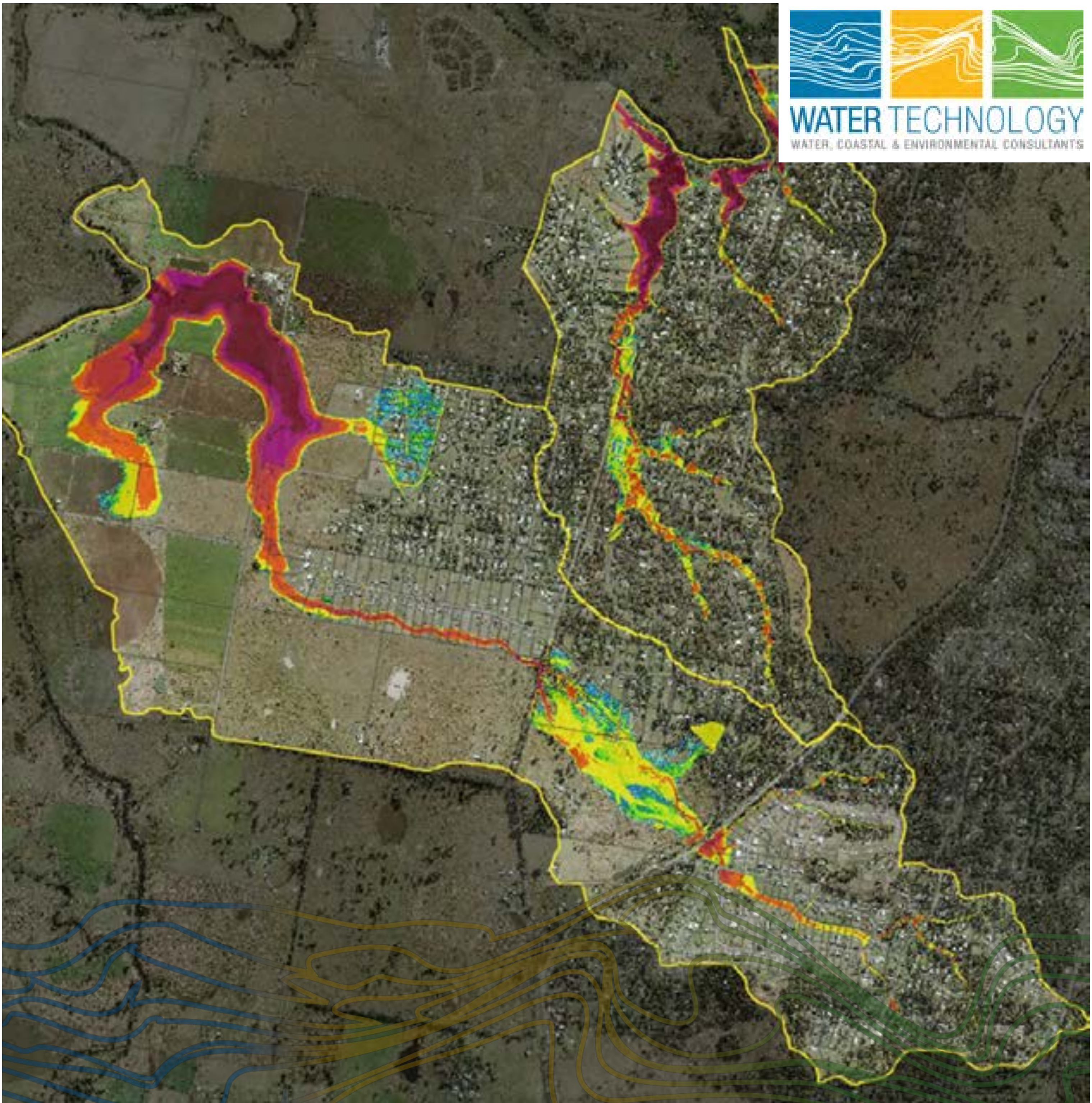

FINAL Report

Days Creek Flood Study 2023

Logan City Council

19 June 2023

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19 June 2023

Janaka Gunawardena / Megan Gould
Logan City Council
PO Box 3226
Logan Central DC QLD 4114

Dear Janaka

Days Creek Flood Study 2023

We have pleasure in providing you with a copy of our draft report prepared in relation to the above as attached.

We trust that this is satisfactory.

Should you have any queries, please don't hesitate to contact the undersigned.

Yours sincerely

Alister Daly
Group Manager

Alister.daly@watertech.com.au

WATER TECHNOLOGY PTY LTD

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1 INTRODUCTION

Water Technology Pty Ltd (WT) have been commissioned by Logan City Council (LCC) (Council) to prepare the Days Creek and Roberts Waterhole Flood Study Update 2023. The subject catchment areas are located in the suburb of Cedar Grove and is bordered by the Logan River to the west and Mount Lindsay Highway to the east. The location of the study area catchments is illustrated in Figure 1-1. The total catchment areas for Roberts Waterhole and Days Creek are approximately 430 and 980 hectares (ha) respectively.

The Days Creek Flood Study was delivered to Final status in 2019 by WT. There was recognition at the time of this study that there was rapid development in the catchment and therefore the model would need updating in the coming years to account for this. Planning for the delivery of Council's new Planning Scheme is underway and it has been identified that additional modelling is required to meet the Planning Scheme requirements. For reasons of efficiency, the model update and additional items detailed in this report are delivered as the Days Creek Flood Study Update 2023.

The key objectives of this study are to provide Council with detailed flood mapping outcomes for the greater Days Creek and Roberts Waterhole catchments 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 Risk Management Plan to inform strategic land use planning to assist Council in preparing a Feasible Alternative Assessment Reporting (FARR) requirement. The Flood Risk Management Plan is to be prepared as a separate and standalone report to this flood study report.

The aim of the study is to gather a comprehensive and robust understanding of the behaviour of creek flooding and creek flood risk by determining flood levels, depths, extents and hazard information for the full range of possible design flood event. In so doing, Council will then have consolidated and consistent flood study information for the catchments 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;
- 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;
- 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 Days Creek and Roberts Waterhole catchments. 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 Days Creek Flood Study 2023.

1.1 Catchment Description

Days Creek flows in an east to west direction through the upstream suburb of Woodhill and the downstream suburb Cedar Grove. The outlet of Days Creek confluences with the Logan River. The total area of the catchment is approximately 9.8 km^2. Roberts Waterhole flows in a south to north direction and is contained within the suburb of Cedar Grove. The outlet of Roberts Waterhole confluences with the Logan River. The total area of the catchment is approximately 4.3 km^2. The respective catchments are illustrated in Figure 1-1.

The catchments are relatively short and narrow, with the longest distance in Days Creek west to east just under 7 km with a width south to north of approximately 2 km. The longest distance in Roberts Waterhole west to east is just under 2 km with a width south to north of approximately 3 km. The catchments are traversed by one (1) major road including Mount Lindesay Highway in the southeast of the catchment. The Days Creek catchment remains relatively undeveloped in the northern areas. Rural residential and open space land use dominates the remaining areas of the catchments, with no areas zoned as emerging communities. The Roberts Waterhole catchment is mainly rural residential with a significant number of small tributaries leading into local dam storages. The main creek channel is poorly defined within a densely vegetated area and runs adjacent to rural residential properties.

The lower parts of both catchments are affected by Logan River backwater in moderate events, with the backwater influence much more pronounced upstream into the catchments in rare Logan River flood events. Both catchments experience significant backwater flooding during the recent February 2022 flood event from the Logan River catchment.

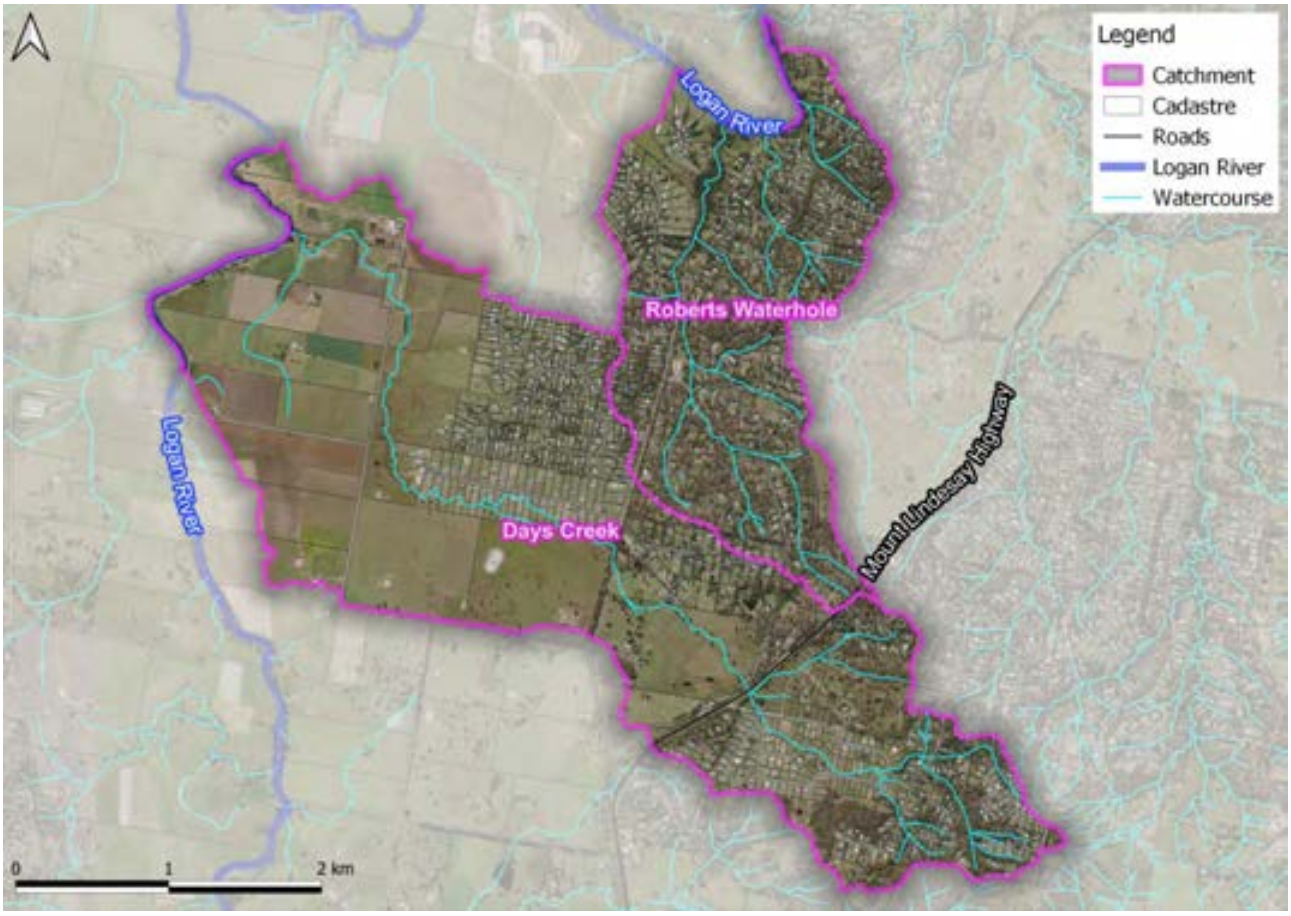

Figure 1-1 Study Catchment Areas

2 DATA REVIEW AND GAP ANALYSIS

2.1 Introduction

Extensive background study data and information was provided by LCC for the previous 2019 study and this current study update. Water Technology has undertaken a detailed and comprehensive information review of all background material provided and undertook a gap analysis to identify any missing information. A summary of the data review undertaken, and subsequent gap analysis is documented separately below.

2.2 Previous Studies

A number of previous flood and drainage related studies have been prepared within the subject catchment study areas. A brief summary of the relevant and pertinent studies previously prepared are discussed separately below.

Flood Investigation and Site Based Stormwater Management Plan for a Proposed Residential Sub-Division on Irwin Road, Woodhill (HCE Engineers, March 2011) (HCE, 2011) (HCE, 2011a) (HCE, 2011b)

This study was prepared in connection with the Brumby Drive development which is located between Irwin and Undallah Road. A hydrologic and hydraulic analysis was undertaken to provide the basis for the flood analysis and stormwater management plan which accompanied an operational works application for the development. The proposed development comprised a 65.7ha low density residential development along with an upgrade and formalisation of the adjacent Days Creek tributary, which was designed to convey the 1% AEP flood event. The hydrology model was developed in XP-RAFTS and calibrated to a rational method under pre and post developed conditions. A HEC-RAS hydraulic model was established and utilised to inform the hydraulic design of the channel augmentation works. Analysis was undertaken for the 39%, 10%, 5%, 2% and 1% Annual Exceedance Probability (AEP) design events and concluded that the proposed development with the associated works proposed resulted in no adverse impact to adjoining properties.

This study is of specific relevance to the current assessment as it relates to a specific downstream since developed area that is located within the Days Creek catchment. As such, this study has been used to compare the new design flood estimates prepared under this current study.

Hydraulic Model Development of the Logan River Tributaries (AECOM, 2014)

The Logan and Albert River flood model was subject to ongoing revisions during the course of 2013. As a result of the regional flood model revisions, gaps in flood data sets at the confluence of local waterway tributaries with the Logan and Albert Rivers were identified to exist. LCC commissioned AECOM to undertake hydrologic and hydraulic modelling to provide flood data sets to infill the missing gap areas and to provide overall consistency and continuality of flood related information between the local waterway assessments and the regional floodplain assessments for the Logan and Albert Rivers. The study included the development of approximately seventy (70) localised and discrete hydraulic models which were developed using a combination of 1D HEC-RAS and 2D TUFLOW models. The models were used to assess a range of design events and durations to provide connectivity in flood data at the confluences of the local and regional catchment systems. Post processing techniques were used to “smooth” flood surfaces between the models and to provide the continuity of data in a consistent manner.

Of relevance, this study included an assessment of both the Days Creek and Roberts Waterhole catchments and is therefore of specific relevance to the current assessment. As such, this study has been used to compare the new design flood estimates prepared under this current study.

Logan-Albert Rivers Flood Study (WRM, August 2021) (WRM, 2021)

The Logan-Albert Rivers hydraulic flood modelling was originally developed by Engeny in 2011 (Engeny 2011). The flood study was subject to a technical review which was undertaken by KBR in 2012 (KBR 2012). Following the technical review being completed, LCC commissioned WRM in 2016 to update the previously developed models informed from the KBR 2012 review, and to recalibrate the Logan and Albert River flood models based on recent historical flood events. Following the model update and re-calibration, WRM subsequently updated the design discharge and flood level estimates. The updated hydrologic and hydraulic models were calibrated to discharge and water level hydrograph records during two (2) significant flood events of January 2013 and March 2017. A flood frequency analysis was also prepared, utilising four (4) of the available stream gauges and analysed for further calibration. The updated hydraulic model was used to estimate design flood levels from the Logan-Albert Rivers for all standard storm events ranging from the 39% to the 0.2% AEP, and additionally included assessment of the PMF flood event. The derived flood levels from the WRM hydraulic model are considered to be the most up to date estimates for the Logan and Albert River catchment and were adopted to inform all design planning across the LGA.

Days Creek and Roberts Waterhole Flood Study 2018 / 2019 (Water Technology, March 2019)

Water Technology previously completed the Days Creek and Roberts Waterhole Flood Study 2018 / 2019 in March 2019. LCC commissioned this study to develop local hydrologic and hydraulic models to ascertain design flood levels, flood planning levels and understand flood risks within each catchment. Water Technology conducted extensive investigations, utilising all previous modelling to develop the local XPRAFTS and TUFLOW models.

This study represents the latest hydrologic and hydraulic models for the catchments and therefore this study has used these models as the basis for this flood study update.

2.3 Digital Flood Model Data

Digital copies of the relevant flood models to inform the current investigation were provided by LCC as part of the 2019 flood study and this current study. These included:

- A digital copy of the local HEC-RAS hydraulic model and the XP-RAFTS hydrology model for the proposed residential subdivision off Irwin Road (Edenvale Estate, Brumby Drive) (HCE 2011) (HCE 2011a) (HCE 2011b);
- Digital copies of Days Creek and Roberts Waterhole Logan River tributary TUFLOW hydraulic models (System 21 & 22 infill models) as developed by AECOM (AECOM 2014);
- A digital copy of the Logan River regional TUFLOW hydraulic sub-model prepared by WRM (WRM 2016). The standard events included in the supplied model included the 39% to the 0.2% AEP events and contained the 6, 9, 12, 18, 24, 30, 36, 48 and 72 hour storm durations. The model files include setup files and we understand that the sub-model has also been verified back to the larger regional model. A digital copy of the Logan and Albert flood study report as well as selected result files for which the models relate were also provided; and
- A copy of the regional XP-RAFTS model for the Upper Logan Design Model. This included digital hydrological model data for the 39% to 0.2% AEP design events across multiple storm durations ranging to 72-hours.

Each of the above digital data sets has been considered and utilised in the current assessments to inform the updated flood models developed as part of this study.

2.4 Topographic Data

The available topographic data provided by LCC includes the 2021 1-meter Digital Elevation Model (DEM) LiDAR data set. We understand that the 2021 LiDAR data represents the most current topographical data available for the catchment. The supplied data was used to inform all model development tasks undertaken for this study. The LiDAR data covers the full extent of Days Creek and Robert's Waterhole catchments and is suitable for the purposes of informing this study. No technical documentation was provided on the LiDAR data collection and as such we are not aware of LiDAR data accuracy. An illustration of the topography data for both the Days Creek and Robert's Waterhole catchments is presented in Figure 2-1 based on the DEM.

In addition to the 2021 LiDAR data, we also understand that LCC have historical LiDAR data sets which were taken at specific historical periods in time. Whilst historical LiDAR data can be used to better inform model calibration outcomes given topographical changes in the catchment, in the absence of calibration data for the subject catchments the historical LiDAR is considered to be of limited use to the current study. The calibration aspects are discussed separately in Section 6.

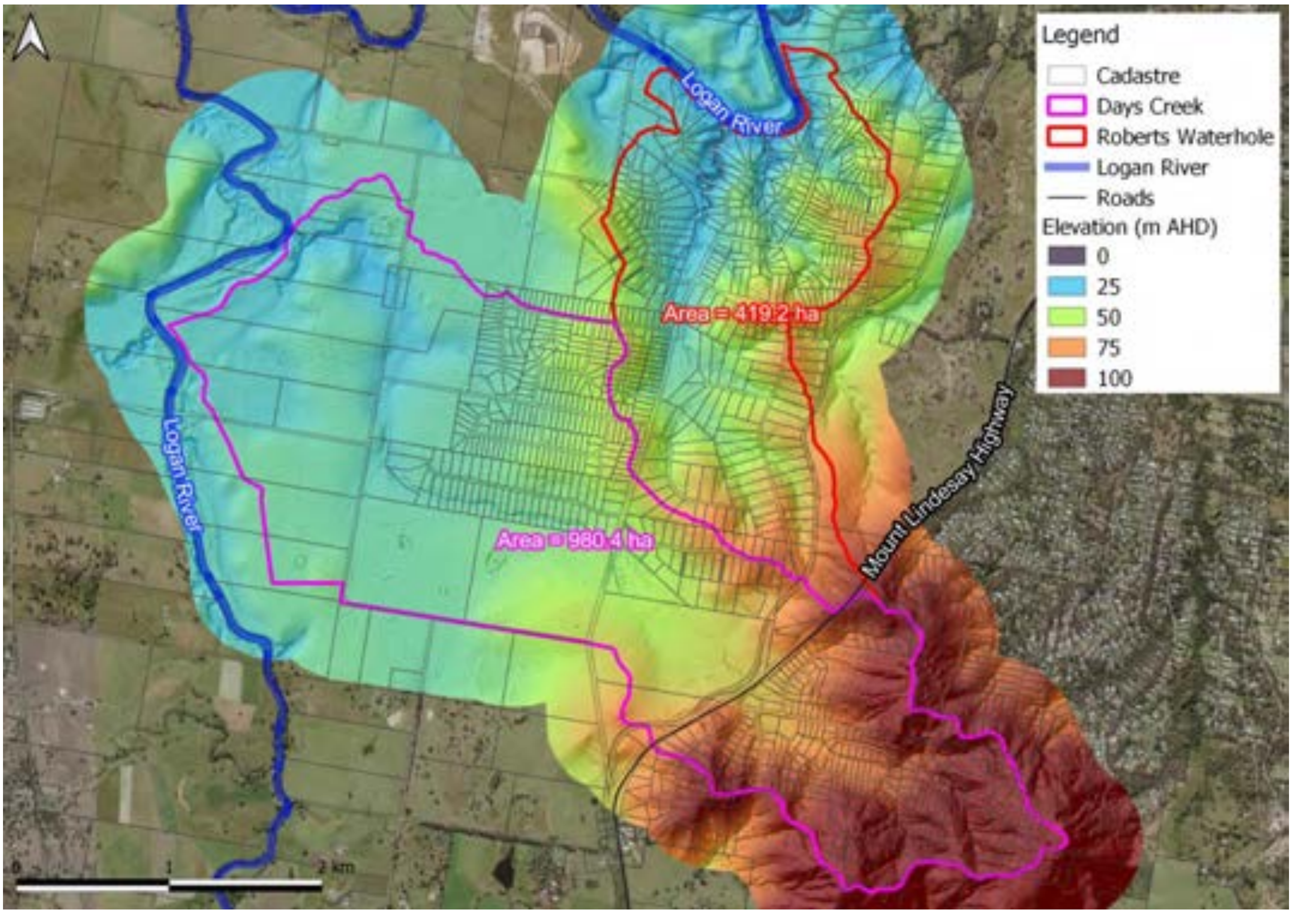

Figure 2-1 2021 LiDAR 1m DEM

2.5 GIS Data

A range of GIS data sets were provided in an ESRI geodatabase format by LCC to inform this study. A summary of the supplied GIS data is provided in Table 2-1. All data has been reviewed and, where available, was found to be suitable to inform this investigation.

Table 2-1 LCC Supplied GIS Data

Filename	Description
logan_lga_2021_10cm_mosaic_gda94.tif logan_lga_2021_10cm_mosaic_gda94_catchment.tif	Aerial Image Tiles (date assumed 2021)
Stormwater_Box_Culverts	Stormwater Culvert network
Stormwater_Pipies	Stormwater Pipe Network
Stormwater_Pits	Stormwater Pit Network
Stormwater_Headwalls	Stormwater Headwalls
Waterway_Corridors	Waterway Corridors as per LCC 2015 Planning Scheme
Plan_LPS2015_Zone	Landuse As Per LCC 2015 Planning Scheme

It is noted that the supplied stormwater network data contains details on network types, dimensions, and elevations. The provided stormwater network data was however found not to be complete and was missing the following information:

- Several road culvert structures throughout the catchment were not included in the database (i.e. absence of GIS records against that observed during the site inspections);
- Invert level information included in the GIS data was incomplete and not available for the majority of cross drainage structures. Additionally, upon further review, the invert level information that was provided was found to contain incorrect information and errors;
- Culverts and crossings associated with the obsolete railway which traverses the upstream reaches of the catchments was also not included in the database. A site inspection of this area was since undertaken by representatives of LCC on the 18 April 2018 to collect the structure dimensions. Information provided by LCC included structure sizes and associated site photographs. However, survey of invert levels was not collected; and
- Missing driveway culverts along Brumby Drive (in the Days Creek catchment) have been assumed at 0.3 m RCP with inverts assumed from the 2021 LiDAR.

As noted above, LCC advised that the invert level data included in the GIS data sets for drainage structures was known to be incorrect and to be in error. Accordingly, invert level information contained in the GIS data sets has not been utilised directly in this study and alternative approaches were needed to be undertaken in respect to representation of the stormwater data for the model. This aspect is discussed separately in Section 2.7.

2.6 LCC Supplied Structure Data

Owing to the incorrect data and errors in the GIS data sets relating to drainage invert levels, LCC have previously embarked on a process of capturing invert level data using traditional survey techniques. For the Days Creek and Roberts Waterhole catchments, LCC completed survey of approximately 40 separate drainage structures and had compiled the survey information in a MS Excel spreadsheet. A copy of this data set was provided to WT for this study and to better inform structure data. An illustration of the survey data collected by LCC is presented in Figure 2-2 which has been used to inform structure invert levels accordingly.

water Culverts

Structure ID	Description	Required Info	Barrel size	Number of.	Easting	Northing	Upstream IL (mAHD)	Downstream IL (mAHD)	Road Deck level (mAHD)	PSM (mAHD)
1	PSM				509053.629	6940385.239				13.589
2	Upstream Invert Level	Round RCP -2375m	600	Single	498824.358	6918738.284	57.379			
3	Downstream Invert Level	Round RCP	600	Single	498804.031	6918797.868		52.28		
4	Road Level (unable to survey Upstream and Downstream Invert Levels	Round RCP	1050	Single	498721.531	6918295.209			48.347	
5	**DISREGARD**				498684.499	6919171.04				
6	Road Level	Round RCP - 60 degree skew	1200	Single	498681.018	6919162.865			27.309	
7	Upstream Invert Level	Round RCP	1200	3	498429.909	6918639.049	30.956			
8	Downstream Invert Level	Round RCP	1200	3	498421.163	6918648.133		30.857		
9	Road Level				498427.226	6918646.098			32.713	
10	**DISREGARD**				497727.687	6919028.483				
11	Upstream Invert Level	Round RCP	1050	Single	497719.934	6919038.098	28.657			
12	Downstream Invert Level	Round RCP	1050	Single	497727.634	6919028.489		28.606		
13	Road Level				497723.19	6919032.889			30.59	
14	Upstream Invert Level	Round RCP	650	Single	497673.39	6918708.952	31.352			
15	Downstream Invert Level	Round RCP	650	Single	497688.15	6918709.842		31.092		
16	**DISREGARD**				497680.356	6918708.453				
17	Road Level				497680.729	6918708.691			32.954	
18	Upstream Invert Level	Round RCP	850	Single	497661.589	6918660.369	32.971			
19	Downstream Invert Level	Round RCP	850	Single	497676.772	6918659.35		31.573		
20	Road Level				497668.854	6918659.745			33.333	
21	Upstream Invert Level	Round RCP - 45 degree skew	900	3	497674.759	6917531.948	39.529			
22	Downstream Invert Level	Round RCP - 45 degree skew	900	3	497686.384	6917537.254		39.237		
23	**DISREGARD**				497680.387	6917533.955				
24	Road Level				497680.393	6917534.431			40.81	
25	Upstream Invert Level	Round RCP - 80 degree skew	1050	Single	497743.653	6916982.878	48.685			
26	Downstream Invert Level	Round RCP - 80 degree skew	1050	Single	497730.876	6917011.106		48.24		
27	Road Level				497736.732	6916999.29			50.085	
28	Upstream Invert Level (unable able to survey downstream invert level)	Round RCP - 75 degree skew	900	Single	497835.892	6916820.722	57.543			
29	Road Level				497822.309	6916839.881			58.425	
30	Downstream Invert Level	Round RCP	900	3	498357.227	6917102.24		50.278		
31	Road Level				498364.112	6917102.227			52.041	
32	Upstream Invert Level	Round RCP	1050	Single	498369.093	6917106.069	50.344			
33	Upstream Invert Level	Round RCP	600	Single	496922.995	6917177.958	42.725			
34	Downstream Invert Level	Round RCP	600	Single	496912.952	6917197.707		41.262		
35	Road Level				496918.443	6917188.179			42.571	
36	Upstream Invert Level	Round RCP	900	2	496917.945	6917283.158	38.733			
37	Downstream Invert Level	Round RCP	900	2	496907.158	6917285.233		38.531		
38	Road Level				496912.805	6917284.445			40.361	
39	Downstream Invert Level	Round RCP	750	Single	496920.738	6917419.649		38.072		
40	Upstream Invert Level	Round RCP -1375m	750	Single	496951.922	6917413.84	39.613			
41	Road Level				496935.738	6917416.291			39.77	
42	Upstream Invert Level	Round RCP	600	Single	498987.351	6915989.053	87.339			
43	Upstream Invert Level	Round RCP	600	Single	498926.74	6915955.699	83.019			
44	Upstream Invert Level	Round RCP	675	Single	499346.608	6914973.801	91.458			
45	Downstream Invert Level	Round RCP	675	Single	499330.39	6914978.921		90.23		
46	Road Level				499340.6	6914975.116			92.192	
47	PSM				509053.613	6940385.261				13.593

Figure 2-2 LCC Surveyed Structure Data (Source – LCC, 2018)

2.7 Structure Data Summary and Structure Database

Figure 2-3 provides an illustration of the extent of existing hydraulic structure data represented across both the Days Creek and Roberts Waterhole catchment areas which have been compiled based on the above supplied information as well as being confirmed via a series of site inspections undertaken by WT.

The following additional comments are made in respect to the structure data:

- The majority of the 'full structure data set' referenced previously were found to be represented within the as-constructed drawings provided by LCC. That is, all stormwater data such as invert level information was included in the as-constructed information supplied at least for the extent to which the as-constructed extended;
- As noted previously, invert level data included in the supplied GIS geodatabase was found to be incorrect and in error and could therefore not be directly used;
- The LCC supplied MS Excel survey data provides a good basis on which to infill invert level data; and
- In the absence of surveyed invert level data, invert levels for drainage structures can be readily informed using the 2021 LiDAR DEM. This process was applied in the development of the subsequent catchment models and to otherwise inform structure data.

Figure 2-3 has been compiled and consolidated into a common format for inclusion in the hydraulic model. Additionally, a MS Excel structure database has also been prepared as a record of all hydraulic structure data for each of the Days Creek and Roberts Waterhole catchments. A copy of the structure database is included in Appendix A and also forms a project deliverable to LCC as part of this project.

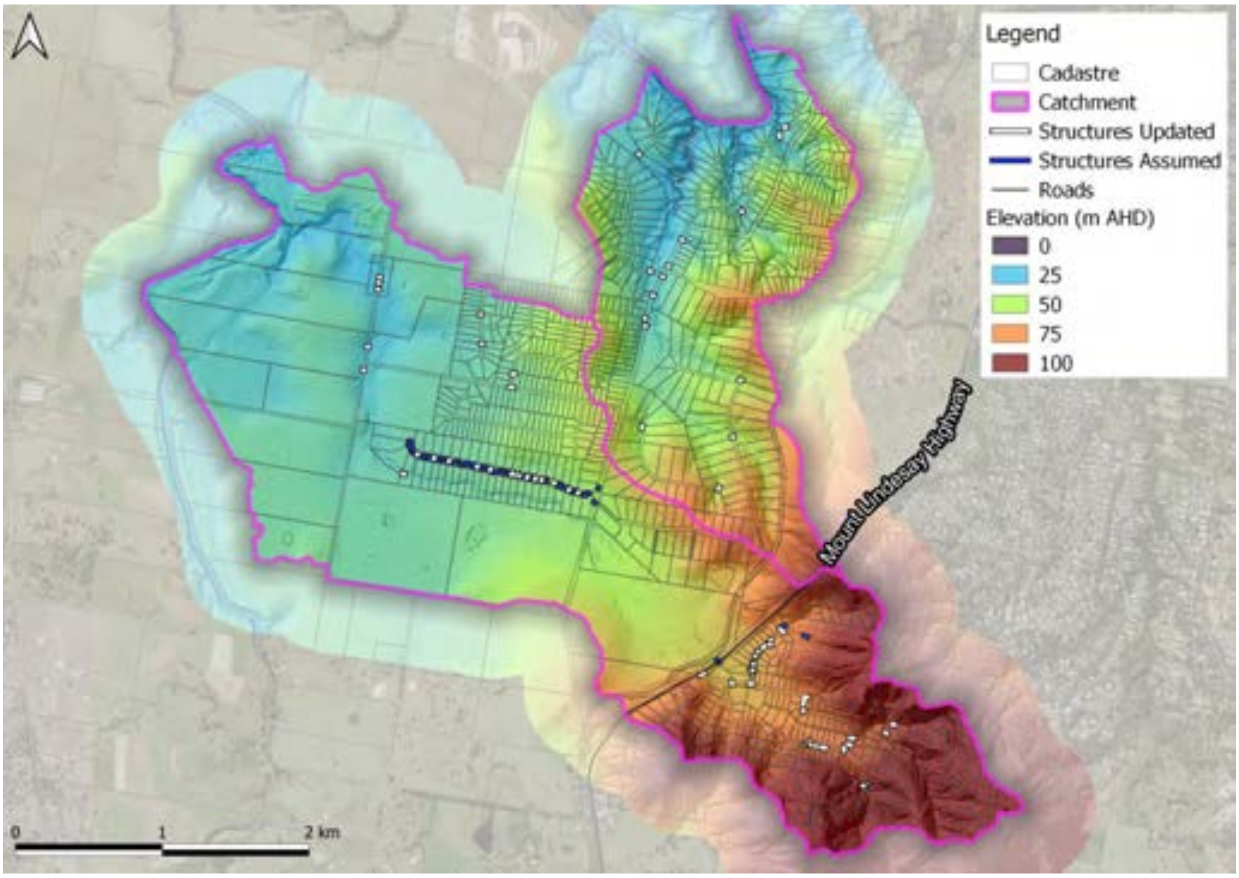

Figure 2-3 Structure Data Summary and Data Extent Included

2.8 Rainfall and River Level Data

Rainfall and river level data for the Days Creek and Roberts Waterhole catchments were not available due to the catchments not containing any gauges. Neighbouring catchment rainfall and stream gauges were provided by LCC, however has not been directly used in the current study. The model calibration and validation aspects are discussed separately in Section 6.

2.9 Data Gaps

On the basis of the above data review, there is an extensive amount of background information that is suitable and can be readily used to inform the current investigation. The key limitation in respect to the background data sets however relates to the information available on the existing stormwater network data. As discussed previously, the existing stormwater network represented within the local catchment areas were found to be inadequate in respect to structure details, be that sizes or invert level information. Attempts have since been made to better address the missing information though:

- A series of site inspections undertaken by WT which included physical site measurements and observations;
- Site inspections undertaken by LCC which also included physical site measurements and observations;

- LCC attempts to source railway as-constructed data sets; and
- Assumed driveway culverts along Brumby Drive.

Despite the above, where detailed survey invert level information was unable to be obtained, in agreeance with LCC invert levels were estimated using the 2021 LiDAR data.

Outside of the above, LCC has additionally provided as-constructed details for the residential development being constructed on Mahoney Road which includes an upgrade to the channel arrangements in Days Creek. The development arrangements are not represented within the current LiDAR data as this represents recent work having been completed following the LiDAR capture date. The as-constructed data therefore provides the best information to inform topography and has been used on this basis.

On the basis of the comprehensive data review and subsequent gap analysis, and noting the structure invert level limitations outlined above, there are no undue gaps or missing information that would otherwise compromise the study outputs. As such, it is believed that all relevant and appropriate data as sourced and provided are sufficient for the purposes of this study.

3 MODEL PHILOSOPHY AND OVERVIEW

3.1 Modelling Approach

The modelling approach applied for this project is inclusive of the preparation of separate hydrology and hydraulic models for each of the Days Creek and Roberts Waterhole catchments. The development of separate hydrology and hydraulic models to inform the study represents a fully supported approach as part of the Australian Rainfall and Runoff (ARR) 2019 guidelines (ARR2019).

3.2 Software Platforms

In accordance with the project brief, all models have been prepared based on the following LCC approved software platforms:

- All catchment hydrologic models have been developed using the standard XP-RAFTS coupled with the Storm Injector platform; and
- All hydraulic modelling has been prepared using the TUFLOW HPC platform and GPU solver.

The model schematisation approach undertaken for this study has included separate and discrete XP-RAFTS and TUFLOW models for each of the Days Creek and Roberts Waterhole catchments (i.e. 2 separate hydologic and 2 separate hydraulic models).

3.3 Hydrology Model Philosophy

The following points briefly outline the philosophy applied for the development of the hydrological models for this study. More detailed information in relation to the development of the XP-RAFTS models is presented separately in Section 4.

- All models are based on the current best practice guidelines represented in ARR2019;
- In accordance with ARR2019 recommendations, a Monte Carlo approach is not necessary or required for this study. Rather, the Ensemble Event (EE) approach has been adopted based on ARR2019 guidelines and is appropriate given the scale and nature of the catchment; and
- The methodology applied for the development of the XP-RAFTS models has included a detailed breakdown of sub-catchments for each of the Days Creek and Roberts Waterhole catchments.

3.4 Hydraulic Model Philosophy

The following points briefly outline the philosophy applied for the development of the hydraulic models for this study. More detailed information in relation to the development of the TUFLOW models is presented separately in Section 5.

- The hydraulic modelling philosophy is based on preparing separate and discrete highly detailed 1D/2D hydraulic models to cover the two (2) subject catchments;
- The TUFLOW HPC platform was adopted as it represented the current release but additionally includes a GPU solver which beneficially aids in simulation times;
- In defining the model structure and grid size, consideration has been given to the conflicting factors of model resolution and detail in accurately defining floodplain characteristics and the model run time.

Model schematisation and testing performed demonstrated that it was practical to utilise a highly detailed 3m grid resolution model whilst also resulting in practical model run times (i.e. approximately 1-hour). Accordingly, a 3m grid resolution was adopted for both catchments; and

- All TUFLOW hydraulic models have been prepared based on the current best practice guidelines represented in ARR2019.

4 HYDROLOGIC MODEL

4.1 Introduction

To assess local flooding characteristics for each of the Days Creek and Roberts Waterhole catchments, hydrologic models have been developed using the XP-RAFTS software. The following section of this report aims to provide a detailed summary of the XP-RAFTS hydrological model development and setup prepared for each of the Days Creek and Roberts Waterhole catchments.

4.2 XP-RAFTS Sub-Catchments

The sub-catchment delineation for each of the Days Creek and Roberts Waterhole catchments was informed using a 1m DEM prepared from the 2021 LiDAR data. In all cases, individual sub-catchment areas across both models were generally represented to be less than 30-hectare. The XP-RAFTS sub-catchment delineation prepared for the Days Creek and Roberts Waterhole catchments is illustrated respectively in Figure 4-1 and Figure 4-2. A summary of the sub-catchments applied for both catchments is presented in Table 4-1.

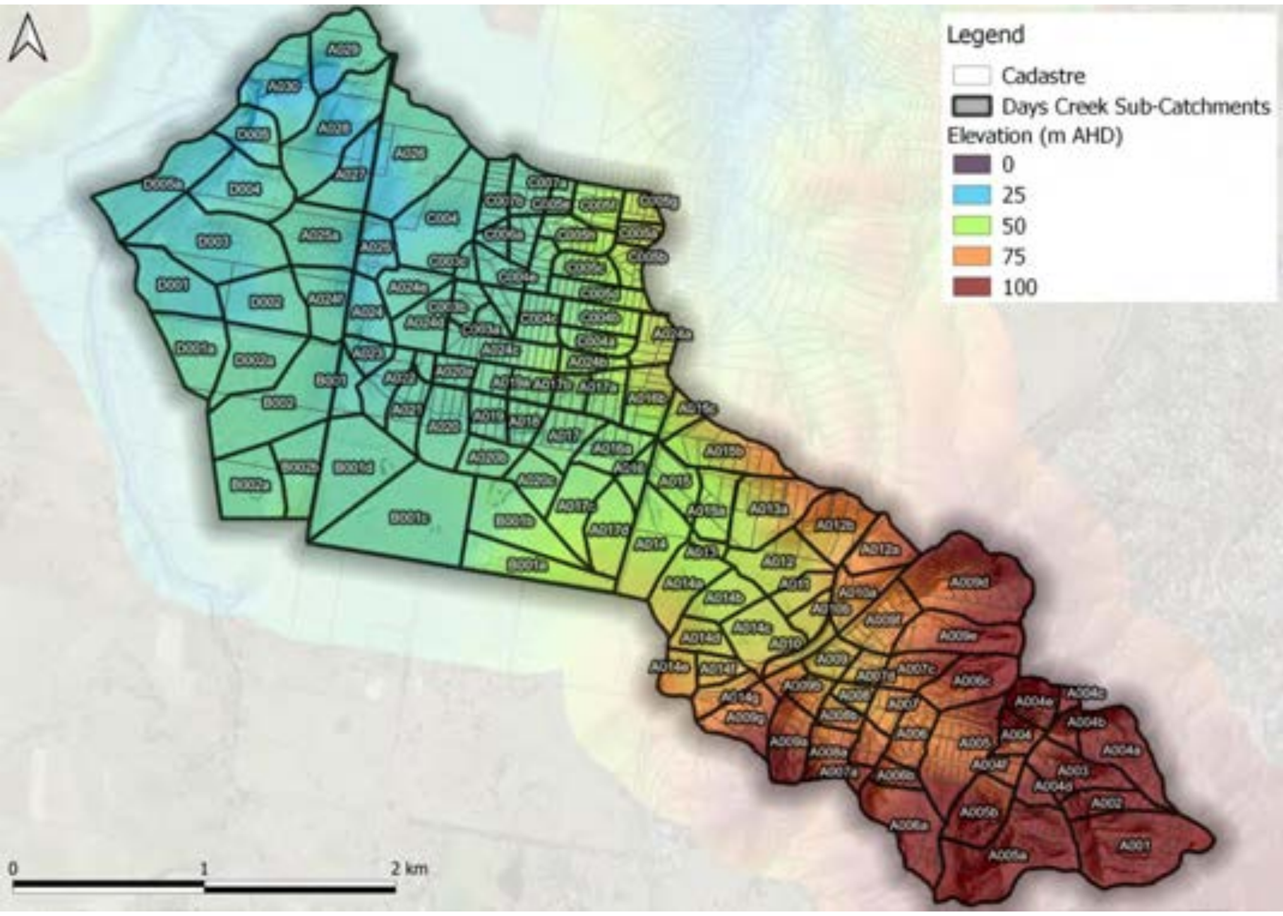

Figure 4-1 XP-RAFTS Sub-Catchments – Days Creek

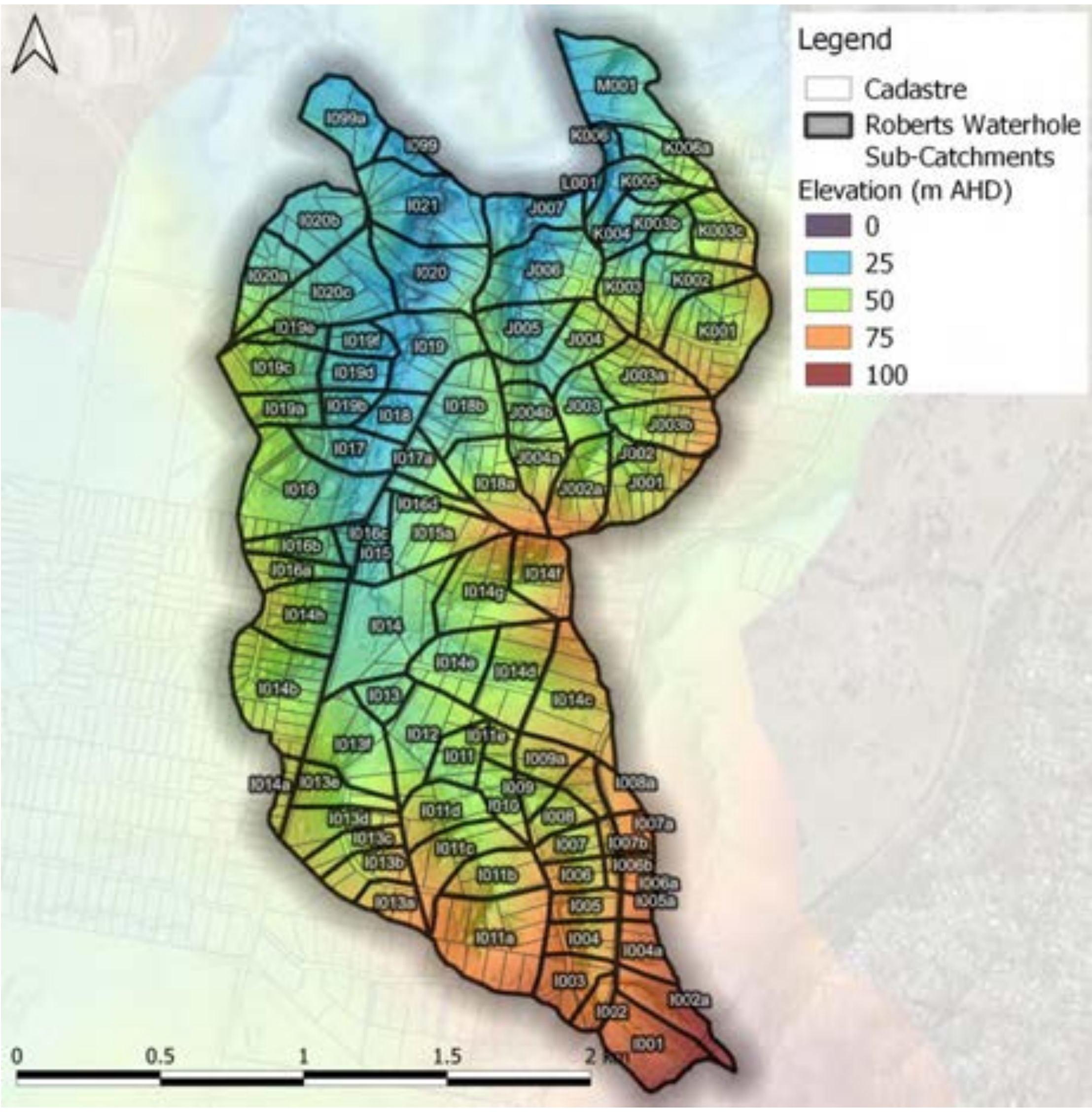

Figure 4-2 XP-RAFTS Sub-Catchment – Roberts Waterhole

Table 4-1 XP-RAFTS Sub-Catchment summary

Parameter	Days Creek	Roberts Waterhole
Overall Catchment Area (ha)	987.7	422.3
Total number of sub-catchments	127	93
Largest sub-catchment area (ha)	29.0	12.7
Smallest sub-catchment area (ha)	1.4	0.6
Average sub-catchment area (ha)	7.8	4.5

4.3 Design Rainfall

4.3.1 Design Events up to the 0.05% AEP Event

IFD parameters adopted for the assessment have been sourced using the most recent IFD information prepared by the Bureau of Meteorology (BoM) and released in association with the ARR2019 revision. As each of the Days Creek and Roberts Waterhole catchments were less than 20 km^2 in area, a uniform spatial pattern is the recommended approach in ARR2019 for application of a single IFD. The actual IFD data sets applied for the analysis have been taken directly from the Data Hub as part of the ARR2019 procedures. An extract from the ARR2019 Data Hub is included in Appendix B and includes a summary of the IFD values adopted for this study.

4.3.2 Preburst Depths

Preburst rainfall depths were applied in the Storm Injector model based on the median preburst rainfall outlined in ARR2019 Data Hub, a copy of which is included in Appendix B. A summary of the median preburst rainfall depths based on duration and AEP is summarised in Table 4-2. Preburst depths applied for standard durations and events not represented in Table 4-2 have been interpolated and extrapolated. Preburst has been applied in the design event modelling (50% median values) process through subtraction from the Initial Loss values utilising the Storm Injector ARR2019 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.

Table 4-2 ARR2019 Median Preburst Depths for Days Creek and Roberts Waterhole (Source – ARR2019)

Duration (mins)	Design AEP (%)					
	50	20	10	5	2	1
60	0.8	2	2.8	3.6	4.2	4.7
90	0.2	0.6	0.9	1.1	8.9	14.6
120	0	1	1.6	2.2	11.4	18.2
180	0	2.7	4.5	6.2	22.9	35.5
360	0.2	5.7	9.4	12.9	28.2	39.6
720	3.5	10.3	14.7	19	31.2	40.4
1080	0	8.3	13.7	19	30	38.2
1440	0.4	7	11.3	15.5	24.8	31.7

4.3.3 Temporal Patterns

A point location at the centroid of each of the Days Creek and Roberts Waterhole catchments has been selected on which point temporal patterns were derived. Areal temporal patterns have not been considered as critical storm durations throughout both catchments were less than 12 hours. Temporal pattern information determined from the ARR2019 Data Hub is included in Appendix B.

4.3.4 Probable Maximum Precipitation

An analysis of the Probable Maximum Flood (PMF) has been completed as part of this study. This assessment included an analysis of the Probable Maximum Precipitation (PMP) which was assessed using XP-RAFTS and Storm Injector based on the Generalised Short-Duration Method (GSDM). Rare to extreme rainfall temporal patterns were determined utilising the derived design temporal distribution presented in Table 1 of Chapter 5 in the Bureau of Meteorology's GSDM methodology as presented in Table 4-3.

Table 4-3 Design Temporal Distribution of Short Duration PMP (Source – BoM, 2018)

% of time	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
% of PMP	0	4	10	18	25	32	39	46	52	59	64	70	75	80	85	89	92	95	97	99	100

4.3.5 Climate Change Increase in Rainfall Intensity

An analysis of climate change in respect to increases in rainfall intensity has been completed as part of this study. Specifically, this has included a sensitivity analysis undertaken for the 50% 20%, 10%, 5%, 2%, 1%, 1 in 200 and 1 in 500 AEP events to assess the effect of climate change via the application of increased rainfall intensities. These events have been selected and simulated for the ARR2019 climate change factors representing the year 2090 RCP 4.5 climate change scenario as a requirement for the LCC Flood Hazard Matrix as part of the FRMS. In addition, sensitivity on the 2090 RCP 6 and 2090 RCP 8.5 climate change scenarios has been selected for the 1% AEP.

4.3.6 Rainfall Design Losses

Without any 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 Days Creek and Roberts Waterhole are based on the ARR Datahub. Table 4-4 summarises the ARR2019 Data Hub design losses. As shown in Table 4-4 the PMF design AEP event has zero rainfall losses applied.

Table 4-4 Summary of ARR 2019 Design Losses

Design Event	Design Losses	
	Initial Loss (mm)	Continuing Loss (mm/hr)
Up to 1 in 2000 AEP	24	1.6
PMF	0	1

4.4 XP-RAFTS Links

The XP-RAFTS models have been prepared based on a link routing method using the Muskingum-Cunge routing methodology. The method derives the channel travel time ('K') and weighting coefficient ('X') from a user defined cross section. Multiple cross sections were extracted using the DEM and applied to the hydrologic routing links for both the Days Creek and Roberts Waterhole catchments. The application of cross sections taken from the DEM allows physical representation of the catchment conditions which is then applied via the link routing to more appropriately reflect catchment routing conditions.

4.5 Catchment Land Use

In accordance with the project briefing requirements, the catchment land use scenario considered for the flood study update represents a fully developed catchment scenario in accordance with LCC's ultimate land use intent as articulated in the current Planning Scheme. As such, catchment land use for application in the XP-RAFTS models was determined in accordance with the planning scheme land use designation for which fraction impervious values in accordance with Section 4.05 of the Queensland Urban Drainage Manual (QUDM) were applied.

Each of the sub-catchments in the XP-RAFTS model was determined based on the planning scheme zone classifications, with the overall percentage imperviousness for each sub-catchment prepared based on a spatially area averaged basis. The land use classifications were informed on the basis of Council's interactive mapping system which represents the latest and current strategic plan for the land use zones represented throughout the catchments. Figure 4-3 and Figure 4-4 illustrate the catchment land use maps respectively for Days Creek and Roberts Waterhole catchments based on Council's current strategic plan. Fraction impervious values adopted for each of the respective land use zone classification are summarised in Table 4-5 below

Table 4-5 FI Values Adopted based on Land Use Classification

Land Use	Fraction Impervious
Road	0.9
Community Facilities	0.9
Rural Residential	0.15
Rural	0.05
Open Space	0
Environmental Management and Conservation	0
Special Purpose	0

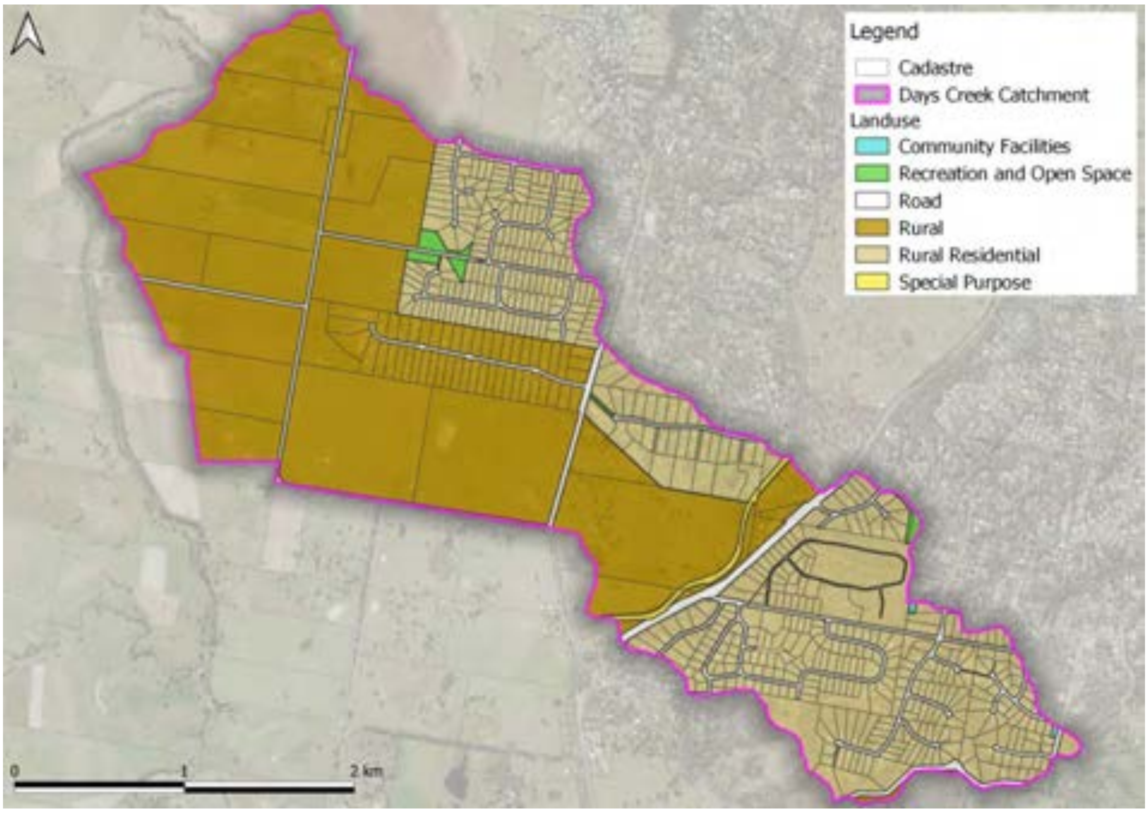

Figure 4-3 Landuse Classification Map – Days Creek

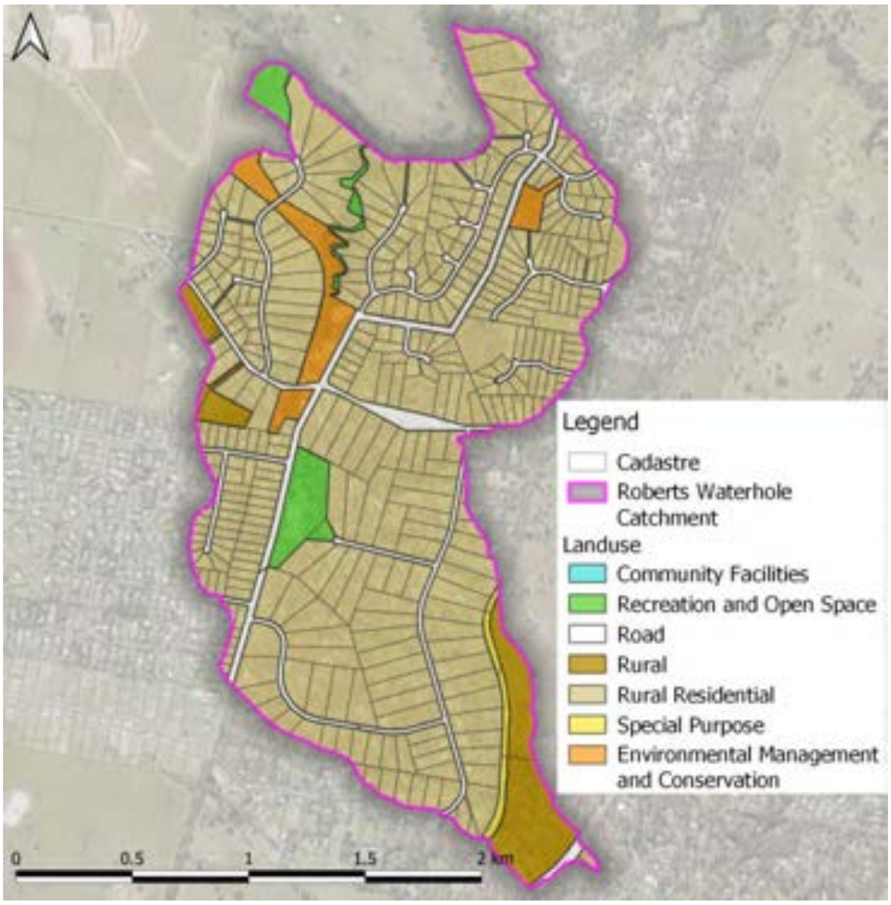

Figure 4-4 Landuse Classification Map – Roberts Waterhole

4.6 PERN Values

The PERN values for both models have been derived based on aerial data. The PERN values represent *"Mannings "n" representative of the average sub-catchment roughness"* (XP-Solutions, 2013). The PERN values applied have the effect of translating the catchment hydrograph modification factors (B modification values). Due to the PERN representing a hydrograph modification factor based on a representation of the catchment roughness for the pervious and impervious areas separately, broad scale values are appropriate and have subsequently been applied in the XP-RAFTS model. The PERN values adopted for the XP-RAFTS models are summarised in Table 4-6 and have been determined having regard to the hydraulic model and subsequent model calibration and validation approaches discussed separately in Section 6.

Table 4-6 PERN Model Parameters

XP-RAFTS Split Sub-Catchment	Sub-Catchment PERN Description	PERN Value
Pervious	Rural/Rural Residential	0.06
Impervious	Impervious Surfaces	0.02

4.7 Areal Reduction Factors

Areal Reduction Factors (ARF) represent a method to convert point rainfall intensities to applicable intensities over a larger catchment. The inclusion of ARF's provides a correction factor between the catchment rainfall depth (for a given combination of AEP and duration) and the mean of the point rainfall depths across a catchment. That is, smaller catchments are expected to experience higher intensity storms over the whole of the catchment area compared to larger catchments.

The inclusion of ARF's is recommended in ARR2019 for catchments greater than $1km^2$ in area to $30,000km^2$, with partial storms recommended for catchments greater than $5,000km^2$. For the Days Creek catchment and Roberts Waterhole catchments having areas of approximately $9.8km^2$ and $4.3km^2$ respectively, ARF's are to be applied as recommended in ARR2019.

Given the intent of the current study is to provide a future flood overlay map under the planning scheme and to derive flood planning levels upon which development compliance will be assessed, it may be appropriate to adopt an ARF of unity which does not adjust rainfall depths and results in a degree of conservatism. However, while this approach may be appropriate, it is strictly not in accordance with ARR2019. Accordingly, for the purposes of this study, ARF's have been applied to all storms as per ARR2019 guidance for all durations and for catchment areas of between 1 and 10 km^2. The ARF's have been calculated based on the area to the centroid of each catchment. That is, ARF's based on an area of $4.5km^2$ for the Days Creek catchment and $2.1km^2$ for the Robers Waterhole catchment. A summary of the ARF's for events greater than the 1% AEP are presented in Table 4-7, with the ARF's for the 1% and more frequent AEP's being of a similar magnitude. As can be seen from Table 4-7, the ARF's are close to unity owing to the small catchment sizes and the subsequent reduction in rainfall depths are therefore relatively minor (approximately 1-8%).

Table 4-7 Summary of Aerial Reduction factors

Duration (mins)	Days Creek			Roberts Waterhole		
	0.5% AEP	0.2% AEP	0.05% AEP	0.5% AEP	0.2% AEP	0.05% AEP
30	0.927	0.924	0.918	0.969	0.968	0.965
45	0.936	0.931	0.925	0.973	0.971	0.968
60	0.940	0.935	0.929	0.975	0.973	0.970
90	0.943	0.938	0.930	0.976	0.974	0.970
120	0.944	0.938	0.930	0.977	0.974	0.970
180	0.947	0.940	0.930	0.977	0.975	0.970
360	0.969	0.966	0.961	0.987	0.986	0.984

4.8 Model Calibration and Validation

Calibration and validation processes undertaken for the respective XP-RAFTS models prepared for each of the Days Creek and Roberts Waterhole catchments is subject to a separate detailed discussion which is presented in Section 6.

4.9 Design Event Modelling

The detailed XP-RAFTS runoff-routing hydrology model of both the Days Creek and Roberts Waterhole catchments has been adopted for the design event modelling for this study and has been used to assess the full suite of design events and storm durations. Specifically, this has included the 63% AEP through to 0.05% AEP events (1 in 2 AEP to 1 in 2000 AEP events) as well as the PMF event for durations from 15-minutes to 360-minutes.

5 HYDRAULIC MODEL

5.1 Introduction

To assess local hydraulic characteristics for each of the Days Creek and Roberts Waterhole catchments, two (2) discrete 1D/2D TUFLOW models for each of the subject catchments have been developed. The following sections of this report aim to provide a detailed summary of the TUFLOW hydraulic model development and setup prepared for each of the Days Creek and Roberts Waterhole catchments.

5.2 Model Updates and Revision Summary

5.2.1 Boundaries

5.2.1.1 Code Boundary

Due to the separate catchments, two (2) model code boundaries that have been prepared for this study. The two model boundaries contain the major streams and flow paths of the Days Creek and Roberts Waterhole catchments respectively. The following summarises the different code boundaries:

- The Days Creek Model code boundary has been developed to contain the PMF flood extent and spans from eastern Woodhill, upstream of Bamboo Drive, down to the confluence with the Logan River. The downstream boundary of this code boundary has been placed at the catchment outlet, slightly upstream of the Logan River. An additional outflow boundary has been placed on the northern catchment boundary, north of Arthy Drive to relieve any flows that would discharge to an external catchment due to the stormwater network in this area; and
- The Roberts Waterhole model boundary consists of three separate active areas given the three (3) separate outlets that discharge to the Logan River. The majority of the catchments contains the western most flow path which extends up to the Mt Lindesay Highway. The extent of all three boundaries have been sized to contain the PMF flood event. The downstream boundary of each active area is located at the bank of the Logan River, with an additional outflow boundary to the north-west of the catchment boundary to relieve any sheet flow discharging into the external catchment.

5.2.1.2 Inflow Boundaries

Model inflows have been based on the sub-catchment breakdown for both the Days Creek and Roberts Waterhole XP-RAFTS hydrologic models. The inflows have been represented in the hydraulic model as a series of local and total catchment Source Area (“SA”) inflow boundaries. Total catchment inflows have been used where multiple catchments are upstream of the waterway corridors provided by LCC. Routing is therefore undertaken within the hydraulic model but has also been replicated in the XP-RAFTS model for consistency purposes.

5.2.2 Tailwater Boundaries and Coincident Flooding Considerations

It is acknowledged that the lower portions of the Days Creek and Roberts Waterhole catchments are significantly impacted be regional flooding from the Logan River, with the Logan River completely dominating flood planning levels in the downstream reaches. The respective catchment sizes of the Logan River to that of the Days Creek and Roberts Waterhole catchments are vastly different. Note that the Logan River catchment area to the Yarrahappini gauge situated near the study area catchments is approximately 2416km^2 compared to the local catchment study area of approximately 13km^2.

Given the distinctly different catchment areas, the discharge estimates between the regional and local catchments will also be vastly different. For example, the peak discharge for the 2015 event at the Yarrahappini gauge approached 4000m^3/s based on the Department of Natural Resources, Mines and Energy (DNRME) gauge records, with the larger Days Creek catchment 1% AEP peak flows estimated to be within the range of 120m^3/s. The local catchment 1% AEP flow therefore represents only approximately 3% in total peak discharge at the confluence point.

Given the vastly different catchment areas and subsequent peak flows, along with the significant differences in catchment timing, it is unlikely that coincident flooding would occur between the regional and local catchment systems. That is, a 1% AEP local flood event would likely occur in combination with a low water level in the regional Logan River. However, design planning levels at least in the lower portion of the local catchment will be set based on regional logan river levels. As such, the Days Creek and Roberts Waterhole models have used coincident levels based on the ratio of the local catchment to regional catchment size to define the 1% AEP coincident regional level. The ratio of local to regional catchment areas and resultant 1% AEP regional tailwater levels have been calculated using Table 5-1 below.

Table 5-1 Coincident Regional Flood Events for Local Tributary Modelling (Ipswich City Council Implementation Guideline)

Ratio ff Local to Regional Catchment Area (A_L/A_R)	Regional Event Combination to Define 1% AEP Flood Level in Local Tributary (AEP)
<0.001	50
0.001-0.01	20
0.01-0.1	5
0.1-0.2	2.5
>0.2	1

The remaining AEP's have been scaled down (or up) as necessary. The Local River tailwater levels for each AEP have been summarised below in Table 5-2 and Table 5-3 for Days Creek and Roberts Waterhole respectively.

Table 5-2 Design Logan River Tailwater levels – Days Creek

Days Creek Design Event	Proposed DS level (m AHD)	Description (LAFS, WRM 2021)
63.2%	-	Normal depth boundary
50%	-	Normal depth boundary
20%	-	Normal depth boundary
20% RCP 4.5	-	Normal depth boundary
10%	27.79	50% AEP regional flood event at confluence
10% RCP 4.5	27.79	50% AEP regional flood event at confluence
5%	27.79	50% AEP regional flood event at confluence
5% CC RCP4.5	27.79	50% AEP regional flood event at confluence
2%	27.79	50% AEP regional flood event at confluence
2% CC RCP4.5	27.79	50% AEP regional flood event at confluence
1%	30.78	20% AEP regional flood event at confluence

Days Creek Design Event	Proposed DS level (m AHD)	Description (LAFS, WRM 2021)
1% CC RCP4.5	30.78	20% AEP regional flood event at confluence
1% CC RCP6	30.78	20% AEP regional flood event at confluence
1% CC RC.8.5	30.78	20% AEP regional flood event at confluence
0.5%	30.78	20% AEP regional flood event at confluence
0.5% CC RC.4.5	30.78	20% AEP regional flood event at confluence
0.2%	32.67	5% AEP regional flood event at confluence
0.2% CC RC.4.5	32.67	5% AEP regional flood event at confluence
0.05%	32.67	5% AEP regional flood event at confluence
PMP	34.82	1% AEP regional flood event at confluence

Table 5-3 Design Logan River Tailwater levels – Roberts Waterhole

Days Creek Design Event	Proposed DS level (m AHD)	Description (LAFS, WRM 2021)
63.2%	-	Normal depth boundary
50%	-	Normal depth boundary
20%	-	Normal depth boundary
20% RCP 4.5	-	Normal depth boundary
10%	22.32	50% AEP regional flood event at confluence
10% RCP 4.5	22.32	50% AEP regional flood event at confluence
5%	22.32	50% AEP regional flood event at confluence
5% CC RCP4.5	22.32	50% AEP regional flood event at confluence
2%	22.32	50% AEP regional flood event at confluence
2% CC RCP4.5	22.32	50% AEP regional flood event at confluence
1%	26.62	20% AEP regional flood event at confluence
1% CC RCP4.5	26.62	20% AEP regional flood event at confluence
1% CC RCP6	26.62	20% AEP regional flood event at confluence
1% CC RC.8.5	26.62	20% AEP regional flood event at confluence
0.5%	26.62	20% AEP regional flood event at confluence
0.5% CC RC.4.5	26.62	20% AEP regional flood event at confluence
0.2%	31.02	5% AEP regional flood event at confluence
0.2% CC RC.4.5	31.02	5% AEP regional flood event at confluence
0.05%	31.02	5% AEP regional flood event at confluence
PMP	31.02	1% AEP regional flood event at confluence

5.2.3 Model Topography

The model topography represented in the hydraulic models is based on raw 2021 LiDAR data supplied by LCC. The extensive dataset was provided as a 1m raster to form the base elevations of both the Days Creek and Roberts Waterhole hydraulic models. Further topographic modifications have been made to amend misrepresented ground levels around road crossings, culvert inlets/outlets and other significant areas within the model. The model is based on a 3m cell size and employs the Sub-Grid-Sampling (SGS) enhancement which samples the underlying LiDAR at 1m.

5.2.4 Floodplain Roughness

Floodplain roughness values were derived based on LCC provided aerial photography along with multiple site inspections undertaken for both catchments. A summary of the adopted roughness values based on classification type is presented in Table 5-4. Figure 5-1 illustrates the spatial variation in floodplain roughness applied in the hydraulic models. The model roughness for this study has been updated and informed with consideration of the XP-RAFTS hydrology model in a joint calibration process which is discussed separately in Section 6.

A sensitivity assessment has additionally been undertaken on the floodplain roughness. The results of this sensitivity assessment are discussed separately in Section 7.2.8.

Table 5-4 Adopted Floodplain Roughness Values

Roughness Classification	Manning's 'n'
Open Space	0.050
Roads	0.020
Train Line	0.025
Waterbody	0.025
Open Channel	0.050
Overland Flow path (Light brush and trees)	0.060
Medium-Dense Bush	0.080
Rural	0.060
Rural Residential	0.090
Open Urban Areas	0.070
Light Tree Cover	0.100
Dense Tree Cover	0.160

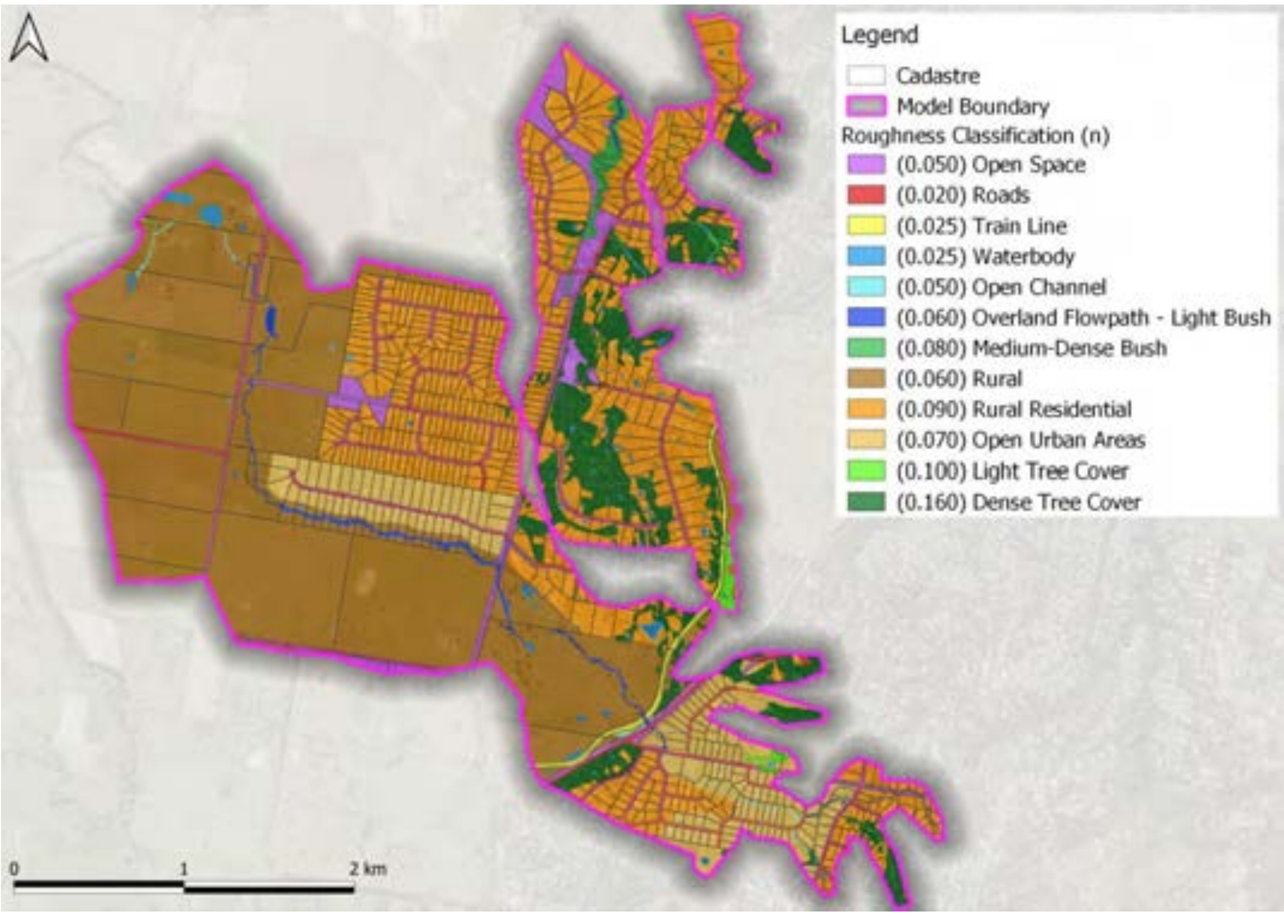

Figure 5-1 Days Creek and Roberts Waterhole Model Spatial Roughness

5.2.5 Hydraulic Structures

5.2.5.1 Bridge Structures

Days Creek is intersected by an obsolete (un-used) railway line in the upper reaches of the catchment which comprises a wooden bridge crossing running parallel to Mt Lindesay Highway. The structure, as illustrated in Figure 5-2, includes four (4) pier groups each comprising three (3) circular piers with no further blockage above the railway tracks. The bridge crossing was represented in the hydraulic model as a layered flow constriction, with Table 5-5 providing a detailed summary of the layered flow constriction parameters applied. Other than this bridge structure, there were no other bridges represented within either of the Days Creek or Roberts Waterhole catchments.

Figure 5-2 Railway Bridge Structure (Source – LCC, 2018)

Table 5-5 Summary of unused railway Bridge Structure Model Parameters

	Railway Bridge
Obvert of Soffit (m AHD)	63.6
Blockage to Soffit (%)	5
FLC to Soffit	0.1
Soffit Depth (m)	0.6
Soffit Blockage (%)	100
FLC of Soffit	1.56

5.2.5.2 Stormwater Pipes and Culverts

LCC provided a partial GIS stormwater structure database containing structure types, sizes and elevations, along with multiple sets of as constructed design drawings containing relevant structure data as part of the base study information. The data sets were subject to review as part of this study for which has been discussed previously in Section 2. As stated previously in Section 2.7, invert level data was adopted using surveyed levels provided by LCC, while elevation data was additionally derived from the supplied 2021 LiDAR survey data for all other structures and in the absence of surveyed information.

5.2.5.3 Hydraulic Structure Design Losses and Blockage Conditions

The hydraulic models prepared for each of the Days Creek and Roberts Waterhole catchment shave included the following structure losses and blockage factors:

- Inclusion of standard (=1) height and inlet/outlet contraction losses at all structures;
- No blockage allowance for stormwater drainage pipes (i.e. no allowance for loss of cross-sectional conveyance area due to sediment deposition or such);
- A 20% design blockage to all cross-drainage culvert crossings (i.e. noting that all existing cross drainage structures across both catchments have less than a 3m clear opening size); and
- A 50% design blockage for all inlet pit structures included in the model. We note that only major inlet pit arrangements have been included in the hydraulic models and the use of a 50% blockage is therefore considered to be appropriate and is conservative.

The blockage factors applied have been based on the guidance provided in the QUDM 2017 with such guidance shown in Figure 5-3 and Figure 5-4 respectively for culverts and pit inlet structure types.

Culvert conditions	Blockage factor	
	Design value	Severe storm [2]
Inlet height < 3 m, or width < 5 m:		
Inlet	20%	100% [4]
Chamber (barrel)	[3]	
Inlet height > 3 m and width > 5 m:		
Inlet	10%	25%
Chamber (barrel)	[3]	[3]
Culvert inlets with effective debris control features for culverts with inlet height < 3 m and width < 5 m	As above	As above
Screened culvert inlets	50%	100%

Notes:

[1] Developed from Engineers Australia (2012).

[2] Refer to discussion below on severe storm investigations.

[3] Adopt 20% bottom-up sediment blockage unless such blockage is unlikely to occur.

[4] The degree of blockage typically depends on availability of suitable bridging matter, such as large branches and fallen trees, that can 'bridge' across the structure opening.

Figure 5-3 Culvert Blockage Factors (Source – QUDM, 2017 Table 10.4.1)

Inlet type	Blockage factor	
	Design value [1]	Severe conditions [2]
Sag kerb inlets:		
Kerb inlet	20%	100 %
Grated	50 %	100%
Combination	[3]	100%
Continuous (on-grade) kerb inlets:		
Kerb inlet	20%	100%
Longitudinal bar grated	40%	100%
Transverse bar grate or longitudinal bar grate incorporating transverse bars	50%	100%
Combination	[4]	100%
Field (drop) inlets:		
Flush mounted	80%	100%
Elevated (pill box) horizontal grate	50%	100%
Dome screen	50%	100%
Open pipe inlets (blockage factors as per culverts)	Refer to Table 10.4.1	

Notes:

[1] Blockage factors applicable for the design of drainage structures.

[2] Maximum blockage factor considered during investigations into the consequences of storm in excess of the nominated major storm, or blockage in excess of 'design' values. Investigations into the likelihood of severe blockage may result in the nomination of a lower blockage value. Full blockage should only be considered in circumstances where suitable blockage material exists within the drainage catchment.

[3] At a sag, the capacity of a combination inlet (kerb inlet with grate) should be taken to be the theoretical capacity of the kerb opening with 100% blockage of the grate.

[4] On a continuous grade the capacity of a combination inlet should be taken to be 90% of the combined theoretical zero-blockage capacity of the grate plus kerb opening.

Figure 5-4 Inlet Pit Blockage Factors (Source – QUDM, 2017 Table 7.5.1)

5.3 Hydraulic Design Event Modelling

The detailed TUFLOW model of both the Days Creek and Roberts Waterhole catchments has been used for the design event modelling for this study and was analysed for the full suite of storm durations and temporal patterns of the 50%, 10% and 1% AEP design evets only. These AEP events were chosen as they apply the frequent, intermediate and rare temporal pattern bins from ARR2019. The critical storms were selected as the median (6^{th} ranked) storm across the catchment. 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 ARR2019 design.

As previously stated, the remaining AEP events (63% AEP through to 0.05% AEP events), were selected based on the critical duration and median temporal pattern selection, based on the frequent, intermediate and rare temporal pattern bins from ARR2019. Section 7 of this report provides a separate discussion on the hydraulic results (and critical duration selection) as well as the further assessments completed in respect to the model sensitivity assessments.

6 MODEL VALIDATION

6.1 Calibration and Validation Approach

Calibration is the process of adjusting parameters to result in an accurate measurement or representation. For flood studies, this includes:

- Hydrology – Calibration of flows to ensure adequate representation of catchment rainfall to runoff conversion processes; and
- Hydraulics – Calibration of water surface levels based on the calibrated flows generated from the hydrological model.

For the current study, there are no at-site gauges located within either of the Days Creek or Roberts Waterhole catchments. The nearest gauges to the site as discussed previously in Section 2.8 are located on the Logan River and therefore do not provide catchment specific calibration data. In the absence of local catchment gauges, calibration is unable to be completed or undertaken as part of this study.

Catchment flows for historical calibration events can however be indirectly derived using a rainfall-runoff model and the application of historical rainfall. That is, the calibration methodology in this instance would then be reliant on the hydraulic model calibration matched to surveyed debris levels or flood marks, with the hydrology and hydraulic models then being subject to joint calibration to optimise calibration outcomes (i.e. discharge and flood level estimates). However, this form of calibration approach is also unable to be undertaken for this study as there are no surveyed debris or flood marks located within the catchment that relate to a local catchment flood event. There is a surveyed flood mark located in the lower reaches of Days Creek but this is also unable to be used directly as the level relates to a regional Logan River flood event as opposed to the local catchment flood event. Accordingly, calibration via surveyed debris and flood marks is also unable to be directly undertaken as part of this study.

In the absence of at-site and catchment-based flood information, formal model calibration is unable to be undertaken for this study. Alternative methods are therefore required which constitute model validation processes and in the absence of being able to specifically undertake calibration processes.

In the absence of site-specific information, a range of alternative approaches for model validation are outlined and suggested in ARR2019. A brief summary of such methods including the associated limitations in the approach are presented separately below. These approaches are also subject to more detailed discussion in the sections of this report which follow.

- **Rational Method**. The Rational Method is not a recommended approach outlined in ARR2019. The Rational Method is however considered appropriate as a reference method for comparison against other methods in the Queensland Urban Drainage Manual (QUDM, 2016).
- **Regional Flood Frequency Estimate (RFFE) Method**. The RFFE approach has been developed as part of ARR2019 and was informed using at site Flood Frequency Analysis (FFA) across multiple sites throughout Australia. The RFFE method is limited to rural catchments with areas less than 1000km^2. However, the RFFE method is not recommended in ARR2019 for application to either Days Creek or Roberts Waterhole catchments given that the catchments comprise residential and urban development of more than 10%.
- **Further Methods**. A range of further and additional methods are also referenced as part of ARR2019 for the determination of catchment design discharge. Such methods include transposition of FFA's, regional based methods, comparison to previous studies and publications (i.e. software based general parameter guidance), etc.

- **Significant Event Validation**. The February 2022 event was selected to be used as a validation of flow for the design event and validation of flood extent. This validation method is possible through the use of calibrated doppler RADAR hydrology and can assist in validating hydrological and hydraulic flow comparisons.

6.2 Adopted Model Validation Approach

Given the discussion outlined in Section 6.1, the following comments are made:

- No formal calibration is able to be undertaken for this study; and
- There is no one single method that is available or should be used for model validation.

Accordingly, the adopted methodology to be applied for this study is to utilise and consider a range of individual and separate methods to provide greater overall confidence in the quantum of design discharge estimates for this study. The methods to be considered will include each of the methods discussed previously.

Consideration of a wide range of methods, and to include the associated limitations of such methods, is an approach that is recommended in ARR2019. Specifically, ARR2019 strongly advises to apply more than one method to any given design situation. The selection of a representative and appropriate design discharge for each of the Days Creek and Roberts Waterhole catchments can then be made with consideration across various methods and for which model validation has then been informed. The following sections of this report summarise the various methods and design discharge estimates for which the model validation approach for this study has been based.

6.3 Model Validation Methods

6.3.1 Rational Method

The Rational Method is currently the primary simplified hydrologic estimation technique for Queensland. It is considered appropriate as a reference method for comparison against other methods in the Queensland Urban Drainage Manual (QUDM, 2016). It is also considered appropriate for application to rural catchments with a catchment area less than 25 km^2 and for urban catchments less than 5 km^2 in area (QUDM, 2016). The catchment area to the outlet of the Days Creek Catchment (area of 9.6 km^2) is larger than the recommended limit for urban areas but is within the limits for application within a rural catchment (i.e. for which the catchment is more closely aligned given current development and future zoning). Discharge estimates prepared within the internal catchment areas and upon smaller areas within the catchment are however compliant with the Rational Method area guidance.

Despite the above limitations with the Rational Method and the fact that the method is not a recommended approach outlined in ARR2019, the approach is none the less appropriate as a method for design discharge estimation for the catchments and has therefore been considered.

The time of concentration for the catchment has been assessed using a combination of an overland flow time component as well as channel flow along the main catchment tributary. The channel flow component was based on an averaged channel velocity from the hydraulic analysis such that channel velocities were reliably informed from the subject catchment and are therefore representative of actual flow velocity and travel times.

The estimate of a coefficient of discharge (C) is required for the Rational Method to adequately represent factors influencing peak catchment discharge such as infiltration and other losses. The C_{10} values as outlined in Table 4.05.3 and 4.05.3 of QUDM were adopted for use in this assessment based on the associated fraction impervious values as determined from QUDM Section 4.05.

The Rational Method was calculated at multiple locations throughout each of the Days Creek and Roberts Waterhole catchments. Specifically, this included four (4) locations within the Days Creek catchment and three (3) locations within the Roberts Waterhole catchment as illustrated respectively in Figure 6-1 and Figure 6-2.

Table 6-1 and Table 6-2 below summarises the Rational Method parameters respectively for each of the Days Creek and Roberts Waterhole catchments. Peak flows at the catchment outlets were determined to be approximately 118m^3/s and 47m^3/s respectively for the Days Creek and Roberts Waterhole catchments using the Rational Method.

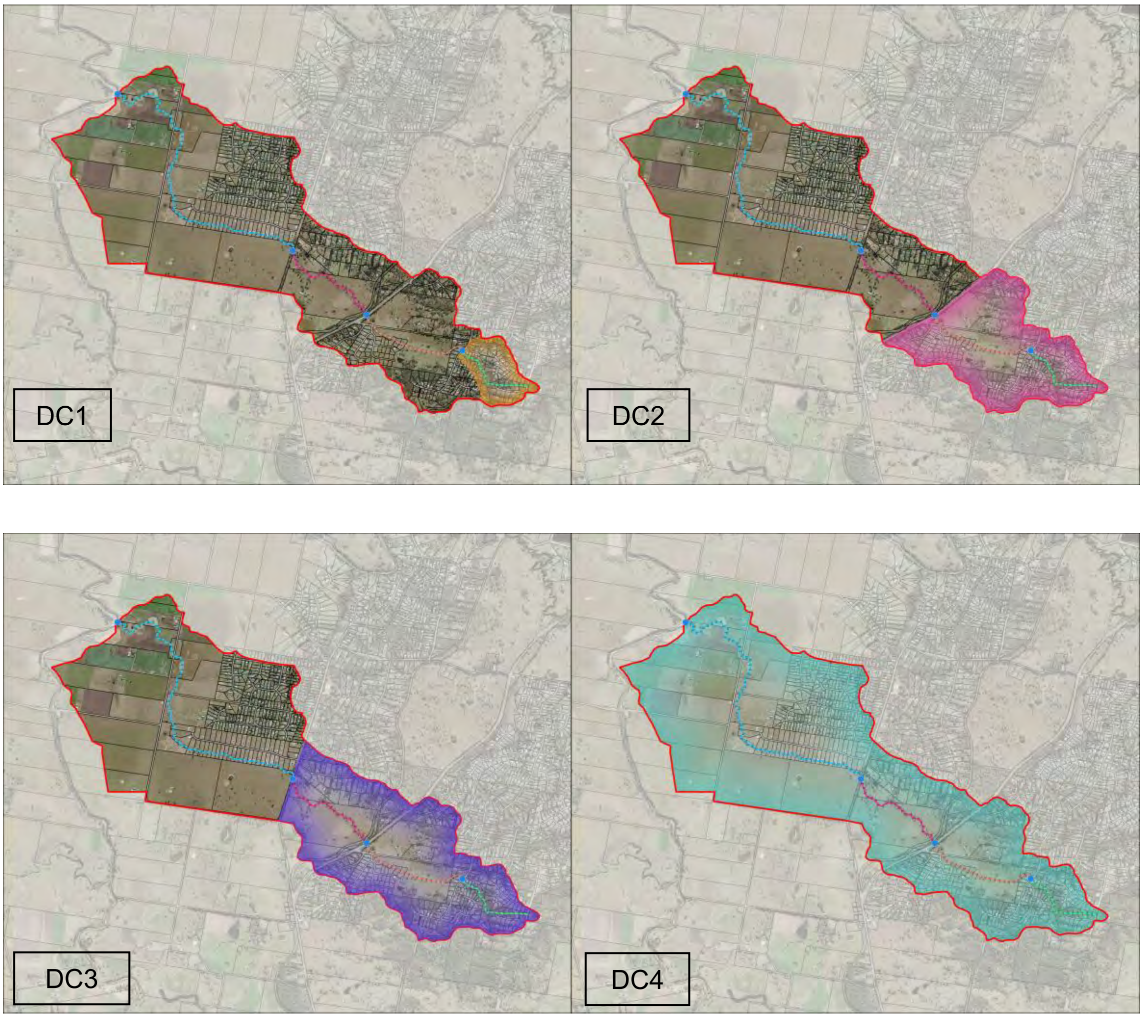

Figure 6-1 Days Creek - Rational Method Sub-catchments

Table 6-1 Rational Method Parameters – Days Creek

Parameter	DC1	DC2	DC3	DC4
Area (ha)	52.85	253.84	400.00	987.88
C_{10}	0.62	0.61	0.59	0.55
Flow path Length (m)	1085	2568	4082	8503
Av. Channel Velocity (m/s)	1.3	1.4	1.5	1.6
Time of Concentration (mins)	21.7	38.4	54.1	97.7
Rainfall Intensity (1% AEP event)	164.1	119	94.8	65.2
1% AEP Peak Discharge (m^3/s)	17.9	61.4	74.6	118.2

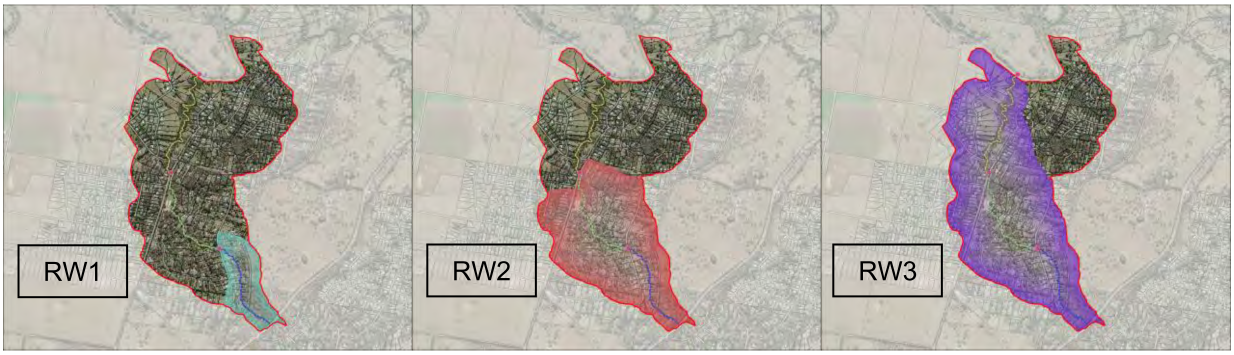

Figure 6-2 Roberts Waterhole Creek - Rational Method Sub-catchments

Table 6-2 Rational Method Parameters – Roberts Waterhole

Parameter	RW1	RW2	RW3
Area (ha)	47.2	193.9	311.1
C_{10}	0.58	0.6	0.6
Flow path Length (m)	1210	1401	1791
Av. Channel Velocity (m/s)	0.8	0.9	1.2
Time of Concentration (mins)	77.8	58.7	34.6
Rainfall Intensity (1% AEP event)	124.9	87.6	76.0
1% AEP Peak Discharge (m^3/s)	11.4	34.0	47.3

6.3.2 RFFE Method

The Regional Flood Frequency Estimate (RFFE) method has been considered as part of this study. The RFFE is recommended for use on rural catchments between 0.5km^2 and 1000 km^2 (ARR2019) and is therefore applicable to both catchments for this study. However, in the strict sense, the RFFE method is not recommended in ARR2019 for application to either Days Creek or Roberts Waterhole catchments given that both catchments are more than 10% affected by existing residential and urban development. Despite this, the RFFE method was applied to provide an estimate of flood magnitude at the catchment outlets only and to provide a further flow validation method for consideration in this study.

The RFFE method discharge estimates for Days Creek and Roberts Waterhole are presented in Table 6-3 and Table 6-4 respectively. The RFFE method outputs are included in Appendix D for each of the Days Creek and Roberts Waterhole catchments.

Peak flows at the catchment outlets were determined to be approximately 180m^3/s and 91.6m^3/s respectively for the Days Creek and Roberts Waterhole catchments. A summary of the RFFE parameters used for each of the catchments is also presented in Table 6-5 and Table 6-6.

The following provides further brief summaries of the RFFE method estimates:

- For the Roberts Waterhole catchment, the RFFE results were found to be extremely sensitive to catchment shape and as such should be treated with caution;
- It was evident that the discharge estimates from the RFFE method were likely to be higher due to the FFA influences in the RFFE method which included several catchments being present in the Gold Coast Hinterland area. The hinterland area is subject to steeper catchments and higher topography, as well as associated orographic rainfall effects being spatially closer to the coast. Each of these aspects will likely skew discharge estimates higher at the subject site; and
- As is typical for flood frequency analysis and the RFFE method, there is large confidence limits identified in the results. The lower and upper bound confidence limits for both catchments results in flows which are greater than +/-300% different in the lower and higher bounds compared to the derived discharge estimate.

Table 6-3 Days Creek (DC4) - RFFE Results

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	22.6	10.7	47.6
20	46.5	22.6	96.5
10	68.8	30.7	154.0
5	95.5	38.2	238.0
2	139.0	47.6	403.0
1	180.0	54.6	581.0

Table 6-4 Roberts Waterhole (RW3) - RFFE Results

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	11.8	5.59	25
20	24.1	11.7	50.1
10	35.4	15.8	79.3
5	49	19.6	122
2	71.2	24.2	206
1	91.6	27.7	296

Table 6-5 Days Creek (DC4) - RFFE Parameters

Variable	Value
Latitude (Outlet)	-27.858
Longitude (Outlet)	152.973
Latitude (Centroid)	-27.877
Longitude (Centroid)	152.973
Catchment Area (km^2)	9.88
Distance to Nearest Gauged Catchment (km)	13.69
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.07
2% AEP 6 Hour Rainfall Intensity (mm/h)	21.97
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.67
Interpolation Method	Natural Neighbor
Bias Correction Value	-0.494

Table 6-6 Roberts Waterhole (RW3) - RFFE Parameters

Variable	Value
Latitude (Outlet)	-27.851
Longitude (Outlet)	152.982
Latitude (Centroid)	-27.863
Longitude (Centroid)	152.983
Catchment Area (km2)	3.11
Distance to Nearest Gauged Catchment (km)	13.79
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.25
2% AEP 6 Hour Rainfall Intensity (mm/h)	22.61
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.72
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.452

6.3.3 Transposition of FFA

Where adequate historical data is available, an at-site flood frequency analysis is generally considered the best available approach to estimate design flood magnitudes. Although there is no at-site gauge on which to undertake an FFA for the subject catchments, transposition of FFA's prepared at adjacent catchment gauges has been considered as an alternative method for this study.

As stated previously, the RFFE model is a regional model that considers a range of existing gauge data and the associated FFA estimates. The FFA's considered can be used to estimate design discharges for ungauged catchments based on neighbouring catchments. When reviewing the RFFE estimates for the site, a detailed review was undertaken for each of the fifteen (15) gauges for which the RFFE estimate was based. The aim of the review was to determine whether any gauges should be excluded from the analysis or whether there was a good gauged catchment which could be transposed to the subject catchments, based on similar catchment characteristics, gauge record and gauging history. Several gauges were excluded as they were much larger than the subject catchment, in different climatic regions or had very poor ratings. Of the remaining gauges, The New Beith gauge (station ID 143033) was considered the closest representative gauge and was adopted for discharge transposition to the subject catchment for the following reasons:

- The catchment is similar in terms of the catchment layout with a relatively steep upper catchment and flat lower catchment, and with some low density rural residential development;
- Catchment areas were within a reasonable size comparison to the subject catchment (i.e. 60 km^2); and
- Closest spatially relevant and appropriate available gauge to the subject site.

The RFFE 1% and 10% AEP peak discharge estimates were extracted for the New Beith gauge and used via transposition to the subject catchments.

There is very little available methodology for transposing discharges between catchments in Queensland. The only applicable method is provided in Grayson et al. (1996) as follows:

$$\frac{Q_C}{Q_G} = \left(\frac{A_C}{A_G}\right)^{0.7}$$

Where:

Q = Discharge (m^3/s)
A = Area (hectares)
C = ungauged catchment
G = gauged catchment

The derived discharge estimates for the Days Creek and Roberts Waterhole catchments based on the Grayson transposition method outlined above is summarised in Table 6-7.

Table 6-7 FFA Transposition Discharge Estimates

Event	Days Creek (DC4)	Roberts Waterhole (RW3)
1% AEP	112.5	50.1
10% AEP	62.4	27.8

It is noted that there are various limitations in transposition techniques. Some of these limitations are discussed as follows:

- Although the New Beith gauge was considered the most similar to the subject catchment, there remains fundamental differences in the catchment characteristics, the primary aspects being associated with steepness, dense vegetation in the upper catchment as well as urban development and higher fraction impervious levels in the bottom portion of the catchment;
- Gauge ratings and discharge estimation reliability. It is noted that the highest gauged flow was 25 m^3/s at a 3.38 m local gauge height. This represents a relatively low gauged flow compared to the maximum of 385 m^3/s; and
- Gauge period. The gauge history of the New Beith gauge includes only 24 years which is relatively short and likely to be unreliable on which to base a 1% AEP discharge estimates.

However, despite these limitations in approach, the use of the method also needs to be considered in the broader context of use in terms of providing a further method for discharge estimation for the catchments and therefore for overall model validation purposes.

6.3.4 Regional Equations

Palmen and Weeks (2009) developed regression equations relating discharge to catchment area based upon rural catchments with areas of less than 1,000 km^2. The study was based on 289 Queensland catchments and therefore has some degree of local context. Equations were developed to provide discharge estimates for the 2, 5, 10, 20, 50 and 100-year Average Recurrence Interval (ARI) events. As an example, the equation for the estimate of the 100 year ARI discharge estimate (i.e. 1% AEP event) is outlined below: -

$$Q_{100} = 7.031 \times Area^{0.644} \times i7250y^{0.899}$$

Where: -

Q100 = 100 year ARI discharge (m^3/s);
Area = catchment area (km^2); and
i72h50y = the design rainfall intensity for the 72 hour, 50 year ARI (mm/h) storm.

The derived discharge estimates for the Days Creek and Roberts Waterhole catchments based on the Palmen and Weeks method are summarised in Table 6-8.

Table 6-8 Palmen and Weeks Discharge Estimates

Parameter	Days Creek (DC4)	Roberts Waterhole (RW3)
Area (km^2)	9.88	3.11
i72h50y (ARR87)	4.42	4.49
1% AEP (Q100) (m^3/s)	117	56
10% AEP (Q10) (m^3/s)	39	18

6.3.5 XP-RAFTS Design Event Models

Design event modelling based on the XP-RAFTS model was presented and discussed previously in Section 4.9. The peak discharge estimates for the Days Creek and Roberts Waterhole catchments based on the XP-RAFTS design event assessment for the critical storm durations are summarised respectively in Table 6-9 and Table 6-10 based on the various catchment reporting locations selected to be commensurable to that used in the Rational Method. The 1% AEP discharge at the catchment outlets for Days Creek and Roberts Waterhole were found to be 121.5m^3/s and 52.2m^3/s respectively.

Table 6-9 Days Creek Discharge Estimate Comparison – XP-Rafts Data Hub Losses

Event	DC1	DC2	DC3	DC4
1% AEP (m3/s)	8.6	46.8	67.7	121.5
10% AEP (m^3/s)	4.6	25.5	34.8	58.0

Table 6-10 Roberts Waterhole Discharge Estimate comparison – XP-Rafts Data Hub Losses

Event	RW1	RW2	RW3
1% AEP (m^3/s)	11.3	36.3	52.2
10% AEP (m^3/s)	5.7	17.2	25.1

6.3.6 Summary of Catchment Discharge Estimates and Discussion

A consolidated summary of catchment discharge estimates based on each of the validation methods described and outlined previously in Section 6.3 are presented in the absence of locally derived stream flow data for the catchment, model calibration is unable to be undertaken. As such, model validation can therefore only be informed using each of the methods considered as outlined previously. In this regard, the following discussion is provided in respect to the model validation results:

- The runoff-routing models prepared using the design rainfall techniques in accordance with ARR2019 was found to compare well across the quantum of catchment discharge estimates prepared using alternative methods;
- There appears to be consistency with the XP-RAFTS estimates in comparison to the FFA transposition method and noting the subsequent limitations in transposition of flows from an adjacent catchment as have been discussed previously in Section 6.3.3;
- The XP-RAFTS estimates were found to compare well with both the Rational Method estimates along with the Palmen and Weeks regional methods; and
- The XP-RAFTS discharge estimates for Days Creek was found to also compare well with HCE 2011, and noting that HCE 2011 utilised the former ARR1987 IFD's.

The RFFE method was found to consistently result in higher peak flood estimates. However, we consider the RFFE method to have limited application in this example given the lack of locally based gauge data which forms the basis of the RFFE design estimates. We additionally also note that strictly speaking, the RFFE method is not valid in this situation given the greater than 10% urban development which exists in both catchments.

We consider that the discharge estimates derived for both Days Creek and Roberts Waterhole catchments based on the XP-RAFTS model are considered to be reasonable and appropriate given the estimates prepared using alternative validation methods. On this basis, we consider the Days Creek and Roberts Waterhole XP-RAFTS models to be suitably validated and applicable for use in this study.

Table 6-11 and Table 6-12 also include discharge estimates prepared as part of previous studies which are included for comparative purposes.

In the absence of locally derived stream flow data for the catchment, model calibration is unable to be undertaken. As such, model validation can therefore only be informed using each of the methods considered as outlined previously. In this regard, the following discussion is provided in respect to the model validation results:

- The runoff-routing models prepared using the design rainfall techniques in accordance with ARR2019 was found to compare well across the quantum of catchment discharge estimates prepared using alternative methods;
- There appears to be consistency with the XP-RAFTS estimates in comparison to the FFA transposition method and noting the subsequent limitations in transposition of flows from an adjacent catchment as have been discussed previously in Section 6.3.3;
- The XP-RAFTS estimates were found to compare well with both the Rational Method estimates along with the Palmen and Weeks regional methods;
- The XP-RAFTS discharge estimates for Days Creek was found to also compare well with HCE 2011, and noting that HCE 2011 utilised the former ARR1987 IFD's; and
- The RFFE method was found to consistently result in higher peak flood estimates. However, we consider the RFFE method to have limited application in this example given the lack of locally based gauge data which forms the basis of the RFFE design estimates. We additionally also note that strictly speaking, the RFFE method is not valid in this situation given the greater than 10% urban development which exists in both catchments.

We consider that the discharge estimates derived for both Days Creek and Roberts Waterhole catchments based on the XP-RAFTS model are considered to be reasonable and appropriate given the estimates prepared using alternative validation methods. On this basis, we consider the Days Creek and Roberts Waterhole XP-RAFTS models to be suitably validated and applicable for use in this study.

Table 6-11 Days Creek Discharge Estimate Comparison

Method	Days Creek	
Rational Method	**1% AEP Discharge (m^3/s)**	**10% AEP Discharge (m^3/s)**
■ DC1	17.9	10.0
■ DC2	61.4	33.8
■ DC3	74.6	40.4
■ DC4	118.2	62.6
RFFE Method (DC4)	180.0	68.8
FFA Transposition (DC4)	112.5	62.4
Palmen and Weeks (DC4)	117.0	39.0
XP-RAFTS (ARR2019 Losses)		
■ DC1	8.6	4.6
■ DC2	46.8	25.5
■ DC3	67.7	34.8
■ DC4	121.5	58.0
Previous Studies		
■ AECOM 2014 – System 22	n/a – Note 1	n/a – Note 1
■ HCE 2011 Study	126.4 – Note 2	74.7 – Note 2
■ WRM 2021 – Logan-Albert Flood Study	n/a – Note 3	n/a – Note 3

Notes

1. Discharge not reported and not readily determinable based on the supplied digital model results. Report notes that the flow estimate has been based on the regional Logan-Albert River XP-RAFTS model.
2. HCE 2011 study based on XP-RAFTS model using ARR1987 IFD parameters. The adopted HCE model included an IL=10mm and a CL=0mm/hr.
3. Sub-catchment delineation performed for the regional flood model does not appropriately represent the local Days Creek and Roberts Waterhole catchments in sufficient scale to enable a representative discharge estimate to be extracted.

Table 6-12 Roberts Waterhole Discharge Estimate Comparison

Method	Roberts Waterhole	
Rational Method	1% AEP Discharge (m^3/s)	10% AEP Discharge (m^3/s)
■ RW1	11.4	6.3
■ RW2	34.0	18.3
■ RW3	47.3	25.3
RFFE Method (RW3)	91.6	35.4
FFA Transposition (RW3)	50.1	27.8
Palmen and Weeks (RW3)	56.0	18.0
XP-RAFTS (IL=25mm, CL=2mm/hr)		
■ RW1	11.3	5.7
■ RW2	36.3	17.2
■ RW3	52.2	25.1
Previous Studies		
■ AECOM 2014 – System 21	n/a – Note 1	n/a – Note 1
■ WRM 2021 – Logan-Albert Flood Study	n/a – Note 2	n/a – Note 2

Notes

1. Discharge not reported and not readily determinable based on the supplied digital model results. Report notes that the flow estimate has been based on the regional Logan-Albert River XP-RAFTS model.
2. Sub-catchment delineation performed for the regional flood model does not appropriately represent the local Days Creek and Roberts Waterhole catchments in sufficient scale to enable a representative discharge estimate to be extracted.

6.3.7 February 2022 Event Validation

6.3.7.1 Synoptic Description of Event

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.

6.3.7.2 Gauge Data

Water levels in Days Creek and Roberts Waterhole were not recorded during the February 2022 flood event. However, water levels in the Logan River were recorded in the vicinity of the catchments at the Yarrahappini Alert (040762-0) and Kilmoylar Rd Alert (540690-0) gauge stations and have been utilised in determining tailwater levels at the outlets of both Days Creek and Roberts Waterhole. This is discussed further in Section 6.3.7.4.

6.3.7.3 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 Days Creek and Roberts Waterhole catchments, 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 with 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 useful. However, this is not possible for this assessment due to the ungauged catchments.

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.

6.3.7.4 Tailwater Boundary

A downstream HT boundary was applied to the TUFLOW models and were based on the Kilmoylar Rd Alert (540690-0) and Yarrahappini Alert (040762-0) gauge along the Logan River. The Kilmoylar Rd Alert gauge is located approximately 2300 metres downstream of the Days Creek and Logan River confluence and was used for the Days Creek model tailwater boundary. The Yarrahappini Alert is located approximately 2000 meters downstream of the Roberts Waterhole and Logan River confluence. As such a tailwater level for the Roberts Waterhole model was derived from interpolating between the two gauge levels. The two gauge levels and interpolated level is provided below in Figure 6-3.

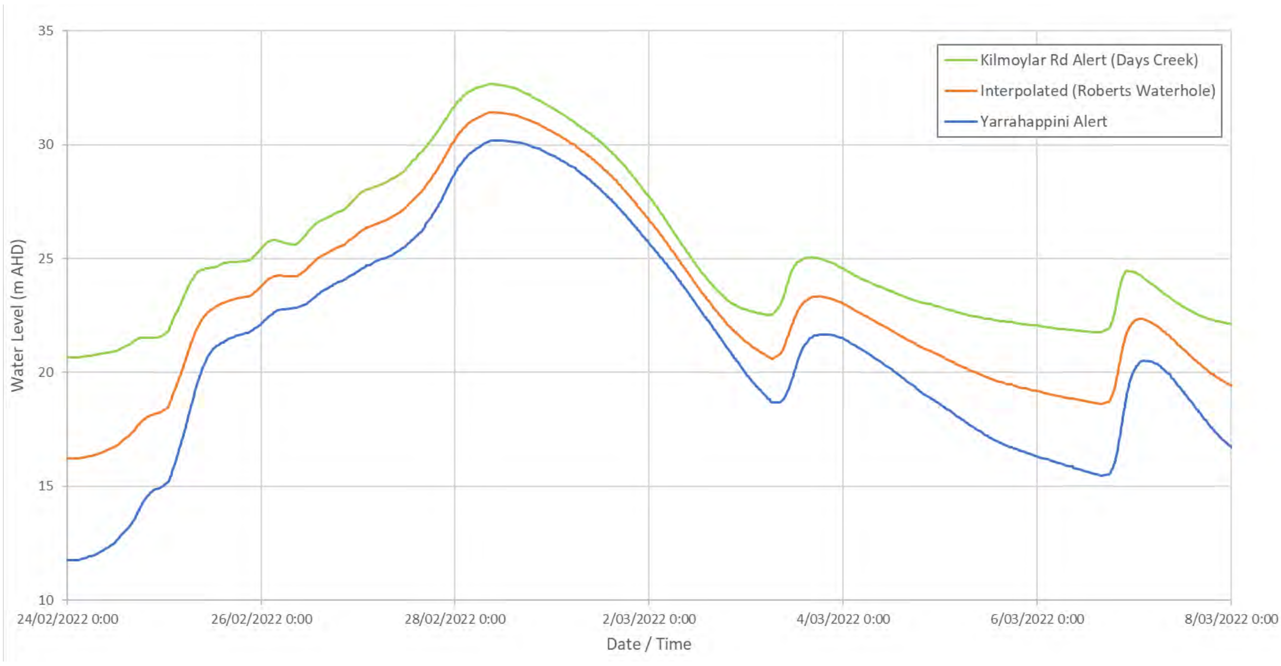

Figure 6-3 Dynamic Tailwater Level Applied to February 2022 Validation Event

6.3.7.5 Hydrologic Modelling

This study has utilised the previously joint calibrated modelling involving both the hydrologic XP-RAFTS and hydraulic TUFLOW model where both models were subject to optimisation and refinement through an iterative analysis process. The XP-RAFTS model was initially validated to the RADAR discharge where loss and routing parameters were selected based on ARR 2019 Data Hub. Ultimately, the validation seeks to achieve hydrologic and hydraulic similarity that will ensure consistency and robustness of the models.

Table 6-13 summarises the rainfall losses applied in the XP-RAFTS validation model. The storm losses were applied using an Initial Loss (IL) and Continuing Loss (CL) rainfall loss model. As this model is not used for calibration and only as a method to validate flows hydrologically and hydraulicly, the ARR Datahub initial loss and continuing loss were adopted and considered appropriate. Storm losses for the validation events have been applied uniformly across the catchment.

Table 6-13 Summary of Adopted Rainfall Losses for Validation

Catchment	Pervious Initial Loss (mm)	Continuing Loss (mm/hr)
Days Creek	24	1.6
Roberts Waterhole	24	1.6

6.3.7.6 Joint Calibration

The comparison of discharge between the XP-RAFTS hydrologic model to the TUFLOW hydraulic model for the February 2022 event is presented in Figure 6-4 and Figure 6-5 for Days Creek and Roberts Waterhole respectively. The location within each catchment has been selected approximately at the middle of the catchment (DC3 for Days Creek and RW1 for Roberts Waterhole) as such to not incorporate downstream tailwater impacts in the hydraulic model. The discharges from both the hydrologic and hydraulic models compare relatively well (within 10%) at the gauge. Generally, the TUFLOW model is consistently slightly lower than the XP-RAFTS model (with localised depressions not accounted for in the XP-RAFTS model) although the shape of the hydrographs is consistent highlighting the hydrologic model is representing the routing well. The joint calibration of the XP-RAFTS and TUFLOW models has allowed overall consistency in the validation outcomes, with the subsequent differences observed well within the bounds typical for a study of this nature.

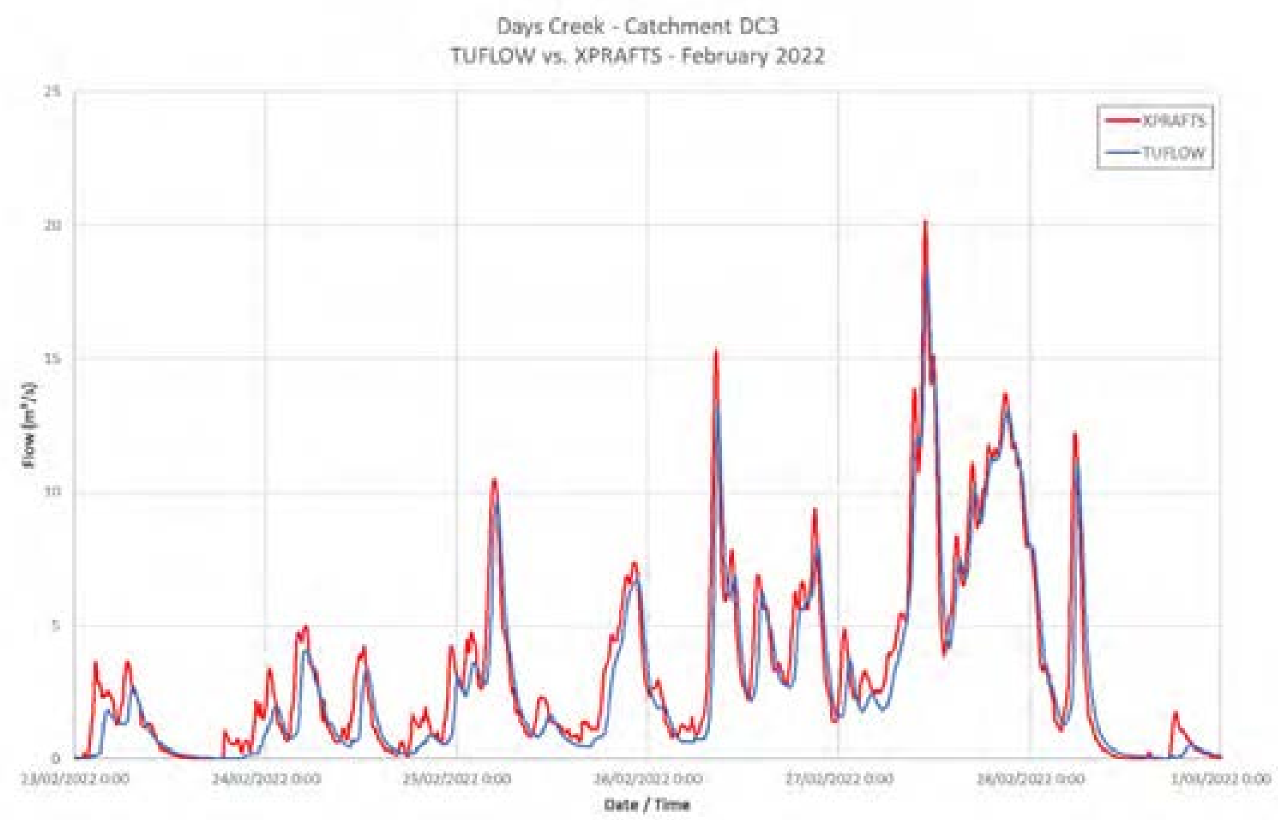

Figure 6-4 XP-RAFTS vs TUFLOW Discharge Comparison for February 2022 event at Days Creek

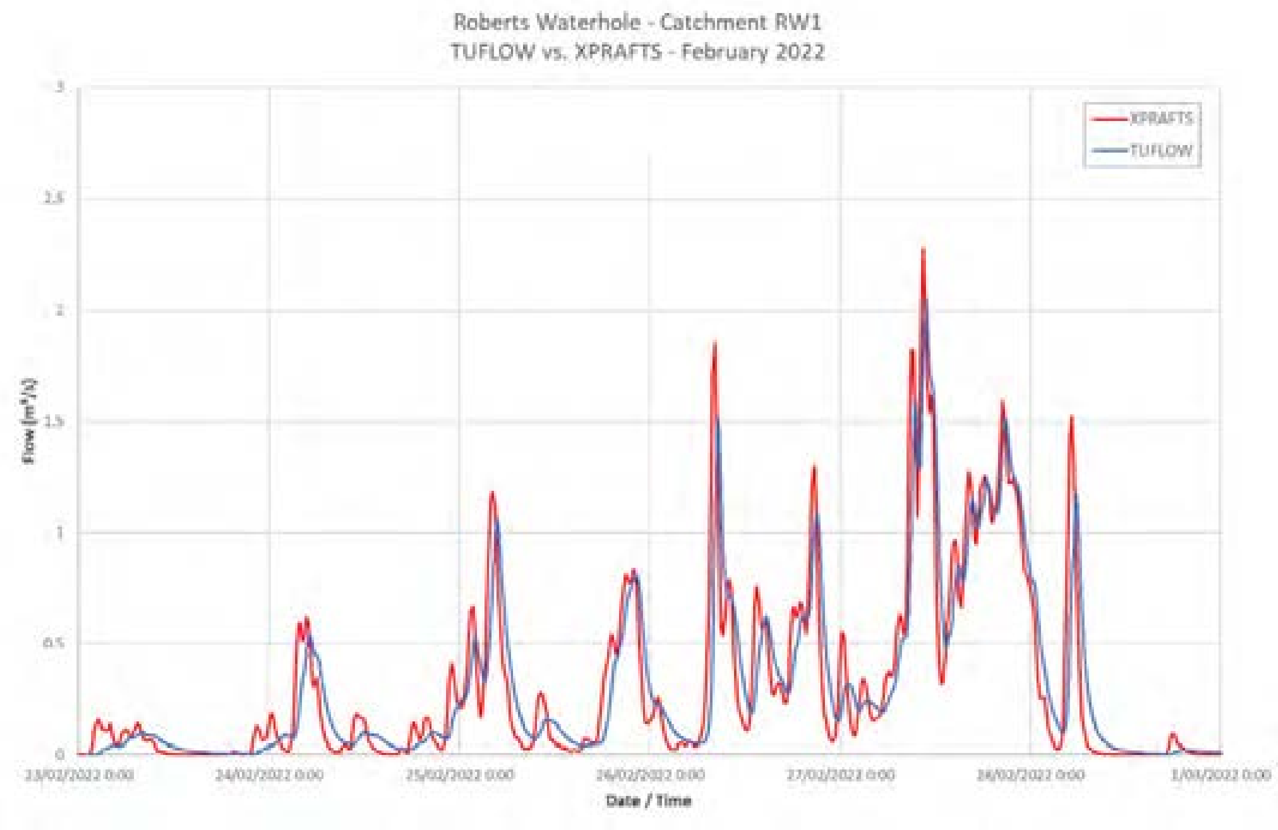

Figure 6-5 **XP-RAFTS vs TUFLOW Discharge Comparison for February 2022 event at Roberts Waterhole**

6.3.7.7 Comparison to Design Event Results

To validate the design event modelling the peak levels for the February 2022 event throughout the catchment were compared against the design estimates. Based on the design levels the February 2022 event was estimated to be between a 50% and 10% AEP event in the areas unaffected by Logan River backwater. These results are consistent with the observed rainfall given the intensities were estimated to be have a similar AEP for the shorter duration (up to 6 hours). The longer durations had intensities greater than 2% AEP although these are not critical for the catchments. Figure 6-7 presents the observed rainfall intensities compared to the BOM IFD values at the Undullah Rd gauge. This comparison gives further confidence to the design event modelling.

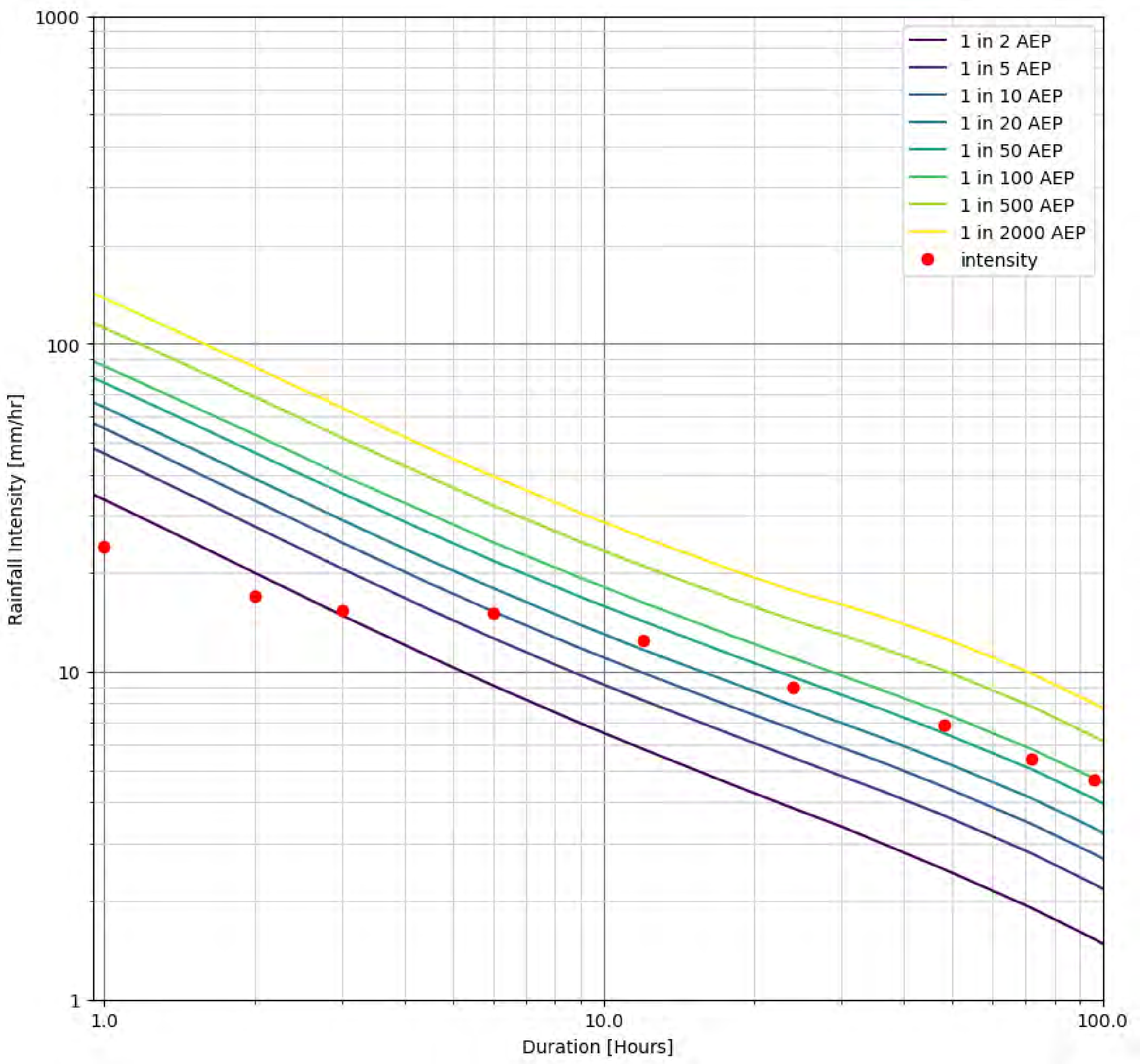

Figure 6-6 IFD Chart for Undullah Rd Gauge (540538) 22 February – 4 March 2022

6.3.7.8 Validation Summary

The joint calibration and validation methodology and results has improved the confidence of the modelling outputs throughout the Days Creek and Roberts Waterhole catchments. Specifically, through comparison of modelled flow and routing parameters, there is increased confidence in both the hydrologic and hydraulic model parameters adopted. The catchments are limited by a lack of data both spatially with no rainfall or river level gauges available within the catchments. It is recommended that as more data becomes available i.e. gauges within the catchments, that the model parameters are reconsidered and confirmed for suitability.

Overall, despite the lack of data, the models replicated the February 2022 event flow. This validation has added significant confidence that both the XP-RAFTS and TUFLOW models are representing the catchments hydraulic response for large flooding events.

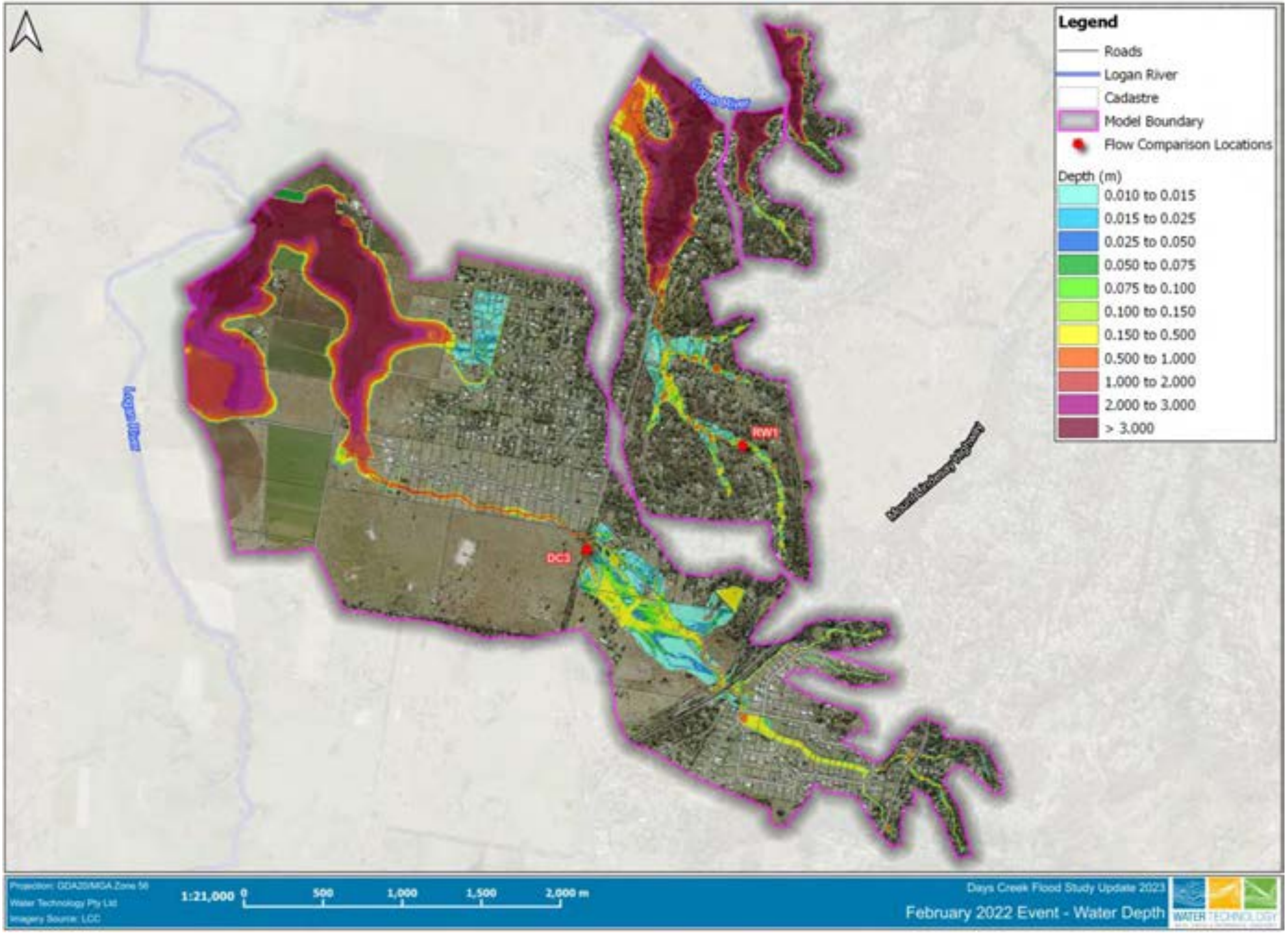

Figure 6-7 Days Creek and Robers Waterhole February 2022 Peak Depth

7 STUDY RESULTS AND DISCUSSION

7.1 Hydraulic Results and GIS Maps

7.1.1 Design Events

As discussed in Section 5.3, the detailed TUFLOW models for both the Days Creek and Roberts Waterhole catchments were analysed for the full suite of storm durations and temporal patterns of the 50%, 10% and 1% AEP design events only, as well as the PMF event. Storm duration from 20 minutes to 720 minutes were selected to be run hydraulically to understand median temporal patterns and critical durations. The remaining AEP events (63% AEP through to 0.05% AEP events), were selected based on the critical duration and median temporal pattern selection, based on the frequent, intermediate and rare temporal pattern bins from ARR2019.

A total of 360 separate hydraulic model simulations have been analysed between both catchments using a highly detailed 3m grid, to inform the critical durations and median temporal patterns only.

7.2 Critical Duration and Temporal Pattern Selection

7.2.1 Approach

The detailed hydraulic results for the 50%, 10% and 1% AEP events have been subject to post-processing for the purposes of selecting critical storm events. In order to achieve the overall envelope of flood results, consideration of multiple storm durations as well as the ensemble temporal patterns (i.e. 10 patterns per duration) needed to be considered for each of the respective design events. In this regard, the TUFLOW "asc_to_asc" utility only returns a mean value when all 10 ensemble input grids have numeric cell values. For cells located at the edge of the flood extent, the resultant grids may not include numerical values across all 10 ensembles which otherwise provides an inaccurate determination of the flood extent. To address this aspect and provide a more representative flood extent, the envelope processing based on the TUFLOW asc_to_asc utility has been processed based on the median as opposed to the mean to minimise the return of null grid cells and therefore attain a better representation of the flood extent.

The general process for the grid enveloping for the model result files is summarised as follows:

- The TUFLOW asc_to_asc utility has been used to extract the respective water levels based on the median grid value. The process was used across all 10 ensemble events per storm duration and design AEP to provide a single envelope grid per storm duration and AEP event;
- The TUFLOW asc_to_asc utility was then used to prepare the maximum envelope grid across the combination of the multiple storm duration ensemble temporal pattern envelope grids from the above; and
- The process enables several critical duration flood envelope grids to be prepared per design AEP
- Critical storms were then selected from observation of dominant storms.

7.2.2 Critical Temporal Pattern GIS Maps

The critical temporal pattern (i.e. TP1 to TP10) for each event and duration was determined from the median hydraulic water surface level calculated between each of the storm ensembles. Critical temporal pattern GIS maps have been prepared for each storm duration from 25-minutes to 720-minutes for each of the 1%, 10%

and 50% AEP events for each respective catchment. The critical temporal pattern GIS maps are included in Appendix G for the Days Creek and Roberts Waterhole catchments.

7.2.3 Critical Duration GIS Maps

A critical duration analysis was completed using the hydraulic model results based on the process discussed previously in Section 7.2.1 and using the median water surface level grids. The critical duration analysis has considered multiple storm durations for each design AEP event. The critical duration GIS maps for the 50%, 10% and 1% AEP events are included in Appendix G with the median temporal pattern GIS maps. Figure 7-1 and Figure 7-2 illustrate the critical duration maps for the 1% AEP event respectively for the Days Creek and Roberts Waterhole catchments, from which the following comments are made:

- The critical duration for Days Creek is dominated by the 90-minute duration for the majority of the catchment. Longer durations comprising 120-minute were found to occur in the lower reaches. The upper reaches of the catchment were found to comprise primarily of the 45-minute storm event; and
- For the Roberts Waterhole catchment, the critical duration was dominated by the 90-minute storm duration. Shorter storm durations were also represented throughout the catchment but to a lesser extent. There were very little occurrences of critical storm durations exceeding a 90-minute duration in the catchment.

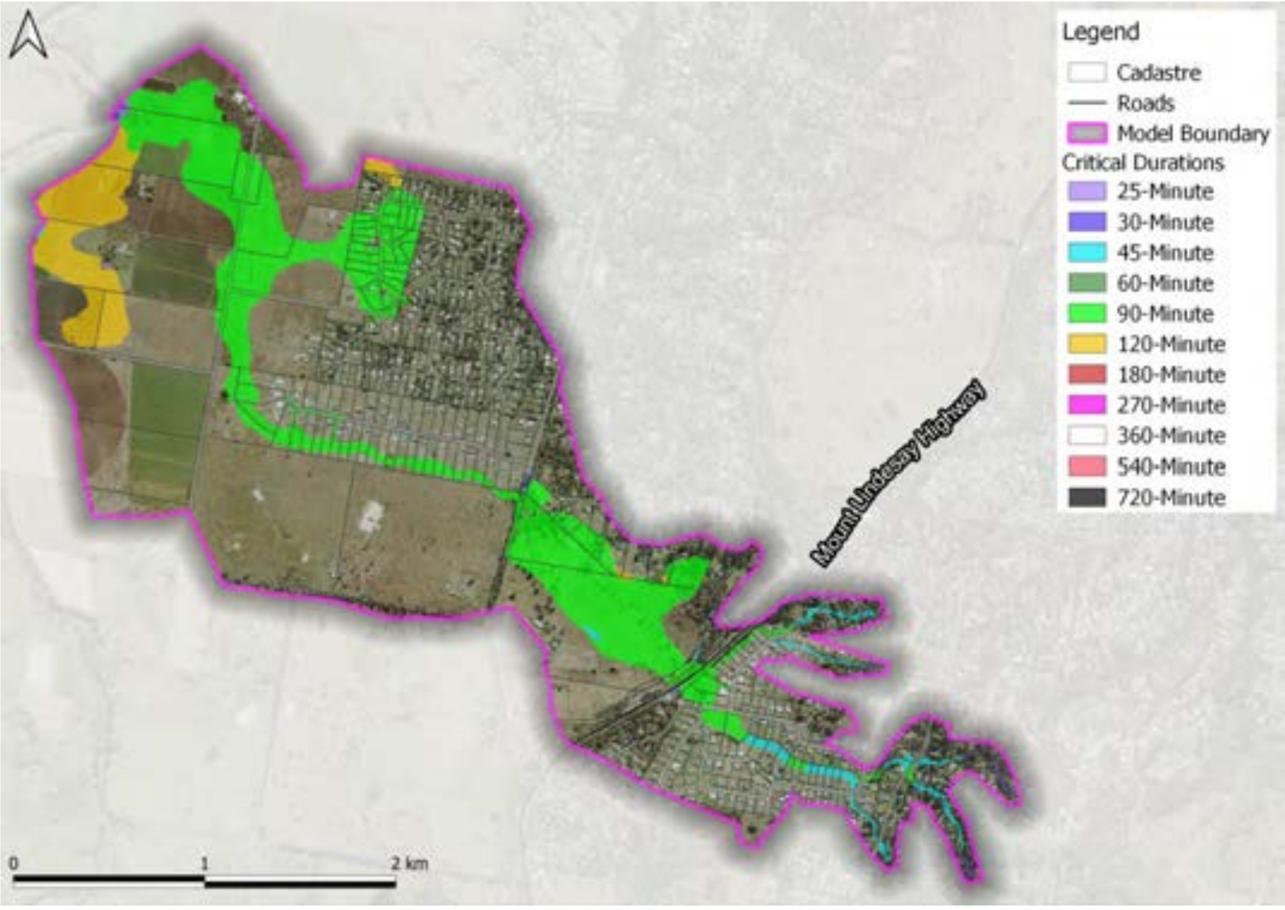

Figure 7-1 Days Creek 1% AEP Critical Duration Map

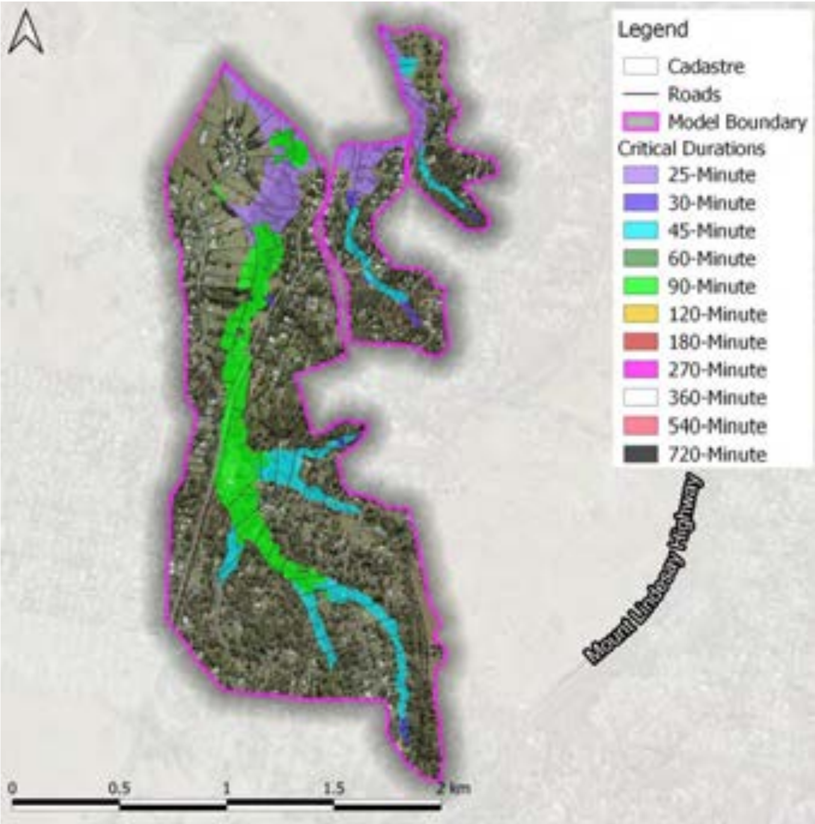

Figure 7-2 Roberts Waterhole 1% AEP Critical Duration Map

7.2.4 Selected Storm Events

A summary of the critical durations and median temporal patterns for all events is presented below in Table 7-1 and Table 7-2 for Days Creek and Roberts Waterhole catchments respectively. Filtering of all storms was undertaken to select a single representative temporal pattern for each applicable duration. Results were compared to the total ensemble results, and results were generally within 50 mm. This was deemed a reasonable difference in the context of the uncertainties associated with the flood study.

Table 7-1 Critical Storms Modelled Per Design Event for Days Creek

AEP	Durations	Temporal Pattern Bin
	Current Climate 2020	
63.2%, 50%, 20%	270min TP05, 540min TP06	Frequent (Point)
10%, 5%	45min TP07, 120min TP07, 180min TP06, 360min TP10	Intermediate (Point)
2%,1%,0.5%, 0.2%, 0.05%	45min TP03, 90min TP03, 120min TP02	Rare (Point)
PMF	30min, 45min	GSDM
	Future Climate 2090 RCP4.5 (9.5% rainfall increase)	
50, 20%	270min TP05, 540min TP06	Frequent (Point)
10%, 5%	45min TP07, 120min TP07, 180min TP06, 360min TP10	Intermediate (Point)
2%,1%,0.5%,0.2%	45min TP03, 90min TP03, 120min TP02	Rare (Point)

AEP	Durations	Temporal Pattern Bin
Future Climate 2090 RCP6 (11.5% rainfall increase)		
1%	45min TP03, 90min TP03, 120min TP02	Rare (Point)
Future Climate 2090 RCP8.5 (19.7% rainfall increase)		
1%	45min TP03, 90min TP03, 120min TP02	Rare (Point)

Table 7-2 Critical Storms Modelled Per Design Event for Roberts Waterhole

AEP	Durations	Temporal Pattern Bin
Current Climate 2020		
63.2%, 50%, 20%	30min TP10, 270min TP06, 540min TP06	Frequent (Point)
10%, 5%	45min TP09, 120min TP07, 180min TP06	Intermediate (Point)
2%,1%,0.5%, 0.2%, 0.05%	30min TP04, 45min TP03, 90min TP03	Rare (Point)
PMF	30min	GSDM
Future Climate 2090 RCP4.5 (9.5% rainfall increase)		
50, 20%	30min TP10, 270min TP06, 540min TP06	Frequent (Point)
10%, 5%	45min TP09, 120min TP07, 180min TP06	Intermediate (Point)
2%,1%,0.5%,0.2%	30min TP04, 45min TP03, 90min TP03	Rare (Point)
Future Climate 2090 RCP6 (11.5% rainfall increase)		
1%	30min TP04, 45min TP03, 90min TP03	Rare (Point)
Future Climate 2090 RCP8.5 (19.7% rainfall increase)		
1%	30min TP04, 45min TP03, 90min TP03	Rare (Point)

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 hydrological box plots in Appendix C demonstrate that the critical duration for the lowest parts of the catchments are less than the 24-hr storm which is not unexpected given the size of the catchments. 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 seen in the hydraulic modelling.

7.2.5 GIS Flood Maps

The results from the design event modelling for the Days 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 7-1 and Table 7-2 and is provided in Appendix E and Appendix F for Days Creek and Roberts Waterhole respectively.

7.2.6 Longitudinal Hydraulic Profile Plots

Longitudinal water surface level plots have been prepared for the Days Creek and Roberts Waterhole catchments in Appendix H. The longitudinal plots generated include a single plot along the main waterway for the Days Creek as well as three (3) separate longitudinal plots for the respective sub-catchments within the Roberts Waterhole catchment. The longitudinal plots illustrate the natural topography as well as hydraulic profile based on the 1% AEP critical duration storm event.

7.2.7 Hydrologic and Hydraulic Similarity

As a further check on model validation and overall model performance a direct comparison of discharges between the hydrologic and hydraulic models for both the Days Creek and Roberts Waterhole catchments has also been undertaken for the design event modelling.

To aid this comparison, the 1% AEP hydraulic models for each of the Days Creek and Roberts Waterhole catchments have been hydraulically assessed for a range of storm durations and using the full set of ten (10) ensemble events as outlined in ARR2019. Specifically, this includes durations of 25, 30, 45, 60, 90, 120, 180, 270, 360, 540 and 720-minute storm events, each having been hydraulically analysed based on the ten (10) ensemble events. The following comments are made in respect to the hydraulic analysis and resultant critical duration assessments:

- The hydraulic critical durations identified in the Days Creek catchment were dominated by the 45, 90 and 120-minute storm events. This result is consistent to that determined using the hydrological model; and
- The hydraulic critical durations identified in the Roberts Waterhole catchment were dominated by the 45 and 90-minute storm events and is again consistent to that determined using the hydrological model.

The above simulations were also used to provide a comparison of critical durations throughout the catchment derived using the hydraulic model and for comparison to that determined using the hydrological model. The hydraulic simulation of a full range of durations and ensembles provides greater confidence in the critical durations throughout the catchment in a hydraulic sense and to specifically include storage and conveyance aspects as well as that associated with front, middle and rear loaded temporal patterns.

Peak discharges at each of the previously define reporting locations (where not impacted by Logan River tailwater influences) in the Days Creek and Roberts Waterhole catchments have been extracted from the hydraulic model and compared to the peak flows from the XP-RAFTS hydrologic model. The flow comparison is presented in Table 7-3 and Table 7-4 respectively for the Days Creek and Roberts Waterhole catchments.

Table 7-3 Days Creek Flow Comparison

Days Creek Model Validation (1% AEP)				
Catchment	DC1	DC2	DC3	DC4
Hydrologic Critical Duration	45-Minute	60-Minute	90-Minute	-
XP-RAFTS Model	8.6	46.8	67.7	-
Hydraulic Critical Duration	90-Minute	90-Minute	90-Minute	-
Hydraulic Critical TP	TP 3	TP 3	TP 3	-
Hydraulic Model	8.2	42.7	60.7	-
% Difference	-4.7	-8.8	-10.3	-

Note
1. The 90-minute event is critical based on the hydraulic analysis.

Table 7-4 Roberts Waterhole Flow Comparison

Roberts Waterhole Model Validation (1% AEP)			
Catchment	RW1	RW2	RW3
Hydrologic Critical Duration	45-Minute	45-Minute	-
XP-RAFTS Model	11.3	36.3	-
Hydraulic Critical Duration	45-Minute	90-Minute	-
Hydraulic Critical TP	TP 3	TP 3	-
Hydraulic Model	10.5	35.5	-
% Difference	-7.1	-2.2	-

Note

1. The 90-minute event is critical based on the hydraulic analysis.

The comparison of discharge estimates between the hydrological and hydraulic models illustrates that the discharge estimates from the hydraulic model are consistently lower compared to the hydrological model. This result is expected and is a typical outcome which reflects the differences in approaches and methods between the hydrological and hydraulic models. More specifically, the differences occur as a result of the storage and routing effects within the catchment which are represented to varying degrees within the models. For example, the routing methodology employed within the hydrological model represents a simplified approach that is unable to account for the full storage effects, despite the use of the more rigorous Muskingum-Cunge routing methodology. Conversely, the hydraulic model provides a much more rigorous account of storage effects through the very nature of representation of the full topography within the model, which in this instance includes a highly detailed 3m grid. By virtue of the fundamental differences in routing methodologies and approaches applied within the models, it is virtually impossible to precisely match discharge estimates across multiple locations, durations and spatially throughout the catchment. The discharge comparisons presented Table 7-3 and Table 7-4 do however show there to be consistency in peak discharge estimates between the hydrology and hydraulic models which are at worst up to approximately 10%. The comparative differences which have been achieved have been reduced through a series of successive model iterations which have occurred through a joint calibration process involving the hydrology and hydraulic models. The remaining differences are attributed to the wide floodplain storage characteristics represented particularly within the lower portions of the catchments which are not able to be accurately accounted for within the hydrological model and associated routing approach. Given the relative differences in peak flow estimates between the hydrology and hydraulic models, the results are considered acceptable and typically within the general range expected for a catchment wide study such as this.

7.2.8 Model Sensitivity Assessments

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

- Increased roughness (1% AEP and 20% AEP):
  - +20% vegetation roughness (SEN1);
  - Increase waterway roughness value of 0.15 (SEN2); and
  - Reduced “Rural” roughness from 0.06 to 0.04 (SEN6 – applicable for Days Creek 1% AEP only).
- Enveloped flood surface of structure blockage (1% AEP and 20% AEP):
  - 100% blockage (SEN3); and

- No blockage (SEN4)
- Tailwater sensitivity (1% AEP only) (SEN5).

Each of the above sensitivity scenarios are discussed and presented separately below. Water level difference maps comparing the critical results of the sensitivity scenarios with the regular design scenario are provided in Appendix I.

7.2.8.1 Floodplain Roughness Sensitivity

The floodplain roughness applied in each of the Days Creek and Roberts Waterhole hydraulic models has been discussed previously in Section 5.2.4.

7.2.8.1.1 MANNINGS INCREASE - +20%

Figure 7-3 and Figure 7-4 presents the difference in peak water level from increasing the vegetation roughness by 20%, for the 20% AEP and 1% AEP sensitivity assessment respectively, across both catchments. 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.

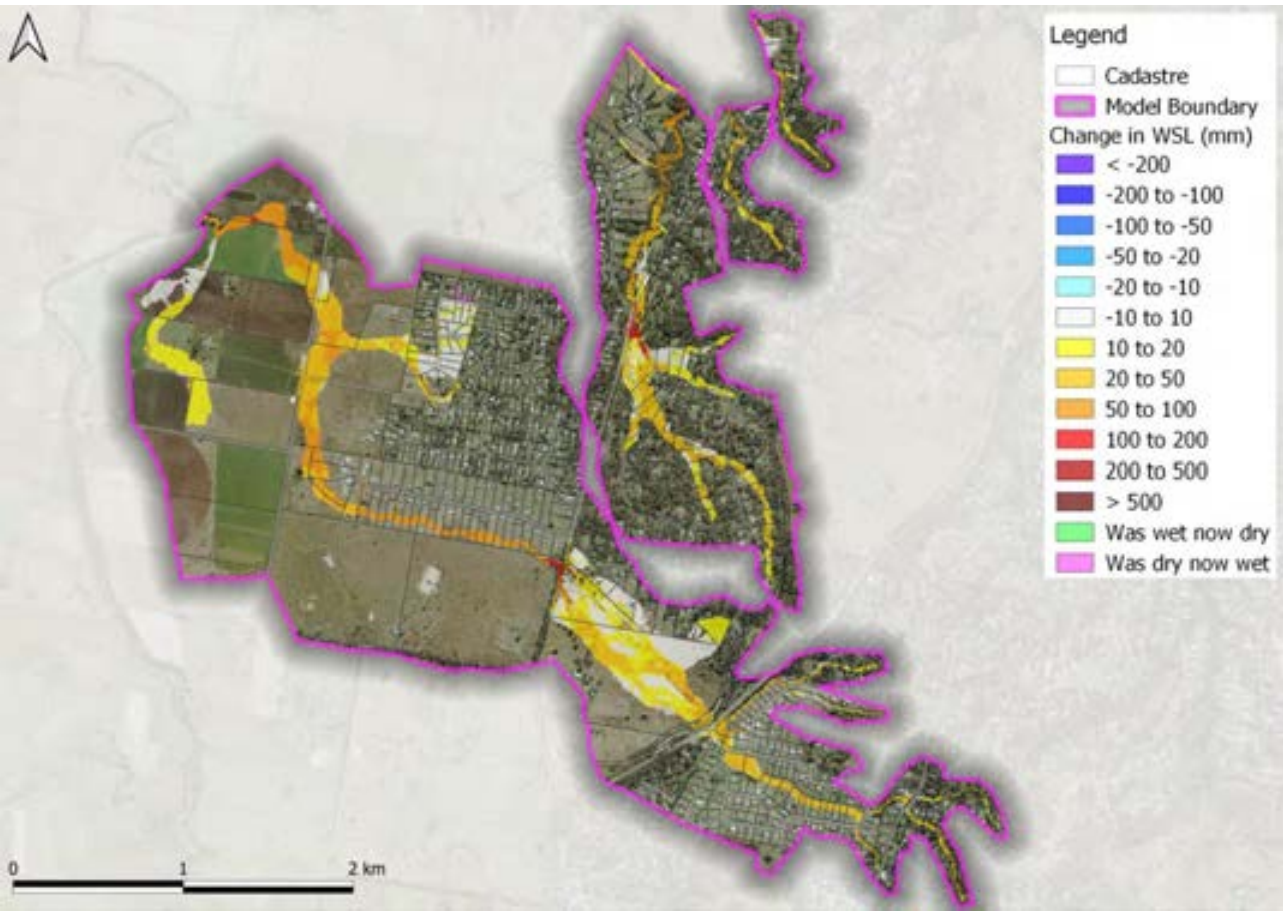

Figure 7-3 20% AEP Peak Water Level Difference Map – Increased Roughness +20%

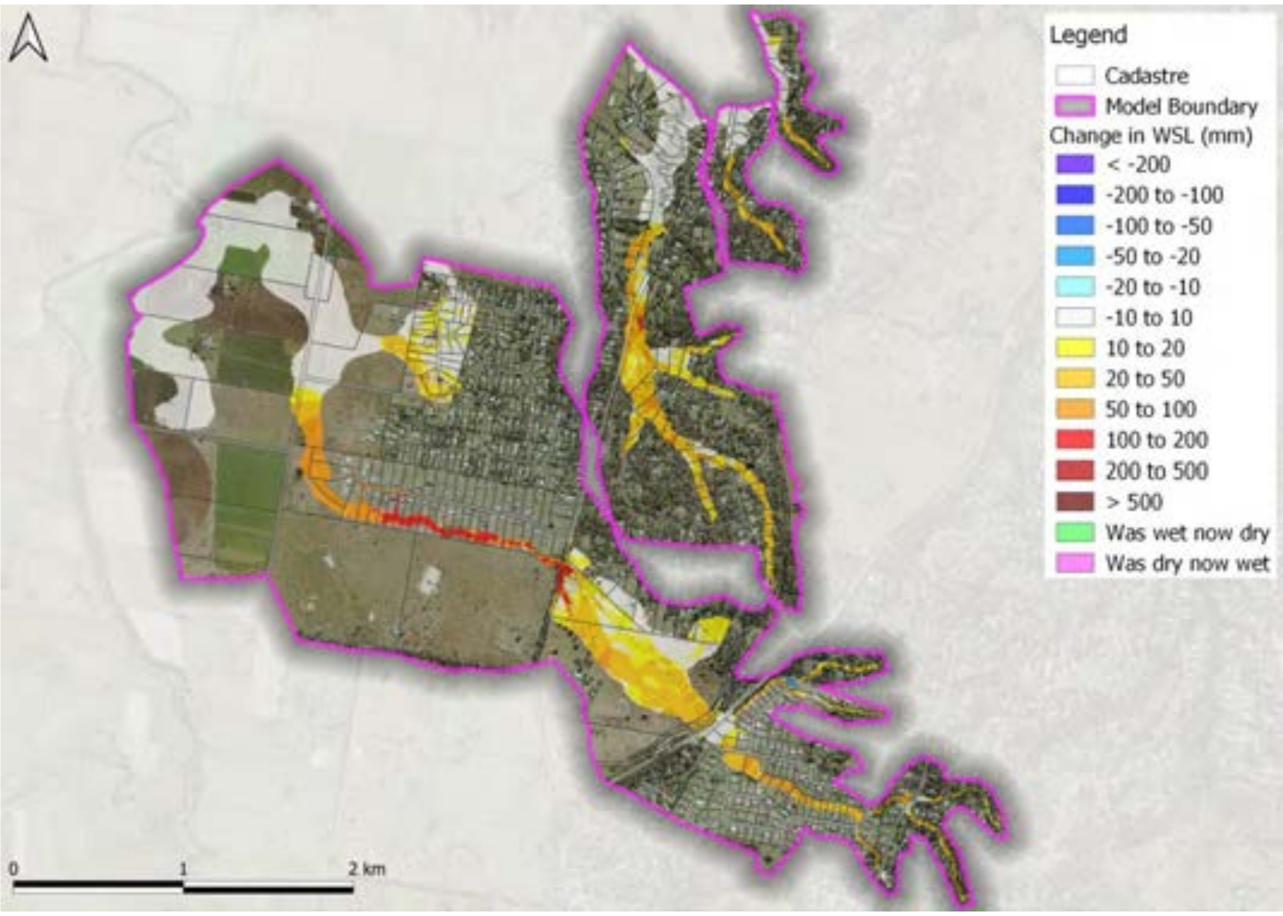

Figure 7-4 1% AEP Peak Water Level Difference Map – Increased Roughness +20%

7.2.8.1.2 WATERWAY REVEGETATION

Figure 7-5 and Figure 7-6 present the difference in peak water levels for the 20% AEP and 1% AEP events respectively, caused by an increased waterway roughness value of 0.15, across both catchments. The increased waterway roughness was limited to the provided waterway corridors. As a result localised reductions in water surface levels are seen in the upper reaches of both Days Creek and Roberts Waterhole.

The lower parts of both catchments are affected by Logan River backwater in the 1% AEP. For this reason, revegetation of the waterway corridor did not affect peak water levels significantly in the lower reaches of the catchments in the 1% AEP. For the 20% AEP in the lower reaches of the catchments, there is significant increases in water levels of up to 600 mm where there is a higher conveyance of flow.

Through the mid sections of Days Creek, flows are highly channelised. As a result, waterway restoration has a major impact in this area, of up to 800 mm in both the 20% and 1% AEP events. An increased flood extent impacting multiple properties along Brumby drive is also seen. This is related to the flat nature of Days creek in this area.

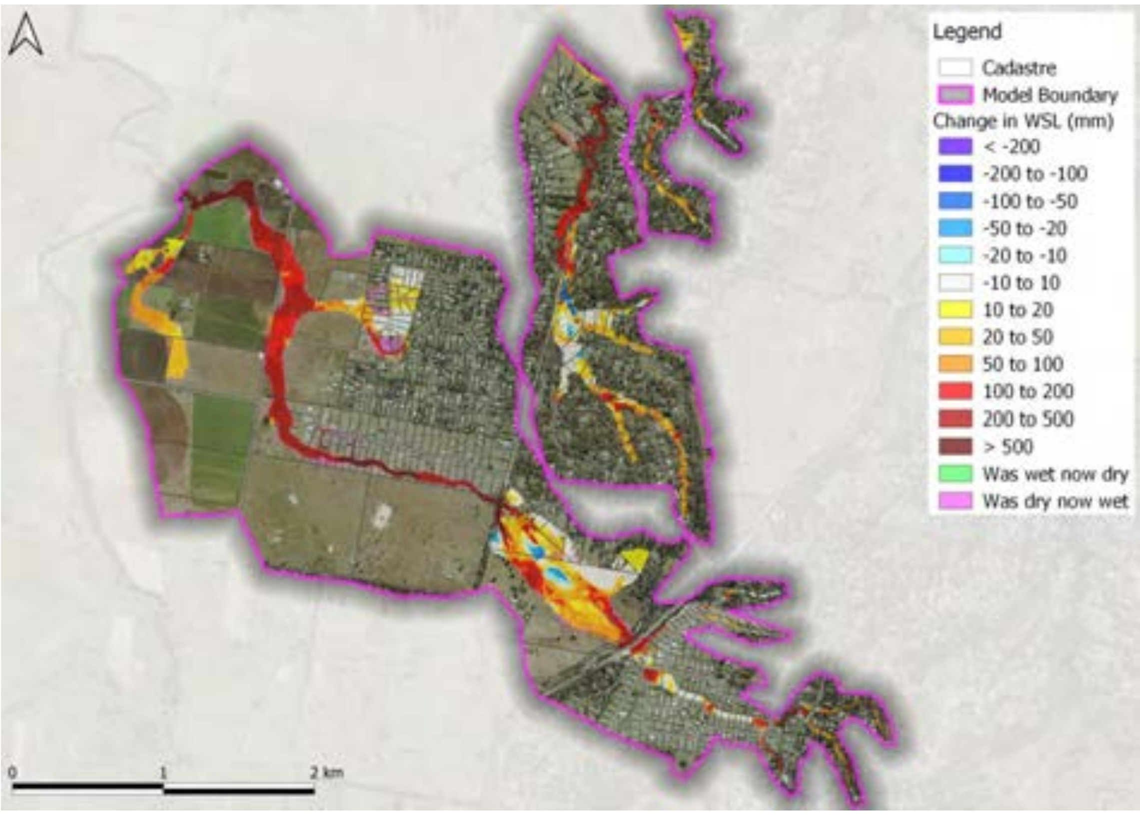

Figure 7-5 20% AEP Peak Water Level Difference Map – Increased Waterway Roughness

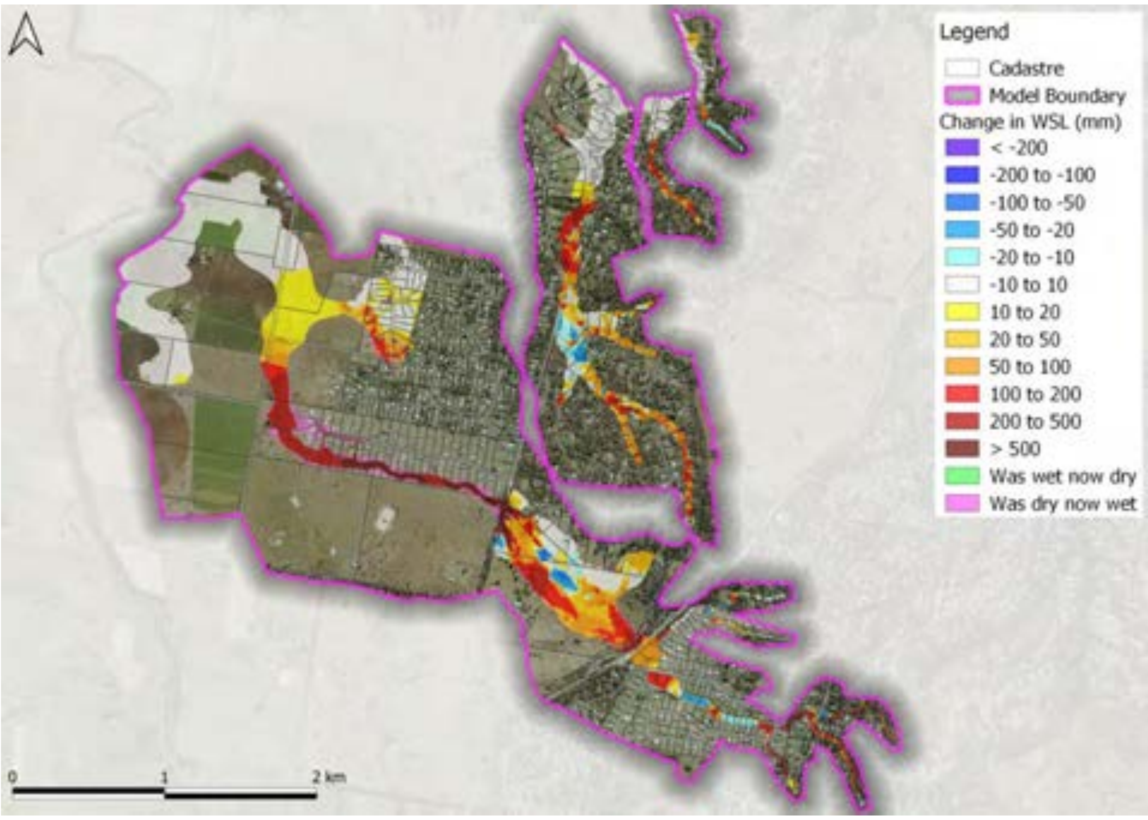

Figure 7-6 1% AEP Peak Water Level Difference Map – Increased Waterway Roughness

7.2.8.1.3 MANNINGS REDUCTION – RURAL LANDUSE (DAYS CREEK ONLY)

Given the catchment characteristics, a large portion of the catchment comprising some 60% was included in the rural roughness category for which a Manning's n roughness of 0.06 was applied.

In order to assess the sensitivity of model water surface level results to a change in roughness condition, a sensitivity analysis has been completed by reducing the rural roughness Manning's n value to 0.04. The results of the sensitivity assessments are presented as the difference in water surface level plots for the 1% AEP event and are illustrated in Figure 7-7 for the Days Creek catchment. The results of the sensitivity assessment are summarised as follows:

- Water levels in the upper catchment areas have either fundamentally remained unchanged (i.e. to within +/- 10mm); and
- The water levels in the lower to middle portion of the Days Creek catchment have been reduced by up to -200 mm as a result of the decrease in roughness for the rural category. This decrease has likely occurred by virtue of the quicker runoff response of the reduced roughness. The peak reduction of up to 200 mm is generally localised to the location of interaction between the regional Logan River tailwater and Days Creek flows.

The resulting change in water levels as a result of the change in floodplain roughness for the rural areas of the catchment is considered to not be overly sensitive and does not change results greater than 200 mm. The adoption of the higher roughness condition of n=0.06 for the study results in conservative water levels and is therefore appropriate given the context of this study.

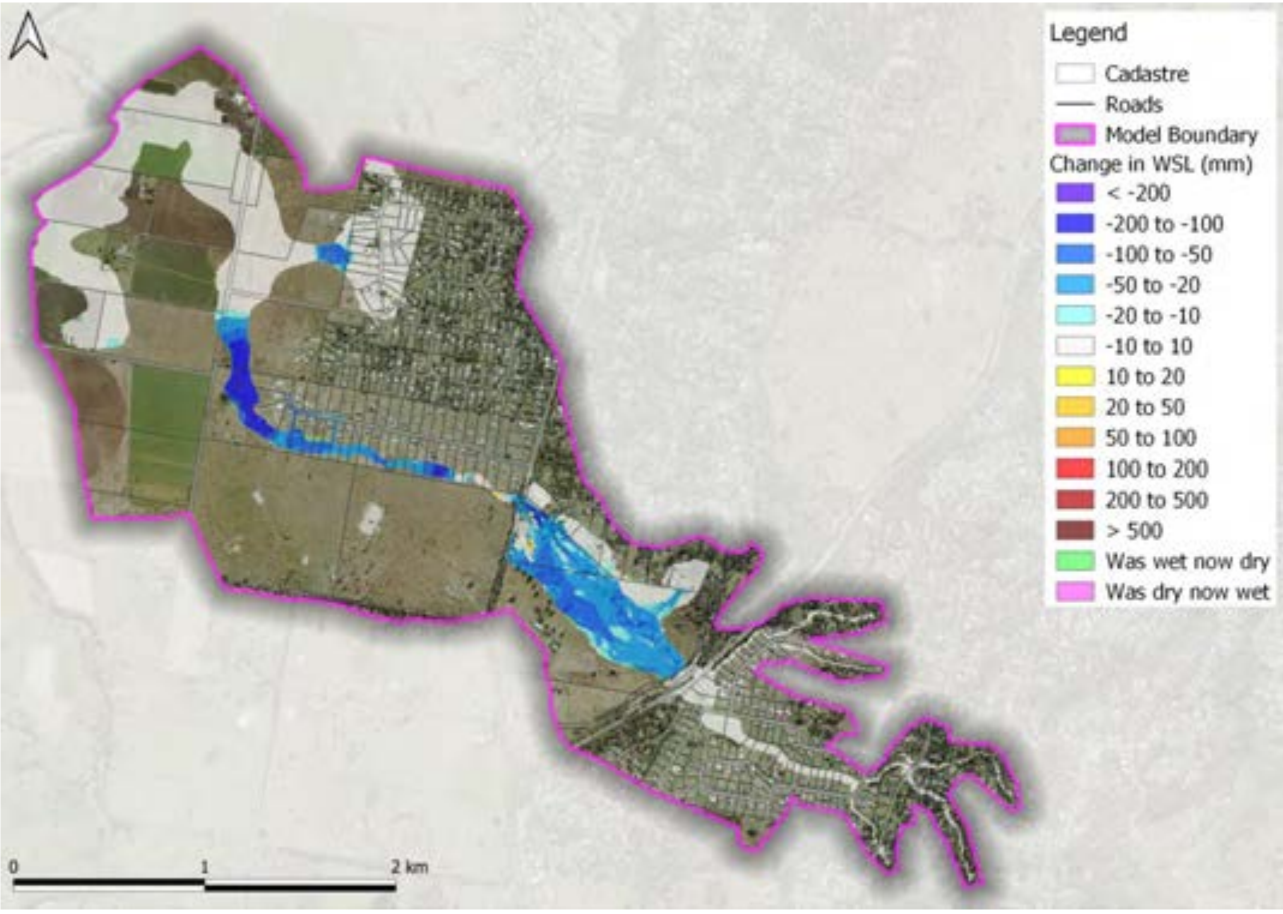

Figure 7-7 Days Creek 1% AEP Peak Water Level Difference Map – Floodplain Roughness Reduction

7.2.8.2 Blockage Sensitivity

Figure 7-8 and Figure 7-9 present the difference in peak water levels for the 20% AEP and 1% AEP events respectively, from the fully blocked/unblocked culverts scenario. The blockage assessment shows that isolated areas located upstream of fully blocked culverts are subject to additional flooding for majority of the catchments. The most sensitive locations within Days Creek were at Mount Lindsay Highway, Mahooney Road and Munroe Drive where upstream flood levels increased by up to 2.2 m in the 20% AEP and 1.6 m in the 1% AEP. As a general comment, Days Creek structures have high immunity and therefore flood levels in the 20% and 1% AEP events were overly sensitive to blockage. Results from the 1% AEP no blockage scenario have also shown that opening the structures under Mount Lindsay Highway and the unused railway, results in an increase of up to 90 mm within the downstream Days Creek flow path. The Roberts Waterhole catchment is generally not overly sensitive to blockage with flood levels isolated to upstream of structures, with the most sensitive areas within 200 mm.

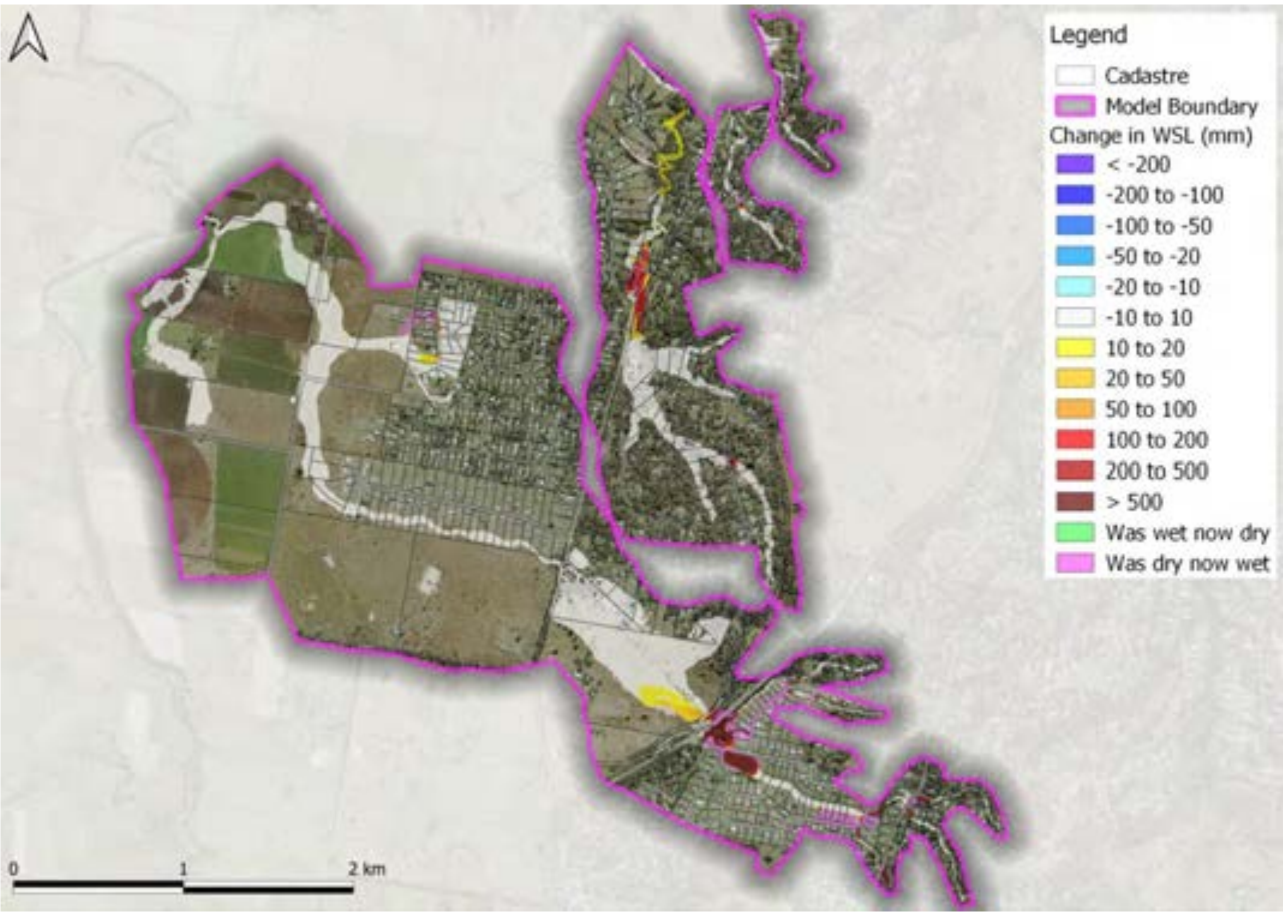

Figure 7-8 20% AEP Peak Water Level Difference Map – Blockage Scenario

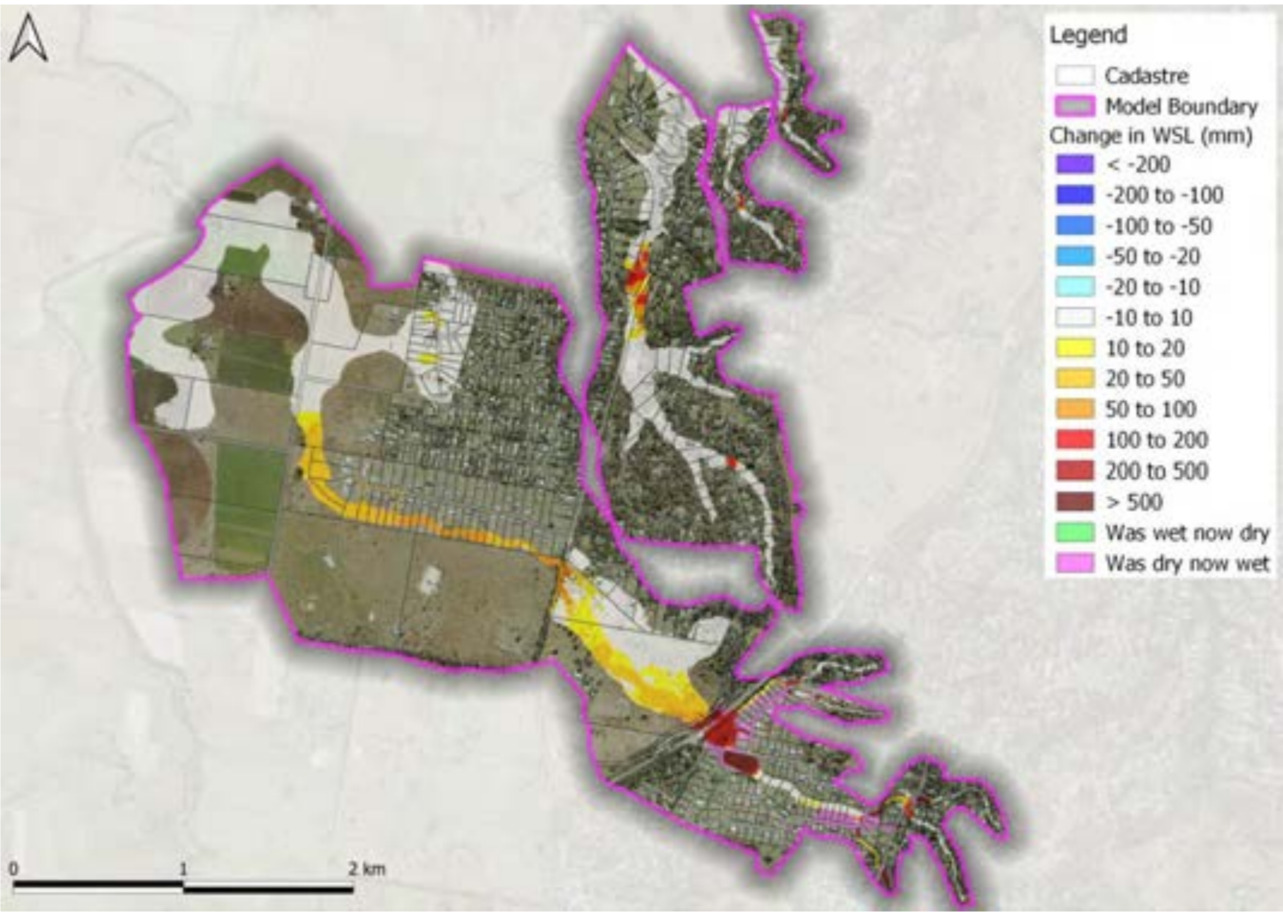

Figure 7-9 1% AEP Peak Water Level Difference Map – Blockage Scenario

7.2.8.3 Tailwater Sensitivity – Joint Probability Zone

7.2.8.3.1 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 7-10 (sourced from ARR 2019) described this concept through schematic longitudinal section of an estuary.

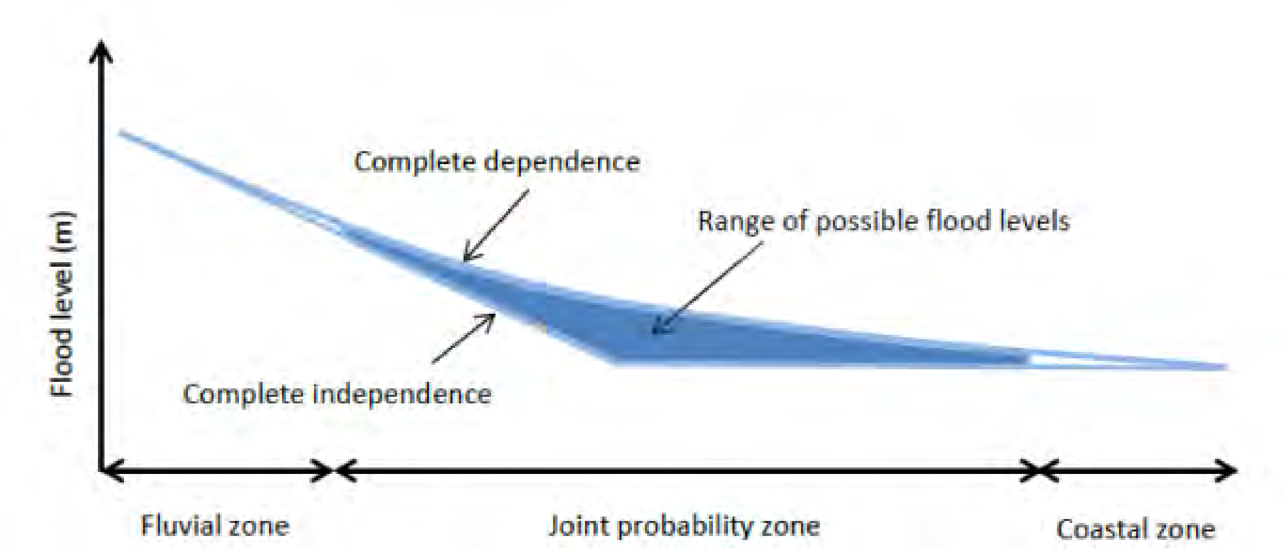

Figure 7-10 Schematic Showing the 'Joint Probability Zone'

7.2.8.3.2 PRE-SCREENING ANALYSIS

The joint probability concept can be applied to Days Creek and Roberts Waterhole catchments to consider the likelihood of both regional (Logan River) and local 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.

7.2.8.3.3 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 (34.82 mAHD) was provided by LCC at the junction of Days 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 7-11 and Figure 7-12 for the Days Creek and Roberts Waterhole catchments respectively presents the difference in flood levels from the analysis. Results within Days Creek show an area of approximately 3 ha at the end of Brumby Drive within the JPZ. The area is mainly confined to the waterway corridor and Brumby Drive swales although there is an increase in flood extent with flood levels rising up to 200 mm adjacent to a private property. Results within Roberts Waterhole show an area of approximately 1 ha upstream of Irwin 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 180 mm adjacent to a private property. It is noted that the differences observed within the JPZ of both catchments are generally lower than standard freeboard provisions.

In conclusion, a more extensive joint probability analysis should not be required for design flood levels within both catchments as the current assumptions are considered reasonable for planning purposes.

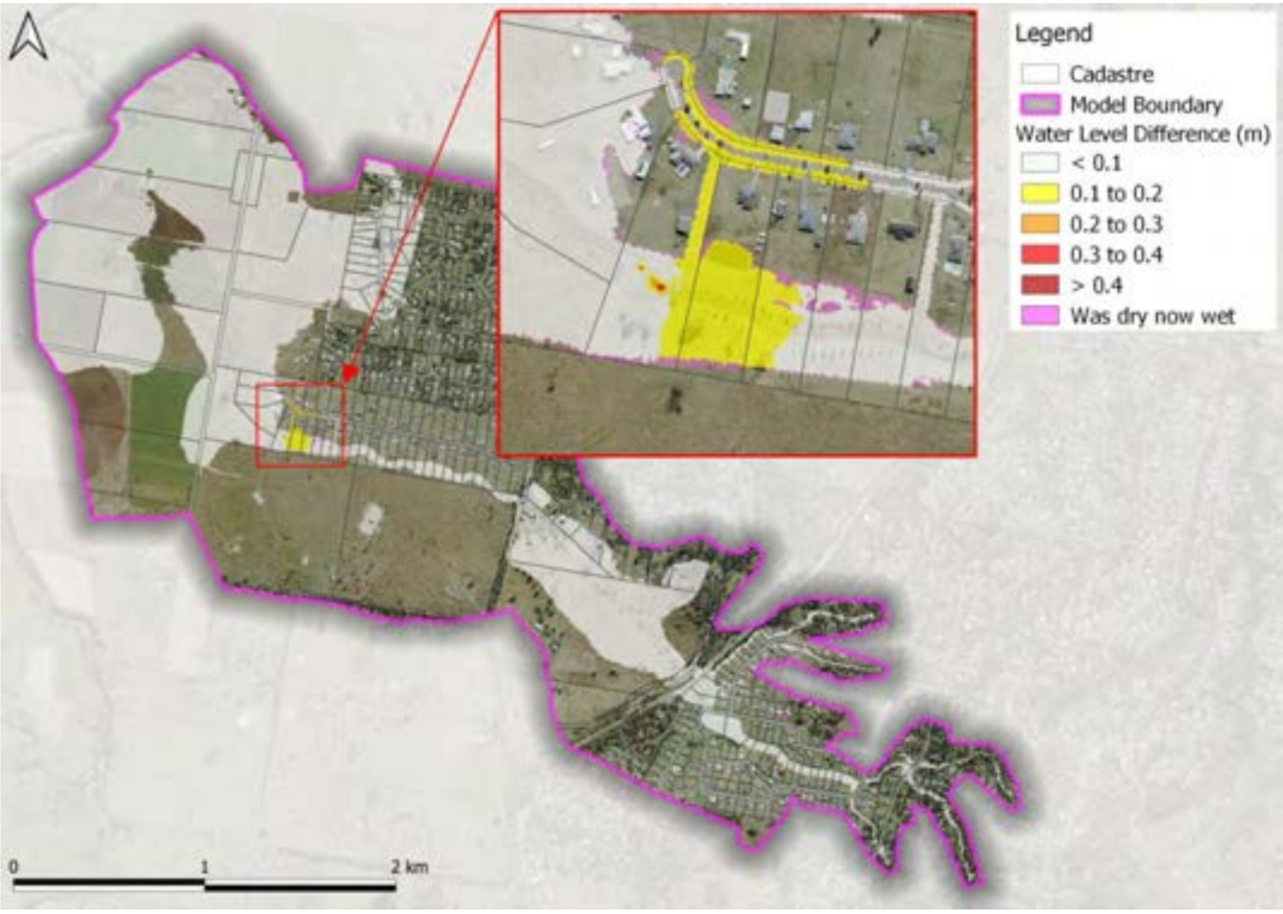

Figure 7-11 Days Creek Tailwater Sensitivity Change in Water Level

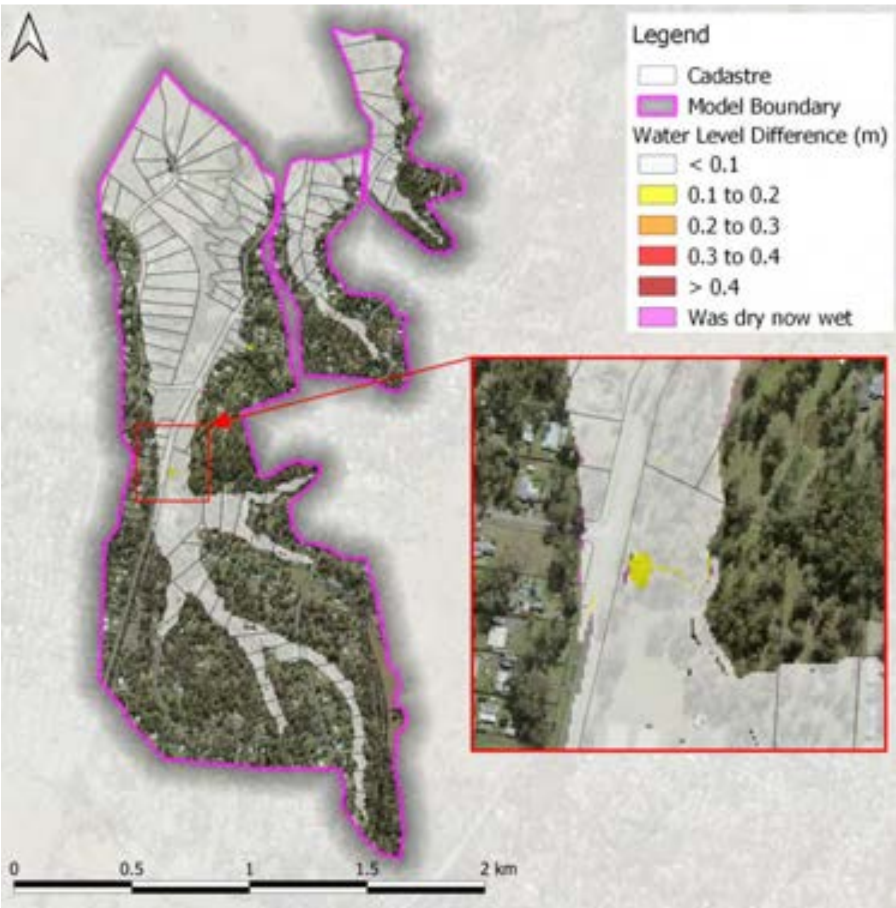

Figure 7-12 Roberts Waterhole Tailwater Sensitivity Change in Water Level

7.2.9 Climate Change and Increased Rainfall Intensity

An analysis of climate change in respect to increases in rainfall intensity has been completed as part of this study. Specifically, this has included an analysis undertaken for the 50% 20%, 10%, 5%, 2%, 1%, 1 in 200 and 1 in 500 AEP events to assess the effect of climate change via the application of increased rainfall intensities. These events have been selected and simulated for the ARR2019 climate change factors representing the year 2090 RCP 4.5 climate change scenario as a requirement for the LCC Flood Hazard Matrix as part of the FRMS. Maps illustrating the climate change results for both the Days Creek and Roberts Waterhole catchments are provided in Appendix E and Appendix F, and includes a series of GIS maps for water surface levels, depths, velocities and hazard.

In addition, sensitivity on the 2090 RCP 6 and 2090 RCP 8.5 climate change scenarios has been assessed for the 1% AEP. The change in water surface level for the 1% AEP with and without climate change are illustrated in Figure 7-13 and Figure 7-14 for the RCP 6 and RCP 8.5 sensitivity scenarios respectively. The results of the sensitivity assessment are summarised as follows:

- The Days Creek Tributary sees an approximate peak increase of 200 mm (RCP 6) and 350 mm (RCP 8.5) within the storage areas at the eastern end of the model extent (including Mount Lindsay Highway); and
- The western, central and eastern tributaries of Roberts Waterhole respectively increase by approximately 80 mm, 50 mm and 40 mm in the RCP 6 climate change scenario and approximately 180 mm, 100 mm and 60 mm in the RCP 8.5 climate change scenario.

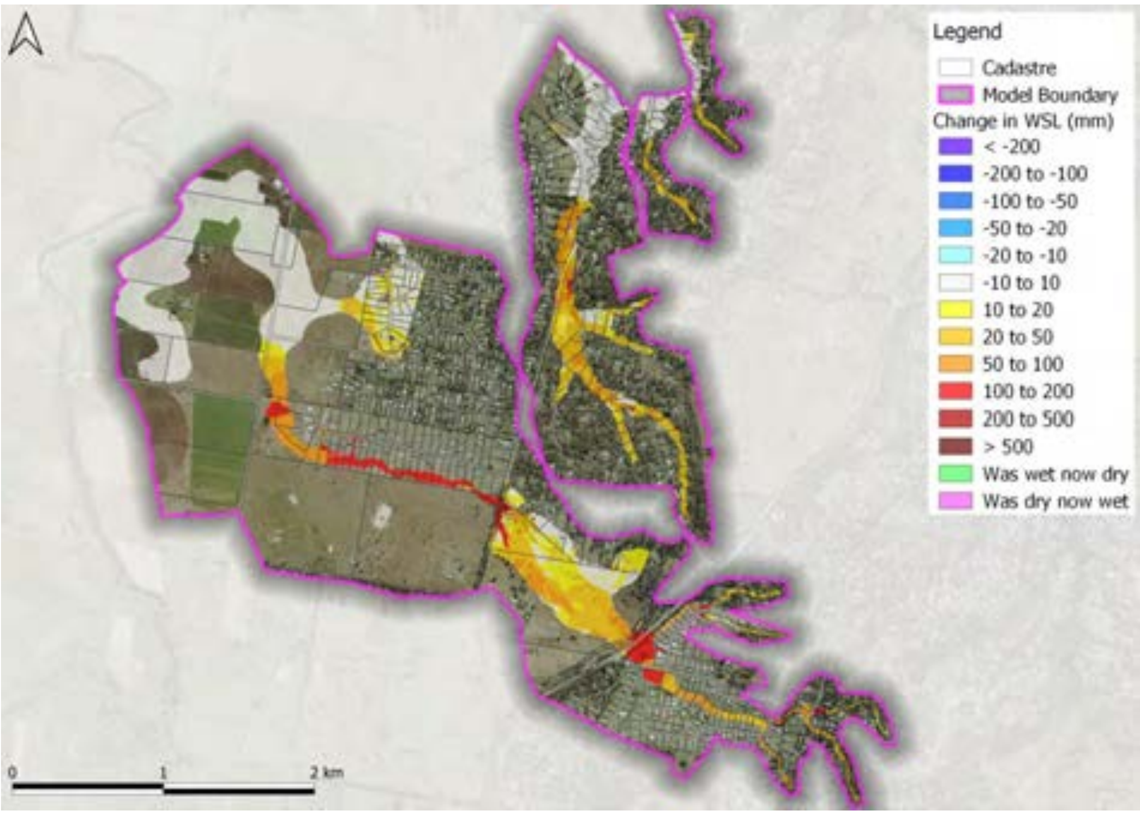

Figure 7-13 1% AEP Climate Change Scenario RCP 6 - Change in Water Surface Levels

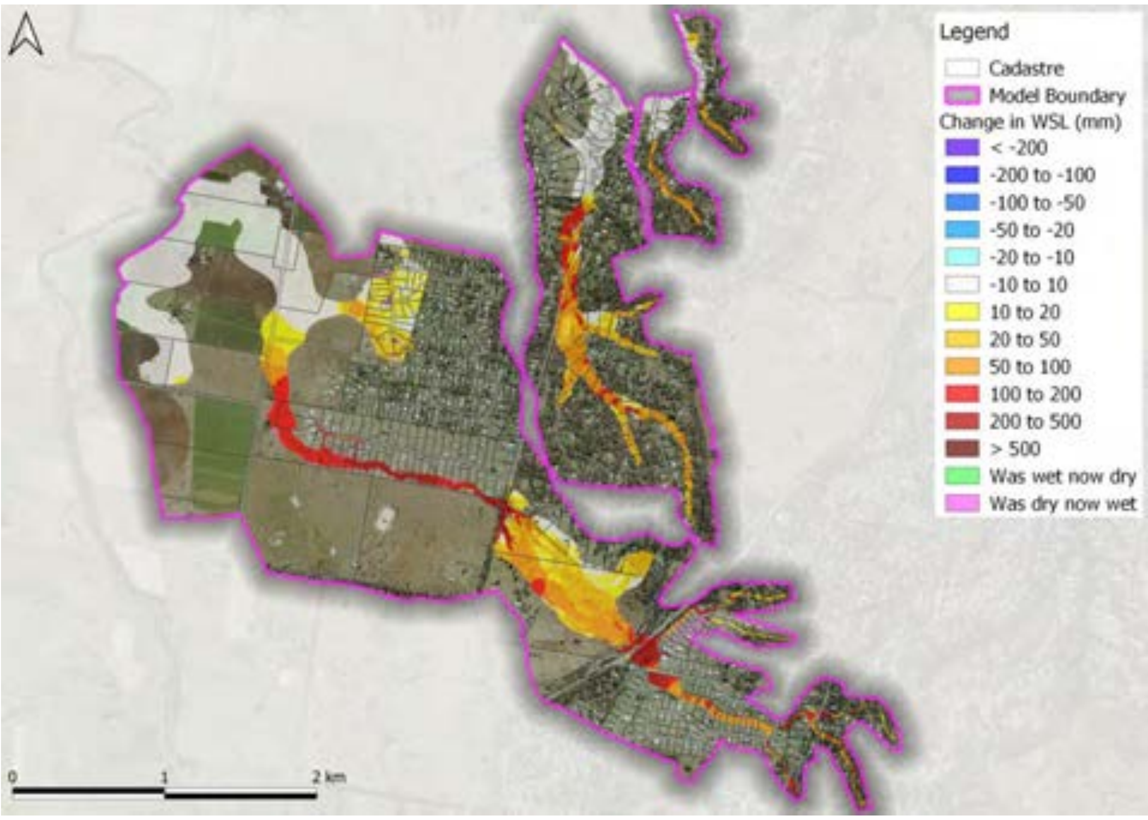

Figure 7-14 1% AEP Climate Change Scenario RCP 8.5 - Change in Water Surface Levels

7.2.10 Catchment Inundation Summary

7.2.10.1 Days Creek

The following provides a brief summary of the results of the Days Creek hydraulic model:

- Inundation along Bamboo Drive in a 2% AEP event;
- 2% AEP immunity to the culvert crossing underneath the Mount Lindesay Highway. Inundation to the Mount Lindesay Highway occurs in the 1% AEP and all higher events. It is recommended that ground elevations in these areas are further investigated to ensure the road crest and drainage channels are correctly represented in the digital terrain model;
- Minor inundation to several properties towards the western end of Deltoro Road. Surround topography has a considerably shallow grade with 1% AEP inundation depths generally not exceeding 100 mm;
- Days Creek flows in the location of brumby drive backwater through the easements inundating only the drainage swales in all events up to the 0.2% AEP. Driveway crossings are inundated in the 0.2% AEP by approximately 10 mm; and
- Inundation to numerous properties and internal roads of the residential area to the north-west section of the catchment (near Whitaker Road) in events as small as the 63.2% AEP event. It is noted that the swale in this area does not contain enough capacity to capture all upstream flows. It is recommended that ground elevations in these areas are further investigated to ensure the drainage channel is correctly represented in the digital terrain model.

7.2.10.2 Roberts Waterhole

The following provides a brief summary of the results of the Roberts Waterhole hydraulic model:

- Inundation to multiple properties immediately north of Boondarn Court in events as low as the 63.2% AEP event;
- Inundation of Deltoro Road in the 10% AEP event;
- Inundation to roads and properties along Irwin Road in the 10% AEP event;
- Inundation of Cedar Grove Road in the 63.2% AEP event due to the upstream floodwater being uncontained within the channel;
- Inundation of properties along the southern section of Couldery Court in the 0.2% AEP event. This inundation is due to large Logan River tailwater;
- Inundation of Brushwood Crescent within the central catchment between Laurel Place and Birch Place in the 2% AEP event;
- Further inundation to Brushwood Crescent between Tamarind Place and Sheoak Place in the 1% AEP event.

7.2.11 Digital Data

The following provides a summary of the digital datasets, along with a brief description, provided to LCC with the completion of the Days Creek and Roberts Waterhole catchment flood study.

- Complete XP-RAFTS hydrology model simulation and result files for the Days Creek and Roberts Waterhole catchments
- Complete TUFLOW hydraulic model simulation and results files for the Days Creek and Roberts Waterhole catchment. Result files include the following FLT grid files:

- Peak water surface level;
- Peak depth;
- Peak velocity;
- Peak velocity x depth product (Z0);
- Peak hazard classification (ZAEM1);
- Peak hazard classification (ZQRA);
- Time of peak water surface level.

Full set of design event maps as summarised in Table 7-1 and Table 7-2.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

This study represents the most up to date flood study revision that has been prepared for the Days Creek and Roberts Waterhole catchments. The update has been informed by previous studies and has been significantly expanded to include a full and detailed refinement of hydrologic and hydraulic models for both catchments using the current ARR 2019 guidance.

The models prepared as part of this 2023 update have been subjected to rigorous calibration and validation procedures and have subsequently been adopted to inform new design flood estimates for the catchment. The methodology has additionally included consideration of most recent ARR 2019 guidelines which account for the ensemble temporal pattern method and their hydraulic impact across both catchments. Key aspects of the work have included:

- Development of two (2) catchment wide XP-RAFTS hydrology models in compliance to the ARR 2019 guidelines;
- The preparation of two (2) localised and highly detailed TUFLOW hydraulic models along with the hydraulic assessment of the ensemble temporal pattern method along all events and relevant durations;
- Development of two catchment wide baseline flood risk assessments to be used by Council to control and coordinate all future development activities and having due regard to flood control and ensuring development compliance;
- An extensive model validation process which involved model validation to multiple methods of recommended hydrologic analysis;
- The assessment of an extensive range of model events, storm durations and temporal patterns to provide comprehensive outputs to better inform flooding and flood risk in the catchment; and
- The preparation of detailed reporting, extensive GIS maps and digital data sets.

8.2 Recommendations

The following recommendations are made in respect to the flood study update:

- The hydraulic models should be updated with the most recent and relevant topographic and structure data as it becomes available. It is recommended that data collected from the following sources should be implemented to better inform the hydraulic model when applicable:
  - Topographic data gathered from future LIDAR projects;
  - Topographic and stormwater structure data proposed with future development applications; and
  - Surveyed topographic and structure data including surveyed culvert and pit inlet levels and sizes.
- General Flood Study Recommendations:
  - LCC formally adopt this study to define flooding in the Days Creek and Roberts Waterhole catchments.
  - LCC adopt the design flood outcomes for all future catchment planning and development related outcomes.

9 REFERENCES

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12. IPWEA (2017), Queensland Urban Drainage Manual, Volume 1, Fourth Edition IEAust (2017);
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14. XP Software (2001), XP-RAFTS, XS Software, Florida, USA.

APPENDIX A
STRUCTURE DATABASE

Structure Database

Catchment	ID	Type	Width/Dia (m)	Height (m)	Length (m)	No of Cells	US Invert (m AHD)	DS Invert (m AHD)
DC	BR_001	Circular Pipe	0.335	N/A	8.273	1	34.074	34.014
DC	BR_002	Circular Pipe	0.335	N/A	5.418	1	34.317	34.21
DC	BR_003	Circular Pipe	0.335	N/A	6.143	1	34.417	34.359
DC	BR_004	Circular Pipe	0.335	N/A	4.454	1	34.43	34.354
DC	BR_005	Circular Pipe	0.335	N/A	5.634	1	34.271	34.224
DC	BR_006	Circular Pipe	0.335	N/A	6.123	1	34.202	34.153
DC	BR_007	Circular Pipe	0.335	N/A	4.768	1	34.242	34.197
DC	BR_008	Circular Pipe	0.335	N/A	6.7	1	34.426	34.372
DC	BR_009	Circular Pipe	0.335	N/A	4.5	1	34.6	34.598
DC	BR_010	Circular Pipe	0.335	N/A	6.36	1	34.62	34.613
DC	BR_011	Circular Pipe	0.335	N/A	5.243	1	34.813	34.795
DC	BR_012	Circular Pipe	0.335	N/A	6.896	1	34.992	34.895
DC	BR_013	Circular Pipe	0.335	N/A	5.409	1	35.315	35.091
DC	BR_014	Circular Pipe	0.335	N/A	5.357	1	35.89	35.88
DC	BR_015	Circular Pipe	0.335	N/A	4.76	1	36.053	35.938
DC	BR_016	Circular Pipe	0.335	N/A	4.808	1	36.388	36.239
DC	BR_017	Circular Pipe	0.335	N/A	4.808	1	36.787	36.771
DC	BR_018	Circular Pipe	0.335	N/A	4.808	1	36.585	36.464
DC	BR_019	Circular Pipe	0.335	N/A	6.744	1	37.121	37.083
DC	BR_020	Circular Pipe	0.335	N/A	8.639	1	36.785	36.758
DC	BR_021	Circular Pipe	0.335	N/A	4.808	1	37.54	37.376
DC	BR_022	Circular Pipe	0.335	N/A	4.808	1	37.6	37.55
DC	BR_023	Circular Pipe	0.335	N/A	4.808	1	38.452	38.423
DC	BR_024	Circular Pipe	0.335	N/A	6.67	1	38.732	38.601
DC	BR_025	Circular Pipe	0.335	N/A	4.808	1	39.004	38.963
DC	BR_026	Circular Pipe	0.335	N/A	5.2	1	40.514	40.423
DC	BR_027	Circular Pipe	0.335	N/A	4.808	1	40.265	40.117
DC	BR_028	Circular Pipe	0.335	N/A	4.808	1	39.202	39.031
DC	BR_029	Circular Pipe	0.335	N/A	4.841	1	41.408	41.397
DC	BR_030	Circular Pipe	0.335	N/A	4.808	1	41.238	41.132
DC	BR_031	Circular Pipe	0.335	N/A	5.479	1	42.582	42.497
DC	BR_032	Circular Pipe	0.335	N/A	5.479	1	43.353	43.16
DC	BR_033	Circular Pipe	0.335	N/A	4.928	1	43.995	43.991
DC	BR_034	Circular Pipe	0.335	N/A	12.703	1	45.789	45.62

Catchment	ID	Type	Width/Dia (m)	Height (m)	Length (m)	No of Cells	US Invert (m AHD)	DS Invert (m AHD)
DC	BR_035	Circular Pipe	0.335	N/A	4.537	1	48.818	48.547
DC	BR_036	Circular Pipe	0.335	N/A	4.447	1	45.256	45.115
DC	BR_037	Circular Pipe	0.335	N/A	4.594	1	44.791	44.595
DC	BR_038	Circular Pipe	0.335	N/A	5.949	1	46.585	46.499
DC	BR_039	Circular Pipe	0.335	N/A	5.53	1	38.64	38.55
DC	BR_040	Circular Pipe	0.335	N/A	4.808	1	38.331	38.173
DC	BR_041	Circular Pipe	0.335	N/A	4.808	1	37.8	37.721
DC	BR_042	Circular Pipe	0.335	N/A	4.808	1	39.955	39.954
DC	BR_043	Circular Pipe	0.335	N/A	4.914	1	39.269	39.216
DC	BR_044	Circular Pipe	0.335	N/A	4.808	1	38.962	38.928
DC	BR_045	Circular Pipe	0.335	N/A	6.228	1	41.404	41.289
DC	BR_046	Circular Pipe	0.335	N/A	4.808	1	41.002	40.958
DC	BR_047	Circular Pipe	0.335	N/A	4.841	1	41.565	41.559
DC	BR_048	Circular Pipe	0.335	N/A	4.302	1	42.777	42.708
DC	BR_049	Circular Pipe	0.335	N/A	4.554	1	42.391	42.201
DC	BR_050	Circular Pipe	0.335	N/A	5.045	1	43.627	43.535
DC	BR_051	Circular Pipe	0.335	N/A	4.808	1	40.406	40.404
DC	CPR_01	Circular Pipe	0.402	N/A	12.16	2	26.3	26.14
DC	CPR_02	Box Culvert	0.6	0.45	14.5	1	26.52	26.38
DC	CPR_03	Circular Pipe	0.402	N/A	12.16	2	26.33	26
DC	CPR_04	Circular Pipe	0.335	N/A	13	1	29	28.81
DC	CPR_05	Circular Pipe	0.402	N/A	12.6	1	28.206	27.95
DC	DC_001	Circular Pipe	0.805	N/A	19.253	2	81.2	80.6
DC	DC_002	Circular Pipe	0.805	N/A	18.262	2	74	73.8
DC	MLH_01	Circular Pipe	1.342	N/A	22.4	6	62.05	62
DC	SC1061	Box Culvert	2.64	0.9	18.906	8	65.35	65.27
DC	SC501539	Box Culvert	0.96	0.45	26.57	3	67.19	67.05
DC	SC50954	Box Culvert	0.72	0.45	21.46	1	36.744	36.698
DC	SC50955	Box Culvert	0.72	0.45	21.45	1	34.72	34.659
DC	SC50956	Box Culvert	0.72	0.45	21.46	1	34.231	34.203
DC	SC50957	Box Culvert	0.72	0.45	22.04	3	33.63	33.56
DC	SC5882	Box Culvert	0.72	0.45	19.29	3	43.275	43.205
DC	SC5883	Box Culvert	0.72	0.45	19.57	1	44.255	44.175
DC	SC5886	Box Culvert	0.72	0.45	19.45	1	41.8	40.73
DC	SC5887	Box Culvert	0.72	0.45	20.32	1	40.89	40.82
DC	SC5888	Box Culvert	0.72	0.45	19.52	3	40.44	40.37

Catchment	ID	Type	Width/Dia (m)	Height (m)	Length (m)	No of Cells	US Invert (m AHD)	DS Invert (m AHD)
DC	SC5891	Box Culvert	0.72	0.45	19.96	1	39.835	39.765
DC	SC5892	Box Culvert	0.72	0.45	19.66	1	39.335	39.265
DC	SC5893	Box Culvert	0.72	0.45	19.49	1	39.12	39.05
DC	SC5894	Box Culvert	0.72	0.45	19.26	1	38.89	38.82
DC	SC5895	Box Culvert	0.72	0.45	18.94	1	37.615	37.545
DC	SC798	Box Culvert	0.48	0.4	8.623	2	34.51	34.41
DC	SD26297	Circular Pipe	0.335	N/A	27	1	95.72	94.45
DC	SD26298	Circular Pipe	1.073	N/A	21.2	4	94.52	94.24
DC	SD26302	Circular Pipe	0.335	N/A	10	1	95.46	95.42
DC	SD26303	Circular Pipe	0.335	N/A	11.67	1	95.4	95.3
DC	SD37692	Circular Pipe	0.671	N/A	20	2	36.5	36.35
DC	SD38922	Circular Pipe	1.073	N/A	21.96	1	91.48	91.2
DC	SD38923	Circular Pipe	1.073	N/A	17.08	2	90.6	90.4
DC	SD39183	Circular Pipe	0.47	N/A	9.76	2	34.25	34.2
DC	SD44583	Circular Pipe	0.335	N/A	26.31	1	69.27	68.76
DC	SD489199	Circular Pipe	0.939	N/A	76.79	1	77.29	75.95
DC	SD489201	Circular Pipe	1.207	N/A	15.197	1	75.93	75.87
DC	SD490686	Circular Pipe	0.939	N/A	29.14	7	84.48	84.18
DC	SD490687	Circular Pipe	0.939	N/A	26.73	2	84.59	84.3
DC	SD490689	Circular Pipe	0.805	N/A	26.84	6	85.35	84.76
DC	SD490691	Circular Pipe	0.335	N/A	33.15	1	81.82	80.89
DC	SD490692	Circular Pipe	0.402	N/A	23.83	1	80.85	79.92
DC	SD490693	Circular Pipe	0.47	N/A	44.46	1	79.84	78.95
DC	SD490694	Circular Pipe	0.335	N/A	1.51	1	79.27	79.1
DC	SD490695	Circular Pipe	0.671	N/A	14.25	1	78.77	78.72
DC	SD490696	Circular Pipe	0.939	N/A	14.38	1	78.4	78.34
DC	SD490697	Circular Pipe	0.335	N/A	14.32	1	79.65	79.37
DC	SD490698	Circular Pipe	0.402	N/A	17.39	1	79.28	78.92
DC	SD490699	Circular Pipe	0.47	N/A	7.26	1	78.84	78.72
DC	SD501496	Circular Pipe	0.268	N/A	15.41	1	70.94	70.59
DC	SD501497	Circular Pipe	0.335	N/A	21	1	70.5	69.81
DC	SD501498	Circular Pipe	0.939	N/A	11	1	68.49	68.38
DC	SD501499	Circular Pipe	0.939	N/A	72.62	1	68.32	66.14
DC	SD501500	Circular Pipe	0.939	N/A	35.79	1	66.08	65.57
DC	SD501501	Circular Pipe	1.073	N/A	53.07	1	65.51	65.26
DC	SD501502	Circular Pipe	1.073	N/A	39.41	1	65.23	65.01

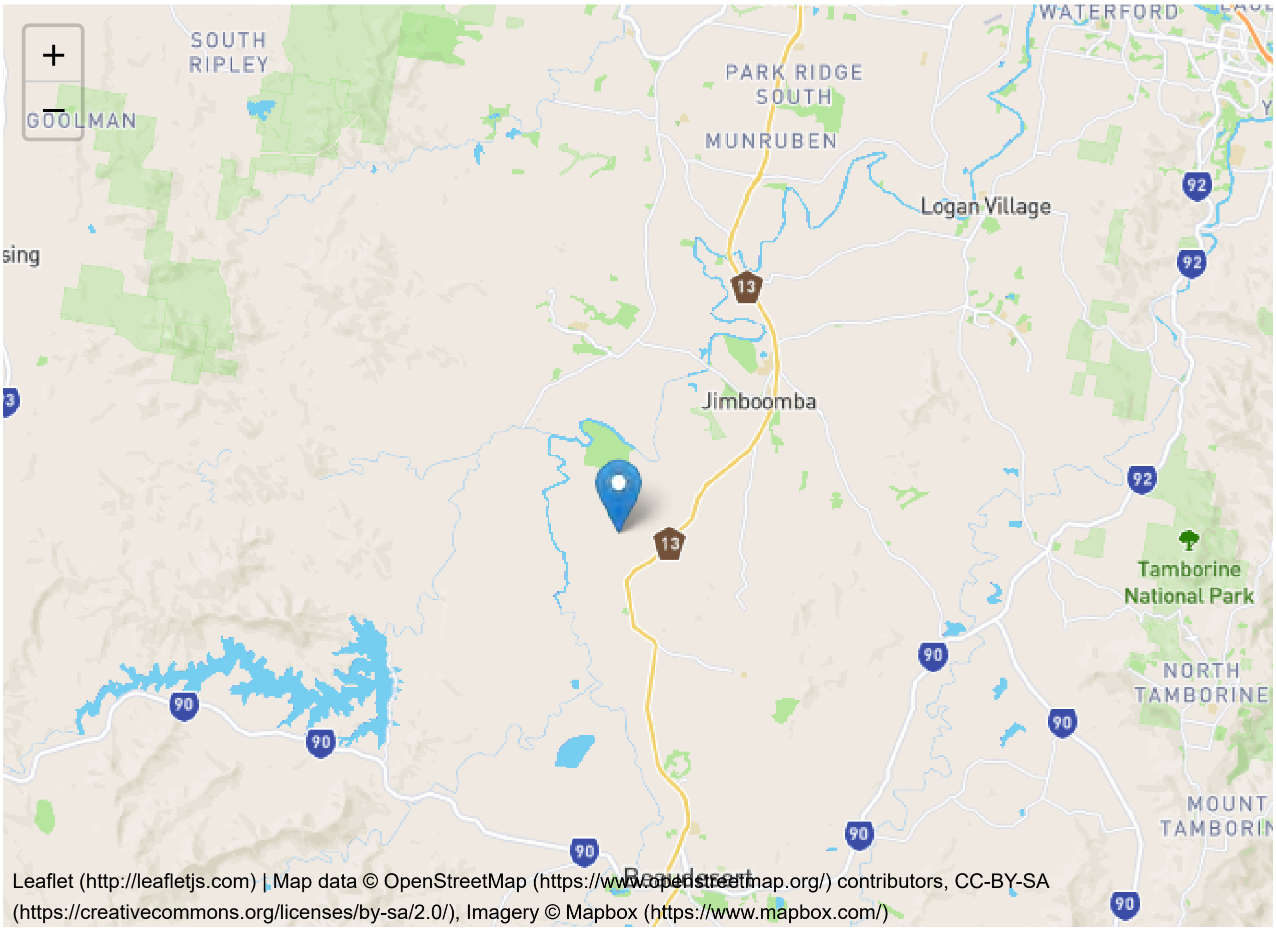
Catchment	ID	Type	Width/Dia (m)	Height (m)	Length (m)	No of Cells	US Invert (m AHD)	DS Invert (m AHD)
DC	SD501503	Circular Pipe	1.207	N/A	11.92	1	64.96	94.9
DC	SD501504	Circular Pipe	0.268	N/A	19	1	66.41	66.21
DC	SD501505	Circular Pipe	0.335	N/A	8.02	1	66.14	65.83
DC	SD501506	Circular Pipe	0.805	N/A	6.32	1	65.46	65.42
DC	SD501507	Circular Pipe	0.537	N/A	7.41	1	66.06	65.8
DC	SD501508	Circular Pipe	0.268	N/A	2.21	1	66.45	66.42
DC	SD501509	Circular Pipe	0.335	N/A	5.19	1	66.44	66.36
DC	SD501510	Circular Pipe	0.335	N/A	5.47	1	66.89	66.81
DC	SD501511	Circular Pipe	0.335	N/A	3.6	1	67.37	37.34
DC	SD501512	Circular Pipe	0.335	N/A	6.67	1	67.41	67.35
DC	SD501517	Circular Pipe	0.939	N/A	9.17	1	68.62	68.54
DC	SD501524	Circular Pipe	0.402	N/A	7.64	1	69.59	69.49
DC	SD501525	Circular Pipe	0.402	N/A	1.72	1	69.6	69.54
DC	SD501526	Circular Pipe	0.805	N/A	36.74	2	73.13	72.94
DC	SD50962	Circular Pipe	0.335	N/A	18	1	32.74	32.5
DC	Thora_04	Circular Pipe	0.671	N/A	12.592	1	37.389	37.148
DC	Thora_05	Circular Pipe	0.671	N/A	10.359	1	37.148	36.95
DC	Thora_06	Circular Pipe	0.671	N/A	25.569	2	37.5	36.95
RW	Bush_01	Circular Pipe	0.47	N/A	13.8	1	31.4	31.02
RW	SD37699	Circular Pipe	1.073	N/A	17.15	1	49.72	49
RW	SD37700	Circular Pipe	0.805	N/A	11	5	50.22	50.04
RW	SD39262	Circular Pipe	1.61	N/A	10.98	3	29.421	29.412
RW	SD39265	Circular Pipe	0.537	N/A	10.98	2	32.39	32.23
RW	SD39267	Circular Pipe	0.335	N/A	9.76	1	30.23	29.8
RW	SD39268	Circular Pipe	0.402	N/A	10.98	2	32.24	32.14
RW	SD39273	Circular Pipe	1.073	N/A	24	3	23.911	23.68
RW	SD39277	Circular Pipe	0.402	N/A	19.6	1	28.346	25.912
RW	SD39278	Circular Pipe	1.207	N/A	19.52	1	44.5	44.4
RW	SD39402	Circular Pipe	1.073	N/A	12.56	3	30.956	30.857
RW	SD39405	Circular Pipe	0.805	N/A	15.95	2	28.81	28
RW	SD39441	Circular Pipe	1.744	N/A	14.35	3	27.28	26.89
RW	SD39544	Circular Pipe	0.939	N/A	12.22	1	28.657	28.606
RW	SD39788	Circular Pipe	0.939	N/A	17.08	1	56.6	56.42

APPENDIX B
ARR2019 DATA HUB OUTPUTS

Australian Rainfall & Runoff Data Hub - Results

Input Data - Days Creek

Longitude	152.97
Latitude	-27.875
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
Interim Climate Change Factors	show



Data

River Region

Division	North East Coast
River Number	45
River Name	Logan-Albert Rivers

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^{b} - c\log_{10}Duration\right)Duration^{-d} + eArea^{f}Duration^{g}\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
East Coast North	0.327	0.241	0.448	0.36	0.00096	0.48	-0.21	0.012	-0.0013

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^{2}}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

ID	1133.0
Storm Initial Losses (mm)	24.0
Storm Continuing Losses (mm/h)	1.6

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECnorth.zip)

code	ECnorth
Label	East Coast North

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECnorth.zip)

code	ECnorth
arealabel	East Coast North

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-27.8752&longitude=152.97&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	17 April 2023 01:30PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.8 (0.025)	2.0 (0.044)	2.8 (0.051)	3.6 (0.056)	4.2 (0.056)	4.7 (0.055)
90 (1.5)	0.2 (0.006)	0.6 (0.012)	0.9 (0.014)	1.1 (0.016)	8.9 (0.104)	14.6 (0.152)
120 (2.0)	0.0 (0.000)	1.0 (0.017)	1.6 (0.024)	2.2 (0.029)	11.4 (0.123)	18.2 (0.173)
180 (3.0)	0.0 (0.000)	2.7 (0.044)	4.5 (0.060)	6.2 (0.071)	22.9 (0.219)	35.5 (0.298)
360 (6.0)	0.2 (0.004)	5.7 (0.075)	9.4 (0.102)	12.9 (0.119)	28.2 (0.214)	39.6 (0.263)
720 (12.0)	3.5 (0.051)	10.3 (0.104)	14.7 (0.123)	19.0 (0.134)	31.2 (0.181)	40.4 (0.205)
1080 (18.0)	0.0 (0.000)	8.3 (0.071)	13.7 (0.097)	19.0 (0.113)	30.0 (0.146)	38.2 (0.163)
1440 (24.0)	0.4 (0.004)	7.0 (0.053)	11.3 (0.070)	15.5 (0.081)	24.8 (0.107)	31.7 (0.119)
2160 (36.0)	0.1 (0.001)	2.8 (0.018)	4.6 (0.024)	6.3 (0.028)	13.5 (0.049)	18.9 (0.059)
2880 (48.0)	0.0 (0.000)	1.6 (0.009)	2.7 (0.013)	3.7 (0.015)	11.9 (0.038)	18.0 (0.050)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.7 (0.005)	3.0 (0.007)

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	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%)**

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Download TXT (downloads/0daad43a-82aa-4599-8b4a-8042d71e86ab.txt)

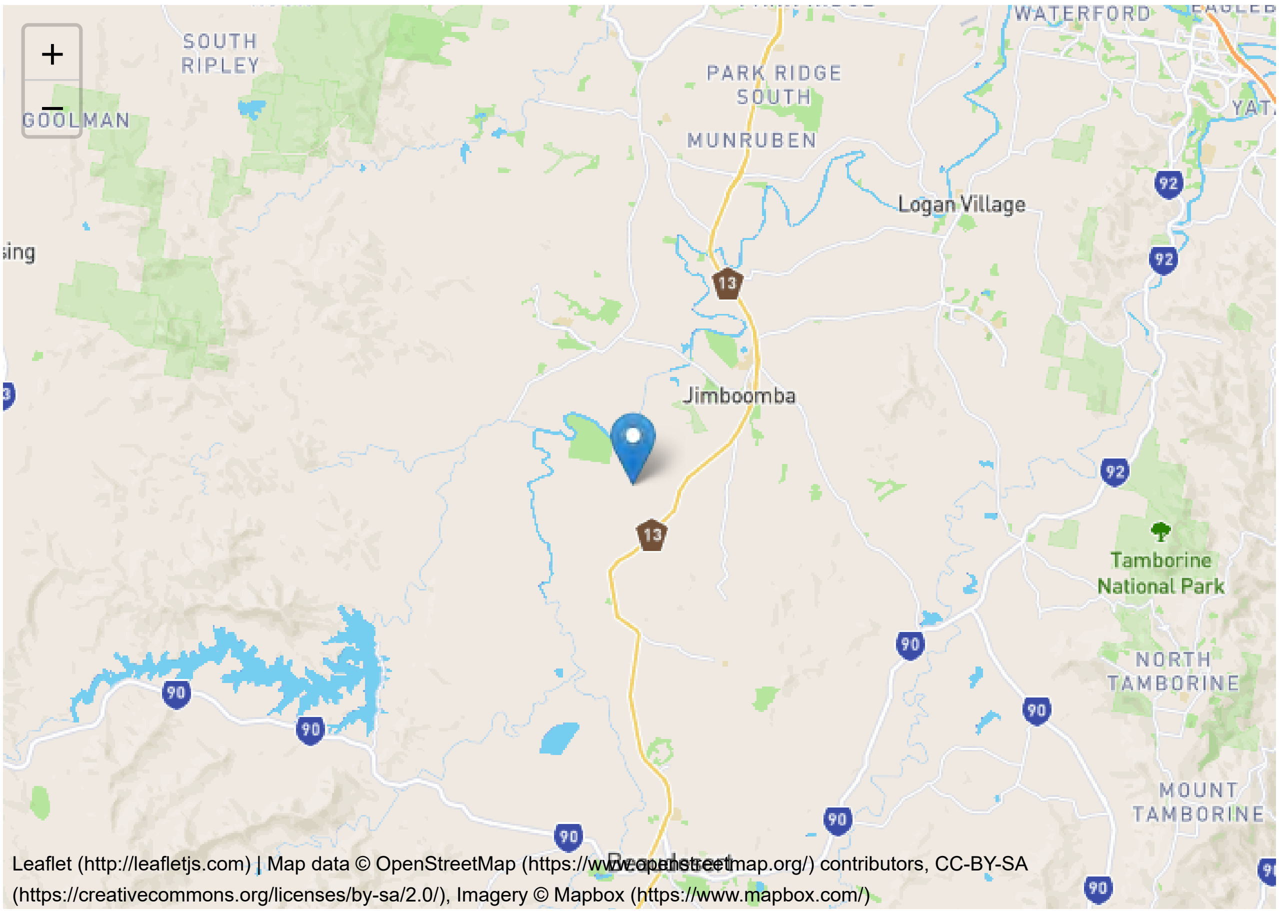
Download JSON (downloads/1599c7d3-24b3-4227-8975-53d2dee5cca6.json)

Generating PDF... (downloads/8b596219-6f66-4dbb-b6cd-5e985a0f36eb.pdf)

Australian Rainfall & Runoff Data Hub - Results

Input Data - Roberts Waterhole

Longitude	152.982
Latitude	-27.862
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
Interim Climate Change Factors	show



Data

River Region

Division	North East Coast
River Number	45
River Name	Logan-Albert Rivers

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v1

ARF Parameters

$$ARF = Min\left\{1, \left[1 - a\left(Area^b - c\log_{10}Duration\right)Duration^{-d} + eArea^f Duration^g\left(0.3 + \log_{10}AEP\right) + h10^{iArea\frac{Duration}{1440}}\left(0.3 + \log_{10}AEP\right)\right]\right\}$$

Zone	a	b	c	d	e	f	g	h	i
East Coast North	0.327	0.241	0.448	0.36	0.00096	0.48	-0.21	0.012	-0.0013

Short Duration ARF

$$ARF = Min\left[1, 1 - 0.287\left(Area^{0.265} - 0.439\log_{10}(Duration)\right).Duration^{-0.36} + 2.26 \text{ x } 10^{-3} \text{ x } Area^{0.226}.Duration^{0.125}\left(0.3 + \log_{10}(AEP)\right) + 0.0141 \text{ x } Area^{0.213} \text{ x } 10^{-0.021\frac{(Duration-180)^2}{1440}}\left(0.3 + \log_{10}(AEP)\right)\right]$$

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v1

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

Note: These losses are only for rural use and are **NOT FOR DIRECT USE** in urban areas

ID	1133.0
Storm Initial Losses (mm)	24.0
Storm Continuing Losses (mm/h)	1.6

Layer Info

Time Accessed	17 April 2023 01:30PM

Version	2016_v1

Temporal Patterns | Download (.zip) (static/temporal_patterns/TP/ECnorth.zip)

code	ECnorth
Label	East Coast North

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip) (./static/temporal_patterns/Areal/Areal_ECnorth.zip)

code	ECnorth
arealabel	East Coast North

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2016_v2

BOM IFDs

Click here (http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016&coordinate_type=dd&latitude=-27.8619&longitude=152.9818&sdmin=true&sdhr=true&sdday=true&user_label=) to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	17 April 2023 01:30PM

Median Preburst Depths and Ratios

Values are of the format depth (ratio) with depth in mm

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.8 (0.025)	2.0 (0.044)	2.8 (0.051)	3.6 (0.056)	4.2 (0.055)	4.7 (0.054)
90 (1.5)	0.2 (0.006)	0.6 (0.012)	0.9 (0.014)	1.1 (0.016)	8.9 (0.102)	14.6 (0.150)
120 (2.0)	0.0 (0.000)	1.0 (0.017)	1.6 (0.024)	2.2 (0.028)	11.4 (0.121)	18.2 (0.170)
180 (3.0)	0.0 (0.000)	2.7 (0.043)	4.5 (0.059)	6.2 (0.070)	22.9 (0.214)	35.5 (0.291)
360 (6.0)	0.2 (0.004)	5.7 (0.073)	9.4 (0.099)	12.9 (0.115)	28.2 (0.208)	39.6 (0.255)
720 (12.0)	3.5 (0.049)	10.3 (0.101)	14.7 (0.119)	19.0 (0.130)	31.2 (0.175)	40.4 (0.197)
1080 (18.0)	0.0 (0.000)	8.3 (0.069)	13.7 (0.094)	19.0 (0.109)	30.0 (0.141)	38.2 (0.157)
1440 (24.0)	0.4 (0.004)	7.0 (0.051)	11.3 (0.068)	15.5 (0.078)	24.8 (0.103)	31.7 (0.115)
2160 (36.0)	0.1 (0.001)	2.8 (0.017)	4.6 (0.023)	6.3 (0.027)	13.5 (0.047)	18.9 (0.057)
2880 (48.0)	0.0 (0.000)	1.6 (0.009)	2.7 (0.012)	3.7 (0.014)	11.9 (0.037)	18.0 (0.048)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	1.7 (0.005)	3.0 (0.007)

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

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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%)**

Layer Info

Time Accessed	17 April 2023 01:30PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Download TXT (downloads/1c8cf4a4-5141-40e9-9d8d-3f48b979ad03.txt)

Download JSON (downloads/fe257c5d-4b81-4d71-ad2b-49d9b4fa1856.json)

Generating PDF... (downloads/4604d83a-a309-41d5-88ae-7c0694b1dd50.pdf)

IDF Table for Days Creek Catchment (mm/hr)

Duration (min)	AEP (%)							AEP (1 in X)		
	63.2	50	20	10	5	2	1	1 in 200	1 in 500	1 in 2000
20	59.2	67.4	93	110	127	148	164	183	212	259
25	52.3	59.5	82.1	97.2	112	131	146	163	188	231
30	46.9	53.3	73.5	87.2	100	118	131	147	170	208
45	35.9	40.9	56.4	67	77.5	91.5	102	114	133	163
60	29.4	33.3	46	54.8	63.6	75.4	84.7	94.8	110	135
90	21.8	24.8	34.2	40.9	47.6	56.9	64.3	71.9	83.4	102
120	17.6	20	27.6	33.1	38.7	46.4	52.6	58.8	68.2	83.8
180	13.1	14.8	20.5	24.7	29	34.9	39.8	44.4	51.4	63
270	9.75	11.1	15.4	18.6	21.9	26.5	30.3	33.7	39	47.6
360	7.98	9.07	12.7	15.3	18.1	22	25.1	27.9	32.2	39.3
540	6.1	6.94	9.77	11.8	14	17	19.5	21.6	25	30.5
720	5.08	5.8	8.2	9.96	11.8	14.4	16.4	18.2	21.1	25.7
1080	3.96	4.54	6.47	7.88	9.34	11.4	13	14.5	16.8	20.5
1440	3.33	3.83	5.49	6.7	7.95	9.69	11.1	12.4	14.4	17.6

IDF Table for Roberts Waterhole Catchment (mm/hr)

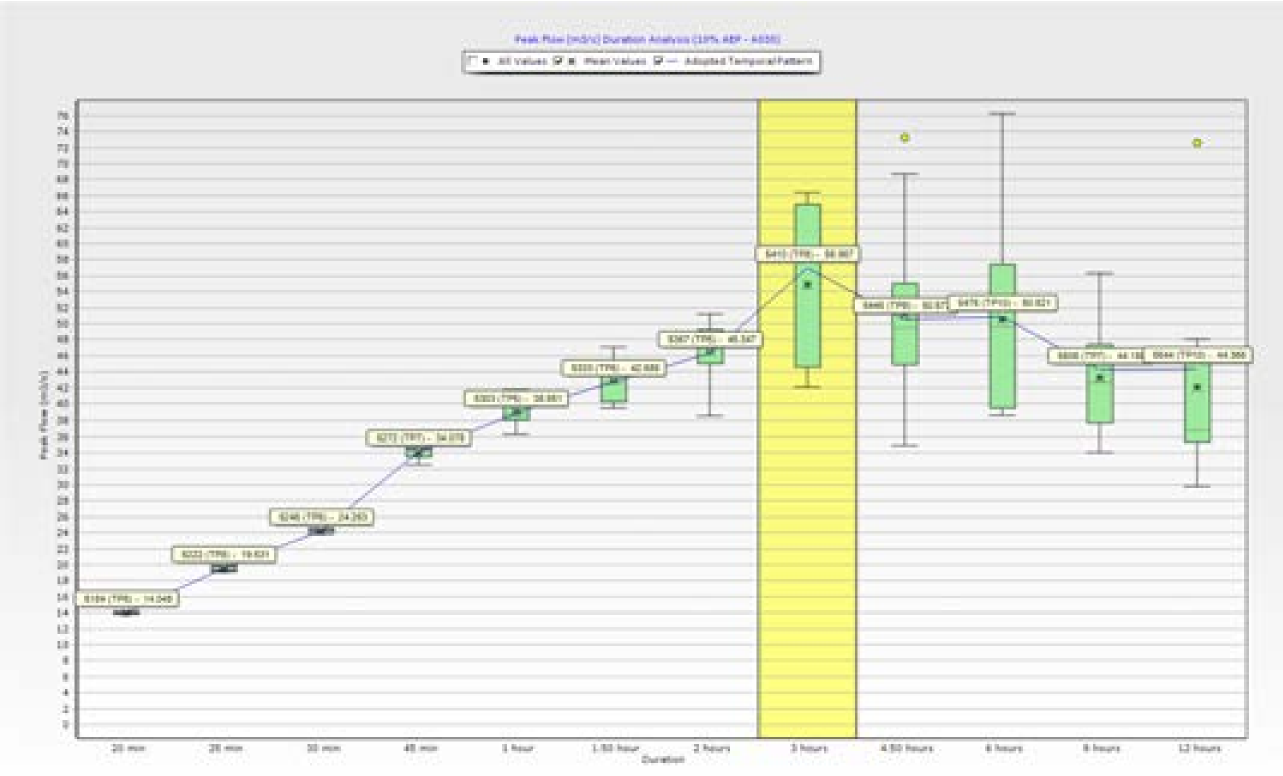
Duration (min)	AEP (%)							AEP (1 in X)		
	63.2	50	20	10	5	2	1	1 in 200	1 in 500	1 in 2000
20	59.4	67.6	93.3	110	127	148	164	183	212	260
25	52.4	59.7	82.4	97.6	112	132	146	163	189	231
30	47	53.5	73.8	87.5	101	118	132	147	171	209
45	36	41	56.7	67.4	77.9	92.1	103	115	134	164
60	29.5	33.5	46.3	55.2	64.1	76.1	85.5	95.6	111	136
90	21.9	24.9	34.6	41.3	48.2	57.6	65.1	72.8	84.6	104
120	17.7	20.2	28	33.6	39.3	47.2	53.5	59.8	69.4	85.2
180	13.2	15	20.9	25.1	29.5	35.7	40.7	45.3	52.5	64.4
270	9.9	11.2	15.7	19	22.4	27.2	31.1	34.6	40	48.9
360	8.13	9.25	13	15.7	18.6	22.6	25.9	28.7	33.2	40.5
540	6.24	7.12	10.1	12.2	14.5	17.6	20.2	22.4	25.8	31.5
720	5.21	5.96	8.46	10.3	12.2	14.9	17	18.9	21.8	26.6
1080	4.08	4.68	6.69	8.16	9.69	11.8	13.5	15.1	17.4	21.3
1440	3.43	3.95	5.68	6.95	8.25	10.1	11.5	12.9	14.9	18.3

APPENDIX C
BOX AND WHISKER PLOTS

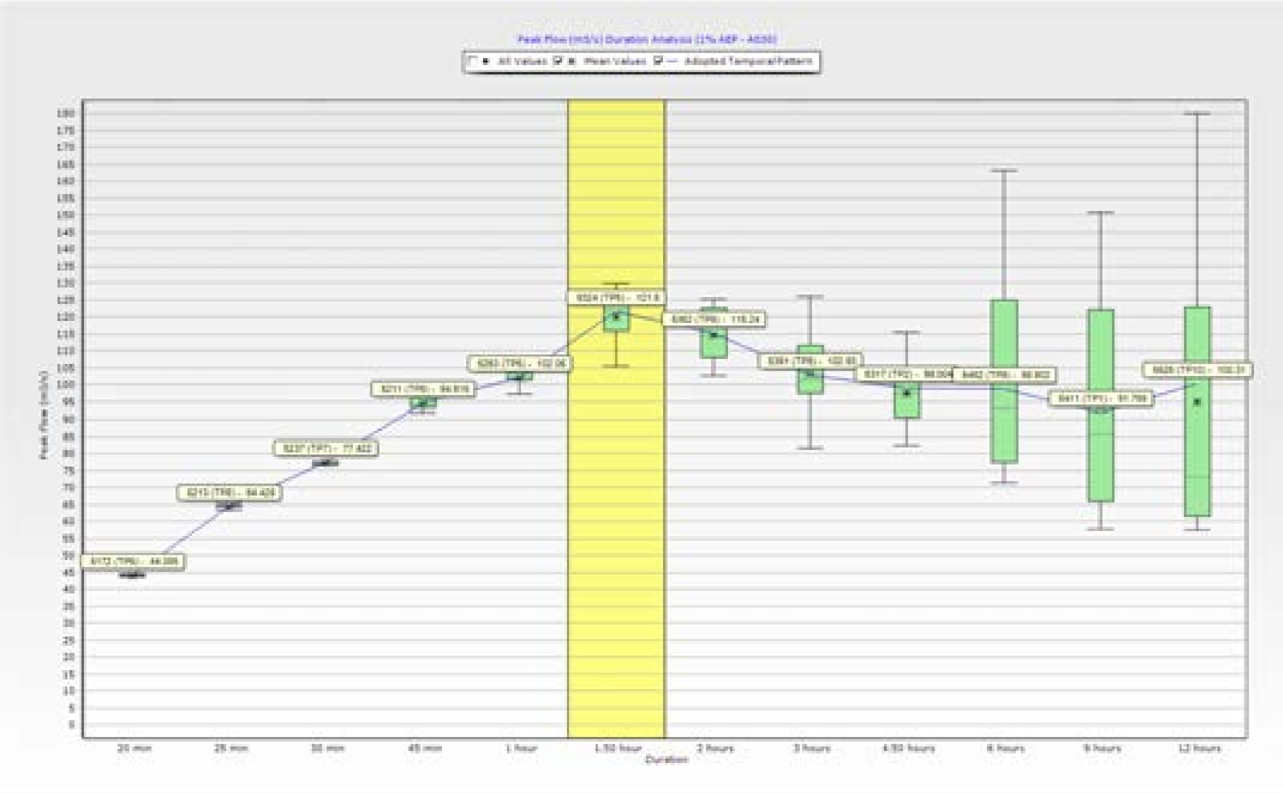
DAYS CREEK

Comparison of Storm Ensembles of different durations for AEP = 50%

Comparison of Storm Ensembles of different durations for AEP = 10%

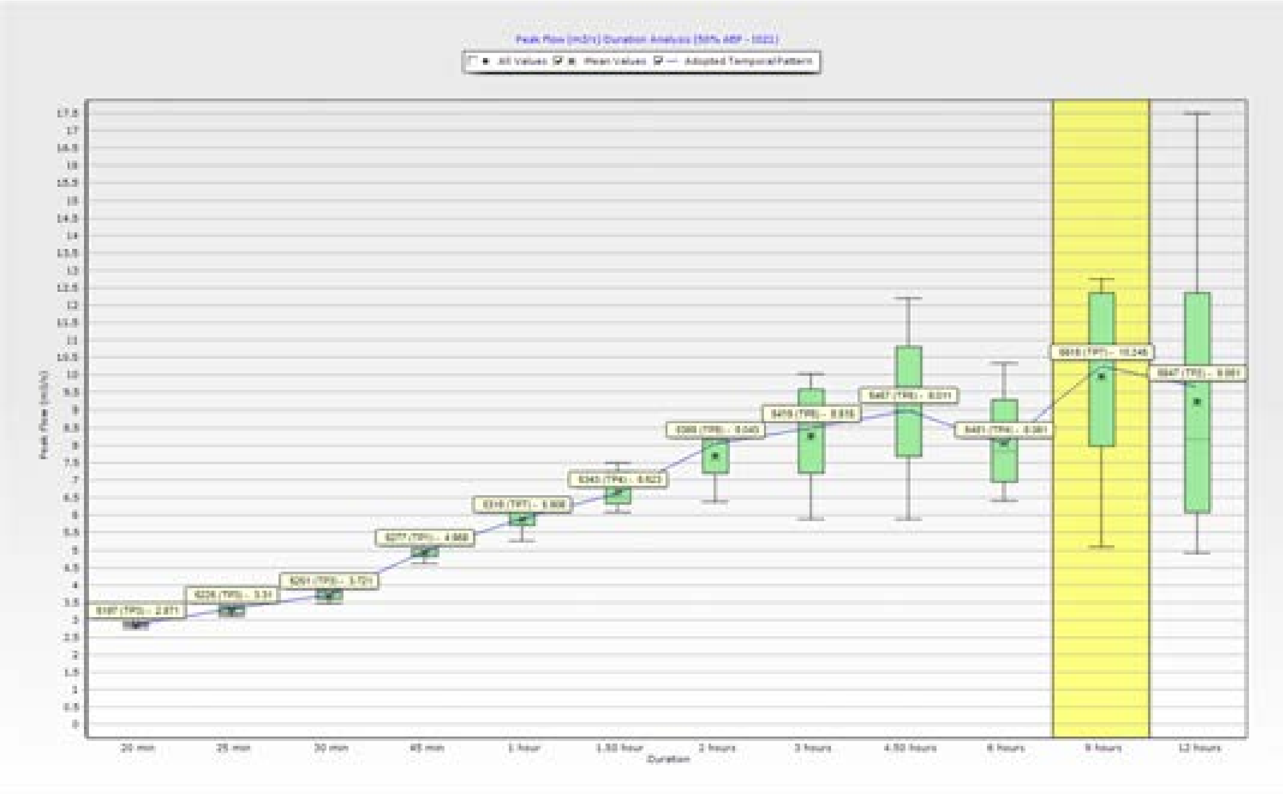


Comparison of Storm Ensembles of different durations for AEP = 1%



ROBERTS WATERHOLE

Comparison of Storm Ensembles of different durations for AEP = 50%

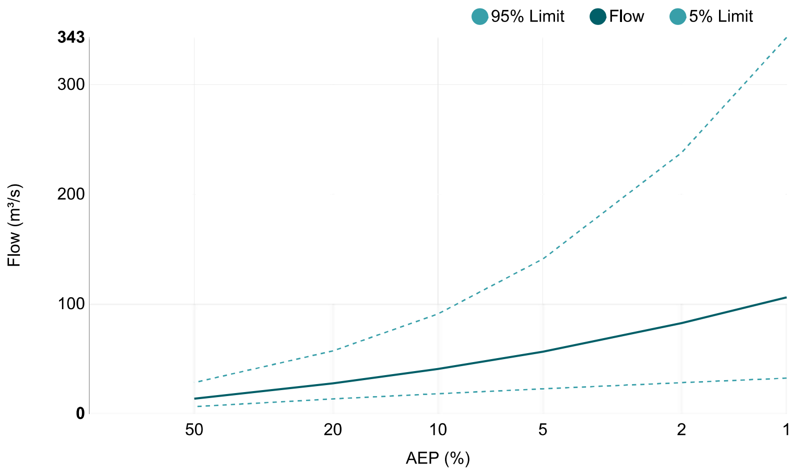


Comparison of Storm Ensembles of different durations for AEP = 10%

Comparison of Storm Ensembles of different durations for AEP = 1%

APPENDIX D
REGIONAL FLOOD FREQUENCY ESTIMATION (RFFE) MODEL DATA OUTPUTS

Results | Regional Flood Frequency Estimation Model - DC4



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	13.4	6.35	28.3
20	27.6	13.4	57.2
10	40.7	18.1	90.9
5	56.5	22.6	141
2	82.5	28.2	238
1	106	32.3	343

Statistics

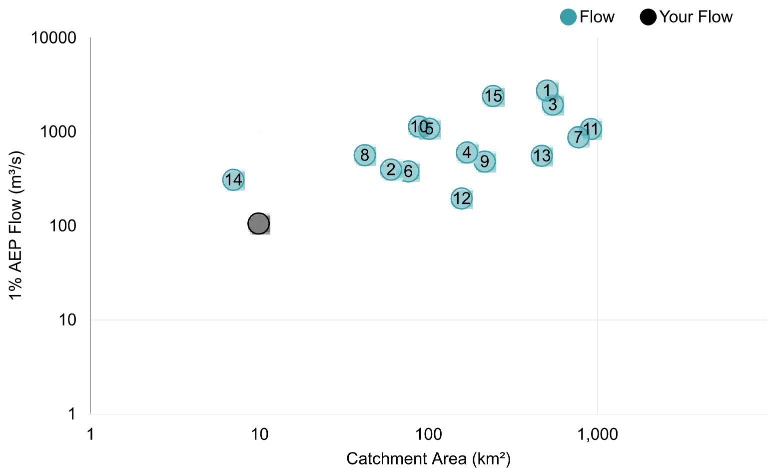
Variable	Value	Standard Dev
Mean	2.526	0.440
Standard Dev	0.937	0.304
Skew	0.114	0.030

Note: These statistics come from the nearest gauged catchment. Details.

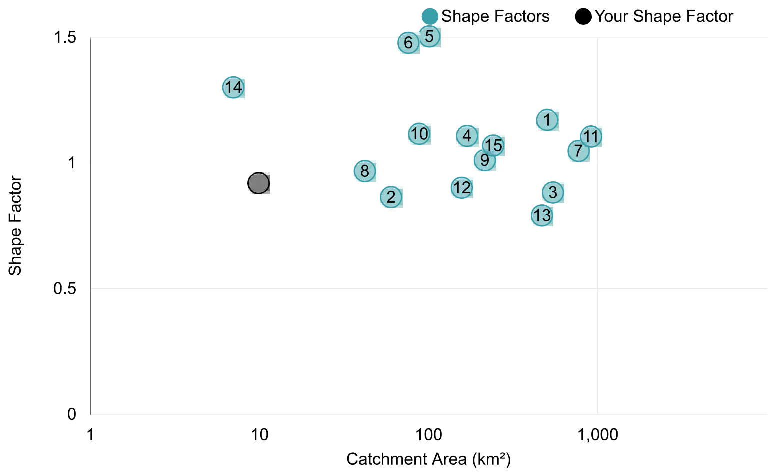
Correlation		
1.000		
-0.330	1.000	
0.170	-0.280	1.000

Note: These statistics are common to each region. Details.

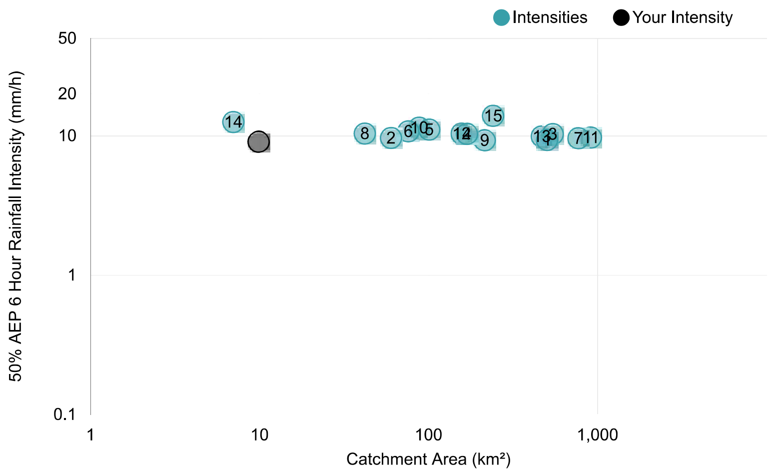
1% AEP Flow vs Catchment Area



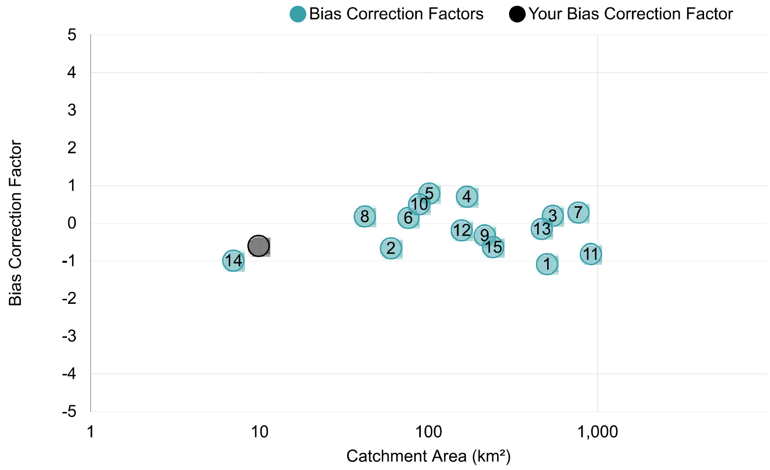
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area

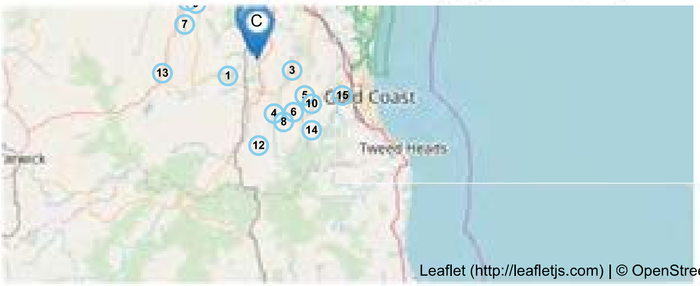


Download

TXT PDF Nearby JSON

Input Data

Date/Time	2018-04-26 10:59
Catchment Name	Days Creek Catchment
Latitude (Outlet)	-27.857
Longitude (Outlet)	152.953
Latitude (Centroid)	-27.876
Longitude (Centroid)	152.973
Catchment Area (km^2)	9.878
Distance to Nearest Gauged Catchment (km)	12.22
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.065273
2% AEP 6 Hour Rainfall Intensity (mm/h)	21.967471
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.92
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.602



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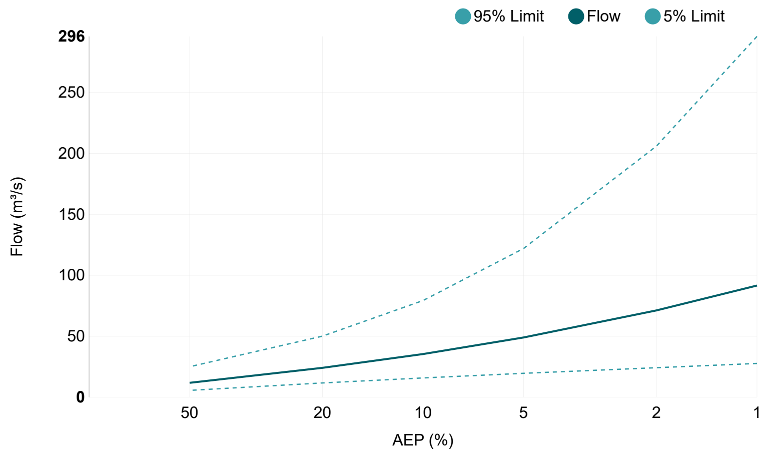
Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (http://arr.ga.gov.au/revision-projects/project-list/projects/project-5) on the ARR website. Send any questions regarding the method or project here (mailto:admin@arr-software.org).

ENGINEERS AUSTRALIA (http://www.engineersaustralia.org.au)

WESTERN SYDNEY UNIVERSITY (http://www.uws.edu.au)

Results | Regional Flood Frequency Estimation Model - RW3



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	11.8	5.59	25.0
20	24.1	11.7	50.1
10	35.4	15.8	79.3
5	49.0	19.6	122
2	71.2	24.2	206
1	91.6	27.7	296

Statistics

Variable	Value	Standard Dev
Mean	2.660	0.472
Standard Dev	0.687	0.312
Skew	0.111	0.030

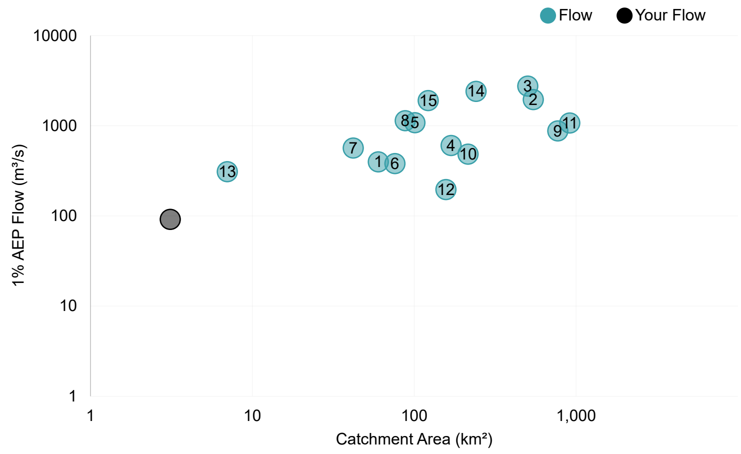
Note: These statistics come from the nearest gauged catchment. Details.

Correlation

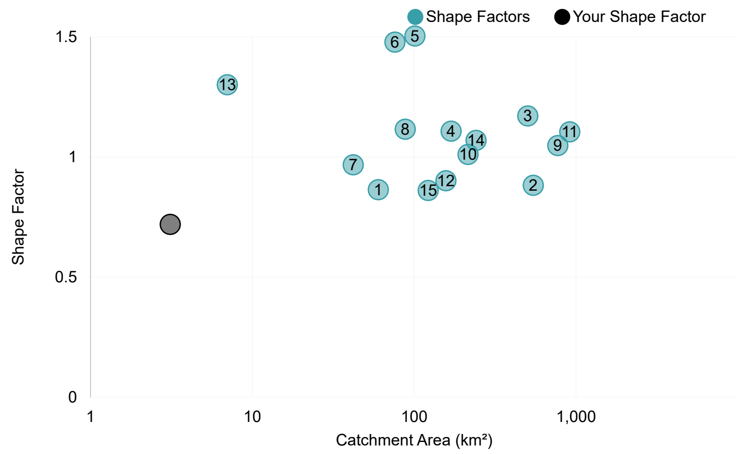
1.000		
-0.330	1.000	
0.170	-0.280	1.000

Note: These statistics are common to each region. Details.

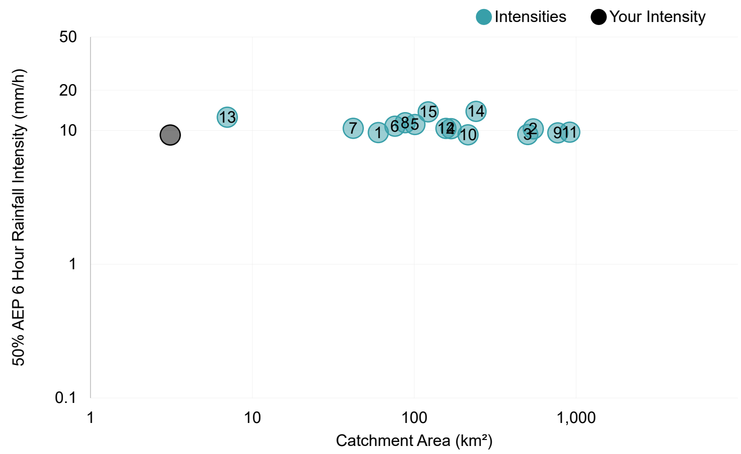
1% AEP Flow vs Catchment Area



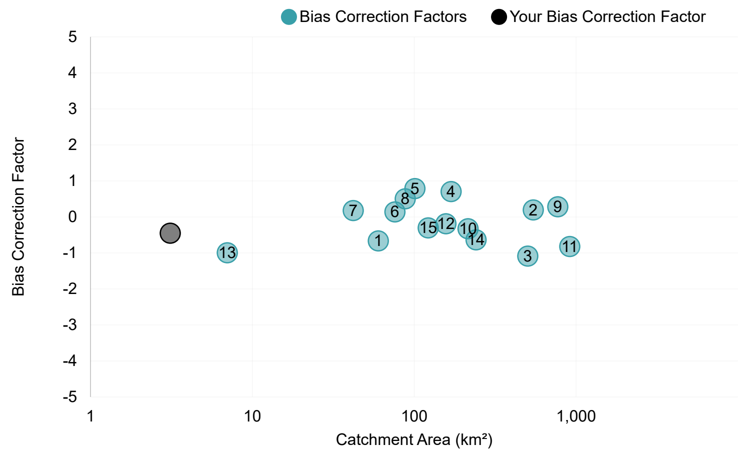
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



Download

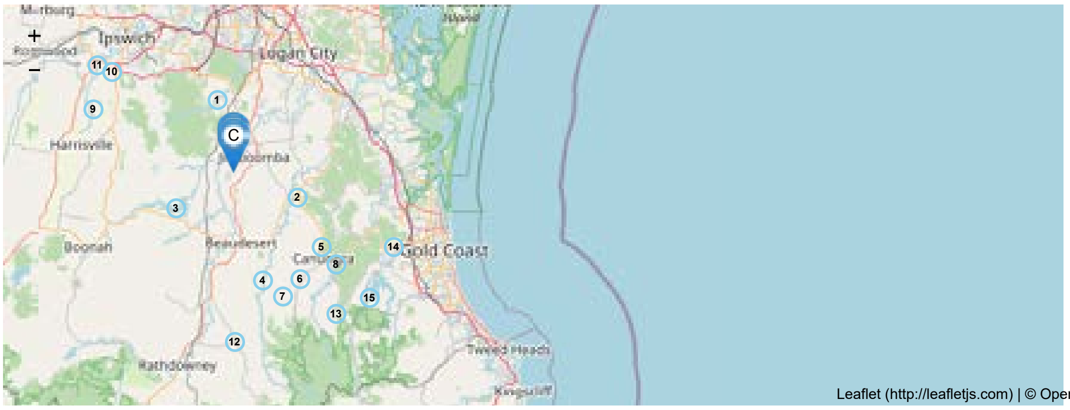
TXT Nearby JSON

Input Data

Date/Time	2023-05-02 14:00

Input Data

Catchment Name	Roberts Waterhole
Latitude (Outlet)	-27.851254
Longitude (Outlet)	152.982425
Latitude (Centroid)	-27.862654
Longitude (Centroid)	152.982518
Catchment Area (km^2)	3.11
Distance to Nearest Gauged Catchment (km)	13.79
50% AEP 6 Hour Rainfall Intensity (mm/h)	9.251317
2% AEP 6 Hour Rainfall Intensity (mm/h)	22.610622
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.72
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.452



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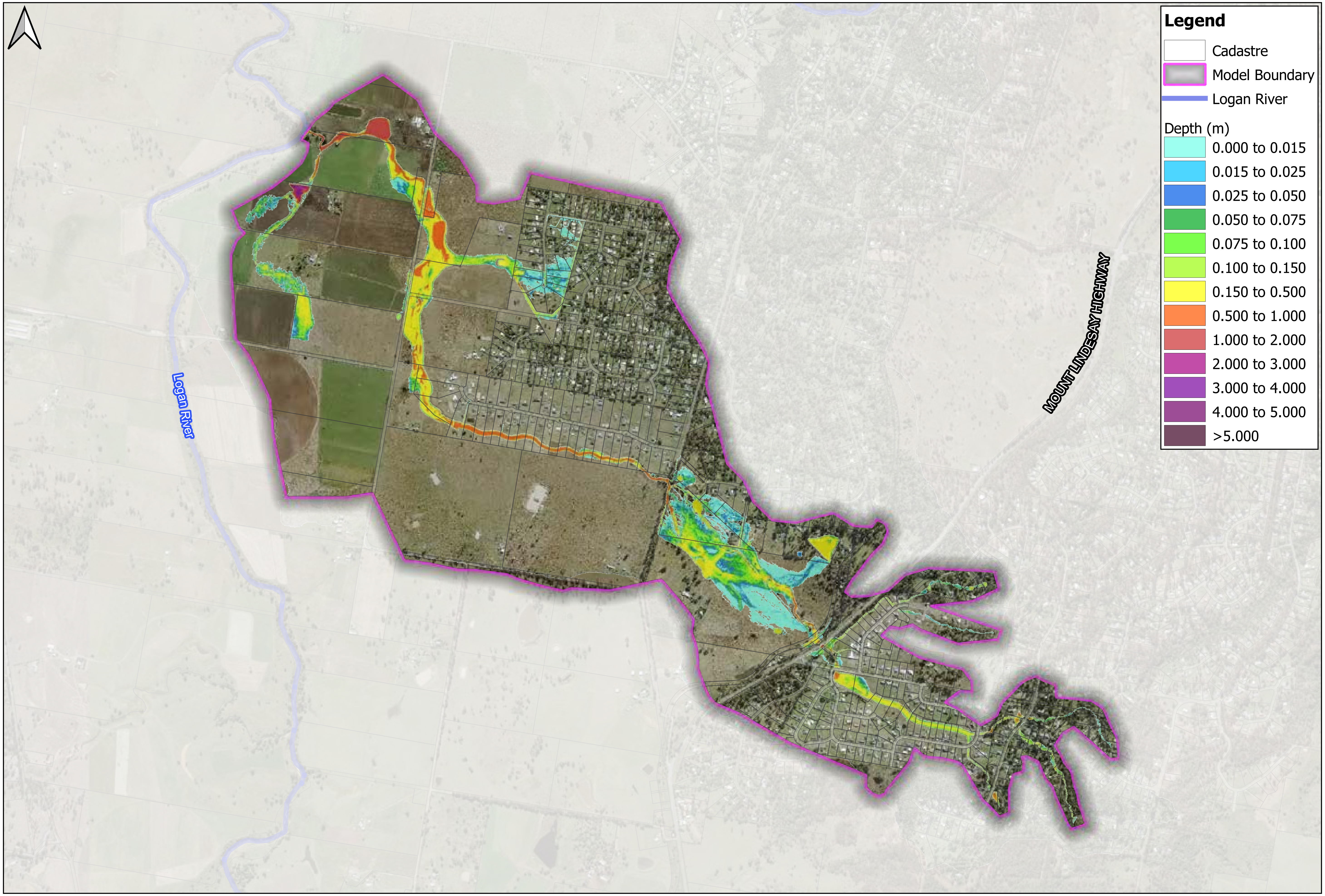
ENGINEERS AUSTRALIA (http://www.engineersaustralia.org.au)

WESTERN SYDNEY UNIVERSITY (http://www.uws.edu.au)

APPENDIX E
DAYS CREEK HYDRAULIC MODEL CRITICAL DURATION GIS MAPS



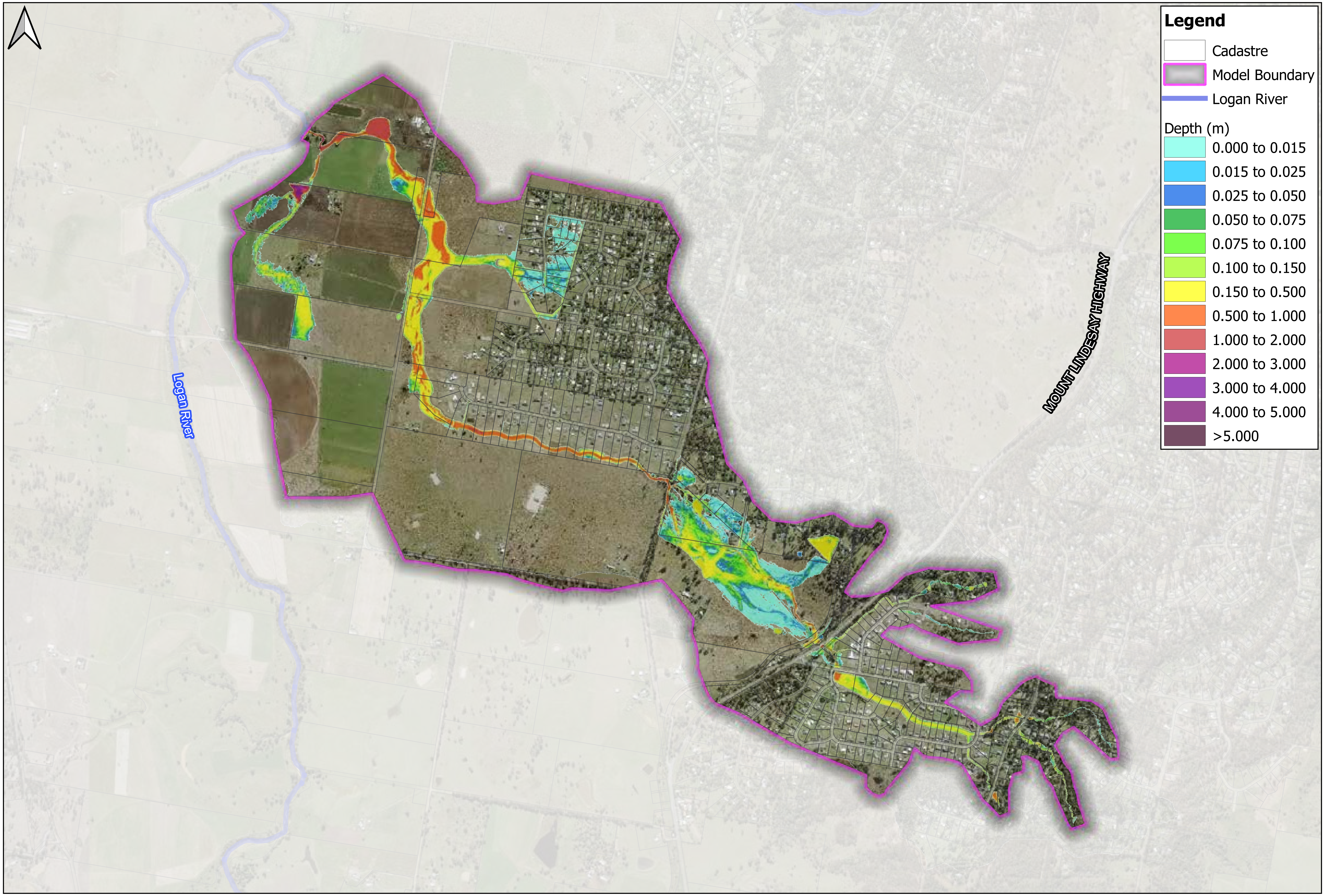
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 63.2% AEP Peak Water Depth



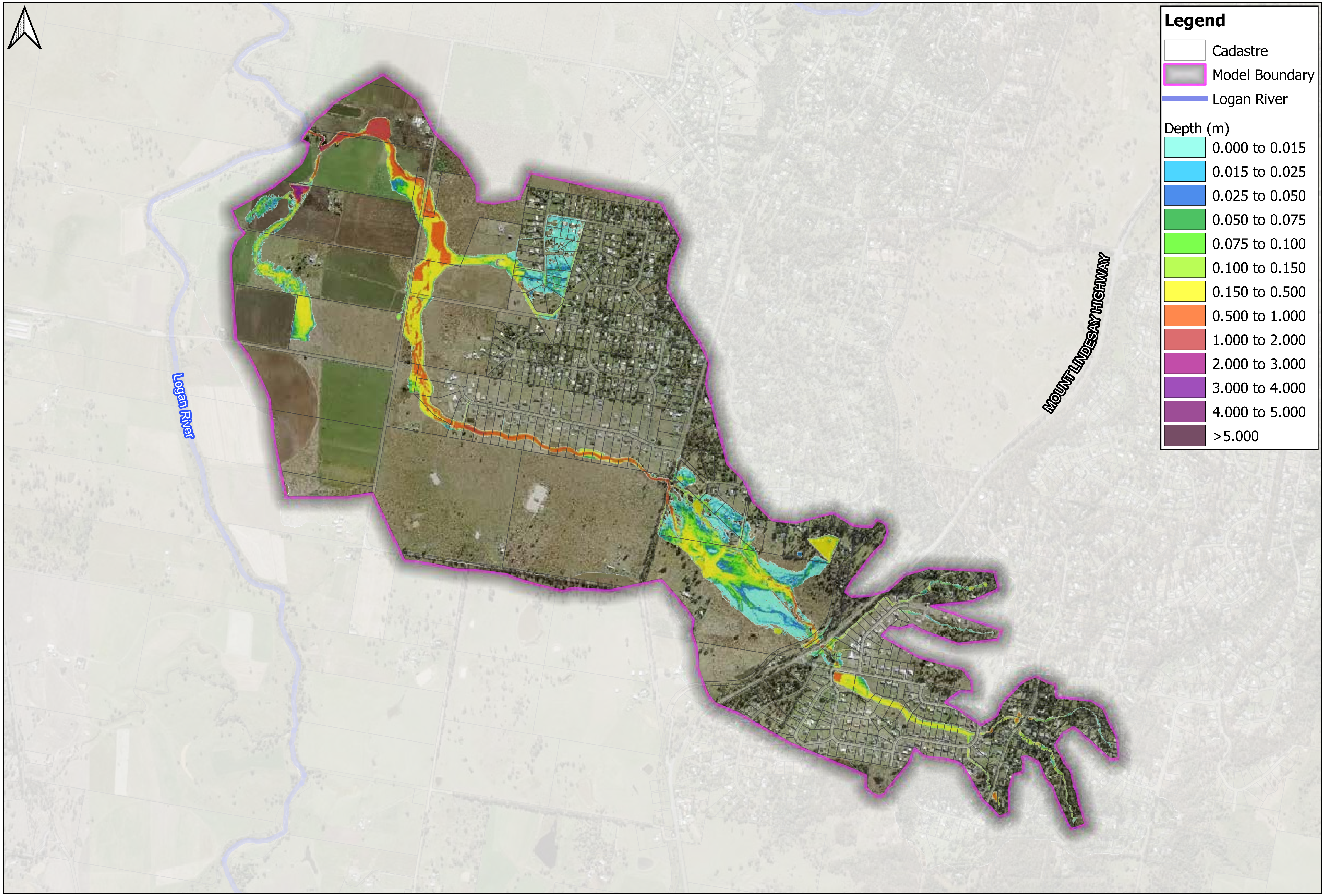
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 50% AEP Peak Water Depth



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

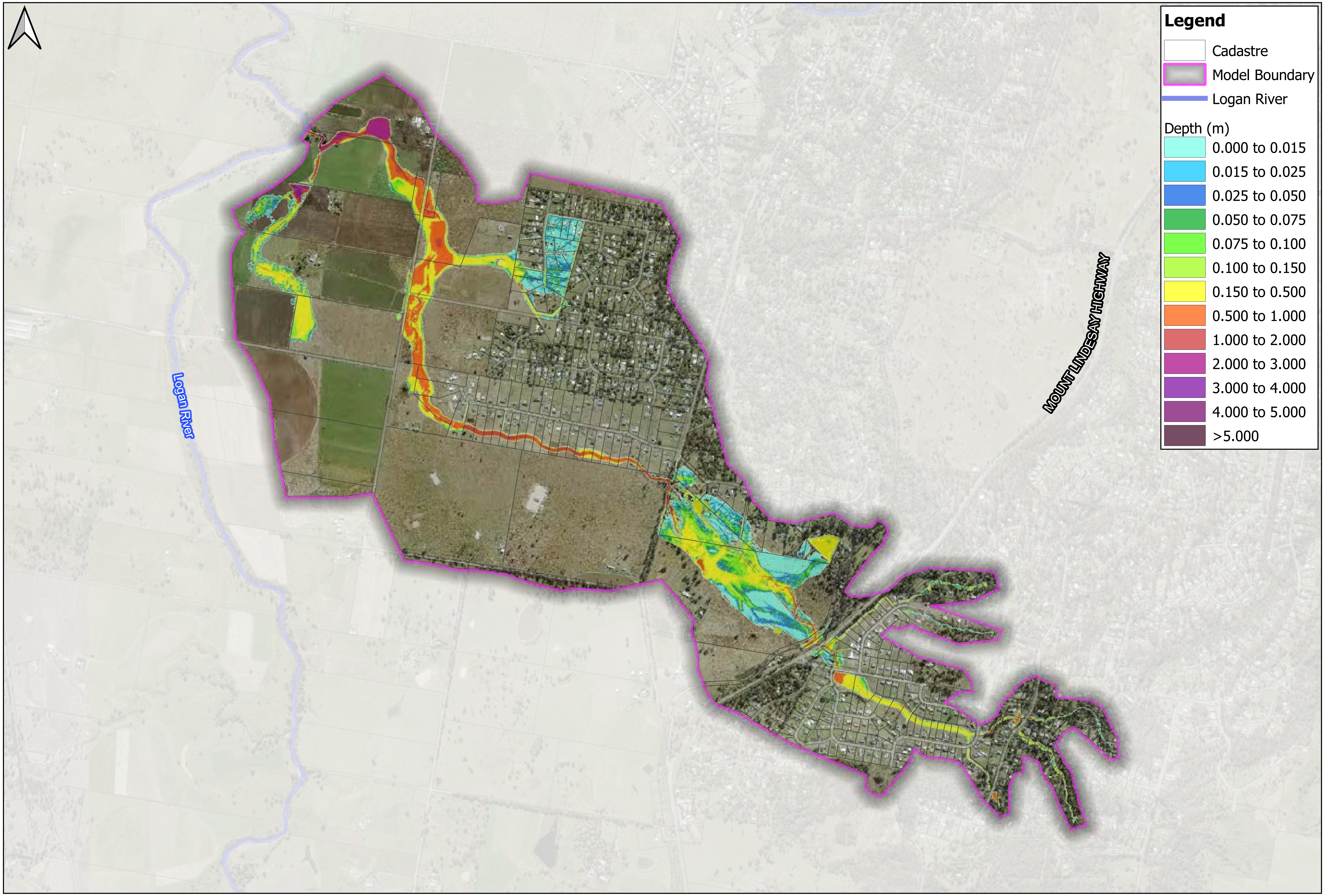
1:20,000

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

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



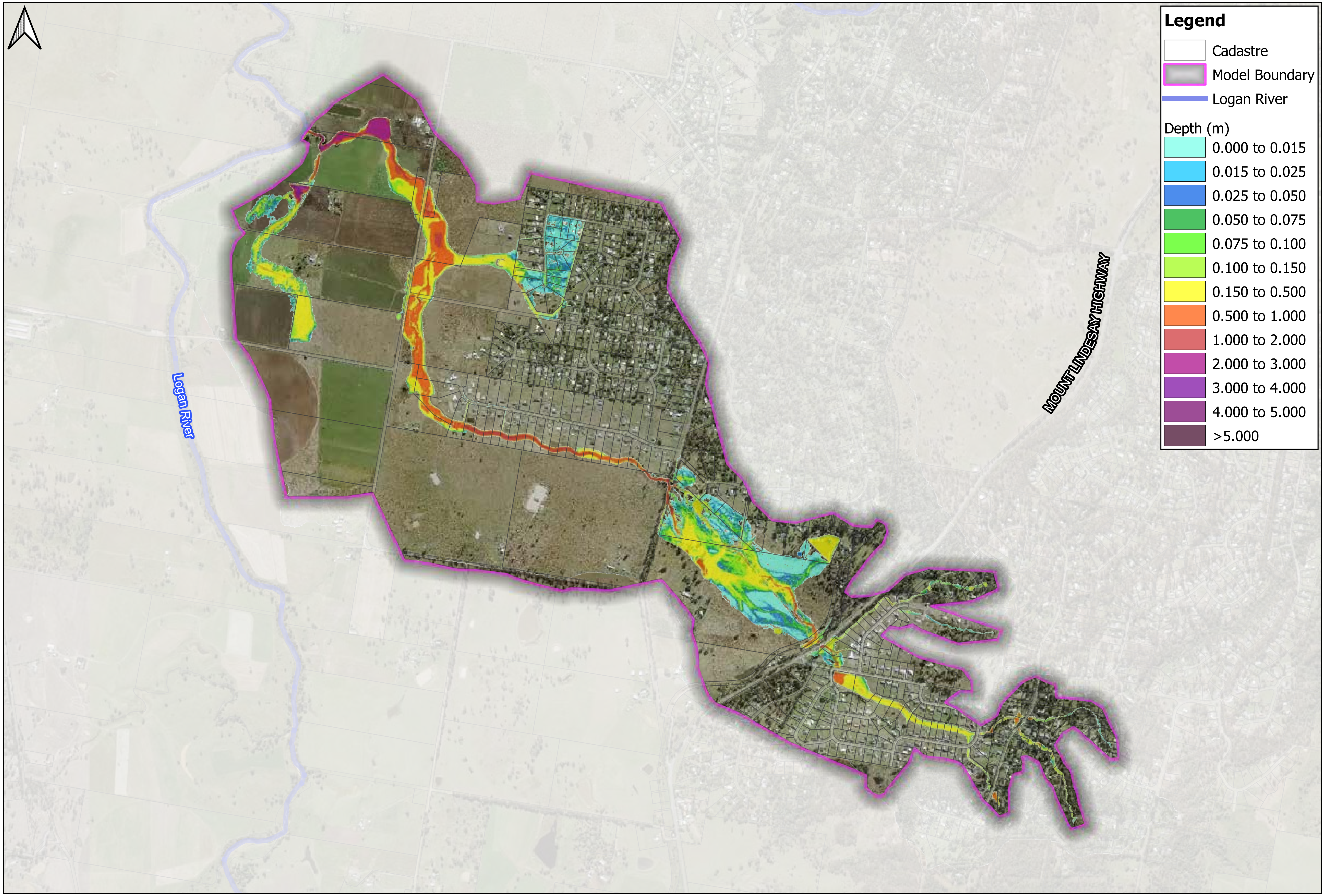
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 20% AEP Peak Water Depth

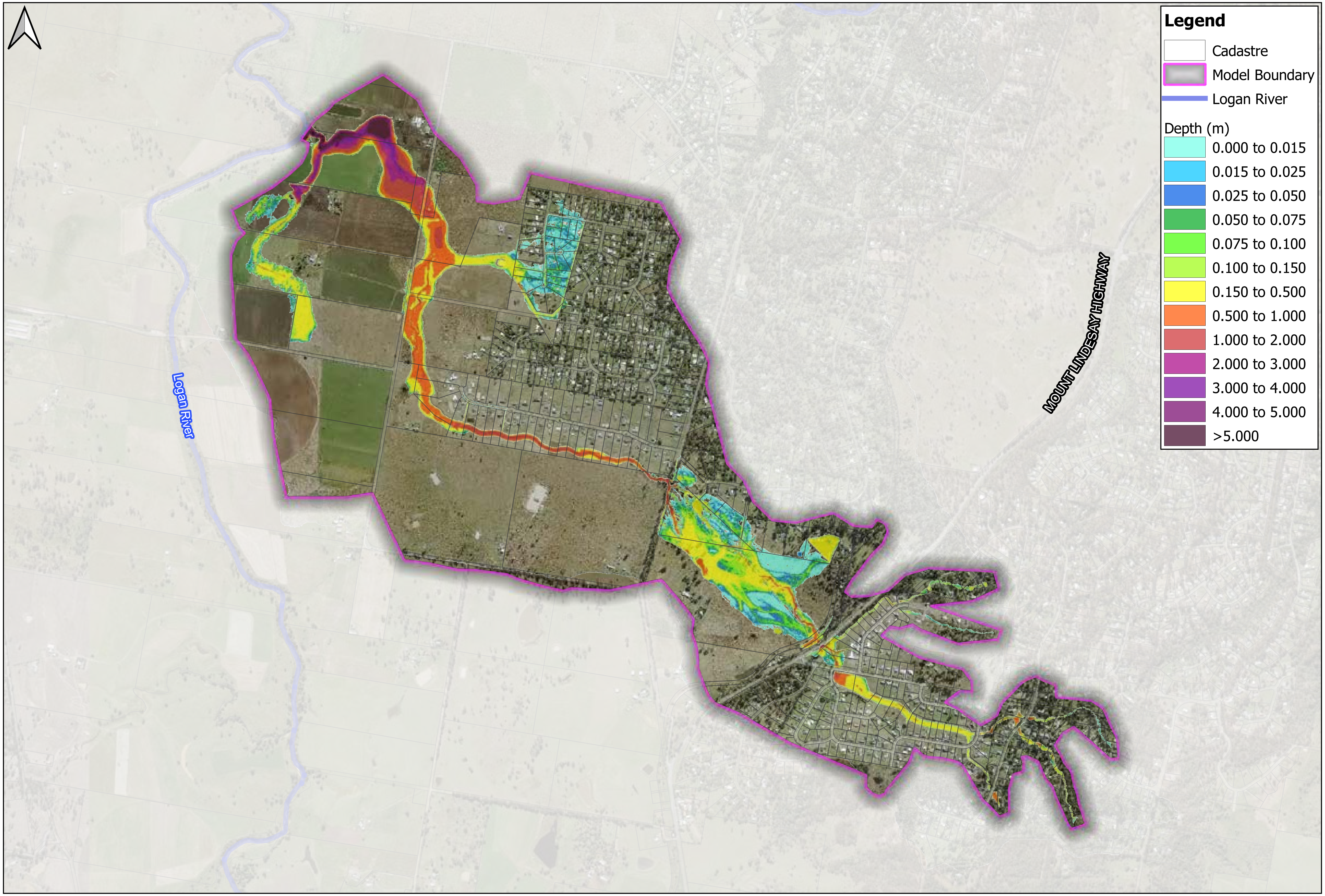


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 20% AEP CC (RCP4.5) Peak Water Depth



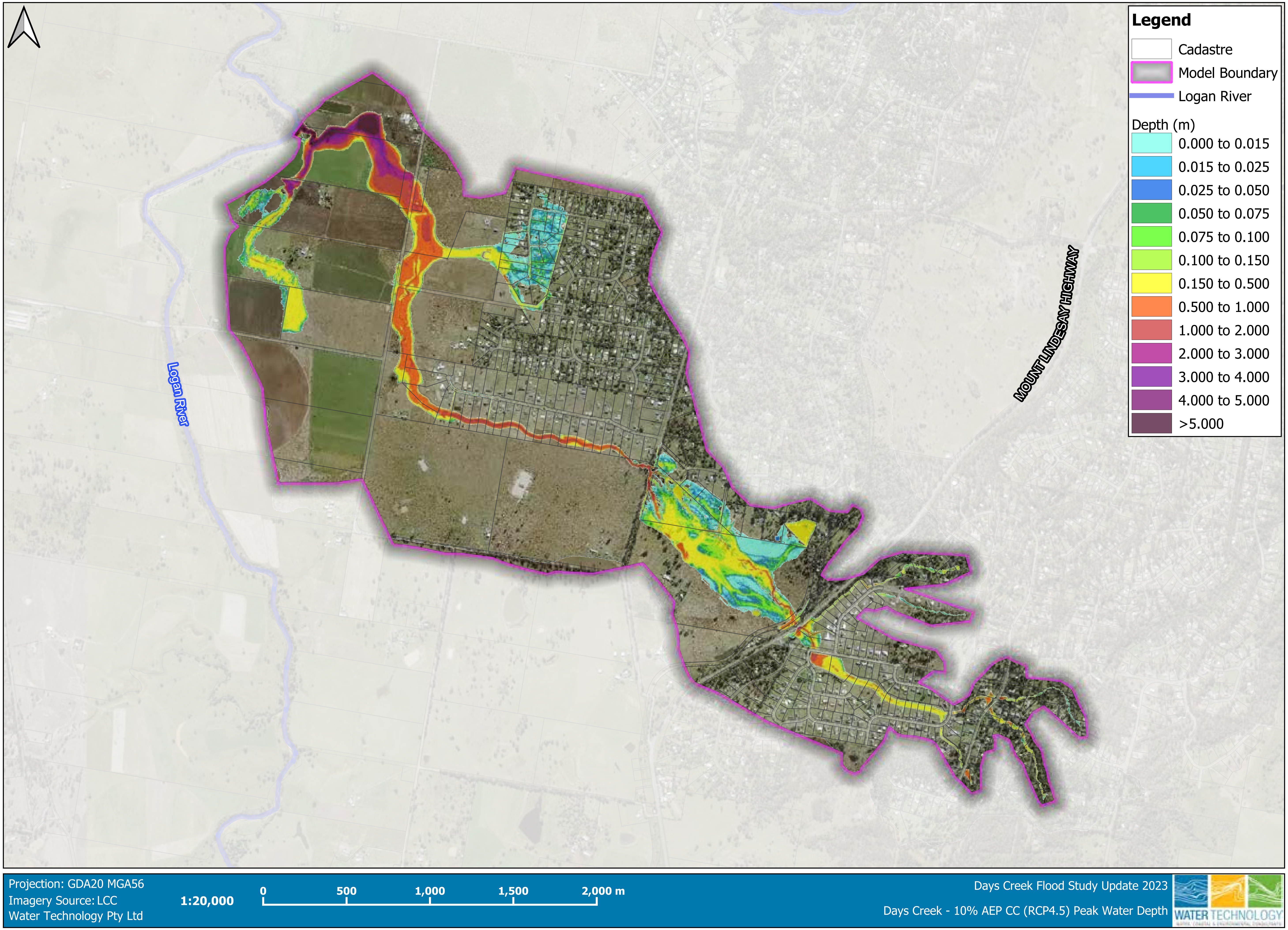
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

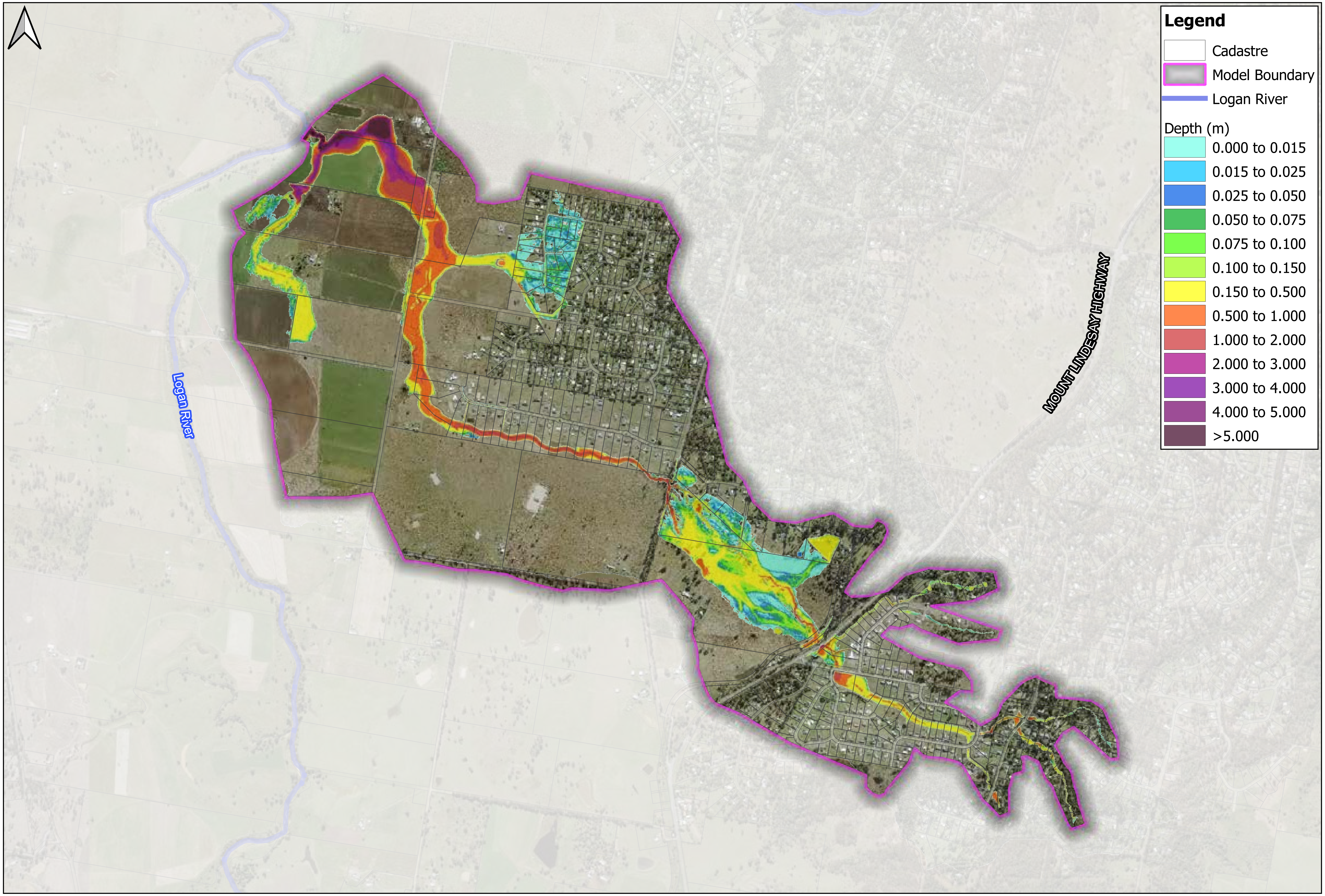
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 10% AEP Peak Water Depth


Legend
Cadastre
Model Boundary
Logan River
Depth (m)
0.000 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 to 4.000
4.000 to 5.000
>5.000
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:20,000
0
500
1,000
1,500
2,000 m
Days Creek Flood Study Update 2023
Days Creek - 10% AEP CC (RCP4.5) Peak Water Depth
WATER TECHNOLOGY

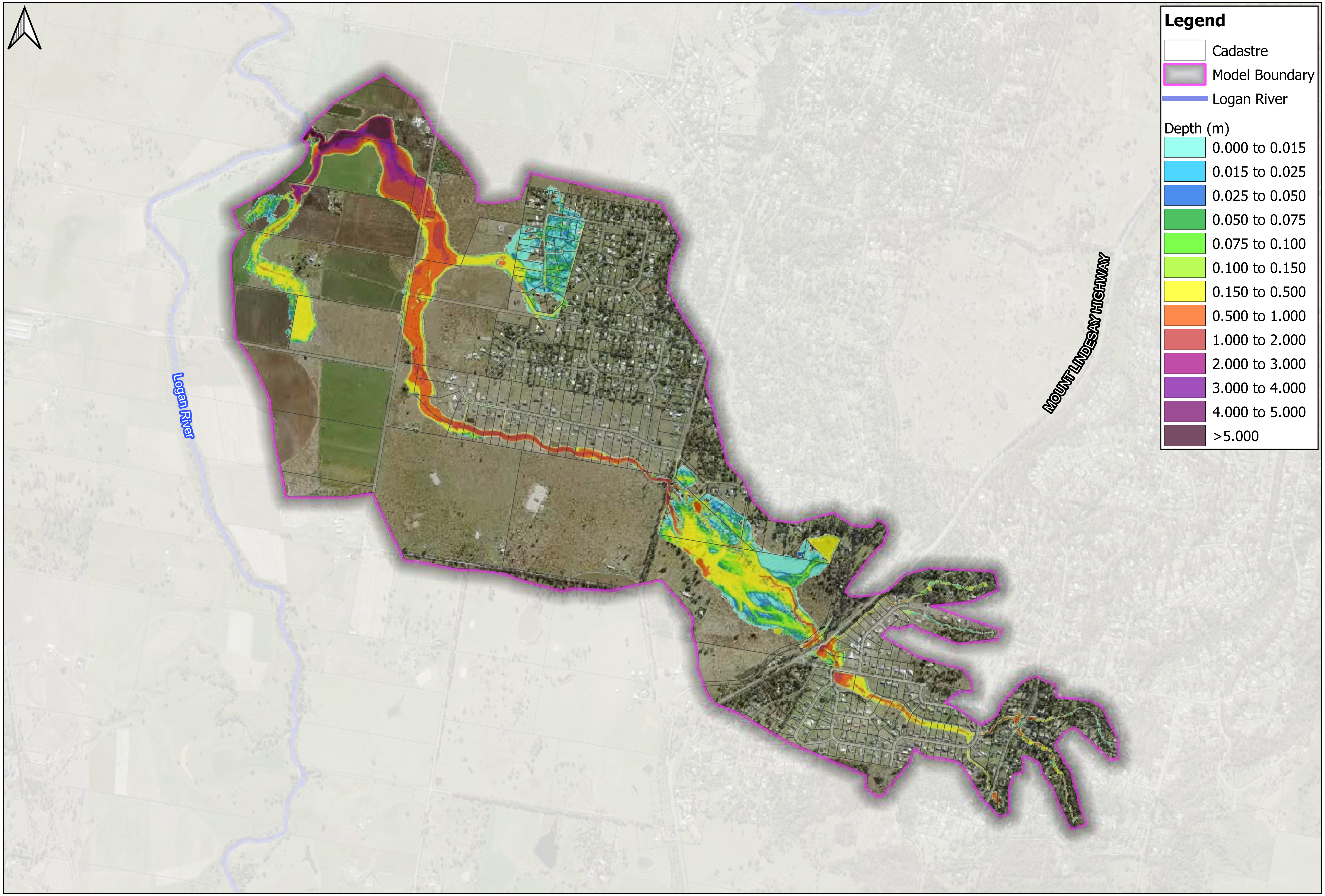


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

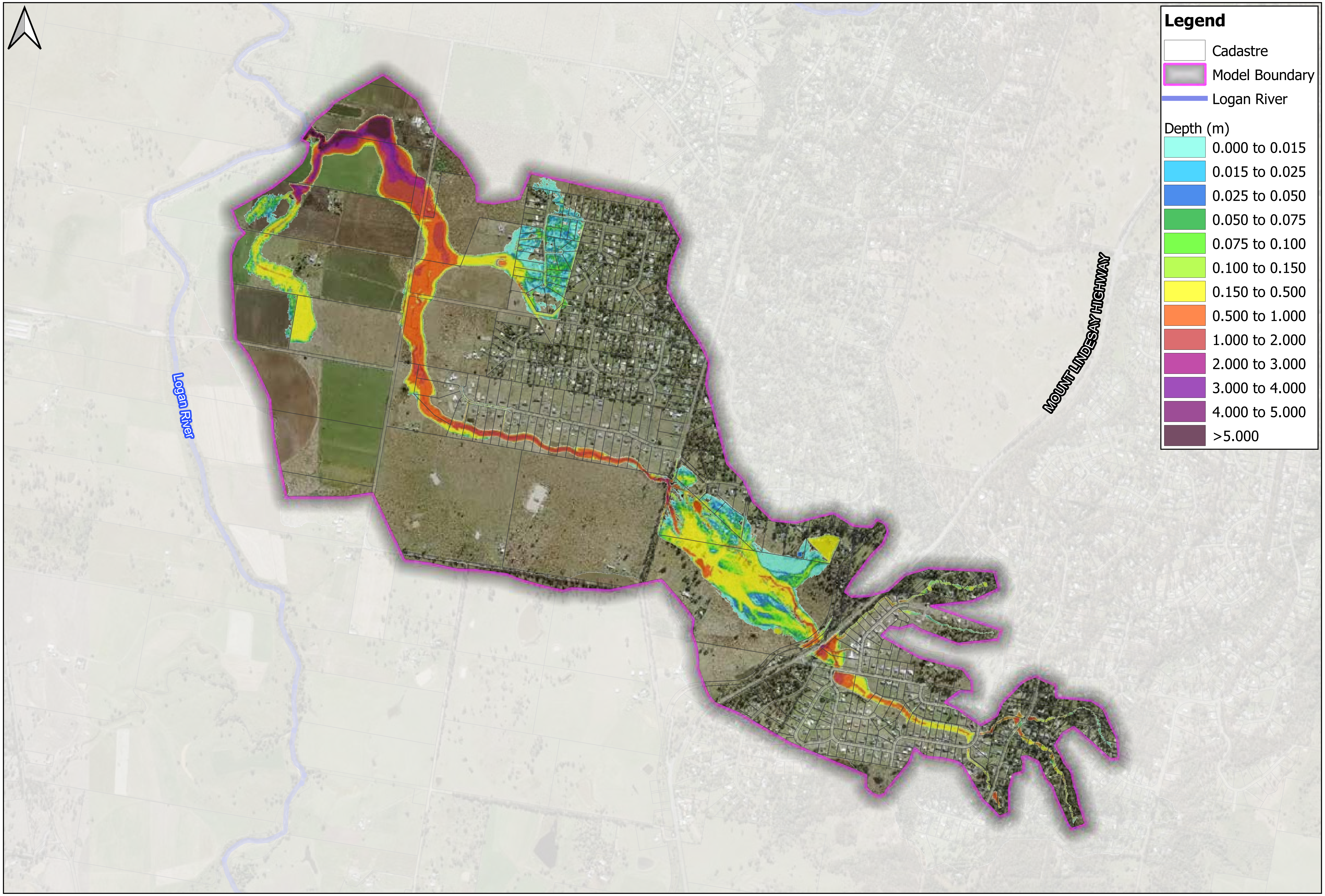
Days Creek - 5% AEP Peak Water Depth



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

Days Creek Flood Study Update 2023

Days Creek - 5% AEP CC (RCP4.5) Peak Water Depth



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

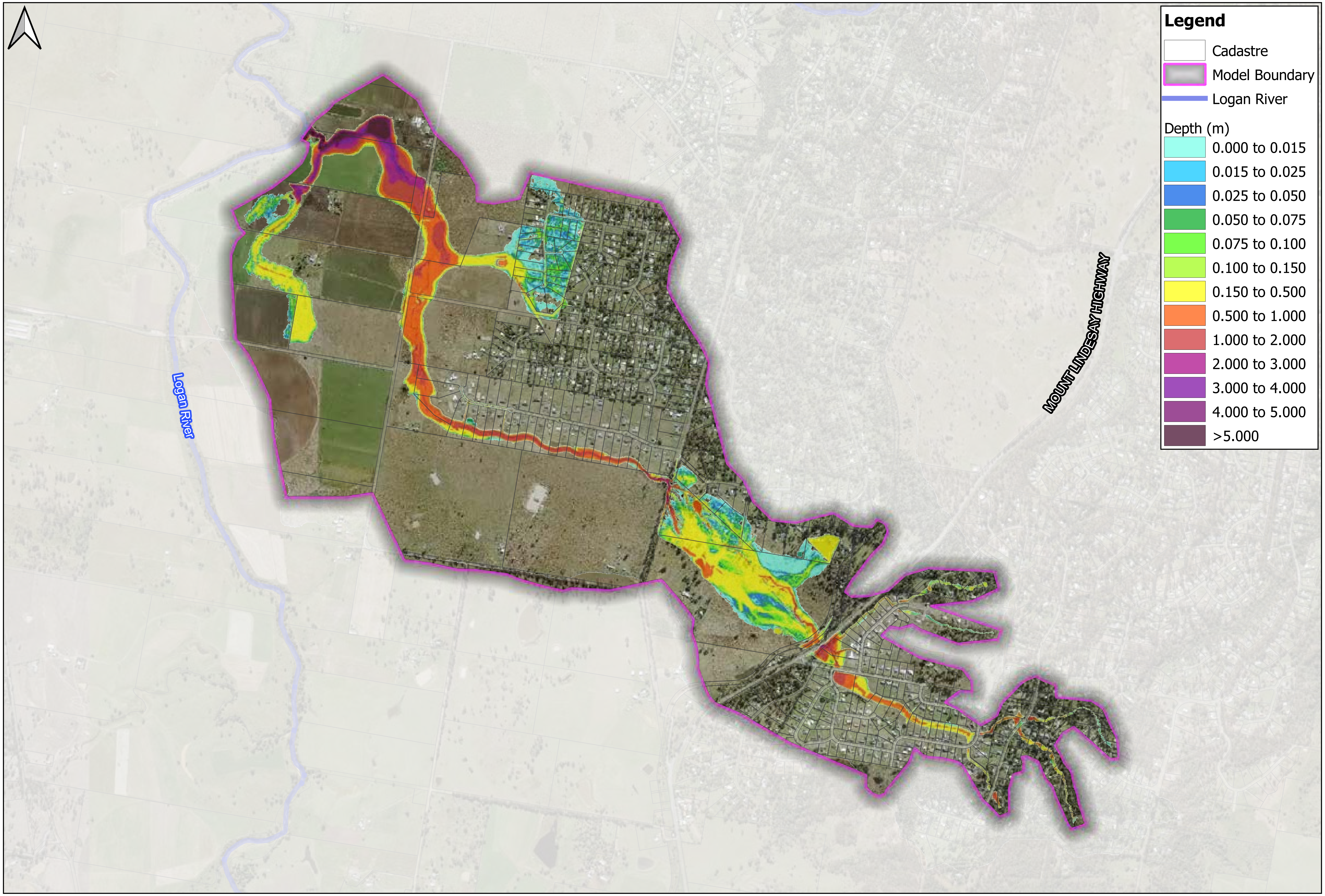
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 2% AEP Peak Water Depth

WATER TECHNOLOGY



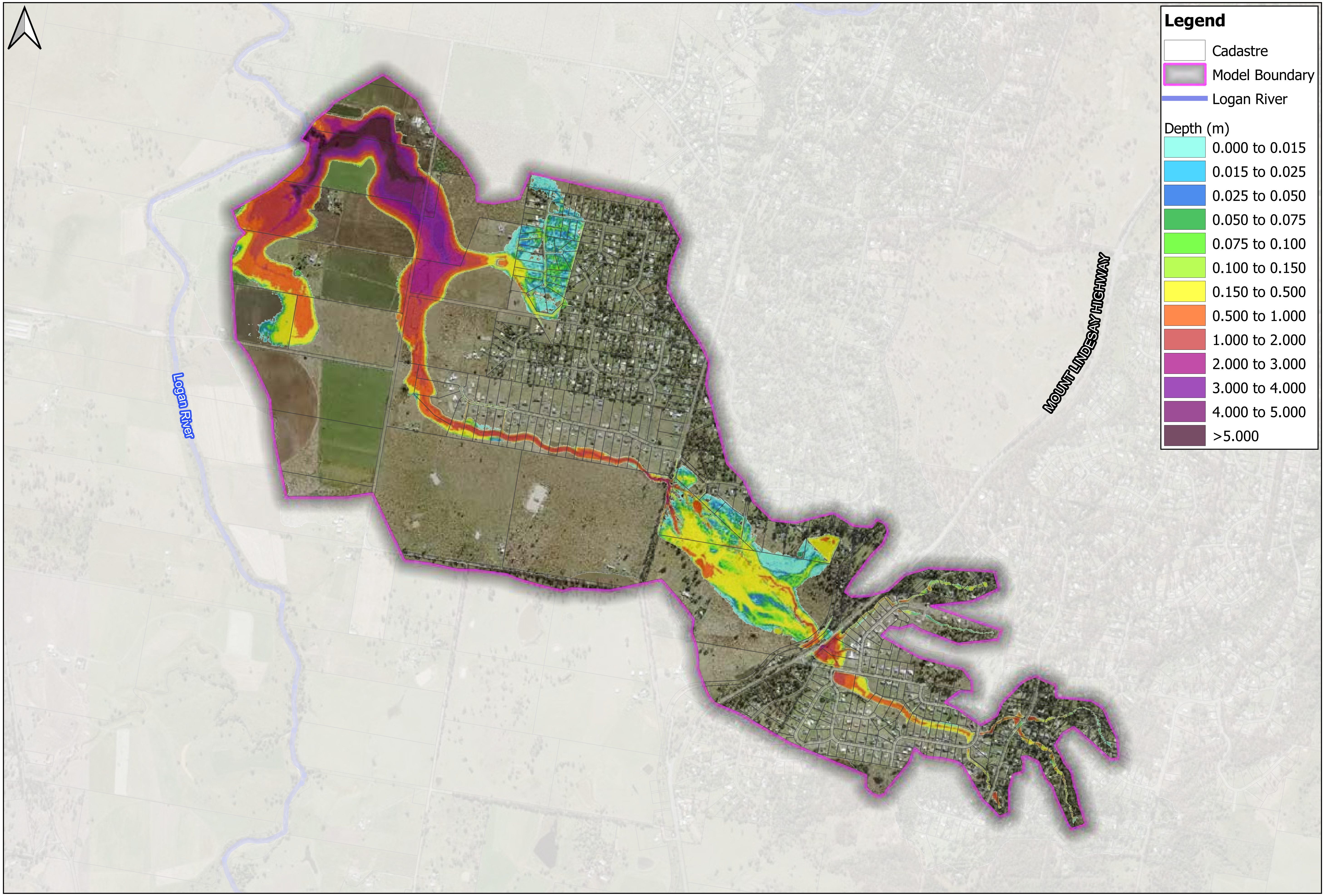
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 2% AEP CC (RCP4.5) Peak Water Depth



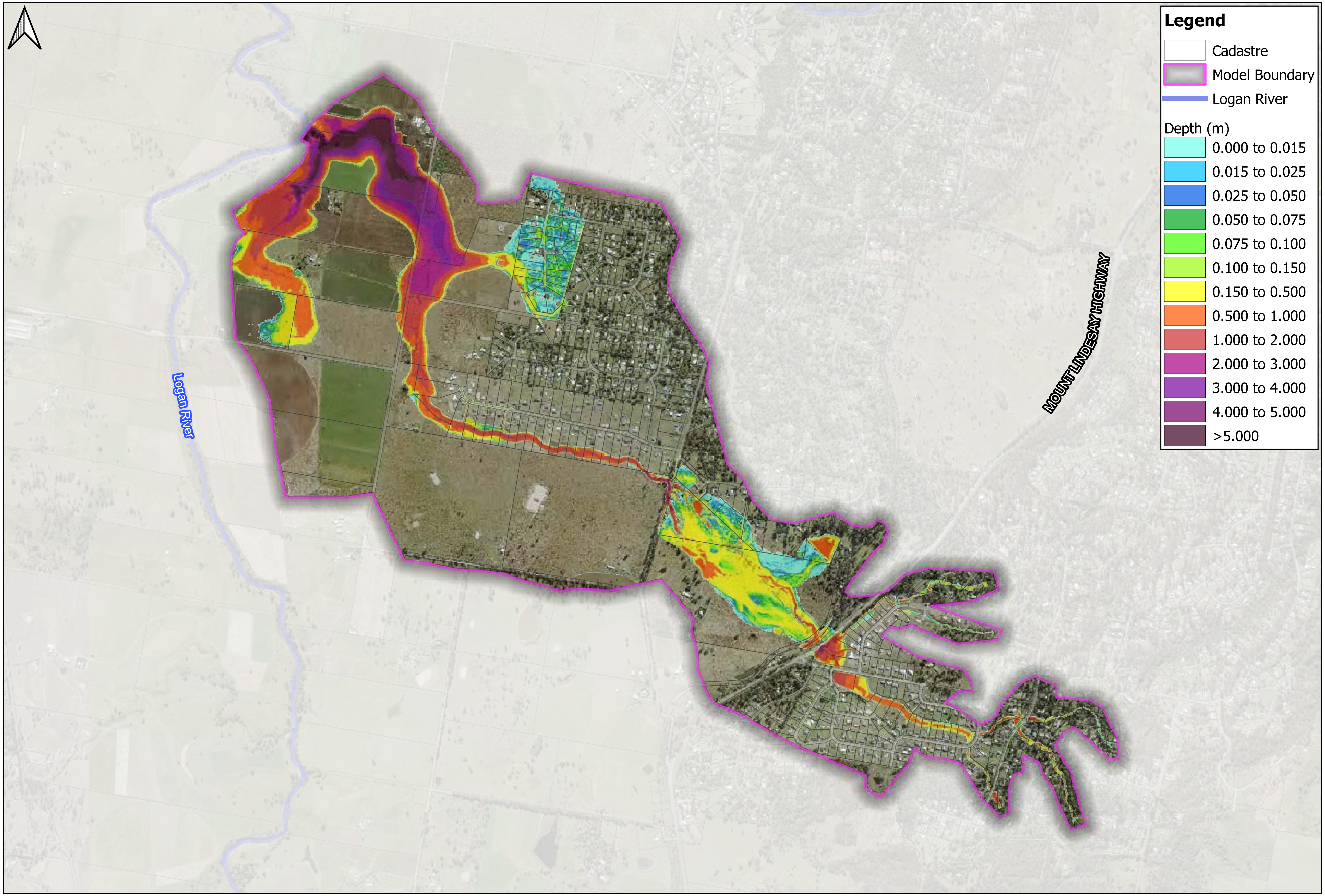
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 1% AEP Peak Water Depth

WATER TECHNOLOGY

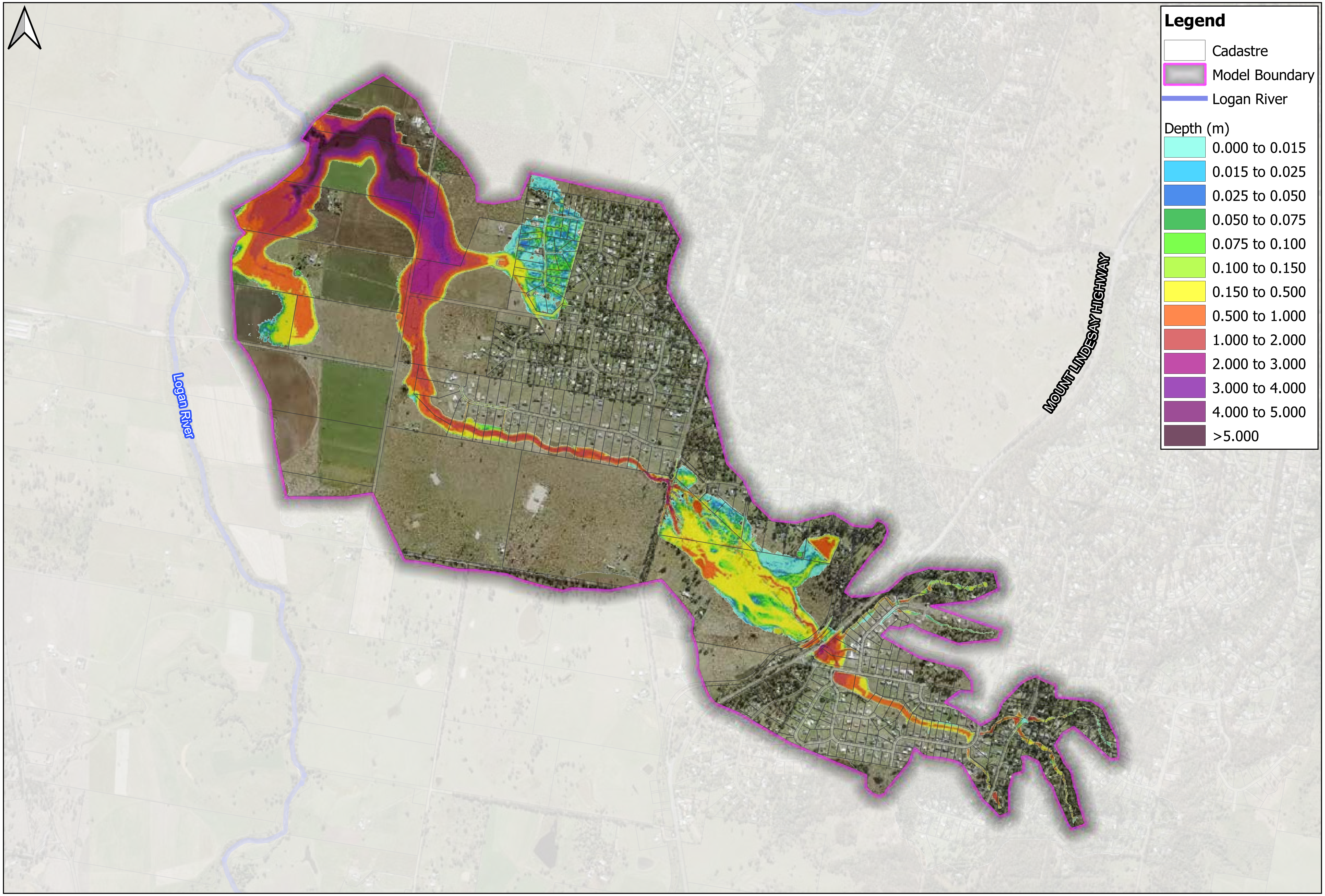


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 1% AEP CC (RCP4.5) Peak Water Depth



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

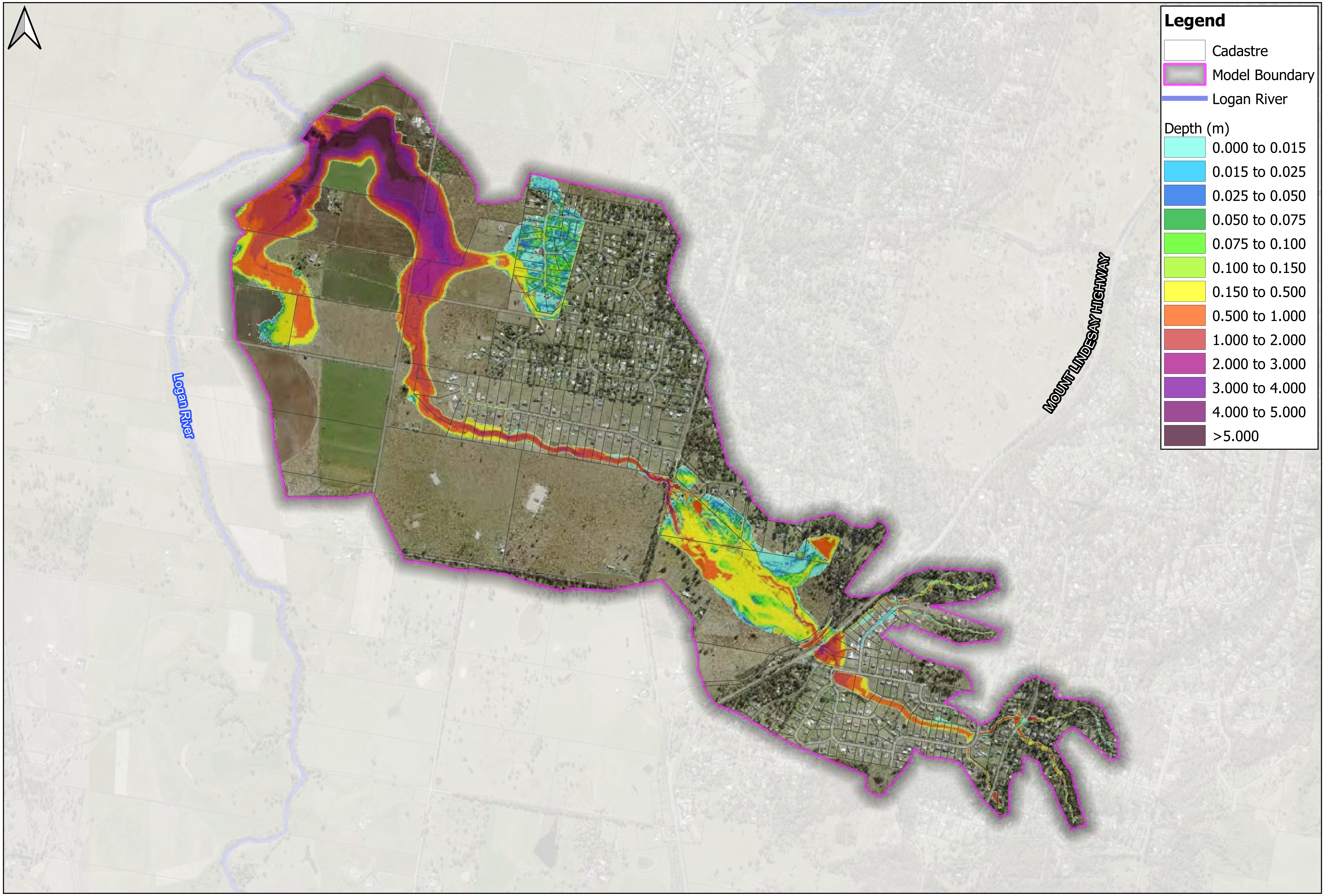
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 0.5% AEP Peak Water Depth

WATER TECHNOLOGY



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

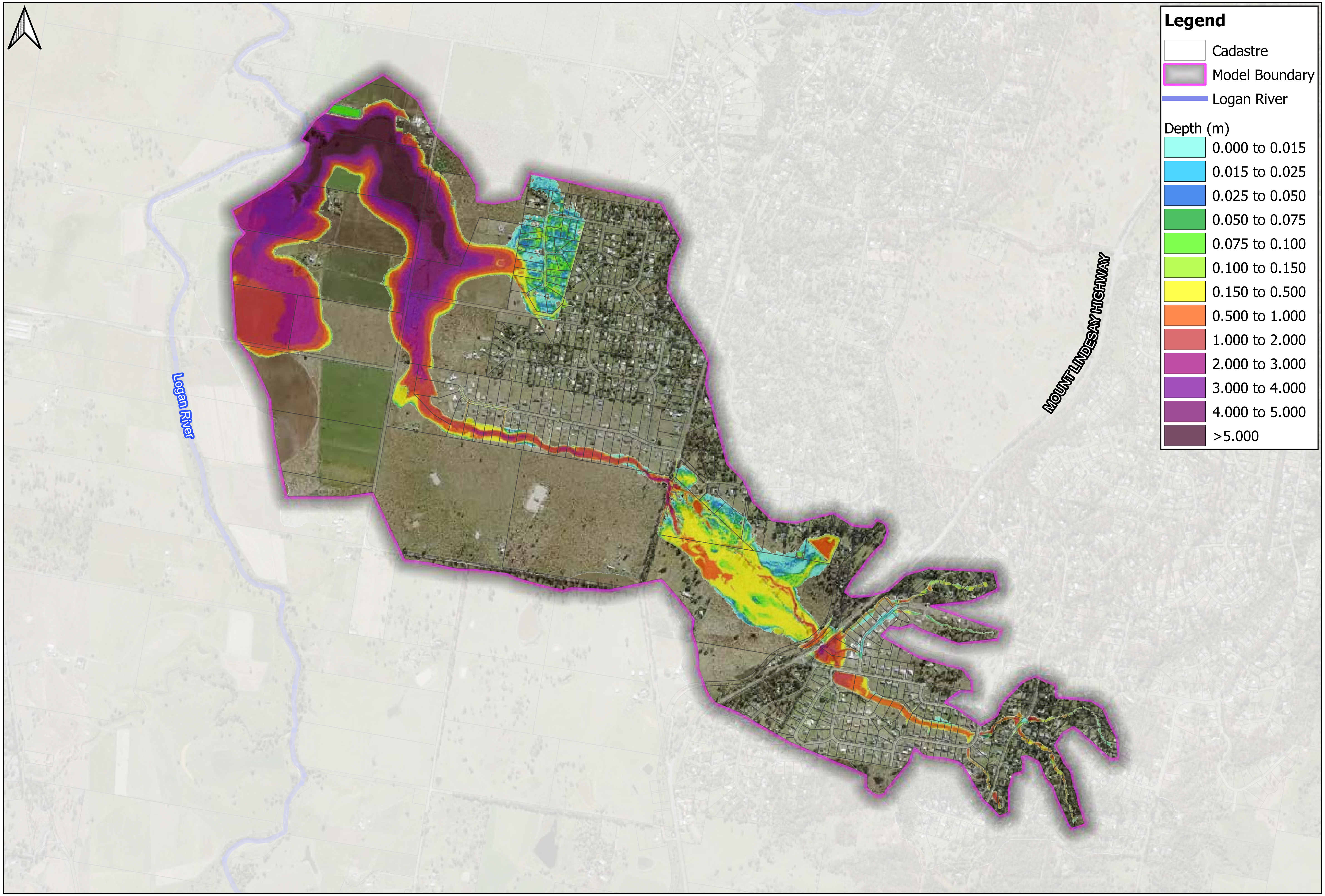
1:20,000

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

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



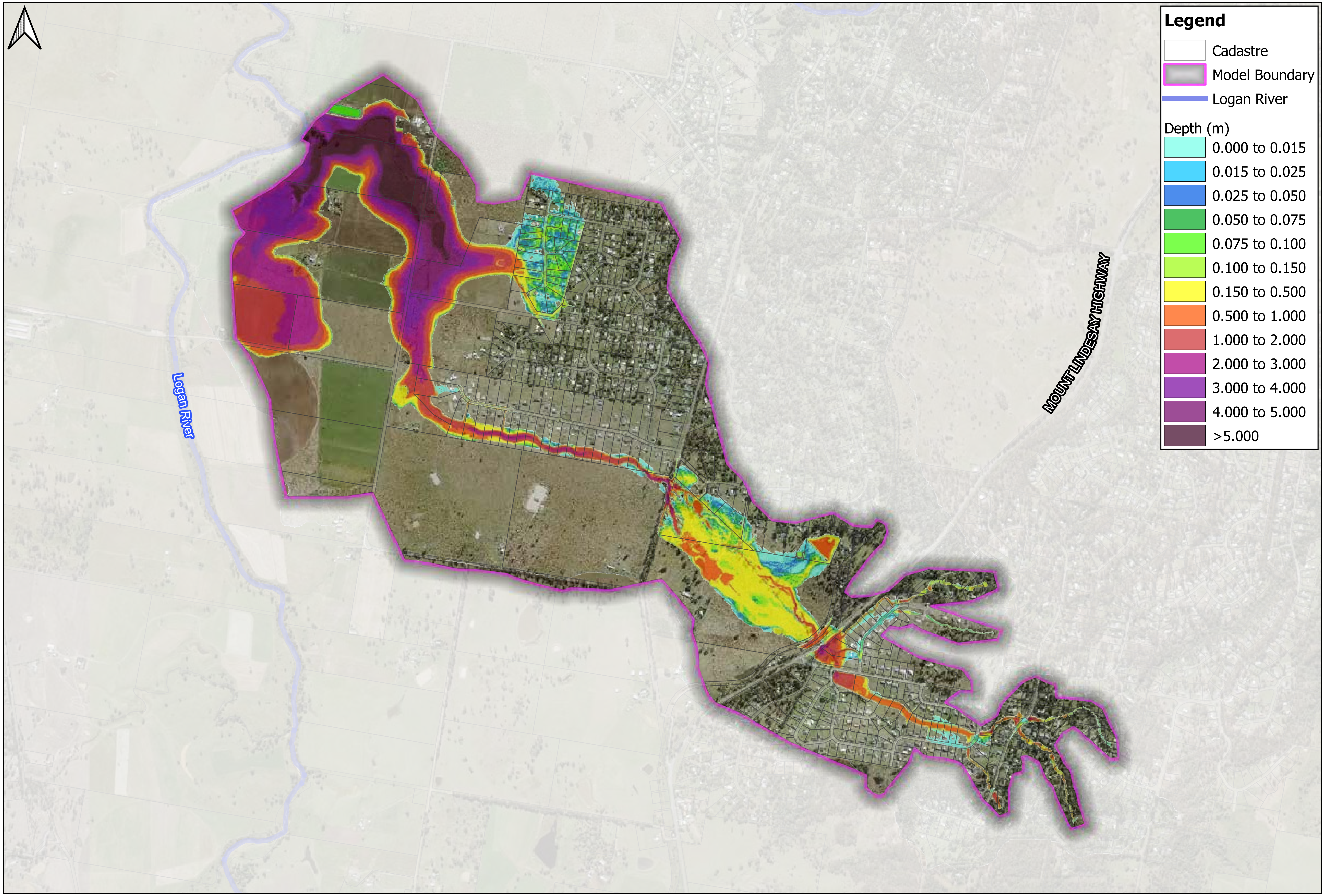
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 0.2% AEP Peak Water Depth



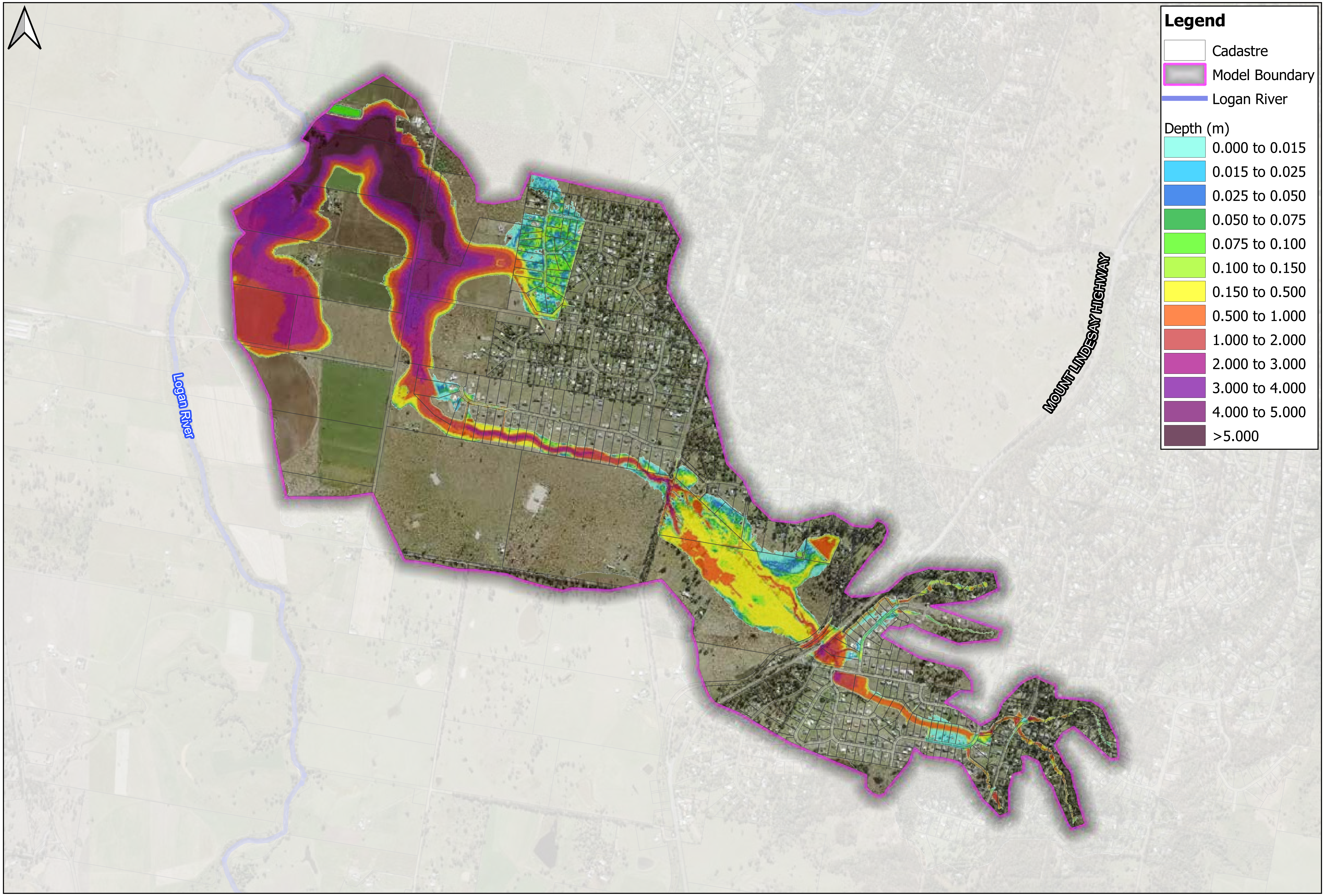
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 0.2% AEP CC (RCP4.5) Peak Water Depth



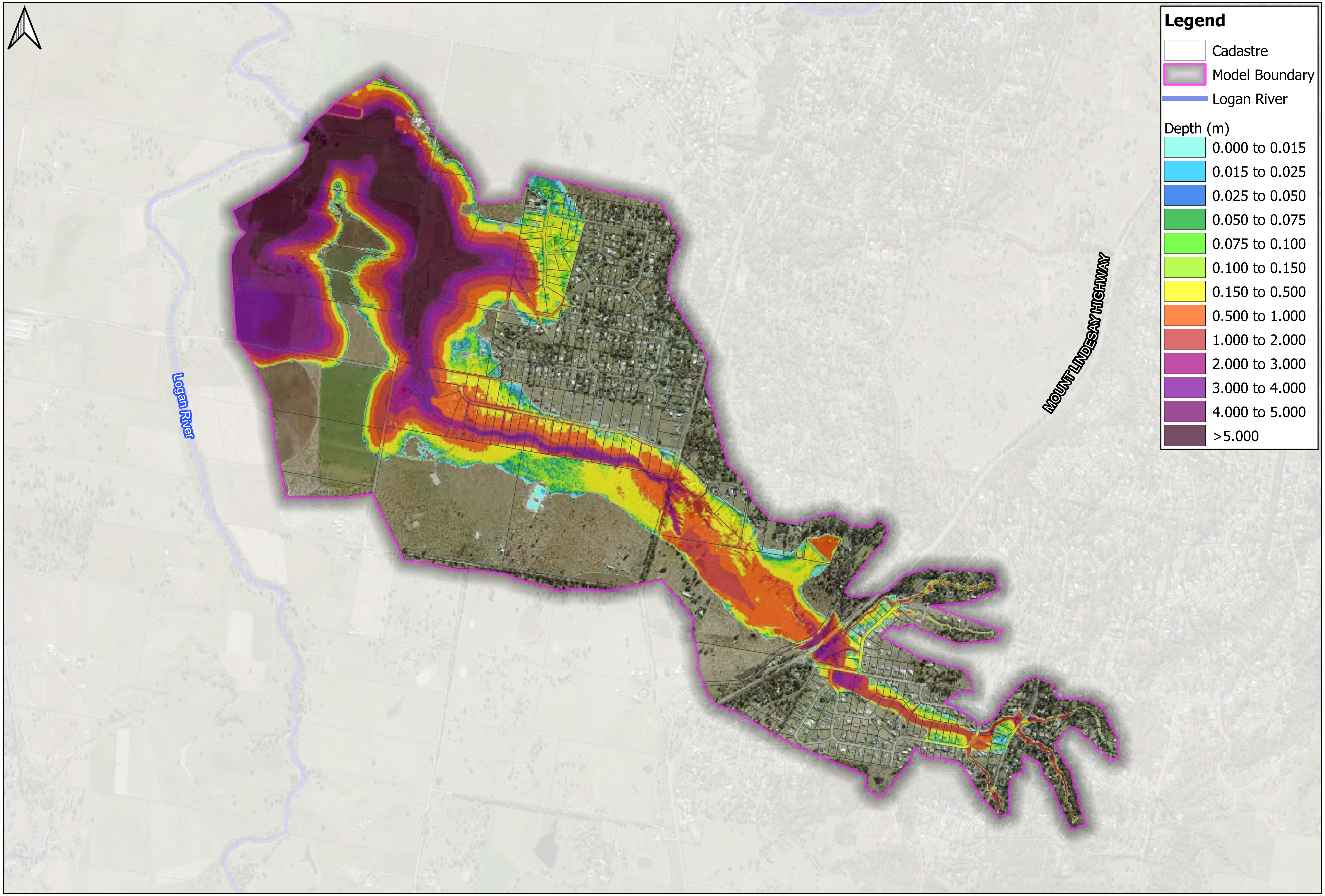
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 0.05% AEP Peak Water Depth



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

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - PMF Peak Water Depth

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

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 63.2% AEP Peak Water Velocity

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

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 50% AEP Peak Water Velocity

WATER TECHNOLOGY

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

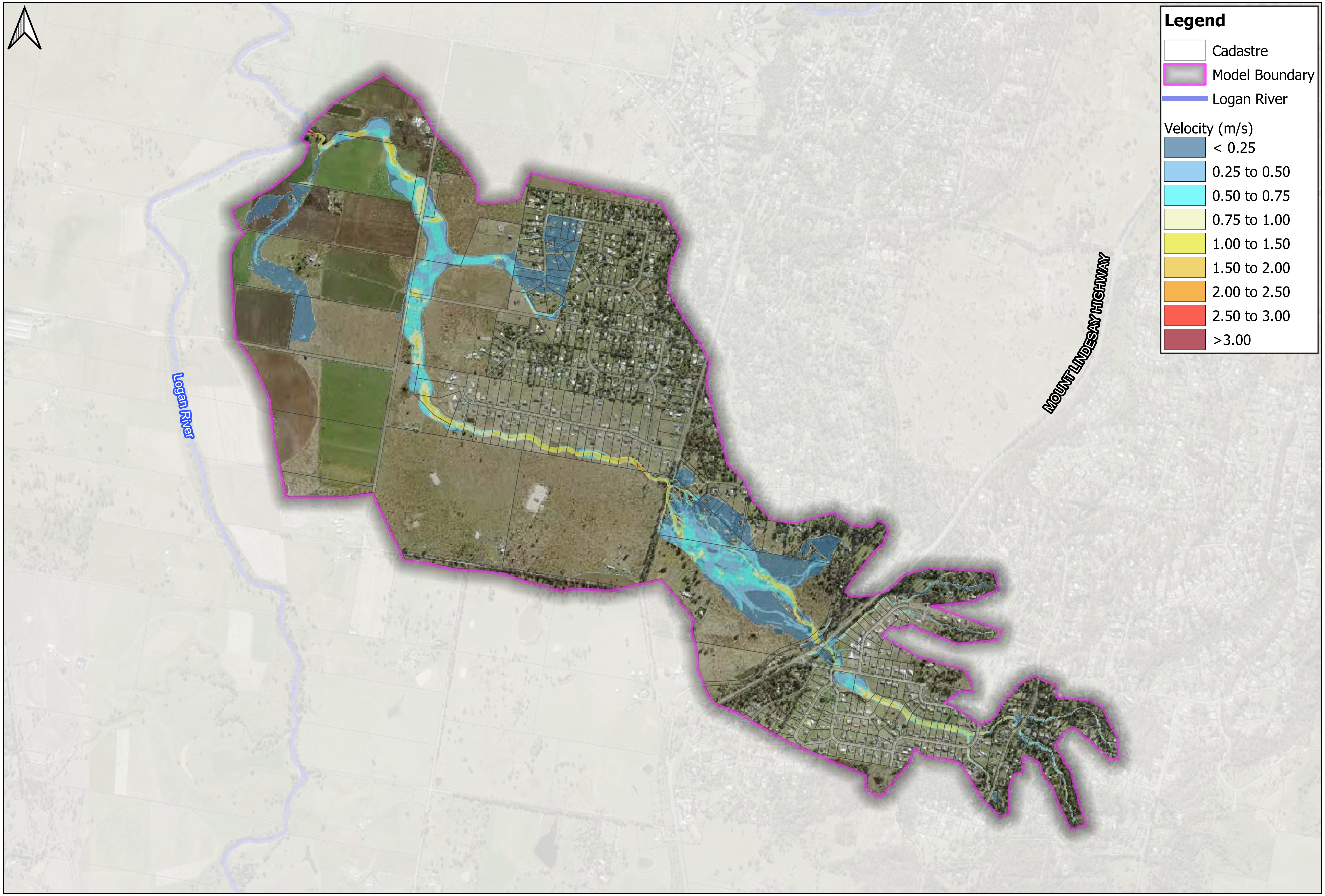
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 50% AEP CC (RCP4.5) Peak Water Velocity

WATER TECHNOLOGY



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

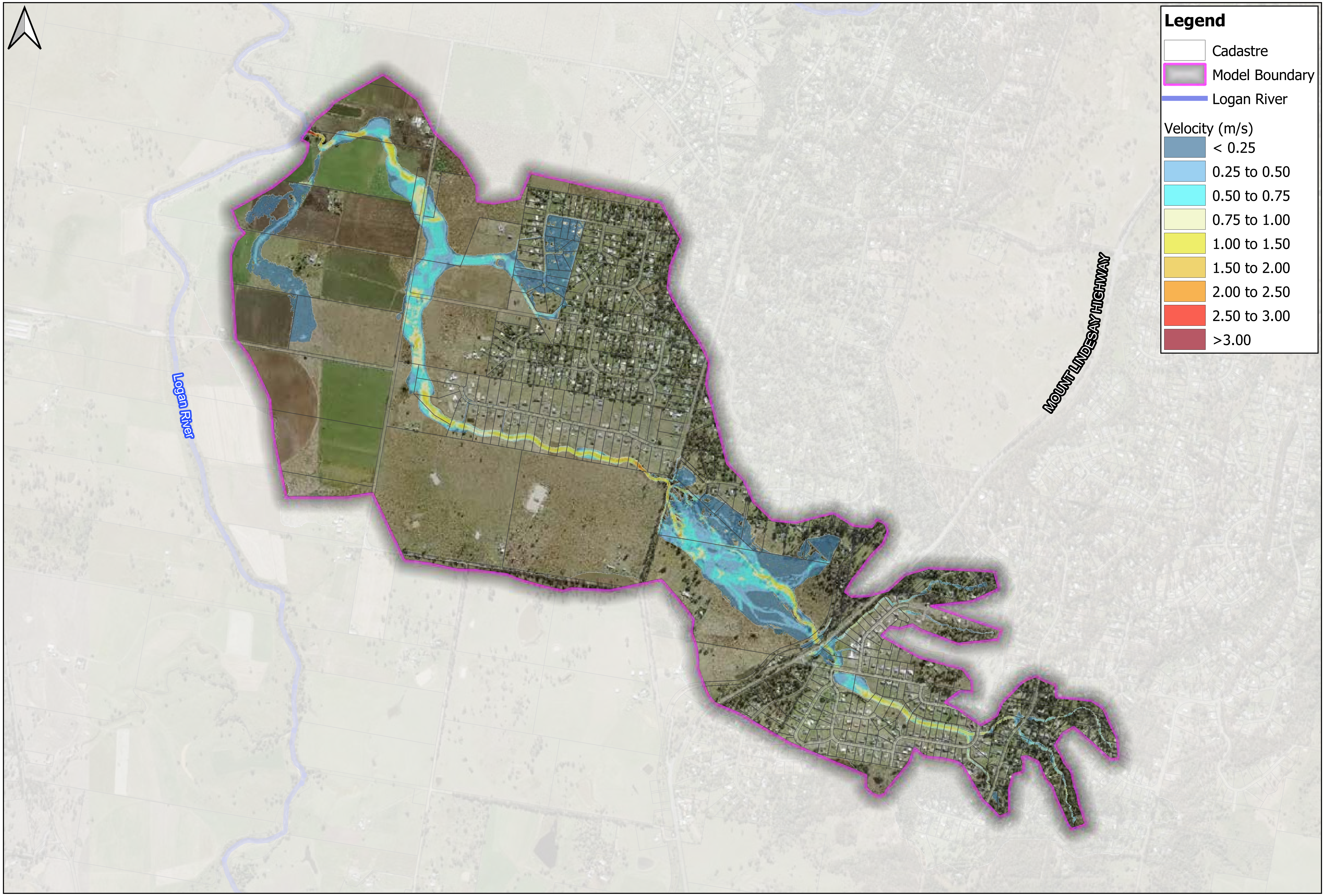
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 20% AEP Peak Water Velocity

WATER TECHNOLOGY



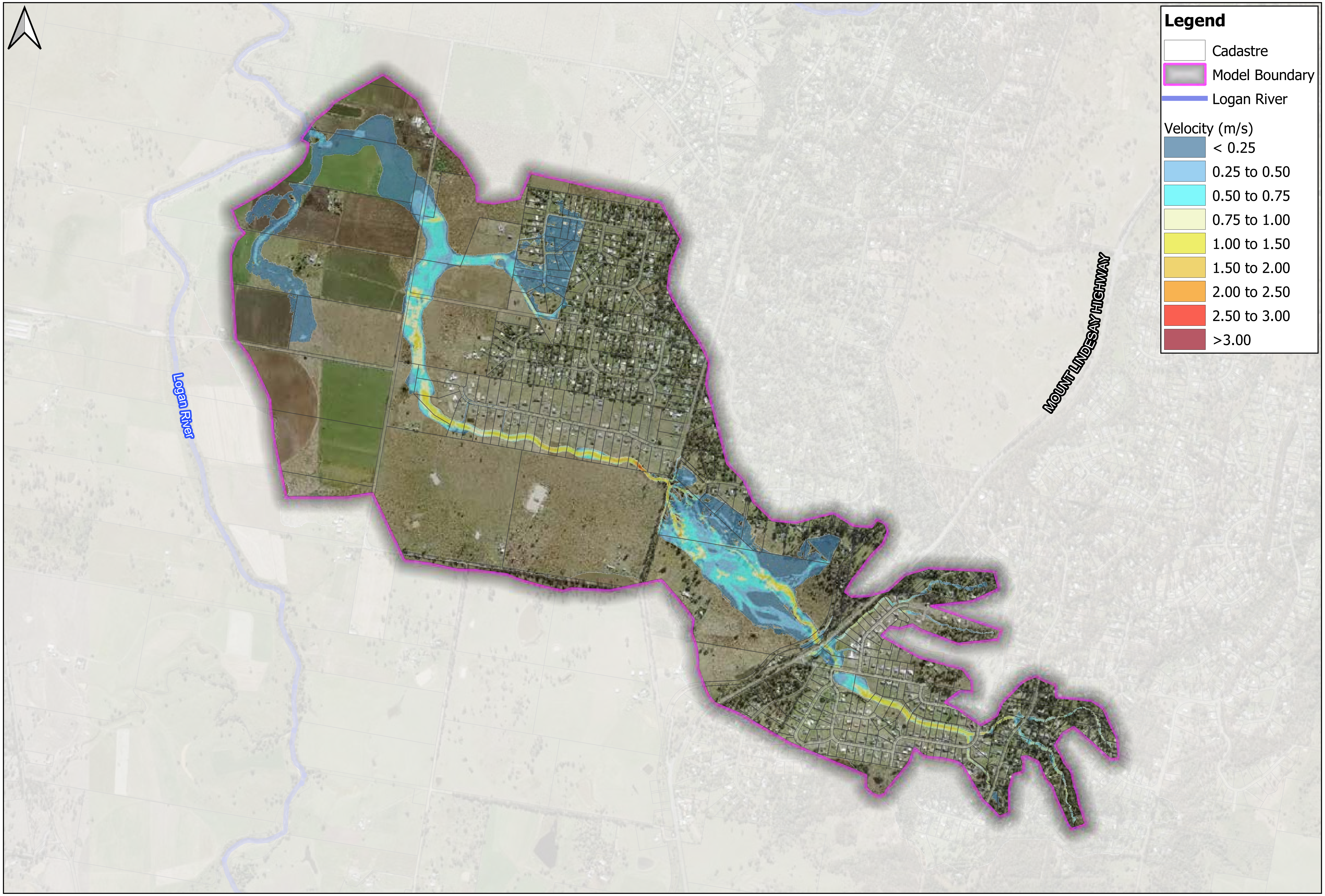
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

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



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

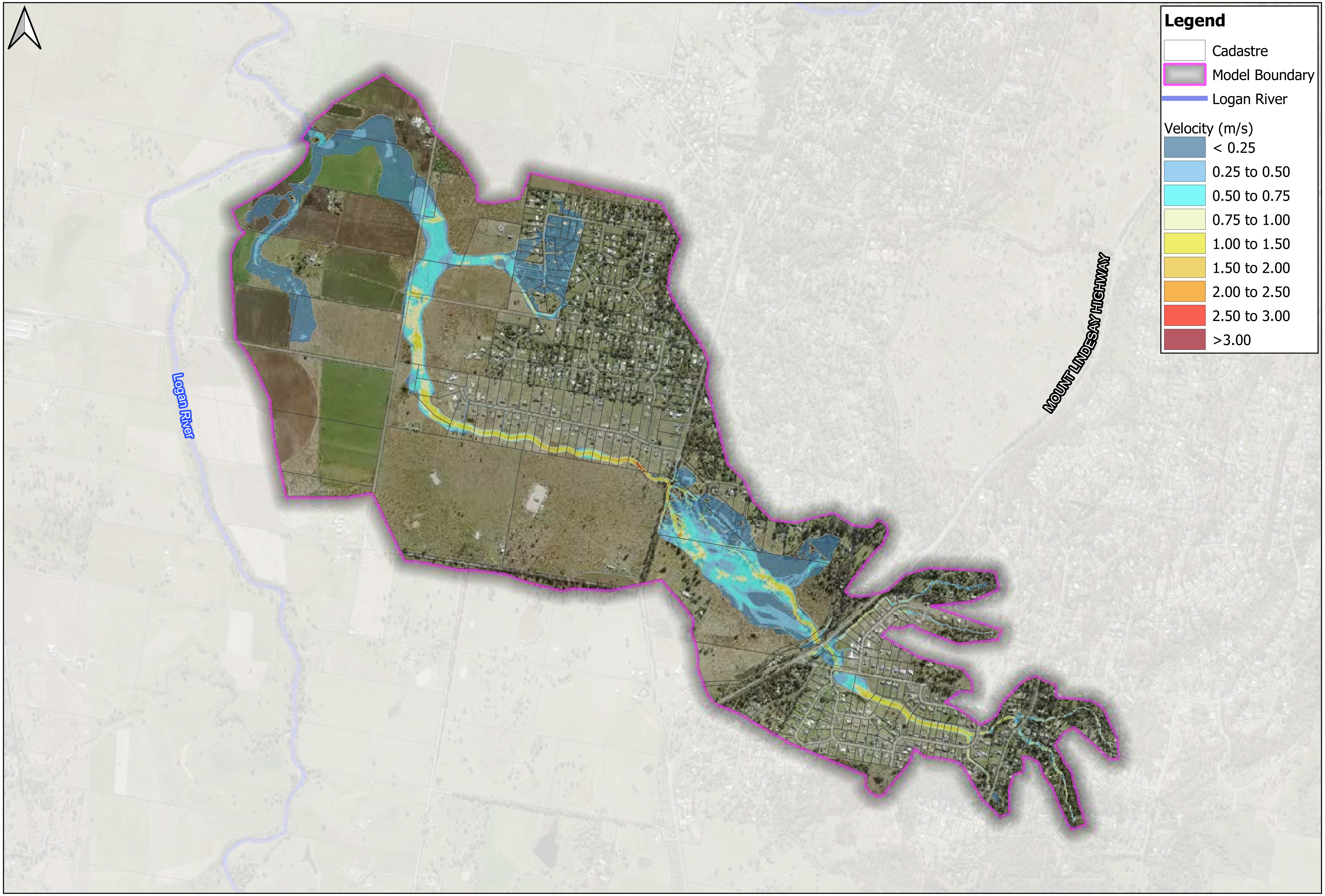
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 10% AEP Peak Water Velocity

WATER TECHNOLOGY



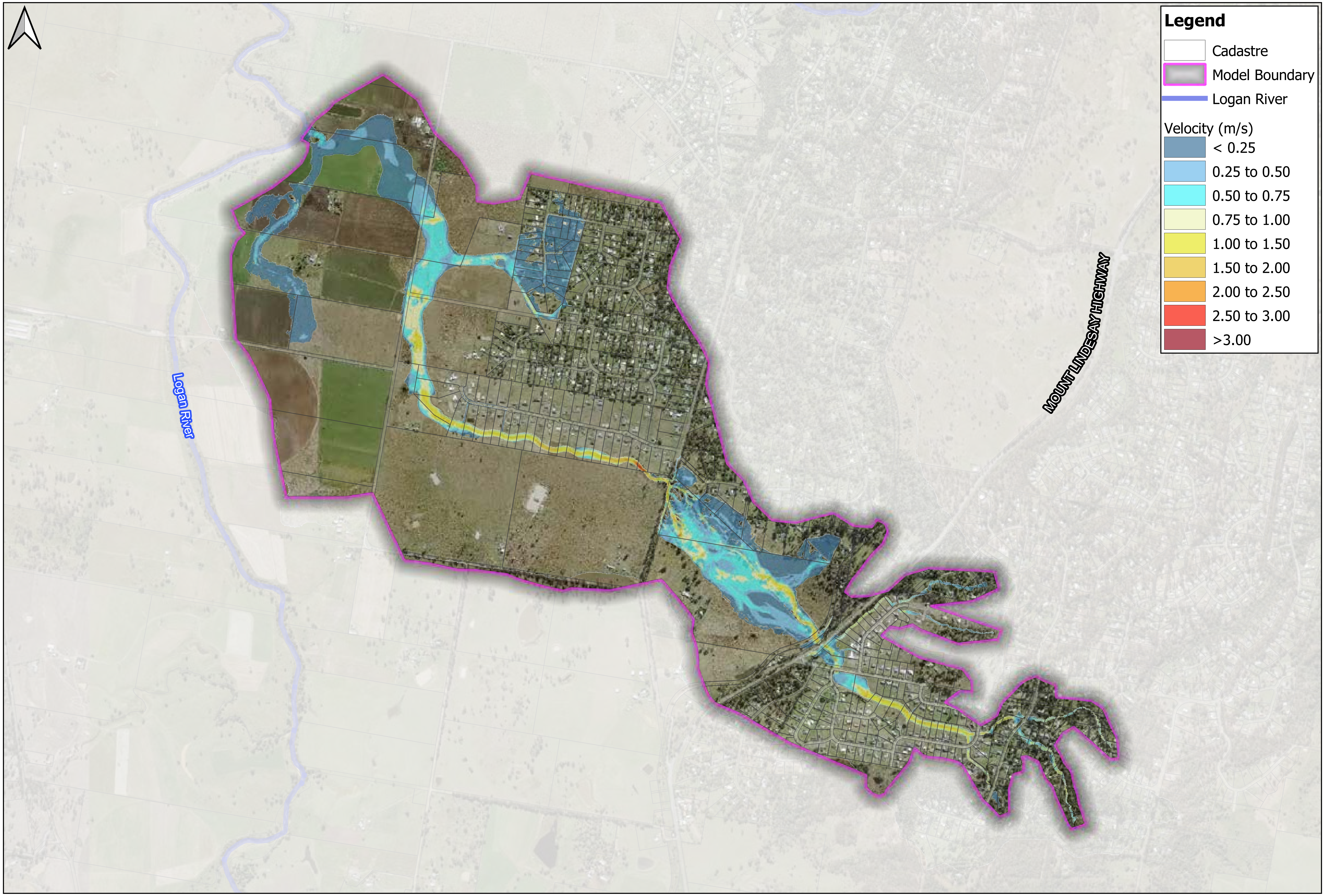
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

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



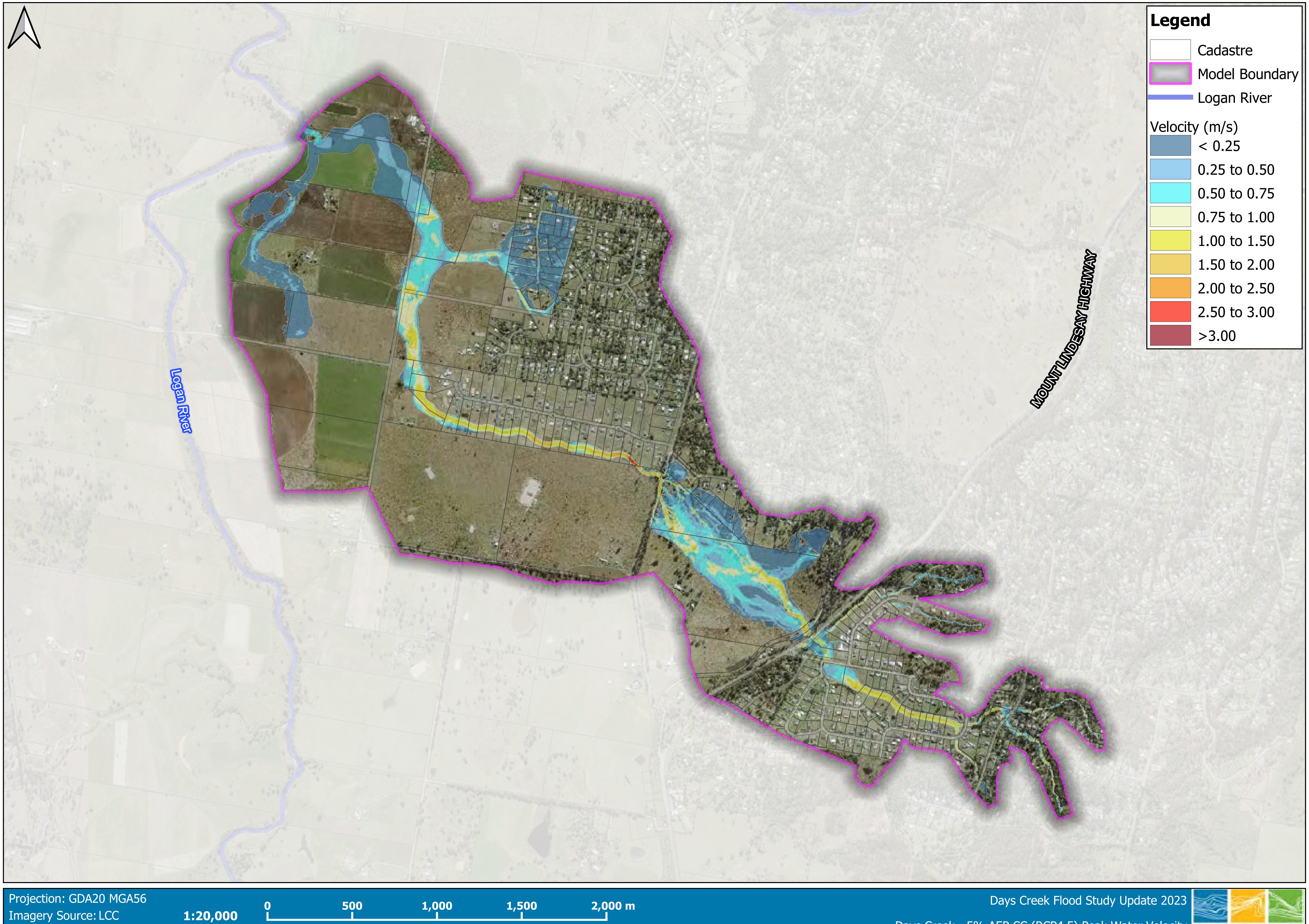
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 5% AEP Peak Water Velocity



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

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 5% AEP CC (RCP4.5) Peak Water Velocity

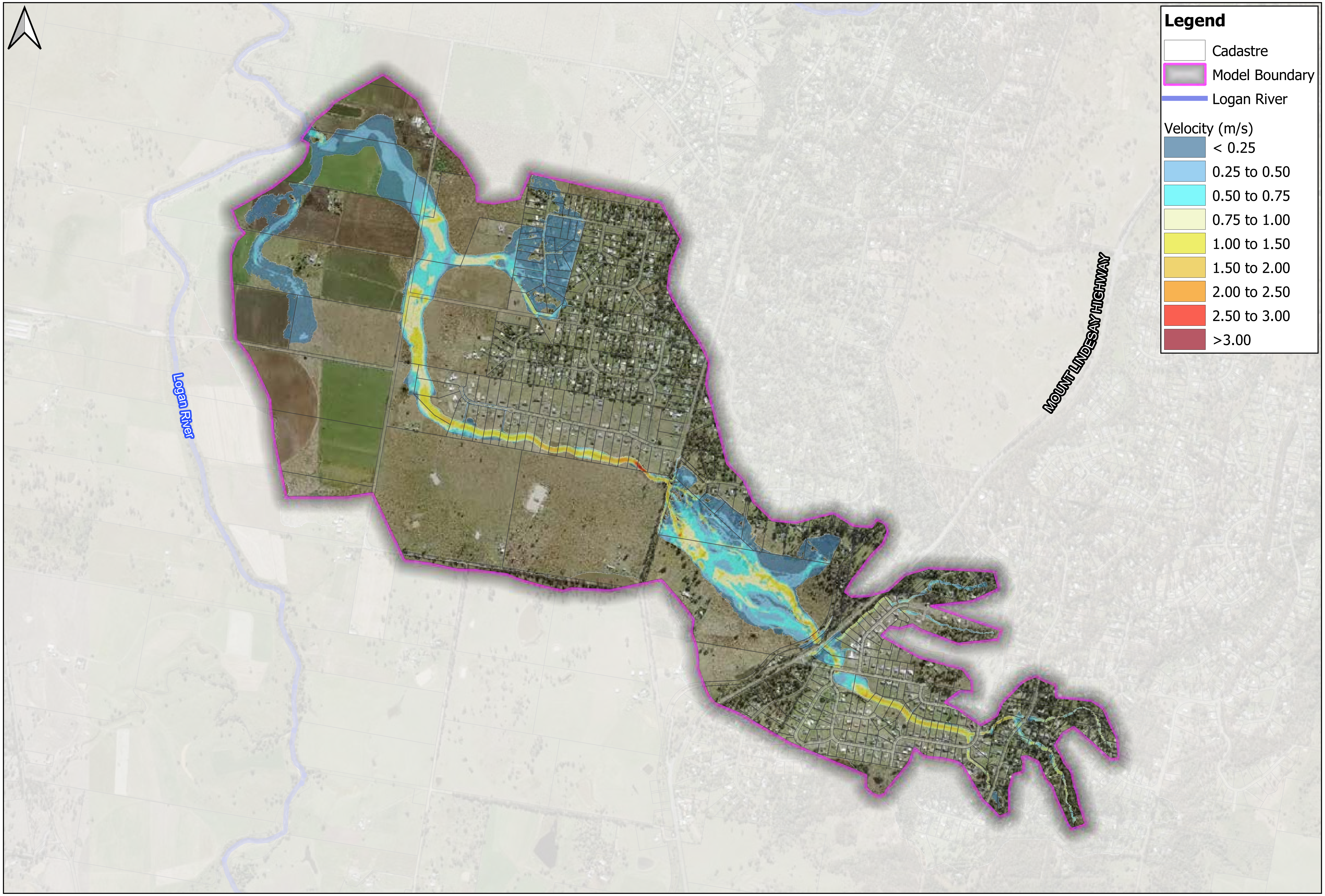
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 2% AEP Peak Water Velocity



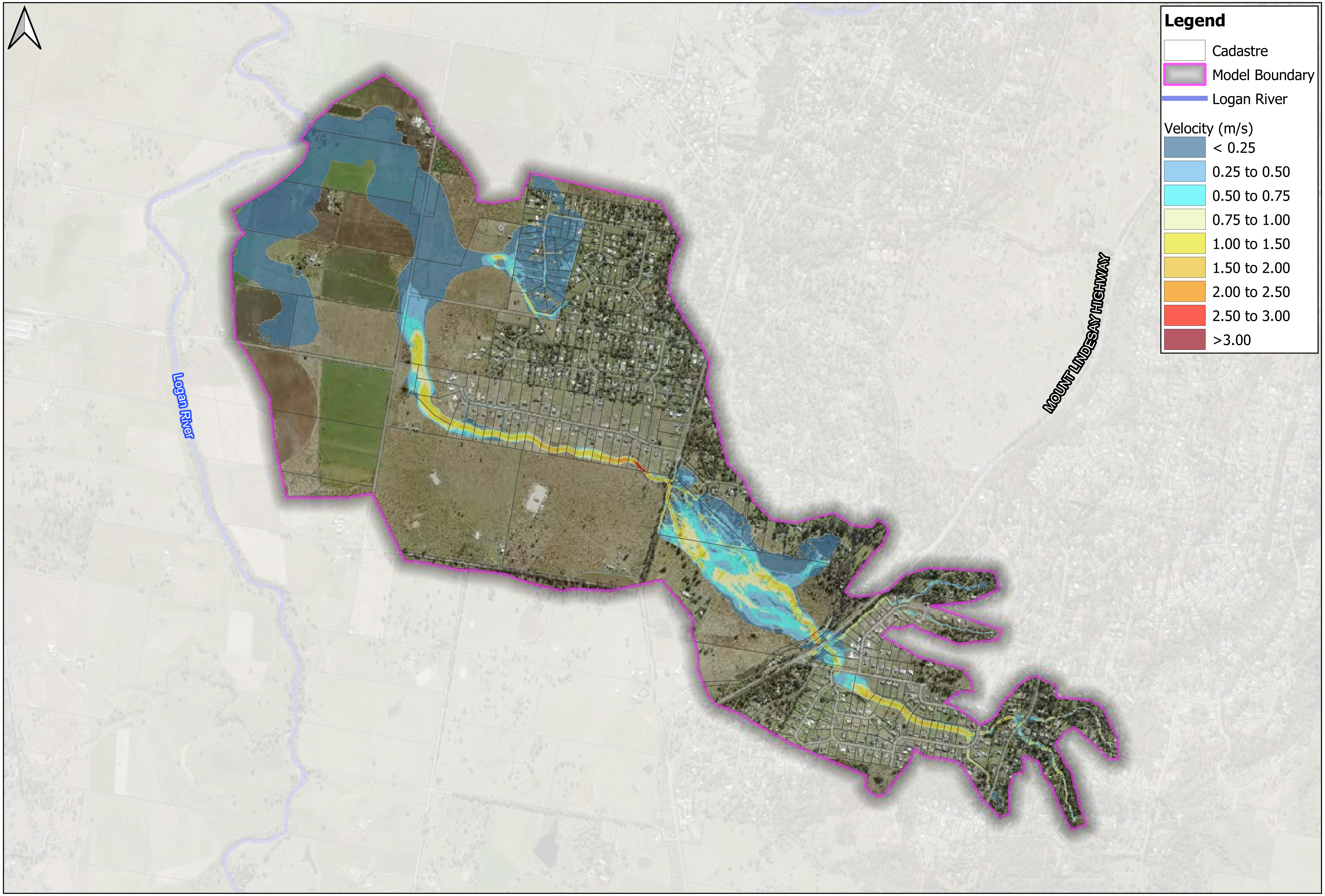
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

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



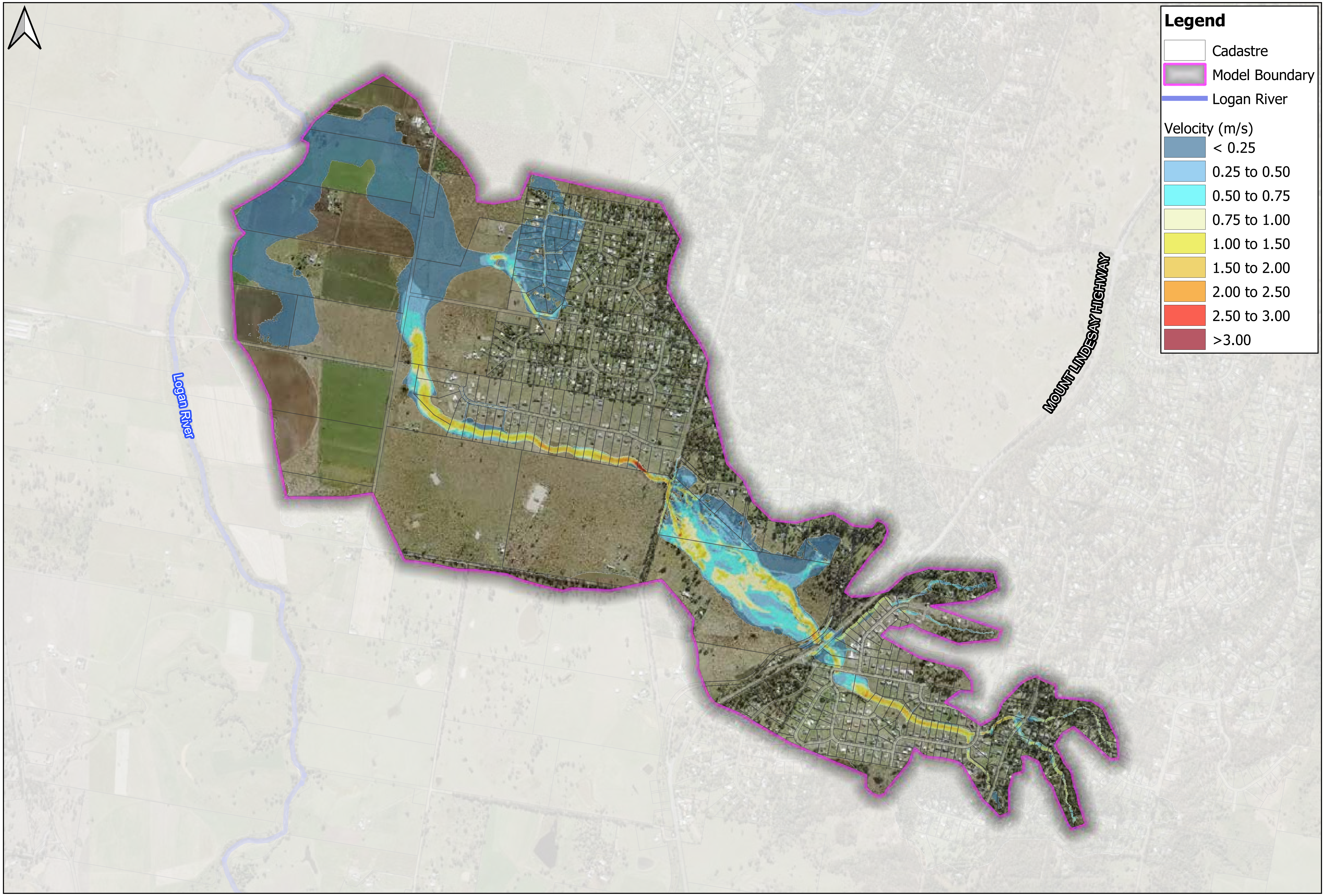
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 1% AEP Peak Water Velocity



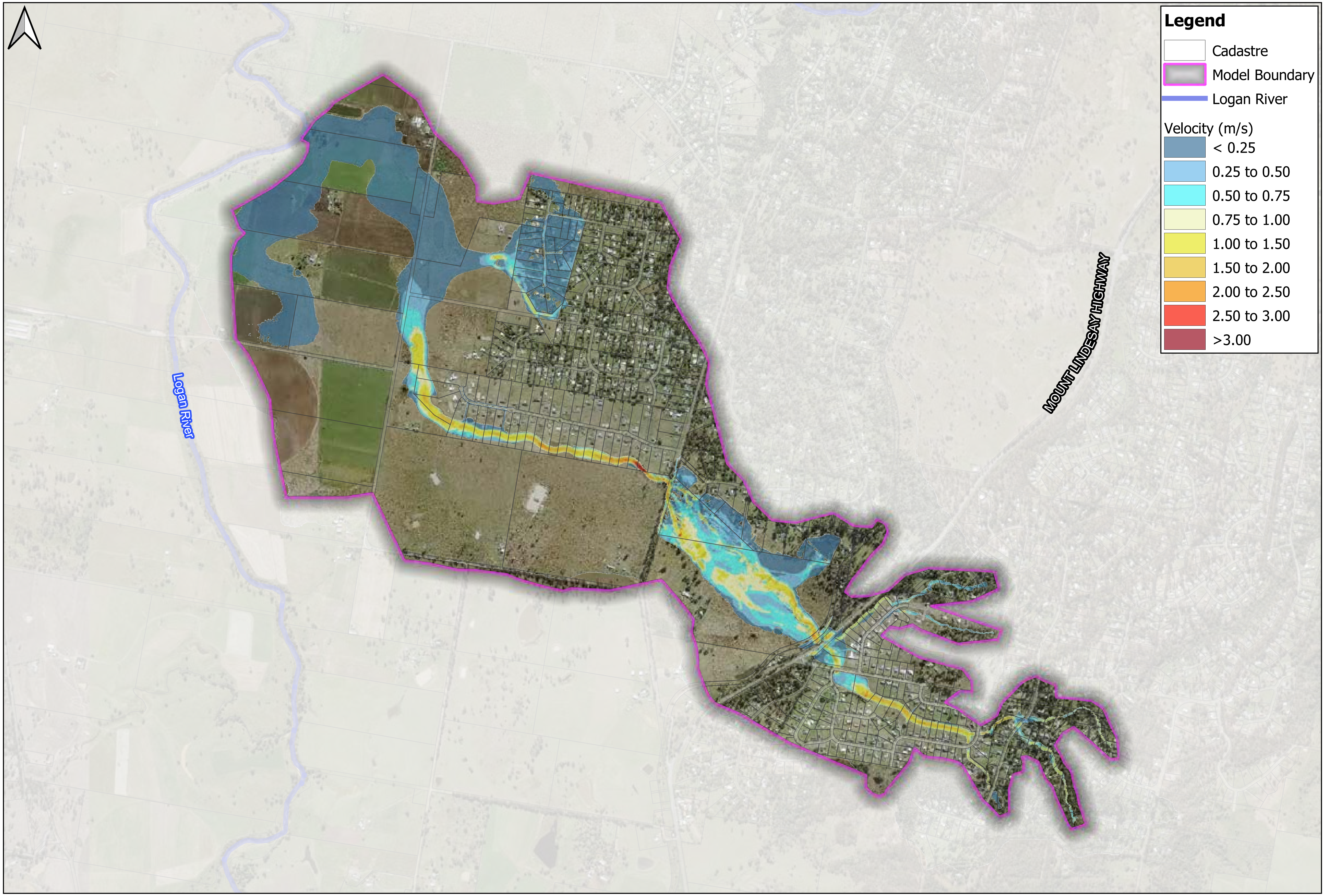
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

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



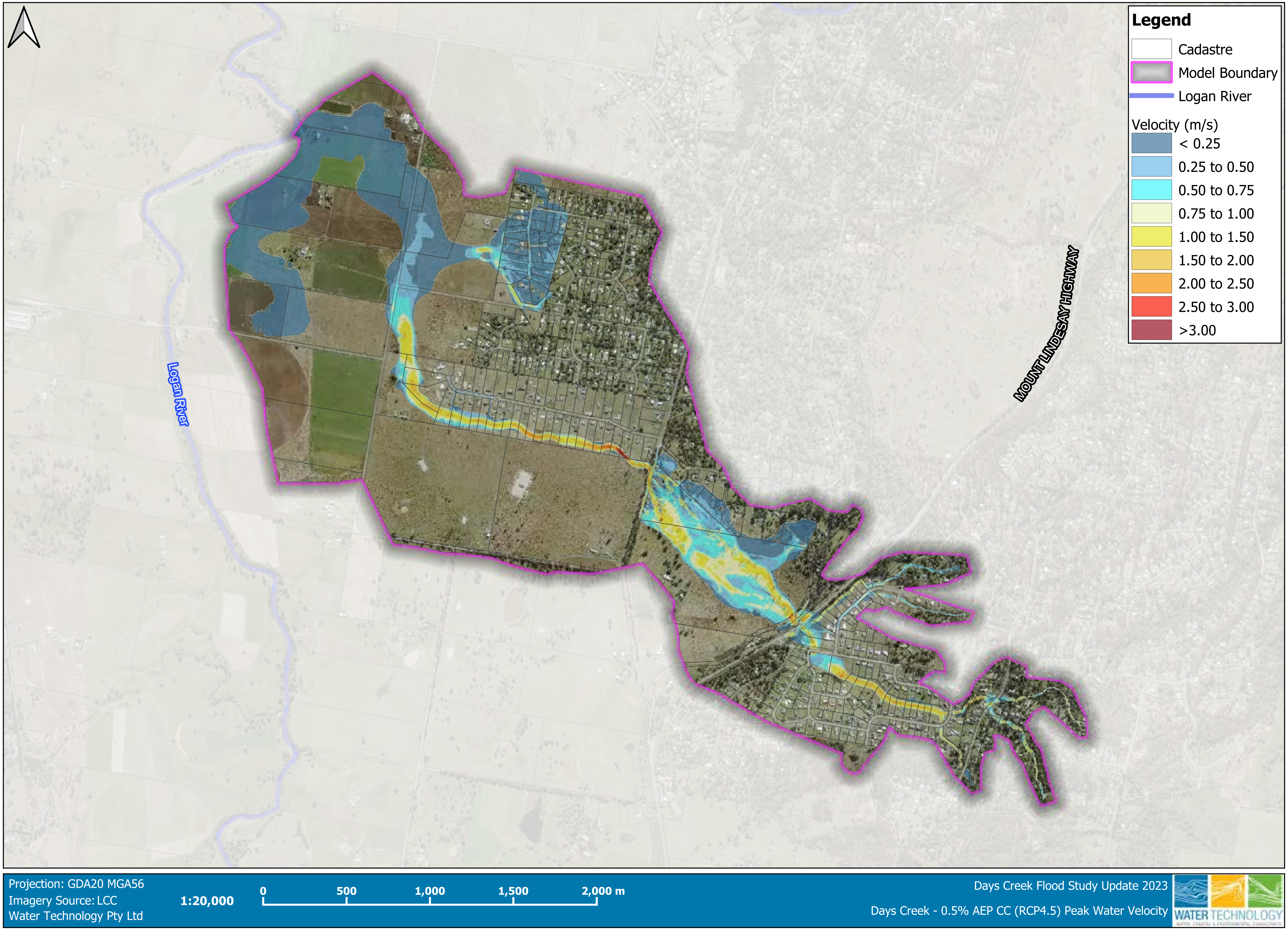
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 0.5% AEP Peak Water Velocity



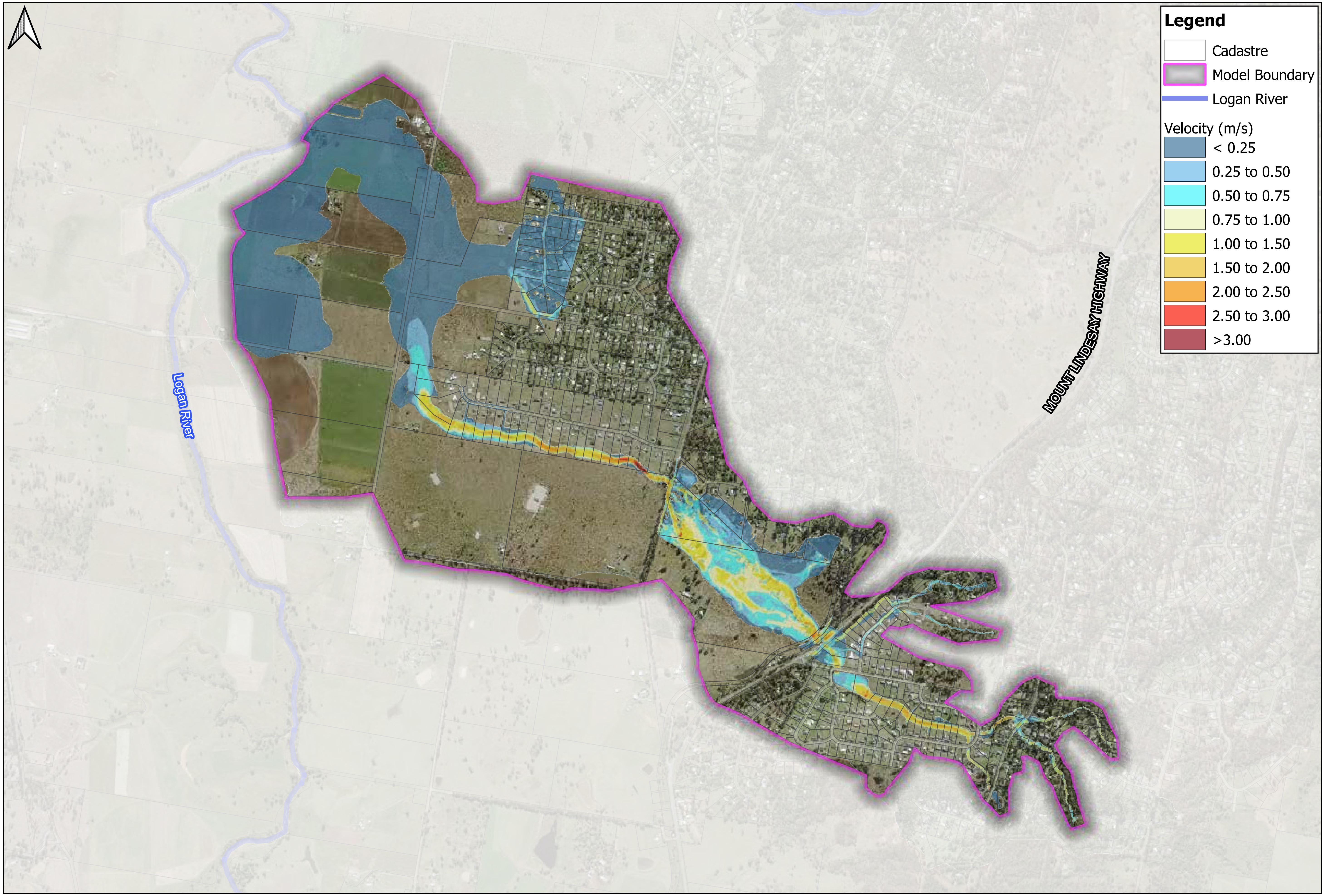
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



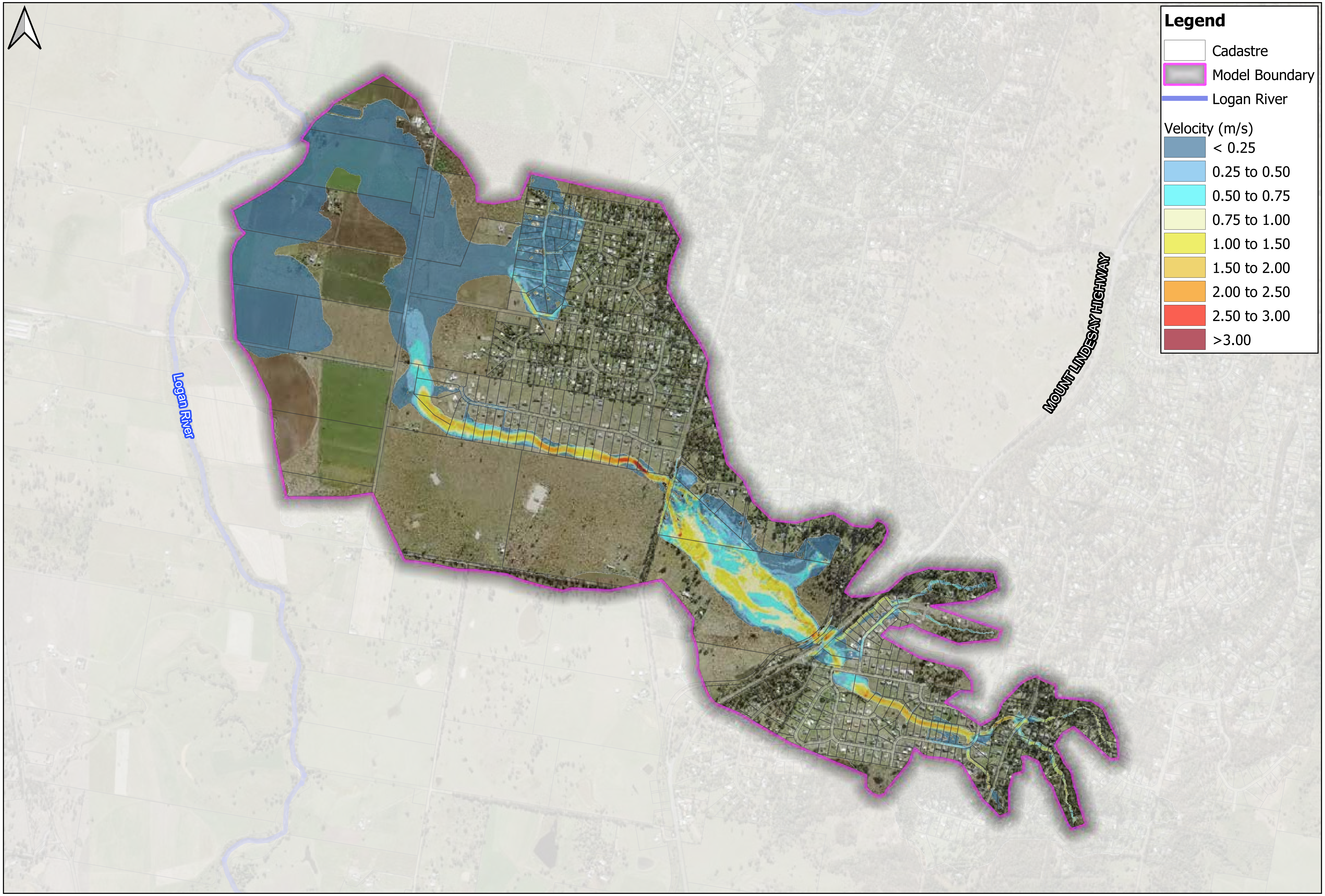
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 0.2% AEP Peak Water Velocity



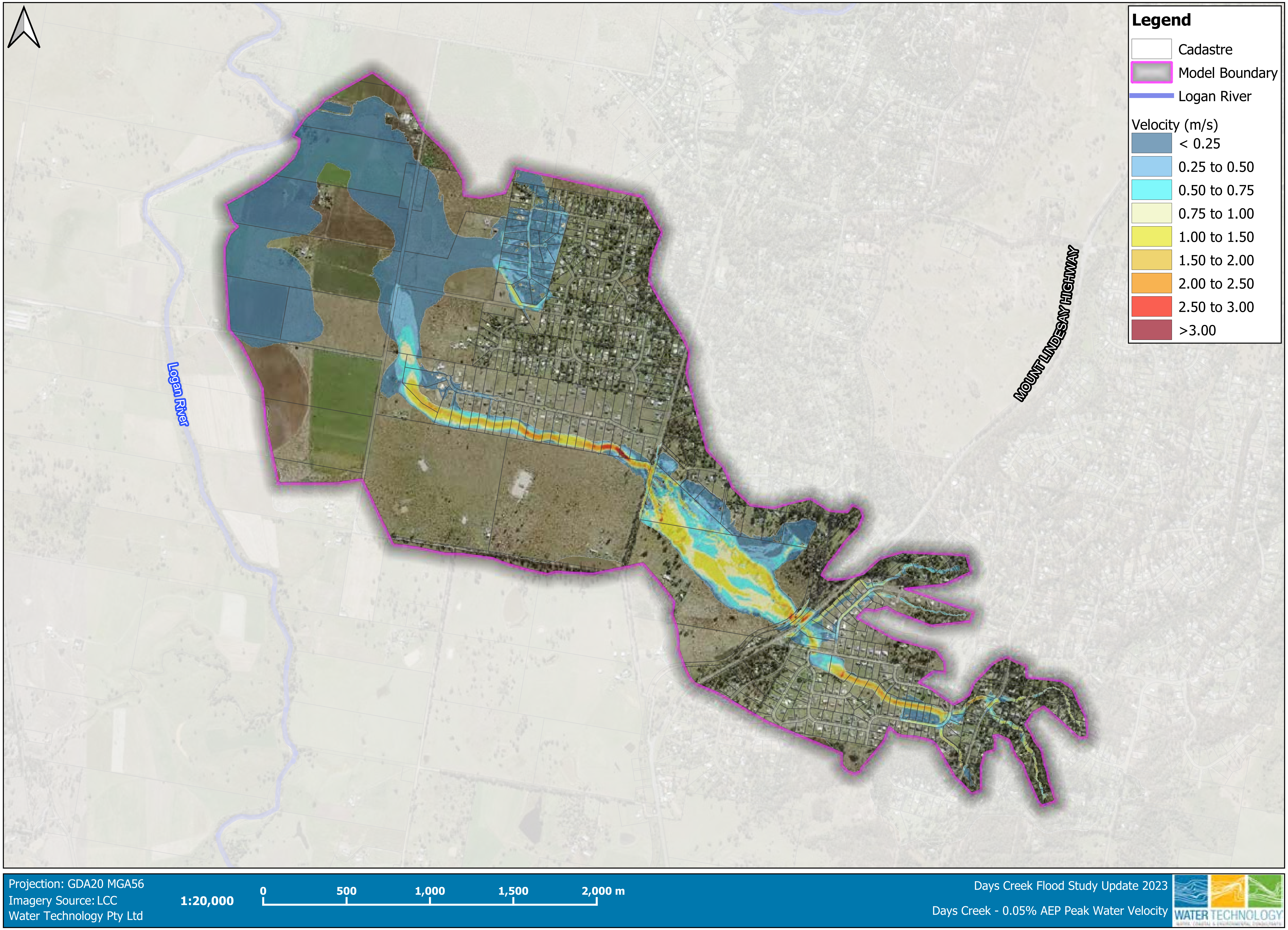
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

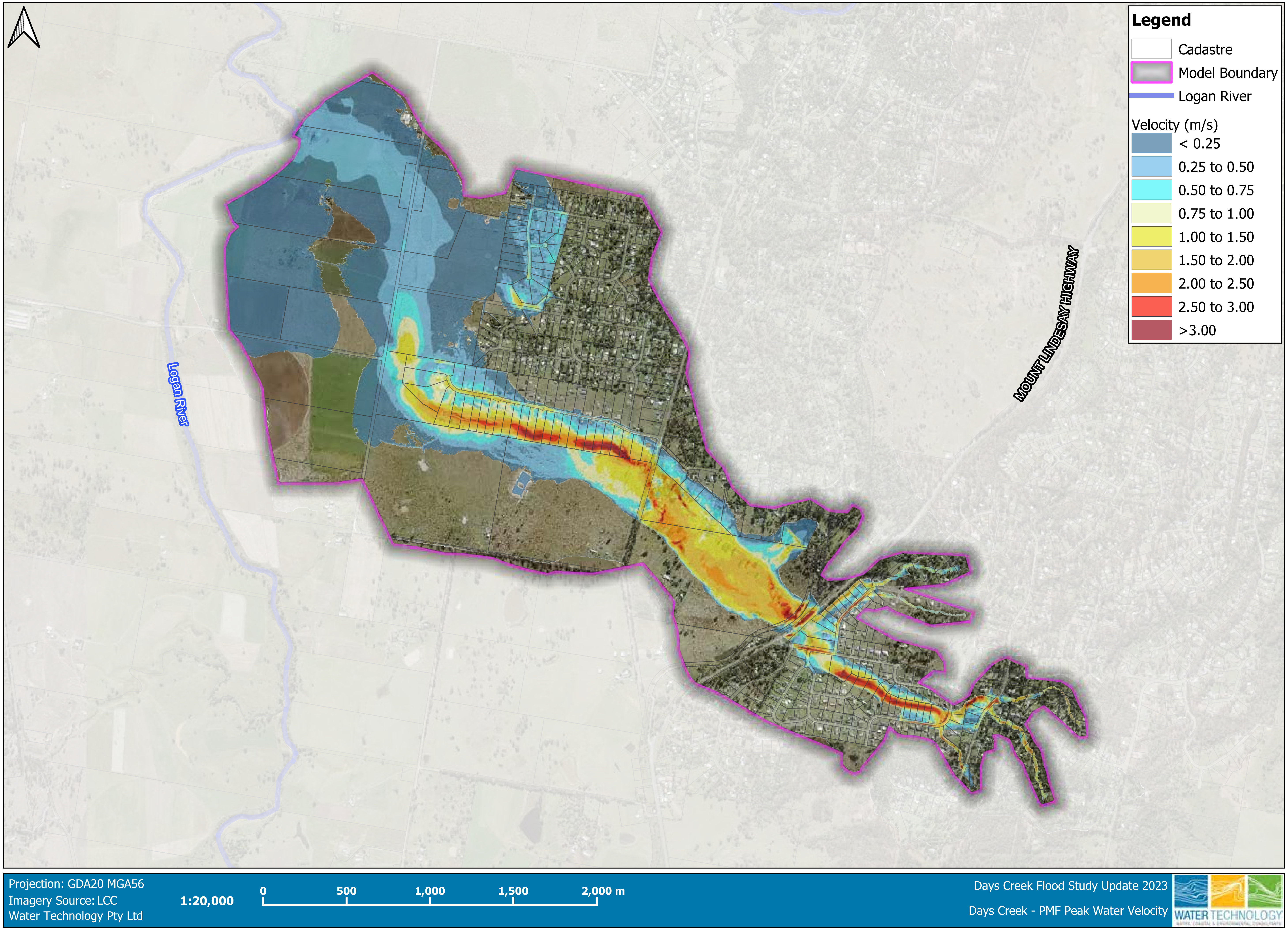
Days Creek Flood Study Update 2023

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

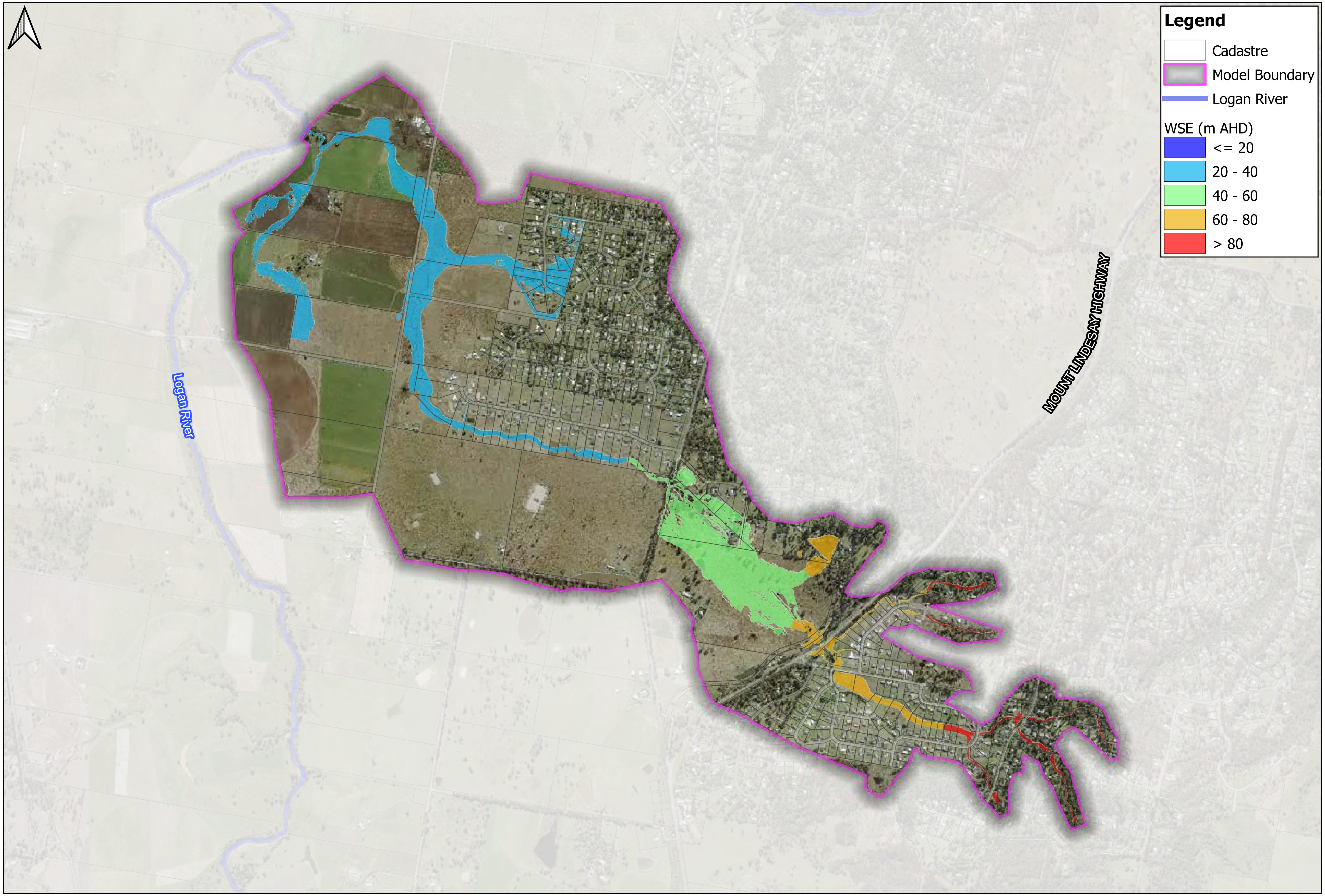


Days Creek Flood Study Update 2023

Days Creek - 0.05% AEP Peak Water Velocity



Legend
Cadastre
Model Boundary
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
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:20,000
0
500
1,000
1,500
2,000 m
Days Creek Flood Study Update 2023
Days Creek - PMF Peak Water Velocity
WATER TECHNOLOGY



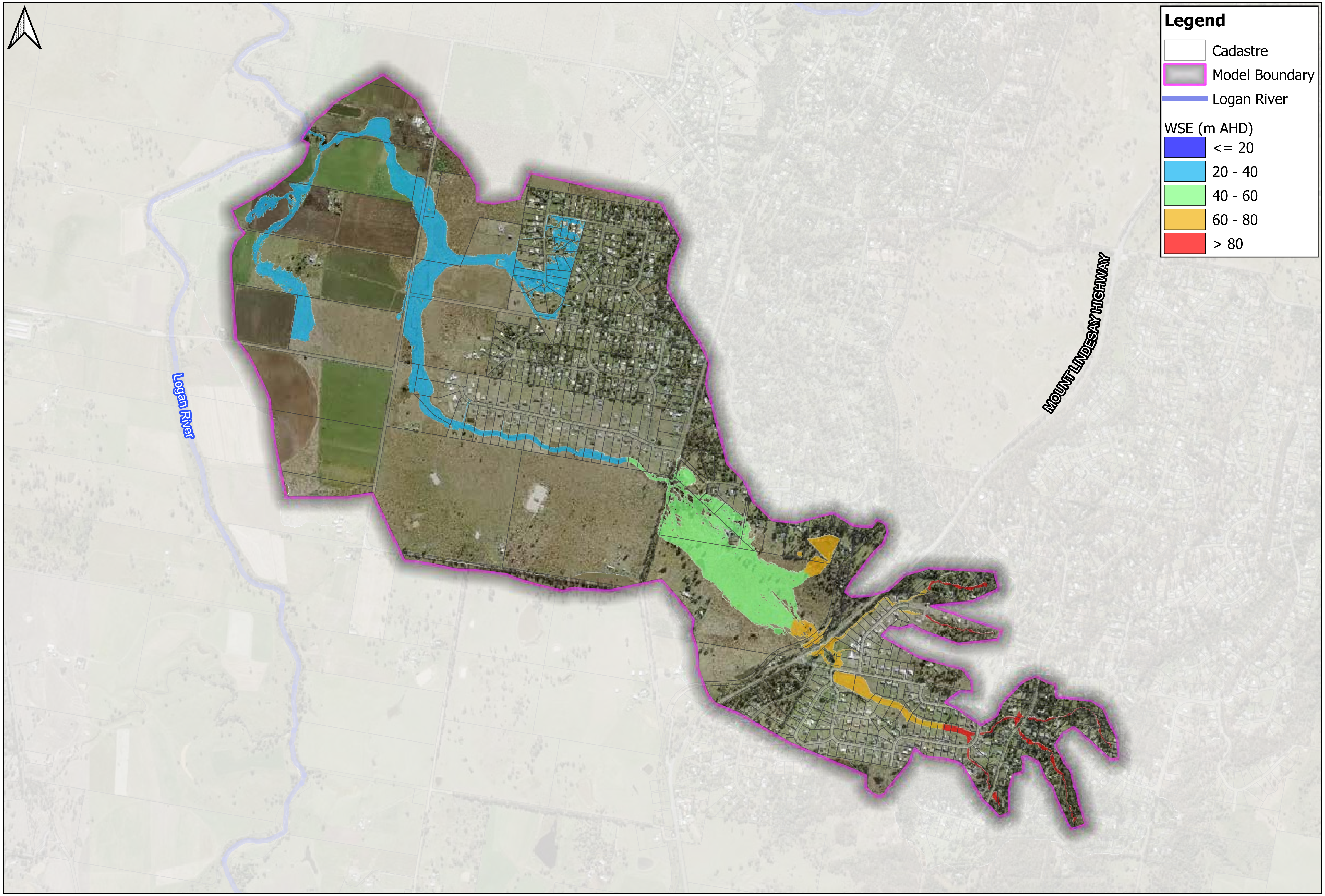
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 63.2% AEP Peak Water Surface Elevation

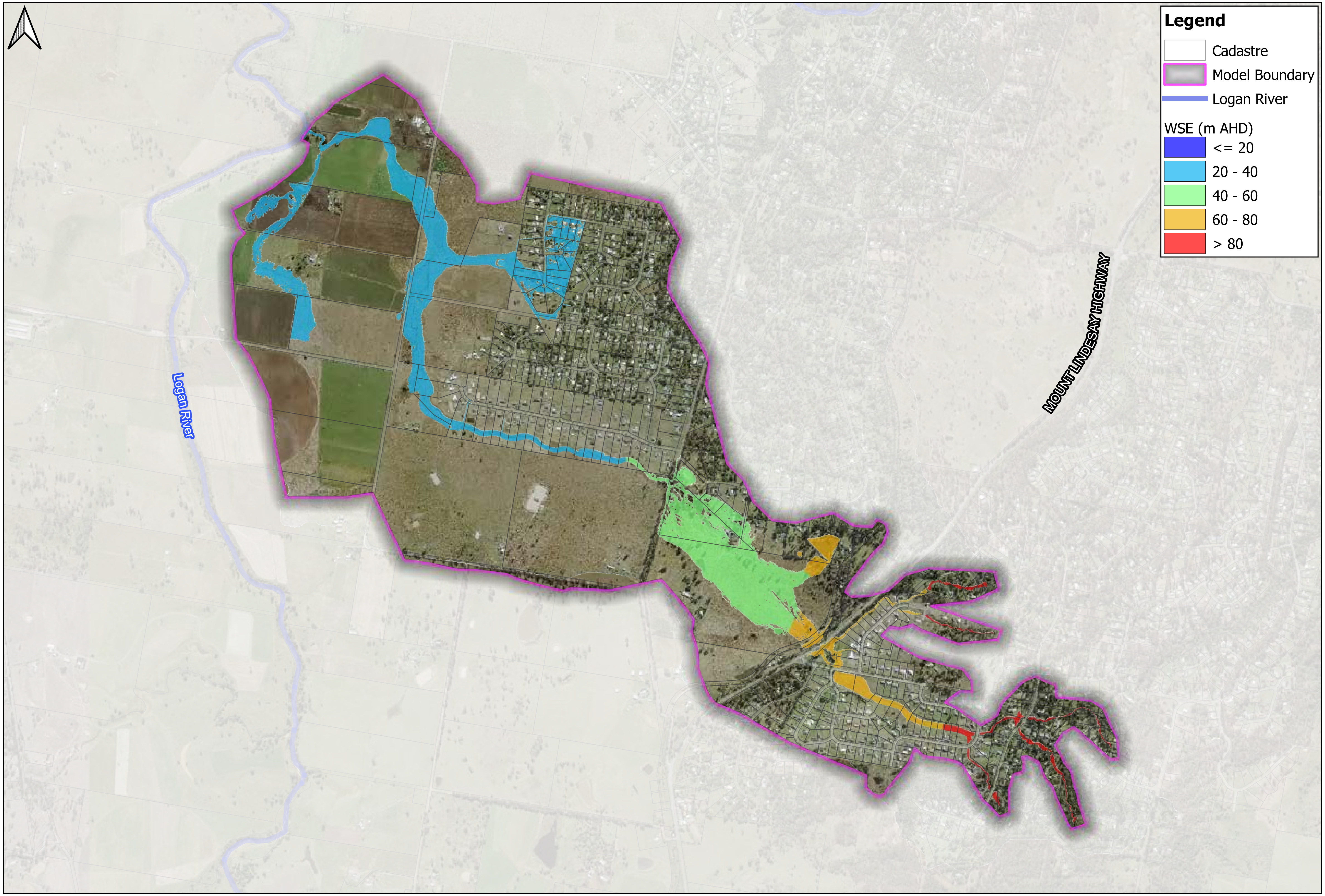


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 50% AEP Peak Water Surface Elevation



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

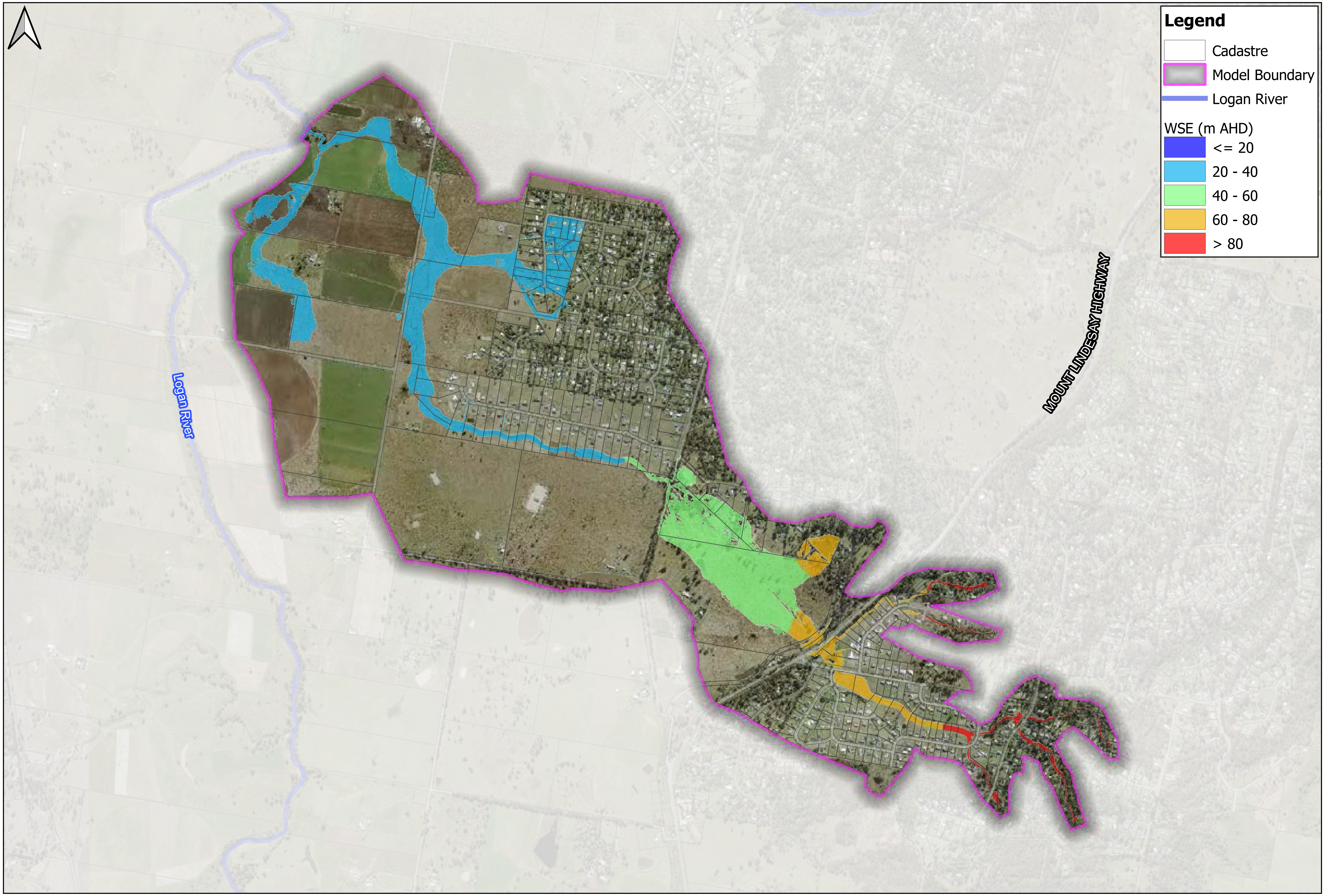
1:20,000

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

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



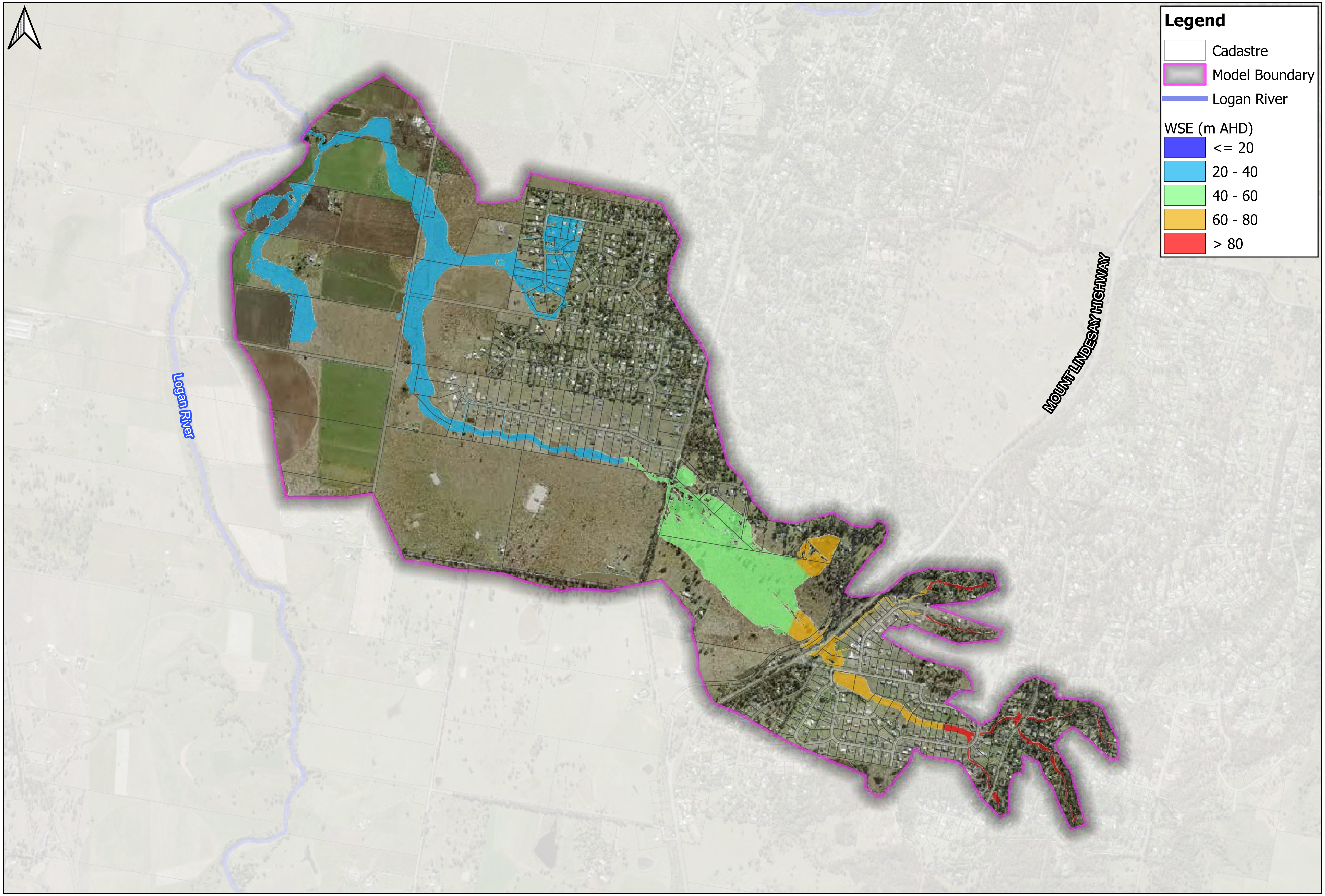
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 20% AEP Peak Water Surface Elevation



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

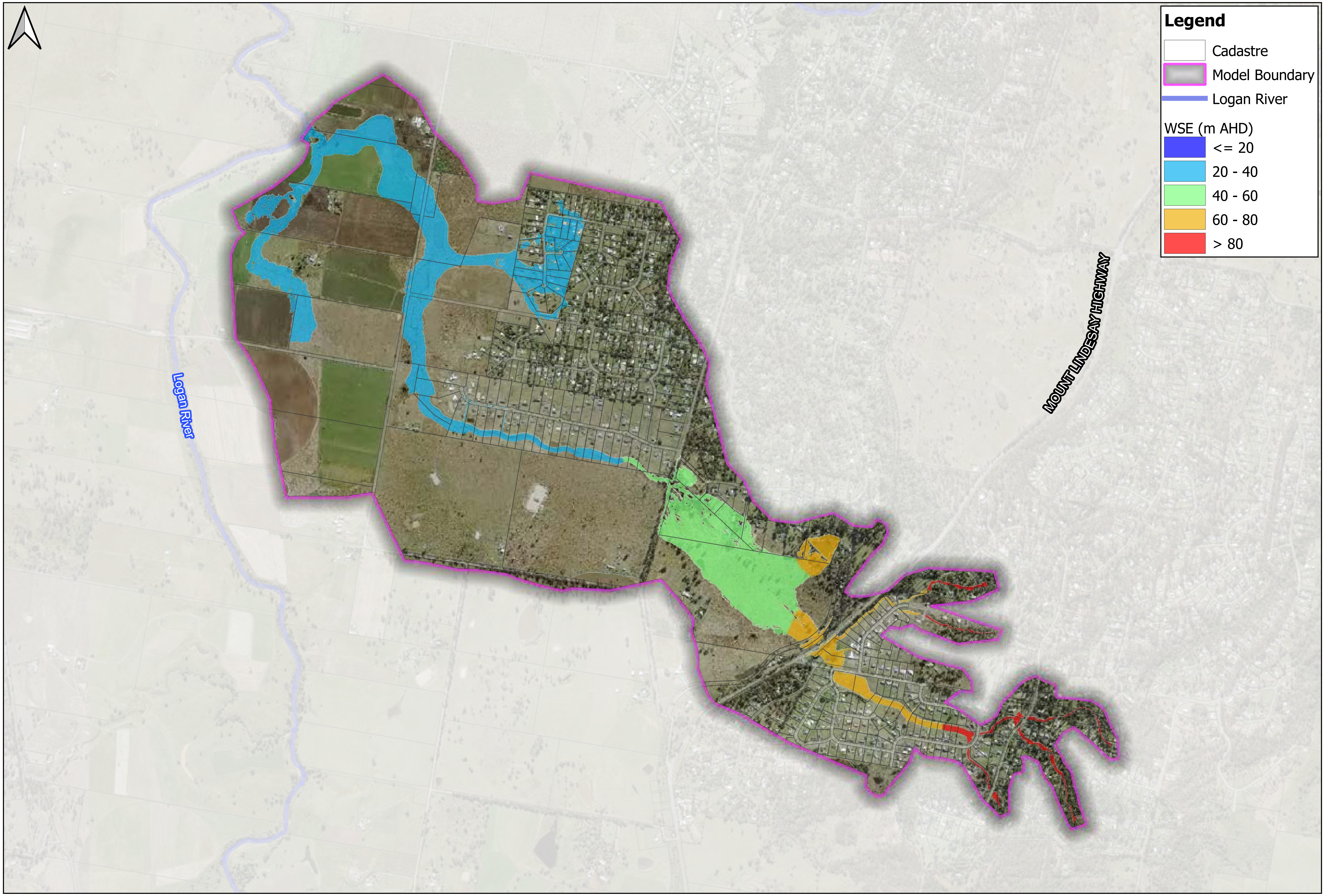
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 20% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY



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

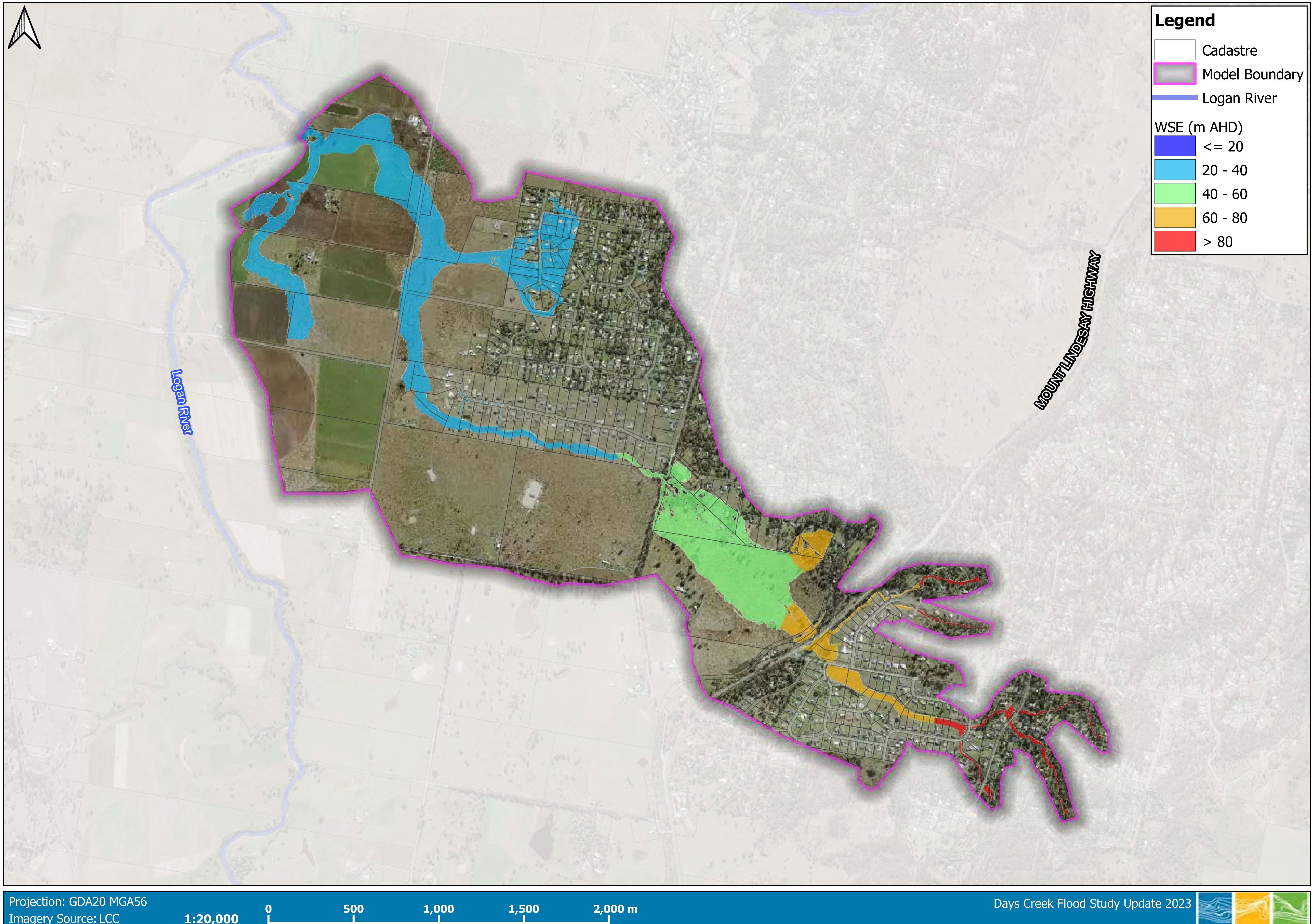
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 10% AEP Peak Water Surface Elevation

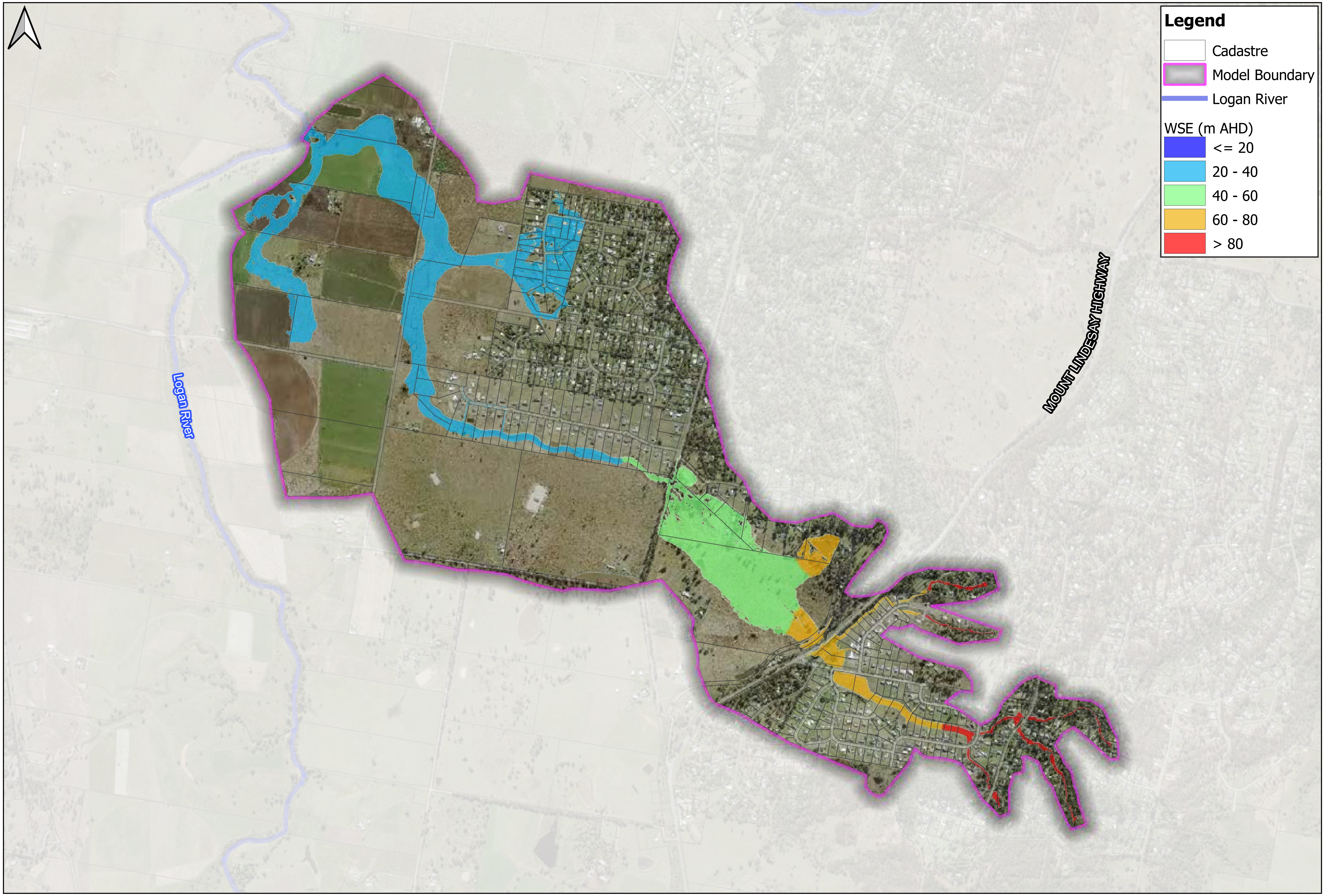
WATER TECHNOLOGY



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

Days Creek Flood Study Update 2023

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



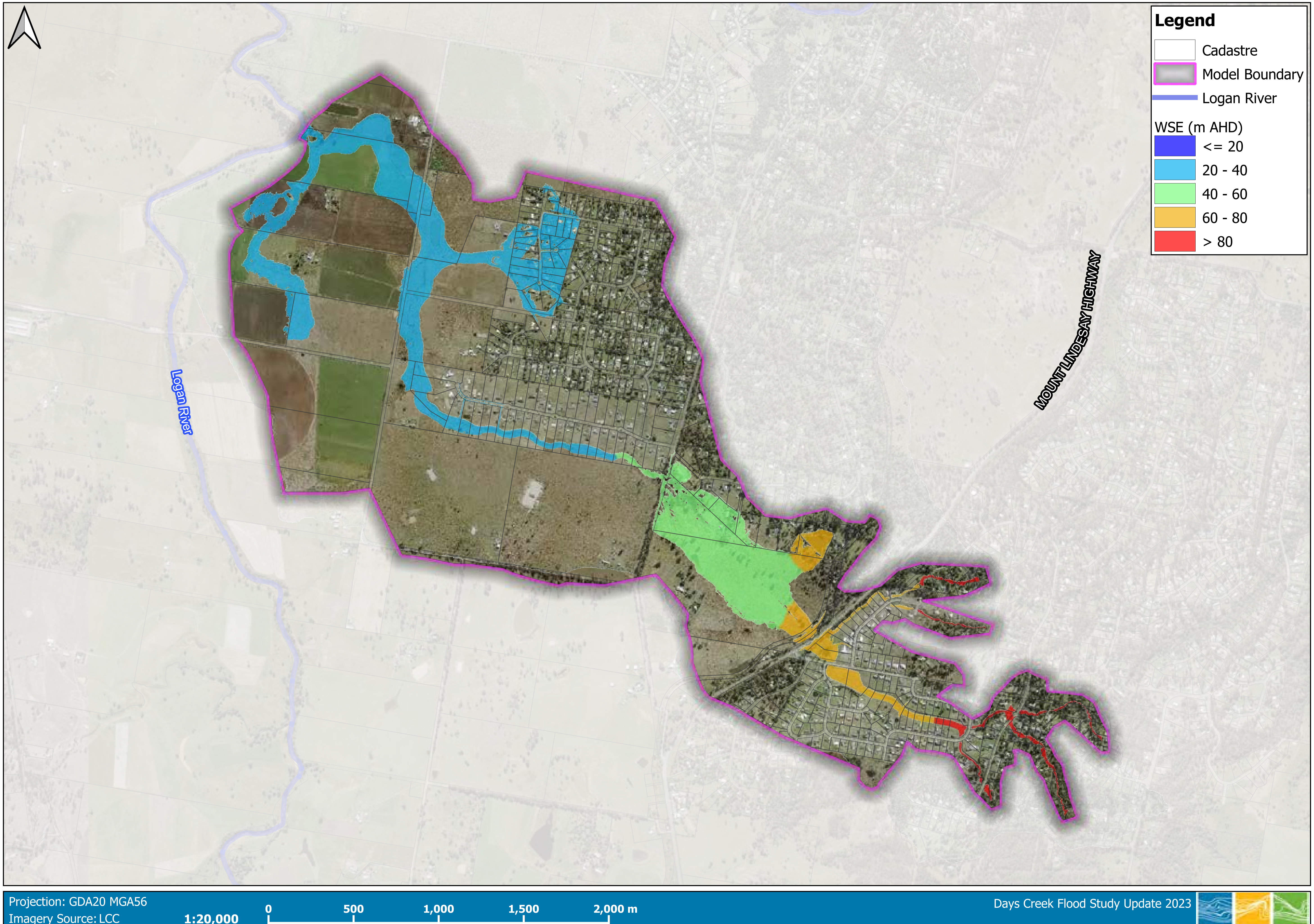
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 5% AEP Peak Water Surface Elevation

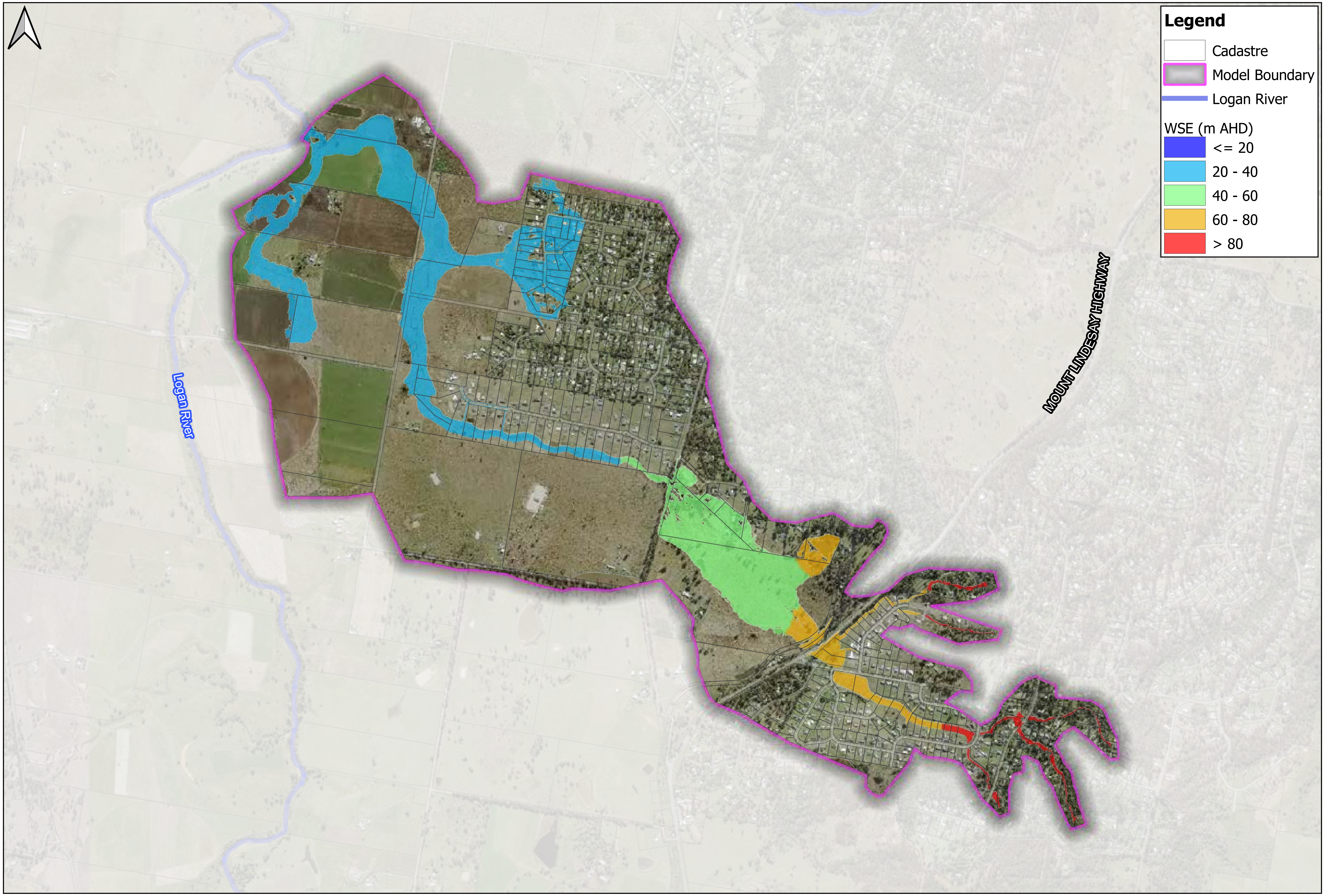


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

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



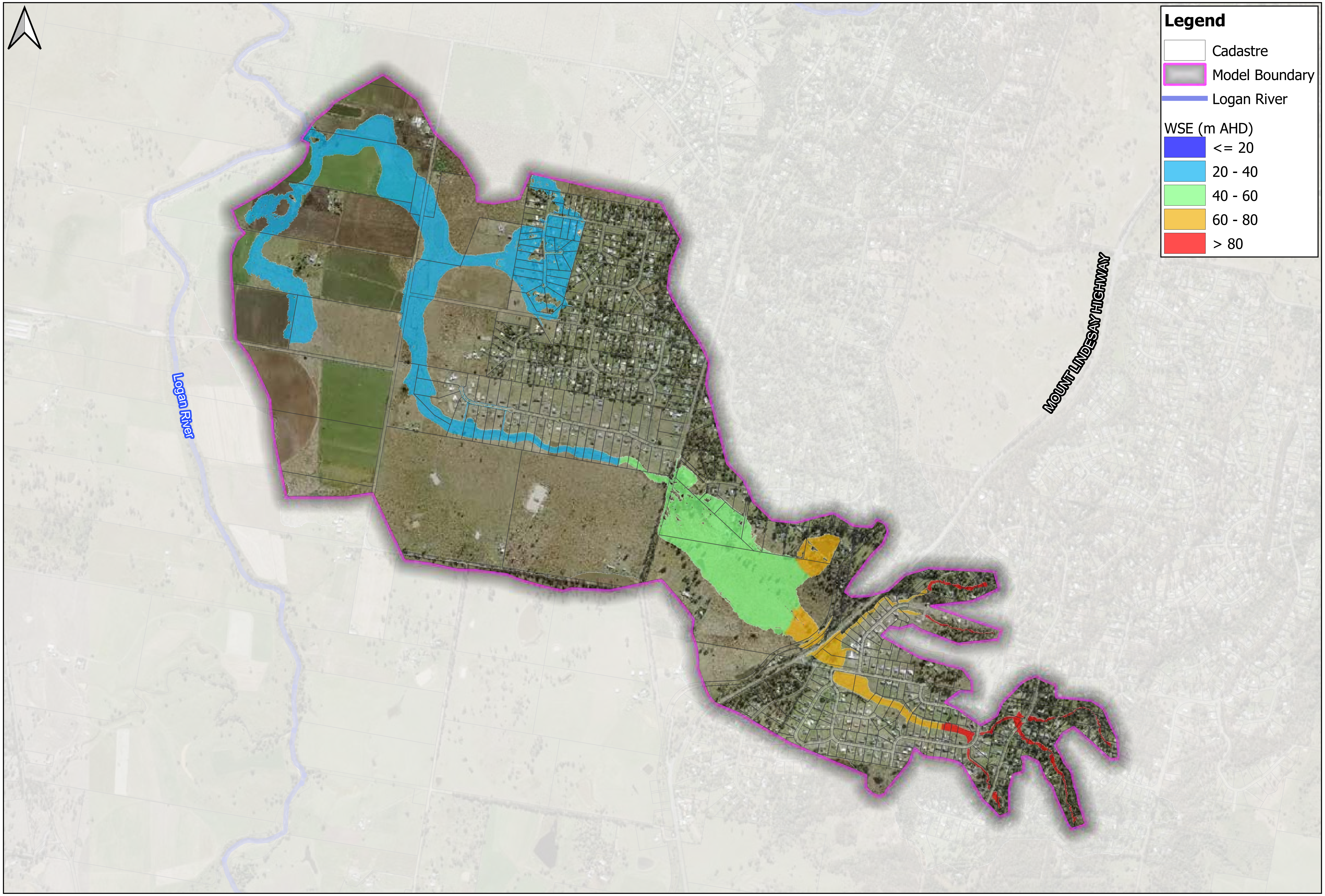
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 2% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



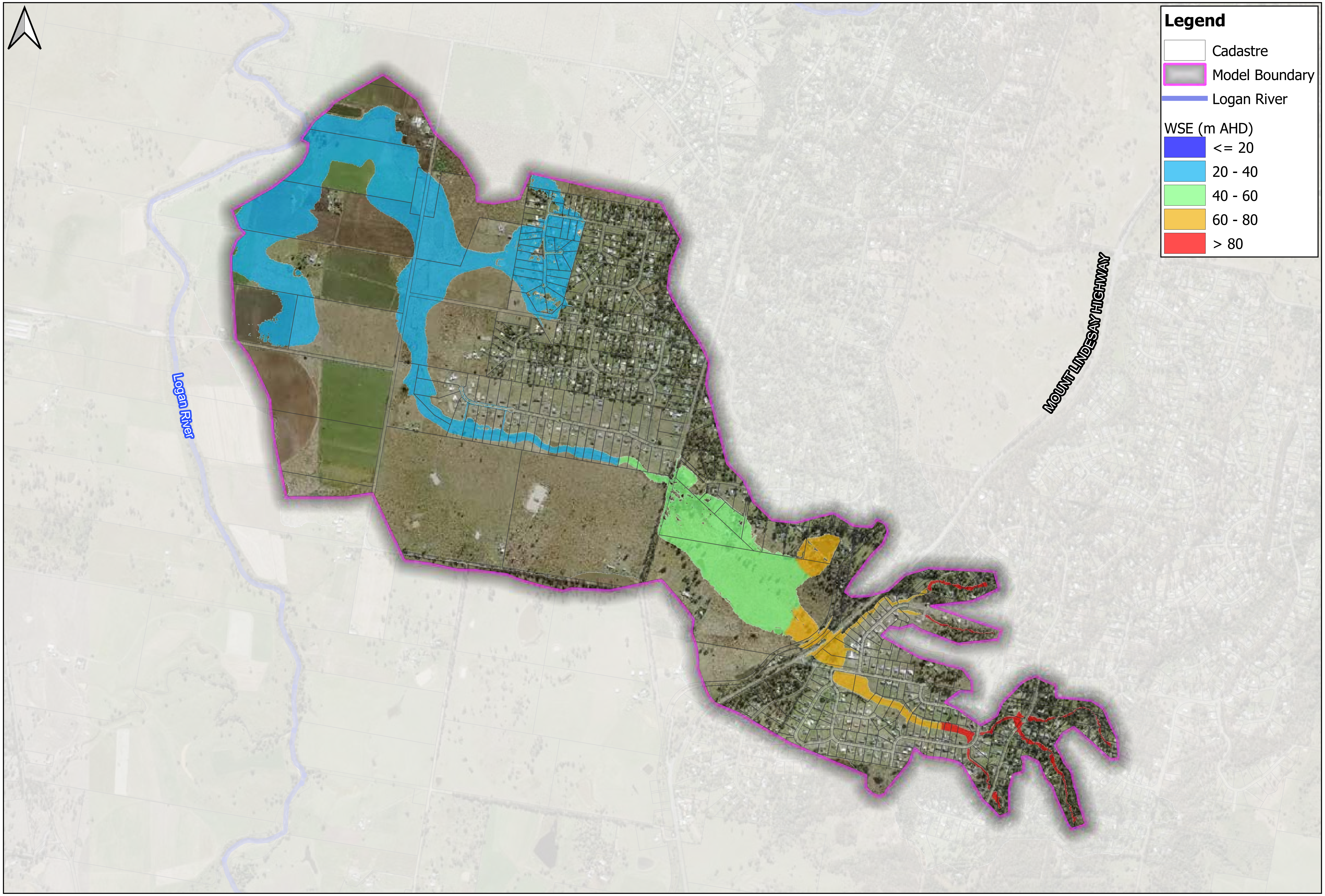
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 2% AEP CC (RCP4.5) Peak Water Surface Elevation



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

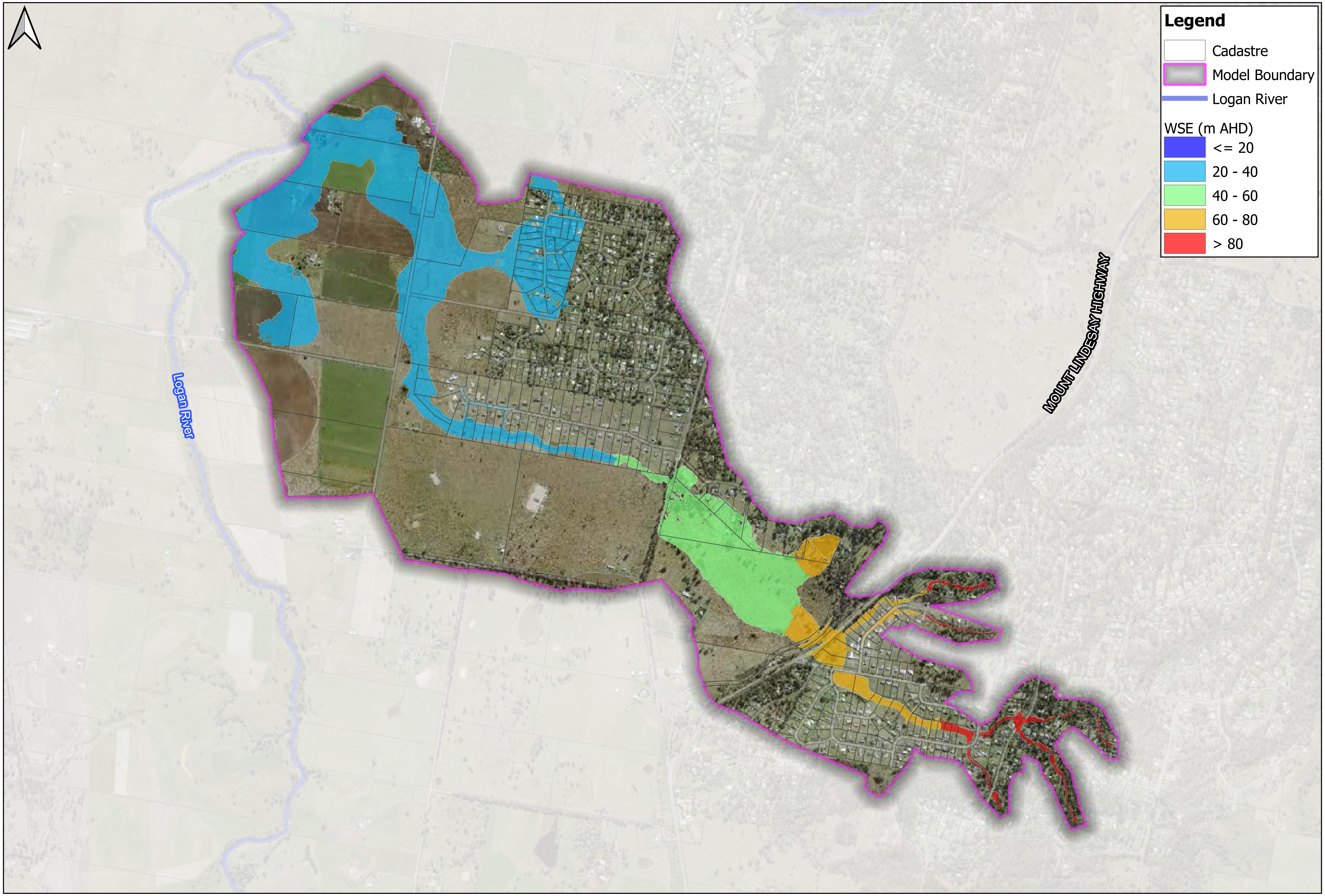
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 1% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



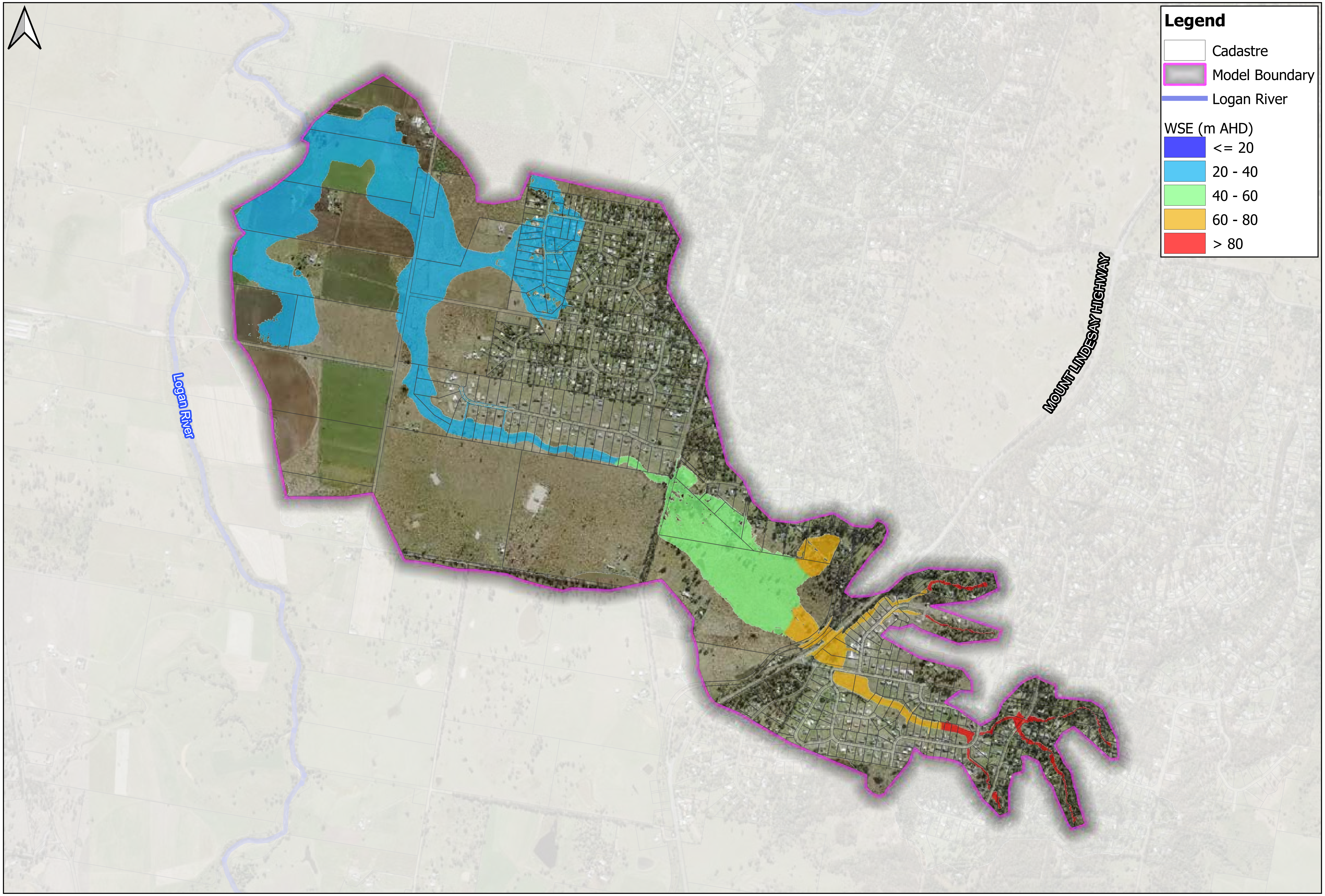
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

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



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Imagery Source: LCC
Water Technology Pty Ltd

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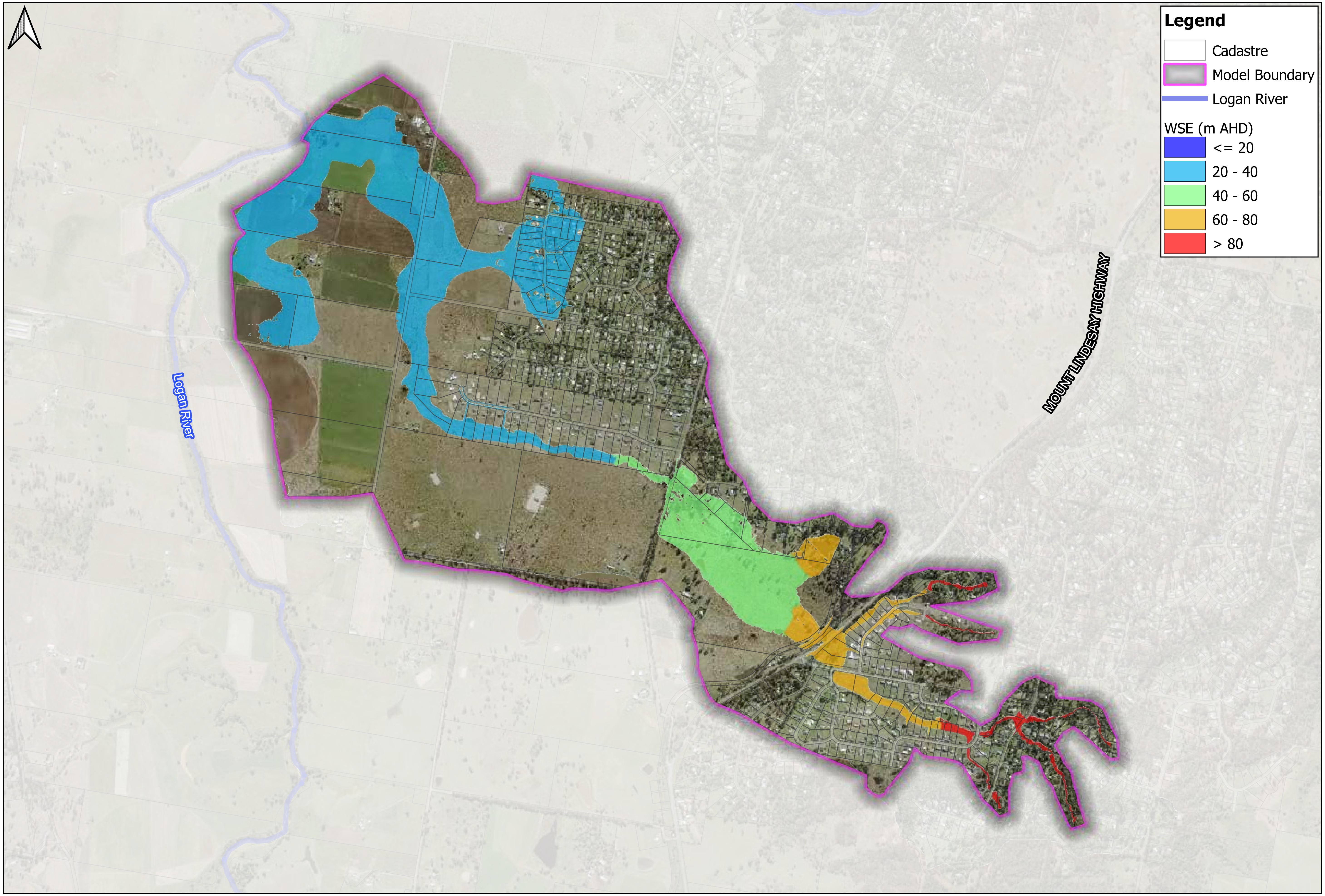
Days Creek Flood Study Update 2023

Days Creek - 0.5% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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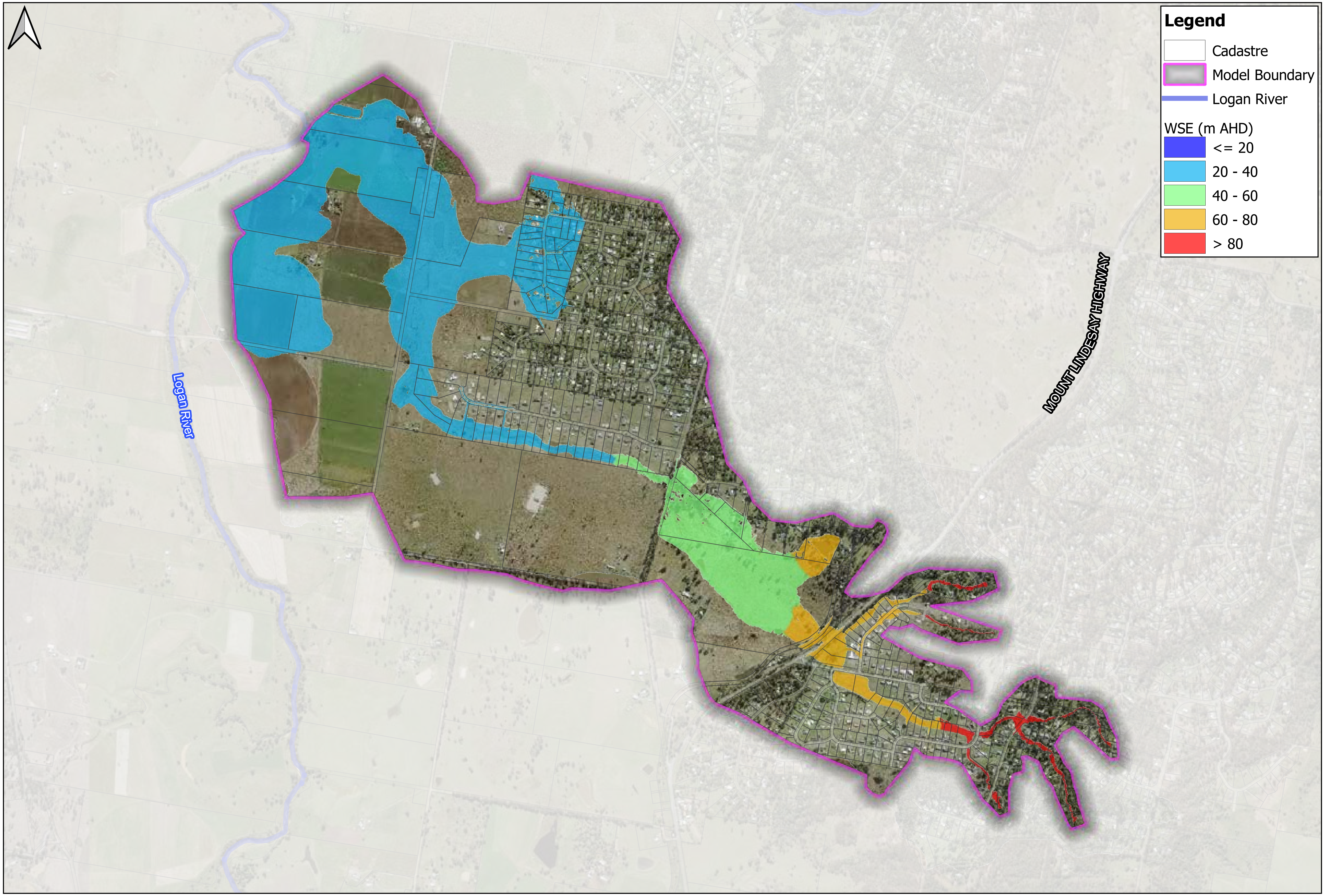
Days Creek Flood Study Update 2023

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



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Imagery Source: LCC
Water Technology Pty Ltd

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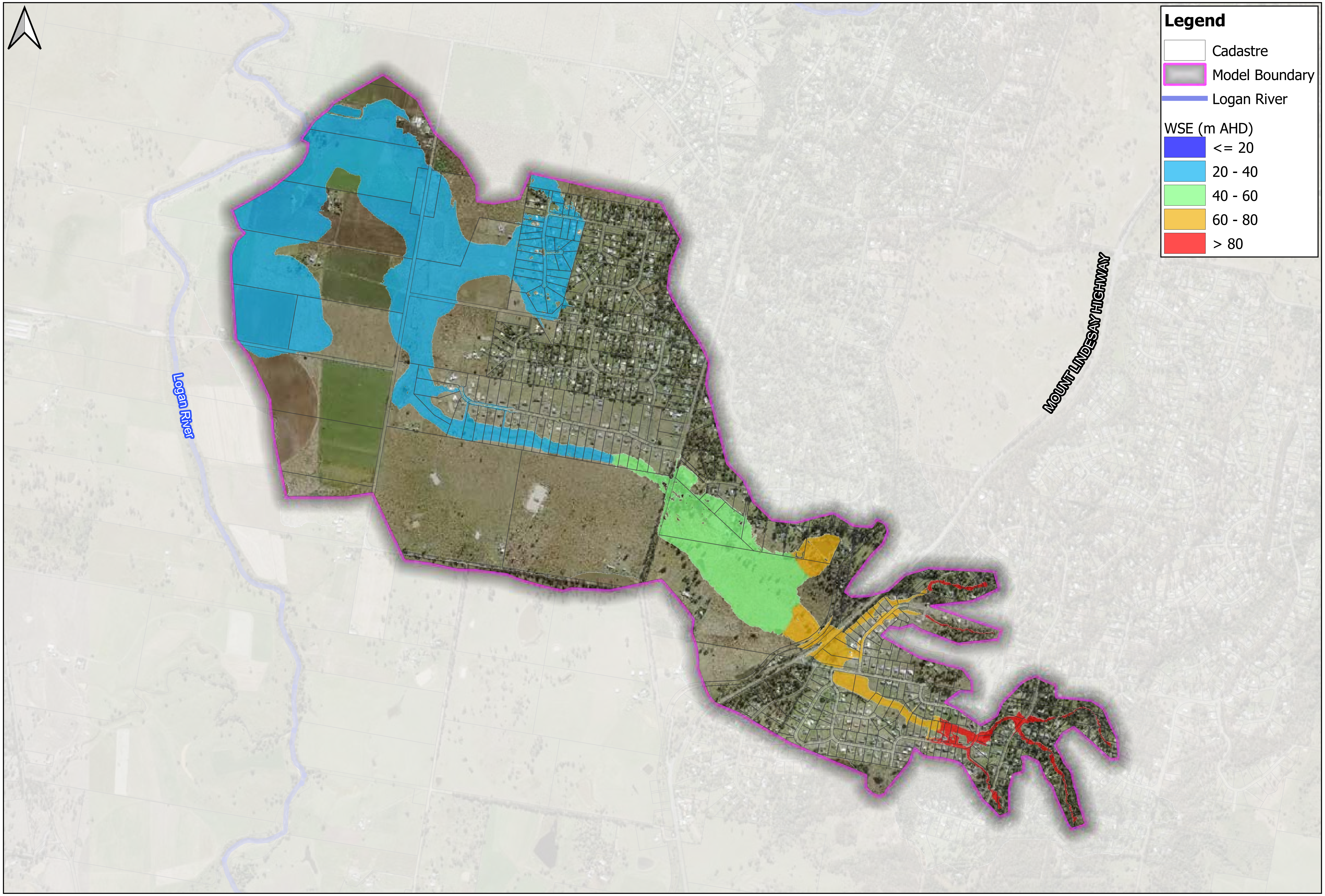
Days Creek Flood Study Update 2023

Days Creek - 0.2% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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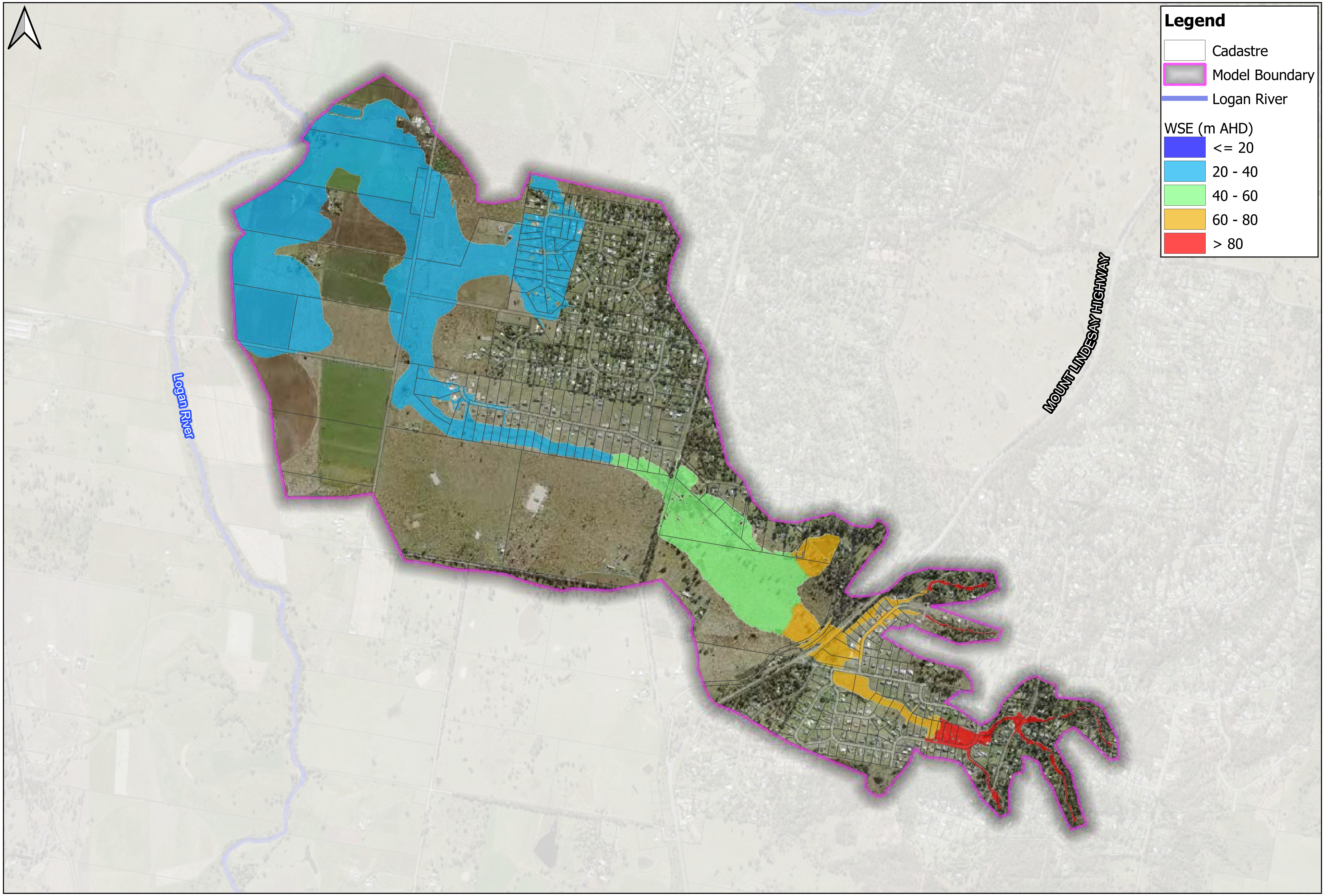
Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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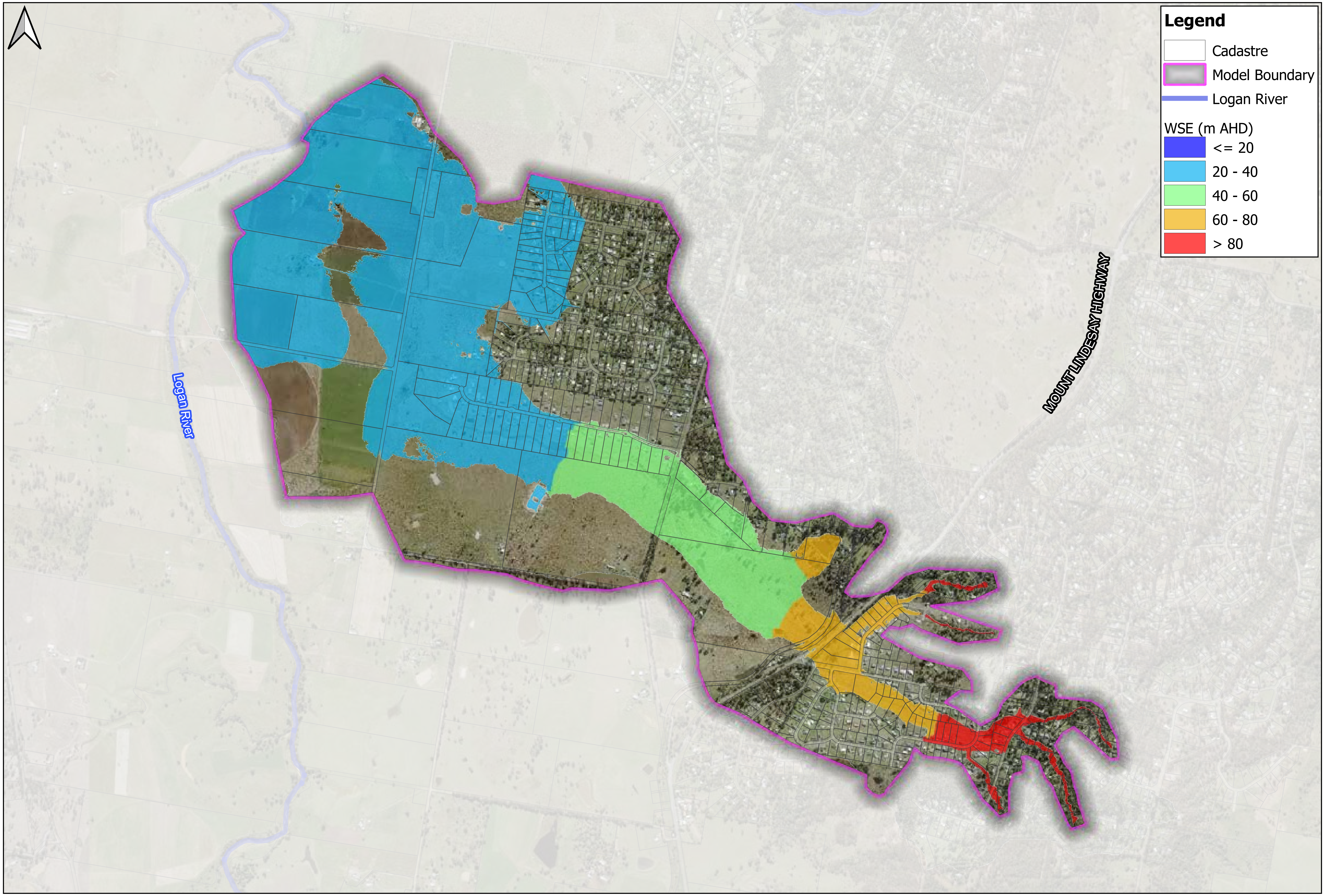
Days Creek Flood Study Update 2023

Days Creek - 0.05% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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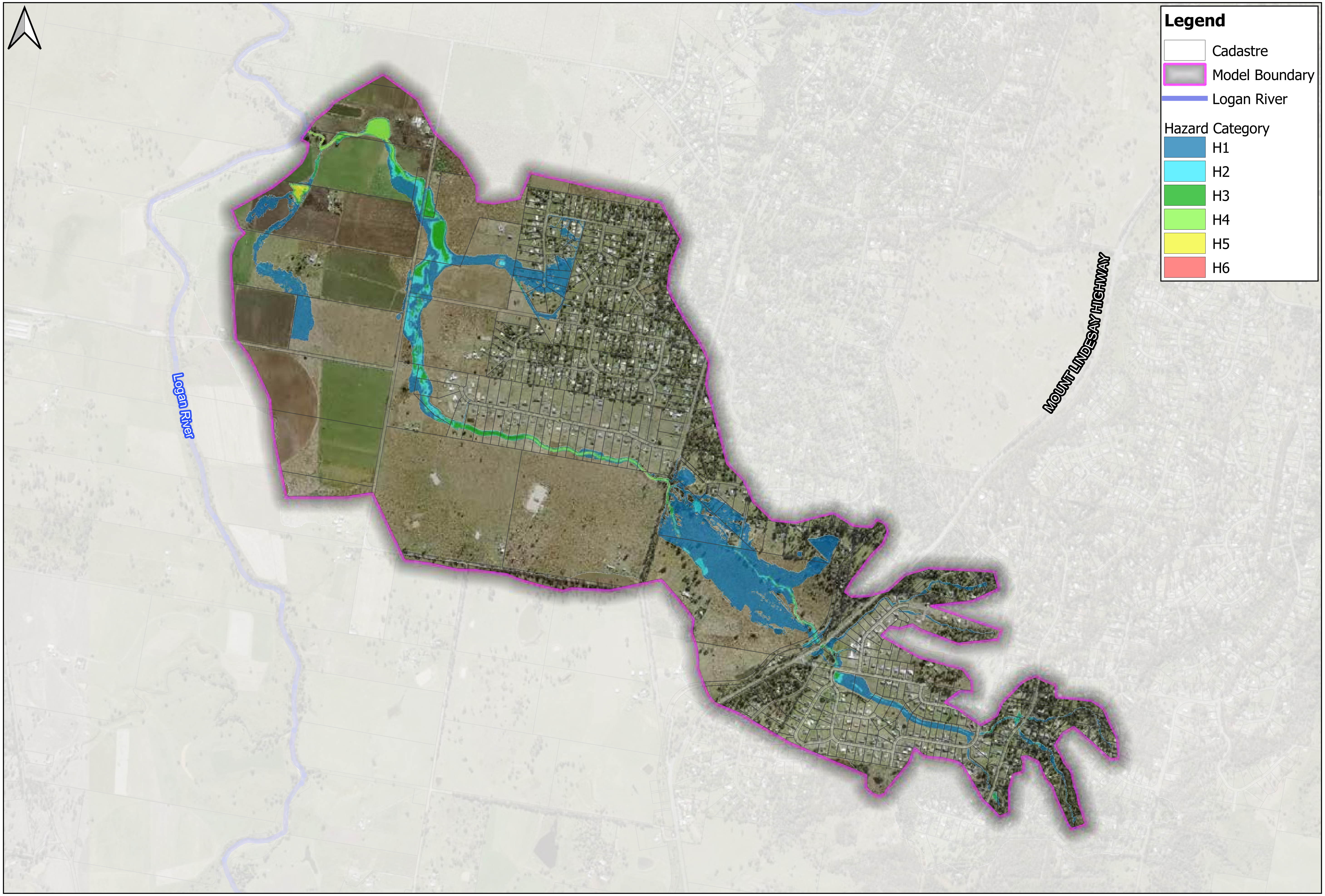
Days Creek Flood Study Update 2023

Days Creek - PMF Peak Water Surface Elevation



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Water Technology Pty Ltd

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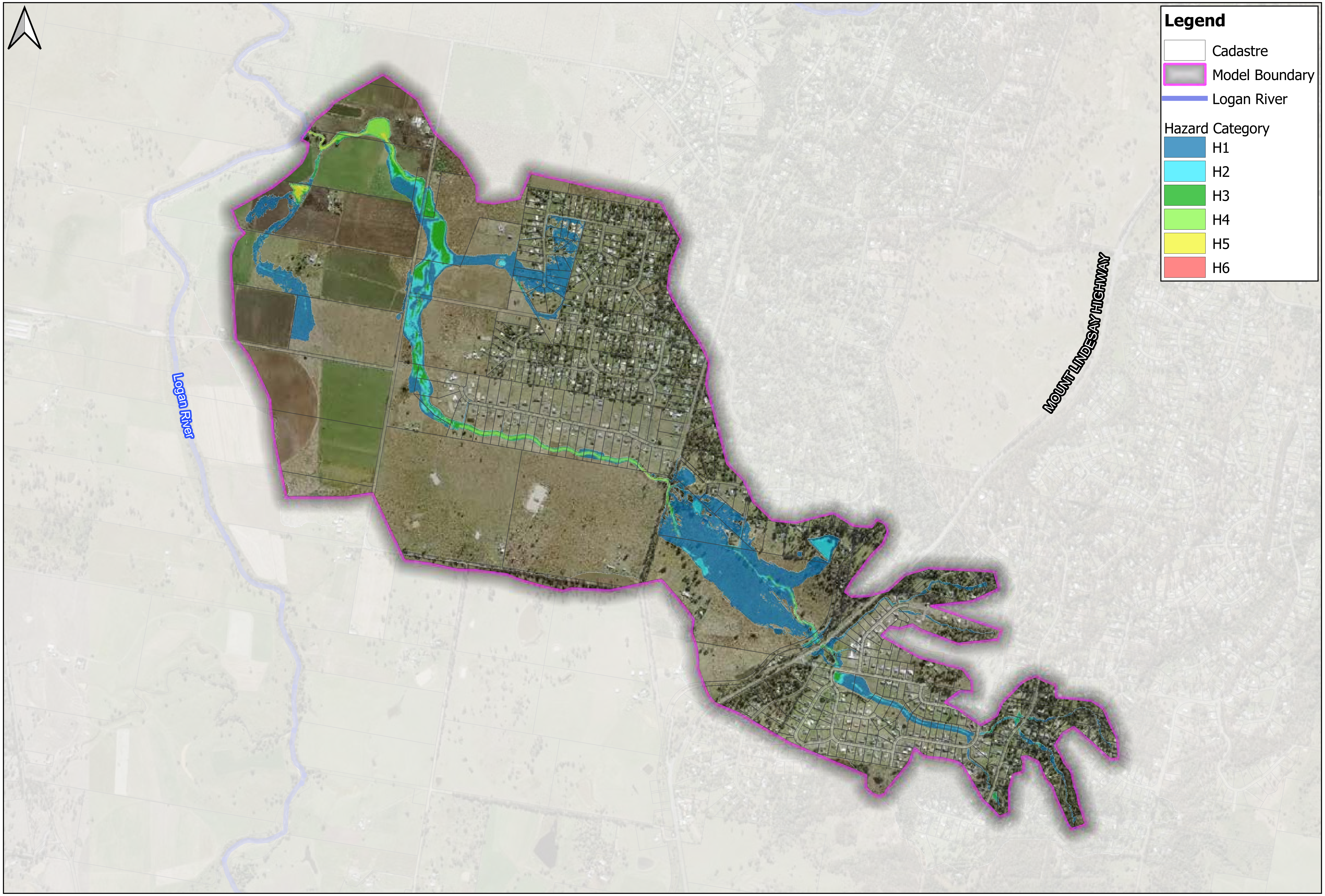
Days Creek Flood Study Update 2023

Days Creek - 63.2% AEP Peak Water Hazard Category



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Water Technology Pty Ltd

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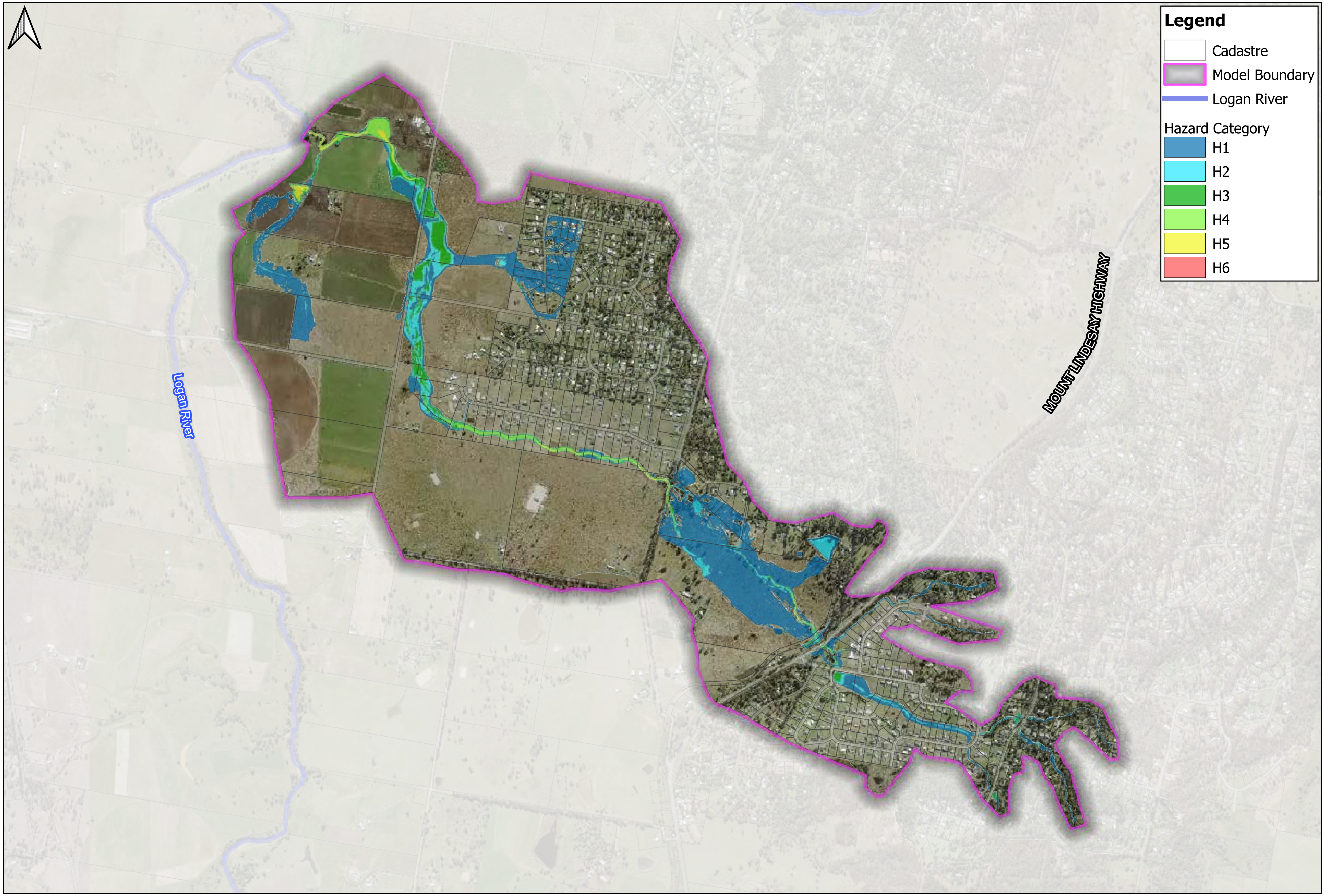
Days Creek Flood Study Update 2023

Days Creek - 50% AEP Peak Water Hazard Category

WATER TECHNOLOGY



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Water Technology Pty Ltd

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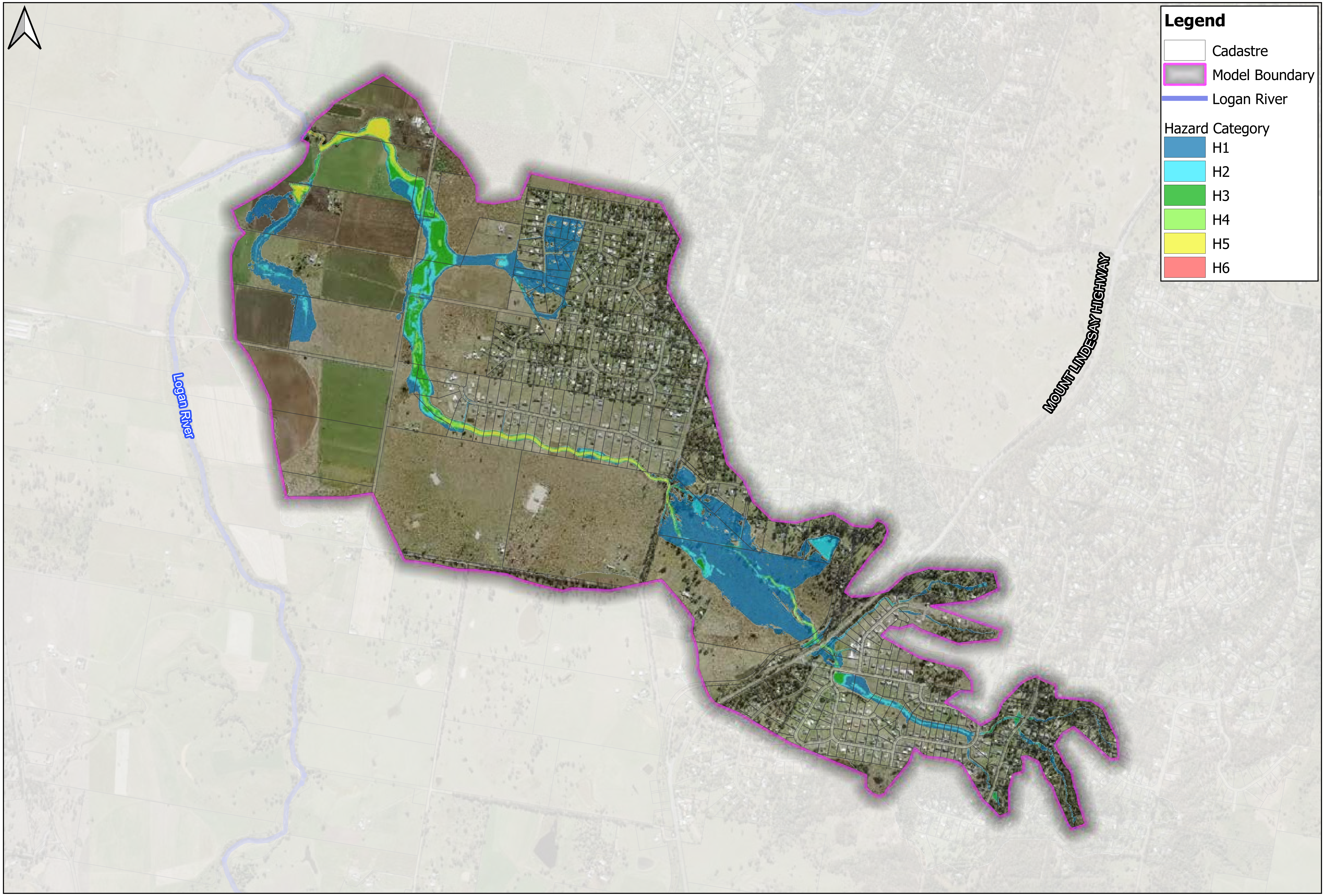
Days Creek Flood Study Update 2023

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



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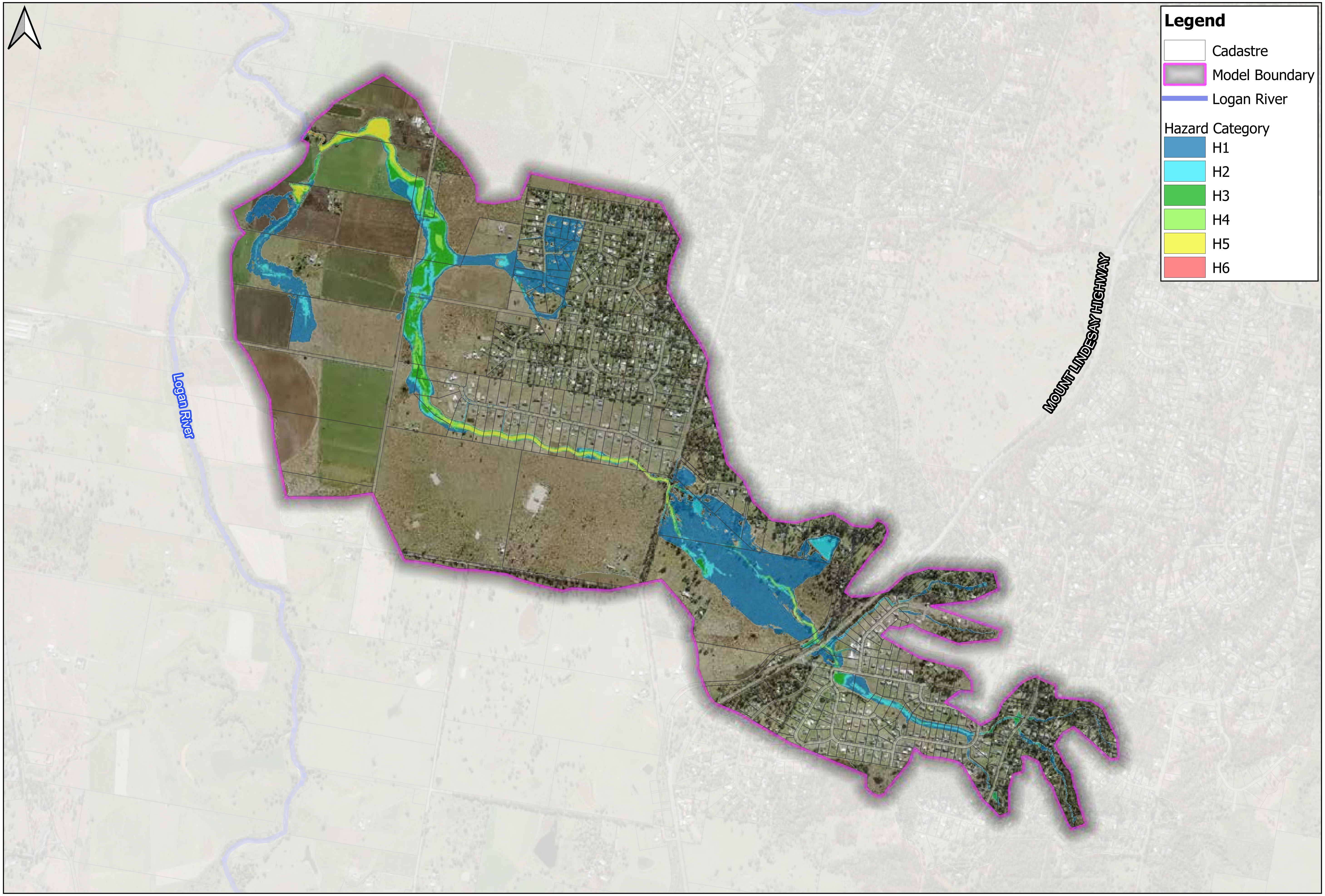
Days Creek Flood Study Update 2023

Days Creek - 20% AEP Peak Water Hazard Category



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Imagery Source: LCC
Water Technology Pty Ltd

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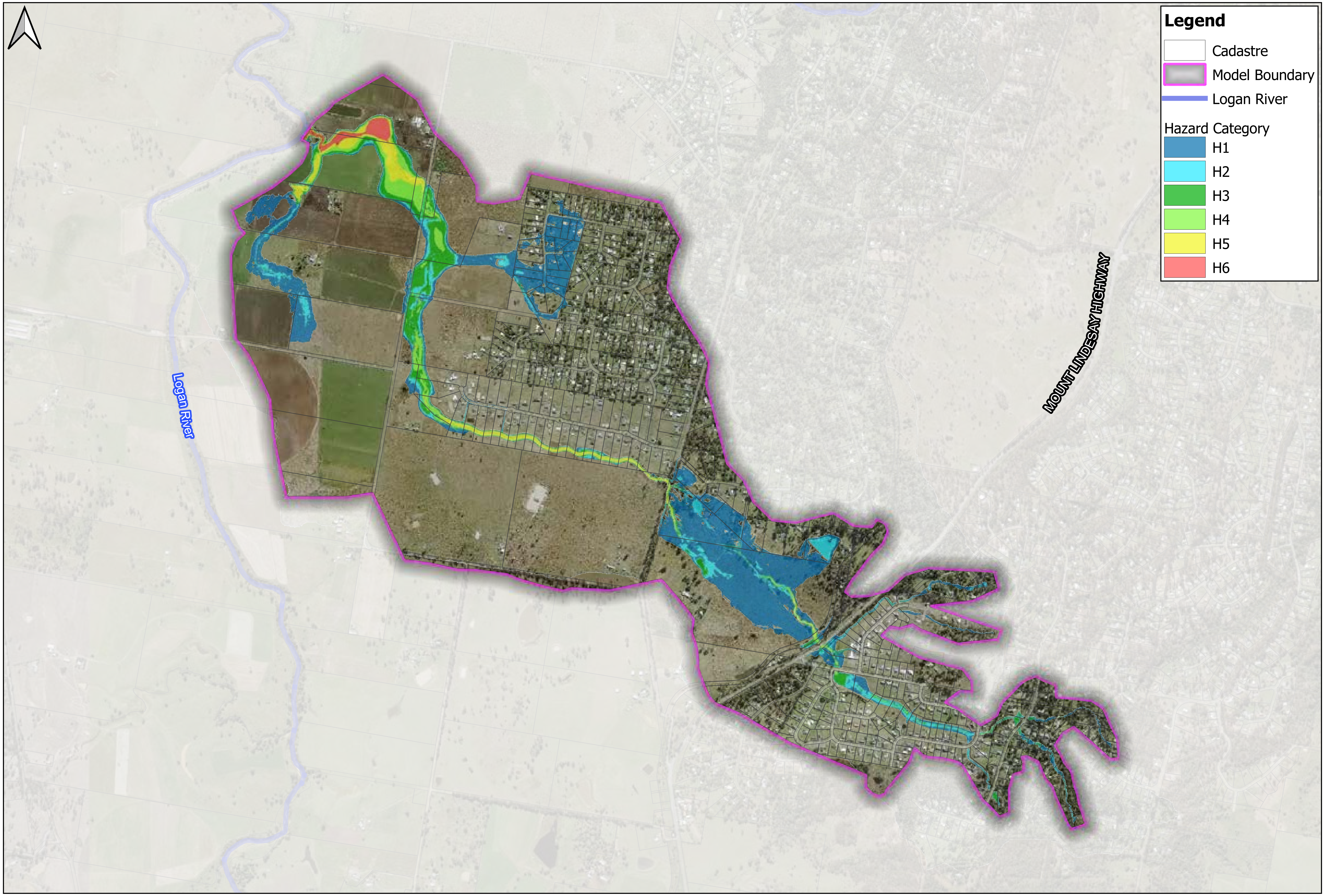
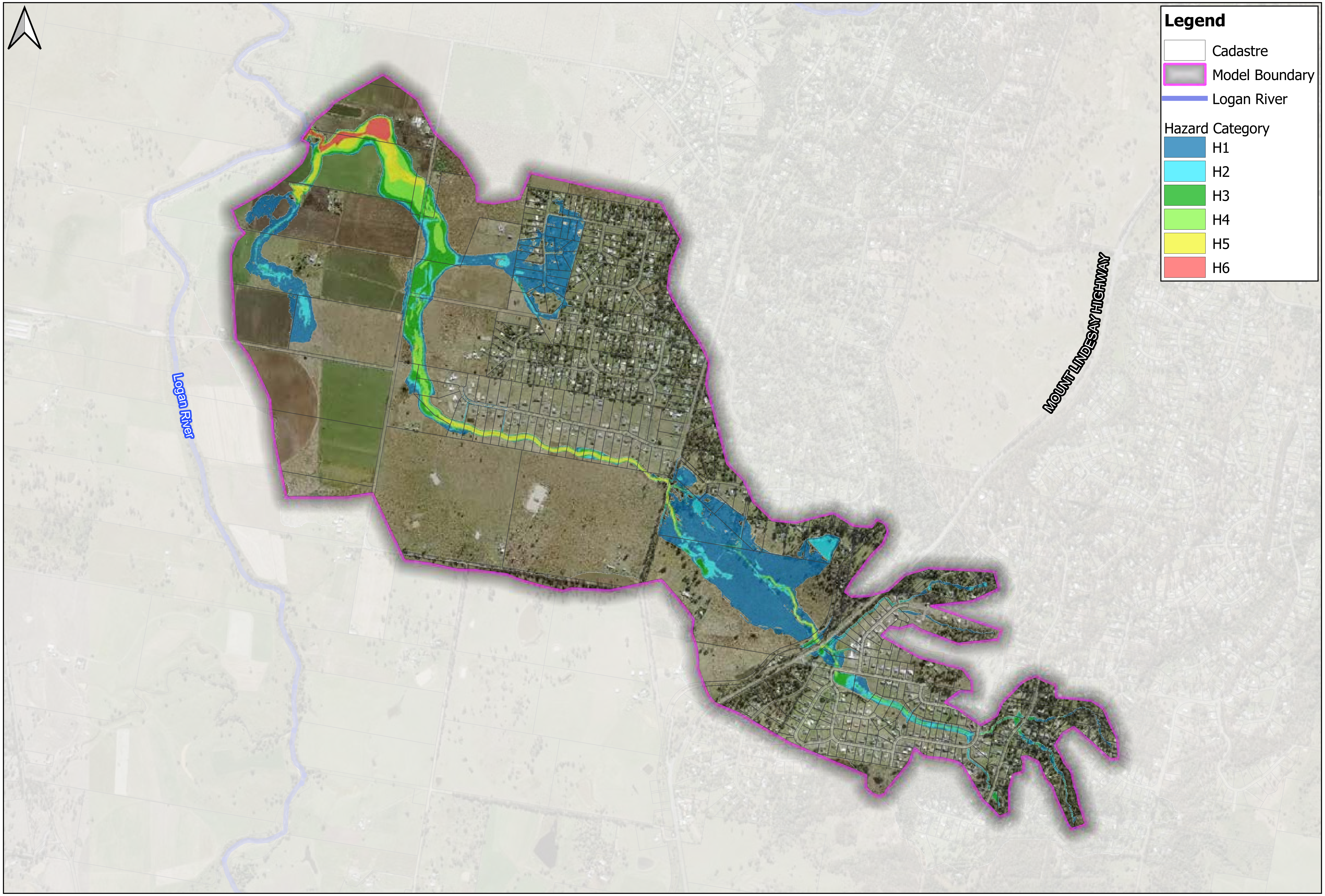
Days Creek Flood Study Update 2023

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



Days Creek Flood Study Update 2023

Days Creek - 10% AEP Peak Water Hazard Category



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Imagery Source: LCC
Water Technology Pty Ltd

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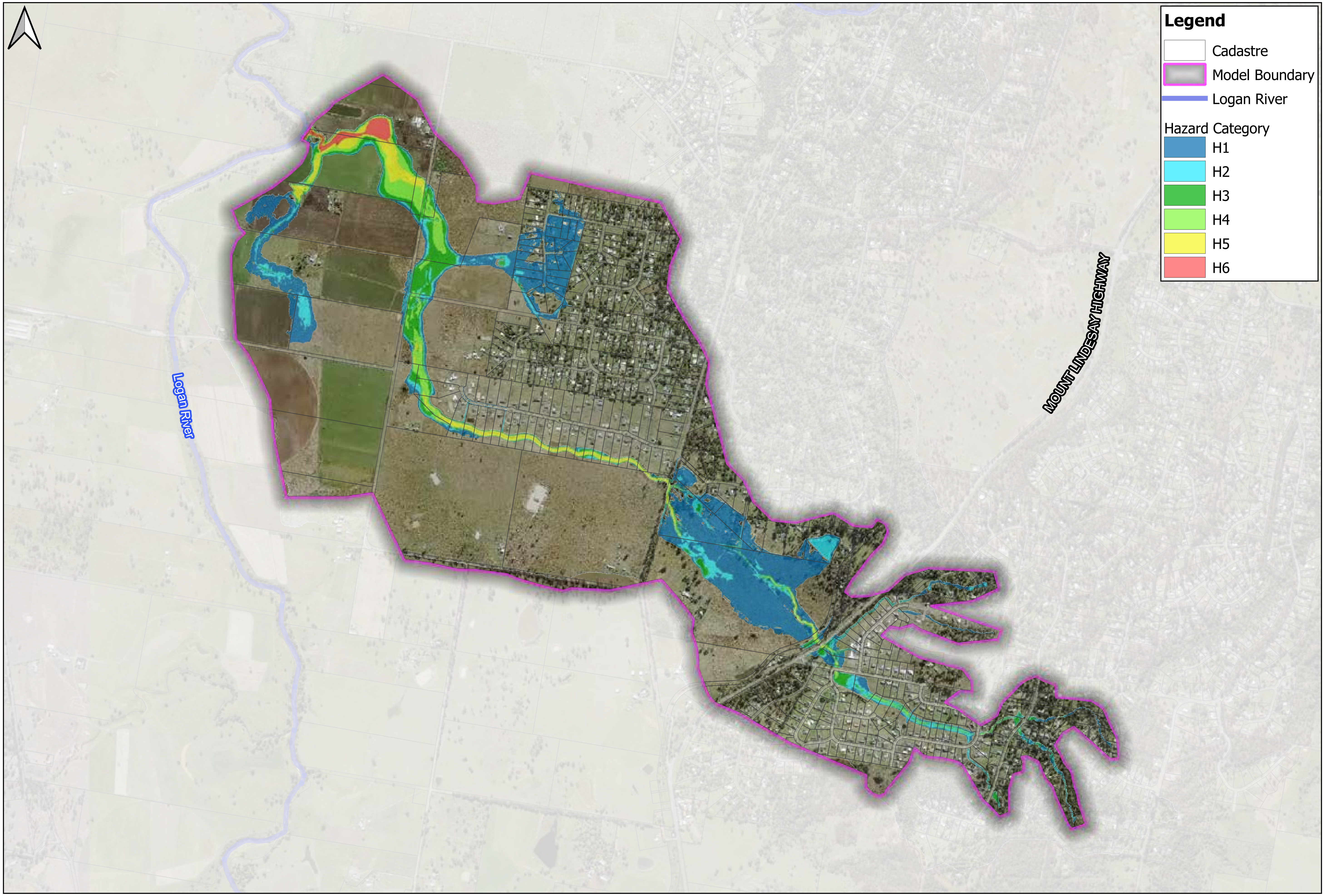
Days Creek Flood Study Update 2023

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



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Water Technology Pty Ltd

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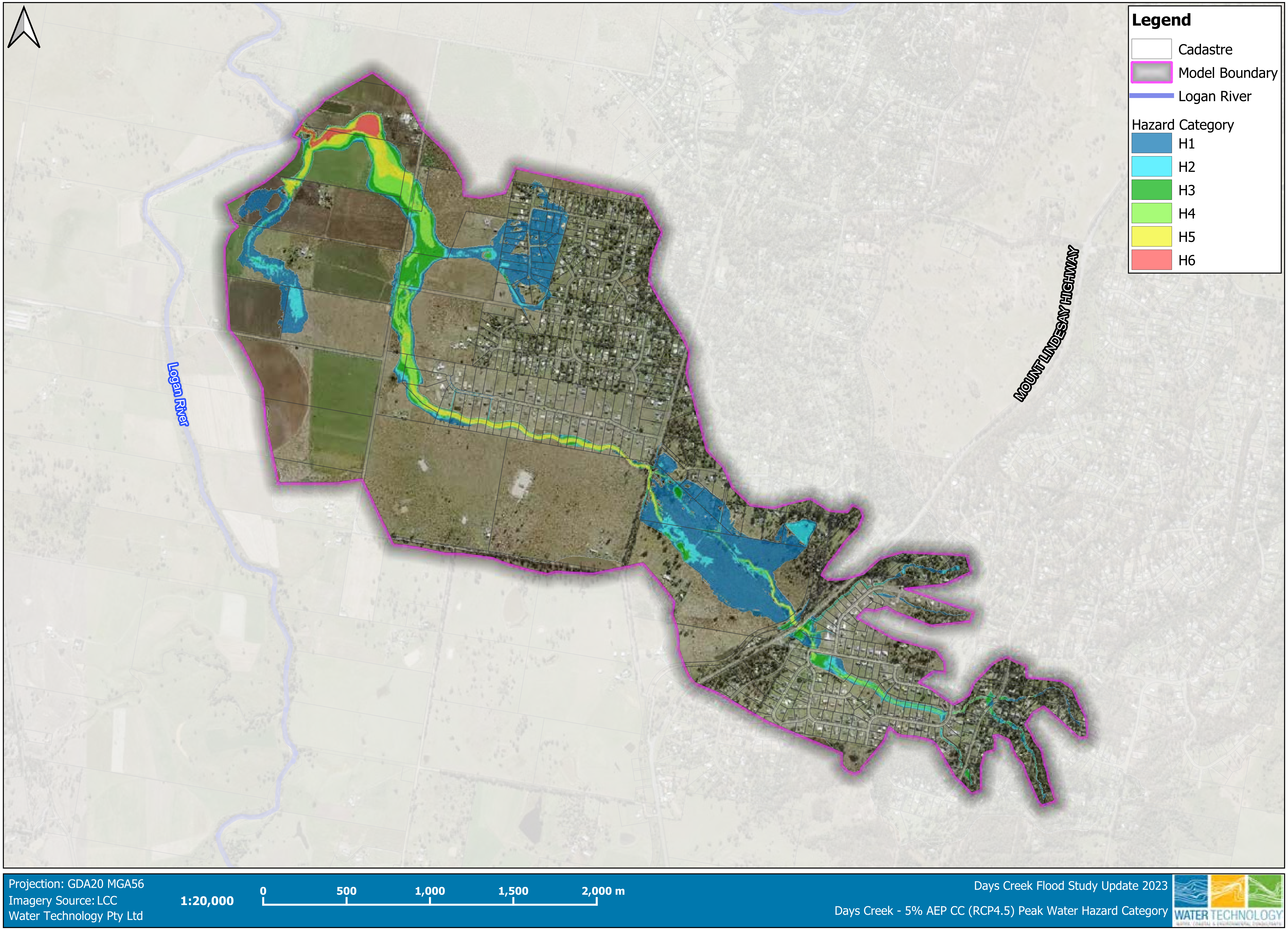
Days Creek Flood Study Update 2023

Days Creek - 5% AEP Peak Water Hazard Category



Legend
Cadastre
Model Boundary
Logan River
Hazard Category
H1
H2
H3
H4
H5
H6
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
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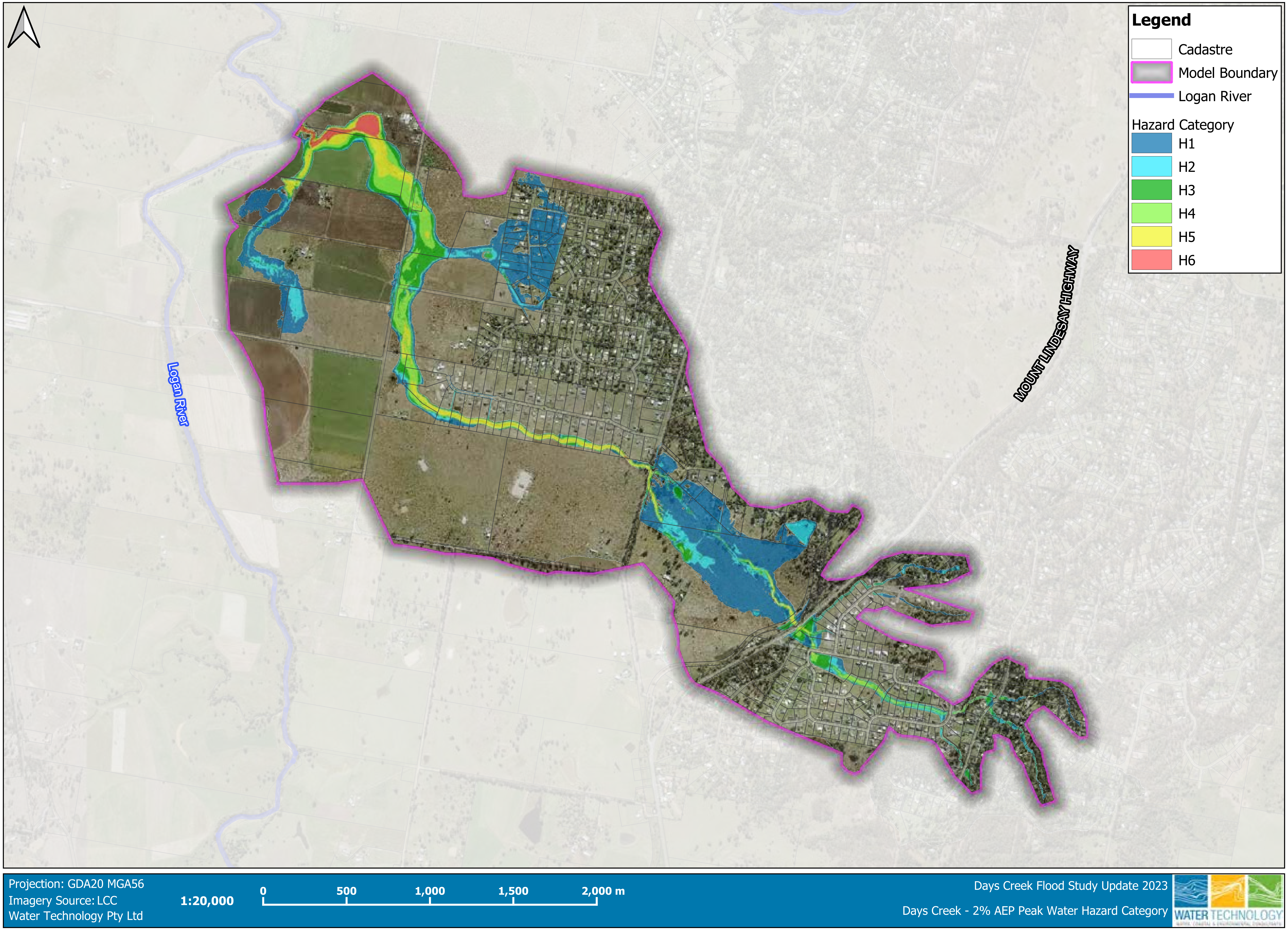
2,000 m
Days Creek Flood Study Update 2023
Days Creek - 5% AEP CC (RCP4.5) Peak Water Hazard Category



Legend
Cadastre
Model Boundary
Logan River
Hazard Category
H1
H2
H3
H4
H5
H6
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
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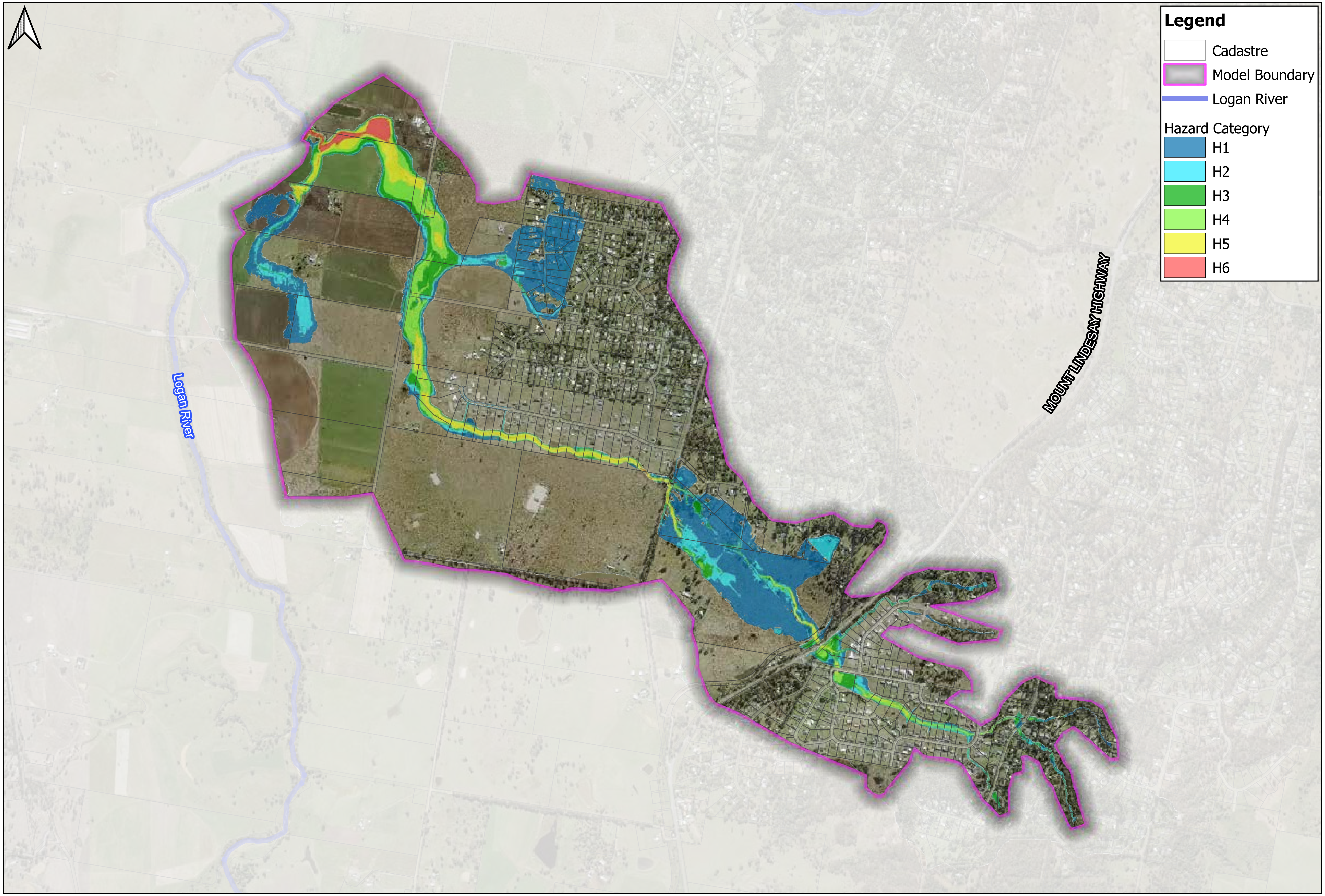
2,000 m
Days Creek Flood Study Update 2023
Days Creek - 2% AEP Peak Water Hazard Category



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Imagery Source: LCC
Water Technology Pty Ltd

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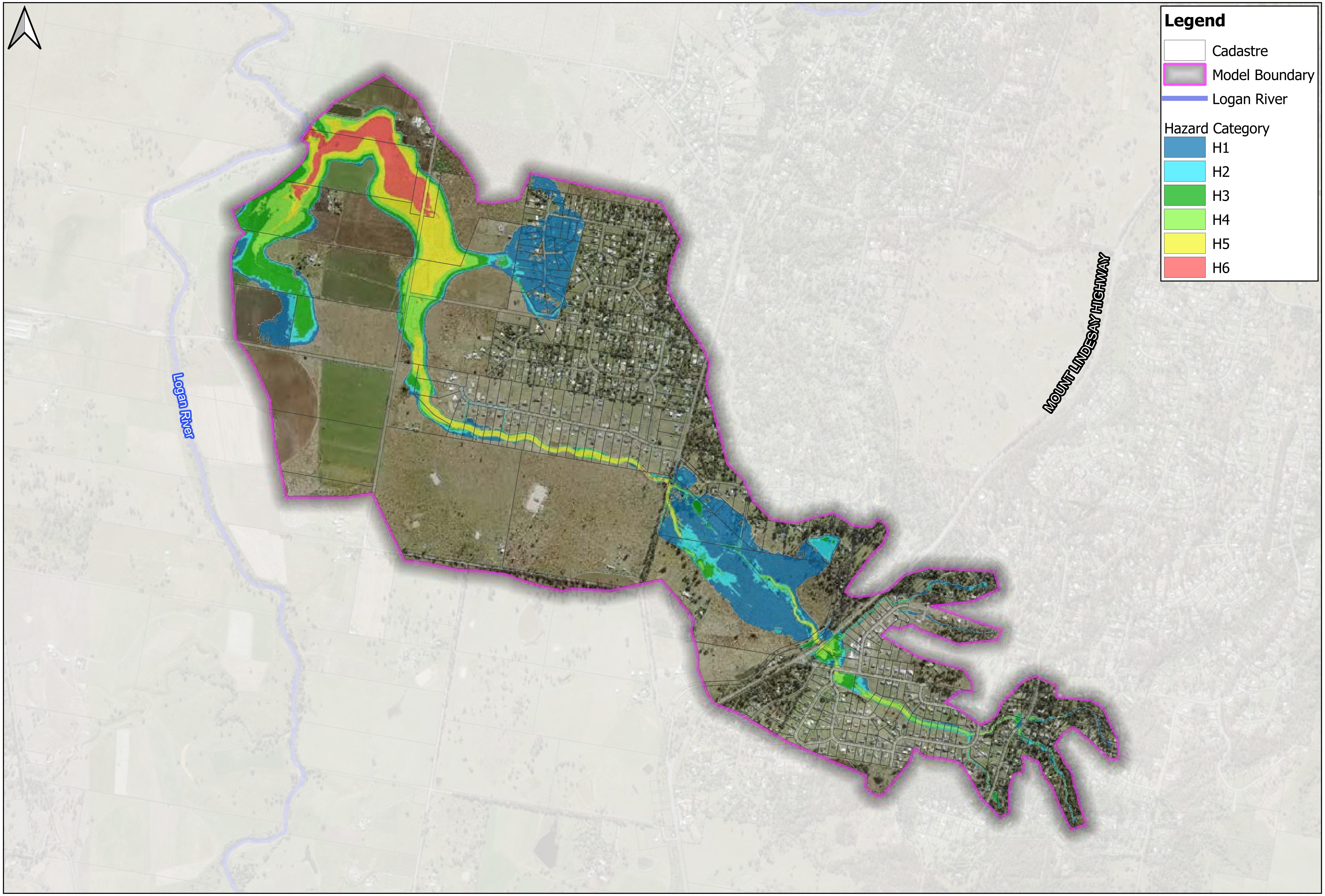
Days Creek Flood Study Update 2023

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



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Water Technology Pty Ltd

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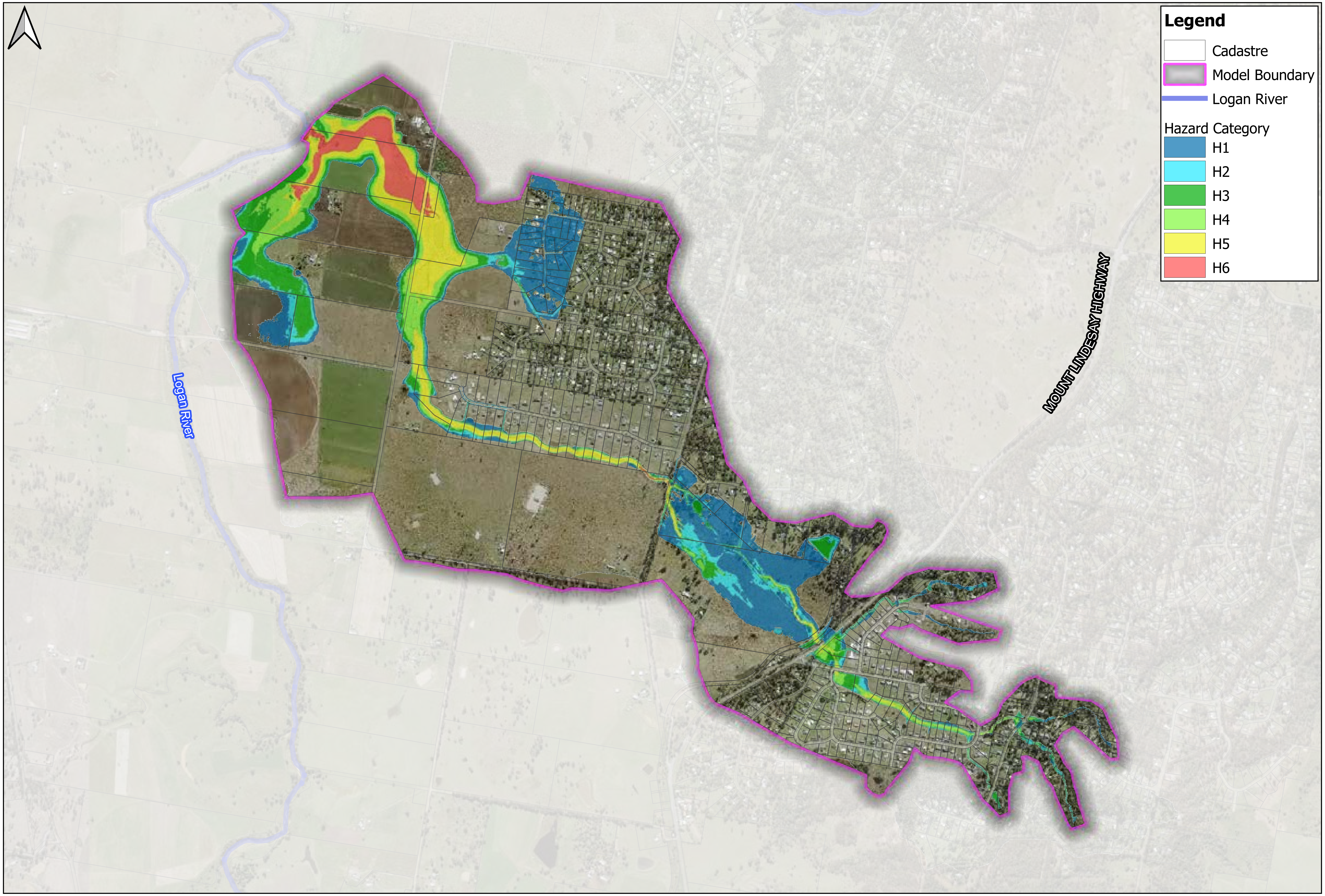
Days Creek Flood Study Update 2023

Days Creek - 1% AEP Peak Water Hazard Category



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Water Technology Pty Ltd

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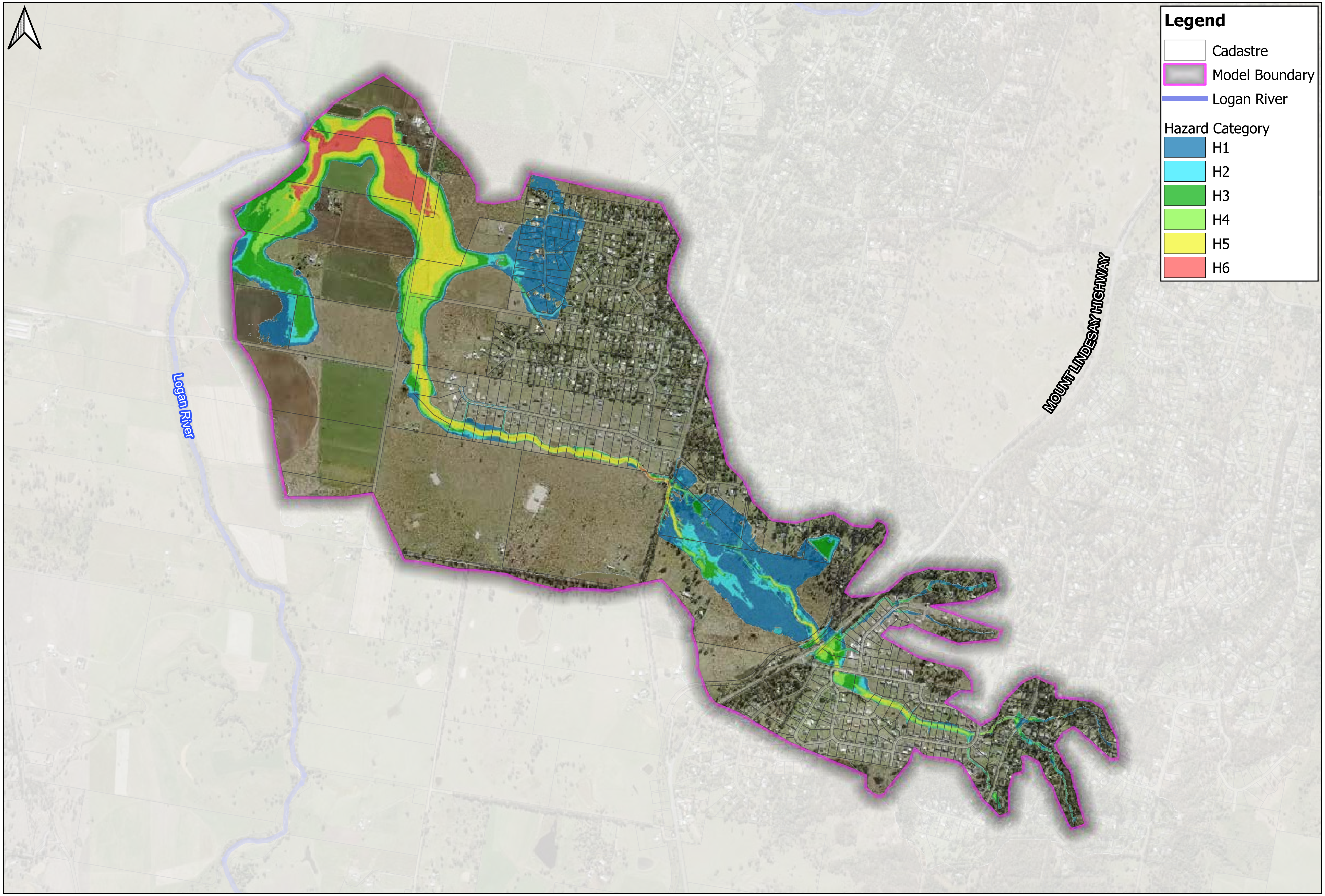
0 500 1,000 1,500 2,000 m

Days Creek Flood Study Update 2023

Days Creek - 1% AEP CC (RCP4.5) Peak Water Hazard Category



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Imagery Source: LCC
Water Technology Pty Ltd

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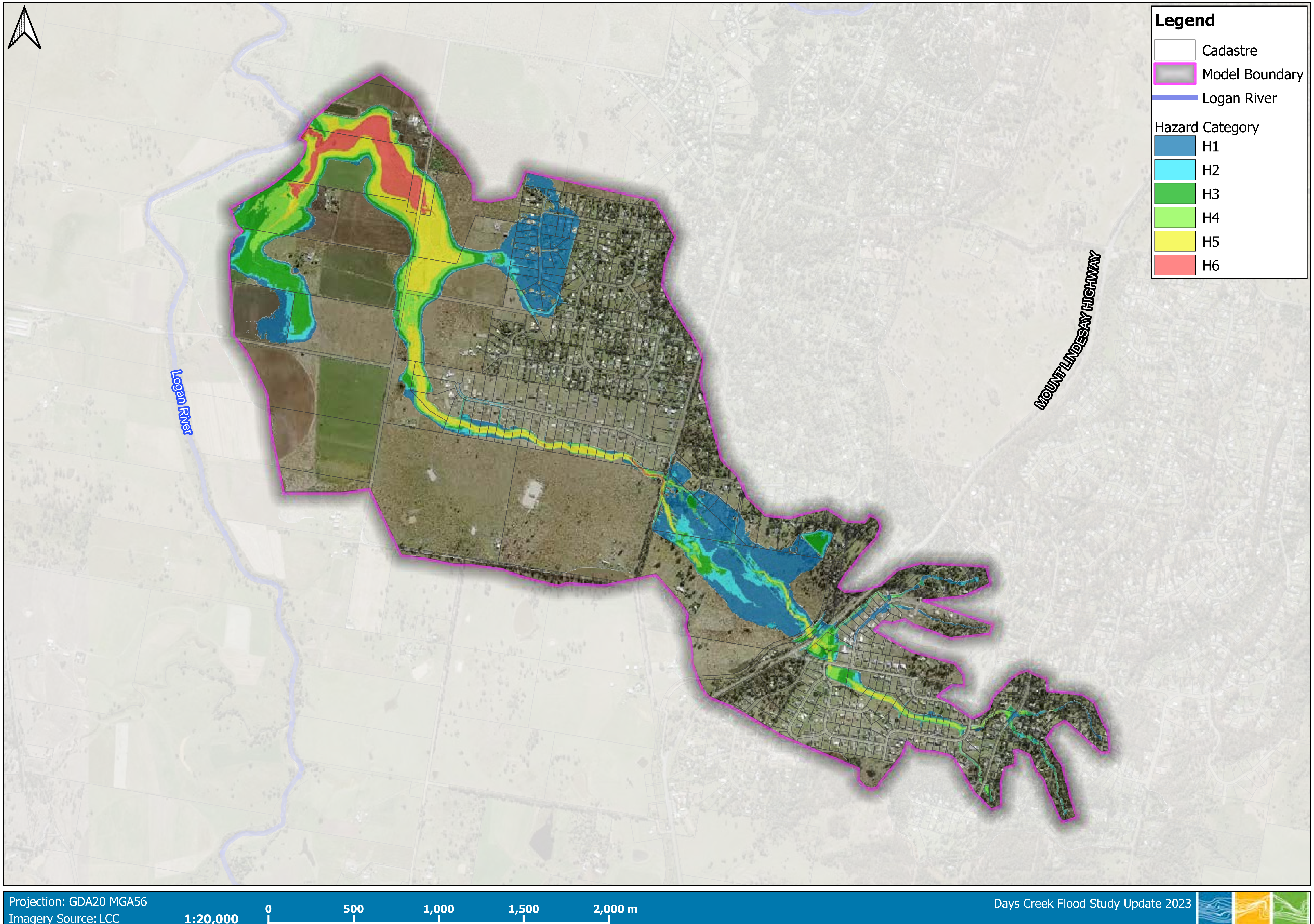
Days Creek Flood Study Update 2023

Days Creek - 0.5% AEP Peak Water Hazard Category



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Water Technology Pty Ltd

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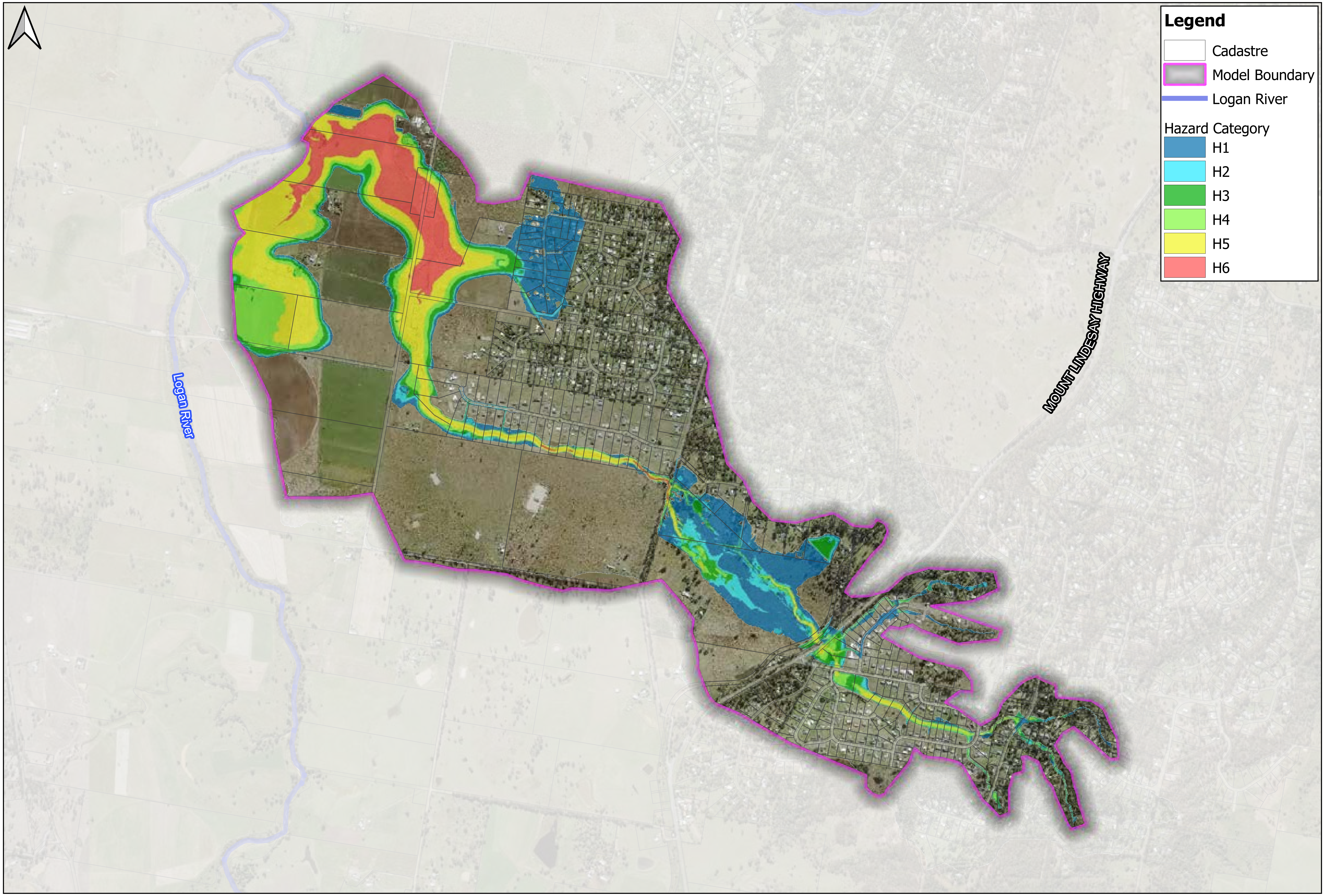
Days Creek Flood Study Update 2023

Days Creek - 0.5% AEP CC (RCP4.5) Peak Water Hazard Category



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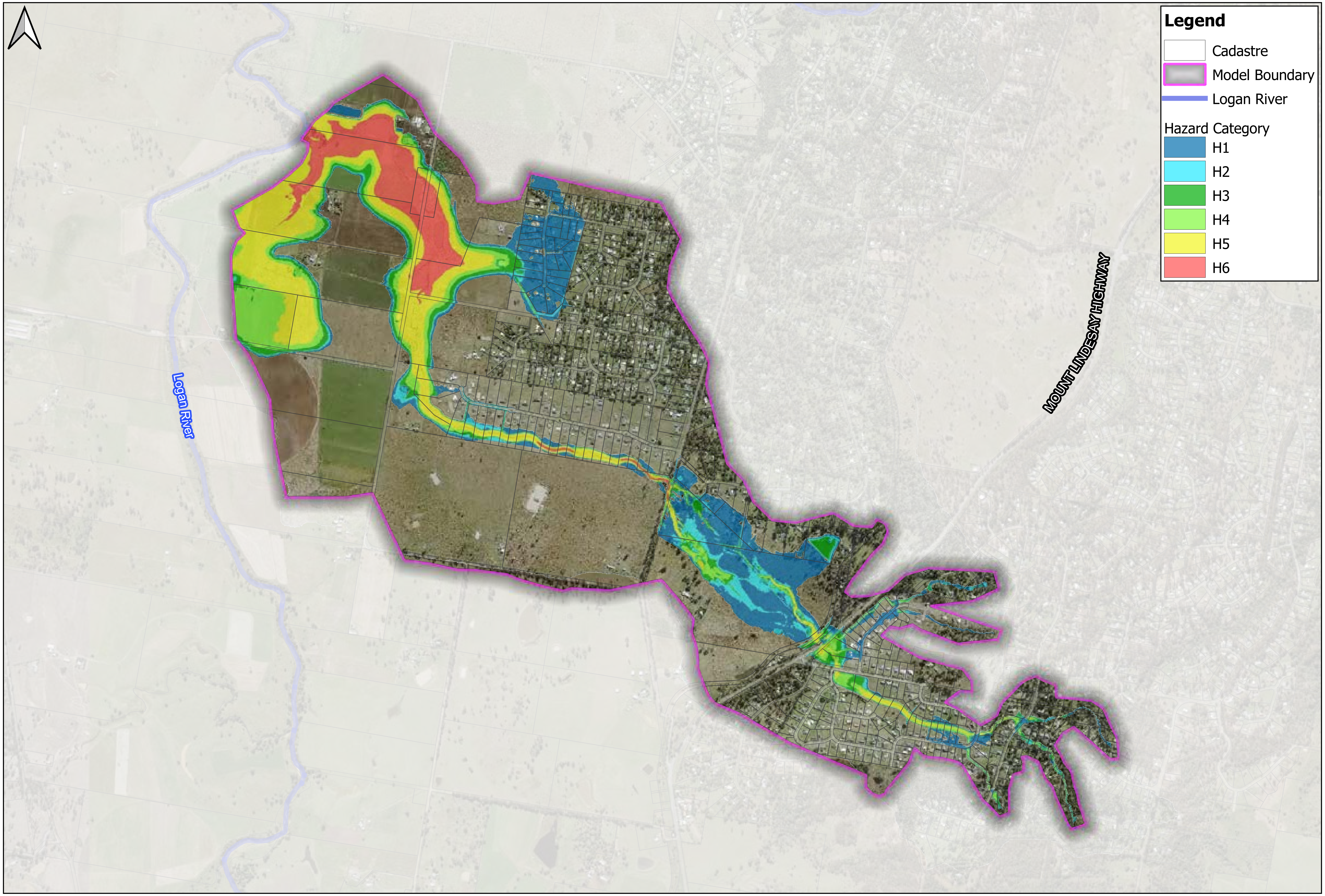
Water Technology Pty Ltd

Days Creek Flood Study Update 2023

Days Creek - 0.2% AEP Peak Water Hazard Category



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Water Technology Pty Ltd

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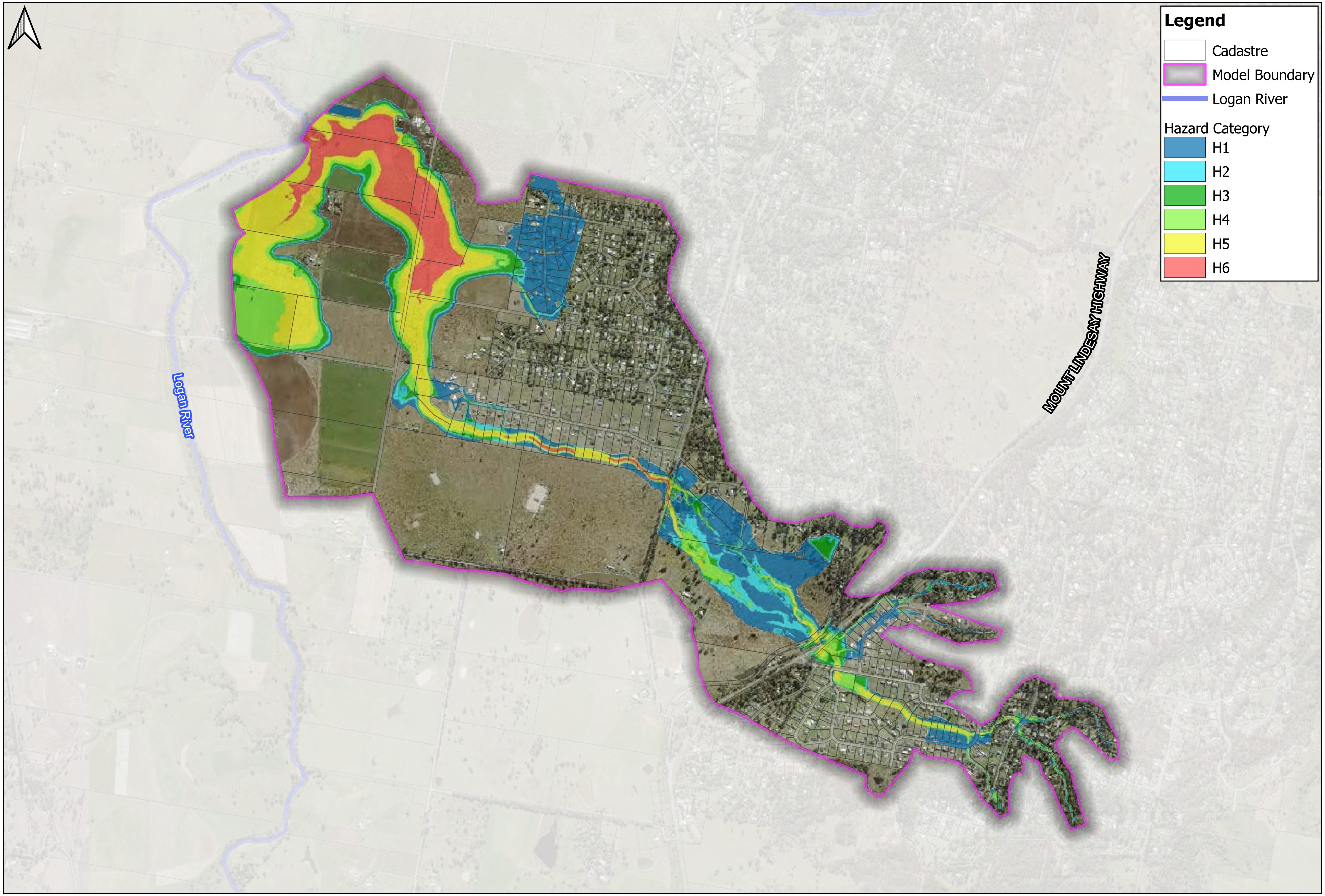
Days Creek Flood Study Update 2023

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



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Imagery Source: LCC
Water Technology Pty Ltd

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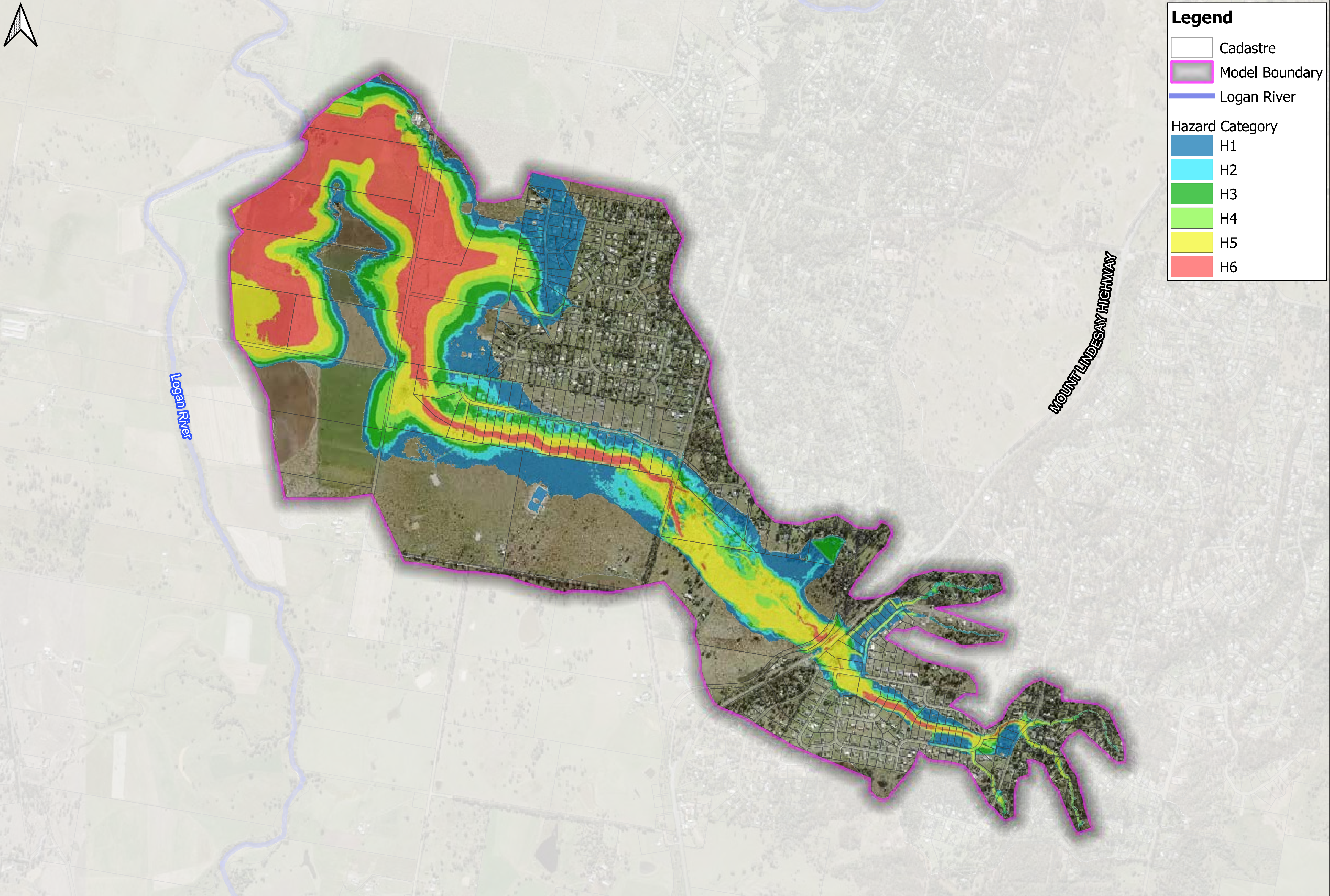
Days Creek Flood Study Update 2023

Days Creek - 0.05% AEP Peak Water Hazard Category

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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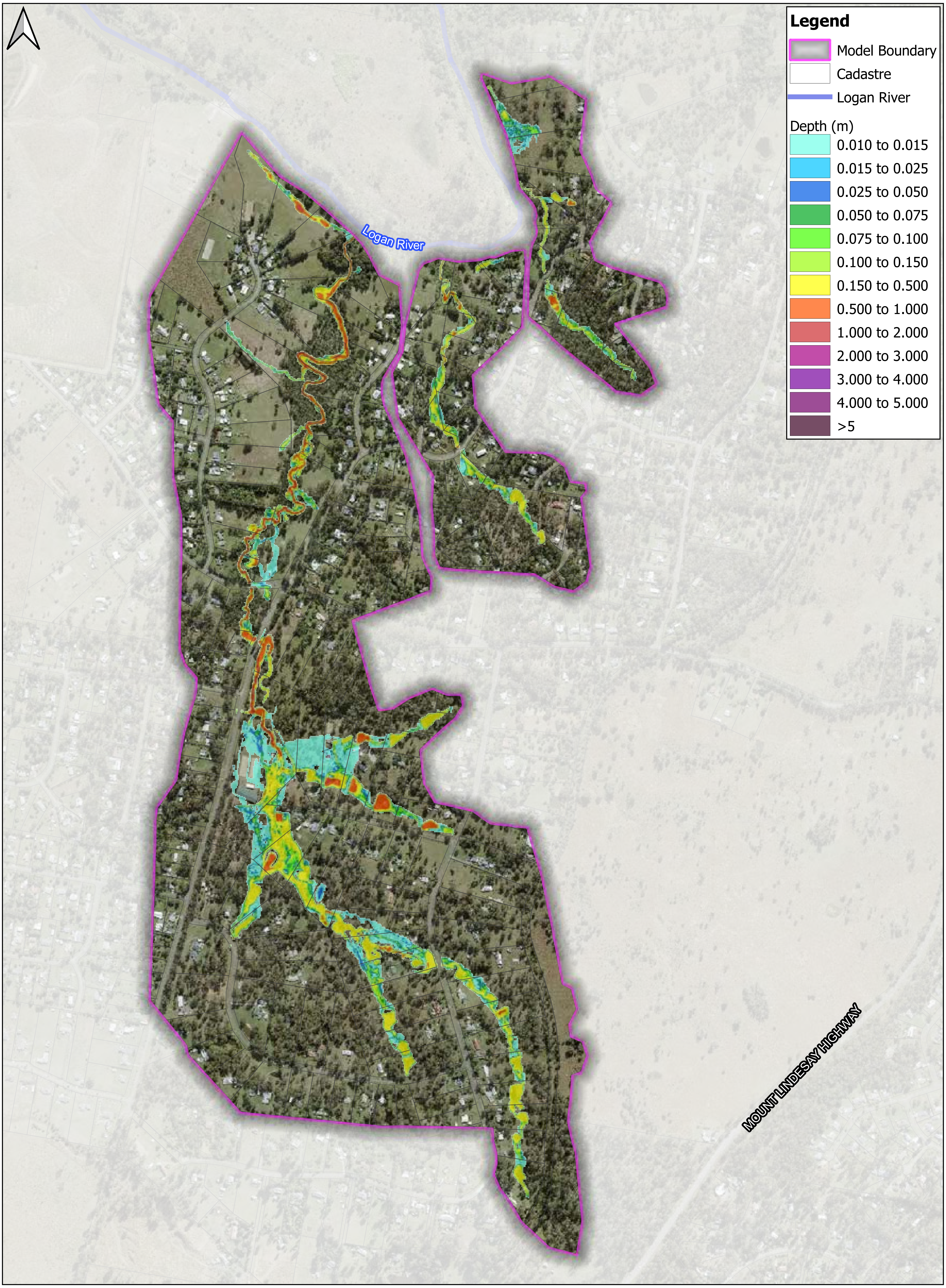
Days Creek Flood Study Update 2023

Days Creek - PMF Peak Water Hazard Category

APPENDIX F
ROBERTS WATERHOLE HYDRAULIC MODEL CRITICAL DURATION GIS MAPS



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

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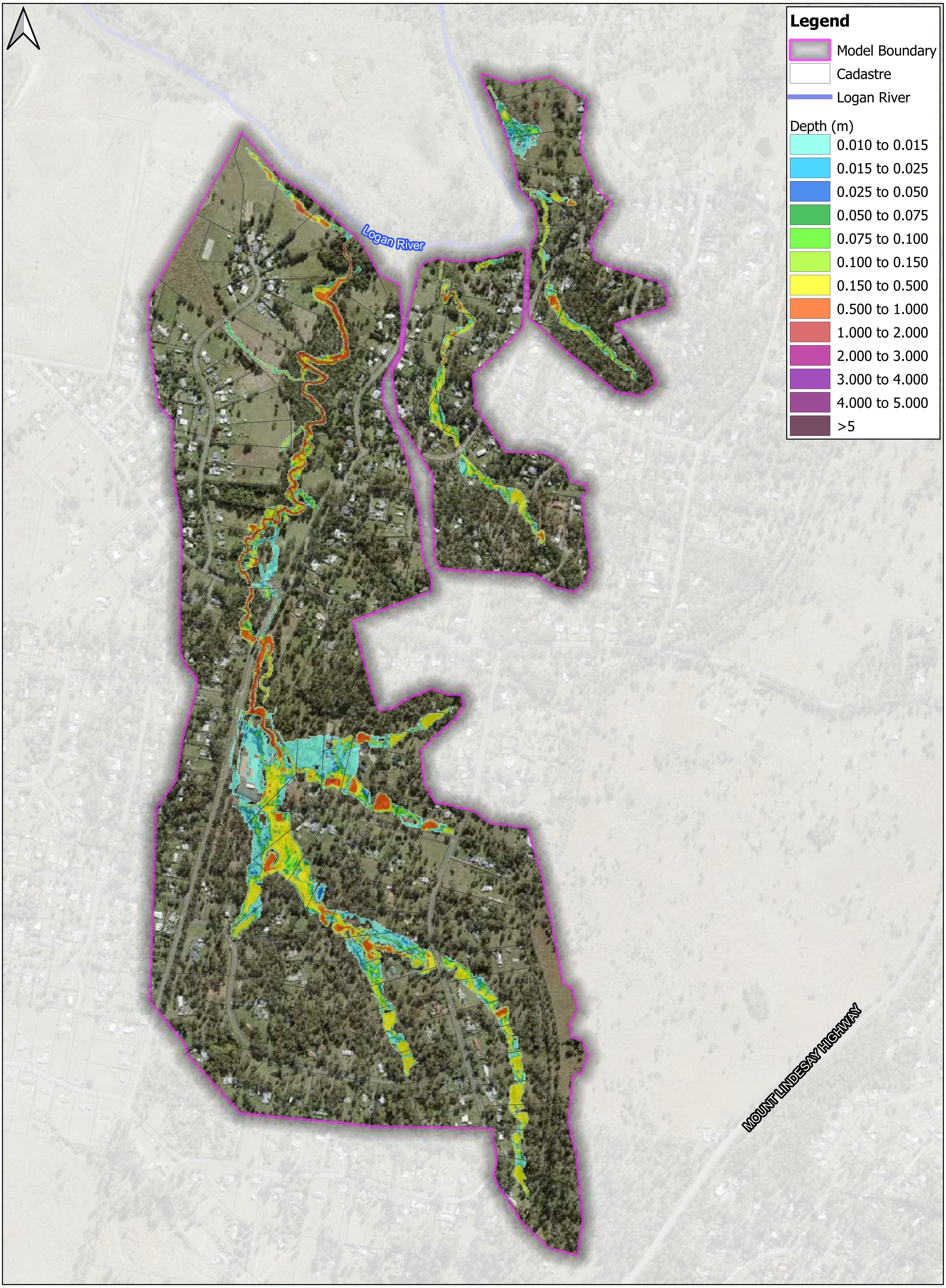
Days Creek Flood Study Update 2023

Robert's Waterhole - 63.2% AEP Peak Water Depth

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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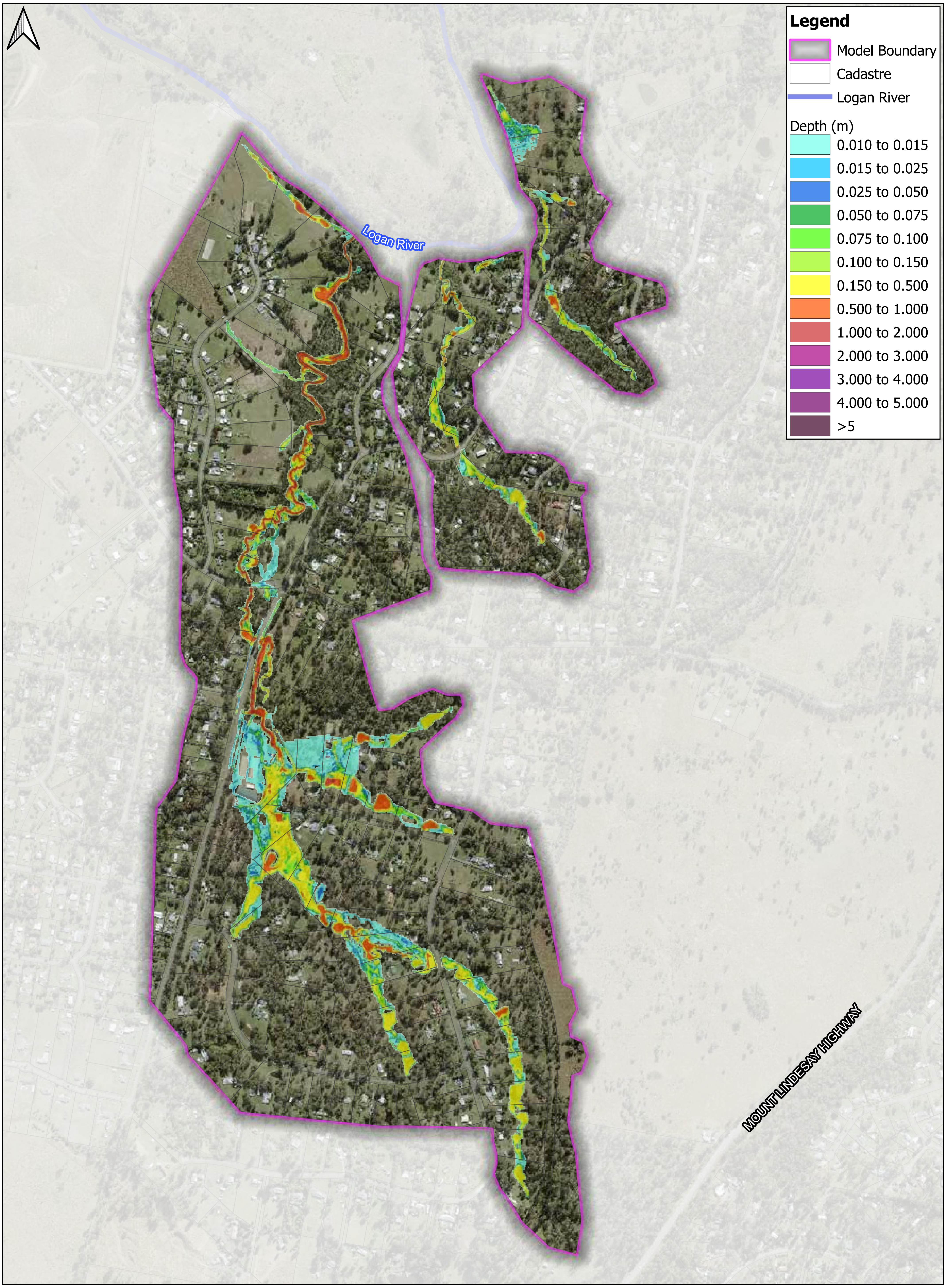
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd
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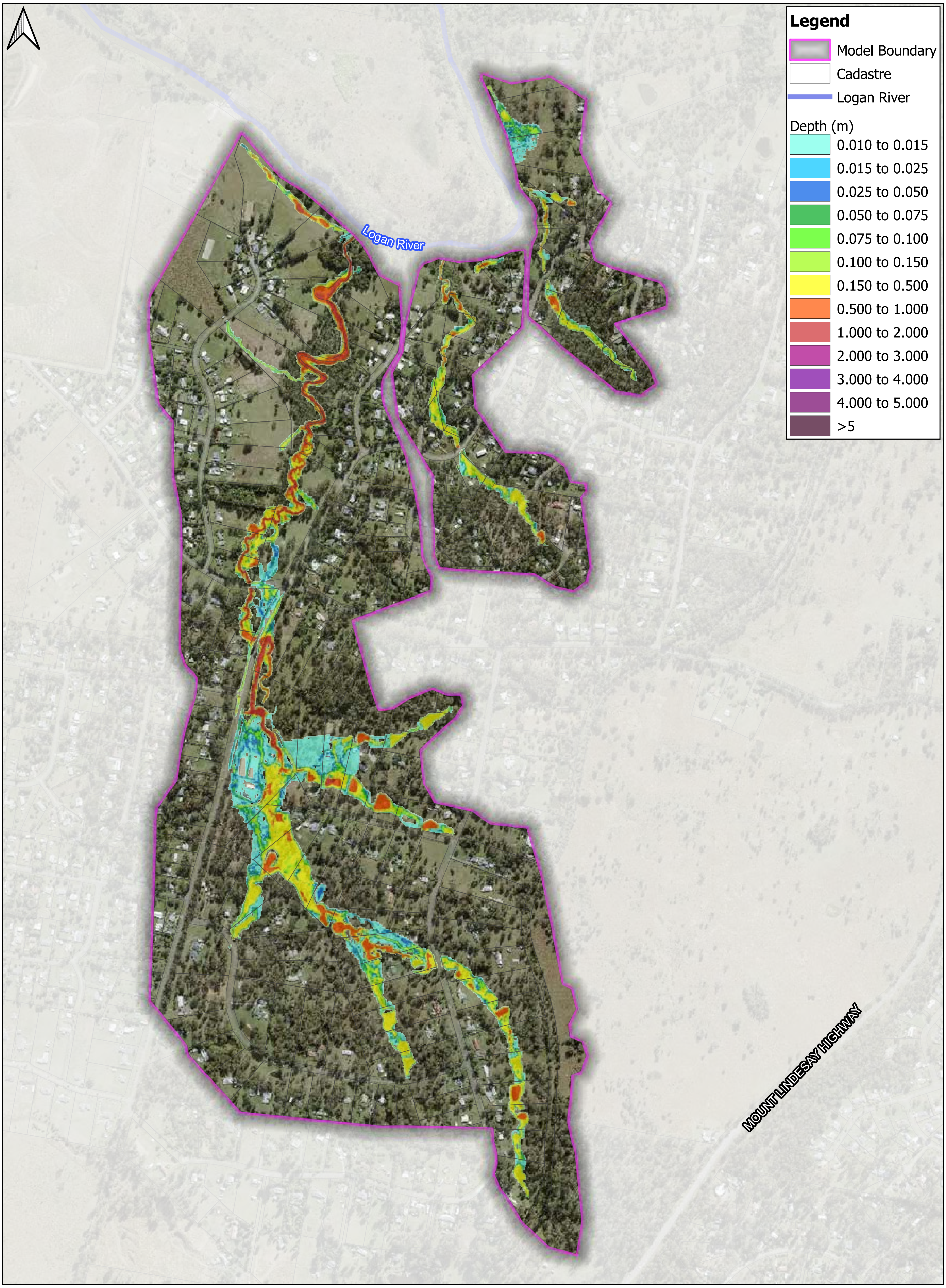
Days Creek Flood Study Update 2023
Roberts Waterhole - 50% AEP CC (RCP4.5) Peak Water Depth



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Imagery Source: LCC
Water Technology Pty Ltd

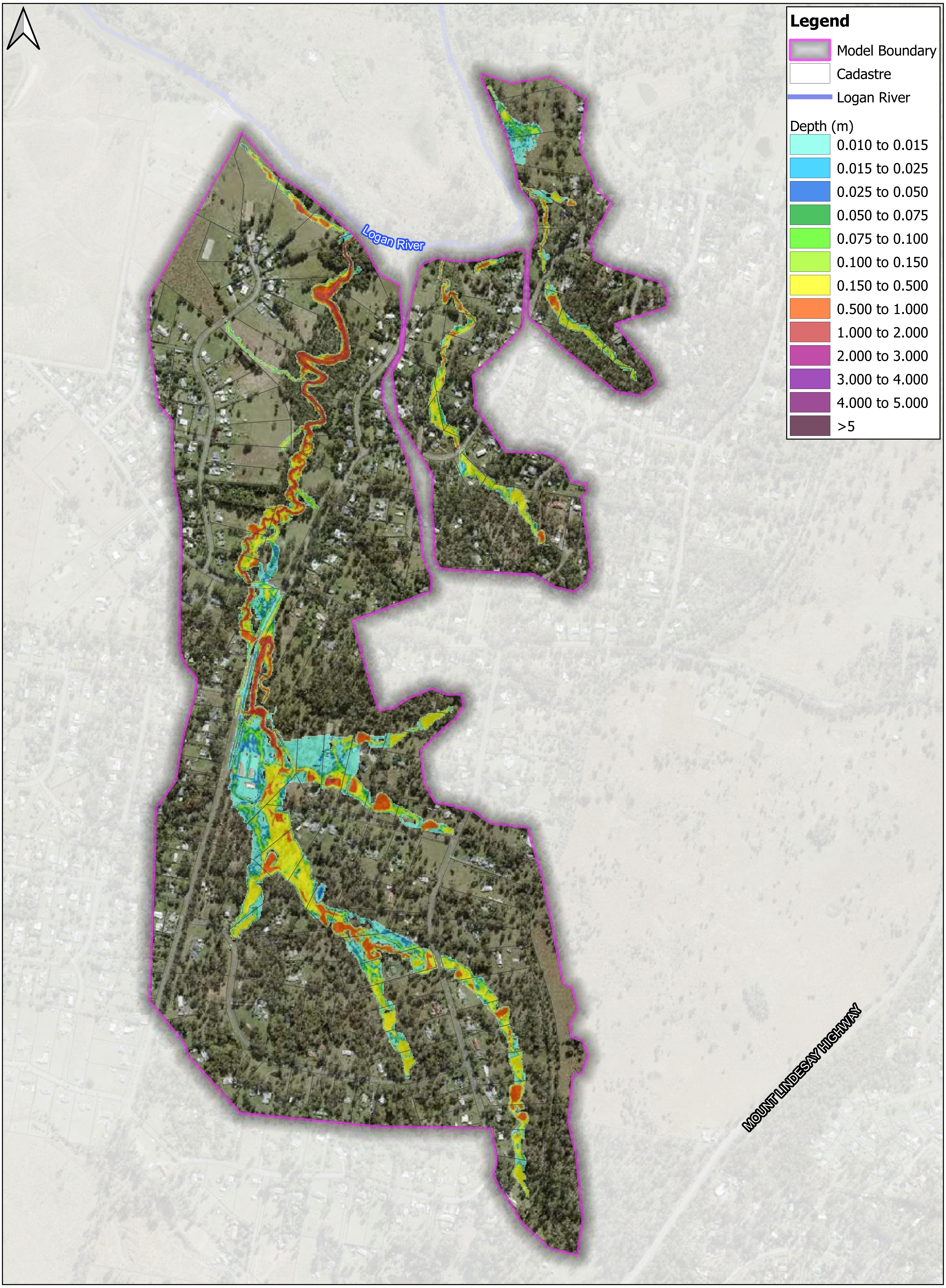
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

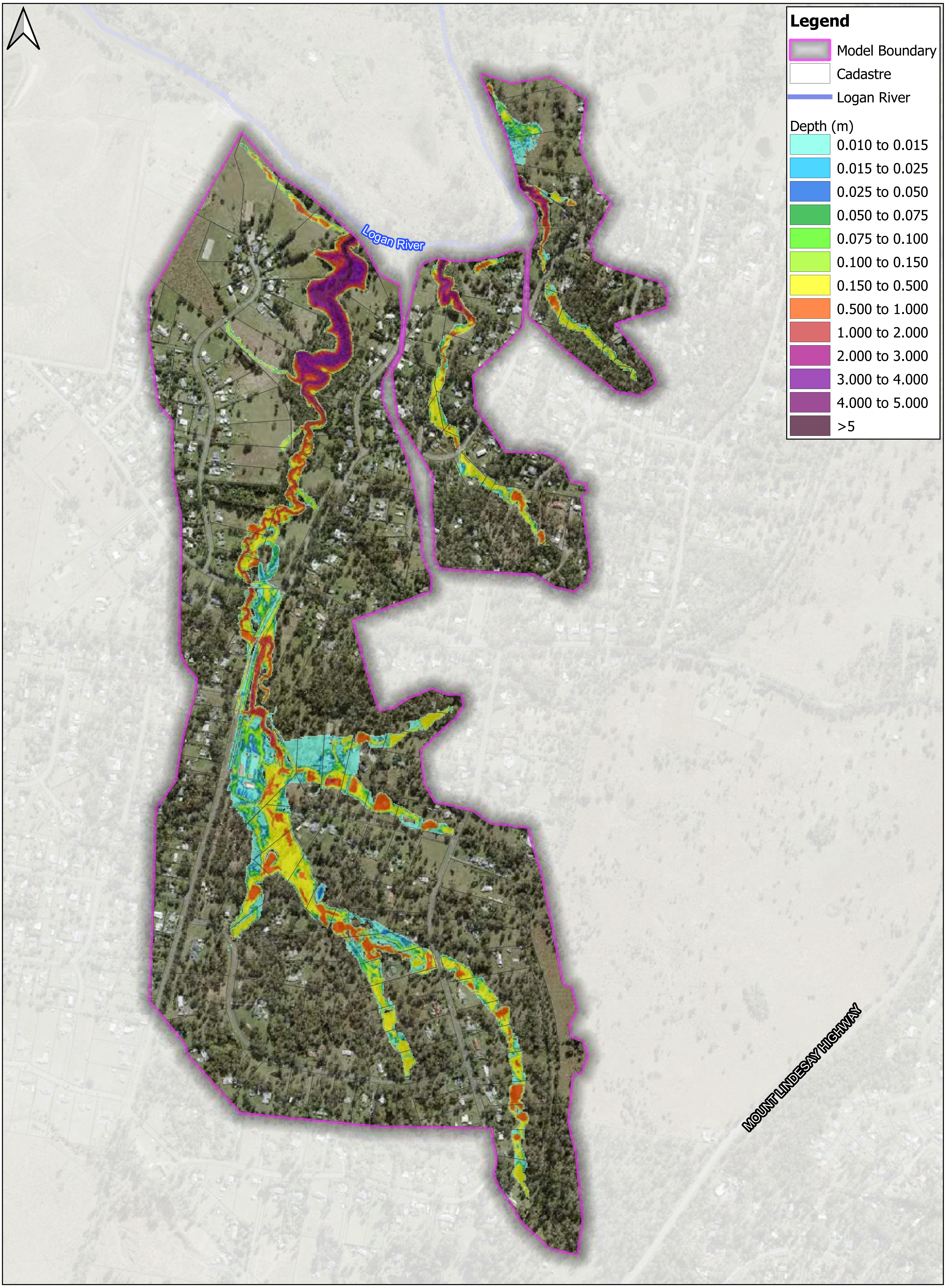
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

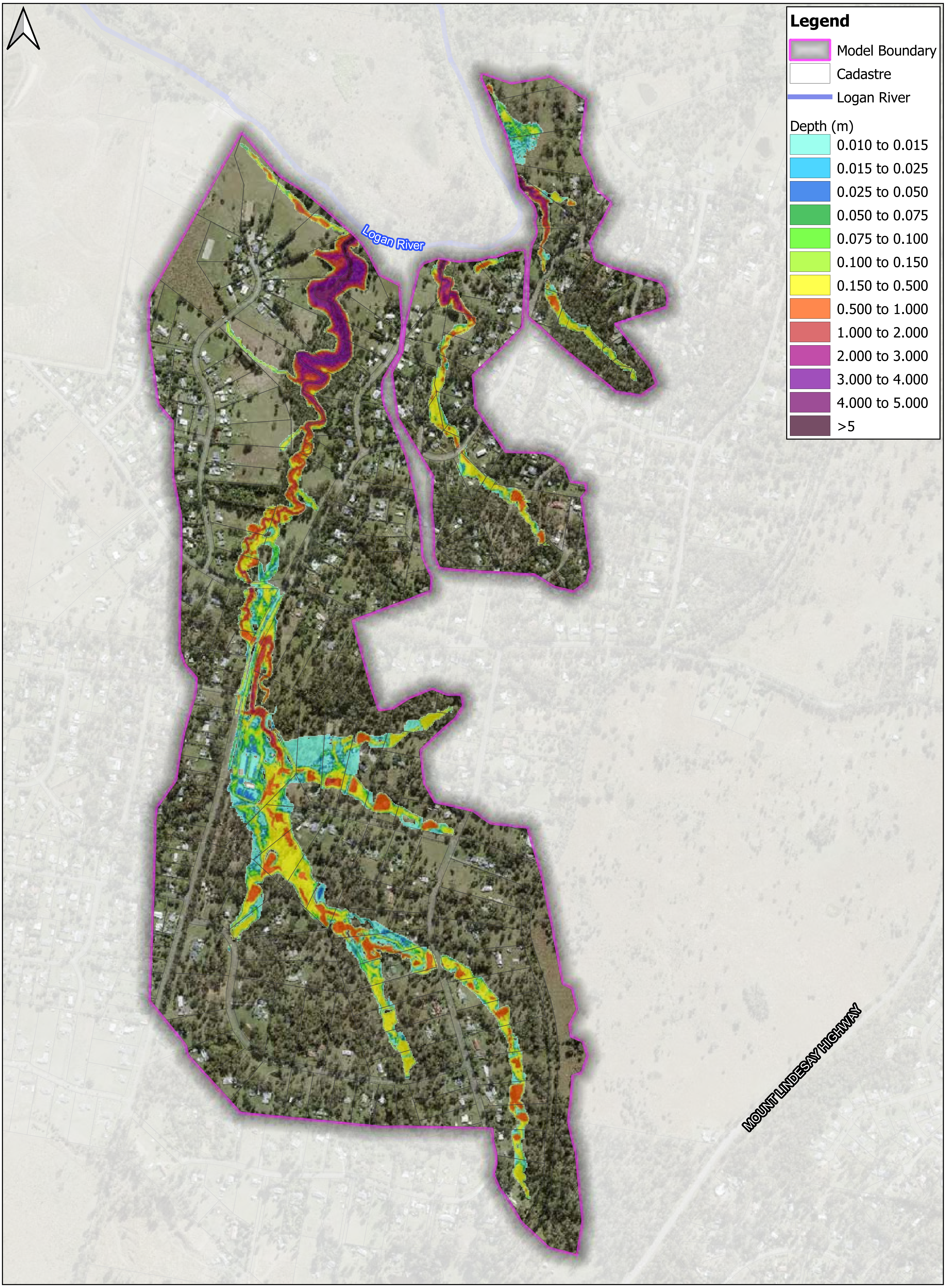
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

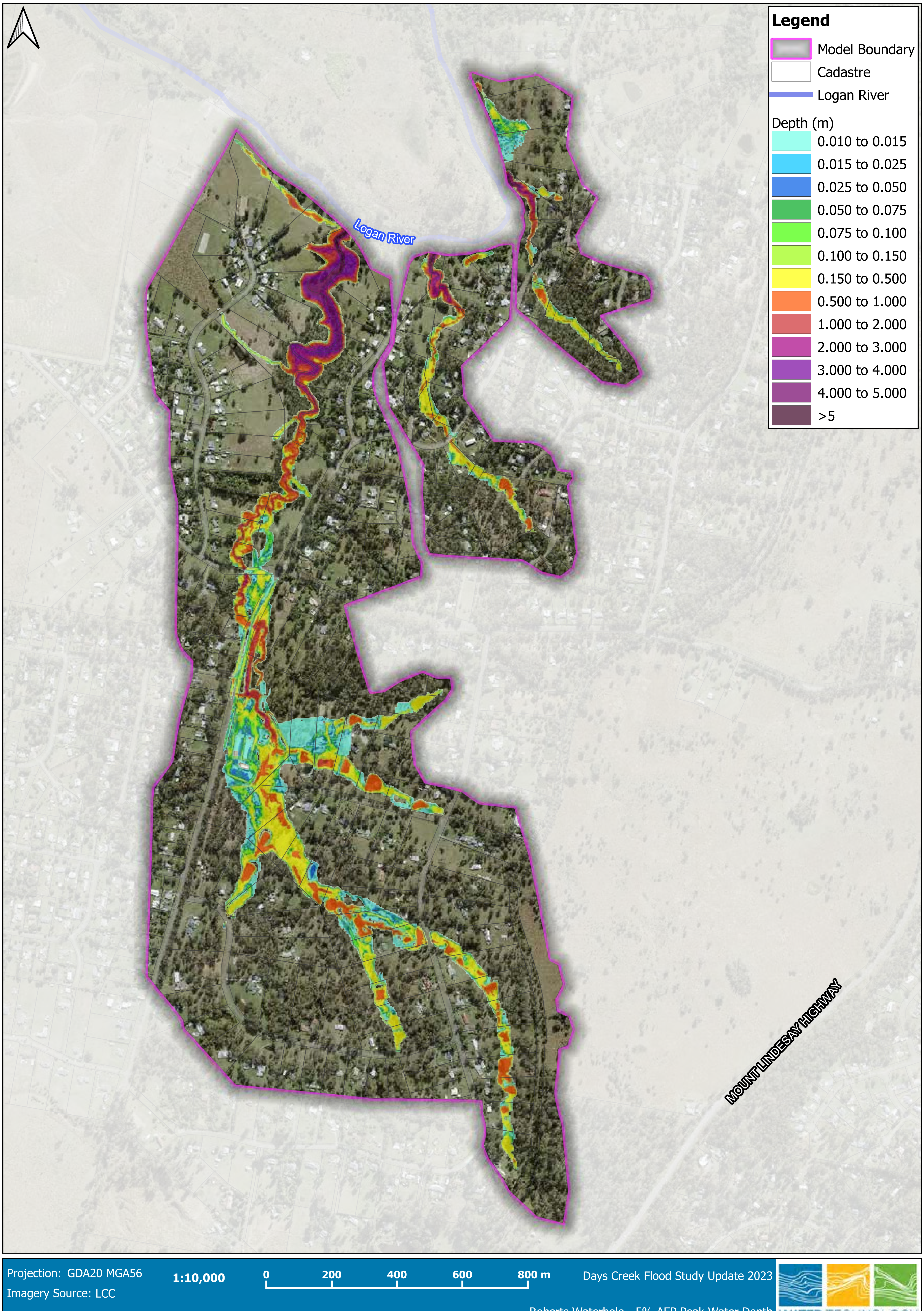
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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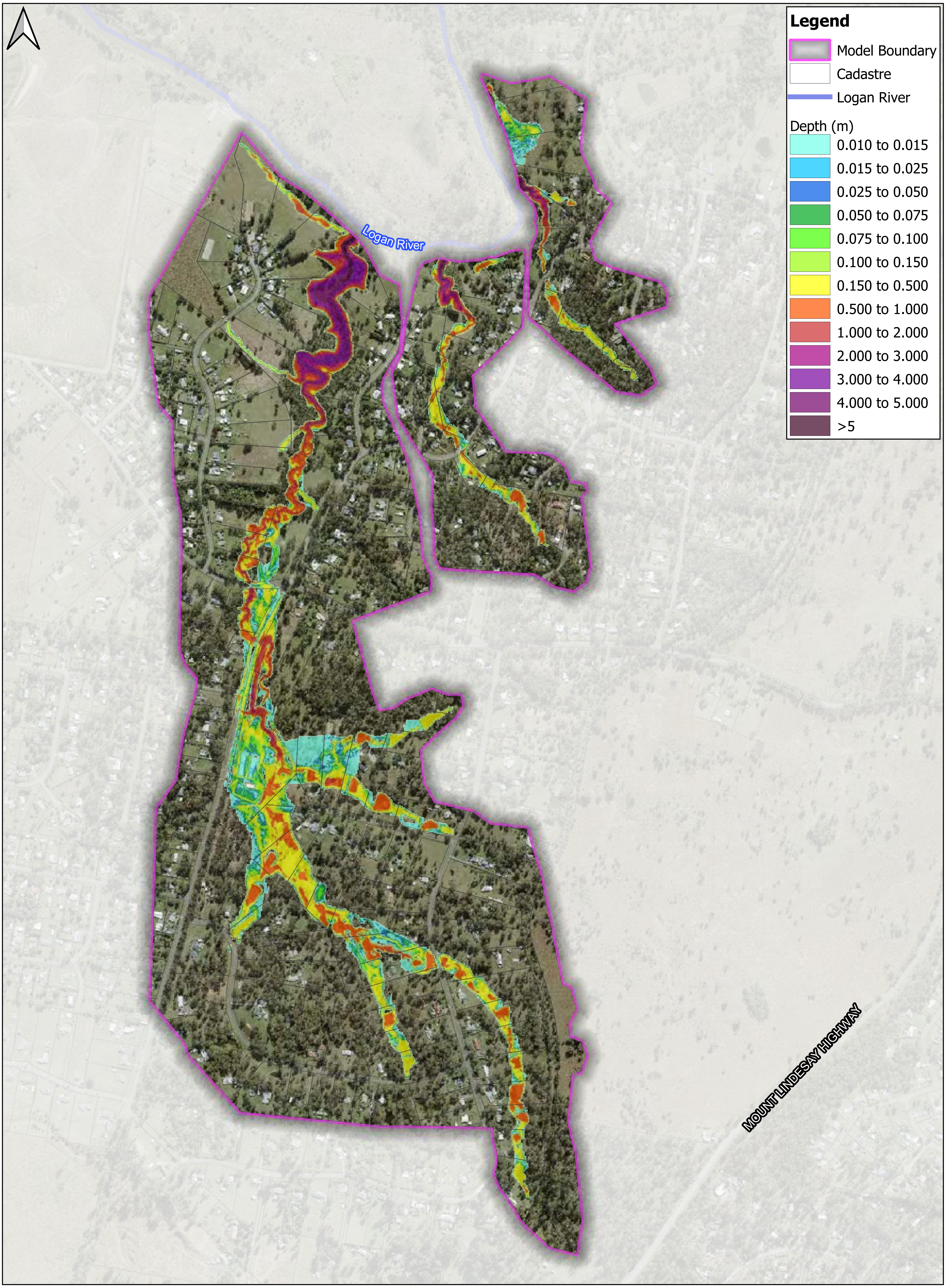
Imagery Source: LCC
Water Technology Pty Ltd

Days Creek Flood Study Update 2023
Roberts Waterhole - 5% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

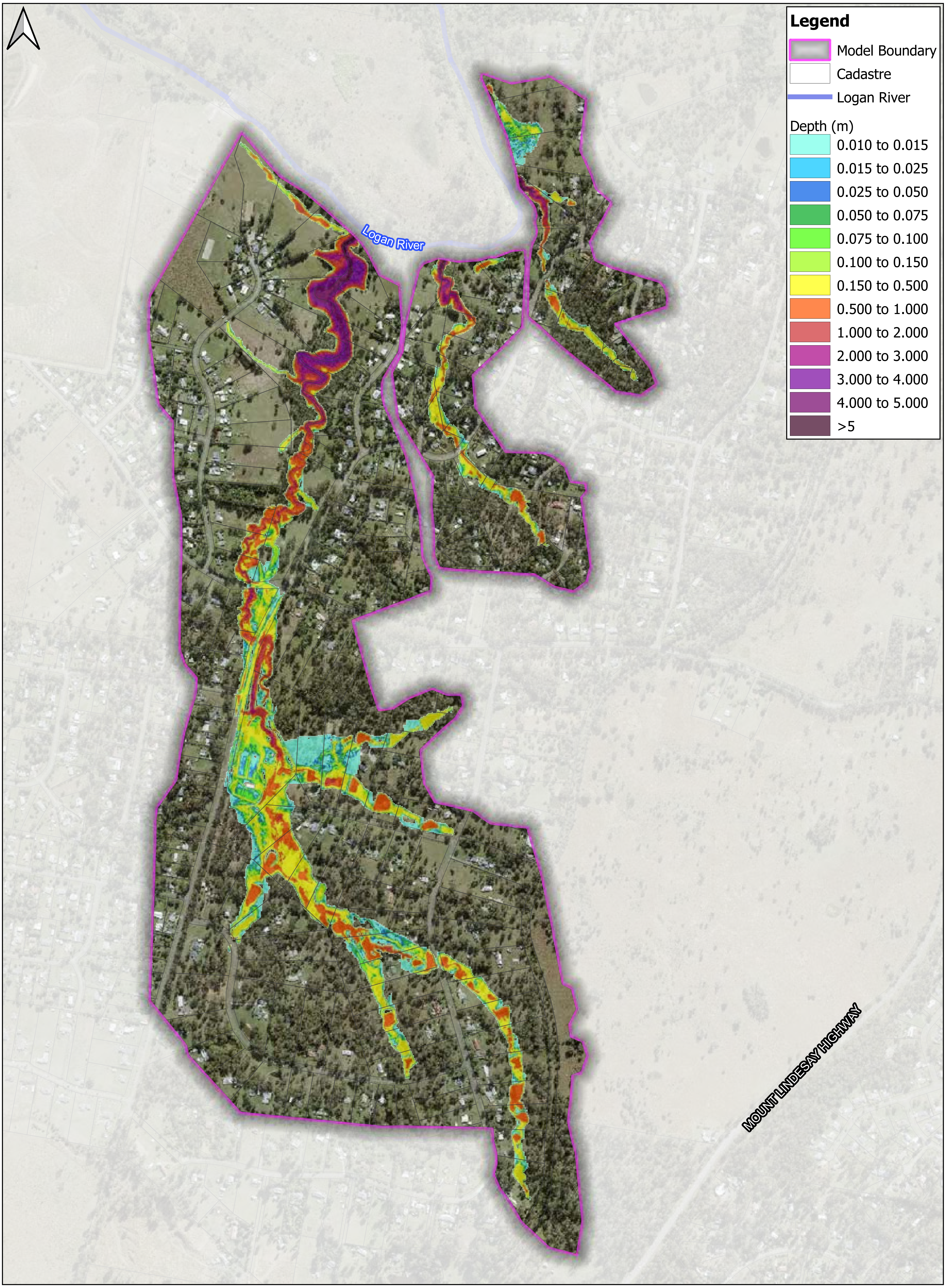
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 5% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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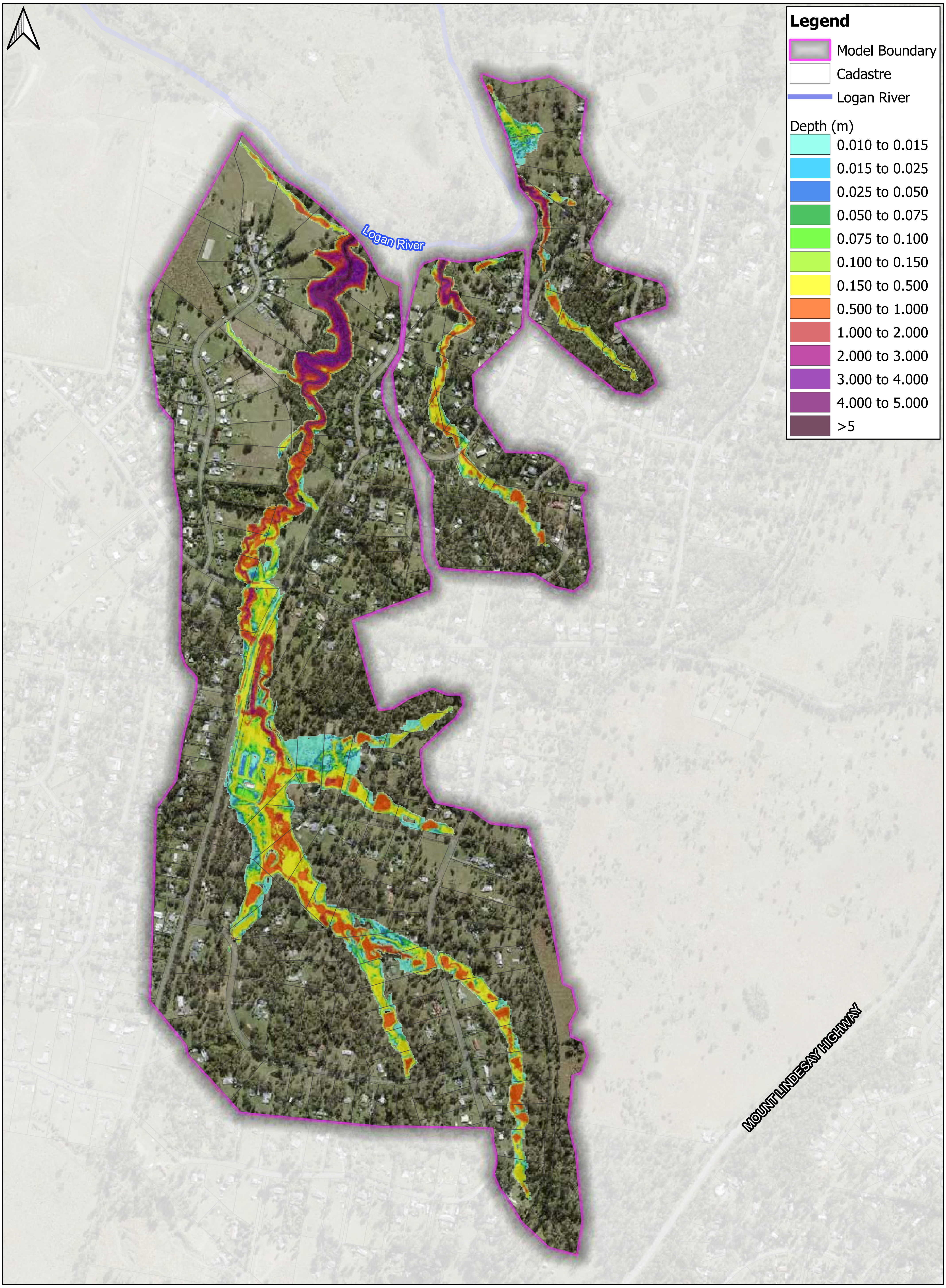
Days Creek Flood Study Update 2023

Roberts Waterhole - 2% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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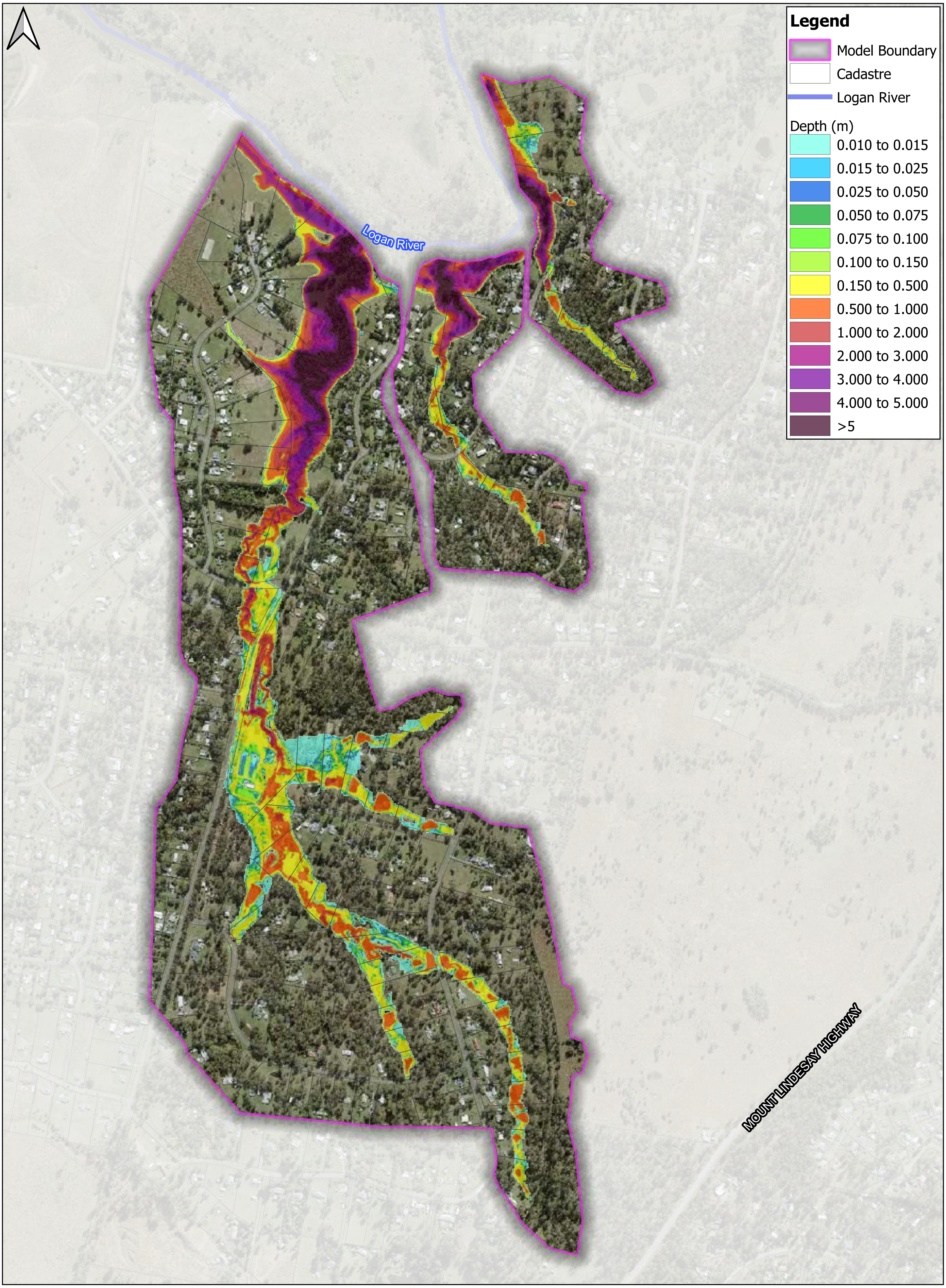
Days Creek Flood Study Update 2023

Roberts Waterhole - 2% AEP CC (RCP4.5) Peak Water Depth

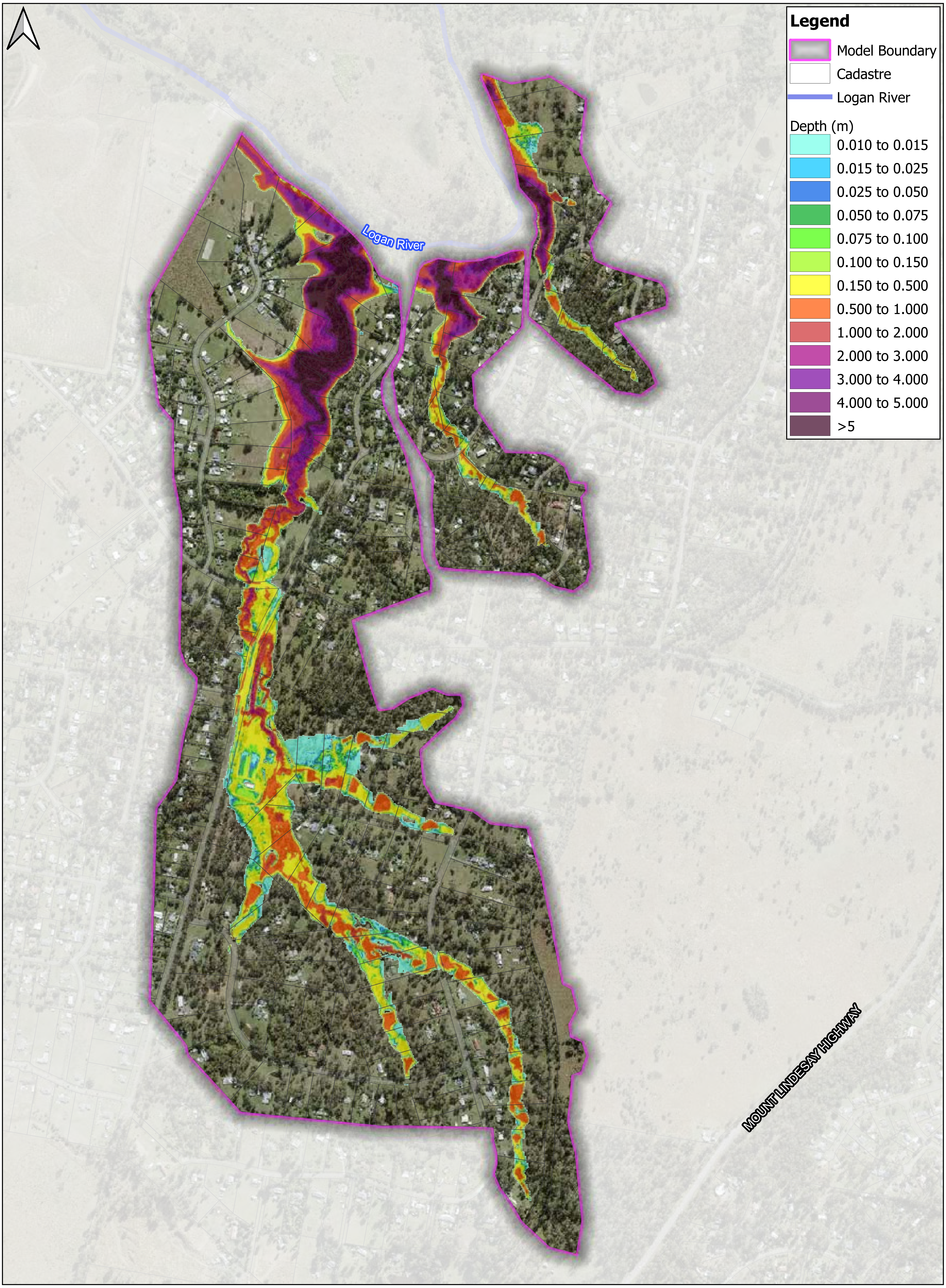


Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

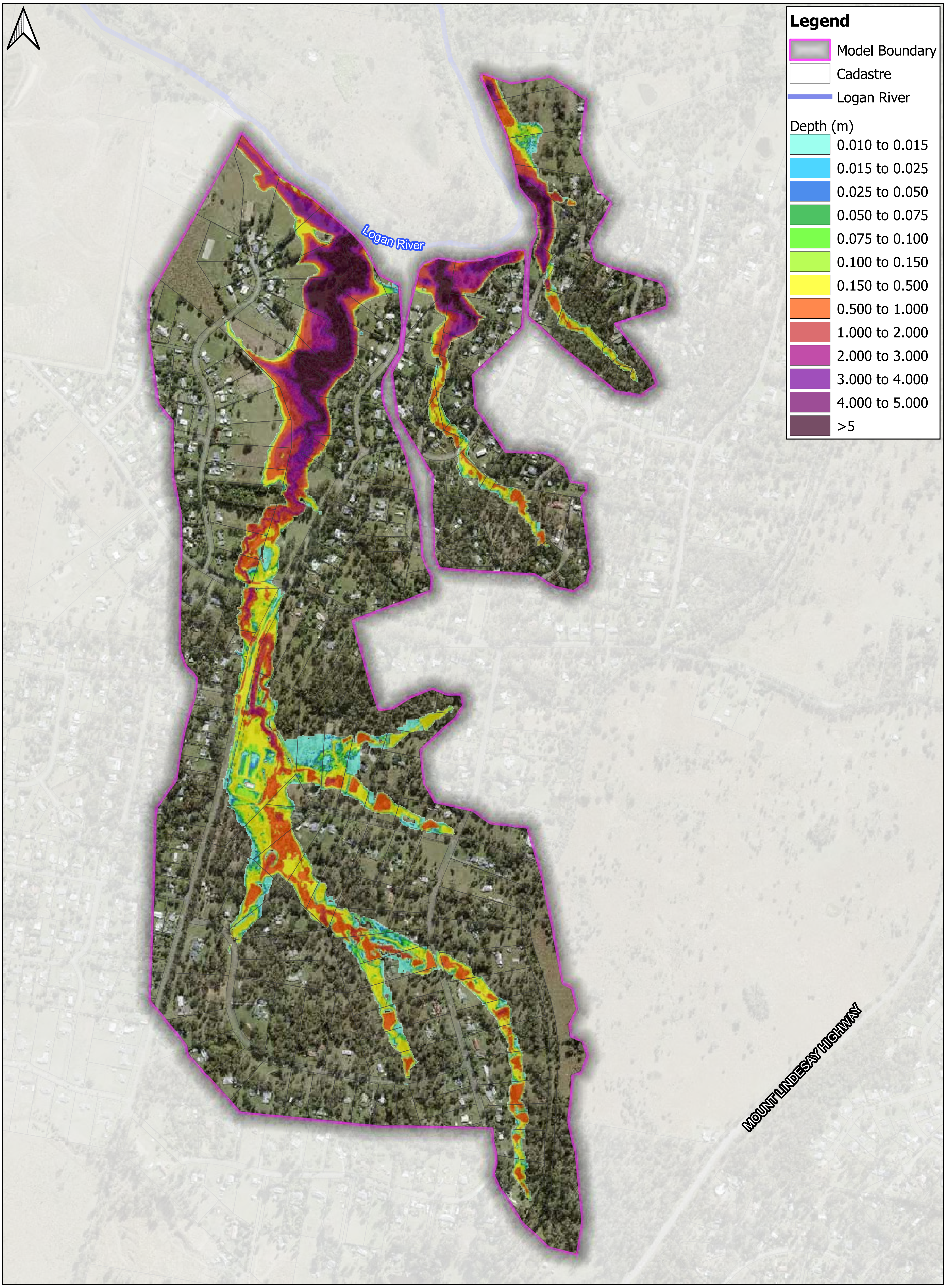
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP CC (RCP4.5) Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

1:10,000

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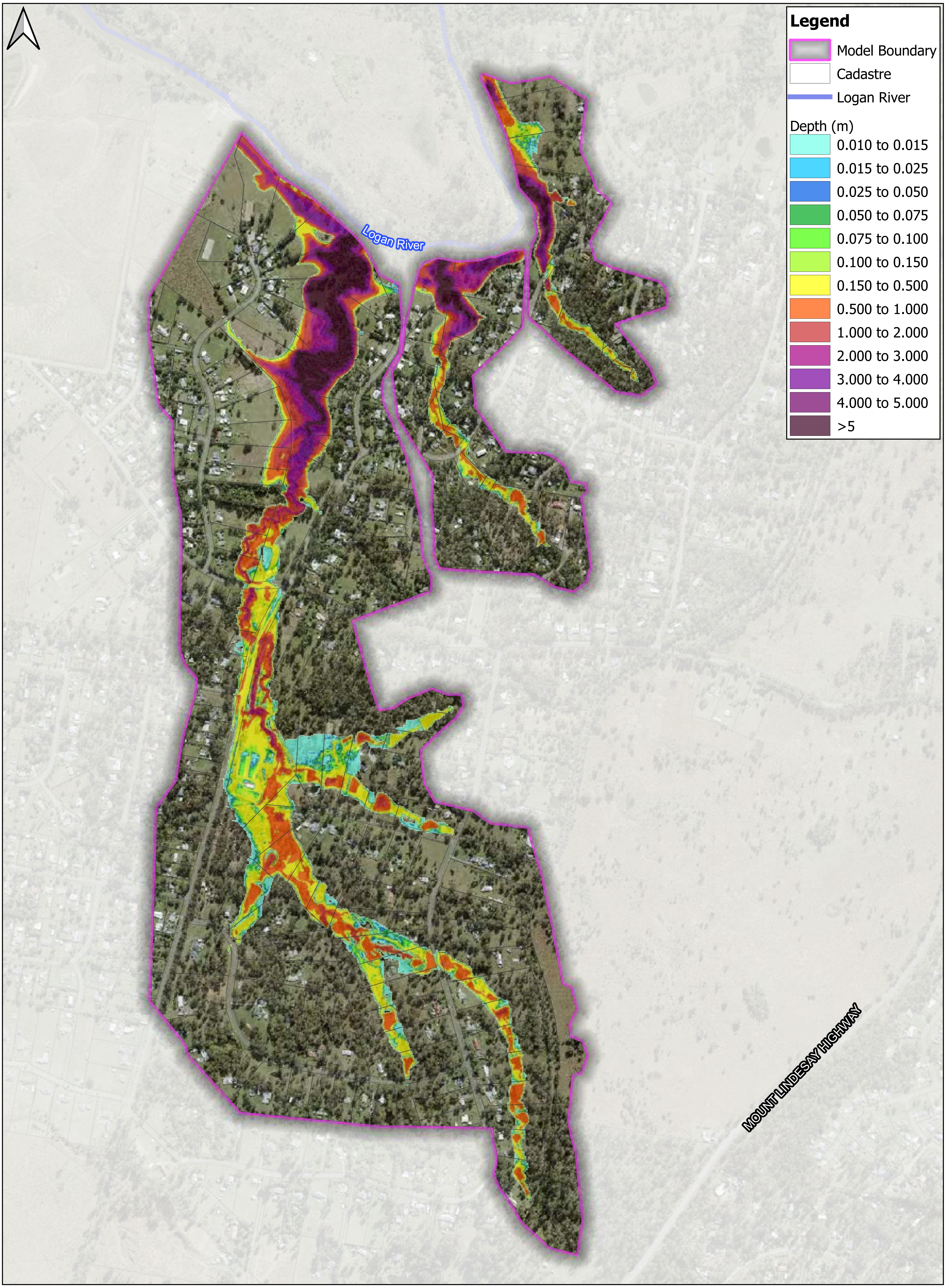
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.5% AEP Peak Water Depth



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Water Technology Pty Ltd

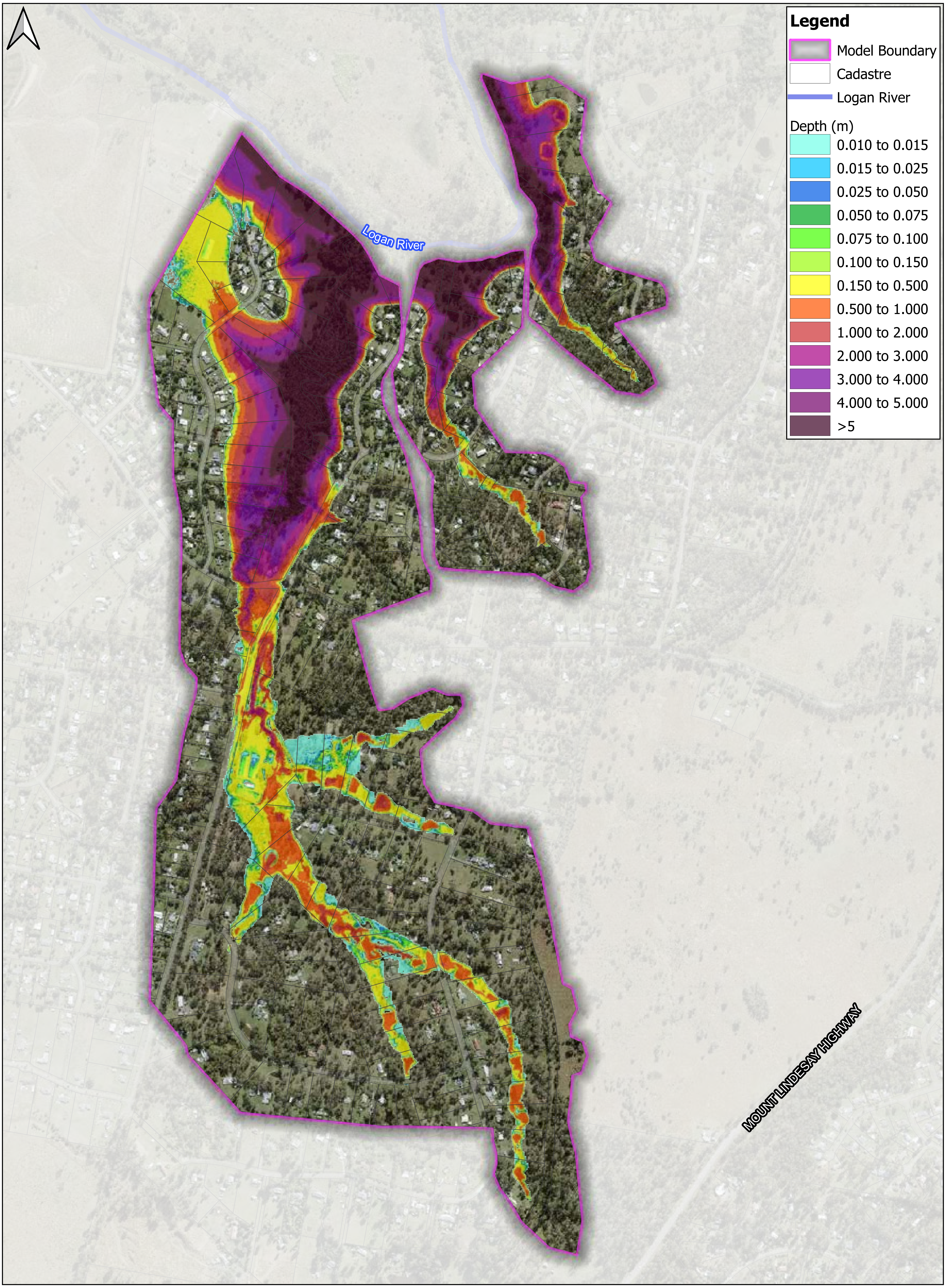
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

1:10,000

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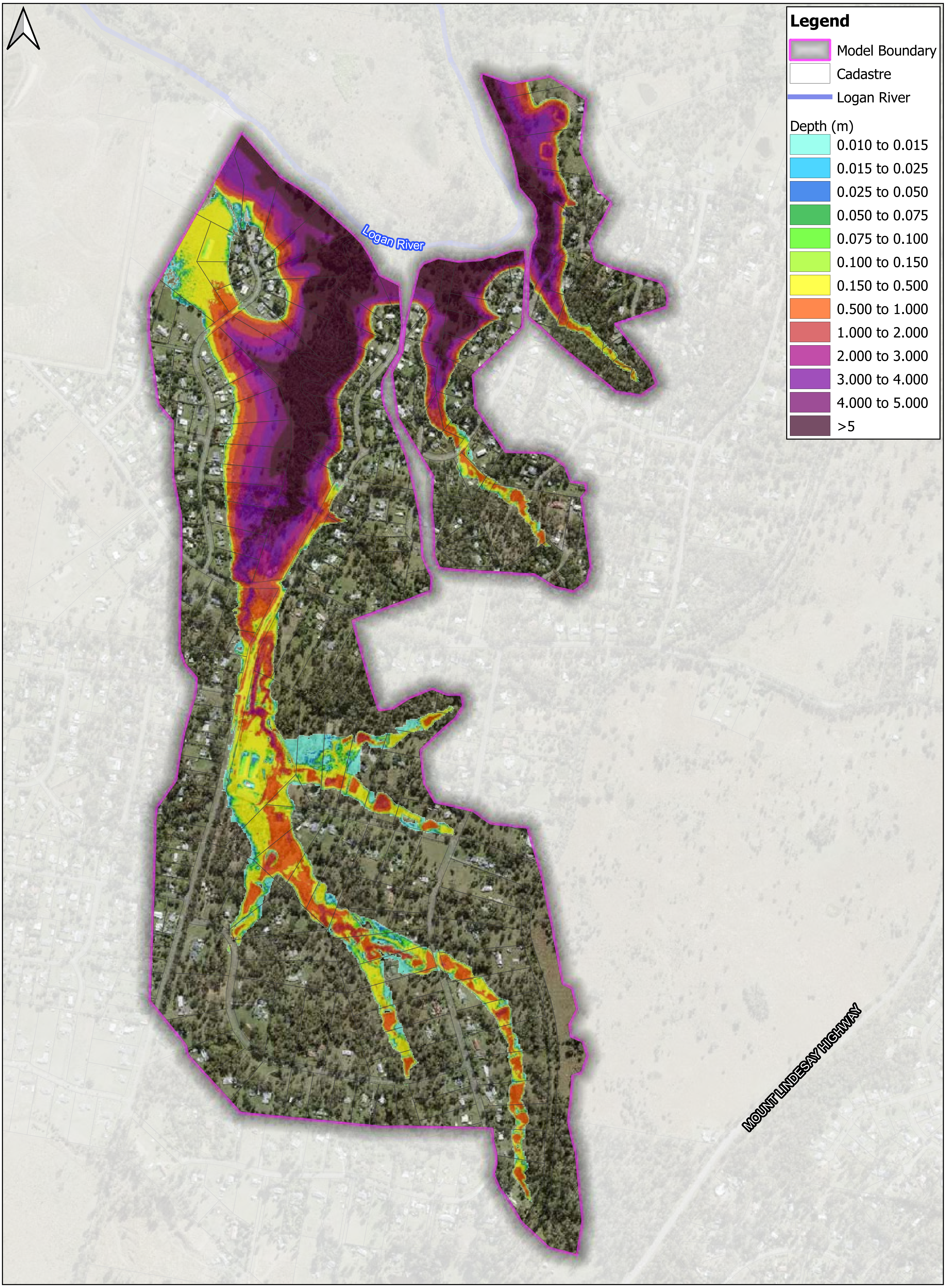
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.2% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



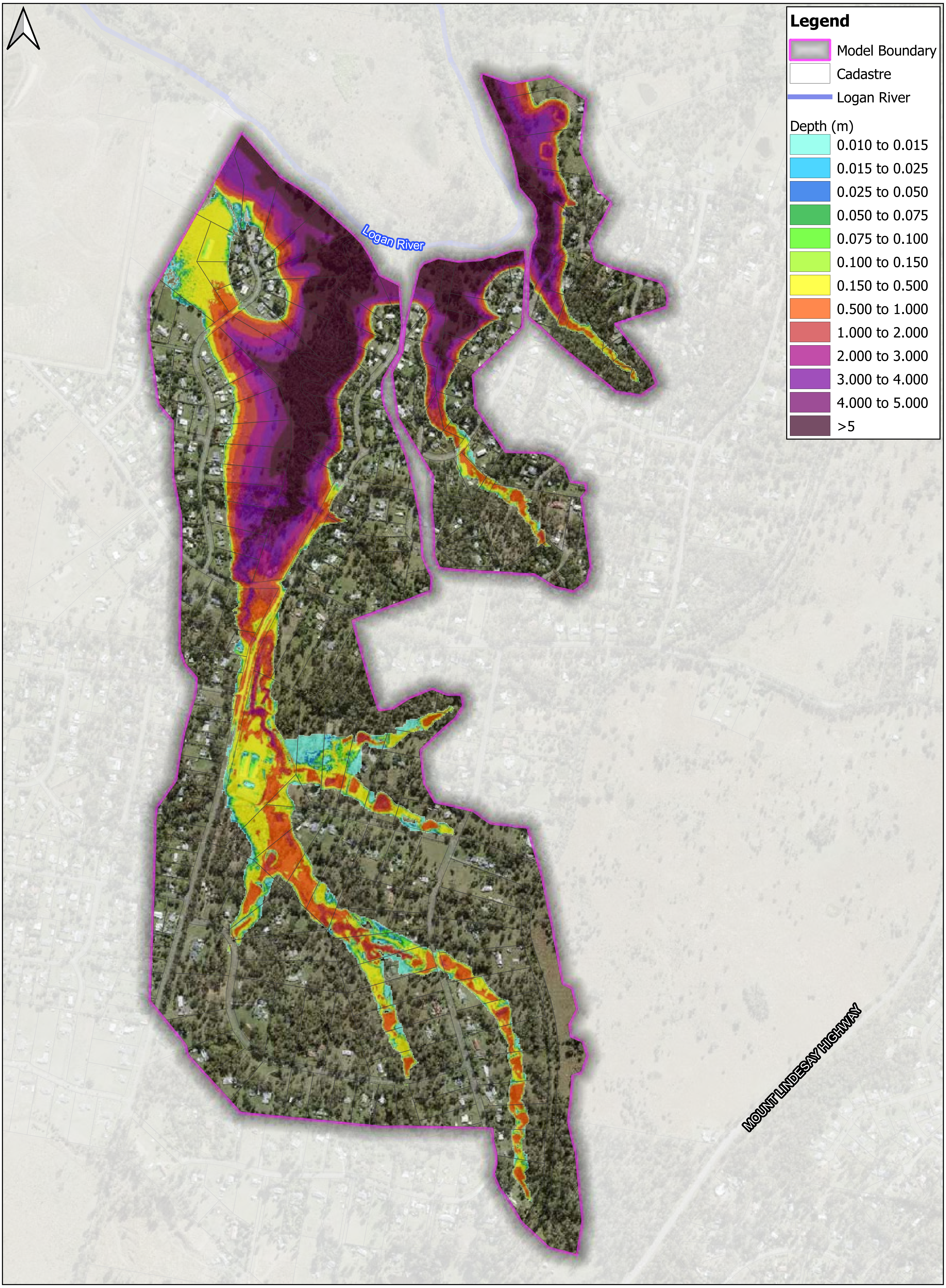
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 0.2% AEP CC (RCP4.5) Peak Water Depth



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

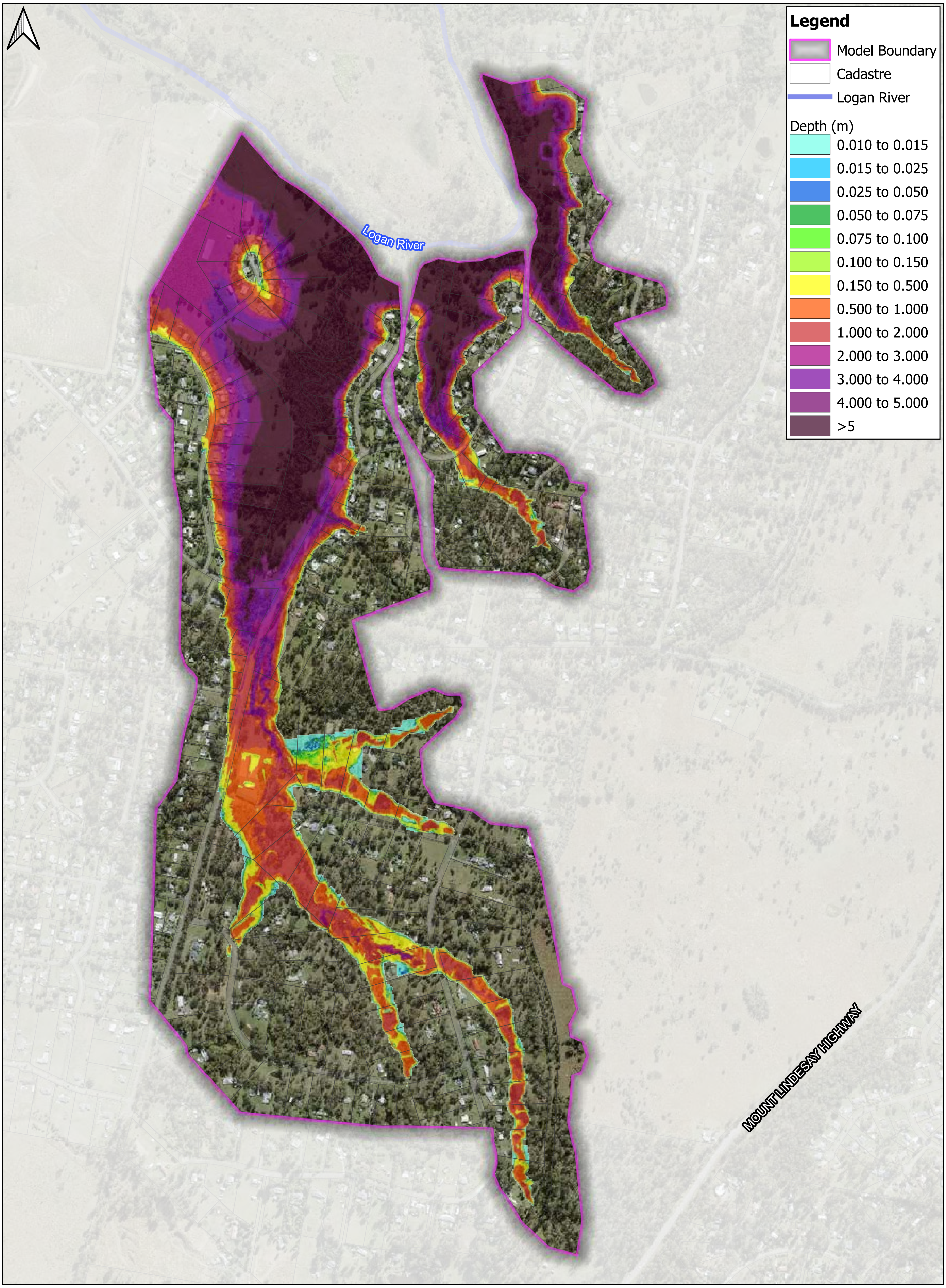
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 0.05% AEP Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

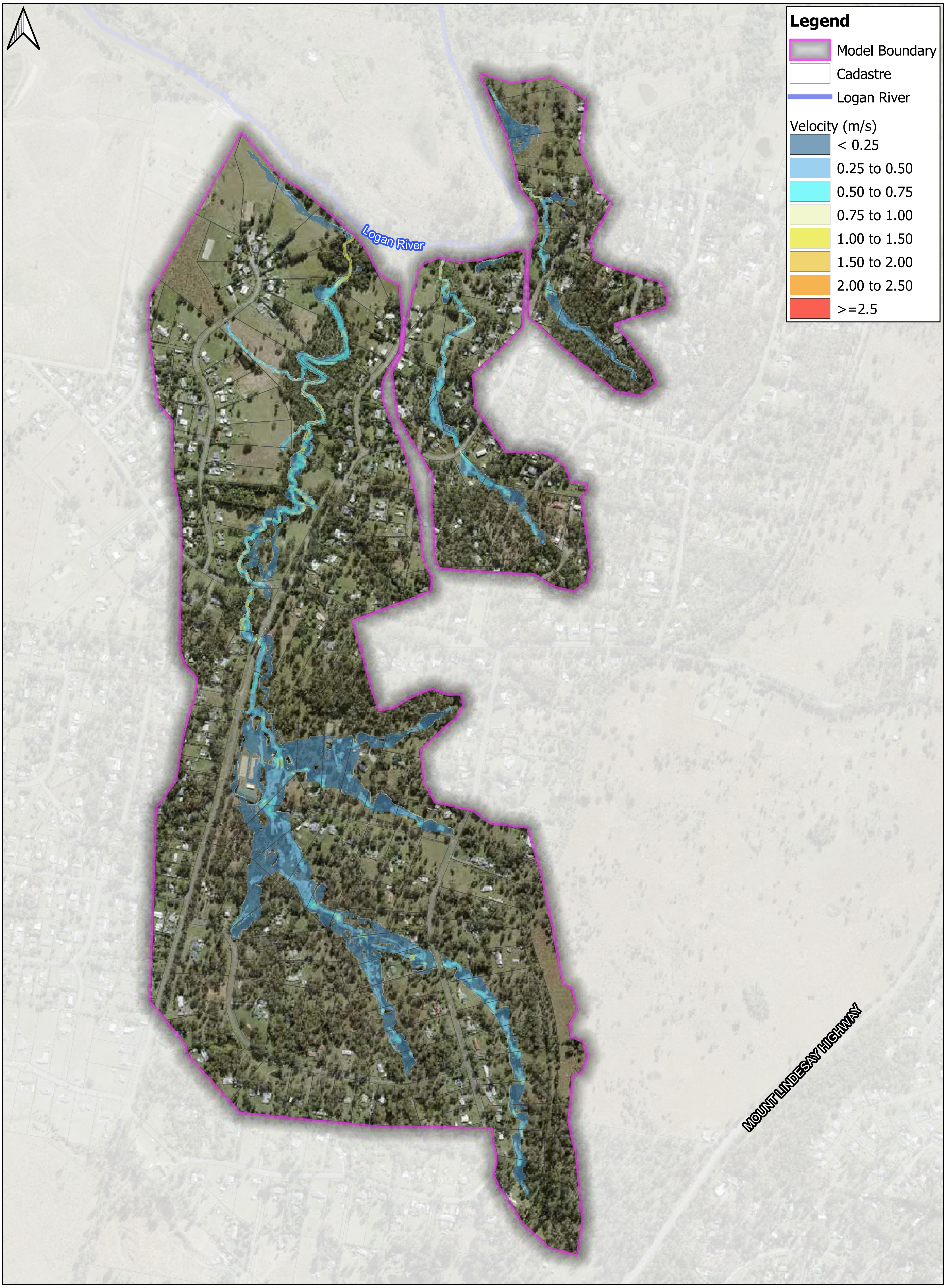
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - PMF Peak Water Depth

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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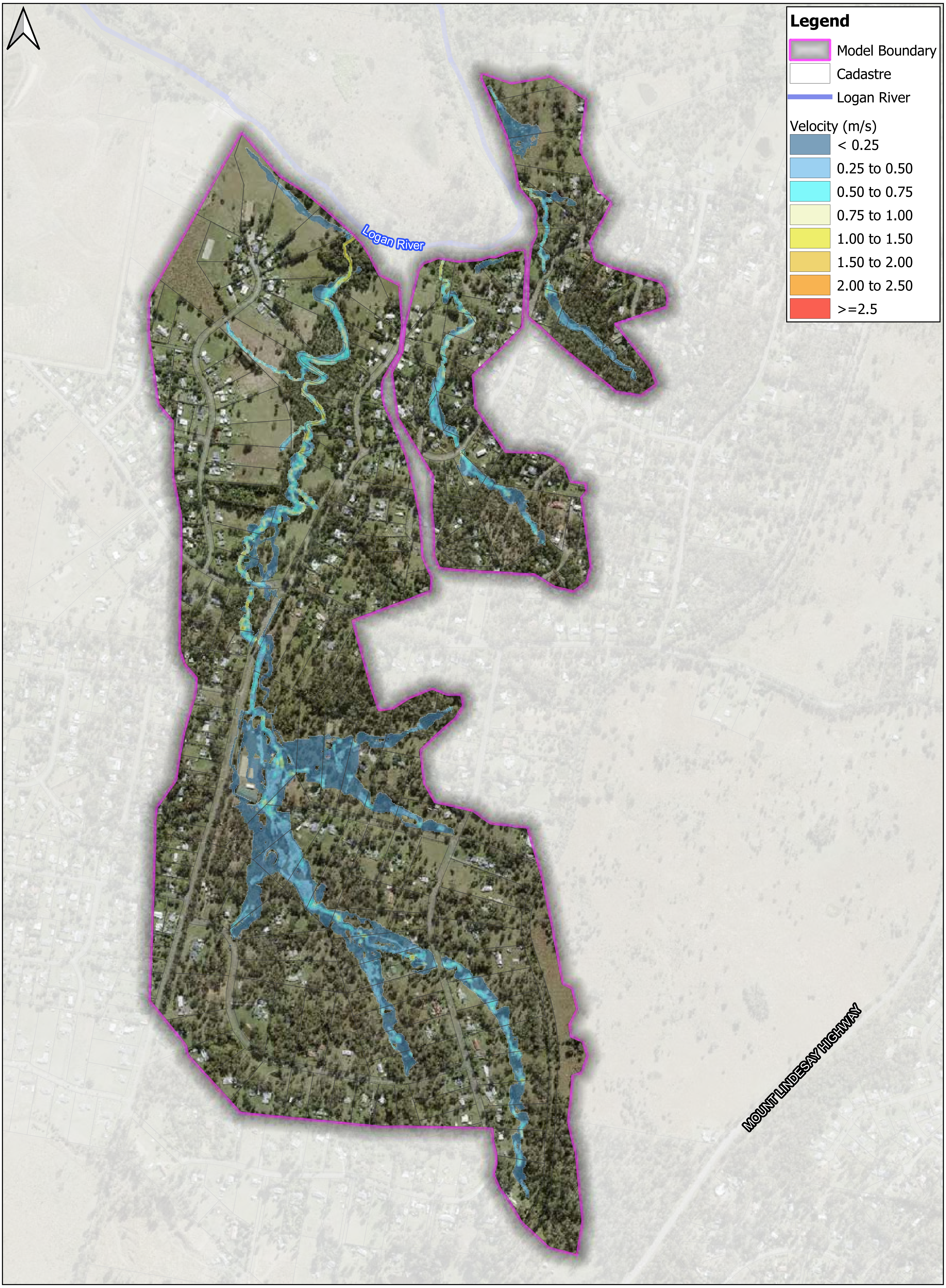
Days Creek Flood Study Update 2023

Roberts Waterhole - 63.2% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56
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Water Technology Pty Ltd

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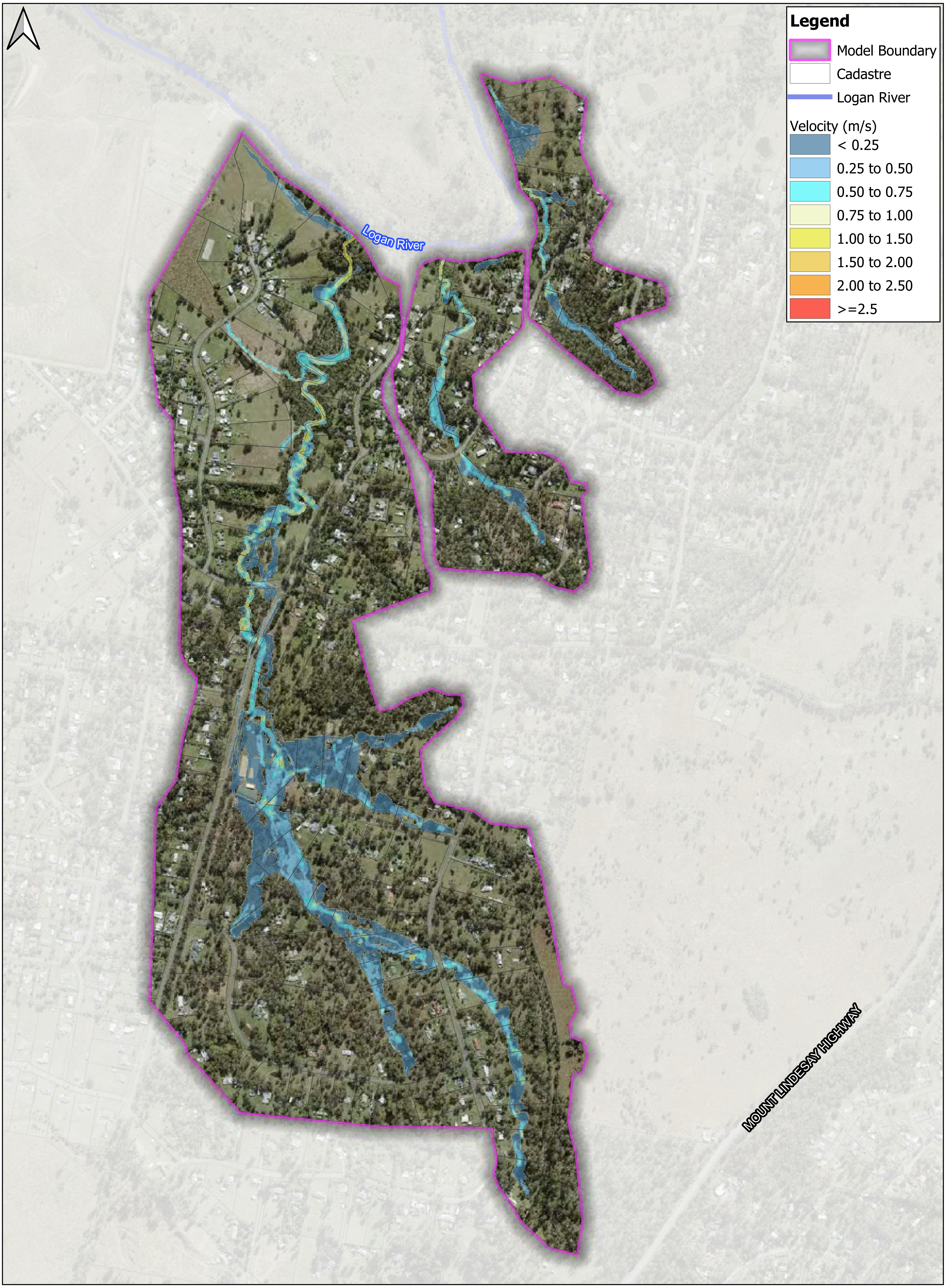
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP Peak Water Velocity



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Water Technology Pty Ltd

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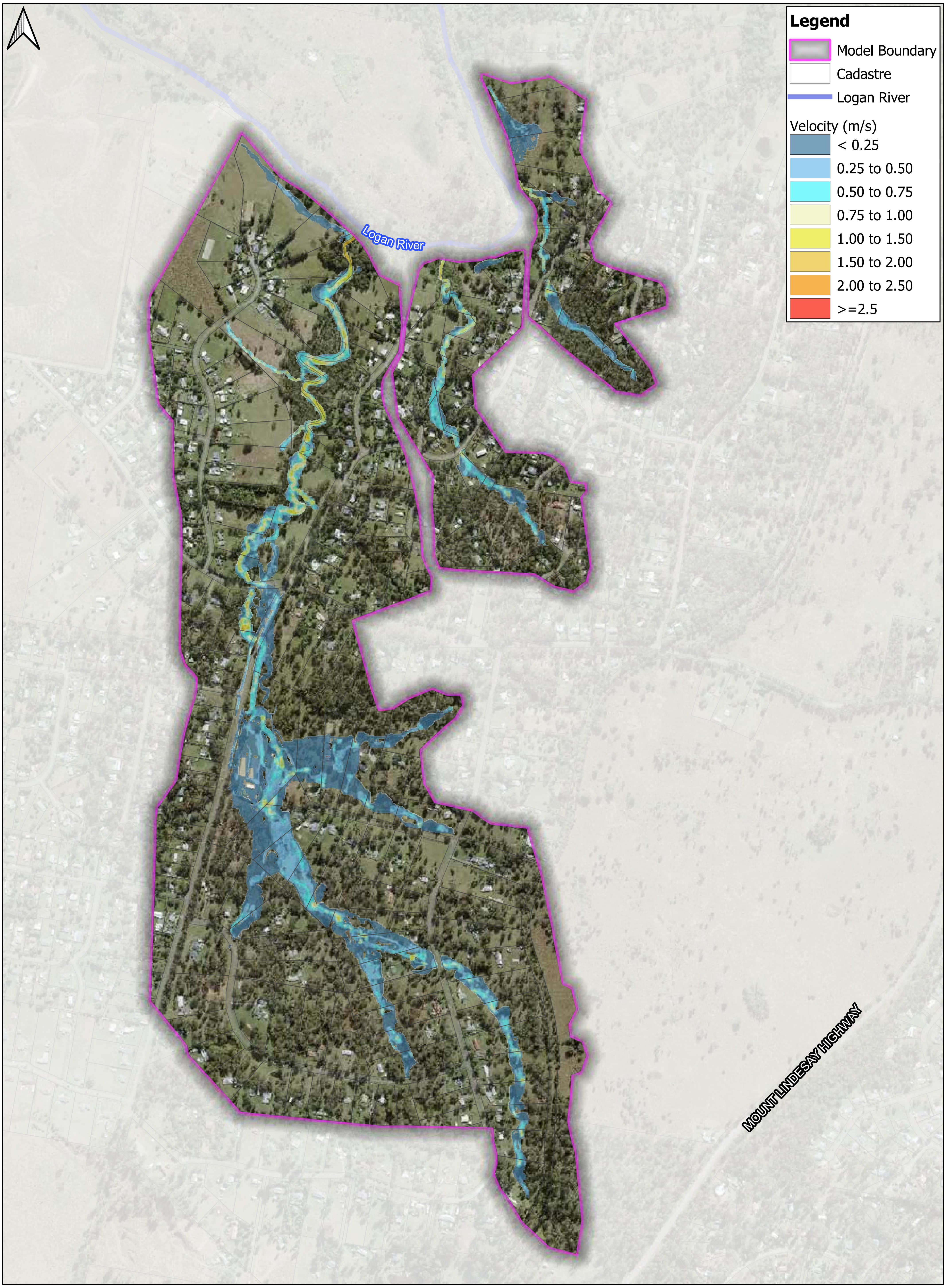
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP CC (RCP4.5) Peak Water Velocity



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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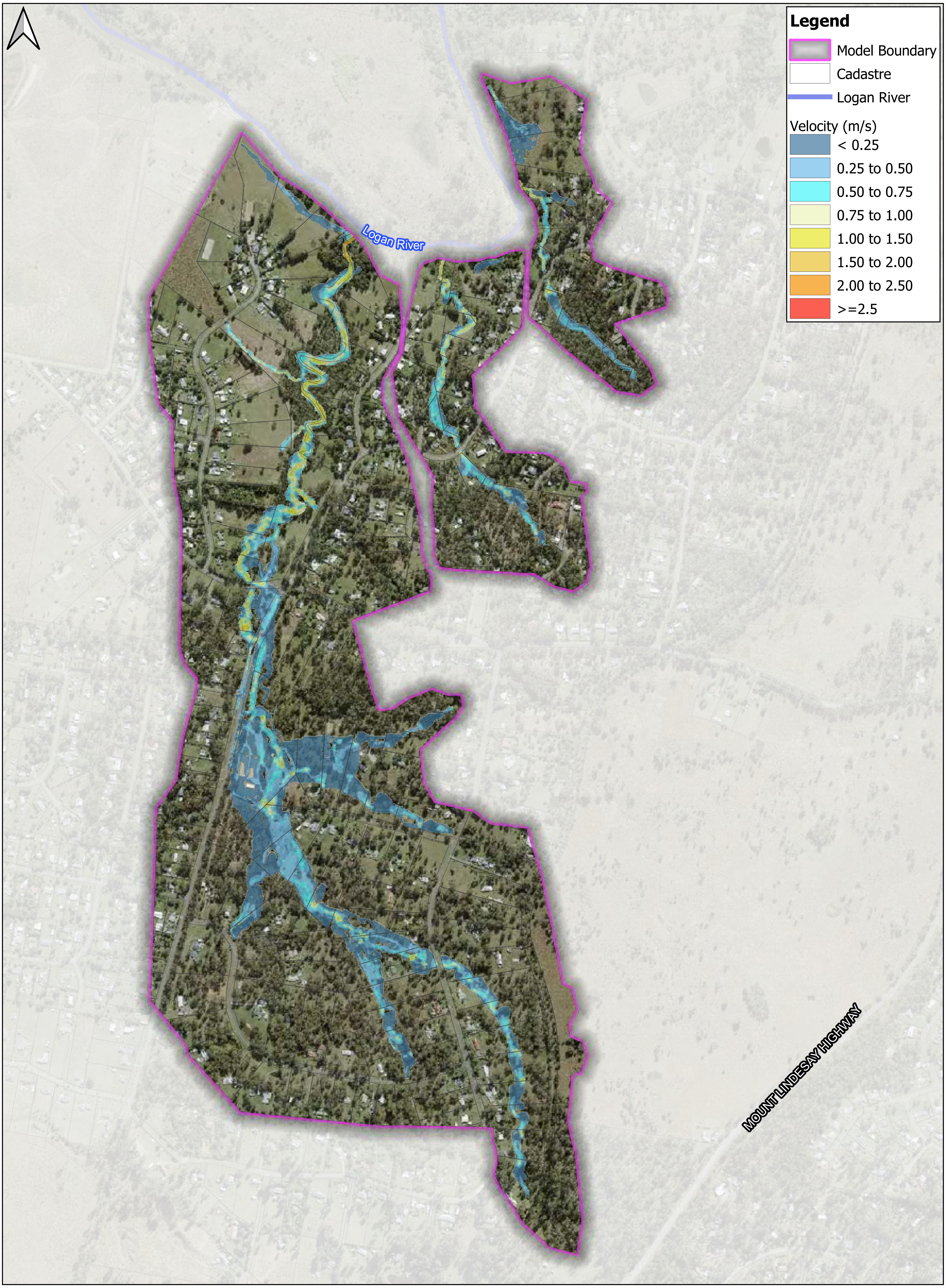
Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

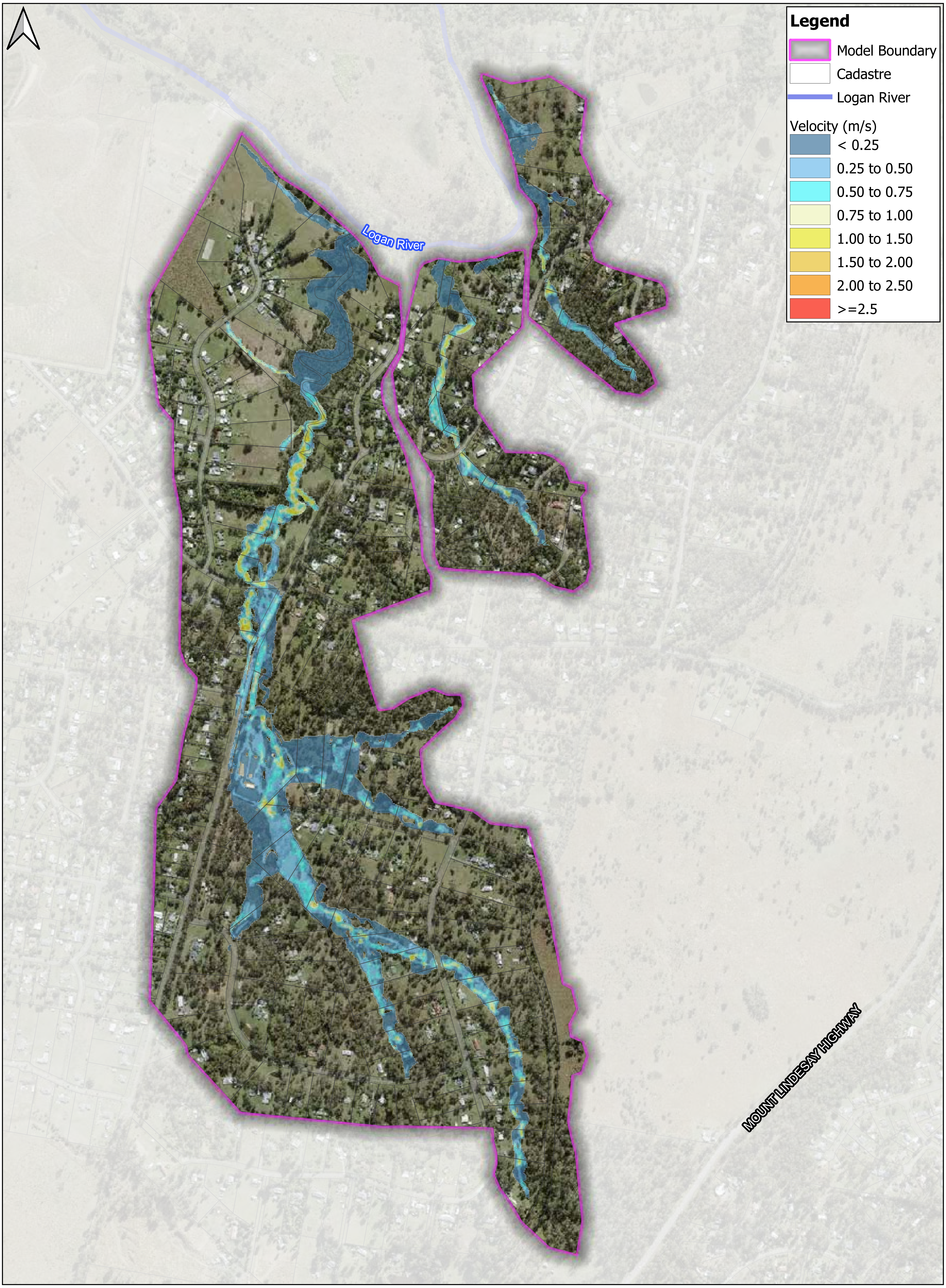
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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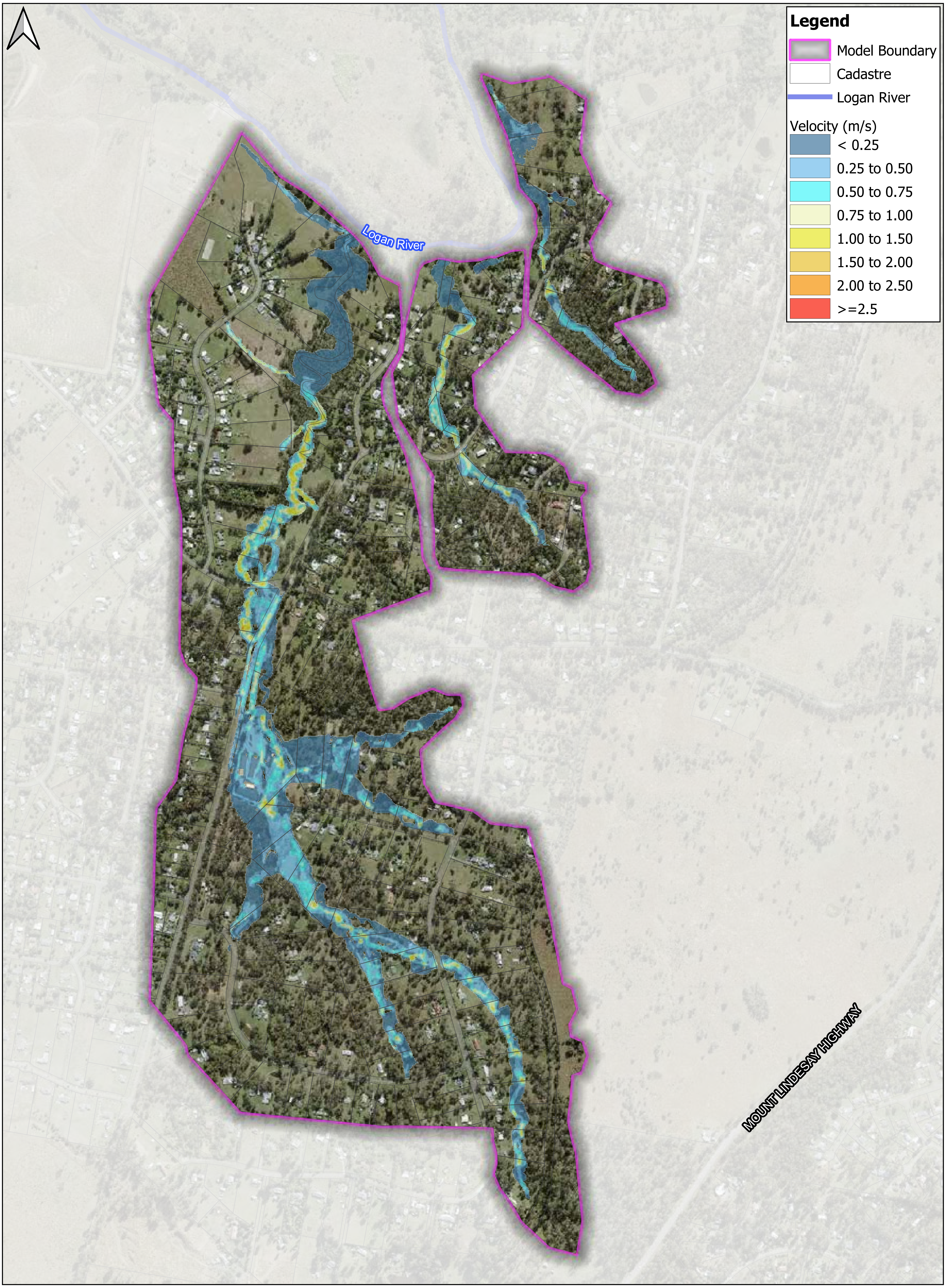
Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

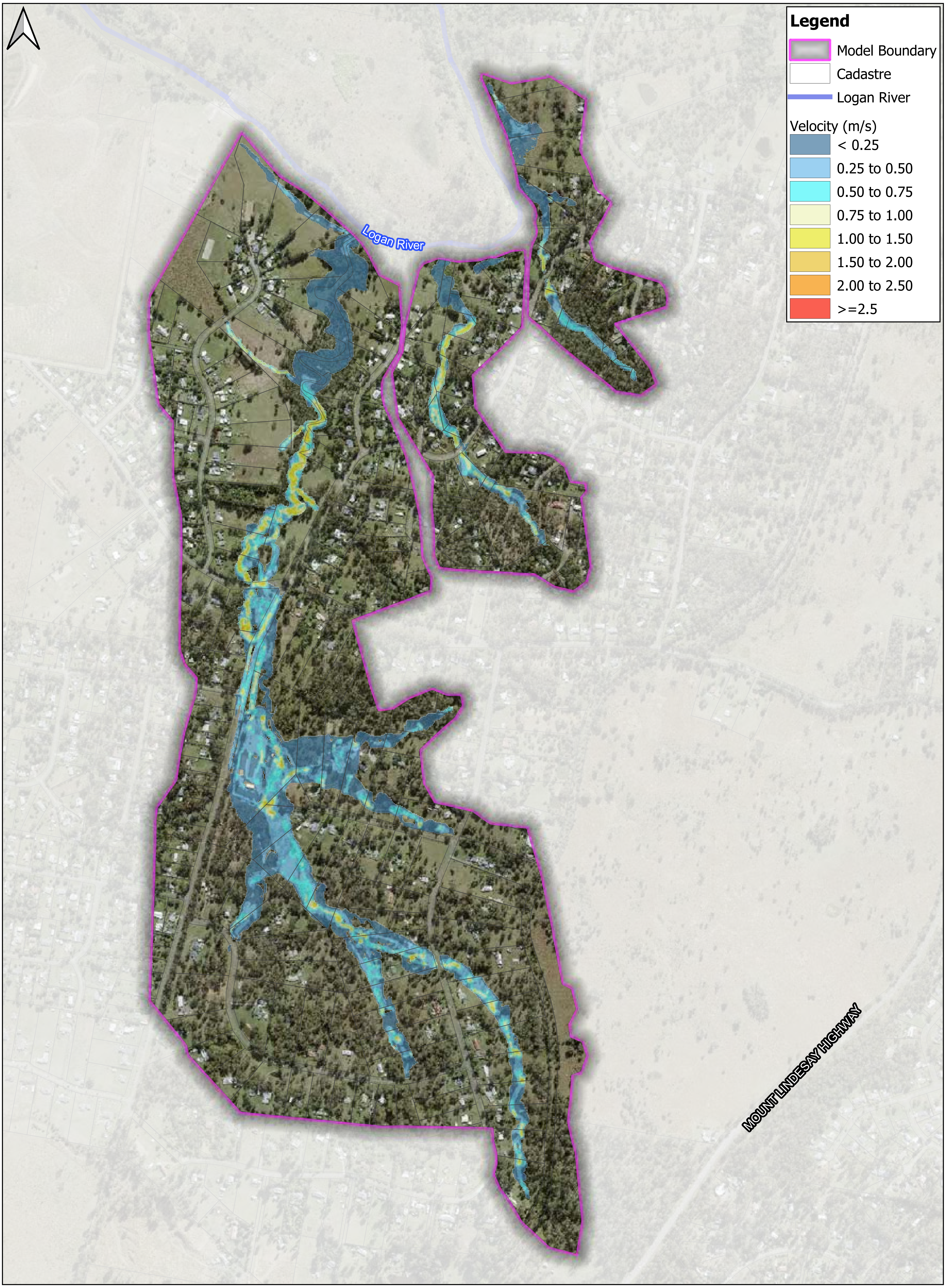
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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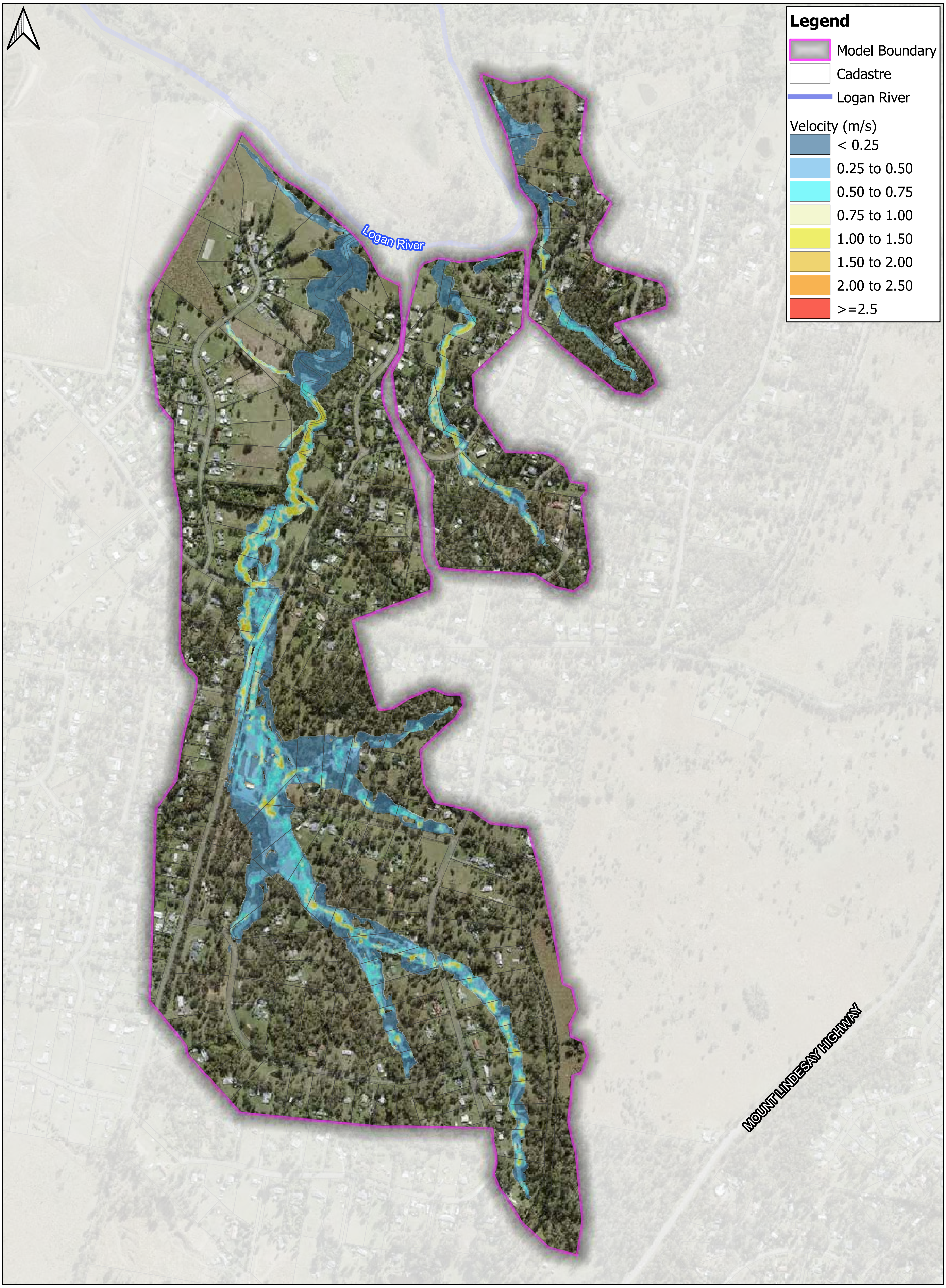
Days Creek Flood Study Update 2023

Roberts Waterhole - 5% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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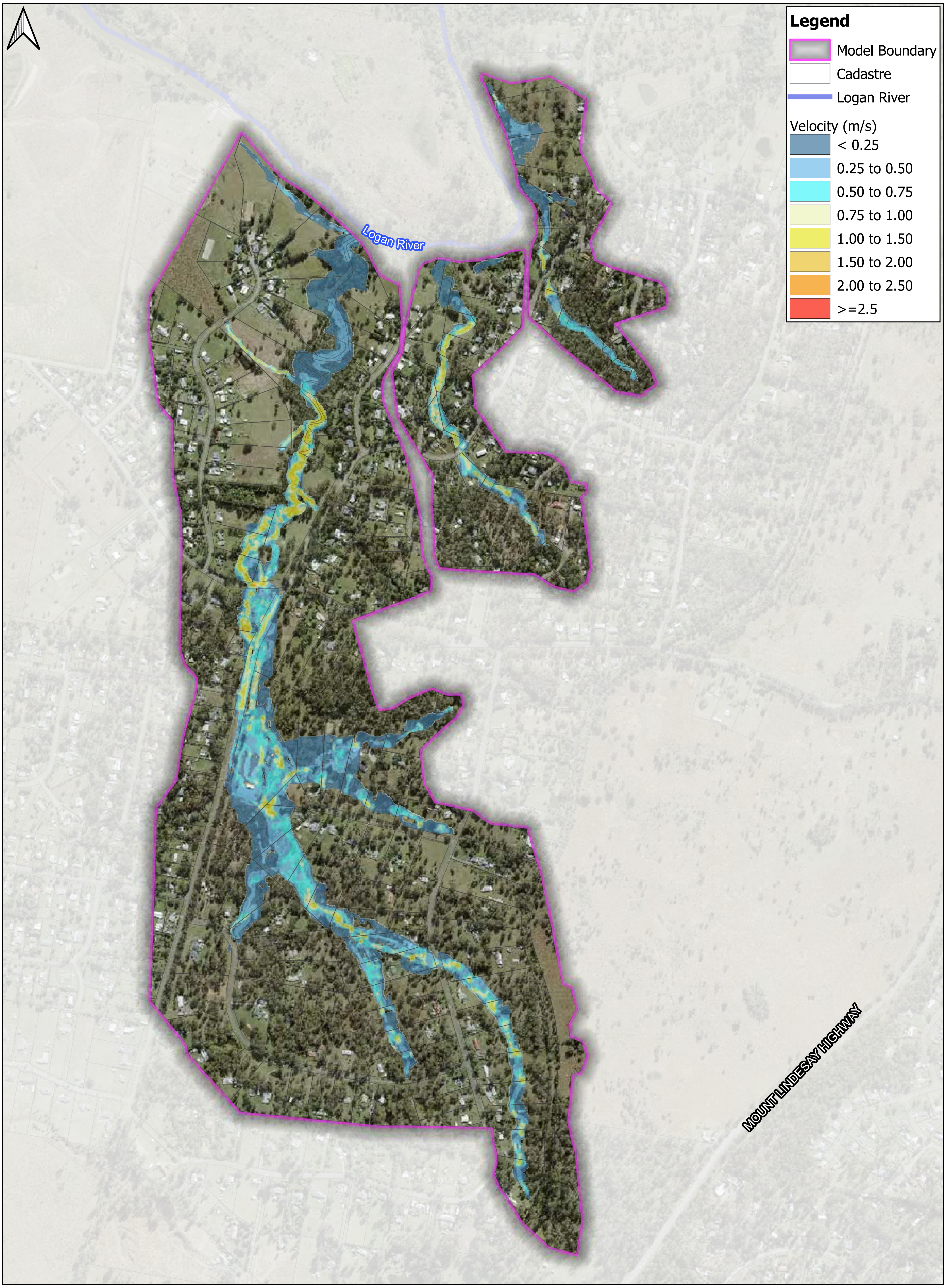
Days Creek Flood Study Update 2023

Roberts Waterhole - 5% AEP CC (RCP4.5) Peak Water Velocity



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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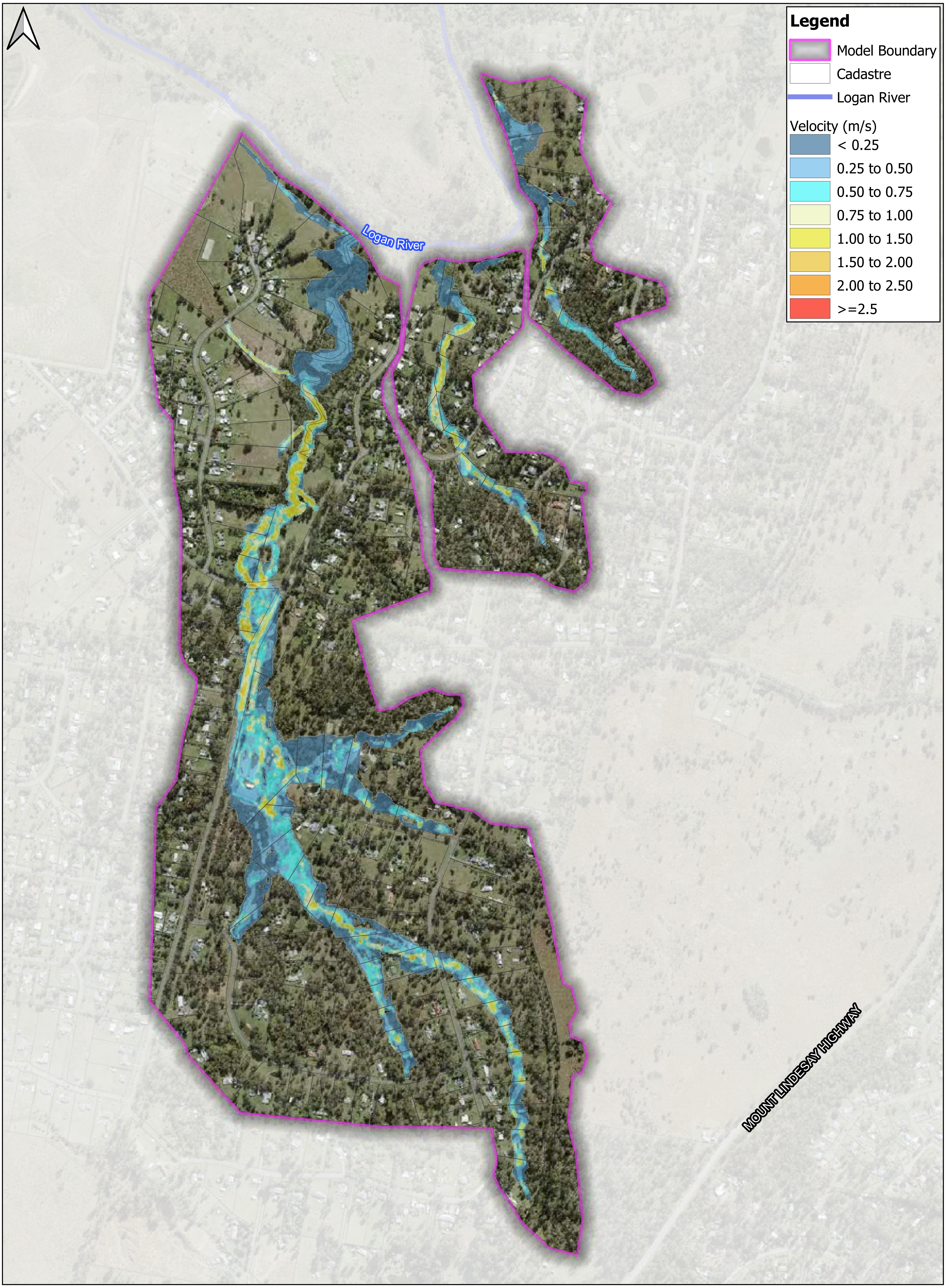
Days Creek Flood Study Update 2023

Roberts Waterhole - 2% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

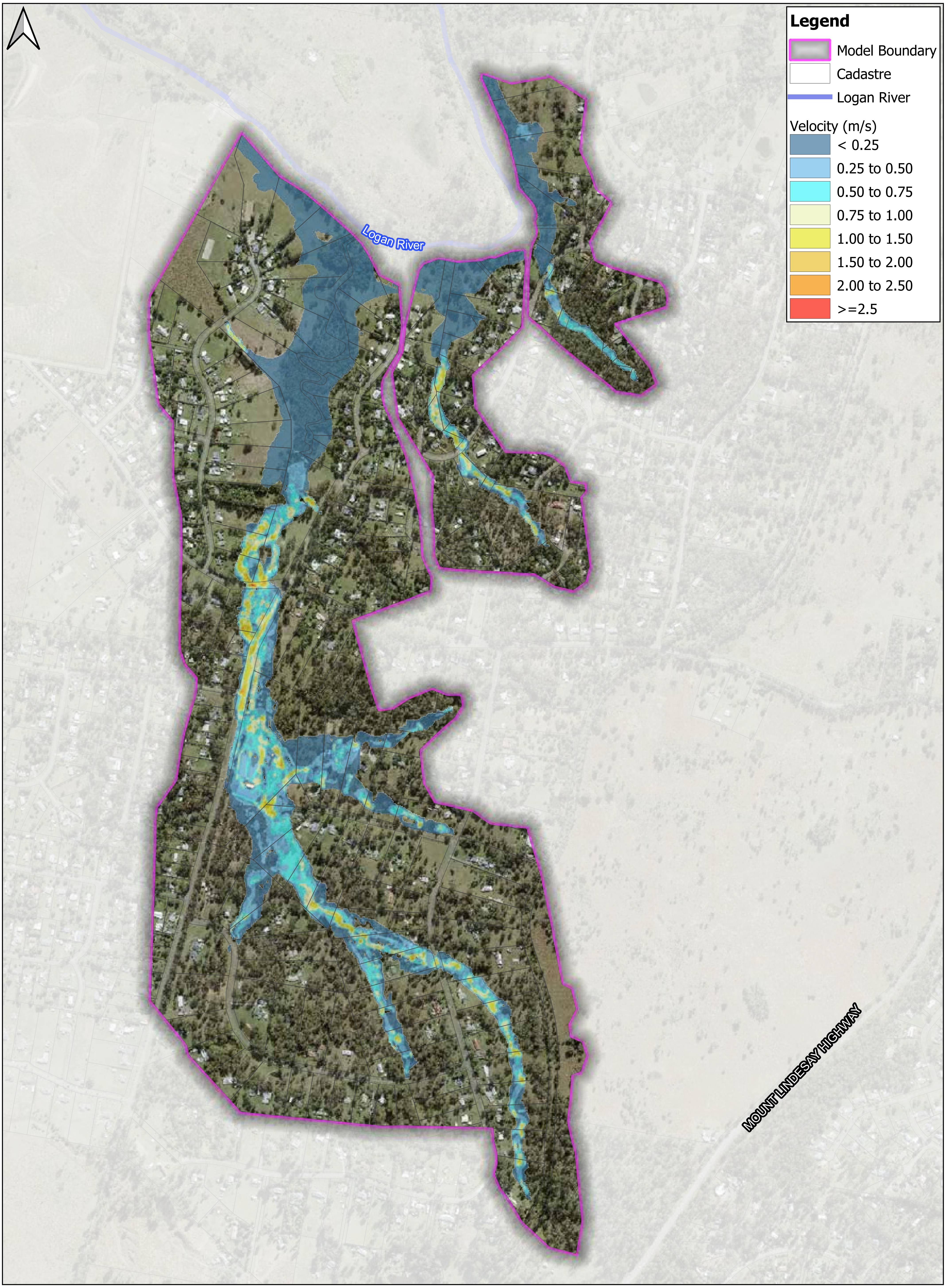
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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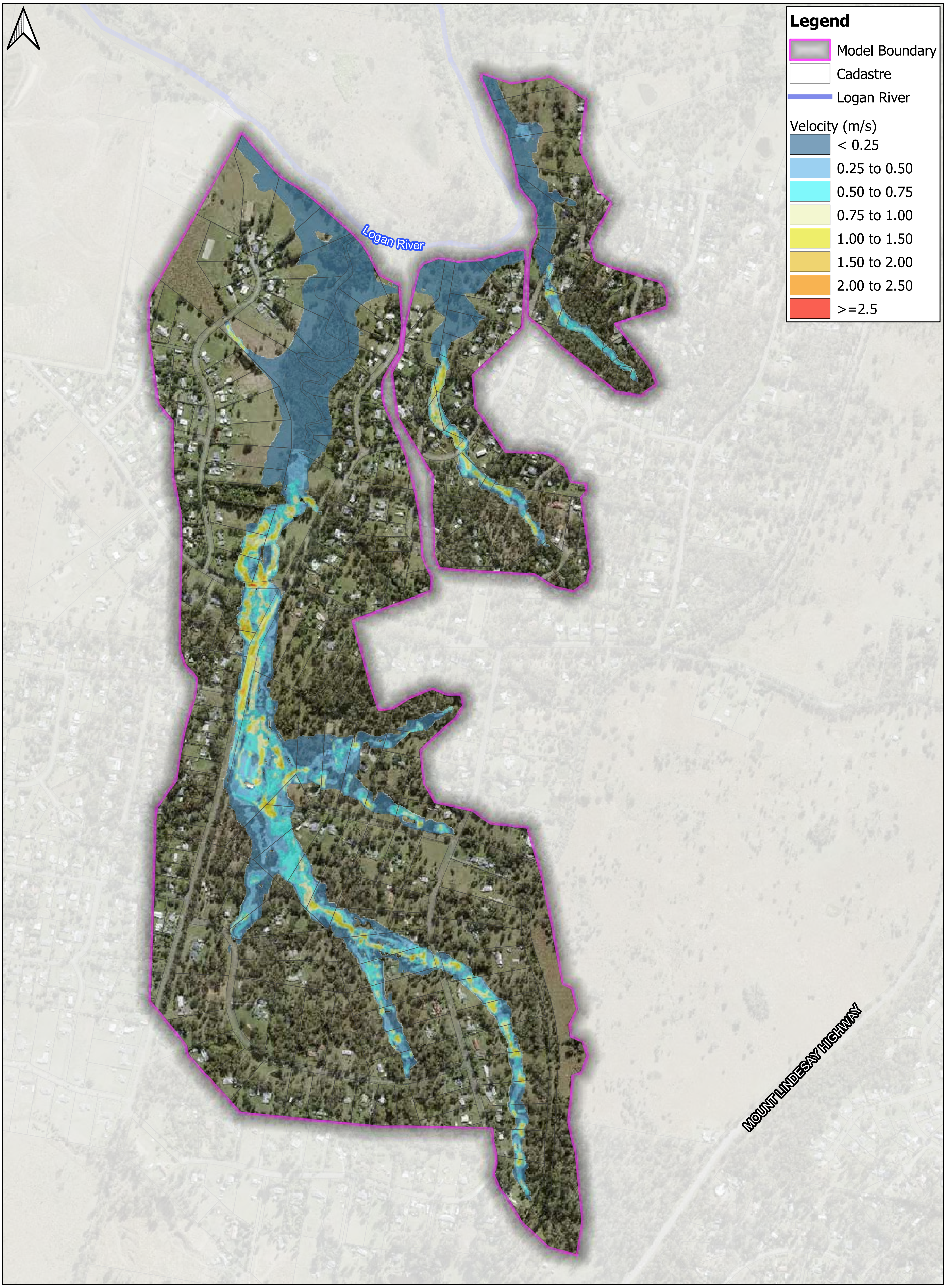
Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

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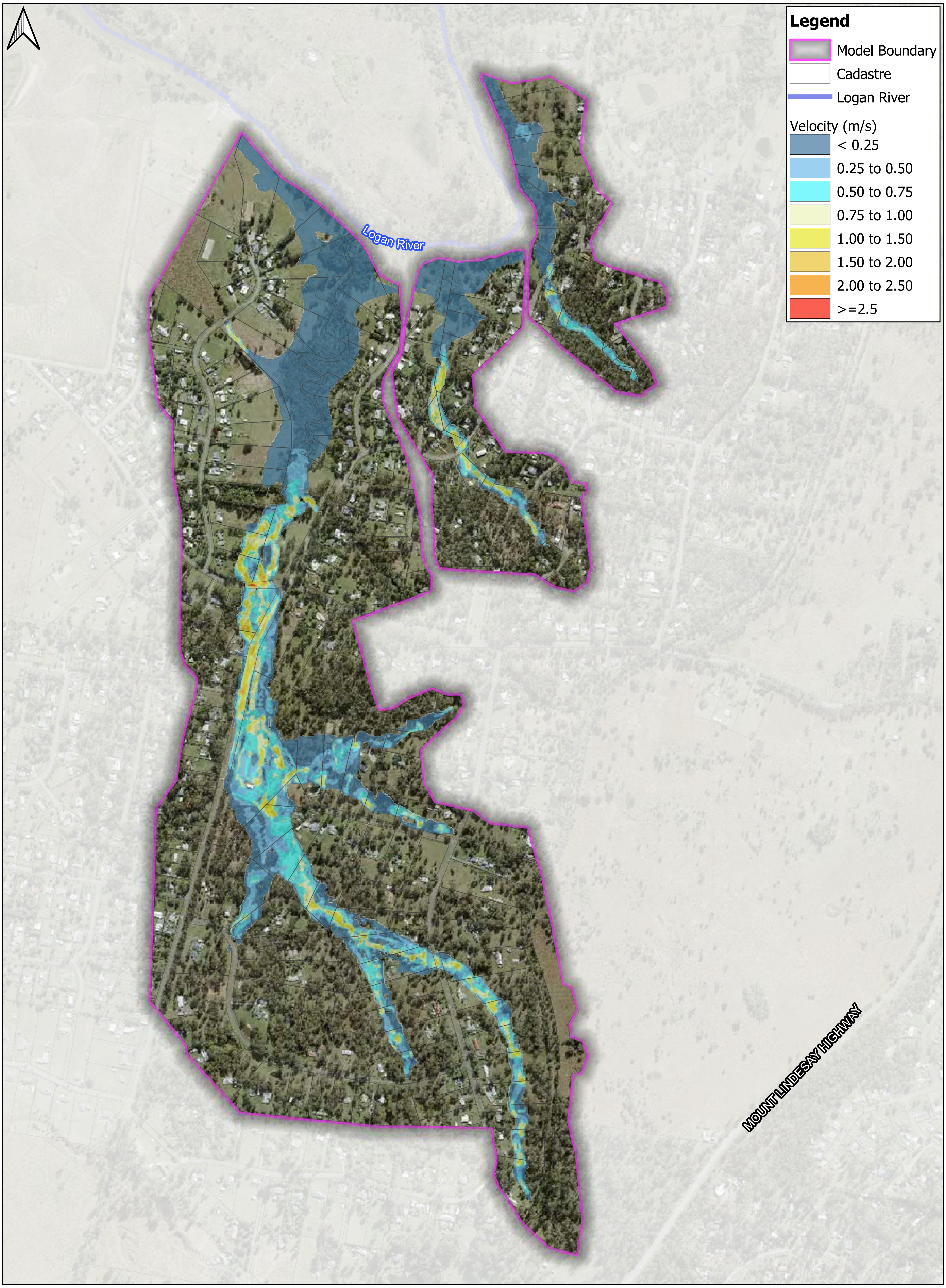
0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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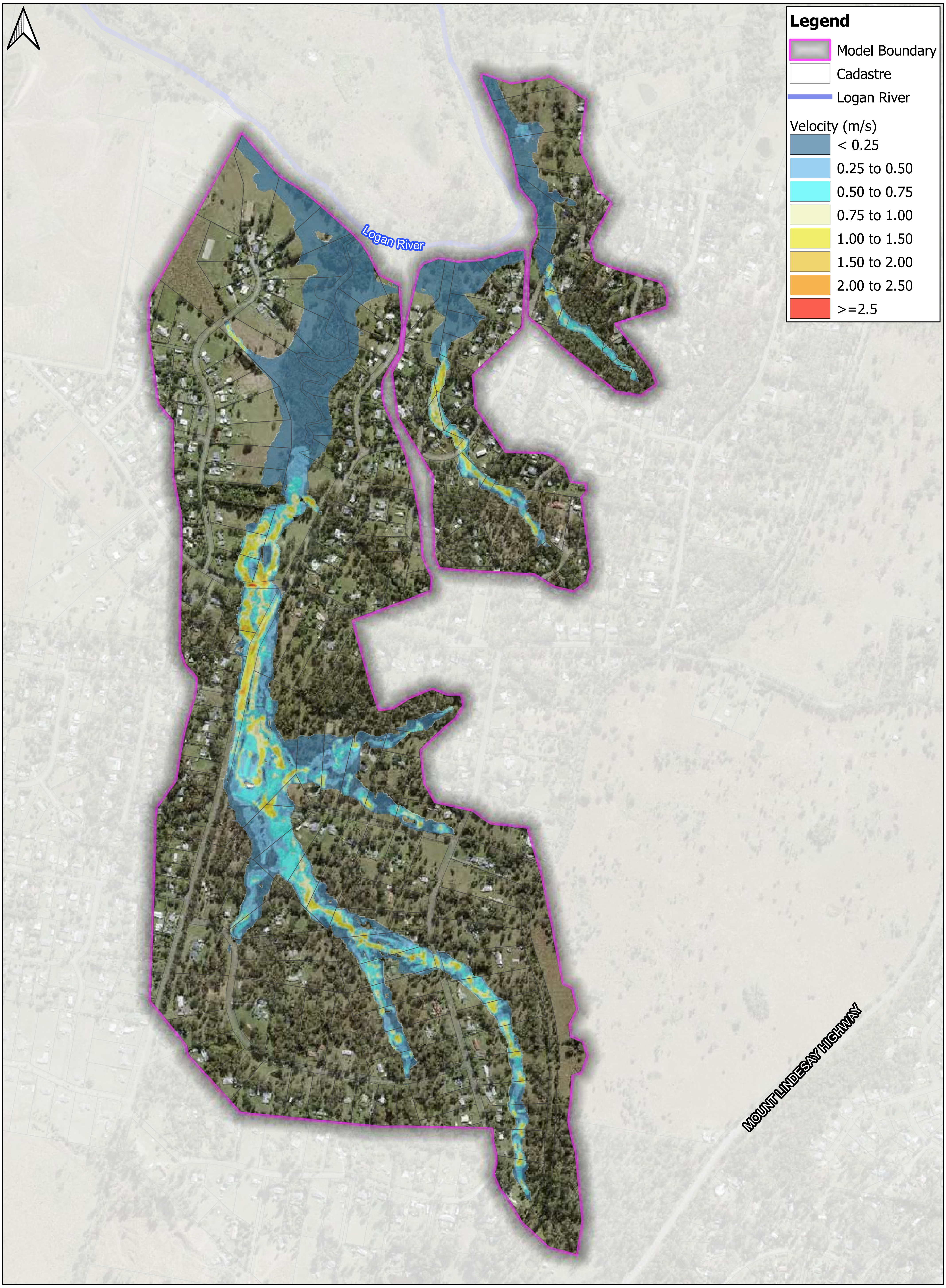
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.5% AEP Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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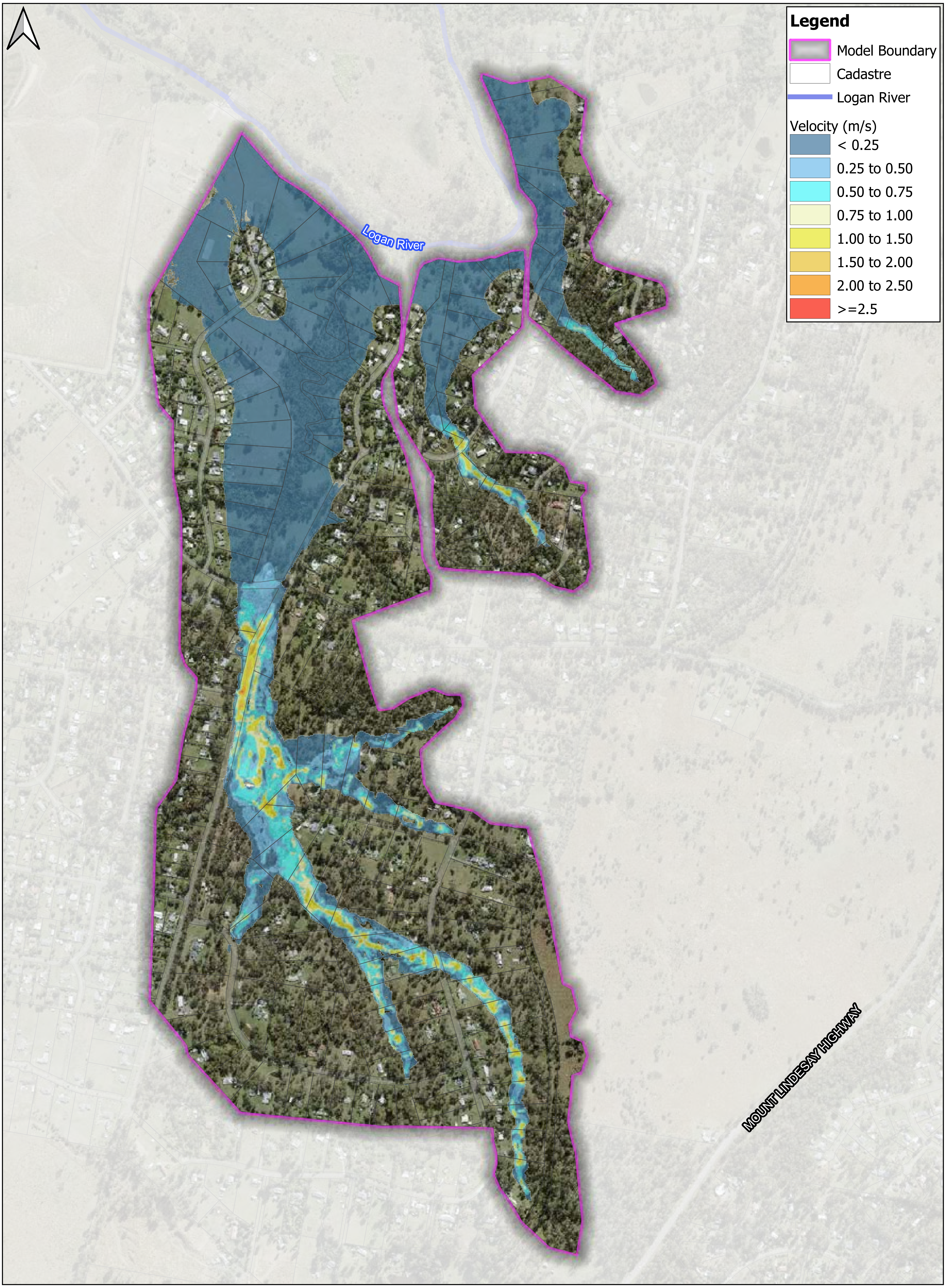
0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

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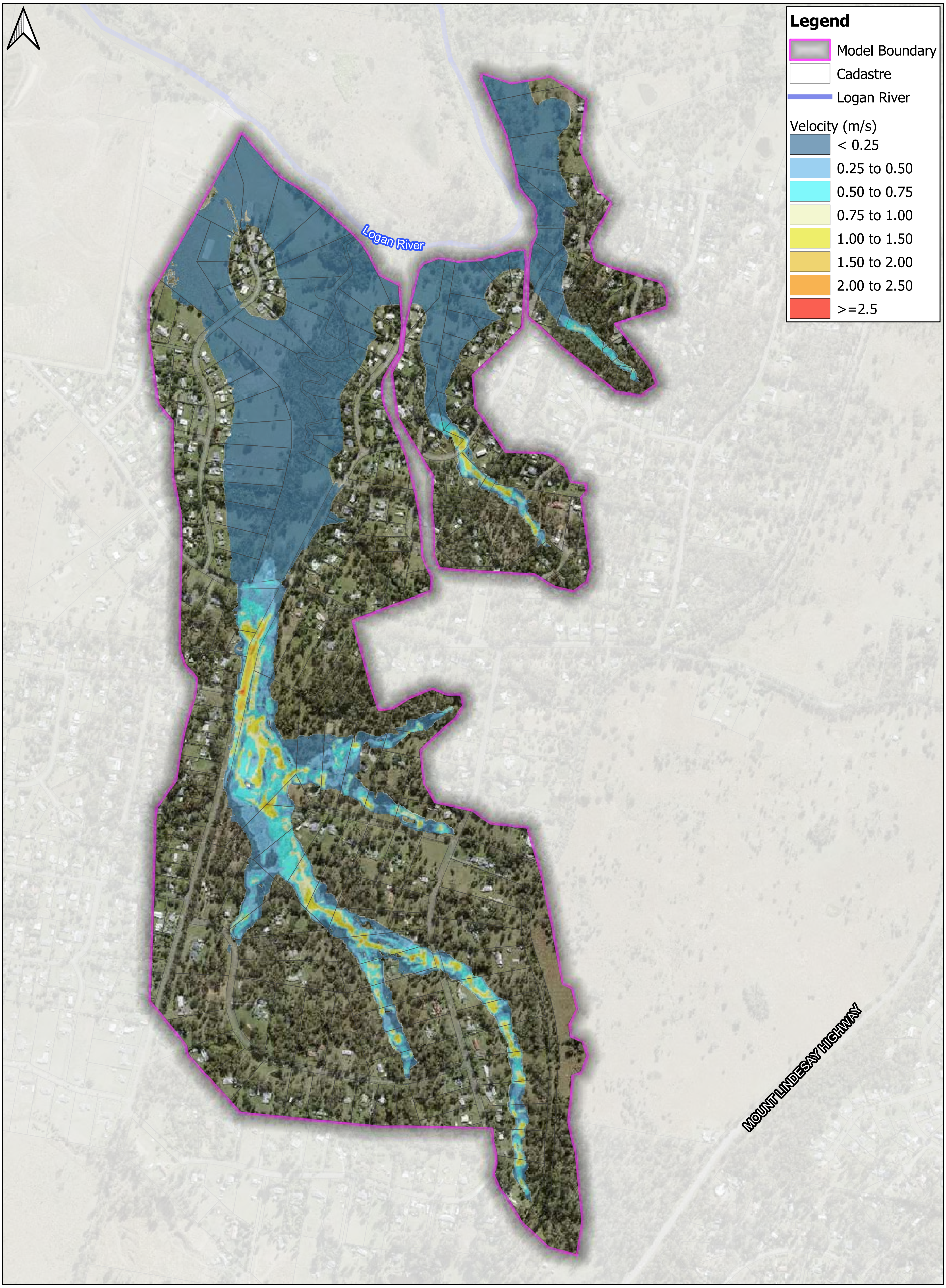
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.2% AEP Peak Water Velocity



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

1:10,000

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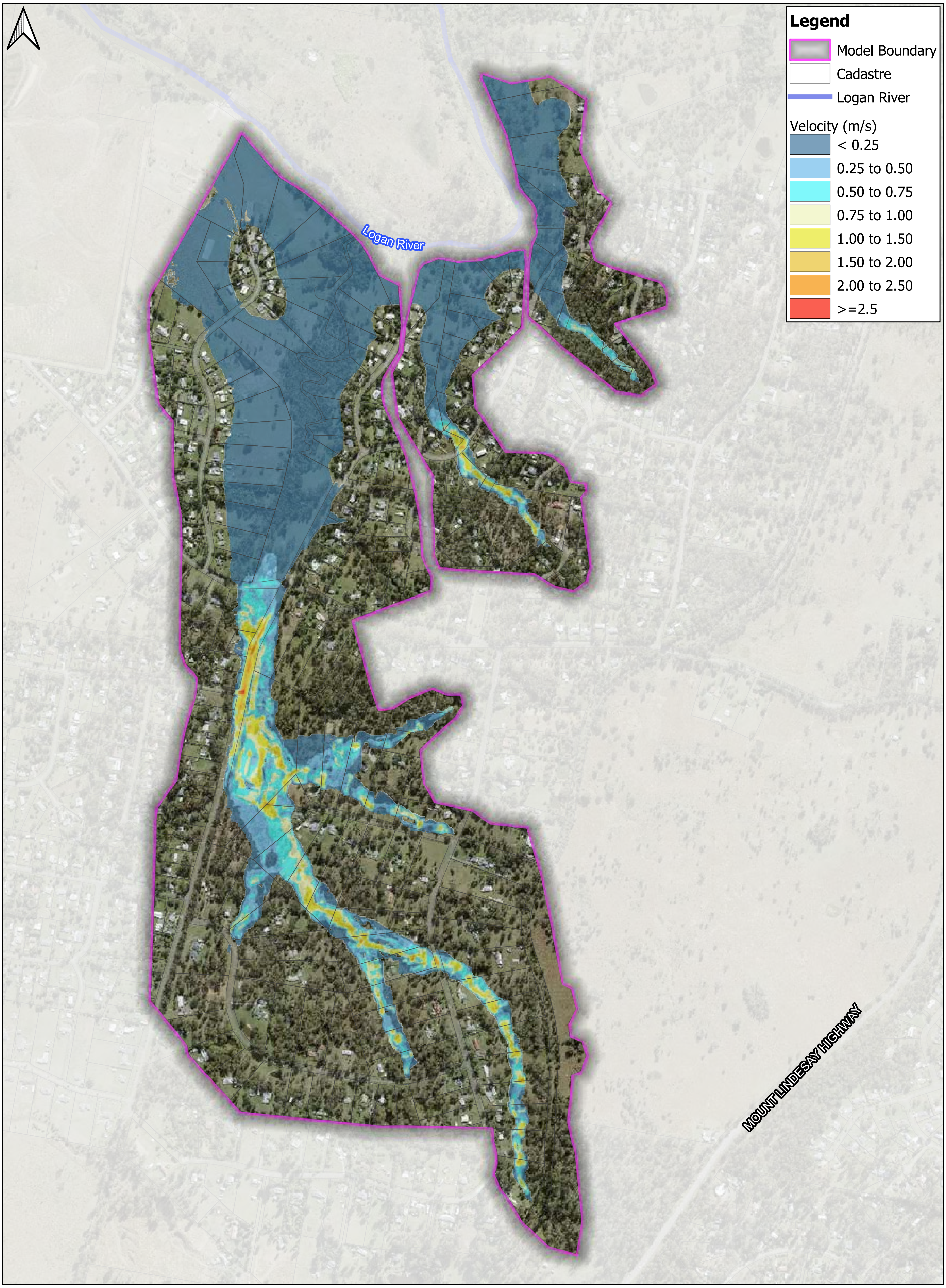
Days Creek Flood Study Update 2023

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



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Imagery Source: LCC

Water Technology Pty Ltd

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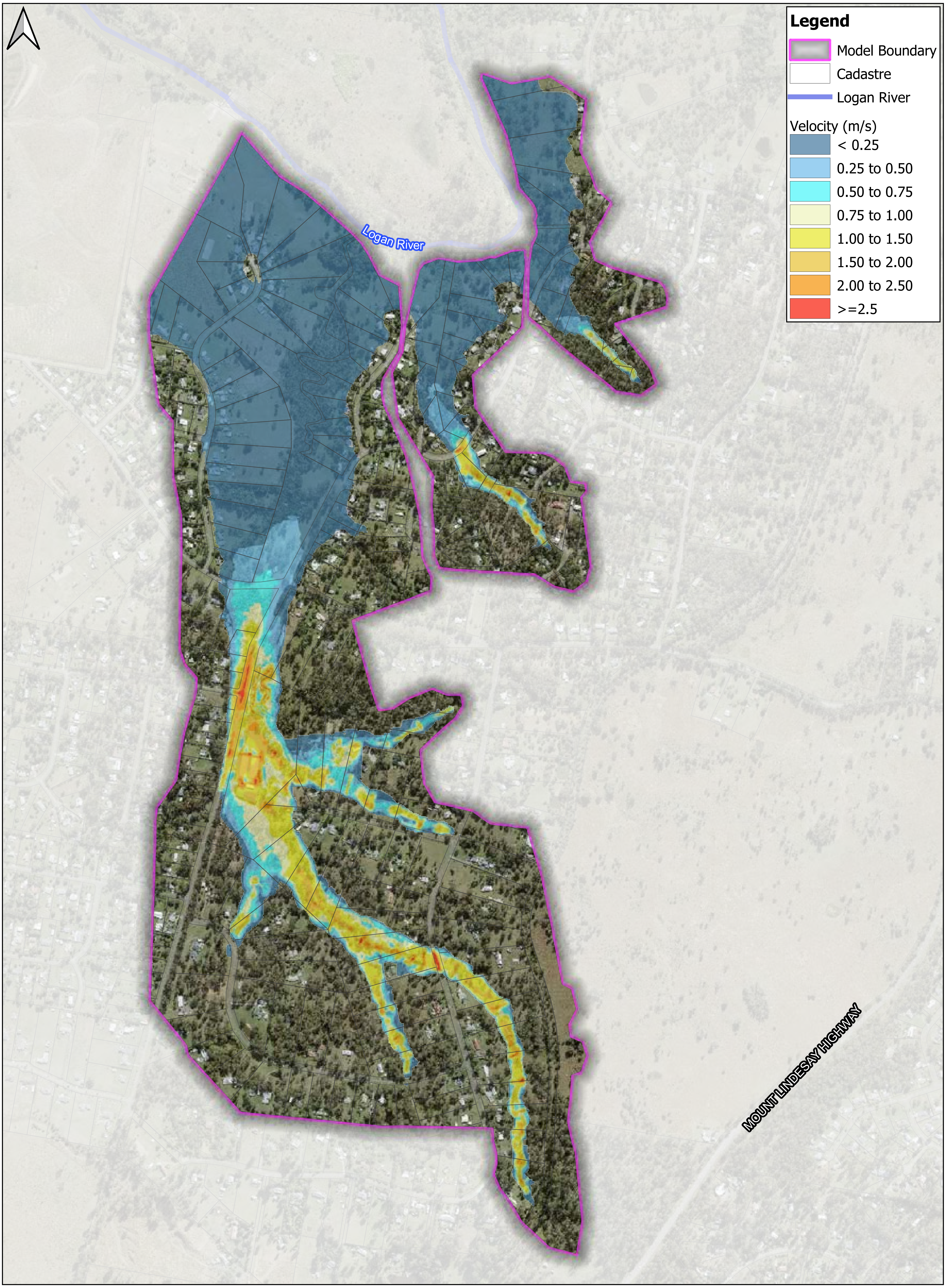
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.05% AEP Peak Water Velocity

WATER TECHNOLOGY



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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - PMF Peak Water Velocity

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 63.2% AEP Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP CC (RCP4.5) Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

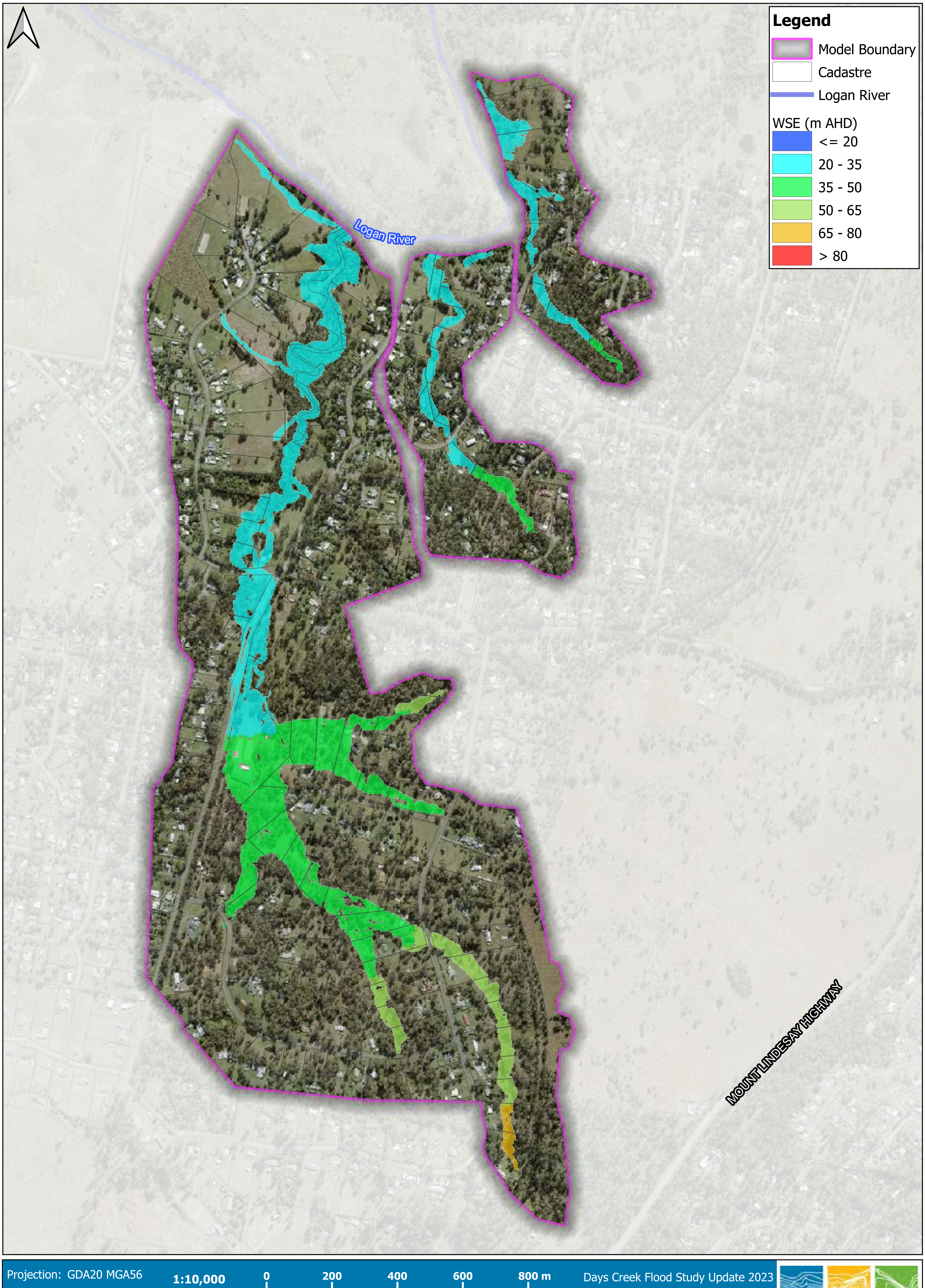
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

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Days Creek Flood Study Update 2023

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

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

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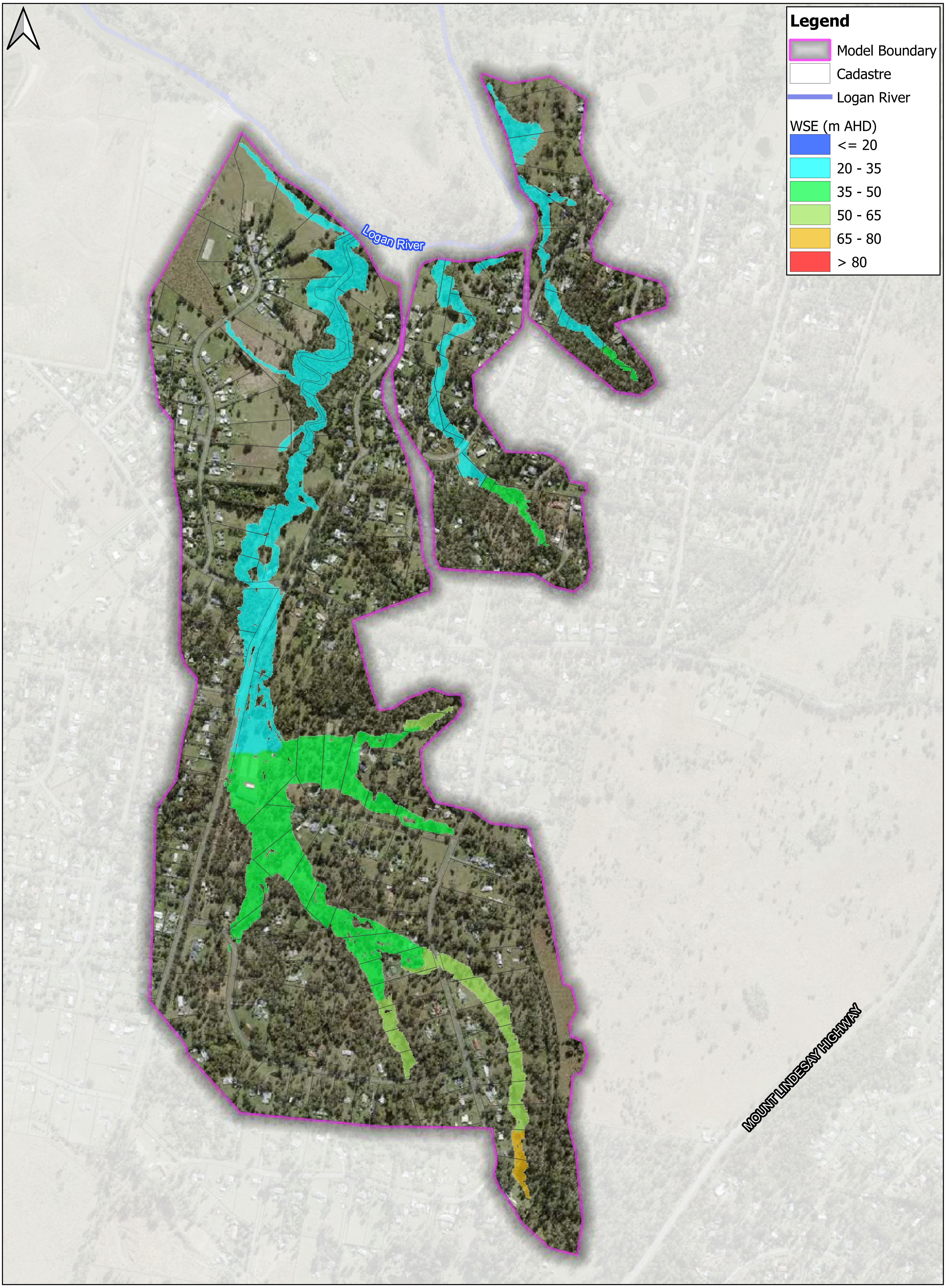
Days Creek Flood Study Update 2023

Roberts Waterhole - 5% AEP Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

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Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

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

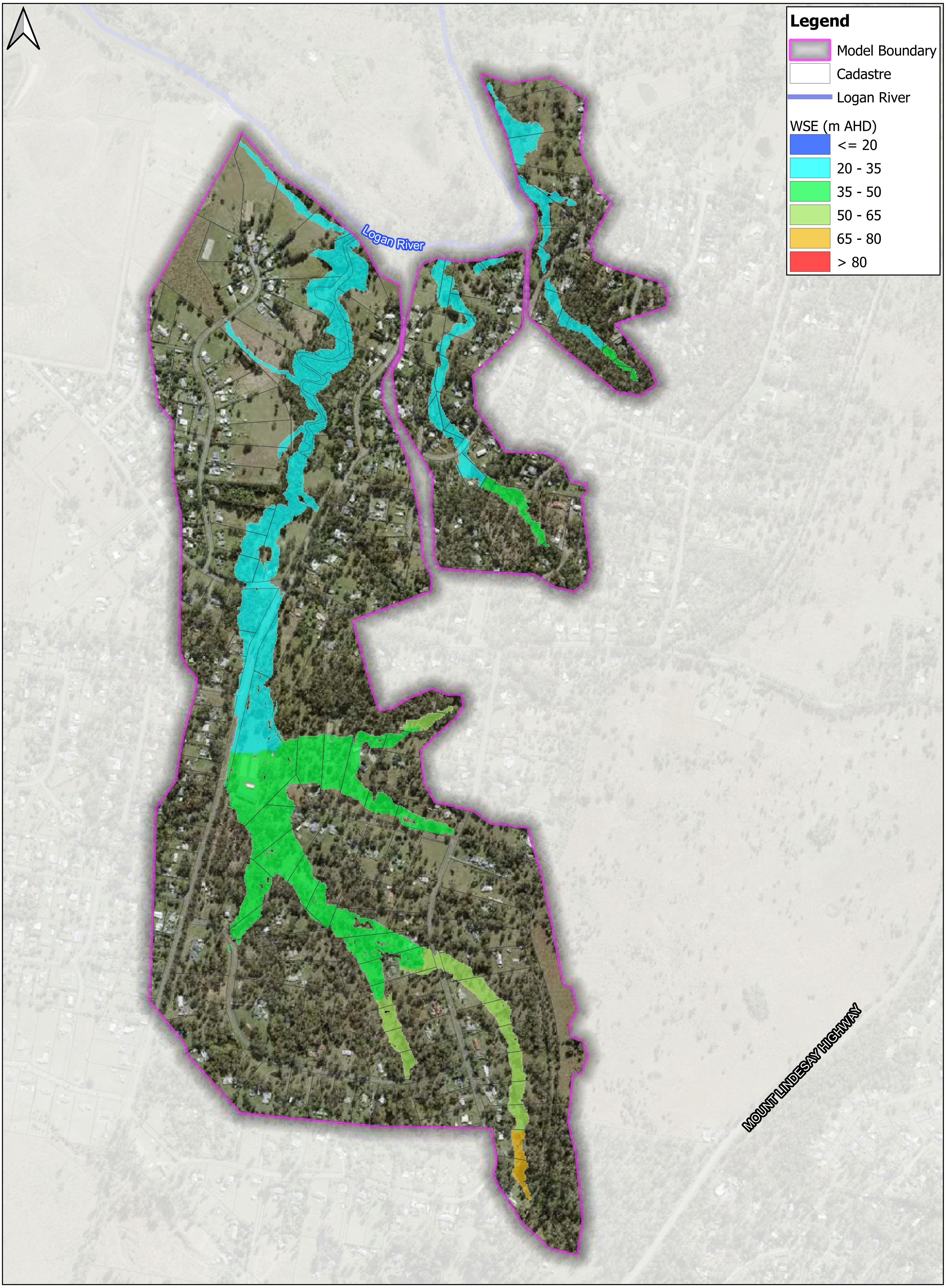
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 2% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



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Water Technology Pty Ltd

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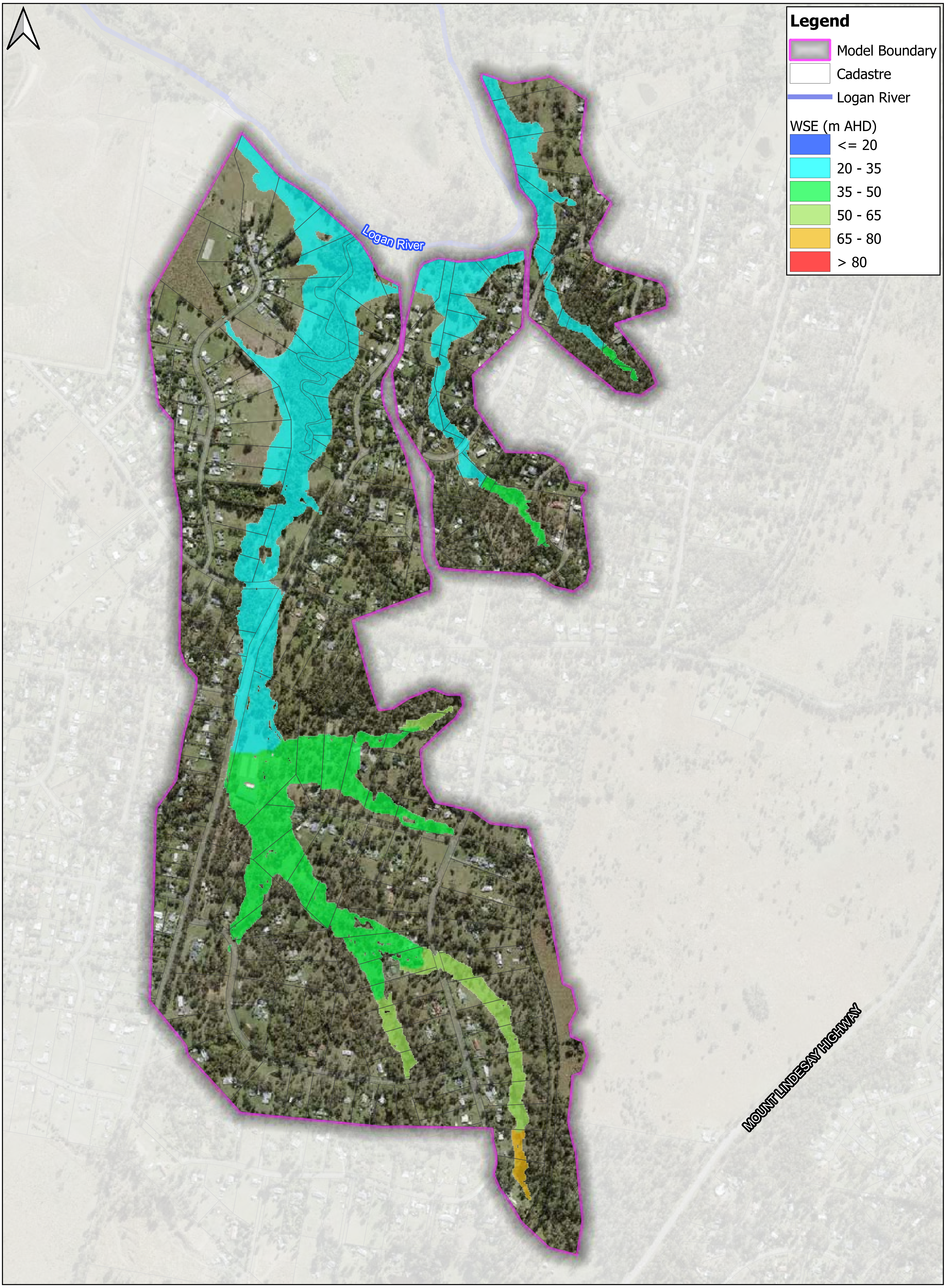
Days Creek Flood Study Update 2023

Roberts Waterhole - 2% AEP CC (RCP4.5) Peak Water Surface Elevation



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Water Technology Pty Ltd
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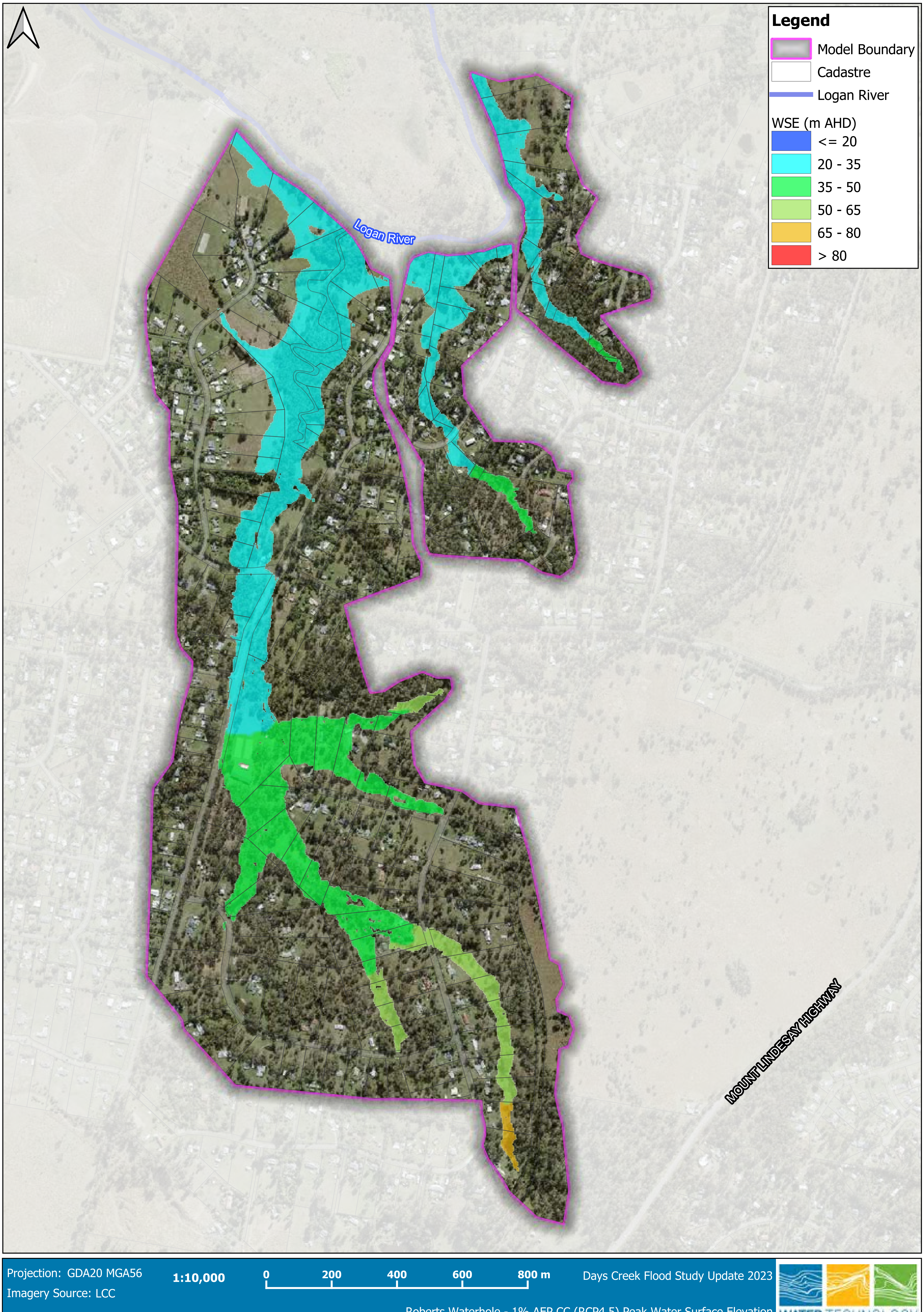
Days Creek Flood Study Update 2023
Roberts Waterhole - 1% AEP Peak Water Surface Elevation



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Water Technology Pty Ltd

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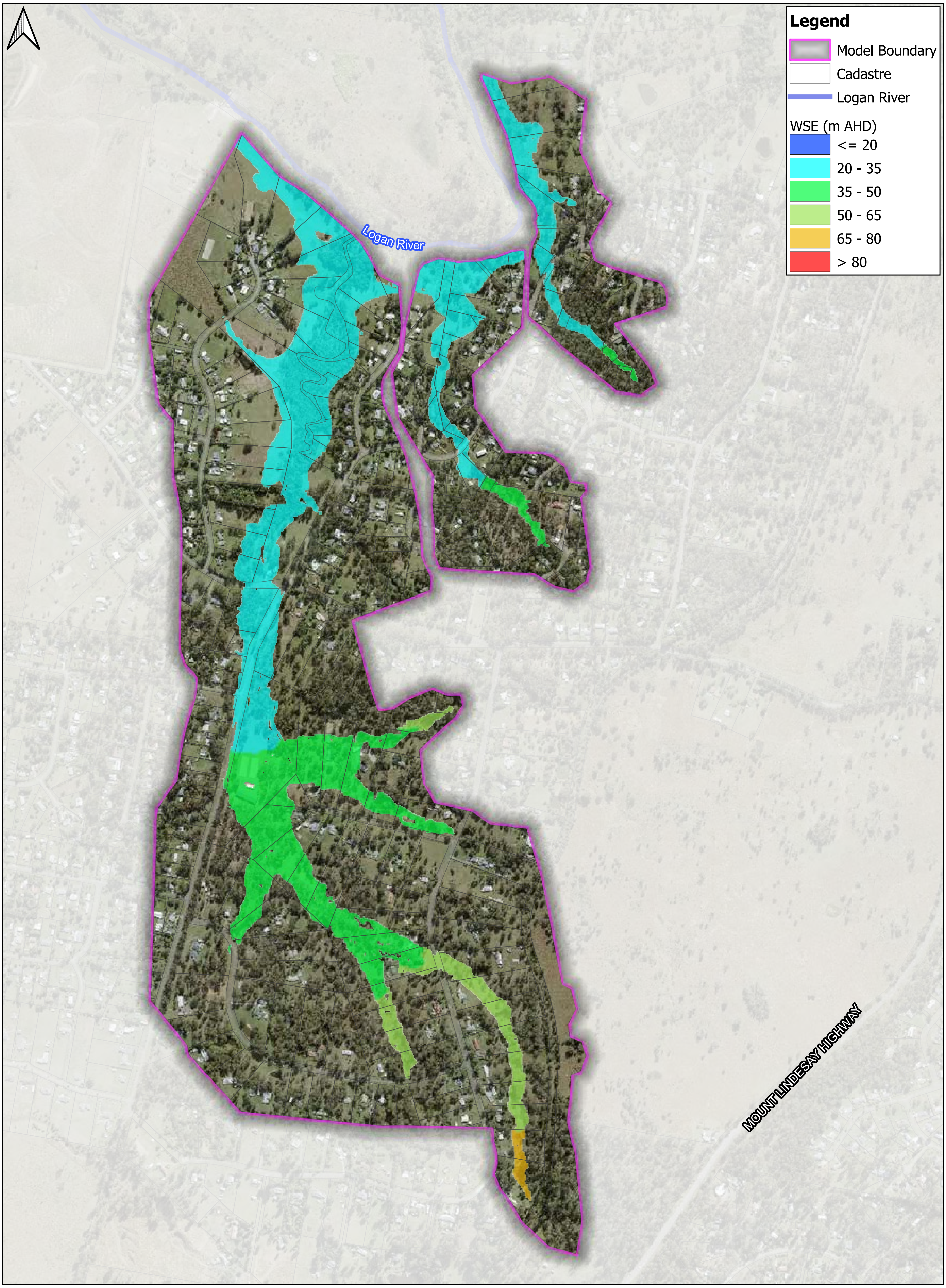
Days Creek Flood Study Update 2023

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



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Water Technology Pty Ltd

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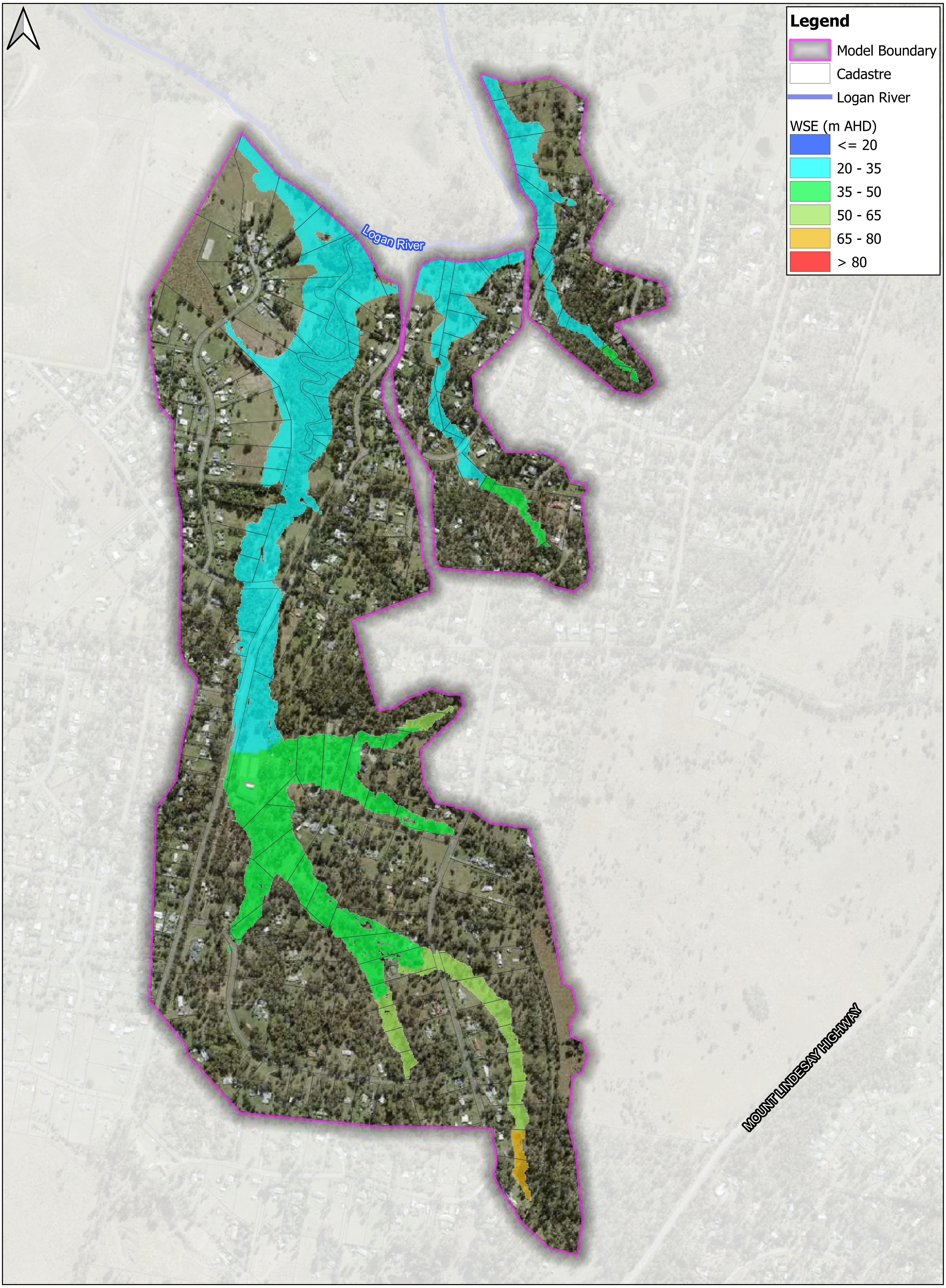
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.5% AEP Peak Water Surface Elevation



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Imagery Source: LCC
Water Technology Pty Ltd

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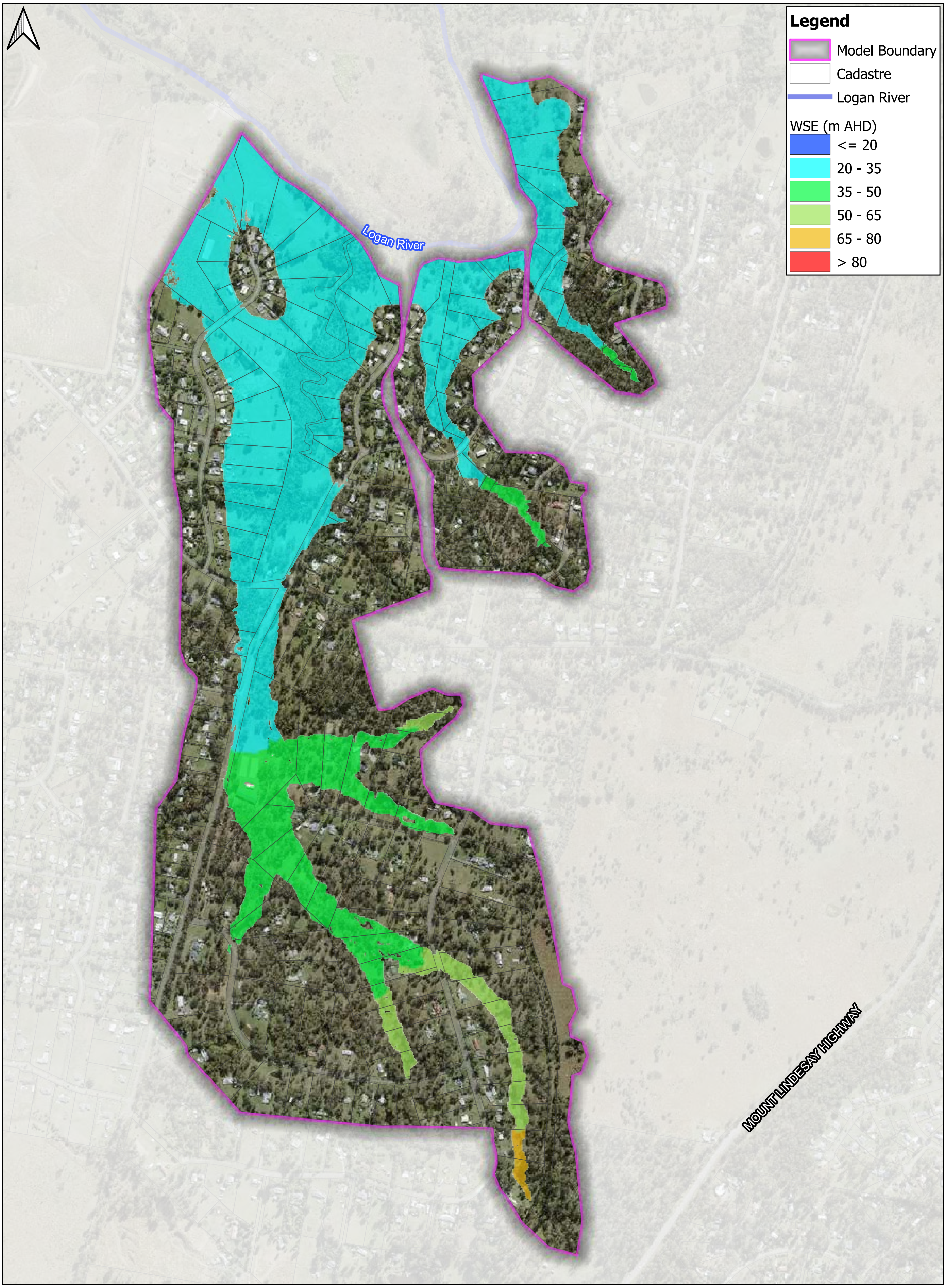
0 200 400 600 800 m

Days Creek Flood Study Update 2023

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



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Imagery Source: LCC
Water Technology Pty Ltd

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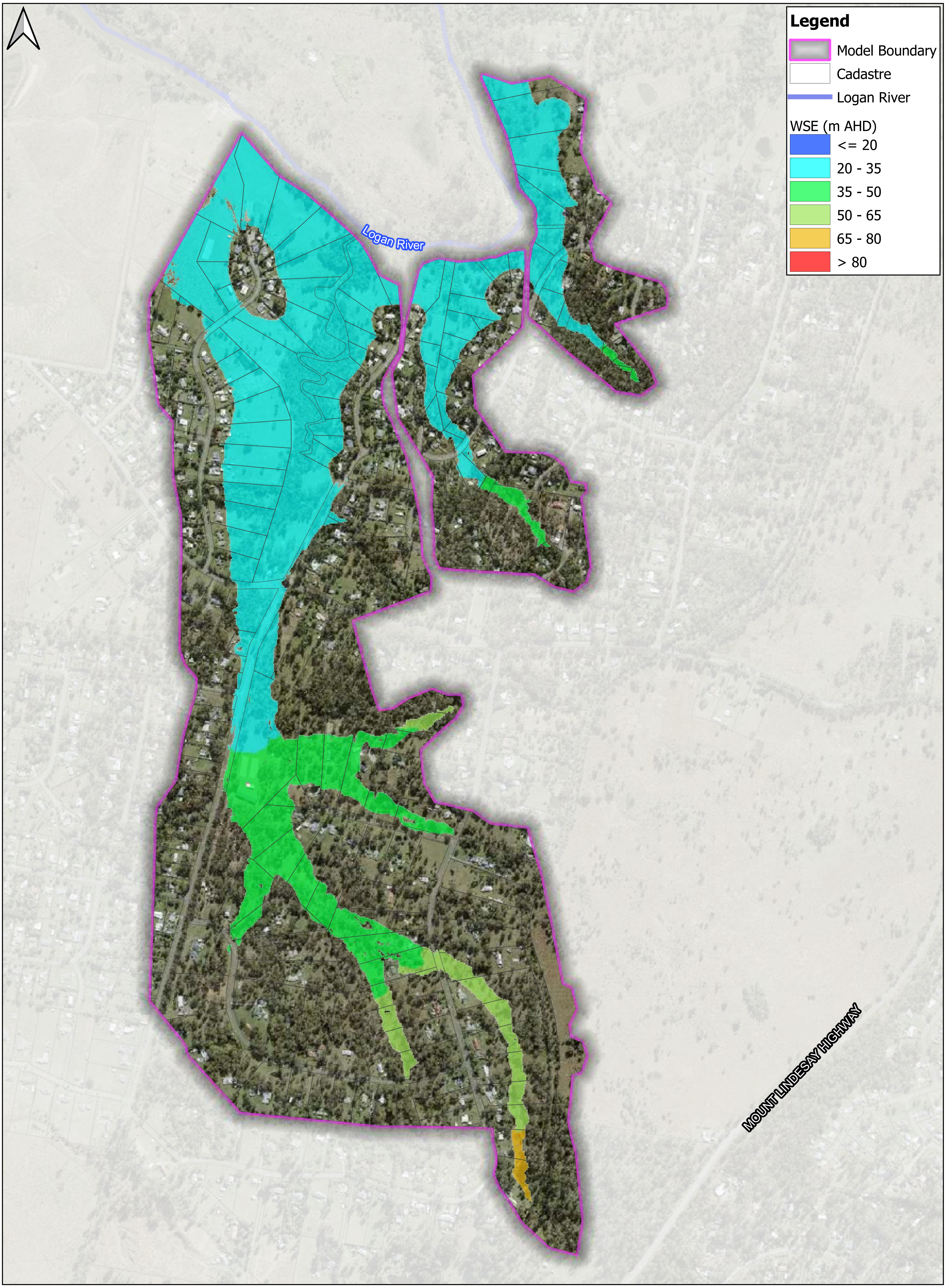
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 0.2% AEP Peak Water Surface Elevation

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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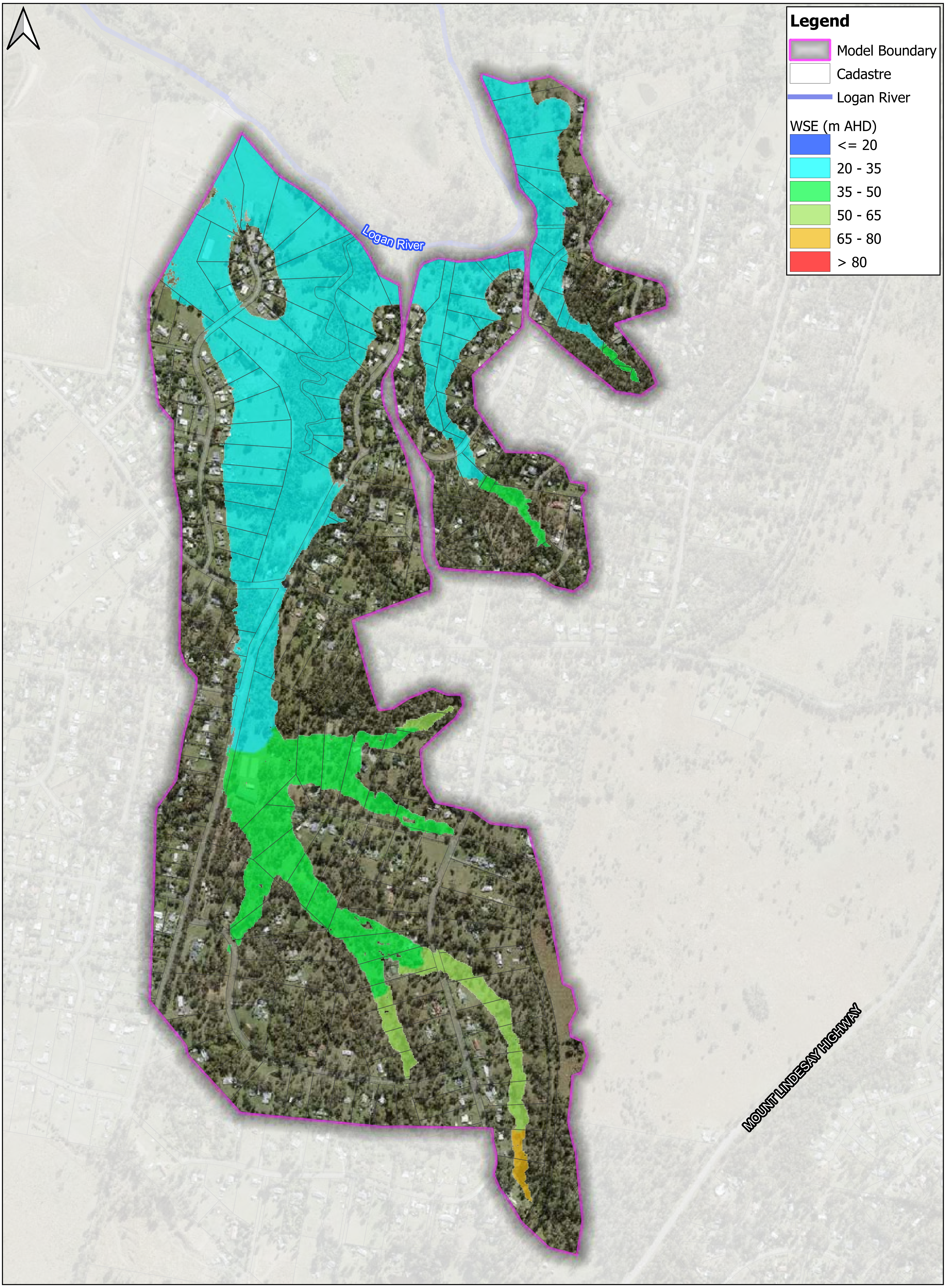
0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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Days Creek Flood Study Update 2023

Roberts Waterhole - 0.05% AEP Peak Water Surface Elevation

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

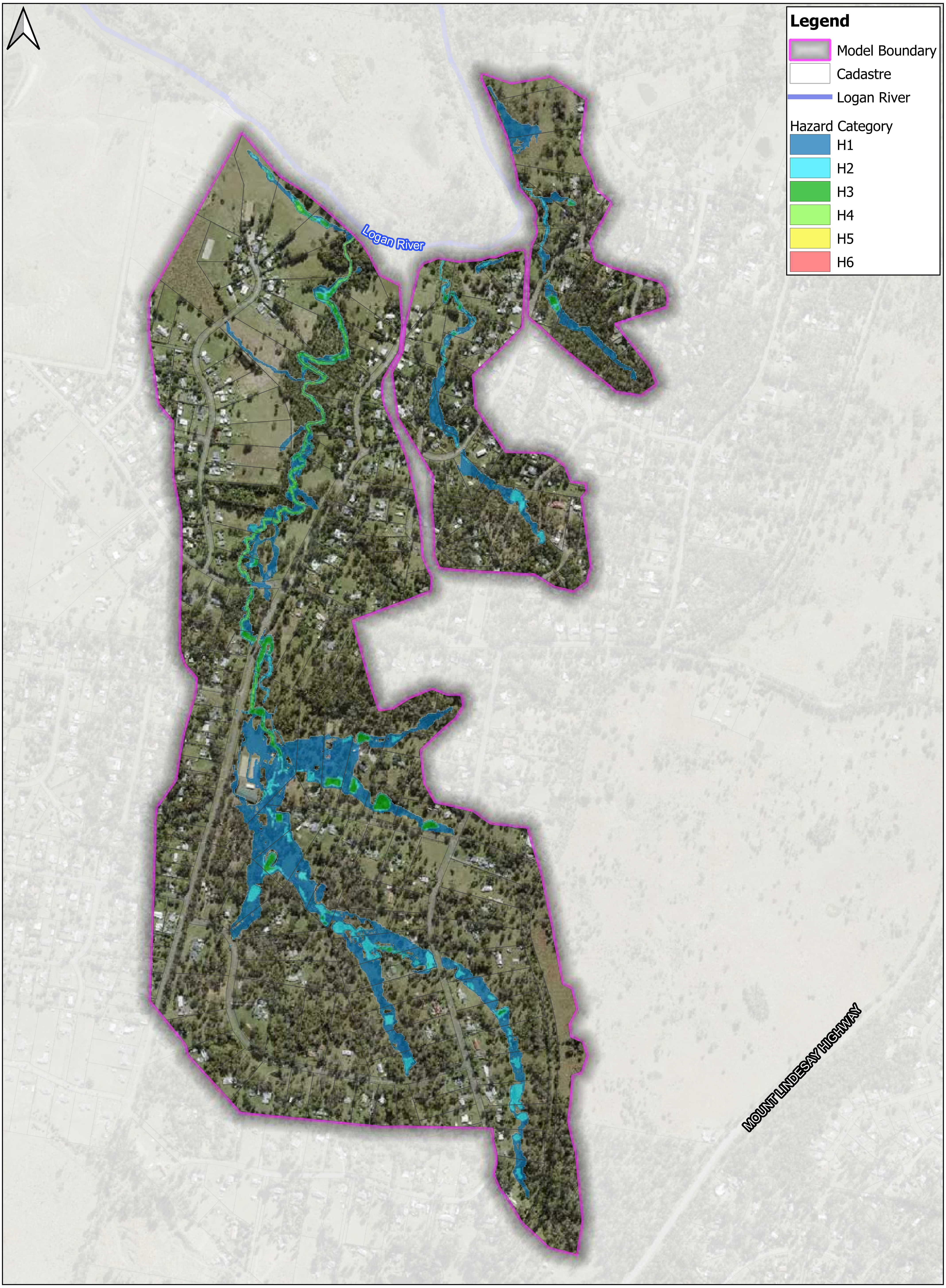
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - PMF Peak Water Surface Elevation

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

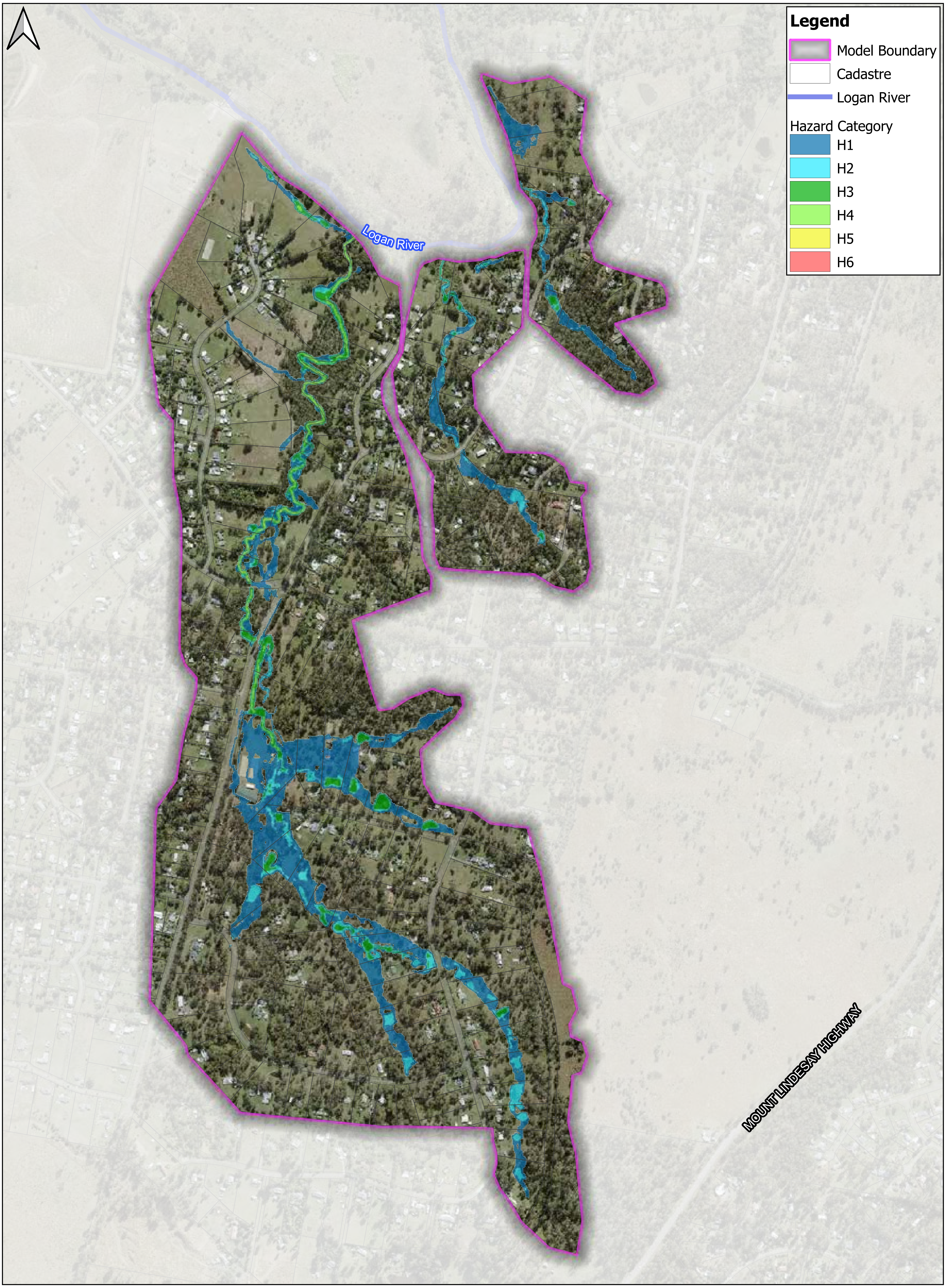
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 63.2% AEP Peak Water Hazard Category

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56

Imagery Source: LCC

Water Technology Pty Ltd

1:10,000

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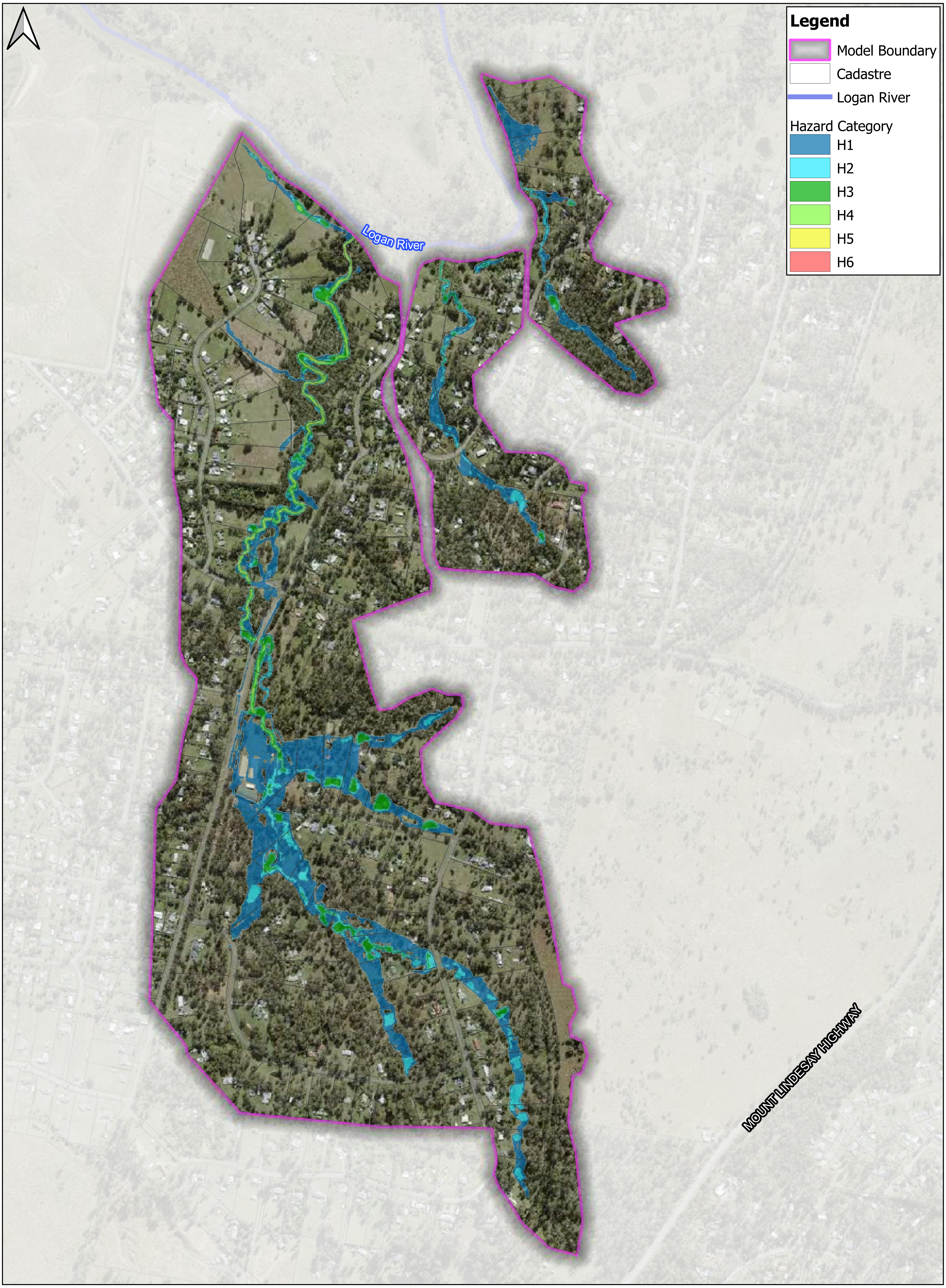
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP Peak Water Hazard Category

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

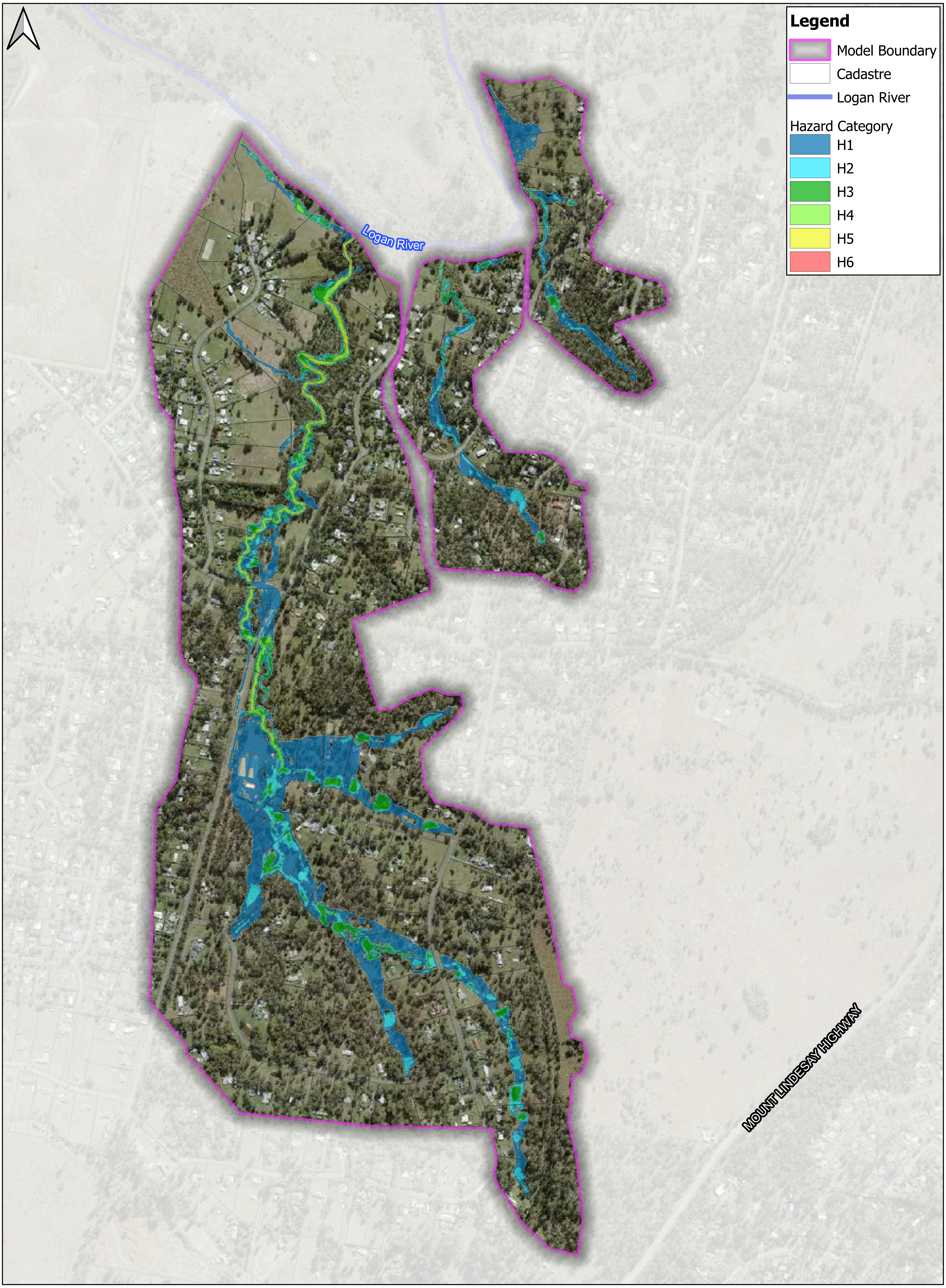
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



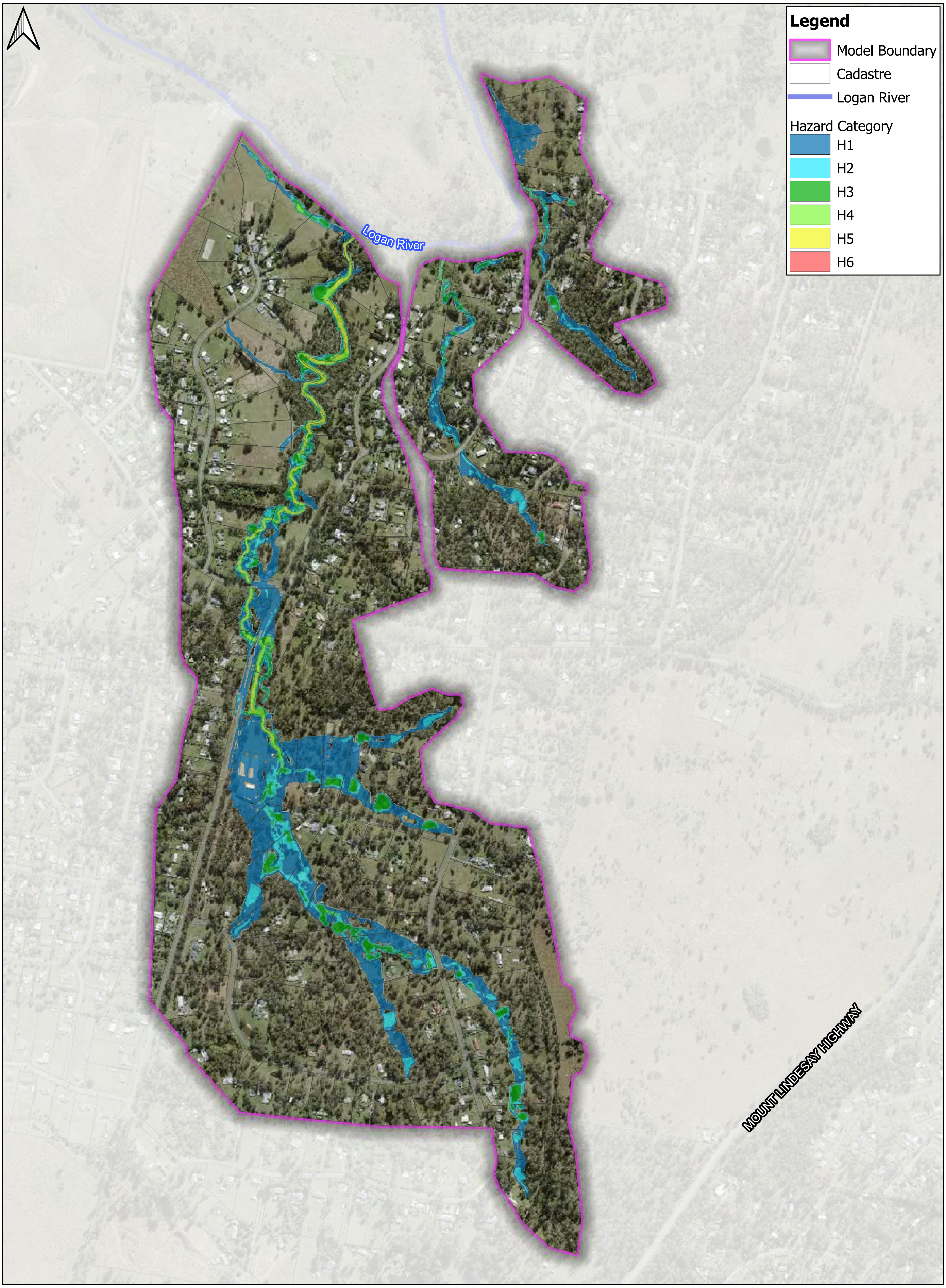
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Peak Water Hazard Category



Projection: GDA20 MGA56

Imagery Source: LCC

Water Technology Pty Ltd

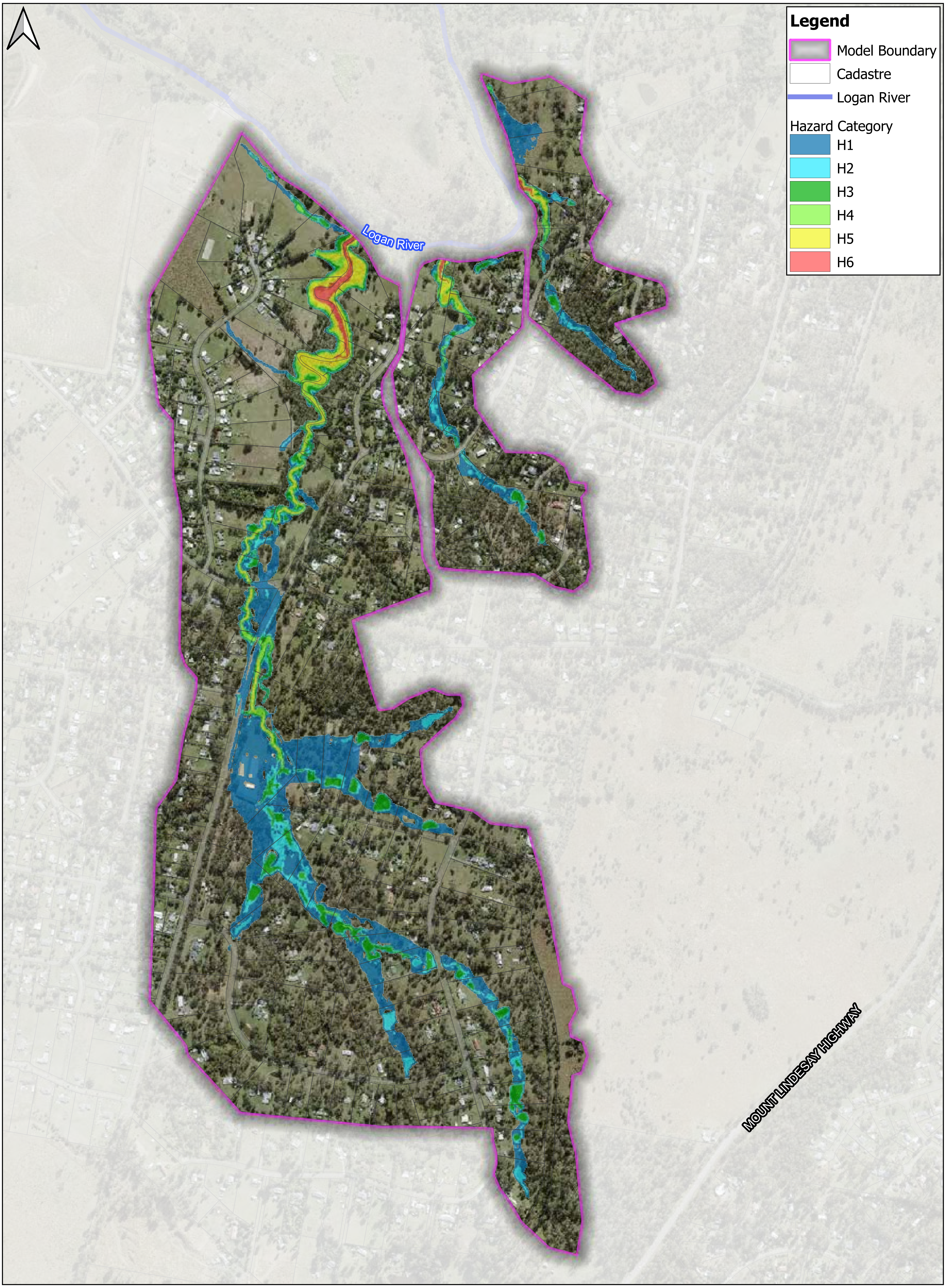
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



Projection: GDA20 MGA56

Imagery Source: LCC

Water Technology Pty Ltd

1:10,000

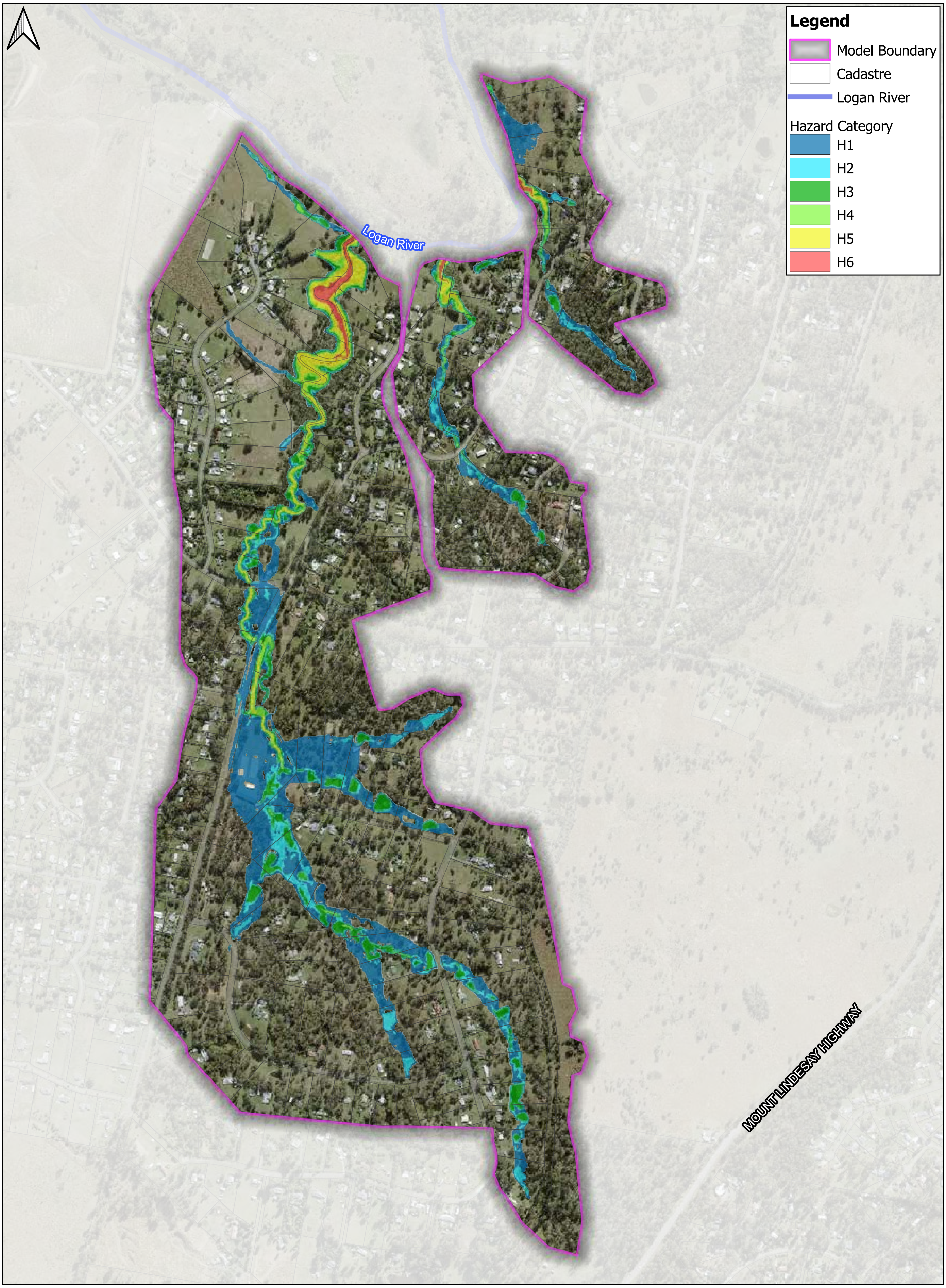
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP Peak Water Hazard Category

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56

Imagery Source: LCC

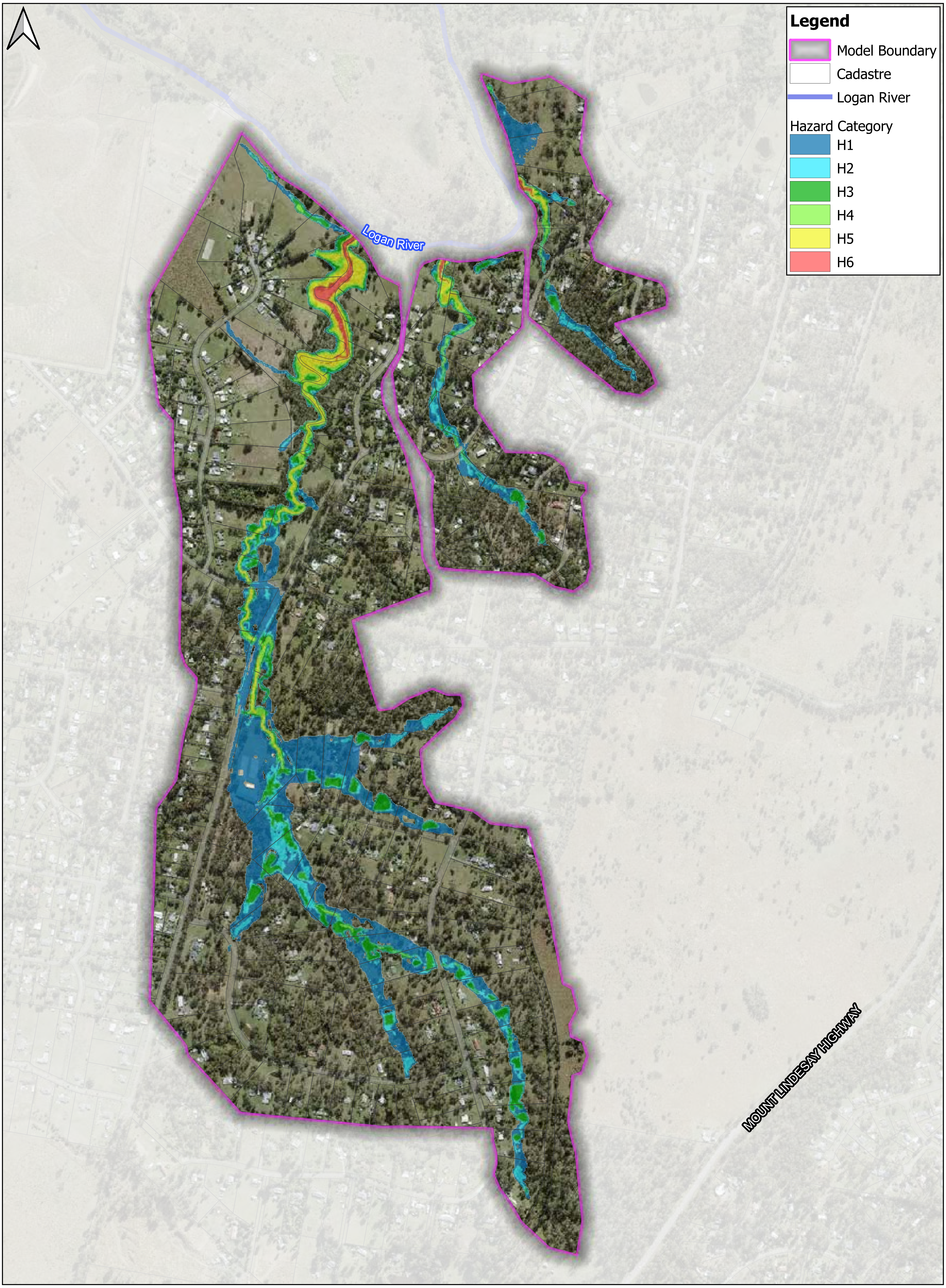
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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



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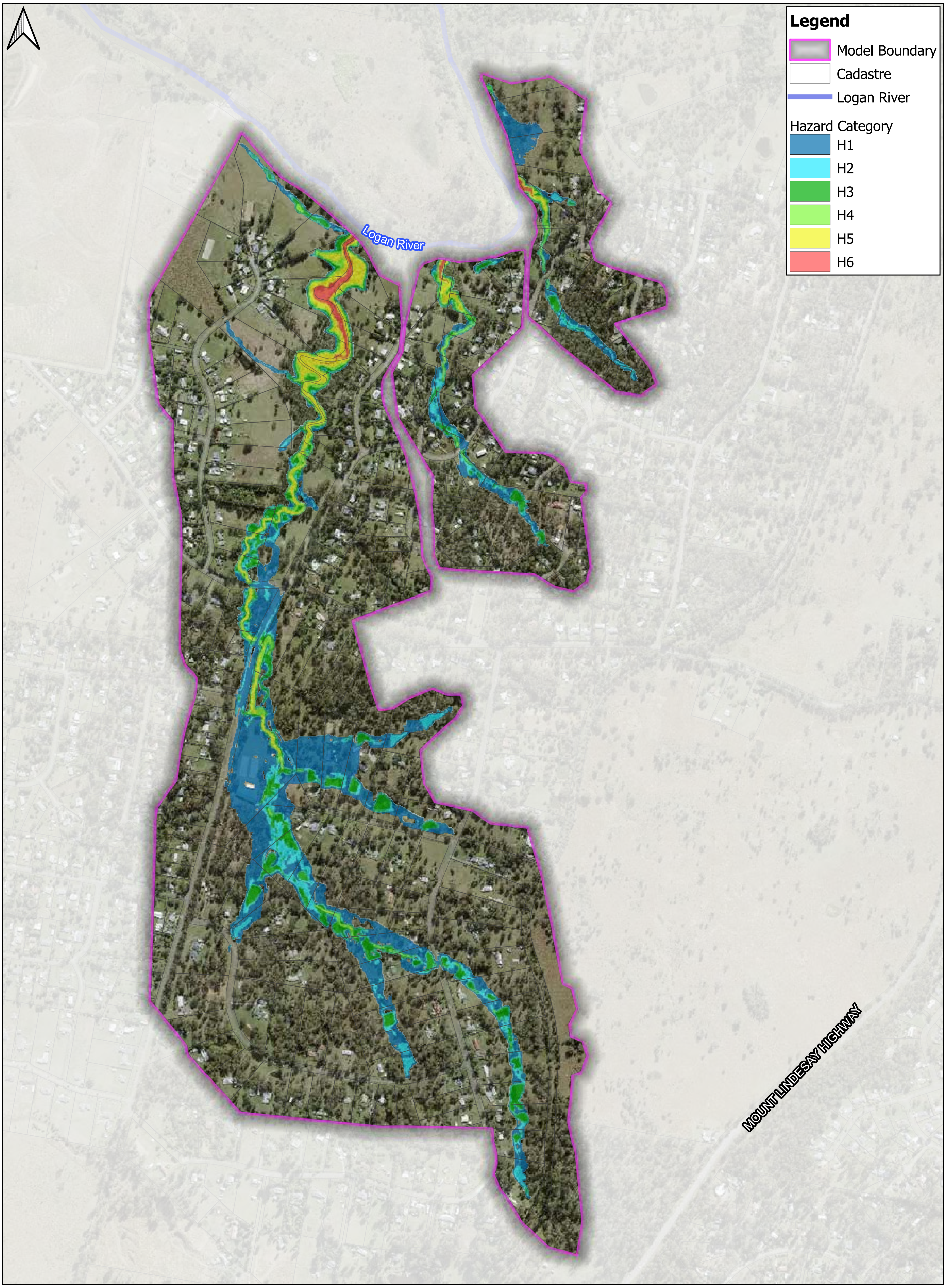
Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 5% AEP Peak Water Hazard Category



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

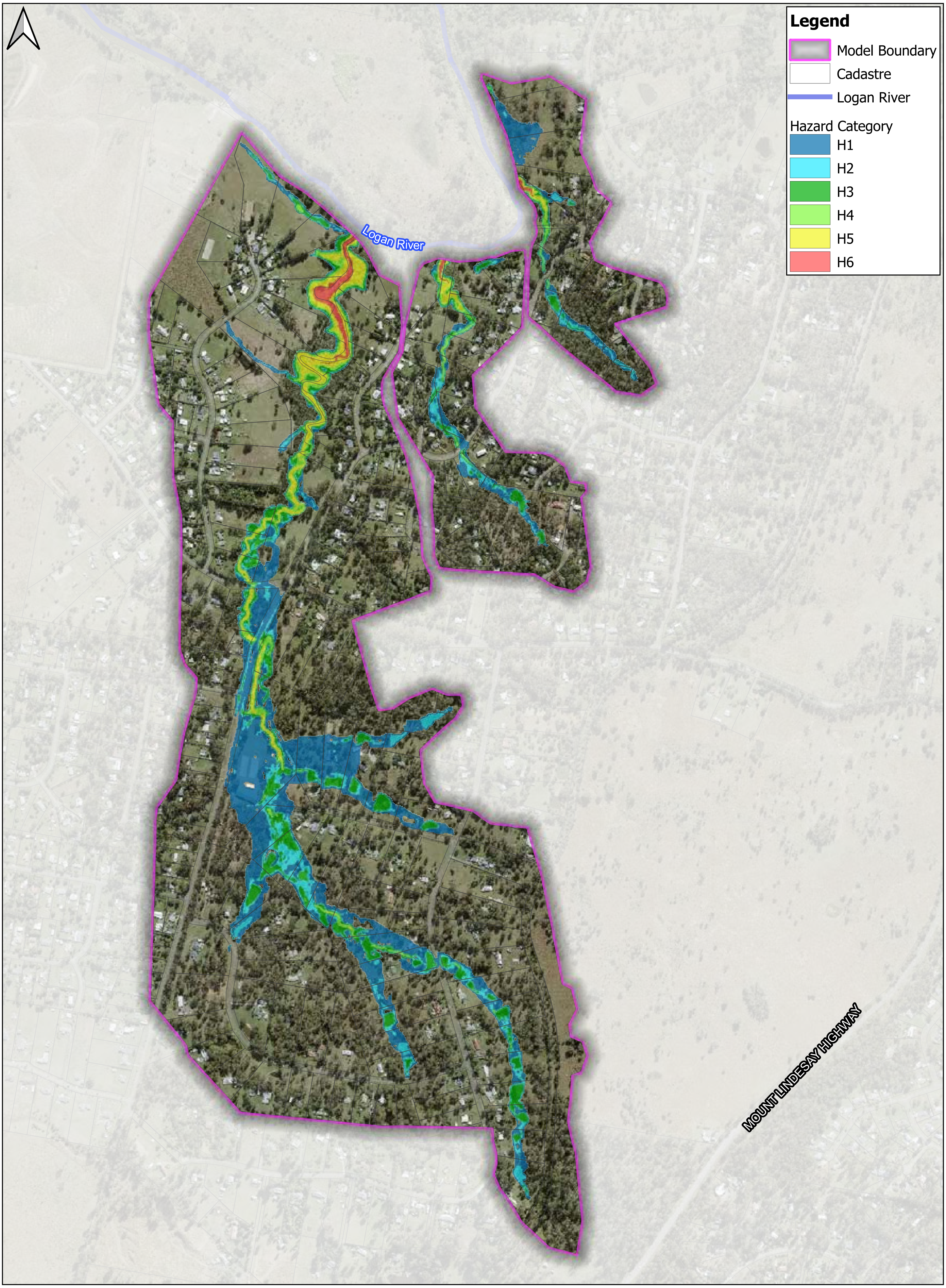
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY



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

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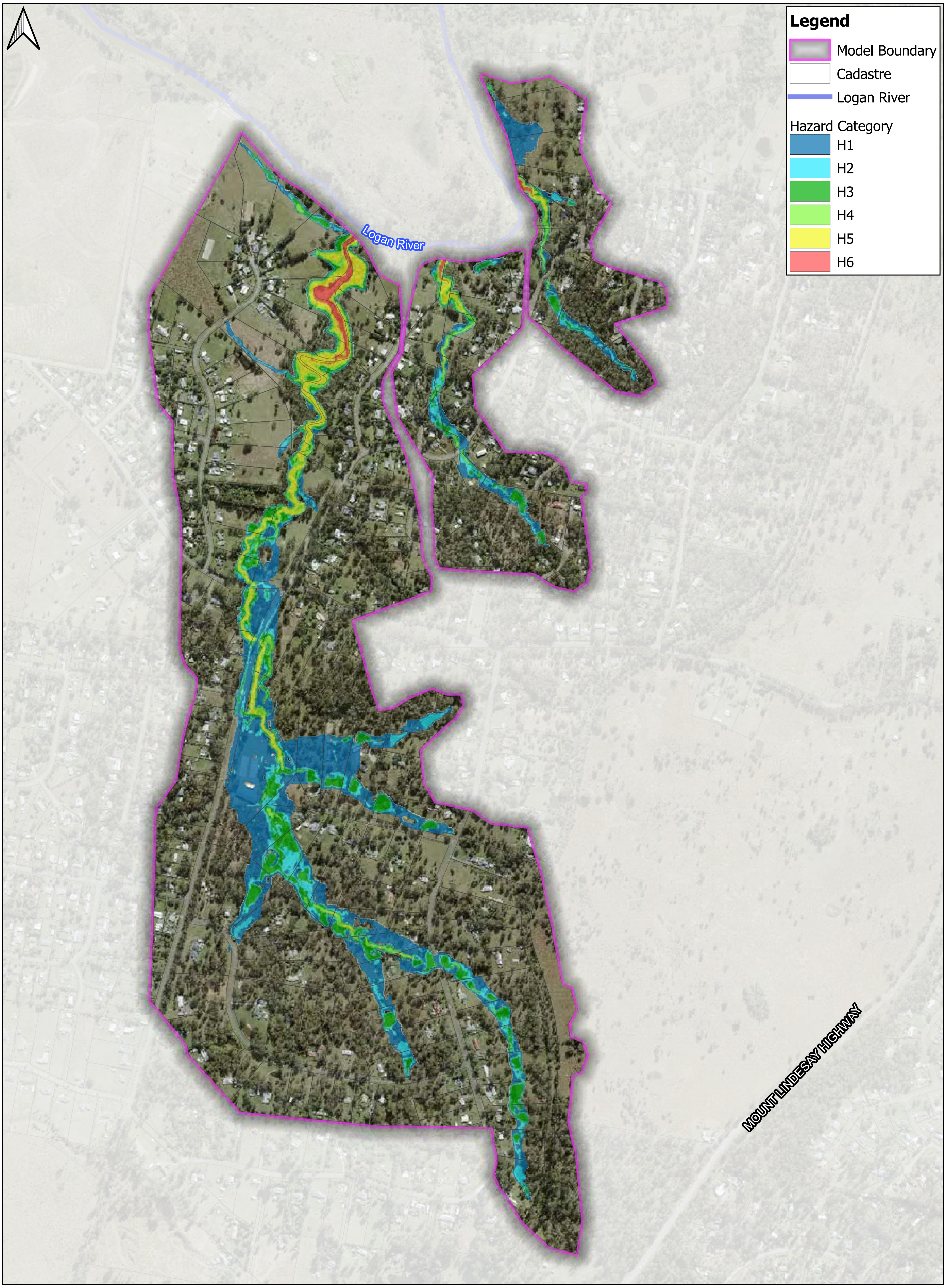
Days Creek Flood Study Update 2023

Roberts Waterhole - 2% AEP Peak Water Hazard Category



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Imagery Source: LCC
Water Technology Pty Ltd

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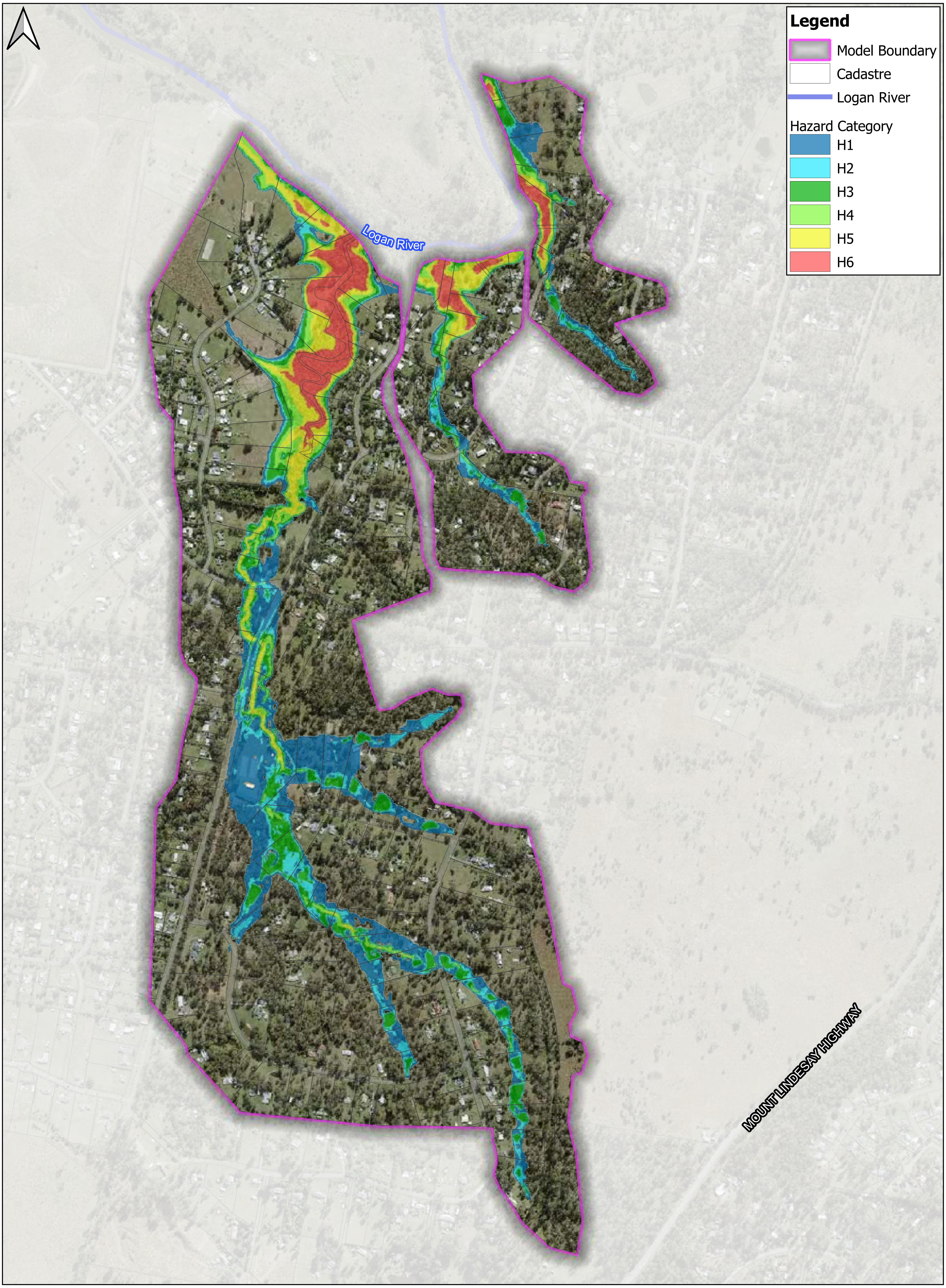
Days Creek Flood Study Update 2023

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



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Water Technology Pty Ltd

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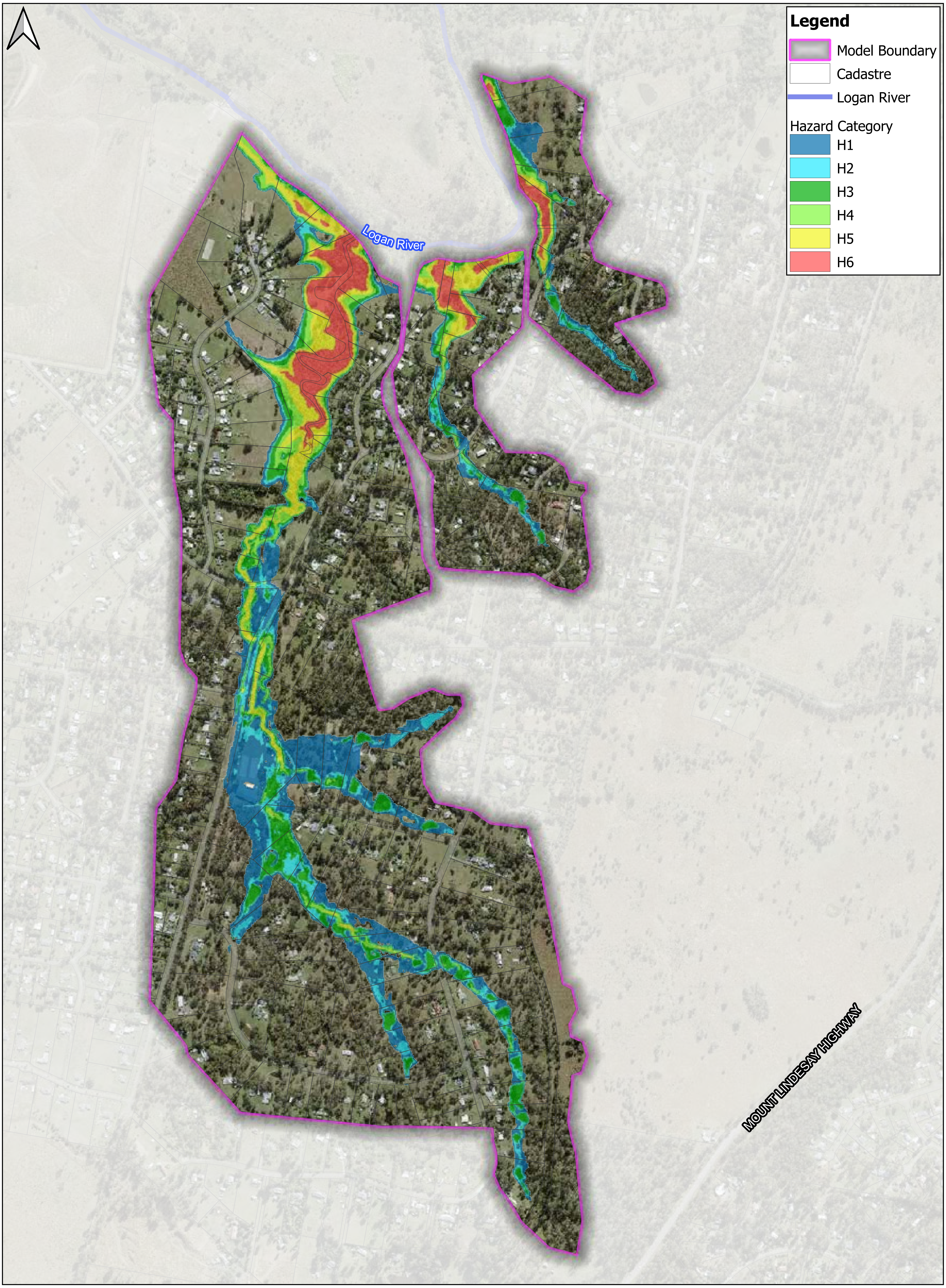
Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Peak Water Hazard Category



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Water Technology Pty Ltd

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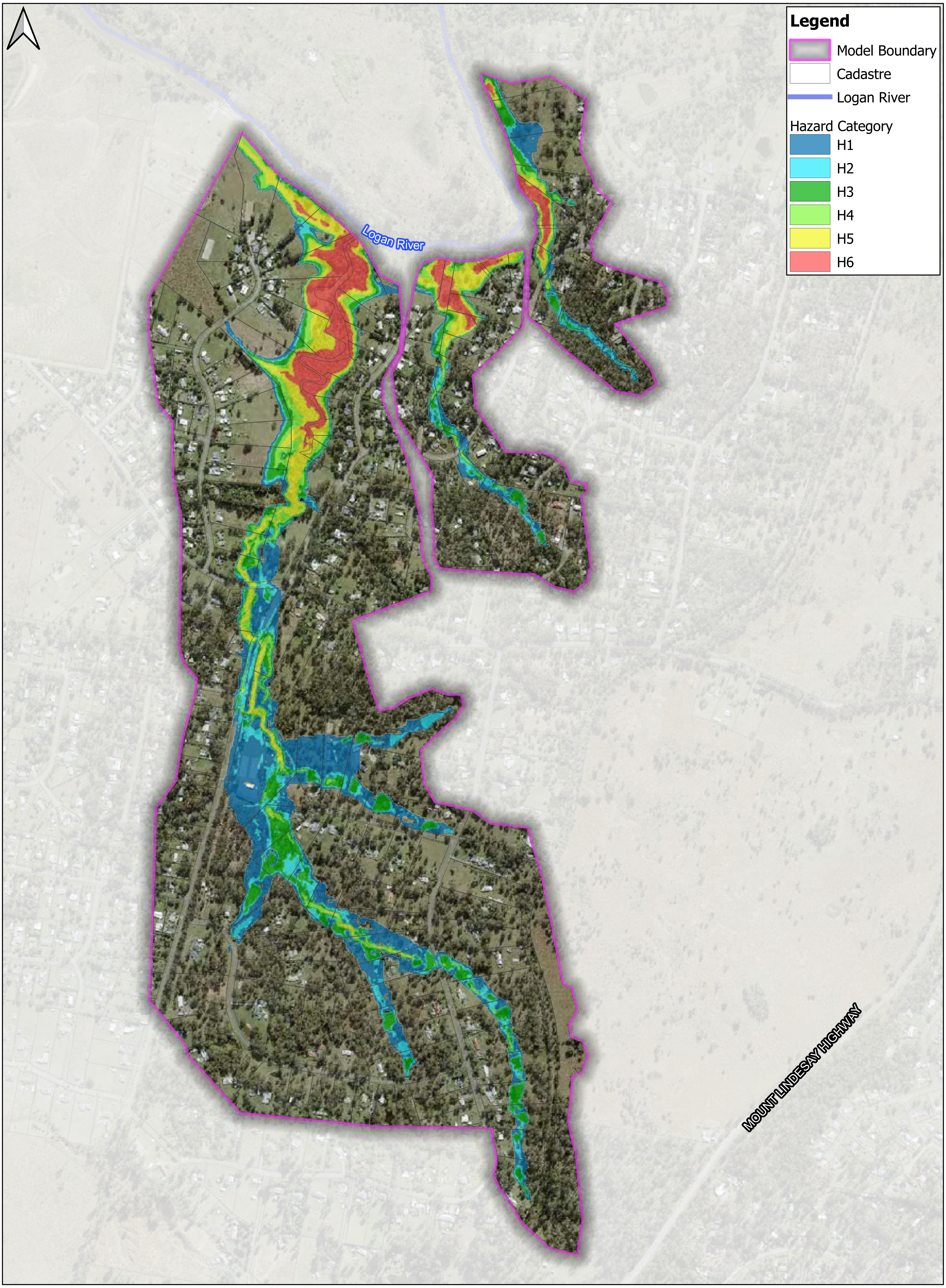
Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP CC (RCP4.5) Peak Water Hazard Category



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Water Technology Pty Ltd

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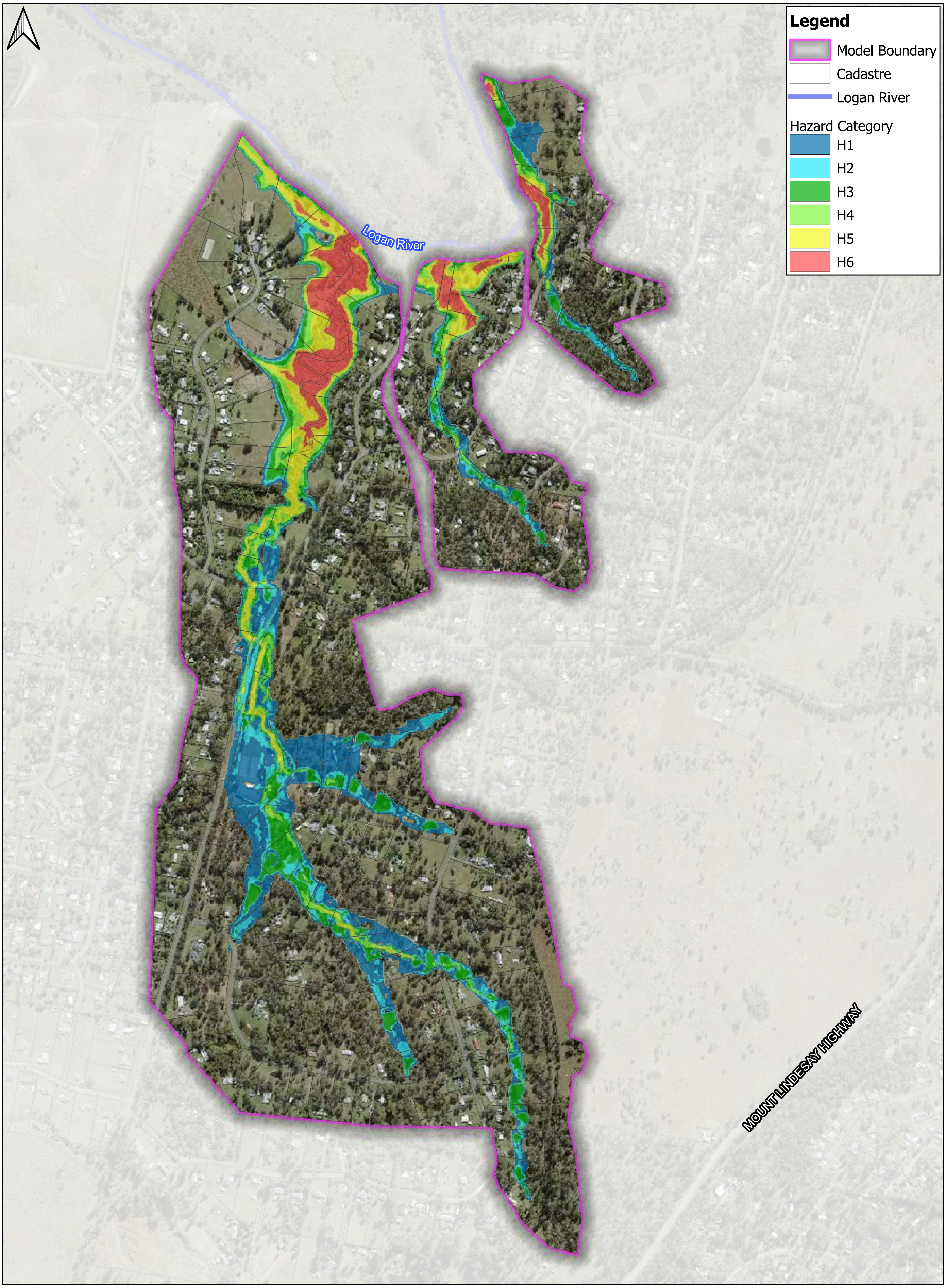
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.5% AEP Peak Water Hazard Category



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Water Technology Pty Ltd

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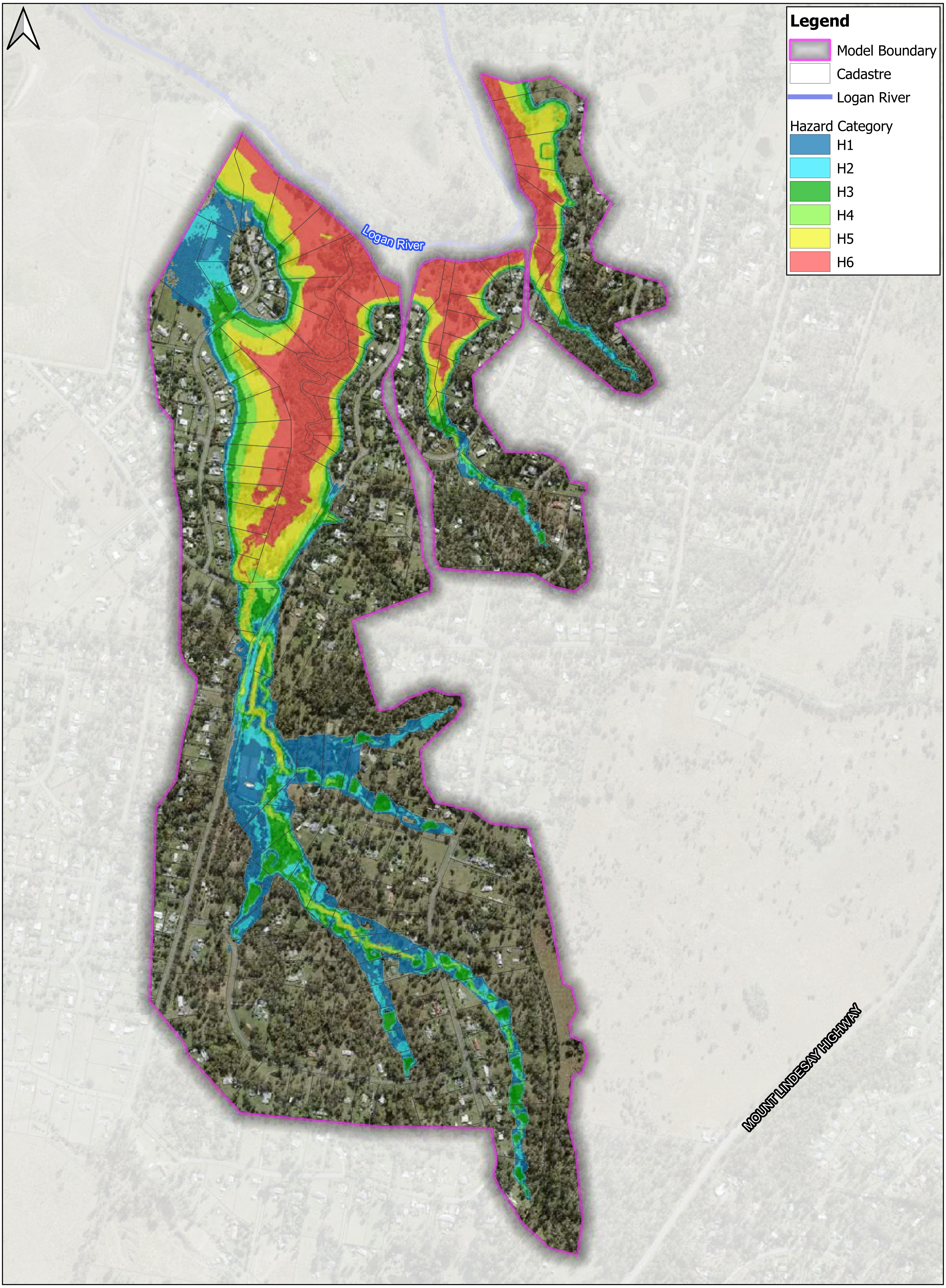
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.5% AEP CC (RCP4.5) Peak Water Hazard Category



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Water Technology Pty Ltd

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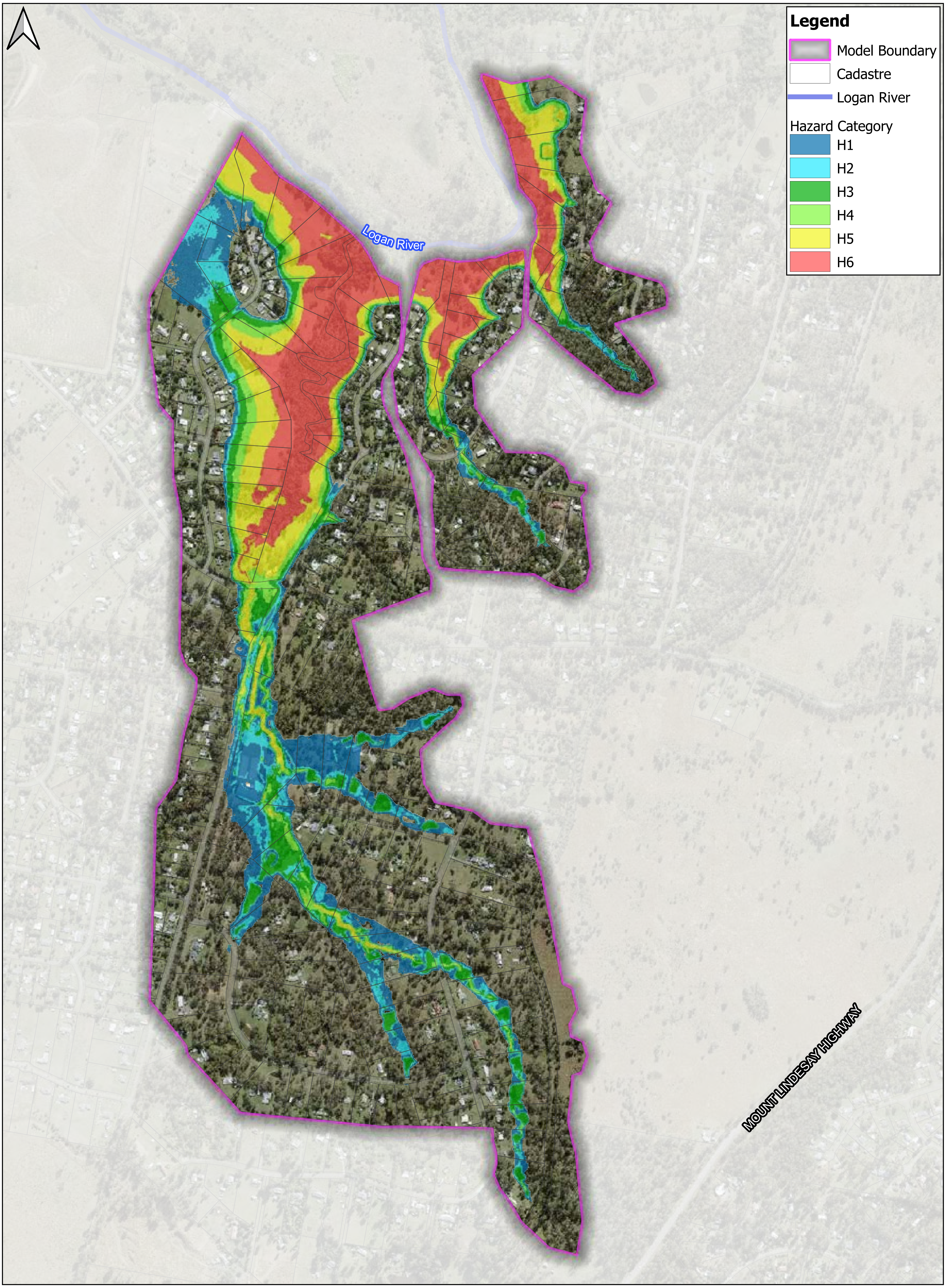
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.2% AEP Peak Water Hazard Category

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

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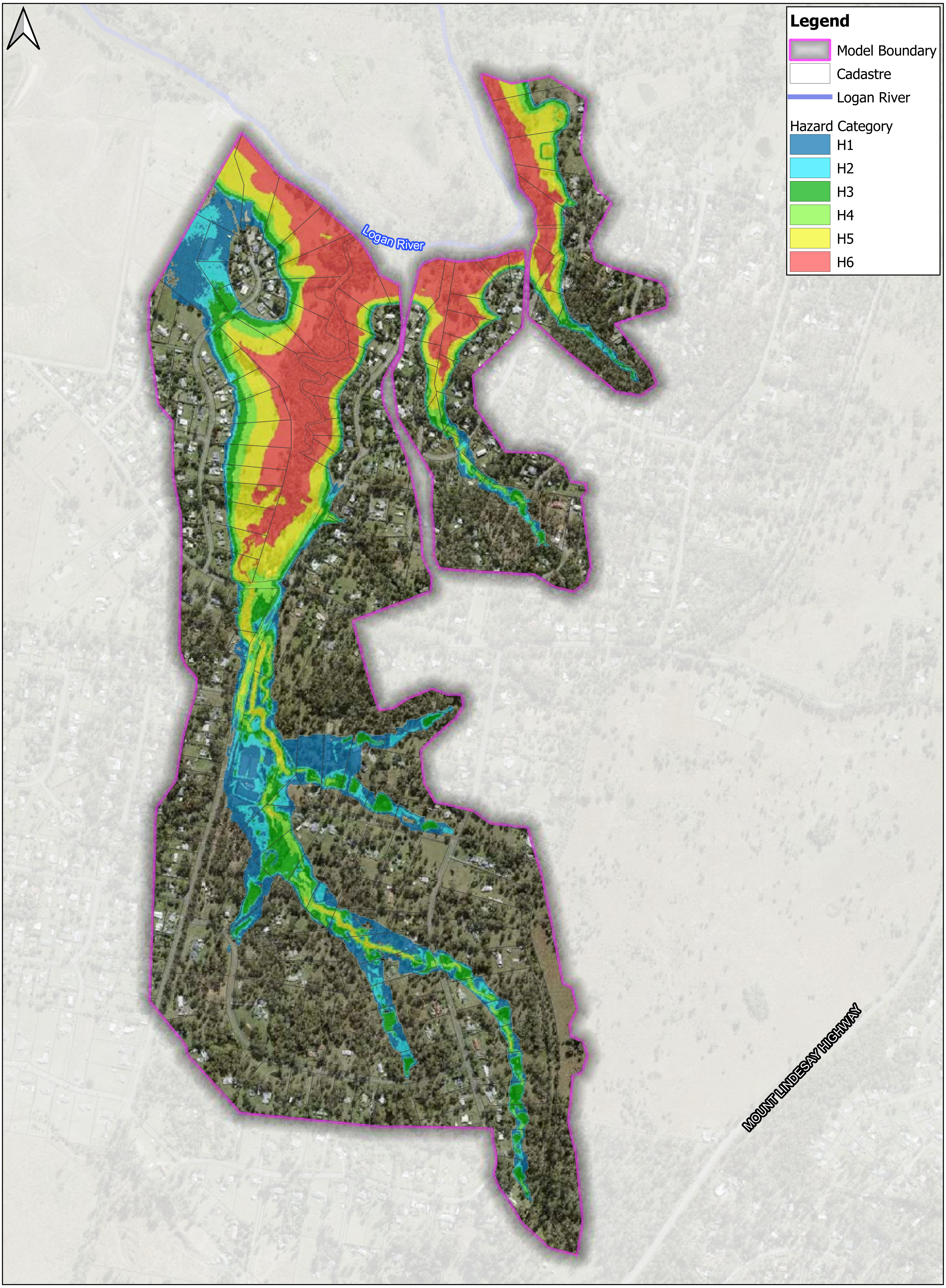
Days Creek Flood Study Update 2023

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

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC

Water Technology Pty Ltd

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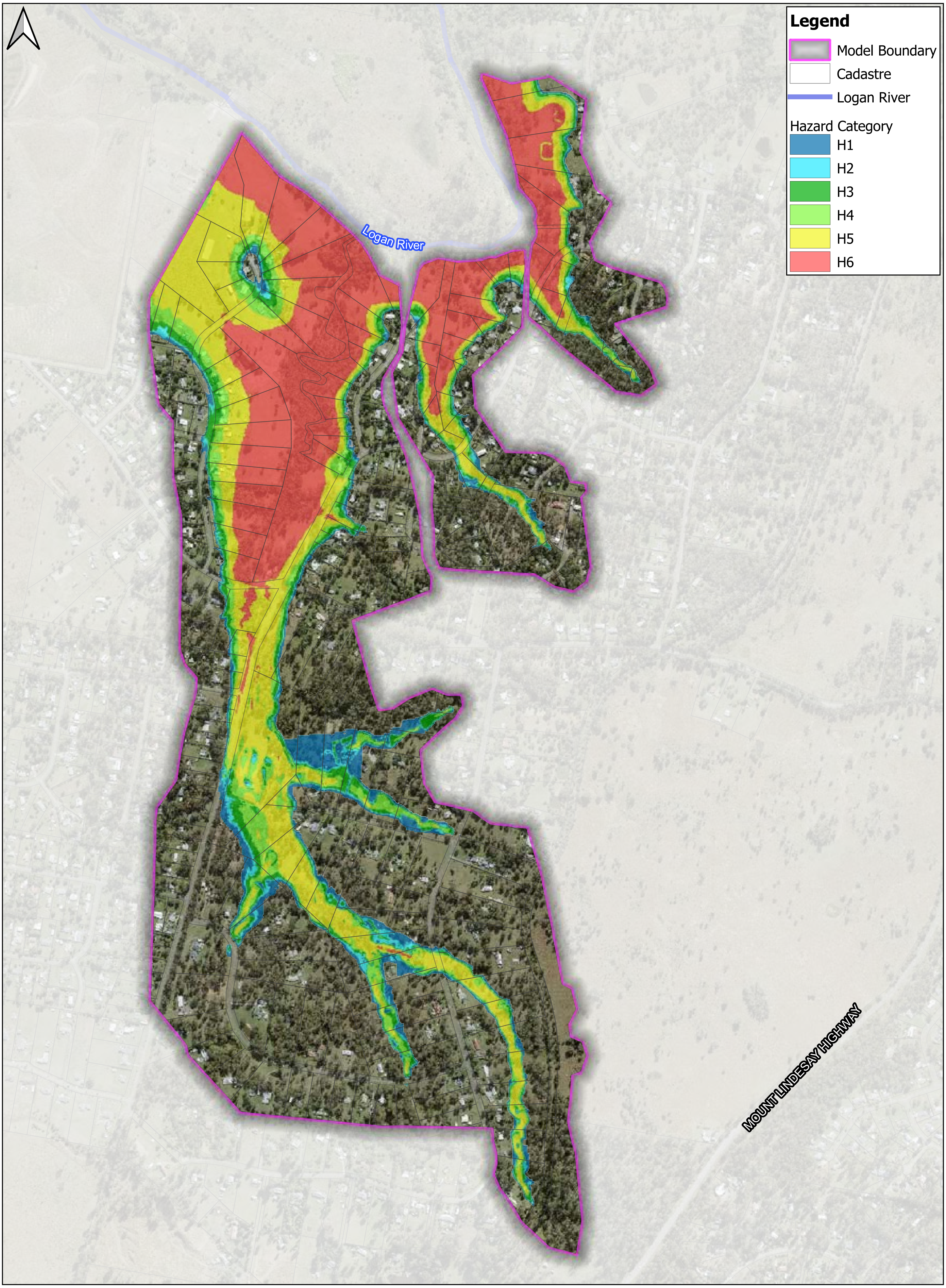
Days Creek Flood Study Update 2023

Roberts Waterhole - 0.05% AEP Peak Water Hazard Category



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Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

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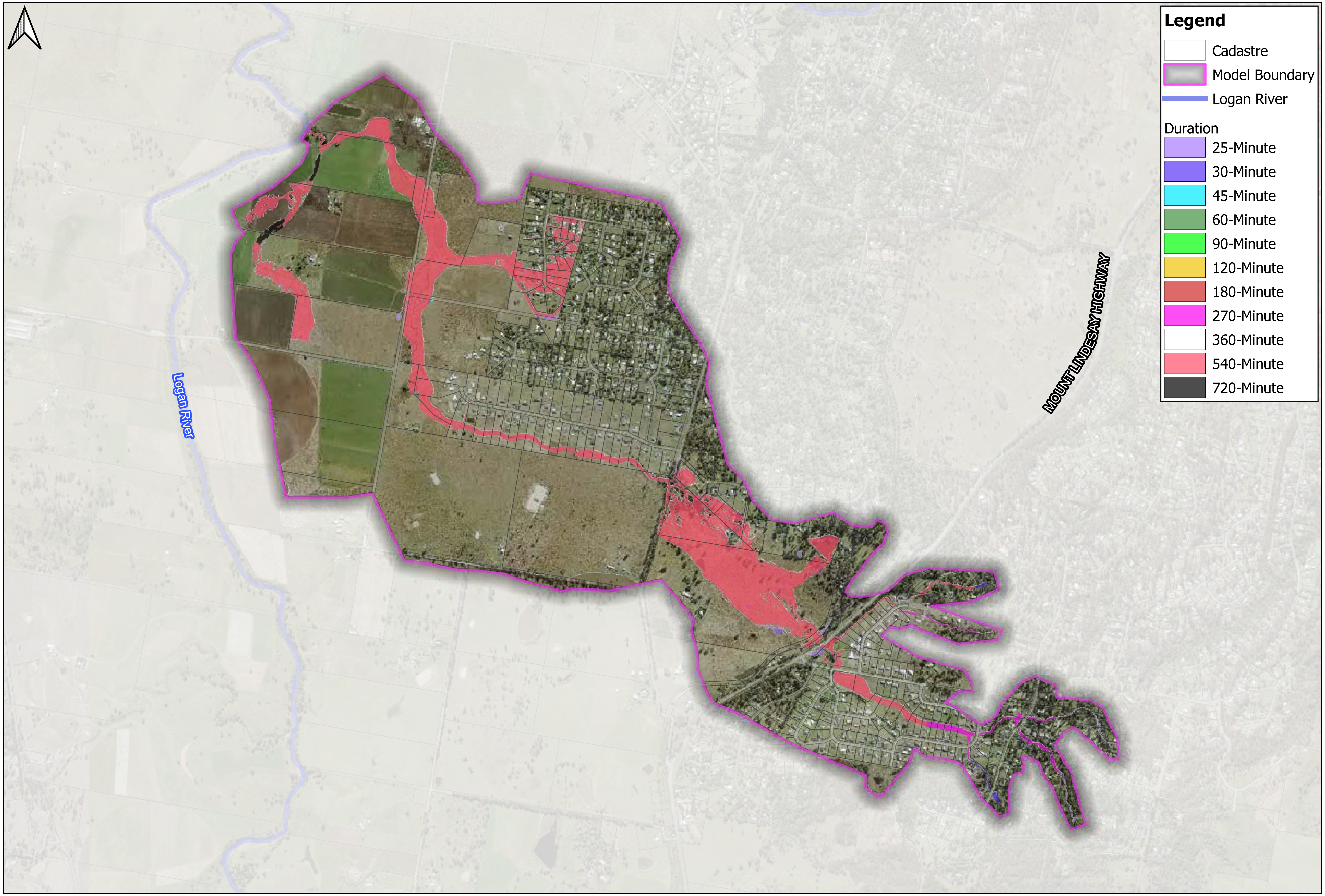
Days Creek Flood Study Update 2023

Roberts Waterhole - PMF Peak Water Hazard Category

APPENDIX G
HYDRAULIC MODEL CRITICAL TEMPORAL PATTERN GIS MAPS



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Water Technology Pty Ltd

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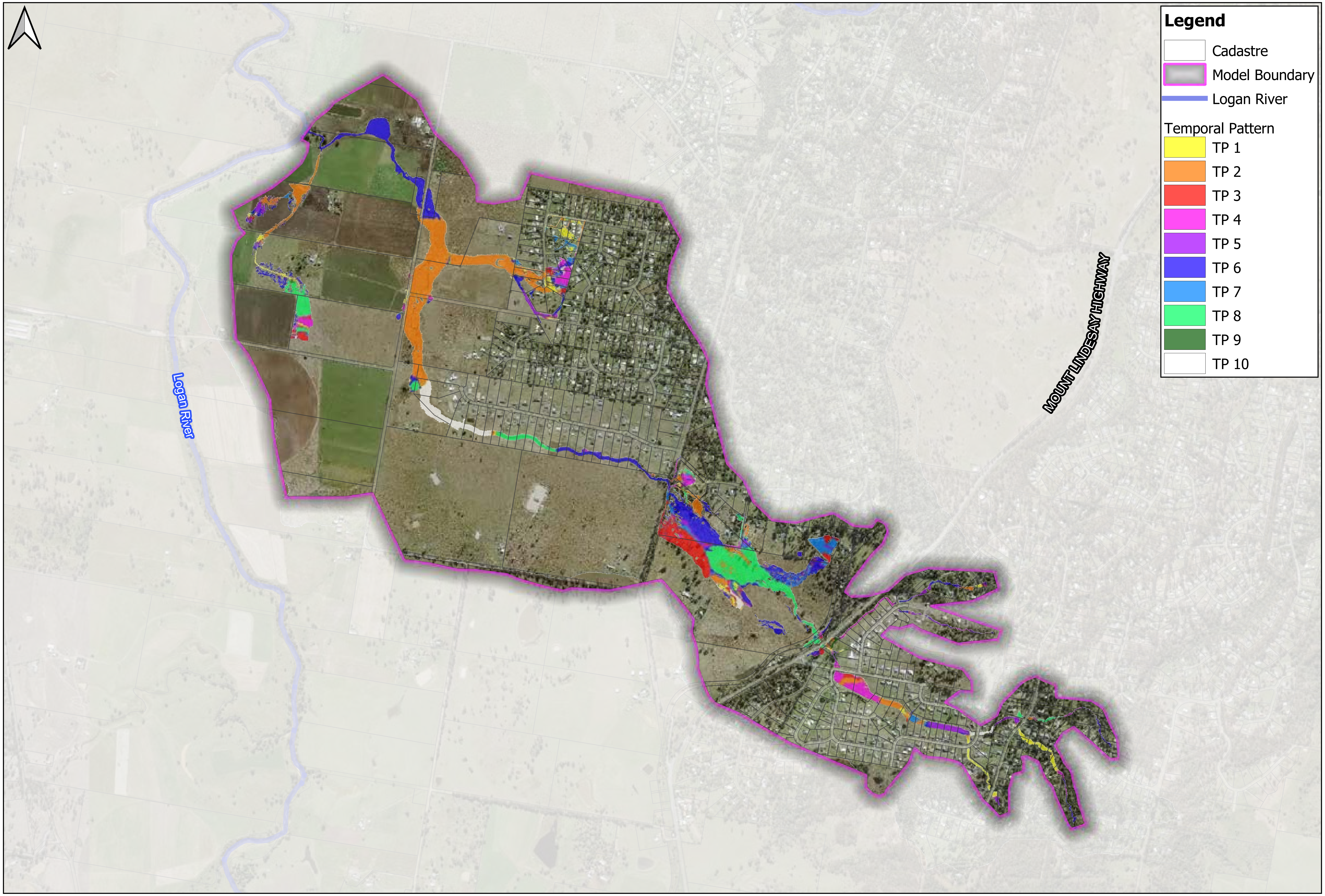
Days Creek Flood Study Update 2023

Days Creek - 50% AEP Critical Duration

WATER TECHNOLOGY



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Water Technology Pty Ltd

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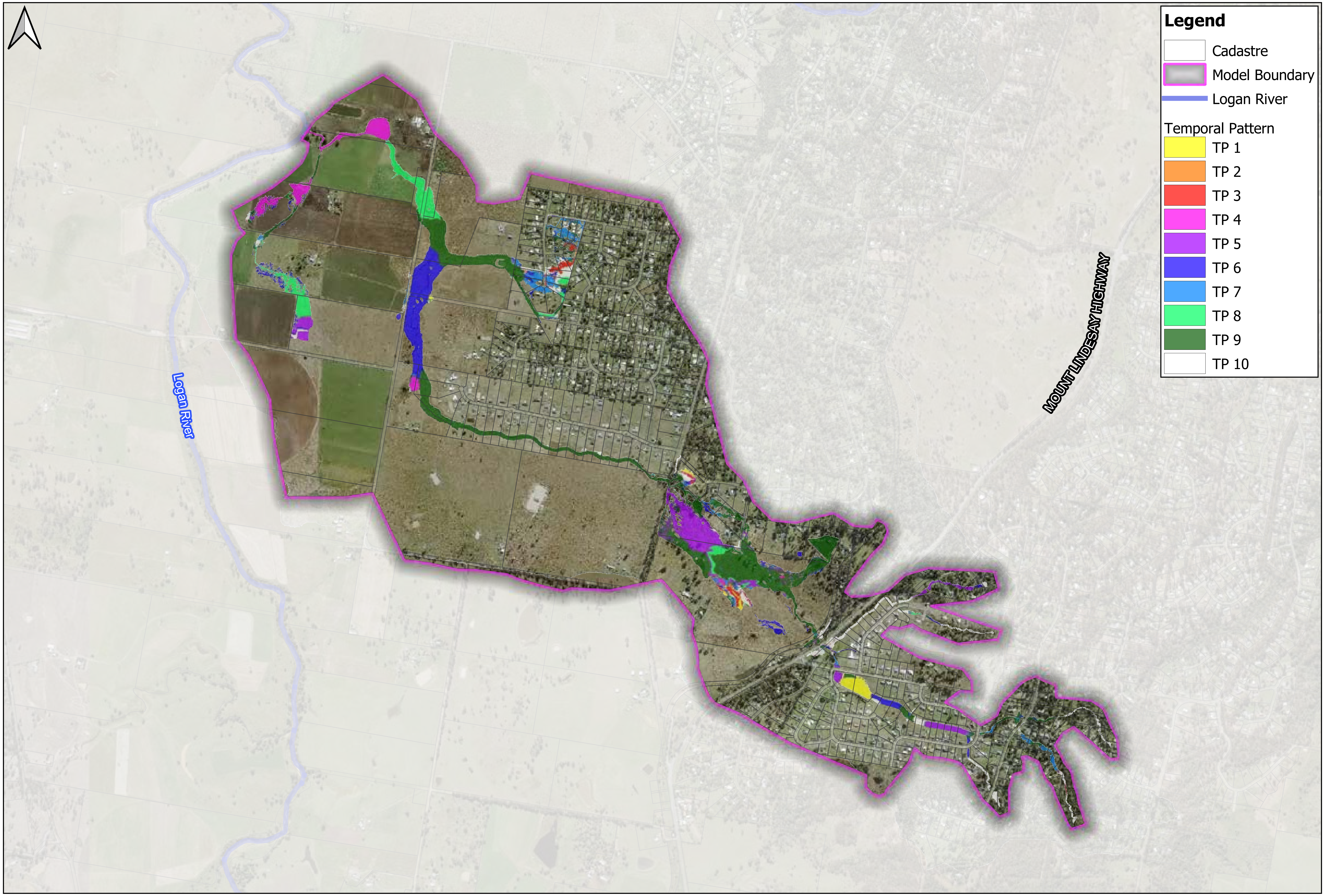
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 25-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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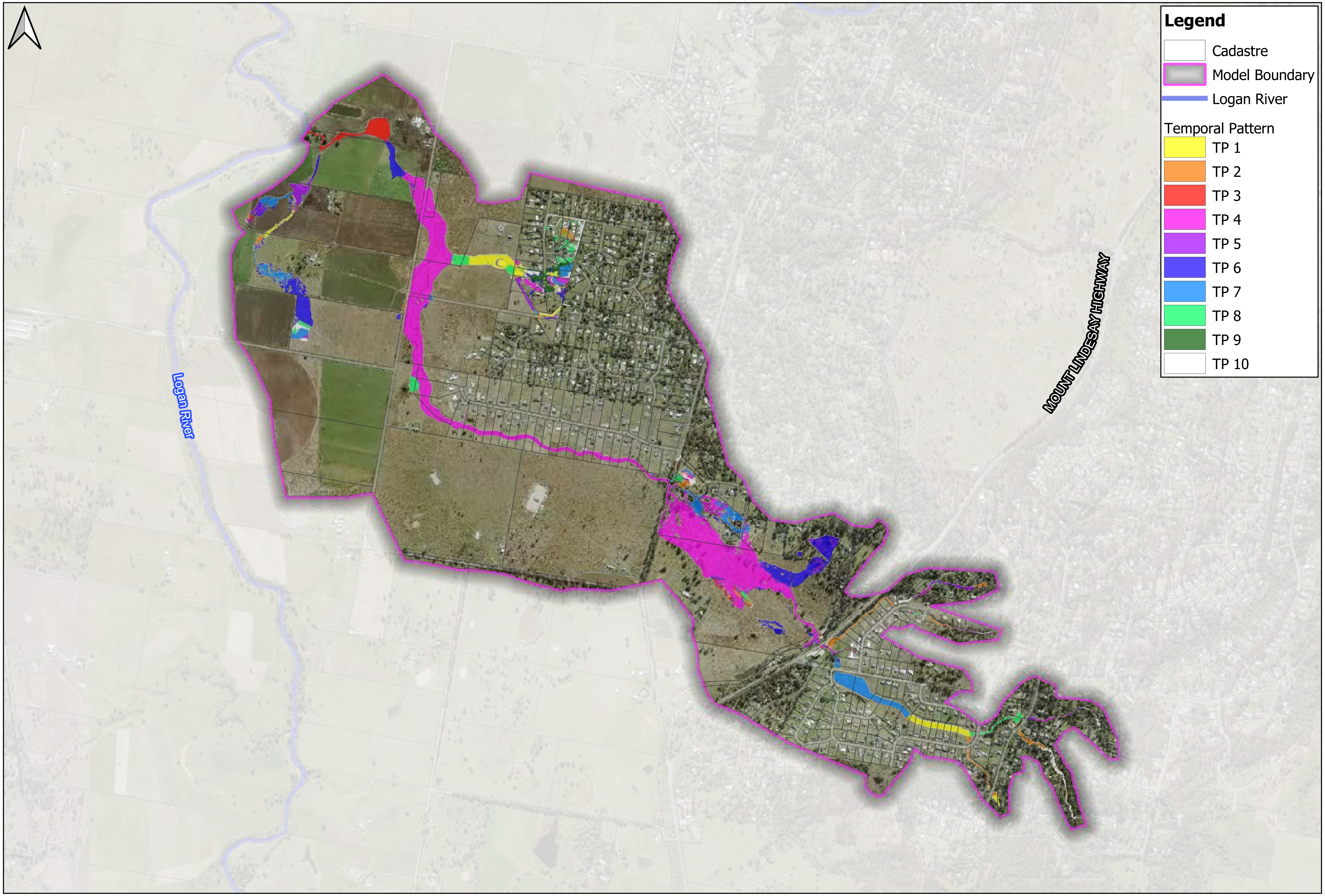
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 30-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

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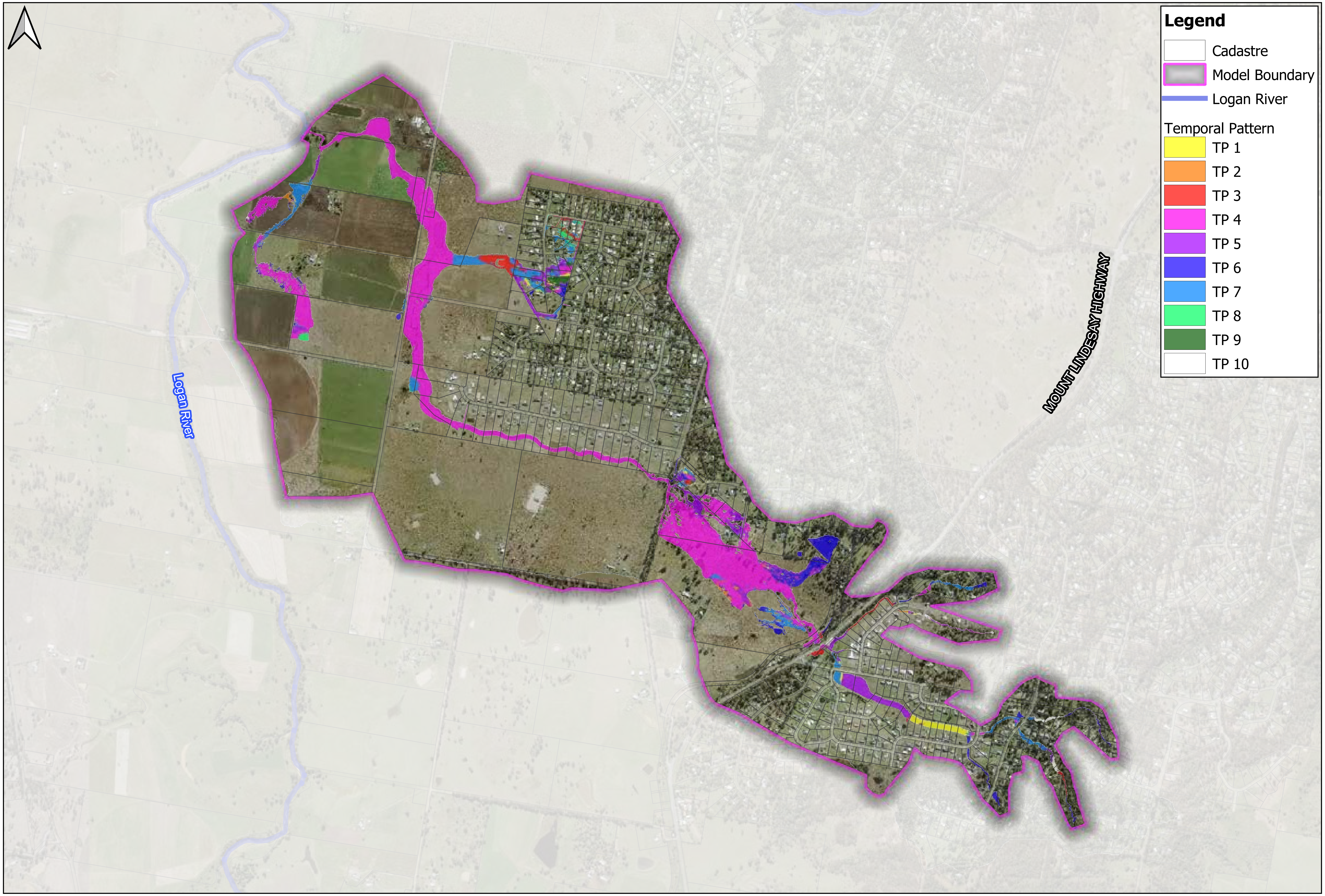
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 45-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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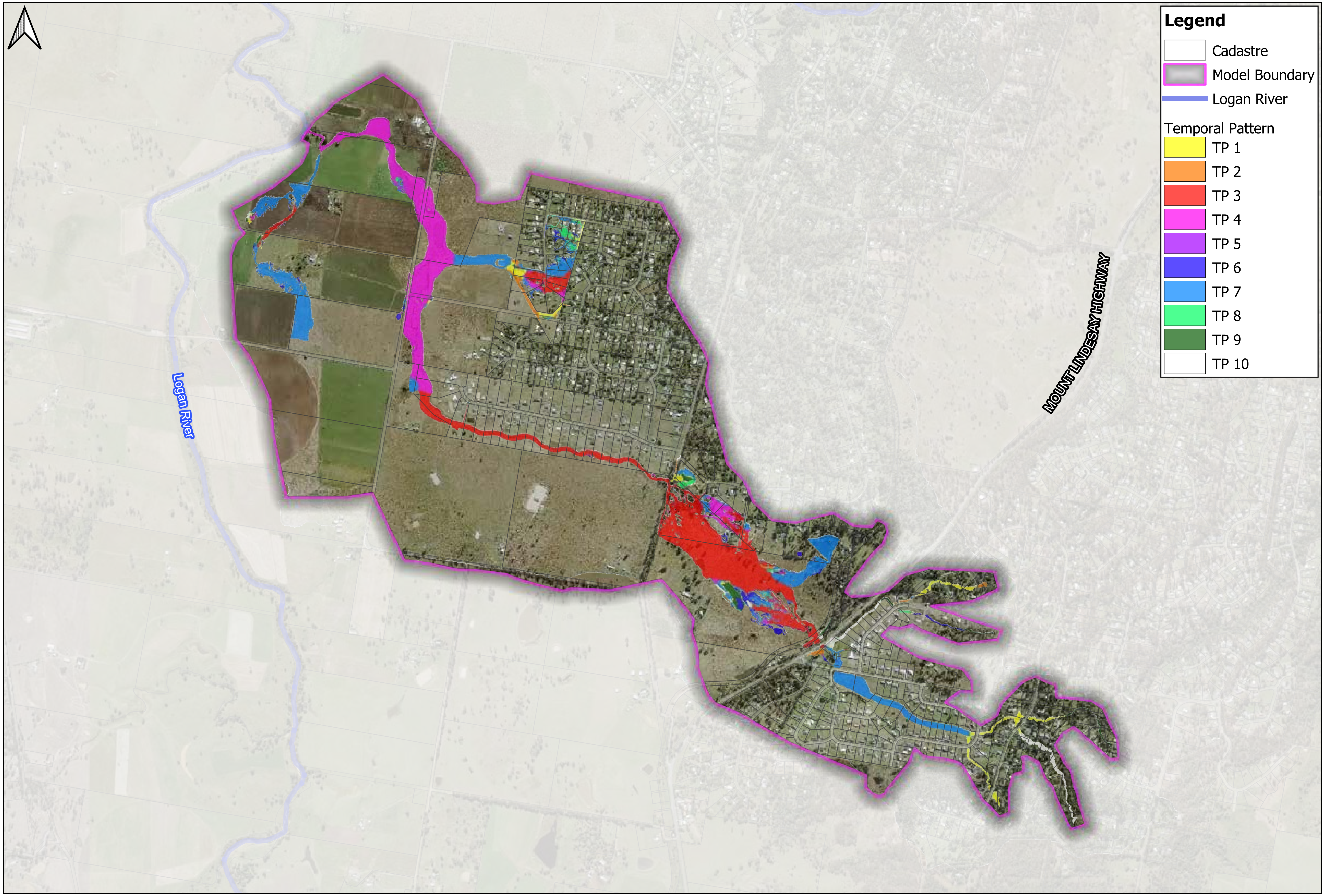
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 60-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

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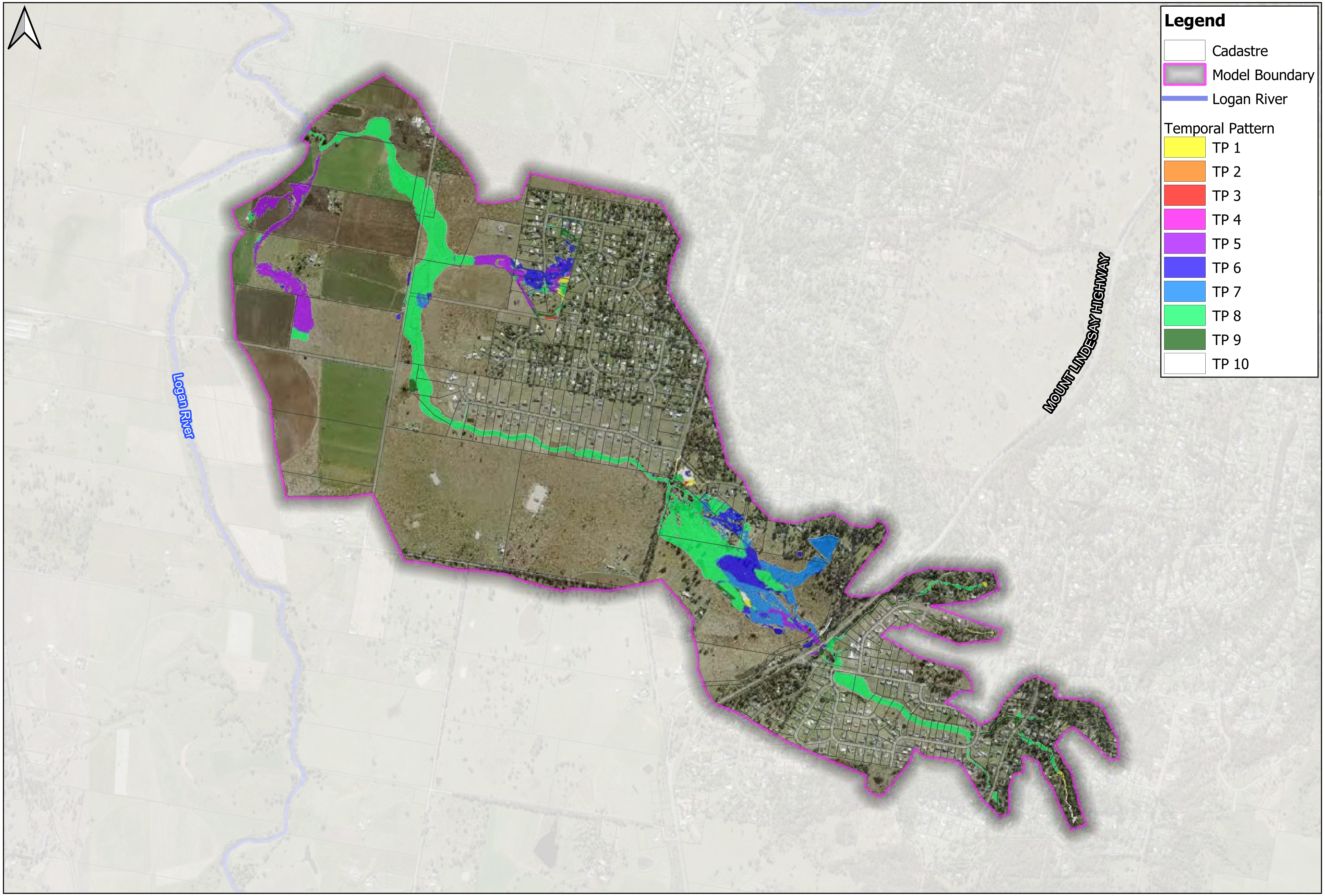
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 90-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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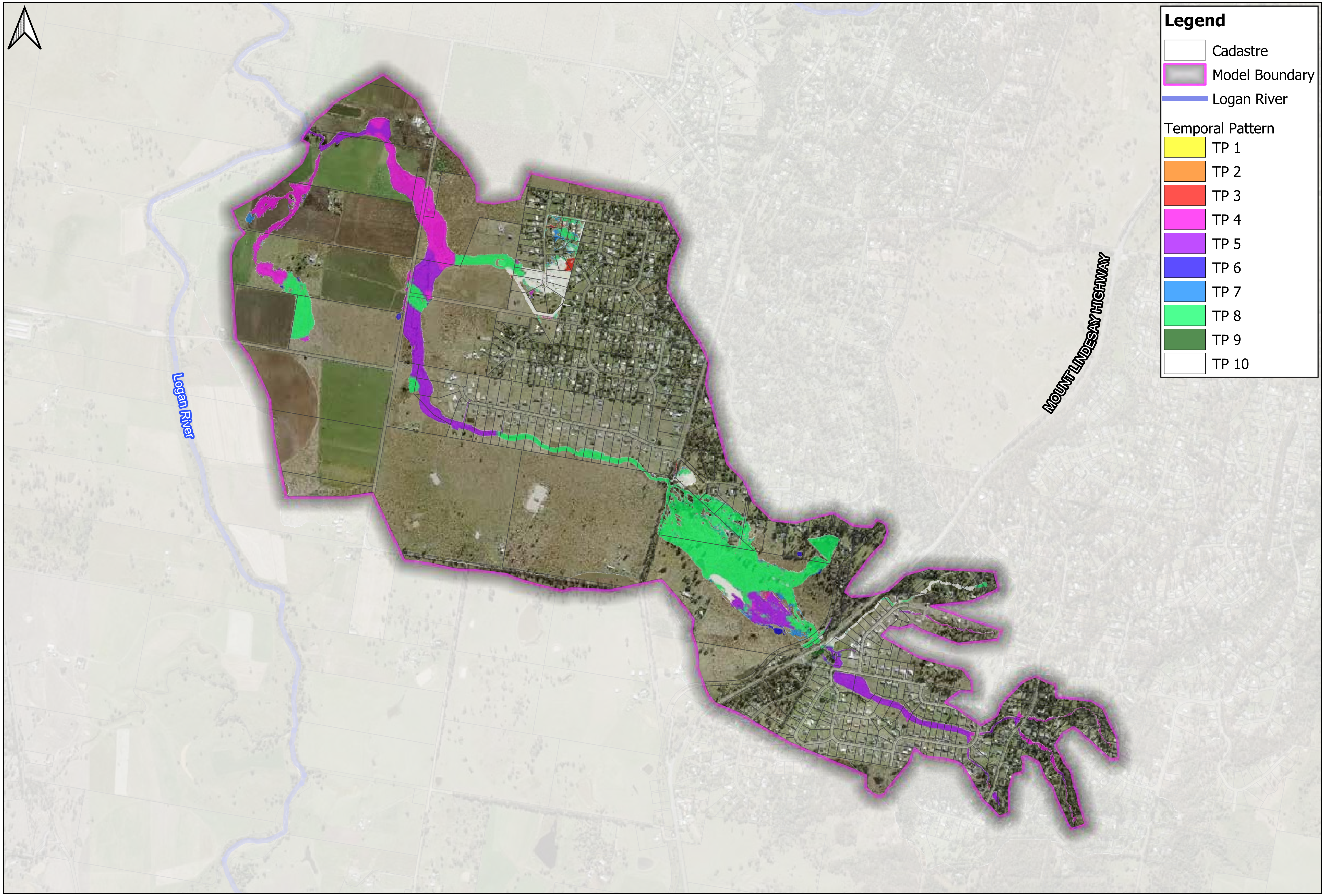
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 120-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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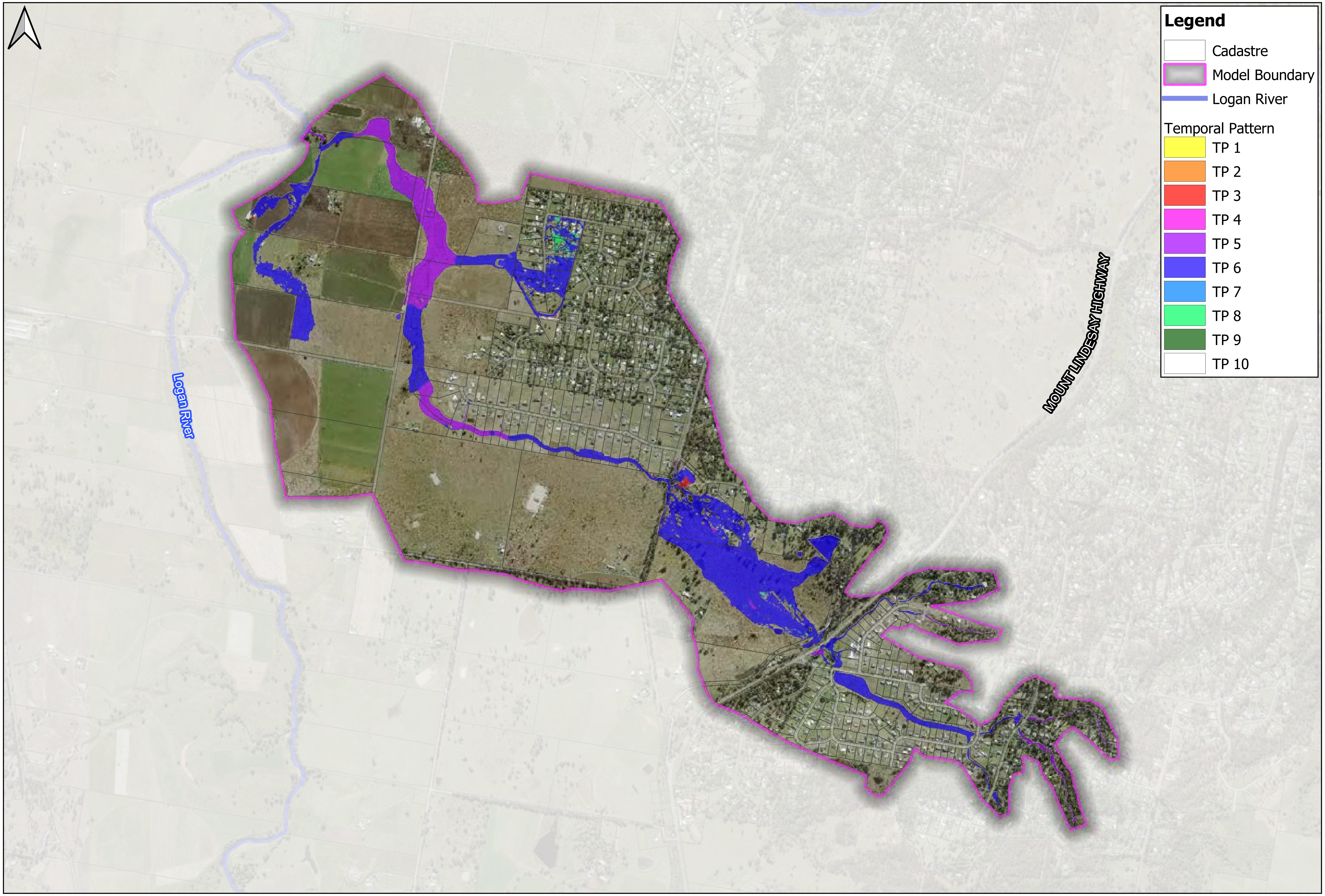
0 500 1,000 1,500 2,000 m

Days Creek Flood Study Update 2023

Days Creek - 50% AEP 180-Minute Duration - Critical Temporal Pattern



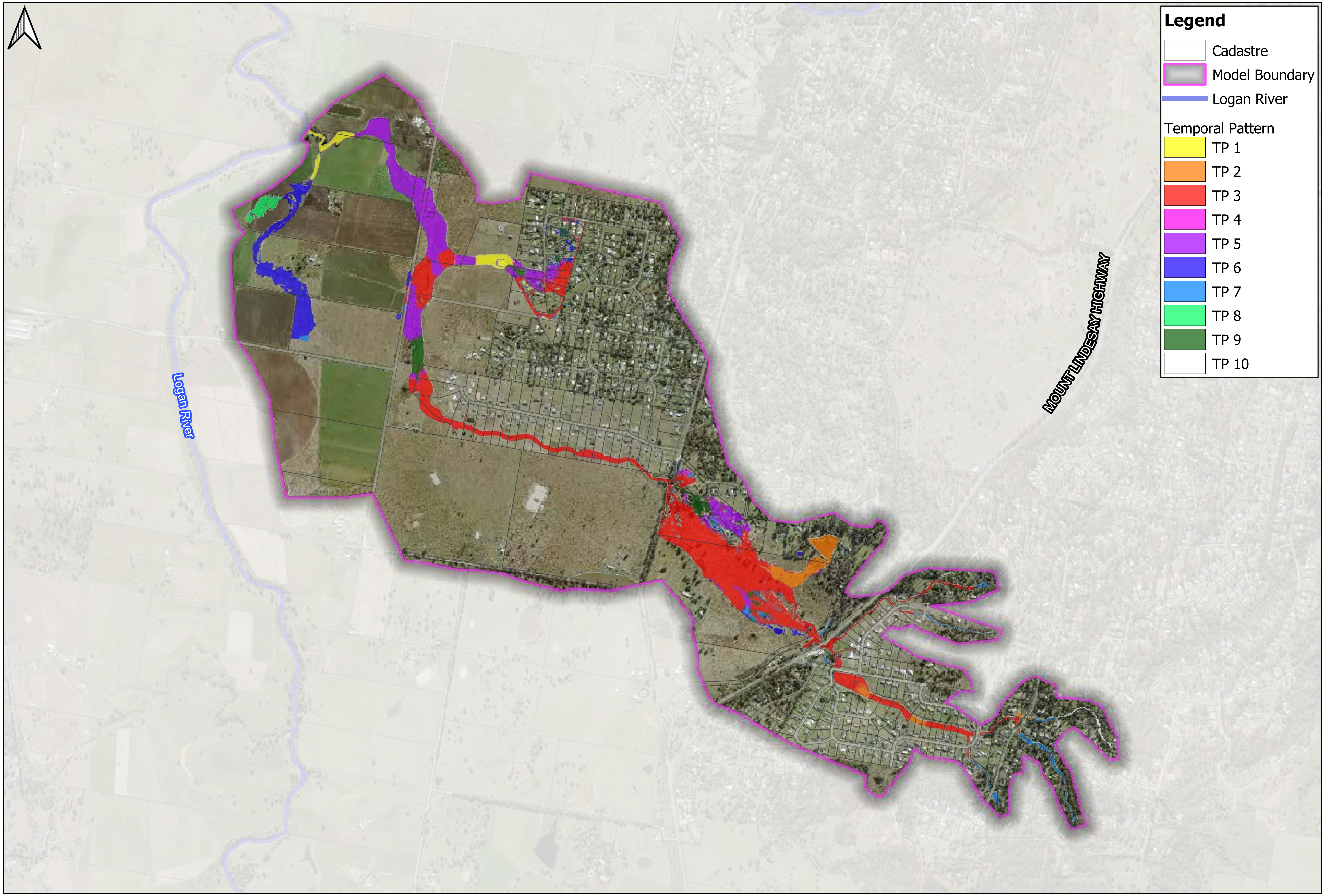
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 50% AEP 270-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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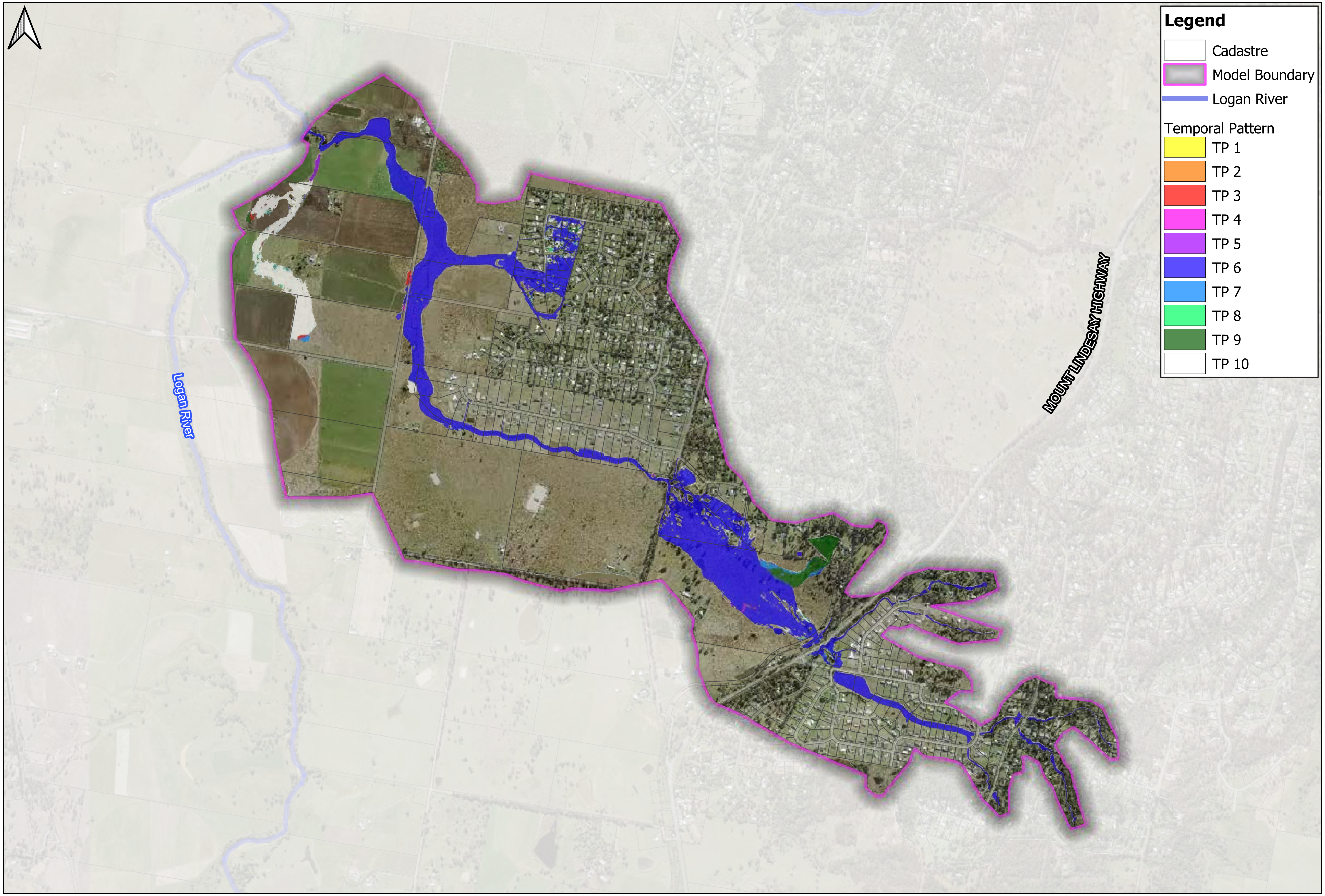
0 500 1,000 1,500 2,000 m

Days Creek Flood Study Update 2023

Days Creek - 50% AEP 360-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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

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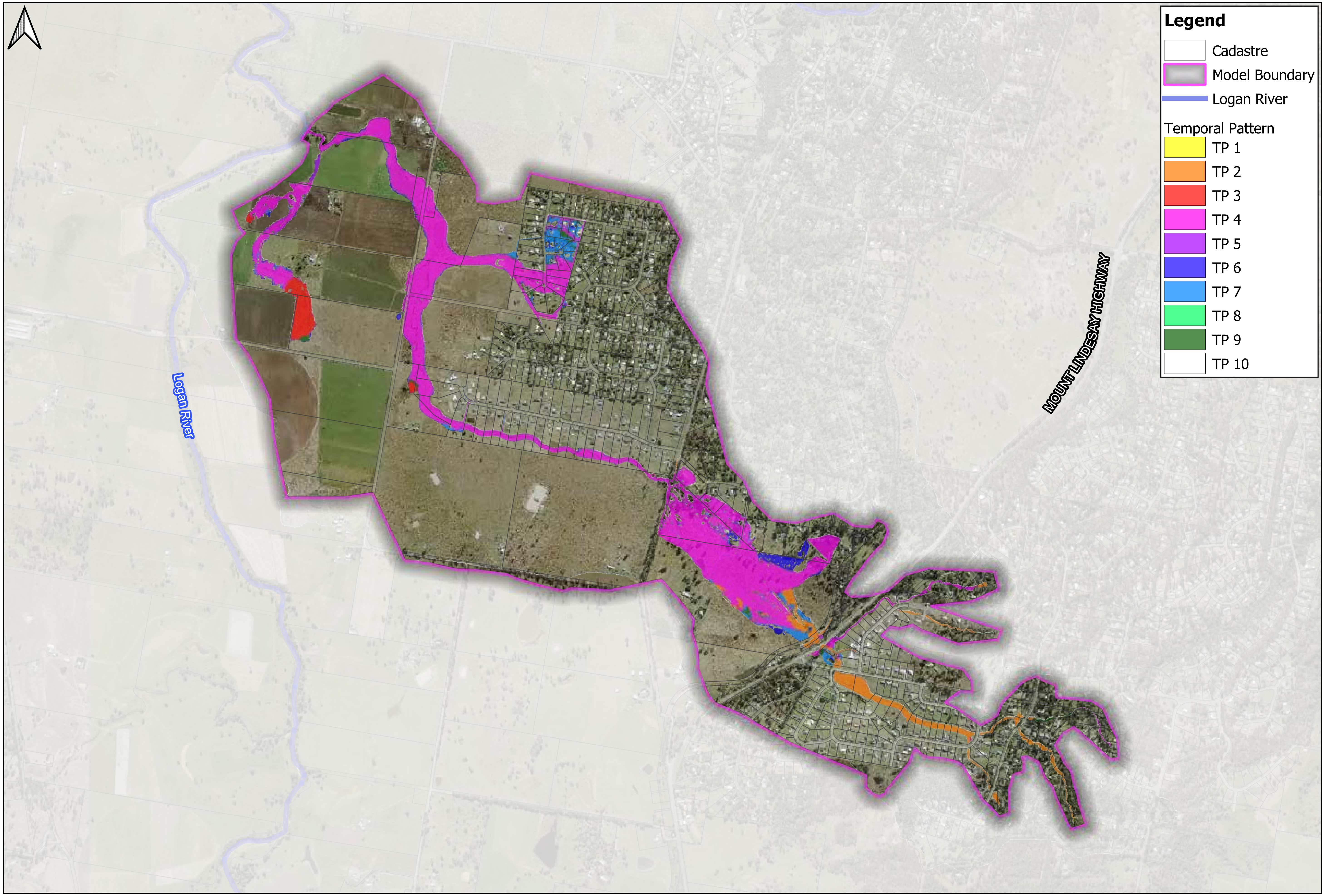
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 540-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

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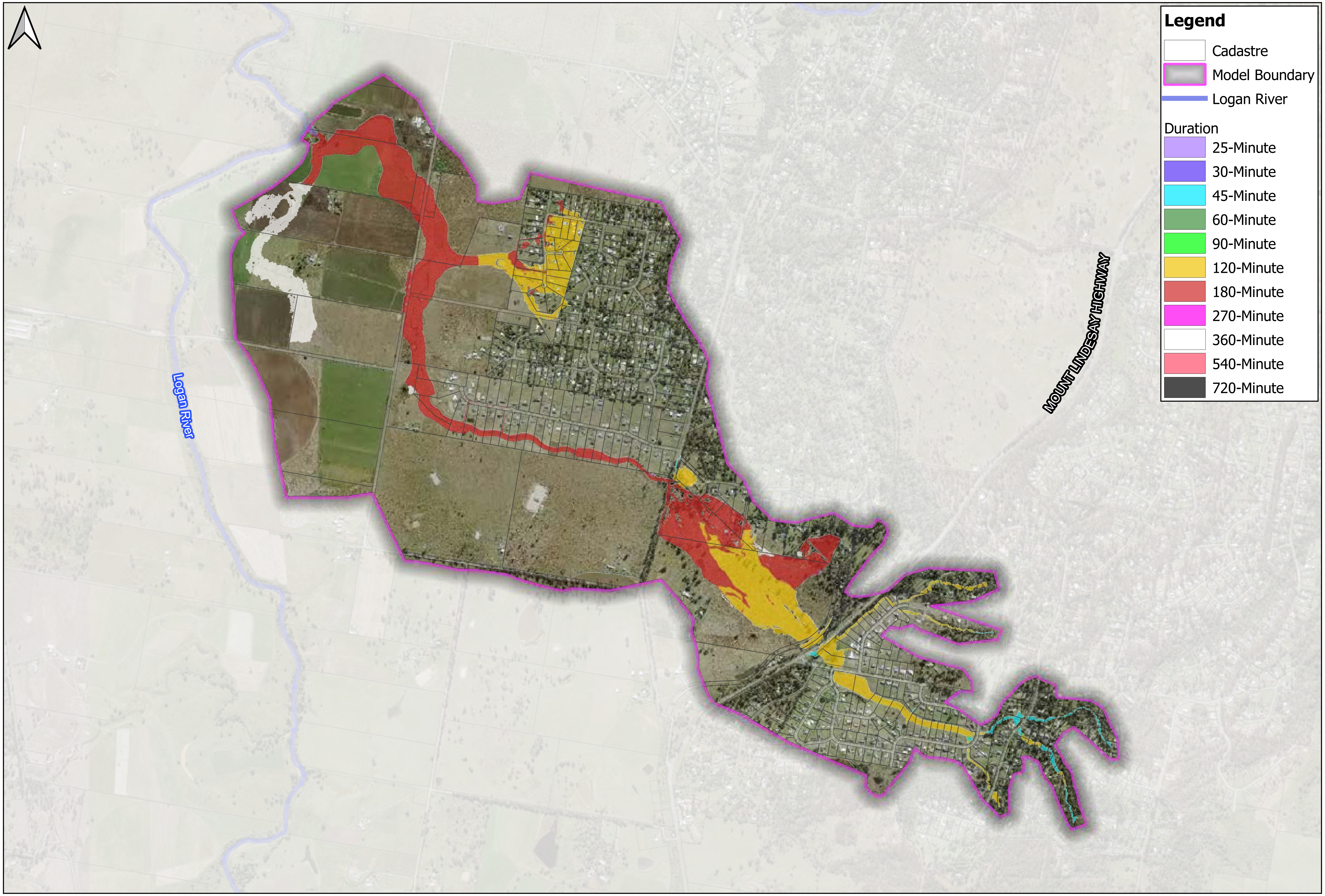
Days Creek Flood Study Update 2023

Days Creek - 50% AEP 720-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

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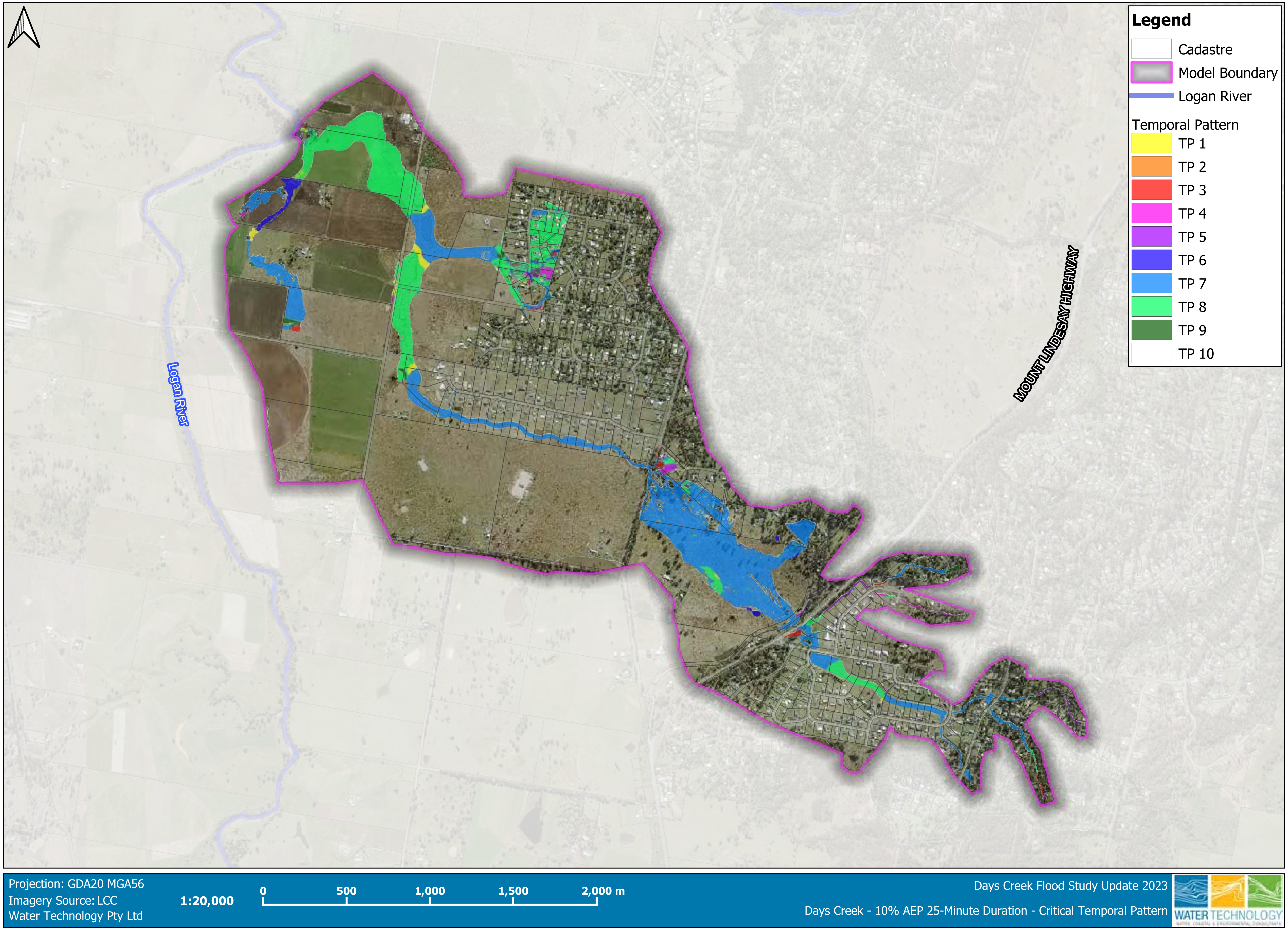
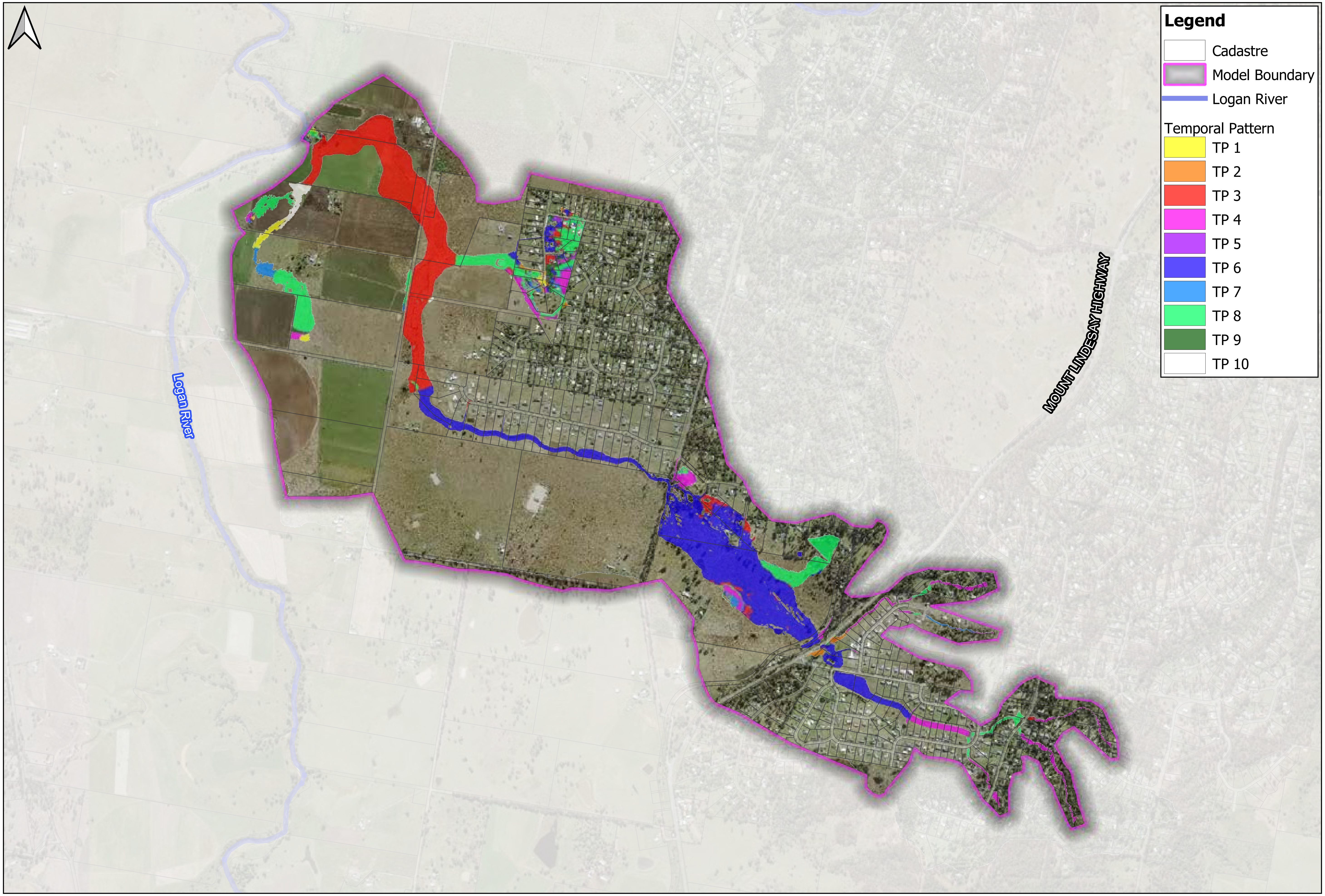
Days Creek Flood Study Update 2023

Days Creek - 10% AEP Critical Duration



Days Creek Flood Study Update 2023

Days Creek - 10% AEP 25-Minute Duration - Critical Temporal Pattern



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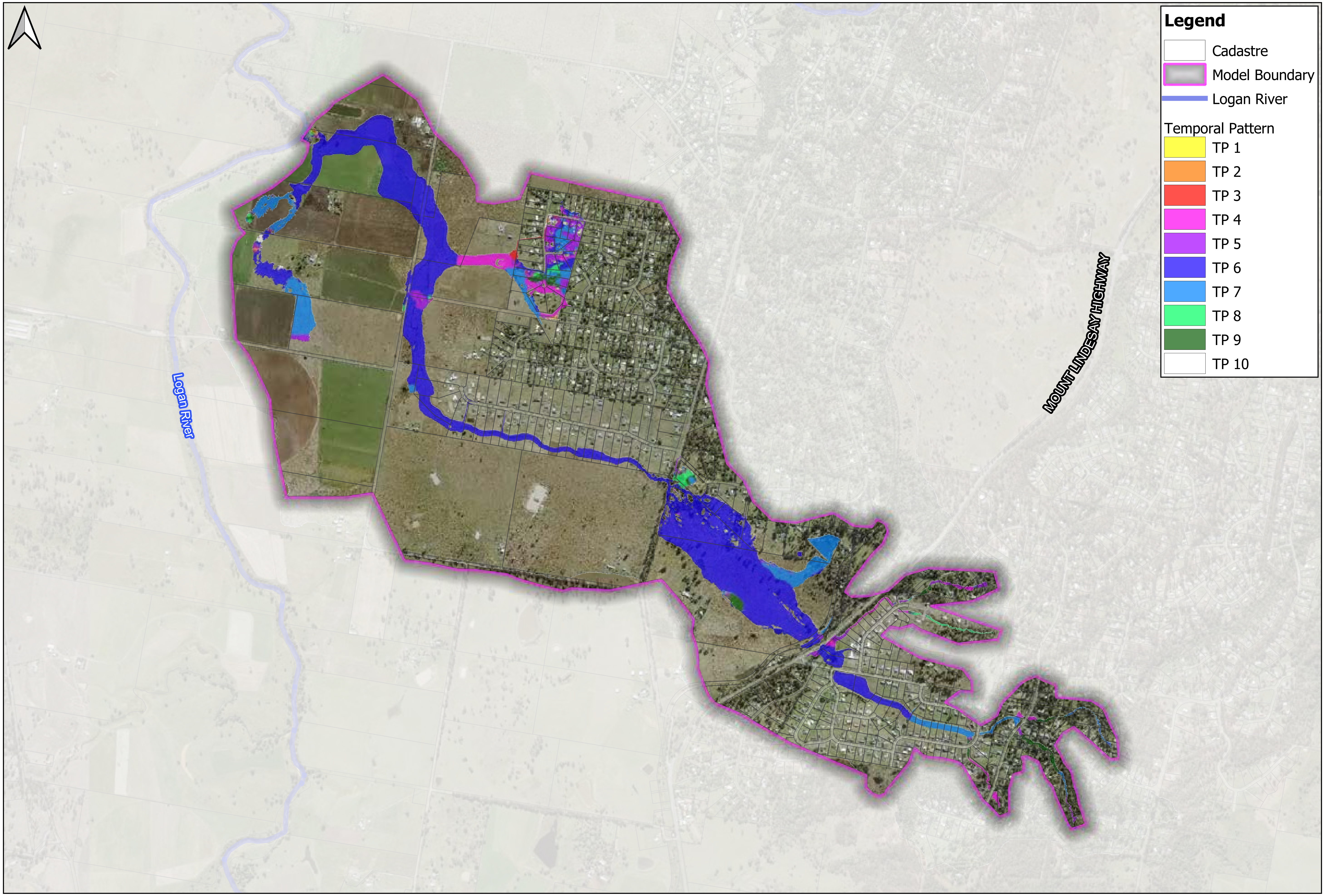
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 30-Minute Duration - Critical Temporal Pattern



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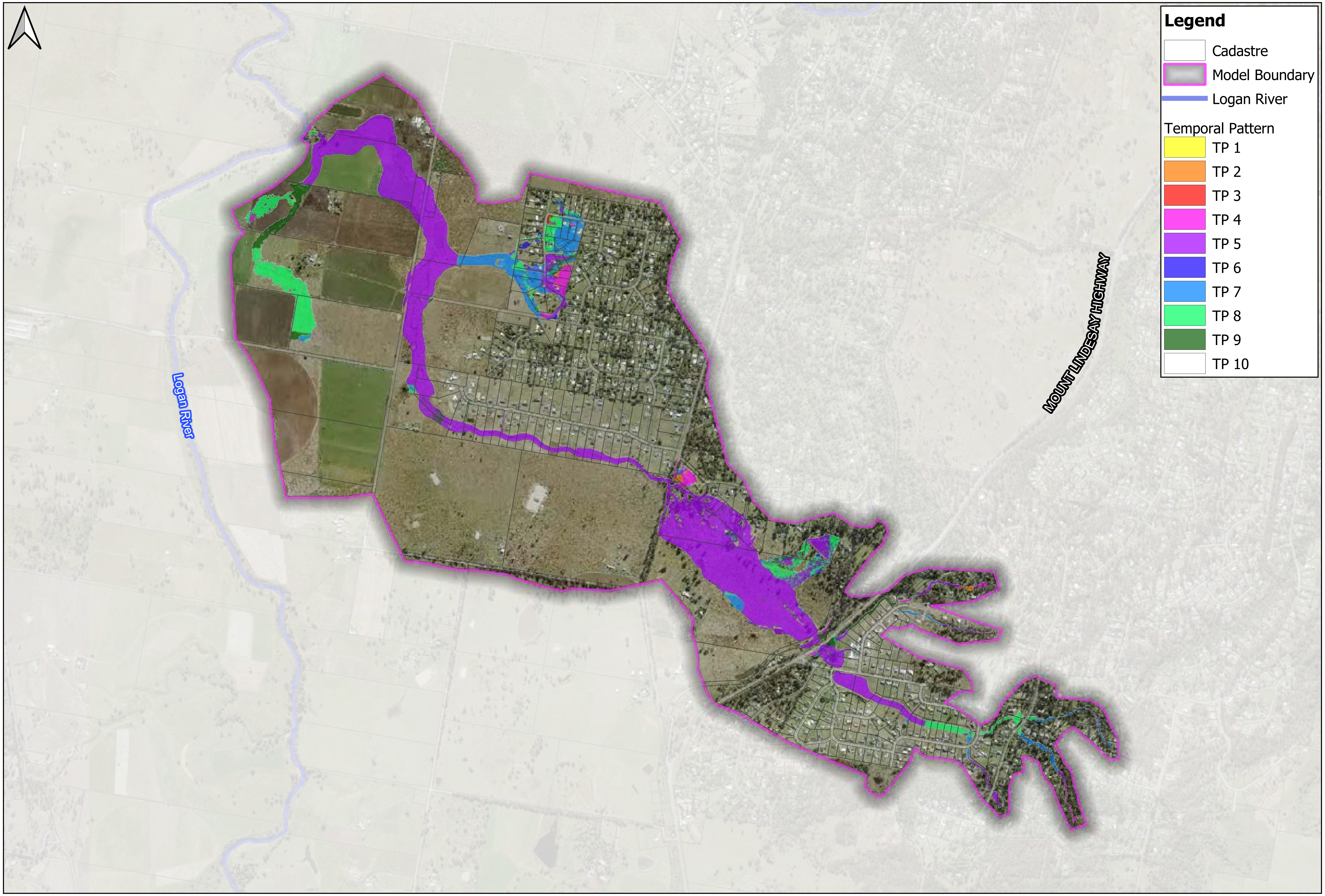
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 45-Minute Duration - Critical Temporal Pattern



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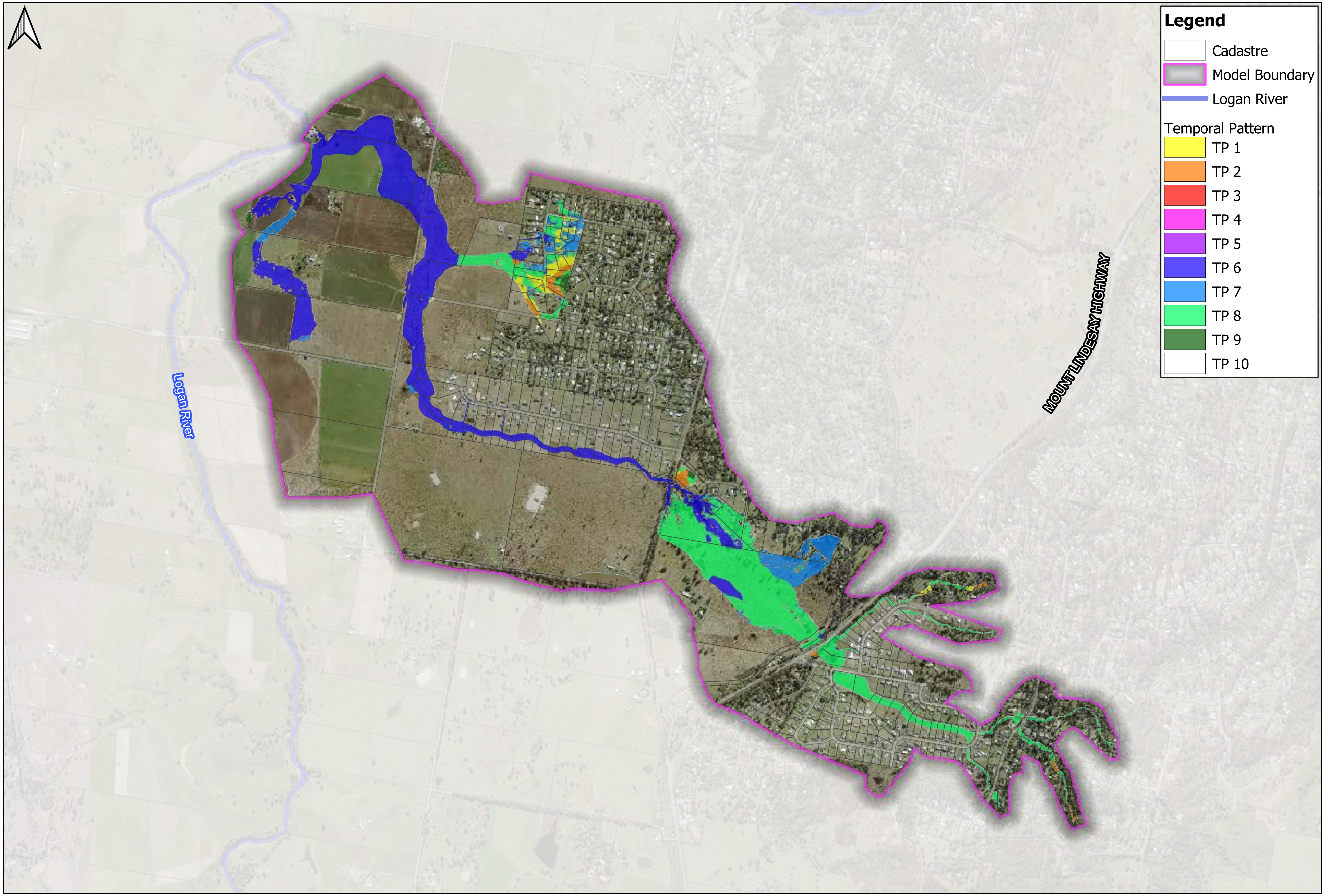
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 60-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

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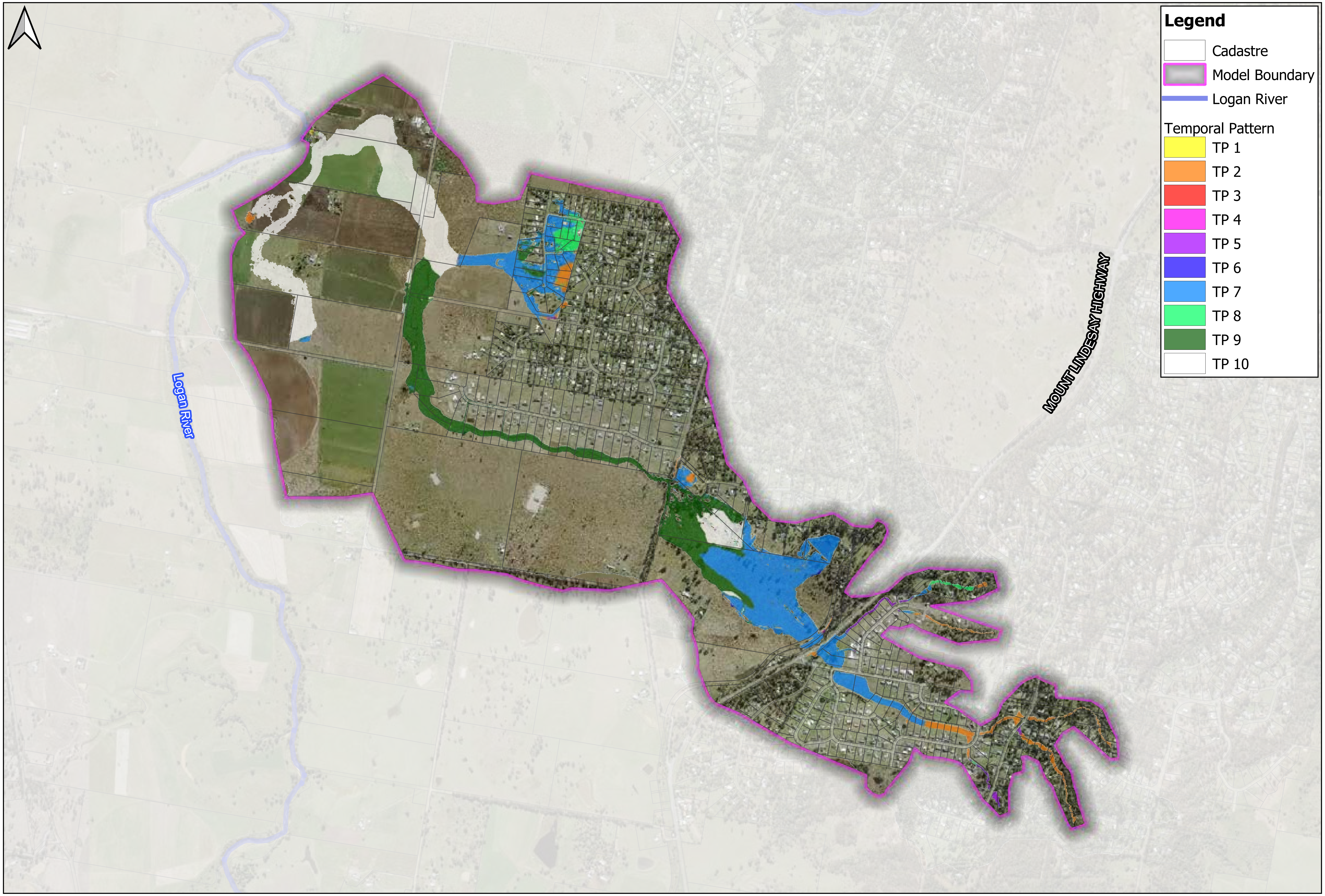
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 90-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

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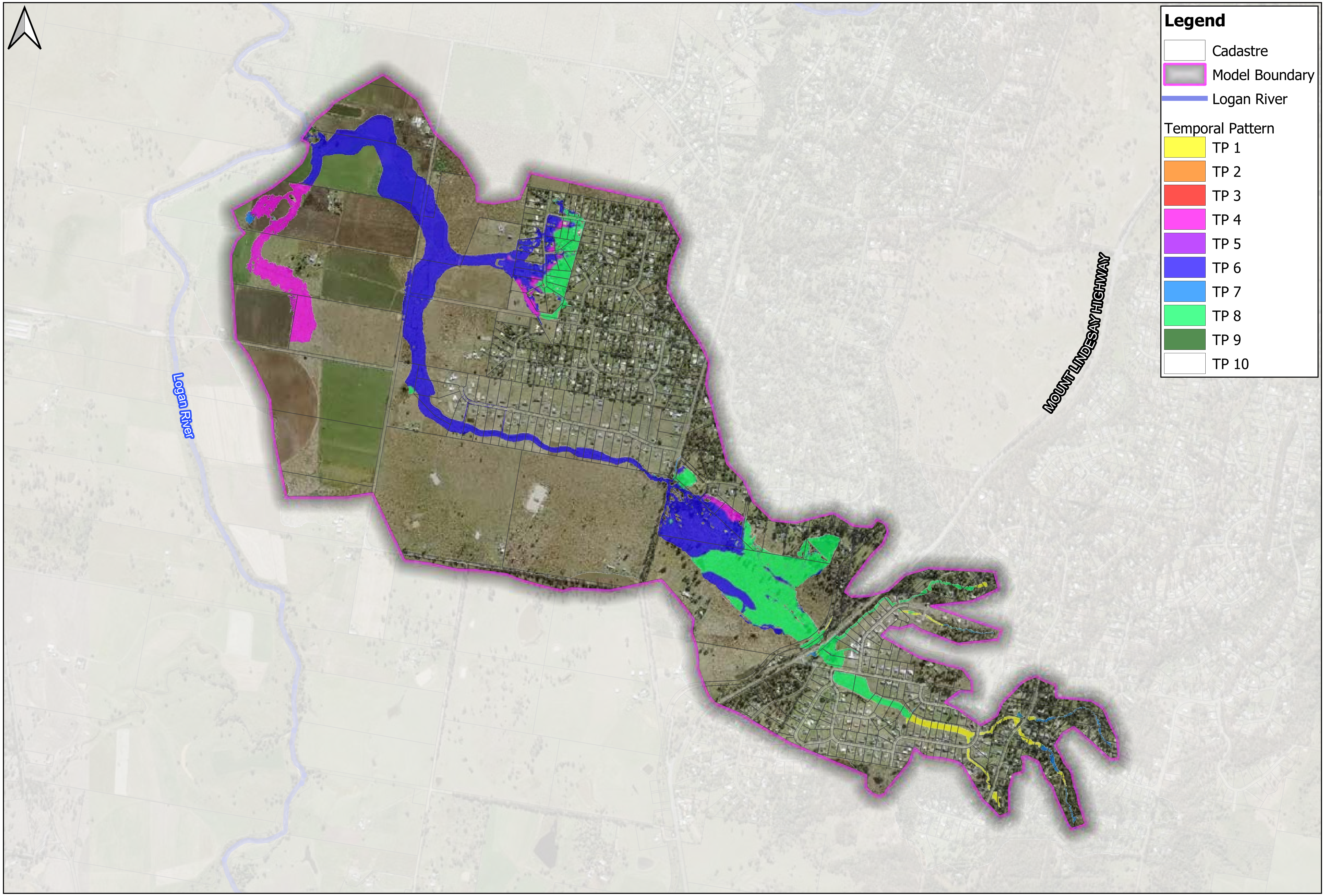
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 120-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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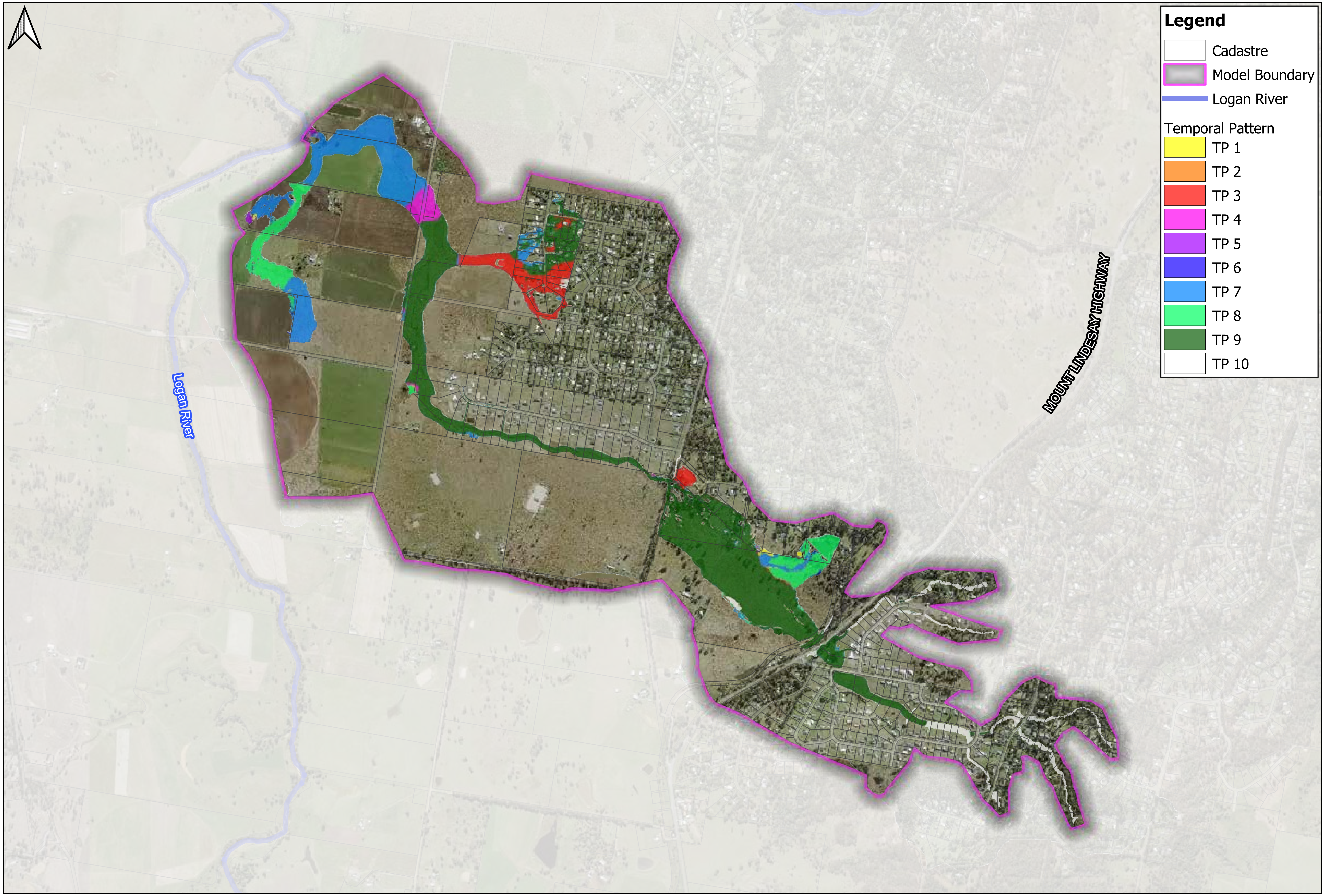
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 180-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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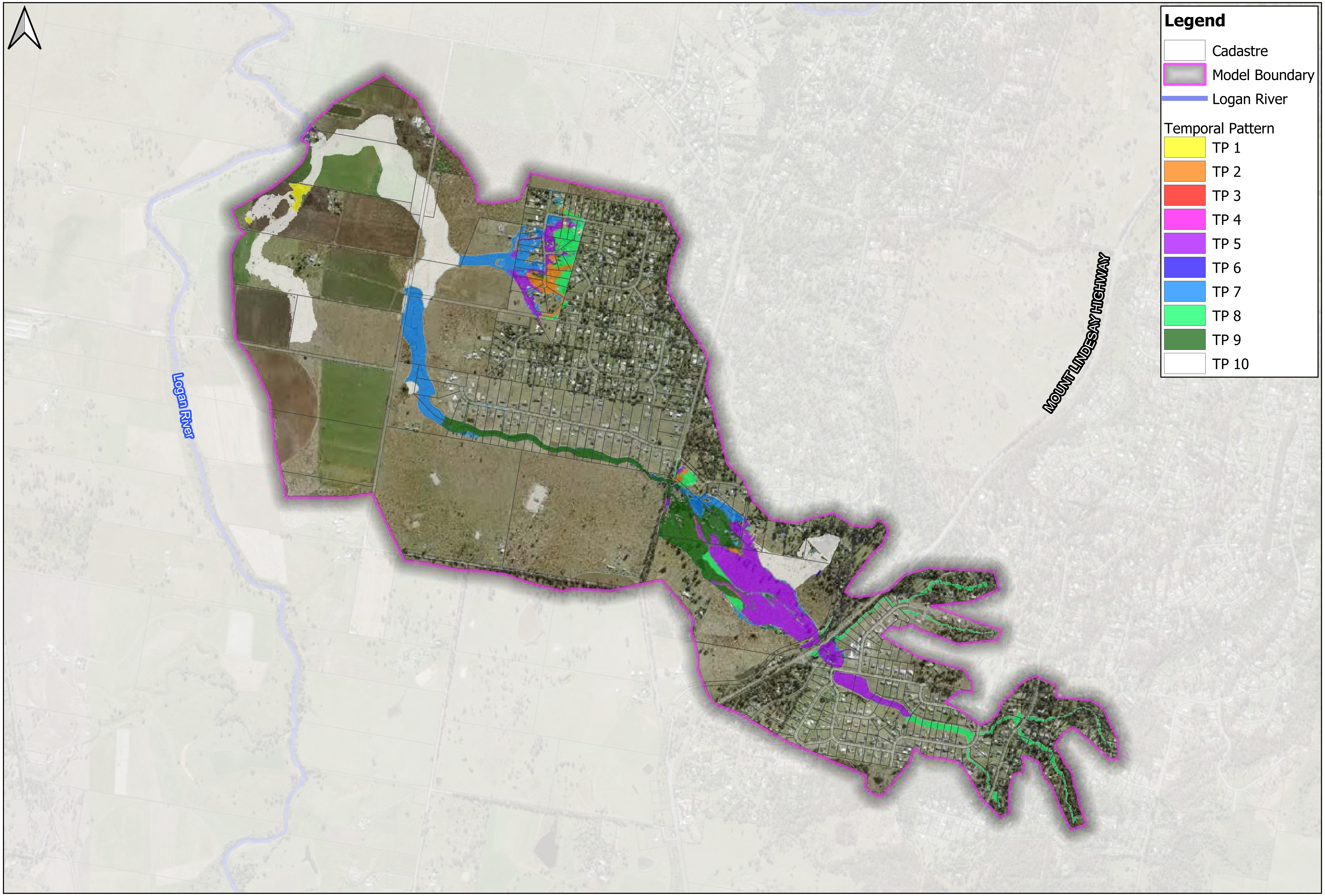
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 270-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Water Technology Pty Ltd

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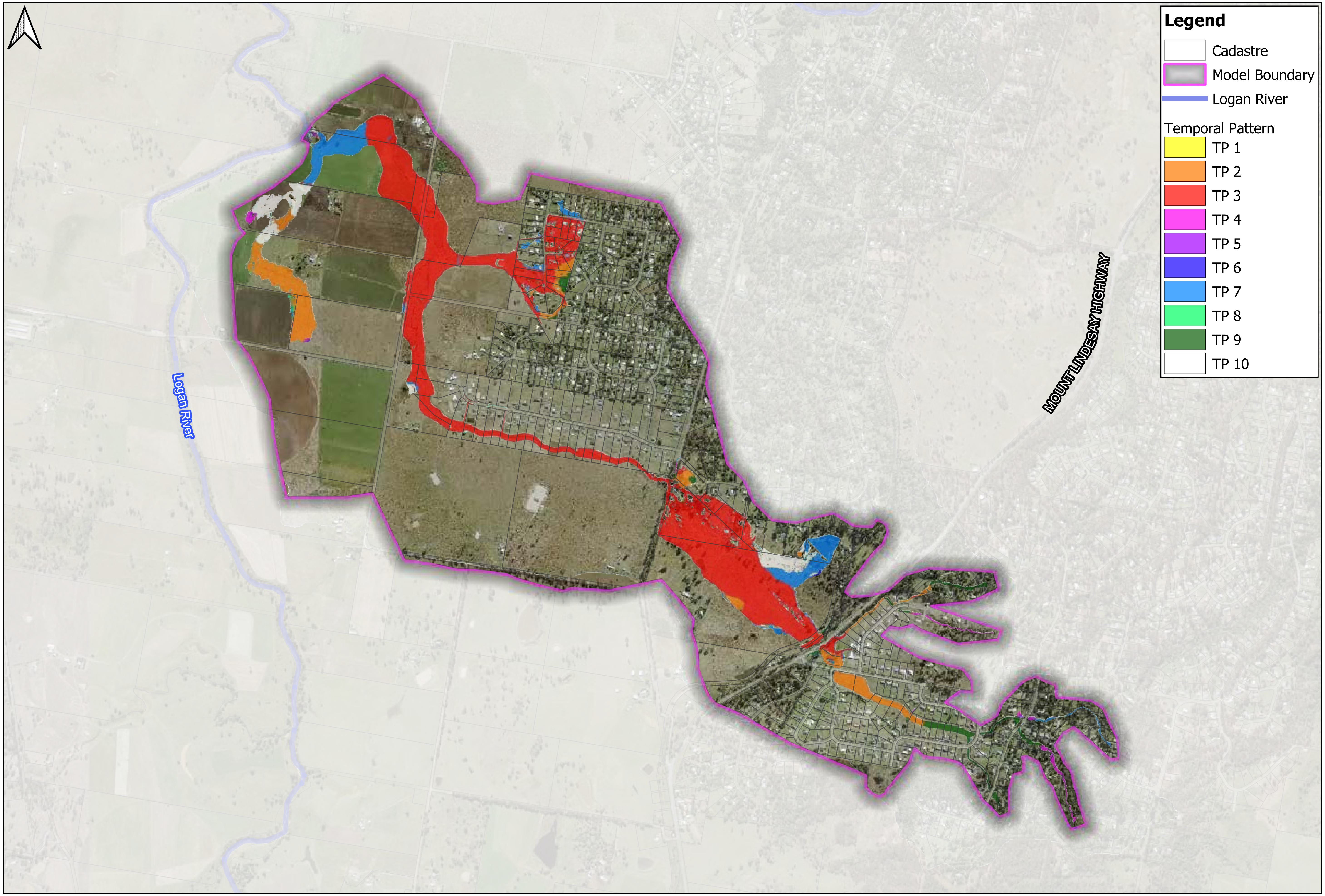
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 360-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Water Technology Pty Ltd

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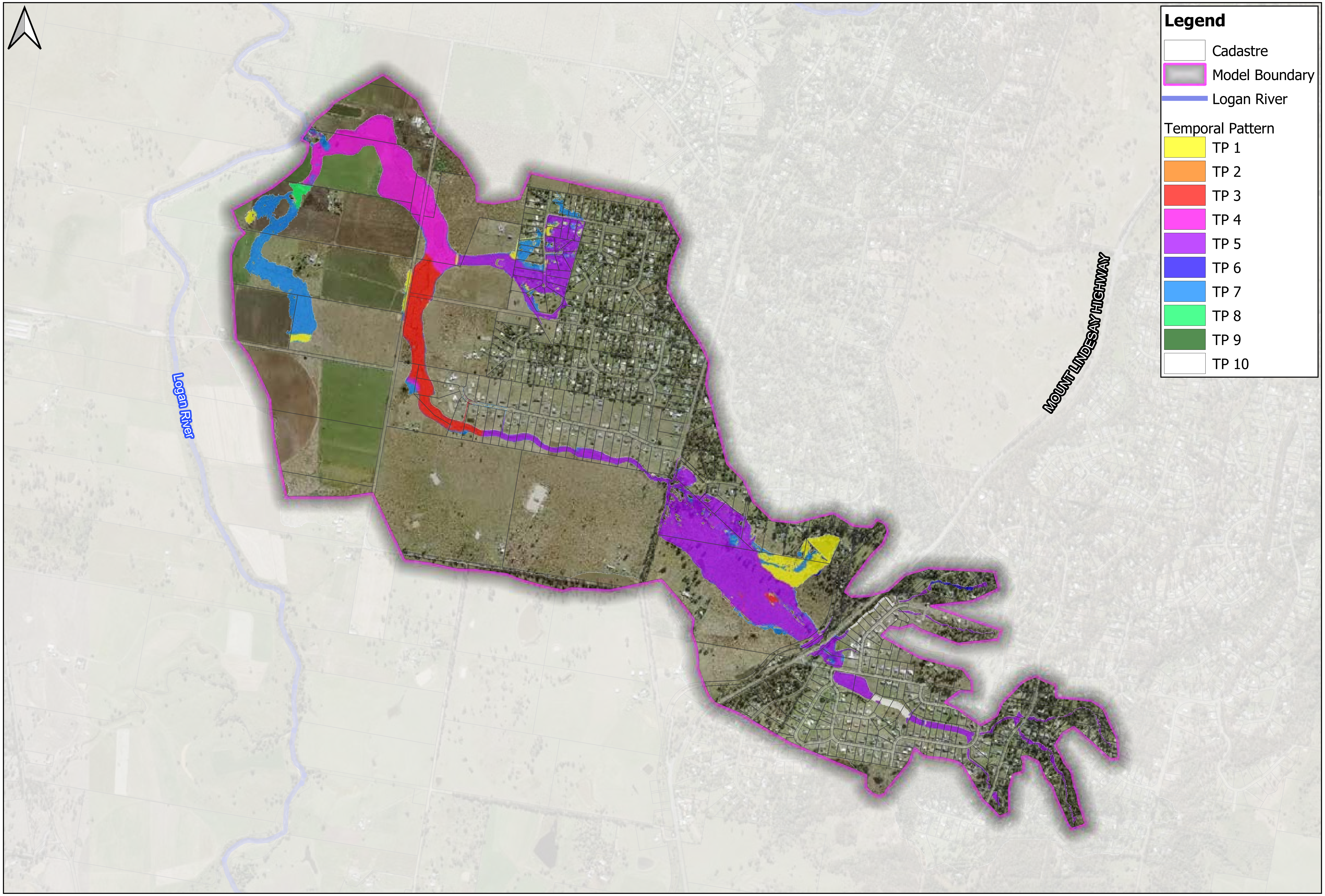
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 540-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Water Technology Pty Ltd

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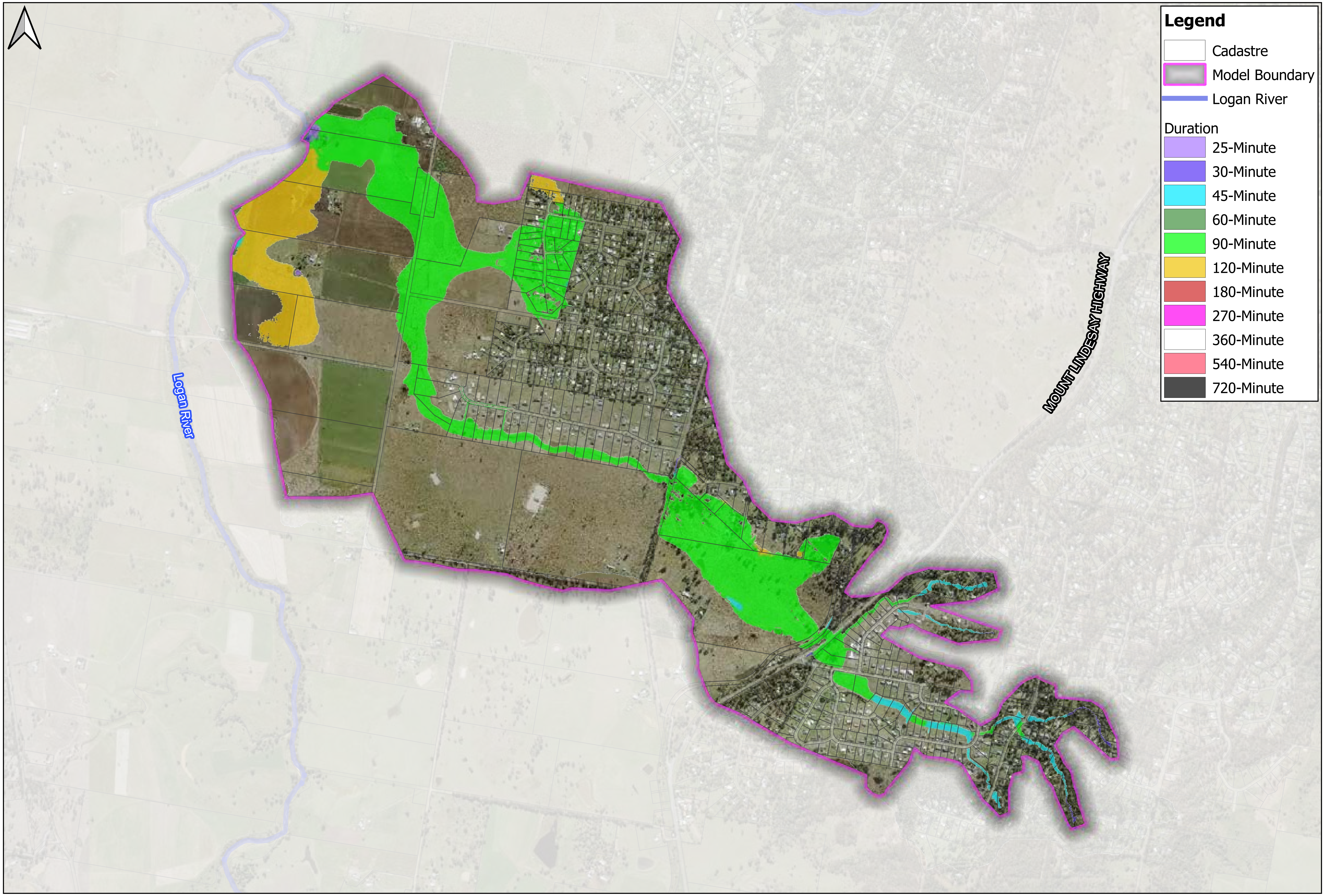
Days Creek Flood Study Update 2023

Days Creek - 10% AEP 720-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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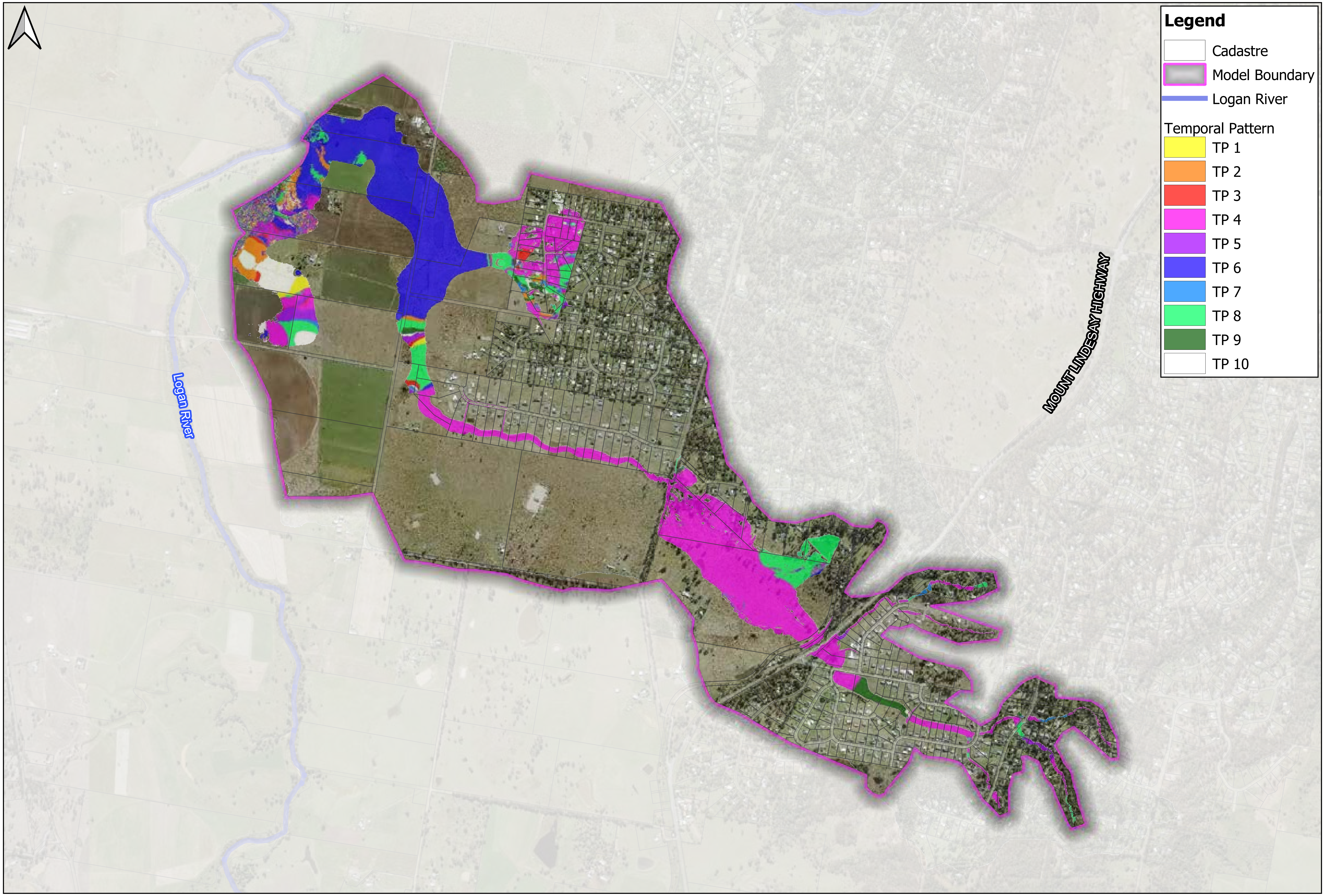
Days Creek Flood Study Update 2023

Days Creek - 1% AEP Critical Duration

WATER TECHNOLOGY



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Water Technology Pty Ltd

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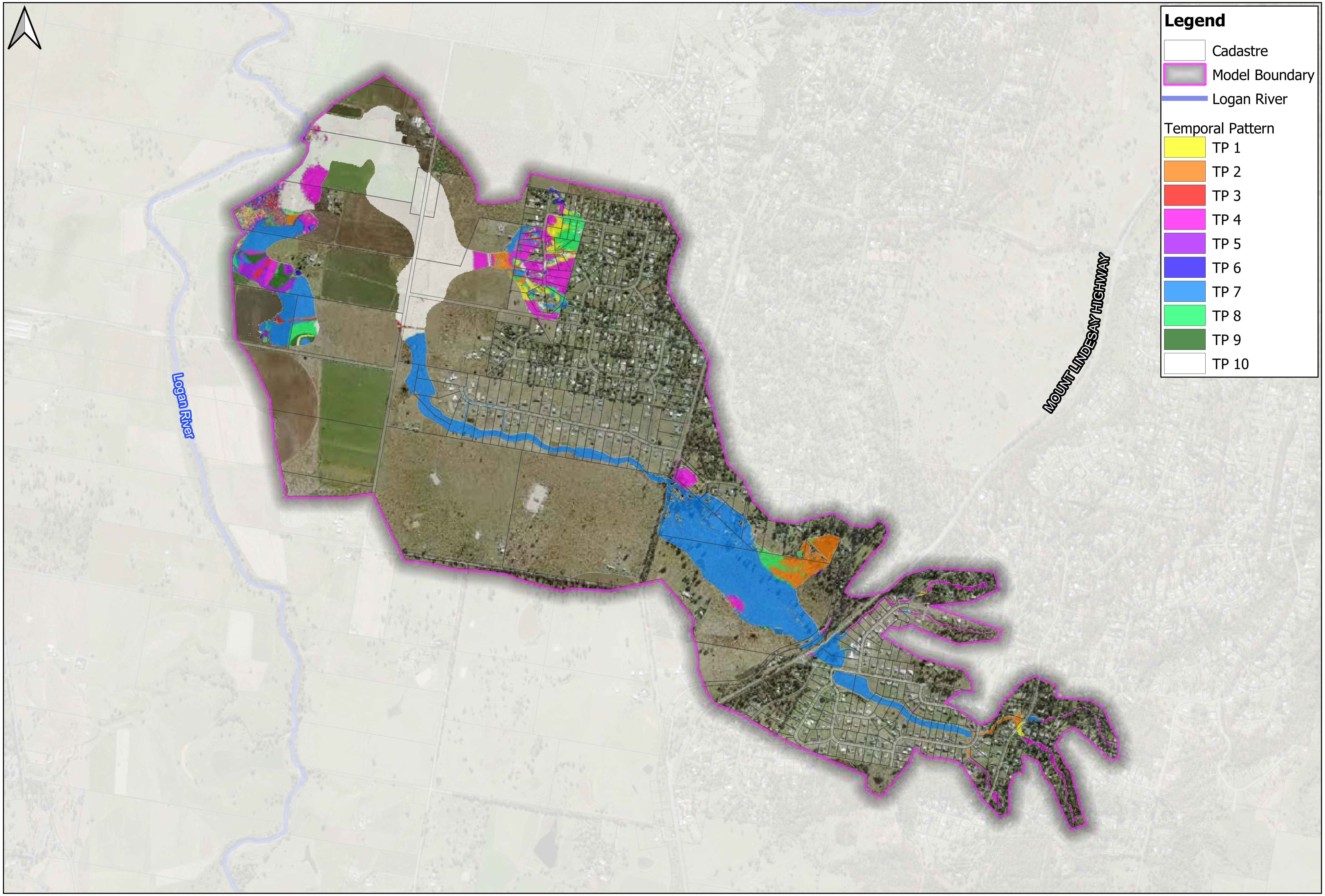
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 25-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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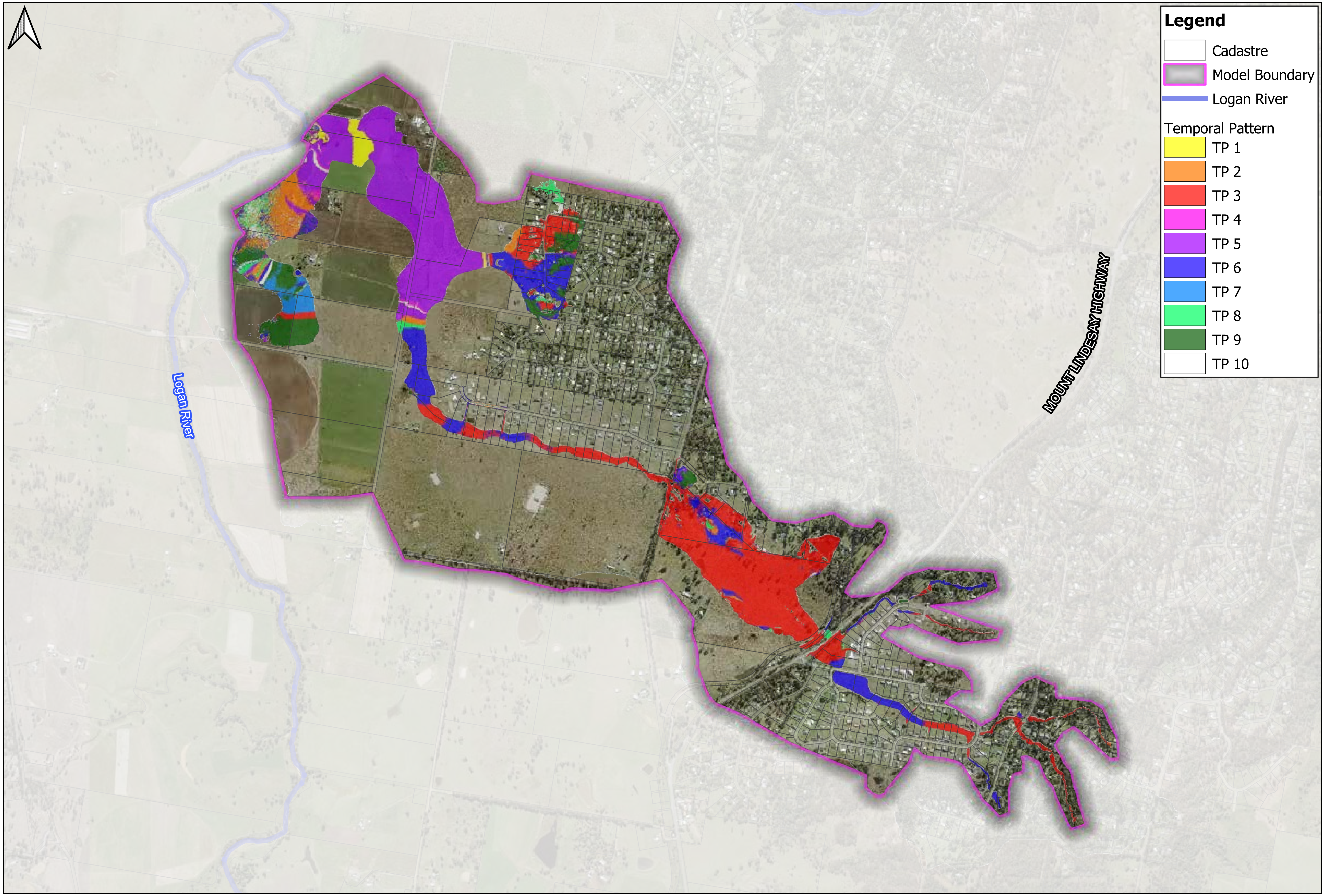
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 30-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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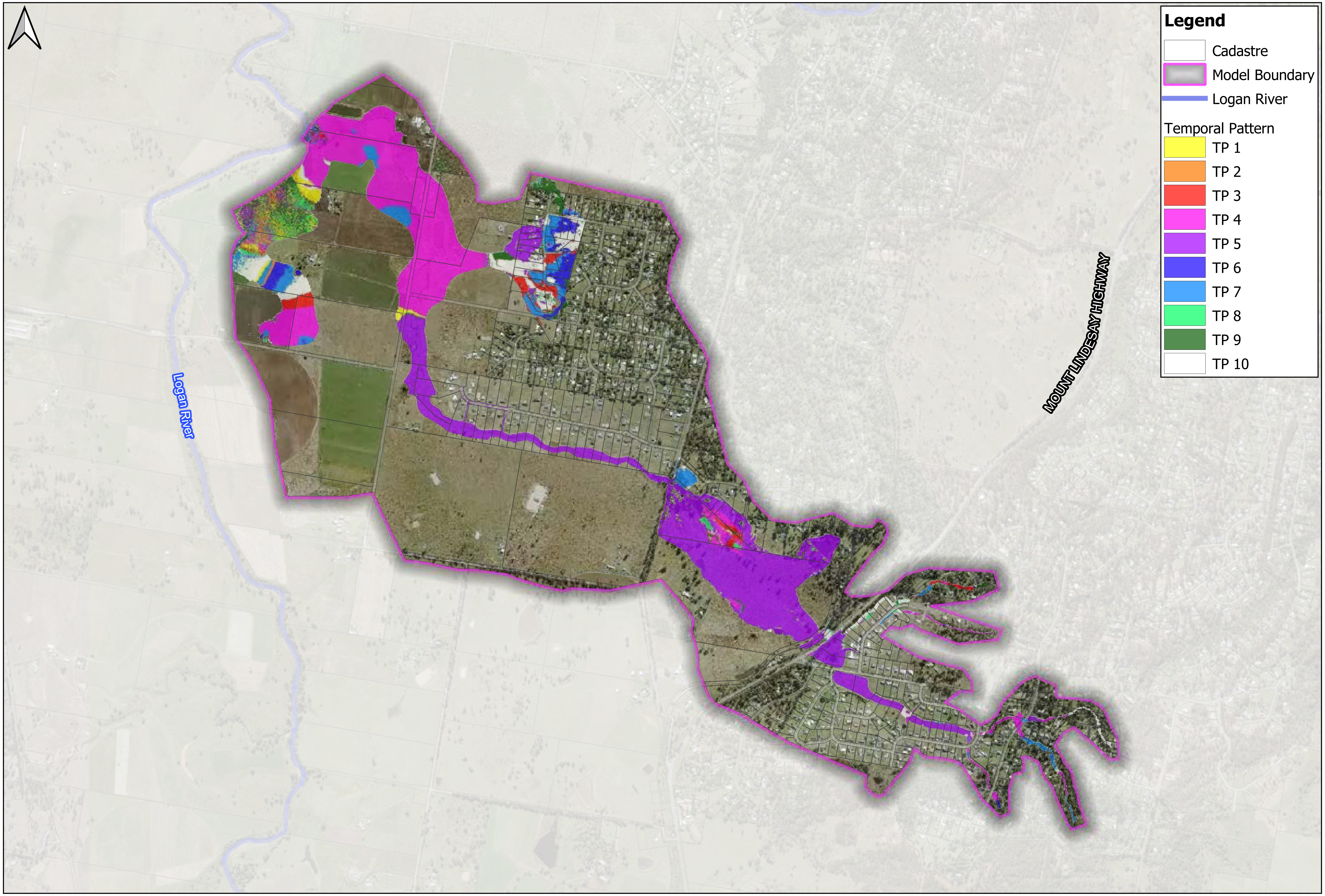
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 45-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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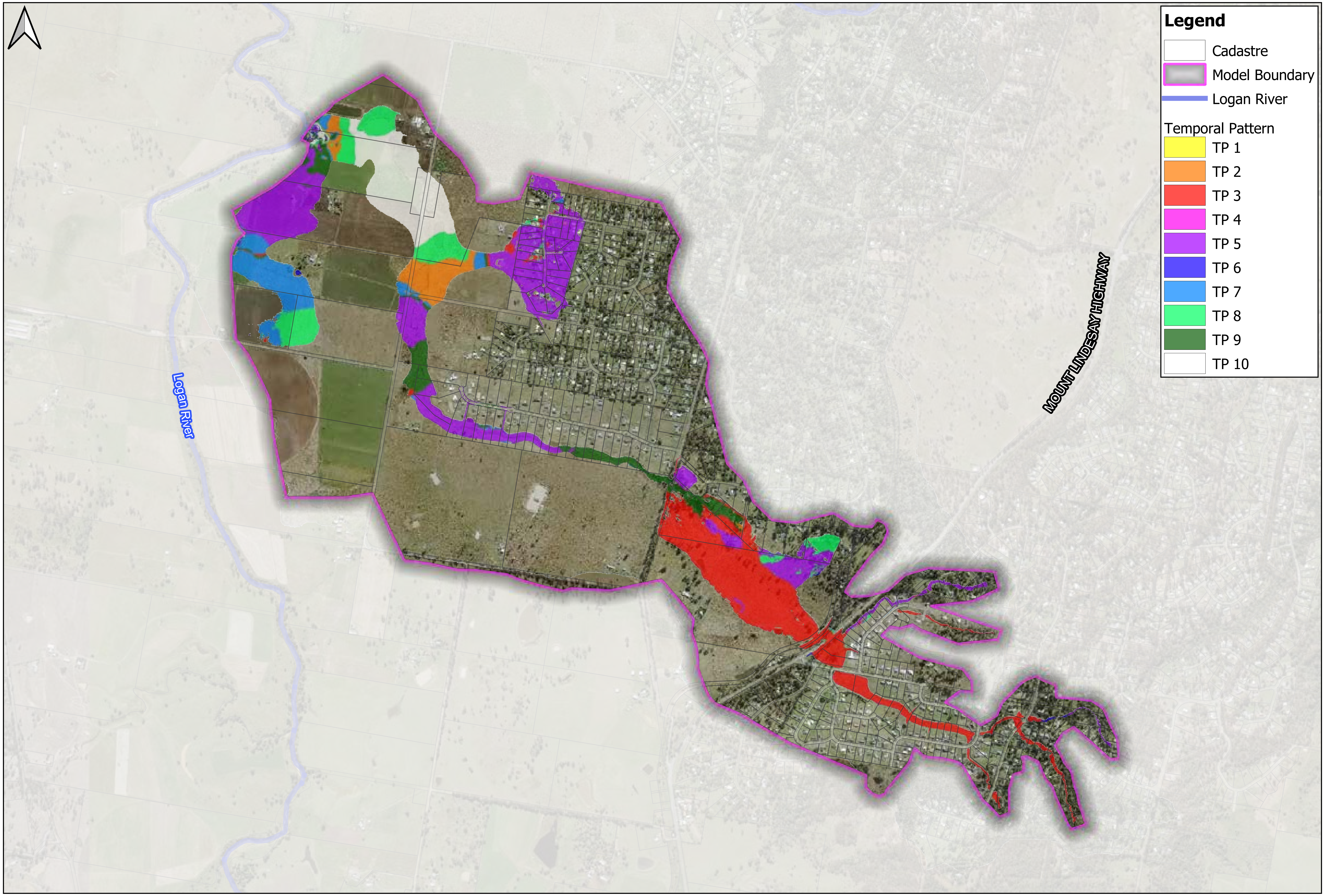
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 60-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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Imagery Source: LCC
Water Technology Pty Ltd

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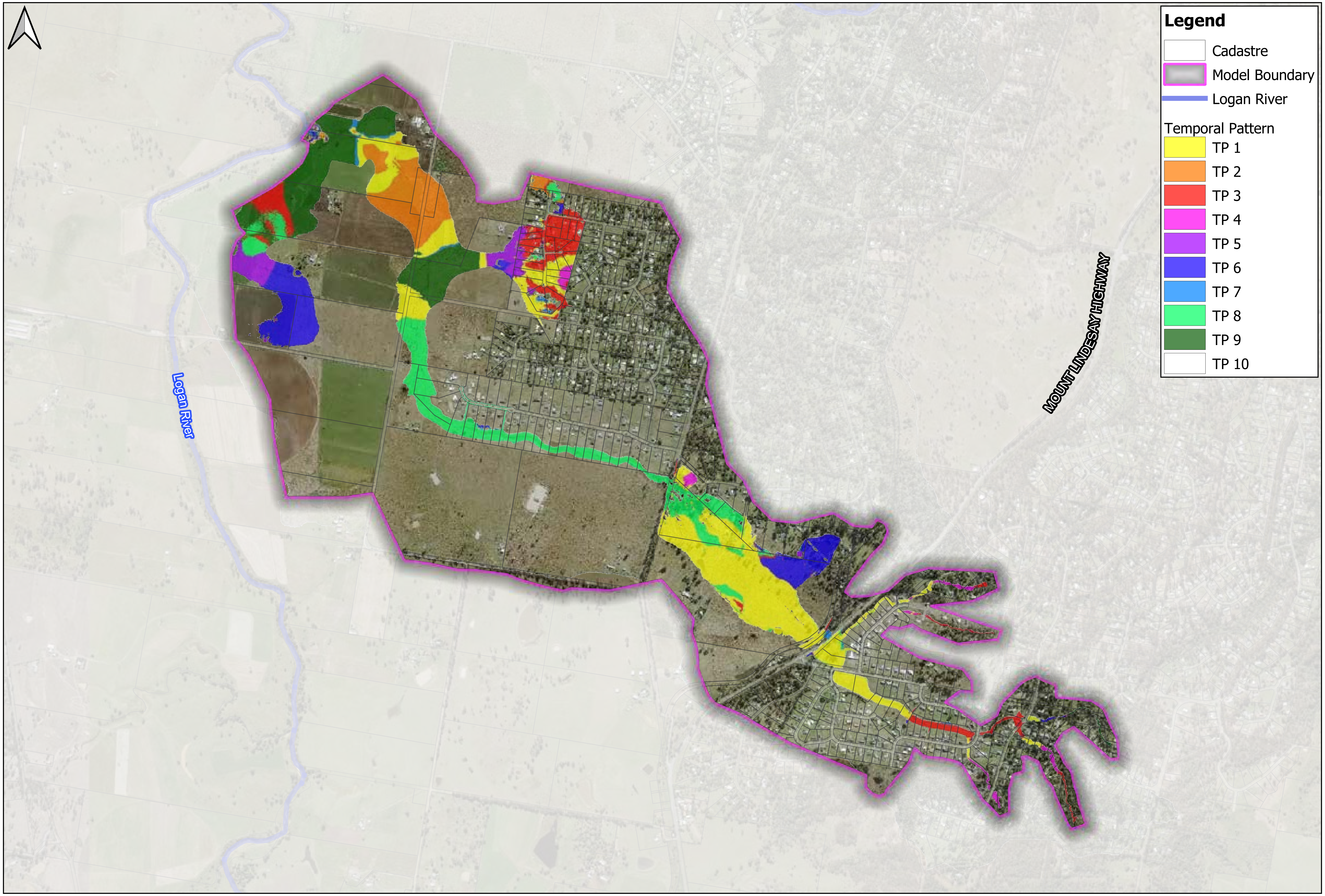
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 90-Minute Duration - Critical Temporal Pattern



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

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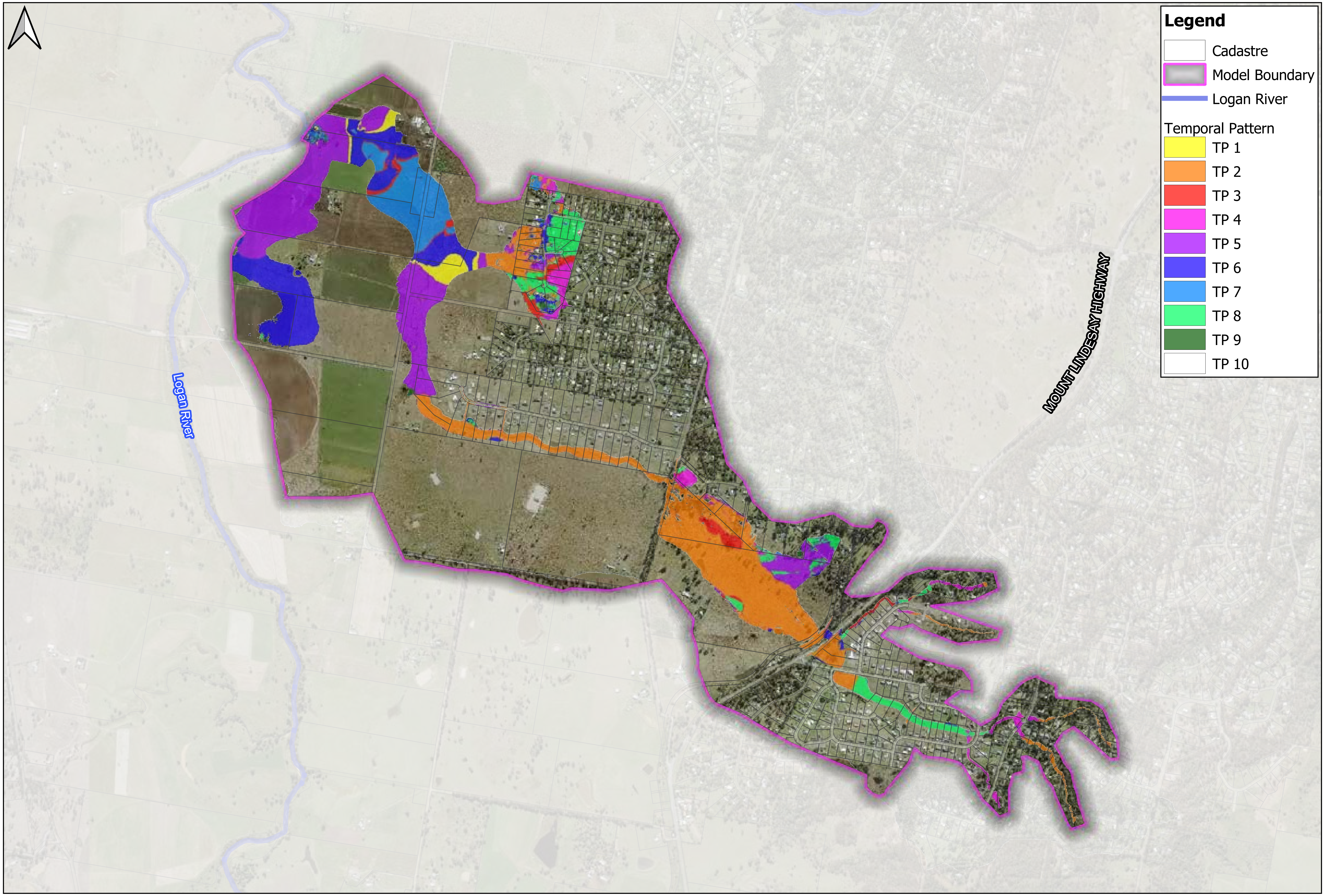
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 120-Minute Duration - Critical Temporal Pattern



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

1:20,000

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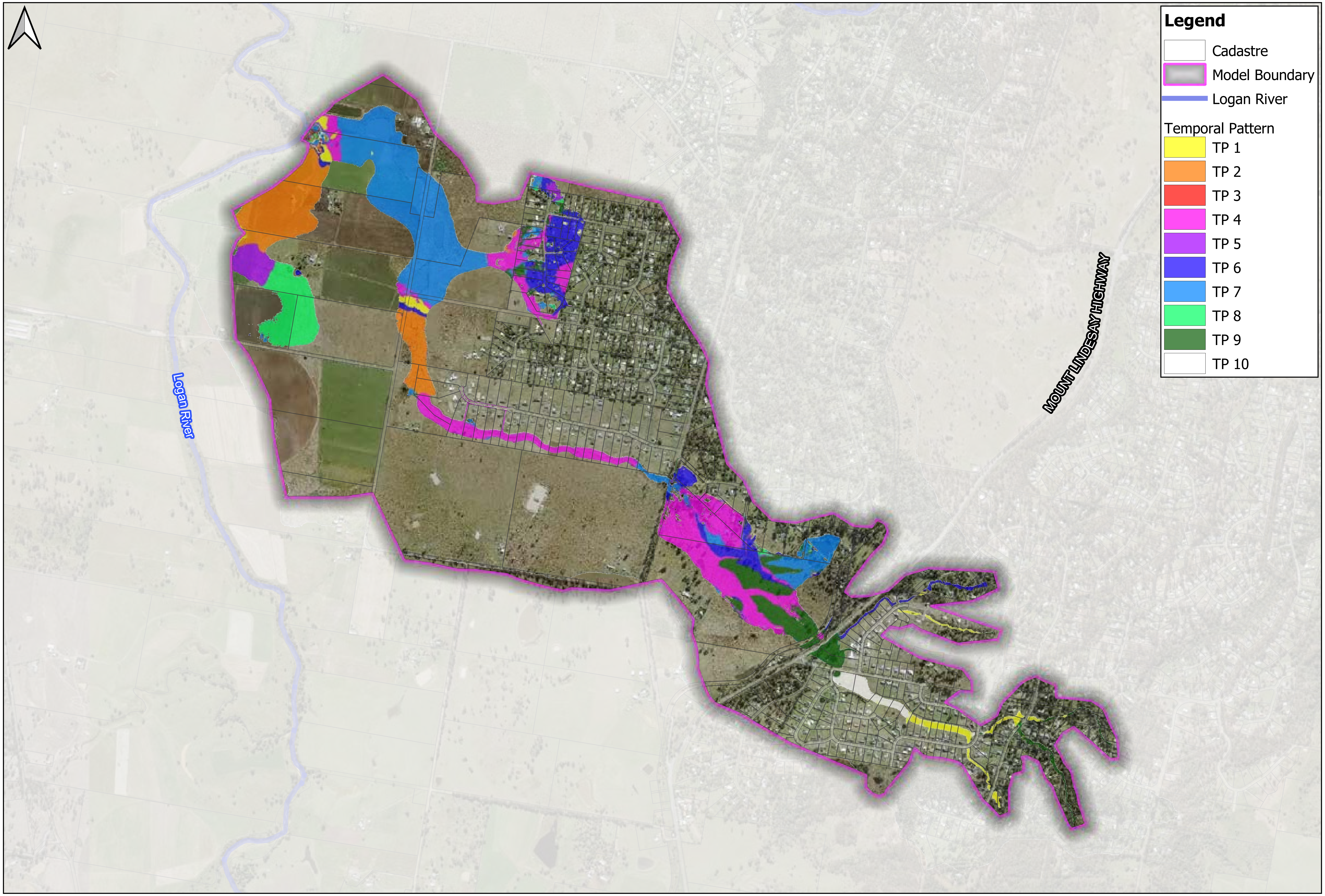
Days Creek Flood Study Update 2023

Days Creek - 1% AEP 180-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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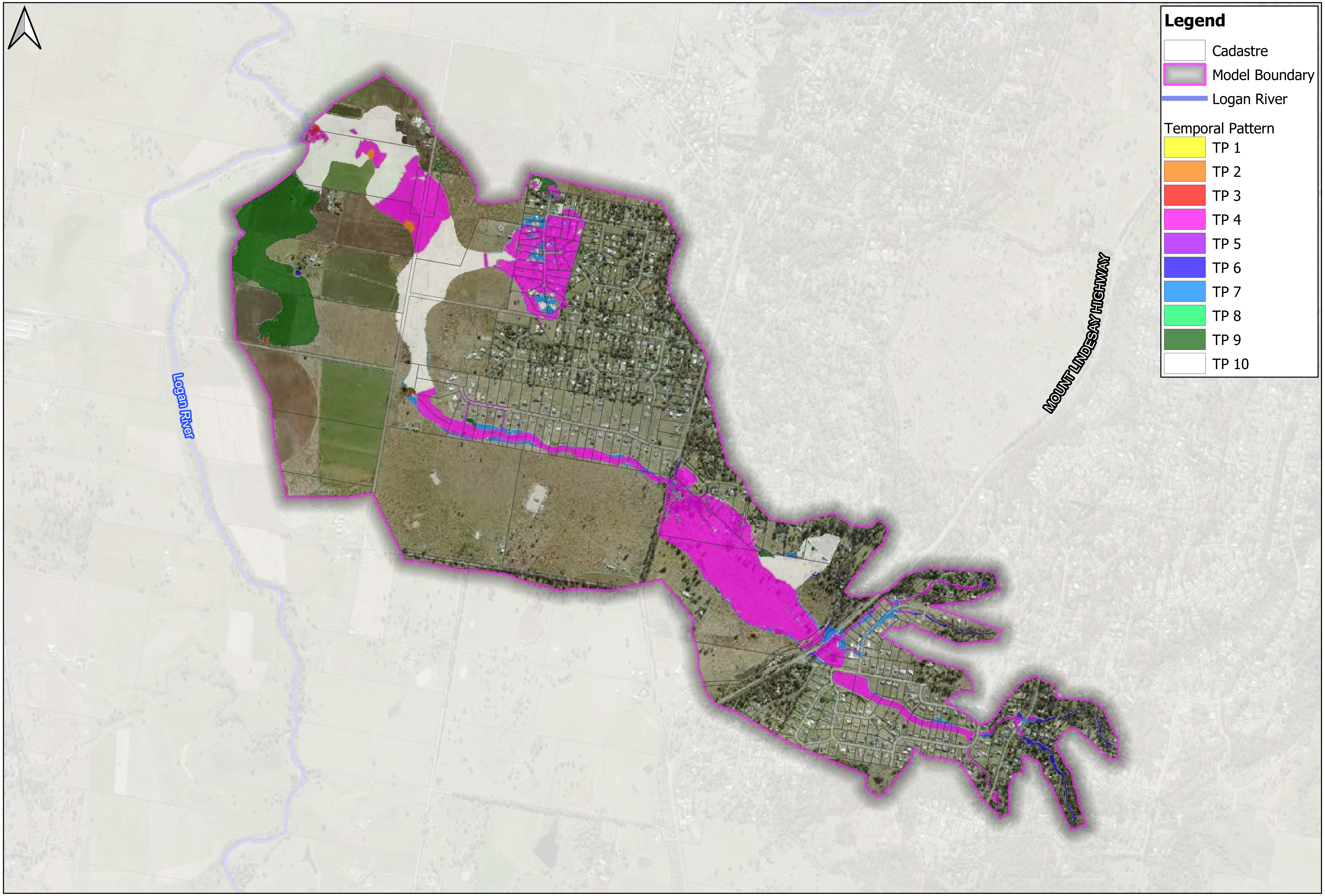
Water Technology Pty Ltd

Days Creek Flood Study Update 2023

Days Creek - 1% AEP 270-Minute Duration - Critical Temporal Pattern



Projection: GDA20 MGA56
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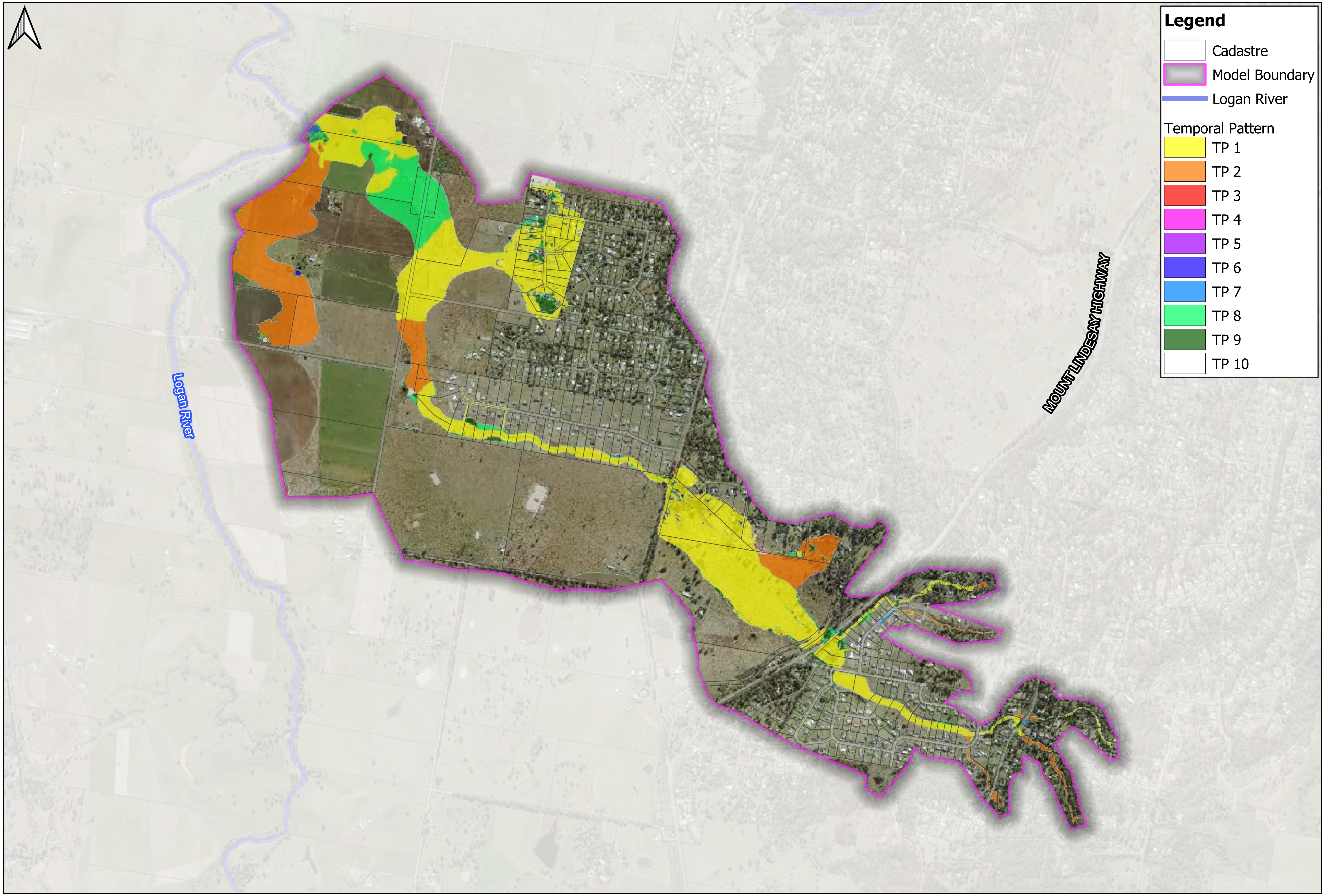
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

Days Creek - 1% AEP 360-Minute Duration - Critical Temporal Pattern



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

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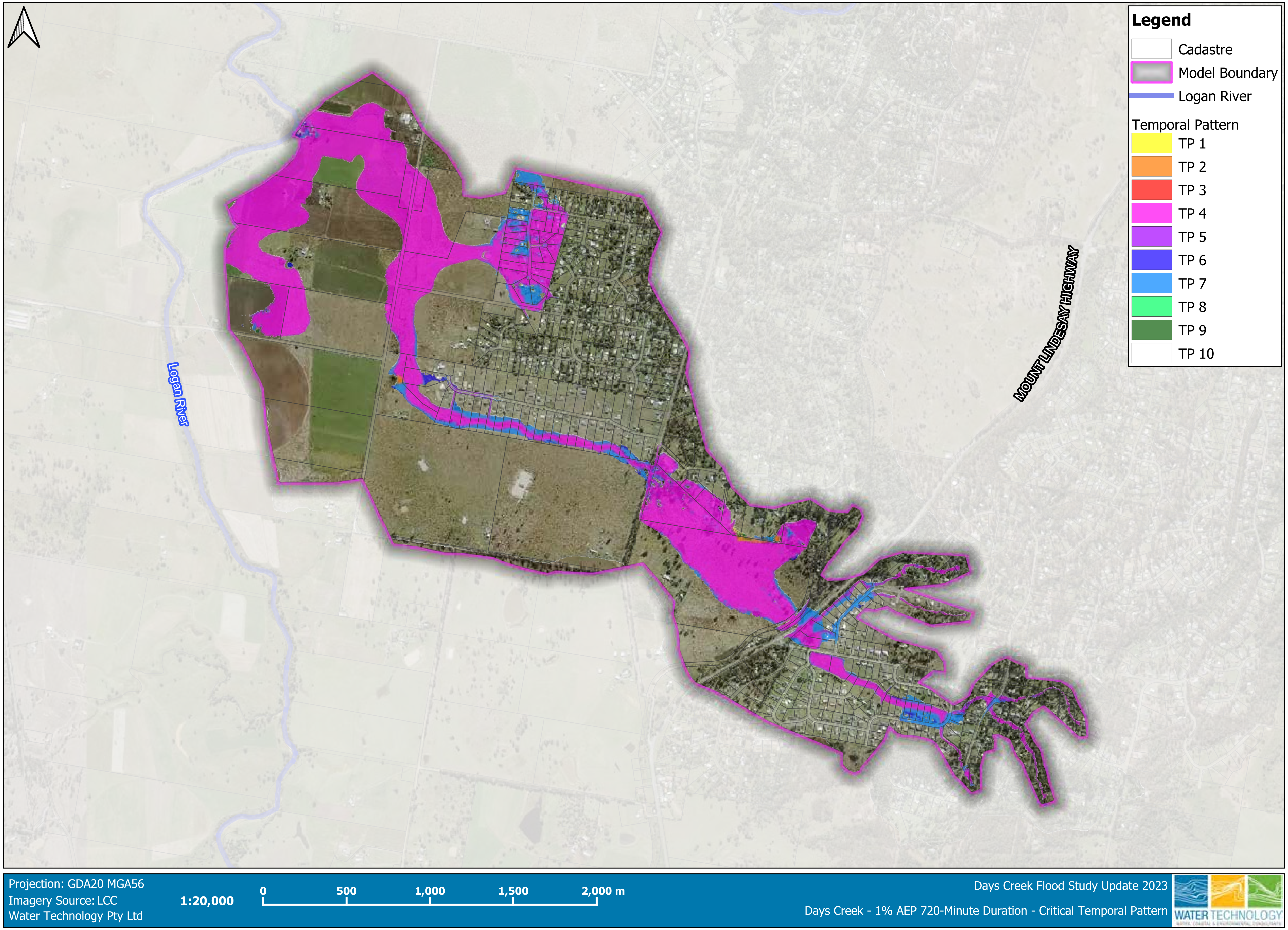
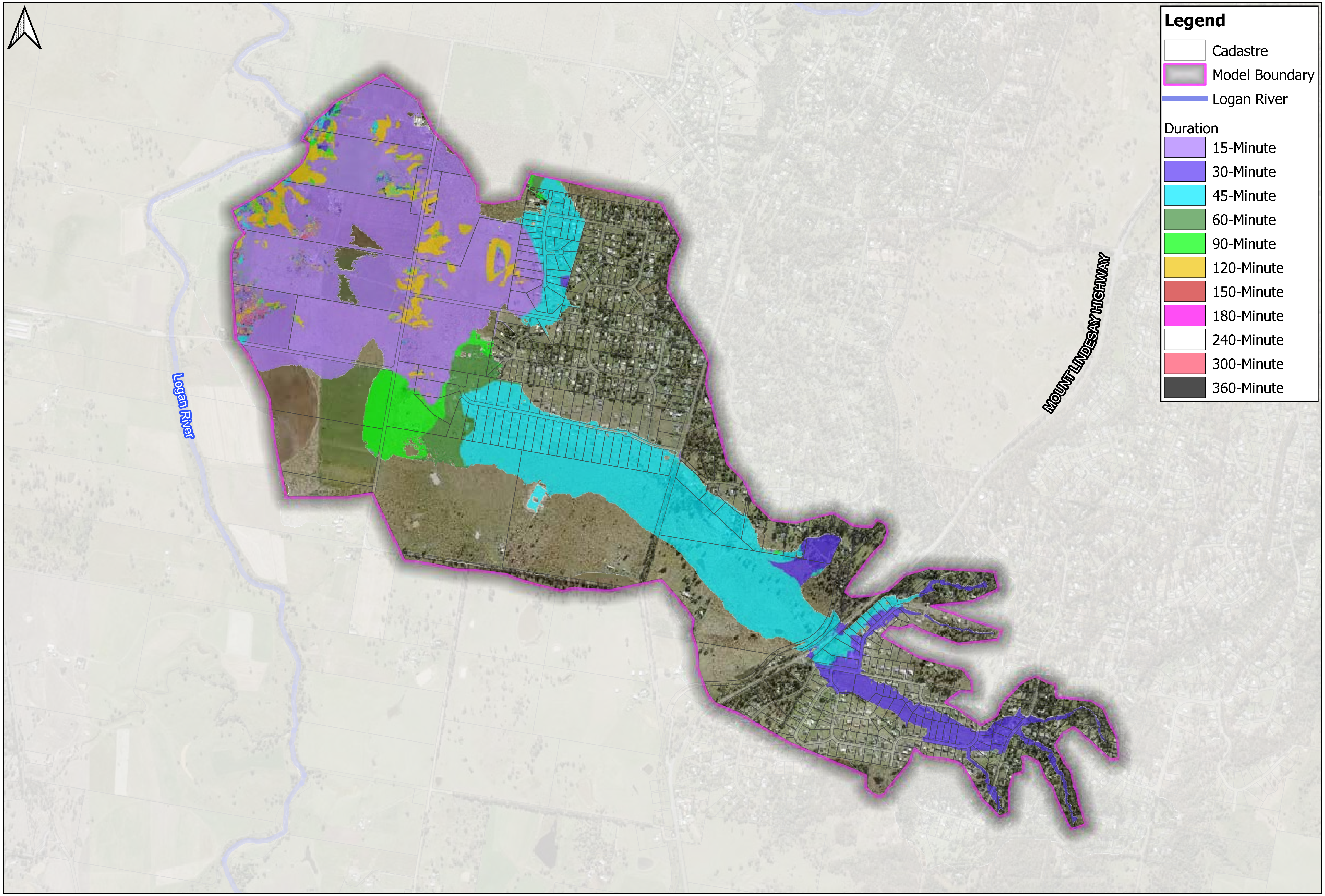
0 500 1,000 1,500 2,000 m

Days Creek Flood Study Update 2023

Days Creek - 1% AEP 540-Minute Duration - Critical Temporal Pattern



Legend
Cadastre
Model Boundary
Logan River
Temporal Pattern
TP 1
TP 2
TP 3
TP 4
TP 5
TP 6
TP 7
TP 8
TP 9
TP 10
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:20,000
0
500
1,000
1,500
2,000 m
Days Creek Flood Study Update 2023
Days Creek - 1% AEP 720-Minute Duration - Critical Temporal Pattern



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

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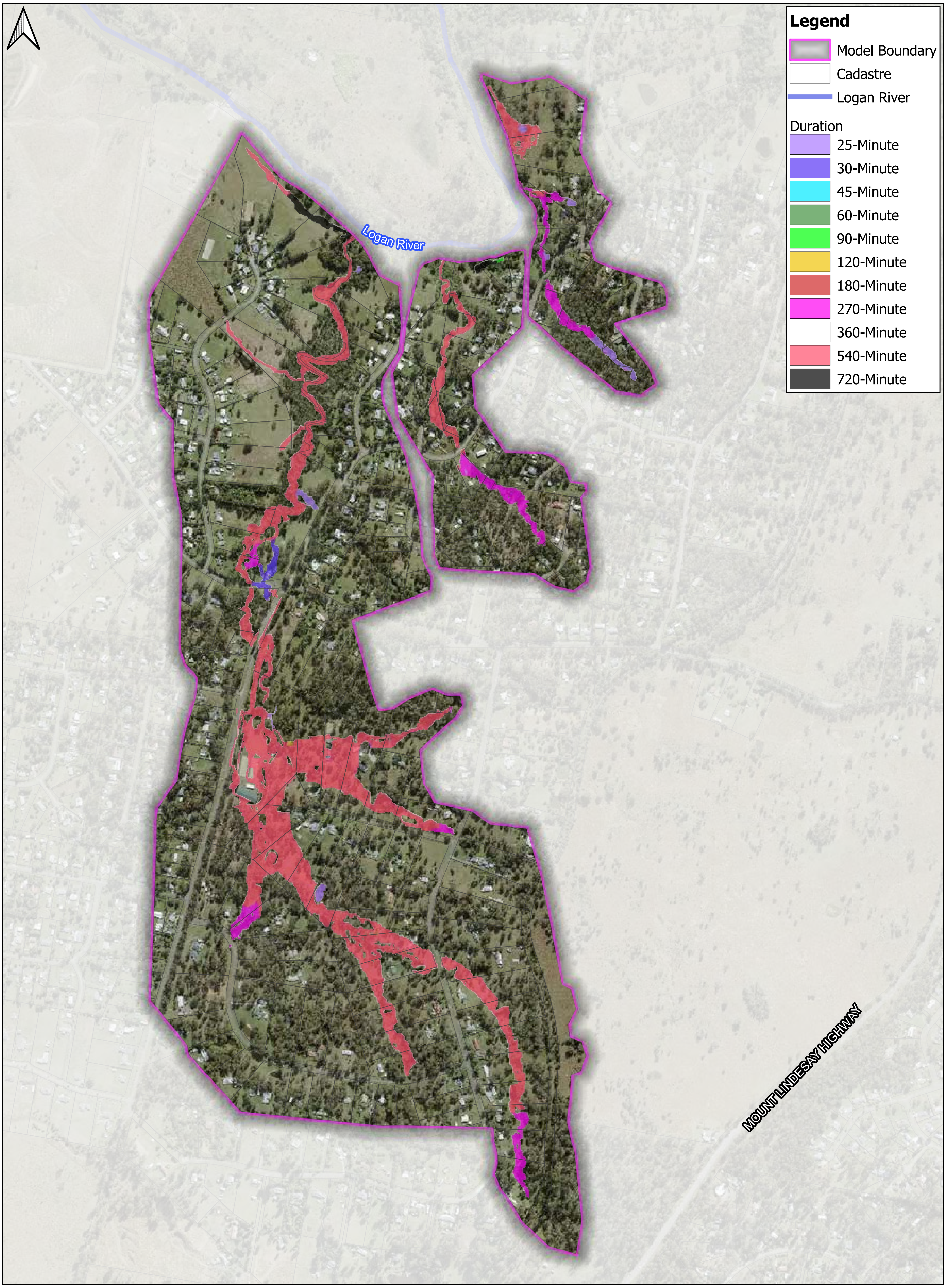
Days Creek Flood Study Update 2023

Days Creek - PMF Critical Duration

WATER TECHNOLOGY



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

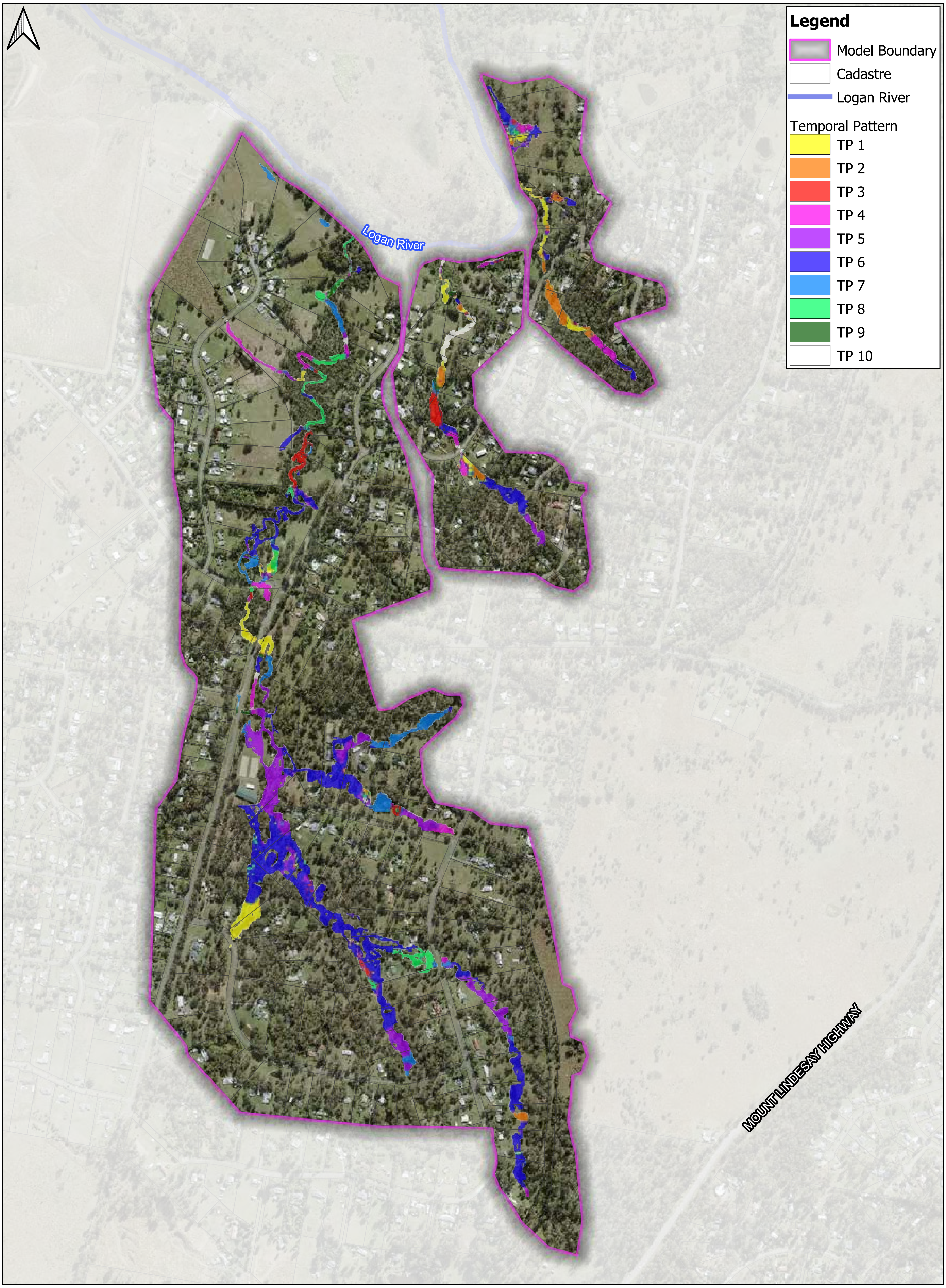
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP Critical Duration

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

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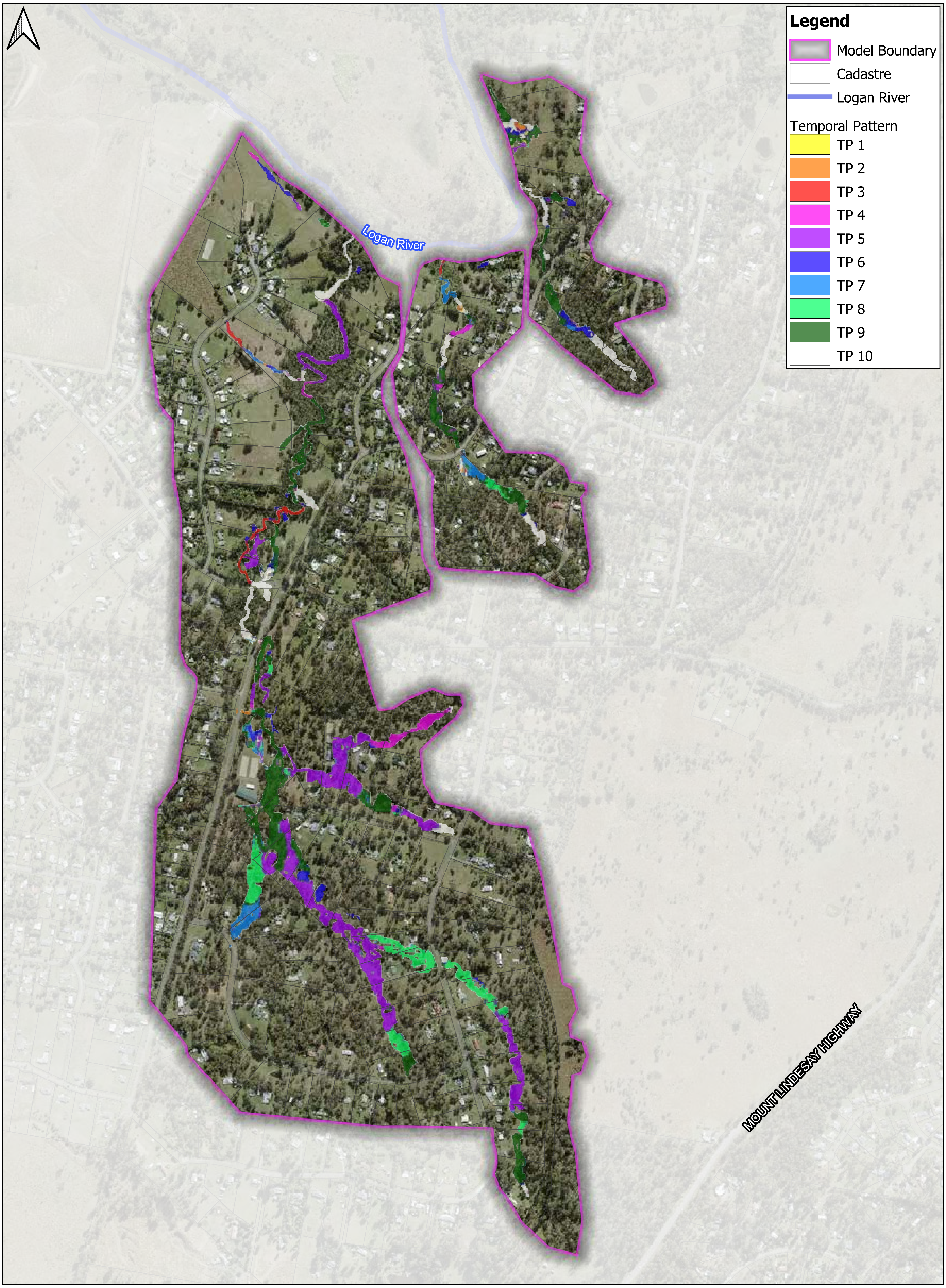
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 25-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY



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

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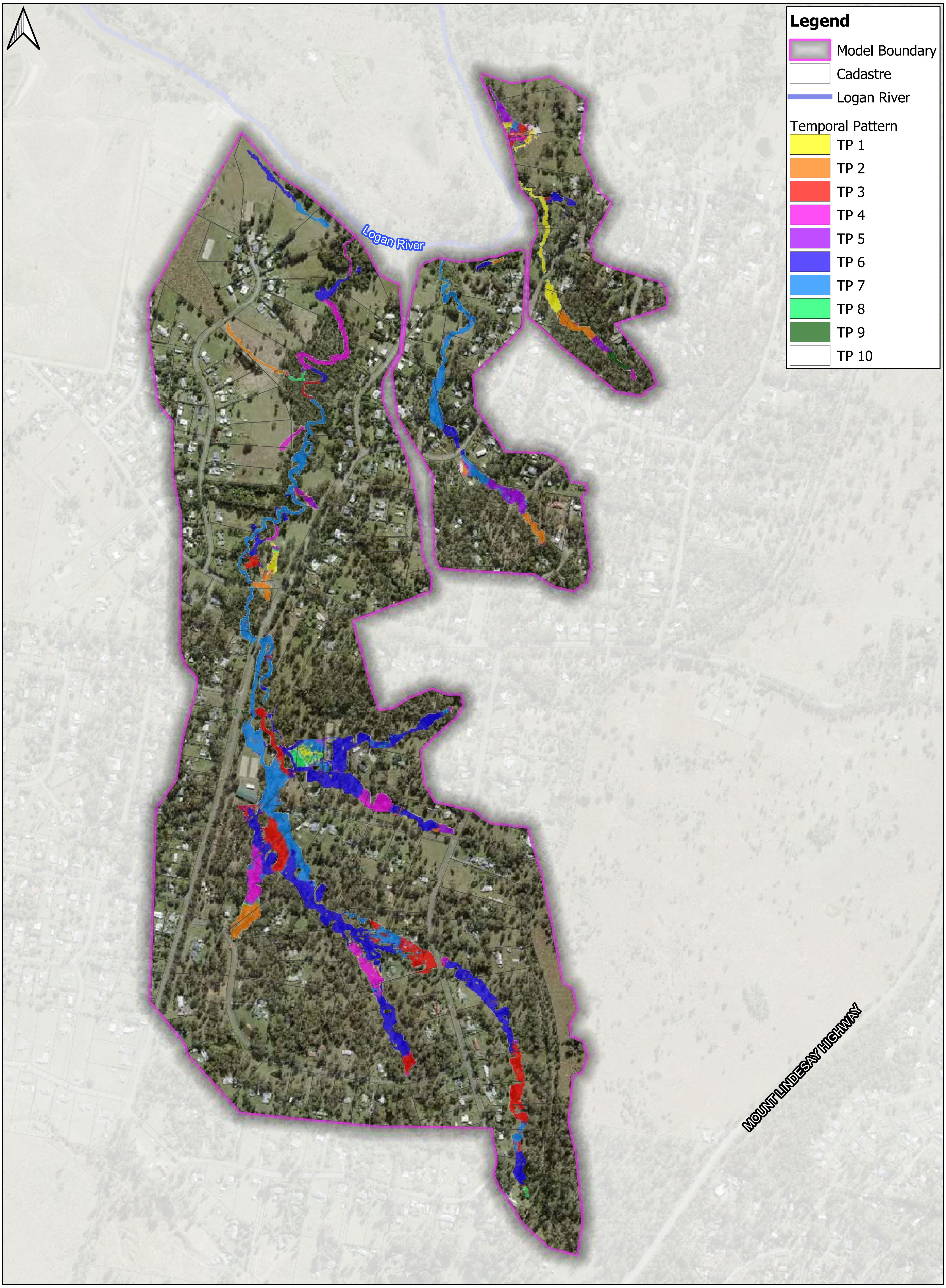
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 30-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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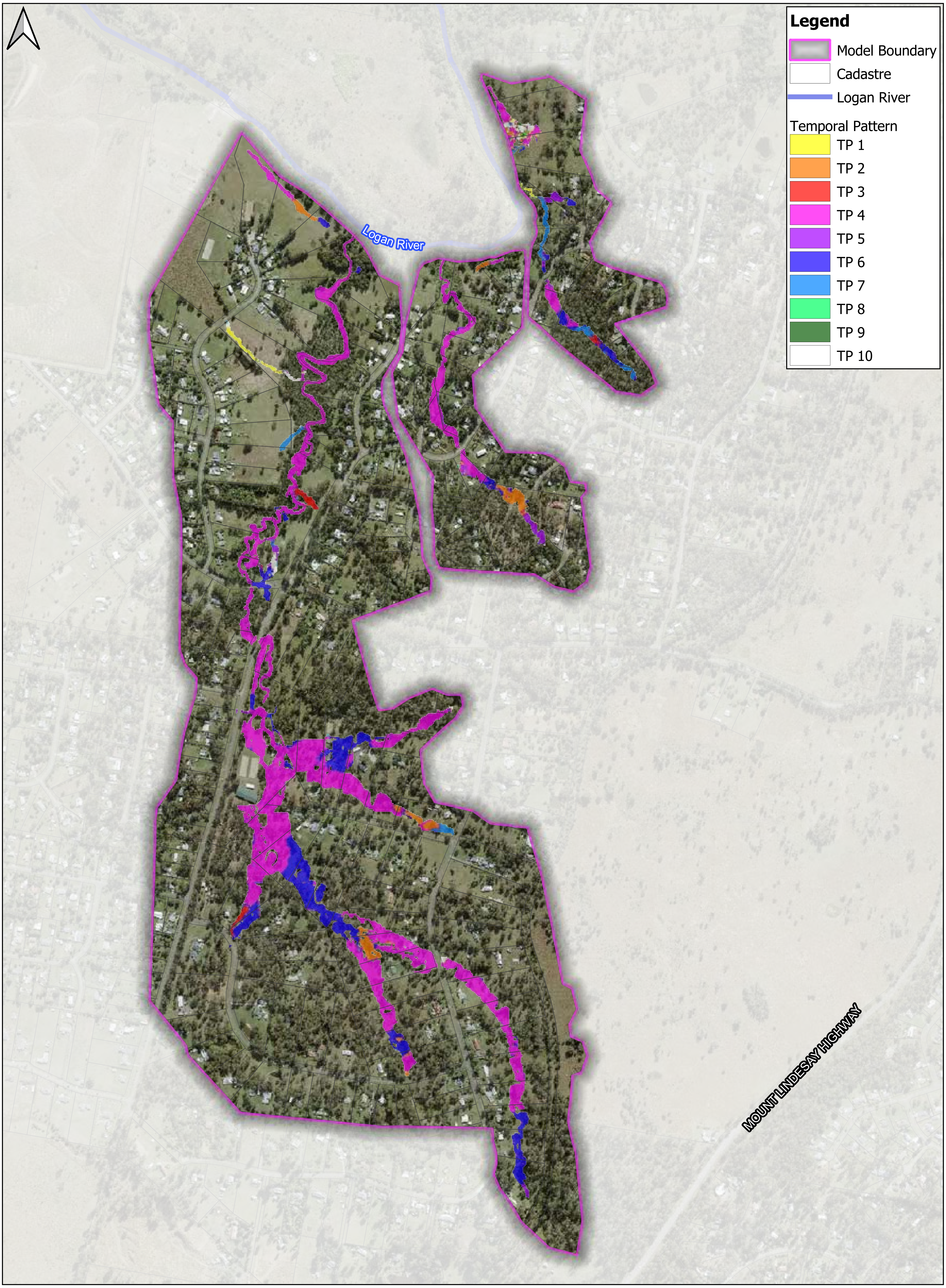
Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 45-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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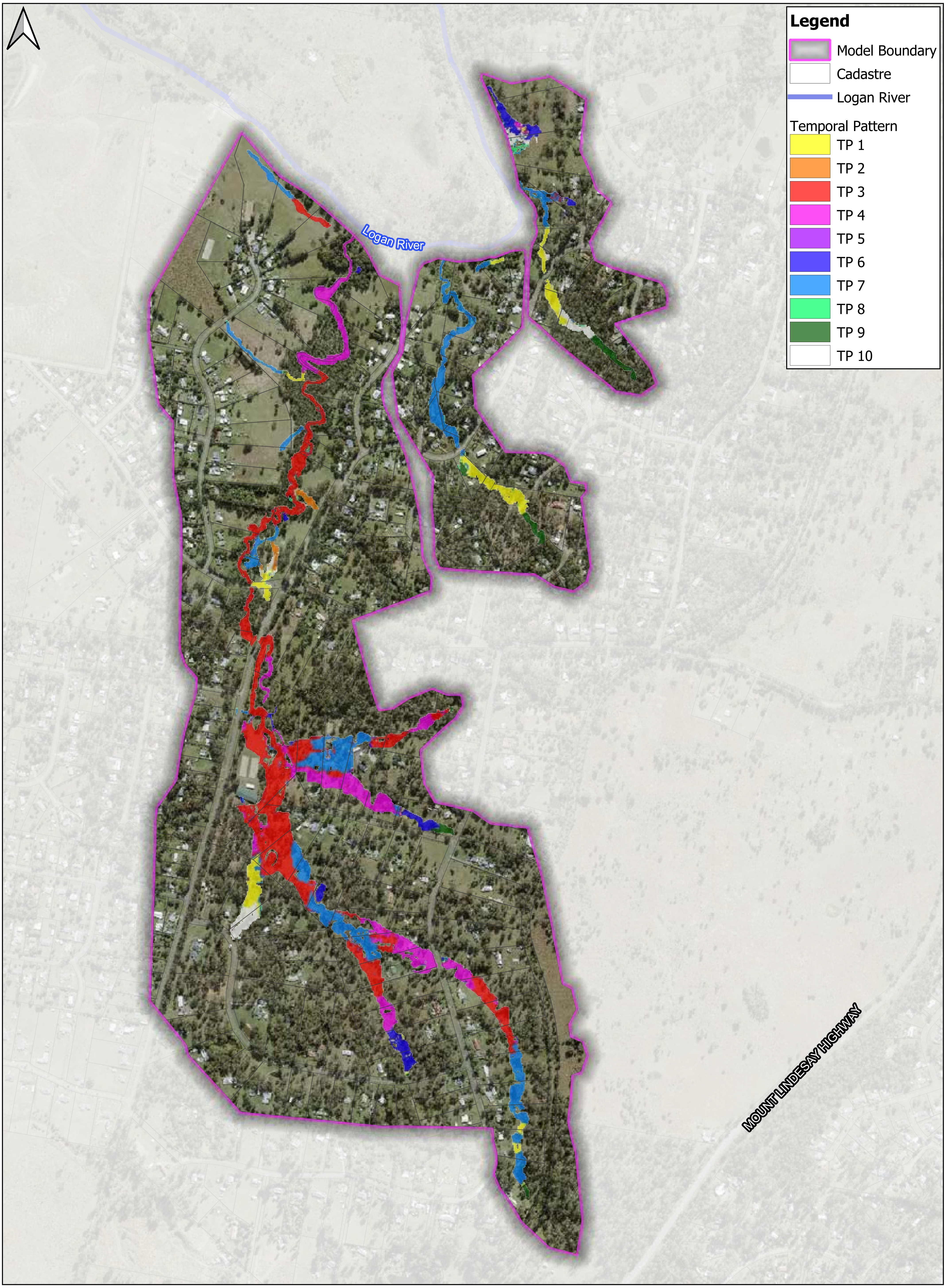
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 60-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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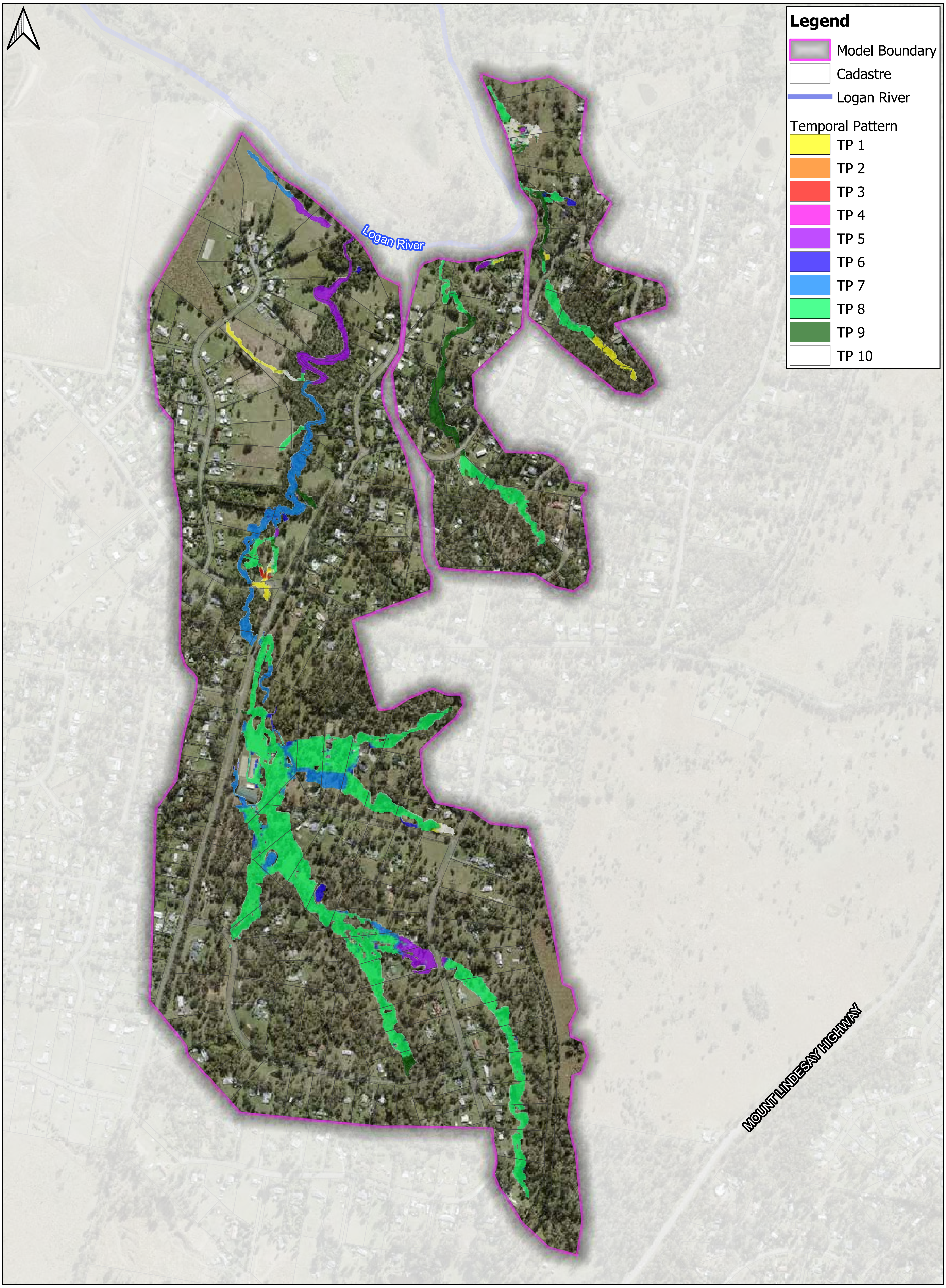
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 90-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

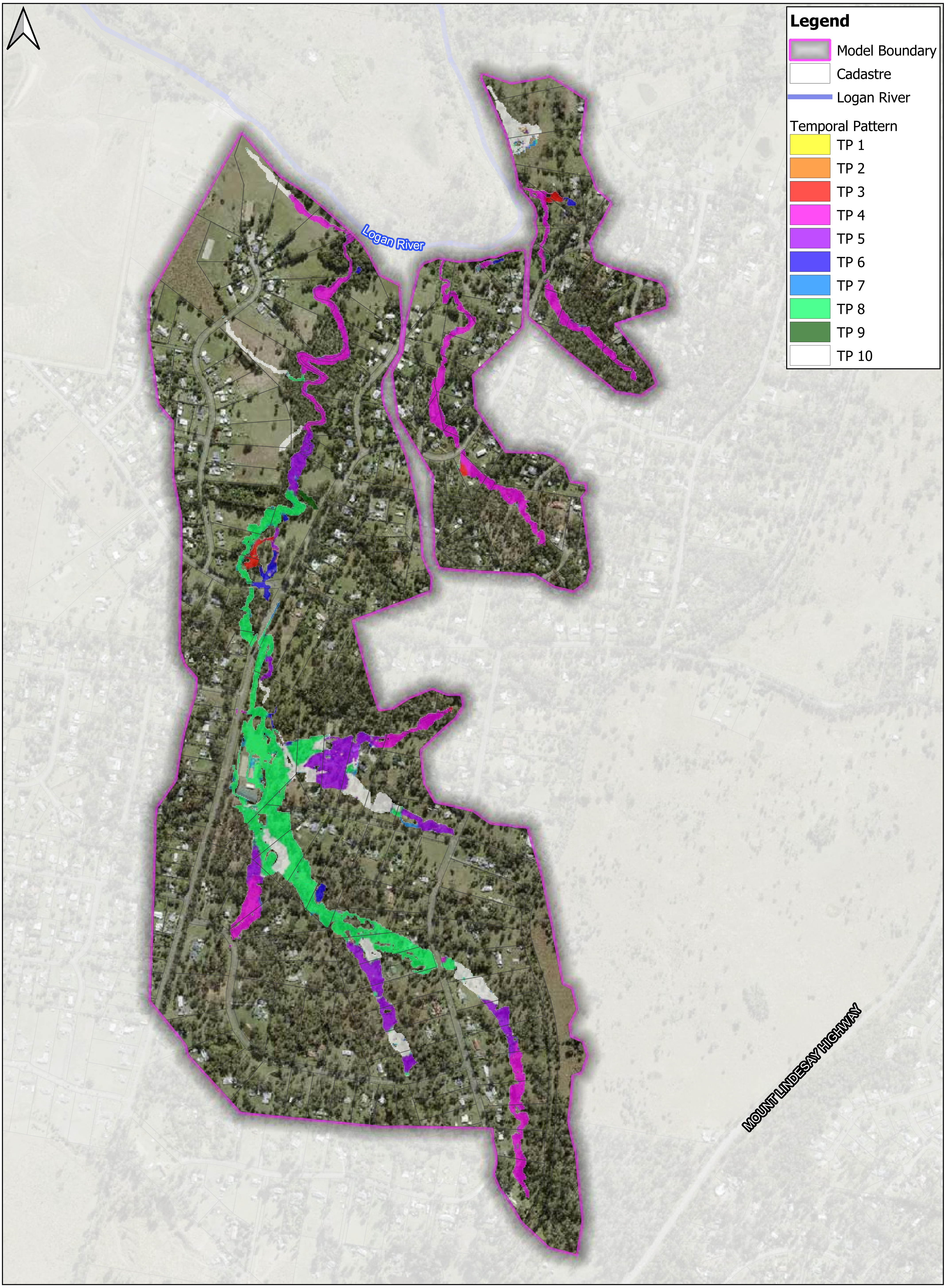
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 120-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

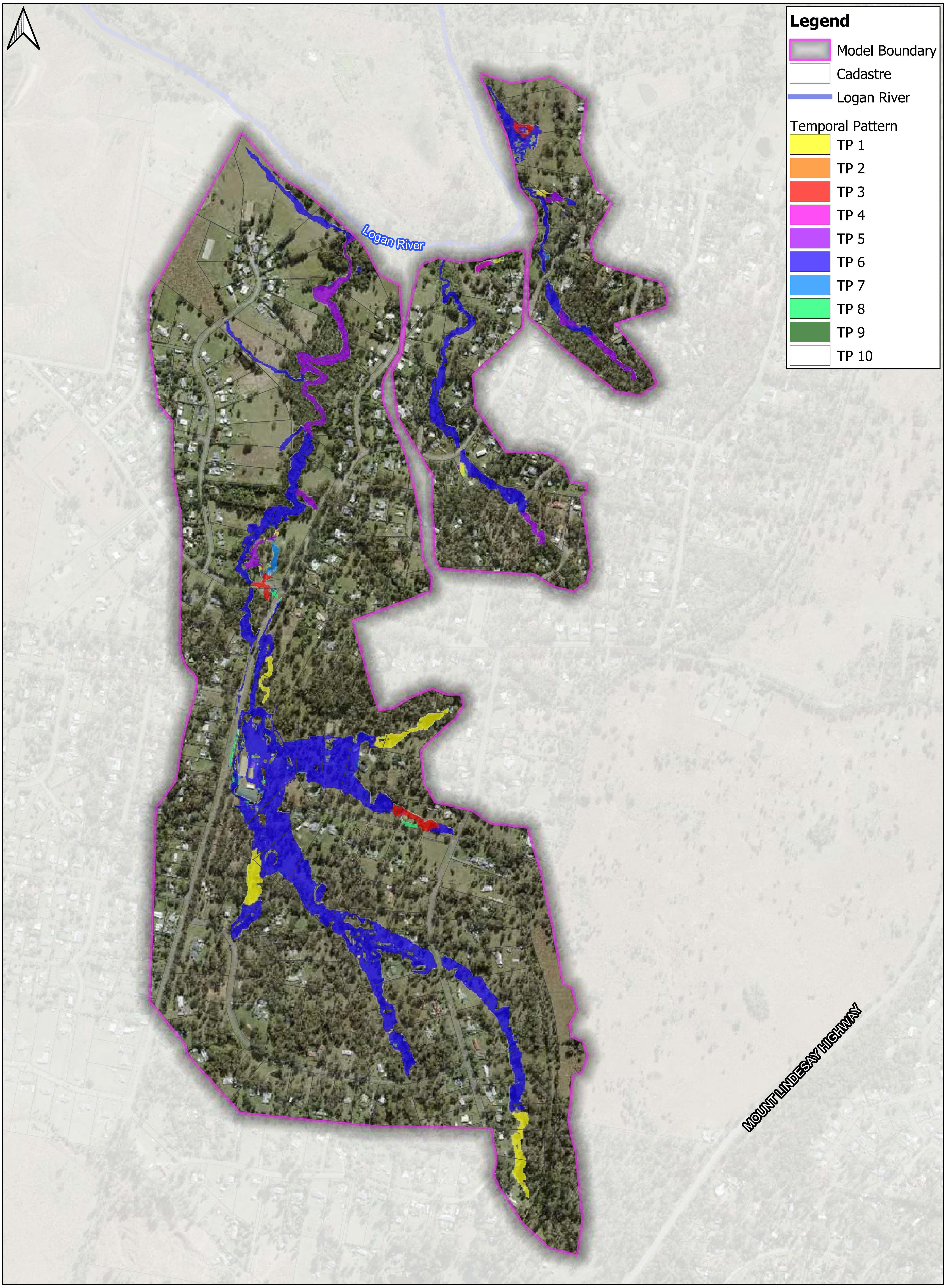
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 180-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

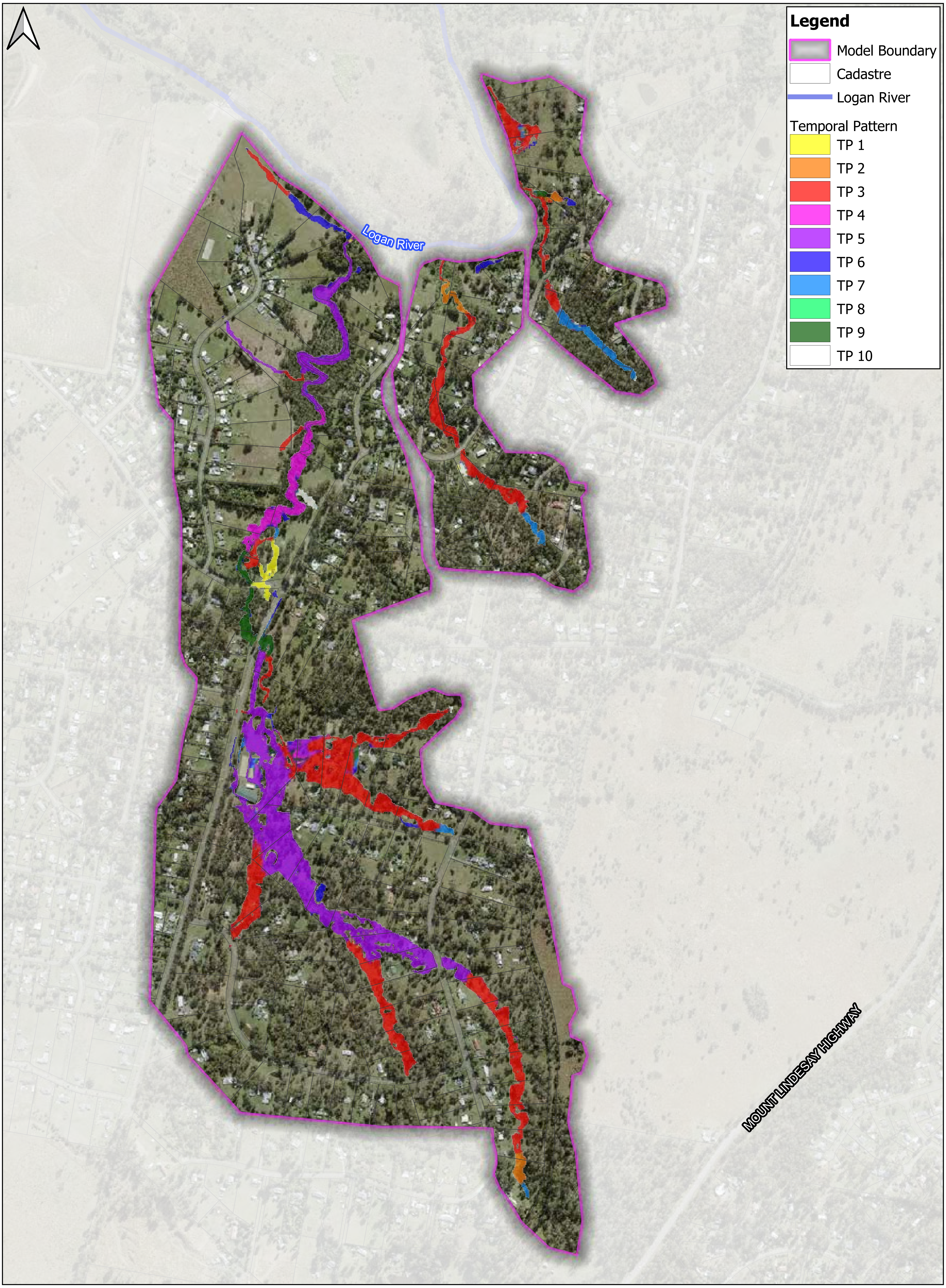
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 270-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

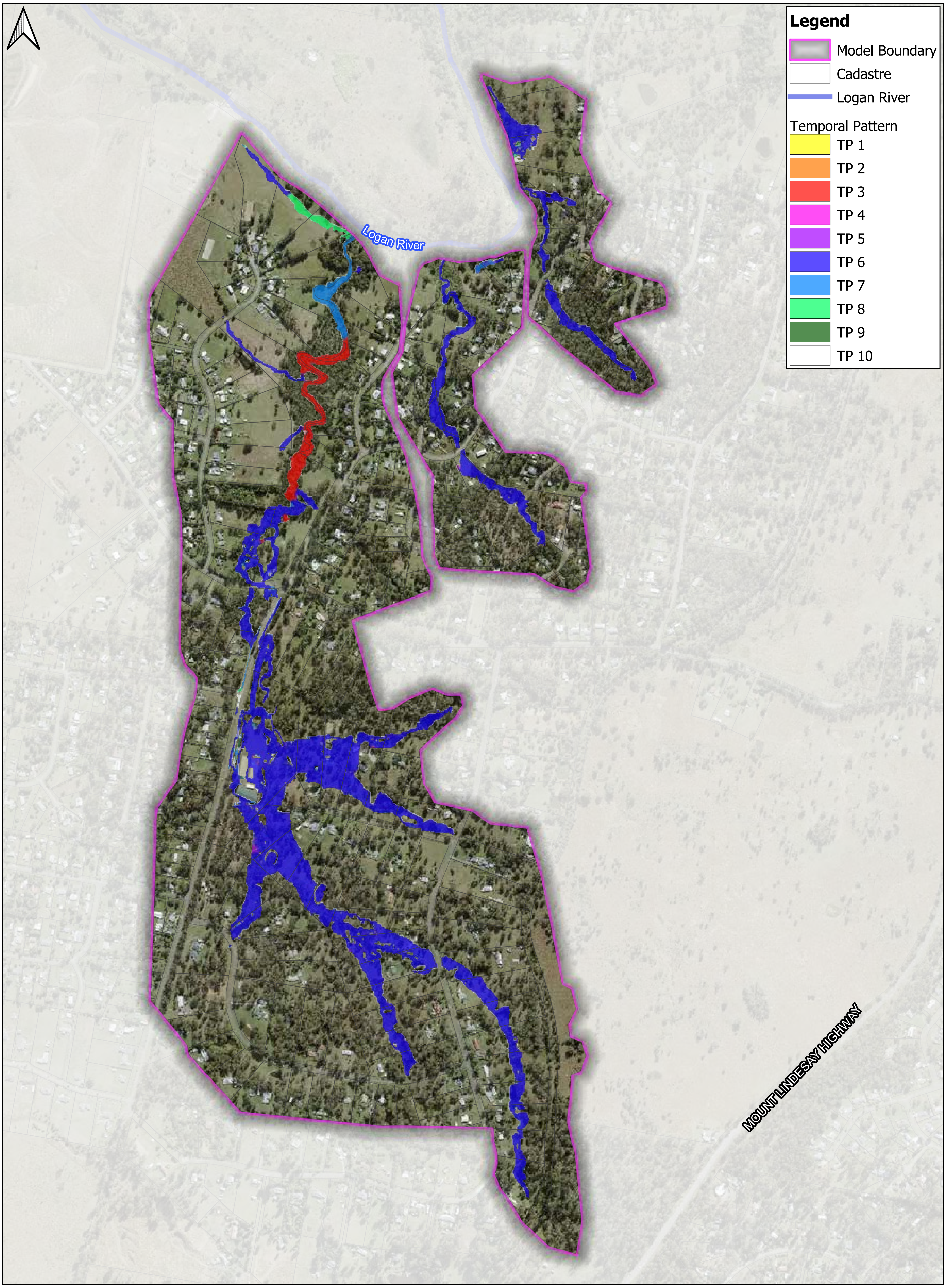
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 360-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56

Imagery Source: LCC

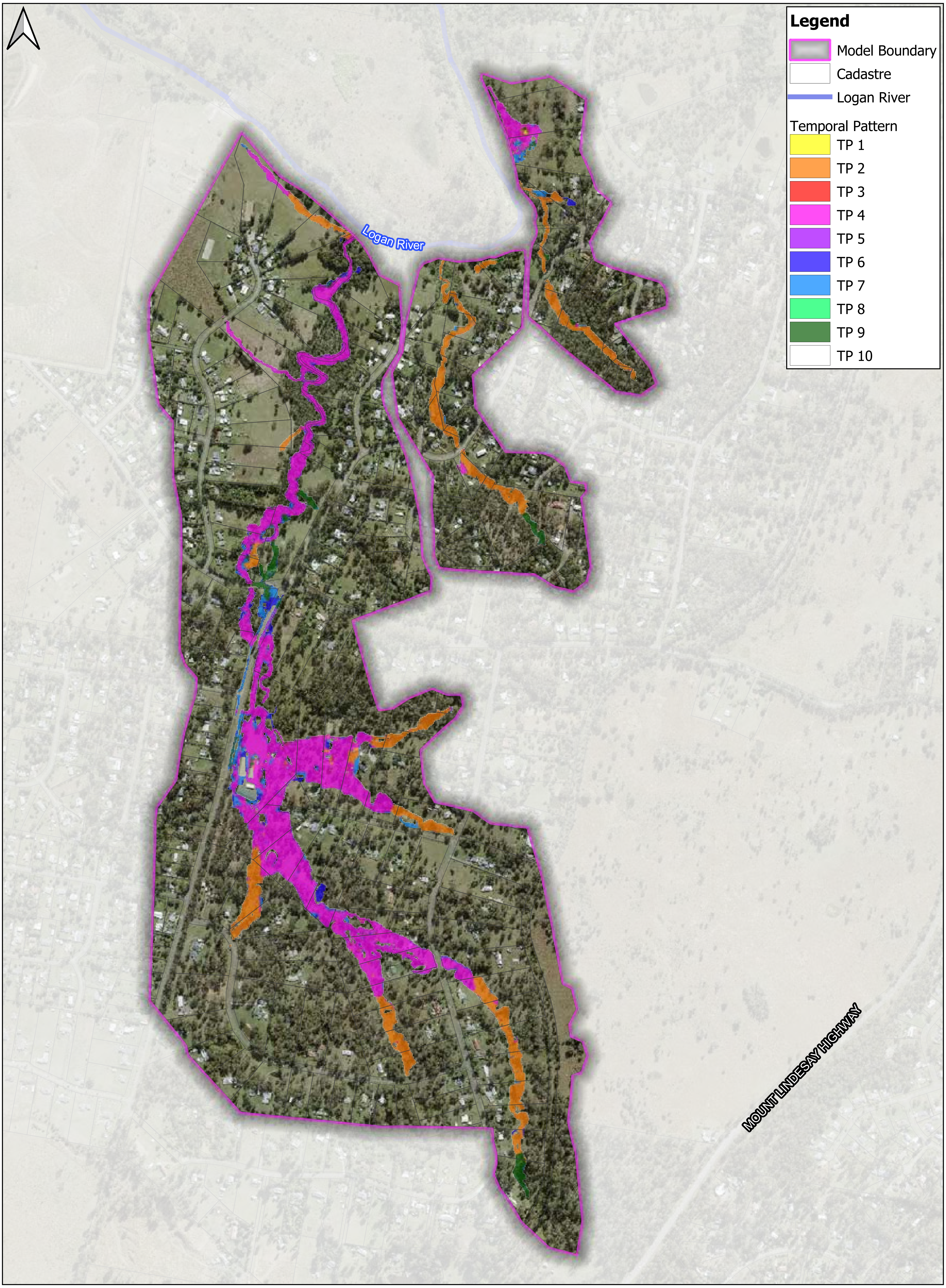
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 540-Minute Duration - Critical Temporal Pattern



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

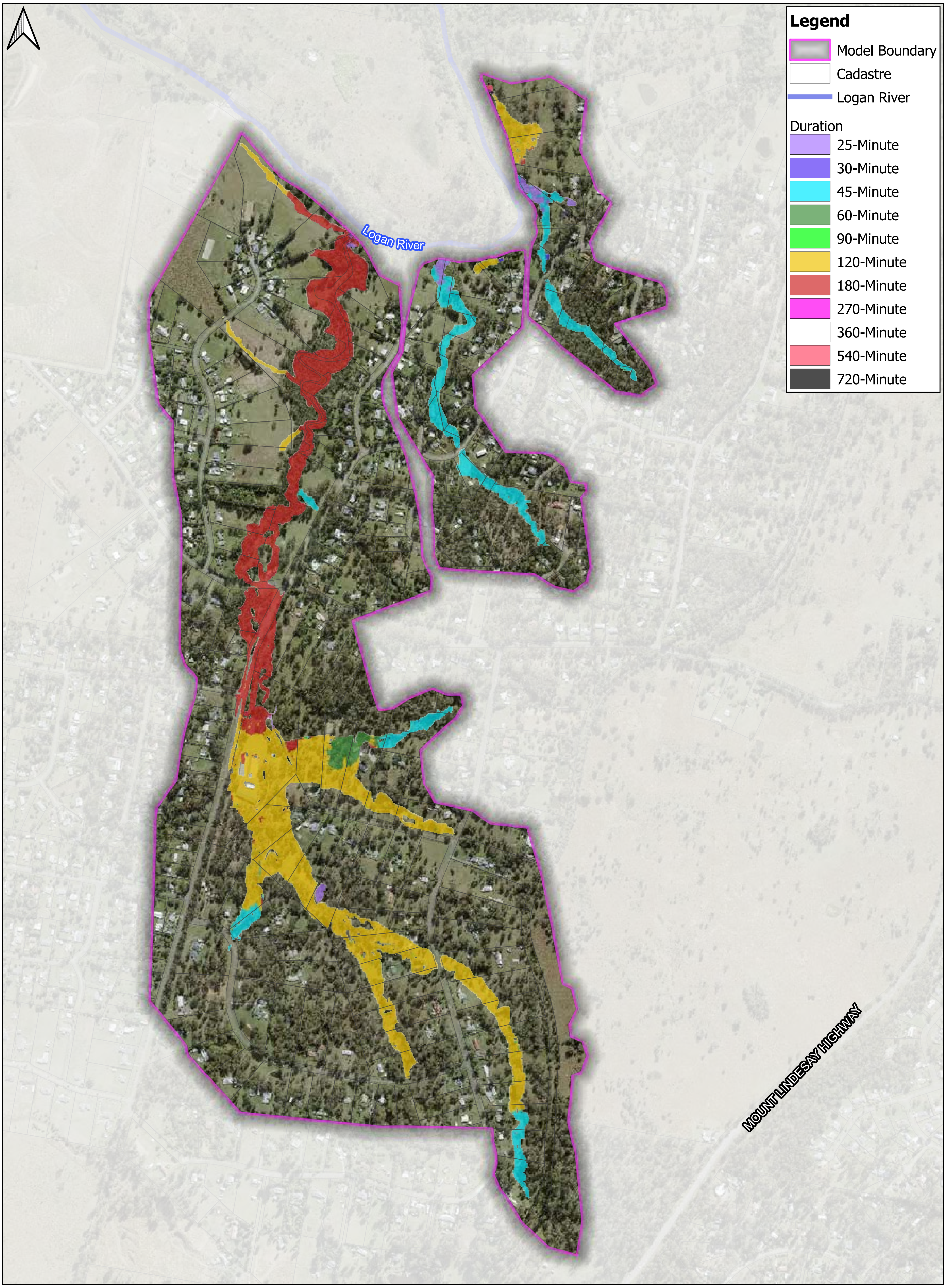
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 50% AEP 720-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

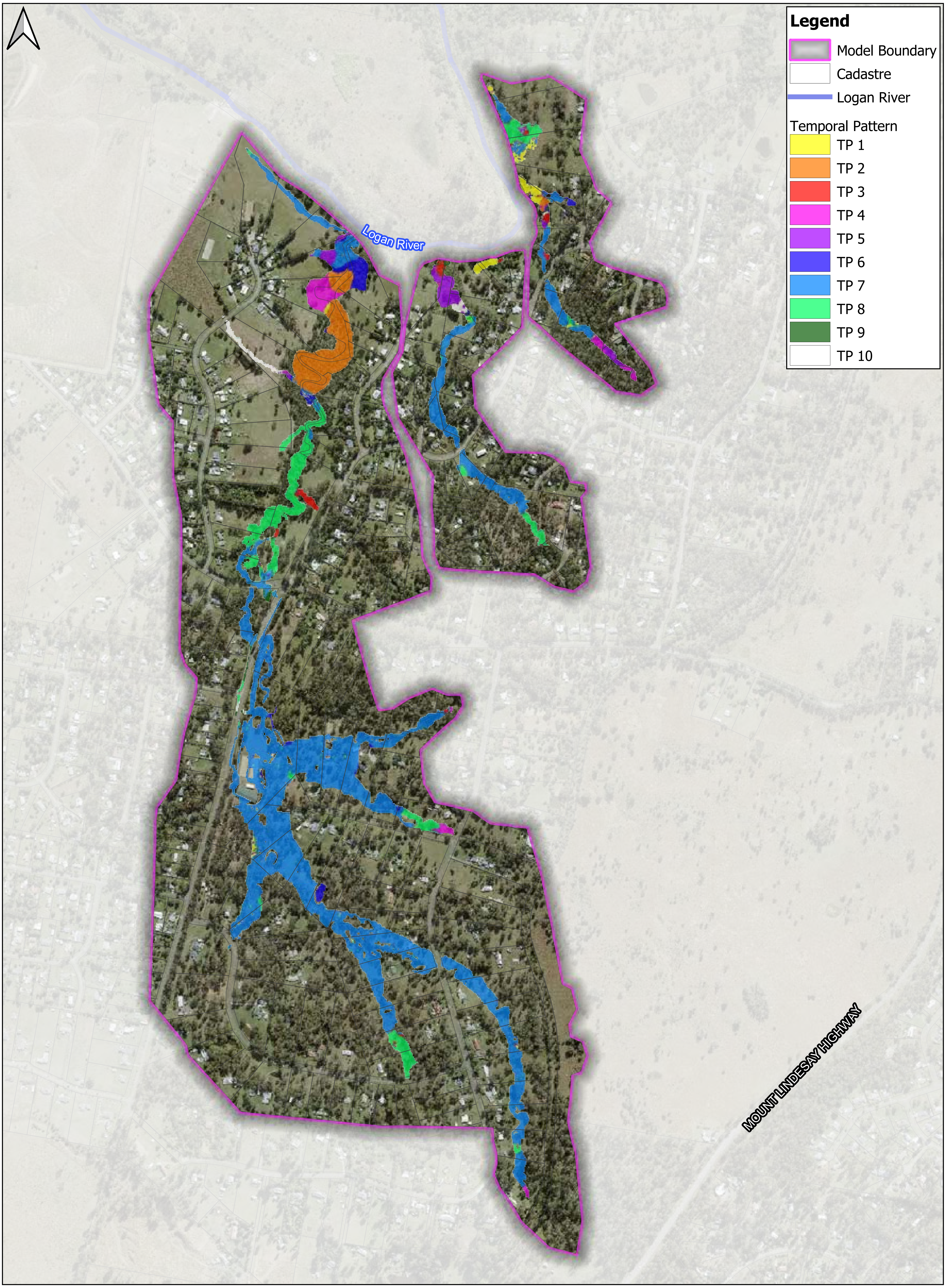
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP Critical Duration

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56

Imagery Source: LCC

Water Technology Pty Ltd

1:10,000

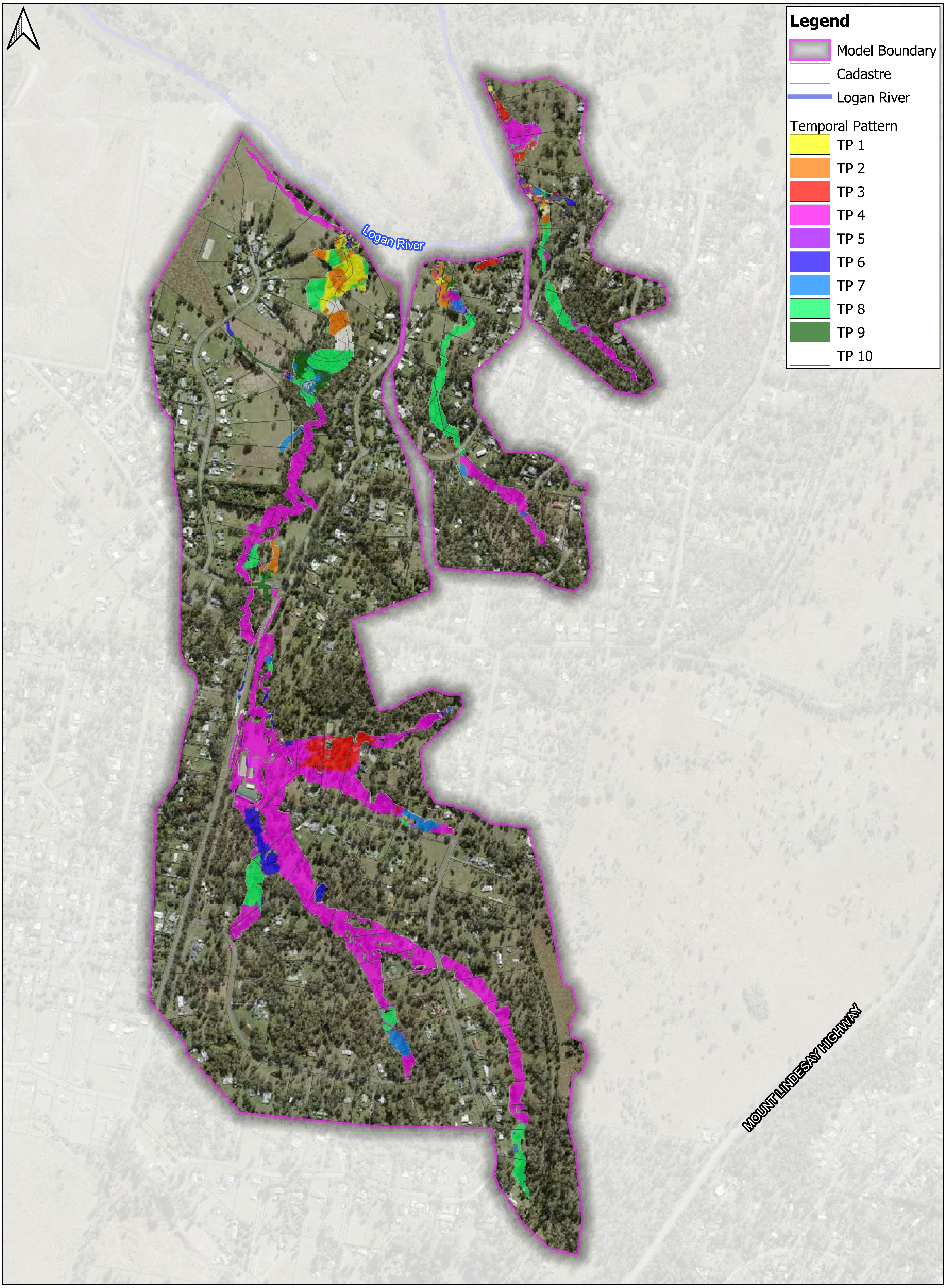
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 25-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

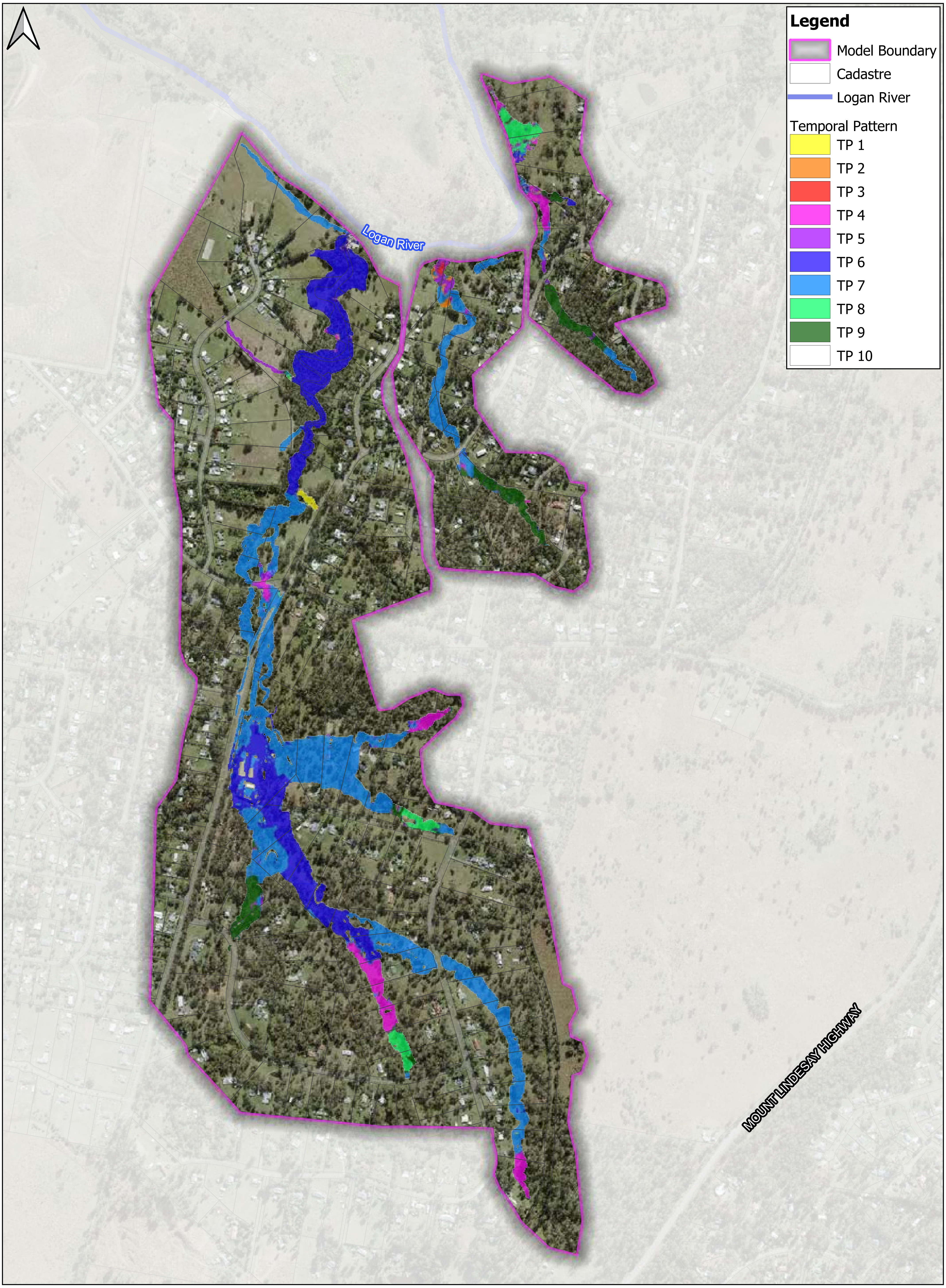
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 30-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

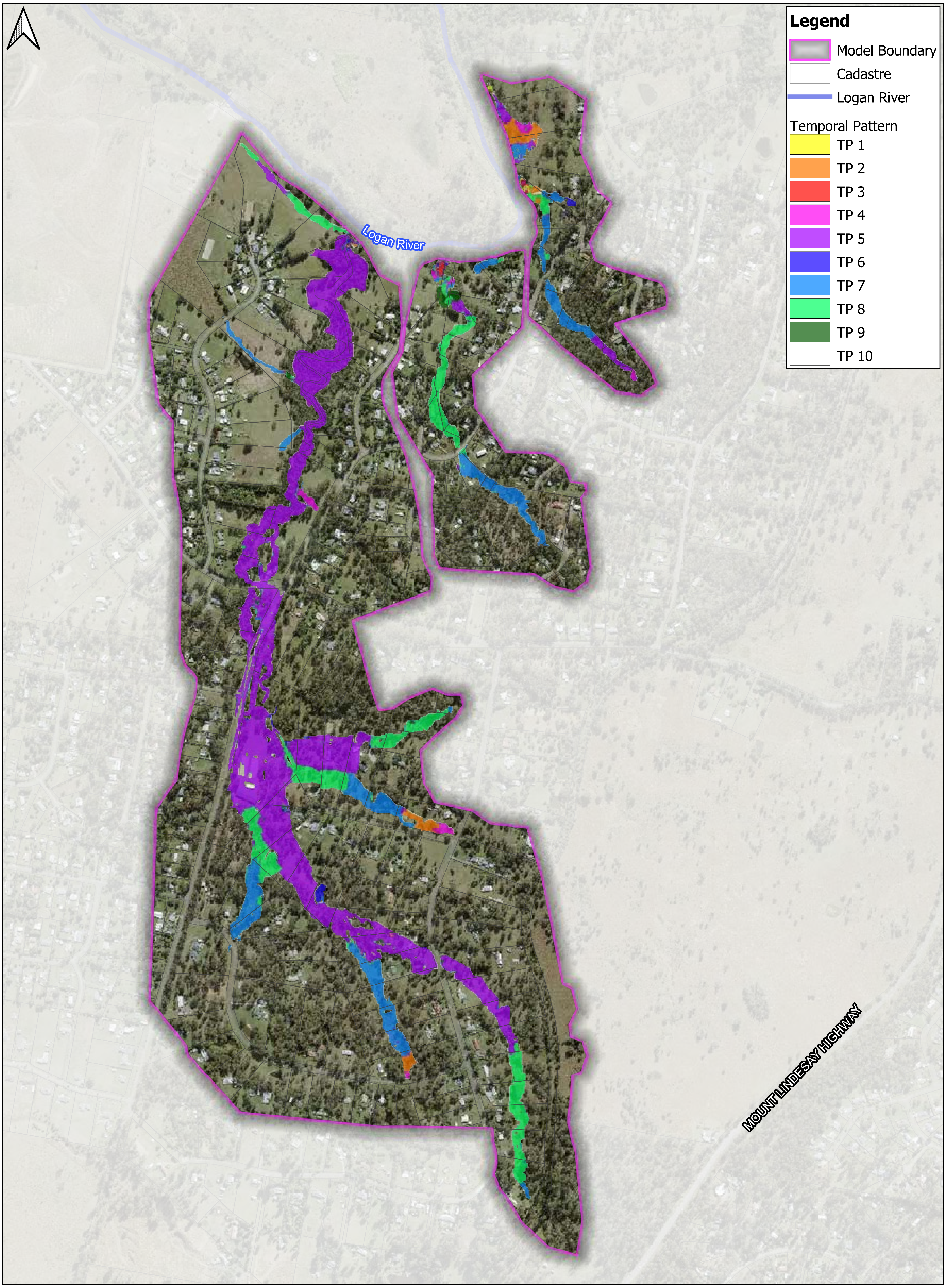
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 45-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

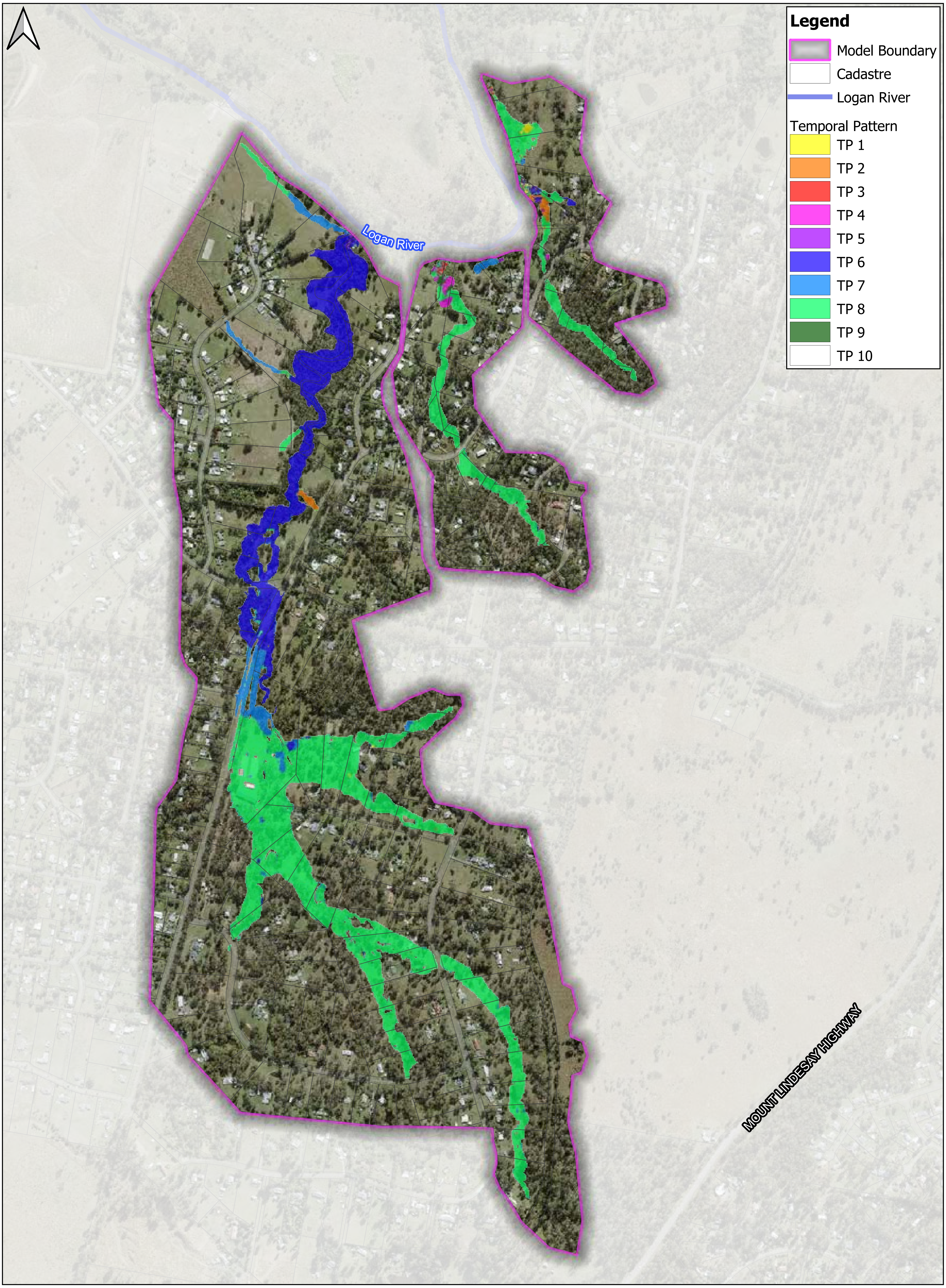
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 60-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

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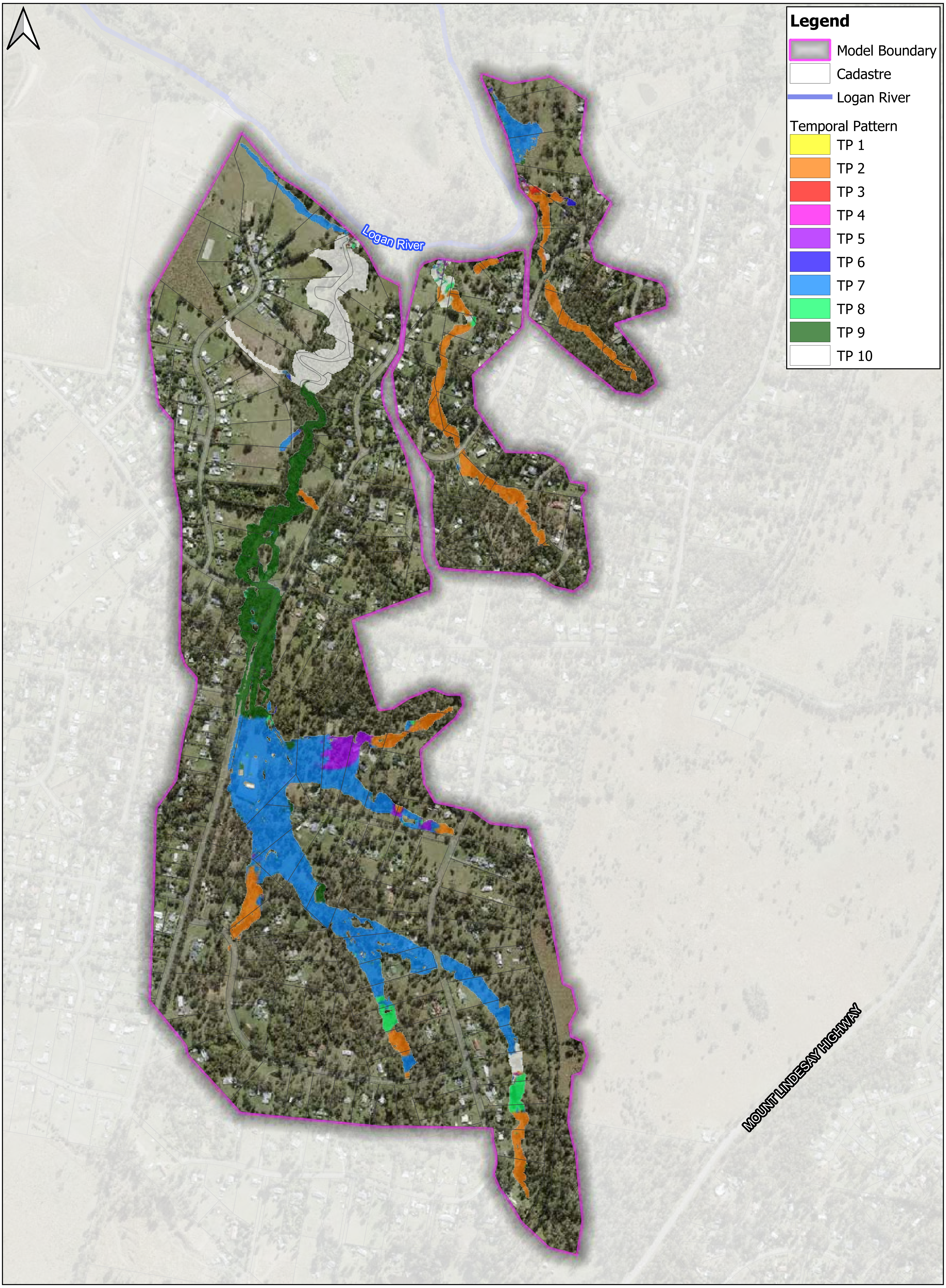
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 90-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

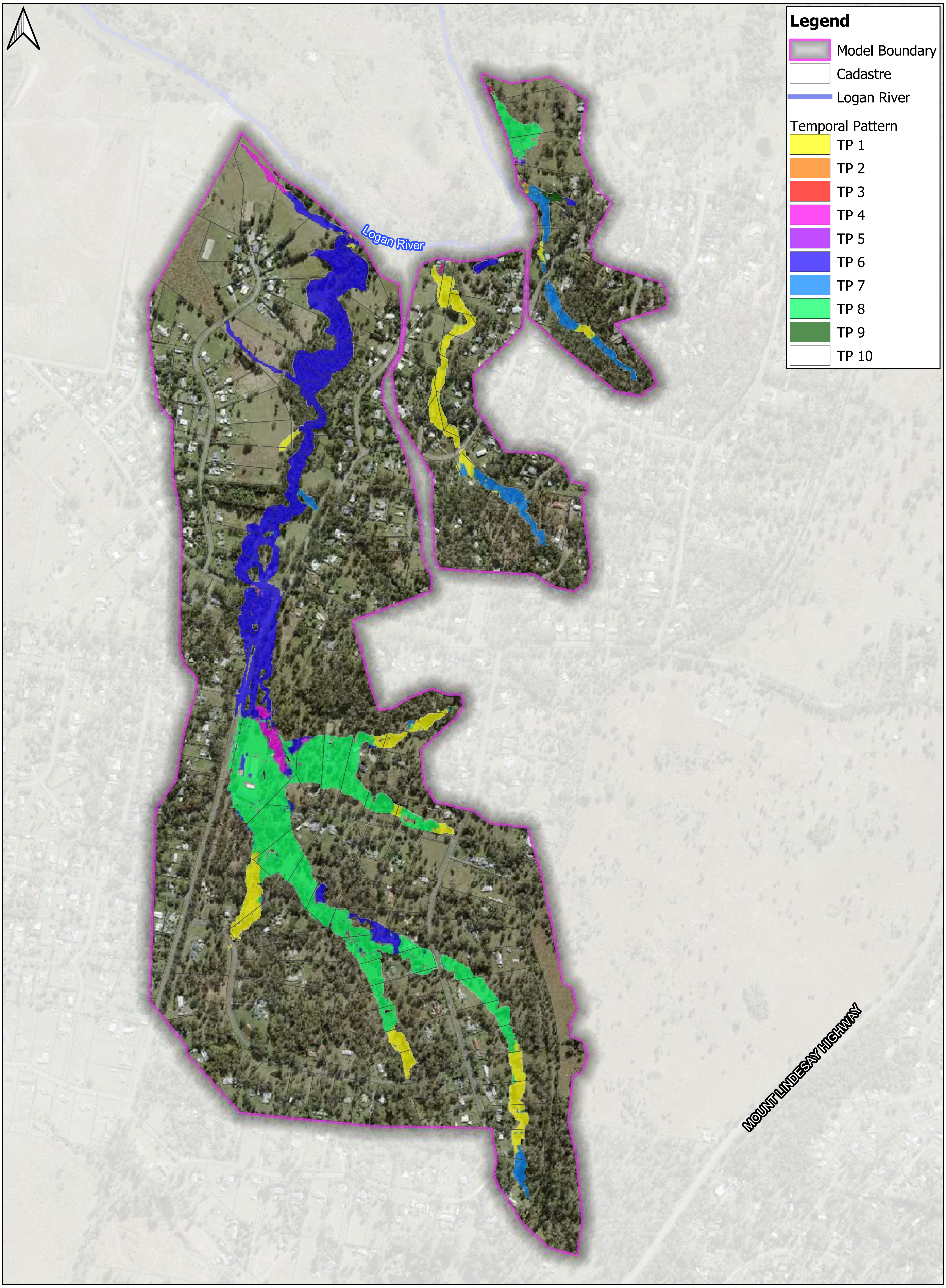
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 120-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

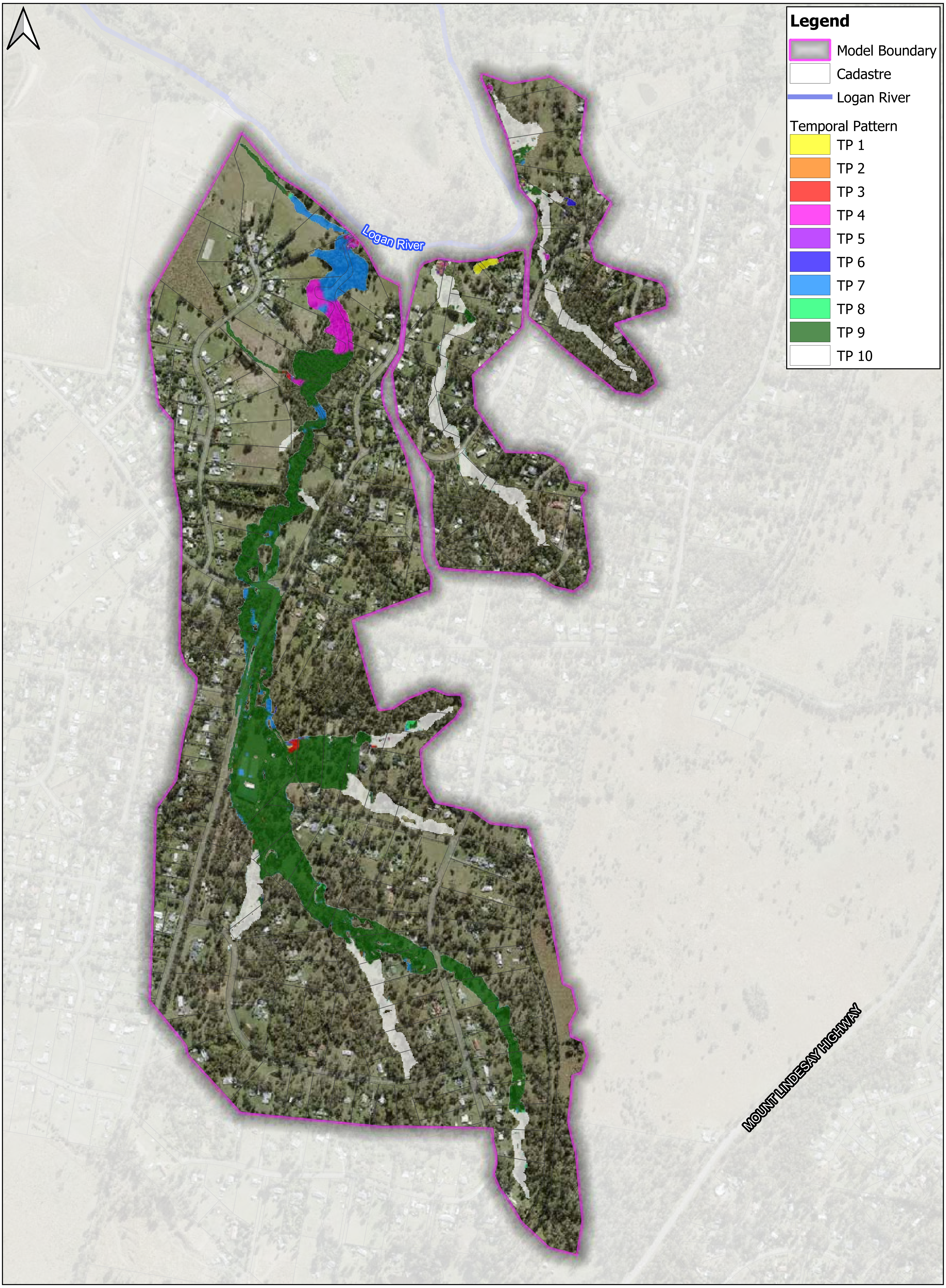
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 180-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

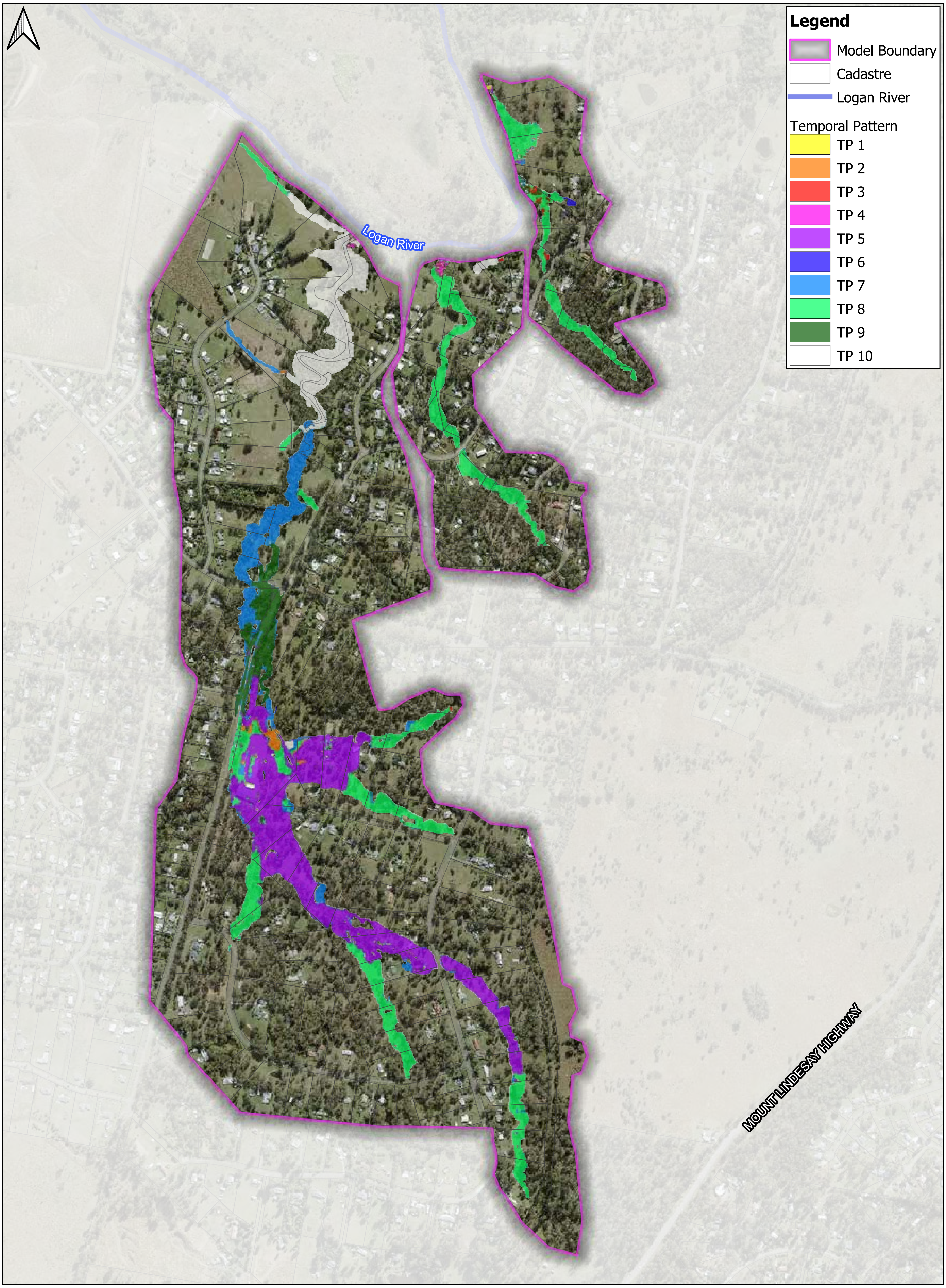
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 270-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56

Imagery Source: LCC

Water Technology Pty Ltd

1:10,000

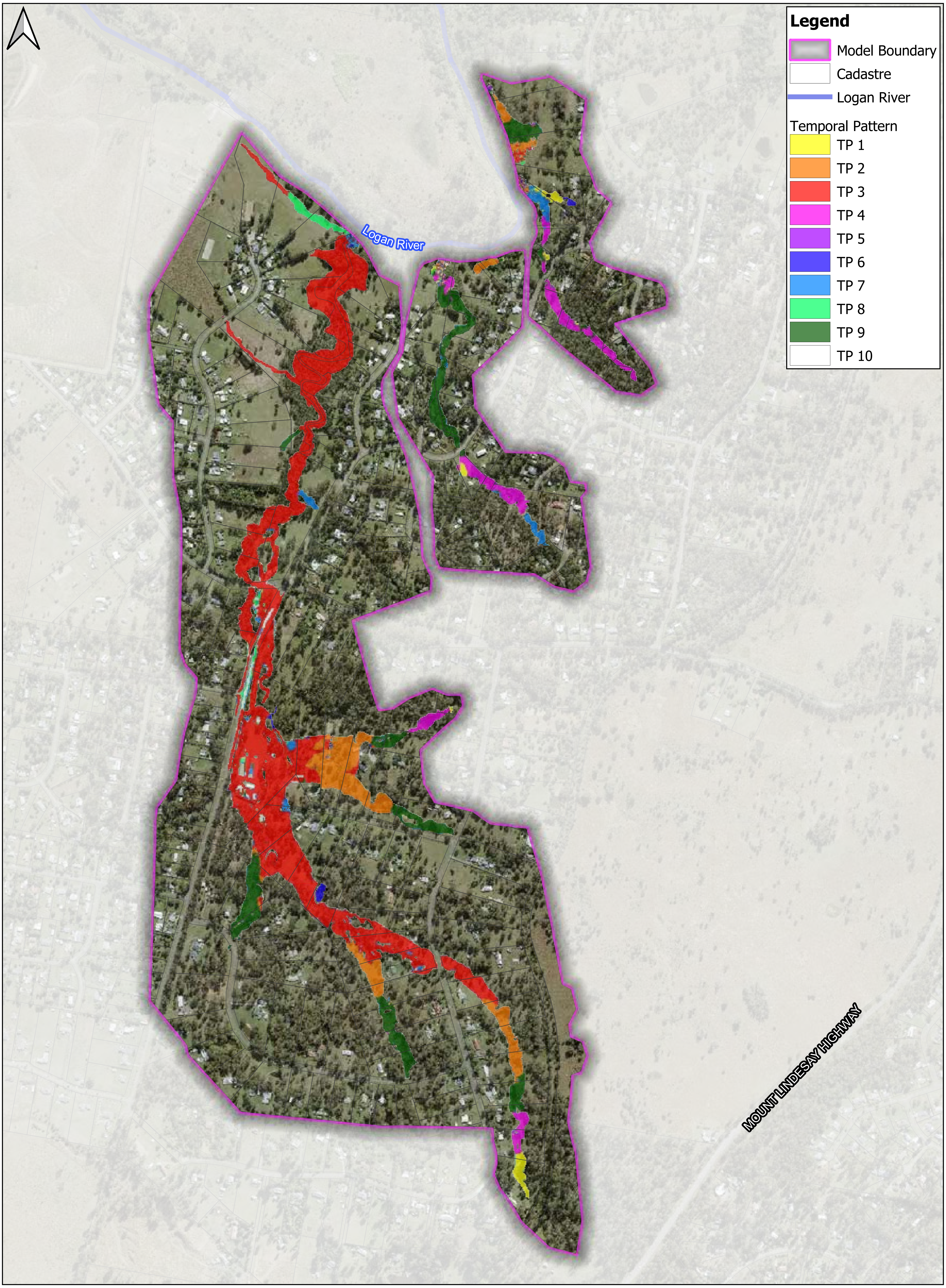
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 360-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

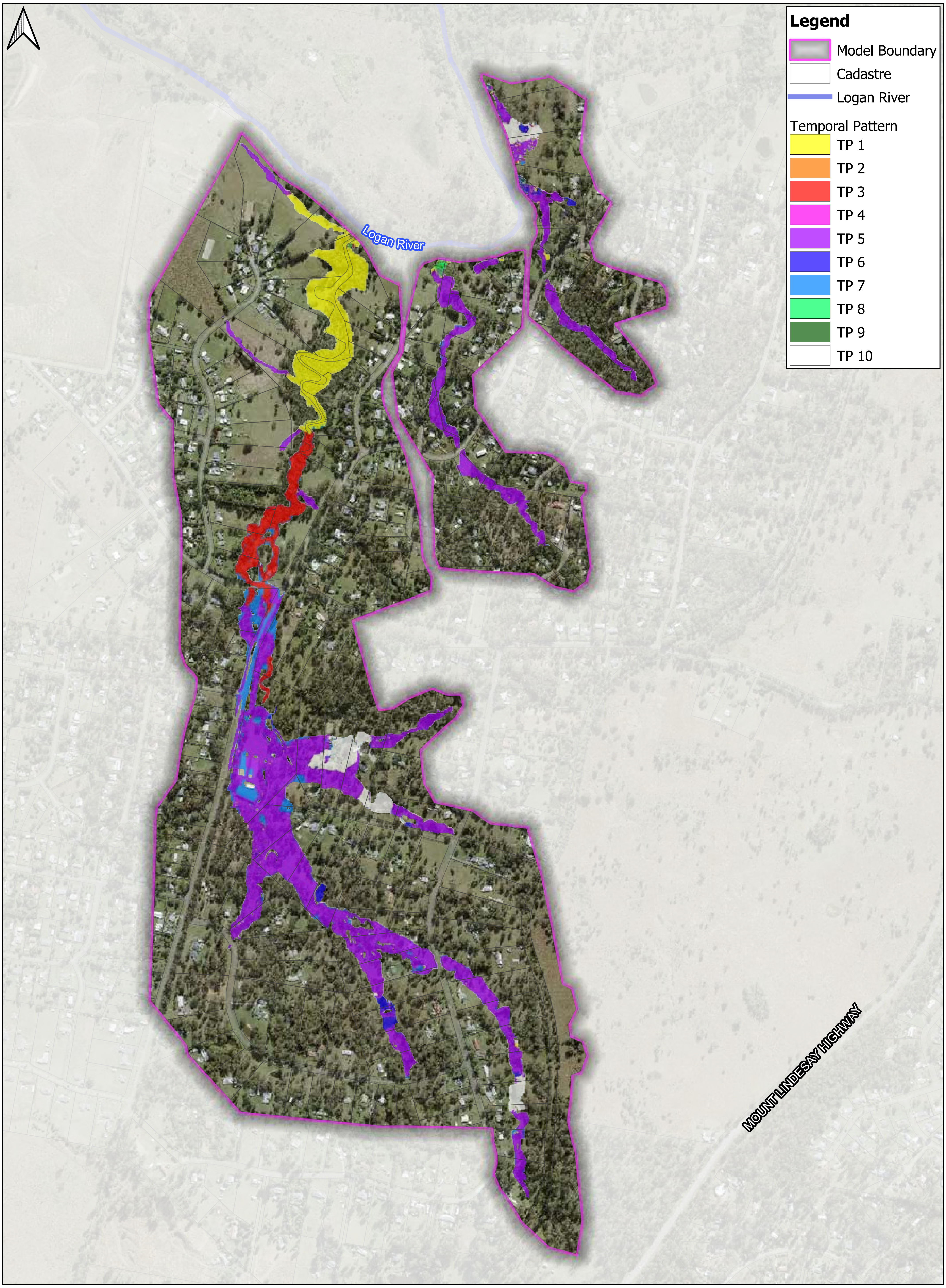
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 540-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

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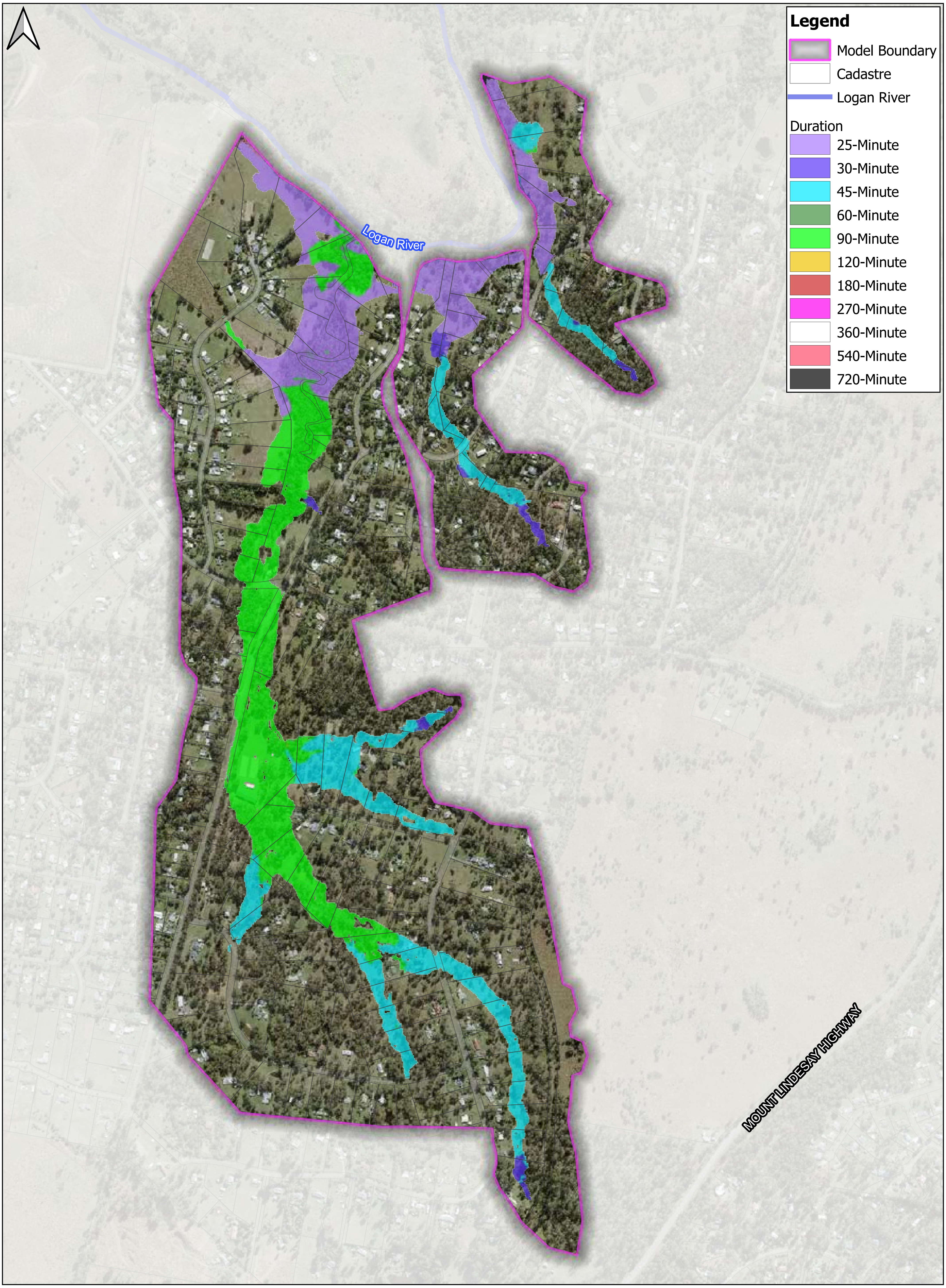
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 10% AEP 720-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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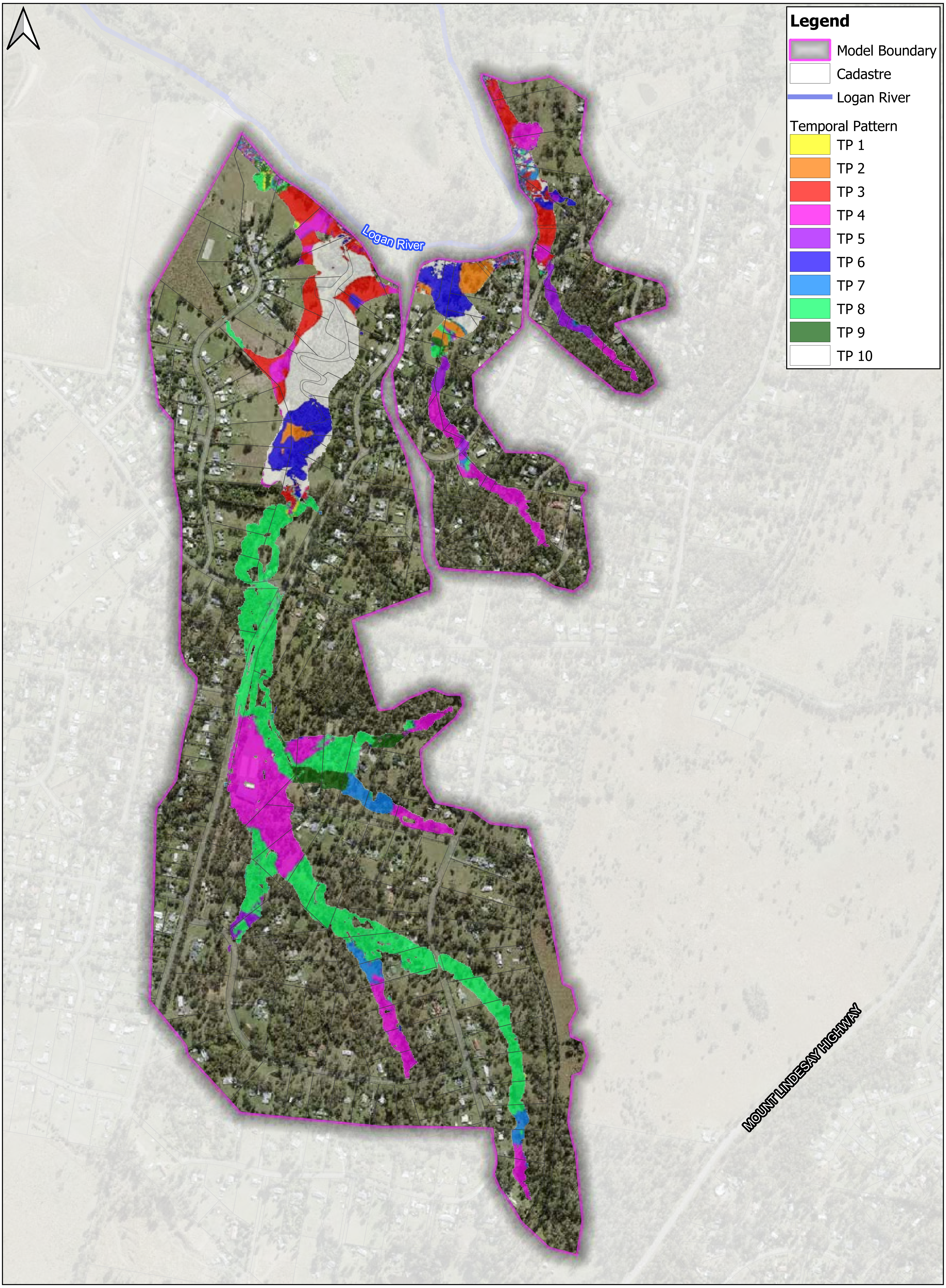
Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Critical Duration



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Imagery Source: LCC
Water Technology Pty Ltd

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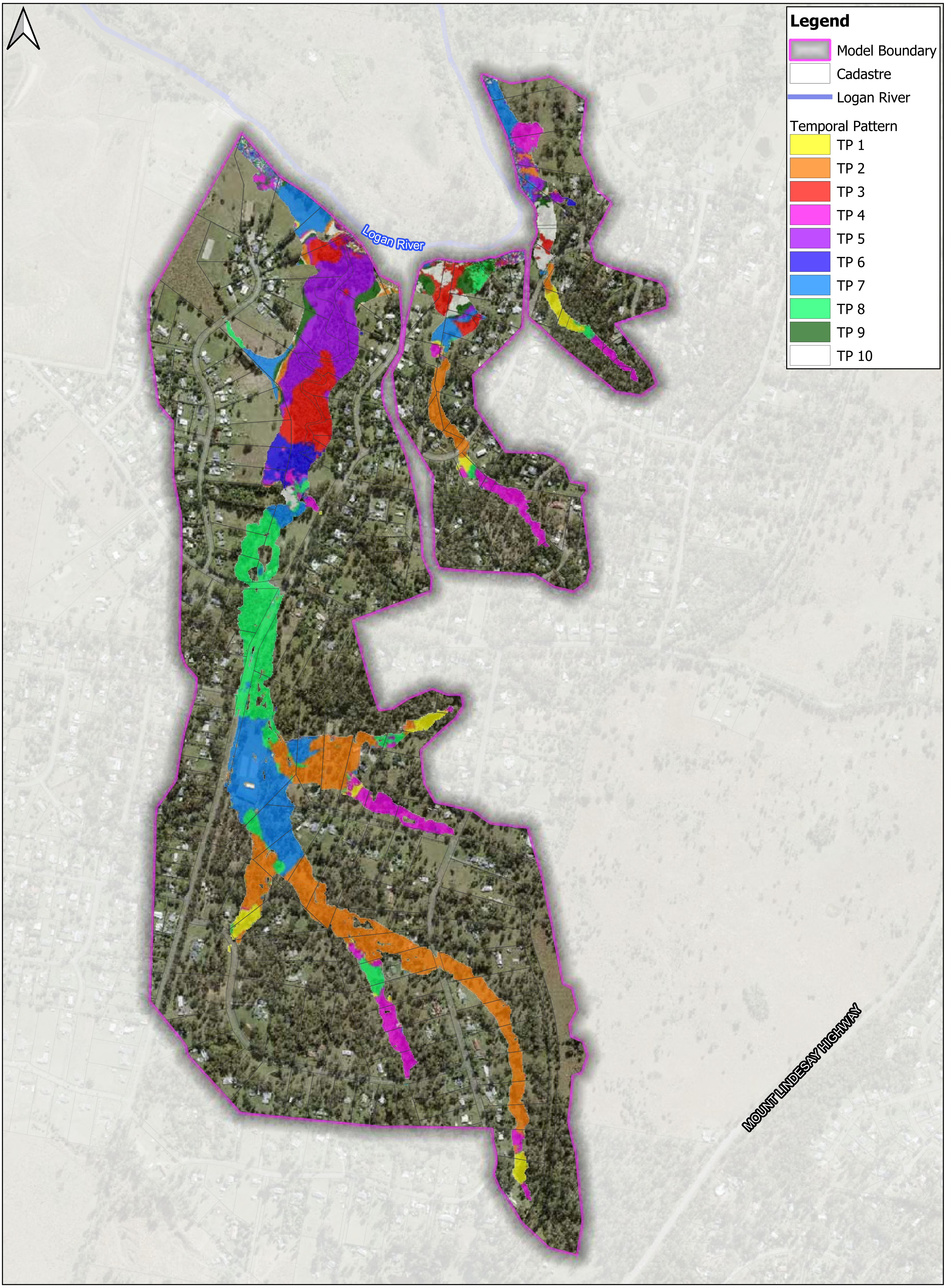
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 25-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Water Technology Pty Ltd

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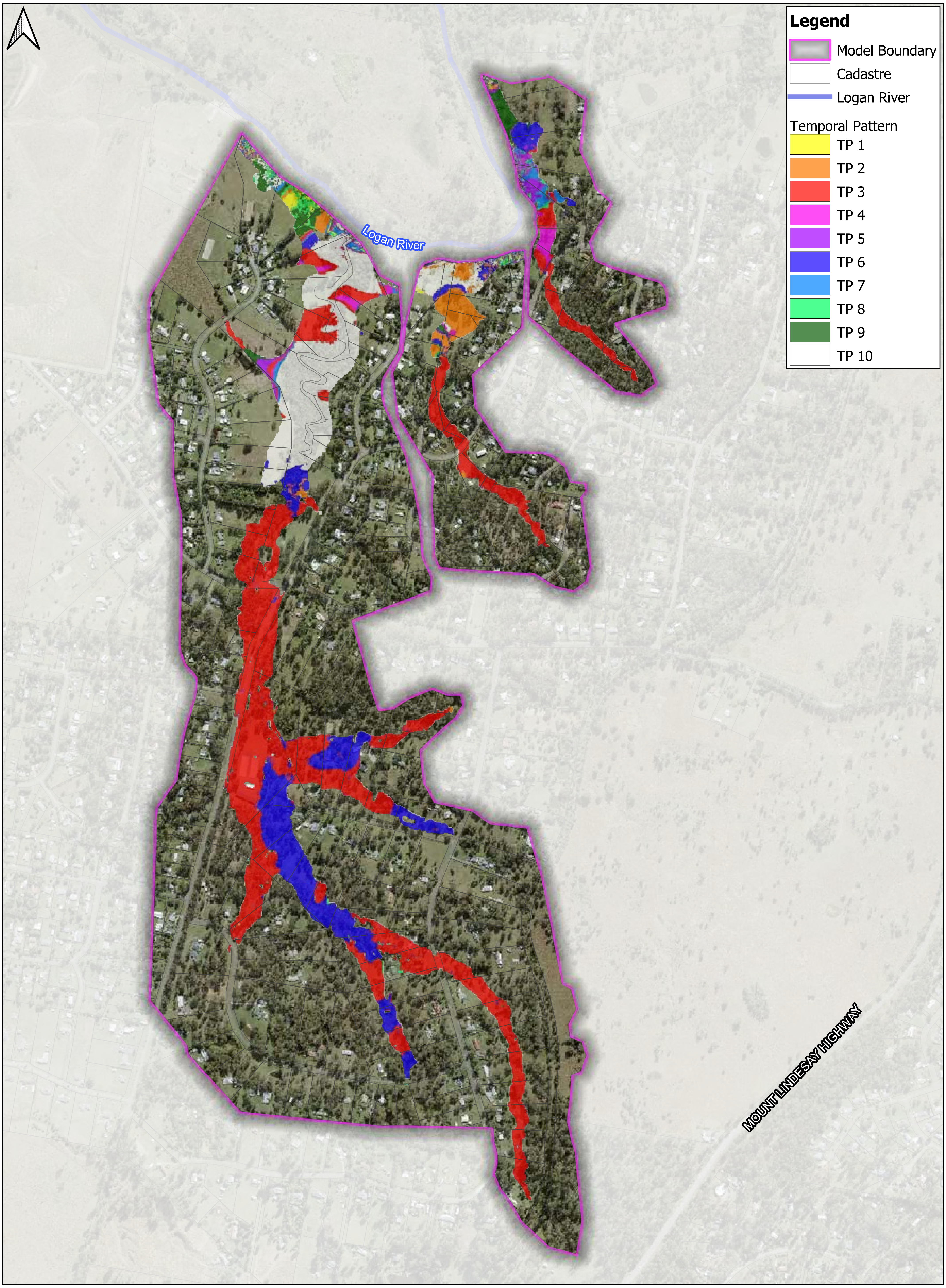
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 30-Minute Duration - Critical Temporal Pattern



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Water Technology Pty Ltd

1:10,000

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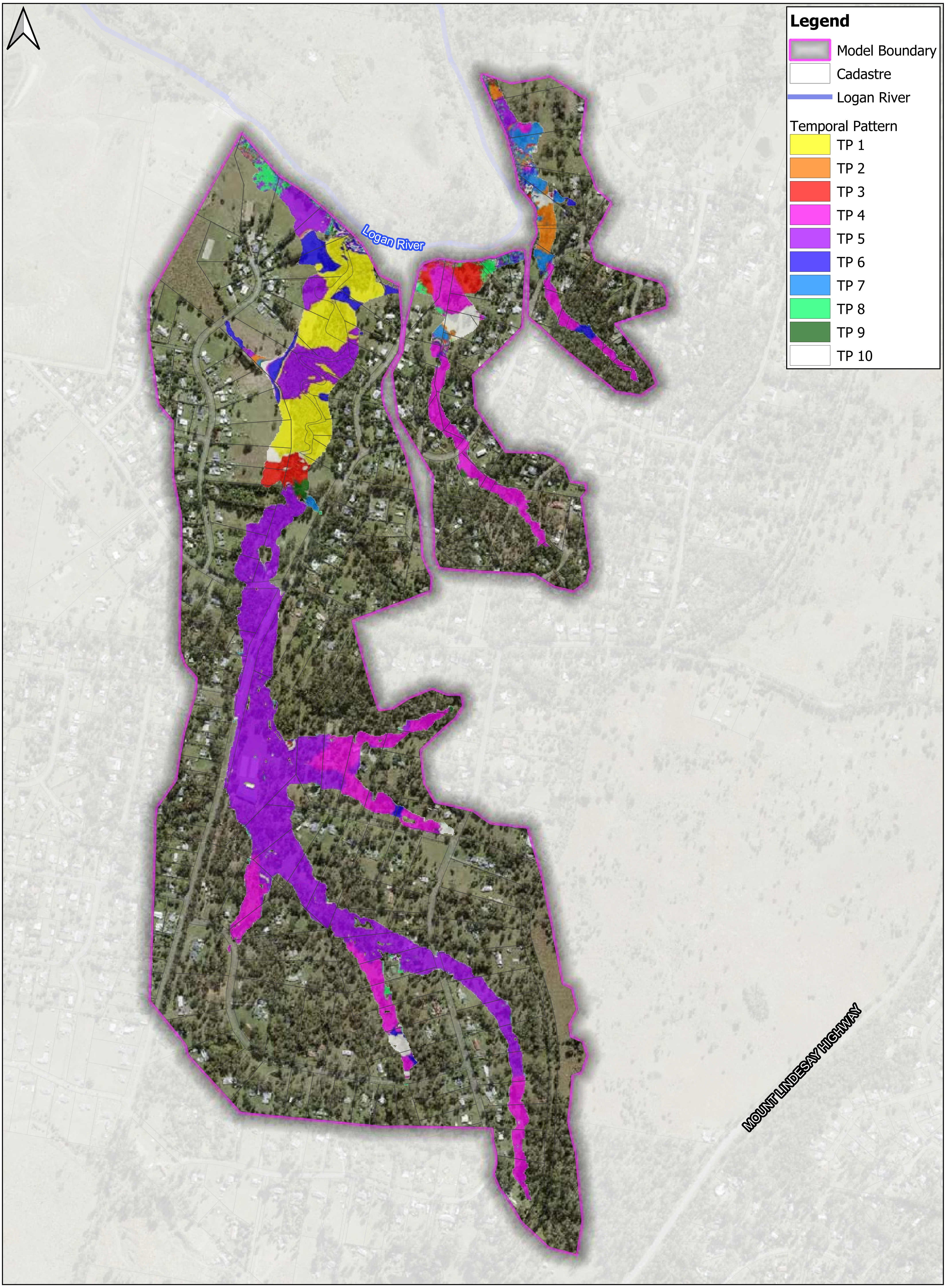
Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 45-Minute Duration - Critical Temporal Pattern



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Imagery Source: LCC
Water Technology Pty Ltd

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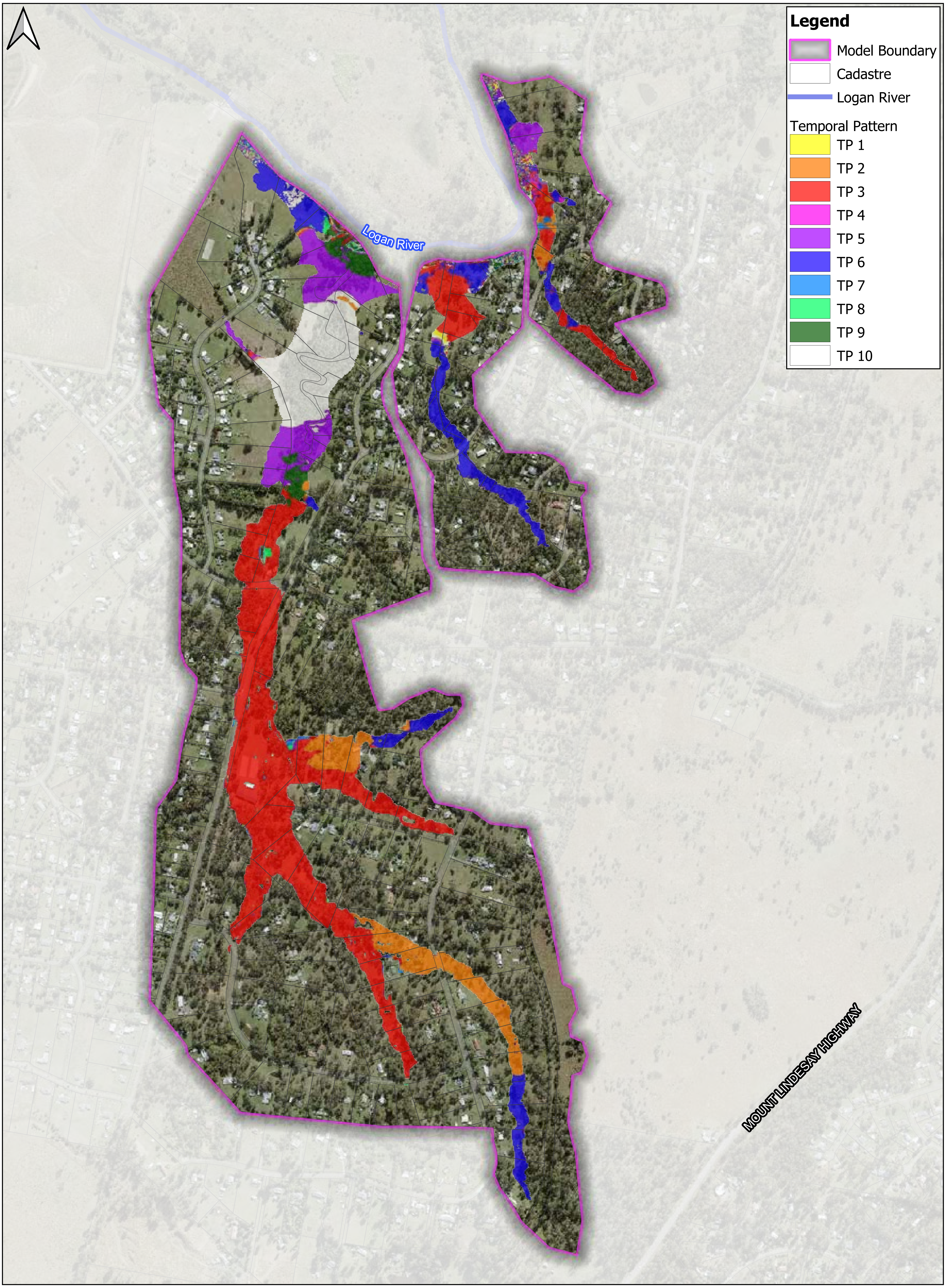
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 60-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

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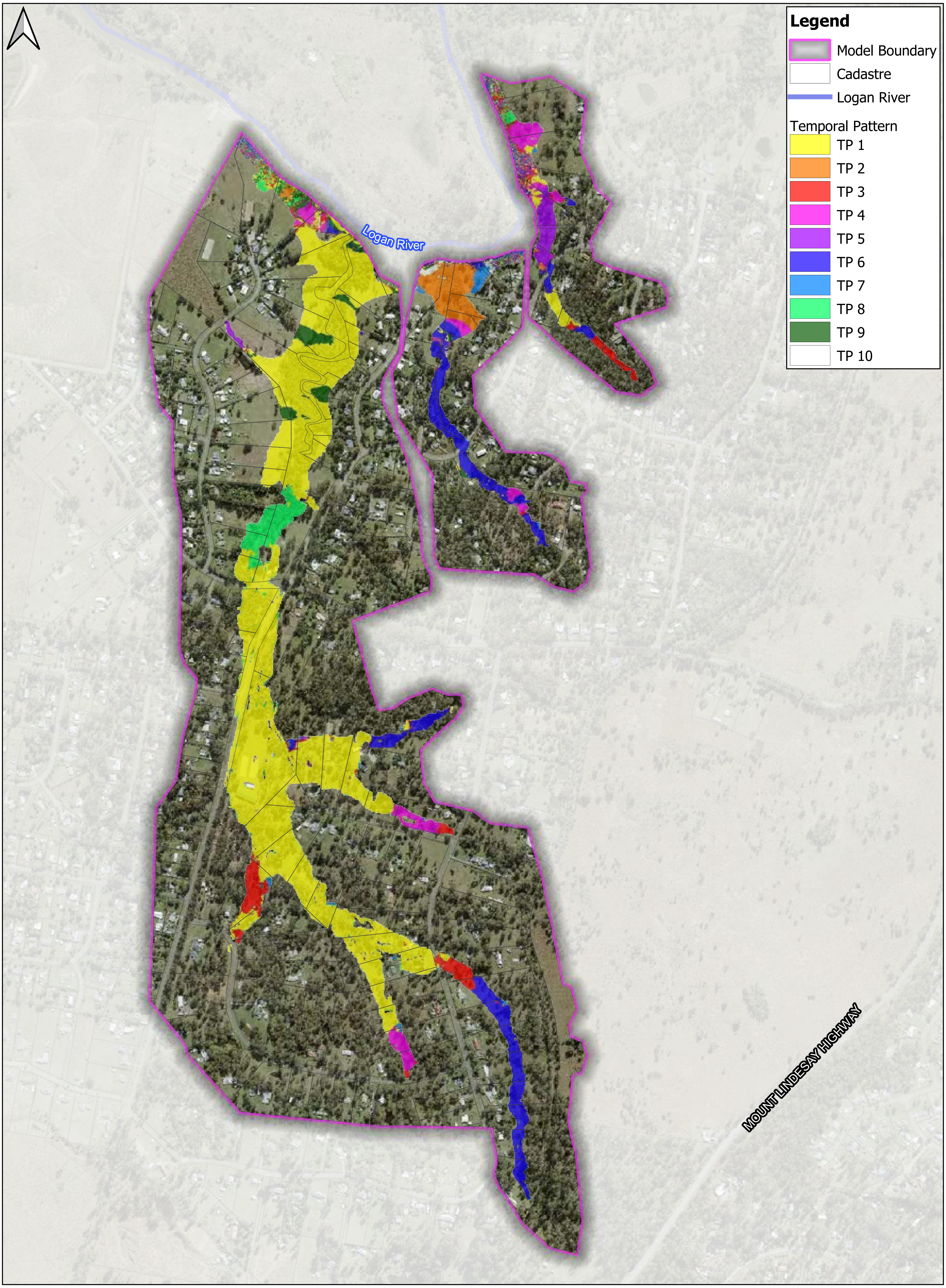
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 90-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Projection: GDA20 MGA56

Imagery Source: LCC

Water Technology Pty Ltd

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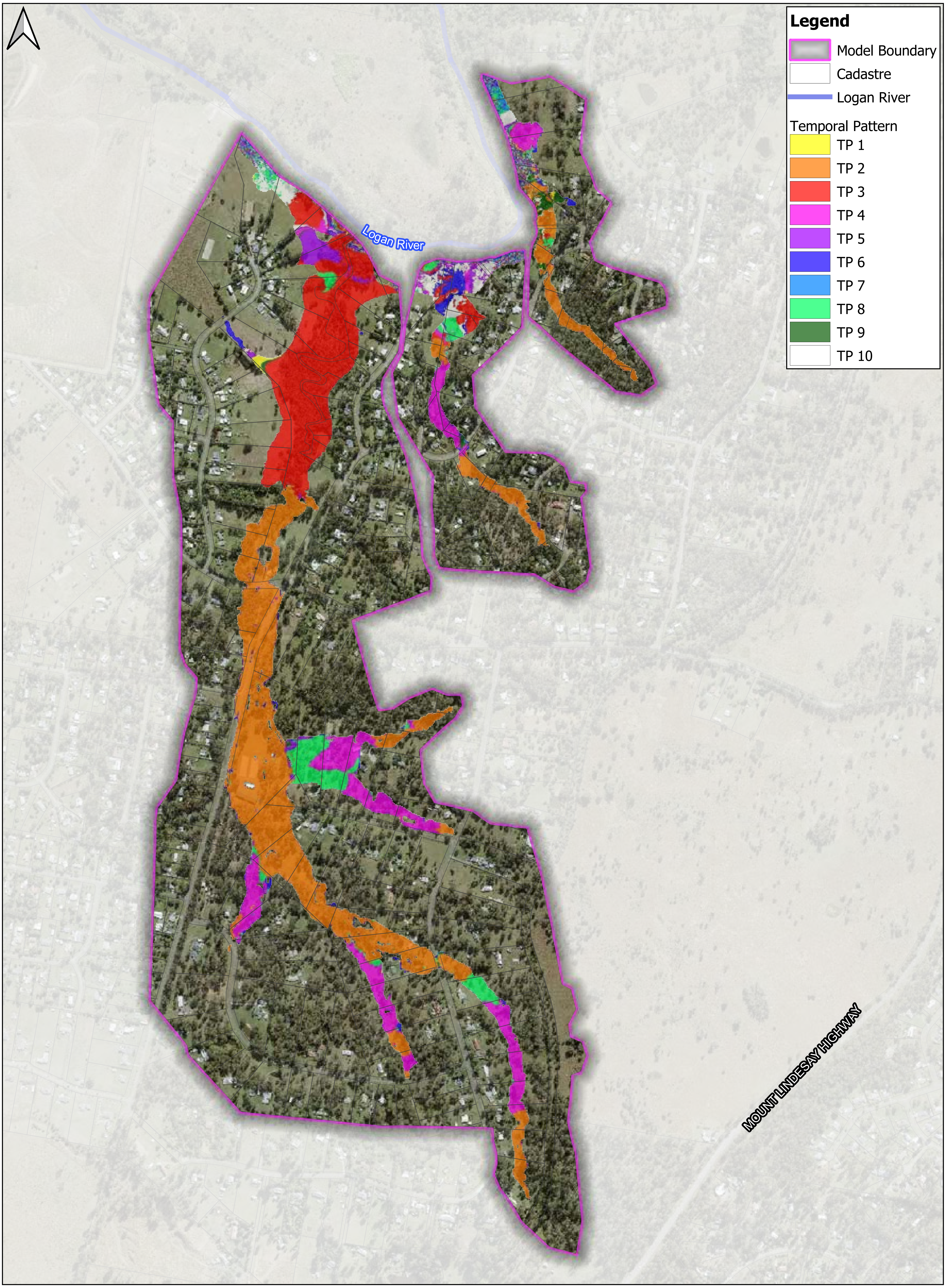
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 120-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY

WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

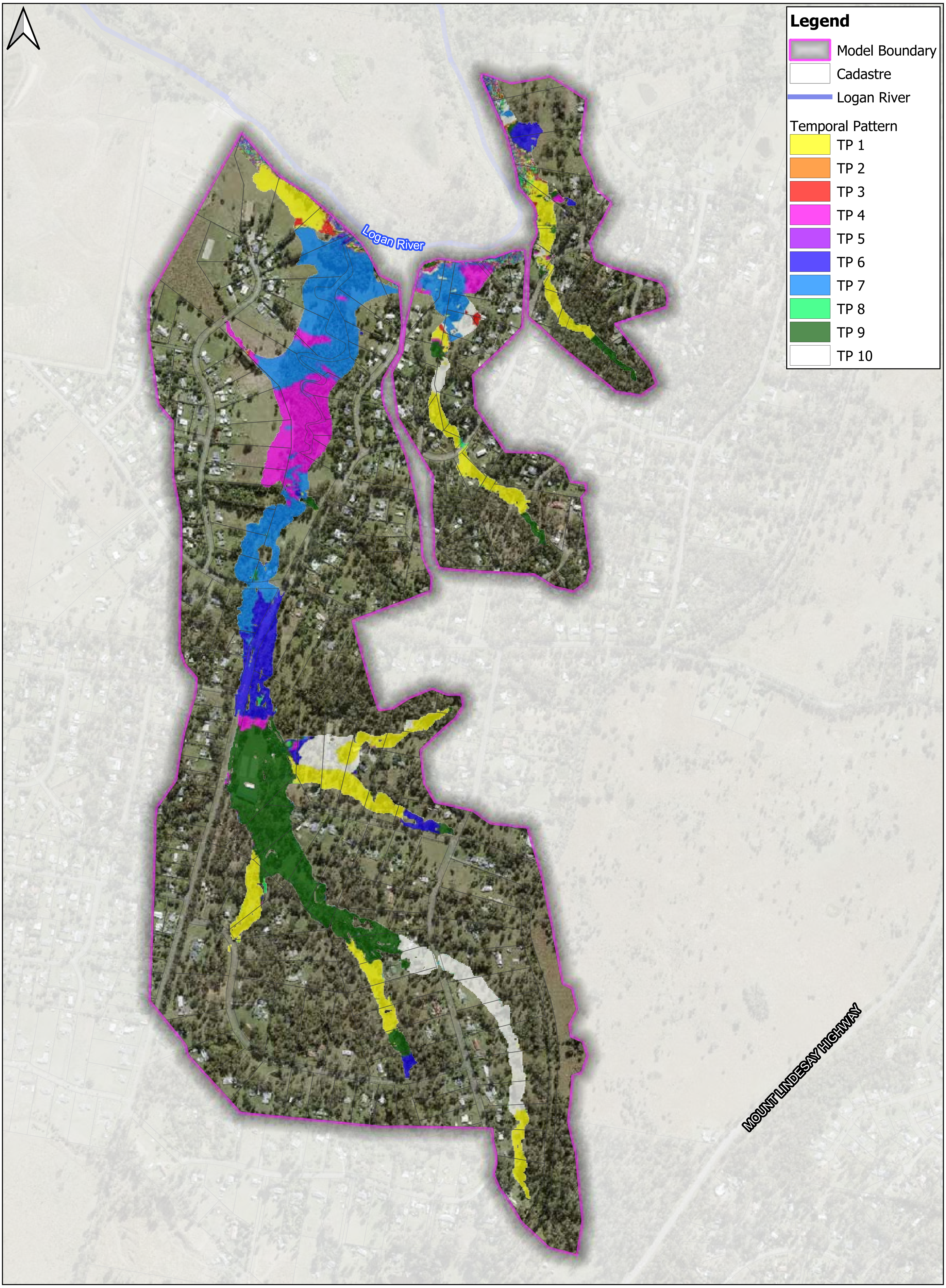
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 180-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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Imagery Source: LCC
Water Technology Pty Ltd

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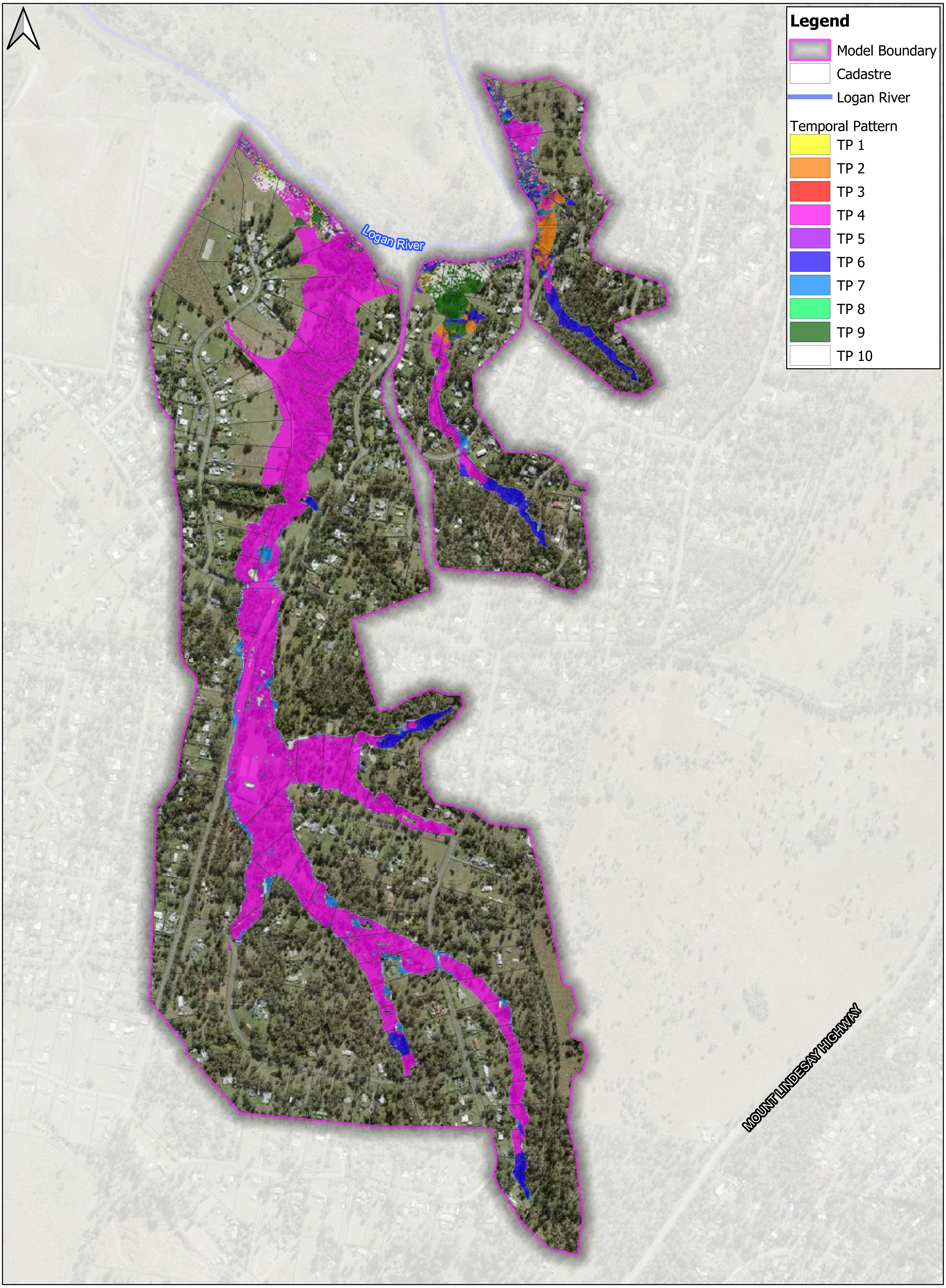
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 270-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

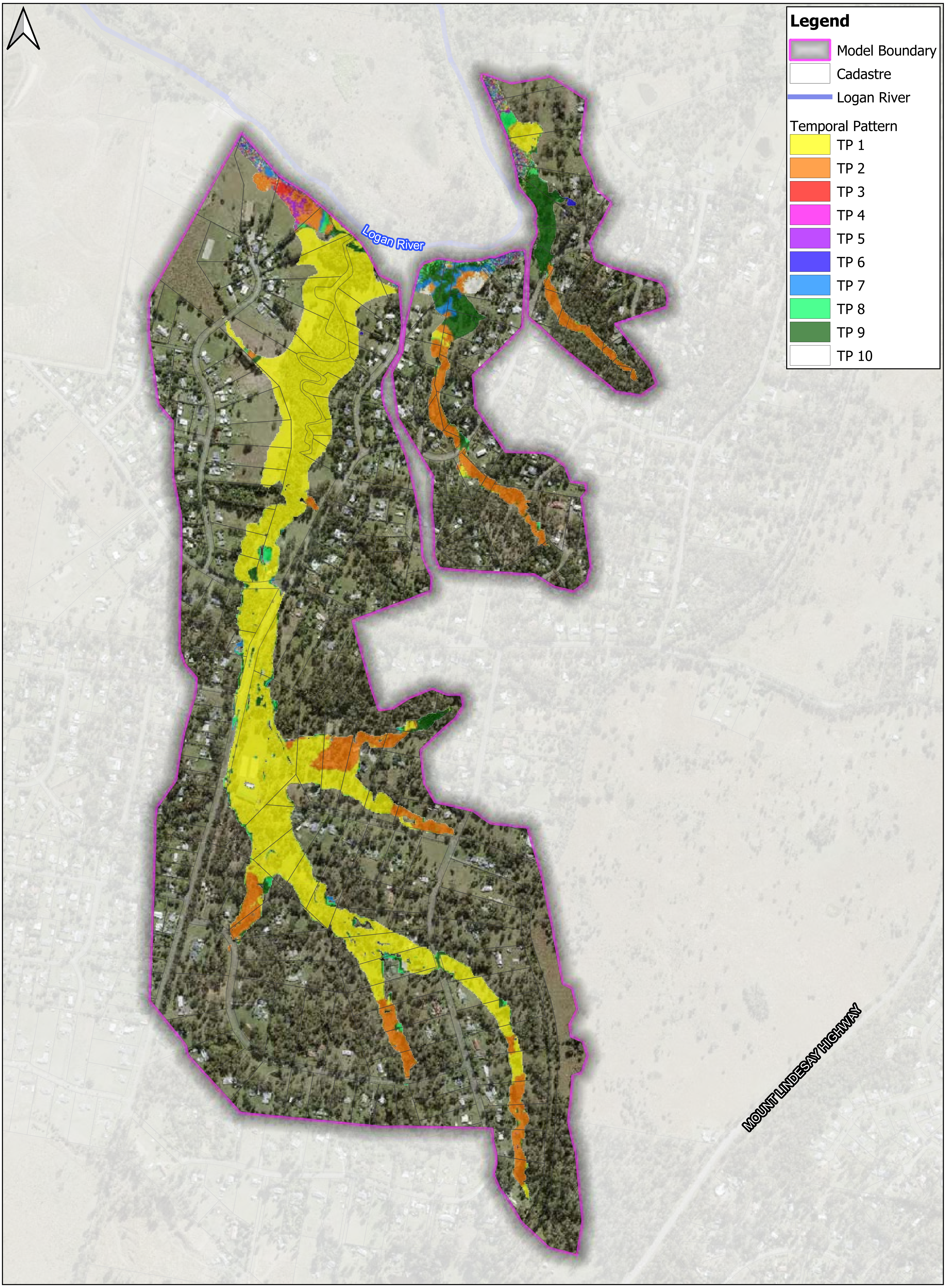
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 360-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

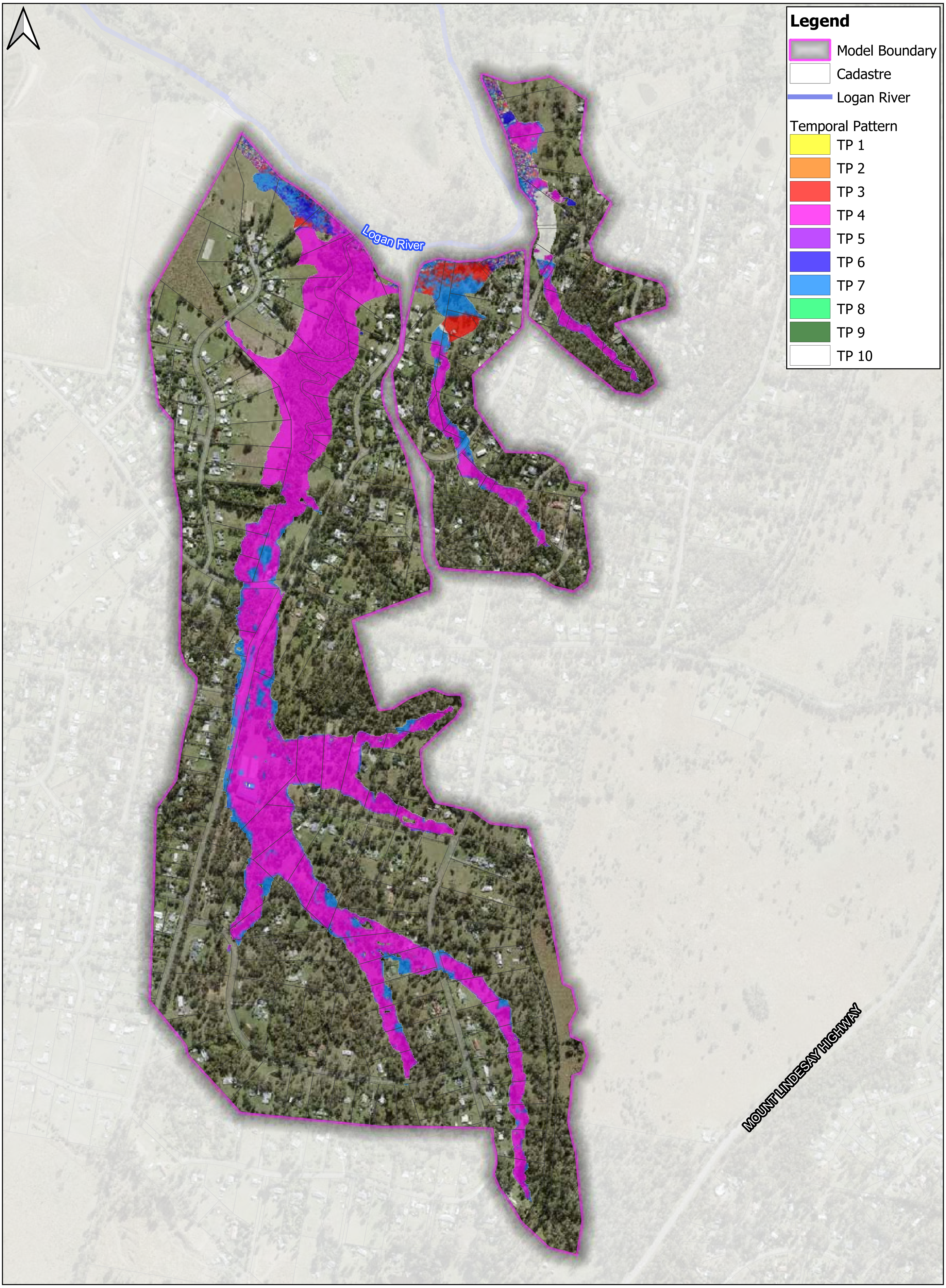
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 540-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

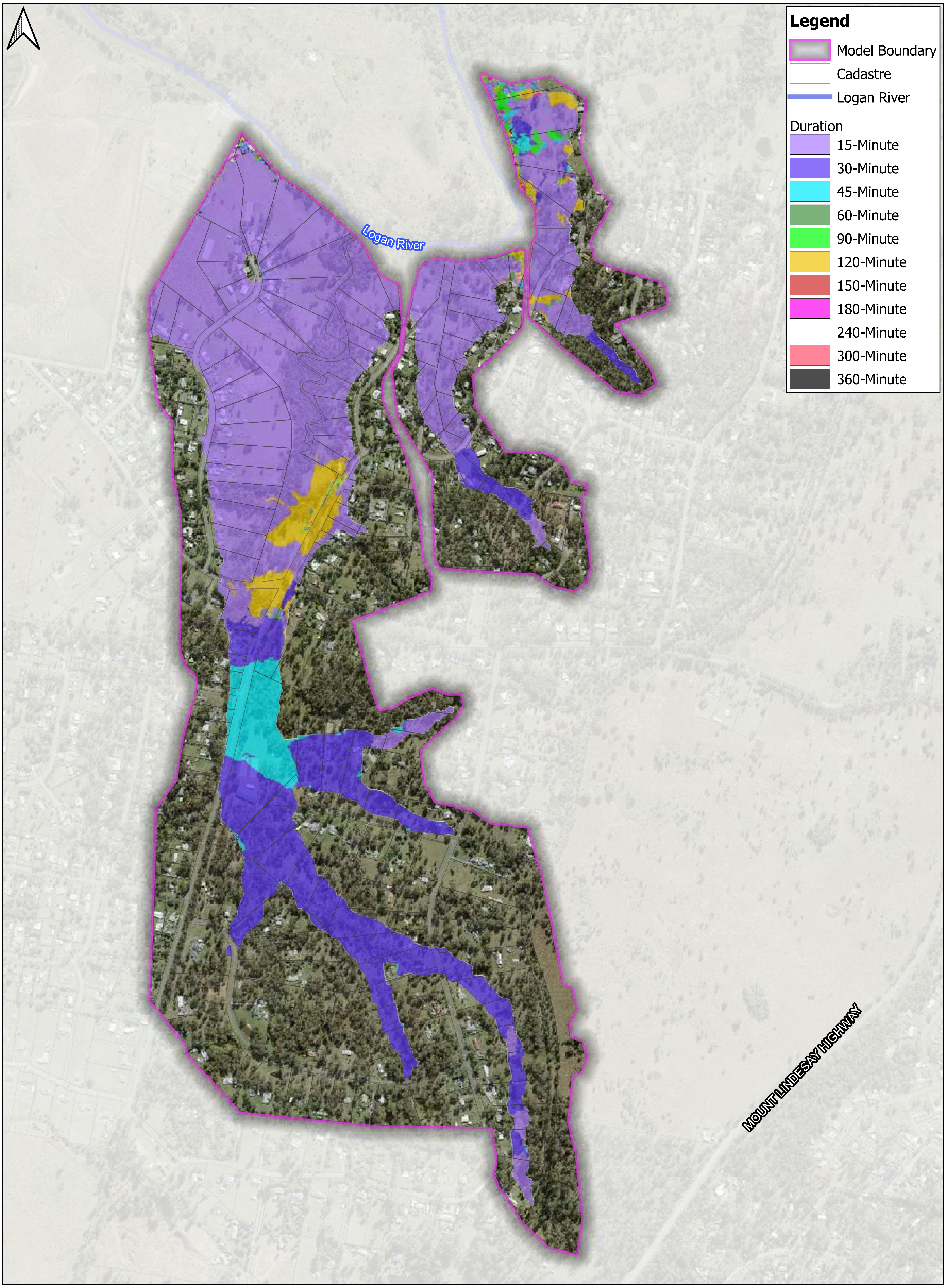
1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP 720-Minute Duration - Critical Temporal Pattern

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



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

1:10,000

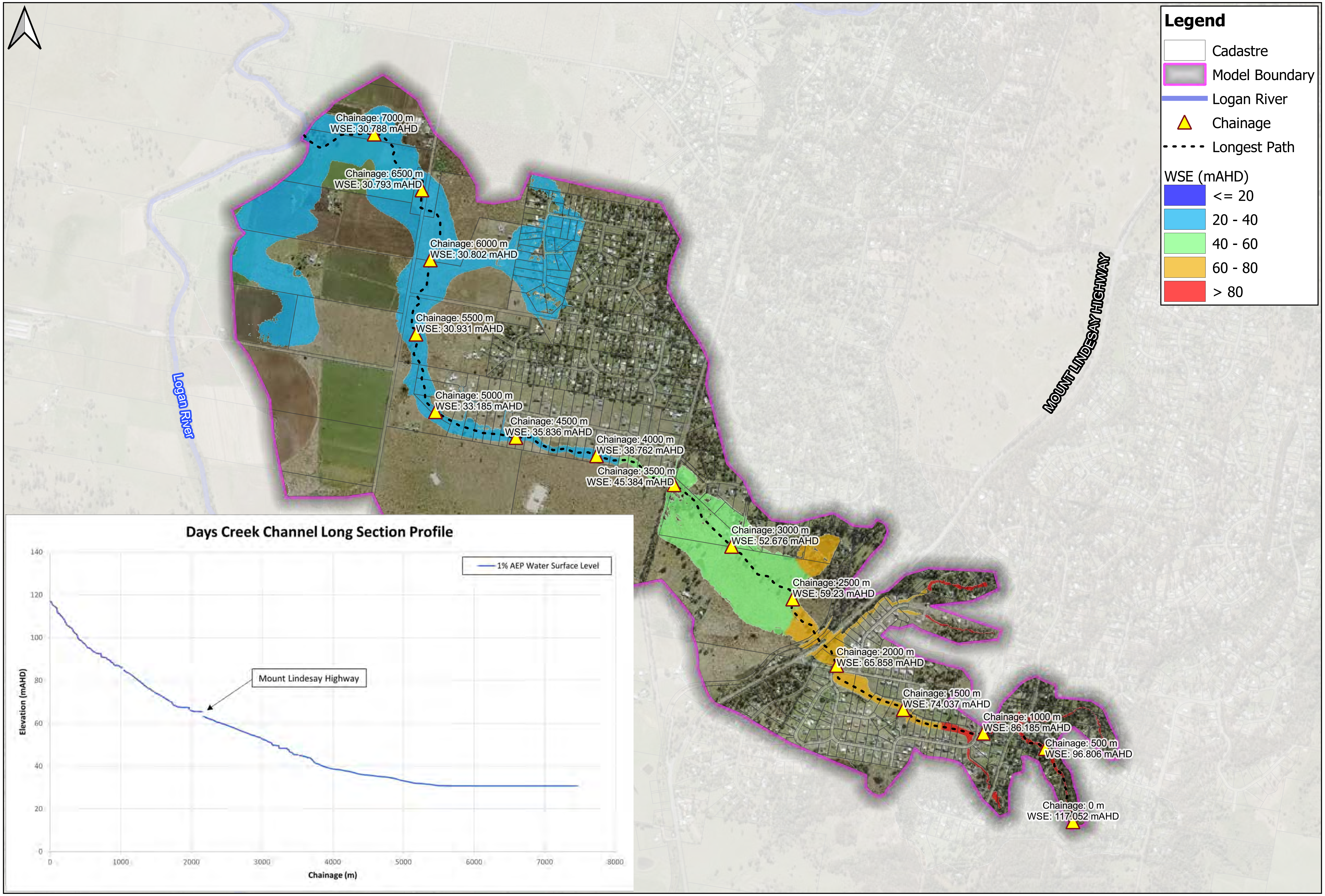
0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - PMF Critical Duration

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX H
DAYS CREEK AND ROBERTS WATERHOLE LONGITUDINAL PROFILES



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

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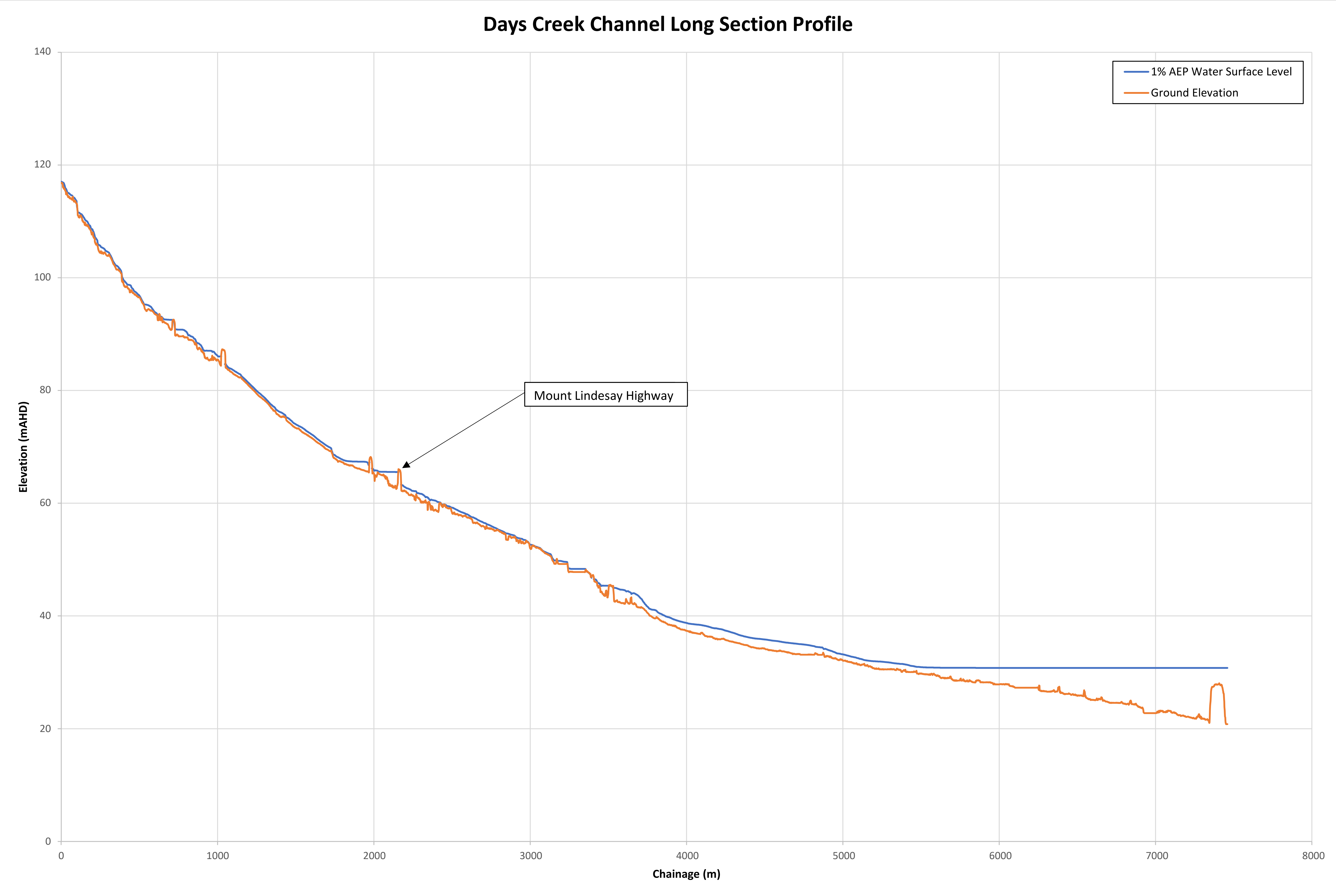
0 500 1,000 1,500 2,000 m

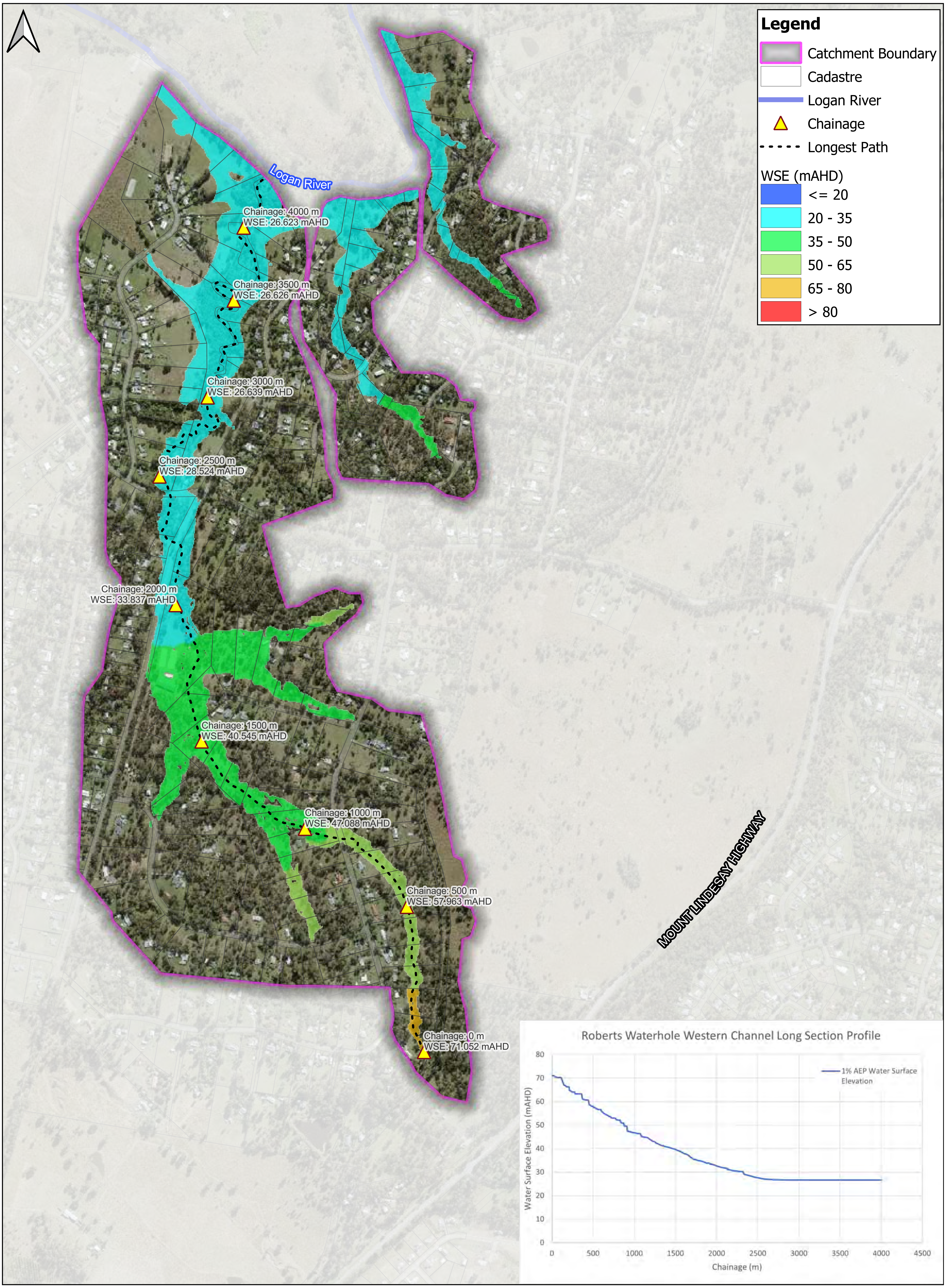
Days Creek Flood Study Update 2023

Days Creek - 1% AEP Longitudinal Water Surface Elevation Profile

WATER TECHNOLOGY



Days Creek Channel Long Section Profile
Elevation (mAHD)
140
120
100
80
60
40
20
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Chainage (m)
1% AEP Water Surface Level
Ground Elevation
Mount Lindesay Highway



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

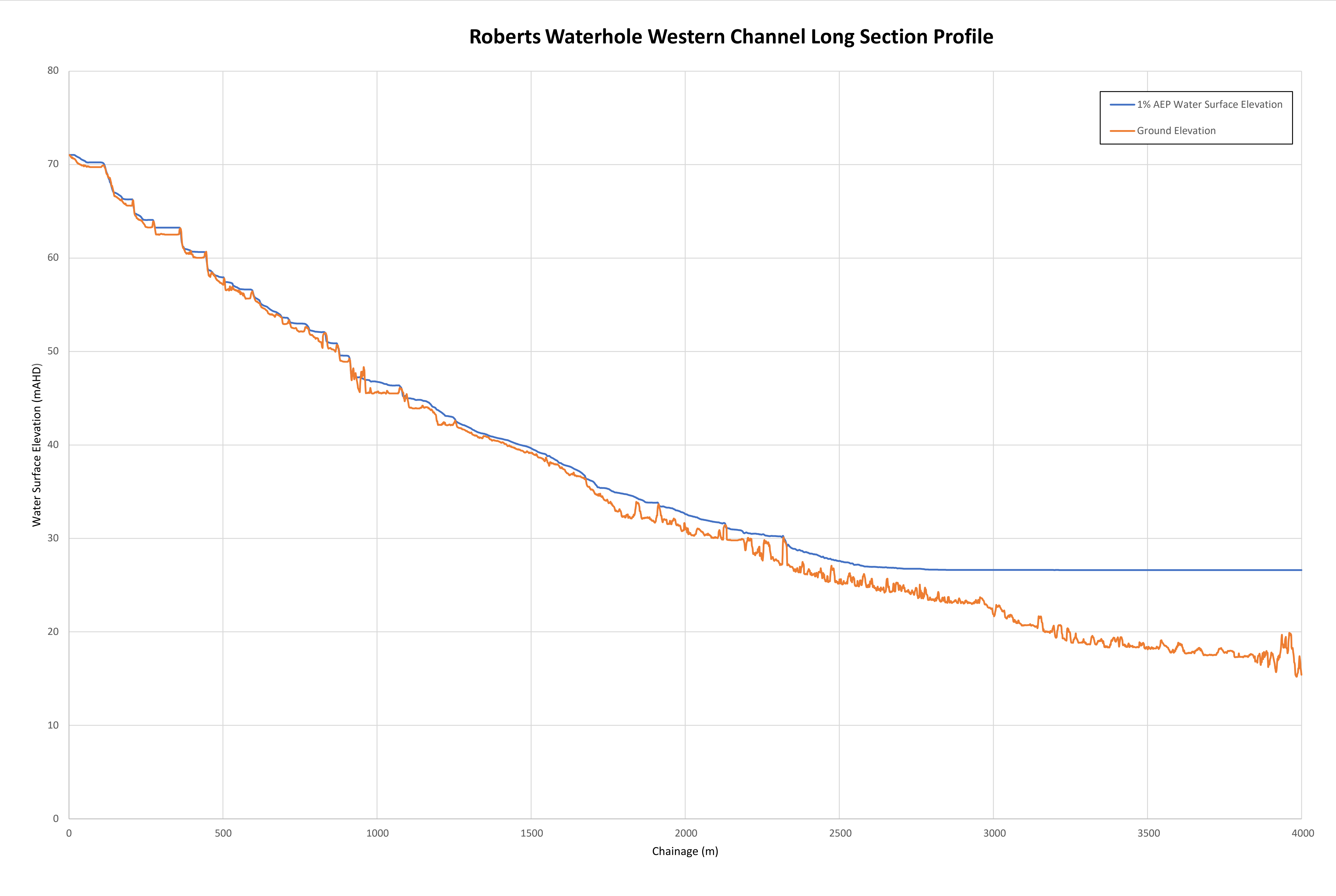
1:11,000

0 200 400 600 800 m

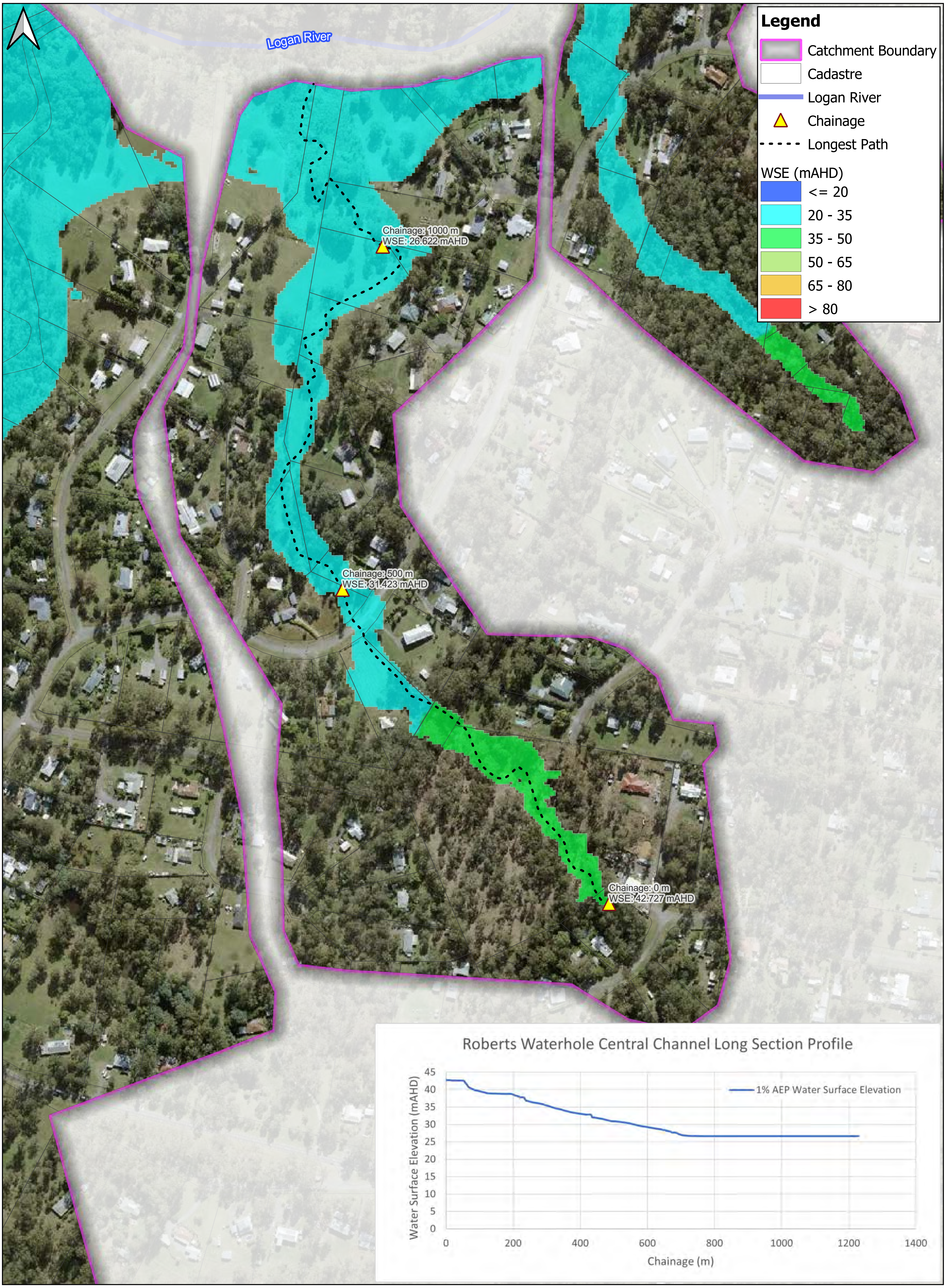
Days Creek Flood Study Update 2023

Roberts Waterhole 1% AEP Longitudinal Water Surface Elevation Profile - Western Tributary

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS



Roberts Waterhole Western Channel Long Section Profile
80
70
60
50
40
30
20
10
0
Water Surface Elevation (mAHD)
0
500
1000
1500
2000
2500
3000
3500
4000
Chainage (m)
1% AEP Water Surface Elevation
Ground Elevation



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

1:3,500

0 50 100 150 200 m

Days Creek Flood Study Update 2023

Roberts Waterhole 1% AEP Longitudinal Water Surface Elevation Profile - Central Tributary

WATER TECHNOLOGY
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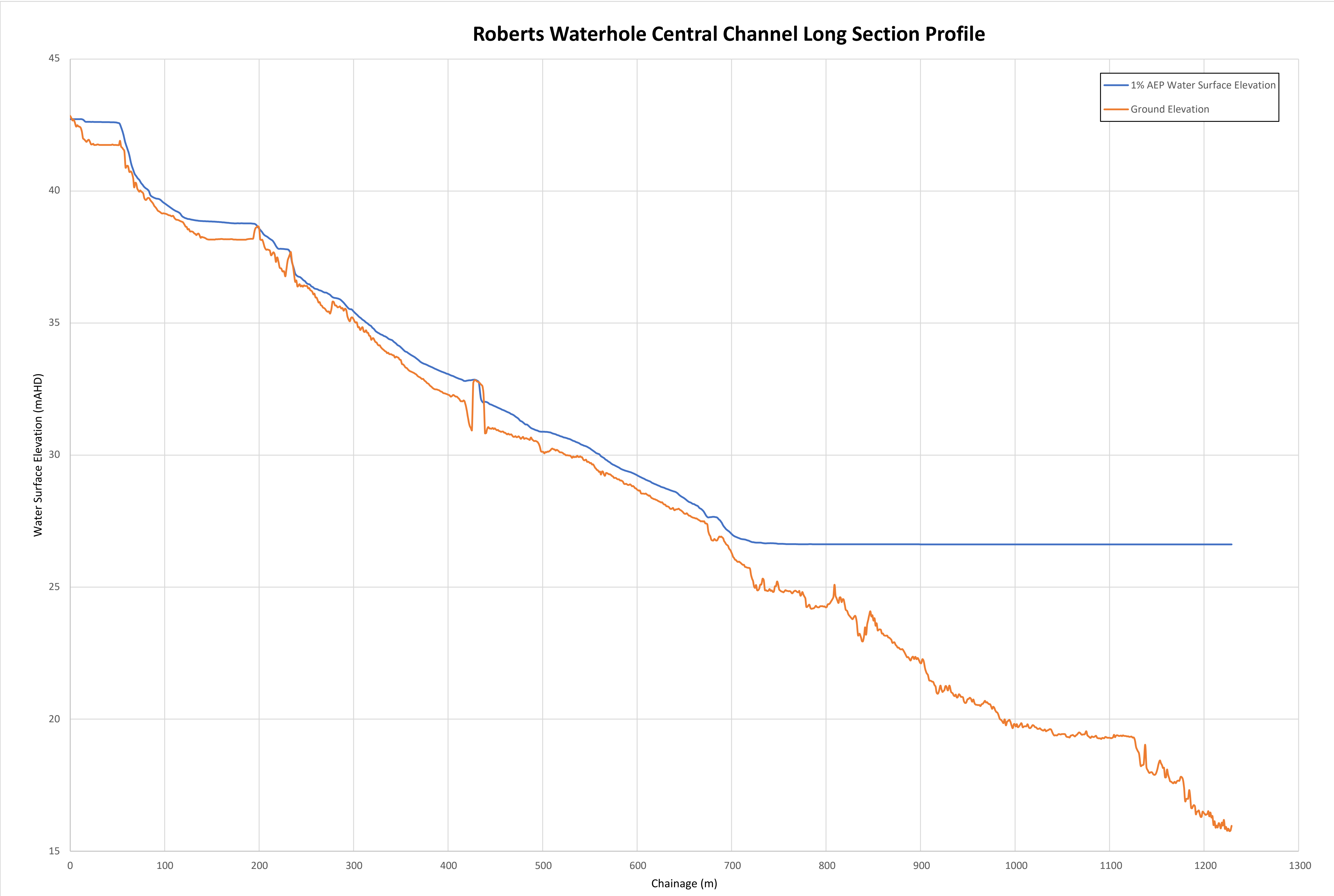
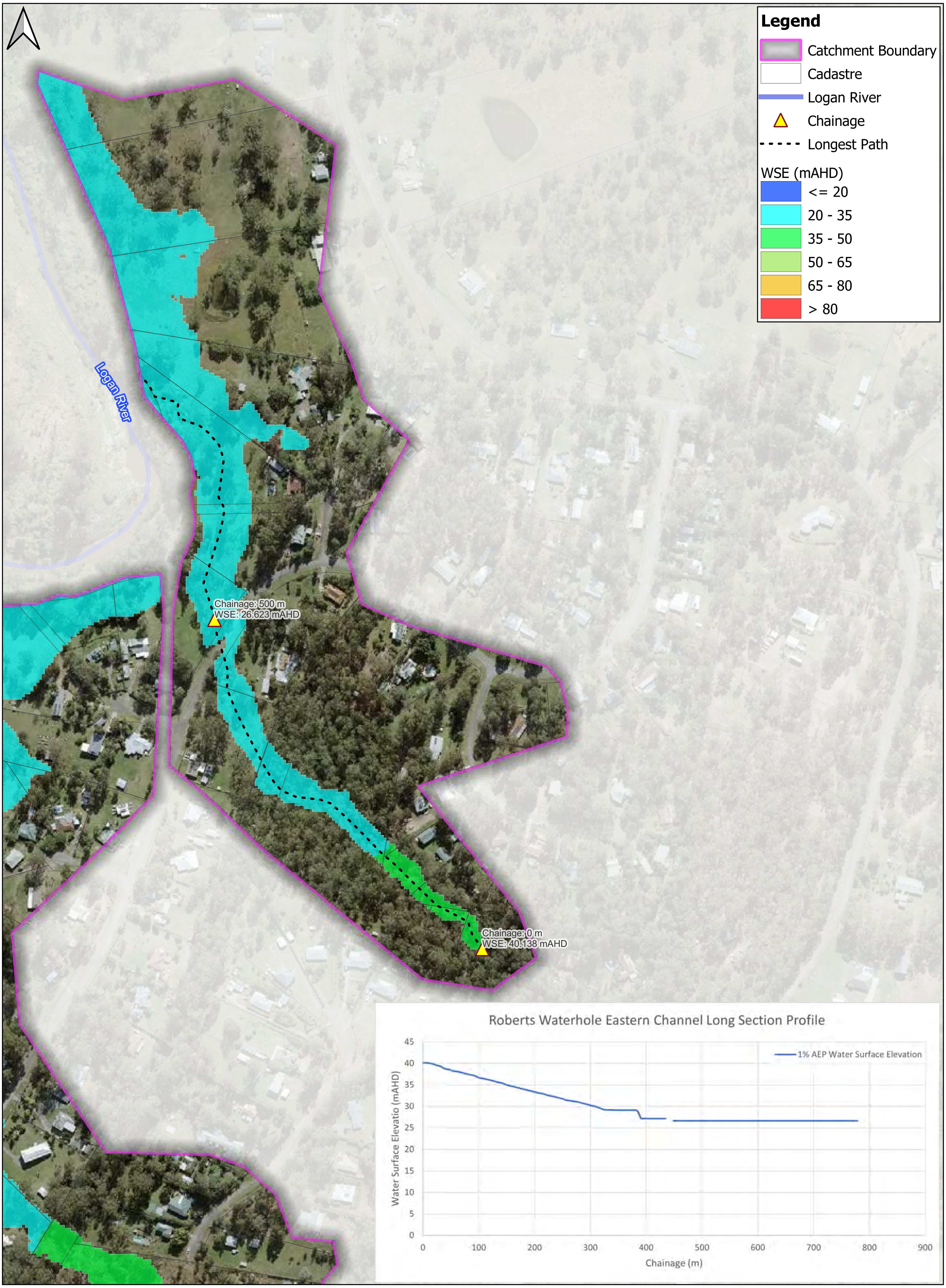


Roberts Waterhole Central Channel Long Section Profile
1% AEP Water Surface Elevation
Ground Elevation
Water Surface Elevation (mAHD)
Chainage (m)
45
40
35
30
25
20
15
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300



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

1:3,500

0 50 100 150 200 m

Days Creek Flood Study Update 2023

Roberts Waterhole 1% AEP Longitudinal Water Surface Elevation Profile - Eastern Tributary

WATER TECHNOLOGY


Roberts Waterhole Eastern Channel Long Section Profile
1% AEP Water Surface Elevation
Ground Elevation
Water Surface Elevatio (mAHD)
Chainage (m)
45
40
35
30
25
20
15
10
0
100
200
300
400
500
600
700
800

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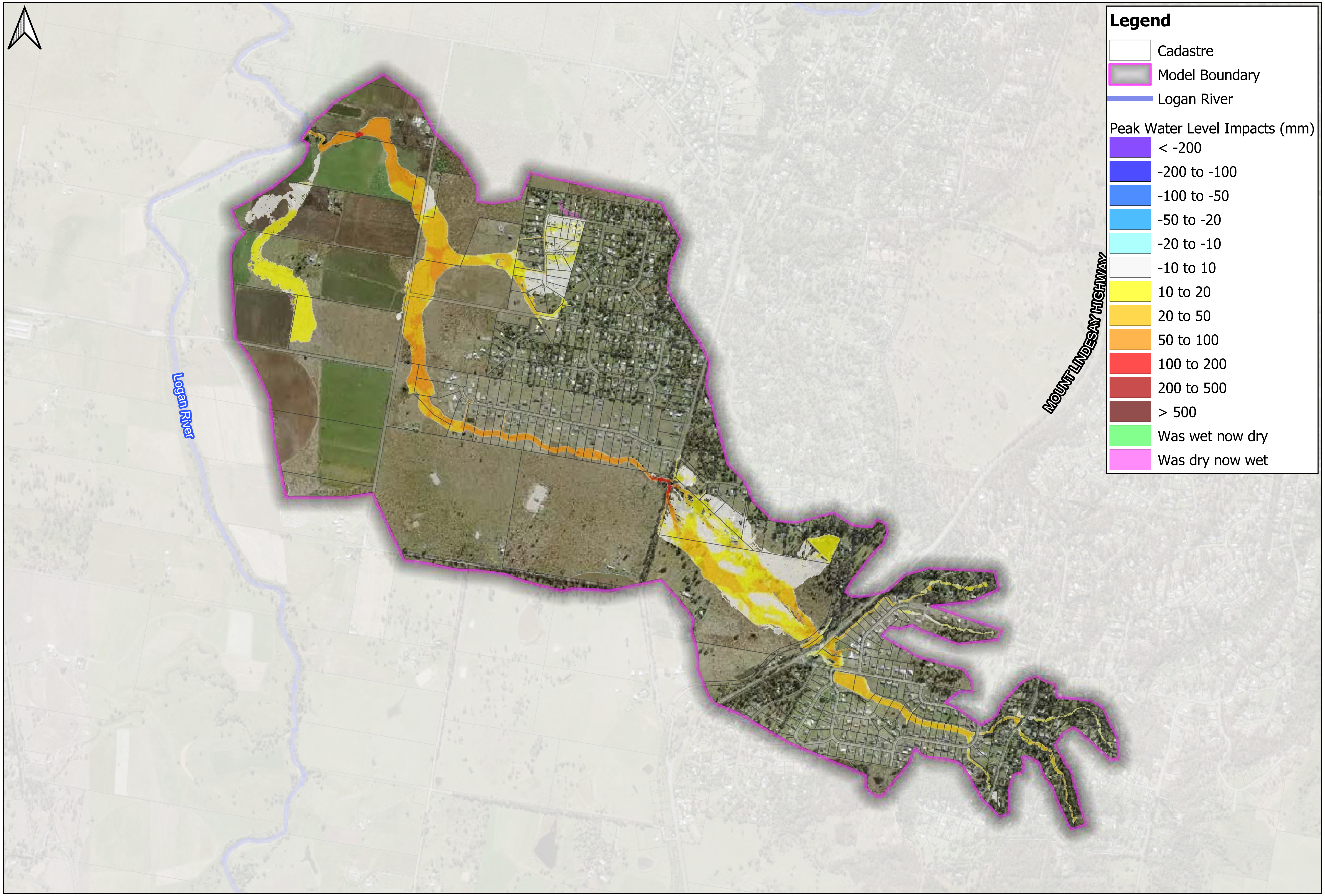
APPENDIX I
MODEL SENSITIVITY GIS MAPS



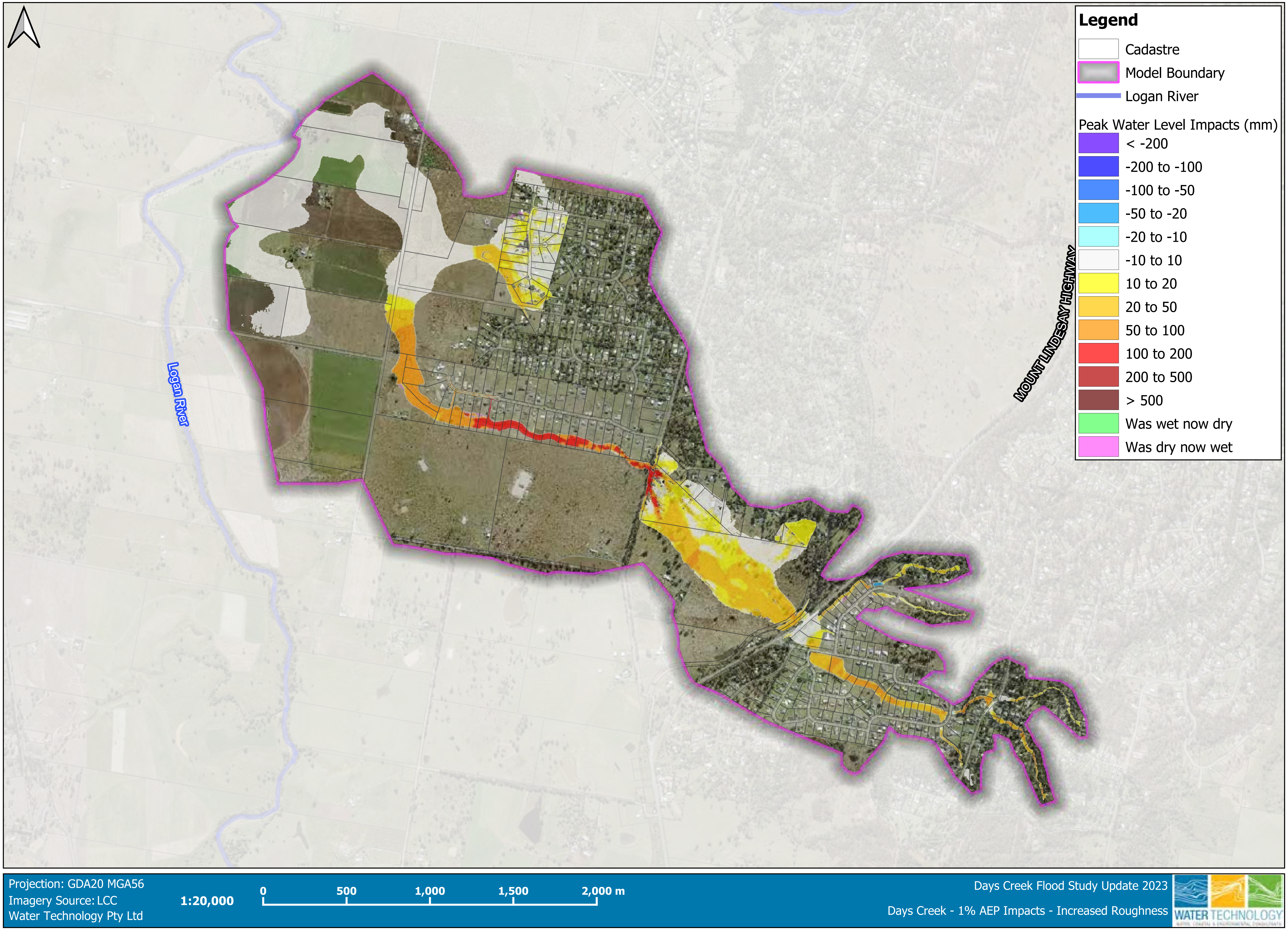
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

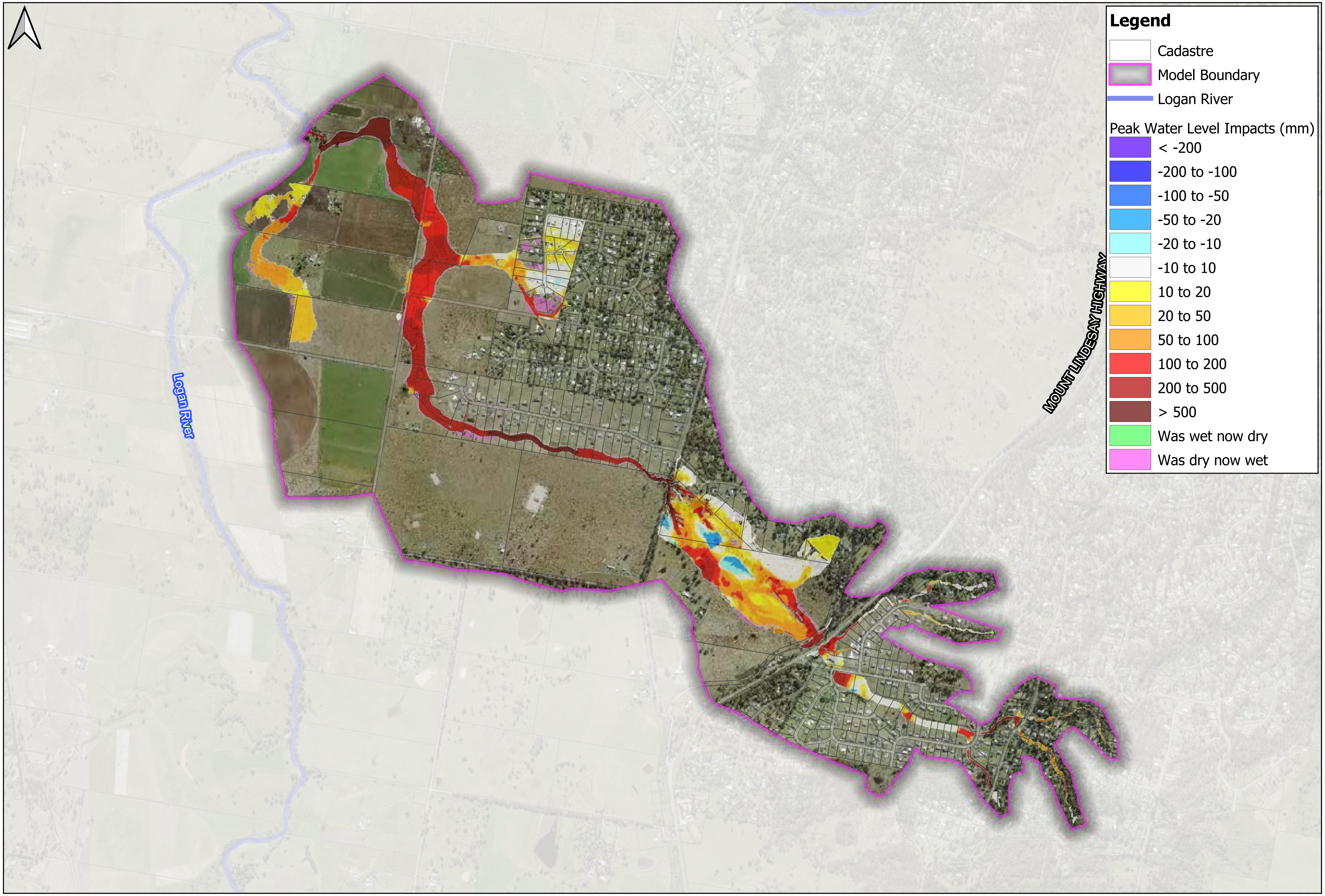
0 500 1,000 1,500 2,000 m

Days Creek Flood Study Update 2023

Days Creek - 20% AEP Impacts - Increased Roughness



Legend
Cadastre
Model Boundary
Logan River
Peak Water Level Impacts (mm)
< -200
-200 to -100
-100 to -50
-50 to -20
-20 to -10
-10 to 10
10 to 20
20 to 50
50 to 100
100 to 200
200 to 500
> 500
Was wet now dry
Was dry now wet
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:20,000
0 500 1,000 1,500 2,000 m
Days Creek Flood Study Update 2023
Days Creek - 1% AEP Impacts - Increased Roughness



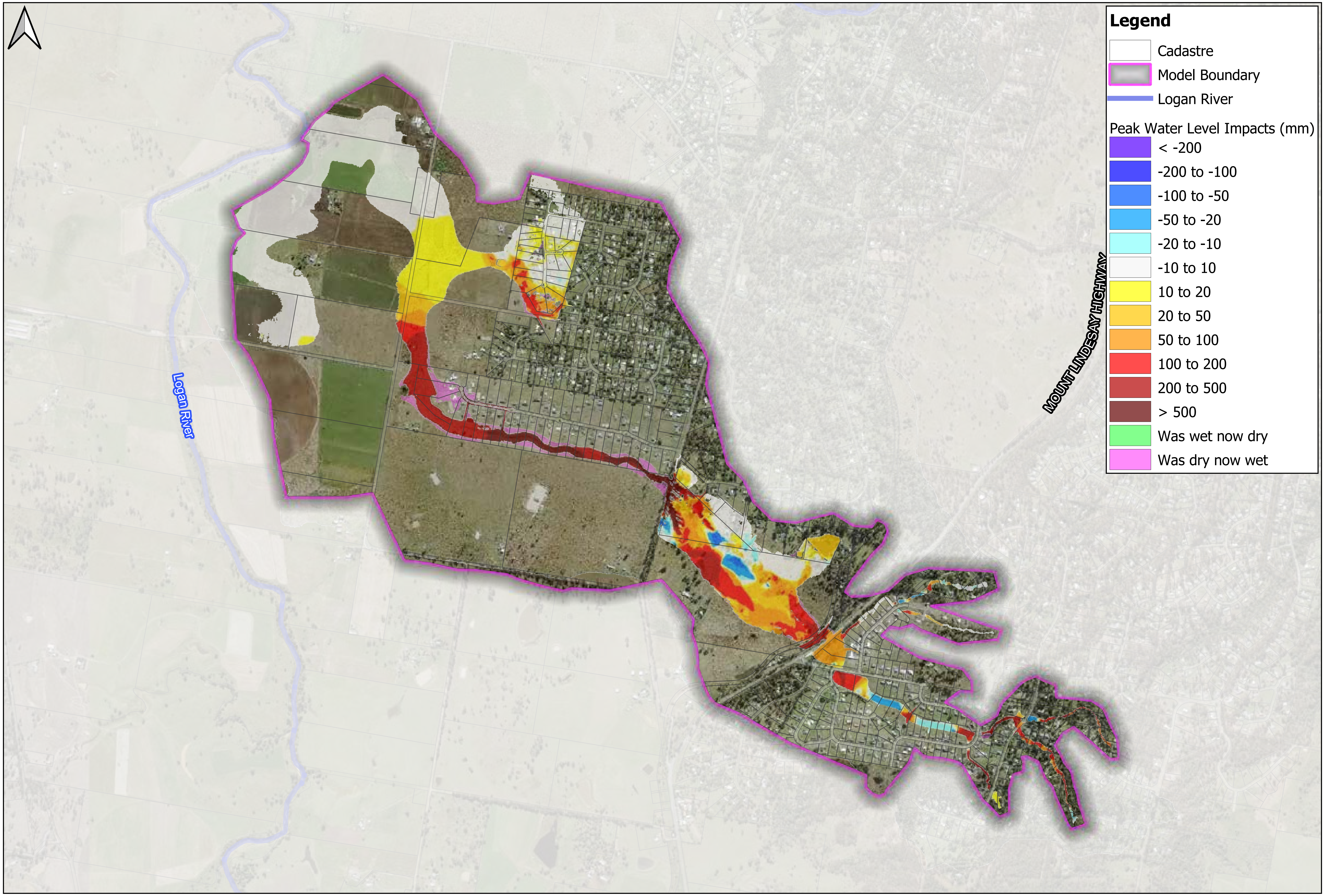
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 20% AEP Impacts - Waterway Restoration



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

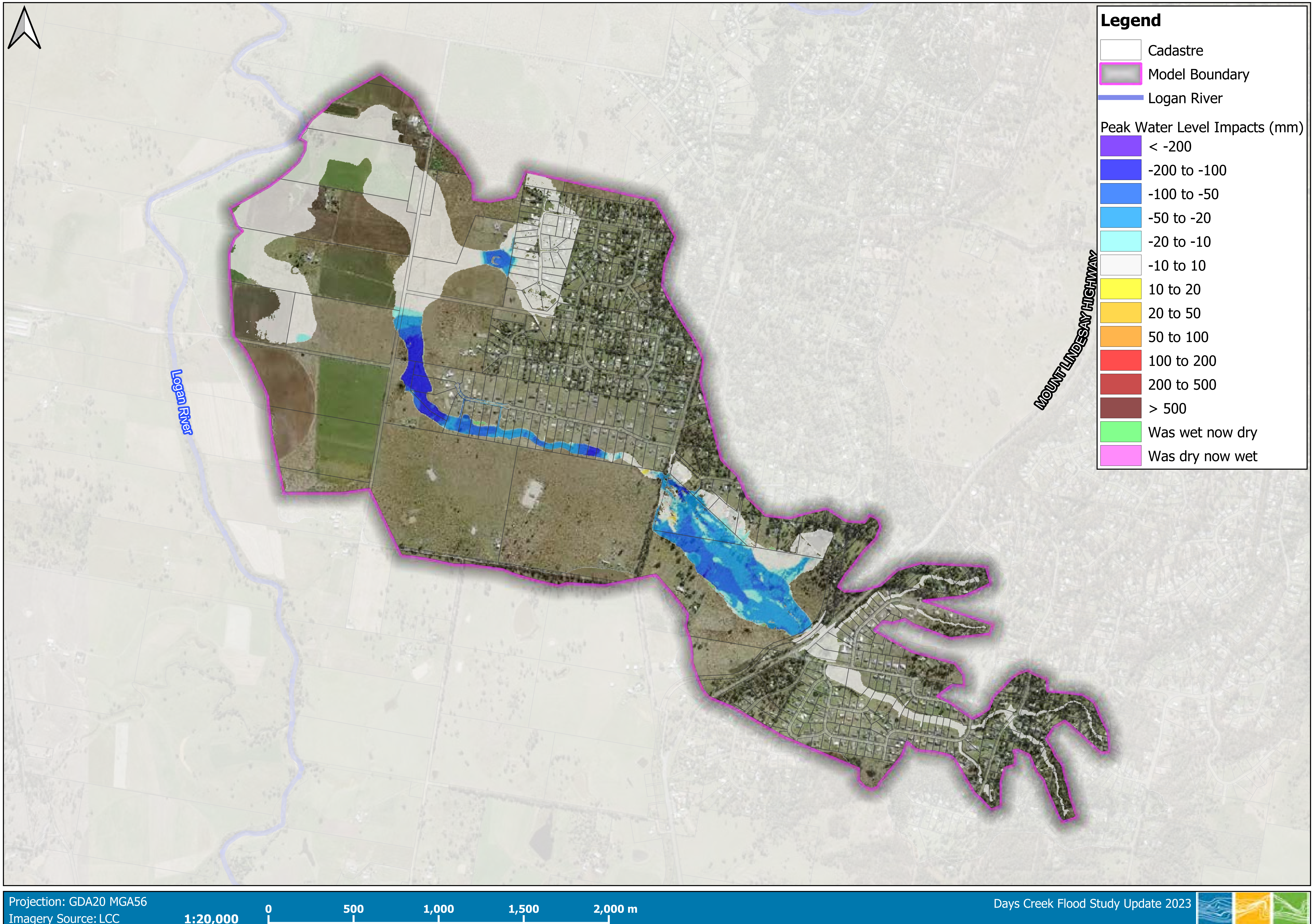
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 1% AEP Impacts - Waterway Restoration

WATER TECHNOLOGY



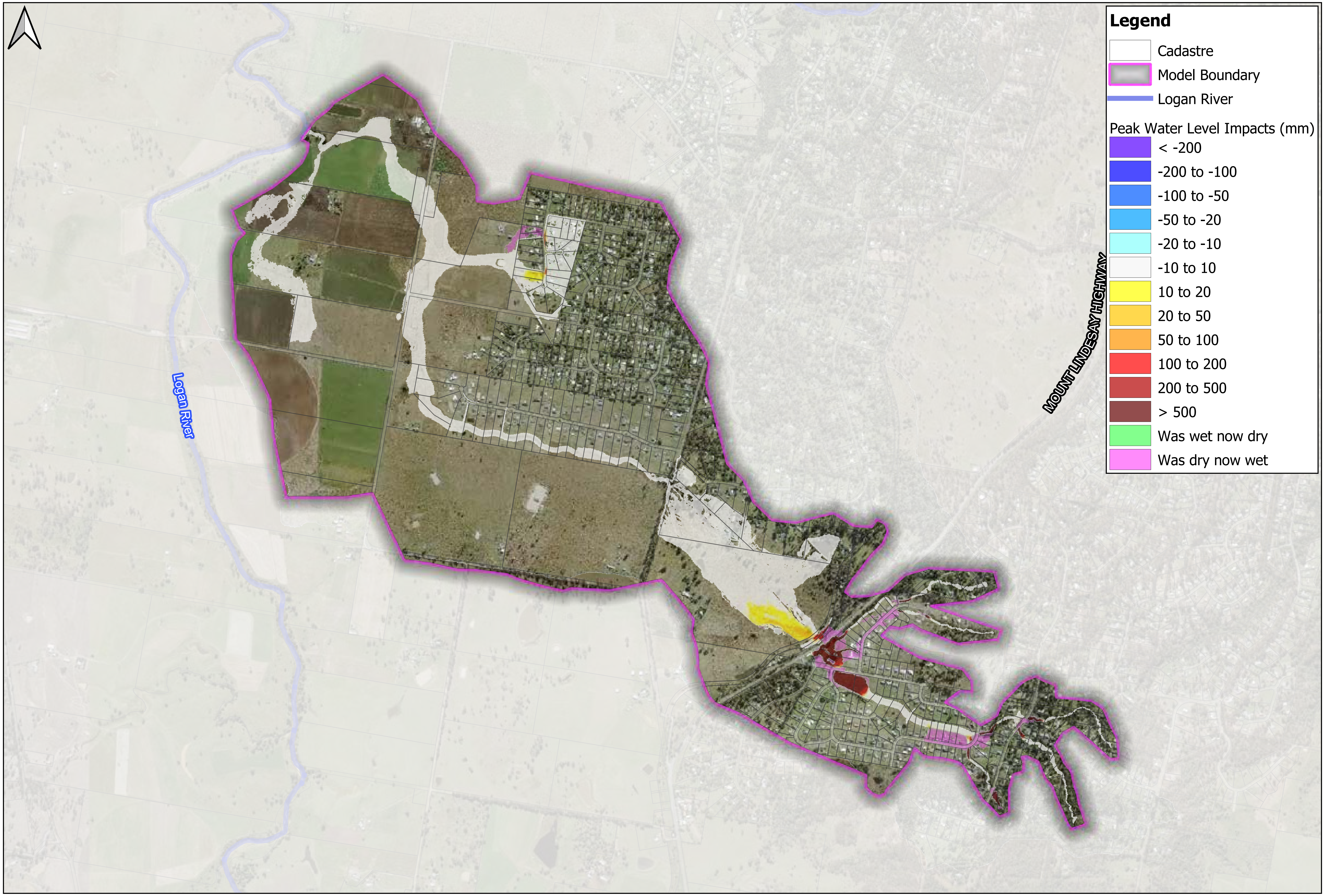
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:20,000

Days Creek Flood Study Update 2023

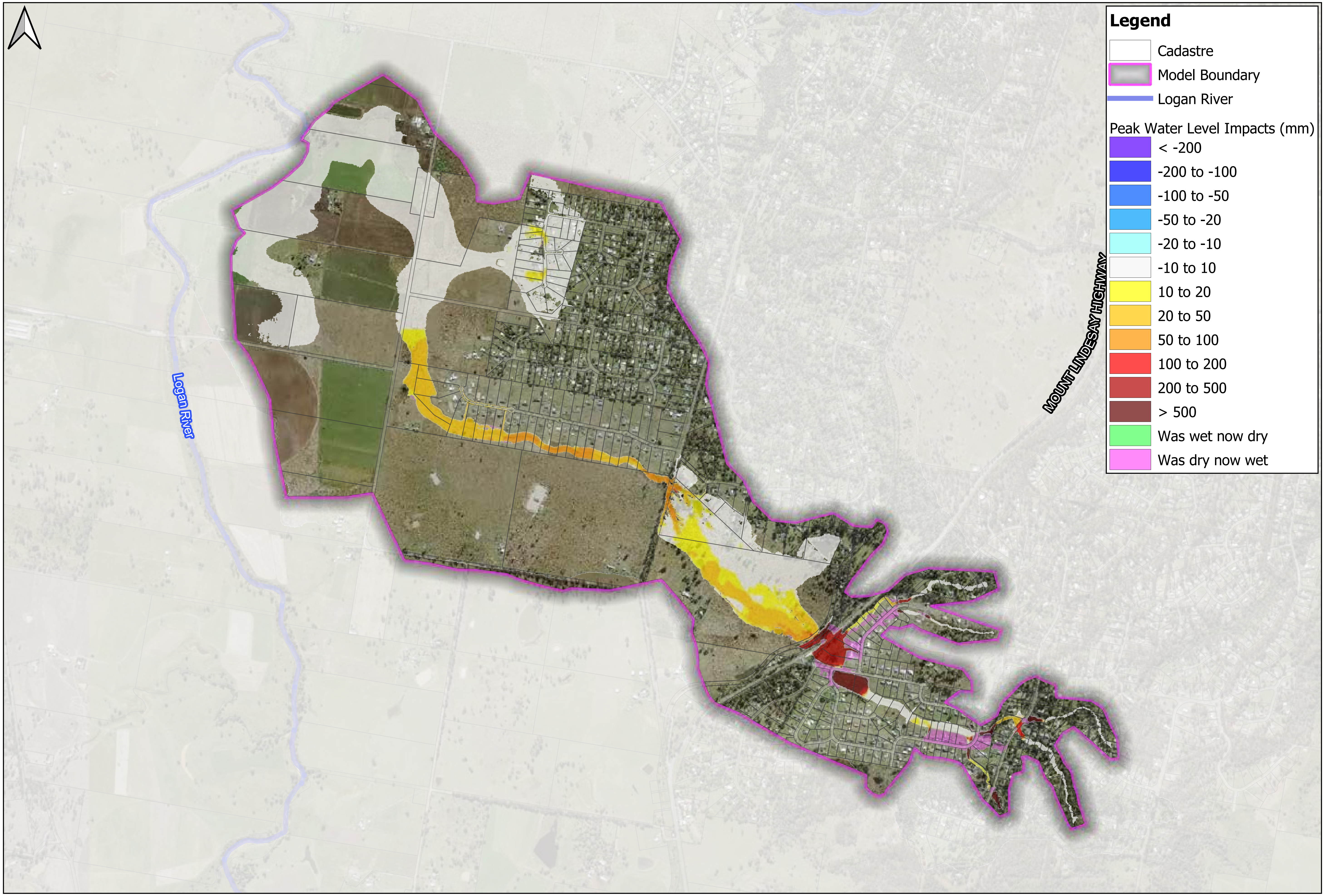
Days Creek - 1% AEP Impacts - Roughness Reduction

WATER TECHNOLOGY



Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:20,000

Days Creek Flood Study Update 2023
Days Creek - 20% AEP Impacts - Blockage Envelope



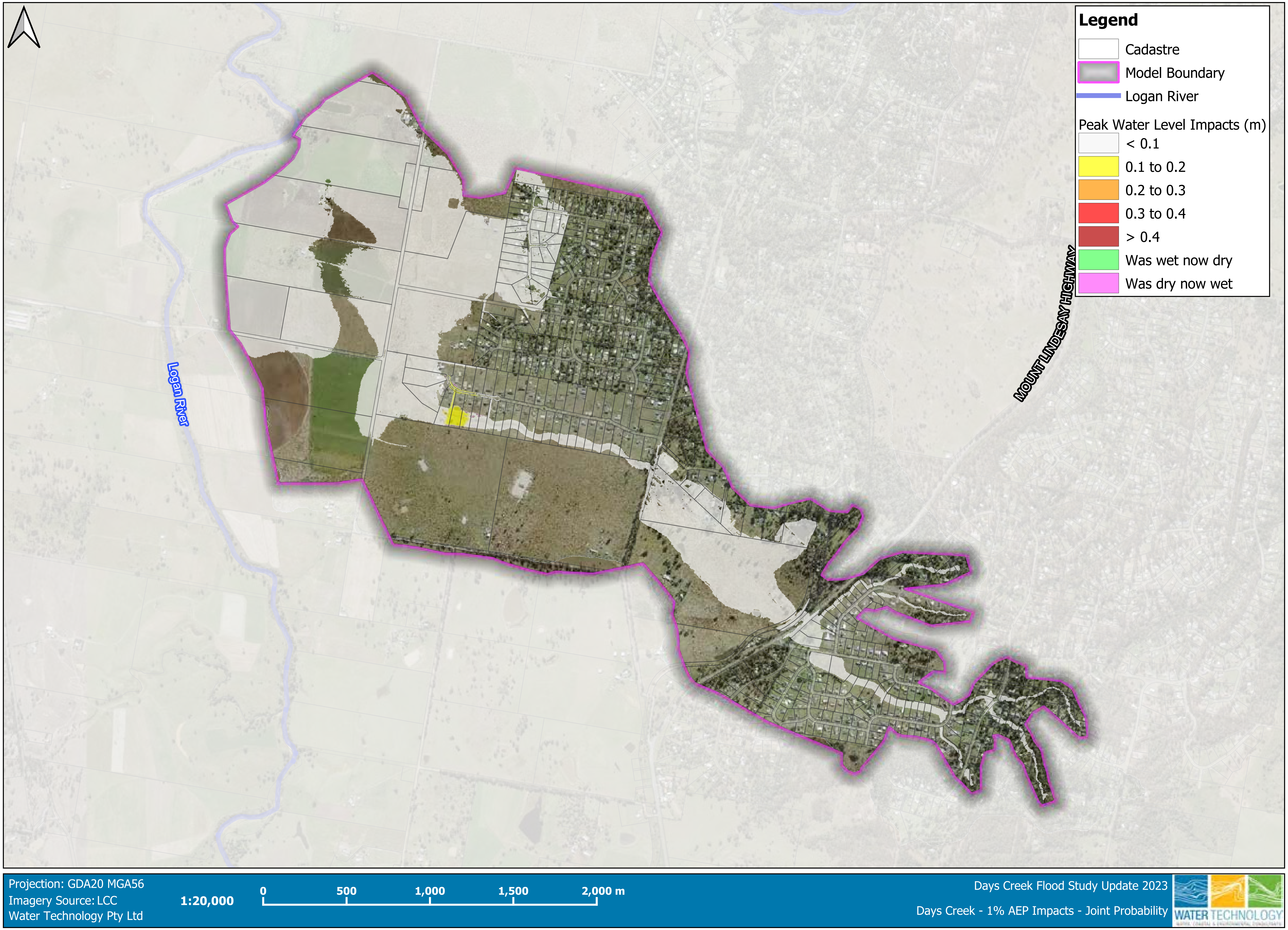
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

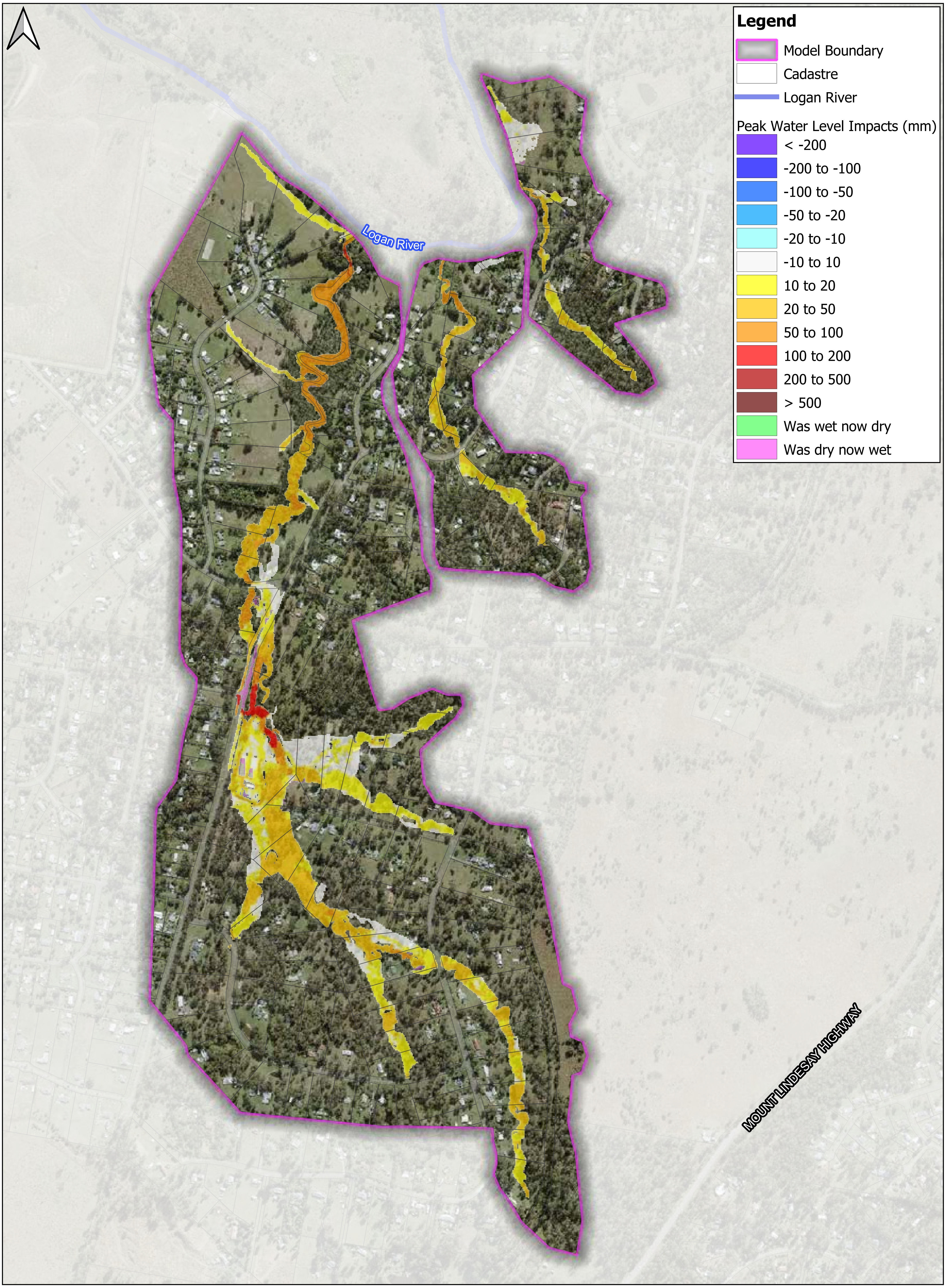
1:20,000

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

Days Creek Flood Study Update 2023

Days Creek - 1% AEP Impacts - Blockage Envelope


Legend
Cadastre
Model Boundary
Logan River
Peak Water Level Impacts (m)
< 0.1
0.1 to 0.2
0.2 to 0.3
0.3 to 0.4
> 0.4
Was wet now dry
Was dry now wet
Logan River
MOUNT LINDESAY HIGHWAY
Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd
1:20,000
0
500
1,000
1,500
2,000 m
Days Creek Flood Study Update 2023
Days Creek - 1% AEP Impacts - Joint Probability
WATER TECHNOLOGY



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

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Impacts - Increased Roughness

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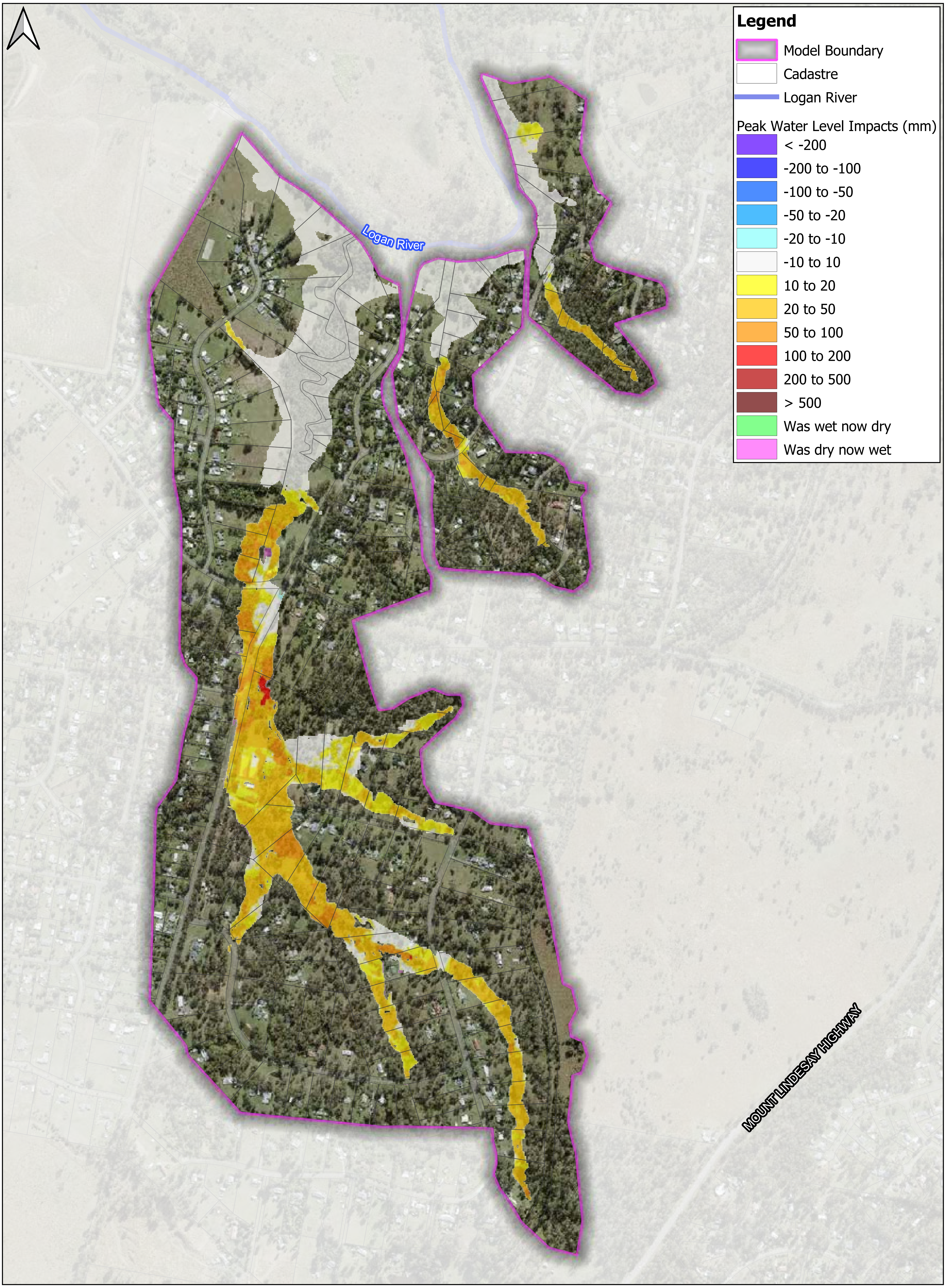

Projection: GDA20 MGA56
Imagery Source: LCC
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1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Impacts - Increased Roughness

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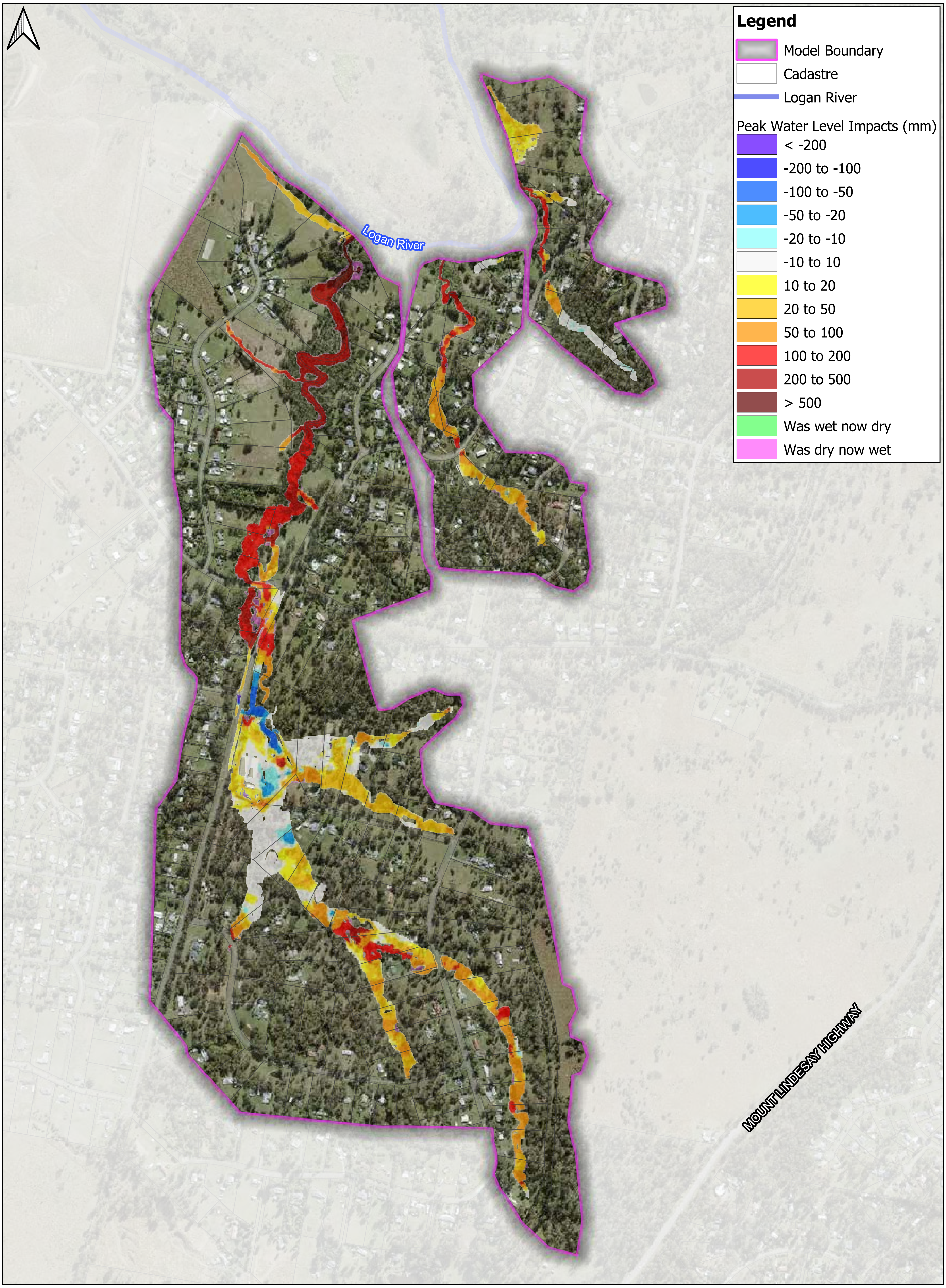

Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Impacts - Waterway Restoration

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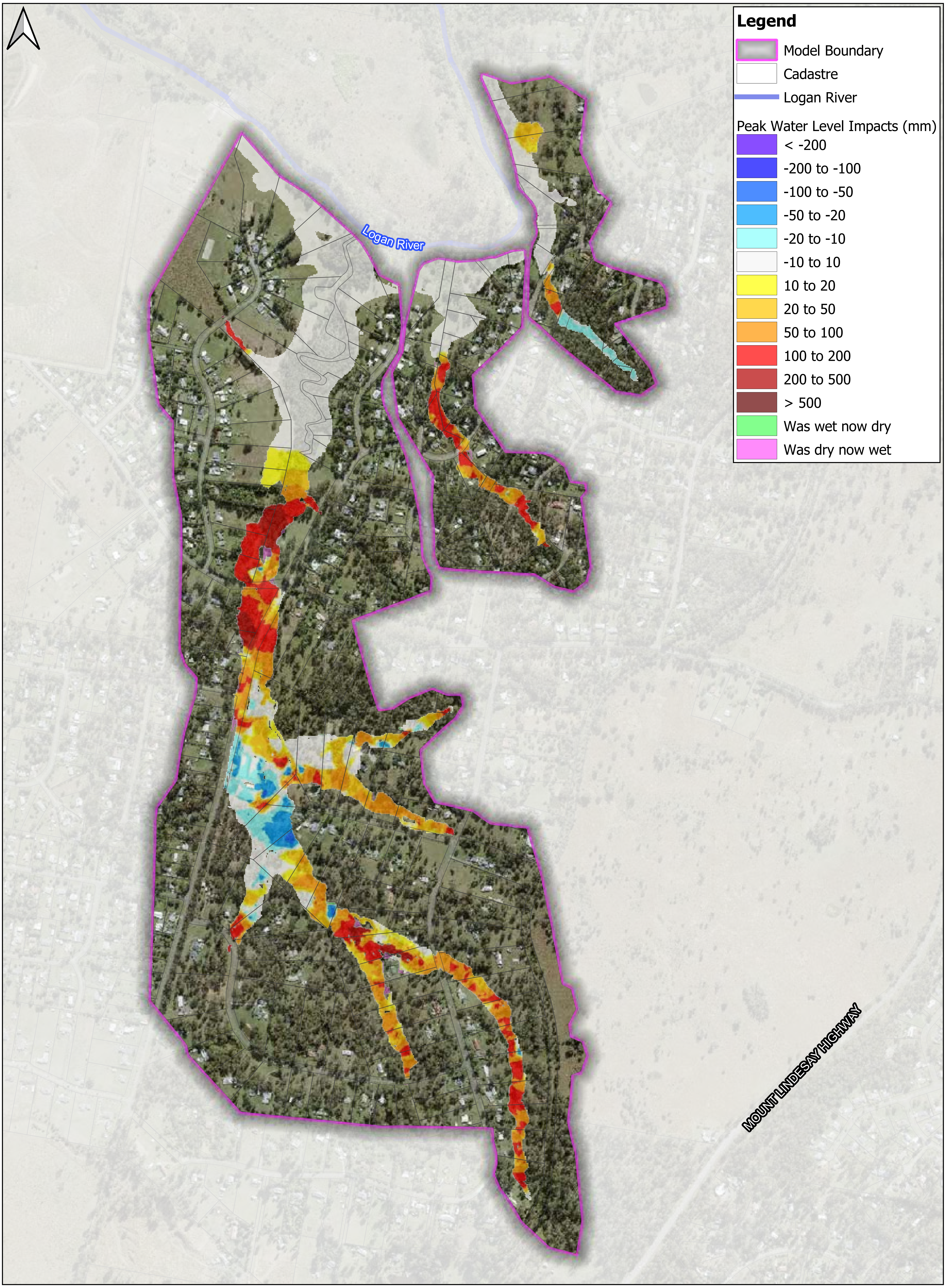

Projection: GDA20 MGA56
Imagery Source: LCC
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1:10,000

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Impacts - Waterway Restoration

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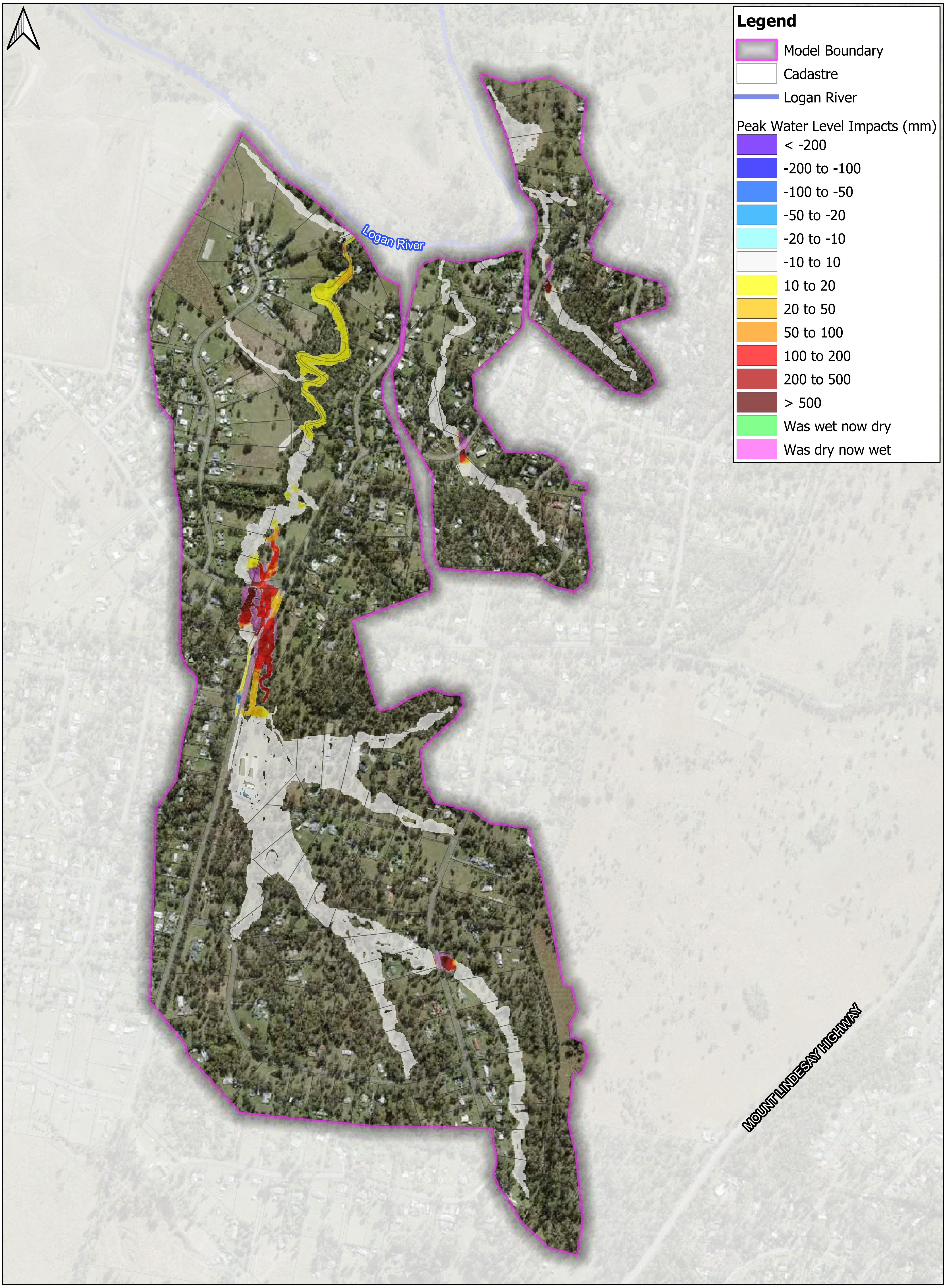

Projection: GDA20 MGA56
Imagery Source: LCC
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1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 20% AEP Impacts - Blockage Envelope

WATER TECHNOLOGY
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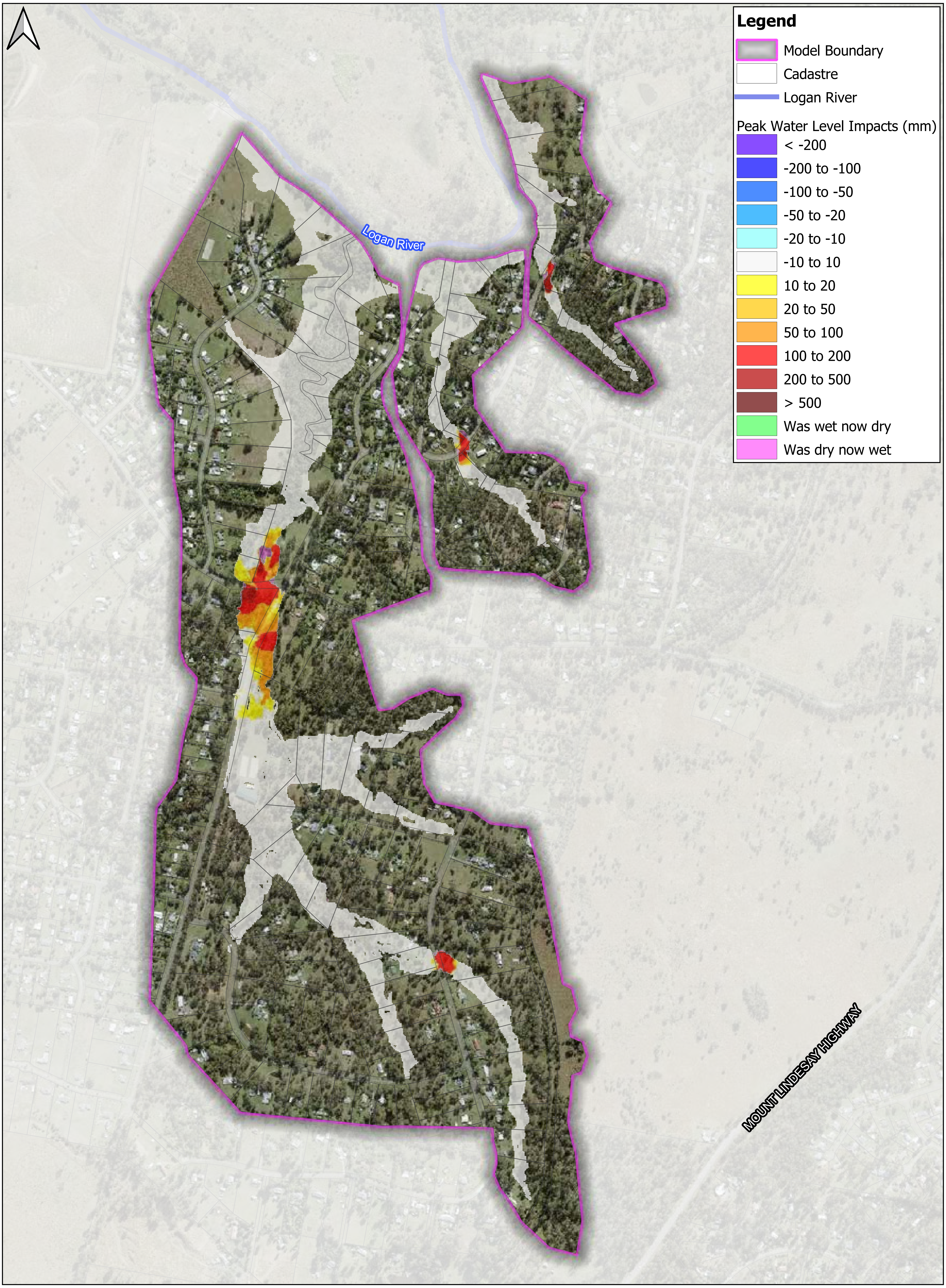

Projection: GDA20 MGA56
Imagery Source: LCC
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1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Impacts - Blockage Envelope

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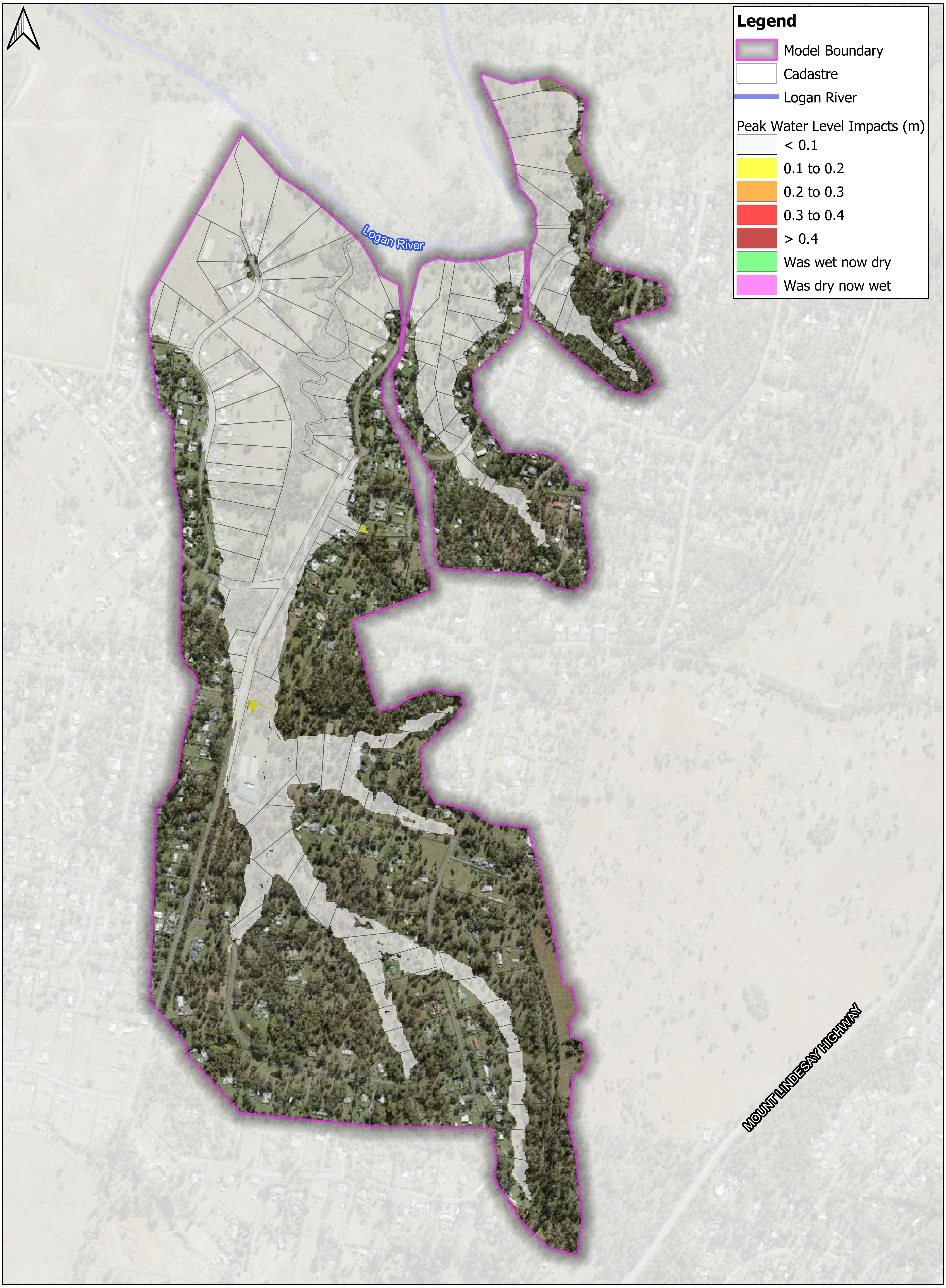

Projection: GDA20 MGA56
Imagery Source: LCC
Water Technology Pty Ltd

1:10,000

0 200 400 600 800 m

Days Creek Flood Study Update 2023

Roberts Waterhole - 1% AEP Impacts - Joint Probability

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