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1 December 2016

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Attention: Mr Daniel Maurici

Southern Buffer, Warriewood Flood and Stormwater Management

1 STUDY AREA

Calibre Consulting has been commissioned to investigate alternatives to the cut/fill balance and flood storage design as previously provided by Calibre Consulting as part of the Planning Proposal PP0007/13. The previous study indicated that the site can be developed with no loss in temporary flood storage through use of suspended floor levels or cut/fill options.

The works for the proposed options are contained within the study site boundary, with no effect to the land outside the boundary. This report indicates that a revised cut/fill option for the site can be provided with no loss in temporary flood storage in line with the results of the previous study undertaken by this office. The configuration presented is preliminary and detailed flood modelling will be undertaken at design phase to establish the accurate developable land and ensure no aggravating of flood levels. A glossary of terms used in the report has been included at the back of the report.

The study site is shown in Figure 1 and included the private land owner's properties.

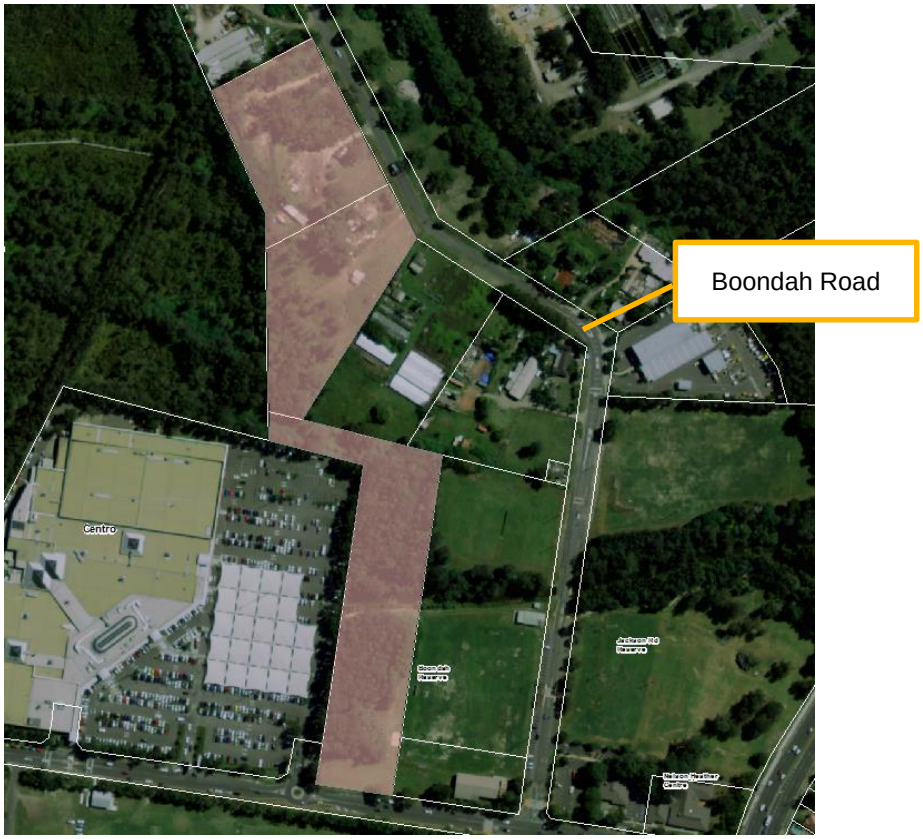

Figure 1: Study area (subject site shaded)

Flows from Narrabeen Creek travel around the Donato property and under Macpherson St. The Creek runs parallel to Boondah Road, before dissecting Jackson Road reserve and travelling under Boondah Road as shown in Figure 2. The Creek flows through Boondah Reserve and under the Centro car park through a number of large box culverts and discharging into Mullet Creek downstream of the Warriewood Wetlands weir.

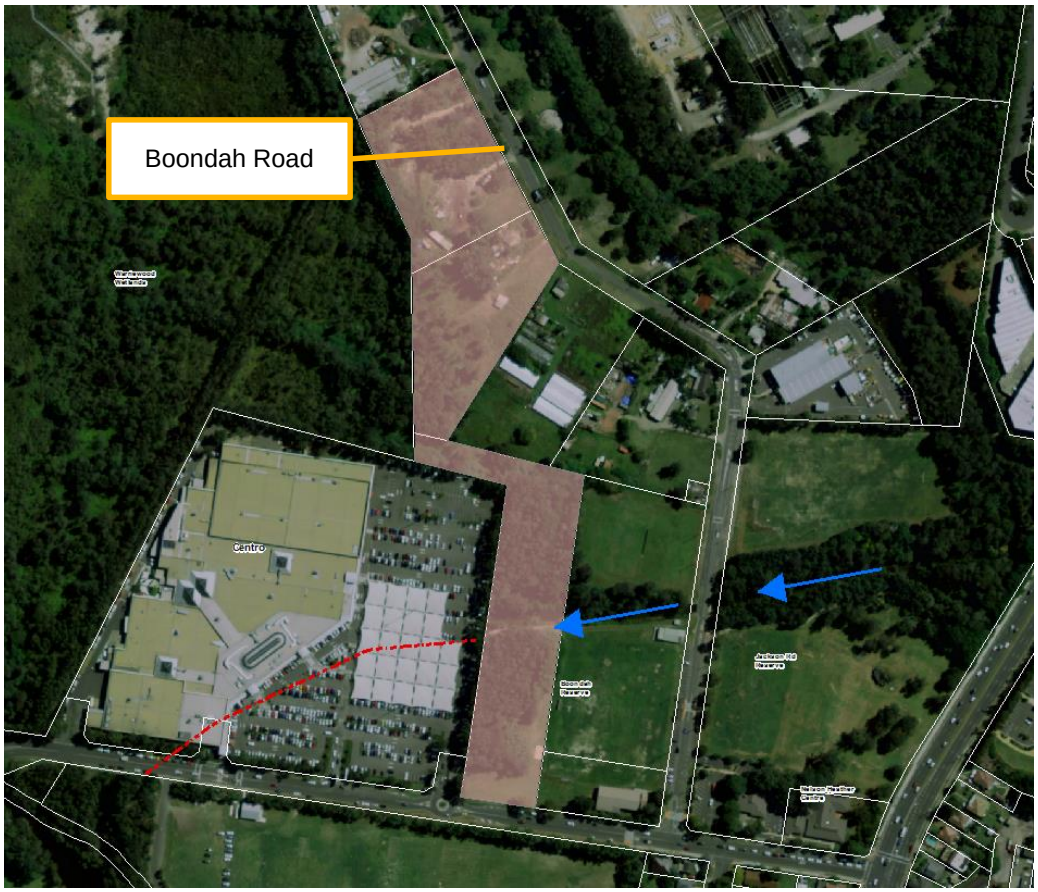

Figure 2: Flow regime

During large storm events, the Narrabeen Lagoon water level rises and ponds up to the study site.

1.1 Ground Water

Ground water levels were taken recently from four boreholes throughout the study area. The results showed that the ground water depth was 2.7m at the development area and 1.4m at the proposed flood storage zone and under croft area. The bore hole results are summarised in Figure 3.

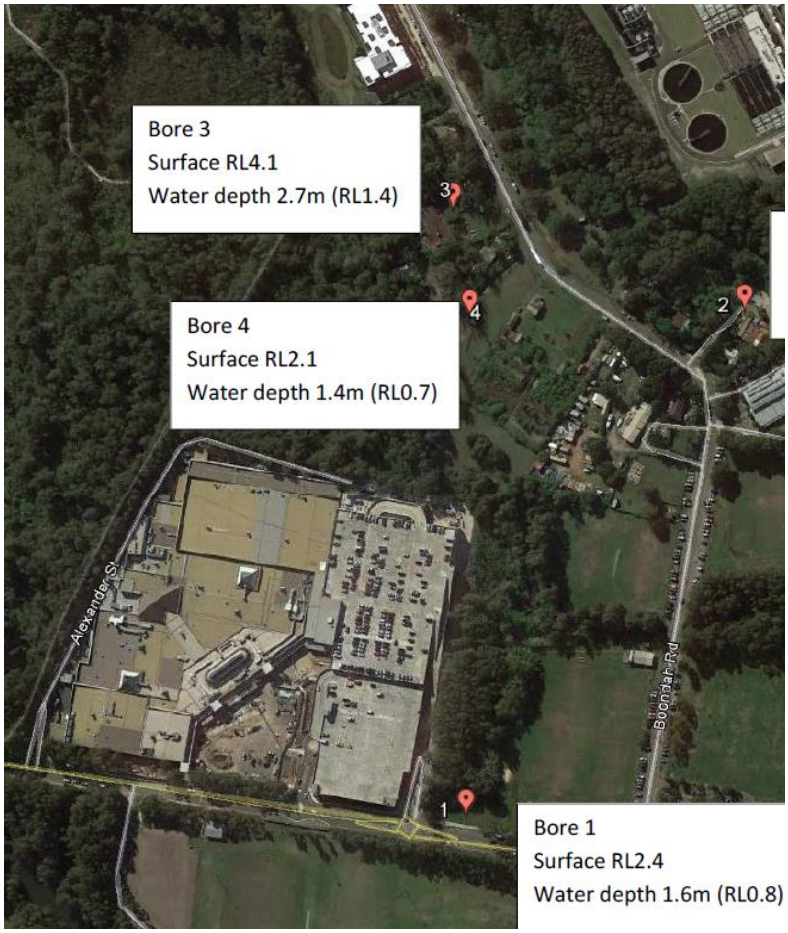

Figure 3: Ground water depths

Any excavation within the flood storage zone will need to ensure sufficient cover over the ground water level is maintained.

2 PREVIOUS STUDIES

2.1 Warriewood Valley Strategic Review (2011)

Cardno, Lawson and Treloar prepared a flood study of the Warriewood Valley for Pittwater Council in 2003 which was updated in 2005. The study utilised aerial photography with some ground survey for topography data. The study presented 100 year ARI and PMF flood levels for the Warriewood Valley including the Southern Buffer. The study demonstrated that the flood behaviour for the lower parts of the study area are governed by backwater flooding from Warriewood Wetlands and Narrabeen Lagoon. The 2005 results presented for the study site show a 100 year ARI flood level of 3.15m AHD and the hazard mapping shows a high hazard along the low lying areas and low hazard on the higher areas within the site boundary.

Cardno (2009) prepared a *Draft Narrabeen Creek Floodplain Risk Management Study*. The study estimated that a 0.9m sea level rise and 30% increase in rainfall intensities would result in a water level rise of 0.61m above existing levels in Narrabeen Lagoon.

Warriewood Valley Strategic Review (2011) utilised Light Detection and Ranging (LiDAR) data with an accuracy of +/- 150mm and commissioned a new Hydrology Report. The Hydrology Report utilised a sensitivity analysis undertaken as part of the 2005 study combined with the estimated rise of water level of 0.61m in Narrabeen Lagoon, derived from a previous study, to scale the existing flood levels and provide an estimate of flood effects due to climate change. It should be noted that the estimated 0.61m rise in tailwater in Narrabeen Lagoon is based on assumptions of a 0.9m sea level rise and a 30% increase in rainfall intensity; these values are at the top of the range of theoretical estimated effects of climate change in the year 2100. The study proposed that the majority of the Southern buffer, including almost all of the private lands, will provide compensatory cut for fill for properties along the Jacksons Road frontage (owned by Pittwater Council and the Crown). The study also proposed the filling of a small portion to the north (Cassius Investments) from compensational cut from the Sydney Water property.

The Warriewood Strategy Review presented a development land classification; categories (A-G) were assigned to land within the strategic study. The strategic review introduced Category G, which was assigned to land where the floor levels are above the Flood Planning Level (FPL), but below the FPL plus climate change. The land along Jackson Road was categorised as G. It is important to note that the categories for each parcel are based on "modifications" as a result of recommendations from the strategic study, the categories do not reflect existing scenario. Essentially, the result of the Hydrology Study is that the study site is utilised as cut and therefore undevelopable ("category F") **after the cut/fill exercise proposed** and it does not conclude that this is the case for the existing scenario. This is not clearly relayed in the Strategic Study Report which misrepresents the findings of the Hydrology Report by stating that it concludes, *"..the central areas are not suitable for development due to flood depth and flow path requirements."*, a conclusion that is not reached or reported in the Hydrology Report.

2.2 Narrabeen Lagoon Flood Study (2013)

The *Narrabeen Lagoon Flood Study* was prepared for Warringah and Pittwater Councils by BMT WBM to define the existing flood behaviour in the Narrabeen Lagoon and associated catchment. The study utilised the 2D hydraulic model *TUFLOW* to model the existing flood regime.

The *Narrabeen Lagoon Flood Study* (2013) has revised the 1% AEP to 3.04m AHD and PMF flood level of 4.9m AHD. For the purpose of this preliminary exercise the conservative 3.15m AHD (Warriewood Valley Strategic Review) flood level was also analysed. The detailed flood modelling to be undertaken as part of future studies will utilise the latest regional flood model available.

The mitigation options presented as part of this study would also update the category of the study site.

The *Narrabeen Lagoon Flood Study* identified the creek flows as a flood way (shown in red on Figure 4), however the site is dominated by flood fringe (blue) and flood storage (yellow). The hazard mapping indicated that the site was predominately low hazard with some isolated areas of high hazard during the 1% AEP event.

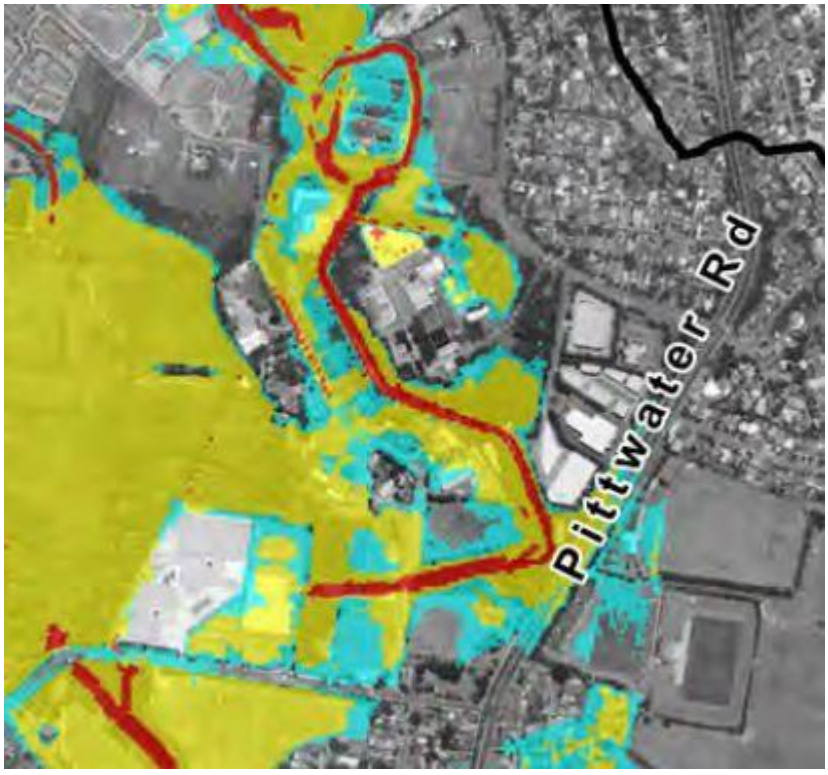

Figure 4: Hydraulic Categories

The study undertook a sensitivity analysis to predict future potential flood levels as a result of climate change (increase in rainfall intensity and sea level rise). The study determined that the 1% AEP flood level could be 3.8m AHD for the year 2050 and 4.3m AHD for the year 2100.

3 FLOOD MANAGEMENT STRATEGY

The scheme proposed within the Warriewood Strategic Review relies on the cooperation from the private land holders, Sydney Water and the Department of Lands in order to ensure no loss of flood storage.

The strategy also identifies some of the existing playing fields as a source of cut for flood storage. It is understood that the playing fields have been constructed on old tips that are sealed with clay capping then topsoil. Any excavation of the playing fields will breach the capping and expose the contents of the tip which is likely to render the resulting land unusable as playing fields unless significant remediation, filling and/or recapping of the tips occurred. This issue is not raised at all and introduces significant limitations to the proposal presented by the Strategic Review as the contents of the tips and the amount of useable fill that may be generated is not known.

This report has been prepared to investigate a strategy for the private land. The proposed site is dominated by flood fringe and flood storage; as a result, the proposed flood management strategy aims to maintain or increase the available existing flood storage. The strategy involves a cut to provide flood storage and fill to provide a flood free development pad. The strategy also utilised an under croft car park area that allows for flood storage to be utilised beneath the development during storm events.

Cut and Fill:

The NSW Government *Floodplain Development Manual* provides the definition of flood storage as the parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.

The Cardno (2005) study recognised that the flood regime in the buffer was driven by backwater from Narrabeen Lagoon. This suggests that the management of flooding could be achieved by maintaining the existing flood storage.

A portion of the existing site remains above the 1% AEP based on the current ground survey undertaken. Figure 5 shows the flood free areas for a number of scenarios.

Figure 5: Existing flood free land from various studies

The filling strategy adopted as part of this submission was to balance the cut and fill within the study site to a minimum surface level of the 1% AEP flood level to ensure no net loss of floodplain storage below the 1% AEP flood level. It is proposed to excavate non-filled areas within the floodplain to compensate for filled areas to provide the balance of floodplain storage (Figure 6). An under croft overflow parking with combined flood storage will also be utilised to provide additional flood storage above that of existing levels.

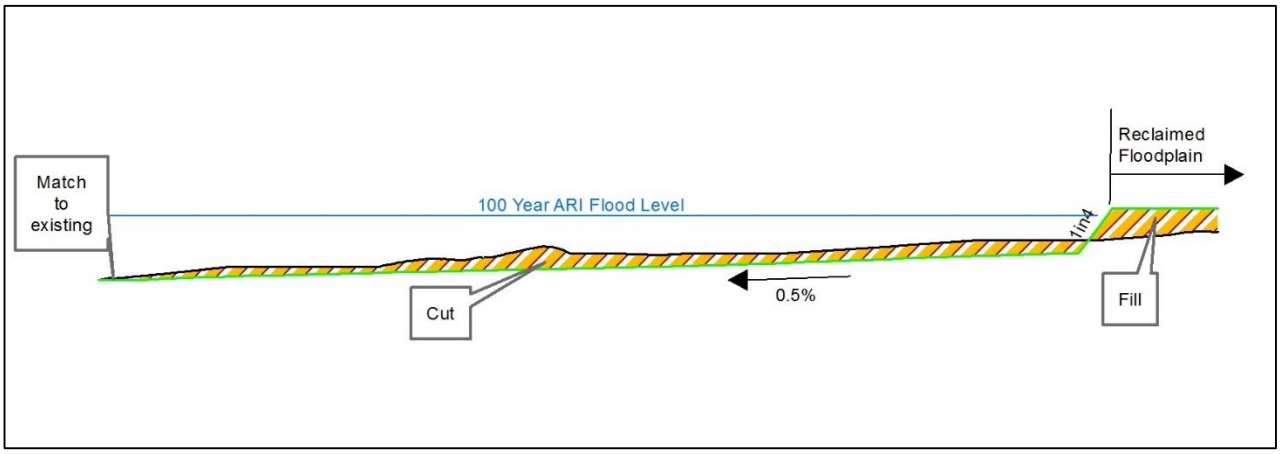

Figure 6: Schematic Representation of Cut and Fill Strategy

The modelled fill/cut strategy results in an increase to existing flood storage under the proposed developed scenario below the 1% AEP flood level. The positive effects of this strategy are that flood storage is moved from areas high in the floodplain to a level lower in the floodplain. This provides greater flood storage for more frequent floods than currently exists and potentially reduces flood levels for those flood events.

Floodplain storage is provided through the excavation of an area adjacent to the proposed fill platforms at a cut batter no greater than 1(V) in 4(H). The total surface area of the proposed flood storage area has been sized to achieve no decrease in flood storage for all events up to the 1% AEP.

Under croft flood storage

Under croft flood storage is proposed to be utilised to increase the potential flood storage above that of the existing conditions. The under croft area will be utilised for dry weather overflow car parking for the retail component. Retail parking is also available at higher levels above the flood levels and residential parking will be located in the basement.

The report to the Joint Regional Planning Panel for the additions to Warriewood Shopping Centre identified that commercial areas have less risk to life than residential areas and accepted the reduced floor level height below the council Flood Planning Level (FPL). As part of this proposal, the floor levels will be above the flood planning levels, and the car parking will be designed in accordance with the Northern Beaches Council DCP Section B3.18 for flooding above 300mm depths.

Figure 7: Typical Under croft parking in Warriewood

The retail under croft parking will only be utilised in dry weather condition. Roof top parking is made available above flood levels. A flood management and evacuation strategy will be prepared in the event of a storm event.

The DCP provides conditions for parking within floodways or flood storage areas. The under croft parking will ensure that all structures are designed and constructed to ensure structural integrity for immersion up to the 1% AEP. Evacuation to a floor level above the PMF will be available. Vehicle barriers will be provided to prevent floating vehicles leaving the site.

Figure 8 shows the development footprint and proposed under croft areas.

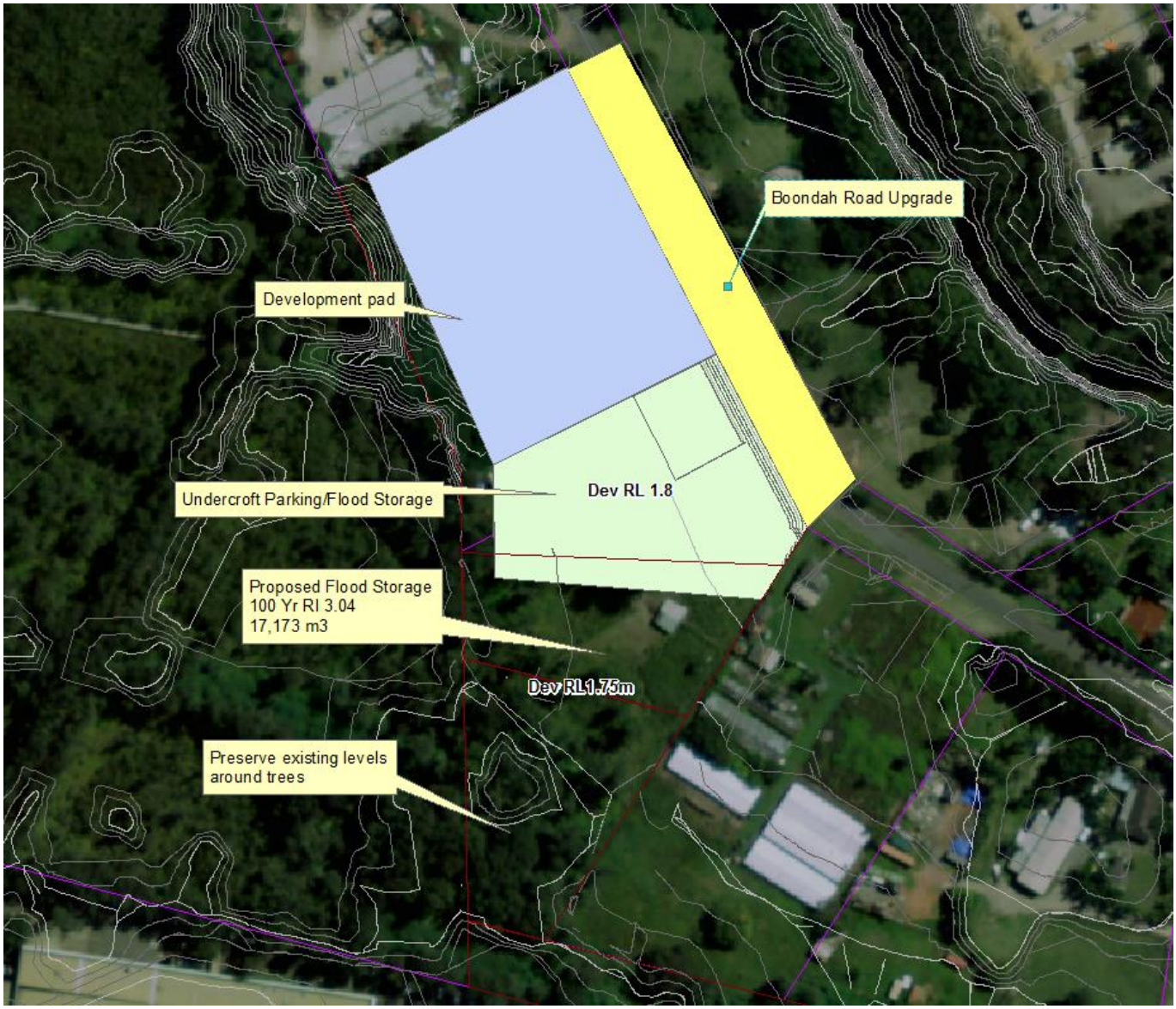

Figure 8: Developable area

There is additional flood storage source within the southern site shown on Figure 9. The area outside the protected fauna could achieve approximately 1600m^3 of storage if required.

Figure 9: Additional flood storage source

The flood storage was analysed for various flood scenarios.

Scenario	Existing flood storage (m^3)	Proposed flood storage (m^3)	Proposed flood storage with Southern storage (m^3)
Narrabeen Lagoon Study 1 % AEP (RL 3.04m)	10,600	14,200	15,900
Warriewood Valley Study 1 % AEP (RL 3.15m)	11,500	15,000	16,700
Climate Change (RL 3.8m)	21,700	23,800	25,400

The proposal achieves a developable area of 1.3 hectare, raising of Boondah Road adjacent to the development and a balance in cut/fill with under croft area to provide a greater flood storage than available under existing conditions within the site for the 1% AEP storm event. The configuration of the development area is preliminary and indicative for the purpose of this study. More detailed investigation and flood studies will be undertaken and detailed as part of the design process.

3.1 Emergency Response Planning:

The proposed flood response planning for the site for the 1% AEP plus climate change event will apply and provide floor levels above the 1% AEP with freeboard are proposed as required by Council during this event. During such an event the flood evacuation could be vertical evacuation and therefore occupants remain inside their dwellings and move to the upper levels in the retail centre. Shelter in place strategy will be utilised when rainfall is too intense to evacuate.

The evacuation for events up to the 1% AEP is per the Warriewood Valley Strategic Review (2011), which includes the raising of Boondah Road to provide flood free access to Macpherson Street, as shown below in Figure 10 taken from figure 11-2 of the *Warriewood Valley Strategic Review* (2011).

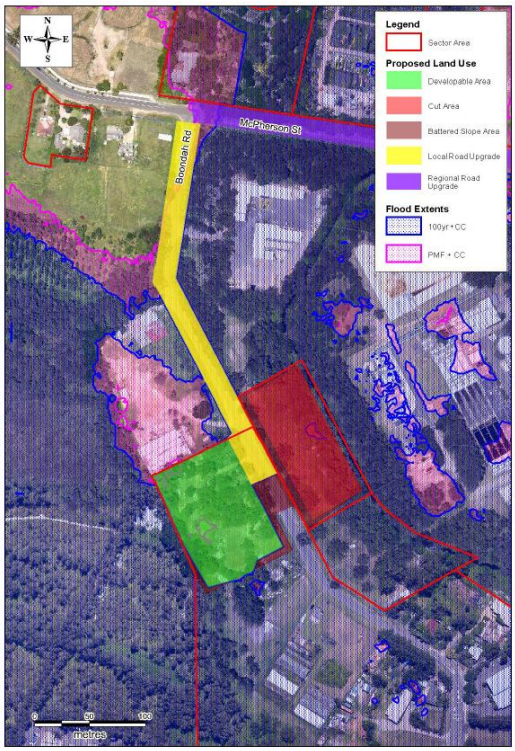

Figure 10: Boondah Road upgrade

The *Warriewood Valley Strategic Review* (2011) proposes raising the area of Boondah Road (shown in yellow) to be raised to above the 1% AEP to provide an emergency access path to the site available during all events. This is the preferred option for this site as it removes the periods of isolation that would be experienced by people during a vertical style evacuation procedure. Raising of Boondah Road and matching to upgraded section of Boondah Road to the north would allow the site to be evacuate via Boondah Road and Macpherson Street in accordance with the Warriewood Valley Strategic Review. The strategy has allowed Boondah road to be lifted to RL 3.3m, above the 1% AEP.

4 STORMWATER MANAGEMENT

4.1 Onsite Detention (OSD) Requirements

The Warriewood Valley Water Management Specification provides site storage requirements (SSR) and permissible site discharge (PSD) for Sector 15. These were estimated from the XP-RAFTS modelling undertaken by Lawson & Treloar for Pittwater Council. These factors were determined as being an SSR of 457 m^3/ha.

The detention could be contained within a basin, detention tank or free space within rainwater tanks.

The document recognises that the lower end of the valley including the subject site, does not require OSD for the 1% AEP, but could be required for the smaller events like the 20% AEP. This would result in a smaller basin/detention tank. Modelling will be undertaken at the Development Application Stage to size an appropriate detention volume to ensure no aggravating of existing peak flows.

4.2 Water Quality

Water quality modelling of the proposed development will be undertaken as part of the development application using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software package developed by the Cooperative Research Centre for Catchment Hydrology (CRCCH). MUSIC enables the user to model the transfer of pollutants through a catchment and provides an aid in determining the treatment strategy required to meet the water quality objectives applicable to the site. The critical pollutants to be modelled are Gross Pollutants, Total Nitrogen (TN), Total Phosphorous (TP) and Total Suspended Solids (TSS).

The generation, transfer and removal of these critical pollutants will be modelled through the treatment strategy employed. Only the critical pollutants will be addressed, however the treatment devices will provide mitigation of other pollutant loads, such as heavy metals, since they are predominantly associated with fine sediment. The primary pollutant trap will intercept pollutants, such as litter, rubbish or leaves, therefore minimising the runoff of oxygen demanding substances.

The water quality treatment will be undertaken using a treatment train of rainwater tanks, bioretention swales within the landscaping or proprietary products. Opportunities for collection and reuse of roof stormwater existing throughout the site.

5 CONCLUSION

The proposal indicates that the site can be developed with increase in temporary flood storage through use of the revised cut/fill and under croft area. The proposed mitigation options allow the existing playing fields to be maintained whilst not requiring the filling of Pittwater Road or Jacksons Road and are considered as viable options to facilitate development of the private lands. In addition, the permanent opening of Narrabeen Lagoon would significantly reduce the flood levels in the Buffer and should be considered.

Habitable floor levels and basement entrance will be set above the flood planning level (above the 1% AEP flood level).

The information is preliminary and detailed flood modelling will be undertaken at any design phase to establish the accurate developable land and ensure no aggravating of flood levels using the current regional flood model.

Yours sincerely
Calibre Consulting

Troy Eyles
Senior Engineer – Water and Environment

GLOSSARY OF TERMS

Australian Height Datum	National survey datum corresponding approximately to mean sea level.
Annual Exceedance Probability	The chance of a flood of a given size or larger occurring in any one year, generally expressed as percentage probability. For example, a 100 year ARI flood is a 1% AEP flood. An important implication is that when a 1% AEP flood occurs, there is still a 1% probability that it could occur the following year.
Average Recurrence Interval (ARI)	Is the long term average number of years between the occurrences of a flood as big as, or larger than the selected flood event. The Cardno (2005) study identified the 100 year ARI flood level as 3.15m AHD.
Catchment	The catchment at a particular point is the area of land which drains to that point.
Design floor level	The minimum (lowest) floor level specified for a building.
Design flood	A hypothetical flood representing a specific likelihood of occurrence (for example the 100 year or 1% probability flood). The design flood may comprise two or more single source dominated floods. The Cardno (2005) study identified the 100 year ARI flood level as 3.15m AHD.
Development	Existing or proposed works which may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodway's and buildings.
Digital Terrain Model	A three-dimensional model of the ground surface that can be represented as a series of grids with each cell representing an elevation (DEM) or a series of interconnected triangles with elevations (TIN).
Flood	Above average river or creek flows which overtop banks and inundate floodplains.
Flooding	The State Emergency Service uses the following definitions in flood warnings: *Minor flooding:* causes inconvenience such as closing of minor roads and the submergence of low level bridges *Moderate flooding:* low-lying areas inundated requiring removal of stock and/or evacuation of some houses. Main traffic bridges may be covered. *Major flooding:* extensive rural areas are flooded with properties, villages and towns isolated and/or appreciable urban areas are flooded.
Flood hazard	The potential threat to property or persons due to flooding.
Flood level	The height or elevation of flood waters relative to a datum (typically the Australian Height Datum).
Floodplain	Land adjacent to a river or creek which is inundated by floods up to the probable maximum flood that is designated as flood prone land.
Flood Planning Levels (FPL)	Are the combinations of flood levels and freeboards selected for planning purposes to account for uncertainty in the estimate of the flood level. Pittwater Council require a 500mm freeboard above the 100 year ARI flood level, at the study site the FPL is 3.65m AHD.
Flood proofing	Measures taken to improve or modify the design, construction and alteration of buildings to minimise or eliminate flood damages and threats to life and limb.
Floodplain Management	The coordinated management of activities which occur on flood liable land.
Flood storages	Floodplain areas which are important for the temporary storage of flood waters during a flood.
Floodways	Those areas of the floodplain where a significant discharge of flow occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if they are partially blocked, would cause significant redistribution of flood flows, or a significant increase in flood levels.
Freeboard	A factor of safety usually expressed as a height above the flood standard. Freeboard tends to compensate for the factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels. For Pittwater Council the required freeboard is 500mm above the 100 year ARI flood level.
Geographical Information System	A form of computer software developed for mapping applications and data storage. Useful for generating terrain models and processing data for input into flood estimation models.

High hazard	Danger to life and limb; evacuation difficult; potential for structural damage, high social disruption and economic losses. High hazard areas are those areas subject to a combination of flood depth and flow velocity that are deemed to cause the above issues to persons or property.
Low hazard	Flood depths and velocities are sufficiently low that people and their possessions can be evacuated.
Peak flood level, flow or velocity	The maximum flood level, flow or velocity occurring during a flood event.
Probable Maximum Flood (PMF)	An extreme flood deemed to be the maximum flood likely to occur at a particular location. The Cardno (2005) study identifies the PMF flood level of 4.45m AHD at the study site.
Probable Maximum Precipitation	The greatest depth of rainfall for a given duration meteorologically possible over a particular location. Used to estimate the probable maximum flood.
Runoff	The amount of rainfall from a catchment which actually ends up as flowing water in the river of creek.
Triangular Irregular Network	A mass of interconnected triangles used to model three-dimensional surfaces such as the ground (see DTM) and the surface of a flood.

REFERENCES

AECOM (2010). Coastal Inundation at Narrabeen Lagoon – Optimising Adaptation Investment Australian Government Department of Climate Change

BMT WBM (2013) Narrabeen Lagoon Flood Study Warringah and Pittwater Council

Cardno (2011) Warriewood Valley Strategic Review – Hydrology Study, Pittwater Council

Cardno Lawson Treloar (2005) Warriewood Valley Flood Study, Pittwater Council

Public Works Department (1990) Narrabeen Lagoon Study, Public Works Department

Webb, Mckeown & Associates (2003/2006) Flood Risk Report – Proposed Construction of a Multipurpose Sports Centre 1525 Pittwater Road North Narrabeen