Flood Impact and Risk Assessment

67-75 Lords Road, Leichhardt

Platino Properties

22 December 2023

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

SUMMARY

Water Technology Pty Ltd (WT) was commissioned by Platino Properties to prepare a Flood Impact and Risk Assessment (FIRA) for a proposed development over land located at 67-75 Lords Road, Leichhardt, NSW.

Flood modelling has been undertaken to quantify existing and post-development flood behaviour at the site and to demonstrate that, with the proposed mitigation measures in place, the proposed development will not result in any material impacts on flooding external to the site.

Additionally, existing flood risk at the site and potential impacts of the development on flood risk external to the site have been addressed.

Key findings of this FIRA are:

- Flood behaviour
  - The site is subject to some degree of flooding during all design events considered, which is concentrated within the western lot.
  - Flooding impacting the site is a result of flash flooding in response to short duration storm events.
  - The site is primarily a flood storage area and flood storage volumes within the site will be maintained across all events by the provision of compensatory storage.
  - A portion of the site has a secondary flood conveyance function during the PMF only and this will be maintained by the development.
- Proposed development
  - The developed site area will be filled to a minimum level of 4.6 mAHD (0.5 m above Council's 1% AEP flood level).
  - The proposed development includes management measures to ensure the development has no material impact on flood behaviour external to the site. The recommended measures are:
    - Compensatory flood storage (in a free-draining basement tank) to offset any loss of storage from filling the site.
    - A boundary wall for flood control (to mirror the function of the existing building).
- Flood risk
  - Flooding in the catchment occurs in response to short durations storms during which there is insufficient time for flood warnings to be issued.
  - Existing management plans indicate that evacuation is not recommended.
  - Risks to the development and user of the development have been minimised by filling the site to a level that achieves flood immunity (up to the 0.2% AEP).
  - Potential risks of the development on neighbouring property and its users, infrastructure and the environment have been mitigated by the management measures described above.

CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background

Water Technology Pty Ltd (WT) was commissioned by Platino Properties to prepare a Flood Impact and Risk Assessment (FIRA) for a proposed development over land located at 67-75 Lords Road, Leichhardt, NSW (the Site), within the Inner West Council (IWC) local government area. The Site is formally described as Lot 1 on DP940543 and Lot 1 on DP550608 and occupies a total area of 1.06 hectares, as shown on Figure 1-1.

Figure 1-1 Site Location

1.1.1 Purpose

New development without effective consideration of potential impacts on existing flood behaviour can:

- change flood behaviour and have adverse impacts on the flood risk to the existing community;
- place the development and its users at an unacceptable level of flood risk; and
- affect flood emergency response with adverse impacts on the ability of the existing community to respond to floods.

This can lead to increased flood risk due to adverse impacts of the development on the existing community or users of the proposed development. These impacts can be limited by appropriate selection of mitigation measures including consideration of development type, flood related development controls and flood constraints at the location.

A fit for purpose flood impact and risk assessment (FIRA) is intended to understand flood constraints and effectively manage flood risks posed to and by new development. Accordingly, the aim of the FIRA is to identify and analyse:

- the impacts of the proposed development on the flood risk to the existing community;
- the impacts and risks of flooding on the development and its users; and
- how these impacts can be managed to minimise the growth in risk to the community due to the development.

1.1.2 Proposed Development

Development is proposed over a 0.90 ha portion of the site, occupying the entire area of Lot 1 on DP940543, whilst the landform within the lower-lying western lot (Lot 1 on DP550608) will remain unchanged. The proposed mixed-use development comprises four multi-storey buildings, with the ground level to be occupied by commercial uses and the upper levels residential use. Basement carparking will be provided to service the development. The proposed development is depicted on Figure 1-2 and copies of the layout plans are included in Appendix A.

Figure 1-2 Proposed Development (SJB Architects)

1.2 Project Context

A planning proposal has been submitted to the NSW Department of Planning and Environment (DPE) in respect of the proposed development and the Planning Panel has recommended that the project proceed to gateway determination.

DPE has advised the client that a Flood Impact and Risk Assessment (FIRA) be prepared in accordance with the NSW Flood Risk Management Manual (FRMM) (published June 2023) and is to be included with the next stage of the development application to demonstrate that the proposal can achieve acceptable outcomes with respect to flooding.

This report constitutes the required FIRA.

1.3 FIRA Requirements

The category of FIRA undertaken to support an application for a development proposal depends on the availability of existing information related to flood behaviour and the proposed development.

Based on the known flood risk at the site, a detailed FIRA has been undertaken to support the planning proposal. The pathway to the detailed FIRA is shown in Figure 1-3 as documented in *Flood impact and risk assessment – Flood risk management guideline LU01* (LU01) (NSW DPE, June 2023).

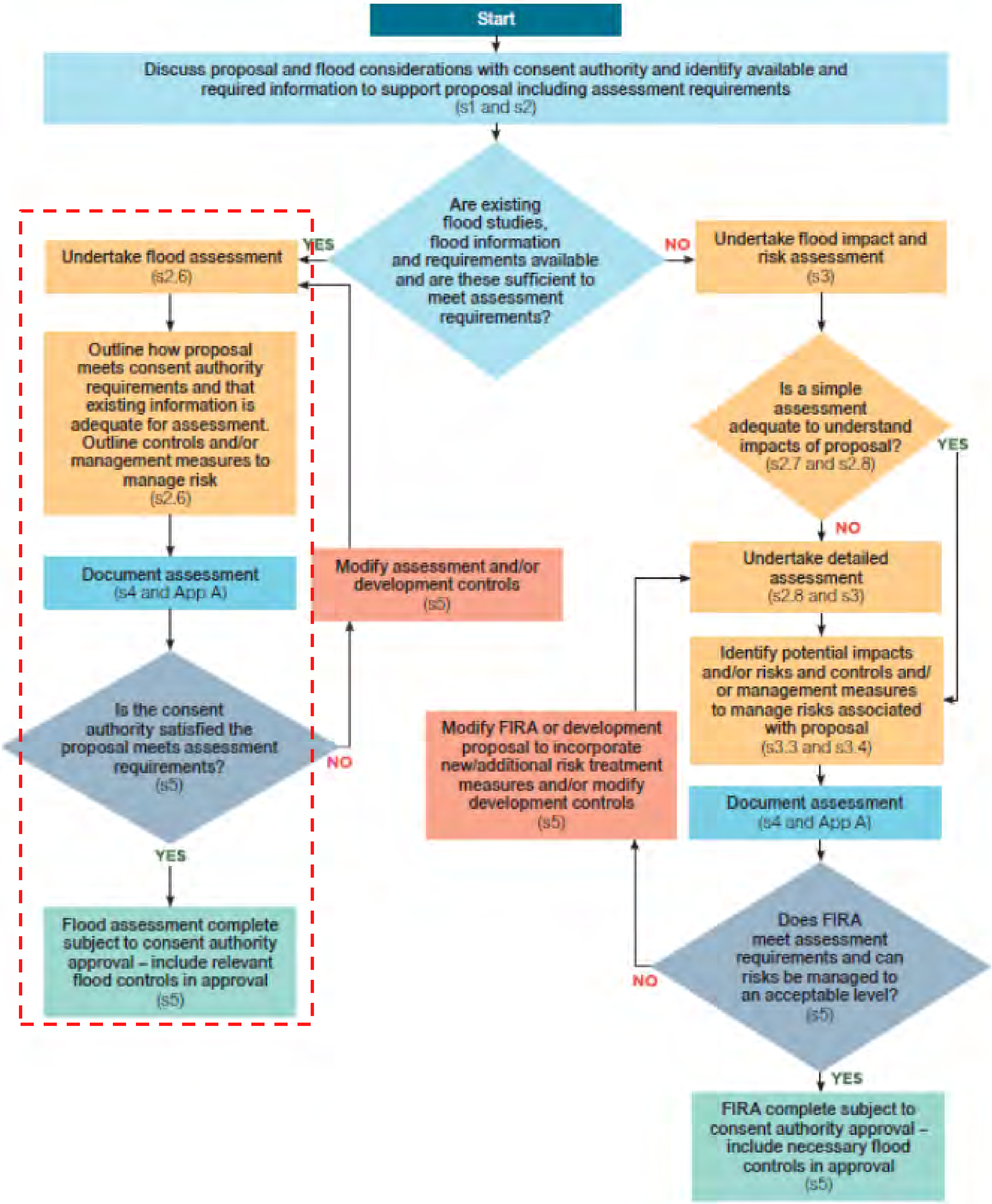

Figure 1-3 Flood Impact and Risk Assessment Process – extracted from LU01

2 BACKGROUND

2.1 Study Area

2.1.1 Site Description

The site is situated at the western end of Lords Road, adjacent to its intersection with Kegworth Street. It is bounded by Lords Road to its south, an unnamed road easement and adjacent residential development fronting Davies Street to its east, Lambert Park sports field to its north and an embankment for the light rail to its west.

2.1.2 Existing Development

The site has historically been developed and is currently occupied by a warehouse development. The primary building divides the site from west to east, spanning the entire length of the site between its southern to northern boundaries and occupying just over half of the total site area. A smaller building is located in the southeastern corner of the site and the remainder of the site is covered by hardstand driveway and parking areas. The existing site conditions are shown on Figure 2-1.

Figure 2-1 Existing site conditions

2.1.3 Site Landform and Drainage Characteristics

The site grades to the west with elevations ranging from approximately 2.8 to 8.7 mAHD. The site area to the east of the existing building falls towards the building. Runoff from this area collects in an open drain around the building perimeter and is piped under the building by subsurface drainage.

The land to the west of the building falls to a depression in the landform at the western site boundary. The local trunk drainage network enters the site, collects site runoff in a number of existing stormwater pits and discharges west into Hawthorne Canal via a pipe under the light rail embankment.

Existing site features are defined in the detailed ground survey, shown in Figure 2-2 (complete survey plans are included in Appendix B).

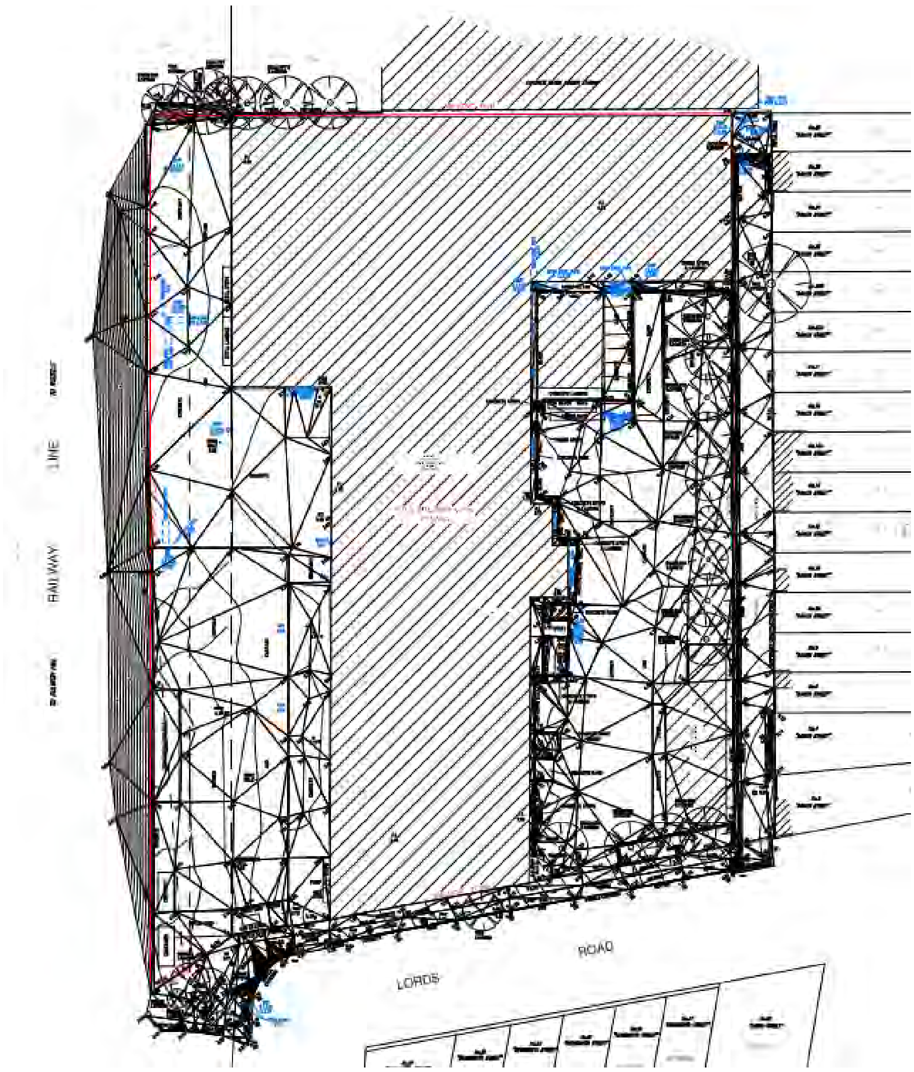

Figure 2-2 Site Survey Plan (Norton Survey Partners, 28/09/2023)

2.1.4 Catchment Description

The site is situated within the catchment of Hawthorne Canal, a 2.5 km long constructed concrete lined channel running northwards to its discharge point at Iron Cove on the Parramatta River. The canal is tidal over the majority of its length, with the tidal influence extending upstream of Parramatta Road (located 2.1 km from the outlet).

The total catchment area addressed by IWC's Hawthorne Canal sub-model is 698 hectares and includes the canal catchment as well as a small area discharging directly to Iron Cove, just north of the canal outlet.

The site is located approximately 1.5 km upstream of the outlet and is separated from the Canal by an embankment supporting the light rail. The modelling described in this report addresses the upper portion of the catchment, to a short distance downstream of Marion Street, and considers a total catchment area of 453 hectares. This includes 84 hectares to the southeast, and upstream of, the site.

The catchment is fully developed and is occupied by a combination of low-medium density housing, higher density residential unit developments and commercial uses, with a few isolated areas of open space. Given the historical nature of development within the catchment, limited provisions were made for overland flow conveyance through the catchment.

Runoff from the catchment area east of Hawthorne Canal generally flows in a north-westerly direction until it reaches the light rail embankment immediately east of the canal.

There are multiple drainage outlets of varying form and capacity through the light rail embankment at various locations to the south of the site, catering for a significant portion of upstream catchment runoff. However, when the capacity of these structures is exceeded, the remainder of catchment runoff is intercepted by the embankment and flows overland in a northerly direction towards and into the site.

An additional, lower level, embankment exists along the southern boundary of the sport fields, immediately north of the site, which effectively traps overland flows within the site and prevents the passage of overland flow north from the site in all but the most extreme flood events, when the embankment is overtopped (at approximately RL 5.2 mAHD).

2.2 Known Flood Behaviour

Previous flood studies undertaken to characterise flood behaviour across the catchment are described in Section 3. The most relevant of these is the LFS. A review of the flood behaviour from the modelling underpinning the LFS is included in Section 3.2.1. Based on this, flooding at the site exhibits the following characteristics:

- Type
  - The catchment is subject with flash flooding characterised by rapid rise and fall of floodwaters.
  - Flood inundation at the site is predominantly associated with offline flood storage for overland flow from the upstream catchment where discharge to the receiving waterbody (Hawthorne Canal) is limited by the capacity of the pedestrian tunnel through the light rail embankment at Lords Road (in combination with other upstream drainage infrastructure further to the south). The majority of overland flow that enters the site from the south drains back across the same site boundary as floodwaters recede and discharges to Hawthorne Canal via the pedestrian tunnel.
  - Low flows trapped within in the site are discharged through the minor stormwater drainage network.
  - During the PMF the western portion of the site becomes an overland flowpath for conveyance of higher level flows to the north.
- Frequency and duration of inundation
  - The western portion of the site is subject to some degree of inundation during all modelled flood events (results provided by IWC for 1 in 5 year event and above).
    - During the 1 in 5 year event, inundation (to a depth exceeding the mapping cutoff of 0.15 m) is limited to a small area (approximately 350m²) surrounding the inlet pits to the subsurface drainage network and a maximum depth of approximately 0.5 m.

- The extent and depth of inundation progressively increases with larger, less frequent events, such that the entire site area west of the central building is inundated during the 1 in 100 year flood, with a maximum depth of approximately 1.6 m.
- The modelled inundation extent does not increase significantly between the 100 year ARI and PMF events (as buildings have been represented as obstructions in the modelling), however flood level and depth increases substantially, with a maximum depth of approximately 4.3 m.

- Flooding within the catchment is most significant in response to short duration storms.
  - For the 1 in 100 year event, the critical duration at the site is 60 minutes, with the flood peak occurring at 50 minutes and floodwaters receding from the site within 2 hours.
  - For the PMF, the critical duration at the site is 45 minutes. In this storm, the flood peak within the site occurs at 45 to 50 minutes and floodwaters recede from the site within 2.5 hours.

- Existing flood behaviour
  - We have not been made aware of any documented flooding issues at the site (aside from the modelled influence of floodwaters).
  - Survey data indicates floor levels on the western side of the existing building are 3.7 to 4.0 m AHD. Based on IWC's modelling, at this level the building:
    - will remain flood free during a 1 in 20 year flood event (3.50 to 3.65 mAHD);
    - may be partially impacted by flooding during a 1 in 50 year event (3.90 to 3.95 mAHD); and
    - will entirely be impacted by a 1 in 100 year flood event (4.10 mAHD).
  - There is a sag point located within the western portion of the site that is drained solely by the sub-surface stormwater drainage network. Should the drainage network become blocked, there is no alternative flowpath for low flows and this water will become trapped and will pond within the site indefinitely to a maximum depth of approximately 0.45 m over an area of approximately 500m² in the southwest of the site. Above this level, stored floodwaters can drain freely to the south as the flood peak recedes.
- Hydrologic/hydraulic controls' effect on flooding
  - Light rail embankment – this is the most substantial hydraulic control in the catchment, intercepting overland flow towards the west and preventing runoff from directly discharging to Hawthorne Canal. Discharge from the catchment is instead controlled by the capacity of multiple pipes, culverts and other openings at various locations along the embankment.
  - Pipes/culvert outlets at Hathern Street, Beeson Street and (near) Kegworth Street – these drainage structures cater for discharge of runoff/overland flow from the upstream catchment to Hawthorne Canal. As the capacity of each structure (and the connected upstream drainage networks) is exceeded, runoff remains on the surface as overland flow which generally flows east-northeast towards the rail embankment, then north to Lords Road and the site.
  - Stormwater drainage network through site – the subsurface drainage network collecting runoff from Kegworth Street and Lords Road enters the site from the south and discharges to Hawthorne Canal via a single 750 mm diameter pipe located central to the site. The infrastructure caters for minor storm event runoff from the roads, land to the east and from the site itself. The kerb inlets in Lords Road and Kegworth Street are elevated above the invert of the overland flowpath that runs between Kegworth Street and the rail embankment and runoff from the upstream catchment to the southeast can only enter the drainage network once flood levels on the overland flowpath are high enough to inundate the road.

- Lords Road pedestrian tunnel – this is a significant structure (width 3.09 m and height 2.4 to 2.8 m) that caters for discharge of all residual overland flow from the catchment in events up to and including the 1 in 100 year flood.
  - The tunnel is relatively flat and its invert is elevated at approximately 2.0 mAHD, such that it is not directly impacted by low flows in the downstream canal, but is influenced by downstream flooding.
  - The 1 in 100 year flood level upstream of tunnel (4.1 mAHD) is well below the tunnel obvert (4.8 mAHD) such that the tunnel does not run full. However, discharge through the structure is controlled by its width, and temporary inundation of upstream land (including the site) occurs in response to this discharge control.
  - The 1 in 100 year flood level in the canal at the tunnel outlet peaks at 3.7mAHD with similar timing to the discharge peak from the upstream catchment. The model results show a small backflow occurs prior to overland flow from the upstream catchment reaching the tunnel. However, the magnitude (< 0.3 m^3/s), duration (~ 2 minutes) and volume of backflow is insignificant in the context of the catchment runoff (i.e. backflow from Hawthorne Canal is not the source of flooding within the site).
  - During the PMF, floodwaters rise to above the tunnel obvert and its capacity is exceeded, resulting in additional overland flow entering and traversing the site. Early backflow occurs for under 10 minutes, peaking at 3.6 m^3/s, prior to the upstream flood wave reaching the tunnel. Again, in the context of the overall flood event, the volume of back flow is insignificant and not a source of flooding at the site.
- Sportsfield embankment – immediately to the north of the site, an embankment exists along the southern side of the sportsfield which is a primary control on the containment of floodwaters within the site and the passage of overland flow to the north. The crest of the embankment is approximately RL 5.2 mAHD, meaning that no discharge occurs in the 1 in 100 year flood (RL 4.1 mAHD). The embankment overtops in the PMF (after the pedestrian tunnel is fully submerged at RL 4.8 mAHD) and flow spreads across the sportsfields (which are already inundated at that time). The peak PMF level across the sportsfields (5.8 mAHD) is higher than the bund but remains lower than the flood level within the site (6.8 mAHD).
- Existing site warehouse building – the existing building footprint spans the entire length of the site from south to north, and the entire width of the eastern lot along its northern boundary.
  - During the 1 in 50 year and 1 in 100 year flood events the building has a minor influence on flood levels in the west of the site by limiting the extent to which flow entering the site from the south can spread eastwards across the site. In these events, flood levels are at most 0.25 m and 0.40 m above the building floor level, respectively, so the influence of the building is only realised near the peak of the flood and limited to a very short duration surrounding the peak. No overland flowpaths conveying regional flood flows are blocked or restricted by the building during these events.
  - Conversely, during the PMF, the existing building functions as a significant hydraulic control on the passage of floodwaters through the site.
    - By spanning the length of the site from south to north, the building effectively constrains floodwaters to the western side of the site and prevents them from spreading east and discharging over the site boundary to the adjacent laneway. This is despite ground levels at the eastern site boundary and within the laneway being lower than the PMF level in the west of the site.
    - At the site's northern boundary, the level at which discharge to the sportsfield commences is controlled by the embankment located external to the site. However, once floodwaters

reach this level, the rate of discharge over the embankment is controlled by the width of the flowpath. At the narrowest point between the existing building and the light rail embankment, the flowpath width at the level of overtopping (5.2 mAHD) is approximately 5 metres. This increases to around 17 m at the peak PMF level (6.8 mAHD).

- If the existing building within the site is removed, and development of the site does not provide an equivalent hydraulic control at the site's northern boundary, the width of the flowpath over the embankment (at RL 5.2 mAHD) will increase to approximately 20m between the light rail embankment and the western side of the neighbouring building immediately north of the site.

2.3 Flood History

To our knowledge, there are no documented records or observations of historical flooding of flood levels at the site. Historical observations within the subject catchment are limited to two observation points during a single event and exhibit poor correlation with ground surface levels at the same locations. Design flood levels, for planning purposes, were derived from the LFS, and are described in Section 3.1.

2.4 Emergency Management

2.4.1 Emergency Management Framework and Existing EM Plans

2.4.1.1 NSW Statewide Context

Emergency management in NSW is governed by the *State Emergency and Rescue Management Act 1989 (SERM Act)*. The *State Emergency Management Plan (EMPLAN)* elaborates on the legislative requirements of the Act and describes the New South Wales approach to emergency management, the governance and coordination arrangements and roles and responsibilities of agencies. The Plan is supported by hazard specific sub plans and functional area supporting plans.

In the context this FIRA and consideration of the site's location, the following plans and sub-plans apply:

- New South Wales State Flood Plan (March 2018)
- Sydney Metropolitan Region Emergency Management Plan (January 2022)
- Inner West Council Flood Emergency Sub Plan (December 2021)

The NSW State Flood Plan sets out high level arrangements for the emergency management of flooding in NSW, whilst specific local arrangements for functional areas are detailed in the NSW SES Local Flood Plans. The plan identifies the primary goals for flood emergency management in NSW as:

- Protection and preservation of life;
- Establishment and operation of flood warning systems;
- Issuing of community information and community warnings;
- Coordination of evacuation and welfare of affected communities;
- Protection of critical infrastructure and community assets essential to community survival during and emergency incident;
- Protection of residential property;
- Protection of assets and infrastructure that support individual and community financial sustainability and aid assisting a community to recover from an incident; and

- Protection of the environment and conservation values considering the cultural, biodiversity and social values of the environment.

2.4.1.2 Regional Emergency Management Context

The *Sydney Metropolitan Region Emergency Management Plan (January 2022)* sets out the EMPLAN at a regional level and should be read in conjunction with the relevant Local EMPLAN's and corresponding Consequence Management Guidelines (CMG). It identifies the Inner West Council Local EMPLAN as the relevant plan for the IWC LGA, however no such plan can be found on IWC's website, and the website indicates that the Inner West Emergency Management Plan is 'to be published soon'.

The regional plan is reviewed every 3 years and takes control over the local management plan when certain escalation triggers are reached. An excerpt of the control escalation triggers that redirect the control to the regional authority is reported below:

- When an emergency grows beyond the capability of a Local Emergency Operations Centre (LEOC).
- When the emergency crosses two or more local emergency management boundaries and the change in control structure will improve the emergency response.
- When significant impacts are foreseen (i.e. Political, Environmental, Social, Technological, Infrastructure or Economic).
- When directed by the State Emergency Operation Controller (SEOCON).

Triggers for de-escalation and demobilisation measures are reached when:

- When the incident has scaled back such that a regional level response is no longer required.
- When the response has transitioned to a long-term recovery process and can be handed over the appropriate entities.
- When no further intervention/control is required at a regional level.

In the context of the site, and specifically in reference to flood-related emergency, flooding at the site and within the catchment occurs as flash-flooding with little to no warning time. Therefore, it is unlikely that the regional plan will be triggered during the course of any flood event. Accordingly, the provisions of the IWC Flood Emergency Sub Plan will, for all intents and purposes, define the immediate actions to be taken during any flood event.

2.4.1.3 Inner West Council Flood Emergency Sub Plan

The NSW SES maintains information on the nature of flooding and effects of flooding on the community in the Inner West Council LGA and is the entity responsible for co-ordinating local scale flood response.

Whilst no overall local emergency management plan currently exists for the Inner West LGA, the Inner West Council Flood Emergency Sub Plan, prepared and maintained by the NSW SES and endorsed by IWC outlines local emergency response procedures for flooding.

The plan details strategies and actions to be taken:

- for the prevention/mitigation of flood risk associated with a from a strategic planning perspective;
- in preparation for a flood emergency;
- in response to a flood emergency; and
- during recovery operations.

Much of the information in the plan pertains to responsibilities and actions of the SES and other agencies in respect of maintaining, reviewing and updating the plan, development and maintenance of flood intelligence systems and development, maintenance and preparation of warning systems. The following details specific flood response and warning actions from the plan:

- Flood response operations will begin:
  - On receipt of a Bureau of Meteorology (BoM) Severe Weather Warning or Thunderstorm Warning that includes heavy rain or storm surge; or
  - On the receipt of a BoM Flood Watch or Flood Warning; or
  - On receipt of warnings for flash flood; or
  - On receipt of a dam failure alert; or
  - When other evidence leads to an expectation of flooding.
- Flood Warning
  - Strategy: Timely and effective warnings are distributed to the community.
    - Actions:
      - The BoM issues public weather and flood warning products before and during a flood. These may include:
        - Severe Thunderstorm Warnings with reference to heavy rainfall
        - Regional Severe Thunderstorm Warnings with reference to heavy rainfall
        - Detailed Severe Thunderstorm Warnings (for Sydney / Newcastle / Wollongong) with reference to heavy rainfall,
        - Severe Weather Warnings with reference to heavy rainfall and/or storm surge,
        - Flood Watches, and
        - Flood Warnings.

The mapping included in the local plan only identifies the area to which the plan applies (which includes the site) and no specific evacuation routes or arrangements are defined.

2.4.2 Warning Systems, Preparation and Response Times

The *Leichhardt Flood Risk Management Plan* (LFRMP) (Cardno, November 2017) notes the following:

- Effective Warning Time
  - Critical durations for all storms 5 year ARI to PMF is between 15 minutes and 2 hours and peak of the flow occurs within this time.
  - The short critical durations suggest that there is insufficient time to alert residents for the purposes of evacuation of significant flood preparations.
- Duration of Flooding
  - Flooding durations are generally less than a couple of hours, and as such this is not considered as a key issue for study area with regards to increased flood risk or high hazardous conditions.
- Effective Flood Access
  - Significant areas within the catchment do not have effective flood access (considered as a road with flood depth less than 0.3 m).

- In these areas, for the duration of the flooding, evacuation is generally not recommended.
- In this type of short duration flooding, residents are as likely to put themselves in harm's way by evacuating rather than staying indoors.

In short, given the nature of flooding in the catchment, there is insufficient time for flood warnings to be issued and evacuation is not recommended.

3 AVAILABLE INFORMATION

3.1 Flood Certificate

A Flood Certificate for the site (dated 24 October 2018) was obtained from IWC by our client, a copy of which is included in Appendix C. The flood information contained in the certificate was derived from the *Leichhardt Floodplain Risk Management Study* (Cardno, November 2017) (the LFRMS) which includes the *Leichhardt Flood Study* (Cardno, 2015).

The Flood Certificate identifies the following flood levels at the site:

- 100 year ARI flood level = 4.10 mAHD
- Probable Maximum Flood (PMF) level = 6.80 mAHD
- Flood planning level = 100 year ARI flood level plus 500 mm freeboard = 4.60 mAHD.

The mapped inundation extents and high hazard areas from the flood certificate are shown on Figure 3-1.

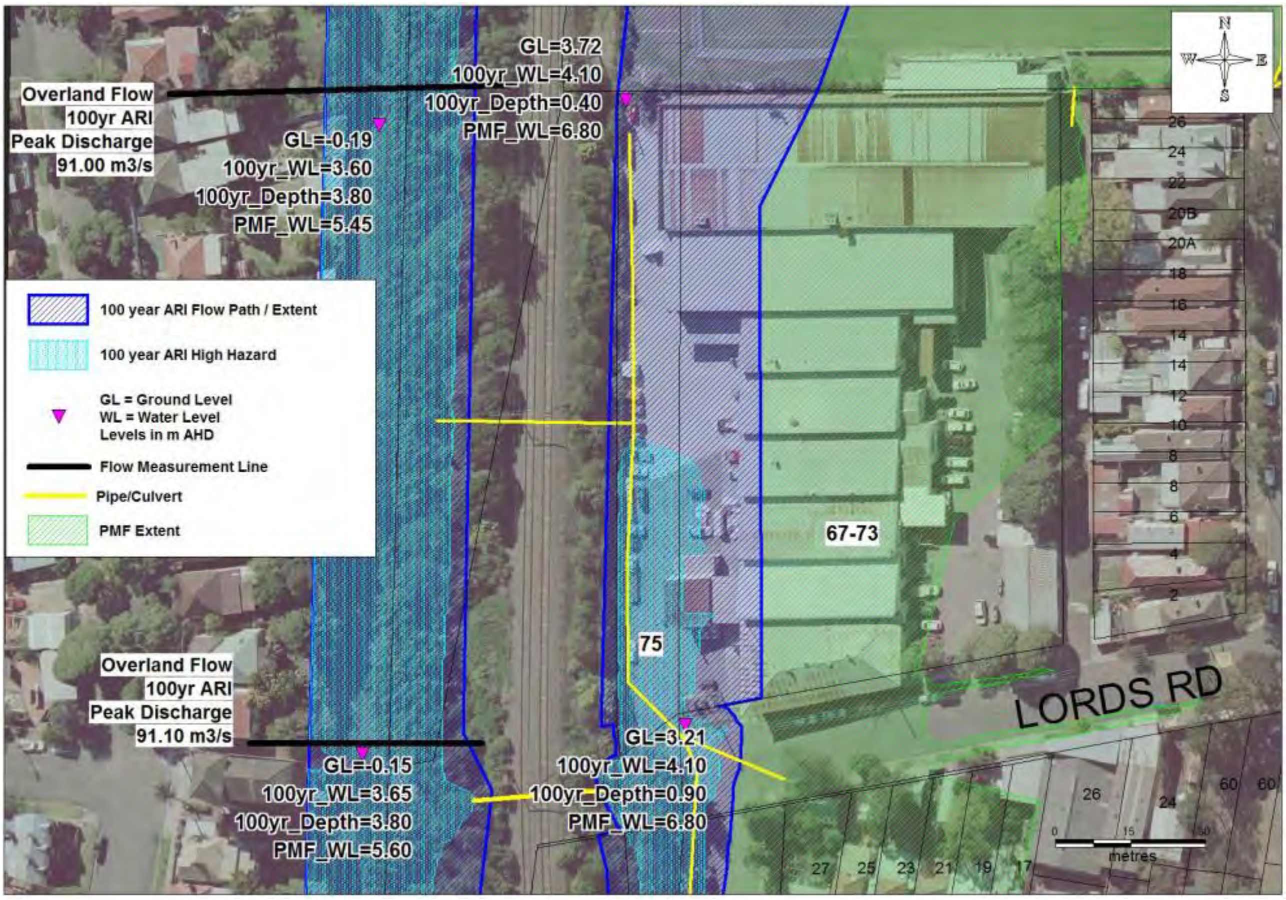

Figure 3-1 IWC Flood Certificate Map

3.2 Leichhardt Flood Study 2015

IWC has existing regional flood modelling of the Leichhardt area, which is described in the *Leichhardt Flood Study Final Report LJ2629* prepared by Cardno for (the former) Leichhardt Council and dated 27 May 2015. The flood study was informed by eight separate sub-models covering the former Leichhardt Council area, within the site being situated within the Hawthorne Canal sub-model.

The model was developed in the software package, Sobek, and comprises a high resolution (1 metre) 2-dimensional schematisation of the catchment surface, with 1-dimensional representation of the sub-surface drainage network. Local catchment hydrology has been represented using a rainfall-on-grid approach, with external catchment inflows derived from an XP-RAFTS hydrological model of the upstream sub-catchments.

At the request of our client, IWC provided a copy of the regional model and corresponding results to WT for the purpose of this assessment. Whilst the supplied model could be read and interrogated for review purposes, errors were encountered when trying to run the model. Sobek software is no longer commonly used in the industry in Australia, and limited support was available through Council (or their consultant who developed the model) to resolve these errors in a timely manner, thereby preventing the Sobek model from being used as the basis of the impact assessment. IWC subsequently agreed to WT developing a new local hydraulic model to assess impacts associated with the proposed development.

Notwithstanding this, a comprehensive review of the model inputs, results and modelled hydraulic behaviour was undertaken by WT and the Sobek model inputs and assumptions (hydraulic structures, surface roughness assumptions etc.) have been used to inform the preparation of new local hydraulic model (in TUFLOW) and the outcomes of the new model verified against the supplied Sobek model results. The new local hydraulic model is described in Section 5 of this report.

3.2.1 Sobek Model Review and Regional Flood Behaviour

3.2.1.1 1% AEP Design Event

The 1% AEP flood extent from the flood certificate is denoted by the hatched area in Figure 3-2 and suggests inundation extends across the northern site boundary and over the adjacent sports field.

Figure 3-2 IWC Sobek Model - 1% AEP Flood Extent

A review of the Sobek model topography and results provided by IWC shows that, for the 1% AEP flood event, inundation within the site is hydraulically isolated from inundation within the sports field, with the two areas separated by a bund situated outside of the site boundary. The elevation of the bund adjacent to the inundated site area is approximately 5.2 mAHD. The 1% AEP flood level within the site is 4.1 mAHD, and the flood level in the sports field is higher at 4.5 mAHD.

Whilst the inundation mapping presented on IWC's Flood Certificate may intentionally be conservative, it is the modelled flood behaviour that requires consideration when assessing flood impacts associated with the development. In the absence of an overland flowpath to the north, the inundated area in the west of the site is not a major conveyance path (for the 1% AEP flood) and effectively operates as flood storage area.

The subsurface drainage network through the site has limited capacity and caters for minor event stormwater runoff only. Discharge via this system is strongly influenced by the flood levels in the downstream canal and, during flood, the primary function provided by the network is to drain floodwaters that pond within the site once the regional flood peak in the downstream canal has passed.

The provision of a flood storage balance within the site should therefore be sufficient to manage impacts in events up to and including the 1% AEP flood, providing flows entering the site from the south are not substantially impeded by the development.

3.2.1.2 PMF

During the PMF, the embankment immediately north of the site becomes inundated and there is an exchange of flows between the site and the sports field – creating potential for any afflux within the site to propagate offsite. The extent of inundation within the existing site from Council's model results is however, much less than the area shown on the flood certificate, as depicted on Figure 3-3.

Figure 3-3 IWC Sobek Model - PMF Extent

Based on Council's model, there is a second overland flowpath situated within the laneway adjacent to the eastern site boundary, which also discharges north to the sports fields during the PMF. This flowpath primarily caters for runoff which is generated and remains offsite. This overland flowpath from the laneway into Lambert Park is now highly constrained because a building extension now presents a solid wall across the northern end of the laneway, inhibiting the passage of overland flow to Lambert Park.

Within the site, and based on the drainage network schematisation in IWC's model, local overland flows in the east of the site become trapped at a sag point against the existing building. In the model, runoff accumulates to an elevation that is higher than the ground level at the site boundary, resulting in modelled discharge to the laneway, and subsequently the sports field.

Survey data for the site indicates that there is sub-surface drainage infrastructure in place that collects flow at the sag point and connects into the modelled drainage network in the west of the site. This part of the drainage network is not represented in Council's model which effectively considers it to be fully blocked.

For the purpose of the flood impact assessment, the drainage schematisation in the model has been updated to include this drainage infrastructure in the existing case representation of the site in the same way as the drainage network within the western portion of the site has been represented, providing better representation of overland flow and drainage behaviour within the site.

Notwithstanding this, the observed hydraulic behaviour within the site is controlled by the interaction of local surface runoff with the existing buildings. This internal flow behaviour will change in response to the proposed development. Unlike the existing site conditions, the buildings within the proposed development will be both set back from the site boundary, and separated from each other, providing opportunity for surface runoff from the site to be conveyed through the site to the west, rather than becoming trapped and ponding within the site.

3.3 Leichhardt Floodplain Risk Management Study (LFRMS)

The LFRMS prepared by Cardno for (the former) Leichhardt Council and dated November 2017, builds on LU01(2015) to further define existing flood behaviour and associated hazards and to investigate possible mitigation options to reduce flood damage and risk.

Model updates to further define existing flood behaviour, reflecting upgraded drainage systems and additional data collected of existing drainage systems (subsequent to the preparation of LU01) were limited to four of the nine catchment areas addressed in the flood study. This did not include the Hawthorne Canal catchment and associated sub-model and therefore has no bearing on the site.

The LFRMS considered a range of flood risk management options to reduce the flood risk including flood modification, emergency response modification and property modification.

Council has not provided any advice to indicate whether any of the identified measures have been further considered or implemented, so as per Council's requirements, the modelling for this FIRA has adopted the infrastructure represented in the supplied regional model.

The overall recommendations of the study found that eliminating all flood risks from the study area would be impractical. Instead, it recommends that measures be taken to ensure that existing and future development is exposed to an 'acceptable' level of risk.

3.4 Leichhardt Floodplain Risk Management Plan (LFRMP)

The LFRMP summarises flooding behaviour in the catchment, noting that:

'A large majority of the flooding within the study area occurs outside of the main creek systems, when the capacity of stormwater pits and pipes are exceeded. When this occurs, overland flows proceed down roads and through properties. At a number of locations within the study area, historical development has occurred

perpendicular to the overland flow paths and across existing depressions and low points. Therefore, rather than follow the roads or via designated flowpaths, the overland flows tend to proceed through properties. In addition, the density of development across the study area, such as townhouses and terrace housing, can result in a complete obstruction to overland flow, the only overland flowpath then available is directly through actual dwellings.'

Key findings of the LFRPM with respect to emergency response were outlined in Section 2.4.2. In short, given the nature of flooding in the catchment, there is insufficient time for flood warnings to be issued and evacuation is not recommended.

3.5 Hawthorne Canal Flood Study

The Hawthorne Canal Flood Study was prepared by WMA Water in February 2015 for (the former) Ashfield and Marrickville Council's. Hydrological modelling was undertaken using DRAINS and hydrographs representing sub-catchment runoff were extracted for input to the hydraulic model. The hydraulic modelling was completed using TUFLOW.

The modelling undertaken to inform the study considered the entire Hawthorne Canal catchment area, including the land within (the former) Leichhardt LGA. However, as Leichhardt Council was not involved in the study, the level of detail included in the model within the Leichhardt LGA was significantly less than throughout the remainder of the model. Sub-catchments were defined at a much lower resolution, and the sub-surface drainage network included in that area of the model was limited to major infrastructure owned by Sydney Water.

The drainage network through the site was not modelled, nor was the drainage network discharging through the railway embankment at Hathern Street, or the culvert outlet just south of Kegworth Road. Accordingly, within the model, all runoff that would discharge at these locations remains on the surface, is intercepted by the light rail embankment flows to the only available discharge point through the embankment being the pedestrian tunnel at Lords Road. The additional flow to this outlet, and corresponding volume of runoff temporarily stored in the landform upstream of the outlet, directly influences flood levels across the site, meaning that the model is not representative of anticipated flood behaviour in the vicinity of the site and should not be referenced in this respect.

The information in the flood study can however be usefully referenced with respect to structure details for major crossings over Hawthorne Canal (at Parramatta Road and Marion Street).

Modelled flows and flood levels in Hawthorne Canal have also been considered. However, as the results differ substantially from the outcomes of the Sobek modelling, their use as a secondary data source for validating the local flood model is limited (particularly in the context of IWC's requirements for the local model to be calibrated to the LFS).

3.6 Site Ground Survey Data

A historical ground survey plan for the site, based on survey undertaken on 19 November 2004, was provided by Platino Properties to inform the flood assessment. This plan was provided as a PDF and the data was not available in electronic format for inclusion in the model.

A subsequent detail ground survey was undertaken in September 2019, specifically to inform the flood study. A digital elevation model (DEM) was generated from the survey data for use in the modelling. Copies of the ground survey plans are provided in Appendix B.

3.7 Other Data

IWC provided the following electronic datasets which have been referenced in preparation of this report:

- Sobek hydraulic model including:
  - Model files
  - Complete results for all modelled storms
  - Post-processed model results for each event
  - GIS flood extents (5 year, 20 year, 100 year and PMF)
- XP-RAFTS model files
- Sobek sub-model catchment boundaries (GIS)
- Pit and pipe database (GIS)
- Other data associated with Leichhardt Flood Study including:
  - Sydney Water Historical Flood Information Database
  - Sydney Water GIS data (stormwater drainage lines, stormwater structure locations, catchment areas)
  - Final pit and pipe survey data (GIS) and structure photos from survey
  - Cross-section data for drainage channels and major structures including (12D model, DWG files for each cross-section, scanned field notes and photos)
- Building footprints (GIS layer)

4 FLOOD RELATED REQUIREMENTS

Whilst IWC is the Local Government Authority (LGA) responsible for the area within which the site is situated, we understand that the State will be the planning authority responsible for assessing the project. Where practicable, the requirements and requests from both authorities have been considered to inform this report, however where requirements differ, state planning requirements have been considered to take precedence over local council requirements.

4.1 State Planning Requirements

Email correspondence from NSW Department of Planning & Environment (DPE) to our client on 6 October 2023 forwarded the following general advice (received from flood specialists in EHG) regarding the preparation of flood studies in light of the new Flood Risk Management Manual.

We would like to draw the following documents to your consultant's attention:

- *Within the flood risk management toolkit on NSW DPE's website, the particular additional document that is relevant for private developments is LU01 'Flood Impact and Risk Assessment', which is located here: https://www.environment.nsw.gov.au/research-and-publications/publications-search/flood-impact-and-risk-assessment.*
- *This should not be read as to replace the obligations for consideration around the Section 9.1 Direction – however, the document is particularly useful as it outlines the minimum reporting requirements EHG need to undertake an analysis against the Ministerial Direction.*
- *Appendix A in particular steps through all minimum reporting requirements which must be completed by the applicant.*

4.1.1 Flood Impact and Risk Assessment – Flood Risk Management Guideline LU01

The *Flood impact and risk assessment – Flood risk management guideline LU01* (LU01) (NSW DPE, June 2023) published alongside the FRMM, provides advice on the scope and scale of a *Flood Impact and Risk Assessment* (FIRA) to examine flood constraints and how to manage flood risks posed to and by a new development, and has been used to inform the modelling approach and as a framework for scope of works undertaken for this assessment.

This FIRA has been prepared to specifically address the requirements of LU01, as described in Section 1.3, and follows the report structure outlined in Appendix A of that guideline.

4.1.2 Environment Planning and Assessment Act 1979 – Section 9.1 Directions

Requirements for flooding are set out in Section 4.1 of the Local Planning Directions, as listed below.

Objectives

The objectives of this direction are to:

(a) ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and

(b) ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.

Application

This direction applies to all relevant planning authorities that are responsible for flood prone land when preparing a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.

Direction 4.1

(1) A planning proposal must include provisions that give effect to and are consistent with:
- *(a) the NSW Flood Prone Land Policy,*
- *(b) the principles of the Floodplain Development Manual 2005,*
- *(c) the Considering flooding in land use planning guideline 2021, and*
- *(d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.*

(2) A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Employment, Mixed Use, W4 Working Waterfront or Special Purpose Zones.

(3) A planning proposal must not contain provisions that apply to the flood planning area which:
- *(a) permit development in floodway areas,*
- *(b) permit development that will result in significant flood impacts to other properties,*
- *(c) permit development for the purposes of residential accommodation in high hazard areas,*
- *(d) permit a significant increase in the development and/or dwelling density of that land,*
- *(e) permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*
- *(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,*
- *(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or*
- *(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.*

(4) A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:
- *(a) permit development in floodway areas,*
- *(b) permit development that will result in significant flood impacts to other properties,*
- *(c) permit a significant increase in the dwelling density of that land,*
- *(d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*
- *(e) are likely to affect the safe occupation of and efficient evacuation of the lot, or*
- *(f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.*

(5) For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.

Consistency

A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Planning Secretary (or their nominee) that:

> *(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or*
> *(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or*
> *(c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or*
> *(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.*

Note: *In this direction:*
(a) "flood prone land" "flood storage" "floodway" and "high hazard" have the same meaning as in the Floodplain Development Manual 2005.
(b) "flood planning level" "flood behaviour" and "flood planning area" has the same meaning as in the Considering flooding in land use planning guideline 2021.
(c) Special flood considerations are outlined in the Considering flooding in land use planning guideline 2021 and an optional clause in the Standard Instrument (Local Environmental Plans) Order 2006.
(d) Under the floodplain risk management process outlined in the NSW Government's Floodplain Development Manual 2005, councils may produce a flood study followed by a floodplain risk management study and floodplain risk management plan.

4.2 Inner West Council Requirements

IWC has an existing regional flood model of the catchment that is described in the *Leichhardt Flood Study Final Report LJ2629* (the LFS) prepared by Cardno for (the former) Leichhardt Council and dated 27 May 2015. Further details of the existing flood study are described in Section 3.2.

IWC's initial preference was for the impact assessment to be undertaken using the existing regional flood model. The model was developed using the Sobek hydraulic modelling software and a copy was provided to WT for the purpose of this assessment. The supplied model could not be run using the specified version of the software and returned simulation errors that have not been resolved. As Sobek is no longer commonly used in the local context, Council (and their original consultant) were not in a position to provide assistance to resolve the errors.

To allow the planning proposal to progress, WT proposed to develop a new local flood model (using TUFLOW) for our client for the specific purpose of this assessment.

In email correspondence dated 27 September 2023, Council indicated no objection to the development of a new TUFLOW model for the purpose of assessing the impacts of the development, but expressed specific preferences with respect to some model inputs to ensure consistency with the Sobek results and provide for like-for-like comparison.

The specific items detailed by Council's to be applied in the modelling are summarised below.

- Catchment
  - The SOBEK model catchment was limited to the area immediately around Parramatta Road and included the upper reaches of the catchment as inflow nodes.
  - The TUFLOW model should either:
    - 1 - Apply the existing XP-RAFTS inflows from the existing model; or
    - 2 - Extend the TUFLOW catchment to include the areas previously modelled with XP-RAFTS.

- Roughness
  - The roughness values should be consistent with the roughness values used for the SOBEK model.
- Rainfall Pattern
  - Council has noted model differences arising from the different temporal rainfall patterns between ARR1987 compared with ARR2019.
  - As the development is reviewing impact of flooding compared with existing analysis, the model should use the ARR1987 rainfall patterns used for the Leichhardt Flood Study, rather than ARR2019 patterns.
- Calibration
  - The model should be calibrated against the January 1991, February 1993 and April 1998 storm events and the model output files from the SOBEK model to ensure consistency of results and afflux assessment.

Details on how these items have been considered in the modelling are provided in Section 5.3.

5 HYDRAULIC MODEL DEVELOPMENT AND CALIBRATION

5.1 Overview

As Council's existing Sobek hydraulic model of the catchment could not be utilised for the hydraulic impact assessment, WT developed a new local hydraulic model of the catchment utilising the latest version of TUFLOW modelling software. The TUFLOW model was developed in two phases:

1. A calibration model was established to replicate the inputs and assumptions contained within the regional Sobek model wherever practicable. The model was run for a single storm event (critical duration 100 year ARI storm at the site) and results verified against the Sobek model results for the same storm for calibration purposes.
2. The model was then amended to incorporate updated topographic data for the catchment, improved representation of the stormwater drainage network based on IWC's GIS data and to include site-specific inputs from detailed ground survey of the site. This model was used as the basis for the impact assessment and was run using revised hydrological inputs derived in accordance with ARR2019.

Inner West Council specifically requested that any new local hydraulic model be calibrated against their existing flood model (which was used to inform the planning levels on the Flood Certificate), and comparisons undertaken for this purpose are described in Section 5.4.

5.2 Hydraulic Model Development

To confirm local flood and overland flow behaviour in the vicinity of the site, a detailed 1D/2D TUFLOW model has been developed. A summary of the model inputs and assumptions for the two model phases is provided in Table 5-1 and selected parameters are addressed in further detail below.

Table 5-1 Summary of TUFLOW model inputs and assumptions

Item	Phase 1: Calibration model	Phase 2: Impact assessment
Software	■ Hydraulic: TUFLOW build 2023-03-AB (using HPC solution scheme) ■ Hydrology: XP-RAFTS	
Modelling approach	■ Rain-on-Grid within hydraulic model extent ■ Hydrographs for external/upstream inflows (from hydrological model)	
Resolution	■ 1m cell size (as per regional model)	
Coordinate system	■ GDA 2020 MGA Zone 56	
Model extent (Section 5.2.1)	■ Covers southern (upstream) portion of the regional Hawthorne Canal sub-model. ■ Includes catchment contributing to the major overland flowpaths surrounding and through the site. ■ Downstream boundary in Hawthorne Canal approx. 100m north of Marion Street. ■ Phase 2 only: refinement of eastern model boundary to align with catchment divide.	

<table>
<tr><th>Item</th><th>Phase 1: Calibration model</th><th>Phase 2: Impact assessment</th></tr>
<tr><td>Topography
(Section 5.2.2)</td><td>■ Sobek model DEM
■ Based on 2006 ALS data augmented with survey data for Hawthorne Canal
■ Building footprints raised by 3m in supplied model DEM (no additional input needed)</td><td>■ Base: 2020 LiDAR
■ Building footprints raised to obstruct overland flow (as per regional model) using GIS data from IWC
■ Hawthorne Canal: trimmed DEM from regional model
■ Existing site & surrounds: detailed ground survey</td></tr>
<tr><td>Roughness
(Section 5.2.3)</td><td colspan="2">■ Landuse based Manning's 'n' values based on Sobek roughness and advice from IWC
■ Phase 2 only: revised roughness values within site as appropriate</td></tr>
<tr><td>Hydraulic structures
(Section 5.2.4)</td><td colspan="2">■ Bridges over Hawthorne Canal (Parramatta Road and Marion Street): modelled as 2d bridges with reference to cross-section data in Sobek model, IWC data package and the separate Hawthorne Canal Flood Study (2015).
  ■ Form loss coefficients used as calibration parameter
■ Major culverts under rail embankment (near Kegworth Street, and Lords Road): modelled as 1d culverts with tabulated irregular cross-sections and invert levels extracted from Sobek model.
■ Stormwater drainage network:
  ■ Pipes: properties from Sobek model
  ■ Manholes: 'closed' pits from Sobek model represented as manhole junctions
  ■ Pits: modelled as Q type pits with locations and levels from Sobek model
■ Phase 2 only: updated drainage network details within and surrounding site from detailed survey data.</td></tr>
<tr><td>Boundary conditions
(Section 5.2.5)</td><td colspan="2">■ Upstream inflow boundaries: hydrographs extracted from XP-RAFTS model (as per Sobek model).
■ Rainfall inputs: rainfall hyetographs applied as rain-on-grid over entire 2D model extent.
■ Downstream boundary: normal depth boundary with water surface slope based on regional model results within Hawthorne Canal and adjusted for model calibration.
  ■ Additional normal depth boundaries applied at downstream model limits on eastern side of rail embankment to prevent artificial ponding against model boundary.
■ Initial conditions: initial water level of 1.0 mAHD corresponding with fixed tailwater level in regional model.</td></tr>
</table>

<table>
<tr><th>Item</th><th>Phase 1: Calibration model</th><th>Phase 2: Impact assessment</th></tr>
<tr><td>Hydrology
(Section 5.2.6)</td><td>

ARR1987 hydrology
100 year ARI 60 minute storm only
i.e. 100 year ARI critical duration storm at the site (based on Sobek model results)
Inflow hydrographs for upstream and external catchment runoff directly from IWC XP-RAFTS model.
Excess rainfall hyetograph taken from Sobek model inputs for same storm event (no losses in TUFLOW model).
</td><td>

ARR2019 hydrology
Design events:
10%, 5%, 2%, 1%, 0.5% and 0.2% AEP's
1%, 0.5% and 0.2% AEP climate change scenarios (RCP 8.5 for year 2090)
PMF
Inflow hydrographs from IWC XP-RAFTS model re-run with ARR2019 hydrology.
Total rainfall hyetographs extracted from XP-RAFTS.
Initial and continuing losses applied in TUFLOW materials layer.
</td></tr>
<tr><td>Reporting points and map outputs</td><td colspan="2">

Reporting points:
Selected 2d_po flow lines at Sobek 2D history lines for comparison purposes.
2d_po water level points at each flow line (no water level history points defined in Sobek within local model extent).
Phase 2 only: additional reporting lines and points at selected locations of interest within and surrounding site.
Map outputs:
A map-cutoff depth of 0.05 m was defined within the hydraulic model.
Note: this represents a conservative assumption relative to post-processing of the Sobek map outputs which excluded areas with depths less than 0.15 m and velocity-depth product less than 0.1 m²/s.
Map outputs were generated for maximum water level, depth, velocity, velocity-depth product and hazard vulnerability classification.
Post-processing of the rain-on-grid outputs was undertaken to filter out isolated wet areas (<100 m² area) not directly connected to continuous overland flowpaths.
Post-processing for the PMF only also applied a minimum depth criteria of 0.1 m. This was necessary to limit the mapping to areas of overland flow moving through the catchment and exclude extensive 'wet' areas solely associated with the much higher incremental rainfall depths applied to the model during the PMF storms.
</td></tr>
</table>

5.2.1 Model Extent

The model extent was selected to reflect the upstream portion of the regional model such that the catchment contributing to the major overland flowpaths through the site and the sportsfield immediately north of the site was included. The model extent also includes the reach of Hawthorne Canal to which these flowpaths discharge.

For the Phase 1 model, which used the DEM from the Sobek model, the eastern catchment boundary remained unchanged from the regional model (as this was also the limit of the supplied DEM).

For the Phase 2 model, the eastern catchment boundary was refined in reference to the 2020 LiDAR and extends to the catchment divide, such that the full extent of the contributing catchment was included in the model.

The extent of the local hydraulic model is shown on Figure 5-1 alongside the existing regional sub-model extent.

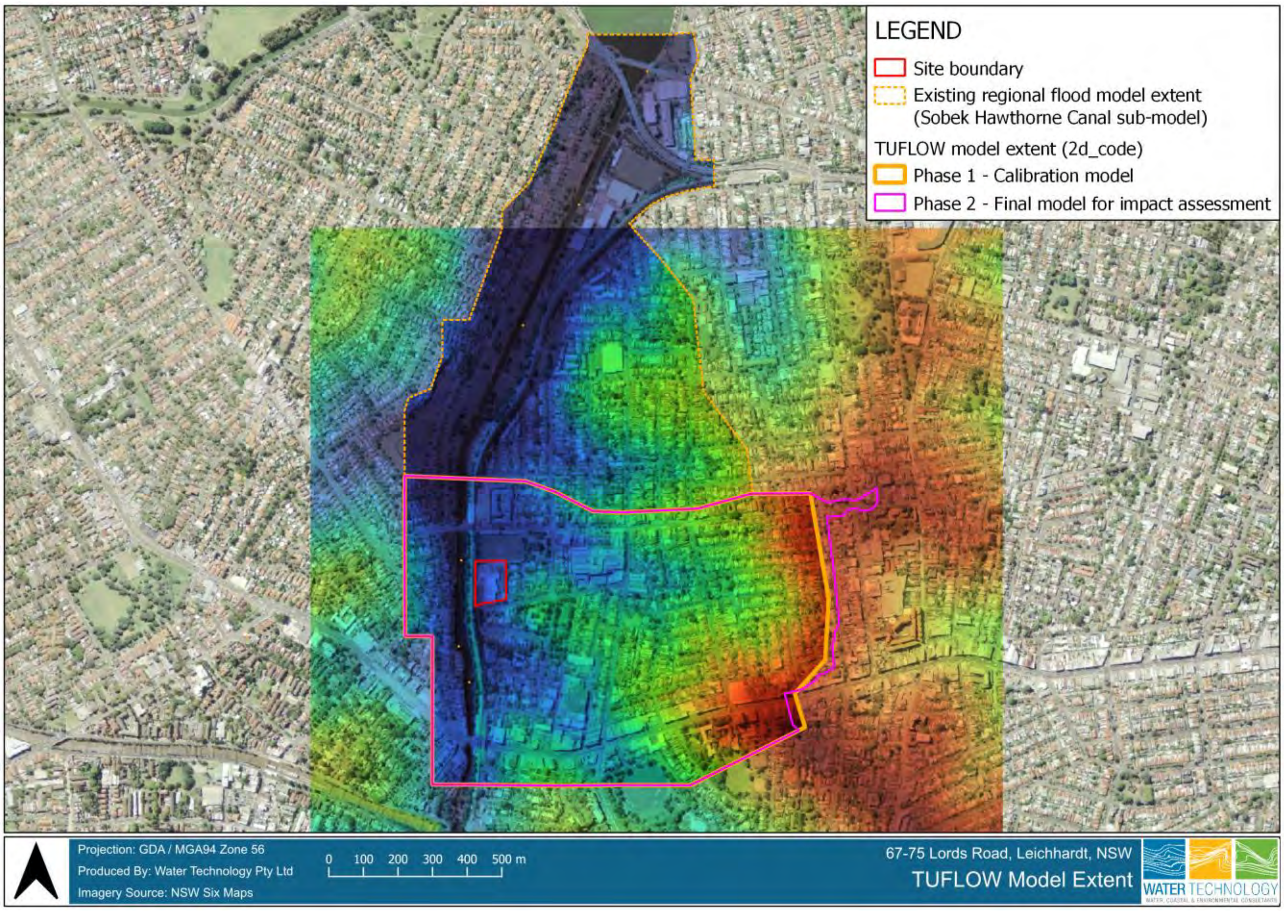

Figure 5-1 TUFLOW Model Extent

5.2.2 Topography

The overall model topography for the final existing case (Phase 2) model is shown in Figure 5-2.

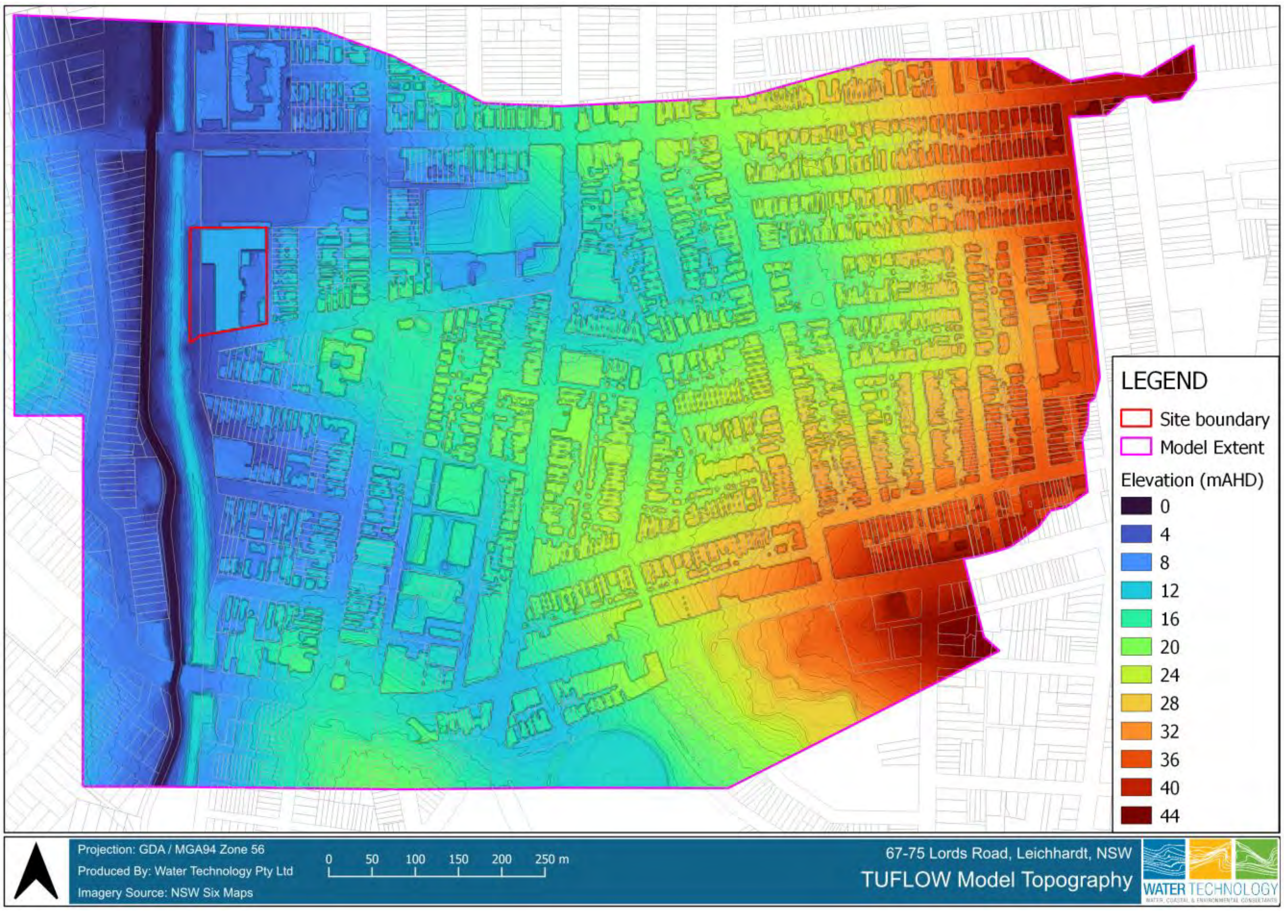

Figure 5-2 TUFLOW Model Topography

5.2.3 Surface Roughness

Manning's 'n' surface roughness values across the catchment were defined to mirror the surface roughness grid contained on the Sobek model. The surface roughness assumptions were revised within the site to reflect existing site conditions. Amendments to surface roughness assumptions outside the site were limited to correcting minor errors in the Sobek model inputs.

The landuse-based surface roughness types are shown on Figure 5-3 and surface roughness values are provided in Table 5-2.

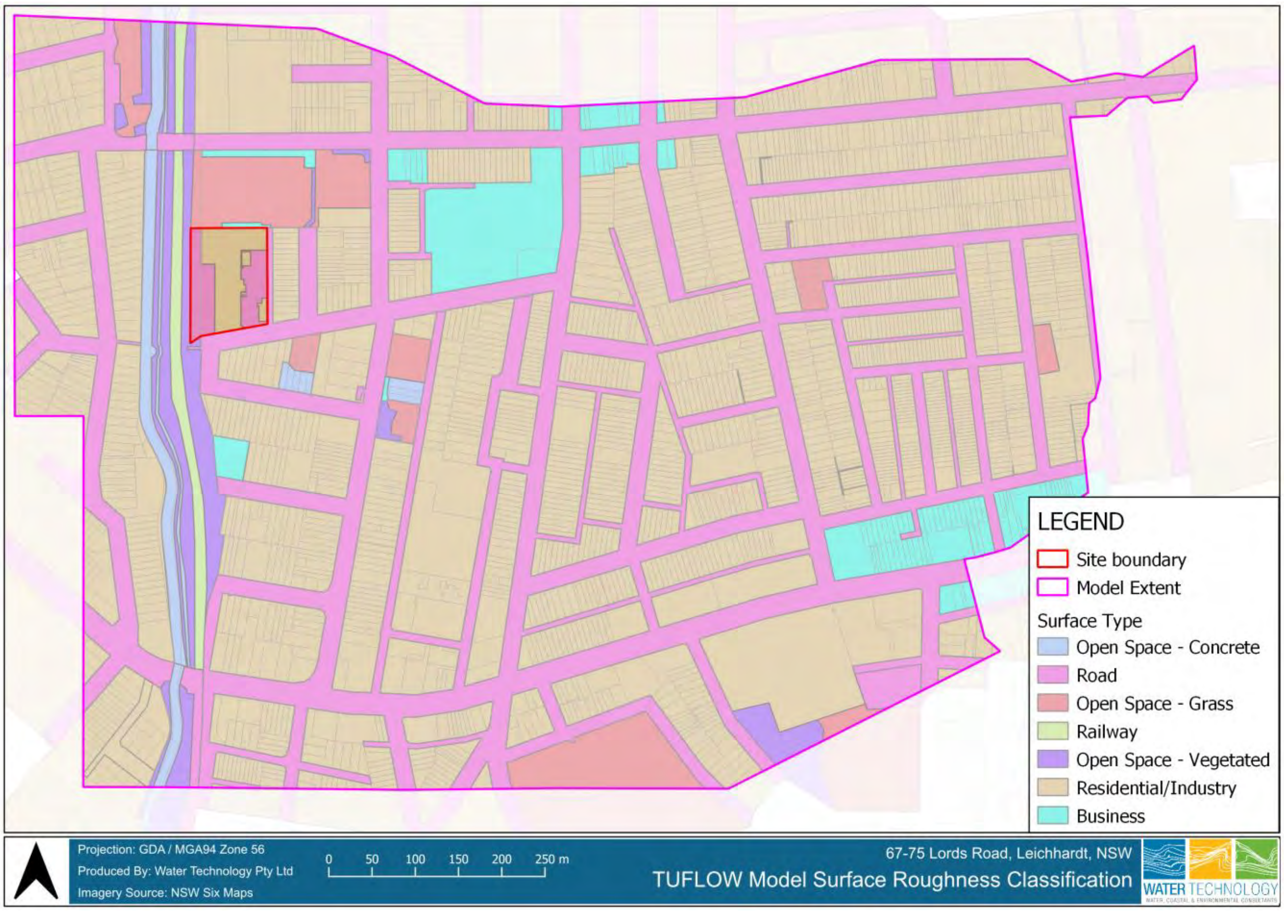

Figure 5-3 TUFLOW Model Surface Roughness

Table 5-2 Surface Roughness Values

Description	Manning's 'n'
Open Space - Concrete	0.015
Road	0.020
Open Space – Grass	0.030
Railway	0.035
Open Space – Vegetated	0.050
Residential/Industry	0.100
Business	0.150

5.2.4 Hydraulic Structures

Details of the sub-surface stormwater drainage network and other hydraulic structures included in IWC's Sobek model were converted to TUFLOW file formats for representation in the local model.

The modelled drainage network (for the Phase 1 model) is shown on Figure 5-4.

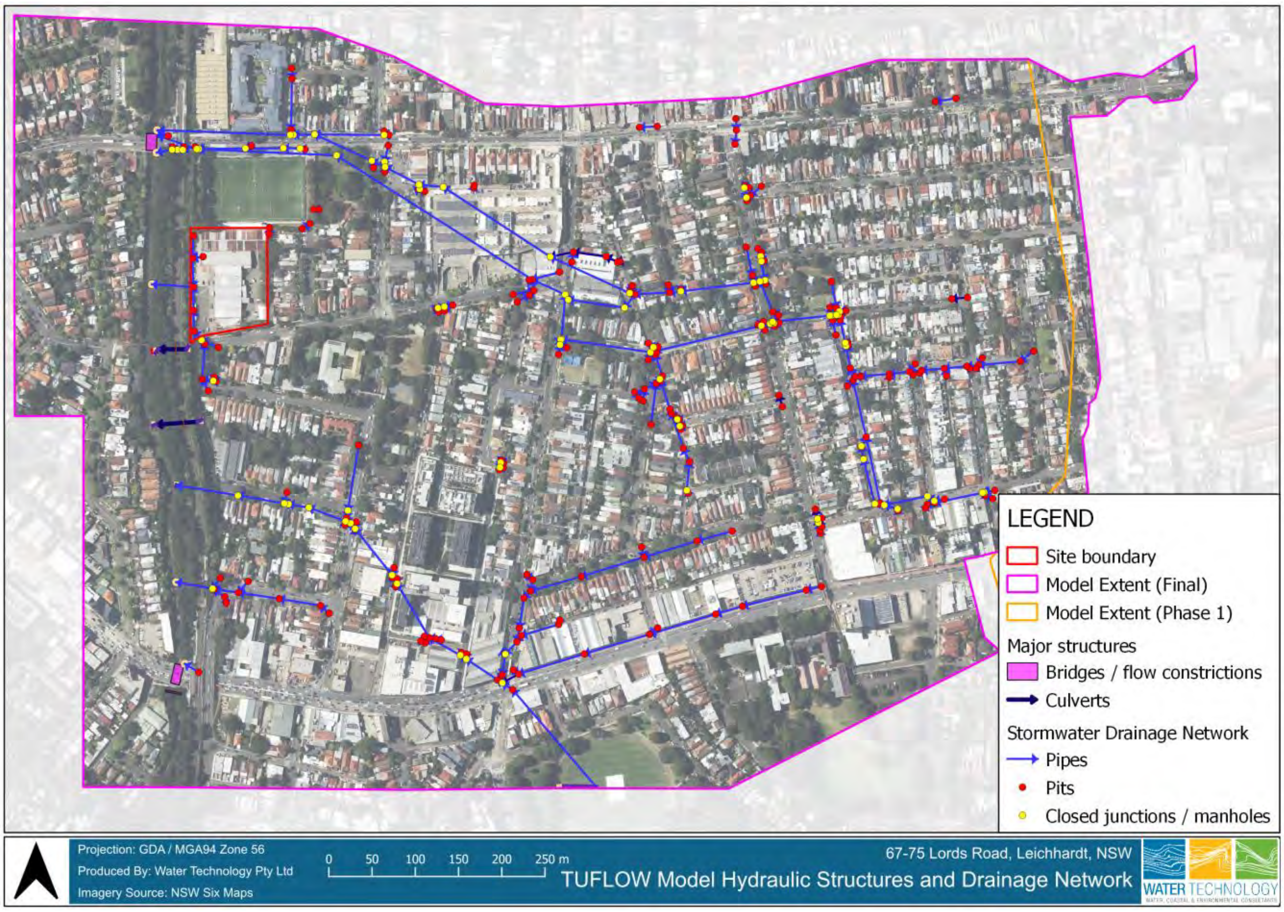

Figure 5-4 Hydraulic Structures and Stormwater Drainage Network

5.2.4.1 Major Structures

Within the local model extent, there are four (4) major structures that were modelled as stand-alone culverts in the Sobek model. These are:

- Bridge over Hawthorne Canal at Parramatta Road
- Bridge over Hawthorne Canal at Marion Street
- Culvert under the rail embankment just south of Kegworth Street
- Pedestrian tunnel under the rail embankment at Lords Road

In the TUFLOW model, the bridges have instead been represented as layered flow constrictions defined using 2D bridge elements (2d_bg) and their properties have been defined with reference to the field survey data (photos, sketches) and cross-sections plots contained in the data package from Council, and also the 2015 Hawthorne Canal Flood Study described in Section 3.5.

A separate structure has also been defined in the model to represent the flow constriction from the pipeline crossing the canal a short distance upstream of Parramatta Road.

The form loss coefficients (FLC values) have been used as a calibration parameter for these structures to return model outcomes in Hawthorne Canal that are comparable to the Sobek model (to the extent that is practicable given the inherent instabilities influencing the Sobek model results). The model inputs for these structures are given in Table 5-3.

Table 5-3 Modelled Bridge Structures/Flow Constriction Details

Parameter	Pipeline	Parramatta Road	Marion Street
Channel invert (mAHD) (model DEM)	0.45	0.41	-0.20
Pier blockage (%)	0	0	10
Pier FLC	0.15	0	0.3
Deck soffit (mAHD)	2.51	5..2	2.77
Deck depth (m)	1.03	2.10	1.38
Deck width (m)	1	24	20
Deck blockage (%)	100	100	100
Rail depth (m)	0	1.70	1.12
Rail blockage (%)	100	100	60
Super structure FLC	0.3	0.15	0.15
Super structure IPf	1.6	1.6	1.6

The two culverts have been modelled as 1D network elements with irregular cross-sections (as defined in the Sobek model). Table 5-4 provides the details of the major crossing structures included in the model.

Table 5-4 Modelled Culvert Structure Details

<table>
<tr><th>Location</th><th>Length (m)</th><th>US IL (mAHD)</th><th>DS IL (mAHD)</th><th>Cross section details</th></tr>
<tr><td>Culvert near Kegworth Street
</td><td>30</td><td>1.17</td><td>1.02</td><td><table>
<tr><th>Stage (m)</th><th>Total width (m)</th></tr>
<tr><td>0</td><td>1.24</td></tr>
<tr><td>0.62</td><td>1.24</td></tr>
<tr><td>0.68</td><td>1.23</td></tr>
<tr><td>0.74</td><td>1.22</td></tr>
<tr><td>0.80</td><td>1.19</td></tr>
<tr><td>0.86</td><td>1.15</td></tr>
<tr><td>0.92</td><td>1.09</td></tr>
<tr><td>0.98</td><td>1.02</td></tr>
<tr><td>1.03</td><td>0.92</td></tr>
<tr><td>1.09</td><td>0.80</td></tr>
<tr><td>1.15</td><td>0.63</td></tr>
<tr><td>1.21</td><td>0.37</td></tr>
<tr><td>1.24</td><td>0</td></tr>
</table></td></tr>
<tr><td>Lords Road Pedestrian Tunnel
</td><td>26</td><td>2.31</td><td>1.99</td><td><table>
<tr><th>Stage (m)</th><th>Total width (m)</th></tr>
<tr><td>0</td><td>3.09</td></tr>
<tr><td>2.40</td><td>3.09</td></tr>
<tr><td>2.44</td><td>3.08</td></tr>
<tr><td>2.48</td><td>3.03</td></tr>
<tr><td>2.51</td><td>2.96</td></tr>
<tr><td>2.55</td><td>2.86</td></tr>
<tr><td>2.59</td><td>2.72</td></tr>
<tr><td>2.63</td><td>2.53</td></tr>
<tr><td>2.67</td><td>2.30</td></tr>
<tr><td>2.71</td><td>1.99</td></tr>
<tr><td>2.74</td><td>1.58</td></tr>
<tr><td>2.78</td><td>0.92</td></tr>
<tr><td>2.80</td><td>0</td></tr>
</table></td></tr>
</table>

5.2.4.2 Stormwater Drainage Network

Physical properties of the pipes (invert levels, diameter, length) and invert levels for the pits and manholes/pipe junctions have been adopted directly from the Sobek model.

All pit inlets have been represented as 'Q' type pits in TUFLOW. The dimensions of each pit structure were referenced from the drainage network GIS data provided by ICC and depth-discharge curves were derived using combination of weir and orifice equations based on common pit dimensions (a lumped approach was used with a single curve being adopted for pits of similar dimensions).

This differs from the way the pits were modelled in Sobek due to differences in the way the drainage network is schematised in the two models. In Sobek, pits were defined by crest widths and the model uses the weir equation to calculate inflow. All pits were also modelled with a maximum flow rate of 0.4 m^3/s (independent of dimensions or hydraulic head at the inlet).

Preliminary TUFLOW simulations were carried out using depth-discharge curves derived from the weir equation only and a maximum flow rate of 0.4 m^3/s to replicate structure definitions in Sobek. However, during the calibration process, it was found that the standard TUFLOW approach to deriving pit inlet curves returned a better overall fit for flood levels throughout the catchment.

The Sobek model schematisation for the PMF storms (but not the 100 year storms) also included a storage area of 10 m^2 in each pit structure. This has not been replicated in TUFLOW as the physical form of the subsurface drainage infrastructure does not change in response to how much rainfall the catchment receives.

5.2.4.3 Existing Site Drainage

For the final Phase 2 model (i.e. existing case for the impact assessment) drainage structure information within and immediately surrounding the site was revised using site survey data. The modelled drainage arrangements for the existing site are shown on Figure 5-4.

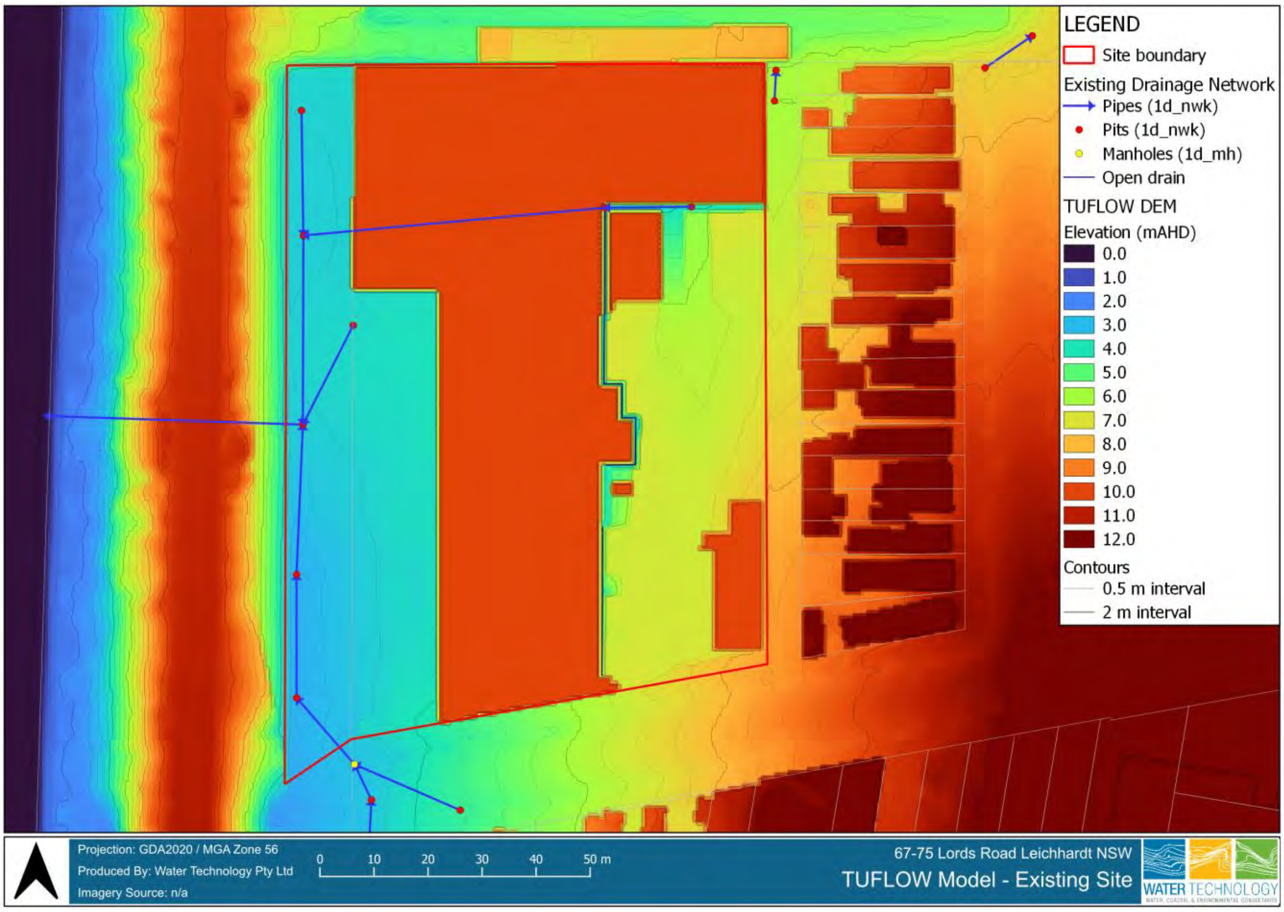

Figure 5-5 TUFLOW Model Schematisation – Existing Site

5.2.5 Boundary Conditions

The downstream boundary was defined in Hawthorne Canal, approximately 150 m north of Marion Street. This location provides sufficient separation from the site (in terms of both distance and hydraulic grade) such that flood behaviour within and around the site can be well represented.

Hawthorne Canal discharges directly to the Parramatta River at Iron Cove at the boundary of the regional model, approximately 1.2 km downstream of the adopted local model boundary.

During development of Council's regional model, consideration was given to the frequency and magnitude of storm tides in Sydney Harbour (i.e. the lower Parramatta River). A risk-based approach was applied to derivation of the tailwater level for modelling purposes, with the adopted tailwater condition (which is equalled or exceeded 1% of the time) being a fixed level of RL 1.0 mAHD applied across all events.

At this RL, there is a small volume of water contained within the Hawthorne Canal at the model boundary and extending upstream past the site. However, the flood levels and associated flow volumes in the canal are substantially higher. Given this, and the presence of a longitudinal hydraulic grade on the flood surface within the canal at the local model boundary (i.e. no significant backwater influence from downstream road crossings), the local model adopted a normal-depth boundary at its downstream limit.

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The water surface slope for the normal depth boundary in Hawthorne Canal was initially estimated from the hydraulic grade of the 100 year ARI flood surface from that canal reach in Council's model. This slope was iteratively adjusted until good correlation with the Sobek model water levels was achieved in the canal reach downstream of Marion Street. The resulting water surface slope of 0.0002 m/m was adopted for all design events except the PMF for which a slope of 0.0005 m/m was used (reflecting the much steeper hydraulic grade along the canal during the PMF).

Additional normal-depth boundaries were defined at selected locations along the northern model boundary to accommodate secondary minor overland flowpaths and prevent artificial accumulation of surface runoff against the model boundary.

Inflow hydrographs representing runoff from external upstream catchments were generated from IWC's XP-RAFTS model and applied at three (3) locations within the proposed model extent, correlating with the inflow locations to the Sobek model.

Direct rainfall was applied evenly across the entire model area in keeping with regional model assumptions.

5.2.6 Hydrology

IWC's existing regional model follows the hydrological modelling methodology of ARR1987, which has since been superseded. This section provides a summary of how the hydrological assumptions were represented in the TUFOW modelling. More details on the ARR2019 hydrological modelling are provided in Section 6.1.2.

5.2.6.1 Phase 1: Calibration Model

The Phase 1 modelling was undertaken using ARR1987 hydrology for the 100 year ARI critical duration (60 minute) storm at the site to provide like-for-like comparison to the regional model for calibration purposes.

Upstream boundary inflow hydrographs were the same as those used in Sobek modelling and rainfall hyetographs taken directly from the Sobek model inputs were used. Council's flood study report indicated that the model used excess rainfall hyetographs, so the TUFLOW model adopted zero losses in conjunction with the ARR1987 excess rainfall.

5.2.6.2 Phase 2: Impact Assessment

Hydrological inputs for the flood impact assessment were adopted to accord with the guidance in the updated ARR2019, which provides recommendations and inputs for modelling of both rare events and climate change scenarios, which require consideration for the FIRA, but are not considered in Council's existing model.

To address the FIRA recommendations, the following design events were considered.

- 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP
- Climate change scenarios 1% AEP, 0.5% AEP and 0.2% AEP (RCP 8.5 for year 2090)
- Probable Maximum Flood (PMF)

The PMF was modelled using the runoff hydrographs and excess rainfall hyetographs from Council's existing model as described above for Phase 1.

For all other design storm events, Council's XP-RAFTS model was re-run using ARR2019 hydrology (described in Section 5.2.6) across the full range of durations (10 minutes to 6 hours) and temporal patterns. Hydrographs representing total runoff from the upstream sub-catchments were exported from XP-RAFTS and applied as inflows to the TUFLOW model.

Total rainfall hyetographs were also exported from XP-RAFTS and applied as direct rainfall inputs to TUFLOW. The exported hyetographs represent total rainfall inclusive of pre-burst depths, prior to the application of any losses.

Accordingly, initial and continuing losses for use with the ARR2019 rainfall were defined in the TUFLOW materials layer. To remain consistent with the Sobek modelling approach (which used uniform excess rainfall), the same losses were applied across all material types. These losses, calculated proportionally based on an overall impervious fraction of 60 percent, are:

- Initial loss = 3.32 mm
- Continuing loss = 0.288 mm/hr

In the context this assessment, the scale of the proposed development, and the iterative modelling approach required to formulate a suitable mitigation strategy, running hydraulic model simulations across the full range of design events, durations and temporal patterns is neither practical nor materially beneficial. The storm selection process for the modelling is detailed in Section 6.1.3.1.

5.3 Response to Council Requirements for Flood Model Development

IWC's requested specifications for development of the local flood model were outline in Section 4.2. Details on how they were considered or implemented in the TUFLOW modelling are provided below.

- Catchment area
  - The model covers the upstream portion of Council's Hawthorne Canal sub-model and adopts upstream/external inflow hydrographs generated using Council's XP-RAFTS model (with no changes to the sub-catchment/node or flowpath/link properties in that model).
- Surface roughness
  - Informed by the SOBEK roughness grid and adopts the same land-use based Manning's n throughout the catchment.
  - Differences from the SOBEK model are limited to refinement of the roughness values within the site (pre- and post-development) and corrections to errors in Sobek roughness grid (e.g where a Manning's n value of 0.1 was applied across a portion of the concrete channel upstream of Parramatta Road).
- Rainfall patterns
  - Council's preference for the use of ARR1987 hydrology as per the regional model is noted. However, given that the existing flood study does not cover the full range of design events required to be considered in the FIRA, nor does it address climate change, for which current best practice recommendations (interim factors) are designed to be used in conjunction with ARR2019, the opportunity for like-for-like comparisons against the existing study results are limited,
  - Instead, the TUFLOW model has been run using ARR1987 hydrology for verification purposes only.
  - ARR2019 hydrology has been used for the impact assessment, and, in the absence of any gauge data within the catchment, the modelling has incorporated factoring of the IFD's (an approach has been used for a major regional flood study in a neighbouring LGA) so as to limit the (widely known) significant reduction in peak catchment discharge that is typically seen compared to the ARR1987 hydrology.
- Calibration
  - Whilst the Leichhardt Flood Study broadly addresses model calibration against the January 1991, February 1993 and April 1998 storm events, the flood information used for that calibration is

predominantly located outside of the bounds of the Hawthorne Canal (HC) sub-model, and therefore of no relevance to the local TUFLOW model.

- Within the subject catchment, there are no calibration points for the January 1991 and April 1998 flood events.
- The are two 'calibration points' within the subject catchment identified for the February 1993 event, both of which appear to come from historical observations from Council's files. The limited information contained in the flood study report for these locations indicates the historically observed flood levels are inconsistent with ground levels (from the 2006 ALS data) and the observed flood level is noted to be below the ground level at one of them. The calibration outcomes at both locations were poor with differences between the observed and modelled flood levels of 0.6 to 1.3 m.
- Based on this, the HC sub-model itself is, in effect, an uncalibrated model that adopts assumptions consistent with calibrated models of adjacent catchments. Modelling of the adjacent catchments is outside the scope of this FIRA and as such, adoption of model input assumptions and comparison to the results of the HC model is the only feasible calibration option and the adopted approach.

5.4 Phase 1 Model - Calibration Outcomes

The calibration model was run for the critical duration 100 year ARI storm at the site (100 year 60 minute ARR1987) to provide a direct comparison to the Sobek model outputs for the same storm event.

Calibration of the Phase 1 TUFLOW model was undertaken using an iterative process in reference to modelled peak flood levels, and timing and magnitude of peak flows at key reference locations throughout the model, with a specific focus on hydraulic behaviour within and surrounding the site.

The calibration process was used to both select a suitable water surface slope to apply at the normal depth downstream model boundary in Hawthorne Canal, and also to derive appropriate form loss coefficients (FLC's) for the bridge structures over Hawthorne Canal at Parramatta Road and Marion Street. The adopted model inputs, following the calibration process, were described in Section 0.

5.4.1 Mapped Flood Level Comparison

Figure 5-6 provides a spatial comparison of the difference between the TUFLOW modelled peak flood level and the peak flood level from the supplied Sobek model results for the selected design storm in the vicinity of the site.

The results show a good correlation in flood levels in Hawthorne Canal at the downstream model boundary and a reasonable correlation in Hawthorne Canal upstream of Marion Street, where overland flows interacting with the site discharge via the culvert (pedestrian/bikeway tunnel) at Lords Road and the low flow pipe outlet from the site.

Overall, modelled flood levels are within ± 0.2 m across the majority of the model area. Significant localised differences at the two bridges (Parramatta Road and Marion Street) are because the structures have been modelled in the 2D domain in TUFLOW, whereas the peak 'flood levels' in the Sobek 2D outputs at these locations represent shallow runoff from direct rainfall onto the road surface/bridge deck, returning levels which are considerably higher that the flood levels in the canal either side of the crossing.

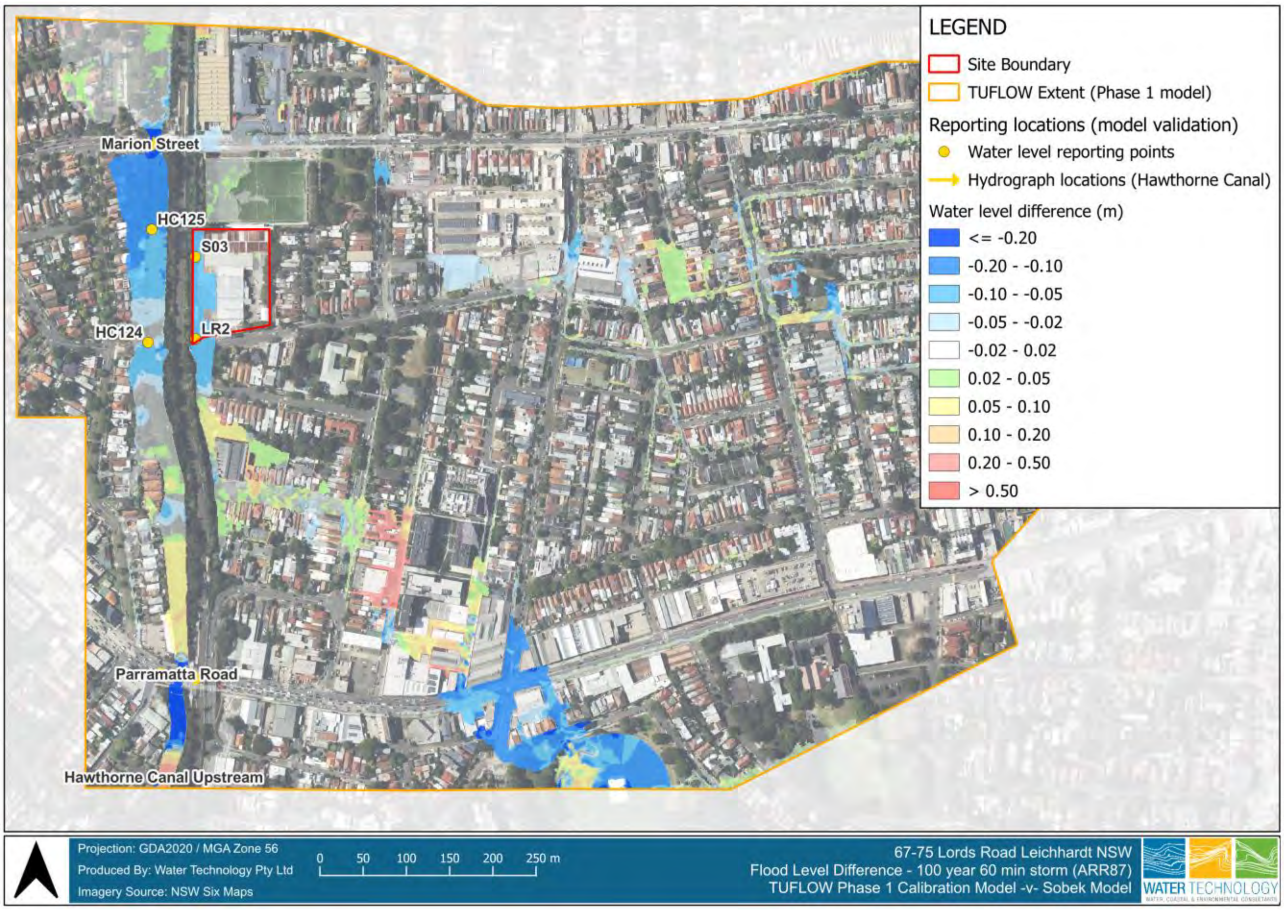


Figure 5-6 Flood level difference – TUFLOW calibration model versus Sobek model (100 year 60 min storm)

The modelled peak flood levels within the site and in Hawthorne Canal (at the locations shown on Figure 5-6) are compared in Table 5-5.

Table 5-5 Phase 1 Calibration model peak flood level comparison (ARR1987 100 year 60 minute storm)

Location	Sobek Hawthorne Canal sub-model Flood Level (mAHD)	TUFLOW Phase 1 Calibration model Flood Level (mAHD)	Difference (m)
LR2 – Site	4.11	4.05	-0.06
S03 – Site	4.11	4.05	-0.06
HC124 – Hawthorne Canal	3.65	3.61	-0.03
HC125 – Hawthorne Canal	3.61	3.51	-0.10

5.4.2 Hydrographs and Timing of Discharge

Discharge and water level hydrographs have been compared at selected locations within the models where pre-defined Sobek model outputs were available. The selected locations are shown on Figure 5-6 and discussed herein.

5.4.2.1 Hawthorne Canal - Upstream Location

Figure 5-7 presents a comparison of flows in Hawthorne Canal, approximately 10 m downstream of the upstream model boundary and 110 m upstream of Parramatta Road.

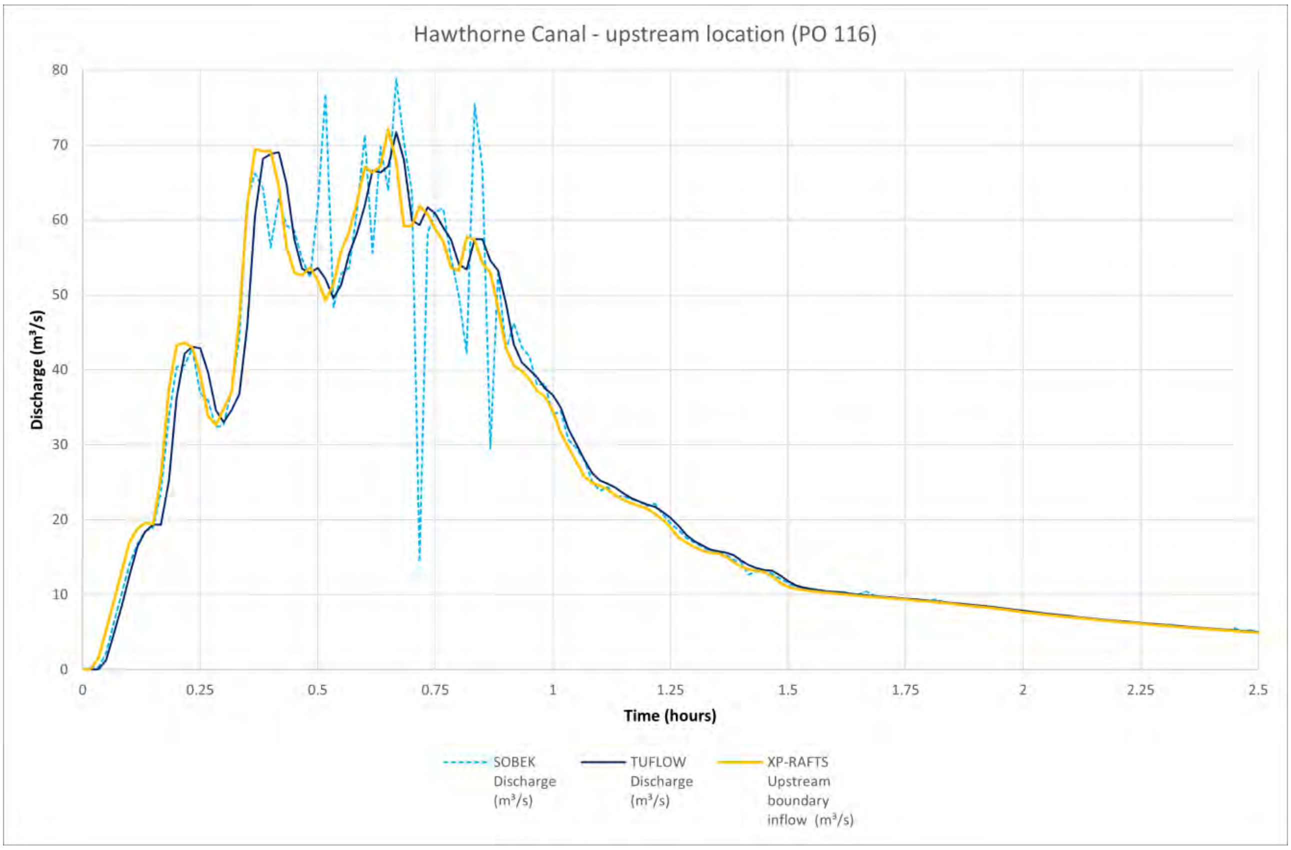


Figure 5-7 Model output comparison – Hawthorne Canal upstream location

The XP-RAFTS hydrograph representing discharge from the upstream catchment, that has been applied as an inflow at the upstream boundary of both models is also shown for comparison purposes. (Note: no water level comparison has been undertaken at this location as no time-series water level data is included in the Sobek model outputs).

The discharge from the TUFLOW model closely follows the upstream inflow hydrograph, with a short delay of approximately 1 minute. This represents the hydraulic behaviour that would be expected a short distance downstream of the inflow location in a well schematised and stable hydraulic model, particularly given the well-defined and relatively uniform shape of the constructed canal.

When comparing the results of the two hydraulic models, there is good agreement between the models with respect to timing of discharge and a reasonable correlation between the magnitude of the TUFLOW discharge and the average behaviour of the Sobek discharge. However, it is evident that there is a significant amount of numerical noise in the Sobek outputs, indicating the presence of numerical instabilities within the Sobek model. The numerical range of the noise shows overall errors well in excess of 50 percent of the expected flow, and artificial inflation of the peak discharge by around 10 percent. This provides an important context with respect to differences observed further downstream and the degree to which any meaningful model-to-model calibration can be achieved.

5.4.2.2 Hawthorne Canal – Parramatta Road bridge

Flood levels upstream and downstream of the bridge, and discharge through the bridge are compared in Figure 5-8.

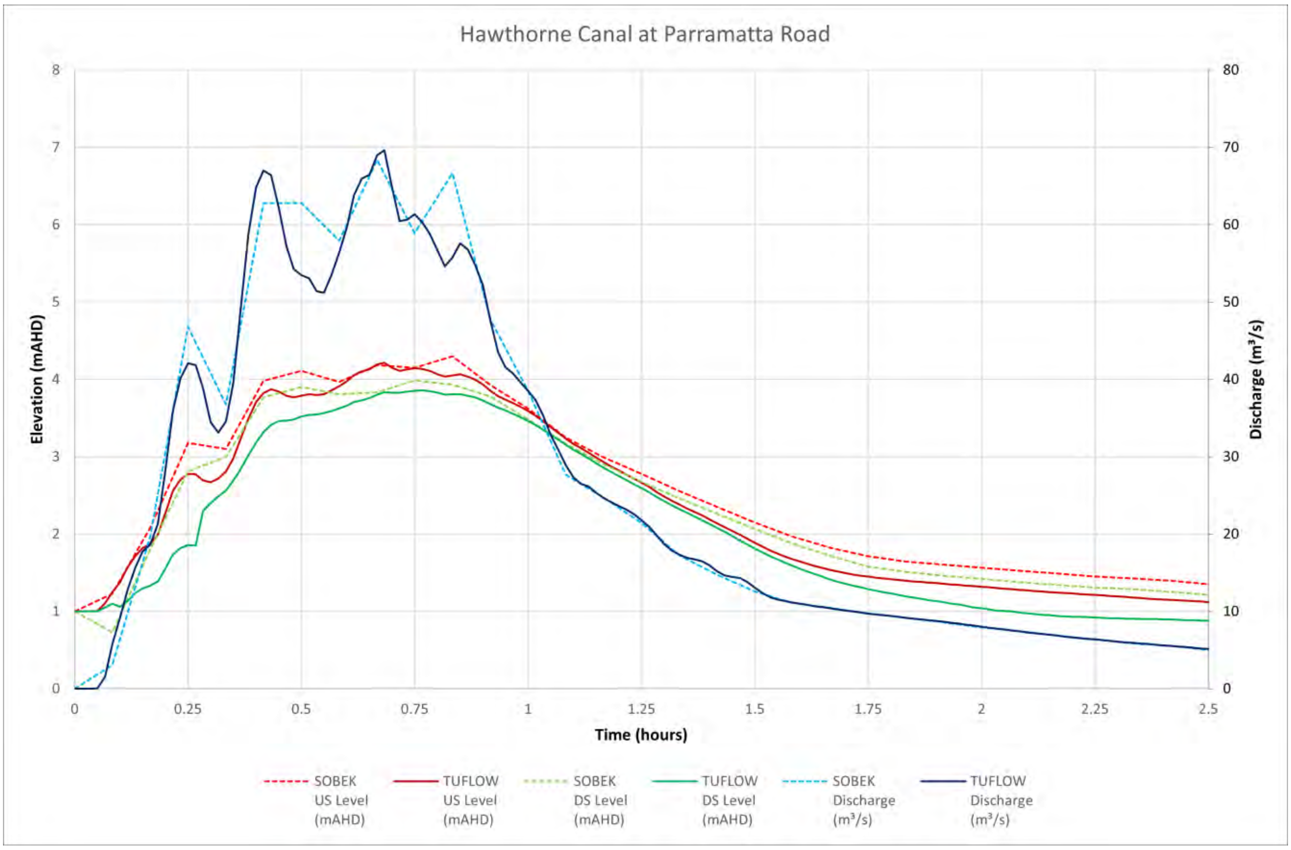


Figure 5-8 Model output comparison – Hawthorne Canal at Parramatta Road

It is noted that the bridge has been modelled as a culvert structure in the Sobek model and the associated time-series outputs (shown on the figure) only recorded in 5-minute intervals. The Sobek model outputs do not include water level reporting points in the 2D domain, so the plotted levels come from the 1D structure results and the peak levels do not fully align with the corresponding peak level in the 2D domain.

The timing of discharge, as flow moves downstream in the canal, remains well-correlated between the two models and the overall peak discharge is similar. Surrounding the peak, there are some notable differences in flow behaviour between the two models, such as the additional spike in flow after the peak in the Sobek results but not in TUFLOW. The model noise noted at the upstream location in Sobek is somewhat hidden by the less-frequent output interval but appears responsible for the observed differences in the model results.

There are notable differences in water levels between the two model, both upstream and downstream of the crossing. In general, the rise and fall in water levels seen in the Sobek outputs correlate with the corresponding rise and fall in flows, confirming the influence of the underlying model instability on the water surface levels as well as flows. This makes any 'calibration' against the Sobek model results very difficult to achieve.

Notwithstanding this, the modelled head loss over the crossing is similar in both models, validating the adopted FLC values for the structure.

5.4.2.3 Hawthorne Canal – Marion Street Bridge

Flood levels upstream and downstream of the bridge, and discharge through the bridge are compared in Figure 5-9.

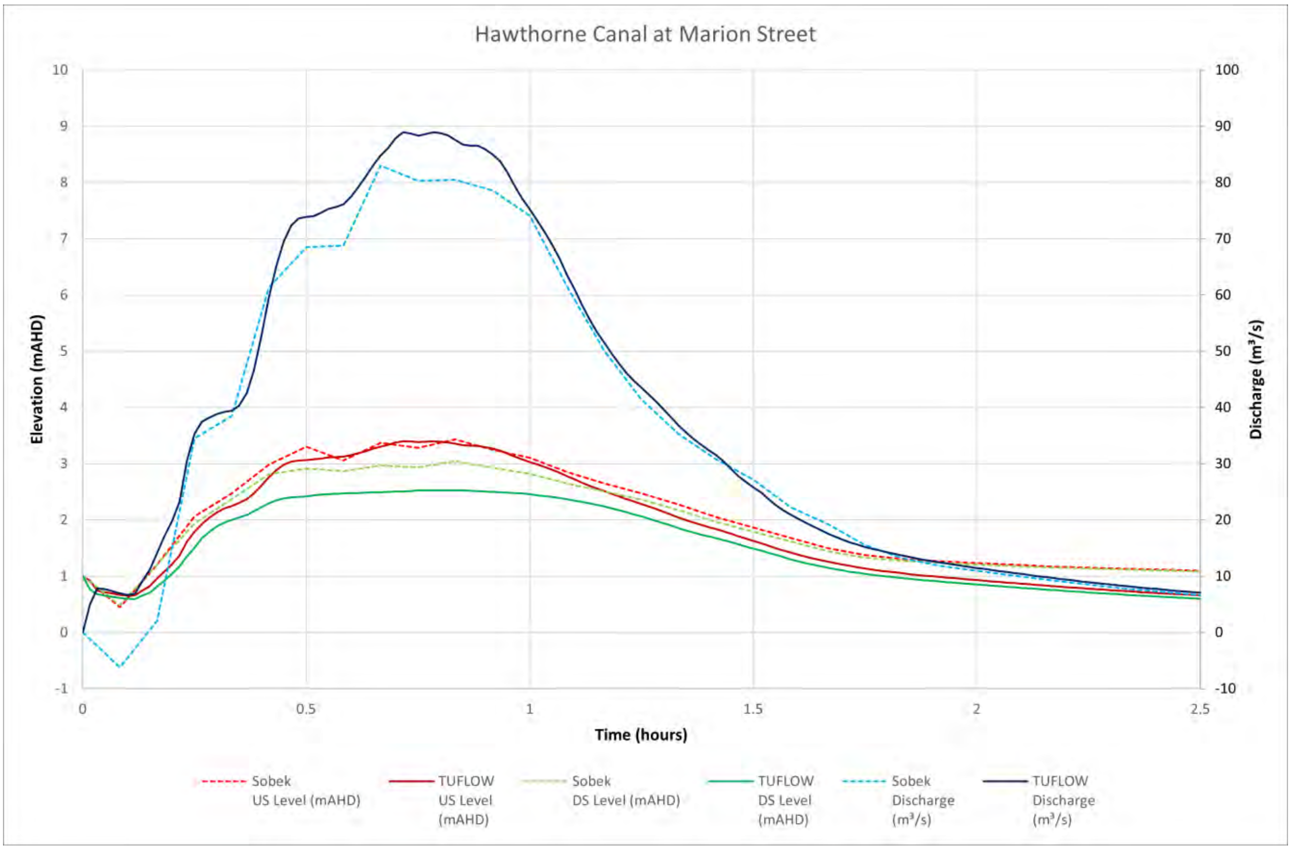


Figure 5-9 Model output comparison – Hawthorne Canal at Marion Street

Similar to the Parramatta Road bridge the structure was modelled as a culvert in the Sobek model and the associated time-series outputs (shown on the figure) only recorded in 5-minute intervals.

Discharge timing is well correlated however there is a notable difference in modelled flow for a half hour period around the peak, and the peak flow from the TUFLOW model is notably higher. This correlates with the time at which the water levels in the canal are above the bridge soffit. Again, it is unclear to what degree the numerical noise in the Sobek model is influencing the results at this location.

Upstream water levels appear to correlate well between the two models, however downstream of the crossing, the outputs suggest the Sobek water level is approximately 0.5 m higher. This difference is not seen in the comparison between the 2D flood levels (presented in Figure 5-6) downstream of the crossing.

5.4.3 Model Calibration Summary

Overall, the results presented show that the TUFLOW Phase 1 model returns a reasonable correlation with the Sobek model outcomes. Where differences exist, these appear to be associated with numerical noise indicating the presence of instabilities in the Sobek model.

In this context, any more in-depth calibration or adjustment of the TUFLOW model against the Sobek results is not warranted and the Phase 1 model is considered to be 'fit-for-purpose' in respect of quantifying flood behaviour in the catchment relative to data available at the time the Sobek model was prepared.

5.5 Phase 2 Model - Verification

Phase 2 of the model development involved model updates and amendments to represent existing catchment conditions for the purpose of this FIRA. In this respect, the Phase 1 model was updated to reflect the most recent topographic data for the catchment (2020 LiDAR) and to include site-specific information from detailed ground survey for the site, as described in Section 5.2.

Prior to undertaking the existing case flood modelling for the impact assessment (refer to Section 6), the Phase 2 model was run for the same storm (100 year 60 min ARR87) to provide a direct comparison to the outcomes of the Phase 1 model and identify whether the updates result in any major changes to flood levels across the catchment.

5.5.1 Flood Level Comparison

Figure 5-6 provides a spatial comparison of the difference in TUFLOW model results between the final Phase 2 model and the Phase 1 calibration model.

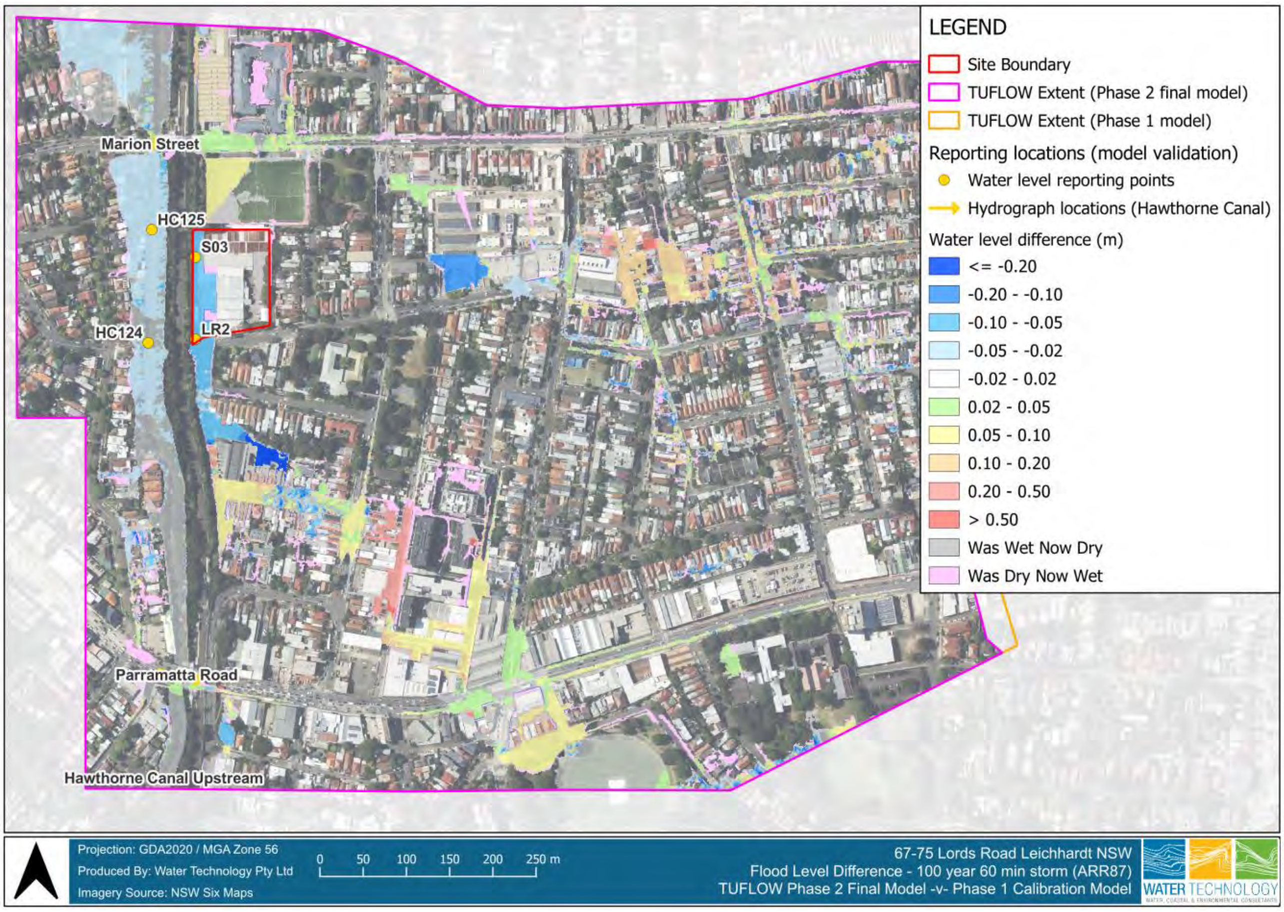


Figure 5-10 Flood level difference – Final (Phase 2) model v Phase 1 model (ARR1987 100 year 60 min storm)

Overall, peak flood levels between the two models generally differ by less than 0.1 m, with more substantial differences in a few upstream areas, separated from the site. A good correlation (± 0.05 m) is seen along the entire length of Hawthorne Canal. Within the site, the modelled levels are marginally lower (- 0.06 m) than for the calibration model. This can in part be attributed to a relative increase in storage area within the west of the site, where buildings areas represented as obstructions the original model no longer exist (denoted by the 'was dry now wet' classification on the above figure).

The modelled peak flood levels within the site and in Hawthorne Canal are compared in Table 5-6.

Table 5-6 Phase 2 final model verification - peak flood level comparison (ARR1987 100 year 60 minute storm)

Location	TUFLOW Phase 1 Calibration model Flood Level (mAHD)	TUFLOW Phase 2 Final model Flood Level (mAHD)	Difference (m)
LR2 – Site	4.05	3.99	-0.06
S03 – Site	4.05	3.99	-0.06
HC124 – Hawthorne Canal	3.61	3.60	-0.01
HC125 – Hawthorne Canal	3.51	3.48	-0.03

Based on the above, the final Phase 2 model is considered 'fit-for-purpose' to be used as a basis for assessment of impacts associated within the development.

6 PRE-DEVELOPED MODELLING AND ANALYSIS

6.1 Existing Flood Modelling

6.1.1 Overview

A new local flood model was developed specifically for the purpose of this FIRA and verified against the outcomes of Council's existing flood model for the catchment. The overall model development was described in Section 5.2 and outcomes of the Phase 1 model calibration described in Section 5.4.

Phase 2 of the model development included updates and amendments to represent existing catchment conditions for the purpose of this FIRA. The Phase 2 model was verified against the Phase 1 model using the same design storm as for the calibration, and the results in Section 5.5 confirm the model is fit-for-purpose and suitable to assessing impacts associated with development of the site.

6.1.2 XP-RAFTS Hydrological modelling

As outlined in Section 5.2.6.2, hydrological inputs for the flood impact assessment were adopted to accord with the guidance in the updated ARR2019. The XP-RAFTS model used for the Leichhardt Flood Study was provided by Council and used to generate suitable inputs to the flood model. Storm data in the model was updated to accord with ARR2019 recommendations but no other changes were made.

6.1.2.1 ARR2019 Data Hub

Design rainfall parameters such as temporal patterns, pre-burst values, areal reduction factors and model losses were obtained from the ARR 2019 Data Hub (http://data.arr-software.org/) for a location near the centroid of the catchment.

The hub data and associated model assumptions are summarised as:

- Temporal patterns: East Coast South
- Model losses - derived using the NSW specific recommendations:
  - Pervious initial loss: Probability neutral burst losses
    - Note: for the design events and durations modelled, losses range from 4.1 to 10.6 mm.
  - Pervious continuing loss = 0.4 x 1.8 mm/hr = 0.72 mm/hr
  - Impervious initial loss = 1.0 mm
  - Impervious continuing loss = 0 mm/hr
- Pre-burst rainfall
  - 75th percentile pre-burst depths
  - Injected over 10 time-steps prior to the start of the temporal pattern.
- Aerial Reduction Factors (ARF) were applied in the model.

6.1.2.2 IFD Data

Intensity-Frequency-Duration (IFD) data was sourced from the Bureau of Meteorology's IFD tool (noting there are no region-specific IFD's applicable to the catchment). Due to the relatively small catchment size, a single set of IFD data was adopted and applied uniformly over the catchment.

Initial model simulations (for the 1% AEP) returned significantly lower peak discharge from the modelled upstream catchment areas than for the equivalent ARR1987 design event (100 year ARI), despite the adoption of 75th percentile (rather than median) pre-burst depths. (The 90th percentile depths were also considered, but by comparison returned excessively high peak flows.)

Although direct and full calibration of ARR2019 hydrological model outcomes against those from ARR1987 (using the previous IFD's) is neither required nor warranted, such a significant reduction in upstream catchment runoff will carry over to reductions in catchment runoff volumes, flows and peak flood levels in the hydraulic model. In the context of this project, where Council has previously established flood planning levels at the site, it is preferable that the modelled flood levels used to inform the impacts assessment are, in some way, comparable to the established planning levels.

The underestimation of peak catchment discharge when using the updated ARR2019 BOM IFD's is well established and many region-specific data sets have been derived to address this, however nothing is published for region addressed by this assessment.

Accordingly, consideration was given to the approach undertaken for regional scale modelling in a nearby catchment and based on this, a decision was made to factor the IFD's. Recent analysis undertaken for the much larger Parramatta River catchment derived a multiplication factor of 1.19 (i.e a 19% increase in rainfall depths) to be applied across all rainfall events.

Applying this factor to the IFD's for the subject local catchment still returned notably lower flows (and runoff volumes) than ARR87 estimates – possibly associated with the smaller scale of the catchment and significantly shorter critical storms.

As there is no suitable data to inform the derivation of a factor specific to the local catchment using similar methods, a direct comparison of the ARR2019 and ARR1987 IFD data was undertaken. For the 1% AEP design event, and considering a range of durations (15 minutes to 3 hours) relevant to the scale of the catchment, the ARR1987 rainfall depths were found to be, on average 27% higher than the ARR2019 BoM IFD depths. Informed by these differences, a factor of 1.27 was adopted and applied across all design events.

The modelled ARR2019 1% AEP peak discharge across all storms from the three external upstream catchments is compared to the ARR1987 peak discharge from Council's original model in Table 5-1

Table 6-1 XP-RAFTS - upstream catchment discharge comparison

Upstream sub-catchment	ARR1987 100 year ARI Peak flow (m^3/s)	ARR2019 1% AEP Peak Discharge (m^3/s)
C9 (upstream inflow to local catchment SW of site)	23.4	22.5
C10-D1 (upstream inflow to Hawthorne Canal)	86.1	73.4
C11 (local inflow from catchment west of canal)	14.5	14.0

The peak inflow to Hawthorne Canal remains lower than equivalent ARR1987 estimates, however good agreement is seen for the smaller local catchments. Importantly, the runoff from C9, which eventually contributes to overland flows at the site is comparable between the two hydrological models.

6.1.2.3 Climate Change considerations

Impacts associated with future climate change were considered in the hydrological modelling by increasing the rainfall to reflect the worst-case scenario (RCP8.5) for the maximum planning horizon (2090) addressed by ARR2019. The proportional increase in rainfall for this scenario is 19.7%, which was applied to the factored IFD's (i.e. an overall increase of 52% above the BoM IFD's). Climate change simulations were carried out for the 1%, 0.5% and 0.2% AEP's.

6.1.3 Design Events for Hydraulic Modelling

To address the FIRA recommendations, the following design events were considered.

- 10% AEP, 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP
- Climate change scenarios 1% AEP, 0.5% AEP and 0.2% AEP (RCP 8.5 for year 2090)
- Probable Maximum Flood (PMF)

6.1.3.1 Design Event Selection – ARR2019

For all design storm events (except the PMF), the XP-RAFTS model was re-run using ARR2019 hydrology (described above) across the full range of durations (10 minutes to 6 hours) and temporal patterns. Runoff hydrographs rainfall hyetographs were exported from XP-RAFTS and applied to the TUFLOW model, as described in Section 5.2.6.2.

In the context of this assessment, the scale of the proposed development, and the iterative modelling approach required to formulate a suitable mitigation strategy, running hydraulic model simulations across the full range of design events, durations and temporal patterns is neither practical nor materially beneficial.

To optimise the hydraulic model run times, post-processing and data handling requirements for the modelling, a range of critical storms (duration and TP) were selected to provide representative coverage of peak flood behaviour across the catchment.

The ARR2019 temporal patterns are grouped in bins based on design event frequencies – with the same temporal patterns applied to all storms in that bin. The design events considered in this project fall within the following bin's:

- Intermediate bin – 10% AEP and 5% AEP
- Rare bin – 1% AEP to 0.2% AEP (and climate change events)

TUFLOW model simulations were run for the full range of durations and temporal patterns for the 5% AEP (intermediate bin) and 1% AEP (rare bin) design events and peak water level results were processed to:

- First, calculate the median result across the ten temporal patterns for each duration and identify the corresponding temporal pattern; and
- Second, calculated the maximum of the duration-based medians and identify the critical duration.

The critical durations and corresponding temporal patterns were reviewed across the catchment to select a range of individual storms that were representative of critical behaviour across the catchment. The selected storms below were then used for model simulations for all design events in that bin:

- Rare bin – 2% AEP to 0.2% AEP (and climate change events)
  - 10 minute TP07
  - 25 minute TP03
  - 30 minute TP03
  - 45 minute TP01
  - 60 minute TP03

- Intermediate bin (10% AEP and 5% AEP)
  - 15 minute TP04
  - 20 minute TP08
  - 30 minute TP06
  - 45 minute TP08
  - 90 minute TP05

Comparisons of the peak flood level surface generated from the selected storms to the surface from all storms are presented in Figure 6-1and Figure 6-2, respectively for the 1% AEP and 5% AEP design events.

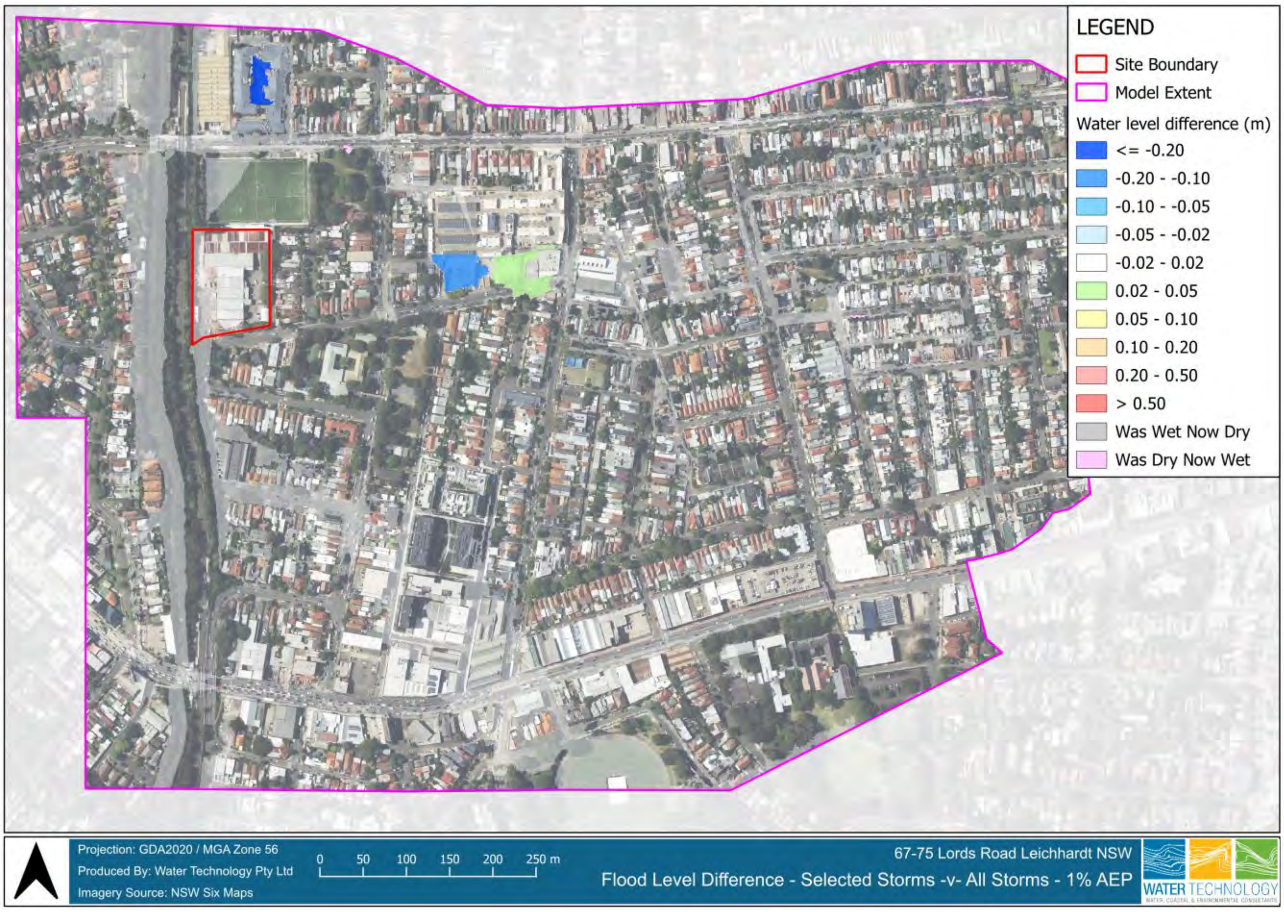


Figure 6-1 Validation of Selected 'Rare' Storms – 1% AEP

For the 1% AEP, the selected storms provide excellent representation of peak flow levels across the catchment.

For the 5% AEP, the envelope of selected storms returns a marginally higher flood level in Hawthorne Canal. In this case, the critical duration (45 minutes) is the same in the southwest of the site as it is in Hawthorne Canal, however the median temporal pattern differs. The median temporal pattern in Hawthorne Canal returned an underestimation of flood levels in the south-west of the site, so the more conservative option of using the median TP within the site and slightly overestimating levels in the canal was adopted.

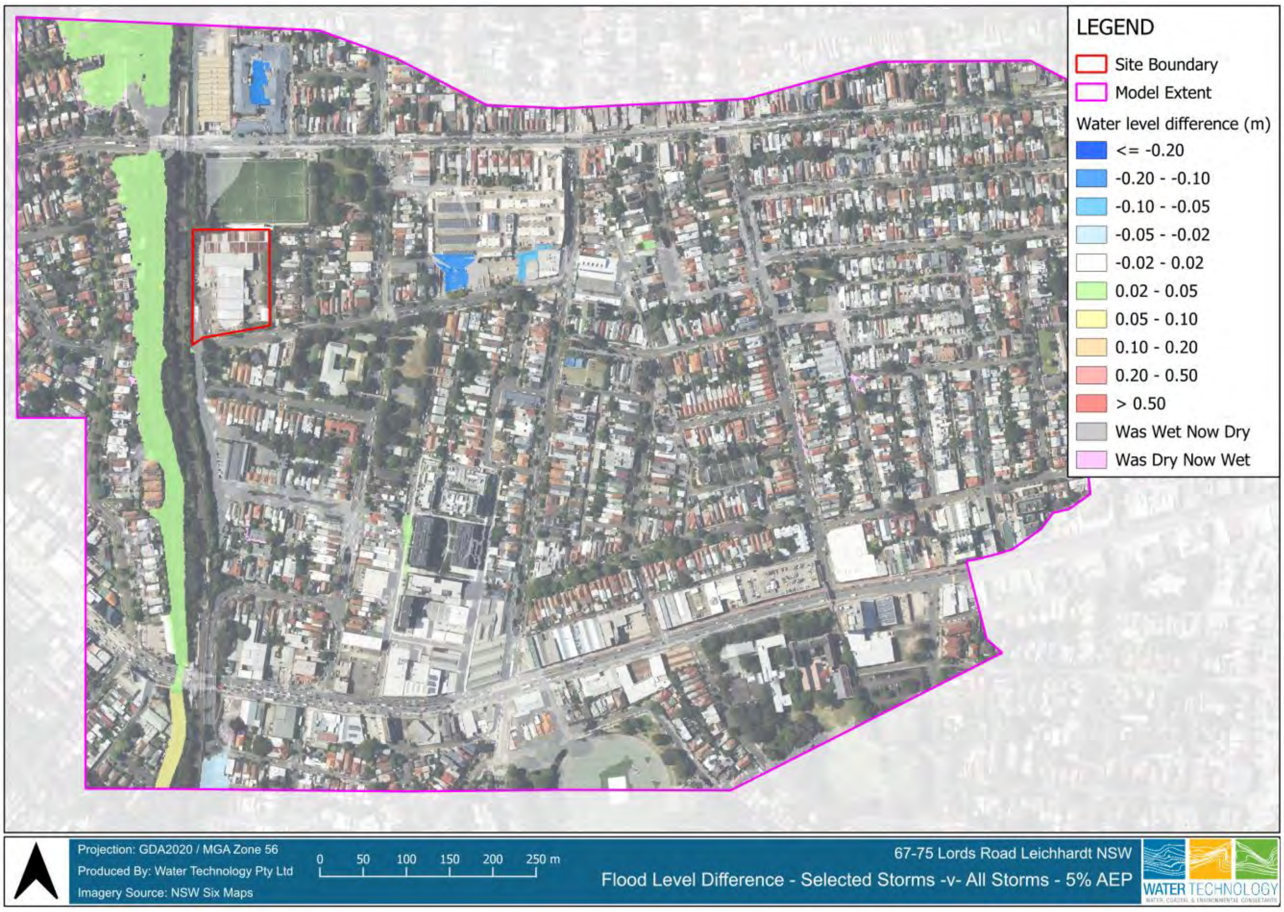


Figure 6-2 Validation of Selected 'Intermediate' Storms – 5% AEP

6.1.3.2 Design Event Selection – PMF

The existing case model was initially run for durations of 15, 30, 45, 60, 90 and 120 minutes to identify the critical duration storms across the catchment. The selected storms used for the impact assessment are:

- PMF: 15, 30, 45 and 60 minutes

A comparison of the peak flood level surface for the selected storms to that for all storms is provided in Figure 6-3, indicating excellent representation of the peak flood levels is achieved by only considering the selected storms.

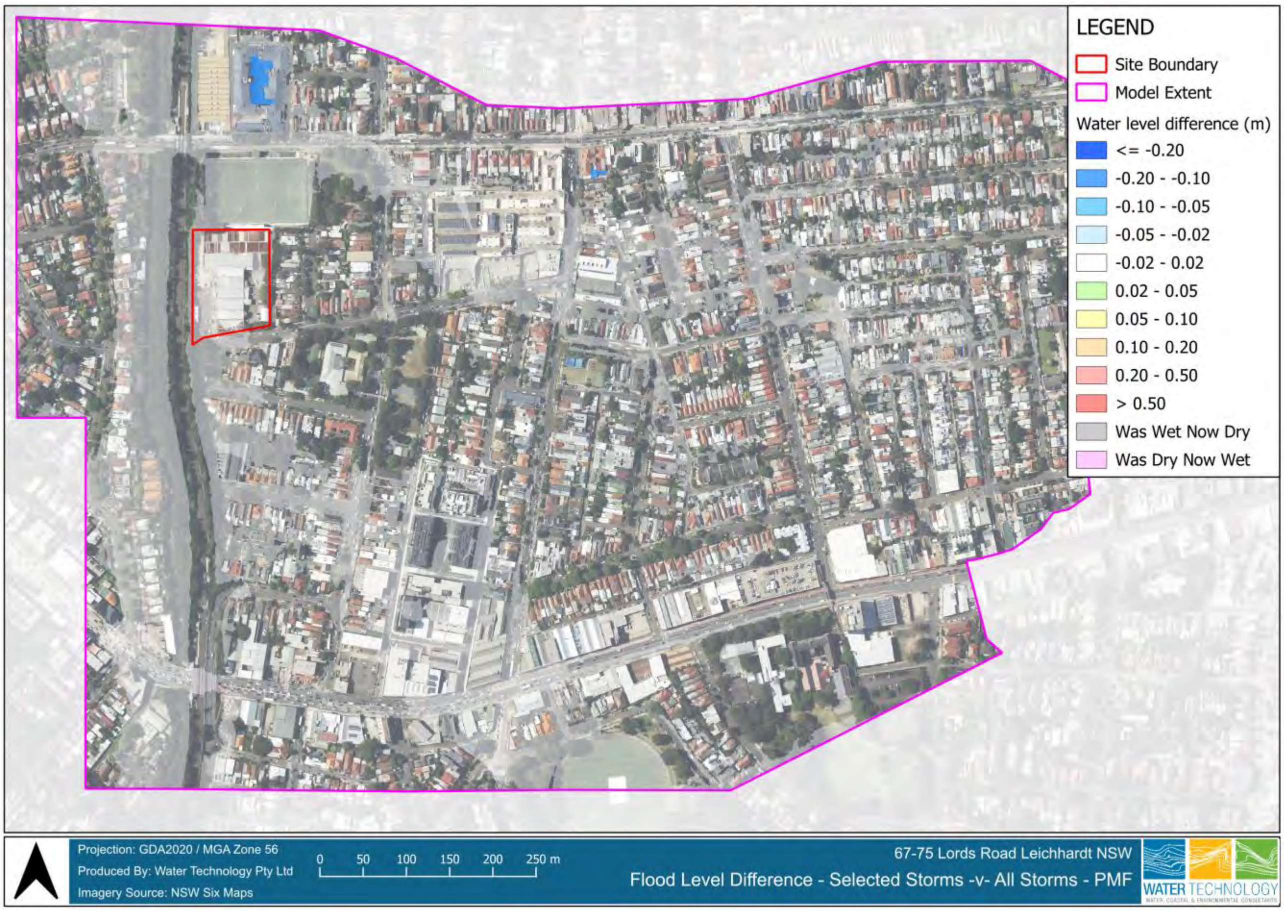


Figure 6-3 Validation of Selected Storms – PMF

6.1.4 Existing Model Results

6.1.4.1 Flood Mapping

Maps depicting the existing case model results are provided in Appendix D. The mapping includes:

- Peak flood levels – all design events
- Peak flood depths – 1% AEP
- Peak velocities – 1% AEP
- Flood Hazard – all design events.

6.1.4.2 Flood Extent

Figure 6-4 summarises the existing flood extents within and surrounding the site across the range of modelled design events.

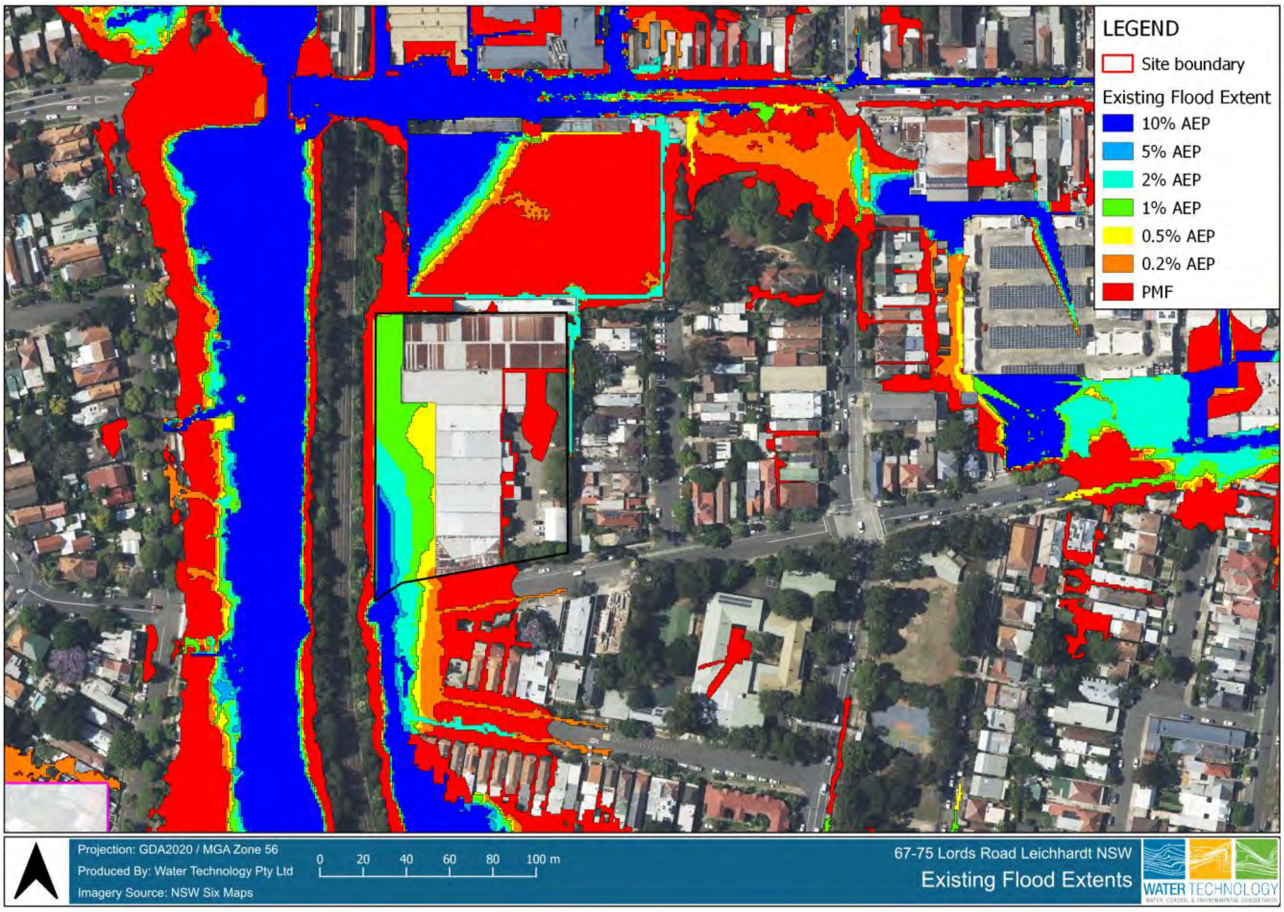


Figure 6-4 Existing Flood Extent

6.1.4.3 Flood Levels

Figure 6-5 shows the locations of water level reporting points and flow reporting lines referenced in the model results.

Figure 6-5 Model reporting locations

Peak flood levels at selected reporting points within and surrounding the site are given in Table 6-2.

Table 6-2 Existing Case Flood Levels at Reporting Points

Location	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Site							
LR2	3.05	3.16	3.55	3.82	4.03	4.34	6.94
S03	-	-	-	3.81	4.03	4.34	6.90
Hawthorne Canal							
HC123	3.12	3.23	3.46	3.65	3.81	4.05	6.10
HC124	3.01	3.11	3.32	3.52	3.68	3.93	5.88
HC125	2.90	3.00	3.21	3.40	3.56	3.81	5.64
HC126	2.80	2.89	3.10	3.29	3.45	3.71	5.55

6.2 Existing Flood Impacts

6.2.1.1 Summary of Existing Flood Behaviour

The site is influenced by flash flooding across the full range of modelled design events (10% AEP to PMF). Flood behaviour across the range of events is summarised below:

- 10% AEP, 5% AEP and 2% AEP
  - Flooding is confined to the carparking area in the south-western corner of the site and does not interact with any building structures.
  - The site remains accessible from Lords Road via driveways on both the eastern and western sides of the central building.
  - Lords Road is flood free adjacent to the site, and flooding within the Kegworth Street road reserve immediately south of the site is generally confined to the west of the road pavement.
  - Flood hazard within the inundated site area is low to moderate and classified as follows:
    - 10% AEP – H1 (generally safe for vehicles, people and buildings).
    - 5% AEP – combination of H1 and H2 (unsafe for small vehicles).
    - 2% AEP – combination of H1, H2 and H3 (unsafe for vehicles, children and the elderly).
- 1% AEP
  - Flooding extends the full length of the site along its western boundary, and east to the existing building. Depending on the locations of openings (windows, doors etc.) some areas within the building (minimum floor level is 3.7 mAHD) may be subject to shallow inundation.
  - Inundation is confined at the north-western site boundary by the embankment located immediately north of the site.
  - The site remains accessible from Lords Road via the driveway on the eastern sides of the building, however the majority of the western driveway access is inundated.
  - Lords Road is flood free adjacent to the site, and Kegworth Street is partially inundated south of the site.
  - Flood depths over the inundated site area are variable and generally remain below 1 metre. Depths are highest in the southwest of the site, with a maximum depth of 1.13 m on the southwestern site boundary.
  - Velocities are low and do not exceed 1.0 m/s anywhere within the site.
  - The highest flood hazard classification within the site remains at H3.
- 0.5% AEP and 0.2% AEP
  - The entire site area west of the existing building is inundated.
  - Flooding remains contained at the northwestern site boundary and does not extend offsite.
  - Flood levels (4.03 mAHD and 4.34 mAHD, respectively) exceed the building floor levels (3.7 to 4.0m AHD) and parts of the building will also be inundated.
  - The site remains accessible from Lords Road via the driveway on the eastern side of the building, but the western driveway is inundated.
  - Lords Road is flood free adjacent to the eastern portion of the site. The western end of Lords Road is inundated and Kegworth Street is inundated over one lane (in the 0.5% AEP) and both lanes (in the 0.2% AEP).

- Flood hazard:
  - 0.5% AEP – hazard increases to H4 (unsafe for vehicles and people) in the southwestern corner of the site.
  - 0.2% AEP – flood depths increase such that the majority of the inundated site area is H3 or H4 and no inundated areas remain generally safe (H1). External and adjacent to the southern site boundary, the hazard surrounding the entrance to the pedestrian tunnel under the light rail is higher at H5.
- PMF
  - The entire site area west of the existing building is inundated and parts of the site east of the building are also inundated (to a depth greater than 0.1m).
  - Flood levels (approx. 6.9 mAHD) are significantly higher than building floor levels and the building will be inundated to a significant depth.
  - Flood levels also exceed the height of the embankment north of the site, with floodwaters conveyed northwards through the site and discharging across the northern site boundary into the sportsfield.
  - Inundation over Lords Road extends east past the existing building and across part of the eastern site access, however the modelling suggests that most of the driveway remains flood free and site access (or egress may remain available).
  - The flood hazard within the western portion of the site and over the western end of Lords Road and Kegworth Street is significant (H5 or higher).

6.2.1.2 Impacts of Climate Change

Maps showing the climate change flood levels and impacts of climate change (relative to current climate) for the existing site are provided in Appendix E.

Climate change flood levels at selected reporting points within the site are tabulated below, for comparison to the respective current climate levels.

Table 6-3 Existing Case Impacts of Climate Change

Location	1% AEP Climate change (mAHD)	1% AEP Impact of climate change (m)	0.5% AEP Climate change (mAHD)	0.5% AEP Impact of climate change (m)	0.2% AEP Climate change (mAHD)	0.2% AEP Impact of climate change (m)
LR2	4.27	0.46	4.50	0.47	4.84	0.51
S03	4.27	0.46	4.50	0.47	4.84	0.50

The results indicate that predicted future increases in rainfall intensity will result in corresponding increases in flood levels across the site. For the 'worst case' (RCP 8.5) climate scenario adopted in the modelling, flood levels at the site will be approximately 0.5 m higher than current flood levels.

7 POST-DEVELOPED MODELLING AND ANALYSIS

7.1 Proposed Development Flood Modelling/Assessment

7.1.1 Developed Case Model Schematisation

The TUFLOW model layout for the developed site is shown in Figure 7-1 and amendments made to represent the proposed development within the model are described below.

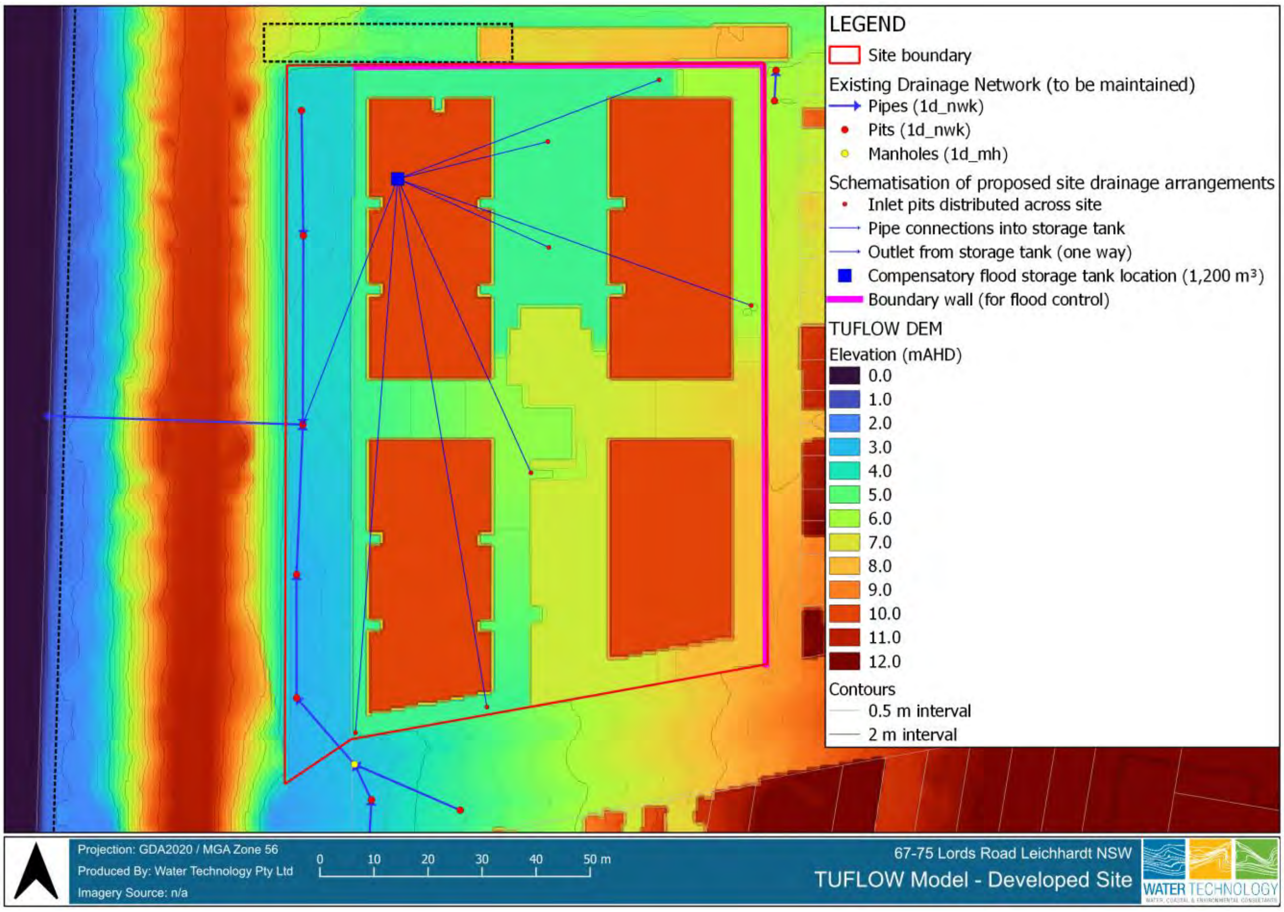


Figure 7-1 TUFLOW Model – Developed Site

7.1.1.1 Model Topography

Development is proposed over a 0.90 ha site area comprising the entire eastern site lot (Lot 1 DP 940543), which the western lot (Lot 1 DP 550608) has been assumed to remain unchanged by the development. The minimum fill level has been set at RL 4.6 mAHD to provide 500mm freeboard above Council's DFL (4.1 mAHD).

Design surface levels from the proposed development plans (in Appendix A) were used to build a DEM of the proposed development within the model, which is depicted on the above figure.

7.1.1.2 Mitigation Measures

- Boundary wall for flood control
  - As the proposed buildings within the site are set back from the boundary, and the surrounding ground levels are below the PMF the provision of a boundary wall for flood control is required (along the northern and eastern site boundaries) to provide the equivalent function of the existing building in controlling discharge to the north and preventing discharge to the east of the site.
- Compensatory Flood Storage
  - The proposed works within the site will result in a loss of (above ground) flood storage during mid-range flood events.
  - To offset this storage loss and mitigate any associated hydraulic impacts, the development proposes to provide a compensatory flood storage tank in the basement of the north-western building. Given the available elevation difference between the filled site levels and the existing low-flow pipe outlet from the site (RL 0.9 mAHD), it is intended that the compensatory storage tank will be free-draining with a connection to the existing pipe outlet from the site.
  - The tank is intended to primarily collect and hold stormwater runoff generated within the site until the flood peak passes, after which the tanks will discharge via gravity. To mitigate impacts across all design events, a single lower level inlet (above the 1% AEP but below the 0.5% AEP flood level) is needed to allow some regional floodwater to enter the tanks and utilise the compensatory storage during events exceeding the 1% AEP. The future stormwater drainage design for the site will need to reflect this.
  - The tank has been represented on the model by a storage node, and pit inlets have been distributed across the developed site area to collect runoff from the rain-on grid model and convey it to the tank. A one-way outlet pipe provides for discharge from the tank to the existing pipe outlet from the site, whilst preventing backwater from the stormwater drainage network from filling up the tank. Note that, the modelled schematisation has been setup to reflect the function of the site stormwater drainage post-development and is not intended to represent the actual locations on any future infrastructure (which is subject to detailed design).

7.1.2 Developed Case Model Results

7.1.2.1 Flood Mapping

Maps depicting the developed case model results are provided in Appendix F and developed case flood impacts in Appendix G. The mapping includes:

- Peak flood levels – all design events
- Peak flood depths – 1% AEP
- Peak velocities – 1% AEP
- Flood Hazard – all design events
- Flood level impacts – all design events
- Velocity impacts – 1% AEP
- Change in Flood Hazard Classification – all design events

7.1.2.2 Flood Extent

Figure 7-2 summarises the developed case flood extents within and surrounding the site across the range of modelled design events.

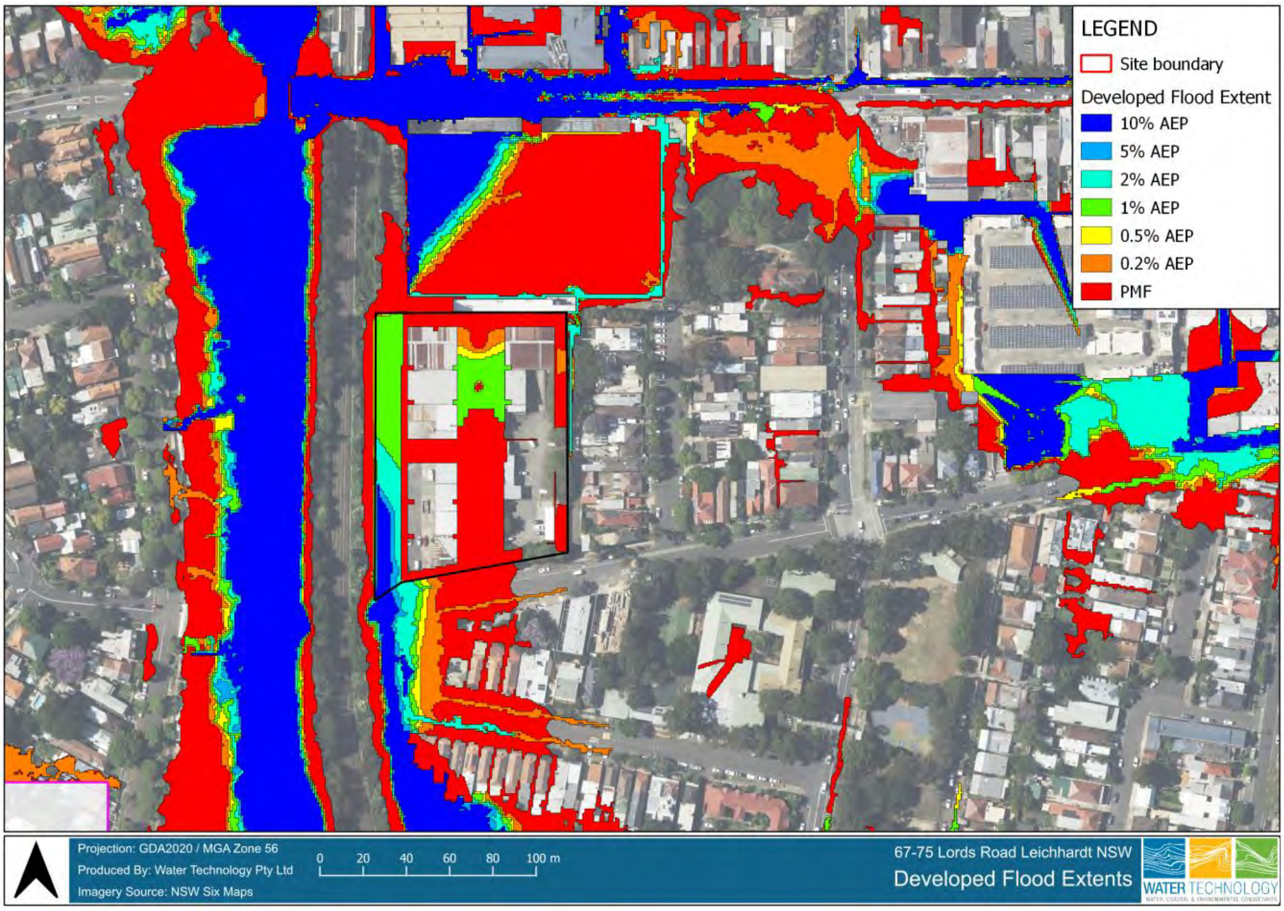


Figure 7-2 Developed Flood Extent

7.1.2.3 Flood Levels

Post-development peak flood levels at selected reporting points are given in Table 7-1.

Table 7-1 Developed Case Flood Levels at Reporting Points

Location	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Site							
LR2	3.04	3.16	3.55	3.82	4.03	4.33	6.90
S03	-	-	-	3.82	4.03	4.33	6.87
S14	-	-	-	4.65	4.65	4.66	6.89
Hawthorne Canal							
HC123	3.12	3.23	3.46	3.66	3.81	4.06	6.09
HC124	3.00	3.11	3.32	3.52	3.68	3.93	5.86
HC125	2.89	2.99	3.21	3.40	3.56	3.81	5.62
HC126	2.79	2.89	3.10	3.29	3.45	3.71	5.53

It is noted that, for the 1% 0.5% and 0.2% AEP events, the inundated site area at and around S14 represents shallow site runoff draining to the internal drainage network and is independent of and not influenced by the regional floodwaters in the west of the site. The developed ground level in this area of the site is RL 4.6 mAHD and modelled flood depths are less than 0.1 m. Detailed design of the site's internal stormwater drainage network will collect such runoff and convey it to the compensatory flood storage tank.

7.2 Flood Impacts of Proposed Development

7.2.1 Summary of Developed Flood Behaviour

Flood behaviour external to the site generally remains consistent with existing catchment conditions. Post-development flood behaviour within the site is summarised below:

- 10% AEP and 5% AEP
  - Flooding is confined to the western lot that is not proposed for development.
  - Flood hazard is consistent with existing site conditions:
    - 10% AEP – H1 (generally safe for vehicles, people and buildings).
    - 5% AEP – combination of H1 and H2 (unsafe for small vehicles).
- 2% AEP
  - Flooding is contained within the southern half of the western lot, confined by the proposed site fill.
  - Flood hazard within the inundated site area is predominantly H2 and H3 (unsafe for vehicles, children and the elderly).
- 1% AEP, 0.5% AEP and 0.2 % AEP
  - The entire western lot is inundated and the proposed development footprint is generally flood free.
  - Shallow (up to 0.1 m) inundation mapped in the central site area is representative of site runoff draining to the inlet pits. Future detailed design of the site's internal stormwater drainage network will cater for this runoff.
  - For the 1% AEP:
    - Flood depths in the undeveloped site area are variable and generally remain below 1 metre, consistent with existing conditions.
    - Velocities are low and do not exceed 1.0 m/s anywhere within the site.
  - Flood hazard in the western lot is consistent with existing conditions:
    - 1% AEP - The highest flood hazard classification within the site remains at H3.
    - 0.5% AEP – hazard increases to H4 (unsafe for vehicles and people) in the southwestern corner of the site.
    - 0.2% AEP – flood depths increase such that the majority of the inundated site area is H3 or H4 and no inundated areas remain generally safe (H1). External and adjacent to the southern site boundary, the hazard surrounding the entrance to the pedestrian tunnel under the light rail is higher at H5.
- PMF
  - Inundation covers the entire western lot and also extends across the eastern lot, surrounding the two western buildings and reaching the western side of the eastern buildings. Floodwater also surround the north and east of the north-east building.
  - The flood hazard within the western lot remains consistent with existing conditions (H5 and higher).
  - The flood hazard surrounding the buildings within the developed site area varies from H1 to H5.

- The developed site maintains flood free access to Lords Road from its south-eastern corner.

7.2.2 Flood Level Impacts

Mapping of flood level impacts associated with the proposed development is provided in Appendix G. Post-development peak flood level impacts at selected reporting points are given in Table 7-1.

Table 7-2 Developed Case Flood Levels at Reporting Points

Location	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
Site							
LR2	0.00	0.00	0.00	0.01	0.00	-0.01	-0.03
S03	-	-	-	0.00	0.00	-0.01	-0.03
Offsite (east of embankment)							
X11	0.00	0.00	0.00	0.00	0.00	0.00	-0.03
X18	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.04
Hawthorne Canal							
HC123	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
HC124	0.00	0.00	0.00	0.00	0.00	0.00	-0.01
HC125	0.00	0.00	0.00	0.00	0.00	0.00	-0.02
HC126	0.00	0.00	0.00	0.00	0.00	0.00	-0.02

The results demonstrate that the proposed development, including mitigation measures, will have no material impact on flood levels within or surrounding the site.

7.2.3 Velocity Impacts

Mapping of velocity impacts for the 1% AEP design event is included in Appendix G and shown no adverse impacts associated with the development.

7.2.4 Changes in Flood Hazard Classification

Mapping of changes in flood hazard classification are provided in Appendix G for all modelled events.

There are no material changes in flood hazard classification external to the site across all design events.

Some minor differences (± one hazard class) are noted within the sports field north of the site for the PMF event only. The differences are in areas that are fully surrounded by floodwaters with high risk (H4 and H5) and on the interface between these classifications. The land is both inaccessible during the PMF and unsafe for vehicles and people under both existing and developed site conditions.

7.2.5 Duration of Inundation

Flow and flood level hydrographs at the southern site boundary (LR2) for the critical duration (45 minute) 1% AEP, 0.2% AEP and PMF events presented in Figure 7-3 and Figure 7-4. These demonstrate that the development will have no significant impact on the timing of flows entering (and exiting) the site, nor the time and duration of flooding at the site boundary.

As there is limited hydraulic grade across the flood affected areas in the west of the site, the plots are representative of general behaviour and timing across the site.

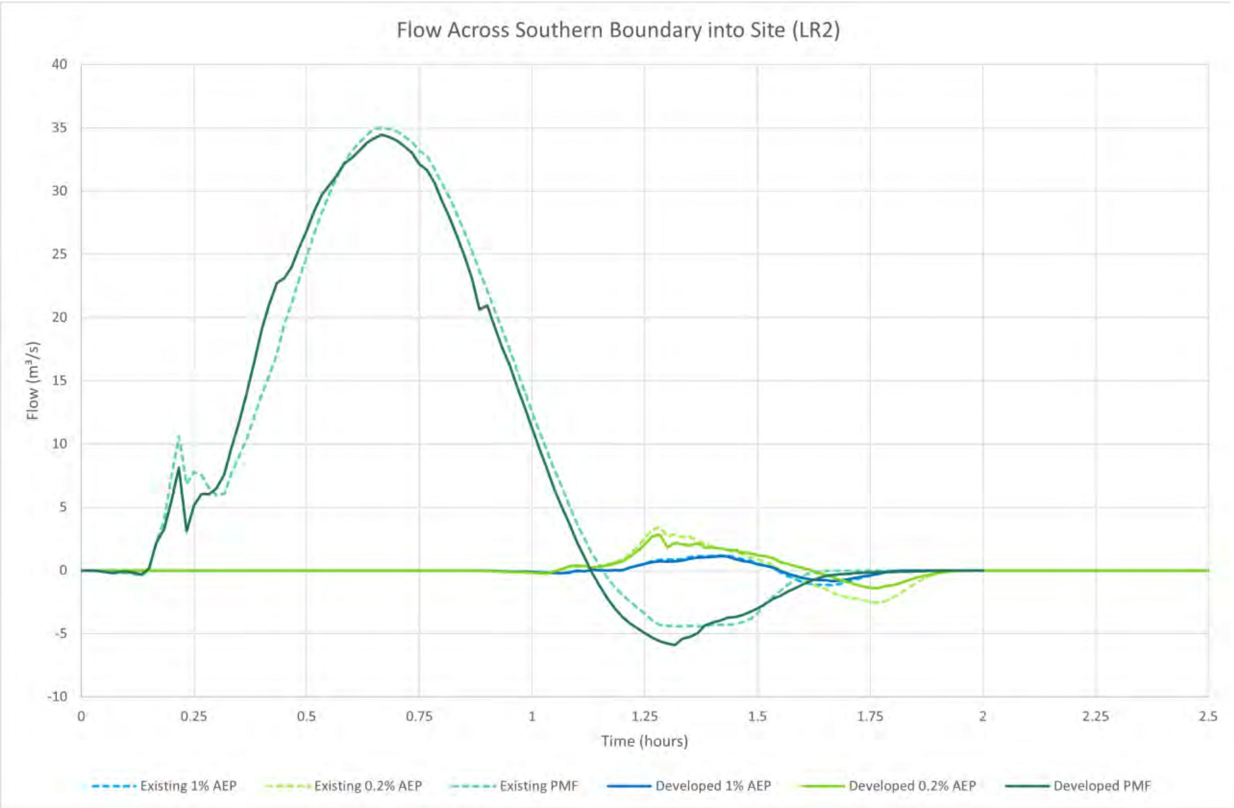


Figure 7-3 Flow Hydrograph Comparison at Southern Site Boundary

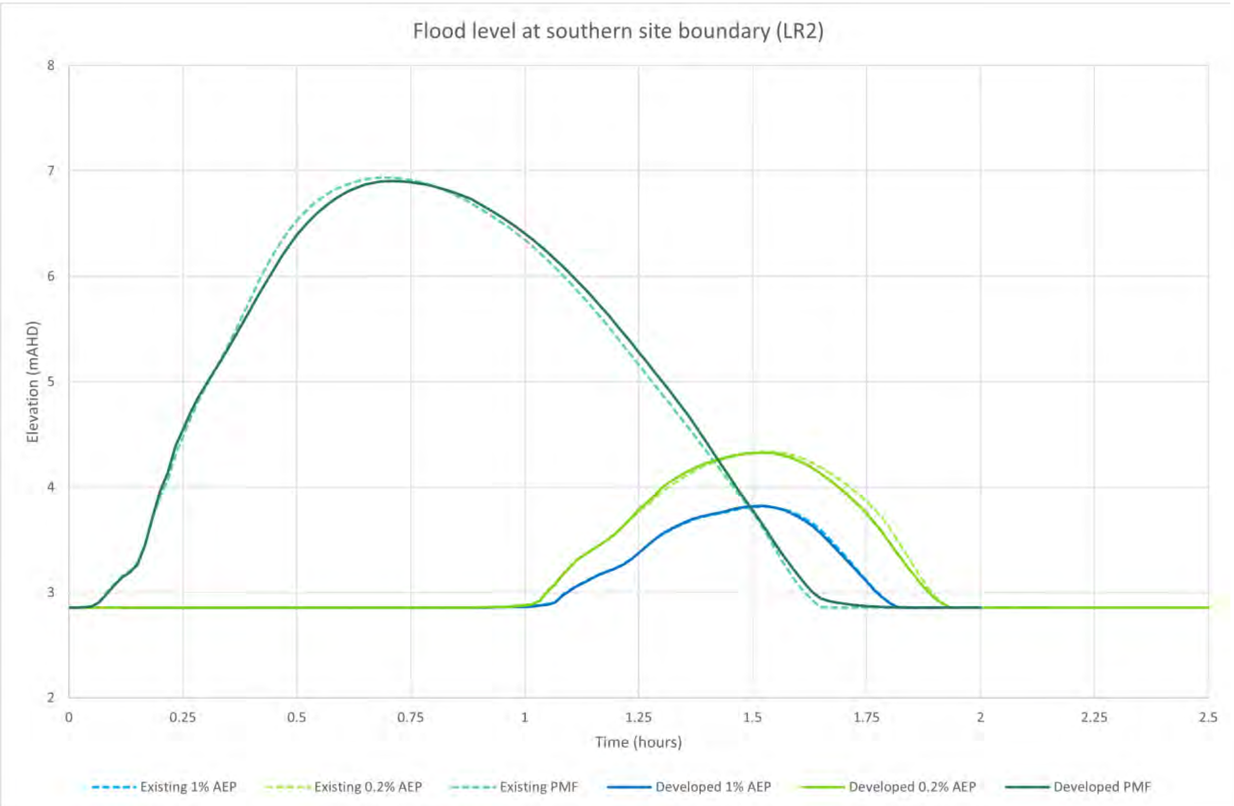


Figure 7-4 Flood Level Hydrograph Comparison at Southern Site Boundary

7.2.6 Impacts of Climate Change

Maps showing the post-development climate change flood levels and impacts of climate change (relative to current climate) for the site are provided in Appendix H.

Climate change flood levels at selected reporting points within the site are tabulated below, for comparison to the respective current climate levels.

Table 7-3 Developed Case Impacts of Climate Change

Location	1% AEP Climate change (mAHD)	1% AEP Impact of climate change (m)	0.5% AEP Climate change (mAHD)	0.5% AEP Impact of climate change (m)	0.2% AEP Climate change (mAHD)	0.2% AEP Impact of climate change (m)
LR2	4.26	0.44	4.49	0.47	4.81	0.49
S03	4.26	0.44	4.49	0.47	4.81	0.49
S14	4.66	0.01	4.66	0.01	4.68	0.02

The results indicate that predicted future increases in rainfall intensity will result in corresponding increases in flood levels across the site. For the ‘worst case’ (RCP 8.5) climate scenario adopted in the modelling, flood levels at the site will be up to 0.5 m higher than current flood levels – consistent with the anticipated impacts of climate change for existing site conditions.

The minimum fill level proposed for the site is RL 4.6 mAHD. Land at this elevation will remain flood free for the climate change 1% AEP and 0.5% AEP scenarios, but will be inundated by the 0.2% AEP climate change flood event (and above) by depths of under 0.25 m. The inundated areas are classified as low hazard and remain safe during this event.

8 KEY RISKS TO BE MANAGED

8.1 Risk Assessment Philosophy

In accordance with the Flood Impact and Risk Assessment Guideline LU01 (State of NSW, 2023), the risk assessment considered:

- Risk to public safety,
- Risk to property;
- Risk to infrastructure; and
- Risk to the environment.

The risk assessment has considered events from the 1% AEP up to the PMF.

8.2 Public Safety

The risk to public safety can be categorised into two key groups:

1. Risk to life for those at the development site; and
2. Risk to life for those at neighbouring properties.

The risk to persons at the development site is proposed to be mitigated by filling the site to 0.5 metres above the 1% AEP flood level. Based on the modelling undertaken, at this level, the development footprint will remain flood immune up to the 0.2% AEP design event. Given the nature of flooding in the catchment, being flash flooding in response to short duration events, warning times are insufficient and evacuation is not a recommended response. Residual risk during the PMF will be managed by controlling the use on the ground floor of the development to limit risk to vulnerable populations. Users in the western buildings (which become surrounded by floodwaters) may require retreat to the upper levels for a short period of time (under 2 hours) until the flood peak recedes.

The risks to persons at neighbouring properties does not change as a result of the development as all external hydraulic impacts associated with the development have been mitigated.

8.3 Property

The risk to property can be categorised into two key groups:

1. Risk to the proposed development; and
2. Risk to neighbouring properties caused by the development.

Risk to the proposed development has been minimised by filling the site to 0.5 metres above the 1% AEP flood level, which is estimated to provide at least 0.2% flood immunity to the development footprint.

The proposed development does not enhance existing flood risk to neighbouring properties as all external hydraulic impacts associated with the development have been mitigated.

8.4 Infrastructure & Environment

The proposed development does not result in any material impacts on flood behaviour (levels, depths, velocity etc.) external to the site. Accordingly, there is no change to the existing flood risk for the surrounding road or rail infrastructure. Similarly, there is no enhancement of the existing flood risk for the receiving environment.

9 CONCLUSIONS AND RECOMMENDATIONS

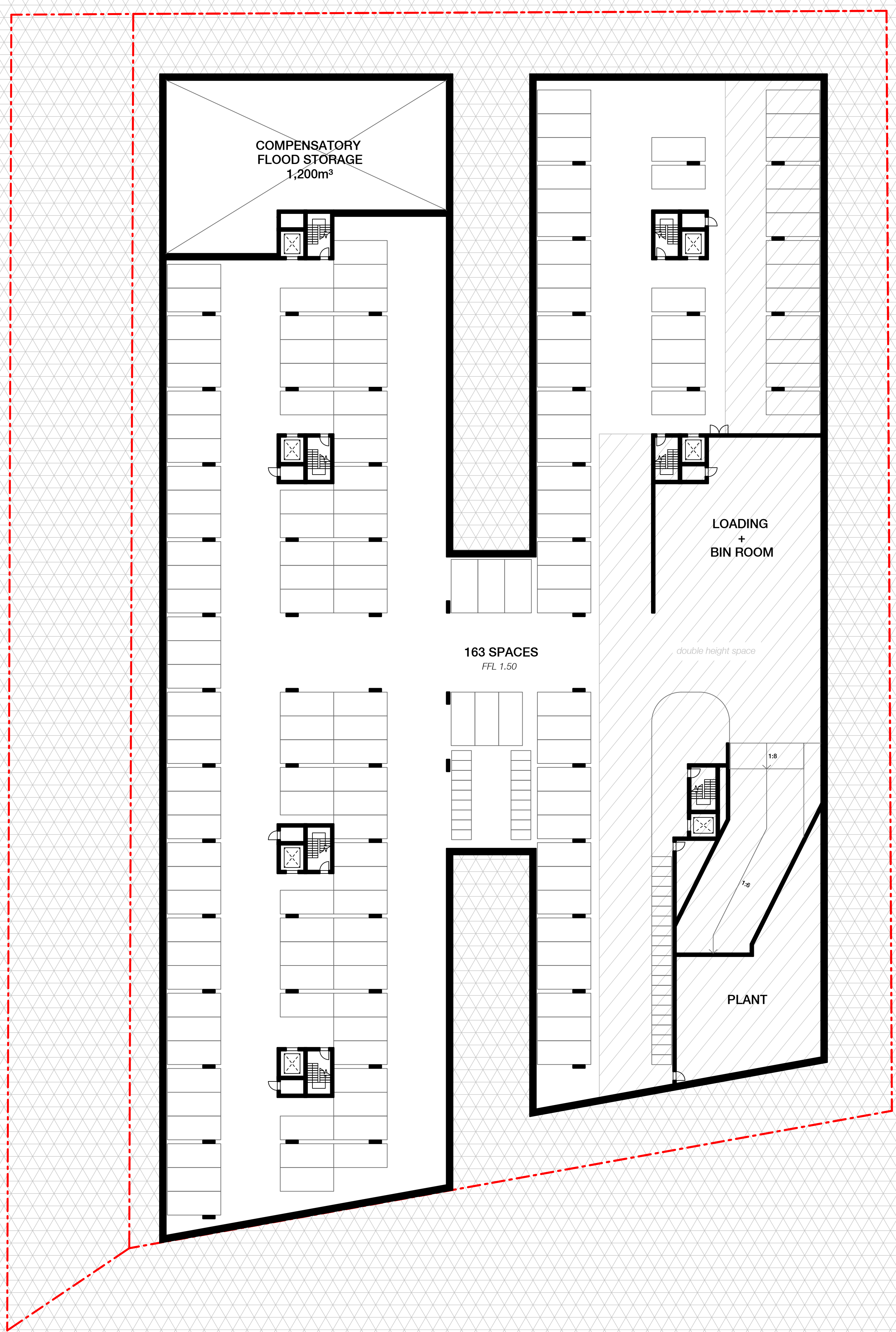
Water Technology was commissioned by Platino Properties to prepare a Flood Impact and Risk Assessment (FIRA) for a proposed development at 67-75 Lords Road Leichhardt, NSW.

This report has described modelling undertaken to quantify existing and post-development flood behaviour at the site and to confirm that impacts associated with the proposed development are adequately mitigated. Additionally, existing flood risk at the site and potential impacts of the development on flood risk external to the site have been addressed.

Key finding of this FIRA are:

- Flood behaviour
  - The site is subject to some degree of flooding during all design events considered, which is concentrated within the western lot.
  - Flooding impacting the site is a result of flash flooding in response to short duration storm events.
  - The site is primarily a flood storage area and flood storage volumes within the site will be maintained across all events by the provision of compensatory storage.
  - A portion of the site has a secondary flood conveyance function during the PMF only and this will be maintained by the development.
- Proposed development
  - The developed site area will be filled to a minimum level of 4.6 mAHD (0.5 m above Council's 1% AEP flood level).
  - The proposed development includes management measures to ensure the development has no material impact on flood behaviour external to the site. The recommended measures are:
    - Compensatory flood storage (in a free-draining basement tank) to offset any loss of storage from filling the site.
    - A boundary wall for flood control (to mirror the function of the existing building).
- Flood risk
  - Flooding in the catchment occurs in response to short durations storms during which there is insufficient time for flood warnings to be issued.
  - Existing management plans indicate that evacuation is not recommended.
  - Risks to the development and user of the development have been minimised by filling the site to a level that achieves flood immunity (up to the 0.2% AEP).
  - Potential risks of the development on neighbouring property and its users, infrastructure and the environment have been mitigated by the management measures described above.

APPENDIX A
DEVELOPMENT LAYOUT PLANS



Basement Plan

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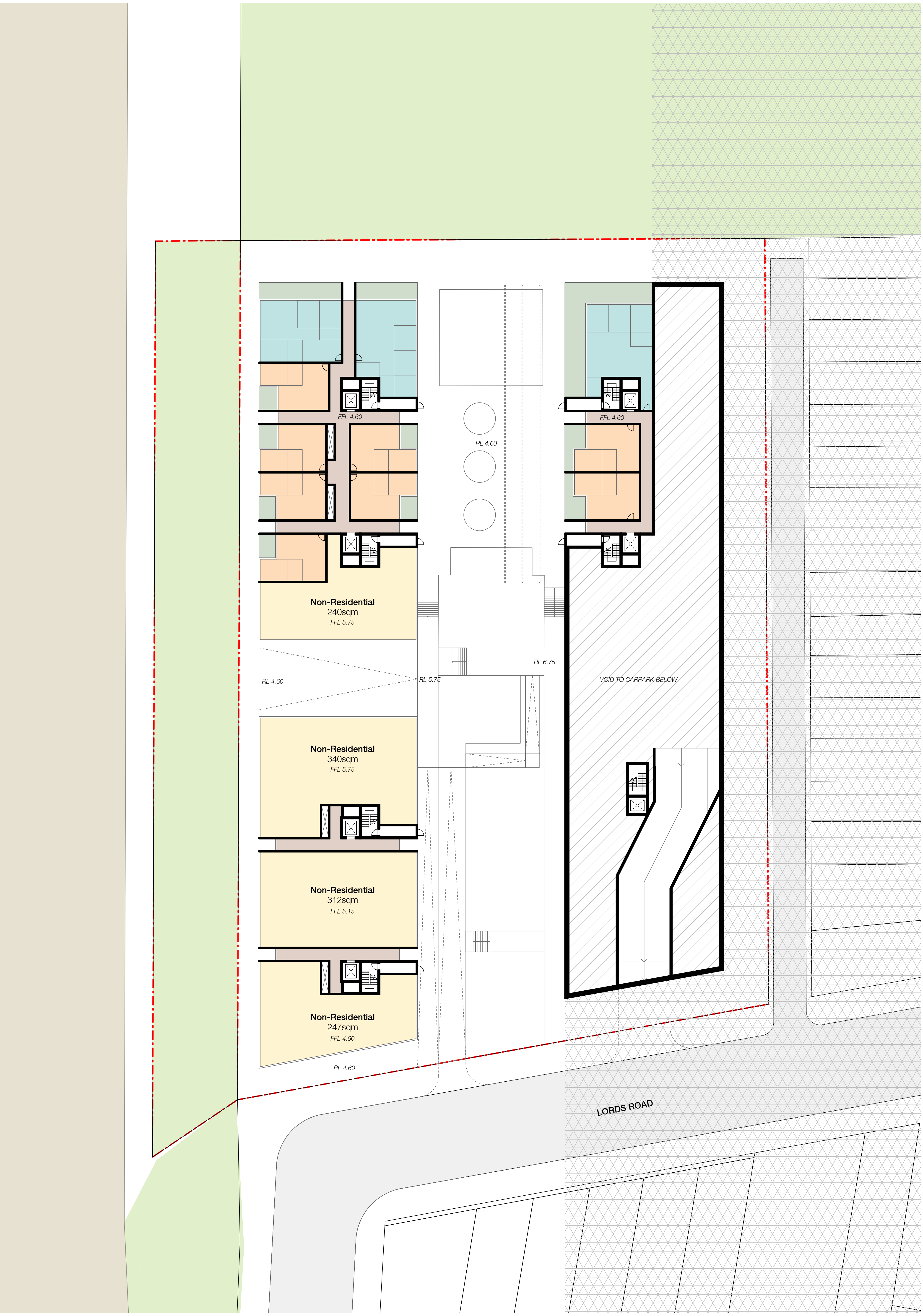
Drawing number
[00]
Revision number
[00]

Project number
6624
Project name
Lords Road

Project address
67-75 Lords Road, Leichardt
Client
Platino

SJB Architects
Level 2, 490 Crown Street, Surry Hills NSW 2010
T. 61 2 9380 9911 sjb.com.au
SJB Architecture (NSW) Pty Ltd
ABN 20 310 373 425 ACN 081 094 724
Adam Haddow 7188 John Pradel 7004



Ground Plan (WEST)

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Drawing number
[00]
Revision number
[00]

Project number
6624
Project name
Lords Road

Project address
67-75 Lords Road, Leichardt
Client
Platino

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Ground Plan (EAST) + Level 1 Plan (WEST)

Scale
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0 5 10 15 20 25

Drawing number
[00]

Revision number
[00]

Project number
6624

Project name
Lords Road

Project address
67-75 Lords Road, Leichhardt

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Typical Lower Level

Scale
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0 5 10 15 20 25

Drawing number [00]	**Project number** 6624	**Project address** 67-75 Lords Road, Leichardt	
Revision number [00]	**Project name** Lords Road	**Client** Platino	

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Typical Upper Level

Scale
1:500@A3

0 5 10 15 20 25

Drawing number
[00]
Revision number
[00]

Project number
6624
Project name
Lords Road

Project address
67-75 Lords Road, Leichardt
Client
Platino

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SJB Architecture (NSW) Pty Ltd
ABN 20 310 373 425 ACN 081 094 724
Adam Haddow 7188 John Pradel 7004

Level 8 Plan (WEST) + Roof Plan (EAST)

Scale
1:500@A3
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Drawing number
[00]
Revision number
[00]

Project number
6624
Project name
Lords Road

Project address
67-75 Lords Road, Leichardt
Client
Platino

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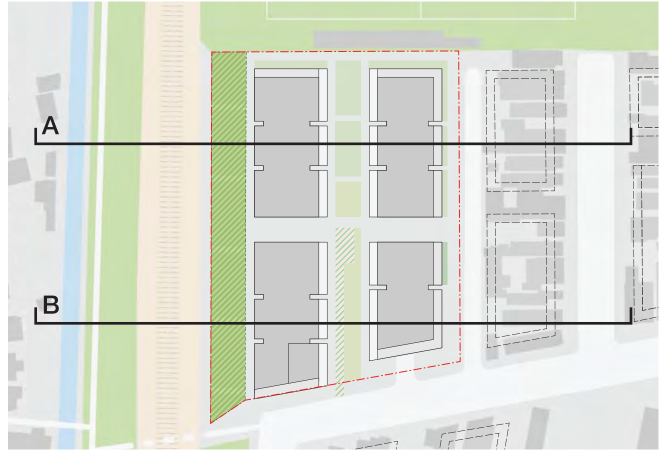
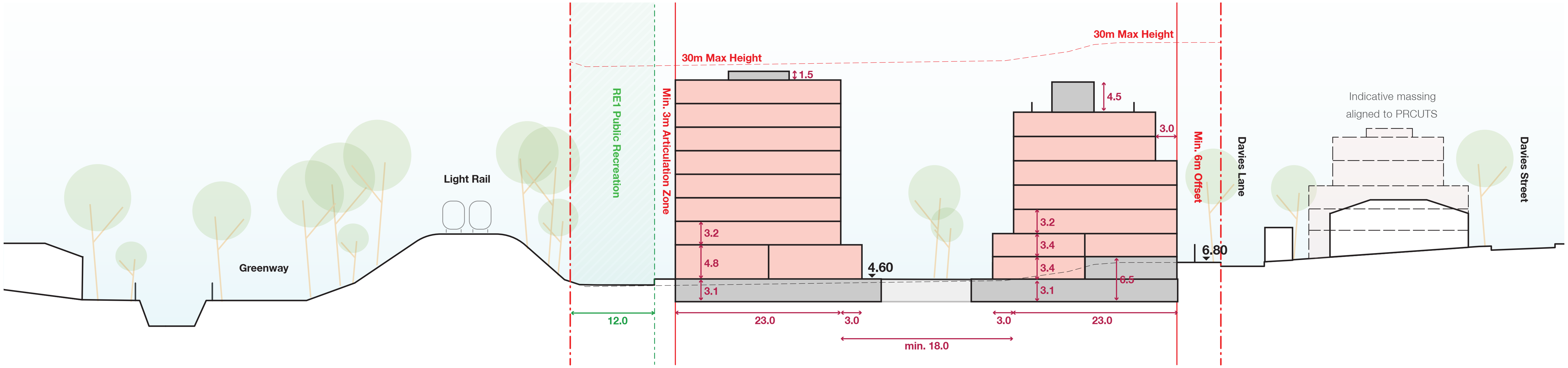
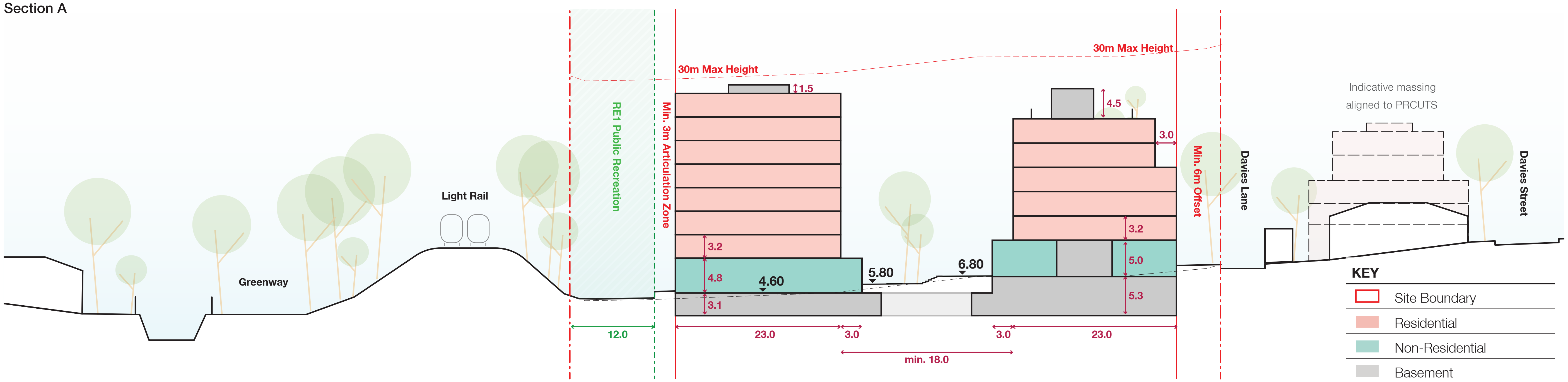
SJB Architecture (NSW) Pty Ltd
ABN 20 310 373 425 ACN 081 094 724
Adam Haddow 7188 John Pradel 7004

1.3 Sections





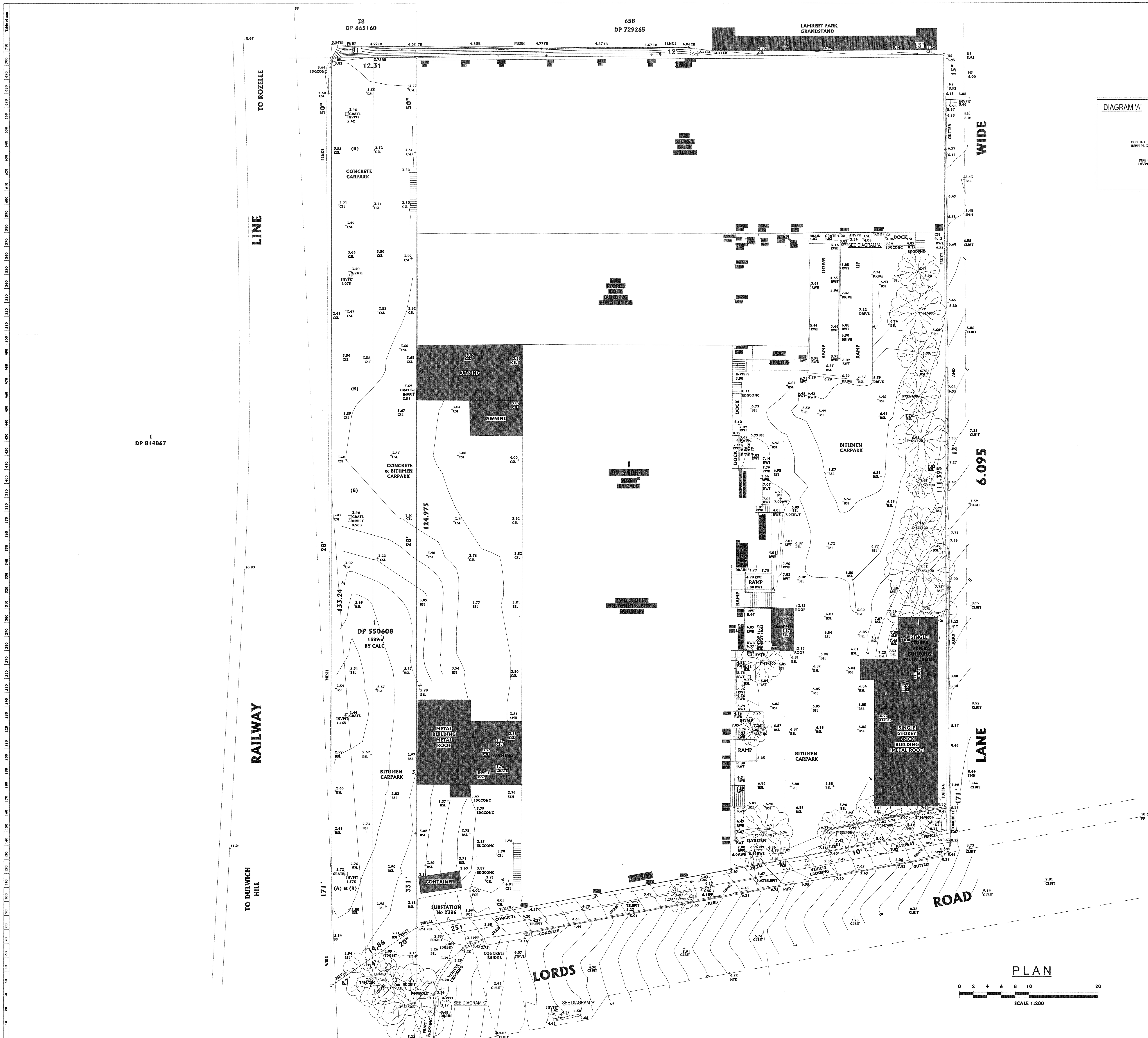
Section A

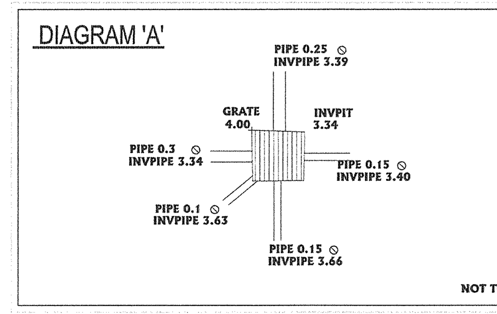


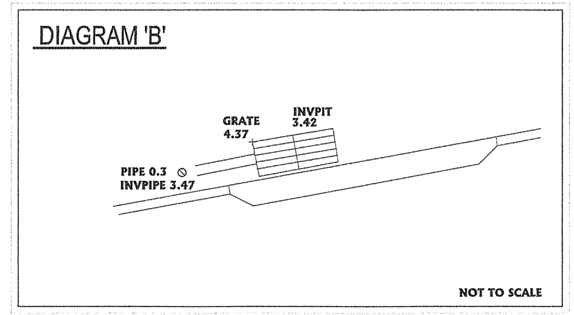
Section B

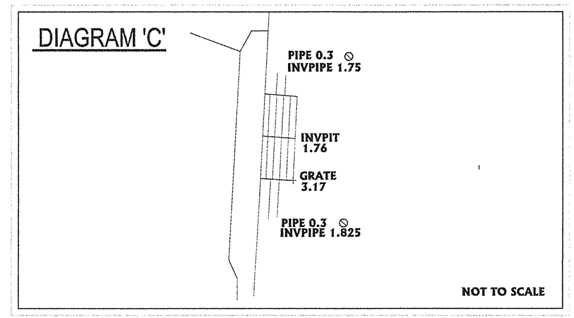
NTS

APPENDIX B
SITE SURVEY









KEY

70.69 FLOOR	DENOTES FLOOR LEVEL
70.69 RIDGE	DENOTES LEVEL OF RIDGE
70.69 BSL	DENOTES POSITION AND LEVEL OF THE BITUMEN SURFACE
70.69 ROOF	DENOTES LEVEL OF THE ROOF
70.69 GRATE	DENOTES POSITION AND LEVEL OF THE GRATE
70.69 DRIVE	DENOTES POSITION AND LEVEL OF THE DRIVEWAY
70.69 EDGCONC	DENOTES POSITION AND LEVEL OF THE EDGE OF CONCRETE
70.69 CLBIT	DENOTES LEVEL OF CENTRE LINE OF BITUMEN
70.69 NS	DENOTES POSITION AND LEVEL OF THE NATURAL SURFACE
70.69 CSL	DENOTES POSITION AND LEVEL OF THE CONCRETE SURFACE
70.69 RWT	DENOTES POSITION AND LEVEL OF A POINT ON THE TOP OF A RETAINING WALL
70.69 RWB	DENOTES POSITION AND LEVEL OF A POINT ON THE BOTTOM OF A RETAINING WALL
70.69 PARAPET	DENOTES LEVEL OF PARAPET
70.69 GAS	DENOTES POSITION AND LEVEL OF THE GAS MARKER
70.69 TELEPIT	DENOTES POSITION AND LEVEL OF THE TELSTRA PIT
70.69 SLH	DENOTES POSITION AND LEVEL OF THE SEWER LAMP HOLE
70.69 PP	DENOTES POSITION AND LEVEL OF THE POWER POLE
70.69 EDGEBIT	DENOTES POSITION AND LEVEL OF THE EDGE OF BITUMEN
70.69 HYD	DENOTES POSITION AND LEVEL OF THE HYDRANT
70.69 STPVL	DENOTES POSITION AND LEVEL OF THE STOP VALVE
70.69 BB	DENOTES POSITION AND LEVEL OF A POINT ON THE BOTTOM OF A BANK
70.69 TB	DENOTES POSITION AND LEVEL OF A POINT ON THE TOP OF A BANK
70.69 FCE	DENOTES POSITION AND LEVEL OF THE FENCE
70.69 INVPIT	DENOTES POSITION AND LEVEL OF THE INVERT OF THE PIT
70.69 Tx54/400	DENOTES POSITION AND LEVEL OF THE TREE SPREAD(RAD)/TRUNK(DIA)
	DENOTES OVERHEAD POWER LINE
	DENOTES UNDERGROUND SEWER
	DENOTES UNDERGROUND WATER
	DENOTES UDERGROUND TELSTRA SERVICES
	DENOTES UNDERGROUND POWER
PIPE 0.15 ⦸	DENOTES DIAMETER OF PIPE
INVPIPE 3.66	DENOTES LEVEL OF THE INVERT OF THE PIPE

PLAN

0 2 4 6 8 10 20

SCALE 1:200

NOTES

LOT AREAS AND BOUNDARY DIMENSIONS HAVE BEEN COMPILED FROM DEPOSITED PLANS AVAILABLE AT LAND AND PROPERTY INFORMATION. NO BOUNDARY SURVEY OR INVESTIGATION HAS BEEN MADE AND NO BOUNDARIES HAVE BEEN MARKED. ACCORDINGLY THE POSITION OF IMPROVEMENTS RELATIVE TO BOUNDARIES SHOWN HEREON IS DIAGRAMMATIC ONLY.

BEARINGS SHOWN ON THIS PLAN ARE ORIENTATED TO MAGNETIC NORTH VIDE DP 940543. IF SHADOW DIAGRAMS ARE TO BE CALCULATED THEY MUST BE CALCULATED USING TRUE NORTH.

CONTOUR INTERVAL 1.0m MAJOR, 0.2m MINOR

WHERE POSSIBLE STORMWATER PITS HAVE BEEN MEASURED AND DETAILS SHOWN IN DIAGRAMS ON THIS PLAN. ALL OTHER PITS WERE NOT ACCESABLE AND AS SUCH PIPE SIZES AND INVERTS HAVE NOT BEEN MEASURED.

THIS PLAN IS TO BE USED IN CONJUNCTION WITH 1766-PROFILES AND 1766-FLOORPLAN PREPARED BY USHER & COMPANY PTY LTD.

SERVICES & UTILITIES SHOWN ON THIS PLAN HAVE BEEN LOCATED BY REFERENCE TO SERVICE PLANS FROM STATUTORY AUTHORITIES. THEY HAVE BEEN LOCATED FROM STATED DIMENSIONS AND/OR BY SCALING AND THEIR LOCATION IS APPROXIMATE. SERVICE DETAILS SHOULD BE CONFIRMED WITH THE RELEVANT SERVICE AUTHORITY DURING DESIGN & PRIOR TO ANY CONSTRUCTION.

PLEASE NOTE UNDERGROUND GAS LINES ARE NOT SHOWN ON THE PLAN FROM THE RELEVANT STATUTORY AUTHORITY HOWEVER GAS MARKERS HAVE BEEN LOCATED AND ARE SHOWN ON THIS PLAN IN FOOTPATH ON LORDS ROAD.

(A) EASEMENT FOR ELECTRICITY SUPPLY VIDE DP 1054391
(B) EASEMENT FOR DRAINAGE AND ACCESS FOR MAINTENANCE 6 WIDE VIDE DP 1054391

Usher & Company Pty Limited A.B.N. 16 083 321 233
GEOMATICS SURVEYING AND DEVELOPMENT SERVICES
Suite 23, 1-3 Havilah Street, Chatswood NSW 2057
PO Box 1199, CHATSWOOD NSW 2057
Phone: (02) 9411 8166
Fax: (02) 9411 8177
Email: surveyone@bigpond.com

APPROVED

Amendments

ISSUE	DATE	DETAILS
INITIAL	22-11-2004	
1	29-11-2004	Underground services added according to service plans from statutory authorities

PLAN:
SHOWING DETAIL AND LEVELS AT
67-75 LORDS ROAD
LEICHHARDT
BEING LOT 1 DP 940543
AND LOT 1 DP 550608

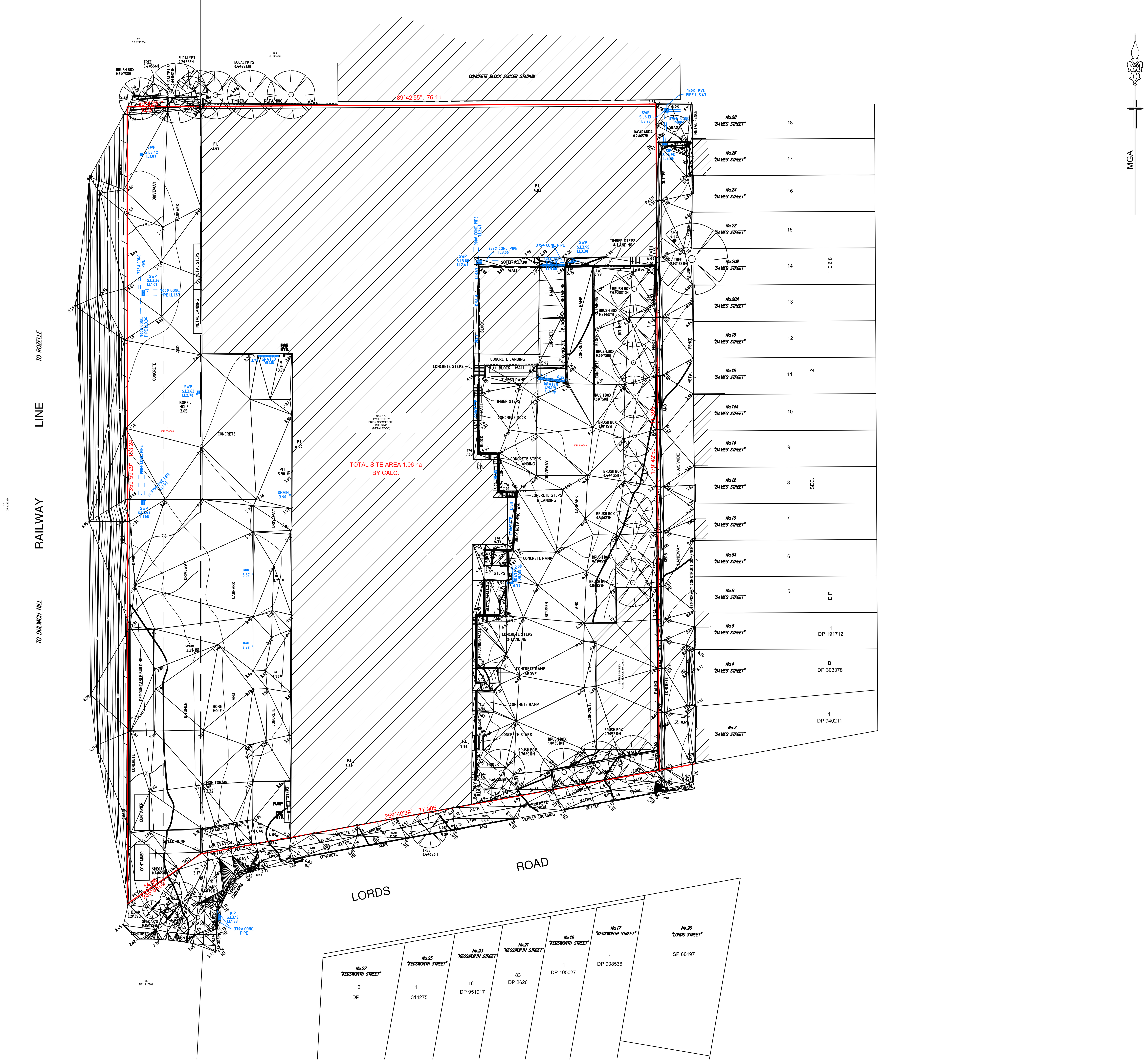
LGA:	LEICHHARDT
SUBURB:	LEICHHARDT
ORIGIN:	SSM 98319 RL 14.906 AHD SCIMS 27/08/04
REDUCTION RATIO:	PLAN: 1:200
DATUM:	AHD
DATE OF SURVEY:	19 November 2004
SURVEYED BY:	MBW
DRAWN BY:	MBW

THIS PLAN IS FOR THE EXCLUSIVE USE OF
PLATINO PROPERTIES

AO

PLAN REFERENCE: 1766-DET-1

ISSUE: 1



THIS PLAN HAS BEEN PREPARED FOR FLOOD STUDY PURPOSES.
FURTHER SURVEY INLCUDING BOUNDARY REDEFINITION WILL
BE REQUIRED PRIOR TO SUBMISSION WITH A DA TO COUNDIL

NOTES:

1) BOUNDARIES COMPILED FROM PLANS ON PUBLIC RECORD.
   BOUNDARY REDEFINITION HAS NOT BEEN UNDERTAKEN.

2) ORIGIN OF LEVELS :

3) UNDERGROUND SERVICES HAVE NOT BEEN INVESTIGATED.

4) (G) DENOTES GUTTER LEVEL.
   (TW) DENOTES TOP OF WALL LEVEL.
   0.3Ø10S,8H DENOTES TREE SIZE 0.3 TRUNK DIAMETER, 10 SPREAD, 8 HIGH.
   SMH DENOTES SEWER MANHOLE
   KIP DENOTES KERB INLET PIT
   GV DENOTES GAS VALVE
   PP/LP DENOTES POWER AND LIGHT POLE
   SIP DENOTES SEWER INSPECTION POINT
   SWP DENOTES STORMWATER PIT
   I.L DENOTES INVERT LEVEL
   S.L DENOTES SURFACE LEVEL
   VC DENOTES VEHICLE CROSSING
   PC DENOTES PRAM CROSSING
   (A) DENOTES EASEMENT FOR ELECTRICITY SUPPLY (VIDE DP1054391)
   (B) DENOTES EASEMENT FOR DRAINAGE AND ACCESS FOR MAINTENANCE 6 WIDE (VIDE DP1054391)
   (C) DENOTES EASEMENT FOR NOISE AND VIBRATION (VIDE DL9656893)
   (D) DENOTES EASEMENT FOR ELECTROLYSIS (VIDE VIDE DL9656893)

5) TREE NAMES SHOWN CONSTITUTE OUR OPINION ONLY.
   IF TREE SPECIES IDENTIFICATION IS IMPORTANT FOR DESIGN OR HERITAGE REASONS,
   THEY SHOULD BE DETERMINED BY A QUALIFIED ARBORIST.

ISSUE	DATE	AMENDMENT

TITLE:	PLAN SHOWING SELECTED DETAIL & LEVELS OVER 67-73 LORDS ROAD, LEICHHARDT 2040		
LGA:	INNER WEST	REFERENCE: 23866	
CLIENT :	PLATINO PROPERTIES	DATE: 28.09.23	SHEET
SCALE (AT A1) 1:350	DATUM : AHD	SURVEYOR: MM	1

Norton Survey Partners
SURVEYORS & LAND TITLE CONSULTANTS
A.C.N. 618 980 475
SUITE 1
505 BALMAIN ROAD
LILYFIELD N.S.W. 2040
PH +61 2 9555 2744
office@nspartners.com.au

NOTES:

1) BOUNDARIES COMPILED FROM PLANS ON PUBLIC RECORD.
BOUNDARY REDEFINITION HAS NOT BEEN UNDERTAKEN.

2) ORIGIN OF LEVELS :

3) UNDERGROUND SERVICES HAVE NOT BEEN INVESTIGATED.

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(A) DENOTES EASEMENT FOR ELECTRICITY SUPPLY (VIDE DP1054391)
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THEY SHOULD BE DETERMINED BY A QUALIFIED ARBORIST.

SCALE A1 1:200

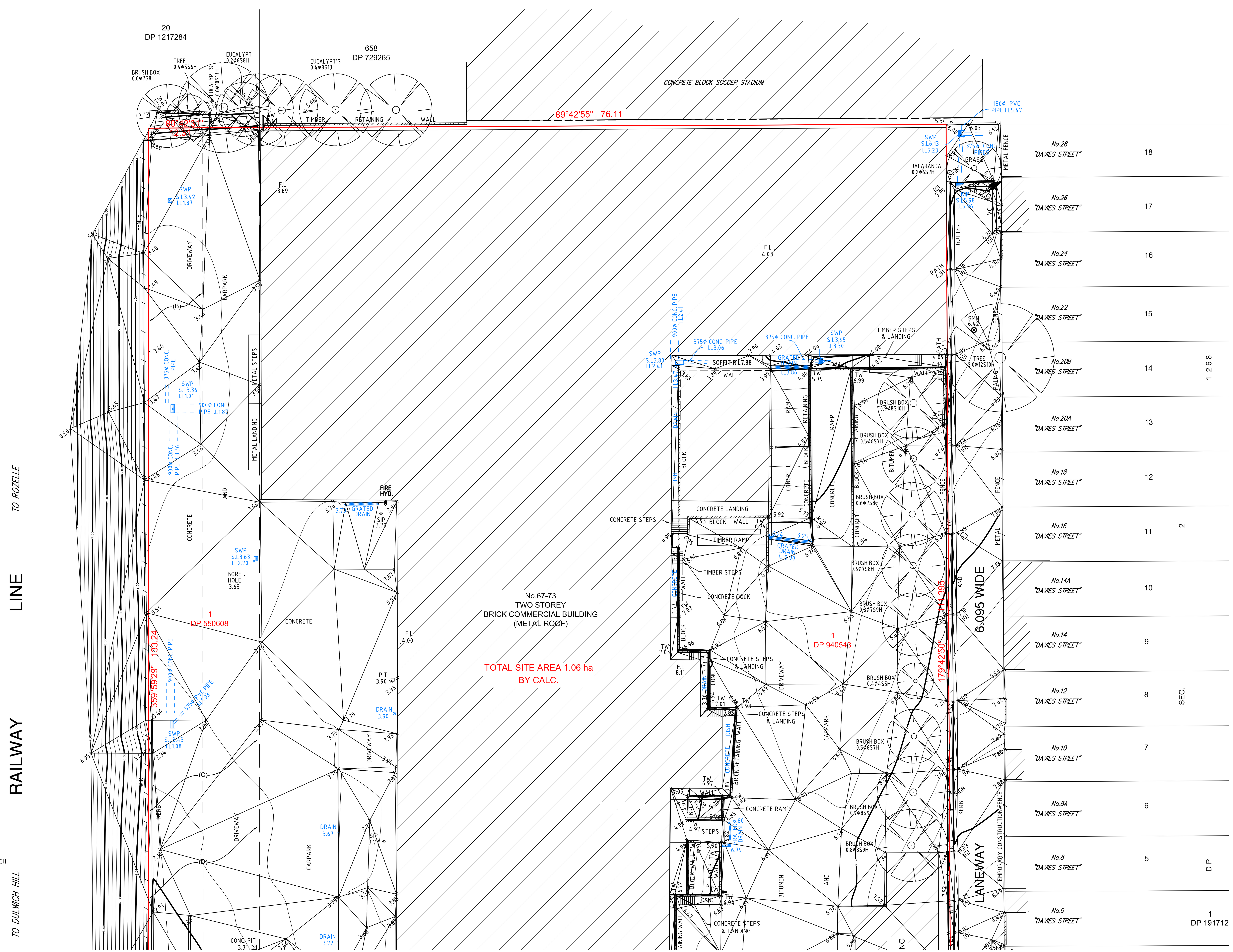
0 4m 8m 12m 16m 20m

SCALE 1:200

ISSUE	DATE	AMENDMENT

TITLE:	PLAN SHOWING SELECTED DETAIL & LEVELS OVER 67-73 LORDS ROAD, LEICHHARDT 2040		
LGA:	INNER WEST	REFERENCE: 23866	
CLIENT :	PLATINO PROPERTIES	DATE: 28.09.23	SHEET 2
SCALE (AT A1) 1:200	DATUM : AHD	SURVEYOR: MM	

Norton Survey Partners
SURVEYORS & LAND TITLE CONSULTANTS
A.C.N. 618 980 475
SUITE 1
505 BALMAIN ROAD
LILYFIELD N.S.W. 2040
PH +61 2 9555 2744
office@nspartners.com.au



NOTES:

1) BOUNDARIES COMPILED FROM PLANS ON PUBLIC RECORD.
BOUNDARY REDEFINITION HAS NOT BEEN UNDERTAKEN.

2) ORIGIN OF LEVELS :

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ISSUE	DATE	AMENDMENT

TITLE:	PLAN SHOWING SELECTED DETAIL & LEVELS OVER 67-73 LORDS ROAD, LEICHHARDT 2040		
LGA:	INNER WEST	REFERENCE: 23866	
CLIENT :	PLATINO PROPERTIES	DATE: 28.09.23	SHEET 3
SCALE (AT A1) 1:200	DATUM : AHD	SURVEYOR: MM	

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SURVEYORS & LAND TITLE CONSULTANTS
A.C.N. 618 980 475
SUITE 1
505 BALMAIN ROAD
LILYFIELD N.S.W. 2040
PH +61 2 9555 2744
office@nspartners.com.au

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX C
FLOOD CERTIFICATE

INNER WEST COUNCIL

Contact: James Ogg
Phone: (02) 9392 5641

24 October 2018

Richard McLachlan
C/o Platino Properties
Suite 11, Level 2, 20 Young Street
Neutral Bay NSW 2089

Flood Certificate

As requested, attached is the Flood Level Information Report for the following address:

- **67-75 Lords Road, Leichhardt**

The information contained in the report is derived from the Leichhardt Flood Study (November 2017 prepared by Cardno).

The information is provided in good faith and in accordance with the provisions of s.733 of the Local Government Act.

Should you have any questions please call Council's Stormwater & Emergency Planning Section on 9392 5000.

Yours faithfully

James Ogg
COORDINATOR – STORMWATER & EMERGENCY PLANNING

INNER WEST COUNCIL

Property Flood Level Information Report

Applicant Name	Richard McLachlan	**Our Ref**	648
Property Address	67-75 Lords Road, Leichhardt		
Date of Issue	24 October 2018		

About this Report

This report provides flooding information for the area in the vicinity of the above property. This information can be used to assist in understanding the extent of flooding affecting this property and can be used to assist in preparation of a Flood Risk Management Report in accordance with Section E1.1.4 of Council's Development Control Plan (DCP 2013). It is recommended that the information in this report be interpreted by a suitably qualified professional.

This report includes two pages; this cover page with an explanation of the information provided, and the second page is a figure providing information on the flooding behaviour in the area. The figure includes peak water levels, depths and flow rates for the 100 year ARI and peak water levels for the Probable Maximum Flood event.

The flood levels provided are based on available information including numerical modelling results prepared by Cardno for Leichardt Council. Further details are available in the *Leichhardt Flood Study* (Cardno, 2017). All flood levels and depths are provided to the nearest 0.05 metres.

Definitions

The following provides a brief definition of some of the key terms utilised in this report:

Average Recurrence Interval (**ARI**)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. The 100 year ARI flood event can be expressed as having a 1% chance of occurrence in any given year or as the flood that could occur once every 100 years.
Probable Maximum Flood (**PMF**)	The PMF is the largest flood that could conceivably occur at a particular location. This event is used to determine what might occur in events larger than a 100 year ARI.
100 year ARI Flow Path/Extent	The area of land expected to be inundated by either a flow path or mainstream flooding during a 100 year ARI flood event. The extents are limited to the areas where depths of flow are greater than 150mm.
100 year ARI High Hazard	Areas within the 100 year ARI flood extents where the depth and/or velocity of flow is likely to represent a possible danger to personal safety; evacuation by trucks is difficult; able-bodied adults would have difficulty wading to safety; and/or potential for structural damage to buildings.
Flood Planning Level (**FPL**)	The Flood Planning Level is calculated by adding a 500 mm freeboard onto the 100 year ARI flood level.
Freeboard	The freeboard is incorporated into the Flood Planning Level to provide a factor of safety to the flood levels. It accounts for a number of factors, including wave action, localised obstructions to flows, and model uncertainty.
Australian Height Datum (**AHD**)	A common national surface level datum approximately corresponding to mean sea level.

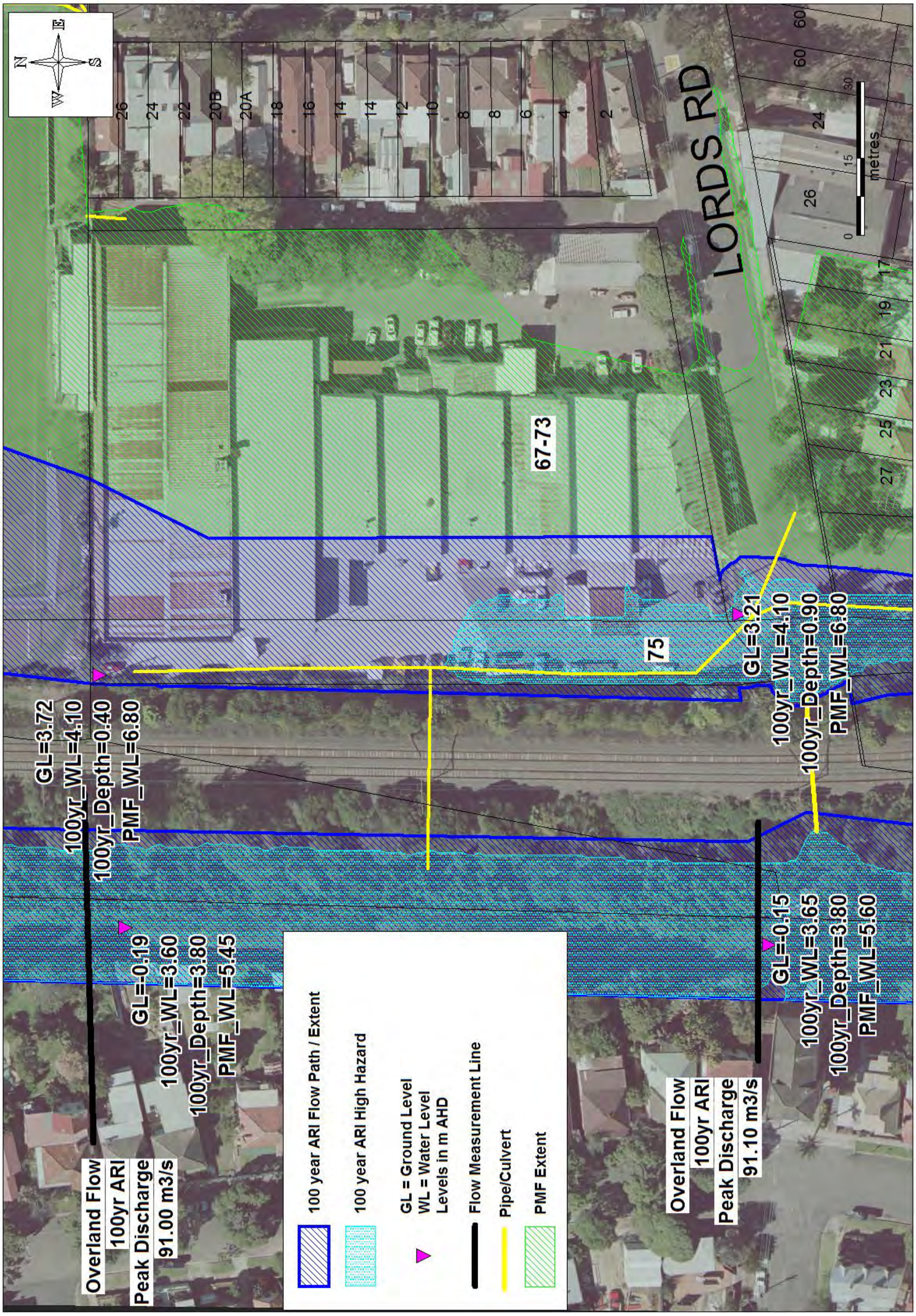
Notes

The ground levels shown on the attached figure are based on aerial survey data undertaken by AAM Hatch on behalf of Council. The ground levels should be verified by a suitably qualified surveyor.

The location of stormwater pits and pipes on the attached figure are indicative only. The location and dimensions of pipelines should be verified by a suitably qualified surveyor.

The water depths shown are provided at the location shown and are indicative only. They do not necessarily represent the maximum depth in the area. For example, where a point is located on the centreline of a road, the depths will be higher within the road gutter.

The information is provided in good faith and in accordance with the provisions of s.733 of the *Local Government Act*.



The information provided is in good faith and in accordance with the provisions of s.733 of the *Local Government Act*.

The aerial photo was taken by AAM Hatch and is dated at 2006.

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX D
EXISTING CASE FLOOD MAPPING


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - 10% AEP
WATER TECHNOLOGY

LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - 5% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - 2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56

Produced By: Water Technology Pty Ltd

Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

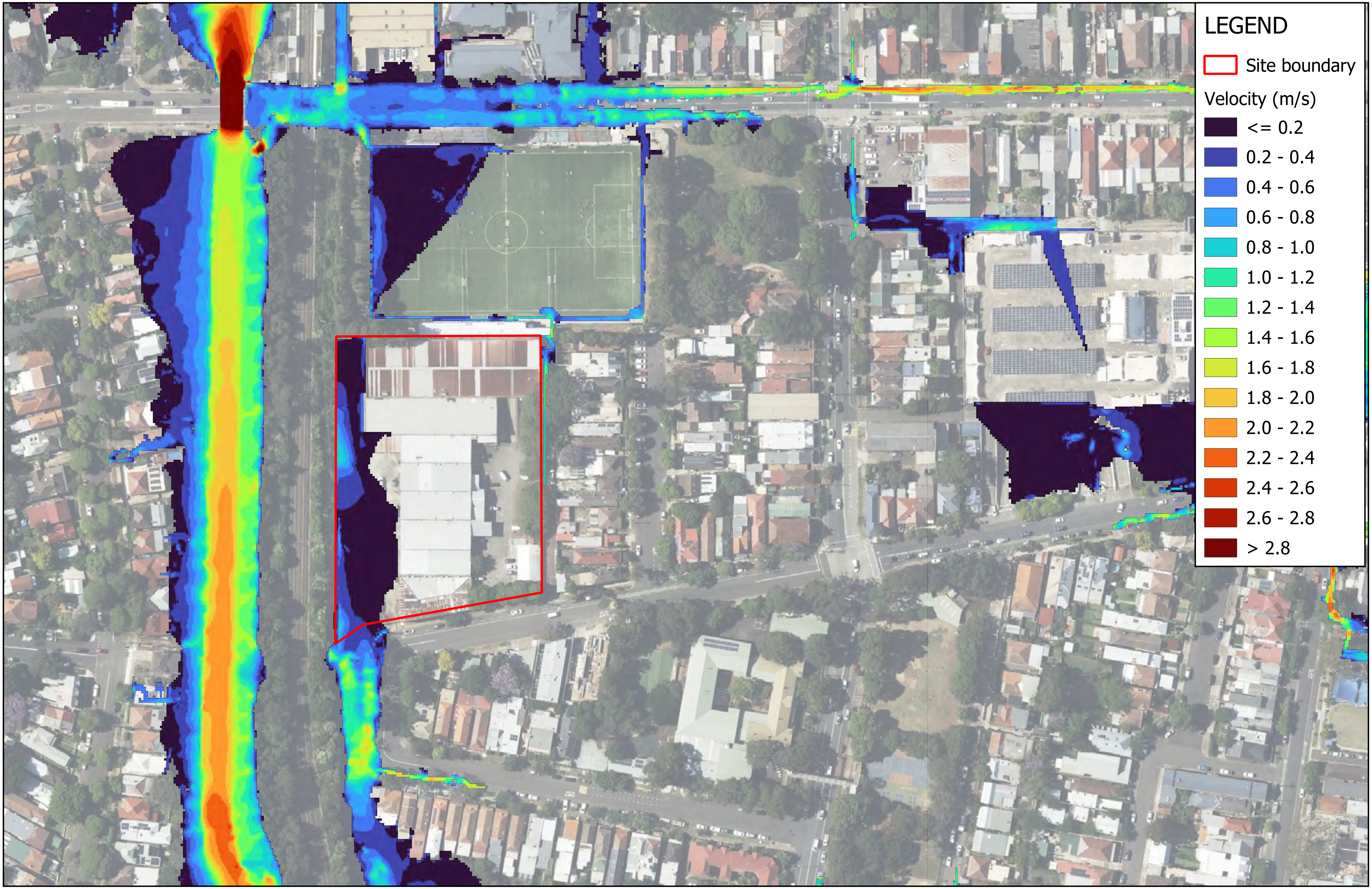
Existing Case - Flood Levels - 1% AEP


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - 0.5% AEP
WATER TECHNOLOGY


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - 0.2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - PMF
WATER TECHNOLOGY


LEGEND
Site boundary
Depth (m)
<= 0.100
0.100 - 0.200
0.200 - 0.500
0.500 - 1.000
1.000 - 1.500
1.500 - 2.000
2.000 - 5.000
> 5.000
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Depth - 1% AEP



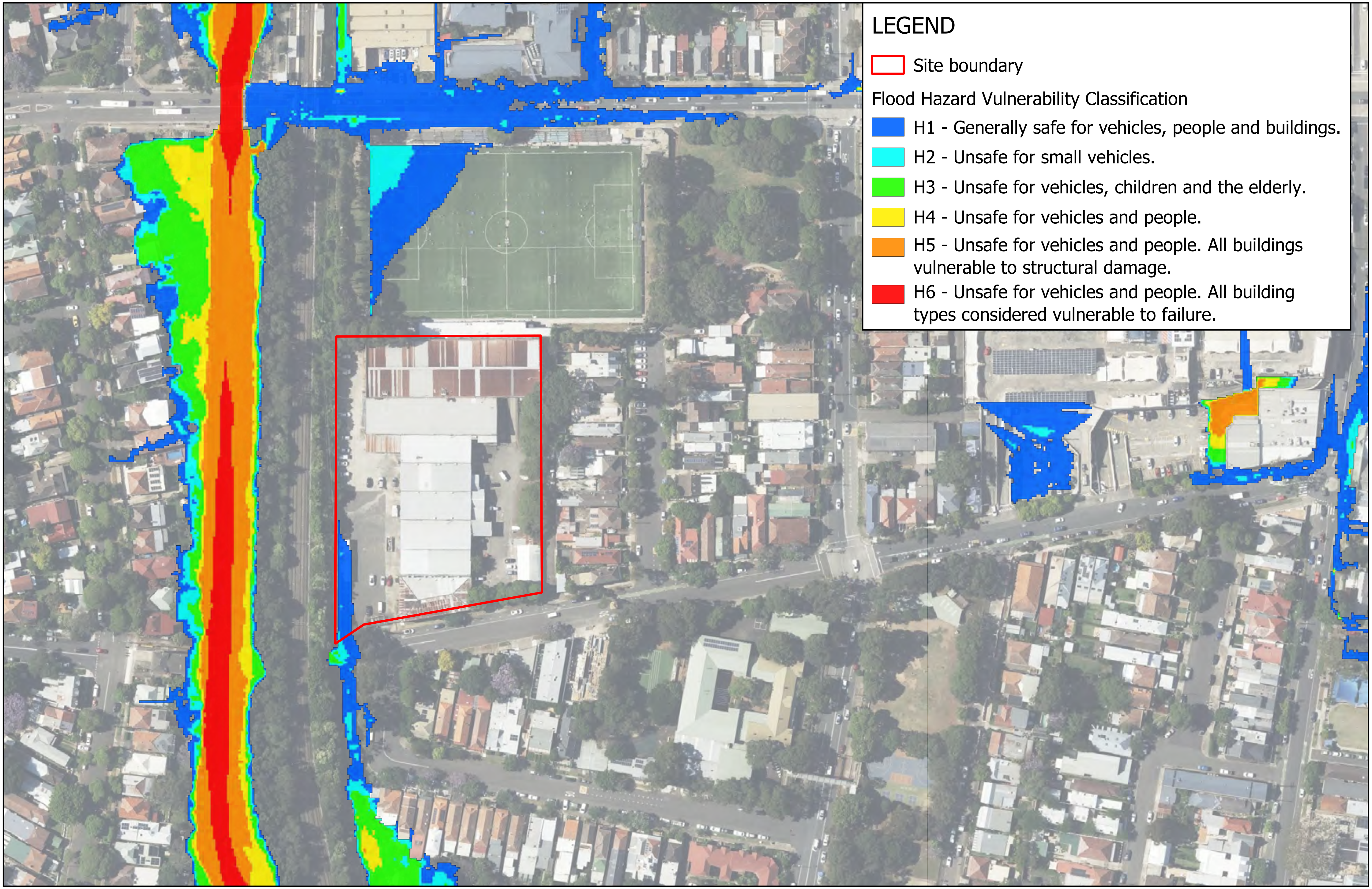
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Velocity - 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

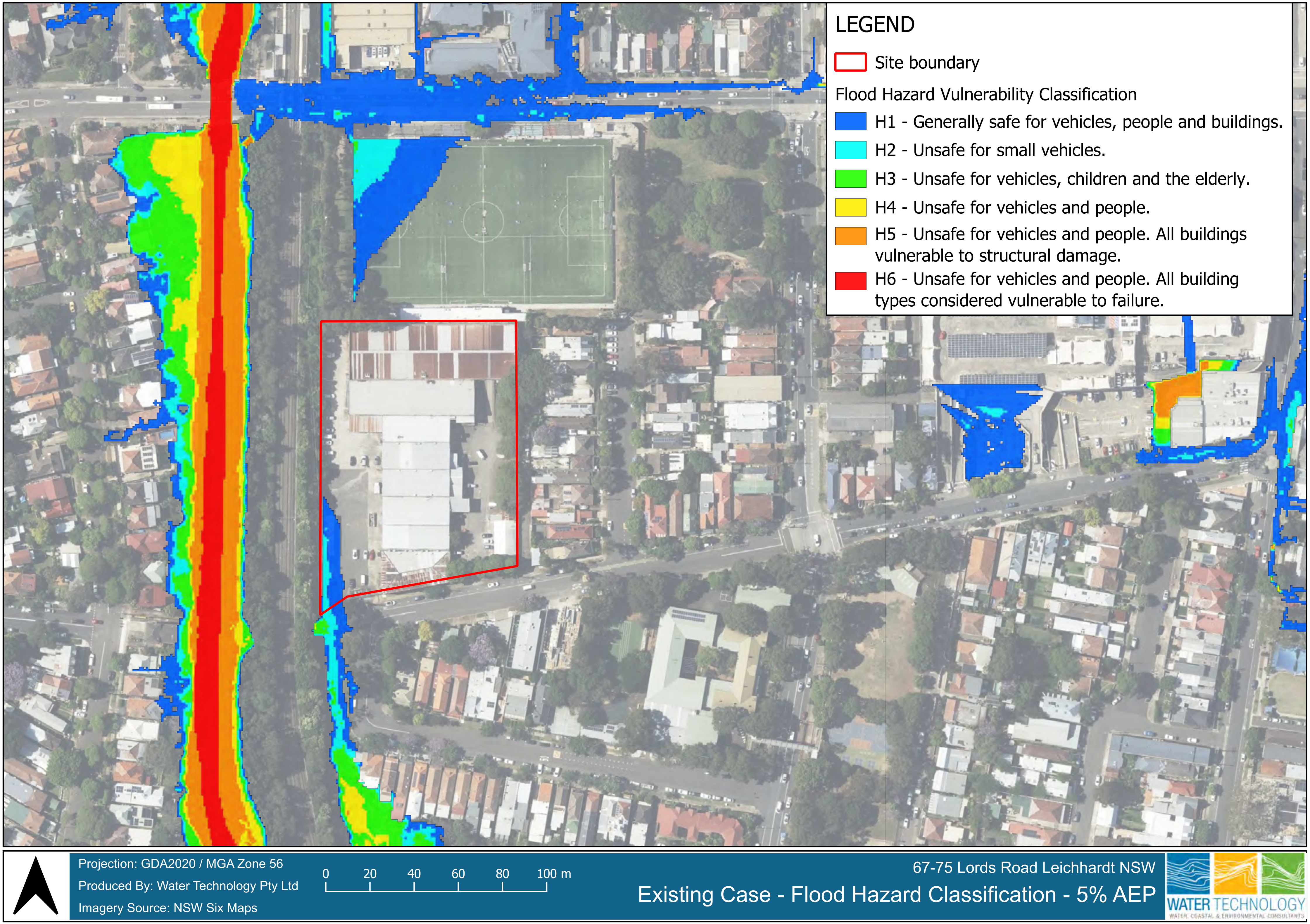


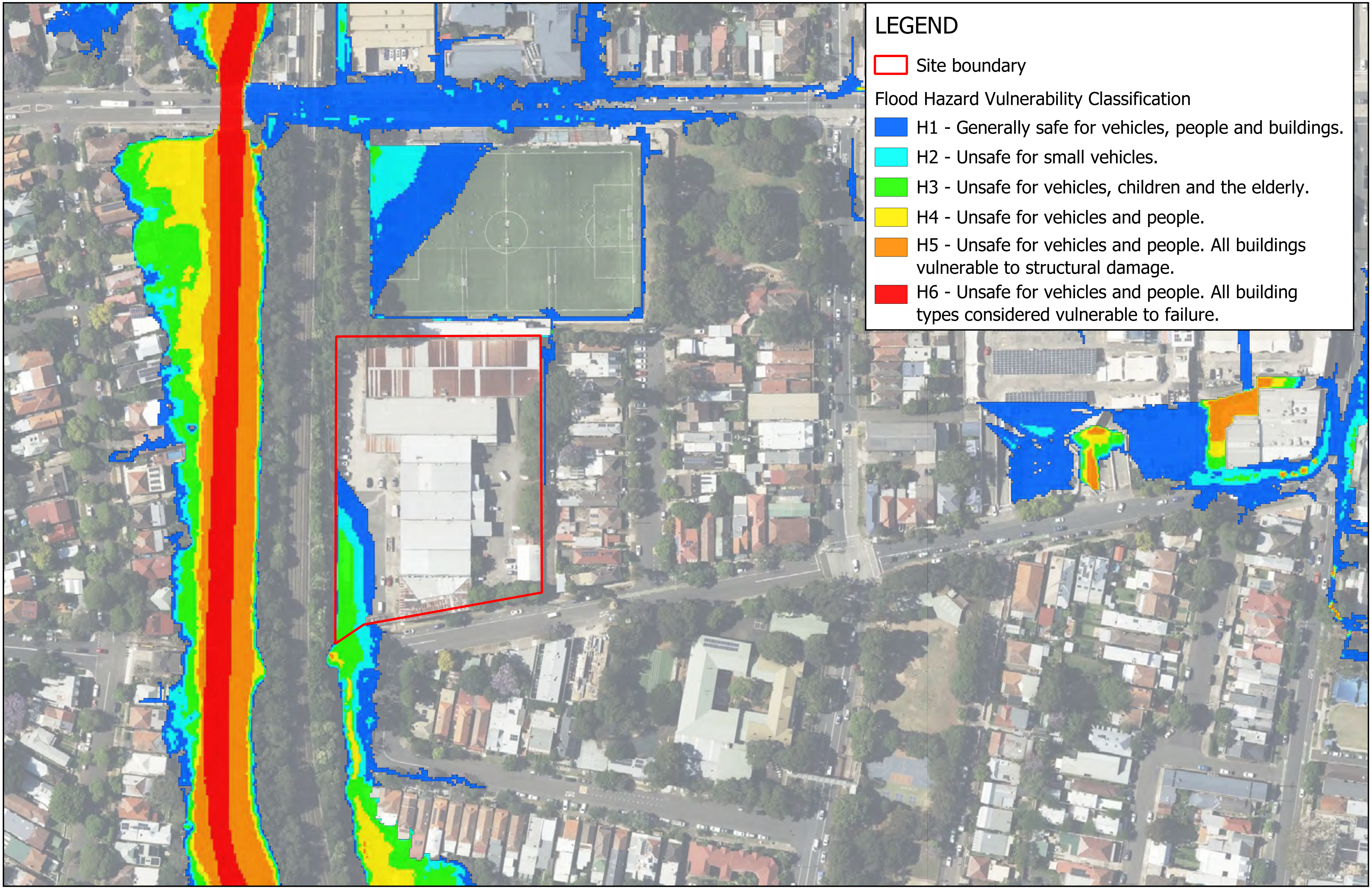
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - 10% AEP

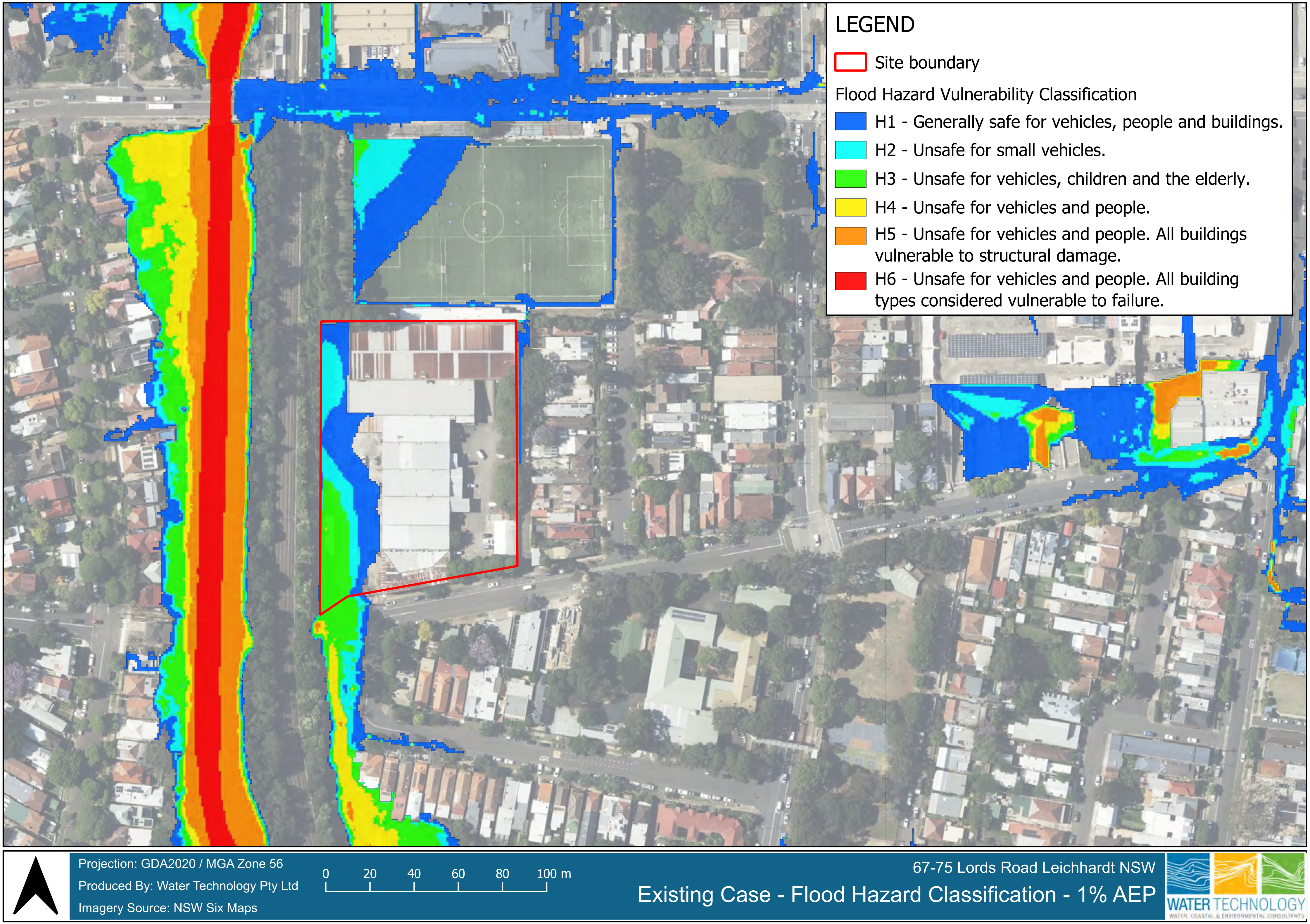
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Hazard Classification - 5% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - 2% AEP

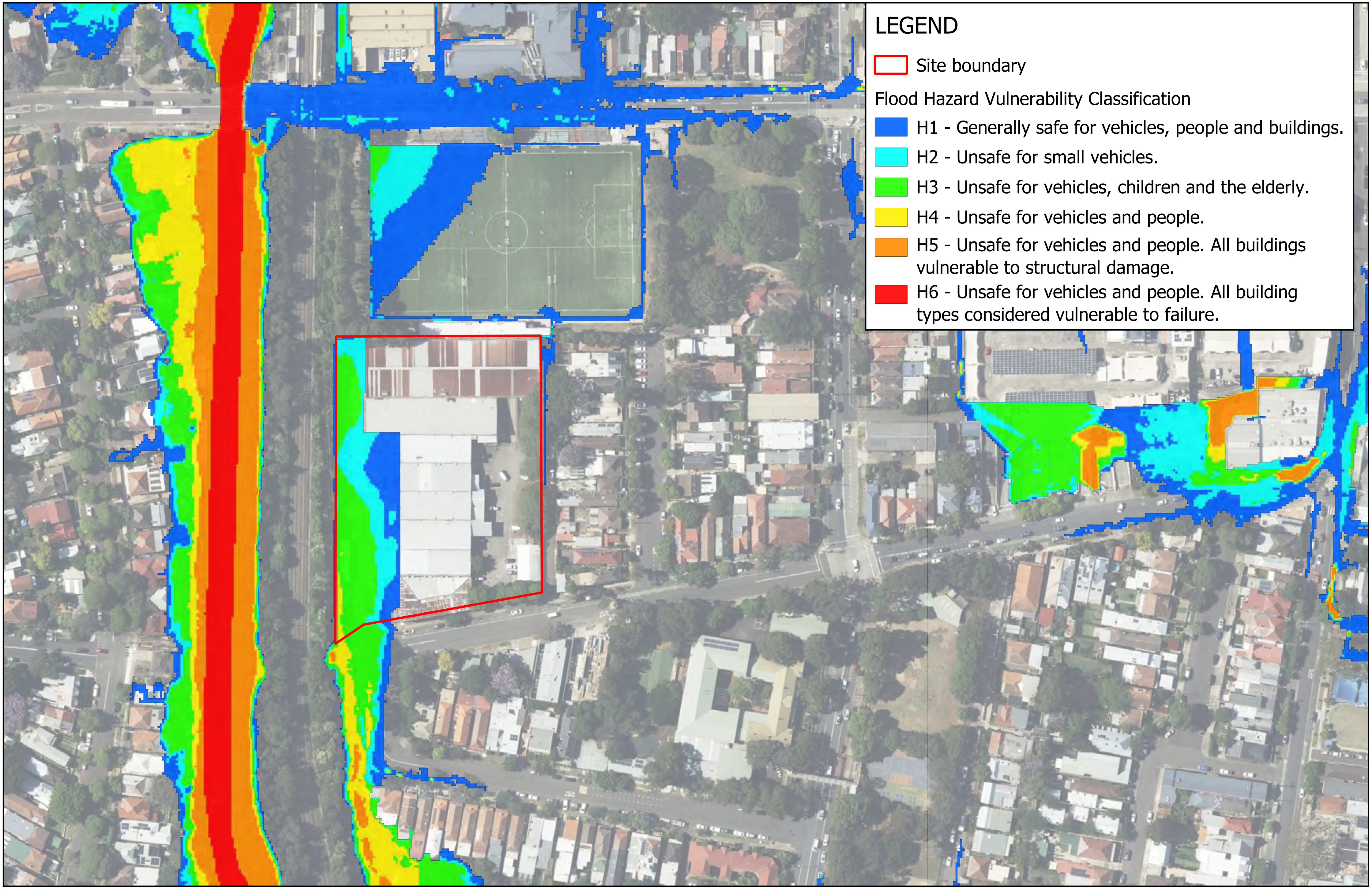


Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - 1% AEP

WATER TECHNOLOGY WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

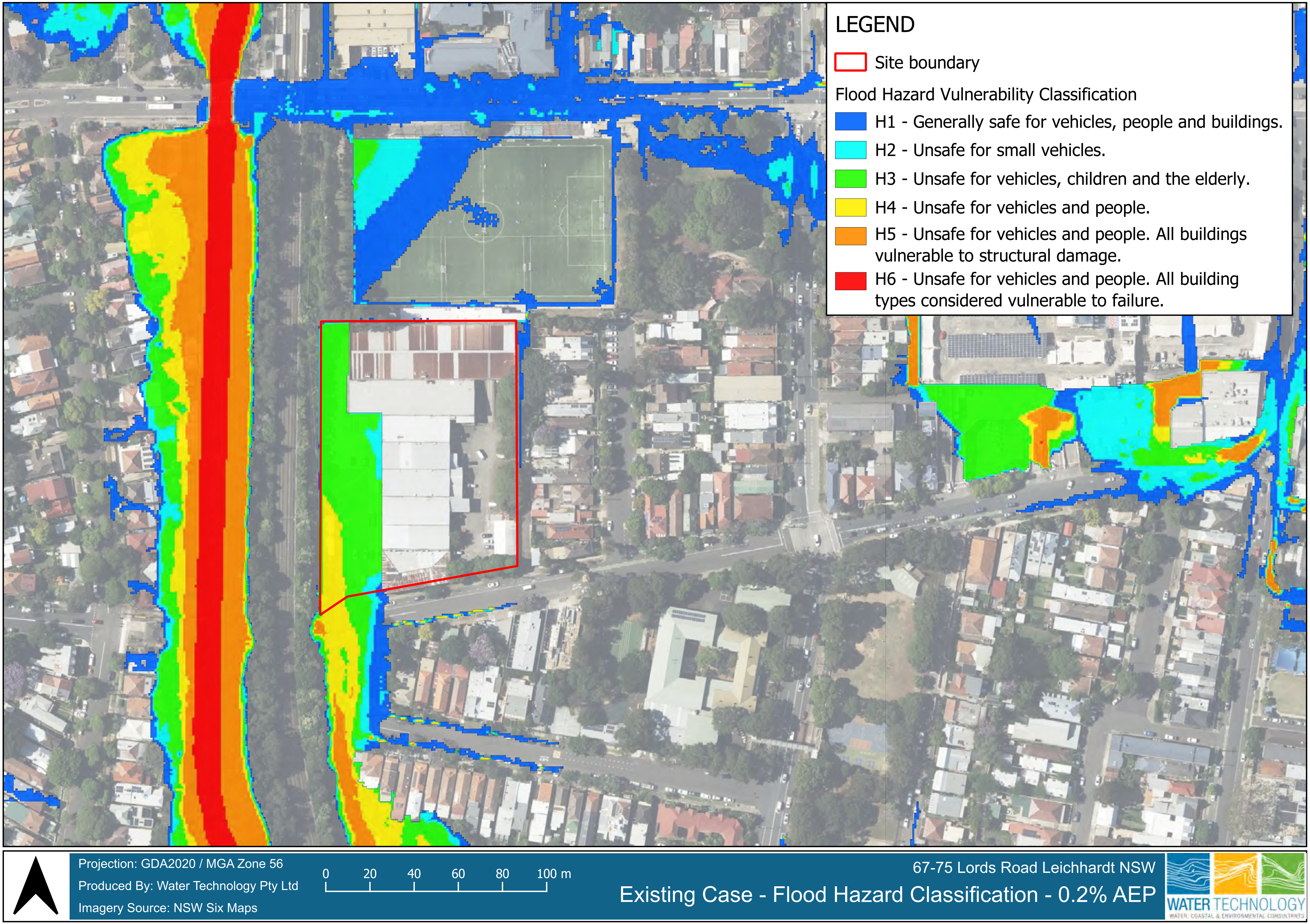


Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - 0.5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS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Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Hazard Classification - 0.2% AEP
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - PMF

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX E
EXISTING CASE CLIMATE CHANGE MAPPING


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Flood Levels - Climate Change 1% AEP
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Levels - Climate Change 0.5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Levels - Climate Change 0.2% AEP

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - Climate Change 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - Climate Change 0.5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Flood Hazard Classification - Climate Change 0.2% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Impact of Climate Change - 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

LEGEND
Site boundary
Change in Flood Level (m)
<= 0.0
0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
Was Wet Now Dry
Was Dry Now Wet
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Existing Case - Impact of Climate Change - 0.5% AEP
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Existing Case - Impact of Climate Change - 0.2% AEP

APPENDIX F
DEVELOPED CASE FLOOD MAPPING

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - 10% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - 5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - 2% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - 1% AEP

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - 0.5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56

Produced By: Water Technology Pty Ltd

Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - 0.2% AEP

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours
(0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0
20
40
60
80
100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Levels - PMF
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Depth - 1% AEP

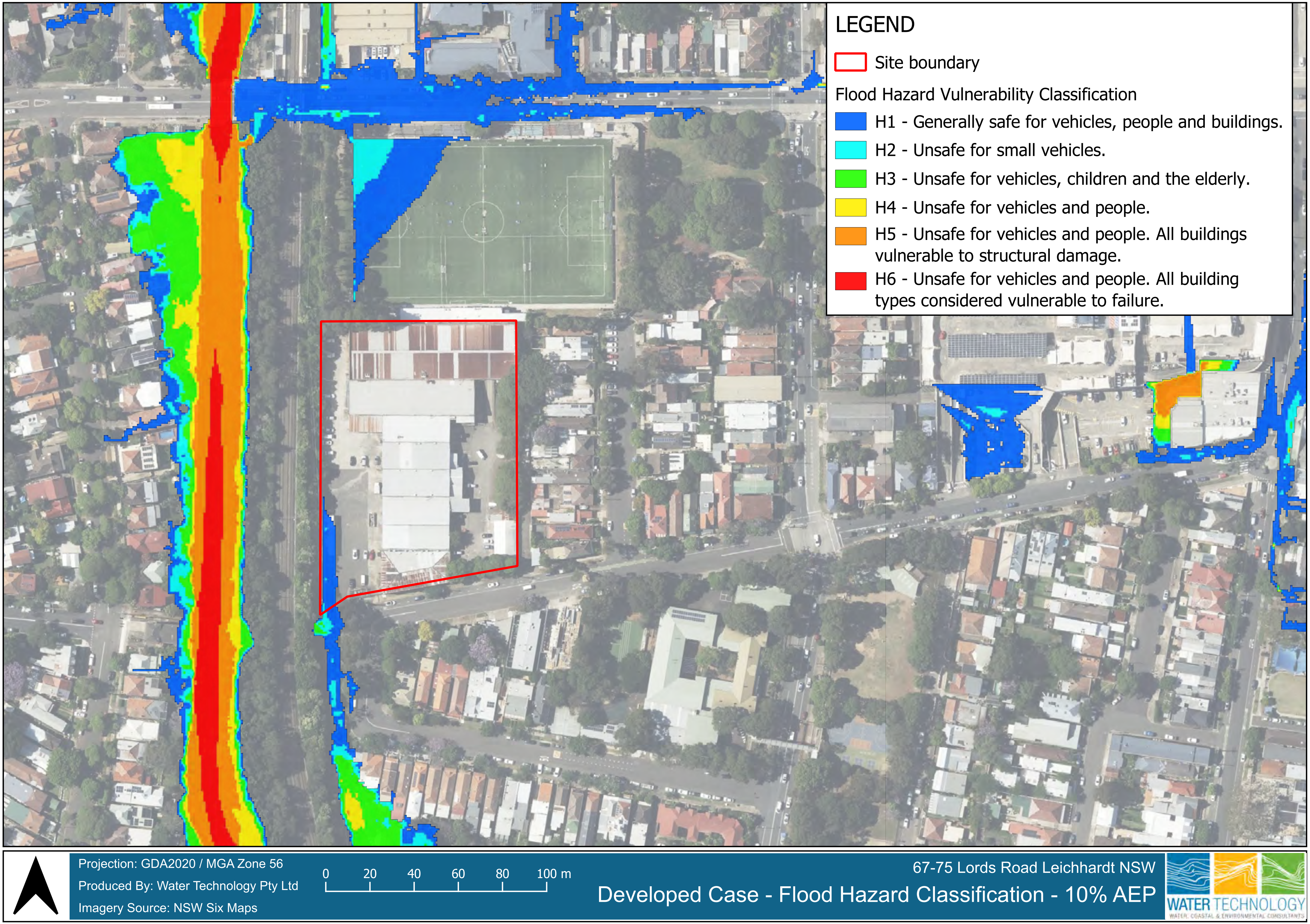
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

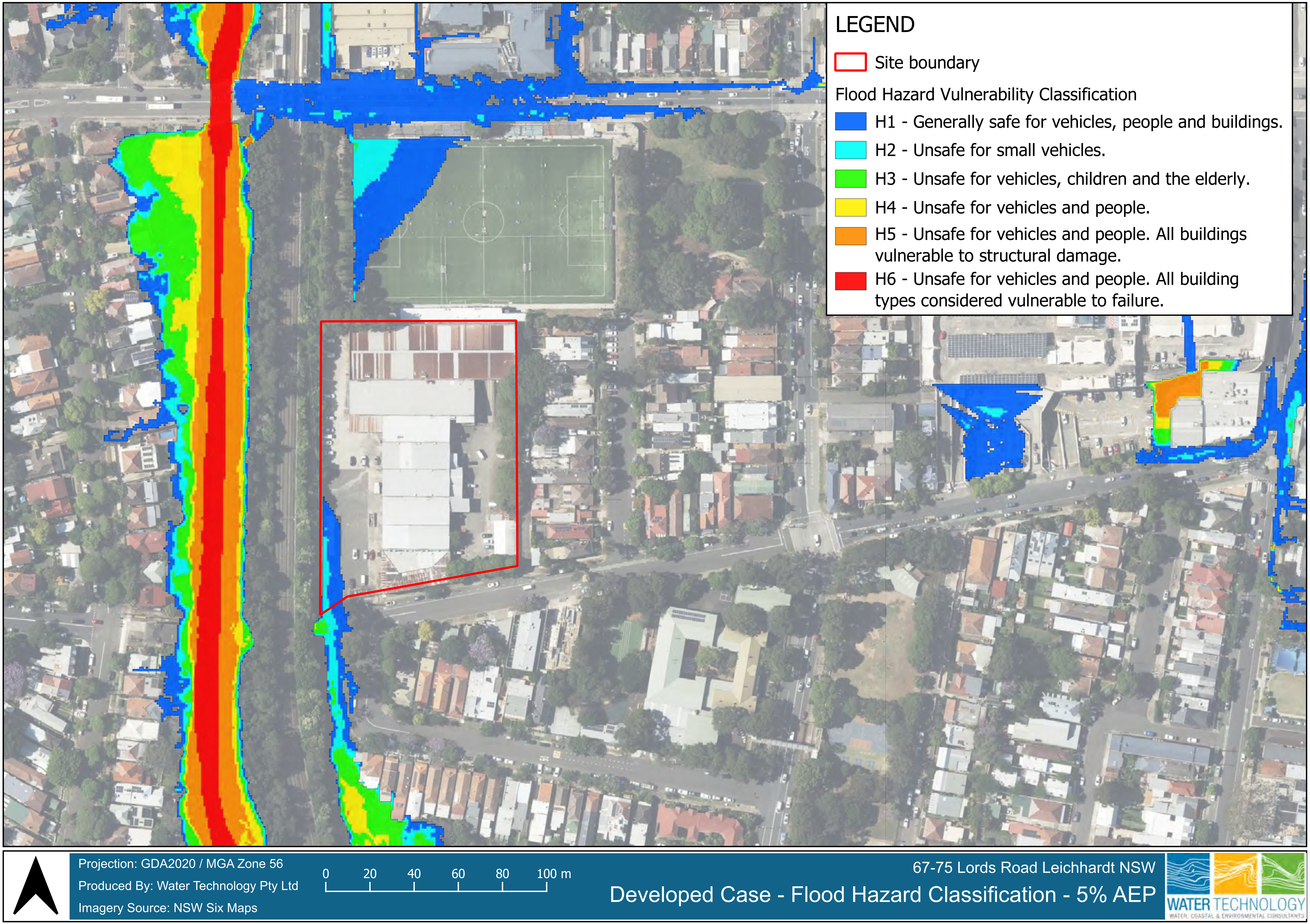
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

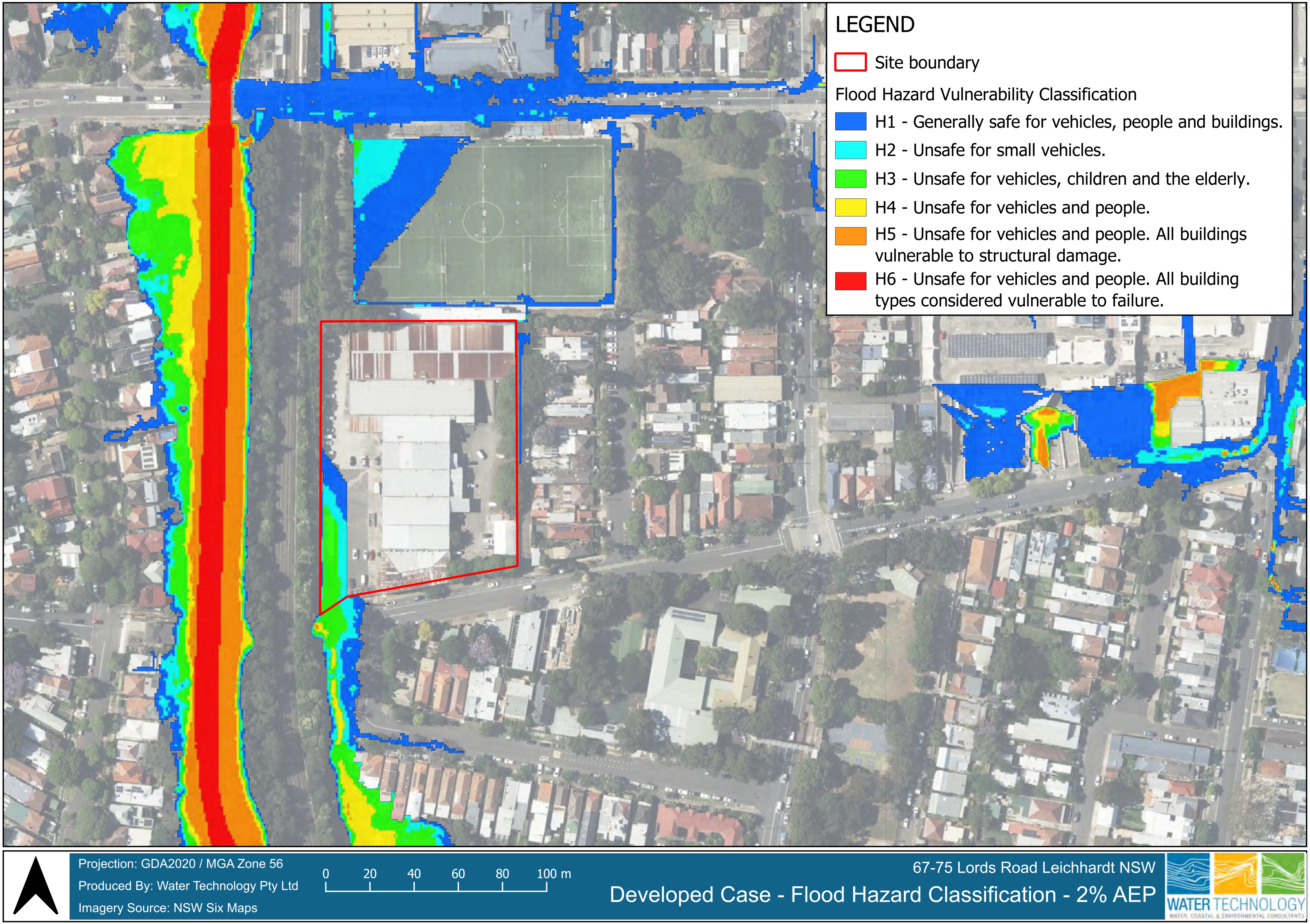
Developed Case - Flood Velocity - 1% AEP

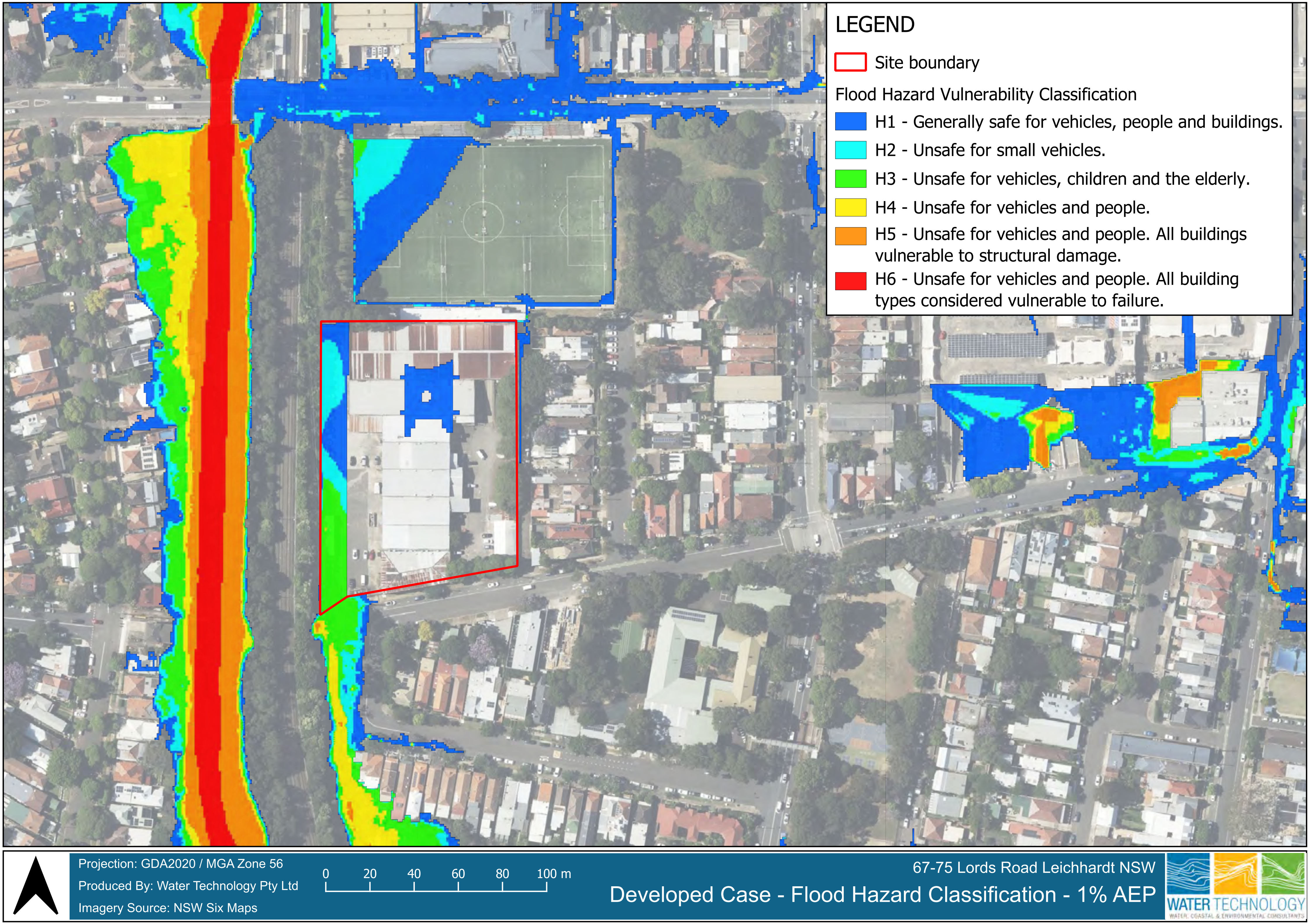
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - 10% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - 5% AEP
WATER TECHNOLOGY


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - 2% AEP
WATER TECHNOLOGY

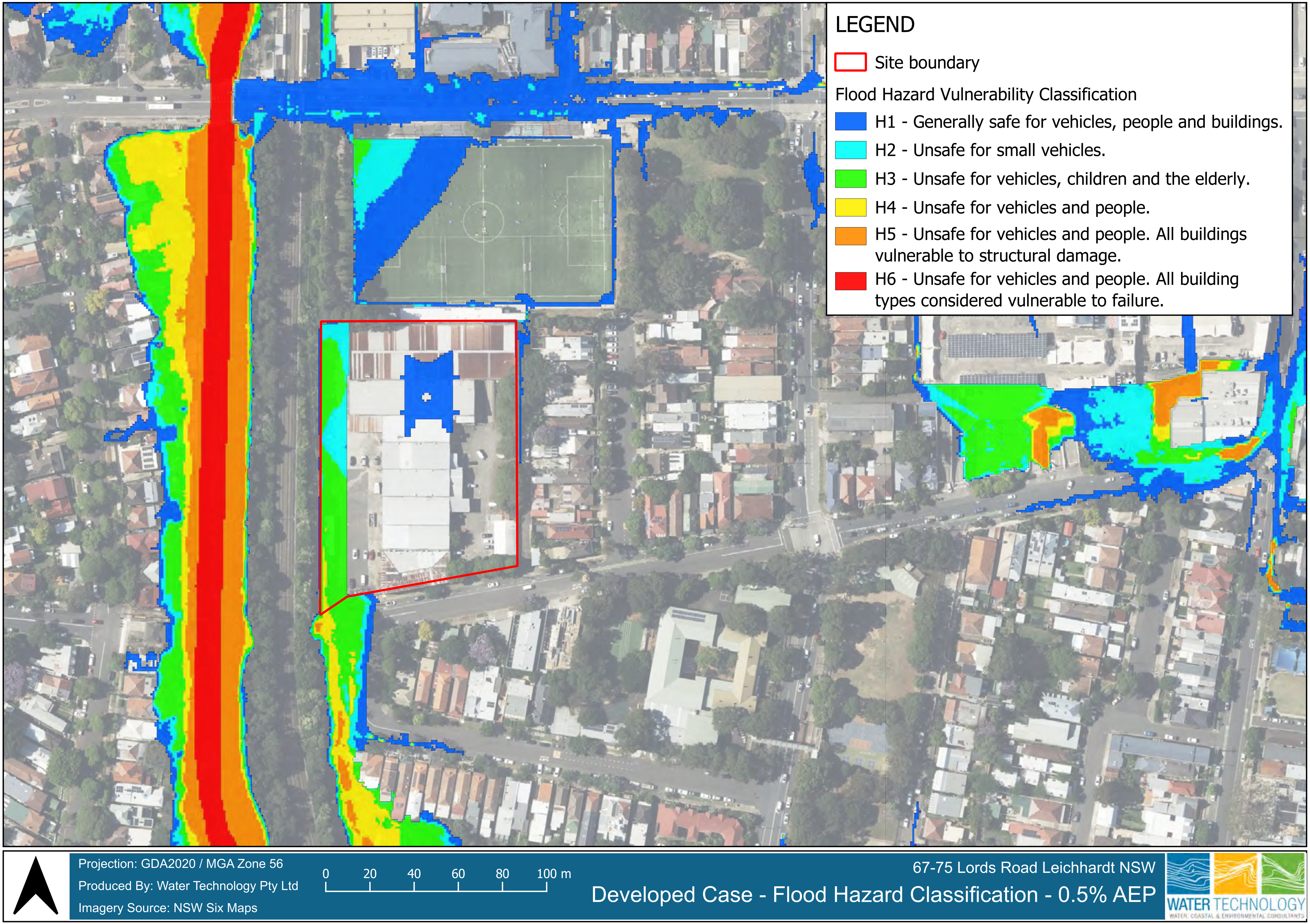


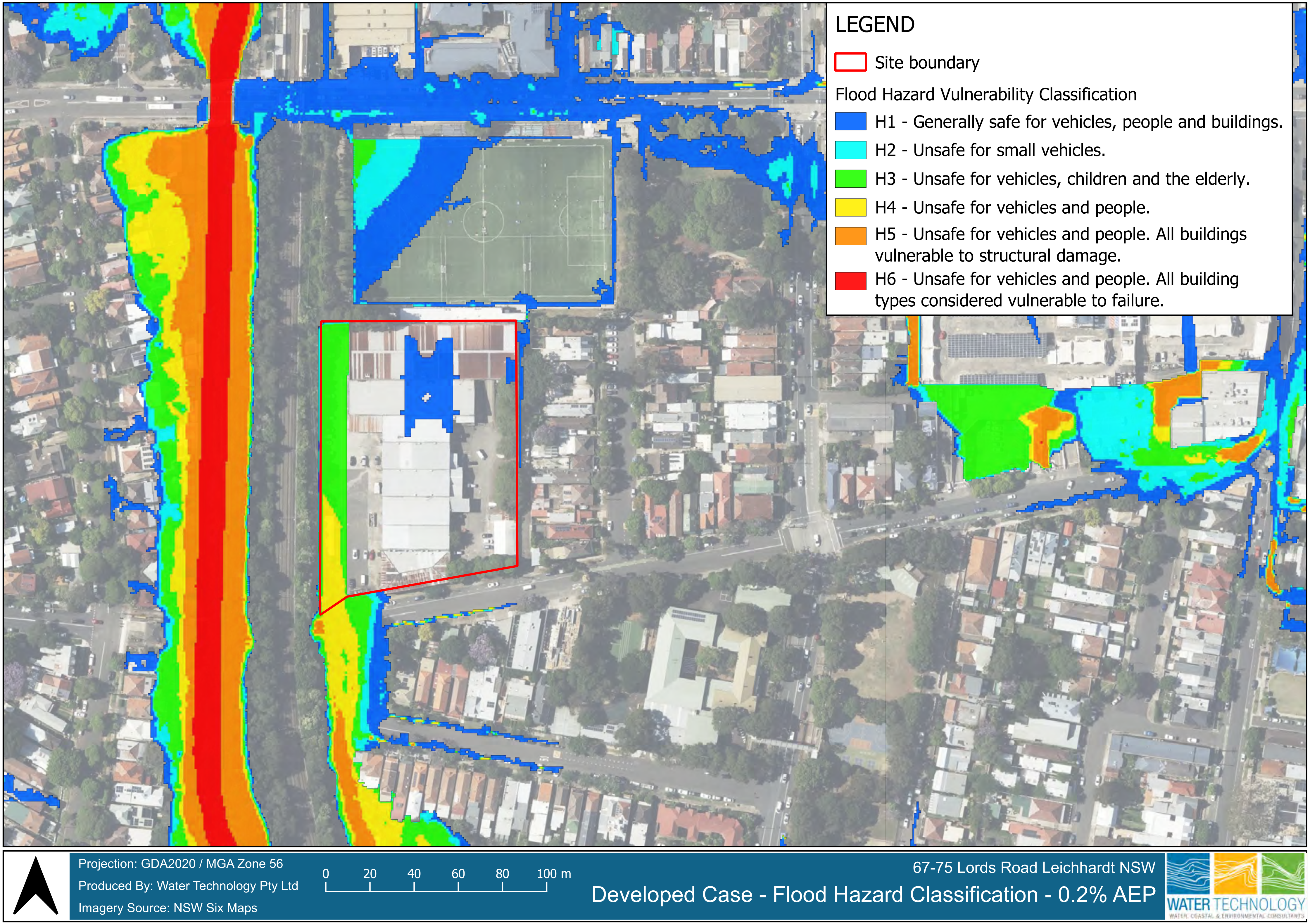
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

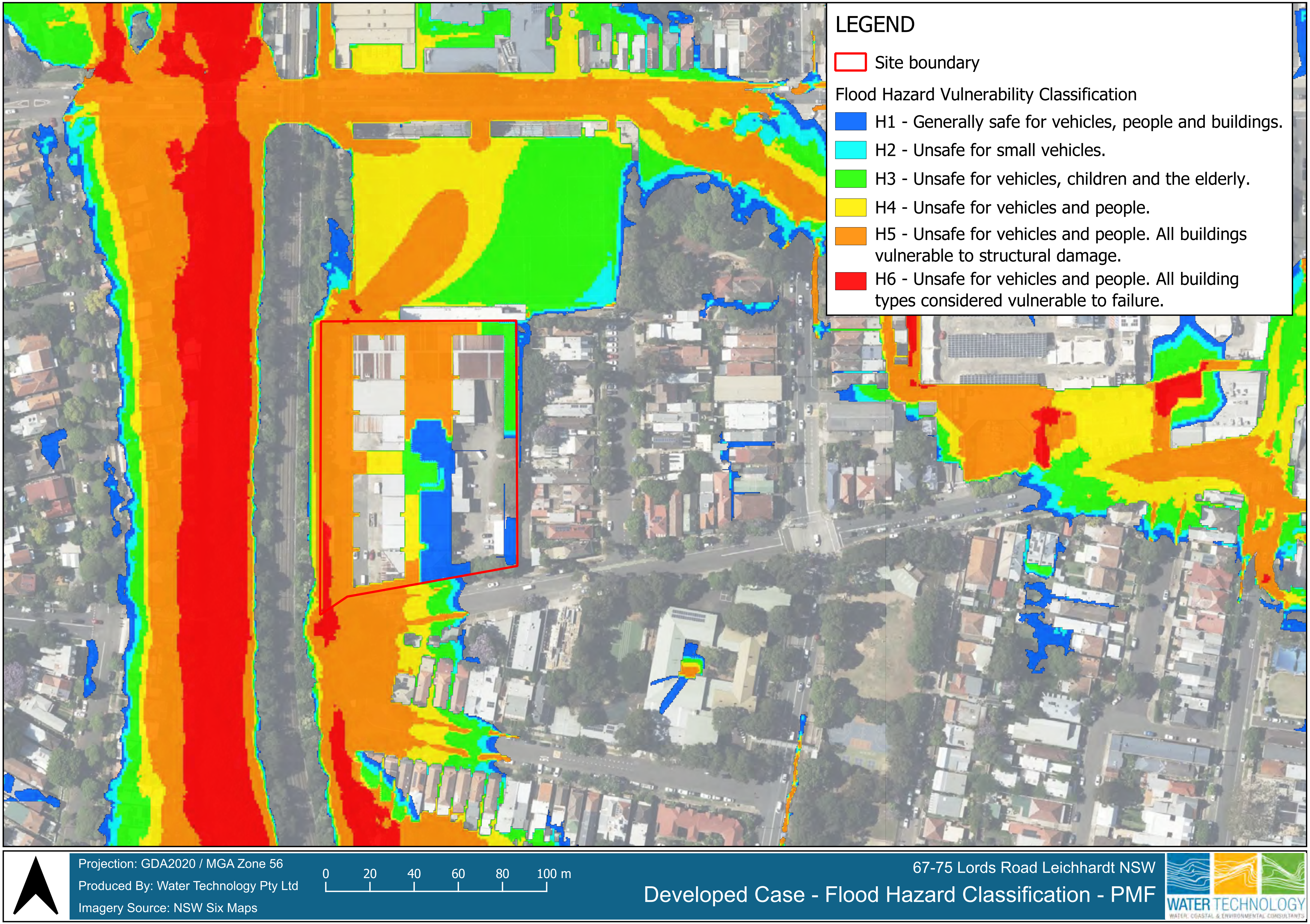
67-75 Lords Road Leichhardt NSW

Developed Case - Flood Hazard Classification - 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - 0.5% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0
20
40
60
80
100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - 0.2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - PMF
WATER TECHNOLOGY

APPENDIX G
DEVELOPED CASE FLOOD IMPACT MAPS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Level Impacts - 10% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Level Impacts - 5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Level Impacts - 2% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Level Impacts - 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Level Impacts - 0.5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Level Afflux (m)
<= -0.05
-0.05 - -0.04
-0.04 - -0.03
-0.03 - -0.02
-0.02 - -0.01
-0.01 - 0.01
0.01 - 0.02
0.02 - 0.03
0.03 - 0.04
0.04 - 0.05
0.05 - 0.10
0.10 - 0.20
> 0.20
Was Wet Now Dry
Was Dry Now Wet
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Level Impacts - 0.2% AEP
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Level Impacts - PMF

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Velocity (m/s)
<= -0.50
-0.50 - -0.40
-0.40 - -0.30
-0.30 - -0.20
-0.20 - -0.10
-0.10 - 0.10
0.10 - 0.20
0.20 - 0.30
0.30 - 0.40
0.40 - 0.50
> 0.50
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Velocity Impacts - 1% AEP
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Change in Flood Hazard - 10% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Developed Case - Change in Flood Hazard - 5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Change in Flood Hazard Classification
-4
-3
-2
-1
0
1
2
3
4
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0
20
40
60
80
100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Change in Flood Hazard - 2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Change in Flood Hazard - 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Change in Flood Hazard - 0.5% AEP

WATER TECHNOLOGY WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Change in Flood Hazard Classification
-4
-3
-2
-1
0
1
2
3
4
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Change in Flood Hazard - 0.2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Developed Case - Change in Flood Hazard - PMF

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

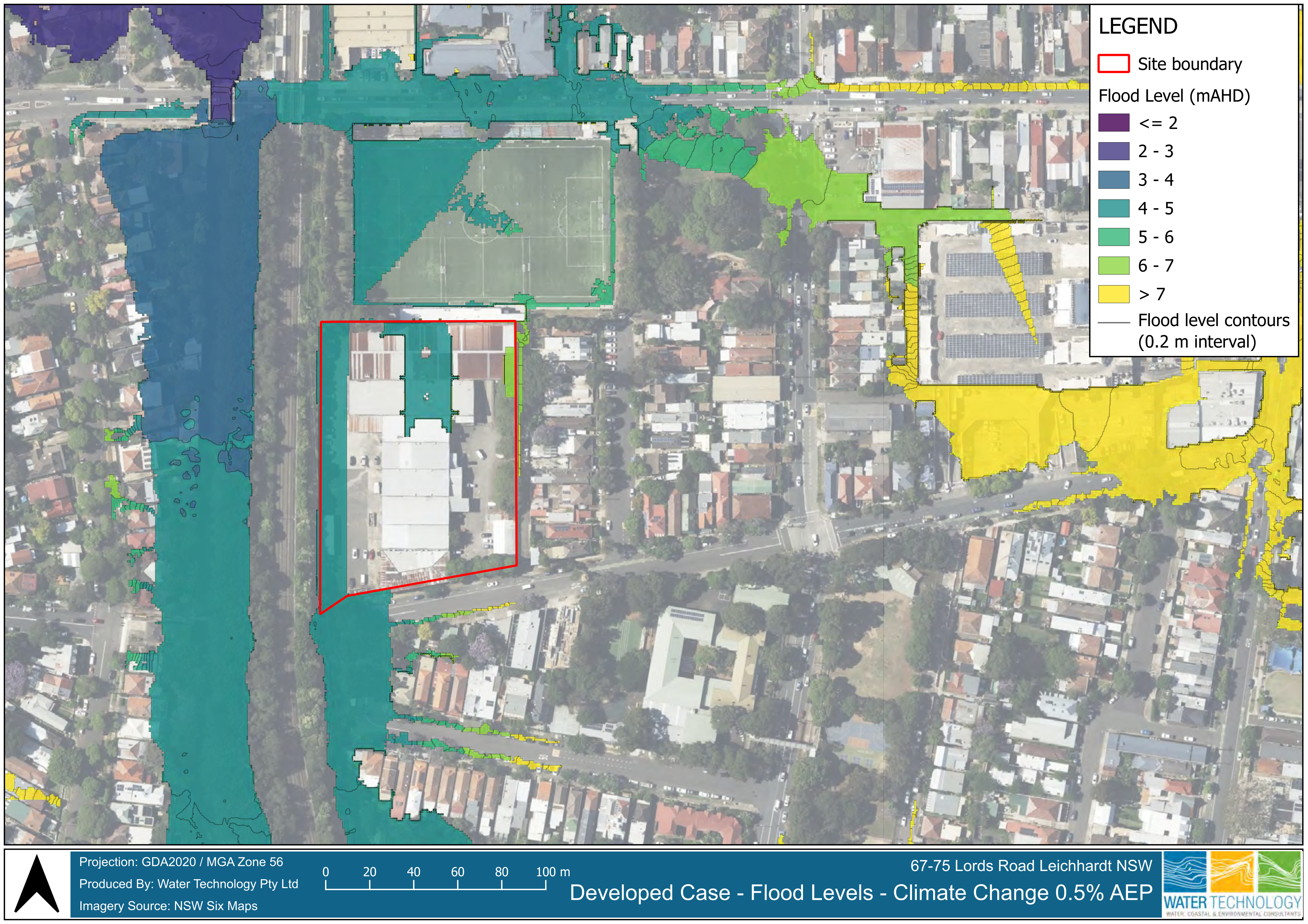
APPENDIX H
DEVELOPED CASE CLIMATE CHANGE MAPPING

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Levels - Climate Change 1% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours (0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Levels - Climate Change 0.5% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Level (mAHD)
<= 2
2 - 3
3 - 4
4 - 5
5 - 6
6 - 7
> 7
Flood level contours (0.2 m interval)
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Levels - Climate Change 0.2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

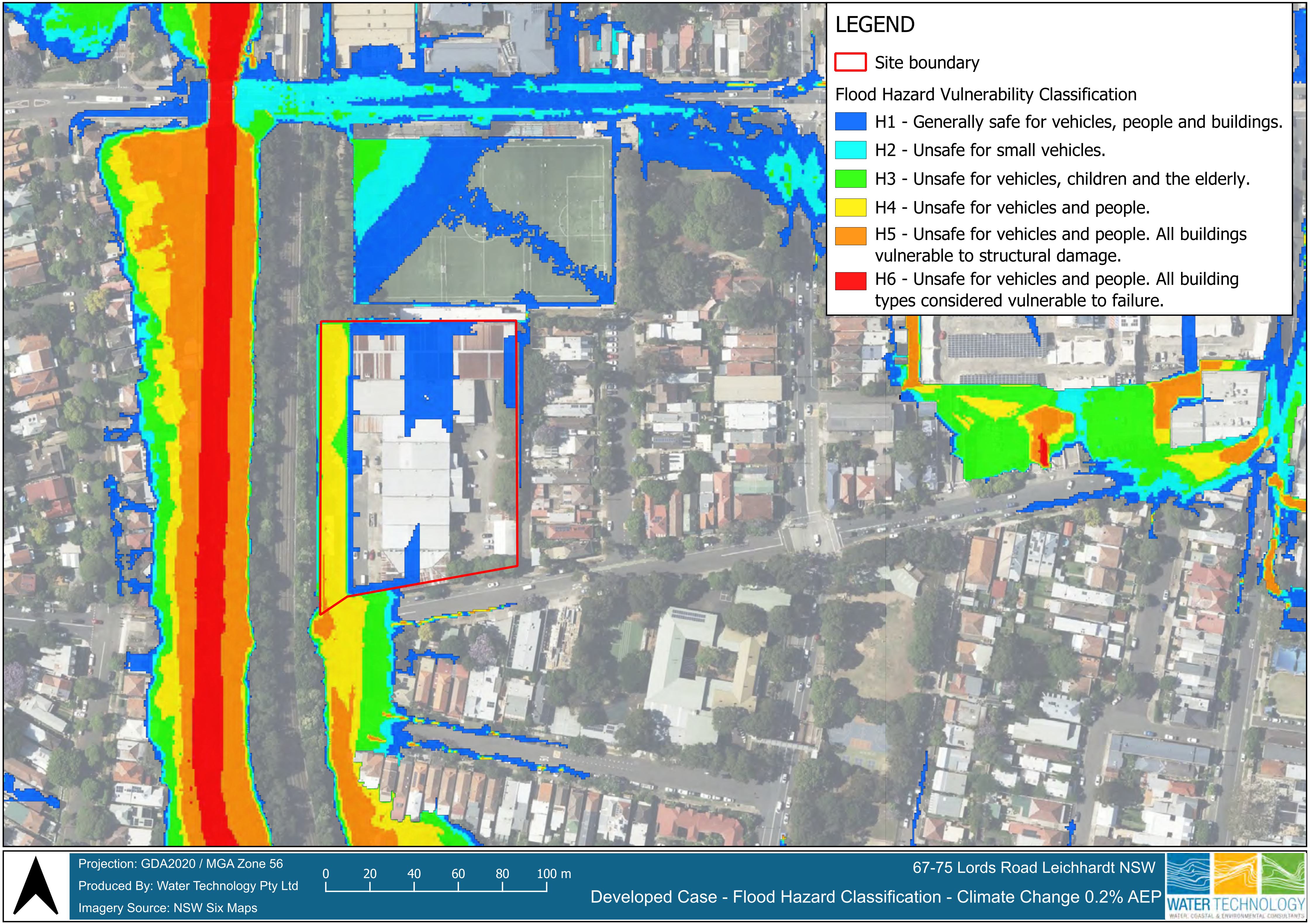
Developed Case - Flood Hazard Classification - Climate Change 1% AEP

Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Flood Hazard Classification - Climate Change 0.5% AEP

WATER TECHNOLOGY WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Flood Hazard Vulnerability Classification
H1 - Generally safe for vehicles, people and buildings.
H2 - Unsafe for small vehicles.
H3 - Unsafe for vehicles, children and the elderly.
H4 - Unsafe for vehicles and people.
H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage.
H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Flood Hazard Classification - Climate Change 0.2% AEP
WATER TECHNOLOGY

Projection: GDA2020 / MGA Zone 56

Produced By: Water Technology Pty Ltd

Imagery Source: NSW Six Maps

67-75 Lords Road Leichhardt NSW

Developed Case - Impact of Climate Change - 1% AEP

WATER TECHNOLOGY WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Projection: GDA2020 / MGA Zone 56

Produced By: Water Technology Pty Ltd

Imagery Source: NSW Six Maps

0 20 40 60 80 100 m

67-75 Lords Road Leichhardt NSW

Developed Case - Impact of Climate Change - 0.5% AEP

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS


LEGEND
Site boundary
Change in Flood Level (m)
<= 0.0
0.0 - 0.1
0.1 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.6
0.6 - 0.7
0.7 - 0.8
> 0.8
Was Wet Now Dry
Was Dry Now Wet
Projection: GDA2020 / MGA Zone 56
Produced By: Water Technology Pty Ltd
Imagery Source: NSW Six Maps
0 20 40 60 80 100 m
67-75 Lords Road Leichhardt NSW
Developed Case - Impact of Climate Change - 0.2% AEP
WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800

Sydney

Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150
Telephone (02) 9354 0300

Brisbane

Level 5, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460

Adelaide

1/198 Greenhill Road
Eastwood SA 5063
Telephone (08) 8378 8000

Perth

Ground Floor, 430 Roberts Road
Subiaco WA 6008
Telephone (08) 6555 0105

New Zealand

7/3 Empire Street
Cambridge New Zealand 3434
Telephone +64 27 777 0989

Wangaratta

First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Geelong

51 Little Fyans Street
Geelong VIC 3220
Telephone (03) 8526 0800

Wimmera

597 Joel South Road
Stawell VIC 3380
Telephone 0438 510 240

Gold Coast

Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227
Telephone (07) 5676 7602

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