Our Ref: 80017026-L02:BCP/bcp
Contact: Dr Brett C. Phillips

10th August 2018

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The Manager
Scentre Design & Construction Pty Ltd
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Attention: Mr Wail Thomas

Dear Wail,

UPDATED FLOOD IMPACT ASSESSMENT OF WESTFIELD WARRINGAH MALL PROJECT – STAGE 2 REDEVELOPMENT

Cardno has been engaged by Scentre Design & Construction to assist in the preparation of a Development Application for Westfield Warringah Mall Stage 2 project for The Northern Beaches Council. The project is the second stage of the Westfield Warringah Mall Project comprising of the redevelopment and refurbishment of the existing Westfield shopping complex. The purpose of the project can be summarised as follows:

1) Stage 1 (not part of this scope) – Parallel Fashion Mall is an existing shopping centre with approximately 125,000m^2 Gross Leasable Area (GLA) over multiple storeys including 4,322 car spaces. This section has been completed under the previous develop application DA2008/1742 to add an additional:

    - 8,000m^2 GLA.
    - 328 car spaces.

2) Stage 2 – Hospitality, Lifestyle and Entertainment is the second stage of redevelopment for Westfield Warringah Mall. Scentre Group Design & Construction is seeking Development Application approval for modifications and additions to the mall including adjustments to the existing on grade car park that will facilitate:

    - Existing GLA: 136,220m^2 and Incremental GLA: 9,845m^2.
    - Cars will be provided in a Ratio 4:1 Car/100m^2 GLA ca. 400.
    - Rebuilt Cinema Complex.

This Flood Impact Assessment has been prepared on behalf of Scentre Design & Construction seeking Development Application Approval for Westfield Warringah Mall Project – Stage 2 Redevelopment.

This report is to be read in conjunction with Cardno's Concept Design drawings for Westfield Warringah Stage 2 DA and the Stormwater report which outlines the proposed stormwater drainage network for the proposed on-grade car park, loading dock, water quality controls and the erosion and sediment control plan.

1. SITE DESCRIPTION

1.1 Location

Westfield Warringah Stage 2 development is located on the eastern side of the existing Warringah Mall next to the intersection of Condamine Street and Pittwater Road, Brookvale. The development site is currently used as an on-grade carpark and businesses. Figure 2-1 shows the extent of works in Westfield Warringah Mall Stage 2.

Figure 1 Extent of Westfield Warringah Stage 2 Development (after (Nearmap 2017)

1.2 Proposed Development

Scentre Design & Construction is seeking Development Approval for an on-grade car park and development of facilities for additional Gross Leasable Area that connects into the existing mall, currently undergoing redevelopment, which will facilitate for the following:

1) Existing GLA: 136,220m^2 and Incremental GLA: 9,845m^2.

   GLA incremental break up:

   - Specialty 1,195 sqm
   - Food Shops 575 sqm
   - Restaurant 2,150 sqm
   - Mini Major 9,480 sqm
   - Major -2,010 sqm
   - Lifestyle, others -1,545 sqm

2) Cars will be provided in a Ratio 4:1 Car/100m^2 GLA ca. 400.

3) Rebuilt Cinema Complex.

2. PREVIOUS STUDIES

Warringah Mall is a major regional shopping centre located within the Brookvale Creek catchment in the Sydney's northern suburbs. Prior to 2004 it was identified that under existing conditions Warringah Mall is flooded by overland flows and overflows from Brookvale Creek in major storms.

The land uses within the Brookvale Creek catchment include residential and industrial/commercial developments as well as a significant area of bushland known as Allenby Reserve (see **Figure 2**).

The 2006 Peninsula Industrial Estate Floodplain Management Study assessed flooding under existing conditions and the merits of a number of structural management options that could achieve a balance between reducing flood hazard and flood damages and protecting the environment of the Brookvale Creek floodplain.

In December 2006 Warringah Council requested an assessment of options for the Warringah Mall site that did not have any liability costs for Council. A 2007 report titled Managing Flooding of Warringah Mall assessed four schemes (Cardno Willing, 2007). Schemes 1 and 2 were based on constructing a basin in Allenby Reserve on alternative sites plus limited drainage augmentation works in the Peninsula Industrial Estate. Schemes 3 and 4 were Schemes 1 and 2 plus additional drainage augmentation works in Warringah Mall respectively. A multi-criteria assessment of the four schemes concluded that Scheme 3 achieved the greatest reductions in the estimated population at risk and flood damages in the Peninsula Industrial Estate, Warringah Mall and the at-grade car parks. A key component of Scheme 3 was the proposed Allenby Reserve Basin (Option A2).

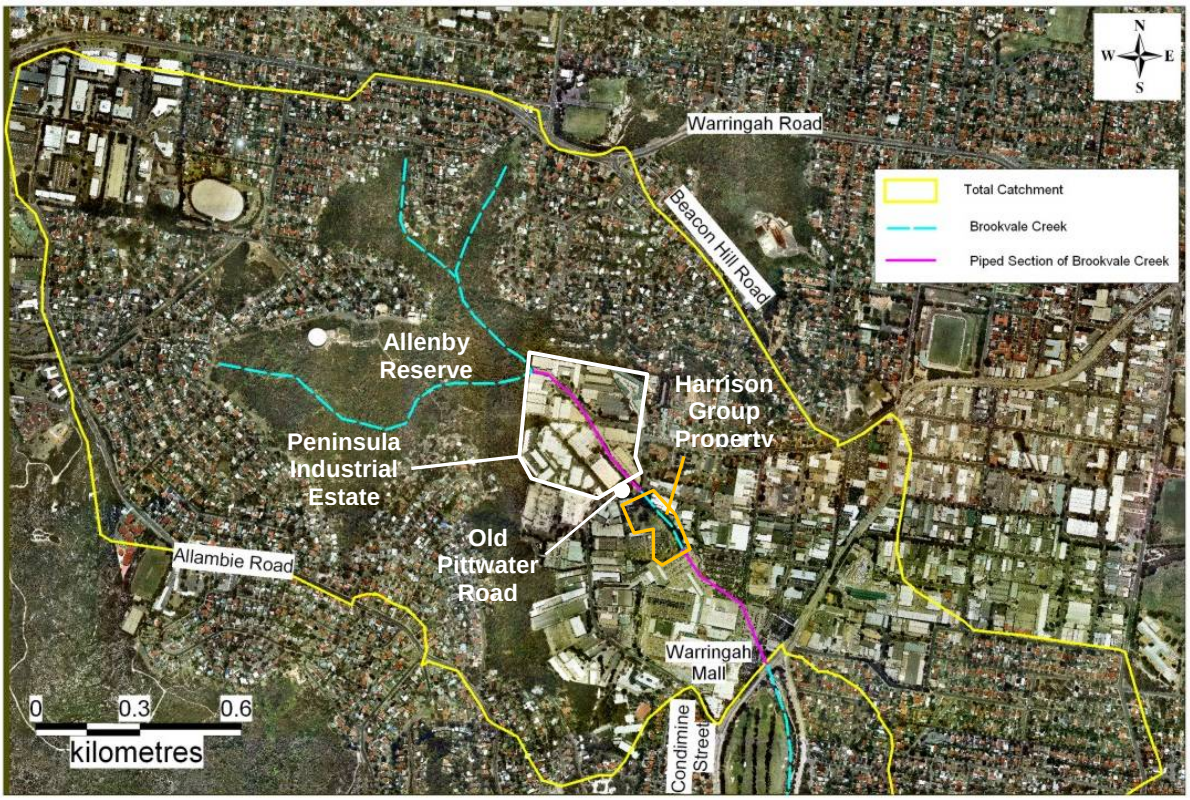


Figure 2 Open and Piped Reaches of Brookvale Creek and its Catchment

However Warringah Council advised that it would not support Scheme 3 because in its view the public benefits did not outweigh its concerns regarding the location of the basin within the reserve and its potential adverse environmental impacts. Consequently the co-owners of Warringah Mall need to implement a scheme of works within Warringah Mall that reduces overland flooding along the primary overland flowpath during a 100 yr ARI event to a Low Hazard rating without any upstream works.

Subsequently, in December 2008 a report titled Warringah Mall Flood Impact Assessment was submitted to Council as part of a series of documents supporting two Development Applications that were submitted to Council (Cardno Willing, 2008). These Development Applications covered proposed stormwater augmentation works within the Warringah Mall site and as part of a First Stage Retail development.

In April 2009 Council engaged an external Peer Reviewer to review the hydrological and hydraulic assessments and the proposed stormwater augmentation stormwater works. The floodplain model was updated in accordance with discussions with Council and its Peer Reviewer and the sensitivity of 100 yr ARI flooding at Warringah Mall to inlet blockage, pit losses and works proposed for the Palm Tree Car Park was tested. The final values of floodplain model parameters were agreed as part of the peer review process. The final model was then run to identify final amendments to the augmentation works to meet Council's requirements.

2.1 Flood Behaviour prior to DA1741 and DA1742

As discussed by MHL, 1992 and Webb McKeown, 2001 there are no recorded streamflow data for Brookvale Creek. Likewise there are no water level recorders within the study area. A very limited number of observed flood levels were available for historical major rainfall events in March 1975, March 1977, February 1986, January 1989 and April 1992.

Almost all of the historical flood levels were observed at a single location within the Harrison Group property located at 71-79 Old Pittwater Road located immediately upstream of Warringah Mall (see **Figure 2**).

2.1.1 Hydrology

The hydrological analyses undertaken previously included the:

- Collation and review of historical storms and flood events in the Brookvale Creek catchment;
- Calibration of a previously assembled hydrological model (**xprafts**) of the catchment against historical data when available and against estimates of historical peak flows reported by Webb McKeown & Associates, 2001;
- Estimation of historical peak flows at key locations in the Brookvale Creek catchment in order to assess the severity of historical storms in comparison with design storms. The inferred severity of a number of historical storms was as follows: March 1975 (20 yr ARI), March 1977 (2 yr ARI), February 1986 (5 yr ARI), January 1989 (20 yr ARI) and April 1992 (10 yr ARI);
- Estimation of design flood hydrographs at key locations in the Brookvale Creek catchment for the 20yr ARI, 50yr ARI, 100yr ARI, 10,000yr ARI, 100,000 yr ARI and Probable Maximum Flood (PMF) events for input into the floodplain model, and the
- Assessment of a number of basin options.

2.1.2 Hydraulics

A unified 1D and 2D **xpswmm2D** model of the Brookvale Creek floodplain including the drainage systems and overland flowpaths between Kentwell Road (located around 800 m downstream of Candamine Street) and Allenby Reserve (upstream) was assembled. The Brookvale Creek channel between Old Pittwater Road and Warringah Mall through the Harrison Group property (refer Figure 1) was also modelled as a 1D section linked to the 2D floodplain to provide better definition of the channel geometry.

Within the limits of the available information the model was calibrated using available historical flood levels. This model was then run to estimate the flood levels and flow velocities at key locations on the Brookvale Creek floodplain for the 20 yr ARI, 50 yr ARI, 100 yr ARI, 10,000 yr ARI, 100,000 yr ARI and PMF design storms design storms under existing conditions and 20 yr ARI, 50 yr ARI, 100 yr ARI design storms with various flood mitigation measures in place.

2.1.3 Calibration

The hydrological model was not calibrated directly against historical flow data but was instead compared with historical flood estimates. Similarly the hydraulic model was only calibrated against flood levels observed at a single location as summarised in **Table 1**. Where appropriate the models were configured so as to be consistent with previous models. Similar model parameters and values were adopted where appropriate.

The estimated 100 yr ARI design flood depths under existing conditions are presented in **Figure 3**.

Table 1
Comparison of Observed and Predicted Historical Flood Levels at 71-79 Old Pittwater Rd

		Estimated Peak Flood Level (m AHD)			
Storm	**Recorded Peak Flood Levels (m HAD)**	2001 Study	Difference (cm)	2007 Study	Difference (cm)
Apr-92	12.78 m AHD	12.6 - 12.7	- 17 to -7	12.80	+ 2
Jan-89	12.82 m AHD (after Powter, 1989	12.7 - 12.9	-12 to +8	12.75	-7
Feb-86	12.37 m AHD (after Powter, 1989) 12.44 m AHD (after W L Blackhouse, 2000)	12.2 - 12.4	-24 to +3	12.50	-13 to - 6
Mar-77	12.80 m AHD (after Powter, 1989)	12.2 - 12.3	-67 to -50	12.40	-47 to -40
	12.87 m AHD (after W L Blackhouse, 2000)				
Mar-75	13.03 m AHD (after Powter, 1989)	12.8 - 12.9	-23 to -13	12.85	- 18

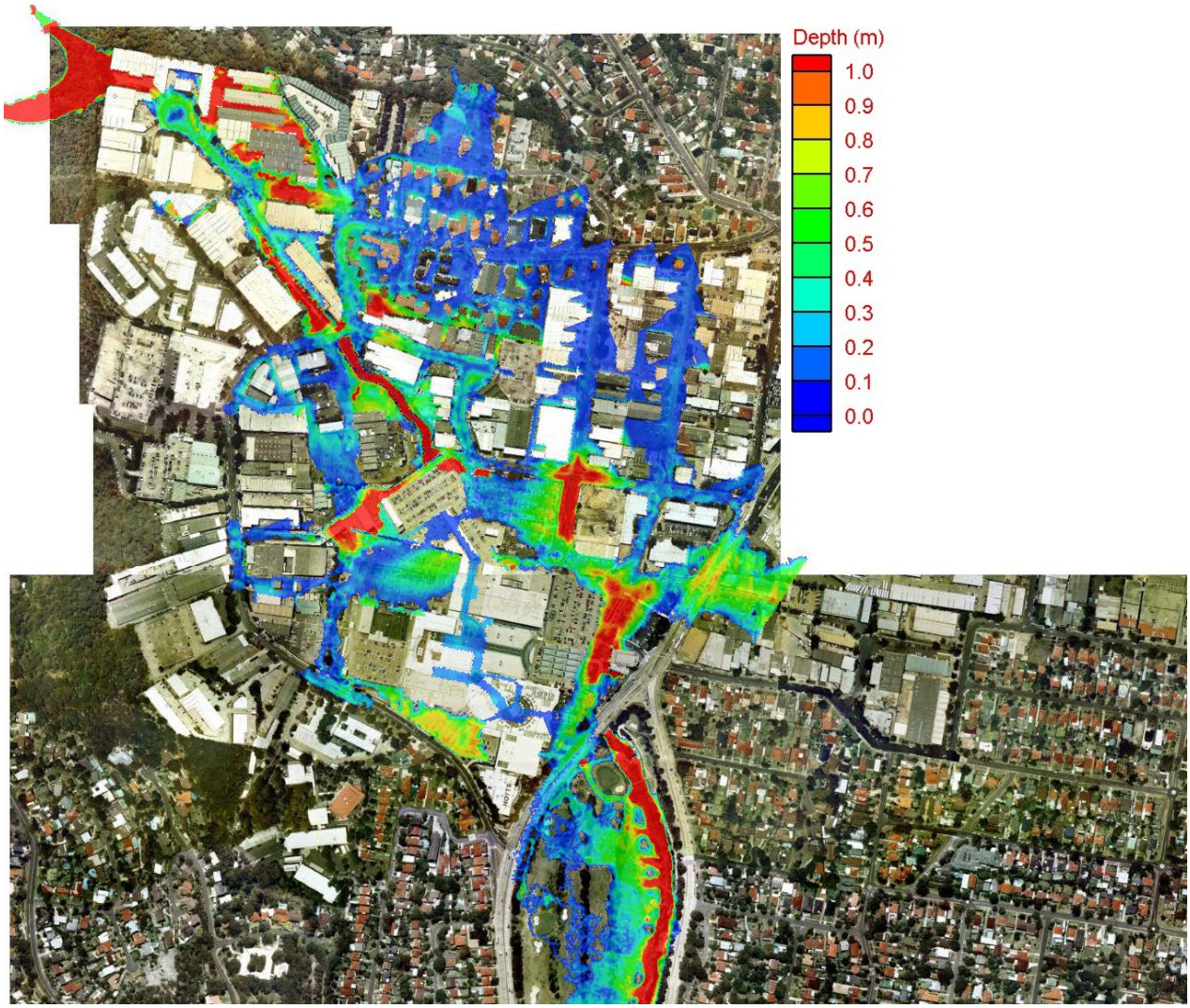


Figure 3 100 yr ARI Flood Depths under Existing Conditions

2.2 Stormwater Augmentation

A proposed augmentation scheme is described in Cardno Willing, 2008. The 2008 scheme evolved based on consideration of the need to minimise flood impacts on the land adjoining the upstream boundary of Warringah Mall (the Harrison Group property) and the need to minimise or if possible eliminate the need for any augmentation works on the adjoining upstream property to direct overflows from Brookvale Creek into the augmentation scheme. Other considerations included (refer Figure 3):

- The need to reduce the frequency of overland flows spilling from Cross Street and then down the access road to the Woolworths loading dock;
- The need to eliminate the overland flows that enter the Starfish (now Blue) Car Park under 2008 Conditions in events up to the 100 yr ARI event and if possible under climate change;
- Identification of a preferred alignment within the constraints of existing and/or planned development on the Warringah Mall site;
- Avoidance as far as possible of the relocation of any existing services;
- Likely constraints on the construction of a crossing under Condamine Street;
- Potential flooding impacts downstream of Condamine Street; and
- The footprints of future development identified in the Masterplan for Warringah Mall.

The stormwater augmentation scheme proposed in 2008 is presented in **Figure 4**.

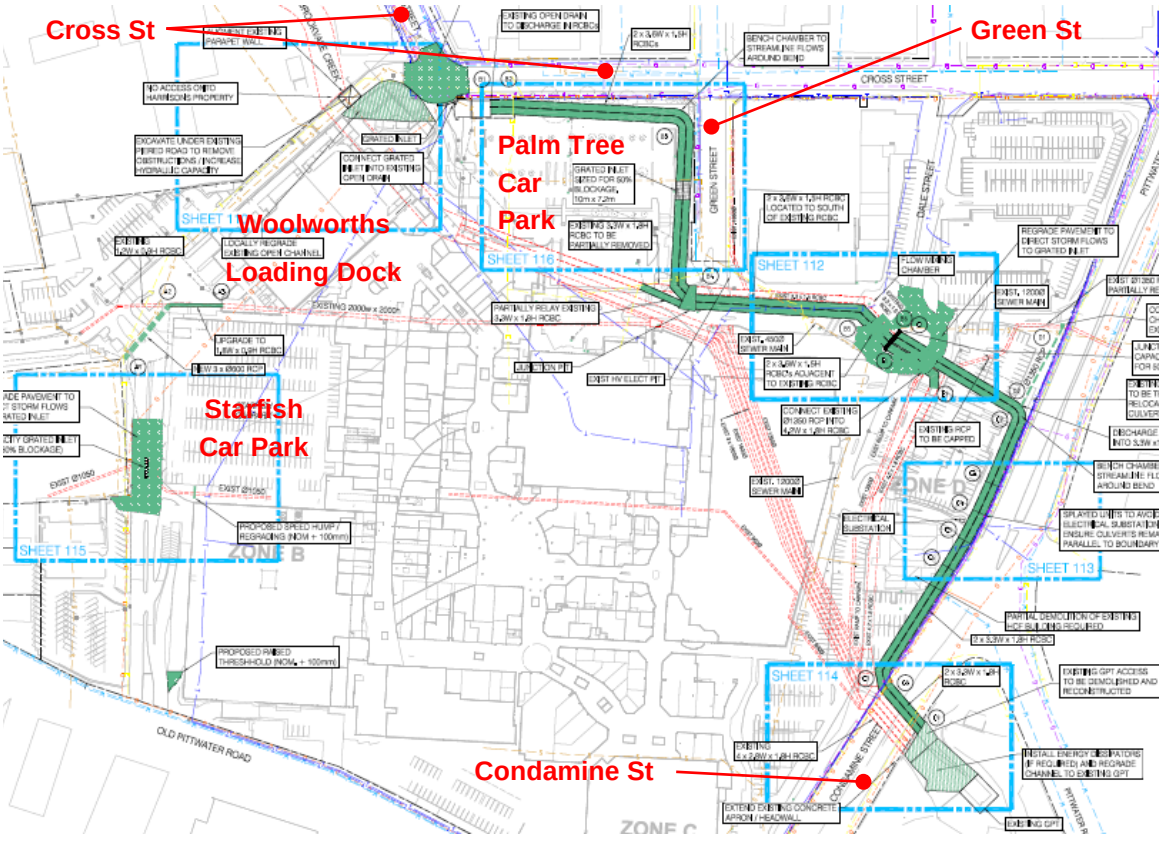


Figure 4 2008 Proposed Stormwater Augmentation Works (shown in green)

2.2.1 Sensitivity Testing

In response to requests from the then Warringah Council and Council's Peer reviewer the testing of the sensitivity of 100 yr ARI flood behaviour was undertaken in respect of the following matters:

- Different design storm burst durations (1.5 hour, 2 hour and 3 hour bursts) as well as a 9 hour storm burst to assess the effect on known flood ponding areas within the floodplain eg. upstream of Old Pittwater Road crossing (refer Figure 1), Green Street (refer **Figure 4**), etc;
- Penetrations of the existing culvert upstream of Old Pittwater Road;
- Partial blockage of the inlets and proposed overflow structures on Brookvale Creek located on the upstream boundary of Warringah Mall;
- Partial blockage of the culvert inlet located on the eastern boundary of Allenby Reserve (see **Figure 2**);
- Partial blockage of the inlet to the proposed additional culverts to be constructed around the northern and eastern sides of the Palm Tree (now Green) Car Park (refer **Figure 4**);
- Adjustment of the roughness values for residential areas;
- Adjustment of losses at major drainage structures within Warringah Mall;
- Proposed details of the new entries to a planned multi-storey Palm Tree (now Green) Car Park ; and
- Proposed details for landscaping over the additional culverts to be constructed around the northern and eastern sides of the Palm Tree (now Green) Car Park (refer **Figure 4**)

Other sensitivity testing that was requested by AMP Capital Investors was to test the impact of removal of a further section of the parapet wall at the upstream end of Warringah Mall with 50% and 0% blockage.

A total of 18 sensitivity runs were undertaken using the hydraulic model of the proposed Stormwater Development Application (DA) measures.

It was concluded that the 1.5 hour storm burst gave slightly higher peak 100 yr ARI flood levels at most locations in comparison with the 2 hour, 3 hour and 9 hour storm bursts. The 1.5 hour storm burst was adopted as the benchmark for all subsequent assessments.

The penetrations of the existing culvert upstream of Old Pittwater Road were found to have minimal impact on the estimated 100 yr ARI flood levels downstream of Old Pittwater Road.

It was concluded that nil blockage conditions give the greatest lowering of 100 yr ARI flood levels in Brookvale Creek while partially increasing flood levels in Green Street. Conversely, partial blockage of the culvert inlet on Brookvale Creek and of the overflow outlet and the slot in the parapet wall only partially lowers 100 yr ARI flood levels in Brookvale Creek while partially lowering the flood levels in Green Street.

It was concluded from these runs that increasing the losses in major chambers would generally increase 100 yr ARI flood levels in Warringah Mall by up to 4 cm and in Green Street by up to 24 cm.

It was concluded that increasing the total length of the parapet wall that is lowered to 10 m (from 5 m) has a small effect on 100 yr ARI flood levels within Warringah Mall while in Green Street the local increase could be up to 4 cm.

Based on the outcomes of the sensitivity tests the hydraulic model of the Stormwater DA conditions was adjusted as follows:

- the inlet and outlet loss coefficients on several conduits in several key structures were adjusted;
- the total length of the parapet wall that is to be lowered was increased to 10 m (from 5 m).

Two runs were then undertaken for the 0% blockage scenario (Run 19) and the 50% blockage scenario (Run 20). It was concluded from these runs that in comparison with 100 yr ARI flood levels under Existing Conditions (with the same degrees of blockage) that the Stormwater DA works:

- Lower the 100 yr ARI flood levels downstream of Old Pittwater Road on average by up to 8 cm;
- Decrease the 100 yr ARI flood levels in Green Street by around 45 cm; and
- Lower the 100 yr ARI flood level in Brookvale Creek immediately upstream of Warringah Mall by up to 67 cm (depending on the degree of blockage of the culvert entry);
- Has a minimal impact on 100 yr ARI flood levels downstream of Condamine Street.

Based on discussions at a meeting with Council and Council's Peer Reviewer held in November 2009, it was agreed that Runs 19 and 20 were to be adopted as the basis for any final assessments of the Stormwater DA and/or First Stage Retail schemes which would include any additional measures to meet Council's required freeboard at entries to Warringah Mall.

2.2.2 Flood Impact Assessment

The flood depths, velocities and flood hazards for the 100 yr ARI design storm under the amended Stormwater DA conditions were assessed and the 100 yr ARI flood depths and flood hazards are given in **Figures 5** and **6** respectively.

The intent of the works in the vicinity of the Cross Street car park is to provide locally at least 300 mm freeboard above the local 100 yr ARI flood level to protect the entry to Woolworths from the Palm Tree (now Green) Car Park. It is proposed to construct a low wall around the edge of the existing open section of an engineered waterway to 11.15 m AHD and to tie this low wall into the raised entry hump and proposed landscape mound(s) to prevent floodwaters in Cross Street from outflanking these works (refer **Figure 4**).

The flood impact assessment confirmed that the 300 mm freeboard would be achieved opposite the Cross Street roundabout in accordance with Council's requirement.

The intent of the works proposed on the boundary of the Starfish (now Blue) car park (refer Figure 3) is to exclude overland flows from the car park and instead to confine overland flows to the existing roads. It was concluded from the flood impact assessment that the 500 mm freeboard would be achieved opposite the Starfish (now Blue) car park in accordance with Council's requirement for any new development.

Figure 5 100 yr ARI Flood Depths under Amended Stormwater DA Conditions

It was also concluded from the results of the assessment of the proposed amended Stormwater DA that the augmentation works provide a significant beneficial reduction in flood levels and overland flows within Warringah Mall and a beneficial reduction in flood hazard and risk posed to persons visiting or working within Warringah Mall. In a 100 yr ARI event the augmentation works:

- Succeed in excluding overland flows from the retail areas within Warringah Mall;
- Reduce flood levels in Brookvale Creek from Warringah Mall upstream to Old Pittwater Road;
- Lower the 100 yr ARI flood level in Green Street by up to 57 cm;
- Reduce overland flooding along the primary overland flowpath through the external car parks of Warringah Mall and its associated internal roads and reduce the overland flows to Low Hazard throughout Warringah Mall except for a small section of the access road connected to Pittwater Road (north of the Castle (now Red) Car Park) in accordance with Council requirements;
- Provide at least 300 mm freeboard to the entries to Warringah Mall from the Palm Tree (now Green) Car Park and at least 500 mm freeboard to entries to Warringah Mall from the Starfish (now Blue) Car Park in accordance with Council requirements; and
- Increase flood levels by up to 3 cm only in the Warringah Golf Course immediately downstream of Condamine Street.

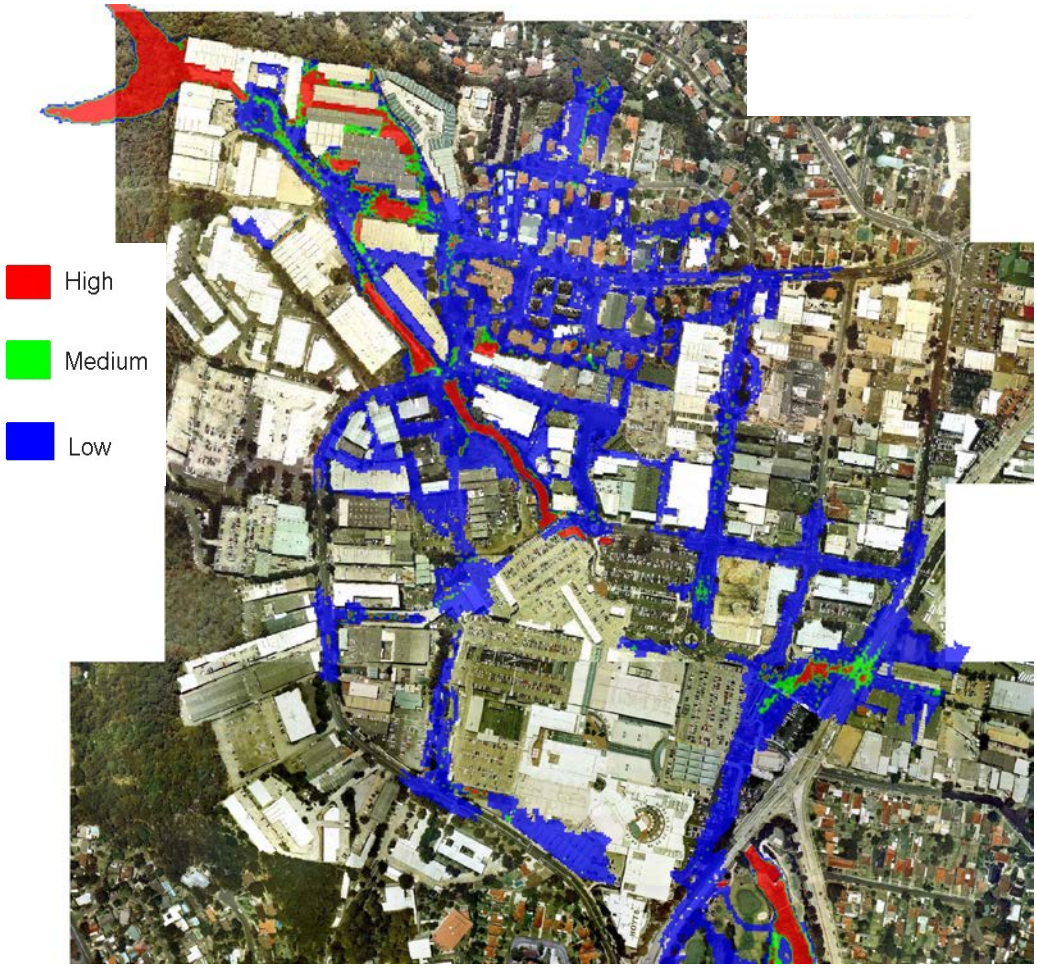


Figure 6 100 yr ARI Flood Hazards under Amended Stormwater DA Conditions

2.3 Physical Model Studies

This scheme further evolved to respond to opportunities presented by subsequent planned development for Warringah Mall and to services constraints identified on the site. The stormwater augmentation scheme proposed in 2013 (shown in green) is presented in **Figure 4** while the locations of Chambers B4 and B6 are presented in **Figure 7**.

In 2014 detailed consideration of the outcomes of physical modelling of Chambers B4 and B6 (refer **Figure 7**) and the interaction of the proposed works with other services, the feasibility of relocating services at the southern end of Green Street, traffic management during construction, construction sequencing and potential hydraulic impacts during construction led changes to the 2013 scheme including changes to the Condamine Street crossing and re-alignment of the new stormwater culverts through the Bing Lee site. The 2014 stormwater augmentation scheme is presented in **Figure 8**.

2.3.1 Chamber C6 Physical Model Study

In 2015 stormwater was conveyed by 1 x 4.2 m (W) x 1.8 m (H) + 2 x 1350 mm diameter conduits + 1 x 1500 mm diameter conduit + 3 x 1.8 m diameter conduits + 1 x 900 mm diameter conduit discharges into a large chamber (Chamber C6) which in turn discharged into 4 x 2.8 m (W) x 1.8 m (H) culverts which conveyed stormwater under Condamine Street and into the Brookvale Creek GPT. As part of planned augmentation works it was proposed to connect two new 3.3 m (W) x 1.8 m (H) culverts into a re-constructed Chamber C6 (refer **Figure 8**) and to lower the two central culvert under Condamine Street by up to 1.0 m.

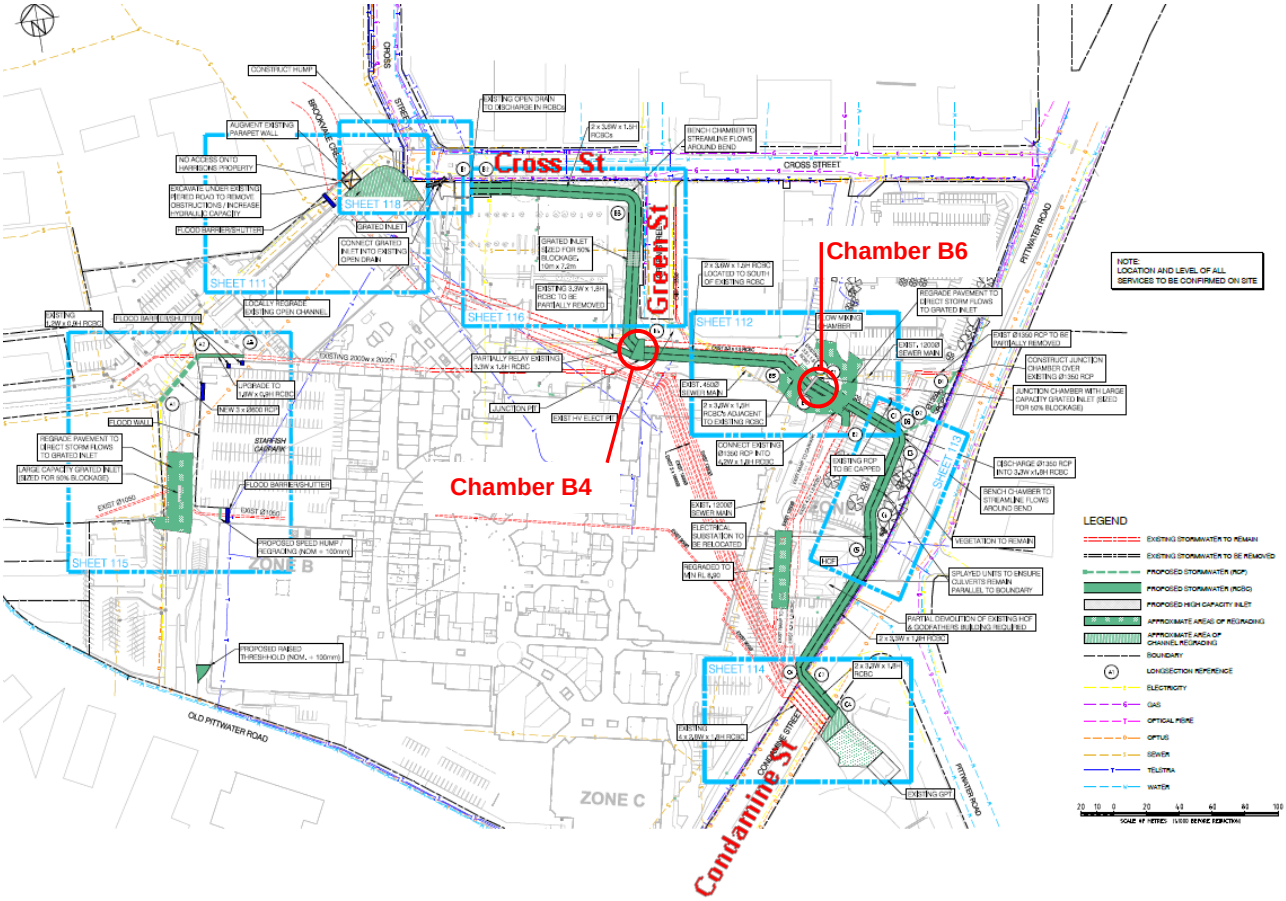


Figure 7 Location of Chambers B4 and B6

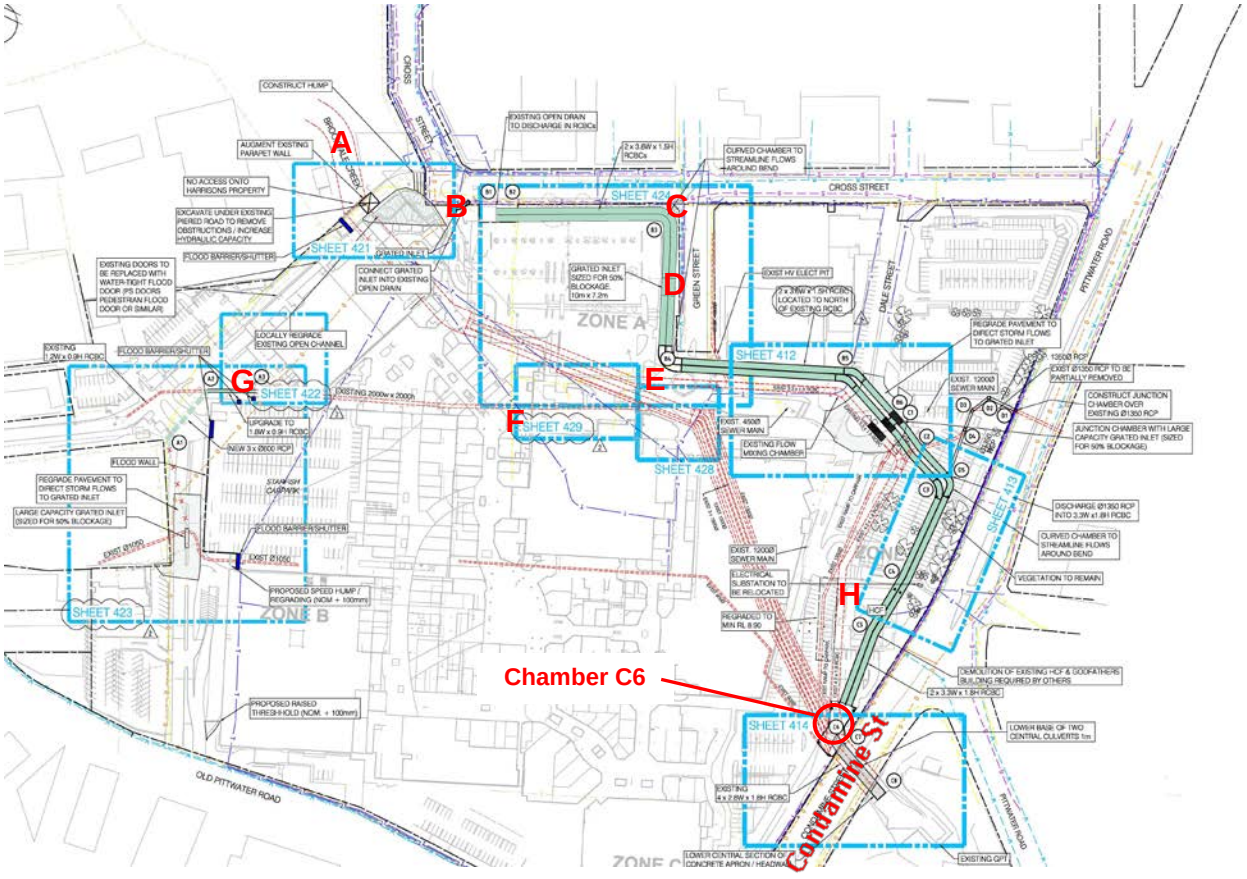


Figure 8 Location of Chamber C6

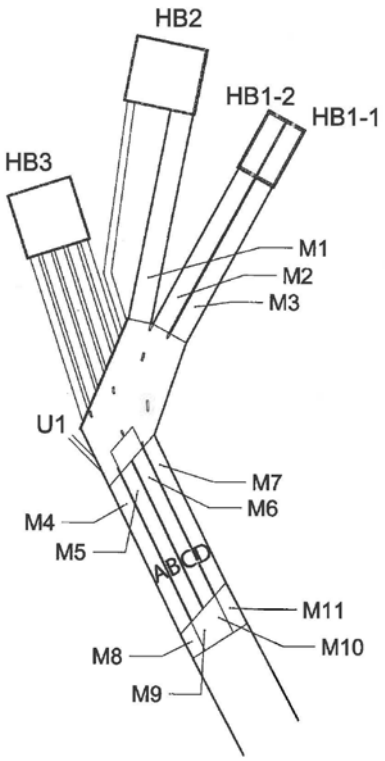


Figure 9 Chamber C6 Physical Model Layout and Location of Manometer Tapping Points (after WRL, 2015)

One of the conditions of consent required a physical model study of Chamber C6 and the Condamine Street crossing to confirm the hydraulic losses which were assumed in the computer model studies and to provide advice on how the hydraulic losses in Chamber C6 can be minimized.

The Physical Model

Prior to constructing the physical model the layout of Chamber C6 was reviewed and adjusted to further streamline flows through the chamber and to reduce hydraulic losses. The model layout is given in **Figure 9**.

A Froude scale of 16.3: 1 was used for this model and **Table 1** summarises the various scaling ratios. This precise scale was adopted to best match the prototype pipes to available acrylic pipe diameters. The scale provided flow depths that could be accurately measured and ensured that head losses had suitable resolution. The culverts have a relatively flat grade in some parts and the scale ensured that frictional and surface tension effects did not become dominant. At this scale, the form losses and turbulence were accurately represented. This scale ensured that maximum prototype flow rates were achievable, with total prototype flow of 70.3 m^3/s being represented by 65.5 L/s in the model.

Table 1 Model Scaling Ratios

Ratio	Symbol	Formula	Value
Length ratio	L_R	16.3	16.3
Time ratio	T_R	$L_R^{0.5}$	*4.04*
Velocity ratio	V_R	$L_R^{0.5}$	*4.04*
Flow ratio	Q_R	$L_R^{2.5}$	*1073*

The model was constructed with a marine plywood base and acrylic walls and roofs for culverts and the chamber. Acrylic pipes were used for all pipe inlets. In parts of the model an expanded PVC base was used in order to allow for raising and lowering of the invert level for design modifications.

Five separate water supplies were applied to the model to supply the ten separate inflows to chamber C6. Two head boxes (HB1-1 and HBl-2) were constructed to control the flow into the proposed twin culverts (U9 and Ul0) upstream of chamber C6 with one head box for each culvert. One head box (HB2) was constructed to control the flow into the existing culvert (US) and the easternmost pipe (U7). One head box was constructed to control the flow into the five central pipes (U2-U6).Inflow into the westernmost pipe (Ul) was not controlled with a head box and was piped directly into the model.

Testing was carried out under five different steady state inlet boundary conditions and two different tailwater boundary conditions, based on hydrograph data provided by Cardno.

Physical Model Cases

Four design configurations were tested, starting with Cardno's proposed alternative to the DA approved scheme and proceeding with three successive modifications to this design. The designs are outlined as follows.

> The **Case 1** model was constructed as per the initial designs provided by Cardno, being the initial proposed alternative to the DA approved design. It involved a reconstructed C6 chamber and the lowering by 1.0 m of: the invert level of the two central culverts under Condamine Street; a small section upstream of these culverts inside C6; and downstream of these culverts on the apron.
>
> **Case 2** tested lowering the same area as in Case 1 by 740 mm (as opposed to 1.0 m in Case 1) to allow for a blinding slab to cover construction joints in the lowered culverts.
>
> **Case 3** considered increasing the size of the lowered section inside chamber C6, including the area upstream of the two outer culverts (the culverts themselves were not lowered). The extent of lowering remained 1.0 m, as in Case 1. Figure 10a presents the Case 3 flow conditions observed under peak flow conditions at the tailwater level WL1.
>
> **Case 4** was a final option where the size of the lowered section inside chamber C6 was between that of Case 1 and Case 3. The depth of lowering was 740 mm. Figure 10b presents the Case 4 flow conditions observed under peak flow conditions at the tailwater level WL1

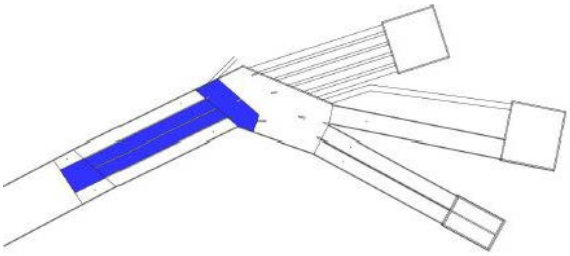
The physical model and the modifications to the initial model which were undertaken and tested are described in the 2015 UNSW WRL Report titled “Warringah Mall Chamber C6 Physical Model Study”.

Results

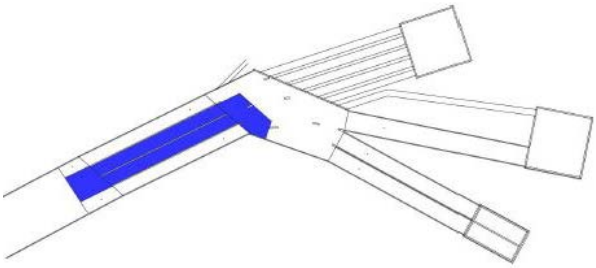
The model study concluded (WRL, 2015):

> *The best performing options were Case 3 and Case 4. Hydraulic losses in chamber C6 were minimised in Case 3 and flow in the Condamine Street culverts was most evenly distributed in Case 4.*

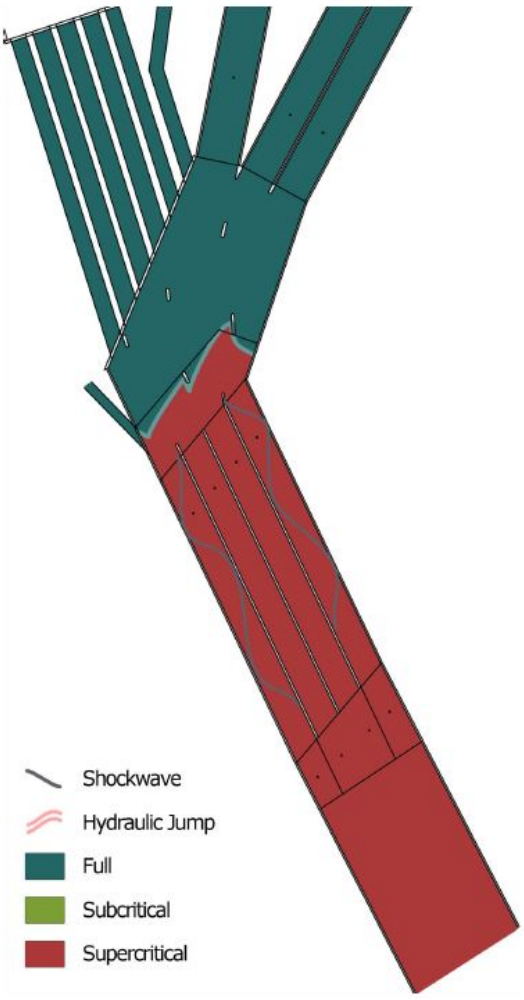
The total inflow cross sectional area was larger than the total outflow cross sectional area for chamber C6 in all cases. However, the physical model has demonstrated that the conveyance under Condamine Street is adequate due to the supercritical flow observed in these culverts. Further, it was found that any blockages downstream of the Condamine Street culverts {which are known to increase downstream levels by up to 0.5m) are unlikely to disrupt the supercritical flow in the culverts.



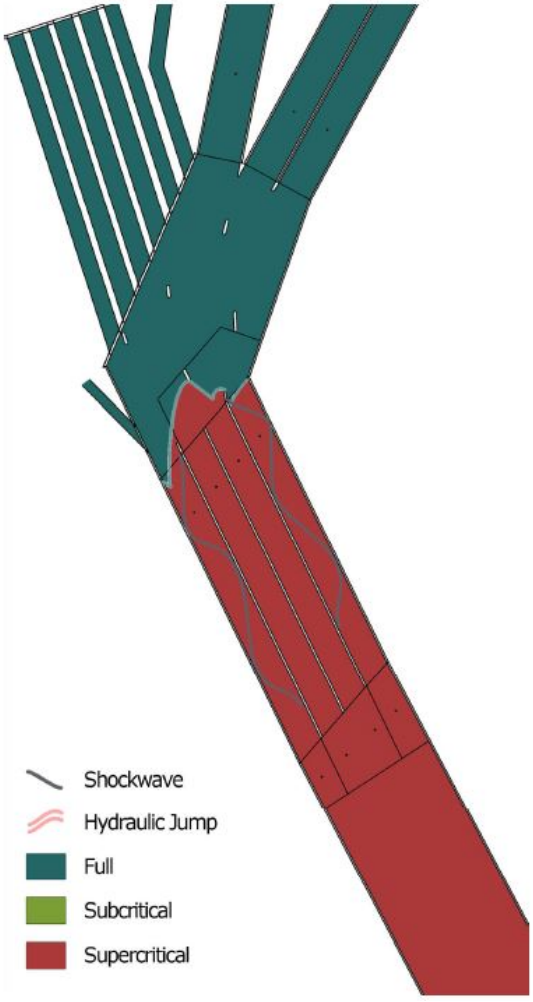
Case 3 Lowered Section in Blue



Case 4 Lowered Section in Blue



(a) Case 3 Peak Flow Conditions



(b) Case 4 Peak Flow Conditions

Figure 10 Observed Peak Flow Conditions in Chamber C6 and in Condamine Street Culverts (after WRL, 2015)

Warringah Mall Numerical Model

The Warringah Mall numerical model was modified to include nodes at Locations M1, M2 and M3 in order to compare the recorded and predicted heads (water levels) at these locations. It was found that the predicted heads at M1, M2 and M3 were all lower than observed. The numerical model at Chamber C6 was modified to match the observed flood levels at M1, M2 and M3 for Case 4 with 0% blockage flows which were adopted for the physical model tests. The comparison of the recorded and predicted heads (water levels) at M1, M2 and M3 are given in **Table 2.**

It was concluded that the modified model gave excellent agreement with the observed peak water levels and was suitable for estimating 100 yr ARI flood levels upstream and downstream of Chamber C6.

Table 2 Comparison of Peak Water Levels (m AHD) at Locations M1, M2 and M3 under Case 4 Conditions with 0% Blockage

Location	Observed WL (m AHD)	Predicted WL (m AHD)	Difference (cm)
M1	8.13	8.10	-3
M2	8.06	8.04	-2
M3	8.00	8.04	4

Table 3 Summary of Impacts of Model Reconfiguration at Chamber C6

Reference Point	In comparison to Previous DA1742 S96 Results	In comparison to Existing Conditions
Upstream of Warringah Mall (A)	Local increases of up to 7 cm	Still achieves a reduction in flood levels of up to 27 cm.
Cross St Roundabout (B)	No change	Local flood level is 10 cm lower
Intersection of Cross St and Green St (C)	Local increase of 3 cm.	Still achieves a local 73 cm reduction
Green St Low Point (D)	Local increase of 18 cm	Still achieves a local 72 cm reduction
Green St Roundabout (E)	Remains dry if two pit lids outside the Post Office are sealed or are raised to prevent surcharge	Substantial improvement as achieved by the previous DA1742 S96 scheme
DJ Loading Dock (F)	Local increase of 3 cm.	Up to a 58 cm reduction
Woolworths Loading Dock (G)	Local increase of 4 cm.	Substantial improvement as achieved by the previous DA1742 S96 scheme
Near Condamine St (H)	No more than 1 cm difference	

Results

The modified model was then re-run to estimate the 100 yr ARI flood levels under 0% and 50% inlet blockage scenarios. **Table 3** summarises the impacts of the model adjustments in the vicinity of Chamber C6 at locations of primary interest (refer **Figure 9**). While there have been some local increases eg. Green St low point it is our view that the local changes do not adversely impact on any adjoining properties and the Stormwater DA will deliver significant reductions in 100 yr ARI flood levels in areas of concern eg. Green Street low point.

3. FLOOD IMPACT ASSESSMENT

The floodplain model which was modified to include the proposed Stage 2 Redevelopment works was the Stormwater DA floodplain model described above.

3.1 Results

The estimated 100 yr ARI flood levels for both 0% and 50% blockage of key stormwater inlets under Stage 2 Redevelopment Conditions are plotted in **Figures 11** and **13** respectively. The 100 yr ARI flood level differences under Stage 2 Redevelopment Conditions benchmarked against DA1742 conditions for both 0% and 50% blockage of key stormwater inlets are plotted in **Figures 12** and **14** respectively.

As described in our previous assessments, Table A.5 from the 2010 Warringah Mall Flood Impact Assessment Addendum has been updated to include:

- The estimated 100 yr ARI flood levels for both 50% and 0% blockage of key stormwater inlets under Existing Conditions,
- Updated estimated 100 yr ARI flood levels under the Stage 2 Redevelopment for both 50% and 0% blockage of key stormwater inlets;
- Additional reference locations as follows:
  - Reference locations 221, 222 – DJ Loading Dock
  - Reference Locations 300 – 307 – Green St, Cross St and Dale St
  - Reference Locations 401 -404 – “Bus Deport” subcatchment east of Pittwater Road
  - Reference Locations 501-505 – Anchor Car Park / Coles Loading Dock

The locations of the reference points are given in **Attachment A**. The updated Table A.5 is given in **Attachment B**.

Two sets of drawings each comprising two sheets which map the flood level differences benchmarked against predevelopment conditions (prior to DA1741 or DA1742) upstream, within and downstream of Warringah Mall for the Stage 2 Redevelopment under 0% and 50% blockage scenarios are given in **Attachment C**.

4. CONCLUSIONS

It is concluded from the assessments that:

(i) The Stage 2 Redevelopment does not have an adverse impact on 100 yr ARI flood levels on any adjoining buildings;

(ii) It does have minor local impacts on 100 yr ARI flood levels in Dale Street;

(iii) There are local impacts on the 100 yr ARI flood levels in several locations within Warringah Mall eg. in the vicinity of the Chamber B6 inlets which are confined by the proposed re-grading works

(iv) To avoid any flooding in the vicinity of the new Hoyts complex entry it will be necessary to seal an existing surcharge pit in this area.

5. REFERENCES

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Manly Hydraulics Laboratory (1992) “Manly Lagoon Flood Study”, *Report MHL603*, prepared for NSW Public Works Department, June.

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Webb McKeown & Associates Pty Ltd (2001) “Warringah Mall Shopping Centre Stage 1 – Hydrologic Assessment”, *Draft Report*, August.

We would be pleased to further discuss our findings upon request.

Yours faithfully

Brett C. Phillips

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Dr Brett C. Phillips
Director, Water Engineering
for **Cardno**

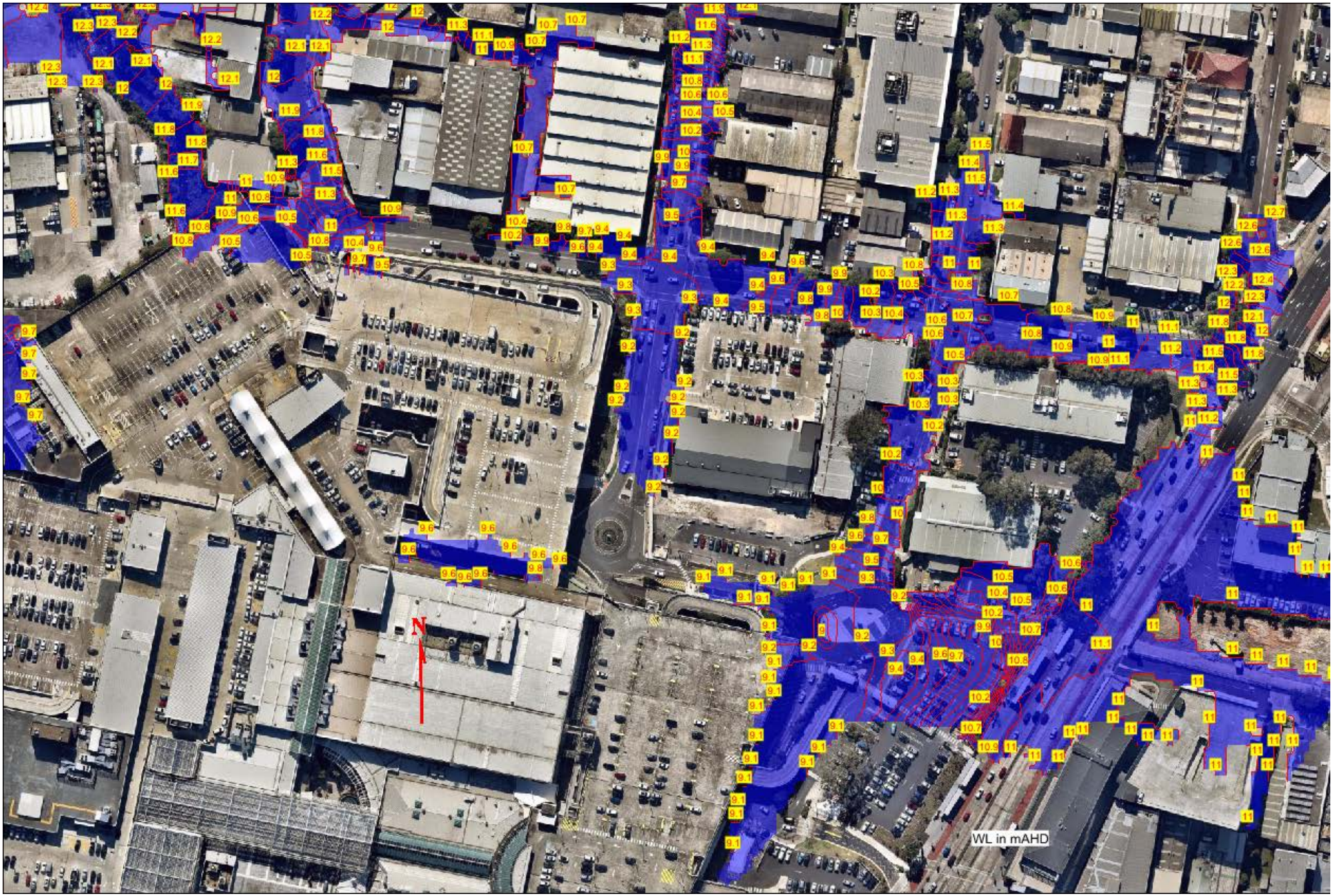

Figure 11 100 yr ARI Flood Levels under Stage 2 Redevelopment - 0% Blockage

Figure 12 Incremental 100 yr ARI Flood Level Difference - Stage 2 Redevelopment less DA1742 Conditions – 0% Blockage

Figure 13 100 yr ARI Flood Levels under Stage 2 Redevelopment - 50% Blockage

Figure 14 Incremental 100 yr ARI Flood Level Difference - Stage 2 Redevelopment less DA1742 Conditions – 50% Blockage

Attachment A

Table A.5 Updated Comparison of Stage 2 DA with Existing Conditions (xpswmmV10)

Attachment B

Existing Conditions

Updated Stormwater DA + Brookvale Creek Design + Stage 2 Redevelopment

08 Aug 2018 | 08 Aug 2018

			100yr 1.5h ARI 50% Blockage			100yr 1.5h ARI 0% Blockage					08 Aug 2018 100yr 1.5h ARI DA 50% Blockage					08 Aug 2018 100yr 1.5h ARI DA 0% Blockage					
Survey Point	**Floor Level** (mAHD)	**Street Address**	Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Diff (cm)	Max FL (m AHD)	Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Diff (cm)	Diff (cm)	Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Diff (cm)	Diff (cm)	Max FL (m AHD)
			(a)			**(b)**			**(b)-(a)**		(bi)			(bi)-(a)	(bi)-(aa)	(bj)			(bj)-(b)	(bj)-(ab)	
P1	19.43	15 Clearview Place	20.46	109	103	20.46	109	103	0	20.46	20.46	109	103	0	0	20.45	108	102	-1	-1	20.46
P2	19.40	15 Clearview Place	20.35	115	95	20.35	115	95	0	20.35	20.35	115	95	0	0	20.35	115	95	0	0	20.35
P3	20.23	14 Clearview Place	19.88	69	0	19.88	69	0	0	19.88	19.88	69	0	0	0	19.88	69	0	0	0	19.88
P4	19.23	Unit 11/16-18 Clearview Place	19.10	9	0	19.10	9	0	0	19.10	19.10	9	0	0	0	19.10	9	0	0	0	19.10
P5	19.25	Unit 10B/16-18 Clearview Place	19.10	2	0	19.10	2	0	0	19.10	19.10	2	0	0	0	19.10	2	0	0	0	19.10
P6	19.30	Unit 10/16-18 Clearview Place	19.27	7	0	19.27	7	0	0	19.27	19.27	7	0	0	0	19.27	7	0	0	0	19.27
P7	19.30	Unit 9/16-18 Clearview Place	19.38	11	8	19.38	11	8	0	19.38	19.38	11	8	0	0	19.38	11	8	0	0	19.38
P8	19.30	Unit 8/16-18 Clearview Place	19.35	11	5	19.35	11	5	0	19.35	19.35	11	5	0	0	19.35	11	5	0	0	19.35
P9	19.26	Unit 7A/16-18 Clearview Place	19.33	10	7	19.33	10	7	0	19.33	19.33	10	7	0	0	19.33	10	7	0	0	19.33
P10	19.26	Unit 7/16-18 Clearview Place	19.31	10	5	19.31	10	5	0	19.31	19.31	10	5	0	0	19.31	10	5	0	0	19.31
P11	19.26	Unit 6/16-18 Clearview Place	19.30	4	4	19.30	4	4	0	19.30	19.30	4	4	0	0	19.30	4	4	0	0	19.30
P12	19.28	Unit 5/16-18 Clearview Place	19.30	12	2	19.30	12	2	0	19.30	19.30	12	2	0	0	19.30	12	2	0	0	19.30
P13	19.29	Unit 4/16-18 Clearview Place	19.29	10	0	19.29	10	0	0	19.29	19.29	10	0	0	0	19.29	10	0	0	0	19.29
P14	19.26	Unit 3/16-18 Clearview Place	19.29	43	3	19.29	43	3	0	19.29	19.29	43	3	0	0	19.29	43	3	0	0	19.29
P15	19.27	Unit 2/16-18 Clearview Place	19.27	68	0	19.27	68	0	0	19.27	19.27	68	0	0	0	19.27	68	0	0	0	19.27
P16	19.23	Unit 12/16-18 Clearview Place	19.31	18	8	19.31	18	8	0	19.31	19.31	18	8	0	0	19.31	18	8	0	0	19.31
P17	19.27	Unit 13/16-18 Clearview Place	19.30	6	3	19.30	6	3	0	19.30	19.30	6	3	0	0	19.30	6	3	0	0	19.30
P18	19.25	Unit 13/16-18 Clearview Place	19.08	8	0	19.08	8	0	0	19.08	19.08	8	0	0	0	19.08	8	0	0	0	19.08
P19	19.26	Unit 12/16-18 Clearview Place	19.16		0	19.16		0	0	19.16	19.16		0	0	0	19.16		0	0	0	19.16
P20	19.26	Unit 1 / 16-18 Clearview Place	19.02	18	0	19.02	18	0	0	19.02	19.02	18	0	0	0	19.02	18	0	0	0	19.02
P21	16.51	Unit 1 / 16-18 Clearview Place	18.92	251	241	18.92	251	241	0	18.92	18.92	251	241	0	0	18.92	251	241	0	0	18.92
P22	17.35	19 Clearview Place	18.25	106	90	18.25	106	90	0	18.25	18.24	105	89	-1	-1	18.24	105	89	-1	0	18.24
P23	18.21	19 Clearview Place	18.25	137	4	18.25	137	4	0	18.25	18.25	137	4	0	0	18.24	136	3	-1	-1	18.25
P24	17.04	Unit 1/20 Clearview Place	18.25	124	121	18.24	123	120	-1	18.25	18.24	123	120	-1	-1	18.24	123	120	0	0	18.24
P25	16.69	21 Clearview Place	18.21	161	152	18.21	161	152	0	18.21	18.21	161	152	0	0	18.20	160	151	-1	-1	18.21
P26	17.06	Unit 2/20 Clearview Place	17.98	93	92	17.98	93	92	0	17.98	17.98	93	92	0	0	17.98	93	92	0	0	17.98
P27	18.21	19 Clearview Place	18.73	59	52	18.72	58	51	-1	18.73	18.73	59	52	0	0	18.73	59	52	1	1	18.73
P28	16.62	Unit 5/22 Clearview Place	17.60	108	98	17.60	108	98	0	17.60	17.60	108	98	0	0	17.60	108	98	0	0	17.60
P29	16.58	Unit 4/22 Clearview Place	17.58	104	100	17.58	104	100	0	17.58	17.58	104	100	0	0	17.58	104	100	0	0	17.58
P30	16.55	Unit 3/22 Clearview Place	17.58	108	103	17.57	107	102	-1	17.58	17.57	107	102	-1	0	17.57	107	102	0	0	17.57
P31	16.63	21 Clearview Place	17.14	53	51	17.14	53	51	0	17.14	17.14	53	51	0	0	17.14	53	51	0	0	17.14
P33	16.30	21 Clearview Place	17.14	84	84	17.14	84	84	0	17.14	17.15	85	85	1	1	17.14	84	84	0	0	17.15
P34	19.04	21 Clearview Place	18.06	36	0	18.06	36	0	0	18.06	18.06	36	0	0	0	18.06	36	0	0	0	18.06
P35	16.67	close to 20 Clearview Place	17.13	93	46	17.13	93	46	0	17.13	17.14	94	47	1	1	17.14	94	47	1	1	17.14
P36	16.67	close to 20 Clearview Place	17.13	123	46	17.13	123	46	0	17.13	17.14	124	47	1	1	17.14	124	47	1	1	17.14
P37	15.83	close to 20 Clearview Place	17.13	140	130	17.13	140	130	0	17.13	17.14	141	131	1	1	17.14	141	131	1	1	17.14
P38	16.25	Unit 2 / 22 Clearview Place	17.40	120	115	17.40	120	115	0	17.40	17.40	120	115	0	0	17.39	119	114	-1	-1	17.40
P39	16.57	Unit 1 / 22 Clearview Place	17.17	69	60	17.16	68	59	-1	17.17	17.16	68	59	-1	-1	17.16	68	59	0	0	17.16
P40	16.81	Clearview Place	17.20	40	39	17.20	40	39	0	17.20	17.20	40	39	0	0	17.19	39	38	-1	-1	17.20
P41	16.90	Unit 1/84-85A Old Pittwater Road	16.83	8	0	16.83	8	0	0	16.83	16.83	8	0	0	0	16.83	8	0	0	0	16.83
P42	17.17	82B Old Pittwater Road	16.98	2	0	16.98	2	0	0	16.98	16.98	2	0	0	0	16.98	2	0	0	0	16.98
P43	16.65	Clearview Place	16.84	24	19	16.83	23	18	-1	16.84	16.83	23	18	-1	-1	16.83	23	18	0	0	16.83
P44	16.52	22A Clearview Place	17.02	60	50	17.02	60	50	0	17.02	17.02	60	50	0	0	17.02	60	50	0	0	17.02
P45	17.01	22 Clearview Place	16.88	15	0	16.88	15	0	0	16.88	16.88	15	0	0	0	16.87	14	0	-1	-1	16.88
P48	15.98	22B Clearview Place	16.84	102	86	16.84	102	86	0	16.84	16.84	102	86	0	0	16.84	102	86	0	0	16.84
P50	16.21	98 Clearview Place	16.84	81	63	16.84	81	63	0	16.84	16.83	80	62	-1	-1	16.83	80	62	-1	0	16.83
P51	19.94	Old Pittwater Road	15.84	1	0	15.84	1	0	0	15.84	15.84	1	0	0	0	15.84	1	0	0	0	15.84
P52	16.5	Old Pittwater Road	15.80	4	0	15.80	4	0	0	15.80	15.80	4	0	0	0	15.80	4	0	0	0	15.80
P53	16.45	Old Pittwater Road	15.53		0	15.53		0	0	15.53	15.53		0	0	0	15.53		0	0	0	15.53
P54	14.97	Old Pittwater Road	15.52	77	55	15.52	77	55	0	15.52	15.52	77	55	0	0	15.52	77	55	0	0	15.52
P55	14.93	Old Pittwater Road	15.25	39	32	15.25	39	32	0	15.25	15.25	39	32	0	0	15.25	39	32	0	0	15.25
P56	14.94	Old Pittwater Road	15.14	35	20	15.14	35	20	0	15.14	15.14	35	20	0	0	15.14	35	20	0	0	15.14
P57	14.93	Old Pittwater Road	15.14	36	21	15.14	36	21	0	15.14	15.14	36	21	0	0	15.14	36	21	0	0	15.14
P58	14.93	Old Pittwater Road	15.14	29	21	15.14	29	21	0	15.14	15.14	29	21	0	0	15.14	29	21	0	0	15.14
P59	14.94	Old Pittwater Road	15.14	29	20	15.14	29	20	0	15.14	15.14	29	20	0	0	15.14	29	20	0	0	15.14
P60	14.94	Old Pittwater Road	15.14	36	20	15.14	36	20	0	15.14	15.14	36	20	0	0	15.14	36	20	0	0	15.14
P61	14.96	Old Pittwater Road	15.14	34	18	15.14	34	18	0	15.14	15.14	34	18	0	0	15.14	34	18	0	0	15.14
P62	14.94	Old Pittwater Road	15.14	32	20	15.14	32	20	0	15.14	15.14	32	20	0	0	15.14	32	20	0	0	15.14
P63	14.95	Old Pittwater Road	15.14	32	19	15.14	32	19	0	15.14	15.14	32	19	0	0	15.14	32	19	0	0	15.14
P64	14.89	Suit2/98 Old Pittwater Road	15.14	41	25	15.14	41	25	0	15.14	15.14	41	25	0	0	15.14	41	25	0	0	15.14
P65	14.89	Suit2/98 Old Pittwater Road	15.14	42	25	15.14	42	25	0	15.14	15.14	42	25	0	0	15.14	42	25	0	0	15.14
P66	14.91	Suit1/98 Old Pittwater Road	15.14	43	23	15.14	43	23	0	15.14	15.14	43	23	0	0	15.14	43	23	0	0	15.14
P67	14.91	Suit1/98 Old Pittwater Road	15.14	37	23	15.14	37	23	0	15.14	15.14	37	23	0	0	15.14	37	23	0	0	15.14
P69	16.45	Unit 2/100 Old Pittwater Road	15.08	0	0	15.08	0	0	0	15.08	15.08	0	0	0	0	15.08		0	0	0	15.08
P71	16.41	Unit 2/100 Old Pittwater Road	15.08	10	0	15.08	10	0	0	15.08	15.08	10	0	0	0	15.08	10	0	0	0	15.08
P72	17.48	Unit 1/100 Old Pittwater Road	15.05		0	15.05		0	0	15.05	15.04		0	-1	-1	15.04		0	-1	-1	15.04
P73	14.74	98 Old Pittwater Road	15.14	61	40	15.14	61	40	0	15.14	15.14	61	40	0	0	15.14	61	40	0	0	15.14
P74	14.72	98 Old Pittwater Road	15.14	51	42	15.14	51	42	0	15.14	15.14	51	42	0	0	15.14	51	42	0	0	15.14
P75	14.71	98 Old Pittwater Road	15.14	61	43	15.14	61	43	0	15.14	15.14	61	43	0	0	15.14	61	43	0	0	15.14
P76	14.73	98 Old Pittwater Road	15.14	57	41	15.14	57	41	0	15.14	15.14	57	41	0	0	15.14	57	41	0	0	15.14
P77	14.75	98 Old Pittwater Road	15.14	53	39	15.14	53	39	0	15.14	15.14	53	39	0	0	15.14	53	39	0	0	15.14
P78	14.75	98 Old Pittwater Road	15.14	58	39	15.14	58	39	0	15.14	15.14	58	39	0	0	15.14	58	39	0	0	15.14
P79	14.76	98 Old Pittwater Road	15.85	119	109	15.85	119	109	0	15.85	15.86	120	110	1	1	15.85	119	109	0	0	15.86
P80	14.75	98 Old Pittwater Road	15.74	109	99	15.74	109	99	0	15.74	15.73	108	98	-1	-1	15.73	108	98	-1	-1	15.73
P81	14.75	98 Old Pittwater Road	15.63	98	88	15.63	98	88	0	15.63	15.63	98	88	0	0	15.63	98	88	0	0	15.63
P82	14.74	98 Old Pittwater Road	15.41	77	67	15.41	77	67	0	15.41	15.42	78	68	1	0	15.42	78	68	1	0	15.42
P83	14.73	98 Old Pittwater Road	15.30	67	57	15.30	67	57	0	15.30	15.30	67	57	0	0	15.30	67	57	0	0	15.30
P85	14.72	Suite 8/98 Old Pittwater Road	14.97	35	24	14.97	35	24	0	14.97	14.97	35	25	0	0	14.97	35	25	0	0	14.97
P86	14.72	Suite 9/98 Old Pittwater Road	14.92	37	20	14.92	37	20	0	14.92	14.92	37	20	0	0	14.92	37	20	0	0	14.92
P87	14.68	Suite 10/98 Old Pittwater Road	14.91	30	23	14.91	30	23	0	14.91	14.91	30	23	0	0	14.91	30	23	0	0	14.91
P88	14.70	Suite 11/98 Old Pittwater Road	14.87	24	17	14.87	24	17	0	14.87	14.87	24	17	0	0	14.87	24	17	0	0	14.87
P89	14.71	Suite 12/98 Old Pittwater Road	14.85	33	14	14.85	33	14	0	14.85	14.86	34	15	1	1	14.86	34	15	1	1	14.86
P90	14.71	Suite 13/98 Old Pittwater Road	14.83	38	12	14.83	38	12	0	14.83	14.83	38	12	0	0	14.83	38	12	0	0	14.83
P91	14.71	Suite 14/98 Old Pittwater Road	14.82	32	11	14.82	32	11	0	14.82	14.82	32	11	0	0	14.82	32	11	0	0	14.82
P92	14.68	Suite 15/98 Old Pittwater Road	14.80	31	12	14.80	31	12	0	14.80	14.80	31	12	0	0	14.80	31	12	0	0	14.80
P93	14.68	Suite 16/98 Old Pittwater Road	14.80	34	12	14.80	34	12	0	14.80	14.80	34	12	0	0	14.80	34	12	0	0	14.80
P94	14.68	Suite 17/98 Old Pittwater Road	14.79	36	11	14.79	36	11	0	14.79	14.79	36	11	0	0	14.79	36	11	0	0	14.79
P95	14.69	Suite 18/98 Old Pittwater Road	14.79	34	10	14.79	34	10	0	14.79	14.79	34	10	0	0	14.79	34	10	0	0	14.79
P96	14.70	Suite 19/98 Old Pittwater Road	14.78	27	8	14.78	27	8	0	14.78	14.78	27	8	0	0	14.78	27	8	0	0	14.78
P97	16.63	65 Cross Street	15.09	44	0	15.09	44	0	0	15.09	15.09	44	0	0	0	15.09	44	0	0	0	15.09
P98	13.47	65 Cross Street	13.55	20	8	13.55	20	8	0	13.55	13.55	20	8	0	0	13.55	20	8	0	0	13.55
P99	14.10	38A Cross Street	13.54	38	0	13.54	38	0	0	13.54	13.54	38	0	0	0	13.54	38	0	0	0	13.54
P100	14.23	38B Cross Street	13.54	47	0	13.54	47	0	0	13.54	13.54	47	0	0	0	13.54	47	0	0	0	13.54
P101	14.16	38 Cross Street	13.54	34	0	13.54	34	0	0	13.54	13.54	34	0	0	0	13.53	33	0	-1	-1	13.54
P102	14.29	65 Cross Street	13.53	25	0	13.53	25	0	0	13.53	13.54	26	0	1	1	13.53	25	0	0	0	13.54
P103	13.9	34 Cross Street	13.50	16	0	13.50	16	0	0	13.50	13.50	16	0	0	0	13.50	16	0	0	0	13.50
P104	12.09	32 Cross Street	13.39	140	130	13.39	140	130	0	13.39	13.39	140	130	0	0	13.39	140	130	0	0	13.39
P105	13.69	32 Cross Street	13.24	29	0	13.24	29	0	0	13.24	13.24	29	0	0	0	13.24	29	0	0	0	13.24
P106	13.41	30 Cross Street	12.86	22	0	12.86	22	0	0	12.86	12.86	22	0	0	0	12.86	22	0	0	0	12.86
P107	13.35	28 Cross Street	12.67	10	0	12.67	10	0	0	12.67	12.67	10	0	0	0	12.67	10	0	0	0	12.67
P108	13.24	Cross Street	12.65	25	0	12.65	25	0	0	12.65	12.66	26	0	1	1	12.65	25	0	0	0	12.66
P109	13.09	26 Cross Street	12.66	9	0	12.66	9	0	0	12.66	12.66	9	0	0	0	12.66	9	0	0	0	12.66
P110	11.86	Unit 7 / 16-22 Cross Street	12.76	100	90	12.76	100	90	0	12.76	12.77	101	91	1	1	12.77	101	91	1	1	12.77
P112	11.87	Unit 1 / 16-22 Cross Street	12.56	79	69	12.56	79	69	0	12.56	12.56	79	69	0	0	12.56	79	69	0	0	12.56
P113	14.22	102 Old Pittwater Road	14.61	124	39	14.61	124	39	0	14.61	14.60	123	38	-1	-1	14.60	123	38	-1	-1	14.60
P114	14.23	102 Old Pittwater Road	14.61	49	38	14.61	49	38	0	14.61	14.61	49	38	0	0	14.60	48	37	-1	-1	14.61
P115	13.13	33 Cross Street	13.54	79	41	13.54	79	41	0	13.54	13.54	79	41	0	0	13.54	79	41	0	0	13.54
P116	13.01	33 Cross Street	13.32	41	31	13.32	41	31	0	13.32	13.32	41	31	0	0	13.32	41	31	0	0	13.32
P117	13.16	33 Cross Street	13.46	31	30	13.46	31	30	0	13.46	13.46	31	30	0	0	13.46	31	30	0	0	13.46
P118	13.24	31 Cross Street	12.97	2	0	12.97	2	0	0	12.97	12.97	2	0	0	0	12.97	2	0	0	0	12.97
P119	13.21	31 Cross Street	12.50	16	0	12.50	16	0	0	12.50	12.50	16	0	0	0	12.50	16	0	0	0	12.50
P120	12.54	29 Cross Street	12.38	26	0	12.38	26	0	0	12.38	12.38	26	0	0	0	12.38	26	0	0	0	12.38
P121	12.32	14 Cross Street	12.36	6	4	12.36	6	4	0	12.36	12.36	6	4	0	0	12.36	6	4	0	0	12.36
P122	12.01	12 Cross Street	12.16	25	15	12.16	25	15	0	12.16	12.16	25	15	0	0	12.16	25	15	0	0	12.16
P123	14.16	75 Old Pittwater Road	14.65	59	49	14.65	59	49	0	14.65	14.65	59	49	0	0	14.65	59	49	0	-1	14.65
P124	13.11	33 Cross Street	12.67	13	0	12.67	13	0	0	12.67	12.67	13	0	0	0	12.66	12	0	-1	0	12.67
P125	12.22	29 Cross Street	12.27	20	5	12.27	20	5	0	12.27	12.27	20	5	0	0	12.27	20	5	0	0	12.27
P126	12.15	10 Cross Street	12.02	9	0	12.02	9	0	0	12.02	12.02	9	0	0	0	12.02	9	0	0	0	12.02
P127	11.9	8 Cross Street	11.81	32	0	11.81	32	0	0	11.81	11.80	31	0	-1	-1	11.80	31	0	-1	-1	11.80
P128	12.53	25 Cross Street	12.59	53	6	12.49	43	0	-10	12.59	12.33	27	0	-26	-24	12.23	17	0	-26	-22	12.33
P129	12.13	29 Cross Street	12.61	58	48	12.52	49	39	-9	12.61	12.39	36	26	-22	-20	12.36	33	23	-16	-13	12.39
P130	12.16	25 Cross Street	12.54	43	38	12.46	35	30	-8	12.54	12.30	19	14	-24	-22	12.24	13	8	-22	-19	12.30
P131	12.18	25 Cross Street	12.03	11	0	12.02	10	0	-1	12.03	12.03	11	0	0	1	12.03	11	0	1	1	12.03
P132	12.04	23 Cross Street	12.04	13	0	12.03	12	0	-1	12.04	12.03	12	0	-1	-1	12.03	12	0	0	0	12.03
P133	12.12	21 Cross Street	11.94	24	0	11.93	23	0	-1	11.94	11.93	23	0	-1	0	11.93	23	0	0	0	11.93
P134	9.95	19 Cross Street	11.36	151	141	11.21	136	126	-15	11.36	11.14	129	119	-22	-12	11.00	115	105	-21	-13	11.14
P137	14.61	Old Pittwater Road	12.79	19	0	12.72	12	0	-7	12.79	12.67	7	0	-12	-10	12.67	7	0	-5	-2	12.67
P138	12.99	Old Pittwater Road	12.91		0	12.91		0	0	12.91	12.91		0	0	0	12.91		0	0	0	12.91
P139	12.90	Old Pittwater Road	13.04	24	14	13.04	24	14	0	13.04	13.04	24	14	0	0	13.04	24	14	0	0	13.04
P140	13.12	Old Pittwater Road	13.14	12	2	13.14	12	2	0	13.14	13.14	12	2	0	0	13.14	12	2	0	0	13.14
P141	12.31	Old Pittwater Road	12.41	20	10	12.27	6	0	-14	12.41	12.20		0	-21	-19	12.02		0	-25	-20	12.20
P142		Brookvale Creek upstream of Mall	12.18	394		11.99	375		-19	12.18	11.93	369		-25	-22	11.60	336		-39	-30	11.93
P143			12.19	394		11.99	374		-20	12.19	11.93	368		-26	-22	11.60	335		-39	-31	11.93
P144			12.24	411		12.06	393		-18	12.24	11.95	382		-29	-26	11.63	350		-43	-35	11.95
P145			12.30	381		12.13	364		-17	12.30	12.08	359		-22	-19	11.85	336		-28	-21	12.08
P146			12.38	419		12.23	404		-15	12.38	12.18	399		-20	-17	12.00	381		-23	-17	12.18
P147			12.57	429		12.47	419		-10	12.57	12.28	400		-29	-27	12.14	386		-33	-29	12.28
P148			12.63	429		12.54	420		-9	12.63	12.40	406		-23	-21	12.29	395		-25	-22	12.40
P149			12.70	447		12.62	439		-8	12.70	12.51	428		-19	-17	12.42	419		-20	-17	12.51
P150			12.76	430		12.70	424		-6	12.76	12.61	415		-15	-14	12.54	408		-16	-14	12.61
P151			12.76	348		12.70	342		-6	12.76	12.61	333		-15	-14	12.55	327		-15	-13	12.61
P152			12.95	361		12.91	357		-4	12.95	12.86	352		-9	-8	12.83	349		-8	-7	12.86
P153			13.03	343		12.99	339		-4	13.03	12.95	335		-8	-7	12.92	332		-7	-6	12.95
P154			13.11	475		13.07	471		-4	13.11	13.04	468		-7	-6	13.01	465		-6	-5	13.04
P155		Harrison Property	12.20	33		12.01	14		-19	12.20	11.94	7		-26	-23	11.61			-40	-32	11.94
P156			12.26	14		12.08			-18	12.26	11.99			-27	-24	11.81			-27	-19	11.99
P157			12.51	3		12.39			-12	12.51	12.25			-26	-23	12.09			-30	-26	12.25
P158			12.66	60		12.58	52		-8	12.66	12.46	40		-20	-18	12.38	32		-20	-17	12.46
P159			12.71	48		12.64	41		-7	12.71	12.52	29		-19	-18	12.44	21		-20	-17	12.52
P160			12.80	99		12.73	92		-7	12.80	12.64	83		-16	-14	12.58	77		-15	-13	12.64
P161			12.96	11		12.96	11		0	12.96	12.96	11		0	0	12.96	11		0	0	12.96
P162			13.65	24		13.64	23		-1	13.65	13.64	23		-1	-1	13.64	23		0	0	13.64
P163			12.78	31		12.71	24		-7	12.78	12.61	14		-17	-15	12.54	7		-17	-15	12.61
P164		Driveway to Woolworth Loading Dock	10.96	109		10.84	97		-12	10.96	9.87			-109	-60	9.87			-97	-20	9.87

Existing Conditions

Updated Stormwater DA + Brookvale Creek Design + Stage 2 Redevelopment

08 Aug 2018 — 08 Aug 2018

Survey Point	Floor Level (mAHD)	Street Address	100yr 1.5h ARI 50% Blockage: Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	100yr 1.5h ARI 0% Blockage: Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Diff (cm)	Max FL (m AHD)	100yr 1.5h ARI DA 50% Blockage: Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Diff (cm)	Diff (cm)	100yr 1.5h ARI DA 0% Blockage: Flood Level (mAHD)	Depth over Ground (cm)	Depth over Floor (cm)	Diff (cm)	Diff (cm)	Max FL (m AHD)
			(a)			(b)			(b)-(a)		(bi)			(bi)-(a)	(bi)-(aa)	(bj)			(bj)-(b)	(bj)-(ab)	
P165			11.01	82		10.86	67		-15	11.01	10.19			-82	-32	10.19			-67	-7	10.19
P166			11.11	57		10.92	38		-19	11.11	10.90	36		-21	18	10.83	29		-9	21	10.90
P167		Roundabout in Cross Street	11.34	68		11.21	55		-13	11.34	10.88	22		-46	-7	10.80	14		-41	-5	10.88
P168			11.19	26		11.13	20		-6	11.19	11.09	16		-10	0	11.09	16		-4	0	11.09
P169		Palm Tree Carpark	10.54	15		10.51	12		-3	10.54	10.43	4		-11	0	10.43	4		-8	0	10.43
P170			10.15	27		10.14	26		-1	10.15	9.85			-30	-31	9.85			-29	-32	9.85
P171			10.15	55		10.14	54		-1	10.15	9.49			-66	-67	9.49			-65	-68	9.49
P172			10.15	63		10.13	61		-2	10.15	9.47			-68	-69	9.47			-66	-70	9.47
P173			10.15	39		10.13	37		-2	10.15	9.77	1		-38	-39	9.77	1		-36	-40	9.77
P174			10.74	15		10.70	11		-4	10.74	10.55			-19	0	10.55			-15	0	10.55
P175			10.15	99		10.14	98		-1	10.15	9.39	23		-76	-78	9.39	23		-75	-79	9.39
P176			10.15	106		10.14	105		-1	10.15	9.33	24		-82	-84	9.33	24		-81	-85	9.33
P177			10.15	114		10.14	113		-1	10.15	9.27	26		-88	-90	9.26	25		-88	-92	9.27
P178		Green Street	10.15	120		10.14	119		-1	10.15	9.25	30		-90	-91	9.25	30		-89	-93	9.25
P179			10.15	130		10.14	129		-1	10.15	9.26	41		-89	-90	9.26	41		-88	-92	9.26
P180			10.15	132		10.13	130		-2	10.15	9.26	43		-89	-90	9.26	43		-87	-91	9.26
P181			10.15	80		10.13	78		-2	10.15	9.45	10		-70	-71	9.45	10		-68	-72	9.45
P182			10.08	11		10.10	13		2	10.10	9.80			-28	-28	9.80			-30	-31	9.80
P183			9.91	45		9.93	47		2	9.93	9.43			-48	-49	9.43			-50	-54	9.43
P184			9.83	58		9.86	61		3	9.86	9.25			-58	-48	9.25	0		-61	-51	9.25
P185			9.83	64		9.85	66		2	9.85	9.20	1		-63	-52	9.20	1		-65	-54	9.20
P186			9.83	88		9.85	90		2	9.85	8.99	4		-84	-71	9.02	7		-83	-71	9.02
P187			9.81	120		9.83	122		2	9.83	9.13	52		-68	-55	9.14	53		-69	-57	9.14
P188			9.77	138		9.79	140		2	9.79	9.12	73		-65	-54	9.13	74		-66	-55	9.13
P189			9.74	139		9.76	141		2	9.76	-	-		-	-	-	-		-	-	-
P190			9.63	64		9.64	65		1	9.64	-	-		-	-	-	-		-	-	-
P191			9.48	44		9.49	45		1	9.49	-	-		-	-	-	-		-	-	-
P192		Starfish Carpark Entrance	10.96	88		10.84	76		-12	10.96	10.17	9		-79	-29	10.17	9		-67	0	10.17
P193			11.00	1		11.00	1		0	11.00	10.98			-2	0	10.98			-2	0	10.98
P194			11.07	1		11.07	1		0	11.07	11.01			-6	0	11.01			-6	0	11.01
P192_1			10.96	91		10.84	79		-12	10.96	10.06	1		-90	-40	10.06	1		-78	-2	10.06
P193_1			10.96	15		10.84	3		-12	10.96	10.88	7		-8	0	10.88	7		4	0	10.88
P194_1			11.08	18		11.08	18		0	11.08	10.94	4		-14	0	10.94	4		-14	0	10.94
P217			10.96	146		10.84	134		-12	10.96	9.72	22		-124	-74	9.73	23		-111	-34	9.73
P195		Starfish Carpark	10.98	3		10.98	3		0	10.98	10.98	3		0	0	10.98	3		0	0	10.98
P196			10.80	16		10.79	15		-1	10.80	10.58			-22	0	10.58			-21	0	10.58
P197			10.80	58		10.78	56		-2	10.80	-					-					-
P198			10.80	29		10.78	27		-2	10.80	-					-					-
P199			10.80	27		10.79	26		-1	10.80	10.54	1		-26	0	10.54	1		-25	0	10.54
P200			10.86	10		10.86	10		0	10.86	10.76			-10	0	10.76			-10	0	10.76
P201			10.83	6		10.83	6		0	10.83	10.77			-6	0	10.77			-6	0	10.77
P202			10.80	35		10.79	34		-1	10.80	10.50	5		-30	0	10.50	5		-29	0	10.50
P203			10.80	37		10.78	35		-2	10.80	-					-					-
P204		Warringah Golf Course	5.78	71		5.80	73		2	5.80	5.79	72		1	6	5.80	73		0	5	5.80
P205			5.19	21		5.21	23		2	5.21	5.21	23		2	5	5.22	24		1	5	5.22
P206			4.18	76		4.20	78		2	4.20	4.21	79		3	6	4.22	80		2	5	4.22
P207			3.70	89		3.72	91		2	3.72	3.73	92		3	5	3.74	93		2	4	3.74
P208			3.38	225		3.39	226		1	3.39	3.40	227		2	4	3.41	228		2	4	3.41
P209			3.37	71		3.39	73		2	3.39	3.40	74		3	5	3.41	75		2	4	3.41
P210			3.34	82		3.35	83		1	3.35	3.36	84		2	4	3.37	85		2	4	3.37
P211			2.90	135		2.92	137		2	2.92	2.93	138		3	4	2.93	138		1	3	2.93
P212			2.74	229		2.74	229		0	2.74	2.75	230		1	1	2.75	230		1	1	2.75
P213			2.71	94		2.71	94		0	2.71	2.71	94		0	0	2.71	94		0	0	2.71
P214			2.71	91		2.71	91		0	2.71	2.71	91		0	0	2.71	91		0	0	2.71
P215			2.74	69		2.74	69		0	2.74	2.74	69		0	0	2.75	70		1	1	2.75
P216			2.71	108		2.71	108		0	2.71	2.71	108		0	0	2.71	108		0	0	2.71
P300	11.12	4 Cross St	10.78	10	0	10.75	7	0	-3	10.78	10.68		0	-10	0	10.68		0	-7	0	10.68
P301	10.12	2 Cross St	10.15	93	3	10.13	91	1	-2	10.15	9.40	18	0	-75	-77	9.40	18	0	-73	-79	9.40
P302	10.08	(Cross St)	10.15	86	7	10.13	84	5	-2	10.15	9.44	15	0	-71	-73	9.44	15	0	-69	-74	9.44
P303	10.45	Cross St	10.37	10	0	10.37	10	0	0	10.37	10.37	10	0	0	0	10.37	10	0	0	0	10.37
P304	10.87	2 Dale St	10.95	9	8	10.95	9	8	0	10.95	10.95	9	8	0	0	10.95	9	8	0	0	10.95
P305	10.08	26 Green St	10.15	91	7	10.13	89	5	-2	10.15	9.48	24	0	-67	-69	9.48	24	0	-65	-71	9.48
P306	10.65	24 Green St	10.15	50	0	10.13	48	0	-2	10.15	9.81	16	0	-34	-36	9.81	16	0	-32	-38	9.81
P307	11.55	20 Green St	10.27	14	0	10.27	14	0	0	10.27	10.27	14	0	0	0	10.27	14	0	0	0	10.27
221		DJ Loading Dock	10.24	*104*		10.28	*108*		4	10.28	9.68	*48*		-56	-25	9.68	*48*		-60	-56	9.68
222		DJ Loading Dock	10.21	*111*		10.23	*113*		2	10.23	9.68	*58*		-53	-25	9.68	*58*		-55	-54	9.68
401		Bus Depot Sucatchment east of Pittwater R	11.07			11.07			0	11.07	11.04			-3	-3	11.04			-3	-3	11.04
402		Bus Depot Sucatchment east of Pittwater R	11.06			11.06			0	11.06	11.03			-3	-3	11.04			-2	-2	11.04
403		Bus Depot Sucatchment east of Pittwater R	11.06			11.06			0	11.06	11.03			-3	-3	11.03			-3	-3	11.03
404		Bus Depot Sucatchment east of Pittwater R	11.06			11.06			0	11.06	11.03			-3	-3	11.03			-3	-3	11.03
501		Anchor Car Park	9.53	*62*		9.53	*62*		0	9.53	9.53	*62*		0	0	9.53	*62*		0	0	9.53
502		Anchor Car Park	9.53	*64*		9.53	*64*		0	9.53	9.53	*64*		0	0	9.53	*64*		0	0	9.53
503		Anchor Car Park	9.53	*66*		9.53	*66*		0	9.53	9.53	*66*		0	0	9.53	*66*		0	0	9.53
504		Anchor Car Park	9.53	*60*		9.53	*60*		0	9.53	9.53	*60*		0	0	9.53	*60*		0	0	9.53
505		Anchor Car Park / Coles Loading Dock	9.53	*71*		9.53	*71*		0	9.53	9.53	*71*		0	0	9.53	*71*		0	0	9.53

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August 2018

FIGURE 5 - SHEET 1
WATER LEVEL DIFFERENCES-100YR ARI
Stage 2 DA Redevelopment Less Predevelopment - 0% Blockage

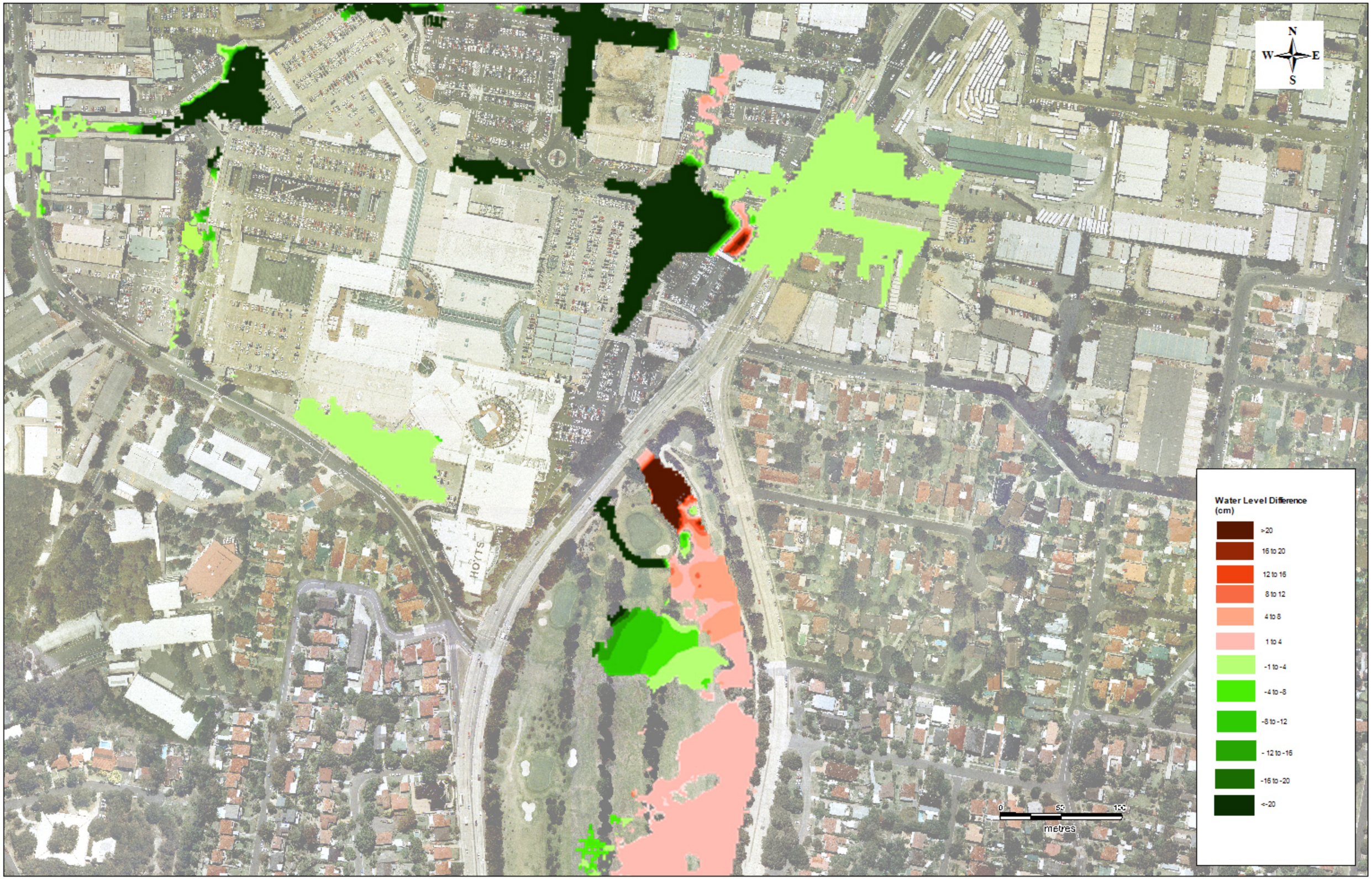

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FIGURE 5 - SHEET 2
WATER LEVEL DIFFERENCES-100YR ARI
Stage 2 DA Redevelopment Less Predevelopment - 0% Blockage

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August 2018

FIGURE 6 - SHEET 1
WATER LEVEL DIFFERENCES-100YR ARI
Stage 2 DA Redevelopment Less Predevelopment - 50% Blockage

Cardno

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August 2018

FIGURE 6 - SHEET 2
WATER LEVEL DIFFERENCES-100YR ARI
Stage 2 DA Redevelopment Less Predevelopment - 50% Blockage