Stellen
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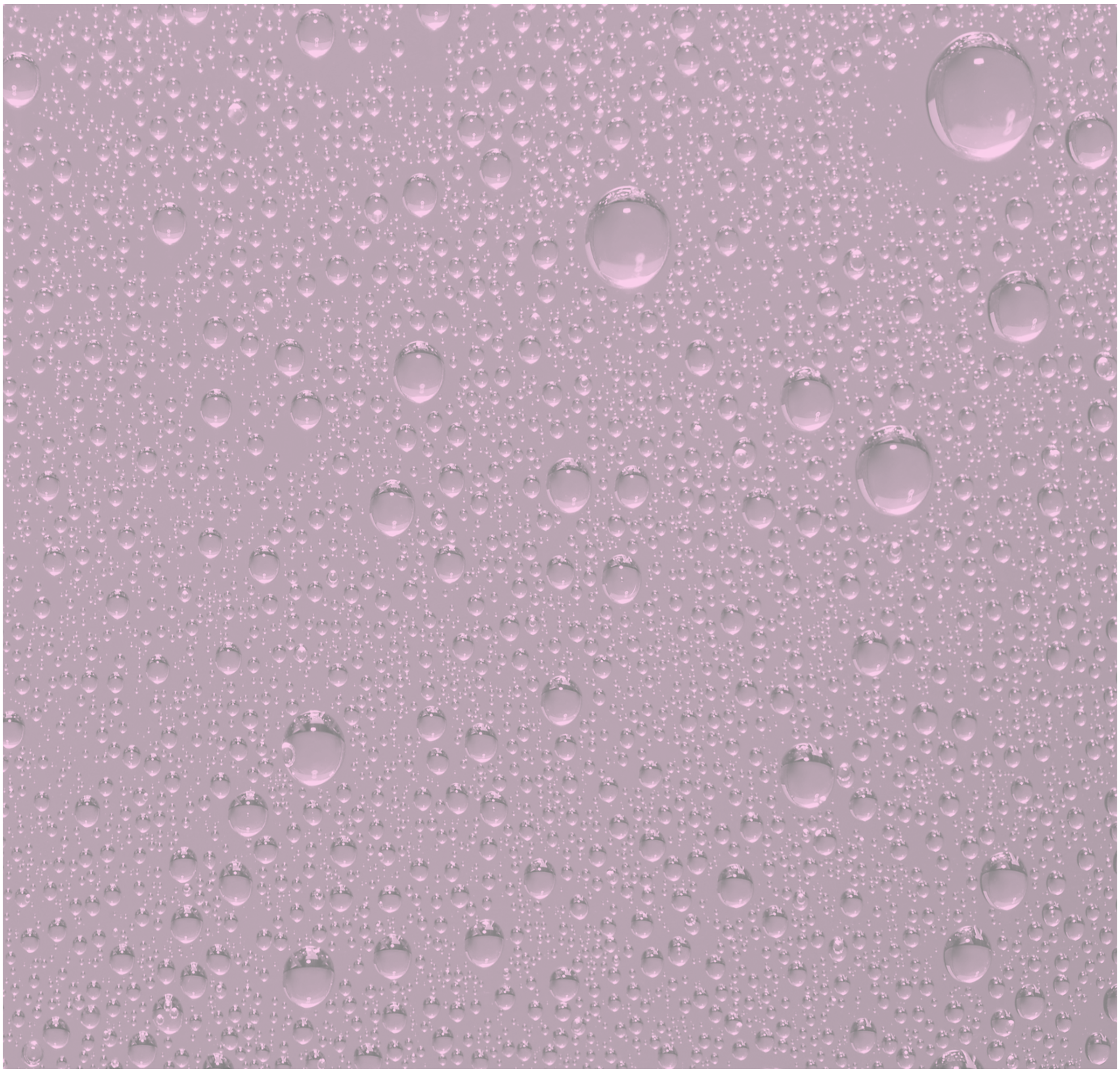
Stellen Consulting
Level 1, 27 Belgrave Street
Manly NSW 2095

PO Box 151
Freshwater NSW 2096

+61 450 460 496 tel
ABN 61 149 095 189

Overland Flow Assessment Report

Proposed Development at 63-71 Waterloo Rd, Macquarie Park



Overland Flow Assessment

Proposed development at 63-71 Waterloo Rd, Macquarie Park

Prepared for our clients:

UT 65 Pty Ltd
c/o Alton Property Group
Level 3, 9 Barrack Street
Sydney, NSW 2000

Prepared by:

Stellen Consulting

Level 1, 27 Belgrave Street, Manly, NSW 2095, PO Box 151 Freshwater PO, NSW 2096

T. +61 450 460 496

www.stellenconsulting.com.au

ABN 61 149 095 189

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Prepared by Mohamud Ibrahim

Reviewed by Logan English-Smith

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Revision	Date	Details	Authorised	
			Name/Position	Signature
0	06.05.2021	DA Submission	Logan English-Smith Senior Engineer	
1	01.07.2021	DA Submission	Logan English-Smith Senior Engineer	
2	29.10.2021	s34 Submission	Logan English-Smith Operations Manager	
3	06.12.2021	Council RFI	Logan English-Smith Operations Manager	

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Executive Summary

Stellen Consulting was engaged to assess the proposed development at 63-71 Waterloo Rd, Macquarie Park in reference to potential impacts arising from overland flow through the site. This report provides a detailed assessment of the flow information specific to the site and the proposed development.

A combined 1D/2D HEC-RAS model was established for pre and post-development conditions based on available survey/elevation data and architectural drawings to assess the predicted flow depths and velocities during the 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events.

Based on the evaluations of the proposed design using available flood information and the HECRAS flood model results, the:

- Subject site is affected by flooding during the 5% AEP event and larger.
- Overall, given the introduction of the road across the overland flow path, and the significant offsetting effects of the additional flood storage, the net impacts of the development to the existing flood regime are reasonable.
- The model predicts there will be a decrease in flood depths of up to 16mm downstream of the site and an increase of up to 29mm at a location in the swale along the north-eastern boundary of the site (an area already affected by overland flow) in the design scenario (20% blockage).
- Provisional hazard classifications for adjacent properties are largely unchanged outside the proposed development up to and including the design scenario.
- Design has the proposed lower ground floor level above the relevant FPL.
- Creation of a road with fully blocked culverts (as agreed with the council) has not increased the flooding of critical areas such as habitable floor levels and basement of the proposed development. The proposed development is protected from flooding in the event of full blockage of the proposed culverts (4 off 4.2m x 0.75m).
- Recommended emergency response is to shelter-in-place. Safe shelter is available in all levels above lower ground floor level.

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Contents

1.0 Introduction

Stellen Consulting was engaged to assess the proposed development at 63-71 Waterloo Rd, Macquarie Park in reference to potential impacts arising from overland flow.

Council flood modelling for the catchment notes the site as affected by overland flow during large storm events. Therefore, an assessment of the general flooding constraints and requirements is required for the site.

This report provides detailed assessment of the flow information specific to the site and assesses the proposed development in accordance with the relevant requirements of the City of Ryde Development Control Plan 2014.

2.0 Information Relied Upon

The following documentation has been used in the preparation of this overland flow assessment report:

- Architectural drawings by Aplus Design Group, dated 29/10/2021.
- Survey by LTS Registered Surveyors (REF: 50352 001DT)
- Macquarie Park Floodplain Risk Management Study & Plan (April 2010) by Bewsher Consulting
- Overland Flow Assessment Report for proposed development at 45-61 Waterloo Road, Macquarie Park (Revision 5 dated 18.10.2019)
- TUFLOW results files by Bewsher Consulting (provided by City of Ryde)
- Approved Master Plan for 45-61 Waterloo Road by Turner (drawing list in NOD LDA2018/0172)
- DA civil design plans for 45-61 Waterloo Road by AECOM
- DRAINS model outputs by AECOM (REF: 211011 60651031 MacSquare ARR19 1% AEP)

3.0 Site Description

The subject site, known as 63-71 Waterloo Rd, Macquarie Park (DP 1043041), is approximately 1.839ha in area and generally falls away from Waterloo Road with the low-lying land along the north-east boundary forming an existing overland flow path.

Currently, there are two commercial buildings on site. Figure 1 displays the subject site (red boundary) and location plan. The proposed works are shown in the architectural drawings prepared by Aplus Design Group (refer to s2.0 above).

Figure 1 - Site locality and previous development (SIX Maps)

4.0 Overland Flow

4.1 General

The Macquarie Park Floodplain Risk Management Study & Plan predicts that during large storm events the site is affected by local runoff as a result of an existing overland flow path through the site along the north-eastern boundary (refer to Figure 2). The overland flow path runs north through adjoining properties from upstream of Waterloo Road, through the site and ultimately into the Lane Cove River. To support the development of the site, an assessment of the general flooding constraints and requirements is required.

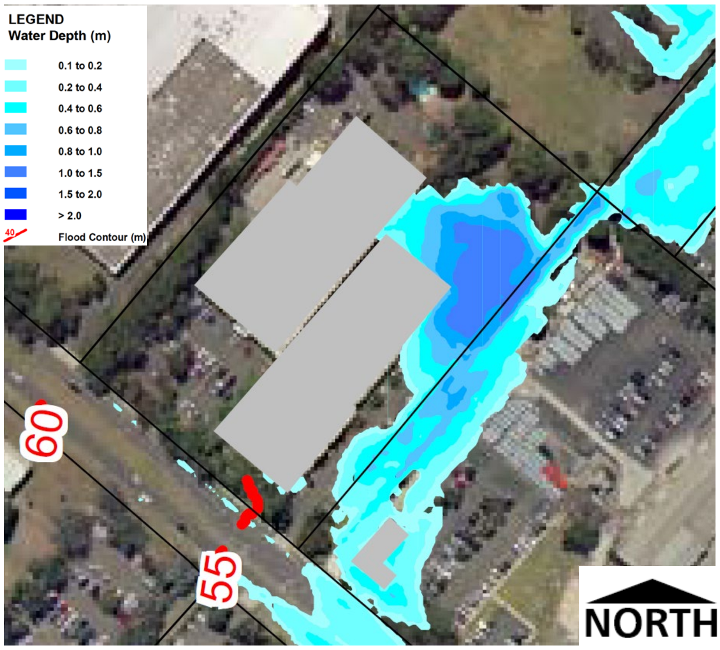

Figure 2 - 1% AEP predevelopment flood depths (Figure 8.4 in Macquarie Park Floodplain Risk Management Study & Plan, 2010)

4.2 Previous Flood Modelling

Bewsher Consulting P/L completed the "Macquarie Park Floodplain Risk Management Study & Plan" for the City of Ryde. Details of these investigations were presented in a "Flood Study Report" in April 2010.

This report identified and modelled stormwater flows within the Macquarie Park catchment for a range of storm events and was correlated to actual significant storm events during November 1984 and March 1990 to ensure that the results were representative of actual flood conditions.

Additionally, a site-specific preliminary flood report was prepared in May 2020 by Calibre Professional Services Pty Ltd (ref 18-001048). The purpose of this assessment was to determine the impact of flood waters on proposed development of the site.

4.3 Overview of Approach

The following steps were taken to quantify the potential overland flow:

1. Define the catchment contributing flows for the site and determine the design flow rates.
2. Develop a predevelopment HEC RAS 2D model and calibrate against Council flood model.
3. Carry out preliminary sizing of the culverts using HY-8 and predevelopment flood model results.
4. Develop a combined 1D/2D HECRAS model for both pre-development and post-development scenarios.
5. Compare the post-development water surface levels, depths, velocities, and hazard classifications with the pre-developed base scenario, particularly for impacts on adjacent properties.

The following assumptions and requirements were made/used in the modelling:

- Storage of pipes within the site is conservatively ignored.
- A conservative scenario that includes the approved masterplan for the neighbouring site (45-61 Waterloo Road, Macquarie Park NSW) was used as a predevelopment base case to assess the impact of the development on the flood regime.
- A blockage factor of 20% was adopted as design factor (hereinafter referred to as design scenario) based on Table 10.4.1, s10.4 of Queensland Urban Drainage Manual and Chapter 6 (Blockage of Hydraulic Structures) of ARR2019 guidelines. Additionally, the likelihood and consequences of 0%, 50 and 100% blockage scenarios were considered to better understand and manage any flood risk in the event of partial and full blockage.
- The blockage was implemented by reducing the culvert's area by the estimated percentage blockage (BDES%) in accordance with general industry practice.

4.4 Estimation of the Contributing Flows

Bewsher Consulting completed the Macquarie Park Floodplain Risk Management Study & Plan for the City of Ryde in April 2010.

During a review of the available flood information, it was found that the predicted peak flow rate provided by City of Ryde differed significantly from the peak flow published within the Bewsher Report. The predicted 1% AEP peak flows for the site are shown below along with the calculation method.

Bewsher Report: 6.6 m^3/s (TUFLOW model)

City of Ryde: 9.98 m^3/s (DRAINS model)

The difference in predicted peak flows is a result of the method used for the calculation of each. The peak flow provided by City of Ryde comes from a DRAINS model and the peak flow predicted by Bewsher uses TUFLOW. Compared to TUFLOW, DRAINS has limited capabilities in predicting overland flow and does not account for diffusion of flow or flood storage within the topography of the land.

Plot Output (PO) lines from Council's TUFLOW flood model and associated results files by Bewsher for the area surrounding the site are shown in Figure 3 which was created in QGIS using a combination of the TUFLOW results files and NSW Base Map.

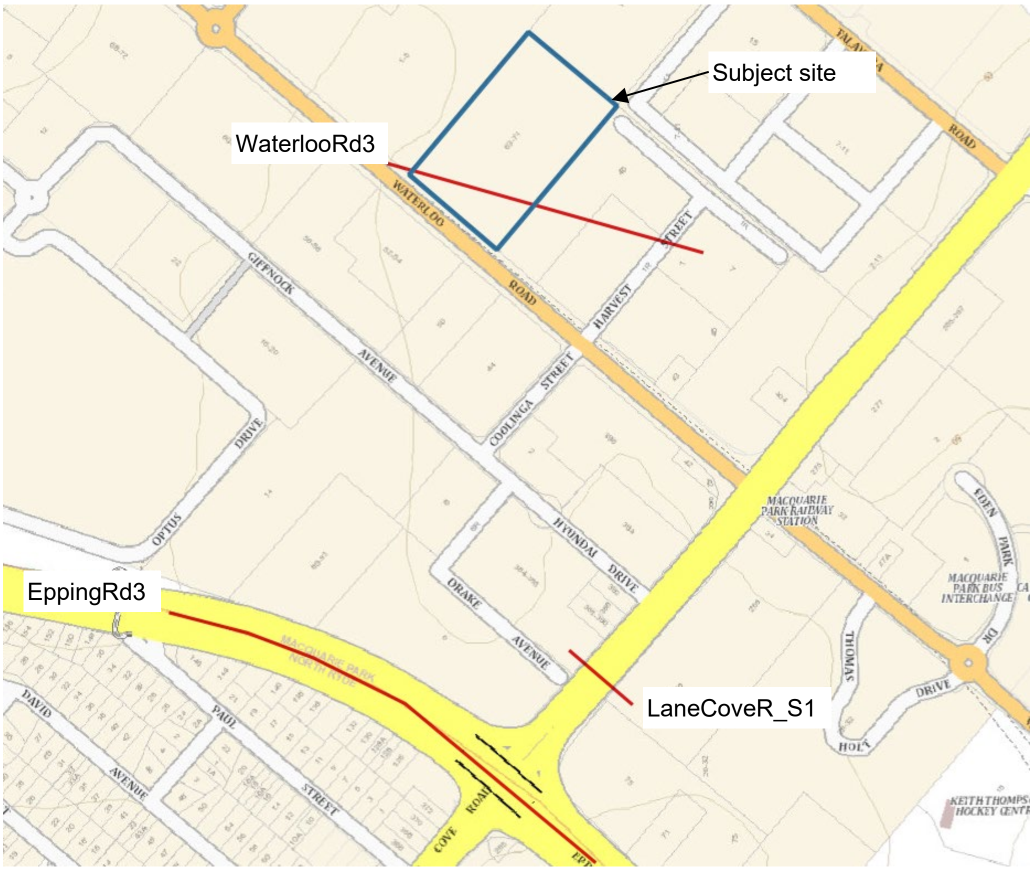

Figure 3 - TUFLOW PO lines within the site locality with NSW Base Maps underlayer

The WaterlooRd3 and EppingRd3 PO's directly correspond to the published Study Area Flow Locations (Figure 10, Bewsher 2010) I2 and I1. PO LancoverR_S1 does not correspond to any published Study Area Flow Location within the report. Table 1 below shows a comparison between the peak published flows and those from the TUFLOW results files for a number of varying storm intensities and durations.

Table 1 - Published results (Bewsher, 2010) vs. TUFLOW results (Bewsher, 2010)

Location		Epping Rd (Industrial Ck)	Waterloo Rd (Industrial Ck)
ID in Figure 10, Bewsher 2010		I1	I2
TUFLOW PO Label		EppingRd3	WaterlooRd3
Bewsher Report Flows (m^3/s)	1% AEP 2-hour Blocked	0.6	6.6
	1% AEP 9-hour Unblocked	0.2	2.5
	PMF 15-min Unblocked	3	26.2
	PMF 3-hour Unblocked	3.6	11.1
TUFLOW Result Files Flow (m^3/s)	1% AEP 2-hour Blocked (PIL_ExgB100y2h_02s_PO.csv)	0.633	6.642
	1% AEP 9-hour Unblocked (PIL_Exg100y9h_02s_PO.csv)	0.174	2.532
	PMF 15-min Unblocked (PIL_ExgPMF15m_02s_PO.csv)	3.021	26.195
	PMF 3-hour Unblocked (PIL_ExgPMF3h_02s_PO.csv)	3.615	10.969

The peak flows extracted from the TUFLOW model have been used as an input to the HECRAS 2D Model in this study.

The local catchment flows from the subject site and neighbouring 45-61 Waterloo Road site have also been calculated to consider the effects of the development flows on the neighbouring properties. It is assumed that all areas upstream WaterlooRd3 Plot Output (PO) line (including areas within the site draining to that section) are included in the TUFLOW model. Figure 4 illustrates the extent of the additional contributing catchments.

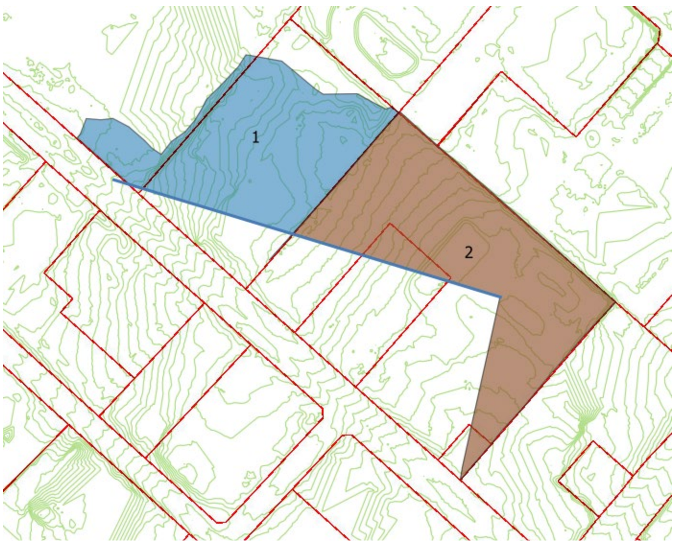

Figure 4 - Local catchments

Due to the small size of the local catchments, the rational formula was conservatively applied to estimate the peak flow rate using an impervious fraction of 80%:

$$Q_p^{Catchment} = \frac{\mathrm{F} \times \mathrm{C} \times \mathrm{i} \times A}{3600}$$

Where,

Q_p is the flow rate in l/s,

F is the frequency factor,

C is the run-off coefficient,

i is the rainfall intensity in mm/hour corresponding to the critical storm duration, and;

A is the catchment area in m^2

Rainfall intensities of 44.9mm/hr (100-year, 2-hr storm), 34mm/hr (100-year, 2-hr storm), and 605mm/hr (PMF, 15-min storm) are used to calculate the flow rates. Table 2 presents the contributing areas and peak flows.

Table 2 - Local catchments and flow rates

Catchment ID	Areas (m^2)	1% AEP Peak flow (m^3/s)	5% AEP Peak flow (m^3/s)	PMF flow (m^3/s)
1	21,124	0.25	0.17	2.84
2	25,465	0.31	0.20	3.42

The above additional flows have been added to the model as internal inflows to the hydraulic model (refer to s4.5) in order to consider the flooding impacts on neighbouring properties.

4.5 Hydraulic Model

A HEC-RAS 2D model was established for pre and post-development conditions based on available survey data and architectural drawings to assess the flow depths and velocities during the 1% AEP and PMF events.

The modelled terrain is based on 1-metre by 1-metre resolution raster grid DEM data compiled from Geoscience Australia's elevation foundation database.

The HECRAS 2D model was developed from approximately 40m upstream of the south-eastern boundary and approximately 80m downstream of the north-eastern boundary of the development site, along the overland flow path. Peak flows obtained from the 2010 Bewsher TUFLOW model were assigned to the upstream ends of the 2D flow area in the HEC-RAS model. Normal depth was selected as the downstream boundary condition using bed slopes measured from the available terrain data as the estimated energy slope.

Architectural features of the proposed development such as buildings and roads were incorporated into the model by using RASMAPPER, Civil3D and QGIS in order to satisfactorily model the impact of the proposed development on the predicted flood flows. The future development on the neighbouring lot (LDA2018/172: 45-61 Waterloo Road), including buildings E and F and Roads 1 and 16, were included in the predevelopment base case model as per the approved masterplan.

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The model terrain was modified to provide cut volume for additional flood storage along the north-eastern boundary of the site. The proposed cut depths (post-development minus predevelopment surface levels), computed using Saga "Raster volume" processing tool in QGIS, are shown in Appendix A, Figure 36.

Breaklines and refinement areas were used at critical locations to ensure there was no leakage in the 2D flow area.

A Manning's 'n' roughness value of 0.05 was used for the general catchment surface, with the exception of impervious areas (n=0.02) and rip rap (n=0.15).

The proposed box culverts (4 off 4.2m x 0.75m) were modelled as Storage Area/2D Area connections within HEC-RAS. The connection is modelled as a structure (spillway/weir) along the centreline of the 2D area, with the culvert modelled through the spillway/weir.

4.6 Calibration of Hydraulic Model

The goal of this project is to create a hydraulic model to simulate flood processes with reasonable accuracy.

The following was performed to check and improve the performance of the developed hydraulic model:

- The time step is controlled by the model using the courant condition to ensure model stability
- Mass balance of the model has been checked for losses to ensure errors are less than 1% to 2% in accordance with s10.4.2 of Book 7, ARR 2019 (Ball, et al., 2019)
- Signs of instability, such as unrealistic jumps or discontinuities in flow behaviour, oscillations, and excessive reductions in time step or iterations required to achieve convergence have been checked.

The model results have been validated using council provided data. Figure 5 shows the locations of spot points across the development site and adjacent properties, and Table 3 shows the water surface elevations (WSE) at the spot points under pre-development conditions for the 1% AEP storm events.

It is worth noting that there are several differences between Council's flood model and the site specific HECRAS 2D model, including the following:

- Council's model is based on 2007 ALS data and does not take into account changes that have occurred since that time, for example the development downstream of the subject site.
- Council's model used a 2m resolution mesh whereas the 2D area of the current model is based on a 1m resolution with breaklines and refinement regions with resolutions of 0.5m.

Notwithstanding these differences, the water surface elevations at the spot locations are in good agreement with Council's modelling results, as shown in Table 3, except for point C. The depth at location C has been checked and it is consistent with the HECRAS Model results. On this basis, the difference in water surface elevation at point C is considered as an anomaly and is likely a result of the difference in the terrain models.

Figure 5 - Overland flow level points

Table 3 - Comparison of council provided flood information and model results

Location	**100 Year ARI WSE (m) Council model**	**100 Year ARI WSE (m) HECRAS model**
A	53.59	53.58
B	53.00	52.98
C	53.55	53.36
D	53.01	52.96
E	52.95	52.95
F	52.95	52.95
G	52.95	52.96
H	52.95	52.95

4.7 Results

4.7.1 General

The goal of this project is to create a hydraulic model to simulate flood processes with reasonable accuracy. The hydraulic model has been prepared with the data available and accessible with reasonable cost and time, given the nature and size of the project. Like any mathematical model, hydraulic modelling is sensitive to a range of inputs and assumptions, each adding some level of uncertainty to the result. Some of these inputs include rainfall intensities, temporal patterns, terrain models, new and existing buildings and the models themselves. The results have been interpreted in the context of the likely model uncertainties, its nature and risks of this project.

4.7.2 Summary of Results

Using the results of the model as described, the impact of the new development on flood behaviour immediately upstream and downstream of the new development has been examined. Figure 6 shows the water depths during the 1% AEP rain event. Detailed flood characteristics for both the pre and post-development scenarios are provided in Appendix A.

Overall, comparison between modelling results for the predevelopment base scenario and post-development design condition (20% blockage) show that there is a decrease in flood depths of up to 16mm downstream of the site (refer depth spectrums in the figures).

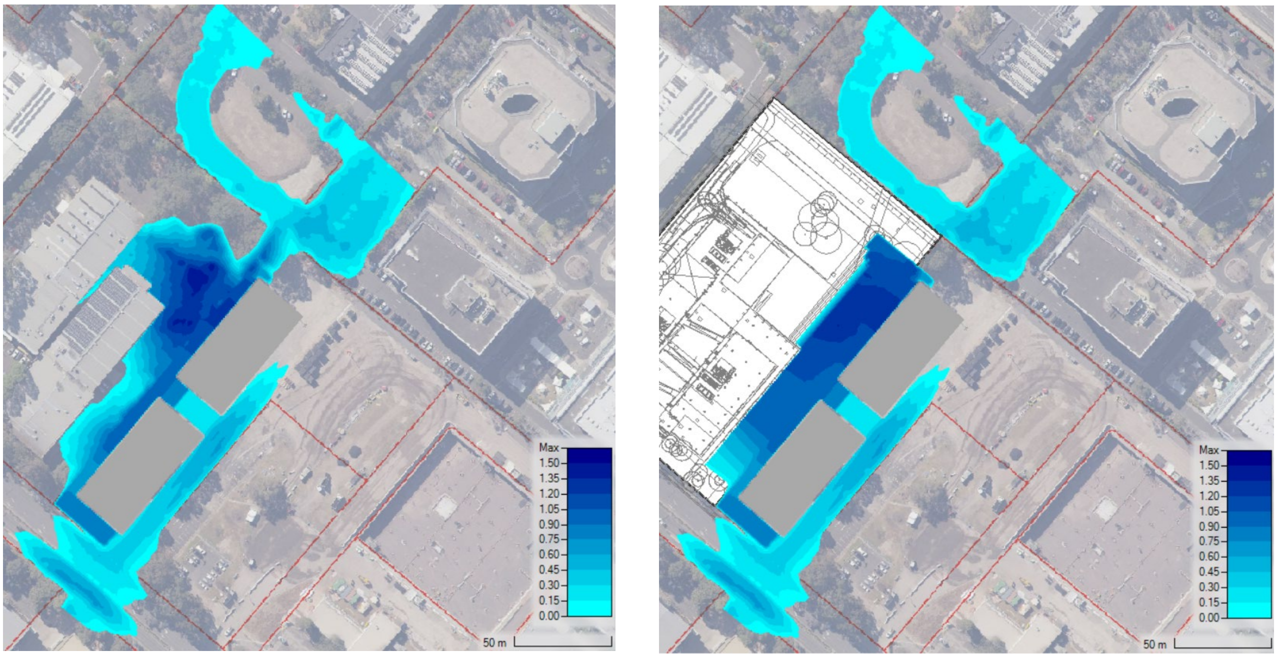

Figure 6 - 1% AEP water depths (m) for pre-development base scenario (left) and post-development design scenario (right)

Figure 7 shows the difference between the pre-development base case and post-development (design scenario – 20% blockage) flood depths with a lower bound of 0.01m. The bulk of afflux values are shown to occur within the subject site due to the proposed development. The results also show that there would be some areas of afflux at locations A, B and C.

The difference in depths at location A is due to terrain merging, as well as the difference in cell faces alignments and the 2D area resolution of the hydraulic model. In HECRAS 2D, the computations are done at cell faces. Given the grid face at location A aligns with the interface between two merged terrains, it results in a linear and localised depth difference.

At locations B (Figure 7) and D and E (Figure 8), the afflux varies from 10 to 15mm. This can be attributed to the error tolerance of the DEM data and calculations within the flood model, and it is less than 20mm, which is typically an industry acceptable level of variance.

The model predicts that flood depth increases from 10mm to approximately 29mm at Location C (Figure 7). This increase is within an overland flow path and is confined within the immediate vicinity of the site boundary. Overall, the increase in depths at locations A, B, C, D and E are not expected to have a significant effect on the downstream properties for the following reasons:

– the increased depths are localised, and/or occur within an existing overland flow path, and hence do not impact on the adjacent sites,

– the flood hazard classifications at these locations remain similar for pre and post development, refer to the following section 4.10 for discussion.

Additionally, the modelling results (refer to Figure 13 through to 15, Appendix A) also show that the maximum velocity-depth product at the site access points and proposed road is less than the limiting value of 0.4m^2/s during the 1% AEP rain event. This complies with the requirement of s2.3.1, Part: 8.2 Stormwater Management Technical Manual, City of Ryde Development Control Plan 2014.

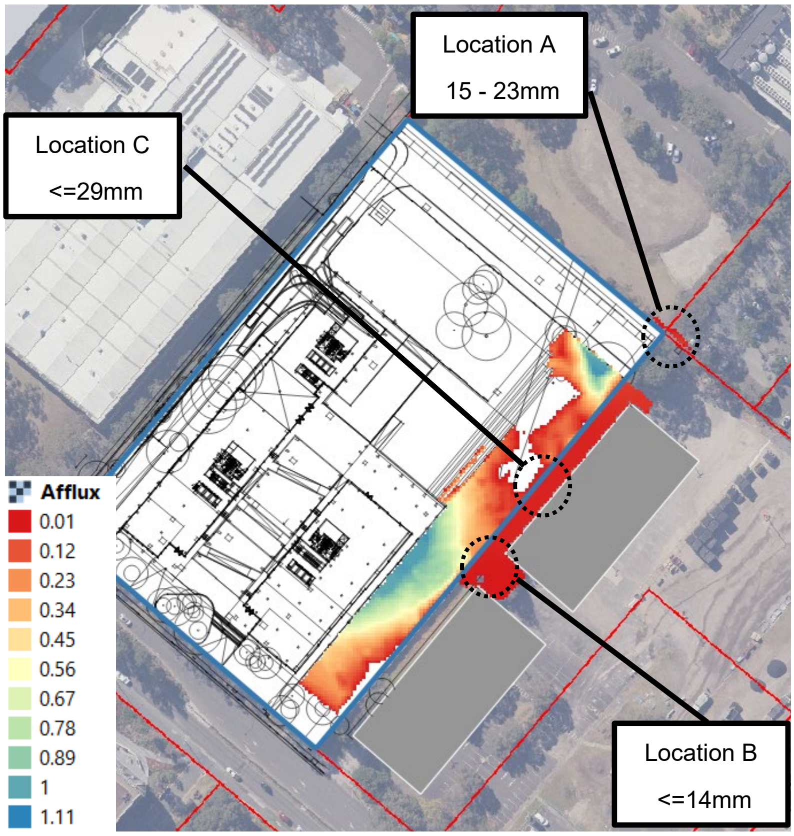

Figure 7 - 1% AEP Flood Afflux (pre vs. post) – Design Scenario (20% blockage)

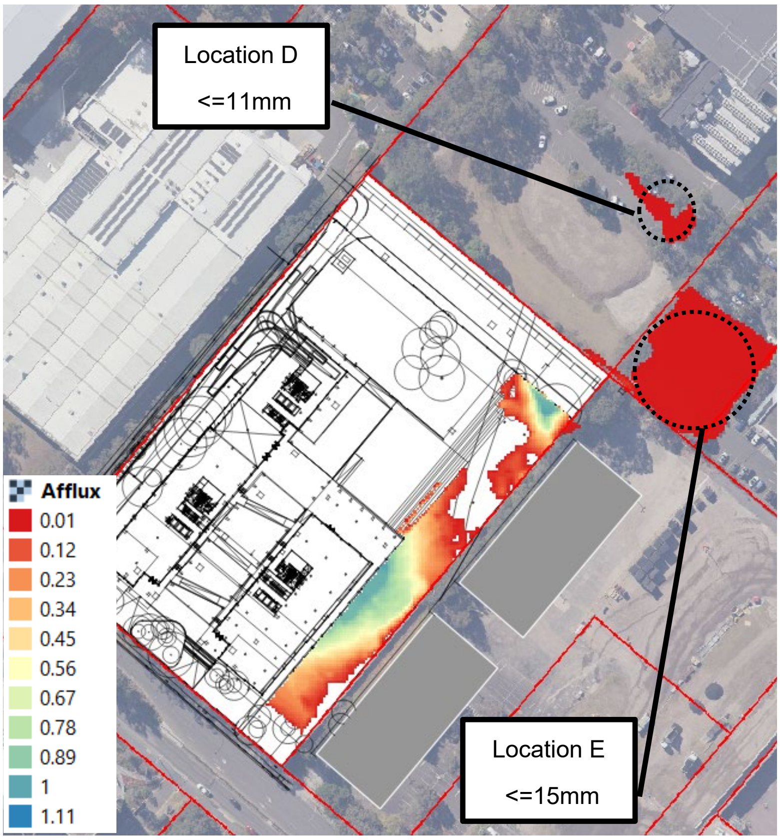

Figure 8 - 1% AEP Flood Afflux (pre vs. post) – 0% Blockage

4.8 Flood Planning Level

The flood model predicts that during the 1% AEP and PMF rain events, the site will be subject to overland flow from Waterloo Road. As a result of this, the basement carpark and ground floor area of the development must be adequately protected against the inundation of floodwaters. Given the topography of the site and nature of the overland flow, the flood planning level applicable to the development varies across the site.

Figure 9 and Figure 10 show the 1% AEP and PMF flood Water Surface Elevation (WSE) for the post-development scenario which form the basis of the flood planning levels for the development.

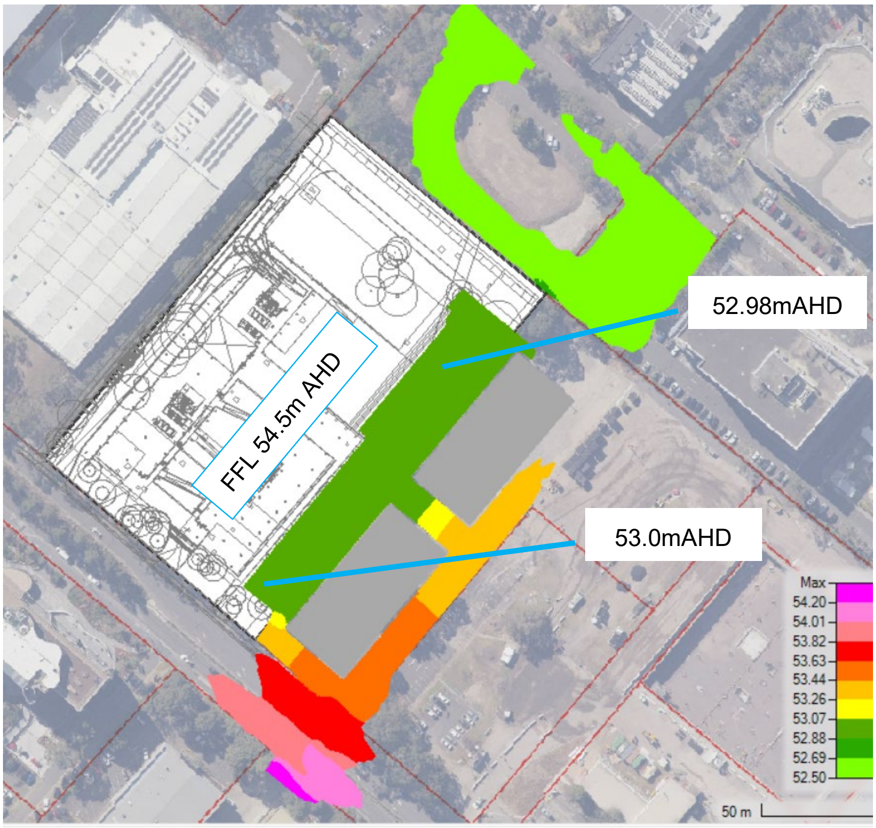

Figure 9 - 1% AEP Flood, Post-development WSE, Design Scenario (20% Blockage) (m AHD)

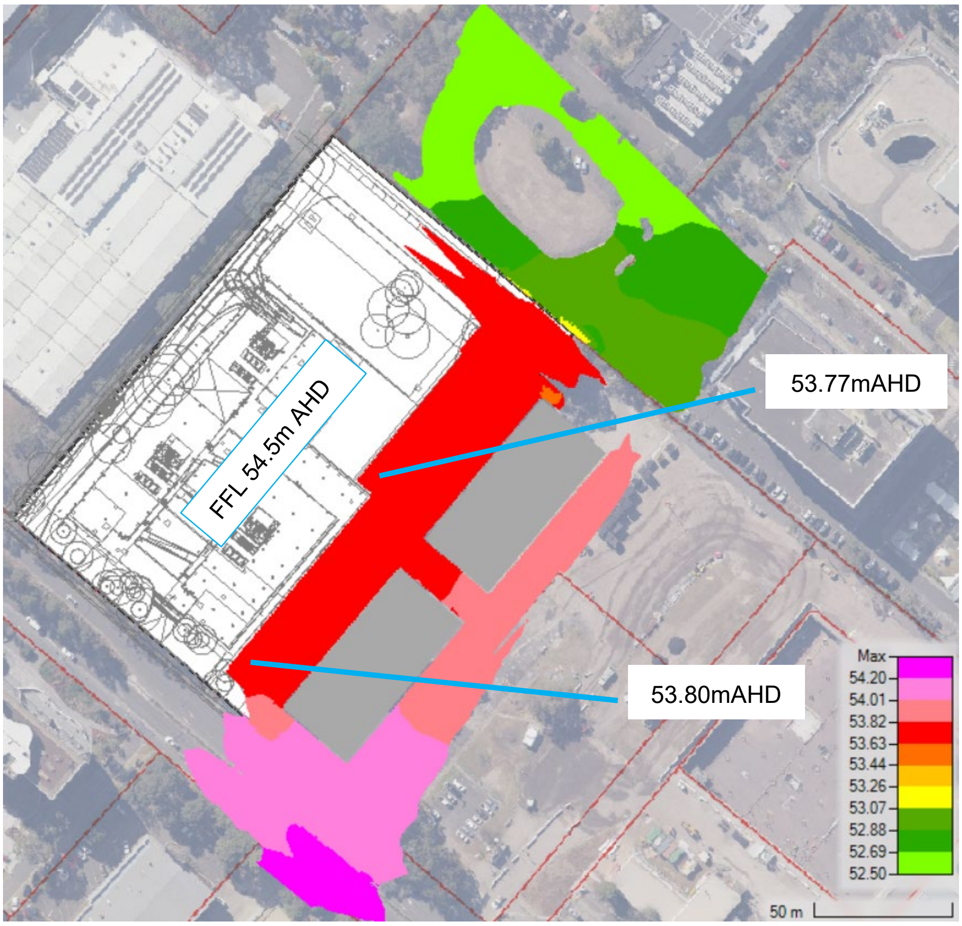

Figure 10 – PMF Flood, Post-development WSE (mAHD)

As a result of the access points to the basement carparking area, the development must be flood proofed up to the PMF or the Flood Planning Level (FPL) (flood level + 300mm freeboard), whichever is higher. This means that the ground floor level of the building must also be protected at the PMF flood level due to the access points to the basement.

Within Figure 9 and Figure 10, a number of PMF flood water surface levels are shown which are critical in determining the following flood planning levels for the development.

- Lower Ground floor level:
  - **FPL** = Maximum (1% AEP Flood WSE + Freeboard, PMF Flood WSE)

    = Maximum (53.3mAHD, 53.8mAHD)

    FPL = 53.8mAHD

  For this site, the 1%AEP + freeboard is generally lower than the PMF.

The design has the proposed lower ground floor level at RL 54.5m AHD which is above the relevant FPL for the site (53.8m AHD).

4.9 Model Sensitivity

In addition to the design blockage, additional models with the culverts 0%, 50% and 100% blocked were run to check the consequences of blockages. Sensitivity analysis of the 50% and 100% blockage scenarios have been analysed to assess whether a significant change in flood level results. However, this is not adopted as a design criterion. Water surface elevations for both the PMF and 1% AEP events are provided in Appendix A. The new Road 1 profile acts as a failsafe weir, allowing water to safely overtop during large flows and blockages.

The maximum water level within the site in the event of 100% blockage of culverts during the PMF flood event is 54.26m AHD (refer to Appendix A, Figure 26), which is lower than the proposed lower ground floor level set at 54.5m AHD.

The proposed solution is considered robust as the proposed development is protected from flooding for all events up to PMF, including 100% culvert blockage scenario.

4.10 Hydraulic Hazard

Hydraulic hazard classification maps were prepared with hydraulic hazards assigned in accordance with the recommendations outlined in ARR 2019 (Book 6, Chapter 7 – Table 6.7.3, 6.7.4 & Figure 6.7.9). Pre and post-development hydraulic hazard maps are shown side by side in Figure 11 below. Hydraulic hazard for pre vs. post development scenarios remains largely unchanged outside of the subject site.

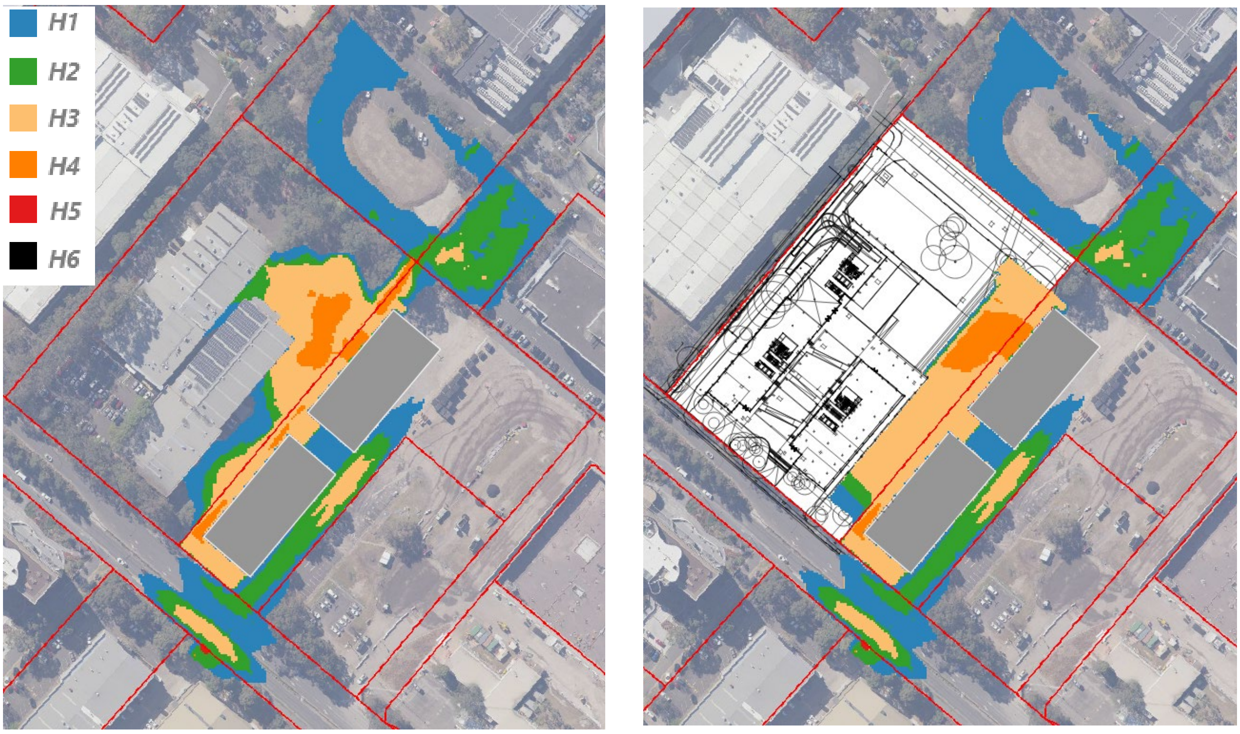

Figure 11 - Hazard Classification – Predevelopment Base Scenario (left) and Post-development Design Scenario (20% Blockage) (right)

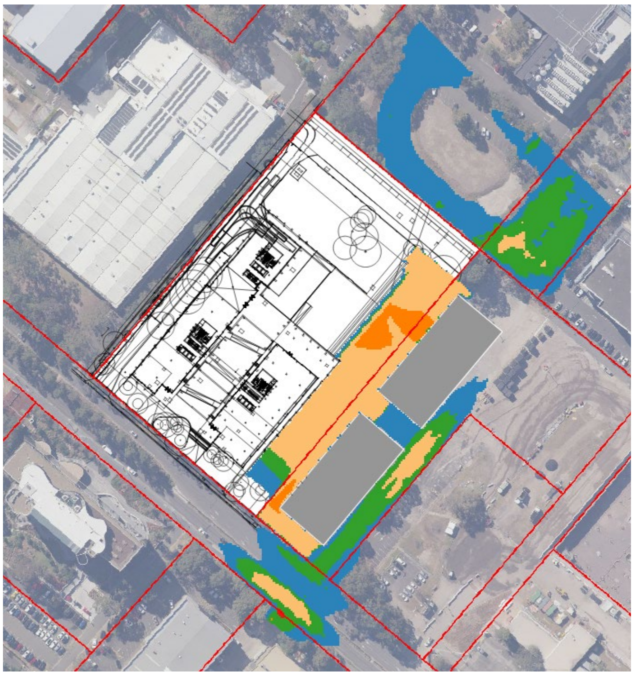

Figure 12 - Hazard Classification – Post-development Scenario (0% Blockage)

5.0 Assessment of Council Flood Controls

The development as currently proposed consists of two new commercial buildings, with shared basement parking. The development is classed as a combination of "Carparking Areas" and "Retail, Commercial & Industrial Development" in accordance with the DCP and a number of development related flood controls apply. The applicable flood controls are listed and assessed below.

<u>Carparking Areas (s4.4.2)</u>

a) *To minimise property damage, the following finished surface levels must be attained for new parking areas.*

- *For open parking areas, no less than the 100yr ARI flood level*

  (Not applicable)

- *For enclosed parking areas, the parking area must be no less than the 100yr ARI flood level plus 150mm freeboard.*
  (Not applicable)

- *Basement parking or parking at levels below the adjacent flood levels, a bunded crest at the estimated PMF (probable maximum flood) level prior to descent into the parking area, must be provided such that inundation of the area is prevented.*

  The proposed basement entry is outside the PMF flood extent, including during the 100% blockage of the proposed culverts.

- *For new parking areas associated with concessional development, parking areas are to be elevated to habitable floor level.*
  (Not applicable)

b) *New parking areas must not divert overland flow or reduce flood storage such to adversely impact the surrounding area.*

(Not applicable)

c) *Large open parking areas (greater than 10 car spaces) must provide adequate restraints or barriers to prevent vehicles leaving the site up to the 100yr ARI flood event.*
(Not applicable)

d) *The utilisation of existing parking areas must not result in the increased risk to property damage or threat to public safety.*

(Not applicable)

Retail, Commercial & Industrial Development (s4.4.6)

a) *Commercial development on land subject to flood risk categorised as high will not be permitted unless it can be clearly demonstrated that development under this section can be undertaken on the land without jeopardising public safety and access, property damage or adverse ramifications of the pre-developed flood regime by means of a Flood Impact Statement.*

As the development site is located within a significant overland flow path, this report forms the basis of the required Flood Impact Statement.

b) *Floor levels of habitable and non-habitable areas must comply with the freeboard requirements as stated in Table 2.1 of the Stormwater Technical Manual. If these levels cannot be practically achieved for the entire floor area (E.g., for reasons of accessibility from a public space) then a lesser level may be considered subject to consideration of the extent or scale of property damage and risk to public safety.*

The lower ground floor level for the building is set at 54.5m AHD, which is higher than the FPL (53.8mAHD), to adequately protect the lower ground floor and basement from inundation during severe storm events.

c) *New structures subject to flood waters and major overland flows (excluding those sites located in Overland Flow Precincts) must be designed and constructed to withstand the anticipated hydrostatic forces. For all parts of the development potentially exposed to floodwater, below the minimum freeboard requirement, the development structure must:*

   a. *be constructed of flood compatible building components in accordance with the Stormwater Technical Manual.*

   All aspects of the proposed development at or below the PMF level will be constructed of flood compatible materials in accordance with the “Stormwater Technical Manual” and the “Reducing

Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas", Hawkesbury-Nepean Floodplain Management Steering Committee (2006).

b. *A structural engineer must certify that the completed works are designed and capable of withstanding forces subject to forces of floodwater, debris, buoyancy forces anticipated by the 100yr ARI flood event.*

All aspects of the proposed development at or below the 1% AEP flood levels will be designed and certified by a structural engineer as capable of withstanding forces subject to floodwater, debris, buoyancy forces anticipated by the 1% AEP flood event.

d) *Development must not adversely impact the existing flood regime in terms of diverting major overland flows or reduce flood storage such to adversely impact the surrounding area. The submitted Flood Impact Statement must demonstrate the development does not;*

i) *Reduce the pre-developed level of flood storage.*

ii) *Increase flood levels or velocities such to adversely impact adjoining dwellings.*

The development reduces flow depths downstream of the site, and there is a minor increase of depths at some areas along the north-eastern boundary of the site. Overall, the net impacts of the development to the existing flood regime are acceptable as they are confined to the site within what, for all intents and purposes, is now a precinct detention basin; or are impacting areas already affected by overland flow.

e) *All goods and materials must be stored at the minimum habitable floor level, complying with the freeboard requirements as stated in Table 2.1 of the Stormwater Technical Manual, unless the site is located in an Overland Flow Precinct in which case this may be reduced to 500mm above the adjoining ground level. Exemptions from this may be considered if it can be demonstrated in the Flood Impact Statement, that the materials will not adversely impact the surrounding environment or can be damaged if subject to stormwater inundation.*

Given that the lower ground floor level and all potential flood entry points to the basement are above the relevant FPLs, all goods will be adequately protected from floodwaters.

f) *If the development under this development type category involves subdivision of the land, it must be demonstrated that potential development of this newly created allotment can comply with controls under this section.*

(Not applicable)

g) *A restrictive covenant must be placed on the title of the land to ensure there are no further significant works and alterations to the landform or development are undertaken without the approval of Council such to impact on floodwaters.*

This item is subject to instruction from our client.

6.0 Flood Emergency Response

In general, two possible solutions are available to all flood affected developments to allow for the safe refuge of the occupants above the 1% AEP water level. The two options are:

1. Evacuate the area and move to an area outside of the flood extent and above the PMF, or;

2. Shelter-in-place move to an area above the floodwaters within the development and wait for floodwaters to subside.

Each of the above options was considered in preparation of the Flood Response Plan for the occupants of the development.

The recommended emergency response is to shelter in place at levels above the lower ground floor level until floodwaters subside or emergency services advise otherwise.

7.0 Conclusions and Recommendations

This report provides flood risk assessment for the proposed development at 63-71 Waterloo Rd, Macquarie Park. Based on the information extracted from Macquarie Park Floodplain Risk Management Study & Plan, the site is affected by overland flow during the 1% AEP event.

The model predicts a reduction of flow depths downstream of the subject site during the design storm scenario (20% blockage). While the model also does predict an increase in flood depth for some areas along the north-eastern boundary, this level of increase is considered minimal; is within a defined flow path; and is within the accuracy of the hydraulic model itself. Therefore, it is concluded that these affluxes will not result in any adverse impacts to the surrounding properties.

In the event of a flood emergency, safe refuge can be taken within the building at levels above the PMF.

The following are recommended to be implemented in the design.

- All potential flood entry points shall be flood-proofed to or above the relevant FPL (refer to s4.8 and s4.9).
- Provide debris/access grates for the box culverts under Road 1 as per Queensland Urban Drainage Manual (QUDM)
- The proposed basement design must include appropriate measures to satisfactorily protect against the ingress of groundwater and surface water, subject to the recommendations of further geotechnical investigation of the site
- All goods and materials must be stored above or within an area flood proofed to the FPL complying with the freeboard requirements as stated in Table 2.1 of the Stormwater Technical Manual.
- All new structures below the FPL must be constructed of flood compatible materials, and
- Flood advisory signs are to be mounted in area frequented advising occupants of what to do if a flood occurs.

References

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.

Bewsher Consulting Pty Ltd (2011), Macquarie Park Floodplain Risk Management Study & Plan.

New South Wales Government, 2005, Floodplain Development Manual: For Management of Flood Liable Land.

NSW Government (2005), Floodplain Development Manual: The Floodplain Development Manual and the Flood Prone Land Policy guide local government in managing flood risk in their communities.

Appendix A – Results

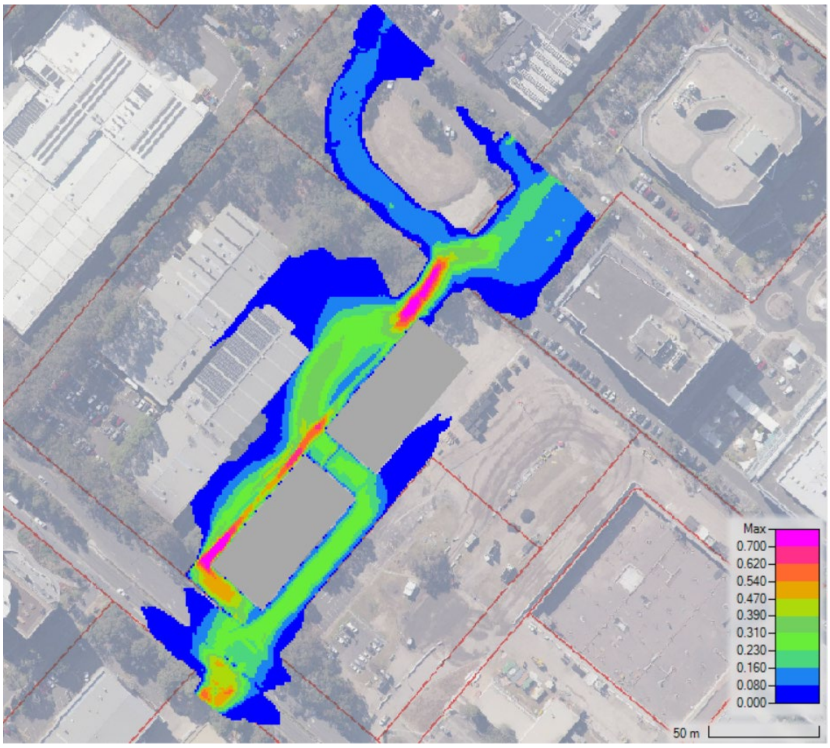

Figure 13 - 1% AEP, pre-development base scenario, velocity depth product (m^2/s)

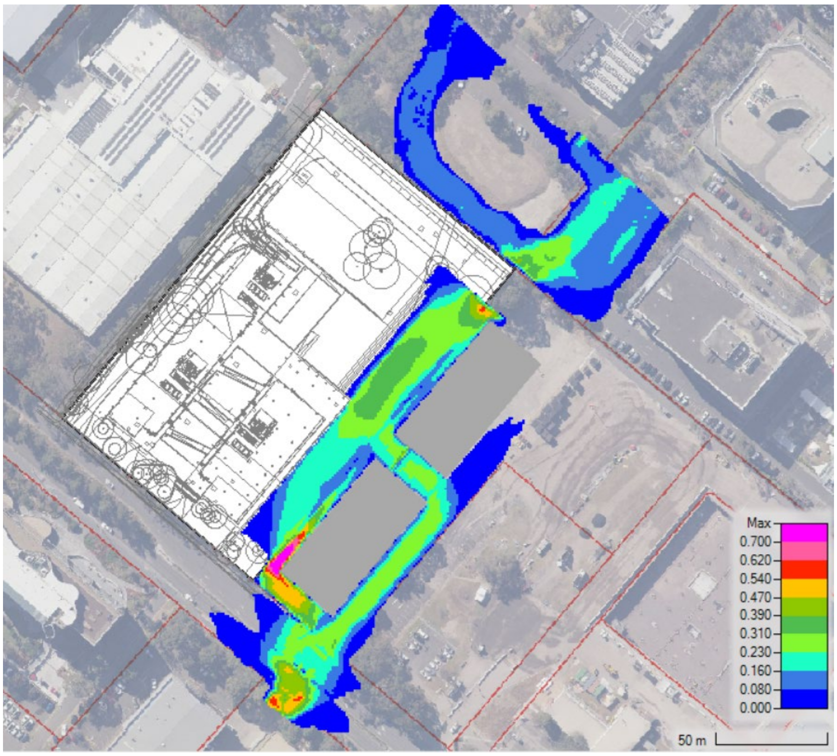

Figure 14 - 1% AEP, post-development scenario (0% Blockage), velocity depth product (m^2/s)

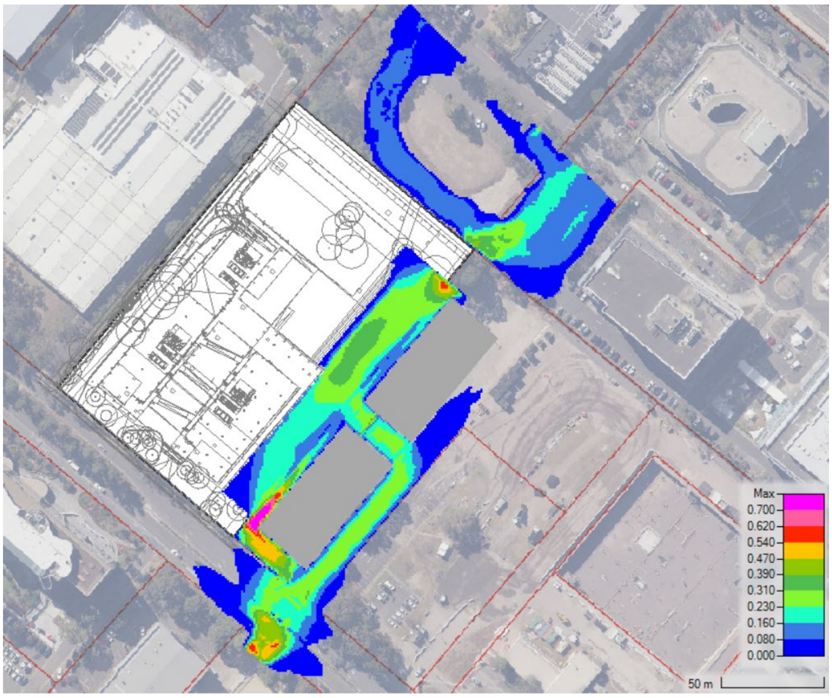

Figure 15 - 1% AEP, post-development design scenario (20% blockage), velocity depth product (m^2/s)

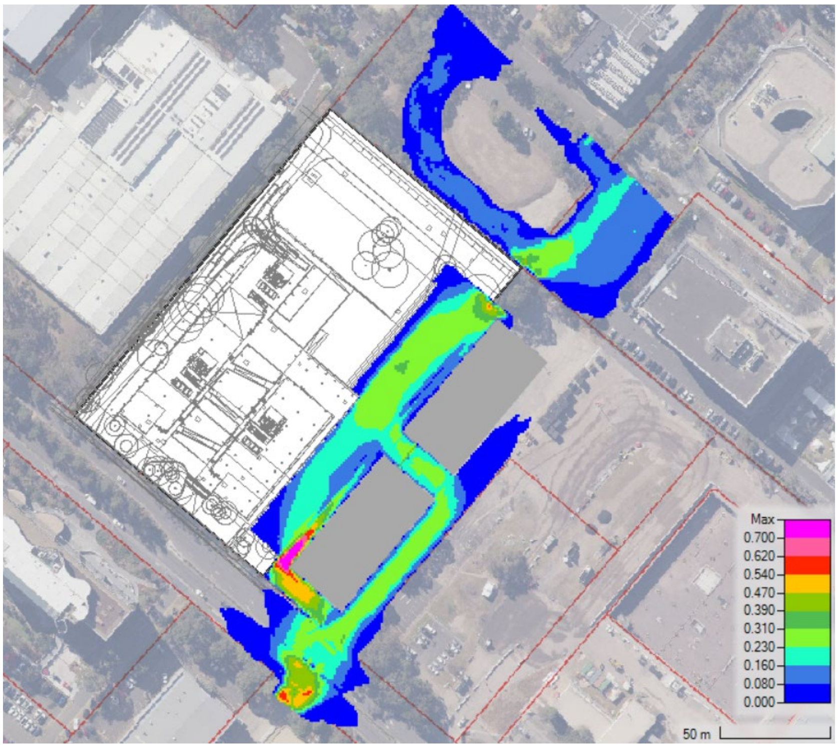

Figure 16 - 1% AEP, post-development scenario (50% Blockage), velocity depth product (m^2/s)

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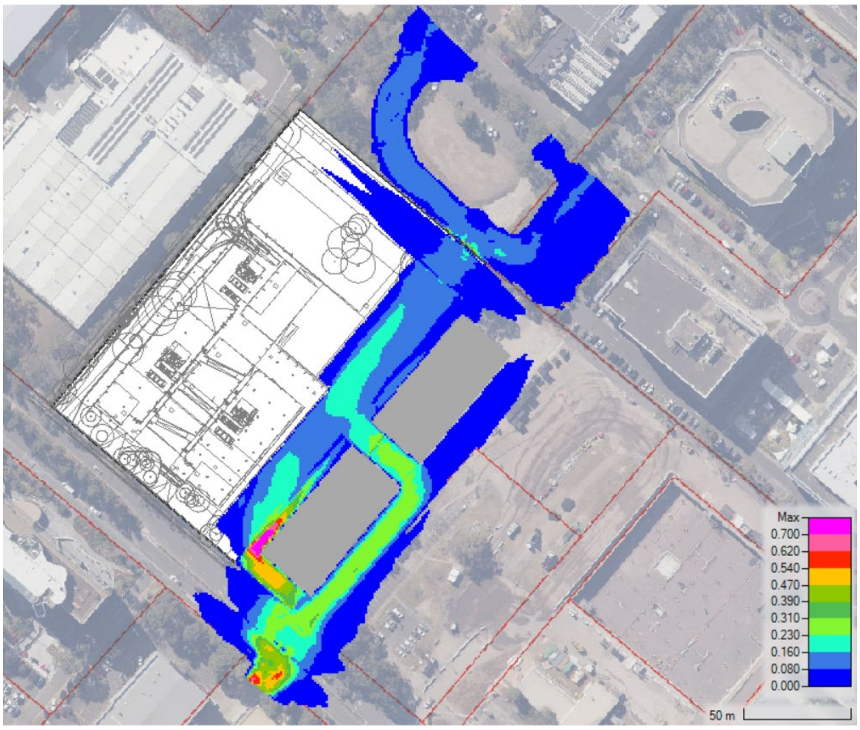

Figure 17 – 1% AEP, Post-development scenario (100% blockage) velocity depth product (m^2/s)

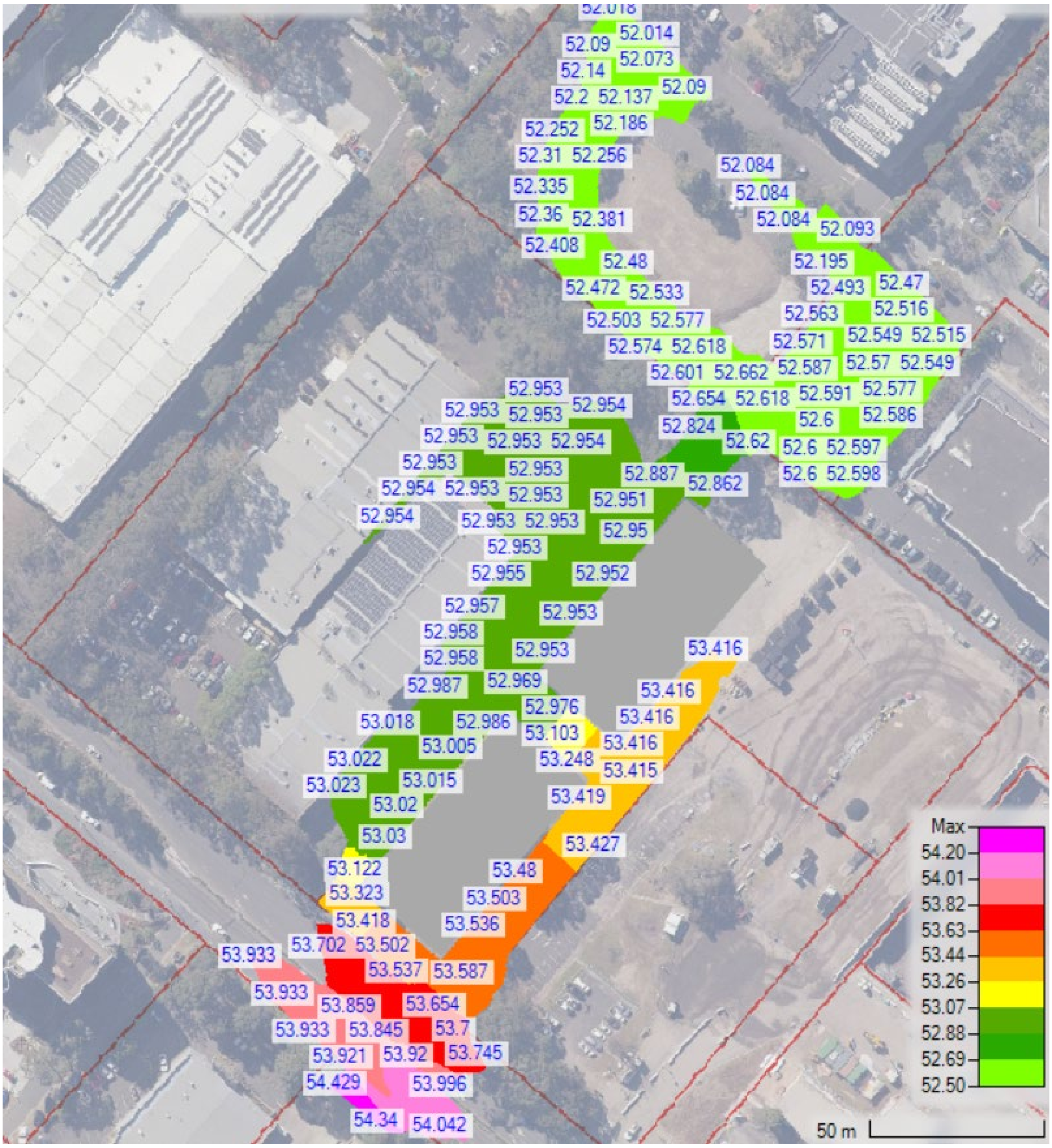

Figure 18 – 1% AEP, Predevelopment base scenario, WSE (m AHD)

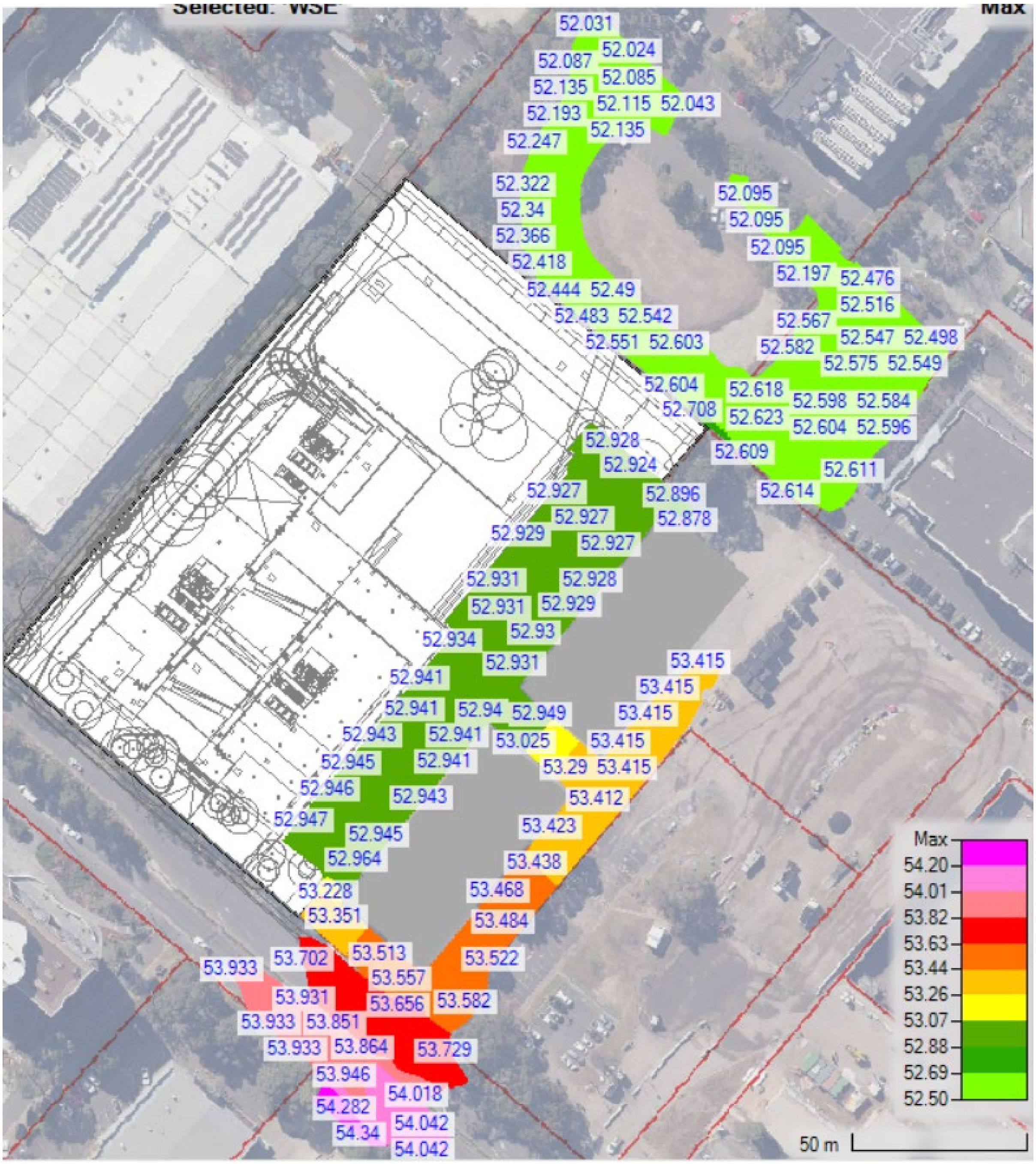

Figure 19 – 1% AEP, Post-development, 0% blockage, WSE (m AHD)

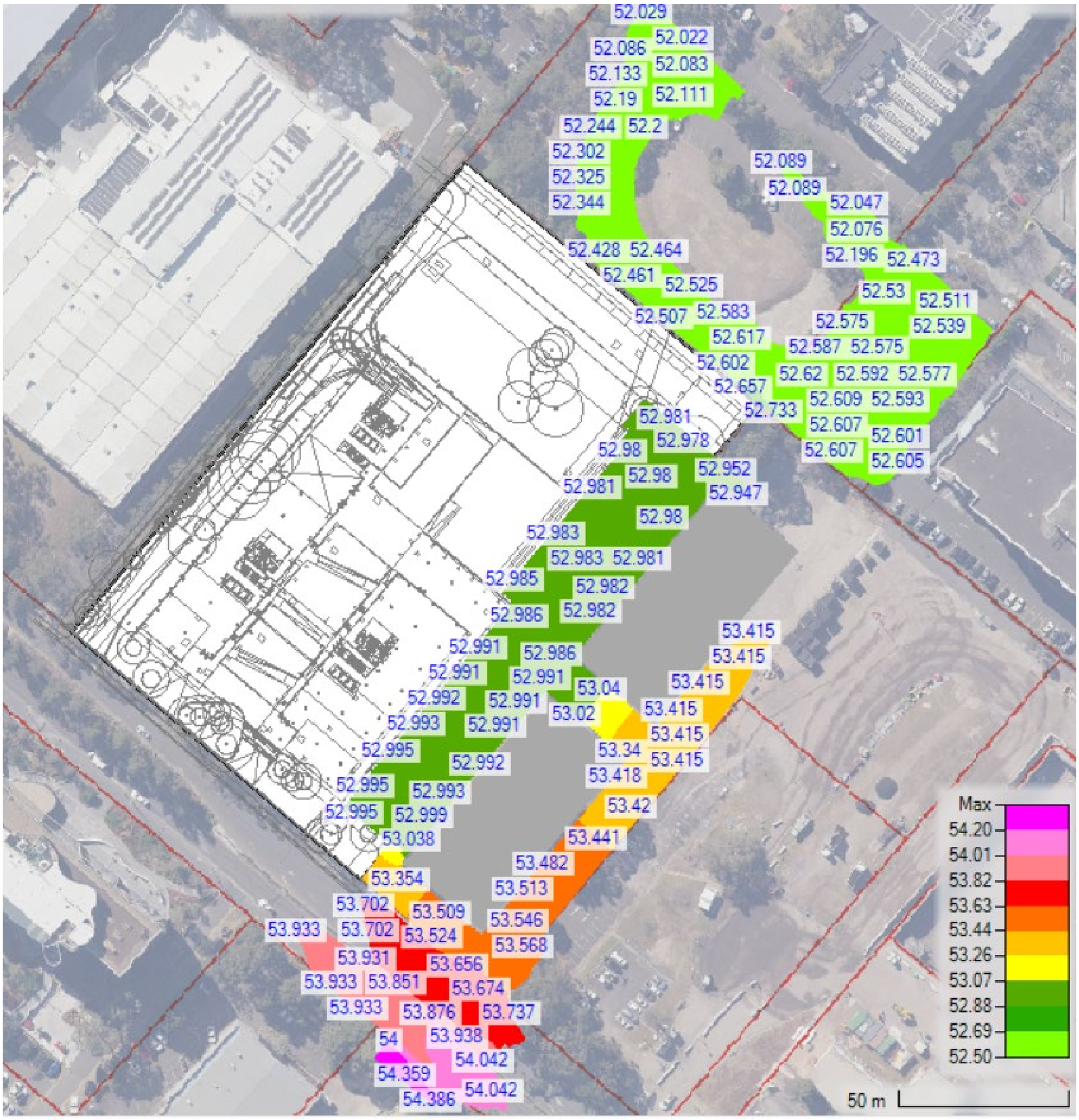

Figure 20 – 1% AEP, Post-development, design scenario (20% blockage), WSE (m AHD)

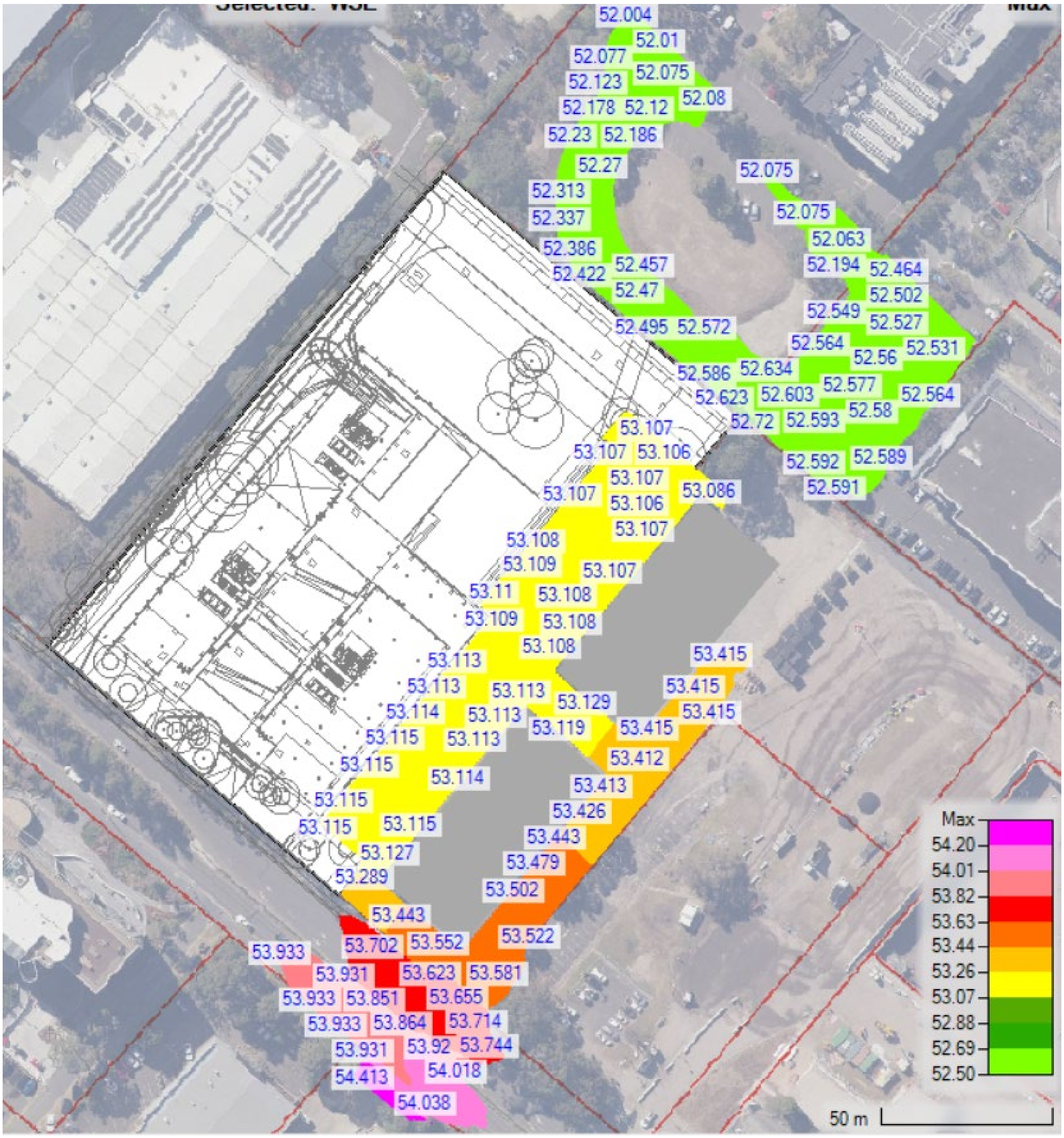

Figure 21 – 1% AEP, Post-development, 50% blockage, WSE (m AHD)

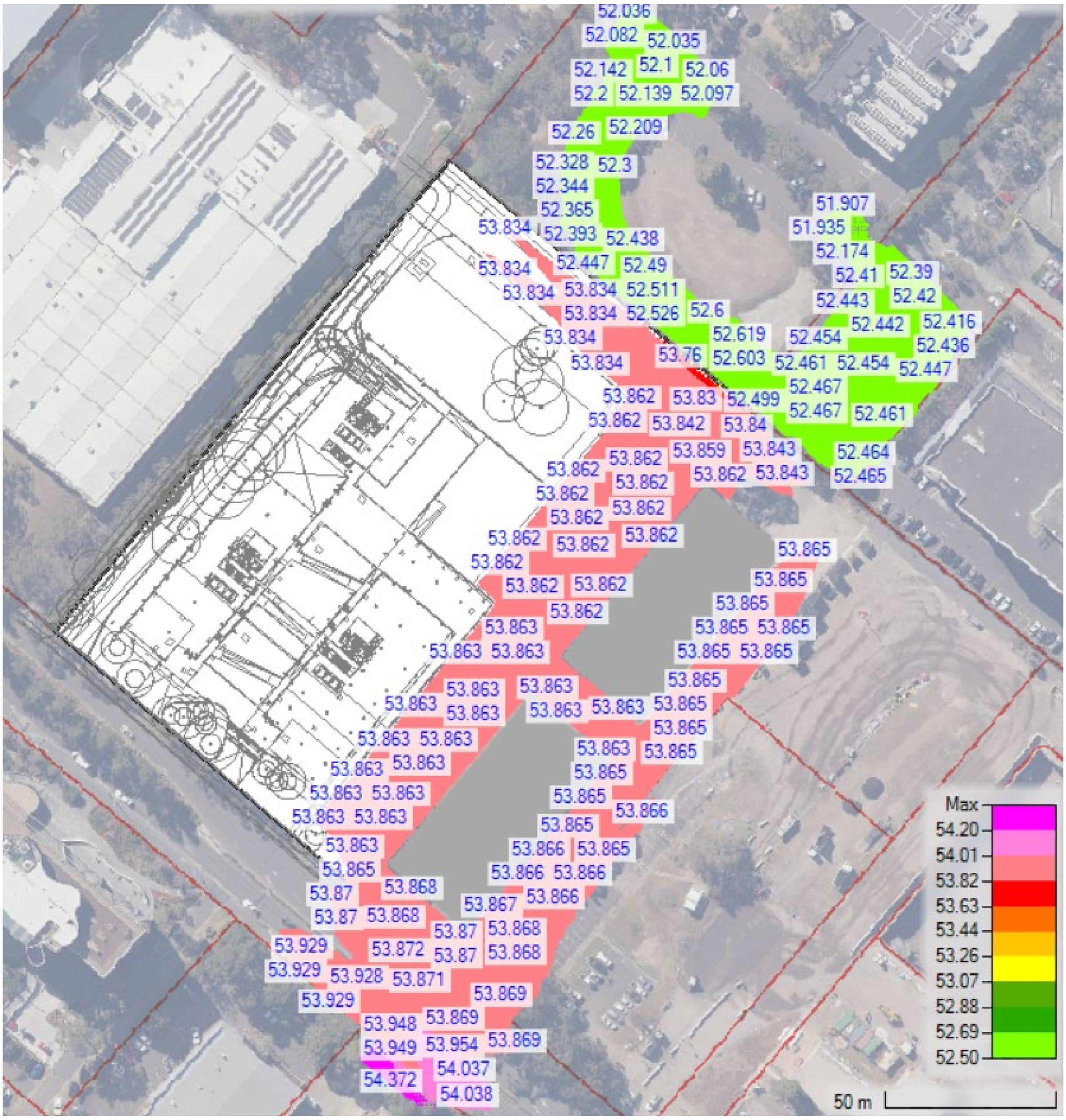

Figure 22 – 1% AEP, Post-development, 100% blockage, WSE (m AHD)

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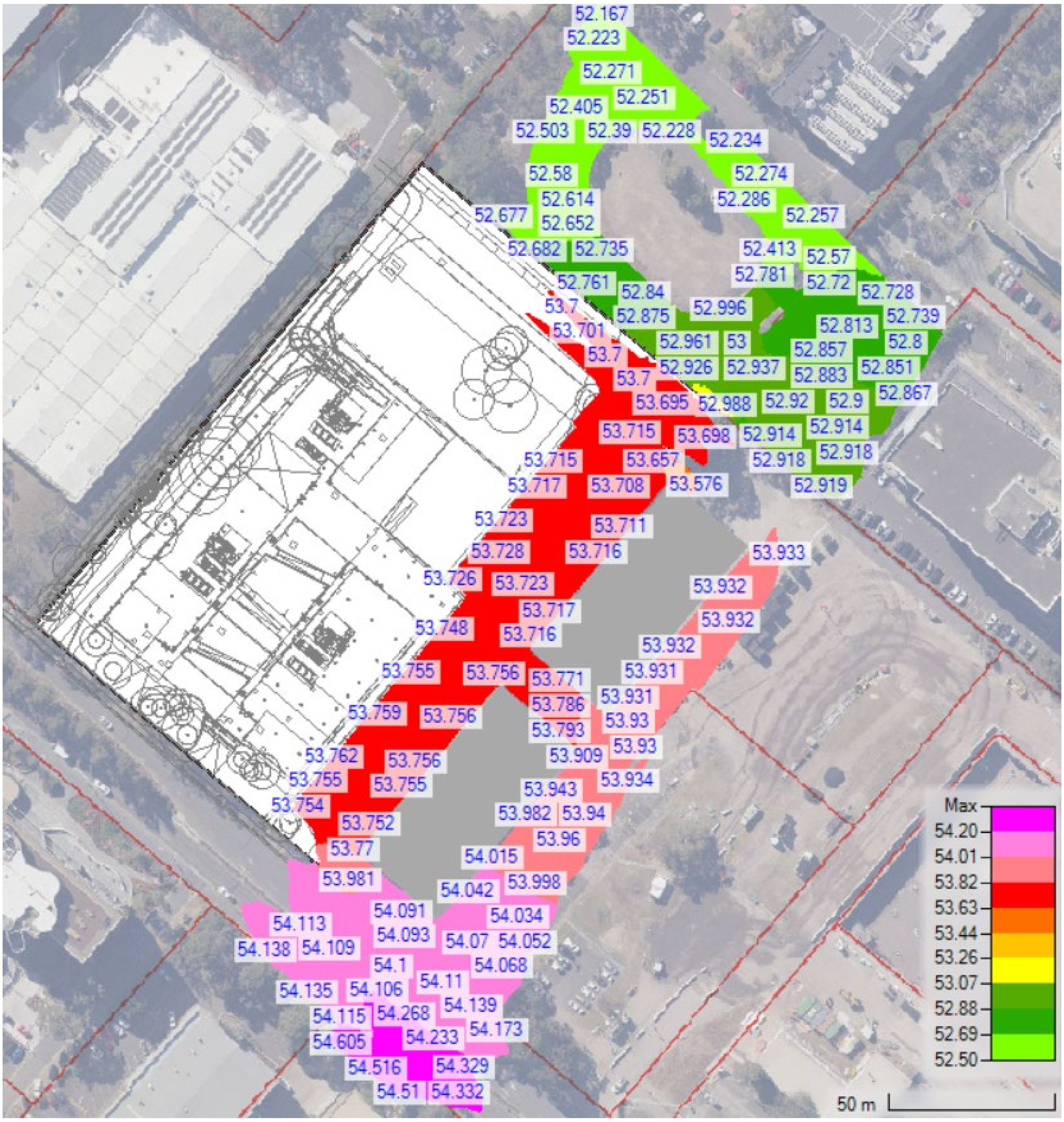

Figure 23 – PMF, Post-development, 0% blockage, WSE (m AHD)

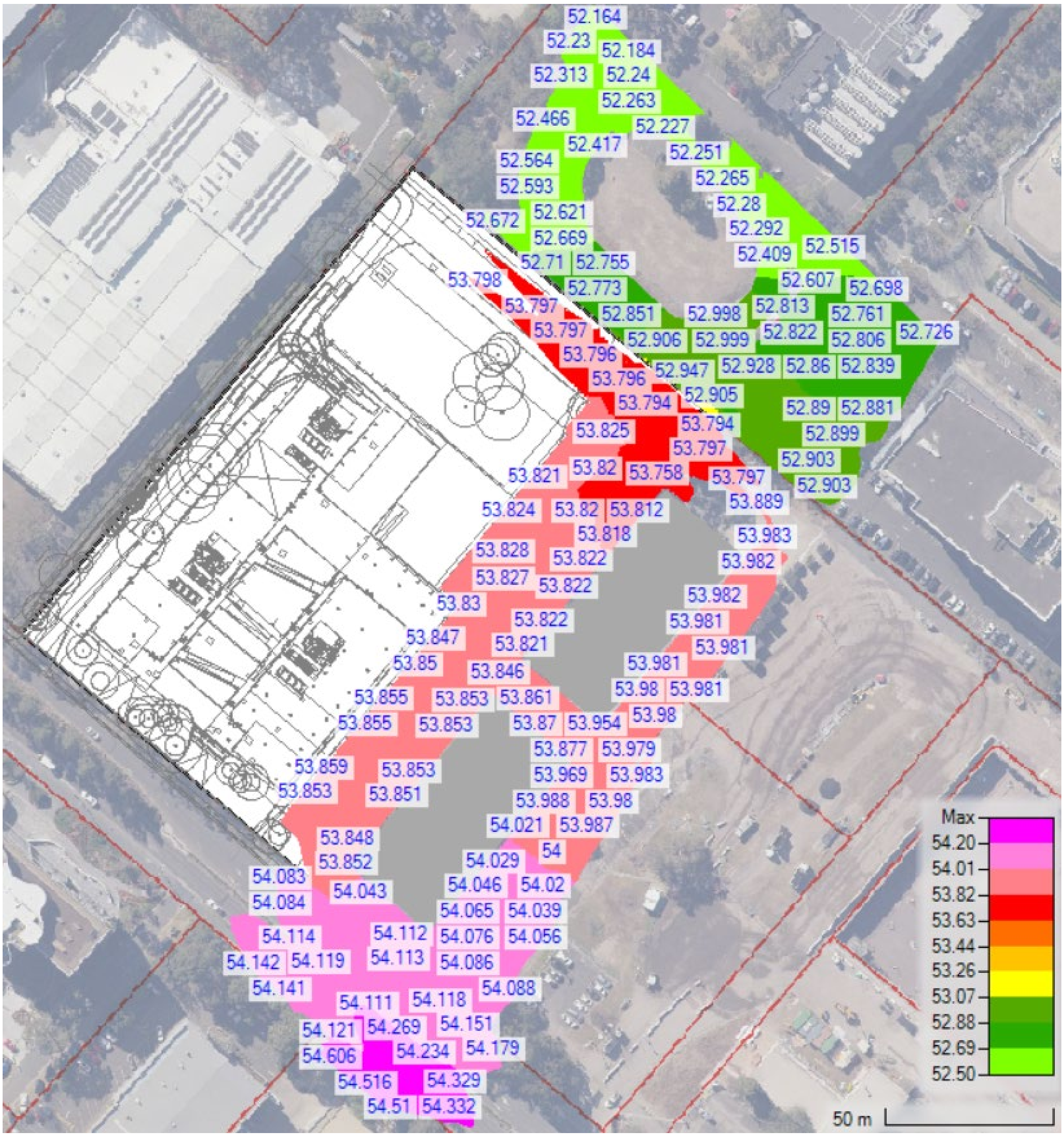

Figure 24 – PMF, Post-development, design scenario (20% blockage), WSE (m AHD)

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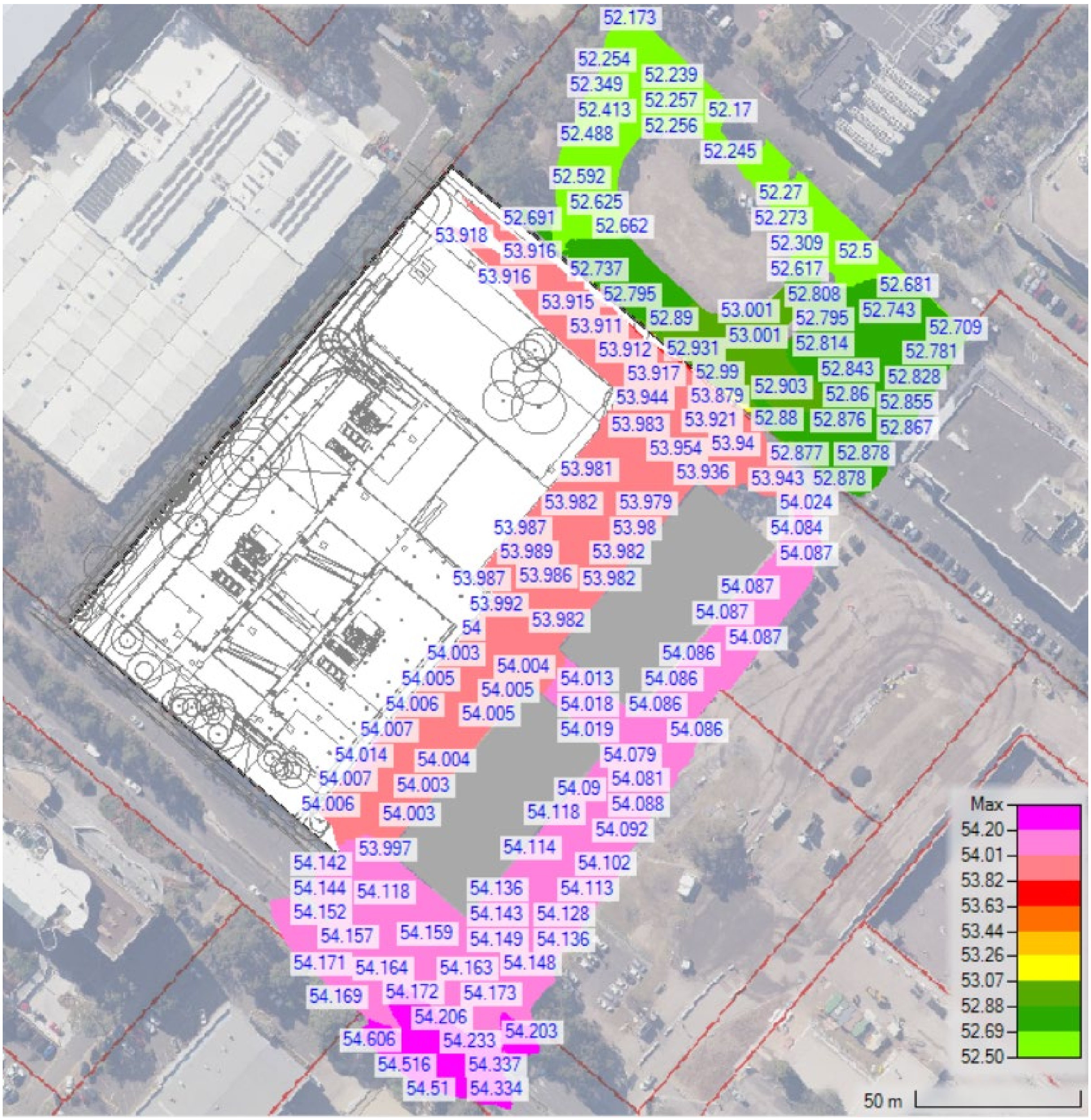

Figure 25 – PMF, Post-development, 50% blockage, WSE (m AHD)

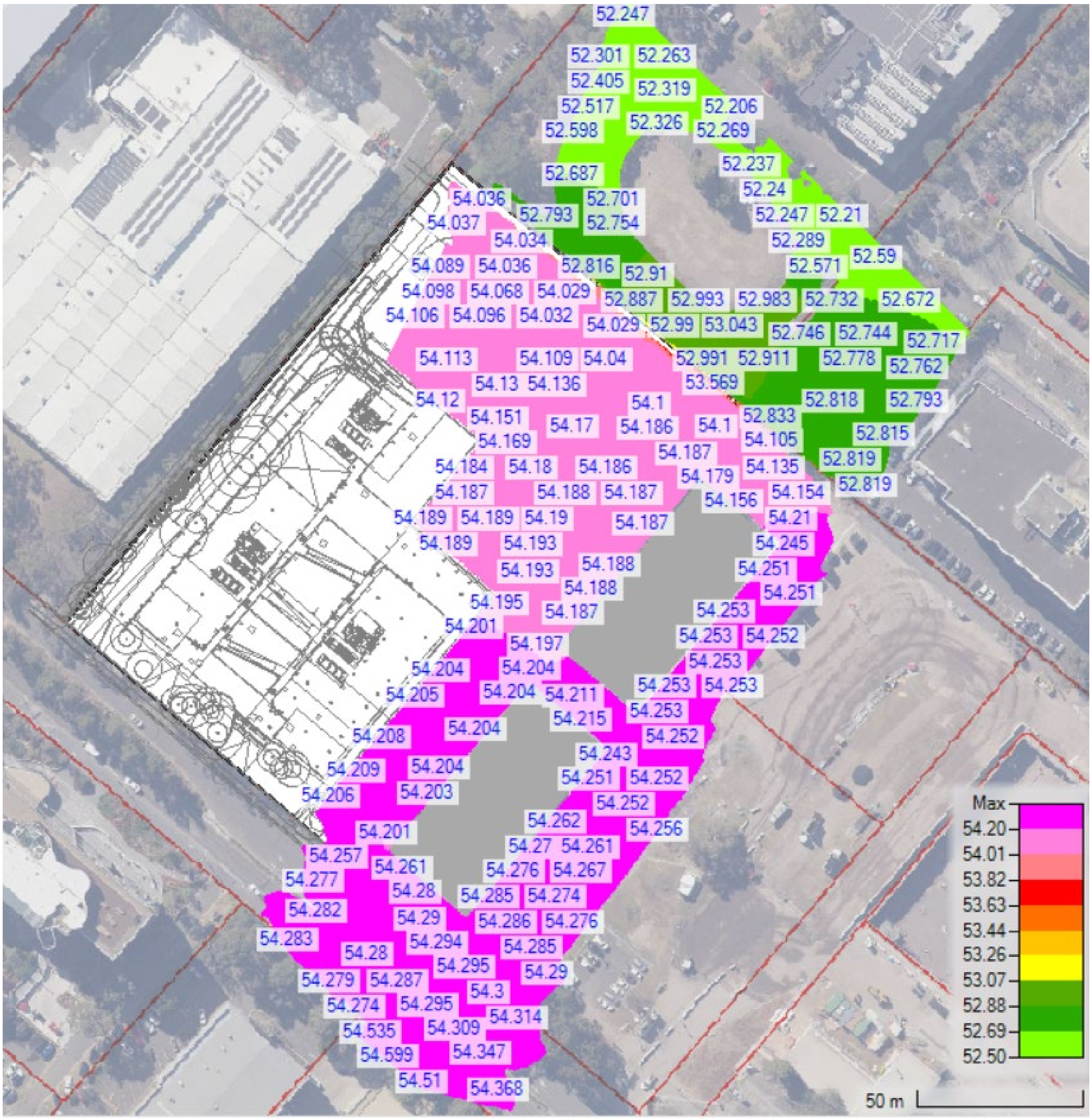

Figure 26 – PMF, Post-development, 100% blockage, WSE (m AHD)

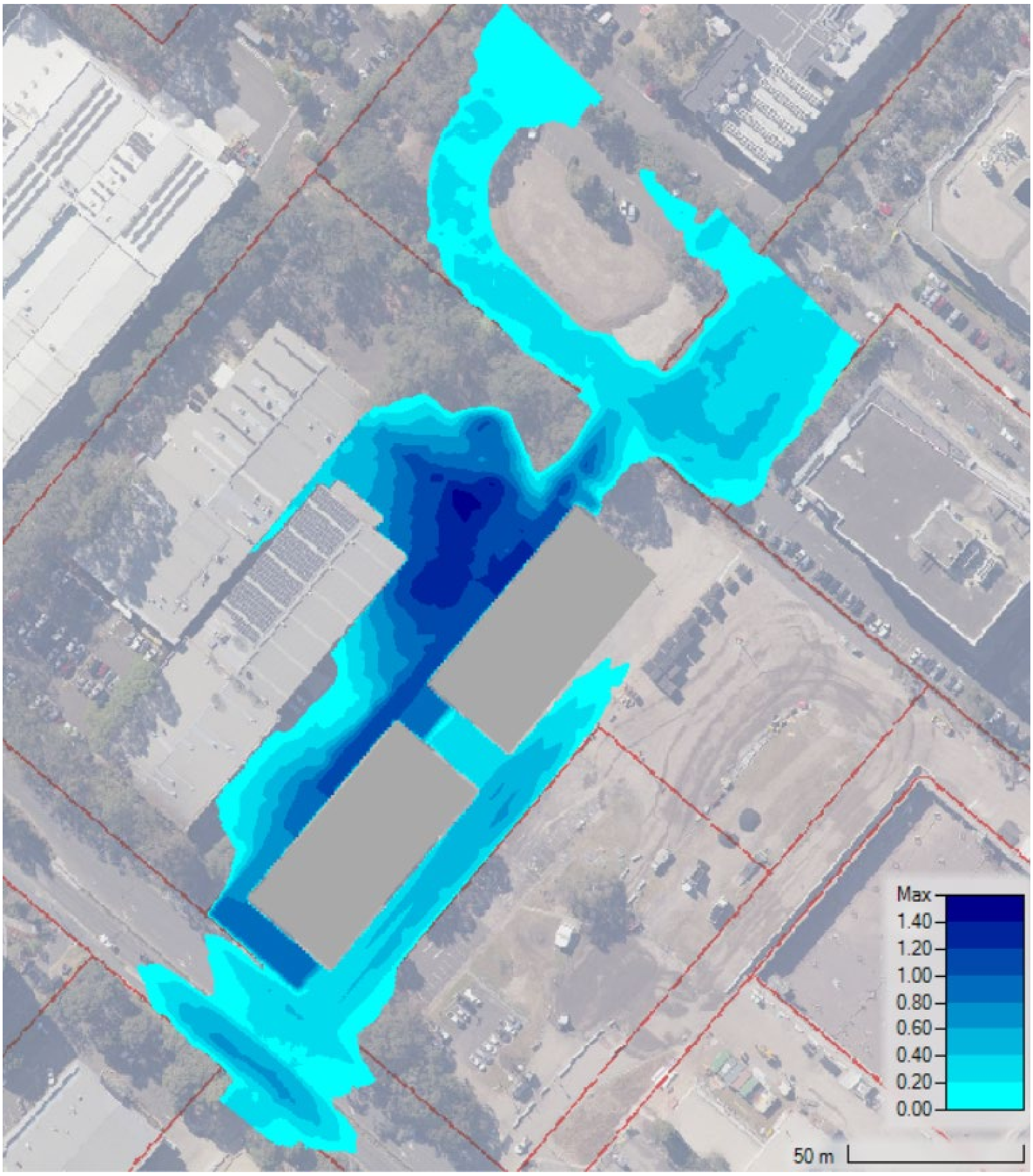

Figure 27 – 1% AEP, Predevelopment base scenario, depth (m)

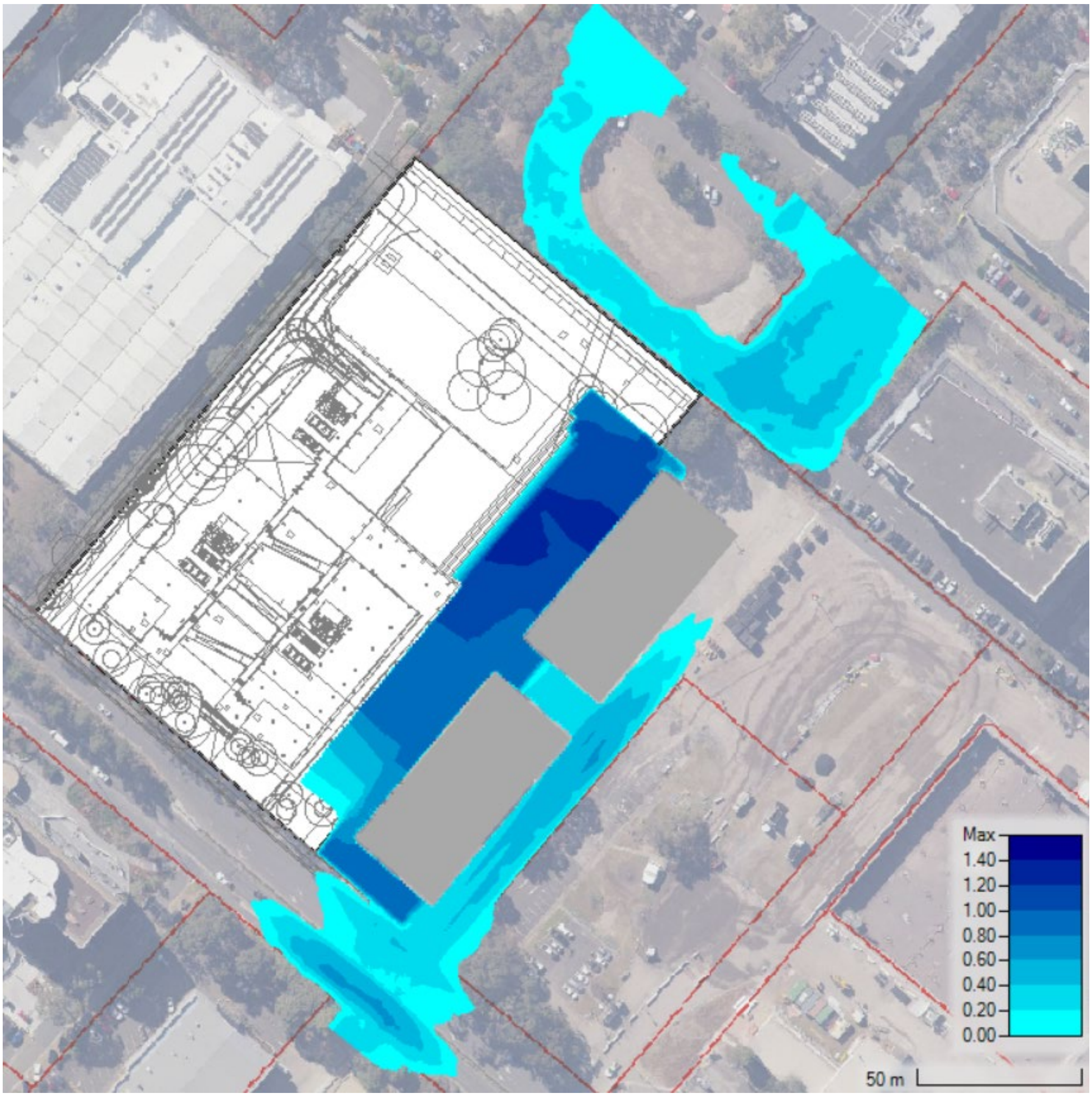

Figure 28 – 1% AEP, Post-development, 0% blockage, depth (m)

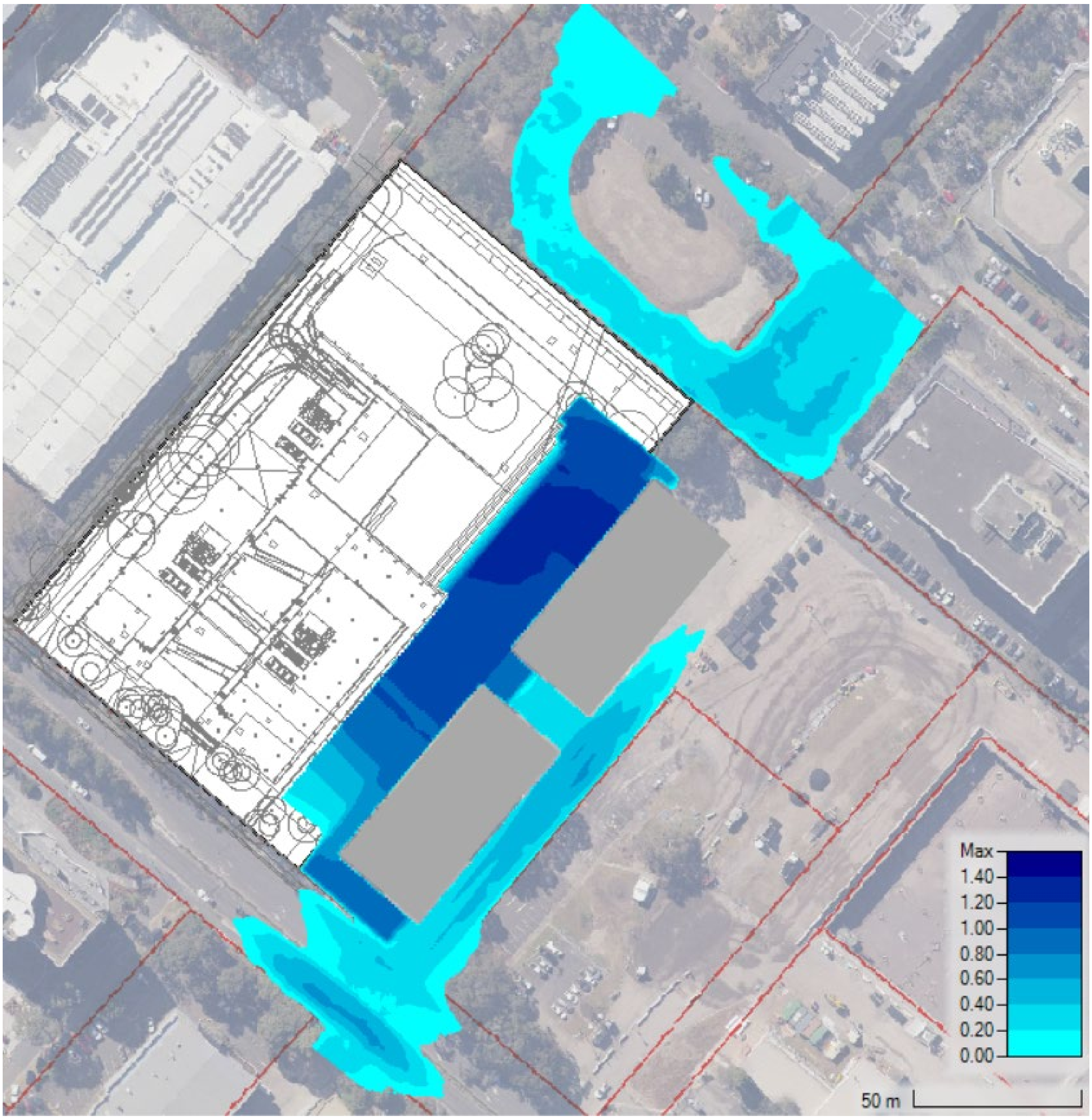

Figure 29 – 1% AEP, Post-development, design scenario (20% blockage), depth (m)

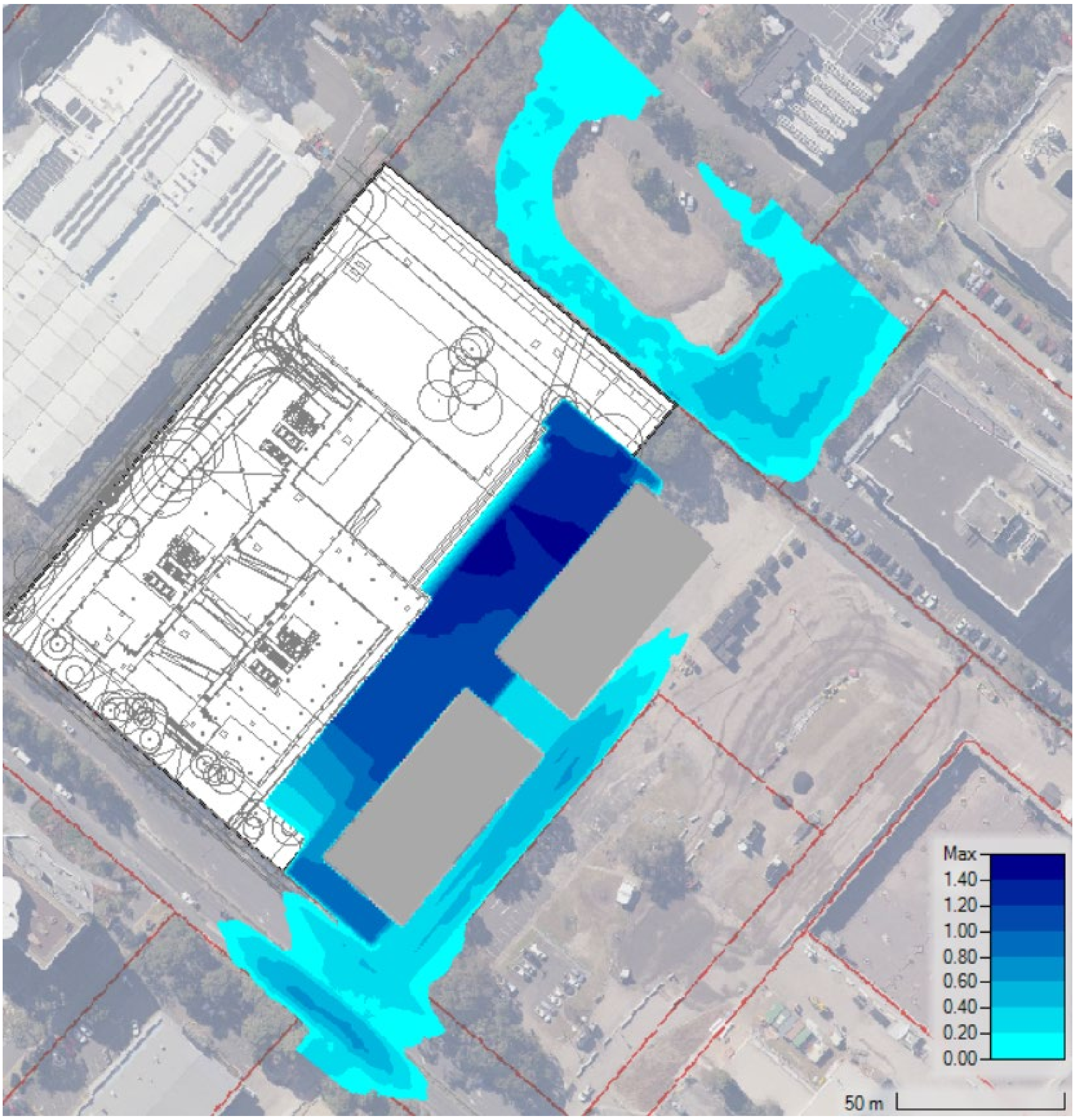

Figure 30 – 1% AEP, Post-development, 50% blockage, depth (m)

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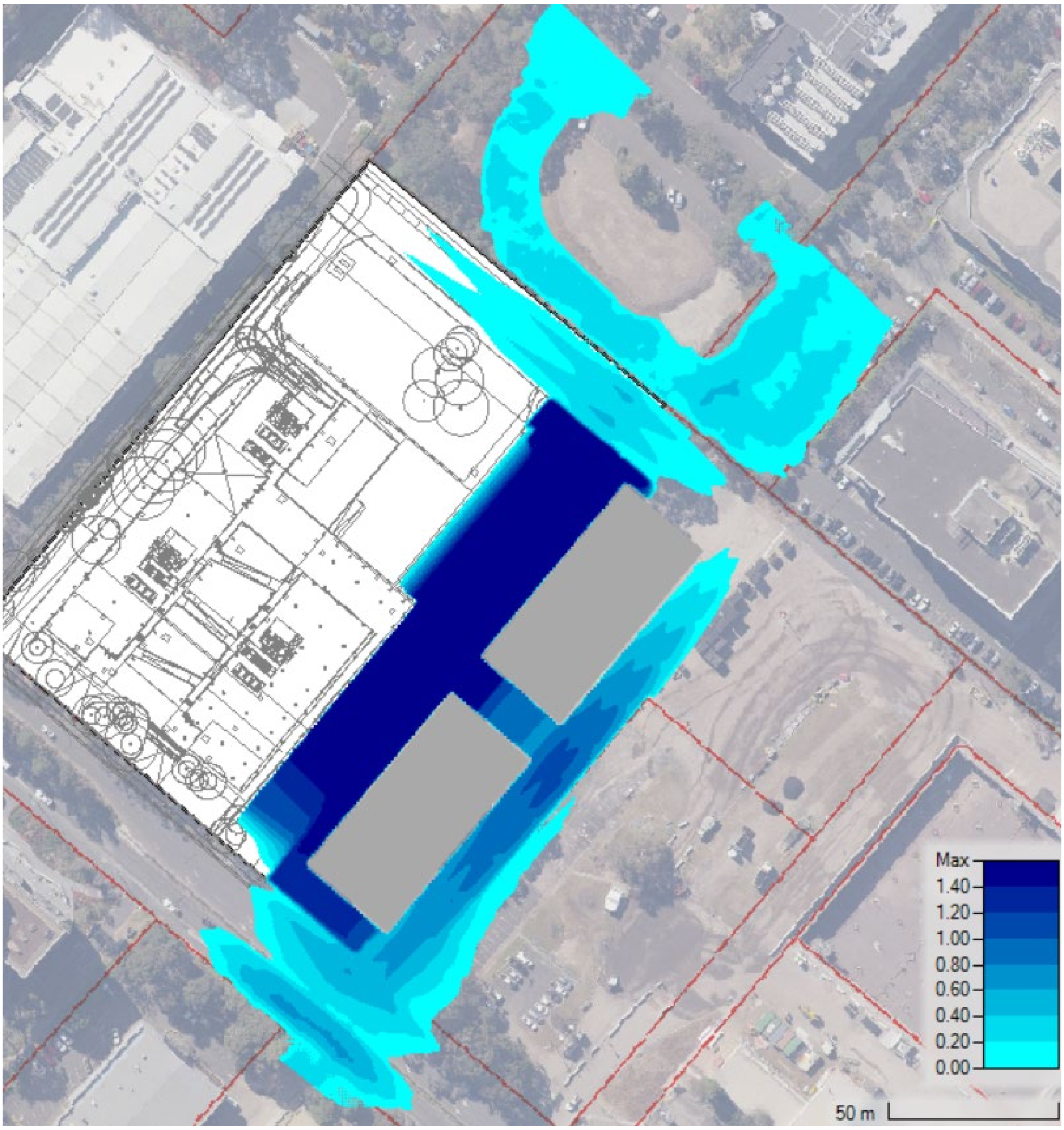

Figure 31 – 1% AEP, Post-development, 100% blockage, depth (m)

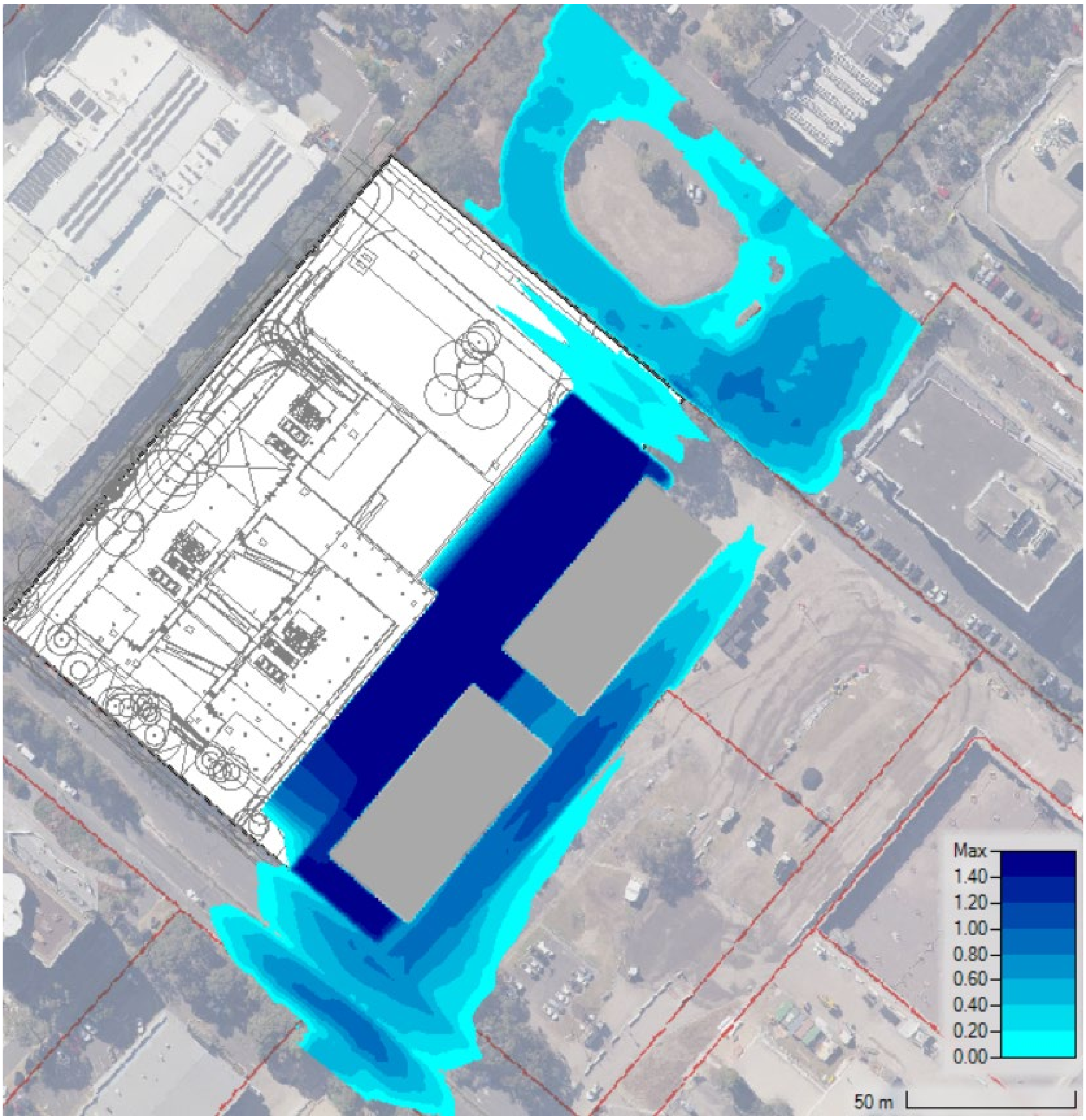

Figure 32 – PMF, Post-development, 0% blockage, depth (m)

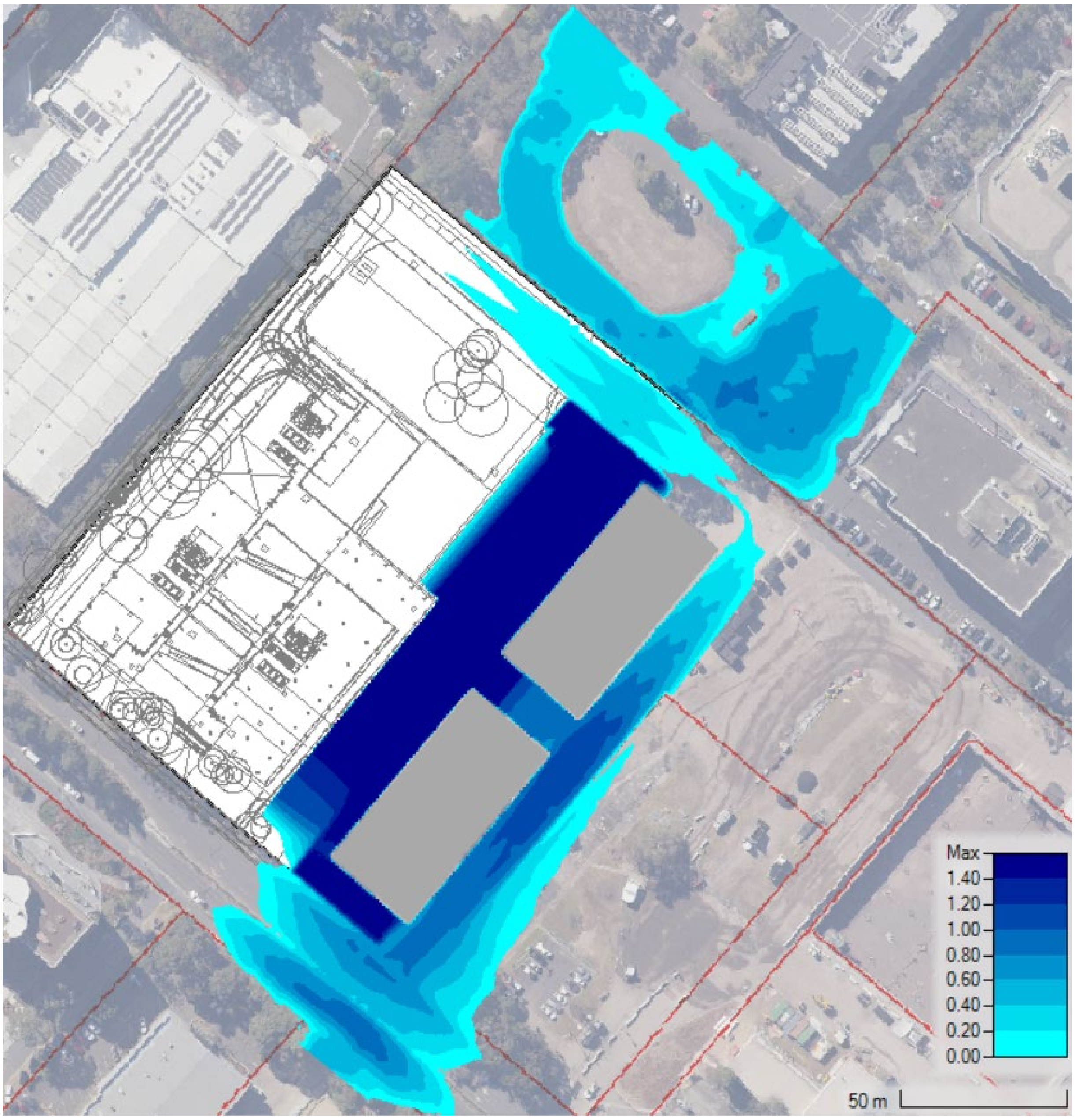

Figure 33 – PMF, Post-development, design scenario (20% blockage), depth (m)

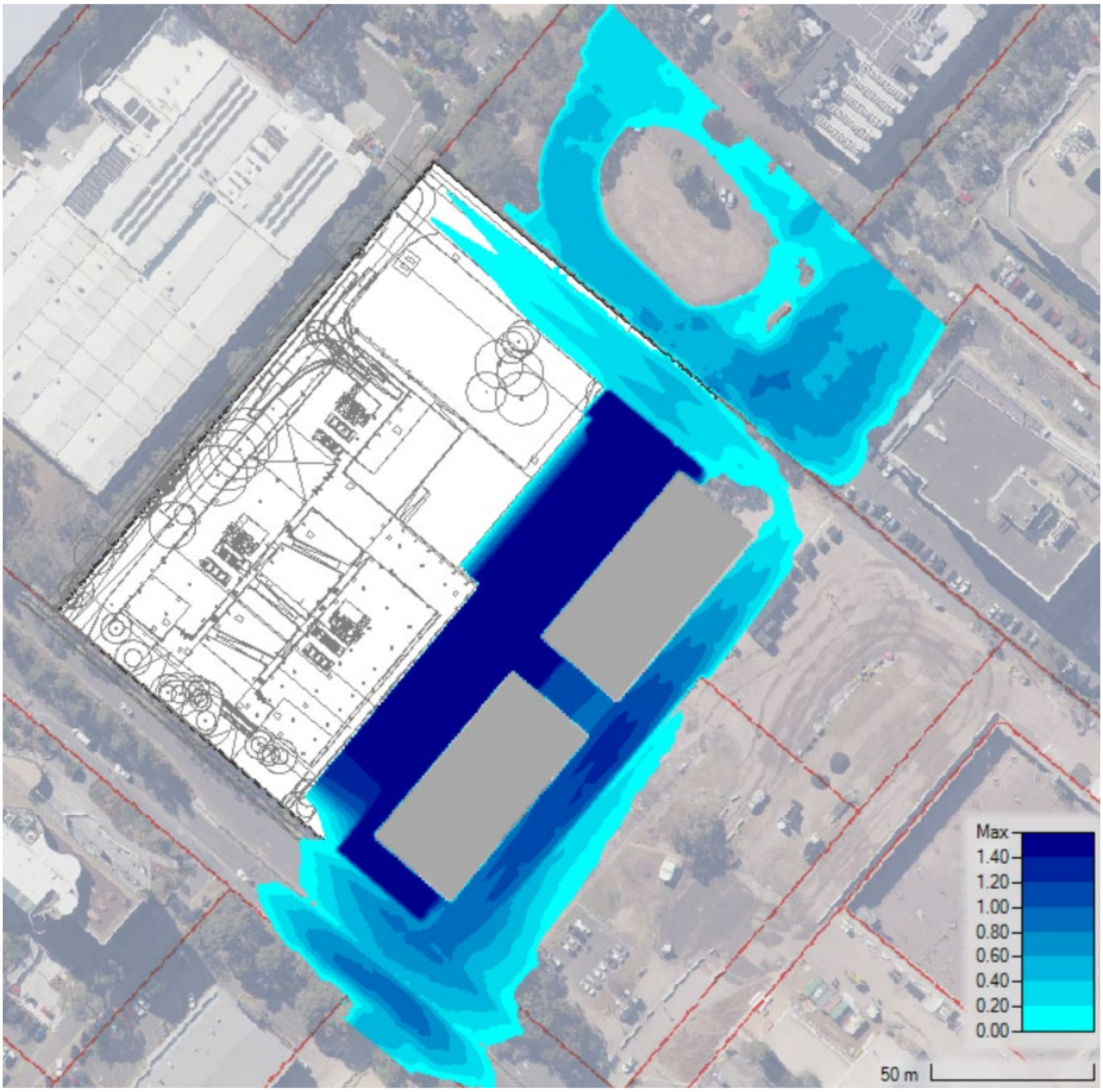

Figure 34 – PMF, Post-development, 50% blockage, depth (m)

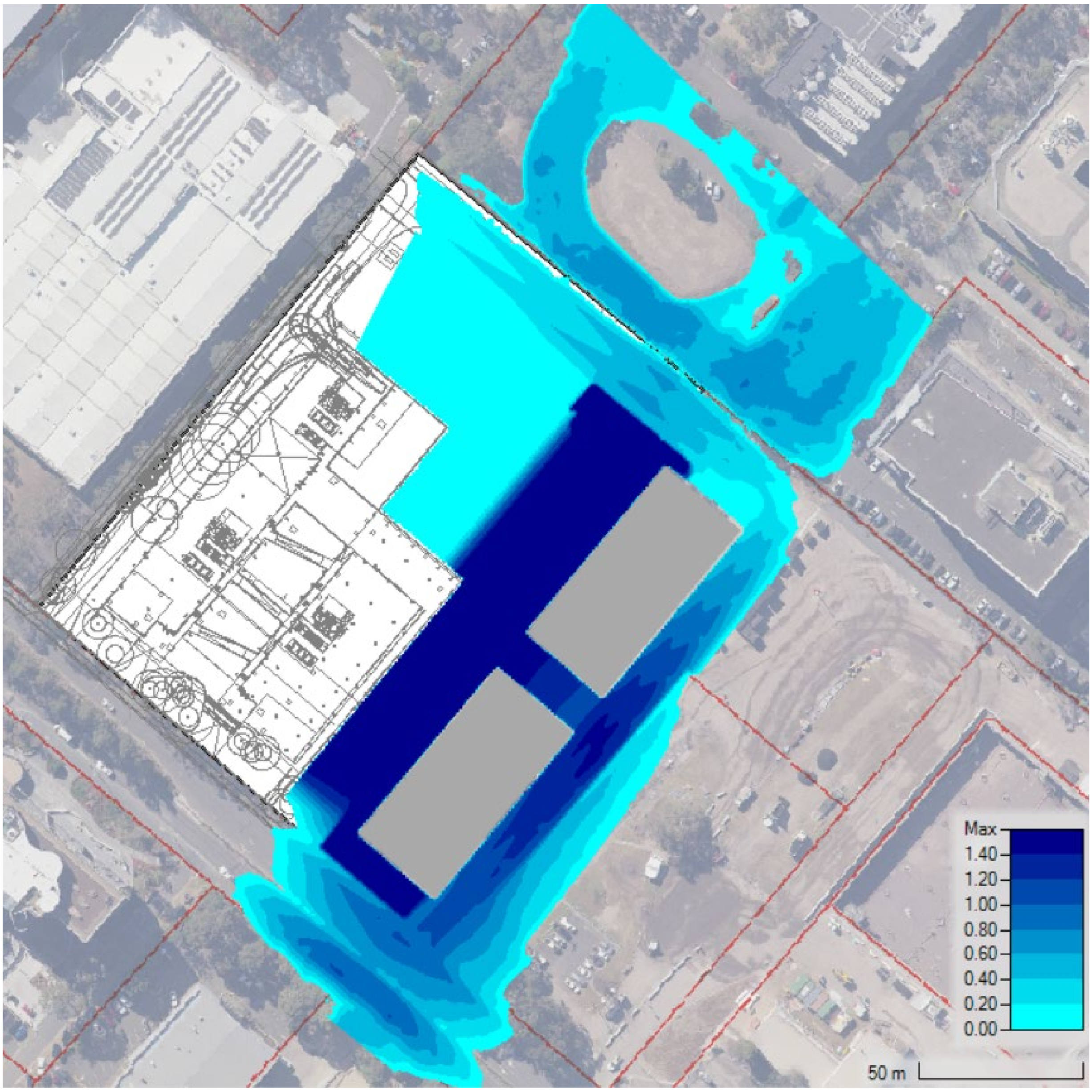

Figure 35 – PMF, Post-development, 100% blockage, depth (m)

Figure 36 – Proposed Cut Depths (m)