ACOR CONSULTANTS

STORMWATER MANAGEMENT REPORT
For a Proposed Residential Development

Suite 2.01, Level 2
4 Ilya Avenue
ERINA NSW 2250

PO Box 3772
Fountain Plaza
ERINA NSW 2250

T 02 4324 3499

www.acor.com.au

ENGINEERS

MANAGERS

INFRASTRUCTURE PLANNERS

DEVELOPMENT CONSULTANTS

Client: **Castle Larool DM Pty Ltd**

Property: **Carramarr Road and Larool Crescent, Castle Hill**

Date: **4 July 2018**

Document Identification

Our Reference: **GO150722**

For and on behalf of ACOR Consultants (CC) Pty Ltd

Quality Information

Version	Description	Date	Author	Signature	Reviewer	Signature
1.0	Stormwater Management Report	18/03/2016	Bruce Kenny		Leigh Appleyard	
2.0	DRAFT Revised Stormwater Management Report	01/02/2018	Bruce Kenny			
3.0	Stormwater Management Report	14/02/2018	Bruce Kenny			
4.0	DRAFT Revised Stormwater Management Report	03/07/2018	Bruce Kenny			
5.0	Revised Stormwater Management Report	04/07/2018	Bruce Kenny			

Distribution

No. of Copies	Format	Distributed to	Date
1 (v 1.0)	pdf	Michael Gee	18/03/2016
1 (v 2.0)	pdf	Michael Gee	01/02/2018
1 (v 3.0)	pdf	Michael Gee	14/02/2018
1 (v 4.0)	pdf	Michael Gee	03/07/2018

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D ACOR Consultants (CC) Pty Ltd Stormwater Quality Report, Reference GO150722, Sheets Q1.01 to Q1.06, Issue A, dated 19 October 2015

1.0 Introduction

The Hills Shire Council has established principles and options for the management of stormwater. The Hills Shire Council identifies all stormwater management issues which must be addressed to maintain ongoing protection of the local environment, property and receiving waters. Their stormwater quality, stormwater conservation and flow management targets have been identified in accordance with the relevant regulatory requirements, in order to address broader stormwater management and ecological issues. This provides a framework for the sustainable stormwater management.

The qualitative and quantitative assessment of the stormwater management issues also allow identification for opportunities which may be integrated within future infrastructure which may ultimately enhance and protect the surrounding environment and receiving waters.

The purpose of this report is to assess stormwater management strategies and provide a framework for future development which encompasses best management practice for:

- Stormwater Water Quality Treatment
- Stormwater Water Quantity Treatment
- Overland Flow Management
- Existing Stormwater Infrastructure Remediation.

The development controls outlined in The Hills DCP 2012 which relate to the stormwater issues are identified under Part B Section 5 Clause 3.17, Part C Section 6 and Appendix B.

2.0 Background

2.1 Site Description

The subject site incorporates the properties known as Lot16 – 19 being No.'s 4, 6, 8, 10, 12, 14, 16, 18, 20 & 22 Larool Crescent and No.'s 44, 46, 48 & 50 Carramarr Road, Castle Hill.

The subject site comprises an area of 10,150 square metres and is identified on the survey plans prepared by LTS Lockley comprising three (3) sheets reference 41889DT sheets 1 to 3 (copies enclosed under Annexure A).

The subject site is bounded by Larool Crescent along its northern, eastern and southern boundaries and Carramar Road along its western boundary.

The site is currently supporting residential development.

2.2 Site Survey

The site has been the subject of a detail survey inundated by LTS Lockley. Details of this survey area depicted on the survey plan reference 41889DT sheets 1 to 3 (copies enclosed under Annexure A).

For the purpose of our flood modelling, supplementary LIDAR survey was obtained from the NSW Government Land and Property Information (LPI).

3.0 Stormwater Management

Our assessment of the site has identified a series of stormwater management issues which must be addressed in order to meet the development controls outlined under Section 1. These issues principally relate to stormwater quality, quantity, hydrology and management. Consequences of not addressing these issues would adversely impact on future development.

In order to establish a framework for future development, we have identified and discussed in the following sections the principle matters associated with the stormwater management. These matters will need to be incorporated in future development and include:

- Management of overland flow. – refer section 3.1 below.
- Management of the property stormwater drainage system. – refer section 3.2 below.
- Management of existing infrastructure. – refer section 3.3 below.
- Management of stormwater quality – refer section 3.4 below.

3.1 Management of Overland Flow

The subject site is partially impacted by overland flow. In order to establish the overland flow behaviour affecting the subject site, we have undertaken a detailed overland flow assessment. In this regard, we refer to our Flood Impact Assessment, Reference GO150722, version 2.0, dated 3 July 2018 (copy enclosed under Annexure B).

The findings of our overland flow assessment reveal that a small portion of the southern corner of the site is impacted by overland flow. In order to manage this flow, it is proposed that future development should incorporate a deflection wall installed partially along the eastern and southern boundaries. In this regard, we refer to sheet reference GO150722/G2/B which depicts the alignment and extent of the deflection wall (copy enclosed under Annexure C).

Future development will need to address the following items associated with Flood Risk Management which include:

- Flood Planning Levels.
- Evacuation management.
- Flood compatible material.

- Flood related structural adequacy issues.
- Flood affecting adjoining properties.

The finding of the report indicates that these issues can be readily managed in the future redevelopment of the site. Accordingly, it is our view that future development can reasonably incorporate flood mitigation measures which meet the intent of Part C Section 6 of The Hills DCP 2012.

3.2 Management of Property Stormwater Drainage System and Stormwater Quantity

The subject site is primarily a developed residential catchment. Much of the stormwater that falls on this catchment, as rainfall, percolates into the soil where it is either lost through evaporation, evapotranspiration, or flows into groundwater and then into the existing stormwater infrastructure. The proportion of stormwater reaching the existing external stormwater system will increase significantly as a result of future development. This is a consequence of increased impervious surfaces, which prevent water percolating into the soil, as well as lost opportunities for infiltration resulting from future underground stormwater networks. These issues will result in a significant modification to the natural hydrology observed prior to development. As a consequence, future development must incorporate appropriate stormwater quantity infrastructure which addresses:

- Reduced stream base flow.
- Increased peak flows.
- Increased erosion and incision to channels resulting from increased velocities and sediment supply.
- Potential downstream flooding.

Accordingly, with increased impervious areas associated with the proposed development, the volume and velocity of runoff will increase. Attenuation of these increased flows is required to protect the geomorphic form of the receiving waters and to moderate downstream flooding. An acceptable method of flow attenuation includes the use of below ground storage tanks.

The strategy to meet stormwater quality targets propose a series of strategically placed below ground storage tanks. The indicative tank arrangement is detailed on sheet reference GO150722/G6/B (copy enclosed under Annexure C).

The lawful point of discharge for the on-site stormwater detention system is the existing pit adjacent to the south west boundary reference to sheet GO150722/G3/B (copy enclosed under Annexure C).

Based on the foregoing, we are of the view that future redevelopment of the site can incorporate an appropriate stormwater management system which will meet the development controls.

3.3 Existing Stormwater Infrastructure

We note that the subject site is currently traversed by an existing 1200 diameter RCP. In this regard, we refer to sheets reference GO150722/G3, G4 and G5 (copies attached under Annexure C). Future development may require the relocation of the 1200 diameter stormwater pipe. It is our view that the proposed realignment depicted on Sheet G3 into Larool Crescent road reserve provides an acceptable outcome.

3.4 Stormwater Quality Management

Increased urbanisation and associated development, if left unmanaged, impacts adversely on the environmental values of waterways. Resulting degradation of the waterway results from diminished stormwater quality, increased volumes of stormwater runoff and increases in flood frequencies. Developed urbanised areas will generate increased stormwater flows which transport greater pollution loads. This results from increased impervious areas and associated human activity. Stormwater run-off originating from impervious areas transport a range of pollutants which include suspended solids, litter, nutrients, heavy metals, hydrocarbons, oil and grease.

The provision of appropriate measures to manage pollutants transported in stormwater run-off from future development is essential to maintain and protect the ecology of the receiving stormwaters.

Based on the foregoing the following targets have been identified as industry standard and are consistent with the Australian and New Zealand Environment Conservation Council (ANZECC), Upper Parramatta River Catchment Trust – WSUD TECHNICAL GUIDELINES FOR WESTERN SYDNEY – 2004 and Landcom Water Sensitive Urban Design – Book 1 Policy (DRAFT). Based on these documents the targets for pollution control are listed in Table 1 following:

Objective	**Performance Measure and Target**
1. Pollution Control	(a) 45% reduction in the mean annual load of Total Nitrogen (TN). (b) 45% reduction in the mean annual load of Total Phosphorus (TP). (c) 80% reduction in the mean annual load of Total Suspended Solids. (d) 90% reduction in the mean annual load of Gross Pollutants.

In accordance with the development controls, we have undertaken a Water Quality Assessment using MUSIC software.

The “Model for Urban Stormwater Improvement Conceptualisation” (MUSIC) is based on modelling software developed by the former CRC for Catchment Hydrology and the current eWater CRC and represents an accumulation of the best available knowledge and research into urban stormwater management in Australia.

MUSIC estimates stormwater flow and pollution generation and simulates the performance of stormwater treatment devices individually and as part of a treatment train (individual devices connected to a series to improve overall treatment performance). By simulating the performance of stormwater quality improvement measures, MUSIC provides information on whether a proposed system conceptually would achieve flow and stormwater quality targets.

The strategy to meet stormwater quality targets proposes a series of proprietary devices which are detailed in our Stormwater Quality Report, Reference GO150722, Sheets Q1.01 to Q1.06, Issue A, dated 19 October 2015 (copy enclosed under Annexure D).

As a consequence of our MUSIC modelling, we have determined that future redevelopment of the site can incorporate appropriate stormwater quality measures which will meet the performance requirements outlined in the development controls.

4.0 Conclusion

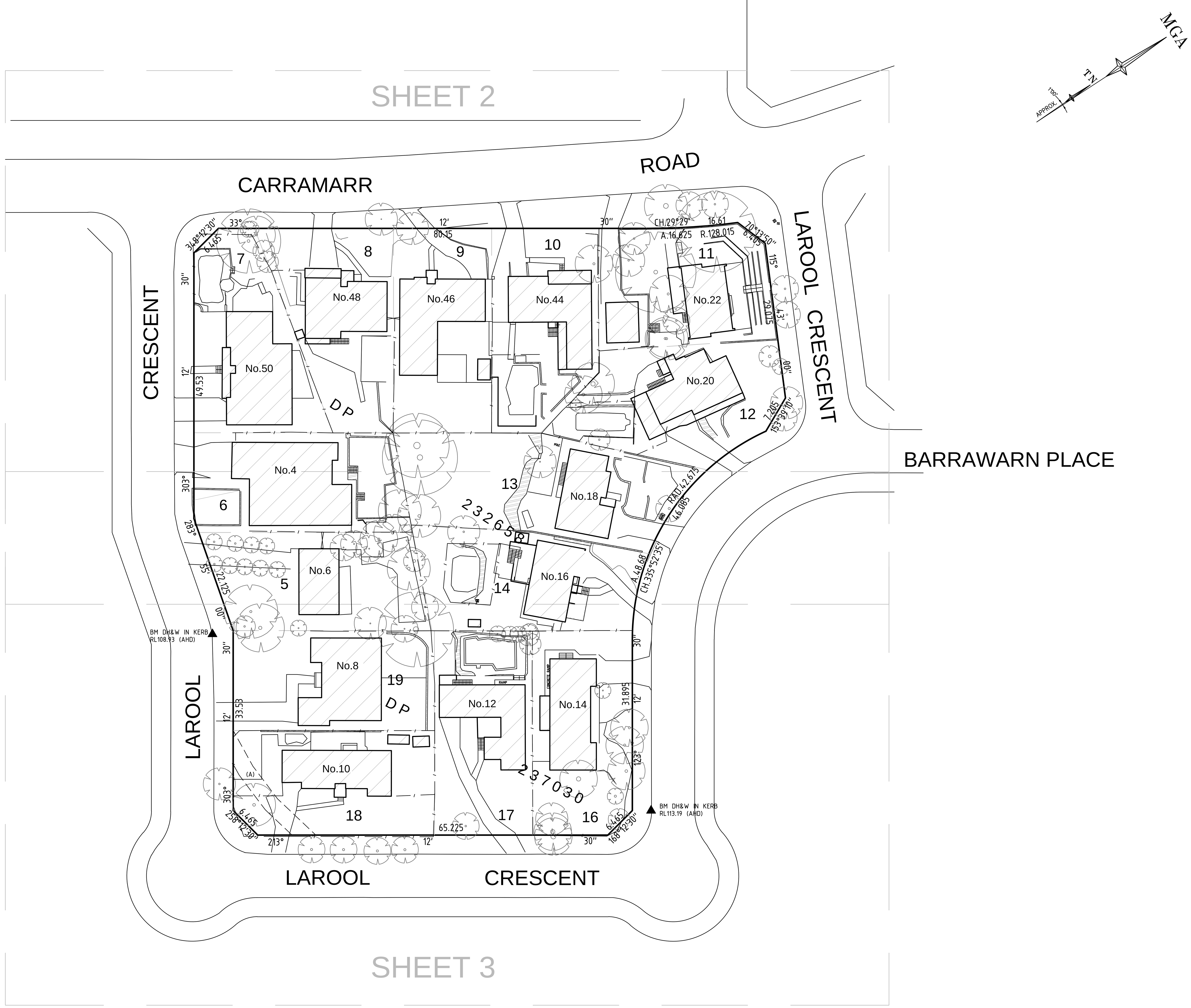
Based on the foregoing we have determined that appropriate stormwater measurements can be implemented with future development of the subject site, which will meet the intent of the relevant development controls.

ANNEXURE A

LTS Lockley plans
Reference 41889DT
Sheets 1 to 3

LEGEND

BENCH MARK	▲
TELSTRA PIT	TEL
ELECTRIC LIGHT POLE	ELP
ELECTRICITY PIT	ESWITCH
POWER POLE	PP
STREET SIGN	SS
GRATED INLET PIT	GIP
KERB INLET PIT	KIP
SEWER INSPECTION POINT	SIP
SEWER VENT	SEV
SEWER MANHOLE	SMH
STOP VALVE	SV
SPRINKLER	SPRK
IRRIGATION	IRR
HYDRANT	HYD
WATER METER	WM
WATER TAP	TAP
WATER VALVE	WV
VEHICLE CROSSING	(VC)
PRAM CROSSING	(PC)
RIDGE	RDG
BLOCK RETAINING WALL	BLK.RW
BRICK RETAINING WALL	BRW
RENDERED RETAINING WALL	RRW
ROCK RETAINING WALL	RK.RW
TOP OF GUTTER	TOG
UNDERSIDE OF AWNING	USA
GAS	G
TELSTRA	T
WATER	W
STORMWATER	SW
SEWER	S
ELECTRICITY (OVERHEAD)	P



(A) EASEMENT TO DRAIN WATER 3.05 WIDE (DP237030)

NOTES

1. THE BOUNDARIES HAVE NOT BEEN MARKED
2. ALL AREAS AND DIMENSIONS HAVE BEEN COMPILED FROM PLANS MADE AVAILABLE BY THE OFFICE of LAND & PROPERTY INFORMATION (NSW) AND ARE SUBJECT TO FINAL SURVEY
3. ORIGIN OF LEVELS ON A.H.D. IS TAKEN FROM **SSM 61848** R.L. **109.954** (A.H.D.) IN ROWALLAN AVENUE
4. CONTOUR INTERVAL **0.5 m**
5. CONTOURS ARE INDICATIVE ONLY. ONLY SPOT LEVELS SHOULD BE USED FOR CALCULATIONS OF QUANTITIES WITH CAUTION
6. KERB LEVELS ARE TO THE TOP OF KERB UNLESS SHOWN OTHERWISE
7. FLOOR LEVELS SHOWN ARE THRESHOLD LEVELS. NO INVESTIGATION OF INTERNAL FLOOR LEVELS HAS BEEN UNDERTAKEN
8. AN INVESTIGATION OF UNDERGROUND SERVICES HAS BEEN MADE. UNDERGROUND SERVICES HAVE BEEN DETECTED BY "DOWN UNDER DETECTION SERVICES" AND ARE APPROXIMATE ONLY. SOME SERVICES SUCH AS FIRE&WATER SUPPLY, GAS AND OPTICAL FIBRE CABLING DO NOT HAVE METALLIC TRACING WIRES OR METAL PIPES AND MAY NOT HAVE BEEN DETECTED. SERVICES HAVE ALSO BEEN PLOTTED FROM RELEVANT AUTHORITIES RECORDS AS SUPPLIED BY DIAL BEFORE YOU DIG.
9. 8/.4/7 DENOTES TREE SPREAD OF 8m, TRUNK DIAMETER OF 0.4m & APPROX HEIGHT OF 7m
10. BEARINGS SHOWN ARE MGA (MAP GRID OF AUSTRALIA) ADD APPROX. 1°00' FOR TRUE NORTH

0 8 12 16 24 32 40
SCALE 1:400 @ A1

Revision	Date	Description	Reference
D	00/00/00	-	00
C	00/00/00	-	00
B	00/00/00	-	00
A	00/00/00	-	00

THIS IS THE PLAN REFERRED TO IN MY LETTER DATED:

....
Registered Surveyor NSW

LTS LOCKLEY
Registered Surveyors NSW
www.ltsl.com.au

Suite 1, Level 1
810 Pacific Highway
Gordon NSW 2072
Locked Bag 5
Gordon NSW 2072
P 1300 587 000
F 02 9499 7760

Client CASTLE LAROOL DM PTY LTD

Drawing title PLAN OF DETAIL AND LEVELS OVER LOTS 5 - 14 IN DP232658 AND LOTS 16 - 19 IN DP237030 BEING No.'s 4, 6, 8, 10, 12, 14, 16, 18, 20 & 22 LAROOL CRESCENT & No.'s 44, 46, 48 & 50 CARRAMARR ROAD, CASTLE HILL

datum AHD
site Area 10054m² BY TITLE 10125m² BY SURVEY
LGA THE HILLS SHIRE
project number -
scale 1:400 @A1
reference number 41889DT
date of survey 10/05/15
SHEET 1 OF 3 SHEETS

SHEET 2

SHEET 3 ADJOINS

SEE SHEET 1 FOR NOTES AND LEGEND

SCALE 1:200 @ A1

Revision	Date	Description	Reference
D	00/00/00	-	00
C	00/00/00	-	00
B	00/00/00	-	00
A	00/00/00	-	00

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datum AHD

site Area 10054m² BY TITLE, 10125m² BY SURVEY

LGA THE HILLS SHIRE

project number -

scale 1:200 @A1

reference number 41889DT

date of survey 10/05/15

SHEET 2 OF 3 SHEETS

SHEET 3

SEE SHEET 1 FOR NOTES AND LEGEND

SCALE 1:200 @ A1

Revision	Date	Description	Reference
D	00/00/00	-	00
C	00/00/00	-	00
B	00/00/00	-	00
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Suite 1, Level 1
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datum	project number	reference number
AHD	-	41889DT
site Area 10054m² BY TITLE 10125m² BY SURVEY	scale 1:200 @A1	date of survey 10/05/15
LGA THE HILLS SHIRE	SHEET 3 OF 3 SHEETS	3

ANNEXURE B

ACOR Consultants (CC) Pty Ltd Flood Impact Assessment
Reference GO150722
Version 2.0
Dated 3 July 2018

ACOR CONSULTANTS

Suite 2.01, Level 2
4 Ilya Avenue
ERINA NSW 2250

PO Box 3772
Fountain Plaza
ERINA NSW 2250

T 02 4324 3499

www.acor.com.au

ENGINEERS

MANAGERS

INFRASTRUCTURE PLANNERS

DEVELOPMENT CONSULTANTS

FLOOD IMPACT ASSESSMENT
For a Proposed Residential Development

Client: Castle Larool DM Pty Ltd

Property: Lots 5-14 DP 232658 & Lots 16-19 DP 237030
(No.'s 4-22 Larool Crescent and 44-50 Carramarr Road)
Castle Hill

Date: 4 July 2018

Document Identification

Our Reference: **GO150722**

For and on behalf of ACOR Consultants (CC) Pty Ltd

Quality Information

Version	Description	Date	Author	Signature	Reviewer	Signature
1.0	DRAFT Revised Flood Impact Assessment	01/02/2018	Amanda Newman		Bruce Kenny	
2.0	DRAFT Revised Flood Impact Assessment	03/07/2018	Amanda Newman		Bruce Kenny	
3.0	Revised Flood Impact Assessment	04/07/2018	Amanda Newman	ANewman	Bruce Kenny	[signature]

Distribution

No. of Copies	Format	Distributed to	Date

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Annexures

Annexure A ACOR Consultants (CC) Pty Ltd Flood Plans, reference GO150722, sheets F1 to F8, revision C, dated 3 July 2018

1.0 Introduction

ACOR Consultants (CC) Pty Ltd (ACOR) has been commissioned to prepare a 100 Year ARI Flood Impact Assessment in accordance with the requirements of The Hills Development Control Plan (DCP) 2012 Part C Section 6 Flood Controlled Land and The Hills Local Environmental Plan (LEP) 2012 Clause 7.3. The Flood Impact Assessment is supported by a flood study which investigates flood behaviour throughout the overland flooding catchment impacting the subject site. This includes the analysis of:

- Surface runoff across the catchment;
- Flooding towards the lower part of the catchment; and
- Backwater flooding impact on the subject site.

A two-dimensional computer model of the catchment was established to analyse overland flood behaviour under existing and proposed catchment conditions. The model provides information on the extent of flood inundation, flood depths and flood velocities throughout the catchment for the 100 Year ARI overland flood event. Results from this study form the technical basis for the subsequent flood risk management plan which identifies problem areas and investigates options to reduce the risk of flooding.

1.1 Objective

The objective of the study is to define local overland flooding in accordance with the Floodplain Development Manual (NSW DIPNR 2005) and The Hills DCP 2012 Part C Section 6. It involved the following steps:

- Attend the site to assess the anticipated extent and nature of flooding and identify hydraulic controls likely to impact on flooding behaviour;
- Develop hydrologic model to determine 100 Year ARI flood hydrographs; and
- Develop hydraulic model to determine 100 Year ARI flood levels, velocities and provisional hazard categories; and
- Review flooding behaviour and provide recommendations to ensure that future redevelopment of the site will meet flood compatibility standards.

1.2 Site Description

The subject site is identified on the survey plans prepared by LTS Lockley, reference 41889DT, sheets 1 to 3, dated 10 May 2015. The subject site is comprised of the sites known as:

- Lot 5 DP 232658 (No. 6) Larool Crescent, Castle Hill;
- Lot 6 DP 232658 (No. 4) Larool Crescent, Castle Hill;
- Lot 7 DP 232658 (No. 50) Carramarr Road, Castle Hill;
- Lot 8 DP 232658 (No. 48) Carramarr Road, Castle Hill;
- Lot 9 DP 232658 (No. 46) Carramarr Road, Castle Hill;

- Lot 10 DP 232658 (No. 44) Carramarr Road, Castle Hill;
- Lot 11 DP 232658 (No. 22) Larool Crescent, Castle Hill;
- Lot 12 DP 232658 (No. 20) Larool Crescent, Castle Hill;
- Lot 13 DP 232658 (No. 18) Larool Crescent, Castle Hill;
- Lot 14 DP 232658 (No. 16) Larool Crescent, Castle Hill;
- Lot 16 DP 237030 (No. 14) Larool Crescent, Castle Hill;
- Lot 17 DP 237030 (No. 12) Larool Crescent, Castle Hill;
- Lot 18 DP 237030 (No. 10) Larool Crescent, Castle Hill; and
- Lot 19 DP 237030 (No. 8) Larool Crescent, Castle Hill.

The subject site is bounded by Carramarr Road to the west and Larool Crescent to the north, south and east. The subject site is located amongst residential development.

The subject site has a total area of 10,150 square metres and is zoned R2 Low Density Residential (The Hills Shire Council 2018). Current development of the site consists of 14 single residential dwellings and associated ancillary structures.

The site owner proposes to demolish the existing structures on site and construct a multi-unit residential complex consisting of 180 dwellings distributed across five buildings. The primary features of the proposed design are depicted in 'Preferred Design Option – Typical Level Plans' prepared by AE Design Partnership, dated 22 June 2018.

1.3 Flood Characteristics

The site is located in close proximity to an overland flow path. An area of approximately 41 ha drains through the overland flow path at the southern intersection of Larool Crescent and Carramarr Road. The location of the subject site within the overland flow catchment is depicted in Figure 1 (refer GO150722/F1/C, copy enclosed under Annexure A).

Land use within the overland flow catchment is mainly residential, with commercial and retail development dominating the upper reaches of the catchment. Elevations within the catchment are generally within the range 100 m AHD to 160 m AHD.

No adopted Flood Study or Floodplain Risk Management Plan covering overland flows within the catchment was discovered during a review of available flood information within The Hills Shire Council LGA.

2.0 Available Data

This flood study used topographic, flooding and rainfall data obtained from a number of sources. The origin and types of information underpinning the assumptions used in this study are presented below.

2.1 Published Flood Data

No published flood information applicable to the subject site was discovered during a review of available flood information within The Hills Shire Council LGA.

2.2 Survey Data

Survey information adopted for this study has been collated from the following sources:

- ALS survey provided by NSW Spatial Services;
- GIS layers of cadastre and satellite imagery provided by NSW Spatial Services; and
- Site survey prepared by LTS Lockley, reference 41889DT, sheets 1 to 3, dated 10 May 2015.

2.3 Design Storm Event Data

This study uses design rainfall intensity-frequency-duration (IFD) data, derived for the latitude and longitude of the study area. This IFD data was issued by the Hydrometeorological Advisory Service of the Australian Bureau of Meteorology in April 1997.

The IFD data provides average rainfall intensities of design storm events for recurrence intervals up to and including the 100 Year ARI event.

Uniform areal distribution of design storms has been assumed for the catchment due to its small area. Rainfall depths and temporal patterns were developed for the 100 Year ARI design storm events using techniques described in Australian Rainfall and Runoff (Pilgrim 1998). Estimated average design storm rainfall intensities for the full range of 100 Year ARI storm events considered are presented in Table 1.

Table 1: Average design rainfall intensities.

Duration	Intensity (mm/hr)	Duration	Intensity (mm/hr)
5 min	222.9	45 min	81.0
10 min	170.9	1 hour	68.8
15 min	142.8	90 min	55.3
20 min	124.4	2 hour	47.3
25 min	111.2	3 hour	37.8
30 min	101.0	4.5 hour	30.1

3.0 Hydrologic Modelling

Hydrologic modelling was undertaken within TUFLOW using the Direct Rainfall ('rainfall on the grid') methodology. In the hydraulic model, rainfall is applied directly to the 2D terrain, and the hydraulic model automatically routes the flow as determined by the elevation and roughness grids and any included 1D pipeline network.

Direct rainfall modelling is a relatively new feature of hydraulic modelling and it is still being tested on a number of catchments to ensure it is reliably representing the flood behaviour of a given catchment. Runoff is generated over the entire catchment, rather than the more traditional approach of calculating an inflow hydrograph and lumping this in at an assumed location(s). This 'direct rainfall' approach means the whole catchment will be 'wet' and the hydraulic modelling results need to be filtered to show only those cells that genuinely represent areas of catchment flooding. This was achieved by only mapping inundation at cells with a flood depth greater than 0.05 metres.

Direct rainfall was applied to the area indicated as '2D model domain' in Figure 1 (refer GO150722/F1/C, copy enclosed under Annexure A). The design storm events applied to the catchment are the design storm events described in Section 2.3. During hydrologic and hydraulic modelling of the catchment 100% blockage of Council's piped drainage system was assumed.

4.0 Hydraulic Modelling

A TUFLOW 1D/2D model was used to hydraulically route flows through the catchment and to derive flow depths, velocities and hazard for the pre-development and post-development scenarios. This section describes the hydraulic modelling approach and hydraulic model development.

4.1 Choice of Hydraulic Model

Different hydraulic modelling approaches can be applied according to the floodplain's hydraulic characteristics and the objectives of the study. The simpler methods lump the left and right overbank floodplain areas and the main channel into a one-dimensional (1D) representation. This approach is relatively simple and computationally fast, and is generally appropriate for modelling flows through pipe networks and straight sections of formed open channel. The main limitation of such 1D modelling approaches is that flow is assumed to occur in a linear direction, and the water levels across the floodplain are assumed to be at the same level as the main channel.

A more detailed two-dimensional (2D) approach is recommended in areas where significant differences can occur between the channel flood level and the floodplain flood levels. This approach is also preferable where separate flow paths and flow around catchment obstructions occur, as is the case in this study. This is a more complex analysis, which requires greater data requirements and computational resources.

The TUFLOW 1D/2D model was chosen to model the catchment hydraulics. This modelling system dynamically couples the one-dimensional and two-dimensional flow paths in the floodplain.

4.2 TUFLOW 1D Model Domain

The piped drainage network within the catchment was not represented in the TUFLOW model, as described in Section 3. As such, there is no 1D model domain in this study.

4.3 TUFLOW 2D Model Domain

The 2D hydraulic model domain covers the area indicated as '2D model domain' in Figure 1 (refer GO150722/F1/C, copy enclosed under Annexure A). A square grid was utilised for this study, with a grid size of 2 m. Each grid element contains information on ground topography (see Section 4.3.1), surface resistance to flow (see Section 4.3.4) and initial water level.

The grid cell size of 2 metres is considered to be sufficiently fine to appropriately represent the variations in floodplain topography and land use within the study area. It should be noted that TUFLOW samples elevation points at the cell centres, mid-sides and corners, as a consequence a 2 m square cell size results in surface elevations being sampled every 1 m.

Linear features that potentially influence flow behaviour, such as gullies and levees were incorporated into the topography using 3D 'breaklines' to ensure that these were accurately represented in the model. It is noted that although brick walls and fences could also significantly affect local overland flow paths, these have not been explicitly incorporated into the model in urban areas unless deemed critical to the study, and were instead considered in the setting of appropriate Manning's 'n' values for these areas.

4.3.1 Topography

A 1 m grid Digital Elevation Model (DEM) was generated for the catchment using ALS survey data. This DEM was used to represent ground elevations throughout the catchment.

Land use categories were assigned to areas of the catchment based on examination of aerial photography and satellite imagery. These land use categories were used to assign roughness and infiltration parameters during modelling. Further detail on the modelling of infiltration and catchments roughness is contained in Section 4.3.3 and Section 4.3.4 respectively.

4.3.2 Building Footprint

The footprints of buildings surrounding critical flow paths are modelled as blocked elements within the 2D domain. Building footprints were digitised and removed from the active 2D domain to prevent floodwaters entering buildings. Some large buildings within the catchment were modelled with increased roughness in order to represent the potential for storage of floodwaters within the buildings. Building outlines were determined from aerial photographs and site survey.

In general, buildings far away from the subject site or far from critical flow paths were modelled at ground level with other landform disturbances by adjusting the Manning's 'n' hydraulic roughness value (see Section 4.3.4).

4.3.3 Infiltration

Infiltration losses were modelled using an Initial Loss/Continuing Loss (IL/CL) infiltration model. Initial losses and continuing loss rates were defined for each land use category. The adopted loss parameters are presented in Table 2 in Section 4.3.4, alongside the roughness parameters, for each land use category.

4.3.4 Roughness

The hydraulic roughness of a material is an estimate of the resistance to flow and energy loss due to friction between a surface and the flowing water. A higher hydraulic roughness indicates more flow resistance; for example, a concrete path has a lower hydraulic roughness than a rough vegetated channel as water flows more freely over concrete than through a vegetated channel. Roughness in TUFLOW is modelled using the Manning's 'n' roughness co-efficient. Table 2 lists the adopted Manning's roughness for each land use.

Table 2: Adopted roughness and infiltration parameters.

Land use category	Initial loss (mm)	Continuing loss (mm/hr)	Manning's n
Large buildings	0.0	0.0	If depth < 0.1 m, n = 0.020 If depth > 0.3 m, n = 2.000 Otherwise interpolate n
Reserves – maintained	5.0	2.0	0.030
Reserves – not maintained	5.0	2.0	0.060
Residential	5.0	2.0	0.035
Roads and carparks	0.0	0.0	0.020

4.4 Boundary Conditions

This section describes the boundary conditions imposed upon the model. Typical model boundary conditions include flows entering the model domain from upstream, backwater effects from hydraulic controls such as chokes and streams downstream, and the flow predicted through the model domain by a separate hydrologic model.

4.4.1 Direct Rainfall

A direct rainfall boundary condition was applied to the area indicated as '2D model domain' in Figure 1 (refer GO150722/F1/C, copy enclosed under Annexure A). The direct rainfall method is described in Section 3.

4.4.2 Upstream Boundary

The use of direct rainfall and the selected 2D model domain means hydrologic and hydraulic modelling commenced at the top of the catchment. As such, no upstream boundary conditions were applied.

4.4.3 Downstream Boundary

A stage-discharge (water level versus flowrate) curve was adopted as the downstream boundary condition. This stage-discharge relationship was generated by TUFLOW by specifying a downstream boundary slope.

5.0 Flood Model Results

This section summarises the results of the hydrologic and hydraulic modelling of overland flows within the catchment. The 100 Year ARI overland flood event critical duration and peak flowrate through the catchment are presented. The behaviour of the 100 Year ARI overland floodwaters within the vicinity of the subject site are described in general terms, and the impact of overland flooding on the subject site is discussed.

5.1 Flood Model Validation

As discussed in Section 2.1, a published description of flood behaviour within or near the subject was not available at the time of preparation of this report. In this regard, it is not possible to validate the modelled flood behaviour against an independent source.

5.2 Critical Duration

The design storm from Table 1 which produced the highest peak discharge through the site was selected as the critical duration storm event. The critical duration for the 100 Year ARI storm event is 2 hours.

5.3 Design Peak Flood Flow

The 100 Year ARI peak flowrate passing through the site is approximately 0.4 m^3/s. Approximately 8.7 m^3/s is conveyed along Larool Crescent to the south of the site. At the southern intersection of Larool Crescent and Carramarr Road, the peak 100 Year ARI flowrate is 10.9 m^3/s.

The peak flowrate occurs approximately 40 minutes after the commencement of rainfall.

5.4 Design Flood Characteristics

The 100 Year ARI flood depth, levels, velocity and provisional flood hazard in the vicinity of the subject site were mapped for both pre- and post-development scenarios. The following flood maps are enclosed under Annexure A:

- Figure 2. Pre-development 100 Year ARI flood depth and level plan (refer GO150722/F2/C);
- Figure 3. Pre-development 100 Year ARI flood velocity plan (refer GO150722/F3/C);
- Figure 4. Pre-development 100 Year ARI provisional flood hazard plan (refer GO150722/F4/C);
- Figure 5. Post-development 100 Year ARI flood depth and level plan (refer GO150722/F5/C);
- Figure 6. Post-development 100 Year ARI flood velocity plan (refer GO150722/F6/C); and
- Figure 7. Post-development 100 Year ARI provisional flood hazard plan (refer GO150722/F7/C).

The 100 Year ARI floodwaters impact the pre-development site at elevations between 110.2 m AHD to 108.6 m AHD, causing partial inundation of the site to depths within the range 0.0 m to 0.5 m. Inundation is primarily confined to those parts of the site located adjacent to the southern and eastern site boundaries with Larool Crescent. Pre-development 100 Year ARI floodwater velocities within the site are within the range 0.0 m/s to 2.0 m/s. Floodwater velocities are highest adjacent to the southern and western site boundaries with Larool Crescent. The 100 Year ARI floodwaters pose Low Hazard to occupants of the pre-development site.

Post-development modelling of the site assumes floodwaters are prevented from entering the site.

Those parts of Larool Crescent north of the site are not impacted by 100 Year ARI floodwaters. Inundation of Larool Crescent occurs to the east and south of the site. The 100 Year ARI floodwater depths within Larool Crescent are greatest to the east of the site known as No. 10 Larool Crescent, where the depth of flooding approaches 1.0 m in both pre-development and post-development scenarios. Larool Crescent is also flooded to a depth greater than 0.5 m in the vicinity of the southern intersection of Larool Crescent and Carramarr Road. Floodwater velocities within the southern part of Larool Crescent generally exceed 2 m/s and locally exceed 3 m/s during the 100 Year ARI flood event in both pre-development and post-development scenarios. The southern reach of Larool Crescent is subject to High Hazard conditions during the 100 Year ARI flood event, preventing pedestrian and vehicle access along this part of the road.

Carramarr Road is not impacted by 100 Year ARI floodwaters adjacent to or north of the proposed development site. High Hazard floodwaters cut Carramarr Road just south of the southern intersection with Larool Crescent during the 100 Year ARI flood event.

5.5 Provisional Flood Hazard

The degree of Provisional Hazard attributed to flooding at the subject site is a function of Hydraulic Hazard (relating to the depth and velocity of floodwaters) and is adjusted to account for the following factors:

- Size of flood;
- Effective warning time;
- Flood awareness;
- Rate of rise of floodwater;
- Duration of flooding;
- Evacuation problems;
- Effective flood access; and
- Type of development.

Hazard categories are defined as either high, intermediate or low hazard and are based on the guidelines outlined in the Floodplain Development Manual (NSW DIPNR 2005) and in particular Figure L.2.

The 100 Year ARI floodwaters pose Low Hazard to occupants of the site.

The southern and eastern sections of Larool Crescent experience High Hazard conditions during the 100 Year ARI flood event.

High Hazard floodwaters prevent safe pedestrian and vehicular access along Carramarr Road south of the proposed development site.

5.6 Flood Affectation of the Proposed Development

The 100 Year ARI floodwaters impact Larool Crescent at elevations within the range 110.5 m AHD to 108.3 m AHD, refer Figure 5 (GO150722/F5/C, copy enclosed under Annexure A). In order to protect the proposed development from inundation during the 100 Year ARI flood event, a deflection wall system or similar will be required along the southern and eastern site boundaries. The minimum top of wall level of the deflection wall system should provide a minimum of 0.5 m freeboard to the 100 Year ARI floodwaters. Any pedestrian and vehicle access points proposed along the southern and eastern site boundary should provide crest levels 0.5 m above the adjacent 100 Year ARI floodwater level.

During the 100 Year ARI flood event, Larool Crescent is impacted by High Hazard floodwaters south of the proposed basement carpark access from Larool Crescent, to the southern intersection with Carramarr Road. Evacuation routes and muster points of persons should be designed giving due regard to the High Hazard floodwaters located south of the site.

5.7 Impact of the Proposed Development

The adopted flood modelling approach of assuming the post-development site is entirely flood protected provides a description of the worst-case scenario for potential impact of the proposed development. Final building form, finished surface levels and adopted flood protection measures may result in less disturbance to the existing flood regime than the description provided below.

The impact of the proposed development on 100 Year ARI floodwater levels is depicted in Figure 8 (refer GO150722/F8/C, copy enclosed under Annexure A). The proposed development results in increases in 100 Year ARI floodwater levels within the range 0.00 m to 0.15 m. The increase in 100 Year ARI floodwater level is confined to the south-eastern section of Larool Crescent and is contained within the road reserve. Associated with the increase in 100 Year ARI floodwaters is a minor increase in the 100 Year ARI inundation extents, again contained within the road reserve of Larool Crescent.

The proposed development results in negligible changes in the velocity of 100 Year ARI floodwaters within Larool Crescent. An increase in the extent of High Hazard floodwaters is observed within Larool Crescent, adjacent to the south-eastern corner of the site. Changes to the velocity and hazard of the 100 Year ARI floodwaters are not observed to impact properties or other parts of the roadway.

6.0 Flood Risk Management

Based on the foregoing, we offer the following response having due regard for the requirements of The Hills DCP 2012 Part C Section 6 and the Floodplain Development Manual (NSW DIPNR 2005).

6.1 Floor Level

All habitable and non-habitable floors are to provide a minimum floor level of FPL3, or be flood protected to a minimum level of FPL3. FPL3 provides 0.5 m freeboard to the 100 Year ARI floodwaters. In this regard, the following FPL3 levels apply:

- Building A: 111.0 m AHD;
- Building B: 110.9 m AHD;
- Building C: 109.8 m AHD;
- Building D: not applicable;
- Building E: 108.8; and
- Building F: not applicable.

6.2 Building Components and Method

Flood compatible building materials are to be used below FPL3. We refer to Section 6.1 for FPL3 levels applicable to each building.

Extensive guidance on flood compatible building materials and methods is provided in 'Reducing Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas' (HNFMSC 2006); a selection of the flood compatible materials and practices described in this resource, supplemented with additional guidance provided in Schedule B of The Hills DCP 2012 Part C Section 6, is summarised below.

Flood compatible floor and sub-floor materials include reinforced or mass concrete and masonry.

Flood compatible floor coverings include tiled concrete and polished timber flooring. Fixed carpet, seagrass matting and linoleum are not flood compatible materials; however, rugs which are easily removed prior to flooding (to prevent floor cover damage) or post flooding (to permit drying of the structural floor) are acceptable.

Suitable wall structure materials include solid brickwork, blockwork, concrete and steel frames. Steel frames should be constructed from open sections where possible and have holes drilled into the bottom steel plates to allow water to drain from the frame in the event of immersion.

Flood compatible wall and ceiling linings include fibre-cement board, brick, concrete (including concrete blocks), stone with waterproof grout, clay tiles glazed with waterproof mortar, glass (including glass blocks), plastic sheeting with waterproof adhesive, steel with waterproof applications, exterior grade plywood, and fully sealed solid wood products. Plasterboard is not a flood compatible material as it requires replacement after extended immersion, however for shallow and short duration floods there may be little damage to plasterboard wall linings. It is recommended that sheet wall linings be installed horizontally with a 20-30 mm gap provided between the bottom wall plate and the base of the wall lining to facilitate ventilation and cleaning of the wall cavity after a flood event. The gap may be covered with skirting board when access to the wall cavity is not required.

Insulation should be closed cell type foam. Nails, bolts, hinges and fittings should be made from nylon, brass, stainless steel or hot dipped galvanised steel. Hinges should be of a removable pin type.

Flood compatible doors include solid panel doors with waterproof adhesives, flush doors with marine ply and closed cell foam, metal doors, and aluminium or galvanised steel frame doors. Aluminium frame windows with stainless steel rollers or similar corrosion and water-resistant materials suffer least damage during flood events. Timber framed windows which have been full epoxy sealed before assembly and fitted with stainless steel or brass fittings are also considered flood compatible.

Ancillary structures such as steps and pergolas shall be constructed of water tolerant materials such as masonry sealed hardwood and corrosion resistant metals. Copper Chrome Arsenate (CCA) treated timber is not a flood compatible material.

Connection to mains power supply, including metering equipment should be located above FPL3. All electrical wiring, switches and outlets should, where possible be located above FPL3. Earth core leakage systems or safety switches should be installed. All wiring, connections and conduit below FPL3 should be suitable for submergence in water. Conduits shall be installed so they will be self-draining in the event of flooding.

Heating and air-conditioning systems, including fuel supply and ducting, should be installed above FPL3. Where this is not possible, they should be installed in such a manner as to minimise damage from submersion. This may be achieved through measures such as access for cleaning and draining of water after flood events, manually operated cut off valves for fuel supply lines and ducts, securely fastening heating equipment and fuel storage tanks to prevent buoyancy and movement, and venting of fuel supply tanks at an elevation of 0.6 m above FPL3.

6.3 Structural Soundness

The proposed buildings, or any system used to provide flood protection to FPL3, are to be capable of withstanding floodwaters, including hydrostatic, hydrodynamic, debris impact and buoyancy up to and including FPL3. The structural design should be certified by a practising Structural Engineer with relevant experience designing buildings on flood prone land.

6.4 Car Parking and Driveway Access

The proposed basement carpark entry located on the southern section of Larool Crescent is impacted by 100 Year ARI floodwaters at elevation 108.5 m AHD. The basement carpark entry is to provide a crest level of 109.0 m AHD in order to protect the basement carpark to FPL3 level.

6.5 Evacuation

The State Emergency Service of New South Wales (SES) is responsible for providing flood updates and issuing Flood Evacuation Warnings and Flood Evacuation Orders. Flood information issued by the SES may be received by local, radio and television news, SMS messaging, Facebook and door-knocking in affected communities. The timing for evacuation of persons is to be established in consultation with the SES.

To increase the flood-readiness of the occupants of the site, owners/occupiers of the site should be made aware of FloodSafe kits developed by the SES which aid household and business development of a Flood Emergency Plan. Information regarding FloodSafe kits is available from http://www.floodsafe.com.au/.

We understand the proposed buildings will provide minimum floor levels which are at, or flood protected to, FPL3. In this regard, it is expected that occupants of the site may remain on site during the 100 Year ARI flood event.

Reliable pedestrian access is available from the site during a 100 Year ARI flood event. Pedestrians may access the site using the pedestrian through link access to the northern part of Larool Crescent, and from Carramarr Road.

The 100 Year ARI floodwaters impacting the basement carpark entry are expected to reach depths of approximately 0.5 m and pose High Hazard conditions. In this regard, it is anticipated that vehicle access to and from the site is not available during a 100 Year ARI flood event.

In the event that the 100 Year ARI flood event is expected to be exceeded, strategies should be adopted in accordance with NSW Government operational guidelines and SES Emergency Evacuation operational guidelines.

7.0 Conclusion

The subject site is impacted by 100 Year ARI floodwaters within the range 108.3 m AHD to 110.5 m AHD. Inundation of the site is confined to those parts of the site adjacent to the southern and eastern parts of Larool Crescent. Post-development modelling of the site assumes measures are employed which prevent floodwaters entering the southern and eastern parts of the site; this provides a worst-case scenario for assessing the impact of the proposed development on flood behaviour.

Significant flooding occurs in the southern and eastern parts of Larool Crescent, which are impacted by High Hazard floodwaters.

The northern section of Larool Crescent, and those parts of Carramarr Road adjacent to and north of the proposed development site are not impacted by 100 Year ARI floodwaters.

Reliable pedestrian access is available to and from the site during the 100 Year ARI flood event. It is expected that floodwaters will prevent effective vehicle access to and from the site during the 100 Year ARI flood event.

The basement carpark entry ramp is to provide a minimum crest level of 109.0 m AHD in order to protect the basement to FPL3 level. Buildings in the eastern and southern parts of the site are to provide minimum floor levels equal to, or be flood protected to FPL3 level. Guidance on the FPL 3 level applicable to each building is provided in Section 6.1.

Flood compatible building materials are to be used below FPL3. Guidance on appropriate flood compatible building materials is provided in Section 6.2.

The proposed development has been demonstrated by site specific flood study to have the potential to increase 100 Year ARI flood levels by up to 0.15 m, create minor localised increases in floodwater velocities and provisional flood hazard within the south-eastern parts of Larool Crescent. Changes in flood behaviour are confined entirely to the southern section of the Larool Crescent road reserve. Changes to the behaviour of the 100 Year ARI floodwaters are not predicted to impact private properties. The predicted impacts described in Section 5.7 represent a worst-case scenario, whereby the entire site is assumed to be flood protected above FPL2. Final building form, finished surface levels and adopted flood protection measures may result in lower impact on flood behaviour within Larool Crescent.

Based on the foregoing, the proposed development generally complies with the intent of The Hills DCP 2012 Part C Section 6 and The Hills LEP 2012 provisions for sites impacted by flooding.

8.0 References

New South Wales Department of Infrastructure, Planning and Natural Resources (NSW DIPNR). (2005). *Floodplain Development Manual: the management of flood liable land*. Sydney, NSW: Author.

Pilgrim D H (Ed.). (1998). *Australian Rainfall and Runoff*. Barton, ACT: Institution of Engineers Australia.

The Hills Shire Council. (2017). *The Hills Development Control Plan 2012*.

The Hills Shire Council. (2018). *The Hills Local Environmental Plan 2012 (Amendment No 50)*.

9.0 Glossary

Terminology in this Glossary has been derived or adapted from the Floodplain Development Manual (NSW DIPNR 2005), where appropriate.

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, expressed as a percentage.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
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.
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.
Design flood	A flood event to be considered in the design process.

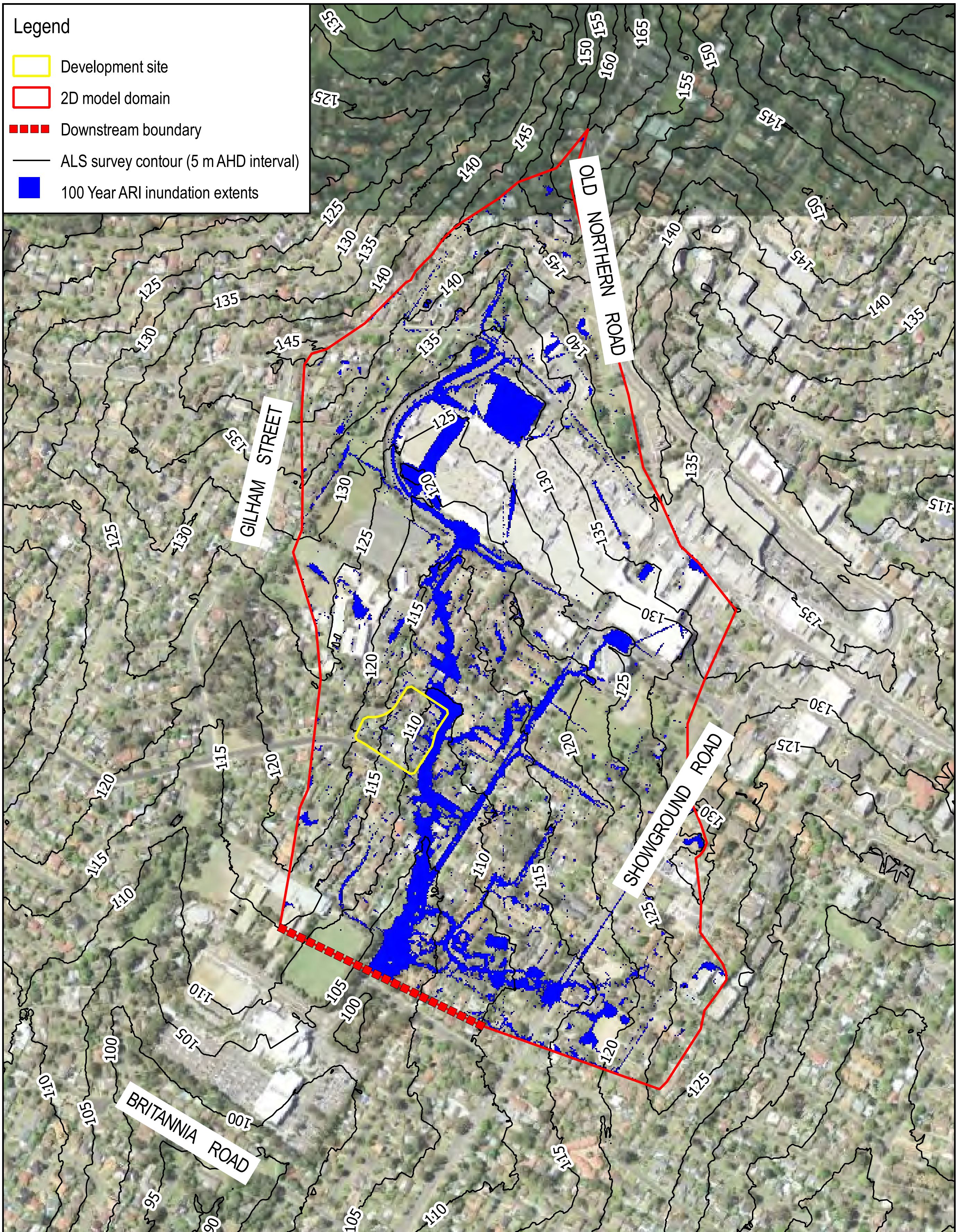
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood hazard	A measure of the floodwaters potential to cause harm or loss. Full definitions of hazard categories are provided in Appendix L of the Floodplain Development Manual (NSW Government, 2005). In summary: • High: conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings. • Low: conditions such that people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Flood planning area	The area of land below the FPL and thus subject to flood related development controls.
Flood planning levels (FPLs)	Combinations of flood levels (derived from significant historical flood events or floods of specific ARIs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans.
Floodplain, flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land.
Floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain.

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. (See Section K5 of Floodplain Development Manual).
Geographical information systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydraulic category	A classification of floodwater hydraulic behaviour. The categories are: • Floodway: those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels. • Flood storage: those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. • Flood fringe: remaining area of flood-prone land after floodway and flood storage areas have been defined
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
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.
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.
Probability	A statistical measure of the expected frequency or occurrence of flooding.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.

ANNEXURE A

ACOR Consultants (CC) Pty Ltd Flood Plans
Reference GO150722
Sheets F1 to F8
Revision C
Dated 3 July 2018



Title: FIGURE 1. TUFLOW MODEL PLAN

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ERINA NSW 2250, Australia
T +61 2 4324 3499

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Client:	CASTLE LAROOL DM PTY LTD
North:	

Job Number:	Sheet:	Revision:	Date:	Designed:	Drawn:	Scale:
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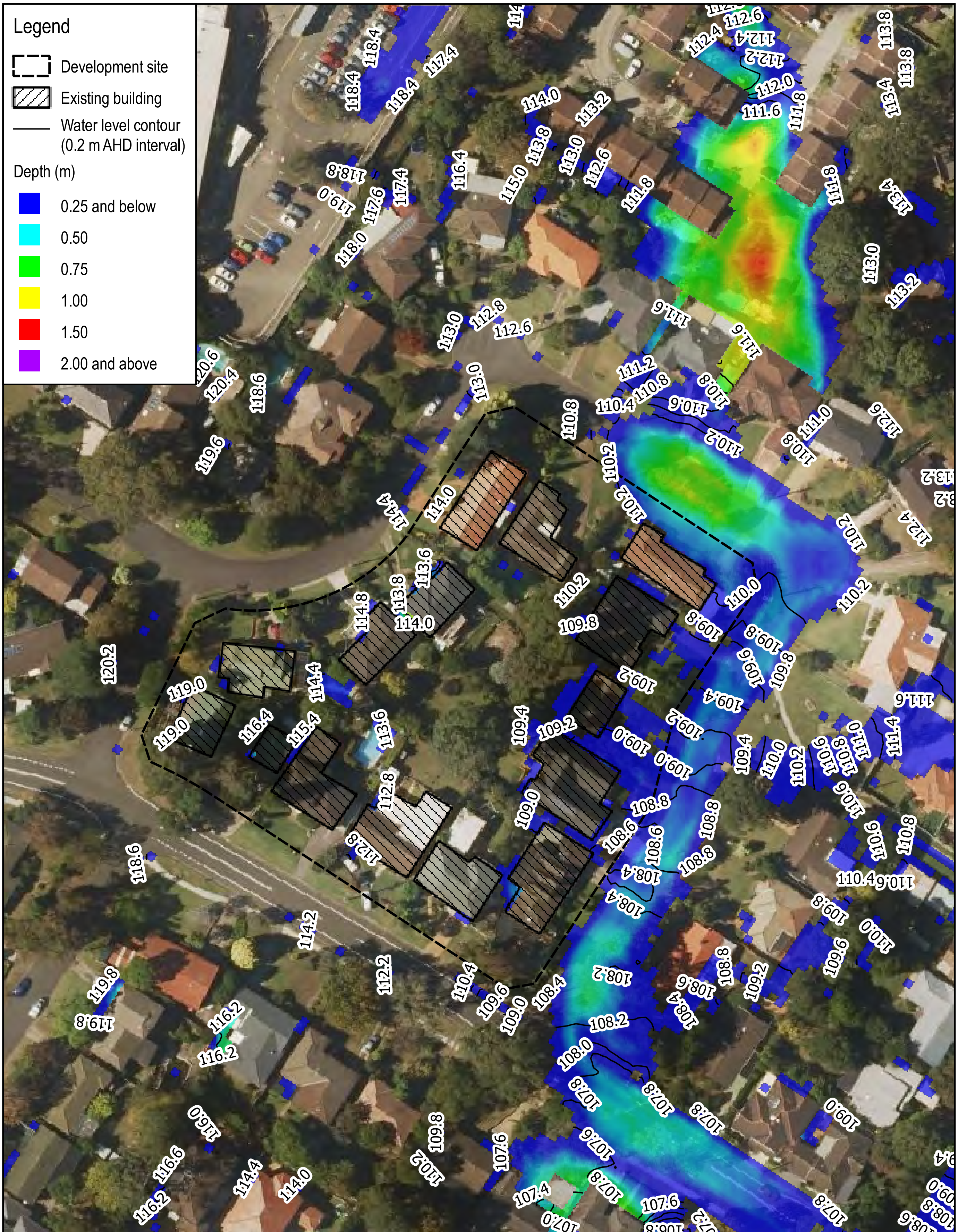

Title: FIGURE 2. PRE-DEVELOPMENT 100 YEAR ARI FLOOD DEPTH AND LEVEL PLAN

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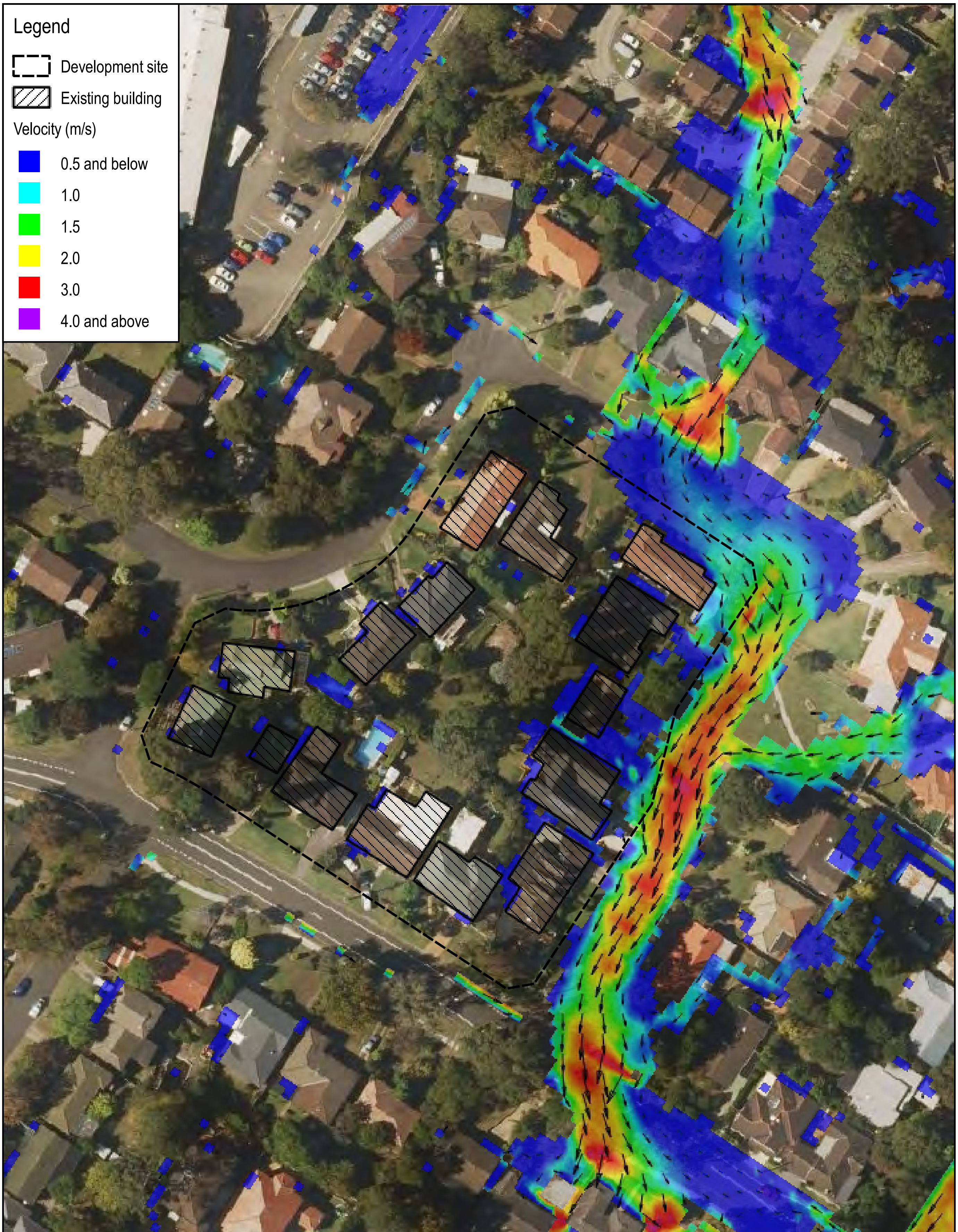

Title: FIGURE 3. PRE-DEVELOPMENT 100 YEAR ARI FLOOD VELOCITY PLAN

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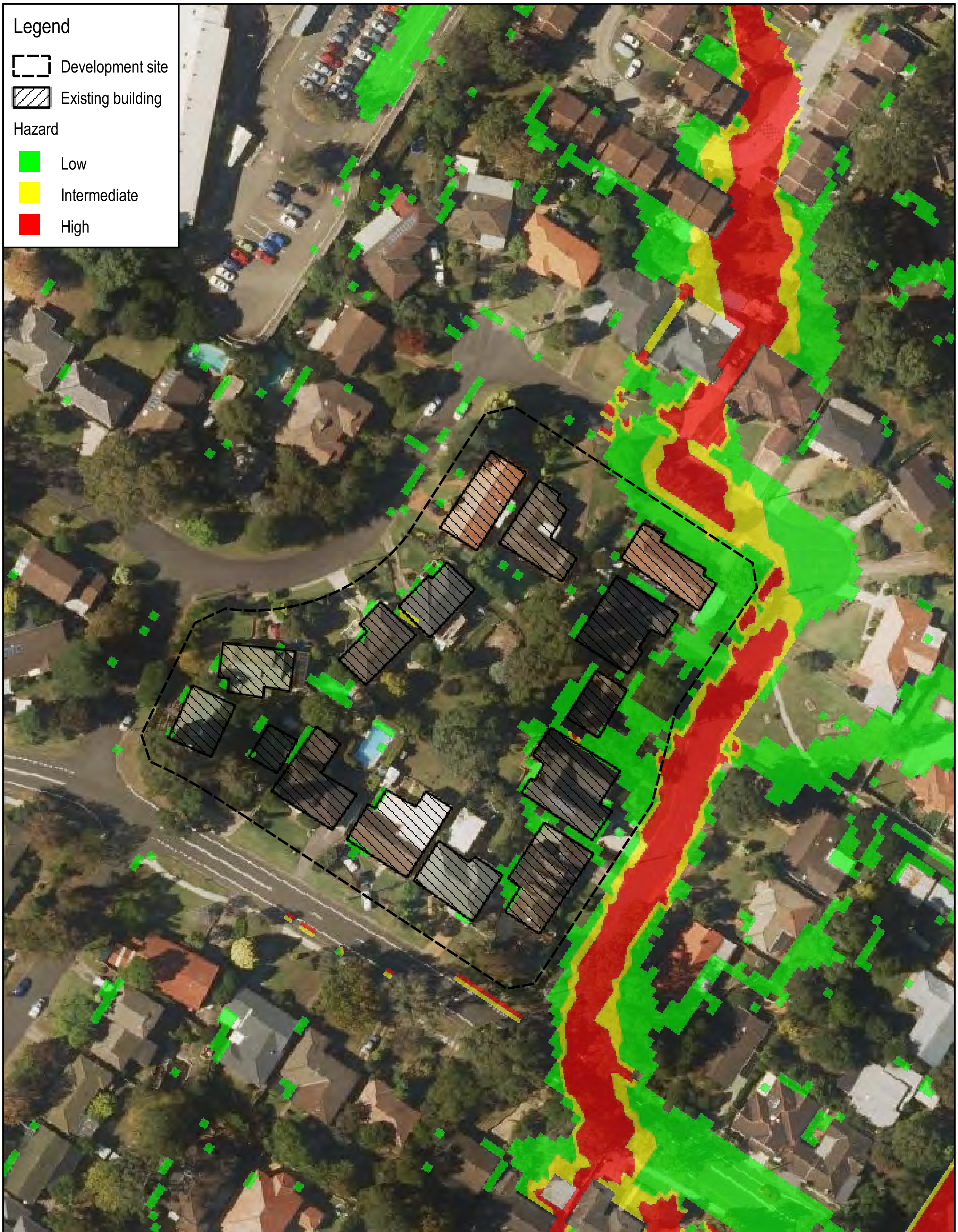

Title: FIGURE 4. PRE-DEVELOPMENT 100 YEAR ARI PROVISIONAL FLOOD HAZARD PLAN

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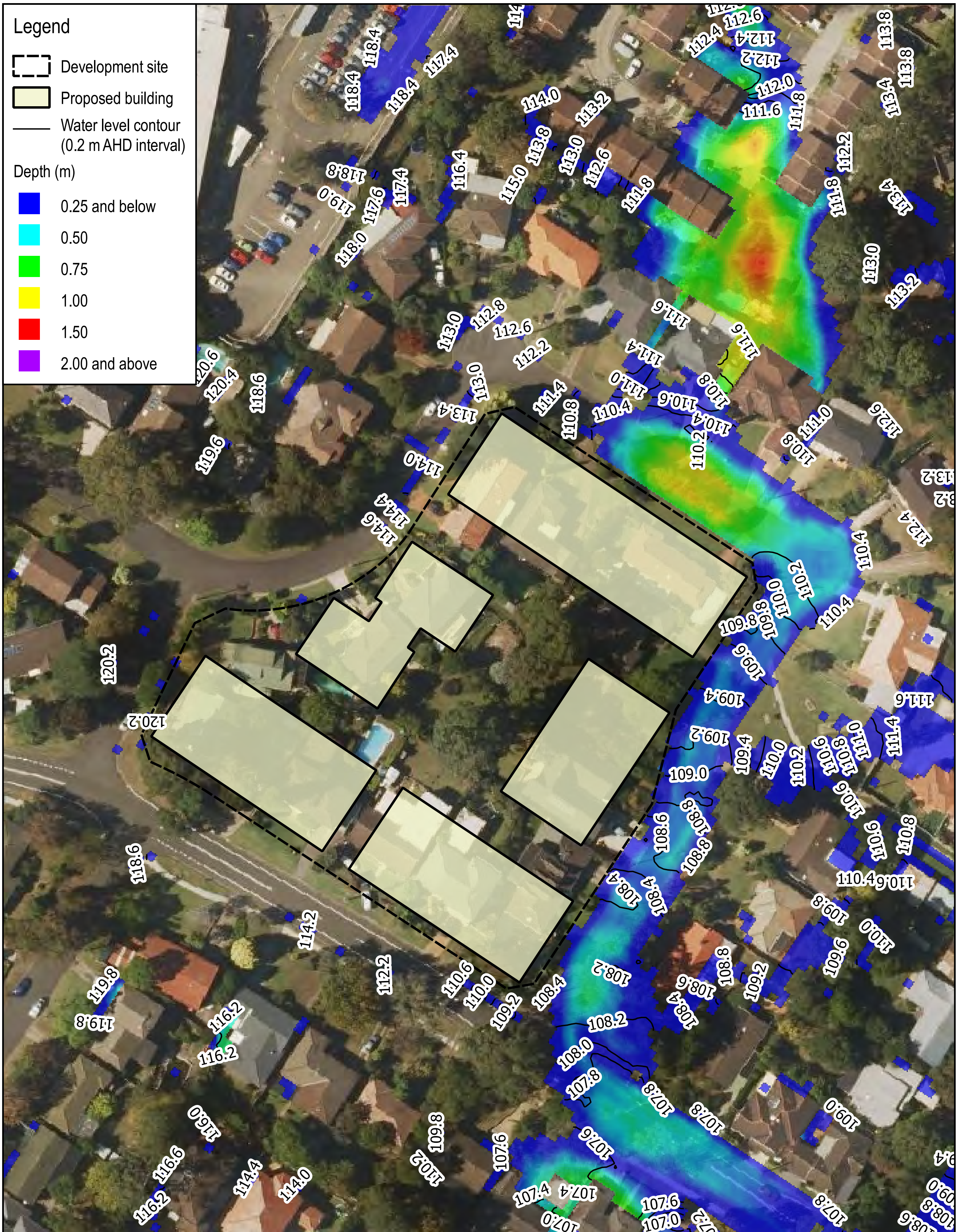

Title: FIGURE 5. POST-DEVELOPMENT 100 YEAR ARI FLOOD DEPTH AND LEVEL PLAN

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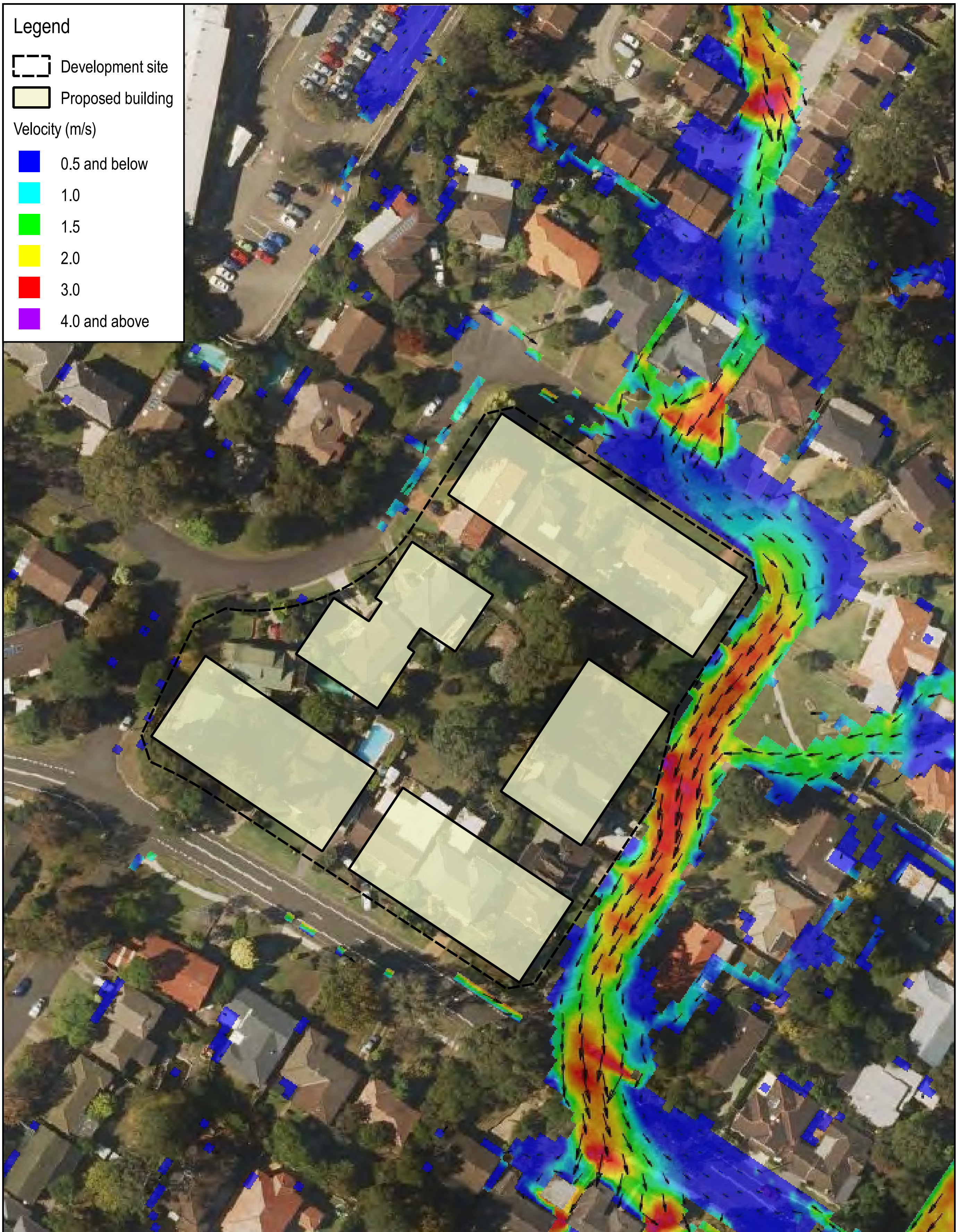

Title: FIGURE 6. POST-DEVELOPMENT 100 YEAR ARI FLOOD VELOCITY PLAN

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T +61 2 4324 3499

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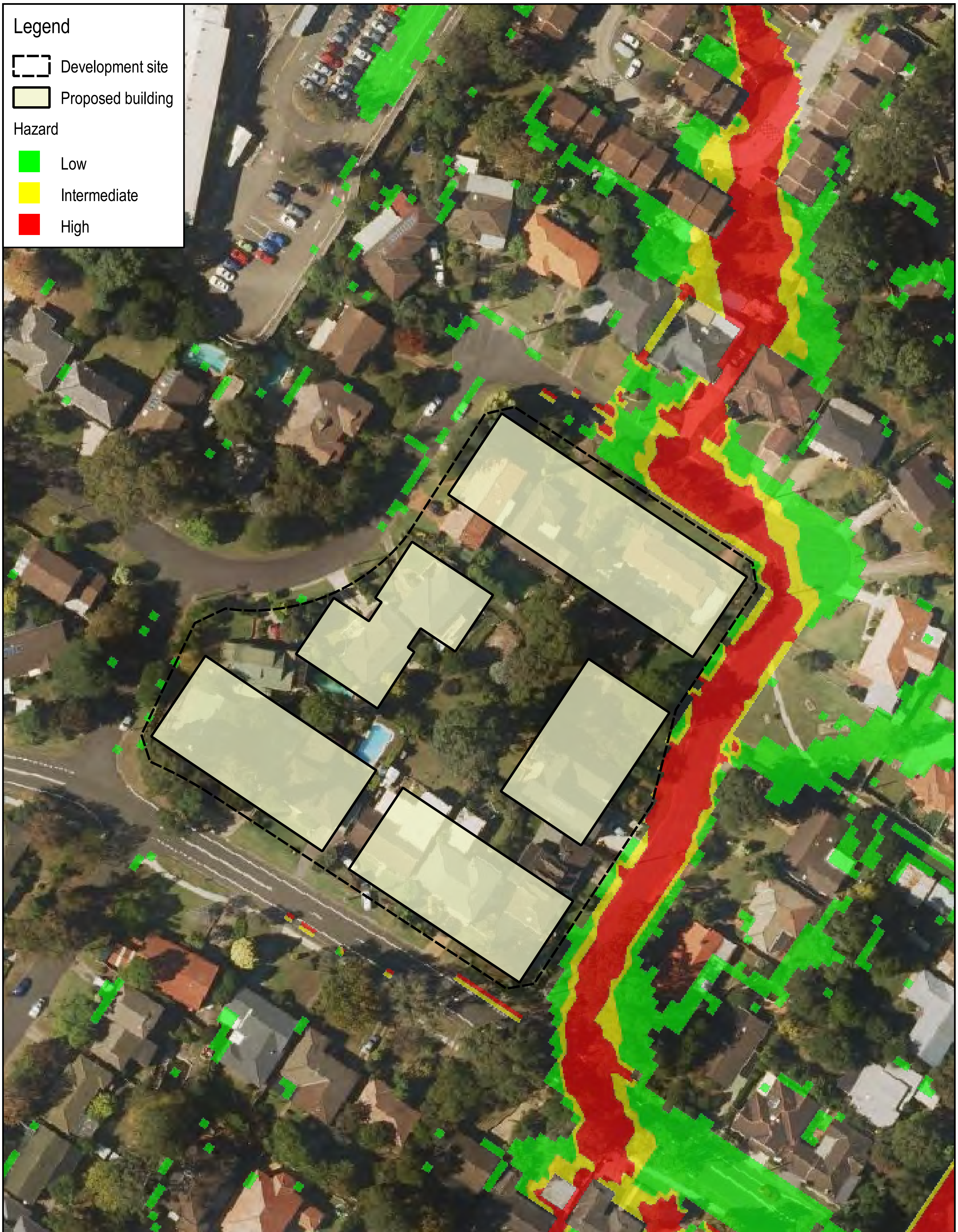
Job Number: GO150722	Sheet: F6	Revision: C	Date: 03.07.2018	Designed: BK	Drawn: AN	Scale: 1:1,200



Title: FIGURE 7. POST-DEVELOPMENT 100 YEAR ARI PROVISIONAL FLOOD HAZARD PLAN

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CASTLE HILL

Client: CASTLE LAROOL DM PTY LTD

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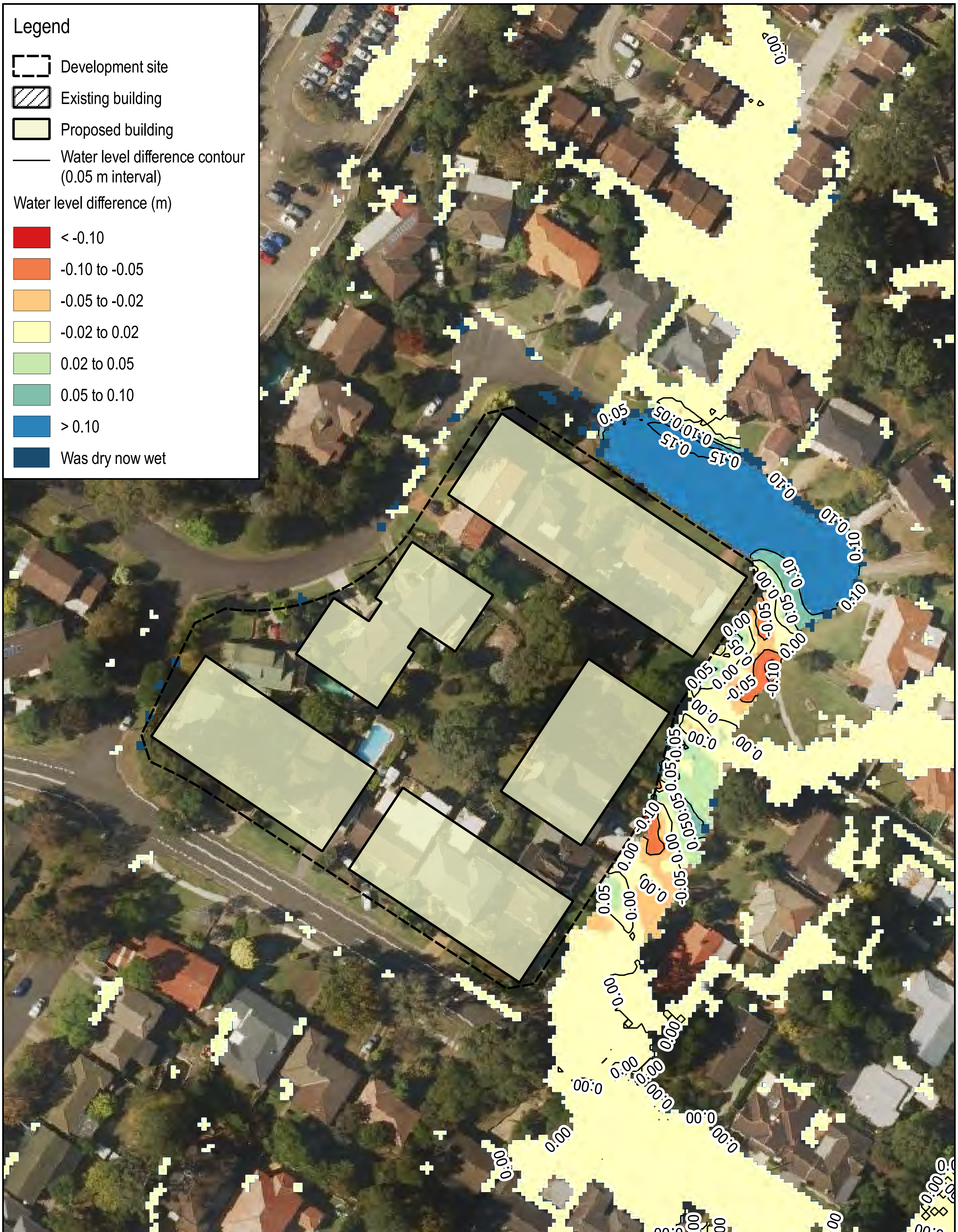
Job Number: GO150722	Sheet: F7	Revision: C	Date: 03.07.2018	Designed: BK	Drawn: AN	Scale: 1:1,200



Title: FIGURE 8. POST-DEVELOPMENT 100 YEAR ARI FLOOD LEVEL DIFFERENCE PLAN

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ANNEXURE C

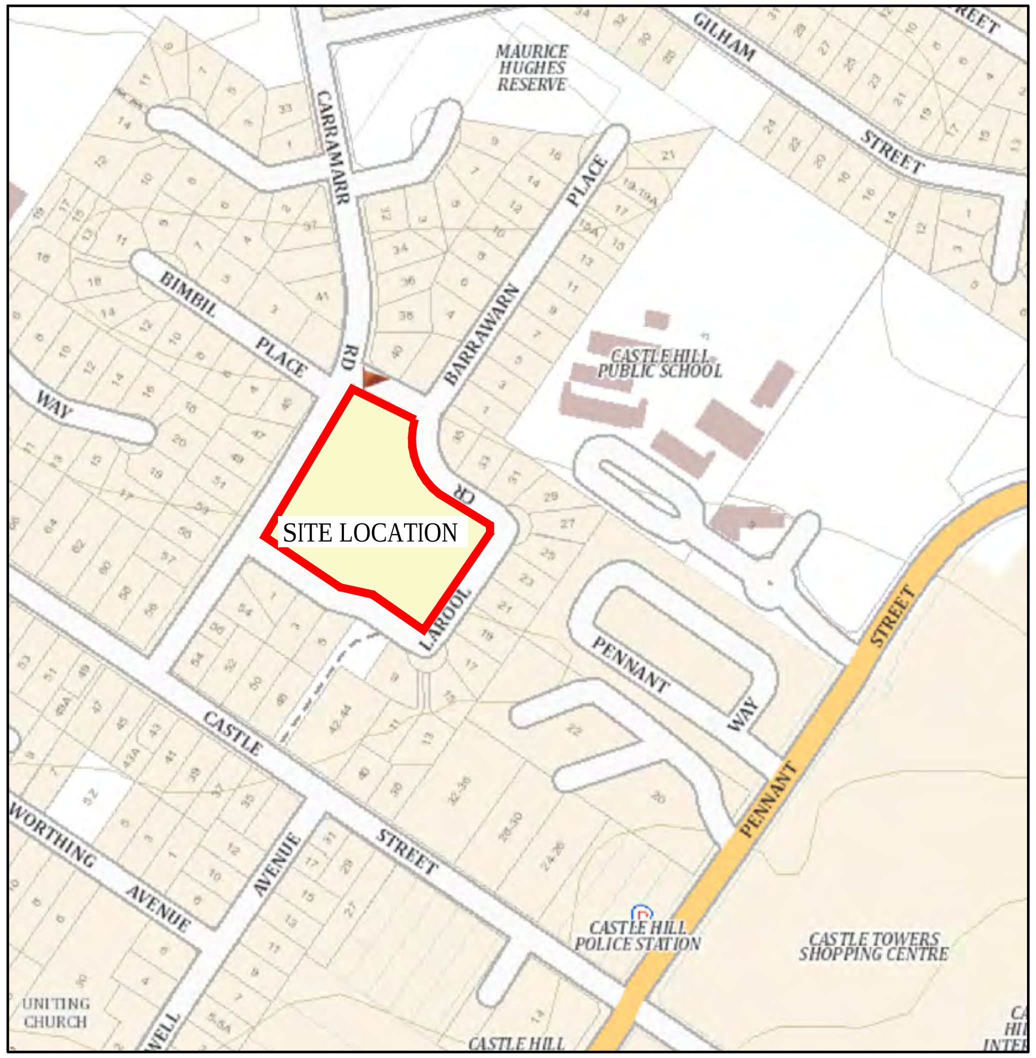
ACOR Consultants (CC) Pty Ltd Stormwater Infrastructure Strategy
Reference GO150722
Sheets G1 to G6
Issue B
Dated 3 July 2018

PROPOSED RESIDENTIAL DEVELOPMENT

CARRAMARR ROAD & LAROOL CRESCENT, CASTLE HILL

STORMWATER INFRASTRUCTURE STRATEGY

CONTENTS:



Issue	Description	Date	Drawn	Approved
B	CLIENT REVIEW	03.07.18	SJ	BK
A	DRAFT ISSUE	01.02.18	SJ	BK

North

Client: CASTLE LAROOL DM Pty. Ltd.

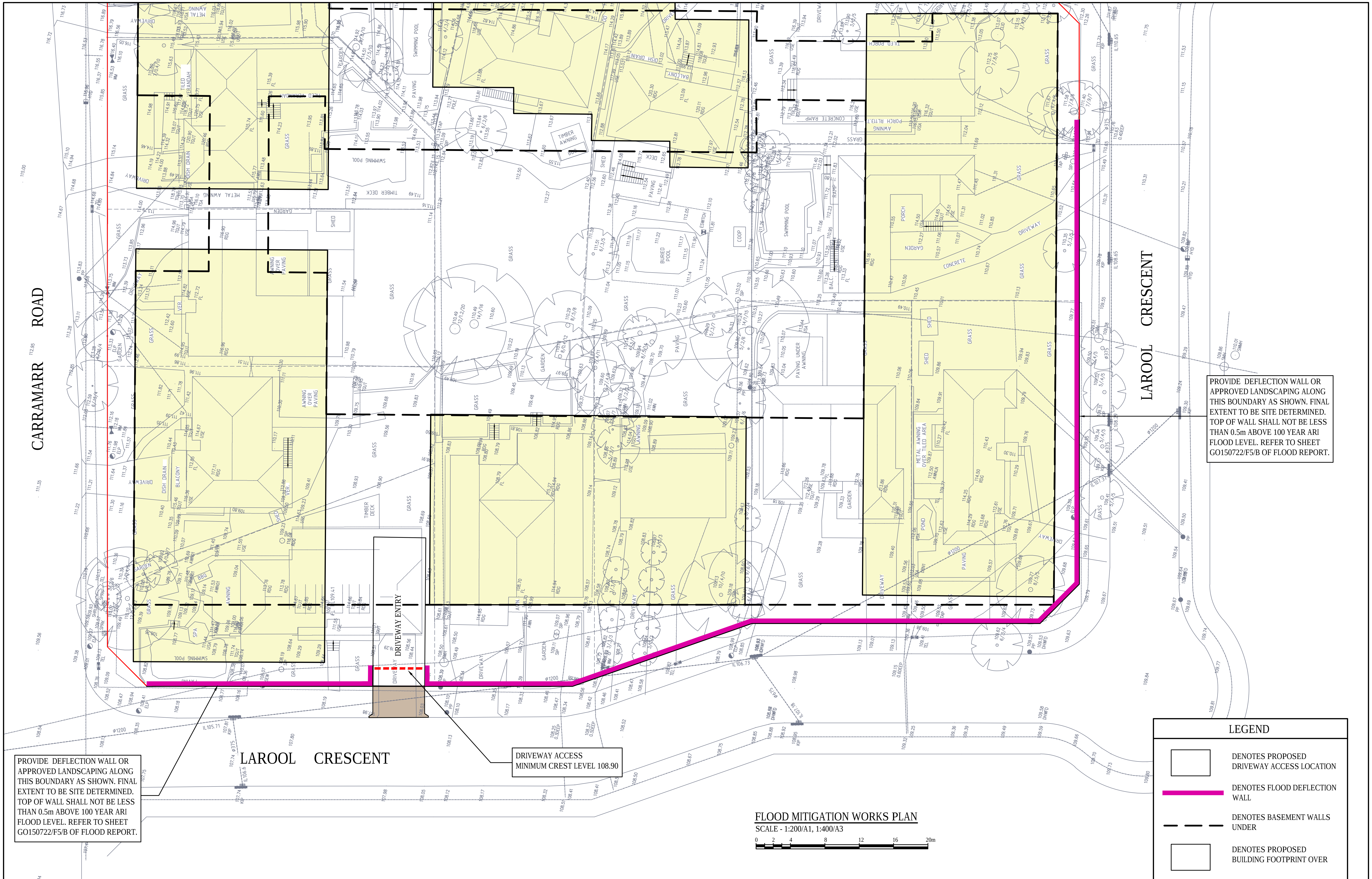
ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

Drawing Title: COVER SHEET

Drawn	Date	Scale	A1	Q.A. Check	Date
SJ	01.02.18	NTS			

Designed	Project No.	Dwg. No.	Issue
BK	GO150722	G1	B



FLOOD MITIGATION WORKS PLAN

SCALE - 1:200/A1, 1:400/A3

0 2 4 8 12 16 20m

LEGEND

- DENOTES PROPOSED DRIVEWAY ACCESS LOCATION
- DENOTES FLOOD DEFLECTION WALL
- DENOTES BASEMENT WALLS UNDER
- DENOTES PROPOSED BUILDING FOOTPRINT OVER

Issue	Description	Date	Drawn	Approved
B	CLIENT REVIEW	03.07.18	SJ	BK
A	DRAFT ISSUE	01.02.18	SJ	BK

0 1cm at full size 10cm

North

Client: CASTLE LAROOL DM Pty. Ltd.

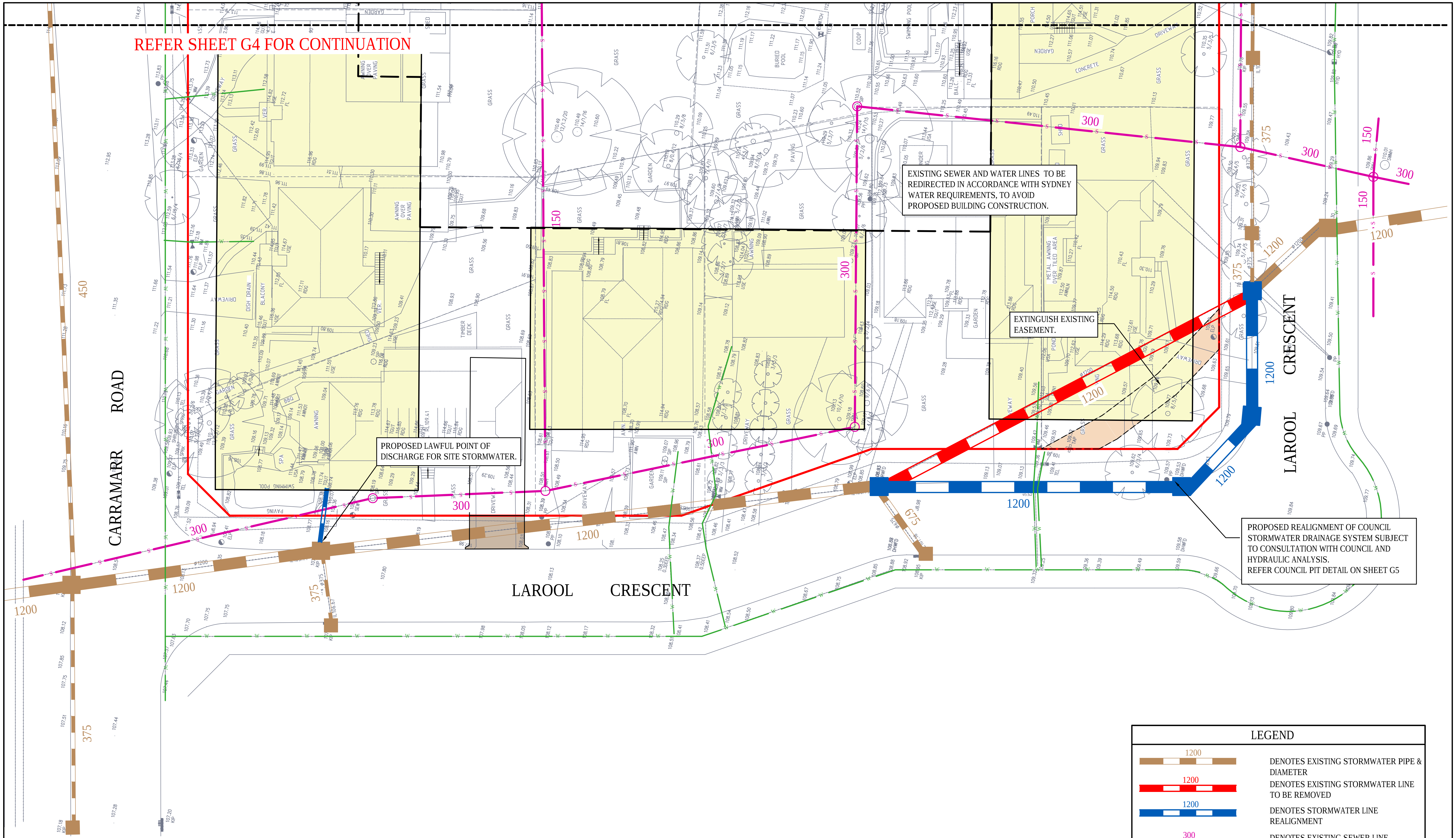
ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
ACOR CONSULTANTS
ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

Drawing Title: FLOOD MITIGATION WORKS

Drawn	Date	Scale	A1	Q.A. Check	Date
SJ	01.02.18	NTS			

Designed	Project No.	Dwg. No.	Issue
BK	GO150722	G2	B



STORMWATER & SEWER INFRASTRUCTURE STRATEGY PLAN - SHEET No.1

SCALE - 1:200/A1, 1:400/A3

0 2 4 8 12 16 20m

LEGEND

1200	DENOTES EXISTING STORMWATER PIPE & DIAMETER
1200	DENOTES EXISTING STORMWATER LINE TO BE REMOVED
1200	DENOTES STORMWATER LINE REALIGNMENT
300 S	DENOTES EXISTING SEWER LINE & DIAMETER
W	DENOTES EXISTING WATER LINE
	DENOTES SITE BOUNDARY
	DENOTES PROPOSED BUILDING ENVELOPE

Issue	Description	Date	Drawn	Approved
B	CLIENT REVIEW	03.07.18	SJ	BK
A	DRAFT ISSUE	01.02.18	SJ	BK

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ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
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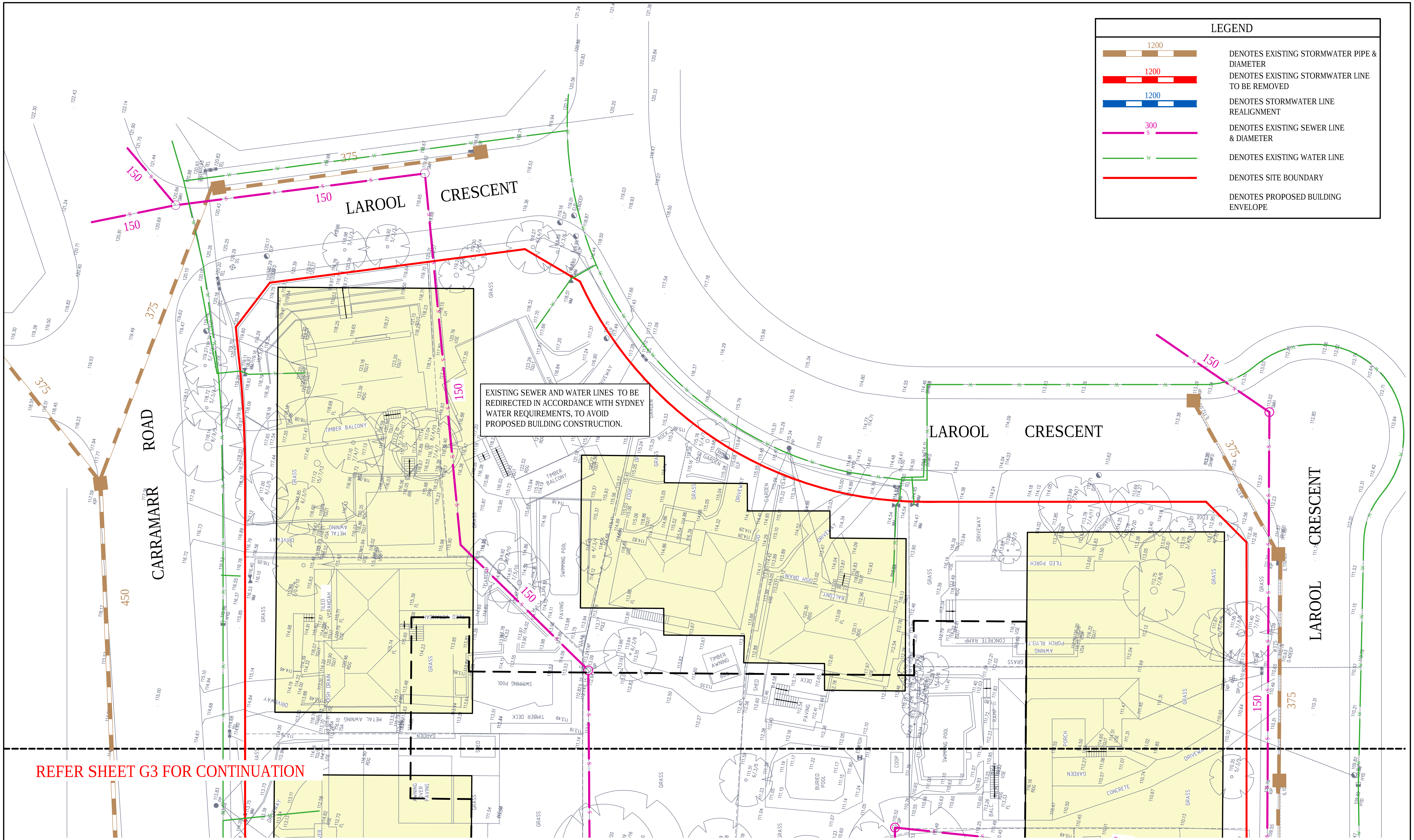
Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

Drawing Title: STORMWATER INFRASTRUCTURE STRATEGY PLAN SHEET No.1

Drawn	Date	Scale	A1	Q.A. Check	Date
SJ	01.02.18	NTS			

Designed	Project No.	Dwg. No.	Issue
BK	GO150722	G3	B



STORMWATER & SEWER INFRASTRUCTURE STRATEGY PLAN - SHEET No.2

SCALE - 1:200/A1, 1:400/A3

0 2 4 8 12 16 20m

Issue	Description	Date	Drawn	Approved
B	CLIENT REVIEW	03.07.18	SJ	BK
A	DRAFT ISSUE	01.02.18	SJ	BK

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ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
ACOR CONSULTANTS
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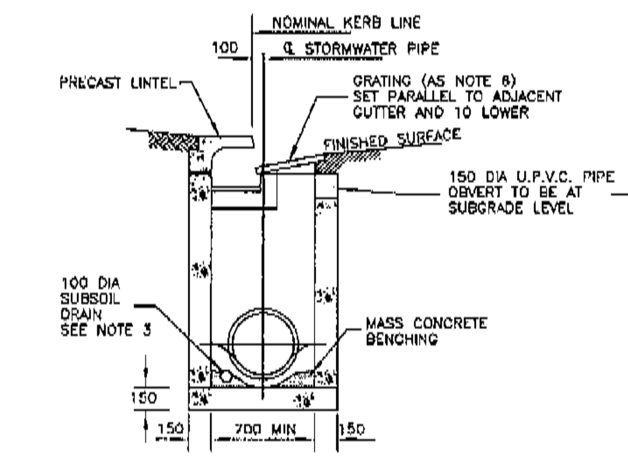
Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

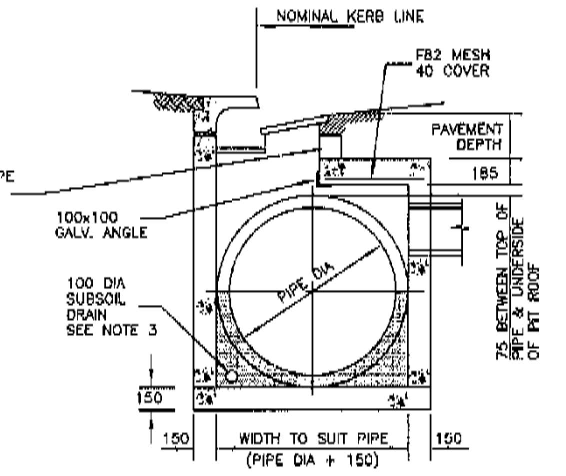
Drawing Title: STORMWATER INFRASTRUCTURE STRATEGY PLAN SHEET No.2

Drawn	Date	Scale	A1	Q.A. Check	Date
SJ	01.02.18	NTS			

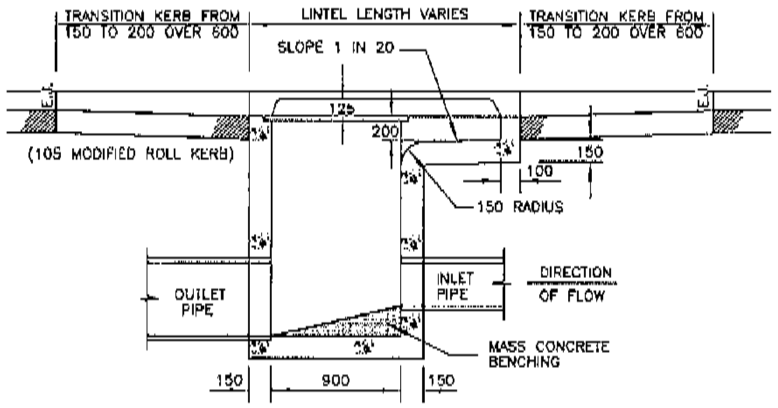
Designed	Project No.	Dwg. No.	Issue
BK	GO150722	G4	B



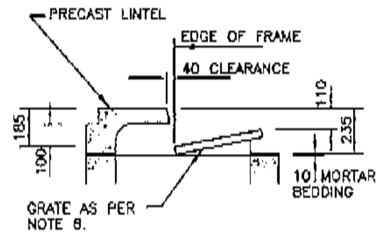
SECTION
STANDARD GRATED KERB INLET PIT
FOR PIPES UP TO 525 DIA



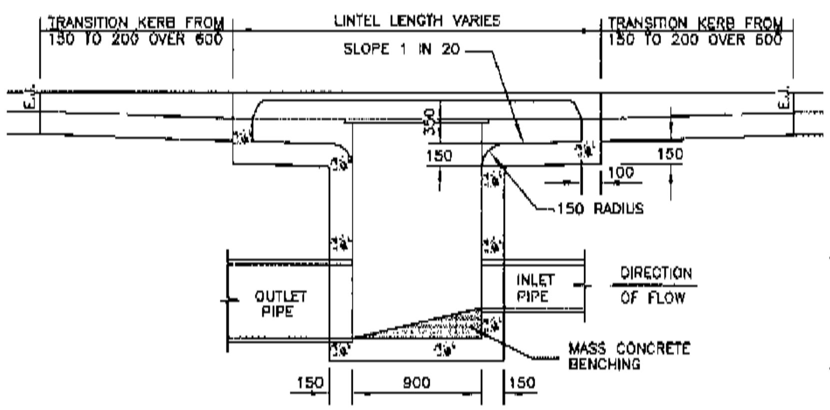
SECTION
(ENLARGED CHAMBER)



SECTION–GRADE PIT



GRATE INSTALLATION
TOLERANCE



SECTION–SAG PIT

NOTES:

1. COMPRESSIVE STRENGTH (F'c) FOR CAST INSITU CONCRETE SHALL BE A MINIMUM 25 MPa AT 28 DAYS.
2. TOP OF BENCHING SHALL BE 1/2 OF OUTLET PIPE DIAMETER.
3. 100mm DIA. SUBSOIL DRAINAGE PIPE 2000 LONG WRAPPED IN FABRIC SOCK TO BE PROVIDED ADJACENT TO INLET PIPES.
4. ALL PITS SHALL BE PROVIDED WITH AN APPROVED LOCKING SYSTEM.
5. PIT GRATE TO BE "WELDLOCK" GULLY GRATE GG 78–51 OR APPROVED EQUIVALENT. (SKIRTED)
6. DURING INSTALLATION OF GRATE AND FRAME ENSURE CLEARANCE BETWEEN LINTEL AND OPEN GRATE. (REFER TO INSTALLATION TOLERANCE)
7. PROVIDE STEP IRONS WHERE PIT IS DEEPER THAN 1200 – SEE SD.6
8. WHERE PITS ARE PROVIDED IN PEDESTRIAN PATHWAYS THE GRATE SHALL BE SUPPLIED WITH A PEDESTRIAN SAFE MESH.
9. WHERE THE PIT DEPTH EXCEEDS 1800 THE WALL AND FLOOR THICKNESS IS TO BE INCREASED AND REINFORCEMENT PROVIDED. (SEE SUBDIVISION SPECIFICATIONS TABLE 6.3)
10. ALL DIMENSIONS ARE IN MILLIMETRES.

THE HILLS Sydney's Garden Shire

THE HILLS SHIRE COUNCIL

DATE: AUG. 2010

GRATED KERB INLET PITS

DRAWING No.: SD.5

Issue	Description	Date	Drawn	Approved
B	CLIENT REVIEW	03.07.18	SJ	BK
A	DRAFT ISSUE	01.02.18	SJ	BK

North

Client: CASTLE LAROOL DM Pty. Ltd.

ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499

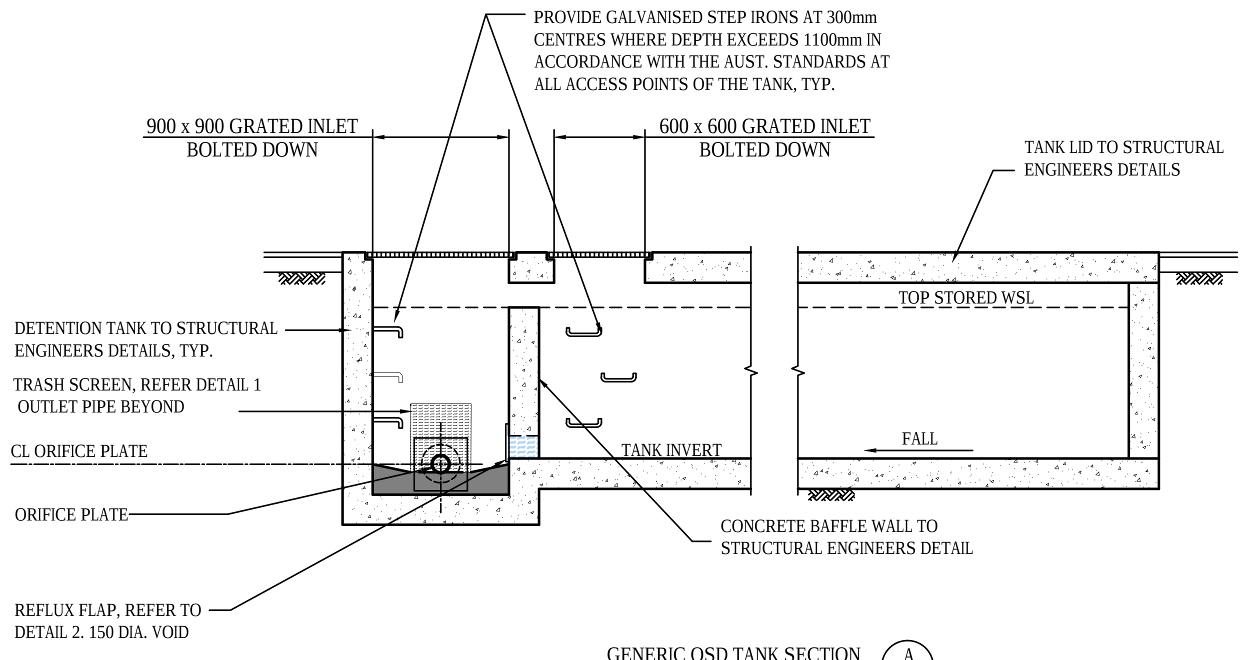
ACOR CONSULTANTS ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

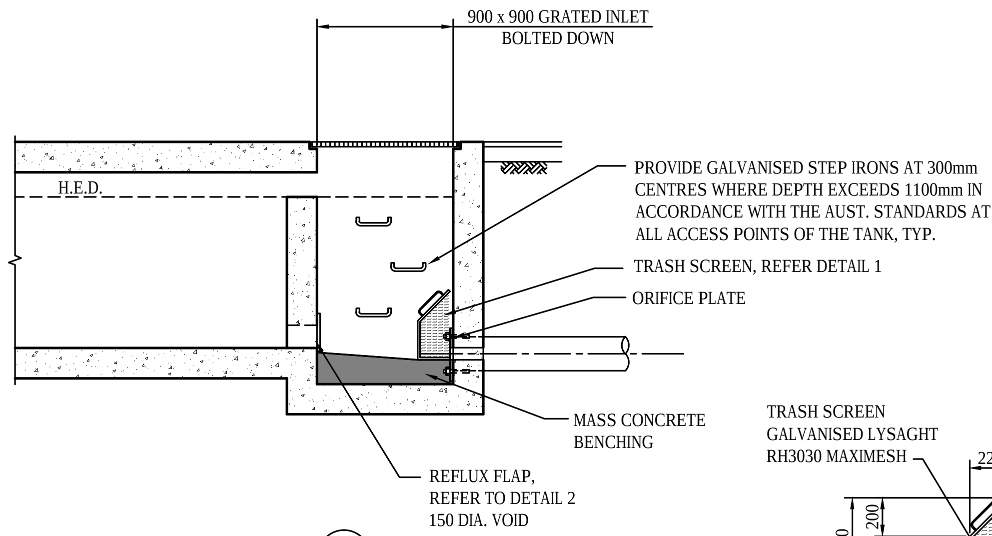
Drawing Title: STORMWATER INFRASTRUCTURE DETAILS SHEET No.1

Drawn	Date	Scale	A1	Q.A. Check	Date
SJ	01.02.18	NTS			

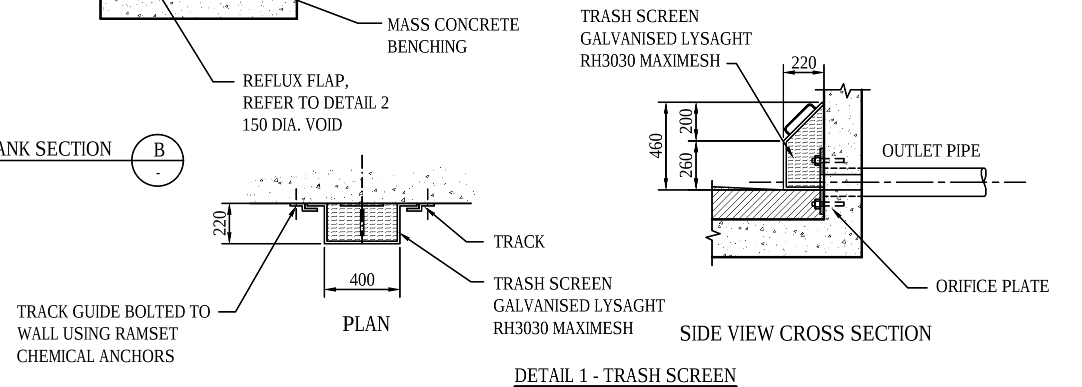
Designed	Project No.	Dwg. No.	Issue
BK	GO150722	G5	B



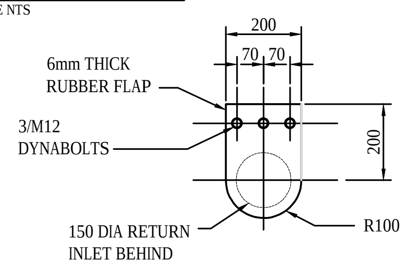
GENERIC OSD TANK SECTION (A)
SCALE 1:25



GENERIC OSD TANK SECTION (B)
SCALE 1:25



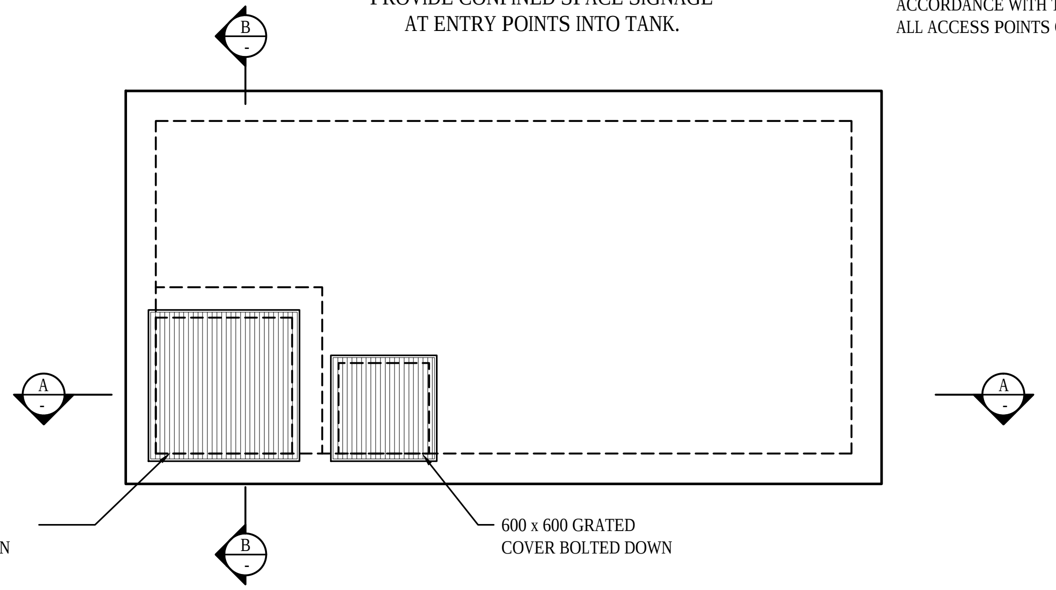
DETAIL 1 - TRASH SCREEN
SCALE NTS



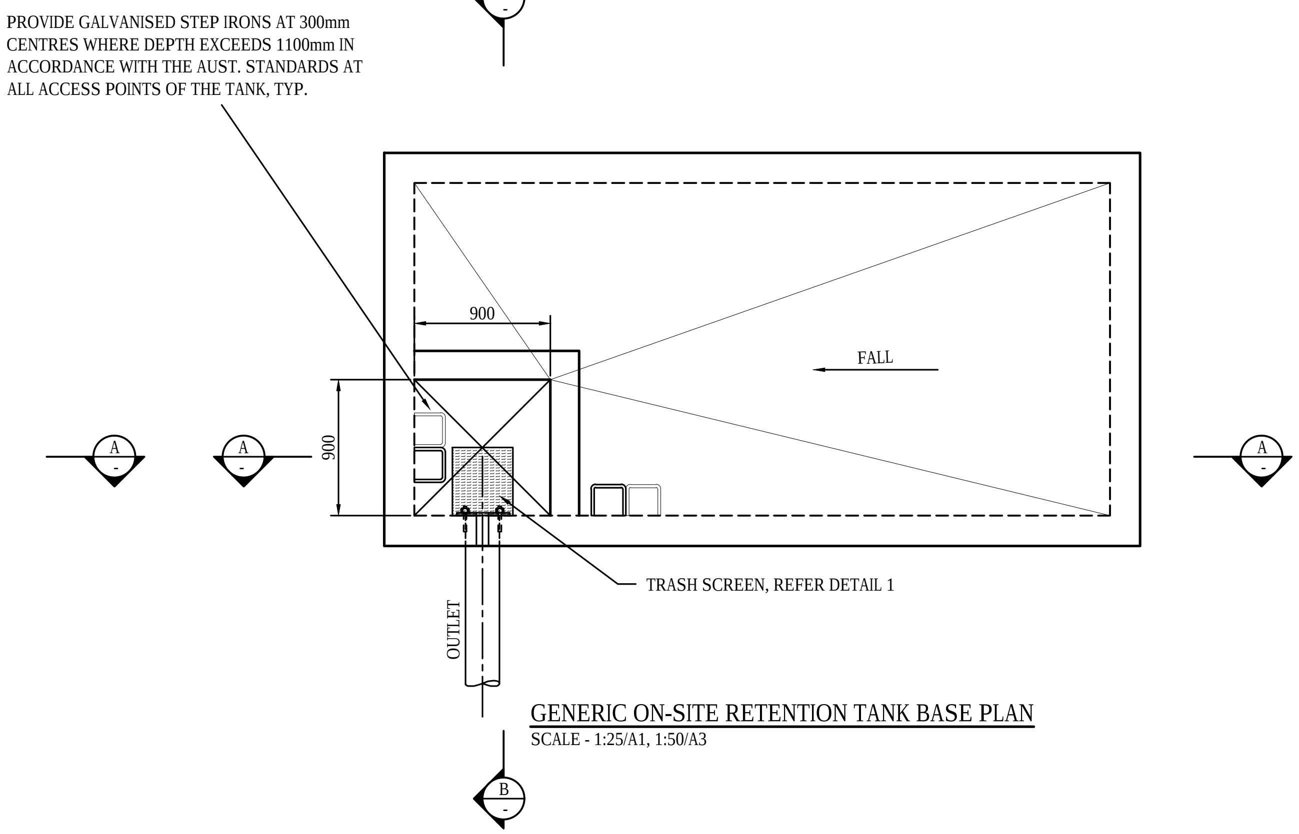
DETAIL 2 - REFLUX FLAP
SCALE 1:10/A1, 1:20/A3

DANGER
CONFINED SPACE
NO ENTRY WITHOUT CONFINED SPACE TRAINING

PROVIDE CONFINED SPACE SIGNAGE AT ENTRY POINTS INTO TANK.



GENERIC ON-SITE DETENTION TANK ROOF PLAN
SCALE - 1:25/A1, 1:50/A3



GENERIC ON-SITE RETENTION TANK BASE PLAN
SCALE - 1:25/A1, 1:50/A3

ON-SITE DETENTION SUMMARY

LOCAL GOVERNMENT.	THE HILLS SHIRE COUNCIL
CATCHMENT	HAWKESBURY RIVER
SITE AREA	10,150m²
SITE SLOPE	6% TO 10%
PERMITTED SITE DISCHARGE	104 l/s
SITE STORAGE REQUIREMENT	362m³/ha
SITE DISCHARGE	105.6 l/s
SITE STORAGE	367m³

Issue	Description	Date	Drawn	Approved
B	CLIENT REVIEW	03.07.18	SJ	BK
A	DRAFT ISSUE	01.02.18	SJ	BK

North

1 0 1cm at full size 10cm

Client
CASTLE LAROOL DM Pty. Ltd.

ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
CONSULTANTS ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project
CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

Drawing Title
STORMWATER INFRASTRUCTURE DETAILS SHEET No.2

Drawn	Date	Scale	A1	Q.A. Check	Date
SJ	01.02.18	NTS			
Designed	Project No.			Dwg. No.	Issue
BK	GO150722			G6	B

ANNEXURE D

ACOR Consultants (CC) Pty Ltd Stormwater Quality Report
Reference GO150722
Sheets Q1.01 to Q1.06
Issue A
Dated 19 October 2015

PROPOSED RESIDENTIAL DEVELOPMENT

CARRAMARR ROAD & LAROOL CRESCENT, CASTLE HILL

STORMWATER QUALITY REPORT

CONTENTS: SHEET No.

Issue	Description	Date	Drawn	Approved
A	CLIENT REVIEW	??	??	LDA

-1 0 1cm at full size 10cm

North

Client: CASTLE LAROOL DM Pty. Ltd.

ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
CONSULTANTS ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

Drawing Title: COVER SHEET

Drawn	Date	Scale A1	Q.A. Check	Date
YF	19/10/2015	AS NOTED		

Designed	Project No.	Dwg. No.	Issue
BK	GO150722	Q1.01	A

1 INTRODUCTION

A CATCHMENT BASED WATER QUALITY MODEL WAS DEVELOPED TO ASSESS THE STORMWATER RUNOFF QUALITY IN ACCORDANCE WITH THE REQUIREMENTS OF THE HILLS SHIRE COUNCIL. IN THIS REGARD WE REFER TO THE PRESCRIBED TARGETS IN THE STORMWATER MANAGEMENT REPORT.

2 STUDY METHODOLOGY

THE OBJECTIVES OF THIS REPORT ARE TO:

- ASSESS THE EXISTING RUNOFF QUALITY FOR THE PRE-DEVELOPMENT SCENARIO AND IDENTIFY STORMWATER QUALITY CONTROLS LIKELY TO IMPACT ON RUNOFF QUALITY.
- ASSESS THE STORMWATER QUALITY FOR THE POST DEVELOPED SCENARIO INCLUDING THWE MEASURES PROPOSED TO MEET THE POLLUTANT REMOVAL TARGETS .

THE REPORT IS BASED ON THE APPLICATION OF MUSIC SOFTWARE (MODEL FOR URBAN STORMWATER IMPROVEMENT CONCEPTUALISATION) . IN THIS REGARD THE MODEL IS DEFINED AS FOLLOWS:

- A STORMWATER QUALITY MODEL TO CONVERT RAINFALL AND EVAPOTRANSPIRATION INTO RUNOFF.
- ESTIMATION OF STORMWATER FLOW AND POLLUTION GENERATION BY SIMULATING THE PERFORMANCE OF STORMWATER TREATMENT DEVICES INDIVIDUALLY AND AS PART OF A TREATMENT TRAIN.

THE MODEL DEFINES WATER QUALITY PROFILES FOR THE PRE AND POST DEVELOPED SCENARIOS. THE POST DEVELOPED MODEL INCLUDES PARAMETERS WHICH REPRESENT THE WATER QUALITY MEASURES.

3 RAINFALL AND EVAPOTRANSPIRATION DATA

FOR THE PURPOSE OF THIS REPORT DATA HAS BEEN OBTAINED FROM NUMEROUS SOURCES, INCLUDING EWATER PLUVIOGRAPH RAINFALL DATA, BUREAU OF METEOROLOGY, ETC.

4 STORMWATER QUALITY MODELLING

4.1 GENERAL

THE FOLLOWING PARAMETERS WERE ASSESSED FOR THE HYDROLOGICAL MODELLING ASSOCIATED WITH THE CATCHMENT.

- RAINFALL/RUNOFF AND EVAPOTRANSPIRATION.
- SUB CATCHMENT DIVERSIONS.
- LAND USE (PERVIOUS AND IMPERVIOUS)

4.2 RAINFALL/RUNOFF AND EVAPOTRANSPIRATION

DAILY RAINFALL DATA WAS OBTAINED FROM THE SYDNEY OBSERVATORY HILL RAINFALL STATION WITH 6 min TIMESTEP. THE DEFAULT MONTHLY AVERAGE POTENTIAL EVAPOTRANSPIRATION DATA IN MUSIC MODEL OF SYDNEY WAS UTILISED IN THIS STUDY IN THE ABSENCE OF THE LOCAL DATA.

5 MUSIC MODEL

THE MUSIC MODEL IS BASED ON A 6 min RAINFALL-RUNOFF MODEL IN CONJUNCTION WITH REPRESENTATIVE BASEFLOW AND STORMFLOW EVENT MEAN CONCENTRATIONS (EMCs).

5.1 WATER QUALITY PARAMETERS

THE ADOPTED VALUES OF VARIOUS MUSIC RAINFALL AND RUNOFF PARAMETERS ARE SUMMARISED IN TABLE 5.1.

TABLE 5.1 - ADOPTED MUSIC RAINFALL/RUNOFF PARAMETERS

PARAMETER	VALUE
IMPERVIOUS AREA PROPERTIES	
RAINFALL THRESHOLD (mm/DAY)	1.5
PERVIOUS AREA PROPERTIES	
SOIL STORAGE CAPACITY (mm)	300
SOIL INITIAL STORAGE (% OF CAPACITY)	7
FIELD CAPACITY (mm)	172
INFILTRATION CAPACITY COEFFICIENT - a	200
INFILTRATION CAPACITY EXPONENT - a	1
GROUNDWATER PROPERTIES	
INITIAL DEPTH (mm)	1
DAILY RECHARGE RATE (%)	25
DAILY BASEFLOW RATE (%)	5
DAILY DEEP SEEPAGE RATE (%)	4

STORMWATER QUALITY IS CHARACTERISED USING EVENT MEAN CONCENTRATION (EMCs) UNDER STORM AND BASE FLOW CONDITIONS. THE VALUE OF WATER QUALITY PARAMETERS ADOPTED IN THIS STUDY IS SUMMARISED IN TABLE 5.2

STORMWATER QUALITY IS CHARACTERISED USING EVENT MEAN CONCENTRATION (EMCs) UNDER STORM AND BASE FLOW CONDITIONS. THE VALUE OF WATER QUALITY PARAMETERS ADOPTED IN THIS STUDY IS SUMMARISED IN TABLE 2.6

TABLE 5.2 - ADOPTED MUSIC WATER QUALITY PARAMETERS

LAND-USE CATEGORY		Log_{10} TSS (mg/L)		Log_{10} TP (mg/L)		Log_{10} TN (mg/L)	
		STORM FLOW	BASE FLOW	STORM FLOW	BASE FLOW	STORM FLOW	BASE FLOW
GENERAL URBAN	MEAN	2.20	1.10	-0.45	-0.82	0.42	0.32
	STD DEV	0.32	0.17	0.25	0.19	0.19	0.12
ROADS	MEAN	2.38	1.10	-0.60	-0.82	0.42	0.32
	STD DEV	0.40	0.17	0.50	0.19	0.19	0.12
ROOFS	MEAN	1.55	1.10	-0.92	-0.82	0.42	0.32
	STD DEV	0.39	0.17	0.29	0.19	0.19	0.12
FOREST	MEAN	1.90	0.90	-1.10	-1.50	-0.075	-0.14
	STD DEV	0.20	0.13	0.22	0.13	0.24	0.13

5.2 STORMWATER TREATMENT MEASURES

THE PROPOSED STORMWATER TREATMENT MEASURES INCLUDED IN THE POST DEVELOPED MODEL INCLUDE:

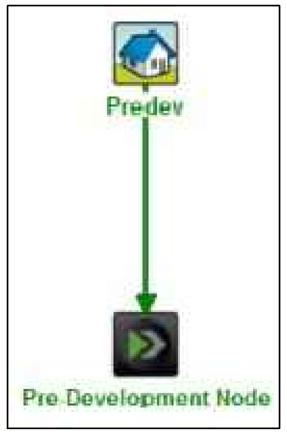
- 362,000 LITRE OSD TANK
- 12 SPEL STORMSACKS HOUSED IN CONCRETE VAULT
- 8 SPEL STORMSACK PIT INSERTS

THE SCHEMATIC LAYOUT FOR THE PRE AND POST DEVELOPED MUSIC MODELS ARE DEPICTED ON SHEET Q1.06.

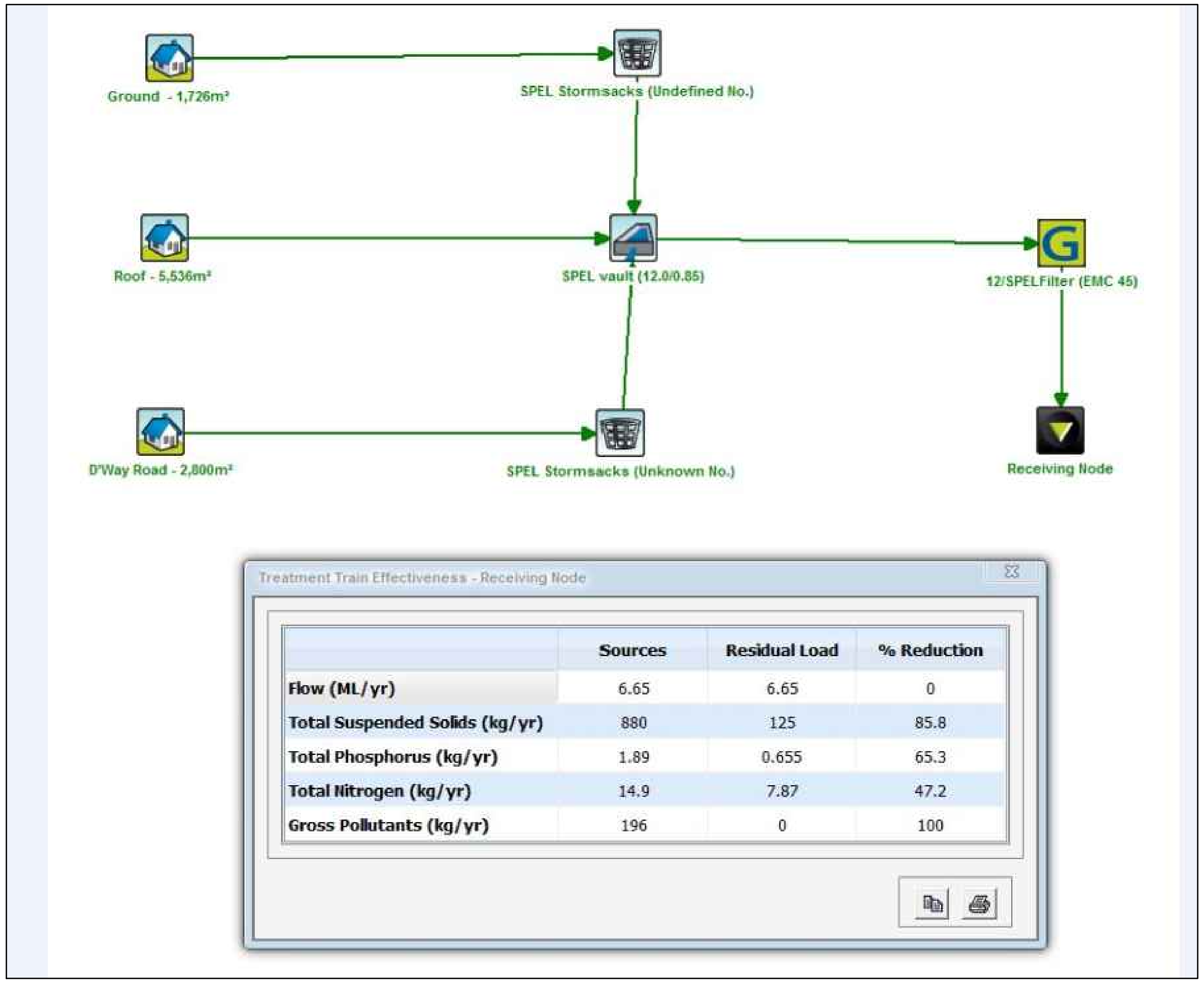
6 RESULTS & CONCLUSION

BASE ON THE FOREGOING THE PROPOSED WATER QUALITY MEASURES ACHIEVE THE REQUIRED NUTRIENT REMOVAL TARGET LEVELS. IN THIS REGARD WE REFER TO TABLE ON SHEET Q1.06.

7 PRE-DEVELOPMENT & POST DEVELOPMENT MUSIC MODELS

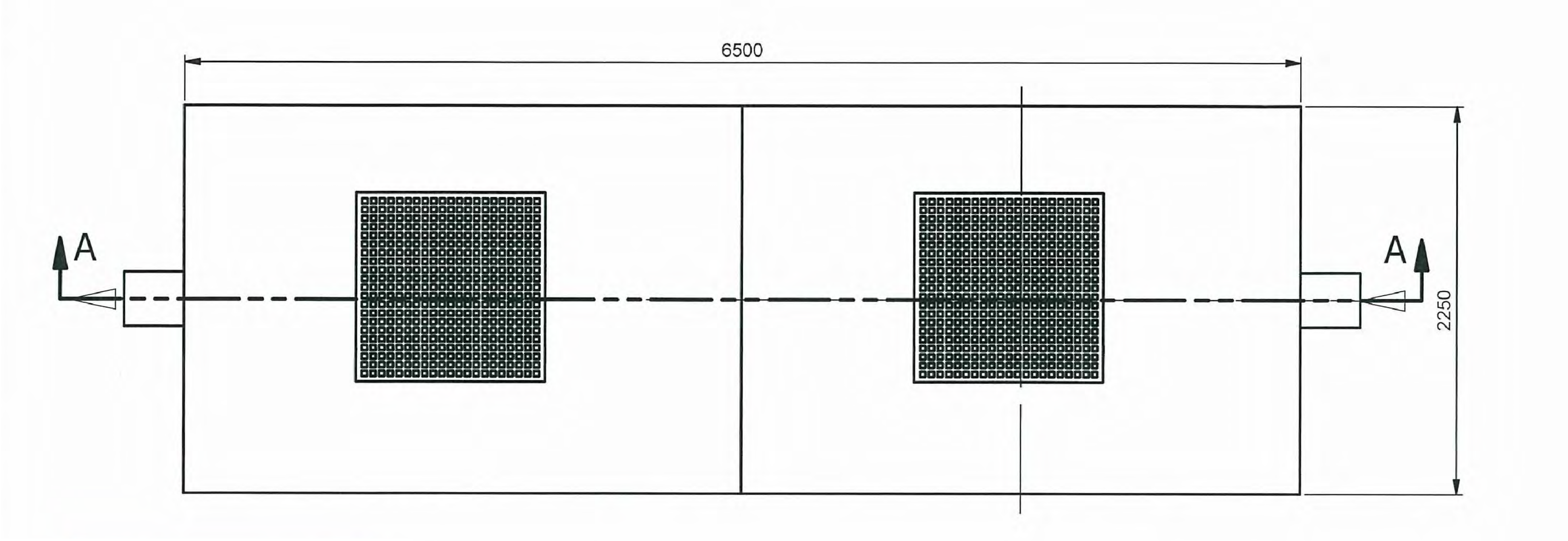


PRE-DEVELOPMENT MUSIC MODEL
SCALE - NTS

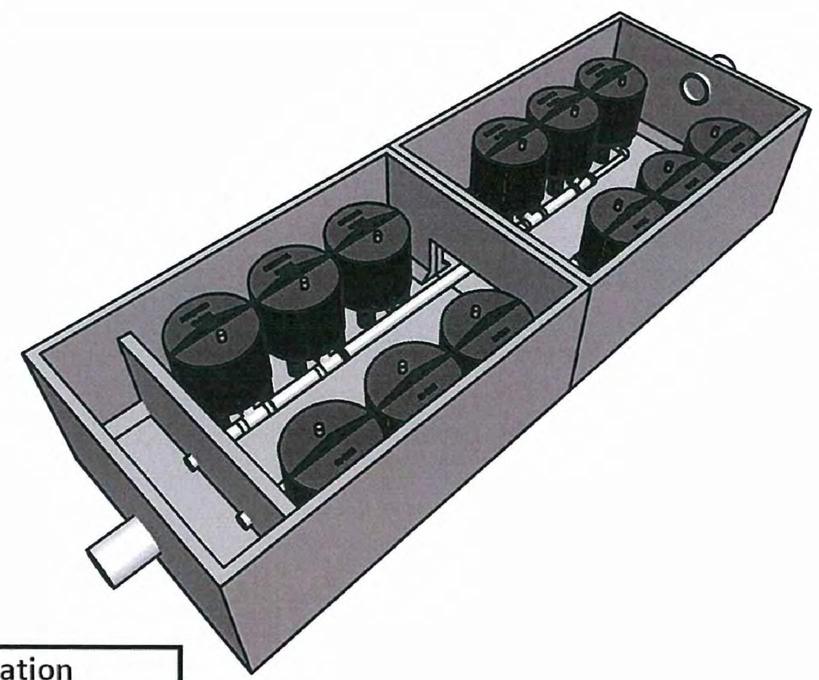


	Sources	Residual Load	% Reduction
Flow (ML/yr)	6.65	6.65	0
Total Suspended Solids (kg/yr)	880	125	85.8
Total Phosphorus (kg/yr)	1.89	0.655	65.3
Total Nitrogen (kg/yr)	14.9	7.87	47.2
Gross Pollutants (kg/yr)	196	0	100

POST-DEVELOPMENT MUSIC MODEL
SCALE - NTS

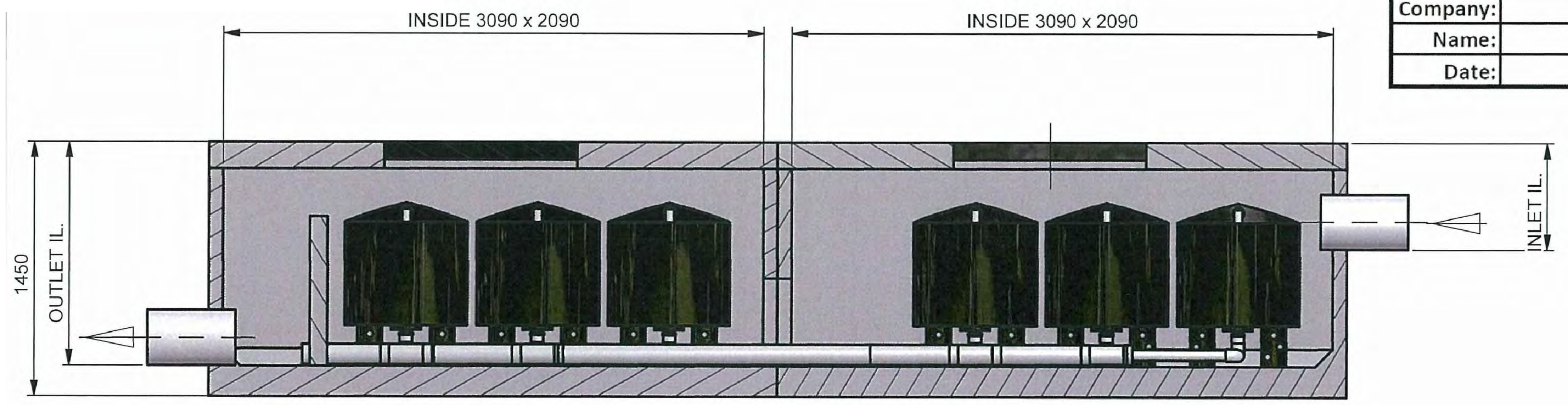


PLAN VIEW

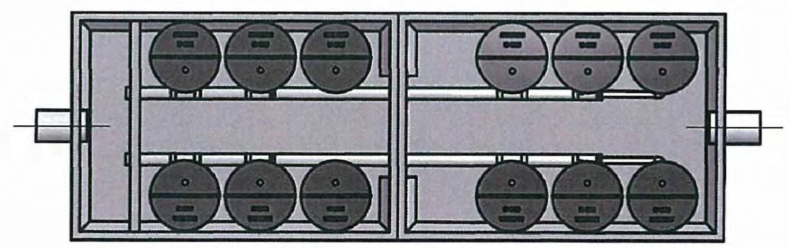


ISOMETRIC VIEW

Site Level Confirmation	
Finished Surface Level (FSL)	RL:
Access Cover Thickness	mm
Inlet Invert Level	RL:
Outlet Invert Level	RL:
Company:	
Name:	
Date:	



SECTION A-A



PLAN VIEW
SECTION VIEW

SPEL VAULT & SPELFILTER (12) WATER TREATMENT SYSTEM
SCALE - NOT TO SCALE

Treatment System É SPEL

Issue	Description	Date	Drawn	Approved

North

Client: CASTLE LAROOL DM Pty. Ltd.

ACOR CONSULTANTS
ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

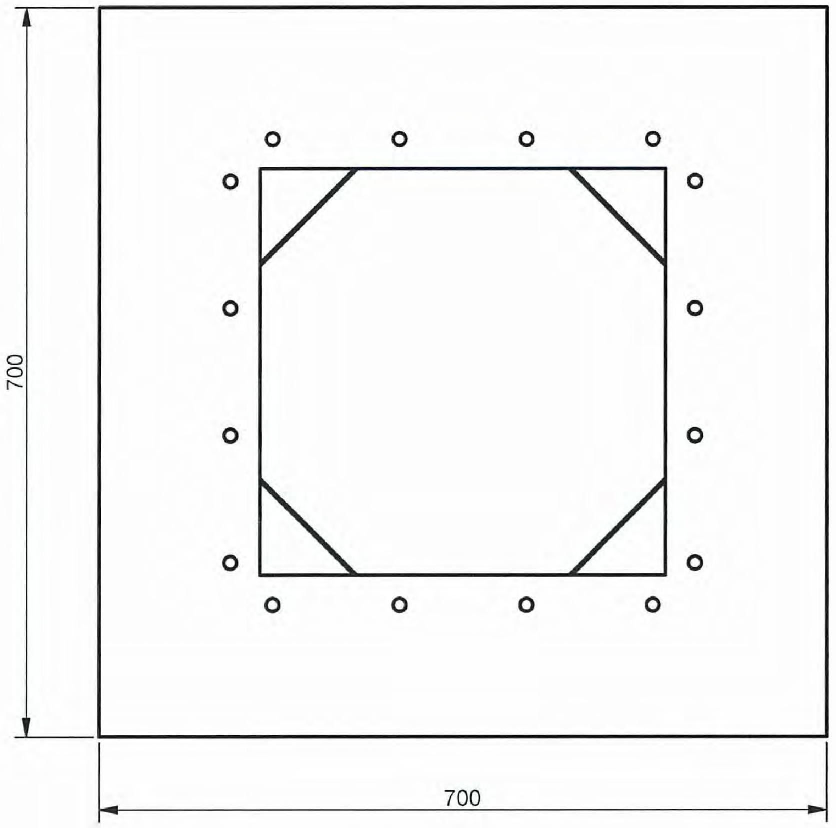
ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499

Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

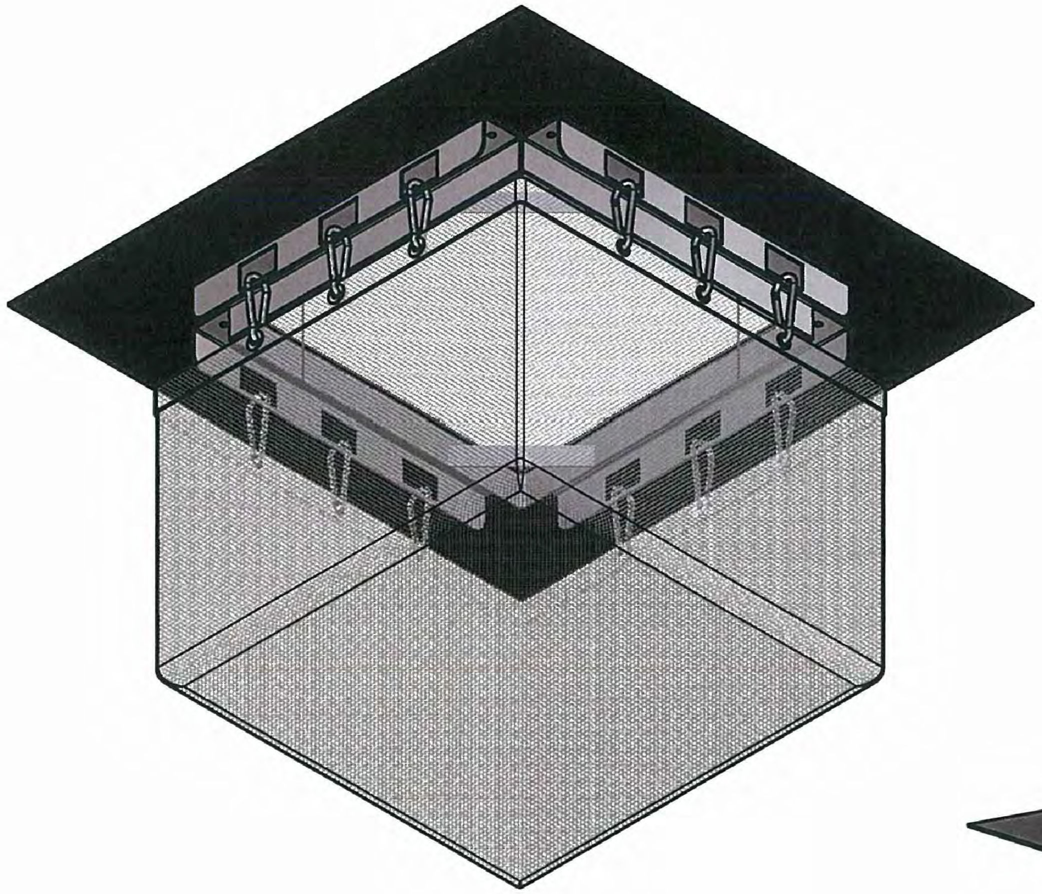
Drawing Title: STORMWATER QUALITY REPORT SHEET No.5

Drawn	Date	Scale A1	Q.A. Check	Date
YF	19/10/2015	AS NOTED		

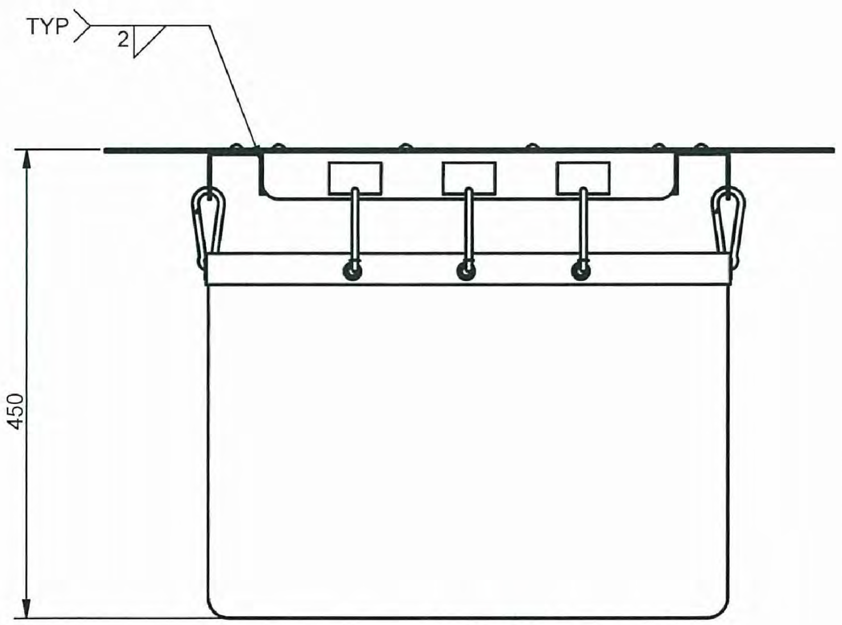
Designed	Project No.	Dwg. No.	Issue
BK	GO150722	Q1.05	A



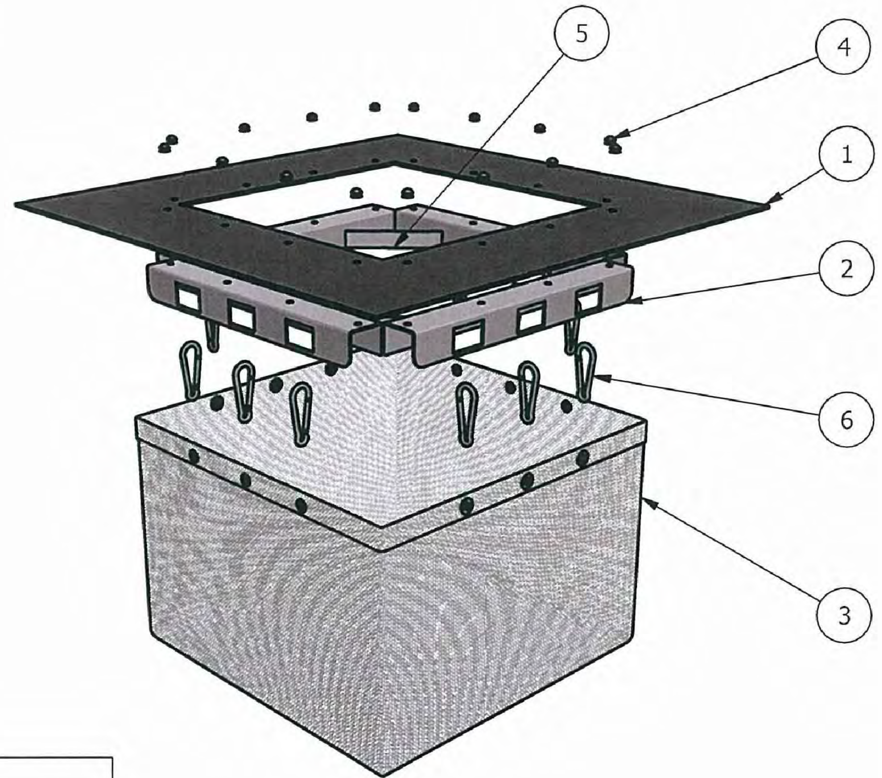
PLAN VIEW



ISOMETRIC VIEW
BOTTOM VIEW



ELEVATION VIEW



ISOMETRIC VIEW
EXPLOSION

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	PLASTIC SHEETING	HDPE
2	4	SHEET METAL BENDING	STAINLESS STEEL 304
3	1	TEXTILE FABRIC & MESH LINER	HDPE
4	16	BLIND RIVIT 7 DIA.	STAINLESS STEEL 304
5	4	CORNER ESTIFFENER - FLAT BAR 25 x 2 - 141 LG	STAINLESS STEEL 304
6	12	CARABINER CLIP 6	ALUMINIUM

SPEL STORMSACKS (8) WATER TREATMENT SYSTEM
SCALE - NOT TO SCALE

Treatment System É SPEL

Issue	Description	Date	Drawn	Approved

North

Client: CASTLE LAROOL DM Pty. Ltd.

ACOR Consultants (CC) Pty Ltd
58-62 Hills Street
Gosford NSW 2250
T +61 2 4324 3499
ACOR CONSULTANTS ENGINEERS | MANAGERS | INFRASTRUCTURE PLANNERS | DEVELOPMENT CONSULTANTS

Project: CARRAMARR ROAD & LAROOL CRESCENT CASTLE HILL
FLOOD MODELLING AND STORMWATER MANAGEMENT

Drawing Title: STORMWATER QUALITY REPORT SHEET No.7

Drawn	Date	Scale A1	Q.A. Check	Date
YF	19/10/2015	AS NOTED		

Designed	Project No.	Dwg. No.	Issue
BK	GO150722	Q1.06	A