Woolooware Bay Town Centre Redevelopment

Retail Civil Infrastructure Report : Project Application

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Approver: Anthony McLandsborough

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1 Introduction

1.1 Scope of Report

AT&L have been engaged by Bluestone Capital Ventures No. 1 Pty Ltd to undertake the Project Application Design and Documentation for the proposed Woolooware Bay Town Centre development.

This report provides a summary of the design principles and planning objectives for the flooding and stormwater management, infrastructure services and general civil engineering for the site.

This report should be read in conjunction with the following reports:

- Cronulla Sharks Redevelopment – Stormwater and Services Report : Concept Application prepared by AT&L dated March 2012;
- Concept Flooding and Stormwater Quality Assessment: Proposed Toyota Stadium Development by Martens Consulting Engineers, August 2011. (Document Number P1103017JR01V02);
- Woolooware Bay Town Centre Redevelopment – Retail Site: Flood Assessment Report by MWA Water, January 2013;
- Water Management Report: Woolooware Bay Town Centre report by Insync Services Pty Ltd, January 2013;

Summary

This report generally covers the following items:

- Flooding and Stormwater Management
  - Piped and Overland Flows
  - Sedimentation and Erosion Control
- Road Design
- Infrastructure Services

1.2 Site Description

The Cronulla Sutherland Leagues Club site is legally described as Lot 11 DP 526492 and Lot 20 DP 529644 and is known as 461 Captain Cook Drive, Woolooware. Three lots owned by Sutherland Shire Council (being Lot 21 DP 529644, Lot 1 DP 711486 and Lot 1 DP 501920) are also included within the proposed scheme.

The site is located on the northern side of Captain Cook Drive approximately 1.5 kilometres from Caringbah (to the south west) and 2 kilometres from Cronulla (to the south east). The site is bounded by the Solander playing fields to the west, Woolooware Bay to the north, and a service station and gymnasium to the east. The Woolooware Golf Club and the Captain Cook Oval are located to the south of the site across Captain Cook Drive.

The overall site is irregular in shape with an area of approximately 10 hectares, of which approximately 6ha is occupied by Toyota Stadium, Leagues Club building and the eastern carpark and 4ha is occupied by the western training fields and car park. Refer to Figure 1 and 2.

Toyota Stadium (also known as Endeavour Field and Shark Park) and the Cronulla Sutherland Leagues Club building occupy the central portion of the site, and represent a major community and entertainment hub within the region. The western playing fields within the site are private open space used as training fields for the Cronulla Sharks and for local games by the Cronulla Caringbah Junior Rugby League Football Club, whilst the remainder of the site is occupied by car parking.

The Taren Point Employment Area is located approximately 200 metres to the northwest of the site and occupies land located generally between the waterfront, Taren Point Road and the Captain Cook Bridge. Woolooware Railway Station is located 1 kilometre to the south west of the site, and Caringbah Town Centre is approximately 3 kilometres by road to the south west.

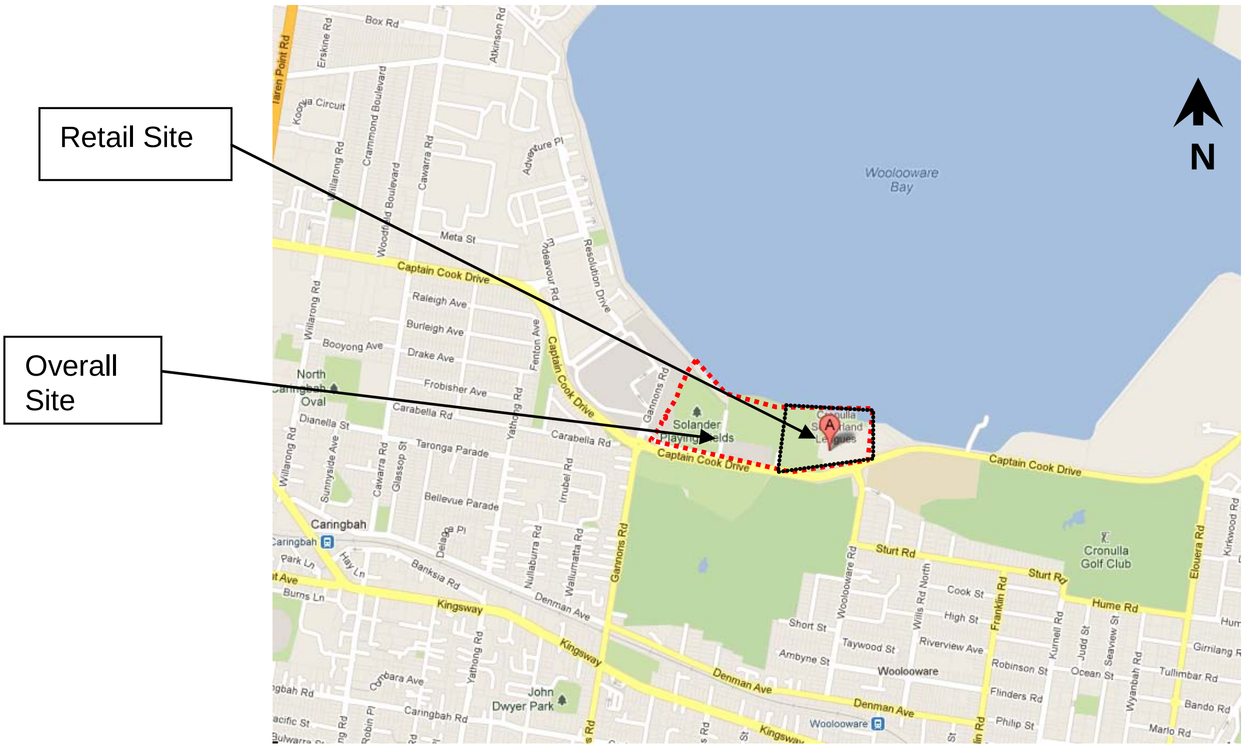


Figure 1 **Locality Plan 1** ***(Source: Google Maps)***

Figure 2 **Locality Plan 2** ***(Source: Near Map)***

1.2.1 Topography

The site is generally flat with a gentle slope towards Captain Cook Drive to the south.

1.2.2 Proposed Development

The proposed mixed use redevelopment of the Cronulla Sutherland Leagues Club site including a new neighbourhood retail centre, residential development and upgrades to the sports facilities, including the Toyota Stadium, will create a new centre and destination location that meets the needs of the surrounding community. The Concept Plan prepared for the site is seeking to develop the site in three stages, being:

Stage 1 - New Neighbourhood Retail Centre, Medical and Leisure facilities on the eastern car park site with rooftop carparking and redevelopment of the Leagues Club facilities;

Stage 2 - Residential Masterplanned Estate on the western car park and field area; and

Stage 3 - Extension and improvement of the Sharks playing field facilities including grandstand extensions.

It is recognised that this site represents an ideal opportunity to provide an environmental benchmark for residential and retail development within NSW. To this effect, a strong commitment has been made to develop the site in such a way which incorporates the latest principles of Ecologically Sustainable Development (ESD).

This Development Application report deals with civil infrastructure associated with Stage 1 of the development; this being the construction of the new retail, medical and leisure facilities over the eastern carpark. Part of this Stage 1 works will include upgrade of Captain Cook Drive which will result in additional stormwater drainage, relocation of existing services, signage and line marking and pavement design. Refer to Civil DA Drawings in Appendix E for details.

2 Stormwater Management

2.1 General Design Principles

The stormwater management plan for the site has been generally designed in accordance with the following codes and guidelines:

- Concept Approval Application No. MP 10_0229 given by the Minister of Planning and Infrastructure dated 27 August 2012. Within this approval is a list of Statement of Commitments which needs to be met. The statements relevant to civil infrastructure are presented in Table 1.
- Sutherland Shire Council Stormwater and On Site Detention Code
- AS 3500.3 National Plumbing and Drainage Code Part 3 - Stormwater Drainage.
- Australia publication "Australian Rainfall and Runoff, Volumes 1 and 2 (AR&R).

Subject	Comments	Approved by	Timing
Traffic Management	The future Project Application for development of the neighbourhood retail centre shall include detailed plans of the following proposed road and intersection upgrades: • Signalised intersection including pedestrian activated traffic signal on Captain Cook Drive at the western entry point • Relocated and signalised intersection of the junction of Captain Cook Drive and Woolooware Road and northern extension of Woolooware Road • Modifications to Captain Cook Drive to accommodate bus bays	Relevant Consent Authority	Relevant application for development

Stormwater and Flooding	Future applications for development shall include a detailed Stormwater Management Plan addressing: • Water quality management measures to be implemented including Water Sensitive Urban Design • Provide details with regards to improvements in water quality and the hydraulic regimes to protect the mangrove areas in the drainage channel and Woolooware Bay	Relevant Consent Authority	Relevant application for development
	Future applications for development shall include a detailed flood assessment incorporating: • Prepare hydrological model of the catchments draining to the site using the RAFTS modelling software. Assessment of the 1 in 20, 1 in 100 year and PMF events climate change impact considered by increasing design rainfall intensities of each storm in accordance with state government policy. • Prepare detailed hydrologic model for the site using the TUFLOW 2D flood modelling system. This will require a detailed contour survey of the site and surrounding areas. • Review pre and post-development flooding inundation levels/extents • Produce hydraulic hazard map for the developed site • Assess development and community safety on flood prone land up to the PMF in accordance with the NSW FDM (2005), relevant sections of Council's DCP and other relevant guidelines.		

	Future applications for development will address the NSW Coastal Planning Guideline: Adapting to Sea Level Rise.		
	Future applications for development will be accompanied by a draft Erosion and Sediment Control Plan.		

- **Table 1 – Statement of Commitments (Civil Infrastructure)**

2.2 Stormwater Management

2.2.1 Hydrology

- Pipe drainage shall be designed to accommodate the 5-year ARI storm event within street, accessway and pathways and 20-year ARI storm event for relief from low point areas and major systems traversing developed areas.
- The combined piped and overland flow paths shall be designed to accommodate the 100-year ARI storm event.
- Where trapped low points are unavoidable and potential for flooding private property is a concern, an overland flowpath capable of carrying the total 100-year ARI storm event shall be provided. Alternatively the pipe and inlet system may be upgrade to accommodate the 100 year ARI storm event.
- Rainfall intensities shall be as per the Intensity-Frequency-Duration table in accordance with the Australian Rainfall and Runoff volume 2.
- Runoff coefficients shall be calculated in accordance with AR&R. The fraction impervious shall be determined from analysis of the subcatchments.
- Flow width in gutter shall not exceed 1.5m for the minor design storm event.
- Velocity depth ratios shall not exceed 0.4 for all storms up to and including the 100 year ARI event.
- Blockage factors of 20% and 50% shall be adopted for pits on grade and at sags respectively for all storm events.
- The maximum spacing between pits shall be 60m.
- The minimum lintel size within a sag shall be 2.4m.
- The minimum lintel size for any road drainage pit shall be 0.9m.

2.2.2 Hydraulics

- A hydraulic grade line HGL design method shall be adopted for all road pipe drainage design. The HGL shall be shown on all drainage long sections.
- The minimum pipe size shall be 375 diameter.
- The minimum pipe grade shall be 0.5%.
- All pipes shall be Rubber Ring Jointed.
- The minimum cover over pipes shall be 450mm in grassed areas and 600mm within carriageways.
- The minimum cover over culverts shall be 300mm within carriageways.
- All trafficable pipes shall be Class 3 Reinforced Concrete Pipes or Fibre Reinforced Cement equivalent.
- The pipe friction coefficients to adopted shall be:

Materials	Mannings – n	Colebrook-White – k	Min. Pipe Class
RCP	0.012	0.3	3
FRC	0.01	0.15	3

Table 2 – Pipe Details

- All pipes classes shall be designed for the ultimate service loads and where applicable, constructions loads will be designed for.
- The flood levels determined in the WMA Water Flood Assessment report have been adopted as the tailwater levels for hydraulic modelling.
- Pit Loss coefficients shall be calculated in accordance with Missouri Charts.
- A minimum 150mm freeboard shall be maintained between pit HGL and pit surface levels.
- Minimum freeboard of 500mm over the 100 year ARI event water surface level will be provided for habitable floor levels and 200mm for garage floors, car parks and pedestrian access ways.
- Pits deeper than 1.2m shall contain step irons at 300 mm centres.

2.2.3 Existing Stormwater

The existing street storm water network was identified from a number of sources including:

- Survey provided by Harrison Friedmann and Associates Pty Ltd Surveyors
- Sutherland Shire Council drawings
- Dial Before You Dig drawings and

- Site Inspections

Internal Site Drainage

The site is located between Woolooware Bay and the Woolooware Golf Course. The site was reclaimed some 30 years ago by landfill of building and domestic refuse.

The site can be divided into these hydrological parts:

- The Toyota Stadium, playing field which drains to the tidal channel. The tidal channel which is shown on the survey drawings within Appendix B is an existing stormwater channel which starts within the Woolooware Golf Course. It drains in a northerly direction beneath Captain Cook Drive, flowing between Toyota Stadium and the western carpark before discharging into the Woolooware Bay;
- The club's building which drains towards Captain Cook Drive's drainage system, which eventually discharges to the tidal channel;
- The carpark adjacent to the club's building. Approximately one third of the bitumen covered carpark area drains towards Captain Cook Drive, one third discharges to Woolooware Bay as a diffuse outflow through grassed buffer located to the east of the site and one third drains through a 150mm diameter pipe directly to the Bay as concentrated flow; and

As mentioned previously this report concentrates on the redevelopment of the eastern carpark adjacent to the club's building into retail, medical and leisure facilities.

Survey Drawings within Appendix B indicate the existing stormwater drainage network within the site. Even though the existing eastern carpark is bitumen sealed, there does not seem to be any evidence of stormwater pits or pipes within the majority of the area. It is likely most of the stormwater drains overland onto Captain Cook Drive to the south and the mangrove swamp to the north. There is however an existing grated pit and 375mm diameter outlet pipe in the south western corner draining a small portion of the carpark. This pipe drains in a south westerly direction and connects into a 900mm diameter storm pipe within Captain Cook Drive. This 900mm diameter pipe then drains along Captain Cook Drive in a westerly direction before discharging into the tidal channel adjacent the western playing fields.

To the north west of the existing carpark are two 225mm diameter pipes which outlet into the mangrove swamp.

Stormwater drainage also exists to the south east of the existing carpark adjacent the Caltex petrol station entrance off Captain Cook Drive. Existing pits pick up stormwater within the Caltex and Fitness First driveway and carpark and drain in an easterly direction along Captain Cook Drive before discharging via a swale drain into the mangrove area to the east of Fitness First.

2.2.4 Proposed Stormwater

With the construction of the retail centre over the existing eastern carpark, new stormwater drainage will need to be built to drain the additional impervious areas. The upgrade of Captain Cook Drive will also require additional stormwater drainage.

As the proposed retail development is large in area (approximately 1.9Ha) a number of existing stormwater networks will likely be required to drain all stormwater off site. A Stormwater Catchment Plan is shown in Appendix E.

Stormwater from the southern portion of the club building will likely need to be directed into the existing network within Captain Cook Drive to the south east of the site. This will also include the loading dock and entrance road off Captain Cook Drive. This is shown as area G in the catchment plan.

The new entrance road off Captain Cook Drive to the east of the carpark adjacent to the Fitness First building will also require a new stormwater network which will be directed into the Captain Cook Drive drainage system. This system drains to the east along Captain Cook Drive and will then discharge into the mangrove swamp east of the Fitness First building. This connection into the mangrove swamp Captain Cook Drive. This is shown as area E in the catchment plan.

A grassed landscaped area to the north of the retail area will be dedicated for bio-filtration to both convey stormwater from retail and carparking hardstanding areas and treat the water to ensure the Sutherland Shire Council target reductions are met. This stormwater will then discharge into the entrance road system. This is shown as area F in the catchment plan.

There is also the option of utilizing the two existing 225mm diameter outlets into the mangrove swamp to discharge the northern part of the proposed club building. This will be confirmed at detailed design stage.

DRAINs modelling software has been used to calculate the Hydraulic Grade Line (HGL) for all stormwater networks. DRAINs data files and output results are attached in Appendix C. The proposed stormwater network for the retail site and associated roadworks are shown in the Civil DA drawings.

On Site Detention

The purpose of On Site Detention (OSD) systems is to detain storms and reduce peak discharge rates, however volumetric runoff remains unchanged. OSD is usually beneficial in the upper and middle parts of the catchment. However, OSD is ineffective in the downstream parts of the catchment, such as for this development, and can even increase the peak discharge because of the coincidence of peaks of the catchment hydrograph and the outlet hydrograph from the OSD. Therefore, OSD is not recommended for this development on the basis that there is no significant benefit and increases risk of the peak discharge value coinciding. This will need to be confirmed with Sutherland Shire Council.

2.2.5 Water Sensitive Urban Design (WSUD)

Policy and Guidelines

The stormwater design considers the following guidelines:

- Australian Rainfall Quality (2006);
- Department of Environment and Climate Change NSW (DECC), Management Urban Stormwater: Urban design (Consultation Draft, 2008)
- Sutherland Shire Council Stormwater and On Site Detention Code

Objectives

Sutherland Shire Council Guidelines encourage best practice urban stormwater management with the aim to achieve the below target reductions:

Pollutants	Reduction Objectives
Total Suspended Solids (TSS)	70%
Total Phosphorus (TP)	20%
Total Nitrogen (TN)	35%
Gross Pollutants	Retention of litter greater than 50mm to be maximum extent possible for storm events up 1 in 3 month ARI

Table 3 – Target Reductions

In order to achieve these reductions, a treatment train approach will be implemented into the development where the stormwater treatment flow path for runoff would generally be:

1. Runoff from roofed areas would be collected and detained in rainwater tanks with an overflow by-pass to a bioretention swale where it would be filtered and treated biologically ;
2. Excess flows from the bioretention swales would flow to the pipe drainage system designed to cater for the 20 year ARI event;
3. Stormwater exiting the pipe drainage system would pass through a GPT to remove remaining coarse sediment, litter, debris, oils and greases; and;
4. Stormwater would drain from the GPT to the discharge point either in the tidal channel or Woolooware Bay. Appropriate scour protection measures will be in place at all outlets;

5. Reduce gross pollutants entering the tidal channel through external catchments via implementation of a trash rack at the upstream end of the culvert under Captain Cook Drive.

A Water Management Report for the retail development written by Insync Services Pty Ltd discusses the proposed methodology for the water consumption reduction strategies to meet the Environmental Sustainable Development (ESD) targets for the development. Refer to Appendix H. Within this report stormwater harvesting is discussed with a rainwater tank proposed for the retail site to reduce potable water usage. This report also discusses the water quality treatment required to re-use the rainwater.

MUSIC Analysis

The software package developed by the CRC for Catchment Hydrology termed "MUSIC" (Model for Urban Stormwater Improvement Conceptualisation) was used to assess the effectiveness of the proposed "treatment train" and therefore ensure compliance with the proposed objectives.

All MUSIC input and output data are shown in Appendix D.

As shown in the Stormwater Catchment Plan in Appendix E the retail site comprises two different catchments. The entire multi storey carpark, northern extension of the club building and the entrance road off Captain Cook Drive comprise one catchment. This is shown as catchment F in the Catchment Plan. This stormwater will drain via a bio-retention swale north of the carpark and discharge into the entrance road system before draining along Captain Cook Drive into the proposed Council stormwater network south of the Fitness First building.

The second catchment incorporates the majority of the re-developed club building and the main entrance and loading dock off Captain Cook Drive as indicated by catchment G in the Catchment Plan. All the stormwater from this area will drain via specified treatment gullies and discharge into the 900mm diameter pipe within Captain Cook Drive.

2.2.6 Flooding and Overland Flows

Hydraulic modelling of the entire catchment through DRAINS software was carried out for all catchments in the Retail development stage. All input data and results are shown in Appendix C.

WMA Water has carried out a flood assessment report for the retail site. This report is attached in Appendix F.

This report used DRAINS and TUFLOW software to determine the design flood levels and hazard information for the 20 and 100 year ARI storm events and the Probable Maximum Flood (PMF) for both the existing and post developed site. Within the modelling it was determined the maximum 100 year flood level along Captain Cook Drive is RL 2.46mAHD and the PMF peak flood level is RL 3.14mAHD. Given the proposed finished floor level of the retail development is RL 4.00mAHD it is summarised the site is not at risk to flooding and is compliant with Sutherland Shire Council's development controls.

The proposed entrance road level off Captain Cook Drive is at RL 2.60mAHD which is still above the maximum 100 year flood level.

The WMA Water report also summarised the impacts of flood depths around the site with the development. It was determined the proposed retail development results in up to 50mm off-site impacts for the 100 year ARI storm, however this can be mitigated by upgrading the stormwater drainage network within Captain Cook Drive. The proposed civil drawings indicate these upgrade works.

The report has also taken into account climate change in line with the Statement of Commitments as in Table 1. It summarised the peak flood levels would increase by 0.2m as a result of climate change. This 0.2m rise would still result in peak flood levels being below the finished floor levels and as such still be compliant with Council's development controls.

The 20 and 100 year ARI post development flood levels determined in the flood assessment report were adopted as tailwater levels for the DRAINS analysis for stormwater design purposes. All DRAINs results are within Appendix C.

It should be noted the WMA Water Flood Report concludes the retail development does not affect the existing flood levels of the tidal channel adjacent to Toyota Stadium. A separate flood report will be carried out for the residential development to determine the impacts of this development on the tidal channel and surrounding areas.

3 Sedimentation and Erosion Control

3.1 Sedimentation and Erosion Control (Construction)

Stormwater runoff generated from within the works area during construction will likely contain sediments and oils from construction machinery. A number of options are available for the removal of these contaminants from stormwater, some of which include:

- Wheel wash down/ Cattle Shaker Grid
- Sedimentation settlement pits
- Sediment fences
- Diversion banks
- Stabilisation of finished areas
- Cut off drains

3.2 Implementation of devices

Preliminary Engineering plans have been developed in accordance with Department of Housing, *Managing Urban Stormwater, Soils and Construction*, Fourth Edition. The contractor shall implement all aspects of the plans relating to the particular area where construction is taking place. Following are possible levels of control that are to be constructed.

- The vehicular access points are to be stabilised preferably with cattle shaker grid and washdown.
- Sediment fence and filter socks are to be placed at the downstream end of the site to prevent runoff.
- Kerb inlet sediment traps to be installed at existing and proposed stormwater pits.
- Areas disturbed by road and stormwater construction shall be stabilised (progressively) as soon as practically possible after completion of works.

4 Road Design

4.1 Captain Cook Drive

As mentioned previously, the retail development involves upgrading and widening works of Captain Cook Drive and Woolooware Road. These upgrade works have been proposed by McLaren Traffic Engineering Consultants. Refer to Drawings in Appendix B. The majority of the works will involve the alteration of the Captain Cook Drive / Woolooware Road intersection. Refer to drawing Civil DA Drawings proposed road alignments. These intersection drawings have received Approval in Principal from the RMS.

Currently there is no kerb and gutter along Captain Cook Drive east of the intersection with Woolooware Road. Included in the upgrade works will be constructing kerb and gutter on both sides of Captain Cook Drive to match into Council's upgrade works east of the Fitness First Building. Vehicle crossovers into the existing Caltex Service Station and Fitness First building will also need to be constructed.

Included within the upgrade works will be an extension of the Woolooware Road north of the intersection with Captain Cook Drive to service the proposed loading dock within the retail carpark. Currently there is only a minor access road and carpark off Captain Cook Drive which services the Caltex station and Fitness First. This road will be removed and a new dual lane Council road will be constructed at the intersection of Captain Cook Drive and Woolooware Road.

4.2 Horizontal and Vertical Geometry

The internal roads, access ways, loading docks and carparking bays have been designed generally in accordance with Sutherland Shire Council's DCP, AS2890.1, and AS1428.1.

4.3 Pavement

All new pavements will be designed based on the requirements of Austroads Pavement Design Guide - A Guide to the Structural Design of Road Pavements and Sutherland Shire Council standards. Site specific subgrade CBR values or traffic ESA's are not available at this stage and will require further investigation at the detailed design stage.

5 Services

5.1 Existing

5.1.1 Sewerage (Sydney Water)

There is an existing 1800mm diameter trunk sewer carrier with two 225mm diameter stubs that currently service the site.

As part of the Future Environmental Assessment Requirements within the Concept Approval there is a Sydney Water condition stating “Future applications shall address Sydney Water’s requirements in relation to the required upsizing of the existing 225mm wastewater main to a 300mm main in Captain Cook Drive, will require an extension of at least one metre inside the property boundary”

These upgrade works of the sewerage network within Captain Cook Drive will need to be undertaken as part of Stage 1 (Retail Site) of the Woolooware Bay Town Centre development.

5.1.2 Water (Sydney Water)

There is an existing 100 and 150mm diameter mains in Captain Cook Drive which currently service the site.

As part of the Future Environmental Assessment Requirements within the Concept Approval there is a Sydney Water condition stating “Future applications shall address Sydney Water’s requirements in relation to the required upsizing of the existing 150mm drinking water main to a 200mm main from the existing 375mm main on the corner of Kurnell Road and Hume Road”

These construction and upgrade works of the water main will need to be undertaken as part of Stage 1 (Retail Site) of the Woolooware Bay Town Centre development.

5.1.3 Power (Ausgrid)

Our assessment of power supply for this project is based on the development requiring an 11kV feeder to supply a number of on-site kiosk type substations. It is expected the retail site will require a single chamber type substation.

From the network diagrams received via our DBYD enquiry and initial discussions with Ausgrid, it appears there will be sufficient supply within the existing 11kV overhead and underground cables that front the site along Captain Cook Drive.

With the proposed retail development and associated road works on Captain Cook Drive and Woolooware Road it is likely existing overhead power lines and poles will need to be relocated.

All electrical power requirements for the site and relocation of existing cables and poles will need to be confirmed with Ausgrid at detailed design stages. Preliminary discussions will also be entered into with Ausgrid to explore the option of relocating the existing overhead transmission lines north of the site to underground cables.

5.1.4 Telecommunications (NBN Co)

National Broadband Network (NBN Co) have committed to servicing the future development.

5.1.5 Gas (Jemena)

The existing Gas network in the area consists of:

- 110mm Nylon main (300kPa) near the corner of Captain Cook Drive and Woolooware Road. This main would be suitable for connection depending on the required demand.
- 300mm Secondary main (1050kPa) running along Captain Cook Drive which appears to currently service the site. This main may be suitable for connection depending on the required demand.

Based on our initial discussions with Jemena it is expected the existing services have sufficient capacity to service the development.

6 Conclusion

This report in conjunction with the Civil Engineering drawings listed in Appendix G has demonstrated that a stormwater drainage system consistent with good management practices can be provided for the proposed development. The proposed in ground pipe network can accommodate the 20 year design ARI. Overland flows through the site have been accommodated in the site layout to compensate for the 100 year ARI storm event.

The stormwater management plan demonstrated within this report also complies with the Statement of Commitments required within the Concept Approval issued by the Minister of Planning and Infrastructure.

The flood assessment report carried out by WMA Water within Appendix F also demonstrates compliance with the Statement of Commitments regarding flood assessment. The report:

- investigates the proposed development flood levels,
- effects of flooding within and outside of the site,
- investigates increased flood levels with increases in rainfall intensities due to predicted climate changes ;
- discusses evacuation routes and emergency procedures during flood events

Initial discussions with the various service authorities have determined that the development can be adequately serviced subject to planning and future negotiations.

Appendix A

Photographs

A01 – Existing eastern carpark

A02 – Existing access road to Fitness First off Captain Cook Drive

A03 –View looking west to the north of Fitness First building

A04 - View from Club building looking west over carpark

A05 – Existing entrance to Caltex off Captain Cook Drive

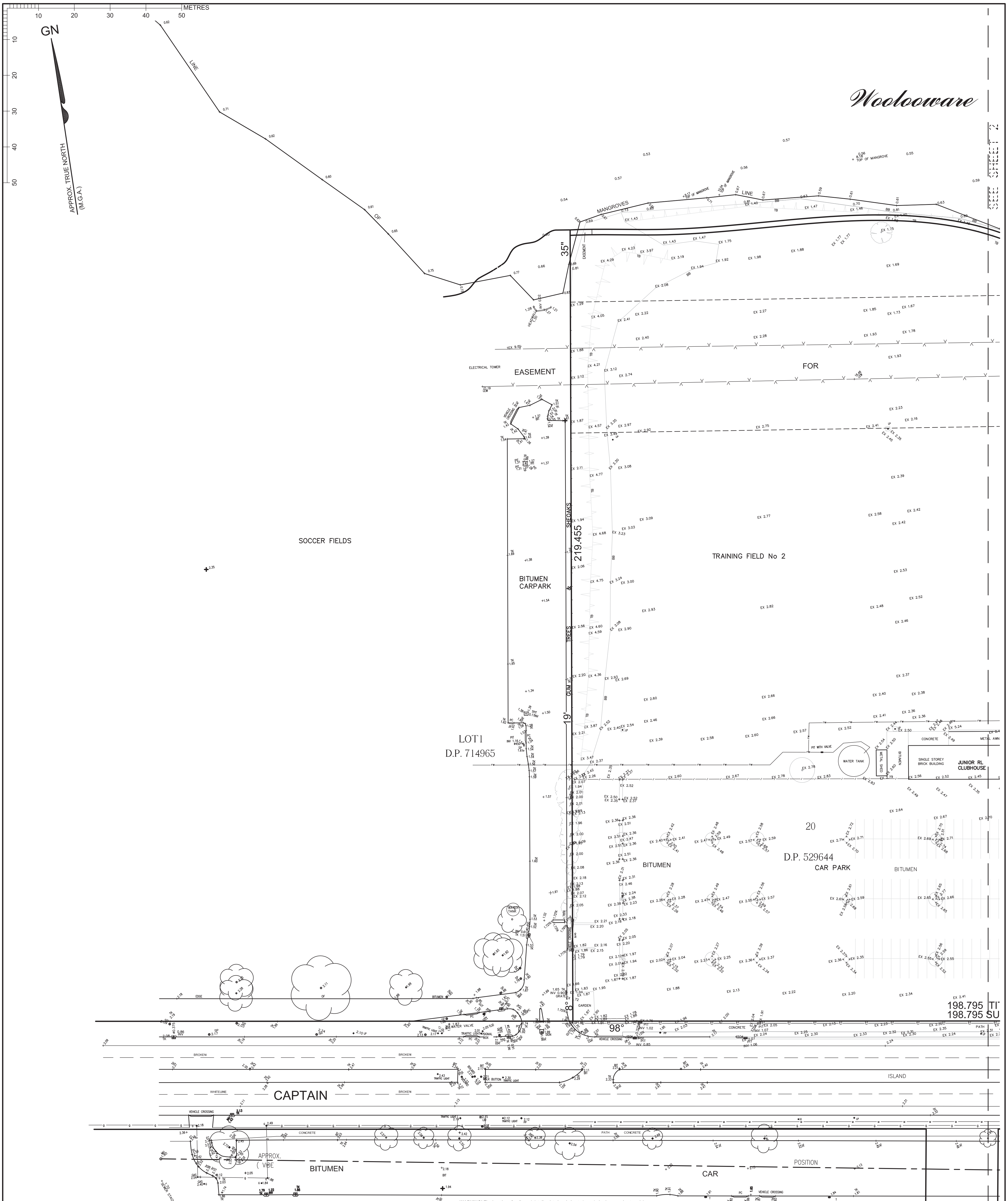
A06 – Existing roundabout at intersection of Captain Cook Drive and Woolooware Rd

A07 – Captain Cook Drive looking east

A08 – Existing Club building

Appendix B

Existing Drawings



WARNING! The location of walls and detail points in relation to boundaries is approximate only!

NOTES

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2. Bearings, distances and areas of boundaries are from the Land and Property Management Authority records only. They are on Map Grid of Australia . If accurate True North is required a further survey would be necessary.
3. Relationship of improvements to boundaries is diagrammatic only. Boundary fences and retaining walls have not been accurately located and may not be shown on this plan.DO NOT SCALE OFF THIS PLAN. Where offsets from improvements, fences or walls to boundaries are critical for future building design and construction they MUST be confirmed by a further boundary survey. This survey has not investigated any subterranean structures.
4. The services information shown on this plan have been determined from visual inspection only and information provided by the relevant authorities through "Dial before you dig" . It is passed on with the understanding that no excavation or works will be commenced without a current services search of all services being obtained from "Dial before you dig" (DBYD) (phone 1100 or fax 1300 652 077) or from any individual service provider. Note that not all services providers are members of DBYD.
5. The location of Sydney Water's Sewer Main has been plotted approximately, based on visible maintenance holes and information from Sydney Water. This information can not be relied on. Any construction near Sydney Water Mains requires further investigation, a Service Protection Report (sewer pegout) and approval from Sydney Water.
6. The locations of spot levels are diagrammatic only. They are accurate to ± 0.3m in relation to boundaries. Levels critical to design, excavation or construction must be verified. If contours are shown they depict the topography rather than represent the exact level at any particular point. Care should be taken if extrapolating levels or contours.
7. The spread of the crown of the trees shown on this plan is diagrammatic only, based on the average spread observed in the field. Prior to any development proposal which might be affected by trees it is recommended that the tree spreads be verified by field inspection.
8. Australian Height Datum was established from PM. 31619 R.L. 1.279 located at the intersection of Captain Cook Drive & Woolooware Road Woolooware . Datum source obtained from S.C.I.M.S. 22/06/2011.
9. The plan has been compiled from field survey information and Plans prepared by Rygate & Company Pty Ltd and Johnathan C. Keen & Co. Pty Ltd

ALL ABOVE NOTES ARE AN INTEGRAL PART OF THIS PLAN

- e — UNDERGROUND ELECTRICAL
- y — OVERHEAD ELECTRICAL
- g — EXISTING GAS
- RECYCLED WATER
- t — EXISTING TELECOMMUNICATIONS
- w — EXISTING WATER
- -/- FENCE

Legend

BB	Bottom of Bank
BFL	Balcony Floor Level
BRW	Bottom Retaining Wall
CONC	Concrete
EC	Edge of Concrete
FL	Floor Level
G	Grate
INV	Invert Level
LW	Lower Window
PC	Pedestrian Crossing
RL	Relative Level
TB	Top of Bank
TG	Top of Gutter
TK	Top of Kerb
TRW	Top Retaining Wall
TW	Top Wall
USG	Underside of Gutter
UW	Upper Window
VC	Vehicle Crossing
W	Window
WC	Toilet
LEW	Lowest Electrical Wire
TETW	Top Of Electrical Tower/Pole
TOC	Table on Concrete
TTTW	Top Of Telecommunication Tower
H	Hydrant
LH	Lamp Hole
LP	Light Pole
MH	Maintenance Hole
PP	Power Pole
SP	Sign Pole
SV	Stop Valve
T	Telstra

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BUILDING, ENVIRONMENTAL & BUSHFIRE CONSULTANTS
WATER SERVICING CO-ORDINATOR FOR SYDNEY WATER
P.O. BOX 4025, KOGARAH BAY, N.S.W. 2217 365 PRINCES HIGHWAY, CARLTON, N.S.W. 2218
PHONE: (02) 9546 2377
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ISO 9001 FS 520963
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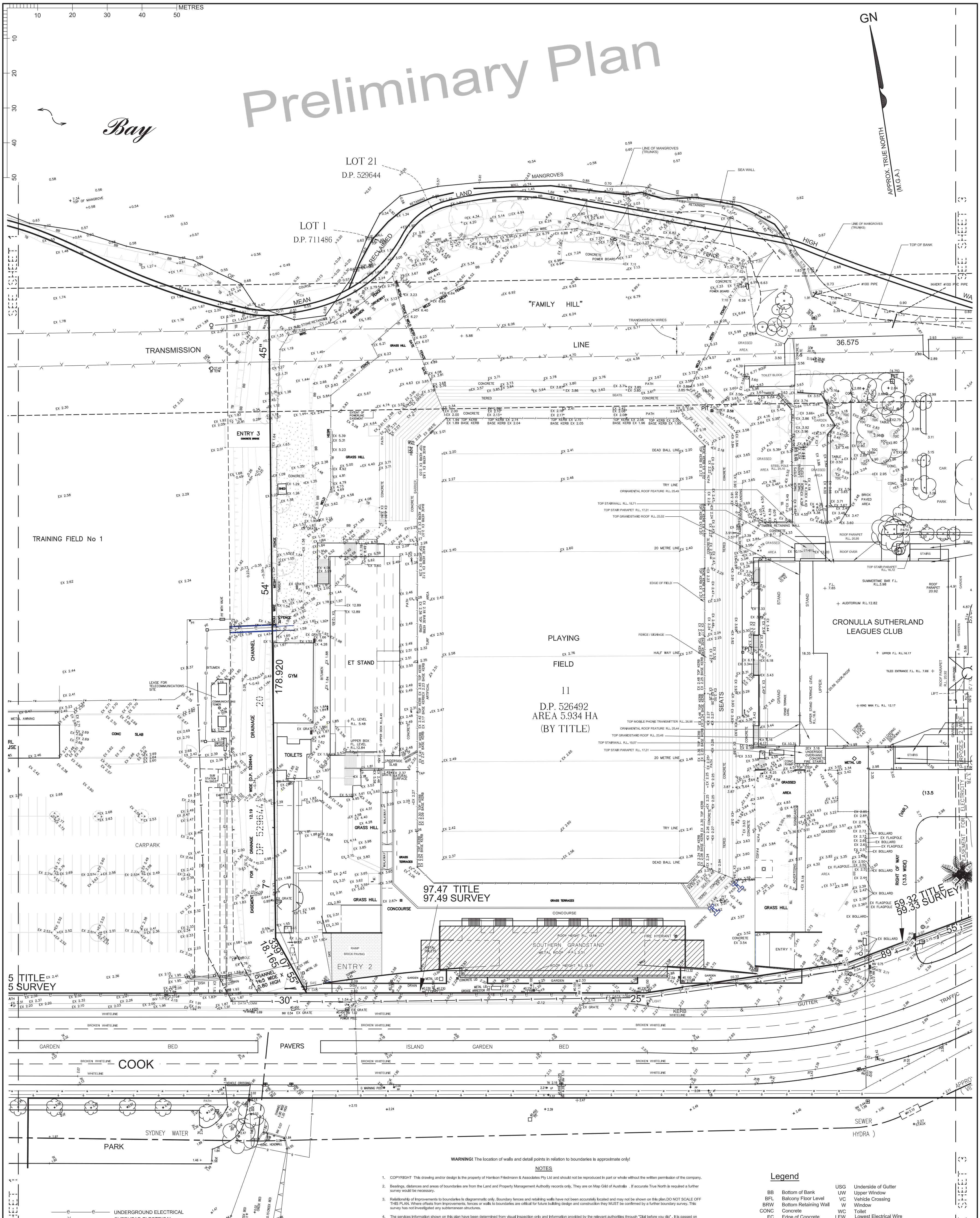
COVER OF EXCELLENCE
JAS-ANZ

PLAN SHOWING SITE DETAILS AND LEVELS FOR BUILDING DESIGN PURPOSES AT CAPTAIN COOK DRIVE WOOLOOWARE LOT 20 IN D.P. 529644 LOT 11 IN D.P. 526492

FOR BLUESTONE CAPITAL VENTURES No.1

REDUCTION RATIO	SURVEYED / DRAWN
1:500 @ A1	ML/CK
DATUM: A.H.D.	CHECKED
DATE: 2/6/2011	REFERENCE: 40966DT SHEET 1 OF 3

CAD FILE NAME: 40966DT DET.DWG PLOTTED: 08/07/11 - 4:38PM



UNDERGROUND ELECTRICAL
OVERHEAD ELECTRICAL
EXISTING GAS
RECYCLED WATER
EXISTING TELECOMMUNICATIONS
EXISTING WATER
FENCE

WARNING! The location of walls and detail points in relation to boundaries is approximate only!

NOTES

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2. Bearings, distances and areas of boundaries are from the Land and Property Management Authority records only. They are on Map Grid of Australia . If accurate True North is required a further survey would be necessary.
3. Relationship of Improvements to boundaries is diagrammatic only. Boundary fences and retaining walls have not been accurately located and may not be shown on this plan.DO NOT SCALE OFF THIS PLAN. Where offsets from improvements, fences or walls to boundaries are critical for future building design and construction they MUST be confirmed by a further boundary survey. This survey has not investigated any subterranean structures.
4. The services information shown on this plan have been determined from visual inspection only and information provided by the relevant authorities through "Dial before you dig" . It is passed on with the understanding that no excavation or works will be commenced without a current services search of all services being obtained from "Dial before you dig" (DBYD) (phone 1100 or fax 1300 652 077) or from any individual service provider. Note that not all services providers are members of DBYD.
5. The location of Sydney Water's Sewer Main has been plotted approximately, based on visible maintenance holes and Information from Sydney Water. This Information can not be relied on. Any construction near Sydney Water Mains requires further investigation, a Service Protection Report (sewer pegout) and approval from Sydney Water.
6. The locations of spot levels are diagrammatic only. They are accurate to ± 0.3m in relation to boundaries. Levels critical to design, excavation or construction must be verified. If contours are shown they depict the topography rather than represent the exact level at any particular point. Care should be taken if extrapolating levels or contours.
7. The spread of the crown of the trees shown on this plan is diagrammatic only, based on the average spread observed in the field. Prior to any development proposal which might be affected by trees it is recommended that the tree spreads be verified by field inspection.
8. Australian Height Datum was established from PM. 31619 R.L. 1.279 located at the intersection of Captain Cook Drive & Woolooware Road Woolooware . Datum source obtained from S.C.I.M.S. 22/06/2011.
9. The plan has been compiled from field survey information and Plans prepared by Rygate & Company Pty Ltd and Johnathan C. Keen & Co. Pty Ltd

ALL ABOVE NOTES ARE AN INTEGRAL PART OF THIS PLAN

Legend

BB	Bottom of Bank	USG	Underside of Gutter
BFL	Balcony Floor Level	UW	Upper Window
BRW	Bottom Retaining Wall	VC	Vehicle Crossing
CONC	Concrete	W	Window
EC	Edge of Concrete	WC	Toilet
FL	Floor Level	LEW	Lowest Electrical Wire
G	Grate	TETW	Top Of Electrical Tower/Pole
INV	Invert Level	TOC	Table on Concrete
LW	Lower Window	TTTW	Top Of Telecommunication Tower
PC	Pedestrian Crossing		Hydrant
RL	Relative Level	LH	Lamp Hole
TB	Top of Bank	LP	Light Pole
TG	Top of Gutter	MH	Maintenance Hole
TK	Top of Kerb	PP	Power Pole
TRW	Top Retaining Wall	SP	Sign Pole
TW	Top Wall	SV	Stop Valve
		T	Telstra

[A] EASEMENT FOR ELECTRICITY AND OTHER PURPOSES 2 WIDE AND 3.3WIDE

[B] RIGHT OF CARRIAGEWAY 4 WIDE AND VARIABLE WIDTH

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FOR BUILDING DESIGN PURPOSES
AT CAPTAIN COOK DRIVE WOOLOOWARE
LOT 20 IN D.P. 529644 LOT 11 IN D.P. 526492

FOR BLUESTONE CAPITAL VENTURES No. 1

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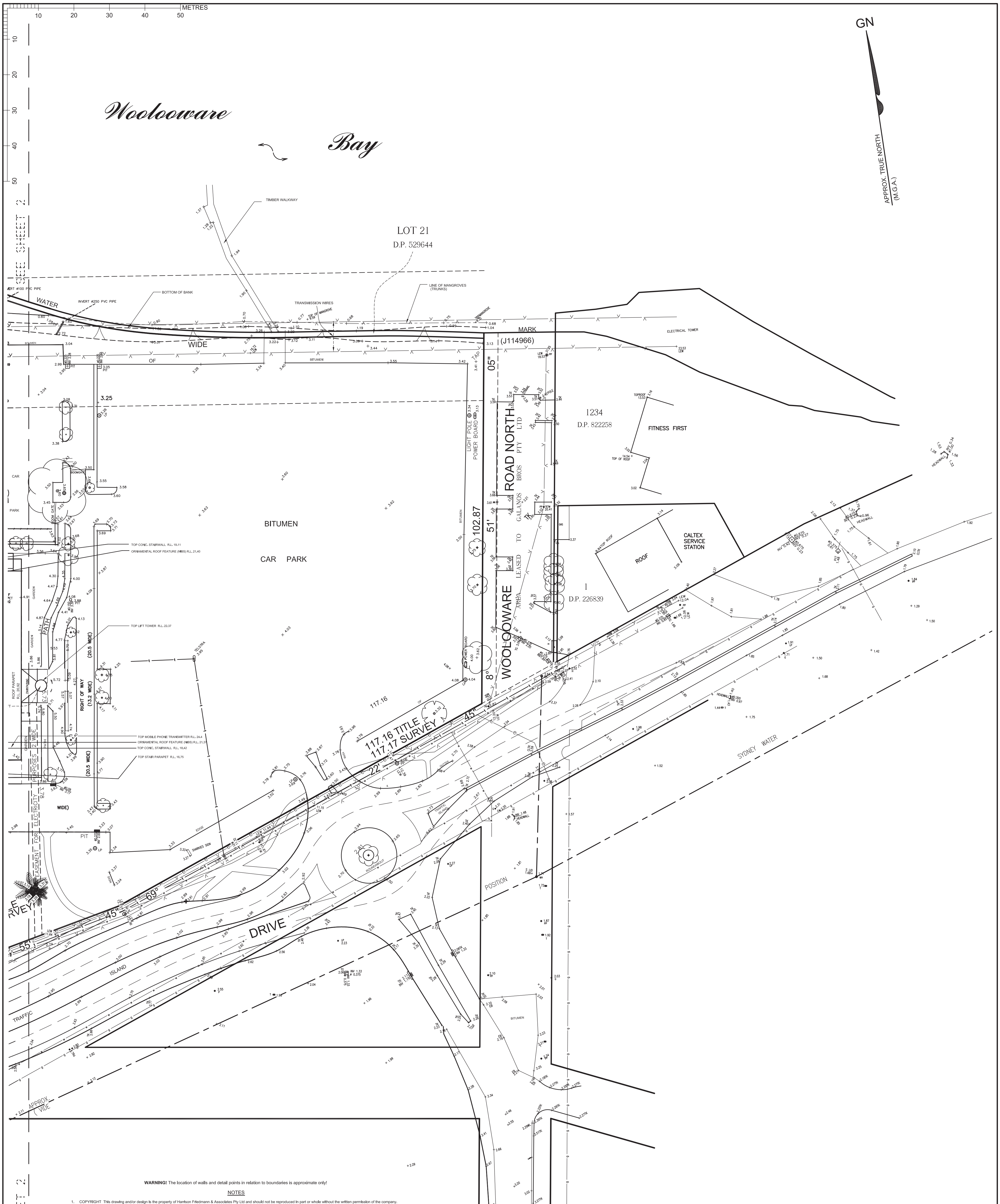
DATE	REFERENCE
2/6/2011	40966DT SHEET 2 OF 3

CAD FILE NAME: 40966DT DET.DWG PLOTTED: 08/07/11 – 4:39PM



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Legend

UNDERGROUND ELECTRICAL
OVERHEAD ELECTRICAL
EXISTING GAS
RECYCLED WATER
EXISTING TELECOMMUNICATIONS
EXISTING WATER
FENCE

		USG	Underside of Gutter
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TG	Top of Gutter	PP	Power Pole
TK	Top of Kerb	SP	Sign Pole
TRW	Top Retaining Wall	SV	Stop Valve
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A.H.D.	
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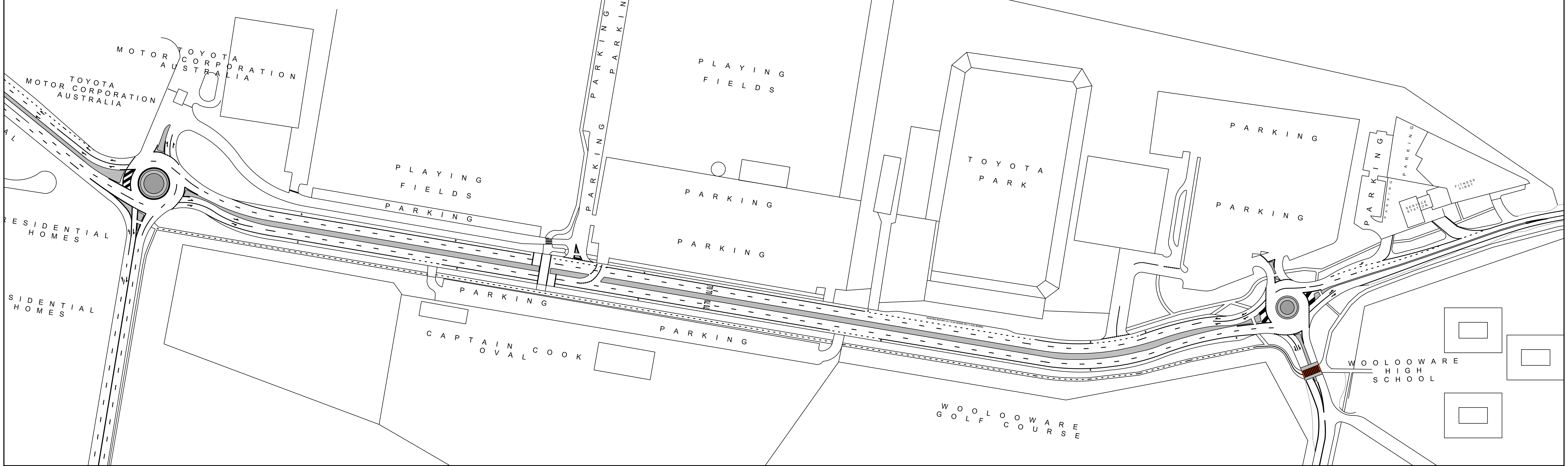
2/6/2011	40966DT SHEET 3 OF 3

CAD FILE NAME: 40966DT DET.DWG PLOTTED: 08/07/11 - 4:40PM

EXISTING ACCESS ARRANGEMENTS



PROPOSED ACCESS ARRANGEMENTS

McLaren Traffic Engineering

Level 1, 29 Kiora Road, Miranda NSW 2228
mclarenc@ozemail.com.au
www.mclarentraffic.com.au
P : (02) 8543 3811
M : 0412 949 578

Client:
CRONULLA SHARKS

Project:
Access plan for Cronulla Sharks Mixed Use DA

Notes:
CONCEPT PLAN ONLY. Not for construction.

New bus bays designed in accordance with "Bus Stop Installation Guide for Local Councils: Design Manual" by State Transit Authority NSW / PPK

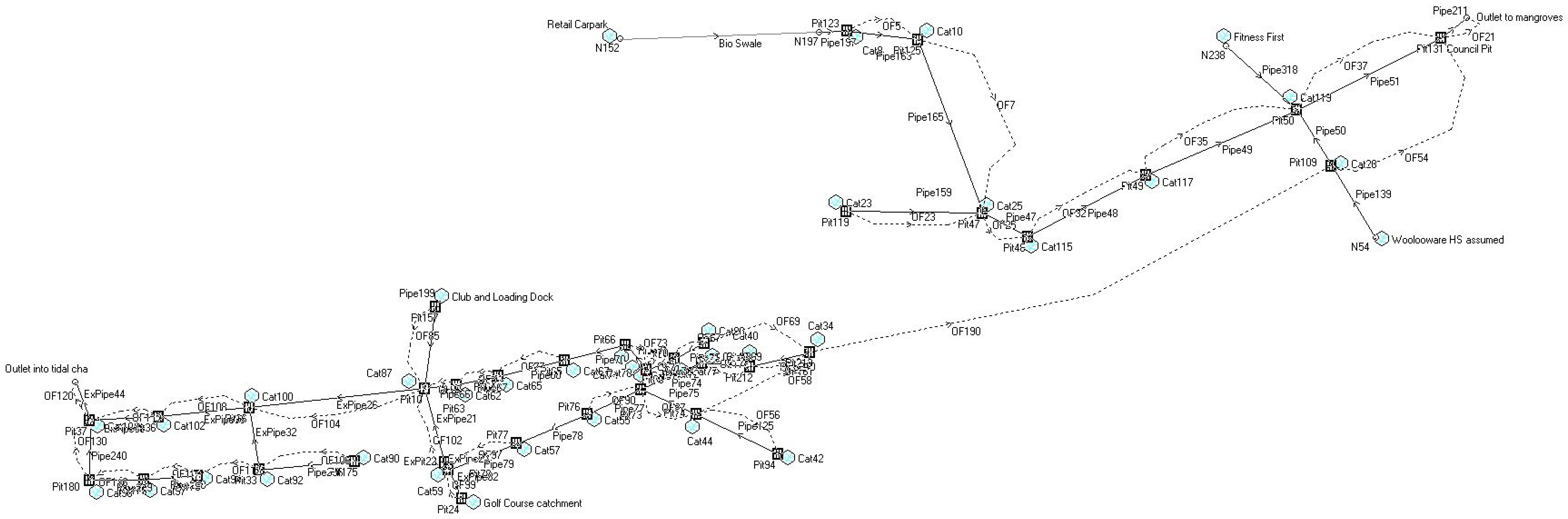
Drawing title:
PROPOSED ACCESS CHANGES

Job No.:	Date:	Drawing no:
10166	23 June 2011	7

Revision	Date	Details

Appendix C

DRAINS Model & Results


Retail Carpark
N152
Bio Swale
Pit123
N197
Pipe197
OF5
Cat10
Cat8
Pit125
Pipe163
Pipe165
OF7
Cat23
Pit119
Pipe159
OF23
Pit47
Cat25
Pipe47
OF25
Pit46
Cat115
OF32
Pipe48
Pit49
Cat117
OF35
Pipe49
Pit50
Cat119
Fitness First
N238
Pipe318
OF37
Pipe51
Pipe211
Outlet to mangroves
OF21
Pit131 Council Pit
Pipe50
Pit109
Cat28
OF54
Pipe139
N54
Woolooware HS assumed
OF190
Pipe199
Club and Loading Dock
Pit157
OF85
Cat87
Pit10
Cat100
ExPipe26
OF104
Outlet into tidal cha
OF120
ExPipe44
Pit37
OF130
Pipe240
Pit180
Cat102
ExPipe32
Pit33
Cat92
Cat90
Pit63
ExPipe21
OF102
ExPit22
Cat59
Pit24
Golf Course catchment
Pit77
Cat57
Pipe78
Pipe79
Pit76
Cat55
Pit66
Cat65
Cat62
Pipe74
Pipe75
Cat80
Cat40
OF69
Cat34
Pit212
OF58
Pit74
Cat44
OF56
Pipe125
Pit94
Cat42

PIT / NODE DETAILS Version 11

Name	Type	Family	Size	Ponding Volume (cu.m)	Pressure Change Coeff. Ku	Surface Elev (m)	Max Pond Depth (m)	Base Inflow (cu.m/s)	Blocking Factor	x	y	Bolt-down lid	id	Part Full Shock Loss	Inflow Hydrograph
Pit24	OnGrade	JUNCTION	1.2 x 1.2 INFILL LID		4.4	2.4		0	0.2	283696.4	6284877	No	48	1 x Ku	No
Pit78	OnGrade	Sutherland	Sutherland 1.8 m lintel		2.1	2.37		0	0.2	283688.4	6284894	No	158	1 x Ku	No
ExPit22	OnGrade	JUNCTION	1.2 x 1.2 INFILL LID		1.6	2.28		0	0.2	283685.8	6284899	Yes	44	1 x Ku	No
Pit10	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.3	2.35		0	0.2	283673.7	6284944	No	20	1 x Ku	No
Pit26	OnGrade	JUNCTION	1.2 x 1.2 GRATED SURFAC		1.6	2		0	0.2	283566.8	6284932	No	52	1 x Ku	No
Pit36	OnGrade	JUNCTION	1.2 x 1.2 GRATED SURFAC		0.5	1.67		0	0.2	283511.1	6284927	No	72	1 x Ku	No
Pit37	OnGrade	JUNCTION	1.2 x 1.2 INFILL LID		1.8	1.64		0	0.2	283469.4	6284925	No	75	1 x Ku	No
Outlet into	Node					0		0		283460.6	6284948		91		
N54	Node					3		0		284254	6285036		104		
Pit109	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.2	1.8		0	0.2	284227.1	6285080	No	245	1 x Ku	No
Pit50	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.4	1.9		0	0.2	284205.9	6285114	No	101	1 x Ku	No
Pit131 Cou	OnGrade	JUNCTION	1.2 x 1.2 GRATED SURFAC		1.1	1.55		0	0.2	284294.3	6285158	No	297	1 x Ku	No
Outlet to r	Node					1.2		0		284309.6	6285170		499		
Pit71	OnGrade	Sutherland	Sutherland 1.8 m lintel		2.8	2.4		0	0.2	283844.3	6284972	No	146	1 x Ku	No
Pit70	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.3	2.5		0	0.2	283826.1	6284962	No	145	1 x Ku	No
Pit69	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.5	2.6		0	0.2	283809.2	6284955	No	143	1 x Ku	No
Pit66	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.2	2.83		0	0.2	283796.4	6284970	No	138	1 x Ku	No
Pit65	OnGrade	Sutherland	Sutherland 1.8 m lintel		0	2.8		0	0.2	283759.3	6284961	No	137	1 x Ku	No
Pit64	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.7	2.8		0	0.2	283718.5	6284951	No	135	1 x Ku	No
Pit63	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.6	2.4		0	0.2	283693.2	6284946	No	133	1 x Ku	No
Pit94	OnGrade	Sutherland	Sutherland 1.8 m lintel		3.1	2.4		0	0.2	283889.6	6284904	No	223	1 x Ku	No
Pit74	Sag	Sutherland	Sutherland	20	2.8	2	0.2	0	0.5	283839.5	6284928	No	152	1 x Ku	No
Pit73	Sag	Sutherland	Sutherland	15	1.3	2.4	0.2	0	0.5	283805.6	6284943	No	151	1 x Ku	No
Pit76	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.5	2.6		0	0.2	283772.8	6284928	No	156	1 x Ku	No
Pit77	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.4	2.59		0	0.2	283729.8	6284910	No	157	1 x Ku	No
Pit119	OnGrade	Sutherland	Sutherland 1.8 m lintel		3.3	2.83		0	0.2	283930.8	6285052	No	281	1 x Ku	No
Pit47	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.2	2.6		0	0.2	284014.2	6285051	No	95	1 x Ku	No
Pit48	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.9	2.45		0	0.2	284041.6	6285036	No	97	1 x Ku	No
Pit49	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.4	2.2		0	0.2	284113.9	6285074	No	99	1 x Ku	No
N152	Node							0		283792.9	6285157		359		
N197	Node					2.8		0		283914.1	6285161		873		
Pit123	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.3	3.1		0	0.2	283931.5	6285162	No	289	1 x Ku	No
Pit125	Sag	Sutherland	Sutherland	10	1.3	3	0.15	0	0.5	283974.6	6285157	No	291	1 x Ku	No
Pit157	Sag	JUNCTION	1.2 x 1.2 GI	15	3	2.3	0.1	0	0.5	283680.3	6284994	No	454	1 x Ku	No
Pit175	OnGrade	Sutherland	Sutherland 1.8 m lintel		4.4	2.12		0	0.2	283631.2	6284900	No	621	1 x Ku	No
Pit33	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.8	2.1		0	0.2	283572.9	6284894	No	64	1 x Ku	No
Pit178	OnGrade	Sutherland	Sutherland 1.8 m lintel		3.7	1.9		0	0.2	283535.4	6284891	No	630	1 x Ku	No
Pit179	OnGrade	Sutherland	Sutherland 1.8 m lintel		1.5	1.86		0	0.2	283502.2	6284888	No	631	1 x Ku	No
Pit180	OnGrade	Sutherland	Sutherland 1.8 m lintel		2.5	1.69		0	0.2	283469.1	6284888	No	632	1 x Ku	No
Pit213	Sag	Sutherland	Sutherland	15	3.3	2	0.15	0	0.5	283908.6	6284966	No	1.25E+08	1 x Ku	No
Pit212	Sag	Sutherland	Sutherland	15	1.4	2.05	0.15	0	0.5	283872.3	6284957	No	1.25E+08	1 x Ku	No
Pit72	OnGrade	Sutherland	Sutherland 1.8 m lintel		0.9	2.12		0	0.2	283842.8	6284959	No	149	1 x Ku	No
N238	Node					2.4		0		284162.8	6285152		1.25E+08		

DETENTION BASIN DETAILS

Name	Elev	Surf. Area	Init Vol. (cu	Outlet Type	K	Dia(mm)	Centre RL	Pit Family	Pit Type	x	y	HED	Crest RL	Crest Lengt	id

SUB-CATCHMENT DETAILS

Name	Pit or Node	Total Area (ha)	Paved Area %	Grass Area %	Supp Area %	Paved Time (min)	Grass Time (min)	Supp Time (min)	Paved Length (m)	Grass Length (m)	Supp Length (m)	Paved Slope(%) %	Grass Slope %	Supp Slope %	Paved Rough	Grass Rough	Supp Rough	Lag Time or Factor	Gutter Length (m)	Gutter Slope %	Gutter FlowFactor	Rainfall Multiplier
Golf Course	Pit24	0.5	50	50	0	10	15	0										0				1

Cat59	Pit78	0.056	90	10	0	5	10	0	0	1
Cat87	Pit10	0.05	90	10	0	5	10	0	0	1
Cat100	Pit26	0.11	90	10	0	5	10	0	0	1
Cat102	Pit36	0.111	90	10	0	5	10	0	0	1
Cat104	Pit37	0.03	90	10	0	5	10	0	0	1
Wooloowa	N54	0.6	70	30	0	10	15	0	0	1
Cat28	Pit109	0.06	90	10	0	5	10	0	0	1
Cat119	Pit50	0.07	90	10	0	5	10	0	0	1
Cat80	Pit71	0.056	90	10	0	5	10	0	0	1
Cat77	Pit70	0.055	90	10	0	5	10	0	0	1
Cat74	Pit69	0.06	90	10	0	5	10	0	0	1
Cat70	Pit66	0.01	90	10	0	5	10	0	0	1
Cat67	Pit65	0.02	90	10	0	5	10	0	0	1
Cat65	Pit64	0.048	90	10	0	5	10	0	0	1
Cat62	Pit63	0.045	90	10	0	5	10	0	0	1
Cat42	Pit94	0.03	90	10	0	5	10	0	0	1
Cat44	Pit74	0.106	90	10	0	5	10	0	0	1
Cat51	Pit73	0.043	90	10	0	5	10	0	0	1
Cat55	Pit76	0.035	90	10	0	5	10	0	0	1
Cat57	Pit77	0.025	90	10	0	5	10	0	0	1
Cat23	Pit119	0.06	90	10	0	5	10	0	0	1
Cat25	Pit47	0.064	90	10	0	5	10	0	0	1
Cat115	Pit48	0.036	90	10	0	5	7	0	0	1
Cat117	Pit49	0.052	90	10	0	5	7	0	0	1
Retail Carp	N152	1.329	95	5	0	10	15	0	0	1
Cat8	Pit123	0.025	90	10	0	5	10	0	0	1
Cat10	Pit125	0.042	90	10	0	5	10	0	0	1
Club and Lc	Pit157	0.6386	90	10	0	8	10	0	0	1
Cat90	Pit175	0.08	90	10	0	5	10	0	0	1
Cat92	Pit33	0.064	90	10	0	5	10	0	0	1
Cat94	Pit178	0.05	90	10	0	5	10	0	0	1
Cat97	Pit179	0.05	90	10	0	5	10	0	0	1
Cat98	Pit180	0.03	90	10	0	5	10	0	0	1
Cat34	Pit213	0.29	90	10	0	6	10	0	0	1
Cat40	Pit212	0.074	90	10	0	5	10	0	0	1
Cat48	Pit72	0.042	90	10	0	5	10	0	0	1
Fitness Firs	N238	0.51	80	20	0	5	10	0	0	1

PIPE DETAILS

Name	From	To	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Type	Dia (mm)	I.D. (mm)	Rough	Pipe Is	No. Pipes	Chg From	At Chg	Chg (m)	Rl (m)	Chg (m)	RL (m)	etc (m)
ExPipe82	Pit24	Pit78	6.89	0.32	0.22	1.45	Concrete, u	900	900	0.3	New	1	Pit24	0					
ExPipe23	Pit78	ExPit22	4	0.22	0.21	0.25	Concrete, u	900	900	0.3	New	1	Pit78	0					
ExPipe21	ExPit22	Pit10	19.97	0.21	0.2	0.05	Concrete, u	900	900	0.3	New	1	ExPit22	0					
ExPipe26	Pit10	Pit26	76.03	0.191	0.1	0.12	Concrete, u	900	900	0.3	New	1	Pit10	0					
ExPipe36	Pit26	Pit36	45.85	0.099	0.044	0.12	Concrete, u	900	900	0.3	New	1	Pit26	0					
ExPipe38	Pit36	Pit37	28.59	0.044	0.01	0.12	Concrete, u	900	900	0.3	New	1	Pit36	0					
ExPipe44	Pit37	Outlet into	7.98	0.01	0	0.13	Concrete, u	900	900	0.3	New	1	Pit37	0					
Pipe139	N54	Pit109	15	0.575	0.5	0.5	Concrete, r	675	675	0.3	New	1	N54	0					
Pipe50	Pit109	Pit50	24.91	0.475	0.35	0.5	Concrete, u	675	675	0.3	New	1	Pit109	0					
Pipe51	Pit50	Pit131 Cou	50	0.515	0.265	0.5	Concrete, u	675	675	0.3	New	1	Pit50	0					
Pipe211	Pit131 Cou	Outlet to m	5	0.265	0.24	0.5	Concrete, r	1050	1070	0.3	New	1	Pit131 Cou	0					
Pipe72	Pit71	Pit70	26.87	0.991	0.857	0.5	Concrete, u	375	375	0.3	New	1	Pit71	0					
Pipe73	Pit70	Pit69	28.56	0.857	0.714	0.5	Concrete, u	375	375	0.3	New	1	Pit70	0					
Pipe71	Pit69	Pit66	16.07	0.714	0.634	0.5	Concrete, u	375	375	0.3	New	1	Pit69	0					
Pipe70	Pit66	Pit65	23.11	0.634	0.518	0.5	Concrete, u	375	375	0.3	New	1	Pit66	0					

Pipe68	Pit65	Pit64	26.55	0.518	0.385	0.5	Concrete, u	450	450	0.3	New	1	Pit65	0
Pipe67	Pit64	Pit63	26.6	0.385	0.252	0.5	Concrete, u	450	450	0.3	New	1	Pit64	0
Pipe66	Pit63	Pit10	10.42	0.252	0.2	0.5	Concrete, u	450	450	0.3	New	1	Pit63	0
Pipe125	Pit94	Pit74	32.1	1.064	0.903	0.5	Concrete, u	375	375	0.3	New	1	Pit94	0
Pipe75	Pit74	Pit73	32.8	0.903	0.739	0.5	Concrete, u	375	375	0.3	New	1	Pit74	0
Pipe77	Pit73	Pit76	29.83	0.739	0.59	0.5	Concrete, u	450	450	0.3	New	1	Pit73	0
Pipe78	Pit76	Pit77	37.82	0.59	0.401	0.5	Concrete, u	450	450	0.3	New	1	Pit76	0
Pipe79	Pit77	Pit78	36.22	0.401	0.22	0.5	Concrete, u	450	450	0.3	New	1	Pit77	0
Pipe159	Pit119	Pit47	14.52	1.63	1.56	0.48	Concrete, u	375	375	0.3	New	1	Pit119	0
Pipe47	Pit47	Pit48	12.28	0.96	0.899	0.5	Concrete, u	600	600	0.3	New	1	Pit47	0
Pipe48	Pit48	Pit49	33.1	0.879	0.714	0.5	Concrete, u	600	600	0.3	New	1	Pit48	0
Pipe49	Pit49	Pit50	39.81	0.714	0.515	0.5	Concrete, u	600	600	0.3	New	1	Pit49	0
Pipe197	N197	Pit123	4.635	2	1.2	17.26	Concrete, u	600	600	0.3	New	1	N197	0
Pipe163	Pit123	Pit125	18.69	1.325	1.232	0.5	Concrete, u	600	600	0.3	New	1	Pit123	0
Pipe165	Pit125	Pit47	53.68	1.232	0.964	0.5	Concrete, u	600	600	0.3	New	1	Pit125	0
Pipe199	Pit157	Pit10	15	0.65	0.5	1	Concrete, u	450	450	0.3	New	1	Pit157	0
Pipe236	Pit175	Pit33	35.71	1.209	1.03	0.5	Concrete, u	375	375	0.3	New	1	Pit175	0
ExPipe32	Pit33	Pit26	18.51	1.03	0.845	1	Concrete, u	375	375	0.3	New	1	Pit33	0
Pipe238	Pit178	Pit179	29.85	0.859	0.71	0.5	Concrete, u	375	375	0.3	New	1	Pit178	0
Pipe239	Pit179	Pit180	19.82	0.709	0.61	0.5	Concrete, u	375	375	0.3	New	1	Pit179	0
Pipe240	Pit180	Pit37	21.91	0.61	0.5	0.5	Concrete, u	375	375	0.3	New	1	Pit180	0
Pipe310	Pit213	Pit212	20.793	1.153	1.049	0.5	Concrete, u	375	375	0.3	New	1	Pit213	0
Pipe309	Pit212	Pit72	13.61	1.049	0.981	0.5	Concrete, u	375	375	0.3	New	1	Pit212	0
Pipe74	Pit72	Pit73	48.45	0.981	0.739	0.5	Concrete, u	375	375	0.3	New	1	Pit72	0
Pipe318	N238	Pit50	6	0.76	0.7	1	Concrete, u	450	450	0.3	New	1	N238	0

DETAILS of SERVICES CROSSING PIPES

Pipe	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	Chg (m)	Bottom Elev (m)	Height of S (m)	etc etc

CHANNEL DETAILS

Name	From	To	Type	Length (m)	U/S IL (m)	D/S IL (m)	Slope (%)	Base Widtl (m)	L.B. Slope (1:?)	R.B. Slope (1:?)	Manning n	Depth (m)	Roofed
Bio Swale	N152	N197	Prismatic	80	3.2	2.8	0.5	1	4	4	0.03	0.8	No

OVERFLOW ROUTE DETAILS

Name	From	To	Travel Time (min)	Spill Level (m)	Crest Length (m)	Weir Coeff. C	Cross Section	Safe Depth Major Stor (m)	SafeDepth Minor Stor (m)	Safe DxV (sq.m/sec)	Bed Slope (%)	D/S Area Contributing %	id	U/S IL	D/S IL	Length (m)
OF99	Pit24	Pit78	3				Dummy us	0.2	0.05	0.6	1	0	610			
OF102	Pit78	Pit10	5				Dummy us	0.2	0.05	0.6	1	0	614			
OF104	Pit10	Pit26	5				8 m wide r	0.3	0.15	0.4	1	0	619			
OF108	Pit26	Pit36	5				8 m wide r	0.3	0.15	0.4	1	0	636			
OF110	Pit36	Pit37	5				8 m wide r	0.3	0.15	0.4	1	0	638			
OF120	Pit37	Outlet into	3				Dummy us	0.2	0.05	0.6	1	0	671			
OF54	Pit109	Pit131 Cou	5				Dummy us	0.2	0.05	0.6	1	0	563			
OF37	Pit50	Pit131 Cou	5				8 m wide r	0.3	0.15	0.4	1	0	545			
OF21	Pit131 Cou	Outlet to n	3				Dummy us	0.2	0.05	0.6	1	0	503			
OF69	Pit71	Pit213	5				Dummy us	0.2	0.05	0.6	1	0	579			
OF67	Pit70	Pit71	4				8 m wide r	0.3	0.15	0.4	1	0	577			
OF71	Pit69	Pit70	3				8 m wide r	0.3	0.15	0.4	1	0	581			
OF73	Pit66	Pit69	4				Dummy us	0.2	0.05	0.6	1	0	583			
OF77	Pit65	Pit64	5				Dummy us	0.2	0.05	0.6	1	0	587			
OF81	Pit64	Pit63	5				Dummy us	0.2	0.05	0.6	1	0	591			
OF83	Pit63	Pit10	5				Dummy us	0.2	0.05	0.6	1	0	593			
OF56	Pit94	Pit74	6				8 m wide r	0.3	0.15	0.4	1	0	565			

OF58	Pit74	Pit213	5		Dummy us	0.2	0.05	0.6	1	0		568
OF87	Pit73	Pit74	4		8 m wide r	0.3	0.15	0.4	1	0		597
OF90	Pit76	Pit73	5		8 m wide r	0.3	0.15	0.4	1	0		601
OF97	Pit77	Pit78	5		8 m wide r	0.3	0.15	0.4	1	0		608
OF23	Pit119	Pit47	5		Dummy us	0.2	0.05	0.6	1	0		531
OF25	Pit47	Pit48	4		8 m wide r	0.3	0.15	0.4	1	0		533
OF32	Pit48	Pit49	5		8 m wide r	0.3	0.15	0.4	1	0		540
OF35	Pit49	Pit50	5		8 m wide r	0.3	0.15	0.4	1	0		543
OF5	Pit123	Pit125	5		Dummy us	0.2	0.05	0.6	1	0		476
OF7	Pit125	Pit47	5		8 m wide r	0.3	0.15	0.4	1	0		478
OF85	Pit157	Pit10	5		Dummy us	0.2	0.05	0.6	1	0		595
OF106	Pit175	Pit33	5		8 m wide r	0.3	0.15	0.4	1	0		627
OF112	Pit33	Pit178	5		8 m wide r	0.3	0.15	0.4	1	0		643
OF114	Pit178	Pit179	5		8 m wide r	0.3	0.15	0.4	1	0		647
OF116	Pit179	Pit180	5		8 m wide r	0.3	0.15	0.4	1	0		650
OF130	Pit180	Pit37	3		Dummy us	0.2	0.05	0.6	1	0		87789205
OF190	Pit213	Pit109	7		8 m wide r	0.3	0.15	0.4	1	0		1.25E+08
OF181	Pit212	Pit213	4		Dummy us	0.2	0.05	0.6	1	0		1.25E+08
OF179	Pit72	Pit212	4		8 m wide r	0.3	0.15	0.4	1	0		1.25E+08

DRAINS results prepared 25 January, 2013 from Version 2012.15

PIT / NODE DETAILS				Version 8			
Name	Max HGL	Max Pond HGL	Max Surfac Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
Pit24	1.97		0.241		0.43	0.179	Inlet Capacity
Pit78	1.97		0.21		0.4	0.157	Inlet Capacity
ExPit22	1.96		0		0.32		None
Pit10	1.94		0.414		0.41	0.359	Inlet Capacity
Pit26	1.85		0.392		0.15	0.068	Inlet Capacity
Pit36	1.67		0.096		0	0.335	Outlet System
Pit37	1.64		0.37		0	0.904	Outlet System
Outlet into	1.64		0.904				
N54	1.82		0.316				
Pit109	1.8		0.215		0	0.772	Outlet System
Pit50	1.87		0.188		0.03	0.146	Inlet Capacity
Pit131 Cou	1.55		0.791		0	0.831	Outlet System
Outlet to n	1.53		0.831				
Pit71	2.29		0.049		0.11	0.015	Inlet Capacity
Pit70	2.27		0.047		0.23	0.014	Inlet Capacity
Pit69	2.24		0.039		0.36	0.012	Inlet Capacity
Pit66	2.16		0.006		0.67	0	None
Pit65	2.08		0.013		0.72	0.001	Inlet Capacity
Pit64	2.06		0.032		0.74	0.008	Inlet Capacity
Pit63	2.01		0.037		0.39	0.009	Inlet Capacity
Pit94	2.14		0.019		0.26	0.003	Inlet Capacity
Pit74	2.13	2.2	0.071	17.1	-0.13	0.047	Outlet System
Pit73	2.11	2.49	0.032	3.4	0.29	0	Inlet Capacity
Pit76	2.07		0.022		0.53	0.004	Inlet Capacity
Pit77	2.02		0.016		0.57	0.002	Inlet Capacity
Pit119	2.61		0.039		0.21	0.012	Inlet Capacity
Pit47	2.6		0.298		0	0.265	Outlet System
Pit48	2.4		0.273		0.05	0.229	Inlet Capacity
Pit49	2.11		0.238		0.09	0.187	Inlet Capacity
N152	3.56		0.771				
N197	3.18		0.763				
Pit123	3.1		0.016		0	0.337	Outlet System
Pit125	3.01	3.15	0.355	8.6	-0.01	0.289	Outlet System
Pit157	2.07	2.4	0.382	12.9	0.23	0.256	Inlet Capacity
Pit175	1.93		0.051		0.19	0.02	Inlet Capacity
Pit33	1.9		0.061		0.2	0.02	Inlet Capacity
Pit178	1.74		0.051		0.16	0.013	Inlet Capacity
Pit179	1.73		0.044		0.13	0.011	Inlet Capacity
Pit180	1.69		0.03		0	0.024	Outlet System
Pit213	2.12	2.15	0.264	12.9	-0.12	0.187	Outlet System
Pit212	2.12	2.2	0.065	12.9	-0.07	0.028	Outlet System
Pit72	2.12		0.027		0	0.02	Inlet Capacity
N238	2		0.31				

SUB-CATCHMENT DETAILS							
Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Golf Cours	0.241	0.148	0.099	10	15	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat59	0.036	0.034	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat87	0.032	0.03	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat100	0.071	0.067	0.006	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat102	0.071	0.067	0.006	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat104	0.019	0.018	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Wooloowa	0.316	0.248	0.072	10	15	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat28	0.039	0.036	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat119	0.045	0.043	0.004	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat80	0.036	0.034	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat77	0.035	0.033	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat74	0.039	0.036	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat70	0.006	0.006	0.001	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat67	0.013	0.012	0.001	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat65	0.031	0.029	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat62	0.029	0.027	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat42	0.019	0.018	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat44	0.068	0.064	0.006	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat51	0.028	0.026	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat55	0.022	0.021	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat57	0.016	0.015	0.001	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat23	0.039	0.036	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat25	0.041	0.039	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat115	0.024	0.022	0.002	5	7	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1

Cat117	0.034	0.032	0.003	5	7	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Retail Carp	0.771	0.746	0.026	10	15	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat8	0.016	0.015	0.001	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat10	0.027	0.026	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Club and Lo	0.382	0.352	0.033	8	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat90	0.051	0.049	0.004	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat92	0.041	0.039	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat94	0.032	0.03	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat97	0.032	0.03	0.003	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat98	0.019	0.018	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat34	0.18	0.169	0.015	6	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat40	0.048	0.045	0.004	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Cat48	0.027	0.026	0.002	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Fitness Firs	0.31	0.276	0.053	5	10	0	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1

Outflow Volumes for Total Catchment (4.70 impervious + 0.86 pervious = 5.56 total ha)

Storm	Total Rainf cu.m	Total Runo cu.m (Runo	Impervious cu.m (Runo	Pervious Runoff cu.m (Runoff %)
AR&R 100	1190.04	1055.48 (8	958.86 (95	96.63 (52.4%)
AR&R 100	1861.46	1710.18 (9	1526.33 (9	183.85 (63.8%)
AR&R 100	2815.34	2638.29 (9	2332.54 (9	305.76 (70.2%)
AR&R 100	3528.44	3326.83 (9	2935.24 (9	391.59 (71.7%)
AR&R 100	4900.83	4650.82 (9	4095.17 (9	555.65 (73.2%)
AR&R 100	6523.5	6209.14 (9	5466.63 (9	742.51 (73.5%)
AR&R 100	7601.43	7235.97 (9	6378.25 (9	857.71 (72.9%)
AR&R 100	9801.84	9293.52 (9	8236.78 (9	1056.75 (69.6%)
AR&R 100	12802.13	12064.86 (	10785.86 (	1279.00 (64.5%)
AR&R 100	16935.96	15637.81 (	14189.40 (	1448.42 (55.2%)
AR&R 100	22241.96	20302.44 (	18687.85 (	1614.59 (46.9%)
AR&R 100	25160.29	22710.42 (	20929.76 (	1780.65 (45.7%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
ExPipe82	0.063	0.1	1.972	1.972	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
ExPipe23	0.231	0.36	1.959	1.955	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
ExPipe21	0.231	0.36	1.945	1.942	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
ExPipe26	0.545	0.86	1.896	1.855	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
ExPipe36	0.767	1.21	1.771	1.67	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
ExPipe38	0.493	0.77	1.668	1.64	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
ExPipe44	0	0	1.64	1.64	AR&R 100 year, 48 hours storm, average 8.34 mm/h, Zone 1
Pipe139	0.316	0.88	1.818	1.8	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe50	0.125	0.35	1.8	1.867	AR&R 100 year, 5 minutes storm, average 257 mm/h, Zone 1
Pipe51	0.528	1.48	1.733	1.55	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe211	0.521	0.58	1.538	1.53	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe72	0.029	0.26	2.278	2.273	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe73	0.057	0.52	2.256	2.237	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe71	0.083	0.75	2.198	2.159	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe70	0.09	0.81	2.121	2.082	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe68	0.101	0.63	2.082	2.059	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe67	0.123	0.78	2.039	2.006	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe66	0.147	0.93	1.98	1.942	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe125	0.016	0.15	2.132	2.129	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe75	0.054	0.49	2.116	2.108	AR&R 100 year, 10 minutes storm, average 201 mm/h, Zone 1
Pipe77	0.125	0.78	2.088	2.07	AR&R 100 year, 10 minutes storm, average 201 mm/h, Zone 1
Pipe78	0.125	0.79	2.058	2.025	AR&R 100 year, 10 minutes storm, average 201 mm/h, Zone 1
Pipe79	0.131	0.83	2.011	1.972	AR&R 100 year, 5 minutes storm, average 257 mm/h, Zone 1
Pipe159	0.036	0.33	2.604	2.6	AR&R 100 year, 5 minutes storm, average 257 mm/h, Zone 1
Pipe47	0.488	1.72	2.437	2.396	AR&R 100 year, 1 hour storm, average 88.2 mm/h, Zone 1
Pipe48	0.517	1.83	2.258	2.109	AR&R 100 year, 10 minutes storm, average 201 mm/h, Zone 1
Pipe49	0.541	1.91	2.052	1.867	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe197	0.762	2.69	3.183	3.1	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe163	0.459	1.62	3.071	3.012	AR&R 100 year, 3 hours storm, average 45.6 mm/h, Zone 1
Pipe165	0.483	1.71	2.827	2.6	AR&R 100 year, 10 minutes storm, average 201 mm/h, Zone 1
Pipe199	0.129	0.81	1.976	1.942	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe236	0.032	0.29	1.924	1.897	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
ExPipe32	0.063	0.57	1.87	1.855	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe238	0.028	0.25	1.732	1.726	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe239	0.054	0.49	1.709	1.69	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe240	0.057	0.52	1.659	1.64	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
Pipe310	0.054	0.49	2.124	2.124	AR&R 100 year, 12 hours storm, average 19.2 mm/h, Zone 1
Pipe309	0.069	0.62	2.12	2.119	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe74	0.07	0.63	2.115	2.108	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
Pipe318	0.311	1.95	2.004	1.867	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1

CHANNEL DETAILS

Name	Max Q	Max V			Due to Storm

	(cu.m/s)	(m/s)	
Bio Swale	0.763	0.86	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF99	0.179	0.179	7.665	0.044	0.03	12.71	0.59	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF102	0.157	0.157	7.665	0.042	0.02	12.35	0.56	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF104	0.359	0.359	1.19	0.174	0.2	5.21	1.13	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF108	0.068	0.068	1.19	0.103	0.1	2.08	0.92	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF110	0.335	0.335	1.19	0.171	0.19	5.04	1.12	AR&R 100 year, 1 hour storm, average 88.2 mm/h, Zone 1
OF120	0.904	0.904	7.665	0.084	0.08	20.79	0.92	AR&R 100 year, 1 hour storm, average 88.2 mm/h, Zone 1
OF54	0.772	0.772	7.665	0.079	0.07	19.72	0.89	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF37	0.146	0.146	1.19	0.129	0.14	2.94	1.05	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF21	0.831	0.831	7.665	0.08	0.07	20.08	0.92	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF69	0.015	0.015	7.665	0.018	0.01	5.84	0.29	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF67	0.014	0.014	1.19	0.064	0.05	0.79	0.78	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF71	0.012	0.012	1.19	0.06	0.05	0.66	0.76	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF73	0	0	7.665	0	0	0	0	
OF77	0.001	0.001	7.665	0.007	0	2.25	0.17	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF81	0.008	0.008	7.665	0.014	0	4.64	0.24	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF83	0.009	0.009	7.665	0.014	0	4.64	0.27	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF56	0.003	0.003	1.19	0.038	0.02	0.31	0.54	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF58	0.047	0.047	7.665	0.026	0.01	8.83	0.4	AR&R 100 year, 1 hour storm, average 88.2 mm/h, Zone 1
OF87	0	0	1.19	0	0	0	0	
OF90	0.004	0.004	1.19	0.043	0.02	0.35	0.58	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF97	0.002	0.002	1.19	0.032	0.02	0.27	0.5	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF23	0.012	0.012	7.665	0.016	0	5.24	0.29	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF25	0.265	0.265	1.19	0.161	0.17	4.51	1.06	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF32	0.229	0.229	1.19	0.148	0.17	3.58	1.14	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF35	0.187	0.187	1.19	0.139	0.15	3.28	1.09	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF5	0.337	0.337	7.665	0.056	0.04	15.23	0.7	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF7	0.289	0.289	1.19	0.165	0.18	4.73	1.07	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF85	0.256	0.256	7.665	0.05	0.03	13.97	0.66	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF106	0.02	0.02	1.19	0.071	0.06	1.02	0.8	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF112	0.02	0.02	1.19	0.071	0.06	1.02	0.82	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF114	0.013	0.013	1.19	0.063	0.05	0.75	0.77	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF116	0.011	0.011	1.19	0.059	0.04	0.61	0.76	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF130	0.024	0.024	7.665	0.021	0.01	7.03	0.33	AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1
OF190	0.187	0.187	1.19	0.139	0.15	3.28	1.09	AR&R 100 year, 1 hour storm, average 88.2 mm/h, Zone 1
OF181	0.028	0.028	7.665	0.022	0.01	7.33	0.35	AR&R 100 year, 30 minutes storm, average 127 mm/h, Zone 1
OF179	0.02	0.02	1.19	0.071	0.06	1	0.82	AR&R 100 year, 1 hour storm, average 88.2 mm/h, Zone 1

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level

CONTINUITY CHECK for AR&R 100 year, 20 minutes storm, average 152 mm/h, Zone 1

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Ch (cu.m)	Difference %
Pit24	212.48	212.48	0	0
Pit78	423.42	423.43	0	0
ExPit22	303.92	303.92	0	0
Pit10	888.26	888.35	0	0
Pit26	998.65	998.65	0	0
Pit36	1052.25	1061.06	0	-0.8
Pit37	1163.22	1163.3	0	0
Outlet into	1162	1162	0	0
N54	272.19	272.19	0	0
Pit109	435.04	439.9	0	-1.1
Pit50	875.57	875.57	0	0
Pit131 Cou	1507.15	1704.35	0	-13.1
Outlet to n	1698.39	1698.39	0	0
Pit71	35.34	35.33	0	0
Pit70	59.19	59.19	0	0
Pit69	79.86	79.86	0	0
Pit66	78.28	78.28	0	0
Pit65	87.94	87.94	0	0
Pit64	111.12	111.12	0	0
Pit63	132.84	132.84	0	0
Pit94	14.49	14.48	0	0
Pit74	65.66	64.22	0	2.2
Pit73	157.3	157.08	0	0.1
Pit76	173.98	173.97	0	0
Pit77	183.91	183.9	0	0
Pit119	28.97	28.85	0	0.4
Pit47	741.67	752.6	0	-1.5
Pit48	769.4	769.4	0	0

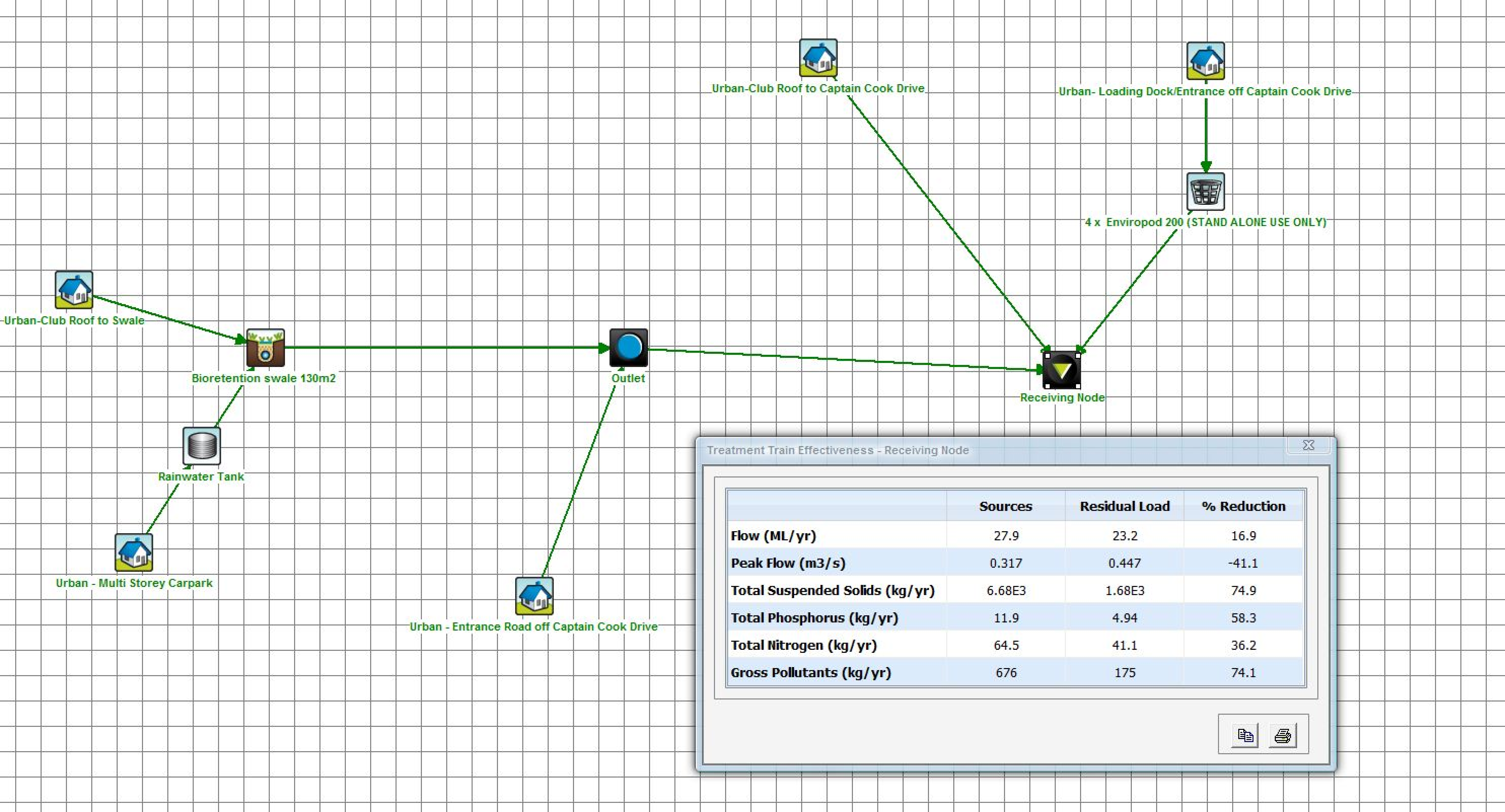
Pit49	794.52	794.52	0	0
N152	650.54	648.65	0	0.3
N197	648.65	645.03	0	0.6
Pit123	657.1	661.87	0	-0.7
Pit125	681.94	681.93	0.16	0
Pit157	308.34	307.85	0	0.2
Pit175	38.63	38.62	0	0
Pit33	69.52	69.52	0	0
Pit178	36.48	36.47	0	0
Pit179	60.62	60.61	0	0
Pit180	75.1	88.63	0	-18
Pit213	165.18	165.23	0	0
Pit212	73.41	72.3	0	1.5
Pit72	86.01	86	0	0
N238	239.19	239.2	0	0

Upwelling occurred at Pit131 Council Pit, Pit123, Pit109, Pit47, Pit37, Pit36
Freeboard was less than 0.15m at Pit213, Pit212, Pit180, Pit179, Pit125, Pit74, Pit72, Pit71, Pit50, Pit49, Pit48, Pit26
Flows were safe in all overflow routes.

The following overflow routes carried water uphill (adding energy): OF179, OF5
These results may be invalid. You should check for water flowing round in circles at these locations. You may need to reformulate the model.

Appendix D

MUSIC Model & Results



	Sources	Residual Load	% Reduction
Flow (ML/yr)	27.9	23.2	16.9
Peak Flow (m3/s)	0.317	0.447	-41.1
Total Suspended Solids (kg/yr)	6.68E3	1.68E3	74.9
Total Phosphorus (kg/yr)	11.9	4.94	58.3
Total Nitrogen (kg/yr)	64.5	41.1	36.2
Gross Pollutants (kg/yr)	676	175	74.1

Appendix E

Stormwater Catchment Plan

Issue	Description	Date
P1	ISSUED FOR INFORMATION	25-01-13

Bar Scales: 0 20 40 60 80m — 1 : 800

THIS DRAWING CANNOT BE COPIED OR REPRODUCED IN ANY FORM OR USED FOR ANY OTHER PURPOSE OTHER THAN THAT ORIGINALLY INTENDED WITHOUT THE WRITTEN PERMISSION OF AT&L

Client: BLUESTONE CAPITAL VENTURES NO.1 PTY LTD

Scales	1 : 800	Drawn	MM
		Designed	MM
Grid	MGA	Checked	AMcL
Height Datum	AHD	Approved	

Project: WOOLOOWARE BAY TOWN CENTRE

Title: STORMWATER CATCHMENT PLAN

Civil Engineers and Project Managers
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Status: FOR INFORMATION — A1

Drawing No.	Project No.	Issue
SKC15	11-59	P1

100mm on Original

V1

Appendix F

WMA Water Flood Assessment Report

BLUESTONE CAPITAL VENTURES
NO 1 PTY LTD

WOOLOOWARE BAY TOWN CENTRE REDEVELOPMENT – RETAIL SITE

FLOOD ASSESSMENT REPORT

JANUARY 2013

Level 2, 160 Clarence Street
Sydney, NSW, 2000

Tel: 9299 2855
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WOOLOOWARE BAY TOWN CENTRE REDEVELOPMENT – RETAIL SITE

FLOOD ASSESSMENT REPORT

JANUARY 2013

Project **Woolooware Bay Town Centre Redevelopment – Retail Site**	**Project Number** **112077**
Client **Bluestone Capital Ventures No 1 Pty Ltd c/o AT&L**	**Client's Representative** Anthony McLandsborough
Authors **Dr Chin Hong Cheah** **Richard Dewar**	**Prepared by**
Date **29 January 2013**	**Verified by**

Revision	Description	Date
1	Draft Flood Assessment Report	18 January 2013
2	Final Flood Assessment Report	29 January 2013

WOOLOOWARE BAY TOWN CENTRE REDEVELOPMENT – RETAIL SITE

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EXECUTIVE SUMMARY

Background: Bluestone Capital Ventures No 1 Pty Ltd is proposing to re-develop the car park on the east side of the Cronulla Sharks Rugby League Club at 461 Captain Cook Drive, Woolooware as a retail centre. The surrounding land has been subject to flooding in the past (notably March 1975 but also more recently in 1983). As a result WMAwater (a specialist water engineering consulting company) was engaged to provide a flood assessment for the existing and post development scenarios.

Approach: A large amount of topographic, survey, pit and pipe and other data was collected and incorporated into the modelling approach. The study adopted best practice approaches using the DRAINS hydrologic model and the TUFLOW 1D/2D (one-dimensional and two-dimensional) hydraulic model to undertake the flood assessment.

Analysis: Design flood level and hazard information were produced for the 20 year ARI, 100 year ARI and Probable Maximum Floods for both existing and post development conditions. In addition analysis was undertaken to assess the possible impacts of a climate change induced sea level rise and rainfall intensity increase.

Floor Levels: The ground floor level for the retail development site is proposed to be at 4 mAHD, which is significantly higher than the 100 year ARI peak flood level of 2.46 mAHD and even the PMF peak flood level of 3.14 mAHD. With the exception of the main entrance off Captain Cook Drive whereby the crest level is proposed to be at 2.6 mAHD which is still above the 100 year ARI peak flood level, all other entrances are proposed at a similar level to the ground flood level (4 mAHD). Therefore, the site is not subject to any flood risk and is in compliance with Council's development controls for flooding.

Impact of Proposed Development: Based on the results generated using the DRAINS hydrologic model and TUFLOW hydraulic model developed for this flood assessment, the proposed retail development results in up to 20 mm off-site impact on the 1% AEP peak flood levels, with the affected area located at the entrance to the development and Captain Cook Drive. However, this impact is regarded as acceptable considering it is on the side of the roadway rather than at residential dwellings where it would increase flood damages.

Climate Change: Overall, the results show that an increase in peak flood level of up to a maximum of 0.2 m can be expected for the development site as a result of climate change and as such would not be an issue considering the proposed floor levels have been designed to be at a level above the PMF flood level plus any increase induced by climate change. However the relatively flat topography means that a small increase in peak level translates to a relatively large increase in flood extent.

Management of the Flood Problem: An evacuation route is proposed which serves as an access route from the site to high ground via Woolooware Road as well as providing access for emergency vehicles (i.e. SES, ambulance) to get to the site. As such, it is pertinent that the proposed new intersection is designed to be flood free up to the 100 year ARI event. A flood response plan should be prepared by the building management to minimise the risk associated with evacuations by providing information regarding evacuation routes, refuge areas, what to do/not to do during floods etc. Any evacuation undertaken would usually be under the direction of the lead agency, the State Emergency Services (SES). As such, it is necessary that SES be made aware of the new retail development and the local SES response planning can be prepared. Since the development proposed is above the PMF, there are no further requirements in regards to the construction as there are no flood liable structures. Nevertheless, reliable pedestrian and vehicle access to a place of refuge should be maintained.

1. INTRODUCTION

1.1. Background

WMAwater has been commissioned by Bluestone Capital Ventures No 1 Pty Ltd (c/o AT&L) to conduct a flood assessment for the proposed Woolooware Bay Town Centre development on Captain Cook Drive in Woolooware. The proposed development comprises residential, retail, landscaped open space, parking as well as entertainment areas. However this report only considers the proposed retail and car parking proposal on the east side of the Cronulla Sharks Rugby League Club. Proposed development in other related areas will be considered in separate reports.

The development site is located within the Woolooware Bay catchment adjacent to Captain Cook Drive and Woolooware Bay and plans describing the development proposal are provided in Appendix B. A glossary of flood related terms is provided in Appendix A.

1.2. Scope of Work

The flood assessment undertaken included the following:

- establishing hydrologic and hydraulic models to represent flood behaviour;
- running the 20Y and 100Y ARI events as well as the PMF;
- defining existing flooding behaviour (current on ground conditions pre-development);
- define proposed development conditions and model for the retial and car parking proposal only;
- incorporate climate change modelling as per NSW Government 2009 guidelines (in September 2012 the NSW Government repealed its sea level rise policy and Councils must now make their own decision);
- assess development impacts both with and without climate change for the range of flood events;
- advise on proposed floor levels in compliance with Council's DCP;
- develop mitigation works in case of impacts;
- assess provisional hazard for the existing and developed case; and
- consider flood safety including evacuation for events up to the PMF.

The report herein documents the assessment and evaluation of flooding in relation to the retail and club development only (assessment for the residential development will be provided in a separate report). The location of the development site is shown in Figure 1. This report does not include any water quality aspect, preparation of a stormwater management plan or erosion/sedimentation assessment.

2. BACKGROUND

2.1. Study Area

The proposed development site is located within the Woolooware Bay catchment which is part of the Sutherland Shire local government area. A significant catchment area of approximately 252 ha drains to the site as shown in Figure 2. Within the site itself, runoff from the playing fields include that of Toyota Park drains to an open, tidal channel. Land use in the catchment is predominately residential upstream with recreational parks and playing fields located downstream. The catchment slopes from south to north towards the Bay with the lower reaches typically flat and low lying.

2.2. Drainage System and Flood Mechanism

The catchment upstream of the development site and Woolooware Golf Course is drained primarily by a Council owned sub-surface pipe system, with natural earth drainage channels located downstream in the golf course. Floodwater discharges into Woolooware Bay either in the form of diffuse outflows or through the tidal channel located west of Toyota Park and the stormwater pipe adjacent to the Solander Playing Fields.

Captain Cook Drive, which is situated along the downstream end of the catchment, acts as a significant barrier to runoff from entering Woolooware Bay. Large quantities of floodwaters would flow from the Woolooware Golf Course onto Captain Cook Drive and subsequently onto the Toyota Park area. Another governing flood mechanism for this part of the catchment is tidal inundation due to its proximity to Woolooware Bay and flat topography.

2.3. Flood History

One of the most recent significant floods that occurred within the Woolooware Bay catchment is the 13th to 16th May 2003 event. This event has been well-documented with newspaper reports and correspondence received by Council record heavy damages to factories, houses and motor vehicles. Many of the community complaints were recorded on Council's customer response management system (CRMS).

Historic photos have been obtained that highlight the potential magnitude of flooding in the region. Photo 1 shows flooding of Captain Cook Drive at the intersection with Gannons Road for the March 1975 event. This event was known to have caused widespread flooding throughout Sydney and the rainfall was documented in Reference 1. It was estimated that based on rainfall and flood records at Miranda this event may have approached a 1 in 1000 ARI for a 12 hour duration and a 1 in 400 ARI for a 2 hour duration.

This event caused widespread flooding in Sans Souci, Kogarah and in others parts of the Sutherland Shire. It is likely that the rainfall intensities will have varied greatly across the area and at this locality the magnitude of the event cannot be accurately determined.

Photo 1: Flooding at the corner of Gannons Rd and Captain Cook Dr, dated March 1975 (courtesy of Ross Myers)

It should be noted that Captain Cook Drive has been raised since 1975 and other works for the adjacent sporting fields will have changed the topography and thus the resulting flood levels. It is likely that filling to create the sporting fields on the north (downstream) side of Captain Cook Drive will have increased flood levels upstream. At the time the assessment of flooding for a proposed development was not as sophisticated or as well understood as today.

Since 2003 there have been several events that have caused flooding of Captain Cook Drive causing traffic disruption (there is video on YouTube of the 12th March 2012 event). These events are likely to have a magnitude of less than 5 year ARI and possibly even more frequent. The magnitude of the rainfall event can only be accurately determined if there is a nearby pluviometer (records rainfall). Whilst there are pluviometers nearby the localised nature of the storms means that an accurate estimate is not always possible.

3. AVAILABLE DATA

3.1. Background

Various items of data as well as reports salient to the study have been collected and reviewed. Most reports and datasets were sourced from Sutherland Shire Council and supplemented by additional survey where required. The assistance of Sutherland Shire Council in this regard is gratefully acknowledged.

Reports were reviewed particularly for topographic/hydrologic parameters as well as observations of historical flood events. The key focus of the exercise was to collect data suitable for the model calibration process. This section provides a brief description of the various forms of data utilised in the study.

3.2. Previous Studies

The main studies reviewed as part of the present assessment included:

- Initial Subjective Assessment of Major Flooding, 2004 (Reference 2);
- Lower Georges River Floodplain Risk Management Study and Plan, 2011 (Reference 3); and
- Lower Georges River Stormwater Management Plan, 1999 (Reference 4).

The minor studies reviewed were:

- Stormwater drainage and water quality strategy for proposed re-zoning of the Sharks eastern site, 2002 (Reference 5); and
- Flood Study for proposed upgrading of Toyota Park for Cronulla Sutherland Leagues Club Ltd, 2007 (Reference 6).

Further descriptions of the above studies are provided in later sections where relevant to the current investigation.

3.3. Design Rainfall

Design rainfalls were obtained from the Bureau of Meteorology (BoM) and temporal patterns were obtained from Australian Rainfall and Runoff (Reference 7). The Intensity-Frequency-Duration (IFD) data for the catchment is provided in Table 1.

Table 1: IFD Data for Woolooware Bay Catchment

Intensity-Frequency-Duration Table

Location: 34.050S 151.150E NEAR.. Woolooware Issued: 22/11/2011

Rainfall intensity in mm/h for various durations and Average Recurrence Interval

	Average Recurrence Interval						
Duration	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	97.8	126	160	180	206	240	266
6Mins	91.6	118	150	168	193	225	250
10Mins	75.0	96.5	124	140	161	188	209
20Mins	54.9	71.1	92.7	105	122	144	160
30Mins	44.7	58.0	76.2	87.0	101	120	134
1Hr	30.3	39.4	52.1	59.8	69.6	82.7	92.7
2Hrs	19.7	25.7	33.9	38.9	45.3	53.7	60.3
3Hrs	15.2	19.7	26.0	29.7	34.6	41.0	45.9
6Hrs	9.69	12.5	16.4	18.6	21.6	25.5	28.5
12Hrs	6.22	8.03	10.4	11.8	13.7	16.1	17.9
24Hrs	4.03	5.20	6.75	7.65	8.85	10.4	11.6
48Hrs	2.57	3.32	4.32	4.90	5.68	6.68	7.46
72Hrs	1.91	2.47	3.21	3.63	4.20	4.95	5.52

(Raw data: 39.7, 8.02, 2.47, 84.21, 16.05, 4.96, skew=0.00, F2=4.29, F50=15.85) © Australian Government, Bureau of Meteorology

Probable Maximum Precipitation (PMP) rainfall depths used to determine the Probable Maximum Flood (PMF) were obtained from Reference 8 using the generalised short-duration method. The maximum duration for which the method is applicable in the region is 6 hours. The parameters used for estimating the PMP are:

- Terrain classification: smooth;
- Adjustment for catchment elevation (EAF): 1;
- Moisture Adjustment Factor (MAF): 0.7; and
- Ellipses enclosing the catchment: A and B (refer to Reference 8 for further explanation of ellipsoid selection).

3.4. Design Tidal Levels

The proximity of the study area to Woolooware Bay means that flood behaviour is influenced by ocean storm and tidal effects. As a result flooding on site can be caused by intense rainfall over the catchment, elevated tidal levels (astronomic tide plus storm surge), or a combination of both.

Design tidal levels adopted for this study are listed in Table 2, based on analyses of tidal records from Fort Denison in Sydney Harbour. It was deemed that the results for Woolooware Bay would be similar.

Table 2: Design Tidal Levels

ARI (years)	Peak Level (mAHD)
20	1.38
50	1.42
100	1.45
Extreme or PMF	Not known but assumed as 1.50

3.5. Survey Data

Airborne Laser Scanning (ALS) data of the study area was obtained from Council to define the ground surface elevations. The ALS data was collected in October 2005 by AAMHATCH. The ALS provides ground level spot heights from which a Digital Terrain Model (DTM) can be constructed (refer to Figure 2). For well defined points mapped in areas of clear ground, the expected nominal point accuracies (based on a 68% confidence level) are ±0.15 m (vertical accuracy). When interpreting the above, it should be noted that the accuracy of the ground definition can be adversely affected by the nature and density of vegetation and/or the presence of steeply varying terrain. This data formed the foundation of the hydraulic model build process.

3.6. Other Spatial Information

A number of spatial datasets were also obtained from Council including:

- property cadastre layer;
- geo-referenced aerial photography of Woolooware Bay catchment; and
- various GIS layers relating to current land use, building outlines, water quality devices, major hydraulic structures and drainage infrastructure.

All GIS data have been provided in a MapInfo/ArcGIS compatible format and these layers were used to aid model schematisation for the hydrologic and hydraulic models.

3.7. Pit and Pipe Data

Council provided a database of the pit and pipe network within the catchment dated 7th December 2011 with physical details including:

- coordinates of each pit;
- linkage between pits;
- pipe type and dimensions; and
- pit details (type of pit, inlet type and dimensions, and depth to invert).

In addition, stormwater drainage data were obtained from RailCorp for the Sutherland – Cronulla railway line. In addition the entire drainage network was re-surveyed by a registered surveyor during the period of February to August 2012 and any new information included. A plan view of the pit and pipe network is shown in Figure 3.

4. HYDROLOGIC MODELLING

4.1. Overview

Hydrologic models suitable for design flood estimation are described in AR&R 1987 (Reference 7). These models or techniques range from simple procedures to estimate peak flows (such as Probabilistic Rational Method) to more complex rainfall-runoff routing models that provide estimates of complete flow hydrographs. In current Australian engineering practice, examples of the more commonly used runoff routing models for rural catchments include RORB, RAFTS and WBNM (Watershed Bounded Network Model). For urban catchments with a significant pit and pipe network DRAINS is the most commonly used hydrologic model in NSW. DRAINS is specifically designed to simulate flow into kerb inlet pits in roads and through and underground pipe network. All these models allow the rainfall depth to vary both spatially and temporally over the catchment, and have parameters governing runoff volume/shape that can be calibrated against recorded data.

For the above reason hydrologic modelling of the Woolooware Bay catchment was carried out using DRAINS. The total catchment represented by the DRAINS model draining across the subject site to Woolooware Bay is 252 ha (note parts of the catchment shown on Figure 3 do not drain to the subject site). Catchment areas for the hydrologic models were delineated using the available topographic information obtained from Council (i.e. DEM generated from the ALS data), aerial photos, drainage network data and field inspection. A total of 112 sub-catchments were found to contribute to the subject site. The sub-catchments are shown in Figure 2. The sub-catchment layout ensures that where hydraulic controls exist, these are accounted for and are able to be appropriately incorporated into the hydraulic routing.

4.2. DRAINS

4.2.1. Introduction

DRAINS (Reference 10) is a hydrologic/hydraulic model that can simulate the full storm hydrograph and is capable of describing the flow behaviour of a catchment and pipe system for real storm events, as well as statistically based design storms. It is designed for analysing urban or partly urban catchments where artificial drainage elements have been installed. The DRAINS model is broadly characterised by the following features:

- the hydrologic component is based on the theory applied in the ILSAX model which has seen wide usage and acceptance in Australia;
- its application of the hydraulic grade line method for hydraulic analysis throughout the drainage system; and
- the graphical display of network connections and results.

DRAINS generates a full hydrograph of surface flows arriving at each pit and routes these through the pipe network or overland, combining them where appropriate. Used in conjunction with a 2D (two-dimensional) hydraulic model, the benefit of DRAINS is that it produces a flow hydrograph at all modelled pits (in this instance for each modelled sub-catchment) that can then be input into the 2D model.[1]

4.2.2. Input Data

For the hydrologic modelling, the sub-catchment details were defined and collated into a spreadsheet for input to DRAINS. Sub-catchment areas were obtained based on the ALS survey and assuming that properties drain to the street and flow in the street is along the gutters and in one direction only (i.e. does not sub-divide at an intersection). The delineation of these sub catchment areas is shown on Figure 2. For each sub-catchment area the proportion of pervious (grassed), impervious (paved), supplementary area (paved area not directly connected to pipe system) was determined from field and aerial photographic inspections. For residential areas (include roads) a relatively high value of % imperviousness was adopted to reflect the likely low infiltration capacity of suburban yards and open space areas.

4.2.3. Adopted Model Parameters

Losses from a paved or impervious area are considered to comprise only an initial loss (an amount sufficient to wet the pavement and fill minor surface depressions). Losses from grassed areas are comprised of an initial loss and a continuing loss. The continuing loss was calculated from an infiltration equation curve incorporated into DRAINS and is based on the estimated representative soil type and antecedent moisture condition. It was assumed that the soil in the catchment has a slow infiltration rate potential and the antecedent moisture condition was assumed saturated. The latter was justified by the fact that the peak rainfall burst can typically occur within a longer event that has a duration lasting days. The adopted parameters for the design runs are summarised in Table 3.

Table 3: Adopted DRAINS Model Parameters

RAINFALL LOSSES	
Paved (Impervious) Area Depression Storage (Initial Loss)	1.0 mm
Supplementary Area Depression Storage (Initial Loss)	1.0 mm
Grassed (Pervious) Area Depression Storage (Initial Loss)	5.0 mm
SOIL TYPE	3
Slow infiltration rates. This parameter, in conjunction with the AMC, determines the continuing loss	
ANTECEDENT MOISTURE CONDITIONS	3
Description	Rather wet
Total Rainfall in 5 Days Preceding the Storm	12.5 to 25 mm

[1] The DRAINS model developed for this study does not account for surface controls or storages (e.g. embankments, local depressions) hence direct comparison of flows with those predicted by the hydraulic model is not possible, with the exception of smaller events whereby overland flow is not dominant.

5. HYDRAULIC MODELLING

5.1. Overview

A key objective of this study is to define the flood behaviour within the existing study area in terms of flood levels, flows and velocities. An integrated one-dimensional/two-dimensional (1D/2D) hydraulic model was used to achieve this using the TUFLOW (Reference 11) hydrodynamic modelling package.

TUFLOW software is widely used for pipe and overland flow hydraulic simulation of unsteady flow systems throughout Australia and the UK. TUFLOW is a finite difference numerical model for the solution of the depth averaged shallow water flow equations (Reference 11). The model is capable of dynamically simulating complex overland flow regimes and interactions with sub-surface drainage systems. It is especially applicable to the hydraulic analysis of flooding in urban areas which is typically characterised by short-duration events and a combination of overland and pipe flow.

For the hydraulic analysis of complex overland flow paths, a combined 1D/2D model such as TUFLOW provides several key advantages when compared to a 1D only model. For example, in comparison to a purely 1D approach, a combined 1D/2D approach can:

- provide localised detail of any topographic and/or structural features that may influence flood behaviour;
- better facilitate the identification of potential overland flow paths and flood problem areas;
- dynamically model the interaction between the drainage system and the complex overland flow paths, including surcharging effects; and
- inherently represent the available flood storage within the 2D model geometry, which is particularly important for assessment of the detention basin performance.

In comparison to previous studies, a 2D model can better define the spatial variations in flood behaviour across the study area. Information such as flow velocity, flood levels and hydraulic hazard can be readily mapped across the model extent. This information can be easily integrated into a GIS-based environment for result presentation.

5.2. Model Extents

The TUFLOW hydraulic model established in this study extends to the whole of the Woolooware Bay catchment. The TUFLOW model incorporated both major subsurface drainage features and overland flow paths within the model extent. The two components were dynamically linked such that the model accounted for the interactions between the drainage system and overland flow behaviour. The TUFLOW model layout is shown on Figure 3.

5.3. Digital Terrain Model

Overland flow paths in the hydraulic model were defined using a DTM. The DTM was compiled largely from the ALS datasets. The DTM was sampled on a regular grid of 3 m square cells for use in the model. This level of detail was deemed to allow sufficient resolution of drainage features while still retaining practical computational run-times for an area of this scale (model runs take approximately 6 hours for a 1 hour rainfall event).

Two DTMs were established to represent the following conditions:

- Existing conditions; and
- Post-development conditions – retail development and upgrade of Captain Cook Drive/Woolooware Road intersection (refer Appendix B).

The DTM for post-development conditions was developed based on concept drawings provided by AT&L (refer Appendix B).

5.4. Breaklines

A number of significant hydraulic features which are likely to impact on the flow behaviour exist within the Woolooware Bay catchment. These hydraulic features are particularly important due to the flat nature of the topography at the downstream parts of the catchment. Breaklines were used throughout the study area in order to define hydraulic controls not well represented in the 3 m DTM used to inform the model grid.

The key benefit of using breaklines is that high resolution height data for significant hydraulic features (such as road kerbs) can be utilised in conjunction with the coarser 3 m DTM for modelling purposes.

Significant hydraulic features found in the study area include:

- road kerbs and gutters;
- major road embankments; and
- Sutherland to Cronulla railway line.

5.5. Key Model Parameters

The hydraulic efficiency of the flow paths within the TUFLOW hydraulic model was represented in part by the hydraulic roughness or friction factor formulated as Manning's 'n'. This factor describes the net influence of surface roughness and incorporates the effects of vegetation and other features which may affect the hydraulic performance of the flow path.

The majority of the catchment consists of urban dwellings with the remainder as generally golf courses and recreational parks located at the downstream parts of the study area. The corresponding Manning's 'n' roughness values adopted for modelling purposes are shown in Table 4. These values have been adopted based on site inspections and also from neighbouring flood studies (i.e. Reference 12). It is important to note that all buildings have been "nulled" or removed from the model grid, hence there is no need to use higher Manning's 'n' for those areas since the "blockage" effect presented by those buildings has already been accounted for. It was assumed that the flood storage presented by the buildings is insignificant.

Table 4: Summary of Manning's 'n' Values

Surface	Adopted Manning's 'n'
Default	0.03
Regular Channel	0.03
Channel with Deep Pool and Weed	0.05
Channel Bank with Heavy Growth/Mangrove	0.1
Roads	0.015
Urban/Dwellings	0.03*
Commercial/Industrial	0.03*
Railway	0.05
Light Vegetation/Golf Course	0.035
Medium Vegetation	0.06

* Buildings have been removed from model grid, hence lower Manning's n can be adopted

The 2D numerical scheme for the TUFLOW model includes an allowance for sub-grid scale turbulence and eddies, features that are too small to be modelled directly. These physical processes result in energy loss and can affect the flow behaviour. Within the TUFLOW model the effects of these sub-grid processes are modelled by the introduction of an eddy viscosity formulation, where energy losses are applied either as a constant term or according to the Smagorinsky formulation, in proportion to the flow velocity and the 2D cell edge length. For this assessment, a combination of the constant and Smagorinsky eddy viscosity formulations were used, with coefficients of 0.1 and 0.2 respectively as recommended in the TUFLOW manual (Reference 11).

5.6. Pits and Pipes Network

Pit and pipe information as described in Section 3.7 was used to create a 1D drainage network in TUFLOW. Pipes of all sizes were included in the TUFLOW model though smaller pipes are generally prone to blockages during storms due to leaves and debris. Temporary blockage may also occur during a storm as the pit entry may be restricted by a vehicle parking over the grate or leaves/silt/branches filling the inlet.

The effect of blockage in urban drainage systems (pipes and open channels) has become a significant factor in design flood estimation following the post flood observations from the North Wollongong August 1998 and Newcastle June 2007 events. However, recent reviews of how blockage should be included in design flood analysis are inconclusive, as it appears that the incidence of blockage is not consistent across all catchments or even within the same catchment. Thus there is no consensus regarding the design approach that should be adopted.

The approach adopted for this study has been to assume 50% blockage at all culverts and pipes, which was consistent with the blockage factor adopted for a neighbouring flood study

(Reference 12). This approach has been adopted to take into account blockage caused by debris (cars, fencing, vegetation) being swept into drainage structures. A site inspection of the box culverts discharging to the open tidal channel west of Toyota Park also affirmed that 50% was a reasonable factor to be adopted in modelling drainage blockage for this study area.

5.7. Boundary Conditions

Local catchment inflows within the TUFLOW hydraulic model extent were derived from the DRAINS hydrologic model. Runoff hydrographs from the hydrologic model (a hydrograph for each of the 112 sub-catchments) are applied at pit locations or low-lying areas within each sub-catchment and used as inflows into the 2D model.

The downstream boundary of the study area is Woolooware Bay and natural variability of water level is expected in the downstream catchment areas from both tidal and catchment flows. For design flood estimation a level in Woolooware Bay is required for calculation of water levels and pipe discharges in the lower parts of the catchment. This tailwater boundary is shown in Figure 3.

5.7.1. Adopted Tailwater Levels

As noted previously, in addition to runoff from the catchment, the downstream areas of the catchment and the tidal channel west of Toyota Park are influenced by backwater effects from high water levels in Woolooware Bay. These two distinct mechanisms produce flooding in the study area but may not result from the same storm. It is acknowledged however that this may not necessarily be the case and that ocean influences may occur in conjunction with rainfall events. Consideration must therefore be given to account for the joint probability of coincident flooding from both catchment runoff and backwater effects from Woolooware Bay.

A full joint probability analysis is beyond the scope of the present study. Recommended in Reference 9 is the 'peak envelope' approach that adopts the highest of the predicted levels from the two mechanisms to estimate design flood levels. The same document also advised that a 100 year ARI ocean event in conjunction with a 100 year ARI rainfall event would likely to produce flood levels greater than the 100 year ARI.

Table 5 sets out the joint probabilities of the ocean and rainfall design events. Thus a 100 year ARI event is an envelope of the 100 year ARI ocean event (1.45 mAHD peak ocean level combined with a 20 year ARI rainfall event) and a 100 year ARI rainfall event (20 year ARI 1.38 mAHD peak ocean level combined with a 100 year ARI rainfall event). For the 20 year ARI event the same ocean and rainfall conditions are used for the ocean and rainfall event scenarios.

Table 5: Adopted Co-incidence of Ocean and Rainfall Events

OCEAN Envelope		**DESIGN FLOOD EVENT (ARI)**	RAINFALL Envelope	
Peak Design Ocean Event (ARI) and level (mAHD)	Co incident Design Rainfall Event (ARI)		Design Rainfall Event (ARI)	Co incident Design Ocean Event (ARI) and level (mAHD)
PMF (1.5)	100 year	**Extreme**	PMF	100 year (1.45)
100 year (1.45)	20 year	**100 year**	100 year	20 year (1.38)
50 year (1.42)	20 year	**50 year**	50 year	20 year (1.38)
20 year (1.38)	20 year	**20 year**	20 year	20 year (1.38)

6. DESIGN FLOOD ASSESSMENT

6.1. Critical Duration

Critical storm duration analysis is undertaken to determine the storm duration that produces the greatest flood levels (at the subject site) for the given design event. A range of storm durations were modelled for the 100 year ARI event and it was found that the critical duration is 1 hour for the development site (see Figure 4). Therefore, for all design events, excluding the PMF, the 1 hour duration was used to determine the peak flood levels.

A similar process was undertaken for the PMF with various PMP durations (15 minutes to 6 hours) modelled so that peak flood levels and associated rainfall durations could be identified. The 45-minute duration PMP was determined to be the critical duration for the development site and was thus used to determine peak flood levels.

6.2. Overview of Results

A number of maps have been produced to display the flood affected regions for the various design events. It should be noted that inundation patterns and/or peak flood levels shown for design events are based on best available estimates of flood behaviour within the catchment. Inundation from local overland flow may vary depending on the actual rainfall event and local influences (parked cars, change in topography, earth works etc.). Tabulated results (Table 6) are provided for ease of comparison between flood events at locations of interest around the study area and these are shown on Figure 1.

Two scenarios are considered and modelled herein: existing conditions and post-development conditions. For the latter, the proposed retail development and upgrade of the intersection at Captain Cook Dr/Woolooware Rd were incorporated into the model. The flood impacts resulting from the proposed works are assessed by comparing the model results between the two scenarios.

Table 6: Design Storm Peak Flood Levels (mAHD) for Existing and Post-Development Conditions

	Existing Conditions			Post-Development Conditions		
LOCATION	**20Y ARI**	**100Y ARI**	**PMF**	**20Y ARI**	**100Y ARI**	**PMF**
1 Captain Cook Dr/Woolooware Rd Intersection East	1.65	1.74	2.31	+0.03	+0.03	+0.11
2 Captain Cook Dr /Woolooware Rd Intersection West	2.28	2.32	2.67	+0.06	+0.05	+0.08
3 Retail Site Entrance	2.41	2.46	3.14	-0.02	-	-0.02
4 Captain Cook Dr	2.39	2.46	3.13	-	-	-
5 Tidal Channel	2.02	2.38	3.06	-	-	-
6 Fitness First Open Drain	1.51	1.53	1.80	-	-	-0.14

Notes: Difference calculated relative to Existing Conditions (i.e. a positive number indicates an increase in flood level compared to existing conditions)

A summary of the results is provided as follows:

- Peak flood depths and levels for all design flood events for existing conditions, Figure 5 - Figure 7;
- Peak flood depths and levels for all design flood events for post-development conditions, Figure 8 - Figure 10;
- Peak flood velocities for all design flood events for post-development conditions, Figure 11 - Figure 13;
- Flood impact map for the proposed development for the 100 year ARI event, Figure 14;
- Flood extents for various climate change scenarios for the 100 year ARI and PMF events, Figure 15 - Figure 16; and
- Provisional flood hazard categorisation for existing conditions and post-development conditions, Figure 17 - Figure 22.

As discussed in Section 5.7.1, a ‘peak envelope’ approach that adopts the highest of the predicted levels from the two flooding mechanisms, i.e. catchment runoff and tidal inundation, has been used to estimate the design flood levels.

6.3. Existing Flood Behaviour

Floodwaters originating from Woolooware Golf Course exceed the capacity of the twin box culverts beneath the roadway and overtop Captain Cook Drive for all the modelled design events. Figure 5 to Figure 7 indicate that the majority of the proposed retail development site remains flood free for all design flood events. The exception is at the low spot of the entrance to the Cronulla Sharks Rugby League Club off Captain Cook Drive whereby in the 100 year ARI event inundation of up to 0.3 m occurs (refer to Figure 6). At this entrance off Captain Cook Drive the site was identified as low provisional (based on depth and velocity) for events up to and including the 100 year ARI event (refer to Figure 18).

6.4. Floor Levels

The ground floor level for the retail development site is proposed to be at 4 mAHD, which is significantly higher than the 100 year ARI peak flood level of 2.46 mAHD and even the PMF peak flood level of 3.14 mAHD. With the exception of the main entrance off Captain Cook Drive whereby the crest level is proposed to be at 2.6 mAHD which is still above the 100 year ARI peak flood level, all other entrances are proposed at a similar level to the ground flood level (4 mAHD). Therefore, the site is not subject to any flood risk and is in compliance with Council’s development controls for flooding.

6.5. Flood Impact Assessment for Development

Associated with the development are the earthworks proposed for the entrance to the retail development as well as the realignment and upgrade of the existing local drainage system from a 375 mm diameter pipe to a proposed 450 mm diameter pipe which will convey more floodwaters to the tidal channel west of Toyota Park. With the proposed works, however, adverse flood impact of up to 20 mm was found for the 100 year ARI flood event (for an area <50 m^2), as shown in Figure 14. This impact is regarded as acceptable considering it is on the side of the roadway rather than at residential dwellings where it would increase flood damages.

An impact assessment was also carried out for the Captain Cook Drive/Woolooware Road intersection upgrade whereby the existing roundabout will be modified to a signalised intersection. Table 6 indicates that the 100 year ARI peak flood levels on the grassed area east and west of the intersection will increase by up to 30 mm and 50 mm respectively as a result of the intersection upgrade. However, with Woolooware Rd raised slightly from the current crest level, inundation depths of less than 100 mm will occur for the 100 year ARI event which provides a safer passage for vehicles during flooding.

6.6. Climate Change

Climate change modelling has also been carried out as per the NSW Government guidelines issued in 2009 (Reference 13). However it should be noted that in September 2012 the NSW Government repealed mandatory compliance with the 0.4 m sea level rise by the year 2050 and 0.9 m sea level rise by the year 2100. Councils in NSW must now make their own decisions regarding the assessment of sea level rise. Sutherland Shire Council has made no formal statement that it is adopting a sea level rise assessment different to Reference 13.

A rainfall intensity increase of 10%, 20% and 30% was assessed as well as sea level rise scenarios by the year 2050 and 2100. The following runs were modelled:

- 100 year ARI event with 10%, 20% and 30% increase in rainfall;
- 100 year ARI event with sea level rise to predicted year 2050 levels (+0.4 m);
- 100 year ARI event with sea level rise to predicted year 2100 levels (+0.9 m);
- 100 year ARI event with sea level rise to predicted year 2100 levels (+0.9 m) plus 10% rainfall increase; and
- PMF event with sea level rise to predicted year 2100 levels (+0.9 m).

The results are tabulated in Table 7 for the 100 year ARI event and Table 8 for the PMF event. Flood extents of the various climate change scenarios are shown in Figure 15 and Figure 16. Overall, the results show that an increase in peak flood level of up to a maximum of 0.2 m can be expected for the development site and as such would not be an issue considering the proposed floor levels have been designed to be at a level above the PMF flood level plus any increase induced by climate change. However the relatively flat topography means that a small increase in peak level translates to a relatively large increase in flood extent.

Table 7: Impacts on 100 year ARI Peak Flood Levels (mAHD) for Climate Change Scenarios

Location	Base Case	Rainfall Increase +10%	Rainfall Increase +20%	Rainfall Increase +30%	Sea Level Rise 2050 Scenario (+0.4m)	Sea Level Rise 2100 Scenario (+0.9m)	Rainfall Increase +10% & Sea Level Rise 2100 Scenario (+0.9m)
1 Captain Cook Dr/Woolooware Rd Intersection East	1.77	+0.05	+0.09	+0.11	+0.06	+0.51	+0.51
2 Captain Cook Dr /Woolooware Rd Intersection West	2.37	+0.02	+0.03	+0.04	-	+0.03	+0.04
3 Retail Site Entrance	2.46	+0.05	+0.10	+0.15	+0.02	+0.14	+0.18
4 Captain Cook Dr	2.46	+0.04	+0.09	+0.15	+0.02	+0.14	+0.18
5 Tidal Channel	2.37	+0.09	+0.16	+0.22	+0.06	+0.22	+0.26
6 Fitness First Open Drain	1.53	-	+0.03	+0.03	+0.26	+0.75	+0.75

Notes: Difference calculated relative to Base Case (i.e. a positive number indicates an increase in flood level compared to non climate change scenario)

Table 8: Impacts on PMF Peak Flood Levels (mAHD) for Climate Change Scenarios

Location	Base Case	Sea Level Rise 2100 Scenario (+0.9m)
1 Captain Cook Dr/Woolooware Rd Intersection East	2.42	+0.05
2 Captain Cook Dr /Woolooware Rd Intersection West	2.75	-
3 Retail Site Entrance	3.12	-
4 Captain Cook Dr	3.12	-
5 Tidal Channel	3.05	+0.02
6 Fitness First Open Drain	1.66	+0.69

Notes: Difference calculated relative to Base Case (i.e. a positive number indicates an increase in flood level compared to non climate change scenario)

7. MANAGEMENT OF THE FLOOD PROBLEM

7.1. Access and Safety during Floods

Flood levels for the PMF event were assessed for the site as this relates to evacuation and overall risk to lives. It also informs the emergency plan, as the PMF flood levels largely determine whether the strategy for response to flooding should be to sit tight or to evacuate immediately.

For both existing and post-development conditions, a peak flood level of 3.2 mAHD is expected at the site in the PMF event. As this is lower than the proposed ground floor car park level (4.0 mAHD), emergency egress during a flood event is not necessary. Nevertheless, an evacuation route as indicated in Figure 21 and Figure 22 is proposed which serves as an access route from the site to high ground via Woolooware Road as well as providing access for emergency vehicles (i.e. SES, ambulance) to get to the site. As such, it is pertinent that the proposed new intersection is designed to be flood free up to the 100 year ARI event. With the existing topography of the intersection, shallow inundation depths (<100 mm) can still be expected as indicated on Figure 9 for the 100 year ARI event.

7.2. Flood Response Plan

A flood response plan should be prepared by the building management to minimise the risk associated with evacuations by providing information regarding evacuation routes, refuge areas, what to do/not to do during floods etc. Any evacuation undertaken would usually be under the direction of the lead agency, the State Emergency Services (SES). As such, it is necessary that SES be made aware of the new retail development and the local SES response planning can be prepared.

Since the development proposed is above the flood planning level, there are no further requirements in regards to the construction as there are no flood liable structures. Nevertheless, reliable pedestrian and vehicle access to a place of refuge should be maintained. Recommendations for an evacuation route have been provided in the previous section.

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Figures

FIGURE 1
STUDY AREA AND PROPOSED DEVELOPMENT

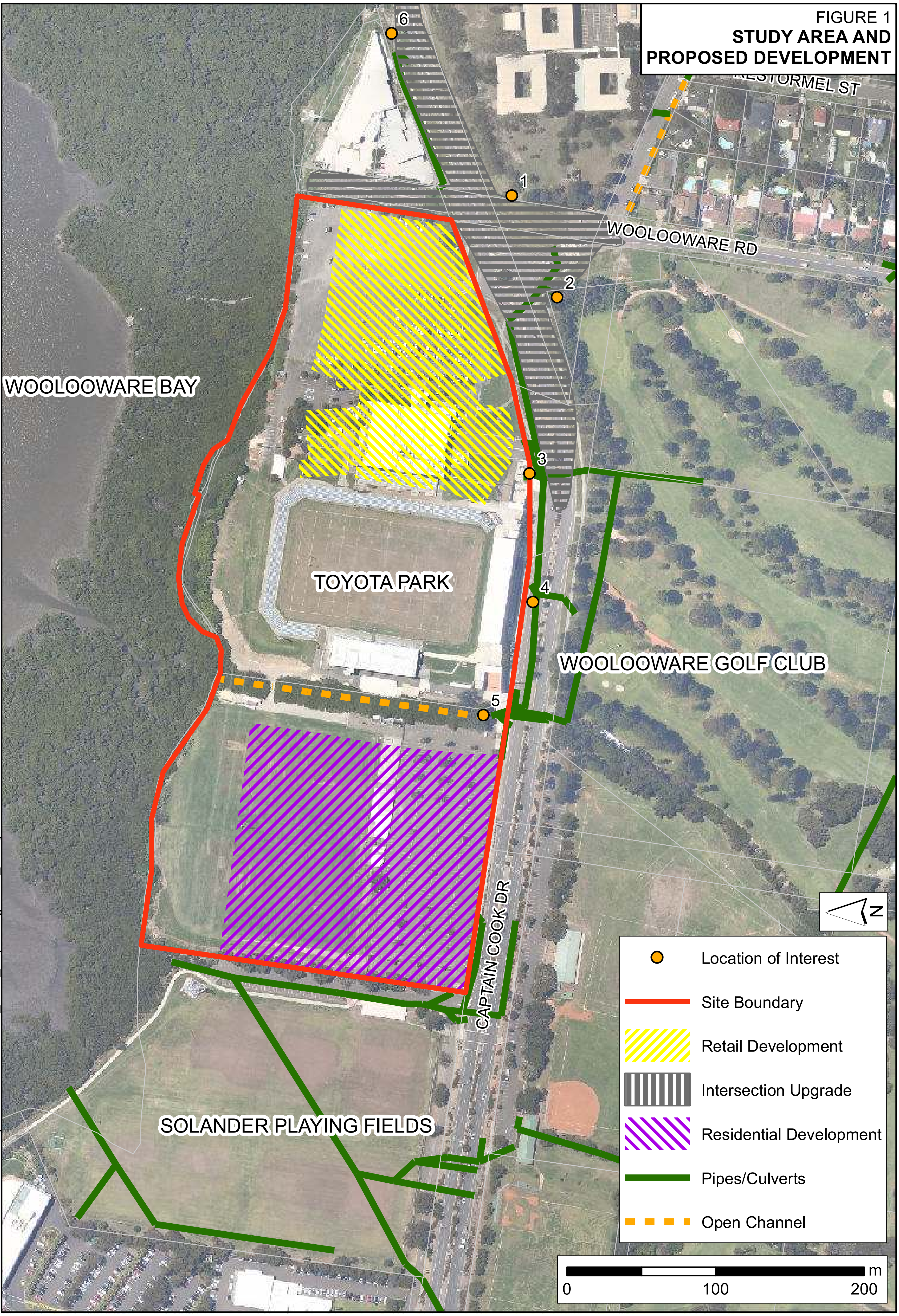

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FIGURE 2
EXISTING TOPOGRAPHY AND SUBCATCHMENTS

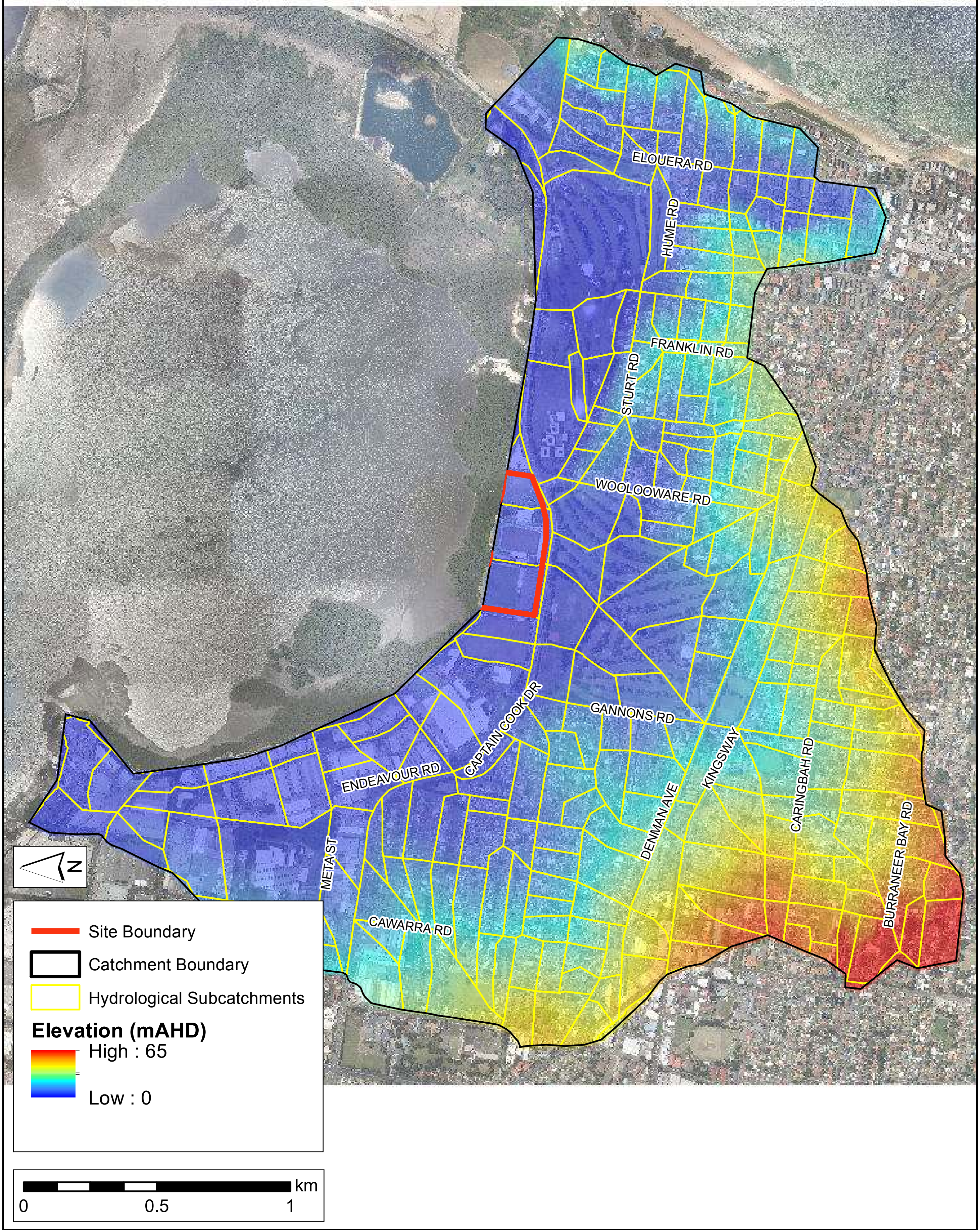

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FIGURE 3
DRAINAGE NETWORK & HYDRAULIC MODEL LAYOUT

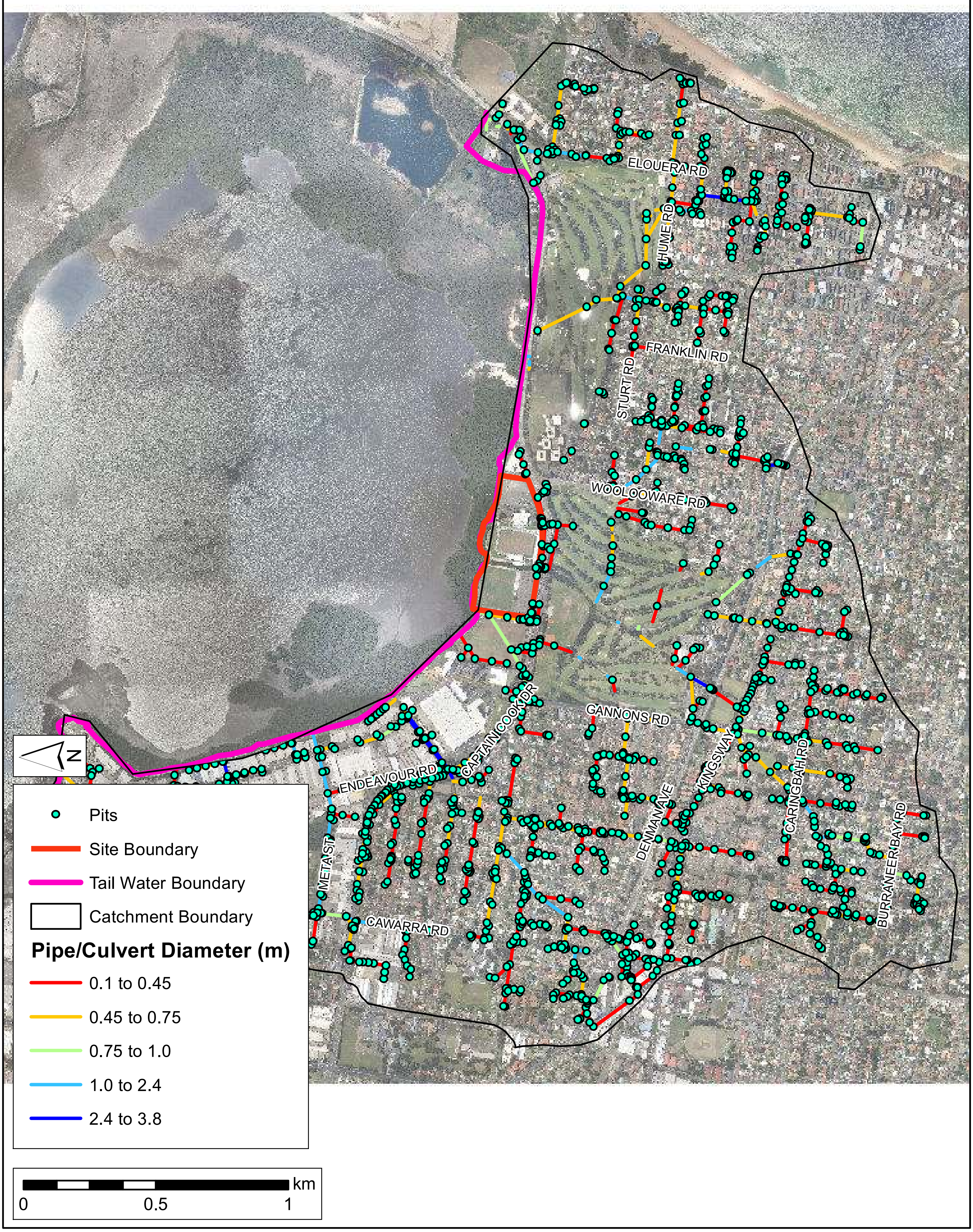

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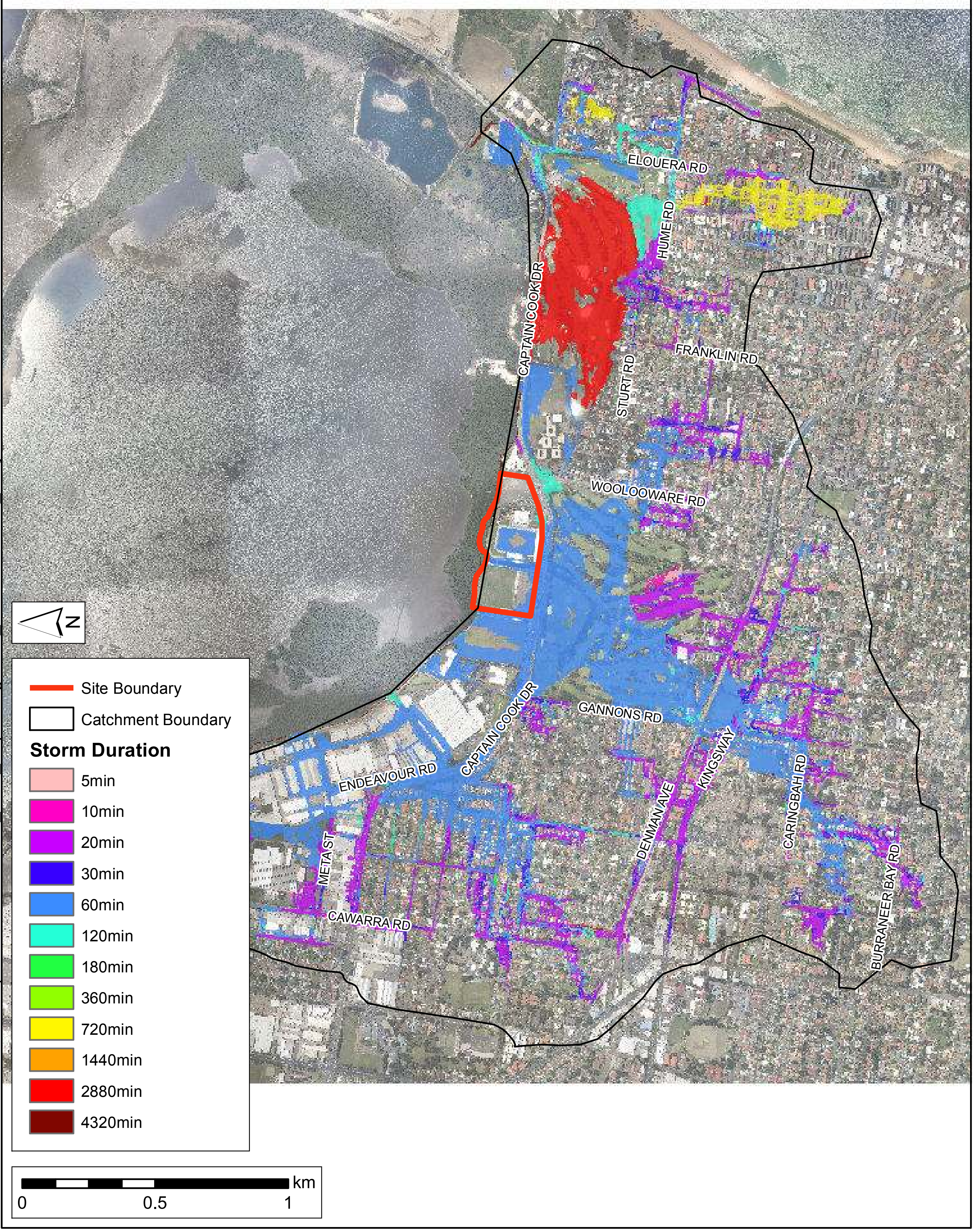
FIGURE 4
CRITICAL DURATION MAP
100Y ARI EVENT



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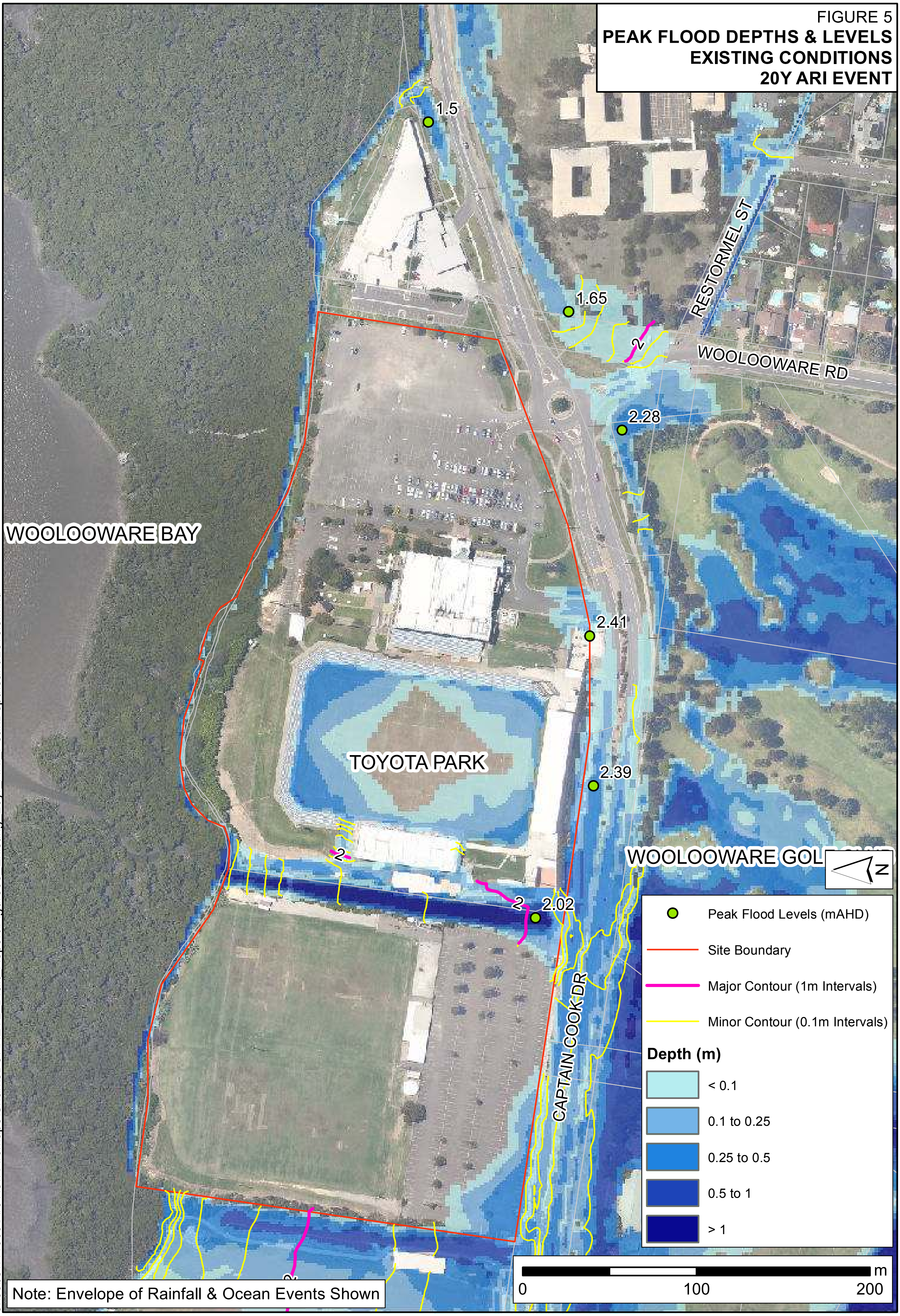
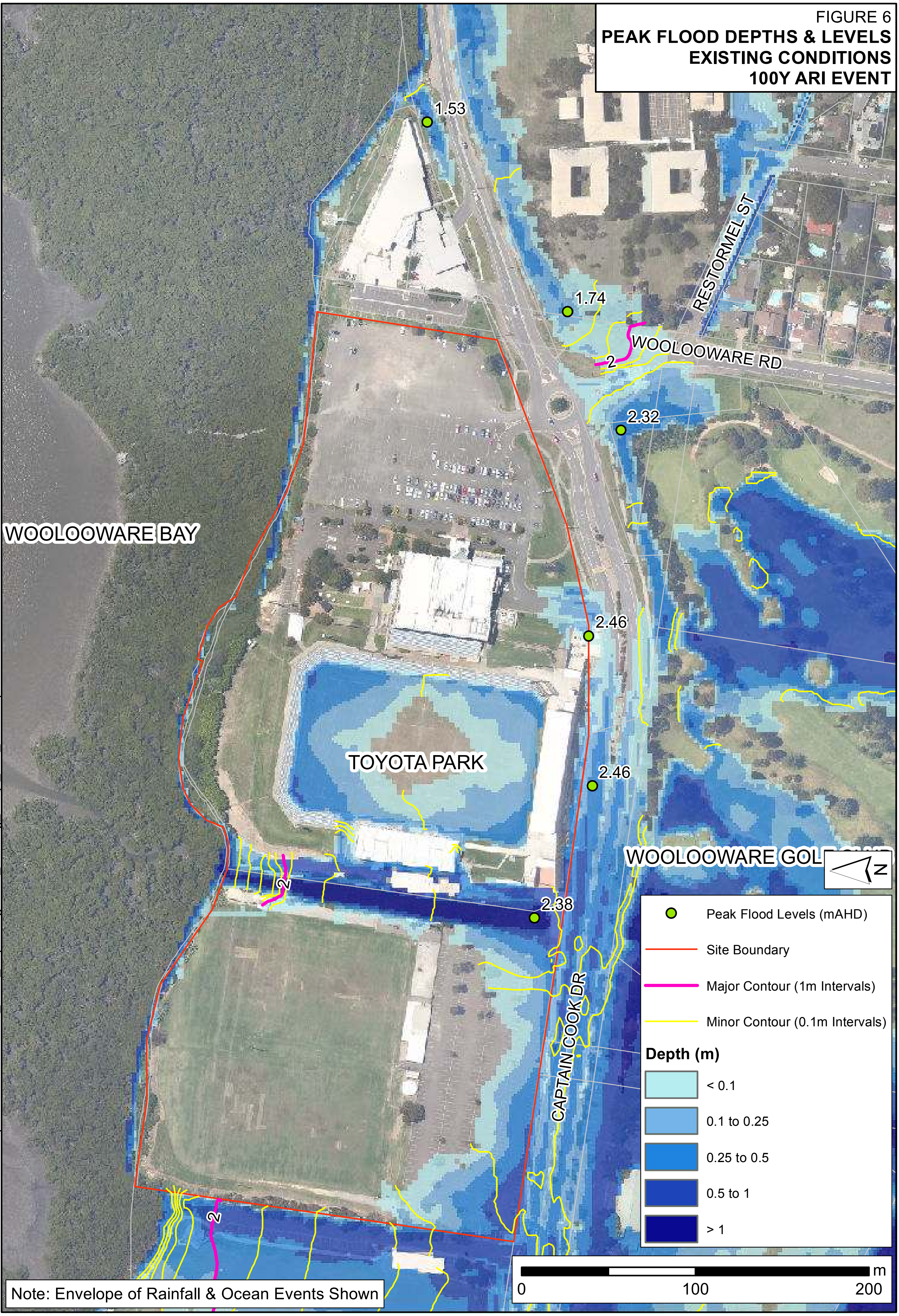


FIGURE 5
PEAK FLOOD DEPTHS & LEVELS
EXISTING CONDITIONS
20Y ARI EVENT
1.5
1.65
2.28
2.41
2.39
2.02
2
RESTORMEL ST
WOOLOOWARE RD
WOOLOOWARE BAY
TOYOTA PARK
CAPTAIN COOK DR
N
Peak Flood Levels (mAHD)
Site Boundary
Major Contour (1m Intervals)
Minor Contour (0.1m Intervals)
Depth (m)
< 0.1
0.1 to 0.25
0.25 to 0.5
0.5 to 1
> 1
m
0
100
200
Note: Envelope of Rainfall & Ocean Events Shown
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure05 Existing 20yr ARI PeakDepthsandLevels.mxd

FIGURE 6
PEAK FLOOD DEPTHS & LEVELS
EXISTING CONDITIONS
100Y ARI EVENT



J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure06 Existing 100yr ARI PeakDepthsandLevels.mxd

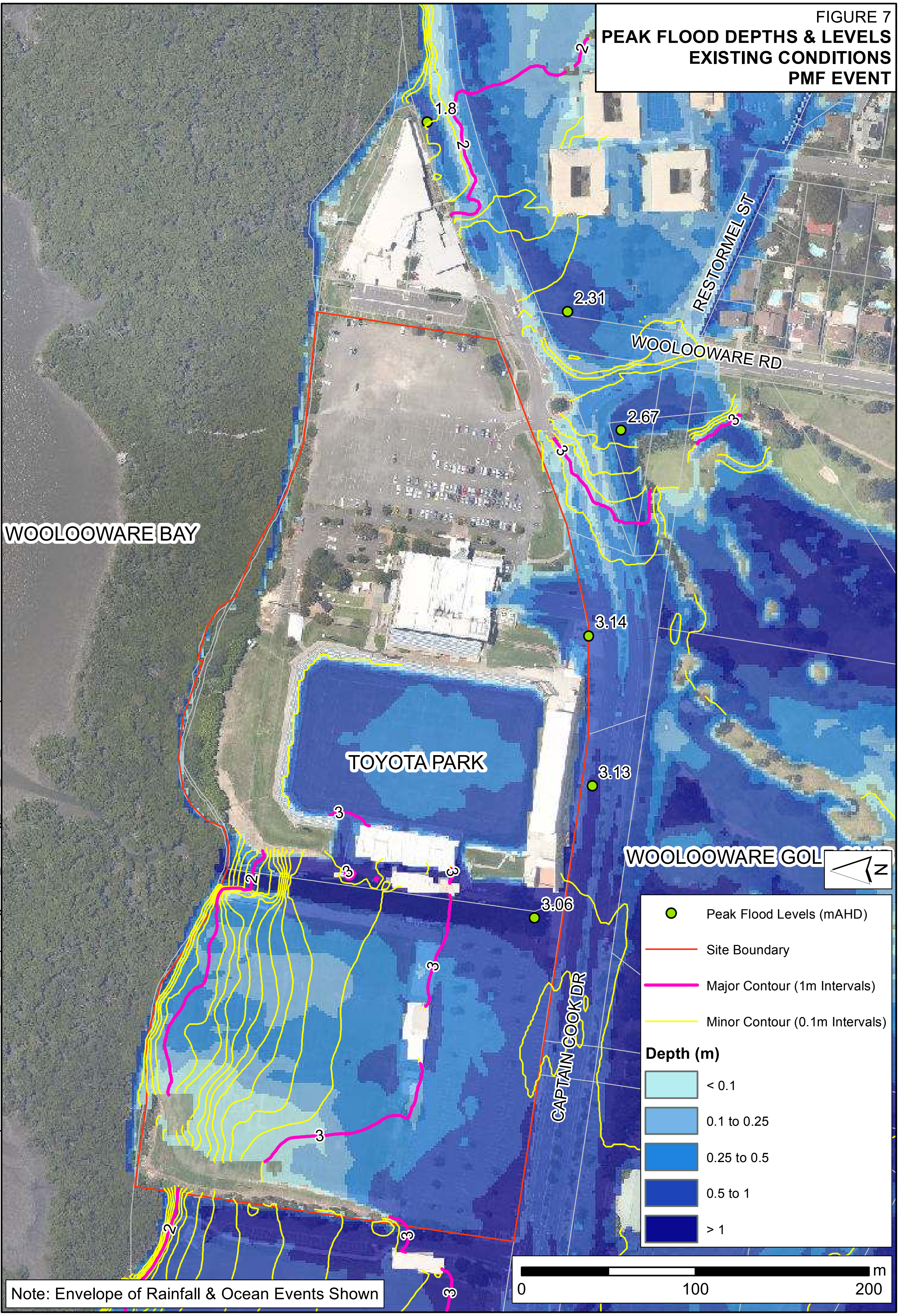
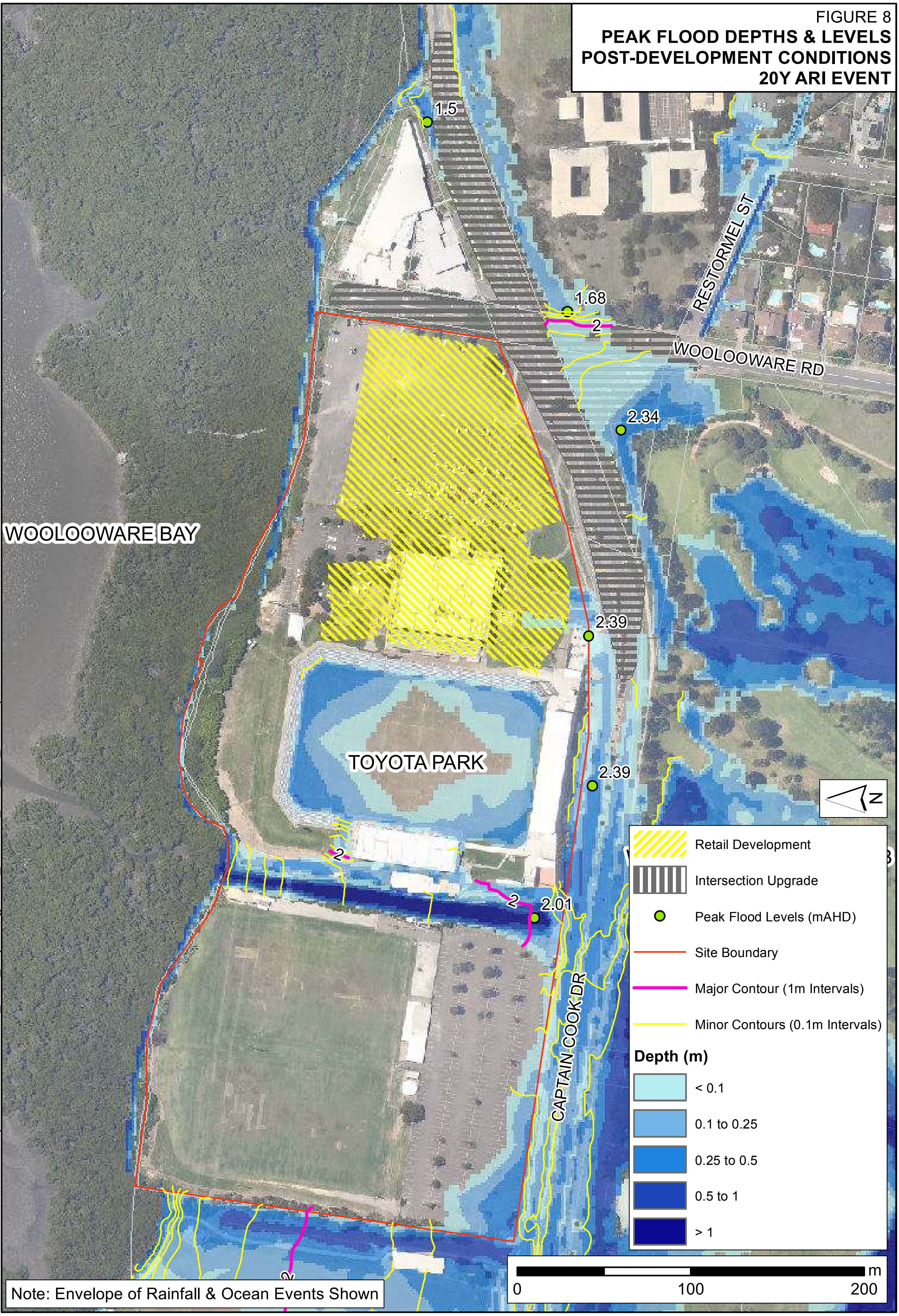


FIGURE 7
PEAK FLOOD DEPTHS & LEVELS EXISTING CONDITIONS PMF EVENT

J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure07 Existing PMF ARI PeakDepthsandLevels.mxd

FIGURE 8

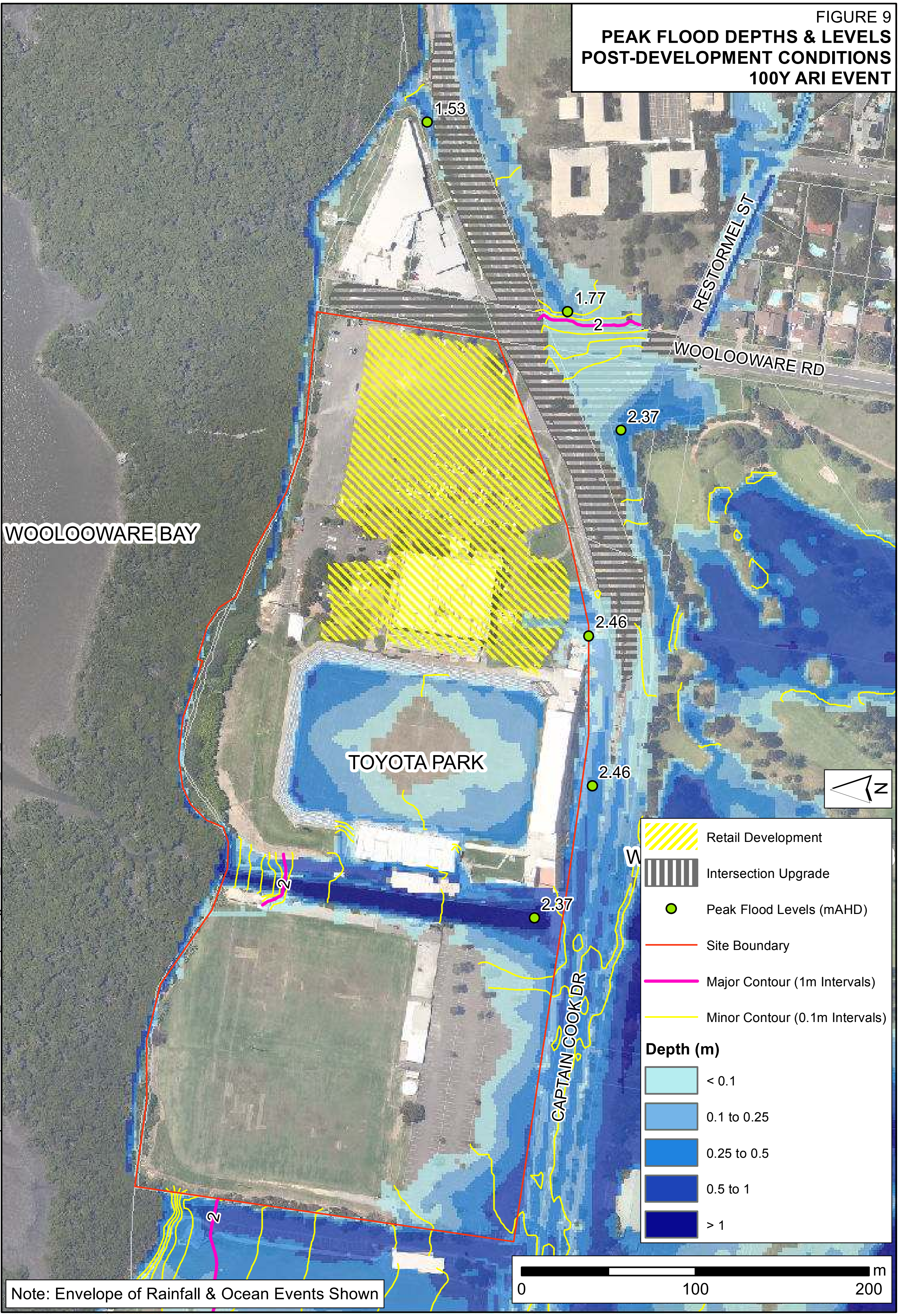
PEAK FLOOD DEPTHS & LEVELS POST-DEVELOPMENT CONDITIONS 20Y ARI EVENT



Note: Envelope of Rainfall & Ocean Events Shown

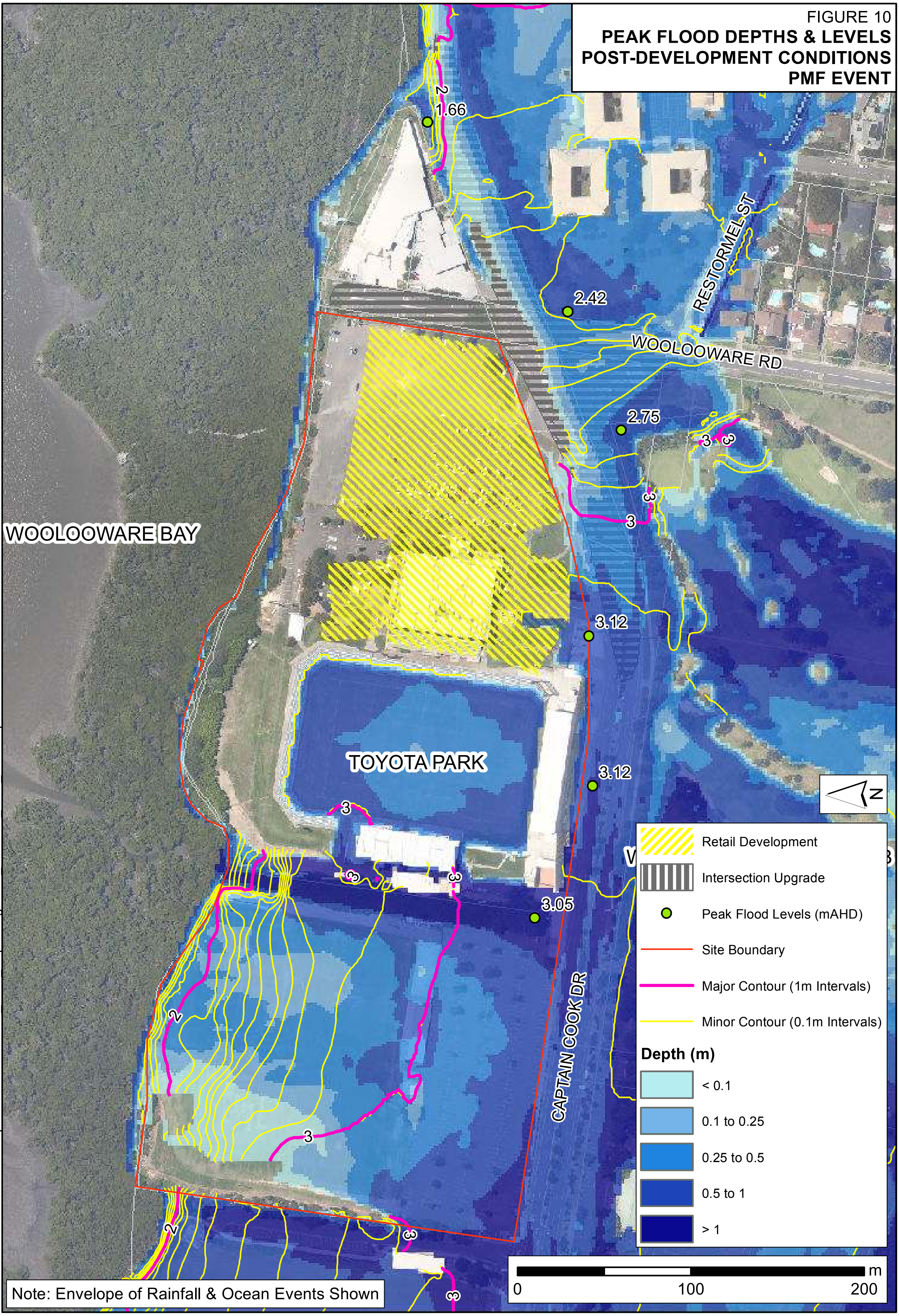
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure08 PostDev 20Y ARI PeakDepthsandLevels.mxd

FIGURE 9
PEAK FLOOD DEPTHS & LEVELS POST-DEVELOPMENT CONDITIONS 100Y ARI EVENT



J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure09 PostDev 100Y ARI PeakDepthsandLevels.mxd

FIGURE 10
PEAK FLOOD DEPTHS & LEVELS
POST-DEVELOPMENT CONDITIONS
PMF EVENT



Note: Envelope of Rainfall & Ocean Events Shown

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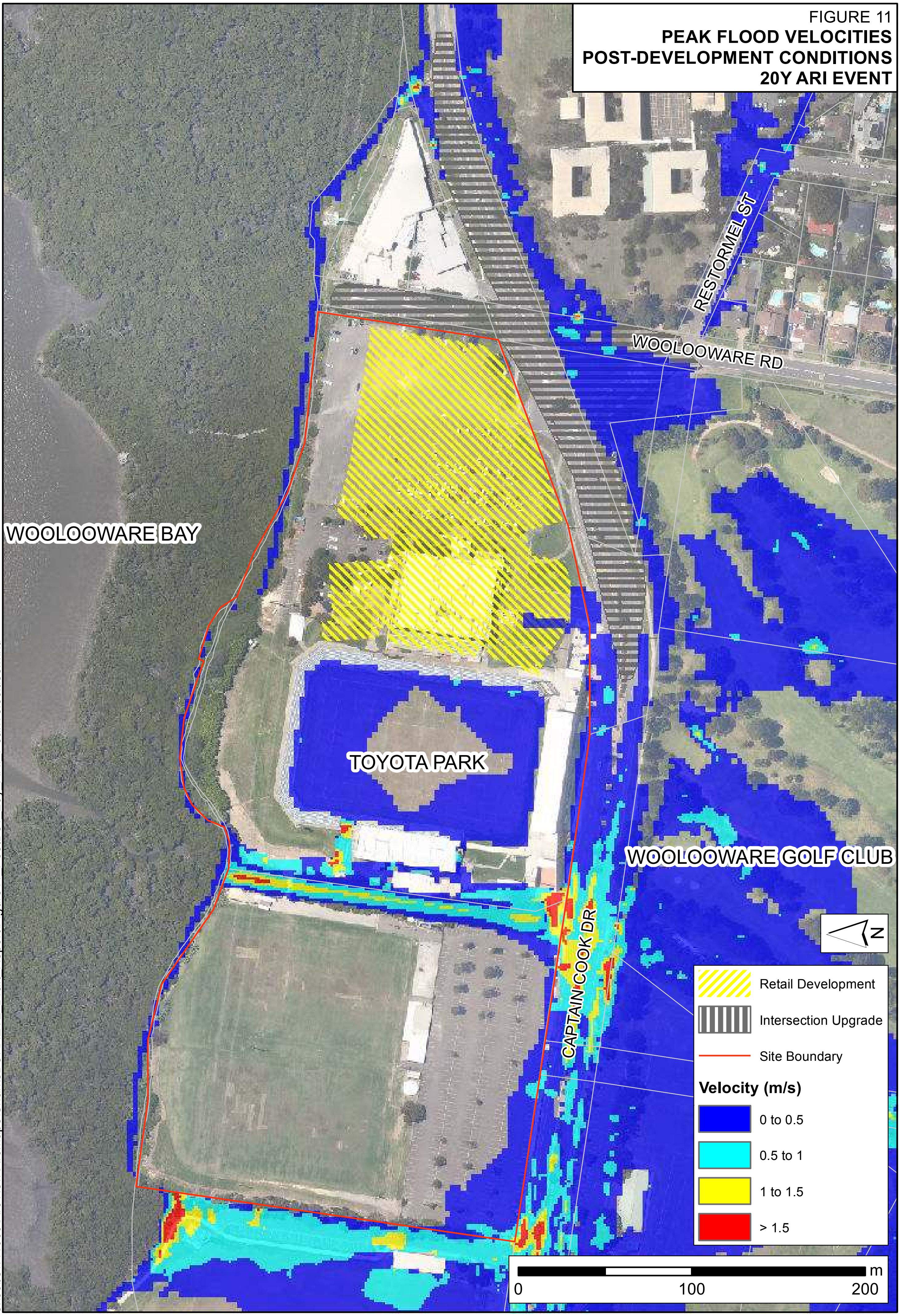

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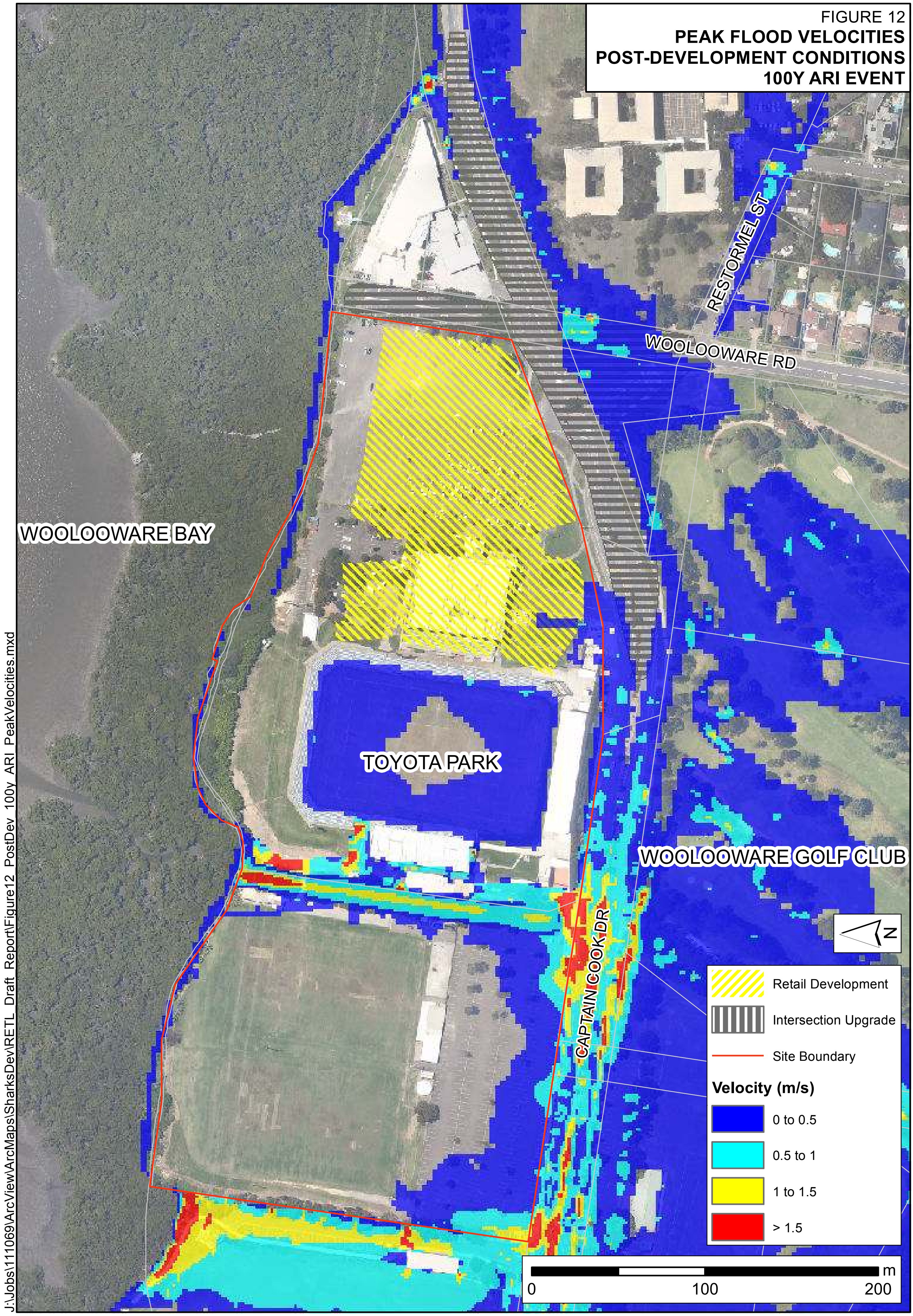
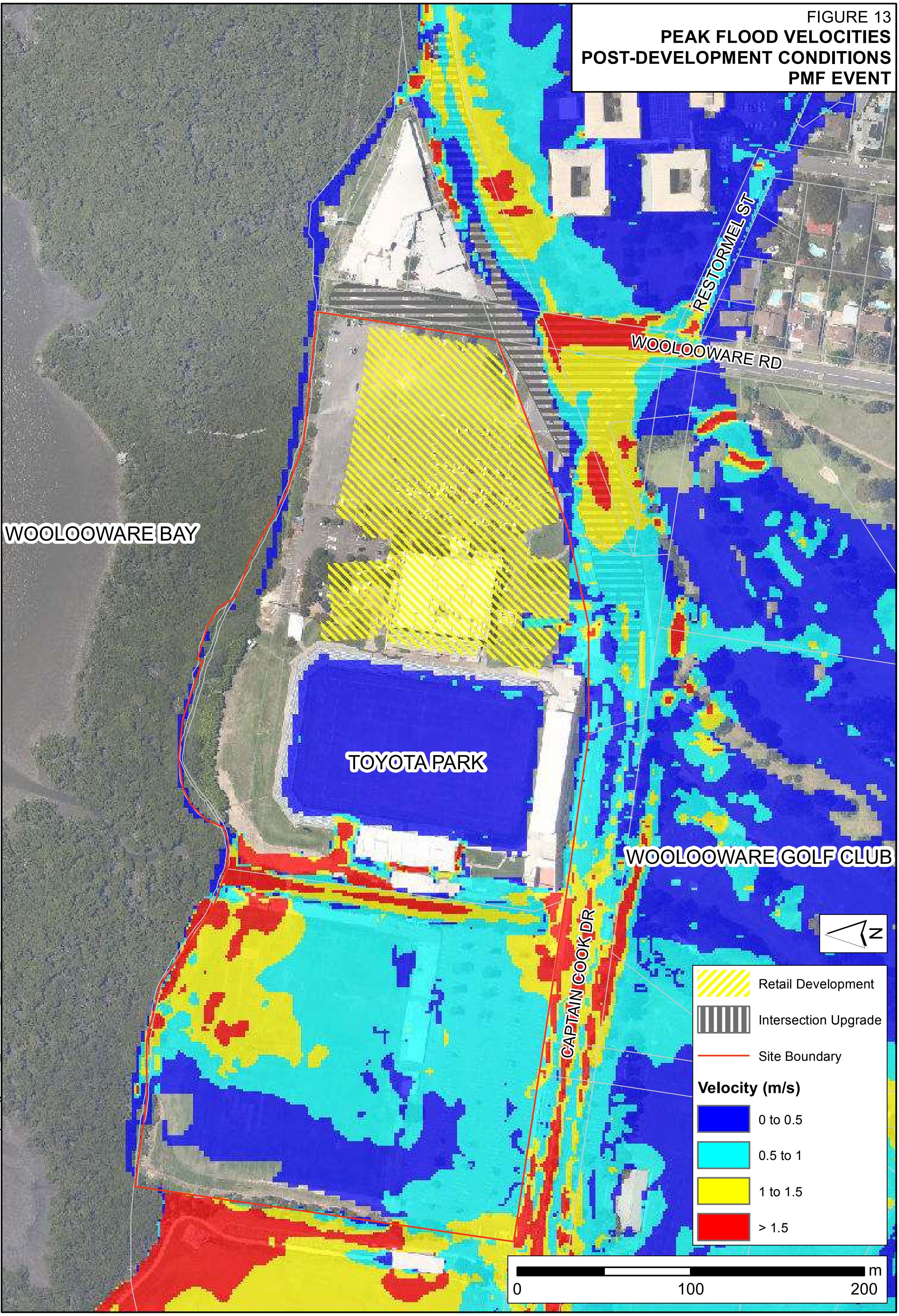


FIGURE 12
PEAK FLOOD VELOCITIES
POST-DEVELOPMENT CONDITIONS
100Y ARI EVENT
WOOLOOWARE BAY
TOYOTA PARK
WOOLOOWARE GOLF CLUB
RESTORMEL ST
WOOLOOWARE RD
CAPTAIN COOK DR
N
Retail Development
Intersection Upgrade
Site Boundary
Velocity (m/s)
0 to 0.5
0.5 to 1
1 to 1.5
> 1.5
0
100
200
m
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL_Draft_Report\Figure12_PostDev_100y_ARI_PeakVelocities.mxd

FIGURE 13
PEAK FLOOD VELOCITIES POST-DEVELOPMENT CONDITIONS PMF EVENT



J:\Jobs\112010\ArcView\ArcMaps\Figure13_PostDev_PMF_PeakVelocities.mxd

FIGURE 14
FLOOD IMPACT MAP
POST-DEVELOPMENT CONDITIONS
100Y ARI EVENT

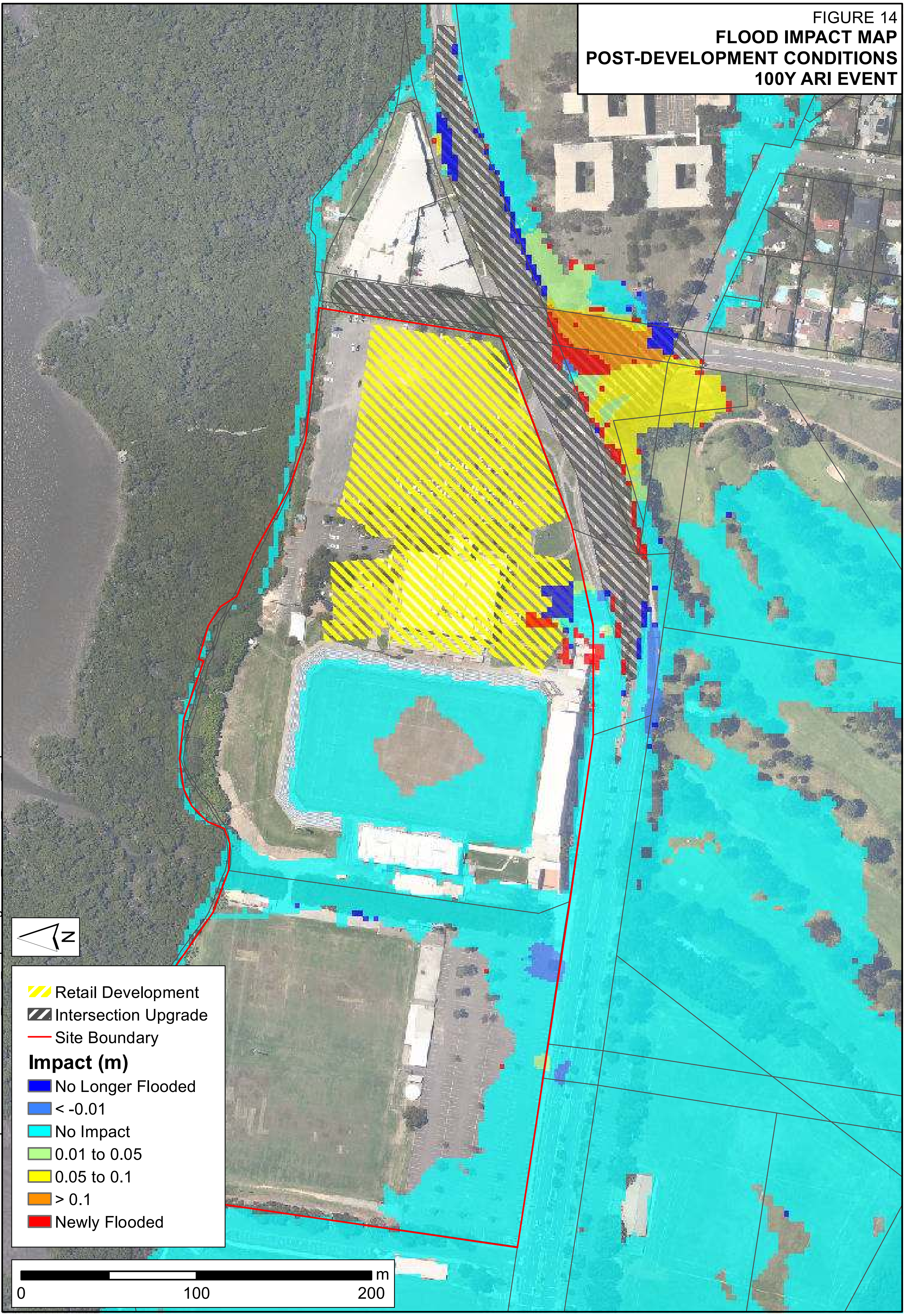


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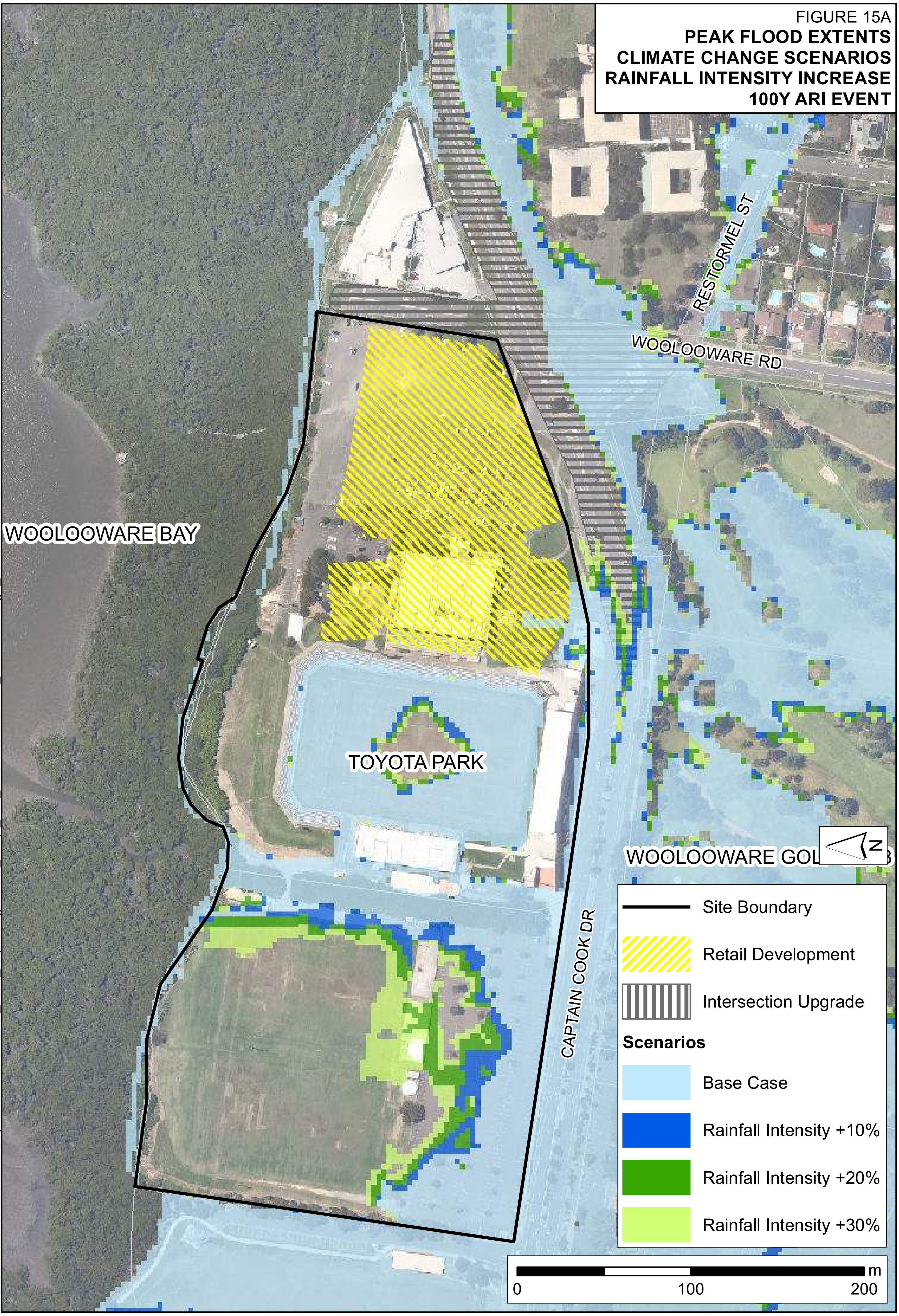
FIGURE 15A
PEAK FLOOD EXTENTS CLIMATE CHANGE SCENARIOS RAINFALL INTENSITY INCREASE 100Y ARI EVENT



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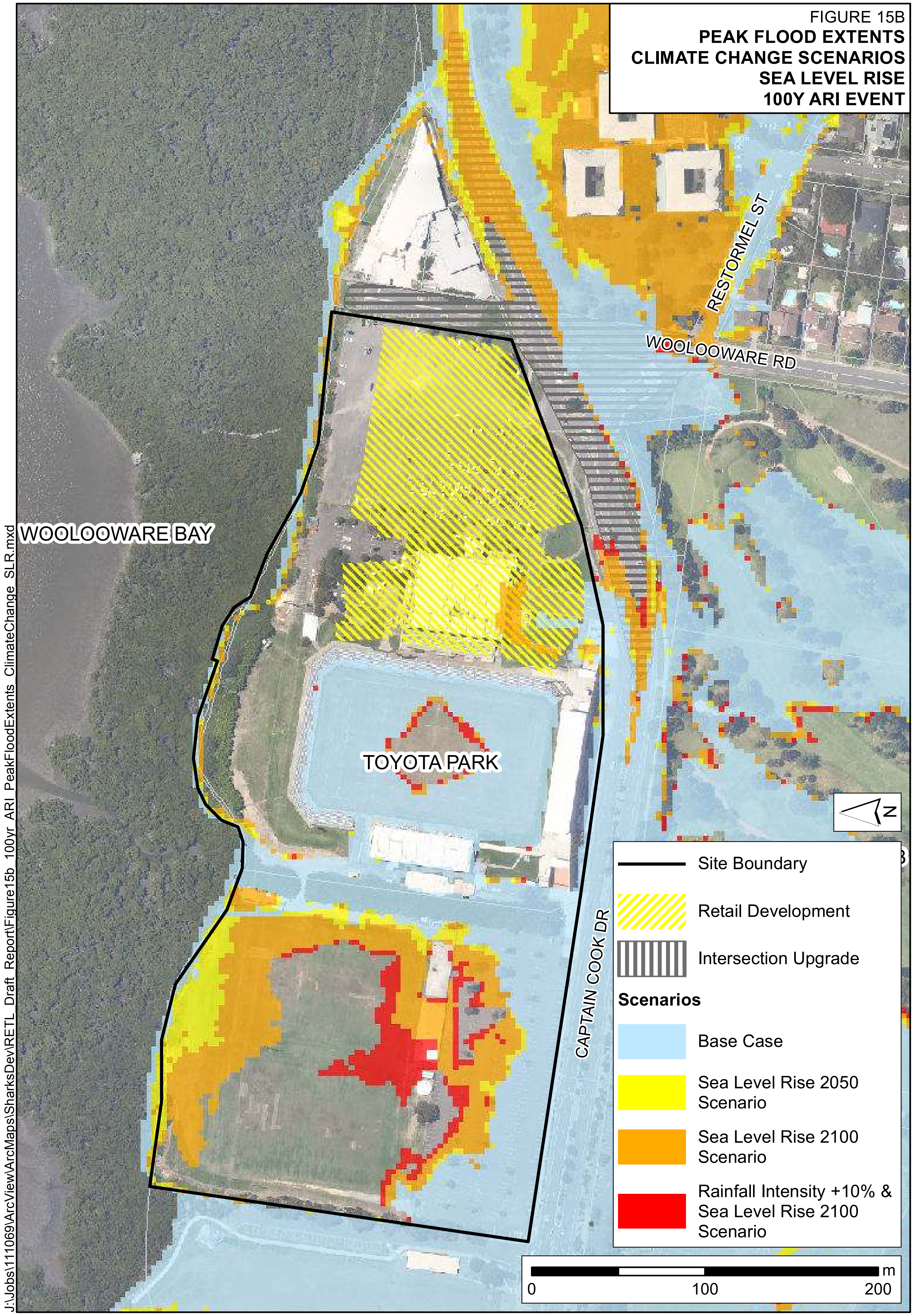


FIGURE 15B
PEAK FLOOD EXTENTS
CLIMATE CHANGE SCENARIOS
SEA LEVEL RISE
100Y ARI EVENT
WOOLOOWARE BAY
RESTORMEL ST
WOOLOOWARE RD
TOYOTA PARK
CAPTAIN COOK DR
N
Site Boundary
Retail Development
Intersection Upgrade
Scenarios
Base Case
Sea Level Rise 2050 Scenario
Sea Level Rise 2100 Scenario
Rainfall Intensity +10% & Sea Level Rise 2100 Scenario
0
100
200
m
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL_Draft_Report\Figure15b_100yr_ARI_PeakFloodExtents_ClimateChange_SLR.mxd

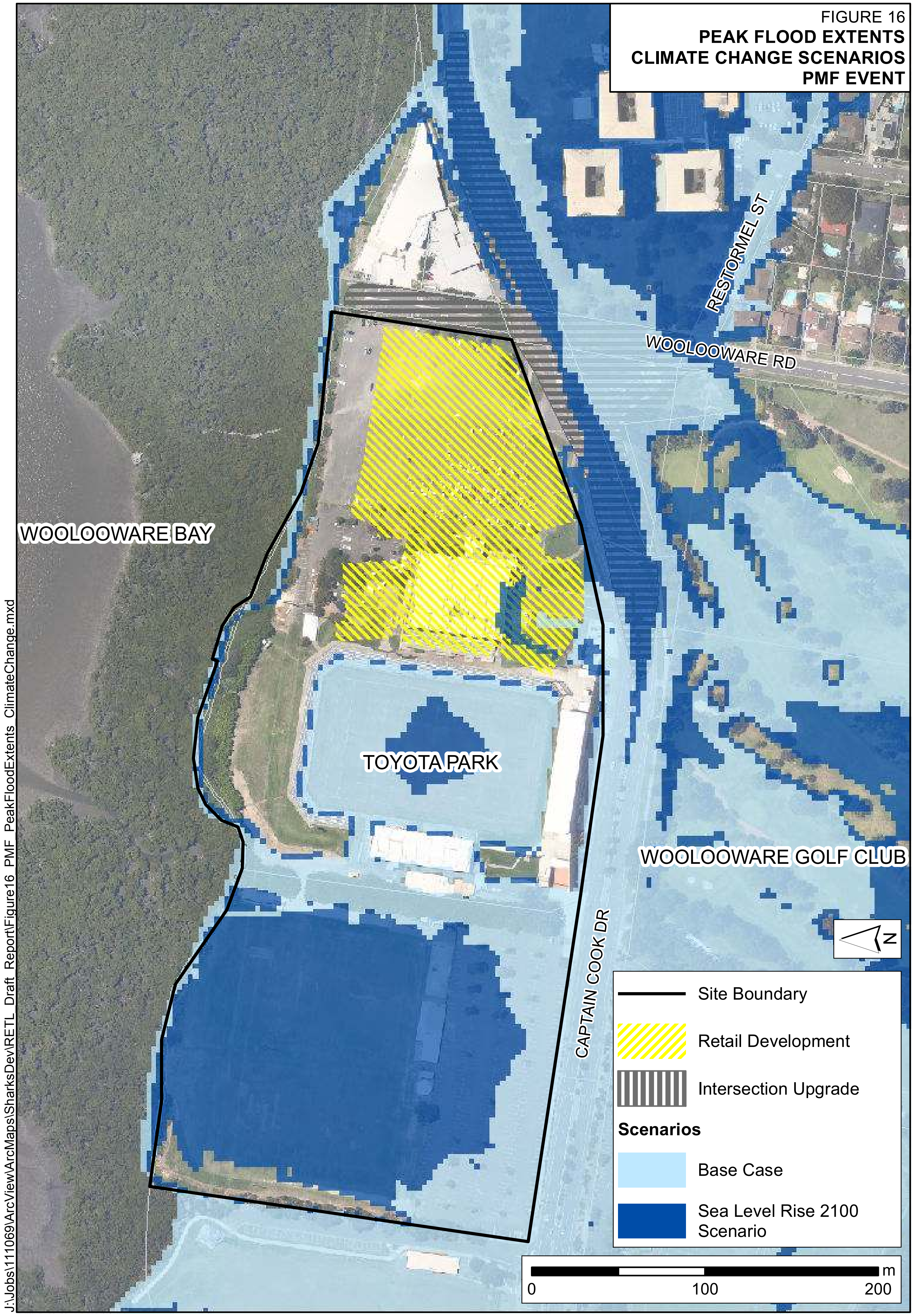
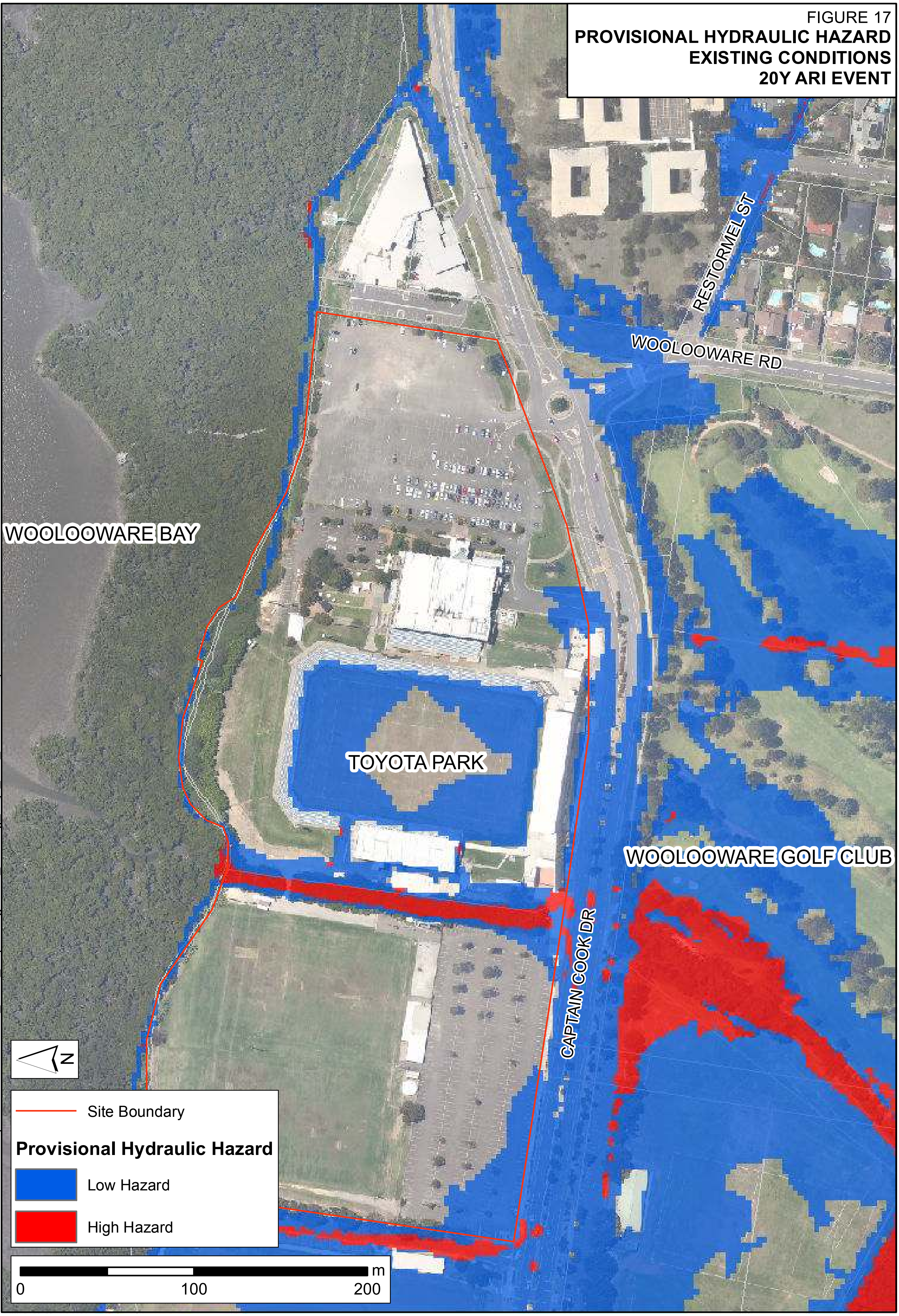


FIGURE 16
PEAK FLOOD EXTENTS
CLIMATE CHANGE SCENARIOS
PMF EVENT
WOOLOOWARE BAY
RESTORMEL ST
WOOLOOWARE RD
TOYOTA PARK
WOOLOOWARE GOLF CLUB
CAPTAIN COOK DR
N
Site Boundary
Retail Development
Intersection Upgrade
Scenarios
Base Case
Sea Level Rise 2100 Scenario
m
0
100
200
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure16 PMF PeakFloodExtents ClimateChange.mxd

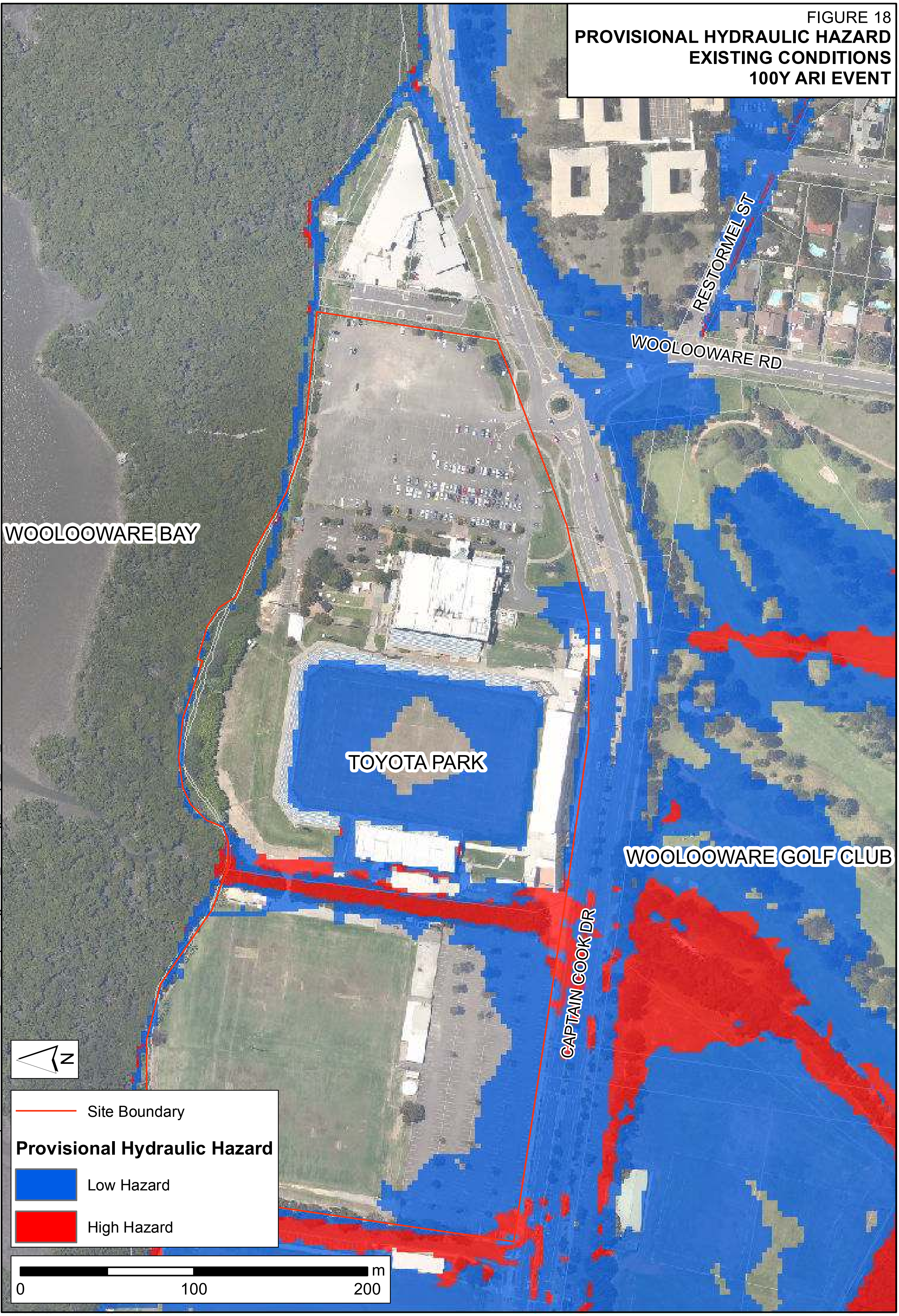
FIGURE 17
PROVISIONAL HYDRAULIC HAZARD EXISTING CONDITIONS 20Y ARI EVENT



J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure17 Existing 20yr ARI ProvisionalHydraulicHazard.mxd

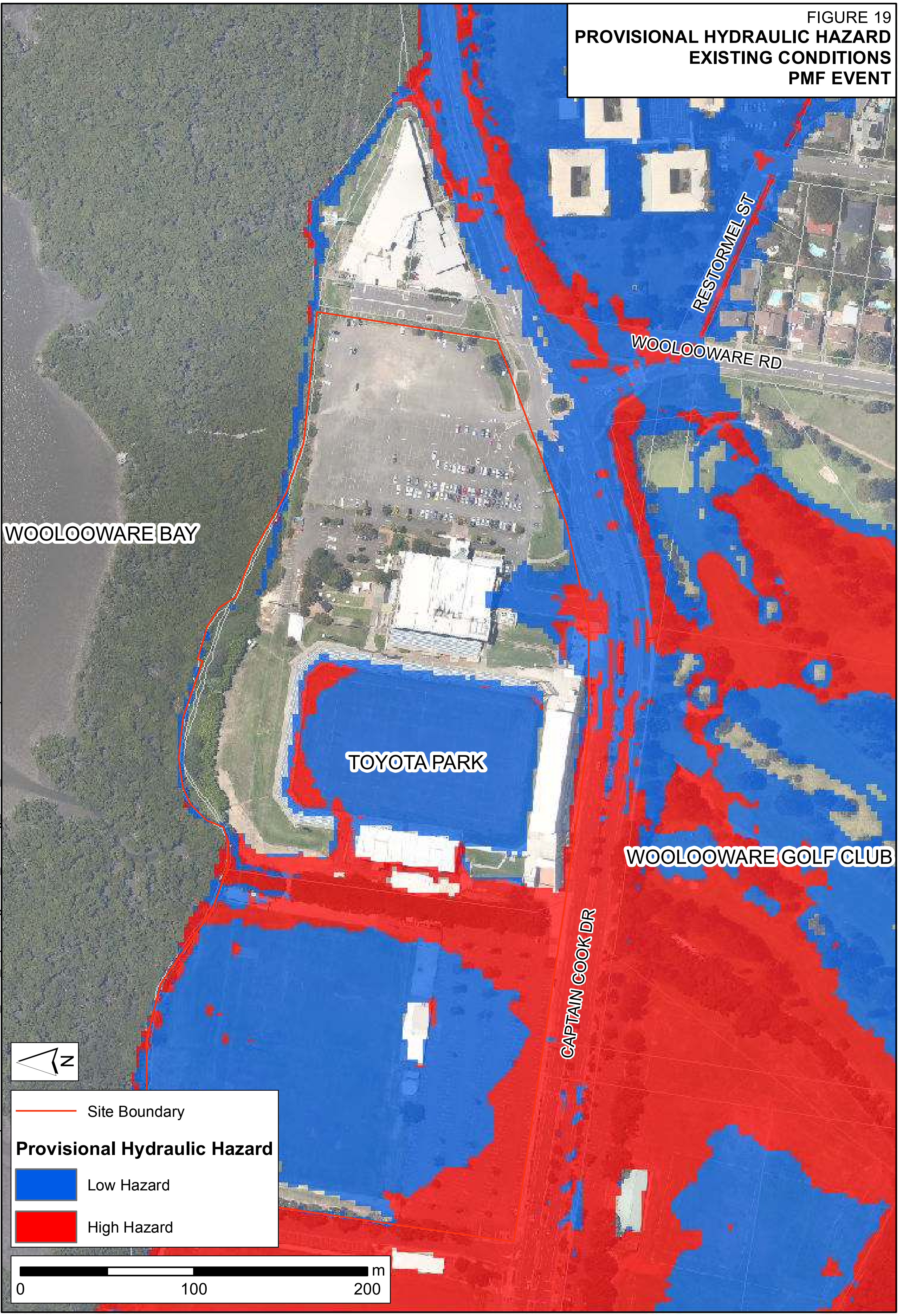
FIGURE 18

PROVISIONAL HYDRAULIC HAZARD
EXISTING CONDITIONS
100Y ARI EVENT



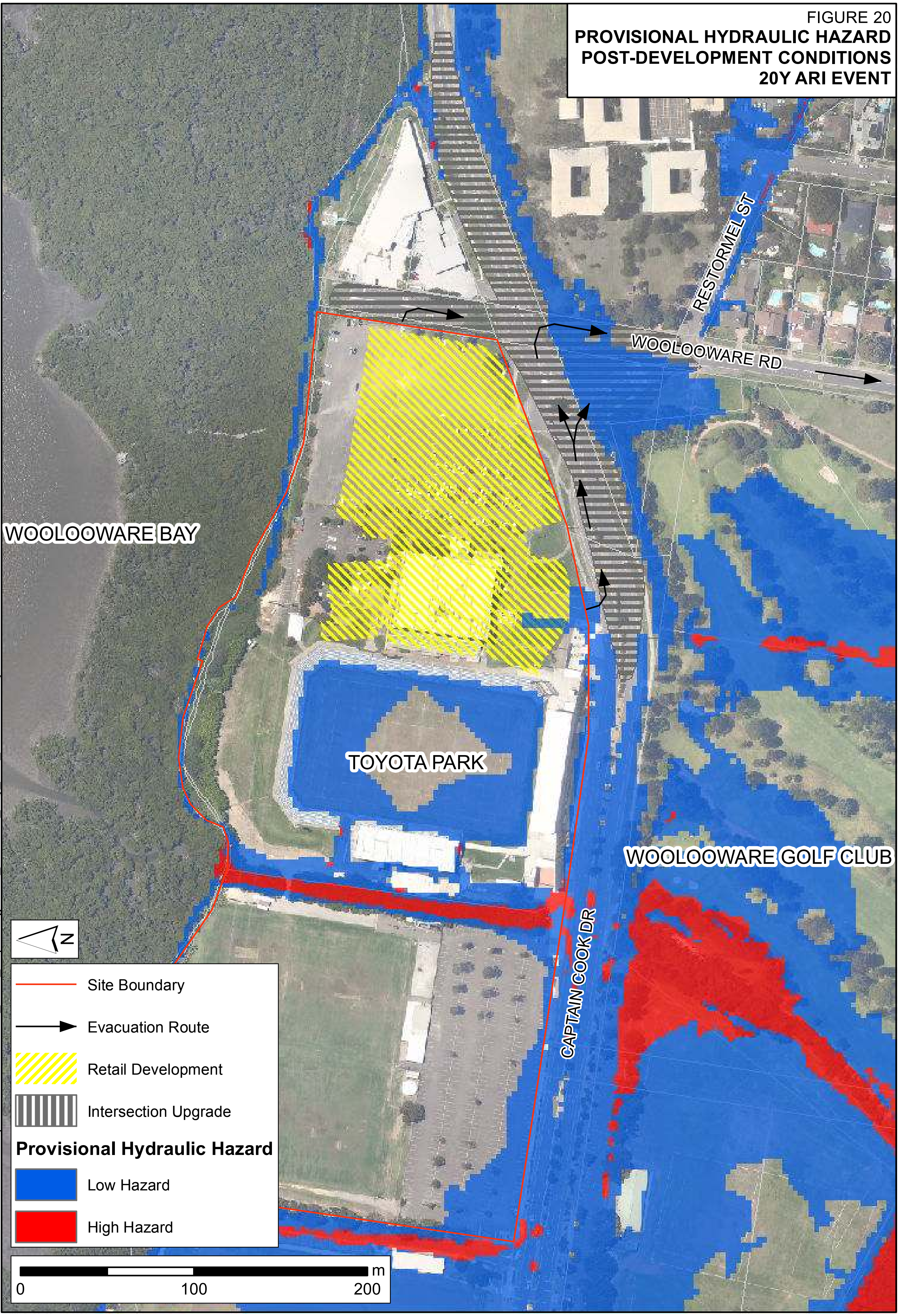
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure18 Existing 100yr ARI ProvisionalHydraulicHazard.mxd

FIGURE 19
PROVISIONAL HYDRAULIC HAZARD EXISTING CONDITIONS PMF EVENT



J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure19 Existing PMF ProvisionalHydraulicHazard.mxd

FIGURE 20
PROVISIONAL HYDRAULIC HAZARD POST-DEVELOPMENT CONDITIONS 20Y ARI EVENT



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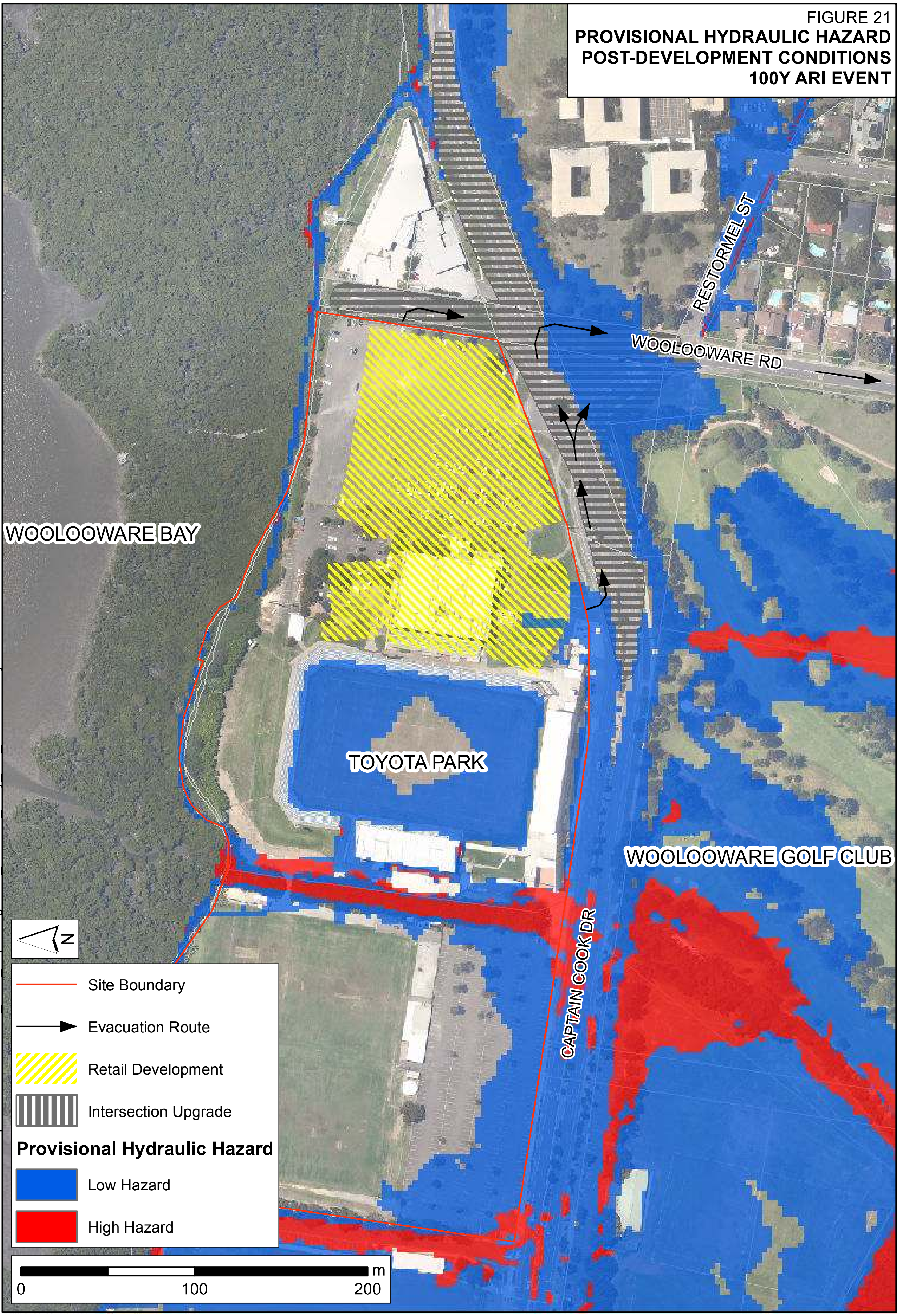


FIGURE 21
PROVISIONAL HYDRAULIC HAZARD POST-DEVELOPMENT CONDITIONS 100Y ARI EVENT

J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL Draft Report\Figure21 PostDev 100y ARI ProvisionalHydraulicHazard.mxd

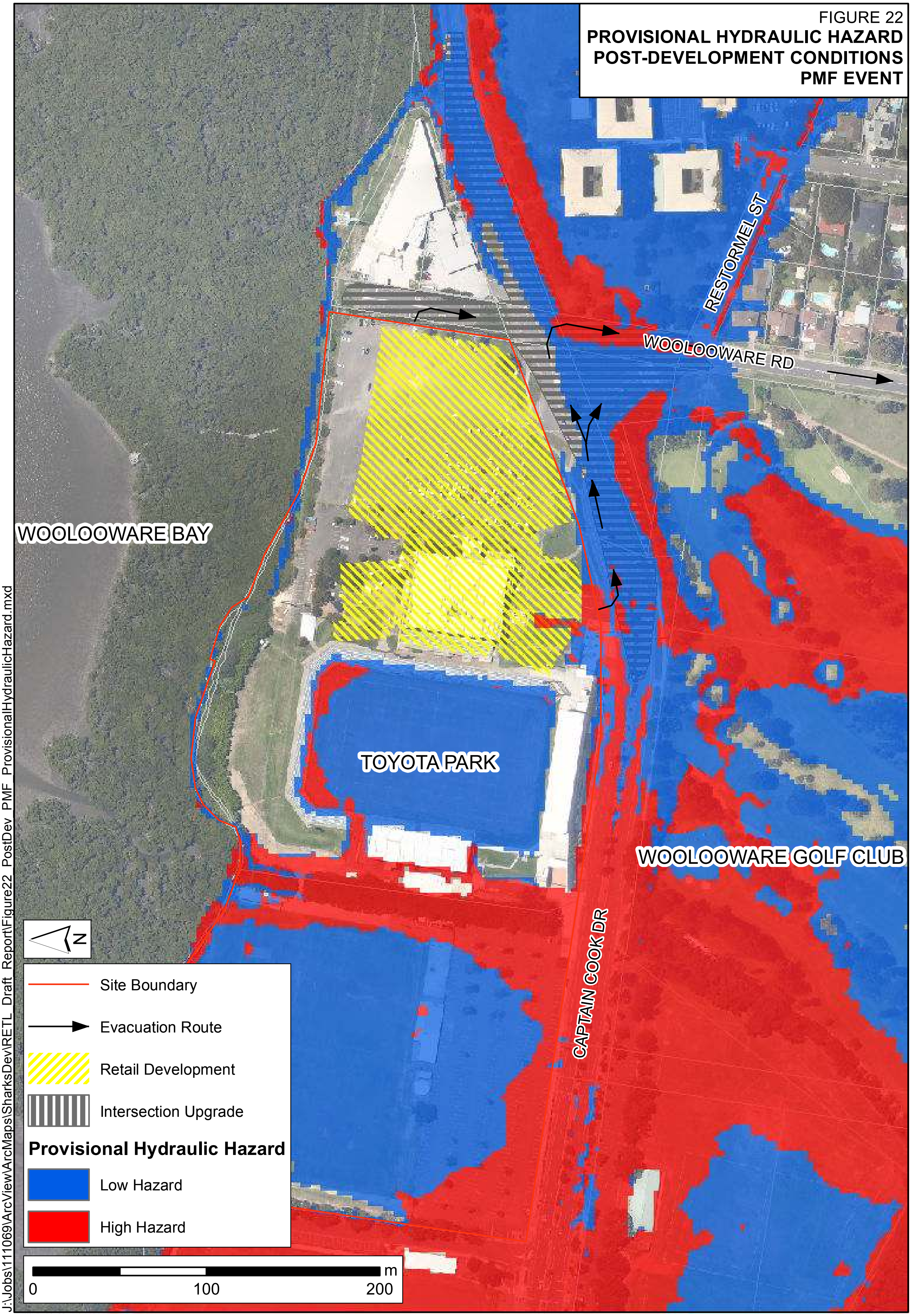


FIGURE 22
PROVISIONAL HYDRAULIC HAZARD
POST-DEVELOPMENT CONDITIONS
PMF EVENT
RESTORMEL ST
WOOLOOWARE RD
WOOLOOWARE BAY
TOYOTA PARK
WOOLOOWARE GOLF CLUB
CAPTAIN COOK DR
N
Site Boundary
Evacuation Route
Retail Development
Intersection Upgrade
Provisional Hydraulic Hazard
Low Hazard
High Hazard
0
100
200
m
J:\Jobs\111069\ArcView\ArcMaps\SharksDev\RETL_Draft_Report\Figure22_PostDev_PMF_ProvisionalHydraulicHazard.mxd

Appendix A

APPENDIX A: GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulfate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulfur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulfate Soil Manual published by Acid Sulfate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, Government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either rezoning or major extensions to urban services.
disaster plan (DISPLAN)	A step by step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of

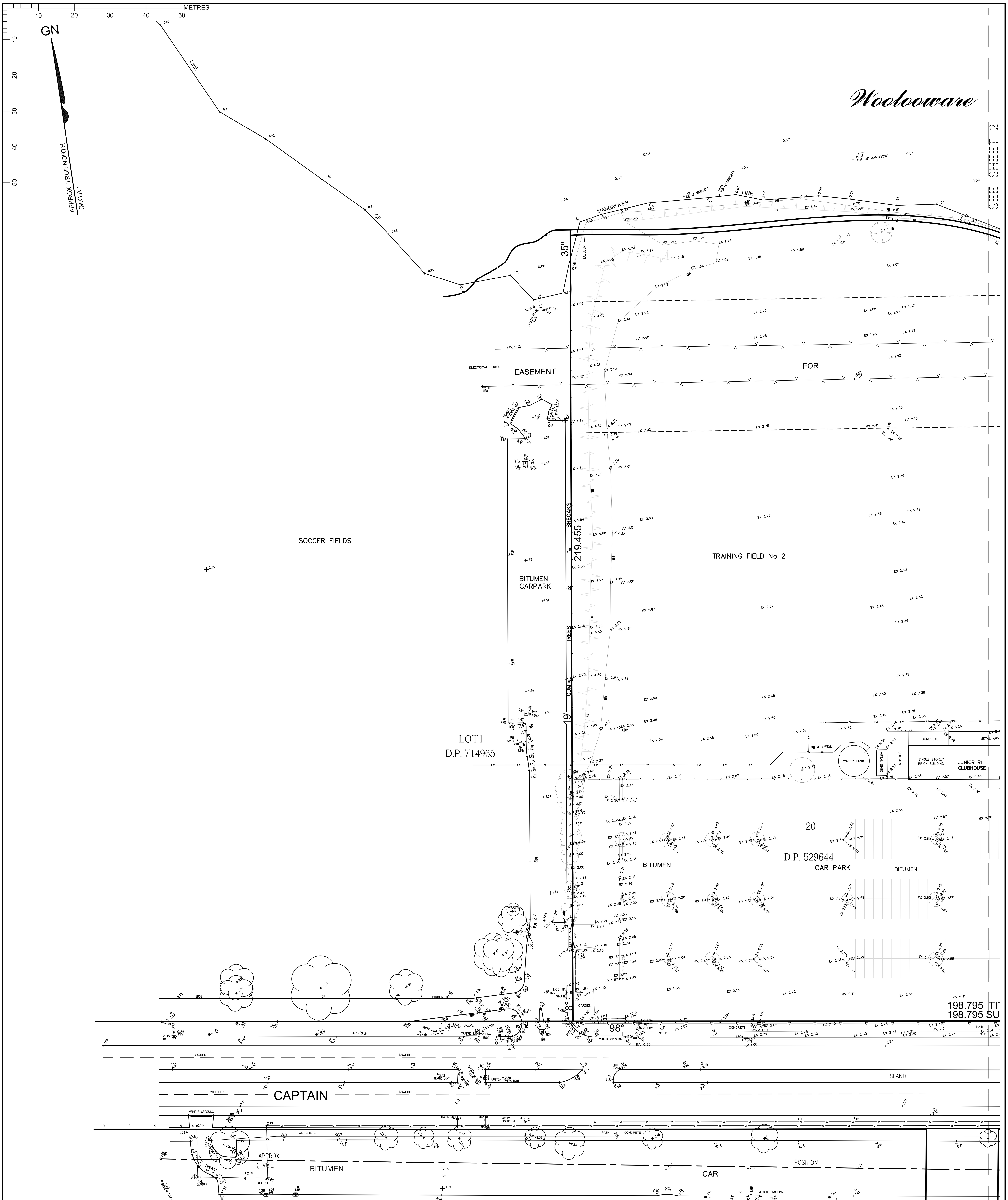
	connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem so as to enable individuals to understand how to manage themselves an their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e. land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.
floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist

	at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the ■flood liable land• concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL•s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the ■standard flood event• in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to as a result of its location on the floodplain. **future flood risk:** the risk a community may be exposed to as a result of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those 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. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas.
floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.
freeboard	Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
habitable room	**in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom. **in an industrial or commercial situation:** an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
hazard	A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.

hydraulics	Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.
hydrograph	A graph which shows how the discharge or stage/flood level at any particular location varies with time during a flood.
hydrology	Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.
local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
local drainage	Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.
mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
major drainage	Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves: • the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or • water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or • major overland flow paths through developed areas outside of defined drainage reserves; and/or • the potential to affect a number of buildings along the major flow path.
mathematical/computer models	The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.
merit approach	The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well being of the State•s rivers and floodplains. The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.
minor, moderate and major flooding	Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood: **minor flooding:** causes inconvenience such as closing of minor roads and the submergence of low level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded. **moderate flooding:** low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered. **major flooding:** appreciable urban areas are flooded and/or extensive rural areas

	are flooded. Properties, villages and towns can be isolated.
modification measures	Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.
peak discharge	The maximum discharge occurring during a flood event.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.
Probable Maximum Precipitation (PMP)	The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.
probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to ▪water level•. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.

Appendix B



WARNING! The location of walls and detail points in relation to boundaries is approximate only!

NOTES

1. COPYRIGHT This drawing and/or design is the property of Harrison Friedmann & Associates Pty Ltd and should not be reproduced in part or whole without the written permission of the company.
2. Bearings, distances and areas of boundaries are from the Land and Property Management Authority records only. They are on Map Grid of Australia . If accurate True North is required a further survey would be necessary.
3. Relationship of improvements to boundaries is diagrammatic only. Boundary fences and retaining walls have not been accurately located and may not be shown on this plan.DO NOT SCALE OFF THIS PLAN. Where offsets from improvements, fences or walls to boundaries are critical for future building design and construction they MUST be confirmed by a further boundary survey. This survey has not investigated any subterranean structures.
4. The services information shown on this plan have been determined from visual inspection only and information provided by the relevant authorities through "Dial before you dig" . It is passed on with the understanding that no excavation or works will be commenced without a current services search of all services being obtained from "Dial before you dig" (DBYD) (phone 1100 or fax 1300 652 077) or from any individual service provider. Note that not all services providers are members of DBYD.
5. The location of Sydney Water's Sewer Main has been plotted approximately, based on visible maintenance holes and information from Sydney Water. This information can not be relied on. Any construction near Sydney Water Mains requires further investigation, a Service Protection Report (sewer pegout) and approval from Sydney Water.
6. The locations of spot levels are diagrammatic only. They are accurate to ± 0.3m in relation to boundaries. Levels critical to design, excavation or construction must be verified. If contours are shown they depict the topography rather than represent the exact level at any particular point. Care should be taken if extrapolating levels or contours.
7. The spread of the crown of the trees shown on this plan is diagrammatic only, based on the average spread observed in the field. Prior to any development proposal which might be affected by trees it is recommended that the tree spreads be verified by field inspection.
8. Australian Height Datum was established from PM. 31619 R.L. 1.279 located at the intersection of Captain Cook Drive & Woolooware Road Woolooware . Datum source obtained from S.C.I.M.S. 22/06/2011.
9. The plan has been compiled from field survey information and Plans prepared by Rygate & Company Pty Ltd and Johnathan C. Keen & Co. Pty Ltd

ALL ABOVE NOTES ARE AN INTEGRAL PART OF THIS PLAN

- UNDERGROUND ELECTRICAL
- OVERHEAD ELECTRICAL
- EXISTING GAS
- RECYCLED WATER
- EXISTING TELECOMMUNICATIONS
- EXISTING WATER
- FENCE

Legend

BB	Bottom of Bank
BFL	Balcony Floor Level
BRW	Bottom Retaining Wall
CONC	Concrete
EC	Edge of Concrete
FL	Floor Level
G	Grate
INV	Invert Level
LW	Lower Window
PC	Pedestrian Crossing
RL	Relative Level
TB	Top of Bank
TG	Top of Gutter
TK	Top of Kerb
TRW	Top Retaining Wall
TW	Top Wall
USG	Underside of Gutter
UW	Upper Window
VC	Vehicle Crossing
W	Window
WC	Toilet
LEW	Lowest Electrical Wire
TETW	Top Of Electrical Tower/Pole
TOC	Table on Concrete
TTTW	Top Of Telecommunication Tower
H	Hydrant
LH	Lamp Hole
LP	Light Pole
MH	Maintenance Hole
PP	Power Pole
SP	Sign Pole
SV	Stop Valve
T	Telstra

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BUILDING, ENVIRONMENTAL & BUSHFIRE CONSULTANTS
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EMAIL: mail@hfasurveyors.com.au

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COVER OF EXCELLENCE

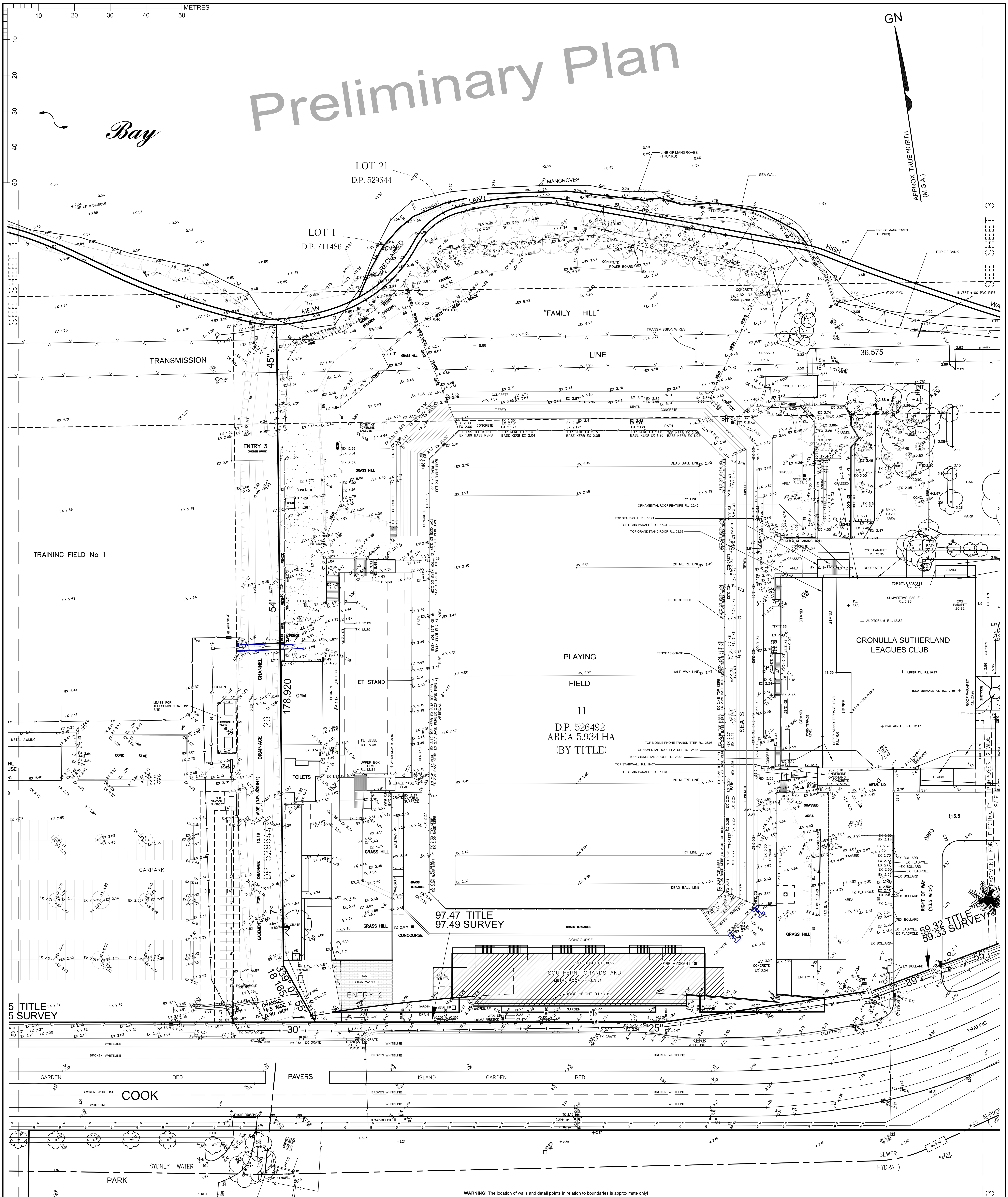
JAS-ANZ

PLAN SHOWING SITE DETAILS AND LEVELS FOR BUILDING DESIGN PURPOSES AT CAPTAIN COOK DRIVE WOOLOOWARE LOT 20 IN D.P. 529644 LOT 11 IN D.P. 526492

FOR BLUESTONE CAPITAL VENTURES No.1

REDUCTION RATIO	SURVEYED / DRAWN
1:500 @ A1	ML/CK
DATUM	CHECKED
A.H.D.	
DATE	REFERENCE
2/6/2011	40966DT SHEET 1 OF 3

CAD FILE NAME: 40966DT DET.DWG PLOTTED: 08/07/11 - 4:38PM



WARNING! The location of walls and detail points in relation to boundaries is approximate only!

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3. Relationship of improvements to boundaries is diagrammatic only. Boundary fences and retaining walls have not been accurately located and may not be shown on this plan.DO NOT SCALE OFF THIS PLAN. Where offsets from improvements, fences or walls to boundaries are critical for future building design and construction they MUST be confirmed by a further boundary survey. This survey has not investigated any subterranean structures.
4. The services information shown on this plan have been determined from visual inspection only and information provided by the relevant authorities through "Dial before you dig" . It is passed on with the understanding that no excavation or works will be commenced without a current services search of all services being obtained from "Dial before you dig" (DBYD) (phone 1100 or fax 1300 652 077) or from any individual service provider. Note that not all services providers are members of DBYD.
5. The location of Sydney Water's Sewer Main has been plotted approximately, based on visible maintenance holes and information from Sydney Water. This information can not be relied on. Any construction near Sydney Water Mains requires further investigation, a Service Protection Report (sewer pegout) and approval from Sydney Water.
6. The locations of spot levels are diagrammatic only. They are accurate to ± 0.3m in relation to boundaries. Levels critical to design, excavation or construction must be verified. If contours are shown they depict the topography rather than represent the exact level at any particular point. Care should be taken if extrapolating levels or contours.
7. The spread of the crown of the trees shown on this plan is diagrammatic only, based on the average spread observed in the field. Prior to any development proposal which might be affected by trees it is recommended that the tree spreads be verified by field inspection.
8. Australian Height Datum was established from PM. 31619 R.L. 1.279 located at the intersection of Captain Cook Drive & Woolooware Road Woolooware . Datum source obtained from S.C.I.M.S. 22/06/2011.
9. The plan has been compiled from field survey information and Plans prepared by Rygate & Company Pty Ltd and Johnathan C. Keen & Co. Pty Ltd

ALL ABOVE NOTES ARE AN INTEGRAL PART OF THIS PLAN

Legend

BB	Bottom of Bank	USG	Underside of Gutter
BFL	Balcony Floor Level	UW	Upper Window
BRW	Bottom Retaining Wall	VC	Vehicle Crossing
CONC	Concrete	W	Window
EC	Edge of Concrete	WC	Toilet
FL	Floor Level	LEW	Lowest Electrical Wire
G	Grate	TETW	Top Of Electrical Tower/Pole
INV	Invert Level	TOC	Table on Concrete
LW	Lower Window	TTTW	Top Of Telecommunication Tower
PC	Pedestrian Crossing		Hydrant
RL	Relative Level	LH	Lamp Hole
TB	Top of Bank	LP	Light Pole
TG	Top of Gutter	MH	Maintenance Hole
TK	Top of Kerb	PP	Power Pole
TRW	Top Retaining Wall	SP	Sign Pole
TW	Top Wall	SV	Stop Valve
		T	Telstra

UNDERGROUND ELECTRICAL
OVERHEAD ELECTRICAL
EXISTING GAS
RECYCLED WATER
EXISTING TELECOMMUNICATIONS
EXISTING WATER
FENCE

[A] EASEMENT FOR ELECTRICITY AND OTHER PURPOSES 2 WIDE AND 3.3WIDE

[B] RIGHT OF CARRIAGEWAY 4 WIDE AND VARIABLE WIDTH

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SHEET 2 OF 3

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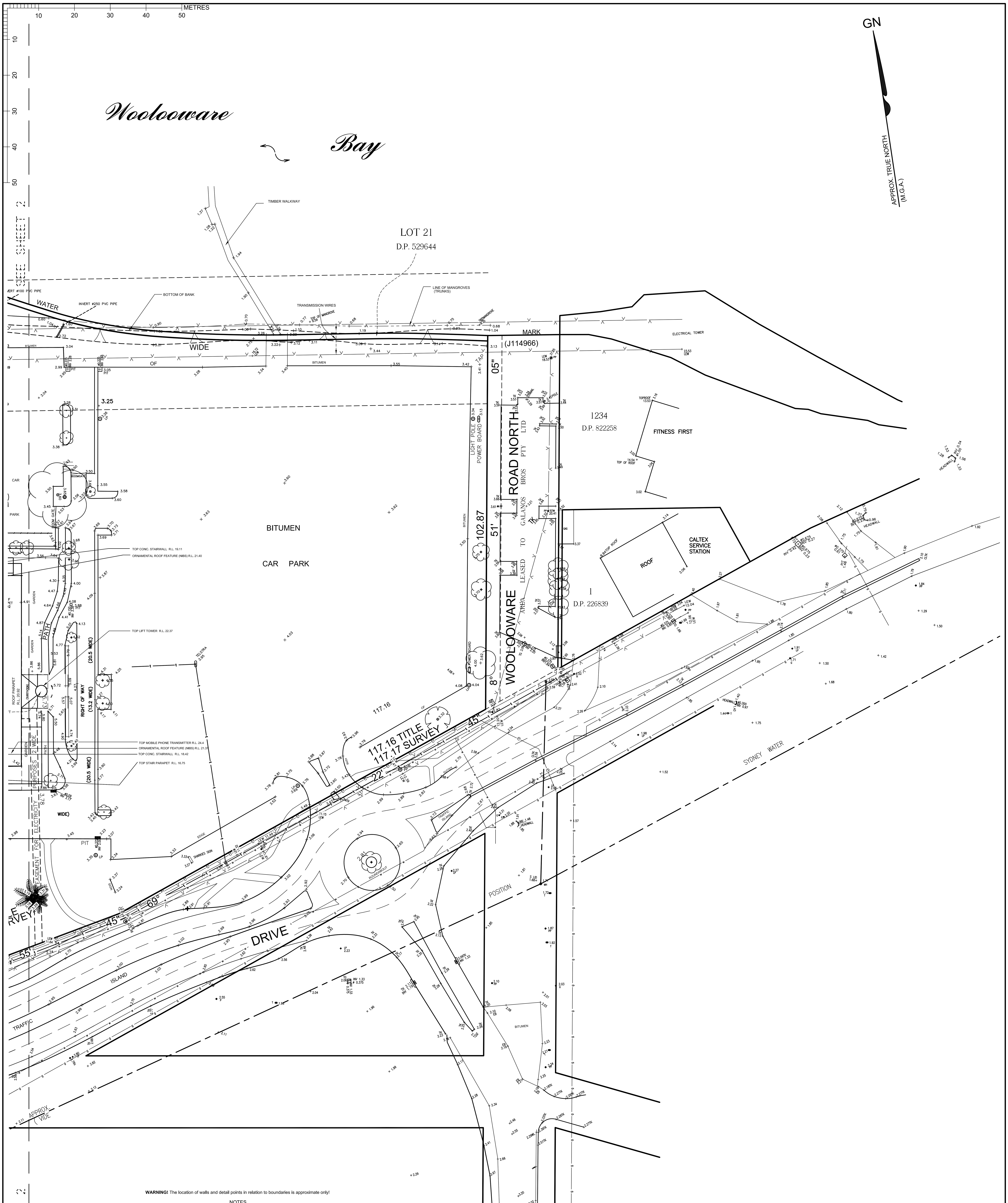

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EXISTING GAS
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DATE	REFERENCE
2/6/2011	40966DT SHEET 3 OF 3

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Appendix G

List of Civil DA Drawings

Document Details

Document Number	Rev	Document Title
C001	A	COVER SHEET AND LOCALITY PLAN
C002	A	NOTES AND LEGENDS
C005	A	GENERAL ARRANGEMENT PLAN
C006	A	TYPICAL ROAD SECTIONS SHEET 1 OF 3
C007	A	TYPICAL ROAD SECTIONS SHEET 2 OF 3
C008	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 1 OF 7
C010	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 1 OF 7
C011	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 2 OF 7
C012	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 3 OF 7
C013	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 4 OF 7
C014	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 5 OF 7
C015	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 6 OF 7
C016	A	ROADWORKS AND STORMWATER DRAINAGE PLAN SHEET 7 OF 7
C080	A	PAVEMENT, SIGNAGE AND LINEMARKING PLAN SHEET 1 OF 3
C081	A	PAVEMENT, SIGNAGE AND LINEMARKING PLAN SHEET 2 OF 3
C082	A	PAVEMENT, SIGNAGE AND LINEMARKING PLAN SHEET 3 OF 3
C090	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 1 OF 7
C091	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 2 OF 7
C092	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 3 OF 7
C093	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 4 OF 7
C094	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 5 OF 7
C095	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 6 OF 7
C096	A	SERVICES AND UTILITIES COORDINATION PLAN SHEET 7 OF 7
C100	A	EROSION AND SEDIMENTATION CONTROL PLAN SHEET 1 OF 3
C101	A	EROSION AND SEDIMENTATION CONTROL PLAN SHEET 2 OF 3
C102	A	EROSION AND SEDIMENTATION CONTROL PLAN SHEET 3 OF 3
C105	A	EROSION AND SEDIMENTATION CONTROL DETAILS
C130	A	INTERSECTION VEHICLE TURN PATH PLAN SHEET 1 OF 2
C131	A	INTERSECTION VEHICLE TURN PATH PLAN SHEET 2 OF 2

Appendix H

Water Management Report

INSYNC SERVICES
PTY LTD

Water Management Report

Woolooware Bay Town Centre

Client:

Bluestone Capital Ventures No. 1 Pty Ltd

Construction Manager:

Parkview Constructions Pty Ltd
Suite 3, 2 Wentworth Park Road
Glebe NSW 2037
(T) 02 9506 1500
(F) 02 9506 1599

Hydraulic & Fire Consultant:

Insync Services Pty Ltd
P.O. Box 6437
Alexandria NSW 2015
(T) 02 9669 4311
(F) 02 9669 4322

Date: 28 February 2013

File: Water Management Report

Review and Approval Record:

Rev	Date	Description of Release	Prepared By	Reviewed By	Approved By
A	11/01/13	Draft Issue	BL	RW	BL
B	28/02/13	Final Issue	BL	RW	BL

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 Background

The aim of this report is to provide an outline of the water management design initiatives that may be considered for this project with regard to hydraulic and wet fire services, and to identify the preferred option together with a recommendation for its inclusion in the project scope of works.

1.2 Water Consumption

Potable water consumption has been estimated throughout the entire development for the base building case to be used as a benchmark against which to compare the efficiency of various potable water consumption reduction strategies that have been proposed.

BASE BUILDING

Water consumption estimates for the base building benchmark have been prepared with regard to the following base data;

- Water Closets – 3 Star WELS rated, having an average flush volume of 4 litres
- Urinals – 3 Star WELS rated, having an average flush volume of 2 litres
- Tapware – 3 Star WELS rated, having a flow rate of 9 litres/minute
- Showers – 3 Star WELS rated, having a flow rate of 9 litres/minute

Category	Water Consumption (kL/week)	Consumption Reduction (kL/week)	Alternative Water Supply (kL/week)	Total Water Saving (%)
Retail Amenities	184.448	0.000	0.000	0%
Retail Tenancies	186.812	0.000	0.000	0%
Gymansium	72.945	0.000	0.000	0%
Medical	33.234	0.000	0.000	0%
Club	126.603	0.000	0.000	0%
Heat Rejection	207.640	0.000	0.000	0%
Irrigation	1.208	0.000	0.000	0%
Totals	**812.890**	**0.000**	**0.000**	**0%**

OPTION 1 – WATER EFFICIENT FIXTURES & TAPWARE

Water consumption estimates for Option 1 have been prepared with regard to the following base data;

- Water Closets – 4 Star WELS rated, having an average flush volume of 3.5 litres
- Urinals – 6 Star WELS rated, having an average flush volume of 1 litres
- Tapware – 6 Star WELS rated, having a flow rate of 4.5 litres/minute
- Showers – 3 Star WELS rated, having a flow rate of 9 litres/minute

Category	Water Consumption (kL/week)	Consumption Reduction (kL/week)	Alternative Water Supply (kL/week)	Total Water Saving (%)
Retail Amenities	127.565	56.883	0.000	31%
Retail Tenancies	186.812	0.000	0.000	0%
Gymansium	64.432	8.514	0.000	12%
Medical	25.082	8.152	0.000	25%
Club	96.382	30.221	0.000	24%
Heat Rejection	207.640	0.000	0.000	0%
Irrigation	1.208	0.000	0.000	0%
Totals	**709.121**	**103.769**	**0.000**	**13%**

OPTION 2 – WATER EFFICIENT FIXTURES & TAPWARE + NON-POTABLE WATER FOR FLUSHING

Water consumption estimates for Option 2 have been prepared with regard to the following base data;

- Water Closets – 4 Star WELS rated, having an average flush volume of 3.5 litres
- Urinals – 6 Star WELS rated, having an average flush volume of 1 litres
- Tapware – 6 Star WELS rated, having a flow rate of 4.5 litres/minute
- Showers – 3 Star WELS rated, having a flow rate of 9 litres/minute
- Non-potable water supply used for 100% of all toilet and urinal flushing

Category	Water Consumption (kL/week)	Consumption Reduction (kL/week)	Alternative Water Supply (kL/week)	Total Water Saving (%)
Retail Amenities	57.556	56.883	70.009	69%
Retail Tenancies	186.812	0.000	0.000	0%
Gymansium	53.953	8.514	10.478	26%
Medical	15.049	8.152	10.033	55%
Club	59.187	30.221	37.195	53%
Heat Rejection	207.640	0.000	0.000	0%
Irrigation	1.208	0.000	0.000	0%
Totals	**581.405**	**103.769**	**127.716**	**28%**

OPTION 3 – WATER EFFICIENT FIXTURES & TAPWARE + NON-POTABLE WATER FOR FLUSHING, HEAT REJECTION & IRRIGATION

Water consumption estimates for Option 3 have been prepared with regard to the following base data;

- Water Closets – 4 Star WELS rated, having an average flush volume of 3.5 litres
- Urinals – 6 Star WELS rated, having an average flush volume of 1 litres
- Tapware – 6 Star WELS rated, having a flow rate of 4.5 litres/minute
- Showers – 3 Star WELS rated, having a flow rate of 9 litres/minute
- Non-potable water supply used for 100% of all toilet and urinal flushing
- Non-potable water supply used for 90% of all cooling tower requirements
- Non-potable water supply used for 100% of all irrigation requirements

Category	Water Consumption (kL/week)	Consumption Reduction (kL/week)	Alternative Water Supply (kL/week)	Total Water Saving (%)
Retail Amenities	57.556	56.883	70.009	69%
Retail Tenancies	186.812	0.000	0.000	0%
Gymnasium	53.953	8.514	10.478	26%
Medical	15.049	8.152	10.033	55%
Club	59.187	30.221	37.195	53%
Heat Rejection	20.764	0.000	0.000	90%
Irrigation	0.000	0.000	0.000	100%
Totals	**393.321**	**103.769**	**315.800**	**52%**

1.3 Description

Option 1 achieves a potable cold water consumption reduction of 13% when compared to the base case benchmark. The improvement in water efficiency is achieved via the installation or more water efficient fixtures and tapware. For a new installation which does not require any equipment to be replaced or retrofitted, the cost of more water efficient fixtures and tapware is equivalent to less efficient fixtures and tapware, and therefore Option 1 to achieve a 13% reduction in potable cold water consumption throughout the development has been assessed as a no cost option.

Option 2 achieves a potable cold water consumption reduction of 28% when compared to the base case benchmark. The improvement in water efficiency is achieved via the installation of more water efficient fixtures and tapware, as well as the substitution of a non-potable water supply for flushing purposes. The non-potable water supply can be provided in either of two ways;

1. Rainwater Harvesting – requiring a rainwater storage tank, a booster pump and filtration system, and a non-potable water reticulation system throughout the development. The cost of a rainwater harvesting system has been estimated at $255,000.

(Infrastructure $170,000 + Reticulation $85,000). A rainwater harvesting system has no ongoing cost for the provision of non-potable water apart from general system maintenance.

2. Recycled Water – requiring a mains supply, booster pump, and a non-potable water reticulation system throughout the development. The cost of a recycled water system has been estimated at $110,000. (Infrastructure $25,000 + Reticulation $85,000). A recycled water system will have ongoing water supply charges in addition to general system maintenance. The cost of water supply requires further investigation with the supplier.

Option 3 achieves a potable cold water consumption reduction of 52% when compared to the base case benchmark. The improvement in water efficiency is achieved via the installation of more water efficient fixtures and tapware, as well as the substitution of a non-potable water supply for flushing purposes, heat rejection and irrigation requirements. The non-potable water supply would need to be provided from two supplies as follows;

1. Rainwater Harvesting (Heat Rejection & Irrigation) – requiring a rainwater storage tank, a booster pump and filtration system, and a non-potable water reticulation system to the cooling towers. The cost of a rainwater harvesting system has been assessed at $180,000. (Infrastructure $170,000 + Reticulation $10,000). A rainwater harvesting system has no ongoing cost for the provision of non-potable water apart from general system maintenance.

2. Recycled Water (Flushing) – requiring a mains supply, booster pump, and a non-potable water reticulation system throughout the development. The cost of a recycled water system has been assessed at $110,000. (Infrastructure $25,000 + Reticulation $85,000). A recycled water system will have ongoing water supply charges in addition to general system maintenance. The cost of water supply requires further investigation with the supplier.

1.4 Summary

Option	Description	Potable Cold Water Reduction	Cost
Base Case	Base building used for benchmark potable cold water consumption	0%	$0
Option 1	Inclusion of water efficient fixtures and tapware	13%	$0
Option 2a	Inclusion of water efficient fixtures and tapware, non-potable water supply (rainwater harvesting) to 100% of all flushing requirements.	28%	$255,000
Option 2b	Inclusion of water efficient fixtures and tapware, non-potable water supply (recycled water) to 100% of all flushing requirements.	28%	$110,000
Option 3	Inclusion of water efficient fixtures and tapware, non-potable water supply (recycled water) to 100% of all flushing requirements. Non-potable water supply (rainwater harvesting) to 90% of heat rejection and 100% of irrigation requirements.	52%	$290,000

NOTE: recycled water supply rates are yet to be clarified and included for Option 2b and Option 3.

2 INTRODUCTION

2.1 Background

Bluestone Capital Ventures No.1 Pty Ltd (the Client), have commissioned Insync Services Pty Ltd (the Hydraulic & Wet Fire Consultant) to prepare a Water Management Report for the proposed Woolooware Bay Town Centre development.

2.2 Aims

The aim of this report is to provide an outline of the water management design initiatives that may be considered for this project with regard to hydraulic and wet fire services, and to identify the preferred option together with a recommendation for its inclusion in the project scope of works.

2.3 ESD Targets

Environmentally Sustainable Development targets for this development have been outlined previously in the Executive Summary to Cronulla Sharks Redevelopment ESD DA Report prepared by Cundall. (Appendix R of the Environmental Assessment Report)

Specifically this Water Management Report seeks to outline the proposed methodology for the water consumption reduction strategies that will be included within the development to meet the following ESD target,

Benchmark	Minimum Requirement	Project Target
Residential	40% reduction in potable cold water consumption compared to the NSW average	40% reduction in potable cold water consumption compared to the NSW average
Leisure / Retail	Not Applicable	Minimise potable cold water consumption in fittings/fixtures, cooling towers and irrigation.

2.4 Briefing Documents

The engineering elements considered in this report have based or taken into consideration the following documents:

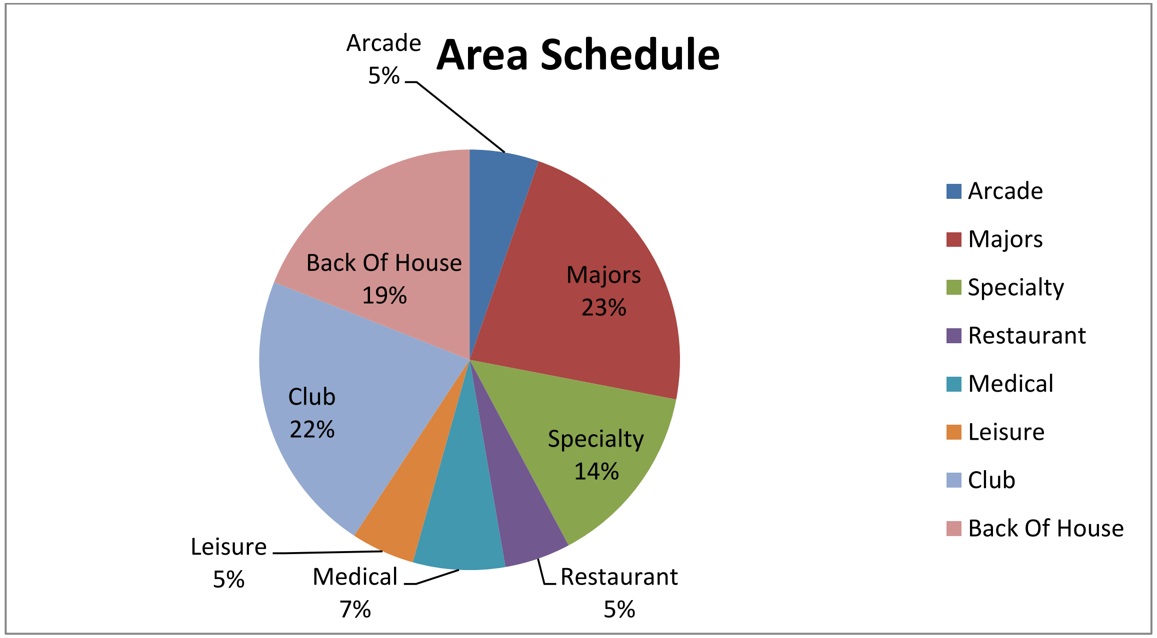
- Development Application architectural drawings prepared by Scott Carver Architects Pty Ltd.

3 BASE DESIGN DATA

3.1 Location & Development Description

The proposed Woolooware Bay Town Centre development is located on Captain Cook Drive.

Woolooware Bay Town Centre development has a total net lettable floor area of 30,511m^2, generally distributed in accordance with the following allocations;



Category	Area
Arcade	1624
Majors	6925
Specialty	4327
Restaurants	1549
Gymnasium	2159
Medical	1493
Club	6642
Back Of House	5792
TOTALS	**30511**

3.2 Population Data

Population data for the Woolooware Bay Town Centre development has been calculated from the following assumptions;

Population	Retail	Gymnasium	Medical	Club
Staff	1/50m2	1/50m2	1/10m2	1/30m2
Visitors	1/3m2	1/3m2	1/10m2	1/3m2

3.3 Fixture Usage Data

Fixture usage data for the Woolooware Bay Town Centre development has been calculated from the following assumptions;

Population	Water Closet	Urinal	Tapware (20 seconds per use)	Showers (5 minutes per use)
Male Staff	1 per day	2 per day	3 per day	0.2 per day
Female Staff	3 per day	0 per day	3 per day	0.2 per day
Male Visitors	0.2 per day	0.4 per day	0.6 per day	0 per day
Female Visitors	0.6 per day	0 per day	0.6 per day	0 per day

3.4 Fixture Water Consumption

Fixture water consumption for the Woolooware Bay Town Centre development has been calculated from the following assumptions;

Fixture	3 Star	4 Star	5 Star	6 Star
Water Closet (L/flush)	4	3.5	3	2.5
Urinal (L/flush)	2	1.5	1	1
Tapware (L/min)	9	7.5	6	4.5
Showers (L/min)	9	7.5	6	6

3.5 Process Water Consumption

Process water consumption for the Woolooware Bay Town Centre development has been calculated from the following assumptions;

Process	Flow Rate
Retail Tenancy	0.11L/m2/day
Food Retail Tenancy	5.23L/m2/day
Supermarket	0.21L/m2/day

4 Water Supply Options

4.1 Water Quality

For the Base Case model, all of the water consumed within the development is potable water drawn from the local Authority potable water supply infrastructure. However not all of the processes generating water consumption throughout the development require a water supply of potable quality (suitable for drinking).

A summary of the water quality requirements for the various building uses detailed within this report is provided below;

Building Use	Water Quality
Toilet Flushing	Non-Potable
Urinal Flushing	Non-Potable
Tapware	Potable
Showers	Potable
Irrigation	Non-Potable
Fire Services	Non-Potable

The range of potential water supply options considered within this report are listed below;

- Potable Authority Mains Water (potable)
- Non-Potable Authority Mains Water (non-potable)
- Stormwater Harvesting (non-potable)

4.2 Potable Authority Mains Water

Potable mains water is traditionally used to supply all of the water requirements within a building. It is of a quality suitable for drinking, and therefore exceeds the quality requirements of many water consuming processes within a building.

Regardless of various water saving initiatives that may be employed within a development, a potable mains water connection will always be required to supply the potable water requirements of the building and to provide a back-up water supply to any non-potable water supplies sources.

4.3 Non-Potable Authority Mains Water

Non-potable mains water is available in some locations and can be used to supply all of the non-potable water requirements within a building. It is of a quality unsuitable for drinking, and therefore requires careful planning regarding its application and integration into developments in order to avoid cross connections and potential contamination of any potable water supplies.

Non-potable mains water can be considered for the Woolooware Bay Town Centre development, as Sutherland Shire Council operates a recycled water plant to service the adjacent Woolooware golf course. The quality, quantity and cost of this water supply are yet to be established and therefore require further consideration with regard to possible inclusion within this development.

4.4 Stormwater Harvesting

Stormwater harvesting refers to the collection of stormwater from the developments internal stormwater drainage system. Stormwater from the stormwater drainage system can be classified as either rainwater where the flow is from roof areas only, or stormwater where the flow is from all areas of the development.

For the purposes of this development, we refer to a rainwater harvesting system, where the following benefits can be achieved over a stormwater harvesting system;

- Rainwater collected from roof areas is generally less polluted than general stormwater drainage.

In general terms the rainwater harvesting system will be an in-line tank for the collection and storage of rainwater. At times when the rainwater storage tank is full rainwater can pass through the tank and continue to be discharged via gravity into the stormwater drainage system. Rainwater from the storage tank will be pumped for distribution throughout the development in a dedicated non-potable water reticulation system.

The collected rainwater is not classified in terms of water quality, but the use of rainwater for cooling tower make up water supply, toilet flushing and spray irrigation systems is recommended as safe practice by all Australian Health Departments. Rainwater falling on roofs is soft, clear and generally low in microbial and chemical contamination.

The use of simple and cost effective rainwater collection and treatment systems ensures reliable operation and water quality for non-potable use. The objective of rainwater treatment is to maintain a high quality of water in the rainwater storage tank. A typical rainwater treatment process would include the following;

1. Primary treatment before water enters the storage tank via a first flush system.
2. Media filtration before to water enters the non-potable cold water reticulation system.
3. UV treatment before water enters the non-potable cold water reticulation system.

The use of rainwater harvesting reduces potable water demand within the development, and the amount of stormwater runoff generated by the development. By collecting the rainwater run-off from roof areas, rainwater tanks provide a valuable water source suitable for flushing toilets and landscape irrigation.

Rainwater harvesting systems can be considered to have the following advantages;

- Collected rainwater is of high quality allowing for uses including toilet flushing, cooling tower make up and un-controlled irrigation.

- Rainwater harvesting can provide a large reduction in potable water consumption.
- Rainwater harvesting is well suited to buildings where the available roof footprint is large for collection of the rainwater.
- Rainwater harvesting systems have a relatively low capital cost.
- Rainwater harvesting systems do not require specialized maintenance.

Rainwater harvesting systems can be considered to have the following dis-advantages;

- Rainwater harvesting systems rely upon favorable climatic conditions.
- Rainwater harvesting systems are relatively inflexible as they rely on gravity discharge from the roof collection point to the storage tank.
- Rainwater harvesting systems are relatively inefficient in terms of their spatial requirements due to the need to store larger volumes of rainwater allowing for periods of little or no rainfall.
- Rainwater harvesting systems require a potable cold water supply make up facility for periods when the storage has been exhausted.

4.4.1 Rainfall Data

Rainfall data for the Woolooware Bay Town Centre development has been sourced from the Bureau of Meteorology, specifically from the Sydney Airport weather station (066037). A summary of the rainfall data is as follows;

January Mean Rainfall	94.0mm
February Mean Rainfall	112.9mm
March Mean Rainfall	116.3mm
April Mean Rainfall	106.3mm
May Mean Rainfall	100.1mm
June Mean Rainfall	120.7mm
July Mean Rainfall	71.0mm
August Mean Rainfall	75.5mm
September Mean Rainfall	60.3mm
October Mean Rainfall	70.7mm
November Mean Rainfall	81.2mm
December Mean Rainfall	74.3mm
Mean Annual Rainfall	1082.8mm
Mean Rain Days > 1mm	96.1

4.4.2 Catchment Data

Catchment data for the Woolooware Bay Town Centre development has been sourced from the architectural drawings prepared by Scott Carver Architects Pty Ltd. A summary of the catchment data is as follows;

Total Catchment Area	18,348m^2
Harvested Catchment	10,091m^2
Harvesting Ratio	55%
Run-off Coefficient	0.95

The total available rainfall harvesting supply with these parameters has been estimated at 199.719kL per week.

5 Base Case - Water Consumption Evaluation

5.1 Retail Amenity Water Requirements

Base case retail amenity water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 3 Star WELS rated water closets, having an average volume per flush of 4 litres.
- 3 Star WELS rated urinals, having an average volume per flush of 2 litres.
- 3 Star WELS rated tapware, having a flow rate of 9.0 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated base case retail amenity water consumption for the parameters listed above is as follows;

Base Building Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	14425	14425	14425	14425	**14425**
Male - Staff	144	144	144	144	**144**
Female - Staff	144	144	144	144	**144**
Male - Visitor	2404	2404	2404	2404	**2404**
Female - Staff	2404	2404	2404	2404	**2404**
Fixture Efficiency	3 Star	3 Star	3 Star	3 Star	
Consumption Per Use	4	2	3	45	
Male - Staff	577	577	1298	1298	**3751**
Female - Staff	1731	0	1298	1298	**4328**
Male - Visitor	1923	1923	4328	0	**8174**
Female - Visitor	5770	0	4328	0	**10098**
Total Consumption (L/day)	**10001**	**2500**	**11252**	**2597**	**26350**
Efficiency (L/m2/day)	**0.69**	**0.17**	**0.78**	**0.18**	**1.83**
Days Of operation Per Week	7	7	7	7	**7**
Total Consumption (kL/week)	**70.009**	**17.502**	**78.761**	**18.176**	**184.448**

The total base case retail amenity water consumption with these parameters has been estimated at 184.448kL per week throughout the development.

5.2 Retail Tenancy Water Requirements

Retail tenant water consumption for the Woolooware Bay Town Centre development, has been modelled based upon actual metered consumption data from similar retail centres. Specifically the base model has been developed upon following information;

- 7 days of building operation per week.
- Non-food tenants having an average water consumption rate of 0.11kL/m^2 per annum.
- Food tenants having an average water consumption rate of 5.23kL/m^2 per annum.
- Supermarkets having an average water consumption rate of 0.21kL/m^2 per annum.
- Majors and Mini Majors having an average water consumption rate of 0.11kL/m^2 per annum.

A summary of the estimated retail tenancy water consumption for the parameters listed above is as follows;

Base Building Assessment	Specialty	Restaurants	Supermarkets	Majors	Totals
Area	4327	1549	4019	2906	12801
Consumption Rate	0.11	5.23	0.21	0.11	
Total Consumption (L/day)	**1304**	**22195**	**2312**	**876**	**26687**
Efficiency (L/m2/day)	**0.30**	**14.33**	**0.58**	**0.30**	**2.08**
Days Of operation Per Week	7	7	7	7	7
Total Consumption (kL/week)	**9.128**	**155.367**	**16.186**	**6.130**	**186.812**

The total retail tenant water consumption with these parameters has been estimated at 186.812kL per week throughout the development.

5.3 Gymnasium Tenancy Water Requirements

Base case gymnasium tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 3 Star WELS rated water closets, having an average volume per flush of 4 litres.
- 3 Star WELS rated urinals, having an average volume per flush of 2 litres.
- 3 Star WELS rated tapware, having a flow rate of 9.0 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated base case gymnasium water consumption for the parameters listed above is as follows;

Base Building Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	2159	2159	2159	2159	2159
Male - Staff	22	22	22	22	22
Female - Staff	22	22	22	22	22

Male - Visitor	360	360	360	360	360
Female - Staff	360	360	360	360	360
Fixture Efficiency	3 Star	3 Star	3 Star	3 Star	
Consumption Per Use	4	2	3	45	
Male - Staff	86	86	194	194	561
Female - Staff	259	0	194	194	648
Male - Visitor	288	288	648	3239	4462
Female - Visitor	864	0	648	3239	4750
Total Consumption (L/day)	**1497**	**374**	**1684**	**6866**	**10421**
Efficiency (L/m2/day)	**0.69**	**0.17**	**0.78**	**3.18**	**4.83**
Days Of operation Per Week	7	7	7	7	7
Total Consumption (kL/week)	**10.478**	**2.620**	**11.788**	**48.059**	**72.945**

The total base case gymnasium water consumption with these parameters has been estimated at 72.945kL per week throughout the development.

5.4 Medical Tenancy Water Requirements

Base case medical tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 3 Star WELS rated water closets, having an average volume per flush of 4 litres.
- 3 Star WELS rated urinals, having an average volume per flush of 2 litres.
- 3 Star WELS rated tapware, having a flow rate of 9.0 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated medical water consumption for the parameters listed above is as follows;

Base Building Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	1493	1493	1493	1493	1493
Male - Staff	75	75	75	75	75
Female - Staff	75	75	75	75	75
Male - Visitor	75	75	75	75	75
Female - Staff	75	75	75	75	75
Fixture Efficiency	3 Star	3 Star	3 Star	3 Star	
Consumption Per Use	4	2	3	45	
Male - Staff	299	299	672	672	1941
Female - Staff	896	0	672	672	2240

Male - Visitor	60	60	134	0	254
Female - Visitor	179	0	134	0	314
Total Consumption (L/day)	**1433**	**358**	**1612**	**1344**	**4748**
Efficiency (L/m2/day)	**0.96**	**0.24**	**1.08**	**0.90**	**3.18**
Days Of operation Per Week	7	7	7	7	7
Total Consumption (kL/week)	**10.033**	**2.508**	**11.287**	**9.406**	**33.234**

The total base case medical water consumption with these parameters has been estimated at 33.234kL per week throughout the development.

5.5 Club Tenancy Water Requirements

Base case club tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 3 Star WELS rated water closets, having an average volume per flush of 4 litres.
- 3 Star WELS rated urinals, having an average volume per flush of 2 litres.
- 3 Star WELS rated tapware, having a flow rate of 9.0 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated club water consumption for the parameters listed above is as follows;

Base Building Assessment	Water Closet	Urinal	Tapware	Showers	Restaurants	Totals
Area	6642	6642	6642	6642	664.2	6642
Male - Staff	111	111	111	111		111
Female - Staff	111	111	111	111		111
Male - Visitor	1107	1107	1107	1107		1107
Female - Staff	1107	1107	1107	1107		1107
Fixture Efficiency	3 Star	3 Star	3 Star	3 Star		
Consumption Per Use	4	2	3	45	5.23	
Male - Staff	443	443	996	996		2878
Female - Staff	1328	0	996	996		3321
Male - Visitor	886	886	1993	0		3764
Female - Visitor	2657	0	1993	0		4649
Total Consumption (L/day)	**5314**	**1328**	**5978**	**1993**	**3474**	**18086**
Efficiency (L/m2/day)	**0.80**	**0.20**	**0.90**	**0.30**	**5.23**	**2.72**
Days Of operation Per Week	7	7	7	7	7	
Total Consumption (kL/week)	**37.195**	**9.299**	**41.845**	**13.948**	**24.316**	**126.603**

The total base case club water consumption with these parameters has been estimated at 126.603kL per week throughout the development.

5.6 Heat Rejection Water Requirements

Water consumption within each mechanical services air conditioning system varies depending upon the location of the building, the type of building construction, and the type of mechanical services systems incorporated. For the Woolooware Bay Town Centre development, the heat rejection water demand has been developed using the following information;

- Gross Floor Area 30,511m^2
- 7 days of building operation per week.
- Average Cooling Tower Water Supply 1.2L/day/m^2

A summary of the estimated heat rejection water consumption for the parameters listed above is as follows;

Base Building Assessment	Arcade	Supermarket	Majors	Specialty	Restaurants	Gymnasium	Medical	Club	Back Of House	Totals
Area	1624	4019	2906	4327	1549	2159	1493	6642	5792	**30511**
Consumption Rate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	
Total Consumption (L/day)	**1949**	**4823**	**3487**	**5192**	**1859**	**2591**	**1792**	**7970**	**0**	**29663**
Efficiency (L/m2/day)	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**0.00**	
Days Of operation Per Week	7	7	7	7	7	7	7	7	7	
Total Consumption (kL/week)	**13.642**	**33.760**	**24.410**	**36.347**	**13.012**	**18.136**	**12.541**	**55.793**	**0.000**	**207.640**

The total base case heat rejection water demand with these parameters is estimated to be 207.640kL per week.

5.7 Outdoor Water Requirements

Water consumption within each landscape irrigation system varies depending upon the nature of the irrigation system, species of planting, and the prevailing climate. For the Woolooware Bay Town Centre development, the base case outdoor water demand has been developed using following information;

- Irrigation area of approximately 500m^2
- Irrigation rate 15mm/m^2

A summary of the estimated irrigation water consumption for the parameters listed above is as follows;

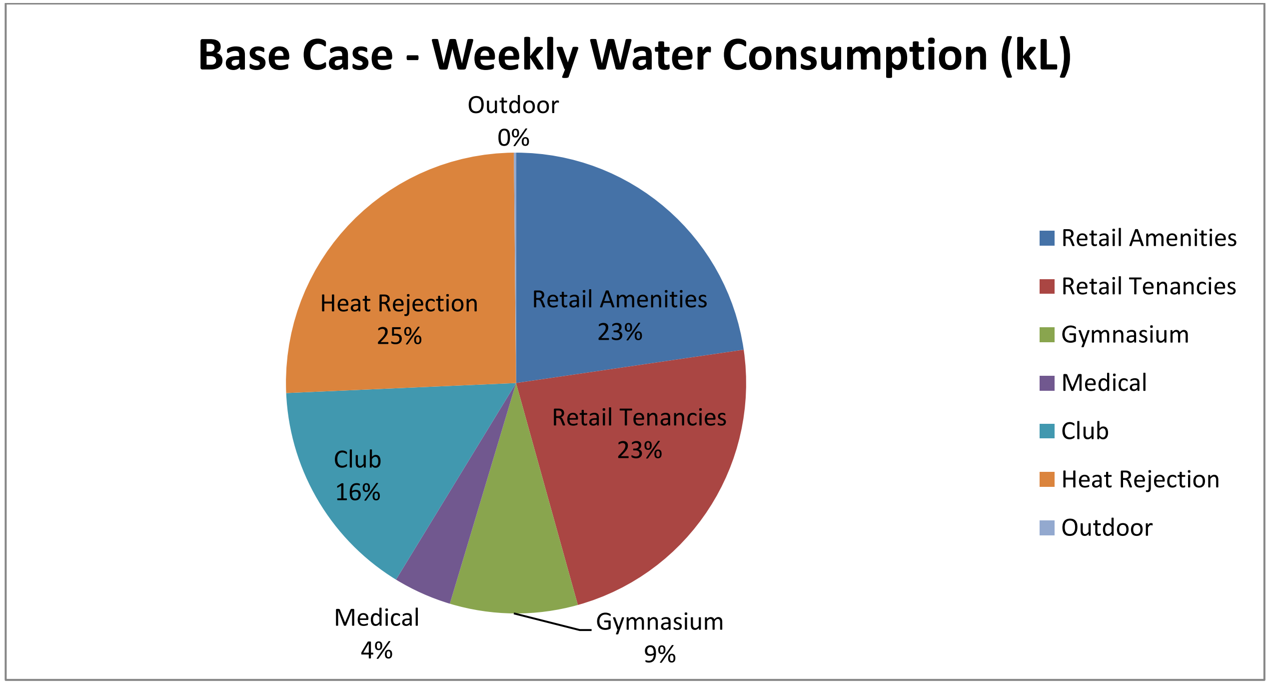
Base Building	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Weeks	4.4	4.0	4.4	4.3	4.4	4.3	4.4	4.4	4.3	**4.4**	4.3	4.4	52.0
Applications	3	3	2	2	2	1	1	1	2	**2**	2	3	

Area	500	500	500	500	500	500	500	500	500	500	500	500	
Irrigation Rate	15	15	15	15	15	15	15	15	15	15	15	15	
Requirement	198	180	132	129	132	65	66	66	129	132	129	198	
Rainfall	94.0	112.9	116.3	106.3	100.1	120.7	71.0	75.5	60.3	70.7	81.2	74.3	1083.3
Monthly	52.000	33.550	7.850	11.350	15.950	0.000	0.000	0.000	34.350	30.650	23.900	61.850	271.450
Weekly	**11.818**	**8.388**	**1.784**	**2.640**	**3.625**	**0.000**	**0.000**	**0.000**	**7.988**	**6.966**	**5.558**	**14.057**	**62.824**

The average base case outdoor water demand with these parameters has been estimated at 1.208kL per week throughout the development.

5.8 Total Base Building Retail Water Consumption

Based on the estimated retail amenity water requirements of 184.448kL per week, the estimated retail tenancy water requirements of 186.812kL per week, the estimated gymnasium water requirements of 72.945kL per week, the estimated medical water requirements of 33.234kL per week, the estimated club water requirements of 126.603kL per week, the estimated heat rejection water requirements 207.640kL per week and the estimated outdoor water requirements of 1.208kL per week, the total retail water consumption for this development will be 812.890kL per week.



6 Option 1 - Water Consumption Evaluation

6.1 Retail Amenity Water Requirements

Option 1 retail amenity water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated option 1 retail amenity water consumption for the parameters listed above is as follows;

Efficiency Assesssment	Water Closet	Urinal	Tapware	Showers	Totals
Area	14425	14425	14425	14425	14425
Male - Staff	144	144	144	144	144
Female - Staff	144	144	144	144	144
Male - Visitor	2404	2404	2404	2404	2404
Female - Staff	2404	2404	2404	2404	2404
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	505	289	649	1298	2741
Female - Staff	1515	0	649	1298	3462
Male - Visitor	1683	962	2164	0	4808
Female - Visitor	5049	0	2164	0	7213
Total Consumption (L/day)	**8751**	**1250**	**5626**	**2597**	**18224**
Efficiency (L/m2/day)	**0.61**	**0.09**	**0.39**	**0.18**	**1.26**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**61.258**	**8.751**	**39.380**	**18.176**	**127.565**
Non-Potable Ratio	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**61.258**	**8.751**	**39.380**	**18.176**	**127.565**

The total option 1 retail amenity water consumption with these parameters has been estimated at 127.565kL per week throughout the development.

6.2 Retail Tenancy Water Requirements

Option 1 retail tenant water consumption for the Woolooware Bay Town Centre development, has been modelled based upon actual metered consumption data from similar retail centres. Specifically the base model has been developed upon following information;

- 7 days of building operation per week.
- Non-food tenants having an average water consumption rate of 0.11kL/m^2 per annum.
- Food tenants having an average water consumption rate of 5.23kL/m^2 per annum.
- Supermarkets having an average water consumption rate of 0.21kL/m^2 per annum.
- Majors and Mini Majors having an average water consumption rate of 0.11kL/m^2 per annum.

A summary of the estimated option 1 retail tenancy water consumption for the parameters listed above is as follows;

Base Building Assessment	Specialty	Restaurants	Supermarkets	Majors	Totals
Area	4327	1549	4019	2906	12801
Consumption Rate	0.11	5.23	0.21	0.11	
Total Consumption (L/day)	**1304**	**22195**	**2312**	**876**	**26687**
Efficiency (L/m2/day)	**0.30**	**14.33**	**0.58**	**0.30**	**2.08**
Days Of operation Per Week	7	7	7	7	7
Total Consumption (kL/week)	**9.128**	**155.367**	**16.186**	**6.130**	**186.812**

The total option 1 retail tenant water consumption with these parameters has been estimated at 186.812kL per week throughout the development.

6.3 Gymnasium Tenancy Water Requirements

Option 1 gymnasium tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated option 1 gymnasium water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Totals

Area	2159	2159	2159	2159	2159
Male - Staff	22	22	22	22	22
Female - Staff	22	22	22	22	22
Male - Visitor	360	360	360	360	360
Female - Staff	360	360	360	360	360
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	76	43	97	194	410
Female - Staff	227	0	97	194	518
Male - Visitor	252	144	324	3239	3958
Female - Visitor	756	0	324	3239	4318
Total Consumption (L/day)	**1310**	**187**	**842**	**6866**	**9205**
Efficiency (L/m2/day)	**0.61**	**0.09**	**0.39**	**3.18**	**4.26**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**9.169**	**1.310**	**5.894**	**48.059**	**64.432**
Non-Potable Ratio	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**9.169**	**1.310**	**5.894**	**48.059**	**64.432**

The total option 1 gymnasium water consumption with these parameters has been estimated at 64.432kL per week throughout the development.

6.4 Medical Tenancy Water Requirements

Option 1 medical tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated option 1 medical water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	1493	1493	1493	1493	1493
Male - Staff	75	75	75	75	75
Female - Staff	75	75	75	75	75

Male - Visitor	75	75	75	75	75
Female - Staff	75	75	75	75	75
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	261	149	336	672	1418
Female - Staff	784	0	336	672	1792
Male - Visitor	52	30	67	0	149
Female - Visitor	157	0	67	0	224
Total Consumption (L/day)	**1254**	**179**	**806**	**1344**	**3583**
Efficiency (L/m2/day)	**0.84**	**0.12**	**0.54**	**0.90**	**2.40**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**8.779**	**1.254**	**5.644**	**9.406**	**25.082**
Non-Potable Ratio	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**8.779**	**1.254**	**5.644**	**9.406**	**25.082**

The total option 1 medical water consumption with these parameters has been estimated at 25.082kL per week throughout the development.

6.5 Club Tenancy Water Requirements

Option 1 club tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.

A summary of the estimated option 1 club water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Restaurants	Totals
Area	6642	6642	6642	6642	664.2	6642
Male - Staff	111	111	111	111		111
Female - Staff	111	111	111	111		111
Male - Visitor	1107	1107	1107	1107		1107
Female - Staff	1107	1107	1107	1107		1107
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star		

Consumption Per Use	3.5	1	1.5	45	5.23	
Male - Staff	387	221	498	996		2103
Female - Staff	1162	0	498	996		2657
Male - Visitor	775	443	996	0		2214
Female - Visitor	2325	0	996	0		3321
Total Consumption (L/day)	**4649**	**664**	**2989**	**1993**	**3474**	**13769**
Efficiency (L/m2/day)	**0.70**	**0.10**	**0.45**	**0.30**	**5.23**	**2.07**
Days Of operation Per Week	7	7	7	7	7	
Weekly Consumption (kL/week)	**32.546**	**4.649**	**20.922**	**13.948**	**24.316**	**96.382**
Non-Potable Ratio	0%	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**32.546**	**4.649**	**20.922**	**13.948**	**24.316**	**96.382**

The total option 1 club water consumption with these parameters has been estimated at 96.382kL per week throughout the development.

6.6 Heat Rejection Water Requirements

Water consumption within each mechanical services air conditioning system varies depending upon the location of the building, the type of building construction, and the type of mechanical services systems incorporated. For the Woolooware Bay Town Centre development, the option 1 heat rejection water demand has been developed using the following information;

- Gross Floor Area 30,511m^2
- 7 days of building operation per week.
- Average Cooling Tower Water Supply 1.2L/day/m^2

A summary of the estimated option 1 heat rejection water consumption for the parameters listed above is as follows;

Efficiency Assessment	**Arcade**	**Supermarket**	**Majors**	**Specialty**	**Restaurants**	**Gymnasium**	**Medical**	**Club**	**Back Of House**	**Totals**
Area	1624	4019	2906	4327	1549	2159	1493	6642	5792	**30511**
Consumption Rate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	
Total Consumption (L/day)	**1949**	**4823**	**3487**	**5192**	**1859**	**2591**	**1792**	**7970**	**0**	**29663**
Efficiency (L/m2/day)	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**0.00**	
Days Of operation Per Week	7	7	7	7	7	7	7	7	7	
Weekly Consumption (kL/week)	**13.642**	**33.760**	**24.410**	**36.347**	**13.012**	**18.136**	**12.541**	**55.793**	**0.000**	**207.640**
Non-Potable Ratio	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**13.642**	**33.760**	**24.410**	**36.347**	**13.012**	**18.136**	**12.541**	**55.793**	**0.000**	**207.640**

The total option 1 heat rejection water demand with these parameters is estimated to be 207.640kL per week.

6.7 Outdoor Water Requirements

Water consumption within each landscape irrigation system varies depending upon the nature of the irrigation system, species of planting, and the prevailing climate. For the Woolooware Bay Town Centre development, the option 1 outdoor water demand has been developed using following information;

- Irrigation area of approximately 500m^2
- Irrigation rate 15mm/m^2

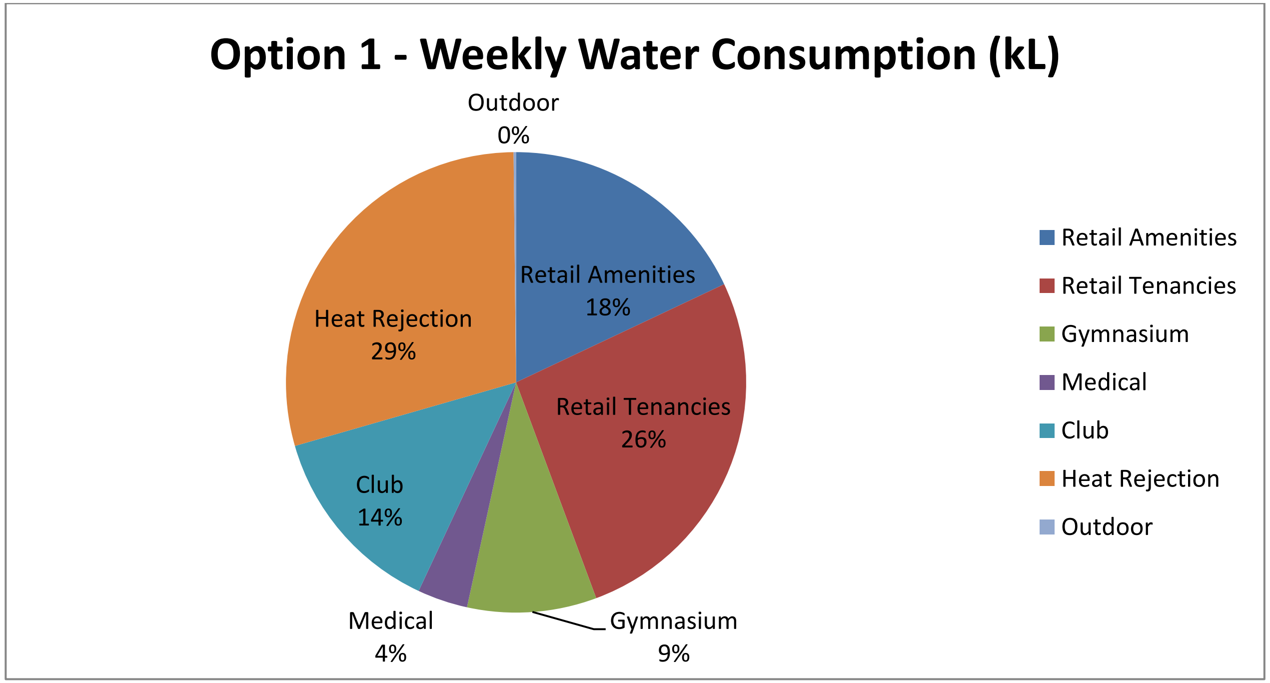
A summary of the estimated option 1 irrigation water consumption for the parameters listed above is as follows;

Water Efficiency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Weeks	4.4	4.0	4.4	4.3	4.4	4.3	4.4	4.4	4.3	**4.4**	4.3	4.4	52.0
Applications	3	3	2	2	2	1	1	1	2	**2**	2	3	
Area	500	500	500	500	500	500	500	500	500	500	500	500	
Irrigation Rate	15	15	15	15	15	15	15	15	15	15	15	15	
Requirement	198	180	132	129	132	65	66	66	129	132	129	198	
Rainfall	94.0	112.9	116.3	106.3	100.1	120.7	71.0	75.5	60.3	70.7	81.2	74.3	1083.3
Monthly	52.000	33.550	7.850	11.350	15.950	0.000	0.000	0.000	34.350	30.650	23.900	61.850	271.450
Weekly Consumption (kL/week)	**11.818**	**8.388**	**1.784**	**2.640**	**3.625**	**0.000**	**0.000**	**0.000**	**7.988**	**6.966**	**5.558**	**14.057**	**62.824**
Non-Potable Ratio	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	11.818	8.388	1.784	2.640	3.625	0.000	0.000	0.000	7.988	6.966	5.558	14.057	62.824

The average option 1 outdoor water demand with these parameters has been estimated at 1.208kL per week throughout the development.

6.8 Total Option 1 Water Consumption

Based on the estimated retail amenity water requirements of 127.565kL per week, the estimated retail tenancy water requirements of 186.812kL per week, the estimated gymnasium water requirements of 64.432kL per week, the estimated medical water requirements of 25.082kL per week, the estimated club water requirements of 96.382kL per week, the estimated heat rejection water requirements 207.640kL per week and the estimated outdoor water requirements of 1.208kL per week, the total retail water consumption for this development will be 709.121kL per week.


Option 1 - Weekly Water Consumption (kL)
Outdoor
0%
Retail Amenities
18%
Heat Rejection
29%
Retail Tenancies
26%
Club
14%
Medical
4%
Gymnasium
9%
Retail Amenities
Retail Tenancies
Gymnasium
Medical
Club
Heat Rejection
Outdoor

7 Option 2 - Water Consumption Evaluation

7.1 Retail Amenity Water Requirements

Option 2 retail amenity water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 2 retail amenity water consumption for the parameters listed above is as follows;

Efficiency Assesssment	Water Closet	Urinal	Tapware	Showers	Totals
Area	14425	14425	14425	14425	14425
Male - Staff	144	144	144	144	144
Female - Staff	144	144	144	144	144
Male - Visitor	2404	2404	2404	2404	2404
Female - Staff	2404	2404	2404	2404	2404
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	505	289	649	1298	2741
Female - Staff	1515	0	649	1298	3462
Male - Visitor	1683	962	2164	0	4808
Female - Visitor	5049	0	2164	0	7213
Total Consumption (L/day)	**8751**	**1250**	**5626**	**2597**	**18224**
Efficiency (L/m2/day)	**0.61**	**0.09**	**0.39**	**0.18**	**1.26**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**61.258**	**8.751**	**39.380**	**18.176**	**127.565**
Non-Potable Ratio	100%	100%	0%	0%	
Non-Potable Contribution (kL/week)	61.258	8.751	0.000	0.000	0.000
Total Consumption (kL/week)	**0.000**	**0.000**	**39.380**	**18.176**	**57.556**

The total option 2 retail amenity water consumption with these parameters has been estimated at 57.556kL per week throughout the development.

7.2 Retail Tenancy Water Requirements

Option 2 retail tenant water consumption for the Woolooware Bay Town Centre development, has been modelled based upon actual metered consumption data from similar retail centres. Specifically the base model has been developed upon following information;

- 7 days of building operation per week.
- Non-food tenants having an average water consumption rate of 0.11kL/m^2 per annum.
- Food tenants having an average water consumption rate of 5.23kL/m^2 per annum.
- Supermarkets having an average water consumption rate of 0.21kL/m^2 per annum.
- Majors and Mini Majors having an average water consumption rate of 0.11kL/m^2 per annum.

A summary of the estimated option 2 retail tenancy water consumption for the parameters listed above is as follows;

Efficiency Assessment	Specialty	Restaurants	Supermarkets	Majors	Totals
Area	4327	1549	4019	2906	12801
Consumption Rate	0.11	5.23	0.21	0.11	
Total Consumption (L/day)	**1304**	**22195**	**2312**	**876**	**26687**
Efficiency (L/m2/day)	**0.30**	**14.33**	**0.58**	**0.30**	**2.08**
Days Of operation Per Week	7	7	7	7	7
Total Consumption (kL/week)	**9.128**	**155.367**	**16.186**	**6.130**	**186.812**

The total option 2 retail tenant water consumption with these parameters has been estimated at 186.812kL per week throughout the development.

7.3 Gymnasium Tenancy Water Requirements

Option 2 gymnasium tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 2 gymnasium water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	2159	2159	2159	2159	2159
Male - Staff	22	22	22	22	22
Female - Staff	22	22	22	22	22
Male - Visitor	360	360	360	360	360
Female - Staff	360	360	360	360	360
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	76	43	97	194	410
Female - Staff	227	0	97	194	518
Male - Visitor	252	144	324	3239	3958
Female - Visitor	756	0	324	3239	4318
Total Consumption (L/day)	**1310**	**187**	**842**	**6866**	**9205**
Efficiency (L/m2/day)	**0.61**	**0.09**	**0.39**	**3.18**	**4.26**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**9.169**	**1.310**	**5.894**	**48.059**	**64.432**
Non-Potable Ratio	100%	100%	0%	0%	
Non-Potable Contribution (kL/week)	9.169	1.310	0.000	0.000	0.000
Total Consumption (kL/week)	**0.000**	**0.00**	**5.894**	**48.059**	**53.953**

The total option 2 gymnasium water consumption with these parameters has been estimated at 53.953kL per week throughout the development.

7.4 Medical Tenancy Water Requirements

Option 2 medical tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 2 medical water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	1493	1493	1493	1493	1493
Male - Staff	75	75	75	75	75
Female - Staff	75	75	75	75	75
Male - Visitor	75	75	75	75	75
Female - Staff	75	75	75	75	75
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	261	149	336	672	1418
Female - Staff	784	0	336	672	1792
Male - Visitor	52	30	67	0	149
Female - Visitor	157	0	67	0	224
Total Consumption (L/day)	**1254**	**179**	**806**	**1344**	**3583**
Efficiency (L/m2/day)	**0.84**	**0.12**	**0.54**	**0.90**	**2.40**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**8.779**	**1.254**	**5.644**	**9.406**	**25.082**
Non-Potable Ratio	100%	100%	0%	0%	
Non-Potable Contribution (kL/week)	8.779	1.254	0.000	0.000	0.000
Total Consumption (kL/week)	**0.000**	**0.000**	**5.644**	**9.406**	**15.049**

The total option 2 medical water consumption with these parameters has been estimated at 15.049kL per week throughout the development.

7.5 Club Tenancy Water Requirements

Option 2 club tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 2 club water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Restaurants	Totals
Area	6642	6642	6642	6642	664.2	6642

Male - Staff	111	111	111	111		111
Female - Staff	111	111	111	111		111
Male - Visitor	1107	1107	1107	1107		1107
Female - Staff	1107	1107	1107	1107		1107
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star		
Consumption Per Use	3.5	1	1.5	45	5.23	
Male - Staff	387	221	498	996		2103
Female - Staff	1162	0	498	996		2657
Male - Visitor	775	443	996	0		2214
Female - Visitor	2325	0	996	0		3321
Total Consumption (L/day)	**4649**	**664**	**2989**	**1993**	**3474**	**13769**
Efficiency (L/m2/day)	**0.70**	**0.10**	**0.45**	**0.30**	**5.23**	**2.07**
Days Of operation Per Week	7	7	7	7	7	
Weekly Consumption (kL/week)	**32.546**	**4.649**	**20.922**	**13.948**	**24.316**	**96.382**
Non-Potable Ratio	100%	100%	0%	0%	0%	
Non-Potable Contribution (kL/week)	32.546	4.649	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**0.000**	**0.000**	**20.922**	**13.948**	**24.316**	**59.187**

The total option 2 club water consumption with these parameters has been estimated at 59.187kL per week throughout the development.

7.6 Heat Rejection Water Requirements

Water consumption within each mechanical services air conditioning system varies depending upon the location of the building, the type of building construction, and the type of mechanical services systems incorporated. For the Woolooware Bay Town Centre development, the option 2 heat rejection water demand has been developed using the following information;

- Gross Floor Area 30,511m^2
- 7 days of building operation per week.
- Average Cooling Tower Water Supply 1.2L/day/m^2

A summary of the estimated option 2 heat rejection water consumption for the parameters listed above is as follows;

Efficiency Assessment	Arcade	Supermarket	Majors	Specialty	Restaurants	Gymnasium	Medical	Club	Back Of House	Totals
Area	1624	4019	2906	4327	1549	2159	1493	6642	5792	**30511**
Consumption Rate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	
Total Consumption (L/day)	**1949**	**4823**	**3487**	**5192**	**1859**	**2591**	**1792**	**7970**	**0**	**29663**
Efficiency (L/m2/day)	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**0.00**	
Days Of operation Per Week	7	7	7	7	7	7	7	7	7	
Weekly Consumption (kL/week)	**13.64**	**33.760**	**24.41**	**36.347**	**13.012**	**18.136**	**12.541**	**55.79**	**0.000**	**207.64**

	2		**0**					**3**		**0**
Non-Potable Ratio	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	**13.642**	**33.760**	**24.410**	**36.347**	**13.012**	**18.136**	**12.541**	**55.793**	**0.000**	**207.640**

The total option 2 heat rejection water demand with these parameters is estimated to be 207.640kL per week.

7.7 Outdoor Water Requirements

Water consumption within each landscape irrigation system varies depending upon the nature of the irrigation system, species of planting, and the prevailing climate. For the Woolooware Bay Town Centre development, the option 2 outdoor water demand has been developed using following information;

- Irrigation area of approximately 500m^2
- Irrigation rate 15mm/m^2

A summary of the estimated option 2 irrigation water consumption for the parameters listed above is as follows;

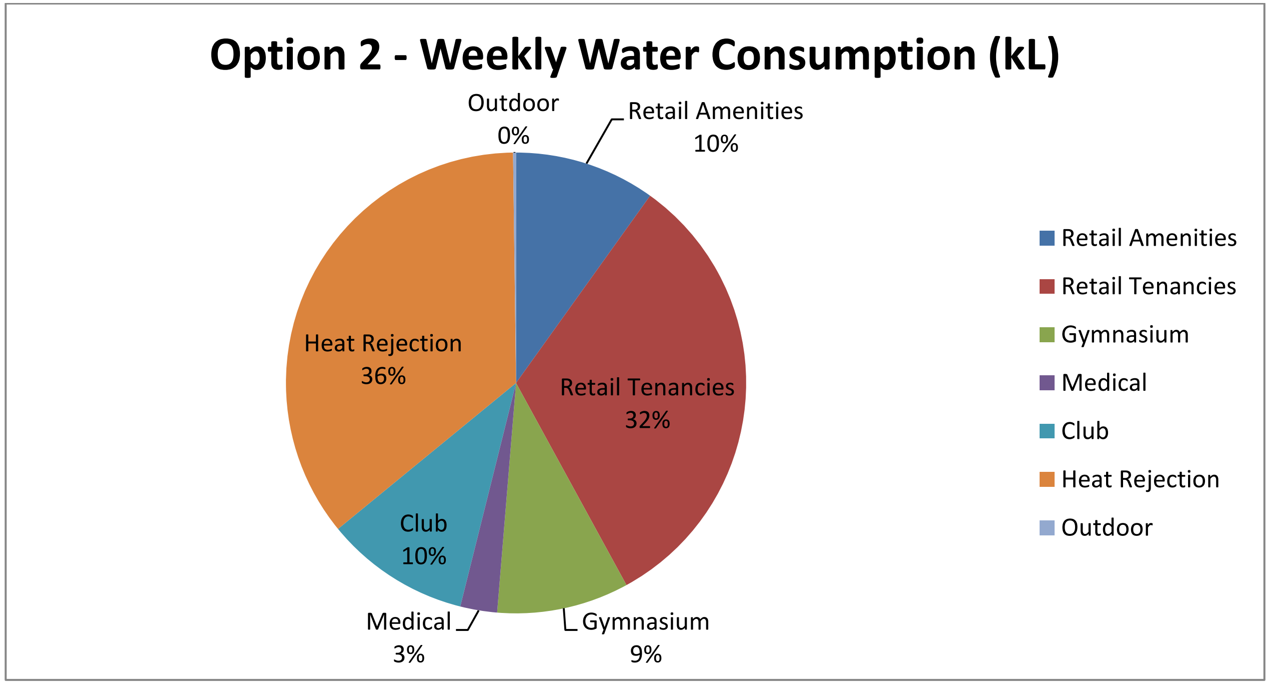
Water Efficiency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Weeks	4.4	4.0	4.4	4.3	4.4	4.3	4.4	4.4	4.3	**4.4**	4.3	4.4	52.0
Applications	3	3	2	2	2	1	1	1	2	**2**	2	3	
Area	500	500	500	500	500	500	500	500	500	500	500	500	
Irrigation Rate	15	15	15	15	15	15	15	15	15	15	15	15	
Requirement	198	180	132	129	132	65	66	66	129	132	129	198	
Rainfall	94.0	112.9	116.3	106.3	100.1	120.7	71.0	75.5	60.3	70.7	81.2	74.3	1083.3
Monthly	52.000	33.550	7.850	11.350	15.950	0.000	0.000	0.000	34.350	30.650	23.900	61.850	271.450
Weekly Consumption (kL/week)	**11.818**	**8.388**	**1.784**	**2.640**	**3.625**	**0.000**	**0.000**	**0.000**	**7.988**	**6.966**	**5.558**	**14.057**	**62.824**
Non-Potable Ratio	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Non-Potable Contribution (kL/week)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Consumption (kL/week)	11.818	8.388	1.784	2.640	3.625	0.000	0.000	0.000	7.988	6.966	5.558	14.057	62.824

The average option 2 outdoor water demand with these parameters has been estimated at 1.208kL per week throughout the development.

7.8 Total Option 2 Water Consumption

Based on the estimated retail amenity water requirements of 57.556kL per week, the estimated retail tenancy water requirements of 186.812kL per week, the estimated gymnasium water requirements of 53.953kL per week, the estimated medical water requirements of 15.049kL per week, the estimated club water requirements of 59.187kL per week, the estimated heat rejection water requirements

207.640kL per week and the estimated outdoor water requirements of 1.208kL per week, the total retail water consumption for this development will be 581.404kL per week.



8 Option 3 - Water Consumption Evaluation

8.1 Retail Amenity Water Requirements

Option 3 retail amenity water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 3 retail amenity water consumption for the parameters listed above is as follows;

Efficiency Assesssment	Water Closet	Urinal	Tapware	Showers	Totals
Area	14425	14425	14425	14425	14425
Male - Staff	144	144	144	144	144
Female - Staff	144	144	144	144	144
Male - Visitor	2404	2404	2404	2404	2404
Female - Staff	2404	2404	2404	2404	2404
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	505	289	649	1298	2741
Female - Staff	1515	0	649	1298	3462
Male - Visitor	1683	962	2164	0	4808
Female - Visitor	5049	0	2164	0	7213
Total Consumption (L/day)	**8751**	**1250**	**5626**	**2597**	**18224**
Efficiency (L/m2/day)	**0.61**	**0.09**	**0.39**	**0.18**	**1.26**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**61.258**	**8.751**	**39.380**	**18.176**	**127.565**
Non-Potable Ratio	100%	100%	0%	0%	
Non-Potable Contribution (kL/week)	61.258	8.751	0.000	0.000	70.009
Total Consumption (kL/week)	**0.000**	**0.000**	**39.380**	**18.176**	**57.556**

The total option 3 retail amenity water consumption with these parameters has been estimated at 57.556kL per week throughout the development.

8.2 Retail Tenancy Water Requirements

Option 3 retail tenant water consumption for the Woolooware Bay Town Centre development, has been modelled based upon actual metered consumption data from similar retail centres. Specifically the base model has been developed upon following information;

- 7 days of building operation per week.
- Non-food tenants having an average water consumption rate of 0.11kL/m^2 per annum.
- Food tenants having an average water consumption rate of 5.23kL/m^2 per annum.
- Supermarkets having an average water consumption rate of 0.21kL/m^2 per annum.
- Majors and Mini Majors having an average water consumption rate of 0.11kL/m^2 per annum.

A summary of the estimated option 3 retail tenancy water consumption for the parameters listed above is as follows;

Efficiency Assessment	Specialty	Restaurants	Supermarkets	Majors	Totals
Area	4327	1549	4019	2906	12801
Consumption Rate	0.11	5.23	0.21	0.11	
Total Consumption (L/day)	**1304**	**22195**	**2312**	**876**	**26687**
Efficiency (L/m2/day)	**0.30**	**14.33**	**0.58**	**0.30**	**2.08**
Days Of operation Per Week	7	7	7	7	7
Total Consumption (kL/week)	**9.128**	**155.367**	**16.186**	**6.130**	**186.812**

The total option 3 retail tenant water consumption with these parameters has been estimated at 186.812kL per week throughout the development.

8.3 Gymnasium Tenancy Water Requirements

Option 3 gymnasium tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 3 gymnasium water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	2159	2159	2159	2159	2159
Male - Staff	22	22	22	22	22
Female - Staff	22	22	22	22	22
Male - Visitor	360	360	360	360	360
Female - Staff	360	360	360	360	360
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	76	43	97	194	410
Female - Staff	227	0	97	194	518
Male - Visitor	252	144	324	3239	3958
Female - Visitor	756	0	324	3239	4318
Total Consumption (L/day)	**1310**	**187**	**842**	**6866**	**9205**
Efficiency (L/m2/day)	**0.61**	**0.09**	**0.39**	**3.18**	**4.26**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**9.169**	**1.310**	**5.894**	**48.059**	**64.432**
Non-Potable Ratio	100%	100%	0%	0%	
Non-Potable Contribution (kL/week)	9.169	1.310	0.000	0.000	10.478
Total Consumption (kL/week)	**0.000**	**0.00**	**5.894**	**48.059**	**53.953**

The total option 3 gymnasium water consumption with these parameters has been estimated at 53.953kL per week throughout the development.

8.4 Medical Tenancy Water Requirements

Option 3 medical tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 3 medical water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Totals
Area	1493	1493	1493	1493	1493
Male - Staff	75	75	75	75	75
Female - Staff	75	75	75	75	75
Male - Visitor	75	75	75	75	75
Female - Staff	75	75	75	75	75
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star	
Consumption Per Use	3.5	1	1.5	45	
Male - Staff	261	149	336	672	1418
Female - Staff	784	0	336	672	1792
Male - Visitor	52	30	67	0	149
Female - Visitor	157	0	67	0	224
Total Consumption (L/day)	**1254**	**179**	**806**	**1344**	**3583**
Efficiency (L/m2/day)	**0.84**	**0.12**	**0.54**	**0.90**	**2.40**
Days Of operation Per Week	7	7	7	7	7
Weekly Consumption (kL/week)	**8.779**	**1.254**	**5.644**	**9.406**	**25.082**
Non-Potable Ratio	100%	100%	0%	0%	
Non-Potable Contribution (kL/week)	8.779	1.254	0.000	0.000	10.033
Total Consumption (kL/week)	**0.000**	**0.000**	**5.644**	**9.406**	**15.049**

The total option 3 medical water consumption with these parameters has been estimated at 15.049kL per week throughout the development.

8.5 Club Tenancy Water Requirements

Option 3 club tenancy water consumption for the Woolooware Bay Town Centre development, has been modelled based upon following information;

- 7 days of building operation per week.
- 4 Star WELS rated water closets, having an average volume per flush of 3.5 litres.
- 6 Star WELS rated urinals, having an average volume per flush of 1 litre.
- 6 Star WELS rated tapware, having a flow rate of 4.5 litres per minute.
- 3 Star WELS rated showers, having a flow rate of 9.0 litres per minute.
- Non-potable water used for 100% of all flushing requirements.

A summary of the estimated option 3 club water consumption for the parameters listed above is as follows;

Efficiency Assessment	Water Closet	Urinal	Tapware	Showers	Restaurants	Totals
Area	6642	6642	6642	6642	664.2	6642

Male - Staff	111	111	111	111		111
Female - Staff	111	111	111	111		111
Male - Visitor	1107	1107	1107	1107		1107
Female - Staff	1107	1107	1107	1107		1107
Fixture Efficiency	4 Star	6 Star	6 Star	3 Star		
Consumption Per Use	3.5	1	1.5	45	5.23	
Male - Staff	387	221	498	996		2103
Female - Staff	1162	0	498	996		2657
Male - Visitor	775	443	996	0		2214
Female - Visitor	2325	0	996	0		3321
Total Consumption (L/day)	**4649**	**664**	**2989**	**1993**	**3474**	**13769**
Efficiency (L/m2/day)	**0.70**	**0.10**	**0.45**	**0.30**	**5.23**	**2.07**
Days Of operation Per Week	7	7	7	7	7	
Weekly Consumption (kL/week)	**32.546**	**4.649**	**20.922**	**13.948**	**24.316**	**96.382**
Non-Potable Ratio	100%	100%	0%	0%	0%	
Non-Potable Contribution (kL/week)	32.546	4.649	0.000	0.000	0.000	37.195
Total Consumption (kL/week)	**0.000**	**0.000**	**20.922**	**13.948**	**24.316**	**59.187**

The total option 3 club water consumption with these parameters has been estimated at 59.187kL per week throughout the development.

8.6 Heat Rejection Water Requirements

Water consumption within each mechanical services air conditioning system varies depending upon the location of the building, the type of building construction, and the type of mechanical services systems incorporated. For the Woolooware Bay Town Centre development, the option 3 heat rejection water demand has been developed using the following information;

- Gross Floor Area 30,511m^2
- 7 days of building operation per week.
- Average Cooling Tower Water Supply 1.2L/day/m^2
- Non-potable water used for 90% of all heat rejection requirements.

A summary of the estimated option 3 heat rejection water consumption for the parameters listed above is as follows;

Efficiency Assessment	**Arcade**	**Supermarket**	**Majors**	**Specialty**	**Restaurants**	**Gymnasium**	**Medical**	**Club**	**Back Of House**	**Totals**
Area	1624	4019	2906	4327	1549	2159	1493	6642	5792	**30511**
Consumption Rate	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	
Total Consumption (L/day)	**1949**	**4823**	**3487**	**5192**	**1859**	**2591**	**1792**	**7970**	**0**	**29663**
Efficiency (L/m2/day)	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**1.20**	**0.00**	
Days Of operation Per Week	7	7	7	7	7	7	7	7	7	

Weekly Consumption (kL/week)	**13.642**	**33.760**	**24.410**	**36.347**	**13.012**	**18.136**	**12.541**	**55.793**	**0.000**	**207.640**
Non-Potable Ratio	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Non-Potable Contribution (kL/week)	12.277	30.384	21.969	32.712	11.710	16.322	11.287	50.214	0.000	186.876
Total Consumption (kL/week)	**1.364**	**3.376**	**2.441**	**3.635**	**1.301**	**1.814**	**1.254**	**5.579**	**0.000**	**20.764**

The total option 3 heat rejection water demand with these parameters is estimated to be 20.764kL per week.

8.7 Outdoor Water Requirements

Water consumption within each landscape irrigation system varies depending upon the nature of the irrigation system, species of planting, and the prevailing climate. For the Woolooware Bay Town Centre development, the option 3 outdoor water demand has been developed using following information;

- Irrigation area of approximately 500m^2
- Irrigation rate 15mm/m^2
- Non-potable water used for 100% of all irrigation requirements.

A summary of the estimated option 3 irrigation water consumption for the parameters listed above is as follows;

Water Efficiency	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
Weeks	4.4	4.0	4.4	4.3	4.4	4.3	4.4	4.4	4.3	**4.4**	4.3	4.4	52.0
Applications	3	3	2	2	2	1	1	1	2	**2**	2	3	
Area	500	500	500	500	500	500	500	500	500	500	500	500	
Irrigation Rate	15	15	15	15	15	15	15	15	15	15	15	15	
Requirement	198	180	132	129	132	65	66	66	129	132	129	198	
Rainfall	94.0	112.9	116.3	106.3	100.1	120.7	71.0	75.5	60.3	70.7	81.2	74.3	1083.3
Monthly	52.000	33.550	7.850	11.350	15.950	0.000	0.000	0.000	34.350	30.650	23.900	61.850	271.450
Weekly Consumption (kL/week)	**11.818**	**8.388**	**1.784**	**2.640**	**3.625**	**0.000**	**0.000**	**0.000**	**7.988**	**6.966**	**5.558**	**14.057**	**62.824**
Non-Potable Ratio	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	
Non-Potable Contribution (kL/week)	11.818	8.388	1.784	2.640	3.625	0.000	0.000	0.000	7.988	6.966	5.558	14.057	62.824
Total Consumption (kL/week)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The average option 3 outdoor water demand with these parameters has been estimated at 0.000kL per week throughout the development.

8.8 Total Option 3 Water Consumption

Based on the estimated retail amenity water requirements of 57.556kL per week, the estimated retail tenancy water requirements of 186.812kL per week, the estimated gymnasium water requirements of 53.953kL per week, the estimated medical water requirements of

15.049kL per week, the estimated club water requirements of 59.187kL per week, the estimated heat rejection water requirements 20.764kL per week and the estimated outdoor water requirements of 0.000kL per week, the total retail water consumption for this development will be 393.321kL per week.