Stormwater and Flooding

Bella Vista and Kellyville TOD Precincts

Department of Planning, Housing and Infrastructure

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→ **The Power of Commitment**

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[Compliance statement]

The Power of Commitment

Acknowledgement of Country

GHD acknowledges Aboriginal and Torres Strait Islander peoples as the Traditional Custodians of the land, water and sky throughout Australia on which we do business. We recognise their strength, diversity, resilience and deep connections to Country. We pay our respects to Elders of the past, present and future, as they hold the memories, knowledges and spirit of Australia. GHD is committed to learning from Aboriginal and Torres Strait Islander peoples in the work we do.

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Definitions/Terminology

Term	Definition
AEP	Annual Exceedance Probability - The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood level (height) has an AEP of 5%, there is a 5% chance (that is, a one-in-20 chance) of such a level or higher occurring in any one year
AHD	Australian Height Datum
ARR 2019	Australian Rainfall and Runoff 2019
Bio-retention	A common stormwater quality treatment method including infiltration of stormwater through a filter media and treatment through a combination of physical, chemical and biological processes
BoM	Bureau of Meteorology
DCP	Development control plan
DFE	Defined Flood Event or design flood
EY	Exceedances per year
IFD	Intensity-Frequency-Duration curves
LEP	Local environmental plan
LiDAR	Light Detection and Ranging Terrain Data
m	Measure of length/height/distance (metres)
mm	Millimetres
mAHD	Metres above Australian Height Datum
m/s	Measure of velocity (metres per second)
MUSIC	The Model for Urban Stormwater Improvement Conceptualisation is the most widely used tool to quantify impacts and mitigation with relation to urban stormwater pollutants. The tool can be utilised to conceptualise stormwater treatment trains and estimate resulting treatment performance
NSW	New South Wales
The Precinct	The Bella Vista and Kellyville Precinct with respect to the Transit Orientated Development (TOD) Program
TOD	Transit Orientated Development rezoning areas
PMF	Probable maximum flood
PMP	Probable maximum precipitation
RFFE	Regional flood frequency estimate
RORB	Runoff routing model
TOD rezoning areas/Blocks	Individual areas within the Transit Orientated Development precincts
Rouse Hill Development Area (RHDA)	the Area within which Sydney Water is the designated authority responsible for the management of trunk drainage land, and within which regional detention basins are provided
Stormwater detention	Detaining runoff temporarily with the objective of reducing the peak rate of runoff released and therefore reducing downstream flooding impacts associated with increasing urbanisation
Stormwater quality objectives	Objectives are commonly defined for catchments with relation to stormwater quality. They may include typical urban pollutants (e.g. nutrients, suspended solids) and be expressed in the form of a required reduction to be achieved, or the achieving of a baseline load
Trunk Drainage Lands (TDL)	Drainage infrastructure intended to collect smaller local drainage systems and appropriately convey to a discharge point. Sydney Water (SW) is designated as the Acquisition Authority for land that is identified for Rouse Hill Trunk Drainage Land (TDL) purposes within the RHDA, Stages 1 to 4
TUFLOW	Two-Dimensional Unsteady Flow model, named TUFLOW
XP_RAFTS	Runoff Analysis and Flow Training Simulator

1. Background

1.1 Introduction

This report presents the stormwater and flood risk management strategy for the Kellyville and Bella Vista Precinct ('the precinct'), which is part of the Transit Orientated Development (TOD) program. It sets out the stormwater and flood risk management integrated into the master planning process.

Land use changes that result from the rezoning, have the potential to alter the existing stormwater quantity and quality, and the flood risk environment. Therefore, several aspects of stormwater and flood risk management need to be integrated into the master plan.

Urban densification can result in a change in runoff generation due to increasing impervious areas. This requires management of impacts during storm events and management of increased flood risk. Water Sensitive Urban Design measures such as detention facilities can be provided at a lot scale or at a larger precinct/regional scale. Flood risk both within the rezoned lands and off-site needs to be managed. The collection and conveyance of stormwater within the precinct to a suitable point of discharge is required, with a particular focus on determining the trunk drainage infrastructure.

Stormwater and flood risk management are required for the Bella Vista and Kellyville Precinct to support development.

Figure 1.1 Impact from external flooding is a critical consideration for precinct planning

Stormwater quantity and flood risk	**Impact on flood risk within rezoned lands and offsite**: Increased runoff generation often requires management via detention to mitigate the impacts on downstream flooding conditions and management of flood risk within rezoned lands. **Flow conveyance and drainage**: Appropriate collection and conveyance infrastructure for stormwater conveyance within and from the precinct

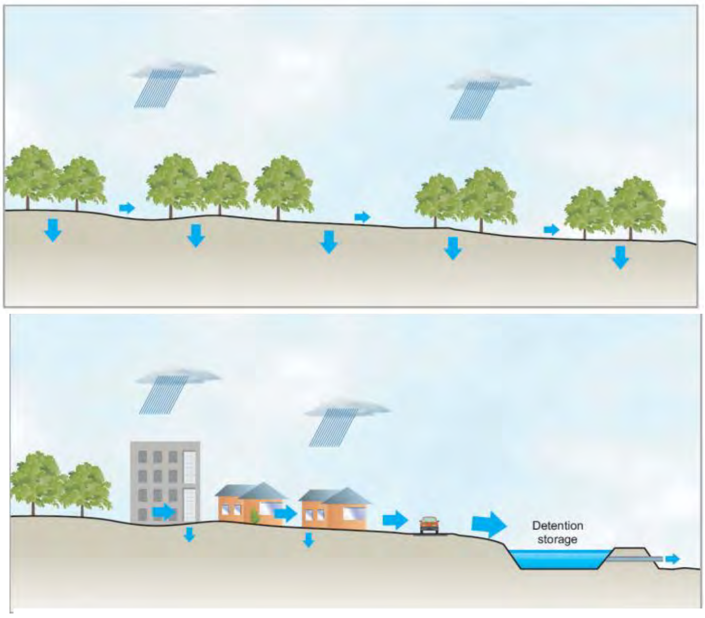

Figure 1.2 Increasing peak runoff rates due to urbanisation can be reduced through provision of detention storage

Urban densification can result in increased generation of urban stormwater pollutants, such as nutrients and suspended solids. Best practice stormwater management using Water Sensitive Urban Design, implements a stormwater treatment train of management facilities. This stormwater treatment train typically includes gross pollutant traps, vegetated swales and bio-retention systems. These can be co-located with water quantity measures such as detention basins, to maximise developable lands.

Stormwater quality

Treating stormwater, if required, to reduce pollutant loads associated with increasing urbanisation and imperviousness

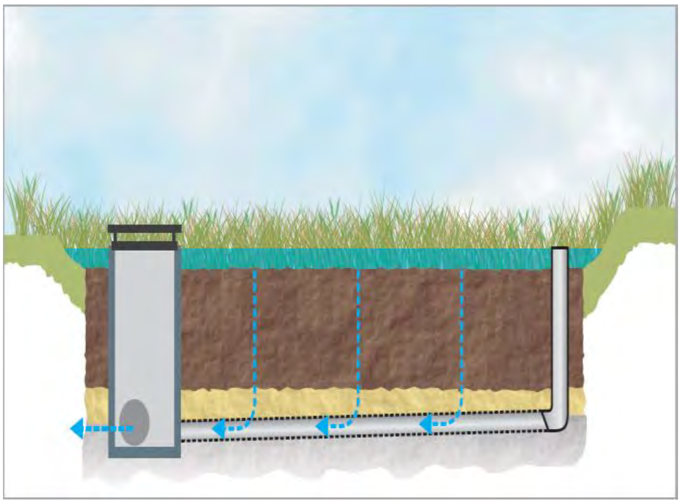

Figure 1.3 Bioretention systems can be used to reduce discharge of urban stormwater pollutants

The TOD precinct areas subject to rezoning are located within the Rouse Hill Development Area (RHDA). Within this area, Sydney Water is the authority responsible for the management of trunk drainage land within the 1% Annual Exceedance Probability (1% AEP) flood extents. These lands include already constructed existing stormwater and flood management infrastructure such as detention basins which have been constructed on-line to waterways. To manage stormwater pollutants, Sydney Water imposes stormwater quality reduction targets for developments that drain to the trunk drainage lands. Typically, these developments must construct stormwater management infrastructure to prescribed levels of pollutant reduction for a suite of typical urban stormwater pollutants, namely gross pollutants, total suspended solids, total phosphorus and total nitrogen.

The proposed TOD precinct rezoning therefore integrates with existing stormwater and flood risk management infrastructure provided by Sydney Water for the RHDA. Potential changes to impervious areas, runoff generation and discharge locations are assessed. Furthermore, this is considered alongside current guidelines and requirements, amongst others the NSW Flood Risk Management Manual 2023, Australian Rainfall and Runoff, the NSW Government Planning Circular PS21-006 and relevant Development Control Plans.

»The precinct drains to Sydney Water managed trunk drainage lands which have existing stormwater and flood risk management infrastructure. «

Existing stormwater and flood risk management infrastructure Integration	
	• The precinct may change impervious areas which may impact the performance of existing stormwater and flood risk management infrastructure provided by Sydney Water for the RHDA. • Requirements and standards have changed since the existing stormwater and flood risk management infrastructure was constructed.

The rezoning and master planning of the Bella Vista and Kellyville Precinct includes assessment of the following:

– Review of existing stormwater and flood risk management infrastructure provided by Sydney Water for the RHDA to determine if it can convey and appropriately manage stormwater from the rezoned precinct, in accordance with current guidelines and requirements. This would require review and update of existing flood modelling undertaken for the RHDA. If the existing stormwater and flood risk management infrastructure underperforms, additional management infrastructure may be required.

Assessment is required, including stormwater, flooding and stormwater quality modelling, to determine required upgrades and additions to existing stormwater and flood management infrastructure, or controls to be imposed upon future development.

– Review of the stormwater quality objectives currently required for the RHDA with respect to their suitability for the rezoned precinct. This may include preparation of a MUSIC stormwater quality modelling examine Water Sensitive Urban Design management measure to meet current guidelines.

The above has been developed into a stormwater and flood risk management strategy for the Bella Vista and Kellyville TOD Precinct, in collaboration with the overall inter-disciplinary master planning process. The following sections of this report describe the above considerations and required assessment in further detail.

1.2 The precinct

Housing is a key priority for the NSW Government. Currently, there is a shortage of diverse and affordable homes in well-located areas, close to where people live and work and close to transport and other amenities. Eight priority high growth areas, – TOD's (Transport Oriented Development - Accelerated Precincts) – near transport hubs in greater Sydney have been identified for accelerated rezoning:

- Bankstown
- Bays West
- Bella Vista
- Crows Nest
- Homebush
- Hornsby
- Kellyville
- Macquarie Park

Rezoning around these transport hubs will create capacity for up to 47,800 new homes over 15 years, within walking distance of these key stations.

The Bella Vista and Kellyville TOD precinct is situated in the areas covering the suburbs of Bella Vista and Kellyville within the Hills Shire Local Government Area (LGA), as well as the suburbs of Stanhope Gardens and Glenwood within the Blacktown Council LGA. The existing land use of the area is predominantly residential, with a mix of 1-2 storey detached dwellings and townhouse precincts, interspersed with areas of undeveloped, government-owned land. The area also includes commercial spaces such as the Norwest Business Park, which features 2-5 storey office buildings. The landscape is characterized by three creek lines with dense vegetation, walking trails, and open spaces, contributing to the local character of the area. The area east of Old Windsor Road has gradually changed over the last 10-20 years, from predominantly large lot residential, and undeveloped or rural land into residential subdivisions with low to medium density housing, and some small apartment buildings. West of Old Windsor Road contains parts of Stanhope Gardens, including Newbury Estate, a master planned community title estate delivered in the early 2000's, with Glenwood developed in the mid 1990's. Urban development within the precinct has substantially occurred and the Metro North West Line passes through the precinct, with the Bella Vista and Kellyville stations located within the precinct.

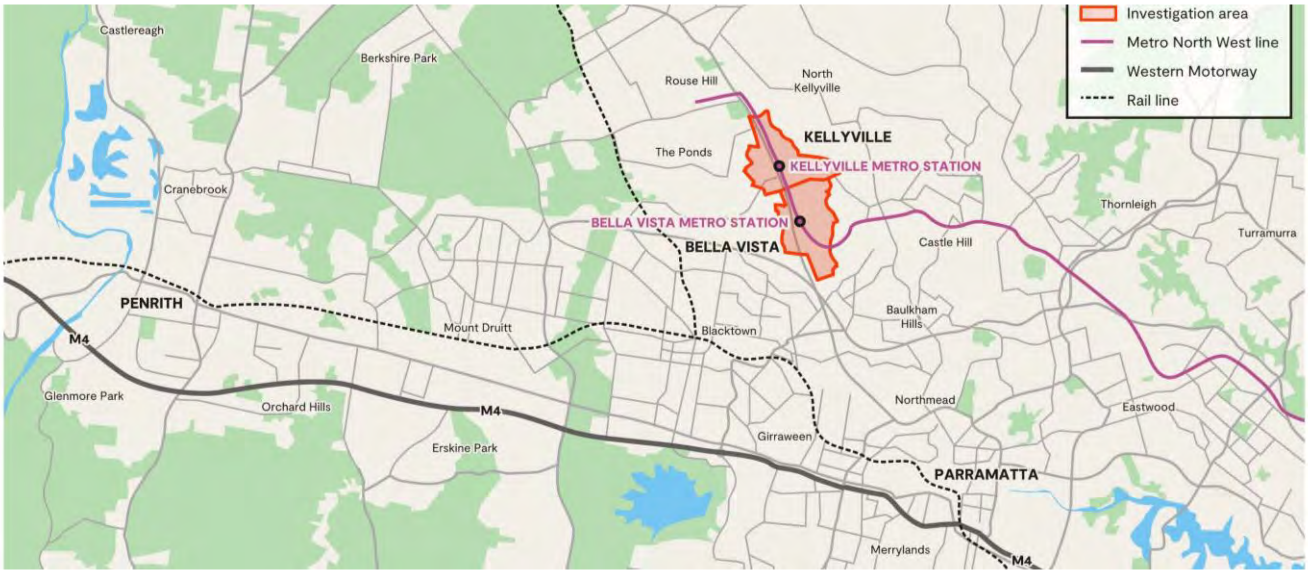

Figure 1.4 Bella Vista and Kellyville Precinct Location

1.3 Past Studies

1.3.1 GHD 1998

In the 1990's GHD undertook studies for the Rouse Hill Stage 1 Area, in particular formulating the trunk drainage strategy for the Rouse Hill Infrastructure Consortium. A strategy review was documented in the *Trunk Drainage – Strategy Review (GHD, 1998)*. The work included modelling of the pre-development case rainfall-runoff, flooding and stormwater quality. GHD designed facilities in the trunk drainage system to satisfy the following design objectives for the stormwater system:

– The 50% and 5% AEP ultimate development case peak flows were not to change by more than ± 15%, from rural case flows.
– The 1% AEP ultimate case peak flows were not to exceed the rural case flows.
– Total Phosphorus average annual loads to be reduced by 60% from the rural case to a target load of 1320kg/year and Total Suspended Solids average annual loads to be maintained at the rural loads (a target load of 747,000kg/year).

It is understood that the GHD assessments were based on the earlier *Vineyard and Rouse Hill Flood Study (Department of Water Resources, 1988)*. Neither the 1988 nor the 1998 studies could be sourced for the present study.

SKM (2009) document that GHD undertook modelling of the rainfall-runoff process using the XP-RAFTS rainfall-runoff software, flood levels using the HEC-2 software and stormwater quality modelling using the AQUALM software. GHD developed the models under rural and ultimate development condition scenarios for the design of the Rouse Hill trunk drainage system.

1.3.2 SKM 2009

SKM was commissioned by Sydney Water in 2007 to undertake the Rouse Hill Integrated Stormwater Strategy Review. The objectives included reviewing and updating the GHD study and modelling, based on the latest available information at that time, with respect to the ultimate development case land use including as-constructed infrastructure and proposed hydraulic structures. The study was undertaken using modelling methods and software current at the time of the study.

The SKM review found the GHD rainfall-runoff modelling to be generally satisfactory, however identified several matters which were updated for both the rural and the ultimate development case. The distribution of impervious area in the urban case GHD model was different to the distribution adopted in SKM's updated model, which was based on updated land use data.

SKM updated the flood modelling undertaken by GHD. This involved the development of a new 1-dimensional (1D) HEC-RAS steady state flood model, rather than adjusting the previous GHD model. This HECRAS model incorporated revised flows, cross sections, hydraulic structures and Manning's n values. The updated cross sections were cut from a Digital Terrain Model (DTM) derived from Aerial Laser Survey (ALS) and topographic survey data. Additional cross section survey was incorporated where available. The model was simulated for 5% and 1% AEP events and the Probable Maximum Flood (PMF) event.

SKM's review of GHD's stormwater quality assessment was limited to what was reported in GHD (1998), since GHD's AQUALM model was not available for review at the time. SKM developed a MUSIC stormwater quality model of the catchment based on the latest available information, including Work As Executed (WAE) drawings, updated land use patterns for ultimate conditions and observations from site inspection. This model included as-built, bioretention systems, wetlands, ponds and swales, and found that the Ultimate Case (with as-built treatment) average annual pollutant loads were significantly higher than the stormwater quality targets set for the Rouse Hill Stormwater Strategy. The study found that the as-constructed stormwater treatment train do not achieve the draft pollutant treatment targets (in terms of reduction of loads generated in the catchment) set by DECC (2007). Several stormwater controls originally recommended for the Rouse Hill Stormwater Strategy were either not constructed as initially modelled or had not been constructed at the date of the review.

1.3.3 WMAwater 2014

WMAwater was engaged by Sydney Water to undertake the Rouse Hill Flood Study (WMA 2014). The purpose was to assist with the management of flood prone land following increased urbanisation and development in the RHDA. Sydney Water identified the need for accurate assessment of flooding conditions to inform future floodplain management decisions. A two-dimensional (2D) TUFLOW unsteady flood model was developed to determine design flood levels, flows, velocities and hazard based on inflows from the SKM (2009) XP-RAFTS rainfall-runoff model. The (2D) TUFLOW unsteady flood model was noted by WMAwater to provide several advantages:

– Provide localised detail of any topographic and/or structural features that may influence flood behaviour.
– Better facilitate the identification of the potential overland flow paths and flood problem areas.
– Dynamically model the interaction between hydraulic structures such as culverts and complex overland flow paths
– Inherently represent the available floodplain storage within the 2D model geometry.
– Provides more accurate flood extent mapping.
– Provide water level and velocity distribution across the floodplain.
– Provide better define the spatial variations in flood behaviour across the study area.

The 2, 6 and 9-hour storms were determined as the critical storm durations for the 1% AEP event by producing the highest flows and flood levels within the RHDA. All flood results were enveloped, reporting the maximum results of these durations. Flood function for the range of design events from the 0.5 Exceedances per year (EY) to the 1% AEP were established. Sensitivity analysis and blockage assessments were undertaken to assess the effects of varying key model parameters. The effects of increases in rainfall intensities were assessed to simulate climate change. Events greater than the 1% AEP, up to the PMF were not considered.

WMA used the existing XP-RAFTS rainfall-runoff model without modification except to reflect a change in the ultimate catchment conditions based on the latest information. The rainfall-runoff and flood models were not calibrated due to lack of available data. However, verification was undertaken by comparing results from the study with similar studies in adjacent catchments and general expectations of catchment flooding behaviour.

1.3.4 Hyder 2015

Hyder Consulting (Hyder 2015) undertook assessments of flooding and drainage relating to the proposed rezoning of the Kellyville Station Precinct and Bella Vista Station Precincts. The study used the Rouse Hill Flood Study (WMAwater, 2014) data as providing the most recent and comprehensive information on flood behaviour in the Kellyville Station Precinct at the time, noting that WMAwater 2014 did not simulate the PMF.

In terms of flooding and drainage the study recommended:

– Flood Planning Levels (FPLs) for the Bella Vista and Kellyville Station Precincts be derived from flood levels included in the Rouse Hill Flood Study, subject to a detailed review of the flood study models and necessary refinements.
– Development controls for stormwater management and flooding be generally consistent with The Hills Shire Council Development Control Plan (DCP 2012). In addition, floodplain management should comply with guidelines.
– Water Sensitive Urban Design (WSUD) pollution reduction targets be consistent with those applied to the North West Growth Centres.
– For the Bella Vista Station Precinct particularly:
  - For areas outside the extents of the RHFS (i.e. to the south of Norwest Boulevard) existing stormwater management facilities (basins/ponds) and overland flow paths need to be considered as part of any development in this area.
  - Development controls for stormwater management and flooding be generally consistent with The Hills DCP 2012 and the Upper Parramatta River Catchment Trust OSD Handbook (4th Edition, December 2005).

1.3.5 Ensure 2018

The objective of this study was to *provide Sydney Water with a strategic plan for the North West Growth Corridor that provides the best liveability outcome for the community for the next thirty years, and for this plan to be supported by all key stakeholders* (Ensure, 2018). This objective was to allow servicing certainty and to assist Sydney Water deliver essential services to meet the projected growth in the area, in the short term. Further, to deliver integrated services to maintain and enhance the liveability and amenity of this region in the most cost effective and sustainable manner, in the medium and long terms.

In terms of stormwater quality modelling, several updates were made to the SKM 2009 MUSIC stormwater model for the purposes of the study assessment. The assessment of stormwater revealed:

- The business-as-usual strategy did not achieve the "original" stormwater quality targets adopted during the master planning stage of the Rouse Hill Development Area.
- The business-as-usual strategy does not achieve contemporary stormwater quality targets including the mean annual percentage load reduction targets set out in the basis of planning i.e. 85%, 65% and 45% reduction in loads of TSS, TP and TN, respectively.
- It is expected that the quantity of stormwater controls in the catchment would need to be more than doubled in terms of the controls' surface area and/or volume to achieve the stormwater quality treatment targets. However, there does not appear to be sufficient available open space to construct this level of additional controls.
- Comparison of the cumulative frequency of flows for the 2016 and 2046 scenarios indicated that for a given frequency, the flows are expected to be 10% to 30% higher in the 2046 scenario. The frequency and duration of flows causing channel erosion is expected to increase as a result.
- Sensitivity testing of the assumed effective imperviousness of the catchment indicated that for 80% effective imperviousness (as a proportion of total imperviousness), flow volumes would be 34% higher than for the adopted 50% effective imperviousness ratio, and pollutant loads 40 – 50% higher. The findings confirmed that the stormwater quality targets applicable to the catchment would not be met.

For the flooding assessments, the XP-RAFTS rainfall-runoff model developed by SKM (2009), further developed by WMAwater (2014), was used to estimate sub-catchment design storm runoff hydrographs. The TUFLOW flood model developed by WMAwater (2014) was used to estimate the design flood conditions. The TUFLOW model includes all major flood management structures which had been constructed to date. The assessment for flooding found that:

- In general, flooding is confined to provisioned trunk drainage corridor areas and property flooding is typically on the fringes of properties.
- The main problem area relating to high flood hazard on properties, particularly at dwellings, is located on the Kellyville overland flow path (which is not located in the TOD precincts).

It is noted that the following updates were made to the available models:

- Corrected catchment area for sub-catchment 45(B) in the XP-RAFTS model and updated inflow hydrographs were input into the TUFLOW model.
- Sydney Water requested to resolve model instabilities in the TUFLOW model. Several reconfigurations were trialled for the 1D channels at these locations but were unsuccessful. Issues potentially contributing to the model instabilities include discrepancies between culvert and channel invert levels, relatively coarse (5m) grid resolution and configuration of model internal boundaries. The channels were converted to 2D in order to resolve the instabilities.
- Two locations were identified where catchment inflows were either missing or double-counted. The TUFLOW model inflow boundaries were reconfigured to account for all model inflows.

The report also outlines the existing water recycling scheme in place for the reuse of wastewater in non-potable activities.

As part of the study, a pilot project to look at opportunities for improved stormwater management was prepared within Elizabeth McArthur Creek. A concept level design of the proposed Elizabeth McArthur Creek pilot stormwater harvesting scheme was undertaken by Permeate Partners in parallel with this Project. The aim was to demonstrate the benefits of providing a 'disconnection of impervious areas' strategy which involves more closely emulating the natural catchment runoff regime by using hydraulic and physical disconnection to the receiving water body. By significantly reducing the mean annual runoff volume to the creek, it was proposed that the condition of the waterway could be protected and potentially remediated, and the ecological health of the waterway improved.

1.3.6 Station Precincts State Significant Development Applications 2020

Concept State Significant Development Applications (SSDAs) were approved in 2022 for both the Kellyville and Bella Vista Station Precincts including the conceptual plans for development of town centres around the stations. Stormwater Management Plans were developed by Stantec for each SSDA (Stantec 2020a, Stantec 2020b). Key outcomes of the plans were as follows:

– With respect to flood impact, allowance has been made for all areas outside SP2 (trunk drainage infrastructure) zoned land to be filled to be at or above the 1% AEP flood level. Encroachment into SP2 area is stipulated to be limited to prevent flood impacts.
– A minimum freeboard of 500 mm is proposed be provided between the 1% AEP flood level and habitable floor levels with the site to be filled to achieve this (noting limitation above).
– Noting the SSDAs are conceptual, general stormwater conveyance strategies are proposed.
– Reference to Sydney Water provision of regional detention in trunk drainage land and not requiring the provision of additional detention in the development area.
– With relation to stormwater quality, adoption of the Sydney Water pollutant reduction targets (refer Section 5.1) was proposed. General stormwater quality treatment trains were proposed for different areas of the precinct such as private allotments, public roads and future development of proposed lots to achieve these targets, except for some existing roads not complying with current best practice WSUD principles.

1.3.7 Elizabeth Macarthur Creek Trunk Drainage Concept Design Report

In 2017 Sydney Water commissioned AAJV to prepare the Elizabeth Macarthur Creek Trunk Drainage Concept Design Report. The purpose of the Elizabeth Macarthur Creek Trunk Drainage Report was to design and document the preferred trunk drainage concept design for Elizabeth Macarthur Creek, including related guidelines for stormwater and floodplain management that could be used to inform planning and development in other similar urban release areas.

The Elizabeth Macarthur Creek Trunk Drainage Report utilised the flood modelling for the Rouse Hill Flood Study (WMA 2014) and refined it to focus on Elizabeth Macarthur Creek. Key refinements included:

– Increasing modelling resolution to improve accuracy.
– Incorporating filling of the Site.
– Flood mitigation/stream improvement measures in Elizabeth Macarthur Creek.
– New vehicular and pedestrian bridges adjacent to the Site.

The Rouse Hill Flood Study hydrologic model was adopted and refined. The flood modelling for the Elizabeth Macarthur Creek Trunk Drainage Report therefore considered the post-development scenario for the Site. The report also considered the 'baseline' flooding scenario, in which the site is not yet developed and proposed works in Elizabeth Macarthur Creek have not yet occurred.

The Elizabeth Macarthur Creek Trunk Drainage Report proposes numerous stream rehabilitation measures to (among other outcomes) mitigate flood affectation of surrounding properties, including the site. The report references allowance being made for future development of the site and filling of flood affected areas such that they are above adjacent flood levels.

Further recent discussion on the Elizabeth Macarthur Creek is provided in Section 2.2.6.

1.4 Limitations/Assumptions/Clarifications

This report has been prepared by GHD for Department of Planning, Housing and Infrastructure and may only be used and relied on by Department of Planning, Housing and Infrastructure for the purpose agreed between GHD and Department of Planning, Housing and Infrastructure as set out in this report.

GHD otherwise disclaims responsibility to any person other than Department of Planning, Housing and Infrastructure arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

The basis of this report is the following key assumptions:

- All flood modelling is based on the XP-RAFTS rainfall-runoff routing model compiled by SKM (2009), further developed by WMAwater (2014), and adopted by Ensure (2018). The XP-RAFTS model was updated to simulate with Australian Rainfall and Runoff 2019 (ARR 2019) methodologies and associated rainfall data. The flood modelling was based on the TUFLOW flood model developed by WMAwater (2014), updated and adopted by Ensure (2018). This model was updated to simulate Australian Rainfall and Runoff 2019 (ARR 2019) methodologies in the latest software versions.
- It is noted that this report is compiled on the basis that the form, development and layouts within individual TOD blocks are unknown, with exception of the change in impervious percentages provided.
- The NSW Flood Prone Land Policy (DPE 2023) applies to urban and rural floodplains in New South Wales and to both flooding from waterways and local overland flooding. Since the local overland flooding is a function of the local topography and design within the TOD areas, which was unknown at the time of the report, this report only applies to the flooding from the Caddies Creek, Elizabeth Macarthur Creek and associated waterways.
- We draw your attention to Section 2.2.7 and matters around the issue of Australian Rainfall and Runoff 2019 Version 4.2 issued on 27/08/2024.

2. Legislative, policy and guideline context

2.1 Legislative requirements

2.1.1 Water Management Act 2000 and Water Act 1912

The *Water Management Act 2000* (WM Act) and the *Water Act 1912* are the key legislation for the management of water within NSW. These Acts regulate the extraction of water, the use of water, the construction of works such as dams and weirs, and the carrying out of activities in or near water sources in NSW. The provisions of the WM Act are being progressively implemented to replace the *Water Act 1912*. Since 1 July 2004, the new licensing and approvals system has been in effect in those areas of NSW covered by commenced water sharing plans, which are made under the WM Act.

A controlled activity approval under the WM Act is required for certain types of developments and activities that are carried out in or near waterfront land. Section 5.23 of the Environmental Planning and Assessment (EP&A) Act provides that an activity approval (including a controlled activity approval) under Section 91 of the WM Act is not required for State significant infrastructure, such as the project. However, the design and construction of the project would consider the NSW Office of Water's guidelines for controlled activities on waterfront land. The floodplain management provisions under the *Water Act 1912* have transitioned to the WM Act, including the provisions of floodplain management plans and 'flood works' i.e. works that affect, or are likely to affect, flooding and/or floodplain functions.

2.2 Policies, planning controls and guidelines

2.2.1 NSW Flood Risk Management Manual and NSW Flood Prone Land Policy

The *NSW Flood Risk Management Manual* (DPE, 2023) provides for the development and implementation of sustainable strategies for managing human occupation and use of the floodplain. It contains the NSW flood prone land policy, the primary objective of which is to reduce the impacts of flooding and flood liability on communities and individual owners and occupiers of flood prone property in NSW.

It provides guidelines in relation to the management of flood liable lands, including any development that has the potential to influence flooding, particularly in relation to increasing the flood risk to people and infrastructure. Project activities that have the potential to increase flood risk through, for example, increasing stormwater runoff would be subject to consideration under the NSW Flood Risk Management Manual. The manual 'promotes the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable'. The NSW Flood Risk Management Manual is supported by several compendium guidelines, which include amongst others:

- AG01-flood-risk-management-administration-arrangements.
- EM01-flood-risk-management-emergency-management-planning-support.
- FB01-flood-risk-management-understanding and managing flood risk.
- FB02-flood-risk-management-flood-function.
- FB03-flood-risk-management-flood-hazard.
- FG01-flood-risk-management-framework-delivery.
- LU01-flood-risk-management-impact-risk-assessment.
- MM01-flood-risk-management-measures.

2.2.2 Planning Circular PS 24-001

The Planning Circular PS 24-001 supplements Planning Circular PS 21-006 *Considering flooding in land use planning: guidance and statutory requirements* and provides additional information to planning authorities in relation to addressing flood risk in land use planning and development assessment under the Environmental Planning and Assessment Act 1979 (EP&A Act). The circular outlines existing flood-related planning policies and provides further information and advice on their application in planning. The circular also provides updates on flood-related policy initiatives underway, including action taken in response to the 2022 NSW Flood Inquiry. Consistent with the findings of the NSW Flood Inquiry 2022, the department recommends applying a risk-based approach when addressing flooding in planning decisions.

2.2.3 Australian Rainfall and Runoff (ARR 2019)

Australian Rainfall and Runoff (Ball J, Babister et al, 2019) (ARR 2019) is the primary technical publication for stormwater and hydrological estimates and design considerations. The technical analysis and development of the hydrologic and hydraulic models, including the management of flooding, has been considered under this guideline. The approaches presented in ARR 2019 are relevant tor policy decisions and projects involving:

– Infrastructure such as roads, rail, bridges, dams and stormwater systems.
– Flood management plans for urban and rural communities.
– Flood warnings and flood emergency management.
– Estimation of extreme flood levels.

2.2.4 Blacktown City Council and The Hills Shire Council

The subject TOD rezoning areas (also referred to as blocks) are bisected by the local government area boundaries of Blacktown City Council and The Hills Shire Council, with the boundary following Old Windsor Road. Blacktown Local Environmental Plan 2015 (Blacktown LEP) covers the TOD rezoning blocks west of Old Windsor Road, while The Hills Shire Council Local Environmental Plan 2019 (The Hills LEP) covers the TOD rezoning blocks east of Old Windsor Road. Clause 5.21 (flood planning) in both LEPs provides the following flood planning objectives:

– minimise the flood risk to life and property associated with the use of land
– allow development on land that is compatible with the land’s flood hazard, considering projected changes as a result of climate change
– avoid significant adverse impacts on flood behaviour and the environment
– enable the safe occupation and efficient evacuation of people in the event of a flood.

Clause 5.21(2) nominates that the flood planning requirements apply in the ‘flood planning area’ (shown on the Flood Planning Map). Considerations for the consent authority include that the development:

– is compatible with the flood function and behaviour on the land
– will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties
– will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood
– incorporates appropriate measures to manage risk to life in the event of a flood
– will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses.

It is noted that both LEPs have not adopted the special flood considerations.

Development control plans support LEPs and provide guidance on stormwater and flooding controls which Council use to assess proposed development. These controls are based on sound management principals.

2.2.5 Local Flood Plans (SES)

Local flood plans are prepared by the NSW State Emergency Service (SES) as part of broader local disaster plans. Local flood plans outline the preparations, responses and recovery actions that are to be undertaken prior to, during and following a major flood event. The local flood plan for the area within the vicinity of the project is the *Blacktown City Council Flood Emergency Sub Plan* (SES, 2023) and *The Hills Shire Council Flood Emergency Sub Plan* (SES, 2023).

The plans provide context to flooding in the region, including the extent and timing of major floods, areas of high risk of flooding which may require evacuation by emergency services, key evacuation routes, and the location of emergency shelters within the area covered by the Plan.

2.2.6 Sydney Water

Sydney Water (SW) is designated as the Acquisition Authority for land that is identified for Rouse Hill Trunk Drainage Land (TDL) purposes within the RHDA, Stages 1 to 4. This land is zoned 5(a) (Special Uses - Trunk Drainage) by the Blacktown City and The Hills Shire Councils Local Environmental Plans and includes Smalls, Second Ponds, Caddies, Strangers, and Elizabeth Macarthur Creeks and their tributaries. The TDL consists of a range of waterway types, including natural or semi-natural creek lines, degraded or rehabilitated channels, grassed/landscaped open swales, constructed stormwater channels and associated infrastructure including wet and dry detention basins, wetlands, culverts/bridges and constructed/decorative ponds.

Several stormwater basins within the SW TDL are declared as part of the NSW Dams Safety Act 2019 and are required to be subject to a rigorous programme of surveillance to ensure the continuing safety of these structures. The remaining drainage assets within the catchment (including a number of basins and the majority of the underground pit and pipe systems) are mainly owned by BCC and THSC. The catchment also includes several farm dams of varying sizes, most of which are privately owned.

The Rouse Hill Trunk Drainage Land :

- provides flood conveyance and/or floodplain storage based on up-to-date modelling of flood behaviour within the catchment.
- contains Sydney Water Trunk Drainage Infrastructure.
- is likely to need to undertake Trunk Drainage Works to address unacceptable flood risks to public areas or infrastructure.
- acquisition of the land would significantly improve access by Sydney Water to and along the Trunk Drainage Land for maintenance purposes.
- Sydney Water may include small areas of land ancillary to that required for flood storage or flood conveyance in the area to be acquired if it assists in the orderly roll out of infrastructure and development of lots.
- The land is close to land already owned, or to be owned, by Sydney Water and its acquisition would enable more effective and efficient debris management, weed control, fire risk reduction and bush regeneration.
- Any other matters that are relevant to achieving the outcomes that Sydney Water is obliged to deliver as Trunk Drainage Authority.

Sydney Water has adopted the “Acquisition of Trunk Drainage Land within the Rouse Hill Development Area, Stages 1 to 4” policy which sets out the criteria for land acquisition. The policy states that Sydney Water will use several criteria to determine whether it wishes to proceed with the acquisition of any land zoned for Trunk Drainage Purposes at any point in time. The ultimate decision is at SW’s discretion given the circumstances at the time.

Sydney Water has developed a guide (Sydney Water 2014) which applies to owners and developers proposing to build a stormwater pipe connecting to a waterway owned or managed by Sydney Water in the RHDA. This applies to connection proposals for residential, commercial, industrial and other government agencies (e.g. Roads and Maritime Services) developments. The guide explains what you need to do when building a stormwater connection into Sydney Water’s natural open channel waterways in the Rouse Hill Development Area (RHDA). Sydney Water allows stormwater connections that ensure:

- stable transition from a constructed drainage system to the natural waterway.

– sustainable water quality management.
– restoration of vegetation following construction.

A meeting was held with Sydney Water and the Department of Planning (25/07/2024) to discuss the Elizabeth Macarthur Creek Trunk Drainage Concept Design. In the meeting, the following key matters were noted:

– Sydney Water was generally of the view that the overall approach for the flood modelling undertaken at that point in time for the current assessment appeared appropriate. It was noted that there are currently several flood models that are available for the TDL lands, and it was agreed that a co-ordinate approach to flooding modelling of the TDL needs to be defined, for ongoing assessments.
– Sydney Water is seeking to improve the management of stream flows (regular flows as opposed to flood flows) and is currently investigating the provision of stormwater harvesting facilities within the RHDA trunk drainage land.
– Opportunistic provision of stormwater harvesting (eg rainwater reuse) within the TOD rezoning areas is beneficial in improving runoff outcomes and assisting the management of the stream erosion index, however a clear numerical criteria was not provided.

2.2.7 ARR 2019 Version 4.2 and DCCEEW Draft Discussion Paper

NOTE: This report was compiled before the issue of the revised version of Australian Rainfall and Runoff Version 4.2 (published 27/08/2024), which includes a revised version of the DCCEEW draft discussion paper. The incorporation of this updated Australian Rainfall and Runoff Version, into the current assessment, is under discussion with Department of Planning, Housing and Infrastructure. Notwithstanding, some of the matters raised in the DCCEEW draft discussion paper have been considered as part of the sensitivity assessment in Section 5.3.4.

The Australian Government Department of Climate Change, Energy and Environment and Water (DCCEEW) has issued a draft discussion paper: *Update to climate change considerations chapter in Australian Rainfall and Runoff - A Guide to Flood Estimation (DCCEEW 2023)*. The key message in the draft discussion paper is that because our climate is changing, unadjusted historical observations are no longer a suitable basis for design flood estimation and that they must be adjusted to reflect the impacts of rising global temperatures.

ARR 2019 provides catchment specific rainfall-runoff parameters, which included rainfall losses and aerial reduction factors. For the simulations, NSW jurisdiction specific parameters are used which account for pre-burst rainfall and adjusted continuing losses. ARR 2019 recommends adoption of BOM 2016 rainfall data. One key matter raised by the draft discussion paper is that the BOM 2016 rainfall data is inherently applicable to a baseline global temperature, that prevailed for the period 1961 to 1990. Since that time to 2024, there has been a 1.07 degree increase in global temperature according to the IPCC 6. The discussion paper therefore suggests that the BOM 2016 rainfall data should be factored to present day, which depending on the storm duration could be a rainfall increase of between 8% and 15%.

At the time of compiling the report, the discussion paper had not been formally adopted. The implication of the discussion paper will be wide ranging in the context of event-based rainfall-runoff modelling in Australia. In an industry workshop convened by Flood Management Australia on 15 August 2024, it was evident that the broader hydrological industry is currently grappling how to adopt the matters raised in the paper.

3. Baseline Conditions

3.1 Defining Baseline Conditions

The GHD 1998 study simulated the pre-development case rainfall-runoff, flooding and stormwater quality of the Rouse Hill Development Area, together with an ultimate development case envisaged at that time. SKM 2009 (Section 1.3.2) reviewed and updating the GHD study and modelling, based on the latest available information with respect to the ultimate development case land use, and included as-constructed infrastructure and proposed hydraulic structures. Ensure 2018 (Section 1.3.5) made several updates to the SKM 2009 models. Ensure 2018 documents that all modelling represented the ultimate development case catchment (assumed to be fully developed conditions beyond the year 2046 planning horizon) and the rural case catchment which was represented coarsely to determine baseline water quality conditions. The Ensure 2018 study only made updates to the ultimate development case catchment as the rural case catchment was not required to be assessed. The Ensure 2018 model data was provided to GHD for the present assessments, which considered two development scenarios:

- Baseline Conditions, which represented the ultimate development case as adopted by Ensure 2018.
- Baseline Conditions with the TOD, which represented the ultimate development case as adopted by Ensure 2018. However, for the TOD precincts areas within the catchment, the impervious percentages were adjusted to values provided by the TOD planners.

3.2 Catchment and Drainage

The Rouse Hill catchment, located in the north-western region of Sydney, is defined by a 66km^2 catchment area within the Caddies Creek catchment. The catchment drains Caddies Creek and its tributaries Smalls Creek, Second Ponds Creek, Elizabeth Macarthur Creek and Strangers Creek, along with several minor tributaries. The catchment drains to Cattai Creek, which ultimately drains to the Hawkesbury River at Cattai. Catchments east of Windsor Road/Old Windsor Road are located within Baulkham Hills Local Government Area (LGA), while catchments to the west are located within Blacktown LGA.

The catchment has experienced significant urban development since the late 1990’s, in the suburbs of Rouse Hill, Kellyville, Kellyville Ridge, Stanhope Gardens, Bella Vista, Parklea, Glenwood and Acacia Gardens. Prior to this the catchment comprised primarily of older urban residential areas in Kellyville and rural areas, some forested areas in the northern and eastern parts of the catchment.

Some rural areas are still present in the area to the north of Bella Vista (the Balmoral Road Release Area), to the west of Rouse Hill and Kellyville Ridge (which includes parts of the Second Ponds Creek Release Area) and areas on the eastern side of Smalls Creek. These areas are likely to be developed in the future.

Elizabeth Macarthur Creek drains from approximately 75 mAHD in the south near Brighton Drive to approximately 44 mAHD near the confluence of Caddies Creek over a distance of approximately 3 km. The average grade through the TOD areas is approximately 1%. Caddies Creek drains from approximately 66 mAHD in the south near Old Windsor Road to approximately 44 mAHD near the confluence of Elizabeth Macarthur Creek over a distance of approximately 3.4 km. The average grade through the TOD areas is slightly less steep at approximately 0.6%, noting that along the way Caddies Creek drains through the Glenwood Reserve Lake.

3.3 Stormwater system

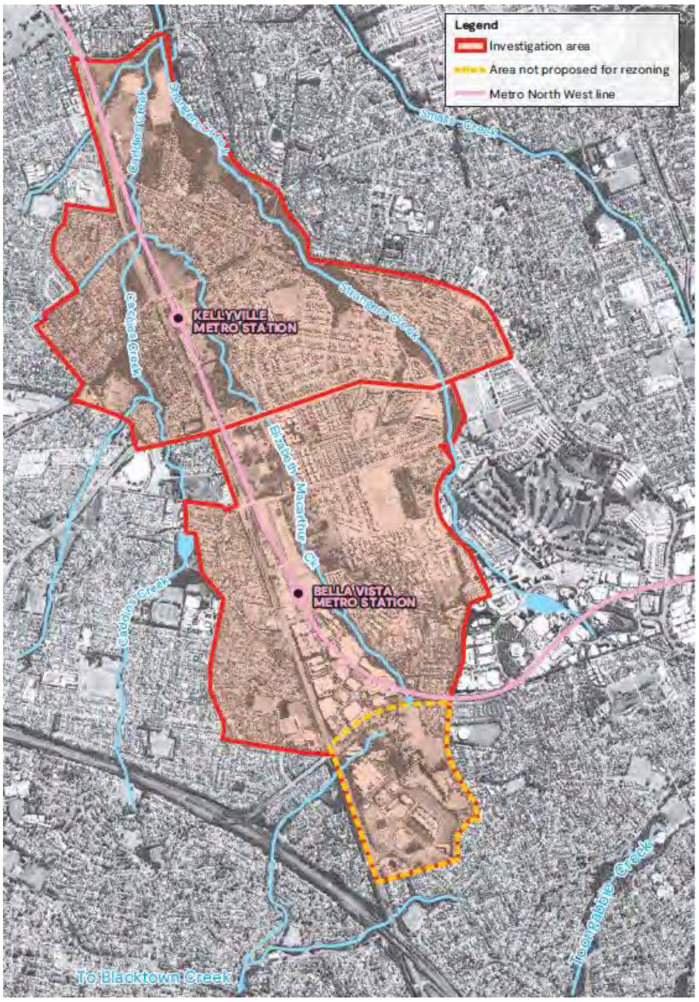

Figure 3.1 Receiving Stormwater System

The precinct predominantly drains to Caddies Creek or its tributaries, in particular Elizabeth Macarthur Creek and Strangers Creek. The investigation boundary includes a small portion at the south, draining to Blacktown Creek, which drains to the Upper Parramatta River. Department of Planning, Housing and Infrastructure have confirmed that this area is not proposed for rezoning. All area subject to rezoning drain to Caddies Creek. Caddies Creek drains to Cattai Creek and the Hawkesbury River, discharging to the ocean at Broken Bay.

The drainage catchments of Caddies Creek are within the Rouse Hill Development Area (RHDA) where Sydney Water is the designated authority. Sydney Water is responsible for the management of trunk drainage land within the 1% AEP flood extents. The trunk drainage land includes stormwater management basins that have been constructed on-line on waterways. Sydney Water currently imposes requirements for discharge of stormwater from developments in the catchment to these trunk drainage lands. Developments for example are required to provide onsite Water Sensitive Urban Design infrastructure to manage stormwater quality. The stormwater quality is required to meet prescribed pollutant reduction for gross pollutants (GP), total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN).

3.3.1 Stormwater Quality

SKM developed a MUSIC stormwater quality model of the RHDA catchment based on Work As Executed (WAE) drawings available at the time (refer Section 1.3.2). This included regional stormwater quality infrastructure installed in response to previous catchment planning undertaken by GHD, however not all infrastructure was constructed as initially modelled or not constructed at all, at the time of the SKM review. Therefore, they found that average annual pollutant loads were significantly higher than the stormwater quality targets set by the Rouse Hill Stormwater Strategy.

The existing RHDA regional stormwater system has provided stormwater quality management infrastructure (refer Section 1.3.2), including ponds, wetlands and bio-retention features, however these are partly not installed consistent with the draft pollutant treatment targets (in terms of reduction of loads generated in the catchment) set by DECC (2007).

3.3.2 Stormwater Quality Modelling

The relevant criteria for the provision of stormwater quality infrastructure for the TOD rezoning (refer Section 5.1) are with respect to the required reduction in pollutant loads from a developed case unmitigated scenario. This is to be undertaken reviewing discharges from each TOD rezoning block respectively. Therefore, the modelling of baseline stormwater quality conditions for the current assessment is not required and has not been undertaken.

3.4 Flooding Environment

3.4.1 Waterway versus Overland Flooding

The NSW Flood Prone Land Policy (DPE 2023) applies to urban and rural floodplains in New South Wales and to both flooding from waterways and local overland flooding. The Policy acknowledges that flooding can result from relatively high stream flow that overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flow paths associated with major drainage, and/or oceanic inundation resulting from super-elevated ocean levels. Since the local overland flooding is a function of the local topography and design within the TOD areas, which was unknown at the time of the report, this report only applies to the flooding from the Caddies Creek, Elizabeth Macarthur Creek and associated waterways. The local overland flooding matters will need to be addressed in future planning and design stages, when the local design within the TOD precincts is established.

3.4.2 Rainfall-runoff and flood models

This assessment has used the following modelling:

– Rainfall-runoff Routing: The XP-RAFTS rainfall-runoff routing model compiled by SKM (2009), further developed by WMAwater (2014), and adopted by Ensure (2018). The XP-RAFTS model was simulated using Australian Rainfall and Runoff 1987 (ARR 1987) methodologies and associated rainfall data. Figure A001 in Appendix A shows the XPRAFTS rainfall-runoff catchments.

– Flood Model: The TUFLOW flood model developed by WMAwater (2014) updated and adopted by Ensure (2018). This model was simulated in the TUFLOW 2013-12-AD (classic, double precision) version of the software. Figure A002 in Appendix A shows the re-simulation of the Ensure 2018 model, comparing the results to the original flood model results. The figure shows that the 1% AEP flood was replicated when using the Ensure 2018 assumptions.

The flood models were simulated and verified against previous studies, which showed that results were able to be replicated.

3.4.3 Model Updates

For the current study, the following model updates were configured:

– The XP-RAFTS model was updated to simulate Australian Rainfall and Runoff 2019 (ARR 2019) methodologies and Bureau of Meteorology (BOM 2016) rainfall data. In simulating using this approach:
  - ARR 2019 simulates ten temporal rainfall patterns rather than a single rainfall pattern.
  - ARR 2019 provides catchment specific rainfall-runoff parameters, which included rainfall losses and aerial reduction factors. For the simulations, NSW jurisdiction specific parameters were used which accounts for pre-burst rainfall and adjusted continuing losses. Given the focus of the assessment, no aerial reduction factors were applied. ARR also recommends adoption BOM 2016 rainfall data, which was adopted.

– The TUFLOW model was updated to simulate in the 2023-03-AE (classic, double precision) version of the software. In simulating under the later version of TUFLOW:
  - Model instabilities were encountered for a handful of the simulations, similar to those encountered by Ensure 2018 (Section 1.3.5), due to the age of the TUFLOW model. Several attempts were made to troubleshoot these instabilities, however with limited success. Given that there were only a few instances, these were not included in the event reporting (see Section 3.4.4)
  - For the PMF event, widespread model instability was encountered. It is noted that none of the available studies has simulated the PMF, and the only PMF data available was simulated by SKM 2009 using a 1D HEC-RAS steady state flood model. Therefore, for the present study the TUFLOW model was updated to simulate the entire model in 2D, replacing the 1D elements in the model with LiDAR data. Figure A003 in Appendix A shows an overlay of the PMF calculated using the updated model with the SKM 2009 mapped PMF. The map shows favourable agreement in terms of flood extent.

3.4.4 Event Reporting

The basis of reporting the results below was that for each of the Annual Exceedance Probability (AEP) storm events, an ensemble of 10 temporal rainfall patterns were simulated for a range of storm durations. For each duration the median peak flood level was identified from the ensemble of rainfall patterns. This was adopted as the design peak level for that storm duration, whereafter the design peak levels were enveloped across all durations to identify the critical duration, and corresponding design peak level. This is an approach acceptable under ARR 2019, however does not precluded a design peak level greater than the critical level adopted.

Figure A004 in Appendix A compares the Ensure 2018 1% AEP flood level calculated with ARR 1987 to the median peak flood level calculated using ARR 2019. The results show a general reduction in flood levels of around 0.1 to 0.2m. An exception is immediately upstream of Old Windsor Road on Caddies Creek where slight model adjustments show an increase. The reduction due to switching from ARR 1987 to ARR2019 is a common phenomenon observed in flood studies. Comparing the Ensure 2018 1% AEP flood level calculated with ARR 1987 in Figure A005 against the upper envelope maximum peak flood level calculated using ARR 2019, shows a slight increase in some areas of 0.05 to 0.1m, with slightly larger changes in a few isolated locations. This would suggest that the results under ARR 2019 compare reasonably to the Ensure 2018 flood levels in the 1% AEP event.

3.4.5 Flood Depth and Levels

Flood maps for the baseline conditions are provided in Appendix B. In the 5% AEP event discharges are predominantly conveyed in the incised creek channel, with some surcharge onto the adjacent floodplain. Along all creeks, flood waters impinge on the TOD precinct boundaries facing Elizabeth Macarthur Creek, Caddies Creek and associated tributaries. As flood events become rarer, the flood depths deepen, with a marginal increase in flood extent. On average, flood levels deepen by approximately 0.1m to 0.15m when comparing the 1% AEP event and the 5% AEP event. In the 0.5% there is a small increase in flood levels of around 0.05m while in the 0.2% AEP flood levels increase by a further 0.1m to 0.15m above the 1% AEP flood, depending on location. In all events simulated, there a flow path across the location of Bella Vista BV8 TOD block. This overland flow path bisects the southern part of the block. In the PMF, wide spread flooding would be expected with increased inundation of the TOD boundaries and flooding extending increasingly onto the TOD blocks. Apart from the flow path across Bella Vista BV8 TOD block, Stanhope Gardens blocks K4, K6 and K8 would be inundated as flood water surcharge Caddies Creek.

3.4.6 Flood Velocity

The flood maps in Appendix B show that in the 5% AEP event elevated flood velocities (1 to 2 m/s) are associated with the creek channels. In some locations on the upper reached of Caddies Creek these velocities increase to 2 m/s to 3 m/s. In the 1% AEP flood, these velocities increase marginally to 1.5 m/s to 2.5 m/s. In location where floodwater surcharge the creeks onto the adjacent flood plain along the TOD boundaries, velocities are generally slower and below 1 m/s. The flow path across the location of Bella Vista BV8 TOD block is simulated to discharge at 0.8 to 1 m/s.

3.4.7 Flood Hazard

Flood mapping showing hydraulic flood hazard is provided in Appendix B. The hydraulic hazard has been categorized following the NSW Flood Risk Management Manual FB03 flood risk categories as shown in Figure 3.2. In the 1% AEP floods, the results show elevated flood hazard (greater than three) within the creek channels. Along the edges of the TOD boundaries, and where flooding extends onto the TOD lands the flood hazard is generally H1 increasing to H2, moving towards the creeks. The flow path across the location of Bella Vista BV8 TOD block location is simulated to discharge at H1 to H2 hazard.

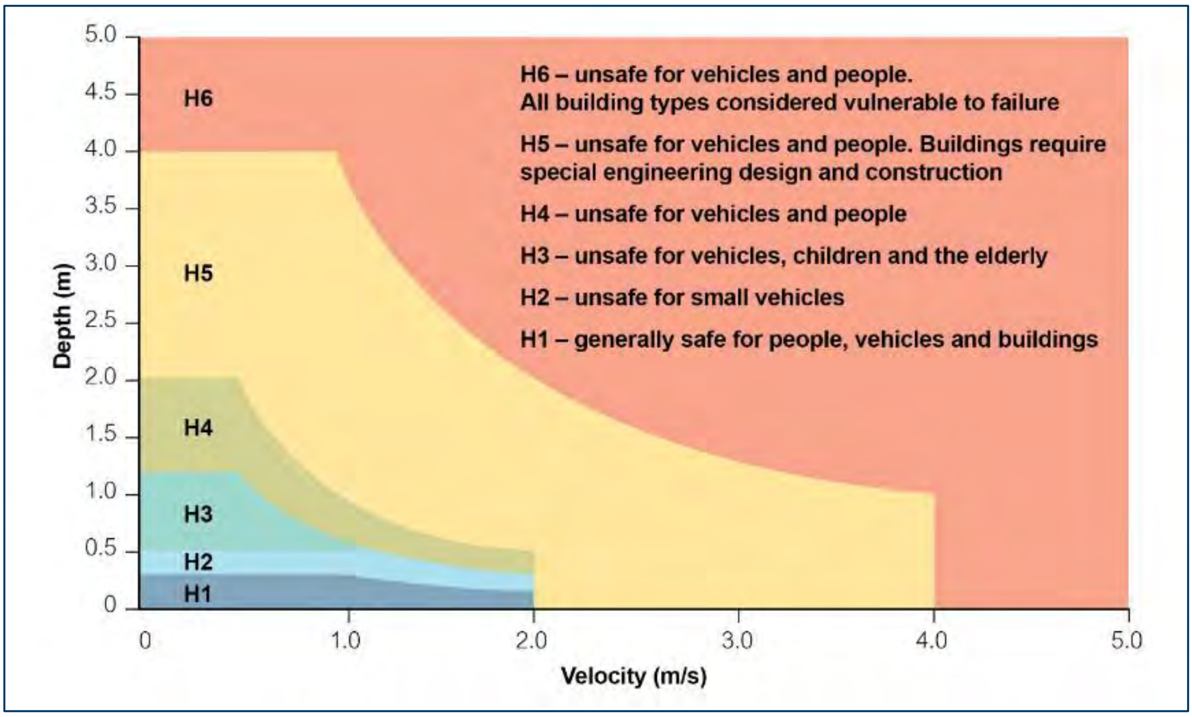

Figure 3.2 NSW Flood Risk Management Manual FB03 flood risk categories

3.4.8 Flood Function

Flood function is defined as three categories under NSW Flood Risk Management Manual FB02 flood function:

- Floodways are generally areas which convey a significant portion of water during floods and are particularly sensitive to changes that impact flow conveyance. They often align with naturally defined channels. For this assessment, the flood function has been defined generally according to Howells 2003.
  - The velocity * depth product is > 0.25 m2/s and the velocity > 0.25 m/s or the velocity is greater than 1 m/s
  - Review of the creek channel banks
- Flood storage areas, which are areas outside of floodways, are generally areas that store a significant proportion of the volume of water and where flood behaviour is sensitive to changes that impact on the storage of water during a flood:
  - Land outside of the floodway if the depth is greater than 0.5 m.
- Flood fringe areas are areas within the extent of flooding for the event but which are outside floodways and flood storage areas. Flood fringe areas are not sensitive to changes in either flow conveyance or storage.
  - Land beyond the flood storage area where the depth is less than 0.5 m

The flood function for the for the Baseline 1% AEP and 0.2% AEP flood are provided in Appendix E. The maps show that the floodway is generally constrained to the creek channel and does not extend onto the TOD lands. The edges of the flood plain are primarily flood storage and flood fringe areas, with flood fringe predominantly along the TOD boundaries where flood waters extend marginally onto TOD blocks. In all events simulated, there a flow path across the location of Bella Vista BV8 TOD block, which is partly designated as a flood way.

3.4.9 Time of Flood Inundation

Flood mapping showing time of flood inundation is provided in Appendix B. The results show times of inundation along the TOD block boundaries of generally less than 1 hour as there are on the edge of the flood extent. In areas of flood storage such as basins, times of inundation are longer extending to 1 to 6 hours as these areas drain after the flood event.

3.4.10 Flood Rate of Rise

The flood level rate of rise shown in Figure 3.3 to Figure 3.5 demonstrate the rapid response of Elizabeth Macarthur and Caddies Creek to flood waters, due to the urban development. Each line on the curve represents a storm temporal pattern (see 3.4.4) which may prevail in this event. This rate of rise demonstrates a flash flooding response to flood events with flood levels substantially increasing with less than 15 minutes. For Caddies Creek the rate of rise is marginally slower due to the influence of the lake in the Glenwood Reserve.

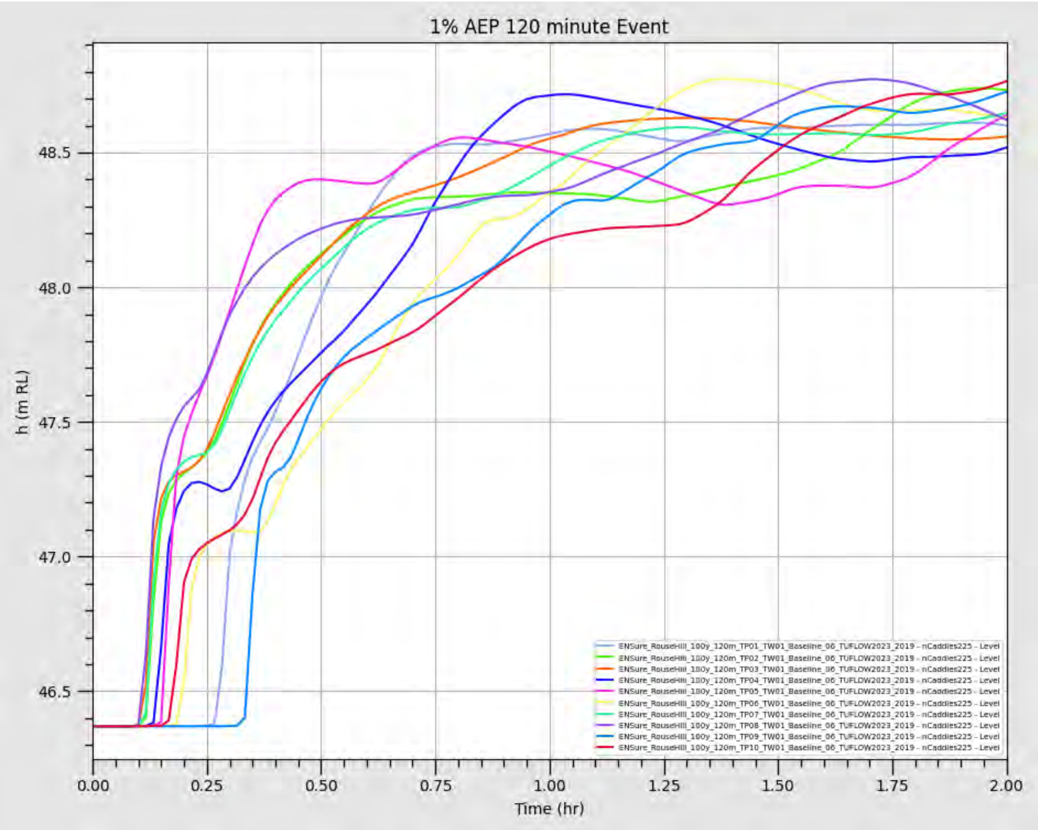

Figure 3.3 Flood Level Rate of Rise Caddies Creek adjacent to TOD Block K8

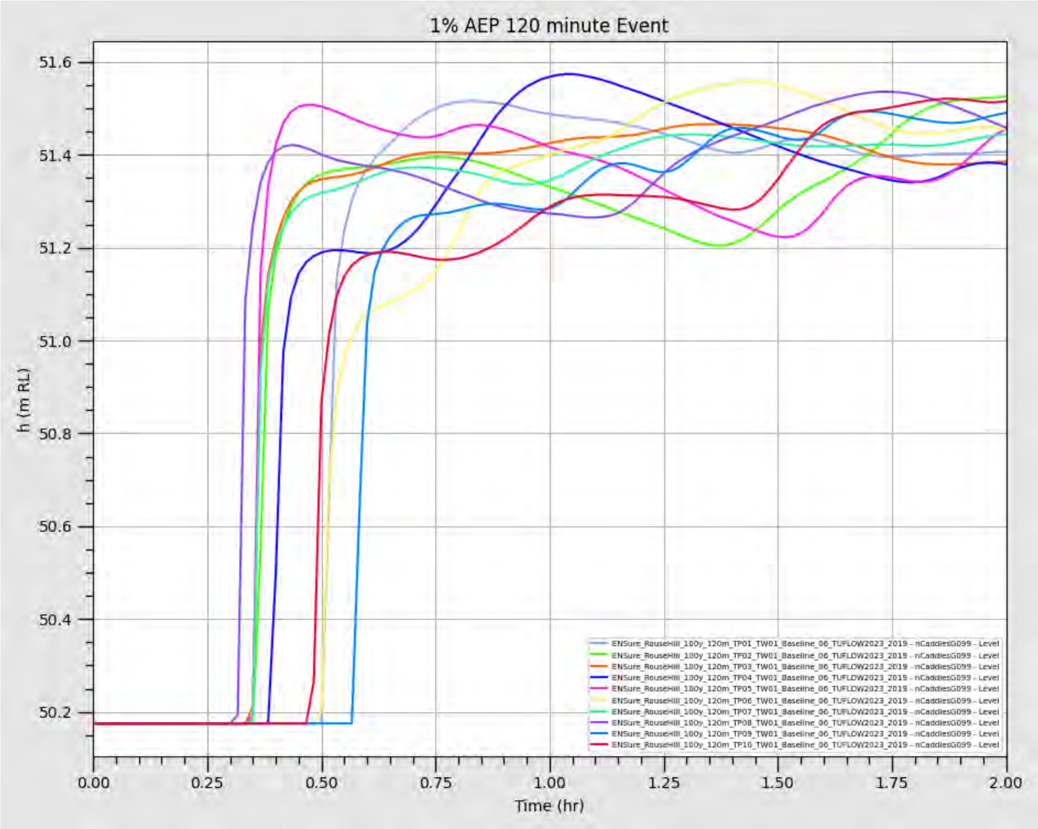

Figure 3.4 Flood Level Rate of Rise Elizabeth Macarthur Creek adjacent to TOD Block K9

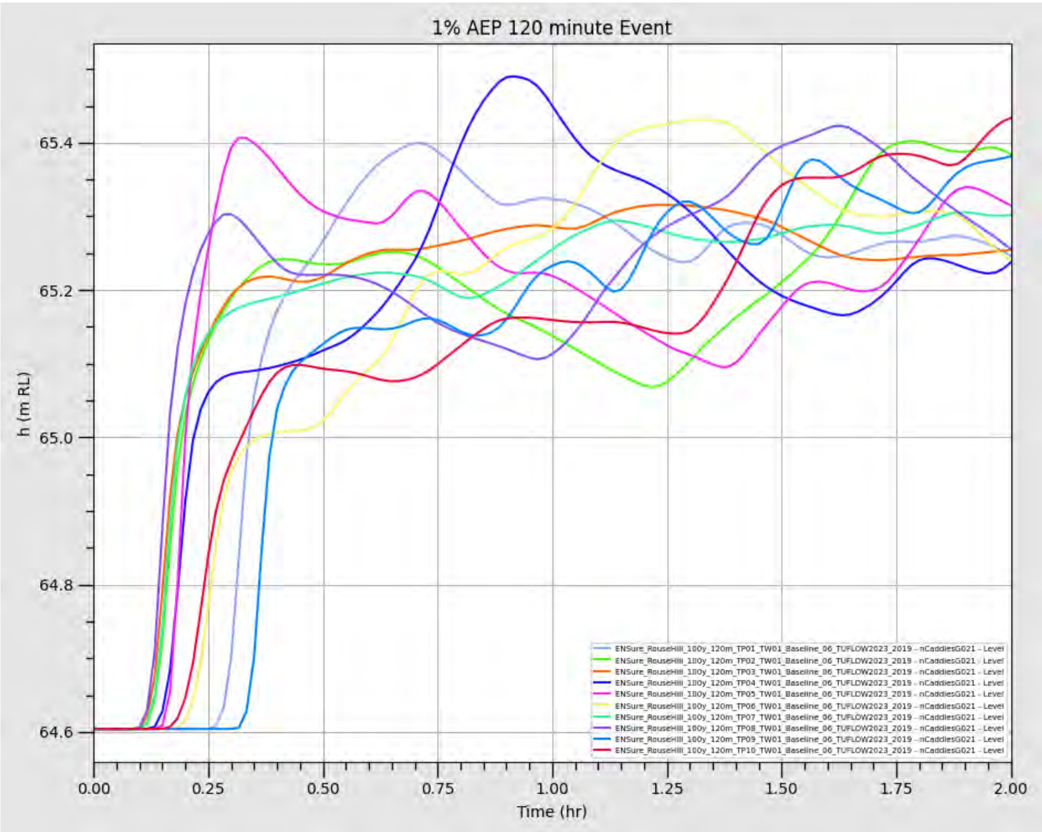

Figure 3.5 Flood Level Rate of Rise Elizabeth Macarthur Creek adjacent to TOD Block BV8

4. Proposed Development

The location of the TOD rezoning areas is shown on Figure 4.1. These rezoning areas are at times referred to as the TOD Blocks. The planning within the TOD area lands is currently underway, with the intended outcome listed in Table 4.1. This information was provided to GHD by DPHI on the 28/06/2024 and may be subject to change. All blocks within the Bella Vista and Kellyville TOD Precincts have been assessed for this evaluation. Please note that focus areas for accelerated rezoning may be subject to change in the final rezoning. The land within the TOD rezoning areas is a mixture of greenfield areas, multiple detached dwellings, Sydney Metro land and detached dwellings on large residential lots. The intention is to develop these lands as high density Residential Flat Buildings (RFBs) with potential local parks (subject to community title constraints), future local centre/open space and a potential playing field. It is noted that this report is compiled on the basis that the development and layouts within individual TOG blocks are unknown, with exception of the change in impervious percentages documented in the table below.

Table 4.1 TOD Changes in Impervious Areas (received 28/06/2024, DPHI)

Block (see Figure 4.1)	Existing permeable area (%)	Assumed maximum imperviousness from rezoning (%)	Change (%)	Current land use	Proposed land use
K4	100	^85	+85	Greenfield	High density RFBs
K5, K6, K8	*25	75	0	Multiple detached dwellings	High density RFBs/ 2 potential local parks - *further changes subject to community title constraints.*
K9	!90	#50	+40	Sydney Metro/ Greenfield	High density RFBs / Future local centre/Open space
BV1/7/14	!90	#50	+40	Sydney Metro/ Greenfield	High density RFBs/ Business park/ Future local centre/ Open space
BV8	!95	$60	+55	4 detached dwellings on large lot residential	High density RFBs/potential playing field - *further changes subject to flood modelling.*
BV17	*25	75	0	Multiple detached dwellings	High Density RFBs
BV18	*25	75	0	Multiple detached dwellings	High Density RFBs/ 1 potential local park

Methodology:

^informed by **Site Specific DCP** - deep soil minimum target of **15%**.

*****informed by **Greener Neighbourhoods Guide** deep soil site targets (detached dwellings 300-600sqm - **25%** minimum of site area)

informed by **Site Specific DCP** where site coverage of future development shall not exceed **50%** of the site area (excluding land to be dedicated or acquired or a public purpose).

$informed by **Site Specific DCP** where maximum site coverage is **60%** for dwellings two storeys or more.

!approximate only. Estimation informed by aerial imagery.

Figure 4.1 TOD Rezoning areas

5. Development Impacts

5.1 Stormwater Quality

Increasing impervious urban areas typically results in an increase in generation of urban stormwater pollutants such as nutrients and suspended solids. Best practice stormwater management involves implementation of Water Sensitive Urban Design strategies in a stormwater treatment train of management facilities. This stormwater treatment train may include features such as gross pollutant traps, vegetated swales, bio-retention systems and proprietary stormwater quality devices. These can be co-located with stormwater quantity measures such as detention basins, to minimise the impact on developable lands.

The TOD rezoning includes potential stormwater quality impacts that require consideration alongside the existing stormwater quality infrastructure in the RHDA.

The proposed rezoning will change catchment impervious and pollutant generation properties, and therefore has potential stormwater impacts requiring consideration. As the proposed rezoning areas are already subject to prior development, understanding what stormwater quality facilities have been constructed as part of this development is important. With relation to this, it is noted:

- All areas subject to rezoning drain to Caddies Creek which is within the RHDA where Sydney Water is the designated authority responsible for the management of trunk drainage lands within the 1% AEP flood extents (refer Section 3.3).
- Water quality modelling for the RHDA catchment was originally undertaken by GHD in 1998. This proposed stormwater quality controls which were predicted to reduce pollutant loads post-development (refer Section 1.3.2).
- SKM noted that not all stormwater quality controls modelled by GHD were installed. SKM updated the stormwater quality modelling which included constructed facilities, and re-calculated stormwater quality performance in terms of pollution reduction percentages (refer Table 5.1). The calculated pollution reduction modelled were below those required by the DECC 2007 target reductions and current standards imposed by Sydney Water for the RHDA.
- It is understood that recent State Significant Development approvals (post 2020) have been granted for some of the lands subject to the proposed rezoning. The relevant approval documents generally refer to the same target reductions referred to above and stipulate stormwater treatment trains for their proposed project elements accordingly.

Table 5.1 Pollutant Reductions Performance and Targets – RHDA overall

Pollutant	Predicted Reduction Achieved SKM, 2009	DECC 2007 Target Reductions	Sydney Water, 2014 Requirement
Total Suspended Solids	31%	85%	85%
Total Phosphorus	23%	65%	65%
Total Nitrogen	23%	45%	45%

Therefore, existing stormwater quality controls within the RHDA exist throughout the catchment but are not compliant in all locations with the Sydney Water 2014 reduction requirements (SKM, 2009). On this basis it is proposed that seeking to satisfy the targets within/for the entire RHDA/receiving system are not achievable within the scope of the TOD rezoning. Rather it is proposed that the rezoning should seek to meet Sydney Water 2014 targets for the discharge from each block, within the TOD precincts, considering the

To manage potential stormwater quality impacts, the TOD rezoning must achieve Sydney Water 2014 pollutant reduction targets for the discharge from each block.

loads discharged from each block. This may be achieved through the utilisation of existing infrastructure (for recent SSD approval areas) or through new infrastructure or requirements imposed on future development lots. With this in place, the potential impacts of the rezoning with relation to stormwater quality are considered to be acceptable.

5.2 Stormwater harvesting and streamflow

In addition to high flow periods posing a risk to flooding, urbanisation increases the overall volume of runoff entering receiving waterways with potential changes to regular “day-to-day” flows and subsequent impacts on ecological values, geomorphology and waterway stability. This is often quantified through the consideration of Mean Annual Runoff Volumes (MARV), that is the overall volume of runoff generated in the long-term average.

This is in contrast to the management of flooding through detention, or delaying of flow releases, management of the MARV typically requires removal of stormwater from the system through increased infiltration or harvesting and reuse.

Sydney Water (Section 2.2.6) does not provide direct numerical requirements for the management of these flows. It is understood based on a meeting between GHD, DPHI and Sydney Water on 25 July 2024 (refer Section 1.3.7) that Sydney Water is seeking to improve the management of regular flows and is currently investigating the provision of stormwater harvesting facilities on their trunk drainage land within the RHDA. Therefore, opportunistic provision of stormwater harvesting within the TOD rezoning areas is considered to be beneficial in improving outcomes, however a clear numerical criteria is not proposed.

5.3 Flood Risk

5.3.1 Model updates for TOD

To model the flood impacts of the TOD precincts on the flooding of Caddies and Elizabeth Macarthur creeks, the rainfall-runoff and flood modelling was updated as follows:

– The XPRAFTS rainfall-runoff model was updated to simulate the changes to impervious areas received from Department of Planning, Housing and Infrastructure (DPHI) on 28/06/2024 in Table 4.1. Figure A006 in Appendix A show a graphical representation of increases in impervious areas when comparing the baseline conditions to the baseline conditions with TOD. The figure shows that in some locations there is an increase in impervious percentages and others there is a decrease in impervious percentages. Table 5.2 lists the change in impervious areas.
– The TUFLOW flood model was updated to simulate the revised inflows due to the changes to the XPRAFTS rainfall-runoff model. For the TOD areas a marginal increase in roughness was made, which adopted a Mannings n of 0.08 for TOD areas. Since the flooding is along the edge of the TOD boundaries, this would provide marginal increases to flood levels (and marginal conservatism) which can be attributed to possible revegetation along the creek banks.
– Flood mapping for Baseline Conditions with the TOD is provided in Appendix C.

Table 5.2 Change in Catchment Impervious Areas

Catchment (see Figure A006 in Appendix A)	Total area (ha)	Baseline Impervious (ha)	Baseline with TOD Impervious (ha)	Change in Impervious %
32.01	32.67	24.44	21.85	-10.6%
32.02	26.44	20.87	15.51	-25.7%
32.03	33.15	25.99	23.15	-10.9%
32.04	57.89	45.16	38.76	-14.2%
32.05	28.91	15.03	17.14	14.1%
32.06	25.03	12.96	13.28	2.4%

Catchment (see Figure A006 in Appendix A)	Total area (ha)	Baseline Impervious (ha)	Baseline with TOD Impervious (ha)	Change in Impervious %
40	25.04	17.63	17.38	-1.4%
41	22.62	17.81	18.04	1.3%
42	18.03	15.44	15.55	0.7%
42.01	27.56	19.65	19.64	-0.1%
42.02	38.53	23.44	22.60	-3.6%
42.03	42.57	30.52	30.56	0.1%
42.04	16.01	10.03	9.94	-1.0%
42.05	14.45	5.95	5.93	-0.4%
42.06	40.37	22.87	22.55	-1.4%
42.07	3.10	0.69	1.02	47.2%
43	37.05	20.63	28.42	37.7%
44	36.66	25.82	26.23	1.6%
51.01	20.45	11.01	11.28	2.4%
53	43.75	25.57	25.68	0.4%
54.01	36.37	21.60	22.32	3.3%

5.3.2 Flood Impacts

The flood impact maps in Appendix D show that that the impact of the Baseline conditions with TOD (See Section 3.1) are marginal. For Elizabeth Macarthur Creek and the majority of Caddies Creek the results indicate that the flood levels will remain approximately similar to the Baseline conditions for the 5%, 1%, 0.5% and 0.2% events. For Caddies Creek upstream of Sunnyholt Road, flood levels are simulated to increase by approximately 0.05m to 0.06 m, with an increase of a similar increment in flood level in the lake in the Glenwood Reserve. Increases in similar magnitude are noted in the tributary between the Stanhope Gardens K5 and K6 blocks.

In a PMF event, flood levels are predicted to increase approximately by 0.1m in Elizabeth Macarthur Creek, with a similar increase in Caddies Creek. It is noted that there is a constriction in the PMF floodplain between the Stanhope Gardens K6 and K8 blocks, which throttle flows and result in attenuation upstream of this location. Notwithstanding, these increases are approximately 0.13m upstream of the constriction.

5.3.3 DFE, Flood Planning Level and Area

The Flood Risk Management (FRM) framework and process provide the basis for understanding variability and uncertainty and considering these in decision-making. An example of accounting for uncertainty in management is the use of freeboard above the level of the Defined Flood Event (DFE) or design flood. Freeboard provides more certainty that the desired reduction in frequency of exposure to flooding chosen by this selection of a DFE is achieved.

Flood Planning Levels (FPLs) will generally be determined by government through the FRM process. FPLs are based on the DFE plus a freeboard. Different FPLs may apply in different areas as the DFE and freeboard selected for an area may be different due to the varying flood behaviour (e.g. shallow flooding from local overland flooding rather than deep flooding from waterways) and risks. In addition, different FPLs may be selected for different types of development, given the varying vulnerability of developments and their users to flooding and the use of community facilities during a flood.

The Flood Planning Area (FPA) is the area below the FPL for typical residential development. It is the area in which the majority of flood related development controls apply to most types of development. Different FPLs may be applied to different types of developments or for different purposes within the FPA. Decisions may also be made to apply controls outside the FPA or to rarer events than the DFE to developments that are, or whose users are, more vulnerable to flooding.

As part of this assessment FPLs have been provided for the following scenarios in Appendix E.

- Flood Planning Level based on 1% AEP BOM 2016 rainfall, this is in accordance with the Australian Rainfall and Runoff 2019 guideline prior to the version released on 27/08/2024.
- Flood Planning Levels based on 1% AEP BOM 2016 rainfall and adjusted for global temperature increases to 2024, using a global temperature increase of 1.07 degrees C.
- Flood Planning Levels based on the 0.2% AEP, which *Flood Risk Management Manual 2023 Guideline: FB01, Understanding and managing flood risk* (DPE 2023) suggests is a reasonable proxy for the scale of change to the 1% AEP BOM 2016 event for changes to flood-producing rainfall events under RCP8.5 in 2090.

5.3.4 Sensitivity Flood Mapping

Several sensitivity flood simulations have been undertaken and are presented in Appendix F.

- Figure F001 compare the Baseline 1% AEP flood levels assuming the maximum envelope flood levels to the median flood levels when considering the ensemble of 10 temporal rainfall patterns, see Section 3.4.4. In general, the flood levels increase by 0.05 to 0.1 m in the waterways adjoining the TOD precincts, with some isolated creek reaches exhibiting increases around 0.1 to 0.2 m.
- Figure F002 compare the Baseline with TOD 1% AEP flood levels assuming the maximum envelope flood levels to the median flood levels when considering the ensemble of 10 temporal rainfall patterns, see Section 3.4.4. In general, the flood levels increase by 0.05 to 0.1 m in the waterways adjoining the TOD precincts, with some isolated creek reaches exhibiting increases around 0.1 to 0.2 m.
- Figure F003 compare the Baseline with TOD 1% AEP flood levels with rainfall adjusted to 2024 based on global temperature increases in accordance with Australian Rainfall and Runoff Version 4.2, versus the 1% AEP flood levels calculated using BOM 2016 rainfall. In general, the flood levels increase by 0.1 to 0.2 m in the waterways adjoining the TOD precincts.
- Figure F004 compare the Baseline with TOD 0.5% AEP flood levels with rainfall adjusted to 2024 based on global temperature increases in accordance with Australian Rainfall and Runoff Version 4.2, versus the 0.5% AEP flood levels calculated using BOM 2016 rainfall. In general, the flood levels increase by 0.1 to 0.2 m in the waterways adjoining the TOD precincts.
- Figure F005 compare the Baseline with TOD PMF flood levels with rainfall adjusted to 2024 based on global temperature increases in accordance with Australian Rainfall and Runoff Version 4.2, versus the PMF flood levels calculated using BOM 2016 rainfall. In general, the flood levels increase by 0.2 to 0.3 m in the waterways adjoining the TOD precincts.

5.3.5 Climate Change

This assessment has adopted *Flood Risk Management Manual 2023 Guideline: FB01, Understanding and managing flood risk* (DPE 2023). The guideline suggests that the 0.5% and 0.2% AEP events are in the order of 15% and 30% more rainfall than the current 1% AEP flood event respectively. These events are considered to provide reasonable proxies for the scale of change to the 1% AEP event for changes to flood-producing rainfall events under RCP4.5 and RCP8.5 at 2090 respectively, with the 0.5% AEP event also similar to RCP8.5 between 2050 and 2060. They can be used for understanding the scale of impacts of change on flood behaviour and the community in the 1% AEP for these scenarios and time periods. The assessment has also simulated the extreme PMF flood event. The flooding associated with the 0.5% AEP and 0.2% AEP events is discussed in various sections of this report, with flood maps provided in the appendices, including the calculation of flood planning levels for the 0.2% AEP event which as provided in Appendix E.

This report was compiled before the issue of the revised version of Australian Rainfall and Runoff Version 4.2 guideline (published 27/08/2024). The climate change matters presented in Australian Rainfall and Runoff Version 4.2 is based on emerging science and has wide ranging implications to the prediction of future flooding as a result of global temperature increases. At the time of this report, the Australian hydrologic community was starting to grapple with the concepts in the revised guideline. The incorporation of this updated Australian Rainfall and Runoff

Version, into the current assessment, is under discussion with Department of Planning, Housing and Infrastructure. It is strongly recommended that ensuing planning stages incorporate forecast predicted impacts on rainfall due to global climate temperature increases, and the recommendations under Australian Rainfall and Runoff.

6. Management Plan – Water Sensitive Urban Design

6.1 Stormwater

The rezoning must seek to meet Sydney Water 2014 reduction targets (Section 2.2.6) for the discharge from each block, within the TOD precincts, considering the loads discharged from each block as a whole. The form of the proposed development in each block determines the most efficient stormwater quality treatment facility. For example, open space areas could include larger bio-retention facilities. In denser areas underground proprietary stormwater quality treatment devices may be appropriate.

Figure 6.1 Bio-retention can be integrated into a number of site features including channels and detention basins

Therefore, a suite of potential stormwater quality management options have been compiled, each developed in consideration of the reduction targets. These can be selected at each location/block based on the nature of the proposed development. They are listed below:

– Impose lot-level requirements on future development to achieve the Sydney Water reduction targets ('the reduction targets').
– Provide proprietary stormwater quality treatment devices that demonstrate via independent testing to be able to achieve the required reduction targets (refer Section 6.1.1).
– Utilise an existing stormwater quality treatment train (such as for the recent SSD precincts – refer Section 1.3.6) predicted via MUSIC modelling to meet the pollution reduction targets.
– Provide a stormwater treatment train consisting of a gross pollutant trap followed by bio-retention treatment which could be in the form of a basin, swale or raingarden. Preliminary MUSIC modelling has been undertaken as a component of this assessment (outlined in Appendix G) stipulating bio-retention filter area requirements on a per hectare catchment basis for different catchment imperviousness values. The area of bio-retention required based on the MUSIC modelling is as follows, interpolating between values provided based on percentage impervious:
  - 20% impervious catchment: 50 m^2 bio-retention filter area per hectare catchment.
  - 40% impervious catchment: 50 m^2 bio-retention filter area per hectare catchment.
  - 60% impervious catchment: 65 m^2 bio-retention filter area per hectare catchment.
  - 80% impervious catchment: 80 m^2 bio-retention filter area per hectare catchment.
  - 100% impervious catchment: 100 m^2 bio-retention filter area per hectare catchment.

A suite of potential stormwater quality treatment strategy options has been developed, each developed considering the reduction targets. These can be selected at each location/block based on the nature of the proposed development

Final stormwater quality treatment measures would be confirmed through the design process. At the current stage of planning, the level of detail is to allocate sufficient land to be set aside (if applicable) and determine general feasibility of developing appropriate controls in the future.

Further information on potential measures implemented in accordance with the above options are discussed in Section 6.1.1.

6.1.1 Stormwater quality measures

A suite of potential stormwater quality treatment strategy options has been developed, each developed in consideration of the reduction targets, with these measures potentially including a range of stormwater quality facilities. Potential measures for inclusion are described further below.

Bioretention

Bioretention systems treat stormwater by passing runoff through an engineered filter media that provides treatment through filtration and bio-logical processes. Vegetation is planted allowing integration into the urban planning and design of the area. Bio-retention systems are effective in providing nutrient uptake and typically utilised as the primary component of a stormwater treatment train in managing nutrient reduction requirements.

Bio-retention systems can be co-located within basins, swales or other urban landscape features such as tree-pits. They are effective in the removal of nutrients.

Bio-retention systems can be co-located within basins, swales or other urban landscape features such as tree-pits. Engineering constraints exist for their installation including the requirement for sufficient grade through the system and for land to be set aside. They can be integrated in a basin with landscaping features such as retaining walls to limit land to be set aside.

Maintenance requirements include regular maintenance of vegetation, inspection and maintenance of associated drainage network, and periodic replacement of the filter media.

Systems typically consist of an extended detention depth above the filter media, a filter media layer including plantings of plants with effective nutrient removal and a subsoil drainage collection system. Higher flow stormflows typically bypass the system through a high-flow pit and pipe system.

Figure 6.2 A small-scale bio-retention system (Source: WaterNSW)

Gross pollutant traps

GPTs are often installed close to the point of discharge from the piped system to manage coarse pollutants and litter. GPTs use a range of methods such as screening, baskets or chambers

Gross Pollutant Traps (GPTs) are stormwater devices typically installed in a sub-surface drainage network to capture primarily coarse litter. They are often installed close to the point of discharge from the piped system to a receiving above ground system such as a grassed swale or bio-retention system. GPTs use a range of methods such as screening, baskets or chambers. Example products are outlined in Holcim, 2024 and Ocean Protect, 2024. High flows are generally diverted around the traps. Periodic maintenance is required, in particular to remove accumulated pollutants.

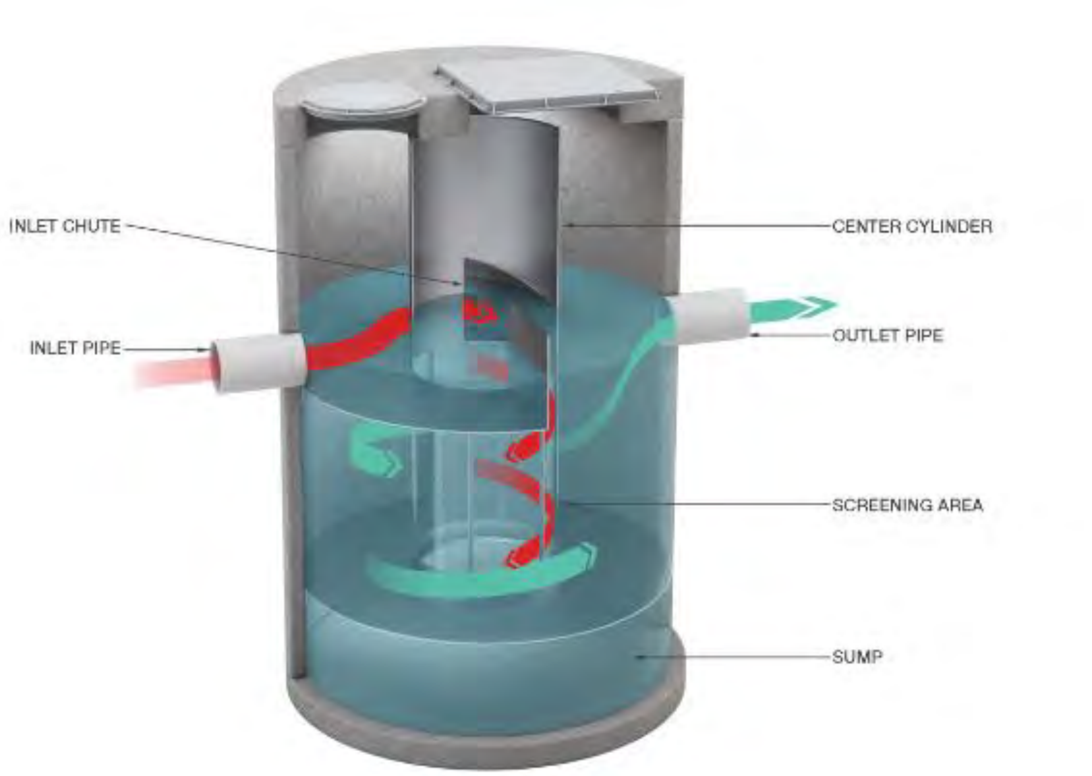

Figure 6.3 GPT Conceptual Sketch (Source: Ocean Protect)

Vegetated swales

Vegetated swales provide a stormwater conveyance function in urban stormwater systems whilst also providing a stormwater quality management function. This is through the filtration of runoff through the vegetation providing removal of coarse sediment and total suspended solids. Vegetation thickness and height is a key function in the effectiveness of vegetated swales. They are regularly integrated into urban landscaping providing aesthetic and public recreation benefit.

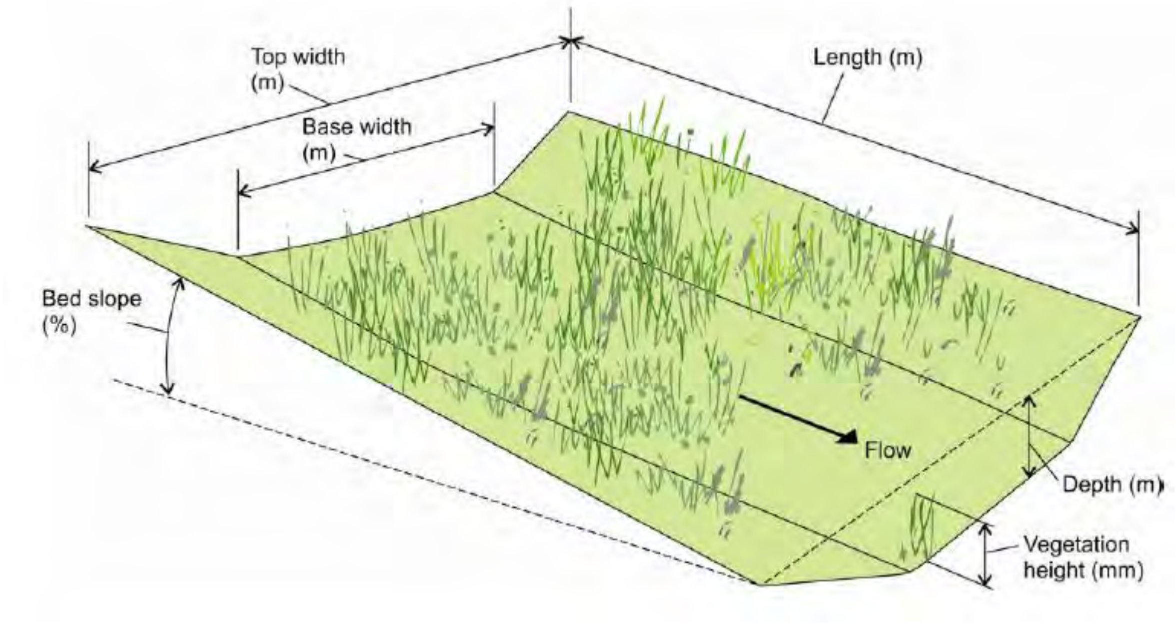

Figure 6.4 A vegetated swale (Source: WaterNSW)

Proprietary treatment devices

Proprietary treatment devices are often used when space is limited and higher order treatment, such as nutrient removal is required.

A range of proprietary treatment devices exist which are typically integrated into subsurface drainage networks, often to achieve a higher level of treatment than a GPT alone and to replicate the functioning of higher-level treatment such as bio-retention. They are often implemented when land to be set aside for features such as bio-retention is not available. A range of treatment measures are implemented including membrane filtration, centrifugal separation or use of an engineered filter media. Maintenance is a key consideration for proprietary devices and can include periodic general clean out as well as the replacement of filter cartridges or media. Some units are capable of meeting the % reduction targets on their own, but often come at a significant capital and ongoing maintenance expense.

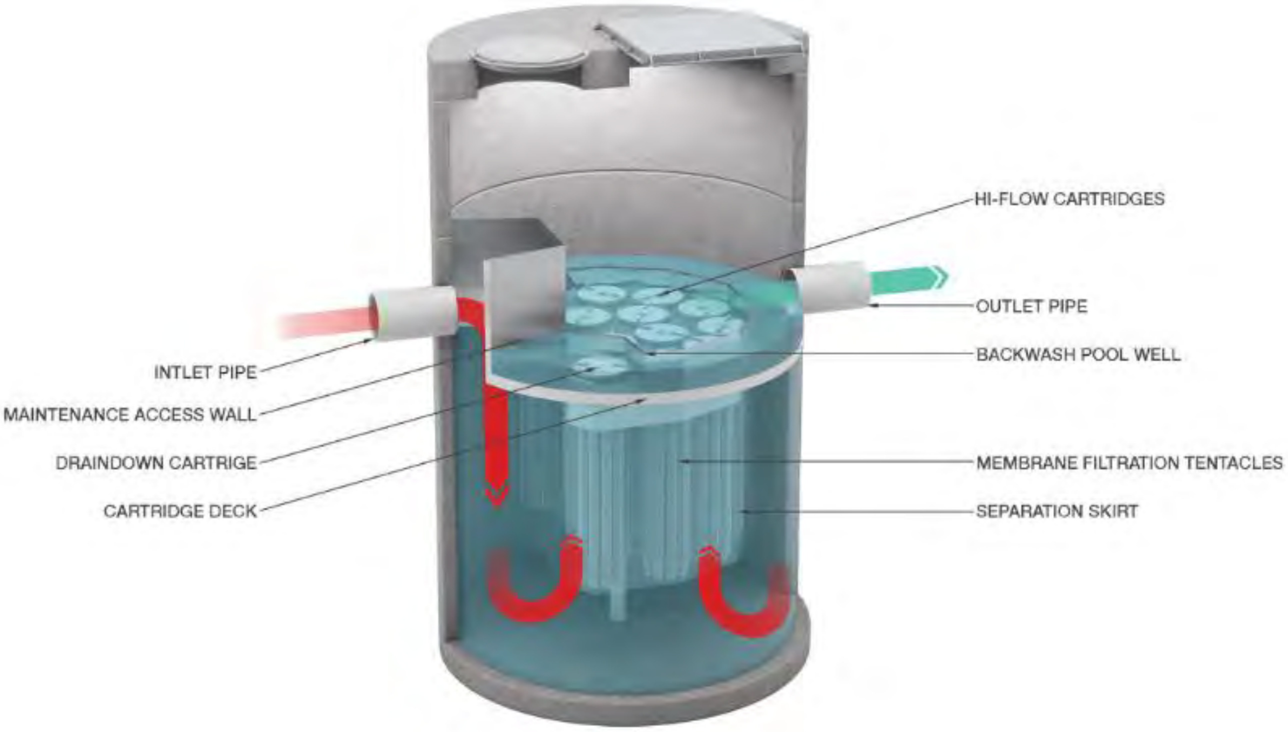

Figure 6.5 A proprietary treatment system (Source: Ocean Protect)

Stormwater reuse

Stormwater reuse is typically provided to reduce reliance on external water supplies. However, it is also effective in removing pollutants from discharge by reducing volumes of stormwater discharged from the system. This could consist of collection of roof water in rainwater tanks or larger scale collection of stormwater at ground level. Reuse is typically for greywater or landscaping applications. As noted in Section 6.1.2, based on consultation with Sydney Water, opportunistic harvesting of stormwater within the TOD rezoning was recommended.

It is critical to note that a recycled wastewater scheme already exists within the rezoning providing supply for non-potable activities (Section 1.3.5). This could limit the demand for recycled stormwater for these purposes which should be considered in the inclusion of any stormwater reuse in the stormwater treatment train.

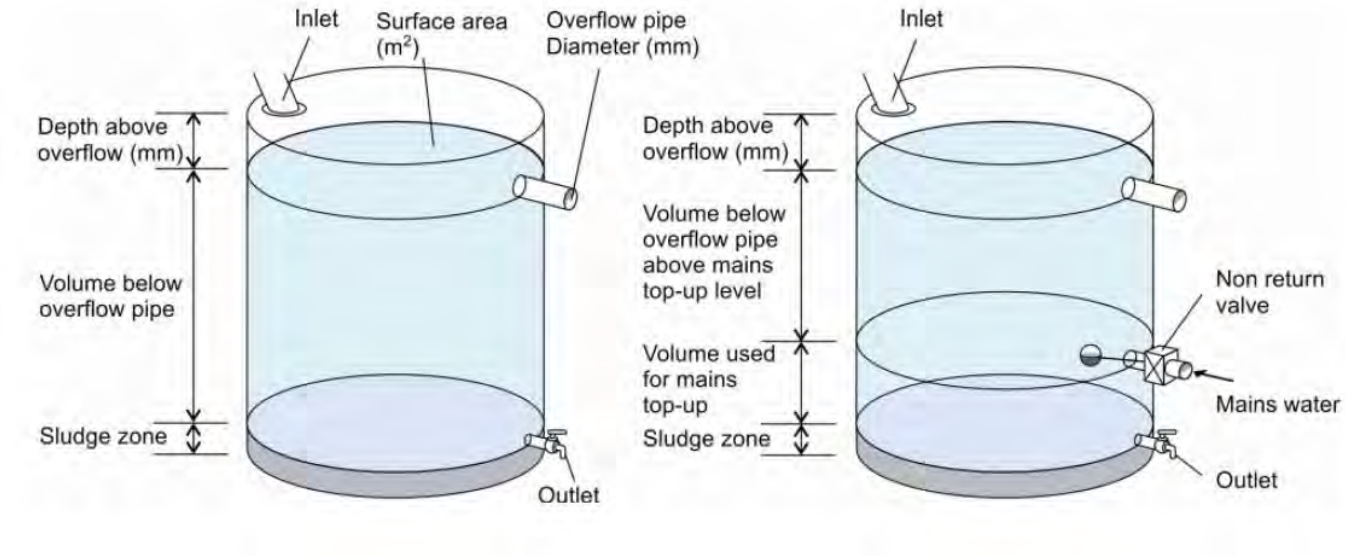

Figure 6.6 Rainwater Tank Conceptual Diagrams (Source: WaterNSW)

6.1.2 Stormwater harvesting and streamflow

As noted in Section 5.2, opportunistic provision of stormwater harvesting within the TOD rezoning areas is considered to be beneficial in improving outcomes, however a clear numerical criteria are not proposed. Therefore, in each TOD rezoning block the possibility for provision of stormwater harvesting is to be considered including the following potential mechanisms:

– Rainwater harvesting in tanks on the lot-scale
– Small ground level stormwater collection features at the lot-scale
– Regional scale collection and underground storage such as under public open space facilities, infrastructure or courtyards
– Regional scale collection in above ground ponds or basins

6.2 Flood Risk

The design of infrastructure within flood affected areas of the TOD must be performed following the requirements of the NSW Flood Risk Management Manual 2023 (particularly Guideline FB01) and in consultation with Sydney Water and Council requirements. Under the Guideline FB01 the following management considerations would apply:

– Floor Level: Allows for varying floor levels for different development types and parts of a development considering flood constraints as well as the cost of future flood damages and disruption.
– Flood Proofing: Flood compatible building considerations for varying development types. This is a means of reducing flood damages to individual properties.
– Structural Soundness: Identifies the scale of assessment required to demonstrate structural soundness to minimise cost of future damages and potential for development components to become floating debris.
– Flood affectation: Identifies how the impacts of the development are to be managed and the risks to the development and its users are to be assessed and considered based on the scale and type of development, its impacts on the existing community and the risk.

- Emergency Response: Considers the availability of existing EM arrangements including flood warning, evacuation routes, evacuation capacity, etc. and potential impacts of the development on evacuation capability of existing development.
- Management and Design: Considers additional factors needed to manage ongoing flood risk

Additional controls, as set out in engineering design guidelines, Council design standards, and planning controls will provide more prescriptive controls to manage flood risk for developments. These controls will generally include:

- Consideration of flood planning levels in design:
  - Flood Planning Levels for the future development of proposed TOD areas may not be governed by flood levels in adjacent creeks, but by the overland flows through the precinct within the public road corridors and other areas. Council's LEP requires that a minimum freeboard of 0.5m shall be provided between the 1% AEP flood level and habitable floor levels. Depending on the nature of the development within the TOD areas, sensitive facilities may require a higher level of flood protection. The exception to this is non-habitable public reserve areas, which may potentially be filled to achieve a reduced clearance to flood levels if desired.
  - Based on the above, Flood Planning Levels applicable to future development of proposed lots could be the higher of either the 1% AEP flood level in the adjacent creeks plus 0.5 m freeboard or the 1% AEP overland flow flood level plus 0.5m freeboard. Where overland flow levels vary around or within a proposed lot, the Flood Planning Level for future development will be based on the overland flow level at a particular location. An overland flow assessment will need to be undertaken during design development of the proposed lot areas to ascertain overland flooding flow depths in the 1% AEP event. These overland flow depths will subsequently be used to inform the Flood Planning Levels for the future development of each proposed lot.
  - In consideration of future climate, flood planning levels are likely to increase due to global temperature rises. In this respect, the reader is referred to 5.3.3 and 5.3.5, which discuss matter related to climate change and provide Flood Planning Levels for the following scenarios:
    - Flood Planning Level based on 1% AEP BOM 2016 rainfall.
    - Flood Planning Levels based on 1% AEP BOM 2016 rainfall and adjusted for global temperature increases to 2024.
    - Flood Planning Levels based on the 0.2% AEP, which Flood Risk Management Manual 2023 Guideline: FB01, Understanding and managing flood risk suggests is a reasonable proxy for the scale of change to the 1% AEP BOM 2016 event for changes to flood-producing rainfall events under RCP8.5 in 2090.
- Land use compatibility within the floodplain:
  - Some land uses, such as public open space, car parks or recreation areas within the proposed TOD areas may be considered more compatible with the floodplain and suitable for use without the levels of flood protection afforded to habitable dwellings. These areas may be lower set, providing a broader stormwater and water quality management functions for the TOD area and allowing some flooding to occur with due consideration of flood risk and safety to the public. Conversely, critical infrastructure may need a higher level of flood immunity.
- Sizing and location trunk drainage infrastructure and overland flow routes:
  - Most councils nominate a "major"/"minor" concept of operations for the sizing of trunk drainage and stormwater infrastructure. Trunk drainage is traditionally sized to safely manage the "minor" storm event, typically the 10% or 5% AEP event, however in some cases, it may be appropriate to size trunk drainage to include additional capacity, to manage future development or mitigate flood impacts.
  - Overland flow paths are typically sized to handle the "major" storm event, typically the 1% AEP event, in order to manage flood risk and public safety in events where the capacity of the local stormwater network is exceeded. Overland flows are typically directed through developed areas through open space/park areas and via the road network.
- Consideration of safe evacuation and egress routes

    - Design of the TOD areas should consider provisions for safe evacuation or egress from the area to the adjoining local road networks in the event of flooding in rare to extreme flood events. This may require additional fill to mitigate flood risk, consideration of higher levels of flood immunity to the TOD road network for facilitate safe evacuation from potentially flood effected areas, or consideration of additional capacity within the trunk drainage network to manage overland flows.
- On-Site Detention (OSD)
    - On site detention may be required to manage the predicted stormwater peak discharge from the TOD areas and manage flood impacts within the receiving watercourse(s). OSD is typically size in order to manage flows up to and including the 1% AEP event.

7. Summary, Conclusions and Recommendations

This report presents the stormwater and flood risk management strategy for the Bella Vista and Kellyville Precinct, which is part of the Transit Orientated Development (TOD) program. It sets out the stormwater and flood risk management, integrated into the master planning process. Land use changes that result from the rezoning have the potential to alter the existing stormwater quantity and quality, and the flood risk environment. Through assessment of flood risk using flood modelling and stormwater quality, management strategies have been developed in accordance with the requirements of guidelines and Sydney Water as designated Acquisition Authority for land that is identified for Rouse Hill Trunk Drainage Land. Based on the available planning information at the time of this report, it is considered that stormwater and flood risk can be managed in the Bella Vista and Kellyville Precinct Transit Orientated Development precincts, provided the management strategies documented in this report are implemented.

This report was compiled before the issue of the revised version of Australian Rainfall and Runoff Version 4.2 guideline (published 27/08/2024). The climate change matters presented in Australian Rainfall and Runoff Version 4.2 is based on emerging science and has wide ranging implications to the prediction of future flooding as a result of global temperature increases. At the time of this report, the Australian hydrologic community was starting to grapple with the concepts in the revised guideline. The incorporation of this updated Australian Rainfall and Runoff Version, into the current assessment, is under discussion with Department of Planning, Housing and Infrastructure. It is strongly recommended that ensuing planning stages incorporate forecast predicted impacts on rainfall due to global climate temperature increases, and the recommendations under Australian Rainfall and Runoff.

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Appendix A

General Report Maps

Data Disclaimer:
This map has been prepared by GHD for NSW Department of Planning, Housing and Infrastructure (DPHE) and may only be used and relied on by DHPE for the purpose agreed between GHD and DHPE. The mapping must not without the prior written consent of GHD be used or relied on by any other entity or person except as permitted pursuant to the Special Conditions of Contract. GHD otherwise disclaims responsibility to any person other than DHPE arising in connection with this map. GHD also excludes implied warranties and conditions to the extent legally permissible. The services undertaken by GHD in connection with preparing this map were limited to those specifically detailed in the report and are subject to the assumptions clarifications and scope limitations set out in the report. The map is based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this map to account for events or changes occurring subsequent to the date that the report was prepared. GHD disclaims liability arising from any of the assumptions being incorrect. GHD has prepared this map based on information provided by DHPE and others (including Government authorities) which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information including errors and omissions in the map or report which were caused by errors or omissions in that information.

Paper Size ISO A3

0 200 400 600 800 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

RAFTS Catchments with TOD areas

Project No.	12640113
Revision No.	0
Date	4/11/2024

FIGURE A001

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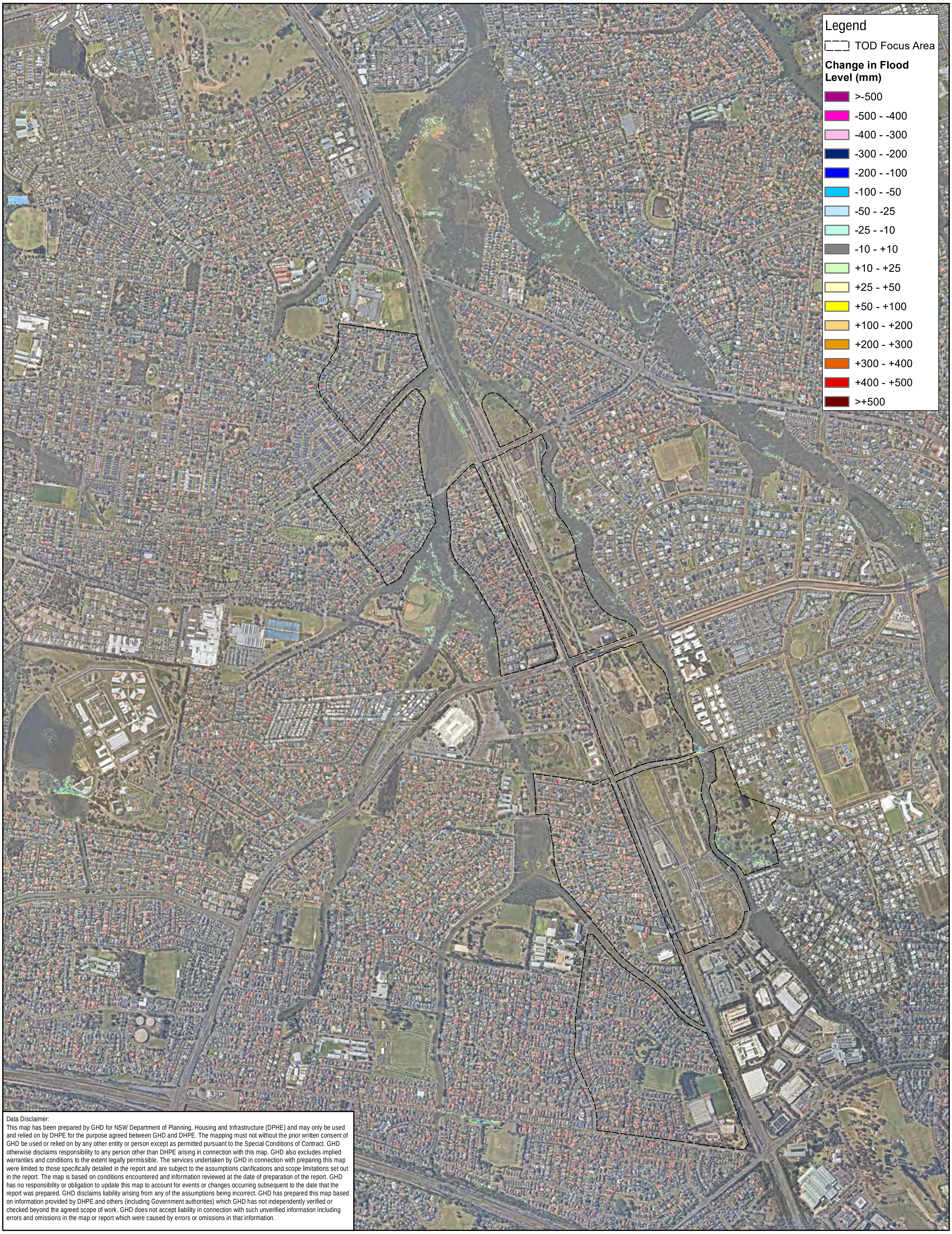
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

Change in Flood Level
GHD TUFLOW 2013 ARR 1987
minus JACOBS - 1% AEP 120 min

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure A002

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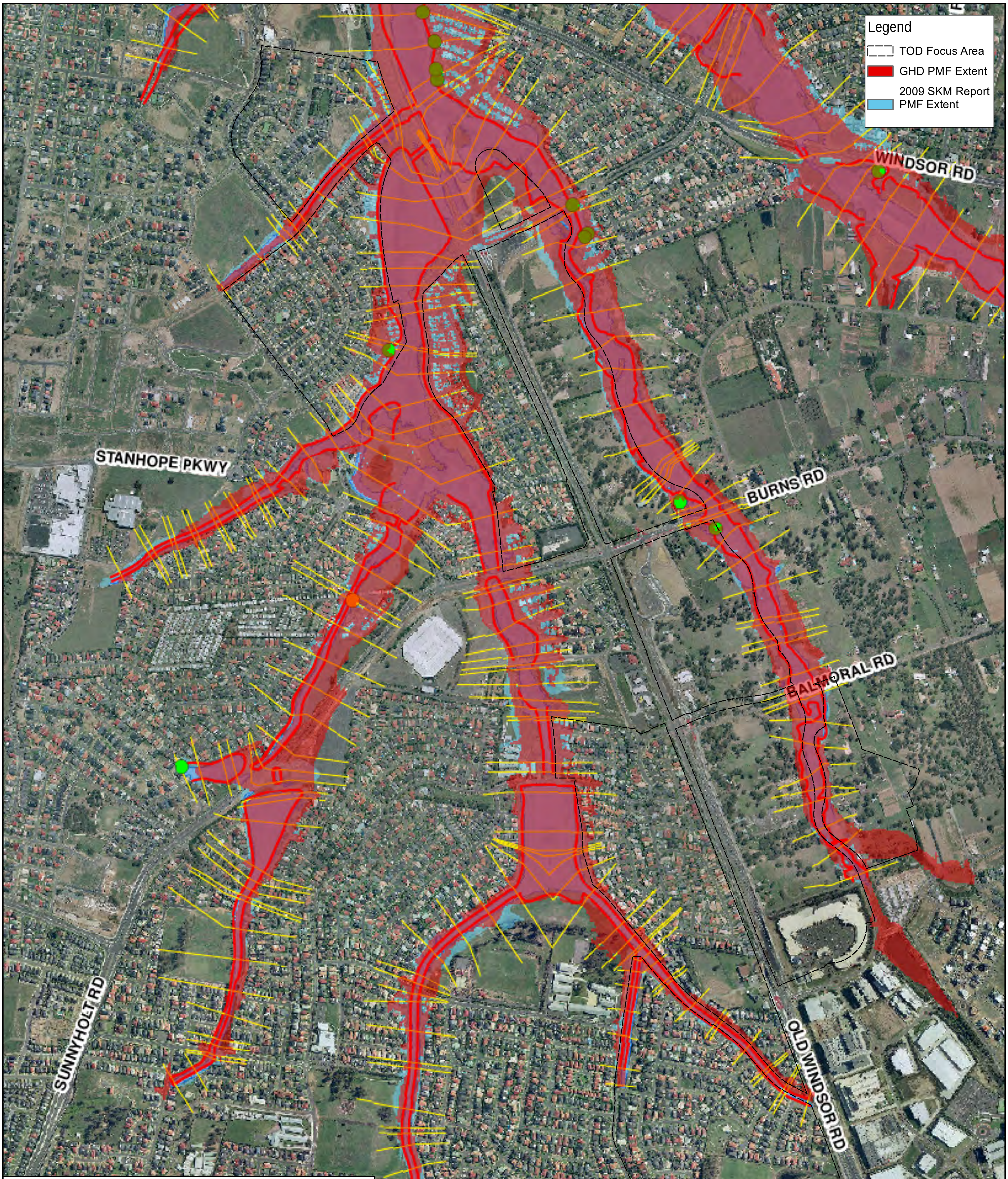
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres
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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

GHD PMF Flood Extent Overlayed on
2009 SKM Rouse Hill Stormwater Combined Report
PMF Flood Extent

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE A003

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Print date: 4/11/2024

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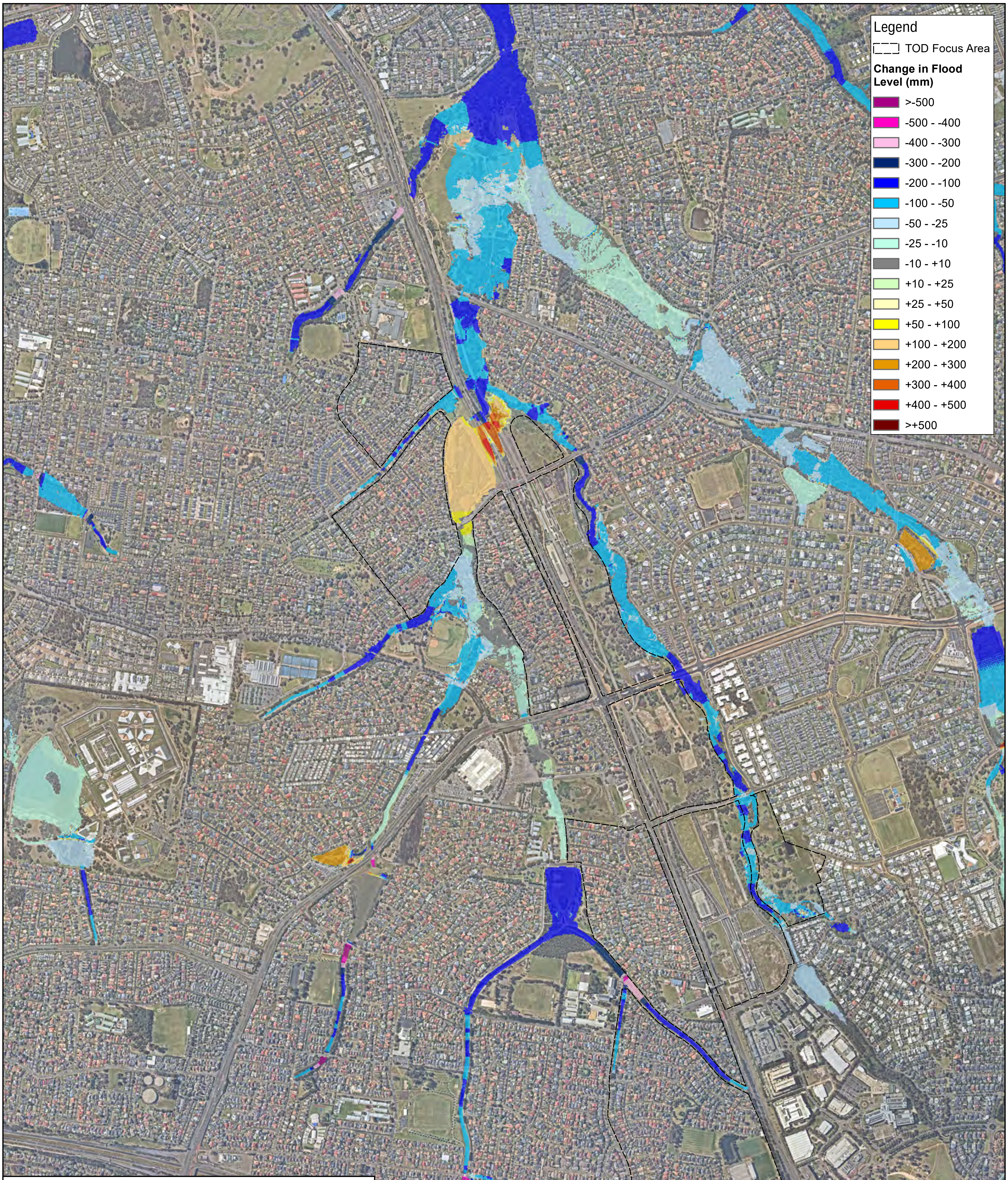

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

Change in Flood Level
GHD V06 TUFLOW 2023 ARR 2019 (Max-Median)
minus JACOBS - 1% AEP

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure A004

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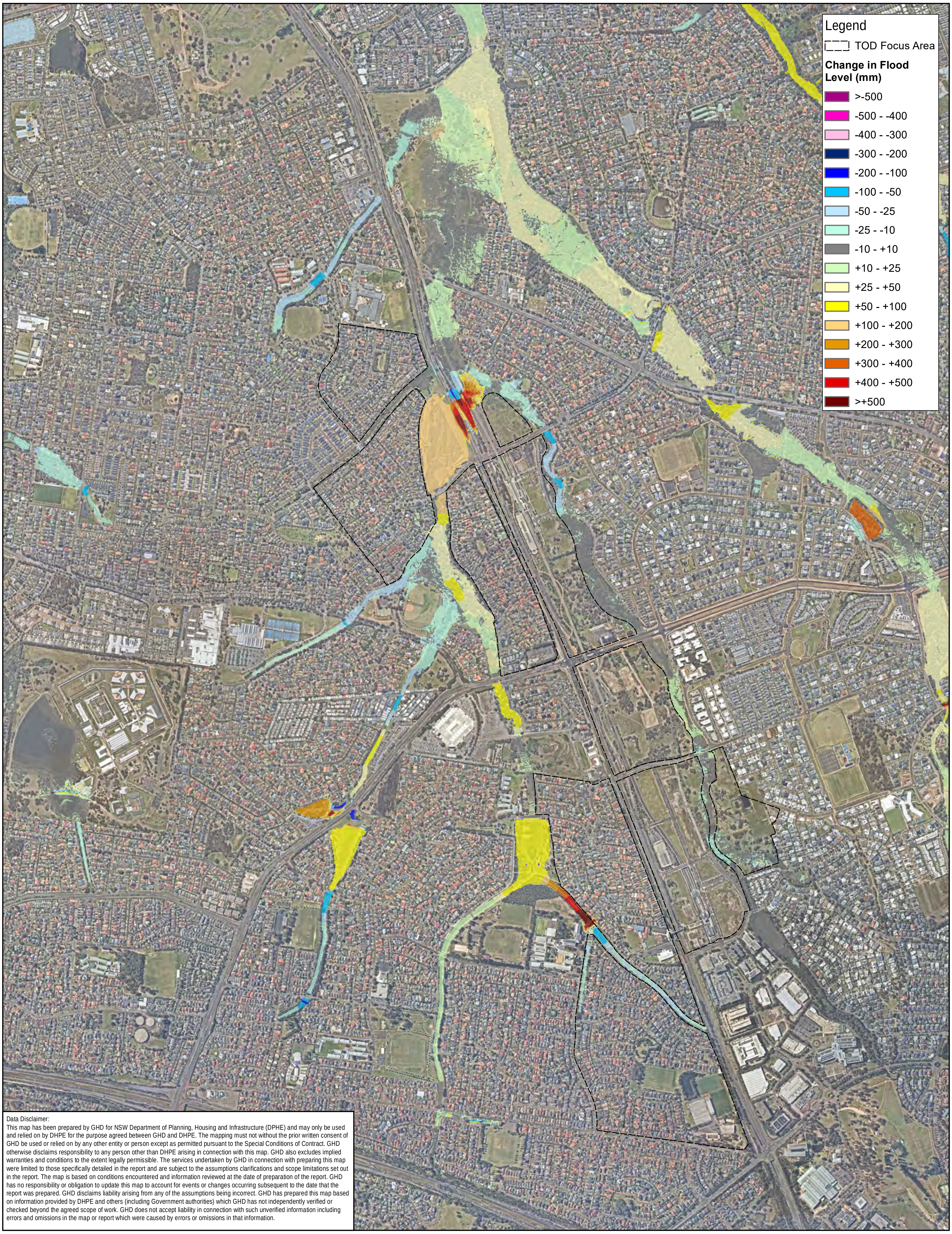
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

Change in Flood Level
GHD V06 TUFLOW 2023 ARR 2019 (Max-Max)
minus JACOBS - 1% AEP

Project No.	12640113
Revision No.	0
Date	4/11/2024

Figure A005

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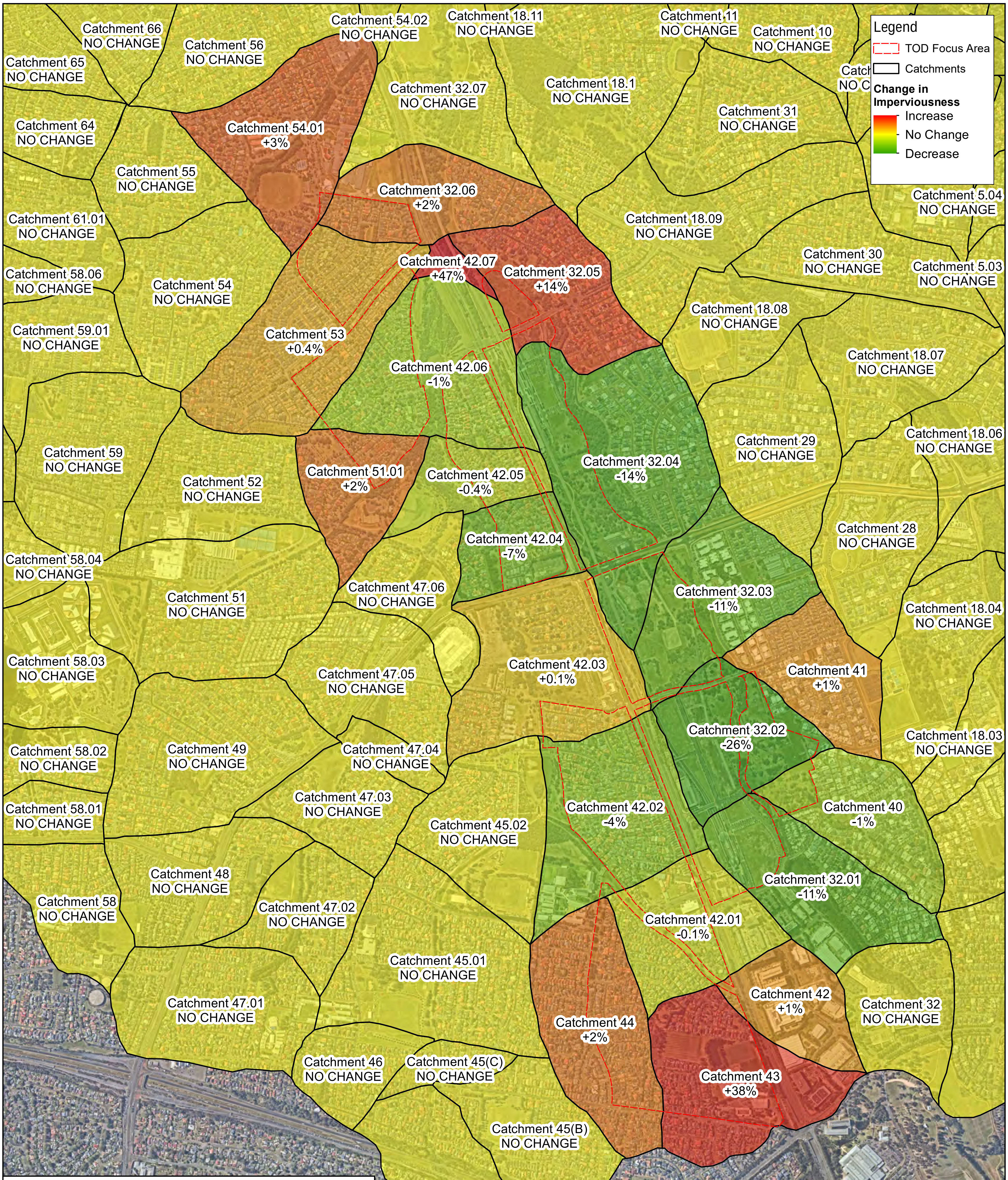
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

Change in Imperviousness (TOD Rezoning)

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE A006

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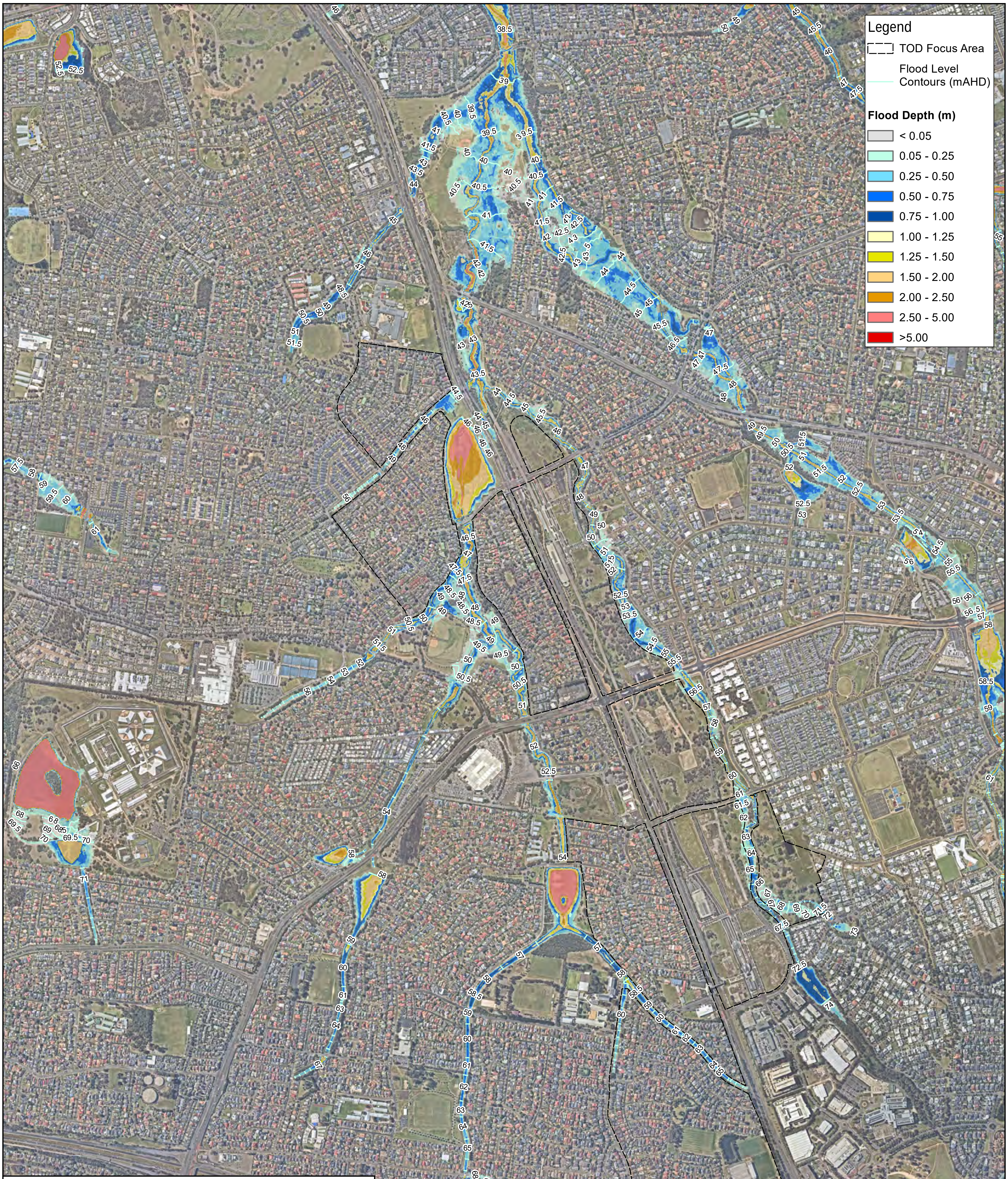
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4

Appendix B

Baseline Flood Mapping



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B001

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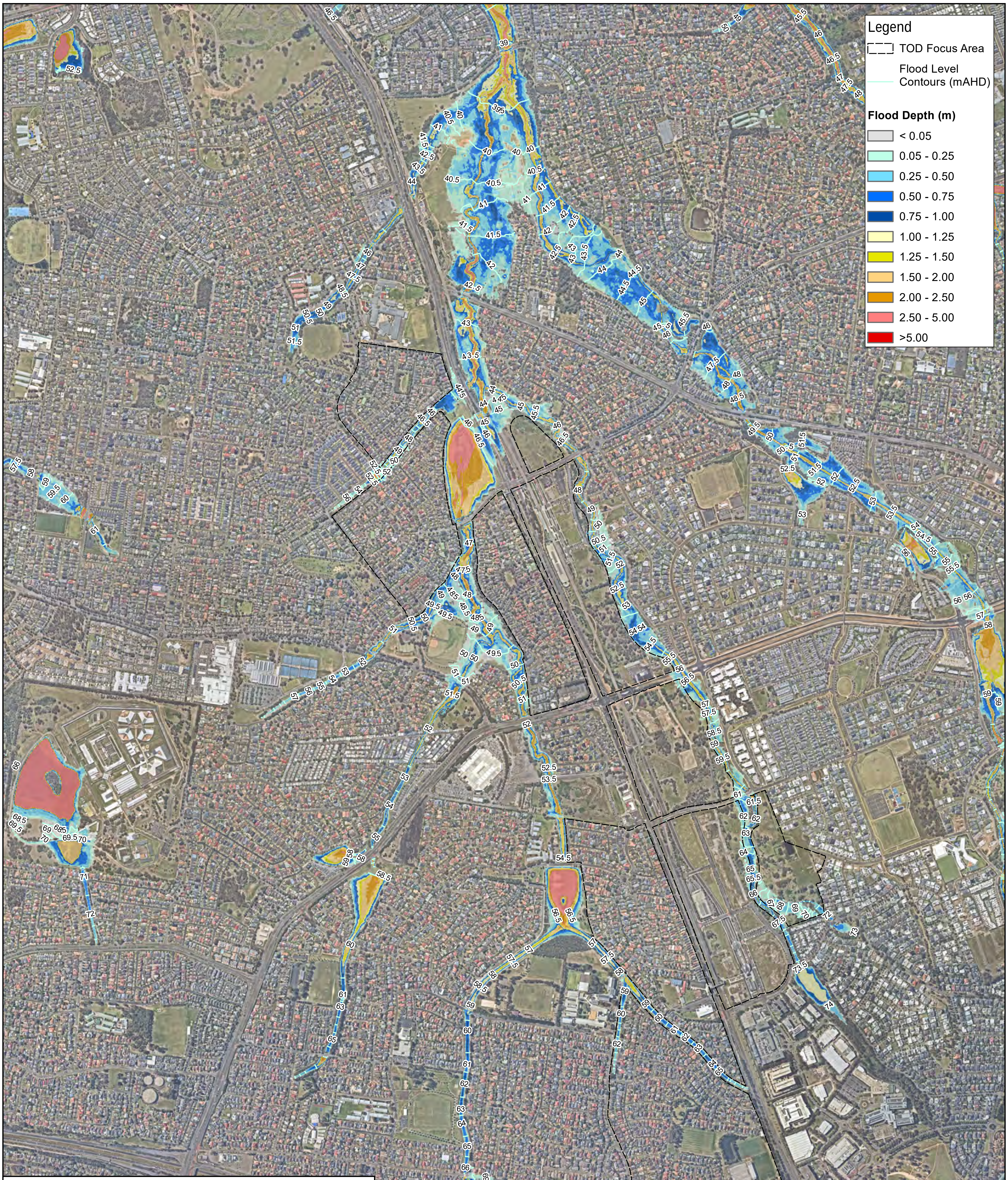
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B002

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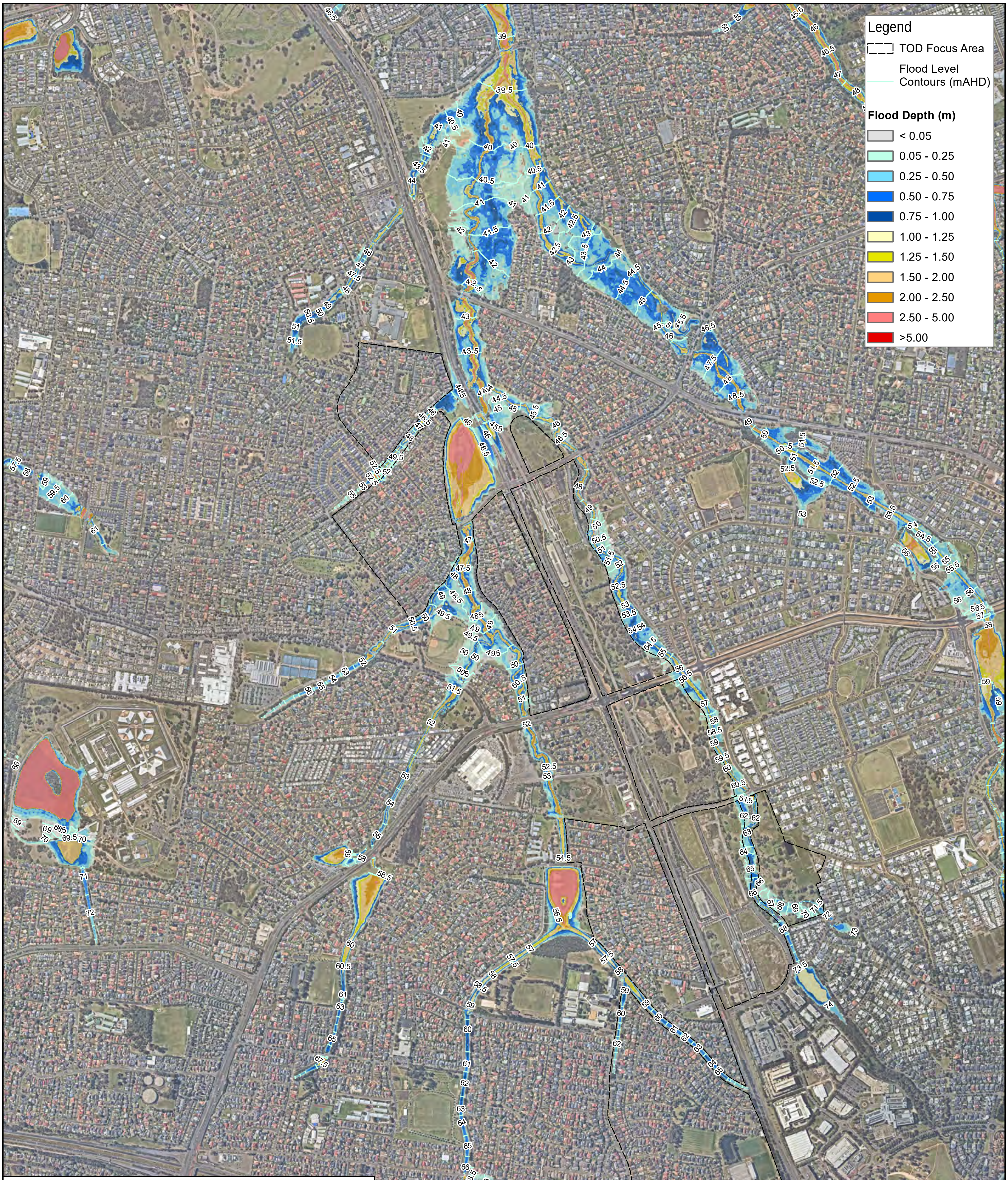

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B003

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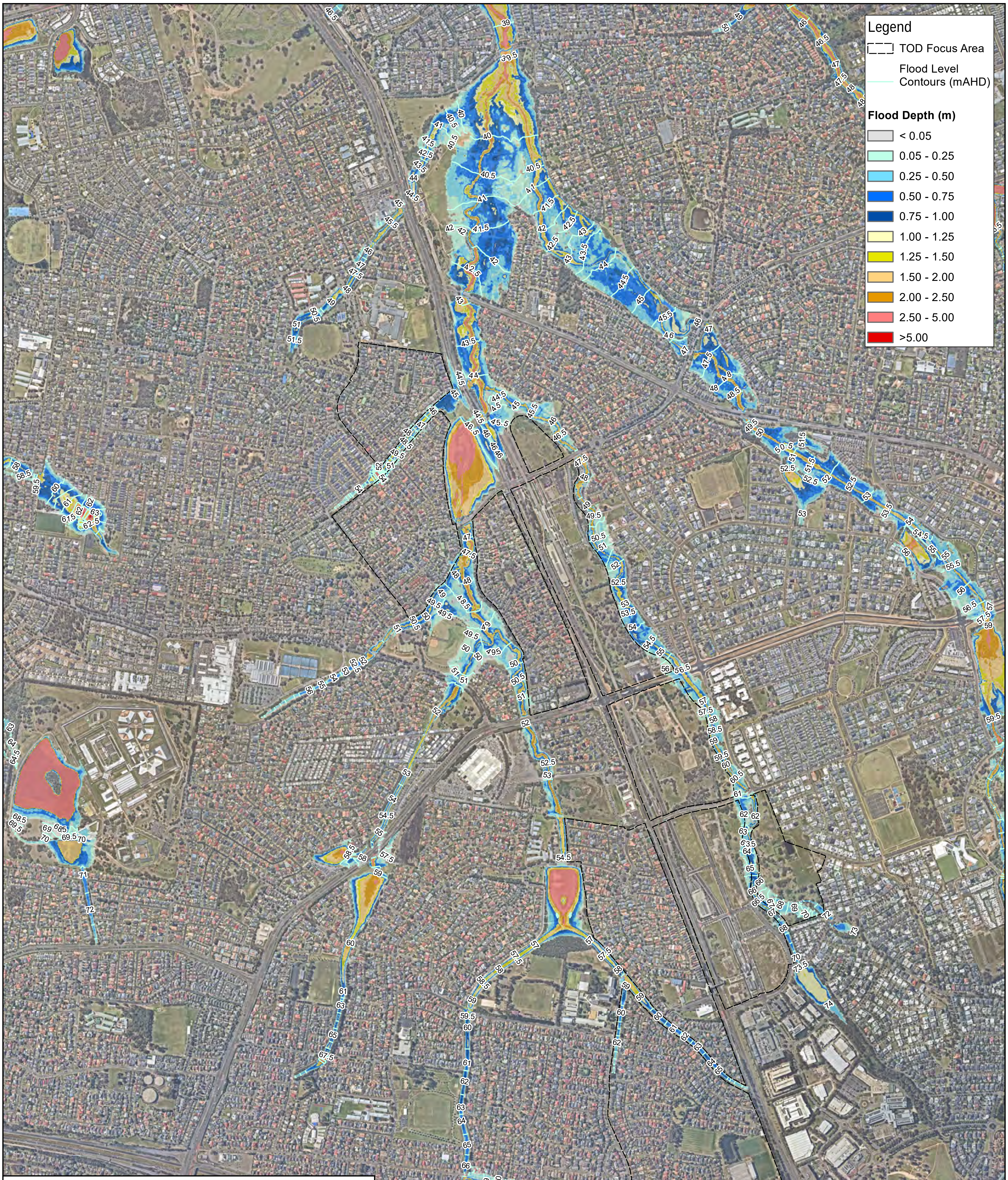
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B004

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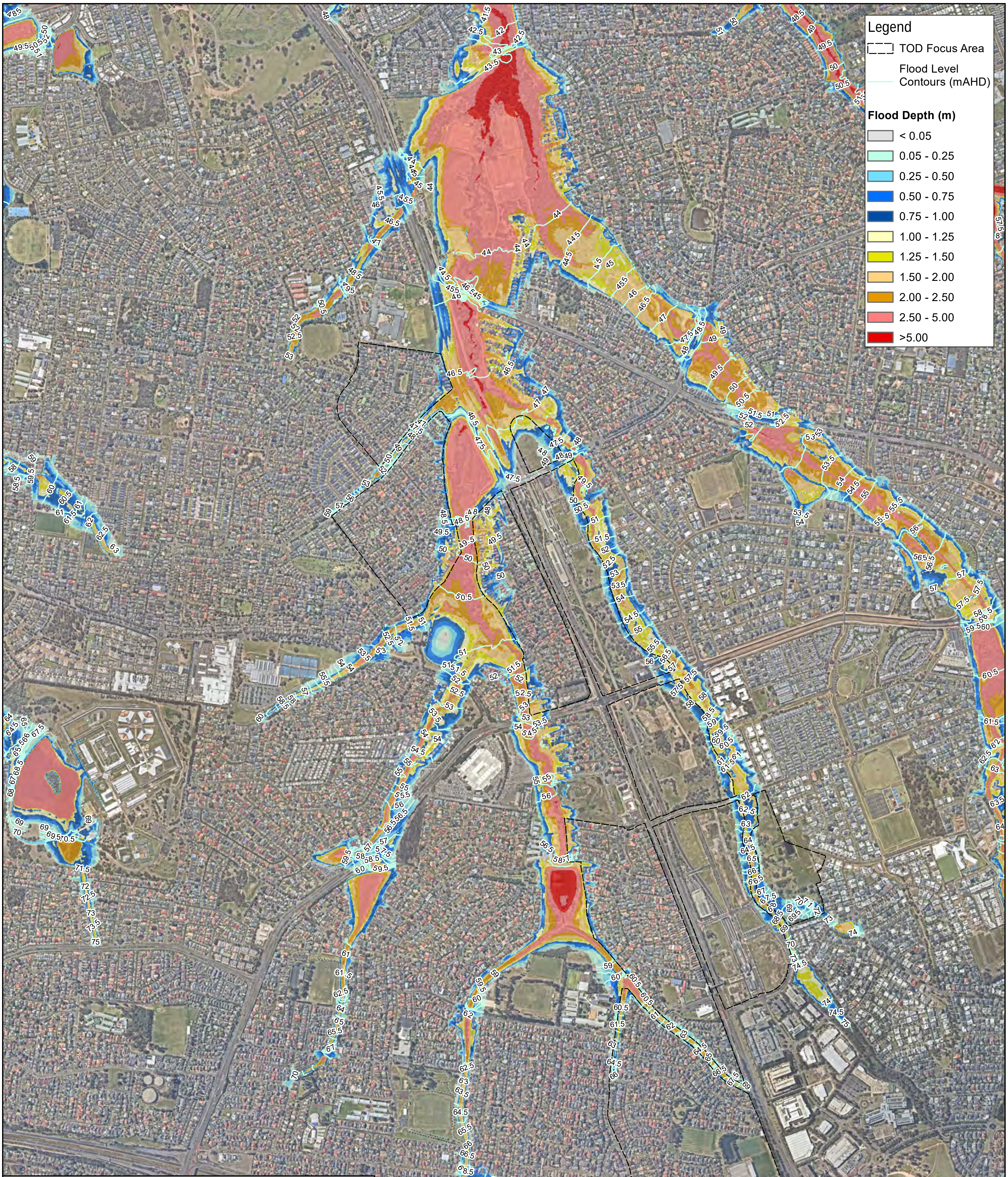
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario
Flood Depth and Flood Level Contours
Max-Max

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B005

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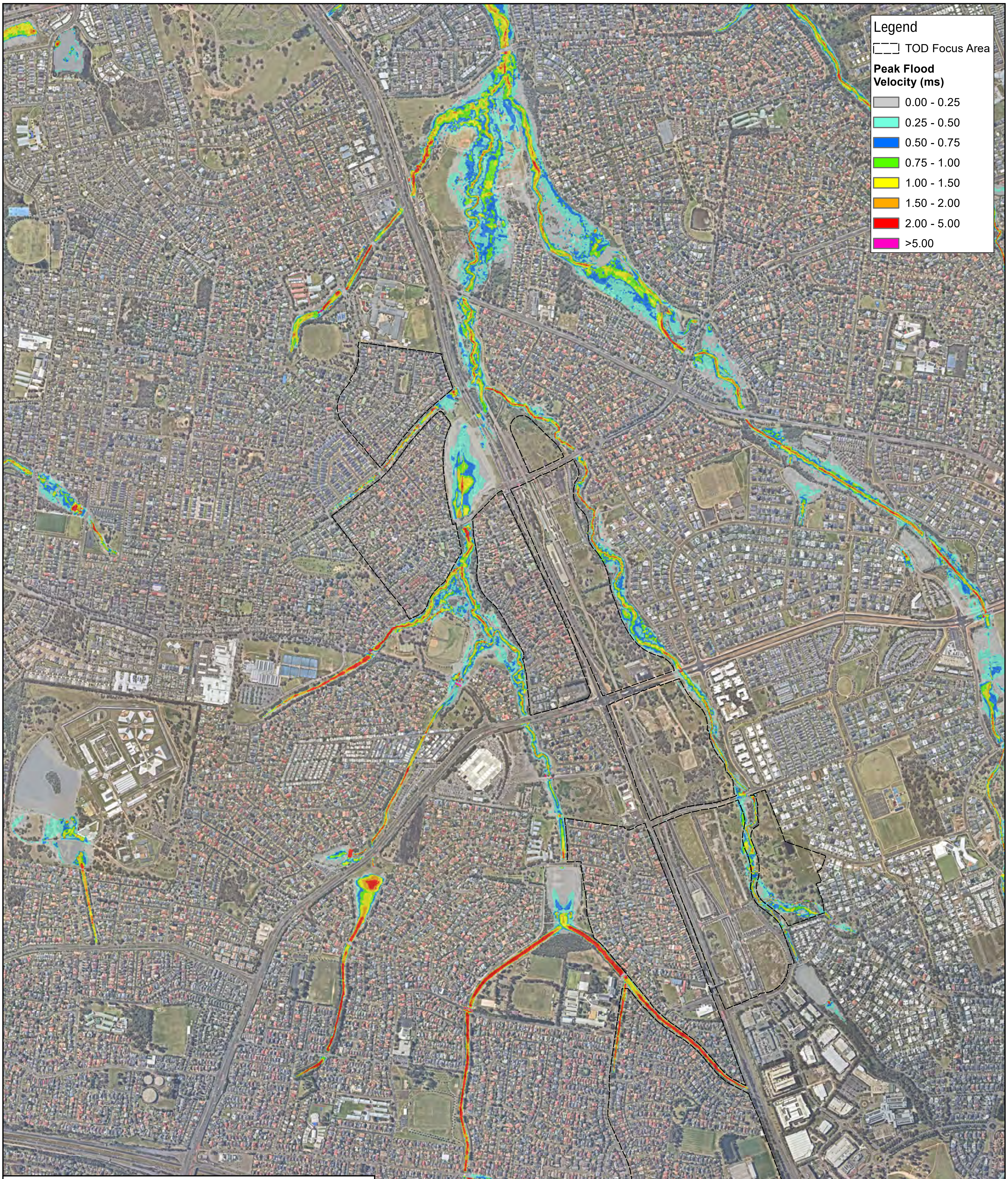
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B006

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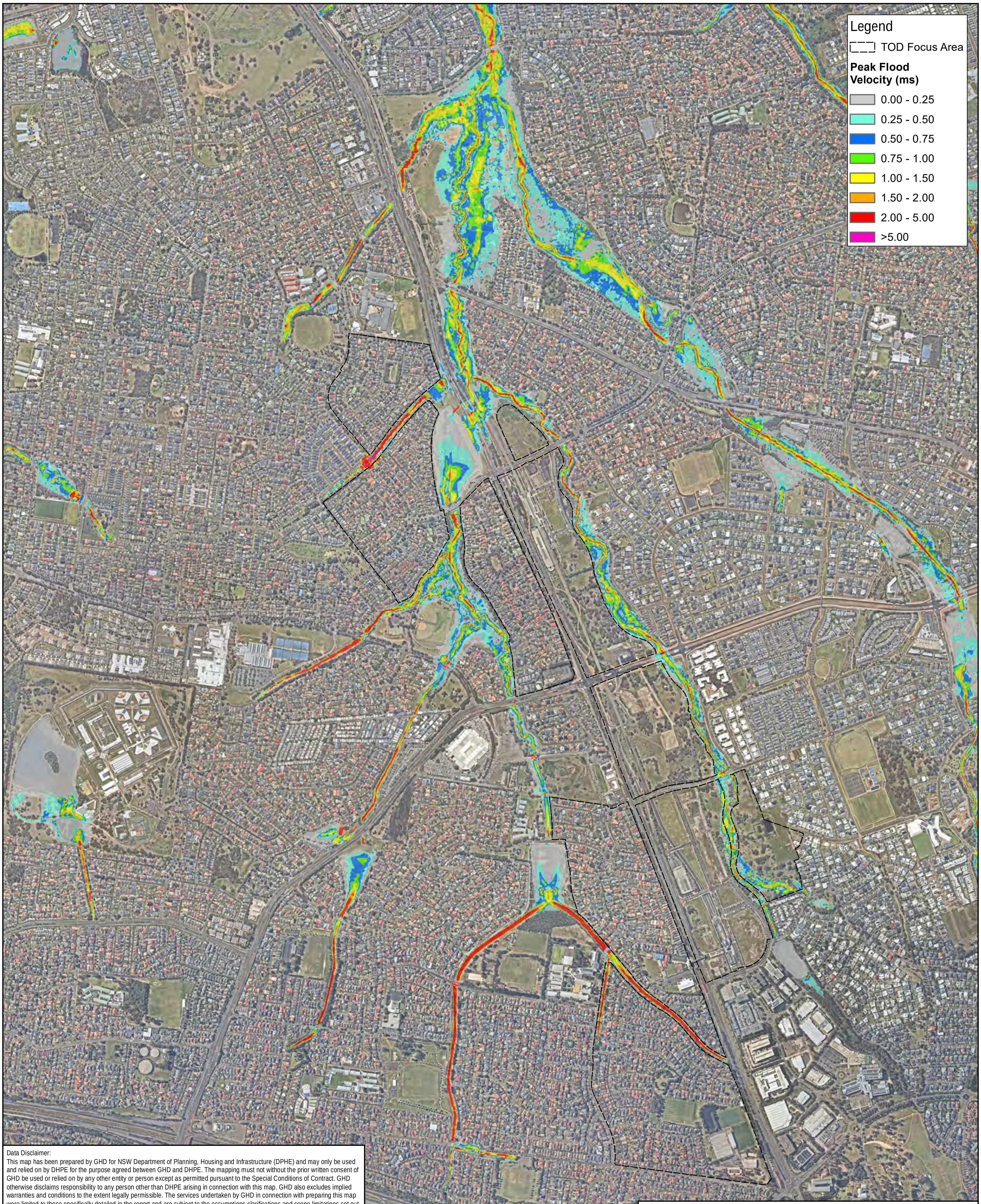

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B007

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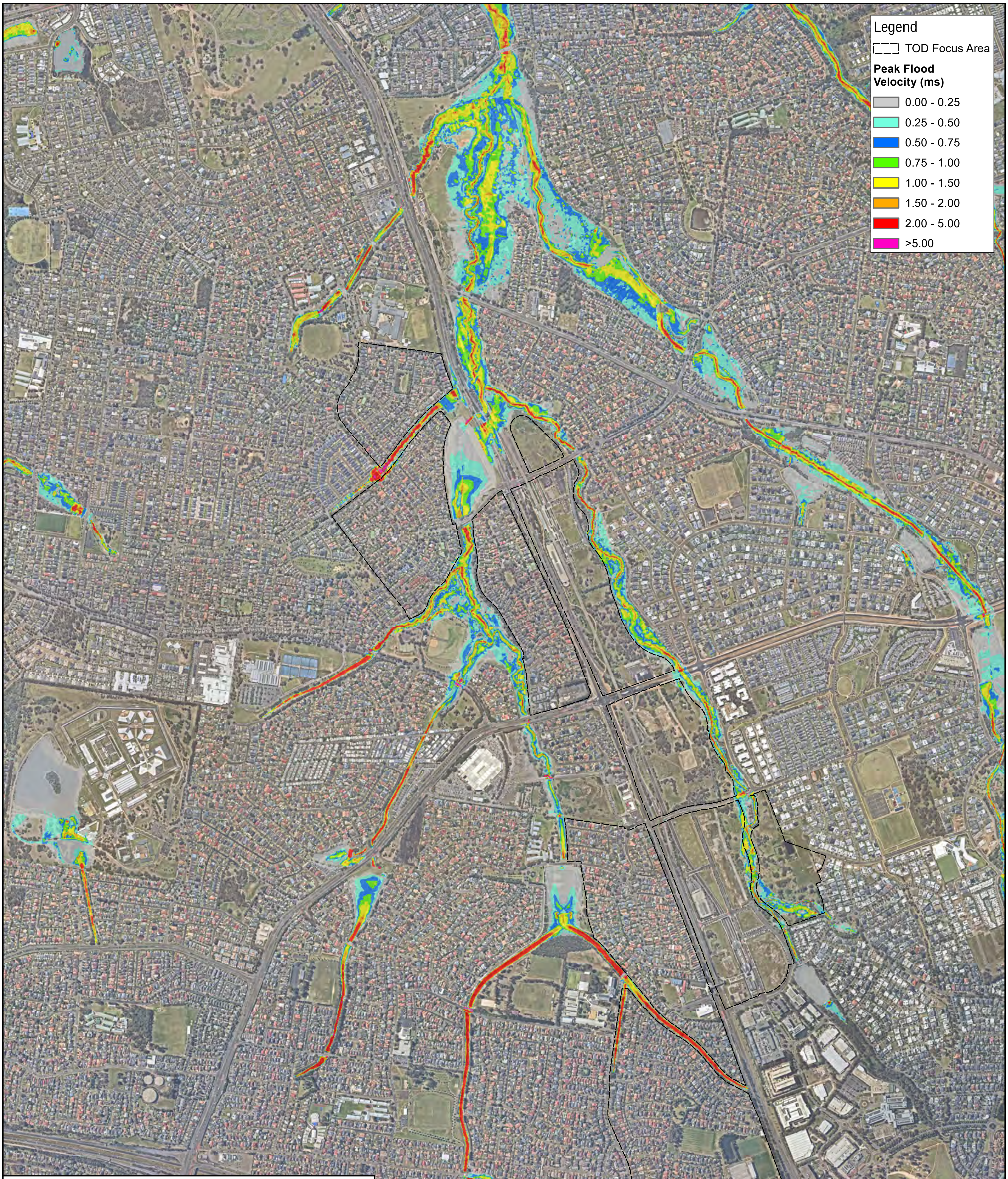

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B008

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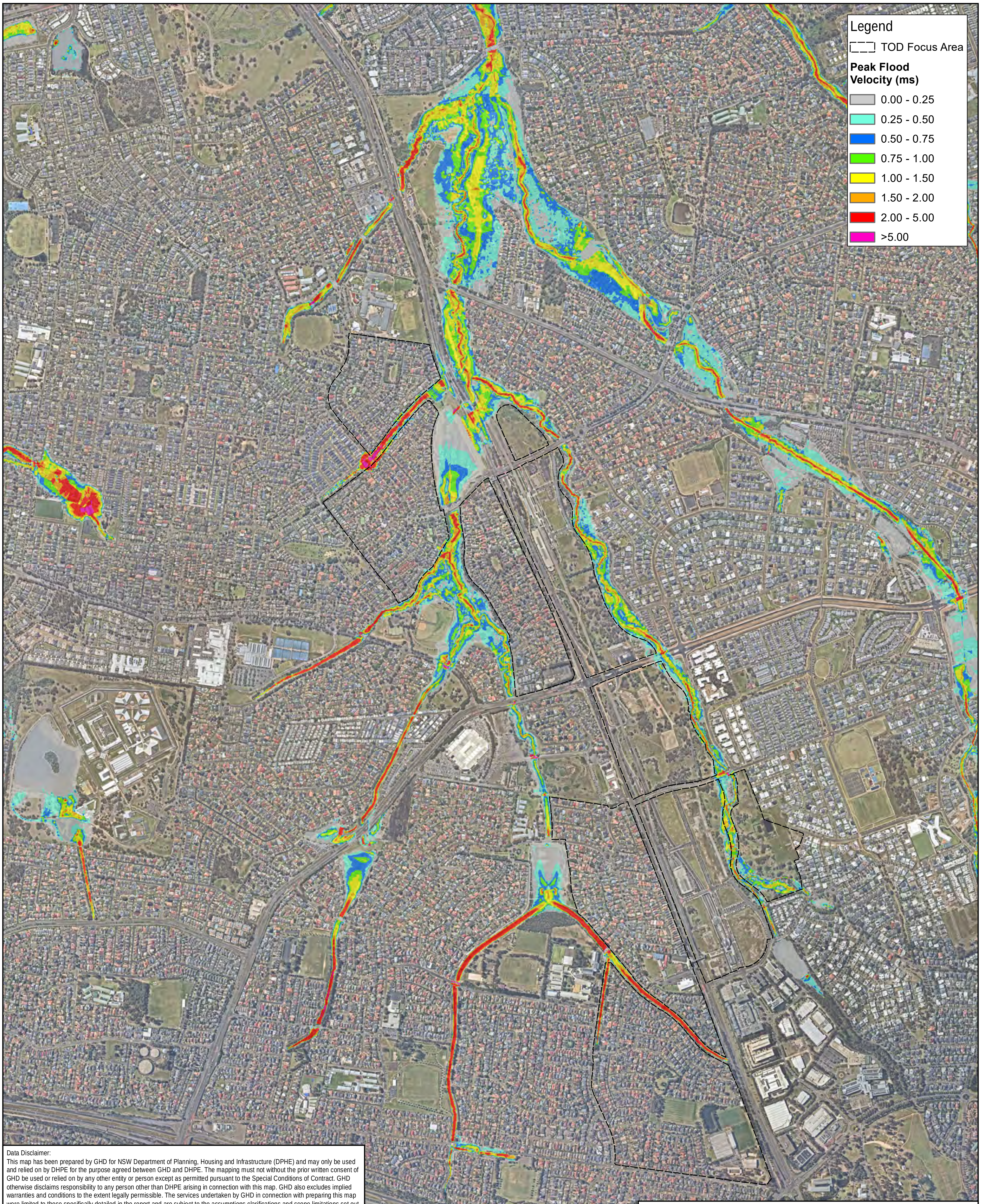
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B009

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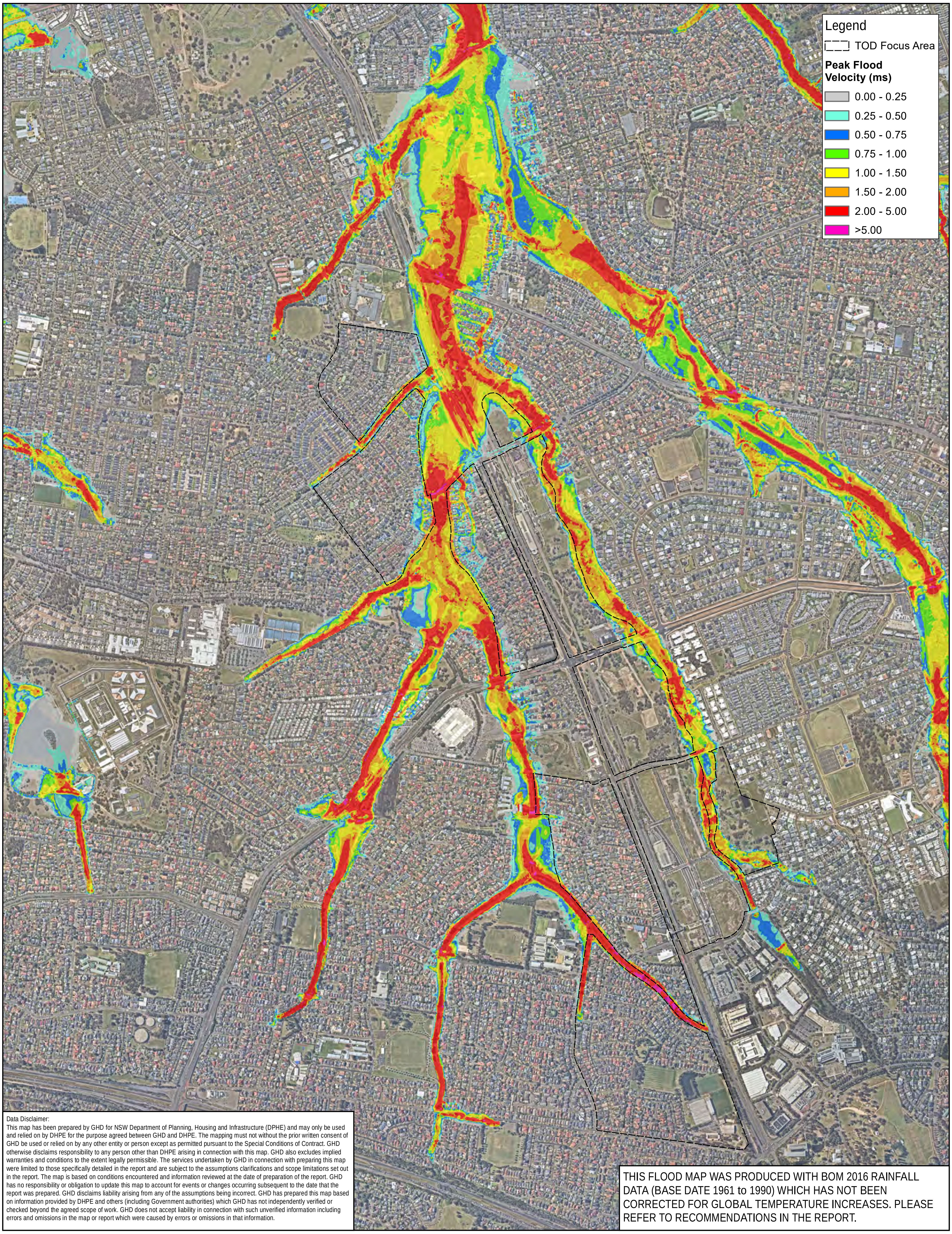
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario

Flood Velocity (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B010

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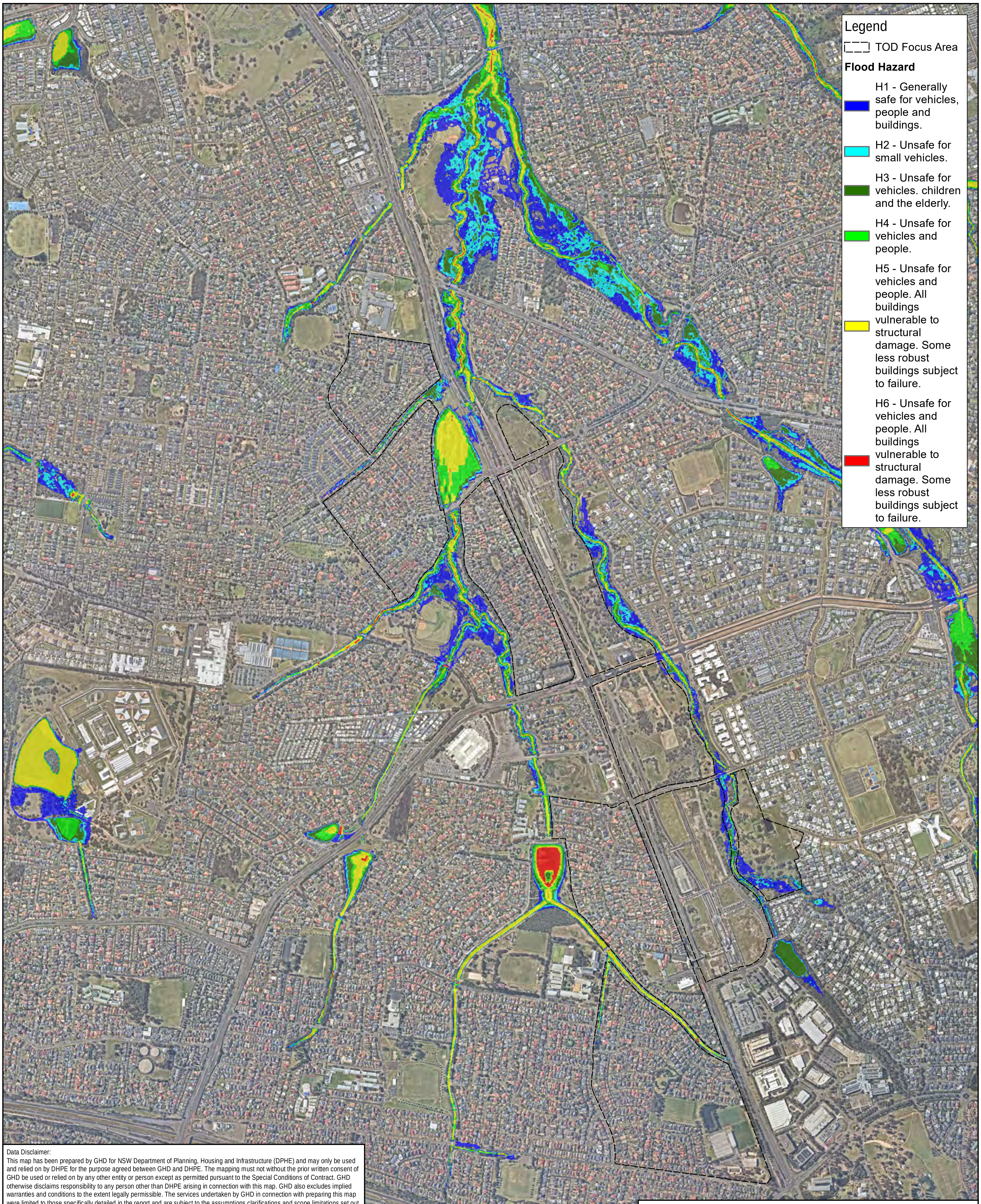
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B011

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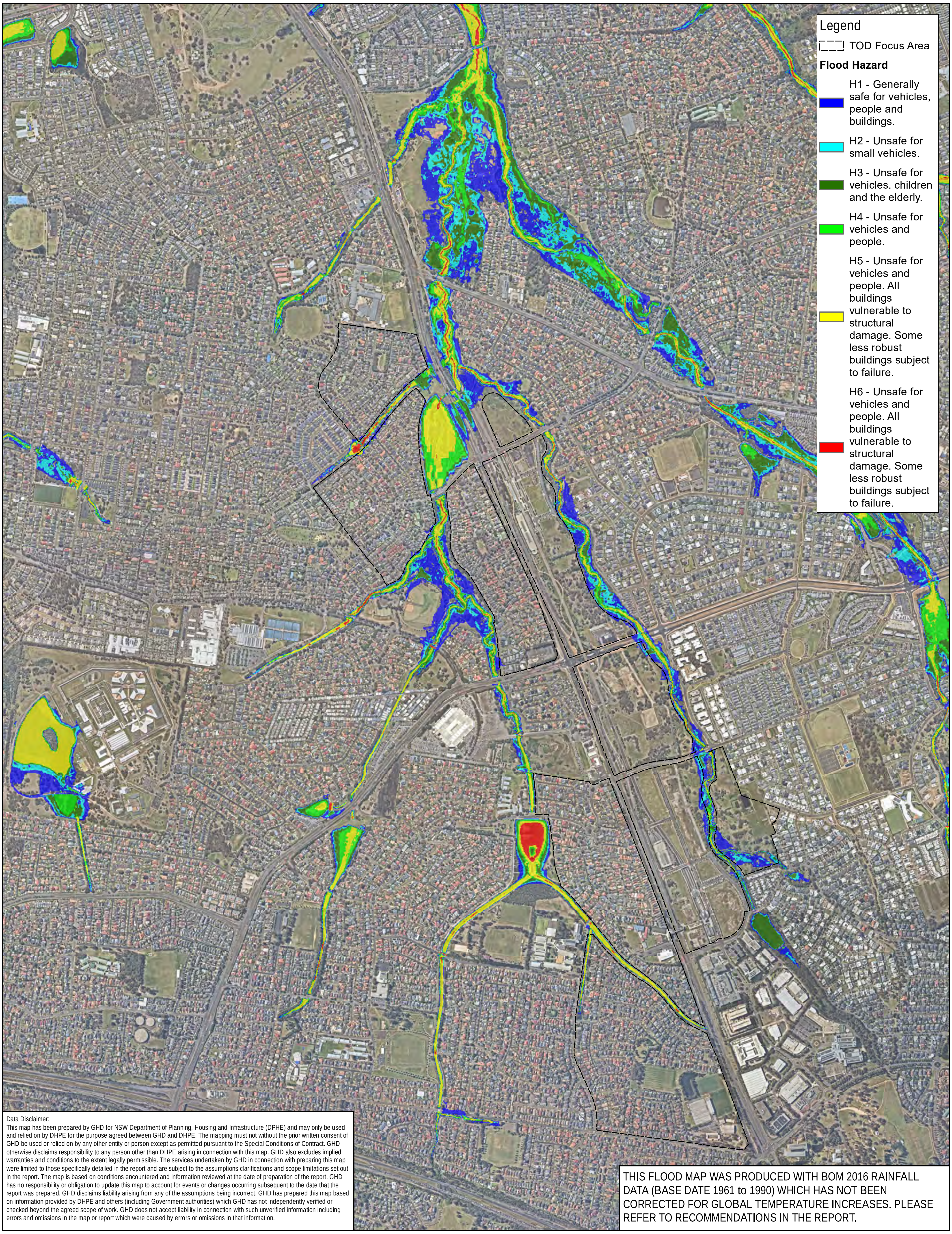
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B012

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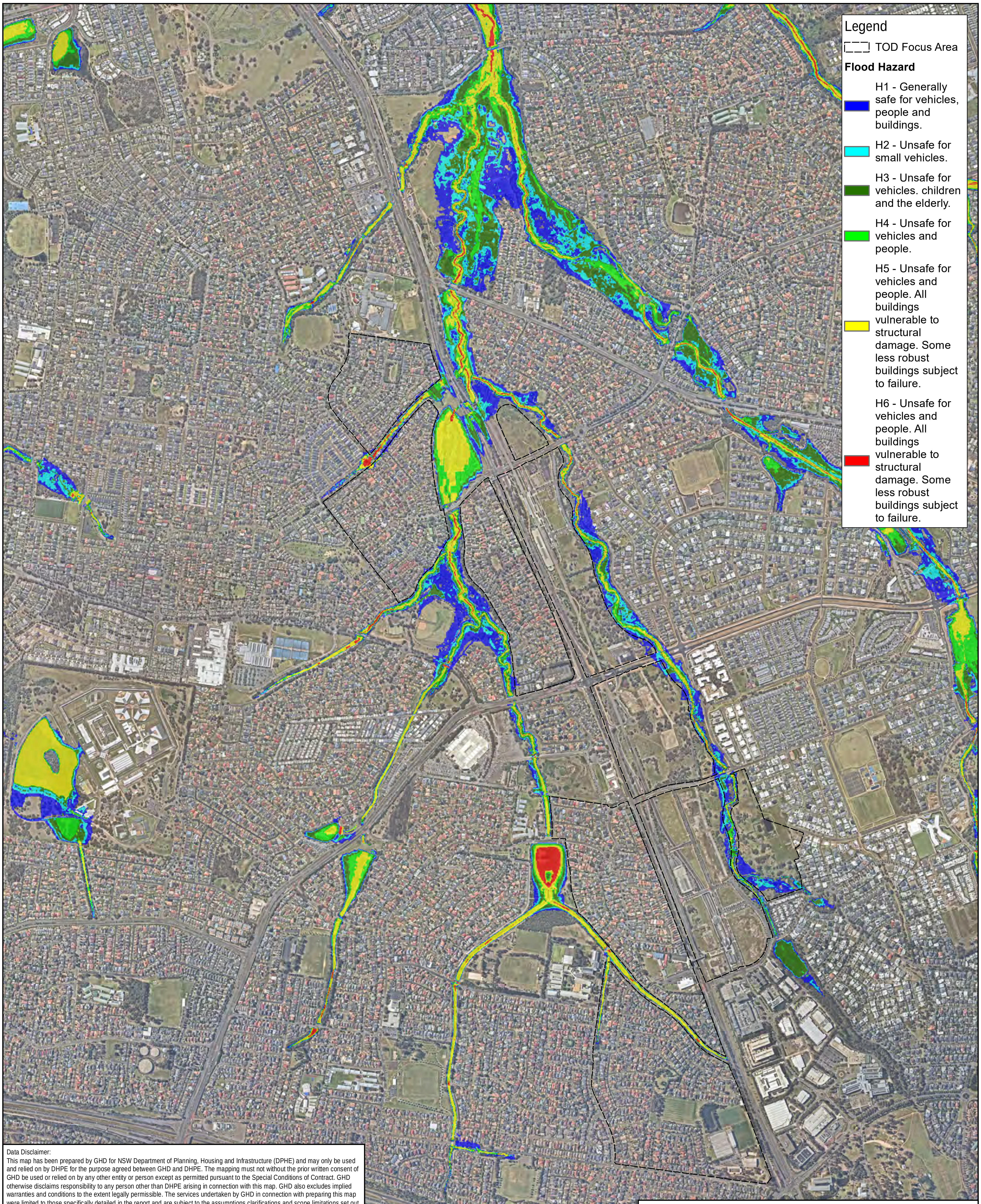

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B013

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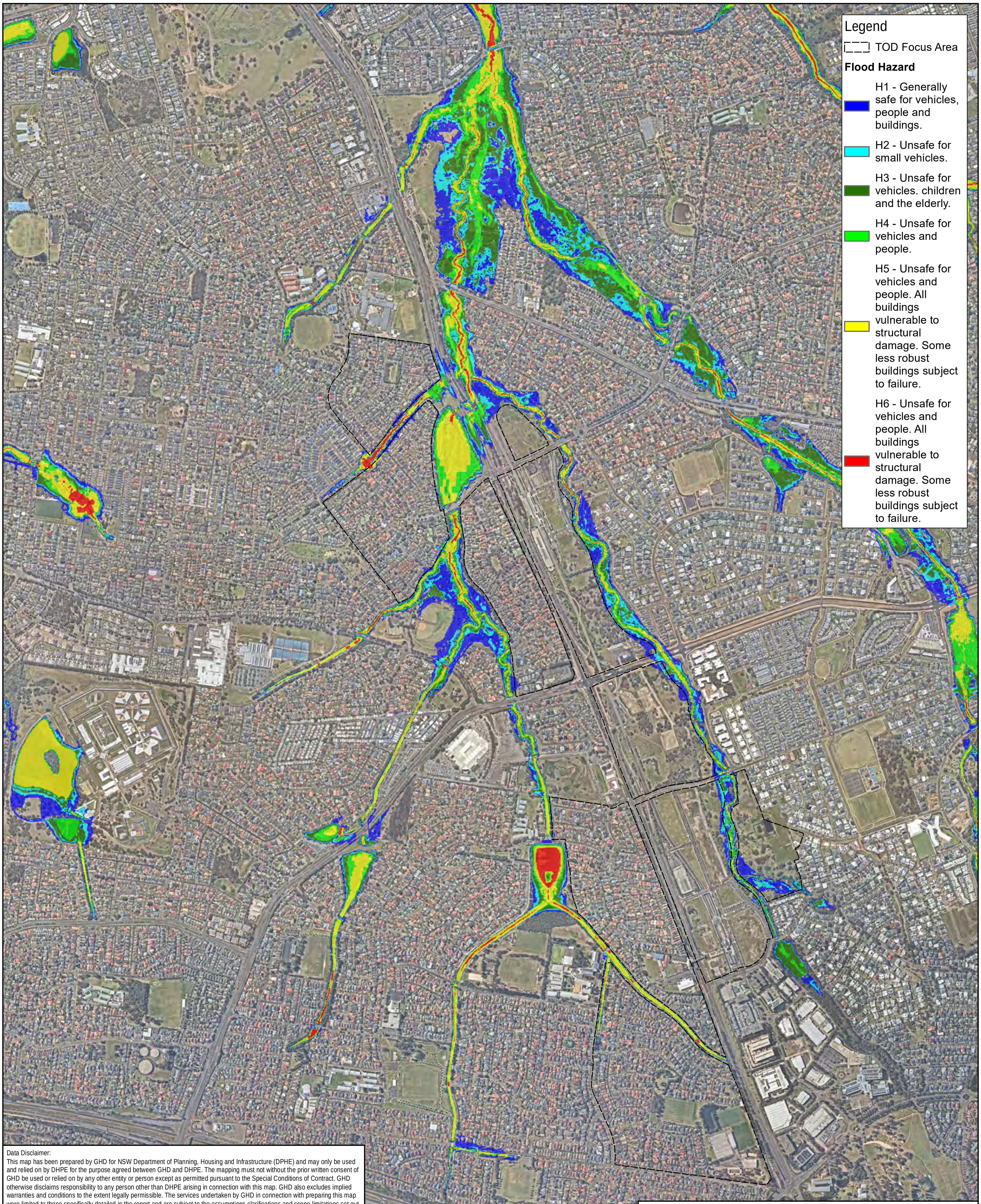

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B014

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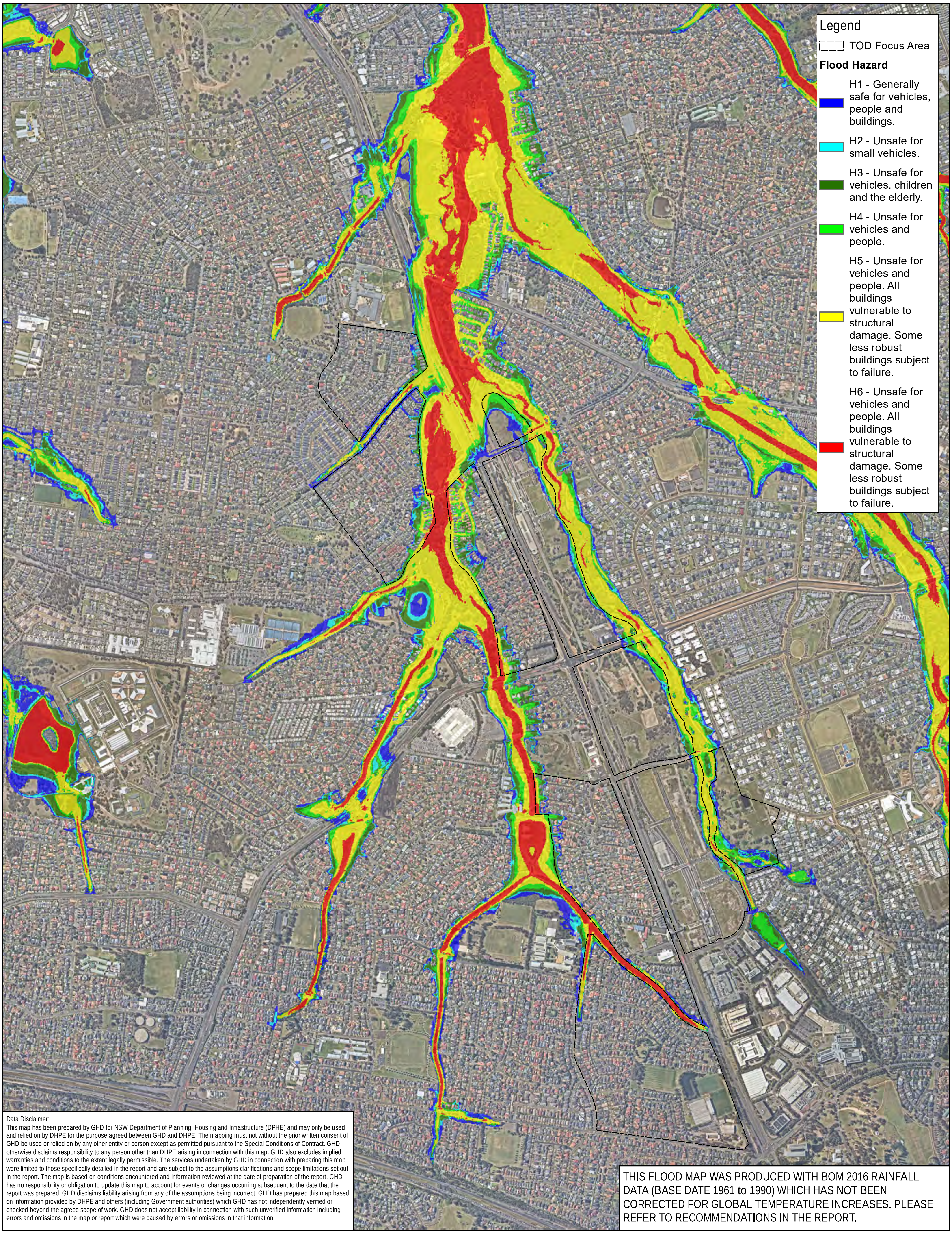

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario

Flood Hazard (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B015

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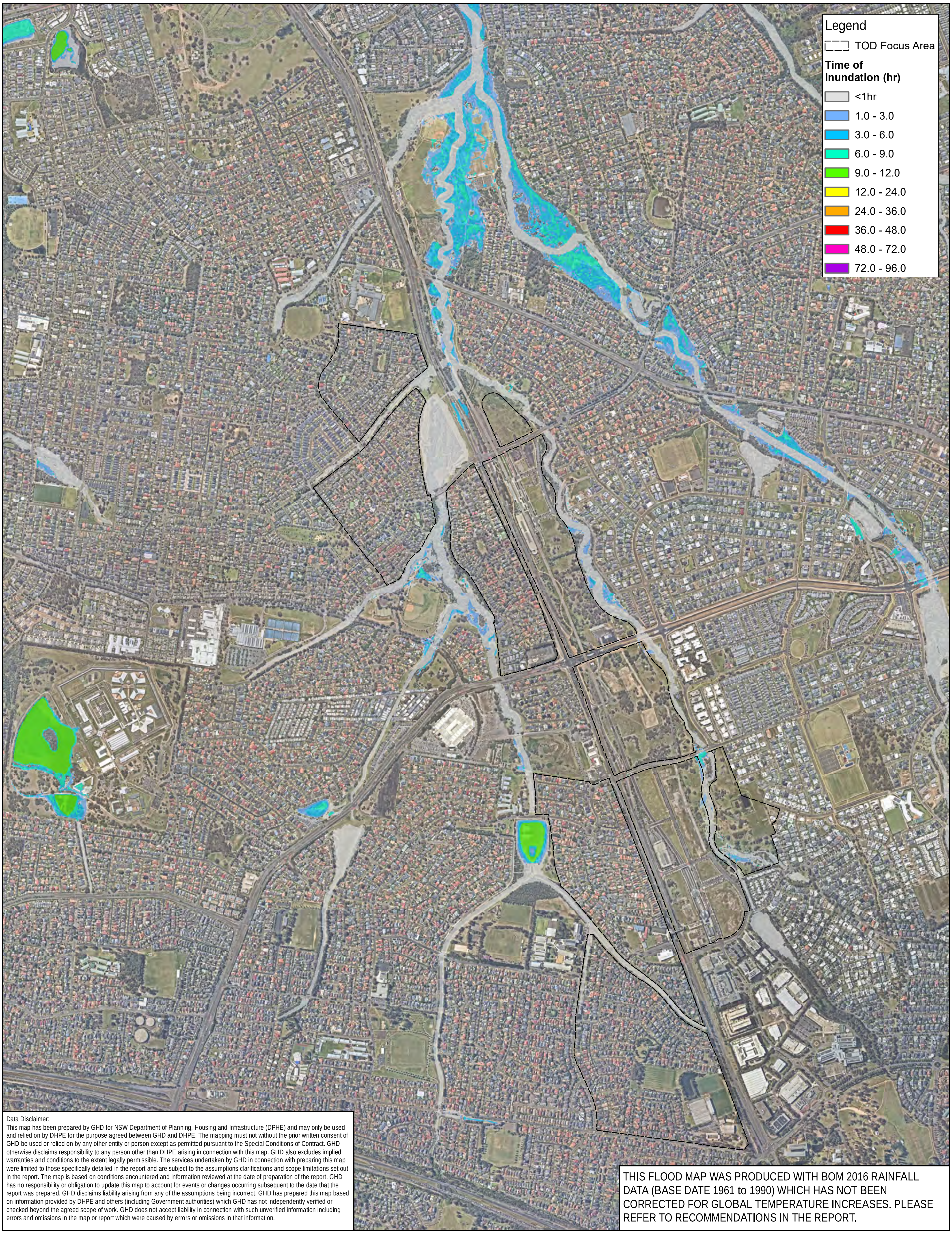
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B016

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Print date: 4/11/2024

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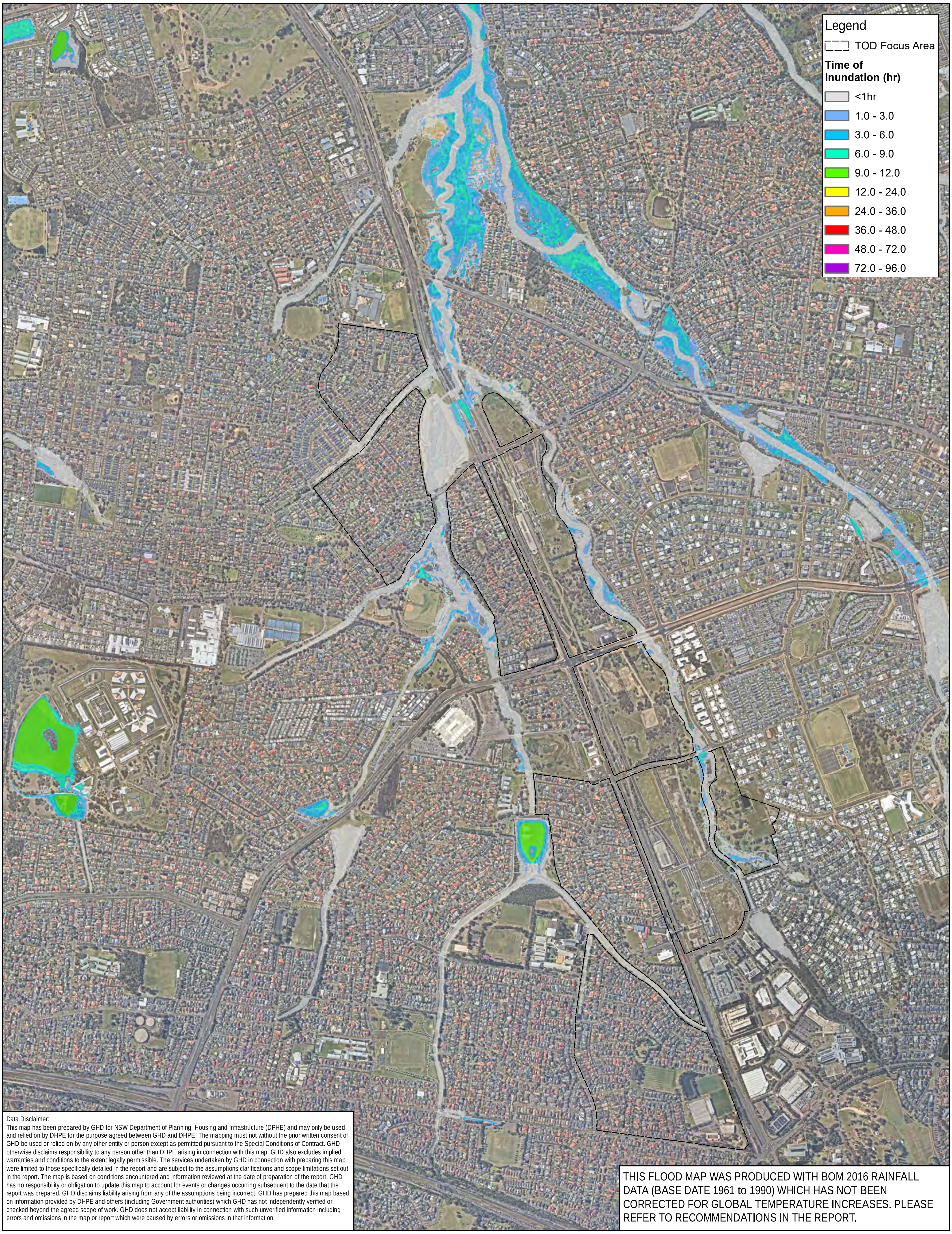

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B017

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Print date: 4/11/2024

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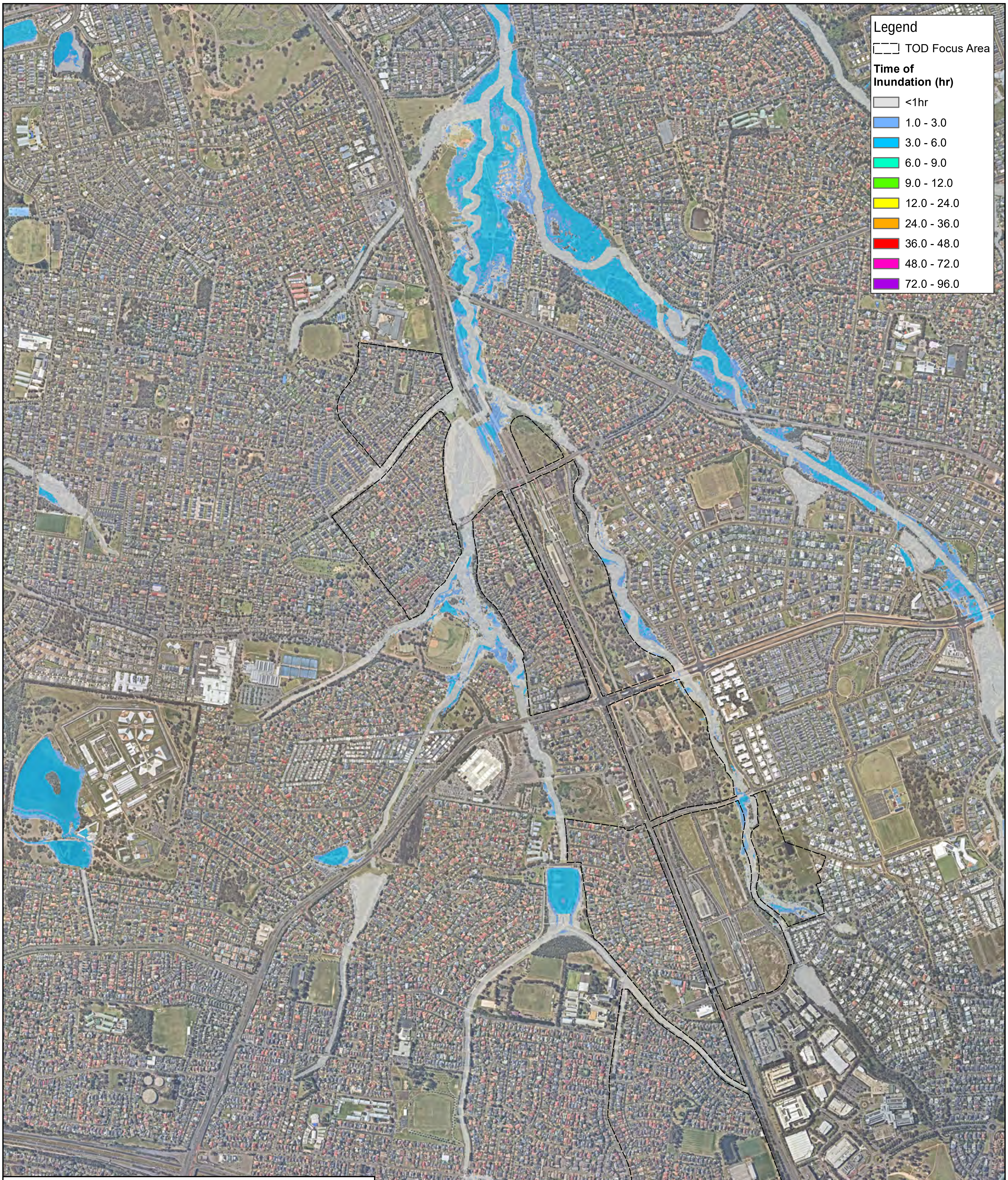

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

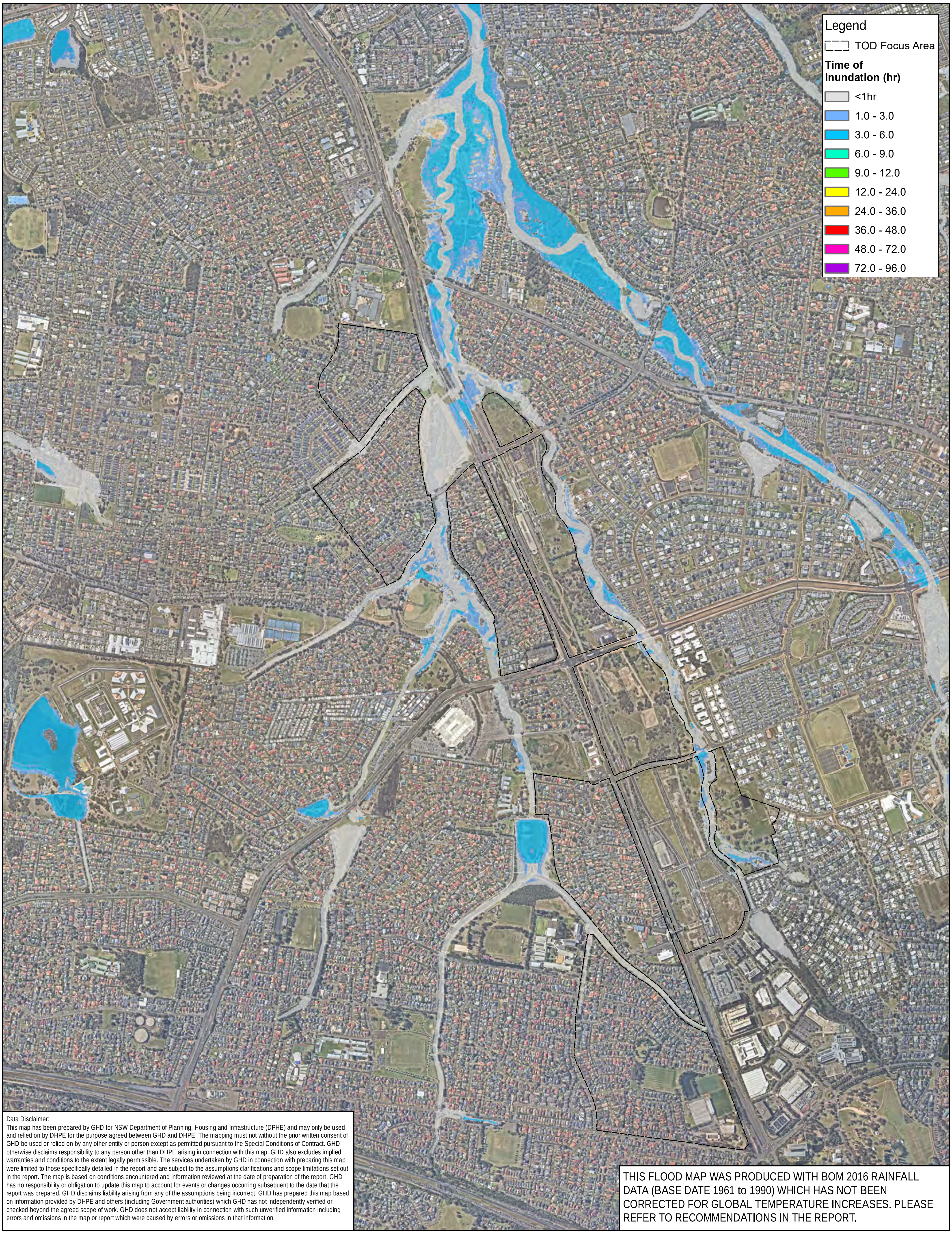
NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario

Time of Inundation (Max-Median)

Project No.	12640113
Revision No.	0
Date	4/11/2024

Figure B018



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

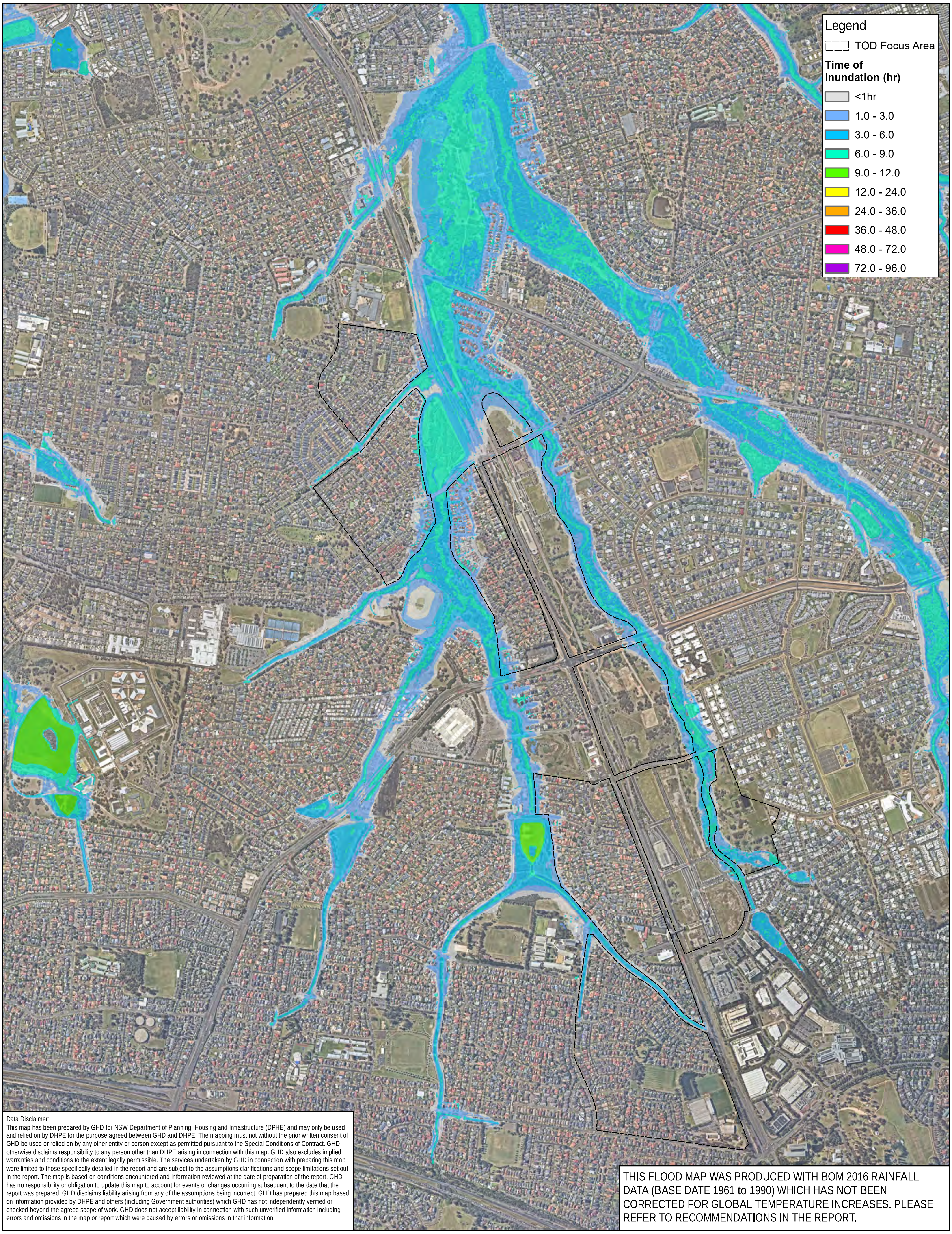
NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B019



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario

Time of Inundation (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure B020

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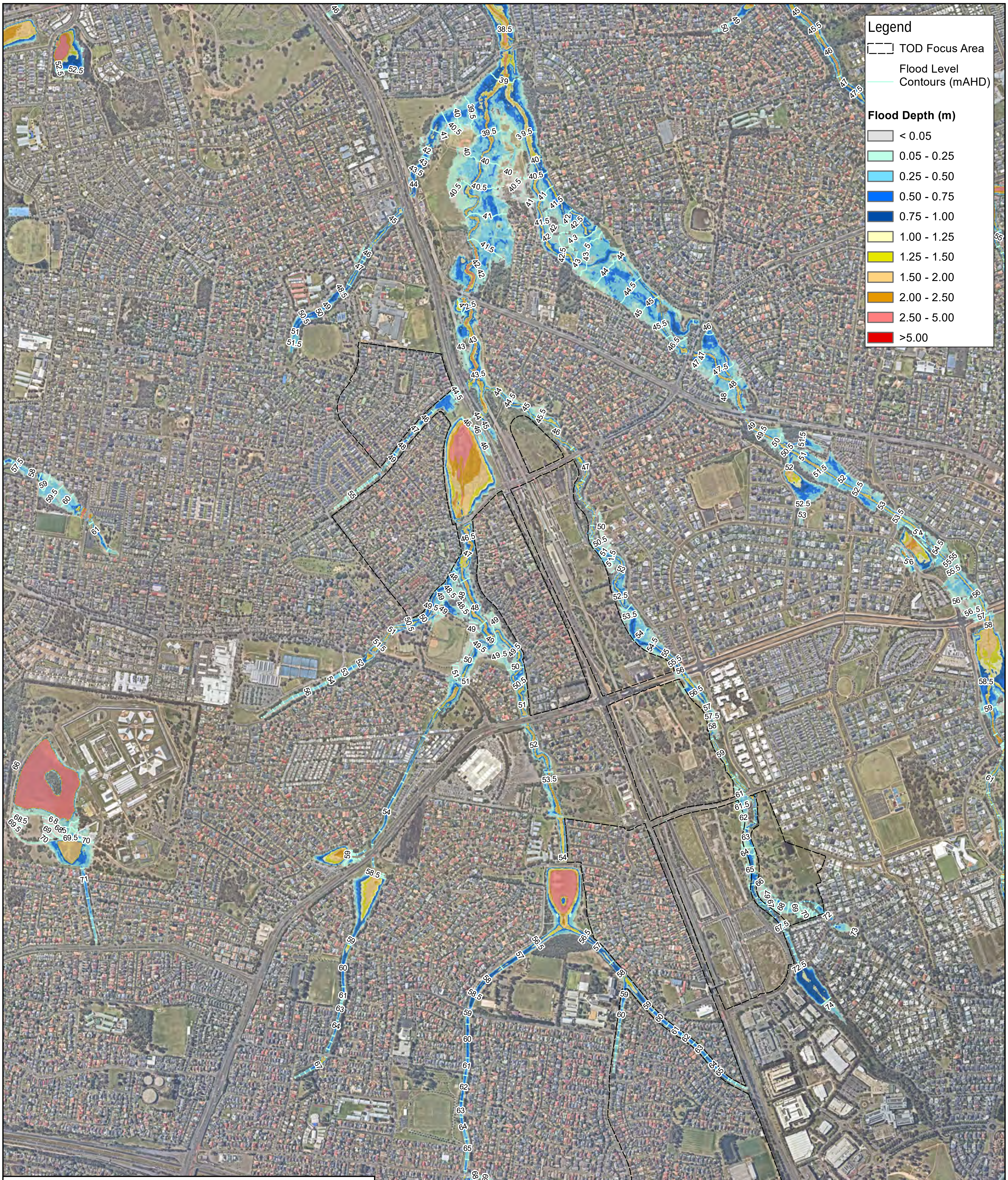
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4

Appendix C

Baseline with TOD Flood Mapping



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0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

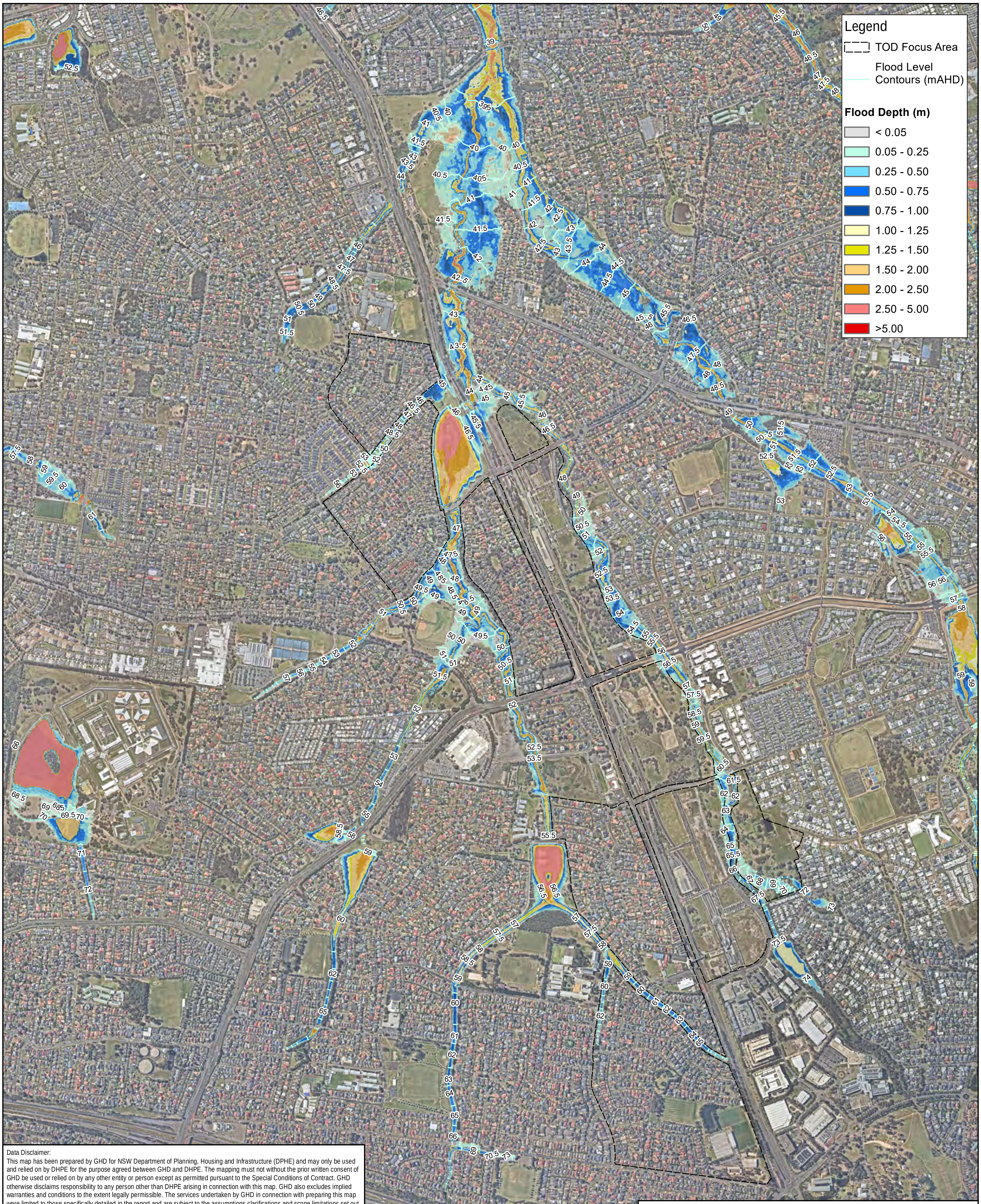
N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario with TOD
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C001



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario with TOD
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C002

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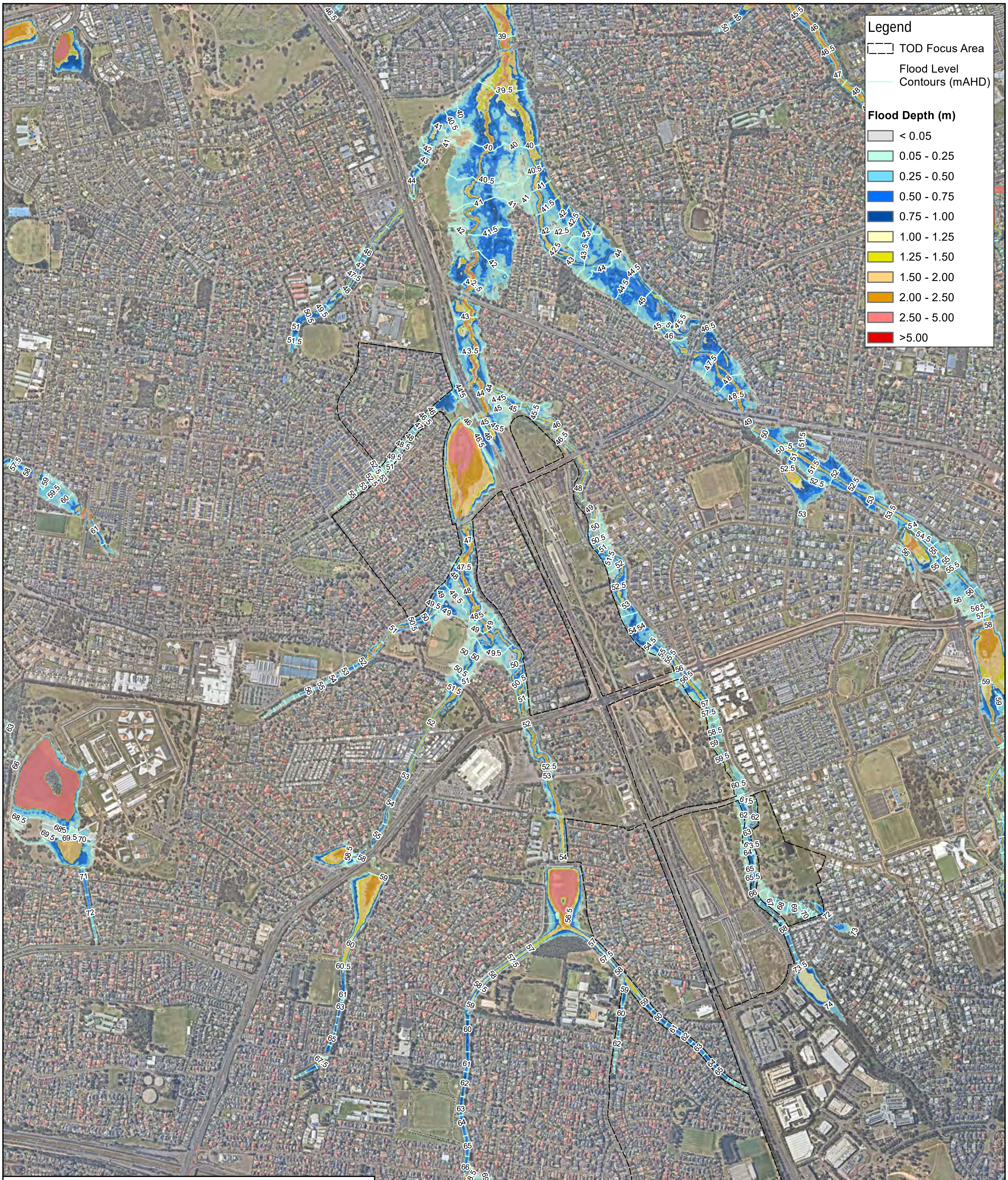

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0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario with TOD
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C003

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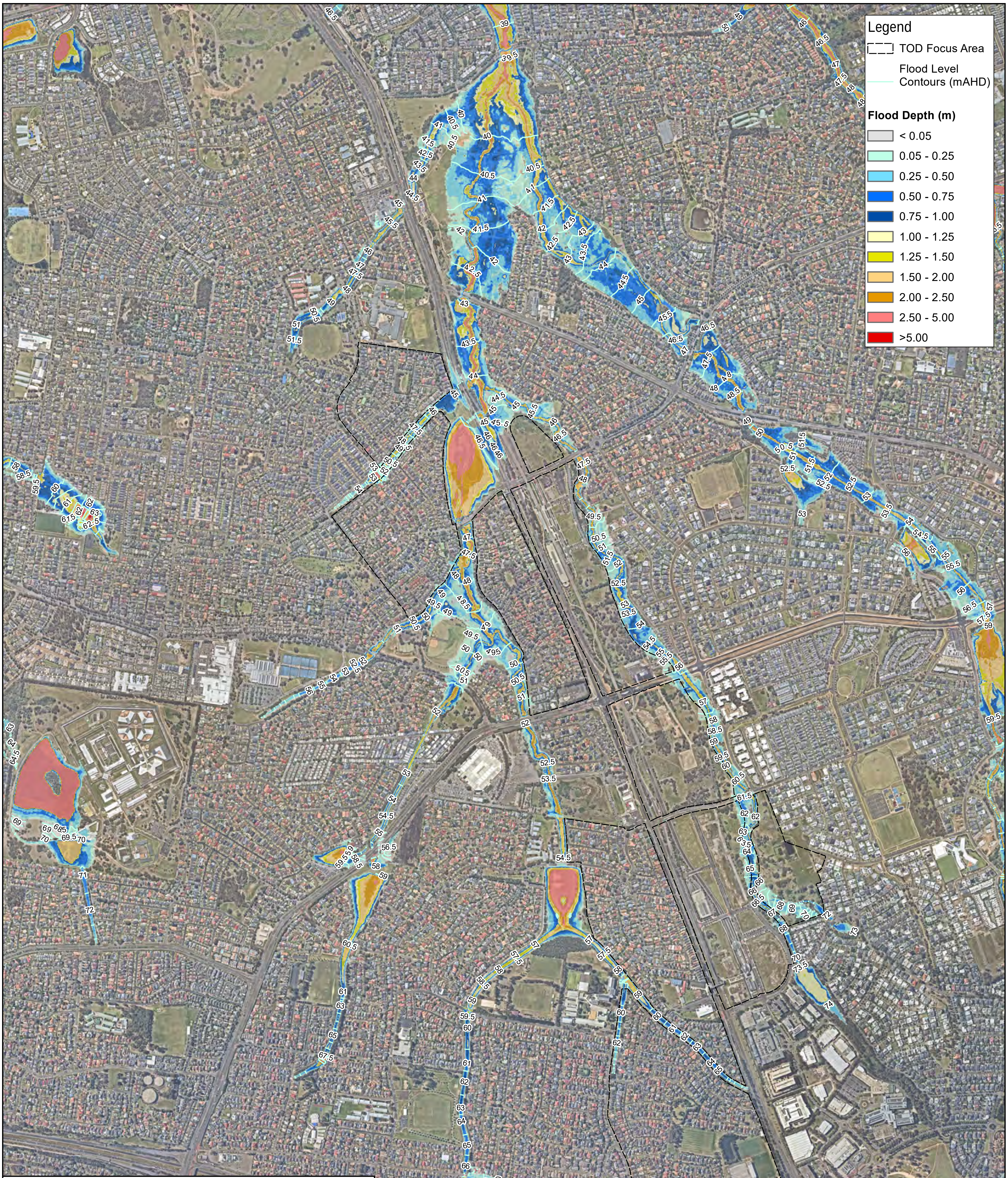
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario with TOD
Flood Depth and Flood Level Contours
Max-Median

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C004

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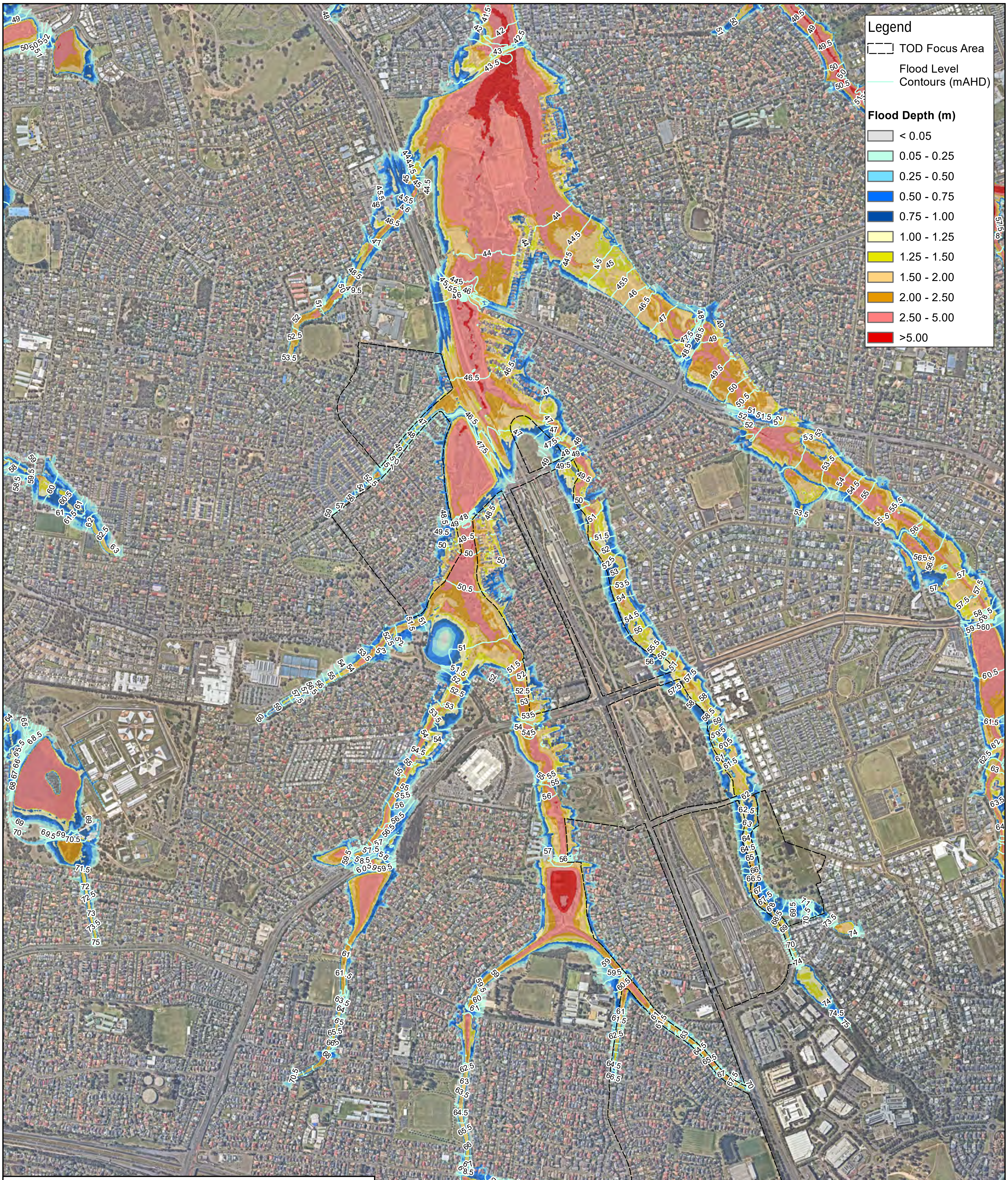
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario with TOD
Flood Depth and Flood Level Contours
Max-Max

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C005

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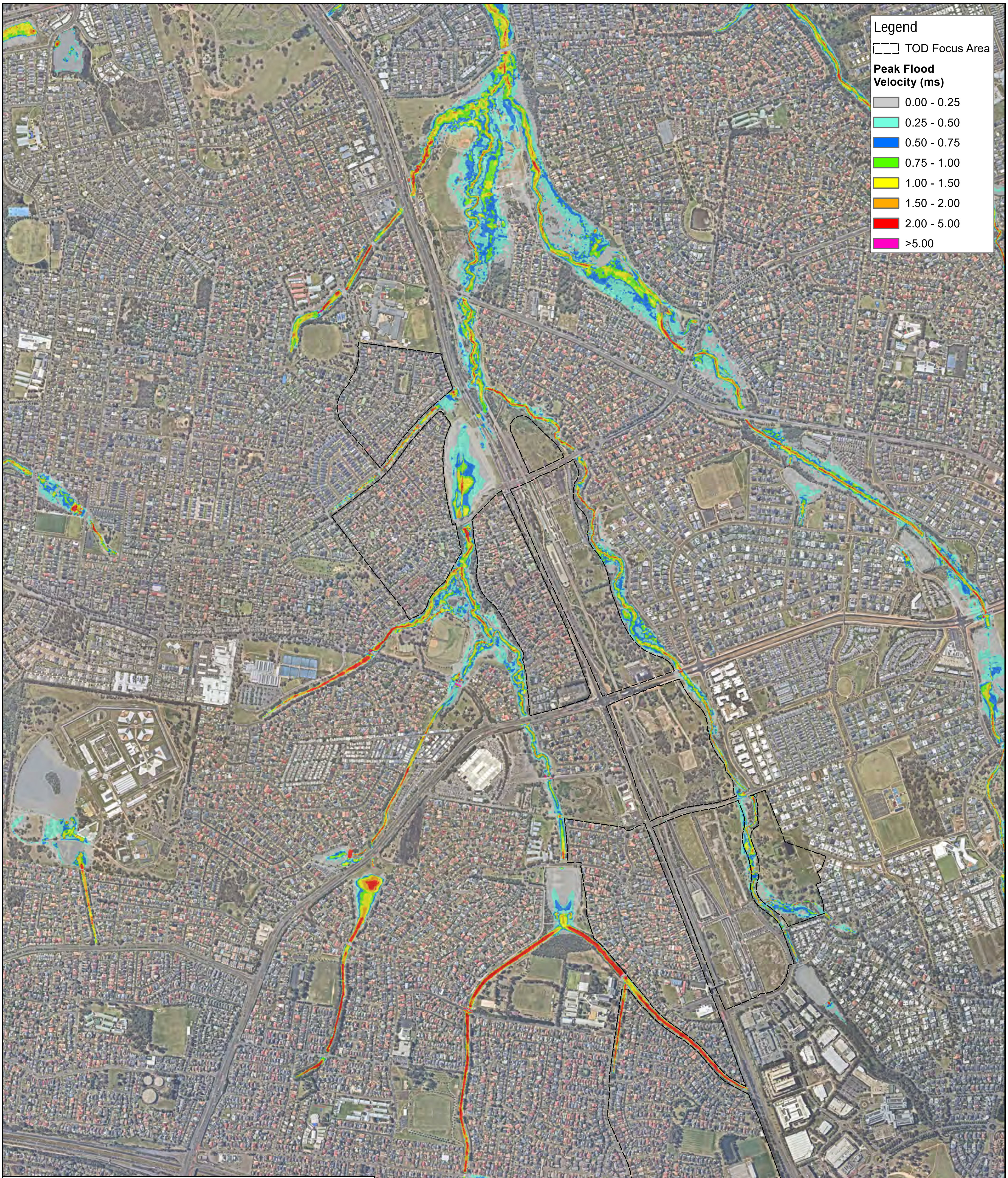
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario with TOD

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C006

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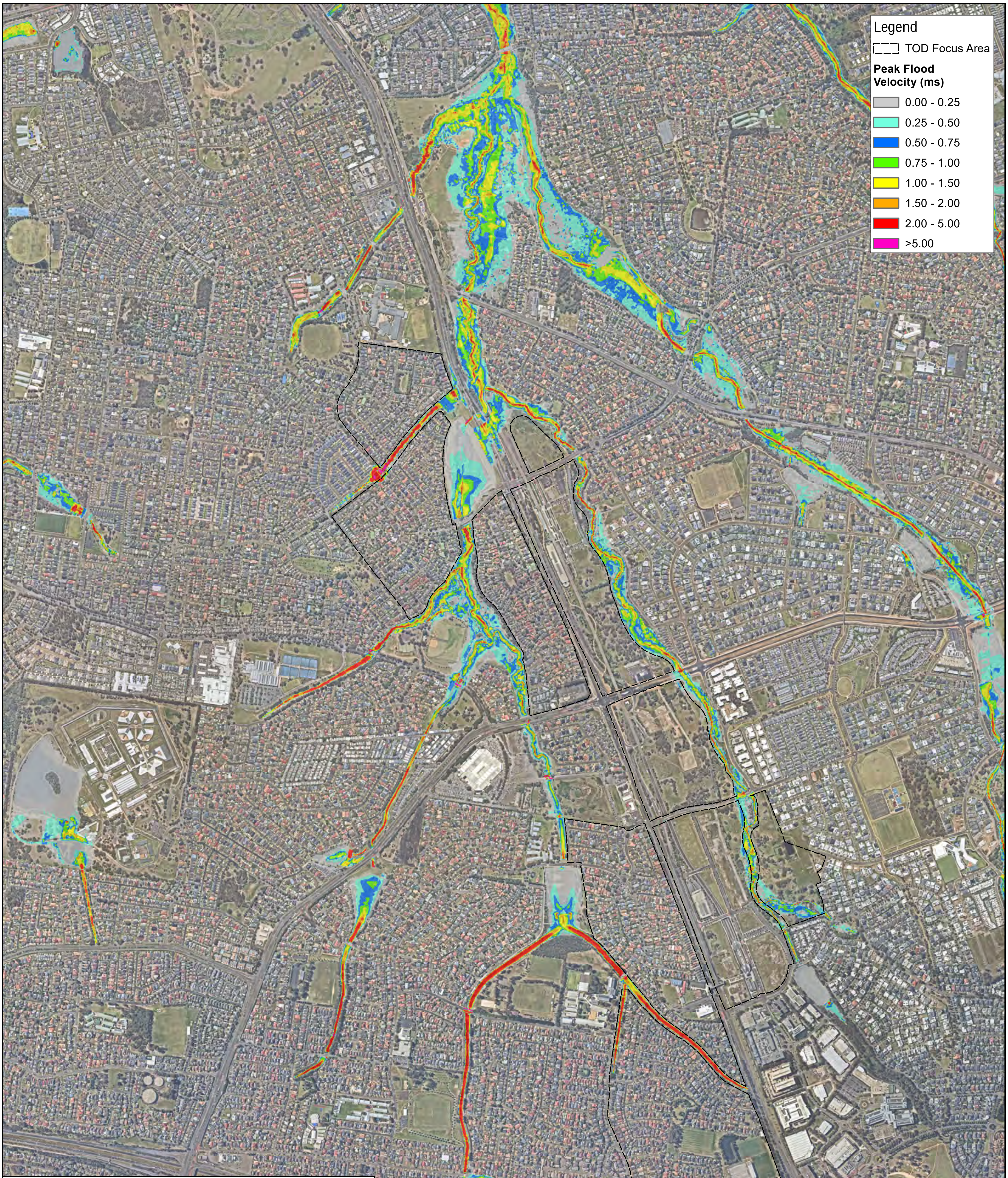
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario with TOD

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C007

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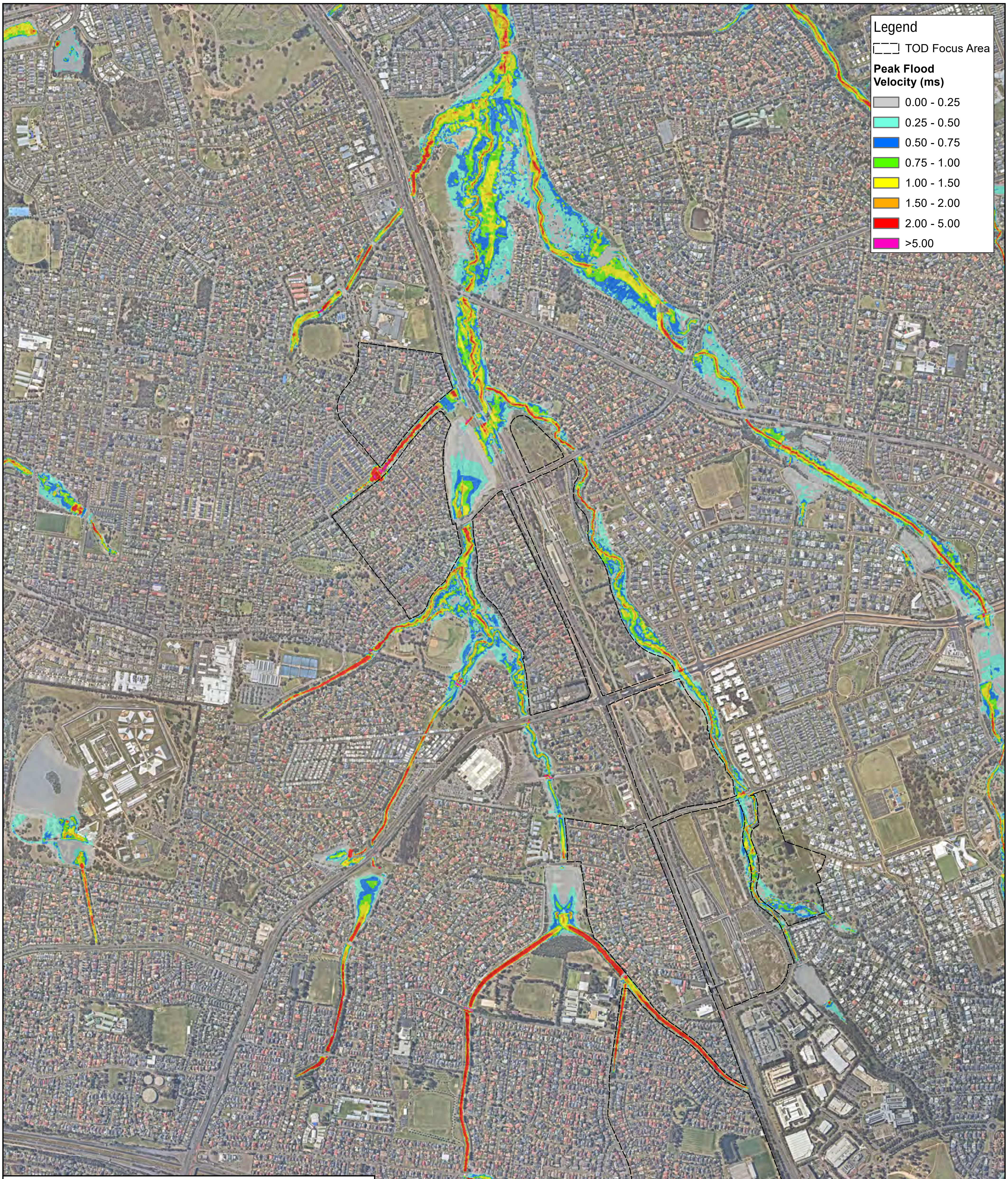

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0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario with TOD

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C008

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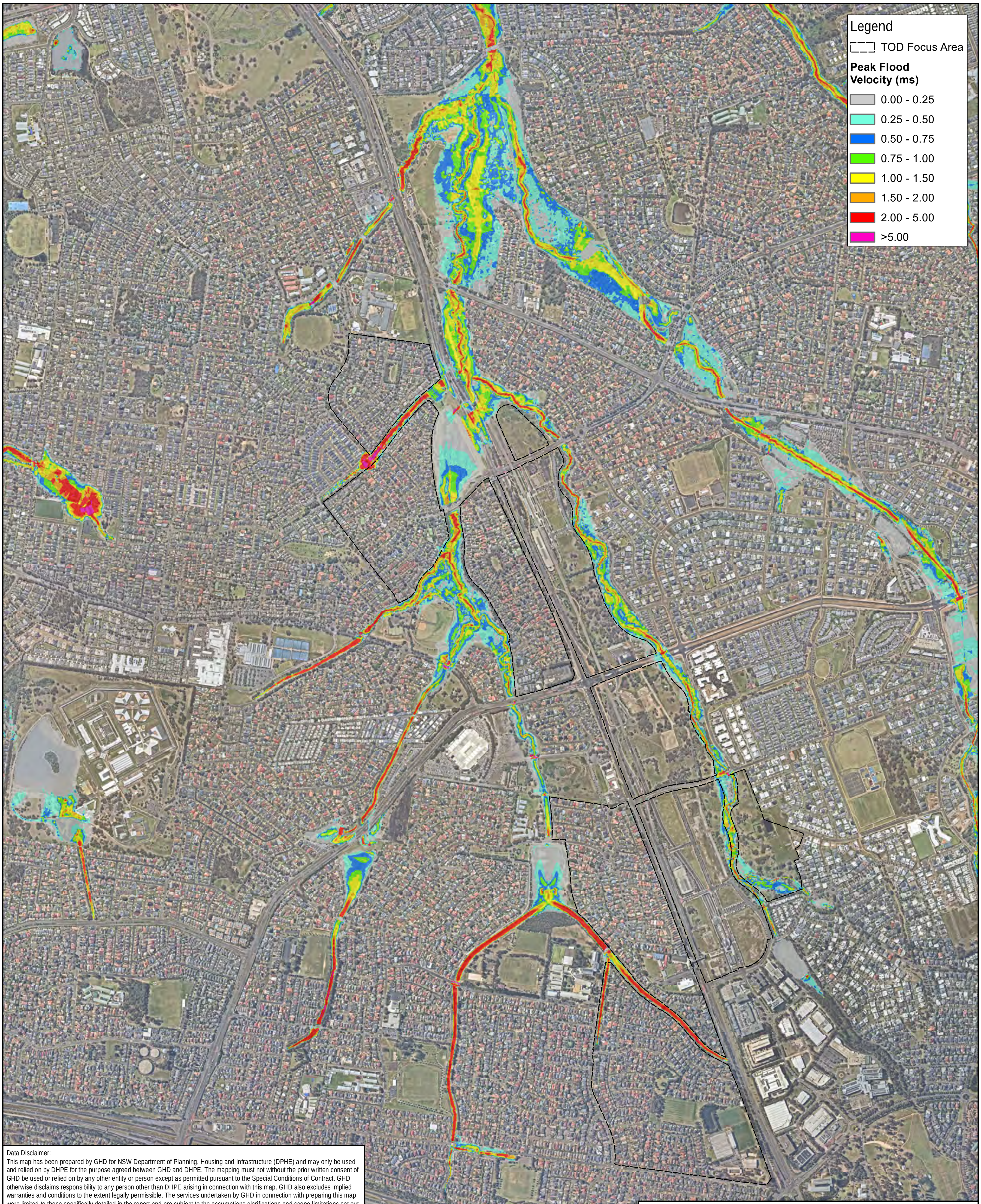
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario with TOD

Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C009

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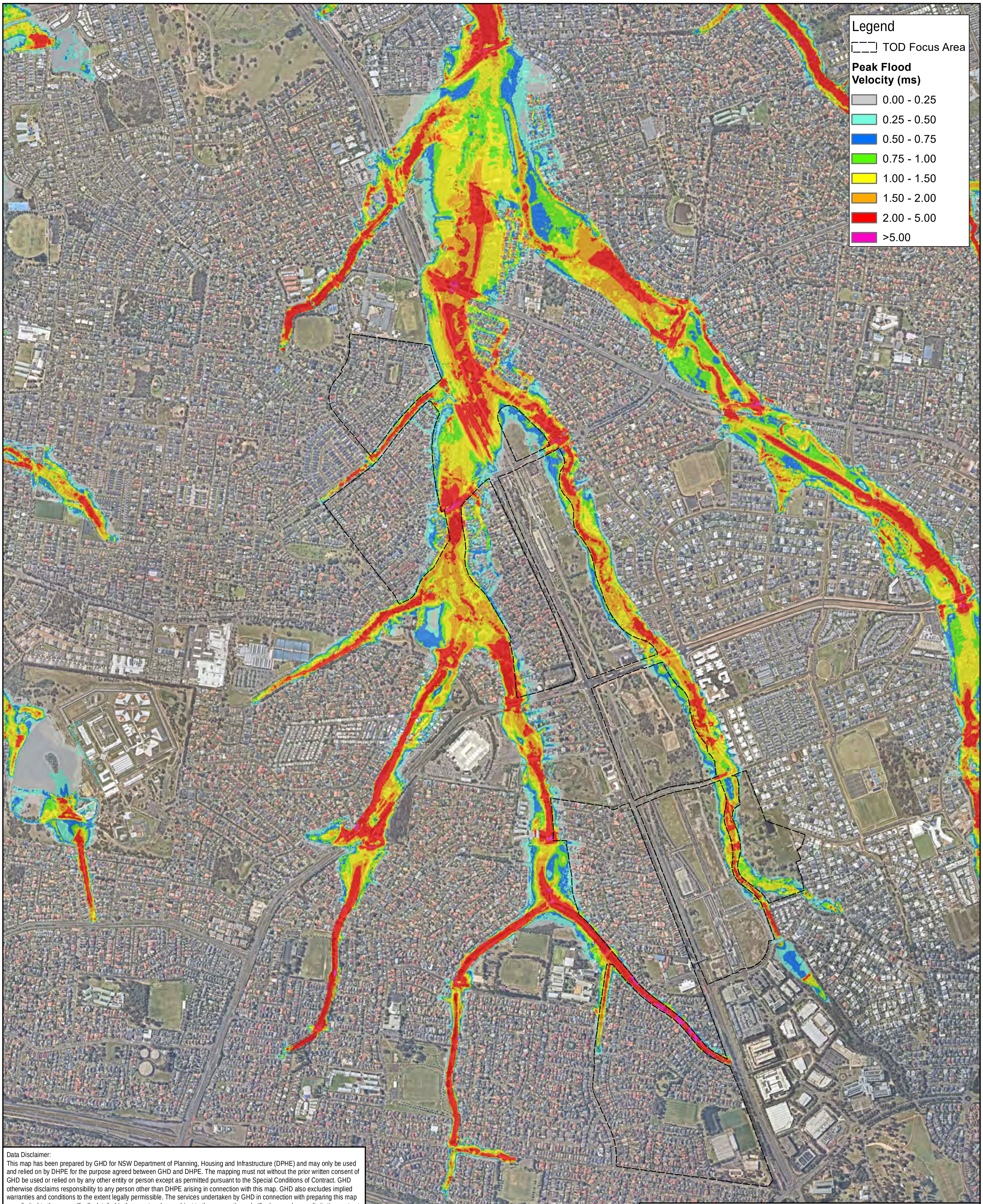
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario with TOD

Flood Velocity (Max-Max)

Project No.	12640113
Revision No.	0
Date	4/11/2024

Figure C010

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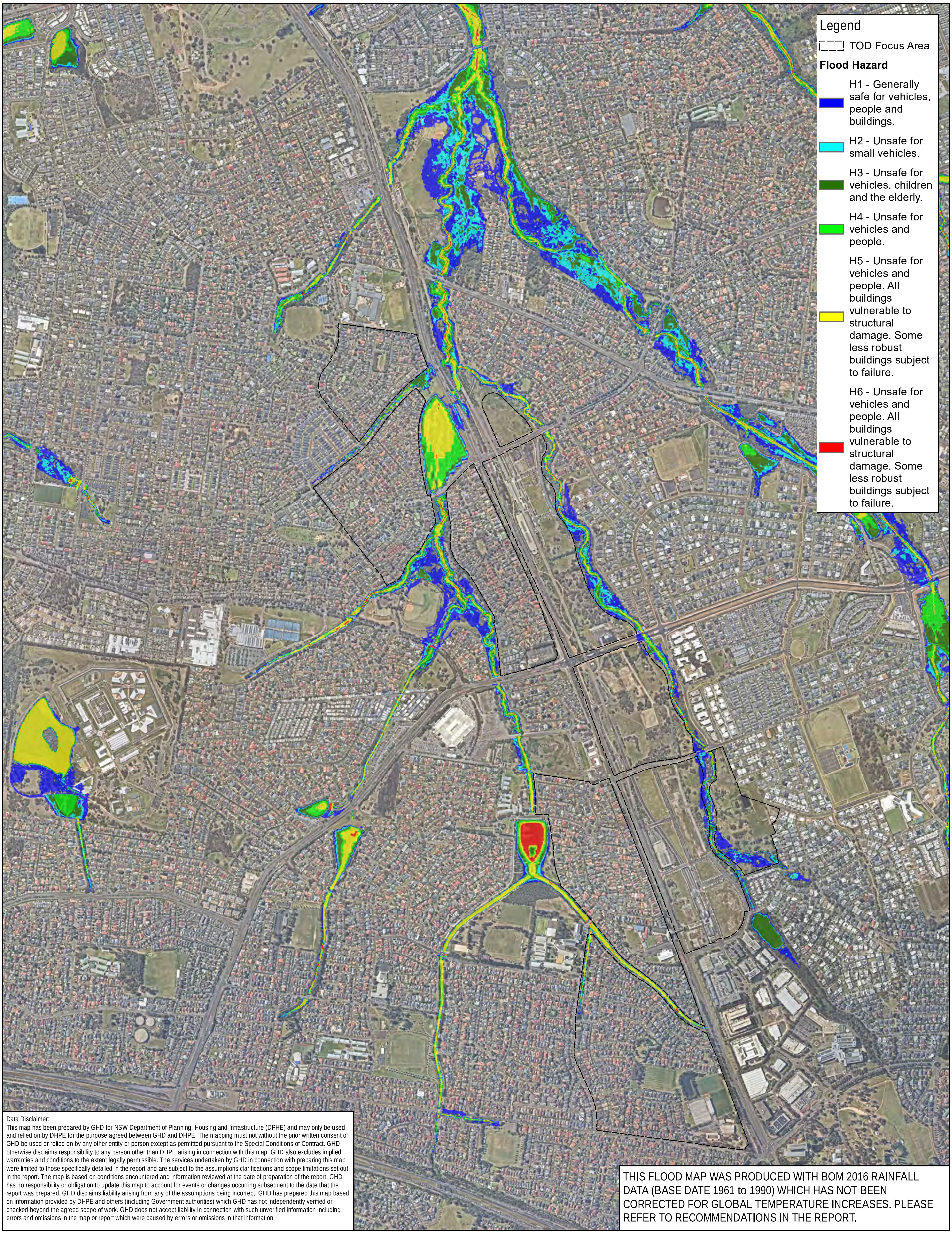

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Paper Size ISO A3
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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario with TOD

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C011

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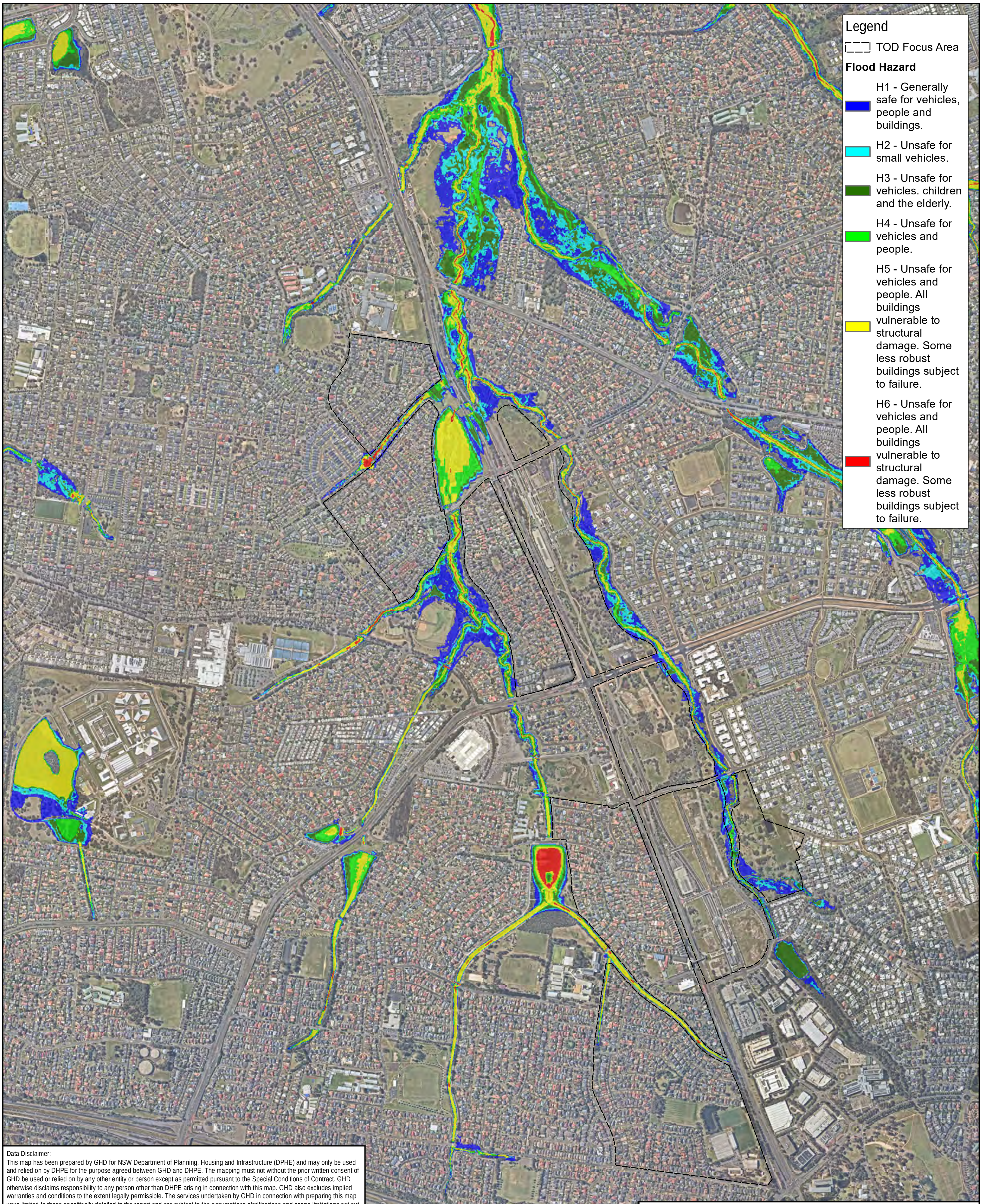

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Paper Size ISO A3
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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

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NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario with TOD

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C012

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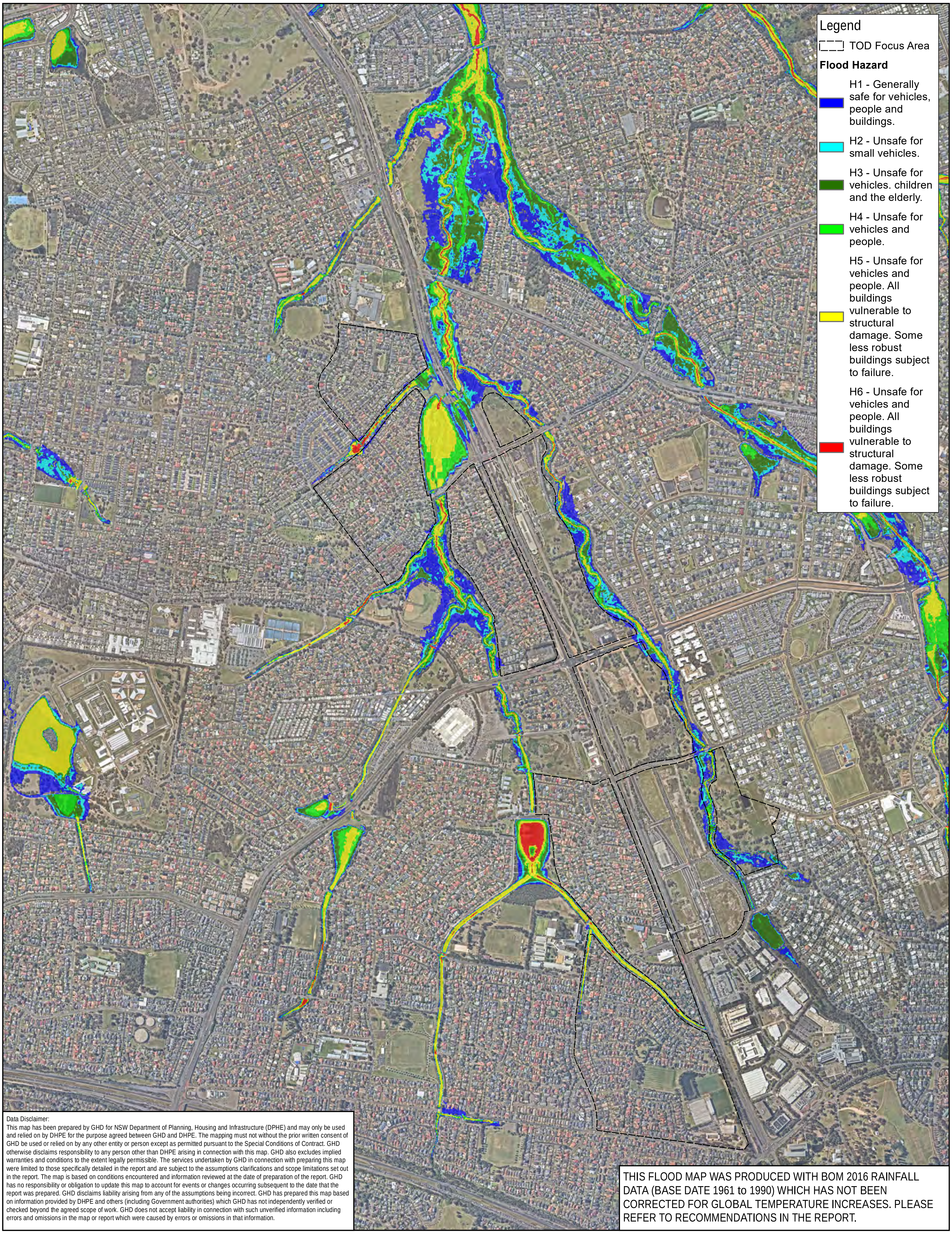

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario with TOD

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C013

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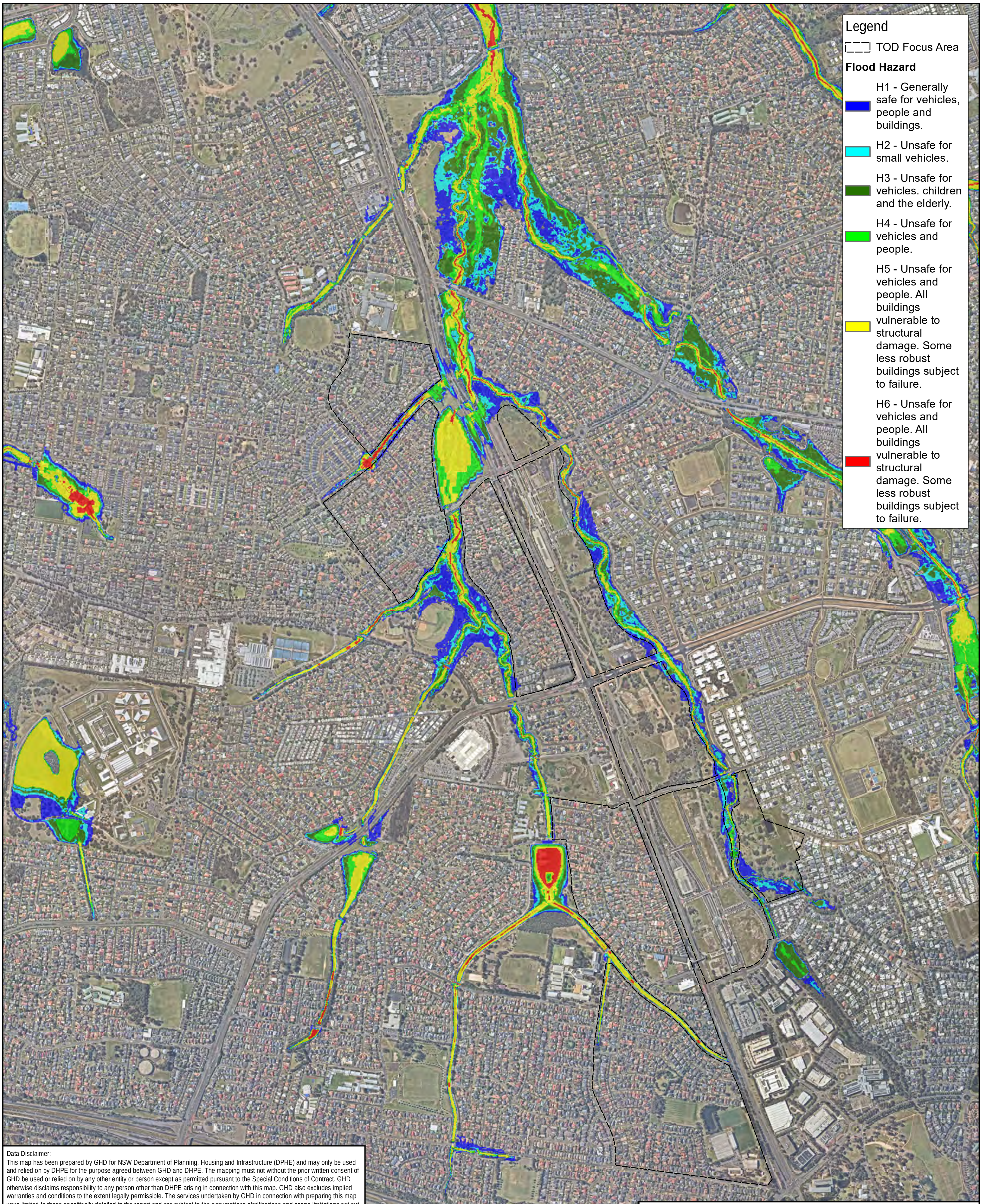

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario with TOD

Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C014

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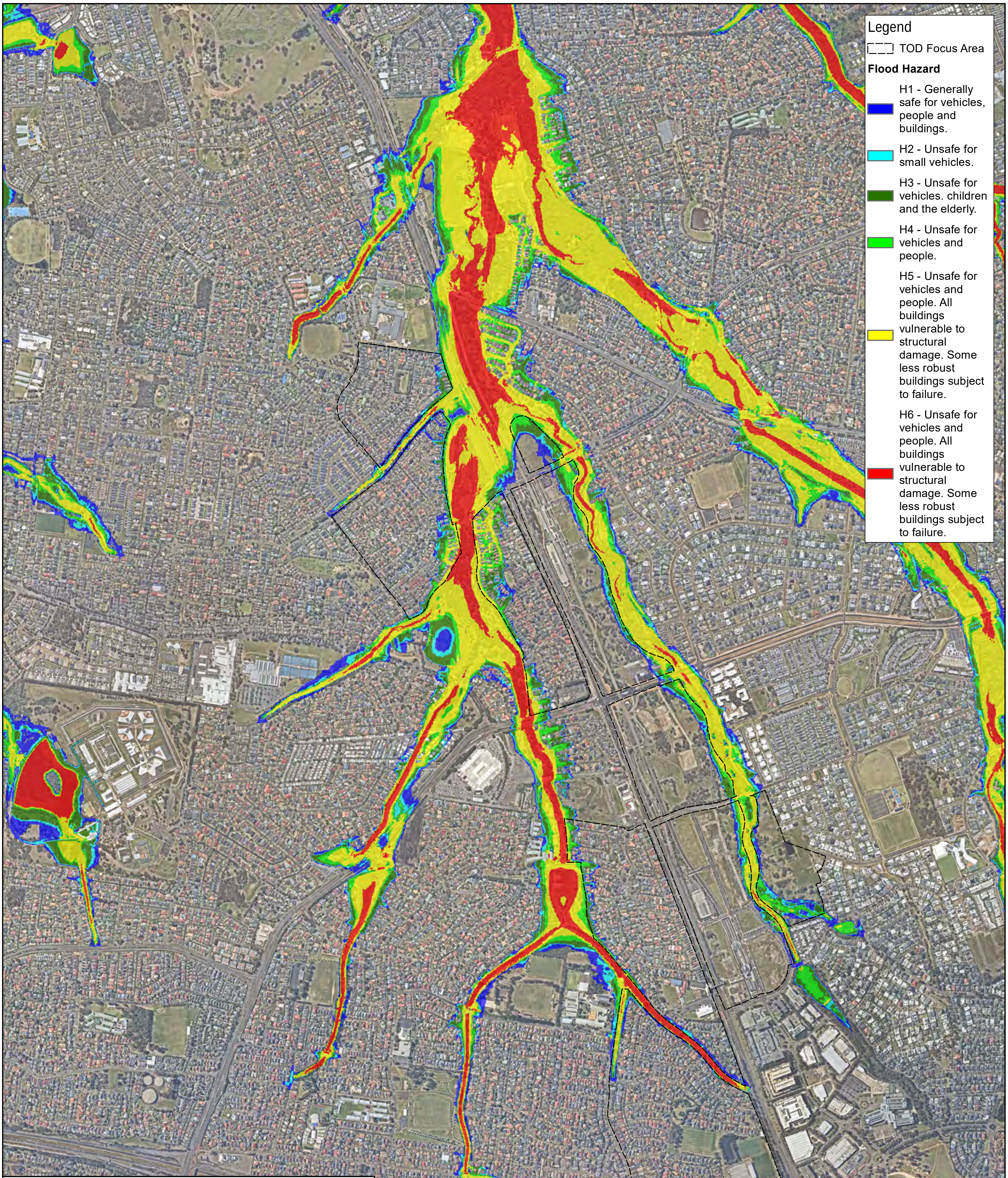

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario with TOD

Flood Hazard (Max-Max)

Project No.	12640113
Revision No.	0
Date	4/11/2024

Figure C015

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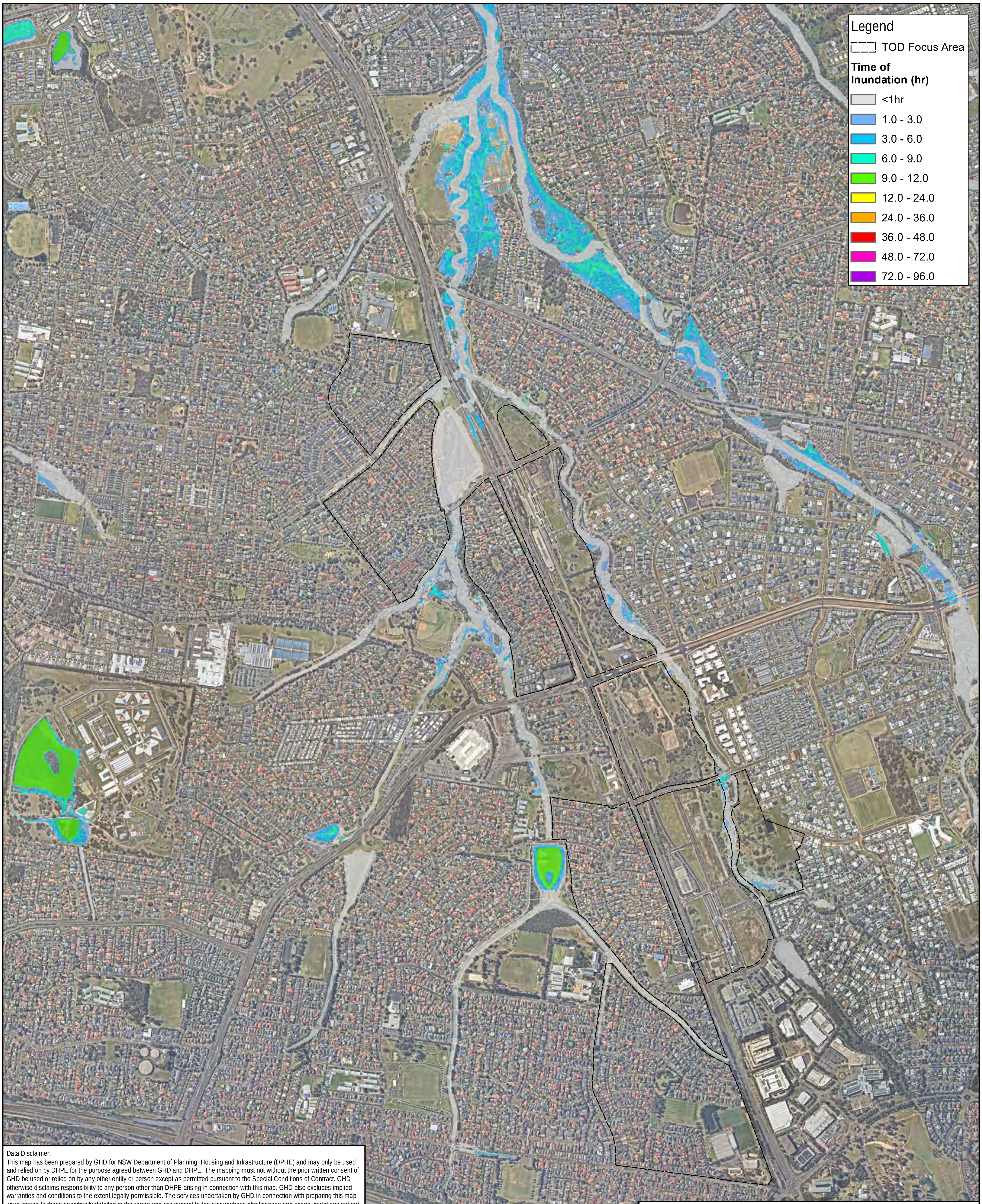

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0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

5% AEP - Baseline Scenario with TOD

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C016

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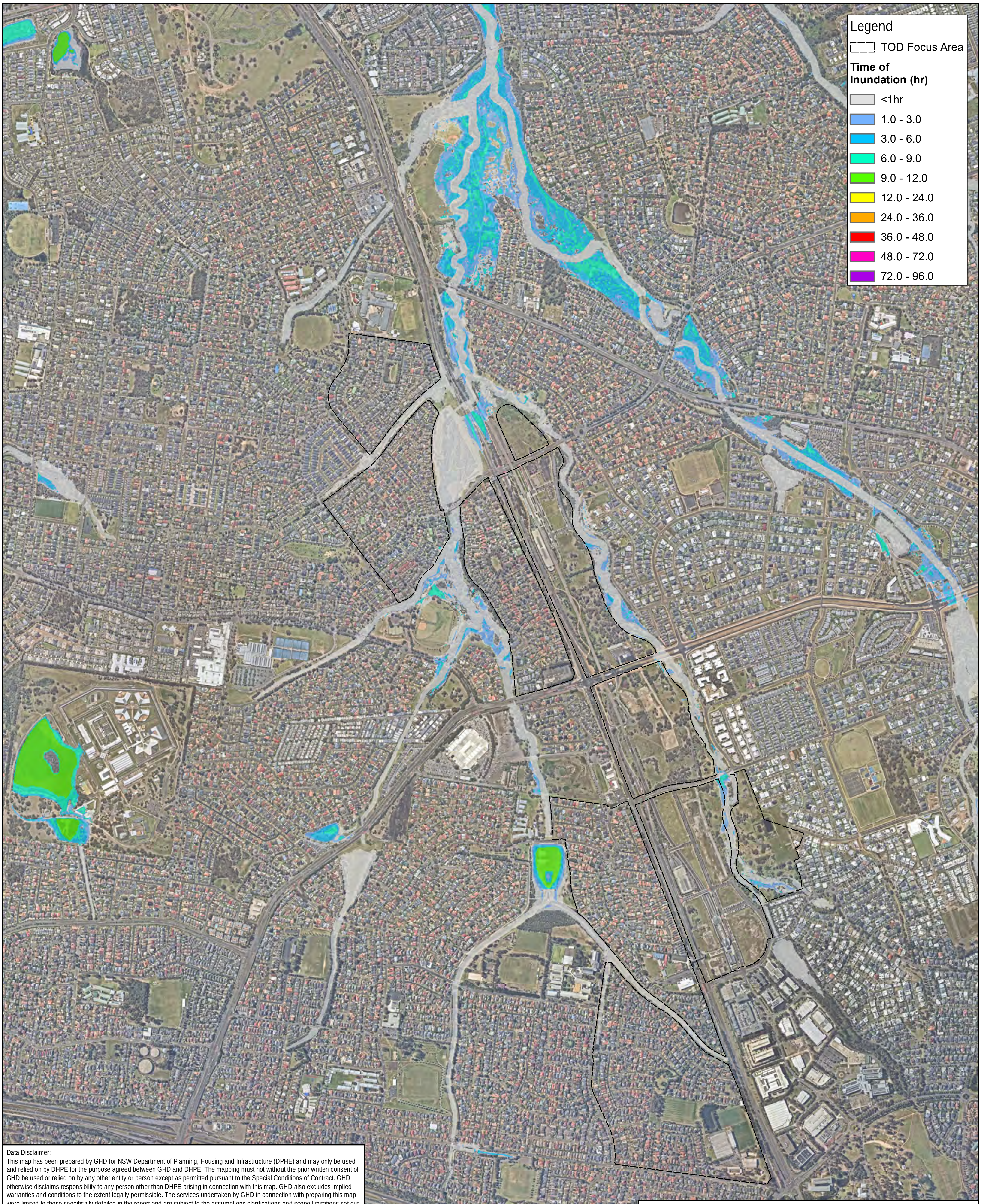
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Baseline Scenario with TOD

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C017

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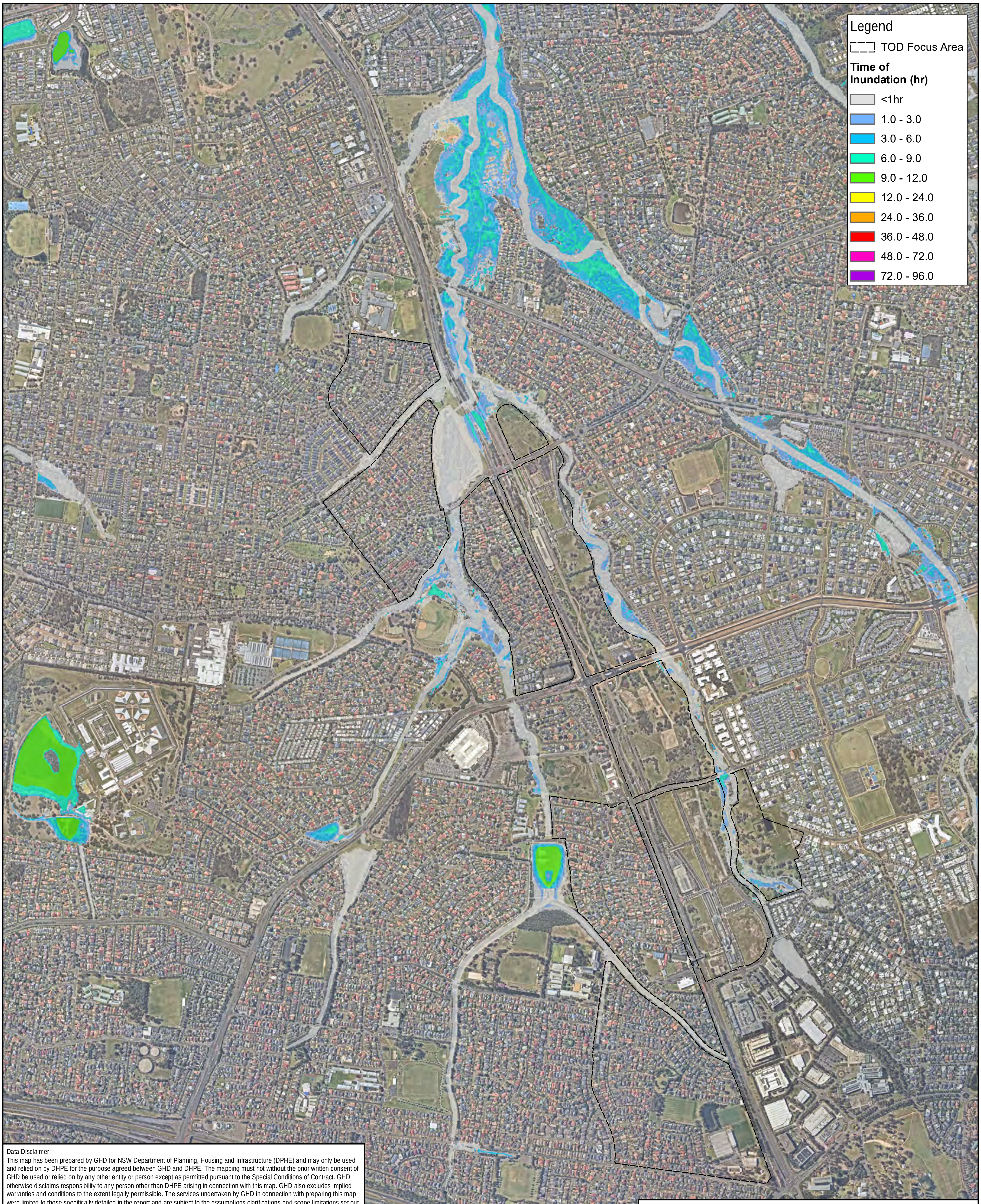

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.5% AEP - Baseline Scenario with TOD

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C018

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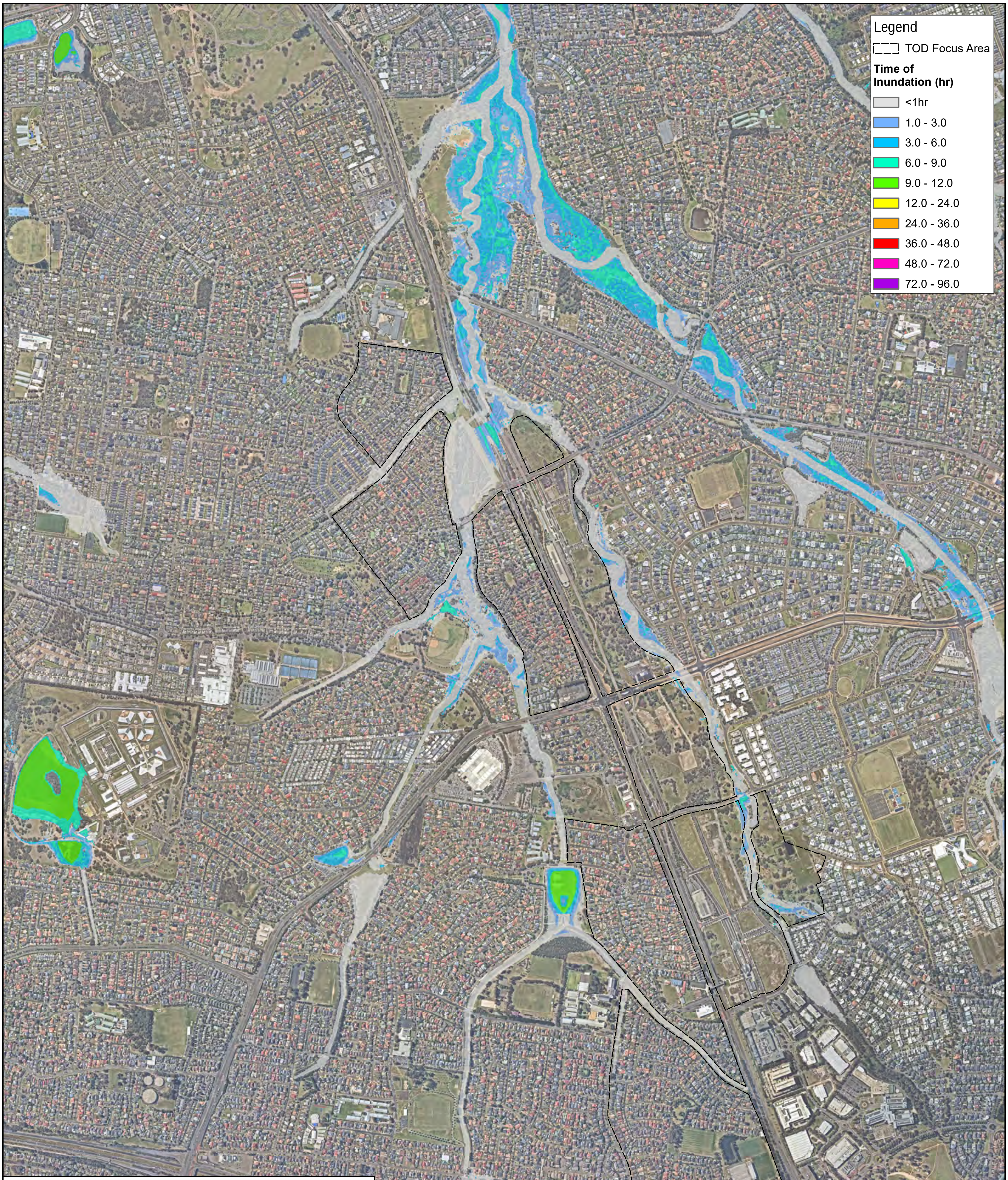
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Baseline Scenario with TOD

Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C019

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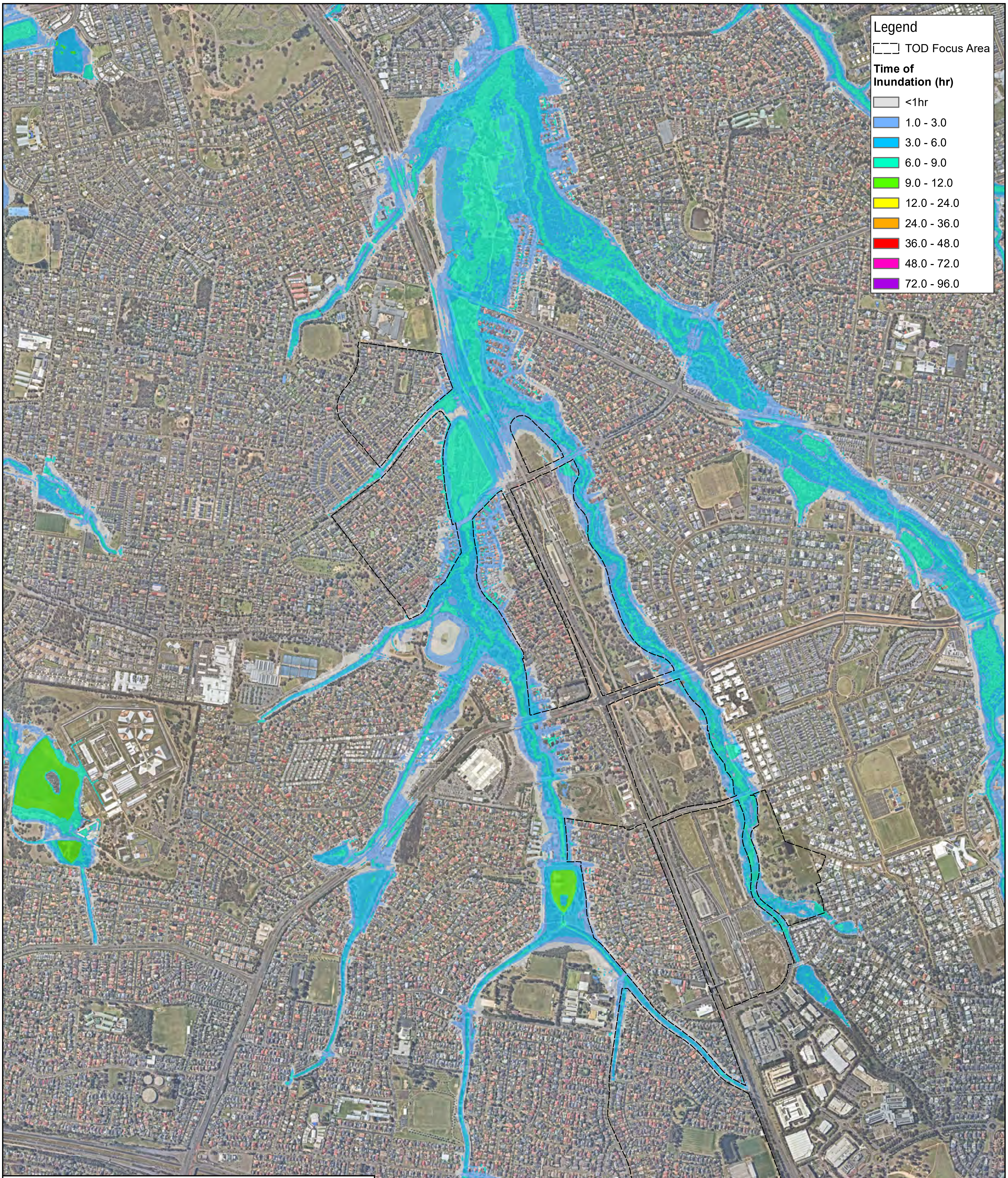
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

PMF - Baseline Scenario with TOD

Time of Inundation (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure C020

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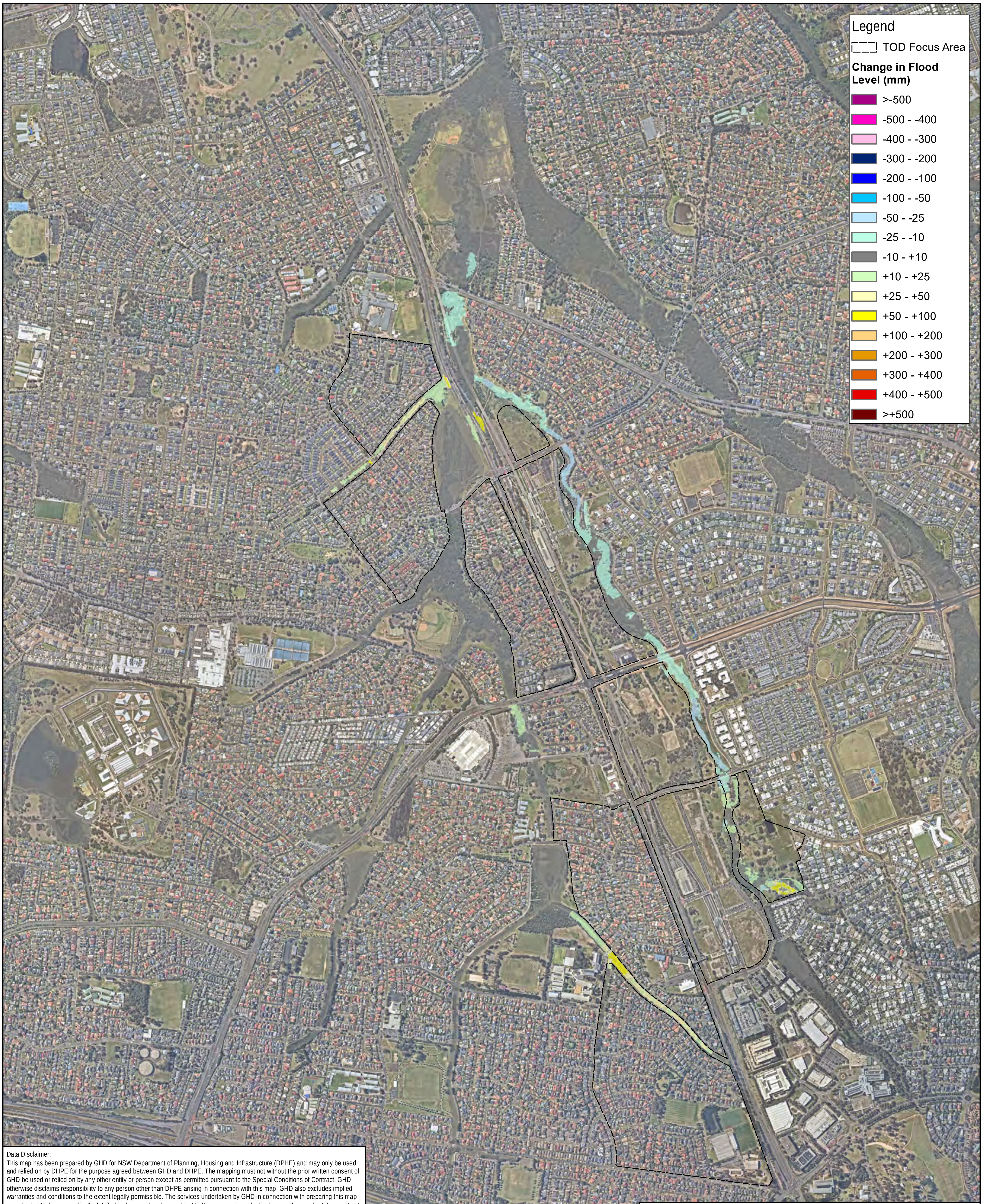
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4

Appendix D

Flood Impact Mapping



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Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
5% AEP
Baseline with TOD minus Baseline

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D001

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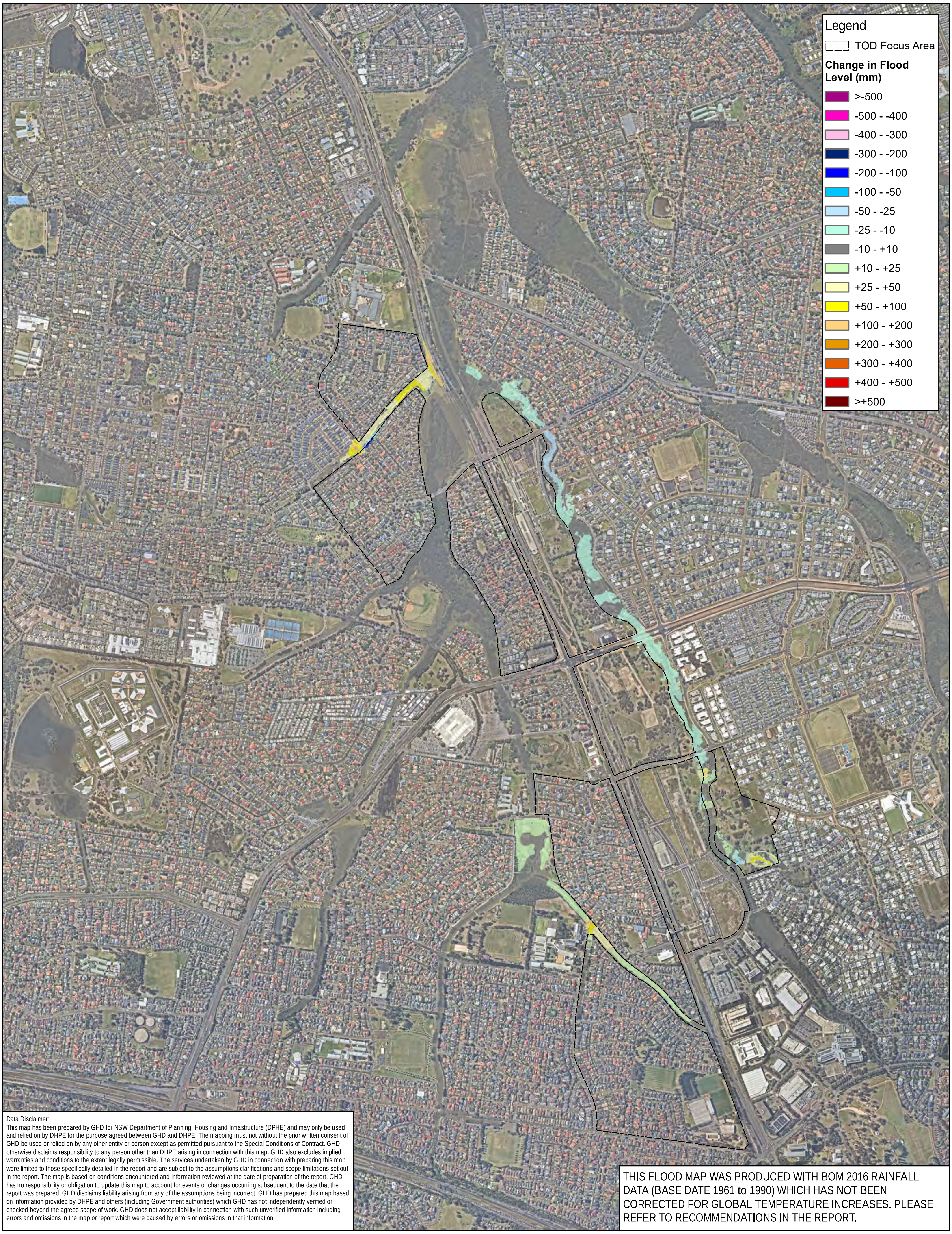

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Paper Size ISO A3
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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
1% AEP
Baseline with TOD minus Baseline

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D002

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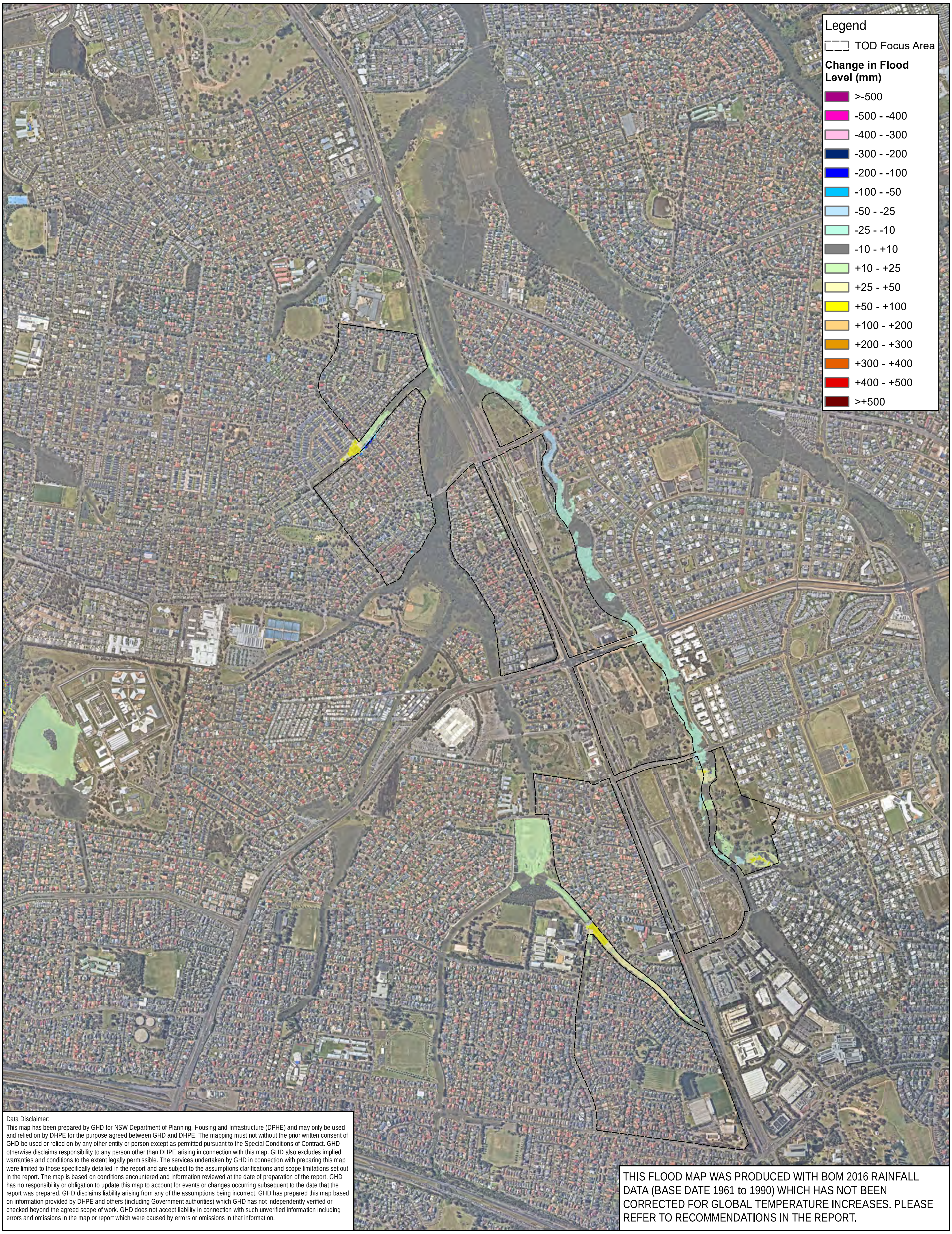

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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.5% AEP
Baseline with TOD minus Baseline

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D003

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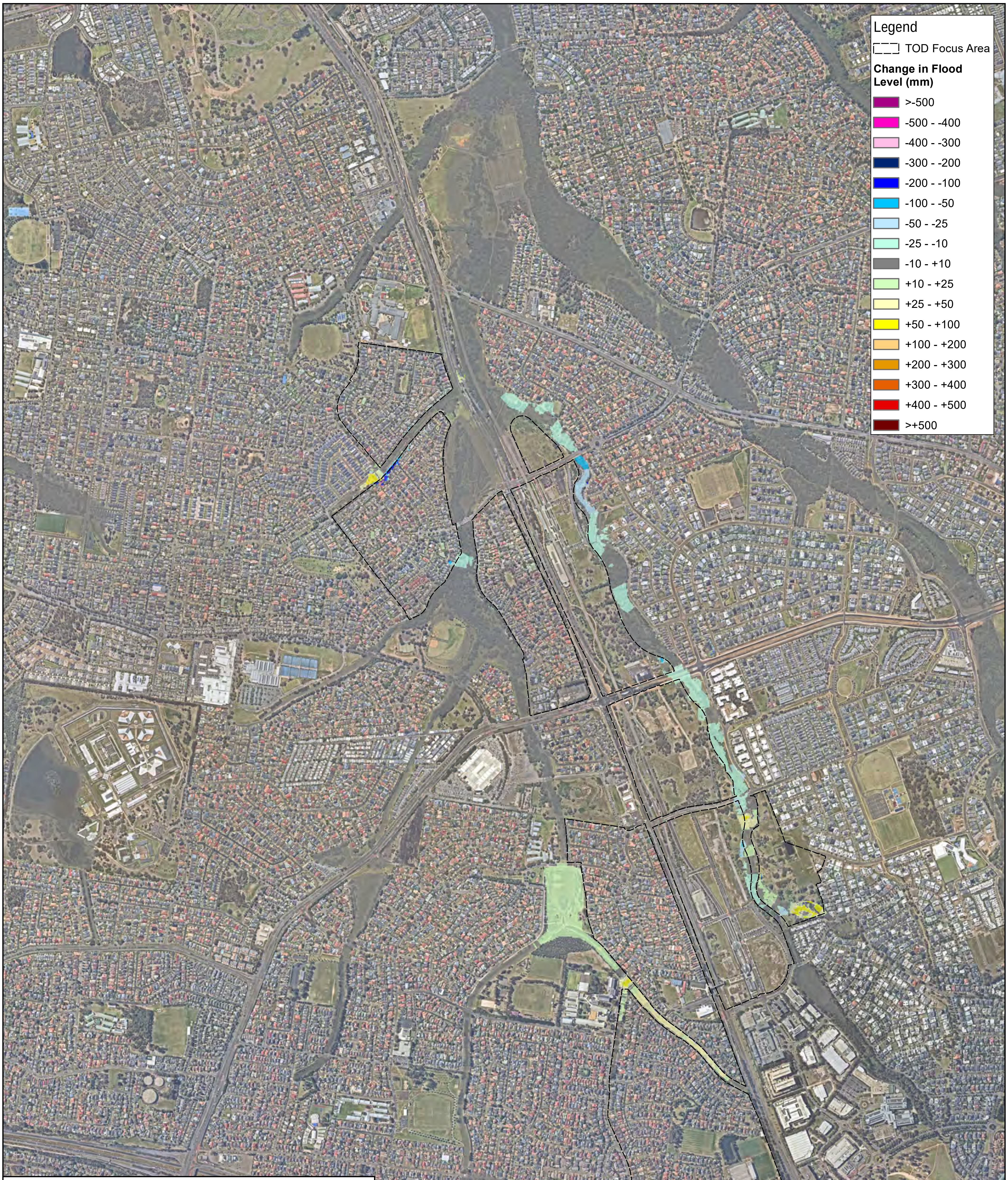
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.2% AEP
Baseline with TOD minus Baseline

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D004

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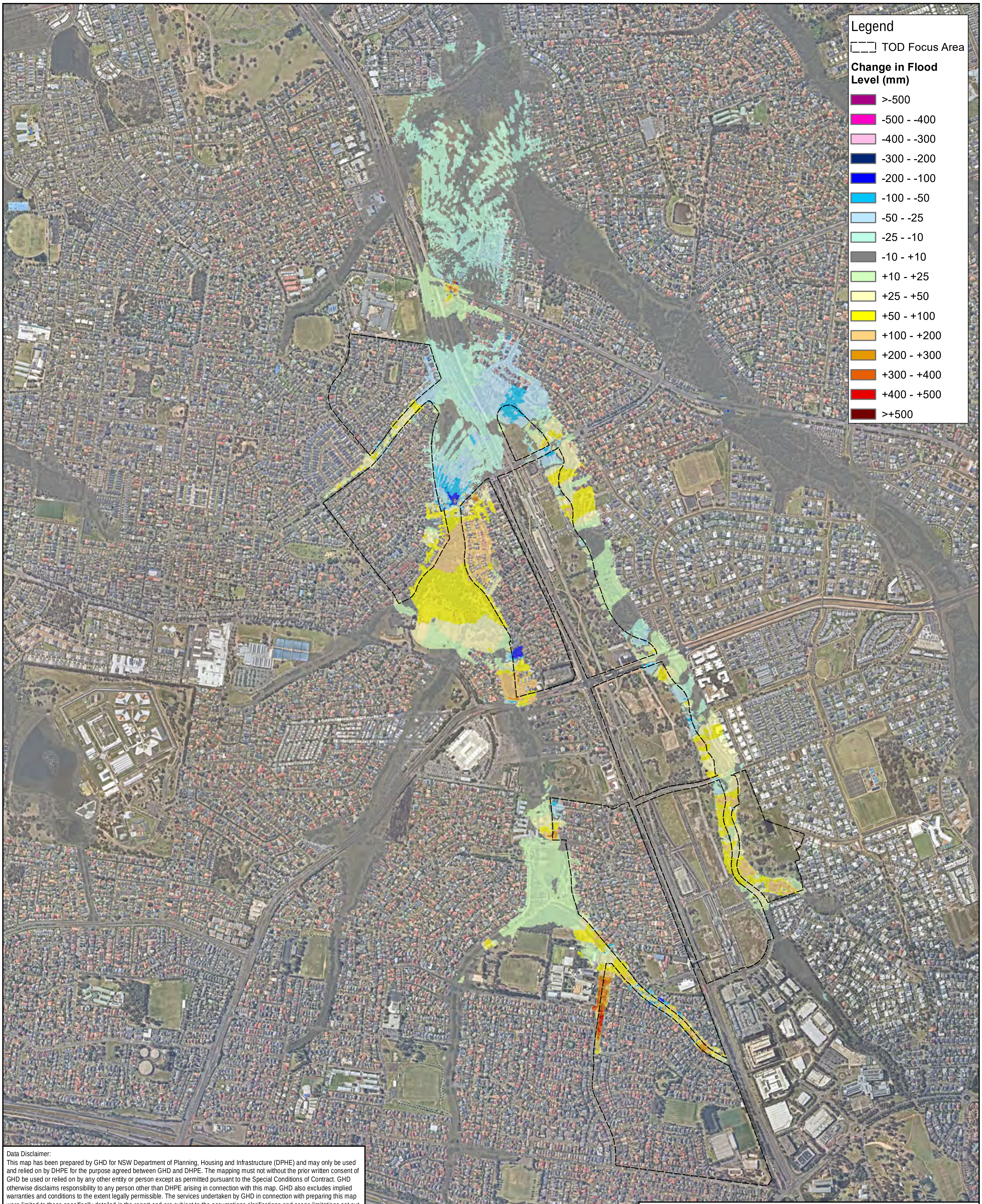

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
PMF
Baseline with TOD minus Baseline

Change in Flood Level (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D005

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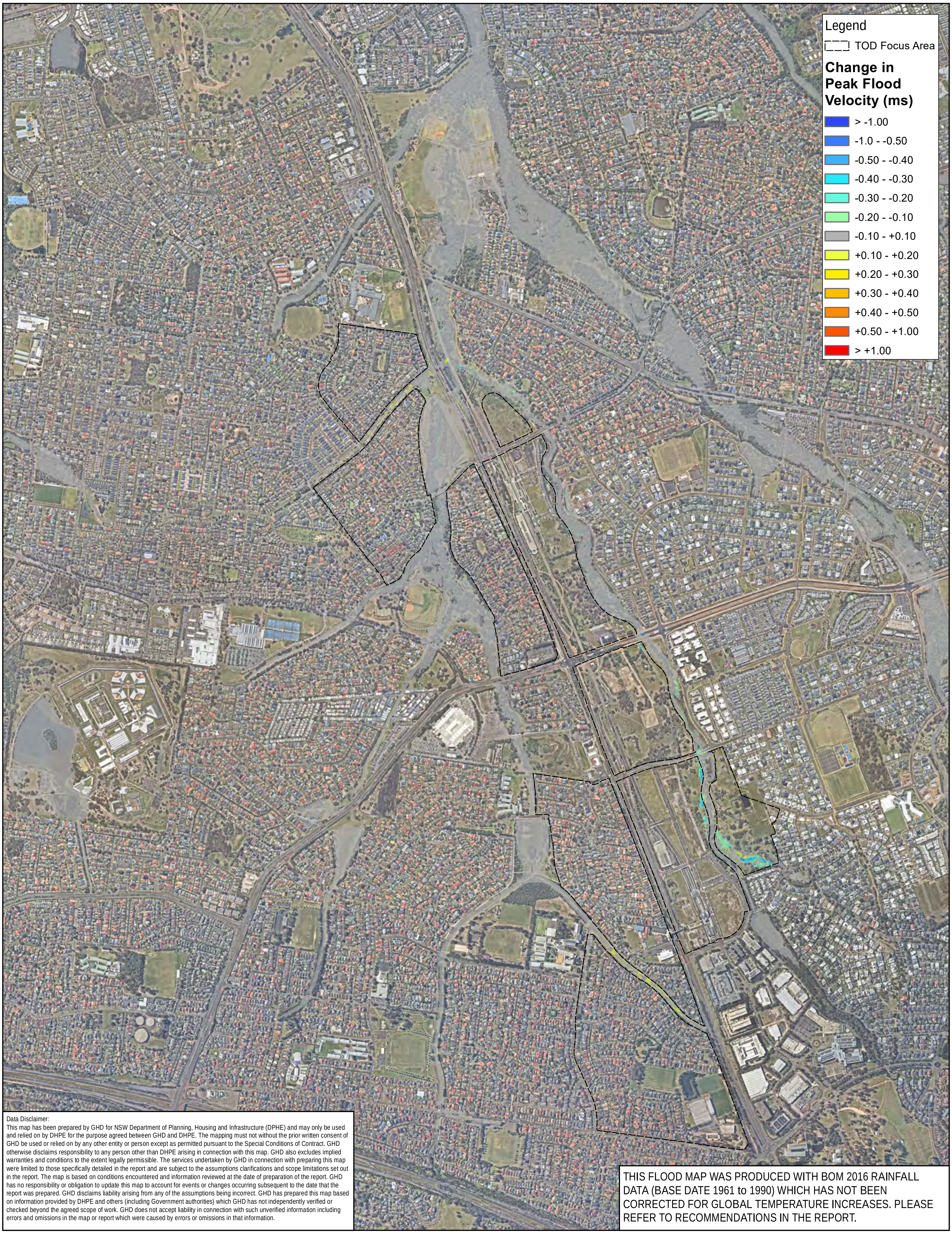
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
5% AEP
Baseline with TOD minus Baseline

Change in Peak Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D006

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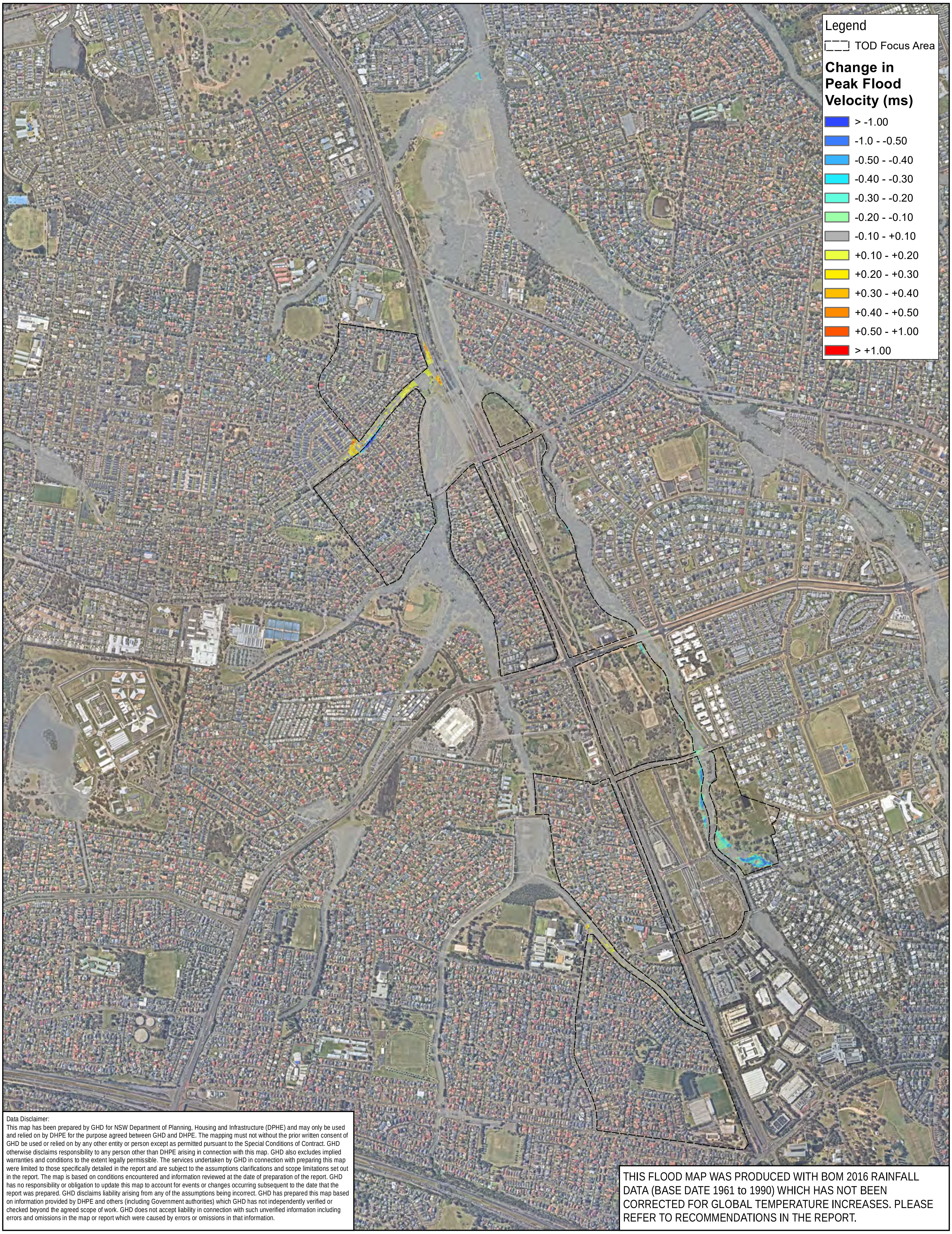

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
1% AEP
Baseline with TOD minus Baseline

Change in Peak Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D007

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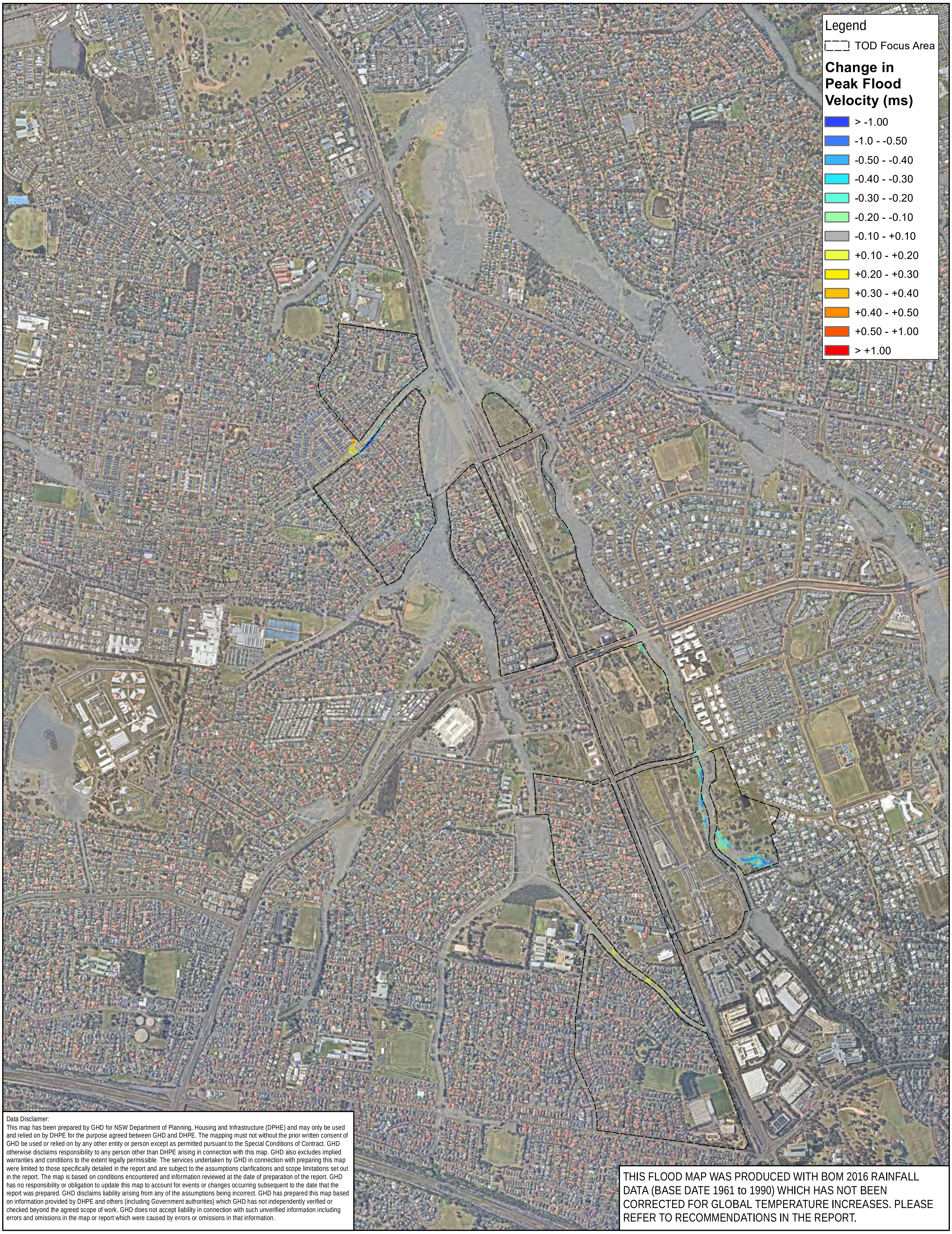
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.5% AEP
Baseline with TOD minus Baseline

Change in Peak Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D008

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Print date: 4/11/2024

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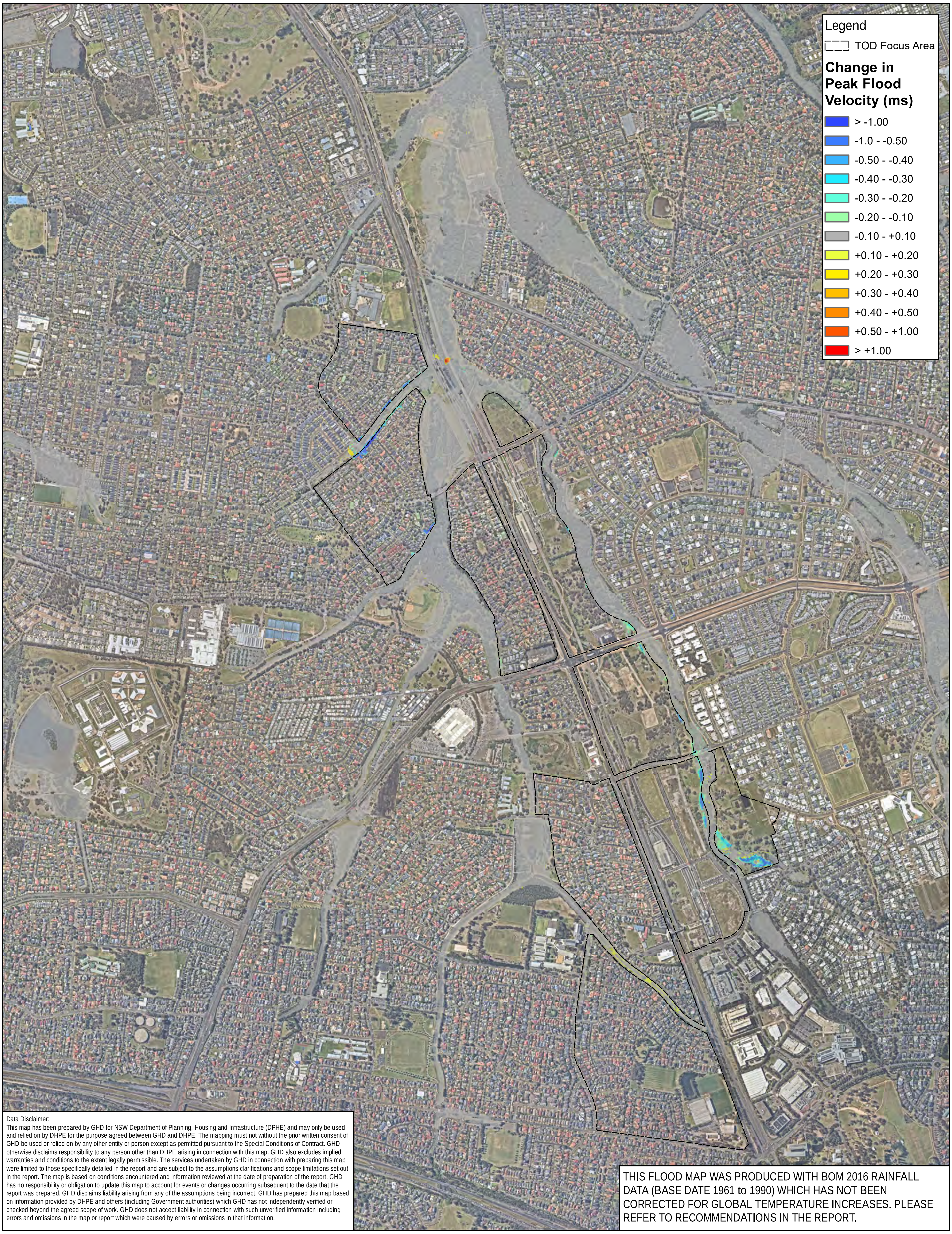

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.2% AEP
Baseline with TOD minus Baseline

Change in Peak Flood Velocity (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D009

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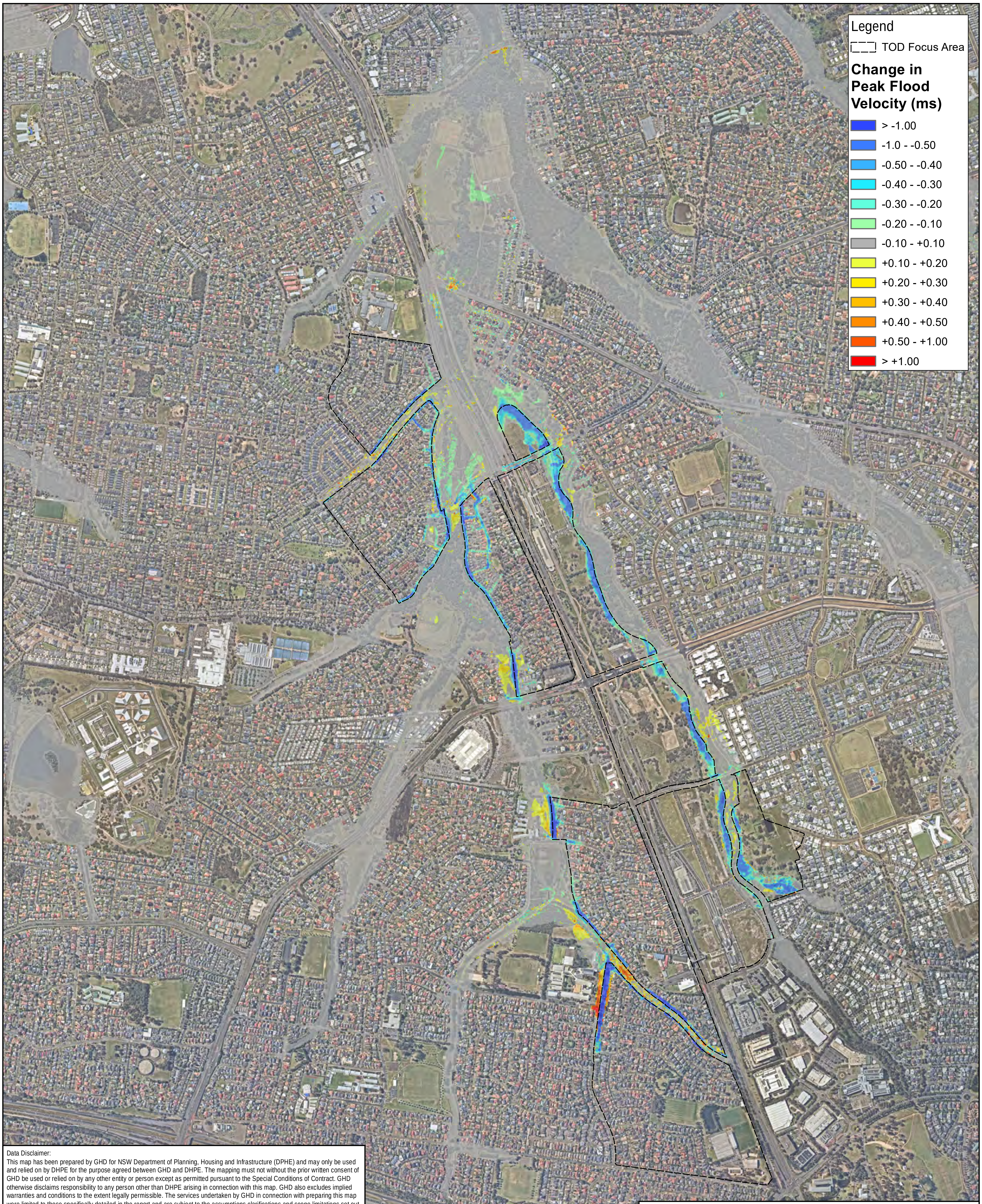

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Paper Size ISO A3
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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
PMF
Baseline with TOD minus Baseline

Change in Peak Flood Velocity (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D010

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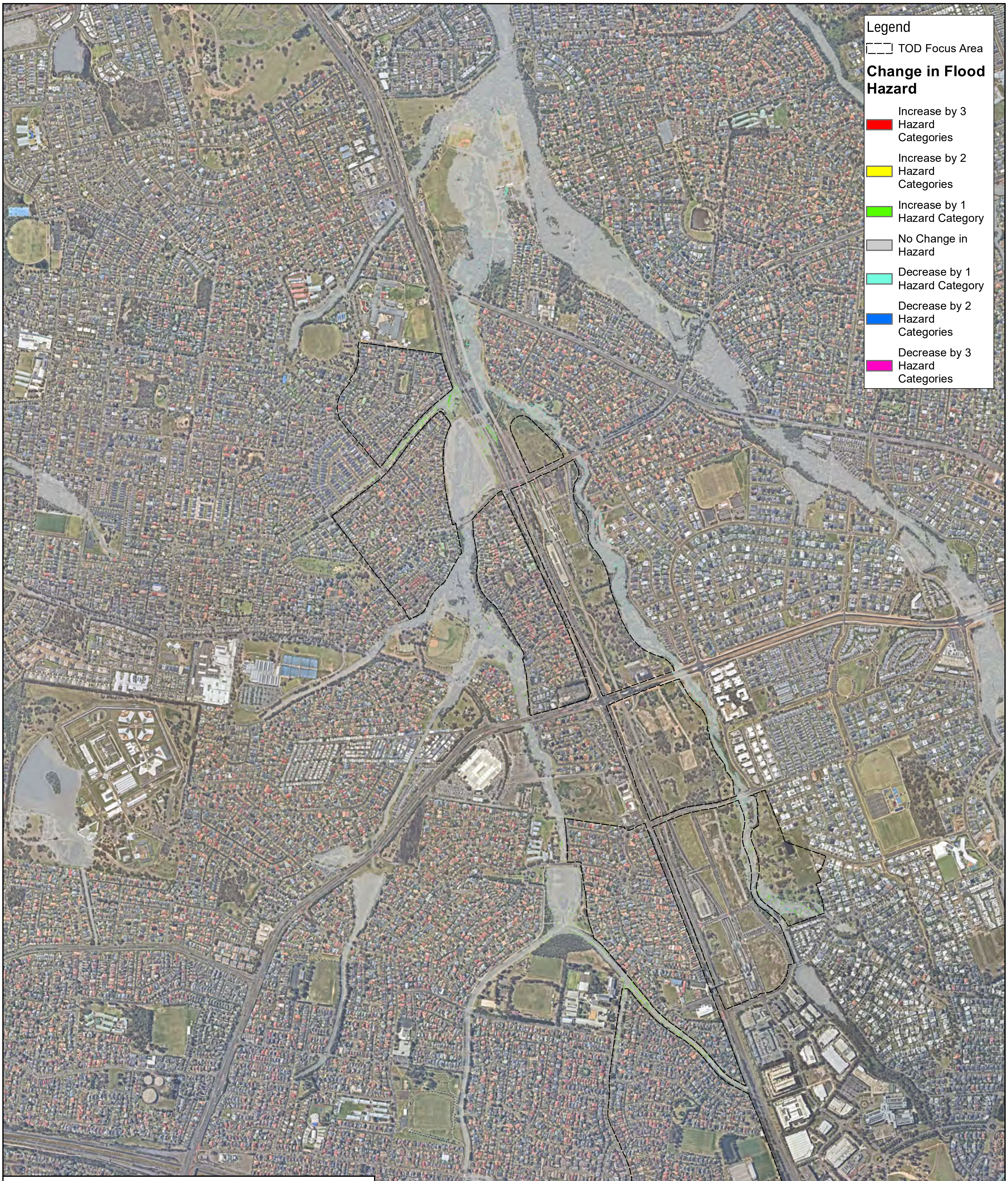

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Metres

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N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
5% AEP
Baseline with TOD minus Baseline

Change in Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D011

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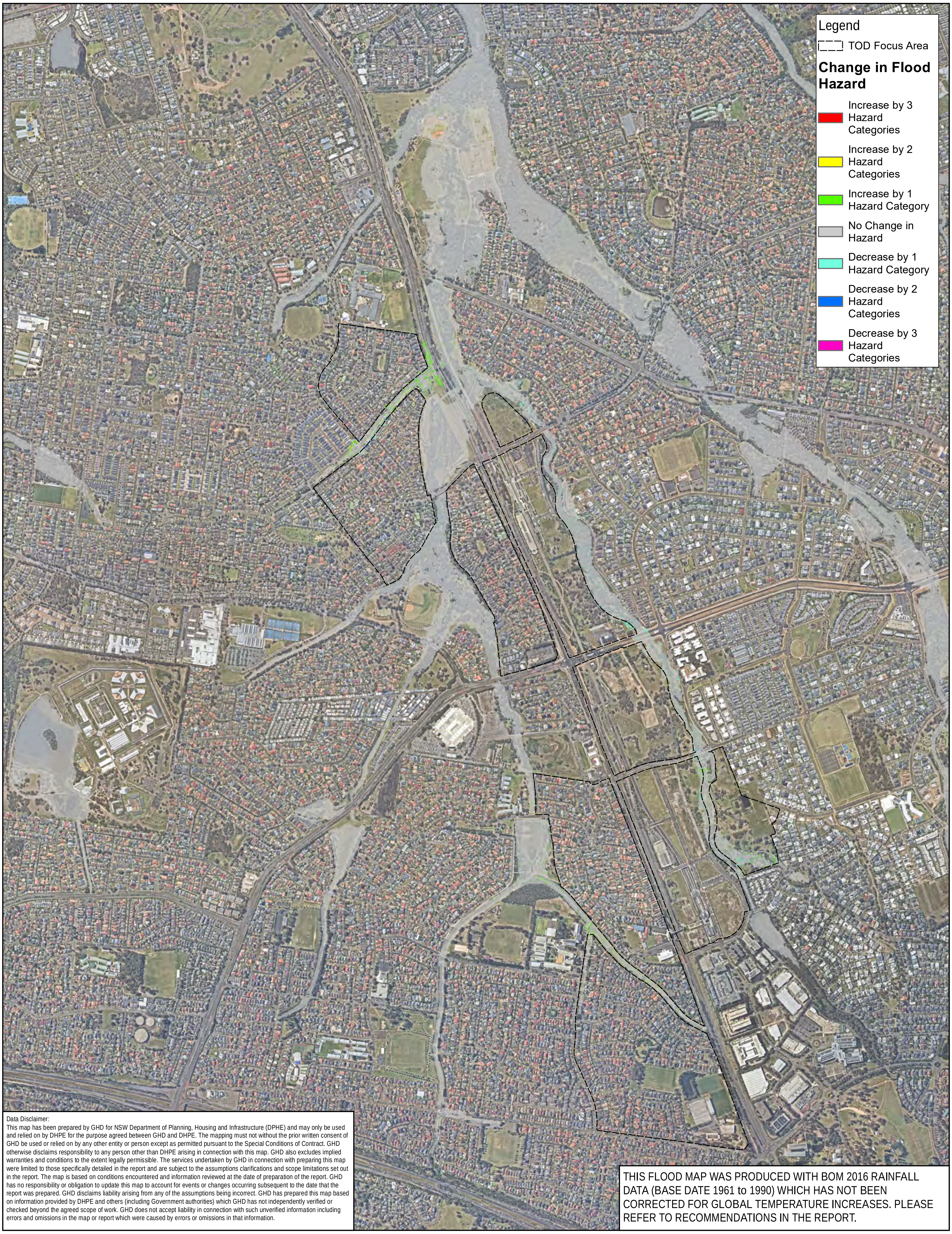

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NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
1% AEP
Baseline with TOD minus Baseline

Change in Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D012

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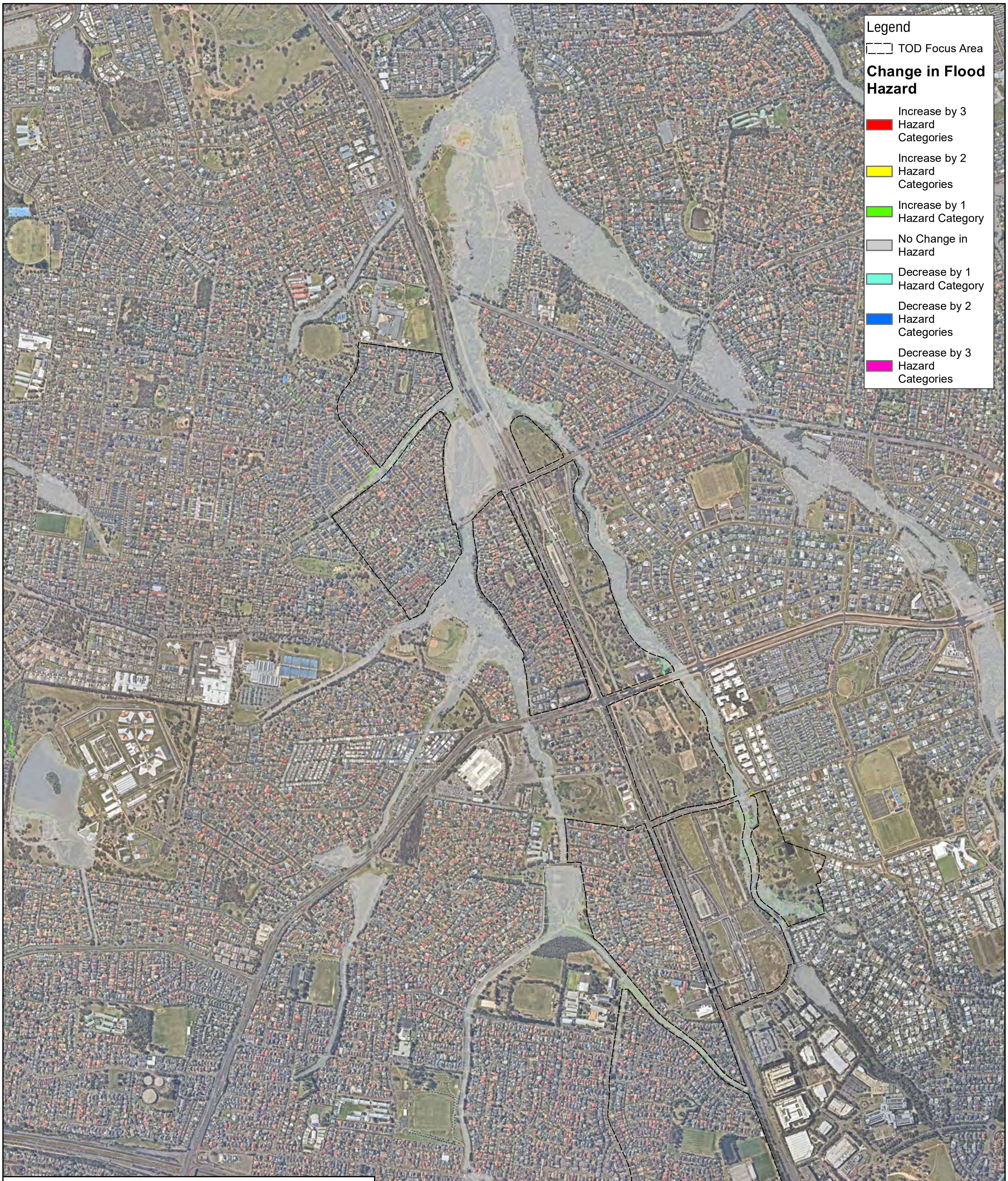

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NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.5% AEP
Baseline with TOD minus Baseline

Change in Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D013

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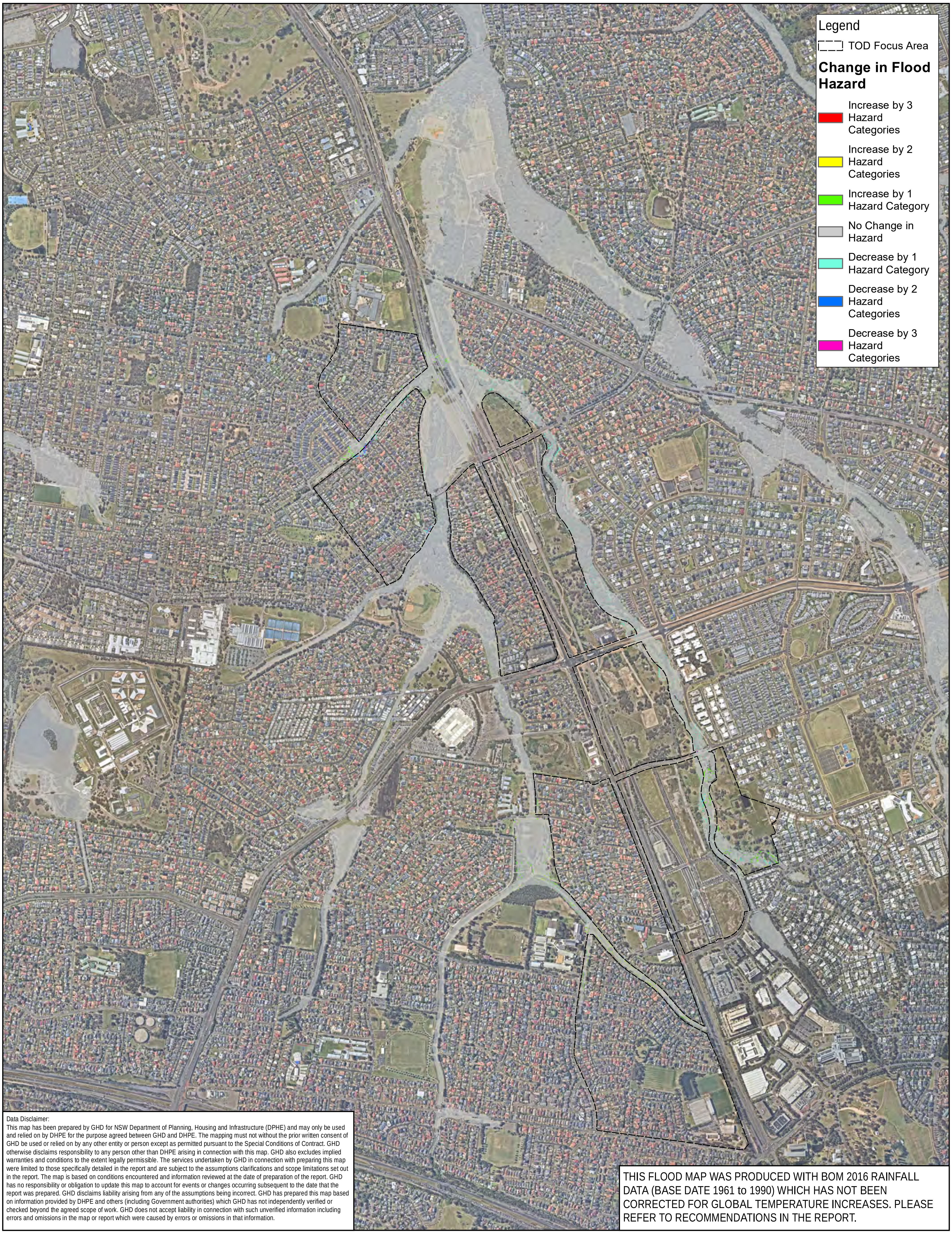

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NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.2% AEP
Baseline with TOD minus Baseline

Change in Flood Hazard (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D014

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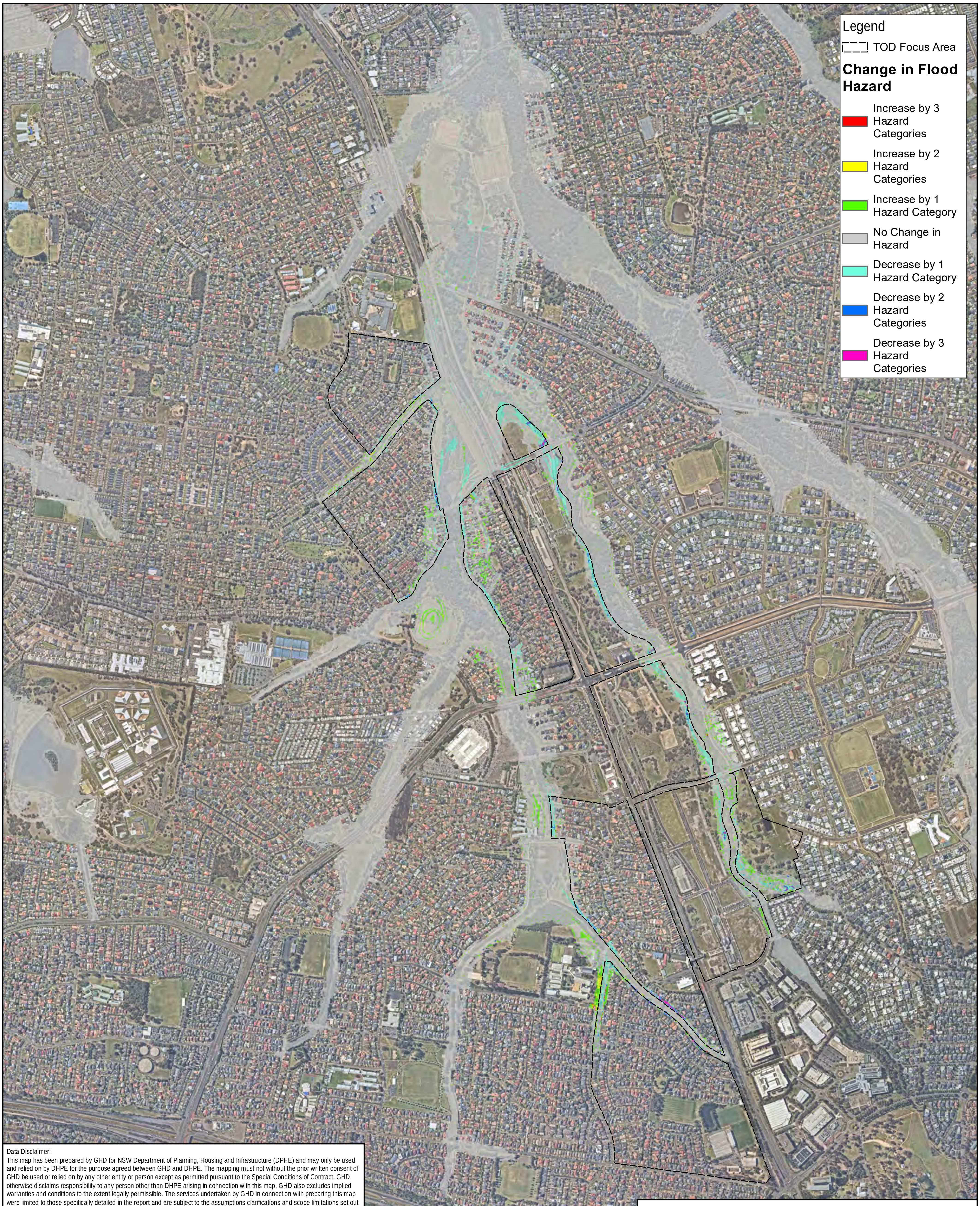
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
PMF
Baseline with TOD minus Baseline

Change in Flood Hazard (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D015

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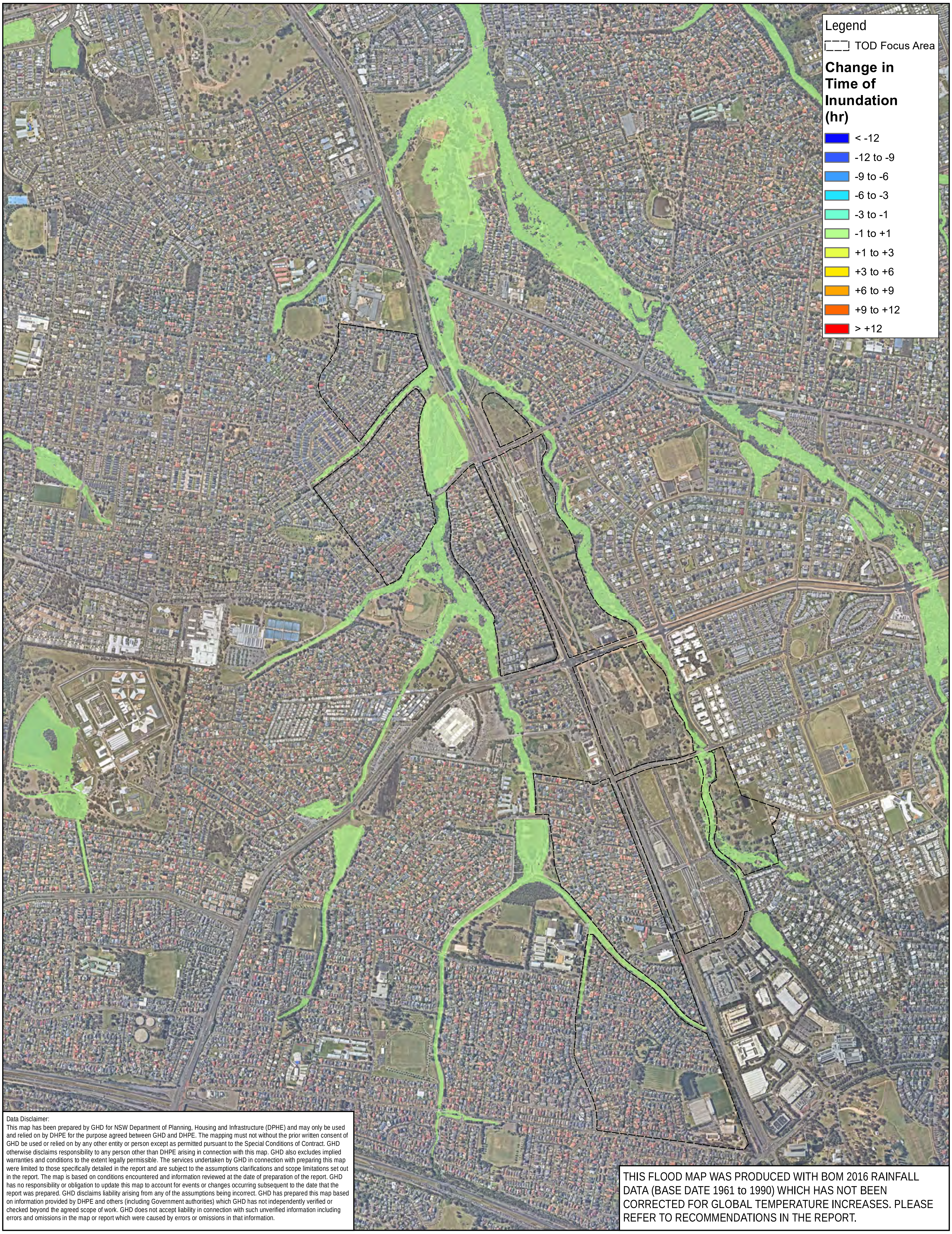
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
5% AEP
Baseline with TOD minus Baseline

Change in Time of Inundation (Max-Median)

Project No.	12640113
Revision No.	0
Date	4/11/2024

Figure D016

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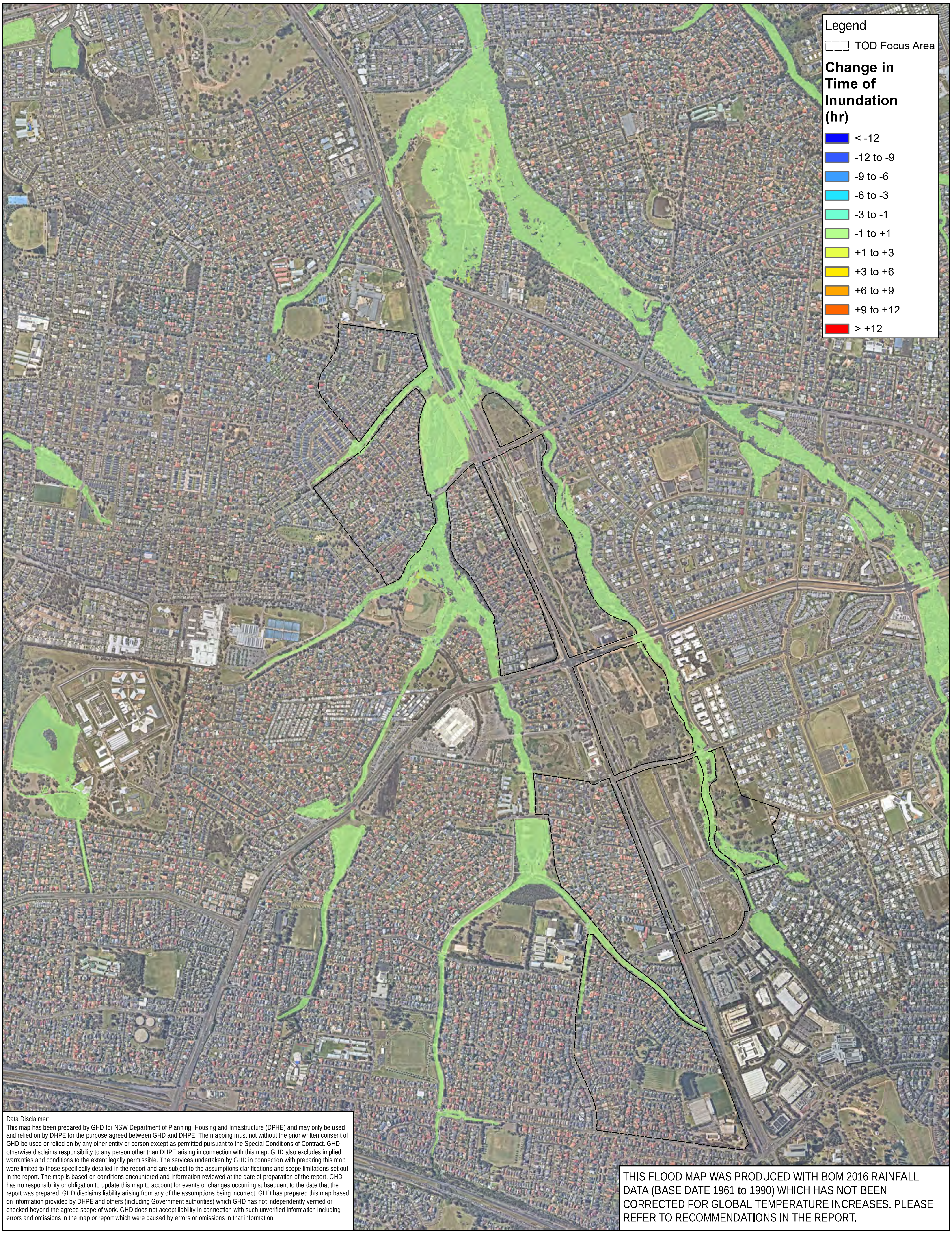
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
1% AEP
Baseline with TOD minus Baseline

Change in Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D017

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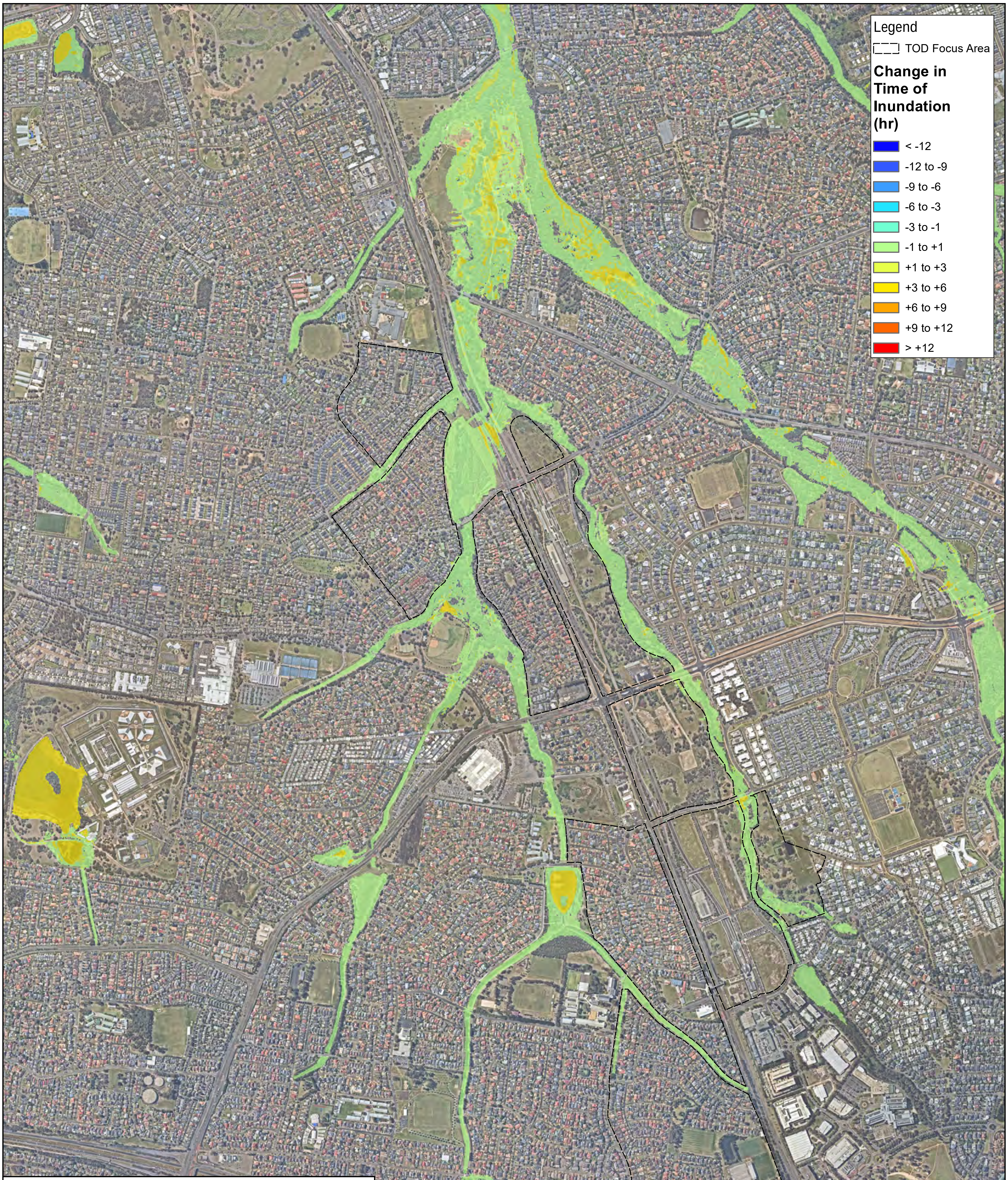
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



THIS FLOOD MAP WAS PRODUCED WITH BOM 2016 RAINFALL DATA (BASE DATE 1961 to 1990) WHICH HAS NOT BEEN CORRECTED FOR GLOBAL TEMPERATURE INCREASES. PLEASE REFER TO RECOMMENDATIONS IN THE REPORT.

Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.5% AEP
Baseline with TOD minus Baseline

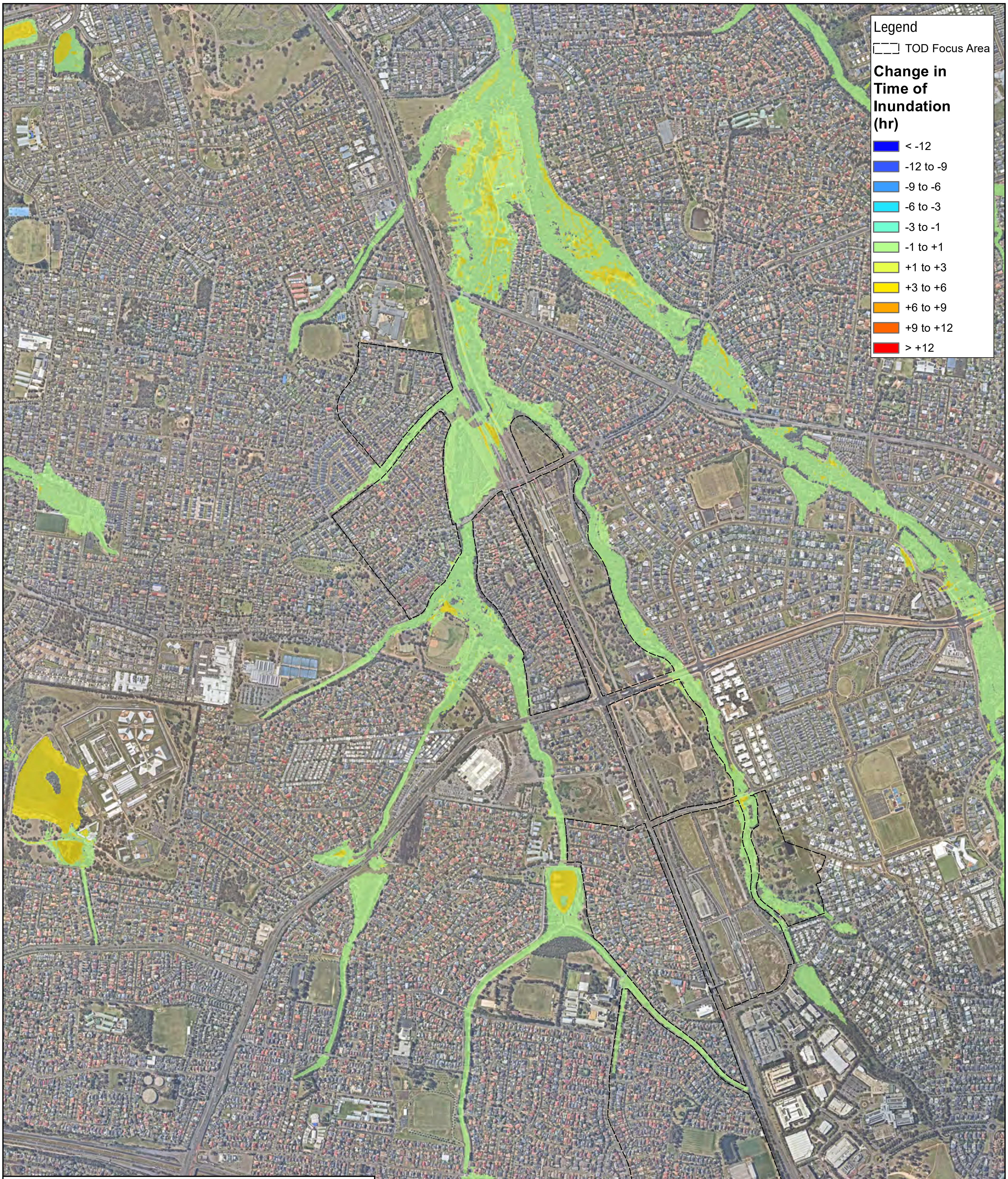
Change in Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D018

\\ghdnet\ghd\AU\Sydney\Projects\21\12640113\GIS\Resources\Templates\AutoFloodMaps\Templates\MXD\12640113_Kellyville_BellaVista_AutoFloodMaps.mxd
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.2% AEP
Baseline with TOD minus Baseline

Change in Time of Inundation (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D019

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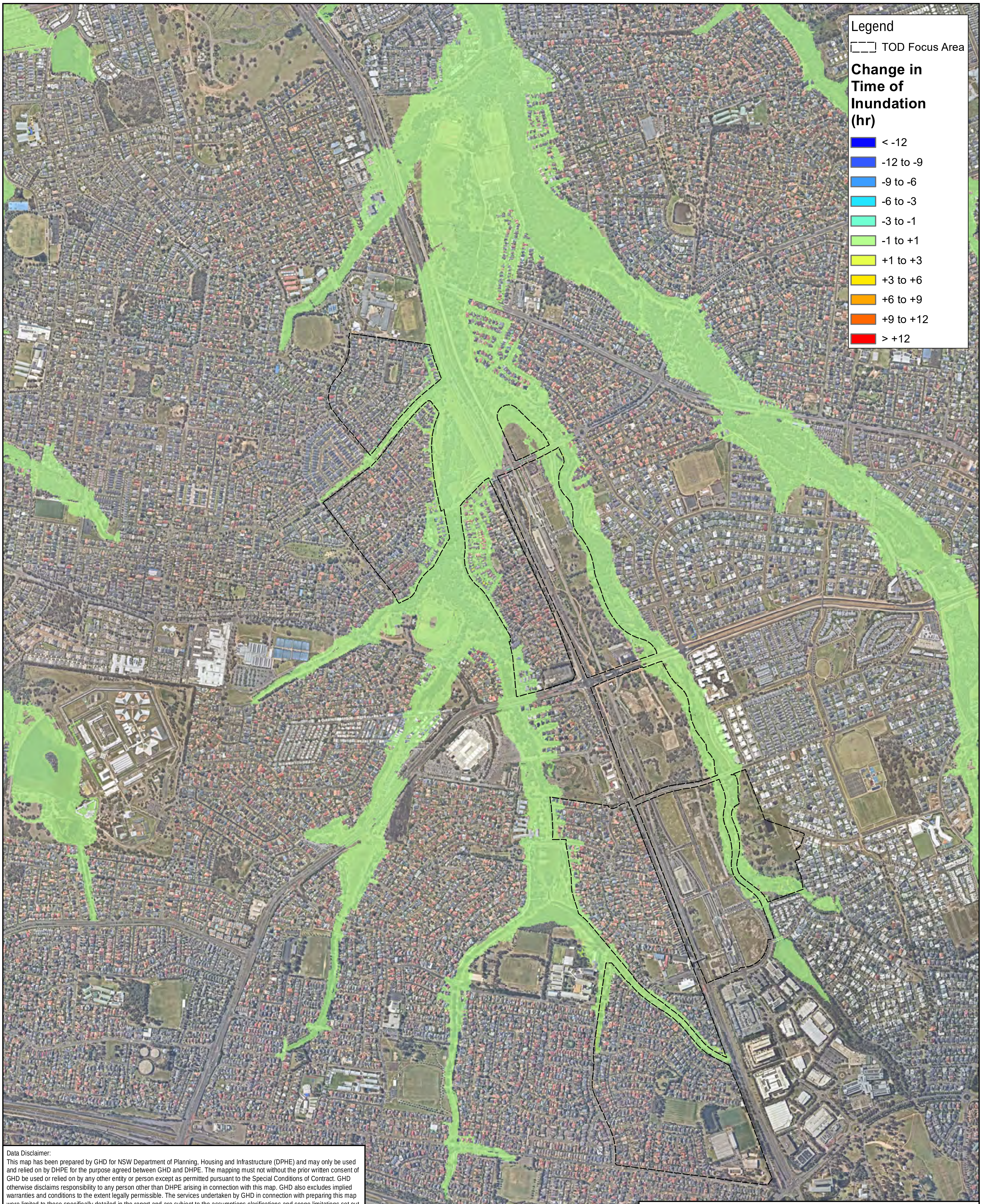
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
PMF
Baseline with TOD minus Baseline

Change in Time of Inundation (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure D020

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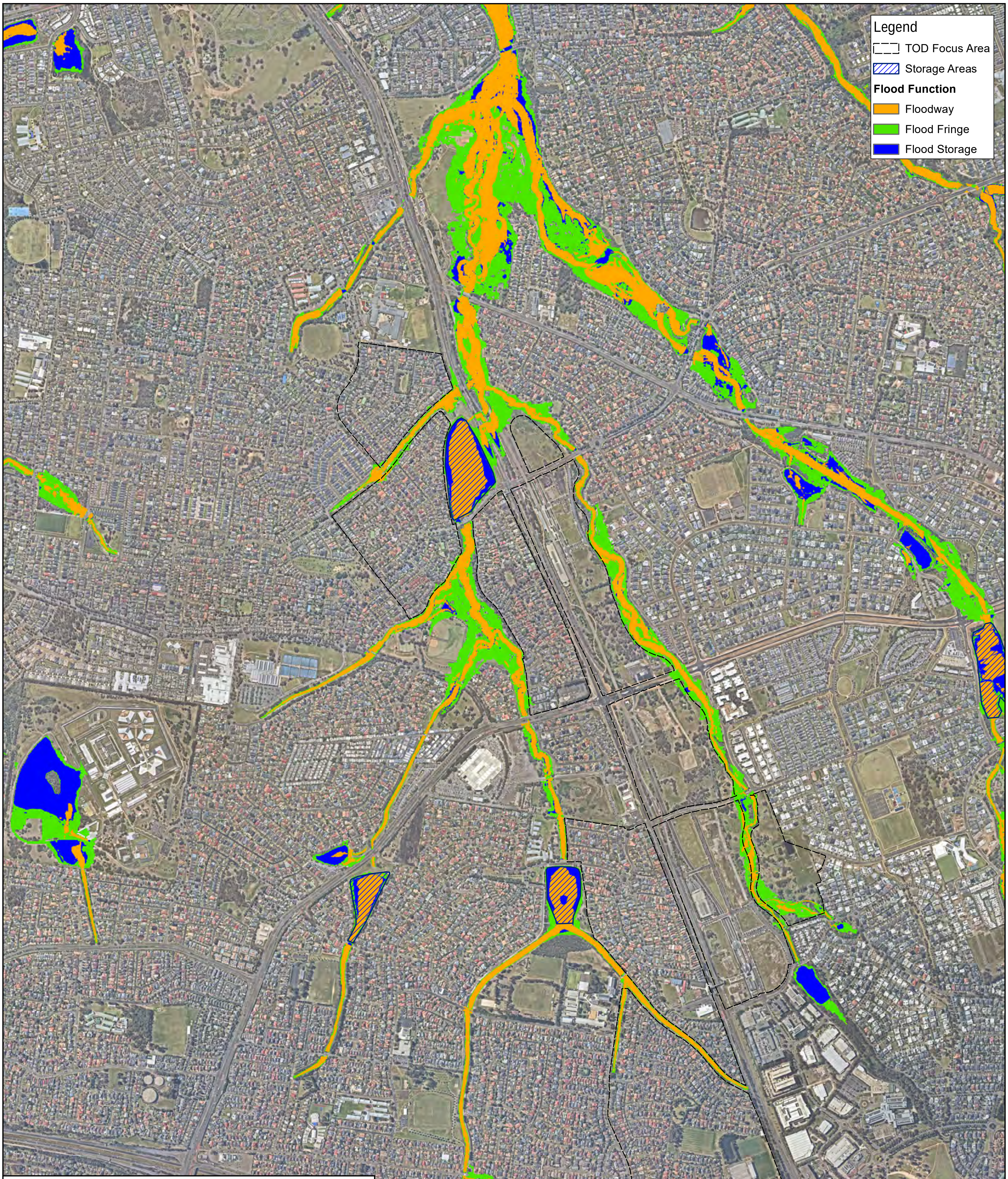
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4

Appendix E

Flood Planning and Flood Function Mapping



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Flood Function
Baseline Scenario

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE E001

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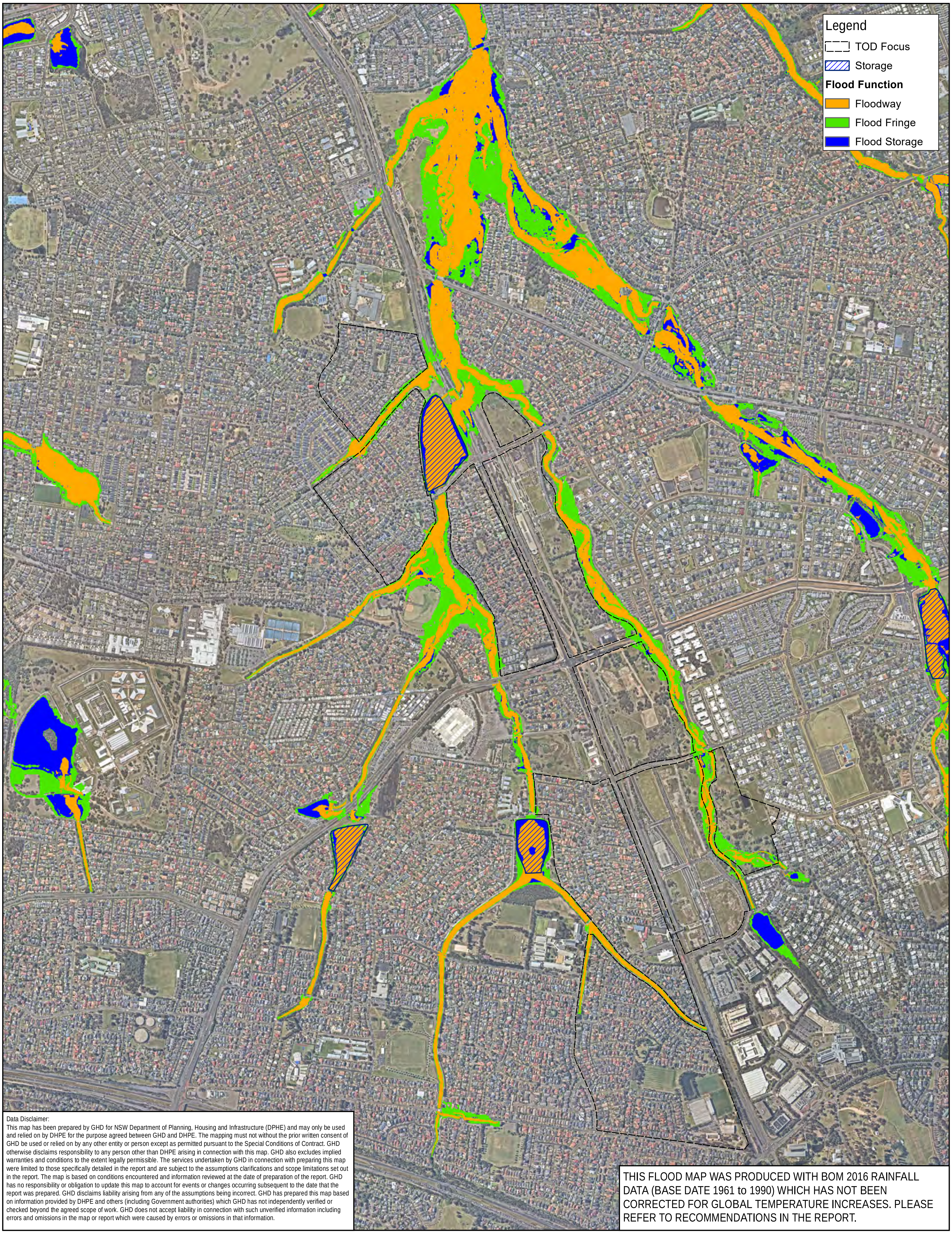

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Flood Function
(used as proxy for 1% AEP under RCP8.5 to 2090)
Baseline Scenario

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE E002

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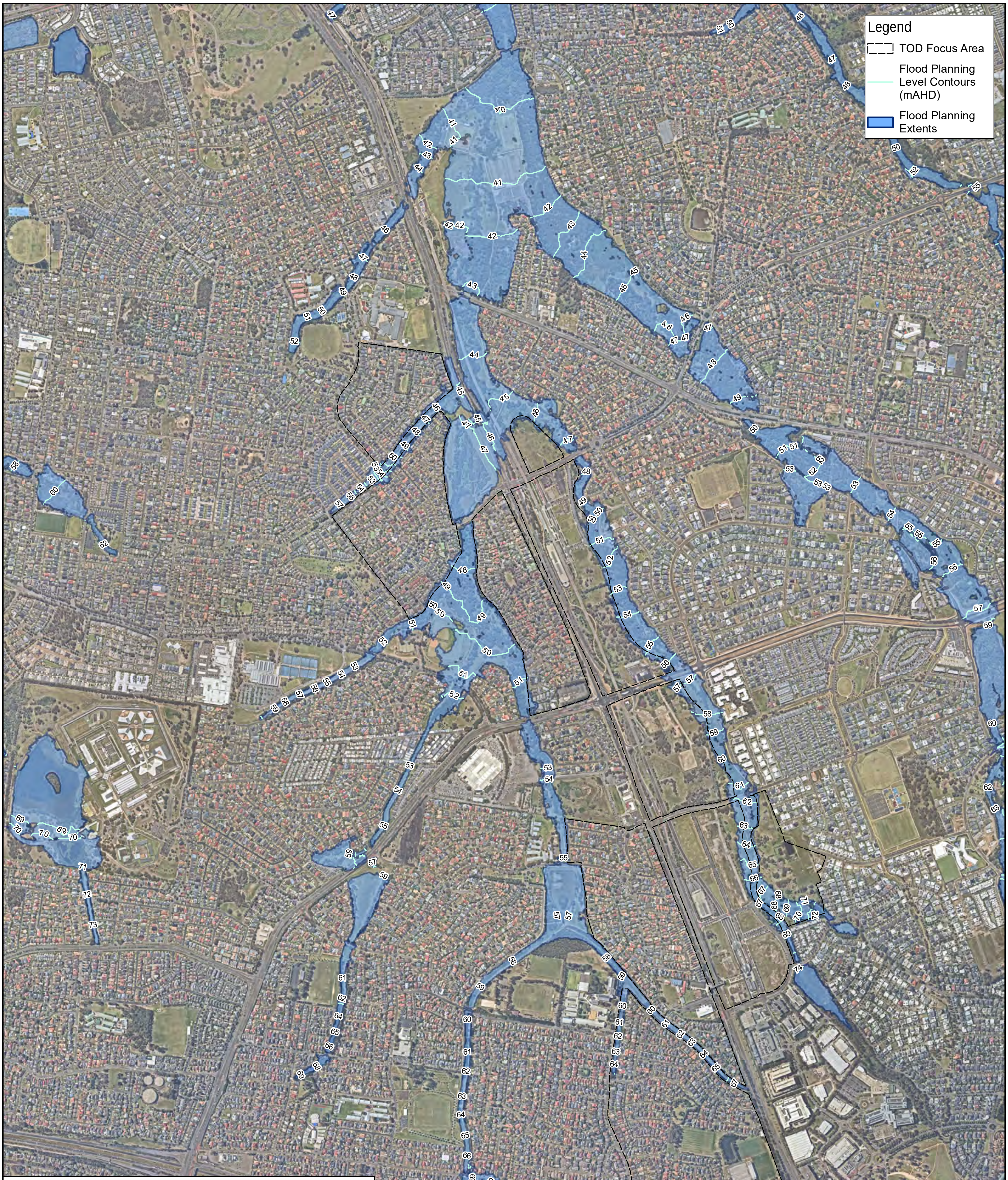

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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Flood Planning Level and Extents (BOM 2016)
Baseline with TOD plus 0.5m freeboard

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE E003

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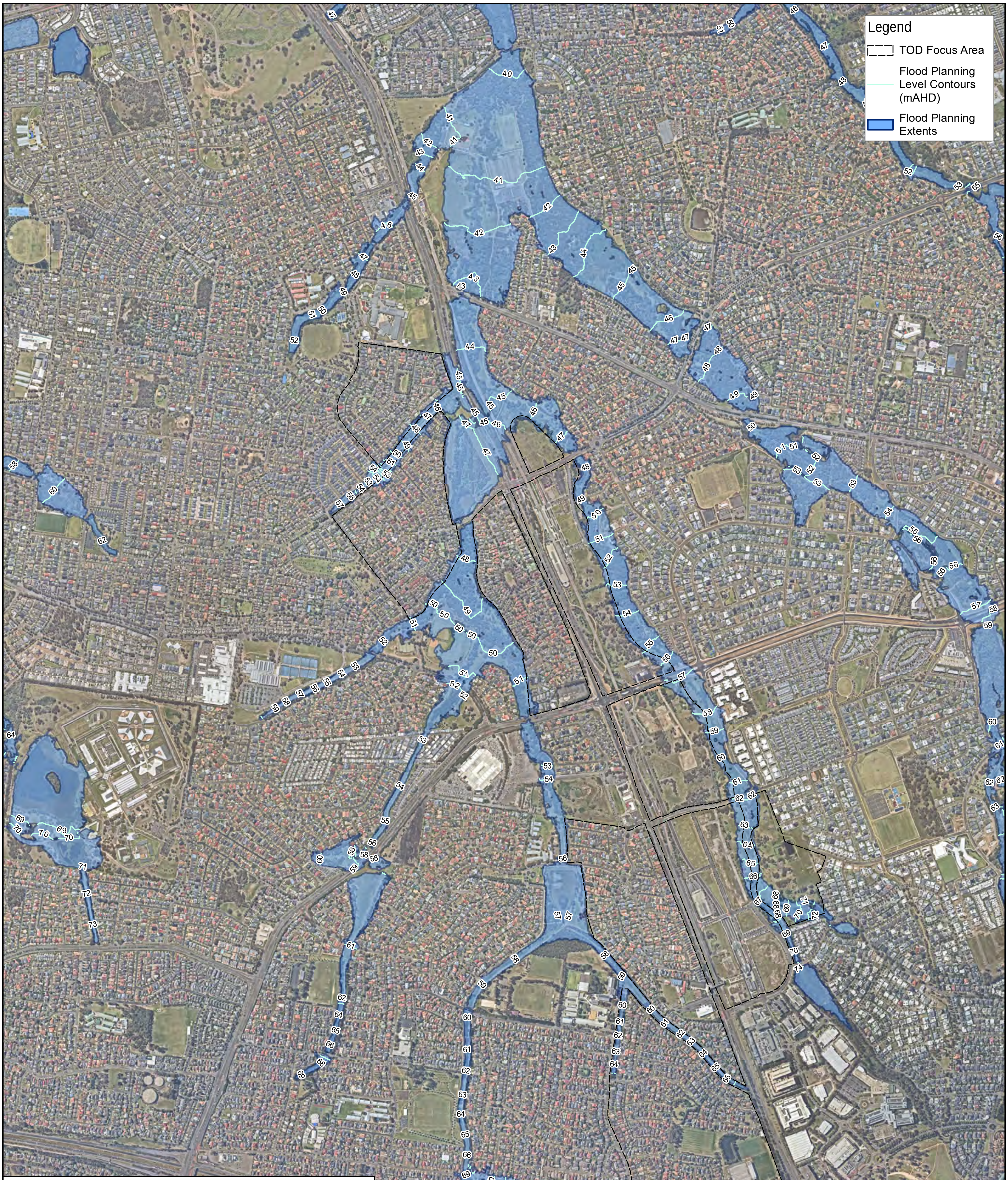

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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Flood Planning Level and Extents (CC 2024)
Baseline with TOD plus 0.5m freeboard

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE E004

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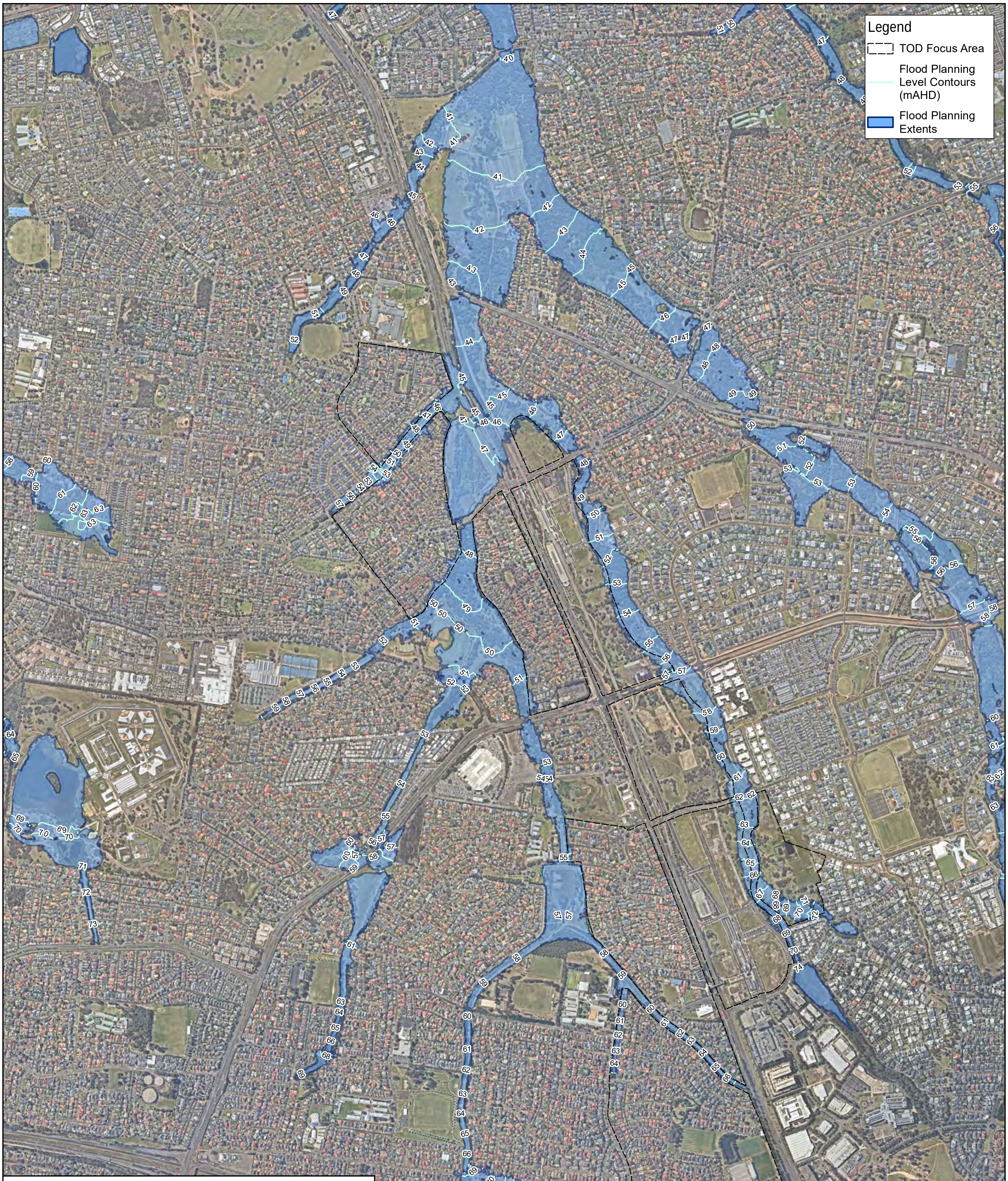
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

0.2% AEP - Flood Planning Level and Extents
(used as proxy for 1% AEP under RCP8.5 to 2090)
Baseline with TOD plus 0.5m freeboard

Project No. 12640113
Revision No. 0
Date 4/11/2024

FIGURE E005

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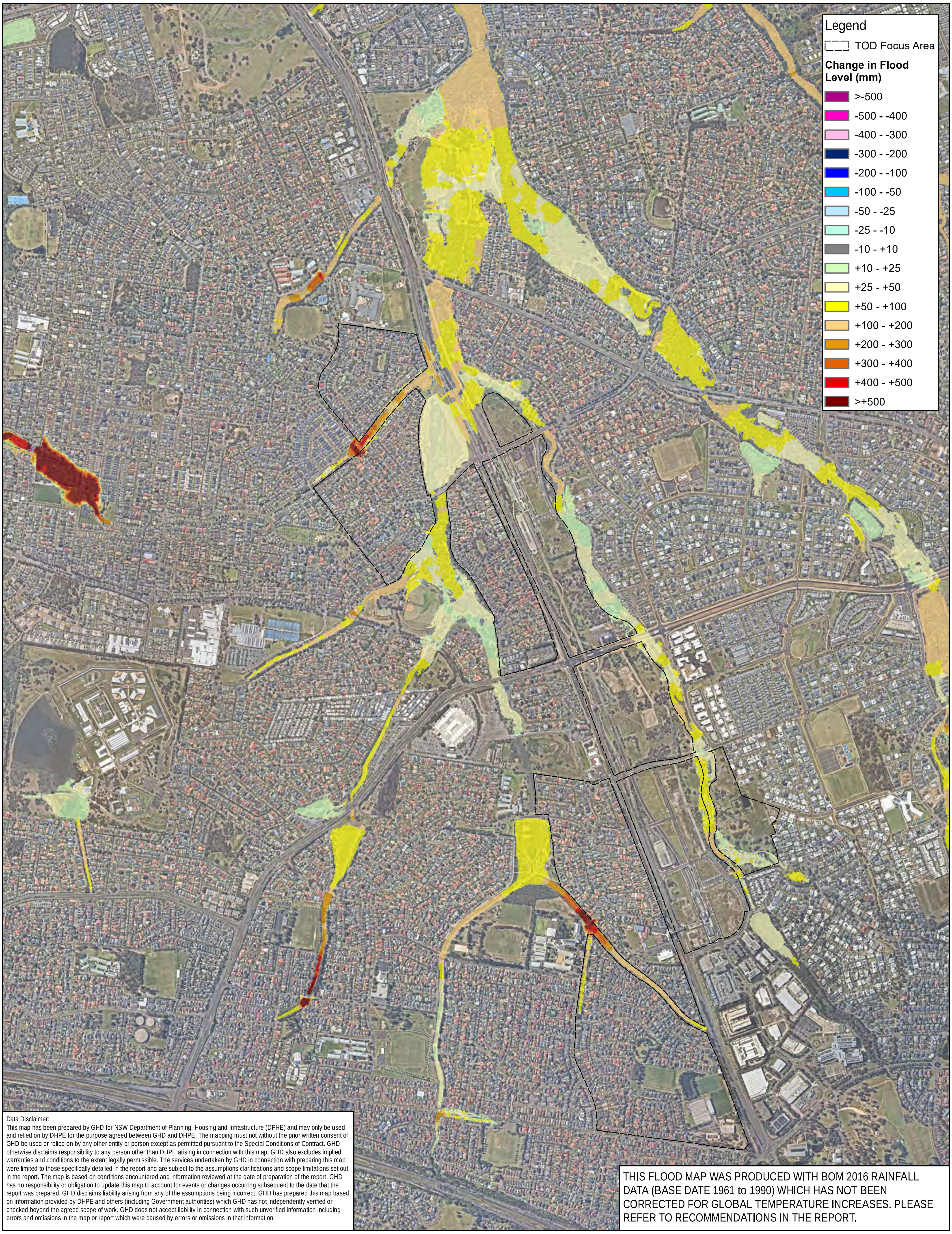
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4

Appendix F

Sensitivity Flood Mapping



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

GHD

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
1% AEP - Baseline Scenario
MAX-MAX minus MAX-MEDIAN

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure F001

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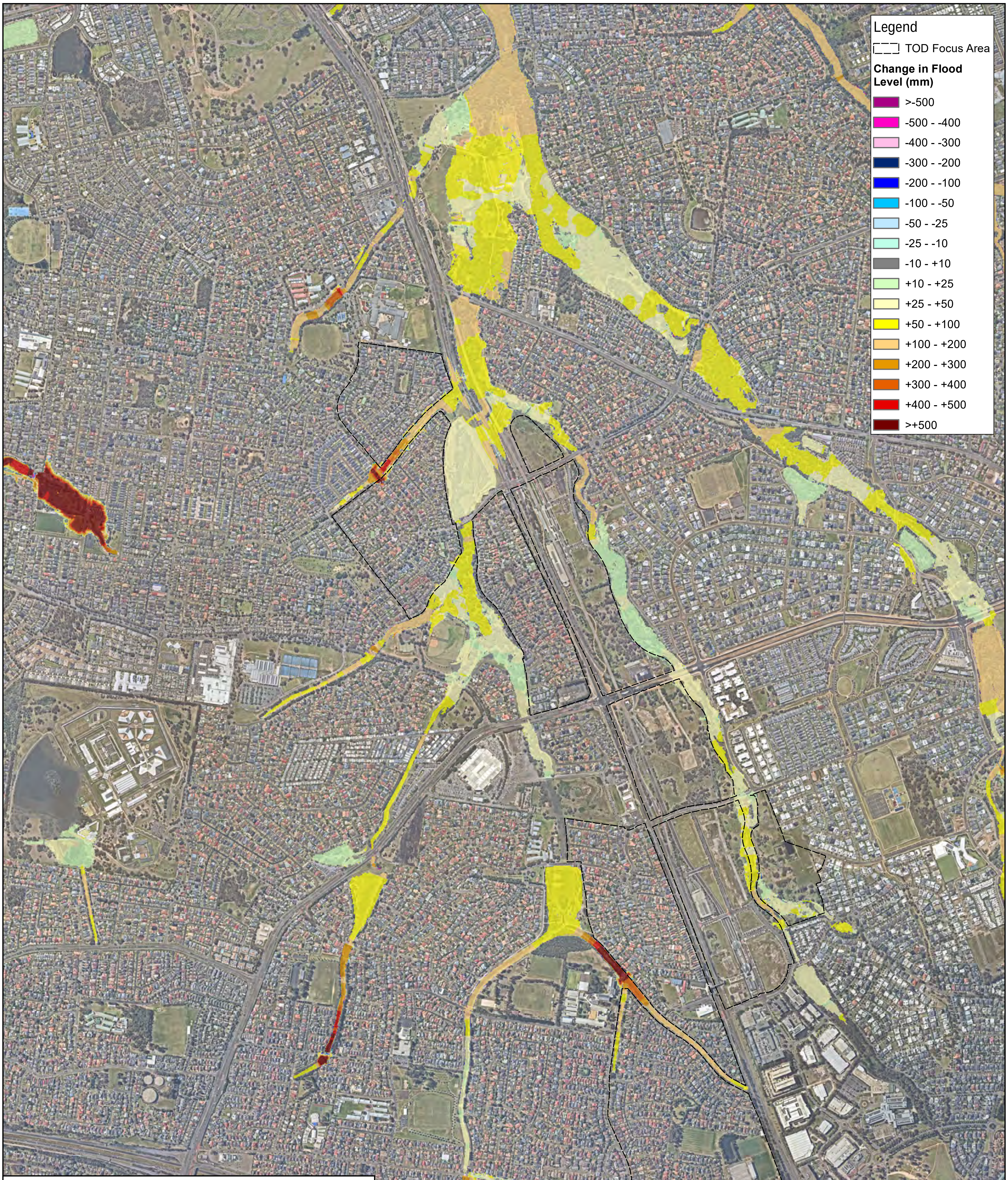
Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3
0 100 200 300 400
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
1% AEP - Baseline with TOD
MAX-MAX minus MAX-MEDIAN

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure F002

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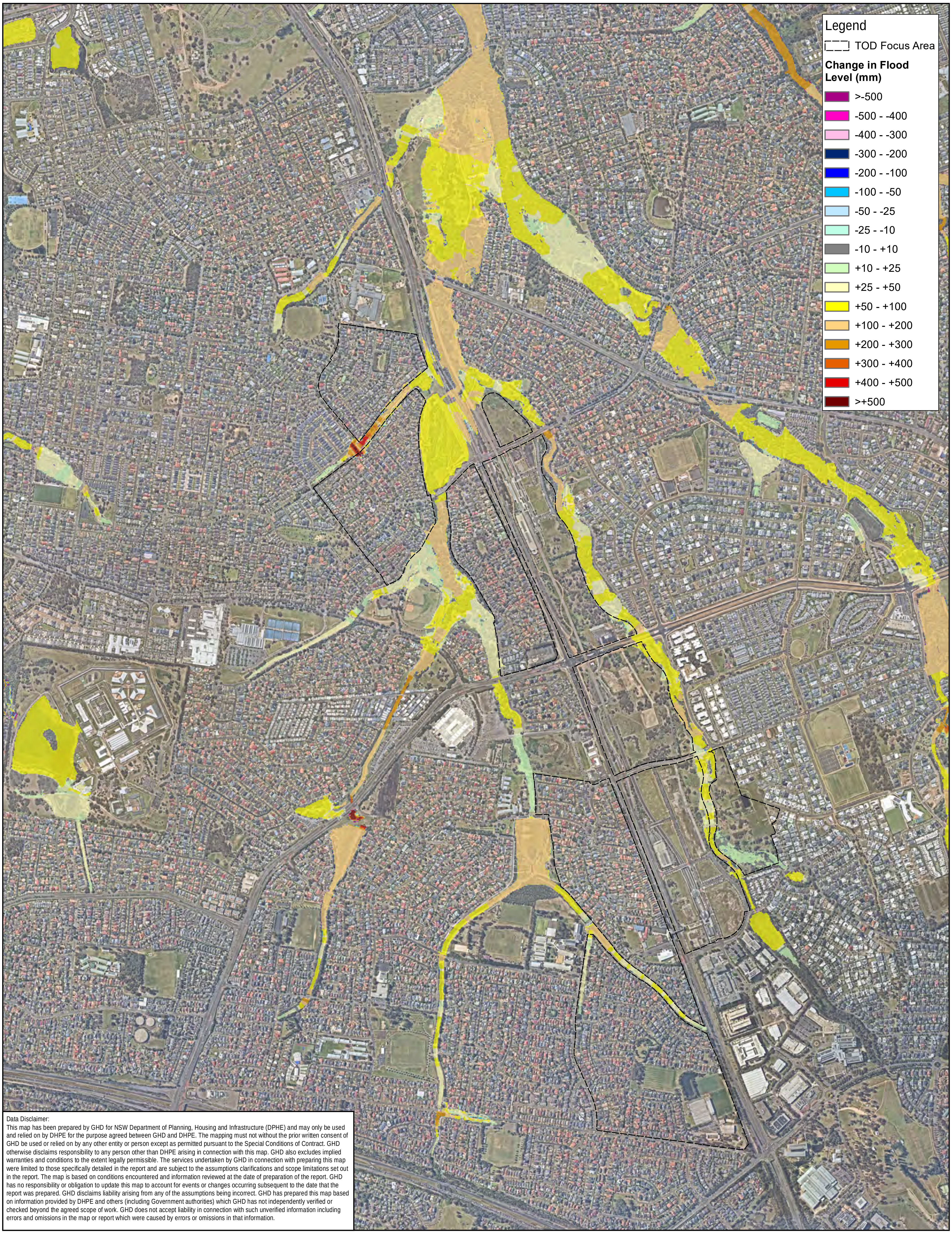
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding

1% AEP - Climate Change (2024)
Baseline with TOD - CC 2024 minus BOM 2016

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure F003

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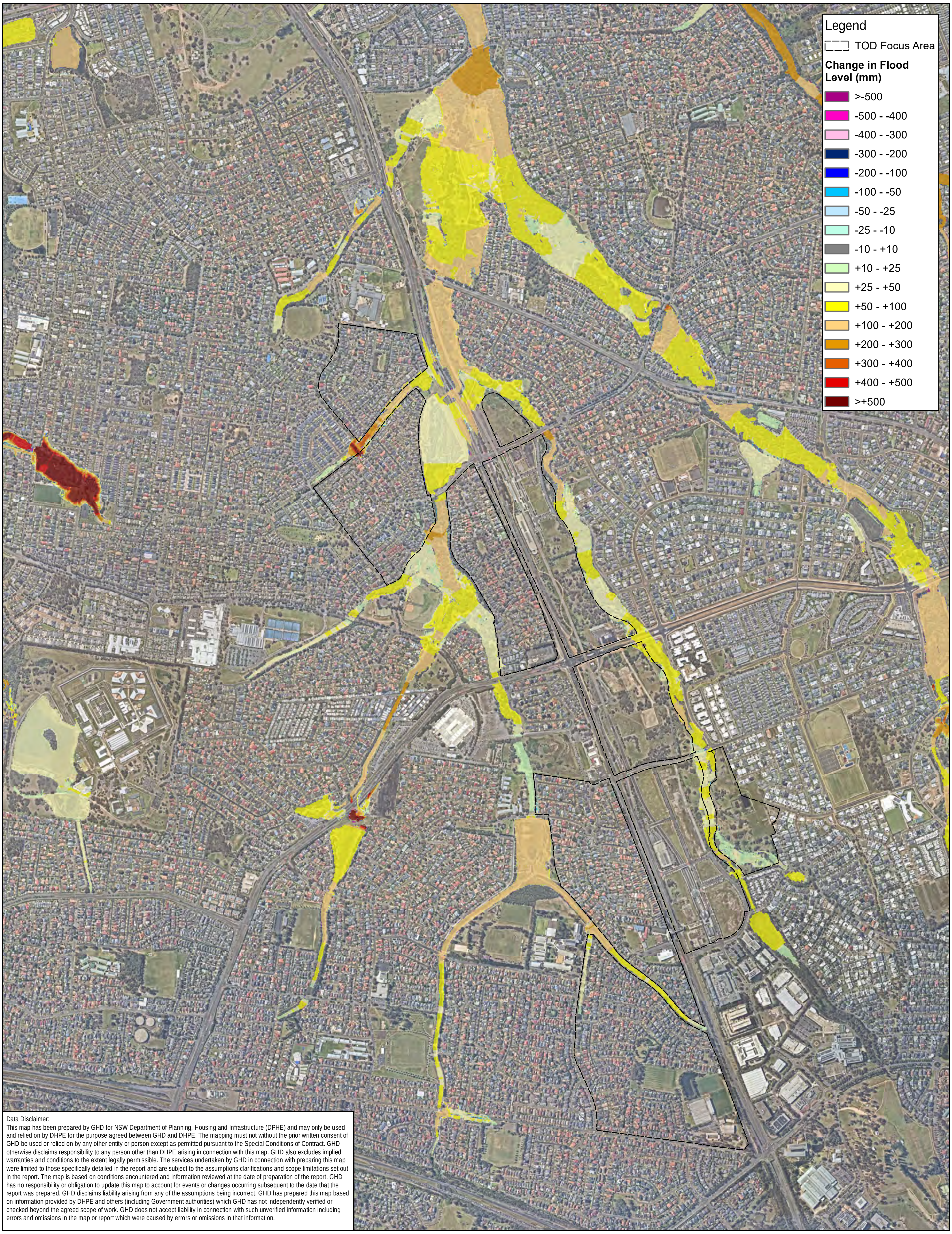
Print date: 4/11/2024

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4



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Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
0.5% AEP - Climate Change (2024)
Baseline with TOD - CC 2024 minus BOM 2016

Change in Flood Level (Max-Median)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure F004

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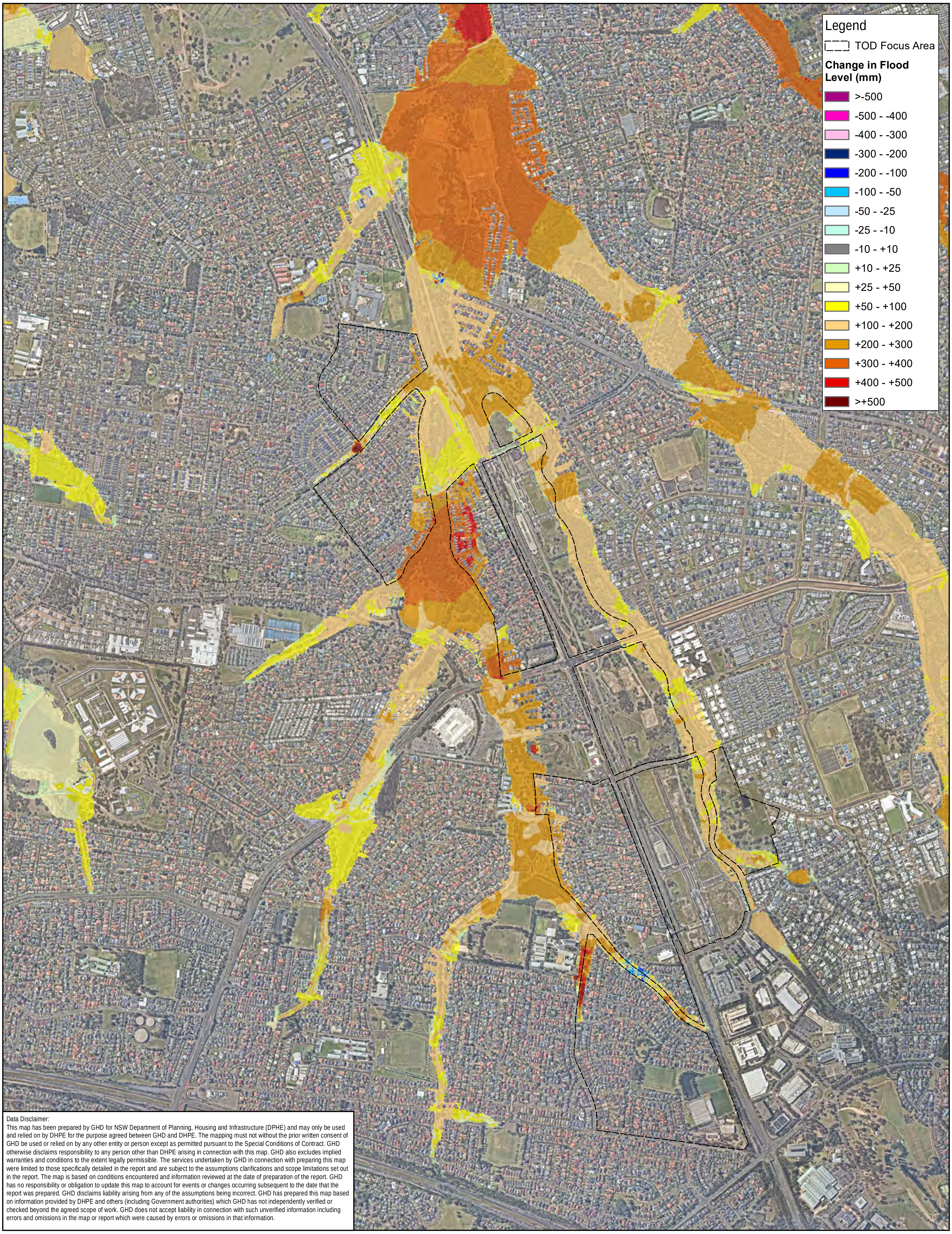

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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

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NSW Department of Planning, Housing and Infrastructure
Bella Vista and Kellyville TOD Rezoning
Drainage and Flooding
PMF - Climate Change (2024)
Baseline with TOD - CC 2024 minus BOM 2016

Change in Flood Level (Max-Max)

Project No. 12640113
Revision No. 0
Date 4/11/2024

Figure F005

Data source: NearMap Aerial Imagery (Date extracted: 4/11/2024). Created by: mrahman4

Appendix G

MUSIC Stormwater Quality Modelling

Background

MUSIC (Model for Urban Stormwater Improvement Conceptualisation) modelling was undertaken to inform the development of a suite of potential stormwater quality treatment strategy options (refer Section 2.2.6) and in particular strategy Option 4 which involves the provision of a stormwater treatment train consisting of a gross pollutant trap followed by bio-retention treatment which could be in the form of a basin, bio-retention swale or raingarden. Bio-retention requirements are stipulated on a per hectare catchment basis for a range of catchment imperviousness values.

The section outlines the MUSIC modelling undertaken to inform the derivation of these bio-retention requirements.

Methodology

Sydney Water does not stipulate specific guidance on MUSIC modelling approach and parameters. Therefore, the MUSIC-link functionality provided by Blacktown City Council (one of the two LGAs of the TOD rezoning areas) was utilised. MUSIC-link allows for the pre-population of key model parameters and climate data.

The model was structured as shown on Figure A.1 including a source generation, gross pollutant trap and bio-retention node.

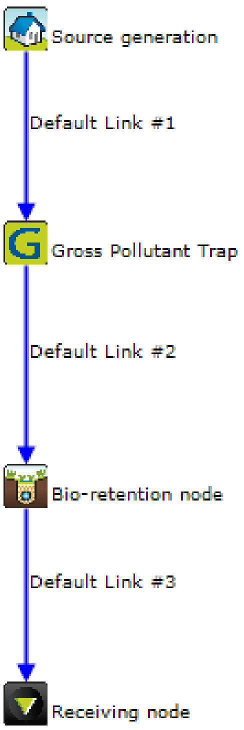

Figure A.1: MUSIC model structure

Key parameters for the modelling, based primarily on the Blacktown Council MUSIC-link functionality are shown in Tables 2 to 6.

Table 8.1 Climate data record and source

Date Range	Data Source
01/01/1967 to 31/12/1976	MUSIC-Link climate data from Blacktown Council

Table 8.2 Pollutant generation properties – BCC MUSIC-Link

Land use / Zoning		Log10 TSS (mg/L)		Log10 TP (mg/L)		Log10 TN (mg/L)	
		Stream flow	Baseflow	Stream flow	Baseflow	Stream flow	Baseflow
BCC Other Impervious areas (Unsealed road) (Urban – Mixed)	Mean	2.15	1.20	-0.60	-0.85	0.30	0.11
	Std Dev	0.32	0.17	0.25	0.19	0.19	0.12

Table 8.3 Scenarios and respective imperviousness

Scenario	Impervious (%)	Pervious (%)
1	100	0
2	80	20
3	60	40
4	40	60
5	20	80

Table 8.4 GPT – reduction rates and source of reduction (Source BCC standard node for OceanSave GPT)

Analyte	Input (mg/L)	Output (mg/L)
TSS	75	75
	1000	300
TP	0.5	0.5
	10	7
Nitrogen	No removal	
Gross Pollutants	0	0
	1000	2

Table 8.5 Bio-retention properties

Filter area (m^2)	Varies by scenario
Surface area (m^2)	Filter area × 1.5
High flow bypass	Based on estimate of 3-month ARI event.
Saturated Hydraulic Conductivity (mm/h)	100
Filter Depth (m)	0.5
TN Content of Filter Media (mg/kg)	800
Orthophosphate Content of Filter Media (mg/kg)	40
Exfiltration Rate (mm/h)	0
Overflow Weir Width (m)	3

Results

Results are indicated for the modelling below in Tables 7 to 11, for each of the modelled scenarios, demonstrating compliance with the Sydney Water reduction targets.

Table 7 Scenario 1 – Modelling results

Pollutant	Source load	Residual load	Percent Reduction
Total Suspended Solids (kg/yr)	1341.14	131.53	90.19
Total Phosphorus (kg/yr)	2.17	0.74	65.85
Total Nitrogen (kg/yr)	16.08	7.93	50.67
Gross Pollutants (kg/yr)	190.73	2.06	98.92

Table 8 Scenario 2 – Modelling results

Pollutant	Source load	Residual load	Percent Reduction
Total Suspended Solids (kg/yr)	1138.79	120.11	89.45
Total Phosphorus (kg/yr)	1.82	0.61	66.39
Total Nitrogen (kg/yr)	13.61	6.66	51.09
Gross Pollutants (kg/yr)	169.55	1.12	99.34

Table 9 Scenario 3 – Modelling results

Pollutant	Source load	Residual load	Percent Reduction
Total Suspended Solids (kg/yr)	880.30	87.81	90.03
Total Phosphorus (kg/yr)	1.48	0.51	65.67
Total Nitrogen (kg/yr)	11.01	5.42	50.81
Gross Pollutants (kg/yr)	143.81	0.50	99.65

Table 8.6 Scenario 4 – Modelling results

Pollutant	Source load	Residual load	Percent Reduction
Total Suspended Solids (kg/yr)	654.62	74.37	88.64
Total Phosphorus (kg/yr)	1.12	0.39	65.32
Total Nitrogen (kg/yr)	8.60	4.26	50.48
Gross Pollutants (kg/yr)	110.83	0.20	99.82

Table 8.7 Scenario 5 – Modelling results

Pollutant	Source load	Residual load	Percent Reduction
Total Suspended Solids (kg/yr)	399.54	49.26	87.67
Total Phosphorus (kg/yr)	0.78	0.27	65.42
Total Nitrogen (kg/yr)	6.01	2.89	51.87
Gross Pollutants (kg/yr)	63.83	0.06	99.91