FINAL Report

Chambers Creek Flood Study 2023

Logan City Council

15 June 2023

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1 INTRODUCTION

1.1 Introduction

Water Technology (WT) have been engaged by Logan City Council (LCC) to prepare the Chambers Creek 2023 Flood Study and Management Plan. The subject catchment area encompasses the majority of the suburbs of Park Ridge and Park Ridge South, and flows downstream through the suburb of Chambers Flat, all of which are located south of Browns Plans and Marsden. Each of the subject suburb areas have been subject to extensive development in recent times, with a large portion of the catchment comprised in the Emerging Community zoning under the Logan Planning Scheme.

The study area catchment is approximately bordered by Park Ridge Road to the north, the Logan River to the east and south, and extends to the west of the Mount Lindsay Highway. The total area of the Cambers Creek catchment is approximately 32.7 km^2, some 3,723 hectares (ha).

The key objectives of this study are to provide Council with detailed flood mapping outcomes for the greater Chambers Creek catchment to fully quantify flood risk using current best practices and most recent topographical information. Separate to this flood study, the greater study additionally includes a Flood Management Plan to inform strategic land use planning to assist Council in preparing a Feasible Alternative Assessment Reporting (FARR) requirement. The Flood Management Plan is to be prepared as a separate and standalone report to this flood study report.

The preparation of the detailed and comprehensive flood study for Chambers Creek is particularly critical given the current catchment modelling involving multiple models of varying nature as well as the extensive development that has historically occurred in the catchment. In so doing, Council will then have a consolidated and consistent flood study information for the catchment which can be used to reliably guide future catchment development and land use planning outcomes that is based on current ARR2019 guidance. The flood study for the area will also provide additional benefits as follows:

- The existing (current) flood risk status of previously developed areas, particularly historical development areas including Park Ridge, Park Ridge South and Chambers Creek;
- Adherence to the recommendations following the Queensland Floods Commission of Inquiry;
- A mechanism for Council to control and co-ordinate all future development within the area with due regard to flood control and ensuring development compliance. Previously, the opportunity for co-ordinated and compliant development outcomes has been somewhat limited by individual developers preparing their own hydraulic and flood assessments in the absence of a broader catchment wide, strategic and consistent flood study;
- An opportunity for Council to include the updated flood study outcomes into a future planning scheme amendments for the area;
- Currency in flood control which specifically utilises the most recent 2021 LiDAR data collected by Council;
- Updated flood information to support community awareness and Council's ongoing disaster management functions; and
- An opportunity to provide a higher level and functioning hydraulic model which can be utilised by Council to improve future flood forecasting initiatives.

Given the Planning Scheme setting that the outputs of this project will contribute to, it is critical that the flood study accurately quantifies all flood related inundation and risks occurring throughout the greater Chambers Creek catchment. The subsequent sections of this report aim to provide a detailed and comprehensive documentation relating to the assessment and outputs prepared in relation to the Chambers Creek Flood Study 2023.

2 CATCHMENT DESCRIPTION

Chambers Creek flows in a west to east direction through the upstream suburb of Park Ridge south and the downstream suburb Chambers Flat. The outlet of Chambers Creek confluences with the Logan River. The total area of the catchment is approximately 30 km^2. The catchment is illustrated in Figure 2-1.

The catchment is relatively long and narrow, with the longest distance west to east just under 12 km with a width south to north of approximately 5 km. The catchment is traversed by two (2) major roads including Mount Lindesay Highway in the northwest of the catchment and Chambers Flat Road to the east. The catchment remains relatively undeveloped in the southern areas although there has been historical development occurring in Park Ridge and Park Ridge South. Rural residential and open space land use dominates the catchment, with large areas zoned as emerging communities and is under current and future development pressure in areas in the northern portions of the catchment.

The upper catchment is mainly rural residential with a significant amount of small tributaries leading into local dam storages. Downstream of the Mount Lindsay Highway the main creek channel is poorly defined within a densely vegetated flat conservation area. Moving further downstream and in areas upstream of Chambers Flats Road, the creek runs along adjacent to rural and industrial properties. In the lower parts of the catchment Chambers Creek is perennial and is affected by Logan River backwater in moderate events, with the backwater influence much more pronounced upstream into the Chambers Creek catchment in large Logan River flood events. This was of particular note during the recent February 2022 flood event in the Logan and Albert River catchments.

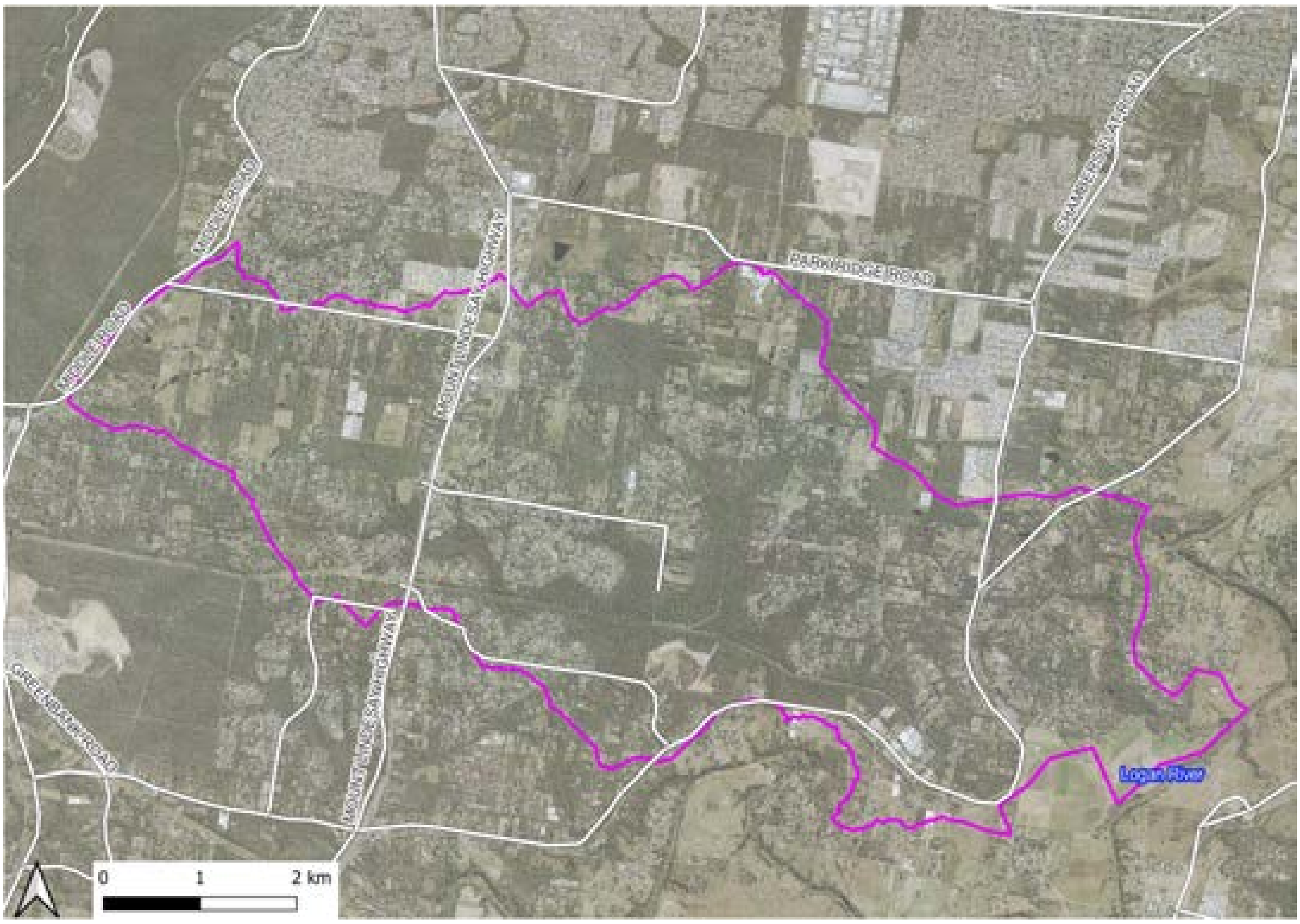

Figure 2-1 Study Catchment Area and General Locality

3 AVAILABLE DATA

3.1 Previous Studies

No previous hydrologic or hydraulic models or reports have been undertaken specifically assessing flood risk for local Chambers Creek flooding. We understand that Council have previously prepared some flood assessments throughout the catchment, but these are isolated in spatial extent, are localised and have been prepared a while ago such that they are now of little relevance especially having regard to the most recent guidance for the preparation of flood studies. The Logan Albert River flood study 2019 incorporated Chambers Creek as an inflow to the main tributary and showed that backwater flood levels occurred throughout the Chambers Creek catchment. No specific hydraulic modelling of the Chambers Creek catchment was however completed in this study, at least not to the extent necessary to guide future catchment development.

3.2 Topographic Data

Recently captured 2021 LiDAR data has been sourced and provided by LCC for the purposes of this study. An illustration of the Chambers Creek catchment extent and topography based on this 2021 LiDAR is presented in Figure 3-1. The LiDAR is the best representation of the current catchment topography and has mainly been utilised in the TUFLOW hydraulic modelling.

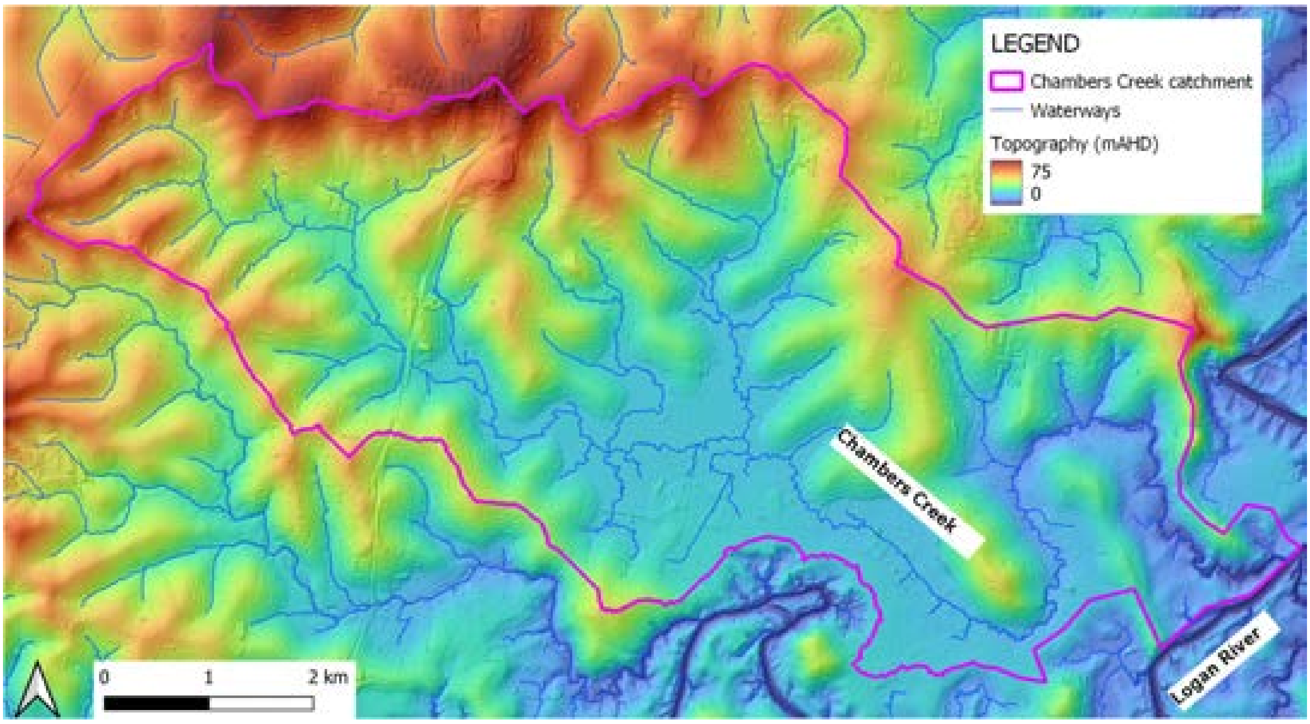

Figure 3-1 2022 LiDAR for Chambers Creek.

3.3 Historical Flood Data

Rainfall and river level data were supplied for model calibration purposes. This includes a mixture of historical rainfall and river level data recorded at the Alert Gauge data as are listed in Table 3-1, with the locations presented in Figure 3-2.

Table 3-1 Alert Rainfall and River Level Data Available

Alert Gauge	Data type	Record length
Chambers Creek Alert	River	October 2017 – Present
Logan Village Alert	Rainfall and River	November 2012 – Present
Maclean Bridge Alert	Rainfall and River	July 2006 – Present
Schmidts Road Alert	Rainfall and River	March 2014 – Present
Stoney Camp Road Alert	Rainfall	November 2017 – Present

The Logan Village Alert gauge, Schmidts Road Alert gauge and the Maclean Bridge Alert gauge are located outside of Chambers Creek Catchment. Subsequently, the water level data reflects the Logan River, not Chambers Creek and therefore is only able to be utilised as downstream boundary conditions for the catchment.

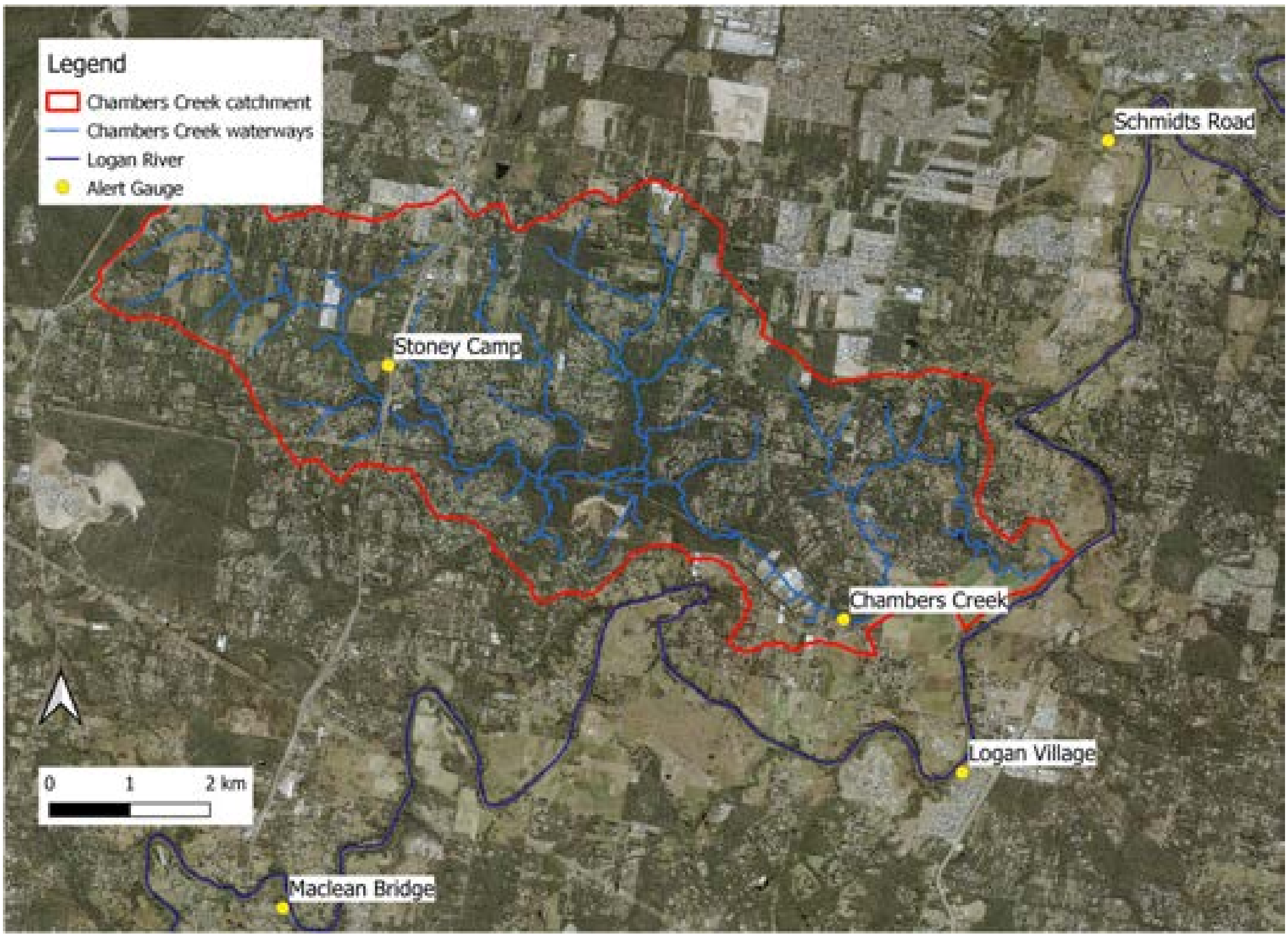

Figure 3-2 Rainfall and River level alert gauges (LCC 2020 aerial imagery)

3.4 Spatial Data

A range of GIS data sets were provided in an ESRI geodatabase format by LCC. A summary of the supplied GIS data is provided in Table 3-2.

Table 3-2 Files contained within Council provided ESRI geodatabase.

Filename	Description
Chambers_Creek Bridges	Granger Road pedestrian bridge located within the Chambers Creek catchment. No bridge length and width, pier or deck dimensions provided. This structure falls outside of the 2015 flood overlay area and may not be critical.
Chambers_Creek Building_Footprint	Building footprints
Chambers_Creek Cadastre	Cadastre
Chambers_Creek Easements	Easements
Chambers_Creek Flood_Survey_Marks_February_2013	Debris line and water levels collected between 30/01/2013 and 26/02/2013
Chambers_Creek Flood_Survey_Marks_February_2020	Debris line and water level. Single date listed – 14/02/2020
Chambers_Creek Flood_Survey_Marks_March_2017	Elevation listed without units, no further description provided
Chambers_Creek Planning_Scheme_2015_Flood_Hazard_Overlay	Flood Hazard Overly from 2015 flood study and planning scheme
Chambers_Creek Planning_Scheme_2015_Zone_Map	Zone map from 2015 planning scheme
Chambers_Creek Road_Parcels	Road network
Chambers_Creek Stormwater_Box_Culverts	Stormwater culvert network.
Chambers_Creek Stormwater_GPT	Gross Pollutant Traps. None located within catchment.
Chambers_Creek Stormwater_Headwalls	Headwalls.
Chambers_Creek Stormwater_Open_Drains	Constructed channels
Chambers_Creek Stormwater_Pipes	Stormwater pipe network.
Chambers_Creek Stormwater_Pits	Stormwater pits.
Chambers_Creek Study_Area	Defined study area
Chambers_Creek Telemetry_water_level_sensor_locations	Telemetry stations in catchment
Chambers_Creek Waterway_Corridor	Waterway corridors
Chambers_Creek Waterway_Creek_Catchment	Catchment margins within study area
Chambers_Creek Waterways	Waterways within data extract region

3.5 Field survey

LCC provided survey data for key structures throughout the catchment, mainly in the lower reaches of Chambers Creek. Table 3-3 and Figure 3-3 present the sizes and locations of the survey structures respectively. These structures have been incorporated into the TUFLOW hydraulic model.

Table 3-3 Field survey structures

Asset no.	Easting	Northing	mAHD	Description length/size
CH4	508298.1	6932322	19.08	7.4m/ 450x1 RCP
CH5	508368.2	6932312	18.72	7.4m/ 600x1 RCP
CH6	508753.5	6931720	12.94	11.0m/ 2800X1800X2 + 3300X1800X1 GR + 700 RCBC
CH7	509497.9	6932113	11.99	16.1m/ 3000X1800X2 RCBC
CH8	509989.1	6932114	12.06	9.6m/ 1200x900x1 RCBC
CH9	508300.1	6932334	18.86	6.8m/ 375x3 RCP
CH10	508660.2	6931529	12.59	5.1m/ 1200x1 + 200x2 (polly) RCP
CH11	508702.7	6931413	13.25	4.3m/ 1x1800x1500 RCBC
CH12	508688.3	6931371	12.82	Bridge (5.0x3.0x0.3)
CH13	508701.1	6931309	12.51	2.8m/ 525x7 RCP
CH14	508830.2	6931141	13.84	Causeway
CH15	508917.2	6930969	14.91	2.6m/ 1050x2 RCP
CH16	509020.5	6930902	14.72	2.4m/ 1500x1 RCP
CH17	509022.8	6930219	16.09	7.3m/ 750x3 RCP
CH18	508185.1	6930280	17.78	5.2m/ 525x3 RCP
CH19	508096.1	6930329	17.35	5.6m/ 750x3 RCP
CH20	508056.8	6930354	18.13	5.0m/ 900X4 RCP
CH21	507944.4	6930418	18.18	4.9m/ 675X4 RCP
CH22	507907.1	6930439	18.41	7.4m/ 900X3 RCP
CH23	507778.2	6930601	18.79	7.4m/ 900x3 RCP

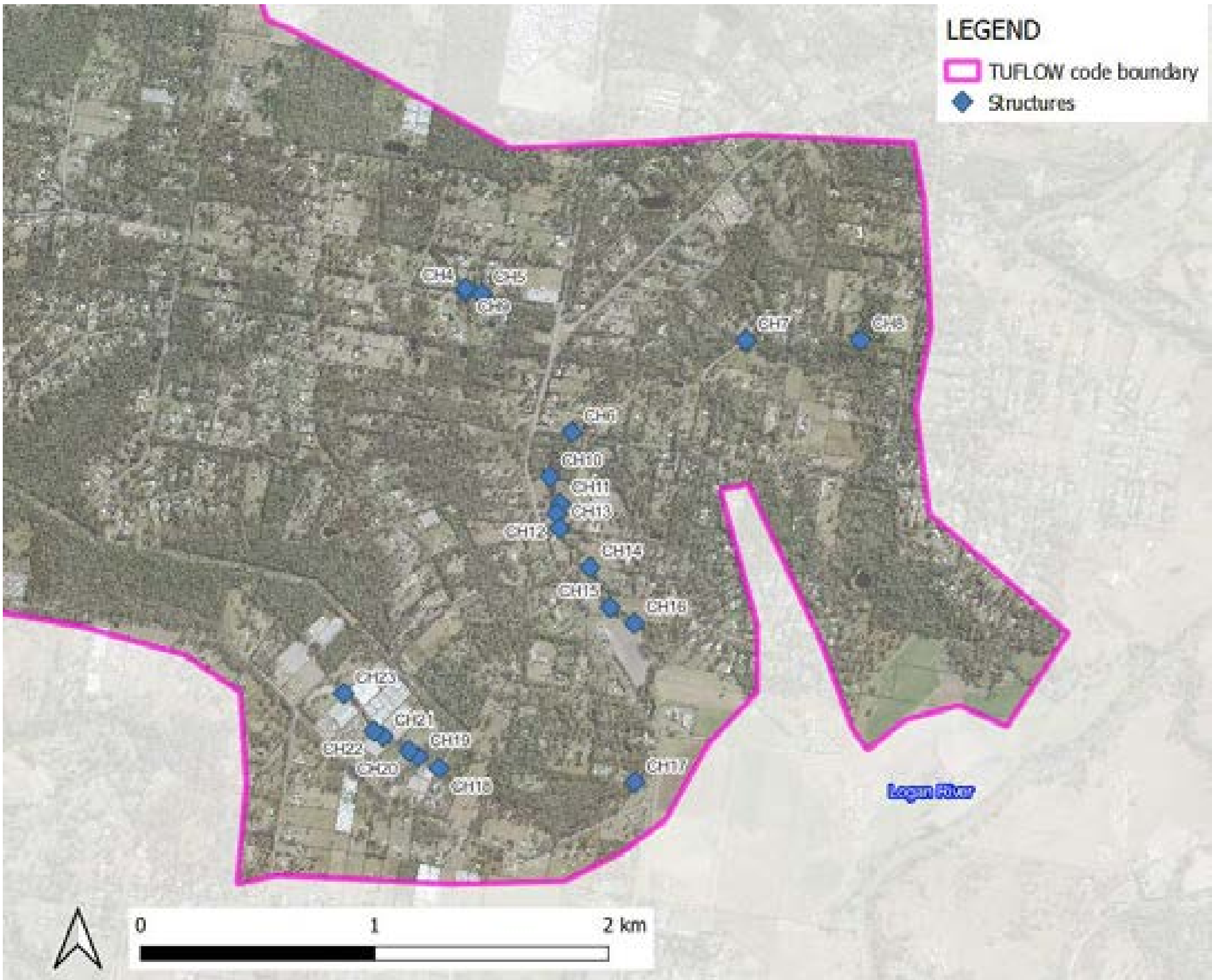

Figure 3-3 Structure survey map

3.6 Software Platforms

In accordance with the project brief, the pre-approved software platforms for LCC includes:

- Hydrology – URBS, WBNM;
- Hydraulics – TUFLOW; and
- GIS - ESRI

For the purposes of this project, WT have adopted the following model platforms:

- All catchment hydrologic models have been developed using the standard URBS platform; and
- All hydraulic modelling will be prepared using the TUFLOW HPC platform.

3.7 Fraction Impervious

Fraction impervious values adopted for each of the respective land use zone classification are summarised in Table 3-4 and have been determined having regard to the guidance provided in the QUDM and for which represents the current guidance outlined in Council's planning scheme for land use fraction imperviousness.

Table 3-4 Fraction impervious values adopted based on land use classification

Land Use	Fraction Impervious	
Community Facilities	0.9	
Emerging Community	Existing	0.2
	Developed	0.8
Environmental Management and Conservation	0	
Low Density Residential	0.65	
Recreation and Open Space	0	
Road	0.9	
Rural	0	
Rural Residential	0.2	
Special Purpose	0	

The fraction impervious values for the Chambers Creek catchment have been assigned in accordance with the 2015 Planning Scheme Zone Map and the Road parcels GIS layers as provided by LCC. Figure 3-4 presents the spatial landuse across the Chambers Creek catchment.

The area zoned as Emerging Community has been considered as equivalent to Rural Residential (0.2) for the existing case, and 0.8 for the fully developed case in accordance with LCC's ultimate land use intent. Accordingly, an average fraction impervious value has been determined for each sub-catchment for both the existing and developed cases.

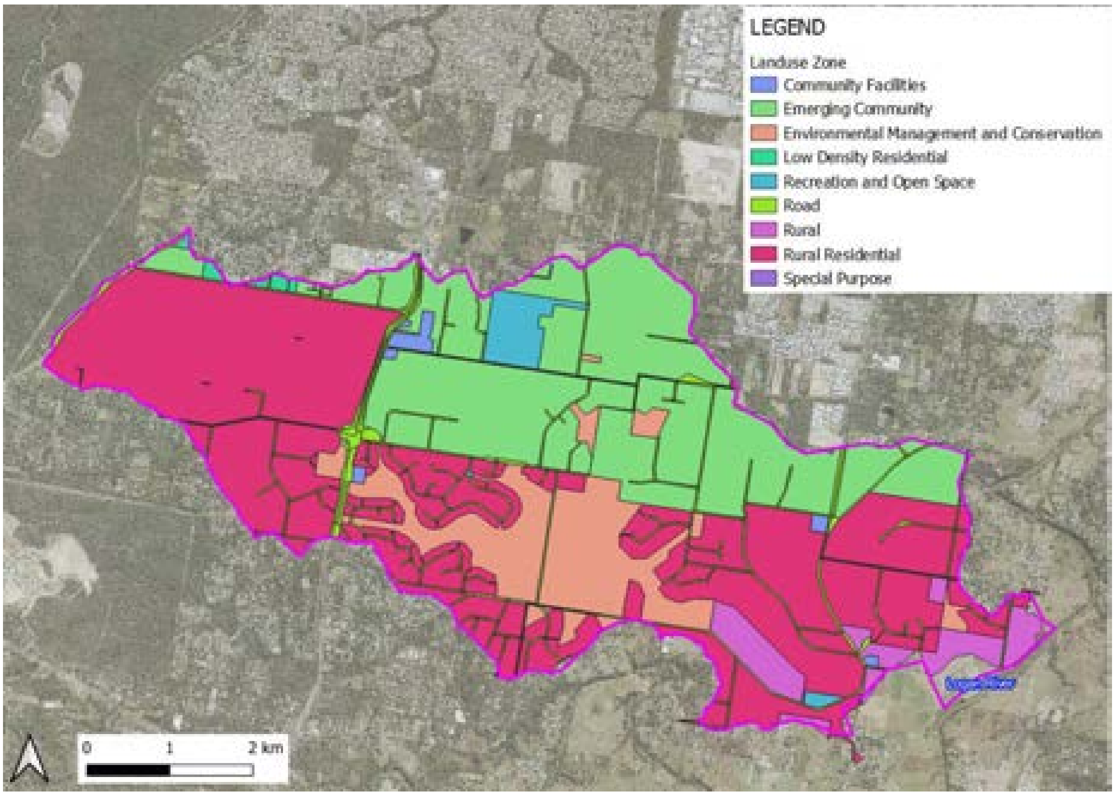

Figure 3-4 Landuse zoning within Chambers Creek catchment

4 MODEL DEVELOPMENT

4.1 Overview

This study has undertaken a joint calibration process involving both the hydrologic URBS and hydraulic TUFLOW model where both models be subject to optimisation and refinement through an iterative analysis process. Ultimately, the calibration seeks to achieve hydrologic and hydraulic similarity that will ensure consistency and robustness of the models. Given the flat and high storage nature of the catchment there are difficulties in representing routing in the hydrologic model and therefore the hydraulic model has been developed to allow for practical runtimes to assist in ARR 2019 design event guidelines.

4.2 Hydrological Model Development

4.2.1 URBS Model Layout

The Chambers Creek URBS model sub-catchment delineation was initially completed using CatchmentSIM and then refined manually using GIS software.

Details of the updated URBS model developed are summarised as follows:

- Contains 172 individual sub-catchments.
- Full calculation and inclusion of all model routing links (i.e. flowpath lengths).
- Inclusion of impervious fraction and Urbanisation based on land use mapping spatial analysis.

Figure 4-1 presents a map of the model configuration and Appendix B provides a detailed tabular summary of the sub-catchment attributes. A summary of the sub-catchment attributes is also presented in Table 4-1 in terms of the variation in UBRS sub-catchment sizes. The URBS model prepared for this study includes channel routing based on river reach lengths derived from GIS and available topographic data.

Table 4-1 URBS subcatchment statistics

Statistic	Value (hectares)
Average	21.6
Maximum	44
Minimum	3.4

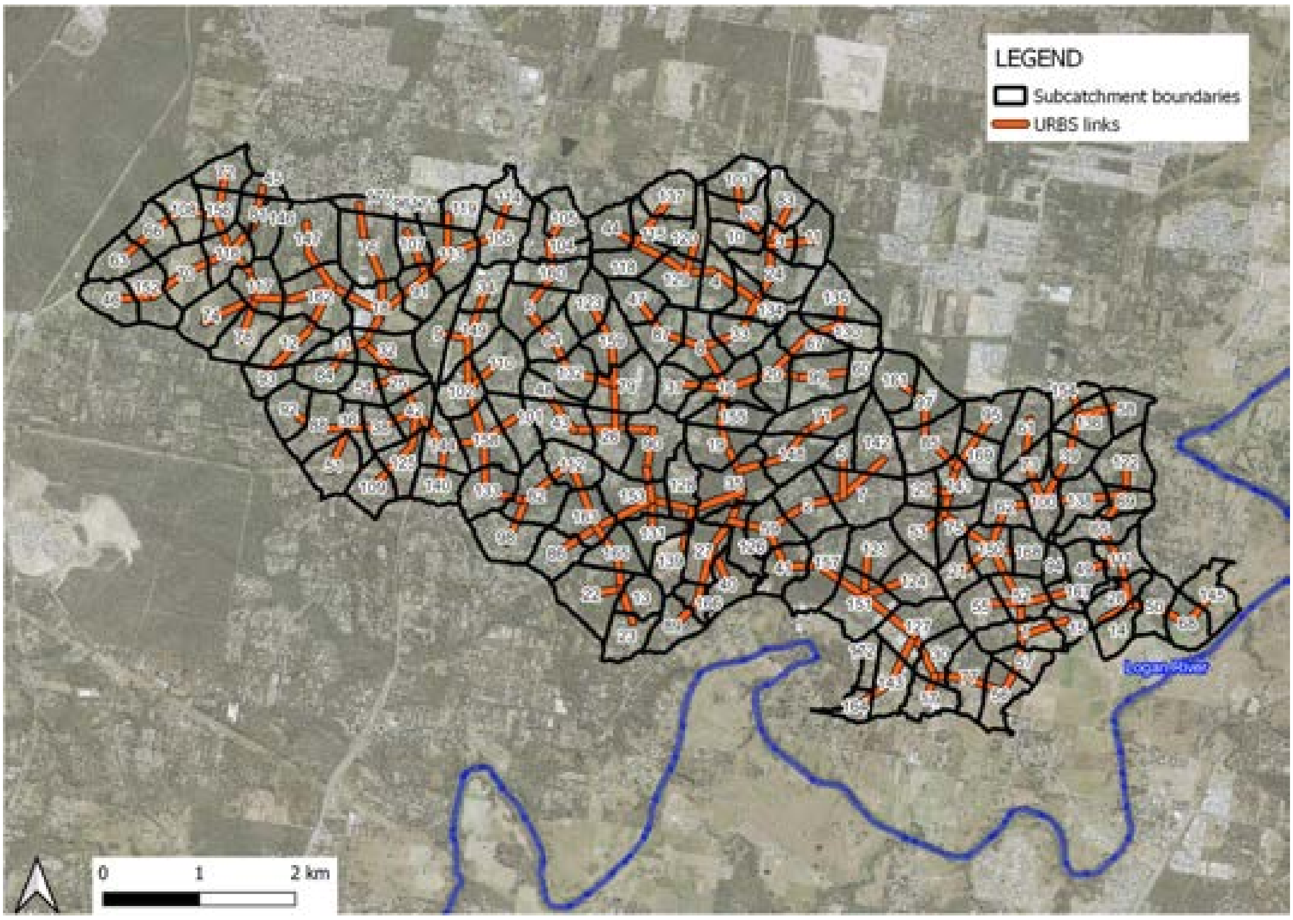

Figure 4-1 URBS model configuration

4.2.1.1 Catchment Storage

The Chambers Creek has significant storage throughout the catchment and therefore there is difficulty representing the catchment utilising a simplistic runoff routing model. An artificial storage curve (SQ) has been applied in the URBS model upstream of the gauge and immediately downstream of the large depression in the catchment where there is widespread inundation throughout Park Ridge (sub-catchment #41) (refer Figure 4-2). URBS uses parameters a and b based on the equation S = axQ^b where S (storage) is in ML and Q (discharge) is in cumecs. The parameters were iterated and refined to best replicate the TUFLOW hydraulic results. It is acknowledged that this approach has significant limitations with estimating flows upstream of the gauge where the storage curve is not being applied. For this reason the TUFLOW model is a better representation of the complex catchment routing and has been relied upon for the design event modelling approach (refer Section 6.6).

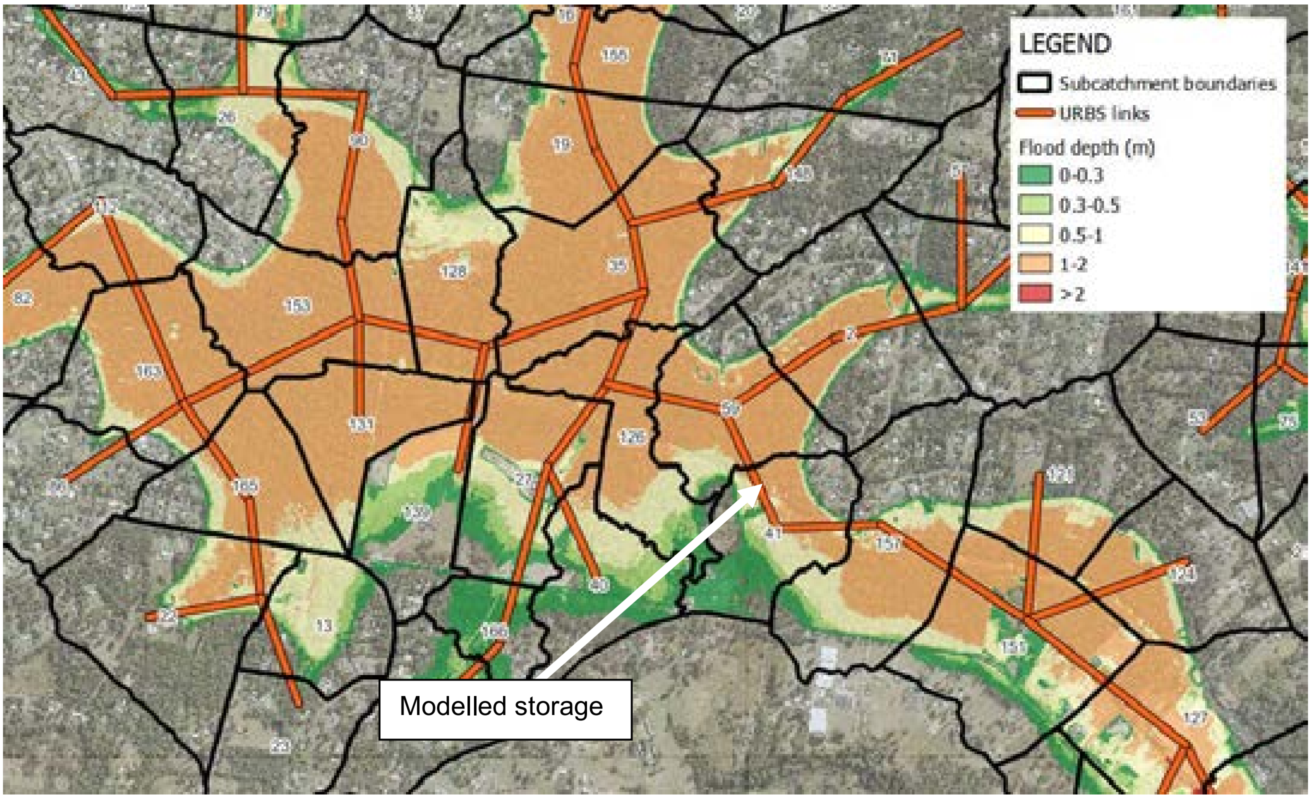

Figure 4-2 Artificial storage modelled in URBS

4.2.2 Model Parameters

Table 4-2 shows the adopted URBS storage routing parameters. These parameters were chosen based on an extensive joint calibration process.

Table 4-2 Adopted URBS parameters for calibration and design event modelling

Parameter	Value
Alpha (reach)	0.5
Beta (subcatchment)	4
M (routing exponent)	0.8

4.2.3 Rating Curve

The URBS model includes a rating curves which has been developed at the Chambers Creek Alert gauge. The rating curves have been derived using the TUFLOW hydraulic model and were also subject to joint calibration processes which involved iterative assessment between the hydrologic and hydraulic models. Despite the extensive joint calibration process, the reliability of the rating curves is limited depending on their location in respect to the model boundaries, lack of available bathymetry, model grid size and roughness parameters used. Furthermore, there have been no rated (measured) flows to validate or inform the rating curve produced. Figure 4-3 presents the rating curve applied in the URBS model to the recorded stream gauge levels.

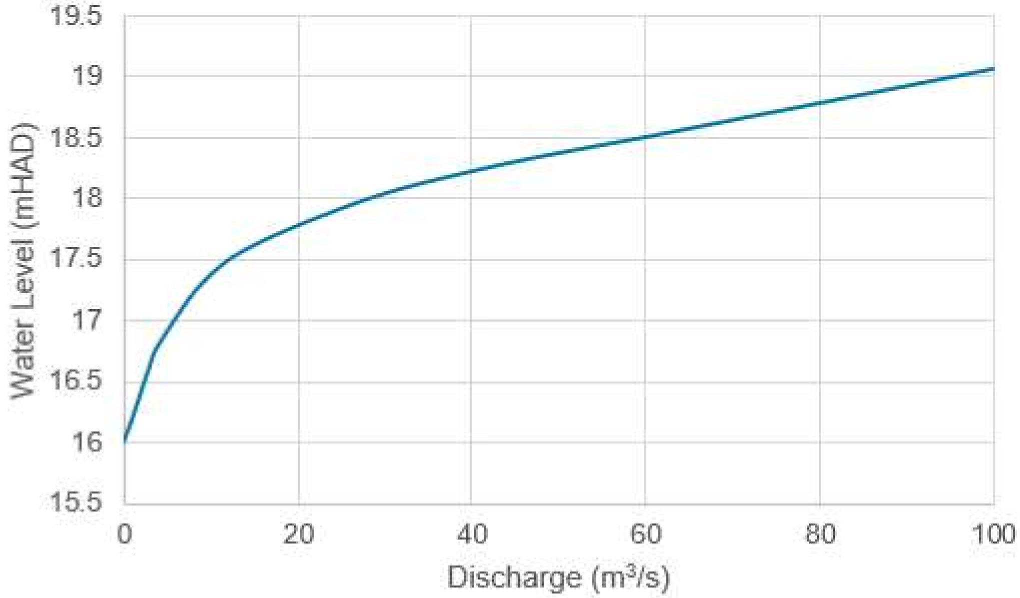

Figure 4-3 Chambers Creek Alert rating curve

4.3 Hydraulic Model Development

4.3.1 Overview

To assess the hydraulic characteristics for the Chambers Creek catchment, a detailed 1D/2D TUFLOW model has been developed. The TUFLOW hydraulic model was developed based on the TUFLOW software version 2020-10-AD-iSP-w64 which incorporates the Highly Parallelised Compute (HPC) solution scheme and represented the latest software version release at the time of project commissioning. All model development and calibration simulations were undertaken using the 2020-10-AD-iSP-w64 build.

The following sections of this report provides details of the TUFLOW hydraulic model developed as part of the study.

4.3.2 TUFLOW Model Layout

The TUFLOW model code boundary includes the entire Chambers Creek catchment through to the confluence with the Logan River. Figure 4-4 presents the TUFLOW model layout for the design event analysis. Note that for the PMF event an additional normal slope (HQ) boundary was required at the southern boundary to allow flows in extreme events to discharge towards the Logan River. This boundary was only engaged in the PMF and for all other design event flows were contained to the catchment.

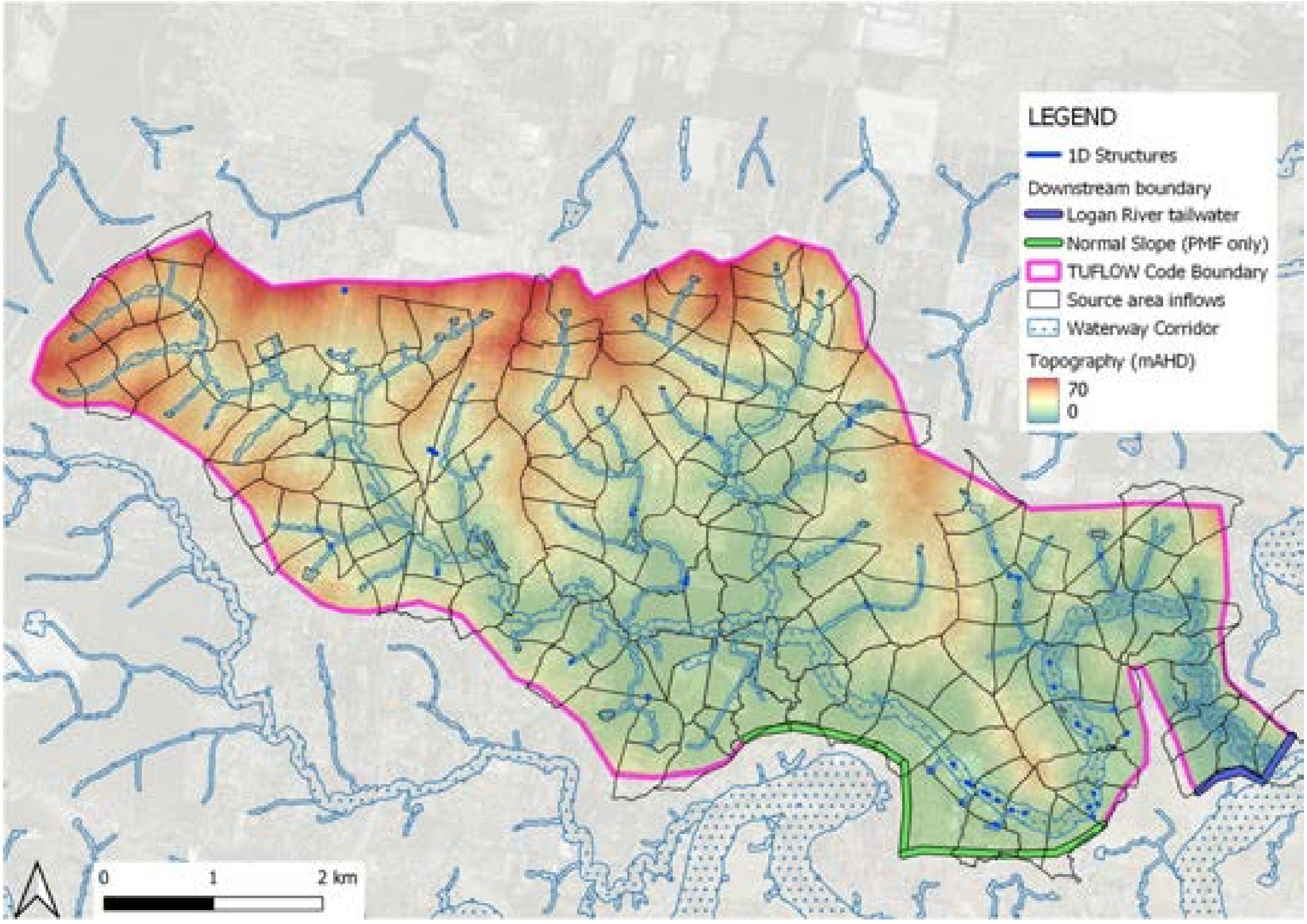

Figure 4-4 TUFLOW model layout

4.3.3 Model Topography

The model base topography is represented using 1m resolution LiDAR data flown in 2021 supplied by Logan City Council. The model is based on a 4m cell size and employs the Sub-Grid-Sampling (SGS) enhancement which samples the underlying LiDAR at 1m.

4.3.4 Floodplain roughness

Floodplain roughness values were derived based on aerial photography using Google Earth, with the values determined based on recommendations outlined in Table 10-1 of Project 15 of the AR&R review, namely "*Two Dimensional Modelling in Urban and Rural Floodplains*". A detailed spatial definition of roughness has been prepared for the flood model update for the hydraulic model and includes specifically defining the main waterway channels as well as overbank floodplain areas. A summary of the adopted roughness values based on classification type is presented in Table 4-3. It is acknowledged that design event simulations consider ultimate landuse in the hydrologic model, it was determined that without any detailed information of future developments that there would be no changes to the floodplain roughness. This assumption is that the waterway corridors would be maintained in future development scenarios.

Figure 4-4 illustrates the spatial variation in floodplain roughness applied in the hydraulic model. The model roughness for this study has been updated and informed with consideration of the joint calibration process involving the URBS hydrology model, with the final roughness derived following numerous model iterations between the hydrology and hydraulic models and for overall model consistency. Building footprint polygons have been included in the design event model. The completeness of the polygons is limited to the data available and does not include areas of recent development. However, this will not fundamentally affect the flood study outcomes, as urban blocks are already included as areas of high roughness and new buildings will tend to be provided with greater than 1% Annual Exceedance Probability (AEP) immunity.

Table 4-3 Adopted Floodplain Roughness Values

Roughness Classification	Manning's 'n'
Waterway with Standing Water Level	0.02
Roads – with Road Reserve	0.025
Waterways clean, winding, some pools and shoals	0.045
Open Space - mostly grass	0.04
Medium Vegetation –Trees and Shrubs	0.09
Dense Vegetation – Trees and Shrubs with Large Undergrowth – (default)	0.12
Urbanised Areas	0.1
Buildings	0.3

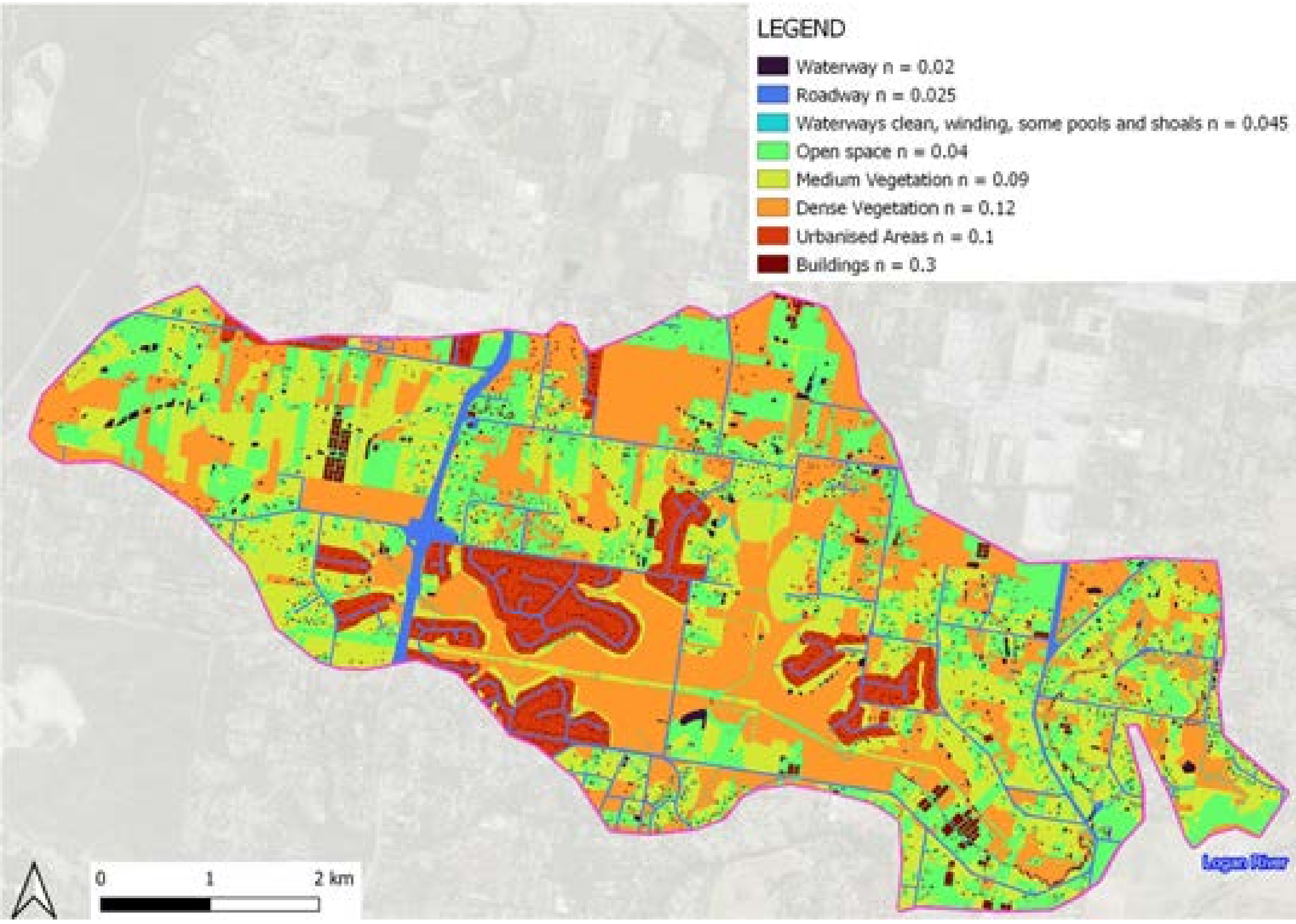

Figure 4-5 TUFLOW Manning's n

4.3.5 Boundary Conditions

Model inflows have been based on the sub-catchment breakdown for the URBS model. The inflows have been represented in the hydraulic model as a series of local catchment Source Area ("SA") polygon inflow boundaries. Inflow boundary locations have been applied directly to the creek and tributaries which was guided by LCC waterway corridor spatial file. It is acknowledged that in some instances routing of sub-catchments is "incorrect" in the TUFLOW model with centroidal inflows being applied in waterway corridor downstream of the sub-catchment itself. The loss of routing ultimately increases flood levels slightly although based on sensitivity testing this was observed to be within 100 mm and was not considered consequential in a flood planning context. This approach was instructed by LCC with the purpose of the model to replicate "creek" flooding and not overland flowpaths which is being assessed in a separate study. The routing of sub-catchment flows is predominantly undertaken within the hydraulic model as there were difficulties in replicating the high storage nature of the catchment in the URBS hydrological model.

For the downstream boundary condition a static tailwater has been applied for the design event modelling based on a coincidental flood event analysis (refer Section 6.5). For the calibration event a dynamic tailwater (Height-Time) based on a nearby Logan River stream gauge was applied (refer Section 5.3).

5 CALIBRATION

5.1 Selection of calibration events and approach

In relation to the overall model calibration tasks for this study, there were 3 (three) events originally nominated (prior to the February 2022 event) for calibration which included November 2018, February 2020 and March 2021. These events were selected as they represented the largest events on record prior to the February 2022 event given the gauge records only extend back to the beginning of 2018. There were significant difficulties in calibrating these events for the following reasons:

- The rated discharge of these events is estimated to be only 22 m^3/s compared with 90 m^3/s for the February 2022 event. Based on preliminary design event analysis, these other historical events are estimated to be approximately only equivalent to a 63% AEP events. At such a low event magnitude there is limited value in utilising the events to inform parameter selection in the context of the much larger February 2022 event and in the context of the overall intent of the flood study to ultimately consider flood events of far greater magnitude (i.e. for flood planning purposes).
- For the 3 smaller events, as the rainfall magnitude is significantly lower, there is a higher chance of rainfall spatial variability. With there only being a single rainfall gauge located within the catchment this is a significant limitation and preliminary results showed poor results which was most likely attributed to rainfall spatial errors.

For these reasons, and in agreement with LCC, only the February 2022 event has been considered for calibration for this flood study. It is recommended that as additional calibration events become available that model parameters are further validated.

There is limited gauged rainfall data within the catchment with only a single gauge and therefore calibrated radar rainfall was adopted to improve representation of the spatial and temporal variability of the rainfall.

5.2 Data Available

5.2.1 Stream Gauge Data

Water levels in Chambers Creek were recorded during the event at the Chambers Creek Alert stream gauging station (540788). Figure 5-1 shows the recorded water level at the Chambers Creek Alert during the event. As evident from this chart, water levels started rising rapidly in Chambers Creek on Friday 25 February 2022, plateaued on 26 February 2022 and then rising again towards a peak of 18.78 mAHD at 21:00 on 27 February 2022.

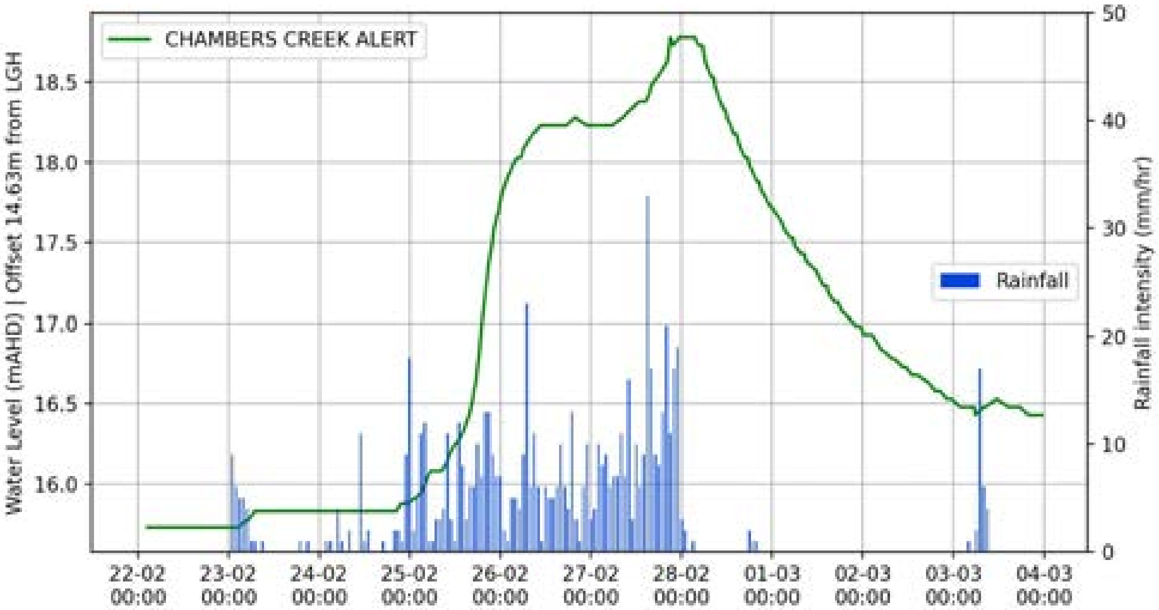

Figure 5-1 Water level at Chambers Creek Alert (Gauge 540788) with hourly rainfall from Park Ridge (Stoney Camp Rd) Alert (540787) 22 February – 4 March 2022

5.2.2 Rainfall Data

5.2.2.1 Synoptic description of events

In late February 2022, an unstable weather system formed in southern Queensland which led to unsettled conditions and heavy rainfall continuing across south-eastern Queensland and parts of eastern New South Wales from 22 February to the end of the month. The Commonwealth Bureau of Meteorology (BoM) made the following comments on the weather system (BOM, 2022):

Intense rainfall led to flash flooding and riverine flooding across large areas of south-east Queensland and the Sunshine Coast, as well as parts of New South Wales, as high daily totals fell on already saturated catchments. Multi-day rainfall totals for the 6-days ending 9 am on 28 February were at least 2.5 times the February average rainfall across parts of south-east Queensland and north-east New South Wales, with some parts of Queensland having received in excess of 5 times their monthly average rainfall for February. Totals for the 6 days were above 200 mm over a large area from the New South Wales Mid North Coast to the Wide Bay and Burnett District in Queensland. More than 30 sites have reported 6-day totals in excess of 1,000 mm (1 metre of rain), with the highest totals mostly between the Gympie region and Numinbah.

5.2.2.2 Gauge Data

The Park Ridge (Stoney Camp Rd) Alert (540787) rainfall station is located in the upper parts of the Chambers Creek catchment. Figure 5-2 shows the rainfall hyetographs and cumulative rainfall recorded at this rainfall station for the February 2022 event.

The available information indicates that the Park Ridge (Stoney Camp Rd) Alert station recorded around 700mm of rainfall in the period 22 February to 4 March 2022. Hourly rainfall totals indicate that several storm events occurred during this period with the 3-day period from 25 February to 28 February 2022 being the most notable.

Table 5-1 and Figure 5-3 shows the recorded rainfall intensities and their estimated Annual Exceedance Probability (AEP) at the Park Ridge (Stoney Camp Rd) Alert (540787). AEPs were estimated by comparing the recorded rainfalls to design rainfall intensities from the Bureau of Meteorology's Intensity-Frequency-Duration (IFD) rainfall data for storm durations of up to 96-hours. The data indicates the following:

- Rainfall intensities for storm durations of less than 3-hours had an Annual Exceedance Probability of less than 1 in 5 AEP;
- Rainfall intensities for the 6-hour – 24 hour storms had an Annual Exceedance Probability of 1 in 10 – 1 in 50 AEP;
- Rainfall intensities for storm durations of greater than 48 hours had an Annual Exceedance Probability of between 1 in 100 and 1 in 500 AEP. It is noted that the critical duration of the Chambers Creek catchment is shorter than 48 hours and therefore AEP not fully applicable to the creek system.

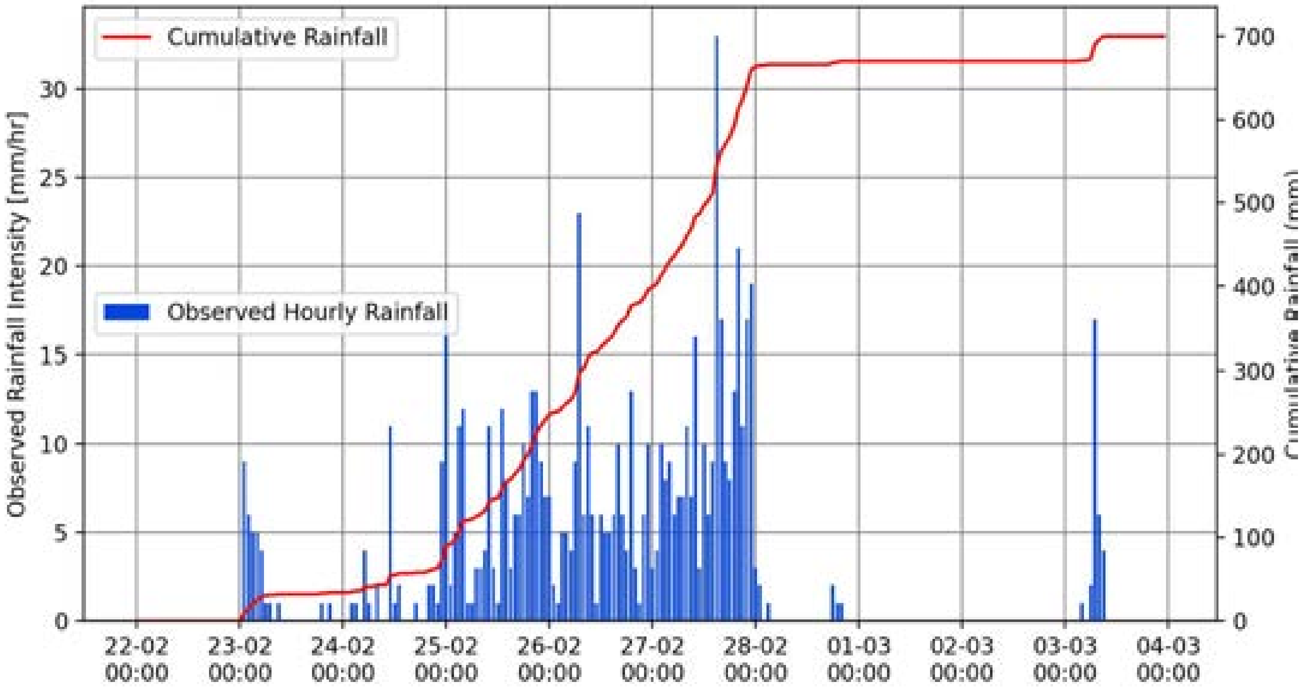

Figure 5-2 Hourly Rainfall Totals at Park Ridge (Stoney Camp Rd) Alert (540787) 22 February to 4 March 2022

Table 5-1 IFD Table for Park Ridge (Stoney Camp Rd) Alert (540787) 22 February – 4 March 2022

Duration		Max Rainfall	Intensity	Observed AEP
(hrs)	(mins)	(mm)	(mm/hr)	(AEP)
1	60	33	33	< 1 in 2
2	120	50	25	1 in 2 – 1 in 5
3	180	61	20.3	1 in 2 – 1 in 5
6	360	101	16.8	1 in 10
12	720	173	14.4	1 in 20 – 1 in 50
24	1440	266	11.1	1 in 50

Duration		Max Rainfall	Intensity	Observed AEP
48	2880	419	8.7	1 in 100
72	4320	589	8.2	1 in 100 – 1 in 500
96	5760	631	6.6	1 in 100 – 1 in 500

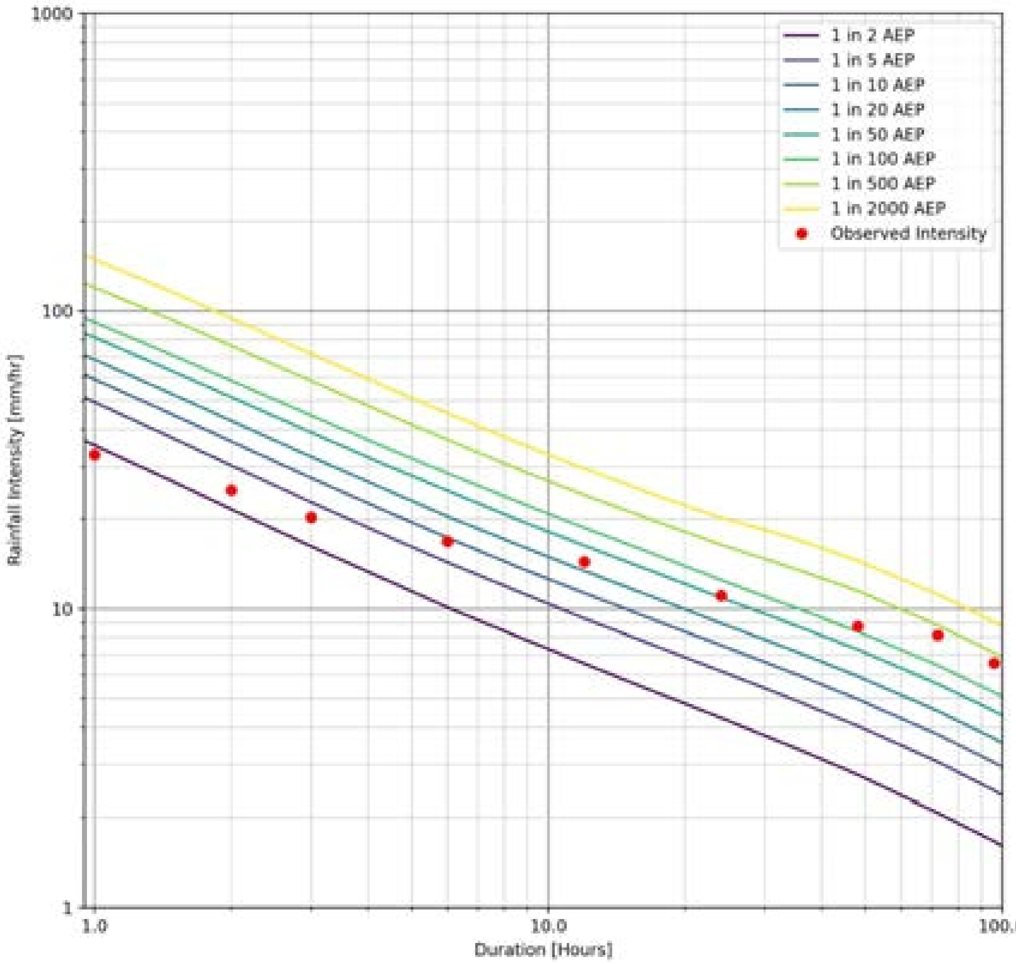

Figure 5-3 IFD Chart for Park Ridge (Stoney Camp Rd) Alert (540787) 22 February – 4 March 2022

5.2.2.3 Calibrated Doppler RADAR

The calibrated Doppler RADAR rainfall dataset is available through the existing BoM's Doppler RADAR network throughout Australia. The rainfall data has been commercial purchased and received in 1km x 1km tiles from the BoM. At the time of this study, this data is made available on the HydroNET platform on a 5-minute timestep. Through HydroNET, the extensive RADAR data sets can be easily accessed in either designated tiles or calculated from the tiles and prepared on a catchment spatial area basis.

The RADAR station at Mt Staplyton uses Doppler RADAR which can *".. determine the speed of precipitation in the atmosphere, toward or away from the radar"* (BoM, 2016). The radar uses the Doppler effect to detect rainfall in the atmosphere discovered by Austrian physicist Christian Doppler in 1842. In the context of hydrological assessments relating to the Chambers Creek catchment, it is considered that there are significant benefits in considering calibrated RADAR rainfall data over the traditional approach of using discrete ground-based rainfall gauging stations to better represent spatial and temporal rainfall variability over the entire catchment. While the traditional approach remains wholly appropriate, it is dependent on a well-distributed gauging network and is a known limitation which such hydrological assessments. Optimal calibration outcomes would likely be achieved where the calibrated RADAR rainfall is combined with traditional gauge data to provide the most certainty in the spatial and temporal rainfall patterns and variability across a catchment. The HydroNET Platform has the ability to prepare such a dataset.

The use of RADAR rainfall data is considered to reduce some of the risks associated with the traditional rain gauge approach as it better informs spatial and temporal catchment rainfall variability across the catchment and for which is a key variable in the rainfall-runoff process. Rainfall temporal and spatial variability may not be well represented across the catchment by the existing rain gauge network, and especially where gauge recording issues occur. For these reasons, calibrated RADAR rainfall has been considered to inform this study and the subsequent calibration outcomes in isolation and without directly using existing rain gauge data. The following summarises the key concepts with respect to calibrated RADAR rainfall data: -

- Precipitation is measured by reflectivity from encountered obstacles. Precipitation estimates from RADAR are an indirect measurement of rainfall;
- Precipitation measured using RADAR is an instantaneous measurement and at a specific point in time;
- Measurement of precipitation is performed at a specific height depending on the RADAR installation. For Mt Staplyton, echoes are detected at an altitude of 3000m (BoM, 2016). Precipitation estimates using RADAR therefore may not accurately represent precipitation occurring at ground level. The RADAR calibration process undertaken by the BoM aims to improve this uncertainty however; and
- A ground check on precipitation estimates using calibrated RADAR rainfall is therefore essential. This results in a product that combines the "best of both worlds".

The calibration process to convert RADAR reflectivity to rainfall totals is undertaken by the BoM and is informed by the available rainfall gauge network selected by the BoM. Specifically, we understand that this includes the 1-minute Automatic Weather Stations (AWS) network.

Figure 5-4 presents the catchment averaged total rainfall for the February 2022 event from the radar and gauge rainfall approaches respectively. The gauge rainfall data is limited to a single gauge in the catchment and therefore is significantly limited spatially. The radar rainfall had a slightly higher cumulative rainfall total although the temporal patterns were broadly very similar.

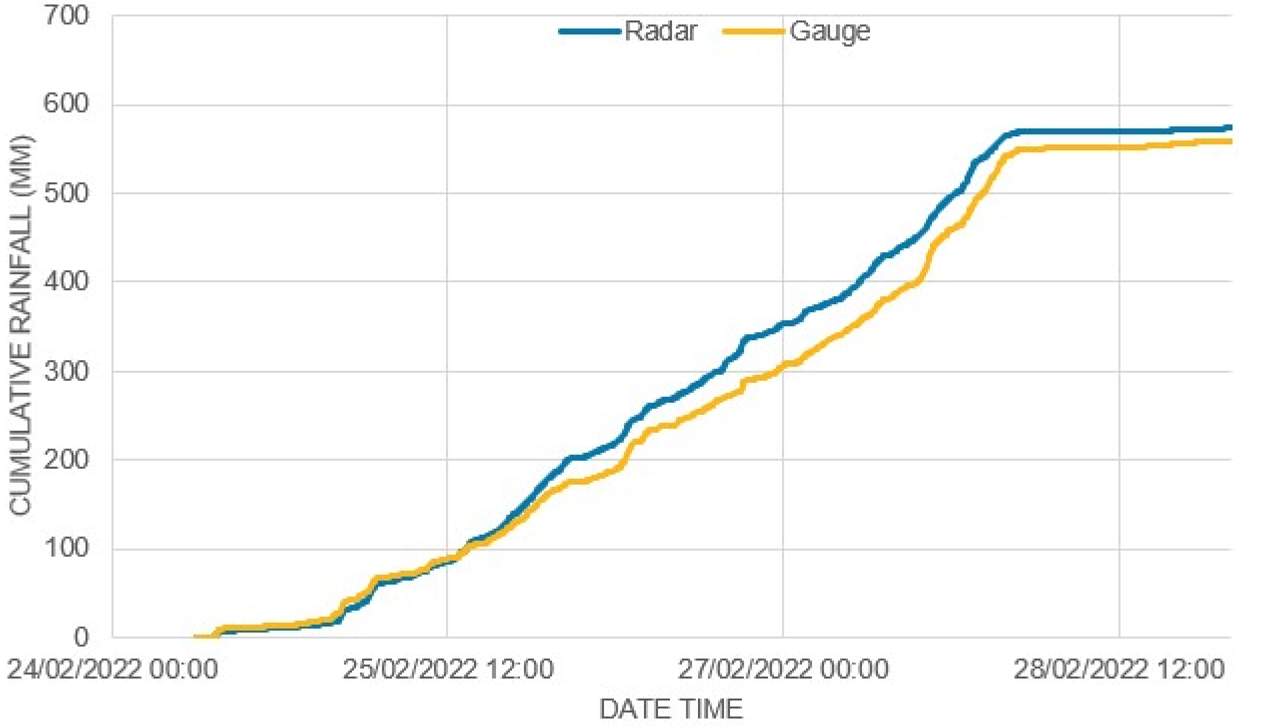

Figure 5-4 Validation of radar rainfall to gauge rainfall

5.3 Tailwater Boundary

A downstream HT boundary was applied to the TUFLOW model and was based on the Logan Village Alert (540596) gauge along the Logan River. The Logan Village Alert gauge is located approximately 2700 metres upstream of the Chambers Creek and Logan River confluence. Based on the gauged recordings along the Logan River the peak at Chambers Creek Alert gauge was not affected by Logan River backwater.

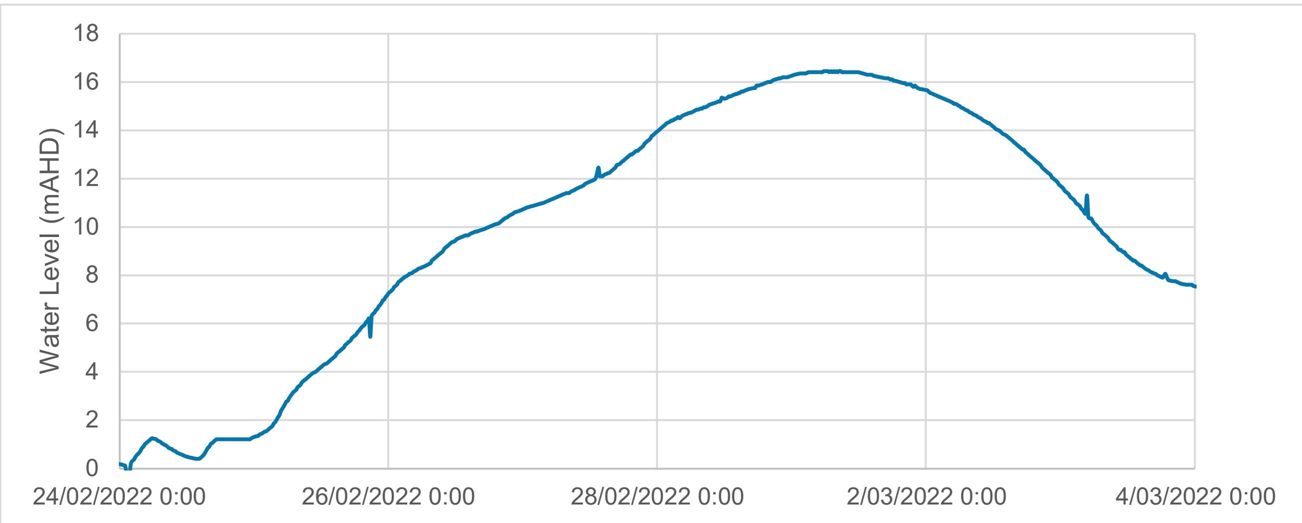

Figure 5-5 Dynamic tailwater level applied to February 2022 Validation event

5.4 Hydrological Modelling

5.4.1 Calibration Approach

This study has undertaken a joint calibration process involving both the hydrologic URBS and hydraulic TUFLOW model where both models be subject to optimisation and refinement through an iterative analysis process. The URBS model was initially calibrated to the rated gauge discharge where loss and routing parameters were selected. These parameters were iteratively updated based on the results of the hydraulic model. Ultimately, the calibration seeks to achieve hydrologic and hydraulic similarity that will ensure consistency and robustness of the models.

5.4.2 Losses

Table 5-2 summarises the rainfall losses applied in the URBS calibration model. The storm losses were applied using an Initial Loss (IL) and Continuing Loss (CL) rainfall loss model. The ARR Datahub suggests an initial loss of 20mm for design event simulation. This is lower than the calibration value identified in this study and may be more appropriate for an urban catchment. However, it is considered that the initial loss observed in the calibration process is consistent and is reflective of the heavily vegetated upstream catchment areas represented in the Chambers Creek catchment for which higher initial losses would be appropriate. In respect to continuing loss, the AR&R 2019 “data hub” recommends a continuing loss of 1.5mm/hr for the Chambers Creek catchment and is consistent with the calibration outcomes and is therefore appropriate. Storm losses for the calibration events have been applied uniformly across the catchment.

Table 5-2 Summary of adopted rainfall losses for calibration and design

Flood Event	Pervious Initial Loss (mm)	Continuing Loss (mm/hr)
2022 Event	40	1.5
ARR Datahub	20	1.5

5.5 URBS Calibration results

Figure 5-6 presents the URBS modelled flow compared with the rated discharge for the Chambers Creek Alert stream gauge. The URBS model has replicated the shape of the hydrograph reasonably well although there is an overestimation of flow at the first peak and then an underestimation of flow at the second and highest peak.

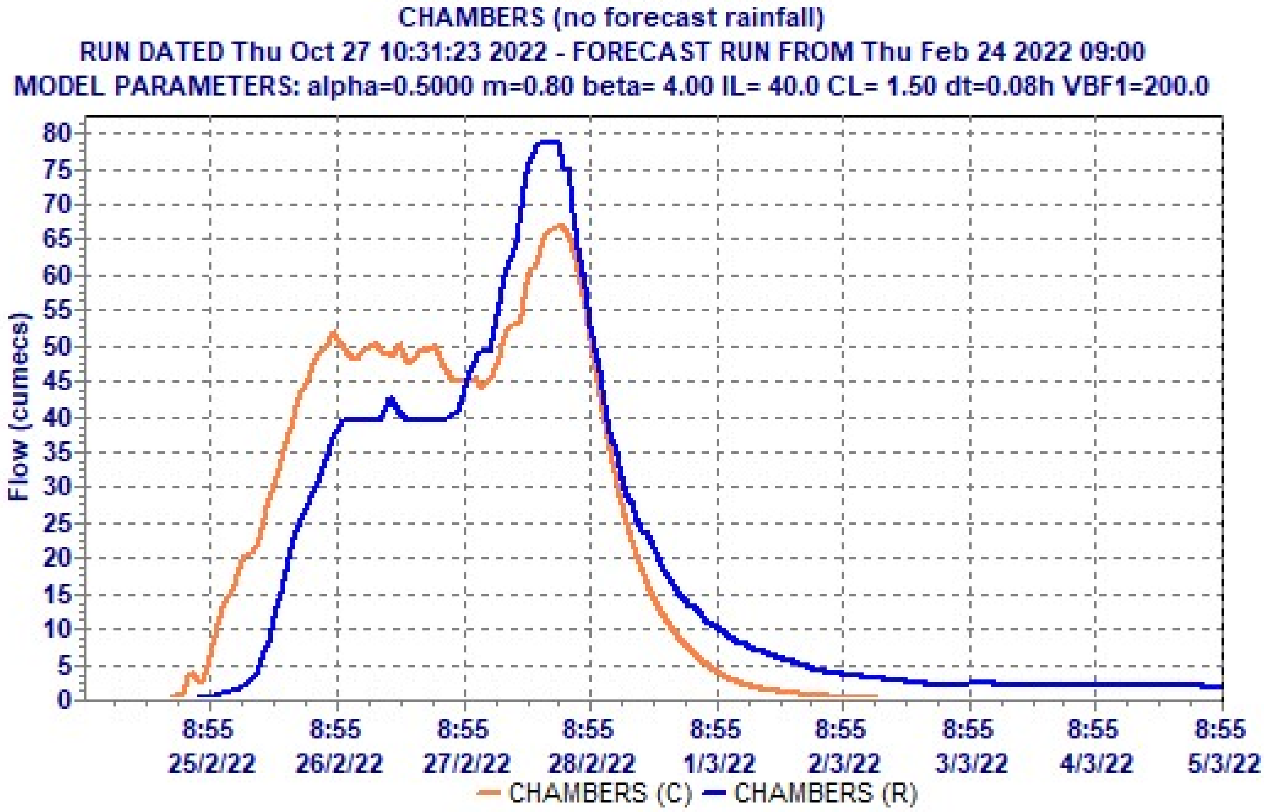

Figure 5-6 **URBS February 2022 Calibration**

5.6 TUFLOW Results

Figure 5-7 presents the TUFLOW modelled water level compared with the recorded stream gauge levels at the Chambers Creek Alert gauge for the February 2022 event. In general, the model has represented the catchment response very well with a good correlation of shape of both rising and receding limbs. The model has underpredicted the peak water level by approximately 200 mm.

Figure 5-9 presents the peak depth results from the TUFLOW model spatially mapped. As can be seen the event lead to widespread inundation across the catchment with several properties inundated.

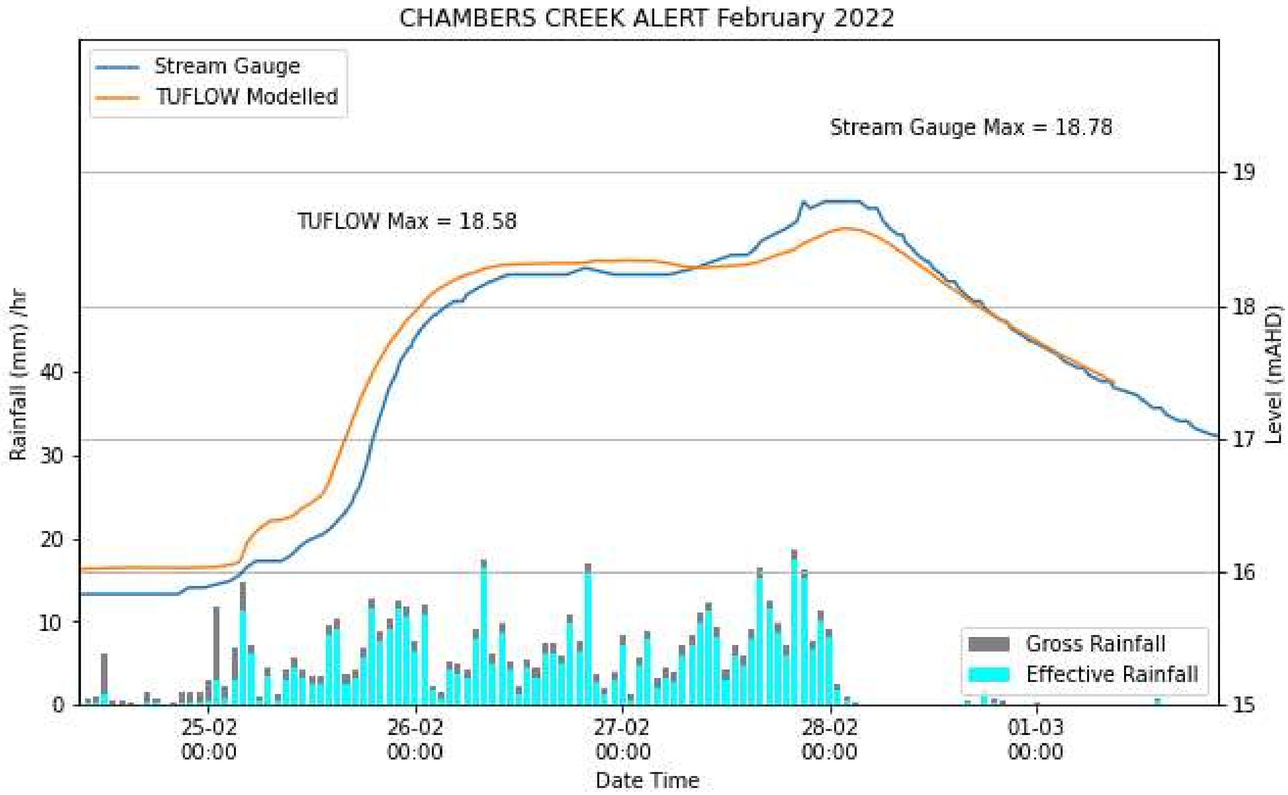

Figure 5-7 Recorded vs TUFLOW modelled levels at the Chambers Alert gauge

5.7 Joint Calibration

The comparison of discharge between the URBS hydrologic model to the TUFLOW hydraulic model for the February 2022 event is presented in Figure 5-8. The discharges from both the hydrologic and hydraulic models compare relatively well (within 10%) at the gauge. There are challenges in the URBS model replicating the TUFLOW model discharges upstream with the significant storages in the upper catchment. Generally, the TUFLOW model is consistently slightly lower than the URBS model (with localised depressions not accounted for in the URBS model) although the shape of the hydrographs is consistent highlighting the hydrologic model is representing the routing well. The joint calibration of the URBS and TUFLOW models has allowed overall consistency in the calibration outcomes, with the subsequent differences observed well within the bounds typical for a study of this nature.

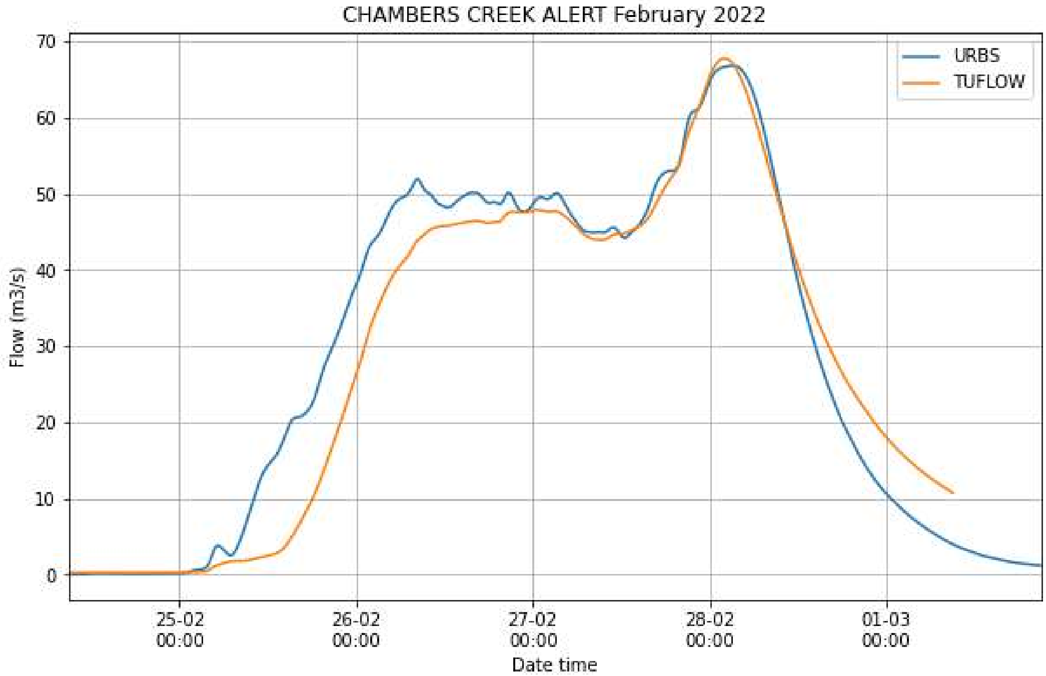

Figure 5-8 URBS vs TUFLOW discharge comparison for February 2022 event at the Chambers Alert gauge

5.8 Calibration Summary

The joint calibration and validation methodology and results has improved the confidence of the modelling outputs throughout the Chambers Creek catchment. Specifically, through comparison of modelled peak levels and gauged hydrographs there is increased confidence in both the hydrologic and hydraulic model parameters adopted. The catchment is limited by a lack of data both spatially with only 1 rainfall gauge within the catchment and temporally with only 4 years of stream gauge records available. It is recommended that as more data becomes available i.e. suitable calibration events, that the model parameters are reconsidered and confirmed for suitability.

Overall, despite the lack of data, the models replicated the February 2022 event which based on IFD analysis was estimated to be over a 2% AEP event for the 24-hour duration. This calibration has added significant confidence that both the URBS and TUFLOW models are representing the catchments hydraulic response for large flooding events.

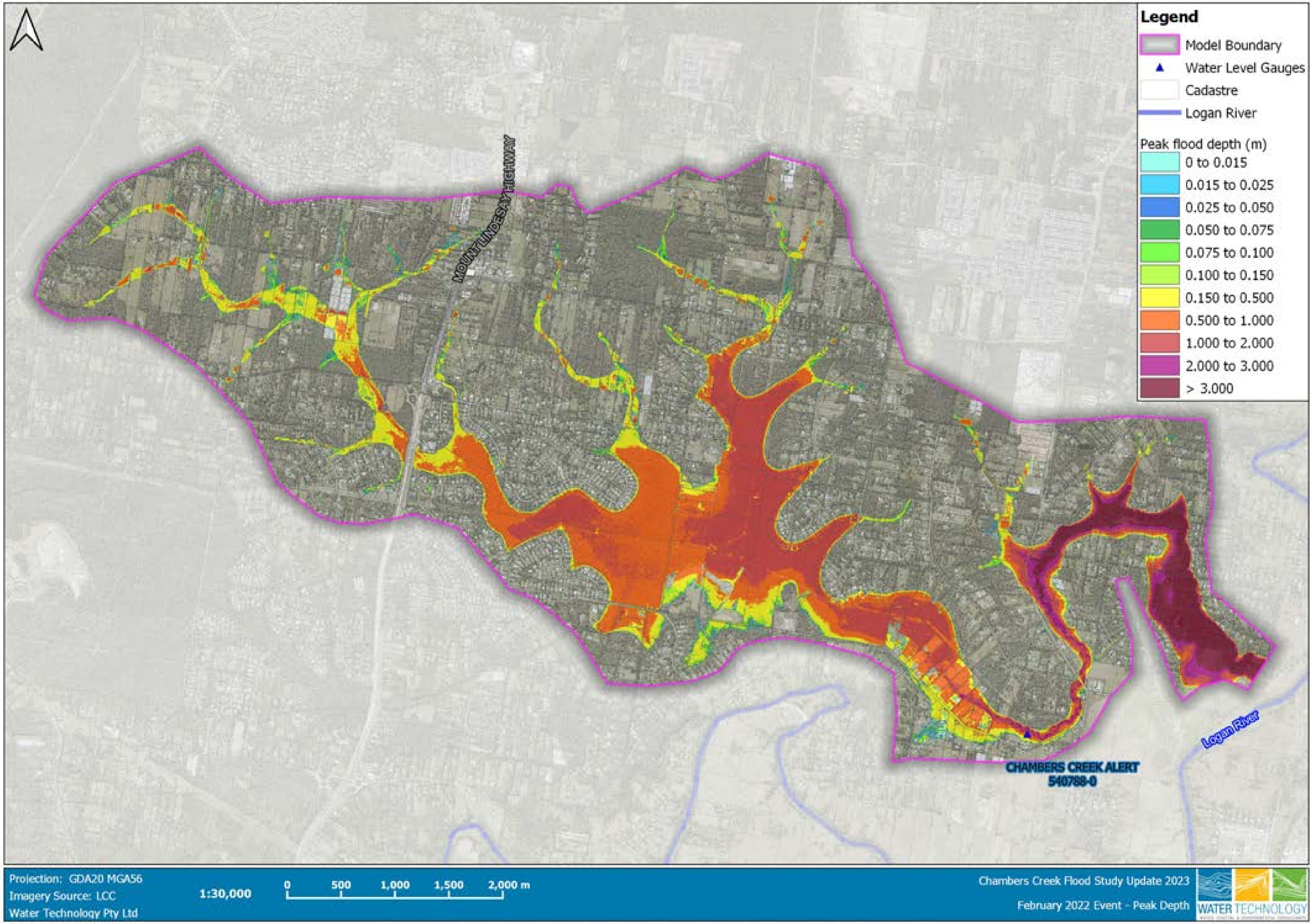

Figure 5-9 Chambers Creek February 2022 peak depth

6 DESIGN EVENT MODELLING

6.1 Design IFD Rainfall

Design flood estimates derived for the Chambers Creek catchment have been based on the design IFD guidance outlined in Australian Rainfall and Runoff 2019 guidelines (ARR 2019) and includes the updated rainfall IFD prepared by the Bureau of Meteorology (BoM).

The design IFD's applied within the URBS model were applied at 3 locations in the upper, middle, and lower catchment respectively. For reference the IFD extracted near the centroid of the catchment is presented in Table 6-1.

Table 6-1 BOM IFD at -27.732,153.058 (units are mm/hr)

Duration (min)	50% AEP	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP
30	56.4	77.9	92.3	106	125	139
45	43.5	60.3	71.8	83.2	98.3	110
60	35.7	49.7	59.4	69.1	82.1	92.3
90	26.9	37.5	45	52.6	63.1	71.3
120	21.9	30.6	36.9	43.3	52.1	59.2
180	16.4	23.1	27.9	32.9	39.8	45.4
270	12.5	17.6	21.3	25.1	30.5	35
360	10.3	14.5	17.7	20.9	25.4	29.1
540	7.96	11.3	13.7	16.2	19.8	22.7
720	6.67	9.49	11.6	13.7	16.7	19.2
1080	5.22	7.48	9.13	10.8	13.2	15.2
1440	4.39	6.33	7.73	9.19	11.2	12.9
1800	3.83	5.54	6.79	8.08	9.88	11.3
2160	3.42	4.97	6.09	7.26	8.89	10.2
2880	2.83	4.14	5.1	6.1	7.48	8.6

6.1.1 Areal Reduction Factors

Areal Reduction Factors (ARF) have not been applied to the design rainfall. Given the total catchment area is 30 km^2 they are applicable in the lower catchment areas. It was decided in agreement with LCC that by applying an ARF catchment wide there would underestimation of flood levels in the upper catchment where the total catchment ARF is not applicable.

6.2 AR&R 2019 Datahub

Design rainfall parameters such as temporal patterns, pre-burst values and areal reduction factors were obtained from the ARR 2019 Data Hub (http://data.arr-software.org/). A parameter set near the centroid of the catchment is presented in Table 6-2 and the raw data is presented in Appendix A. We note that loss values can vary spatially over the catchment, however, these were sampled at several locations throughout the catchment and remained relatively consistent.

Table 6-2 ARR 2019 DataHub Parameters

Parameter	Value
Longitude	153.054
Latitude	-27.738
River Region	North East Coast
River Name	Logan-Albert Rivers
ARF parameters	East Coast North
Storm Initial Losses (mm)	20
Storm Continuing Losses (mm/h)	1.5
Temporal Patterns	East Coast North Point

6.3 Probable Maximum Precipitation

The Probable Maximum Precipitation (PMP) rainfall has been based on the Generalised Short-Duration Method (GSDM). This method is applicable as the duration in the catchment for larger events is less than 6 hours in accordance with Figure 2 in the Hydrometeorological Advisory Service (2003). The PMP rainfall parameters adopted for the analysis have also been based on the Hydrometeorological Advisory Service (2003) and are presented in Table 6-3. The AEP of the PMP is estimated to be 1 in 10,000,000 (1e7) based on Nathan, R., Jordan, P., Scorah, M., Lang, S., Kuczera, G., Schaefer, M., & Weinmann, E. (2016). The GSMD was spatially applied to each subcatchment based on the ellipses with the centre of the storm centred near the centroid of the Chambers Creek catchment. An initial and continuing loss of 0 mm and 1 mm/hr was adopted for the PMP event.

Table 6-3 PMP Rainfall Parameters

Parameter	Value
Temporal Pattern	Table 1 from Hydrometeorological Advisory Service (2003)
Roughness Value	1
Elevation Adjustment Factor	1
Moisture Adjustment Factor	0.83

The PMP rainfall has been applied in the URBS model and subsequently enabled the Probable Maximum Flood (PMF) to be determined for the Chambers Creek catchment.

6.4 Design Event Rainfall Losses

Without any sufficiently long stream gauge records to undertake a comprehensive FFA or consider a wide range of calibration events, rainfall losses adopted for the design event modelling for Chambers Creek are based on the ARR Datahub.

Preburst have been applied in the design event modelling (50% median values) process through subtraction from the Initial Loss values utilising the URBS ARR 2019 datahub toolbox. For events where the preburst exceeds the Initial Loss this excess rainfall has been accounted for through the application of initial water level grid which fills up all localised storages throughout the catchment.

6.5 Adopted Design tailwater conditions

To determine appropriate design tailwater conditions for the confluence of the model with Logan River an assessment of the recent February 2022 event was undertaken in the absence of any long-term data records. Given the significant storage in Chambers Creek and its slow response to rainfall a typical area relationship approach was not considered appropriate. On analysis of the February 2022 event, it can be observed that during the peak of the local Chambers Creek event the Logan River was at an approximate design flood level equivalent to the 5% AEP event as is illustrated in Figure 6-1. Considering the Chambers Creek rainfall was in excess of a 1% AEP magnitude a coincident level of the 5% AEP regional flood was considered appropriate for a 1% AEP local flooding event. This relationship was scaled up and down for the remaining design flood events with the adopted downstream boundary conditions presented in Table 6-4. The tailwaters adopted remained consistent for the climate change scenarios as climate change results in the Logan River were unavailable.

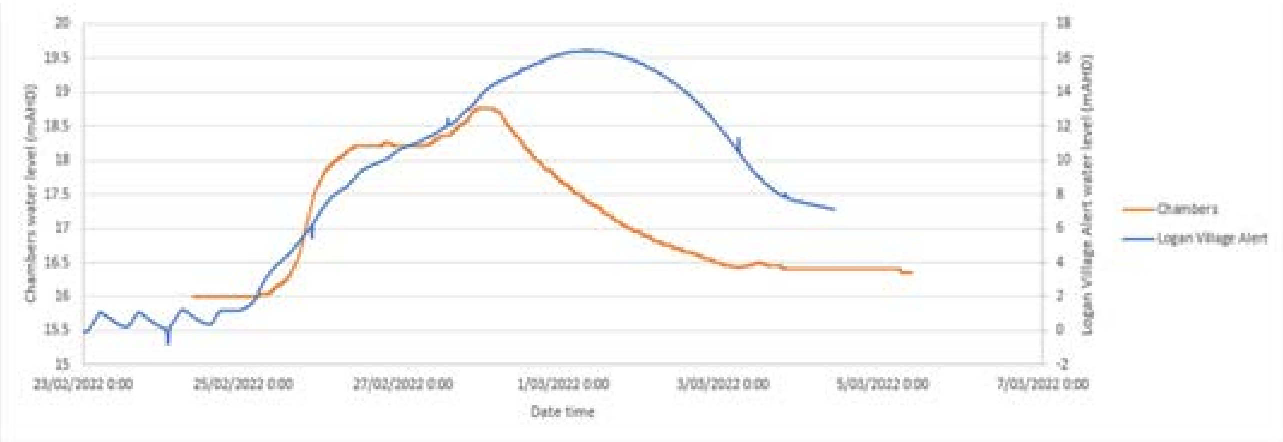

Figure 6-1 February 2022 coincidental flooding analysis

Table 6-4 Design Logan River (2021) tailwater levels

Chambers Design Event	Downstream boundary level (fixed)	Description
50%	1.5 mAHD	Initial water level in Logan River
20%	7.0 mAHD	50% AEP regional flood event at confluence
10%	7.0 mAHD	50% AEP regional flood event at confluence
5%	10.5 mAHD	20% AEP regional flood event at confluence
2%	12.9 mAHD	10% AEP regional flood event at confluence
1%	14.9 mAHD	5% AEP regional flood event at confluence
0.5%	14.9 mAHD	5% AEP regional flood event at confluence
0.2%	14.9 mAHD	5% AEP regional flood event at confluence
0.05%	17.2 mAHD	1% AEP regional flood event at confluence
PMF	17.2 mAHD	1% AEP regional flood event at confluence

6.6 Design Event Structure Blockage

The hydraulic model prepared for the Chambers Creek catchment included the following blockage factors based on an ARR2019 Blockage Assessment. The catchment has been classified as medium for debris potential and adopting an L10 of 2 metres based on imagery and site observations.

Table 6-5 Blockage matrix

ARI	$W < L_{10}$	$L_{10} \leq W \leq 3*L_{10}$	$W > 3*L_{10}$
50% to 10%	25%	0%	0%
5% to 0.5%	50%	10%	0
0.2% to PMF	100%	20%	10%

6.7 Critical Storm Selection and Peak Flow Summary

Considering the catchment has significant storage and there were challenges replicating the TUFLOW discharges in the URBS model it was determined that the hydraulic model would inform ARR 2019 critical storm selection. Discrete locations were chosen around the catchment to extract critical storms for each of the simulated AEPs and all temporal patterns and durations were simulated through the hydraulic model for the 50%, 10% and 1% AEP events. These AEP events were chosen as they apply the frequent, intermediate and rare temporal pattern bins from ARR 2019. The critical storm was selected as the median (6th ranked) storm at each location. This subset of storms represents the probability neutral flood surface across the catchment and reduces the necessity to simulate all temporal patterns and durations for ARR 2019 design. Figure 6-2, Figure 6-3 and Figure 6-4 presents the 50%, 10% and 1% AEP critical storm mapping. The locations where critical storms have been extracted is also shown on the figures.

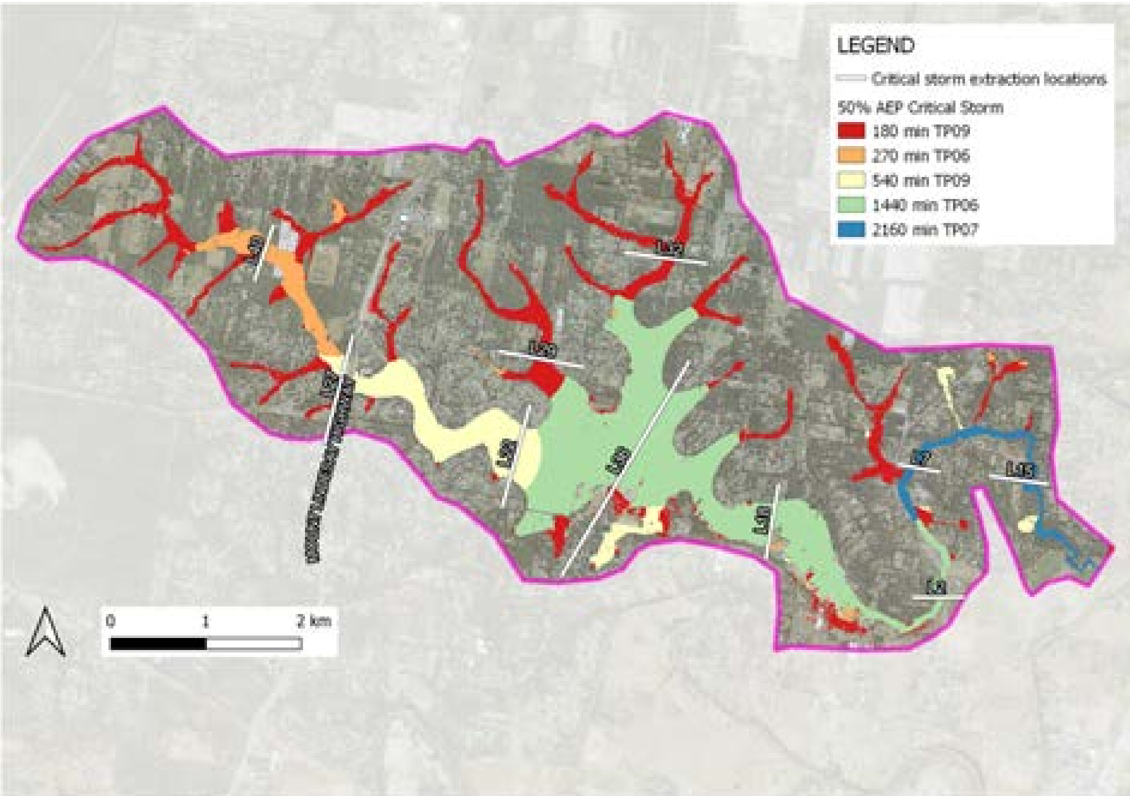

Figure 6-2 50% AEP critical storm map with locations of interest

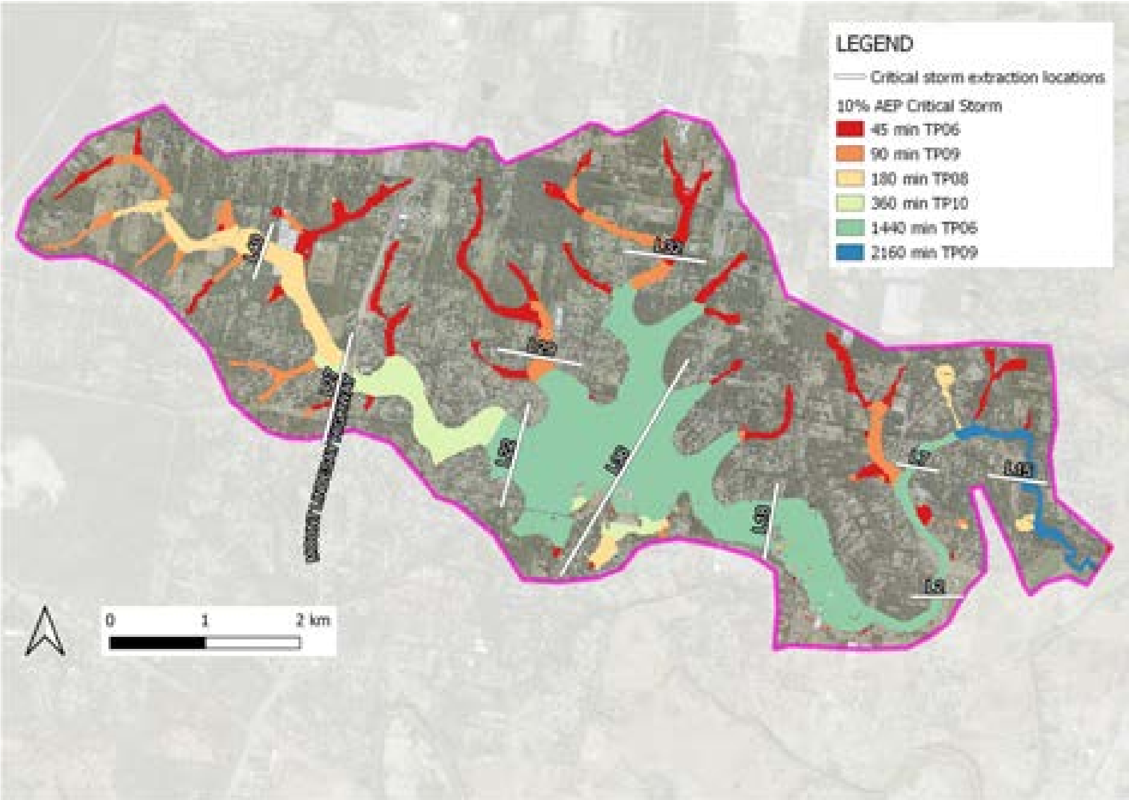

Figure 6-3 10% AEP critical storm map with locations of interest

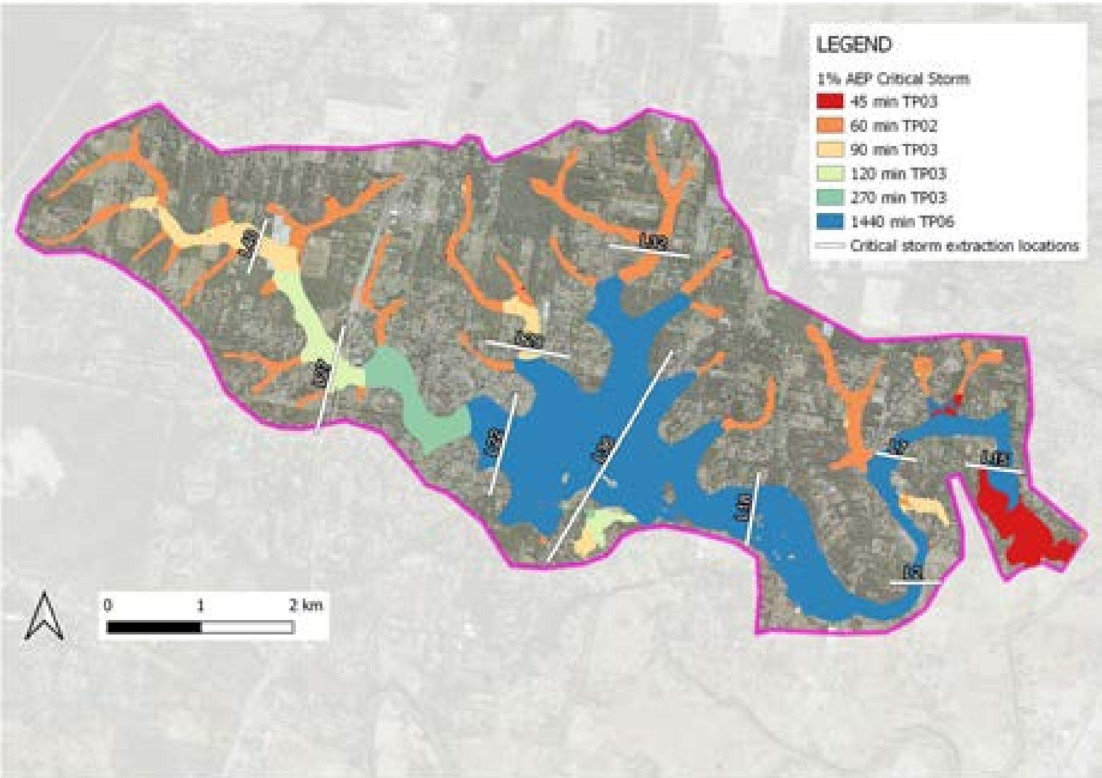

Figure 6-4 1% AEP critical storm map with locations of interest

The full suite of boxplots for the 50%,10% and 1% AEP events at each location are presented in Appendix C. A summary of the peak flows at the locations is presented below in Table 6-6. It is noted that there are storms identified as critical that have not been chosen in the final suite of simulations in Table 6-7. This filtering of storms was undertaken to select a single representative temporal pattern for each duration, results were compared at these locations where the critical storm was not simulated, and results were generally within 50 mm. This was deemed a reasonable difference in the context of the uncertainties associated with the flood study.

To validate the design event modelling the peak flow for the February 2022 event at the Chambers Alert gauge was compared against the design estimates. Based on the design discharges the February 2022 event was estimated to be between a 10% and 1% AEP event which is consistent with the observed rainfall giving further confidence to the design event modelling.

Table 6-6 Peak flow summary at locations of interest

Location of interest	50% AEP		10% AEP		1% AEP	
	Critical Storm	Peak Flow (m^3/s)	Critical Storm	Peak Flow (m^3/s)	Critical Storm	Peak Flow (m^3/s)
ChambAlertL	1440min TP06	19.8	1440min TP06	49.1	1440min TP06	96.1
L7	2160min TP07	19.8	1440min TP03	48.9	1440min TP05	105.8
L15	2160min TP07	25.2	2160min TP09	53	1440min TP10	116.8
L18	1440min TP06	19.9	1440min TP01	48.5	1440min TP01	92.8
L22	0540min TP06	23	0360min TP10	54.7	0270min TP03	96.7
L27	0540min TP09	22.9	0180min TP04	51.7	0120min TP03	96.5
L29	0180min TP09	12.7	0090min TP09	25.5	0060min TP02	44.3
L32	0180min TP09	18.4	0045min TP06	38	0045min TP03	66.8
L36	1440min TP06	20.4	1440min TP06	47.6	1440min TP01	89.9
L40	0270min TP06	13.6	0180min TP08	34.4	0090min TP03	64.7

We note that embedded bursts can exist in long duration storm temporal patterns where periods of rainfall can exceed the annual exceedance probability rare than the burst as a whole. This is sometimes seen in 24-hour storms. The box plots in Appendix C demonstrate that the critical duration for the lowest parts of the catchment are generally the 24-hr storm which is not unexpected given the significant storage throughout the catchment. No obvious anomalies indicating that embedded bursts will be problematic are noted in the plots. All of these durations have been simulated hydraulically. We therefore have no reason to suspect that embedded bursts are artificially and adversely affecting the final flood surfaces.

Table 6-7 Critical storms Modelled Per Design Event

AEP	Durations	Temporal Pattern Bin
Current Climate 2020		
50%, 20%	0180m TP09, 0270m TP06, 0540m TP09, 1440m TP06, 2160m TP07	Frequent (Point)
10%, 5%	045m TP06, 0090m TP09, 0180m TP08, 0360m TP10, 1440m TP06, 2160m TP09	Intermediate (Point)
2%,1%,0.5%, 0.2%, 0.05%	0045m TP03, 060m TP02, 0090m TP03, 0120m TP03, 0270m TP03, 1440m TP06	Rare (Point)
PMF	0060m, 0120m, 0180m, 0240m, 0300m, 0360m	GSDM
Future Climate 2090 RCP4.5% (9.5% rainfall increase)		
50%, 20%	0180m TP09, 0270m TP06, 0540m TP09, 1440m TP06, 2160m TP07	Frequent (Point)
10%, 5%	045m TP06, 0090m TP09, 0180m TP08, 0360m TP10, 1440m TP06, 2160m TP09	Intermediate (Point)
2%,1%,0.2%	0045m TP03, 060m TP02, 0090m TP03, 0120m TP03, 0270m TP03, 1440m TP06	Rare (Point)
Future Climate 2090 RCP6.5% (11.5% rainfall increase)		
1%	0045m TP03, 060m TP02, 0090m TP03, 0120m TP03, 0270m TP03, 1440m TP06	Rare (Point)
Future Climate 2090 RCP8.5% (19.7% rainfall increase)		
1%	0045m TP03, 060m TP02, 0090m TP03, 0120m TP03, 0270m TP03, 1440m TP06	Rare (Point)

6.8 GIS Mapping

The results from the design event modelling for the Chambers Creek Flood Study have been used to prepare a series of GIS maps to quantify the design flood estimate results. The GIS maps prepared include maximum flood depth, peak water surface level, peak velocity and peak flood hazard mapping based on the six (6) H1 through H6 categorisations for all the events listed in Table 6-7. Table 6-8 presents the peak water levels for the design events at the previously identified locations of interest. A long section of the Current Climate AEP events peak water levels along Chambers Creek has been provided in Appendix E.

Table 6-8 Peak water levels at locations of interest

Location of interest	Design Event AEP									
	50%	20%	10%	5%	2%	1%	0.5%	0.2%	0.05%	PMF
L40	29.70	29.86	29.93	30.00	30.10	30.18	30.27	30.37	30.54	31.71
L27	24.57	25.10	25.43	25.93	26.10	26.20	26.27	26.40	26.53	27.53
L29	21.72	21.80	21.87	21.91	21.98	22.03	22.08	22.15	22.24	23.31
L22	20.84	21.02	21.16	21.28	21.40	21.51	21.60	21.73	21.92	23.41
L36	20.72	20.94	21.10	21.22	21.35	21.46	21.55	21.68	21.86	23.19
L18	19.50	19.71	19.87	20.00	20.12	20.22	20.31	20.44	20.64	21.53
L2	16.68	17.01	17.25	17.44	17.60	17.74	17.86	18.03	18.34	19.28
L7	13.09	13.44	13.58	13.79	14.13	15.15	15.23	15.35	17.32	17.79
L15	9.02	9.59	9.73	10.79	12.97	14.92	14.92	14.93	17.23	17.28

6.9 Model Health and Simulation Times

The model was continually reviewed and refined as part of the model development and calibration phases of the project. The outcomes of the calibration and grid size sensitivity testing informed the final model settings and configuration. The following comments are provided in respect to selected log files for the 1% AEP design events:

- Mass balance error 0.00% - this is expected for 2D HPC models, noting that ME can occur in the 1D. Mass error in the 1D is acceptable (culverts are generally stable).
- Warnings and checks largely relate to topography and 1D/2D connections. These are typical for a complex model of this kind, and none were found to be critical.
- The adaptive timestep is stable at approximately 0.5s throughout the simulations. Given the 4m grid size, this is typical and results in very good run times. The dt grid shows that areas within the model which control the timestep are generally located in deep and fast-moving water near the downstream boundary, and in the Chambers Creek main channel. This is typical and generally ideal.
- Control number coefficients are acceptable.
- The 1% AEP 24-hour duration event is run for 44 hours. This is simulated in approximately 2 hours and 10 minutes running on a single NVIDIA GeForce RTX 2080-Ti. (i.e., a 44 hour simulation is completed in approximately 2 hr and 30 minutes). These simulation times are excellent and help facilitate a practical and workable model.

6.10 Sensitivity Assessments

The hydraulic model was simulated for three (3) the sensitivity scenarios and included simulation of the critical storm events for the relevant AEP. The scenarios included the following:

- Increased roughness - +20% vegetation roughness (SEN01a) for 1% AEP event and increase waterway roughness value of 0.15 for 20% and 1% AEP event (SEN01b);
- Enveloped flood surface of 100% blockage and no blockage scenario (SEN02); and
- Tailwater sensitivity.

Water level difference maps comparing the critical results of the sensitivity scenarios with the regular design scenario are discussed herein and are also provided in Appendix F as A3 mapping..

6.10.1 Floodplain roughness

6.10.1.1 Manning's increase +20%

Figure 6-5 presents the difference in peak water level from increasing the vegetation roughness by 20%. With the high storage and low velocity nature of the catchment the water levels are not overly sensitive to Manning's with flood levels generally increasing up to 100 mm. The analysis shows that the catchment is mildly sensitive to roughness variation, however, changes in roughness of 20% are not likely to result in water level changes that would exceed standard freeboard provisions.

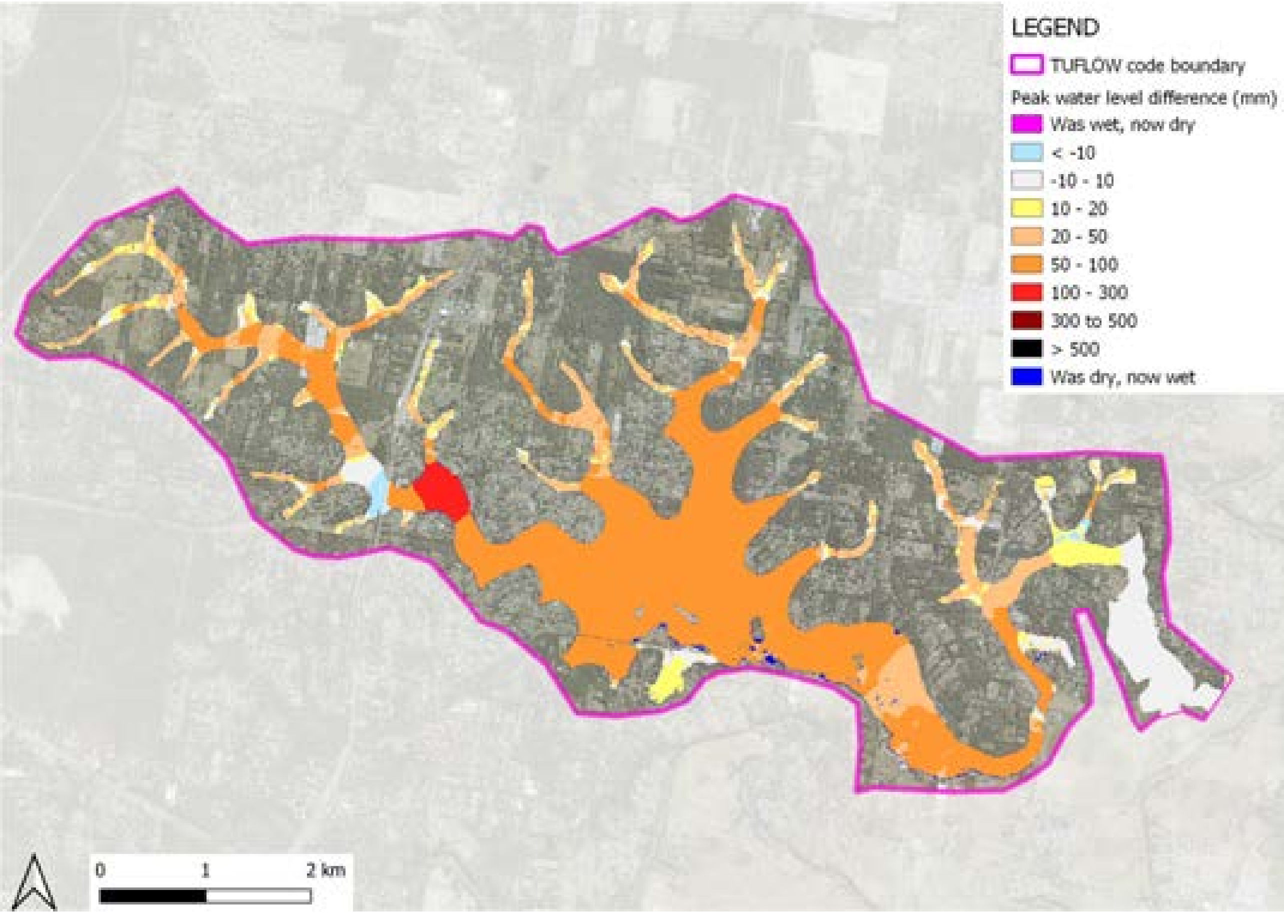

Figure 6-5 1% AEP peak water level difference map – increased roughness +20%

6.10.1.2 Waterway revegetation

Figure 6-6 and Figure 6-7 present the difference in peak water levels for the 20% and 1% AEP events caused by an increased waterway roughness value of 0.15. Chambers Creek only has a defined waterway in the lower parts of the catchment, furthermore, these lower parts of the catchment are affected by Logan River backwater. For these reasons, revegetation of the waterway corridor did not affect peak water levels significantly with increases limited to below 200 mm in the 1% AEP event. For the 20% AEP event where there is more flow in bank the levels were more sensitive with flood levels downstream of Chambers Flat Road increasing by up to 300 mm. There were minor increases in water levels upstream although these were generally limited to below 100 mm for both events.

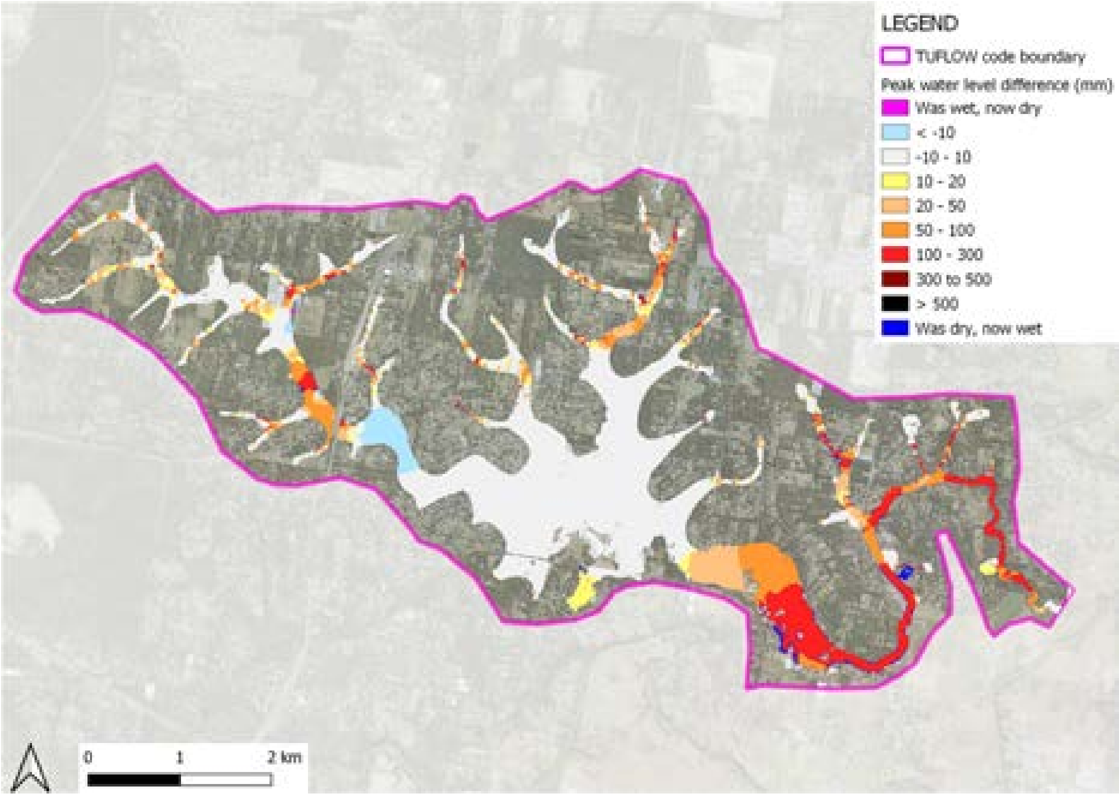

Figure 6-6 5% AEP peak water level difference map – increased waterway roughness

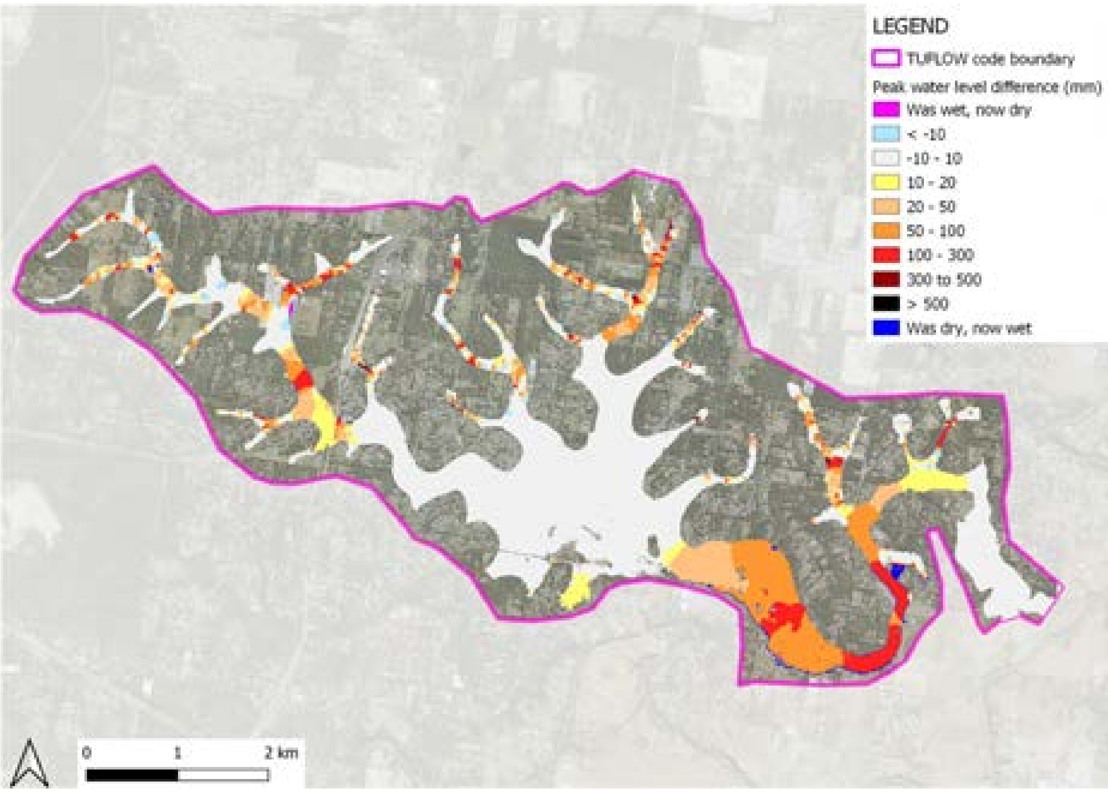

Figure 6-7 1% AEP peak water level difference map – increased waterway roughness

6.10.2 Blockage

Figure 6-8 presents the difference in peak water level for the 1% AEP event from the fully blocked/unblocked culverts scenario. The blockage assessment shows that only isolated areas located upstream of fully blocked culverts are subject to additional flooding. The most sensitive locations were at Mount Lindsay Highway and Carter Road where upstream flood levels increased by up to 250 mm and 450 mm respectively. As a general comment, Chambers Creek structures have very low immunity and therefore flood levels in the 1% AEP event were not overly sensitive to blockage with flood levels generally within 100 mm.

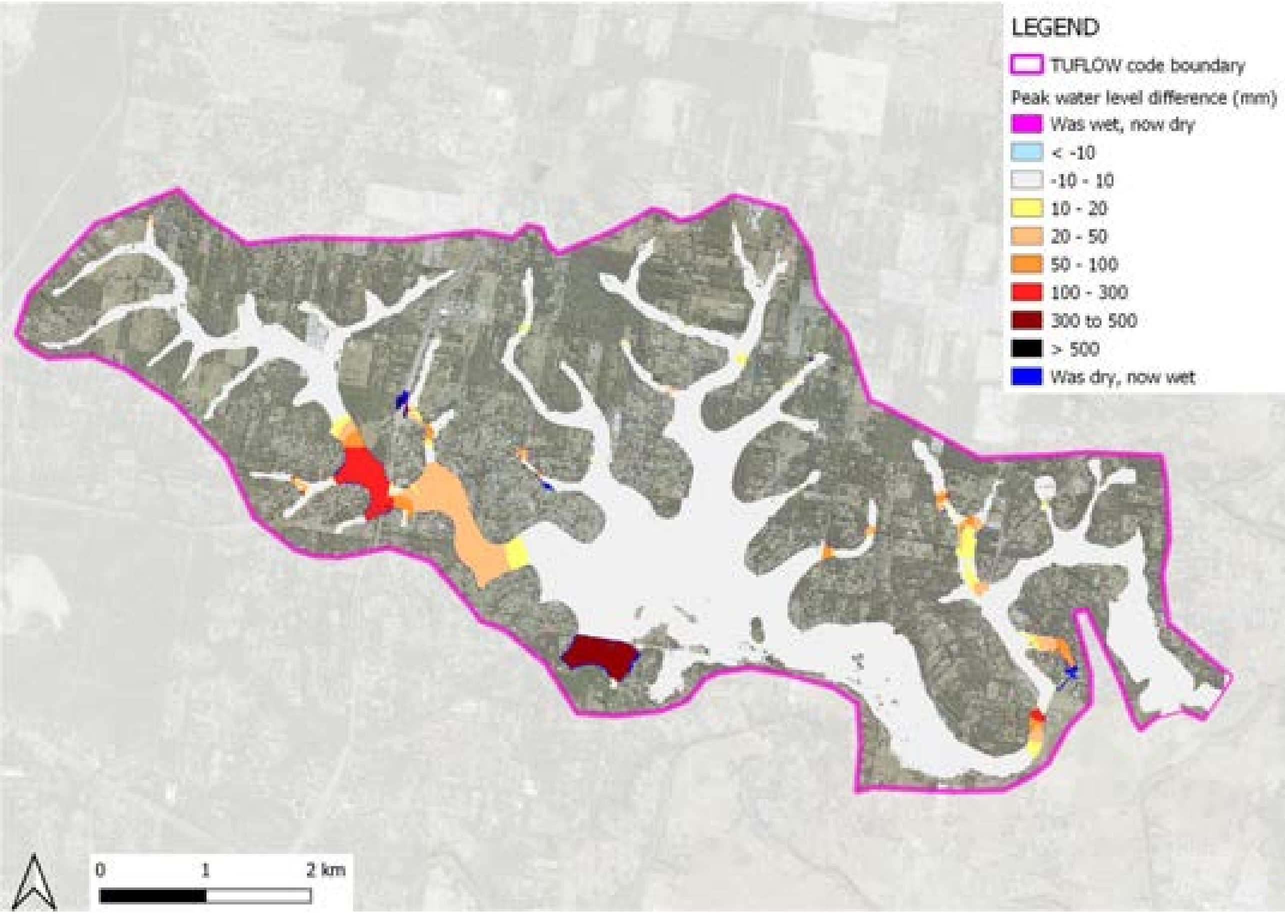

Figure 6-8 1% AEP peak water level difference map – blockage scenario

6.10.3 Tailwater Sensitivity – Joint Probability Zone

6.10.3.1 Overview

Joint probability is a statistical measure that calculates the likelihood of two events occurring at the same time. ARR 2019, Book 6, Chapter 5 describes this concept within respect to the interaction between coastal and catchment flooding. In estuarine regions, flooding can be caused independently by either extreme rainfall or elevated ocean levels (generated by storm surge and/or HAT), or it can be caused by a combination of both.

When both processes are statistically dependent, their interaction needs to be considered to account for areas where design flood levels are influenced by both processes. This region is defined as the 'joint probability zone'. Figure 6-9 (sourced from ARR 2019) described this concept through schematic longitudinal section of an estuary.

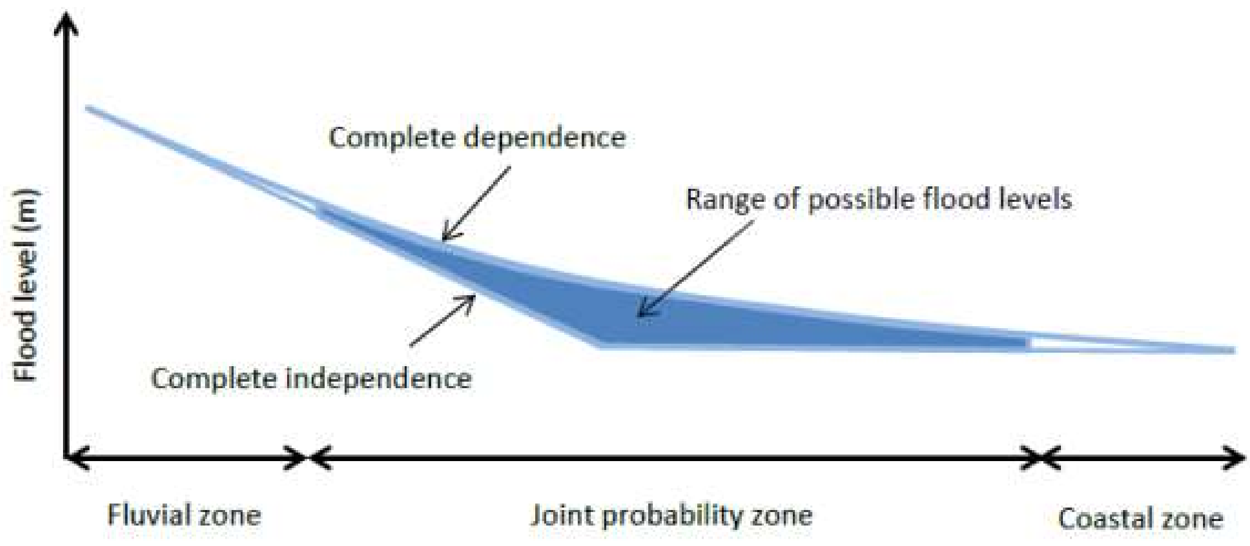

Figure 6-9 Schematic Showing the 'Joint Probability Zone'

6.10.3.2 Pre-screening Analysis

The joint probability concept can be applied to Chambers Creek to consider to the likelihood of both regional (Logan River) and local (Chambers Creek) flooding occurring together.

ARR2019, (Book 6, Chapter 5, Section 5) presents a four-step process for practical implementation of assessment of joint probability termed the design variable method. The first step involves a pre-screening analysis to identify areas within the joint probability zone.

The purpose of the pre-screening analysis is to calculate the outer envelope of flood estimates obtained from the joint probability method, to identify areas where there is a difference between independence and full dependence and to quantify the magnitude of those differences.

6.10.3.3 Methodology

The 1 in 100 AEP design event has been adopted for the pre-screening analysis, which has been undertaken using the following method:

- **Completely independent case**
  - **Independent fluvial only case**: 1 in 100 AEP local creek flood behaviour was assessed by running the hydraulic model for the 1 in 100 AEP design rainfall event for the local catchment in the absence of any tailwater influence (i.e. using a normal depth downstream boundary).
  - **Independent tailwater only case:** the 1 in 100 AEP Logan River flood level (17.2 mAHD) was provided by LCC at the junction of Chambers Creek and Logan River and used to determine the extent of tailwater-based inundation across the local catchment.
  - The flood surfaces for both the independent cases were merged to create a flood surface representative of the **complete independent case**.
- **Completely dependent case**
  - Flood behaviour was assessed by running the hydraulic model for the 1 in 100 AEP design rainfall event with a 1 in 100 AEP tailwater boundary.
- **Joint probability zone (JPZ)**
  - A comparison of the peak flood levels for the completely independent and completely dependent cases was used to identify the spatial and vertical extent of the joint probability zone.
  - A tolerance level of 0.1 m was adopted. Areas with a vertical difference in flood level below the tolerance level were considered to be outside the JPZ.

Figure 6-10 presents the difference in flood levels from the analysis with results showing an area of approximately 8.6 ha immediately upstream and downstream of Chambers Creek road within the JPZ. The area is mainly confined to the waterway corridor although there is an increase in flood extent with flood levels rising up to 300 mm adjacent to a private property. It is noted that the differences observed within the JPZ are generally lower than standard freeboard provisions.

In conclusion, a more extensive joint probability analysis should not be required for design flood levels around Chambers Flats Road as the current assumptions are considered reasonable for planning purposes.

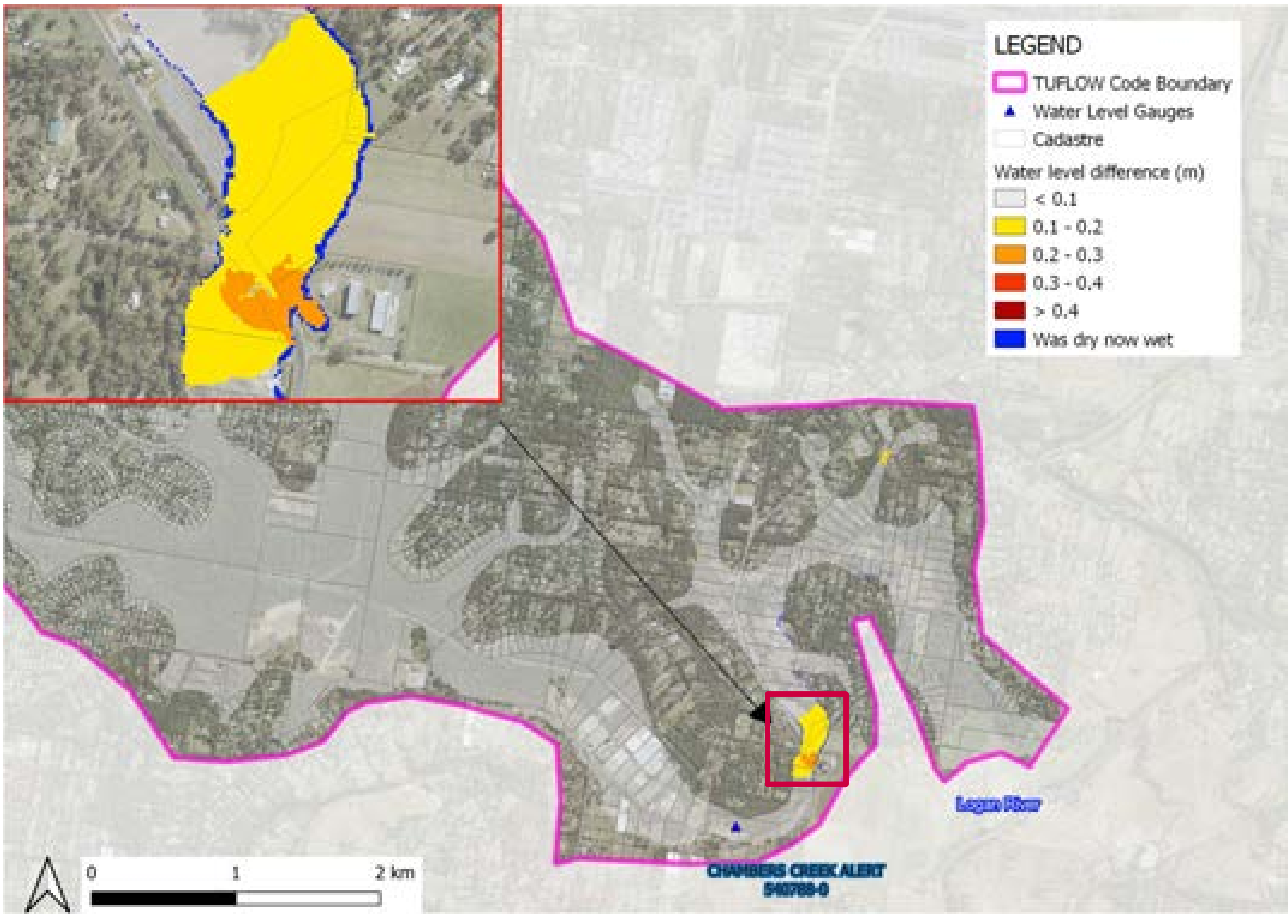

Figure 6-10 Joint probability zone – 1% AEP – Completely dependent minus completely independent case

6.11 Design Event Summary

Design event simulations have been undertaken using the detailed and calibrated URBS and TUFLOW models developed for the catchment. A summary of the design event modelling undertaken is provided as follows:

- All ARR 2019 durations and temporal patterns were simulated for the 50%, 10% and 1% AEP storms. From these results a critical duration analysis was undertaken on TUFLOW peak discharges at a discrete locations around the catchment and a subset of design storms was selected for each AEP.
- Based on design flood levels the February 2022 event was estimated to be between a 10% and 1% AEP event which is consistent with the IFD rainfall analysis undertaken in Section 4 further validating the design event modelling.
- Sensitivity testing was undertaken for several scenarios including increased vegetation roughness, reduced vegetation roughness, and a combination of 100% and no blockage of major culverts. In general the catchment is not overly sensitive to these model parameters due its high storage and low velocity nature. The sensitivities showed that standard freeboard provisions should be appropriate.

The full set of TUFLOW results, check files and logs files have been provided to LCC in line with the project deliverables.

7 SUMMARY

Water Technology (WT) has undertaken a detailed flood study for the Chambers Creek catchment. The study will be used to inform the floodplain risk management study for the catchment and will be used as a basis to inform and support LCC's flood and planning related management and operational activities into the future.

Detailed hydrological and hydraulic models for the catchment were developed as part of this study in accordance with Australian Rainfall and Runoff 2019 (ARR 2019). The detailed URBS and TUFLOW models have been calibrated to the recent February 2022 flood event which was estimated to be a rare flood event (between 10% and 1% AEP) based on rainfall and design flood surface analysis. The catchment is limited by a lack of data both spatially with only 1 rainfall gauge and temporally with only 4 years of stream gauge records available. It is recommended that as more data becomes available i.e. suitable calibration events, that the model parameters are reconsidered and confirmed for suitability.

For the design event modelling all ARR 2019 durations and temporal patterns were simulated for the 50%, 10% and 1% AEP storms. From these results a critical duration analysis was undertaken on TUFLOW peak discharges at a discrete number of locations throughout the catchment and a subset of design storms was selected for each AEP. This robust assessment has allowed a practical modelling approach with the probability neutral flood surface for each AEP design event requiring only 4 to 6 storm events to be simulated. Existing climate and various future climates have been simulated for a full range of AEP events ranging from 50% to the PMF providing LCC a robust resource of flood risk outputs throughout the catchment.

The finalised digital URBS and TUFLOW model files have been provided to LCC separately to this report. A full set of digital TUFLOW results has also been provided to LCC in line with the project deliverable specifications.

8 REFERENCES

1. Australian Rainfall and Runoff (ARR) (2019): A guide to flood estimation, Commonwealth of Australia (Geoscience Australia), 2016.
2. Bureau of Meteorology: Design Rainfall Data System (2016) available at: http://www.bom.gov.au/water/designRainfalls/revised-ifd/
3. The Estimation of Probable Precipitation in Australia: Generalised Short-Duration Method, Hydrometeorological Advisory Service (2003)
4. IEAust (2012) Australian Rainfall and Runoff Revision Project 15: Two Dimensional Modelling in Urban and Rural Floodplains Stage 1 & 2 Report, November, 2012.
5. IEAust (1998), Australian Rainfall and Runoff, A Guide to Flood Estimation, Volume 1 and 2, Editor in Chief DH Pilgrim, Institution of Engineers.

APPENDIX A
ARR 2019 DATAHUB OUTPUT

```
Results - ARR Data Hub
[STARTTXT]

Input Data Information
[INPUTDATA]
Latitude,-27.738000
Longitude,153.054000
[END_INPUTDATA]

River Region
[RIVREG]
Division,North East Coast
River Number,45
River Name,Logan-Albert Rivers
[RIVREG_META]
Time Accessed,28 March 2023 11:08PM
Version,2016_v1
[END_RIVREG]

ARF Parameters
[LONGARF]
Zone,East Coast North
a,0.327
b,0.241
c,0.448
d,0.36
e,0.00096
f,0.48
g,-0.21
h,0.012
i,-0.0013
[LONGARF_META]
Time Accessed,28 March 2023 11:08PM
Version,2016_v1
[END_LONGARF]

Storm Losses
[LOSSES]
ID,17886.0
Storm Initial Losses (mm),20.0
Storm Continuing Losses (mm/h),1.5
[LOSSES_META]
Time Accessed,28 March 2023 11:08PM
Version,2016_v1
[END_LOSSES]

Temporal Patterns
[TP]
code,ECnorth
Label,East Coast North
[TP_META]
Time Accessed,28 March 2023 11:08PM
Version,2016_v2
[END_TP]

Areal Temporal Patterns
[ATP]
code,ECnorth
```

```
arealabel,East Coast North
[ATP_META]
Time Accessed,28 March 2023 11:08PM
Version,2016_v2
[END_ATP]

Median Preburst Depths and Ratios
[PREBURST]
min (h)\AEP(%),50,20,10,5,2,1
60 (1.0),0.3 (0.009),2.9 (0.058),4.6 (0.078),6.2 (0.090),7.1 (0.087),7.8 (0.085)
90 (1.5),0.1 (0.001),2.0 (0.035),3.2 (0.048),4.5 (0.057),11.9 (0.125),17.4
(0.163)
120 (2.0),0.0 (0.000),3.6 (0.059),6.1 (0.082),8.4 (0.097),15.5 (0.149),20.8
(0.176)
180 (3.0),0.4 (0.008),5.1 (0.074),8.2 (0.098),11.2 (0.114),22.7 (0.190),31.4
(0.230)
360 (6.0),0.1 (0.002),7.8 (0.089),12.8 (0.121),17.7 (0.141),30.6 (0.201),40.3
(0.230)
720 (12.0),1.8 (0.022),9.1 (0.080),14.0 (0.101),18.7 (0.114),31.4 (0.157),40.9
(0.178)
1080 (18.0),0.5 (0.005),8.5 (0.063),13.9 (0.084),19.0 (0.097),28.3 (0.119),35.2
(0.129)
1440 (24.0),0.7 (0.007),5.7 (0.038),9.0 (0.049),12.2 (0.055),22.9 (0.085),31.0
(0.100)
2160 (36.0),0.2 (0.001),2.8 (0.016),4.6 (0.021),6.3 (0.024),12.7 (0.040),17.5
(0.048)
2880 (48.0),0.0 (0.000),1.6 (0.008),2.7 (0.011),3.7 (0.013),12.0 (0.033),18.2
(0.044)
4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),1.8 (0.004),3.1
(0.007)
[PREBURST_META]
Time Accessed,28 March 2023 11:08PM
Version,2018_v1
Note,Preburst interpolation methods for catchment wide preburst has been
slightly altered. Point values remain unchanged.
[END_PREBURST]From preburst class

10% Preburst Depths
[PREBURST10]
min (h)\AEP(%),50,20,10,5,2,1
60 (1.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000)
90 (1.5),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000)
120 (2.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
180 (3.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
360 (6.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
720 (12.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
1080 (18.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
1440 (24.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
2160 (36.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
2880 (48.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
```

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4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
[PREBURST10_META]
Time Accessed,28 March 2023 11:08PM
Version,2018_v1
Note,Preburst interpolation methods for catchment wide preburst has been
slightly altered. Point values remain unchanged.
[END_PREBURST10]From preburst class

25% Preburst Depths
[PREBURST25]
min (h)\AEP(%),50,20,10,5,2,1
60 (1.0),0.0 (0.000),0.2 (0.003),0.3 (0.005),0.4 (0.006),0.4 (0.004),0.3 (0.003)
90 (1.5),0.0 (0.000),0.1 (0.001),0.1 (0.001),0.1 (0.002),0.7 (0.007),1.1 (0.011)
120 (2.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.6 (0.006),1.0
(0.009)
180 (3.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),1.1 (0.009),1.9
(0.014)
360 (6.0),0.0 (0.000),0.1 (0.001),0.2 (0.002),0.3 (0.002),2.7 (0.018),4.5
(0.026)
720 (12.0),0.0 (0.000),0.9 (0.008),1.6 (0.011),2.2 (0.013),4.4 (0.022),6.1
(0.026)
1080 (18.0),0.0 (0.000),0.3 (0.002),0.4 (0.003),0.6 (0.003),4.4 (0.018),7.2
(0.026)
1440 (24.0),0.0 (0.000),0.0 (0.000),0.1 (0.000),0.1 (0.000),1.8 (0.007),3.1
(0.010)
2160 (36.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.1 (0.000),0.2
(0.000)
2880 (48.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0
(0.000)
[PREBURST25_META]
Time Accessed,28 March 2023 11:09PM
Version,2018_v1
Note,Preburst interpolation methods for catchment wide preburst has been
slightly altered. Point values remain unchanged.
[END_PREBURST25]From preburst class

75% Preburst Depths
[PREBURST75]
min (h)\AEP(%),50,20,10,5,2,1
60 (1.0),9.4 (0.263),22.0 (0.443),30.4 (0.512),38.4 (0.556),34.0 (0.414),30.7
(0.332)
90 (1.5),2.9 (0.073),17.5 (0.311),27.1 (0.401),36.3 (0.460),67.5 (0.713),90.9
(0.849)
120 (2.0),8.1 (0.185),24.1 (0.393),34.7 (0.470),44.9 (0.518),85.6 (0.822),116.2
(0.982)
180 (3.0),11.9 (0.242),38.5 (0.556),56.1 (0.670),73.0 (0.741),102.0
(0.854),123.7 (0.908)
360 (6.0),20.2 (0.326),38.4 (0.440),50.5 (0.476),62.0 (0.495),100.0
(0.655),128.5 (0.735)
720 (12.0),24.8 (0.309),42.4 (0.372),54.0 (0.389),65.2 (0.397),86.9
(0.434),103.2 (0.449)
1080 (18.0),18.5 (0.197),37.7 (0.280),50.5 (0.307),62.7 (0.322),82.8
(0.348),97.9 (0.359)
1440 (24.0),18.7 (0.178),34.5 (0.227),44.9 (0.242),54.8 (0.249),73.6
(0.273),87.6 (0.284)
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2160 (36.0),13.7 (0.112),22.1 (0.123),27.6 (0.126),32.9 (0.126),47.4
(0.148),58.2 (0.158)
2880 (48.0),3.3 (0.024),12.3 (0.062),18.2 (0.074),23.9 (0.082),49.6 (0.138),68.8
(0.167)
4320 (72.0),0.4 (0.003),5.6 (0.025),9.1 (0.033),12.5 (0.037),30.5 (0.074),44.0
(0.092)
[PREBURST75_META]
Time Accessed,28 March 2023 11:09PM
Version,2018_v1
Note,Preburst interpolation methods for catchment wide preburst has been
slightly altered. Point values remain unchanged.
[END_PREBURST75]From preburst class

90% Preburst Depths
[PREBURST90]
min (h)\AEP(%),50,20,10,5,2,1
60 (1.0),25.0 (0.699),69.8 (1.404),99.5 (1.675),128.0 (1.853),115.7
(1.409),106.5 (1.154)
90 (1.5),14.5 (0.359),53.5 (0.951),79.3 (1.175),104.1 (1.319),176.9
(1.869),231.4 (2.163)
120 (2.0),29.1 (0.665),67.5 (1.101),92.9 (1.258),117.2 (1.354),180.0
(1.727),227.0 (1.918)
180 (3.0),65.3 (1.325),107.1 (1.546),134.8 (1.609),161.3 (1.636),222.1
(1.860),267.7 (1.965)
360 (6.0),56.9 (0.921),85.8 (0.983),104.9 (0.990),123.2 (0.984),192.1
(1.259),243.8 (1.394)
720 (12.0),52.8 (0.660),92.6 (0.813),119.0 (0.858),144.3 (0.878),182.9
(0.912),211.7 (0.921)
1080 (18.0),52.7 (0.561),79.8 (0.593),97.8 (0.595),115.0 (0.590),157.9
(0.664),190.1 (0.697)
1440 (24.0),52.4 (0.498),81.1 (0.535),100.1 (0.540),118.4 (0.537),149.8
(0.556),173.3 (0.561)
2160 (36.0),38.3 (0.312),57.7 (0.322),70.4 (0.321),82.7 (0.316),124.0
(0.388),155.0 (0.422)
2880 (48.0),33.0 (0.243),58.3 (0.293),75.0 (0.306),91.1 (0.311),113.8
(0.317),130.8 (0.317)
4320 (72.0),19.9 (0.130),42.0 (0.186),56.7 (0.203),70.8 (0.211),79.4
(0.192),85.8 (0.180)
[PREBURST90_META]
Time Accessed,28 March 2023 11:09PM
Version,2018_v1
Note,Preburst interpolation methods for catchment wide preburst has been
slightly altered. Point values remain unchanged.
[END_PREBURST90]From preburst class

Interim Climate Change Factors
[CCF]
,RCP 4.5,RCP6,RCP 8.5
2030,0.869 (4.3%),0.783 (3.9%),0.983 (4.9%)
2040,1.057 (5.3%),1.014 (5.1%),1.349 (6.8%)
2050,1.272 (6.4%),1.236 (6.2%),1.773 (9.0%)
2060,1.488 (7.5%),1.458 (7.4%),2.237 (11.5%)
2070,1.676 (8.5%),1.691 (8.6%),2.722 (14.2%)
2080,1.810 (9.2%),1.944 (9.9%),3.209 (16.9%)
2090,1.862 (9.5%),2.227 (11.5%),3.679 (19.7%)

[CCF_META]
Time Accessed,28 March 2023 11:09PM
```

APPENDIX B
URBS SUBCATCHMENT PROPERTIES

URBS subcatch ID	Area (km^2)	Fraction Impervious	Urbanisation (50% Impervious)
1	0.249	0.41	0.82
2	0.319	0.27	0.54
3	0.101	0.8	1
4	0.21	0.8	1
5	0.097	0.81	1
6	0.286	0.8	1
7	0.401	0.27	0.54
8	0.284	0.81	1
9	0.26	0.36	0.72
10	0.15	0.8	1
11	0.214	0.8	1
12	0.276	0.22	0.44
13	0.17	0.3	0.6
14	0.162	0.23	0.46
15	0.119	0.25	0.5
16	0.283	0.8	1
17	0.181	0.23	0.46
18	0.296	0.2	0.4
19	0.258	0.39	0.78
20	0.238	0.8	1
21	0.161	0.21	0.42
22	0.376	0.27	0.54
23	0.202	0.31	0.62
24	0.295	0.8	1
25	0.136	0.29	0.58
26	0.223	0.29	0.58
27	0.229	0.9	1
28	0.177	0.27	0.54
29	0.118	0.2	0.4
30	0.191	0.23	0.46
31	0.118	0.25	0.5
32	0.245	0.22	0.44
33	0.199	0.81	1
34	0.202	0.85	1
35	0.372	0.37	0.74
36	0.112	0.28	0.56
37	0.169	0.8	1

URBS subcatch ID	Area (km^2)	Fraction Impervious	Urbanisation (50% Impervious)
38	0.147	0.25	0.5
39	0.187	0.43	0.86
40	0.198	0.37	0.74
41	0.209	0.25	0.5
42	0.177	0.56	1
43	0.265	0.29	0.58
44	0.2	0.8	1
45	0.086	0.73	1
46	0.201	0.22	0.44
47	0.2	0.81	1
48	0.116	0.81	1
49	0.201	0.21	0.42
50	0.201	0.26	0.52
51	0.264	0.24	0.48
52	0.225	0.26	0.52
53	0.22	0.22	0.44
54	0.134	0.23	0.46
55	0.209	0.29	0.58
56	0.22	0.24	0.48
57	0.145	0.28	0.56
58	0.169	0.8	1
59	0.228	0.22	0.44
60	0.111	0.8	1
61	0.264	0.8	1
62	0.2	0.26	0.52
63	0.201	0.3	0.6
64	0.202	0.8	1
65	0.201	0.26	0.52
66	0.202	0.26	0.52
67	0.189	0.81	1
68	0.202	0.4	0.8
69	0.131	0.26	0.52
70	0.272	0.2	0.4
71	0.34	0.81	1
72	0.186	0.79	1
73	0.14	0.28	0.56
74	0.283	0.2	0.4

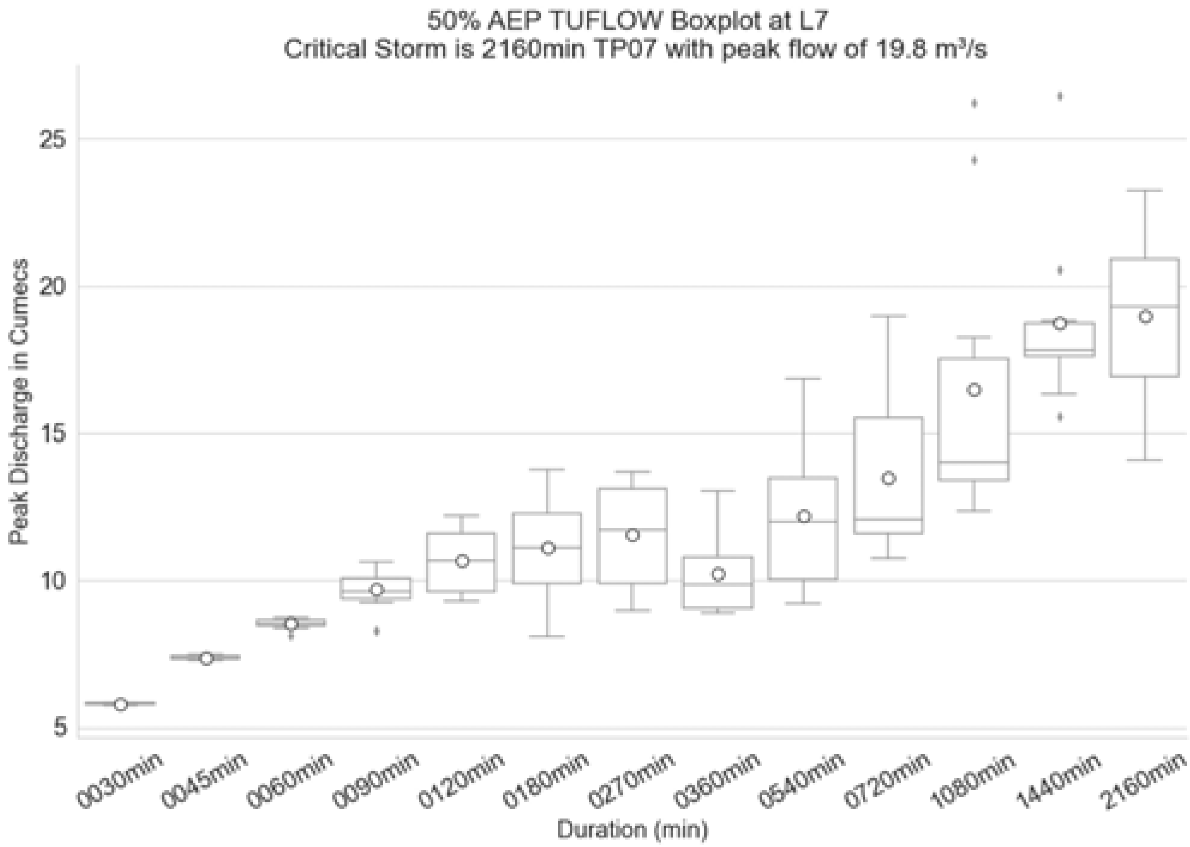
URBS subcatch ID	Area (km^2)	Fraction Impervious	Urbanisation (50% Impervious)
75	0.175	0.22	0.44
76	0.43	0.21	0.42
77	0.258	0.24	0.48
78	0.232	0.21	0.42
79	0.333	0.81	1
80	0.197	0.8	1
81	0.075	0.22	0.44
82	0.306	0.27	0.54
83	0.204	0.8	1
84	0.177	0.25	0.5
85	0.316	0.74	1
86	0.208	0.31	0.62
87	0.212	0.8	1
88	0.258	0.22	0.44
89	0.207	0.26	0.52
90	0.364	0.4	0.8
91	0.199	0.2	0.4
92	0.207	0.2	0.4
93	0.128	0.26	0.52
94	0.085	0.24	0.48
95	0.229	0.81	1
96	0.034	0.83	1
97	0.228	0.8	1
98	0.289	0.29	0.58
99	0.294	0.8	1
100	0.207	0.23	0.46
101	0.227	0.27	0.54
102	0.212	0.56	1
103	0.202	0.8	1
104	0.207	0.82	1
105	0.21	0.8	1
106	0.243	0.8	1
107	0.146	0.21	0.42
108	0.222	0.28	0.56
109	0.195	0.25	0.5
110	0.29	0.81	1
111	0.21	0.24	0.48

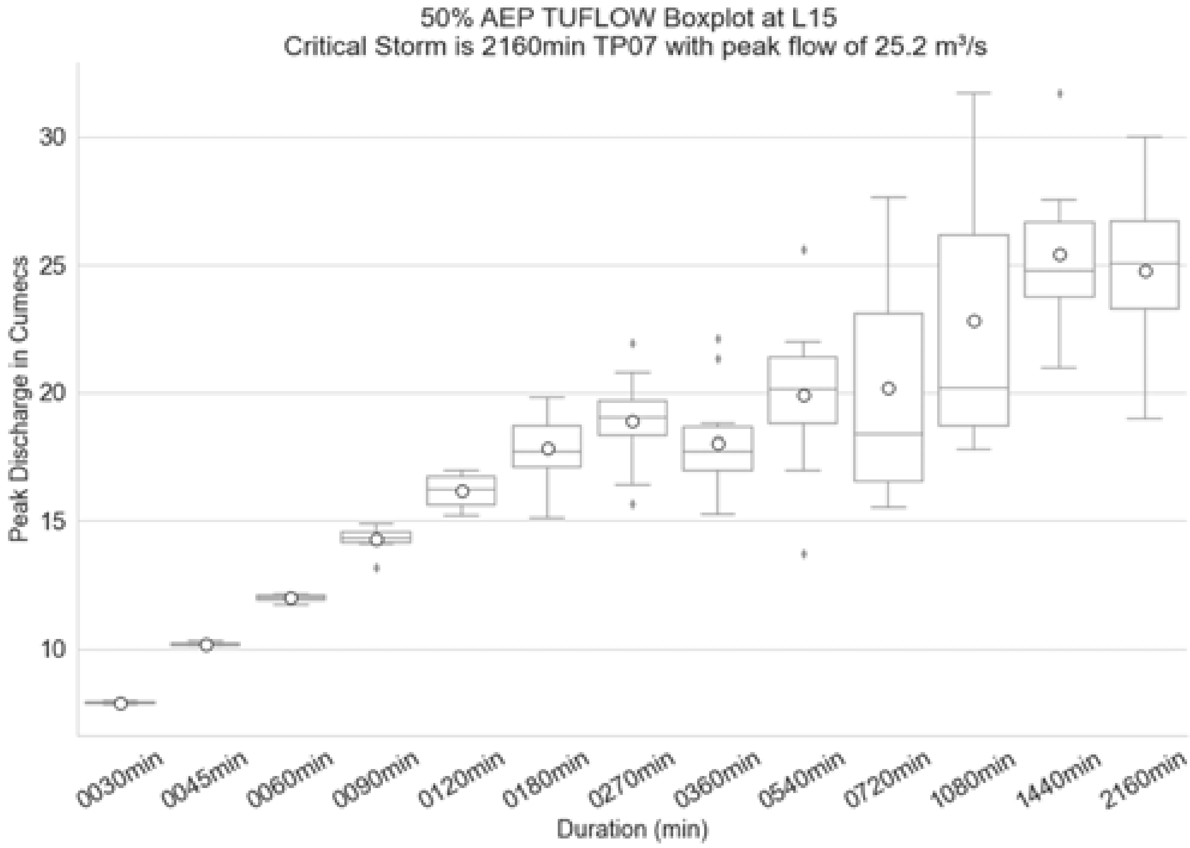
URBS subcatch ID	Area (km^2)	Fraction Impervious	Urbanisation (50% Impervious)
112	0.236	0.27	0.54
113	0.289	0.24	0.48
114	0.171	0.83	1
115	0.178	0.8	1
116	0.223	0.2	0.4
117	0.236	0.2	0.4
118	0.227	0.8	1
119	0.169	0.81	1
120	0.142	0.81	1
121	0.279	0.24	0.48
122	0.292	0.46	0.92
123	0.218	0.81	1
124	0.239	0.23	0.46
125	0.19	0.28	0.56
126	0.212	0.2	0.4
127	0.347	0.25	0.5
128	0.209	0.79	1
129	0.257	0.8	1
130	0.175	0.81	1
131	0.187	0.9	1
132	0.235	0.8	1
133	0.245	0.26	0.52
134	0.23	0.81	1
135	0.281	0.81	1
136	0.216	0.8	1
137	0.225	0.8	1
138	0.227	0.25	0.5
139	0.183	0.49	0.98
140	0.18	0.45	0.9
141	0.208	0.38	0.76
142	0.318	0.76	1
143	0.235	0.24	0.48
144	0.218	0.58	1
145	0.238	0.29	0.58
146	0.174	0.21	0.42
147	0.44	0.23	0.46
148	0.283	0.65	1

URBS subcatch ID	Area (km^2)	Fraction Impervious	Urbanisation (50% Impervious)
149	0.234	0.82	1
150	0.224	0.26	0.52
151	0.353	0.28	0.56
152	0.237	0.2	0.4
153	0.287	0.36	0.72
154	0.117	0.81	1
155	0.205	0.8	1
156	0.173	0.22	0.44
157	0.356	0.28	0.56
158	0.32	0.27	0.54
159	0.246	0.8	1
160	0.22	0.83	1
161	0.247	0.8	1
162	0.388	0.2	0.4
163	0.269	0.25	0.5
164	0.1	0.3	0.6
165	0.204	0.38	0.76
166	0.104	0.24	0.48
167	0.088	0.27	0.54
168	0.166	0.23	0.46
169	0.18	0.82	1
170	0.107	0.73	1
171	0.061	0.8	1
172	0.111	0.26	0.52

APPENDIX C
ARR 2019 TUFLOW PEAK FLOW BOXPLOTS

22020077_R01_V01c_ChambersCreek.docx


50% AEP TUFLOW Boxplot at L7
Critical Storm is 2160min TP07 with peak flow of 19.8 m³/s
Peak Discharge in Cumecs
5
10
15
20
25
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)


50% AEP TUFLOW Boxplot at L15
Critical Storm is 2160min TP07 with peak flow of 25.2 m³/s
Peak Discharge in Cumecs
10
15
20
25
30
0030min
0045min
0060min
0090min
0120min
0180min
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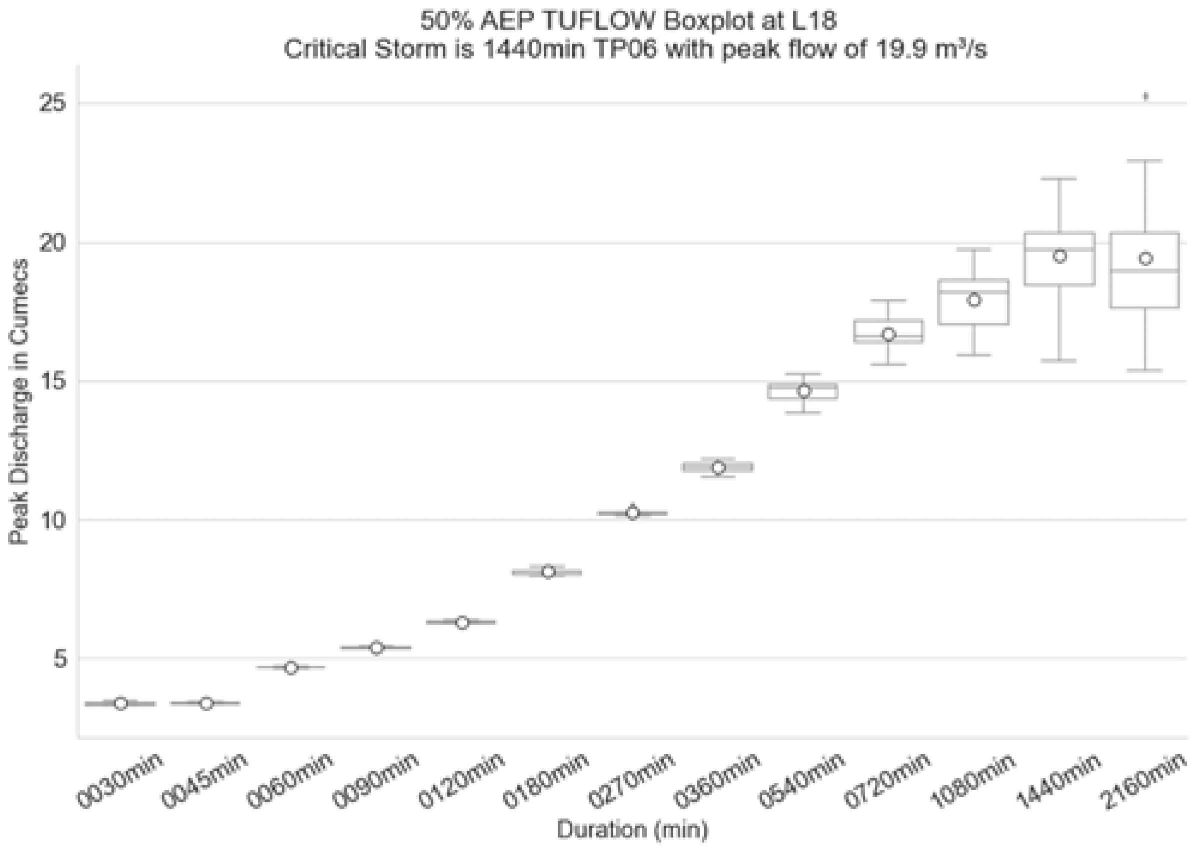
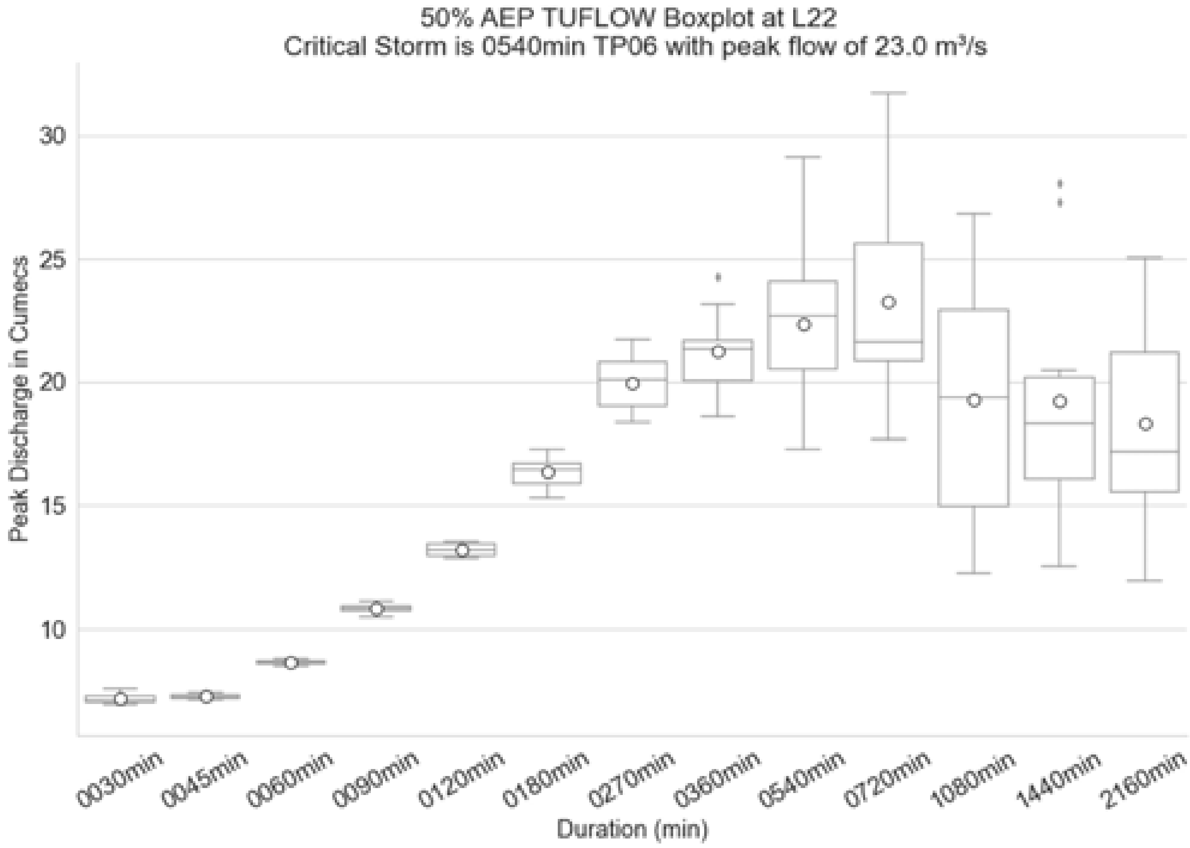
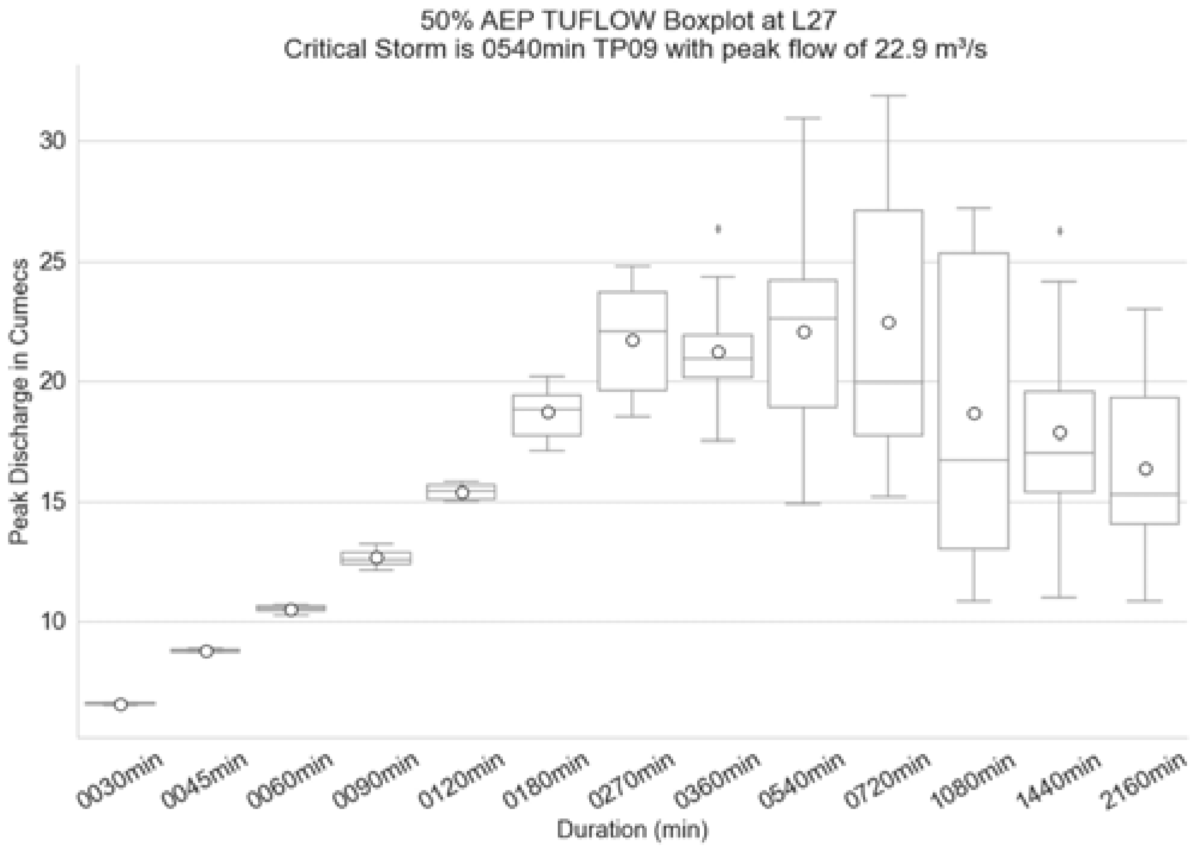
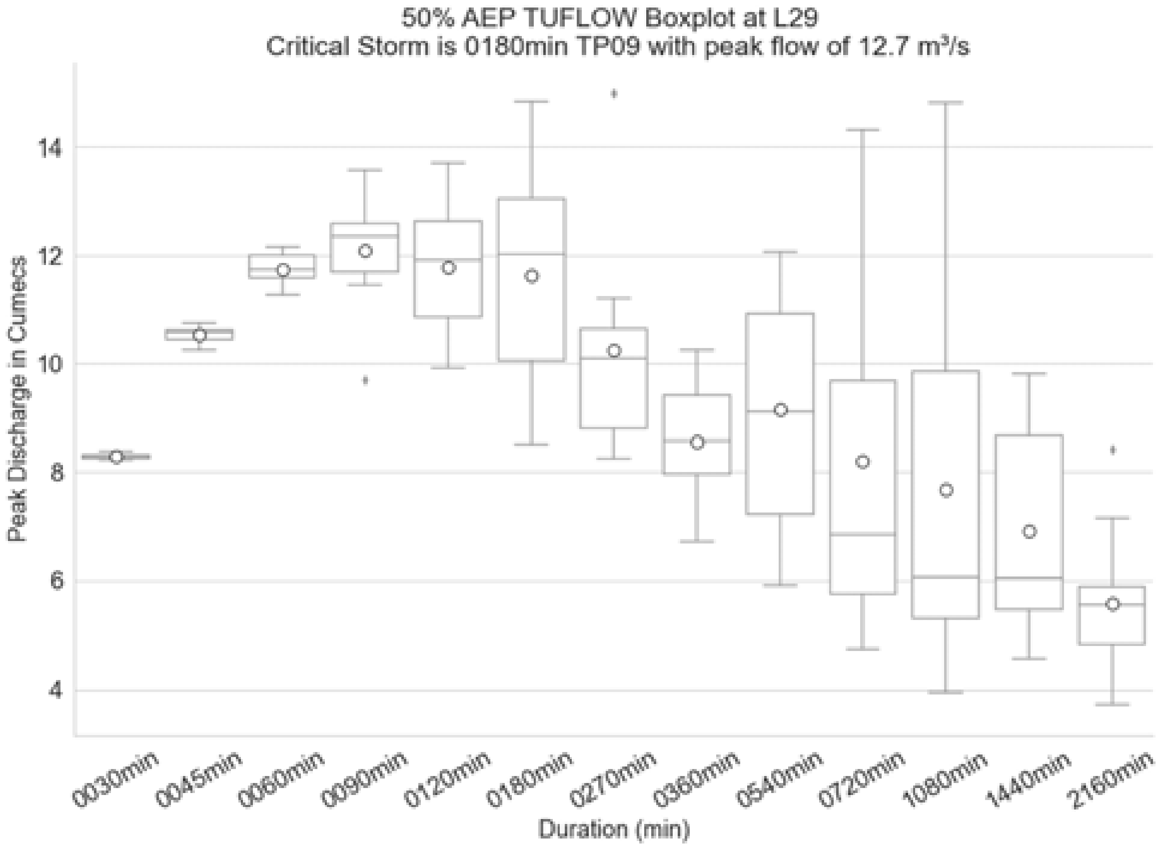
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

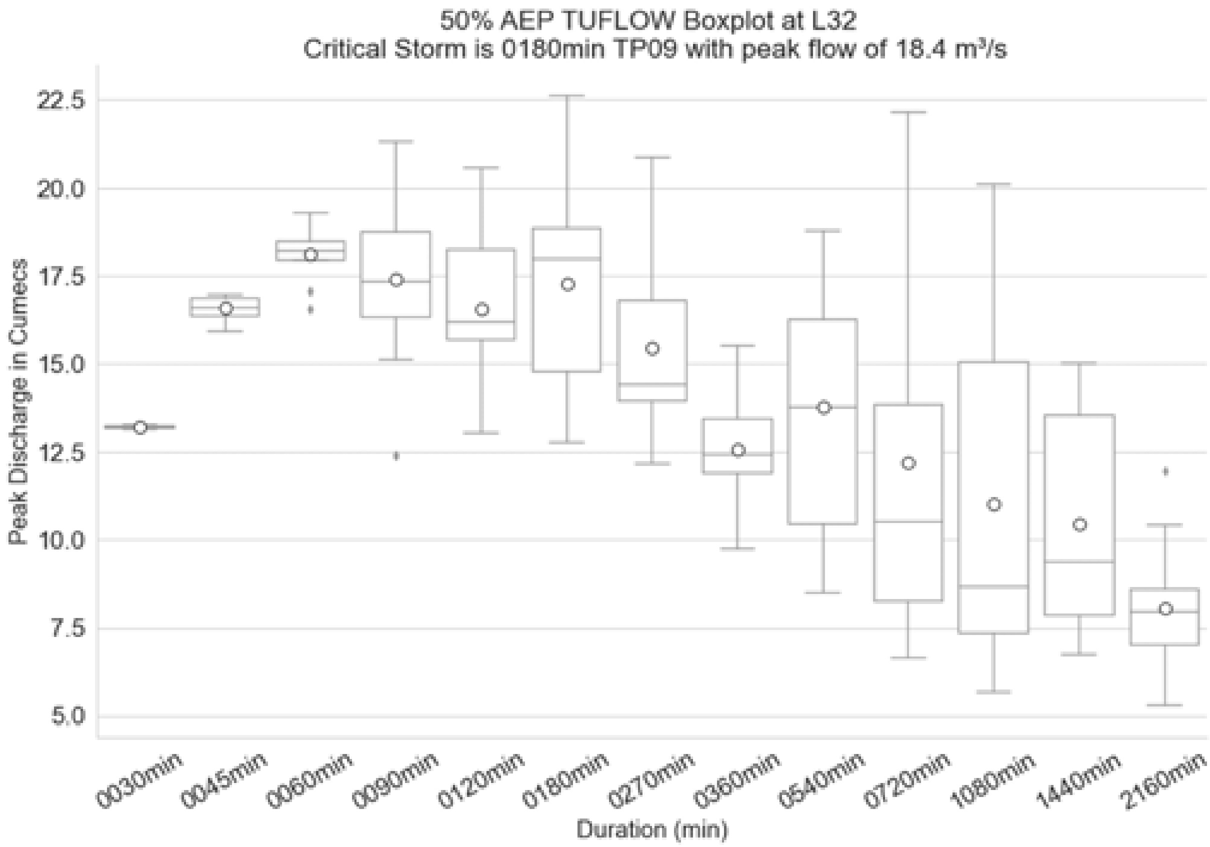


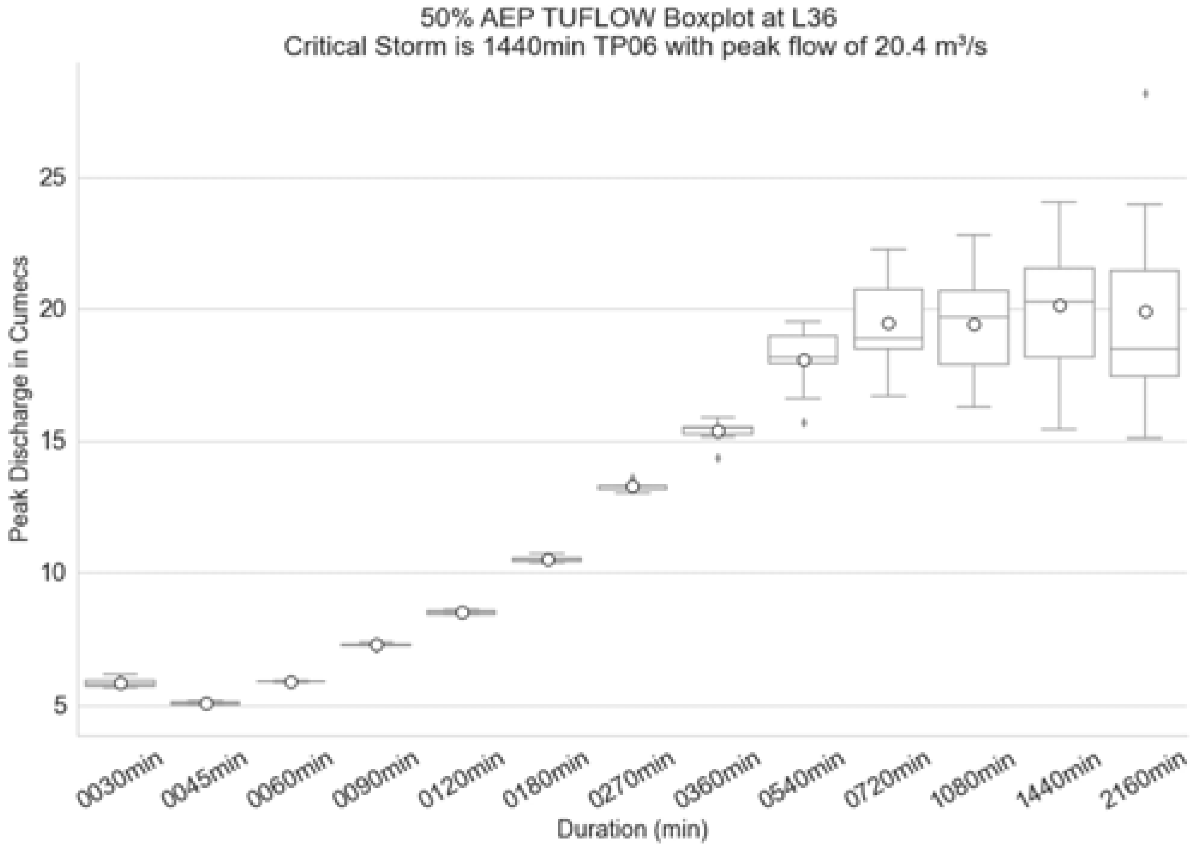


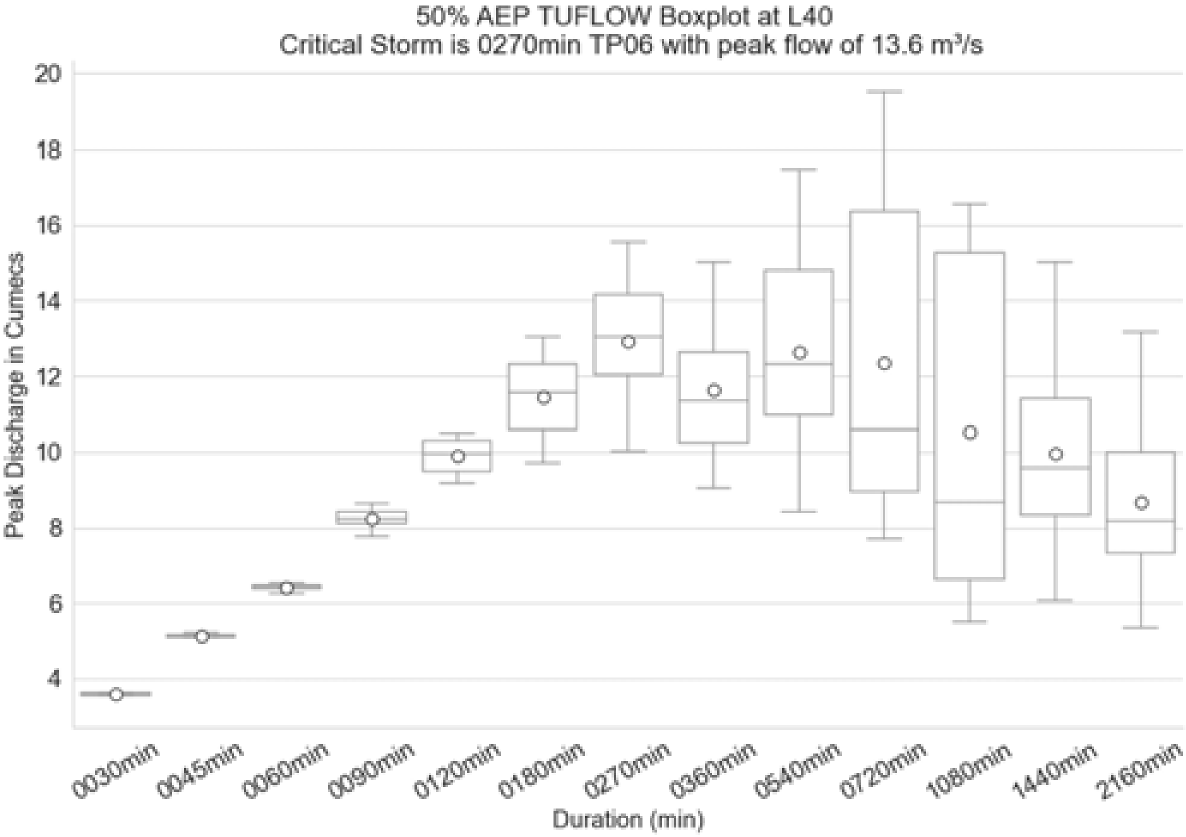
22020077_R01_V01c_ChambersCreek.docx

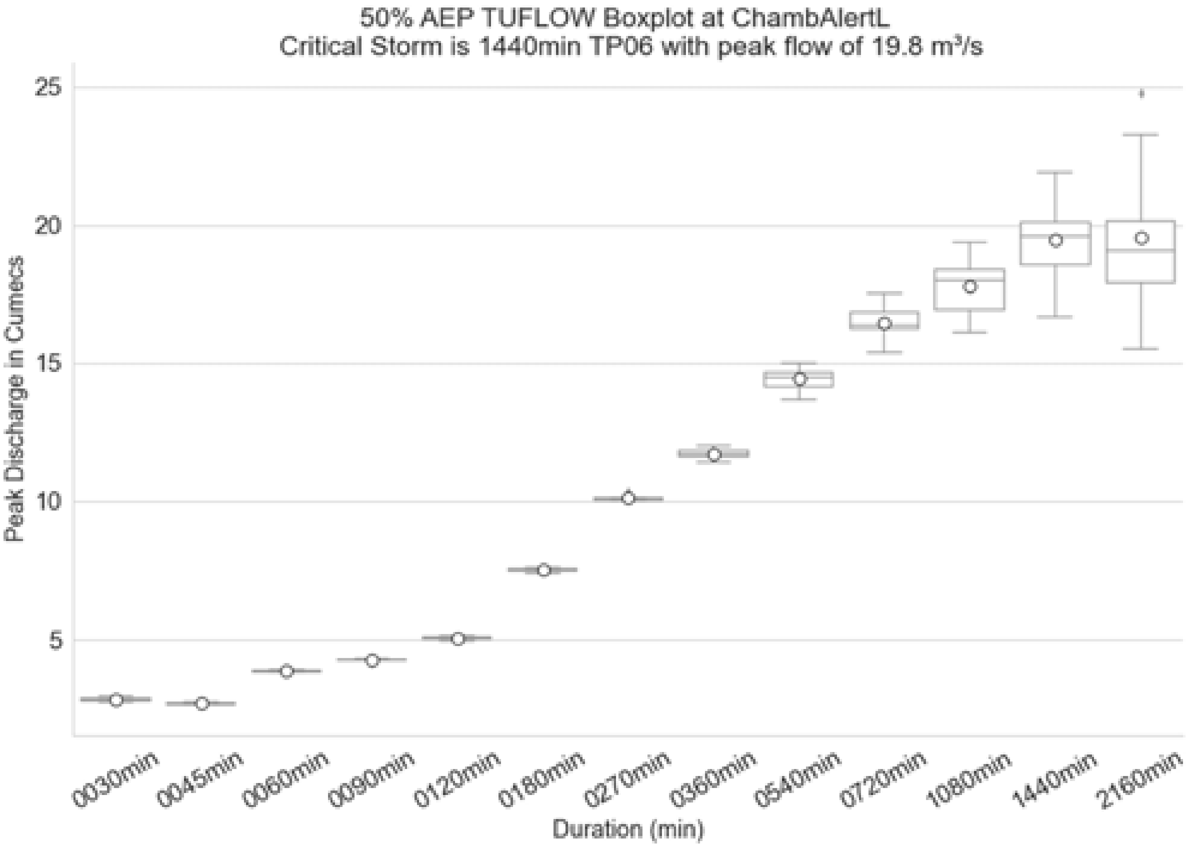

50% AEP TUFLOW Boxplot at L27
Critical Storm is 0540min TP09 with peak flow of 22.9 m³/s
Peak Discharge in Cumecs
10
15
20
25
30
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

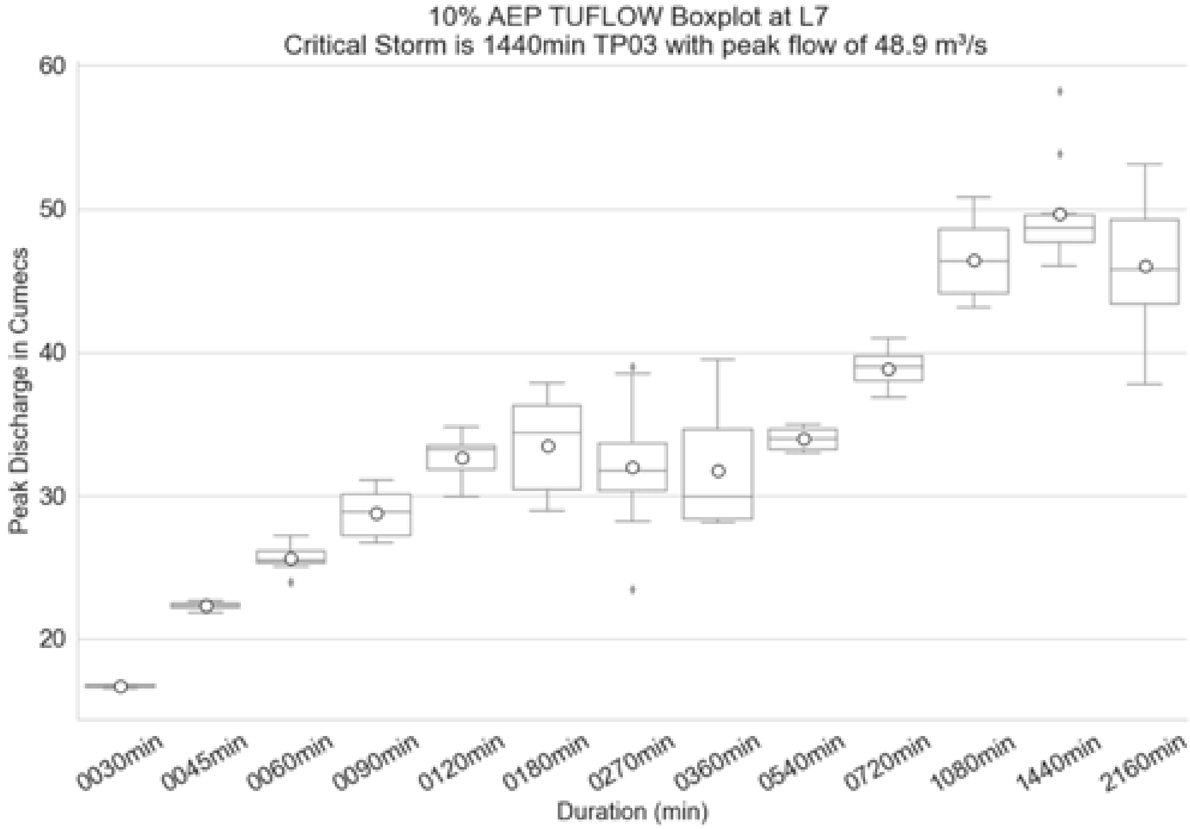

50% AEP TUFLOW Boxplot at L29
Critical Storm is 0180min TP09 with peak flow of 12.7 m³/s
Peak Discharge in Cumecs
4
6
8
10
12
14
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

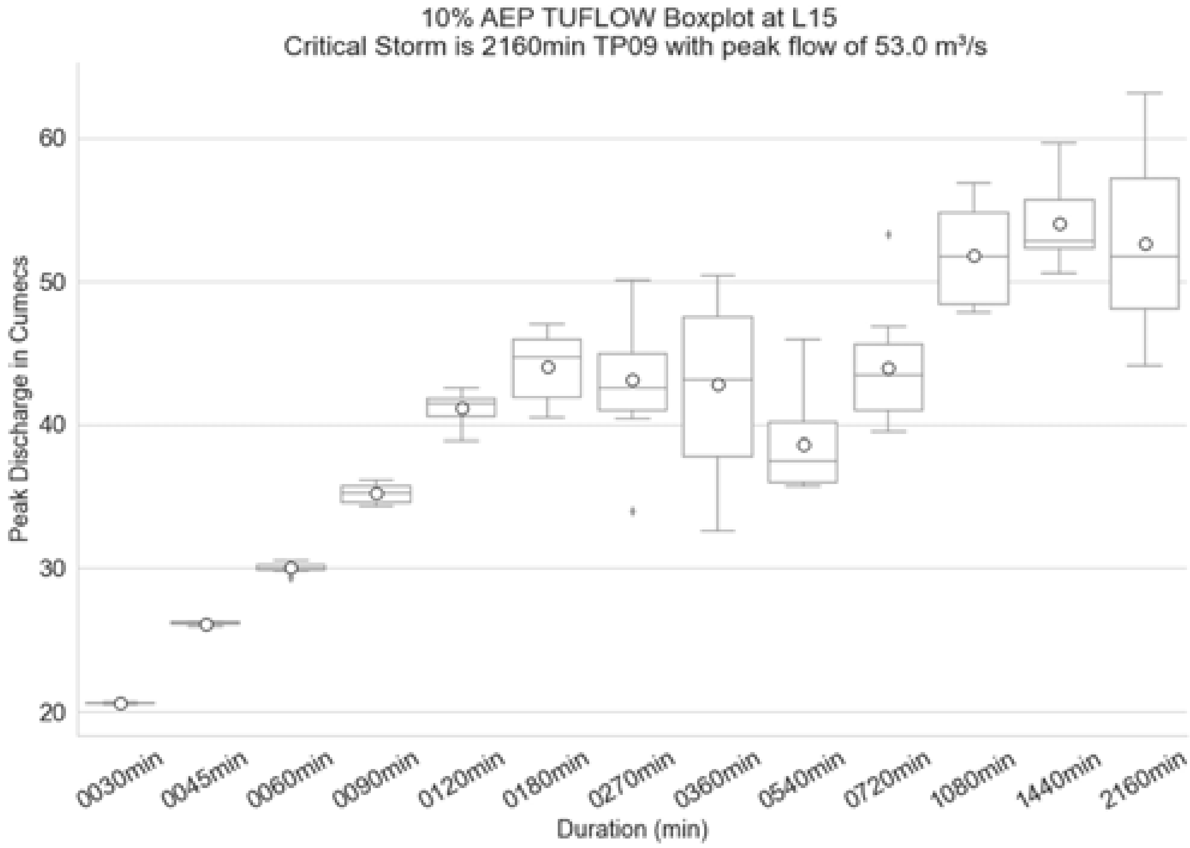

50% AEP TUFLOW Boxplot at L32
Critical Storm is 0180min TP09 with peak flow of 18.4 m³/s
Peak Discharge in Cumecs
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

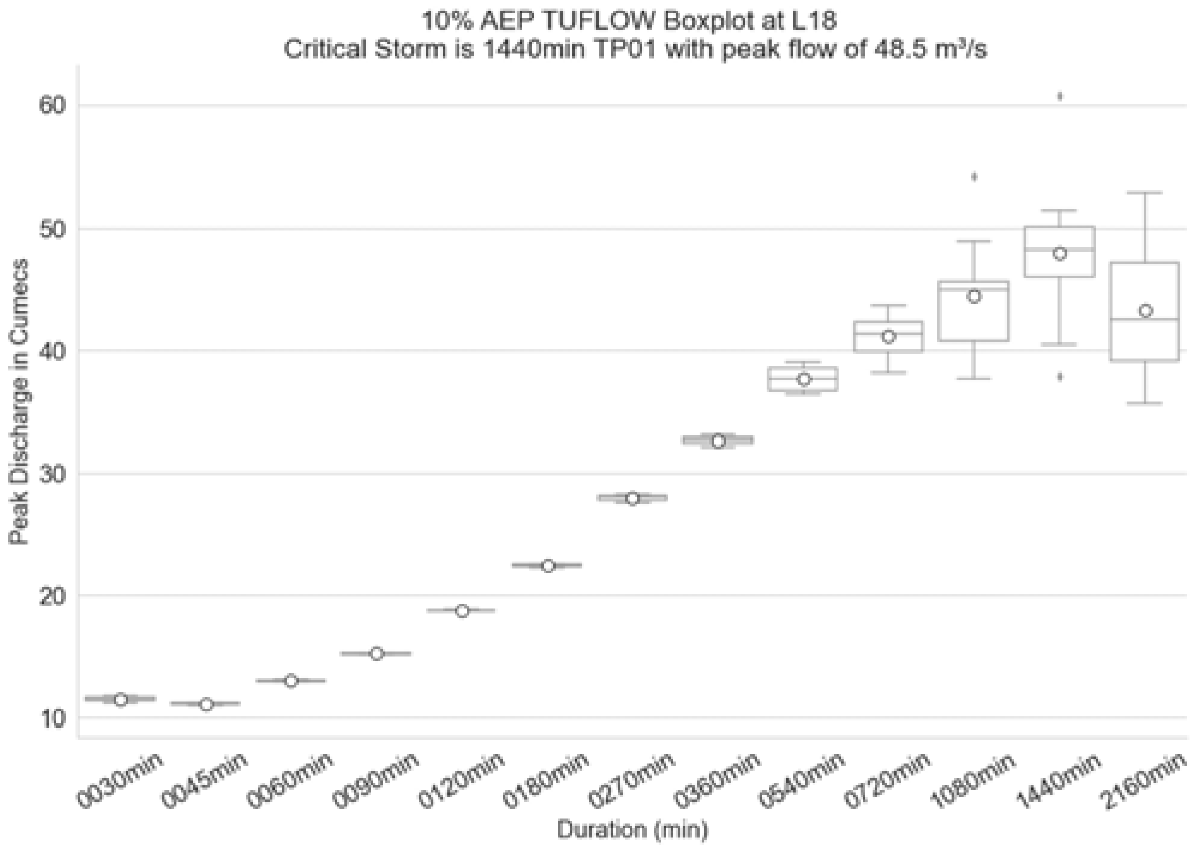

50% AEP TUFLOW Boxplot at L36
Critical Storm is 1440min TP06 with peak flow of 20.4 m³/s
Peak Discharge in Cumecs
25
20
15
10
5
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

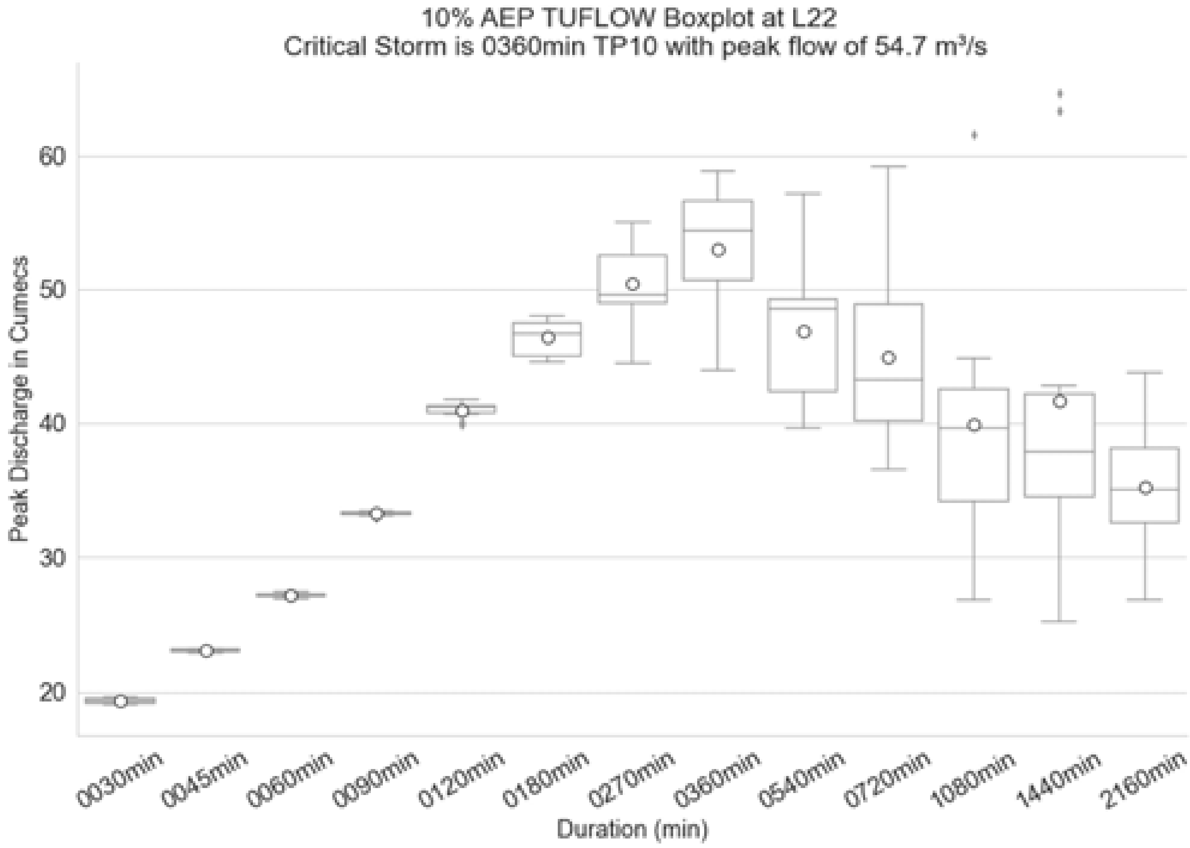

50% AEP TUFLOW Boxplot at L40
Critical Storm is 0270min TP06 with peak flow of 13.6 m³/s
Peak Discharge in Cumecs
Duration (min)
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min


50% AEP TUFLOW Boxplot at ChambAlertL
Critical Storm is 1440min TP06 with peak flow of 19.8 m³/s
Peak Discharge in Cumecs
Duration (min)
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min

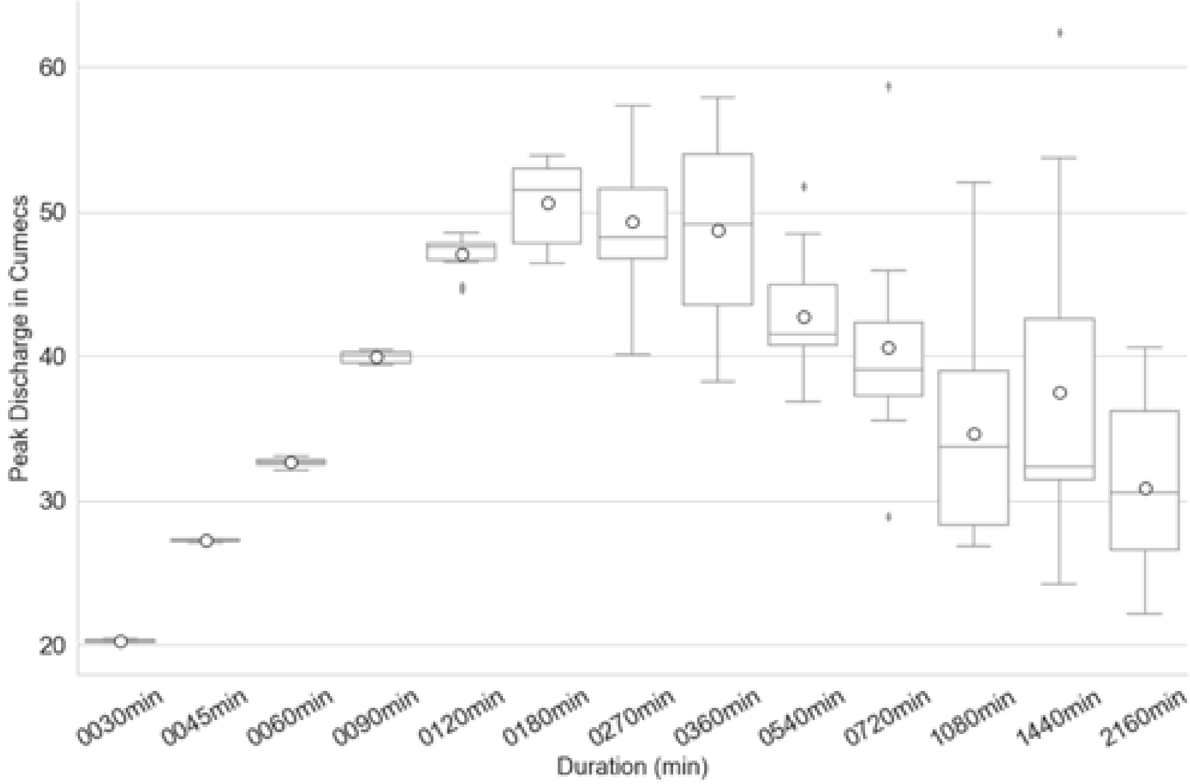

10% AEP TUFLOW Boxplot at L7
Critical Storm is 1440min TP03 with peak flow of 48.9 m³/s
Peak Discharge in Cumecs
60
50
40
30
20
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)


10% AEP TUFLOW Boxplot at L15
Critical Storm is 2160min TP09 with peak flow of 53.0 m³/s
Peak Discharge in Cumecs
60
50
40
30
20
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

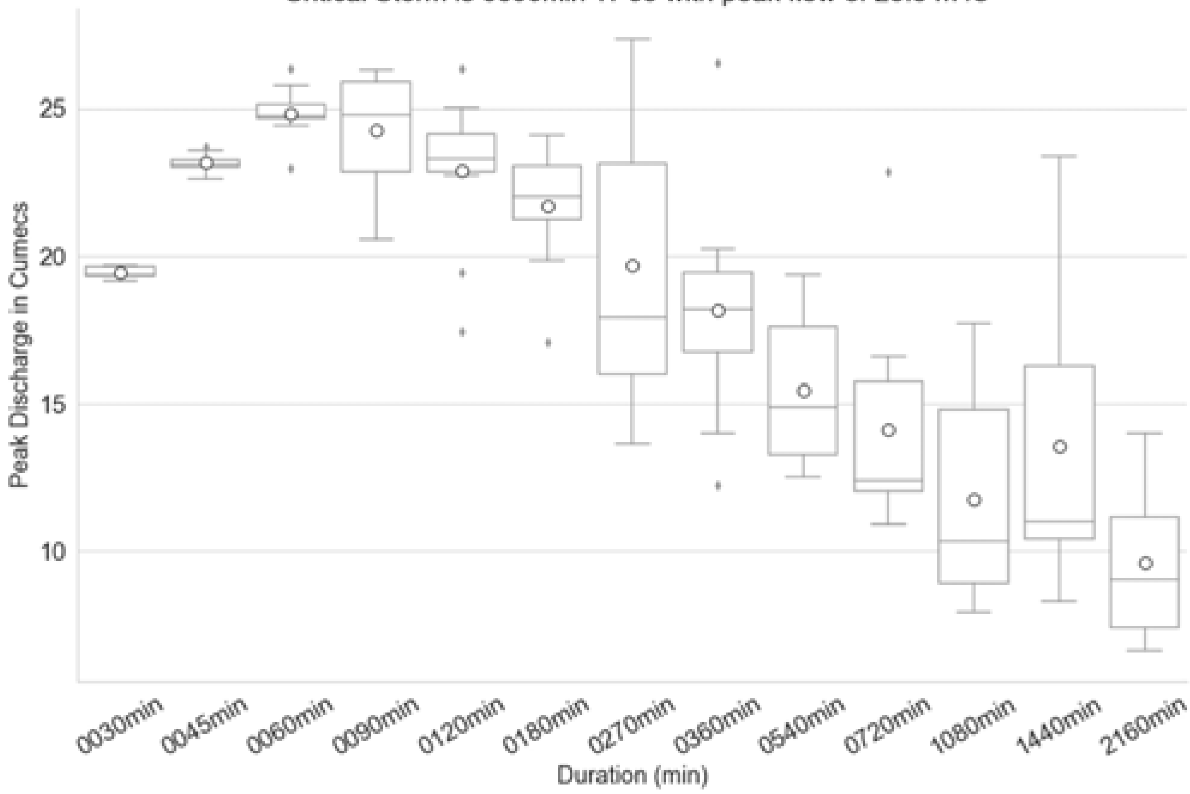

10% AEP TUFLOW Boxplot at L18
Critical Storm is 1440min TP01 with peak flow of 48.5 m³/s
Peak Discharge in Cumecs
60
50
40
30
20
10
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

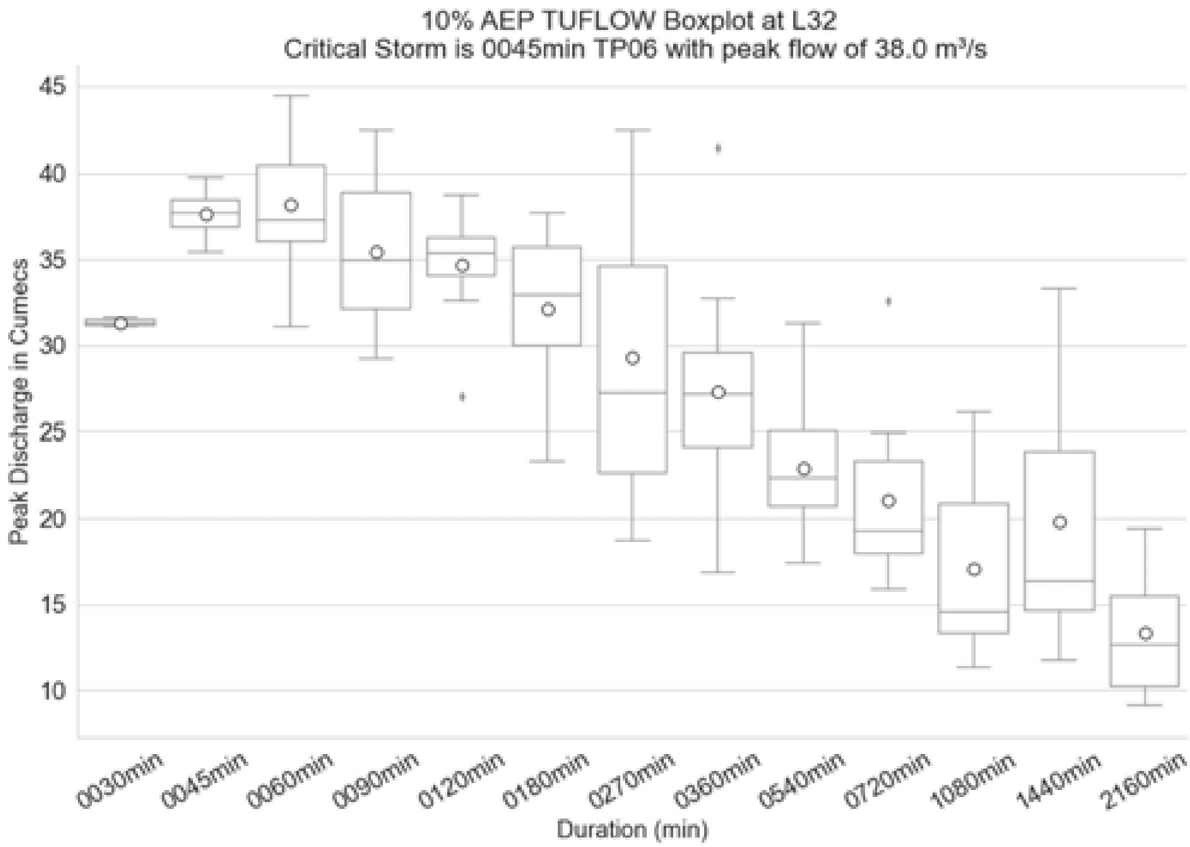

10% AEP TUFLOW Boxplot at L22
Critical Storm is 0360min TP10 with peak flow of 54.7 m³/s
Peak Discharge in Cumecs
60
50
40
30
20
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

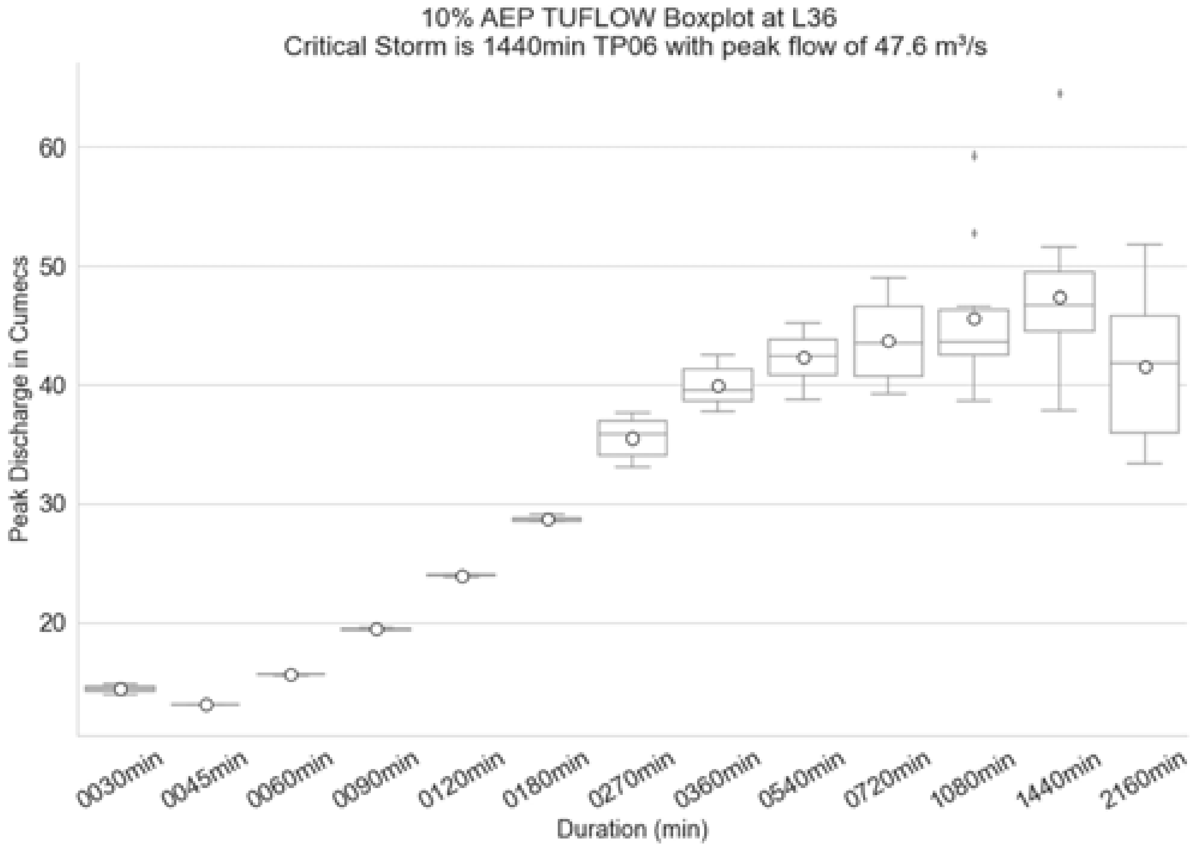
10% AEP TUFLOW Boxplot at L27
Critical Storm is 0180min TP04 with peak flow of 51.7 m³/s

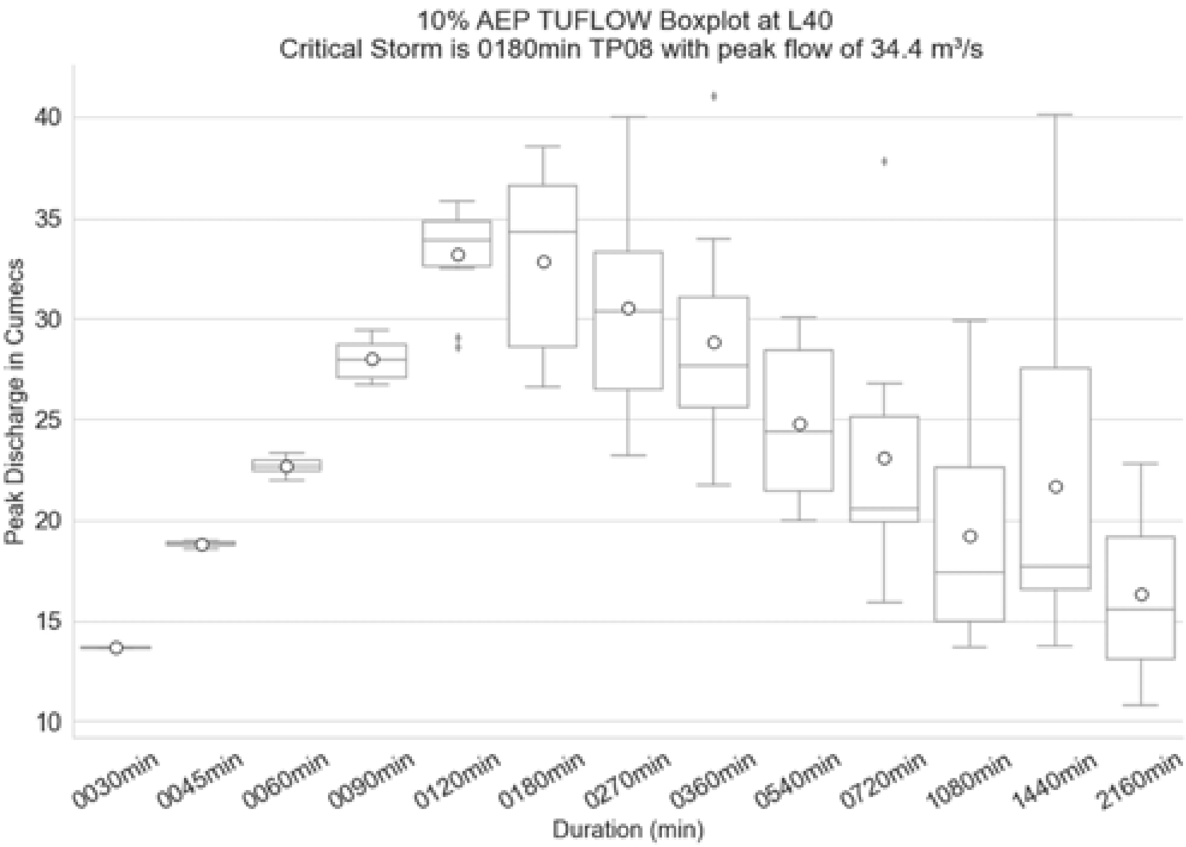


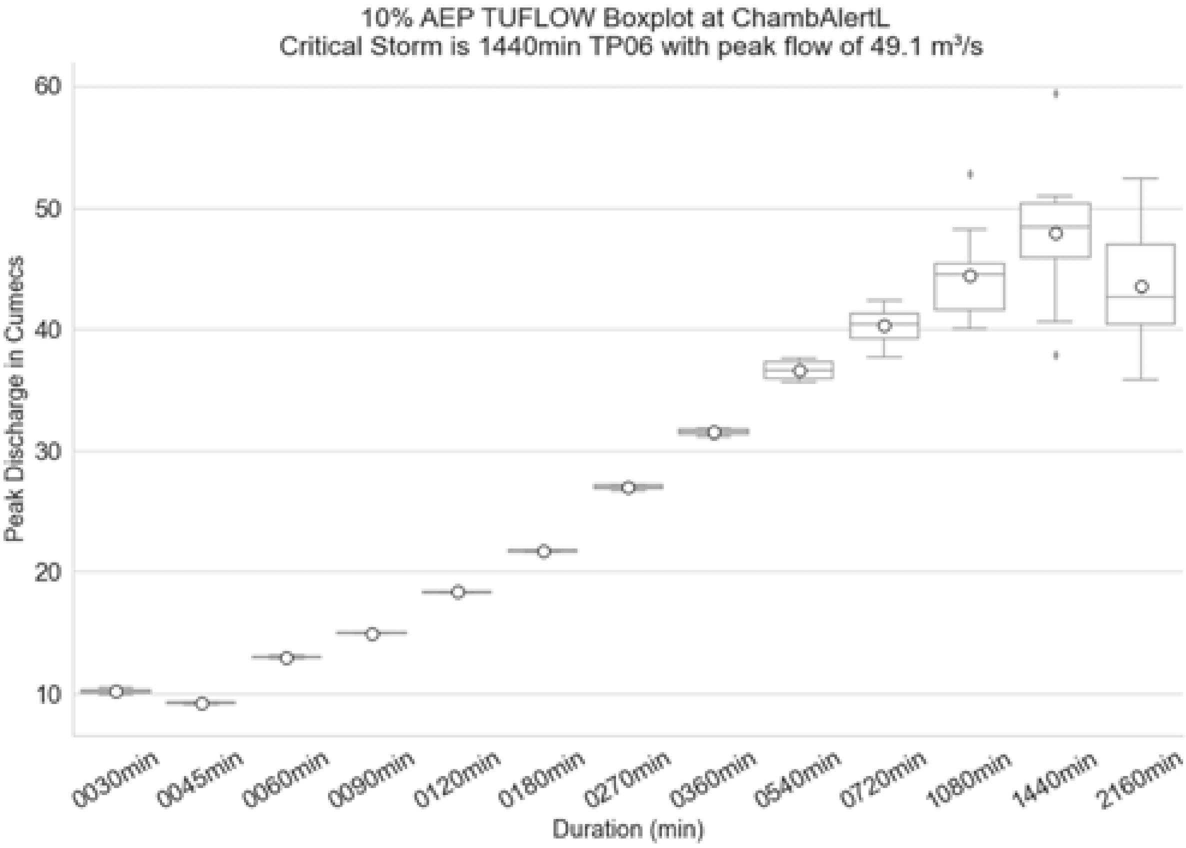
10% AEP TUFLOW Boxplot at L29
Critical Storm is 0090min TP09 with peak flow of 25.5 m³/s



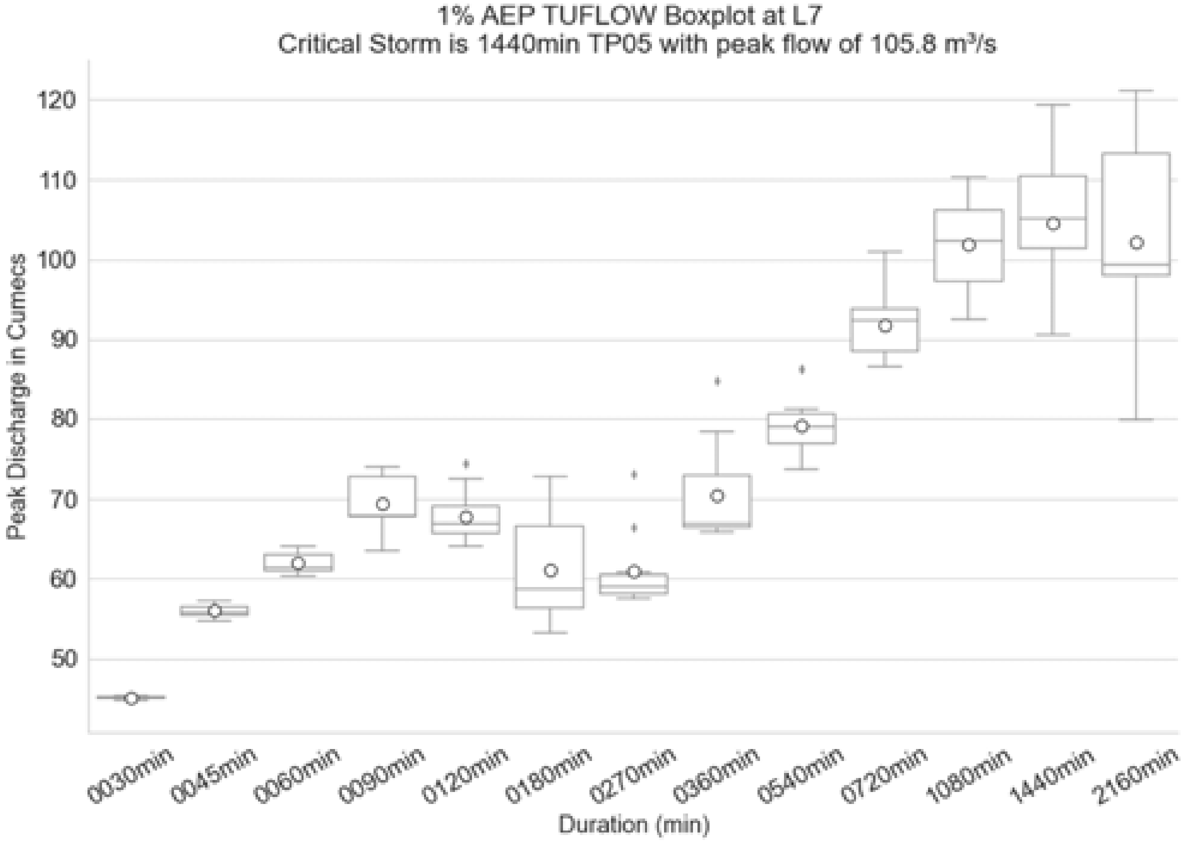

10% AEP TUFLOW Boxplot at L32
Critical Storm is 0045min TP06 with peak flow of 38.0 m³/s
Peak Discharge in Cumecs
10
15
20
25
30
35
40
45
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)

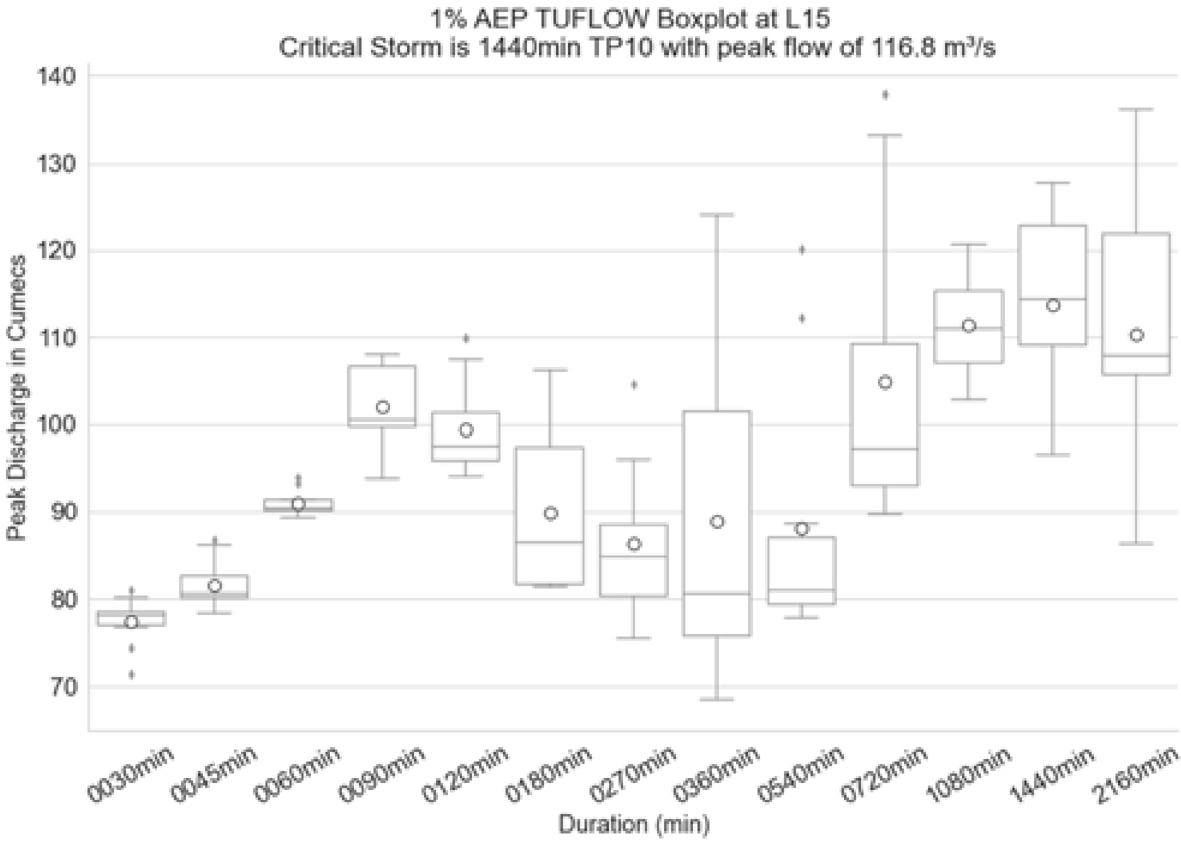

10% AEP TUFLOW Boxplot at L36
Critical Storm is 1440min TP06 with peak flow of 47.6 m³/s
Peak Discharge in Cumecs
20
30
40
50
60
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)





22020077_R01_V01c_ChambersCreek.docx





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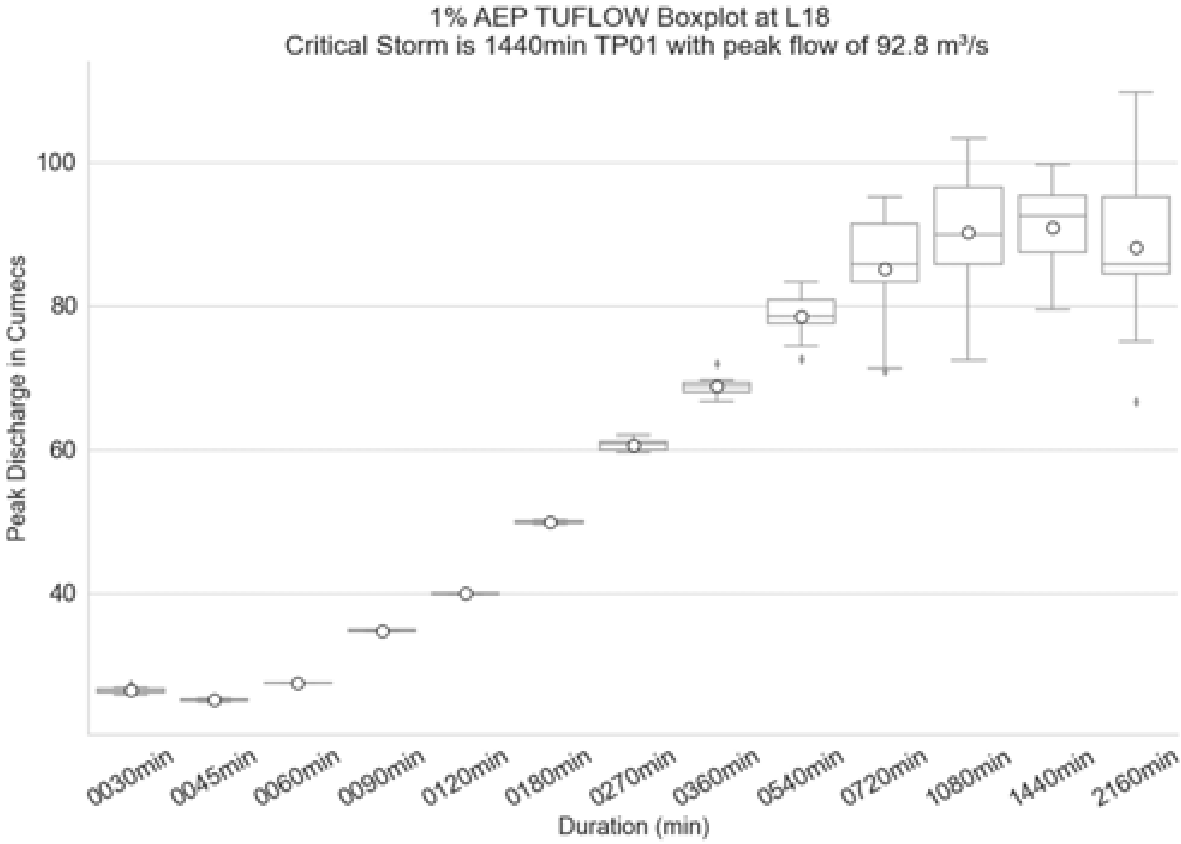
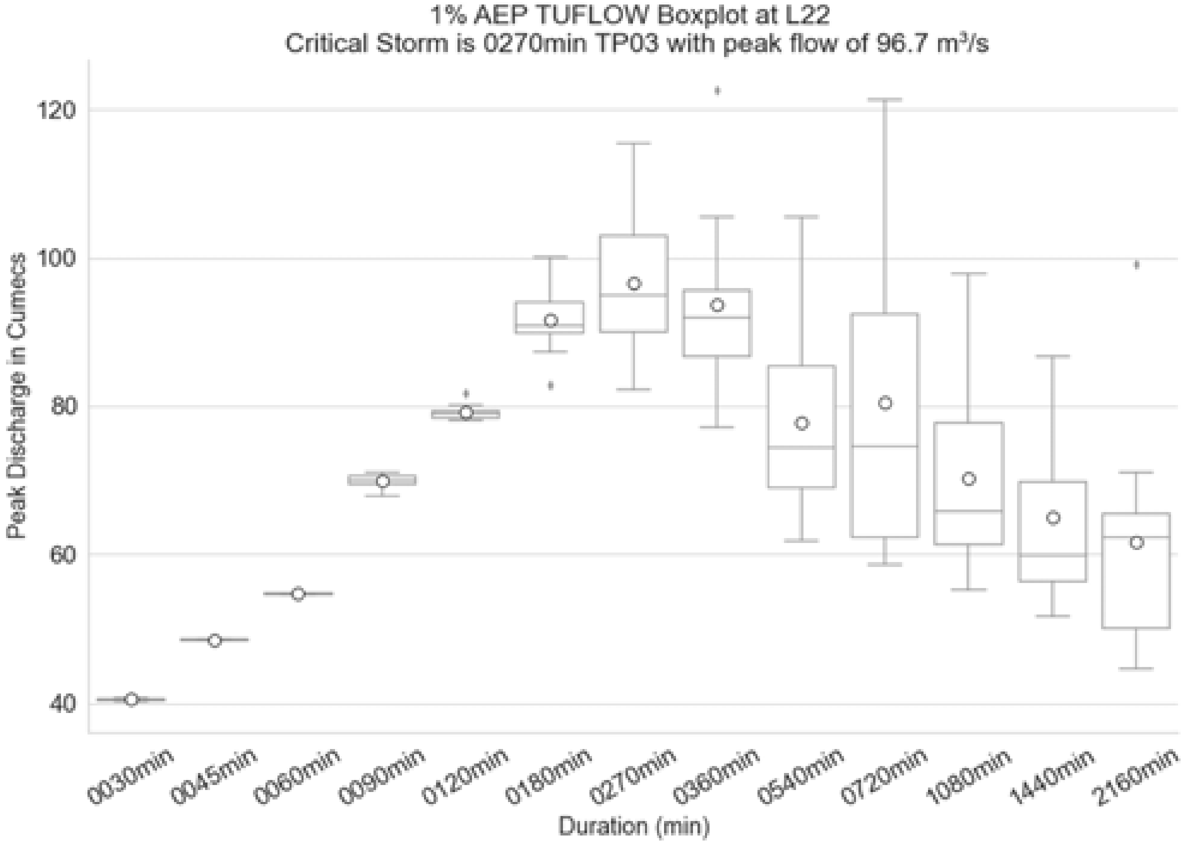
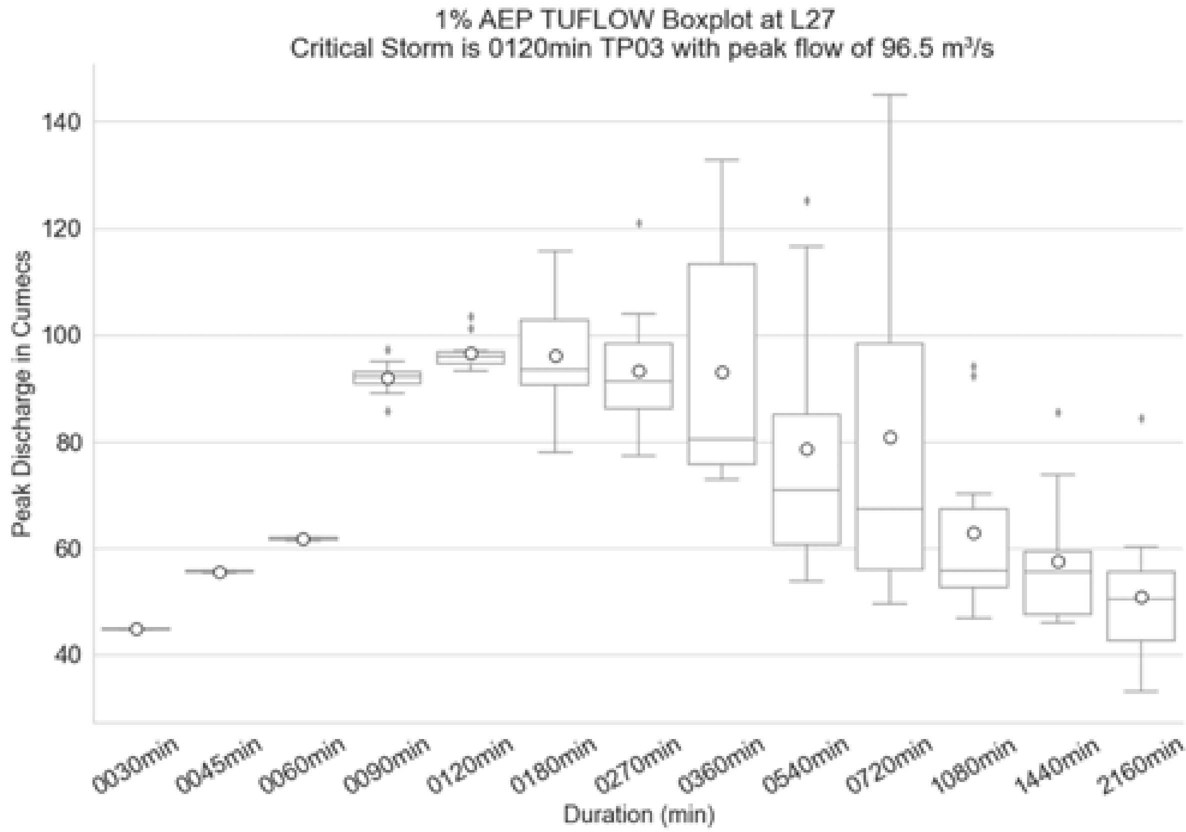
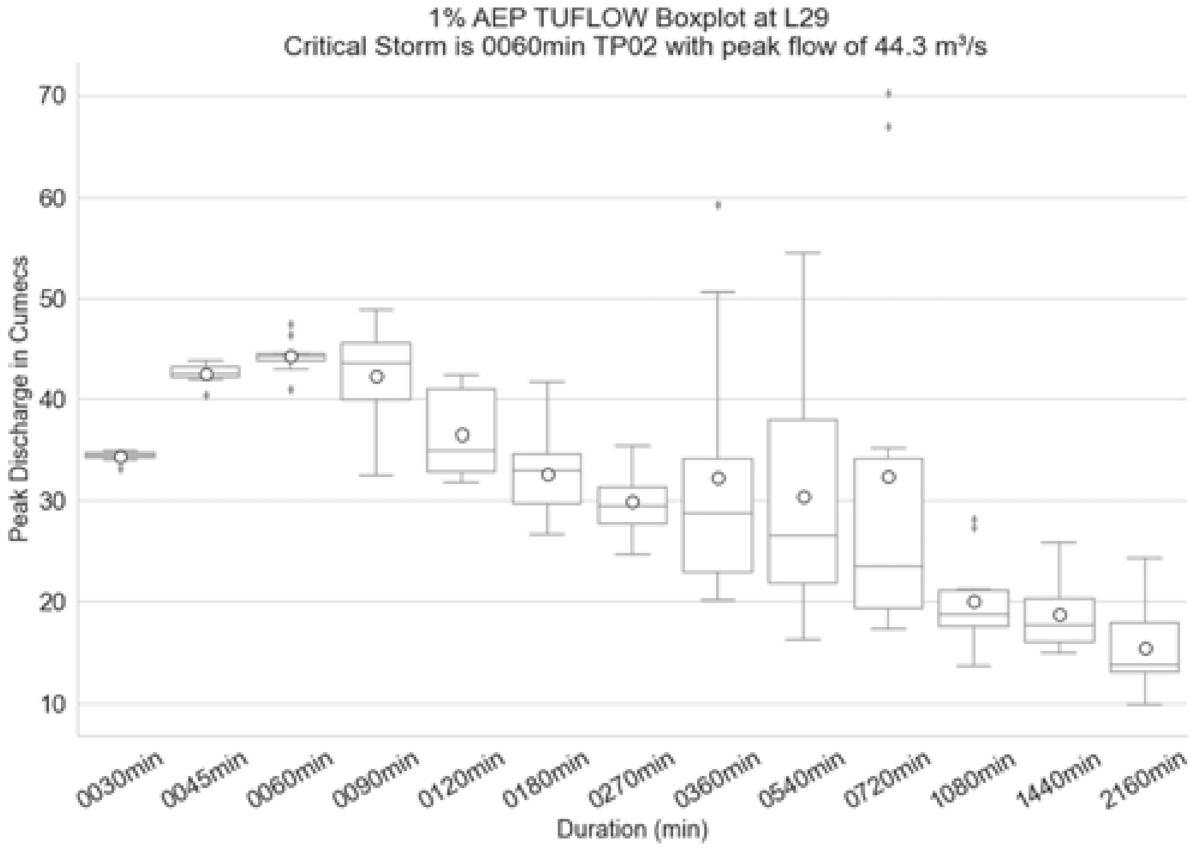
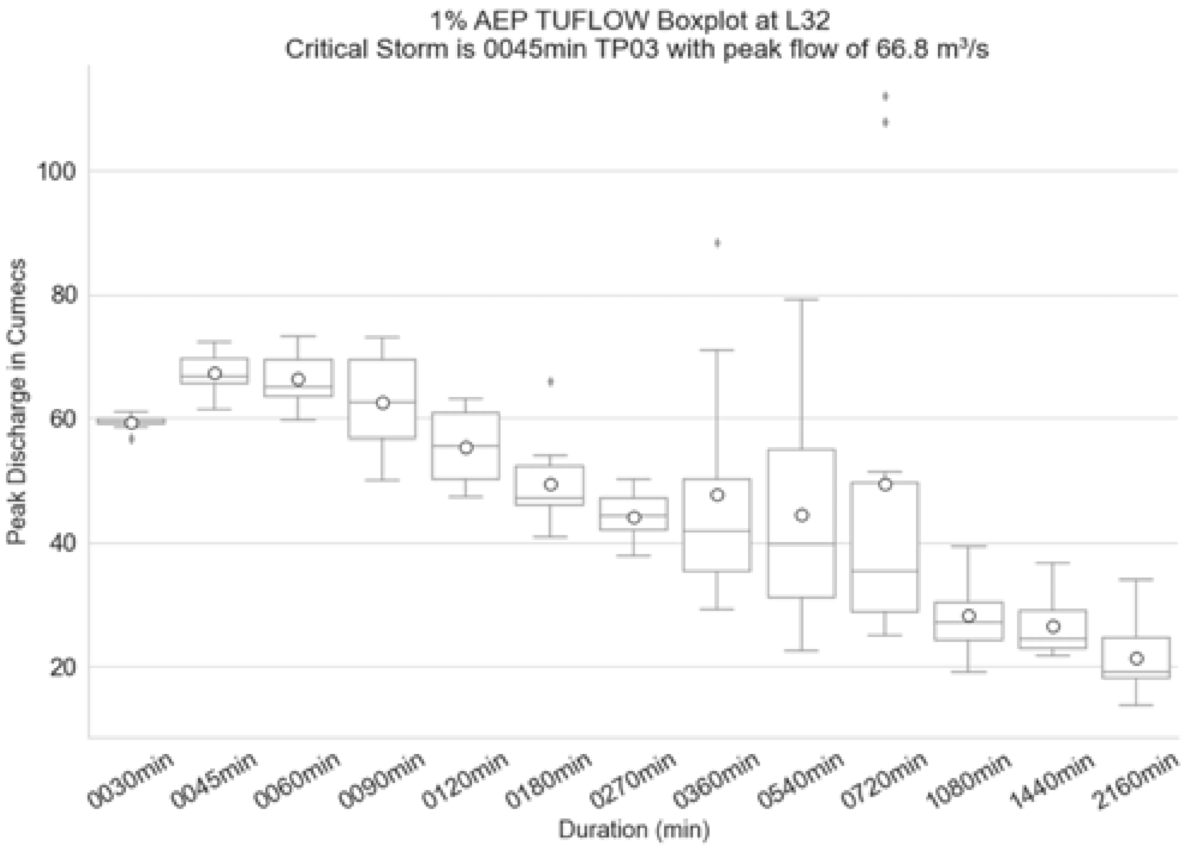
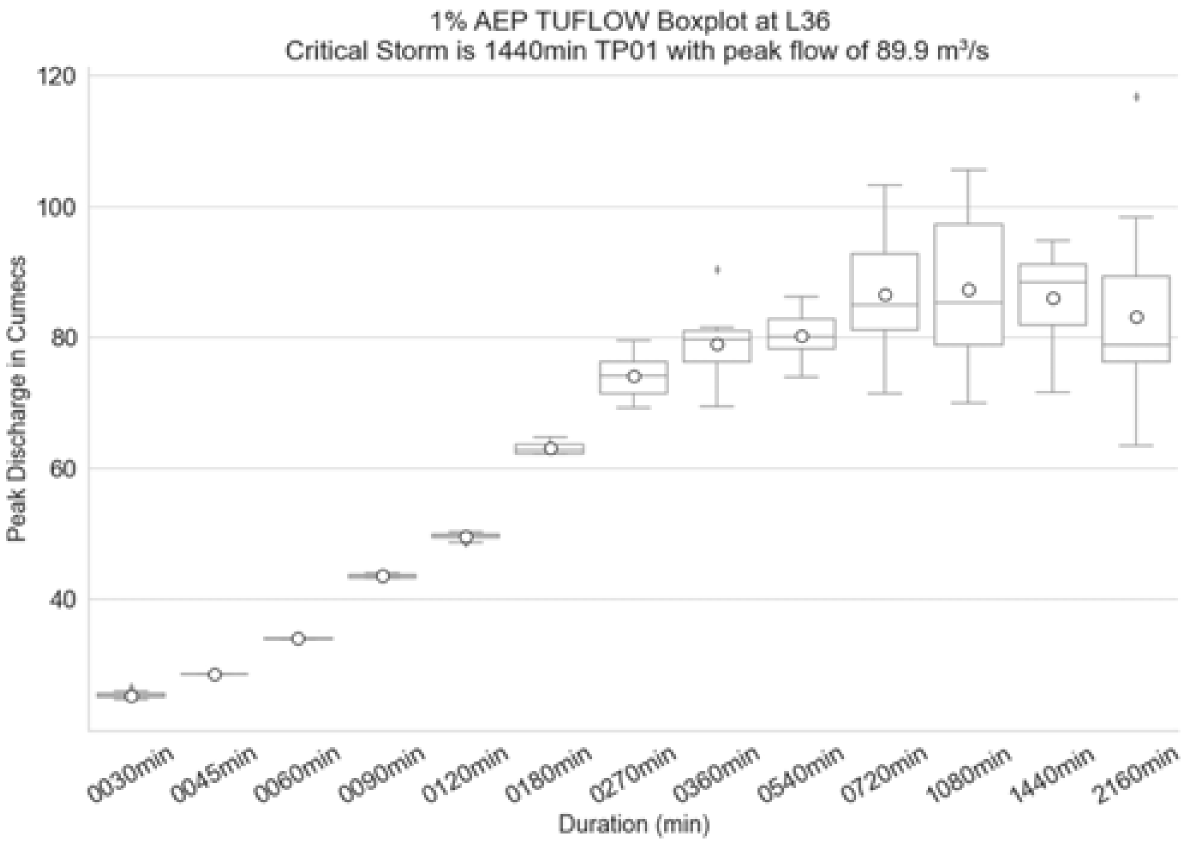

1% AEP TUFLOW Boxplot at L18
Critical Storm is 1440min TP01 with peak flow of 92.8 m³/s
Peak Discharge in Cumecs
100
80
60
40
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)


1% AEP TUFLOW Boxplot at L22
Critical Storm is 0270min TP03 with peak flow of 96.7 m³/s
Peak Discharge in Cumecs
120
100
80
60
40
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)


1% AEP TUFLOW Boxplot at L27
Critical Storm is 0120min TP03 with peak flow of 96.5 m³/s
Peak Discharge in Cumecs
140
120
100
80
60
40
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)


1% AEP TUFLOW Boxplot at L29
Critical Storm is 0060min TP02 with peak flow of 44.3 m³/s
Peak Discharge in Cumecs
70
60
50
40
30
20
10
0030min
0045min
0060min
0090min
0120min
0180min
0270min
0360min
0540min
0720min
1080min
1440min
2160min
Duration (min)





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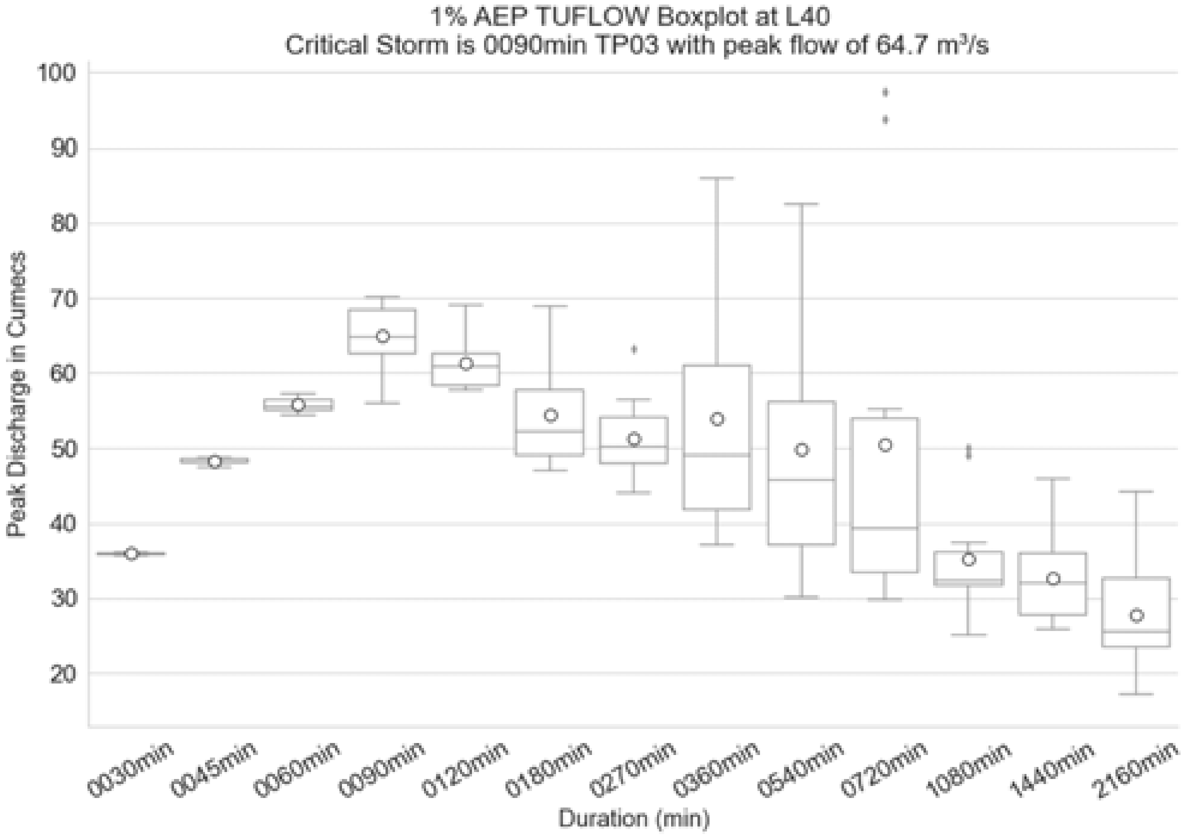
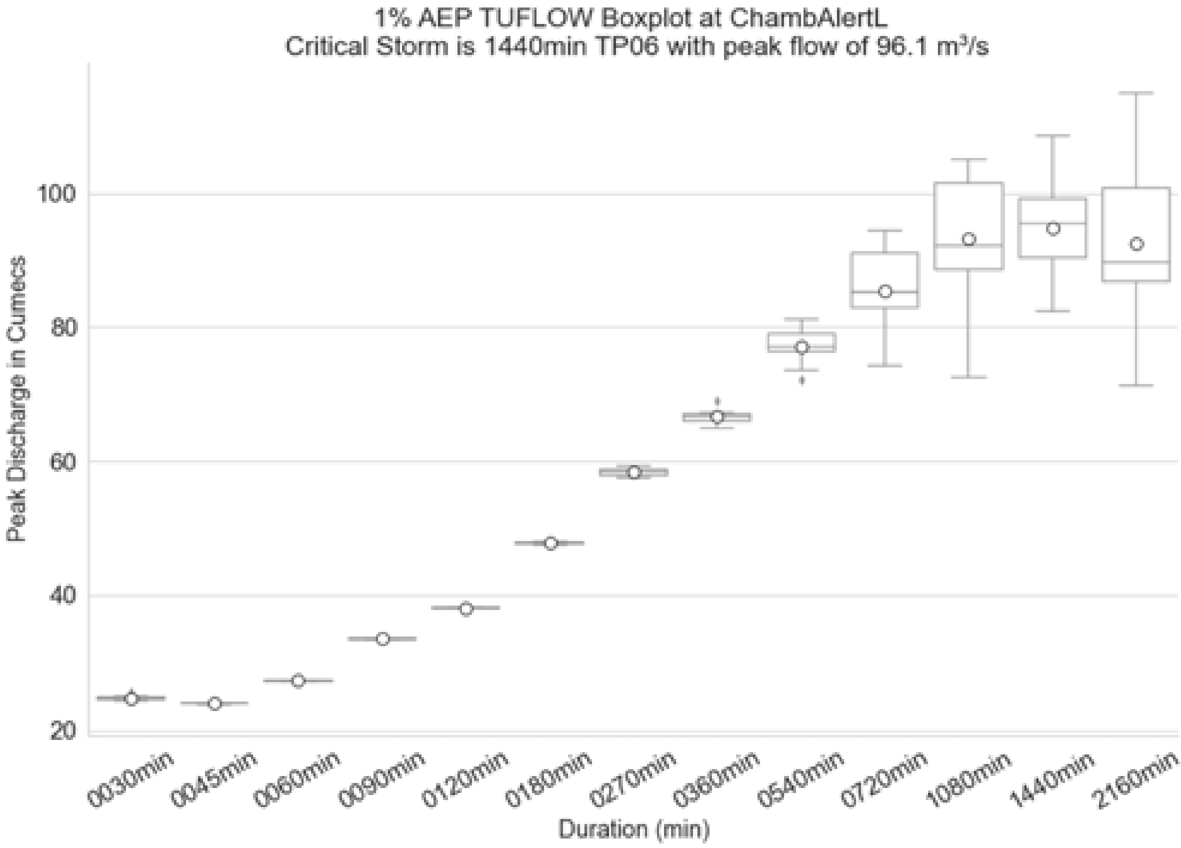
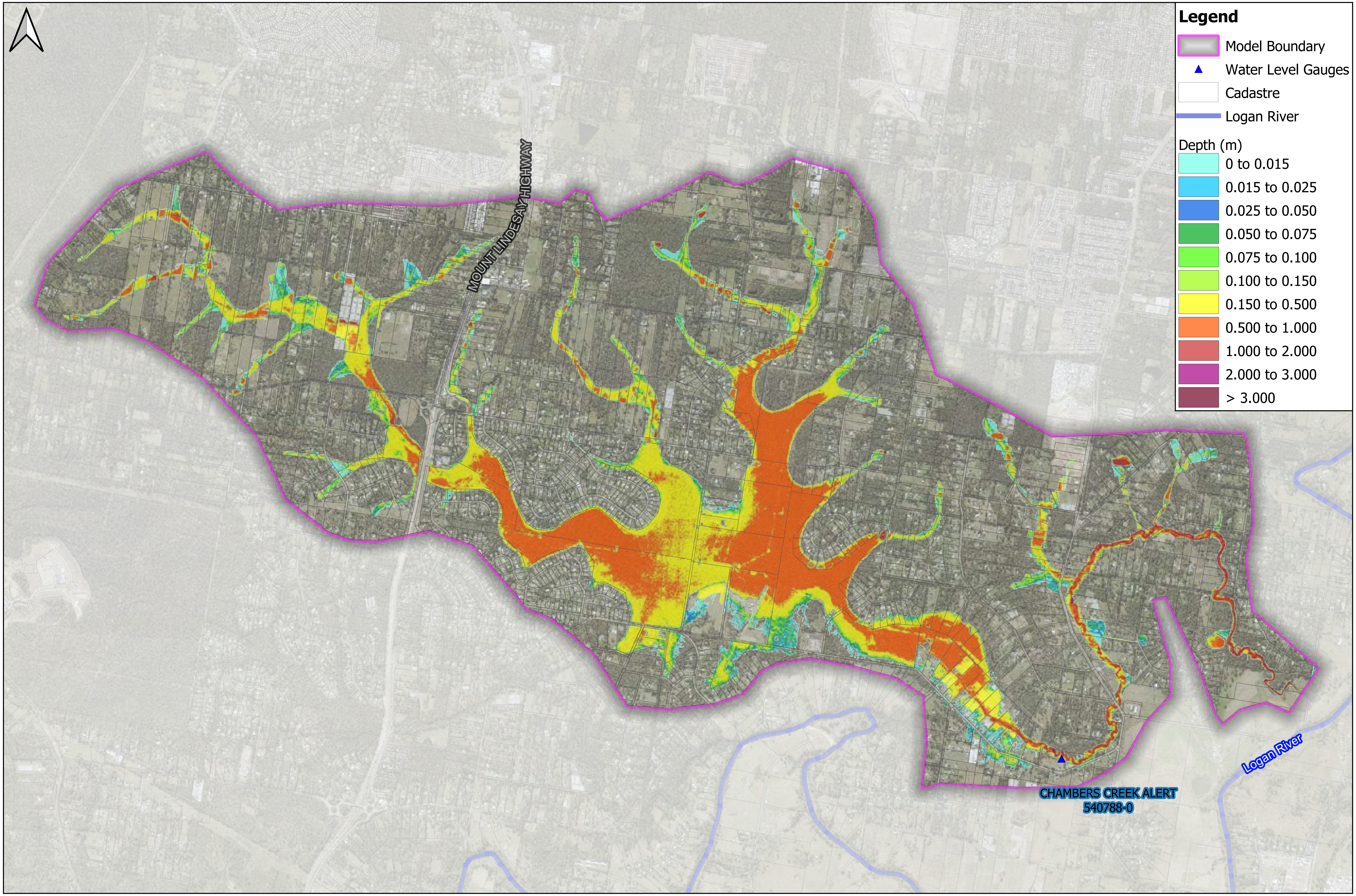




22020077_R01_V01c_ChambersCreek.docx

APPENDIX D
GIS MAPPING



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

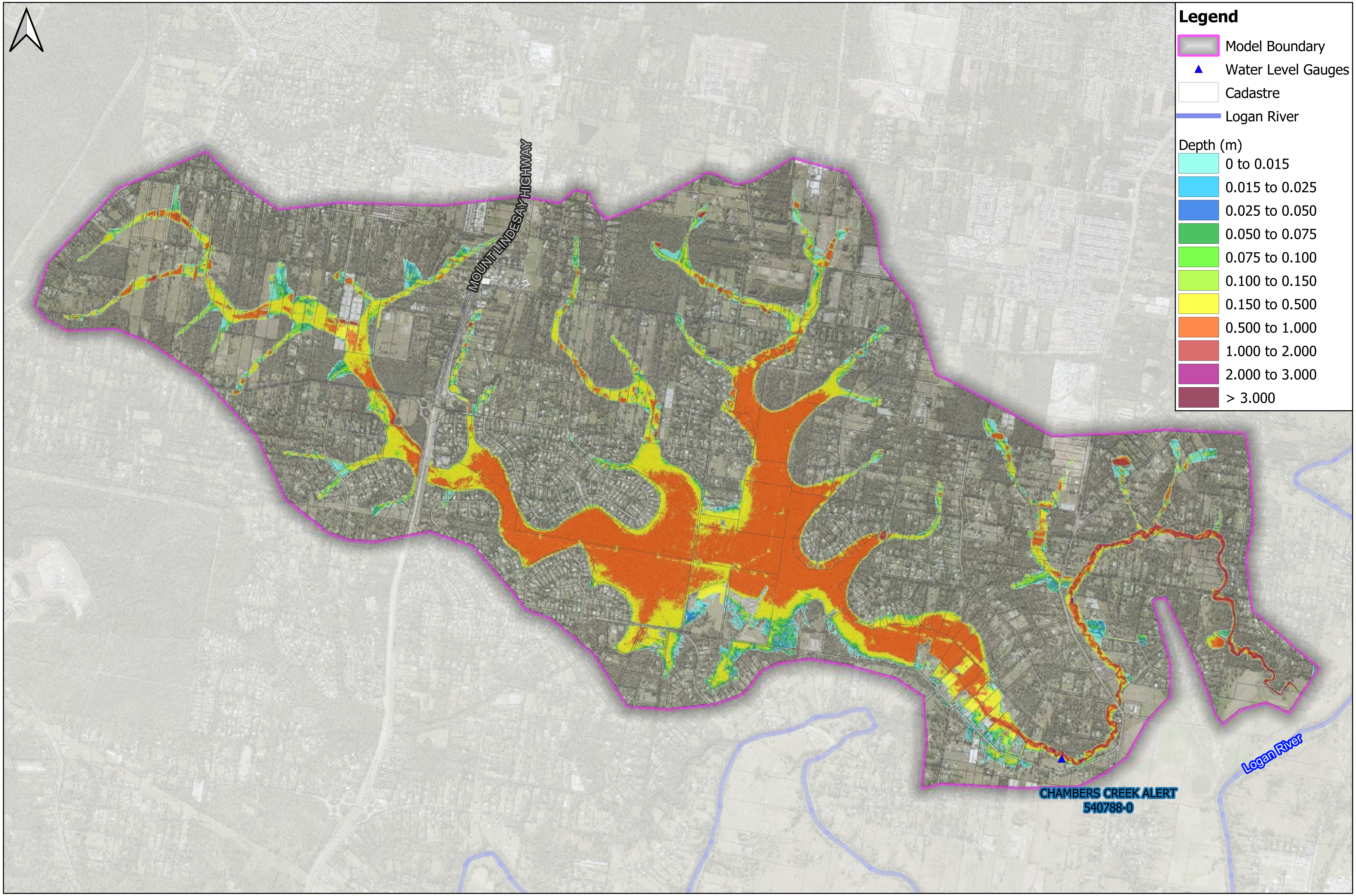
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

50% AEP Peak Water Depth

WATER TECHNOLOGY

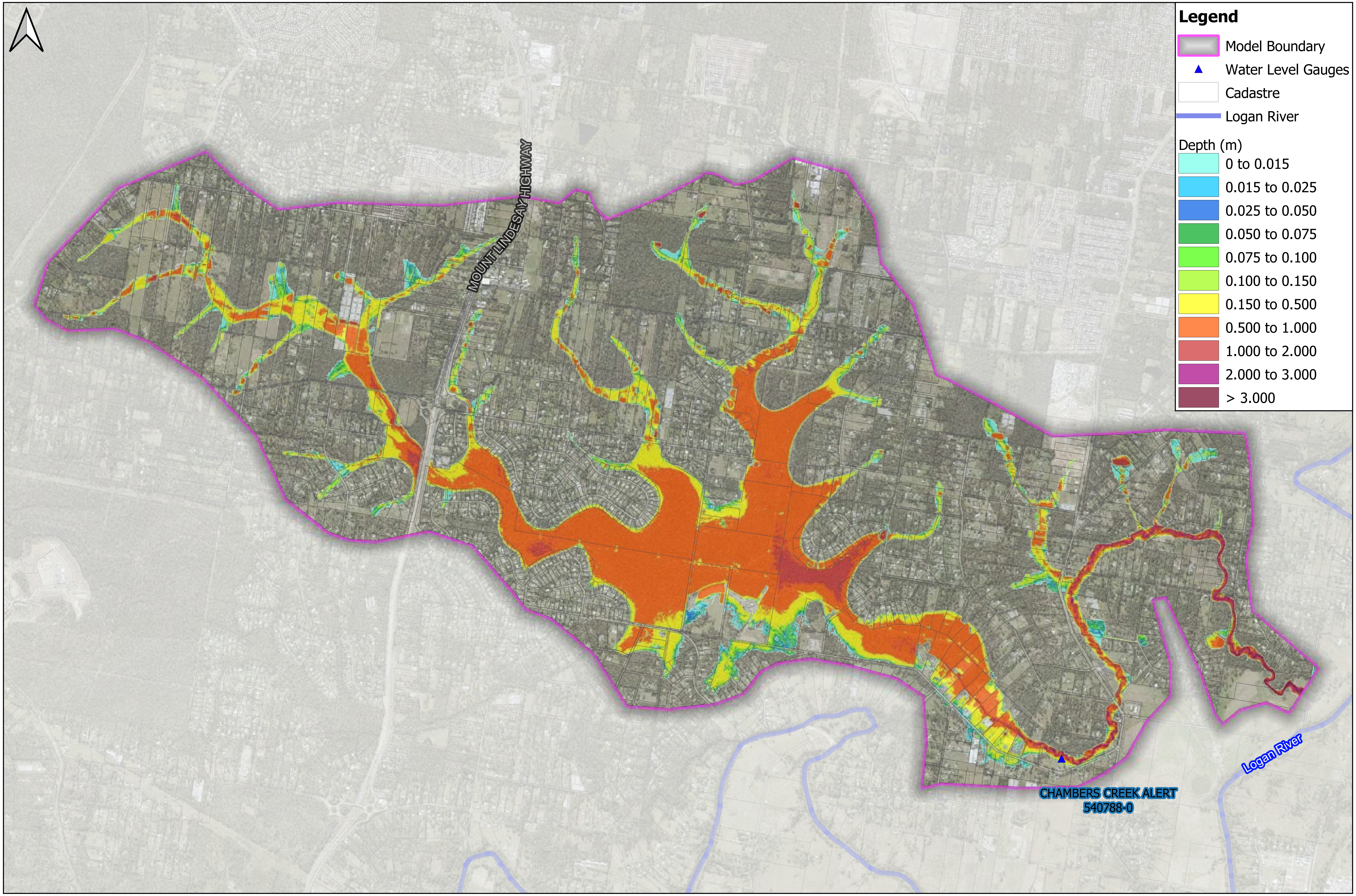


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

50% AEP CC (RCP4.5) Peak Water Depth



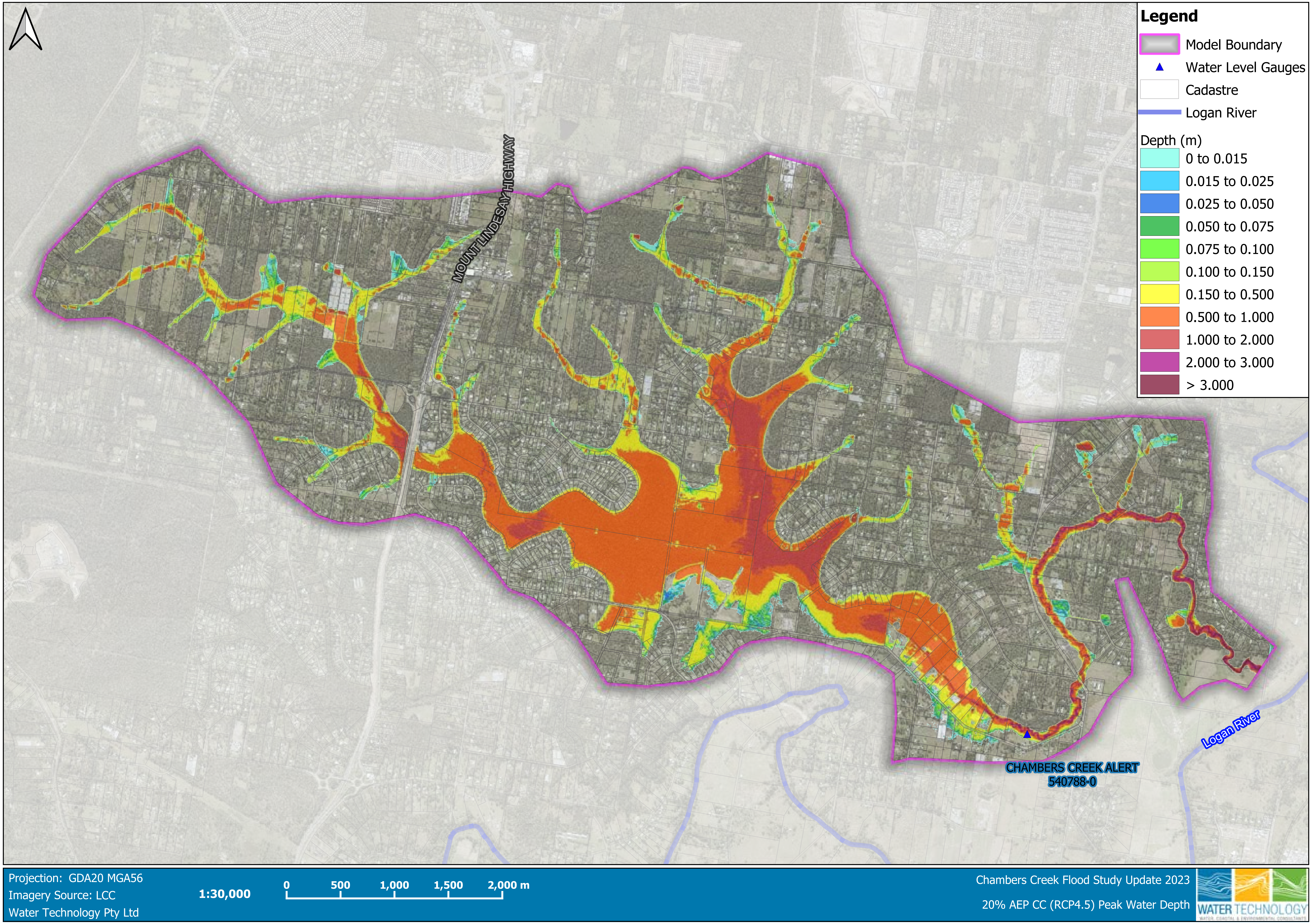
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

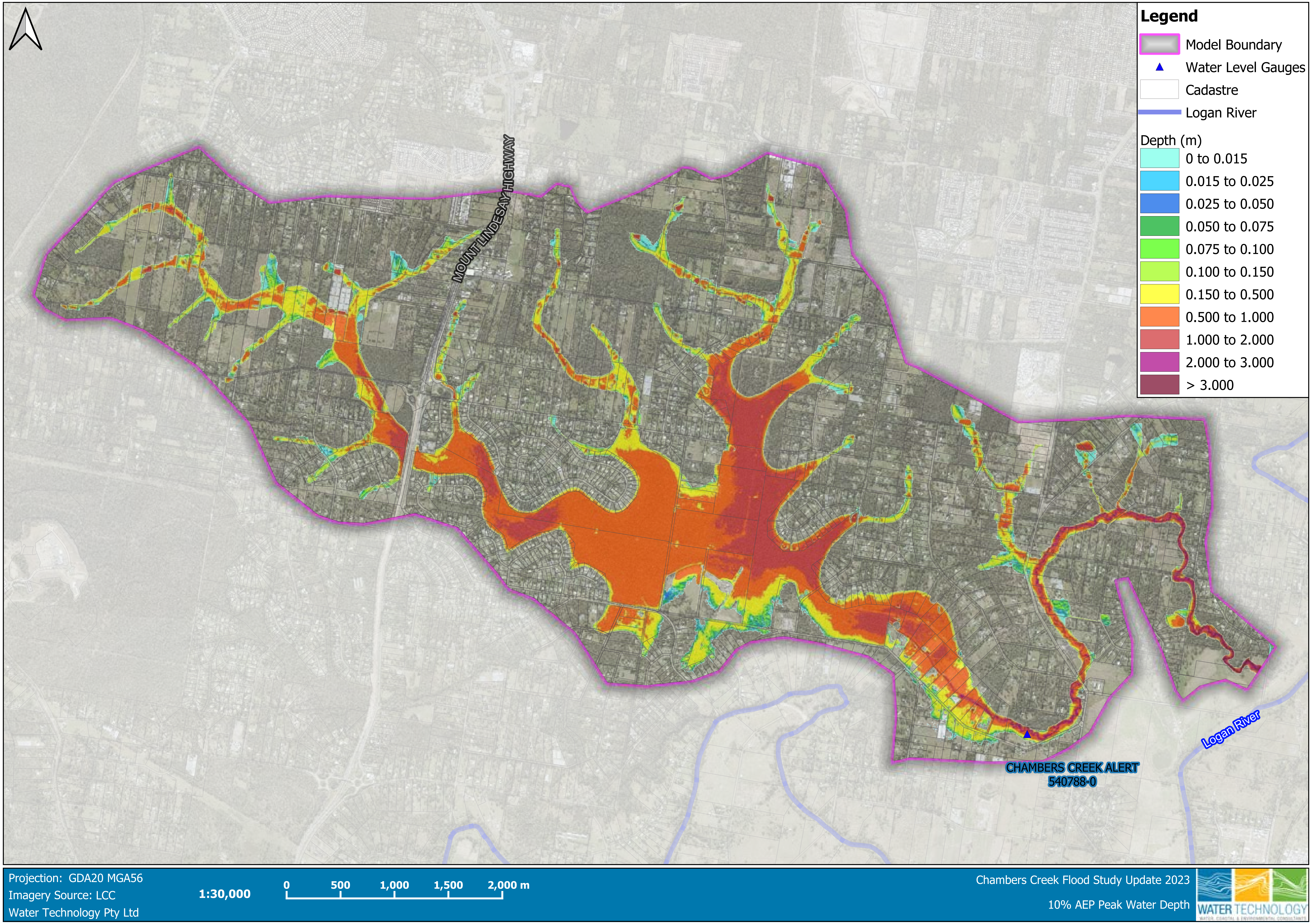
Chambers Creek Flood Study Update 2023

20% AEP Peak Water Depth

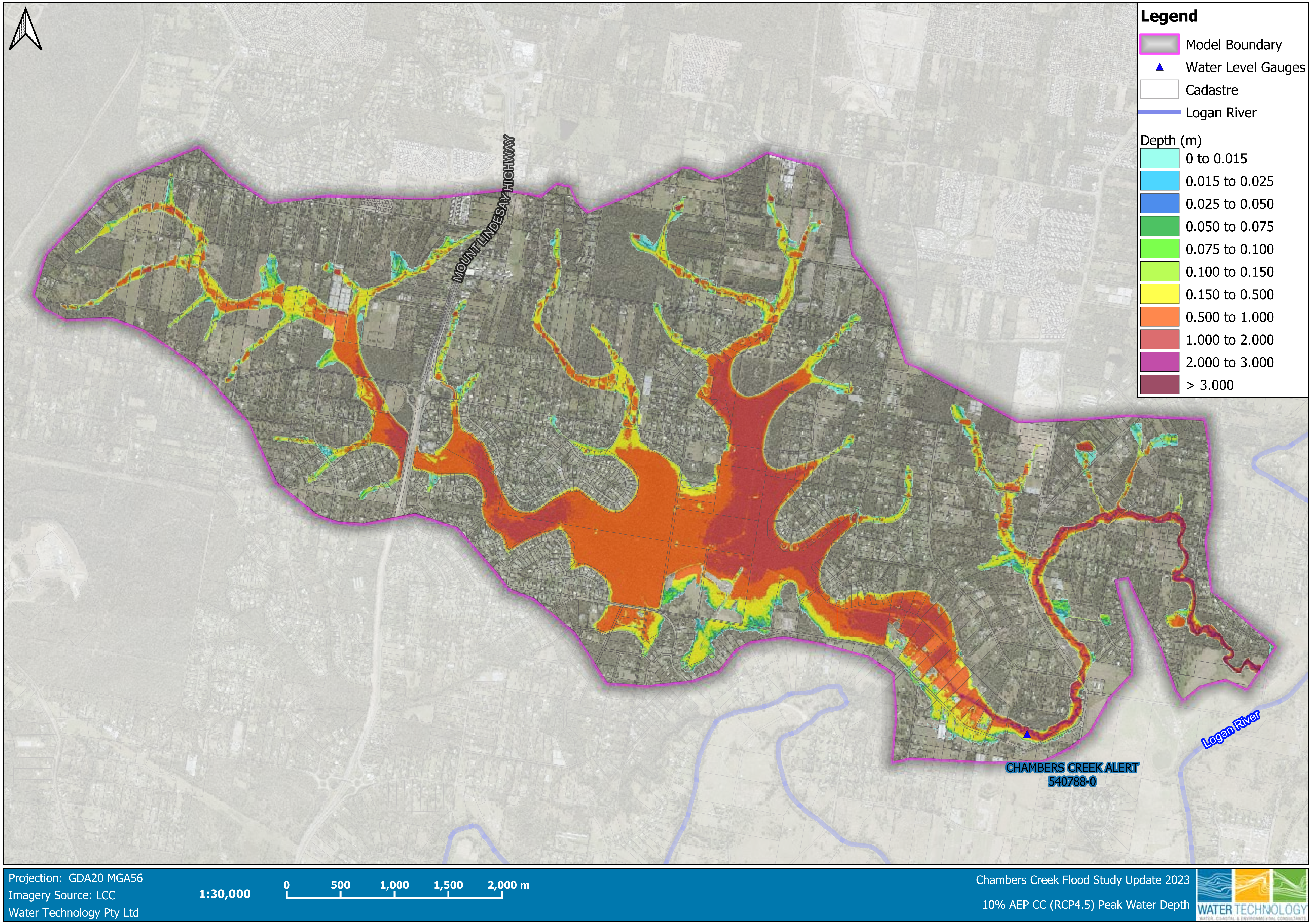
WATER TECHNOLOGY

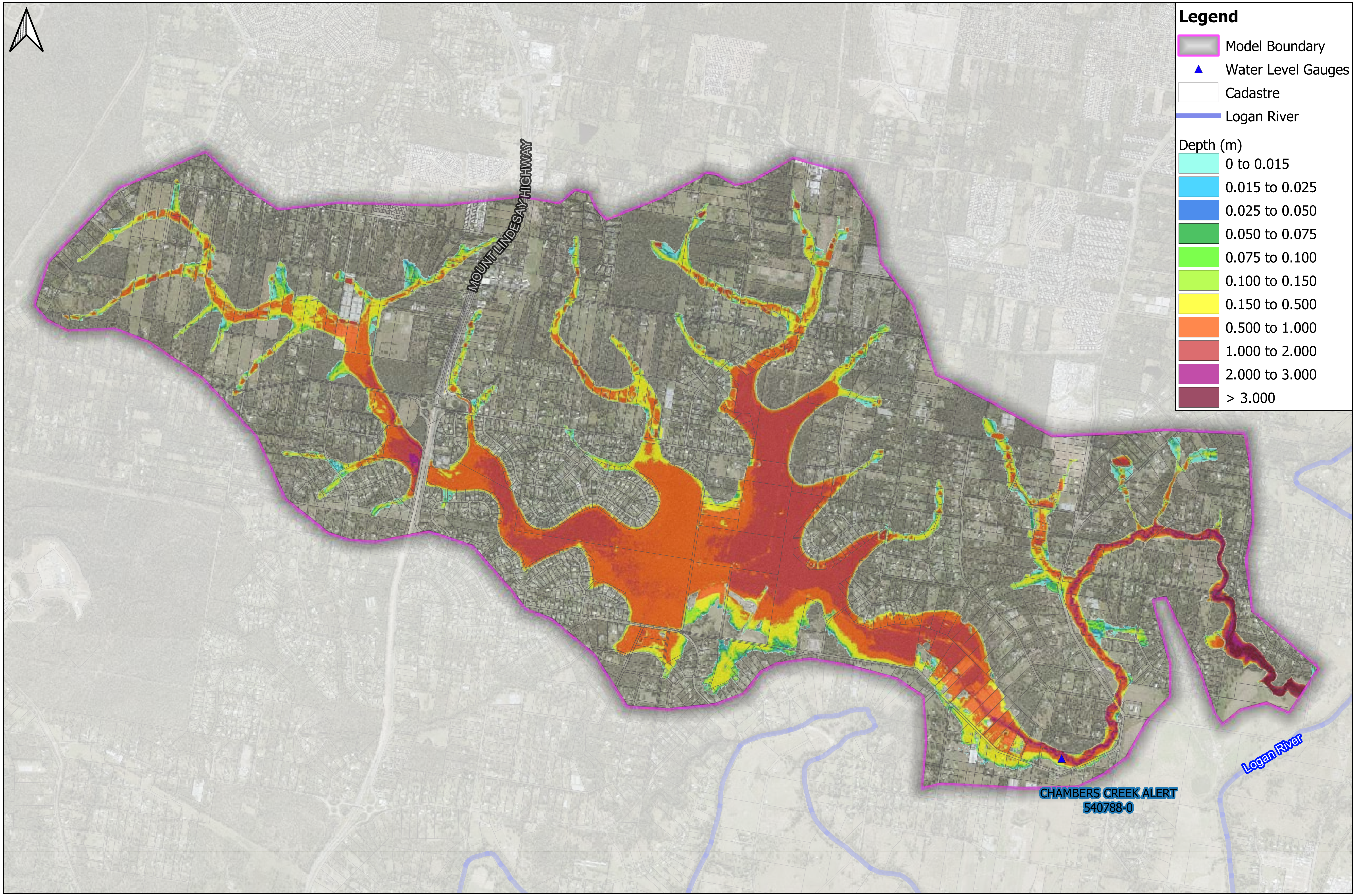


MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Depth (m)
0 to 0.015
0.015 to 0.025
0.025 to 0.050
0.050 to 0.075
0.075 to 0.100
0.100 to 0.150
0.150 to 0.500
0.500 to 1.000
1.000 to 2.000
2.000 to 3.000
> 3.000
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
20% AEP CC (RCP4.5) Peak Water Depth
WATER TECHNOLOGY



Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Depth (m)
0 to 0.015
0.015 to 0.025
0.025 to 0.050
0.050 to 0.075
0.075 to 0.100
0.100 to 0.150
0.150 to 0.500
0.500 to 1.000
1.000 to 2.000
2.000 to 3.000
> 3.000
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
10% AEP Peak Water Depth
WATER TECHNOLOGY


MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Depth (m)
0 to 0.015
0.015 to 0.025
0.025 to 0.050
0.050 to 0.075
0.075 to 0.100
0.100 to 0.150
0.150 to 0.500
0.500 to 1.000
1.000 to 2.000
2.000 to 3.000
> 3.000
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
10% AEP CC (RCP4.5) Peak Water Depth
WATER TECHNOLOGY



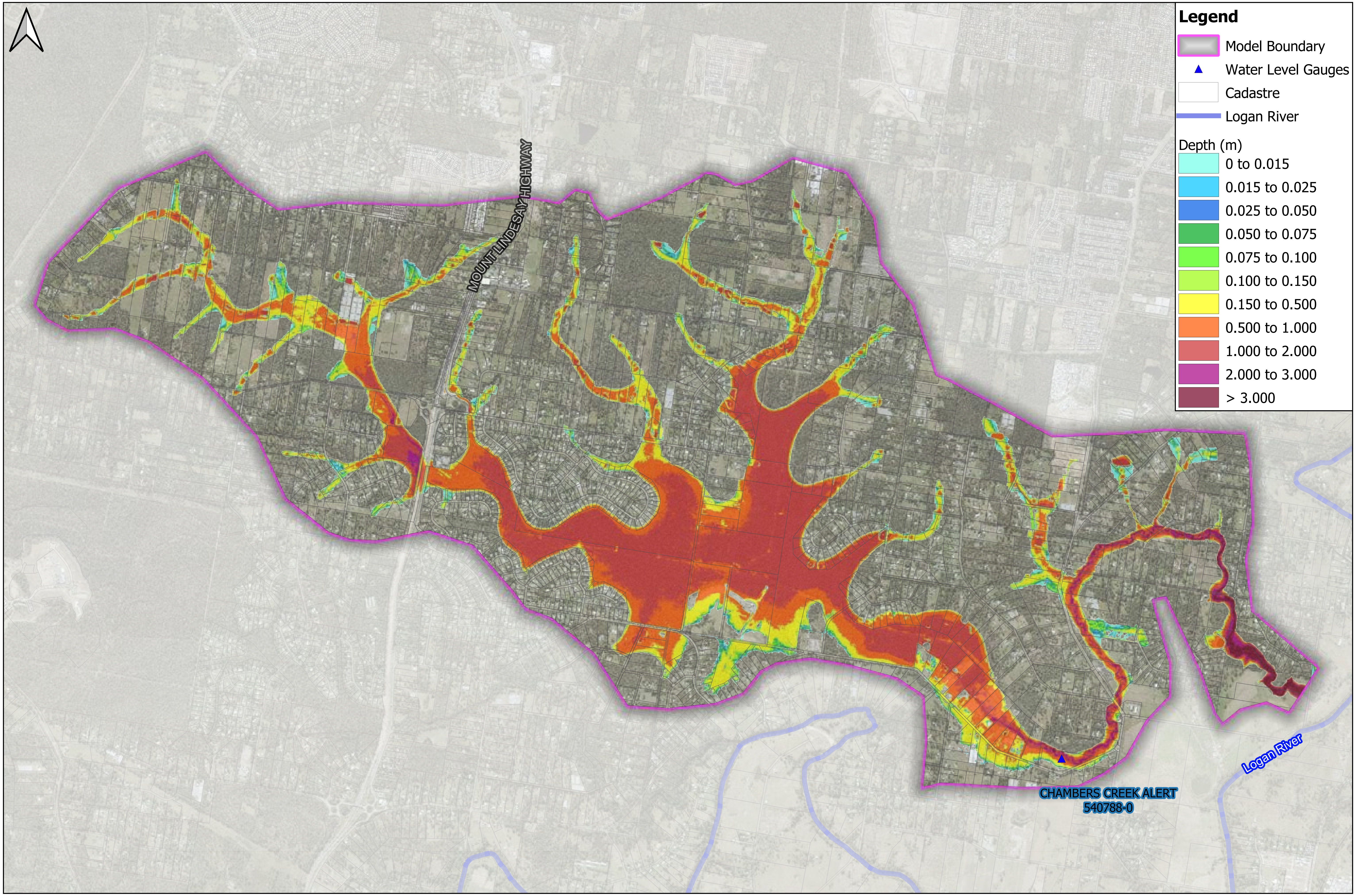
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

5% AEP Peak Water Depth

WATER TECHNOLOGY

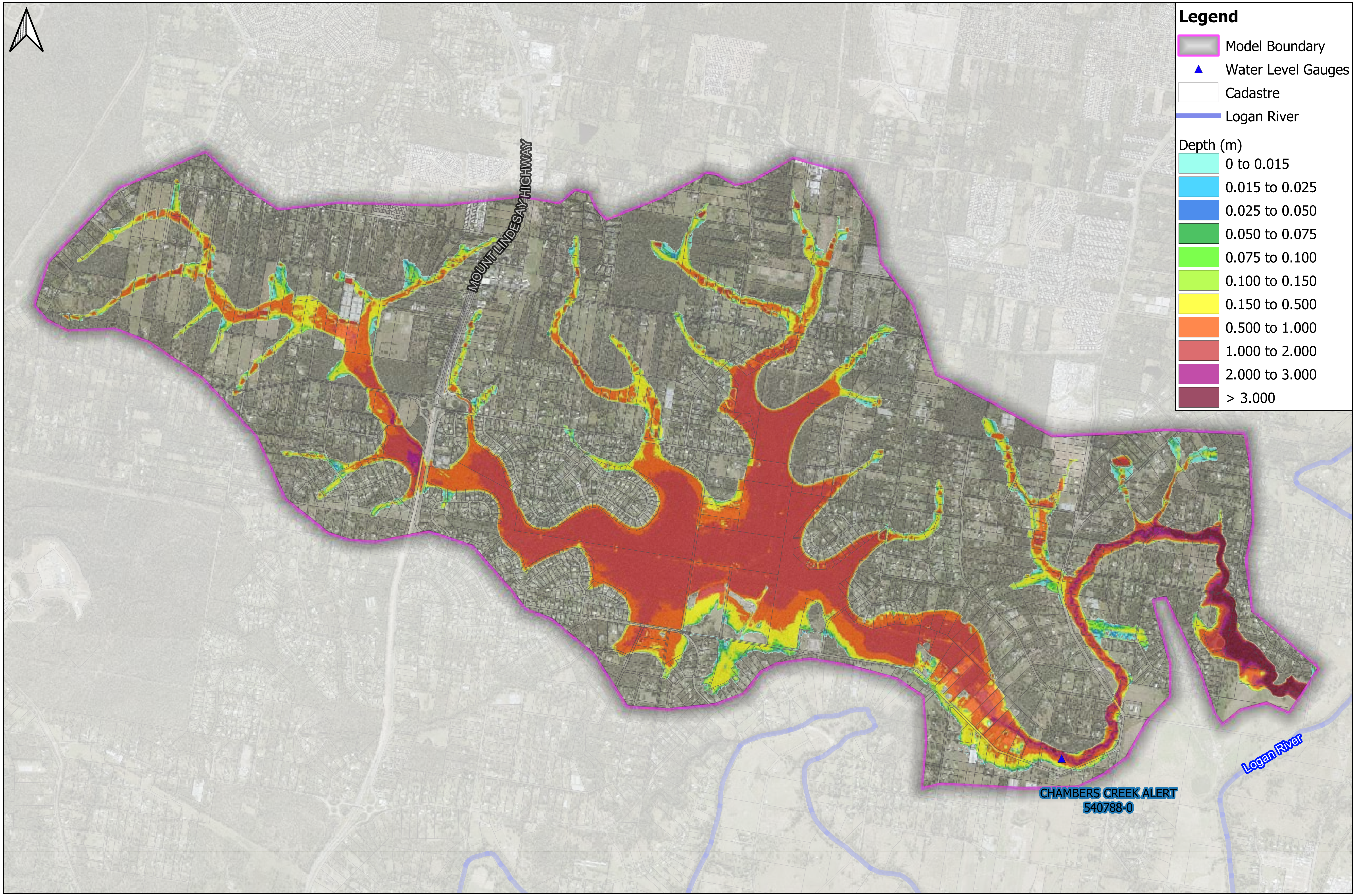


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023
5% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

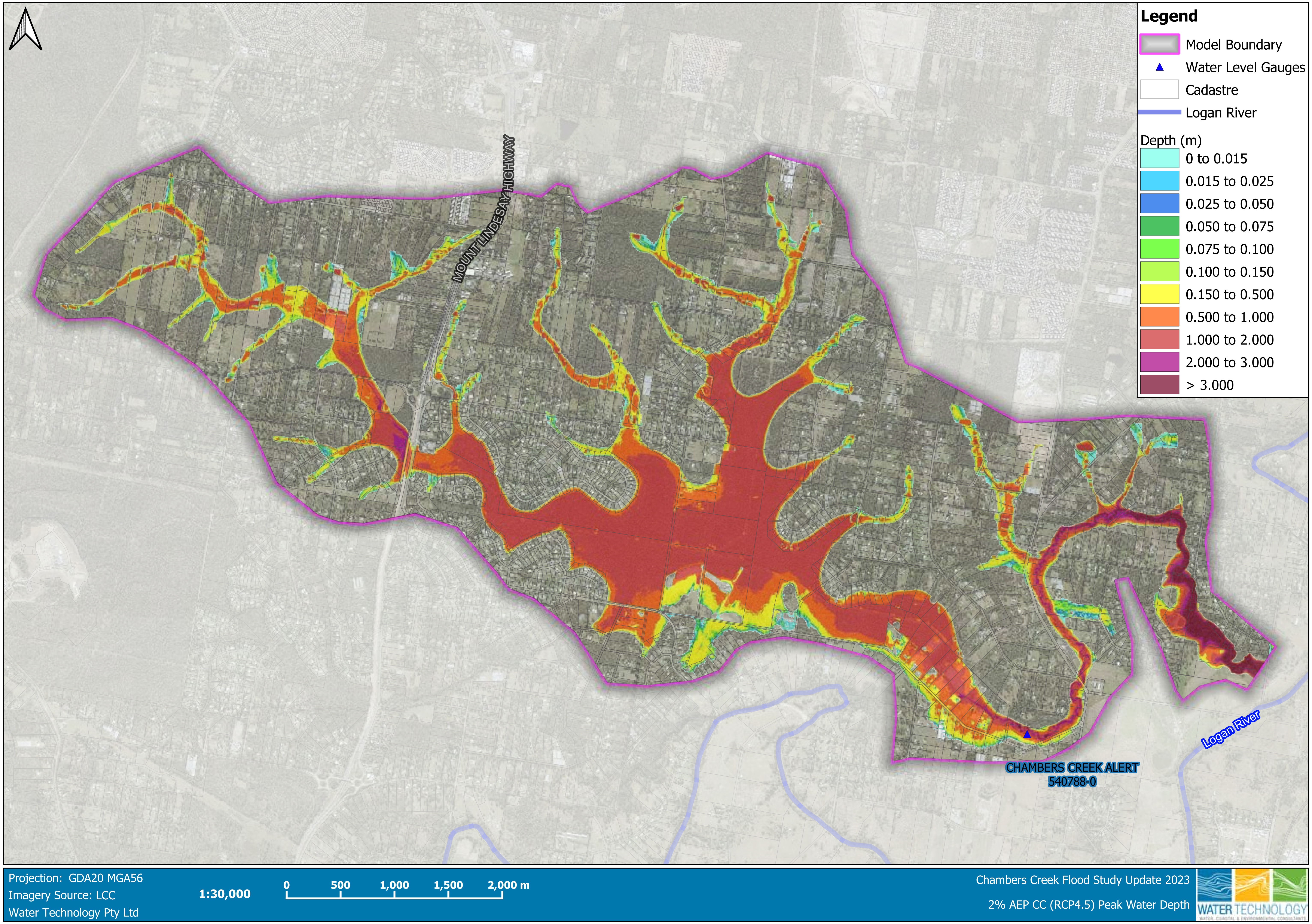
1:30,000

0 500 1,000 1,500 2,000 m

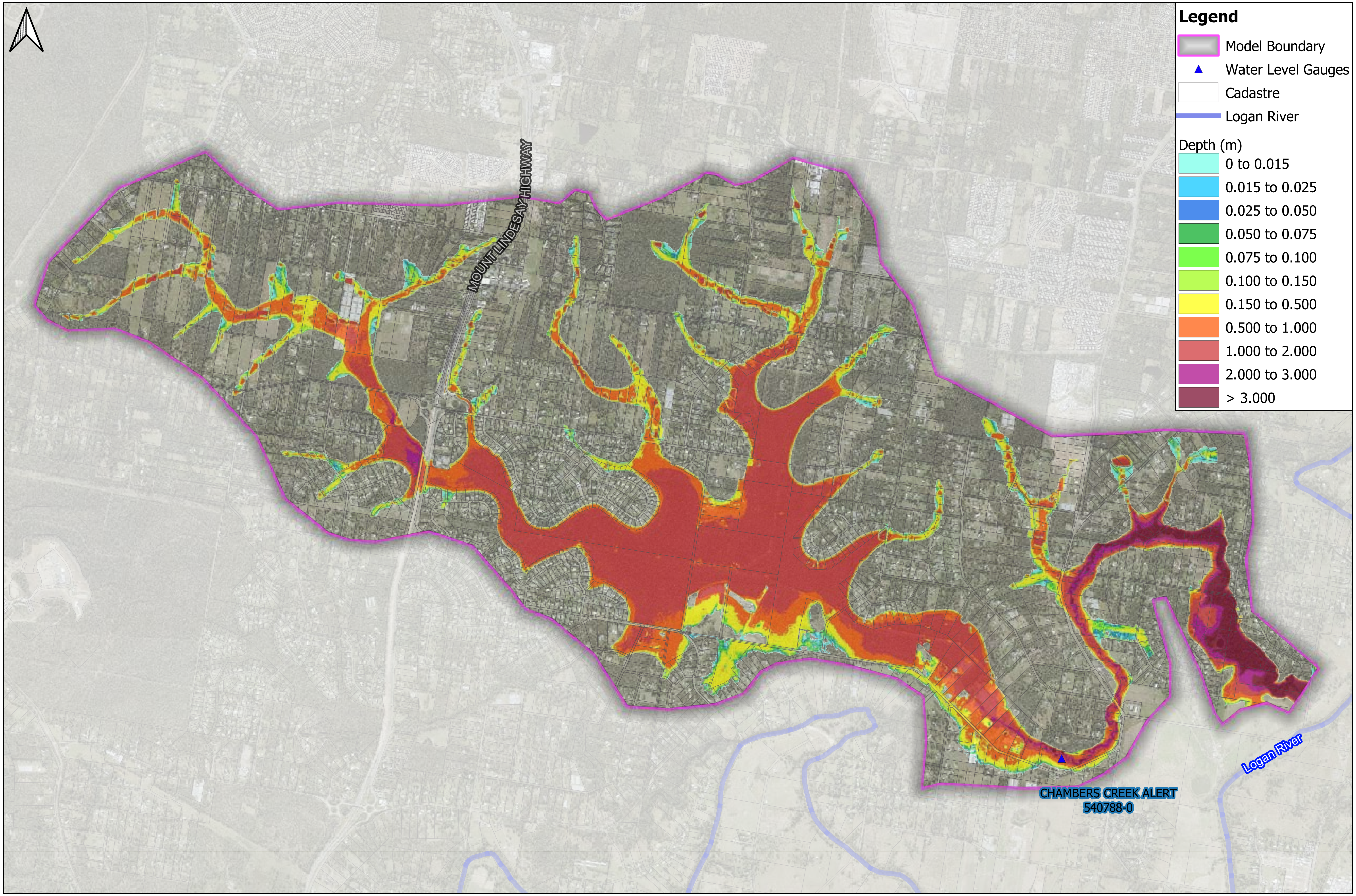
Chambers Creek Flood Study Update 2023

2% AEP Peak Water Depth

WATER TECHNOLOGY



Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Depth (m)
0 to 0.015
0.015 to 0.025
0.025 to 0.050
0.050 to 0.075
0.075 to 0.100
0.100 to 0.150
0.150 to 0.500
0.500 to 1.000
1.000 to 2.000
2.000 to 3.000
> 3.000
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
2% AEP CC (RCP4.5) Peak Water Depth
WATER TECHNOLOGY



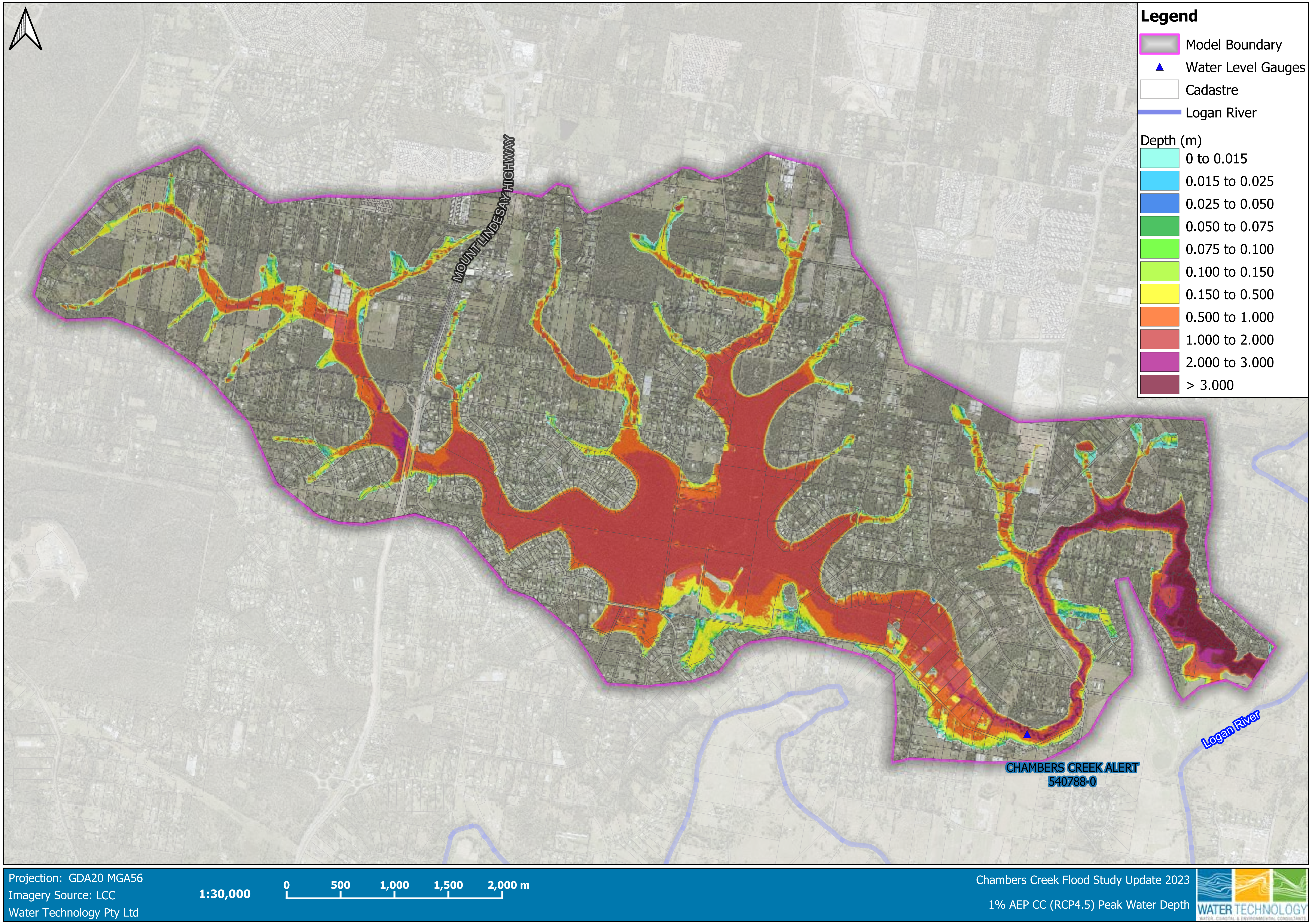
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

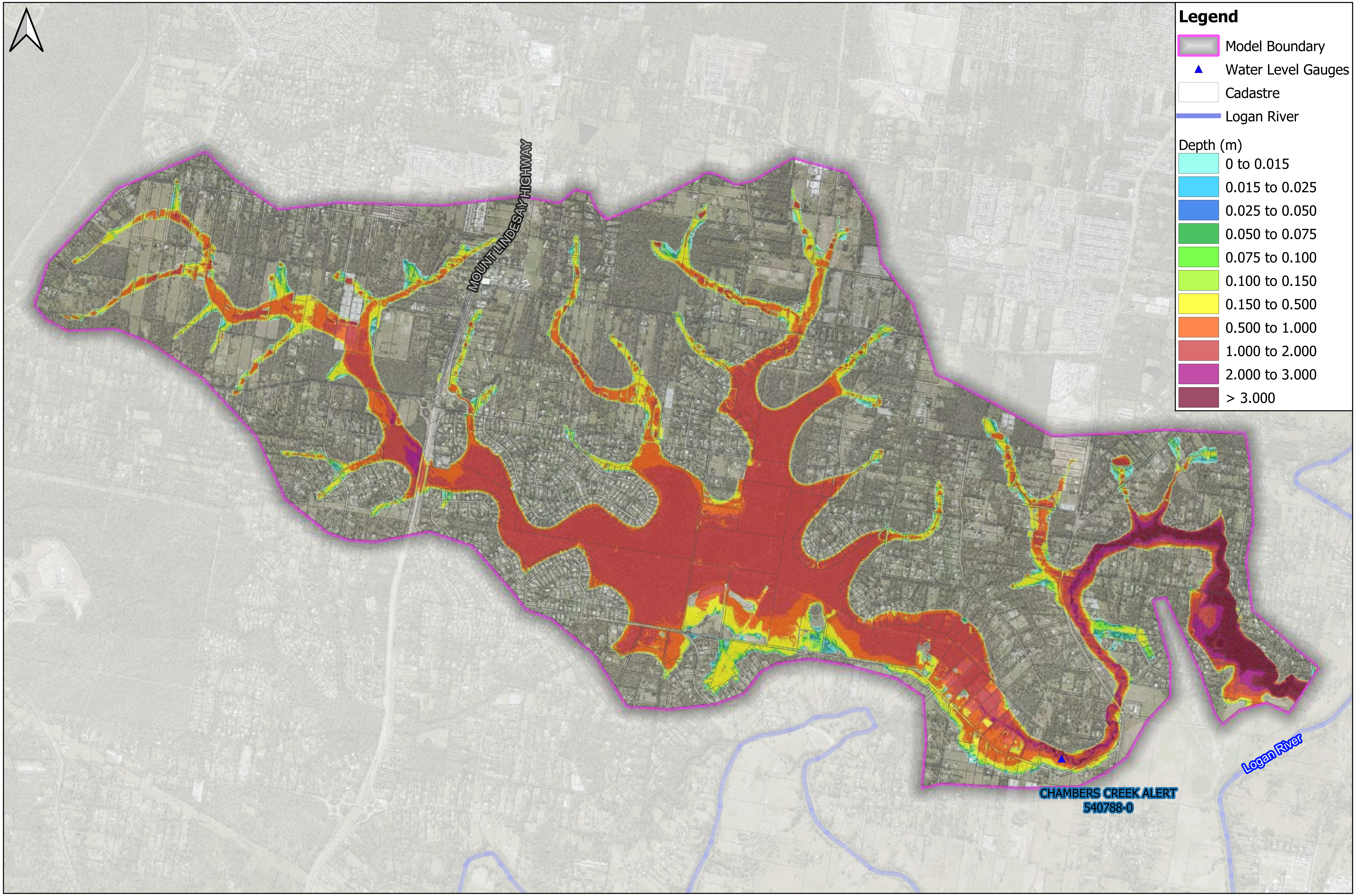
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

1% AEP Peak Water Depth


Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Depth (m)
0 to 0.015
0.015 to 0.025
0.025 to 0.050
0.050 to 0.075
0.075 to 0.100
0.100 to 0.150
0.150 to 0.500
0.500 to 1.000
1.000 to 2.000
2.000 to 3.000
> 3.000
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
1% AEP CC (RCP4.5) Peak Water Depth
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

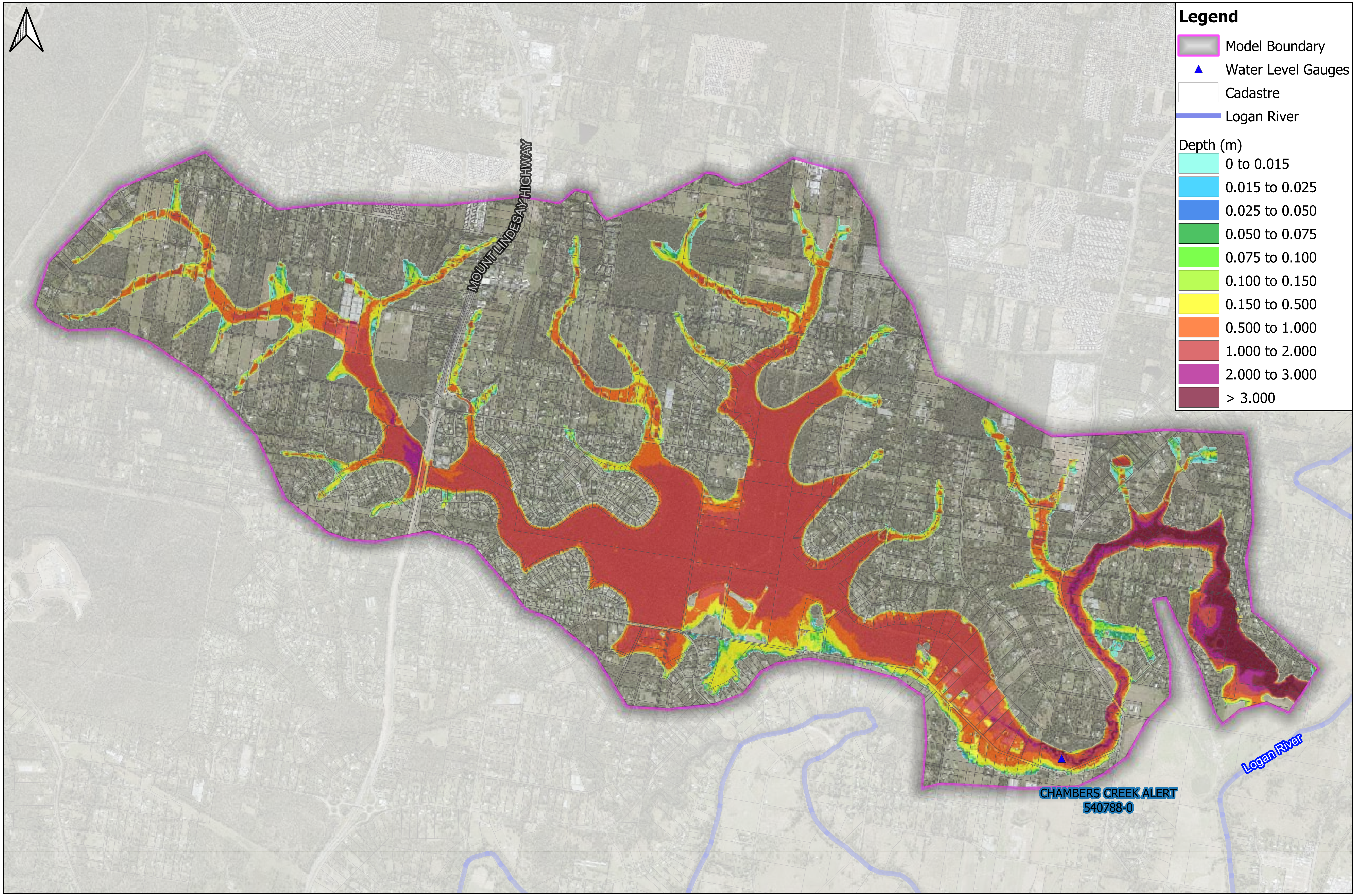
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.5% AEP Peak Water Depth

WATER TECHNOLOGY



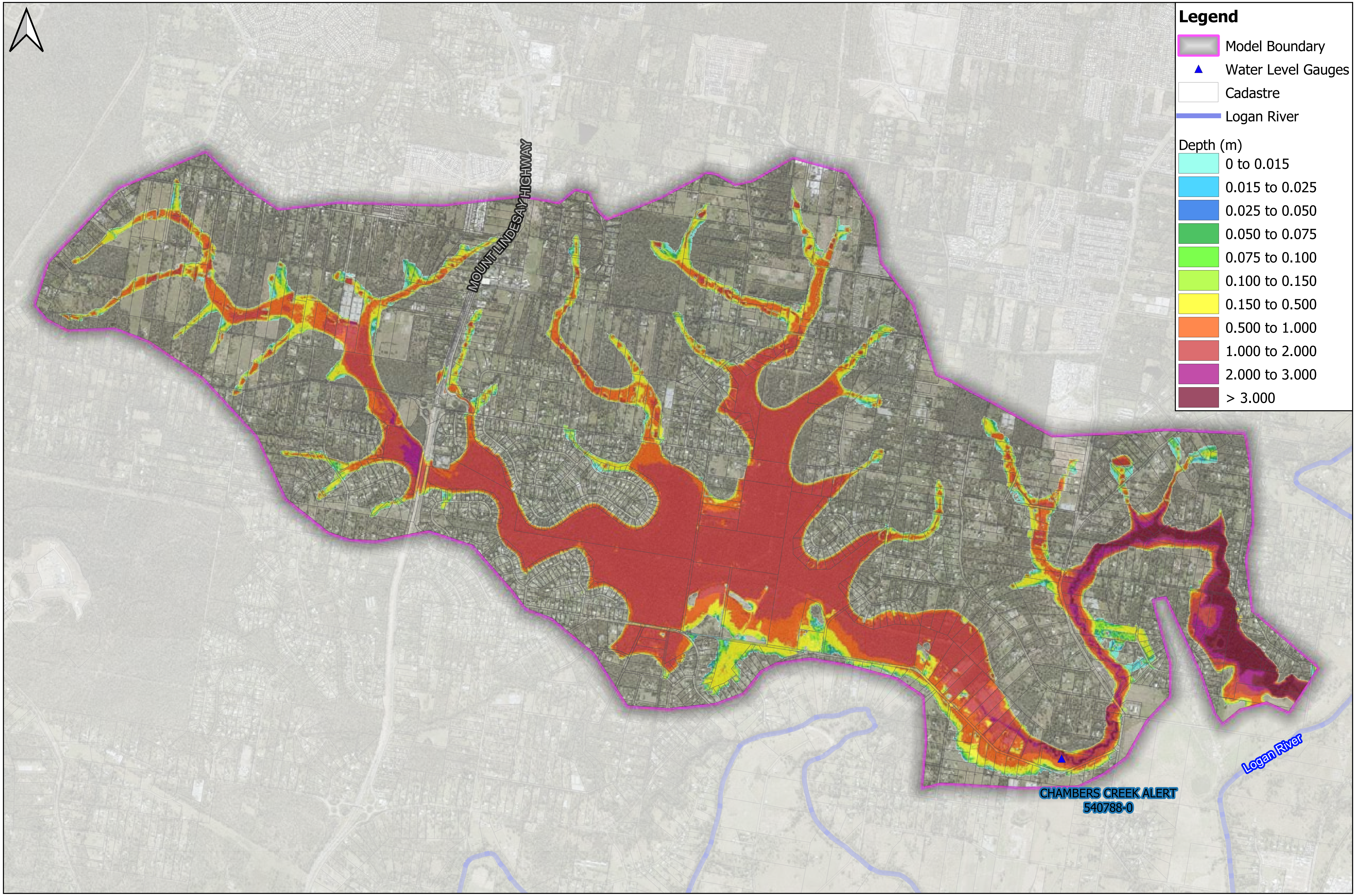
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

0.5% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY



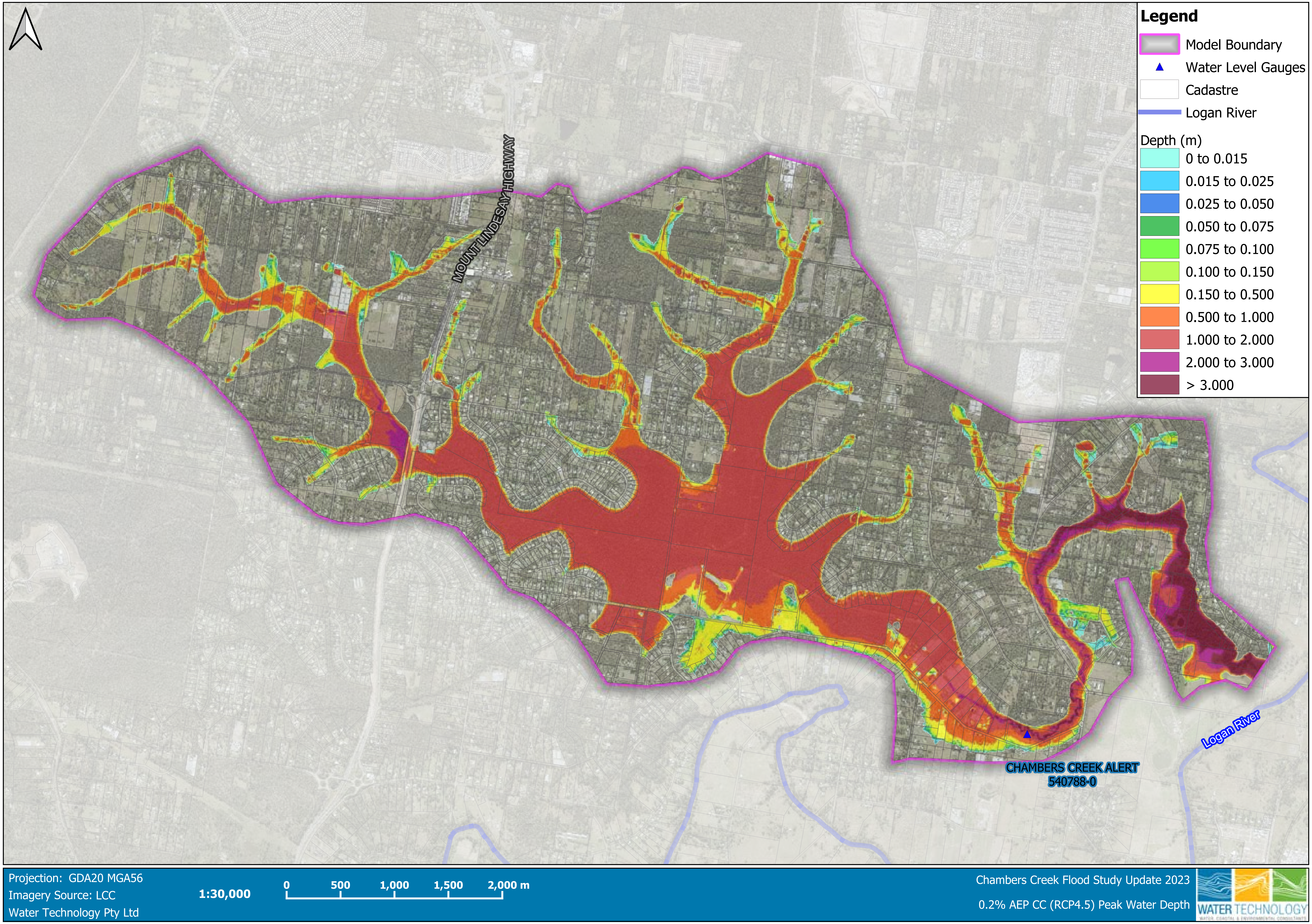
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

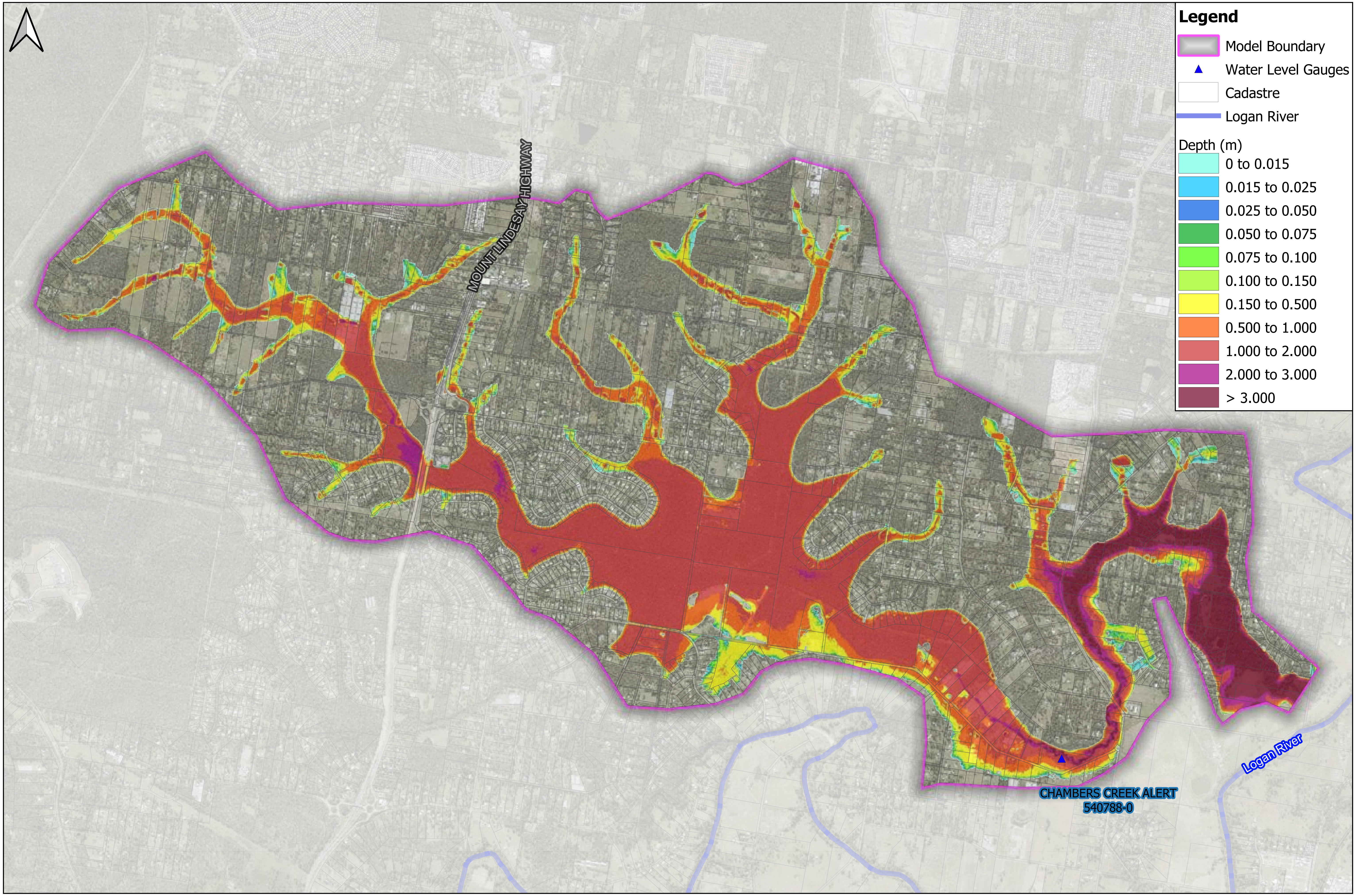
Chambers Creek Flood Study Update 2023

0.2% AEP Peak Water Depth

WATER TECHNOLOGY



Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Depth (m)
0 to 0.015
0.015 to 0.025
0.025 to 0.050
0.050 to 0.075
0.075 to 0.100
0.100 to 0.150
0.150 to 0.500
0.500 to 1.000
1.000 to 2.000
2.000 to 3.000
> 3.000
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
0.2% AEP CC (RCP4.5) Peak Water Depth
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

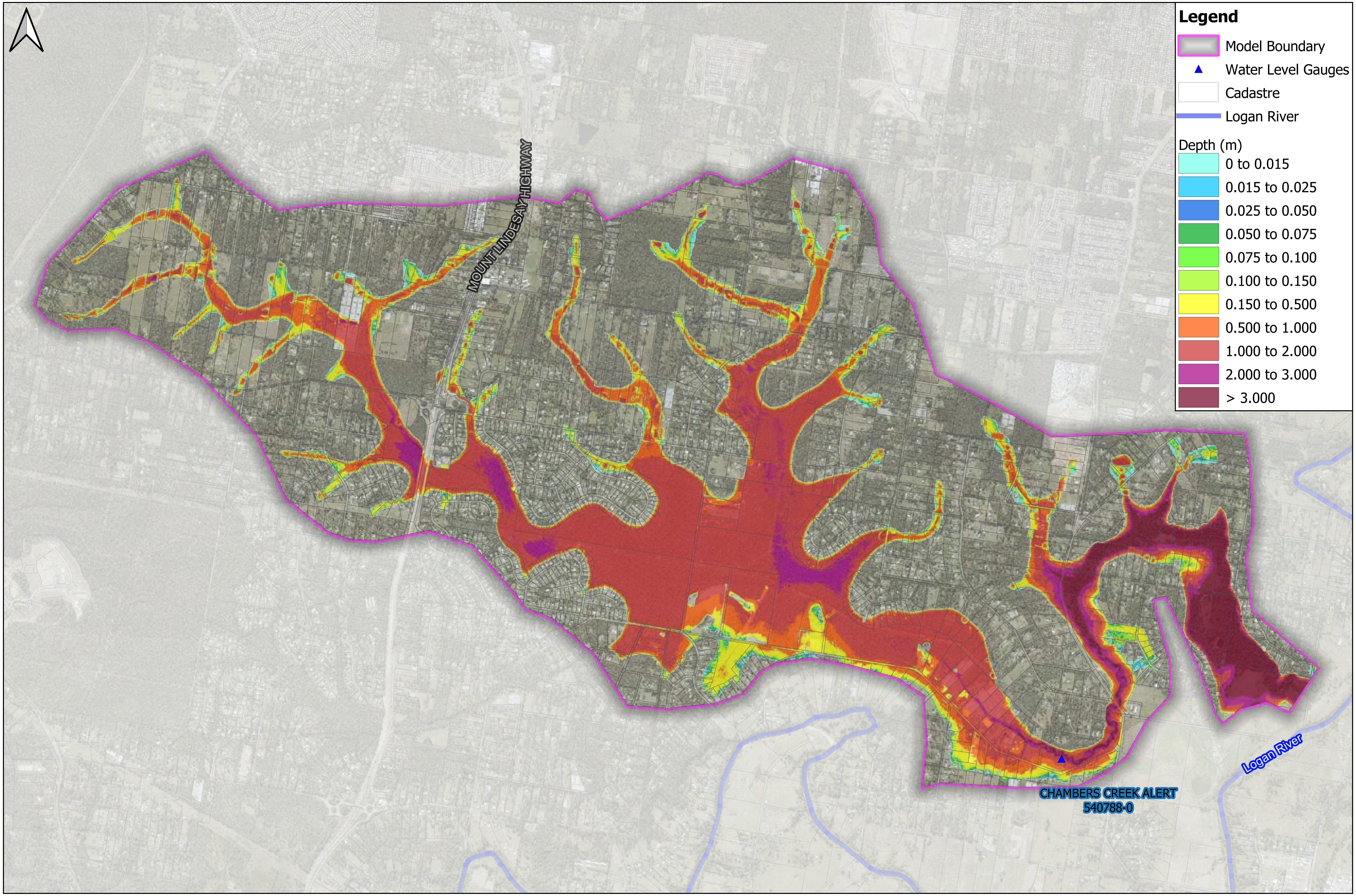
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.05% AEP Peak Water Depth

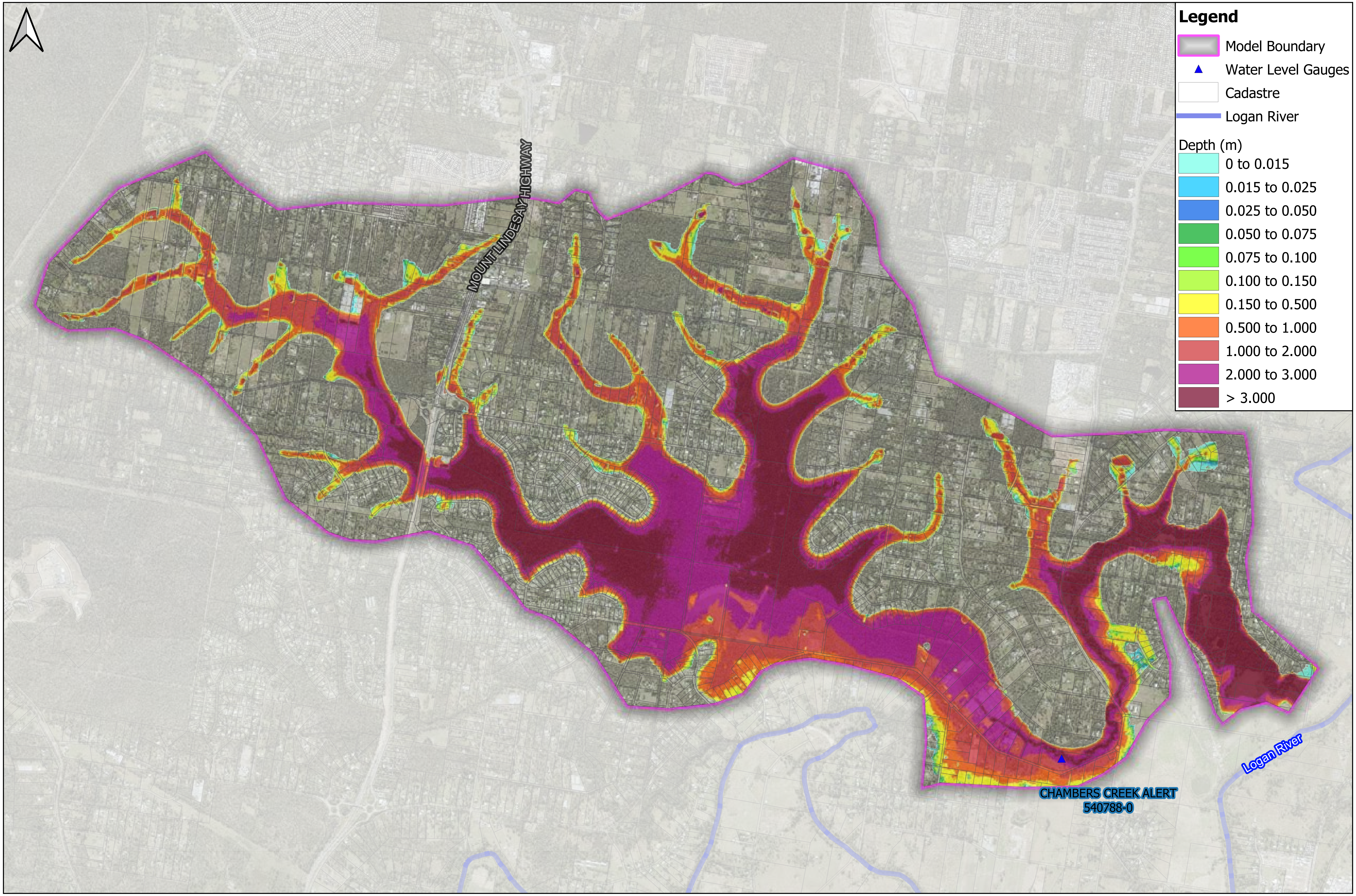
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

Chambers Creek Flood Study Update 2023
0.05% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

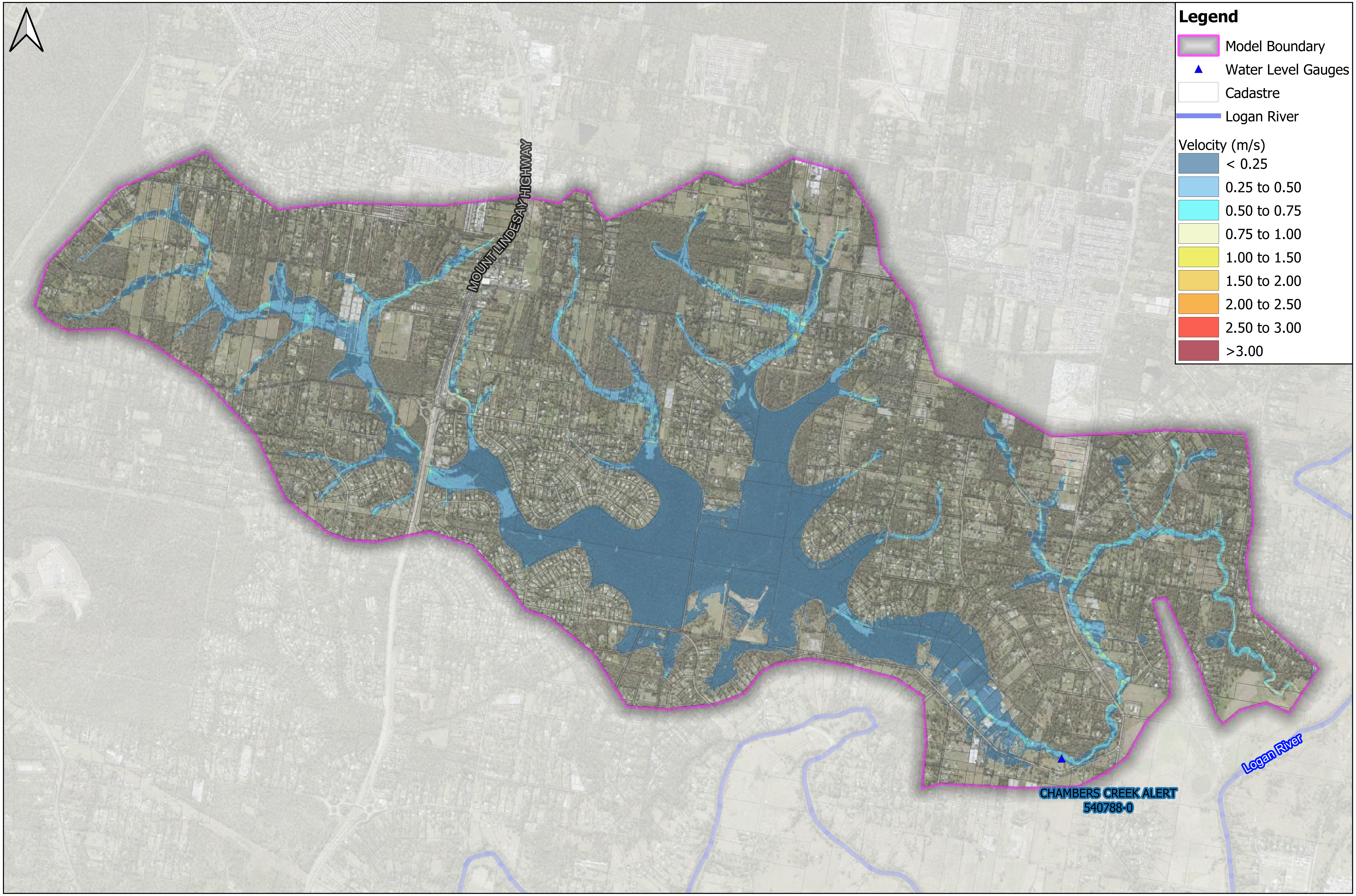
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

PMF Peak Water Depth

WATER TECHNOLOGY



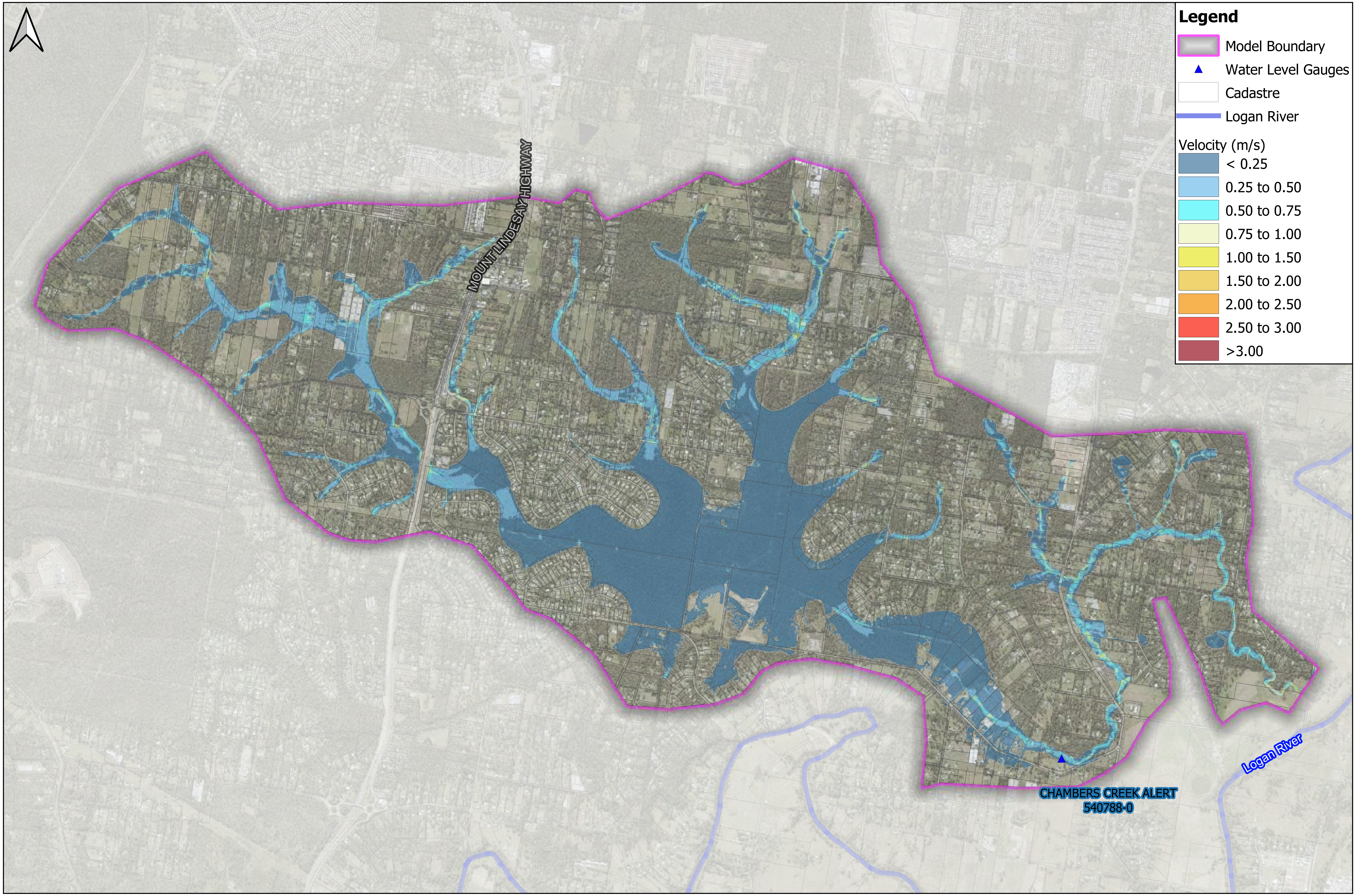
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

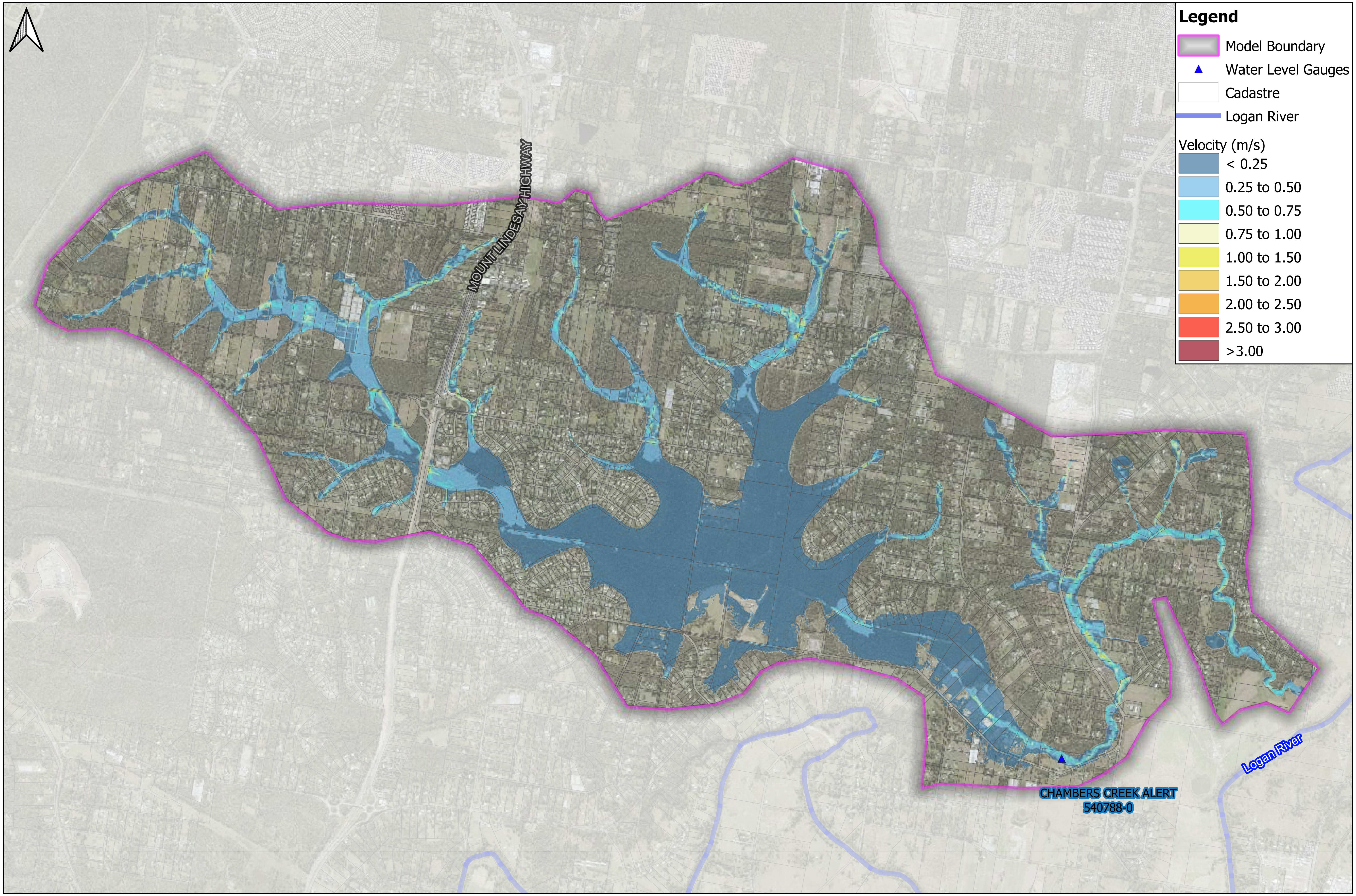
0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

50% AEP Peak Water Velocity



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
50% AEP CC (RCP4.5) Peak Water Velocity



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

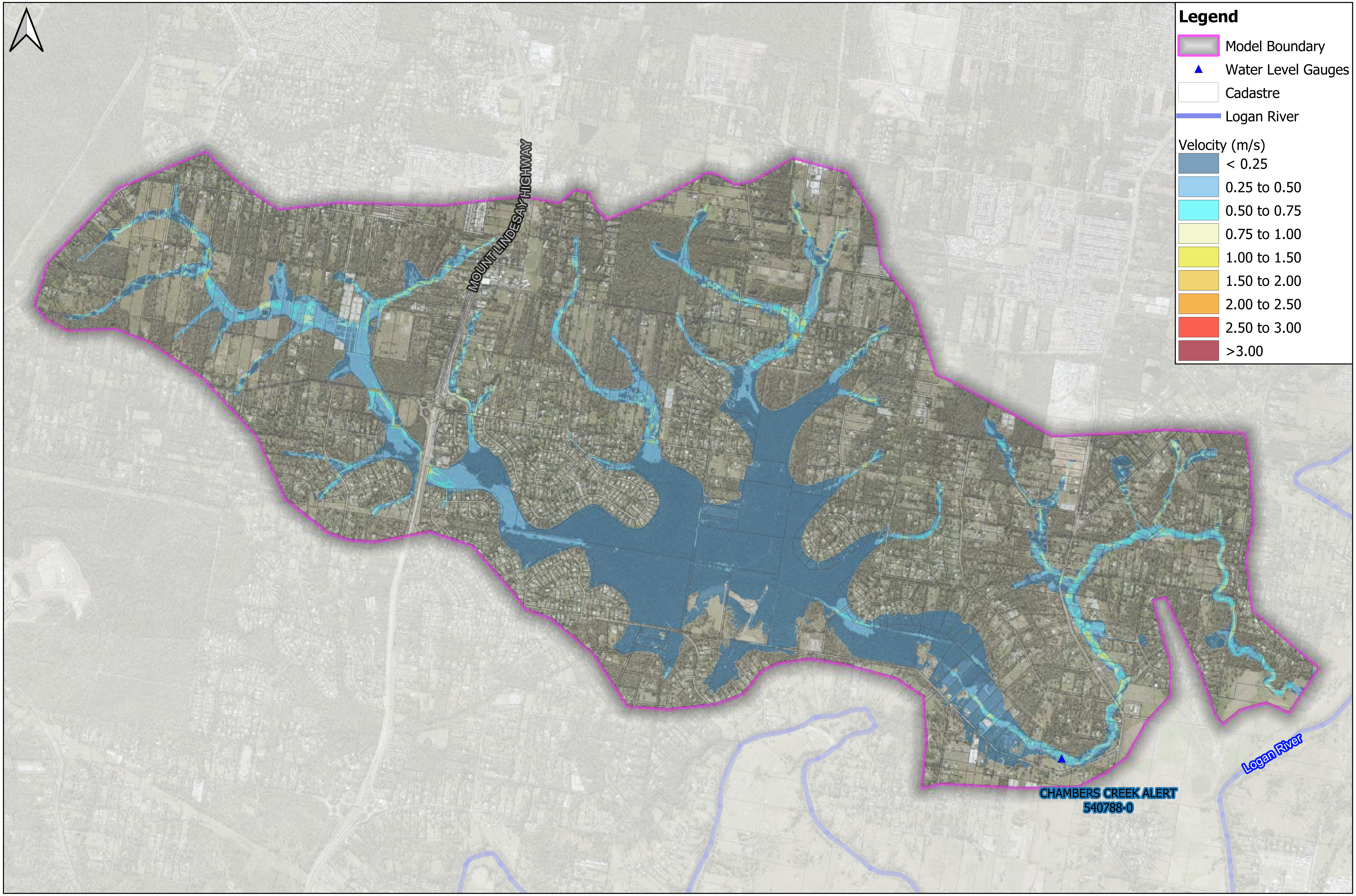
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

20% AEP Peak Water Velocity

WATER TECHNOLOGY



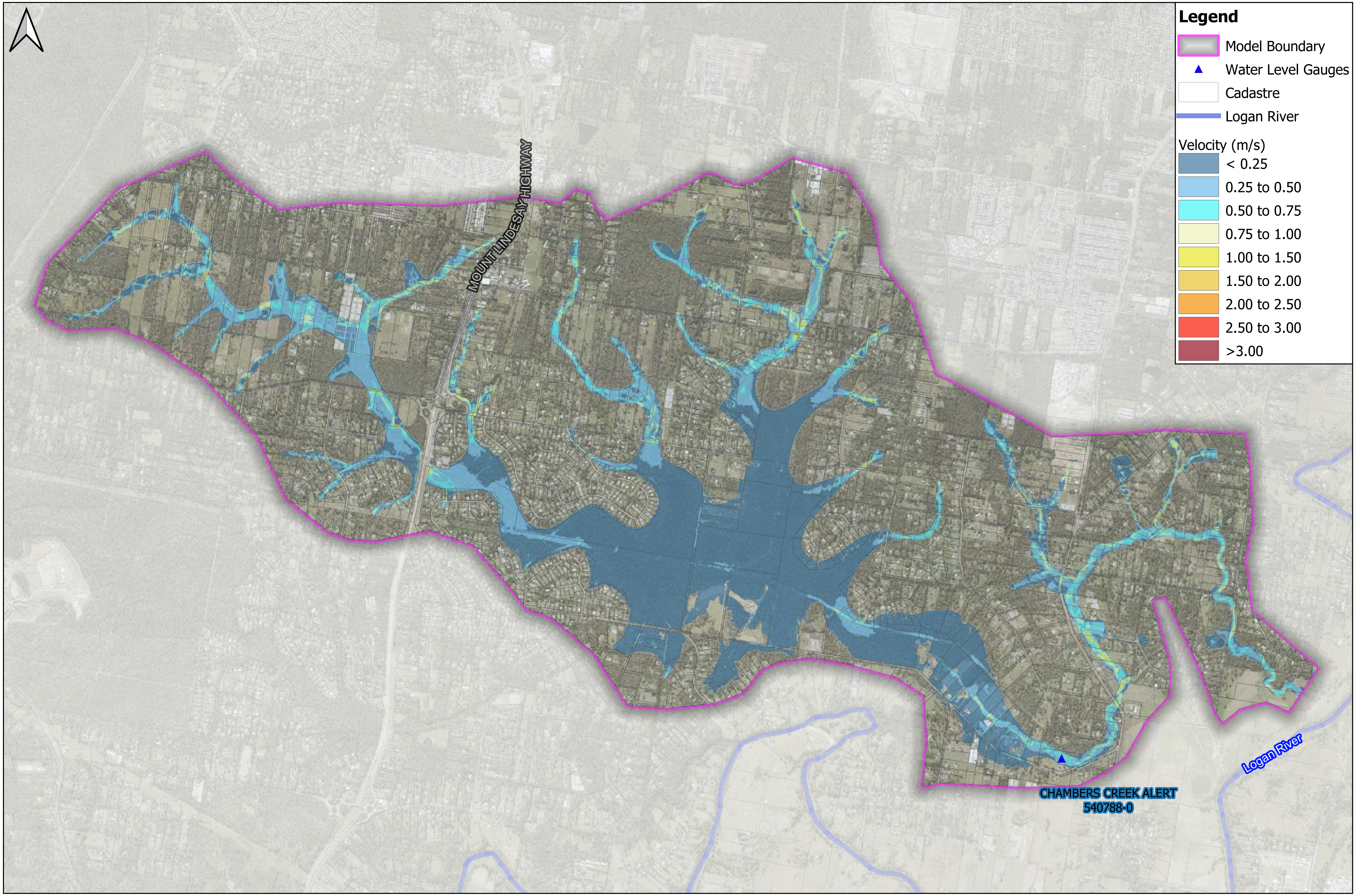
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

20% AEP CC (RCP4.5) Peak Water Velocity



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

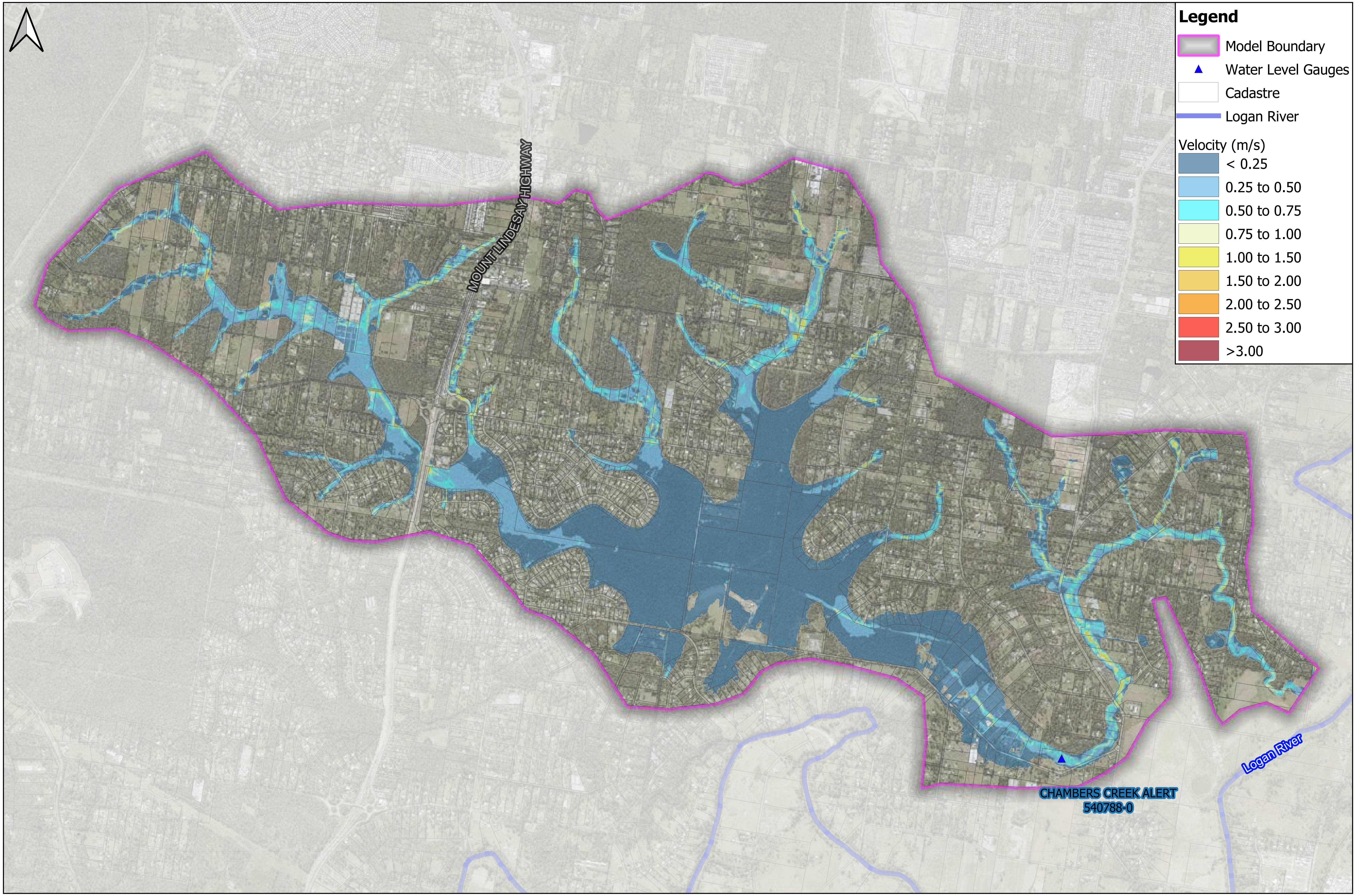
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

10% AEP Peak Water Velocity

WATER TECHNOLOGY



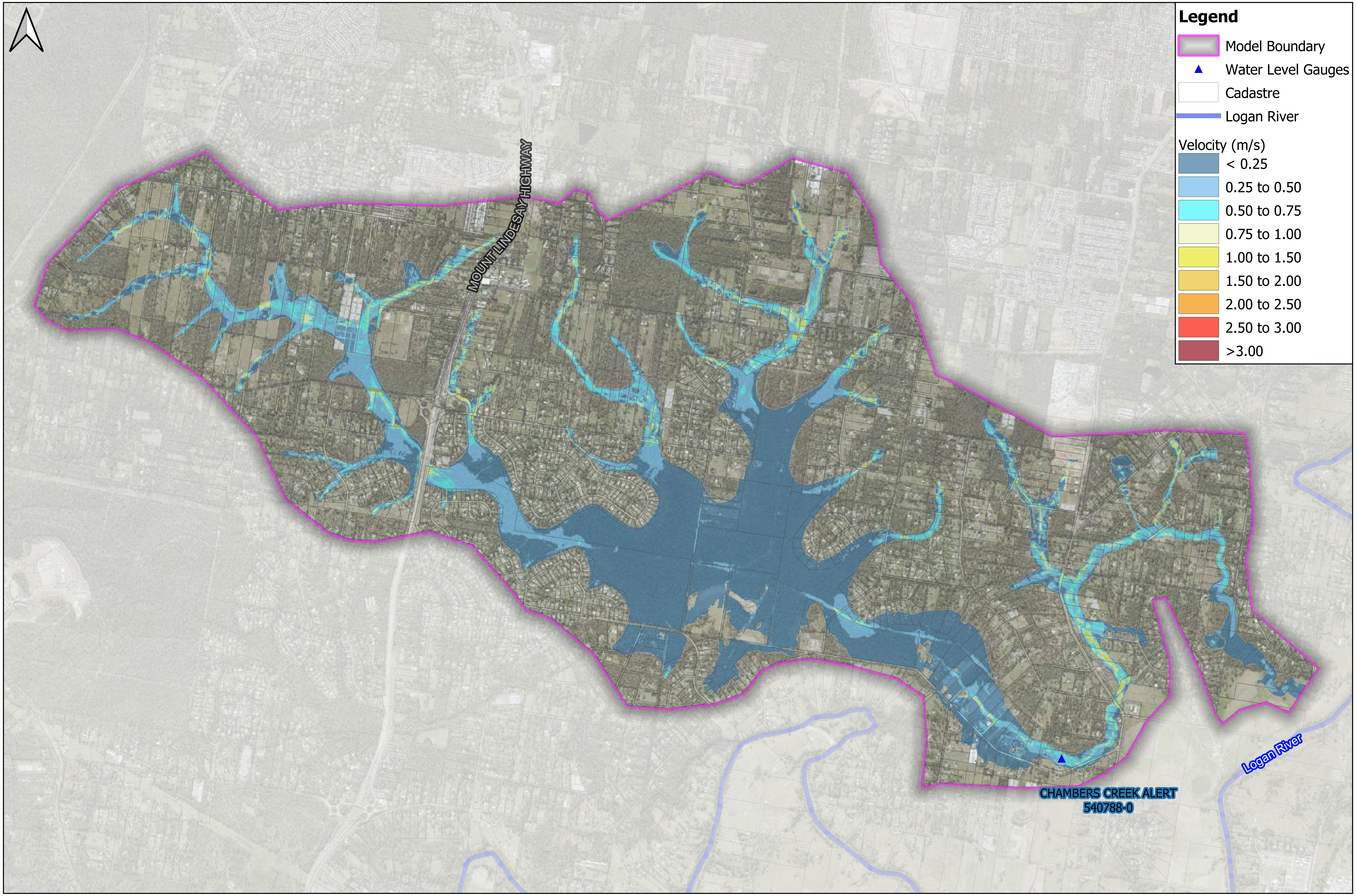
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

10% AEP CC (RCP4.5) Peak Water Velocity

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

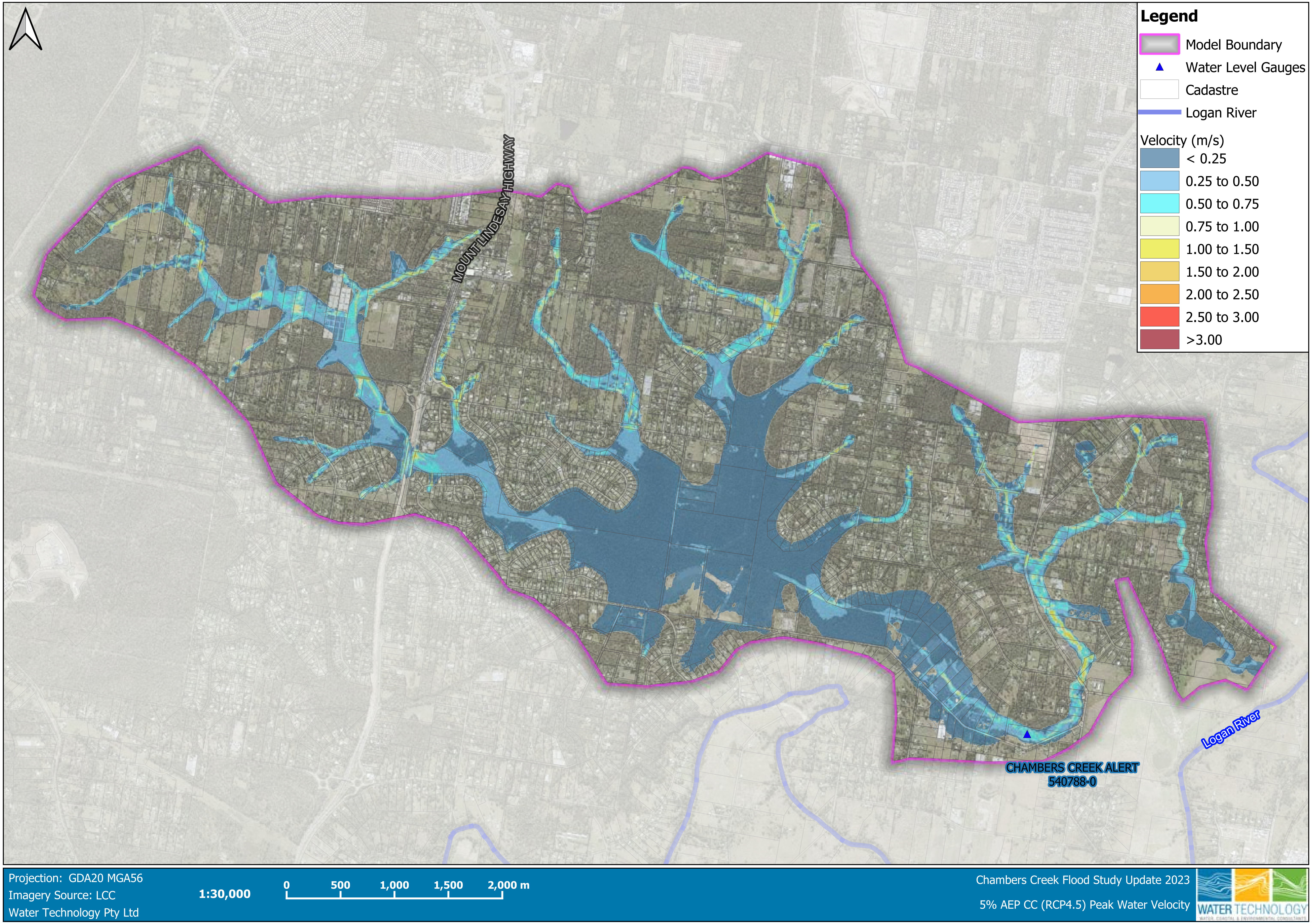
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

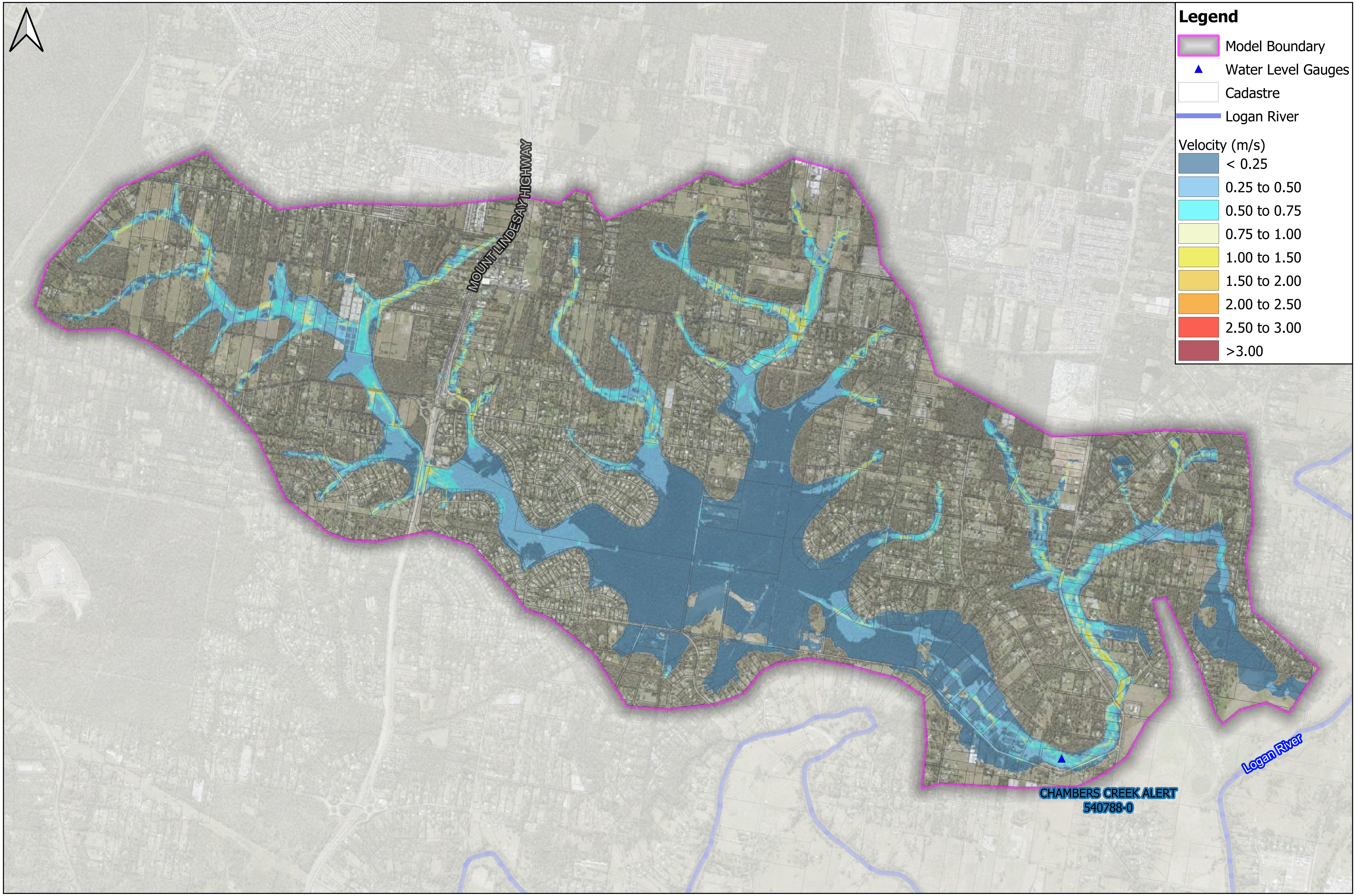
5% AEP Peak Water Velocity

WATER TECHNOLOGY



MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Velocity (m/s)
< 0.25
0.25 to 0.50
0.50 to 0.75
0.75 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0
500
1,000
1,500
2,000 m
Chambers Creek Flood Study Update 2023
5% AEP CC (RCP4.5) Peak Water Velocity
WATER TECHNOLOGY


Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Velocity (m/s)
< 0.25
0.25 to 0.50
0.50 to 0.75
0.75 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0 500 1,000 1,500 2,000 m
Chambers Creek Flood Study Update 2023
2% AEP Peak Water Velocity
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

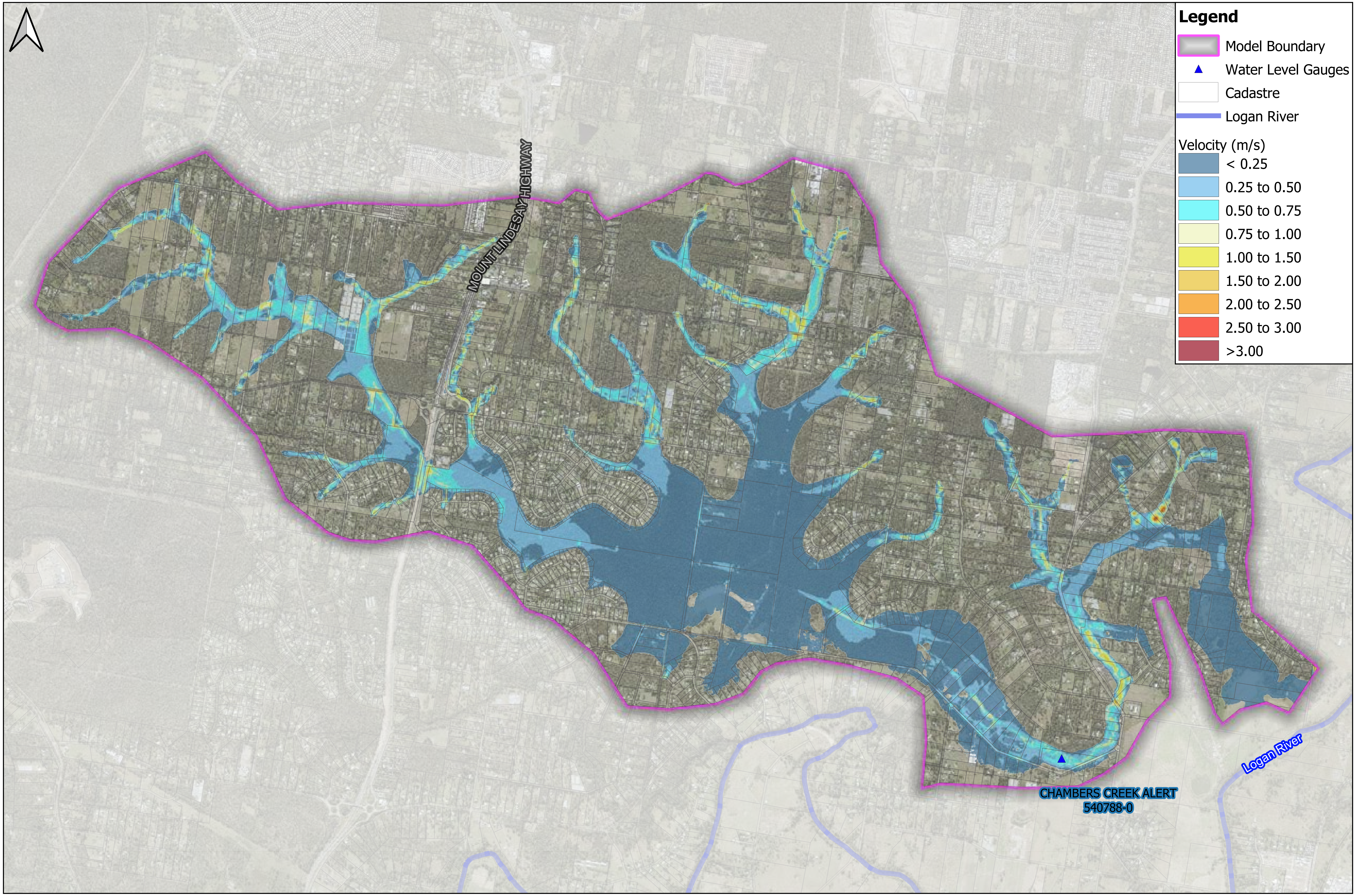
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

2% AEP CC (RCP4.5) Peak Water Velocity

WATER TECHNOLOGY



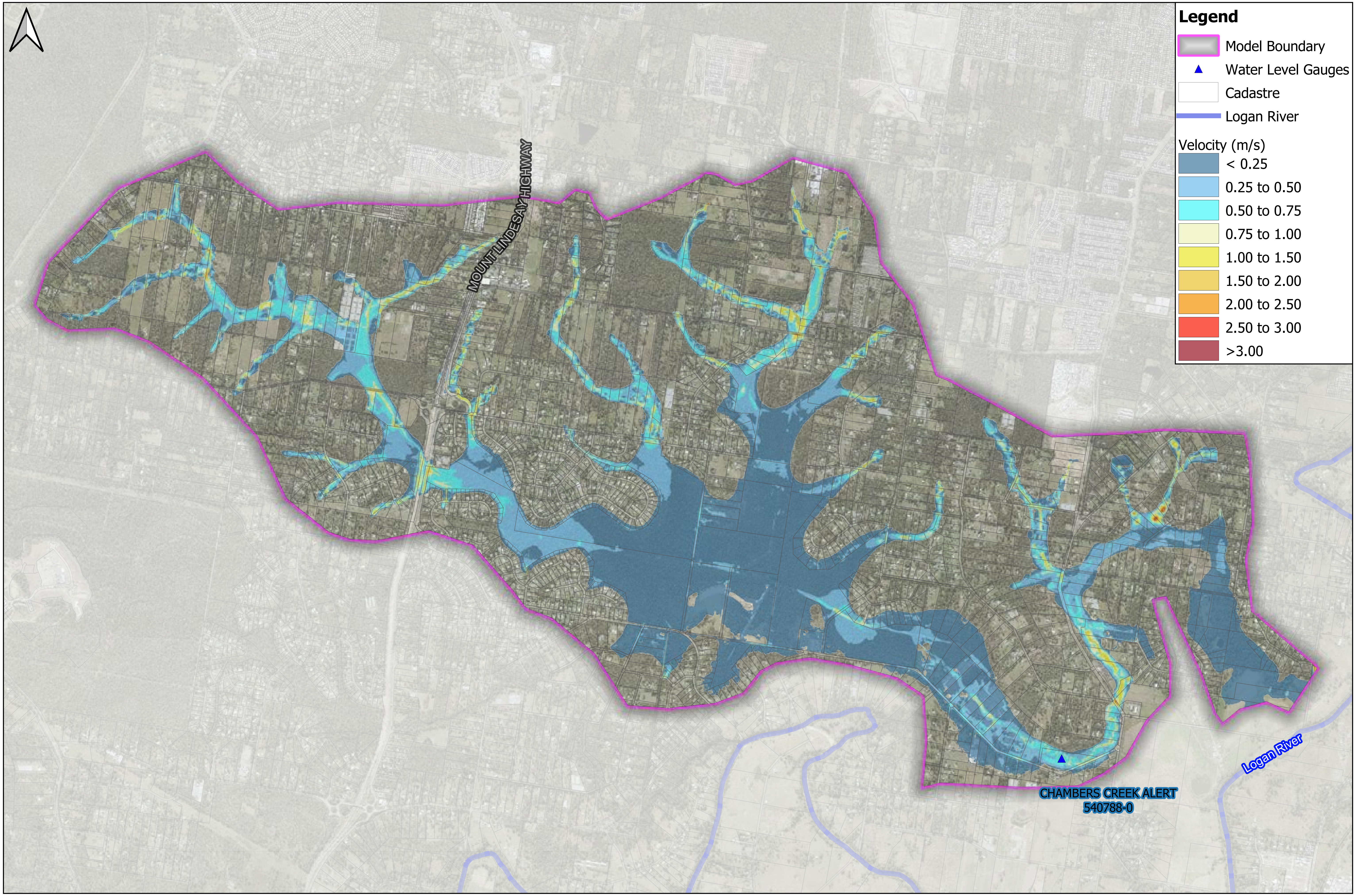
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

1% AEP Peak Water Velocity

WATER TECHNOLOGY

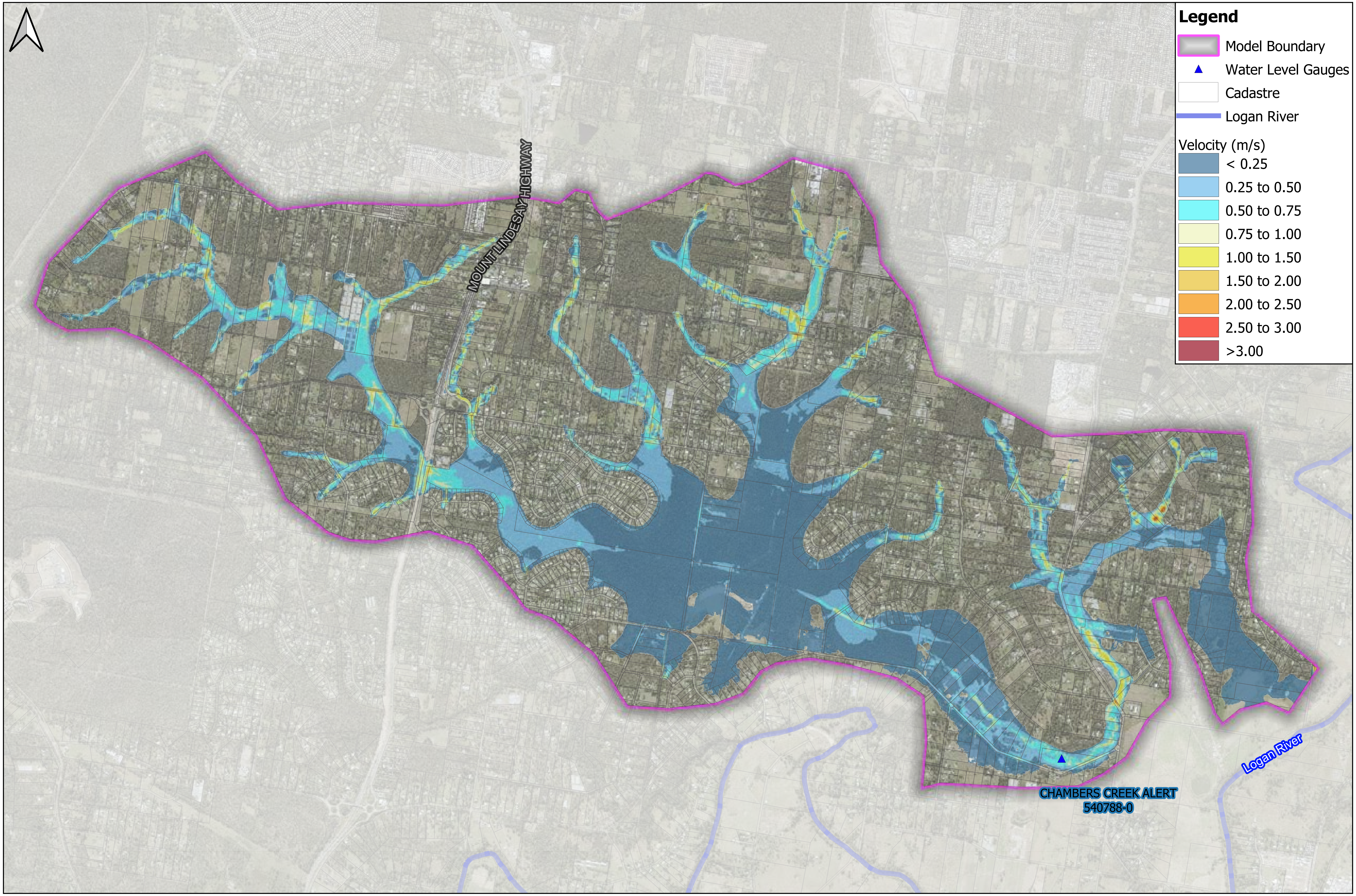


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

1% AEP CC (RCP4.5) Peak Water Velocity



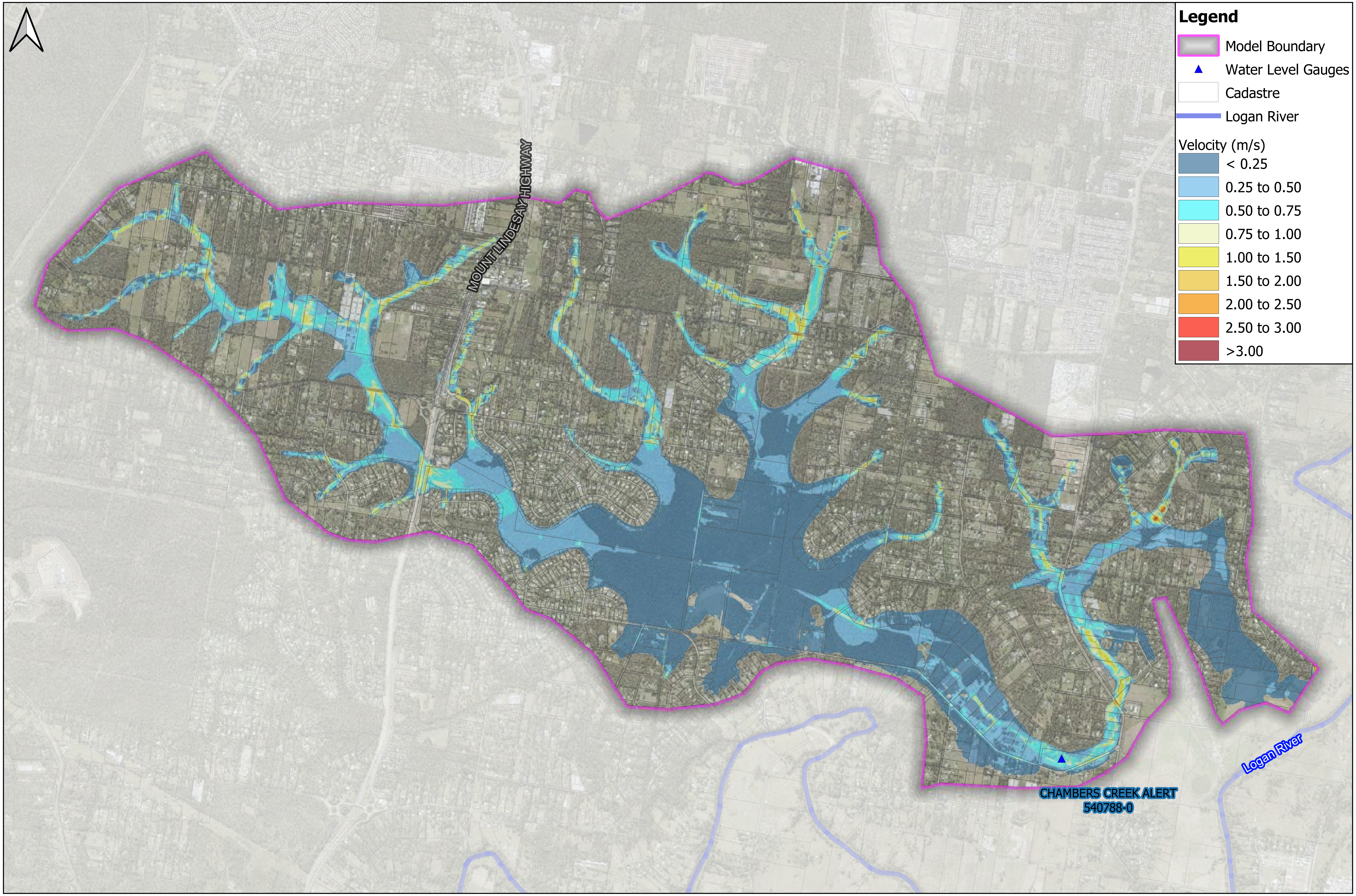
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.5% AEP Peak Water Velocity



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

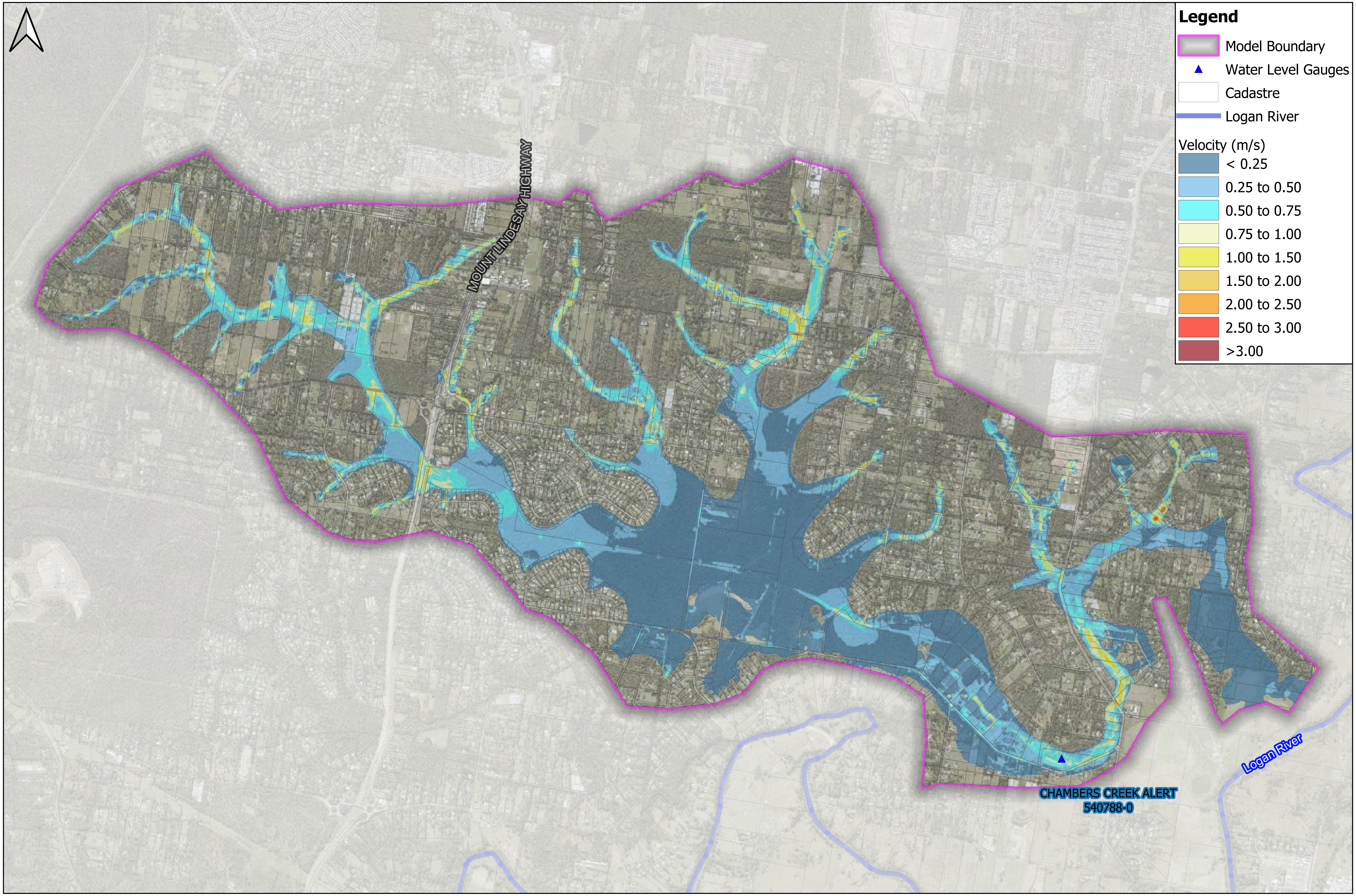
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.5% AEP CC (RCP4.5) Peak Water Velocity

WATER TECHNOLOGY



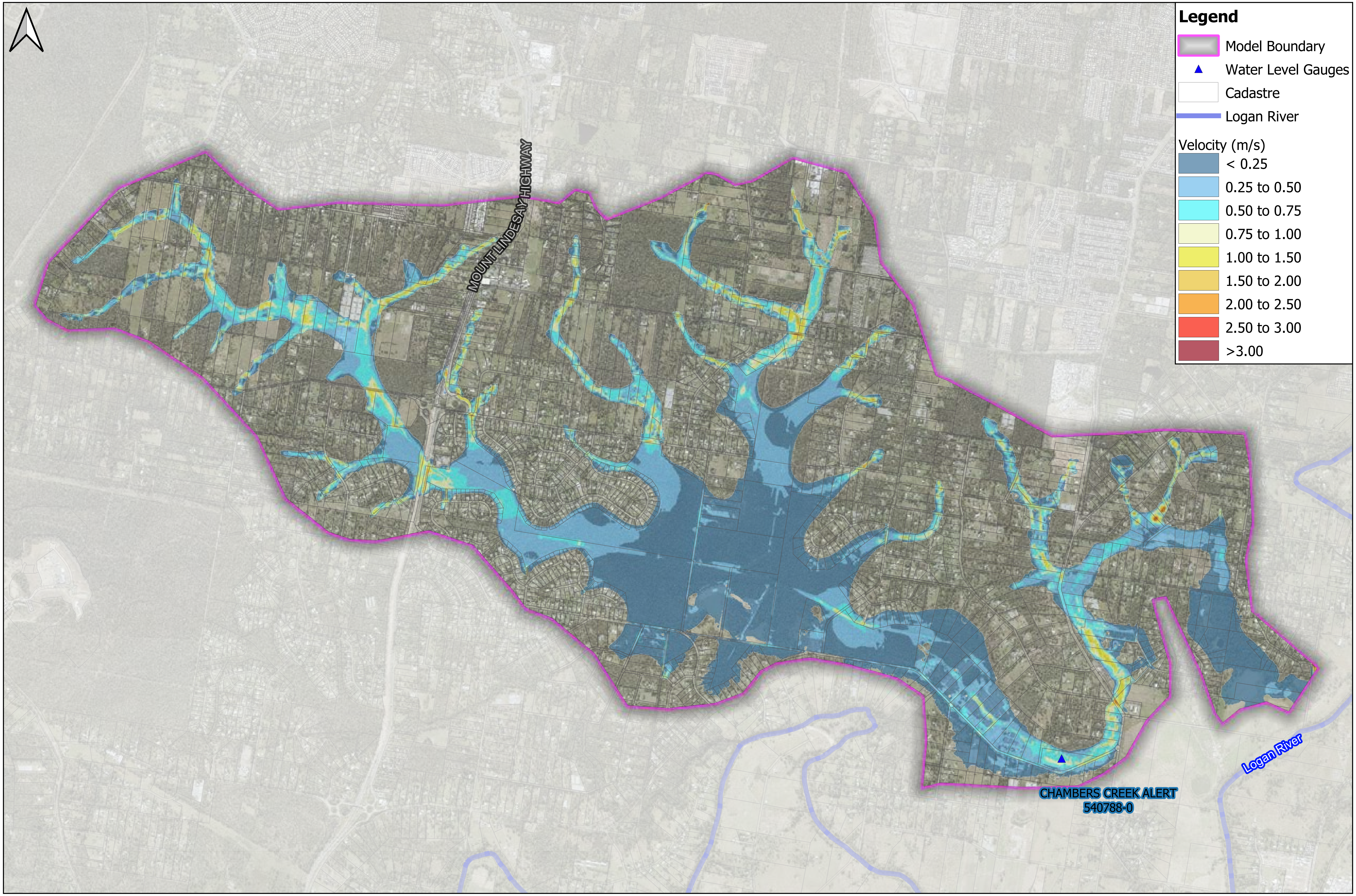
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.2% AEP Peak Water Velocity



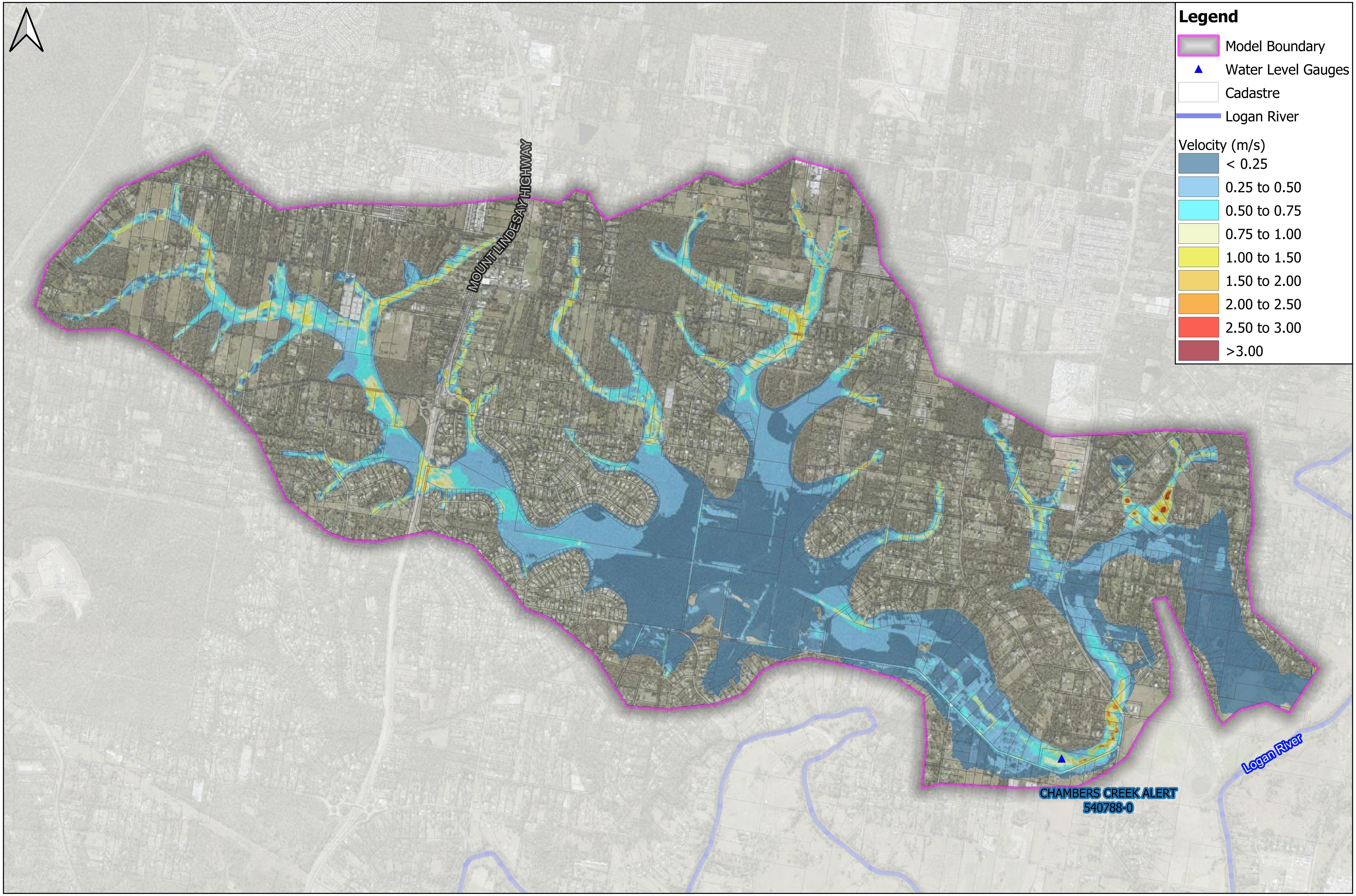
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

0.2% AEP CC (RCP4.5) Peak Water Velocity

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

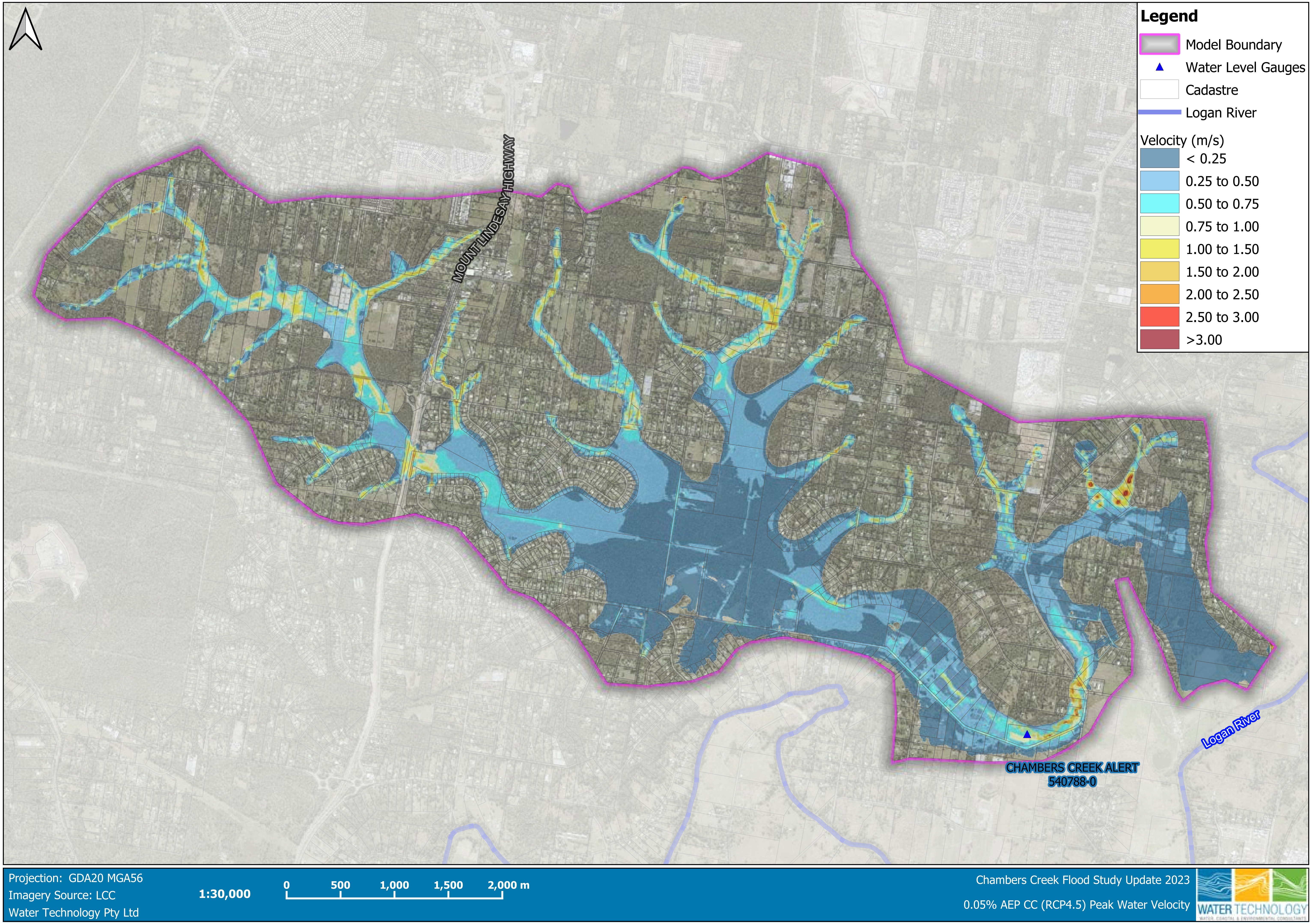
1:30,000

0 500 1,000 1,500 2,000 m

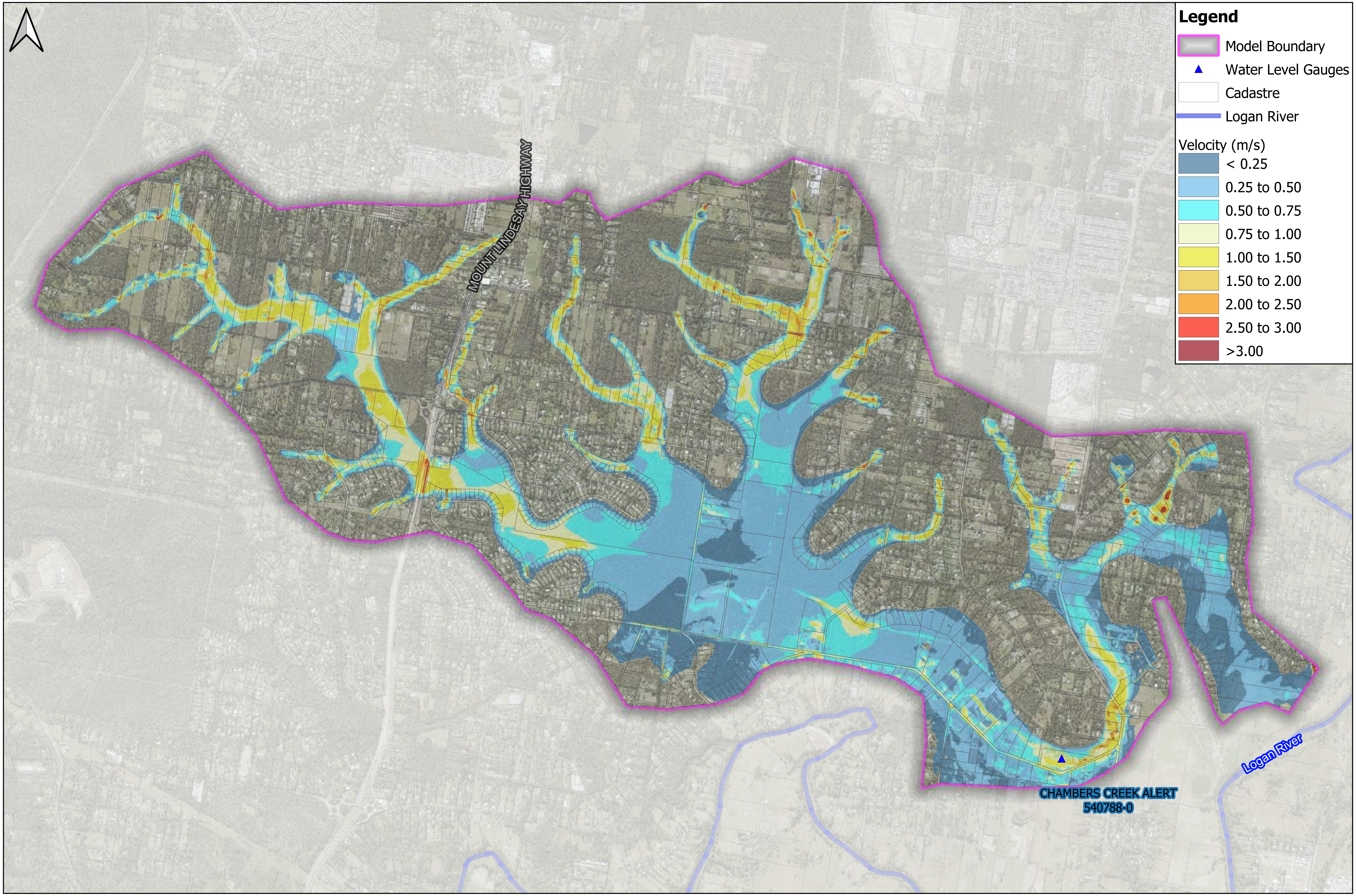
Chambers Creek Flood Study Update 2023

0.05% AEP Peak Water Velocity

WATER TECHNOLOGY



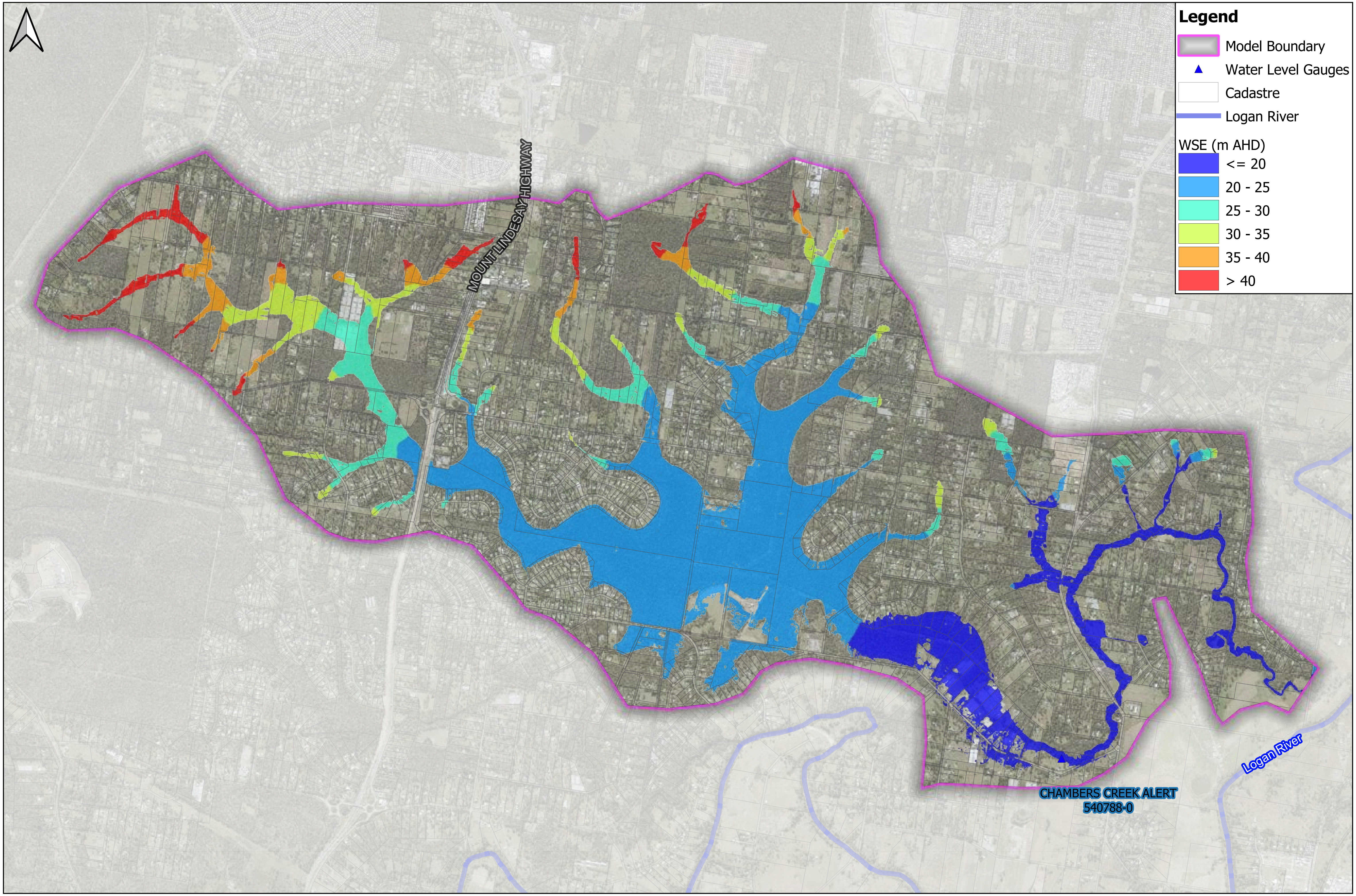
Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Velocity (m/s)
< 0.25
0.25 to 0.50
0.50 to 0.75
0.75 to 1.00
1.00 to 1.50
1.50 to 2.00
2.00 to 2.50
2.50 to 3.00
>3.00
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0
500
1,000
1,500
2,000 m
Chambers Creek Flood Study Update 2023
0.05% AEP CC (RCP4.5) Peak Water Velocity
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

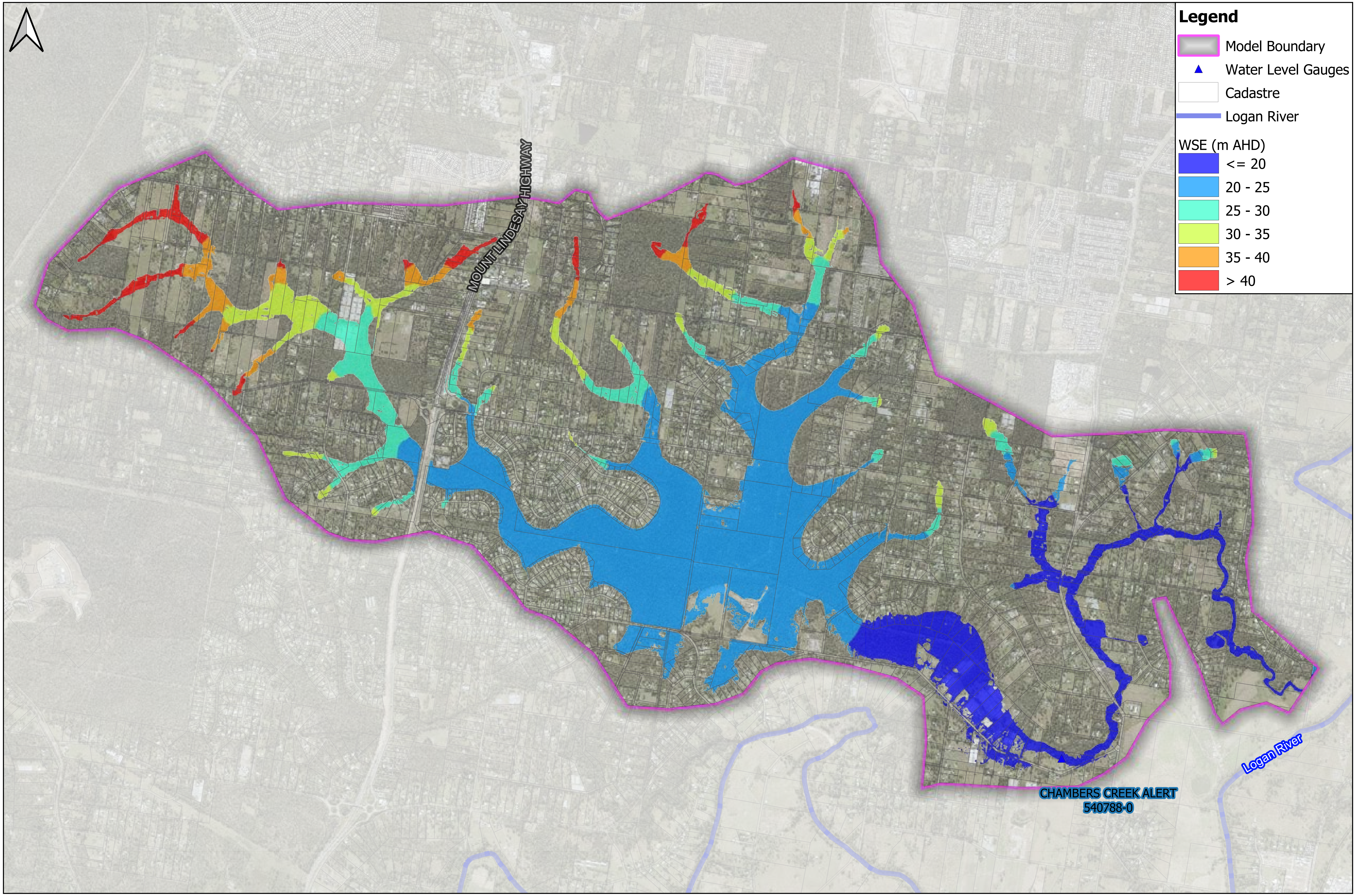
1:30,000

Chambers Creek Flood Study Update 2023
PMF Peak Water Velocity



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000

Chambers Creek Flood Study Update 2023
50% AEP Peak Water Surface Elevation



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

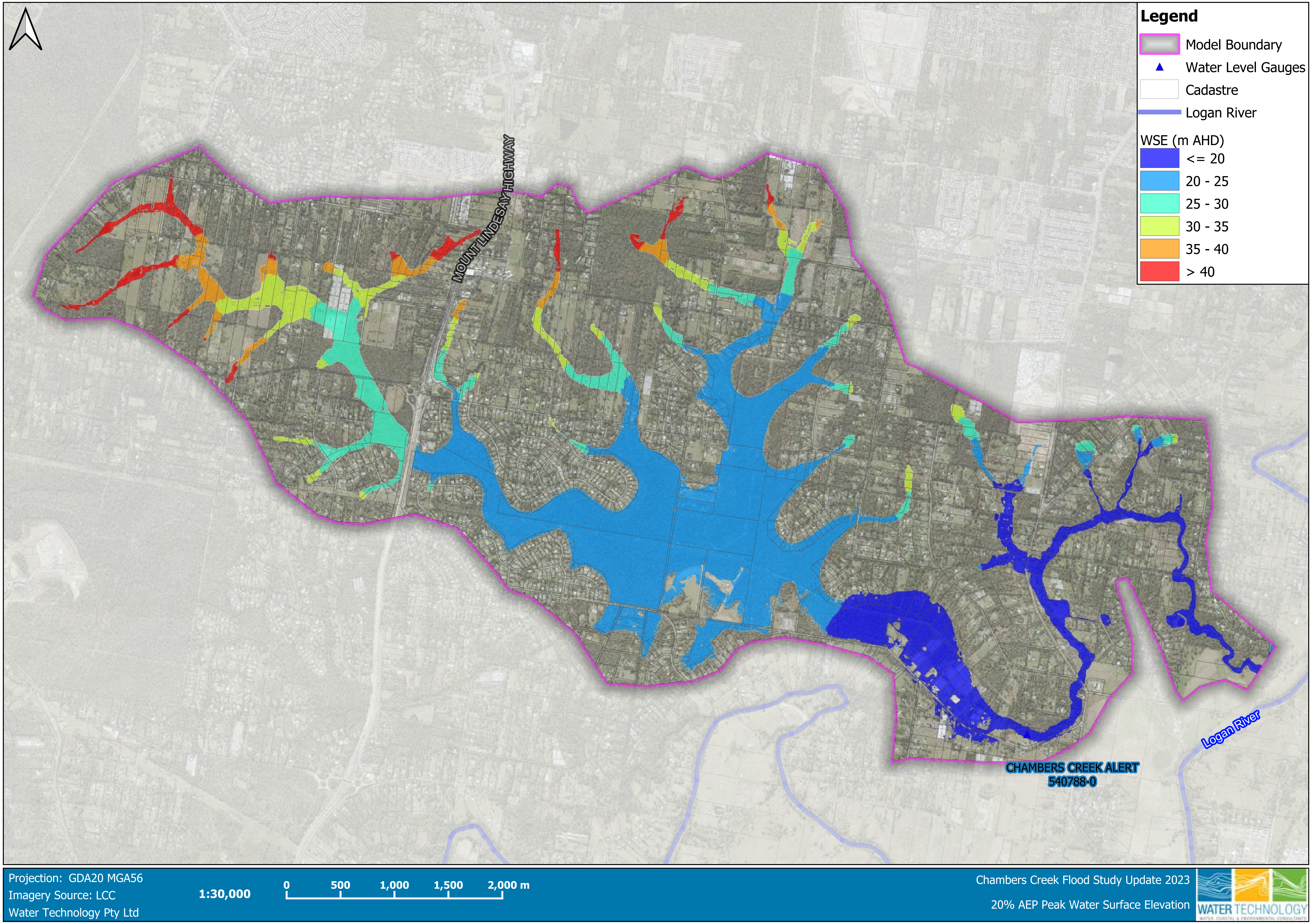
1:30,000

0 500 1,000 1,500 2,000 m

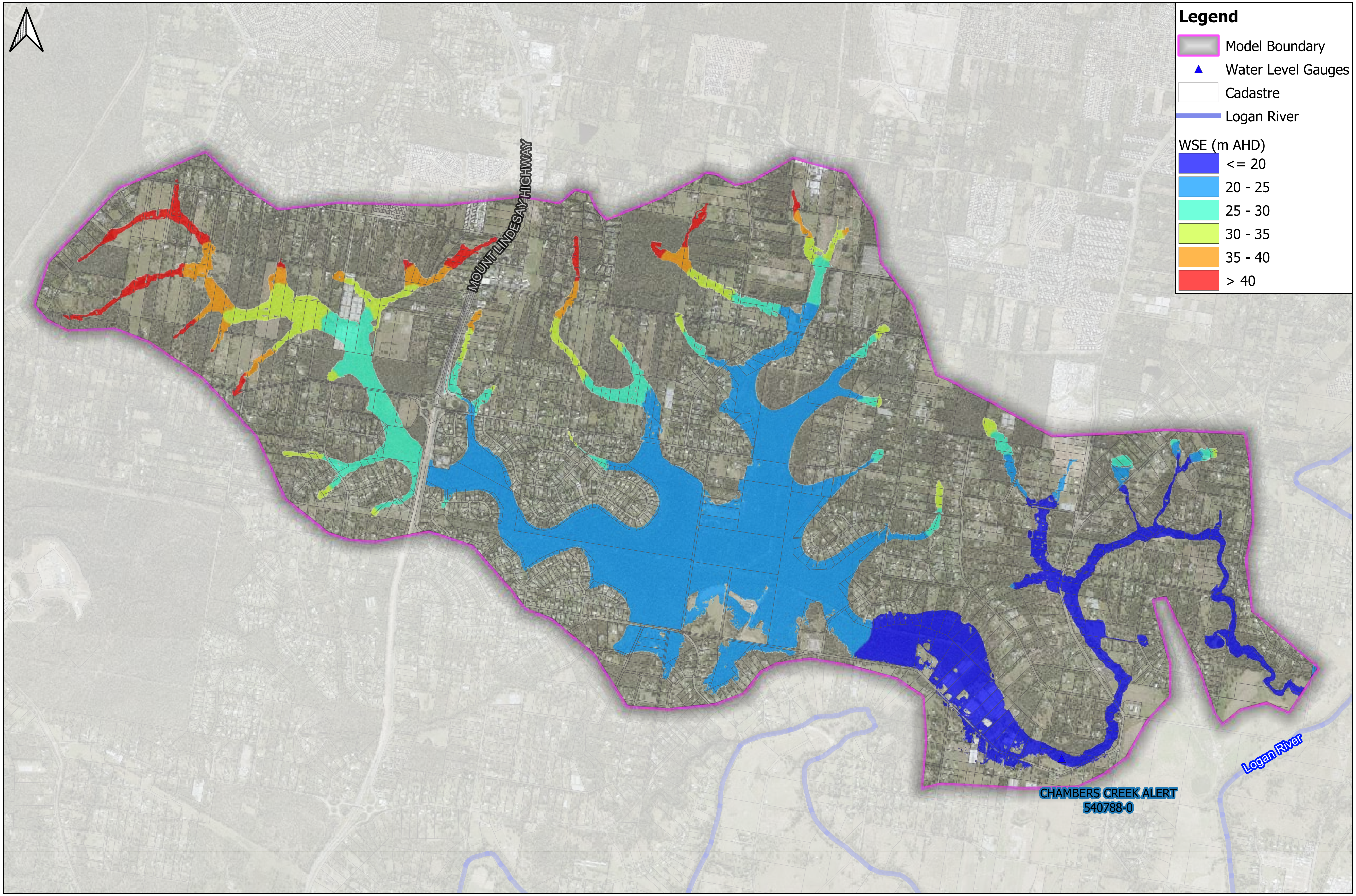
Chambers Creek Flood Study Update 2023

50% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
WSE (m AHD)
<= 20
20 - 25
25 - 30
30 - 35
35 - 40
> 40
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0
500
1,000
1,500
2,000 m
Chambers Creek Flood Study Update 2023
20% AEP Peak Water Surface Elevation
WATER TECHNOLOGY

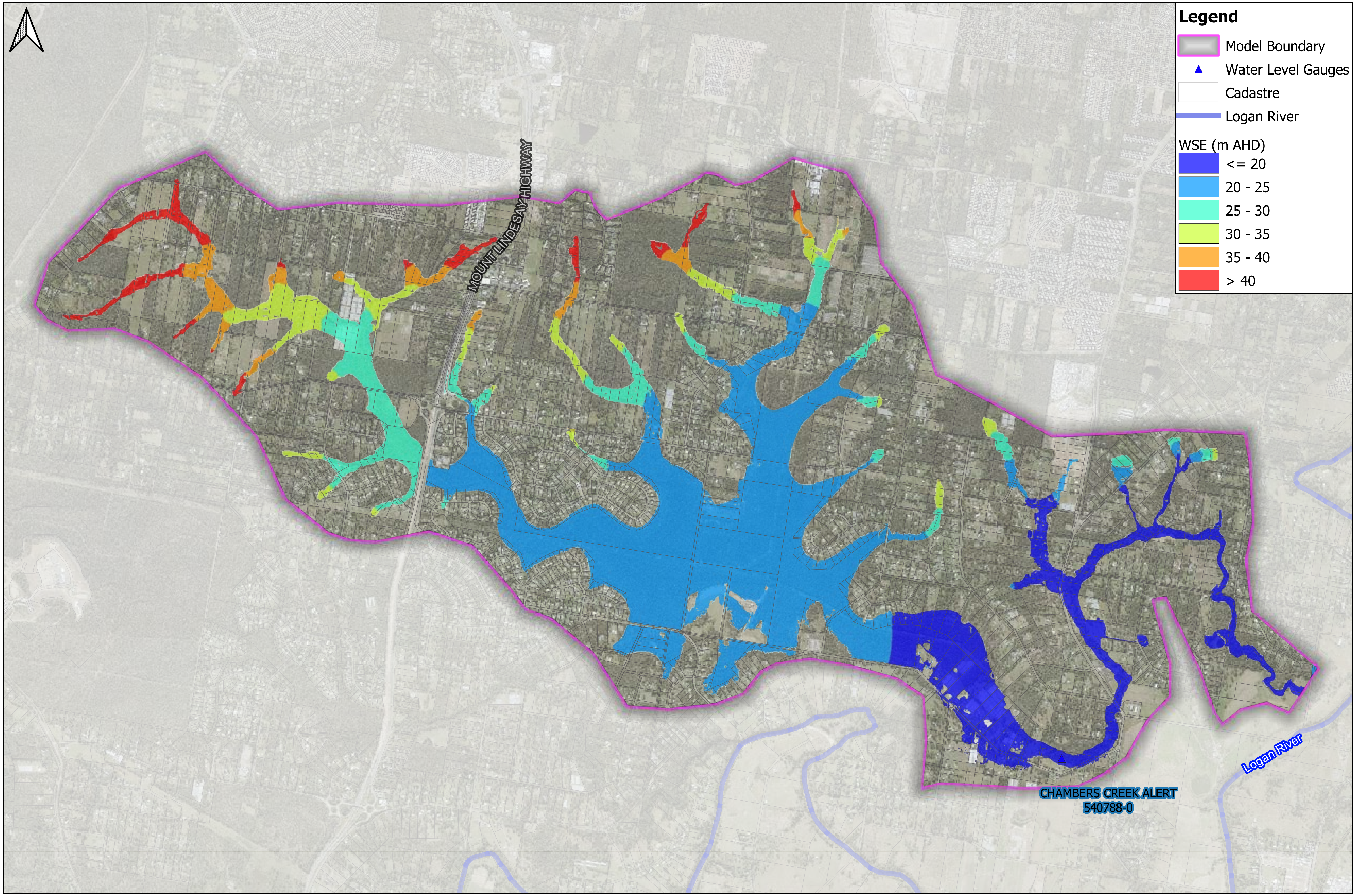


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

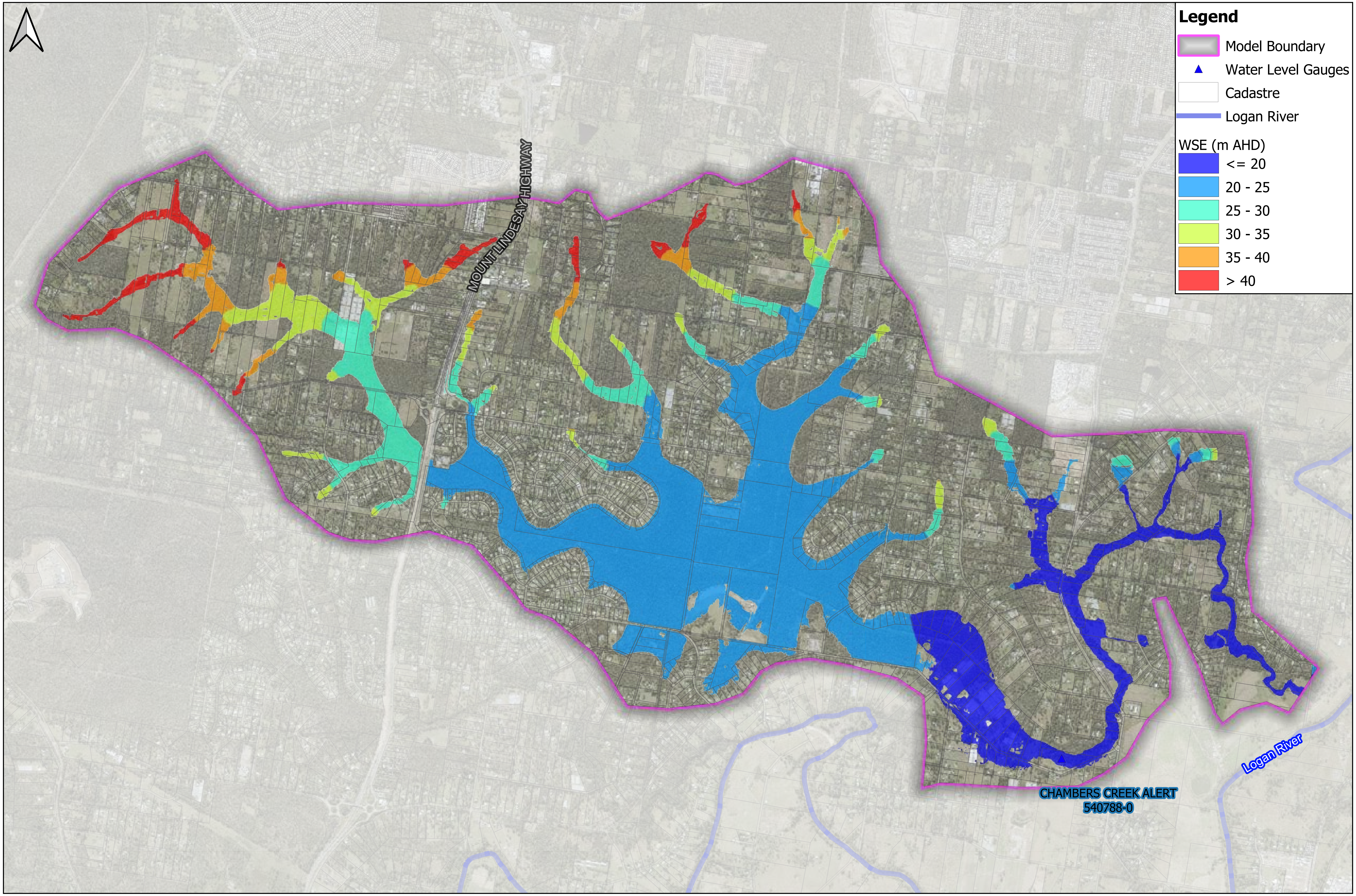
Chambers Creek Flood Study Update 2023
20% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000

Chambers Creek Flood Study Update 2023
10% AEP Peak Water Surface Elevation



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

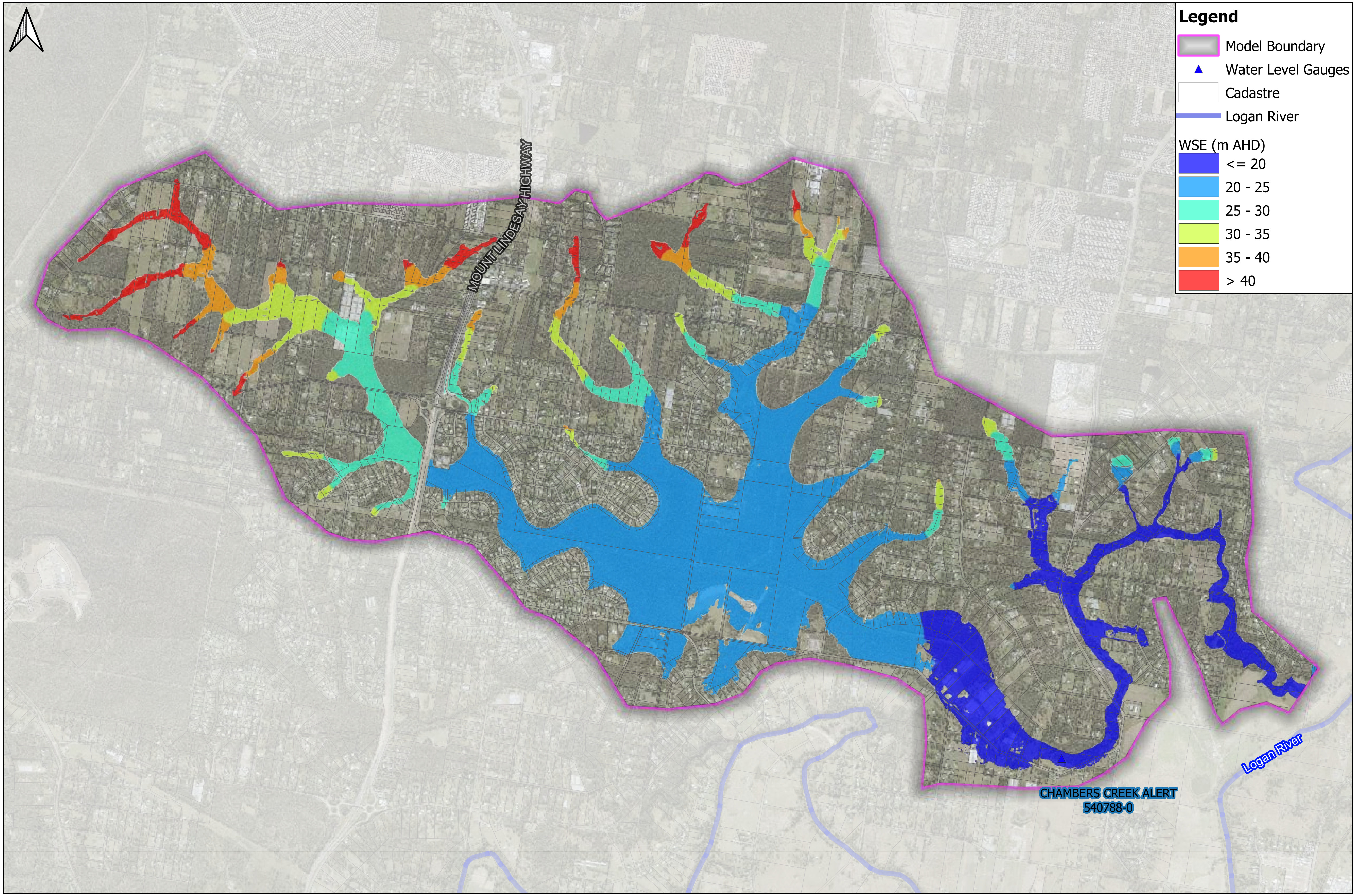
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

10% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



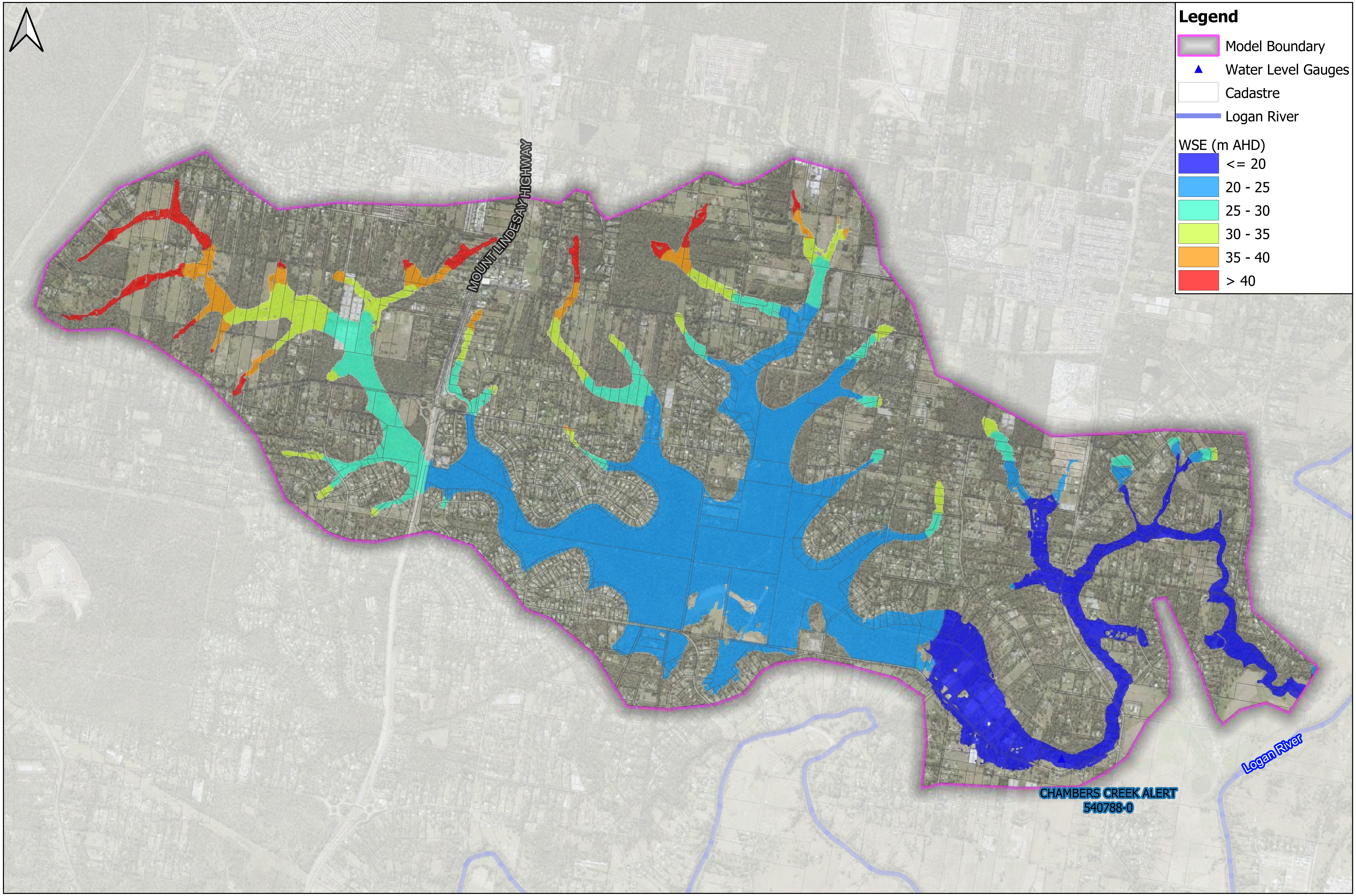
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

5% AEP Peak Water Surface Elevation



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

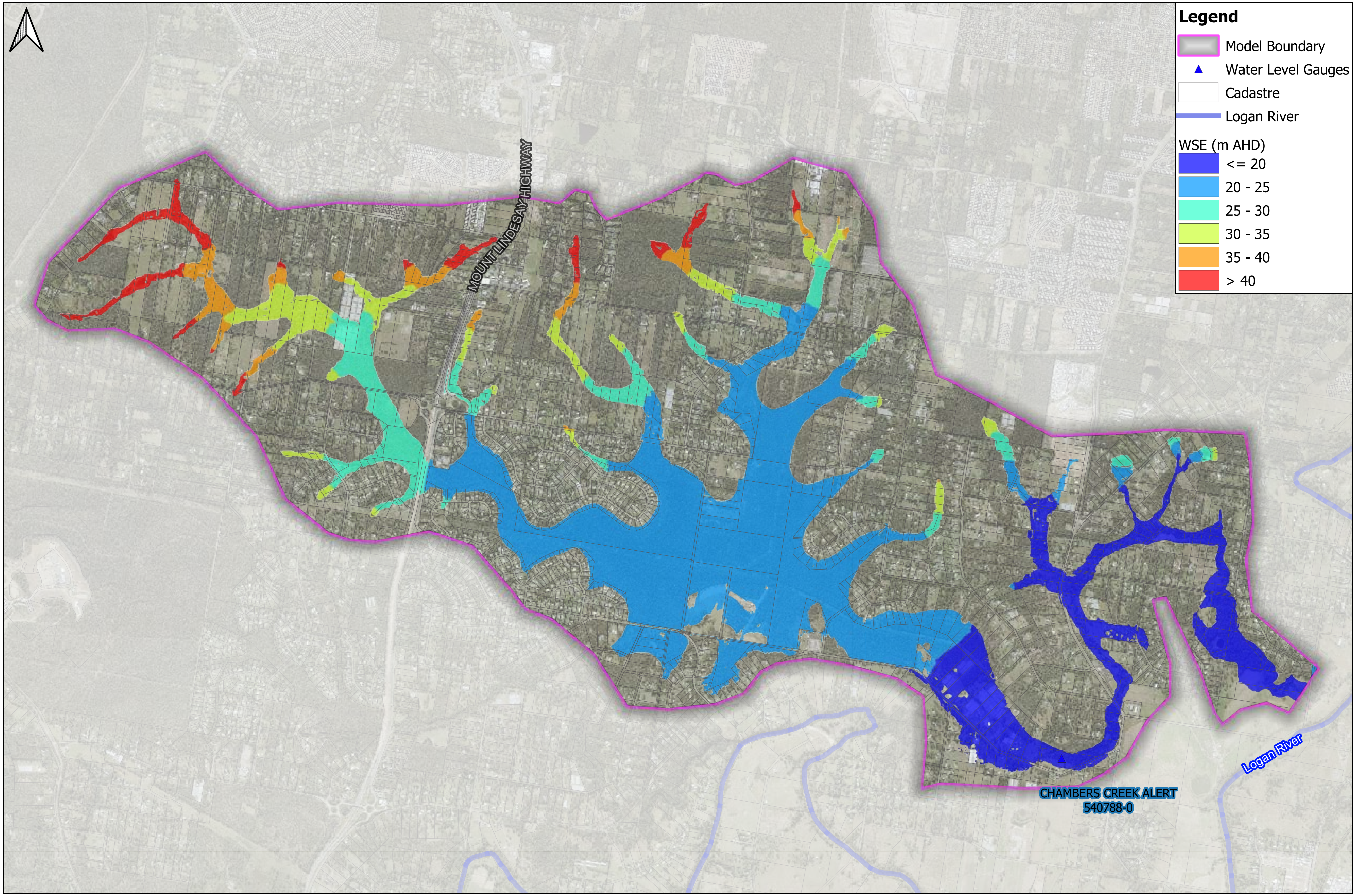
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

5% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

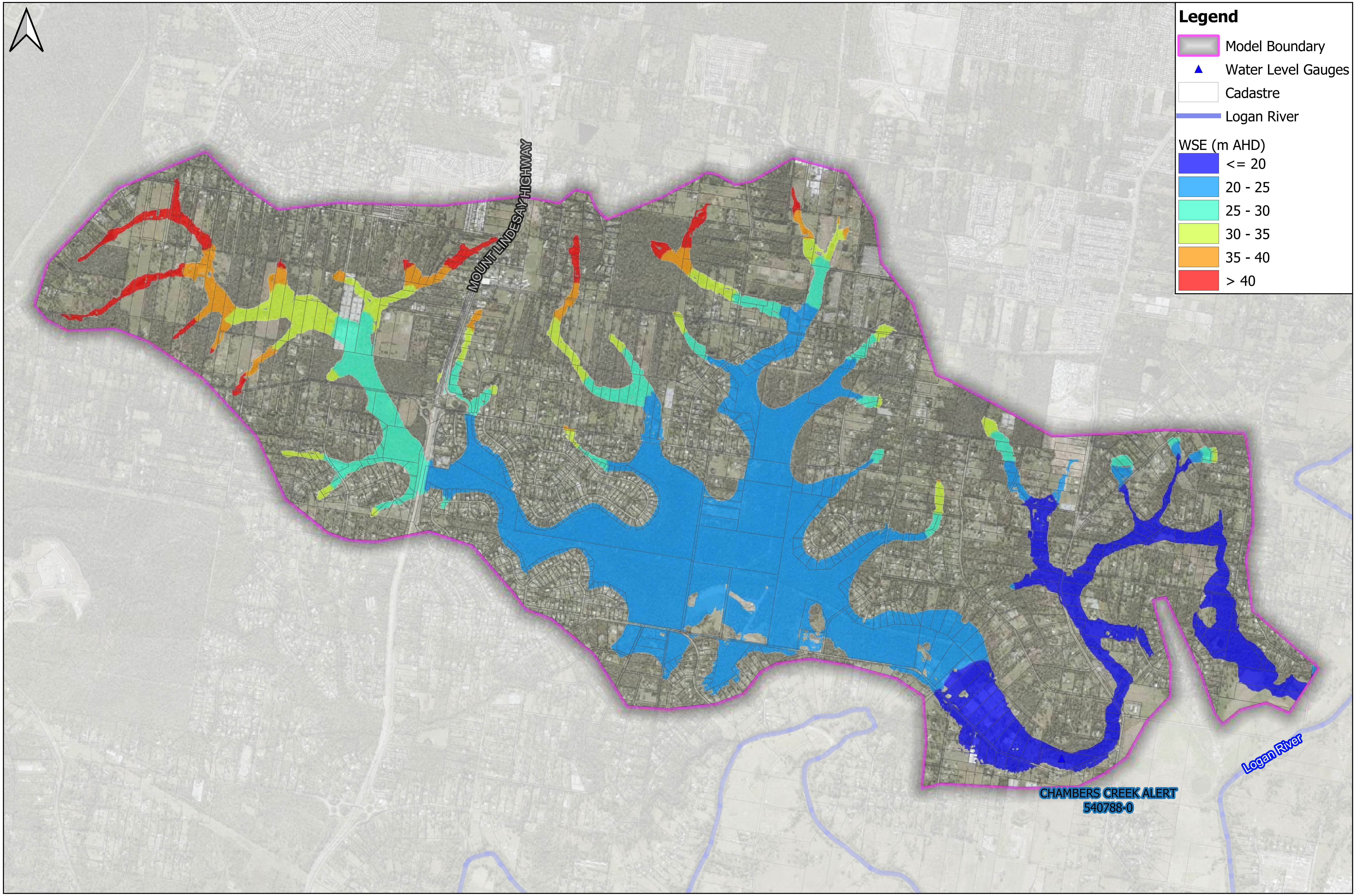
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

2% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



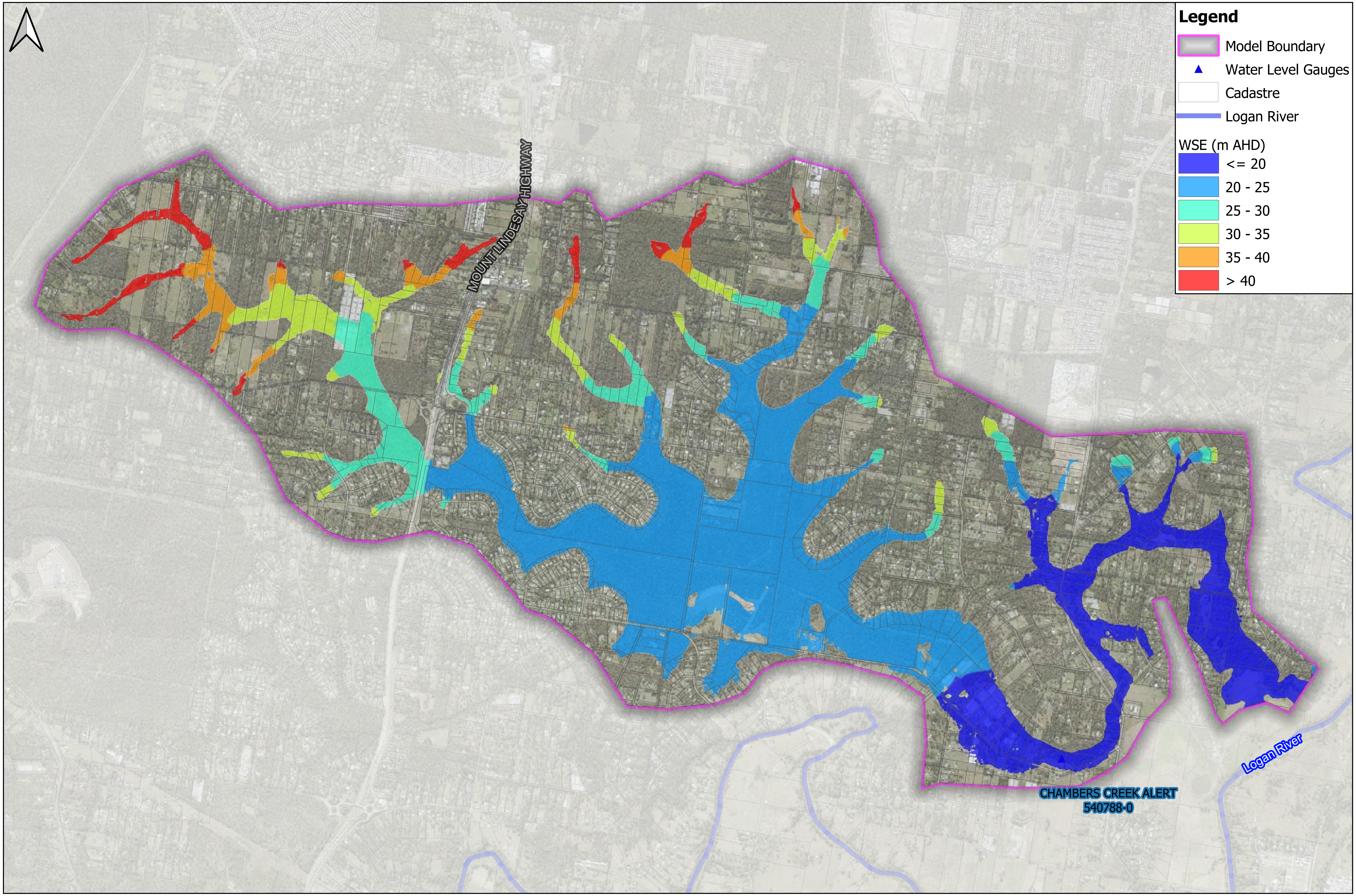
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023
2% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



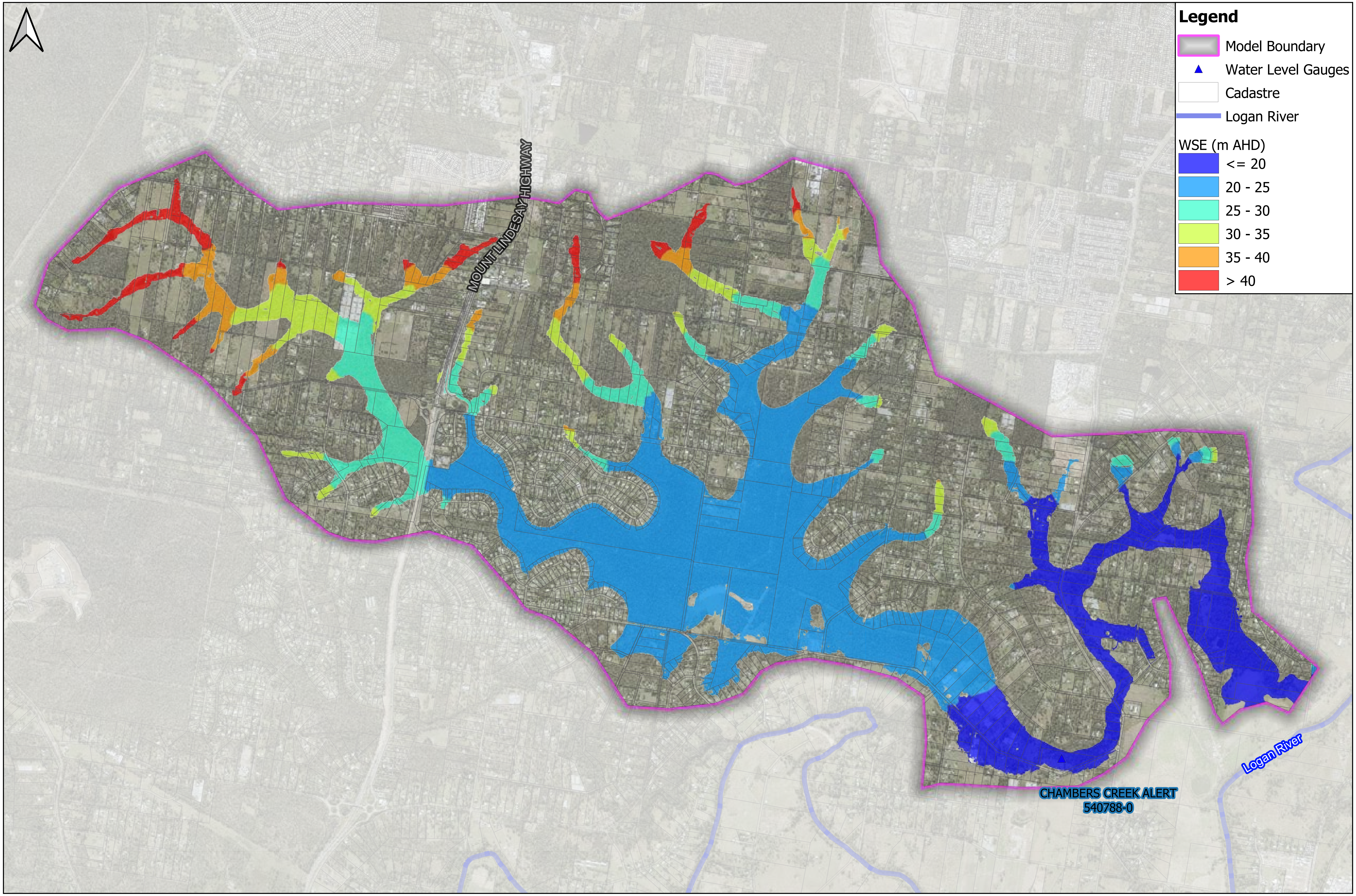
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

1% AEP Peak Water Surface Elevation



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

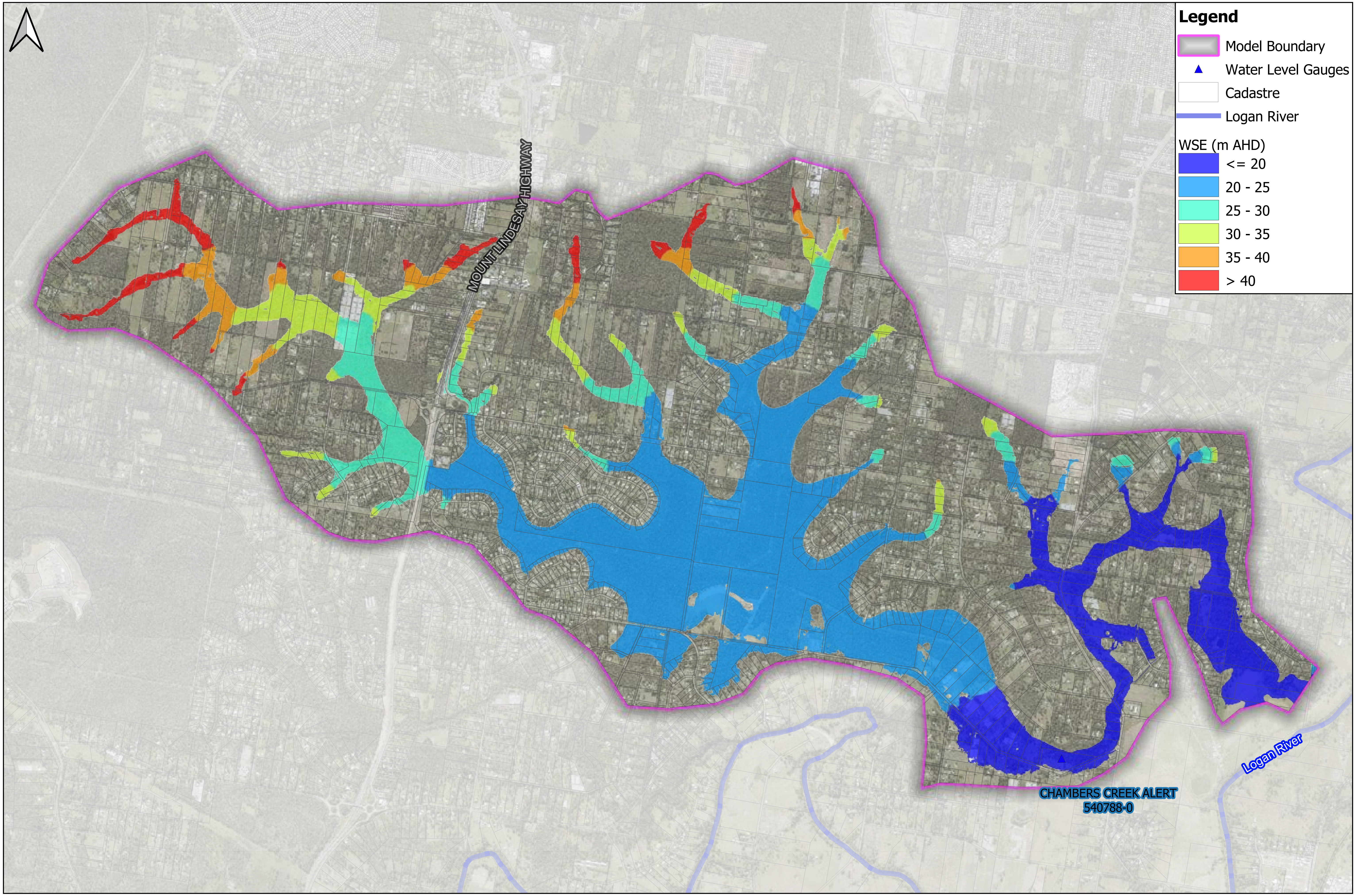
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

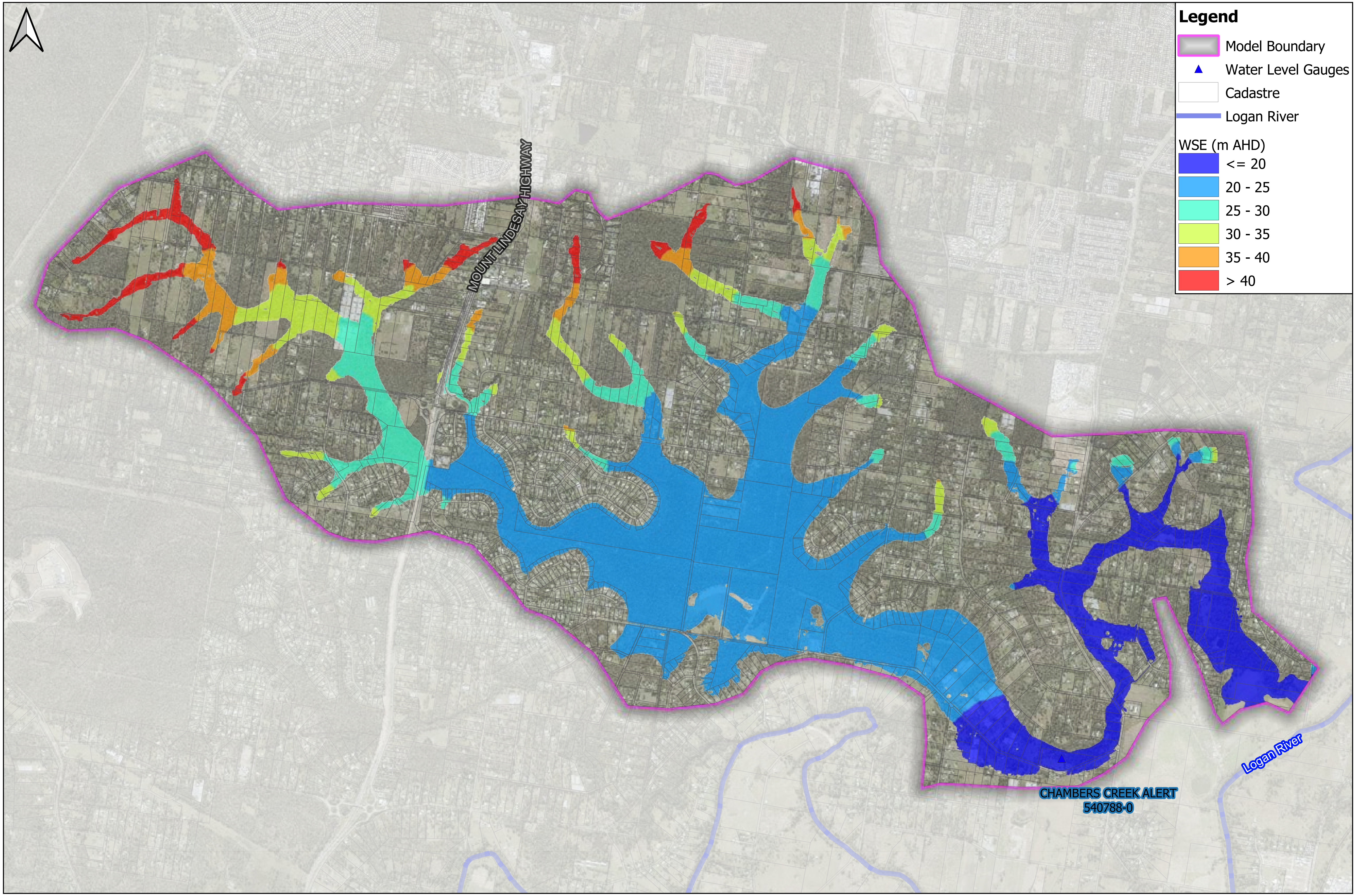
1% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000

Chambers Creek Flood Study Update 2023
0.5% AEP Peak Water Surface Elevation



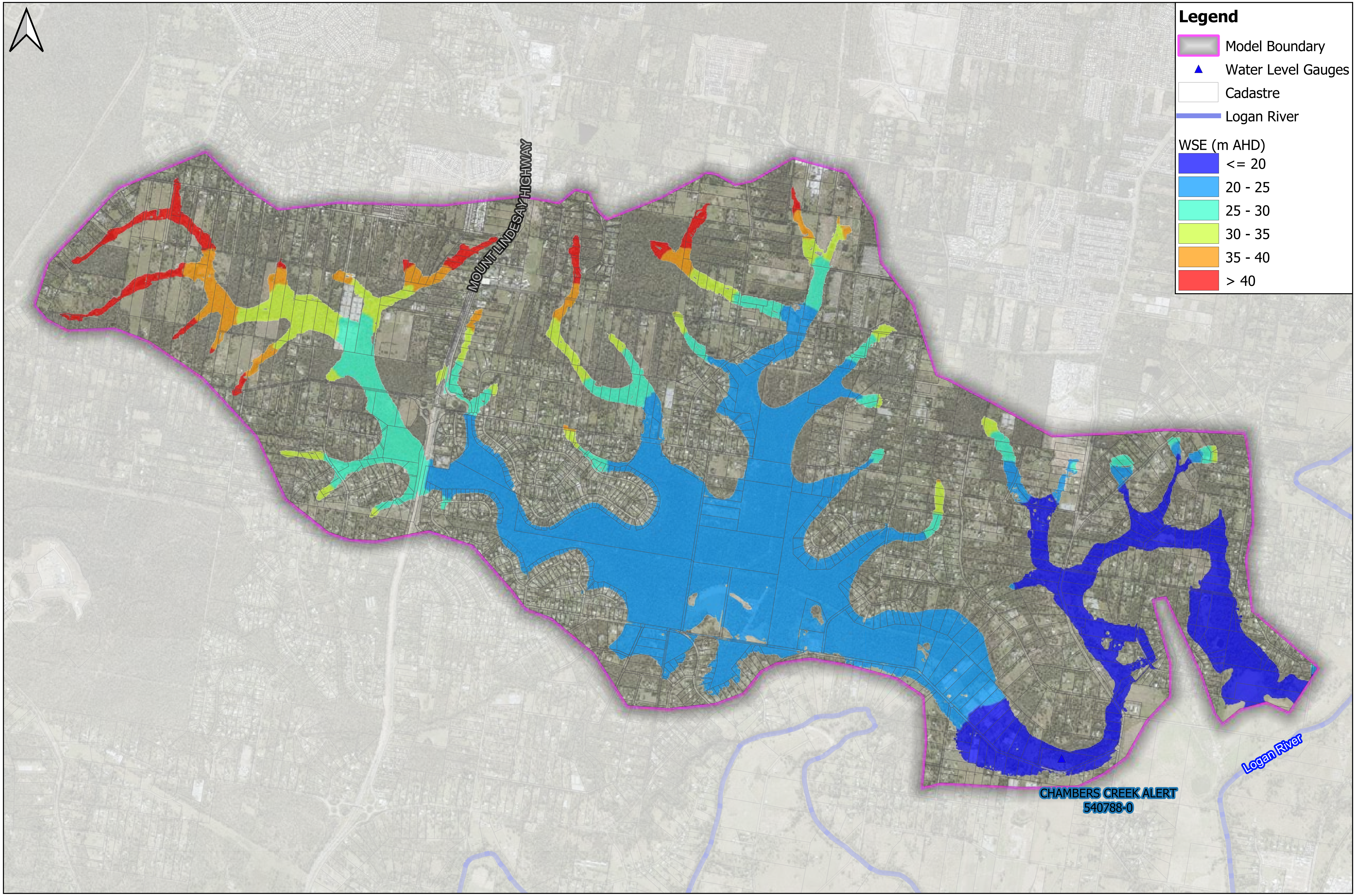
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

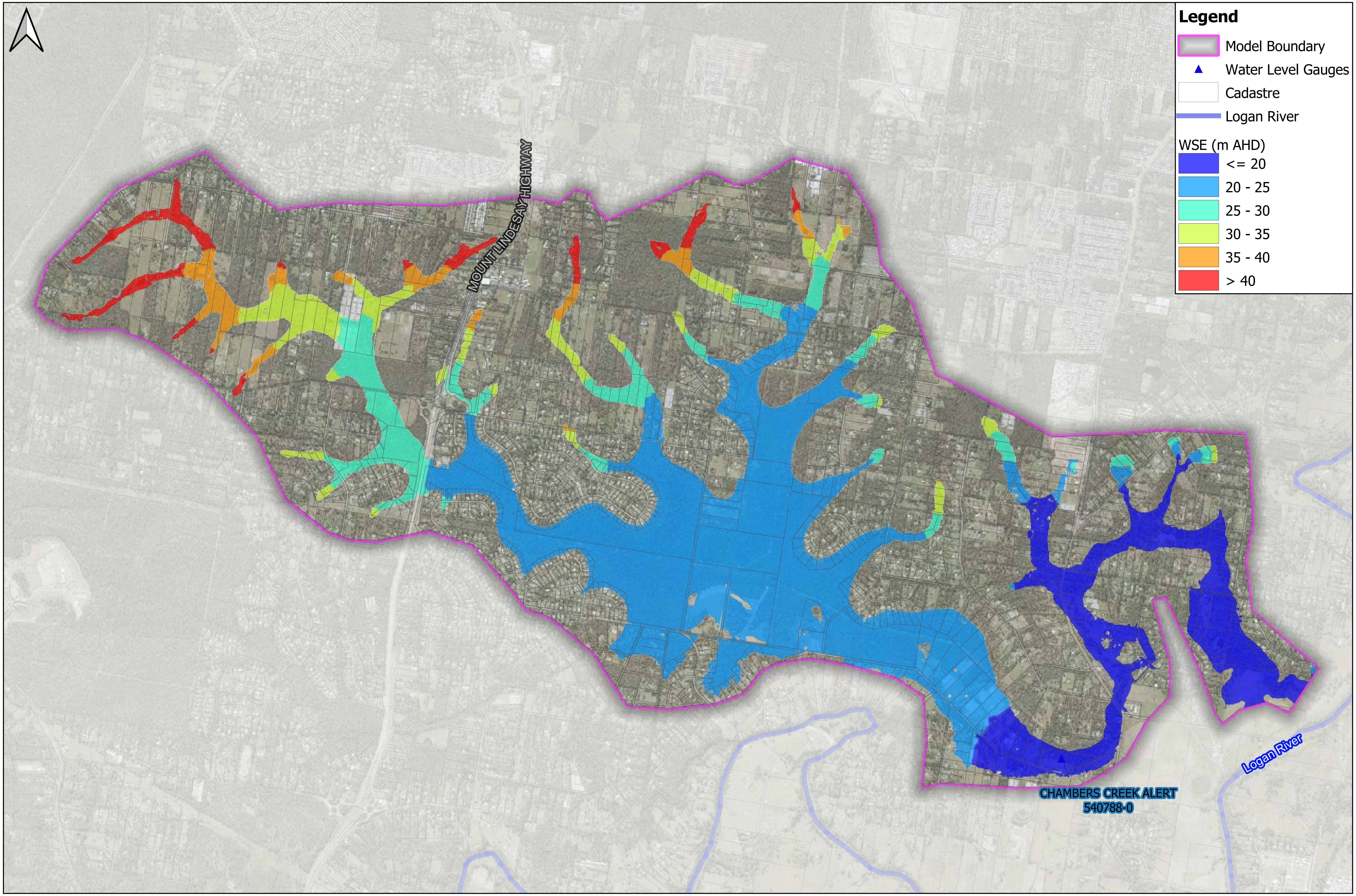
Chambers Creek Flood Study Update 2023

0.5% AEP CC (RCP4.5) Peak Water Surface Elevation



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000

Chambers Creek Flood Study Update 2023
0.2% AEP Peak Water Surface Elevation



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

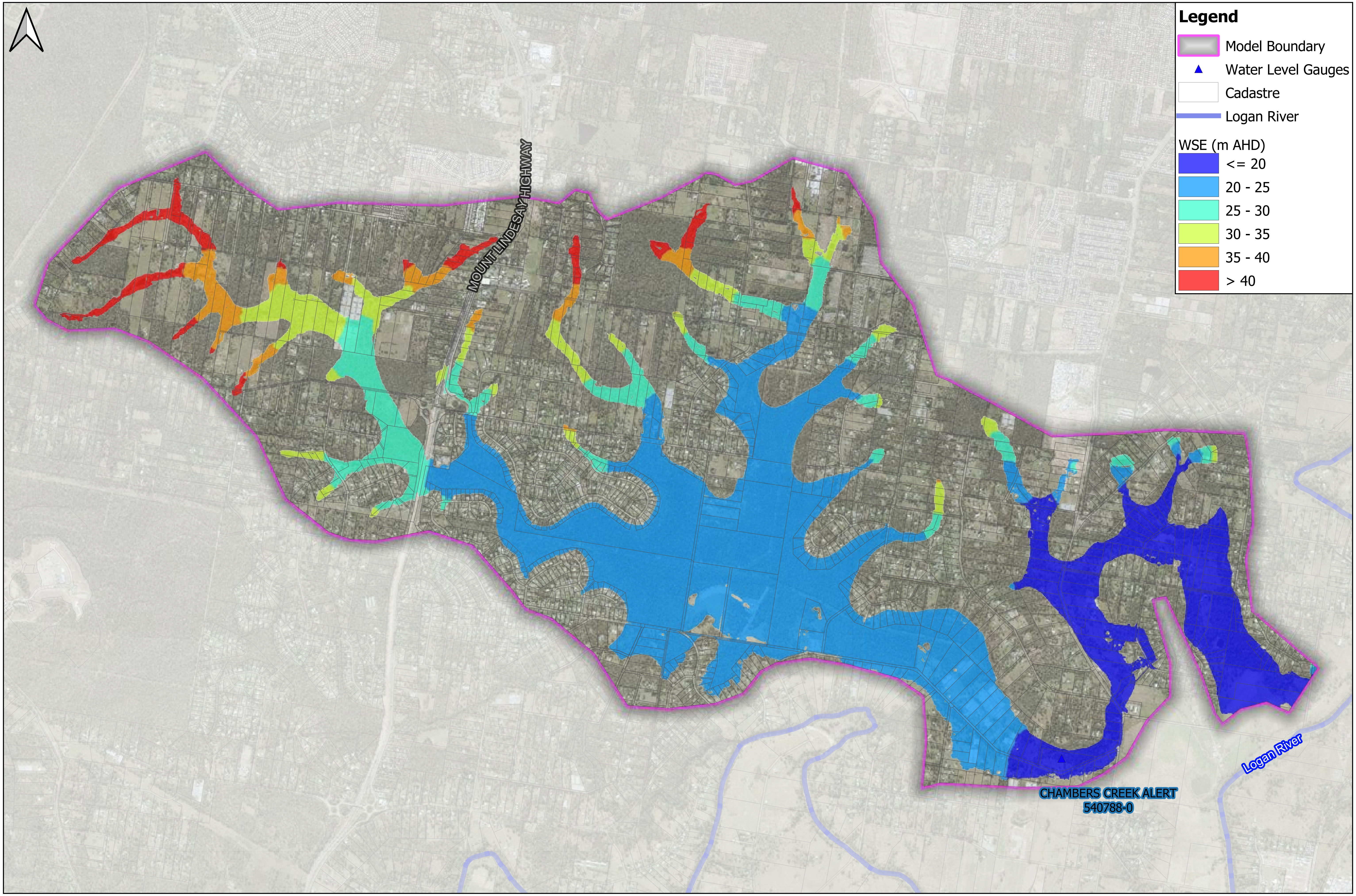
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.2% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY

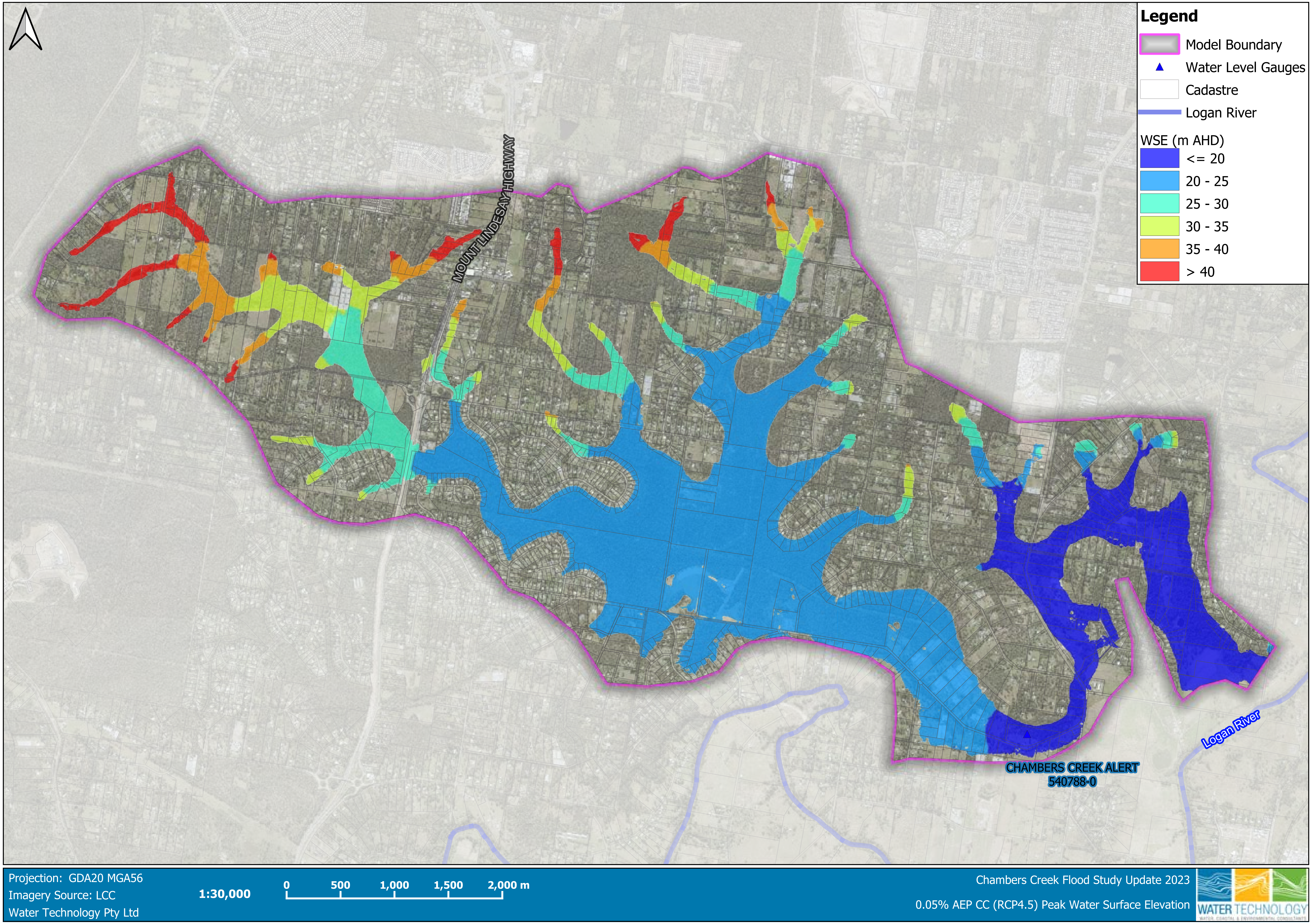


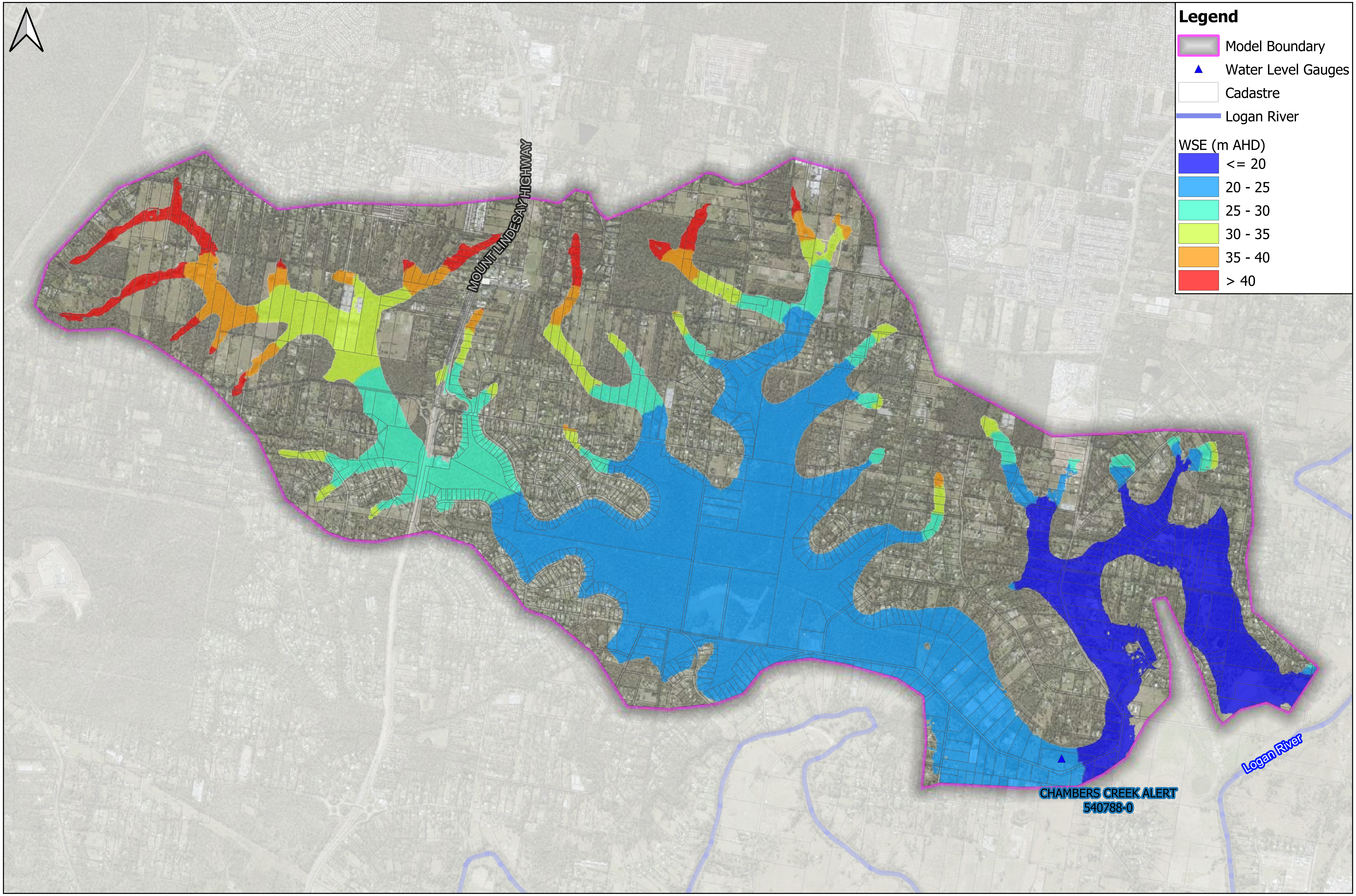
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023
0.05% AEP Peak Water Surface Elevation


Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
WSE (m AHD)
<= 20
20 - 25
25 - 30
30 - 35
35 - 40
> 40
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0
500
1,000
1,500
2,000 m
Chambers Creek Flood Study Update 2023
0.05% AEP CC (RCP4.5) Peak Water Surface Elevation
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

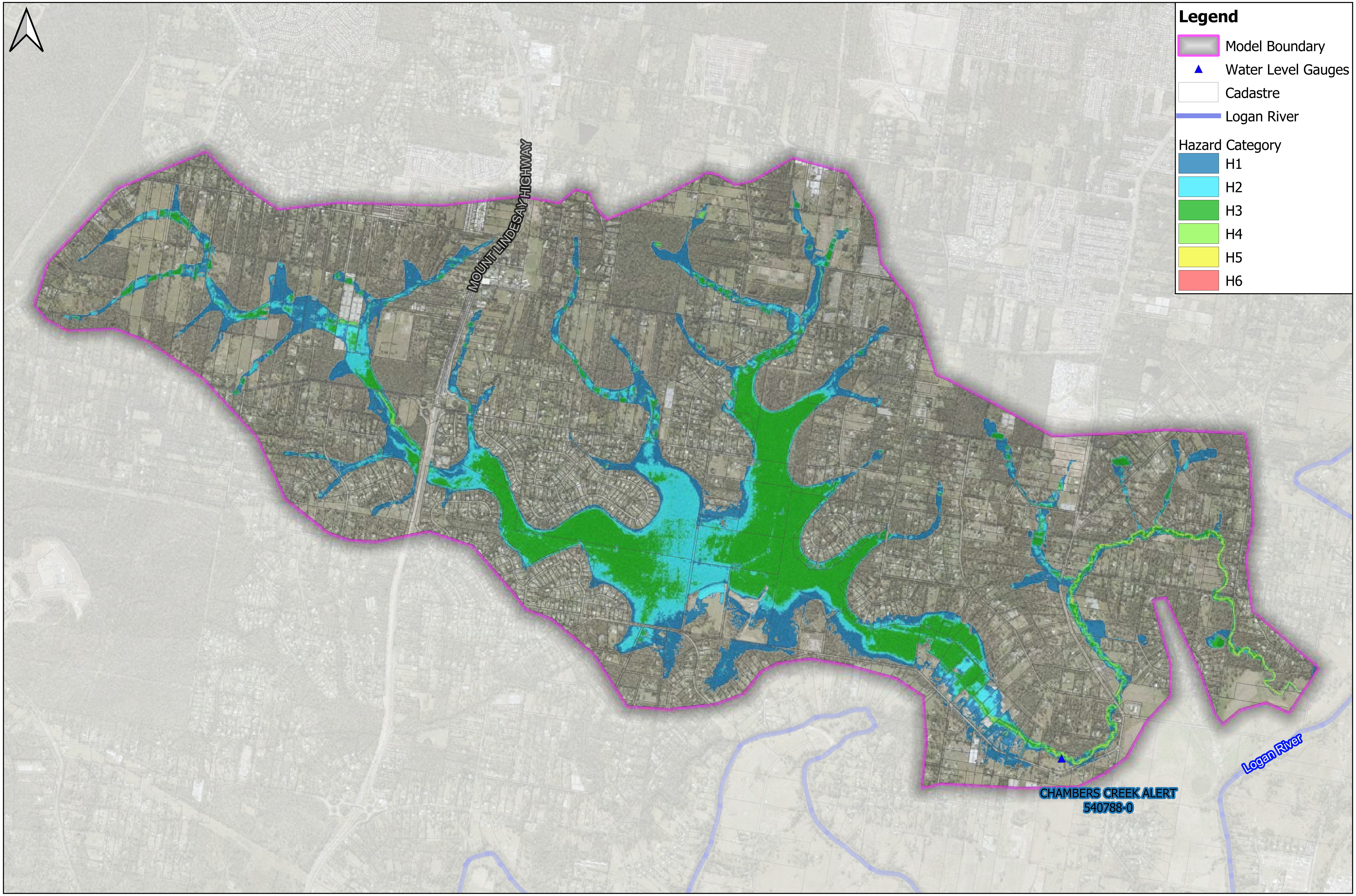
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

PMF Peak Water Surface Elevation

WATER TECHNOLOGY

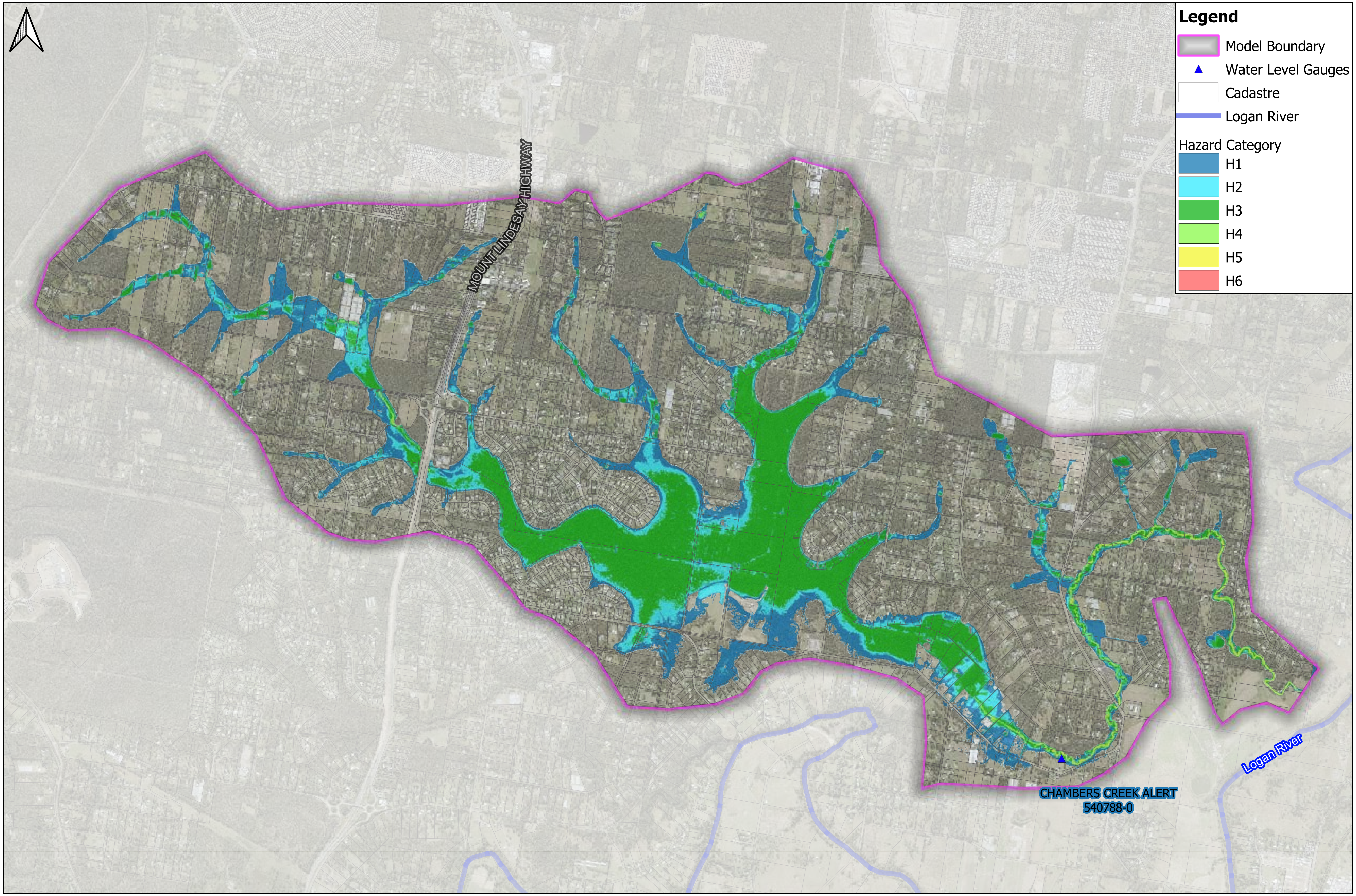


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

50% AEP Peak Water Hazard Category



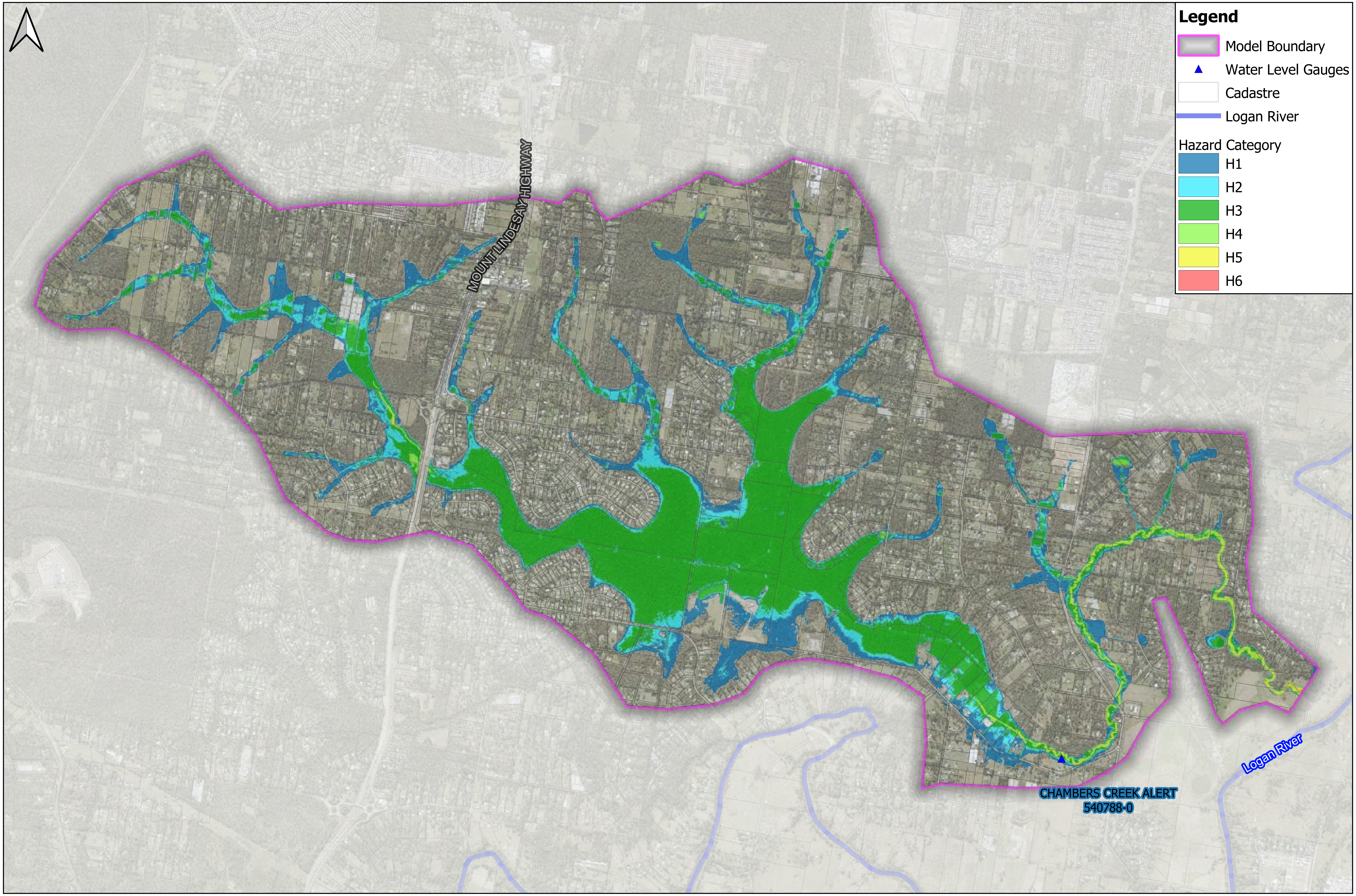
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

50% AEP CC (RCP4.5) Peak Water Hazard Category

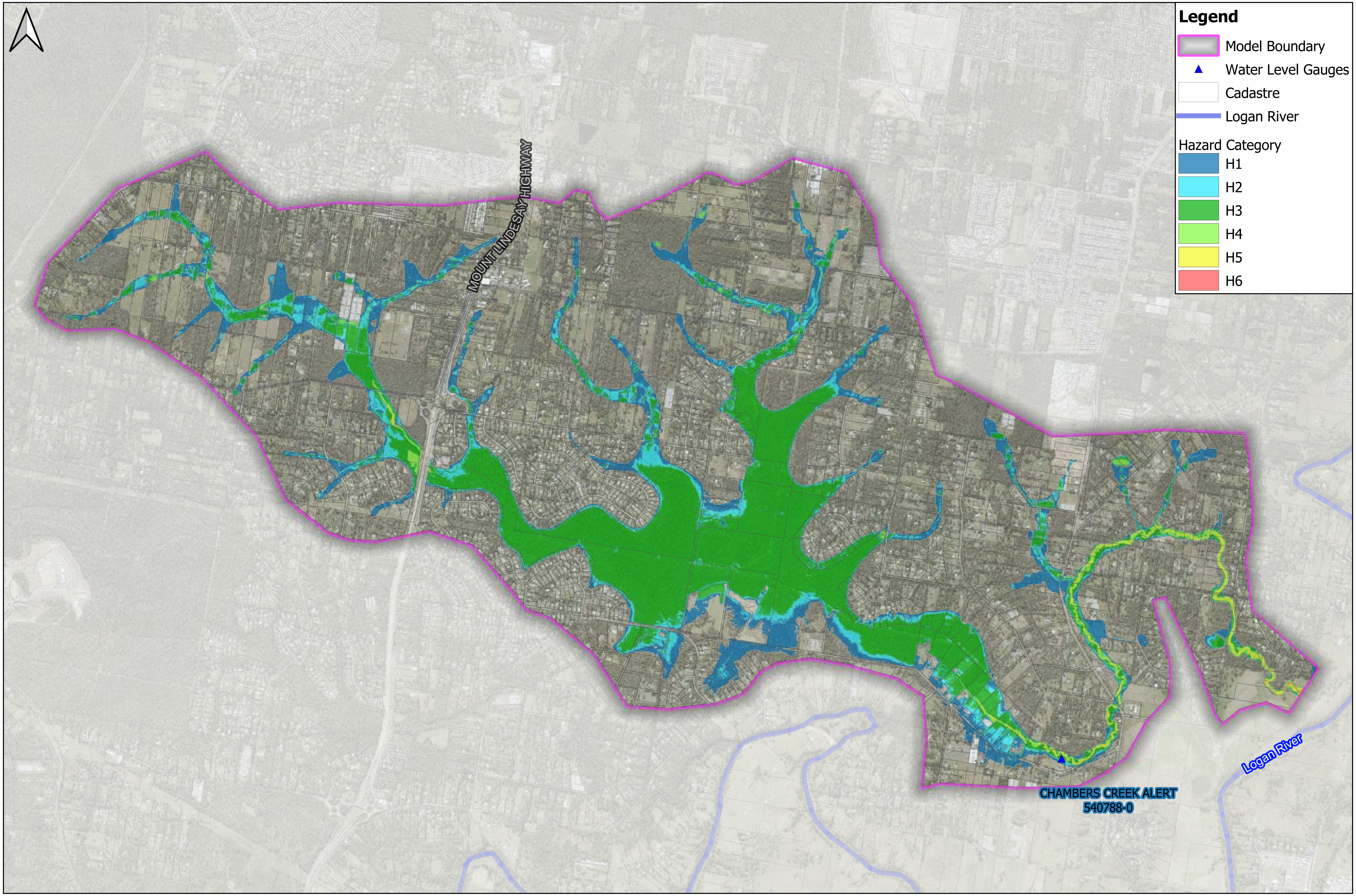


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023
20% AEP Peak Water Hazard Category

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

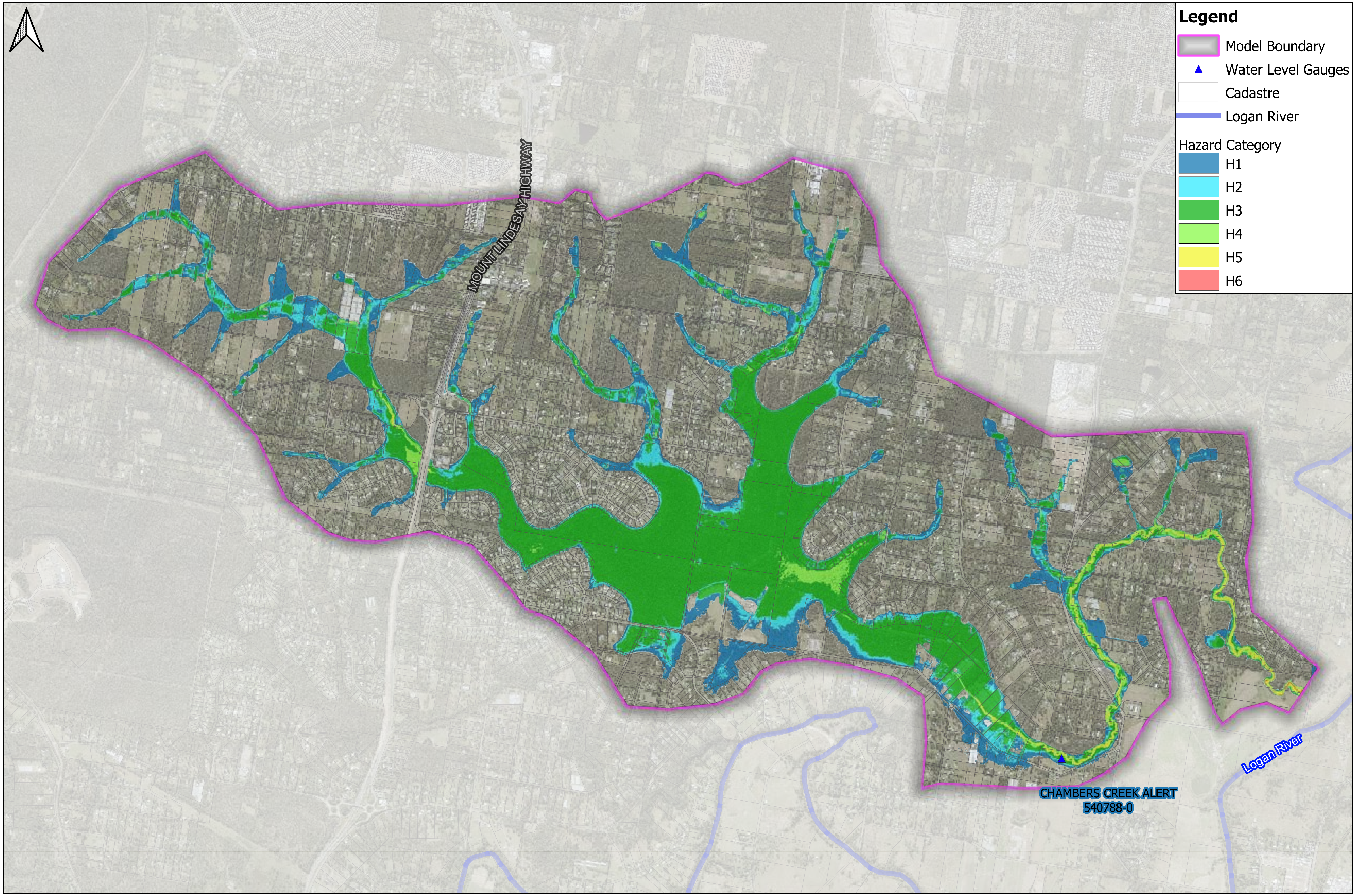
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

20% AEP CC (RCP4.5) Peak Water Hazard Category

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

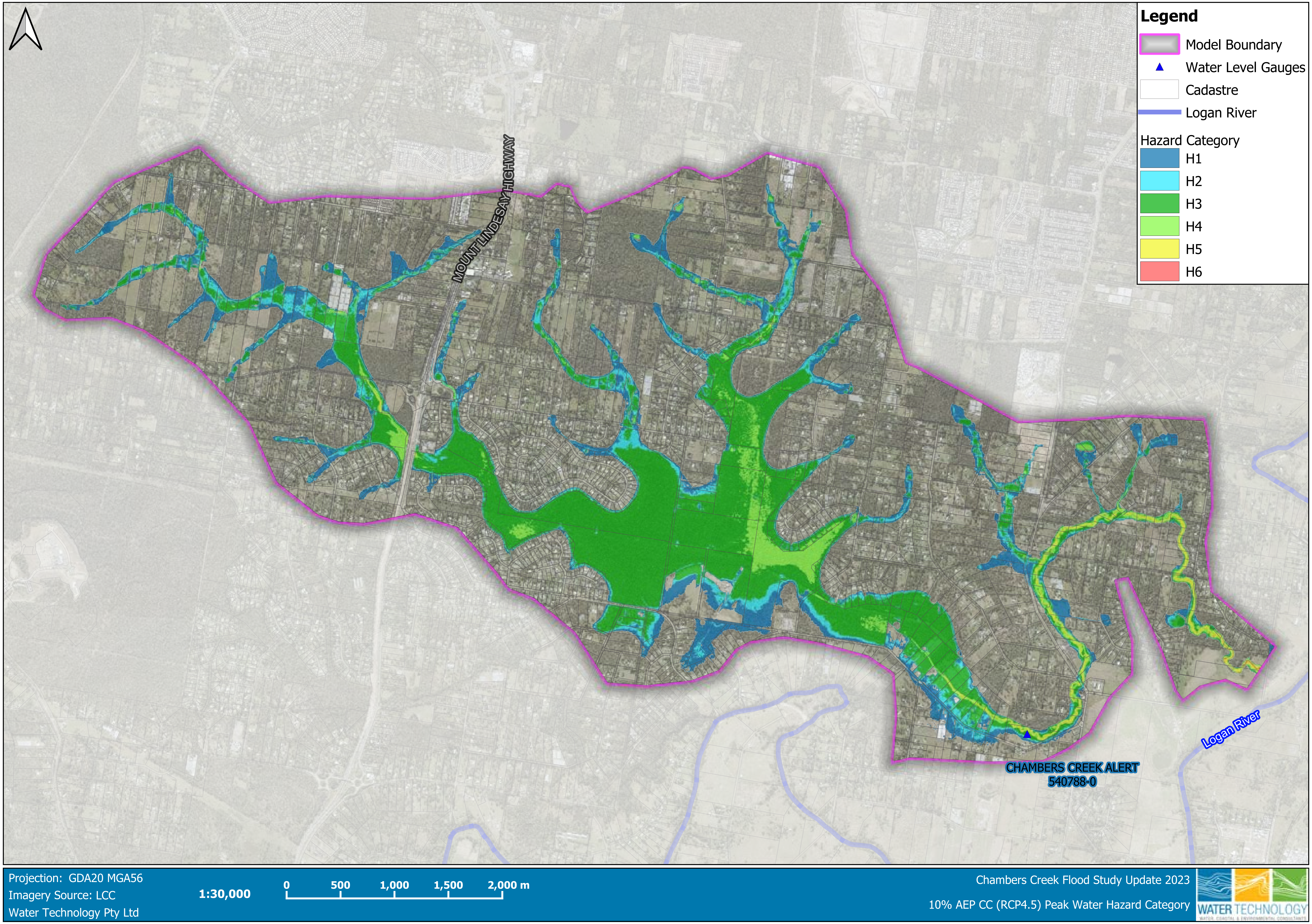
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

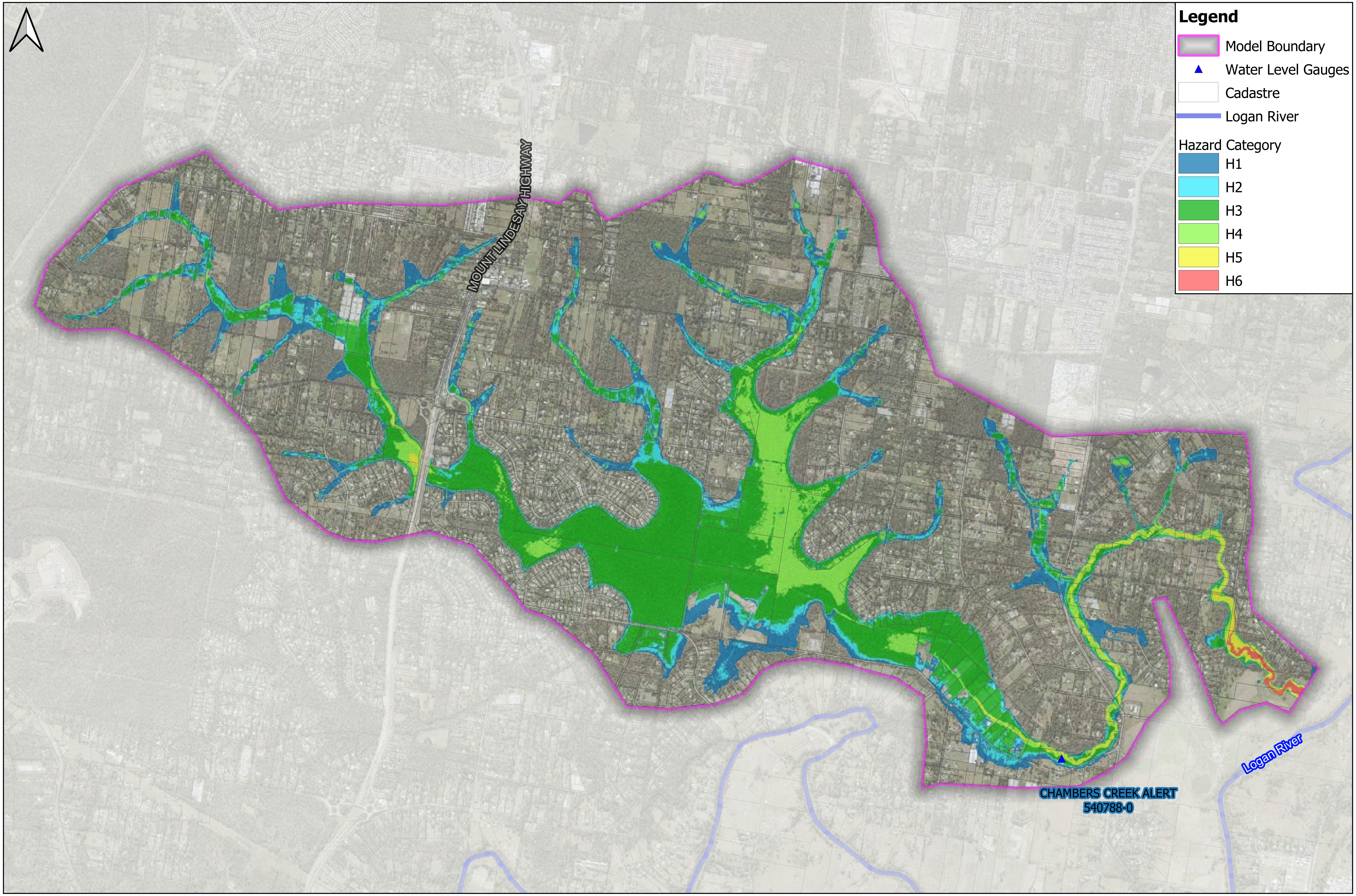
10% AEP Peak Water Hazard Category

WATER TECHNOLOGY



Chambers Creek Flood Study Update 2023

10% AEP CC (RCP4.5) Peak Water Hazard Category



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

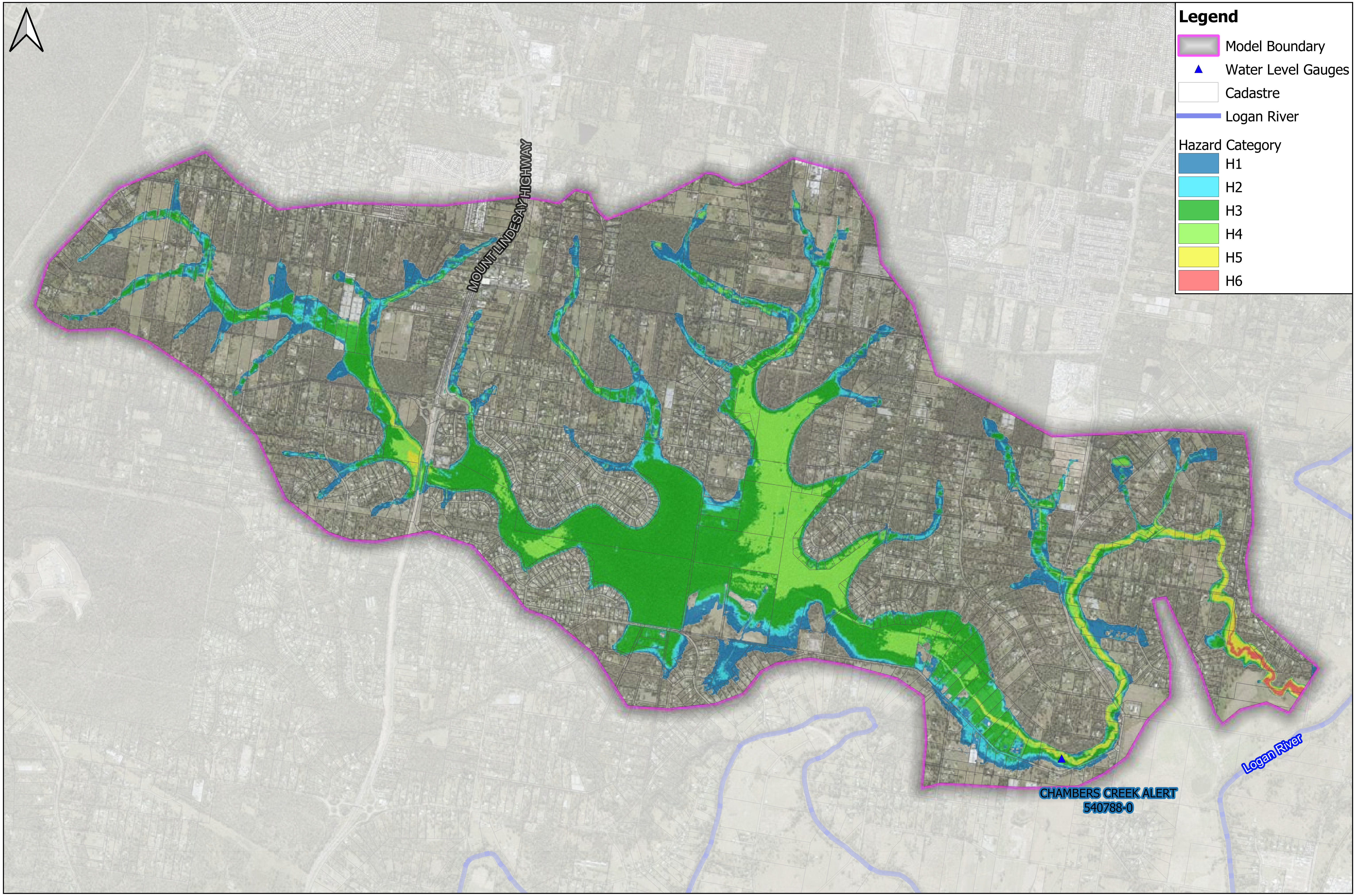
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

5% AEP Peak Water Hazard Category

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

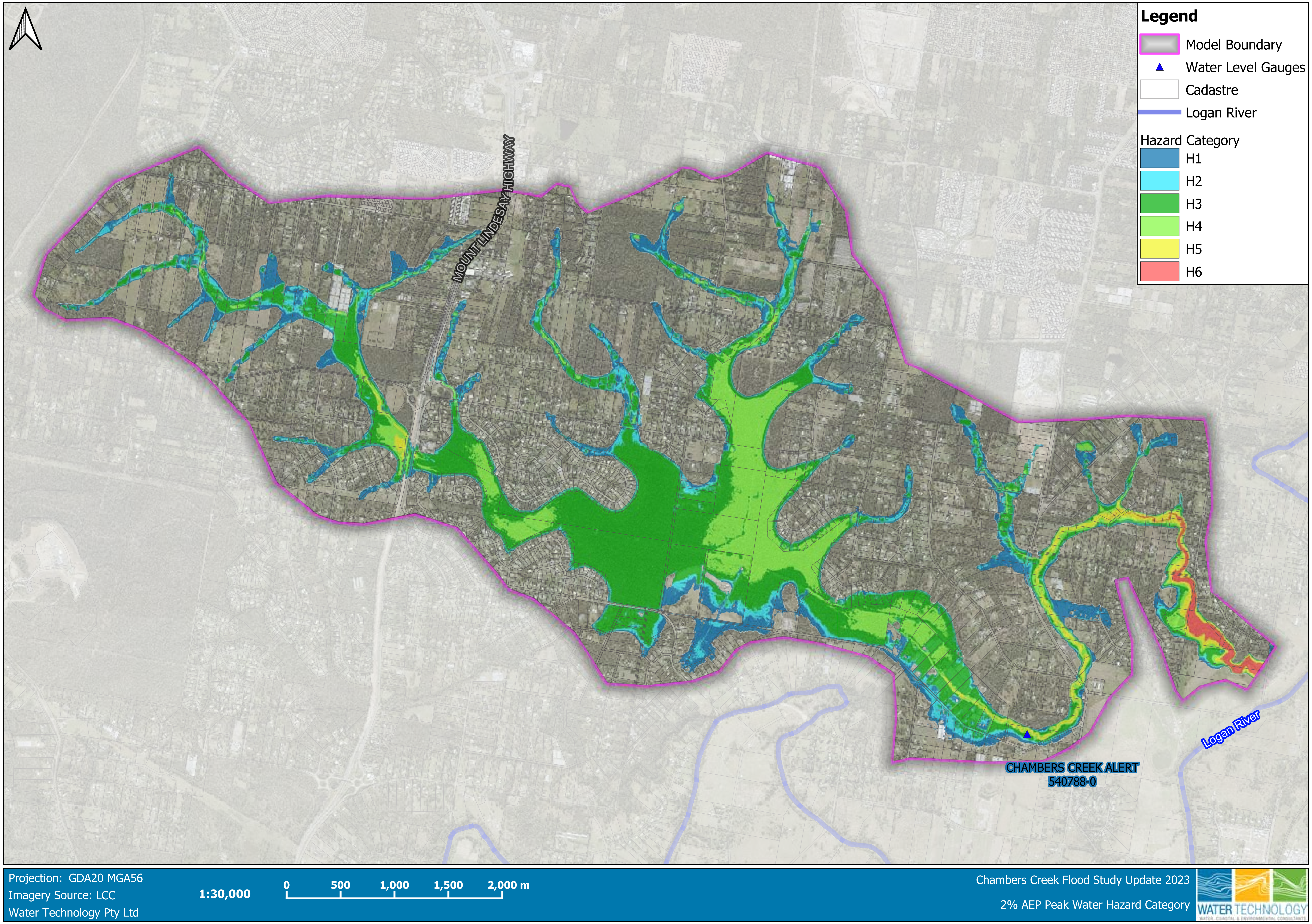
1:30,000

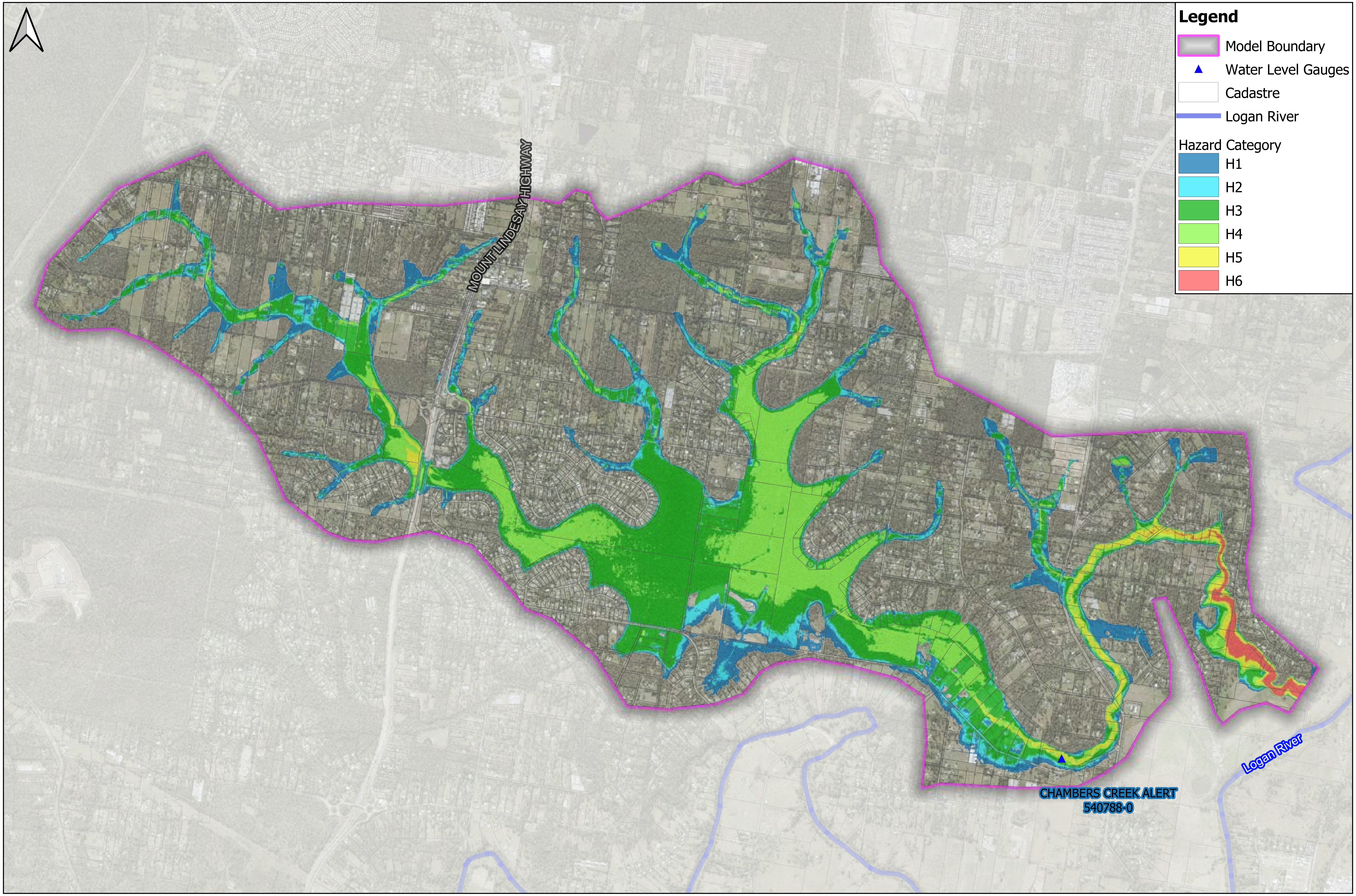
0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

5% AEP CC (RCP4.5) Peak Water Hazard Category

WATER TECHNOLOGY


Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Hazard Category
H1
H2
H3
H4
H5
H6
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0
500
1,000
1,500
2,000 m
Chambers Creek Flood Study Update 2023
2% AEP Peak Water Hazard Category
WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

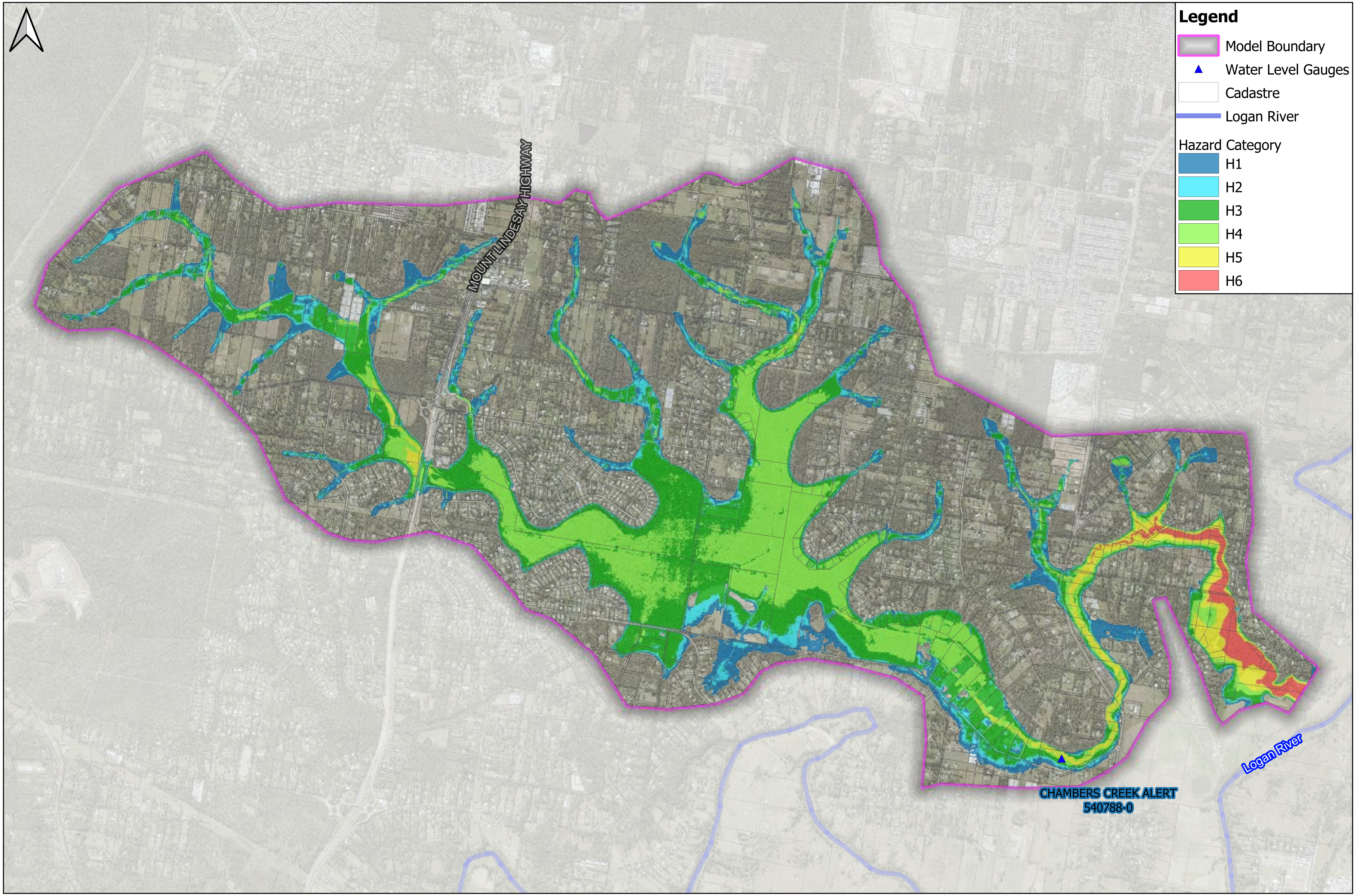
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

2% AEP CC (RCP4.5) Peak Water Hazard Category

WATER TECHNOLOGY



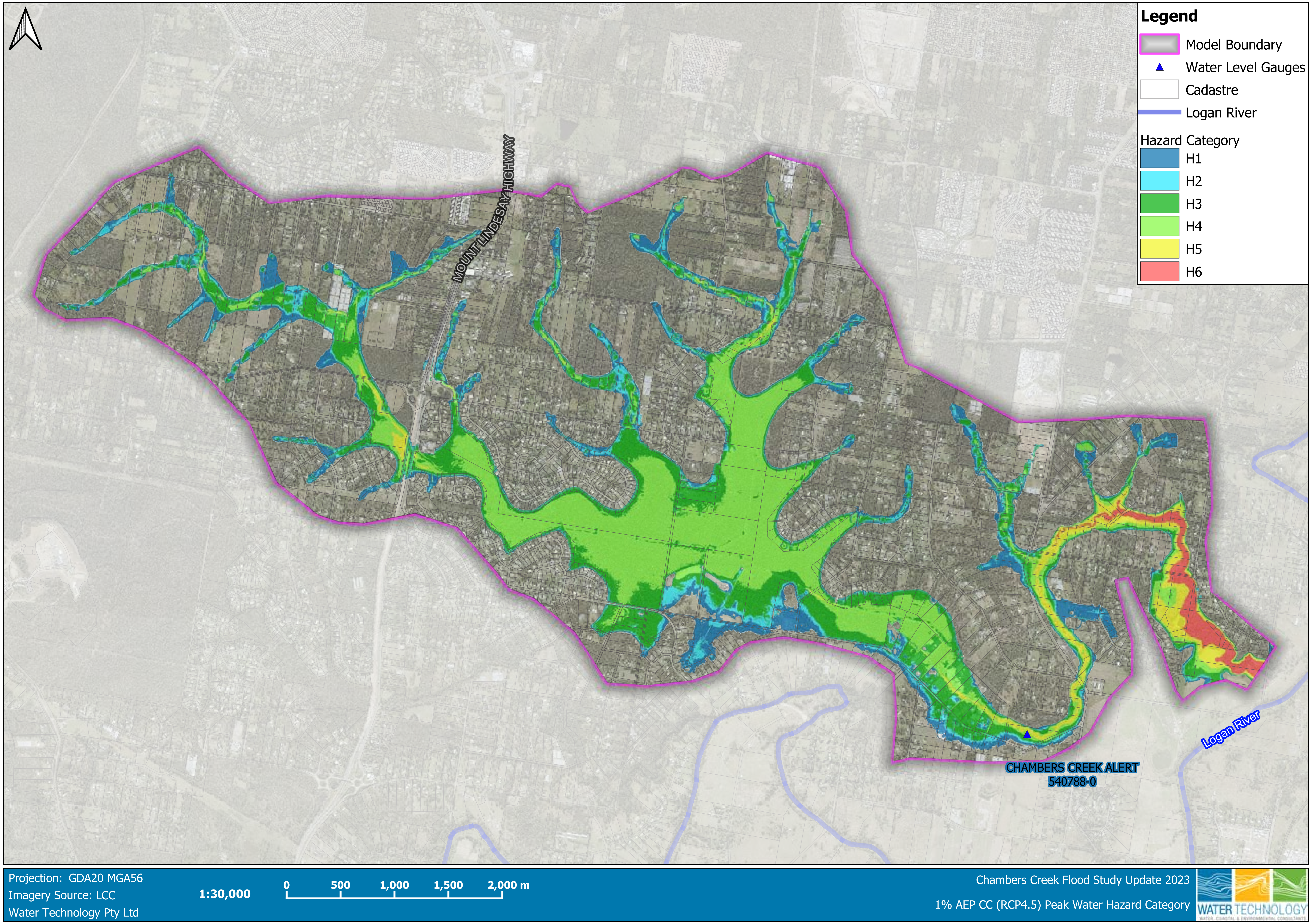
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

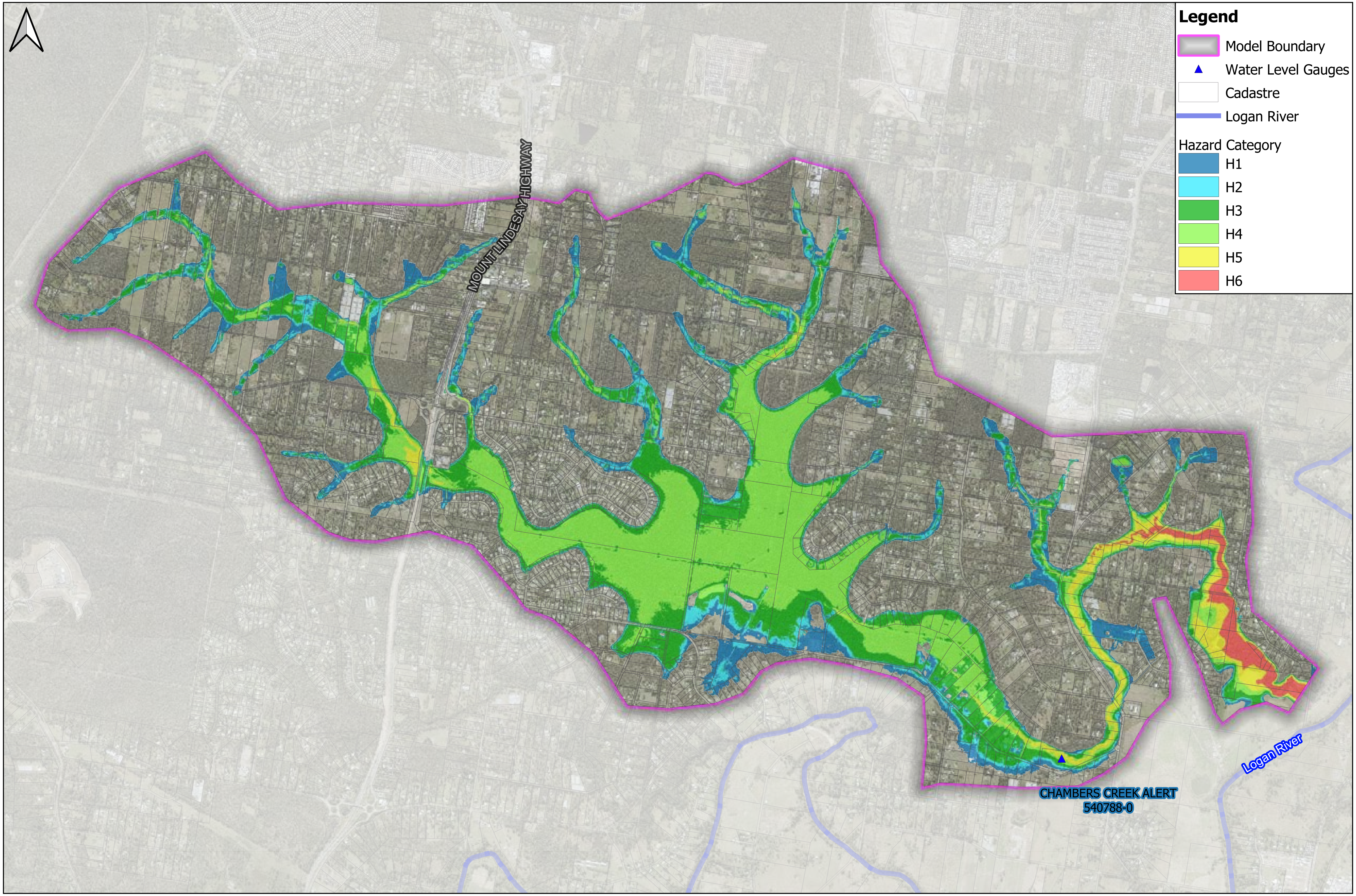
0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

1% AEP Peak Water Hazard Category



Legend
Model Boundary
Water Level Gauges
Cadastre
Logan River
Hazard Category
H1
H2
H3
H4
H5
H6
MOUNT LINDESAY HIGHWAY
CHAMBERS CREEK ALERT
540788-0
Logan River
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:30,000
0
500
1,000
1,500
2,000 m
Chambers Creek Flood Study Update 2023
1% AEP CC (RCP4.5) Peak Water Hazard Category
WATER TECHNOLOGY



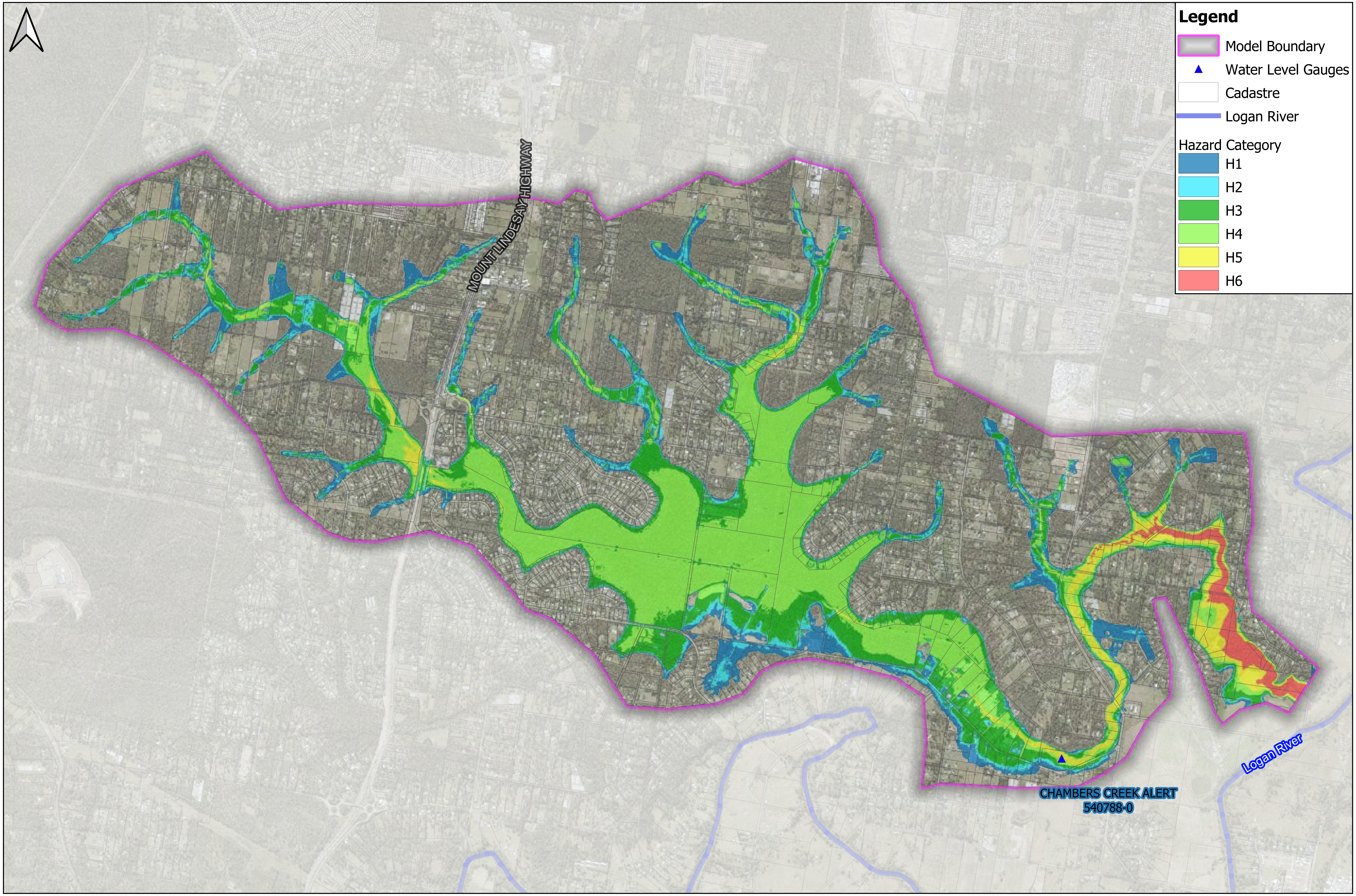
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.5% AEP Peak Water Hazard Category



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

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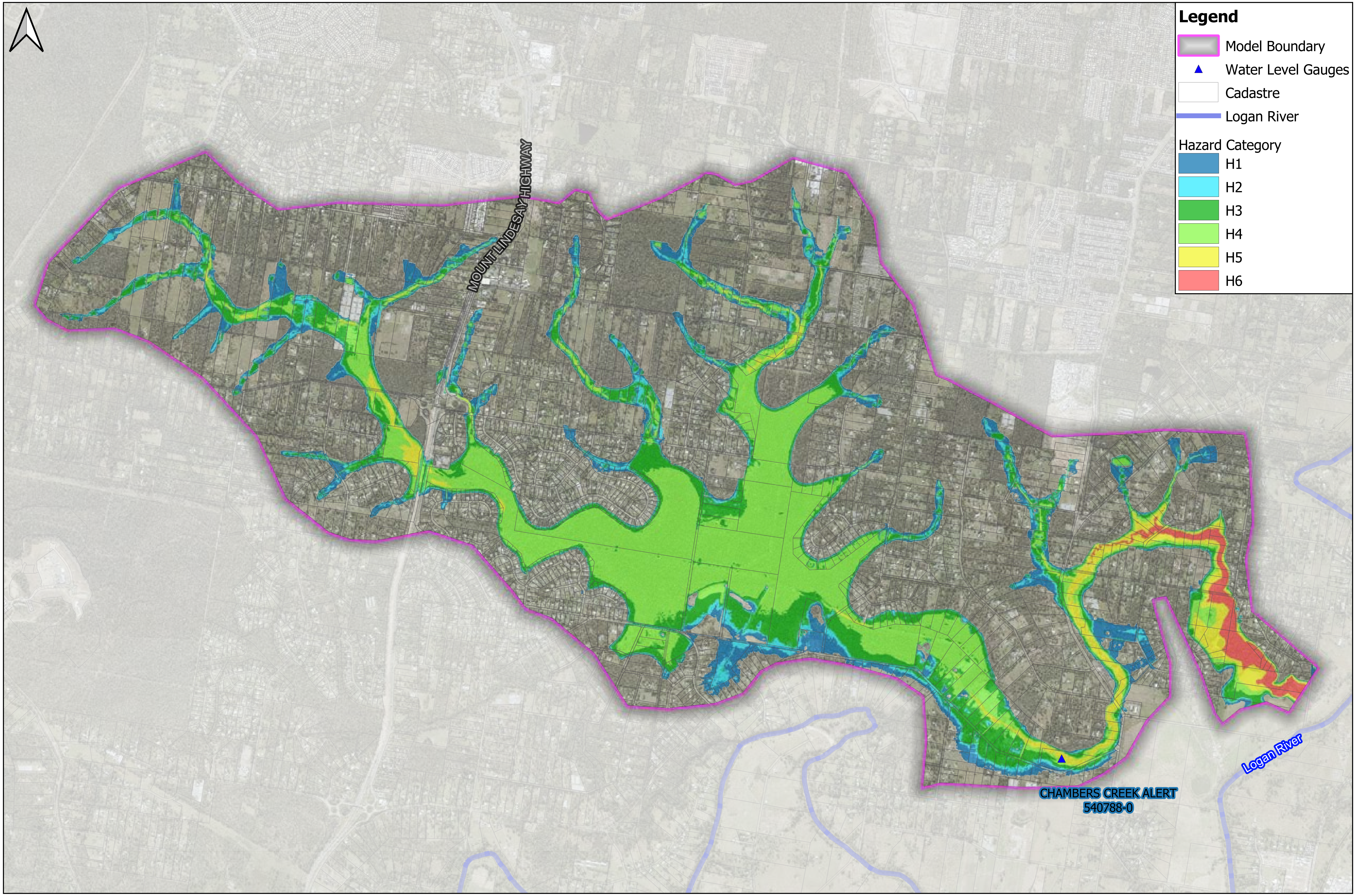
Chambers Creek Flood Study Update 2023
0.5% AEP CC (RCP4.5) Peak Water Hazard Category



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

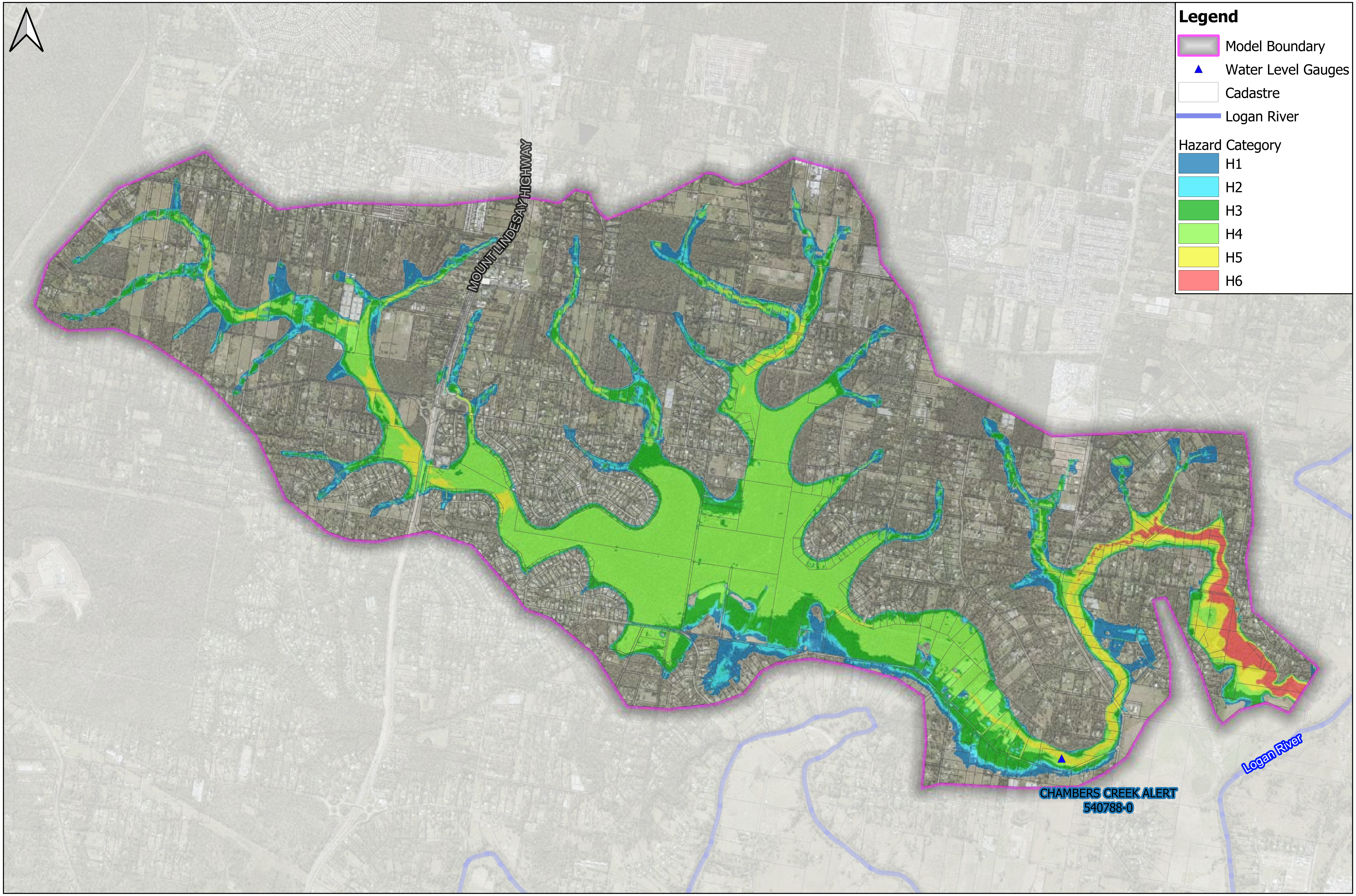
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.2% AEP Peak Water Hazard Category

WATER TECHNOLOGY



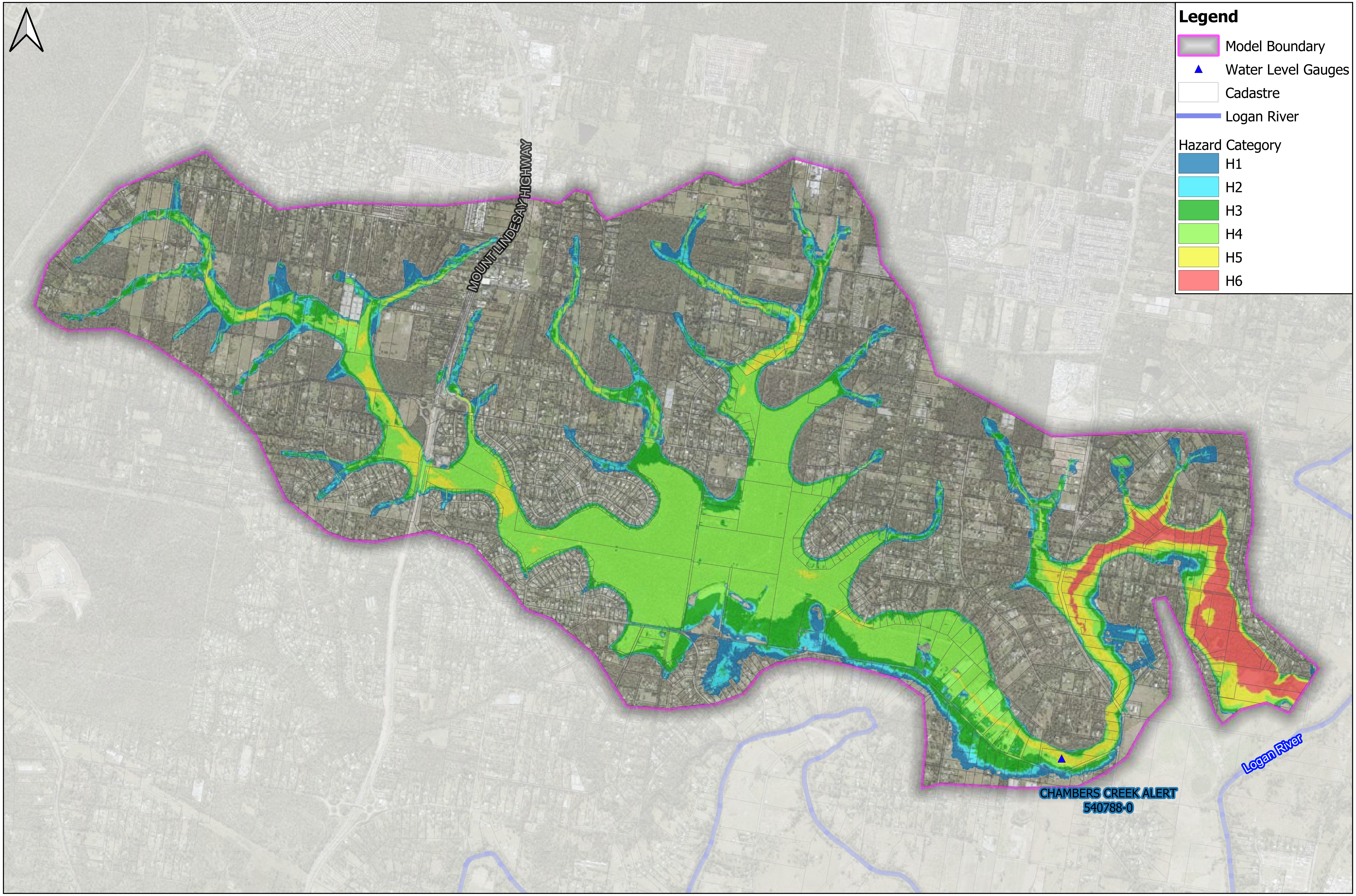
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.2% AEP CC (RCP4.5) Peak Water Hazard Category



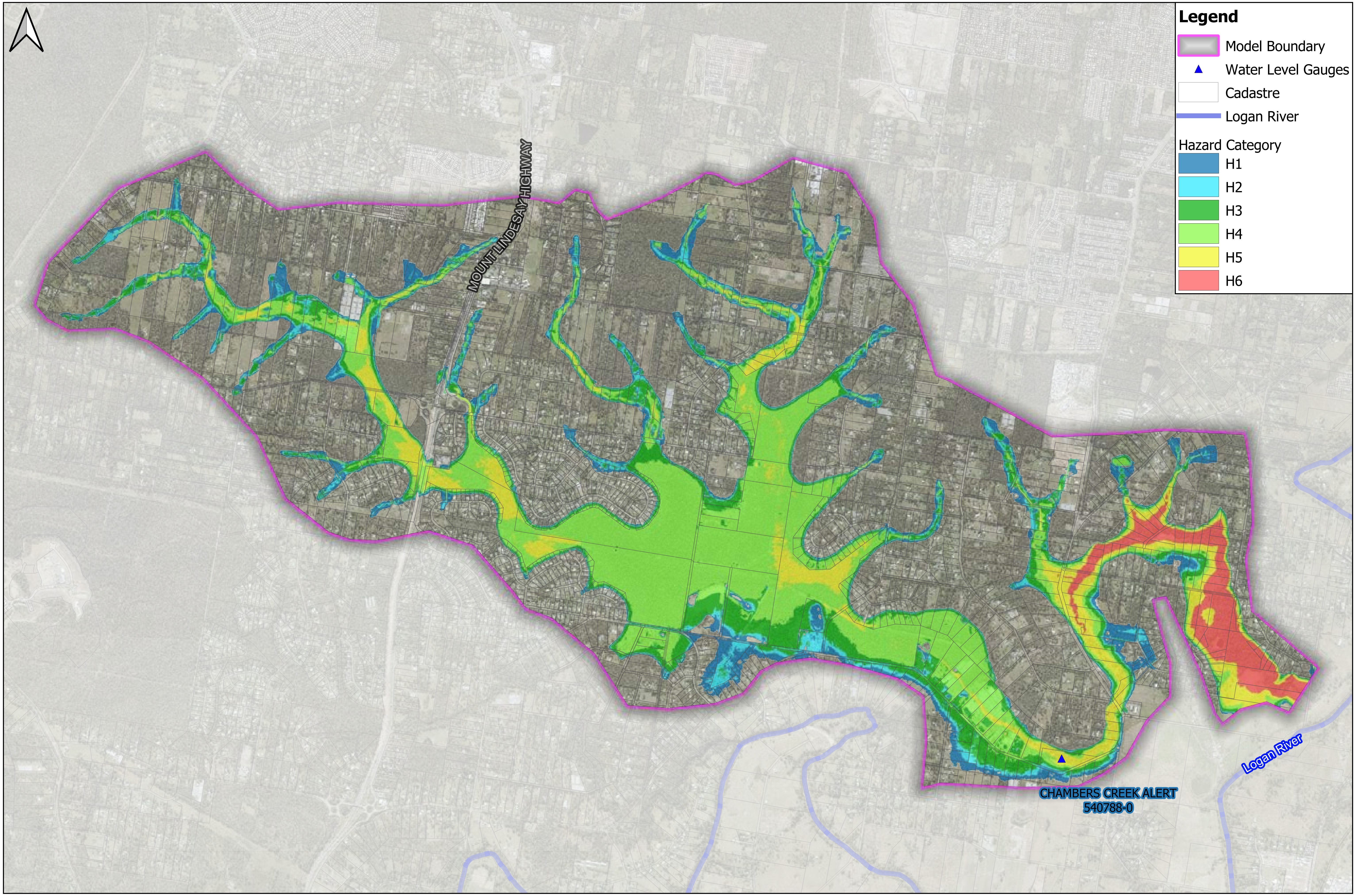
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.05% AEP Peak Water Hazard Category



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

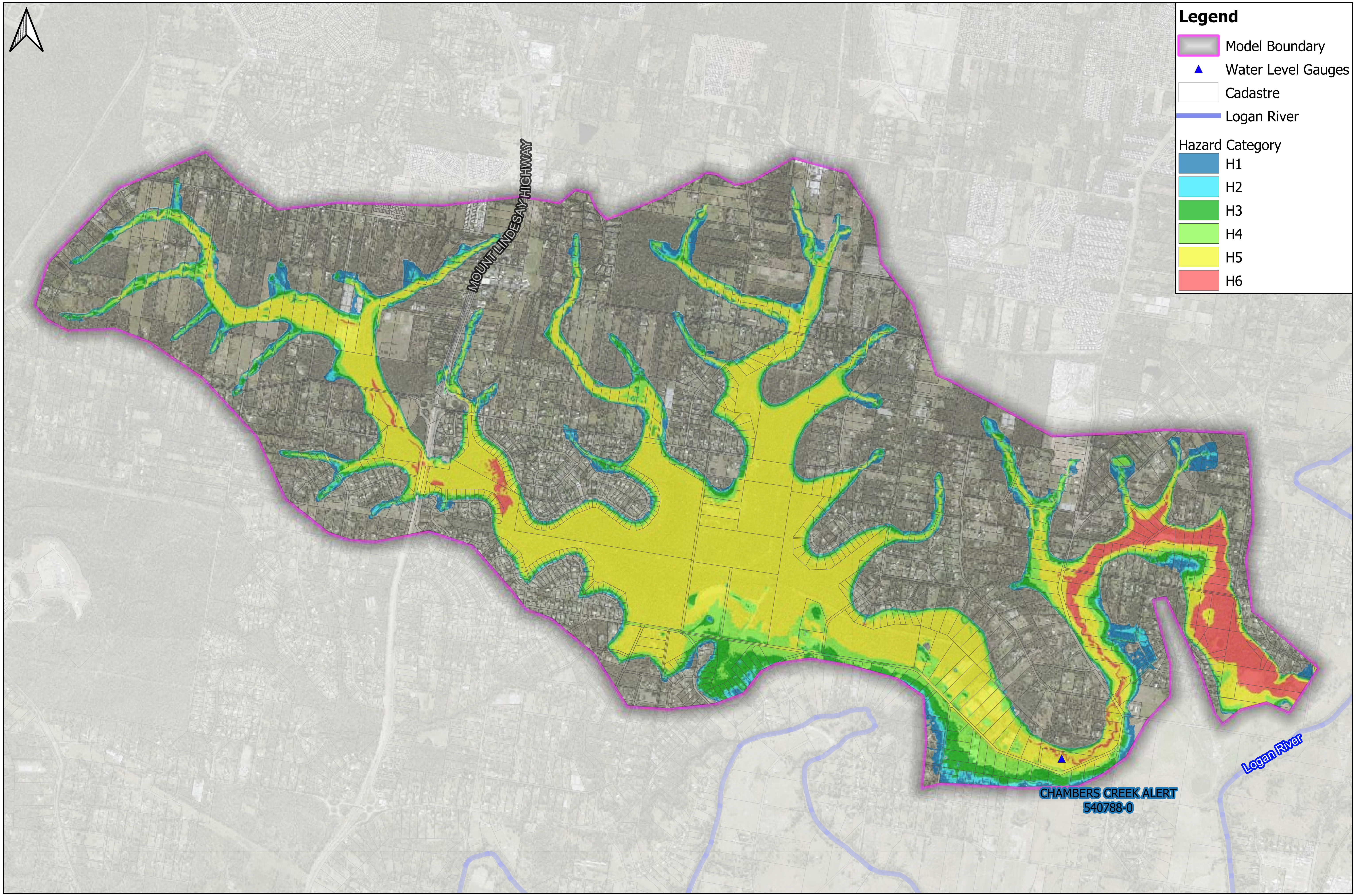
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

0.05% AEP CC (RCP4.5) Peak Water Hazard Category

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

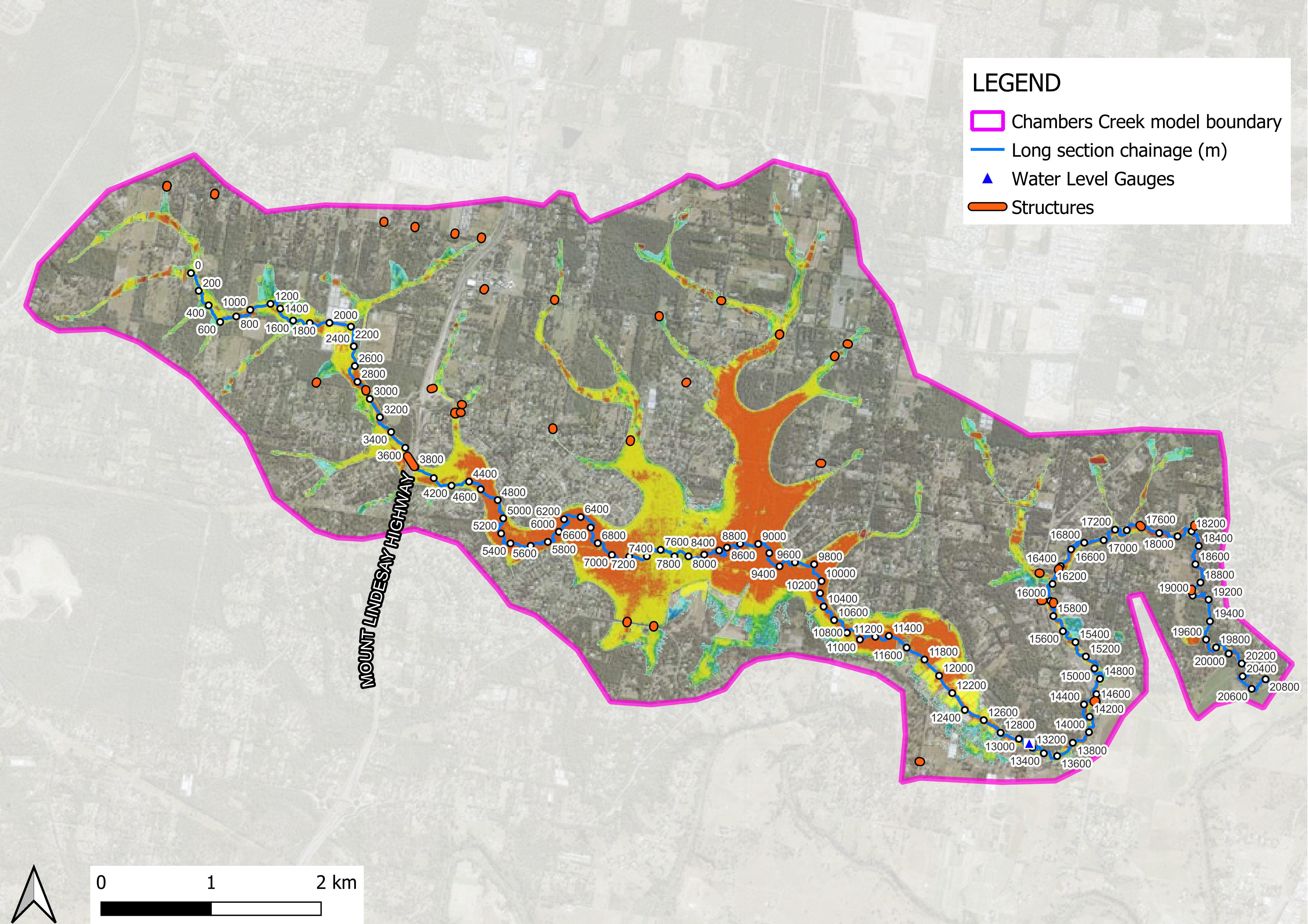
1:30,000

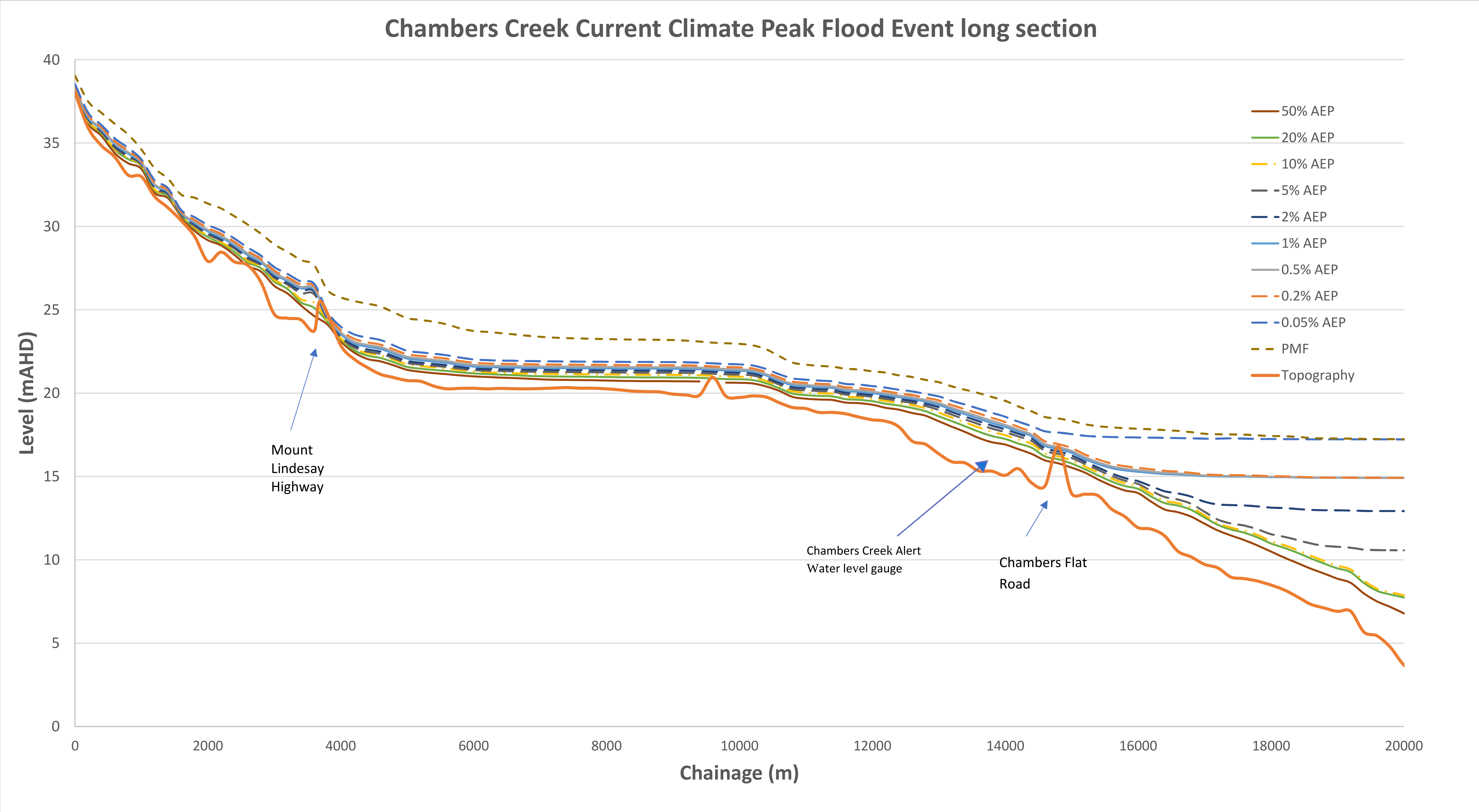
0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

PMF Peak Water Hazard Category

APPENDIX E
HYDRAULIC MODEL RESULTS LONG SECTION

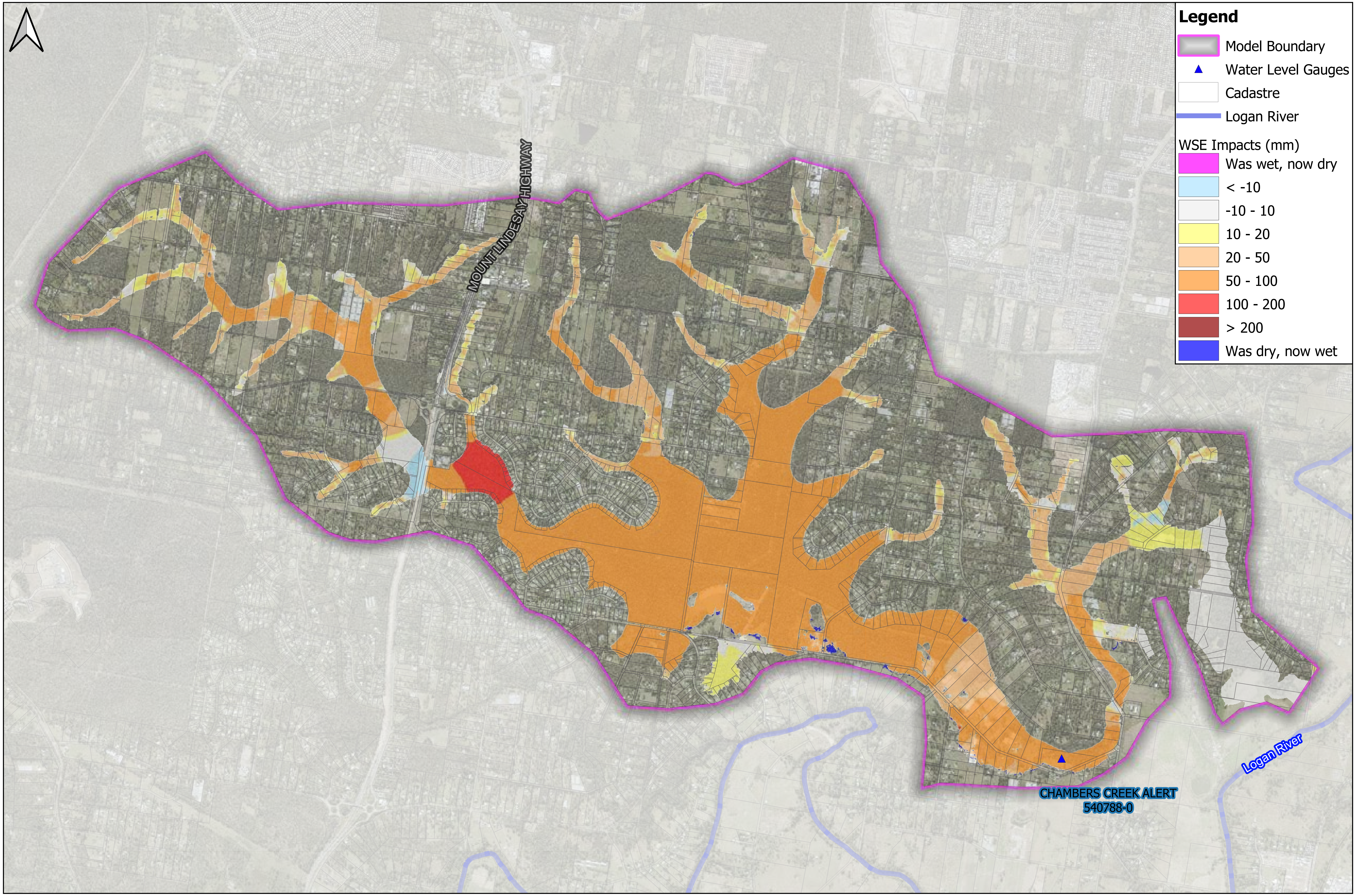

LEGEND
Chambers Creek model boundary
Long section chainage (m)
Water Level Gauges
Structures
MOUNT LINDESAY HIGHWAY
0
1
2 km



Chambers Creek Current Climate Peak Flood Event long section
Level (mAHD)
Chainage (m)
0
5
10
15
20
25
30
35
40
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
50% AEP
20% AEP
10% AEP
5% AEP
2% AEP
1% AEP
0.5% AEP
0.2% AEP
0.05% AEP
PMF
Topography
Mount Lindesay Highway
Chambers Creek Alert Water level gauge
Chambers Flat Road

APPENDIX F
SENSITIVTY IMPACT MAPPING

22020077_R01_V01c_ChambersCreek.docx



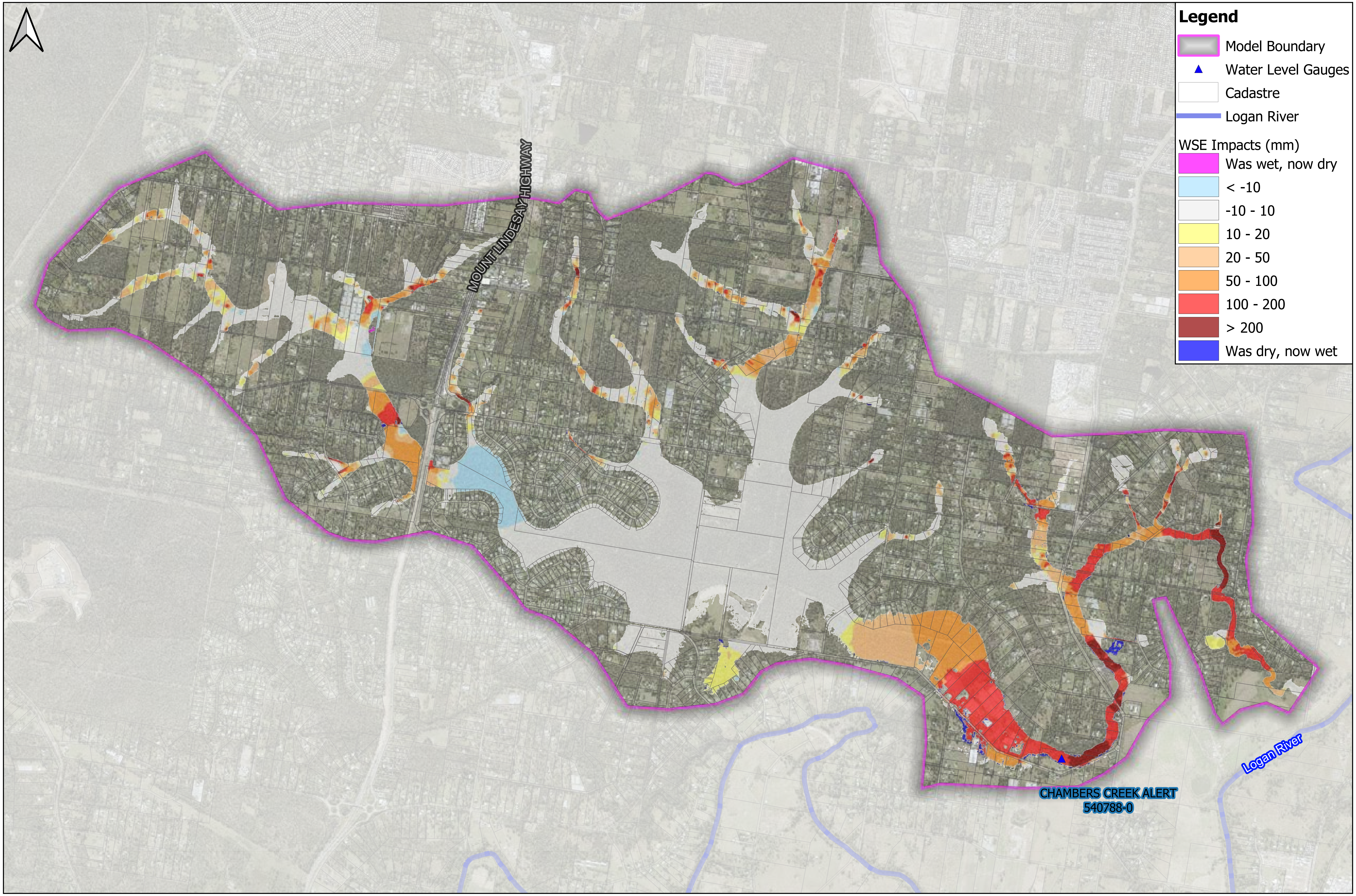
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

1% AEP Impacts - Increased Roughness (+20%)

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

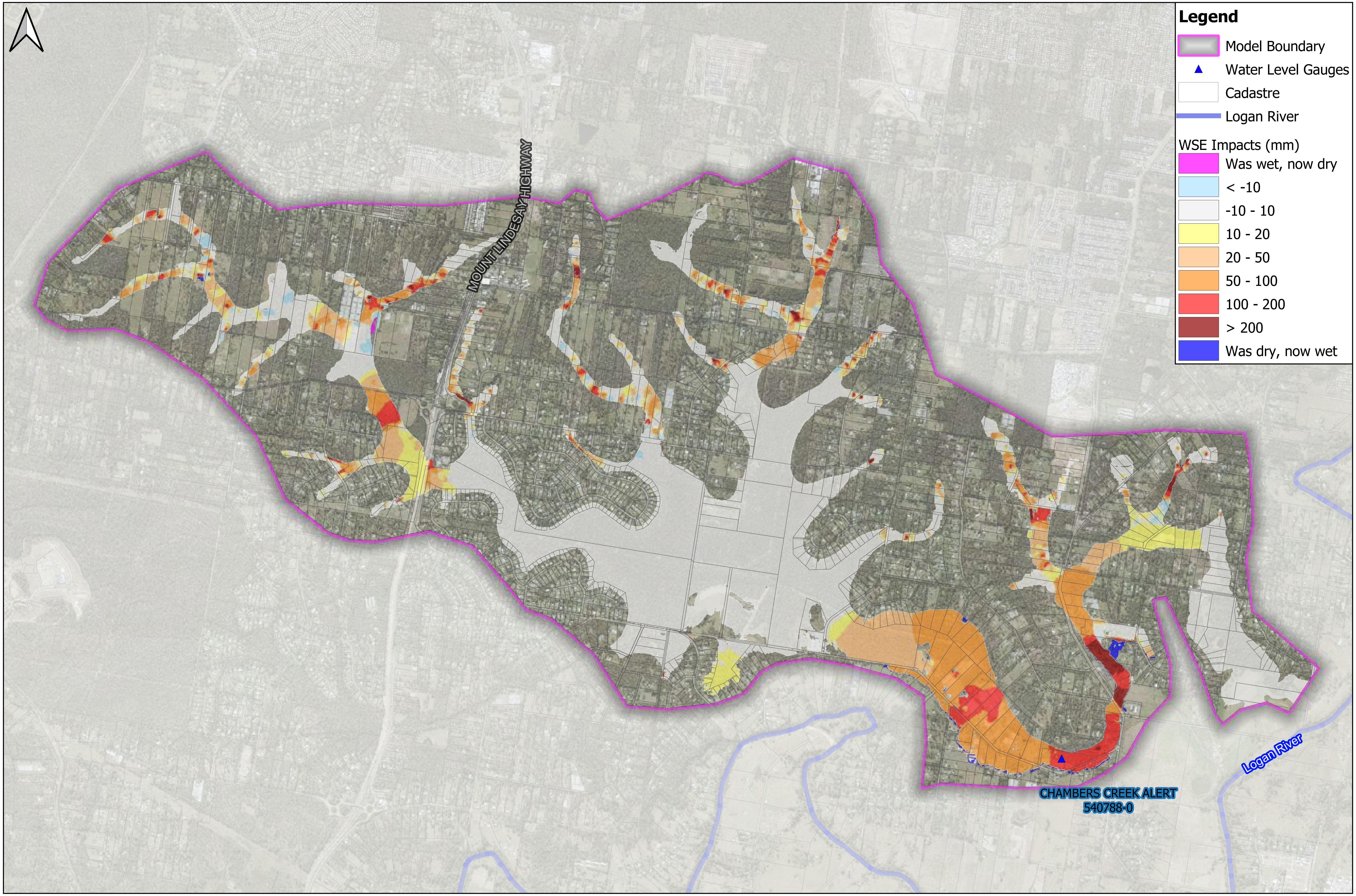
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

20% AEP Impacts - Waterway Restoration

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

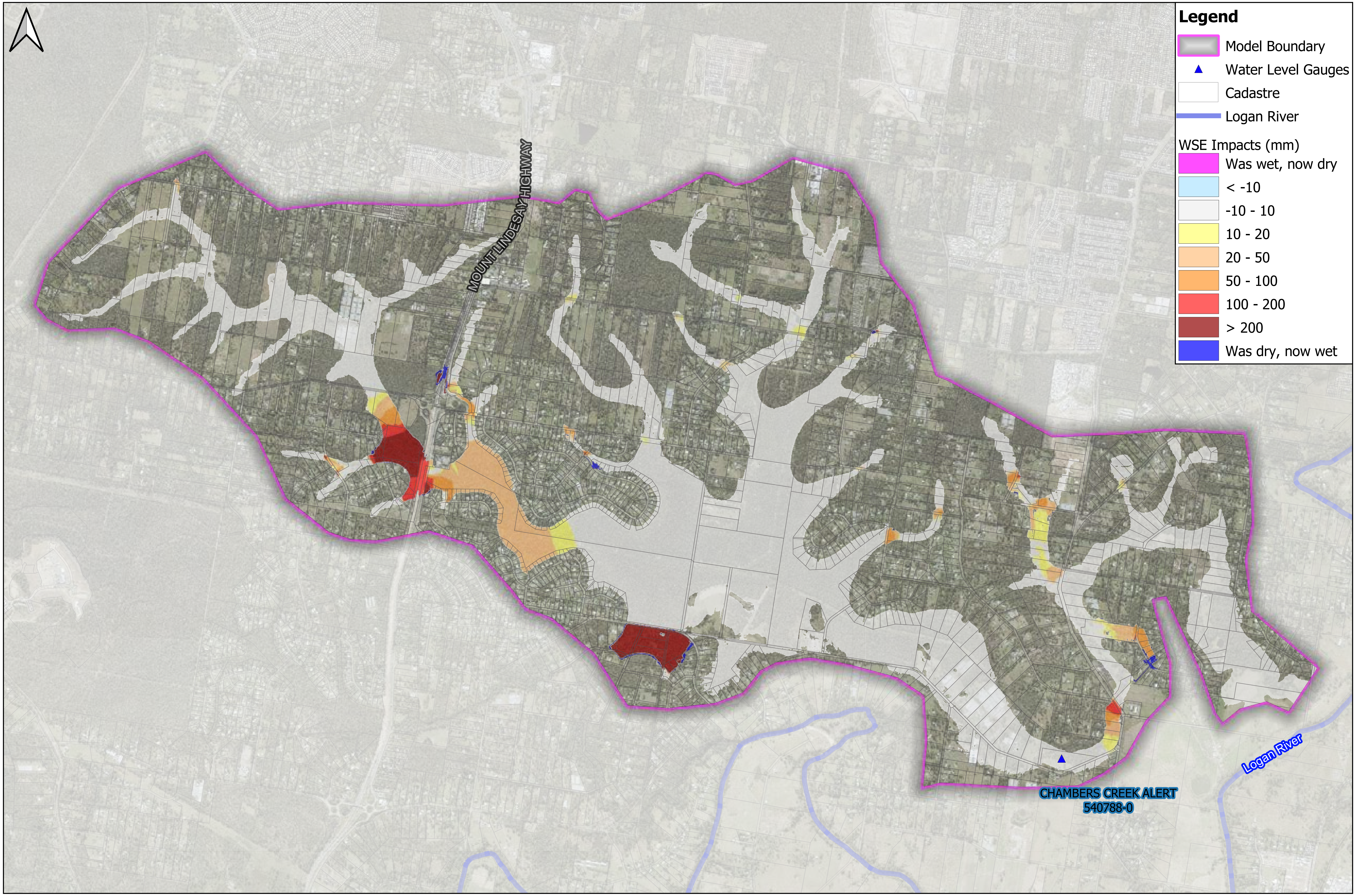
1:30,000

0 500 1,000 1,500 2,000 m

Chambers Creek Flood Study Update 2023

1% AEP Impacts - Waterway Restoration

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:30,000

Chambers Creek Flood Study Update 2023

1% AEP Impacts - Blockage Envelope

WATER TECHNOLOGY

WATER TECHNOLOGY
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Eastwood SA 5063
Telephone (08) 8378 8000

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Cambridge New Zealand 3434
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Wangaratta VIC 3677
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Geelong

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Geelong VIC 3220
Telephone (03) 8526 0800

Wimmera

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Stawell VIC 3380
Telephone 0438 510 240

Gold Coast

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

watertech.com.au