# Flood Impact Assessment Report

## Carrington Square
## 21-23 Victoria Avenue, Castle Hill

**Prepared for Blueprint Australia Planning Development Management** / 27 July 2023

191928 CAAC

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| PREPARED BY | APPROVED BY | STATUS | ISSUE | DATE |
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# 1.0 Executive Summary

Taylor Thomson Whitting (NSW) Pty Ltd (TTW) has prepared this flood impact assessment to support a Development Application for a proposed mixed-use multi-storey development at 21-23 Victoria Avenue, Castle Hill (the site). This report documents the procedures and findings of hydraulic modelling of the site in existing and proposed conditions in the 1% AEP and PMF events.

A request made to Council to provide the flood model for The Hills Urban Overland Flood Study (May 2017), however, TTW were advised that Council are unable to provide the flood model and associated output files.

Discreet parts of the model and results were provided by The Hills Shire Council, and these were used together with recent survey data and to prepare a hydraulic TUFLOW model for the site to assess the flood conditions of the site and its proximity in the existing conditions for the pre-development scenario.

## 1.1 Approved Predevelopment Flood Model

The pre-development flood model scenario and results were approved by Council on 5 July 2022. The approved flood model was then used as a basis for the site's flood assessment and updated to reflect the post development scenario. All other parameters of the model have not been changed.

A summary of the approved pre-development scenarios provided by council is shown in Table 1; *Flood Modelling Clarification and Responses to Council Comments, 5 July 2022*.

## 1.2 Post development Flood Model

The post development flood model results confirm that:

- The site is generally flood free during the 1% AEP flood event.
- Minor local overland flows on the site are very shallow and are of low hazard with no material overland flow entering the basement car park during flood events up to and including in the 0.2% AEP flood event.
- Proposed flood characteristics are largely consistent with existing site conditions.
- A minimum freeboard of 500mm is available for the lowest occupied commercial areas at 85.70m AHD. This is compliant with Council DCP which requires an FPL of 1% +500mm of freeboard for habitable commercial floors.
- Minimum building floor level is at 85.70m which is 300mm above the 0.2% AEP flood levels at 85.40m.
- Maximum flood levels reach 85.20m AHD over the low point of Victoria Avenue. The entrance to the basement car park level is RL85.70m and remains flood free in the 1% AEP.
- All openings and penetrations to the lower ground levels are to be protected up to 85.70m AHD (the 1% AEP flood level plus 0.5m freeboard).
- The proposed development (including ancillary structures, facades, stairs and barriers) will be constructed with flood compatible materials below RL 85.70m AHD which is the 1% AEP flood level plus 500mm freeboard.
- Flood refuge up to the PMF flood levels will be available on the proposed higher levels via internal stairs.

## Table 1 - summary of the approved pre-development scenarios provided by council (refer to Flood Modelling Clarification and Responses to Council Comments, 5 July 2022)

**Waterways Review Comments on Pre-Developed (Base Case) DRAINS and TUFLOW Models Submitted by Taylor Thompson Whitting (TTW)**
**4/2021/PLP Proposed Development at 15-23 Victoria Avenue, Castle Hill**

| *Key for Colour Coding of Comments* |
|---|
| Needs further action |
| Task completed |
| TTW response |

| Item | Minimum Requirements Based on | Council Review (20 April 2022) | TTW Response | Council Checks |
|---|---|---|---|---|
| ***A. THSC Comments/Action Items Emailed to TTW on 13 December 2021*** | | | | |
| 1 | Based on the attached survey pit 11S2132 invert is 79.98 mAHD (TTW TUFLOW model 80.37mAHD-~390mm difference) and pit 11S2133 invert is 80.37 mAHD (equal to TTW TUFLOW model). Please clarify if this is interpreted correctly. | Pit 11S2132 and 11S2133 invert level is 80.42 mAHD in the updated submission. TTW to confirm this is reflected as per the new survey levels.<br><br>This item is conditionally closed. | TTW confirm that the Pit invert level of 80.42 mAHD is consistent with the new survey. | This has been reflected in the new submitted models. |
| 2 | TTW TUFLOW Model; Pit 11S2132 and 11S2133 inlet type is set to "GrateA_0.2_GradeRd" (On-Grade pit type according to Council's UOFLS), however these are only junction pits (no flow intake) according to our site visit with TTW on 8/10/2021. See attached picture. Please clarify. | Pit 11S2133 Inlet type still remains as on-grade, it should be updated as junction pit type. No inflow intake is expected via this pit.<br><br>Refer to the "Figure A1" tab for further details. | 1D network in TTW TUFLOW model was modified to address the issue. | This has been reflected in the new submitted models. |
| 3 | What is the source of data for the downstream invert levels at the outlet of the pipes (11C2132A and 11C2133A) at the creek? Provided survey data does not extend to this location. | TTW to confirm the levels are updated as per the new site survey.<br><br>This item is conditionally closed. | TTW confirm that the levels are updated as per the new survey. | This has been reflected in the new submitted models. |
| 4 | What is the source of data for the invert level of pits on the opposite side of Victoria Avenue? (Pit IDs:11S21203, 11S1200, 11S120 and 11S1202). | TTW to confirm the levels are updated as per the new site survey.<br><br>This item is conditionally closed. | TTW confirm that pit & pipe invert levels are updated in line with the new survey. | This has been reflected in the new submitted models. |
| 5 | The TTW submission (dated 23/11/2021) pit inlet curves under 1D-bcdbase model folder are zero blockage curves (older data), please confirm that TTW has used the updated inlet curves provided by Council on 27/10/2021. | TTW to confirm that the model has since been updated with the representative blockage, i.e. using the latest pit inlet curves.<br><br>This item is conditionally closed. | TTW confirm that the pit blockage factors in the model are consistent with the blockage curves provided by Council on 27/10/2021. | This has been reflected in the new submitted models. |
| ***B. THSC Comments/Action Items Sent to TTW on 14 September 2021*** | | | | |
| 6 | It is recommended that the DRAINS modelling option be considered for analysis and design of the drainage system. | The submitted DRAINS model appears to have not been updated with the latest survey and CCTV information.<br><br>The pipe flows through the site are significantly different in the DRAINS model compared to the TUFLOW models. For example, peak flows in pipe 11C01814 are estimated to be 6.08 $m^3/s$ and 2.17 $m^3/s$ in TUFLOW and DRAINS, respectively. Differences between the models are expected to be within +/- 20% tolerance.<br><br>The baseline TUFLOW model should be compared against the DRAINS model. An updated DRAINS model will need to be submitted to reflect the changes based on CCTV and survey.<br><br>Refer to "Figure A2" tab for further details. | TTW DRAINS model is now updated based on latest survey data. The results of TTW TUFLOW model agree well with the results of TTW DRAINS model and are within +/- 20% tolerance (refer submitted report) | Resolved. |
| 7 | The model shall be run for a range of storm durations sufficient to identify the critical duration. | Results provided. This item is closed. | | |
| 8 | TUFLOW model to be updated with the pit blockages recommended by THSC Stormwater and Waterways Design. | It appears that this has been updated. TTW to confirm by adding text in the report.<br><br>This item is conditionally closed. | TTW confirm that the pit blockage factors in the model are consistent with the blockage curves provided by Council. (also mentioned in the submitted report). | Resolved. |
| 9 | Large commercial/industrial buildings located within or adjacent to an overland flow path should be represented in the TUFLOW model using a completely impervious "wall" along the upstream face of each building and leaving a break in the wall to allow water to enter. This approach is shown conceptually in the "Attachment 2" Tab, wherein the downstream wall of the building was left open to allow rain falling on the building to "runoff" and contribute to catchment runoff. | TTW to confirm that the submitted model is updated using the approach.<br><br>This item is conditionally closed. | TTW confirm that the building outlines extracted from Council's UOFS (2d_zshape file) were used to define the building blockages and consistent with recommended method by Council. | Resolved. |
| 10 | 2D cell size to be modified so as to reasonably represent the terrain. Furthermore, as is the case within an urban environment, consideration of narrow overland flowpaths (such as between buildings and permanent obstructions) should ensure the minimum cell size is carefully chosen to represent the ground conditions appropriately. A 1 metre cell size is recommended for the proposed development unless a larger grid size is justified. | A 2m cell is used in the TTW model. TTW to confirm and justify that a 2m cell size used in the model is sufficiently representing the terrain. Adding a section to the report would be adequate. | The grid cell size of 2m2 is considered to be sufficiently fine to appropriately represent the variations in topography and land use within the study area. It should be noted that TUFLOW samples elevation points at the cell centres, mid sides and corners, therefore a 2 m2 cell size results in surface elevations being sampled every 1m. | Resolved. |
| 11 | Model verification and establishing the pre-developed models have to be completed to satisfy the minimum requirements. Following are the minimum requirements.<br>i. Carry out peak flows comparison against the results from the UOLFS. The limits of the agreement are ±20% of UOLFS peak flows;<br>ii. Carry out flood level/depths comparisons against the results from UOLFS. The limits of the agreement are ±20% of UOLFS depths; and<br>iii. The Consultant shall obtain Council's concurrence on the verification outcome prior to proceeding with the design (post-developed case) run for the TUFLOW model. | This item is still outstanding. The submitted report missing any discussion of model verification. | Model verification was carried out and outcomes added in the report. It is important to note that the TTW TUFLOW model was updated with latest site-specific survey data which somehow differs considerably from the UOFS data. The data difference between TTW TUFLOW model, TTW DRAINS model and UOFS are summarised in the attached report. | Resolved. |
| ***C. Additional Comments*** | | | | |
| 12 | The Model DEM (*TTW220301b_Pre_G2m_100yr120min_DEM_Z.flt*) shows a spike where elevation reaches up to 4,350 mAHD at the outlet of the culverts. The error appears to have come from an incorrect elevation point in the 2d_zsh files. This leads to an incorrect representation of flood behaviour leaving some part of the area dry at the outlet which should normally be wet.<br><br>Refer to the "Figure A3" tab for further details. | DEM to be revised by rectifying the error. TUFLOW model to be updated with the revised DEM. | TTW TUFLOW model surface was modified at that area to address the issue. | Resolved. |

# 2.0 Introduction

Taylor Thomson Whitting (NSW) Pty Ltd has been engaged by Blueprint Australia Planning Development Management to prepare a Flood Impact Assessment Report in accordance with the Hills Shire Council requirements to support a Planning Proposal for the proposed mixed-use multi-storey development at 21-23 Victoria Avenue, Castle Hill.

The report provides an assessment on flood conditions of the site and summarises the flood modelling results for the Council approved existing and proposed post-development conditions in the 1% AEP and PMF events. The report also provides an impact assessment on neighbouring properties due to the proposed development.

## 2.1 Project Objectives and Methodology

Project scope and objectives are as follows:

- Prepare a detailed hydraulic model (TUFLOW) to suitably reflect the site's flood conditions in the predevelopment and post-development states.
- Determine site flood characteristics for the 1% annual exceedance probability (AEP) flood and probable maximum flood (PMF) events.
- Prepare relevant flood maps including flood extents, depths, levels, velocities, hazards and impacts.
- Comment on the site's flood characteristics and model outcomes in the existing and proposed conditions.
- Confirm that the proposed development is compliant with the Council's flood planning requirements as detailed in The Hills Shire Council Development Control Plan (DCP), 2012; Part C, Section 6 - Flood Controlled Land.

## 2.2 Reference Documents

This report has been prepared in accordance with the following guidelines and policies:

- Australian Rainfall and Runoff Data (2019) with AR&R (2016) rainfall datasets sourced from BoM.
- Australian Rainfall and Runoff (2016) – A Guide to Flood Estimation.
- NSW Department of Infrastructure, Planning and Natural Resources (2005), Floodplain Development Manual.
- The Hills Shire Development Control Plan (DCP, 2012)
- The Hills Shire Local Environment Plan (LEP, 2019)
- THSC Design Guidelines for Subdivision and Developments (2011).

## 2.3 Site

The site is located at 21-23 Victoria Avenue, Castle Hill and is within The Hills Shire Council Local Government Area, as shown in Figure 1.

The site is bordered by Victoria Avenue to the west, Salisbury Road to the north and Carrington Road to the south. The site in existing conditions is fully developed with commercial / industrial development and surrounded by similar commercial and industrial developments. Cattai Creek is located approximately 450m to the east of the site and flows north towards the Hawkesbury River.

The site generally falls from west to east with a natural depression between the two existing buildings within the southern half of the site. Existing levels are 87.70m at the southwest corner, 89.00m at the southeast corner, 90.70 at the northwest corner and 87.80 at the north east corner. Levels at the depression of the site are 85.20 at the eastern boundary, and 85.00 at the western boundary.

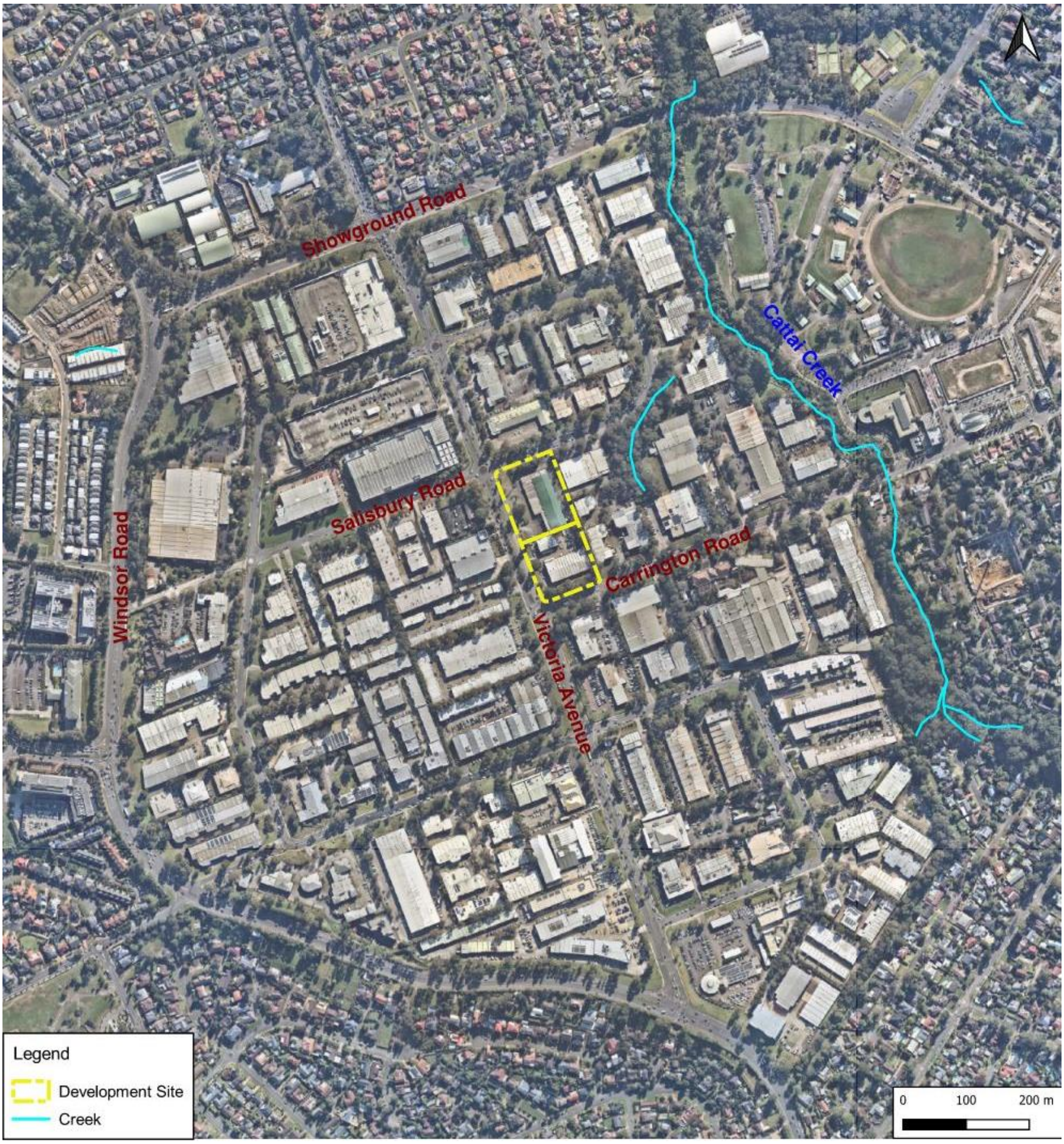


Figure 1 - Site Location and Surrounding area (Six Maps)

# 3.0 Proposed Development

Architectural plan prepared by BatesSmart (July 2023) indicate that the proposed is a multi-storey mixed-use commercial development including two building blocks linked by 20-25m wide linear park which provides pedestrian connectivity, overland flow, and outdoor amenity.

Northern block includes:

- Two lower ground level car parks on level B1 (RL83.4m) and level B2 (RL80.4m) with vehicle access through Victoria Avenue (entrance level of 86.26m) as well as through Salisbury Road (entrance level of 87.7m).
- Retails on level 00 (RL 86.4) and level 01 (RL 91.4) including loading a dock on level 00.
- a proposed childcare on level 01.
- Upper ground car parks (levels 02 to 06).

Southern block includes:

- Two lower ground level car parks on level B1 (RL79.7m) and level B2 (RL82.7m) with vehicle access through Carrington Road.
- Retail and business premises on level 00 (RL88.5m & RL85.7).
- Upper level commercial / business spaces (levels 01 to 11).

The proposed ground floor (level 00), lower ground floor car park plans provided by Bates Smart as shown in Figure 2, Figure 3 and Figure 4 respectively.

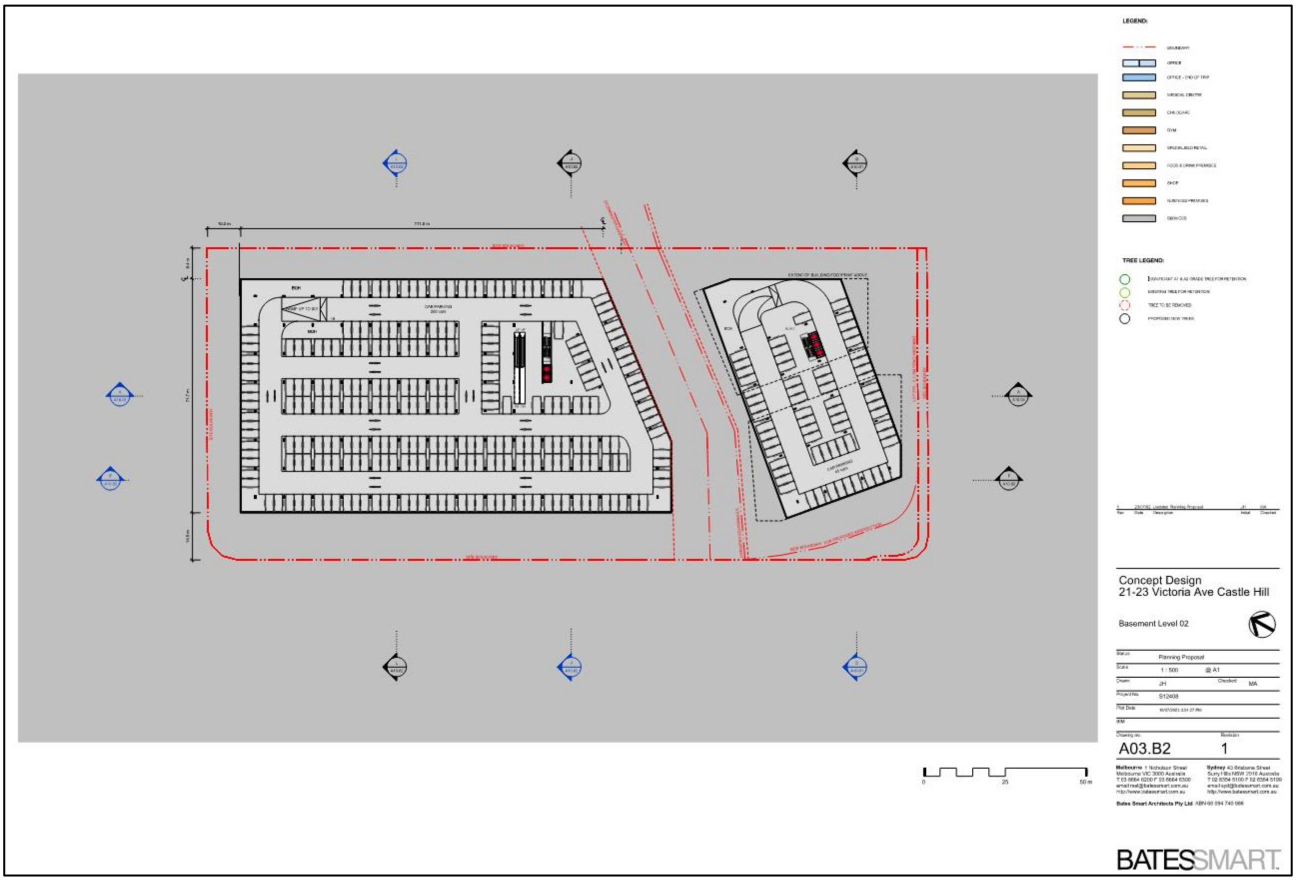


Figure 2 – Proposed Architectural Plan (Level B2)

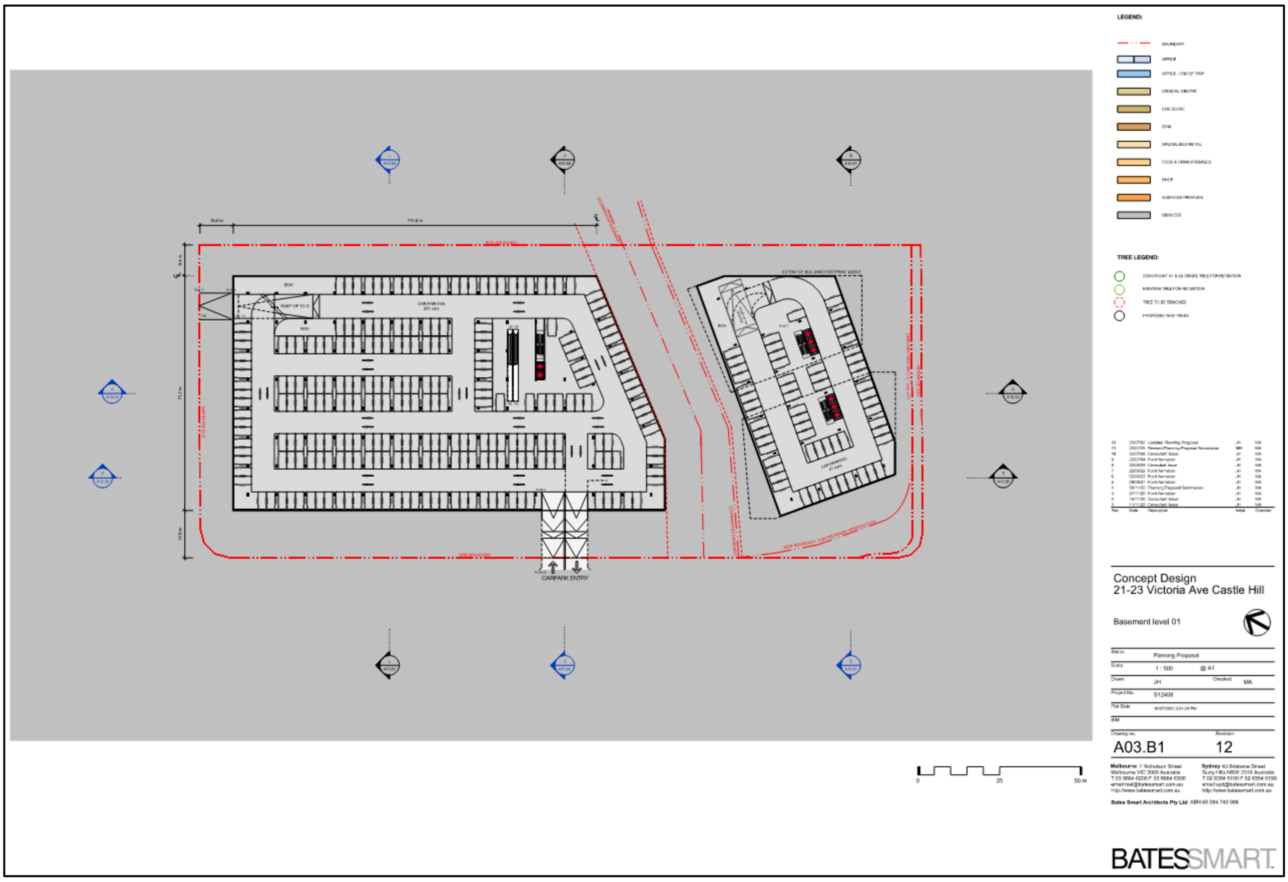


Figure 3 – Proposed Architectural Plan (Level B1)

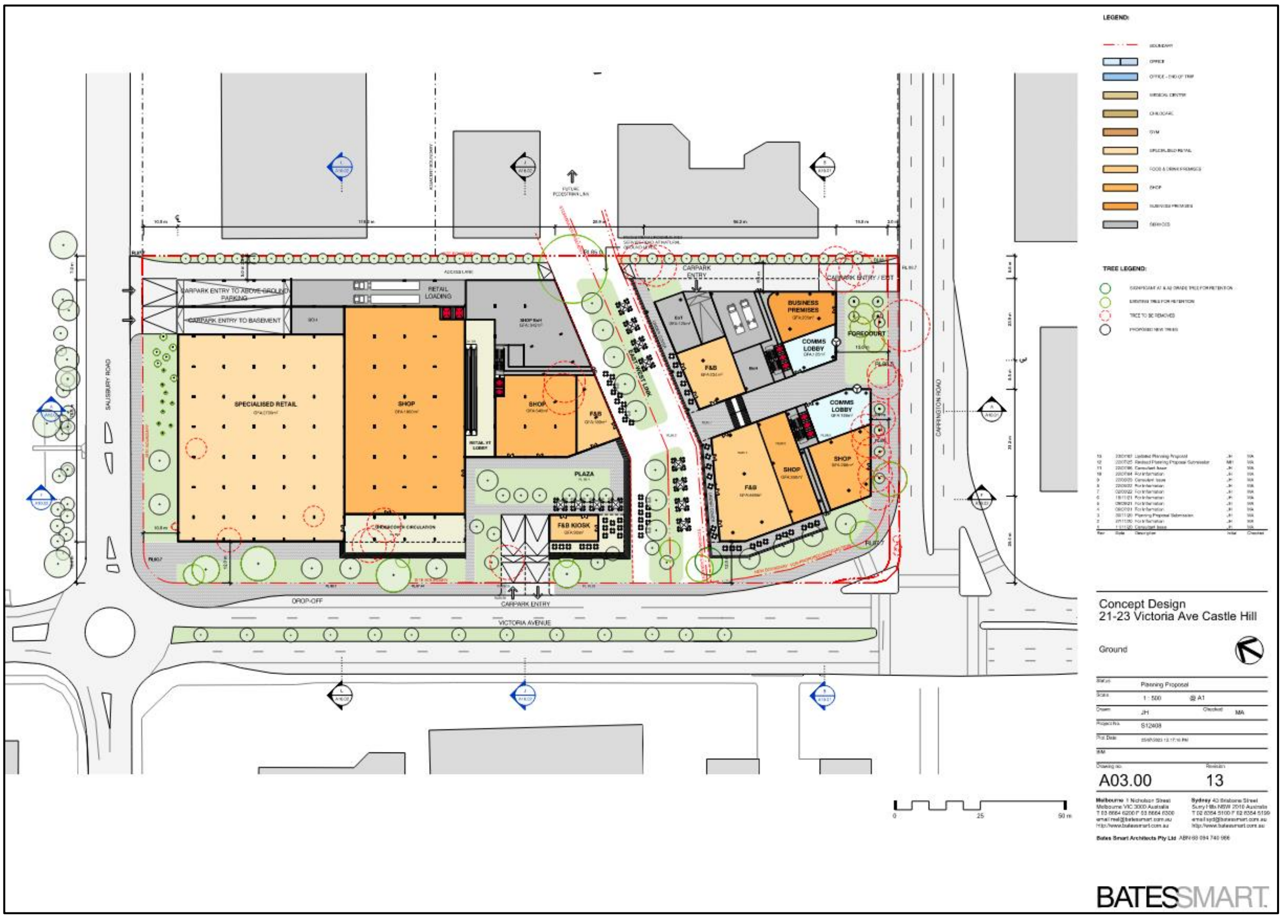


Figure 4 – Proposed Architectural Plan (Level 00)

# 4.0 Available Data

The site falls within the Cattai Creek Catchment which is a sub-catchment of Hawkesbury River Catchment. Catchment Simulation Solutions (CSS) have conducted a flood study for The Hills Shire Council and summarised the outcomes in The Hills Urban Overland Flow Study (May 2017) which is referred to as UOFS in this report. As part of the study, CSS have developed a flood model for the Hills Shire catchments which covers the subject site.

Despite a request made to Council for providing a copy of The Hills Urban Overland Flow Study and model, TTW were advised that the flood report is not publicly available, and Council is unable to provide the flood model and associated output files at the time the request was made. However, Council provided the following flood modelling data to help setting up a hydraulic TUFLOW model for the site in line with UOFS:

- Ground Surface Digital Elevation Model (DEM) data for the extent of the catchment
- Surface materials files
- Rainfall data
- Existing stormwater pit and pipe network GIS and database
- Pit inlet curves (.csv files)
- Map of the 1% AEP flood result extents and flood surface levels to the nearest 0.1m (PDF version).

# 5.0 Hydraulic Flood Model

TUFLOW software was used to develop a dynamic 1d/2d hydraulic model as part of the study. TUFLOW engine version 2013-12-AB-w64-iDP was used to maintain consistency with the UOFS Model.

## 5.1 2D Model Domain

The site upstream catchment delineated using Lidar data. Model boundary extents were generally placed along catchment ridgelines and / or connecting catchment high points surrounding the study area. Total model domain area is 183 ha (approx.). The catchment area is shown in Figure 5.

### 5.1.1 Ground surface elevations

Ground surface elevations were assigned to grid cells within the TUFLOW model based on the elevations data extracted from hydraulic model of The Hills Urban Overland Flow Study (May 2017) as received from Council.

### 5.1.2 Model Cell Size

A square grid was utilised for this study, with the grid size of 2m x 2m. The grid cell size of $2m^2$ is considered to be sufficiently fine to appropriately represent the variations in topography and land use within the study area. It should be noted that TUFLOW samples elevation points at the cell centres, mid sides and corners, therefore a $2m^2$ cell size results in surface elevations being sampled every 1m.

## 5.2 Hydraulic Roughness

The hydraulic roughness of a material is an estimate of the resistance to flow and energy loss due to friction between a surface and the flowing water. A higher hydraulic roughness indicates more resistance to the flow. Roughness in TUFLOW is modelled using the Manning's (n) roughness co-efficient.

Manning's zones were based on the UOFS model data as provided by Council.

## 5.3 1D Model Domain

Detailed stormwater pit and pipe data was provided by the Hills Shire Council for the extent of the catchment and incorporated into the 1d network within the TUFLOW model as shown in Figure 5.

### 5.3.1 Pit Inlet Curves and Blockage Factors

Pit inlet curves were introduced to the 1d model based on the UOFS data (.csv files) as received from Council and factors for 20 and 50 percent blockage at grade and sag pits respectively.

## 5.4 Boundary Conditions

### 5.4.1 Inflow Boundary

The direct rainfall method was used for this study to apply rainfall directly to all cells within the study area, with runoff routed across the 2d domain and conveyed within the 1d hydraulic network. UOFS rainfall information was obtained from the Council and incorporated into the model.

Upstream inflows were incorporated into the model by way of flow hydrographs. Location of upstream inflows to the model domain are shown in Figure 5.

### 5.4.2 Downstream boundary

Downstream boundary was defined approximately 600m downstream of the site (downstream of the existing culvert headwall under Showground Road). Stage-discharge (water level versus flowrate) curve was adopted for the downstream boundary condition. The stage-discharge relationship was generated by TUFLOW by specifying downstream water surface slope. Location of downstream boundary is shown in Figure 5.

## 5.5 Building Footprints

The UOFS model defines the existing buildings by way of introducing high roughness coefficients. Therefore, the impact of existing buildings on overland flows will be included in the model through incorporating the obtained surface materials files from Council.

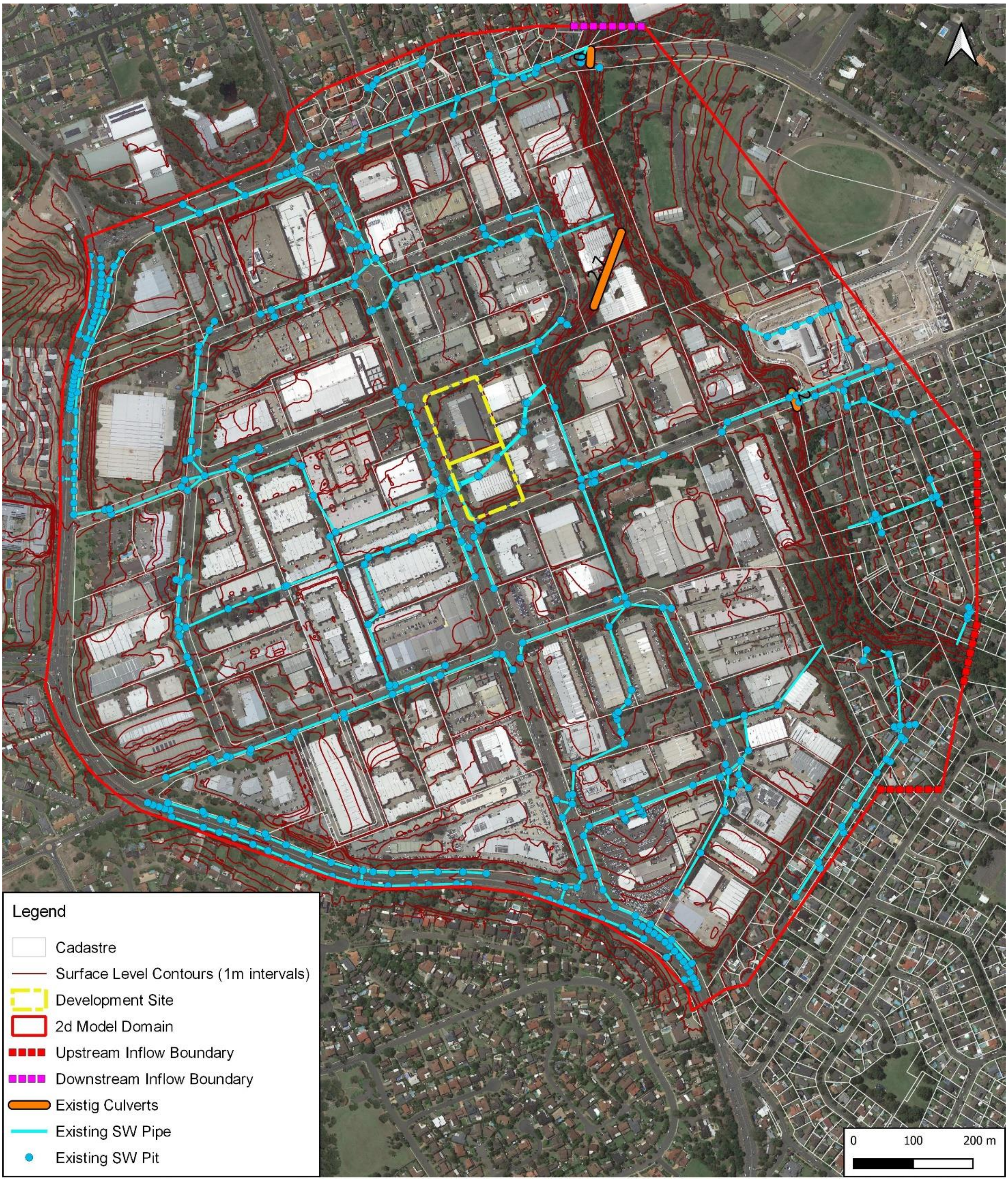


Figure 5 – TUFLOW 1d / 2d Model Domain

# 6.0 Critical Storm Event Durations

The model was run for a range of 1% AEP flood durations as well as for a range of PMF durations to determine the site critical storm durations. The critical 1% AEP and PMF storm durations for the site were determined to be 120 minutes and 30 minutes, respectively. The 1% AEP flood results for various storm durations are compared in Table 2.

Table 2 – 1% AEP Flood Results – 1D & 2D Peak Flows at the Site

| 1% AEP Storm Duration | Combined Pipe Flow in twin 1800 pipes (cu.m/s) | Overland Flow across Victoria Avenue (cu.m/s) | Peak Flood Level on site (m AHD) |
|---|---|---|---|
| 30 minutes | 8.346 | 4.47 | 85.425 |
| 45 minutes | 8.267 | 4.30 | 85.094 |
| 60 minutes | 8.811 | 6.05 | 85.517 |
| **120 minutes** | **9.212** | **7.16** | **85.549** |
| 180 minutes | 8.412 | 4.46 | 85.466 |
| 360 minutes | 7.964 | 3.04 | 85.441 |

Figure 6 also shows the 1% AEP peak flood levels envelope which indicates that the critical storm duration is 120 minutes for the site.

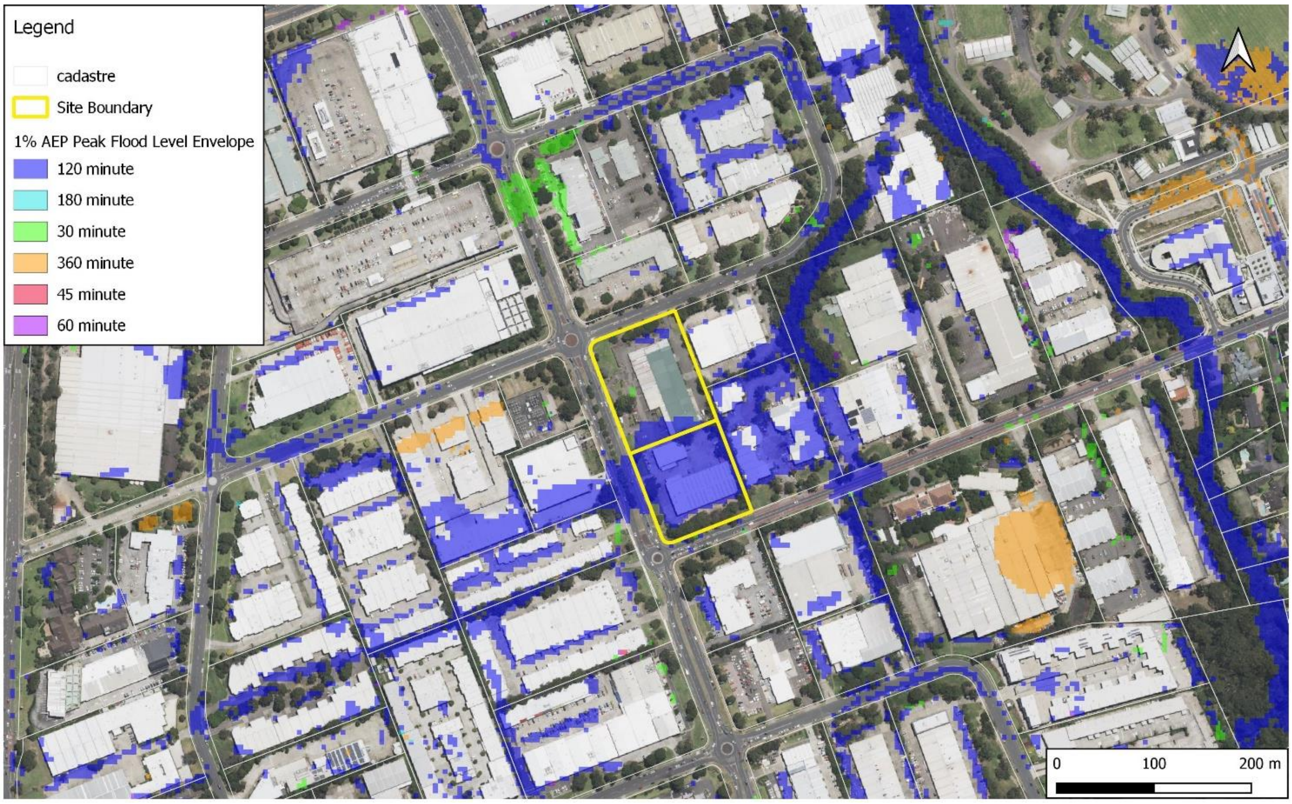


Figure 6 – 1% AEP Peak Flood Level - Envelope Results

# 7.0 Flood Model Validation

In order to carry out a detailed assessment of stormwater pipe flows, overland flows, and flow depths across the site and also understand the potential flood impacts associated with the proposed development, it is first necessary to confirm flood behaviour for existing (i.e., pre-development) conditions.

The TTW existing model was produced based on available data as received from Council. Hence, the TTW model is to be validated based on UOFS model results.

## 7.1 TTW Model – Existing Conditions

The TTW existing model was produced based on available data as received from Council (refer Section 4.0 & Section 5.0).

A comparison between the TTW existing flood model results and UOFS results was carried out for various locations as requested by Council. The locations of comparison are shown in Figure 7 and include the following:

- Peak flow rate onto the site from Victoria Avenue (XS-1).
- Peak Flow rate at the downstream Creek (XS-2).
- Peak flow rate in the existing twin DN1800 pipes through the site.
- Maximum Flood level and depth at the observation point onsite.

The TTW flood extent is also shown to be similar to the UOFS model results as shown in Figure 7. The TTW flood model has a peak 1% AEP (2 hours) flood level within the site of just under RL85.55m which is approximately 50mm higher than the Council results and considered within Council's acceptable limit of +/- 20%.

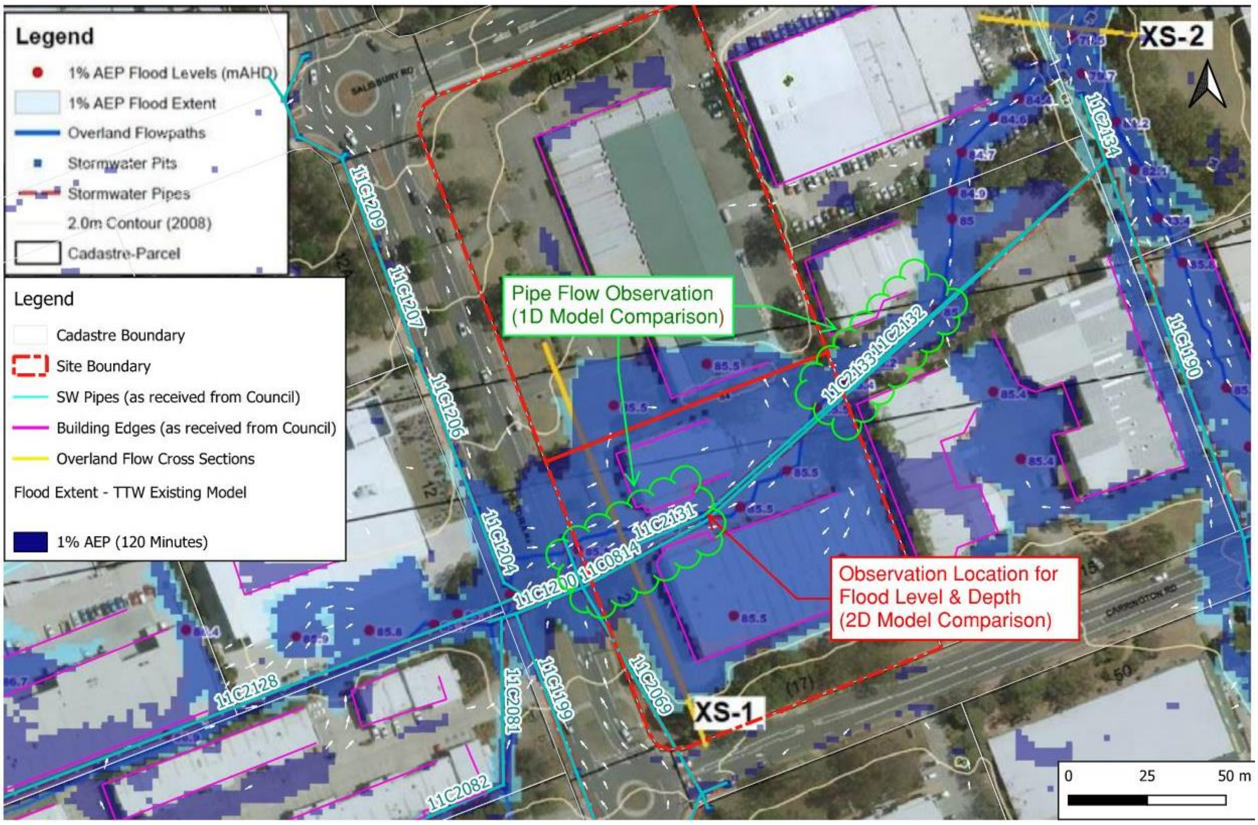


Figure 7 – Flood Comparison locations (1D & 2D) – Overlaid Council's Flood Map Received on 28/11/2021

TTW also prepared a DRAINS model using available data from Council for further comparison to validate the TTW existing TUFLOW model. Figure 8.shows a screenshot of the DRAINS model for the existing site conditions and the results for the 1% AEP (2hrs) storm event.

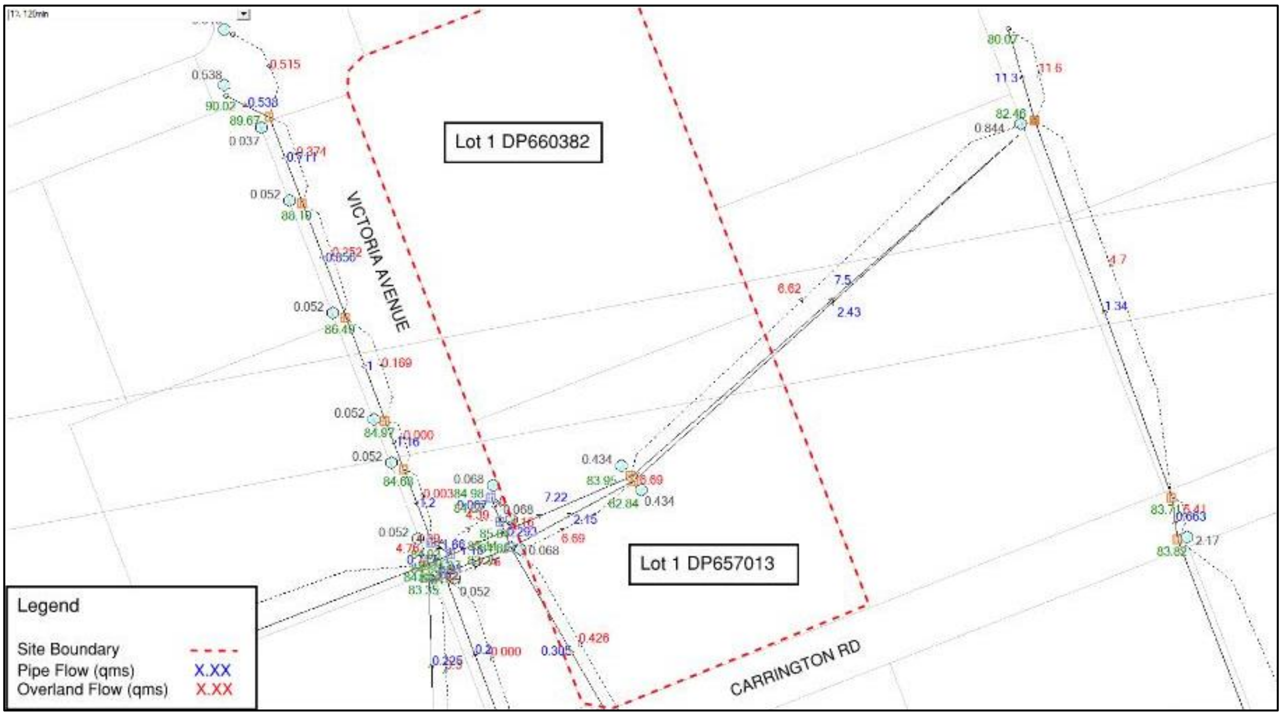


Figure 8 – DRAINS Model Results – 1% AEP (2 hours) Event – Existing Site Conditions

- The comparison between the UOFS, TTW Existing scenario model and TTW DRAINS model is summarised in Table 3 below.

Table 3 – 1% AEP Flood Results Compared with the UOFS

| Location | Council UOFS | TTW Existing Scenario | % Diff to UOFS | TTW DRAINS Model | % Diff to UOFS | % Diff Between TTW DRAINS Model and TTW Existing Scenario |
|---|---|---|---|---|---|---|
| **Pipe Flow 11C2131** | 5.61 | 5.43 | -3.07 | 7.22 | 22.35 | 24.74 |
| **Pipe Flow 11C0814** | 3.84 | 3.95 | 3.00 | 2.15 | -78.51 | -83.86 |
| **Total** | **9.44** | **9.39** | **-0.07** | **9.37** | **-0.79** | **-0.18** |
| **Pipe Flow 11C2132** | 5.77 | 5.28 | -8.36 | 7.50 | 23.13 | 29.56 |
| **Pipe Flow 11C2133** | 3.87 | 4.17 | 7.92 | 2.43 | -59.05 | -71.65 |
| **Total** | **9.63** | **9.45** | **-1.83** | **9.57** | **-0.63** | **1.21** |
| **Overland Flow XS-1** | 9.50 | 7.65 | -19.48 | 6.69 | -42.00 | -14.33 |
| **Overland Flow XS-2** | 15.40 | 19.27 | 25.10 | 22.90 | 32.75 | 15.87 |
| **Overland Flow Leaving the site (via Eastern Boundary)** | N/A | 5.64 | N/A | 7.02 | N/A | 19.63 |
| **Flood Depth at Site (Measured over Pit 11S2132)** | 632mm | 717mm | 13.4 | N/A | N/A | N/A |

The comparison confirms that the TTW Existing scenario model and DRAINS model closely match the UOFS results for the 1% AEP event and are within the Council limit of agreement of +/- 20% difference. The following points are notable in relation to the flow rate observations at XS-1 & XS-2:

- Based on the TTW Existing Model the peak overland flow onto the site from Victoria Avenue (XS-1) is 7.65 $m^3/s$ which is 19.48% lower than that of reported by the Council UOFS Model (9.5 $m^3/s$). However, TTW DRAINS model results confirm that the peak flow from Victoria Avenue onto the site is 7.26 $m^3/s$ which agrees well with that of reported by TTW Existing Model (variation of 5.36%).
- The downstream observation line (XS-2) is located across the Cattai Creek tributary which is a main drainage line to a relatively large catchment. Therefore, the estimated flowrates at XS-2 are not merely showing the flows from the site catchment. Therefore, an additional flowrate observation was defined along the site western boundary to measure the overland flows leaving the site.
- Council notes that their reported peak flows are sourced from Council's Draft Urban Overland Flow Study with help of the WaterRIDE tool and therefore, may not be 100% accurate.

# 8.0 Flood Model Updates (Existing Conditions)

To ensure that the TTW flood model accurately represents the existing flood behaviour, the existing scenario model was further updated to include additional survey and pipe investigation data based on the latest site survey as completed by LTS (January 2022). The following updates applied to the TTW existing model based on the latest survey data:

- New surface tin provided by LTS was merged with previous site survey data as well as with the DEM surface of UOFS received from Council and incorporated into the TUFLOW model to represent the existing model surface. The existing model surface is comprised of:
    - UOFS surface DEM (as provided by Council),
    - Previous site survey data,
    - Latest survey of the overland flow path for the extent of Victoria Avenue all the way to the existing headwalls at downstream Creek.

Hence, the model surface includes all existing topographic surface features e.g., ridges, berms, retaining walls, etc.

- Existing pit & pipe network (1D model) from Victoria Avenue to the downstream discharge headwalls was updated based on the latest survey and CCTV data.

The following modelling factors were also implemented as per confirmed by Council:

- The model grid cell size of $2m^2$ was retained.
- Existing building outlines were represented as blockage on the upstream face of buildings, and an open building face on the downstream wall to allow water to be stored in the building and to allow direct rainfall to escape. Building outlines were provided by Council as 2d_zshape files (extracted from UOFS model) as shown in Figure 9.

The site flood assessment was carried out for the critical storm duration of 2 hours (as described in Section 6.0).


Figure 9 – Existing Building Outlines in TUFLOW Model

In addition, the TTW DRAINS model was updated in line with the TTW TUFLOW model and in accordance with the data provided by Council as well as the latest survey data provided by LTS (January 2022). Figure 8 shows a screenshot of the DRAINS model for the existing site conditions as updated and the results for the 1% AEP (2hrs) storm event. Refer updated DRAINS model as provided for more details.

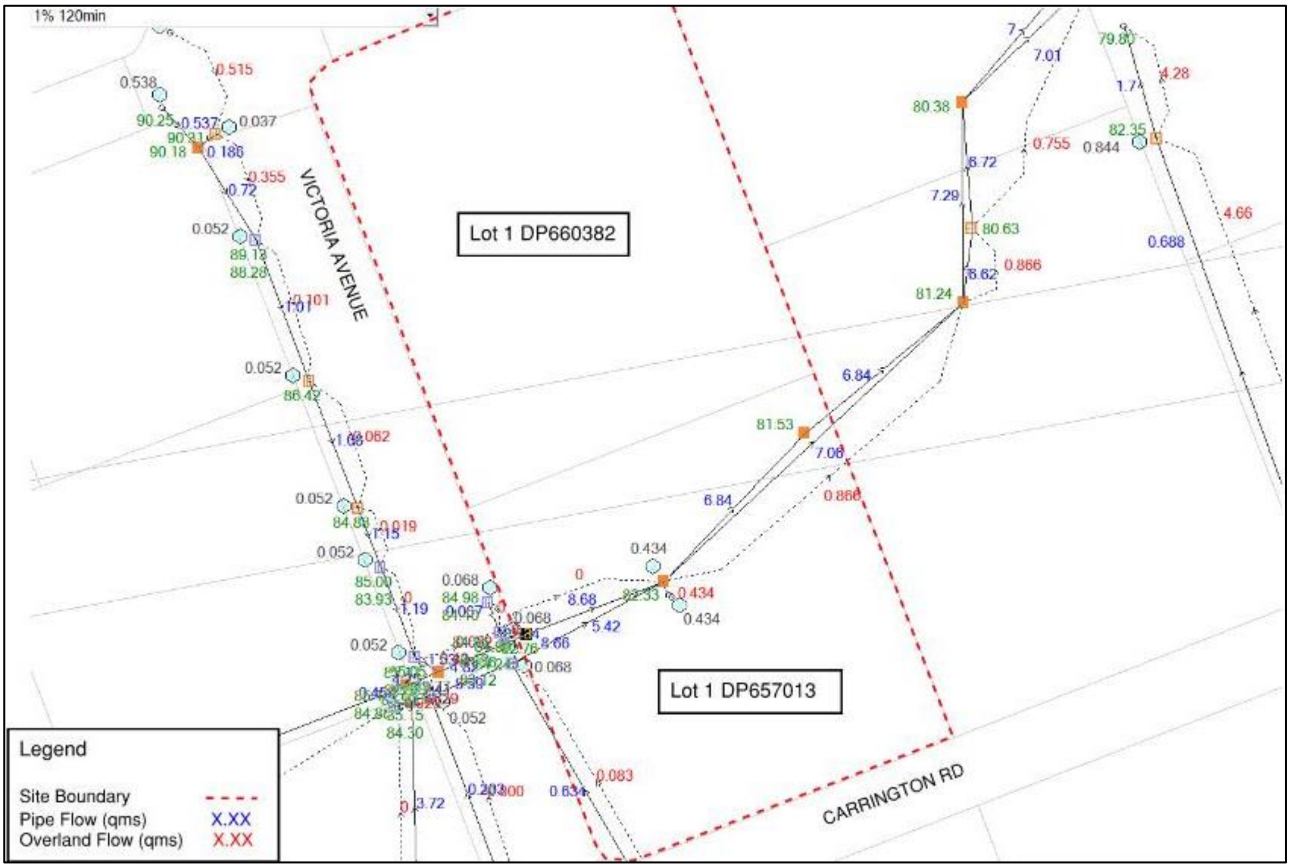


Figure 10 – DRAINS Model Results – 1% AEP (2 hours) Event – Existing Site Conditions (as updated)

## 8.1 Flood Model Results Comparison (Updated TTW Model – Existing Conditions)

A comparison has been made of the UOFS, TTW TUFLOW and TTW DRAINS model for the existing scenario. The comparison (pipe flow & overland flow) was carried out at the locations as defined in flood model validation stage (refer Section 7.0).

The TTW flood extent overlay on the UOFS model results and locations of comparison are shown in Figure 11.

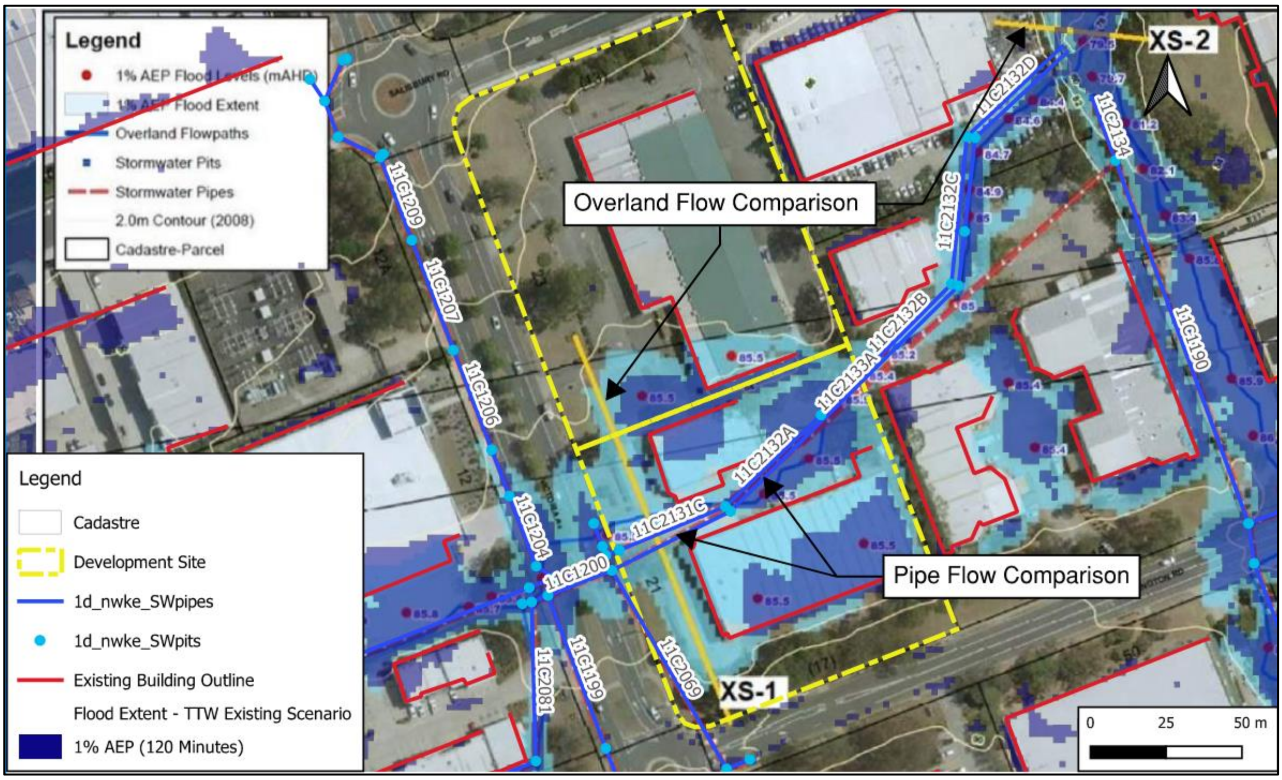


Figure 11 – Flood Comparison locations (1D & 2D) – Overlaid Council's Flood Map Received on 28/11/2021

However, further to Council's comments received on 4 May 2022, additional comparison locations were included to compare the existing flood results between the TTW models and Council's UOFS. These flow locations are shown in Figure 12, with the tabulated flood model results comparison between the UOFS, TTW TUFLOW and TTW DRAINS models for the existing scenario as detailed in

Table 4.


Figure 12 – Flood Comparison locations (1D & 2D) – Based on Email from Council on 04/05/2022

Table 4 – 1% AEP Flood Results Comparison (TTW TUFLOW, TTW DRAINS & UOFS)

| Location | Council UOFS | TTW TUFLOW - Existing Scenario | % Diff to UOFS | TTW DRAINS - Existing Scenario | % Diff to UOFS | % Diff (TTW DRAINS to TTW TUFLOW - Existing Scenario) |
|---|---|---|---|---|---|---|
| Pipe Flow 11C2128 | 5.77 | 6.05 | 5 | 7.70 | -33 | -27 |
| Pipe Flow 11C2081 | 3.87 | 6.52 | 69 | 3.72 | -4 | -43 |
| Combined Pipe Flow at Q1 | 9.63 | 12.57 | 31 | 11.42 | 18 | -9 |
| Overland Flow Q1 | 2.77 | 2.56 | -8 | 1.38 | N/A | -47 |
| Combined Pipe and Overland Flow at Q1 | 12.40 | 15.13 | 25 | 12.80 | 3 | -15 |
| Pipe Flow 11C2131 | 5.42 | 7.38 | 36 | 8.68 | 60 | 18 |
| Pipe Flow 11C0814 | 3.97 | 6.04 | 52 | 5.42 | 37 | -10 |
| Combined Pipe Flow at Q5 | 9.39 | 13.42 | 43 | 14.10 | 50 | 5 |
| Overland Flow Q5 | 9.50 | 0.07 | -99 | 0 | N/A | N/A |
| Combined Pipe and Overland Flow at Q5 | 14.77 | 13.49 | -9 | 14.32 | -3 | 6 |
| Peak Flood Height at H/D2 | 85.53 | 85.35 | -0.2 | N/A | N/A | N/A |
| Peak Flood Height at H3 | 85.53 | 85.31 | -0.3 | N/A | N/A | N/A |
| Peak Flood Height at H/D4 | 85.53 | 85.12 | -0.5 | N/A | N/A | N/A |
| Peak Flood Depth at H/D2 | 0.77 | 0.55 | -39 | N/A | N/A | N/A |
| Peak Flood Depth at H/D4 | 0.72 | 0.24 | -66 | N/A | N/A | N/A |
| Overland Flow Leaving the site (via Eastern Boundary) | N/A | 0.89 | N/A | 1.94 | N/A | 218 |
| Flood Depth at Site (Measured over Pit 11S2132) | 0.63 | 0.13 | -80 | N/A | N/A | N/A |

## 8.2 Discussion

It is notable that the TTW TUFLOW model was originally based on the data provided by Council (i.e., catchment boundary, surface topography, rainfall data, surface material, pit & pipe network, etc.) which was extracted from UOFS model.

The TTW TUFLOW model, however, has been updated with latest site-specific survey data which differs considerably from the UOFS data. The data difference between TTW TUFLOW model and UOFS is summarised below:

- TTW TUFLOW model incorporates more accurate surface data (survey tin) for the extent of Victoria Avenue to the downstream headwalls.
- The existing twin drainage pipe has been updated in TTW TUFLOW model to represent the correct existing drainage pipe structure (i.e., pipe alignment, pipe size, invert levels).
- Downstream discharge point was updated based on the survey data to incorporate two discharge headwalls at downstream Creek.

Therefore, it is expectable that the TTW flood results (DRAINS and TUFLOW) would not be consistent with those of UOFS for the study area.

The main differences between the TTW models and the UOFS (shown in Table 4), are that the pipe flows observed in the twin pipes that run through the site and discharge to Cattai Creek tributary. Peak flow rates through the twin drainage pipes are reported lower in the UOFS than in the TTW models, whilst the overland flow is reported generally higher in the UOFS than the TTW models. These differences are due to the UOFS only having a single pipe and headwall discharging to Cattai Creek tributary, whereas site observation and survey confirms that twin pipes and outfalls exist, and these have been included in the TTW models.

The UOFS with the single pipe and outfall has a lower pipe flow capacity than the twin pipes and twin headwalls, this is reflected in the higher pipe flows observed in the TTW models, which is to be expected. The higher flows observed in the twin pipes in the TTW models is also the reason for the corresponding lower overland flows observed in the TTW models, as a greater proportion of the total flow is able to be conveyed by the twin pipe system. Conversely the lower capacity of the single pipe in the UOFS means that a greater proportion of the total flow is conveyed as overland flow.

When comparing the total combined pipe and overland flows across Victoria Avenue at Q1 (to the west) and Q5 (to the east), the TTW models correspond well with Councils UOFS. The TTW TUFLOW model has a 25% higher combined flow than the UOFS at Q1, and 9% lower combined flow at Q5. The TTW DRAINS model has a 3% higher combined flow than the UOFS at Q1, and 3% lower combined flow at Q5.

## 8.3 Conclusion

The TTW flood modelling results based on the latest survey data confirm that the TTW TUFLOW model results agree well with the TTW DRAINS model results and differences are less than the limits of agreement of ±20% (refer to Table 1). The following points are notable in relation to the flow rate observations in the modelling.

- Based on the TTW Existing Model the overland flow from Victoria Avenue onto the site (through Q5) is very minor (0.07 m3/s). TTW DRAINS model results also confirm that there is no flow from Victoria Avenue onto the site in the 1% AEP storm event.
- The downstream flows into the Cattai Creek tributary are estimated at 18.20 $m^3/s$ and 20.88 $m^3/s$ based on TTW TUFLOW and TTW DRAINS models respectively (variation of 12.8%).

# 9.0 Flood Model Results – Existing Site Conditions

The updated TTW flood model as described in Section 0 was run for the 1% AEP and PMF critical duration events. Flood conditions of the site and the existing flow path in predevelopment state are described in the following sections:

## 9.1 1% AEP Event

The 1% AEP peak flood levels and depths, flood velocities and flood hazards for the updated existing site conditions are shown in Figure 13 to Figure 15.

The updated flood modelling results confirm that:

- Peak flood levels across the existing sag point at Victoria Avenue rise to 85.12m AHD.
- The vast majority of stormwater runoff from the upstream catchment is conveyed within the twin 1800mm pipes (13.42 $m^3$/s) that run east through the site and discharge to a tributary of Cattai Creek.
- Overland flows across the sag point at Victoria Avenue during the 1% AEP event are predominantly contained within the road reserve and therefore, the site is not materially affected by the overland flows from Victoria Avenue.
- Minor flood affection of the site is generally due to minor overland flows overtopping Victoria Avenue into the site via the western site boundary as well as local overland flows onsite which puddle across the low laying areas of the site.
- The site overland flows are largely controlled by the existing berm at the eastern site boundary and therefore, retained on the site.
- The maximum overland flow level across the site reaches up to 85.11m AHD which happens near the southwestern site boundary.
- Flood depths at a few areas across the site reach up to around 1.2m deep during the 1% AEP flood event due to local trapped depressions within the site.
- Flood hazards across the site and within Victoria Avenue are generally low based on NSW provisional hazard category.


Figure 13 – Flood Level & Depth (1%AEP) – Updated Existing Conditions


Figure 14 – Flood Velocity (1%AEP) – Updated Existing Conditions

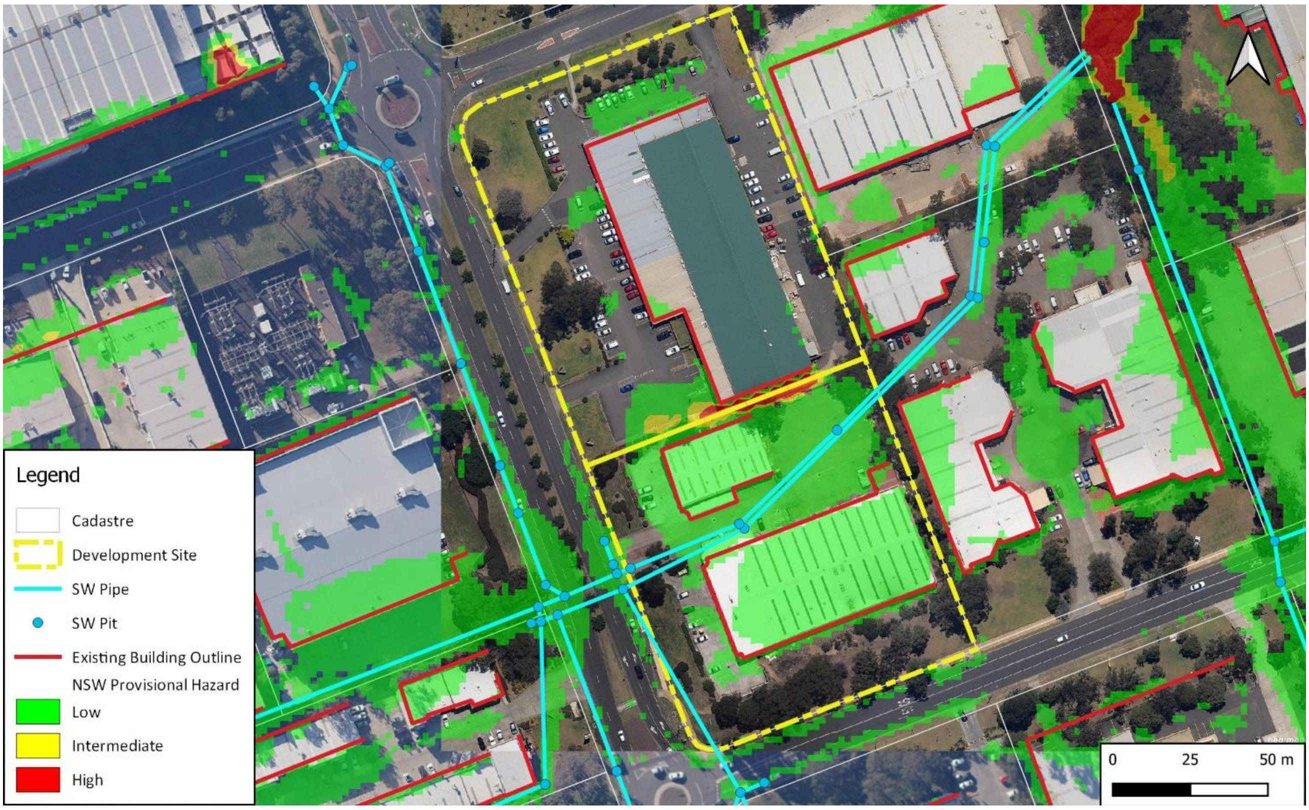


Figure 15 – Flood Hazard (1%AEP) – Updated Existing Conditions

## 9.2 PMF Event

The PMF peak levels and depths, velocities and hazards for the updated existing site conditions are shown in Figure 16 to Figure 18. The flood modelling results confirm that:

- In the PMF event, substantial overland flow from the upstream catchment flows from the west across Victoria Avenue and continues east through the development site towards Cattai Creek
- Floodwaters raise to the level of 86.70m AHD across the exiting sag point at Victoria Ave and overtop onto the site.
- Overland flows enter the site via the western site boundary and raise up to 86.65m AHD before overtopping onto the downstream property.
- Flood depths at the site reach up to around 2.9m deep during the PMF event due to local trapped depressions within the site.
- Flood hazards over the site and across the sag point on Victoria Avenue are generally high based on NSW provisional hazard category.

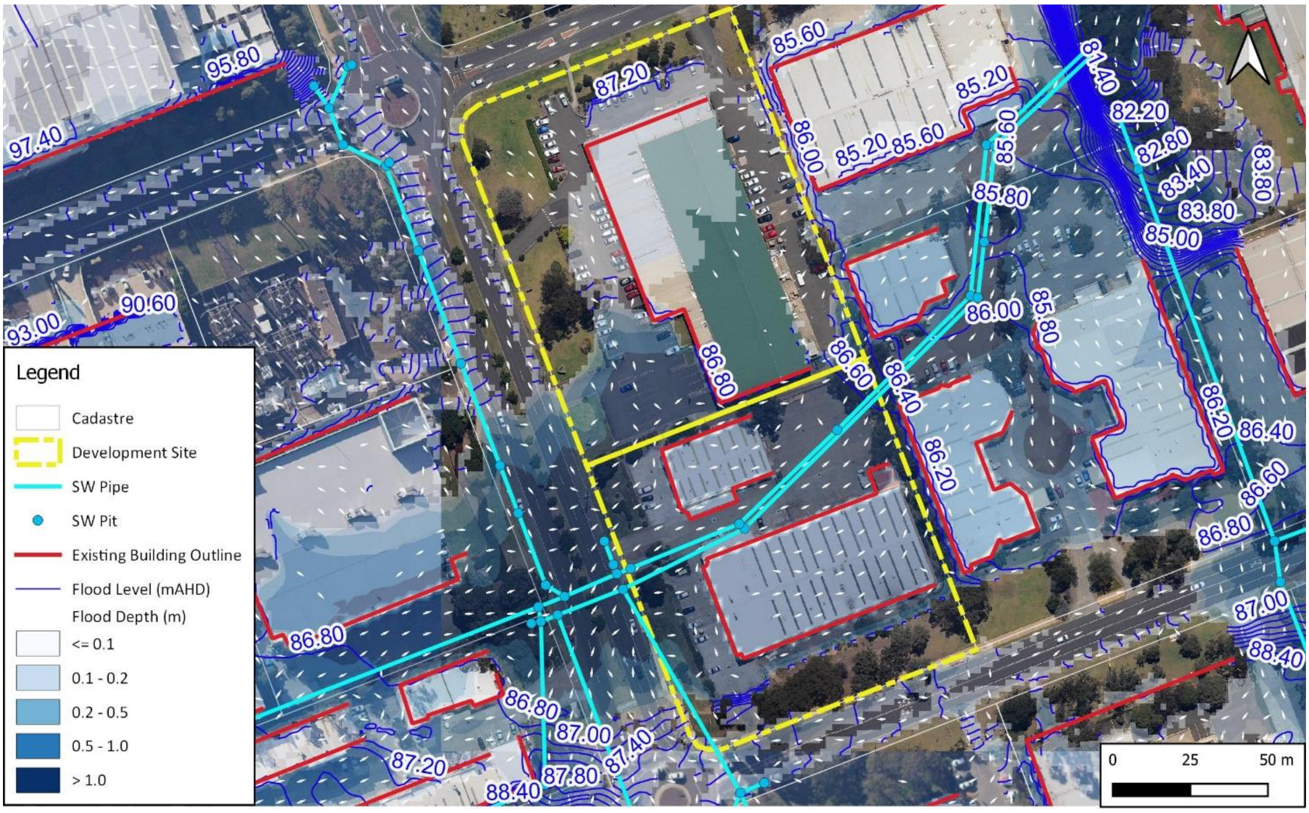


Figure 16 – Flood Level & Depth (PMF) – Updated Existing Conditions


Figure 17 – Flood Velocity (PMF) – Updated Existing Conditions

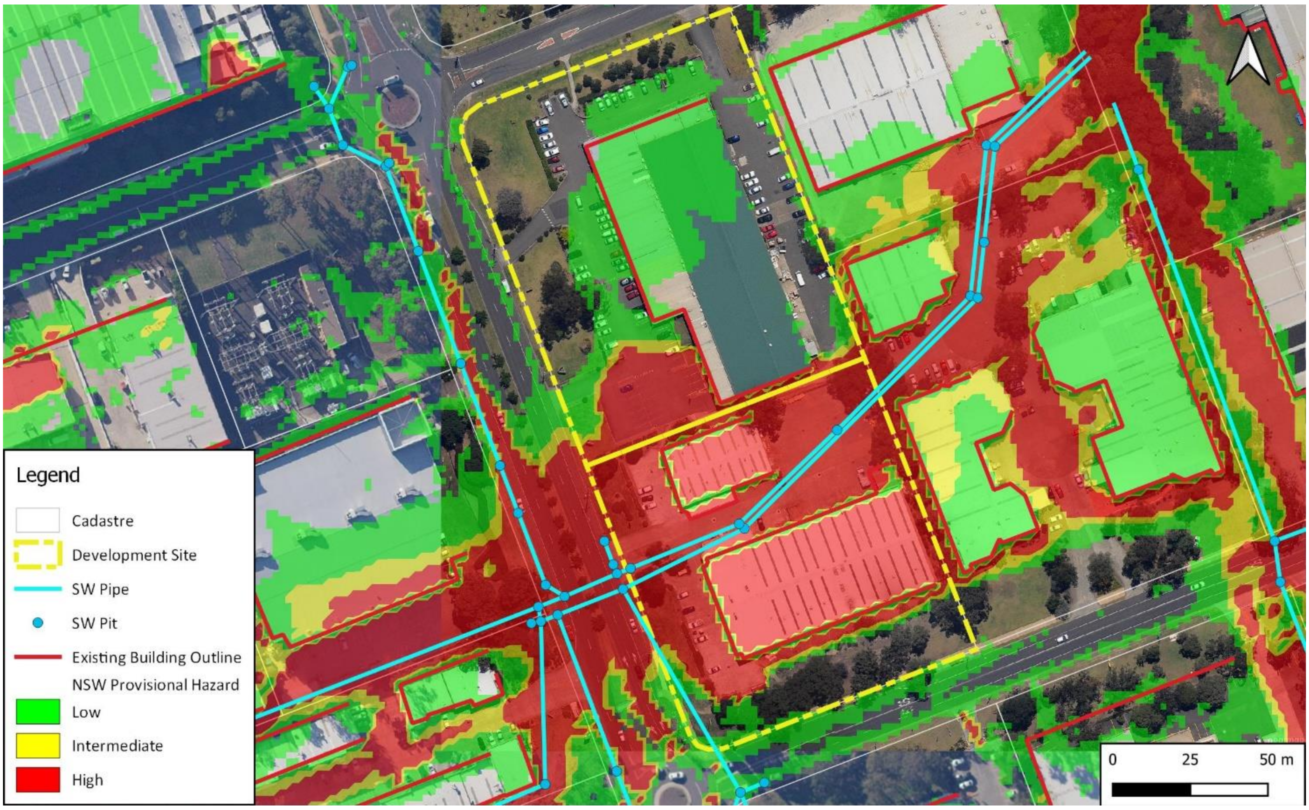


Figure 18 – Flood Hazards (PMF) – Updated Existing Conditions

# 10.0 Flood Model Arrangement – Proposed Site Conditions

The post development scenario was modelled based on the latest proposed architectural layout prepared by BatesSmart (refer Section 3.0). The existing conditions model was modified as follows to simulate the proposed conditions:

- Existing surface levels were updated to reflect the proposed site levels.
- Site manning's zones were updated to represent proposed surfaces.
- Existing buildings onsite were removed and replaced with the proposed buildings to model as flow obstructions.
- Proposed lower ground levels were modelled as 1d elements shown in Figure 19.
- The 1D network was updated to include two proposed inlet pits connected to the twin DN1800 pipes. Location of the proposed pits are shown indicatively in Figure 20. Further details of the proposed pits & pipes and connection arrangement to twin DN1800 pipes will be provided during the detailed design stage.
- The site in proposed conditions incorporates an on-site detention system to regulate site discharge flows during all events up to and including the 1% AEP (refer Stormwater Management Report 220719 for details). Whereas rainfall over the building is expected to overflow the internal drainage system during larger events greater than 1% AEP. The followings were carried out in order to appropriately simulate the impact of rainfall over the site:
    - Direct rainfall over the site was removed.
    - For the 1% AEP event, OSD discharge hydrograph (1% AEP critical duration) was extracted from DRAINS model and applied directly to the trunk drainage pipe within the site to simulate the site discharge through OSD system.
    - For the 0.2%AEP and PMF events, rainfall over the site was represented as a Source – Area (SA) boundary to simulate the overflows from the proposed building roofs as well as the onsite stormwater drainage network.

All other model construction elements remained consistent with the existing conditions model.

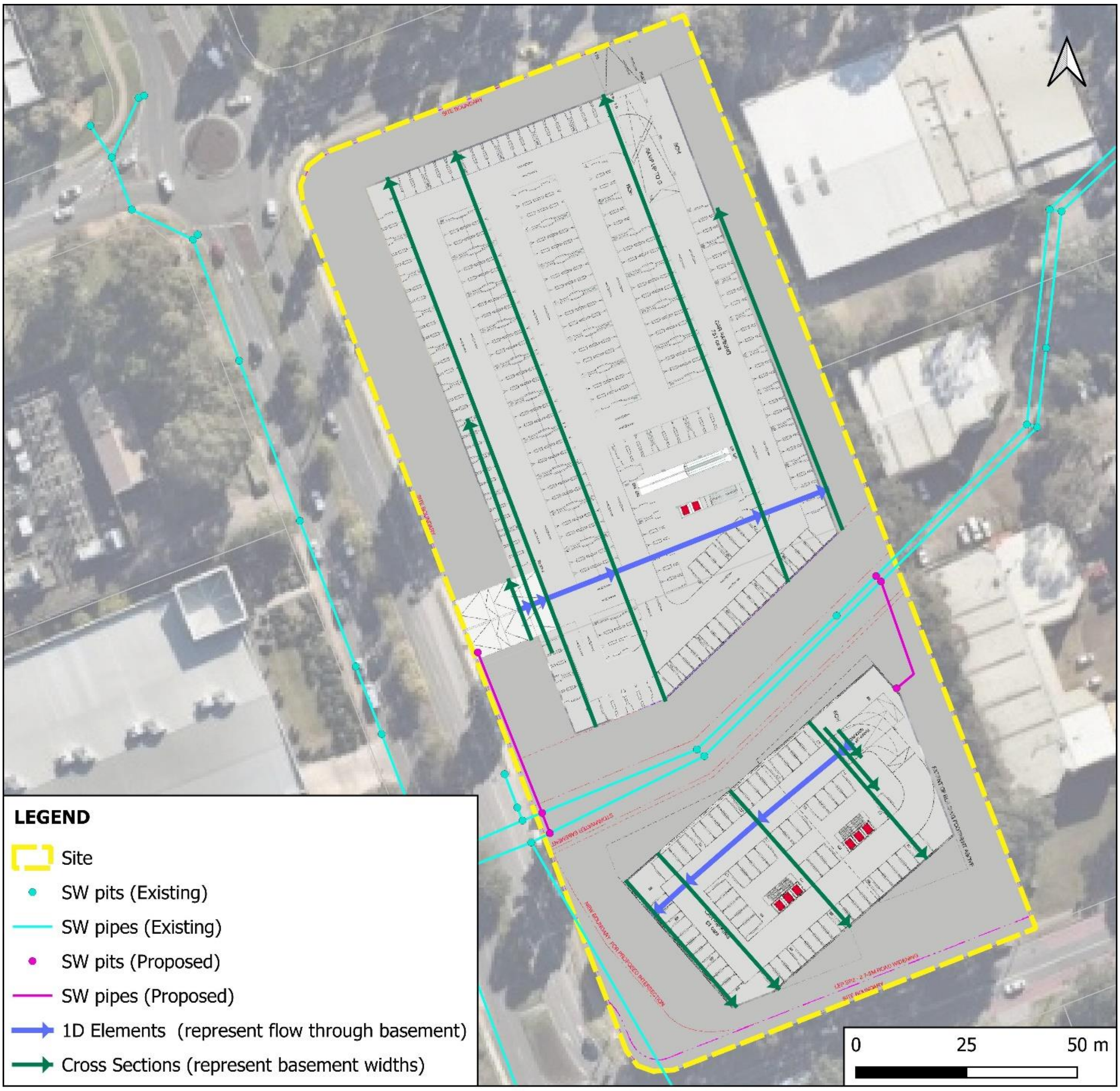


Figure 19 – Proposed Inlet Pit Locations Connected to Existing twin DN1800 Pipes

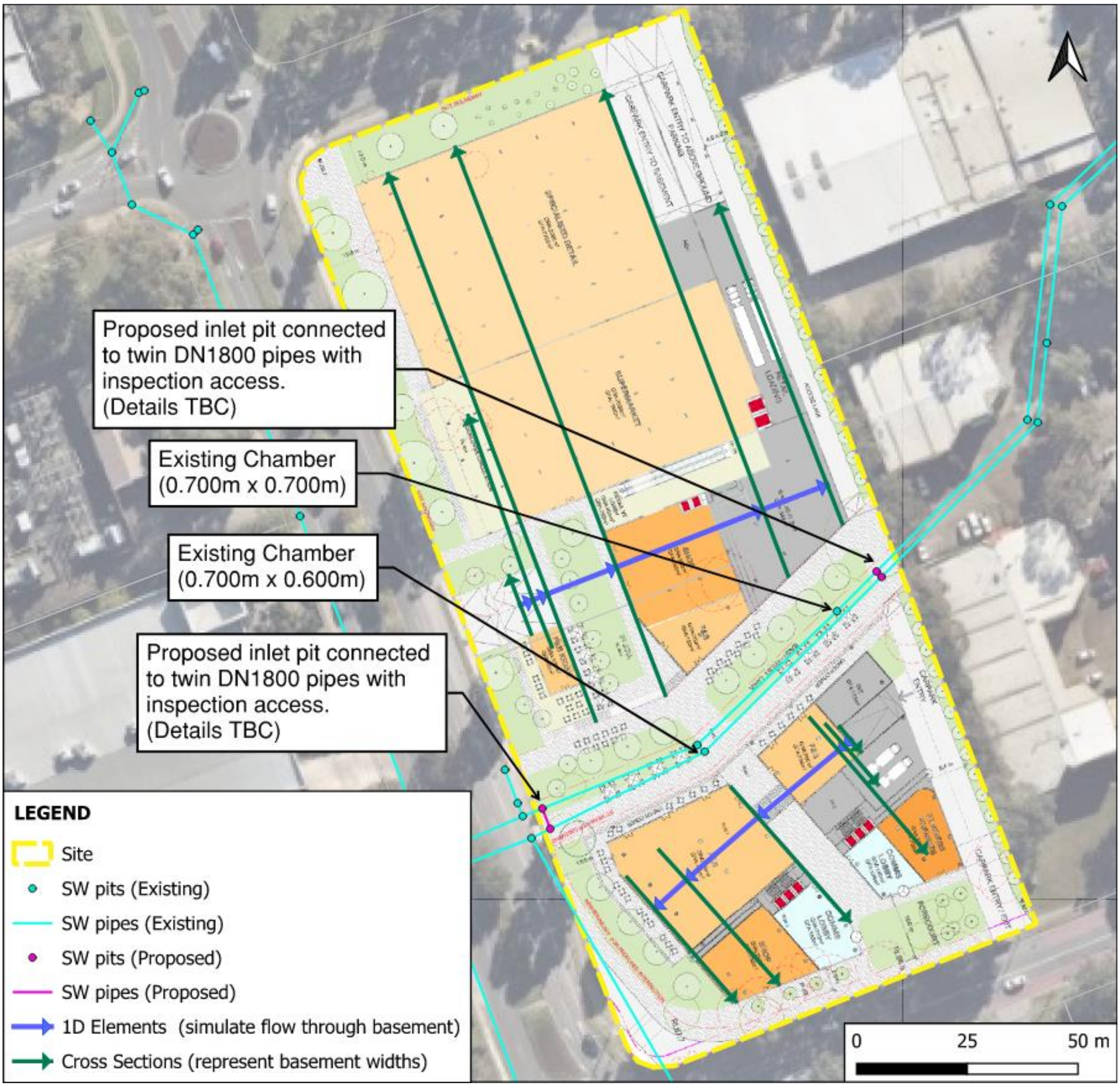


Figure 20 – Proposed Inlet Pit Locations Connected to Existing twin DN1800 Pipes

# 11.0 Flood Model Results – Proposed Site Conditions

## 11.1 1% AEP Event

The 1% AEP post development flood depths/levels, flood velocities, flood hazard and flood impact are shown in Figure 21, Figure 22 and Figure 23 respectively and confirm that:

- Overland flow from Victoria Avenue is contained within the road reserve and effectively conveyed into the existing underground trunk drainage through the drainage network in Victoria Avenue.
- Maximum flood levels reach 85.20m AHD over the low point of Victoria Avenue. The entrance to the basement car park level is RL85.70m and remains flood free in the 1% AEP.
- A minimum freeboard of 500mm is available for the lowest occupied commercial areas at 85.70m AHD. This is compliant with Council DCP which requires an FPL of 1% +500mm of freeboard for habitable commercial floors.
- Small water ponding at the basement car park level (less than 15mm) shown in Figure 21 is due application of rainfall-on-grid method. That small amount of overland flow will be redirected by way of detail earthworks design and internal drainage network.
- Flood hazards across the site and within Victoria Avenue are generally low based on NSW provisional hazard category.

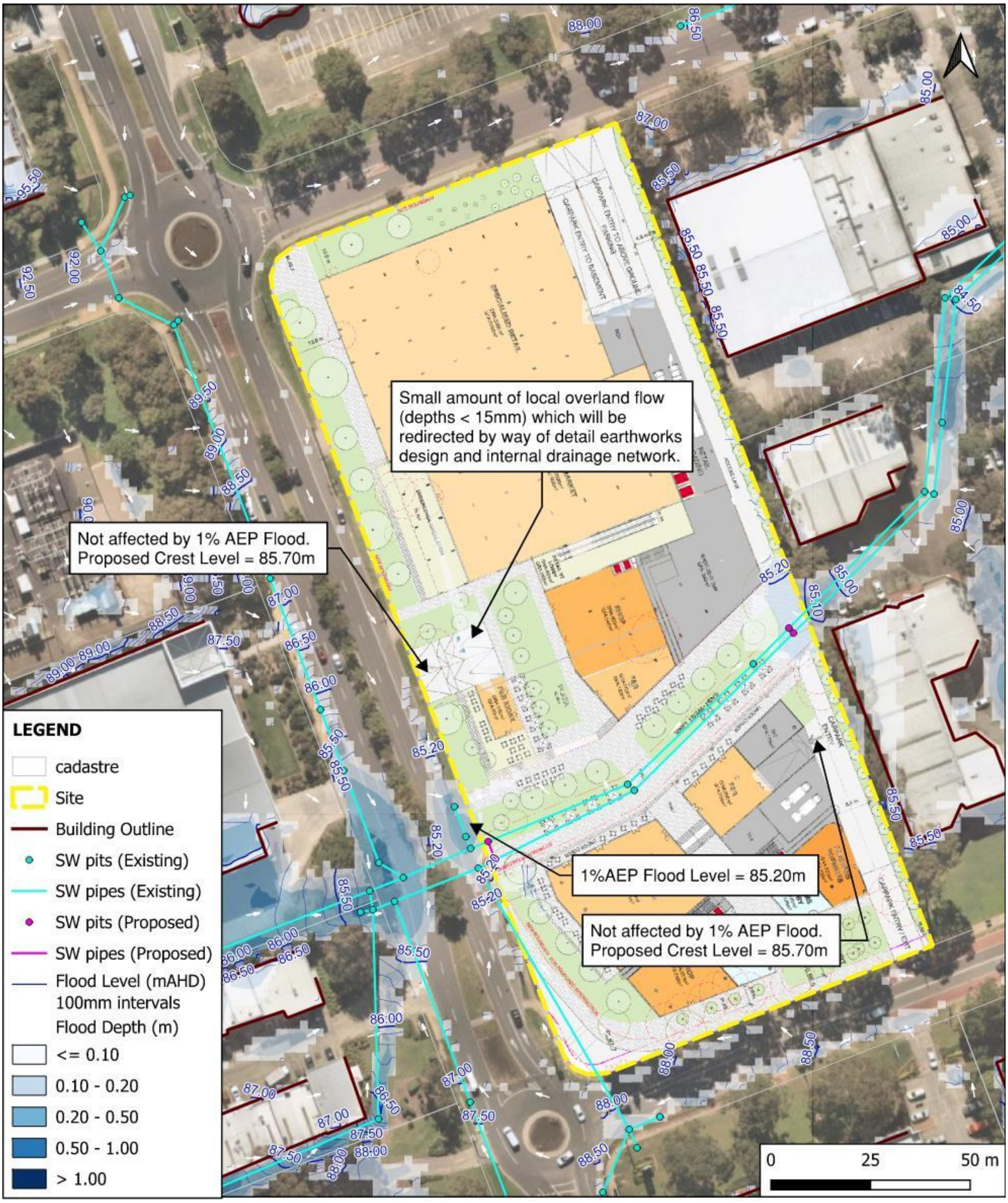


Figure 21 – Flood Levels & Depths (1%AEP) – Post Development Conditions – 2013 Tuflow Engine


Figure 22 – Flood Velocity (1%AEP) – Post Development Conditions – 2013 Tuflow Engine


Figure 23 – NSW Provisional Flood Hazard (1%AEP) – Post Development Conditions – 2013 Tuflow Engine

## 11.2 0.2% AEP and PMF Events

The flood model was also run for the critical 0.2% AEP and PMF events under the post development conditions. The post development flood results confirm that:

- Maximum flood levels reach up to 85.40m AHD and 86.30m AHD across the exiting sag point at Victoria Ave during the 0.2% AEP and PMF events respectively, before flowing onto the site
- Flood flows from Victoria Avenue are effectively conveyed through the proposed linear park and discharge via the eastern site boundary during 0.2% AEP and PMF events. Floodwaters eventually discharge to the downstream property (lot 12 of DP711909) via the eastern site boundary.
- Overland flows across the proposed linear park are shallow (<200mm) and low hazard during the in the 0.2% AEP flood event. However, flood flows over the proposed linear park are as deep as 1.1m and of high hazard during the PMF.
- No material overland flow enters the basement car parks during the 0.2% AEP. However, flood flows entre the basement car parks during the PMF event.
- The amount of flow entering the basement car park during the 0.2% AEP event is insignificant in volume (crest level at entrance is 85.70m) and will be drained into exiting twin DN1800 drainage pipes through proposed internal drainage network.
- Flood hazards across the site and on Victoria Avenue are generally low during the 0.2% AEP event based on NSW provisional hazard category. Minimum building floor level is at 85.70m which is 300mm above the 0.2% AEP flood levels at 85.40m.
- The 0.2% AEP peak flood levels and depths, flood velocities and flood hazards for the post development scenario conditions are shown in Figure 24, Figure 25 and Figure 26 respectively.
- The PMF peak flood levels and depths, flood velocities and flood hazards for the post development scenario conditions are shown in Figure 27, Figure 28 and Figure 29 respectively.


Figure 24 – Flood Levels & Depths (0.2% AEP) – Post Development Conditions (no blockage through car park) – 2013 Tuflow Engine


Figure 25 – Flood Velocity (0.2% AEP) – Post Development Conditions (no blockage through car park) – 2013 Tuflow Engine


Figure 26 – NSW Provisional Flood Hazard (0.2% AEP) – Post Development Conditions (no blockage through car park) – 2013 Tuflow Engine

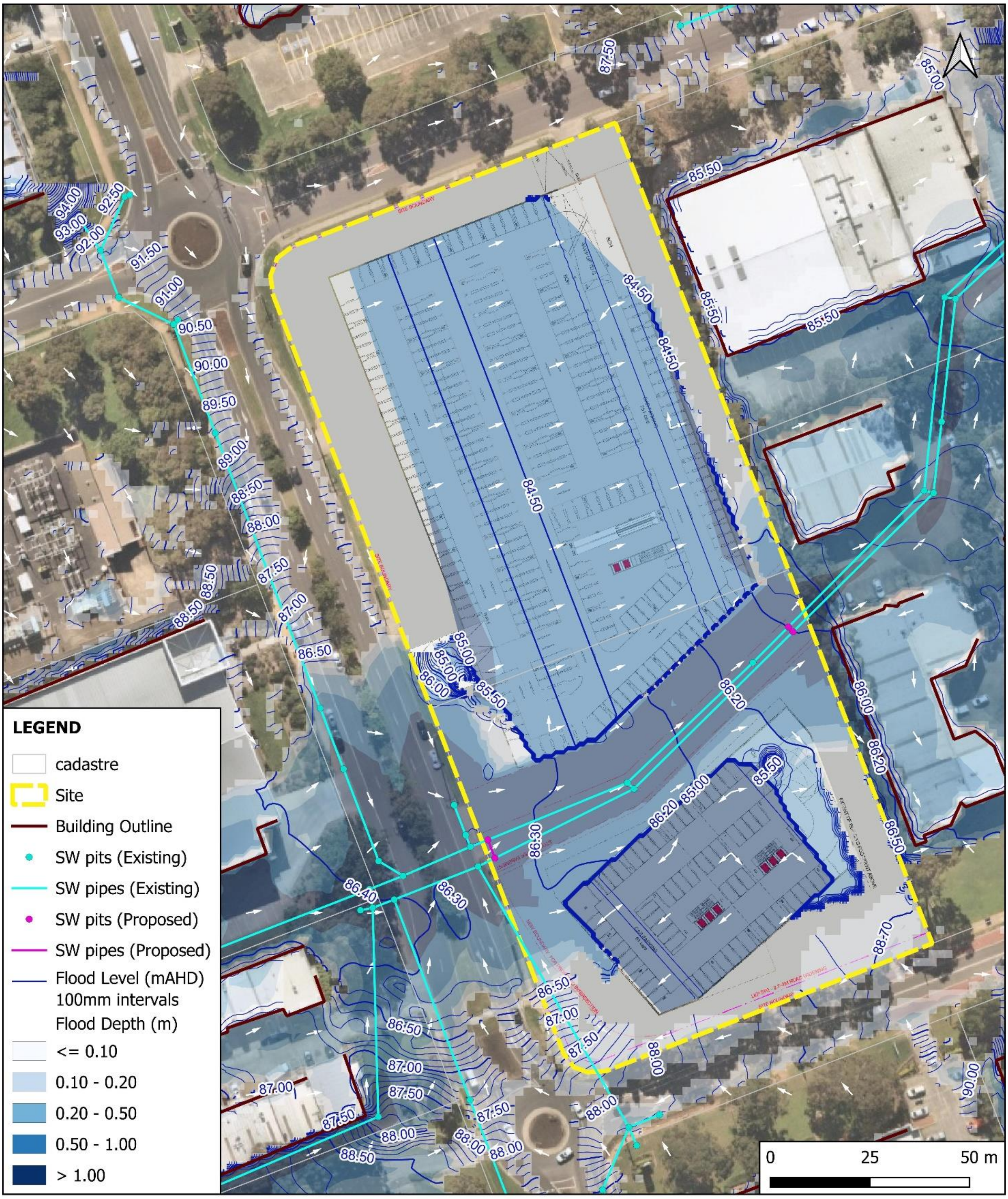


Figure 27 – Flood Levels & Depths (PMF) – Post Development Conditions (no blockage through car park) – 2013 Tuflow Engine

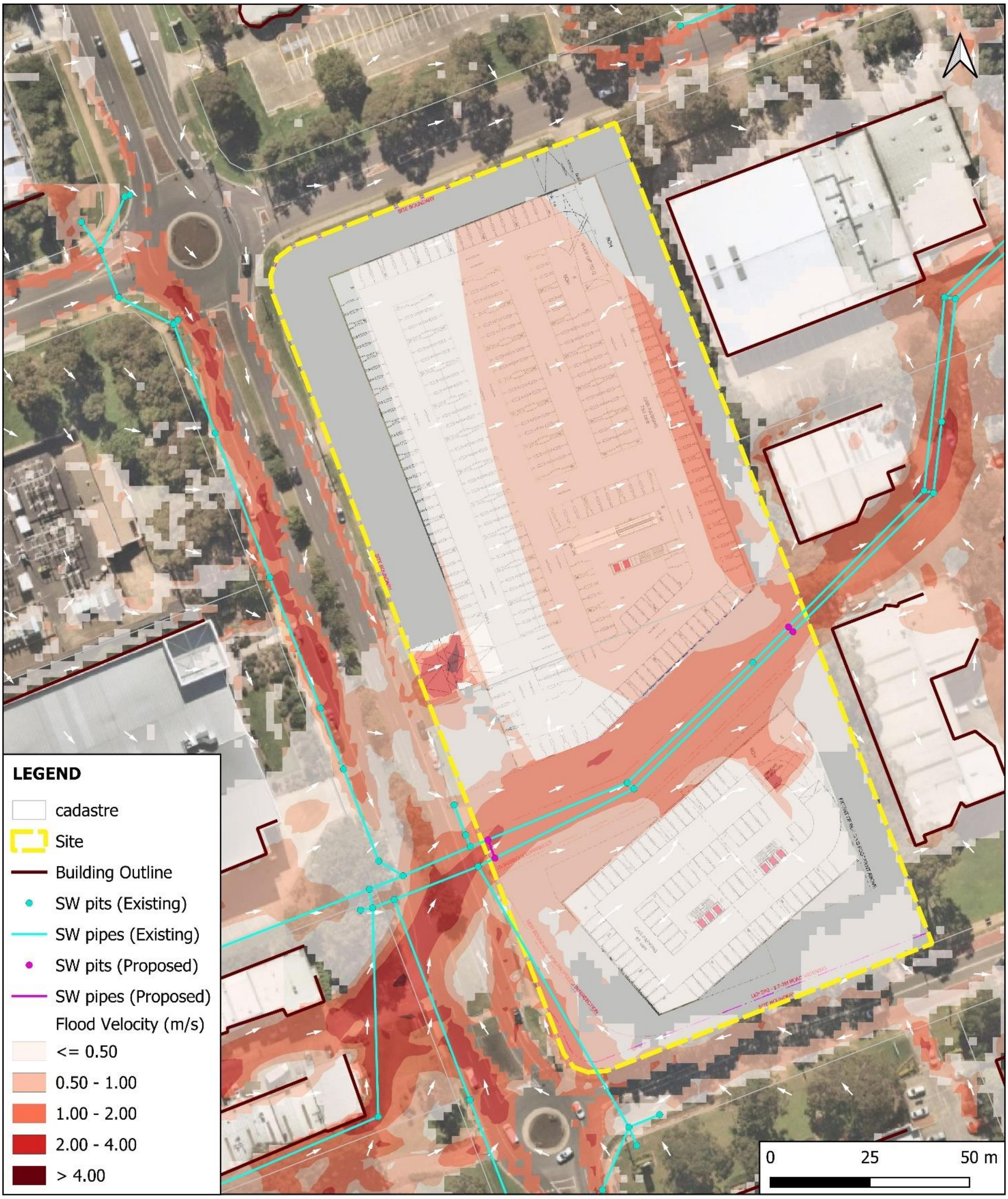


Figure 28 – Flood Velocity (PMF) – Post Development Conditions (no blockage through car park) – 2013 Tuflow Engine

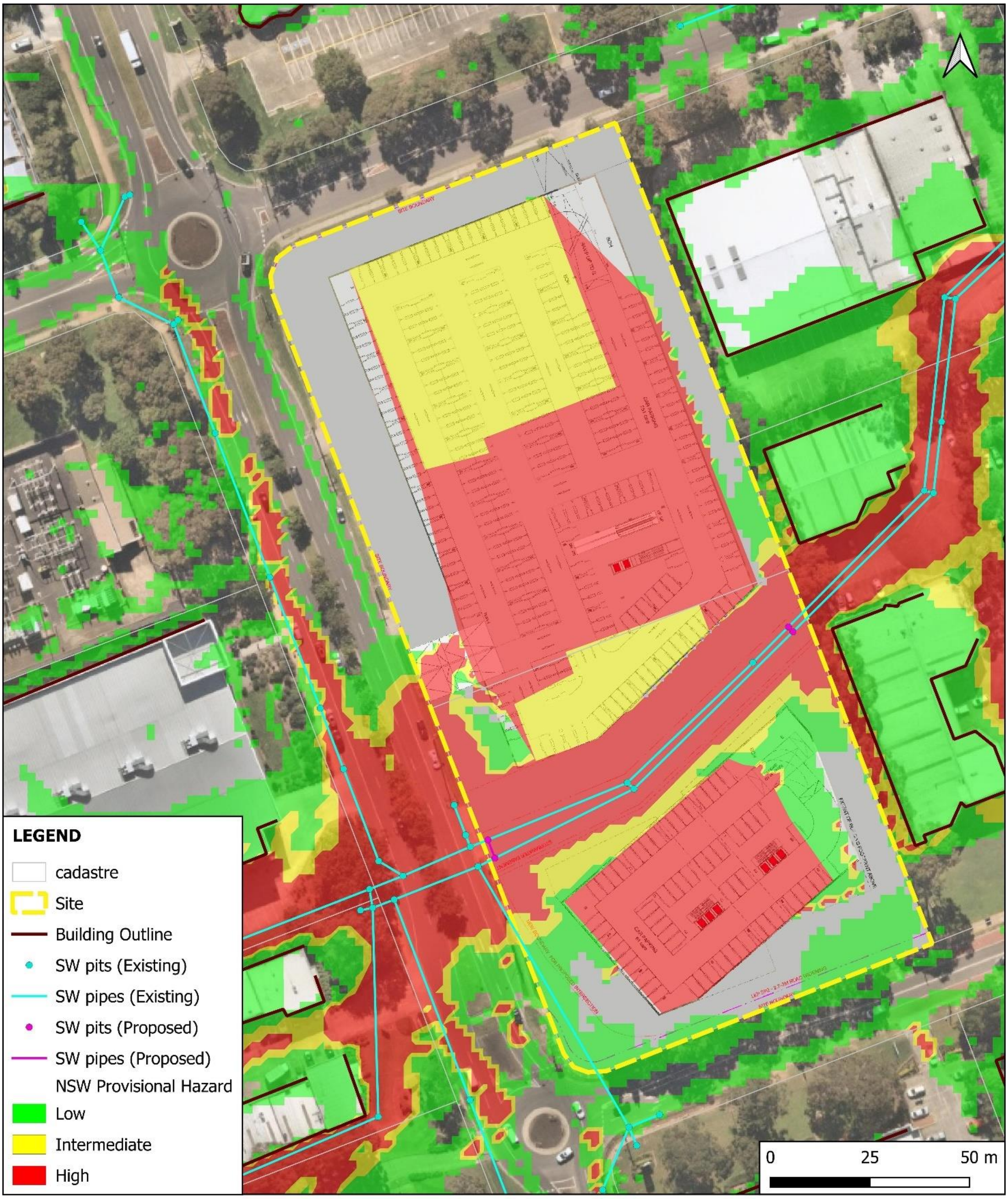


Figure 29 – NSW Provisional Flood Hazard (PMF) – Post Development Conditions (no blockage through car park) – 2013 Tuflow Engine

# 12.0 Offsite Flood Impact Assessment

The post development scenario shows that there is negligible (+/- 20mm) impact to existing upstream and downstream properties. There is a slight localised increase in flood levels (less than 40mm) over a small area of the existing flow path on the downstream property however the this will be addressed during the detail design stage by providing more flood storage onsite.

Flood modelling confirms there is no significant upstream or downstream impact on adjacent properties and does not prejudice development options for these properties. There is also no increase in Flood Hazard within Victoria Avenue or around the development site and the flood hazard remains low in the post development scenario.

Flood level impact maps for the 1% AEP is shown in Figure 30.

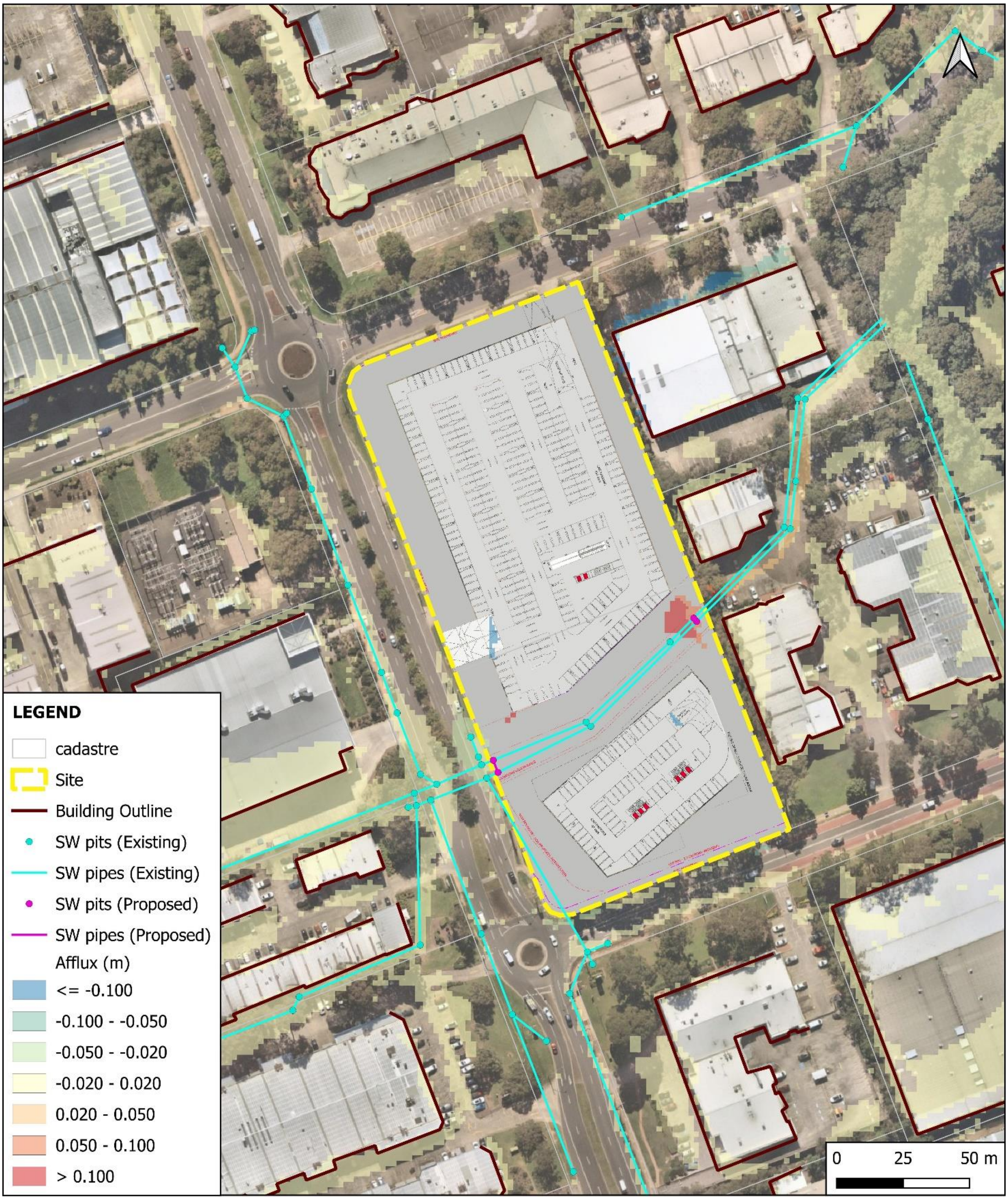


Figure 30 – 1%AEP Flood Level Impact

# 13.0 Conclusions and Recommendations

A detailed hydraulic model has been developed to assess local flood characteristics for the site in the 1% AEP, 0.2% AEP and PMF events under both existing and proposed conditions. Modelling concluded that:

- The site is generally flood free during the flood events up to and including the 1% AEP and overland flow from Victoria Avenue is contained within the road reserve and effectively conveyed into the existing underground trunk drainage through the drainage network in Victoria Avenue.
- Overland flows from Victoria Avenue are effectively conveyed along the proposed linear park and discharge via the eastern site boundary during flood events larger than the 1% AEP.
- Flood hazards across the site and within Victoria Avenue are generally low based on NSW provisional hazard category during the events up to and including the 0.2% AEP.
- No material overland flow enters the basement car parks during storm events up to and including the 0.2% AEP.
- A minimum freeboard of 500mm is available for the lowest occupied commercial areas at 85.70m AHD. This is compliant with Council DCP which requires an FPL of 1% +500mm of freeboard for habitable commercial floors.
- Minimum building floor level is at 85.70m which is 300mm above the 0.2% AEP flood levels at 85.40m.
- Maximum flood levels reach 85.20m AHD over the low point of Victoria Avenue. The entrance to the basement car park level is RL85.70m and remains flood free in the 1% AEP.
- All openings and penetrations to the lower ground levels are to be protected up to 85.70m AHD (the 1% AEP flood level plus 0.5m freeboard).
- The proposed development (including ancillary structures, facades, stairs and barriers) will be constructed with flood compatible materials below RL 85.70m AHD which is the 1% AEP flood level plus 500mm freeboard.
- Flood refuge up to the PMF flood levels will be available on the proposed higher levels via internal stairs.
- Compliance with the Council flood planning level requirements for building and car park levels are achieved.
- Access to existing easement for asset inspection and maintenance is available through the site in proposed conditions.

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