponding within these locations was due to the method in which buildings were modelled within the assessment and the absence of civil design surfaces to represent the future landform around the building. As such, the issue was deemed to be primarily a modelling artefact rather than a design issue.

To confirm this, a revision of the model was undertaken to block buildings A, B and C in a consistent manner within the flood model. This prevents an artificial build-up of overland flow around Block A, resulting in the removal of the overland flow issue. The two plots attached in **Appendix E** confirmed the changes and the removal of the impacts.

It was further noted that the hydraulic model does not currently represent the proposed civil landform that will ultimately be present onsite. Future civil design works should ensure that the overall design adequately drains runoff within the site and does not result in unmanaged areas of ponding or flood depths in excess of 150 mm.

5 Flood Risk Assessment for Seniors Living Development

5.1 Flood Related Development Controls

The Northern Beaches Flood Prone Land Policy 2017 outlines flood controls that apply to developments on flood prone land. The controls are based on both the development type and flood risk precinct.

Seniors Living Development located on 52 Cabbage Tree Road, is classified as both affected by Mainstream (Category 1) and Overland Flow (Major) (Category 3) flooding.

The development controls defined in Section 3.23 of the Pittwater DCP 21 also do not require consideration of PMF overland flow flooding.

5.1.1 Definitions

Definitions of some of the terms which are used in the following sections as defined in Pittwater 21 DCP 2015 (Amendment 19) are listed below:

- **Flood Planning Levels (FPL)** has the same meaning as provided in the Manly LEP 2013, Warringah LEP 2011 and Pittwater LEP 2014. A reduced freeboard will be considered on its merits for properties impacted by peak flood depths less than 0.3 m and velocity depths less than 0.3 m²/s. The reduced freeboard must be appropriately justified in a Flood Management Report prepared by a suitably qualified professional.
- **Probable Maximum Flood (PMF)** is the largest flood that could conceivably occur at a particular location, usually estimated from the probable maximum precipitation.
- **Flood Hazard** is a term used to determine the safety of people and property and is based on a combination of flood depth (above ground level) and flood velocity experienced during a flood. Flood Hazard is classified as either Low Hazard or High Hazard. In High Hazard areas, there is a possible danger to personal safety, able-bodied adults would have difficulty wading and there is the potential for significant structural damage to buildings. In Low Hazard areas, able-bodied adults would have little difficulty wading and nuisance damage to some structures would be possible.
- **Flood Risk Precinct (FRP)** refers to the division of the floodplain on the basis of the level of expected risk to persons and property due to flooding. In this plan the floodplain is divided into the Low, Medium and High flood risk precincts.
 - **Low Flood Risk Precinct** means all flood prone land not identified within the High or Medium flood risk precincts.
 - **Medium Flood Risk Precinct** means all flood prone land that is (a) within the 1% AEP Flood Planning Area; and (b) is not within the High Flood Risk precinct.
 - **High Flood Risk Precinct** means all flood prone land (a) within the 1% AEP Flood Planning Area; and (b) is either subject to a high hydraulic hazard, within a floodway or subject to significant evacuation difficulties (H5 and or H6 Life Hazard Classification).

5.1.2 Development Type

In accordance with the Northern Beaches Flood Prone Land Policy, the proposed development is classified as 'Vulnerable Uses'.

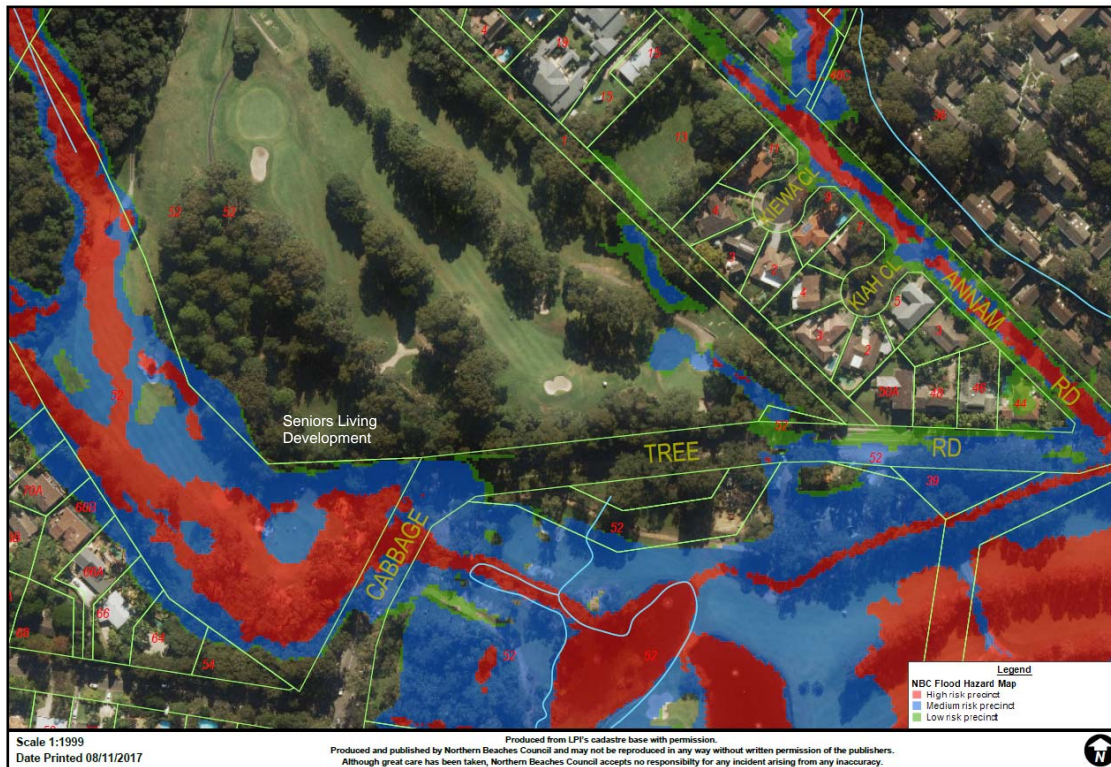


Figure 5-1 Seniors Living Development – Flood Risk Precinct (Northern Beaches Council Project Database)

5.1.3 Flood Risk Precinct

Given the siting of the proposed development, most of the site is flood free. There is a small area of overland flow at the eastern end of the site. The small area of overland flooding site comprises High Flood Risk, Medium Flood Risk and Low Flood Risk Precincts. The High Risk Precinct is small and relates to several isolated “pockets” of High Hazard flow in the 1% AEP event (refer **Figure 4-1**).

The proposed works reduce these precincts to a small Low Risk Precinct due to the small mapped extent of flooding on the site in a PMF under Future Conditions.

The Flood Prone Land Policy stipulates that where a property is located in more than one Precinct, the assessment must consider the controls relevant to each precinct. As such, the relevant controls to the Medium Flood Risk Precinct are outlined in the following sections.

5.1.4 Applicable Controls

Flood Effects Caused by Development

Controls relating to Flood Effects Caused by Development stipulated in the Flood Prone Land Policy are outlined below:

- Certification shall be provided in accordance with Northern Beaches Council's Standard Hydraulic Certification Form (Forms A and A1 of Northern Beaches Council's Guidelines for preparing a Flood Management Report) to the effect that the works have been designed and can be constructed to adequately address flood risk management issues.
- The applicant shall include in their submission, calculations to illustrate that any fill or other structures that reduce the total flood storage are replaced by Compensatory Works.

- Development (including earthworks and subdivision) shall not be approved unless it can be demonstrated in a *Flood Management Report* that it been designed and can be constructed so that in a *Probable Maximum Flood* event:
 - a) There are no adverse impacts on flood levels and velocities caused by alterations to the flood conveyance;
 - b) There are no adverse impacts on surrounding properties; and
 - c) It is sited to minimise exposure to flood hazard.

Where relevant certification shall also be provided in Northern Beaches Council's Standard Certification Form (Forms A and A1 of Northern Beaches Council's Guidelines for preparing a Flood Management Report) to this effect.

The development has been designed and can be constructed so that:

- There are no adverse impacts on flood levels and velocities caused by alterations to the flood conveyance;
- There are no adverse impacts on surrounding properties; and
- It is sited to minimise exposure to flood hazard.

Drainage Infrastructure and Creek Works

- Flood mitigation works or stormwater devices that modify a major drainage system, stormwater system, natural watercourse, floodway or flood behaviour within or outside the development site may be permitted subject to demonstration through a Flood Management Report that they comply with the Flood Prone Land Design Standard found on Council's webpage.
- A Section 88B notation under the Conveyancing Act 1919 may be required to be placed on the title describing the location and type of flood mitigation works with a requirement for their retention and maintenance.

Building Components and Structural Soundness

The minimum floor level at the proposed buildings is 9.3 m AHD which is higher than the PMF level and the Flood Planning Level.

Storage of Goods

Not applicable as no storage of goods is proposed within the PMF or Flood Planning Level.

Flood Emergency Response

There are no issues with Flood Emergency Response. In accordance with Table 1-1 of the *Amended Flood Emergency Response Planning for Development in Pittwater Policy* document, consequently the flood emergency response planning policy does not apply. Although the Flooding Report prepared by Cardno in November 2015 had a section which discusses Flood Emergency Response, which is also included in this report, the discussion states that the site does not enquire any consideration of emergency response.

Floor Levels

Controls relating to Floor Levels stipulated in the Flood Prone Land Policy are outlined below:

- All development structures must be designed and constructed so as not to impede the floodway or flood conveyance on the site, as well as ensuring no loss of flood storage in a 1% AEP Event. Where the dwelling is located over a flow path it must be elevated on suspended pier/pile footings such that the level of the underside of all floors including balconies and decks within the flood affected area are at or above, or raised to the Flood Planning Level to allow clear passage of the floodwaters under the building. The development must comply with the Flood Prone Land Design Standard.

- Where the lowest floor has been elevated to allow the passage of floodwaters, a restriction shall be imposed on the title of the land, pursuant to S88B of the Conveyancing Act 2017 confirming that the undercroft area is not to be enclosed.
- All floor levels within the development shall be at or above the Probable Maximum Flood level or Flood Planning Level whichever is higher.

The proposed developments adheres to all of these controls:

- The proposed structures do not impede overland flows nor flood conveyance through the site nor do they reduce flood storage in a 1% AEP event;
- The proposed dwellings are not located over a flow path; and
- All floor levels within the development are at or above the PMF as required.

Car Parking

Car parks and basement entries will be above the PMF or Flood Planning Level.

Fencing

Not applicable as no fencing is proposed within the PMF extent.

Pools

Not applicable as no pools are proposed within the PMF extent.

5.1.5 Compliance Table

Table 4-1 summarises the compliance of the proposed works in the Seniors Living Development with the flood related development controls.

Table 5-1 Compliance Table

	Compliance		
	NA	Yes	No
A Flood effects caused by Development		X	
B Drainage Infrastructure & Creek Works		X	
C Building Components & Structural		X	
D Storage of Goods	X		
E Flood Emergency Response	X		
F Floor Levels		X	
G Car Parking		X	
H Fencing	X		
I Pools	X		

5.2 Council's Pre-lodgement Report

Pre-lodgement notes on the Seniors Living application, which were prepared by Council staff, raised issues regarding flooding which are discussed as follows.

Table 5-2 Seniors Living application Flooding Related Matters

Council's comments	Compliance	Additional notes
There will be no negative impact on flooding to neighbouring properties in events up to and including the Probable Maximum Flood (PMF) event.	Yes	It is concluded that the off-site increases in velocity in the 1% AEP and PMF events are not significant as they are small areas and mostly located on road reserve or the golf course and do not impact on surrounding private land
There will be no reduction in flood storage in a 1% AEP event.	Yes	Based on the storage volumes calculated there is no reduction in flood storage. In fact, there is a minor increase in flood storage volume compared to existing conditions. In the 1%AEP event flood storage under: Existing conditions is 16,797 m ³ Future conditions is 16,920 m ³ .
All residential floor levels are set at or above the Probable Maximum Flood level or Flood Planning Level whichever is higher.	Yes	The buildings are outside the 1% AEP and PMF flood extents. The minimum floor level at the proposed buildings is 9.3 m AHD which is above the PMF and the Flood Planning Level.
All potential water entry points to basement car parks are at or above the Probable Maximum Flood level or Flood Planning Level whichever is higher.	Yes	Car parks and basement entries will be above the PMF or Flood Planning Level.
All structures are designed and constructed to ensure structural integrity for hydraulic forces in the Probable Maximum Flood event.	Yes	Hazardous or potentially polluting materials will not be stored below the Flood Planning Level
Proposed development should identify appropriate emergency response arrangements in accordance with the Flood Emergency Response planning for Development in Pittwater Policy.	Yes	As the site is not flood affected, evacuation from site is not required during flood events and the site will remain flood free. This offers the potential for the site to be used as a place of refuge for the community during flood events.
Both applications should be accompanied by a Flood Management Report prepared in accordance with Council's Guidelines for preparing a flood management report, which are available on our website.	Yes	Report is prepared in accordance with Council's Guidelines.
Certification shall also be provided in Northern Beaches Council's Standard Certification Form (Form A in Flood Risk Management Policy for Development) to this effect.	Yes	Form A is provided in Appendix F

5.3 Pittwater Local Environmental Plan Clauses (2014)

The sections in the Pittwater LEP related to flood planning and risk are **7.3 Flood Planning** and **7.4 Flood Risk Management**. The objectives of these sections are as follows:

Flood Planning (7.3) clause objectives are as follows:

- to minimise the flood risk to life and property associated with the use of land,
- to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,
- to avoid significant adverse impacts on flood behaviour and the environment.
- is compatible with the flood hazard of the land, and
- will not significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and
- incorporates appropriate measures to manage risk to life from flood, and
- will not significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and
- is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

Flood Risk Management (7.4) clause objectives are as follows:

- in relation to development with particular evacuation or emergency response issues—to enable evacuation of land subject to flooding in events exceeding the flood planning level,
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.
- This clause applies to land between the flood planning level and the level of the probable maximum flood, but does not apply to land subject to the discharge of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard, or other freeboard determined by an adopted floodplain risk management plan.
- Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:
 - (a) caravan parks,
 - (b) child care centres,
 - (c) correctional centres,
 - (d) educational establishments,
 - (e) emergency services facilities,
 - (f) group homes,
 - (g) hospitals,
 - (h) residential care facilities,
 - (i) respite day care centres,
 - (j) seniors housing,
 - (k) tourist and visitor accommodation.

The Seniors Living Development lies generally on flood free land. The proposed works at the Seniors Living Site comply with the flood planning and flood management clauses provided in the Pittwater Local Environmental Plan (2014).

6 Flood Emergency Response

6.1 Adopted Approach

To help minimise the flood risk to occupants, it is important that developments have provisions to facilitate flood emergency response. There are two main forms of flood emergency response that may be adopted by people within the floodplain:

- Evacuation: the movement of occupants out of the floodplain before the property becomes flood affected; and
- Shelter-in-place: the movement of occupants to a building that provides vertical refuge on the site or near the site before their property becomes flood affected.

The merits of the two alternatives vary for each site based on the type of development proposed and the flood behaviour of the site. For the proposed Seniors Living Development the flood risk associated with the development is assumed to be minor with a shelter-in-place approach in place. This conclusion is supported by the following:

- The proposed seniors living site is flood free so the only source of flood risk to life is isolation. Although the risk to life related to isolation for vulnerable developments is higher due to a greater probability of medical emergency during isolation, there is no direct flood hazard as the site is flood free, with isolation seen as a less significant risk to life.
- Based on SES guidance, evacuation is recommended for flood affected developments, where possible. However, evacuation is not recommended for flood free developments. This is due to the following:
 - If flood free development is to evacuate, this places an extraordinary strain on available evacuation routes. Therefore it is recommended that only flood affected properties evacuate to limit congestion and leave routes available for developments in the floodplain that need to evacuate most.
 - The risk to life associated with driving or walking in a PMF rainfall event is considered to be higher than the risk to life associated with shelter-in-place for flood-free sites.
- With respect to duration of isolation, as the evacuation route for the development (Cabbage Tree Road) lies within the Mona Vale mainstream floodplain, the duration of isolation for the site could be considered to be relatively longer than other parts of the Northern Beaches Local Government Area (LGA). However, the duration of isolation for even the PMF event (assumed to be less than 24 hours) is comparatively short in duration when compared to larger riverine floodplains where isolation periods can be over a number of days. As such the risk to life associated with isolation is comparatively low for a sub-daily duration of isolation.
- With respect to warning times, the critical duration for the PMF event is a 2 hour rainfall duration which means that the evacuation route (Cabbage Tree Road) would be inundated less than an hour after the onset of rainfall. This suggests that there is insufficient time to evacuate, and considering the floodplain behaviour for the site; raising of Cabbage Tree Road is unlikely to improve the available warning times significantly to make evacuation a feasible emergency response option for the site.
- Taken in the context of the wider floodplain, the majority of Northern Beaches Local Government Area (LGA) is a "High Flood Island" as it does not have direct flood free access to medical emergency centres such as Mona Vale Hospital. Therefore to impose evacuation requirements for a flood free development, even if a vulnerable development type, would set a precedent for the entire LGA.

Therefore, due to the relative low flood risk to life relating to flood free developments it is recommended that no further consideration of emergency response provisions need to be accounted for other than for the site to adopt a strategy of shelter-in-place for its residents.

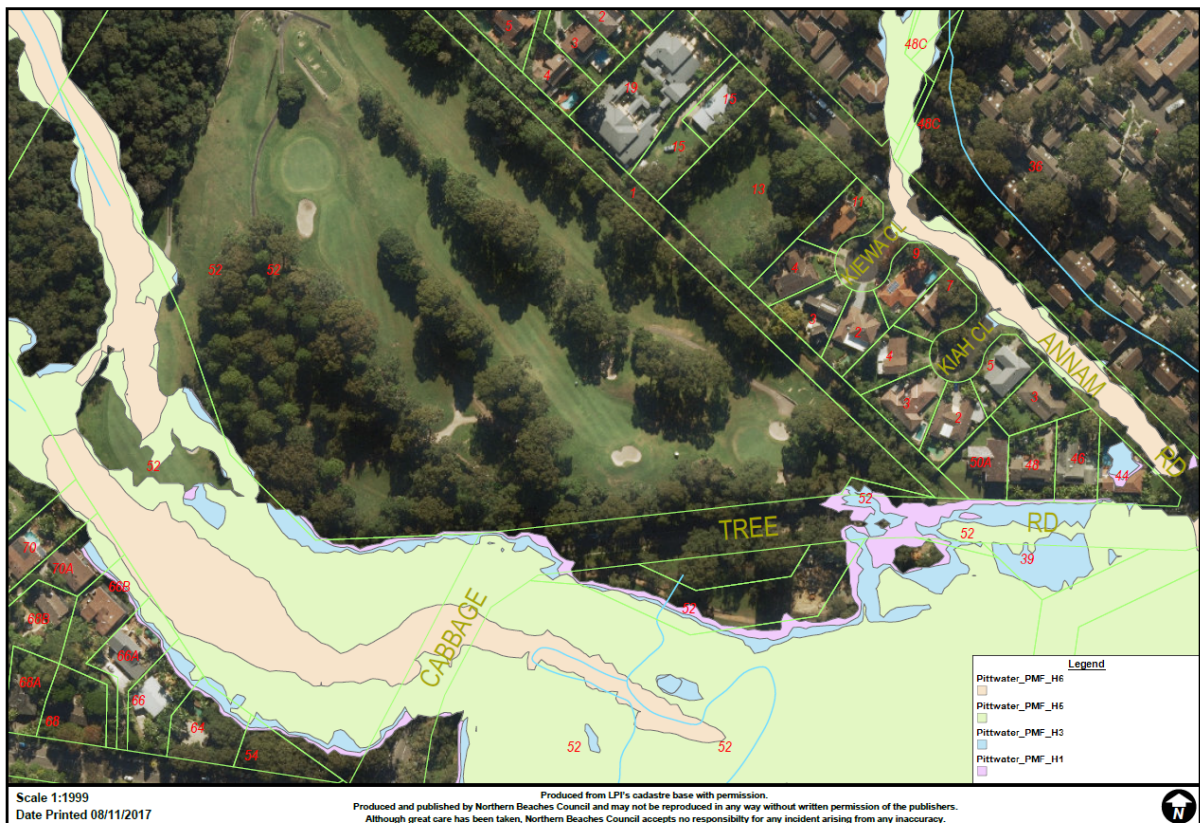
6.2 Council Policy

In 2015 Pittwater Council adopted flood emergency response development controls for all new developments in the floodplain, which are outlined in Section B3.25 and Appendix 15 of the *Pittwater Development Control Plan (DCP)* 21.

The proposed Seniors Living Development falls under the category of “vulnerable development” in accordance with the *Flood Emergency Response Planning for Development in Pittwater Policy*. The policy notes the following with respect to vulnerable development:

The flood risk to life is considered significant for all developments under the “vulnerable development”, therefore it is preferred that these development types not be located within the PMF extent.

One of the outcomes of the policy was Life Hazard Category mapping for the entire Northern Beaches Local Government Area (LGA), which related to flood hazard thresholds based on the Probable Maximum Flood event. The Life Hazard category mapping for the Bayview Golf Course and surrounds is shown in **Figure 5-1**. The mapping shown in **Figure 5-1** shows that the proposed seniors living site (apart from the access point) is not located within any of the Life Hazard Categories identified within the policy. Therefore in accordance with Section 1.2 of the *Flood Emergency Response Planning for Development in Pittwater Policy* (2014) the flood risk for the proposed development is considered “acceptable”.



Source: Northern Beaches Council Project Database

Figure 6-1 Location of Subject Site and Bayview Golf Course

Consequently, and in accordance with Council's *Flood Emergency Response Planning for Development in Pittwater Policy*, it is expected that no flood emergency response provisions would be required for the proposed Seniors Living Development (i.e. no evacuation or shelter-in-place would apply) and the proposed access would not need to be above the Probable Maximum Flood level.

Therefore based on guidance provided within Pittwater Council's *Flood Emergency Response Planning for Development in Pittwater Policy*, the site does not require any consideration of emergency response including road upgrades to provide evacuation routes in the event of flooding. Hence the adopted approach is consistent with Council policy.

6.3 Safe Refuge

As the site is not flood affected, evacuation from the site is not required during flood events and the site will remain flood free. This offers the potential for the site to be used as a place of refuge for the community during flood events. The proposed Seniors Living Development would have publically accessible areas, which would be suitable for use as safe refuge during flood emergency events.

7 Conclusions

This Flood Impact Assessment has been prepared in support of an application for a Site Compatibility Certificate for a proposed Seniors Living Development at Bayview Golf Course.

The existing flood model developed by Royal HaskoningDHV for the *Mona Vale, Bayview, and McCarrs Creek Flood Study Review* has been updated as part of this assessment factoring in the proposal. While the overall model has been based on LiDAR data, the levels on the subject site were updated based on detailed ground survey undertaken in October 2015.

The updated model was re-run to establish benchmark flood levels under Existing Conditions under 1% AEP and PMF conditions. A climate change scenario was also assessed based on Council's Scenario 5, namely 1% AEP rainfall +30% increase in combination with 2100 tailwater conditions.

Iterative modelling was undertaken to identify a Seniors Living Development configuration that best satisfied the DCP requirements.

The existing floodplain model was updated to include the following proposed measures to be implemented as part of the Seniors Living development:

- Constructing a trapezoidal channel at the eastern side of the site to convey the overland flows into twin 750 mm circular pipes to convey the majority of the flow to a location upstream of the existing pipe under Cabbage Tree Road;
- Channel side slopes of 1V : 3H, with a base width of 3 m;
- Installation of 2 x 1.5 m (W) and 0.45 (H) culverts under the driveway in order to control and mitigate runoff from the proposed driveway; and
- Upgrade the existing pipe under Cabbage Tree Road to increase its capacity to locally lower flood levels and reduce flooding impacts at the southeast end corner of the site on Cabbage Tree Road.

The drainage works are detailed in Revision F of the following civil drawings prepared by Marchese Partners and dated 24 August 2018 as follows:

- DA-C-201 CIVIL WORKS CABBAGE TREE ROAD STORMWATER LAYOUT PLAN
- DA-C-202 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL PLAN
- DA-C-221 CIVIL WORKS CABBAGE TREE ROAD STORMWATER LONG SECTION
- DA-C-222 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 1
- DA-C-223 CIVIL WORKS CABBAGE TREE ROAD STORMWATER DETAIL SHEET 2

The Seniors Living Development lies generally on flood free land, therefore the width and depth of flooding on the Seniors Living Development is not extensive.

It was concluded that the impact of the proposed works on flooding would be as follows:

- There is no flooding on the driveway in 1%AEP event or the PMF under Future Conditions;
- There is no flooding on Cabbage Tree Road in the vicinity of the entry in 1%AEP event under Future Conditions;
- Under Existing Conditions in a 1% AEP flood a floodway is mapped at the eastern edge of the subject site; and
- The proposed channel and twin pipes will convey the 1% AEP flow through the site such that the Floodway is no longer present on the site under Future Conditions.

- Under Future Conditions Cabbage Tree Road is affected in the PMF with velocities not exceeding 1.0 m/s.
- The proposed channel and drainage works will convey the 1% AEP flow through the site such that the flood level decreases by up to 2.0 m on the eastern side of the subject site;
- There are no adverse off-site impacts in the 1% AEP and the PMF events with reduced flood levels on Cabbage Tree Road in the vicinity of the driveway entry.

It is concluded that the off-site impacts on velocity in the 1% AEP and PMF events are not significant as they are small areas and mostly located on road reserve or the golf course and do not impact on surrounding private land.

It is further concluded that the proposed Seniors Living Development complies with the relevant flood related development controls.

8 Glossary

Term	Definition																				
Average Recurrence Interval (ARI)	The long-term average period between occurrences equalling or exceeding a given value. For example a 20 year ARI flood would occur on average once every 20 years.																				
Annual Exceedance Probability (AEP)	<p>The probability of an event occurring or being exceeded within a year. For example a 5% AEP flood would have a 5% chance of occurring in any year. An approximate conversion between ARI and AEP is provided.</p> <table> <tr> <th>AEP / EY</th><th>ARI</th></tr> <tr> <td>1</td><td>1 year</td></tr> <tr> <td>39.3 %</td><td>2 year</td></tr> <tr> <td>18.1 %</td><td>5 year</td></tr> <tr> <td>10 %</td><td>10 year</td></tr> <tr> <td>5 %</td><td>20 year</td></tr> <tr> <td>2 %</td><td>50 year</td></tr> <tr> <td>1 %</td><td>100 year</td></tr> <tr> <td>0.5 %</td><td>200 year</td></tr> <tr> <td>0.2 %</td><td>500 year</td></tr> </table>	AEP / EY	ARI	1	1 year	39.3 %	2 year	18.1 %	5 year	10 %	10 year	5 %	20 year	2 %	50 year	1 %	100 year	0.5 %	200 year	0.2 %	500 year
AEP / EY	ARI																				
1	1 year																				
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10 %	10 year																				
5 %	20 year																				
2 %	50 year																				
1 %	100 year																				
0.5 %	200 year																				
0.2 %	500 year																				
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.																				
Exceedances per Year (EY)	The number of times per year a threshold is exceeded.																				
Extreme floods	Less frequent than 1% AEP (up to and including the PMF).																				
Flood	The covering of normally dry land with water from a stream, river, estuary, lake, dam, major drainage and/or due to super-elevated sea levels and/or waves overtopping coastline defences excluding tsunamis.																				
Flood Planning Area	The area of land subject to flood related development controls.																				
Flood Planning Level (FPL)	<p>The combinations of flood levels (derived from significant historical flood events or flood of specific AEP) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.</p> <p>The adopted FPL used for planning controls purposes is derived from a combination of the 100 year Average Recurrence Interval (ARI) flood event level and a freeboard of 500 mm, i.e. the 100 year ARI flood level plus an additional 500 mm height.</p>																				
Floodplain	The area of land which is subject to inundations by floods up to and including the probable maximum flood event, that is, flood prone land.																				
Floodway area	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels.																				

Freeboard	A height added to flood levels to provides reasonable certainty that the risk exposure accepted by deciding on a particular flood is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, driveway crest levels, etc.
Frequent floods	More frequent than 14% AEP.
LiDAR	"Light Detection And Ranging". A survey technique using laser to measure height.
Main Watercourse	The primary means of conveying storm discharge from the catchment and sub-catchment but excluding the minor drainage systems.
Peak Water Level	Maximum water level (m AHD) for the specified AEP event
Peak Depth	Maximum water depth (m) for the specified AEP event
Peak Velocity	Maximum velocity (m/s) for the specified AEP event
Overland Flow	Flooding resulting from the local catchment system.
Probable Maximum Precipitation (PMP)	The theoretical maximum precipitation (rainfall) for a given duration that is physically possible over a given size storm area at a particular geographic location during a certain time of year. The size of the PMP, plus its distribution over space and time are used to calculate the Probable Maximum Flood (PMF).
Probable maximum flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.

9 References

Northern Beaches Council (2017) *Flood Emergency Response Planning for Development in Pittwater Policy*

Northern Beaches Council (2017) *Northern Beaches Flood Prone Land Policy*

RoyalHaskoningDHV (2017) *McCarrs Creek, Mona Vale and Bayview Flood Study Review*, prepared for Northern Beaches Council, July.

Pittwater Local Environmental Plan (2014)

Seniors Living Development

APPENDIX

A

DETAIL SURVEY - DRAWING 9-01-15

Seniors Living Development

APPENDIX

B

DETAIL SURVEY -DRAWING 18990A

Seniors Living Development

APPENDIX

C

FIGURES

Seniors Living Development

APPENDIX

D

FIA ADDENDUM – NOVEMBER 2018

Seniors Living Development

APPENDIX

E

FIA ADDENDUM – JANUARY 2019

Seniors Living Development

APPENDIX

F

FORM A CERTIFICATION