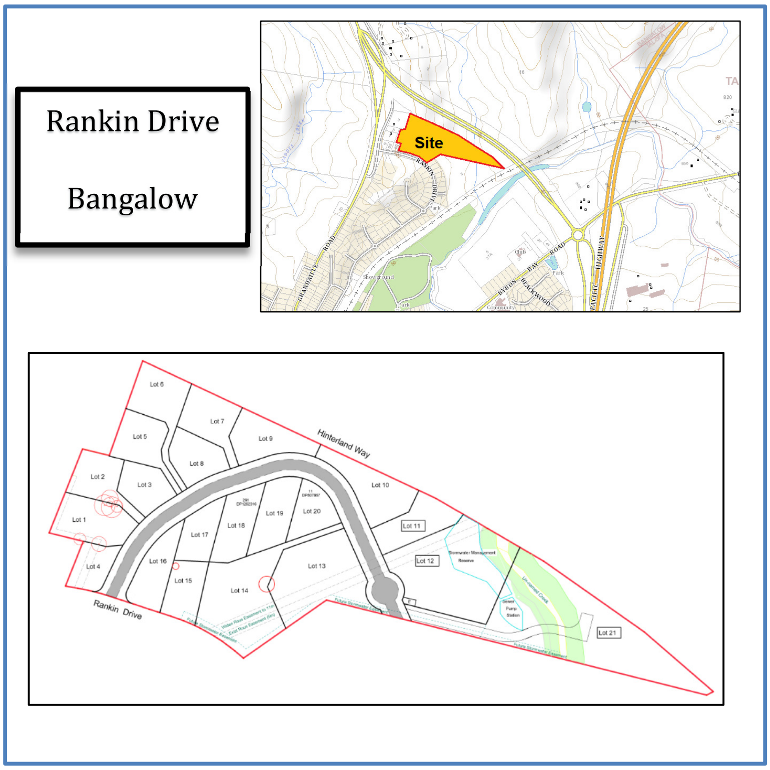
ENGINEERING SERVICES REPORT

FOR A

PLANNING PROPOSAL FOR RESIDENTIAL DEVELOPMENT AND ASSOCIATED WORKS



At
68 Rankin Drive
Bangalow NSW 2479

Upon
Land Titles
Lot 261 DP 1262316 &
Lot 11 DP 807867

Date: June 2023
(Rev A)

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1 EXECUTIVE SUMMARY

This Engineering Services Report is for a planning proposal to create a residential development 68 Rankin Drive, Bangalow.

The planning proposal consists of two landholdings, Lot 261 DP 1262316 (2.332ha) and Lot 11 DP 807867 (1.682ha). The subject lands already have part R2 Low Density Residential Zoning being an area of 1.033ha.

The planning proposal lands have an existing road frontage to local collector road, Rankin Drive. Rankin Drive is a 8m seal road with kerb and gutter on both sides.

An indicative residential development layout has been prepared to assess the infrastructure servicing requirements of the proposal. It is anticipated that the land could service 18 residential lots and 3 small medium density residential lots.

The site would be serviced via a new local street that would be proposed to loop from existing Corlis Crescent (currently a road stub) and reconnect to Rankin Drive at a point approximately 95m east of Satinash Crescent. Preliminary designs of the new local street identify the road gradient would be up to 18% slope which is not uncommon with other local street gradients within the local area (ie Barby Crescent and Ferguson Crescent). As the proposed new local street 'loop' alignment would connect to lands south of the subject site, a temporary culdesac arrangement would be required in the interim - pending construction timelines on the neighbouring lands.

A new 1.2m wide footpath would be constructed within the subdivision's new road corridor and the existing 2m wide shared path on Rankin Drive would be extended for the full frontage of the site.

Stormwater management for the lands has been assessed to determine the treatment train required to achieve compliant quality outcomes. This assessment was undertaken using MUSIC software. The required treatment train includes: residential rainwater reuse tanks + allotment bio-water gardens + Humceptor GPT device + 40m^2 bio-retention basin and 20m of grass swale. The pollutant reduction targets achieved were:

- 80% suspended solids
- 58% phosphorus
- 50% nitrogen
- 100% gross pollutants

Water connectivity would be to the existing mains located within Rankin Drive. Detail design investigation is required as to the level of augmentation works required given the existing mains consist of both a pressurised and gravity fed network.

An existing 525 dia Rous Water trunk main will require relocation. This trunk main has been subject to a previous relocation assessment via DA10.2021.84.2 for a 4 lot subdivision upon the lands. The relocation of the 525mm dia trunk water main involves it being construction on a new alignment adjacent to an existing 300mm dia trunk water main that also crosses the site. These works will result in a combined 11m wide easement corridor as previously agreed in principal with Rous Water.

Gravity sewer connections for the development will require the installation of a sewer pump station. The indicative residential development layout has allocated 235m^2 for the pump station site and a rising main connection to the existing sewer network at the rear of 62 Rankin Drive. This connection point is proposed via existing sewer easements.

Preliminary geotechnical assessment of the site has been undertaken and found the lands suitable for residential development subject to implementation of building controls. These building controls primarily relate to localised steeper lands where slopes are greater than 18^o (>30%). In these locations, engineered structural retaining walls are required for any cut/fill proposals over 1m in height (ie not gravity walls) and the use of light weight or terraced housing forms.

A hydraulic assessment of the un-named creek which runs through the lower portion of the site has been undertaken. This assessment identified the 1% AEP (ie 100yr event) flood level to be RL47.5m. This level has been used within indicative layout plans as a boundary zone to exclude any residential dwelling footprints.

It is demonstrated that the planning proposal lands can safely and effectively comply with Byron Shire Council development policies.

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2 INTRODUCTION

This Engineering Services Report has been prepared to address civil engineering matters associated with the use of lands for the purpose of residential development at 68 Rankin Drive, Bangalow. The site is identified as Lot 261 DP 1262316 and Lot 11 DP 807867 and has collector road frontage to Rankin Drive and boundaries also adjoin with existing residential lands. The common boundary to the north of the site is with the road corridor known as Hinterland Way (ie old Pacific Highway). Refer *Figure 2.0 – Site Location*.

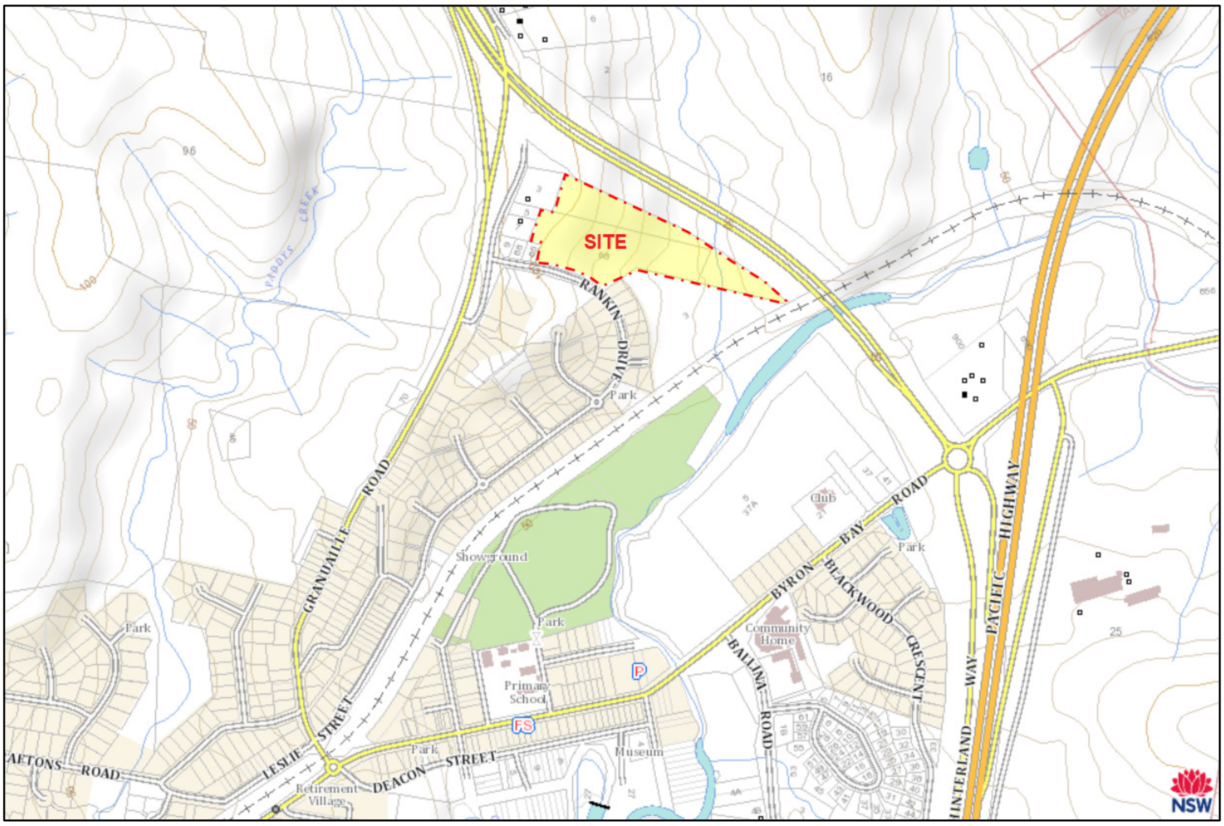


Figure 2.0 – Site Location (Source: SIXmaps.nsw.gov.au)

The subject land holding has an area of 4.014ha, being 2.332ha (Lot 261 DP 1262316) and 1.682ha (Lot 11 DP 807867). There are existing Rous Water easements through the site, one of 5m width and one of 10m width which diagonally traverse the land containing trunk watermains to the nearby water reservoir which also fronts Rankin Drive.

2.1 Specific Proposal Details

The indicative residential development pattern is primarily driven by the need to enable road connectivity through the site so as to provide an inter-connection to the existing Corlis Crescent intersection south of the site. Such connection provides a logical road and pedestrian linkage for the precinct. Infrastructure and development potential for the subject lands is summarised as:

Existing

- Lot 261 DP 1262316	2.332ha
- Lot 11 DP 807867	1.682ha
	4.014ha

- Area of site with exist Zoned R2 Low Density Residential 1.033ha
    - Portion of land at Lot Size Map 600m^2 (0.502ha)
    - Portion of land at Lot Size Map 800m^2 (0.531ha)
- Rous Water Easements 5m wide and 10m wide traverse the site
- Water main 100dia within Rankin Drive frontage
- Gravity sewer main within Rankin Drive and sewer easement benefit available to network through neighboring southern Lot 262 DP 1262316
- Existing un-named watercourse runs through the eastern portion of the site inclusive of road culvert discharge from Hinterland Way.
- Registered stormwater easement benefit available through neighboring southern Lot 262 DP 1262316
- Existing council stormwater from Rankin Drive discharges onto the site at two locations
- Existing 20m APZ bushfire easement on western portion of the site, to be extinguished once dwellings are constructed.

Proposed

An indicative residential development upon the lands would enable:

-	Residential allotments	18 lots
-	Larger medium density allotments	3 lots
-	New 7m wide road pavement within 16m reserve	298m long
-	Drainage easements over existing stormwater pipes	Varies
-	Re-vegetation of buffer to un-named creek	10m wide
-	New stormwater treatments within drainage reserve	600m^2
-	New stormwater GPT	Humeceptor
-	New sewer pump station site	235m^2
-	Part allotment filling of gully adjacent to Rankin Drive	4m depth
-	New 1.2m footpath	298m long
-	New 2m shared footpath (Rankin Drive)	115m long

New telecommunication and electrical supply is proposed to be provided via existing networks from Rankin Drive and allocation has been considered within the indicative subdivision layout for a transformer site. The site is not affected by any existing overhead electrical supply lines.

2.2 Report Reference Documents

The preparation of this report has had regard to the following documents:

- Byron Shire Council *DCP 2014 – Chapter D6 Subdivision (April 2018)*
- Byron Shire Council *DCP 2014 - Chapter B4 Traffic Planning, Vehicle Parking, Circulation and Access (April 2018)*
- Byron Shire Council NRLGM – *Handbook of Stormwater Drainage Design (2013)*
- Byron Shire Council - *Comprehensive Guidelines For Stormwater Management (2014)*
- Australian Standard AS2890.1 – *Parking Facilities Part 1: Off-street Car Parking (2004)*
- Northern Rivers Local Government (NRLG) - *Development Design Specification D1 Geometric Road Design (2018)*

3 ROAD LAYOUT REQUIREMENTS

The access to the development would be from the existing collector road Rankin Drive via a proposed new road corridor. The new road corridor would be on an alignment that would ultimately facilitate a connection to the existing Corlis Crescent stub located south of the site. Refer to Figure 3.1 below. The new road would be of a local street classification in accordance with the NRLG standard, being a 7m wide pavement within a 16m wide road reserve.

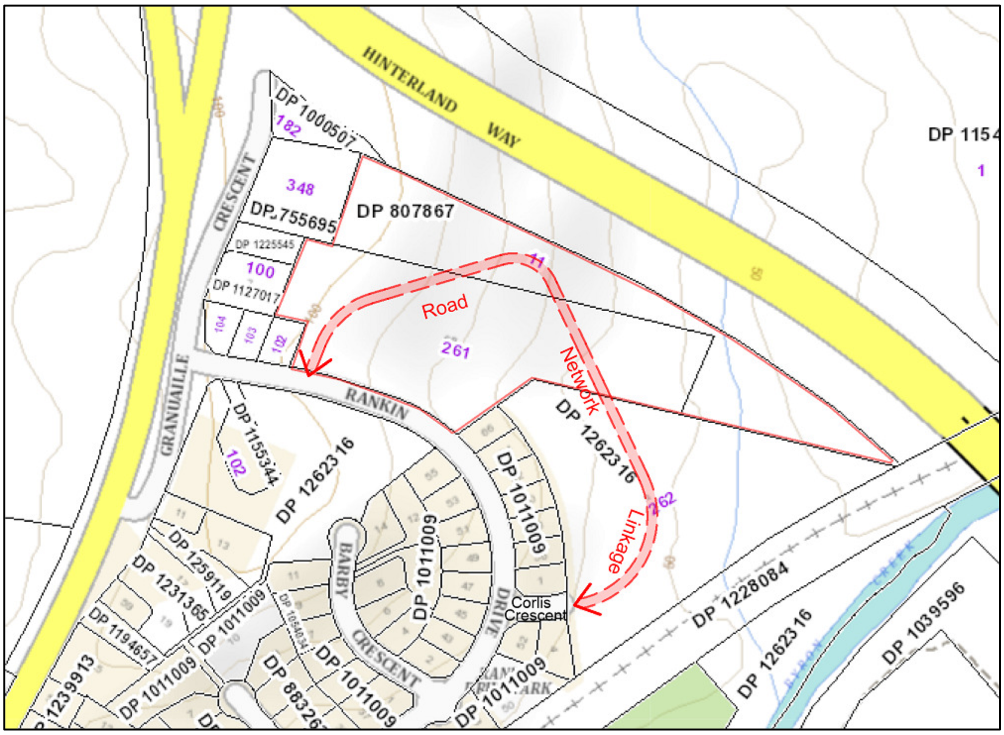


Figure 3.1 – Road Network Linkage

To facilitate staged construction of this new local road link, a temporary culdesac turning head can either be constructed on Lot 261 (if northern linkage proceeds first) or conversely on Lot 262 (if southern linkage proceeds first).

The engineering infrastructure considerations for this planning proposal has been prepared on the basis that the northern linkage would occur first.

Refer to **Appendix 1 – Engineering Concept Plans** for engineering layout plans as referenced within this report.

3.1 Road Long Section Gradients

The subject lands have significant slopes to which the new road linkage will have elevations ranging from RL94m to RL54m over a proposed road length of 298m. This averages out at 13.4% gradient, however when consideration of intersection sightline requirements (ie flat approach to intersection) and limiting disturbance to the existing Rous trunk watermains, sections of the new road will be required to be designed at a maximum 18% slope. Refer to engineering *Drg 1910-SD – 04 Rev C: New Local Street Long Section* within **Appendix 1** for details. The indicative residential design layout has given consideration to maximising the road length (hence to reduce slope) by diagonally traversing the subject site and the ultimate design would seek dispensation from the desirable maximum gradient of 16% based upon the following:

(a) The development location is within a known steeper landform area of Bangalow to which this site will provide a logical infill of residential lands requiring a connection from Corlis Crescent to Rankin Drive. Given the constraint of connecting to an existing road, limited scope to vary levels.

(b) The locality has existing nearby streets that have various road sections that were built at greater than 16% slope and function satisfactorily, namely:

- (i) Barby Cresent 20%
- (ii) Ferguson Crescent 20%
- (iii) Corlis Crescent connector stub 19%
- (iv) Rankin Drive 17%

(c) As the new road will become a loop road, residential users have the option of how best to access (enter or leave) their property (ie via downhill or uphill) so as to minimise slope impacts on allotment entrances.

For traffic generation, intersection sight lines and other traffic related matters, please refer to the *Traffic Impact Statement (April 2023)* report that has been prepared for the development and submitted under separate cover.

3.2 Pathways

As documented within the *Traffic Impact Statement (April 2023)* report, the new local street road corridor will have a 1.2m wide footpath for the full length of its construction.

Additionally, the existing 2m wide shared footpath in Rankin Drive will be extended for the full length of the developments frontage. Refer Figure 3.2 below.

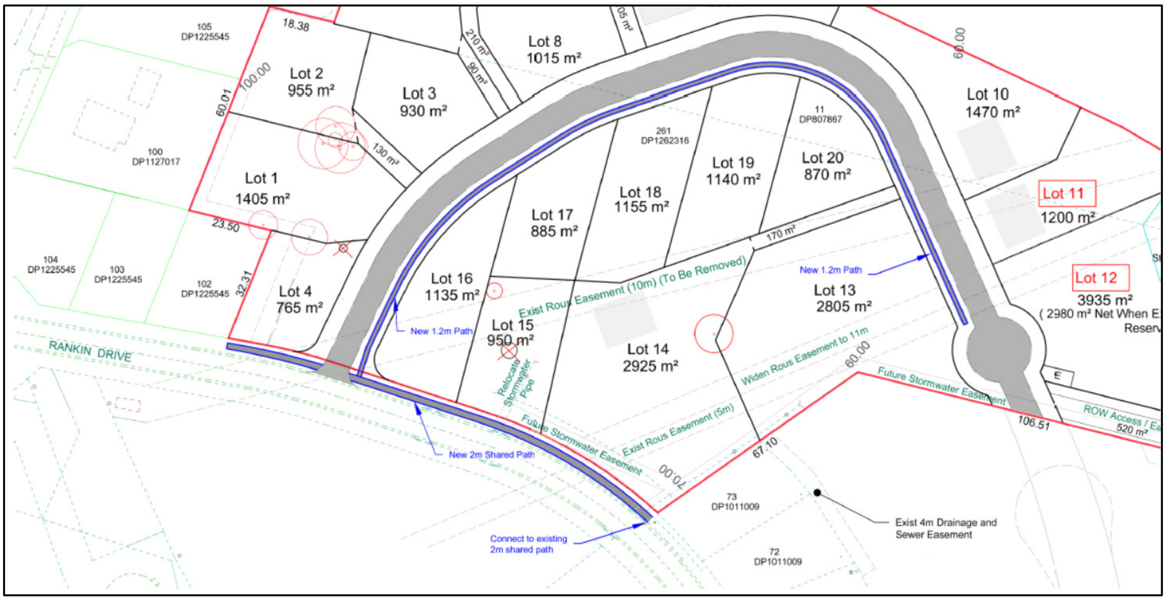


Figure 3.2 – Proposed New Footpaths (Shown in BLUE)

4 STORMWATER MANAGEMENT

The development site has an area of 4ha of which 3.5ha will be treated on the site. Refer to engineering *Drg 1910-RZ-620: Indicative Stormwater Catchment* within **Appendix 1** for catchment details. The site has an average slope of 16%. There are existing road stormwater pipe outlets (x2) which discharge from Rankin Drive onto the site. A major culvert discharges from/under Hinterland Way into an un-named creek which traverses the eastern area of the site. This un-named creek will be subject to installing riparian buffer revegetation/plantings (10m wide) as documented by others.

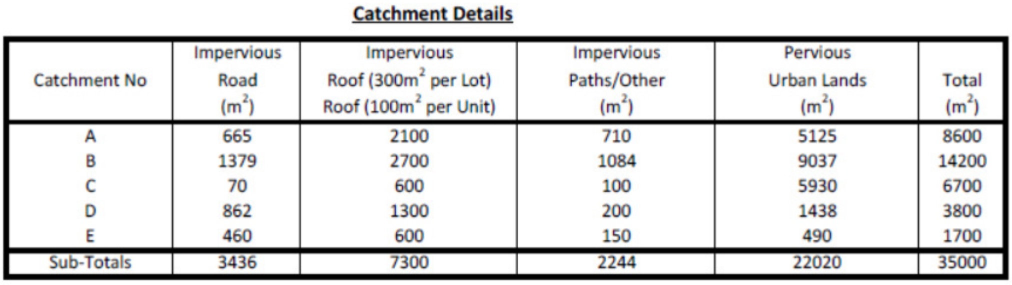
4.1 Stormwater Treatment Matters

The indicative subdivision layout for the planning proposal has been modelled via MUSIC software to ensure consideration (ie sufficient size / location / quality compliance) to treatment of stormwater runoff can be effectively managed. With the site being steep in nature, a key element has been to maximise at source treatment via dwelling rainwater reuse (ie tanks) and also proposing water gardens (ie bio-retention areas) to be constructed on each allotment. Refer to Figure 4.1 for typical example. The installation/

location of the water gardens need to occur in conjunction with the dwelling earthwork design. In summary, it was found that the treatment train of using:

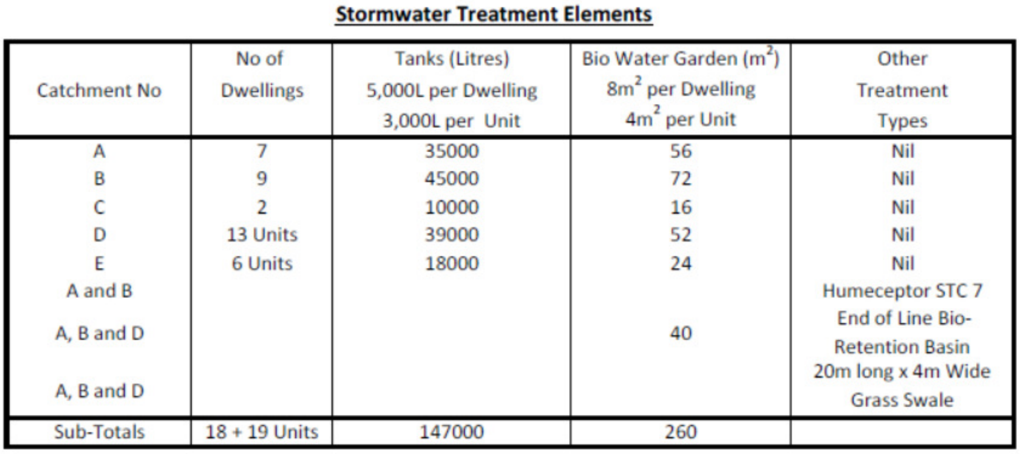
residential rainwater re-use tanks + allotment bio-water gardens + Humeceptor GPT (STC7) + End of Line 40m² bio-retention basin + 20m grass swale

would achieve a compliant stormwater discharge outcome. Modelling catchment details and the model configuration used were as follows:



Catchment Details

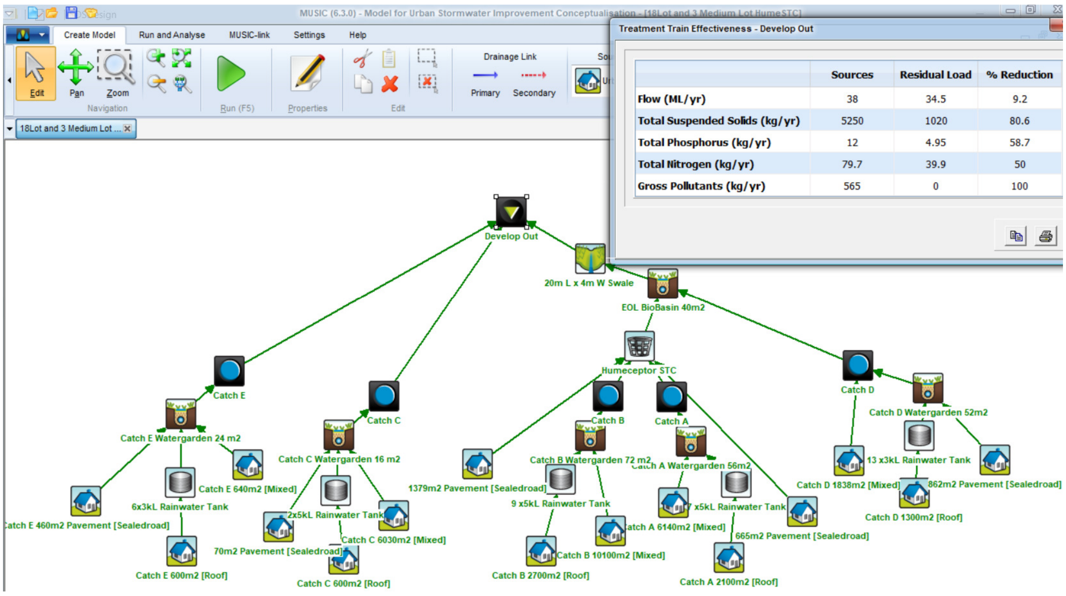
Catchment No	Impervious Road (m^2)	Impervious Roof (300m^2 per Lot) Roof (100m^2 per Unit)	Impervious Paths/Other (m^2)	Pervious Urban Lands (m^2)	Total (m^2)
A	665	2100	710	5125	8600
B	1379	2700	1084	9037	14200
C	70	600	100	5930	6700
D	862	1300	200	1438	3800
E	460	600	150	490	1700
Sub-Totals	3436	7300	2244	22020	35000



Stormwater Treatment Elements

Catchment No	No of Dwellings	Tanks (Litres) 5,000L per Dwelling 3,000L per Unit	Bio Water Garden (m^2) 8m^2 per Dwelling 4m^2 per Unit	Other Treatment Types
A	7	35000	56	Nil
B	9	45000	72	Nil
C	2	10000	16	Nil
D	13 Units	39000	52	Nil
E	6 Units	18000	24	Nil
A and B				Humeceptor STC 7
A, B and D			40	End of Line Bio-Retention Basin
A, B and D				20m long x 4m Wide Grass Swale
Sub-Totals	18 + 19 Units	147000	260	

Figure 4.1 – Example of Typical Water Garden



Treatment Train Effectiveness - Develop Out

	Sources	Residual Load	% Reduction
Flow (ML/yr)	38	34.5	9.2
Total Suspended Solids (kg/yr)	5250	1020	80.6
Total Phosphorus (kg/yr)	12	4.95	58.7
Total Nitrogen (kg/yr)	79.7	39.9	50
Gross Pollutants (kg/yr)	565	0	100

Figure 4.2 – MUSIC Model Network

The modelling demonstrated compliance with Councils pollutant reduction target as compared below:

Pollutant	BSC Target	MUSIC Output	Complies (Yes / No)
Total Suspended Solids	80%	80%	✓ Yes
Total Phosphorus	45%	58%	✓ Yes
Total Nitrogen	45%	50%	✓ Yes
Gross Pollutants	70%	100%	✓ Yes
Water Balance**	38.0 ML (Exist)	34.5 ML (Developed)	9% Volume Reduction

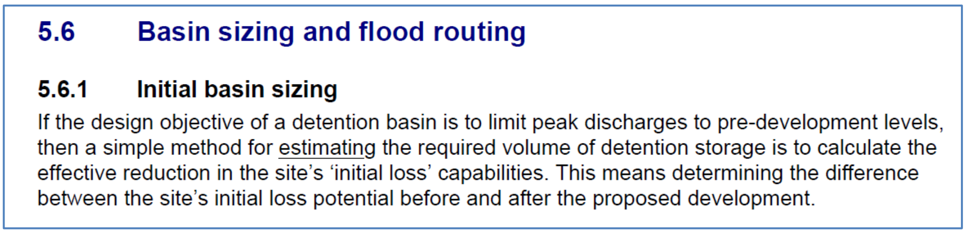
** No compliance level required

4.2 Stormwater Quantity Matters

The MUSIC modelling demonstrates a net 9% reduction in average annual runoff volume from the site which is due to 147m^3 of storage via multiple rainwater tanks for reuse. A further 78m^3 of attenuation storage capacity is also provided within the multiple water garden basins (ie 260m^2 x 0.3m extended depth) which is a by-product of achieving increase in infiltration performance.

The steep sloping nature of the site (ie 16%+) results in very short natural stormwater runoff travel times, which results in lessor changes in volume differences of stormwater runoff for varying surfacing types. Once the catchment becomes fully saturated (ie once initial soil / vegetation losses are absorbed), then runoff from steep catchments is very similar to that of an impervious catchment.

The *Queensland Urban Drainage Manual (IPWEA 2016)* provides engineering guidance as to estimating the initial sizing volume required for a detention basin in achieving pre-development level discharges. Refer extract from Chapter 5.6 below. QUDM nominates an initial loss of 20mm for open bushland / short grass and 2mm for impervious surfaces, thereby there is a net increase of 18mm runoff (ie 20mm – 2mm) for the developments impervious areas.



5.6 Basin sizing and flood routing

5.6.1 Initial basin sizing

If the design objective of a detention basin is to limit peak discharges to pre-development levels, then a simple method for estimating the required volume of detention storage is to calculate the effective reduction in the site's 'initial loss' capabilities. This means determining the difference between the site's initial loss potential before and after the proposed development.

Extract: Chapter 5.6 Basin Sizing and Flood Routing (QUDM 2016)

As tabulated within previous Section 4.1 of this report, the developed catchment would generate an impervious area increase of:

3,463m^2 (pavements) + 7,300m^2 (roofs) + 2,244m^2 (paths/other) = 13,007m^2

hence QUDM net increase in volume required for detention = 13,007 x 0.018 = 234m^3.

This volume can be readily achieved via using 78m^3 of extended depth storage within the water gardens and 157.5m^3 of additional tank storage (ie 21 lots x 7,500L tanks). The final sizing details would be subject to a detailed computer runoff-routing model to accompany the development application for the subdivision.

The summary treatment train concept to achieve stormwater quality and quantity compliance is shown in following Figure 4.3.

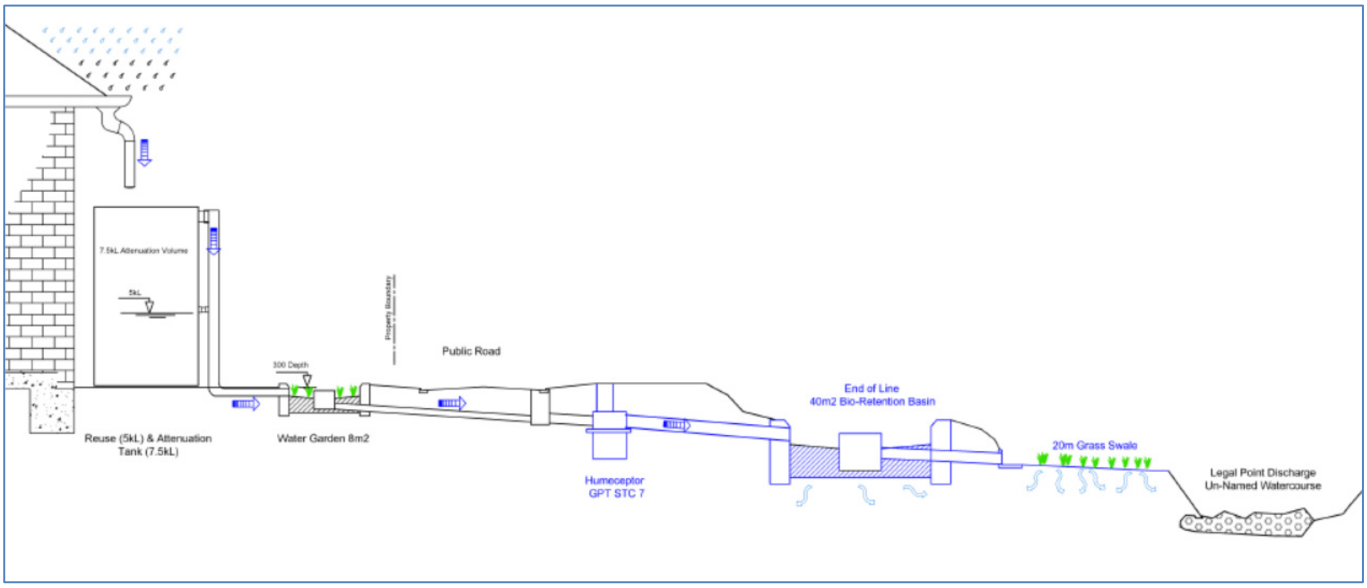


Figure 4.3 – Proposed Stormwater Treatment Train

5 WATER AND SEWER CONNECTIONS

A search of Council DBYD records identifies that an existing 100mm diameter watermain runs along the Rankin Drive frontage and existing gravity sewer lines are present on the western portion of the site and an existing sewer easement enables connectivity to the existing gravity lines that service Rankin Drive dwellings.

5.1 Water Reticulation Matters

The existing water main in Rankin Drive consists of two asset configurations. The higher lands are serviced via a 100mm dia pressurised main (ie RL90m+) given the limited head pressure available due to the close proximity of existing residential lands adjacent to the Rankin Drive water reservoirs. A conventional gravity fed 100mm dia water main is also present within lower levels of Rankin Drive (ie below RL75m) to service those existing homes adjacent to the subject site.

Detail design investigation and hydraulic modelling will be required to ascertain the most appropriate servicing strategy utilising both the pressurised main and gravity fed main. Such modelling and determination of the level of augmentation works required would be assessed at the development application planning phase.

5.2 Sewer Reticulation Matters

There is an existing sewer gravity main on the western boundary of the subject lands, however given this is the elevated portion of the site it is of minimal gravity servicing potential. In early 2020, the creation of Lot 262 DP 1262316 included the registration of a sewer easement that enables a connection point between the planning proposal lands and the existing gravity sewer network at Lot 71 DP 1011009 (the manhole at the rear of 62 Rankin Drive). This connection point would enable a gravity service to 50% of the planning proposal lands, however this connection location would also be very suitable as a rising main discharge point. Refer to engineering *Drg 1910-RZ-600: Indicative Sewer Layout* within **Appendix 1** for sewer servicing details. It is also noted that a similar sewer easement was created midway through the eastern portion of Lot 262 DP 126316 that could also provide a sewer rising main connection route. This alternative easement is significantly longer (approx 200m versus 45m) than the preferred connection at 62 Rankin Drive. Provision has been made within the layout for a 200m^2 pump station site.

5.3 Rous Water Main Relocation

There is an existing 525 dia Rous Water trunk main which traverses the site and has been the subject of previous assessment by Rous Water in association with a four (4) lot subdivision over the lands (refer to DA10.2021.84.2). The design solution was to relocate the 525 dia main within a similar alignment to the existing 300 dia main (that also traverses the property) and provide a wider 11m easement. This wider easement would also enable Rous Water other augmentation / upgrade works. Accordingly, this planning proposal has had strong regard to the requirements raised by Rous Water in past communications and keeps this new ‘easement corridor’ well removed from the primary residential development area. Refer to Figure 5.3 for past agreed details with Rous Water as to relocation of the 525 dia water trunk main.

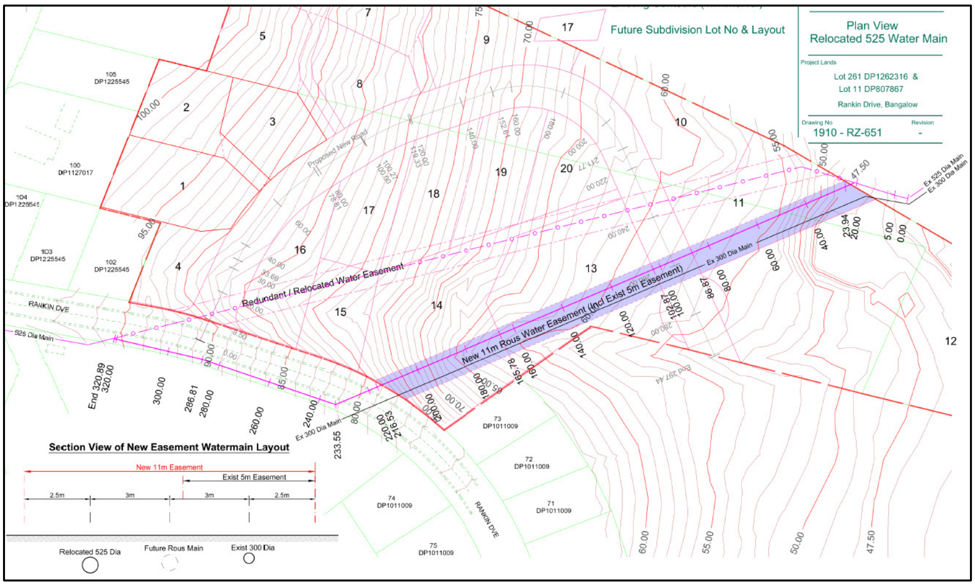


Figure 5.3 – Consolidation of Rous Water Mains into Common Easement Corridor

6 EARTHWORKS AND GEOTECHNICAL MATTERS

A geotechnical investigation and landslip susceptibility assessment was undertaken by Geotech Investigations Pty Ltd (refer to **Appendix 2** – **Broadscale Geotechnical Investigation**) which included 11 test pits and 8 boreholes. Refer to Figure 6 below for an extract of the report boreholes and test pit locations.

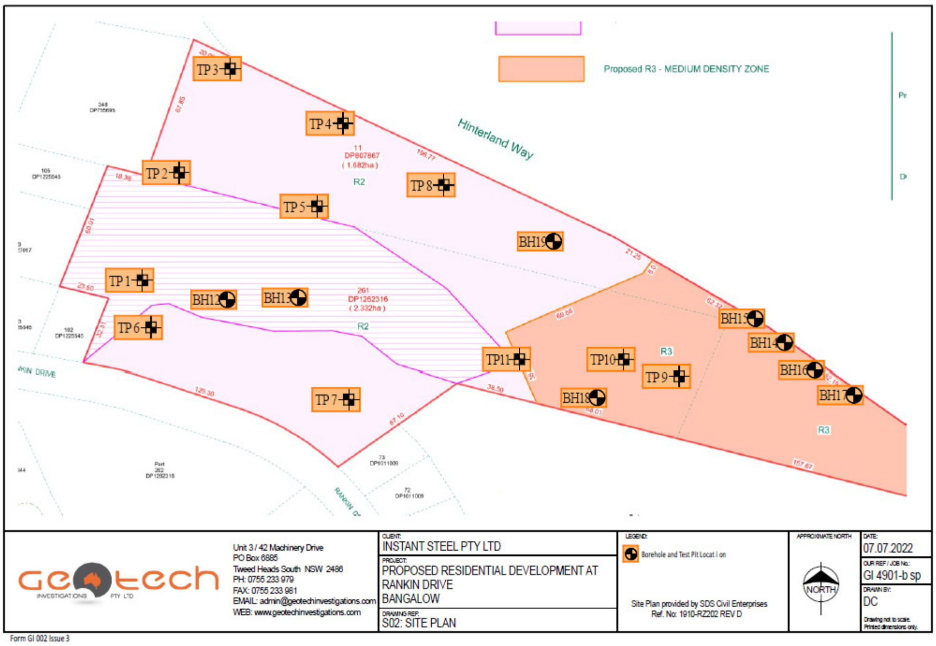


Figure 6 – Extract of Site Plan

The geotechnical investigation identified that where slopes greater than 18° (ie >30%) then implementation of engineered retaining walls combined with stability assessment would be required (ie gravity walls not suitable). Such locations are shown in Figure 6.1 below and primarily affects Lots 5, 6, 7, 8 and 14. The implementation of using retaining structural walls would be required for cut/fil heights above 1m and implementing wide ranging mitigation measures as listed within Table 4 of the geotechnical report, particularly in these steeper sloped areas.

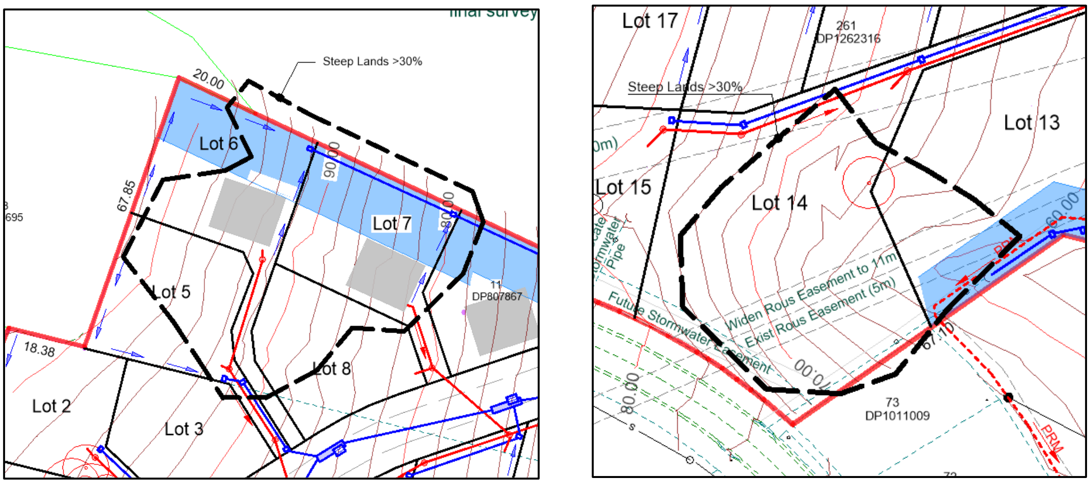


Figure 6.1 – Locations where slope gradient at >30%

There is an existing non-defined gully/depression that runs west to east across future Lot 15 and 16 which will require localised filling to improve land use and to contain the earthworks batter for the new entry loop road and associated intersection. Filling in this location would be from 1m to nominal 4m maximum depth and be undertaken in accordance with Level 1 earthworks supervision requirements. This filling won't occur until such time as the existing Rous Water trunk main is relocated clear of this filling work zone.

7 FLOODING MATTERS

The un-named creek is a 2nd order stream and discharges into Byron Creek at a location adjacent to the eastern end of the Bangalow Showground. A hydraulic assessment using XPSWMM software has been undertaken in June 2022 by Floodworks and a copy of the report is attached within **Appendix 3**. The findings of the assessment was that the 1% AEP water level was RL47.5m AHD. This flood level contour has been shown upon the engineering *Drg 1910-RZ-300: Indicative Subdivision Layout* within **Appendix 1** and no dwelling envelopes are shown within this flood inundation area.

8 COMPLIANCE SUMMARY OF PROPOSAL

This Engineering Services Report has had regard to assessing the infrastructure services and design compliance requirements of the Byron Shire Council development standards and has found that the indicative residential planning proposal is able to demonstrate that:

(i) *The subject lands can provide satisfactory road access and provide appropriate future road network linkage to neighbouring undeveloped lands;*
(ii) *Stormwater management outcomes for the site can be satisfactorily catered for onsite and achieve compliant reductions in pollutant loads and attenuation controls;*
(iii) *Geotechnical management of those lands steeper than 30% can be managed with conventional engineering design;*
(iv) *Residential dwelling envelopes are not required upon 1% AEP lands;*
(v) *The subject lands can be adequately serviced by water and sewer;*
(vi) *Allowance has been made such that the subject lands can be adequately serviced by the existing electrical and telecommunications network.*

7 APPENDICES

Appendix 1 **Engineering Concept Plans (By SDS Civil – 5 Drgs x A3)**

Appendix 2 **Broadscale Geotechnical Investigation Report (By Geotech Investigations Pty Ltd)**

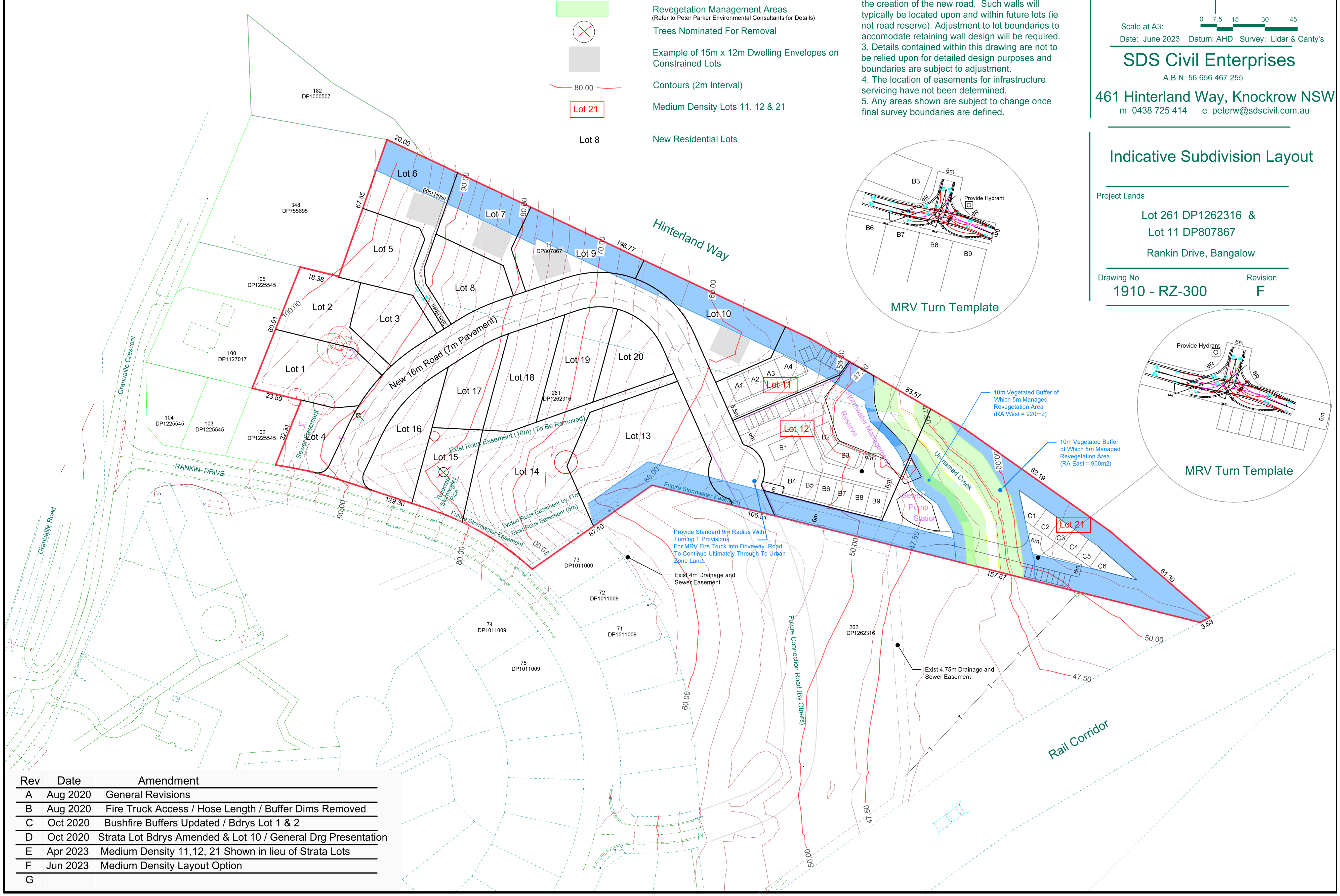
Appendix 3 **Hydraulic Assessment Report (By Floodworks)**

Appendix 1

Engineering Concept Plans

(by *SDS Civil Enterprises*)

Drg No 1910-RZ-300 Rev F: Indicative Subdivision Layout
Drg No 1910-RZ-600 Rev A: Indicative Sewer Layout
Drg No 1910-RZ-610 Rev A: Indicative Stormwater Layout
Drg No 1910-RZ-620 Rev D: Indicative Stormwater Catchment
Drg No 1910-SD- 04 Rev C: New Local Street Longsection



LEGEND

🟦	Bushfire Asset Protection Zones (Refer to BCA Check Assessment for Details)
🟩	Revegetation Management Areas (Refer to Peter Parker Environmental Consultants for Details)
⊗	Trees Nominated For Removal
▨	Example of 15m x 12m Dwelling Envelopes on Constrained Lots
— 80.00 —	Contours (2m Interval)
Lot 21	Medium Density Lots 11, 12 & 21
Lot 8	New Residential Lots

Drawing notes
1. The steep nature of the site will require the installation of some retaining walls associated with the creation of the new road. Such walls will typically be located upon and within future lots (ie not road reserve). Adjustment to lot boundaries to accomodate retaining wall design will be required.
3. Details contained within this drawing are not to be relied upon for detailed design purposes and boundaries are subject to adjustment.
4. The location of easements for infrastructure servicing have not been determined.
5. Any areas shown are subject to change once final survey boundaries are defined.

North Point

Scale at A3: 0 7.5 15 30 45

Date: June 2023 Datum: AHD Survey: Lidar & Canty's

SDS Civil Enterprises

A.B.N. 56 656 467 255

461 Hinterland Way, Knockrow NSW
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Indicative Subdivision Layout

Project Lands

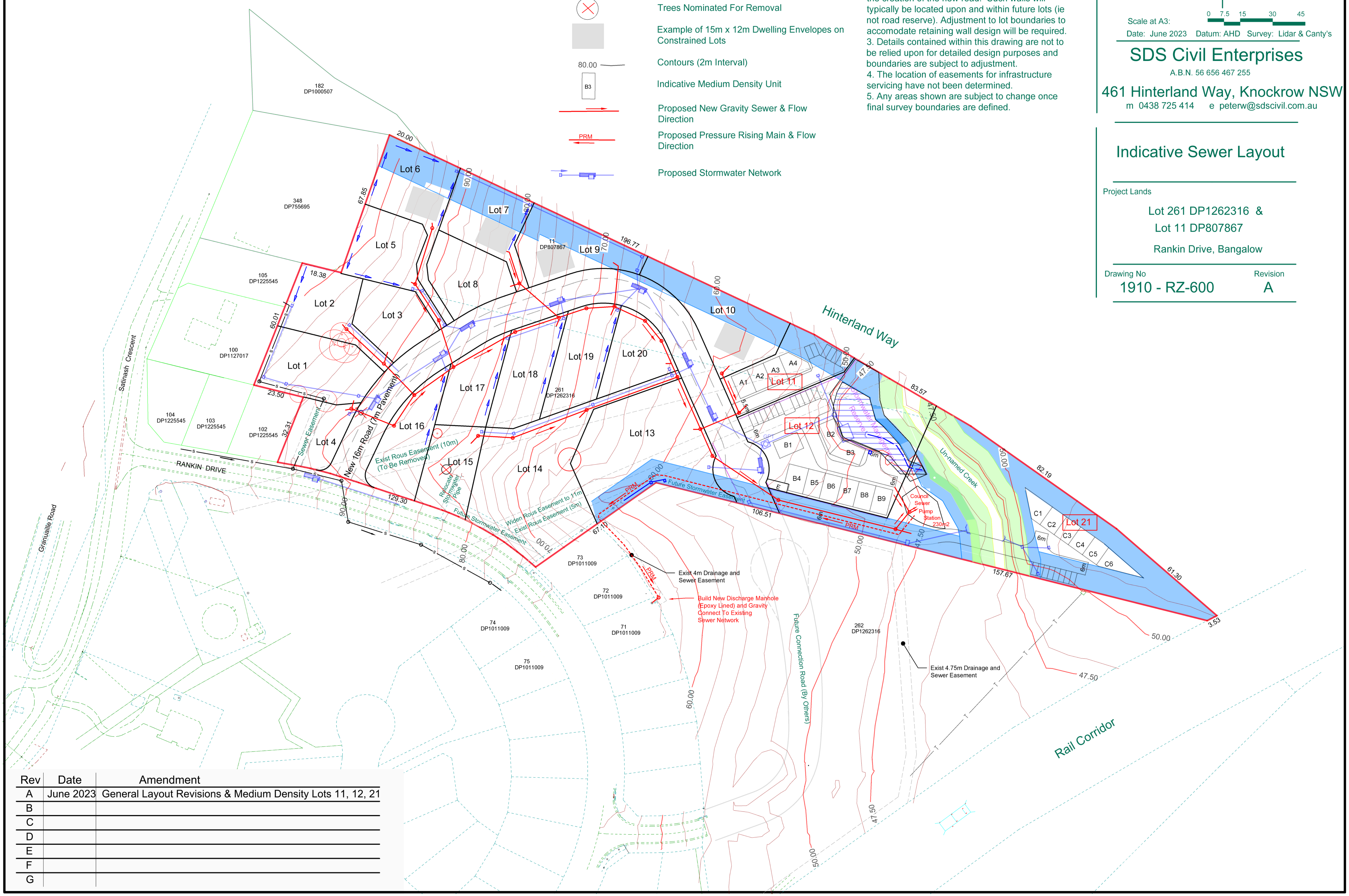
Lot 261 DP1262316 &
Lot 11 DP807867

Rankin Drive, Bangalow

Drawing No: 1910 - RZ-300

Revision: F

Rev	Date	Amendment
A	Aug 2020	General Revisions
B	Aug 2020	Fire Truck Access / Hose Length / Buffer Dims Removed
C	Oct 2020	Bushfire Buffers Updated / Bdrys Lot 1 & 2
D	Oct 2020	Strata Lot Bdrys Amended & Lot 10 / General Drg Presentation
E	Apr 2023	Medium Density 11,12, 21 Shown in lieu of Strata Lots
F	Jun 2023	Medium Density Layout Option
G		



LEGEND

▨ Bushfire Asset Protection Zones
(Refer to BCA Check Assessment for Details)

🟩 Revegetation Management Areas
(Refer to Peter Parker Environmental Consultants for Details)

⊗ Trees Nominated For Removal

▨ Example of 15m x 12m Dwelling Envelopes on Constrained Lots

80.00 — Contours (2m Interval)

B3 Indicative Medium Density Unit

Proposed New Gravity Sewer & Flow Direction

PRM Proposed Pressure Rising Main & Flow Direction

Proposed Stormwater Network

Drawing notes
1. The steep nature of the site will require the installation of some retaining walls associated with the creation of the new road. Such walls will typically be located upon and within future lots (ie not road reserve). Adjustment to lot boundaries to accomodate retaining wall design will be required.
3. Details contained within this drawing are not to be relied upon for detailed design purposes and boundaries are subject to adjustment.
4. The location of easements for infrastructure servicing have not been determined.
5. Any areas shown are subject to change once final survey boundaries are defined.

North Point

Scale at A3: 0 7.5 15 30 45
Date: June 2023 Datum: AHD Survey: Lidar & Canty's

SDS Civil Enterprises

A.B.N. 56 656 467 255

461 Hinterland Way, Knockrow NSW
m 0438 725 414 e peterw@sdscivil.com.au

Indicative Sewer Layout

Project Lands

Lot 261 DP1262316 &
Lot 11 DP807867
Rankin Drive, Bangalow

Drawing No: 1910 - RZ-600
Revision: A

Rev	Date	Amendment
A	June 2023	General Layout Revisions & Medium Density Lots 11, 12, 21
B		
C		
D		
E		
F		
G		

Drawing notes

1. The steep nature of the site will require the installation of some retaining walls associated with the creation of the new road. Such walls will typically be located upon and within future lots (ie not road reserve). Adjustment to lot boundaries to accomodate retaining wall design will be required.
2. Details contained within this drawing are not to be relied upon for detailed design purposes and boundaries are subject to adjustment.
4. The location of easements for infrastructure servicing have not been determined.
5. Any areas shown are subject to change once final survey boundaries are defined.

LEGEND

🟦	Bushfire Asset Protection Zones (Refer to BCA Check Assessment for Details)
🟩	Revegetation Management Areas (Refer to Peter Parker Environmental Consultants for Details)
⊗	Trees Nominated For Removal
■	Example of 15m x 12m Dwelling Envelopes on Constrained Lots
80.00	Contours (2m Interval)
B3	Future Medium Density Units (Indicative Only)
● →	Proposed New Gravity Sewer & Flow Direction
PRM ←	Proposed Pressure Rising Main & Flow Direction
▭ ▪	Road Stormwater Drainage and Junction Pit
→ ▫	Interallotment Drainage Pit & Catch Drain
GPT	Inground Gross Pollutant Trap
▨	Stormwater Treatment Reserve (600 m2)

North Point

Scale at A3: 0 7.5 15 30 45

Date: June 2023 Datum: AHD Survey: Lidar & Canty's

SDS Civil Enterprises

A.B.N. 56 656 467 255

461 Hinterland Way, Knockrow NSW
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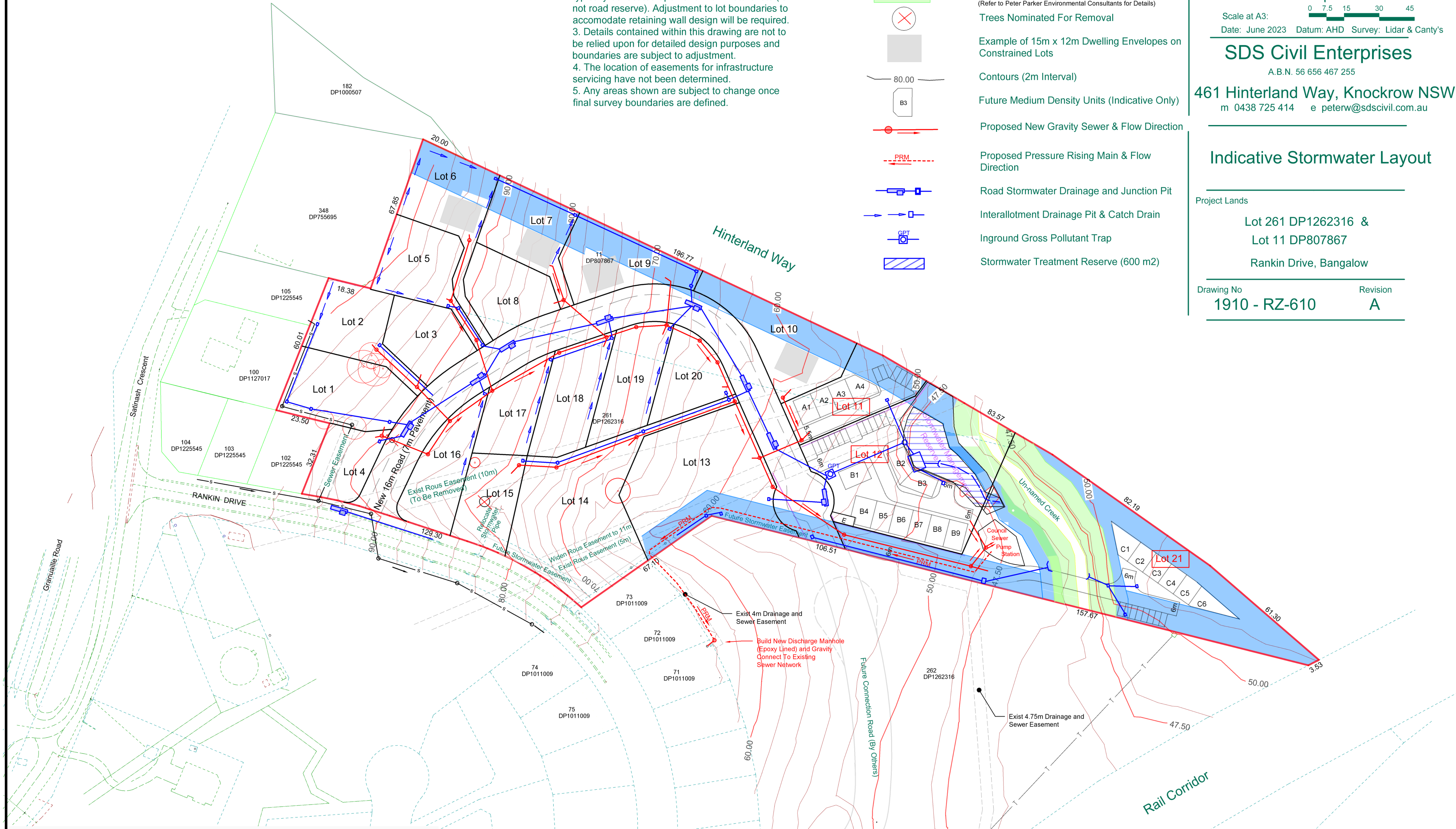
Indicative Stormwater Layout

Project Lands

Lot 261 DP1262316 &
Lot 11 DP807867
Rankin Drive, Bangalow

Drawing No 1910 - RZ-610

Revision A



Rev	Date	Amendment
A	June 2023	General Layout Revisions & Medium Density Lots 11, 12, 21
B		
C		
D		
E		
F		
G		

Drawing notes

1. The steep nature of the site will require the installation of some retaining walls associated with the creation of the new road. Such walls will typically be located upon and within future lots (ie not road reserve). Adjustment to lot boundaries to accomodate retaining wall design will be required.

3. Details contained within this drawing are not to be relied upon for detailed design purposes and boundaries are subject to adjustment.

4. The location of easements for infrastructure servicing have not been determined.

5. Any areas shown are subject to change once final survey boundaries are defined.

LEGEND

⊗	Trees Nominated For Removal
▨	Example of 15m x 12m Dwelling Envelopes on Constrained Lots
80.00	Contours (2m Interval)
B3	Medium Density Units
	Road Stormwater Drainage and Junction Pit
→	Interallotment Drainage Pit & Catch Drain
GPT	Inground Gross Pollutant Trap
▨	Stormwater Treatment Reserve (600 m2)
Catch B (1.42ha)	Water Quality Catchment Areas in hectares

North Point

0 7.5 15 30 45

Scale at A3:

Date: June 2023 Datum: AHD Survey: Lidar & Canty's

SDS Civil Enterprises

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461 Hinterland Way, Knockrow NSW

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Indicative Stormwater Catchment

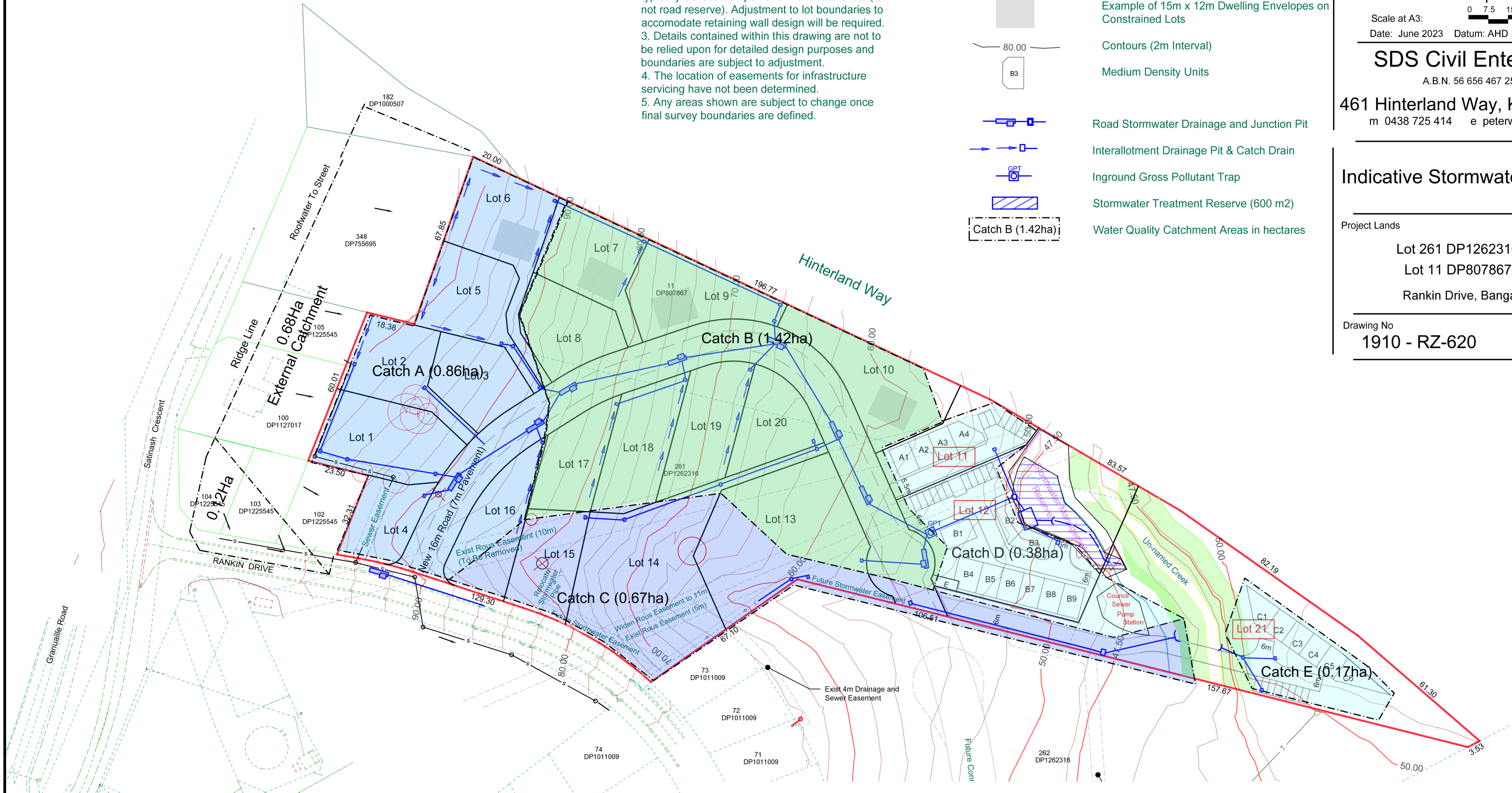
Project Lands

Lot 261 DP1262316 &
Lot 11 DP807867

Rankin Drive, Bangalow

Drawing No 1910 - RZ-620

Revision D



Catchment Details

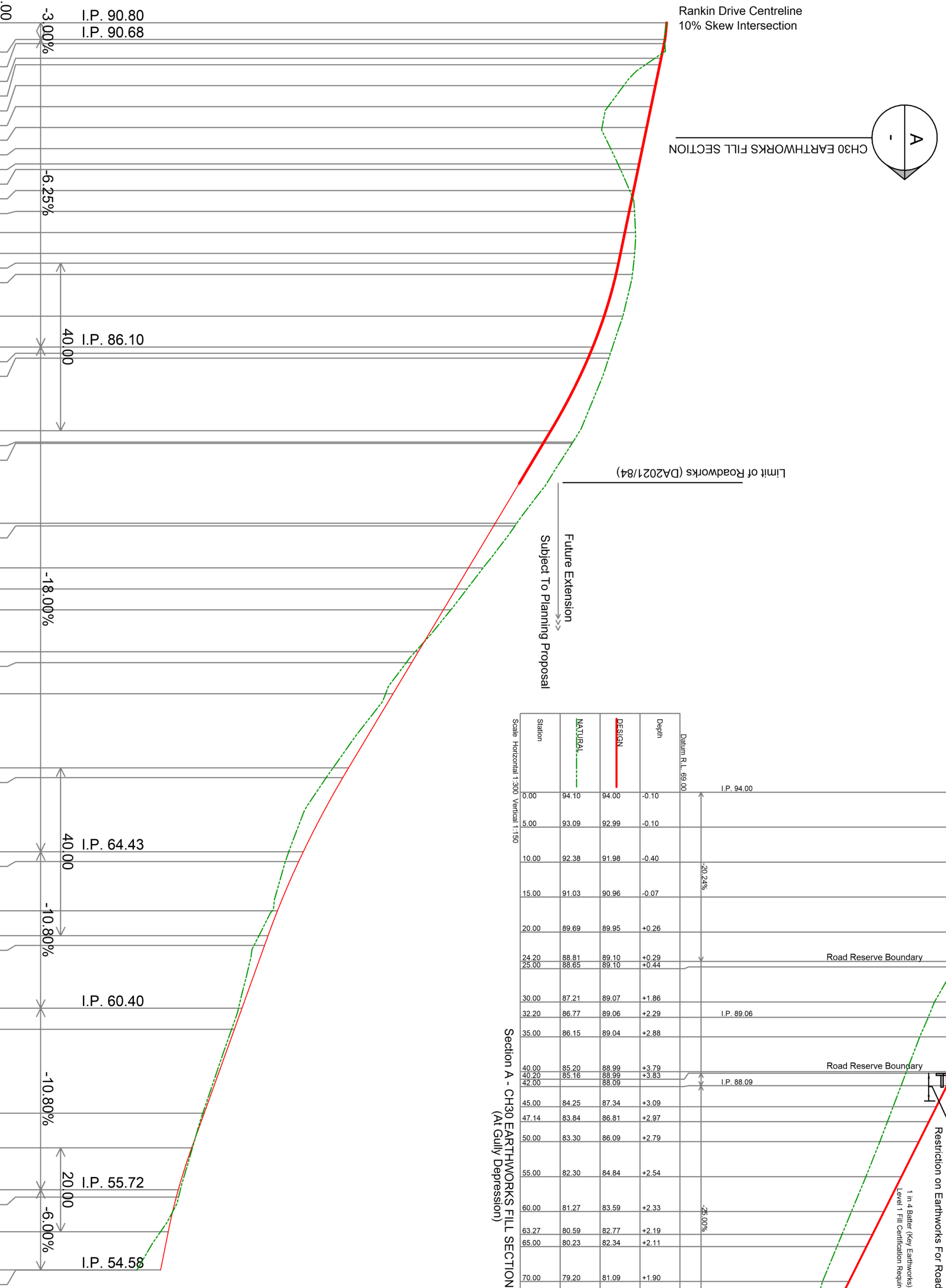
Catchment No	Impervious Road (m^2)	Impervious Roof (300m^2 per Lot) Roof (100m^2 per Unit)	Impervious Paths/Other (m^2)	Pervious Urban Lands (m^2)	Total (m^2)
A	665	2100	710	5125	8600
B	1379	2700	1084	9037	14200
C	70	600	100	5930	6700
D	862	1300	200	1438	3800
E	460	600	150	490	1700
Sub-Totals	3436	7300	2244	22020	35000

Rev	Date	Amendment
A	Jan 2022	External Catchment To West Shown
B	May 2022	Layout Changes Due To Rous Realignment & Drainage
C	June 2022	Sewer & Stormwater Servicing Changes
D	June 2023	Medium Density Lots Modified
E		
F		
G		

Scale Horizontal 1:1000 Vertical 1:300

Station	NATURAL	DESIGN	Depth
0.00	90.80	90.80	+0.00
4.00		90.68	
5.00	90.67	90.62	-0.05
8.50	89.94	90.40	+0.46
10.00	89.29	90.31	+1.02
15.00	87.72	89.99	+2.27
20.00	86.61	89.68	+3.07
25.00	86.17	89.37	+3.20
30.00	86.79	89.06	+2.27
33.66	87.31	88.83	+1.52
35.00	87.50	88.74	+1.25
40.00	88.15	88.43	+0.28
45.00	88.50	88.12	-0.38
50.00	88.57	87.81	-0.76
55.00	88.51	87.49	-1.02
57.31		87.35	
60.00	88.35	87.17	-1.18
70.00	87.66	86.32	-1.34
77.31		85.51	
78.81	86.78	85.33	-1.45
80.00	86.65	85.17	-1.48
97.31		82.50	
100.00	84.08	82.01	-2.07
100.27	84.03	81.96	-2.07
119.33	80.07	78.53	-1.54
120.00	79.93	78.41	-1.52
130.00	77.66	76.61	-1.04
135.00	76.51	75.71	-0.79
140.00	75.35	74.81	-0.53
150.00	72.80	73.01	+0.21
152.61	72.16	72.54	+0.38
160.00	70.68	71.21	+0.53
177.69		68.03	
180.00	66.43	67.62	+1.19
197.69		64.79	
200.00	63.51	64.46	+0.96
211.77	62.58	62.94	+0.36
217.69		62.27	
220.00	61.27	62.02	+0.75
235.00		60.40	
240.00	59.66	59.86	+0.20
260.00	57.60	57.70	+0.10
268.30		56.80	
278.30		55.84	
280.00	55.87	55.70	-0.16
288.30		55.12	
297.40		54.58	
297.44	52.88		

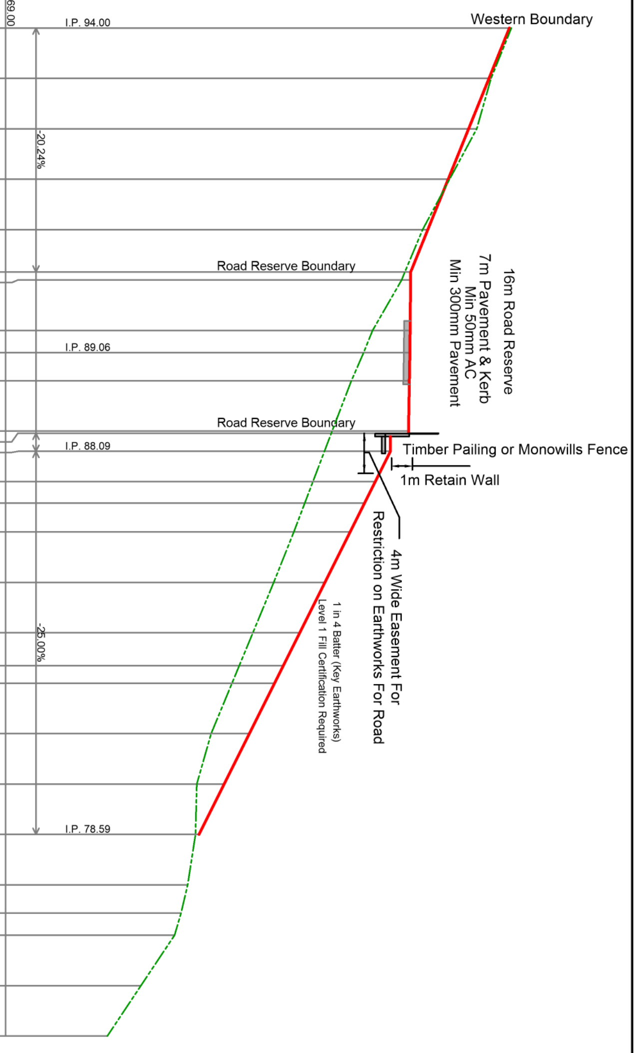
Datum R.L. 43.00



Scale Horizontal 1:300 Vertical 1:150

Station	NATURAL	DESIGN	Depth
0.00	94.10	94.00	-0.10
5.00	93.09	92.99	-0.10
10.00	92.38	91.98	-0.40
15.00	91.03	90.96	-0.07
20.00	89.69	89.95	+0.26
24.20	88.81	89.10	+0.29
25.00	88.65	89.10	+0.44
30.00	87.21	89.07	+1.86
32.20	86.77	89.06	+2.29
35.00	86.15	89.04	+2.88
40.00	85.20	88.99	+3.79
40.20	85.16	88.99	+3.83
42.00		88.09	
45.00	84.25	87.34	+3.09
47.14	83.84	86.81	+2.97
50.00	83.30	86.09	+2.79
55.00	82.30	84.84	+2.54
60.00	81.27	83.59	+2.33
63.27	80.59	82.77	+2.19
65.00	80.23	82.34	+2.11
70.00	79.20	81.09	+1.90
75.00	78.48	79.84	+1.36
80.00	78.42	78.59	+0.17
85.00	78.03		
87.80	77.70		
90.00	77.38		
95.00	75.71		
100.00	74.04		

Datum R.L. 69.00



Section A - CH30 EARTHWORKS FILL SECTION
(At Gully Depression)

Rev	Date	Amendment
A	Jan2022	Relocated Road Intersection and Reduced 20% to 18% Grade
B	May2022	Rous Water Realigned Clear of Fill Shown
C	Aug2022	4m Easement and Fence Type Shown
D		
E		
F		
G		

Scale at A3: Varies
As per Chainages and Levels

Date: May 2022 Datum: AHD Survey: Lidar & Canty's

SDS Civil Enterprises
A.B.N. 56 656 467 255
461 Hinterland Way, Knockrow NSW
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New Local Street Longsection

Project Lands
Lot 261 DP1262316
Rankin Drive, Bangalow

Drawing No 1910 - SD - 04
Revision C

Appendix 2

Broadscale Geotechnical Investigation Report

Ref: GI 4901-B

(by *Geotech Investigations Pty Ltd*)

REPORT ON

BROADSCALE GEOTECHNICAL INVESTIGATION AND LANDSLIDE SUSCEPTIBILITY ASSESSMENT FOR

PROPOSED RESIDENTIAL SUBDIVISION AT

RANKIN DRIVE, BANGALOW

DESCRIBED AS LOT 261 DP 1262316

& LOT 11 DP 807867

PREPARED FOR

INSTANT STEEL PTY LTD

PROJECT REF: GI 4901-B

7 JULY 2022

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GEOTECHNICAL ENVIRONMENTAL DRILLING

TABLE OF CONTENTS

Appendix A:	Proposed ‘Indicative Subdivision Layout’ plan by SDS Civil Enterprises. Site Plan S02
Appendix B:	Engineering Logs – Test Pit Profiles TP 1 to TP 11 Engineering Logs – Borehole Profiles BH 12 to BH 19 Geotechnical Report Standard Notes
Appendix C:	AGS Australian GeoGuide LR7 (Landslide Risk) Guidelines to good and Bad Hillside Practices

1. INTRODUCTION

This report details the results of a broadscale geotechnical investigation and landslide susceptibility assessment for the proposed residential subdivision at Rankin Drive, Bangalow, described as Lot 261 DP 1262316 and Lot 11 on DP 807867.

Geotech Investigations Pty Ltd (GI) was commissioned by Max Campbell of Instant Steel Pty Ltd, the developer, to complete this investigation. It is understood the development may comprise the following:-

- Subdivision into multiple residential large allotments (>800 m^2);
- Two R3 Medium Density lots; and
- New internal road and associated service infrastructure.

Full details of the development have not been finalised at the time of this investigation. However, a proposed 'Indicative Subdivision Layout' plan by SDS Civil Enterprises, referenced DWG Number: 1910 – RZ-2 (Geotech) Rev G has been provided to GI, and is attached in Appendix A.

2. OBJECTIVES AND AGREED SCOPE OF SERVICE

The geotechnical investigation was to determine information regarding the subsurface conditions and how this influences the design of the new structure etc. The investigation and report involved:-

- General site walk-over;
- Excavation and sampling of test pits(s) at 11 locations;
- Drilling and sampling of borehole(s) / Dynamic Cone Penetrometer test(s) at seven locations;
- Summarise the subsurface conditions, including any groundwater observations at the time;
- Typical constraints that these conditions may have on the project;
- Slope stability hazard risk analysis using The Australian Geomechanics Society (AGS) guidelines;
- General earthworks, including safe batter slopes; and retaining wall design parameters;
- Estimated movements relating from Shrink-Swell of cohesive soils;
- Expected Site Classification in accordance with AS2870-2011[1] to assist with footing and slab design; and
- Soil strength information and estimated settlements for footing and slab design.

---

[1] Australian Standard AS2870-2011 *'Residential footings and slabs - Construction'*, Standards Australia

Individual slope stability assessment and site classification reports will be required for each proposed structure as part of their development approval or building application.

3. SITE LOCATION AND DESCRIPTION

A site visit was carried out on the 9th of December 2019 by an experienced Geotechnical Engineer from GI, with the purpose of viewing the subject site and making observations of the local geology, existing vegetation and the existing stability of the natural slopes within and surrounding the site.

The site is approximately 4 hectares in total area, irregular shaped and located to the north of Rankin Drive, bounded to the north by Hinterland Way, with residential properties and Satinash Crescent to the west. In general, the allotment slopes in an easterly direction from RL 110 m AHD in the north west corner down to a stream at RL 48 m AHD, before a gentle rise to RL 53 m AHD in the far eastern corner. Overall gradients were measured at approximately 18 degrees from the western boundary decreasing to less than 10 degrees towards the stream.

Traversing the southern boundary is a gully, from the Rankin Drive boundary, down to the stream. Similarly, a gully traverses beyond the northern boundary within the Hinterland Way road reserve. On the northern side of the site, to the west of the stream, a steep embankment up to 6 m high was observed, possibly the remnants of a burrow area (refer Figure 4).

Figure 1: Looking south east from top of hill

Figure 2: Looking south from western boundary

Figure 3: Looking west from stream

Figure 4: Steep embankment

4. GEOTECHNICAL CONDITIONS

4.1 Geotechnical Model

Reference to geological mapping by the Geological Survey of New South Wales 1:250,000 series 'Tweed Heads' sheet indicates the site is underlain by soils from the Tertiary aged Lismore Basalt of the Lamington Volcanics, which typically comprise *"basalt (agglomerate, bole)".*

4.2 Field Work Methodology

Fieldwork was undertaken on the 9th of December 2019 comprising:-

- The excavation and sampling of 11 test pits, designated TP 1 to TP 11, using a 5.5 tonne hydraulic excavator, fitted with a 450 mm rock toothed bucket and ripping tyne to termination between 0.9 m and 3.1 m depth.
- The drilling and sampling of seven boreholes, designated BH 12 to BH 18, using a vehicle mounted drill rig to termination at 2.8 m depth.

The approximate locations of the test pits and boreholes are shown on Site Plan S02 attached in Appendix A, along with GPS co-ordinates within the engineering logs.

This investigation has been carried out generally in accordance with AS 1726 – 2017[2] in terms of soil description. Material description was assessed using visual and tactile methods. Pocket Penetrometer testing was carried out in the cuttings and walls of the test pits to assess approximate undrained shear strengths of the cohesive soils.

The fieldwork was carried out by an experienced geo-technician and geotechnical engineer who positioned and logged the materials encountered in the test pits / boreholes. At the completion of test locations, the test pits / boreholes were backfilled loosely with excavated spoil and tamped down.

4.3 Field Work Results

The results of the fieldwork are detailed on the Engineering Log attached in Appendix C, along with explanatory notes. Table 1 below provides a summary of these conditions.

---

[2] Australian Standard AS 1726-2017 *'Geotechnical site investigations'*, Standards Australia

Table 1: Summary of Subsurface Conditions *(depth in metres below existing surface level)*

Test Location	"Uncontrolled" Fill	Residual Soils Stiff to hard Clays	Weathered Rock Extremely low to low strength BASALT
TP 1	NE	0 m to 0.6 m	0.6 m to 0.9 m
TP 2	NE	0 m to 2.8 m	NE
TP 3	NE	0 m to 1.5 m	1.5 m to 2.5 m
TP 4	NE	0 m to 1.5 m	1.5 m to 2.8 m
TP 5	NE	0 m to 1.3 m	1.3 m to 2.3 m
TP 6	NE	0 m to 0.5 m	0.5 m to 1.4 m
TP 7	NE	0 m to 1.4 m	1.4 m to 2.1 m
TP 8	NE	0 m to 2.5 m	NE
TP 9	0 m to 1.1 m	1.1 m to 2.7 m	2.7 m to 2.9 m
TP 10	NE	0 m to 2.9 m	NE
TP 11	NE	0 m to 3.1 m	NE
BH 12	NE	0 m to 0.7 m	0.7 m to 2.8 m
BH 13	NE	0 m to 2.8 m	NE
BH 14	0 m to 1.7 m	1.7 m to 2.8 m	NE
BH 15	0 m to 0.3 m	0.3 m to 2.8 m	NE
BH 16	0 m to 0.5 m	0.5 m to 2.8 m	NE
BH 17	0 m to 0.6 m	0.6 m to 2.8 m	NE
BH 18	NE	0 m to 2.8 m	NE
BH 19	NE	0 m to 2.8 m	NE

Notes: NE – Not Encountered

Groundwater seepage was not observed during the investigation, while the boreholes / test pits remained open. It should be noted that groundwater is affected by climatic conditions, varying soil permeability, and will therefore vary over time.

4.4 Laboratory Results

Laboratory testing was undertaken by Border-Tek Pty Ltd on a bulk samples collected during the investigation. Laboratory testing results are summarised in Table 2 below, with Report attached in Appendix C.

Table 2: Summary of Laboratory Testing

Sample Location	Depth (m)	MDD (t/m^3)	OMC (%)	CBR Value (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index
TP 9	0.6-1.5	-	-	-	86	66	20
TP 11	0.4-0.7	1.19	45.5	6	71	57	14

Notes: OMC – Optimum Moisture Content (%)
MDD – Maximum Dry Density (t/m^3)
CBR – California Bearing Ratio (%)

5. ASSESSMENT OF THE LIKELIHOOD OF SLOPE INSTABILITY USING AGS GUIDELINES

5.1 Discussion

Natural hill slopes are formed by processes which reflect the site geology, climate and environment. The natural process can be influenced by human intervention in the form of earthworks, construction or other related activities. The risk associated in hill side construction is far greater than level construction. Good hill side building practices should be adopted to decrease the risk associated with it. Figures on good and bad hillside construction are presented in Appendix C of this report.

To define a slope as being ‘stable’ or ‘unstable’ is not technically feasible, however assessing the likelihood of slope movement can help in defining the stability of the site. Several methods can be adopted to assess the likelihood of slope movement including existing surface features supplemented with knowledge of the subsurface profile and experience gained on similar sites.

A five-fold subdivision of landside likelihood categories has been developed by the Australian Geomechanics Society-Sydney Group (AGS-SG) and is described in their 1985 paper on “Geotechnical Risk Associated with Hillside Development”. In March 2003, the AGS Sub-Committee on landslide Risk Management subsequently published “Landslide Risk Management Concepts and Guidelines” which review the earlier publication and the most current review in the 2007 publications.

The guidelines typically is to define and assess the “risk” as a function of the likelihood or probability of an event occurring (i.e. landslide, batter failure etc.) and the damage that this event may have (i.e. damage to property, loss of life etc.). Landslide and hazard risk zoning is a method of identifying different areas on a site with regard to the potential of a hazard or risk and incorporating this risk into local planning and development. The risk assessment process involves answering the following:-

- What might happen?
- How likely is it?
- What damage or injury may result?
- How important is it?
- What can be done about it?

It is normal to carry out a preliminary assessment of the first two points and is generally based on the site observations and soil profiles.

The causes of slope instability are well documented in the above mentioned literature and include the following factors:-

- Slope angle;
- Underlying geology and soil types;
- Vegetation cover;
- Variable and transient factors such as rainfall intensity, overland water flows, groundwater flows, piezometric pressures and seismic vibrations;
- Presence of soil masses in an unstable condition (ie. past movement);
- Man made factors such as construction activity including earthworks, removal of vegetation and changes to the surface and subsurface drainage, retaining walls, etc.

For any given area some of the above factors can be identified, while other possible contributing factors can be considered. From studying existing slope instabilities and the failure mechanisms, it is possible to make an assessment of the potential, relative likelihood of similar conditions arising in other areas. Slope instabilities can also be induced from man made factors including:-

- The construction of fill slopes;
- Undermining of steep slopes;
- Changing of water flow paths, in particular at the toe of slopes;
- Concentrated stormwater flow onto building platforms;
- Inadequate design and/or construction of retaining walls; and
- Saturation of soil below septic waste disposal absorption fields.

The terminology of the AGS Guidelines has been employed in the descriptions of hazards and the qualitative assessment of the likelihood, consequence and risk of slope instability. The following guidelines can be used for describing the likelihood of slope movement:-

Likelihood	**Probability**	**Qualitative Risk**	**Significance**
Barely Credible	10^{-6}	Very Low	Acceptable
Rare	10^{-5}	Low	Usually Acceptable
Unlikely	10^{-4}	Moderate	May be tolerated
Possible	10^{-3}	High	Unacceptable
Likely	10^{-2}	Very High	Unacceptable
Almost Certain	10^{-1}	Extremely High	Unacceptable

Any proposed residential development should generally include works which result in 'acceptable' or 'usually acceptable' risk level to the property after construction. In some cases, subject to appropriate monitoring and maintenance programs, a 'may be tolerated' risk may be accepted. Definitions of acceptable and tolerable risk included in the AGS Guidelines are attached as Appendix C.

5.2 Risk Categorisation

The site has been qualitatively classified in general accordance with the methods of the AGS. The effect of these hazards on the site has been summarised in Table 3, together with a qualitative assessment of likelihood, consequence and risk to the property in its proposed conditions.

Table 3: Hazard and Risk Summary for Proposed Residential Subdivision

Hazard	Likelihood	Possible Consequence	Risk Category
Creep of near surface soils	Possible	• Insignificant damage to ancillary structures and landscaping.	Low
Landslip in natural slopes greater than 18° and less than 26 degrees	Unlikely	• Major damage to dwellings, roads and services.	**Moderate**
Landslip in natural slopes between 10° and 18°	Rare	• Major damage to dwellings, roads and services.	Low
Landslip in natural slopes less than 10°	Barely credible	• Major damage to dwellings, roads and services.	Low
Landslip in excavated embankments or filled platforms	Possible	• Major damage to dwellings, roads and services.	**High**
Surface water from upper slopes weakening founding soils	Unlikely	• Minor damage to structures and retaining walls for repair.	Low
Debris (cobbles, boulders, weakened rock fragments) rolling down slope earthworks.	Likely	• Minor damage to downslope structures. • Injury or death to persons.	**Moderate**

The analysis summarised in Table 3 indicates a **"high"** risk item which requires mitigation measures to reduce these risks, and **"moderate"** risk items that may be tolerable however mitigation measures have also been provided to reduce these risks.

5.3 Suggestions to Reduce and Maintain Risk of Instability

The risk mitigation will need to focus on reducing the 'high' risk item to achieve an acceptable risk level, specific mitigation required for areas within the 'moderate' risk categories and maintaining or improving the 'low' risk categories. The recommendations in Table 4 below are designed to maintain or reduce the risk of slope instability to an acceptable level for future development of the site.

Table 4: Risk Mitigation Measures for Proposed Residential Subdivision

Hazard	Hazard Mitigation Measures	Revised Risk Category
Landslip in natural slopes greater than 18° and Less than 26 degrees.	• Limit disturbance of natural slopes greater than 18° • Regulate construction methodology on slopes greater than 18° to ensure construction suits the slope (i.e. pole-type homes, terraced dwellings, etc). • Limit unsupported cut/fill earthworks in areas greater than 18° to less than 1 m. All other cut and fill must be supported using engineered retaining walls with site specific global stability to achieve required Factor of Safety. • Gravity type retaining walls may not be used in these areas. • Prepare and follow detailed Stormwater Management and Erosion Control Plans to limit the concentration of stormwater.	Low
Landslip in excavated embankments or filled platforms	• Cut and fill earthworks to be limited to maximum 3 m depth, Unless Noted Otherwise in report. • All earthworks to be completed to provide “controlled” fill as per section 6.3.2 below • All batter slopes to be prepared as per Section 6.2 below. • Retaining walls must be engineer designed to individual site conditions.	Low
Surface water from ridgeline / upper slopes weakening founding soils	• All surface water from the upper areas be collected and / or diverted away from the building envelopes, into the stormwater system or approved stormwater discharge point. Preventing additional runoff on the site is essential in maintaining and improving the existing risk of instability.	Low
Debris (cobbles, boulders, weakened rock fragments) rolling down slope during earthworks.	• Temporary bund walls, catchment devices (or similar) and buffer zones below each building envelope are suggested to be implemented during construction to reduce this risk of debris flow. • Contractor must provide a suitable SWP/JSA for earthworks with site-specific risk management of excavation and moving of existing boulders.	Low

The following recommendations are a summary and also aimed to assist with reducing or maintaining the risk of slope instability within the proposed building areas:-

- All loads must not surcharge any proposed retaining walls, or the crest of batters, with all loads required to be deepened below the walls' / batters' zone of influence.
- Retaining structures will need to be suitably 'engineered designed', refer to Section 6.4.
- Gravity retaining walls such as boulder, gabion and crib are generally not recommended. They must not be used in areas of Slopes of greater than 18 degrees.
- Embankment protection is to be placed on the embankment faces (e.g. mulching, planting vegetation) to limit the degree of rill erosion from water runoff and drying out / cracking if left exposed, as these will influence the potential for inducing landslips.
- Ensure all stormwater management plans and drainage plans are adhered to, particularly in relation to ensuring that all surface water is collected and diverted away from the building envelopes, top of batters and retaining walls. Preventing additional runoff on the site is essential in maintaining and improving the existing risk of instability.
- Maintain good vegetation over the remainder of the site and provide additional vegetation with good root systems for any batters and cut embankments.

Additional information, which should be adopted during construction, is given in 'AGS Australian Geoguide LR7 (Landslide Risk)' and 'Guidelines to Good and Bad Hillside Practices' attached in Appendix C.

6. INTERPRETATION OF RESULTS

6.1 Proposed Development

It is understood the development will comprise the subdivision of the existing allotments into 19 residential large allotments (>800 m2) and 2 medium density allotments, with a new road from Rankin Drive. Details of earthworks are not known at this time.

6.2 Possible Constraints of Subsurface Conditions to the Project

The results of the investigations indicate generally natural clays of variable thickness over weathered basalt rock. There were localised areas of existing fill, as well as existing stockpiles of soil and tree offcuts.

Excavations, depending on the depth, may encounter difficult conditions due to variable thickness of residual soil over weathered basalt, and the variable strength of the basalt.

6.3 Earthworks

6.3.1 General

General earthworks are anticipated to comprise cut to fill to produce road platforms, with up to 3 m cut and/or fill suggested as a maximum.

Each individual residential allotment will differ in terms of earthworks design and construction methodology, however the advice provided in Table 4 and design recommendations in Table 5 should be followed for details design.

Should additional earthworks be required during detailed civil design, this office must be contacted to provide further advice. In this case, it is likely that further investigation and assessment will be required.

6.3.2 Batter Slopes

Stable batter angles in soils are strongly dependent upon fill type and compaction, soil type and strength, strength of underlying soils, slope angle / height and surcharge loadings. For the purpose of preliminary design, the batter slopes presented in Table 5 are considered to be suitable for the different soil and rock conditions encountered on the site. Restrictions on earthworks are imposed in areas of greater than 18 degrees, refer to Table 4 for more details.

Where soil / rock conditions vary from those presented in Table 5, GI may provide guidance and alternative slope angles on site during construction. At these batter slopes, some movement at and behind the slope crest, as well as some localised slumping of batter faces may occur, however should be considered “unlikely”.

The batter slopes assume that no surcharge loadings will be applied to the crest of the slope, and that no seepage out of the batter is present. If seepage is encountered or present at any stage, site specific geotechnical advice on batter stability should be obtained, and likely positive support options considered. All permanent batter slopes are to be protected from erosion and scour by use of appropriate drainage and vegetation.

Table 5: Slopes Angles for Batter Heights < 3 m (Unsurcharged, Horizontal Ground Behind Crest) (1)

Soil Stratum	Short Term (Maximum)	Long Term (Maximum)(1)
Controlled Fill Batters(2)	1V:1H (45°)	1V:2H (26°)
Residual Soils and extremely weathered basalt	1V:1H (45°)	1V:2H (26°)
Very Low Strength (or better) Basalt**(3)**	1V:0.5H (63°)	1V: 1H (45°) must refer to Note 3

Notes:

(1) A geotechnical engineer from GI is required to be on site during excavations of embankments and placement of fill batters to confirm safe batter slopes. These slopes assume the batters are not underlain by lower bearing strata.

(2) All 'controlled' fill batters should be overfilled, compacted and cut back at a maximum angle given in Table 5 for filled batters. These slope angles are dependent on the fill material used.

(3) The stability of excavations in rock is often governed by the presence of geological structures such as bedding planes, joints and faults. A suitably experienced Engineering Geologist/Geotechnical Engineer must inspect the excavations at the time of construction to assess whether the slope angles recommended in Table 5 are appropriate for the exposed conditions.

6.3.3 Site Preparation and Fill Placement

Generally, all earthworks are to be carried out in accordance with AS 3798 – 2007[3]. The following earthworks procedures can be used as a preliminary guide to support slab-on-ground and pavements:-

- In building and pavement areas, and areas to accept new fill, the subgrade must be prepared by removing any existing "uncontrolled" fill (where encountered), loose debris, soils that are wet, or contain vegetation or deleterious materials.

  HOLD POINT: Inspection by a geotechnical engineer required

- It is expected that the existing natural clays could be re-used for fill, depending upon the performance requirements, moisture control and conditioning, and ensuring any oversize particles are removed.

- The exposed subgrade should be test rolled using a 12 tonne roller (or similar), loaded water truck or dump truck to determine the presence of any soft spots, which should be excavated out and replaced with compacted select fill.

  HOLD POINT: Inspection by a geotechnical engineer required

- The exposed surface should be tyned to 0.2 m depth, moisture conditioned and then compacted.

  HOLD POINT: Inspection by geotechnical personnel required

---

[3] Australian Standard AS 3798-2007 *'Guidelines on earthworks for residential and commercial developments'*, Standards Australia

- The site area that will accept new fill is required to be benched at a maximum vertical height of 1 m with the bench sloped slightly forward at 1V:10H to promote drainage.

  HOLD POINT: Inspection by geotechnical personnel required

- Structural fill for earthworks should comprise select granular material and be uniformly compacted to 98% Standard MDD (or higher), with moisture content within 2% wet or dry of OMC for cohesive material. Cohesionless material (sand material) is to be compacted to achieve a minimum 70% density index. Layer thickness depends on the compaction equipment, however 200 mm to 250 mm loose layer thickness is generally considered suitable for most mechanical compaction equipment. Where backfill for service trenches is carried out, the above layer thickness applies however if vibrating plates are used, the layers are to be placed in 100mm loose thickness.

  HOLD POINT: Inspection by geotechnical personnel required to 'Level 1' standard

- Field testing must be carried out to confirm the standard of compaction achieved and the moisture content during the construction. The test frequency and extent of testing is to be carried out as per AS 3798, Section 8.0 and compaction testing is to be carried out by a NATA accredited laboratory.

- The placement of fill material to support building loads and pavements must be placed and compacted under 'Level 1' full-time geotechnical inspections and testing.

It is expected that the existing clayey soils will be susceptible to softening due to increase in moisture content, such as following rainfall, etc. Therefore, areas exposed to the elements should be minimised, and a layer of compacted select granular fill should be considered to improve trafficability, especially in access and egress areas.

6.4 Geotechnical Retaining Wall Design Parameters

Flexible retaining walls (i.e. those free to rotate or tilt) may be preliminarily designed using a triangular pressure distribution, adopting the earth pressure parameters and 'active' earth pressure coefficient (K_A) provided in Table 6 below. These include cantilevered, single propped or anchored retaining walls. For design of walls that are rigid and unable to rotate or tilt (i.e. basement wall that is tied to an upper level concrete floor), the 'at-rest' earth pressure coefficient (K_O) should be adopted for design.

The values provided in Table 6 are ultimate values, and appropriate safety factors or strength reduction factors should be included.

Table 6: Geotechnical Retaining Wall Design Parameters (Unfactored)

Soil Stratum	Unit weight (t/m^3)	Undrained Cohesion (kPa)	Pressure Coefficients		
			Active (k_A)	At-rest (k_O)	Passive (k_P)
"Controlled" Fill	1.6 – 1.8	125-200	0.40	0.55	3.33
Stiff clays	1.6	75	0.39	0.56	2.56
Very stiff / hard clays Extremely low strength Basalt	1.8	150	0.36	0.53	2.77
Very low strength Basalt	2.0	450	0.25	0.40	4.00

The design of all retaining walls will need to take into account any surcharge loading behind the walls. The lateral earth pressure coefficients provided in Table 6 have not made allowances for surcharge loadings from existing or future structures and these should be taken into consideration when designing the retaining wall system. Any backfill placed behind the wall should be loose granular material.

Footing sizes for retaining walls could be designed using the parameters given in Section 6.6. The parameters adopted for footings for cantilevered retaining walls should be reduced by one third to account for lateral loads.

6.5 Shrink-Swell Movements and Site Classification

Laboratory testing from one sample indicated a shrink-swell Index (I_{SS}) of 3.8% / pF. Based on laboratory testing from similar soils in this area, this value can vary between 3% / pF and 4% / pF.

The results of calculations reveal that under normal soil moisture variations (i.e. seasonal), y_S values for the natural clay soils encountered in the boreholes are estimated to be in the order of 40 mm to 50 mm. This would suggest that typically each building site in the current natural state would be classified as **"Class H1"** (Highly reactive).

The effect of earthworks must also be considered on design values. The calculations were completed to model the effect of probable cut and fill earthworks, and the y_S values increase to 60 mm to 75 mm. This would indicate a site subject to cut and fill earthworks should be reclassified as **"Class H2"** (very highly reactive).

This classification is relevant to sites subject to seasonal moisture changes only. Abnormal moisture conditions, such as from the removal or planting of trees (including on adjacent sites), poor site drainage, and development of gardens adjacent to the footings, may cause higher movements to occur, probably resulting in damage, which may or may not be within acceptable ranges.

6.6 Footings and Slab-on-Ground

Each individual building area must be investigated and assessed based on the proposed construction, however as a guide, the following comments can assist in preliminary design/evaluation.

Based on the results of the fieldwork, the exposed subgrade in possible building areas is likely to comprise localised areas of “controlled” fill (where existing ‘uncontrolled’ fill has been removed), with exposed residual stiff to hard clays and possibly extremely low strength grading to low strength (or stronger) basalt rock.

Where high level footings are to be considered, all footings, edge beams and internal beams of a slab-on-ground should be founded into uniform ‘controlled’ fill or natural stiff or better clay, where an allowable bearing pressure of 100 kPa may be adopted. Where necessary, footings may be founded into the weathered rock where an allowable bearing pressure of 300 kPa to 500 kPa, or higher, may be considered subject to individual requirements.

No footings are to be placed in fill material where the natural slopes are greater than 18 degrees. In these areas, site specific geotechnical design is required.

Settlements induced by footings loaded to these pressures can be estimated in the order of 1% to 2% of footing width. Additional settlements would be induced in fill material due to self-weight, possibly up to 2% of fill thickness over a 10 year to 20 year period.

6.7 Indicative Pavement Parameters

For preliminary pavement design purposes, based on experience in the area with similar ‘silty clay’ materials, a typical design CBR of 2% to 3% would be expected for these materials at 100 % standard compaction. Confirmatory pavement design parameters must be confirmed during construction, as it will depend on the nature of the subgrade materials.

It is expected that the clay subgrades will exhibit poor subsurface drainage, and it is recommended that subsoil drains be installed early in the works, particularly where pavements adjoin landscaped areas or other water sources.

6.8 General Comments

The above information and calculations are based on existing site soils and assumes moisture conditions within site soils vary due to seasonal effects only. If abnormal moisture conditions occur (due to drying by tree root action, or wetting by leaking pipes, water ponding, etc.), significantly greater movements are considered possible, and the Site Classification should be reconsidered.

It is recommended that good engineering practices be adopted in the design of all structures and foundations and in particular, the following should be considered for movement in sensitive areas underlain with reactive materials:-

- Trees and shrubs should not be planted or be allowed to remain closer than their mature height to movement sensitive structures / features. Where trees exist within this distance, deeper foundations may be required and GI should be notified immediately to provide such recommendations;
- Soil moisture should be controlled to limit moisture content change during or following construction;
- The site should be graded to allow surface water to easily flow into a suitable stormwater system, and prevent ponding, particularly adjacent to the footings; and
- Underground services should be made flexible where possible.

During periods of high rainfall, concentrated surface water runoff or ponding may occur on the site. Suitable drainage and diversion of all runoff into the stormwater articulation systems to prevent water ponding is necessary prior, during and after the construction of any proposed residential development.

7. LIMITS OF INVESTIGATION

Recommendations given in this report are based on the information supplied regarding the proposed building construction in conjunction with the findings of the investigation. Any change in the construction type or building location may require additional testing and/or make recommendations invalid.

Every reasonable effort has been made to locate the test sites so that the test pits and boreholes are representative of the soil conditions within the area to be investigated. The client should be made aware, however, that this assessment has been based on limited site data using relatively limited excavations and small diameter boreholes, and that subsurface conditions may vary across the area.

If you should require any further information or clarification, please do not hesitate to contact this office.

Yours faithfully
For and on behalf of
Geotech Investigations Pty Ltd

Heath Thomas *AdvDipEng(Civil), AMIEAust*
Geotechnical Engineering Associate

James Walle *RPEQ (15701), RPEng (Civil), B.Eng (Civil)*
Senior Geotechnical Engineer

APPENDIX A

PROPOSED ‘INDICATIVE SUBDIVISION LAYOUT’ PLAN BY SDS CIVIL ENTERPRISES, REFERENCED DWG NUMBER: 1910 – RZ-2 (GEOTECH) REV G

SITE PLAN S02

LEGEND

▨	Existing Residential Zone (R2)
⊗	Trees Nominated For Removal
— — —	New 16m Road (7m Pavement)
— 80.00 —	Contours (10m Interval)
E	Future Electrical Substation Easement

Drawing notes
1. The steep nature of the site will require the installation of some retaining walls associated with the creation of the new road. Such walls will typically be located upon and within future lots (ie not road reserve). Adjustment to lot boundaries to accomodate retaining wall design will be required.
3. Details contained within this drawing are not to be relied upon for detailed design purposes and boundaries are subject to adjustment.
4. The location of service easements for general infrastructure servicing have not been determined.
5. Any areas shown are subject to change once final survey boundaries are defined.

North Point

Scale at A3: 0 7.5 15 30 45

Date: June 2022 Datum: AHD Survey: Lidar & Canty's

SDS Civil Enterprises

A.B.N. 56 656 467 255

461 Hinterland Way, Knockrow NSW
m 0438 725 414 e peterw@sdscivil.com.au

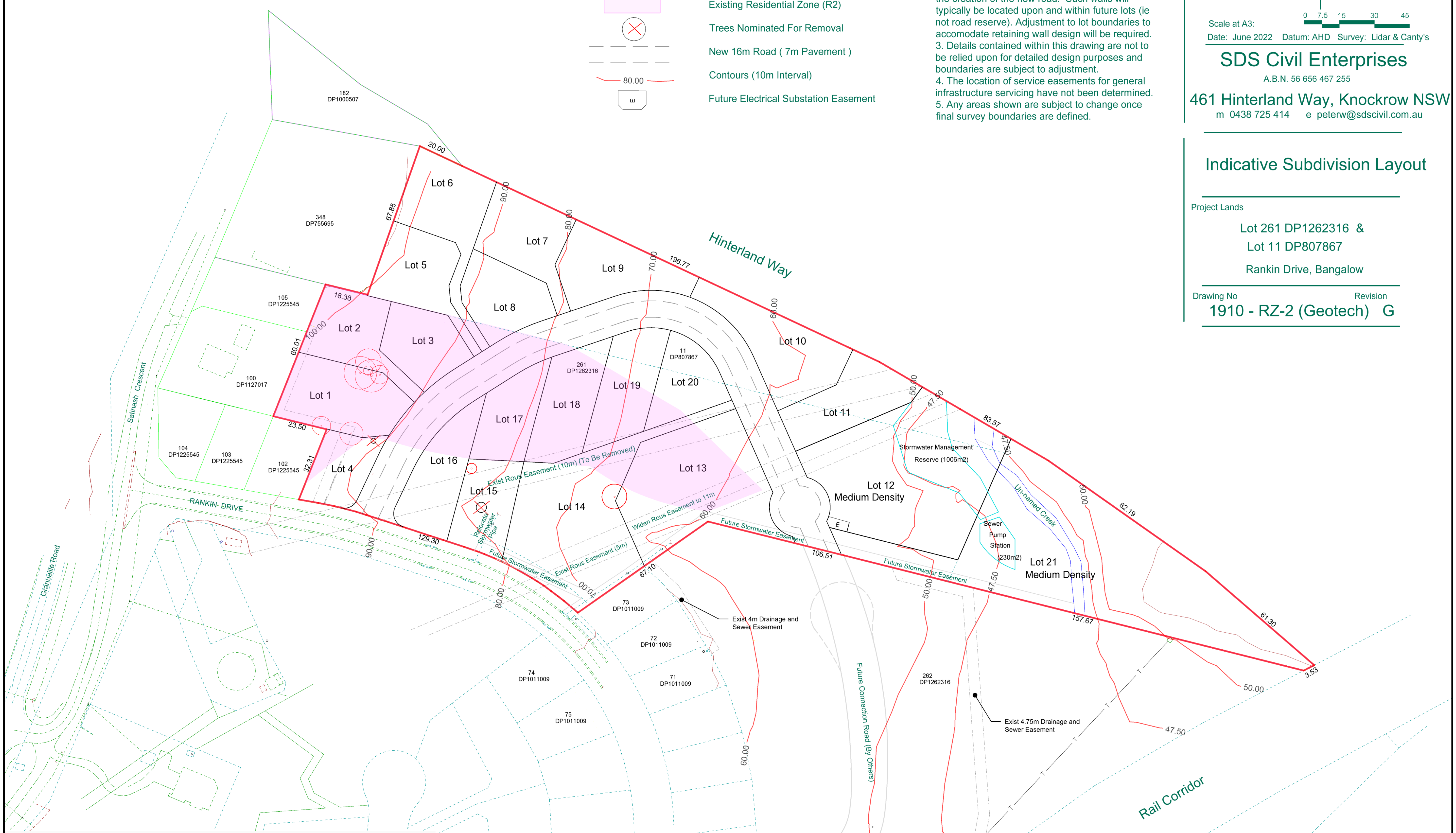
Indicative Subdivision Layout

Project Lands

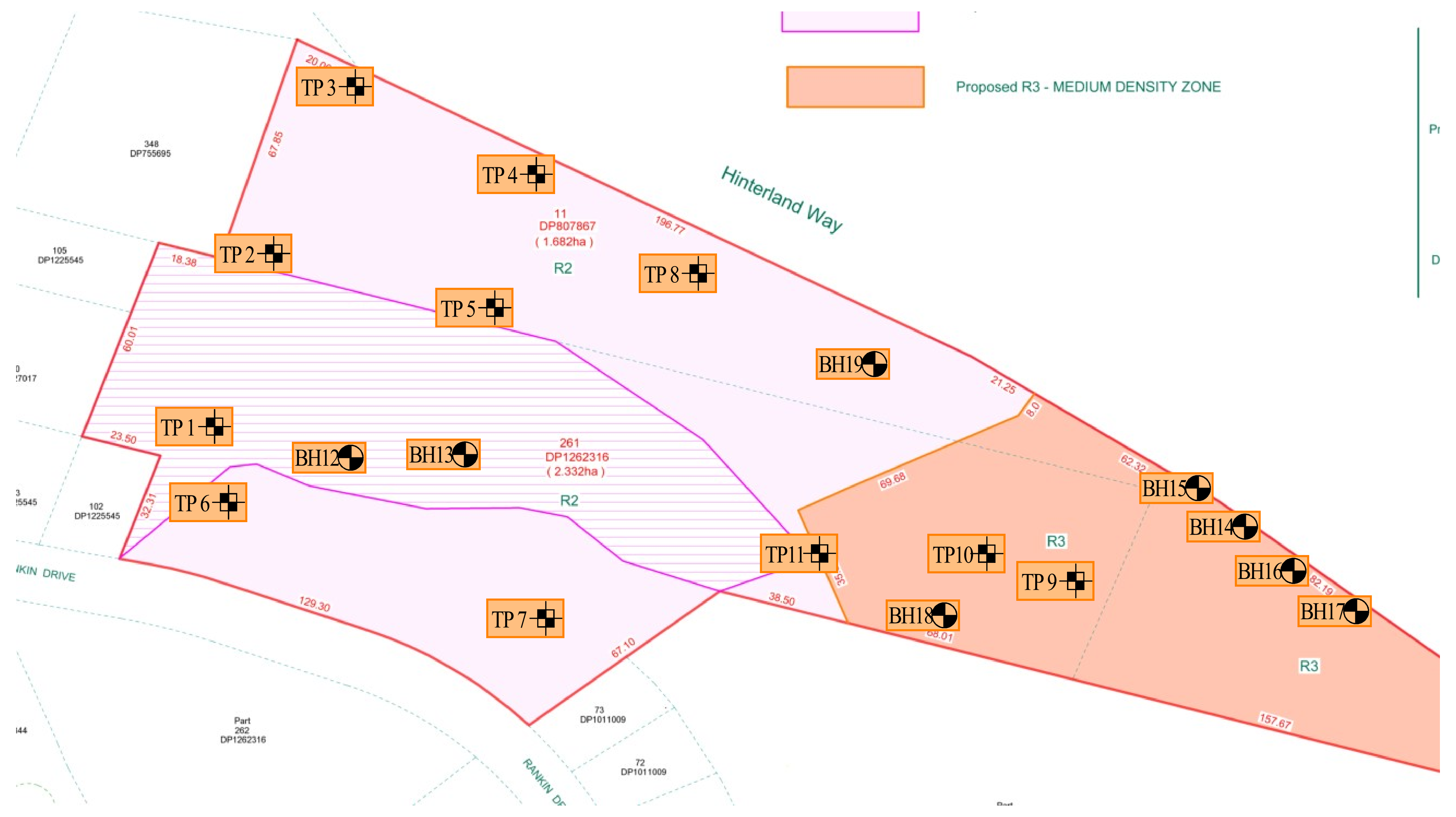
Lot 261 DP1262316 &
Lot 11 DP807867

Rankin Drive, Bangalow

Drawing No 1910 - RZ-2 (Geotech)
Revision G



Rev	Date	Amendment
A	Aug 2020	General Revisions
B	Aug 2020	Fire Truck Access / Hose Length / Buffer Dims Removed
C	Oct 2020	Bushfire Buffers Updated / Bdrys Lot 1 & 2
D	Oct 2020	Strata Lot Bdrys Amended & Lot 10 / General Drg Presentation
E	Nov 2020	Bushfire Buffer and Truck Details Removed
F	June 2022	Access Road Moved South, Rous Watermain Relocated
G	June 2022	Lot 12 and Lot 21 R3 Medium Density & Satinash Crescent



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EMAIL: admin@geotechinvestigations.com
WEB: www.geotechinvestigations.com

CLIENT:
INSTANT STEEL PTY LTD

PROJECT:
PROPOSED RESIDENTIAL DEVELOPMENT AT
RANKIN DRIVE
BANGALOW

DRAWING REF:
S02: SITE PLAN

LEGEND:
● Borehole and Test Pit Locat i on

Site Plan provided by SDS Civil Enterprises
Ref. No: 1910-RZ202 REV D

APPROXIMATE NORTH
NORTH

DATE:
07.07.2022

OUR REF / JOB No.:
GI 4901-b sp

DRAWN BY:
DC

Drawing not to scale.
Printed dimensions only.

APPENDIX B

ENGINEERING LOG – TEST PIT PROFILES TP 1 TO TP 11
ENGINEERING LOG – BOREHOLE PROFILES BH 12 TO BH 19
GEOTECHNICAL REPORT STANDARD NOTES

GEOTECH INVESTIGATIONS PTY LTD

Unit 3/42 Machinery Drive, Tweed Heads South NSW 2486
Ph: 0755 233 979 Fax: 0755 233 981

ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 43.80”	**E:**	153°31’ 34.75”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 1
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL *Oraganics & roots throughout
		0.5	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown, Friable	Hd			
			▦	(DW) BASALT: Fine grained, Dry, Grey & orange brown mottling, Highly fractured	VLw /Lw			
		1.0						
		1.5						
		2.0						
		2.5						
		3.0						
		3.5						
		4.0						
		4.5						

TP 1 TERMINATED AT 0.9m – REFUSAL WITHIN WEATHERED ROCK

METHOD

AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER

▼	Water Level
►	Water Seepage

WEATHERING

EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH

VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS

U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: JW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

GEOTECH INVESTIGATIONS PTY LTD

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Ph: 0755 233 979 Fax: 0755 233 981

ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 42.19”	**E:**	153°31’ 35.77”

CLIENT: INSTANT STEEL PTY LTD	**TEST PIT I.D. :** TP 2
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR **BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB				(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5		(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown, Friable	Hd	PP>450		
		1.0 1.5 2.0 2.5		(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown,	Hd	PP>450		
		3.0 3.5 4.0 4.5						

TP 2 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD		WEATHERING		CONSISTENCY / DENSITY / ROCK STRENGTH				SAMPLES / TESTS	
AD	Auger Drilling	EW	Extremely	VS	Very Soft	D	Dense	U( )	Undisturbed (size in mm)
RT	Ripping Tyne	HW	Highly	S	Soft	VD	Very Dense	D	Disturbed
MS	Mud Support	DW	Distinctly	F	Firm	Fb	Friable	BS	Bulk Sample
NMLC	Rock Coring	MW	Moderately	St	Stiff	ELw	Extremely Low	DCP	Dynamic Cone Penetrometer
RR	Rock Roller	SW	Slightly	VSt	Very Stiff	VLw	Very Low	SPT	Standard Penetrometer Test
TB	Toothed Bucket	F	Fresh	Hd	Hard	Lw	Low	N	Number of blows for SPT / 300mm
TC	Tri Cone			VL	Very Loose	M	Medium	VS	Vane Shear
WB	Wash Bore			L	Loose	H	High	A	Acid Sulfate Sample
				MD	Medium Dense	VH	Very High	PP	Pocket Penetrometer (kPa)

WATER	
▼	Water Level
►	Water Seepage

Logged By: JW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

GEOTECH INVESTIGATIONS PTY LTD

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Ph: 0755 233 979 Fax: 0755 233 981

ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 40.15”	**E:**	153°31’ 36.44”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 3
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown, Friable	VSt/ Hd			
		1.0 1.5	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown, Friable, Traces of EW-HW: BASALT very light & silty	Hd			
		2.0 2.5	▦	(HW) BASALT: Trace of boulders within layer, Fine grained, Dry, Grey & orange brown speckles of pale grey & black, Highly fractured	ELw			
		3.0 3.5 4.0 4.5						

TP 3 TERMINATED AT 2.5m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

	WATER
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

GEOTECH INVESTIGATIONS PTY LTD

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Ph: 0755 233 979 Fax: 0755 233 981

ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 40.95”	**E:**	155°31’ 37.73”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 4
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5 1.0	▥	(CH) Silty CLAY: Trace of sand & boulders, High plasticity, Moist (w<wp), Red/brown	VSt/ Hd			
		1.5	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown, Friable, Traces of EW-HW: BASALT very light & silty	Hd			
		2.0 2.5	▦	(HW) BASALT: Trace of boulders within layer, Fine grained, Dry, Grey & orange brown speckles of pale grey & black, Highly fractured	ELw			
		3.0 3.5 4.0 4.5						

TP 4 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore
	WATER
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 42.50”	**E:**	153°31’ 37.85”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 5
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5 1.0	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark Red/brown, Friable	Hd			
		1.5 2.0	▦	(HW) BASALT: Trace of boulders within layer, Fine grained, Dry, Grey & orange brown speckles of pale grey & black, Highly fractured	ELw			
		2.5 3.0 3.5 4.0 4.5						

TP 5 TERMINATED AT 2.3m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: JW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

GEOTECH INVESTIGATIONS PTY LTD
Unit 3/42 Machinery Drive, Tweed Heads South NSW 2486
Ph: 0755 233 979 Fax: 0755 233 981

ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 47.30”	**E:**	153°31’ 36.47”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 6
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL *Lots of tree roots & organics
		0.5 1.0	▦	(DW) BASALT: Fine grained, Dry, Grey & orange brown mottling, Highly fractured	ELw			
		1.5 2.0 2.5 3.0 3.5 4.0 4.5						

TP 6 TERMINATED AT 1.4m – REFUSAL WITHIN WEATHERED ROCK

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
▶	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 43.80”	**E:**	153°31’ 34.75”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 7
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5 1.0	▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	Hd	PP>400		
		1.5	▦	(HW) BASALT: Trace of boulders within layer, Fine grained, Dry, Grey & orange brown speckles of pale grey & black, Highly fractured	ELw			
		2.0	▦	(DW) BASALT: Fine grained, Dry, Grey & orange brown mottling, Highly fractured	VLw /Lw			
		2.5 3.0 3.5 4.0 4.5						

TP 7 TERMINATED AT 2.1m – REFUSAL WITHIN WEATHERED ROCK

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – TEST PIT PROFILE

GPS: **N:** **E:**

CLIENT: INSTANT STEEL PTY LTD	**TEST PIT I.D. :** TP 8
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR **BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5 1.0 1.5 2.0 2.5	▥	(CH) Silty CLAY: Trace of sand & boulders, High plasticity, Moist (w<wp), Red/brown	VSt/ Hd			
		3.0 3.5 4.0 4.5						

TP 8 TERMINATED AT 2.5m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 45.28”	**E:**	153°31’ 45.40”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 9
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB		0.5 1.0	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w>wp), Dark red/brown	F/ St			FILL *organics & stumps throughout
		1.5	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w>wp), Dark red/brown	VSt			RESIDUAL
	▼	2.0 2.5	▥	(CH) Silty CLAY: Trace of sand, High plasticity, Wet, Dark Red/brown, Friable, Traces of EW-HW: BASALT very light & silty	Hd			
			▦	(HW) BASALT: Trace of boulders within layer, Fine grained, Dry, Grey & orange brown speckles of pale grey & black, Highly fractured	ELw			
		3.0 3.5 4.0 4.5						

TP 9 TERMINATED AT 2.9m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – TEST PIT PROFILE

GPS:	N:	28°40’ 45.50”	E:	153°31’ 43.45”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 10
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB				(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5 1.0 1.5 2.0		(CH) Silty CLAY: Trace of boulders, High plasticity, Moist (w<wp), Red/brown	VSt/ Hd	PP=300-450		
		2.5		(CH) Silty CLAY: Trace of sand, High plasticity, Moist (w<wp), Dark orange/brown & red/brown mottling, Friable, Traces of EW-HW: BASALT very light & silty	Hd			
		3.0 3.5 4.0 4.5						

TP 10 TERMINATED AT 2.9m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By:	JW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – TEST PIT PROFILE

GPS:	**N:**	28°40’ 44.95”	**E:**	153°31’ 41.50”

CLIENT: INSTANT STEEL PTY LTD		**TEST PIT I.D. :** TP 11
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901
EQUIPMENT TYPE: 5.5 TONNE KUBOTA EXCAVATOR	**BUCKET SIZE:** 450mm TB	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
TB			▥	(CH) Sandy CLAY: Trace of silt, High plasticity, Fine to coarse sand, Dry, Dark red/brown	St			RESIDUAL
		0.5 1.0 1.5 2.0 2.5 3.0	▥	(CH) Silty CLAY: Trace of sand & boulders, High plasticity, Moist (w<wp), Red/brown	VSt/ Hd			
		3.5 4.0 4.5						

TP 11 TERMINATED AT 3.1m – LIMIT OF REACH

METHOD	
AD	Auger Drilling
RT	Ripping Tyne
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TB	Toothed Bucket
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
▶	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: JW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

Form GI 003h Issue 3

GEOTECH INVESTIGATIONS PTY LTD

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ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**	

CLIENT: INSTANT STEEL PTY LTD	**BOREHOLE I.D. :** BH 12
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10 **HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5	▥	(CH) Silty Sandy CLAY: Trace of cobbles, High plasticity, Fine to coarse sand, Moist (w<wp), Red/brown	St			RESIDUAL
		1.0 1.5 2.0 2.5	▦	(HW) BASALT: Trace of fine gravel, Fine to coarse grained, Grey & orange/brown mottling	ELw			
		3.0 3.5 4.0 4.5						

BH 12 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD		WEATHERING		CONSISTENCY / DENSITY / ROCK STRENGTH				SAMPLES / TESTS	
AD	Auger Drilling	EW	Extremely	VS	Very Soft	D	Dense	U( )	Undisturbed (size in mm)
C	Casing	HW	Highly	S	Soft	VD	Very Dense	D	Disturbed
MS	Mud Support	DW	Distinctly	F	Firm	Fb	Friable	BS	Bulk Sample
NMLC	Rock Coring	MW	Moderately	St	Stiff	ELw	Extremely Low	DCP	Dynamic Cone Penetrometer
RR	Rock Roller	SW	Slightly	VSt	Very Stiff	VLw	Very Low	SPT	Standard Penetrometer Test
TC	Tri Cone	F	Fresh	Hd	Hard	Lw	Low	N	Number of blows for SPT / 300mm
WB	Wash Bore			VL	Very Loose	M	Medium	VS	Vane Shear
WATER				L	Loose	H	High	A	Acid Sulfate Sample
▼	Water Level			MD	Medium Dense	VH	Very High	PP	Pocket Penetrometer (kPa)
►	Water Seepage								

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

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ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**

CLIENT: INSTANT STEEL PTY LTD	**BOREHOLE I.D. :** BH 13
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10 / **HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5		(CH) Silty Sandy CLAY: Trace of cobbles, High plasticity, Fine to coarse sand, Moist (w<wp), Red/brown	St			RESIDUAL
		1.0 1.5 2.0 2.5		(CH) Silty Sandy CLAY: Trace of fine gravel, High plasticity, Fine to coarse sand, Moist (w<wp), Red/brown with grey & orange/brown mottling	VSt			
		3.0 3.5 4.0 4.5						

BH 13 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
C	Casing
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

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ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**	

CLIENT: INSTANT STEEL PTY LTD	**BOREHOLE I.D. :** BH 14
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10 **HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5 1.0 1.5	▥	(CH) Silty Sandy CLAY: Trace of fine cobbles, High plasticity, Fine to coarse sand, Moist (w<wp), Grey with red/brown & orange mottling	St/ VSt	PP=250-300		FILL
		2.0	▥	(CH) Silty Sandy CLAY: High plasticity, Fine to sand, Moist (w<wp), Orange/brown & Grey mottling	St/ VSt			RESIDUAL
		2.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w<wp), Grey	St/ VSt			
		3.0 3.5 4.0 4.5						

BH 14 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD		WEATHERING		CONSISTENCY / DENSITY / ROCK STRENGTH				SAMPLES / TESTS	
AD	Auger Drilling	EW	Extremely	VS	Very Soft	D	Dense	U( )	Undisturbed (size in mm)
C	Casing	HW	Highly	S	Soft	VD	Very Dense	D	Disturbed
MS	Mud Support	DW	Distinctly	F	Firm	Fb	Friable	BS	Bulk Sample
NMLC	Rock Coring	MW	Moderately	St	Stiff	ELw	Extremely Low	DCP	Dynamic Cone Penetrometer
RR	Rock Roller	SW	Slightly	VSt	Very Stiff	VLw	Very Low	SPT	Standard Penetrometer Test
TC	Tri Cone	F	Fresh	Hd	Hard	Lw	Low	N	Number of blows for SPT / 300mm
WB	Wash Bore			VL	Very Loose	M	Medium	VS	Vane Shear
				L	Loose	H	High	A	Acid Sulfate Sample
				MD	Medium Dense	VH	Very High	PP	Pocket Penetrometer (kPa)

WATER	
▼	Water Level
►	Water Seepage

Logged By:	DAW	**Date:**	09/12/19	**Checked By:**	HT	**Date:**	22/01/2020

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ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**

CLIENT: INSTANT STEEL PTY LTD	**BOREHOLE I.D. :** BH 15
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10 **HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD			▥	(CH) Silty Sandy CLAY: Trace of fine cobbles, High plasticity, Fine to coarse sand, Moist (w<wp), Grey with red/brown & orange mottling	St/ VSt			FILL
		0.5 1.0 1.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Dark orange & brown mottling	St/ VSt			RESIDUAL
		2.0 2.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Orange/brown	St/ VsT			
		3.0 3.5 4.0 4.5						

BH 15 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
C	Casing
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

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Unit 3/42 Machinery Drive, Tweed Heads South NSW 2486
Ph: 0755 233 979 Fax: 0755 233 981

ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**

CLIENT: INSTANT STEEL PTY LTD		**BOREHOLE I.D. :** BH 16
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10	**HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5	▥	(CH) Silty Sandy CLAY: Trace of cobbles, High plasticity, Fine to coarse sand, Moist (w<wp), Red/brown & grey mottling	St			FILL
		1.0 1.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Dark orange & brown mottling	St/ VSt			RESIDUAL
		2.0 2.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Orange/brown	St/ VSt			
		3.0 3.5 4.0 4.5						

BH 16 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
C	Casing
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
►	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

GEOTECH INVESTIGATIONS PTY LTD

Unit 3/42 Machinery Drive, Tweed Heads South NSW 2486
Ph: 0755 233 979   Fax: 0755 233 981

ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**	

CLIENT: INSTANT STEEL PTY LTD	**BOREHOLE I.D. :** BH 17
PROJECT: RANKIN DRIVE, BANGALOW	**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10 **HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5	▥	(CH) Silty Sandy CLAY: Trace of fine cobbles, High plasticity, Fine to coarse sand, Moist (w<wp), Grey with red/brown & orange mottling	St			FILL
		1.0 1.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine to sand, Moist (w<wp), Dark orange & brown mottling	St/ VSt			RESIDUAL
		2.0 2.5	▥	(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Grey	VSt			
		3.0 3.5 4.0 4.5						

BH 17 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
C	Casing
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
▶	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

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ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**

CLIENT: INSTANT STEEL PTY LTD		**BOREHOLE I.D. :** BH 18
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10	**HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5 1.0 1.5		(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Dark grey & brown mottling				RESIDUAL
		2.0 2.5		(CI) Silty Sandy CLAY: Medium plasticity, Fine to coarse sand & Gravel, Moist, Grey & orange/brown mottling	St/ VSt			
		3.0 3.5 4.0 4.5						

BH 18 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
C	Casing
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
▶	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

GEOTECH INVESTIGATIONS PTY LTD

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ENGINEERING LOG – BOREHOLE PROFILE

GPS:	**N:**		**E:**

CLIENT: INSTANT STEEL PTY LTD		**BOREHOLE I.D. :** BH 19
PROJECT: RANKIN DRIVE, BANGALOW		**JOB No.:** GI 4901-a
EQUIPMENT TYPE: GT-10	**HOLE DIAMETER:** 110mm	**PAGE:** 1 of 1

Method	Water	Depth (m)	Graphic Log	Material Description	Consistency / Rel. Density	Sample / Test	DCP Blows / 100mm	Structure and additional observation
AD		0.5 1.0 1.5 2.0		(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Grey/brown	St/ VSt			RESIDUAL
		2.5		(CH) Silty Sandy CLAY: High plasticity, Fine sand, Moist (w>wp), Orange/brown	VSt			
		3.0 3.5 4.0 4.5						

BH 19 TERMINATED AT 2.8m – LIMIT OF INVESTIGATION

METHOD	
AD	Auger Drilling
C	Casing
MS	Mud Support
NMLC	Rock Coring
RR	Rock Roller
TC	Tri Cone
WB	Wash Bore

WATER	
▼	Water Level
▶	Water Seepage

WEATHERING	
EW	Extremely
HW	Highly
DW	Distinctly
MW	Moderately
SW	Slightly
F	Fresh

CONSISTENCY / DENSITY / ROCK STRENGTH			
VS	Very Soft	D	Dense
S	Soft	VD	Very Dense
F	Firm	Fb	Friable
St	Stiff	ELw	Extremely Low
VSt	Very Stiff	VLw	Very Low
Hd	Hard	Lw	Low
VL	Very Loose	M	Medium
L	Loose	H	High
MD	Medium Dense	VH	Very High

SAMPLES / TESTS	
U( )	Undisturbed (size in mm)
D	Disturbed
BS	Bulk Sample
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetrometer Test
N	Number of blows for SPT / 300mm
VS	Vane Shear
A	Acid Sulfate Sample
PP	Pocket Penetrometer (kPa)

Logged By: DAW	**Date:** 09/12/19	**Checked By:** HT	**Date:** 22/01/2020

SCOPE These standard notes may be of assistance when understanding terms and recommendations given in this report. These notes are for general conditions and not all terms given may be of concern to the report attached. The descriptive terms adopted by Geotech Investigations Pty Ltd are given below and are largely consistent with Australian Standards AS1726-1993 'Geotechnical Site Investigations'.

CLIENT can be described and is limited to the financier of this geotechnical investigation.

LEGALITY and privacy of this document is based on communication between Geotech Investigations Pty Ltd and the client. Unless indicated otherwise the report was prepared specifically for the client involved and for the purposes indicated by the client. Use by any other party for any purpose, or by the client for a different purpose, will result in recommendations becoming invalid and Geotech Investigations Pty Ltd will hold no responsibility for problems which may arise.

GEOTECHNICAL REPORTS are predominantly derived using professional estimates determined from the results of fieldwork, in-situ and laboratory testing and experience from previous investigations in the area, from which geotechnical engineers then formulate an opinion about overall subsurface conditions. The client must be made aware that the investigations are undertaken to ensure minimal site impact using test-pits or small diameter boreholes and soil conditions on-site may vary from those encountered during the investigation.

CLIENTS RESPONSIBILITY to notify this office should there be adjustments in proposed structure/location or inconsistencies with material descriptions given in this report and those encountered on site. Geotech Investigations Pty Ltd is able to provide a range of services from on-site inspections to full project supervision to confirm recommendations given in the report.

CSIRO Publication BTF 18 'Foundation Maintenance and Footing Performance: A Homeowner's Guide' explains how to adequately maintain drainage during and post construction which lies as the responsibility of the client. Suitable drainage ensures recommendations given in this report remain valid.

INVESTIGATION METHODS adopted by Geotech Investigations Pty Ltd are designed to incorporate individual project-specific factors to obtain information on the physical properties of soil and rock around a site to design earthworks and foundations for proposed structures. The following methods of investigation currently adopted by this company are summarised below:-

HAND AUGER – investigations enable field work to be undertaken where access is limited. The materials must have sufficient cohesion to stand unsupported in an unlined borehole and there must be no large cobbles boulders or other obstructions which would prevent rotation of the auger.

TEST-PITS – investigations are carried out with an excavator or backhoe, allowing a visual inspection of sub-surface material in-situ and from samples removed. The limit of investigation is restricted by the reach of the excavator or backhoe.

CONTINUOUS SPIRAL FLIGHT AUGERING TECHNIQUES – investigations are advanced by pushing a 100mm diameter spiral into the sub-surface and withdrawing it at regular intervals to allow sampling or testing as it emerges.

WASH BORING – investigations are advanced by removing the loosened soil from the borehole by a stream of water or drilling mud issuing from the lower end of the wash pipe which is worked up and down or rotated by hand in the borehole. The water or mud carries the soil up the borehole where it overflows at ground level where the soil in suspension is allowed to settle in a pond or tank and the fluid is re-circulated or discharged to waste as required.

NON-CORE ROTARY DRILLING – investigations are advanced using a rotary bit with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from feel and rate of penetration.

ROTARY MUD DRILLING – is carried out as above using mud as support and circulating fluid for the borehole drilling. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling.

CONTINUOUS CORE DRILLING – investigations are carried out in rock material, specimens of rock in the form of cylindrical cores are recovered from the drill holes by the means of core barrel. The core barrel is provided at its lower end with a detachable core bit which carries industrial diamond chips in a matrix of metal. Rotation of the barrel by means of the drill rods causes the core bit to cut an annulus in the rock, the cuttings being washed to the surface by a stream of pumped down the hollow drill rods.

TESTING METHODS adopted by Geotech Investigations Pty Ltd to determine soil properties include but not limited to the following:-

U50 – Undisturbed samples are obtained by inserting a 50mm diameter thin-walled steel tube into the material and withdrawing with a sample of the soil in a moderately undisturbed condition.

PP – Pocket Penetrometer tests are commonly used on thin walled tube samples of cohesive soils to evaluate consistency and approximate unconfined compressive strength of saturated cohesive soils. They may also be used for the same purpose in freshly excavated trenches.

VS – Vane Shear test are commonly used in-situ or on thin walled tube samples of cohesive soils by introducing the vane into the material where the measurement of the undrained shear strength is required. Then the vane is rotated and the torsional force required to cause shearing is calculated.

DCP – Dynamic Cone Penetrometer tests are commonly used in-situ to measure the strength attributes of penetrability and compaction of sub-surface materials.

SPT – Standard Penetration Tests are commonly uses to determine the density of granular deposits but are occasionally used in cohesive material as a means of determining strength and also of obtaining a relatively undisturbed sample. Samples and results are obtained by driving a 50mm diameter split tube through blows from a slide hammer with a weight of 63.5kg falling through a distance of 760mm. Blow counts are recorded for 150mm intervals with the sum of the number of blows required for the second and third 150mm of penetration is termed the "standard penetration resistance" or the "N-value".

GEOLOGICAL ORIGINS of sub-surface material plays a considerable role in the development of engineering parameters and have been summarised as follows:-

FILL – materials are man made deposits, which may be significantly more variable between test locations than naturally occurring soils.

RESIDUAL – soils are present in a region as a result of weathering over the geological time scale.

COLLUVIAL – soils have been deposited recently, on the geological time scale, as soils being transported slowly down slope due to gravitational creep.

ALLUVIAL – soils have been deposited recently, on the geological time scale, as water borne materials.

AEOLIAN – soils have been deposited recently, on the geological time scale, as wind borne materials.

SOIL DESCRIPTION is based on an assessment of disturbed samples, as recovered from boreholes and excavations, and from undisturbed materials. Soil descriptions adopted by Geotech Investigations Pty Ltd are largely consistent with AS 1726-1993 '*Geotechnical Site Investigation'*. Soil types are described according to the predominating particle size, qualified by the grading of other particles present on the following bases detailed in Table 1.

COHESIVE SOILS ability to hold moisture known as its liquid limit is the state of a soil when it goes from a solid state to a liquid state described in Table 2

TABLE 1

Soil Classification	Particle Size
Clay	< 0.002 mm
Silt	0.002 – 0.06 mm
Sand	0.06 – 2.00 mm
Gravel	2.00 – 60.0 mm

TABLE 2

Descriptive Type	Range of Liquid Limit %
Of low plasticity	≤ 35
Of medium plasticity	> 35 ≤ 50
Of high plasticity	> 50

Furthermore to soil description cohesive soils are described on their strength (assessed in conjunction with penetration tests) and liquid limit. Non-cohesive soil strengths are described by their density index. With descriptions for cohesive and non-cohesive soils summarised in Table 3.

TABLE 3

COHESIVE SOILS		NON-COHESIVE SOILS	
Term	**Undrained Shear Strength kPa**	**Term**	**Density Index %**
Very soft	≤ 12	Very Loose	≤15
Soft	> 12 ≤25	Loose	> 15 ≤35
Firm	> 25 ≤50	Medium Dense	> 35 ≤65
Stiff	> 50 ≤100	Dense	> 65 ≤85
Very Stiff	> 100 ≤200	Very Dense	> 85
Hard	> 200		

Description of terms used to describe material portion are summarised in Table 4.

TABLE 4

COARSE GRAINIED SOILS		FINE GRAINED SOILS	
% Fines	**Modifier**	**% Coarse**	**Modifier**
≤ 5	Omit or 'trace'	≤ 15	Omit or 'trace'
> 5 ≤12	Describe as 'with'	> 15 ≤30	Describe as 'with'
> 12	Prefix soil as 'silty/clayey'	> 30	Prefix soil as 'sandy/gravelly'

ROCK DESCRIPTIONS are determined from disturbed samples or specimens collected during field investigations. A rocks presence of defects and the effects of weathering are likely to have a great influence on engineering behaviour.

Rock Material Weathering Classification is summarised in Table 5.

TABLE 5

Term	Symbol	Definition
Residual Soils	-	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported
Extremely Weathered Rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded, in water
Distinctly Weathered Rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by iron staining. Porosity may be increased by leaching, or may be decreased due to decomposition of weathering products in pores
Slightly Weathered Rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh rock	FR	Rock shows no signs of decomposition or staining

Rock Material Strength Classification is summarised in Table 6.

TABLE 6

Term	Symbol	Point load index (MPa) I_s50	Field guide to strength
Extremely Low	EL	≤0.03	Easily remoulded by hand to a material with soil properties
Very Low	VL	>0.03 ≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 3cm thick can be broken by finger pressure
Low	L	>0.1 ≤0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece of core 150mm long 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling
Medium	M	>0.3 ≤1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty
High	H	>1.0 ≤3.0	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer
Very High	VH	>3.0 ≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer
Extremely High	EH	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer

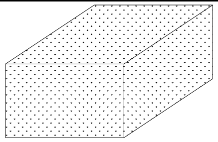
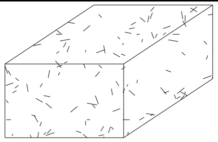
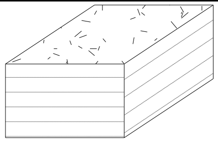
Rock Material Defect Shapes are summarised in Table 7.

TABLE 7

Term	Description
Planar	The defect does not vary in orientation.
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps.
Irregular	The defect has many sharp changes of orientation
Smooth	The defect has a flat even finish
Rough	The defect has a irregular disoriented finish

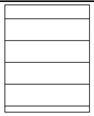
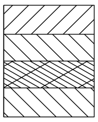
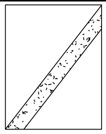
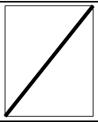
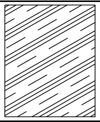
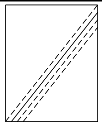
Rock Material Texture and Fabric are summarised in Table 8.

TABLE 8

Geological Description	Massive		Layered (Bedded foliate cleaved)
Diagram			
Fabric Type	Effectively homogenous and isotropic. Bulky or equi-dimensional grains uniformly distributed	Effectively homogeneous and isotropic. Elongated	Effective homogeneous with planar anisotropy. Elongated or tabular grains or pores in a layered arrangement

Rock Material Defect Type is summarised in Table 9

TABLE 9

Term	Definition	Diagram
Bedding	Signifying existence of beds or laminate. Planes dividing sedimentary rocks of the same or different lithology. Structure occurring in granite and similar rocks evident in a tendency to split more or less horizontally to the land surface	
Cross Bedding	Also called cross-lamination or false bedding. The structure commonly present in granular sedimentary rocks, which consists of tabular, irregularly lenticular or wedge-shaped bodies lying essentially parallel to the general stratification and which them selves show pronounced lamination structure in which the laminae are steeply inclined to the general bedding.	
Crushed Seam	A fracture at a more or less acute angle to applied force generally with some pulverized material along its surface	
Joint	A fracture in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.	
Parting	A small joint in rock or a layered rock where the tendency of crystals to separate along certain planes that are not true cleavage planes.	
Sheared Zone	A fracture that results from stresses which tend to shear one part of a specimen past the adjacent part	

APPENDIX C

AGS AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)
GUIDELINES TO GOOD AND BAD HILLSIDE PRACTICES

LANDSLIDE RISK

Concept of Risk

Risk is a familiar term, but what does it really mean? It can be defined as *"a measure of the probability and severity of an adverse effect to health, property, or the environment."* This definition may seem a bit complicated. In relation to landslides, geotechnical practitioners (GeoGuide LR1) are required to assess risk in terms of the likelihood that a particular landslide will occur and the possible consequences. This is called landslide risk assessment. The consequences of a landslide are many and varied, but our concerns normally focus on loss of, or damage to, property and loss of life.

Landslide Risk Assessment

Some local councils in Australia are aware of the potential for landslides within their jurisdiction and have responded by designating specific “landslide hazard zones". Development in these areas is often covered by special regulations. If you are contemplating building, or buying an existing house, particularly in a hilly area, or near cliffs, go first for information to your local council.

Landslide risk assessment must be undertaken by a geotechnical practitioner. It may involve visual inspection, geological mapping, geotechnical investigation and monitoring to identify:

- potential landslides (there may be more than one that could impact on your site)
- the likelihood that they will occur
- the damage that could result
- the cost of disruption and repairs and
- the extent to which lives could be lost.

Risk assessment is a predictive exercise, but since the ground and the processes involved are complex, prediction tends to lack precision. If you commission a landslide risk assessment for a particular site you should expect to receive a report prepared in accordance with current professional guidelines and in a form that is acceptable to your local council, or planning authority.

Risk to Property

Table 1 indicates the terms used to describe risk to property. Each risk level depends on an assessment of how likely a landslide is to occur and its consequences in dollar terms. "Likelihood" is the chance of it happening in any one year, as indicated in Table 2. "Consequences" are related to the cost of repairs and temporary loss of use if a landslide occurs. These two factors are combined by the geotechnical practitioner to determine the Qualitative Risk.

TABLE 2: LIKELIHOOD

Likelihood	Annual Probability
Almost Certain	1:10
Likely	1:100
Possible	1:1,000
Unlikely	1:10,000
Rare	1:100,000
Barely credible	1:1,000,000

The terms "unacceptable", "may be tolerated", etc. in Table 1 indicate how most people react to an assessed risk level. However, some people will always be more prepared, or better able, to tolerate a higher risk level than others.

Some local councils and planning authorities stipulate a maximum tolerable level of risk to property for developments within their jurisdictions. In these situations the risk must be assessed by a geotechnical practitioner. If stabilisation works are needed to meet the stipulated requirements these will normally have to be carried out as part of the development, or consent will be withheld.

TABLE 1: RISK TO PROPERTY

Qualitative Risk		Significance - Geotechnical engineering requirements
Very high	VH	**Unacceptable** without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low. May be too expensive and not practical. Work likely to cost more than the value of the property.
High	H	**Unacceptable** without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable level. Work would cost a substantial sum in relation to the value of the property.
Moderate	M	**May be tolerated** in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as possible.
Low	L	**Usually acceptable** to regulators. Where treatment has been needed to reduce the risk to this level, ongoing maintenance is required.
Very Low	VL	**Acceptable**. Manage by normal slope maintenance procedures.

AUSTRALIAN GEOGUIDE LR7 (LANDSLIDE RISK)

Risk to Life

Most of us have some difficulty grappling with the concept of risk and deciding whether, or not, we are prepared to accept it. However, without doing any sort of analysis, or commissioning a report from an "expert", we all take risks every day. One of them is the risk of being killed in an accident. This is worth thinking about, because it tells us a lot about ourselves and can help to put an assessed risk into a meaningful context. By identifying activities that we either are, or are not, prepared to engage in we can get some indication of the maximum level of risk that we are prepared to take. This knowledge can help us to decide whether we really are able to accept a particular risk, or to tolerate a particular likelihood of loss, or damage, to our property (Table 2).

In Table 3, data from NSW for the years 1998 to 2002, and other sources, is presented. A risk of 1 in 100,000 means that, in any one year, 1 person is killed for every 100,000 people undertaking that particular activity. The NSW data assumes that the whole population undertakes the activity. That is, we are all at risk of being killed in a fire, or of choking on our food, but it is reasonable to assume that only people who go deep sea fishing run a risk of being killed while doing it.

It can be seen that the risks of dying as a result of falling, using a motor vehicle, or engaging in water-related activities (including bathing) are all greater than 1:100,000 and yet few people actively avoid situations where these risks are present. Some people are averse to flying and yet it represents a lower risk than choking to death on food. Importantly, the data also indicate that, even when the risk of dying as a consequence of a particular event is very small, it could still happen to any one of us any day. If this were not so, no one would ever be struck by lightning.

Most local councils and planning authorities that stipulate a tolerable risk to property also stipulate a tolerable risk to life. The AGS Practice Note Guideline recommends that 1:100,000 is tolerable in newly developed areas, where works can be carried out as part of the development to limit risk. The tolerable level is raised to 1:10,000 in established areas, where specific landslide hazards may have existed for many years. The distinction is deliberate and intended to prevent the concept of landslide risk management, for its own sake, becoming an unreasonable financial burden on existing communities. Acceptable risk is usually taken to be one tenth of the tolerable risk (1:1,000,000 for new developments and 1:100,000 for established areas) and efforts should be made to attain these where it is practicable and financially realistic to do so.

TABLE 3: RISK TO LIFE

Risk (deaths per participant per year)	**Activity/Event Leading to Death** (NSW data unless noted)
1:1,000	Deep sea fishing (UK)
1:1,000 to 1:10,000	Motor cycling, horse riding , ultra-light flying (Canada)
1:23,000	Motor vehicle use
1:30,000	Fall
1:70,000	Drowning
1:180,000	Fire/burn
1:660,000	Choking on food
1:1,000,000	Scheduled airlines (Canada)
1:2,300,000	Train travel
1:32,000,000	Lightning strike

More information relevant to your particular situation may be found in other AUSTRALIAN GEOGUIDES:

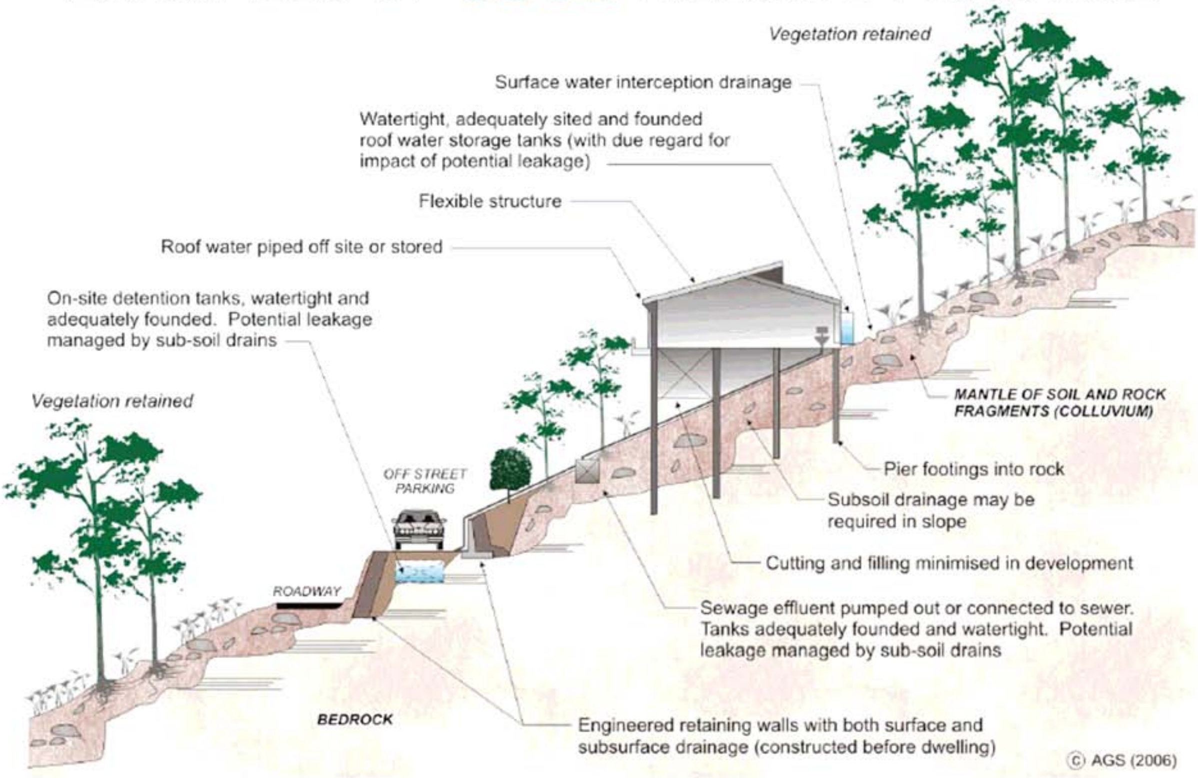
GeoGuide LR1	- Introduction
GeoGuide LR2	- Landslides
GeoGuide LR3	- Landslides in Soil
GeoGuide LR4	- Landslides in Rock
GeoGuide LR5	- Water & Drainage
GeoGuide LR6	- Retaining Walls
GeoGuide LR8	- Hillside Construction
GeoGuide LR9	- Effluent & Surface Water Disposal
GeoGuide LR10	- Coastal Landslides
GeoGuide LR11	- Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.

APPENDIX G - SOME GUIDELINES FOR HILLSIDE CONSTRUCTION

	GOOD ENGINEERING PRACTICE	*POOR ENGINEERING PRACTICE*
ADVICE		
GEOTECHNICAL ASSESSMENT	Obtain advice from a qualified, experienced geotechnical practitioner at early stage of planning and before site works.	Prepare detailed plan and start site works before geotechnical advice.
PLANNING		
SITE PLANNING	Having obtained geotechnical advice, plan the development with the risk arising from the identified hazards and consequences in mind.	Plan development without regard for the Risk.
DESIGN AND CONSTRUCTION		
HOUSE DESIGN	Use flexible structures which incorporate properly designed brickwork, timber or steel frames, timber or panel cladding. Consider use of split levels. Use decks for recreational areas where appropriate.	Floor plans which require extensive cutting and filling. Movement intolerant structures.
SITE CLEARING	Retain natural vegetation wherever practicable.	Indiscriminately clear the site.
ACCESS & DRIVEWAYS	Satisfy requirements below for cuts, fills, retaining walls and drainage. Council specifications for grades may need to be modified. Driveways and parking areas may need to be fully supported on piers.	Excavate and fill for site access before geotechnical advice.
EARTHWORKS	Retain natural contours wherever possible.	Indiscriminatory bulk earthworks.
Cuts	Minimise depth. Support with engineered retaining walls or batter to appropriate slope. Provide drainage measures and erosion control.	Large scale cuts and benching. Unsupported cuts. Ignore drainage requirements
Fills	Minimise height. Strip vegetation and topsoil and key into natural slopes prior to filling. Use clean fill materials and compact to engineering standards. Batter to appropriate slope or support with engineered retaining wall. Provide surface drainage and appropriate subsurface drainage.	Loose or poorly compacted fill, which if it fails, may flow a considerable distance including onto property below. Block natural drainage lines. Fill over existing vegetation and topsoil. Include stumps, trees, vegetation, topsoil, boulders, building rubble etc in fill.
Rock Outcrops & Boulders	Remove or stabilise boulders which may have unacceptable risk. Support rock faces where necessary.	Disturb or undercut detached blocks or boulders.
RETAINING WALLS	Engineer design to resist applied soil and water forces. Found on rock where practicable. Provide subsurface drainage within wall backfill and surface drainage on slope above. Construct wall as soon as possible after cut/fill operation.	Construct a structurally inadequate wall such as sandstone flagging, brick or unreinforced blockwork. Lack of subsurface drains and weepholes.
FOOTINGS	Found within rock where practicable. Use rows of piers or strip footings oriented up and down slope. Design for lateral creep pressures if necessary. Backfill footing excavations to exclude ingress of surface water.	Found on topsoil, loose fill, detached boulders or undercut cliffs.
SWIMMING POOLS	Engineer designed. Support on piers to rock where practicable. Provide with under-drainage and gravity drain outlet where practicable. Design for high soil pressures which may develop on uphill side whilst there may be little or no lateral support on downhill side.	
DRAINAGE		
Surface	Provide at tops of cut and fill slopes. Discharge to street drainage or natural water courses. Provide general falls to prevent blockage by siltation and incorporate silt traps. Line to minimise infiltration and make flexible where possible. Special structures to dissipate energy at changes of slope and/or direction.	Discharge at top of fills and cuts. Allow water to pond on bench areas.
Subsurface	Provide filter around subsurface drain. Provide drain behind retaining walls. Use flexible pipelines with access for maintenance. Prevent inflow of surface water.	Discharge roof runoff into absorption trenches.
Septic & Sullage	Usually requires pump-out or mains sewer systems; absorption trenches may be possible in some areas if risk is acceptable. Storage tanks should be water-tight and adequately founded.	Discharge sullage directly onto and into slopes. Use absorption trenches without consideration of landslide risk.
EROSION CONTROL & LANDSCAPING	Control erosion as this may lead to instability. Revegetate cleared area.	Failure to observe earthworks and drainage recommendations when landscaping.
DRAWINGS AND SITE VISITS DURING CONSTRUCTION		
DRAWINGS	Building Application drawings should be viewed by geotechnical consultant	
SITE VISITS	Site Visits by consultant may be appropriate during construction/	
INSPECTION AND MAINTENANCE BY OWNER		
OWNER'S RESPONSIBILITY	Clean drainage systems; repair broken joints in drains and leaks in supply pipes. Where structural distress is evident see advice. If seepage observed, determine causes or seek advice on consequences.	

EXAMPLES OF GOOD HILLSIDE PRACTICE



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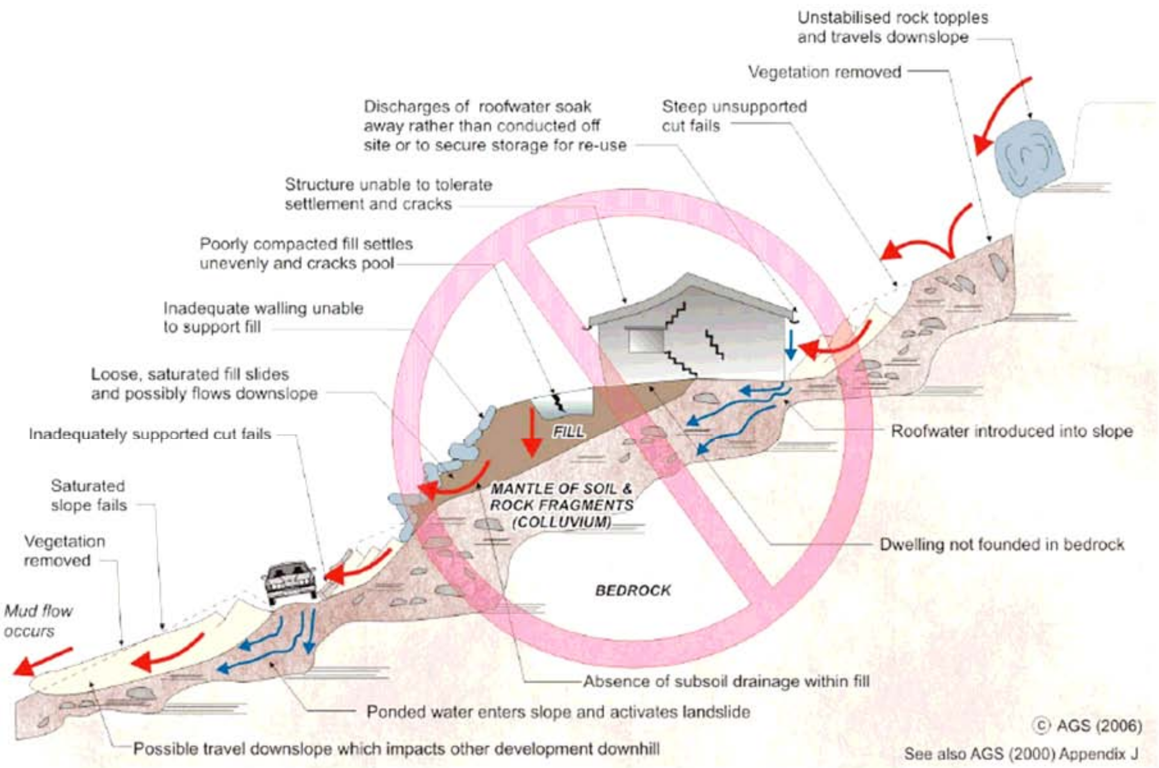
EXAMPLES OF POOR HILLSIDE PRACTICE



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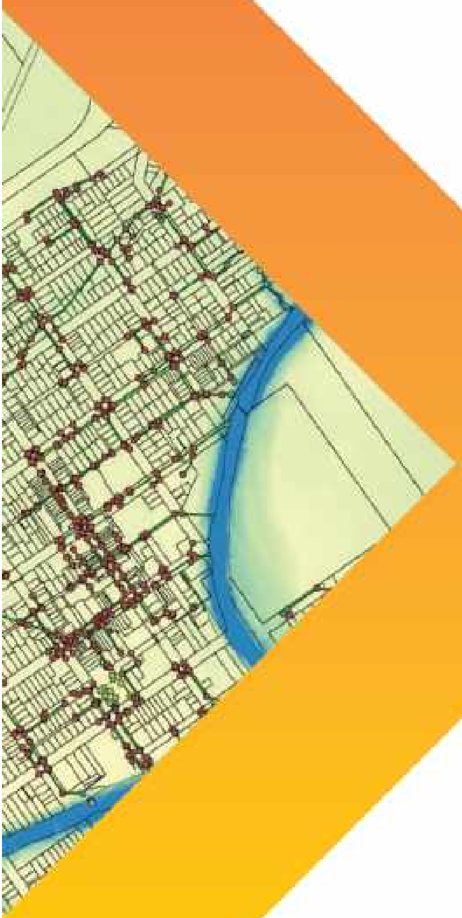
See also AGS (2000) Appendix J

Appendix 3

Hydraulic Assessment Report (Version 1.3)

(by *Floodworks*)

REPORT



68 GRANUAILLE CRESCENT, BANGALOW, NSW

HYDRAULIC ASSESSMENT

Instant Steel Pty Ltd

Contact us to design
the sustainable
towns and cities
of tomorrow.

FLOODWORKS

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Our Ref: FW00007

Date: 21 June 2022

Version 1.3

Important Note

This report has been prepared for the sole use the client, for a specific site (herein 'the site') the specific purpose specified in Section 1 of this report (herein 'the purpose'). This report is strictly limited for use by the client, to the purpose and site and may not be used for any other purposes.

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Version Register

Version	Status	Author	Reviewer	Change from Previous Version	Authorised for Release	
					Signature	Date
-	Draft	TP	DM		D. Mackenzie	18/10/19
1.0	For Issue	TP	DM		D. Mackenzie	25/11/19
1.1	For Issue	TP	DM	Change to Lot Description	D. Mackenzie	19/03/20
1.2	For Issue	TP	DM	Change to lot boundary	D. Mackenzie	02/04/20
1.3	For Issue	TP	DM	Removal of Lot182 DP1000507	D. Mackenzie	21/06/22

Transmission Register

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Max Campbell	mca79997@hotmail.com

Table of Contents

Figures

Tables

1. Introduction

Instant Steel Pty Ltd has requested a hydraulic assessment as part of a proposed Subdivision Development Application for 68 Granuaille Crescent, Bangalow, Lot 261 DP 1262316, Lot 11DP 807867 (the subject site).

The hydraulic assessment will cover the existing case and will determine the flooded extents of the subject creek. Additional information will include velocity, peak depth and hazard assessment.

The key objectives of the project are:

- Reduce flood risk where possible;
- Develop a Hydrology model of the catchment to Australian Rainfall and Runoff (ARR2019) methodology;
- Calibrate model to Regional Flood Frequency Estimation Tool (RFFE) and anecdotal data;
- Construct a base case 1D/2D Tuflow Hydraulic model of the subject site to ARR2019;
- A 1% AEP (100 year ARI) hydraulics assessment will be undertaken to determine the flooded extents of the subject creek. Additional information will include velocity, peak depth and hazard assessment.

The principal objective of this hydraulic assessment is to identify existing maximum water levels, maximum depths, maximum hazards and maximum velocities for the subject site. Detailed 1D/2D modelling has been undertaken to confirm the above objectives.

See Figure 1 below showing the location of the study site. The land area of the subject site is approximately 4.1ha, with a temporal creek running north to south through the eastern portion of the subject site.

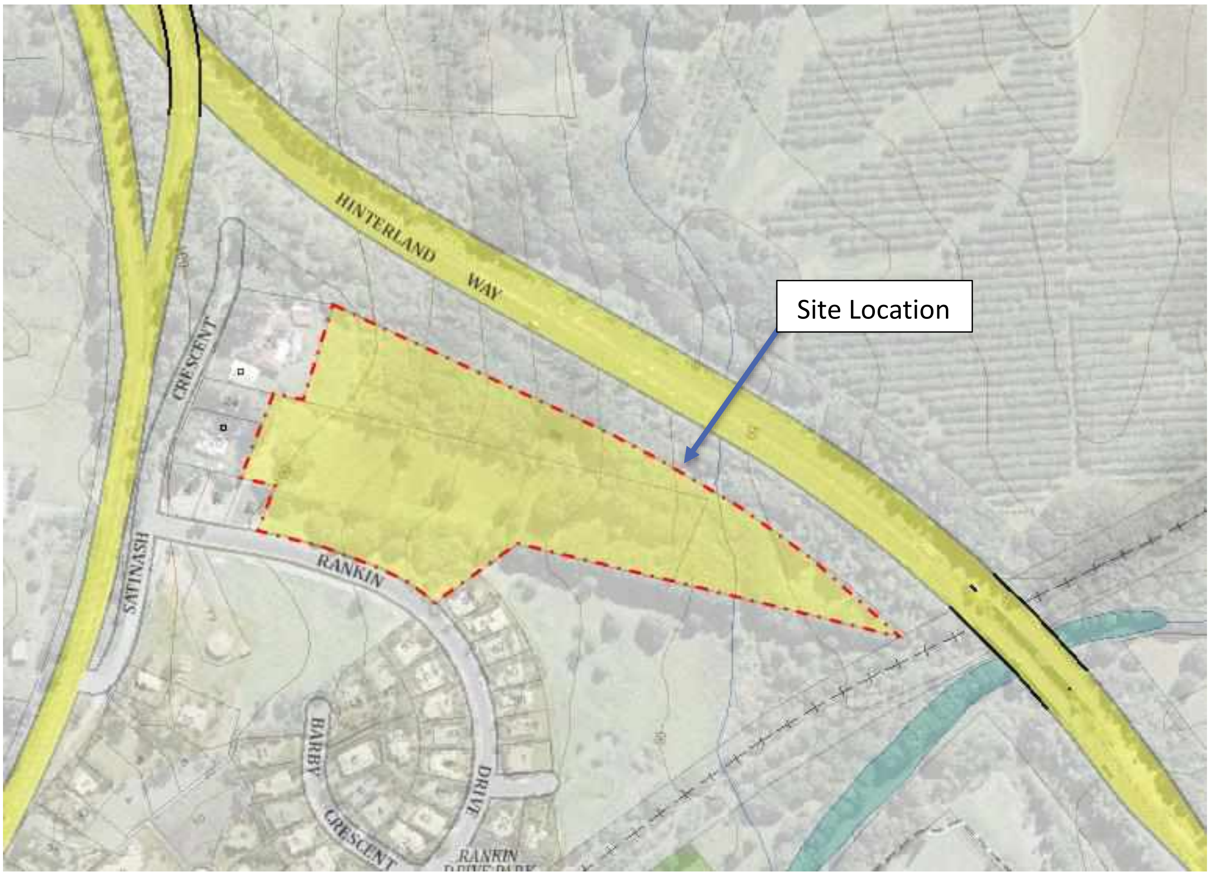


Figure 1 Subject Site

2. Hydrology

2.1. Methodology

The XP-SWMM runoff-routing model has been used to estimate design flood discharges within the study area. The model represents the sub-catchments as a network of nodes linked to either the 1D pipe drainage network or the 2D Digital Terrain Model (DTM) geometric base. The node is defined by its pervious and impervious areas, fraction impervious and average catchment slope. The net rainfall is routed through the network after appropriate losses (initial and continuing) and roughness factors are applied, resulting in a surface runoff hydrograph for each sub-catchment.

The XP-SWMM model was used to estimate the 1% AEP design runoff as per Instant Steel Pty Ltd requirements. All hydrologic assessment has been completed to the Australian Rainfall and Runoff 2019 (ARR2019) methodologies.

A numerical check has been undertaken using the Regional Flood Frequency Estimation model (https://rffe.arr-software.org/) and compared to the XP-SWMM results.

2.2. Hydrologic Model

2.2.1. Configuration

Figure 2 illustrates the extent of the XP-SWMM model. There are 6 catchments (total area is 63.664Ha) used to represent the runoff that contributes to the hydraulic function of the subject site. These catchments were delineated to accurately represent the inflow location and its impact on the subject site.

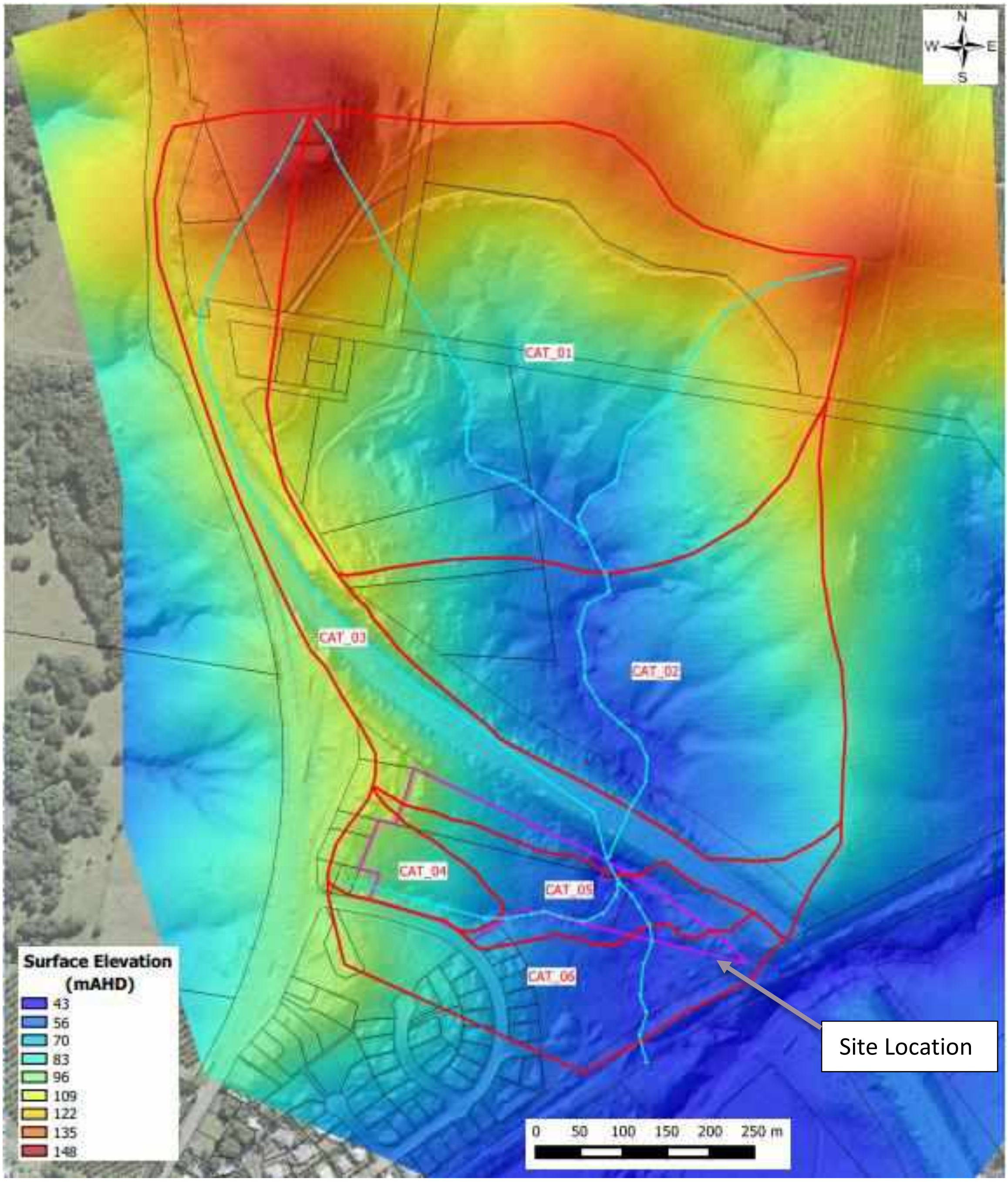


Figure 2 XP-SWMM Model Extents

2.2.2. Hydrologic Routing

Hydrologic modelling has been undertaken using the Laurenson runoff routing method. The Laurenson method requires the catchment to be divided into a pervious (undeveloped) and an impervious (developed) portion. A fraction impervious of 0% has been applied to the undeveloped portion and 100% to the developed portion.

2.2.3. Manning's Roughness

Manning's roughness (n) values is applied to represent the undeveloped and developed portions of the catchment. XP-SWMM allows a range to be applied to represent the varied degree of roughness that could be expected within the catchment.

The manning value used in this model was used as a calibration tool to compare peak flow from XP_SWMM and the ARR Regional Flood Frequency Estimation (RFFE) model.

2.2.4. Rainfall Losses

Initial Loss (IL) and Continuing Losses (CL) were sourced from the Australian Rainfall and Runoff (ARR) Data Hub (*http://data.arr-software.org/*) and were applied to the modelling. The catchment has been modelled as approximately 100% pervious with only a small percentage of roofed area relative to the catchment size. The following loss rates have been adopted:

- Undeveloped Catchment IL = 12.1mm CL = 0.0mm/hr.

2.2.5. Existing Conditions Parameters

Table 1 summarises the XP-SWMM parameters adopted for the existing catchment conditions. The catchments equal area slope was calculated directly from the Digital Terrain Model for the Catchment.

The percentage impervious was determined using Queensland Urban Drainage Manual (QUDM) guidelines for fraction impervious for a Rural Undeveloped as 0% Impervious (QUDM, 2013).

The total contributing catchment is 63.664Ha. The hydrologic factors adopted have been summarised in Table 1.

Table 1 XP-SWMM Hydrologic Model Parameters

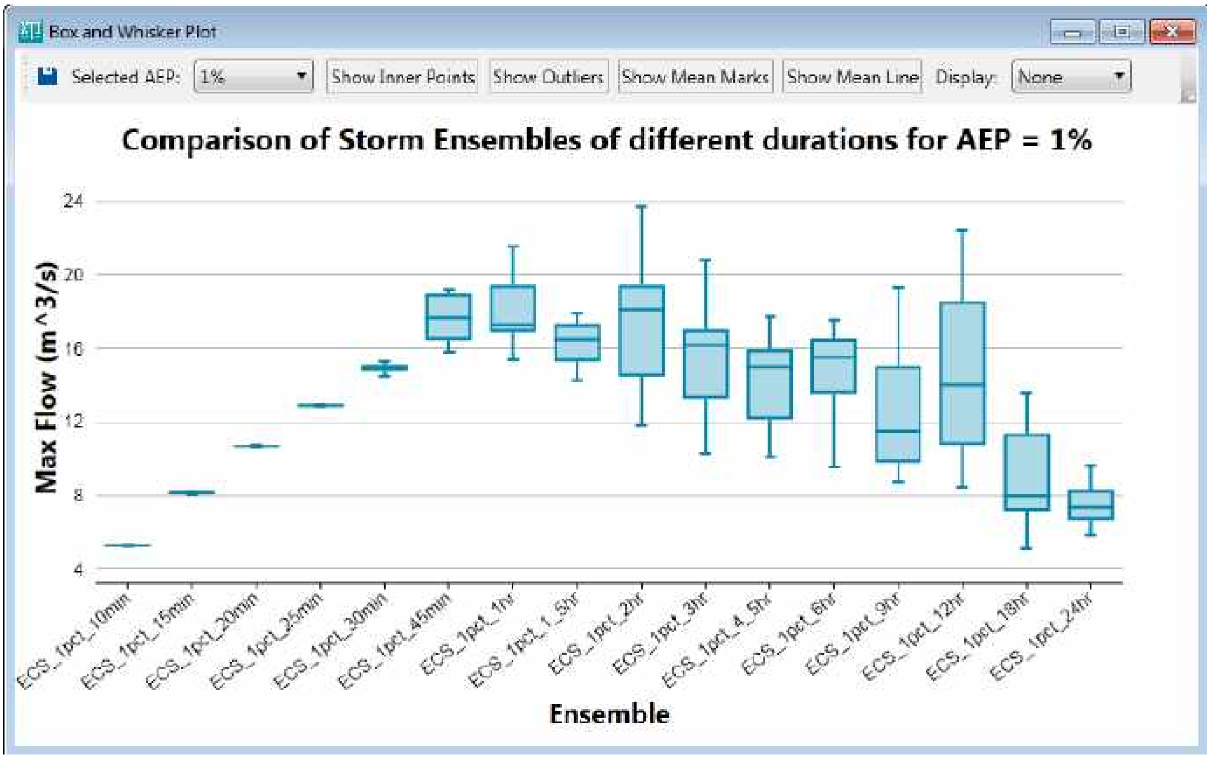
Sub-Catchment	Area (Ha)	Impervious (Ha)	Pervious Area (Ha)	Equal Area Slope (%)
CAT_01	27.964	0.805	27.159	27.964
CAT_02	14.464	0.044	14.420	14.464
CAT_03	11.620	3.198	8.423	11.620
CAT_04	1.637	0.046	1.591	1.637
CAT_05	2.798	0.055	2.743	2.798
CAT_06	5.181	0.550	4.631	5.181

2.3. ARR 2019 Hydrologic Results

The XP-SWMM ARR Storm Generator allows importation of the ARR Data Hub information, including rainfall global database, infiltration global database, and global storm definitions, into XP-SWMM. Information such as the ARR Data Hub Text File, ARR Temporal Patterns Increments File, and Bureau of Meteorology (BOM) IFD table files are used to produce the Annual Exceedance Probability (AEP) and all of the durations for the given location, which are then analysed in the application.

Ten (10) temporal patterns were assessed per duration for each design event with the results statistically assessed using a box and whisker plot to determine the critical storm duration and temporal pattern for the catchment. The box and whisker plot displays' information about the range, median, and quartiles of the results. This plot can easily demonstrate whether a distribution is skewed and whether there are potential outliers in the data set, especially for a large number of observations.

Figure 3 below demonstrates that the highest median storm duration for the 1%AEP, or the 1% Annual Exceedance Probability (AEP) design event, is the 2Hr storm using the standard temporal pattern 10, and producing a peak discharge of **19.00 m³/s**.



Selected AEP: 1%

Display: None

Figure 3 1%AEP Box and whisker plot of Ensemble results

2.4. Flood Frequency Analysis Comparison

ARR Regional Flood Frequency Estimation (RFFE) model has replaced the rational method as a means to compare XPSWMM's calculation of design discharges for the 1%AEP developed conditions at legal points of discharge for the catchment.

The tool requires the geographical coordinates of the catchment centroid and outlet. Based on regional rainfall data at gauged locations near the site the tool produces a statistical estimate of the peak discharge.

The tool has the following limitations:

- The RFFE tool cannot be used for urban catchments, areas where large scale land clearing has occurred or where Dams or other significant Hydraulic controls have significantly affected the natural hydrology (ARR).
- RFFE is not accurate for catchments smaller than 0.5 km^2 or larger than 1000 km^2.
- Catchments that are located more than 300 km from a gauging station used by the tool.

Table 2 and Figure summarises the comparison of the RFFA tool and XP-SWMM peak discharges for the sub-catchment at outlet.

Table 2 XP-SWMM and RFFE Peak Discharge

Event	**Regional Estimation Tool**			**XP_SWMM (ARR2019)**
	Discharge (m3/s)	**Lower Confidence Limit (5%) (m3/s)**	**Upper Confidence Limit (95%) (m3/s)**	
1%AEP	15.4	4.63	51.0	19.00

** Based off Medium Ensemble Storm*

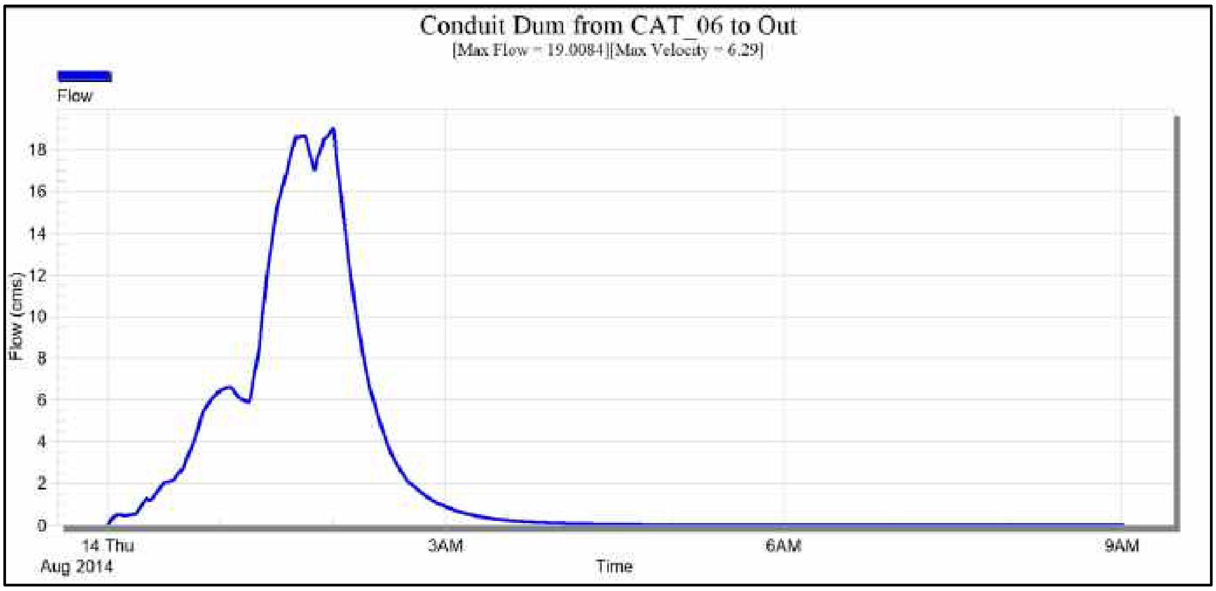


Figure 4 Critical Storm Duration And Temporal Pattern For The Outlet Catchment

3. Overland Flow Hydraulic Assessment

3.1. Objectives

The objective of this overland flow assessment is to demonstrate that the proposed pad does not significantly increase risk within the floodway.

1D/2D TUFLOW has been used for this analysis. The TUFLOW software models the design terrain (i.e. Digital Terrain Model) of the study area as a series of grid points (2D cells). This allows flows in excess of channel capacity or pipe network, to break out and continue along the floodway in the 2D domain, as the topography dictates. The hydraulic structures (i.e. the minor culvert network) have been represented as 1D elements (ESTRY) which is dynamically linked to the 2D elements. The TUFLOW model computes the capacity of the 1D element and once exceeded, the surcharged flow is transferred to the 2D model. Flood levels, discharge and velocity can be extracted from the model as functions of time at required locations.

TUFLOW is an industry standard two-dimensional river analysis model used to estimate flood characteristics such as flood level, velocity and flood depth and any impacts arising from the proposed development has on the surrounding properties.

3.2. 2D Model Set Up

3.2.1. Model Extent

The model extents for the TUFLOW model is presented in Figure 4. The extents were set at an appropriate distance from the subject site. Downstream boundary will be normal depth at the railway bridge.

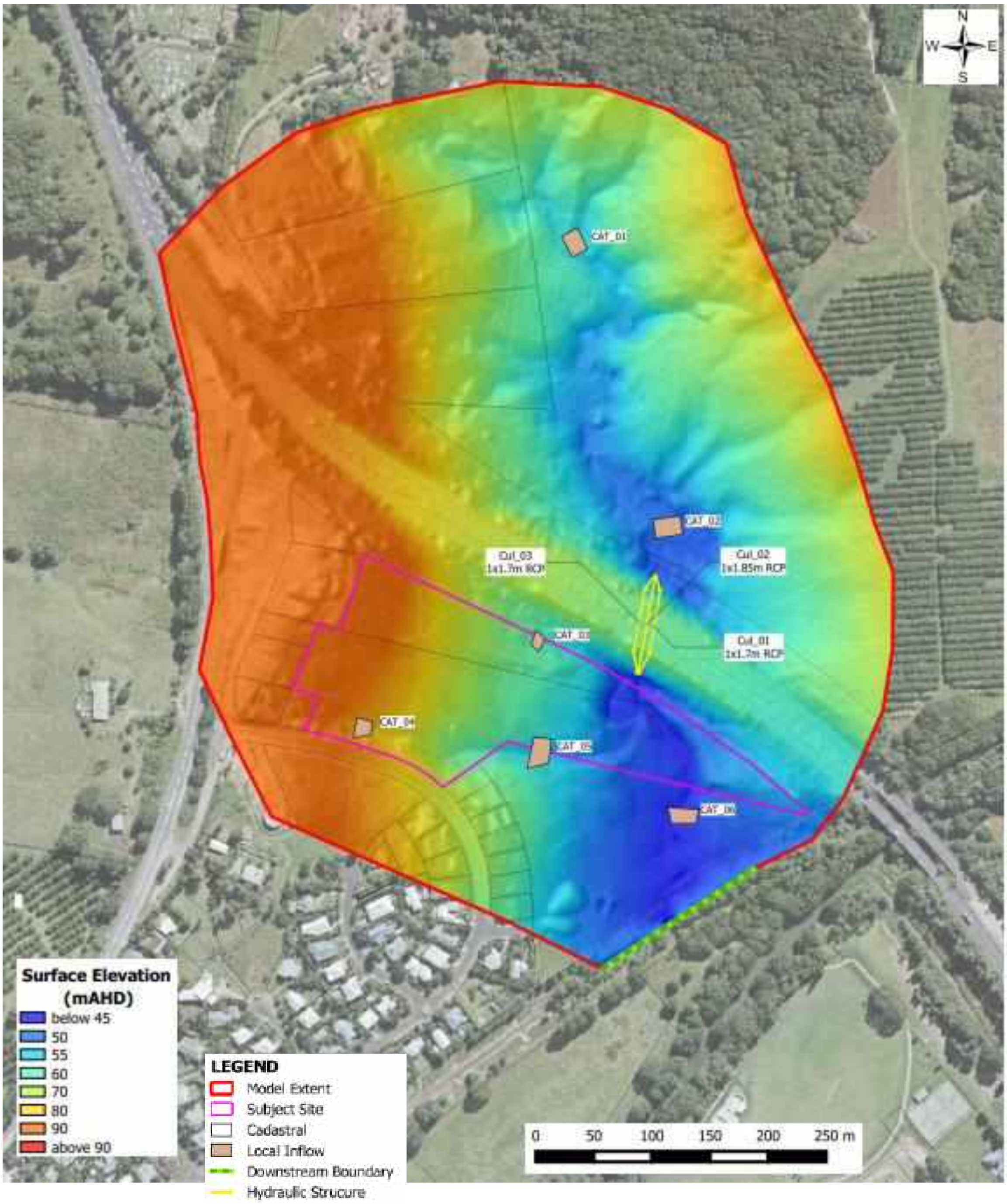


Figure 4 TUFLOW Model Extents

3.2.2. Resolution and Time Step

A grid size of 2m and time step 1s were used in the TUFLOW model for all scenarios. The grid size is based on model efficiency and size constraints for the extents of the model.

3.2.3. Topography Pre-Development

Lidar 1m (2010) data around the subject site were used as the base topography for TUFLOW model. The topography used in the pre-development scenario is shown in Figure 5.

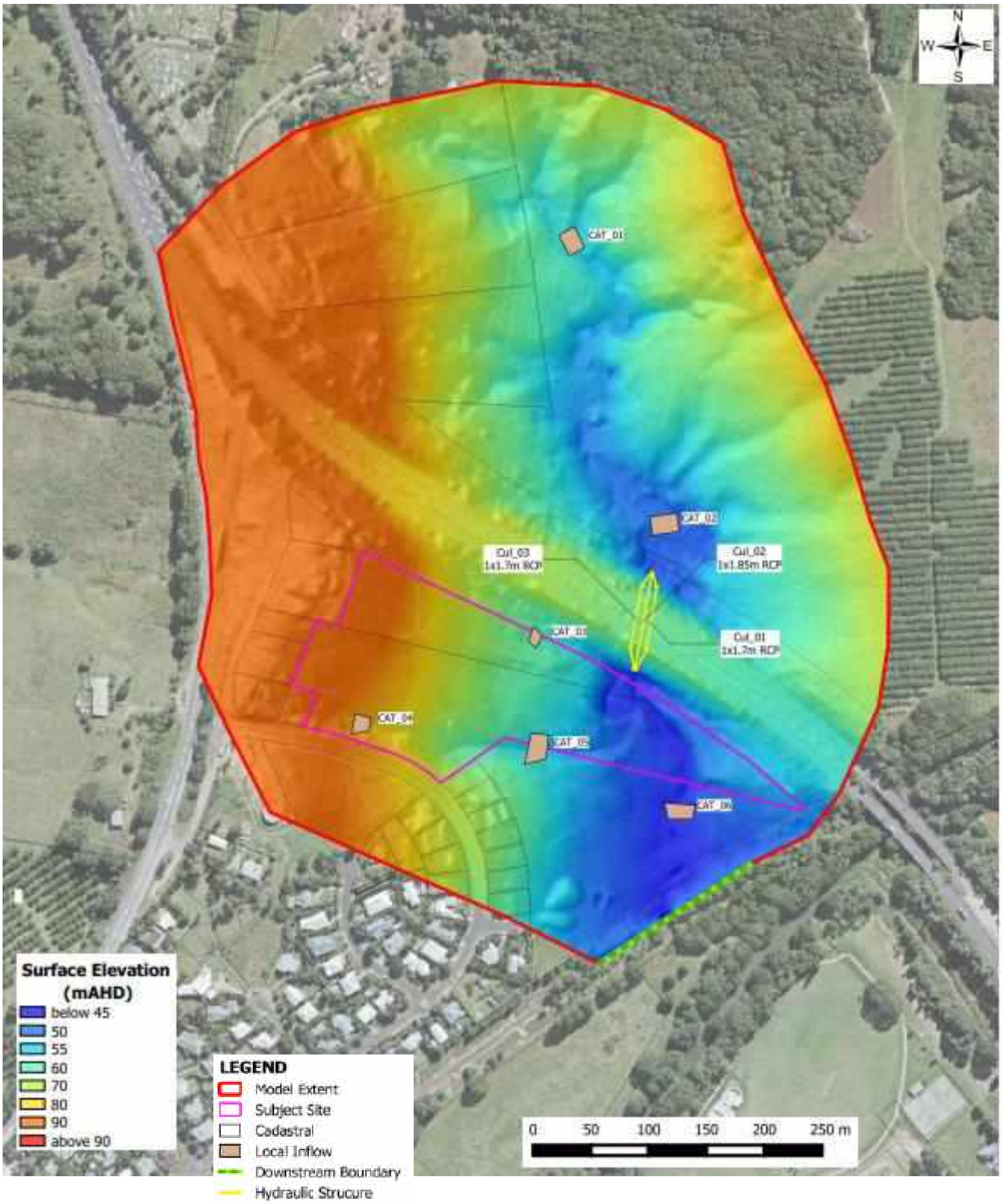


Figure 5 Surface Elevation Data

3.2.4. Roughness

Figure 6 show the roughness adopted in the hydraulic impact assessment model.

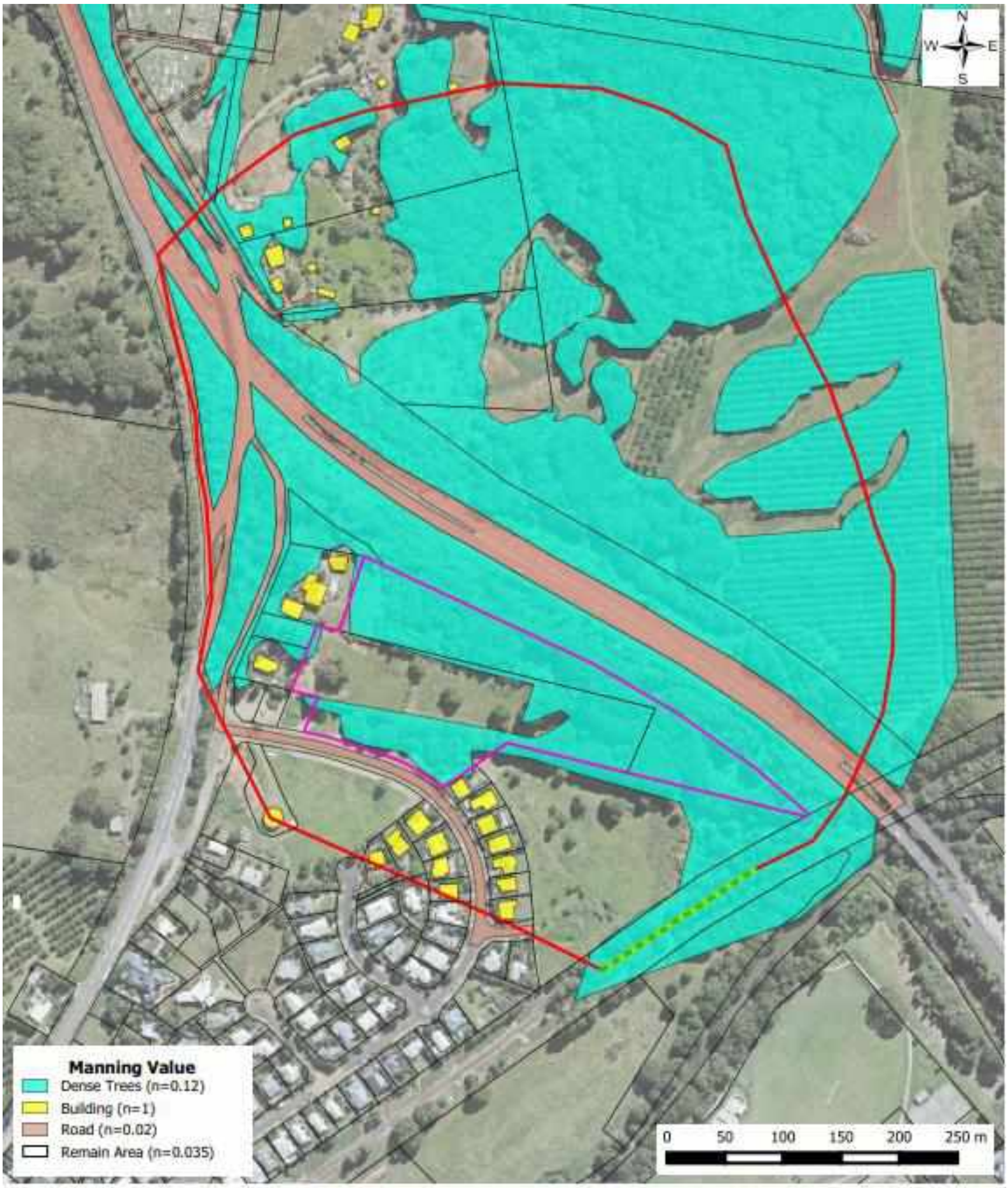


Figure 6 Pre Development Roughness Map

3.2.5. Inflows

The inflows within the TUFLOW model were extracted directly from XPSWMM Hydrology model (ARR2019). See Figure 5 for inflows location.

3.2.6. Rail Bridge

The rail bridge at the downstream boundary was presented by modifying topography to achieve 14.7m bridge opening.

3.3. Existing Case

The existing case includes culvert survey under Hinterland Way (see Figure 5). The pipe roughness was set at Manning n = 0.013.

The 1%AEP design event peak water level, depth, velocity and hazard are shown in Figure 8, Figure 9, Figure 10 and Figure 11 below in respectively.

Within the subject site boundary, peak water level is approximately 47.5mAHD.

Peak water depth at site is 2.0 m, and peak velocity is 1 - 1.2m/s within the creek area.

Flood hazard ranges from H1 to H3 (see Figure 7 below), with H4 Hazard confined within the centre creek area (see Figure 11).

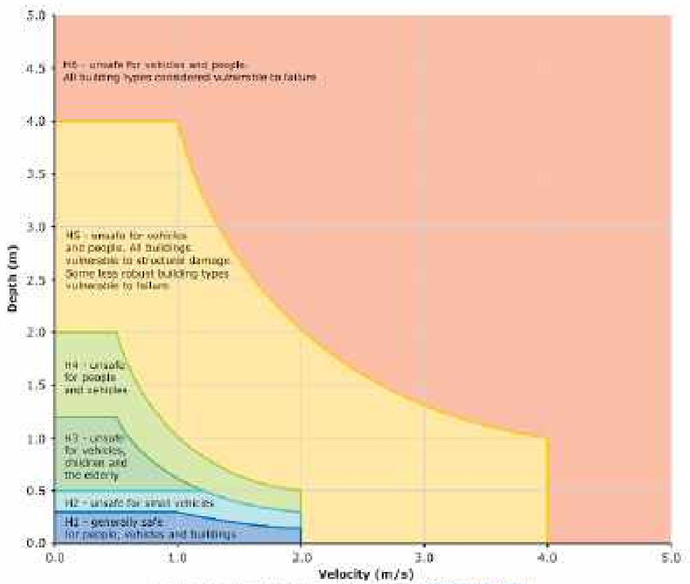


Figure 6.7.8. Combined Flood Hazard Curves (Smith et al., 2014)

Figure 7 ARR2019 Combined Hazard Curves

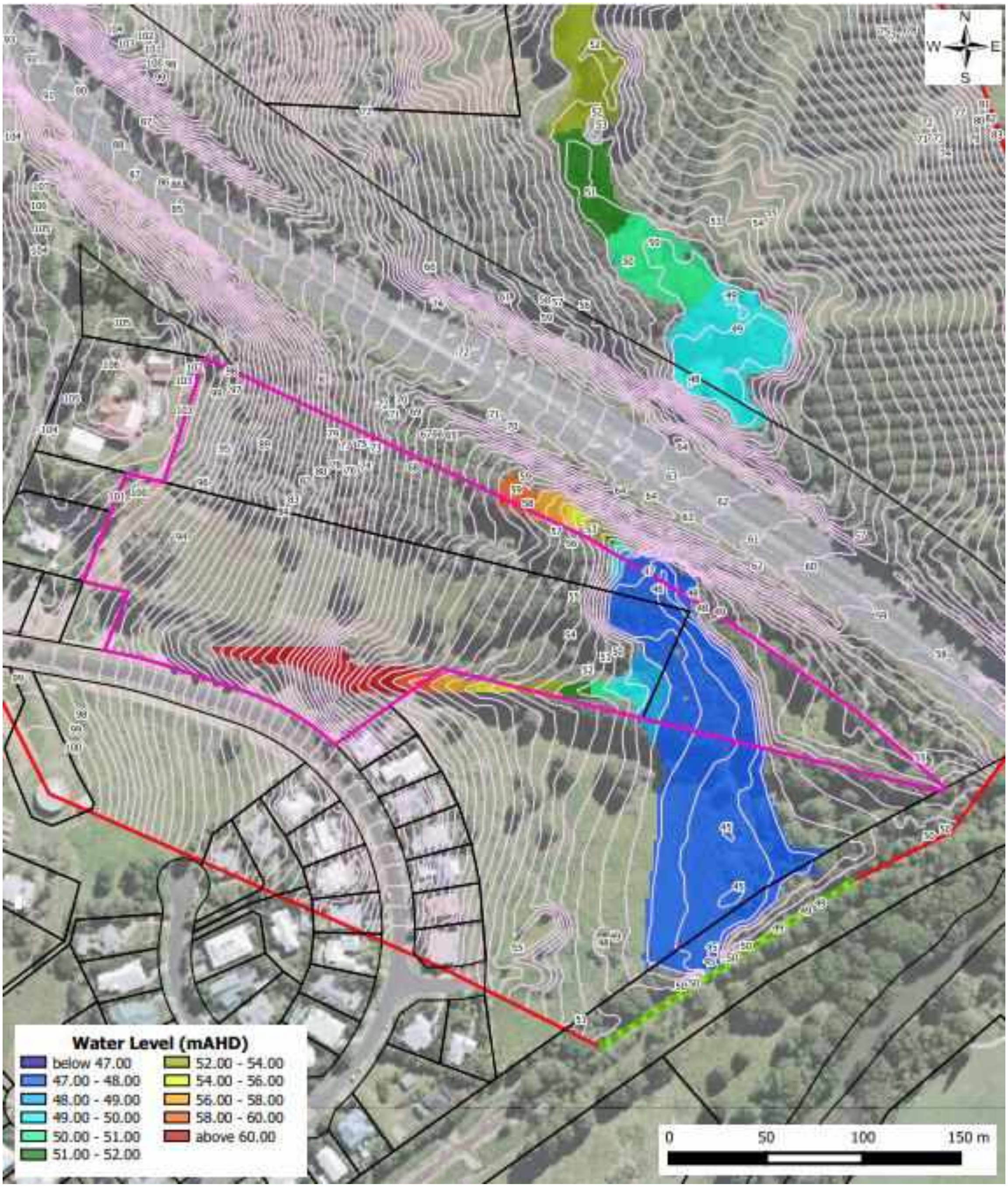


Figure 8 Existing Maximum Water Level – 1%AEP

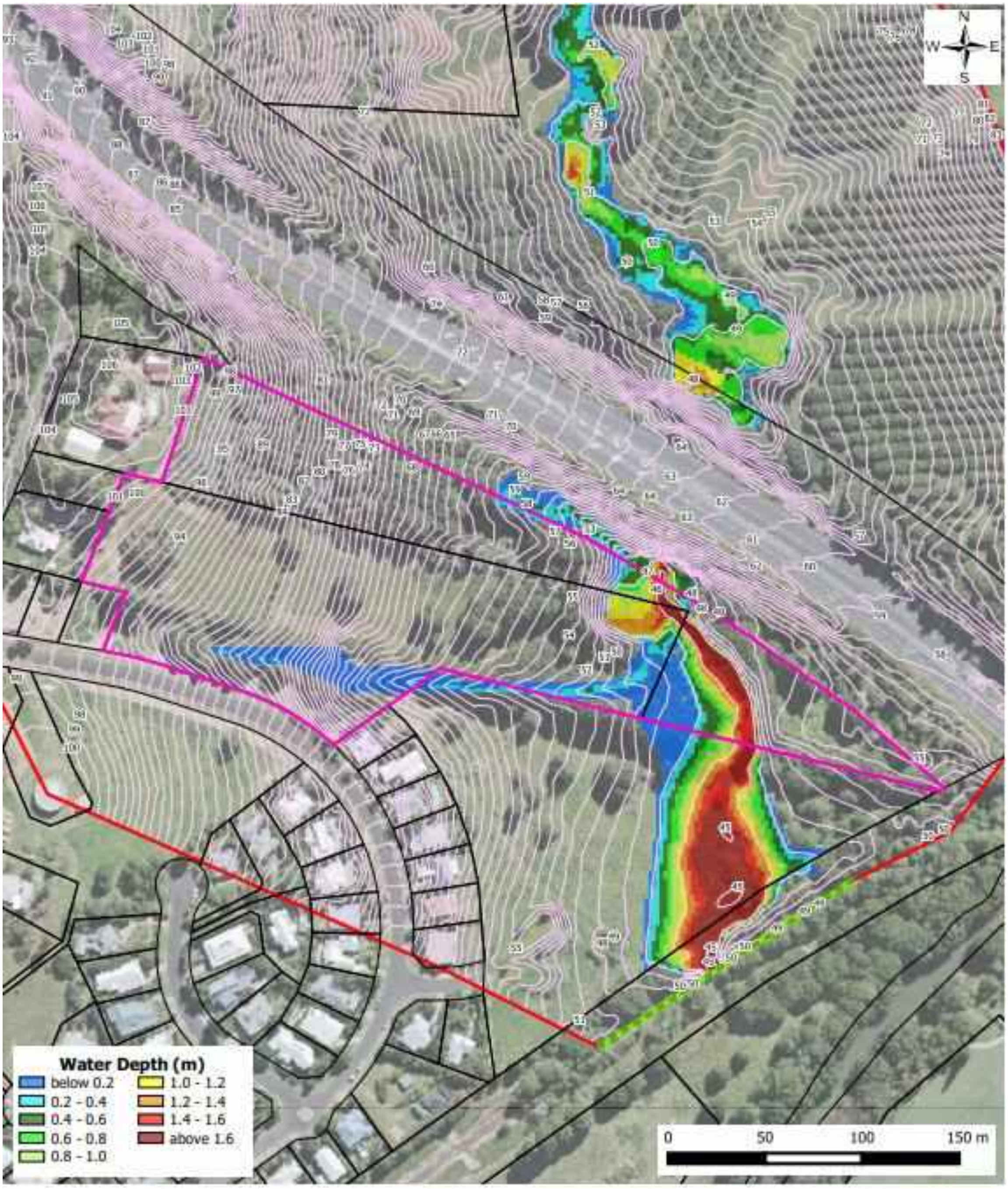


Figure 9 Existing Maximum Depth – 1%AEP

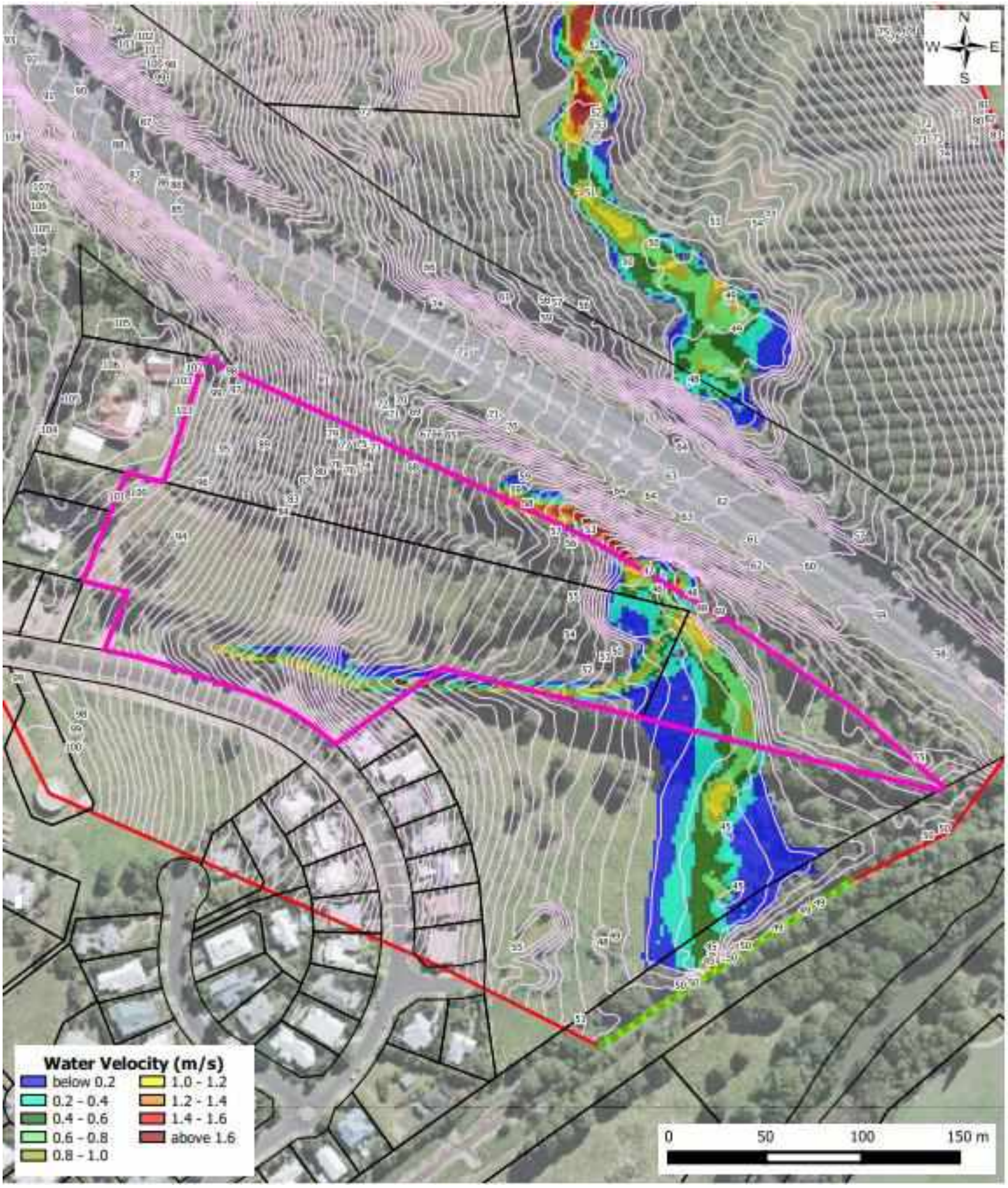


Figure 10 Existing Maximum Velocity – 1%AEP

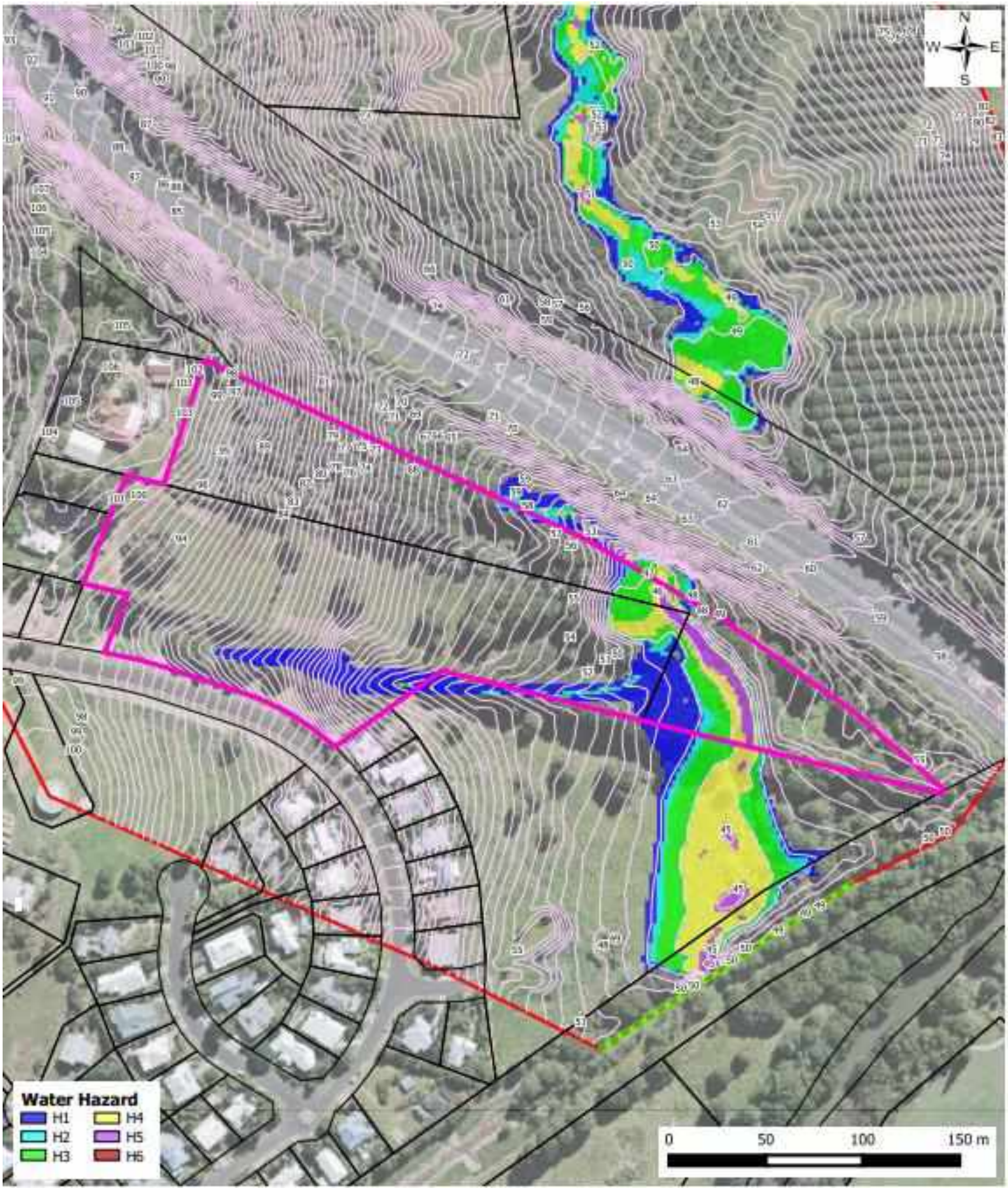


Figure 11 Existing Maximum Flood Hazard – 1%AEP

4. Summary

Floodworks have completed a Hydraulic Impact Assessment for the subject site 68 Granuaille Crescent, Bangalow, NSW.

In summary, the completed Flood Impact Assessment (FIA) concludes the following:

- The XPSWMM model was used to estimate the 1%AEP design runoff for Tuflow model input. All hydrologic assessment has been completed to the Australian Rainfall and Runoff 2019 (ARR2019) methodologies. The XP-SWMM results compared well with Regional Flood Frequency Estimation model
- A fully dynamic 1D/2D linked TUFLOW flood model was developed for the existing and developed cases
- TUFLOW model results indicate the flooded extents of the subject creek. Additional information include velocity, peak depth and hazard assessment
- The 1% AEP design event
    - Peak water level is 47.5mAHD
    - Peak water depth is 2.02 m
    - Peak velocity is 1 - 1.2m/s
    - Flood hazard ranges from H1 to H3, with H4 Hazard confined within the centre creek
- The Flood Planning Level will be 48m AHD (47.5m AHD + 0.5m Freeboard = 48.0m AHD)

5. References

- BOM (2018) Rainfall IFD Data System
- IPWEA 2013, Queensland Urban Development Manual (QUDM)
- Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia
- Elevation - Foundation Spatial Data from http://elevation.fsdf.org.au/

Appendix A 1%AEP Tuflow's Results

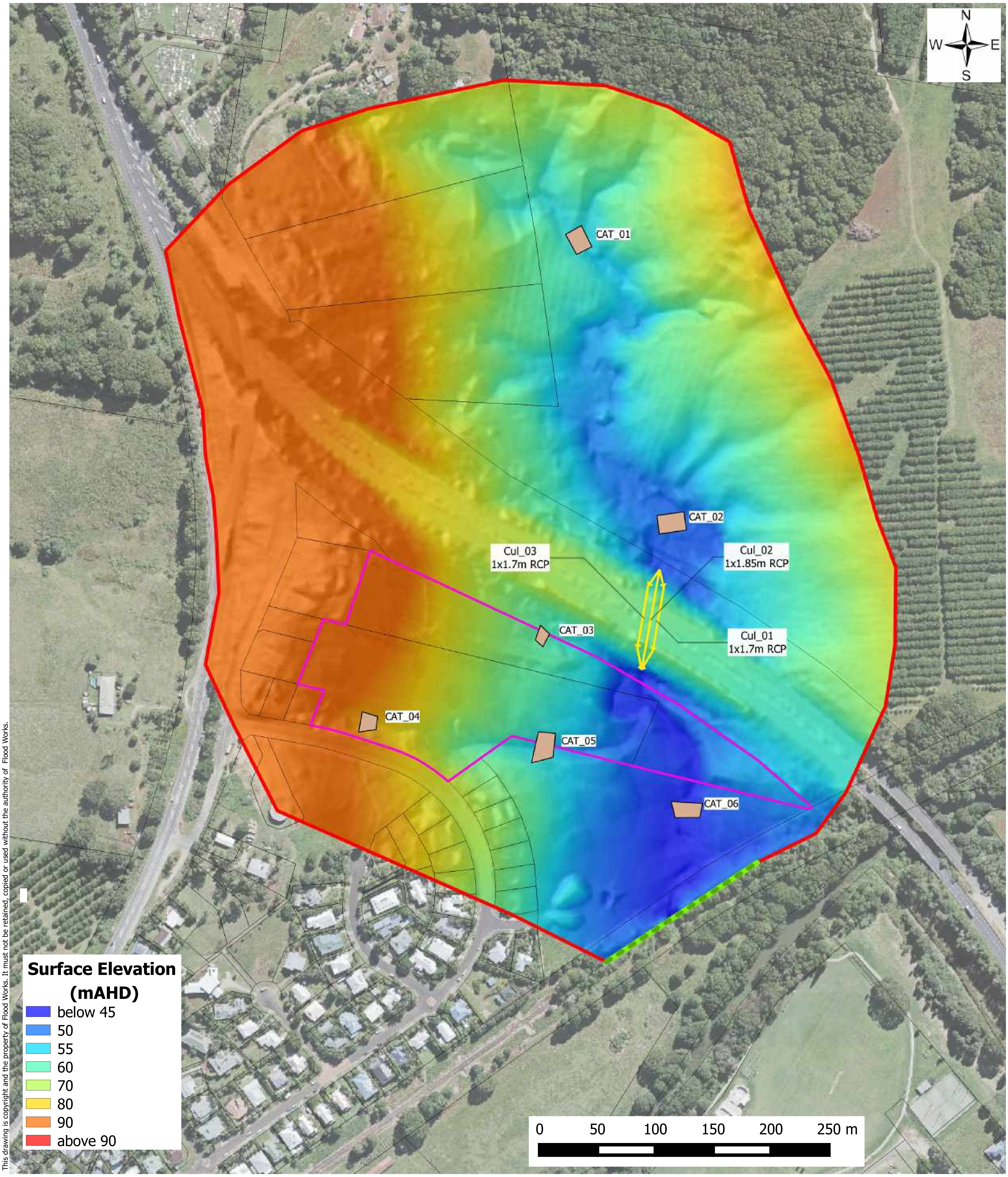


FIG 01 PRE- DEVELOPMENT TUFLOW MODEL FEATURE

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- ▭ Model Extent
- ▭ Subject Site
- □ Cadastral
- 🟫 Local Inflow
- ▬ Downstream Boundary
- → Hydraulic Strucure

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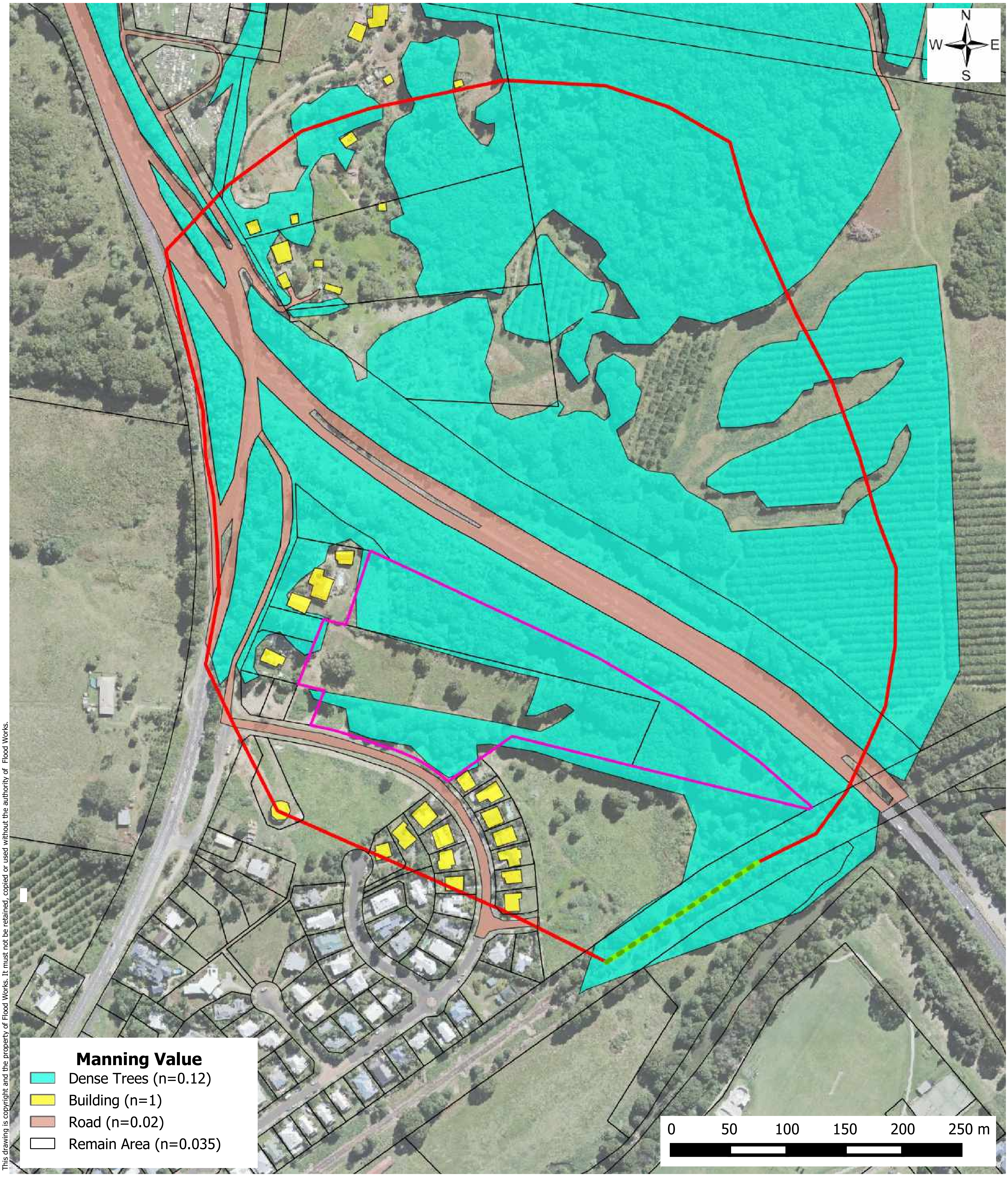

FIG 02 PRE- DEVELOPMENT TUFLOW MODEL MANNING MAP

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- □ Model Extent
- - - Downstream Boundary
- □ Site
- □ Cadastral

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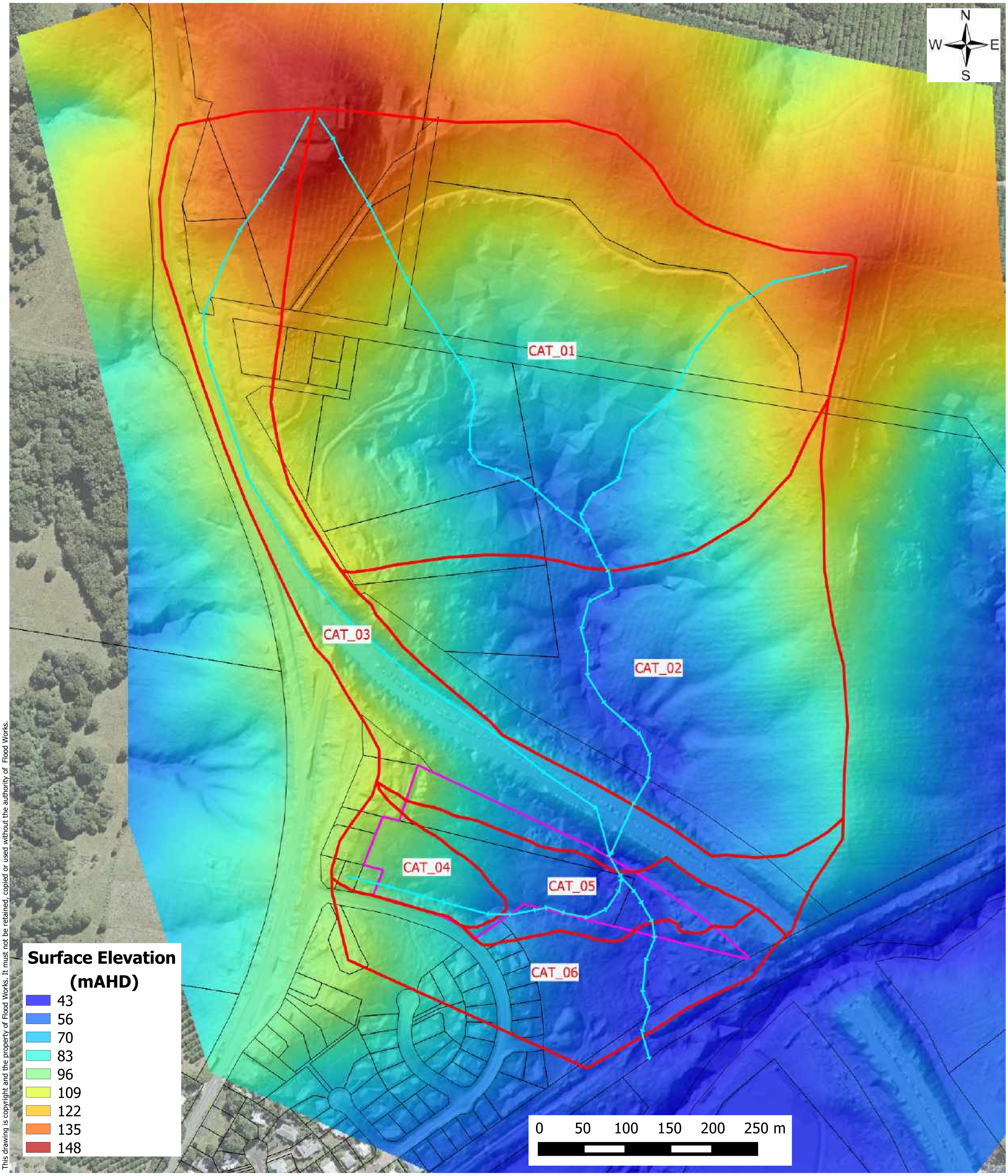

FIG 03 PRE- DEVELOPMENT CATCHMENT PLAN

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- ▭ Sub Catchment
- ▭ Subject Site
- ▭ Cadastral
- → Flowpath

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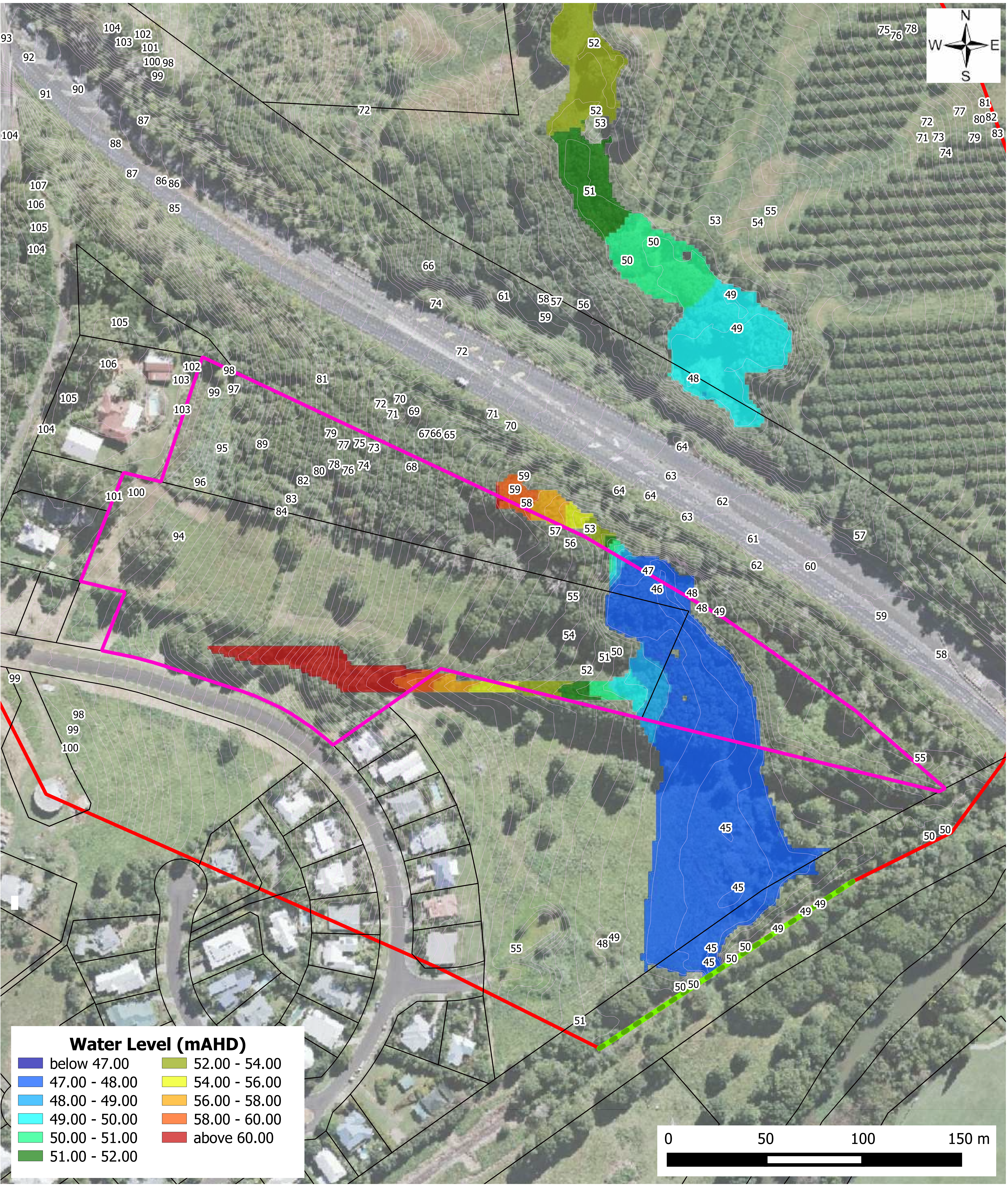

FIG A01 PRE- DEVELOPMENT 1%AEP FLOOD WATER LEVEL

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- 🟥 Model Extent
- Downstream Boundary
- Site
- ☐ Cadastral
- Contours Ground

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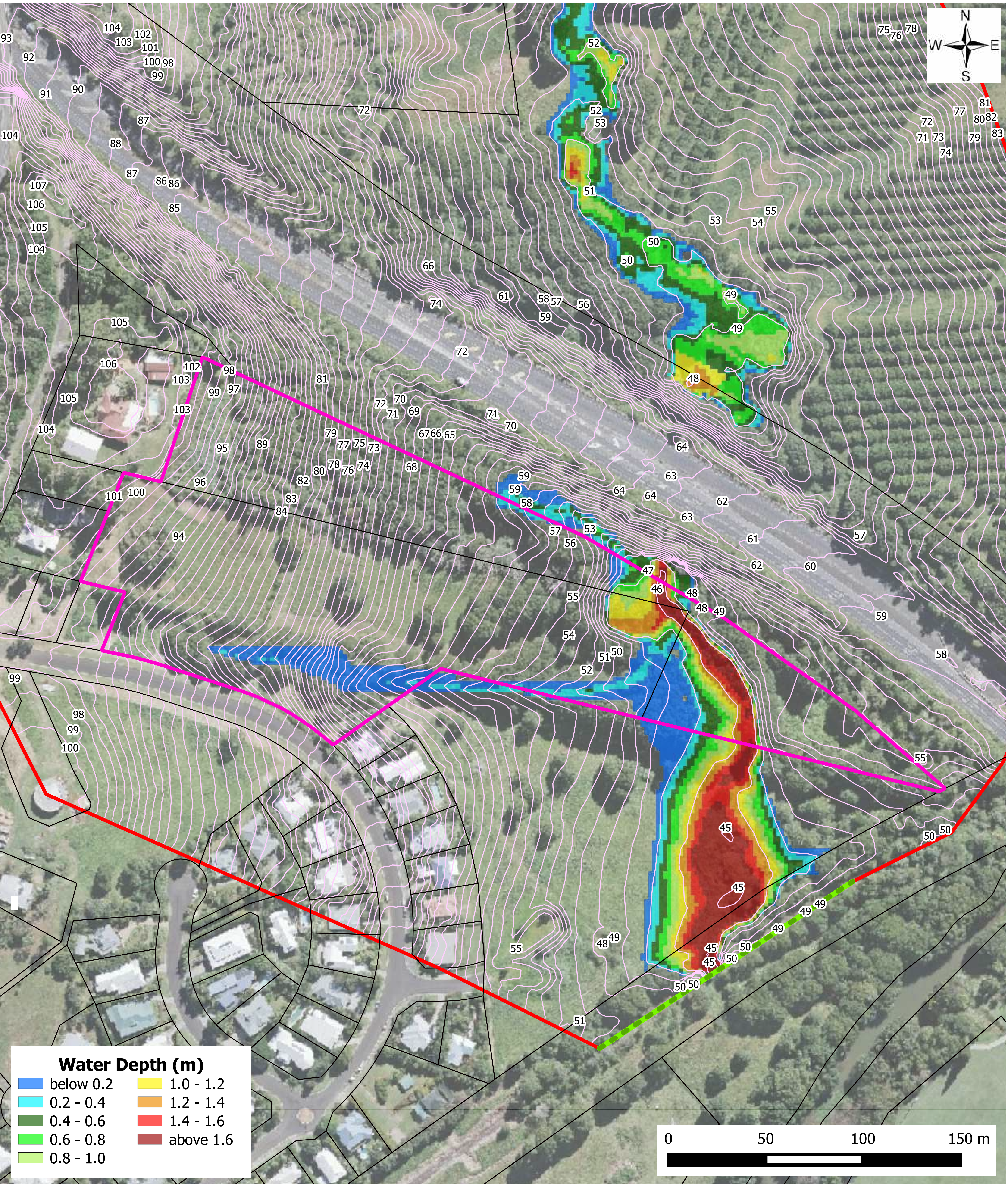

FIG A02 PRE- DEVELOPMENT 1%AEP FLOOD WATER DEPTH

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- 🟥 Model Extent
- Downstream Boundary
- 🟪 Site
- □ Cadastral
- Contours Ground

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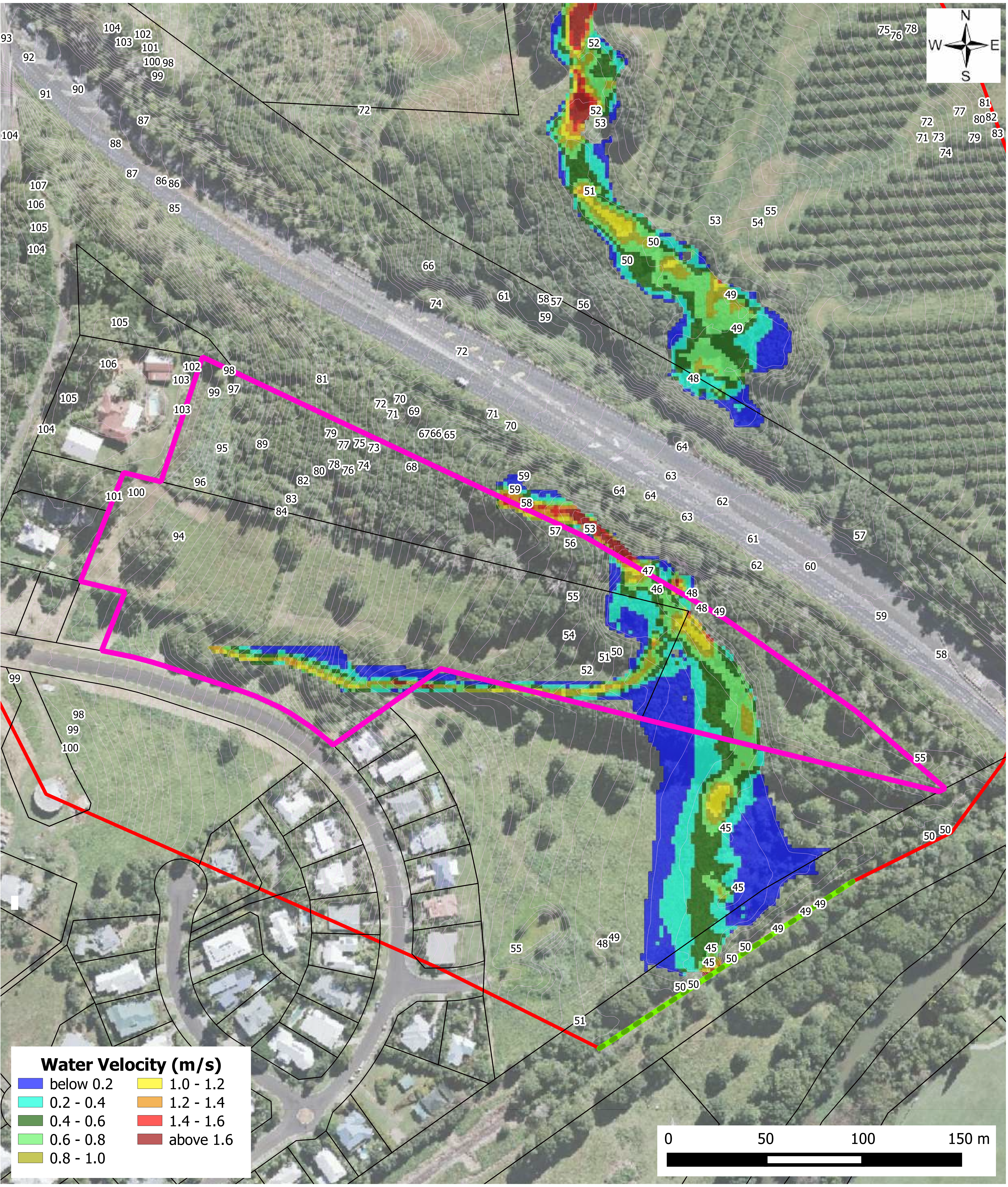

FIG A03 PRE- DEVELOPMENT 1%AEP FLOOD WATER VELOCITY

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- Model Extent
- Downstream Boundary
- Site
- Cadastral
- Contours Ground

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Client

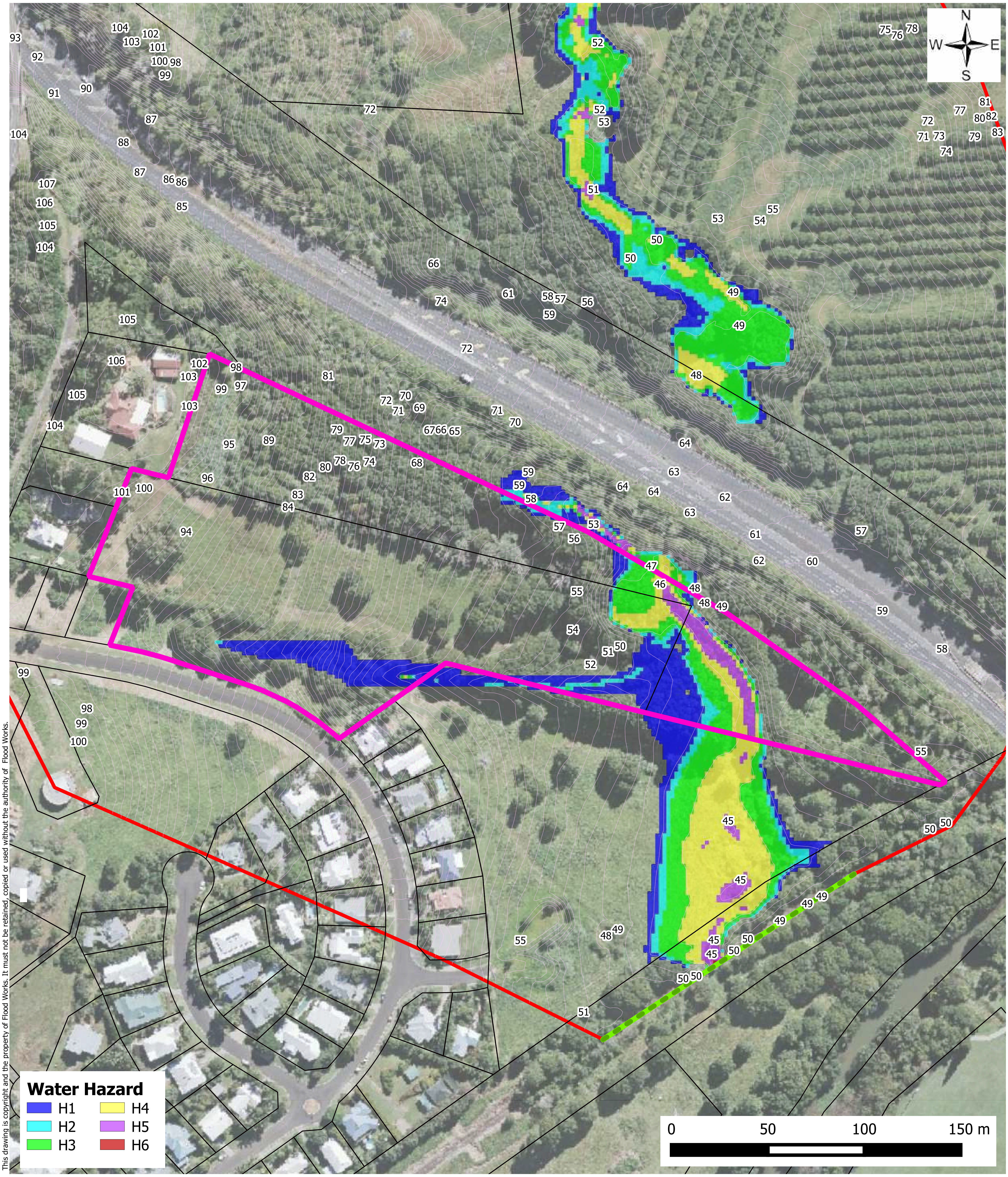

FIG A04 PRE- DEVELOPMENT 1%AEP FLOOD WATER HAZARD

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- ▭ Model Extent
- ╍ Downstream Boundary
- ▭ Site
- ▭ Cadastral
- — Contours Ground

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Client

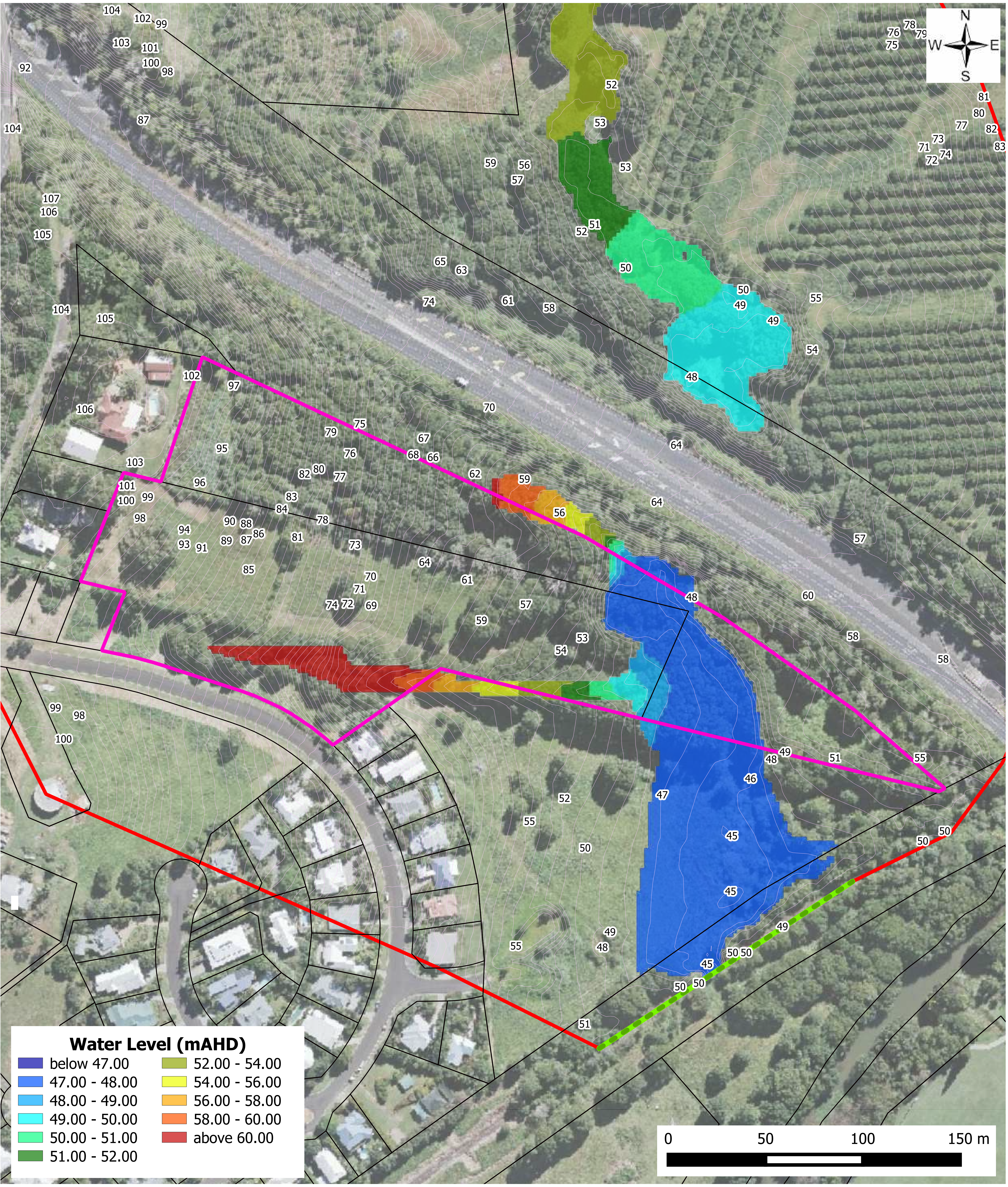

FIG A05 PRE- DEVELOPMENT 1%AEP CLIMATE CHANGE FLOOD WATER LEVEL

LEGEND

- 🟥 Model Extent
- Downstream Boundary
- □ Site
- □ Cadastral
- Contours Ground

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Instant Steel Pty Ltd

Client

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

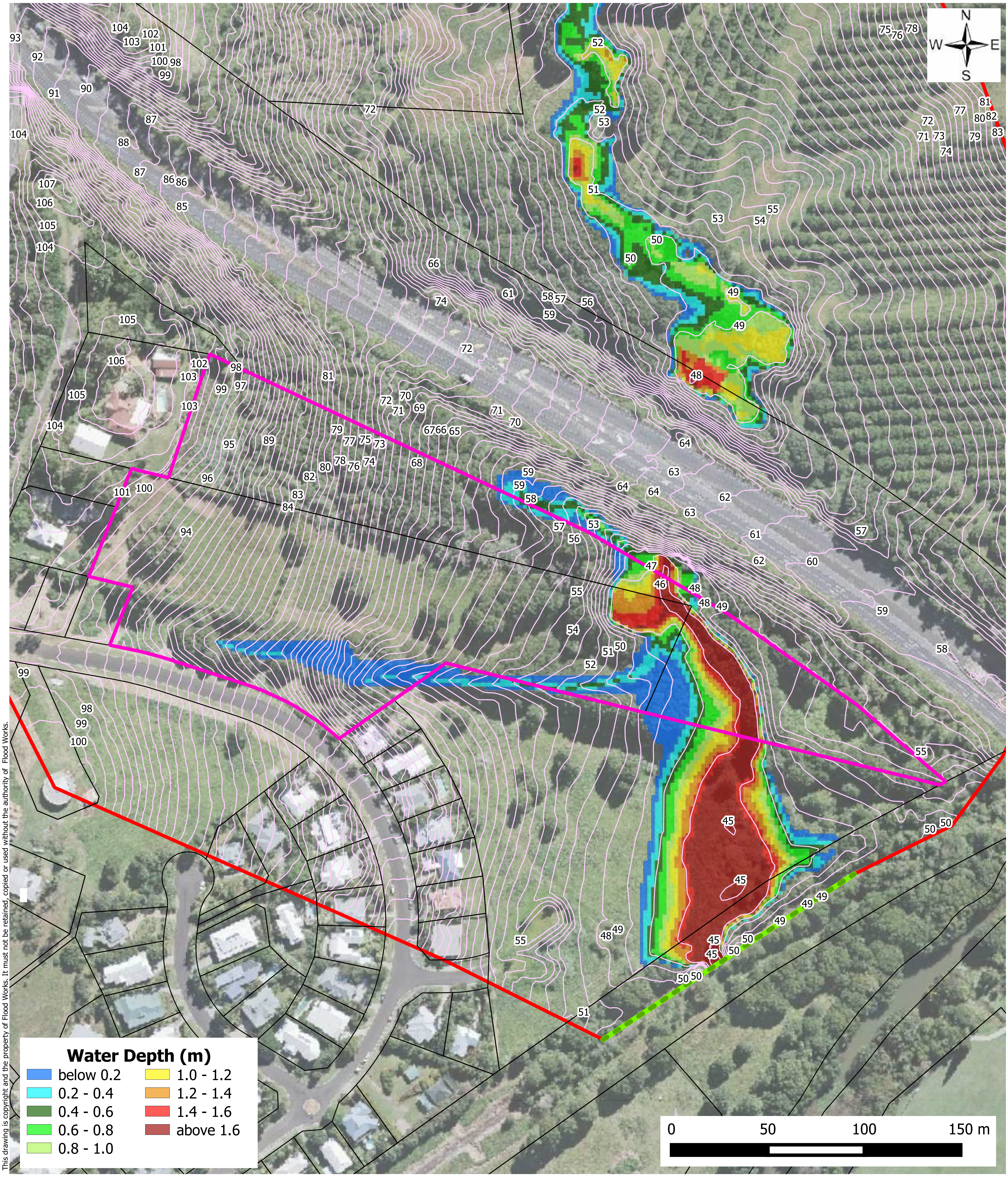

FIG A06 PRE- DEVELOPMENT 1%AEP CLIMATE CHANGE FLOOD WATER DEPTH

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- 🟥 Model Extent
- ▬ Downstream Boundary
- 🟪 Site
- ☐ Cadastral
- — Contours Ground

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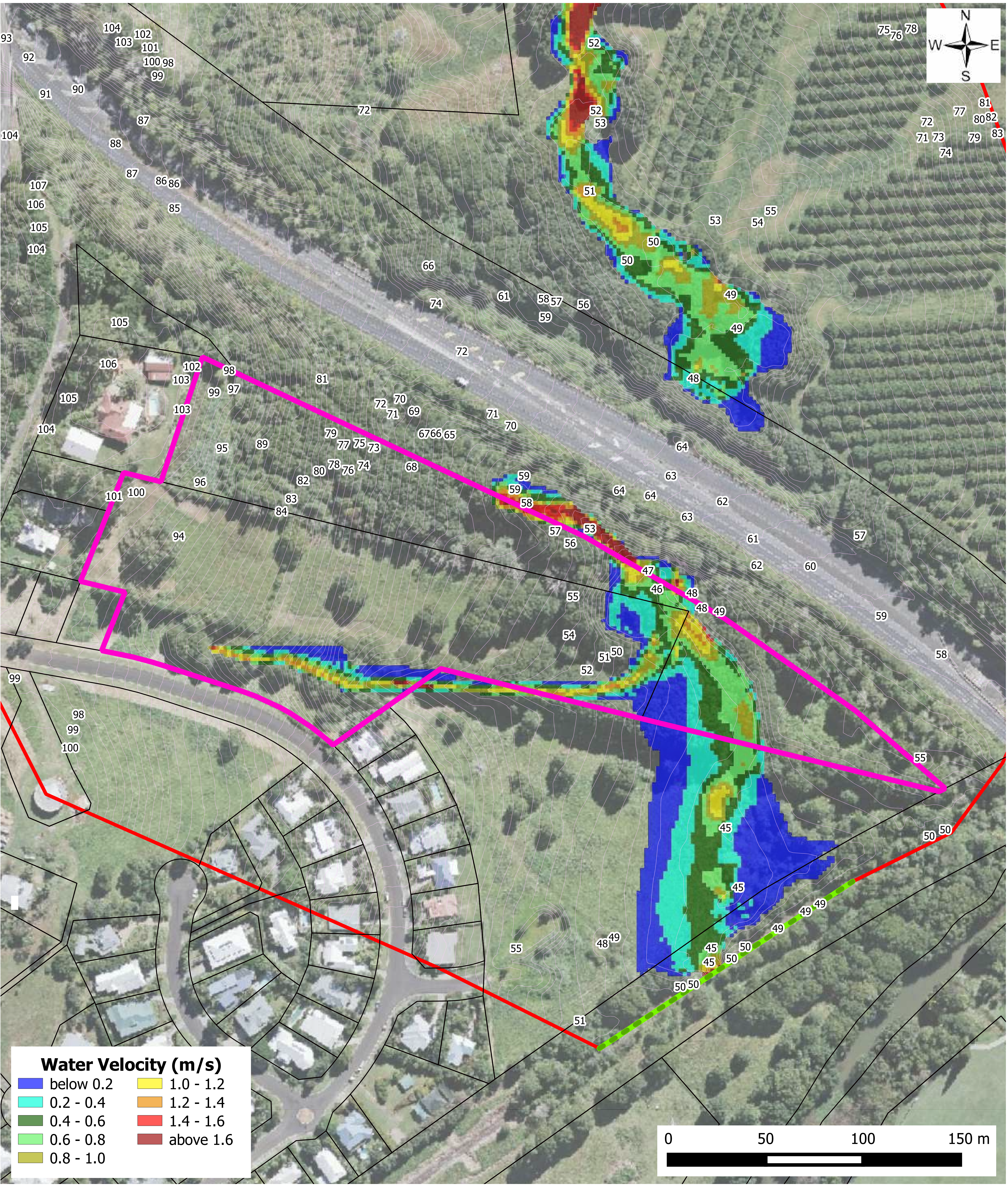

FIG A07 PRE- DEVELOPMENT 1%AEP CLIMATE CHANGE FLOOD WATER VELOCITY

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

- 🟥 Model Extent
- ▬ Downstream Boundary
- ☐ Site
- ☐ Cadastral
- ─ Contours Ground

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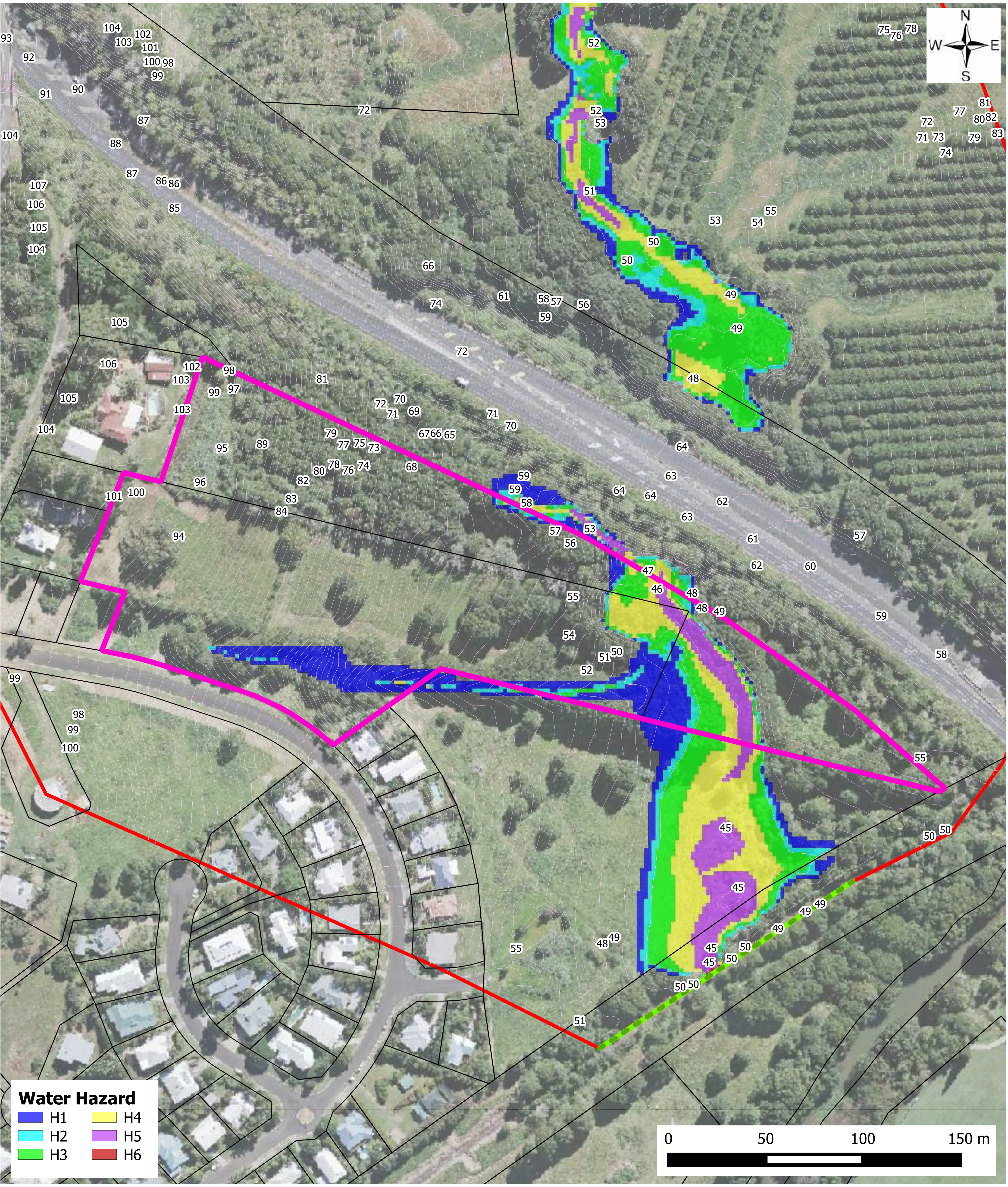

FIG A08 PRE- DEVELOPMENT 1%AEP CLIMATE CHANGE FLOOD WATER HAZARD

PROJECTION: GDA94 / MGA ZONE 56
PROJECT: FW00007 68 Granuaille Crescent, Bangalow
DATE: June 2022

LEGEND

🟥	Model Extent
▬	Downstream Boundary
🟪	Site
☐	Cadastral
—	Contours Ground

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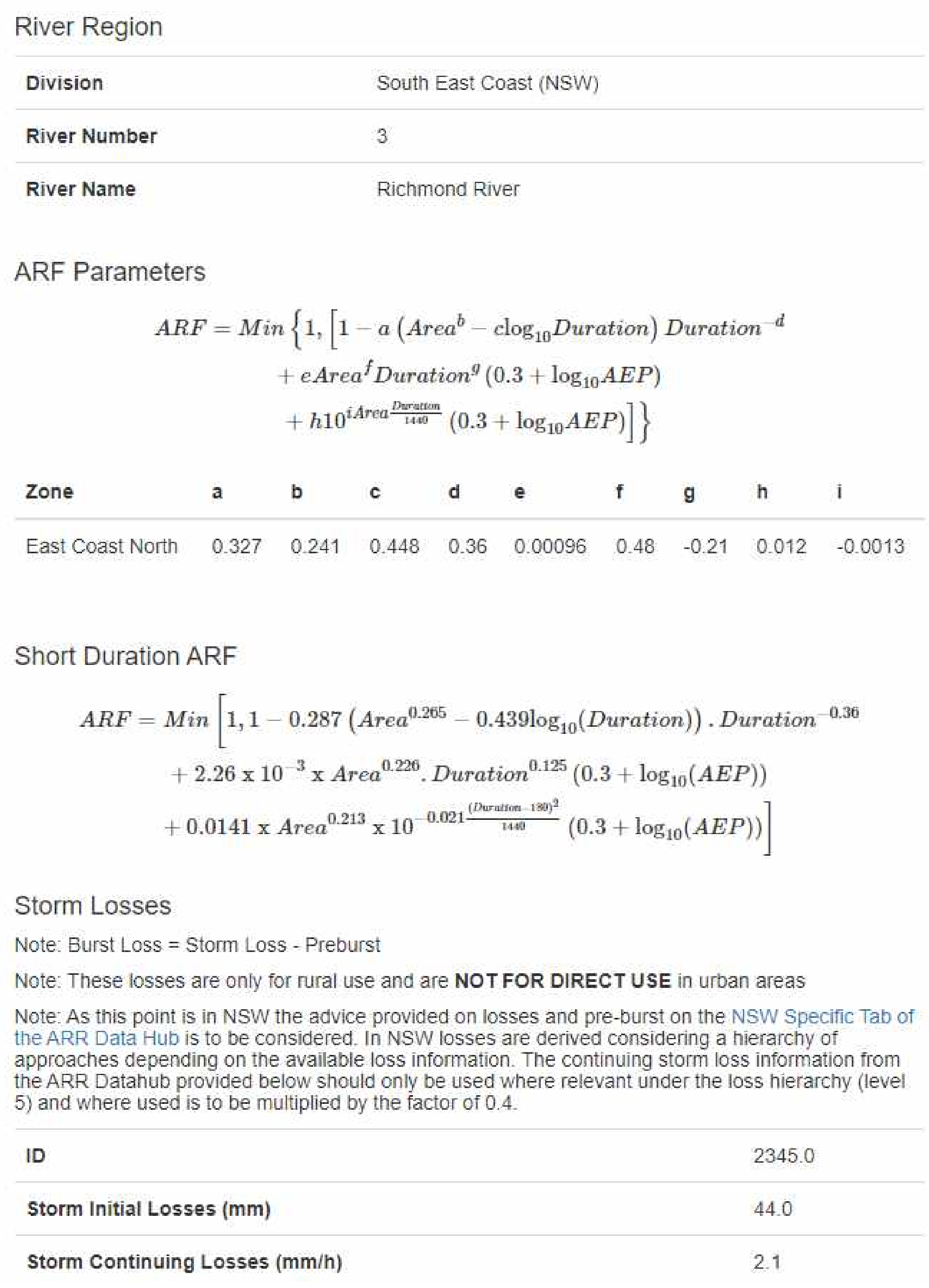
Appendix B Australian Rainfall & Runoff Data Hub – Results



River Region

Division	South East Coast (NSW)
River Number	3
River Name	Richmond River

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} + eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
East Coast North	0.327	0.241	0.448	0.36	0.00096	0.48	-0.21	0.012	-0.0013

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^{2}}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

Note: As this point is in NSW the advice provided on losses and pre-burst on the NSW Specific Tab of the ARR Data Hub is to be considered. In NSW losses are derived considering a hierarchy of approaches depending on the available loss information. The continuing storm loss information from the ARR Datahub provided below should only be used where relevant under the loss hierarchy (level 5) and where used is to be multiplied by the factor of 0.4.

ID	2345.0
Storm Initial Losses (mm)	44.0
Storm Continuing Losses (mm/h)	2.1

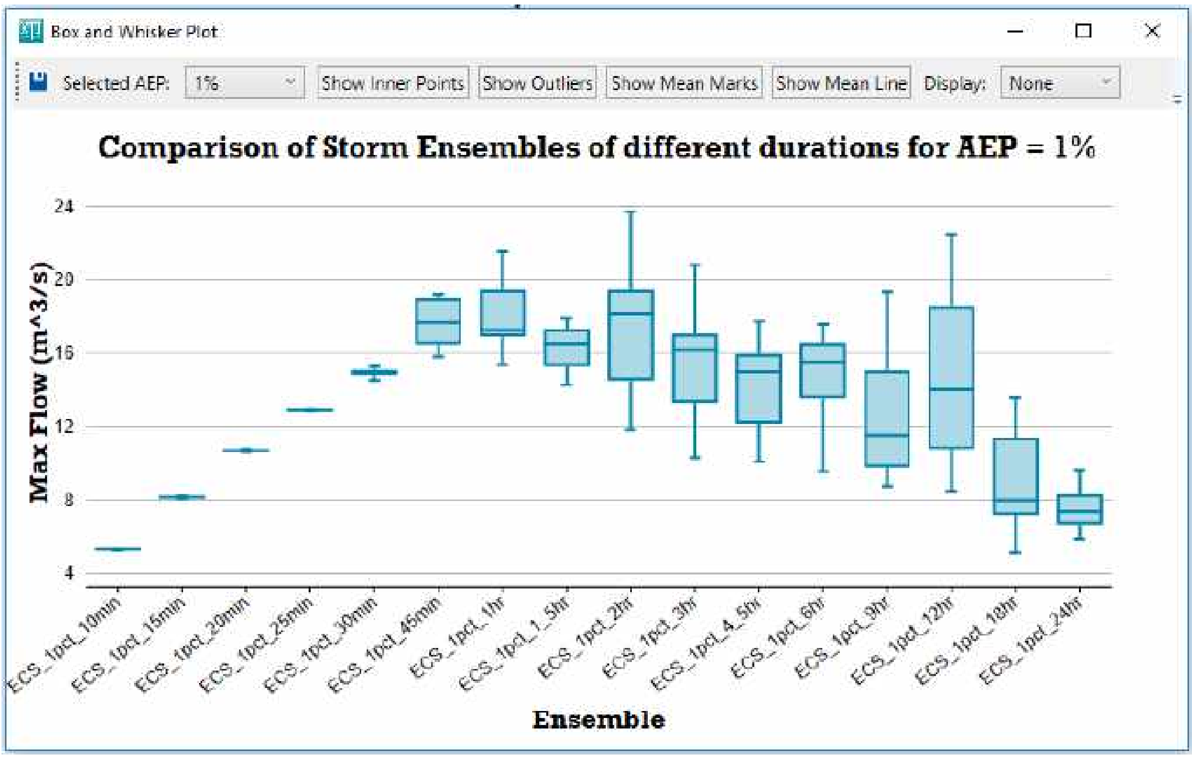
Interim Climate Change Factors

	RCP 4.5	RCP6	**RCP 8.5**
2030	**0.869 (4.3%)**	0.783 (3.9%)	**0.983 (4.9%)**
2040	**1.057 (5.3%)**	1.014 (5.1%)	**1.349 (6.8%)**
2050	**1.272 (6.4%)**	1.236 (6.2%)	**1.773 (9.0%)**
2060	**1.488 (7.5%)**	1.458 (7.4%)	**2.237 (11.5%)**
2070	**1.676 (8.5%)**	1.691 (8.6%)	**2.722 (14.2%)**
2080	**1.810 (9.2%)**	1.944 (9.9%)	**3.209 (16.9%)**
2090	**1.862 (9.5%)**	2.227 (11.5%)	**3.679 (19.7%)**

Probability Neutral Burst Initial Loss

min (h)\AEP(%)	**50**	**20**	**10**	**5**	**2**	**1**
60 (1.0)	24.2	13.2	12.3	12.0	10.8	7.7
90 (1.5)	25.1	14.7	13.3	12.0	10.2	8.3
120 (2.0)	22.4	13.4	13.0	11.1	10.3	6.1
180 (3.0)	21.9	13.7	12.6	10.2	9.6	5.2
360 (6.0)	19.9	12.8	12.2	10.9	11.1	3.5
720 (12.0)	21.9	15.3	15.0	12.2	13.8	4.5
1080 (18.0)	25.8	19.1	19.6	14.9	16.7	5.4
1440 (24.0)	29.9	21.7	21.4	16.5	14.3	5.9
2160 (36.0)	35.3	26.4	24.8	19.6	17.9	6.2
2880 (48.0)	37.4	27.7	26.6	23.7	23.2	7.0
4320 (72.0)	42.3	32.6	32.1	29.6	27.3	11.7

Box and Whisker Plots

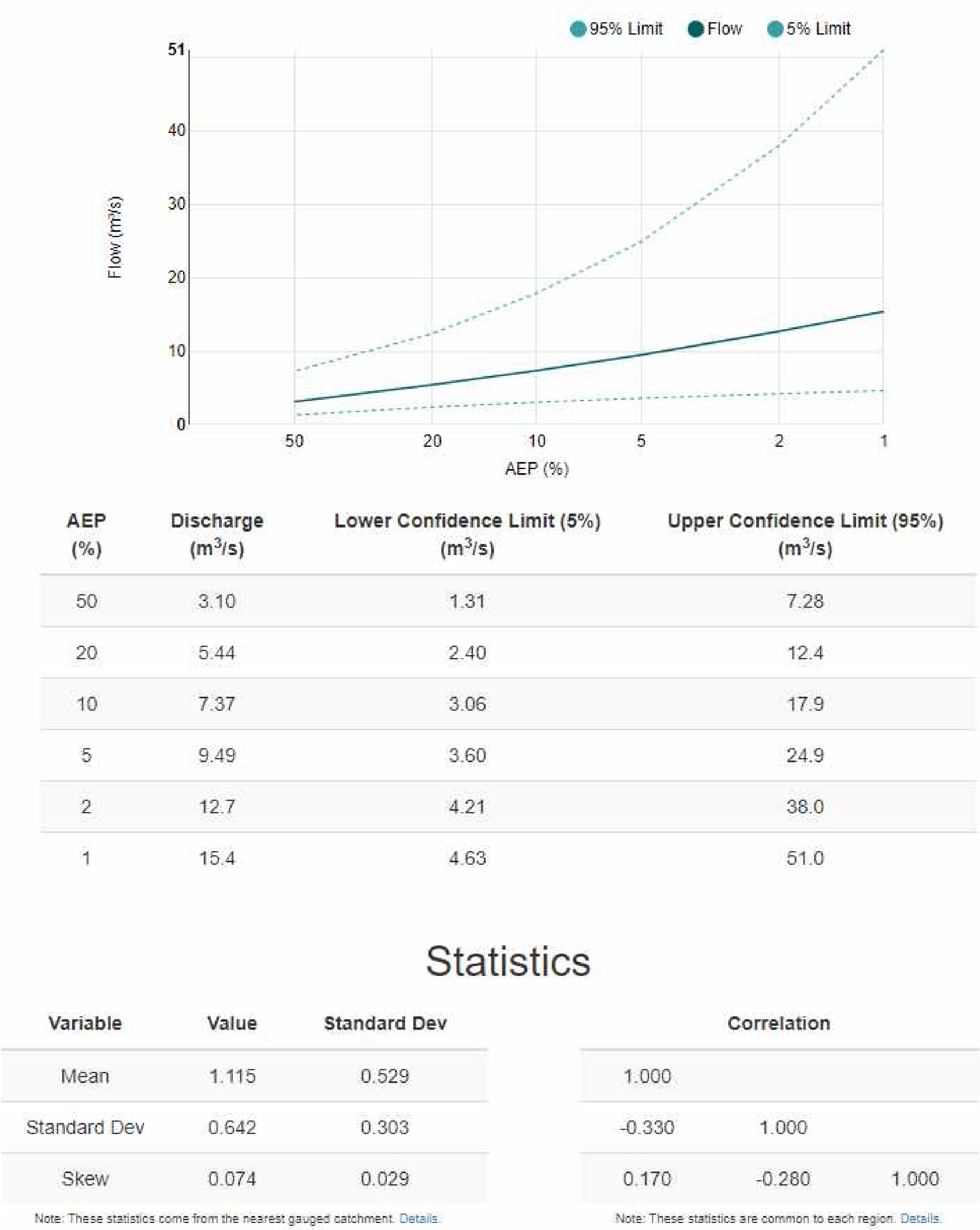


Selected AEP: 1%

Display: None

Figure 12 1%AEP Box and whisker plot of Ensemble results

Appendix C Regional Flood Frequency Estimation (ARR2019)



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	3.10	1.31	7.28
20	5.44	2.40	12.4
10	7.37	3.06	17.9
5	9.49	3.60	24.9
2	12.7	4.21	38.0
1	15.4	4.63	51.0

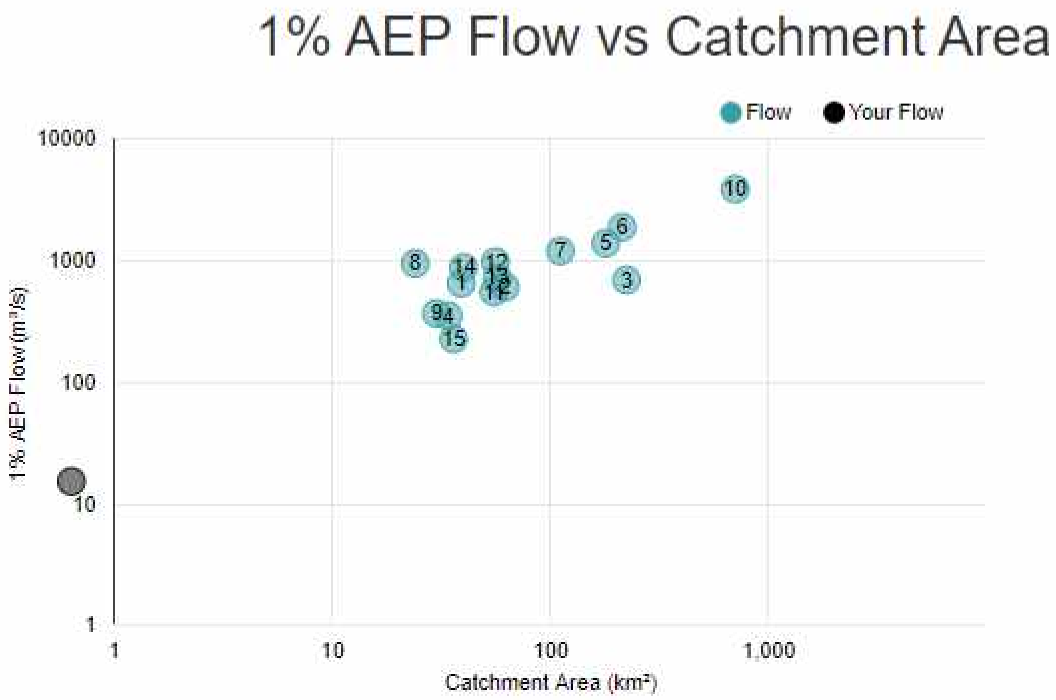
Statistics

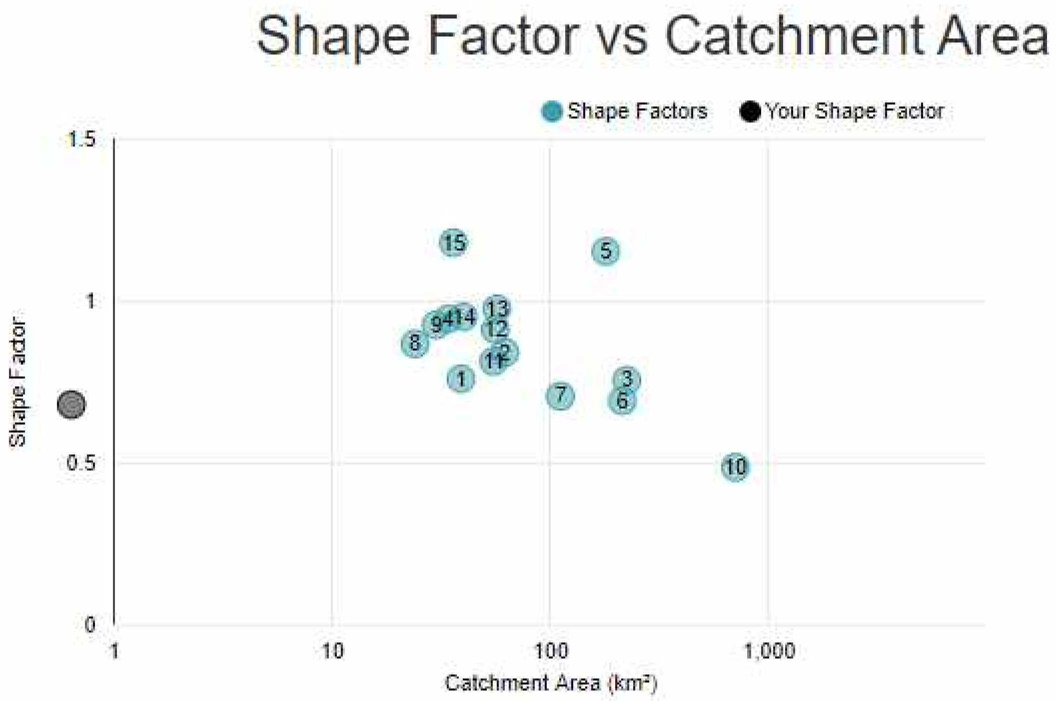
Variable	Value	Standard Dev
Mean	1.115	0.529
Standard Dev	0.642	0.303
Skew	0.074	0.029

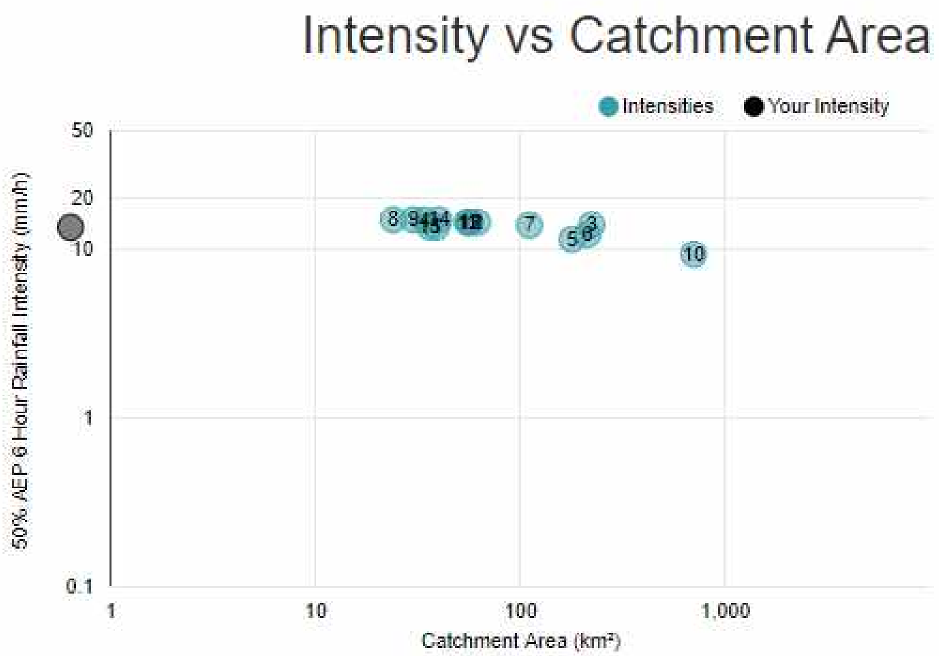
Note: These statistics come from the nearest gauged catchment. Details.

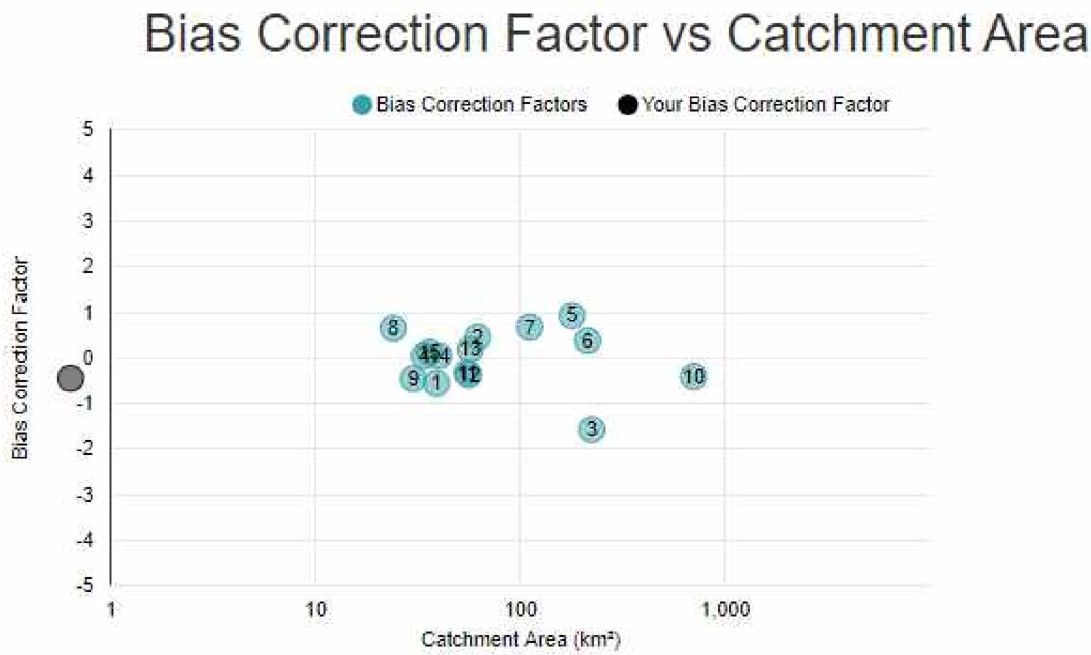
Correlation		
1.000		
-0.330	1.000	
0.170	-0.280	1.000

Note: These statistics are common to each region. Details.


1% AEP Flow vs Catchment Area
Flow
Your Flow
1% AEP Flow (m³/s)
10000
1000
100
10
1
Catchment Area (km²)
1
10
100
1,000
10
6
5
7
3
8
14
12
1
13
11
2
9
4
15


Shape Factor vs Catchment Area
Shape Factors
Your Shape Factor
Shape Factor
1.5
1
0.5
0
Catchment Area (km²)
1
10
100
1,000
15
5
9
4
14
13
12
8
11
2
1
7
3
6
10


Intensity vs Catchment Area
Intensities
Your Intensity
50% AEP 6 Hour Rainfall Intensity (mm/h)
50
20
10
1
0.1
1
10
100
1,000
Catchment Area (km²)
8
9
4
14
15
12
7
5
6
3
10


Bias Correction Factor vs Catchment Area
Bias Correction Factors
Your Bias Correction Factor
Bias Correction Factor
5
4
3
2
1
0
-1
-2
-3
-4
-5
1
10
100
1,000
Catchment Area (km²)
8
7
5
2
13
6
15
14
9
1
12
10
3