Our Ref: X12181.01

Henroth Investments Pty Ltd
c/o the Southern buffer private land owners
46-56 Kippax St
Surry Hills NSW 2010

10th July 2013

Attention: Amy Romero

Dear Amy,

Boondah Precinct Masterplan, Warriewood – Stormwater

1.0 Study Area

Brown Consulting has been commissioned to investigate the flood management for the area known as the Southern Buffer, Warriewood. The study site is shown in figure 1 and included the private land owner's properties. The land owners include Cassius Investments Pty Ltd, Henry Fraser Pty Ltd, Trbojevic, Kamfam Pty Ltd, Henlen Pty Ltd and Rooke.

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This study indicates 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. The land area and configuration presented is preliminary and this report presents the mechanism to manage flooding within the site. Detailed flood modelling will be undertaken at any design phase to establish the accurate developable land, ensure no aggravating of flood levels and meet the flood controls required by Pittwater Council.

Figure 1: Study Area (study site shaded)

2.0 Existing Flow Regime

The flows from Narrabeen Creek travel under Macpherson Street, upstream of the Boondah Road intersection. The Creek runs parallel to Boondah Road, before dissecting Jacksons Road reserve and travelling under Boondah Road. The Creek flows through Boondah Reserve and under the Warriewood Centre car park through a number of large box culverts and discharges into Mullet Creek downstream of the Warriewood Wetlands weir.

During the large storm events Narrabeen Lagoon water levels rise and pond up to the study site.

Figure 2: Flow Regime

2.0 Previous Studies

Cardno, Lawson and Treloar prepared a flood study of the Warriewood Valley for Pittwater Council in 2003 and updated in 2005, the study utilised aerial photography with some ground survey for topography data. The study presented 100 year ARI and PMF 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 RL 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.

Council also undertook the Warriewood Valley Strategic Review (2011) that 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 Strategic Review identified a PMF water level with climate change as RL 4.5m at Jacksons Road.

3.0 Southern Buffer Flood Mitigation

The studies undertaken by Council have identified the site flood behaviour is driven by backwater flooding from Narrabeen Lagoon, as a result maintaining the existing flood storage is the key to managing the floodwaters throughout the site.

The preliminary work undertaken suggests an existing flood storage of 71,200m^3 exists up to a flood level of RL 3.15m (100 year ARI, Cardno 2005). The proposed stormwater management for the site will incorporate suspended floors and cut/fill balance to maintain the existing flood storage.

Suspended Floor Levels:

Development within the Southern buffer will incorporate permeable building footprints for the buildings shown in blue on figure 3. The permeable footprint could be achieved by using piers to raise the habitable floor levels above potential flood waters. The void below the floor levels can provide retail/commercial parking and allows floodwaters to pass during the major events thereby providing an overland flow path and maintaining existing flood storage.

Suspended floors are considered a viable solution for developing in flood prone areas as the option maintains existing flood regimes and ensures no aggravated flood levels. Raised floor levels have been adopted throughout New South Wales including Pittwater LGA.

The existing multi-purpose sport centre at Pittwater Road located downstream of the study area along Mullet Creek is a typical example of a suspended floor development. As a result of the existing building providing flood storage beneath the floor, a flood risk report for the extension to the sport centre has identified it will have a less than ±0.005m impact on existing flood levels for the 100 year ARI storm event and PMF. A similar design could be adopted for the study site to ensure no loss in flood storage and maintain existing flood levels.

The Northern Beaches Indoor Sports Centre (NBISC) located on Namona Street, adjacent to Mullet Creek downstream of the wetlands weir, is also an existing building that adopts a free space below the

floor level for flood storage. A development application for the alterations and additions to the existing building has been approved, the proposal includes additional indoor courts, canteen and office facilities. The existing building and proposed extensions adopted a suspended floor to manage flood water.

The Pittwater Council Boondah Depot has also been constructed with a void beneath the floor level to provide flood storage.

Furthermore, Pittwater DCP21 states that the suspended floor system on open pier/pile footings with openings in perimeter walls to allow the flow of surface water and flood storage up to the level of the 1% AEP flood is recommended for developments within flood affected properties.

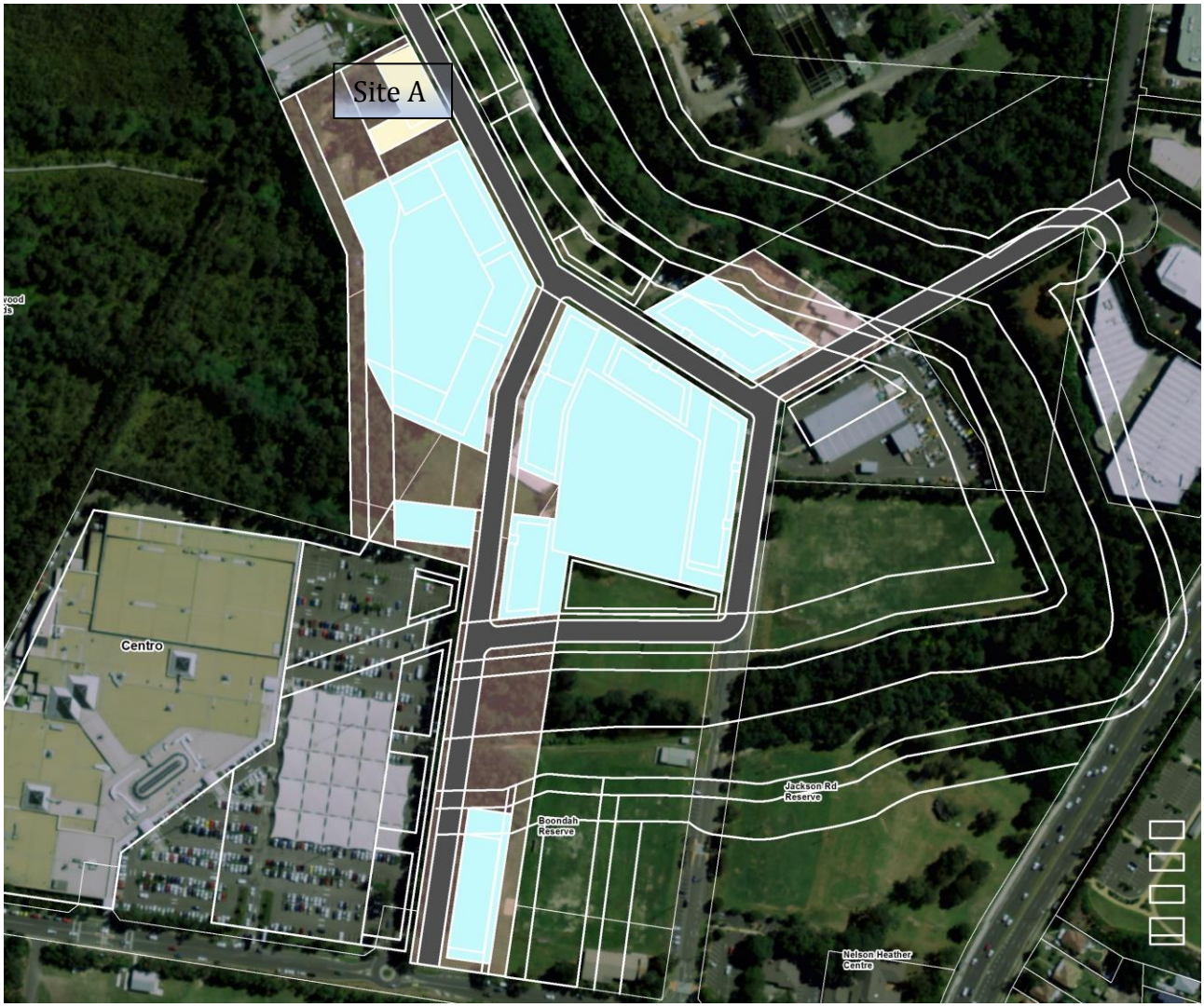

Figure 3: Suspended Flood Levels (blue)

Cut and Fill:

The proposed development will incorporate suspended floor levels within the building areas to maintain the existing flood storage. Each of the building areas, except for site A (refer to figure 3) will incorporate the residential parking above the PMF levels with the flow though openings incorporated into the commercial parking areas. Site A has a relatively small footprint and residential parking will be located below the PMF levels but will be tanked to provide protection from flood waters, as a result the building will not incorporate flow through openings. Furthermore the proposed roads within the development will be lifted to provide flood free access. There may be some losses in the flood storage that could be managed by providing additional cut in the flood storage areas.

To ensure no net loss of floodplain storage below the 100 year ARI 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 4).

The fill/cut strategy would results in no net loss in existing flood storage compared with the volume of floodplain storage in the developed scenario below the 100 year ARI 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.

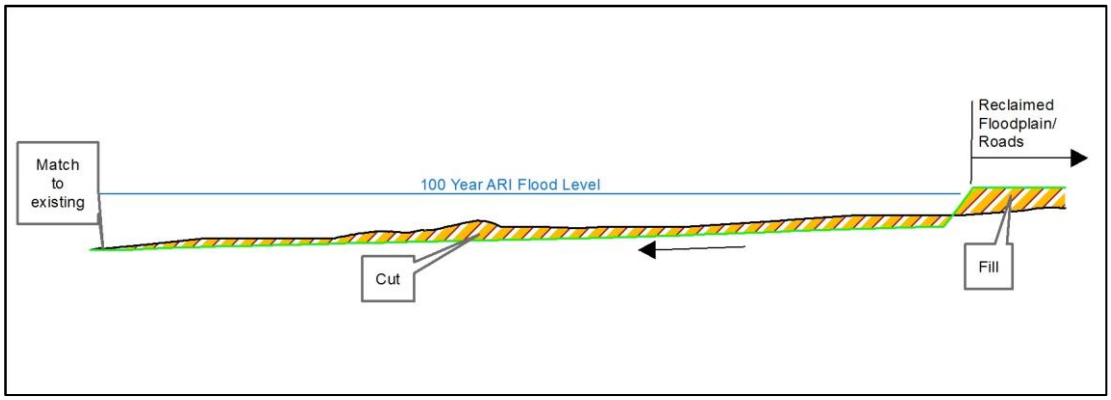

Figure 4 Schematic Representation of Cut and Fill Strategy

4.0 Flow Conveyance

For the minor storm events the flows are conveyed with the creek and directed to the culvert beneath Centro. The proposed development will maintain the conveyance through the creek within the riparian zone and setbacks.

Figure 5 identifies the 5 year ARI floodway, flood fringe and flood storage as presented in the Cardno flood study (2005). The dark purple shows the floodway, where the flow is conveyed within the creek

banks. The proposed development does not encroach on the 5 year ARI floodway area and therefore maintains the existing flood conveyance.

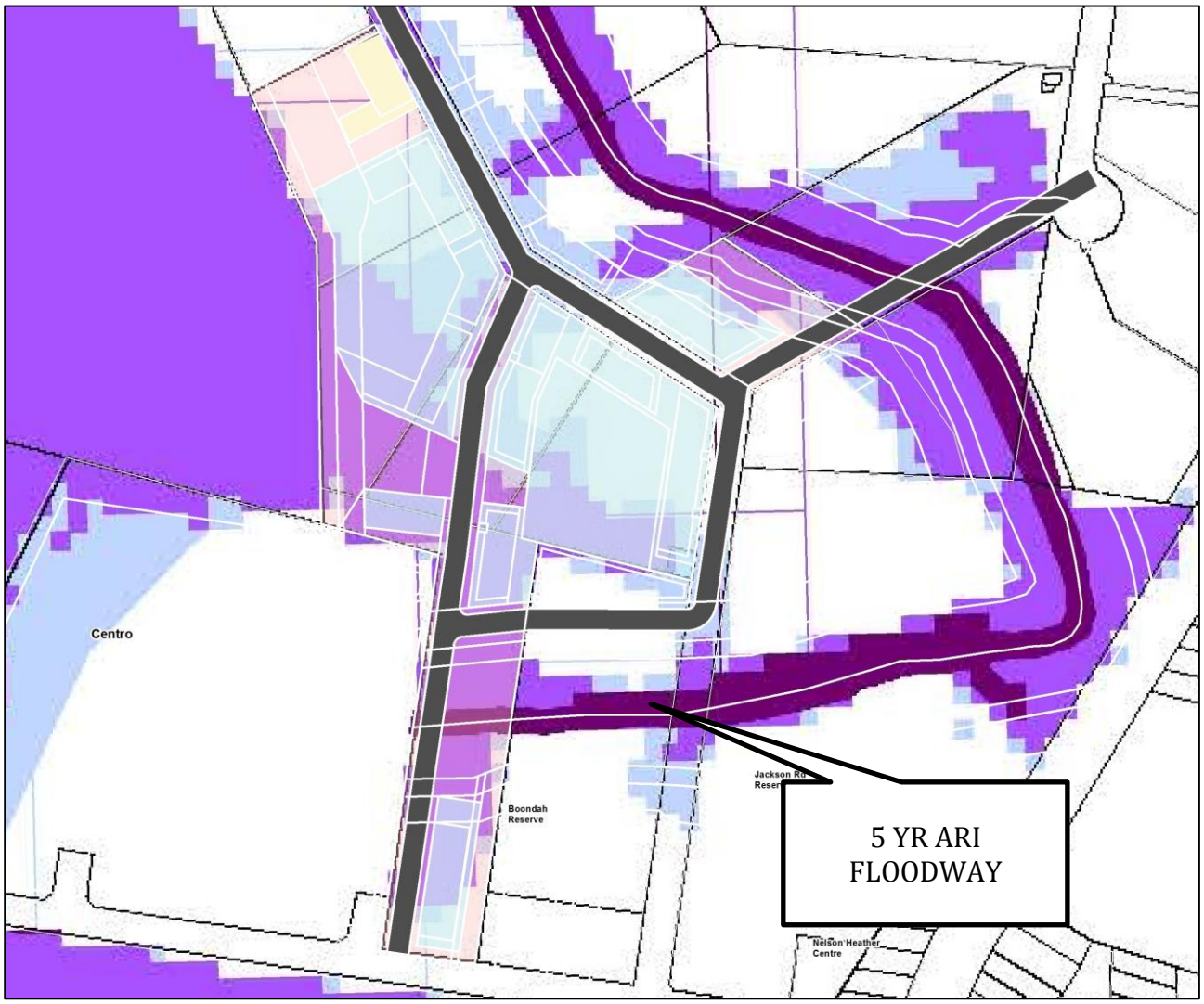

Figure 5 5 Year ARI flood way and flood storage

3.0 Emergency Response Planning:

The proposed suspended floor levels and proposed filling scenarios results in the property and roads being above the 100 year ARI plus climate change and the PMF level. Flood evacuation will be through the upgrade of Boondah Road and the further road upgrades as part of the implementation of the Warriewood Valley evacuation strategy.

During an extreme rainfall event, the intensity of rainfall as well as other factors (wind and debris etc.) may make driving either difficult or potentially more dangerous than shelter in place. The proposed development provides flood free floor levels for the provision of shelter in place if necessary.

5.0 Conclusion

The proposal indicates that the site can be developed with no loss in temporary flood storage through use of suspended floor levels and cut/fill options.

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.

Yours sincerely
Brown Consulting (NSW) Pty Ltd

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 occurrence 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 (2011) study identifies the PMF (+CC) flood level of 4.5m 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

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*