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Job Number: *190006*
Date: *11 June 2021*

David Waghorn
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Dear David,

Re: Flood Investigation for 187 Slade Road, Bexley North

1. Introduction

Development is proposed for the subject Site located at 187 Slade Road, Bexley North. The development is located in an urban area with a 28-hectare upstream catchment. Under current conditions the Site is affected by minor flooding from the carpark to the South-West and from Sarsfield Circuit. The location of the Site is shown in Figure 1.

GRC Hydro have been engaged by Planning Ingenuity to investigate the existing flood liability in relation to Council's planning policies to assess the suitability of development for the Site and to identify flood mitigation measures.

2. Previous Studies

The Bardwell Creek 2D Flood Study Review was undertaken by WMAwater in 2018. The study used a hydrologic model (WBNM) and hydraulic model (TUFLOW) to model design flood behaviour for events ranging from the 20% Annual Exceedance Probability (AEP) to the Probable Maximum Flood (PMF). The modelling system was calibrated and validated to historic events. These models were found to adequately represent flood behaviour in the study area.

The TUFLOW model results were used as the basis for investigating flooding as part of this study. Some model amendments were made by GRC Hydro, in the vicinity of the Subject Site based on observations from Site visits and local knowledge of the area. The key model amendment was to facilitate the existing overland flow path through 232 Slade Road which had previously been blocked out of the model and exacerbated flood levels. Site visit revealed that the building basement is designed to allow flood water throughout the building and discharge into the railway line to the North (see Figure 2).

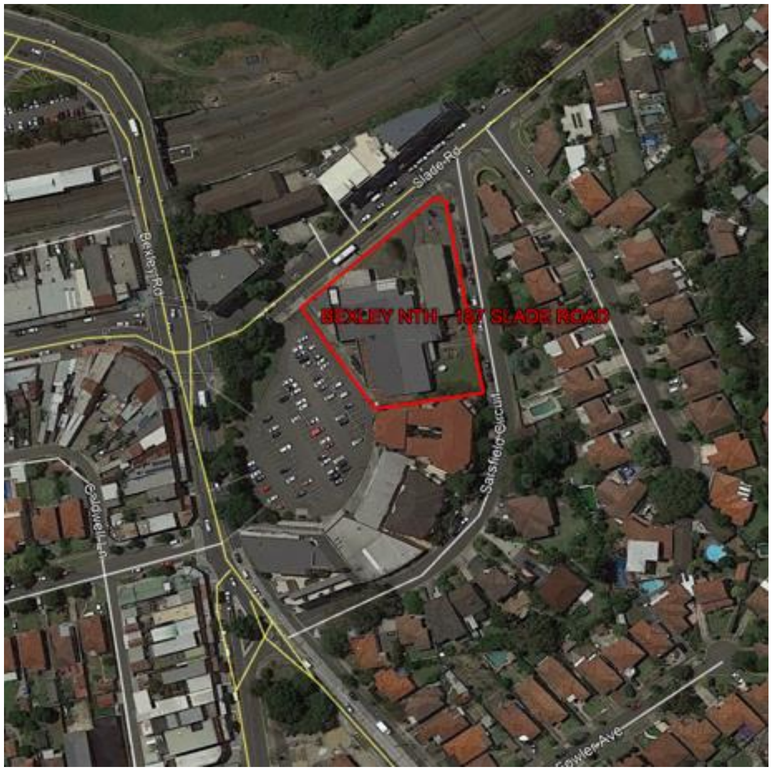


Figure 1: Project Site Location - 187 Slade Road - Bexley North

Figure 2: View of property in 232 Slade Road from Slade Road

3. Existing Flood Behaviour

The Site experiences flooding when rainfall in the catchment to the South exceeds system stormwater capacity and overland flow moves generally from South to North. Both the car park to the West and Sarsfield Circuit convey overland flow. The Site's upstream catchment is shown in Figure 3. Runoff from this catchment arrives at the intersection of Sarsfield Circuit and Bexley Road, flowing North. The flow is then split between Sarsfield Circuit and Bexley Road, with the latter flowing into the car park adjacent to the Site.

Figure 4 shows the 1% AEP flood depths in the vicinity of the Site. On the Site boundary, flood depths range from 0.1 to 0.2 m on Sarsfield Circuit while along the Western boundary there are depths of around 0.15m to 0.6 m (measured in the sag point into the car park area). On Slade Road depths range from 0.1m to 0.6m (measured in the Slade Road Sag point in front of building in 232 Slade Road). The figure also shows stormwater drainage in the vicinity of the Site, including a 900 mm diameter drain that runs underneath the existing building.

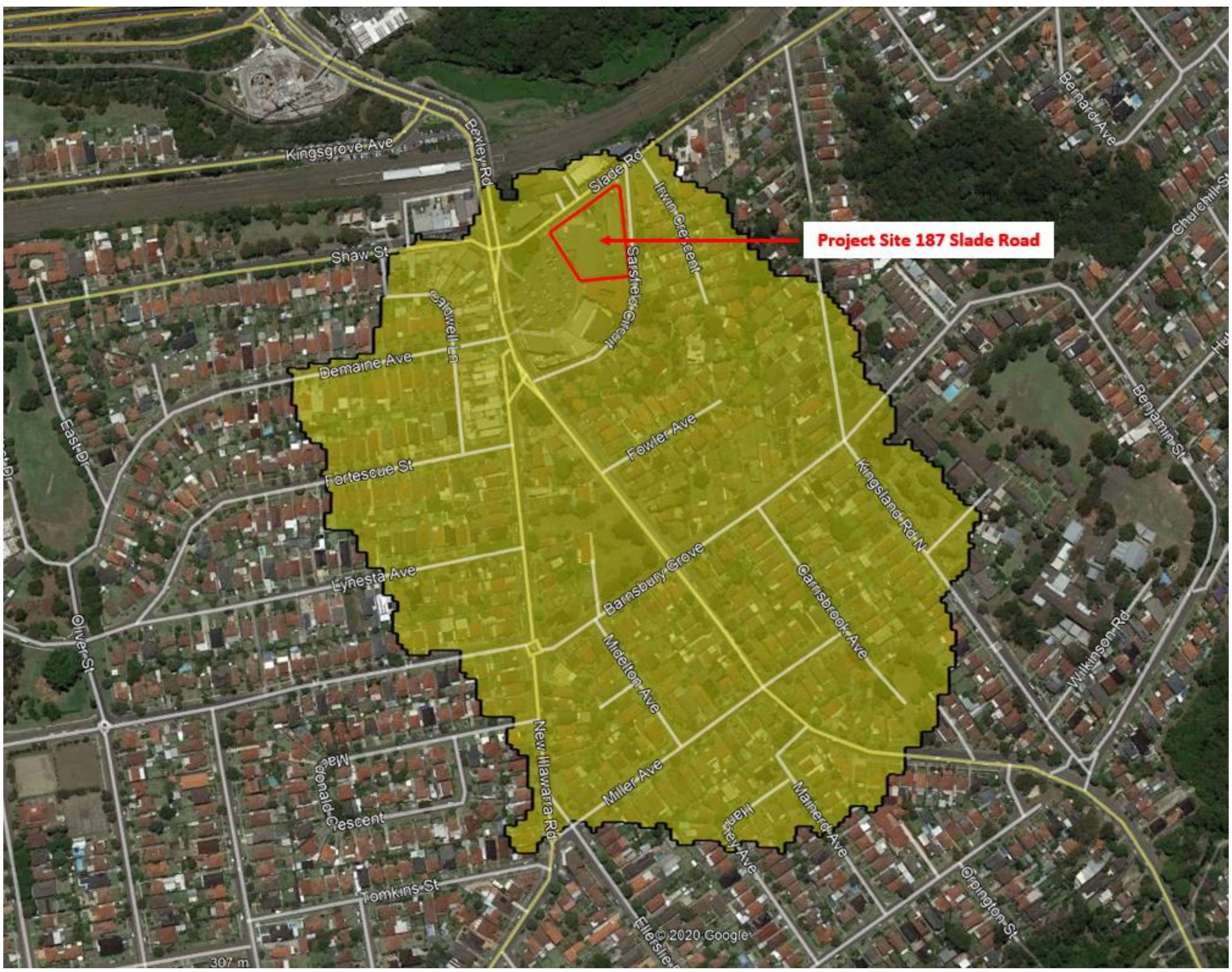


Figure 3: Subject Site upstream catchment (27.8ha)

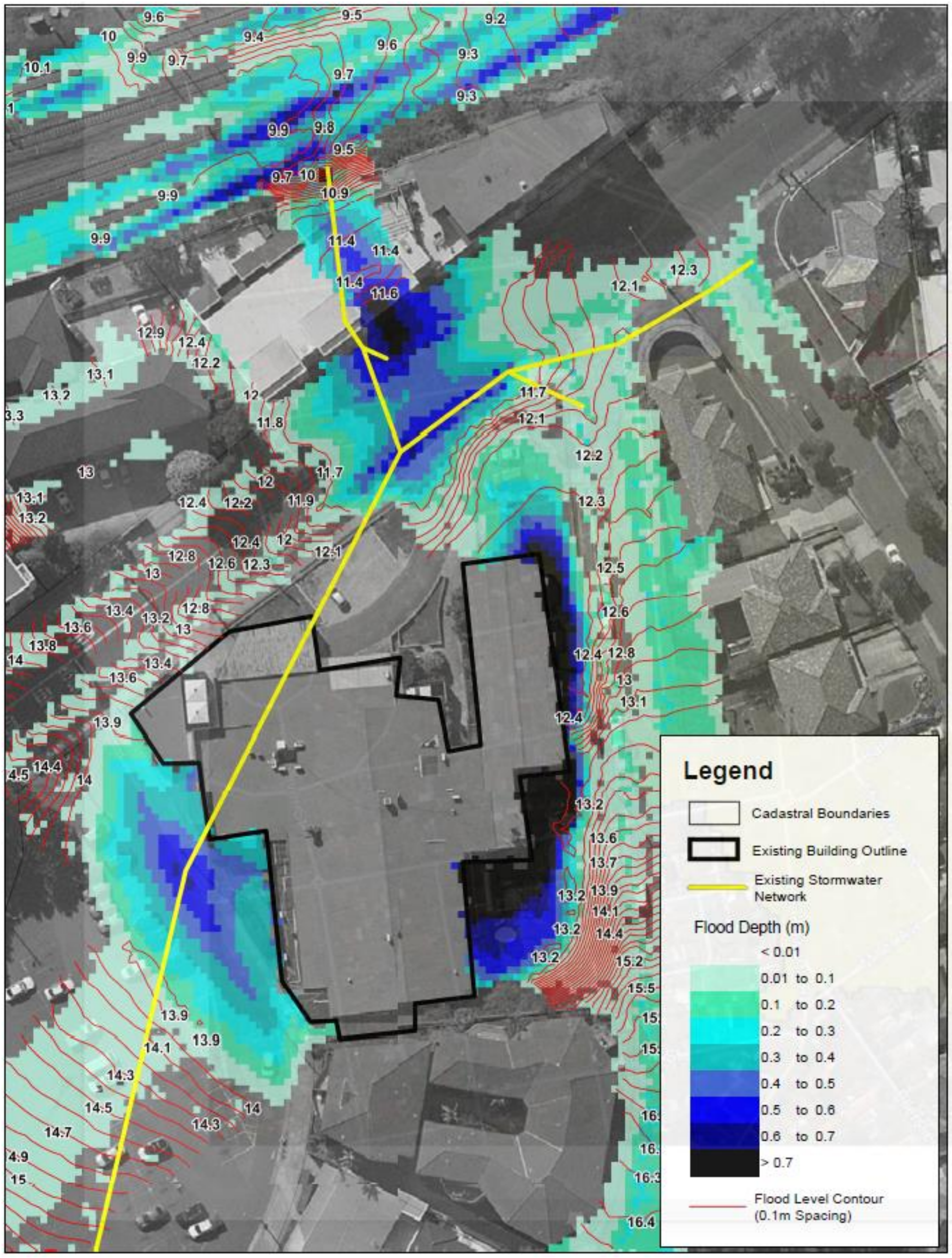


Figure 4: 1% AEP flood depth – existing case

Model results indicate that the relatively new development at the corner of Sarsfield Circuit and Bexley Road (building at 2-6 Sarsfield Circuit) redirected flow on to Sarsfield Circuit that would have otherwise continued on Bexley Road. This has likely contributed to the flood risk at the subject Site.

4. Flood Assessment of Proposed Development

The planning proposal is for an intensification of use of the subject Site whilst maintaining the existing use. The proposed construction consists of two new buildings. The area between the two buildings blocks (Laneway) is a publicly accessible open space. The proposed habitable surface is 2852 m², around 600 m² higher than the existing. Three basement levels are proposed with car access from Sarsfield Circuit at location shown in Figure 5.

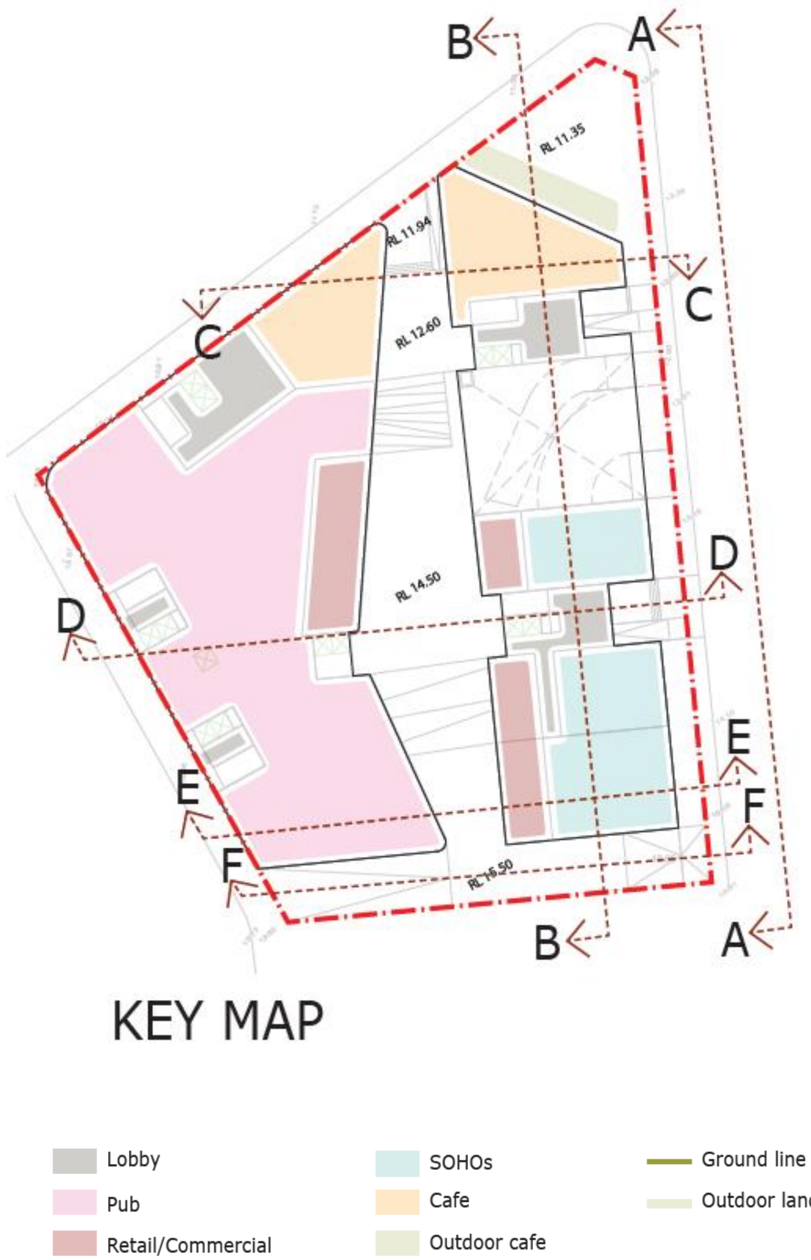


Figure 5: Proposed Development

The proposed development contains several features to replicate the existing flood behaviour and avoid flood level impacts. The features are shown in Figure 6 and are as follows:

1) **Pipe diversion and upgrade**: the existing 900 mm diameter pipe that traverses the Site will be demolished and replaced by a 1050 mm diameter pipe along Slade Road. The larger pipe will reduce friction losses and increase the pipe storage, reducing the hydraulic grade line and the potential impact in the car park area.
2) **Pipe upgrade:** The existing 900 mm pipe that crosses Slade Road will be upgraded to a 1200 mm diameter pipe or to an alternative drainage of similar cross-sectional area.
3) **Swale:** A swale will be included in the building landscaping on the East side of the development, to formalise the drainage path and improve drainage to the stormwater network. The proposed swale is 2m wide and 300-400 mm deep.
   The swale will cross the proposed Car Park access ramp via a 2000mm x 700mm culvert. Swale profile will need to be adequately defined to allow sufficient cover above the crossing structure.
   At the downstream end of the proposed swale, a new pipe (500mm diameter) will join the swale to the existing stormwater network.
4) **Lowered ground**: At the end of the swale (North-East corner of the development), the ground is lowered from the existing level of 12.17 mAHD to 11.35 mAHD (tying into the swale) and then the ground is graded in the North-West direction towards the Slade Road footpath at level 11.23 mAHD.
5) **Connection Lane at South of development**: Following Council's request, a 6m wide lane has been allowed at the South end of the development for connection between the parking area at West and the Sarsfield Circuit. As per Council request, the lane must have a high point ("crest") at lEast 200mm higher than the 1% AEP water level in the Sarsfield Circuit gutter.

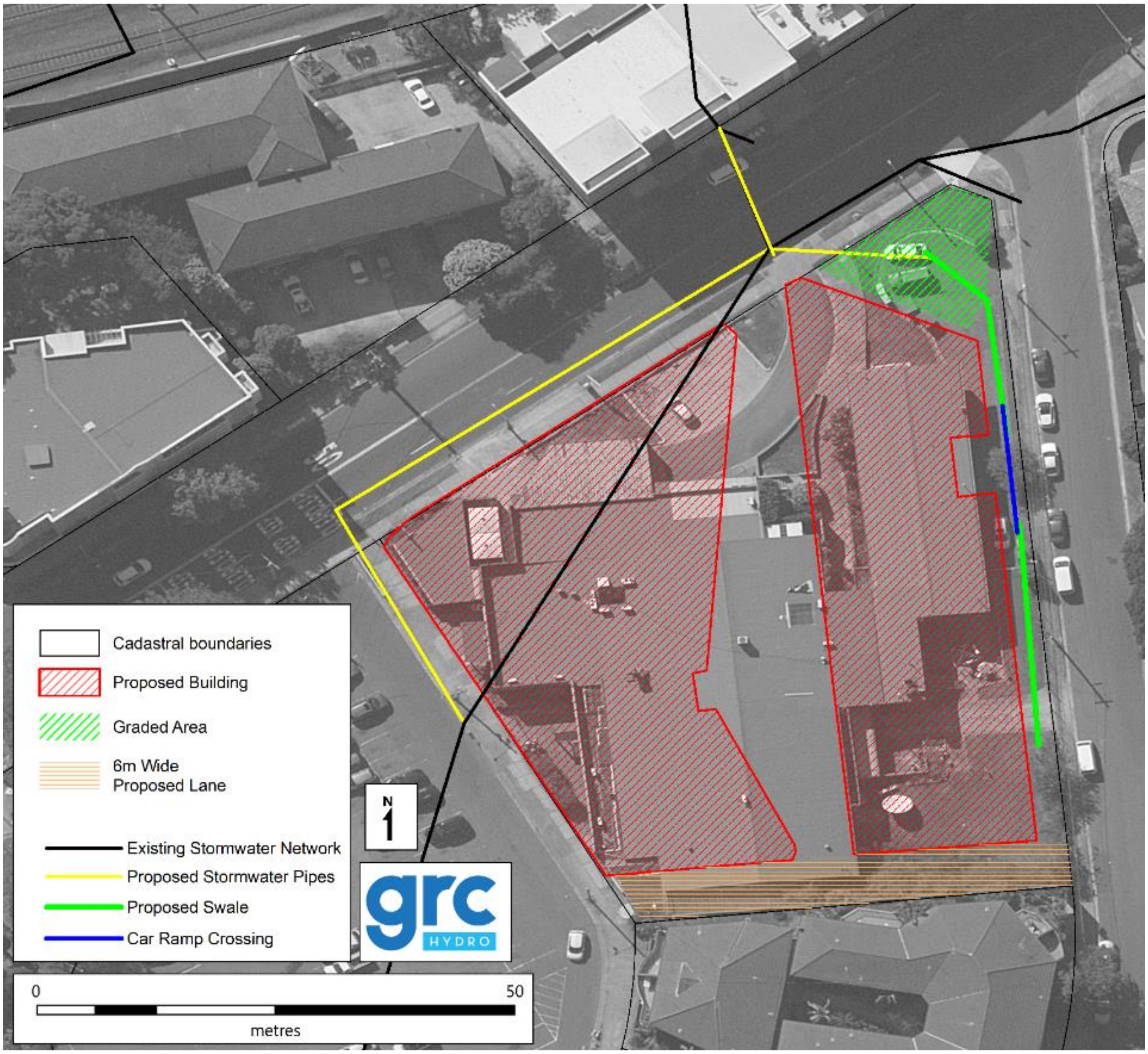


Figure 6: Proposed Flood Mitigation Measures

5. Relevant Planning Policy

Rockdale Development Control Plan

The Rockdale Council Development Control Plan (DCP) 2011 was adopted and is applicable for this development. Development control pertaining to Flood Risk Management can be found in Section 4.1.3 Water Management and are outlined below:

3. *Development must comply with Council's – Flood Management Policy which provides guidelines of controlling developments in different flood risk areas. It should be read in conjunction with the NSW Government's 'Floodplain Development Manual 2005'.*
4. *The filling of land up to the 1:100 Average Recurrence Interval (ARI) flood level (or flood storage area if determined) is not permitted, unless specifically directed by Council in very special and limited locations. Filling of land above the 1:100 ARI up to the Probable Maximum Flood (PMF) (or in flood*

fringe) is discouraged however it will be considered providing it does not adversely impact upon flood behaviour.

5. *Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with the cumulative impact of similar developments likely to occur within the same catchment.*
6. *The impact of flooding and flood liability is to be managed, to ensure the development does not divert the flood waters, nor interfere with flood water storage or the natural functions of waterways. It must not adversely impact upon flood behaviour.*
7. *A flood refuge may be required to provide an area for occupants to escape to for developments where occupants require a higher standard of care. Flood refuges may also be required where there is a large difference between the PMF and the 1 in 100-year flood level that may place occupants at severe risk if they remain within the building during large flood events.*

Rockdale Local Environmental Plan 2011

Section 6.6 Flood Planning for the Rockdale Local Environmental Plan (LEP) outlines flood related controls relevant to the proposed development. These controls are provided below.

6.6 Flood planning

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land,

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

(c) to avoid significant adverse impacts on flood behaviour and the environment.

(2) This clause applies to:

(a) land that is shown as "Flood planning area" on the Flood Planning Map, and

(b) other land at or below the flood planning level.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

(4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual (ISBN 0 7347 5476 0), published in 2005 by the NSW Government, unless it is otherwise defined in this clause.

(5) In this clause:

flood planning level means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.

Flood Planning Map means the Rockdale Local Environmental Plan 2011 Flood Planning Map.

The Flood Planning Map from the Rockdale LEP does not highlight the subject Site as within the Flood Planning Area. This map is shown in Figure 7.

Figure 7:Rockdale LEP Flood Planning Area (subject Site outlined in red – not tagged)

6. Impact of the Proposed Development

The proposed development was schematised in the hydraulic model (TUFLOW). The development was represented as a 'proposed' scenario that modified the building footprints and drainage features around the Site, as described in the previous section. The hydraulic model was then used to assess the impact of the development on existing flood behaviour. The impact maps for the 20%,10% and 1% AEP events are shown in Appendix to this report in Figures 10 to 12.

The figures show that the building has a localised effect on the existing flood behaviour. On the West side of the building there is a slight decrease in flood level of less than 0.1 m. While there is a slight loss of flood storage (black area) this is offset by the increased stormwater capacity.

On Sarsfield Circuit there is also a loss of flood storage against the building, however it is offset by the swale and the level reduction at North-East of the development . The adverse impact is localised at the Southern-East end of the development and it is contained within the subject Site boundaries.

Overall, in regard to flood impact, the proposed development has minimal impacts on flood behaviour and does not result in flood impacts to other private properties or public roads. It will not result in increased requirement for government spending on flood mitigation measures.

7. Minimum Floor Level Requirements

Whilst the Site is flood liable in the 1% AEP event, flood risk itself is minimal. Flood depths are transitory (duration is limited), hazard is relatively minor owing to relative shallowness of flood waters. There is no expectation that flood waters cannot be managed such that risk to life can be managed. Far from being mainstream flooding which can pose a risk to life the flood affectation would more accurately be characterised as being overland flow (stormwater / flood fringe). Few depressed areas at South-East of the Site which are currently characterised as being flood storage will be blocked by the proposed development.

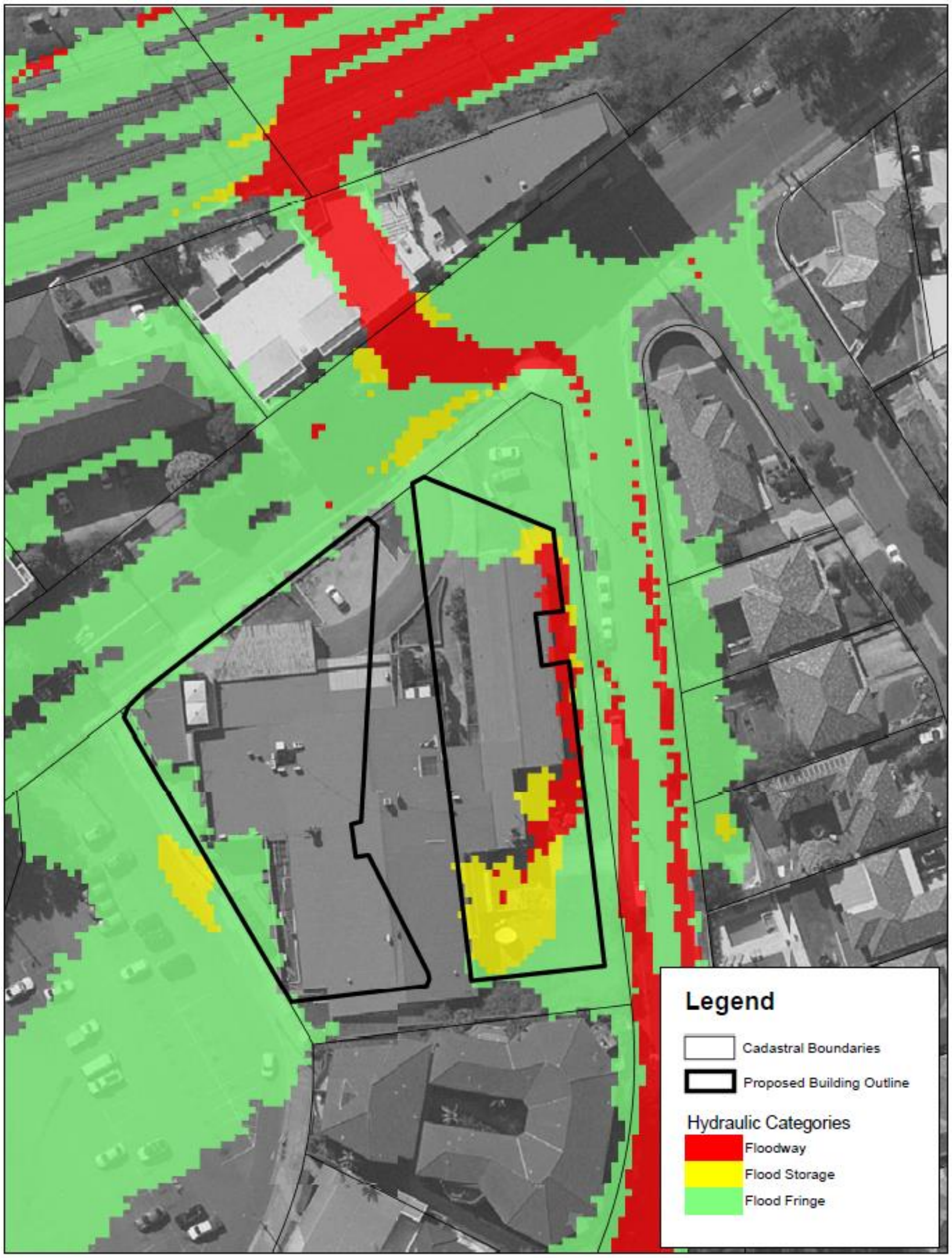


Figure 8: Flood Categories (1%AEP)

The main issue for any development will be achieving a complaint outcome in regard to flood impact. Other issues related to flood related development controls that seek to ensure appropriate development inclusive of levels etc. will be readily achieved. For example:

- Compliance with floor height controls;
- Compliance with controls relating to building resilience.

The PMF (Probable Max Flood) is a consideration in building design and risk management. The Floodplain Development Manual (2005), defines the PMF as *"[...] the largest flood that could conceivably occur at a particular location, usually estimated from Probable Maximum Precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event [...]"*

The PMF provides an upper limit of flooding. As can be seen from results in Figure 9, the PMF does not scale excessively at the Site with PMF levels being generally 0.3 to 0.5 m higher than 1% AEP levels. At North instead the PMF level is more than 1m higher than the 1% AEP level due to the limited capacity of the overland flow throughout the building car park at 232 Slade Road.

Location	1%AEP Level [mAHD]	PMF Level [mAHD]	FPL [mAHD]
Building Entrance "A"	13.1	13.1	13.6
Building Entrance "B"	12.1	13.0	12.6
Building Entrance "C"	13.6	14.0	14.5
Vehicular Entrance "D"	12.9*	13.29	13.39
South end of pedestrian Laneway (Location "E")	N/A	15.5	15.5
Gutter in Sarsfield Circuit at entrance to 6m wide access lane (Location "F")	15.6	15.9	15.85**
Building Entrance "G"	13.9	14.5	14.5
Building Entrance "H"	13.9	14.5	14.5

*= measured on Sarsfield Road

**= crest level at the 6m wide access lane

Table 1 : water levels and proposed FPL

Table 1 provides the computed peak water levels for the 1% AEP event and PMF against the proposed FPLs.

A minimum freeboard of 500mm above the 1%AEP water levels is assured at all building entrances, in respect of Council DCP. Building Entrance "C" is also above the PMF level.

The Vehicular entrance "D" is more than 300mm above the 1%AEP water level and is also above the PMF level.

Following Council's request, a crest at level 15.85m has been provided at the East entrance to the 6m wide lane at South of the subject development, approx. 250mm above the 1% water level in the Sarsfield Circuit gutter.

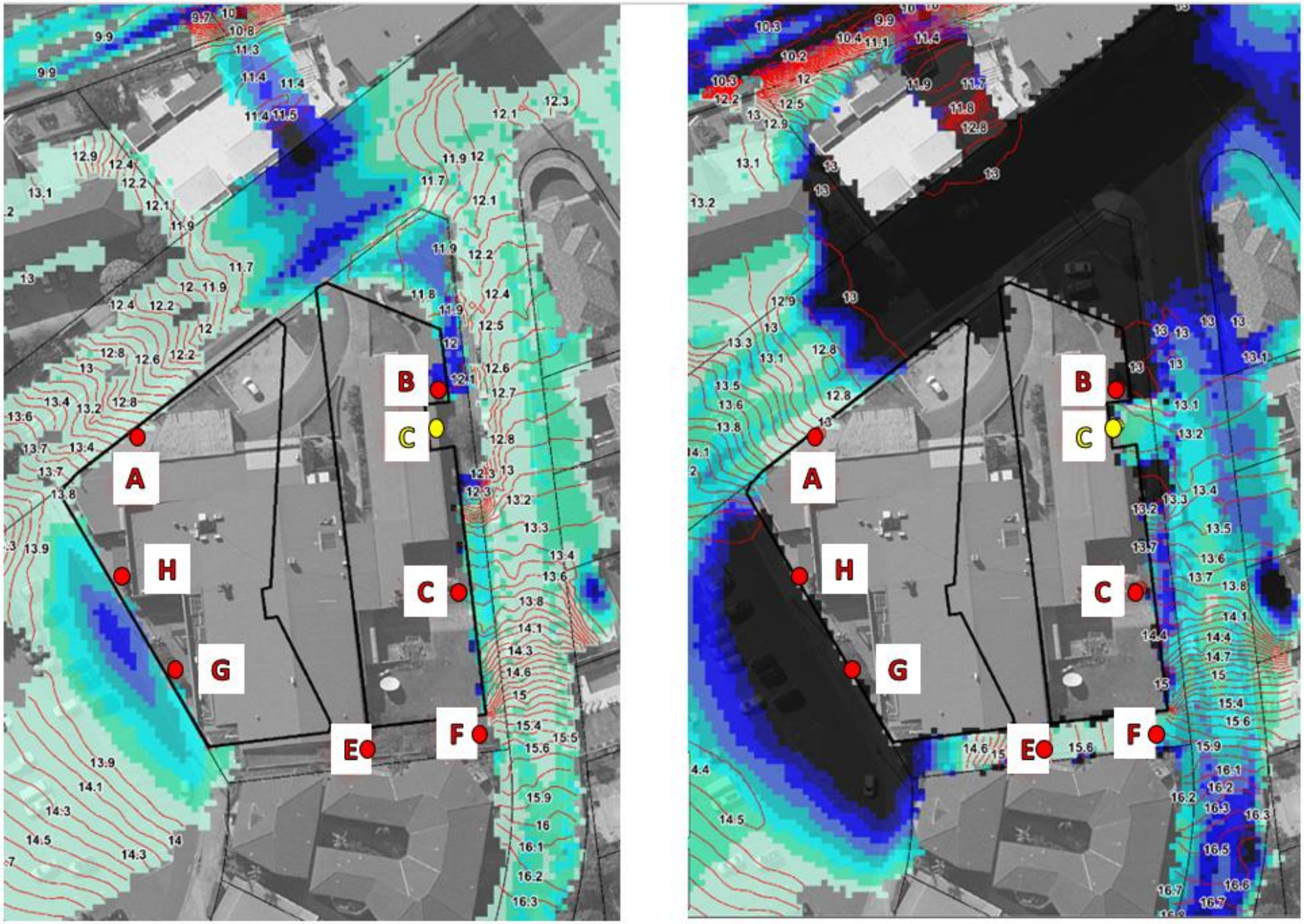


Figure 9: 1%AEP (Left) and PMF (Right) Flood depth Maps

8. Pipe Diversion

As mentioned in Section 4 of this report, the proposed development comprises diversion and upgrade of limited Council's stormwater pipes.

In the Existing Scenario in fact, a 900mm dia. pipe runs under the existing building in 187 Slade Road from the car park at West to a drainage pit on the Slade Road at North of the building (pipe "EXISTING (a)" in Figure 10).

From this pit, a 900mm dia. pipe crosses Slade Road and connects to a large pit located at the entrance of the car park of building in 232 Slade road (pipe "EXISTING (d)" in Figure 10) from where a 1200mm dia. pipe discharge to the railway line at North.

The new stormwater layout proposes to demolish the pipe "EXISTING (a)" and re-route it to North, along Slade Road, to avoid interferences with the new construction (pipes "PROPOSED (b)" and "PROPOSED (c)" in Figure 10). The proposed diversion will increase the length of the pipe by approximately 19m and will introduce some sharper deflection angles that might reduce the capacity of the existing system. To cater for the additional energy losses due to the extended length of the pipe (friction losses) and for the less efficient geometry of the network (minor losses), it is proposed to upsize the diversion pipes to 1050mm dia.

Additionally, it is proposed to upsize the 900mm dia. "EXISTING (d)" pipe to 1200mm dia. "PROPOSED (d)" pipe (or alternative drainage structure of equivalent cross-sectional area) to match the diameter of the pipe discharging to the railway line.

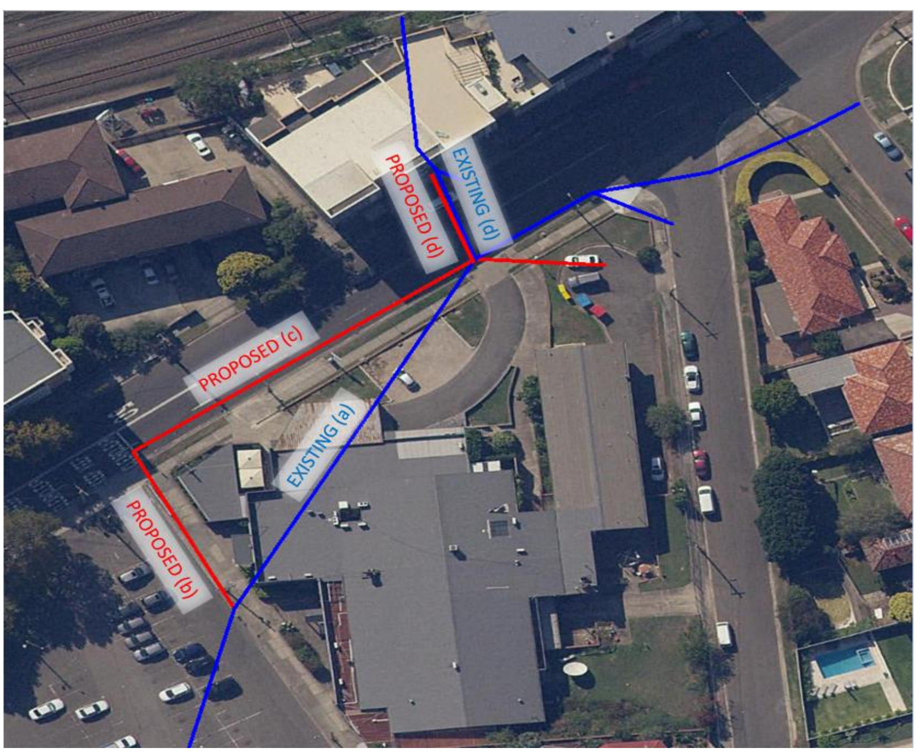


Figure 10: Pipe diversion scheme

TUFLOW simulations were run for events from the 20%AEP to the PMF event to test the new drainage scheme against the existing one.

In TUFLOW, the ENGELUND energy loss approach was used to calculate the minor losses due to the bends and change of direction. This approach calculates the loss coefficients at pipes junctions as sum of entry and exit head losses, losses due to the bend and drop in invert levels (further explanation can be found in Chapter 5.12.5.4 of TUFLOW manual).

Table 2 lists the computed losses coefficients at the peak flow time for the Existing and Proposed pipes in all events from the 20%AEP to PMF. The table reports:

- inlet loss coefficient i.e. the energy losses due to expansion of flow within the manhole at the outlet of the inlet culvert
- additional loss coefficient due to bend and change in invert levels and any manhole energy loss contribution
- outlet loss coefficient i.e. the energy losses due to contraction from the manhole and re-expansion of flow within the entrance of an outlet culvert

AEP	PEAK MINOR HEADLOSS COEFFICIENT (Inlet / Form / Outlet)				
	EXISTING		PROPOSED		
	(a)	(d)	(b)	(c)	(d)
20%	0.19/0.02/0.42	0.16/0.45/0.45	B	0.16/0.80/0.39	0.16/0.77/0.28
10%	0.19/0.02/0.42	0.16/0.45/0.46	0.17/0.16/0.39	0.16/0.80/0.41	0.16/0.77/0.29
1%	0.19/0.02/0.44	0.16/0.41/0.47	0.19/0.16/0.44	0.17/0.79/0.44	0.16/0.76/0.30
PMF	0.17/0.02/0.40	0.18/0.37/0.54	0.18/0.18/0.43	0.17/0.73/0.42	0.16/0.75/0.34

Table 2: TUFLOW minor losses coefficients

Table 2 shows that the total minor loss coefficient (sum of Inlet, Form and Outlet coefficients) increases from 0.65 to 0.79 at the first bend ("EXISTING (a)" and "PROPOSED (b)") and from 1.04 to 1.22 at the last one ("EXISTING (d)" and "PROPOSED (d)").

Additionally, in the proposed scheme, a 90-degree bend is introduced ("PROPOSED (c)") for which a total minor coefficient of around 1.4 is calculated.

Melbourne Water pit loss coefficient table (https://www.melbournewater.com.au/building-and-works/developer-guides-and-resources/standards-and-specifications/loss-coefficient)has been commonly referenced to by other Councils and Authorities . The table provides loss coefficients for a variety of junction pits configurations. A loss coefficient between 1.3 and 1.5 is recommended for pits at "L" bends which validates the coefficient calculated by TUFLOW.

Description	Q_u	Q_l	Q_g	k
Inlet pit with one outlet pipe:				
(a) side entry	-	-	≈Qo	10
(b) grated pit	-	-	≈Qo	5
Inlet pit on through pipe	~0.9Qo	-	some	0.5
	~0.7Qo	-	~0.3Qo	1.3
	~0.5Qo	-	~0.5Qo	2.1
Junction pit on through pipe	≈ Qo	-	-	-
Inlet pit on through pipe with laterals	~0.9Qo	some	some	0.5
	~0.7Qo	some	some	1.1
	~0.5Qo	some	some	1.5
	~0.3Qo	0.7Qo	some	2.0
Junction pit on through pipe with laterals	~0.9Qo	some	-	0.5
	~0.5Qo	~0.5Qo	-	1.5
	~0.2Qo	~0.8Qo	-	2.0
Inlet pit on L bend	-	~Qo	some	1.5
Junction pit on L bend	-	≈Qo		1.3
Inlet bend on T junction with laterals	-	~Qo	some	1.8
Junction pit on T junction with laterals	-	≈Qo		1.6
Drop pit				
(a) direction change less than 45 degrees	~Qo	-	some	2.0
(b) direction change more than 45 degrees	~Qo	-	some	2.5

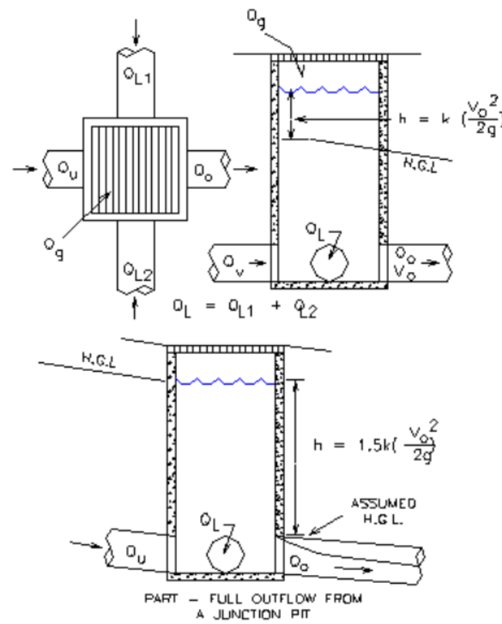


Table 3: Pit loss coefficients from Melbourne Water

TUFLOW also provides indication about the flow regime in the pipes at every simulation time step. All pipes at peak flow time are tailwater controlled with submerged entrance and exit (Flow regime type "F"). An exception is represented by the PROPOSED (b) pipe in the 20%AEP event where an inlet-controlled regime type B is calculated and for this reason TUFLOW does not provide minor loss coefficients results.

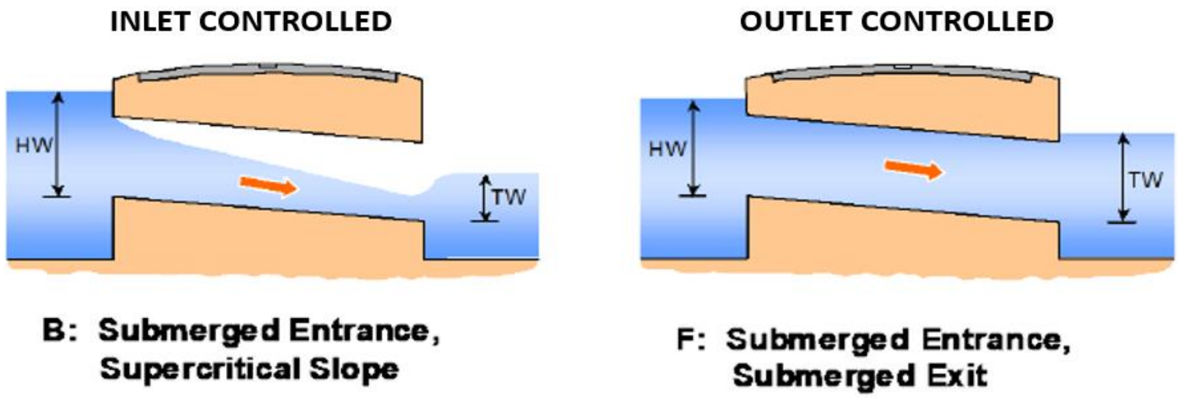


Figure 11: Flow regimes in diversion pipes

Table 4 are the peak flow rates in the existing and proposed network and the peak Hydraulic Grade Line (HGL) at the drainage pit in the car park at West of the Site (where the diversion pipe departs). Peak flow for all the simulated events increased by approximately 30% while the HGL at the pit in the car park ("U/S Peak HGL") reduces approx. by 150 to 200 mm for all events up to the 1% AEP and by 13mm in the PMF.

AEP	PEAK FLOW (m^3/s)					U/S PEAK HGL (mAHD)	
	EXISTING		PROPOSED			EXISTING	PROPOSED
	(a)	(d)	(b)	(c)	(d)		
20%	1.6804	1.919	1.962	1.987	2.579	13.042	12.854
10%	1.961	1.951	2.036	2.063	2.625	13.176	12.955
1%	2.107	2.07	2.258	2.295	2.748	13.526	13.382
PMF	2.306	2.697	2.456	2.668	3.476	14.52	14.507

Table 4: Peak flow rates and HGL in the existing and proposed network

Hand calculation has also been done to compare the existing and proposed pipe configuration. The calculation is based on the Gauckler-Manning-Strickler resistance formula for the friction energy losses calculation and on the TUFLOW computed minor loss coefficients to calculate the losses at each change in direction.

In the table below, a constant inflow of $2m^3/s$ was assumed for both the existing and proposed scheme and the total head loss (friction losses + minor head losses) was calculated under the assumption of uniform flow regime.

	EXISTING	PROPOSED	Comment
Q (m^3/s)	2.000	2.000	constant inflow ~ equal to the 1% AEP flow
Ltot (m)	83.670	101.960	total lenth of pipe = L1+L2
L1 (m)	67.780	86.070	L is the pipe length . L1 refers to pipe (a) in the existing and pipe (b+c) in the proposed
L2 (m)	15.890	15.890	L is the pipe length . L2 refers to is pipe (d) in both the existing and proposed
k	66.660	66.660	Gaukler Strickler coefficient , corresponding to a Manning coefficient = 0.015
dia 1 (m)	0.900	1.050	dia is the pipe diameter. dia1 refers to pipe (a) in the existing and pipe (b+c) in the proposed
dia 2 (m)	0.900	1.200	dia is the pipe diameter. dia2 refers to pipe (d) in both the existing and proposed
A1 (m^2)	0.636	0.866	$A = \pi r^2$ A is the pipe cross sectional area. A1 refers to pipe (a) in the existing and pipe (b+c) in the proposed
A2 (m^2)	0.636	1.131	A is the pipe cross sectional area. A2 refers to is pipe (d) in both the existing and proposed
R1 (m)	0.225	0.263	R is hydraulic radius. R1 refers to pipe (a) in the existing and pipe (b+c) in the proposed
R2 (m)	0.225	0.300	R is hydraulic radius. R2 refers to is pipe (d) in both the existing and proposed
ΔHfr1 (m)	1.102	0.615	ΔHfr is head loss due to frictions. ΔHfr1 refers to pipe (a) in the existing and pipe (b+c) in the proposed
ΔHfr2 (m)	0.258	0.056	ΔHfr is head loss due to frictions. ΔHfr2 refers to pipe (d) in both the existing and proposed
Δhfrtot (m)	1.360	0.670	Δhfrtot is the sum of ΔHfr1+ΔHfr2
V1 (m/s)	3.144	2.310	V is the average pipe cross sectional velocity. V1 refers to pipe (a) in the existing and pipe (b+c) in the proposed
V2 (m/s)	3.144	1.768	V is the average pipe cross sectional velocity. V2 refers to is pipe (d) in both the existing and proposed
φ1	0.650		minor head loss coeff of first bend in existing case
φ2	1.040		minor head loss coeff of second bend in existing case
φ3		0.790	minor head loss coeff of first bend in proposed case
φ4		1.400	minor head loss coeff of second bend in proposed case
φ5		1.220	minor head loss coeff of third bend in proposed case
ΔHBEND1 EXIST (m)	0.327		head loss (m) due to the first bend in the existing network. It is calculated with φ1 and the V^2/(2g) , where V is the velocity of the DS pipe
ΔHBEND2 EXIST (m)	0.524		head loss (m) due to thesecond bend in the existing network. It is calculated with φ2 and the V^2/(2g) , where V is the velocity of the DS pipe
ΔHBENDTOT EXIST (m)	0.851		total head loss due to bends in the existing network.
ΔHBEND1 PROP (m)		0.215	head loss (m) due to the first bend in the proposed network. It is calculated with φ3 and the V^2/(2g) , where V is the velocity in the DS pipe
ΔHBEND2 PROP (m)		0.381	head loss (m) due to the second bend in the proposed network. It is calculated with φ4 and the V^2/(2g) , where V is the velocity in the DS pipe
ΔHBEND3 PROP (m)		0.194	head loss (m) due to the third bend in the proposed network. It is calculated with φ5 and the V^2/(2g) , where V is the velocity in the DS pipe
ΔHBENDTOT PROP (m)		0.790	total head loss due to bends in the proposed network.
Δhtot exist (m)	2.211		sum of friction losses and bend losses in the existing network
Δhtot prop (m)		1.460	sum of friction losses and bend losses in the proposed network

Table 5: Head loss hand calculation – Existing VS Proposed network

Both TUFLOW and the hand calculation demonstrate that the new proposed scheme is hydraulically more efficient than the current one.

In TUFLOW, due to the increased pipe conveyance, peak flow in the diverted pipes is greater than in the existing ones while the peak Hydraulic Grade in the upstream pit (in the West car park) is reduced by approximately 150mm.

In the hand calculation, where same inflow is assumed in the pre and post development scheme, the total energy loss ("Δhtot") in the new scheme is significantly lower.

9. Flood Risk Assessment

The potential risk to life as a result of flooding can be ascertained by assessing the flood hazard. Flood hazard can be quantified by considering the flood depth and velocity in combination (AIDR, 2017).
The hazard categories based on the Australian Emergency Management Institute (2014) of Figure 12 were considered.

Available warning time for the Site is short due to the small size of the catchment upstream of the Site, leading to a “flash flood” classification. Review of the flood models found that the 1%AEP peak flood flow occurs approximately 10 minutes after the rainfall peak which leaves little time for flood evacuation and preparation. Evacuation of the buildings could potentially result in people entering hazardous floodwater areas. For flash flood catchments, the provision of an effective flood warning service is not available due to the difficulties with its prediction. A benefit of the flash flood setting is that the duration of flooding is typically short with hazardous flooding to typically last less than one hour.

Figures 13 and 14 in the Appendix, are the 1%AEP and PMF flood hazard maps for the Existing and Proposed Scenario. In the 1%AEP event, the flood hazard variations are negligible. In the PMF, a slight increase of hazard is shown at the downstream end of the Sarsfield Circuit, which does not modify the overall hazard category of the area. Figures 15 and 16 in appendix highlights changes in flood hazard caused by the new development.

Hazard along the escape routes on Slade Road is generally low, being globally classified as H1 level. However, although significant flow path is only likely to occur in rare flood events, the type of potential flow presents a significant risk to people and vehicles. An analysis of the PMF event therefore yields the requirement that people are not moving around the Site once a certain threshold of depth is crossed. It is clear, however, that this threshold event will occur rarely (less often than once per one hundred years).

The Site access is limited by the trafficability of Slade Road, which is classified as H5 in the PMF as per flood hazard category. Therefore, shelter-in-place for Site occupants is recommended during flood event.

It shall be noted that, given the nature of public accessibility of the proposed Laneway, the proposed Site will represent a safe refuge for people caught by flash flooding.

10. Building Materials

All materials below PMF level in the proposed development shall be flood compatible.
No electrical equipment or wiring shall be installed below PMF level.

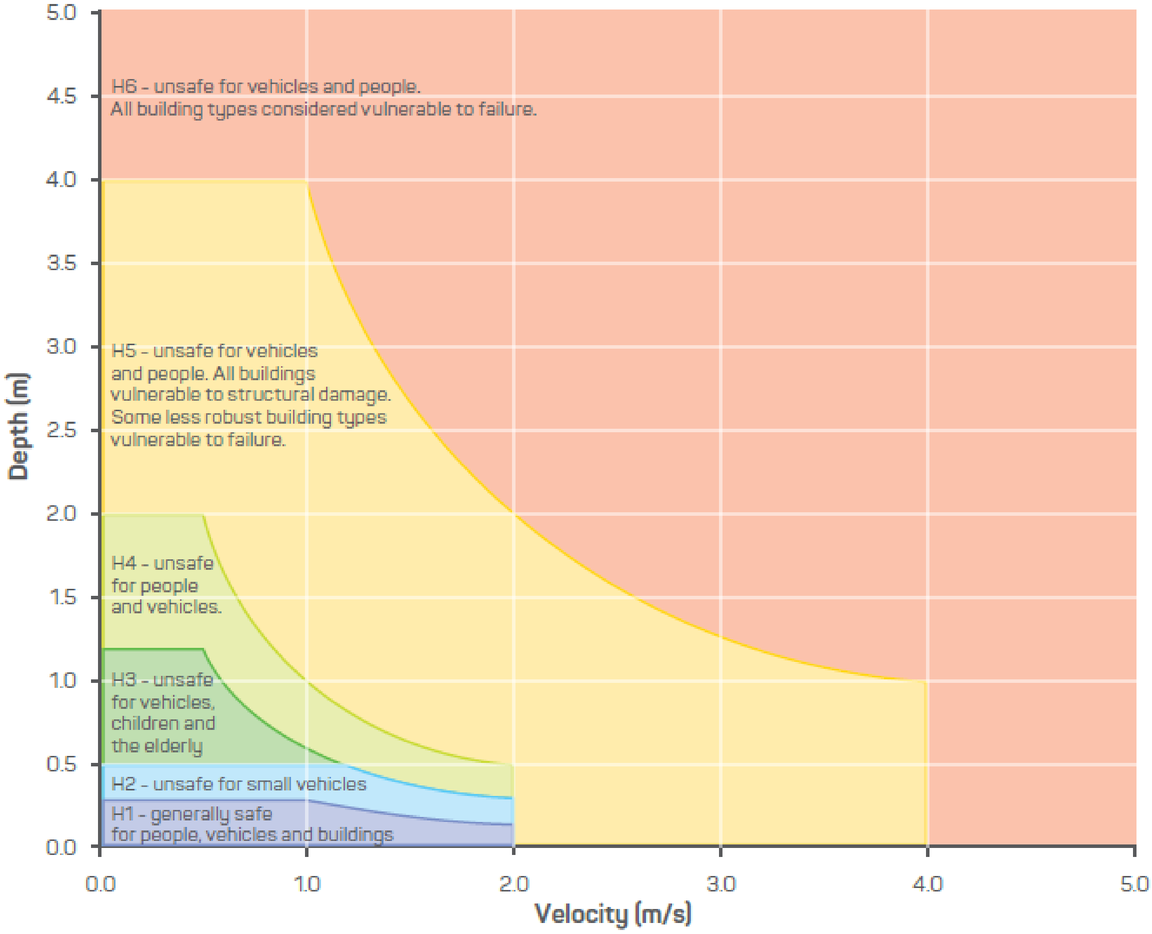


Figure 12: Flood Hazard Category by Australia Emergency Management Institute (2014)

11. Flood Management Plan

The Site is not subject to high level of flood risk and whilst in are events flow does occur, flood free areas in the PMF event are easily accessible on foot.

Hazard is relatively low for all but the rarest events. Flooding will be occurring simultaneously with the rainfall due to the small catchment, but flooding duration will be limited in time.

Due to the limited available warning time and the associated risk of people driving or walking through flood waters, it is not recommended that people evacuate the Site during times of flood and that shelter-in-place policy be adopted. This requires little management to achieve.

It is suggested signage be installed in the basement to advise that during rainfall or following rainfall, care should be taken as residents exit the carpark.

11.1 Preparedness

Preparations for flooding are to be incorporated into the management of the Site. These measures shall be communicated to the staff of the stores and to all residents in the buildings to ensure that the Site is prepared for flooding when it occurs. The preparatory measures are as follows:

- Keep a hard copy and digital version of this Flood Management Plan;
- Brief relevant staff of its content on an annual basis, or more frequently if staff turnover is high. There should always be at least one employee familiar with the Plan on duty whilst the stores are open;
- Brief resident of the buildings with the content of the Plan;
- Design temporary warning signage to marshal Site occupants during a flood including warning signs to not let people leave the Site during flood or accessing the car park;
- Maintain a loudspeaker system inside the Site that can be used for announcements during a flood. A flood warning message should be prepared for disseminations to occupants during times of flood. The message should contain information about the dangers of flood waters and advising people remain within the Site until an all-clear message is announced.

11.2 During a Flood

The main responsibility during a flood is to notify emergency services, to marshal Site occupants into safe areas and to assist those impacted by floodwaters.

The greatest risk is estimated to be to those leaving the Site end entering areas of high flood hazard.

The actions to be taken by the Site management, in chronological orders, are:

1) Call the State Emergency Service and advice that the Site is flooding and that assistance may be required;
2) Erect temporary warning signs at each Site exit stating to remain within the Site;
3) Turn off buildings power to reduce the risk of electrocution;
4) Announce (over the loudspeaker and in-person) to occupants of the Site that flooding is occurring outside and to remain calm and stay within the Site area until flooding passes. The Site should not be evacuated during flood event as the greatest flood risk is experienced in the car park and surrounding roads.
5) Ensure that no one is in the Basement areas;

6) Check outside if any vehicles or pedestrian have been caught in floodwaters or injured. Assist them if safe to do so (fast moving or deep floodwaters should be avoided) and if injuries are noted, call an ambulance;
7) Assist the elderly or those with children in finding a safe area to wait within the building.

11.3 Recovery

Once the floodwater subsides, announce that it is safe to now leave the building and car park, and take down the signage. Attend the occupants that are injured or show symptoms of shock. Call emergency 000 for assistance if required. If electrical or gas services have been inundated do not turn these appliances on until they have been checked by a qualified electrician or gas fitter.

Following the flood event, the Site management should liaise with stores' staff to understand the consequence of the flood event, including where repairs are required. This plan should then be reviewed and updated, if necessary, with any lesson learned. Damages to building, car park or other assets will be dealt with following the flood and they are not the focus of this plan.

12. Overview of Compliance

The proposed development has been assessed in regard to flooding and Council's flood planning controls. Table 6 presents the Development Control Plan controls and our assessment of each for the development.

Relevant Control	GRC Hydro Assessment
Development must comply with Council's – Flood Management Policy which provides guidelines of controlling developments in different flood risk areas. It should be read in conjunction with the NSW Government's 'Floodplain Development Manual 2005'.	The development complies with Council's policy and also with the NSW government's Floodplain Development Manual. The Manual describes how flood-affected areas can be safely developed, by ensuring the development is protected against flooding, and that it does not result in adverse flooding. These are the subject of the remaining controls in this table.
The filling of land up to the 1:100 Average Recurrence Interval (ARI) flood level (or flood storage area if determined) is not permitted, unless specifically directed by Council in very special and limited locations. Filling of land above the 1:100 ARI up to the Probable Maximum Flood (PMF) (or in flood fringe) is discouraged however it will be considered providing it does not adversely impact upon flood behaviour.	The existing Site is fully developed but has small areas of land below the 1:100 ARI flood level. These are not significant flow paths but rather they are low areas where runoff accumulates during a flood. Some low areas will be filled by the proposed development so as to prevent this accumulation from occurring and reduce the flood risk. To ensure there is no significant loss of flood storage, flood impact assessment has been carried out that shows there are no adverse impacts on other properties, as a result of the development.
Development should not adversely increase the potential flood affectation on other development or properties, either individually or in combination with the cumulative impact of similar developments likely to occur within the same catchment.	The Site is located in an urban area with many nearby properties. Impact assessment shows that by upgrading stormwater drainage and inclusion of a swale, there is no adverse impact on properties' flood affectation. The area does not have potential for cumulative impacts due to such development as the catchment is already fully developed.
The impact of flooding and flood liability is to be managed, to ensure the development does not divert the flood waters, nor interfere with flood water storage or the natural functions of waterways. It must not adversely impact upon flood behaviour.	As described, a number of design features, including upgraded stormwater drainage and a swale, have been incorporated into the development, so as to ensure no diversion of flood waters or interference with flood storage. There are no adverse impacts resulting from the development. These conclusions are demonstrated by the modelling carried out.
A flood refuge may be required to provide an area for occupants to escape to for developments where occupants require a higher standard of care. Flood refuges may also be required where there is a large difference between the PMF and the 1 in 100-year flood level that may place occupants at severe risk if they remain within the building during large flood events.	There is not a large difference between the PMF and the 1 in 100-year flood level at the Site, with around 0.3-0.6 m difference. The new development will be protected from flooding and will allow any occupants to take refuge during a flood.

Table 6: DCP Controls

In summary then:

- GRC Hydro have done extensive work on flood modelling at the Site;
- Council have provided a TUFLOW model which is suitable for Site analysis;
- The Site is flood liable albeit to overland flows or what would tend to be called stormwater;
- Council stormwater assets on the Site currently lie under buildings – the re-development is an opportunity to put such assets in locations where they can be accessed should maintenance be required;
- Site's flood liability is very much affected by a re-distribution of flow that resulted from a 2010 development approved at the corner of Sarsfield Circuit and Bexley Road;
- Flood liability of the Site means that compliance with DCP controls is required to be achieved by any development;
- Compliance with risk management requirements (appropriate floor levels, building materials etc.) is straightforward;
- Compliance with impact consent conditions required the following mitigation measures:
    - Swale on the Eastern side of the development; and
    - Pipe diversion on Slade Road; and
    - Pipe upgrade across Slade Road.
- Flood risk can be effectively managed by an evacuation in place response which is the more "natural" or default response in any case.

In Conclusion, the proposed development is a better outcome than the existing as the Site in now protected from flooding. Moreover, the public accessible areas may provide safe refuge to those who are captured by floodwater around the Site.

This report demonstrates that the Site is capable to compliance with Council's requirements: management issues will be discussed as a part of a future Development Application.

Yours Sincerely,

Steve Gray
Director

Email: gray@grchydro.com.au
Tel: +61 413 631 447

APPENDIX

FIGURE 01
189 SLADE ROAD BEXLEY NORTH
PROPOSED CASE SCENARIO
Cadastral boundaries
Proposed Building
Graded Area
6m Wide
Proposed Lane
Existing Stormwater Network
Proposed Stormwater Pipes
Proposed Swale
Car Ramp Crossing
N
grc
HYDRO
0
50
metres

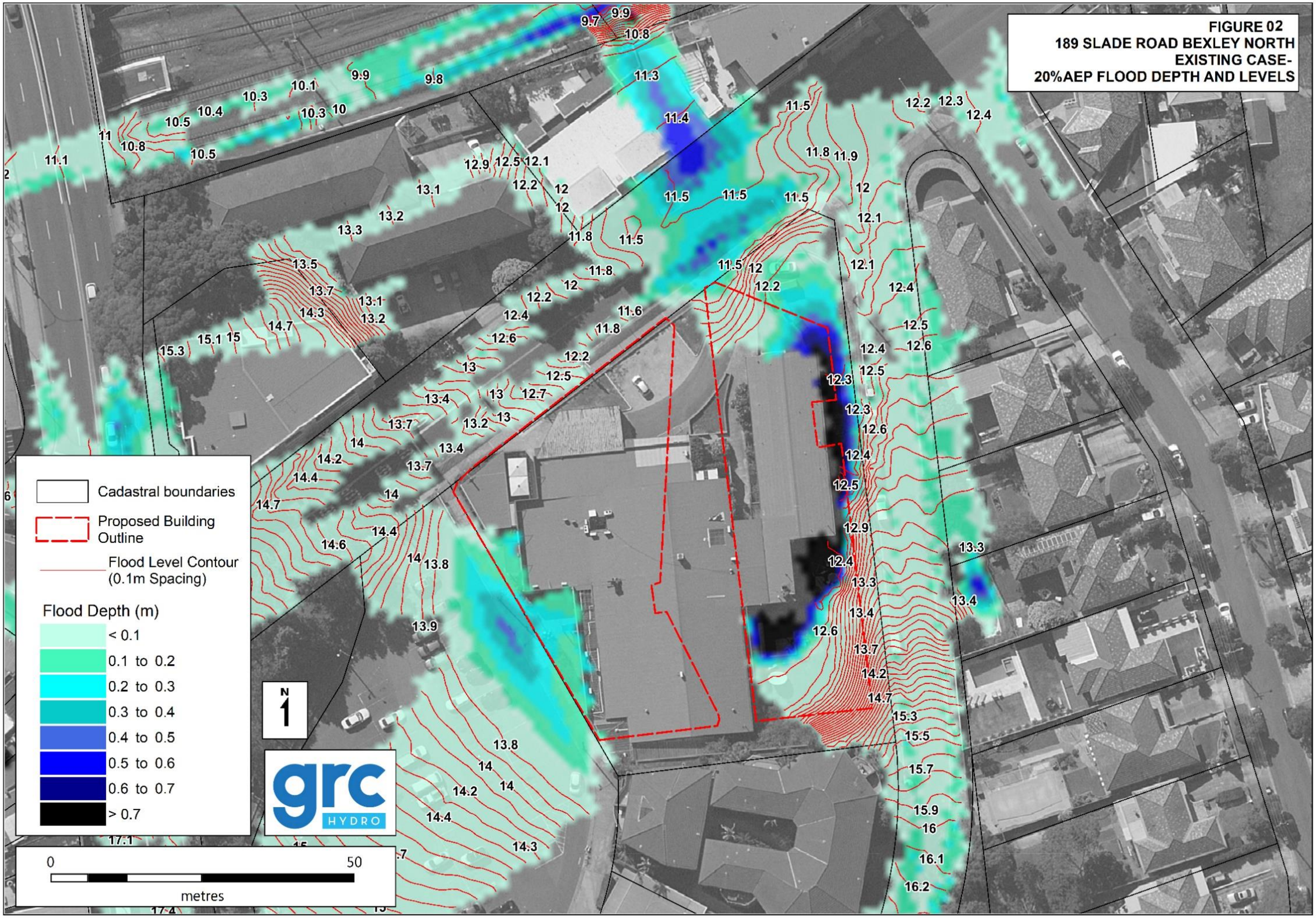


FIGURE 02
189 SLADE ROAD BEXLEY NORTH
EXISTING CASE-
20%AEP FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building Outline
Flood Level Contour (0.1m Spacing)
Flood Depth (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
> 0.7
N
0
50
metres
grc
HYDRO

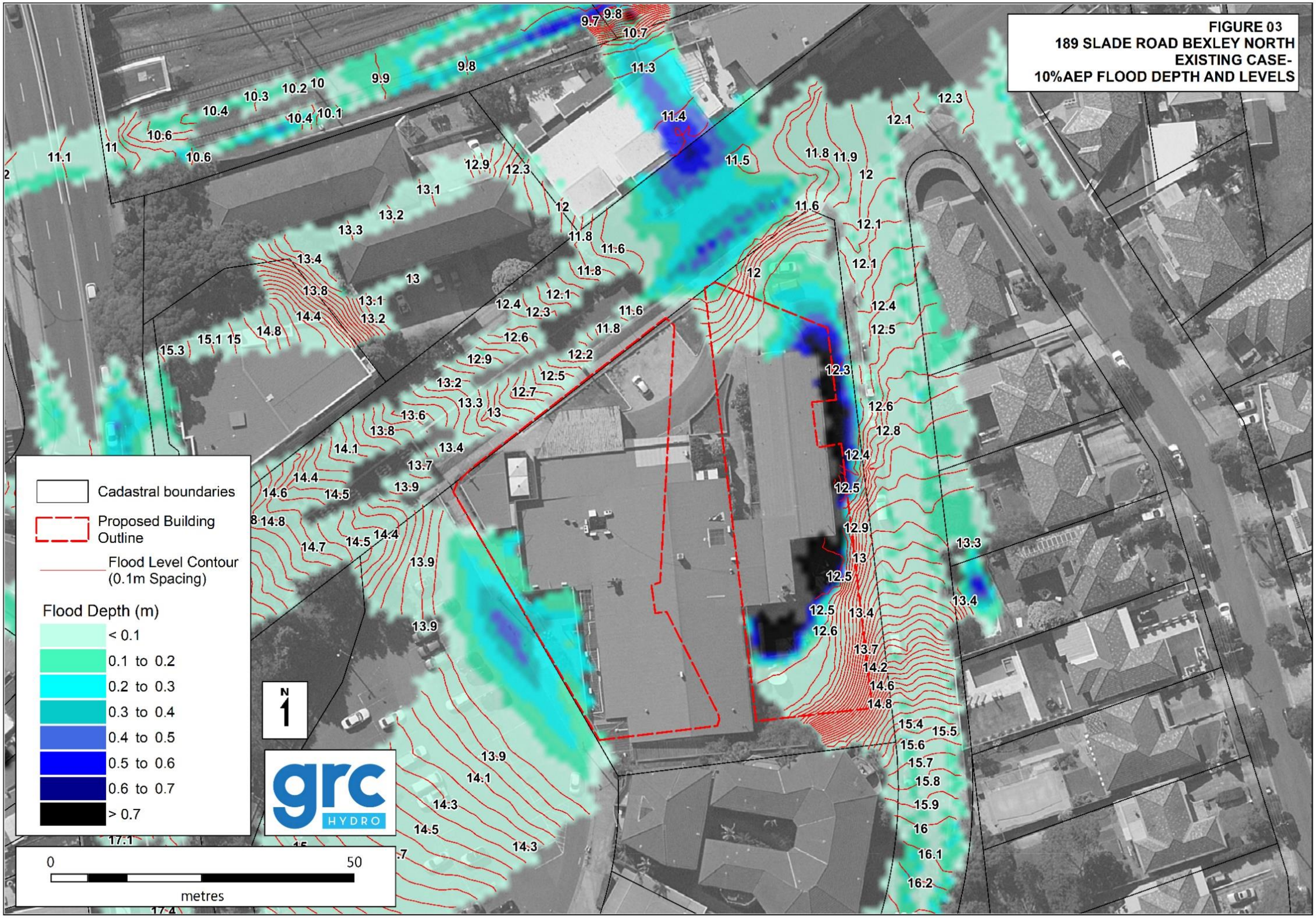


FIGURE 03
189 SLADE ROAD BEXLEY NORTH
EXISTING CASE-
10%AEP FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building Outline
Flood Level Contour (0.1m Spacing)
Flood Depth (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
> 0.7
N
0
50
metres
grc
HYDRO

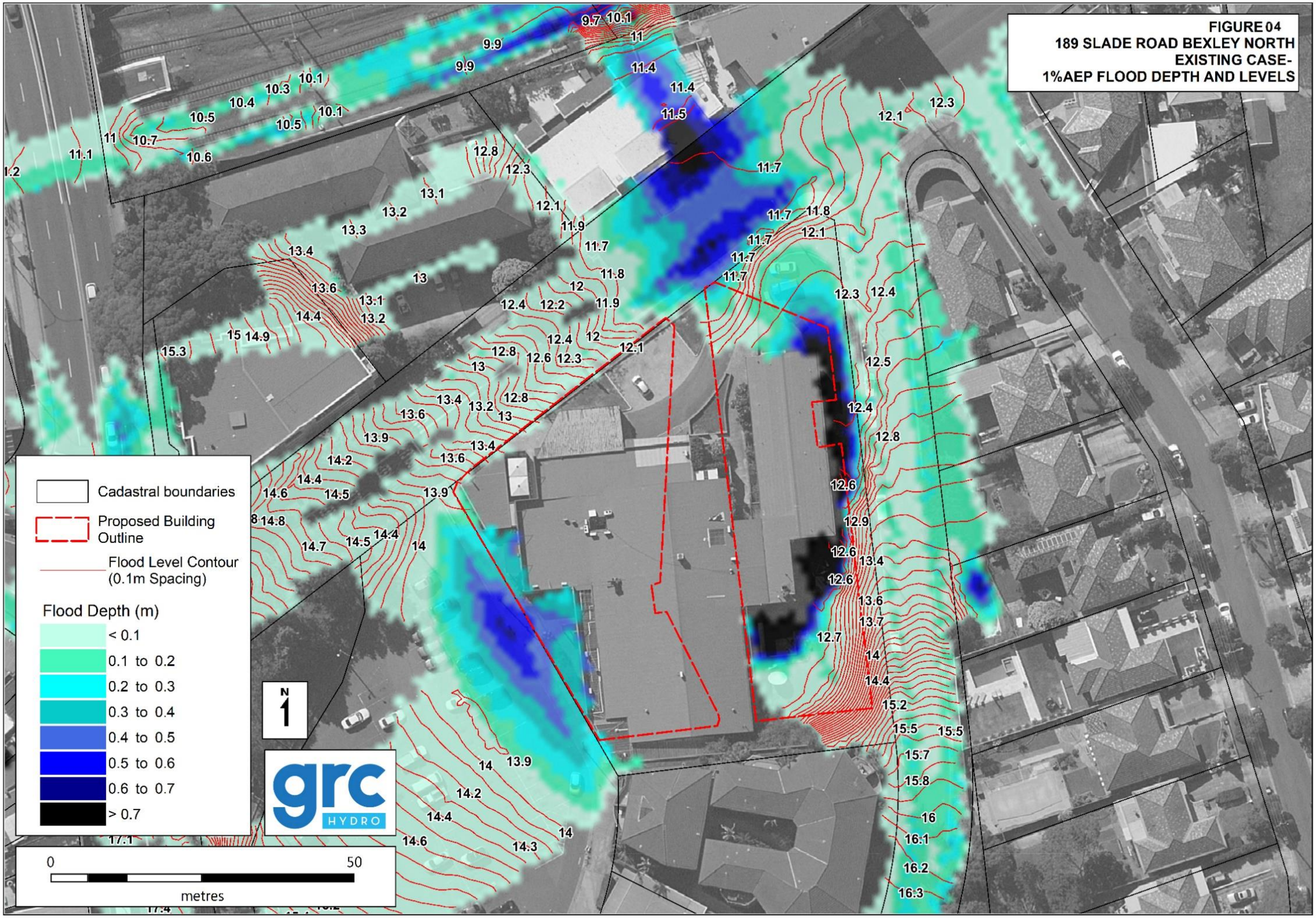


FIGURE 04
189 SLADE ROAD BEXLEY NORTH
EXISTING CASE-
1%AEP FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building Outline
Flood Level Contour (0.1m Spacing)
Flood Depth (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
> 0.7
N
grc
HYDRO
0
50
metres

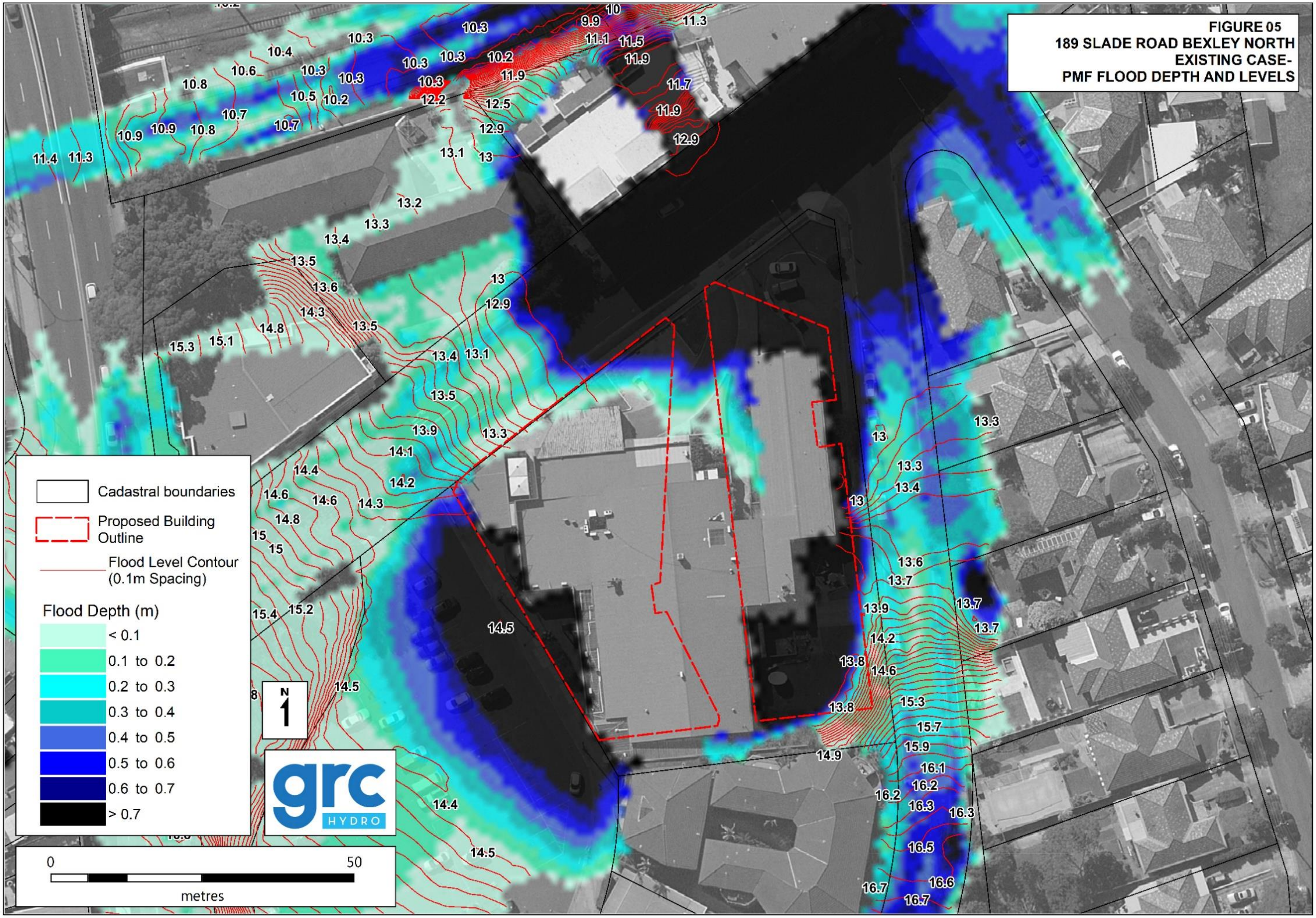


FIGURE 05
189 SLADE ROAD BEXLEY NORTH
EXISTING CASE-
PMF FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building Outline
Flood Level Contour (0.1m Spacing)
Flood Depth (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
> 0.7
N
0
50
metres
grc
HYDRO

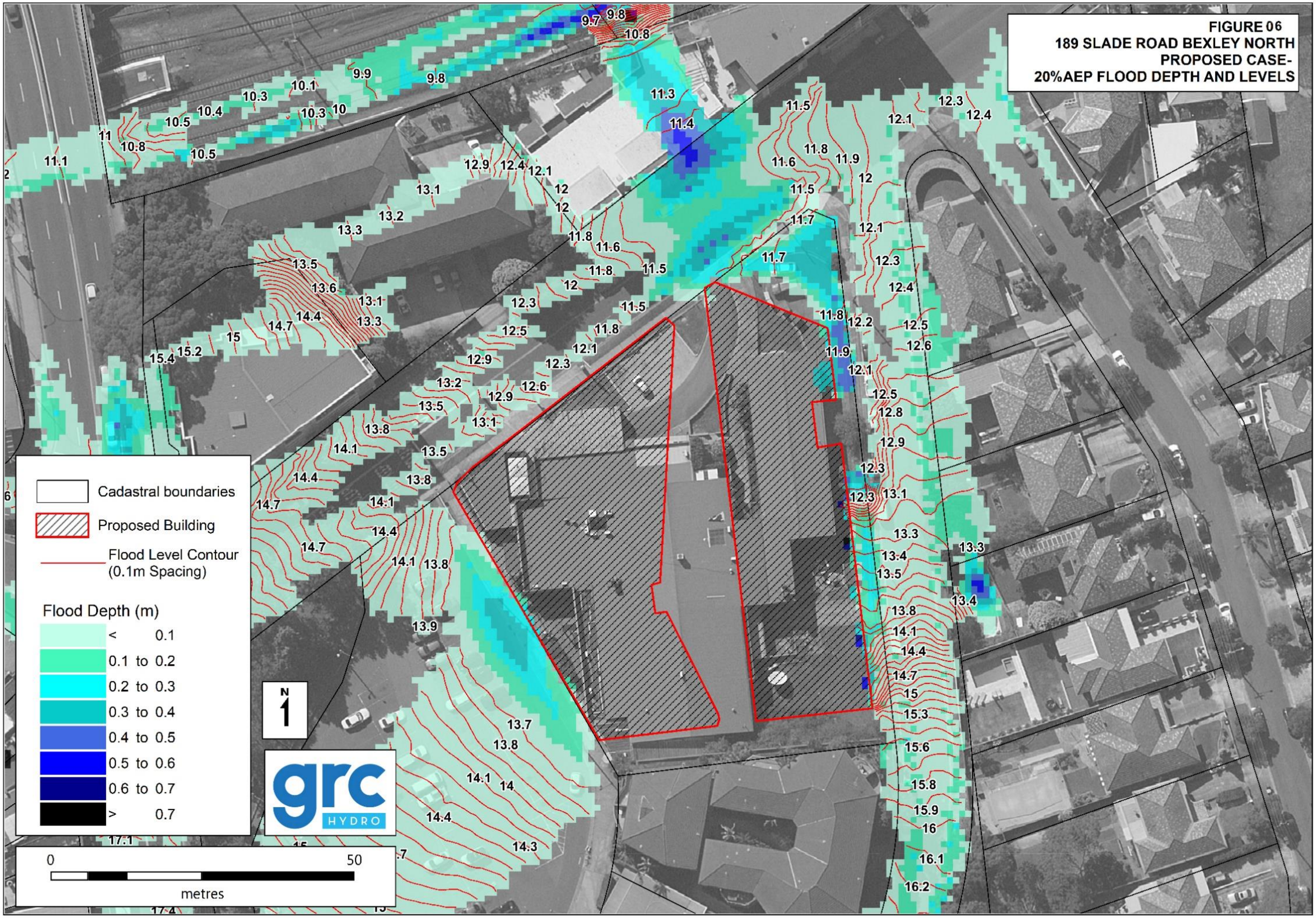


FIGURE 06
189 SLADE ROAD BEXLEY NORTH
PROPOSED CASE-
20%AEP FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building
Flood Level Contour (0.1m Spacing)
Flood Depth (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
> 0.7
N
grc
HYDRO
0
50
metres

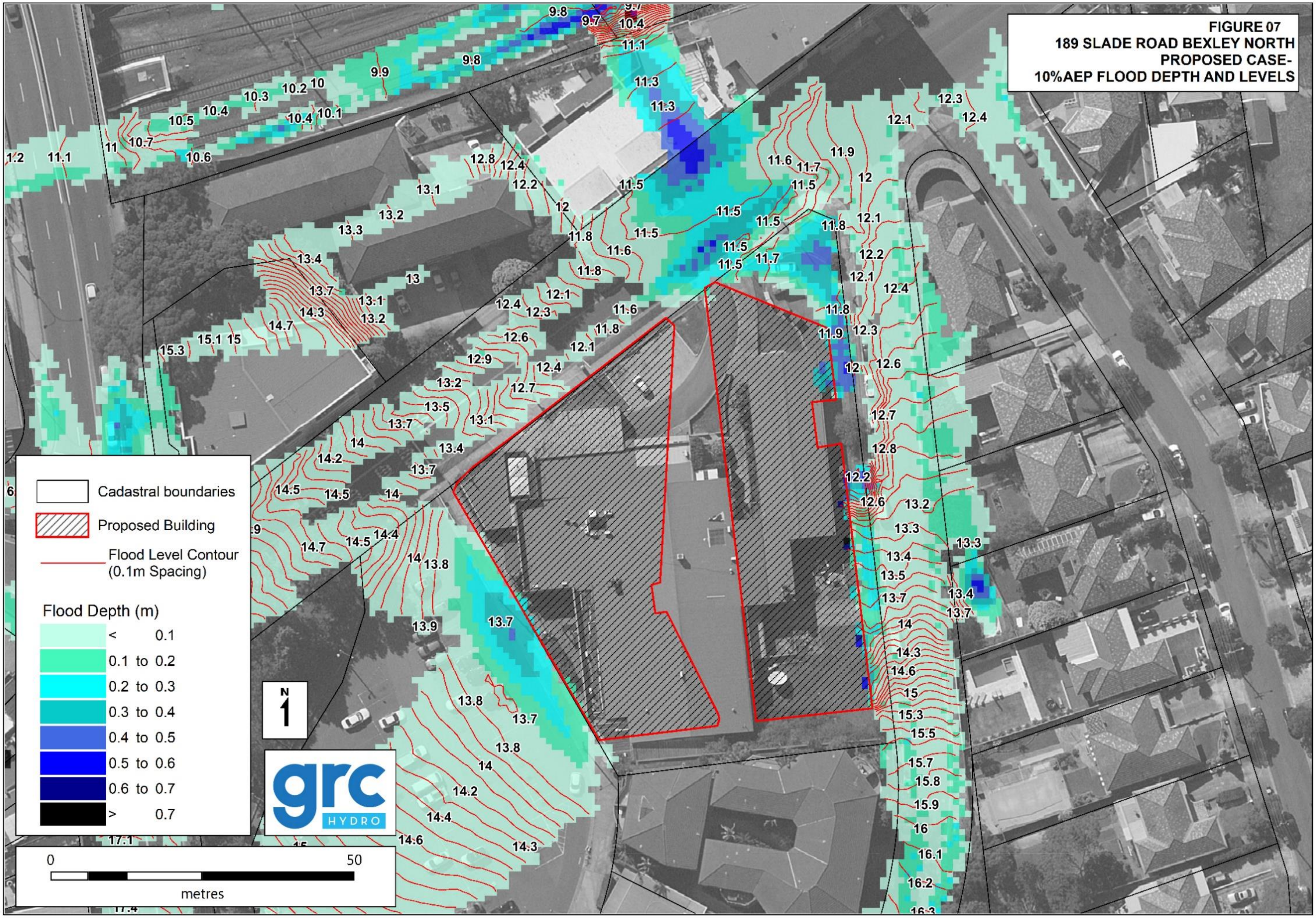


FIGURE 07
189 SLADE ROAD BEXLEY NORTH
PROPOSED CASE-
10%AEP FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building
Flood Level Contour
(0.1m Spacing)
Flood Depth (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
> 0.7
N
grc
HYDRO
0
50
metres

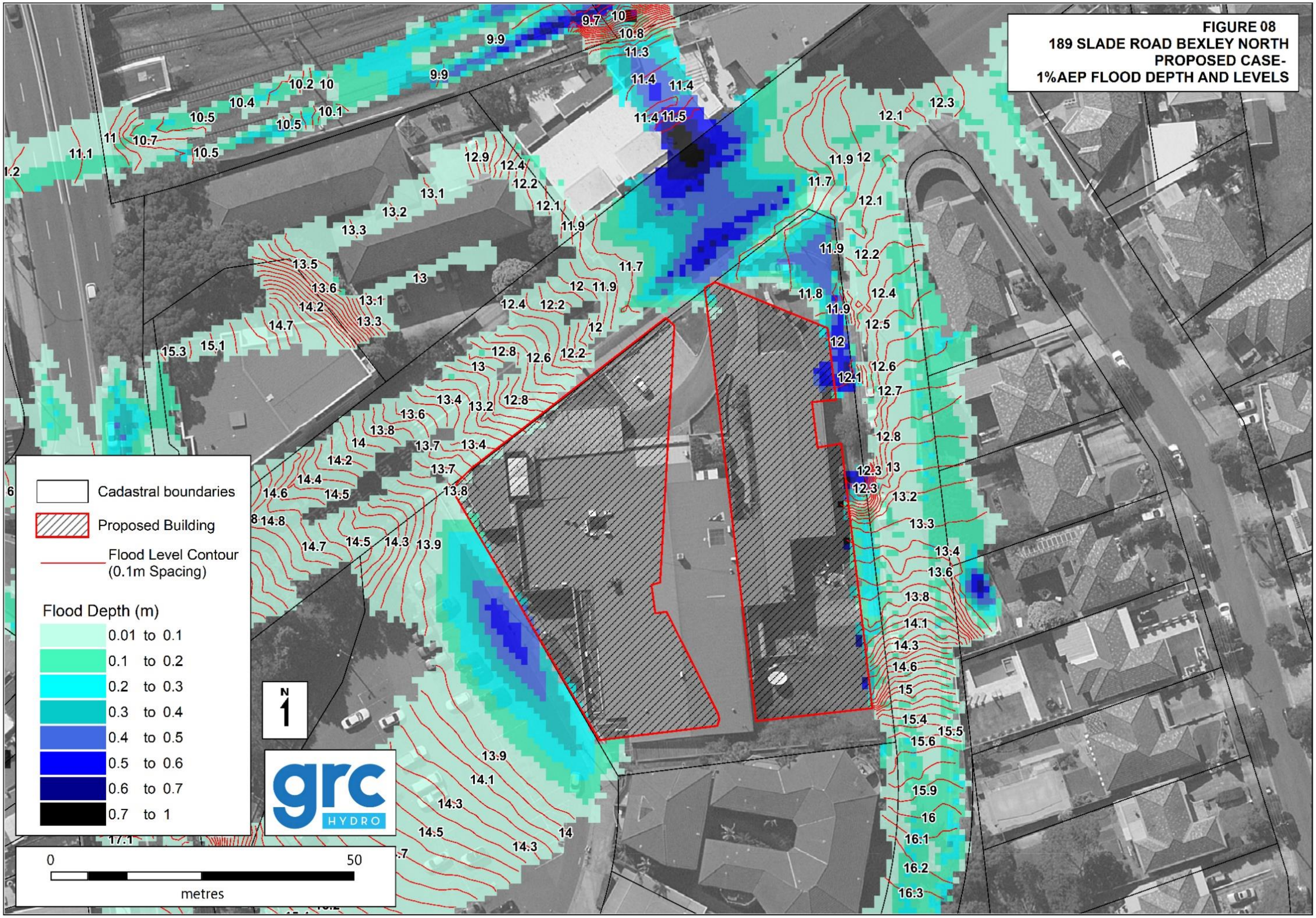


FIGURE 08
189 SLADE ROAD BEXLEY NORTH
PROPOSED CASE-
1%AEP FLOOD DEPTH AND LEVELS
Cadastral boundaries
Proposed Building
Flood Level Contour (0.1m Spacing)
Flood Depth (m)
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
0.4 to 0.5
0.5 to 0.6
0.6 to 0.7
0.7 to 1
N
grc HYDRO
0
50
metres

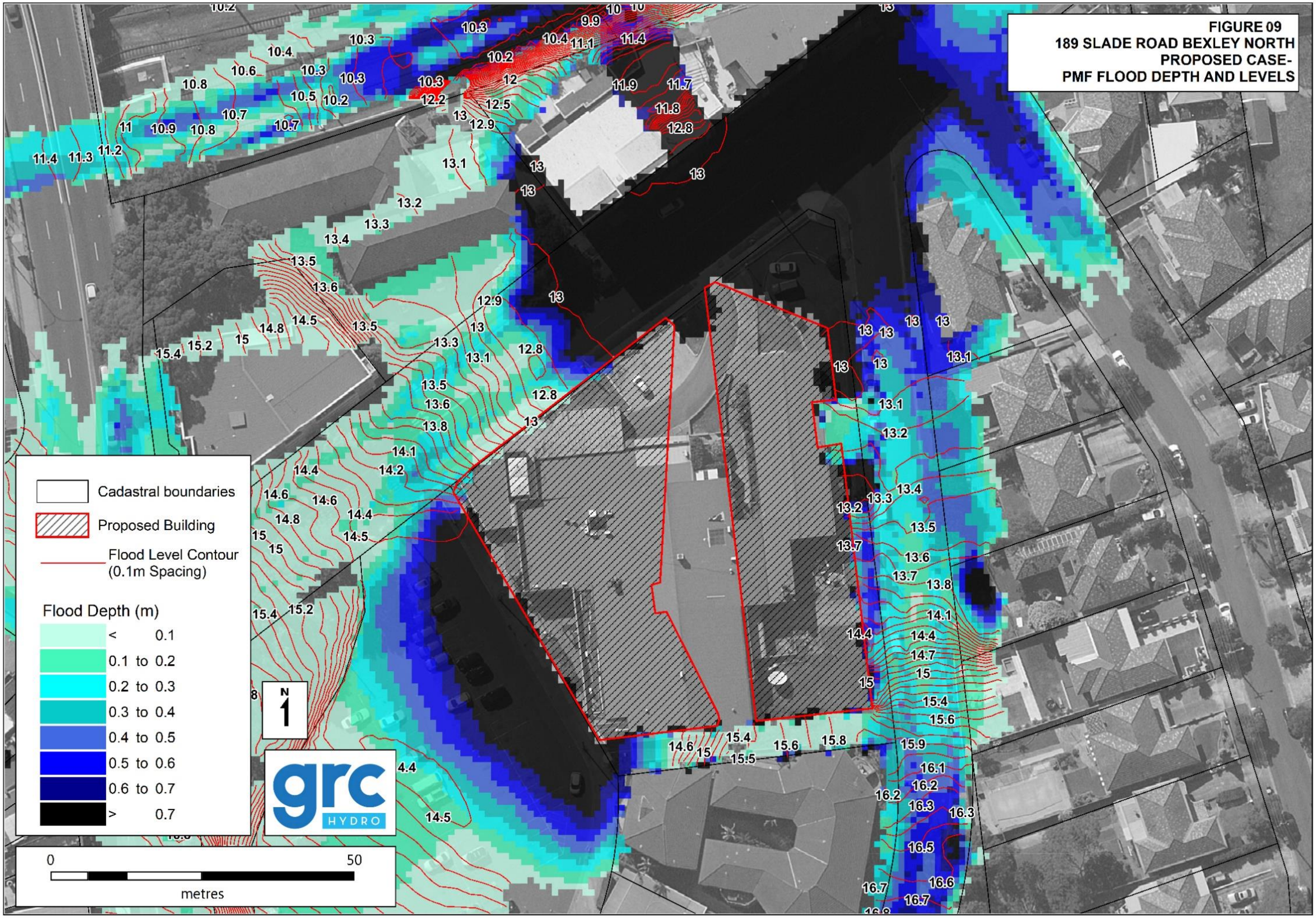


FIGURE 09
189 SLADE ROAD BEXLEY NORTH
PROPOSED CASE-
PMF FLOOD DEPTH AND LEVELS

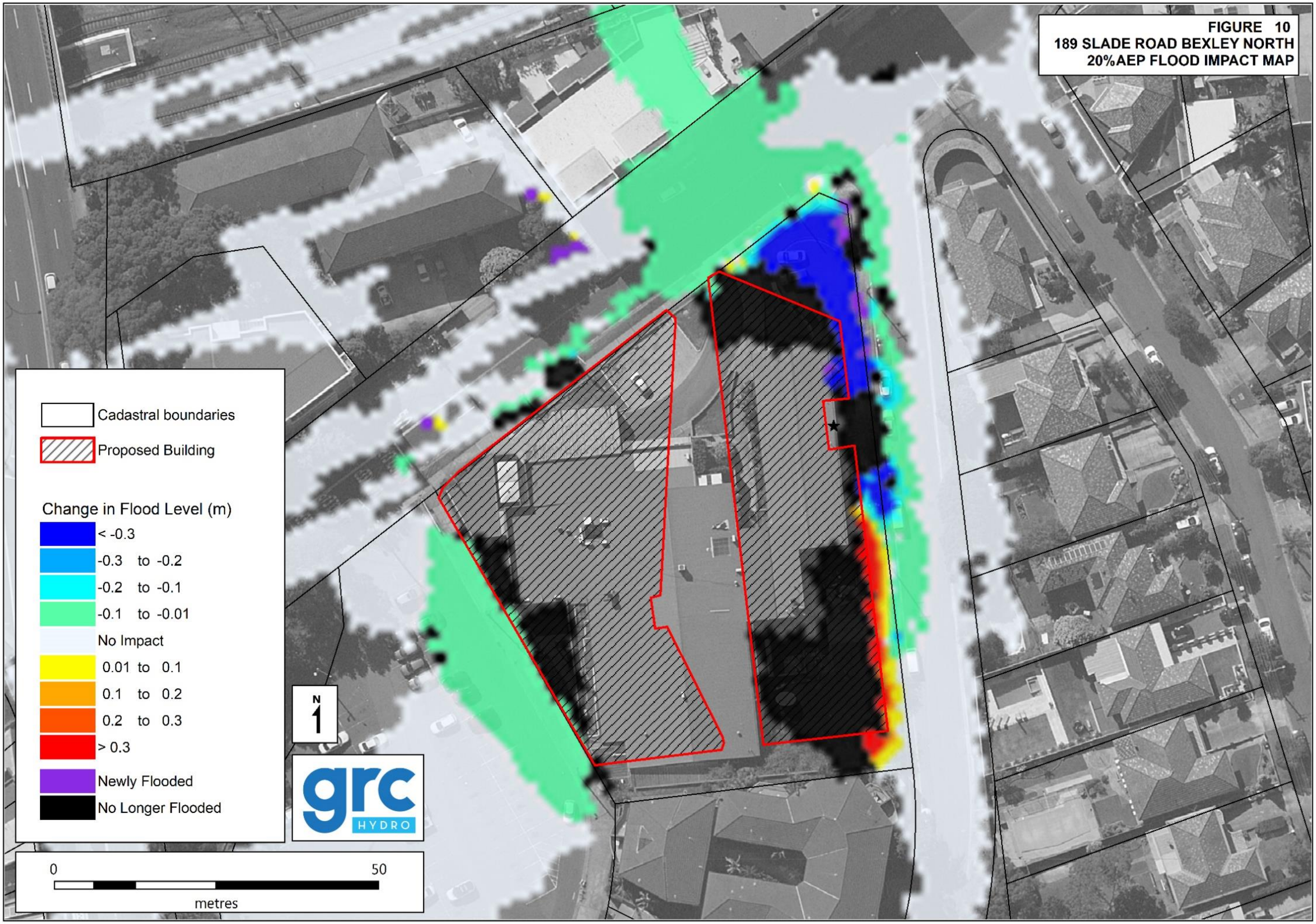


FIGURE 10
189 SLADE ROAD BEXLEY NORTH
20%AEP FLOOD IMPACT MAP
Cadastral boundaries
Proposed Building
Change in Flood Level (m)
< -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.01
No Impact
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
> 0.3
Newly Flooded
No Longer Flooded
N
grc HYDRO
0
50
metres

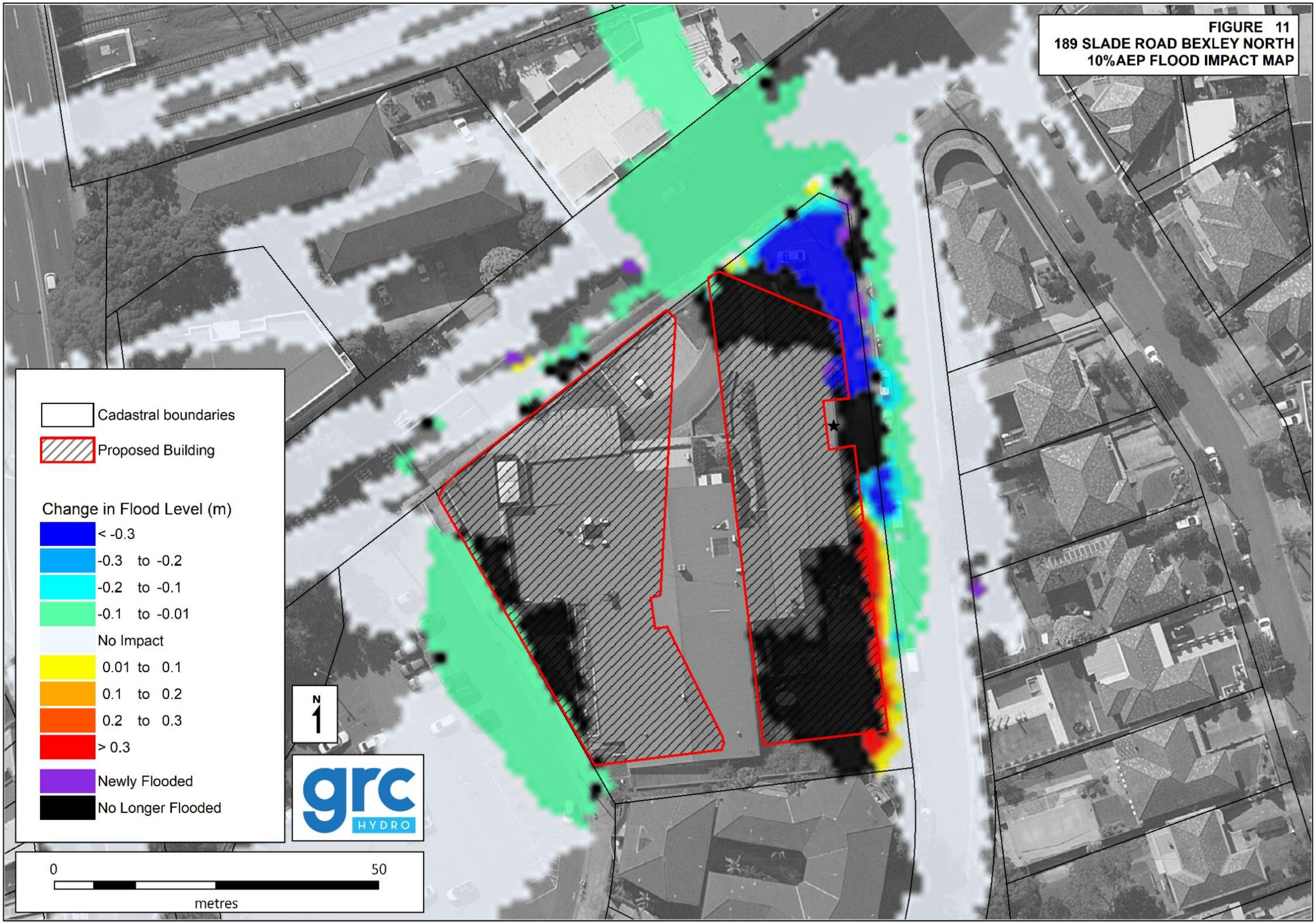


FIGURE 11
189 SLADE ROAD BEXLEY NORTH
10%AEP FLOOD IMPACT MAP
Cadastral boundaries
Proposed Building
Change in Flood Level (m)
< -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.01
No Impact
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
> 0.3
Newly Flooded
No Longer Flooded
N
grc
HYDRO
0
50
metres

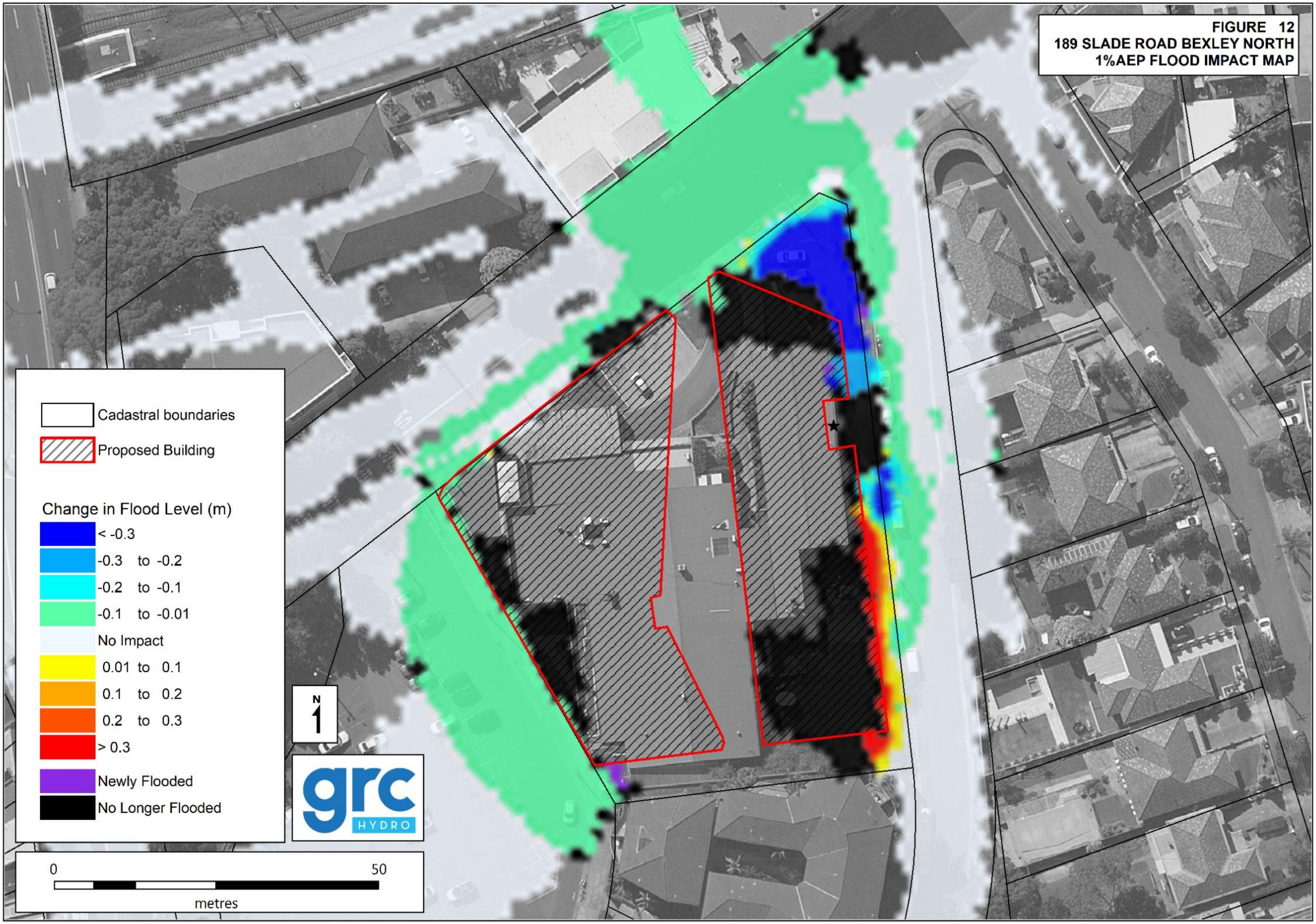
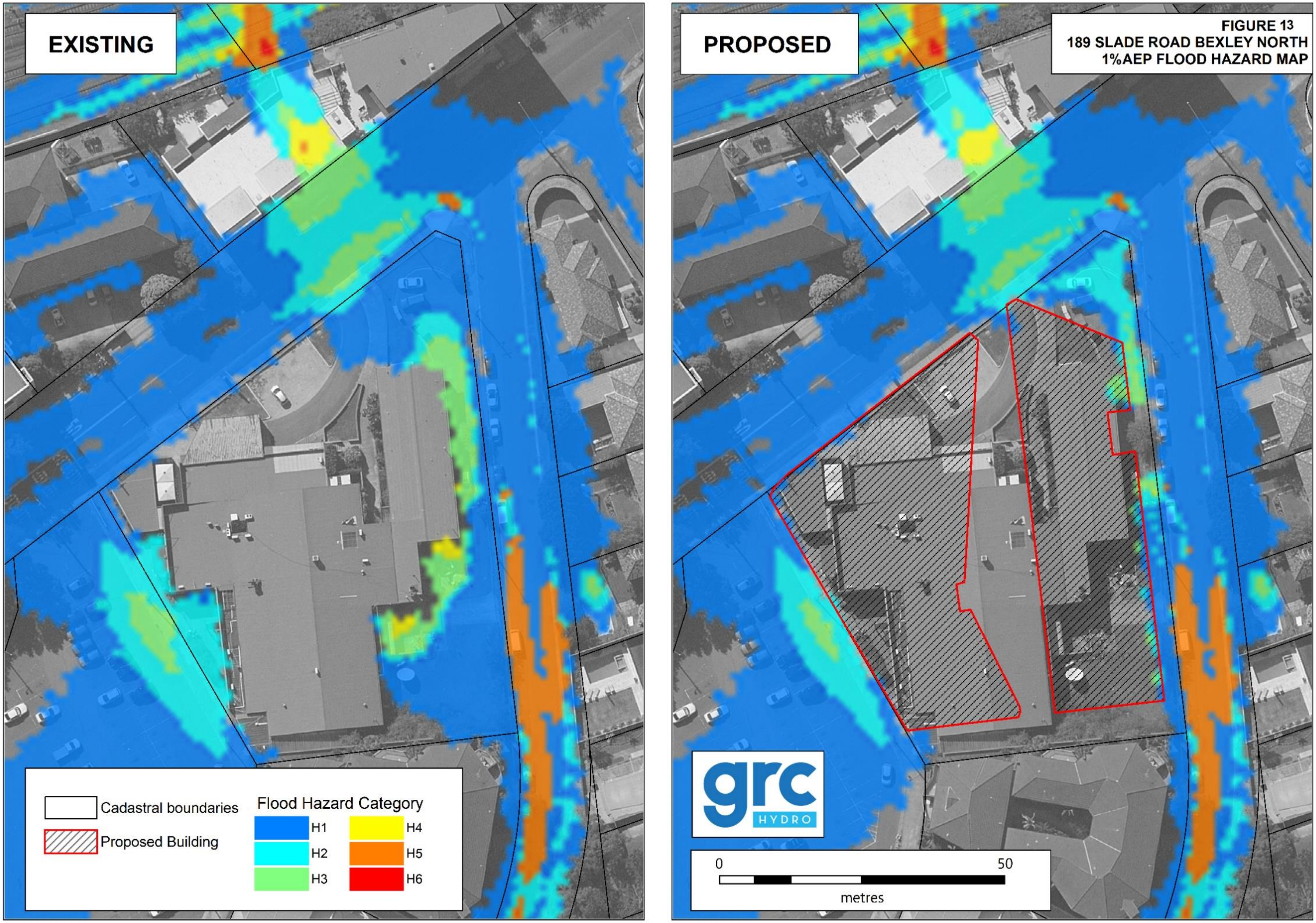
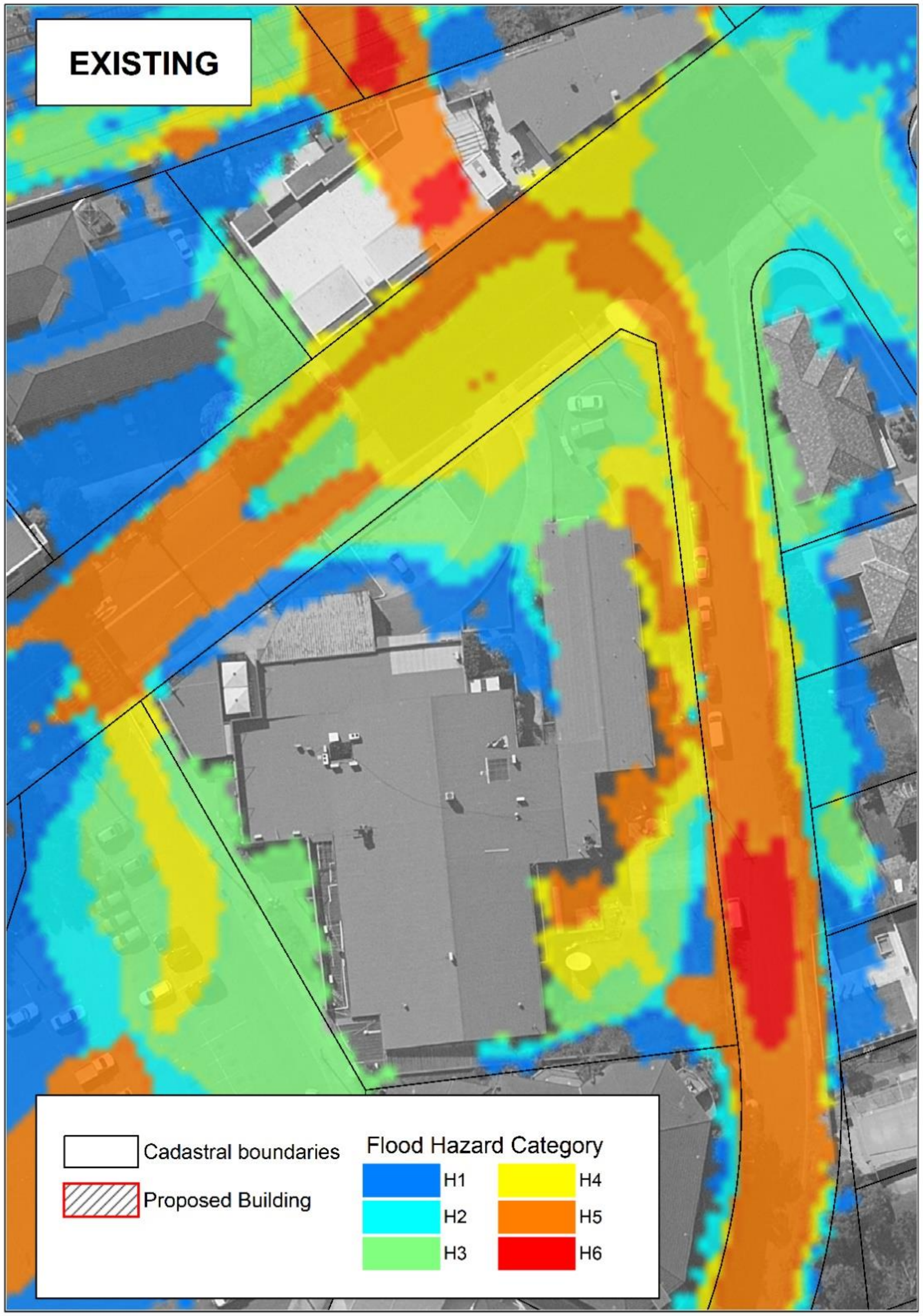
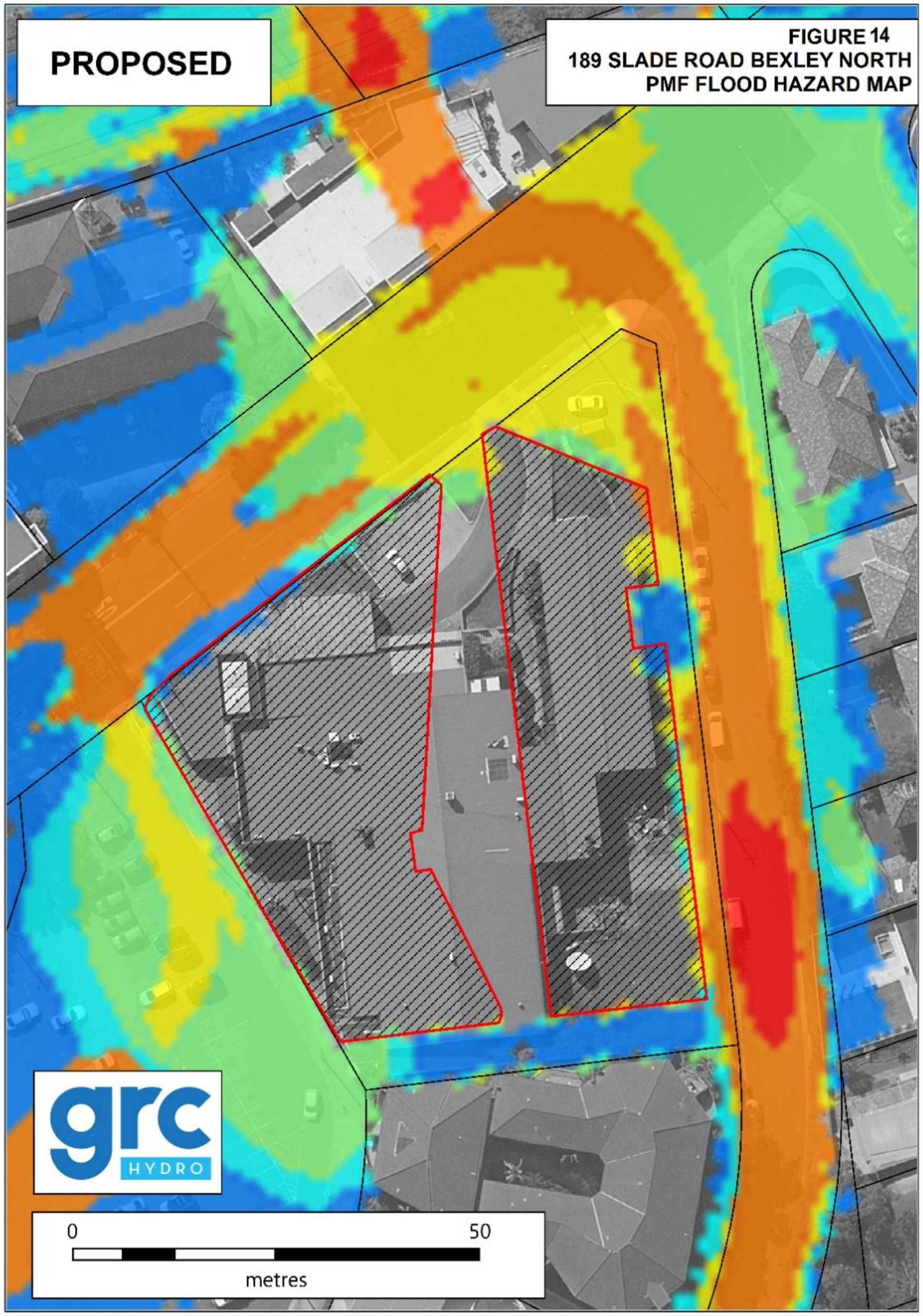


FIGURE 12
189 SLADE ROAD BEXLEY NORTH
1%AEP FLOOD IMPACT MAP
Cadastral boundaries
Proposed Building
Change in Flood Level (m)
< -0.3
-0.3 to -0.2
-0.2 to -0.1
-0.1 to -0.01
No Impact
0.01 to 0.1
0.1 to 0.2
0.2 to 0.3
> 0.3
Newly Flooded
No Longer Flooded
N
grc HYDRO
0
50
metres


EXISTING
PROPOSED
FIGURE 13
189 SLADE ROAD BEXLEY NORTH
1%AEP FLOOD HAZARD MAP
Cadastral boundaries
Proposed Building
Flood Hazard Category
H1
H2
H3
H4
H5
H6
grc
HYDRO
0
50
metres


EXISTING
Cadastral boundaries
Proposed Building
Flood Hazard Category
H1
H2
H3
H4
H5
H6


PROPOSED
FIGURE 14
189 SLADE ROAD BEXLEY NORTH
PMF FLOOD HAZARD MAP
grc
HYDRO
0
50
metres

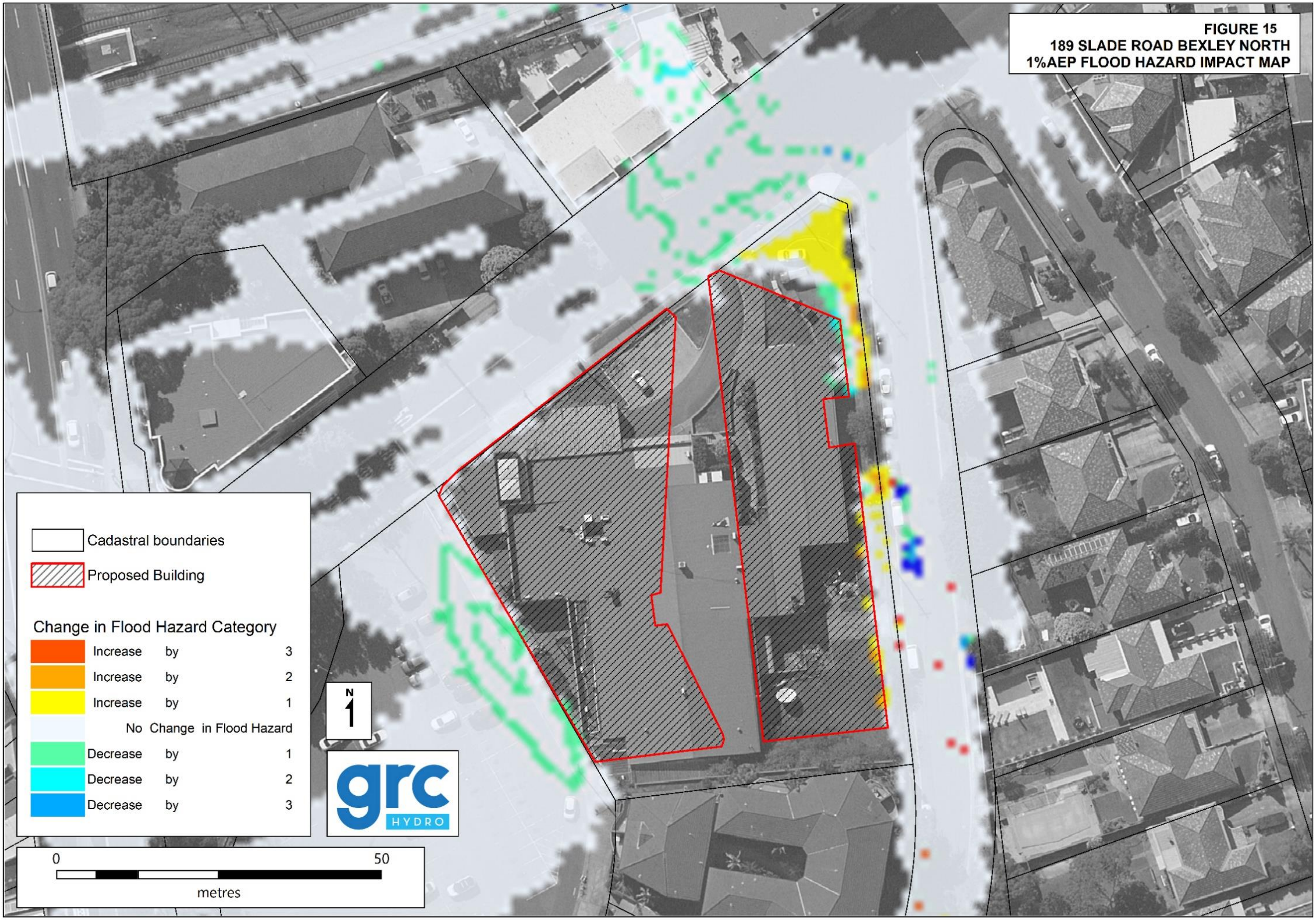


FIGURE 15
189 SLADE ROAD BEXLEY NORTH
1%AEP FLOOD HAZARD IMPACT MAP
Cadastral boundaries
Proposed Building
Change in Flood Hazard Category
Increase by 3
Increase by 2
Increase by 1
No Change in Flood Hazard
Decrease by 1
Decrease by 2
Decrease by 3
N
grc HYDRO
0
50
metres


FIGURE 16
189 SLADE ROAD BEXLEY NORTH
PMF FLOOD HAZARD IMPACT MAP
Cadastral boundaries
Proposed Building
Change in Flood Hazard Category
Increase by 3
Increase by 2
Increase by 1
No Change in Flood Hazard
Decrease by 1
Decrease by 2
Decrease by 3
N
0
50
metres
grc
HYDRO