

APPENDIX F

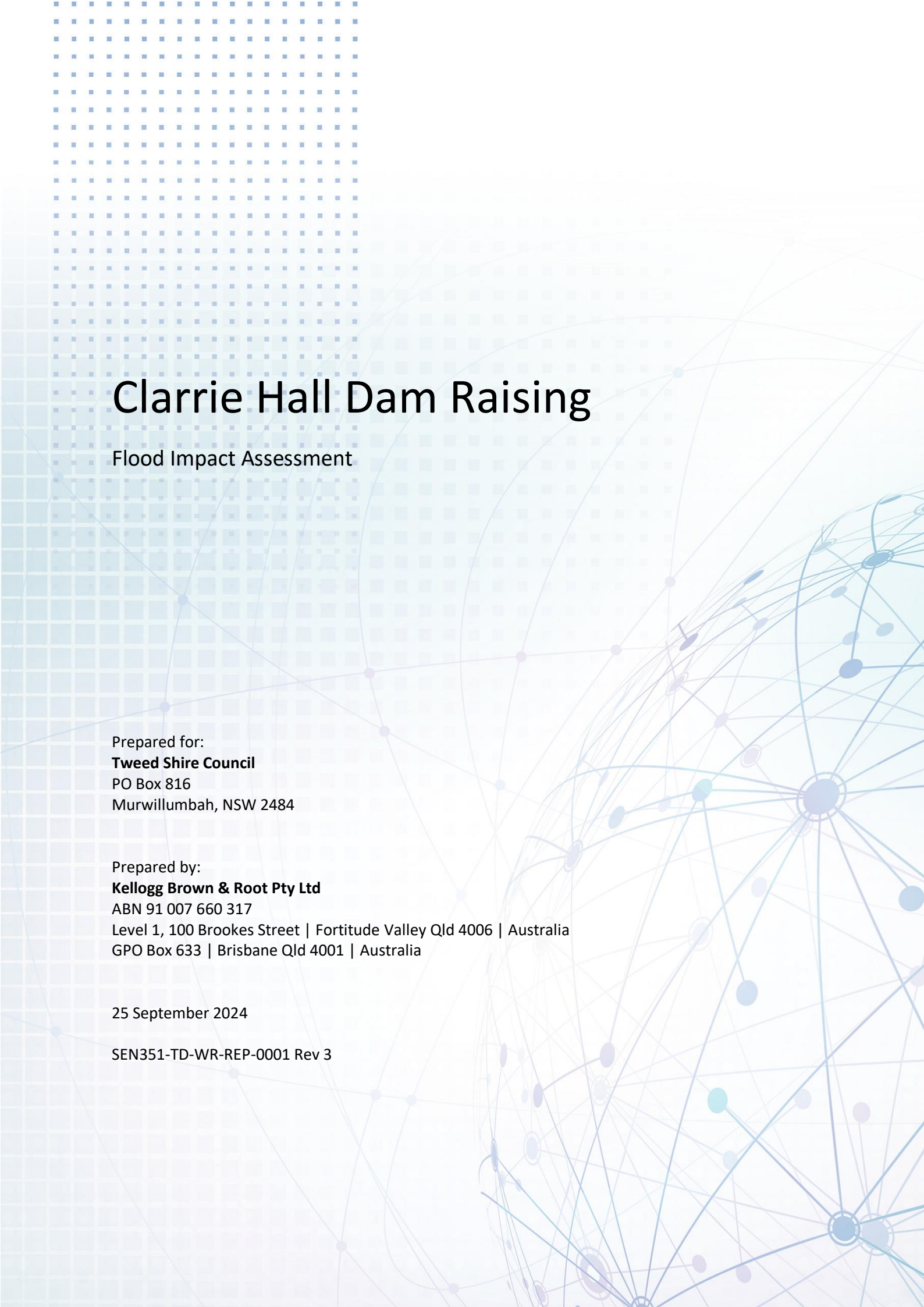
Flooding Assessment





Clarrie Hall Dam Raising

Flood Impact Assessment



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Flood Impact Assessment

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The sole purpose of this report and the associated services performed by Kellogg Brown & Root Pty Ltd (KBR) is to undertake a flood impact assessment for the Clarrie Hall Dam Raising, in accordance with the scope of services set out in the contract between KBR and Tweed Shire Council ('the Client'). That scope of services was defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

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Revision History

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Adopted Terminology

The terminology listed below has been used for this assessment and is consistent with Australian Rainfall and Runoff 2019 (AR&R 2019).

Frequency Descriptor	EY	AEP (%)	AEP	ARI
			(1 in x)	
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
	0.0002	0.02	5000	4999.5
Extreme			↓	
			PMP/	
			PMP Flood	

1 Introduction

1.1 INTRODUCTION

KBR has been engaged by Tweed Shire Council to undertake a Flood Impact Assessment of the proposed raising of Clarrie Hall Dam.

Clarrie Hall Dam is located approximately 15 kilometres (km) south-west of Murwillumbah, New South Wales (NSW), in the Local Government Area (LGA) of Tweed Shire Council. The dam's main supply is flow from Doon Doon Creek, which has its main tributaries, the Pine Log Creek and Commissioners Creek, upstream of McCabes Bridge. Doon Doon Creek generally flows in a northerly direction and joins the Tweed River approximately 1.5 km downstream of the dam. Following this, the Tweed River flows north-easterly through Uki, Dum Dum, Byangum (Byangum Bridge), Bray Park and Murwillumbah before discharging into the ocean at Tweed Heads.

Clarrie Hall Dam has a catchment area of approximately 60 km² and was constructed to provide a supply of drinking water to the Tweed District. The upstream catchment of the dam mainly comprises of rural area, made up of open spaces and highly vegetated land. Settlements located upstream of the dam appear to be mainly scattered isolated farmsteads.

The dam was upgraded in 2014, when the spillway was widened from 22 m to the current 35 m. The existing spillway level is at 61.5 mAHD, which is also its current full supply level (FSL); the embankment wall crest level is 8.9 m higher (at 70.4 mAHD).

The proposed raising of the dam will raise the height of the spillway by 8.5 m to 70.0 mAHD, and the dam embankment level to 77.0 mAHD, thereby increasing its current storage capacity from 16,000 megalitres (ML) to 42,300 ML.

From the *Clarrie Hall Dam Raising – Concept Design Report* (Tweed Shire Council, 2018), it is reported that the existing spillway will be covered by the raised embankment. For the proposed dam configuration, the proposed spillway and the spillway channel are to be higher and be constructed in the left (western) abutment. The spillway will have crest width of 40 m, with the channel width reducing to 15 m at the downstream end, where a flip bucket is to be situated. The proposed raised dam is shown in Figure 1-1.

As the proposed raising of the dam and spillway will cause changes to the flow regime of the dam, a flood impact assessment is required to investigate the impacts on flooding in the surrounding area of the dam. The outcomes from this assessment will also be used to address the Secretary's Environmental Assessment Requirements (SEARs) for the Proposal outlined in Section 1.2. The location of Clarrie Hall Dam is shown in Figure 1-4.

Furthermore, as part of the proposed dam upgrades, McCabes Bridge, which crosses Doon Doon Creek approximately 5.5 km upstream of the dam's spillway is also proposed to be upgraded. The bridge is to be moved approximately 40 m downstream of the current location and the bridge deck raised to 72.0 mAHD. A road realignment of Commissioners Creek Road is also required to facilitate the bridge upgrade. The proposed bridge configuration is shown in Figure 1-2 and Figure 1-3.

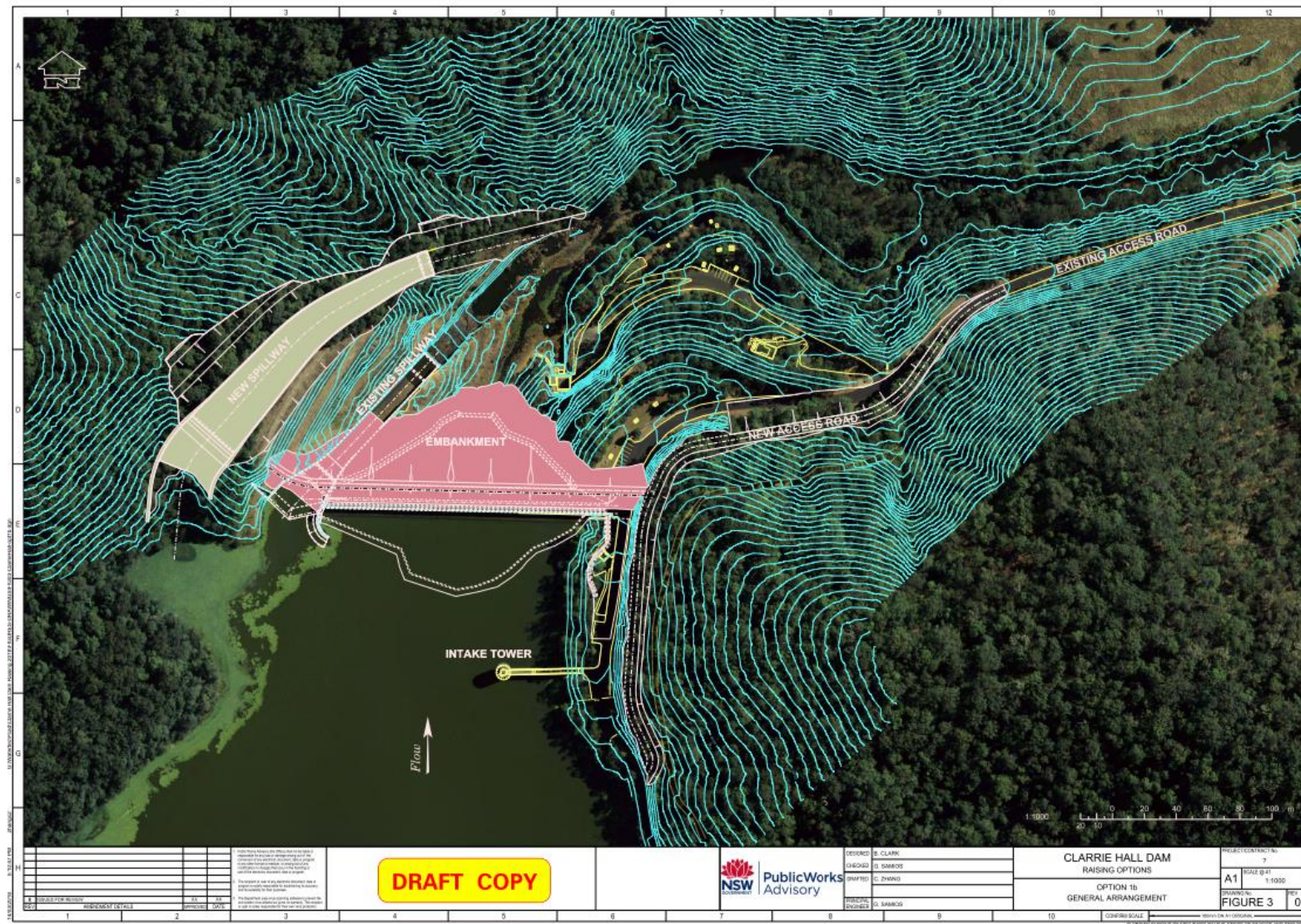


Figure 1-1 Proposed spillway configuration (Tweed Shire Council, 2018)

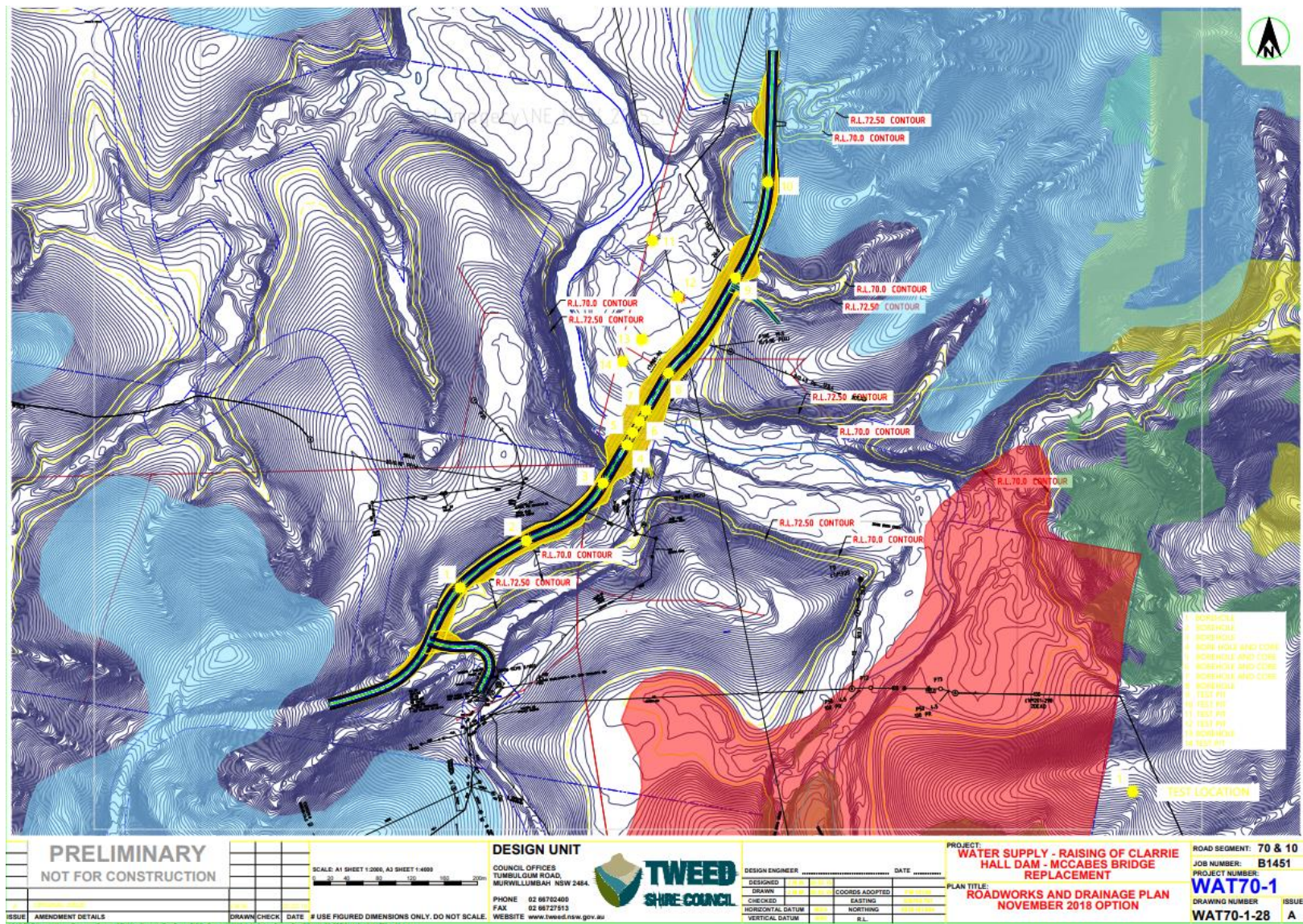


Figure 1-2 Proposed upgrade of McCabes Bridge – proposed road alignment



Figure 1-3 Proposed upgrade of McCabes Bridge – proposed bridge configurations

1.2 SEARS

The information and outcome from this flooding assessment have been used to address the Secretary's Environmental Assessment Requirements (SEARs) related to flooding.

A summary of the relevant SEARs and where they are addressed is included in Table 1-1.

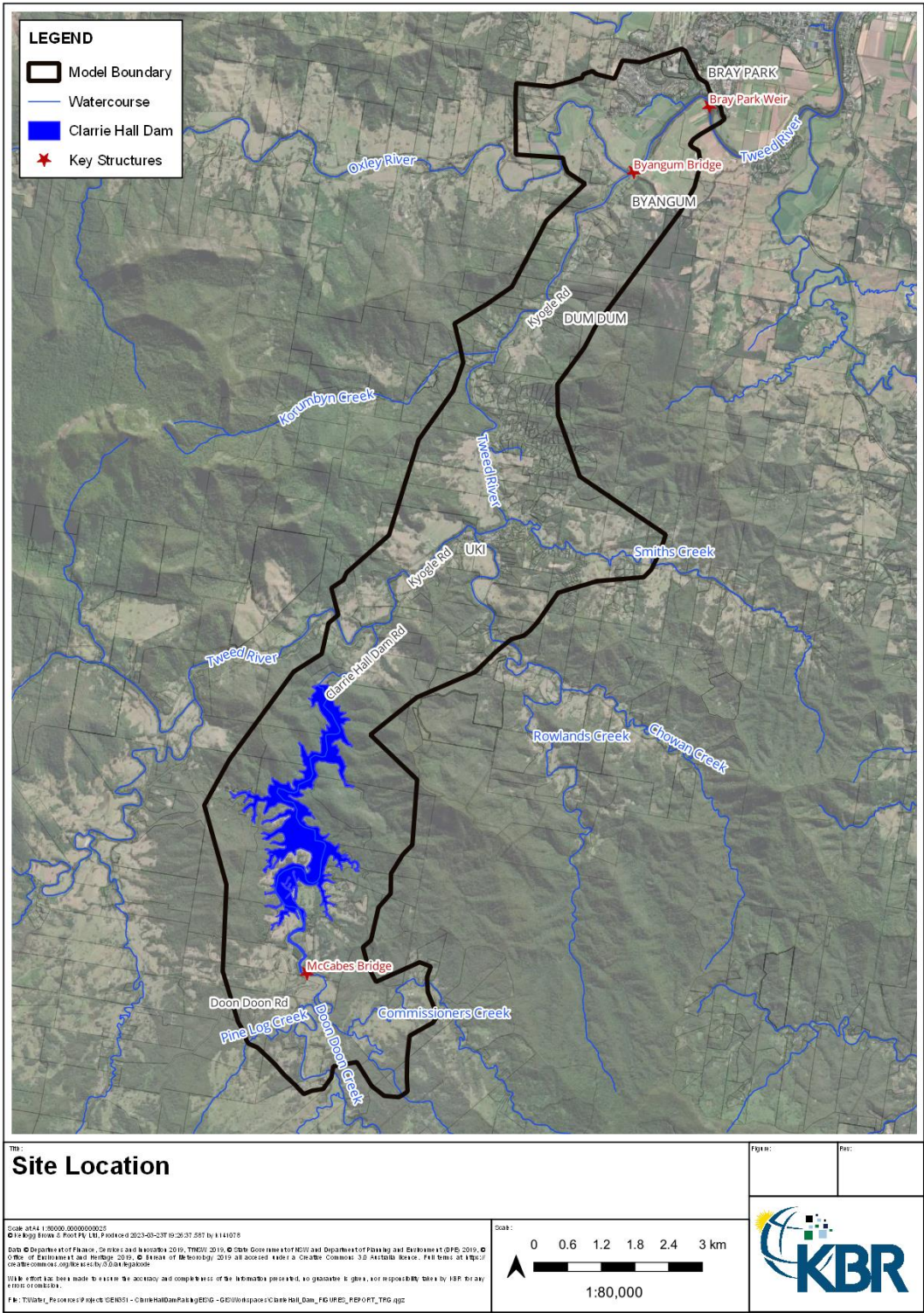
Table 1-1 SEARs relevant to flooding

Relevant Key Issue Requirement/s	Outcomes	Addressed in
1. The Proponent must assess and model the impacts on flood behaviour during construction and operation in a full range of flood events including:		
a) Any detrimental increases in the potential flood affectation of other properties, assets and infrastructure including changes to flood hazard categories.	Increased flood extents upstream of dam are limited to within waterway corridors.	Section 6.5
b) Flood storage capacity of the proposal, including quantifying what flood events can be mitigated by the dam.	Existing dam being upgraded; no mitigation of flood events for existing conditions is proposed.	Section 6.5
c) The effect of the proposal on flood behaviours in the broader catchment including any changes to flood storages.	Increased flood extents upstream of dam are limited to within waterway corridors. Decreased flood extents downstream of dam.	Section 6.5
d) Consistency (or inconsistency) with applicable floodplain risk management plans.	See EIS	EIS
e) Impacts on flood emergency management – these matters must be discussed in consultation with the NSW State Emergency Services and Council	See EIS	EIS
f) Any increase in social and economic costs to the community from changes in flood behaviour.	Increased flood extents upstream of dam are limited to within waterway corridors. Decreased flood extents downstream of dam.	Section 6.5
2. The EIS must include a sensitivity analysis for increase in rainfall intensity as a results of climate change, and the risk and vulnerability of the project to changes in flooding behaviour resulting from climate change in accordance with and using appropriate NSW guidelines, data and modelling (including justification about the use of those guidelines, data and modelling).	Climate change conditions resulted in similar simulated outcomes to current climate change scenario. Difference between Proposed Case and Existing Case shows reduced flood levels downstream of the dam and increased flood levels upstream of the dam which are confined to waterways	Section 6.7

1.3 SCOPE OF WORKS

KBR has addressed the SEARs in this flood assessment through the following methodology:

- Undertaking data collection and reviewing all available data related to the Proposal, including any available hydrological and hydraulic models.
- Developing a TUFLOW hydraulic model of Clarrie Hall Dam to define existing dam conditions, with the dam spillway modelled using the existing rating curve.
- Modifying the TUFLOW hydraulic model to reflect the proposed raised dam conditions, with the dam spillway modelled using the proposed rating curve. The proposed raised dam conditions includes the proposed upgrades at McCabes Bridge.
- Conducting hydraulic simulation for the 5% Annual Exceedance Probability (AEP), 1% AEP, 0.5% AEP, 0.2% AEP and Probable Maximum Flood (PMF) design events. Climate change scenarios have been simulated for all events.
- Undertaking a flood impact assessment to determine the potential effects on flood behaviour caused by the proposed Clarrie Hall Dam upgrade both upstream and downstream for all simulated design events.
- Providing reporting and mapping based on the outcomes of the hydraulic simulations.



2 Available Data

2.1 PREVIOUS STUDIES

Council provided a number of studies relating to the hydrological and hydraulic modelling of the Clarrie Hall Dam. The studies that provide useful information in conducting the hydraulic modelling analysis of the dam raising option are summarised in sections 2.1.1 to 2.1.5.

2.1.1 Flood Hydrology Study – Clarrie Hall Dam (WRM, 2017)

A RORB hydrological model of Clarrie Hall Dam and Tweed River was developed by WRM to predict peak water inflows, outflow and water levels in the raised dam for a number of proposed spillway designs.

2.1.2 Clarrie Hall Dam Raising – Computational Fluid Dynamics Modelling (Advisian, 2018)

A computational fluid dynamics (CFD) hydraulic analysis of the proposed spillway upgrade was conducted by Advisian using the Flow-3D software. The outputs of the modelling, including the spillway rating curves for each option, were documented in the report.

2.1.3 Clarrie Hall Dam Raising – Concept Design Report (Tweed Shire Council, 2018)

Tweed Shire Council investigated a number of concept designs for raising Clarrie Hall Dam. The outcomes from earlier studies were used to compare the benefits of different concept design options, which included a number of spillway configurations. From the comparison, the preferred dam raising option was selected.

2.1.4 Clarrie Hall Dam Raising EIS – Flooding Technical Report (Eco Logical Australia, 2021)

A HEC-RAS 2D hydraulic model of the Clarrie Hall Dam catchment down to Bray Park Weir on the Tweed River was developed by Eco Logical to conduct hydraulic modelling for a range of design flood events. The existing dam and raised dam conditions were hydraulically simulated and their modelled flood outputs compared and documented.

2.1.5 Clarrie Hall Dam Safety Review – Existing Spillway CFD Study (GHD, 2023)

CFD modelling was undertaken by GHD to characterise the hydraulic behaviour of the existing spillway. The Siemens' Simcenter STAR-CCM+ CFD software package was used to determine the spillway rating curve for the existing spillway arrangement.

2.2 TOPOGRAPHIC SURVEY

Topography data for the Clarrie Hall Dam catchment and the Tweed River was provided by Council. Additional Digital Elevation Model (DEM) survey for the Murwillumbah region was sourced from Geoscience Australia (ELVIS, 2023) to supplement the topography data provided by Council. Furthermore, bathymetry data for parts of Doon Doon Creek and the Tweed River was provided by EMM Consulting. Table 2-1 summarises the available topography data, and Figure 2-1 presents the available topography used in the hydraulic model.

Table 2-1 Topography data

Topography data	Survey date	Format	Provider
Hydrographic survey (2017) of Clarrie Hall Dam	2017	xyz	Council
1 m LiDAR survey – Clarrie Hall Dam catchment	2022	ascii	Council
0.5 m LiDAR survey – Tweed River from spillway up to Bray Park Weir	2022	ascii	Council
1 m DEM – Murwillumbah201309-LID1-AHD	2013	ascii	ELVIS
2 m DEM – Murwillumbah201709-LID2-AHD	2017	ascii	ELVIS
Bathymetry	2023	ascii	EMM Consulting

2.3 HYDROLOGY

Council provided a RORB hydrological model developed by WRM and documented in the Clarrie Hall Dam Hydrology Study (WRM, 2017). The hydrological model was developed using Australian Rainfall and Runoff (AR&R) 1987 methods.

For the purpose of the study, the RORB hydrological model was updated with AR&R 2019 methods and is described in more detail in Chapter 3.

2.4 SPILLWAY RATING CURVES

The spillway rating curve for the existing spillway was obtained from the CFD study conducted by GHD in 2023. The rating curve was provided by Council for use in this study. Figure 2-2 shows the rating curve for the existing spillway as modelled in the study conducted by GHD (2023).

A figure of the rating curve modelled for the proposed spillway in the CFD study conducted by Advisian (2018) was also provided by Council. However, the actual values used to generate the proposed spillway rating were not provided. As such, for the purpose of this study, the proposed spillway rating was reproduced in Excel. Figure 2-3 presents the rating curve for the proposed spillway provided by Council and Figure 2-4 presents the proposed rating curve reproduced in Excel, which is used for this study.

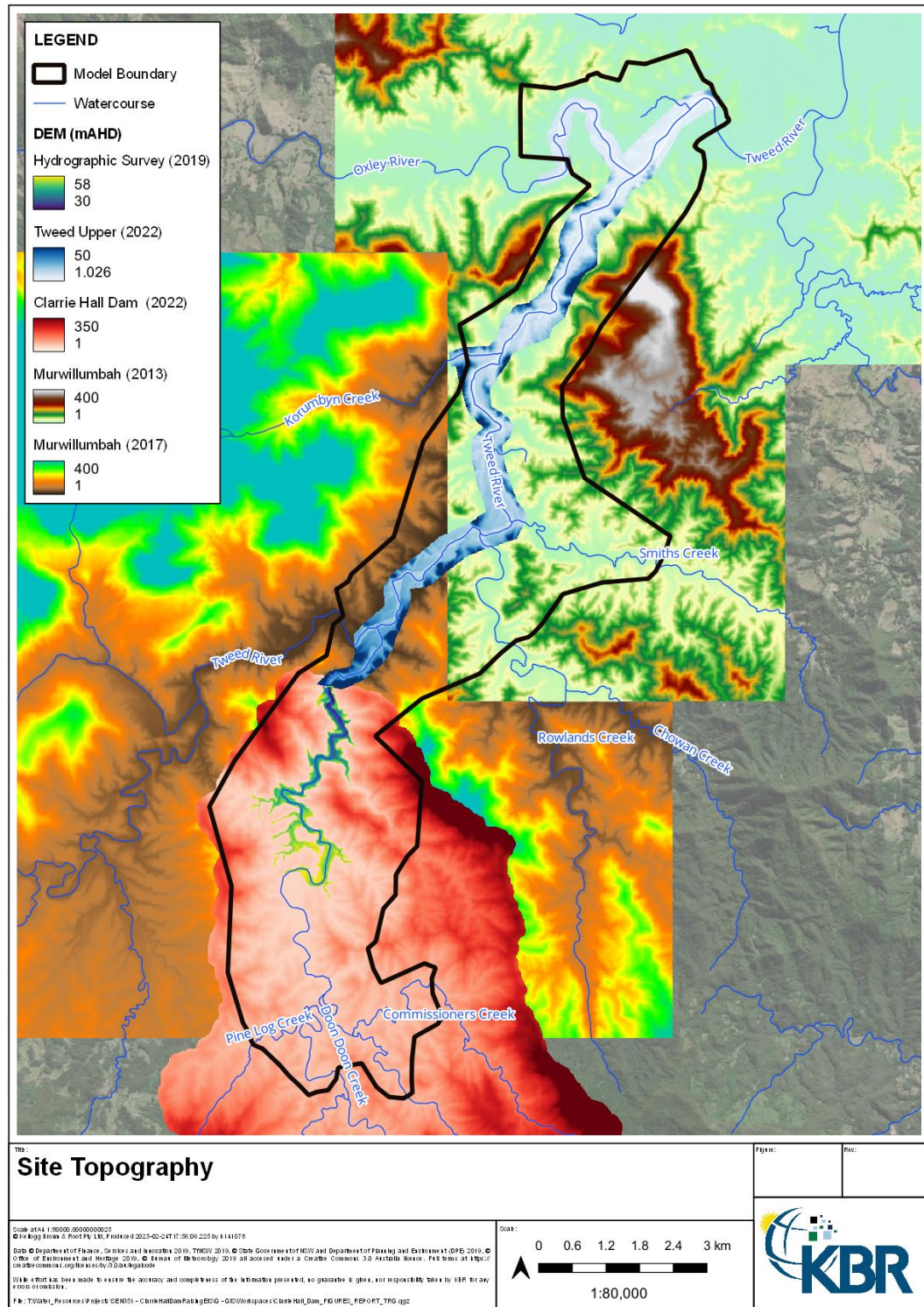


Figure 2-1 Available digital elevation models and extents

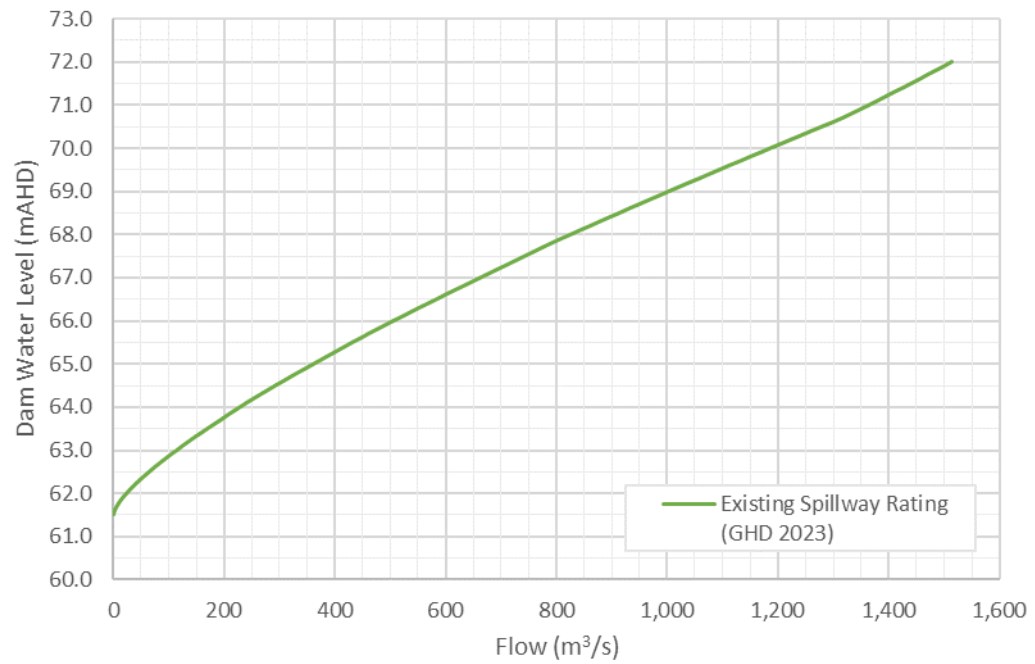


Figure 2-2 Existing spillway rating curve (GHD, 2023)

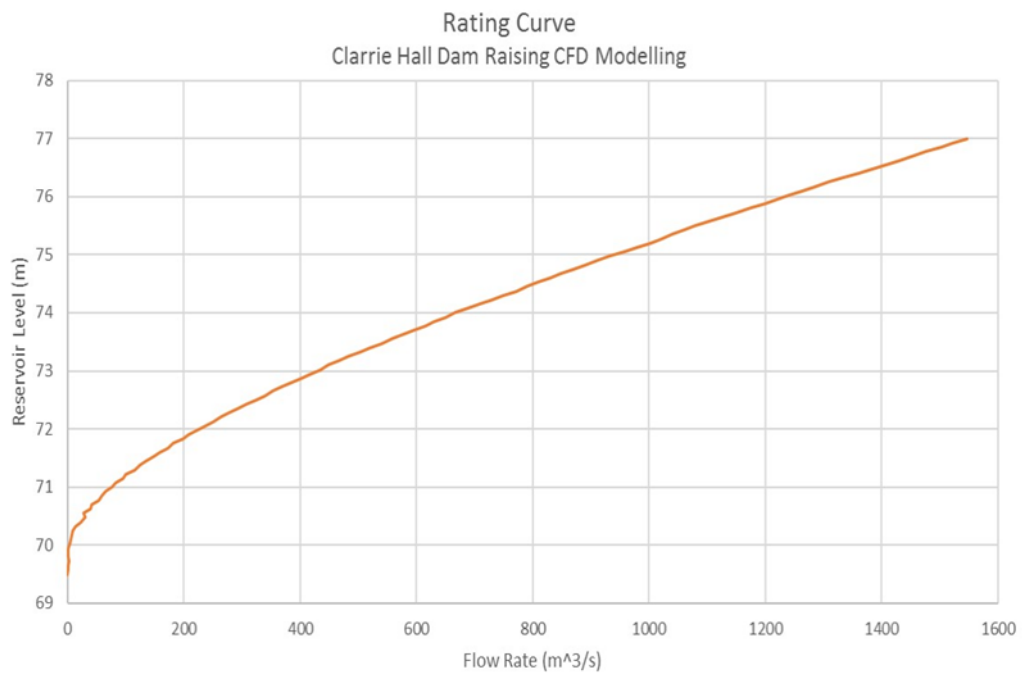


Figure 2-3 Proposed spillway rating curve (Advisian, 2018)

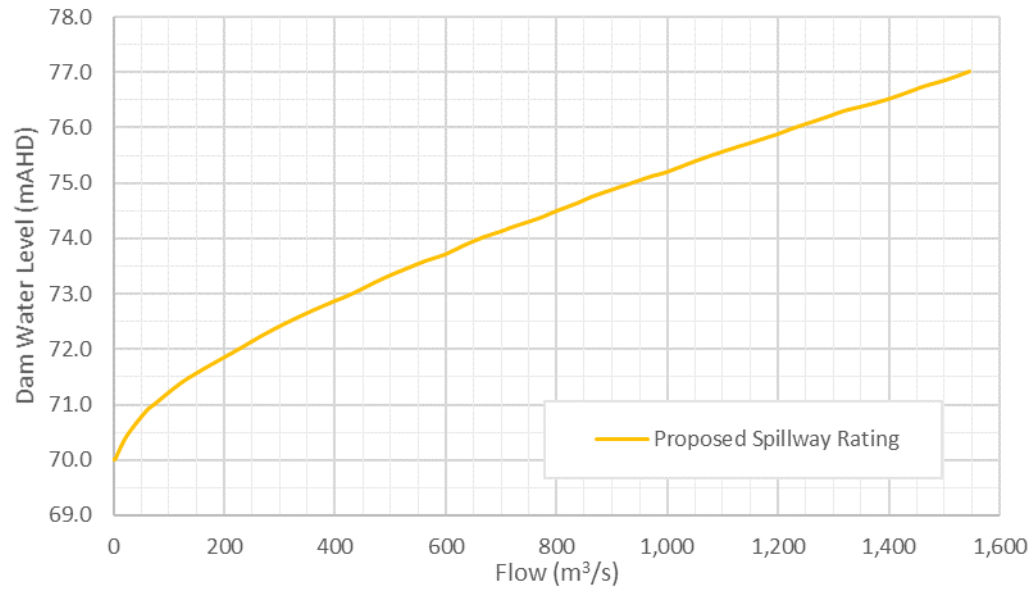


Figure 2-4 Proposed spillway rating curve re-produced in EXCEL

3 Hydrology

3.1 HYDROLOGICAL MODEL

WRM conducted a hydrological study in 2017 to investigate the impacts of raising Clarrie Hall Dam, which was reported in *Flood Hydrology Study – Clarrie Hall Dam* (WRM, 2017). For that study, a calibrated RORB hydrological model of Clarrie Hall Dam and Tweed River was developed to predict peak water inflows, outflow and water levels in the dam for a number of proposed spillway designs.

The following summarises the RORB hydrological model as provided for the study:

- The RORB hydrological model was calibrated against the January 2008, January 2012 and January 2013 flood events.
- Ninety-four sub-catchments with a total catchment area of 574 km² were delineated, of which 60 km² drains to Clarrie Hall Dam. The RORB sub-catchments are presented in Figure 3-1.
- Sub-catchments were mostly vegetated and classified as rural and were assigned as zero percent impervious. However, the sub-catchments S3 and W3, which represent the sub-catchments draining directly to Clarrie Hall Dam, were assigned impervious areas of 10.5% and 20.5%, respectively, to account for the saturated dam area – that is, water already stored within the dam.
- The RORB routing parameters *kc* and *m* were assigned a value of 21.9 and 0.8 respectively, based on the outcomes of the RORB model calibration.
- The appropriate design rainfall depths were derived based on AR&R 1987 methods.
- The initial loss (IL) and continuing loss (CL) approach was adopted for modelling losses.
- Losses for design storm events up to the 100-year ARI (1% AEP) event were based on information available in AR&R 1987 and model calibration. Losses for events greater than 100-year ARI were adopted based on information available in the revised Book VI AR&R (1998). Losses were adopted for the design events as outlined in Table 3-1.

All hydrological inputs derived from AR&R 1987 methodologies were updated to AR&R 2019 as a part of this body of works.

Table 3-1 Losses adopted in the RORB hydrological model

AEP	Catchment	IL (mm)	CL (mm/hr)
≤1% AEP (100-year ARI)	Tweed River	25	1.5
	Oxley River	25	2.0
>1% AEP (100-year ARI)	Whole of Tweed catchment	0	1.0

Figure 3-1 RORB sub-catchments

3.2 HYDROLOGICAL MODEL OUTPUTS

The RORB hydrological model was used specifically to conduct a hydrological analysis of the raised spillway at Clarrie Hall Dam. Outputs from the RORB model included the peak flows at the dam and downstream of the dam, as well as the total flows at each of the sub-catchments' outlets. Local inflows were generated for those sub-catchments that were identified as requiring inflow inputs in the TUFLOW model. There were no changes to the RORB parameters in these simulations of the hydrological model.

3.3 UPDATE TO AR&R 2019 METHODOLOGY

The RORB model was updated to incorporate AR&R2019 guidelines. Updates to the RORB model were complete as per Table 3-2. The RORB routing parameters were maintained as $k_c = 21.9$ and $m = 0.8$.

Table 3-2 AR&R 2019 Hydrological Model Updates

Parameter	AR&R 2019												
Temporal Pattern	AR&R2019 Temporal patterns – East Coast (South)												
Intensity-Frequency-Durations (IFDs)	Updated IFDs based on four centroid locations - Clarrie Hall Dam catchment, - Tweed River (upstream of Dam), - Tweed River (downstream of Dam), - Oxley River. IFDs were assigned to RORB sub-catchments which were within the IFDs Subcatchments.												
Initial Losses	Probabilistic Neutral Burst Initial Loss (PBNIL)												
Continuing Losses	1.24 mm/h (0.4 of Data Hub Loss of 3.1 mm/h) – NSW Specific												
PMP	No changes: - PMP depth estimates <table><tr><th></th><th colspan="2">Rainfall Depth (mm)</th></tr><tr><th>Storm Duration</th><th>Clarrie Hall Dam catchment</th><th>Tweed River Catchment</th></tr><tr><td>24-hour</td><td>1,720</td><td>1,480</td></tr><tr><td>48-hour</td><td>2,460</td><td>2,040</td></tr></table> - Initial losses = 0mm, CL = 1mm/h		Rainfall Depth (mm)		Storm Duration	Clarrie Hall Dam catchment	Tweed River Catchment	24-hour	1,720	1,480	48-hour	2,460	2,040
	Rainfall Depth (mm)												
Storm Duration	Clarrie Hall Dam catchment	Tweed River Catchment											
24-hour	1,720	1,480											
48-hour	2,460	2,040											

Rainfall depths were updated to 2016 IFDs obtained from the BoM website. Rainfall depths were obtained for four centroidal locations for the:

- Clarrie Hall Dam catchment – Clarrie Hall Dam catchment up to confluence of Doon Doon Creek and Tweed River,
- Tweed River US catchment – Tweed River catchment upstream of confluence of Doon Doon Creek and Tweed River,
- Tweed River DS catchment – Tweed River catchment downstream of confluence of Doon Doon Creek and Tweed River, and
- Oxley River catchment.

The rainfall depths were then assigned to respective RORB sub-catchments.

The sub-catchments and centroids used for IFD extraction are presented in Figure 3-2. The rainfall depths extracted for each of the sub-catchments are presented in Table 3-4, Table 3-3, Table 3-5 and Table 3-6.

Table 3-3 Design rainfall depths for durations between 1 and 30 hours – Clarrie Hall Dam catchment

Duration	Rainfall depth (mm)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
1 hour	52.2	62.1	72.2	86.5	97.8	104	116
1.5 hour	61.95	74.7	87.6	106.2	121.35	129	144.15
2 hour	70.4	85.4	101	123.4	141.8	150.4	168
3 hour	85.2	104.1	124.2	153.3	177	187.2	208.8
4.5 hour	103.95	128.25	154.35	190.8	221.4	232.65	259.2
6 hour	120.6	149.4	180.6	223.2	258.6	270.6	301.8
9 hour	149.4	186.3	225	277.2	319.5	333.9	371.7
12 hour	174	217.2	261.6	321.6	368.4	385.2	428.4
18 hour	214.2	266.4	320.4	390.6	444.6	466.2	520.2
24 hour	247.2	307.2	367.2	441.6	499.2	528	590.4
30 hour	273.9	339	402	483	543	588	660

Table 3-4 Design rainfall depths for durations between 1 and 30 hours – Tweed River Upstream catchment

Duration	Rainfall depth (mm)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
1 hour	50.8	60.5	70.4	84.4	95.6	102	114
1.5 hour	60.3	72.6	85.2	103.5	118.35	126	141
2 hour	68.4	83	98	120	138.2	146	164
3 hour	82.5	101.1	120.9	149.1	172.5	182	204
4.5 hour	100.8	125.1	150.3	186.3	216.45	227	254
6 hour	117.6	145.8	176.4	219	253.8	265	296
9 hour	145.8	182.7	221.4	273.6	315.9	329	367
12 hour	170.4	213.6	259.2	319.2	367.2	382	427
18 hour	212.4	264.6	320.4	390.6	446.4	467	522
24 hour	244.8	307.2	367.2	446.4	504	533	596
30 hour	272.7	339	408	489	552	596	669

Table 3-5 Design rainfall depths for durations between 1 and 30 hours – Oxley River catchment

Duration	Rainfall depth (mm)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
1 hour	50.5	60.2	69.9	83.6	94.5	101	114
1.5 hour	59.25	71.25	83.4	101.1	115.35	123.3	138.75
2 hour	66.6	80.6	95	116	133.2	142.2	160
3 hour	79.2	96.9	115.2	141.9	163.8	174.3	195.9
4.5 hour	95.4	117.45	140.85	174.6	202.05	213.75	240.3
6 hour	109.2	135.6	163.2	202.2	234.6	247.2	277.8
9 hour	134.1	166.5	201.6	249.3	288	303.3	340.2
12 hour	154.8	193.2	234	288	332.4	349.2	391.2
18 hour	189	237.6	286.2	349.2	399.6	423	473.4
24 hour	217.92	271.2	326.4	396	451.2	480	537.6
30 hour	241.2	300	360	432	489	531	600

Table 3-6 Design rainfall depths for durations between 1 and 30 hours – Tweed River Downstream catchment

Duration	Rainfall depth (mm)						
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP
1 hour	53.7	64.1	74.4	89.1	101	108	120
1.5 hour	63.9	76.95	90.3	109.5	125.25	133.65	149.55
2 hour	72.6	88.2	104.2	127.4	146.4	156	174.6
3 hour	87.6	107.4	128.1	157.8	182.7	193.8	216.9
4.5 hour	107.1	132.3	158.85	196.2	227.7	240.3	268.65
6 hour	123.6	153.6	184.8	229.2	265.2	279	312
9 hour	153	189.9	229.5	282.6	325.8	342	382.5
12 hour	177.6	220.8	266.4	326.4	374.4	392.4	439.2
18 hour	216	270	324	392.4	446.4	471.6	527.4
24 hour	247.2	307.2	367.2	441.6	499.2	530.4	595.2
30 hour	273.6	336	399	480	540	588	660

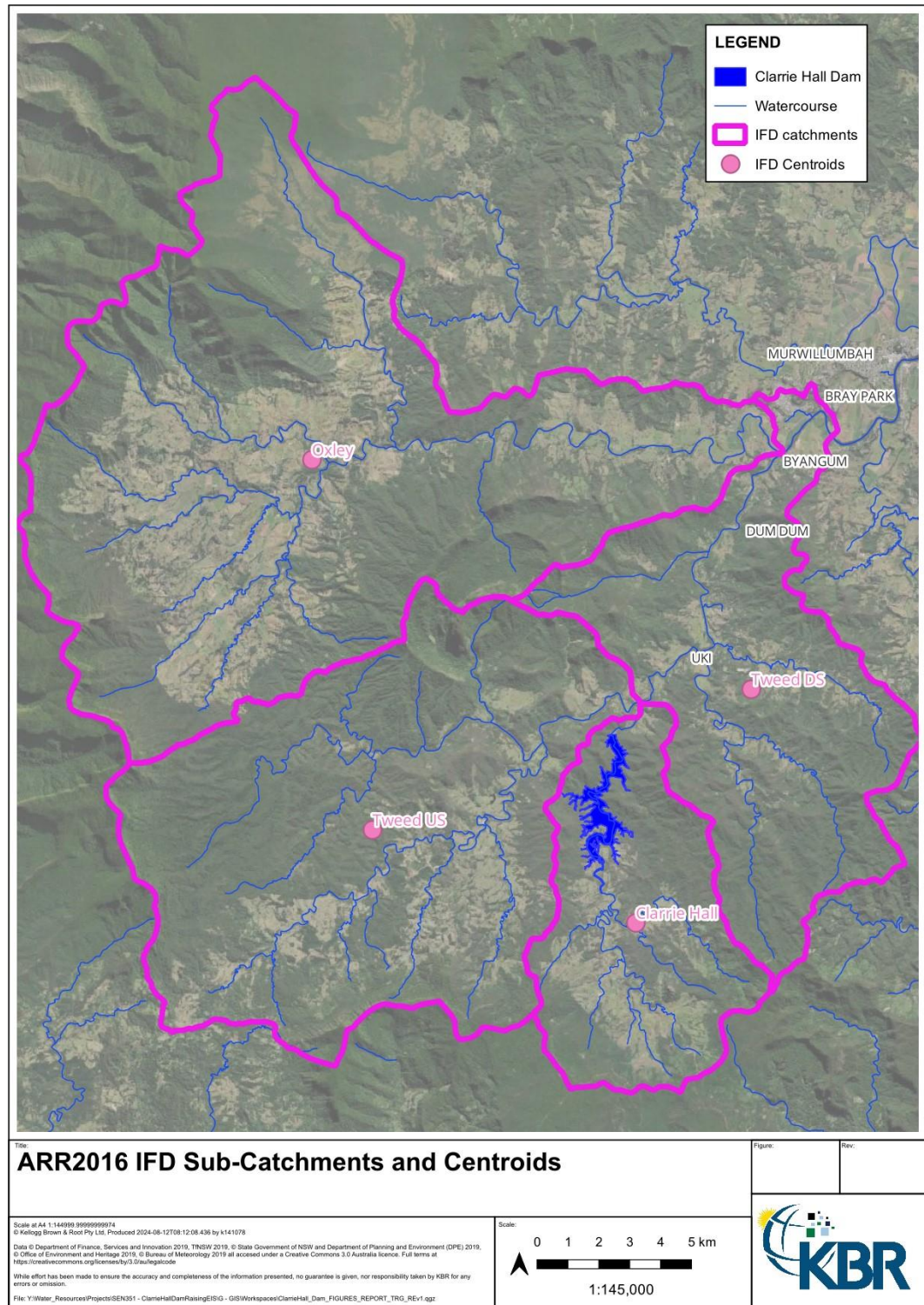


Figure 3-2 IFD Sub-catchments and centroids

3.4

DESIGN EVENTS

The current project scope includes conducting hydraulic simulations for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and the PMF design events, to assess the likely impacts of the proposed raised dam conditions, as well as climate change conditions for each of the design events.

The critical temporal pattern was selected from the full ensemble of durations and patterns run for the 1% AEP, 5% AEP, 0.5% AEP and the 0.2% AEP design events in the calibrated RORB hydrological model.

The critical temporal pattern was selected as the temporal pattern which produced the mean peak flow (bias to two) for each duration for each design AEP at the dam's outlet.

Table 3-7 provides the temporal patterns selected for the RORB hydrological model at the Dam's outlet for a range of durations from the 6-hour duration to the 24-hour duration inclusive.

Table 3-8 provides the critical durations for the Dam and Uki Gauge for the design events.

Table 3-7 Selected temporal pattern for each AEP and each duration

Duration	5% AEP	1% AEP	0.5% AEP	0.2% AEP
6-hour	4729	4694	4694	4694
9-hour	4764	4750	4750	4754
12-hour	4703	4443	4443	4786
18-hour	4710	4819	4819	4819
24-hour	4831	4755	4755	4755

Table 3-8 Critical durations at the Dam and Uki Gauge

Design event (AEP)	Dam		Uki Gauge	
	Existing Case	Proposed Case	Existing Case	Proposed Case
5%	12-hour	24-hour	12-hour	12-hour
1%	9-hour	24-hour	6-hour	6-hour
0.5%	9-hour	24-hour	6-hour	6-hour
0.2%	12-hour	12-hour	6-hour	6-hour
PMF	24-hour	24-hour	24-hour	24-hour

3.5 CLIMATE CHANGE

The climate change scenario applied the updates to the climate change factors proposed in the *"Draft update to the Climate Change Considerations chapter in Australian Rainfall and Runoff: A Guide to Flood Estimation"* (Department of Climate Change, Energy, the Environment and Water, 2024) which is scheduled for release towards the end of 2024.

The update climate change guidelines present temperature projections based on Shared Socioeconomic Pathways (SSPs) that cover a broad range of potential future development options identified as very low (SSP1-1.9), low (SSP1-2.6), medium (SSP2-4.5), high (SSP3-7.0) and very high (SSP5-8.5) emissions pathways.

AR&R 2019 recommends the application of representative concentration pathway (RCP) 4.5, which aligns with the medium development option (SSP2-4.5) in the updated climate change guidelines. For the purpose of the study the more conservative, high development (SSP3-7.0) pathway for the long-term projection (2081-2100) was applied. Climate change factors were calculated and applied to the IFDs.

Table 3-9 shows the climate change factors which were adopted to scale up the IFDs.

Table 3-9 Climate change factors applied to IFDs for each duration

Storm Duration	Climate change factors – SSP3-7.0
<= 1 hour	1.65
1.5 hour	1.59
2 hour	1.54
3 hour	1.49
4.5 hour	1.45
6 hour	1.42
9 hour	1.39
12 hour	1.36
18 hour	1.34
>= 24 hour	1.32

The updated climate change guidelines predicted losses to increase by 7% for initial losses and by 14% for continuing losses for the SSP3-7.0 emissions pathway. This meant PBNIL losses used for this study were predicted to increase by 0.3 mm to 0.9 mm for the 6-hour and 24-hour duration storms, and continuing losses by 0.17mm/h. The minor increase in losses is not overly significant and represents not more than 1.0% of total rainfall depth (with climate change factored). The increases in losses are presented in Table 3-10. Furthermore, current hydrological software does not readily allow for the application of factors to the PBNIL. As such, no climate change factors were applied to the PBNIL and initial losses, which represents a slightly more conservative approach to the climate change scenario.

Table 3-10 Increased losses (climate change factored) in relation to total rainfall depth – Clarrie Hall Dam catchment

Duration	PBNIL losses (mm)		Increase in PBNIL due to Climate change (mm)		Total increase in losses (mm) (IL + CL)		Clarrie Hall catchment - Rainfall Depth with CC factor (mm)		Increase in losses as a %age of Rainfall Depth	
	5% AEP	1% AEP	5% AEP	1% AEP	5% AEP	1% AEP	5% AEP	1% AEP	5% AEP	1% AEP
6 hours	9.2	4.2	0.64	0.29	1.66	1.31	256.5	367.2	0.6%	0.4%
12 hours	10.1	5.2	0.71	0.36	2.75	2.40	355.8	501.0	0.8%	0.5%
18 hours	11.2	5.9	0.78	0.41	3.84	3.47	429.3	595.8	0.9%	0.6%
24 hours	12.9	6.9	0.90	0.48	4.98	4.56	484.7	658.9	1.0%	0.7%

4 Hydraulic Modelling

4.1 MODELLED SCENARIOS

Hydraulic modelling for this study was undertaken using the TUFLOW version 2020-10-AD-iSP. In order to assess and determine the likely flood impacts of the proposed raised dam condition, two scenarios were modelled – for the ‘Existing Case’ and the ‘Proposed Case’, as summarised in Table 4-1.

Table 4-1 Summary of modelled scenarios

Scenario	Summary
Existing Case	Represents the dam in its existing condition, with the spillway level at 61.5 mAHD and the wall of the dam at 70.4 mAHD.
Proposed Case	Represents the dam with the proposed spillway raised by 8.5 m to 70.0 mAHD and the wall of the dam at 77.0 mAHD. The scenario also includes the proposed upgrade to McCabes Bridge.

The following sections outline the TUFLOW hydraulic model setup for both scenarios.

4.2 MODEL EXTENT

The hydraulic model extends from approximately 10 km upstream of the spillway at Clarrie Hall Dam to 400 m downstream of Bray Park Weir, which is situated approximately 15 km downstream of the dam. The TUFLOW model extent is presented in Figure 4-1.

4.3 GRID SIZE

The ability of TUFLOW to support variable grid cell sizes using a quadtree mesh were utilised within the hydraulic model. The benefits of using a quadtree mesh include improved hydraulic computations at specific areas of interest, and typically faster simulation times.

For this study, a 16 m grid was used for the dam’s existing FSL storage at 61.5 mAHD, and an 8 m grid size applied to the rest of the model. These grid sizes allow for adequate representation of topographic features, especially within the creek, where the finer grid size ensures better hydraulic representation of the creek. Within the dam storage area, there is not much variation in water levels; hence, a coarser grid is sufficient to simulate the flow passage through the storage area.

4.4 MODEL BOUNDARIES

The hydrological study of the Clarrie Hall Dam conducted by WRM (2017) forms the basis of the hydrological inputs and was originally conducted using AR&R 1987 methods. The RORB hydrological model, as provided by Council, was updated to incorporate AR&R 2019 methods for the current study. The outputs of the updated RORB hydrological model are used as inflow inputs into the TUFLOW hydraulic model.

Total and local inflow boundary conditions were derived from the RORB model and applied at each of the sub-catchments, based on the sub-catchment delineation. The same hydrological inflows were used for both the Existing Case and the Proposed Case.

Catchment flows entering at the top of the TUFLOW model were applied as flow vs time (QT) boundaries (polylines). Local inflows were applied directly to the 2D domain by applying inflow to the lowest 2D cell in the sub-catchment using 2D surface-area (SA) inflow boundaries (polygons).

An automatically generated head-flow (HQ) boundary was adopted as the downstream boundary with a 0.001 (0.1%) slope assigned based on local topography. The TUFLOW boundaries are presented in Figure 4-1.

4.5 MODEL TOPOGRAPHY

The following LiDAR were used, in order of precedence (with the lower numbered DEMs having higher priority), as the base TUFLOW model topography:

1. Bathymetry Survey of Doon Doon Creek and Tweed River (2023)
2. Hydrographic survey (2017) of Clarrie Hall Dam (2017)
3. 1 m LiDAR of the Clarrie Hall Dam catchment (2022)
4. 0.5 m LiDAR of the Tweed River from the spillway up to Bray Park Weir (2022)
5. 1 m DEM – Murwillumbah201309-LID1-AHD (2013)
6. 2 m DEM – Murwillumbah201709-LID2-AHD (2017).

The available DEMs and their extents are presented in Figure 2-1.

For the Existing Case, terrain modification was done by adding a breakline (2d_zsh line) to enforce the current dam wall crest elevation of 70.4 mAHD within the 2D domain. This ensured that the dam's wall was modelled appropriately in the hydraulic model.

For the Proposed Case, the dam wall is raised to 77.0 mAHD. A breakline (2d_zsh line) was added to enforce the proposed wall level. A design drawing file (WAT70-1_28-A.dwg) of the proposed road alignment for the upgrade McCabes Bridge was provided and converted to a DEM and included in the Proposed Case. The proposed road alignment is shown in Figure 1-2.

There was no requirement to enforce or modify the spillway topographically in the 2D domain, as the spillway was modelled within the 1D domain as a 'Q' channel, as outlined in section 4.6.

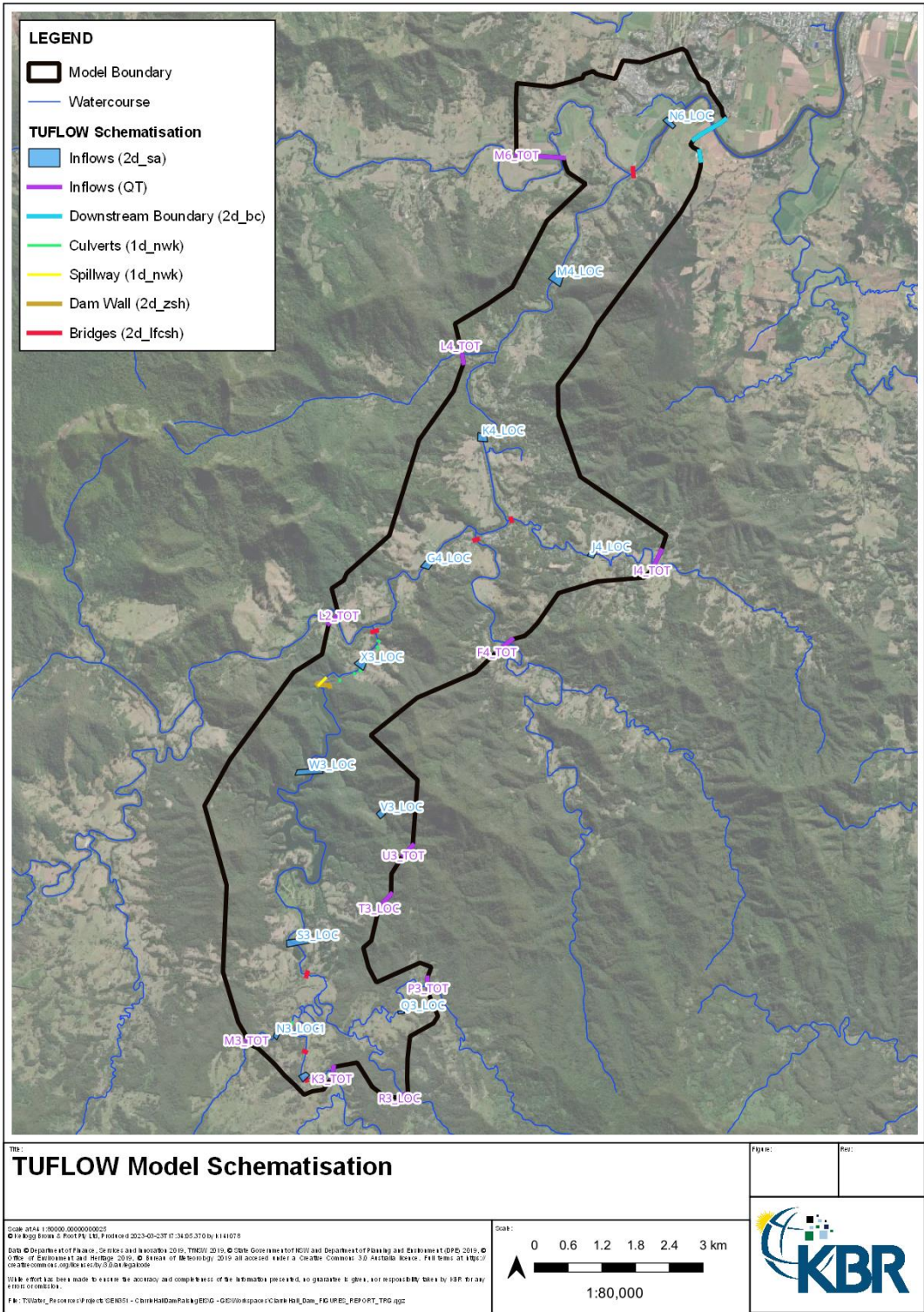


Figure 4-1 TUFLOW model schematisation

4.6 SPILLWAY MODELLING

Tweed Shire Council provided the spillway rating curve for the Existing Case and Proposed Case. The spillway rating curves are as presented in Section 2.4. The spillway was modelled in the 1D domain of TUFLOW as a 'Q' Channel, which applies a depth-discharge relationship to simulate flow over the spillway.

The representation of the spillway structure as a 'Q' structure within the hydraulic model using the depth-discharge relationship ensured that the simulated spillway's flow outputs for both the Existing Case and the Proposed Case matched their respective spillway rating curves provided by Council. The use of a 'Q' channel also meant that the spillway need not be modelled within the 2D domain of the hydraulic model. As such, the discharge location of the modelled 'Q' channel 1D spillway was applied at the creek downstream of the dam for both scenarios.

The spillway rating curves provided for the existing and proposed spillways were used to develop the depth-discharge relationship for both the Existing Case and the Proposed Case, respectively. The depths of flows over the spillway were based on the spillway crests' levels; that is, 61.5 mAHD for the existing spillway and 70.0 mAHD for the proposed spillway (raised by 8.5 m).

Figure 4-2 and Figure 4-3 show the depth-discharge relationships for the existing and proposed spillways, converted from the spillway rating curves, used to model the respective spillways in the TUFLOW hydraulic model. The depth-discharge curves show that at the same depths, higher flows are achieved for the proposed spillway when compared against the existing spillway due to the longer width of the proposed spillway.

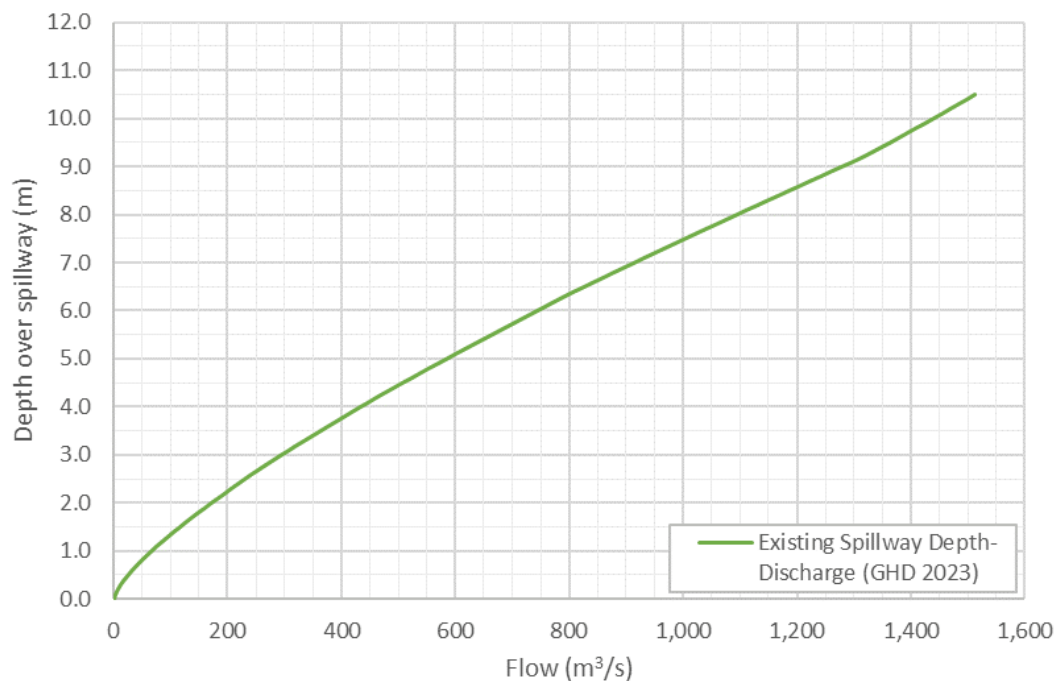


Figure 4-2 Depth-discharge relationship for the existing spillway (Existing Case)

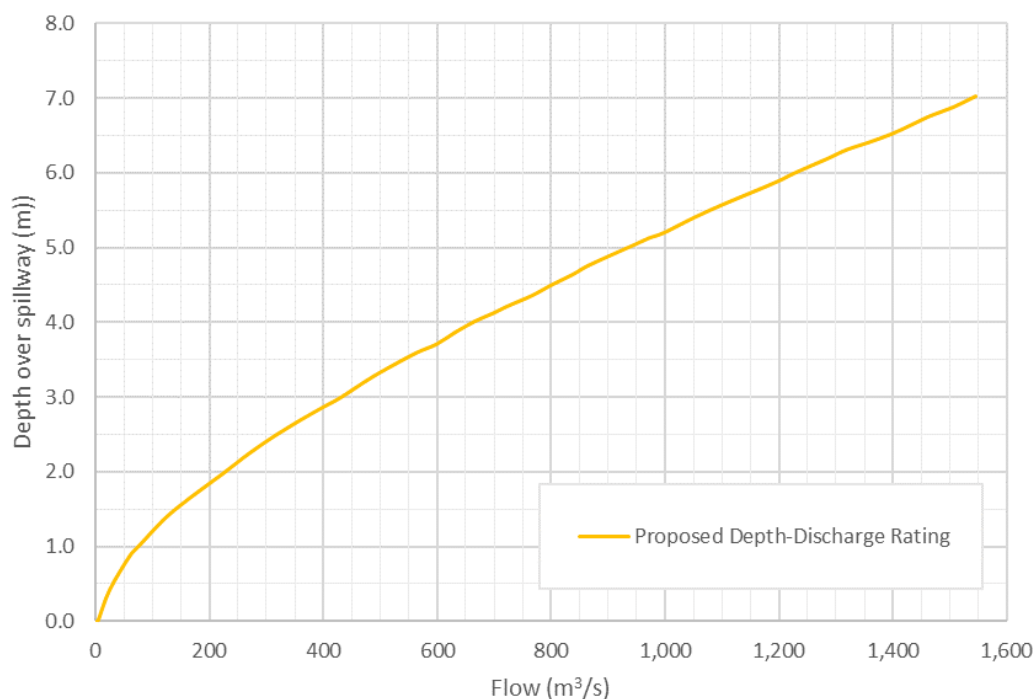


Figure 4-3 Depth-discharge relationship for the proposed spillway (Proposed Case)

4.7

HYDRAULIC STRUCTURES

Hydraulic structures modelled within the hydraulic model includes culverts and bridges and are summarised in sections 4.7.1 and 4.7.2. The locations of the hydraulic structures are shown in Figure 4-1.

4.7.1

Bridges

Bridges that have been identified within the hydraulic model and which were known to affect flow and water levels within Doon Doon Creek and Tweed River were modelled as layered flow constrictions (2d_lfcs) lines. The layered flow constrictions parameters were approximated based on aerial photography and local topography. Table 4-2 presents the bridges identified and included within the hydraulic model. The layered flow constriction parameters for these bridges are presented in Table 4-3.

Table 4-2 Bridges identified within the hydraulic model

Bridge	Description and location
Doon Doon Rd 1	Doon Doon Road crossing Doon Doon Creek; 3.0 km upstream of McCabes Bridge
Doon Doon Rd 2	Doon Doon Road crossing Doon Doon Creek; 2.3 km upstream of McCabes Bridge
McCabes Bridge	At Commissioner Creek Road crossing Doon Doon Creek; upstream of the Clarrie Hall Dam. As part of the upgrade to the dam, this bridge is also proposed to be upgraded
Kyogle Rd 1	Kyogle Road crossing Doon Doon Creek; downstream of Clarrie Hall Dam, close to confluence with Tweed River
Kyogle Rd 2	Kyogle Road crossing Rowlands Creek; close to confluence with Tweed River
Kyogle Rd 3	Kyogle Road crossing Smiths Creek; close to confluence with Tweed River
Byangum Bridge	Kyogle Road crossing Tweed River

Table 4-3 Bridge layered flow constriction (2d_lfcsh) parameters

Lfcsh parameter	Doon Doon Rd 1	Doon Doon Rd 2	McCabes Bridge*	Kyogle Rd 1	Kyogle Rd 2	Kyogle Rd 3	Byangum Bridge
Invert	DEM	DEM	DEM	DEM	DEM	DEM	DEM
dZ	0	0	0	0	0	0	0
Shape_Width (m)	4	4	6 (9)	6	8	8	12
Shape_Options	–	–	–	–	–	–	–
L1_Obvert (mAHD)	79.6	76.2	65.5 (71.0)	29.4	20.1	16	5
L1_pBlockage (%)	5	5	5	5	5	5	5
L1_FLC	0.1	0.1	0.1	0.1	0.1	0.1	0.1
L2_Depth (m)	1	1	1	1	1	1	1
L2_pBlockage (%)	100	100	100	100	100	100	100
L2_FLC	0.42	0.42	0.2 (0.262)	0.2	0.2	0.215	0.2
L3_Depth (m)	1.1	1.1	1.1	1.1	1.1	1.1	1.1
L3_pBlockage (%)	30	30	30	30	30	30	30
L3_FLC	0	0	0	0	0	0	0

*The bridge configurations for the proposed upgrade to McCabes Bridge are presented in parentheses

4.7.2 Culverts

Four cells of 2.1 m by 1.8 m reinforced concrete box culverts were estimated and modelled on Doon Doon Road at its crossing of Pine Log Creek, situated approximately 1.2 km upstream of McCabes Bridge.

Six culverts identified downstream of the dam on Clarrie Hall Dam Road were modelled parallel to Doon Doon Creek. The culverts were all assumed to be 600 mm diameter single-barrel reinforced concrete culverts.

Table 4-4 presents the culverts' parameters used in the TUFLOW model.

Table 4-4 Culvert parameters

Culvert parameters	Culv01	CHD01	CHD02	CHD04	CHD03	CHD05	CHD06
Type	R	C	C	C	C	C	C
Ignore	F	F	F	F	F	F	F
UCS	T	T	T	T	T	T	T
Len_or_ANA (m)	-1	-1	-1	-1	-1	-1	-1
n_nF_Cd	0.013	0.013	0.013	0.013	0.013	0.013	0.013
US_Invert (mAHD)	72.8	49.8	33.5	27.8	27.6	24.1	21.9
DS_Invert (mAHD)	72.65	48.1	32	26.5	26.5	22.9	21.0
Form_Loss	0	0	0	0	0	0	0

Culvert parameters	Culv01	CHD01	CHD02	CHD04	CHD03	CHD05	CHD06
pBlockage (%)	0	0	0	0	0	0	0
Inlet_Type	–	–	–	–	–	–	–
Conn_1D_2D	–	–	–	–	–	–	–
Conn_No	0	0	0	0	0	0	0
Width_or_D (m)	2.1	0.6	0.6	0.6	0.6	0.6	0.6
Height_or_ (m)	1.8	0	0	0	0	0	0
Number_of	4	1	1	1	1	1	1
HConF_or_W	0.6	0	0	0	0	0	0
WConF_or_W	0.9	1	1	1	1	1	1
EntryC_or_	0.5	0.5	0.5	0.5	0.5	0.5	0.5
ExitC_or_W	1	1	1	1	1	1	1

Other culverts within the hydraulic model located downstream of the confluence of Doon Doon Creek and the Tweed River were not modelled as the regional nature of the hydraulic modelling did not warrant inclusion of these structures. Information on additional culverts within the modelled domain were not available and it was not possible to estimate the culverts' parameters (e.g. size and shape) from the aerial imagery as they were not clearly visible.

4.8 HYDRAULIC ROUGHNESS

The hydraulic roughness (Manning's 'n') areas in the TUFLOW model were mainly determined based on aerial imagery. The Manning's roughness values are presented in Table 4-5 and the Manning's roughness distribution in the hydraulic model is shown in Figure 4-4.

Table 4-5 Manning's roughness values

Material	Roughness value
Open space	0.045
Dam spillway	0.020
Watercourse	0.040
Still water body (Dam storage at FSL 61.5 mAHD [Existing Case] and FSL 70.0 mAHD [Proposed Case])	0.025
Dense vegetation	0.100
Road corridor	0.025
Urban area	0.100

4.9 INITIAL WATER LEVEL

The Clarrie Hall Dam was assumed to be at FSL in both the Existing Case and the Proposed Case at the start of the hydraulic simulation – that is, water level at spillway crest levels. Hence, an initial water level (IWL) of 61.5 mAHD and 70.0 mAHD were applied for the Existing Case and Proposed Case, respectively.

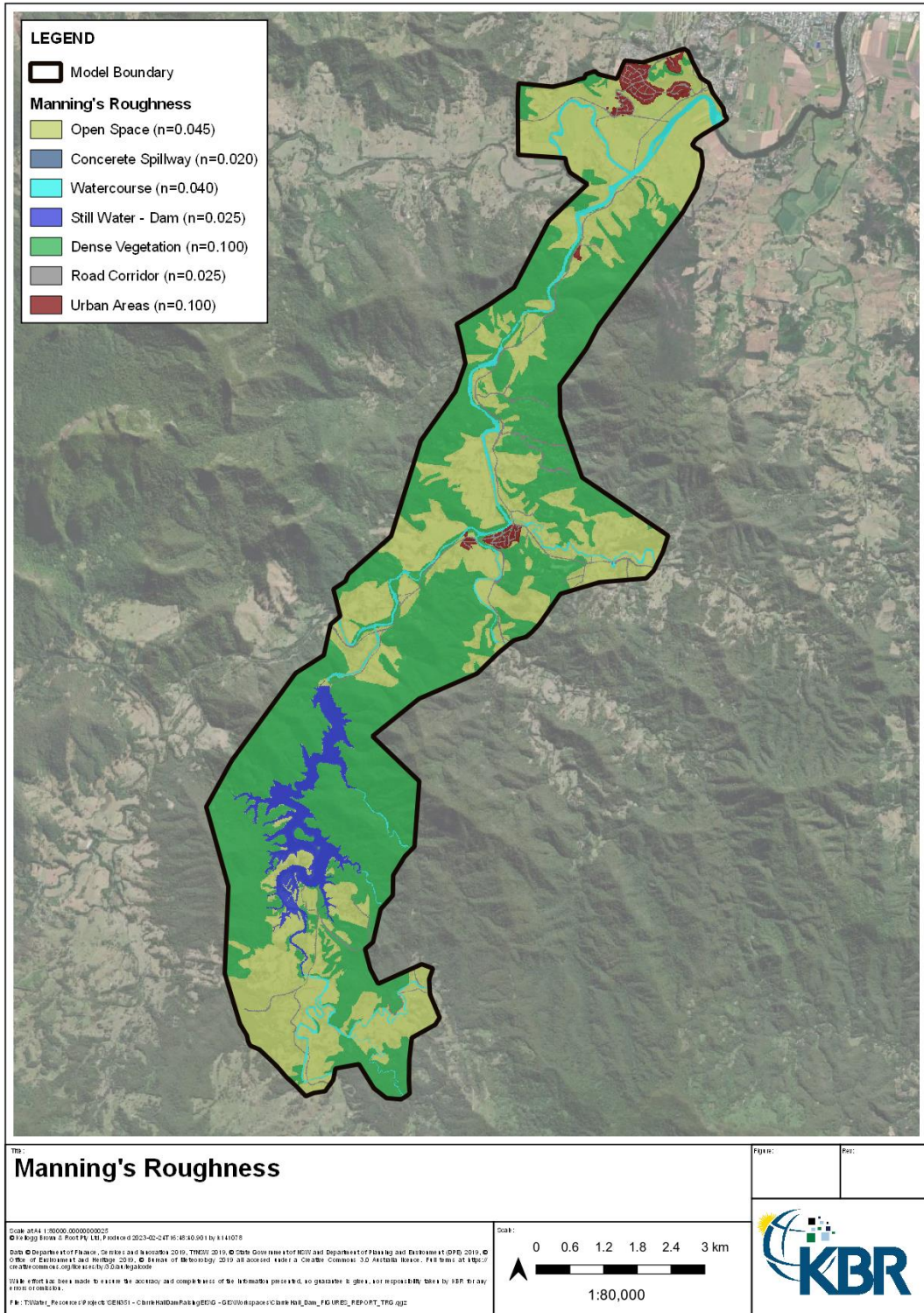


Figure 4-4 Manning's roughness applied in the TUFLOW hydraulic model

5 Validation of Calibration Events

5.1 INTRODUCTION

The WRM (2017) hydrological modelling conducted calibration of the RORB model for three historic events, the January 2008 event, January 2012 event and the January 2013. The calibration was conducted with flows from gauges at the Uki (201900) and Eungella (201001) gauging stations for the 2008 event and, Palmer (558018), Uki and Eungella gauges for the 2012 and 2013 event.

Further information on the calibration can be obtained from the WRM (2017) hydrological modelling reporting.

5.2 VALIDATION MODELLING

The Uki gauge is situated within the bounds of the current TUFLOW model at the town of Uki. The Uki gauge records river flow in the Tweed River and is situated approximately 4.5 km downstream of the dam.

Validation modelling was conducted on the TUFLOW model to determine the performance of the TUFLOW modelling against the three historic events.

The three calibrated RORB models of each of the historic events were provided by Council.

Modelled hydrographs for the required sub-catchments were extracted from the calibrated RORB hydrological models to be used as inflows in the TUFLOW hydraulic model.

5.3 VALIDATION RESULTS

The modelled flows from the TUFLOW hydraulic model were compared against the RORB modelled flows and recorded flows at the Uki Gauge for the three historic events. The modelled and recorded flood hydrographs for the three historic events are presented in Figure 5-1, Figure 5-2 and Figure 5-3.

The TUFLOW validation modelling also shows that the general timing and shape of the TUFLOW and RORB modelled hydrographs are the same indicating similar catchment response in terms of routing providing further validation between the RORB and TUFLOW models.

The calibration of the TUFLOW and RORB models against the historical data shows alignment in timing of the catchment response, with over estimation of peak flows in one event and under in the two other events. This is aligned with the outcomes of the WRM modelling which was previously considered fit for purpose.

The results of the validation event modelling demonstrated that the TUFLOW model is able to produce discharges which suitably replicate recorded flows at the Uki Gauge.

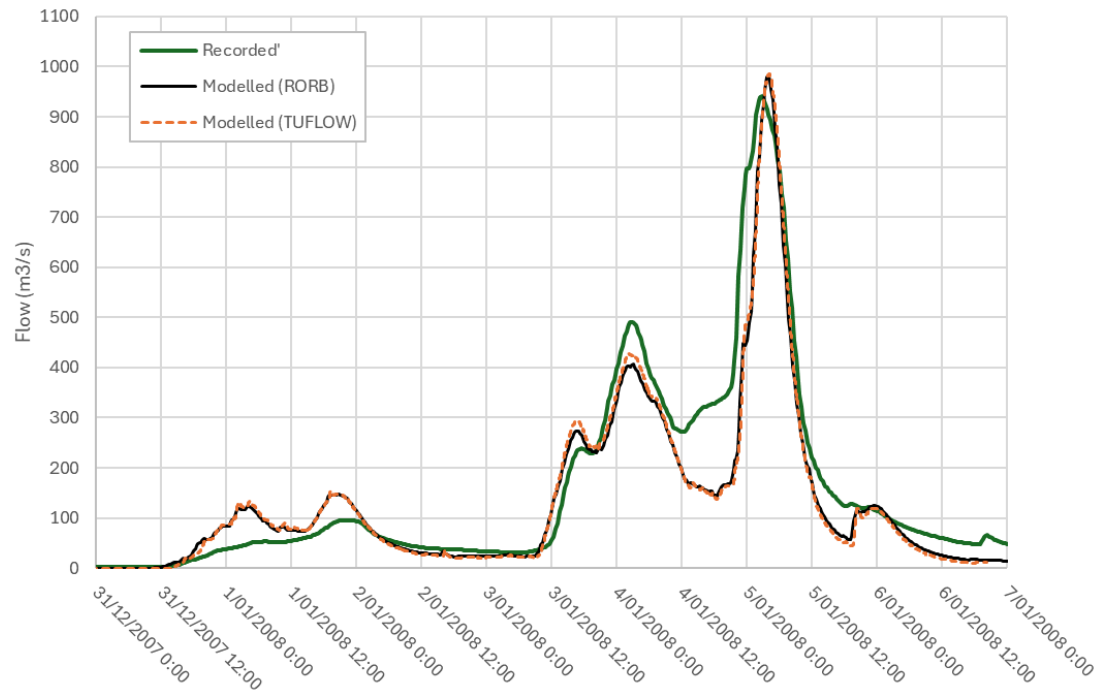


Figure 5-1 Modelled and recorded flow discharges at Uki Gauge – 2008 event

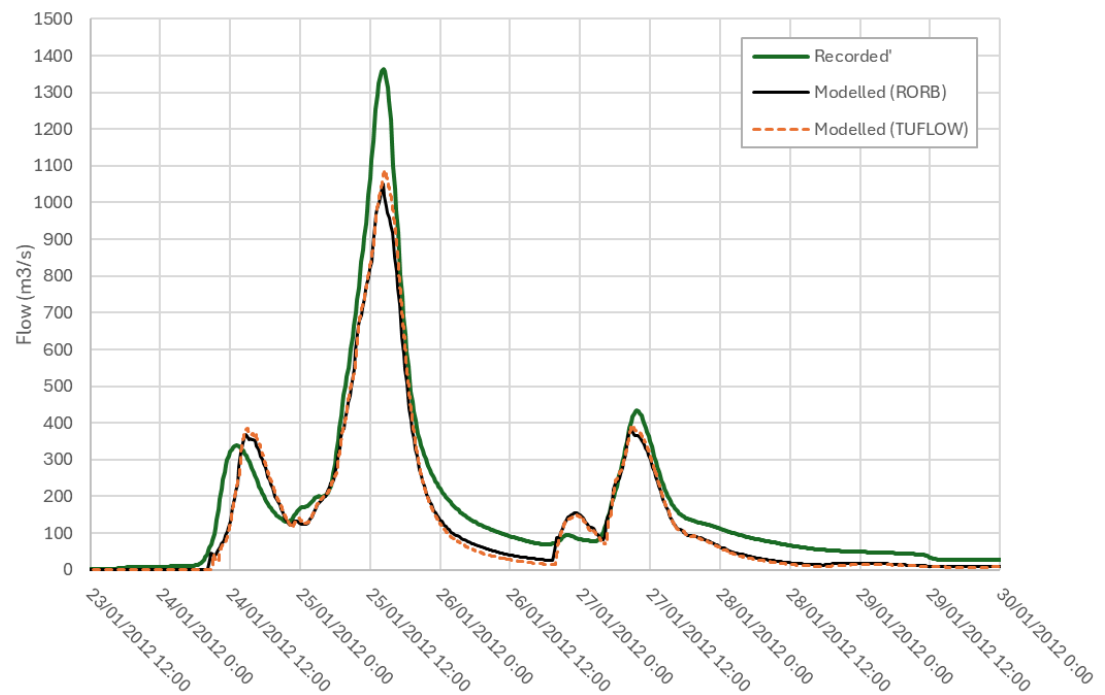


Figure 5-2 Modelled and recorded flow discharges at Uki Gauge – 2012 event

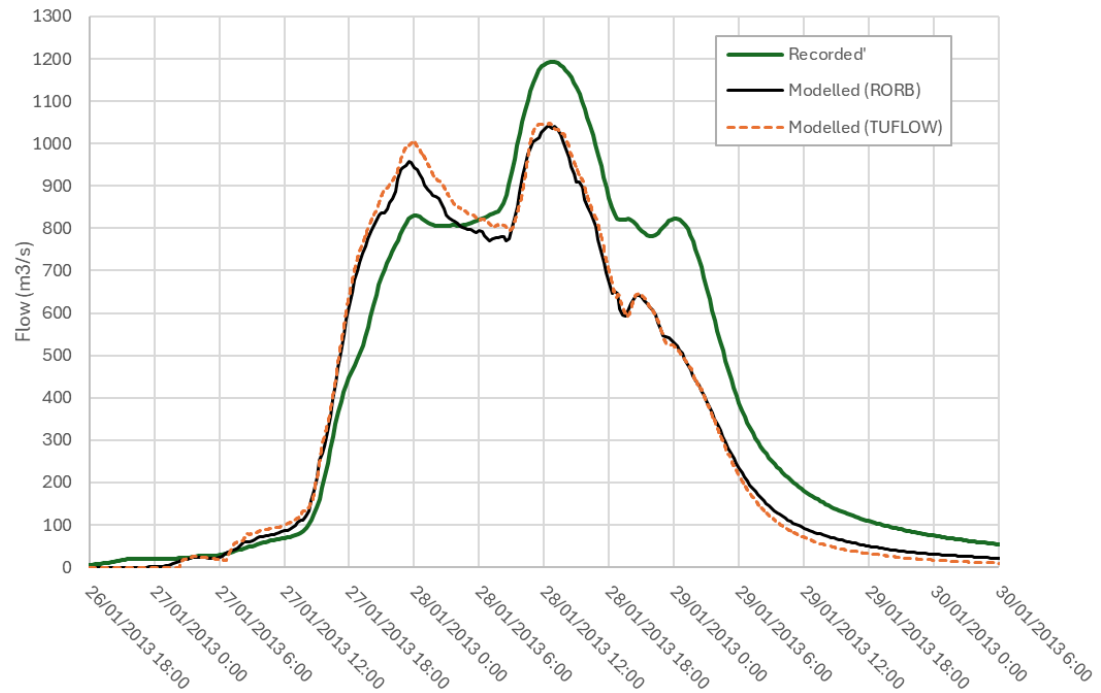


Figure 5-3 Modelled and recorded flow discharges at Uki Gauge – 2013 event

5.4

UKI GAUGE

The gauge at Uki records the flow in the Tweed River at the town of Uki. The Uki rating curve is provided in the BoM Water Data Online (<http://www.bom.gov.au/waterdata/>) and is presented below. A total of 268 gaugings were undertaken over the period of record with the highest gauging undertaken in April 1989 at a gauge height of 3.425 m (12.391 mAHD).

The flows for the three historic events were based on the BoM rating curve. When simulated through TUFLOW, flows are matched at the gauge. However, there are differences in water levels noted above the 4m stage. The BoM rating curve was maintained due to low certainty in flows beyond the recorded stages, as well as to maintain consistency with previous modelling and BoM's basis of understanding.

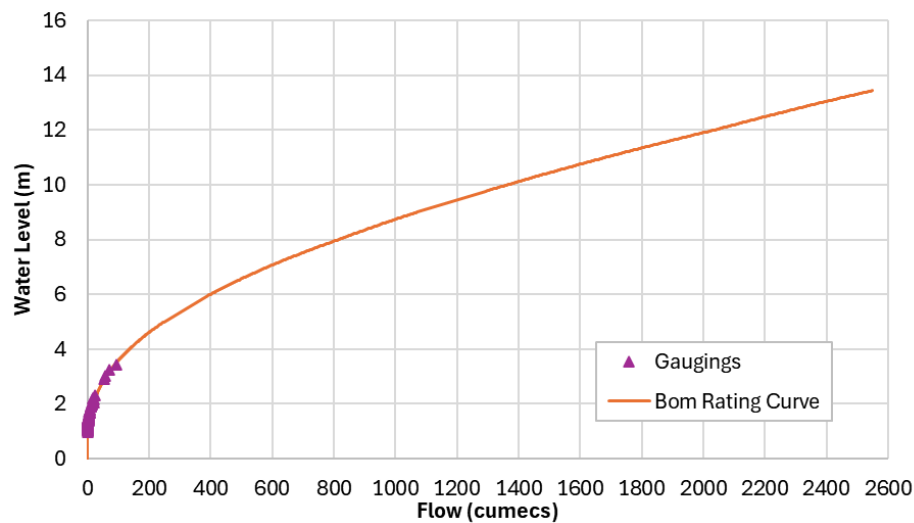


Figure 5-4 Uki Gauge Rating Curve

6 Hydraulic Modelling Results

6.1 MODELLED DESIGN EVENTS

Hydraulic simulations for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and the PMF design events were conducted to assess the likely impacts of the proposed raised dam conditions. The climate change scenarios based on high emissions pathways, SSP3-7.0.

To ensure that the maximum flood levels were captured for both the Existing Case and the Proposed Case, all the durations, 6-hour, 9-hour, 12-hour, 18-hour and 24-hour storm events were modelled for the 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP design events, using the selected temporal patterns outlined in Section 3.4.

The 24-hour and 48-hour storm events were run for the PMF. Results from the hydraulic simulations for the design events are reported in Sections 6.3 to 6.8.

6.2 FLOOD FREQUENCY ANALYSIS

A Flood Frequency Analysis (FFA) was undertaken on recorded stream flow data at the gauge at Uki.

Recorded stream flow gauge data was available from the BoM Water Data Online portal (<http://www.bom.gov.au/waterdata/>) for the years from 1967 to 2023. This data was used to generate an annual maxima series based on the water years (June to July). There was no data recorded between the years 1983 and 1995. In total, 43 years of recorded data at the Uki gauge were used to generate the data.

The Log-Pearson Type III (LPIII) distribution method provided a good fit of the recorded data and was used in the FFA analysis for comparison of the modelled peak flows from TUFLOW. Figure 6-1 provides the LPIII distribution the recorded flows and modelled flow.

The FFA shows that the modelled flows for all modelled design events are within the confidence bounds, thus providing further confidence of modelled flows within the TUFLOW model.

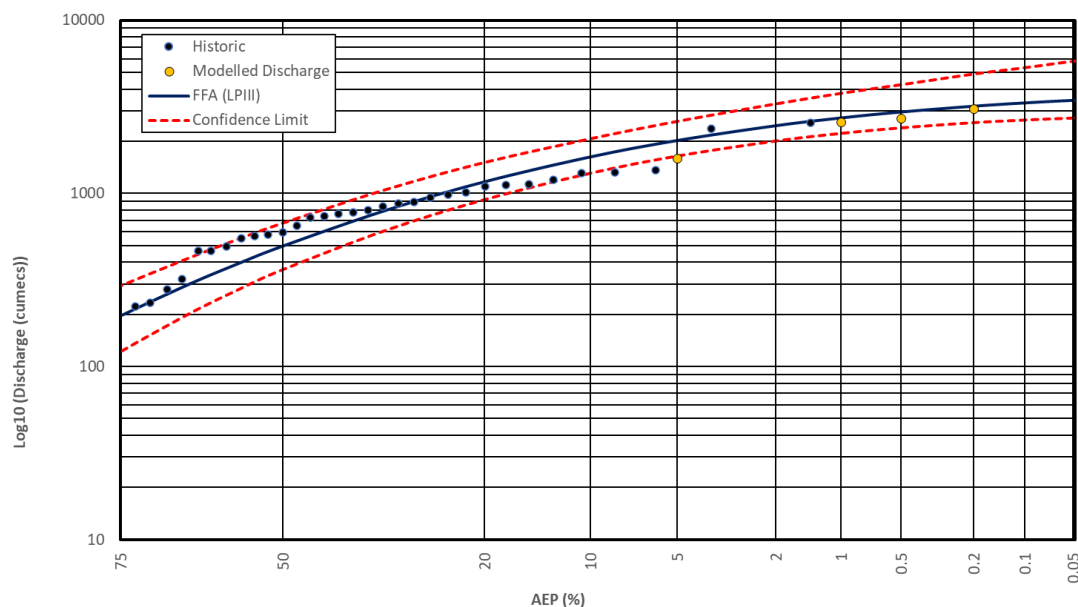


Figure 6-1 FFA Distribution at the Uki Gauge with modelled TUFLOW discharge

6.3 RESULTS AT DAM AND SPILLWAY

6.3.1 Peak Discharges and Water Level

For the Existing Case, the PMF design event modelled a peak water level of 71.05 mAHD at the dam, which overtopped the dam's embankment (currently at 70.4 mAHD). While the spillway discharged a peak flow of 1,367 m³/s during the PMF, a flow of 288 m³/s overtopped the wall of the dam. Some of the overtopped dam water flows onto Clarrie Hall Dam Road and makes its way down the road before re-joining Doon Doon Creek further downstream. Flood depths of not more than 1m are simulated on this stretch of the road.

For the Proposed Case, a peak dam water level of 76.94 mAHD was modelled for the PMF design event. While the modelled water level was higher than the Existing Case, the raised Dam wall elevation of 77.0 mAHD ensured no overtopping of flow from the dam, thus ensuring a safer dam.

In both the Existing Case and the Proposed Case, there is no overtopping of flow at the dam's wall in the 0.5% AEP, 0.2% AEP, 1% AEP and 5% AEP design events.

Table 6-1 shows the modelled discharges and corresponding water level in the dam for all design events. Figure 6-2 and Figure 6-3 present the modelled spillway flows and dam water levels.

Table 6-1 Peak flows at the spillway and corresponding water level in the dam for all design events

Design event (AEP)	Spillway peak flows (m ³ /s)			Dam water level (mAHD)		
	Existing Case	Proposed Case	Difference	Existing Case	Proposed Case	Difference (m)
5%	356	330	-26	64.96 (3.46 m)	72.56 (2.56 m)	7.60
1%	532	493	-39	66.18 (4.68 m)	73.31 (3.31 m)	7.13
0.5%	560	527	-33	66.36 (4.86 m)	73.45 (3.45 m)	7.09
0.2%	661	631	-30	67.00 (5.50 m)	73.87 (3.87 m)	6.87
PMF	1655*	1516	-139	71.05 (9.55 m)	76.94 (6.94 m)	5.89

*Includes spillway flow of 1,367 m³/s and overtopping of the dam's embankment (~288 m³/s) occurring in the PMF design event.

Note: Figures in parentheses are depth above spillway levels: 61.5 mAHD (Existing Case) and 70.0 mAHD (Proposed Case)

6.3.2 Spillway Rating Curve

The PMF 24-hour duration AEP event simulated the maximum flow over the spillway in both the Existing Case and the Proposed Case. The outputs from the PMF 24-hour design event were used to verify that the modelled spillway rating curves are performing as intended. Figure 6-2 and Figure 6-3 present the rating curve for the modelled spillways for the Existing Case and the Proposed Case, respectively; the peak flows and dam water level for all design events are also presented.

The results show that the rating curves derived for the modelled spillway in both the Existing Case and the Proposed Case match their respective provided design stage-discharge curves. Hence, it can be concluded that the spillway has been modelled as intended, thus providing more confidence in the modelled water levels of the dam.

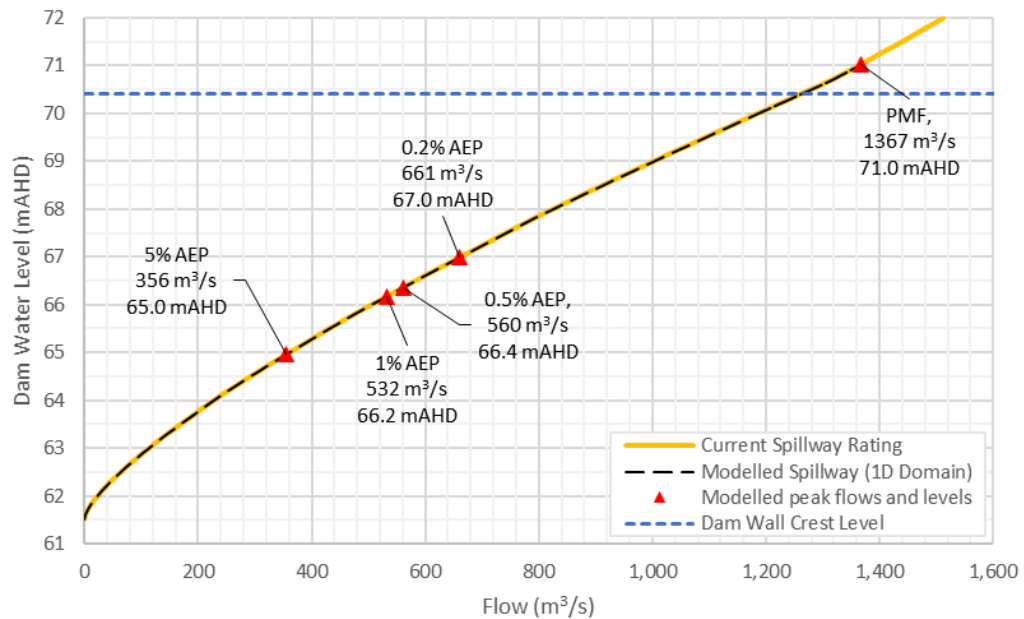


Figure 6-2 Modelled spillway rating curve with peak flows and water levels – Existing Case

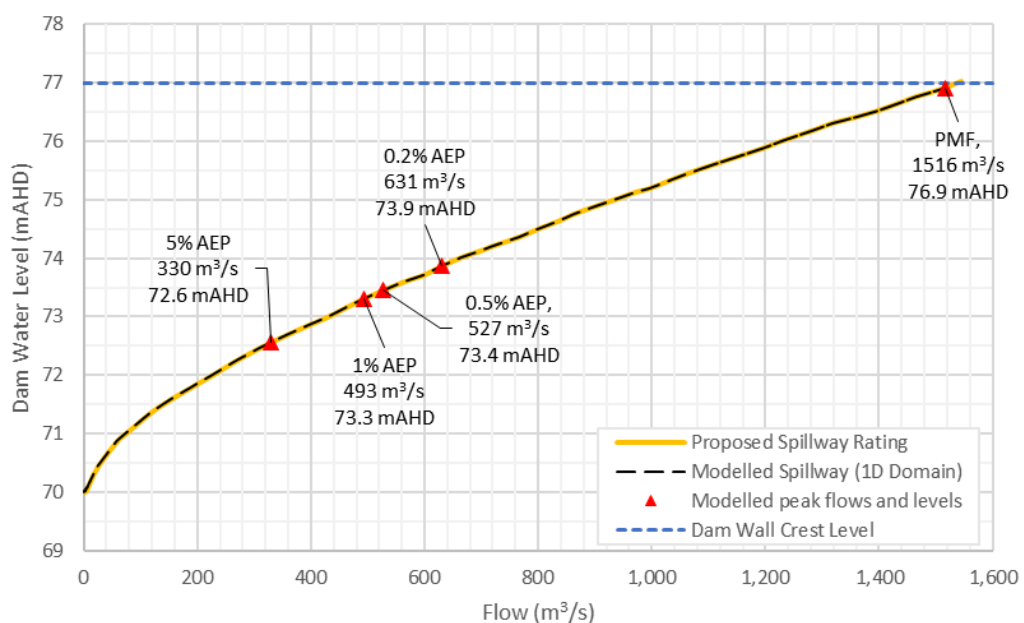


Figure 6-3 Modelled spillway rating curve with peak flows and water levels – Proposed Case

6.4 FLOOD MAPPING

Flood mapping of the results from the hydraulic modelling of the design events for the Existing Case and the Proposed Case are presented in Appendix A and Appendix B respectively, and includes the peak flood depths and levels, peak flood velocities and peak flood hazards. The differences in flood levels, velocities and hazards between the Proposed Case and the Existing Case are presented in Appendix C. For the Climate change scenarios, the differences in Flood levels between the Proposed Case and Existing Case are presented in Appendix D.

6.5 FLOOD IMPACTS

Flood levels and velocities were also extracted at 12 reporting points from locations of interest in both upstream and downstream of the dam. The locations of the reporting are shown in Figure 6-4.

The impacts on flooding due to the raising of the Clarrie Hall Dam for the modelled design events are presented in Appendix C. Section 6.5.1 and section 6.5.2 report on the flood impacts simulated in the modelled area, with the modelled area divided into the area downstream of the dam and the area upstream of the dam, for clarity.

6.5.1 Upstream of the Dam

Peak Flood Levels

Peak flood levels extracted at the locations of the reporting points (RP) for areas upstream of the dam for the Existing Case and the Proposed Case are presented in Table 6-2 and Table 6-3, respectively. The differences in flood levels are presented in Table 6-4. The changes in peak flood level are presented in Appendix C1 to Appendix C5.

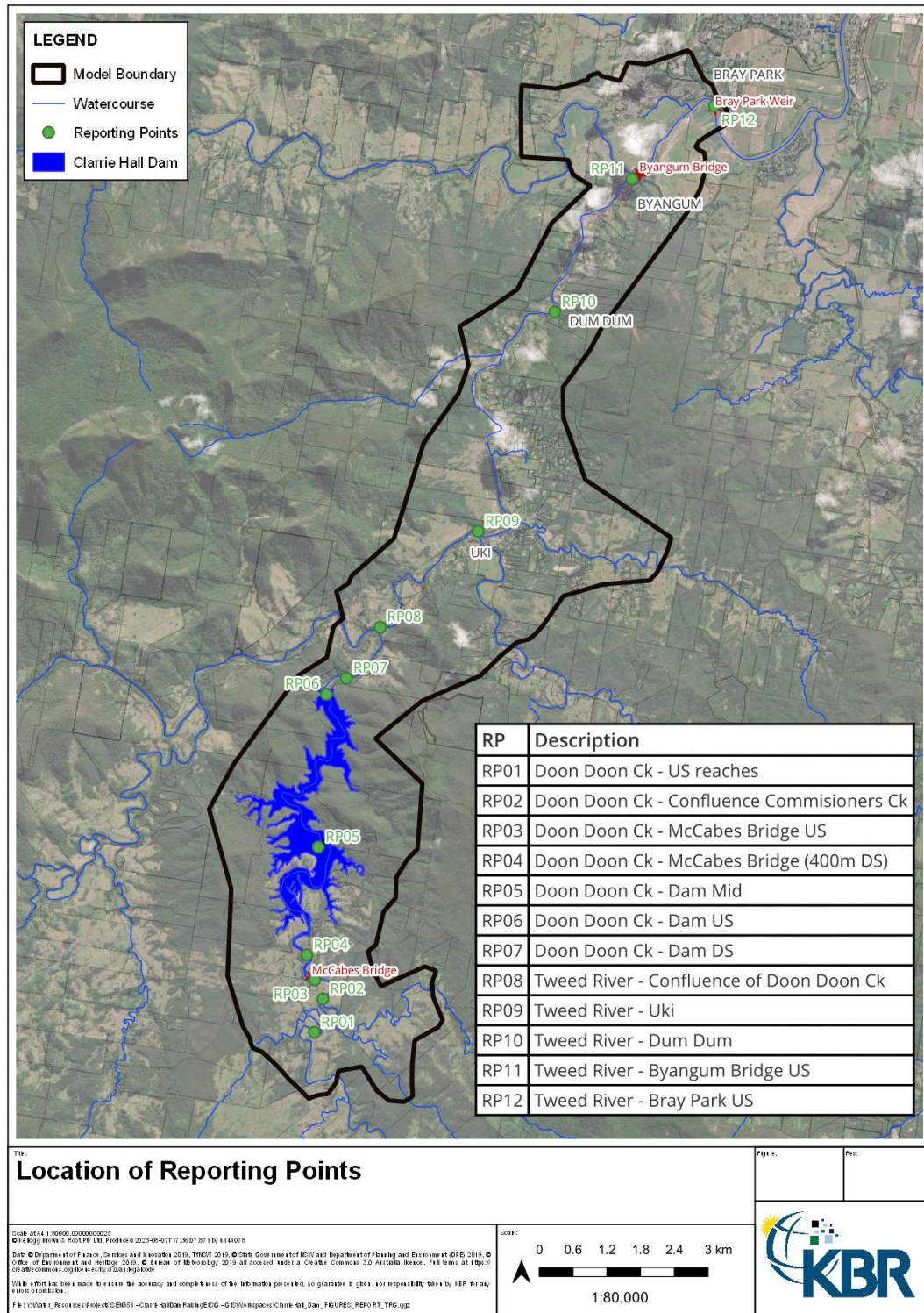


Figure 6-4 Location of reporting points (RP)

Table 6-2 Flood levels (mAHD) upstream of Clarrie Hall Dam – Existing Case

RP	Description	Flood levels (mAHD)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP01	Doon Doon Ck – US reaches	75.00	75.95	76.07	76.24	76.31
RP02	Doon Doon Ck – Confluence Commissioners Creek	68.85	70.15	70.35	70.67	71.97
RP03	Doon Doon Ck – McCabes Bridge US	67.74	68.64	69.06	69.29	71.33
RP04	Doon Doon Ck – McCabes Bridge (400m DS)	65.79	66.71	66.84	67.28	71.18
RP05	Doon Doon Ck – Dam Mid	64.98	66.22	66.40	67.05	71.15
RP06	Doon Doon Ck – Dam US	64.96	66.18	66.36	67.00	71.05

Table 6-3 Flood levels (mAHD) upstream of Clarrie Hall Dam – Proposed Case

RP	Description	Flood levels (mAHD)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP01	Doon Doon Ck – US reaches	75.00	75.97	76.10	76.28	77.29
RP02	Doon Doon Ck – Confluence Commissioners Creek	72.61	73.41	73.55	74.06	77.07
RP03	Doon Doon Ck – McCabes Bridge US	72.59	73.34	73.49	73.92	77.00
RP04	Doon Doon Ck – McCabes Bridge (400m DS)	72.56	73.31	73.46	73.88	76.97
RP05	Doon Doon Ck – Dam Mid	72.56	73.31	73.46	73.88	76.96
RP06	Doon Doon Ck – Dam US	72.56	73.31	73.45	73.87	76.94

Table 6-4 Differences in flood levels (m) upstream of Clarrie Hall Dam – Proposed Case minus Existing Case

RP	Description	Differences in Flood Levels (m)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP01	Doon Doon Ck – US reaches	0.00	0.02	0.03	0.04	0.98
RP02	Doon Doon Ck – Confluence Commissioners Creek	3.76	3.26	3.20	3.39	5.10
RP03	Doon Doon Ck – McCabes Bridge US	4.85	4.70	4.43	4.63	5.67
RP04	Doon Doon Ck – McCabes Bridge (400m DS)	6.77	6.60	6.62	6.60	5.79
RP05	Doon Doon Ck – Dam Mid	7.58	7.09	7.06	6.83	5.81
RP06	Doon Doon Ck – Dam US	7.60	7.13	7.09	6.87	5.89

Upstream of the dam's spillway, flood levels are increased by up to 7.6 m in the dam's storage area. Table 6-4 shows that the water levels in the dam increase by between 5.9 m and 7.7 m for the design events. This flood level increase is due to the raising of the dam and the spillway which results in a higher FSL, as well as all flows out of the dam contained to the spillway.

The maximum rise in peak water level of 7.6 m is less than the dam raising level of 8.5 m. This is due to an increase in dam storage and spillway conveyance.

The severity of the rise in flood levels reduces further upstream of the dam. At the confluence of the Doon Doon Creek and Commissioner's Creek, increases in peak flood level for design events up to the 0.2% AEP event are noted to dissipate. For the PMF event, the increase in peak flood level is simulated to extend further upstream of the confluence.

Flood Velocity

Flood velocities extracted at the reporting locations for areas upstream of the dam for the Existing Case and the Proposed Case are presented in Table 6-5 and Table 6-6, respectively. The differences in flood velocities are presented in Table 5-7.

The differences in flood velocities are presented in Appendix C6 to Appendix C10.

Table 6-5 Flood velocities (m/s) upstream of Clarrie Hall Dam – Existing Case

RP	Description	Flood velocities (m/s)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP01	Doon Doon Ck – US reaches	2.17	2.23	2.24	2.27	2.29
RP02	Doon Doon Ck – Confluence Commissioners Creek	3.16	3.72	3.67	3.82	3.20
RP03	Doon Doon Ck – McCabes Bridge US	1.94	2.61	2.48	2.81	2.45
RP04	Doon Doon Ck – McCabes Bridge (400m DS)	2.28	3.03	3.08	3.20	2.72
RP05	Doon Doon Ck – Dam Mid	0.15	0.20	0.20	0.25	0.27
RP06	Doon Doon Ck – Dam US	0.09	0.12	0.13	0.14	0.29

Table 6-6 Flood velocities (m/s) upstream (US) of Clarrie Hall Dam – Proposed Case

RP	Description	Flood velocities (m/s)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP01	Doon Doon Ck – US reaches	2.17	2.23	2.24	2.28	2.29
RP02	Doon Doon Ck – Confluence Commissioners Creek	1.16	1.76	1.80	1.91	1.54
RP03	Doon Doon Ck – McCabes Bridge US	0.70	1.24	1.28	1.39	1.05
RP04	Doon Doon Ck – McCabes Bridge (400m DS)	0.42	0.78	0.80	0.86	0.63
RP05	Doon Doon Ck – Dam Mid	0.05	0.08	0.08	0.10	0.09
RP06	Doon Doon Ck – Dam US	0.41	0.41	0.41	0.41	0.41

Table 6-7 Differences in flood velocities (m/s) US of Clarrie Hall Dam – Proposed Case minus Existing Case

RP	Description	Differences in flood velocities (m/s)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP01	Doon Doon Ck – US reaches	0.00	0.00	0.00	0.01	0.00
RP02	Doon Doon Ck – Confluence Commissioners Creek	-2.00	-1.96	-1.87	-1.91	-1.66
RP03	Doon Doon Ck – McCabes Bridge US	-1.24	-1.37	-1.20	-1.42	-1.40
RP04	Doon Doon Ck – McCabes Bridge (400 m DS)	-1.86	-2.25	-2.28	-2.34	-2.09
RP05	Doon Doon Ck – Dam Mid	-0.10	-0.12	-0.12	-0.15	-0.18
RP06	Doon Doon Ck – Dam US	0.32	0.29	0.28	0.27	0.12

Flood velocities are generally lower in the upstream reaches of the dam. However, in the vicinity of the spillway, the velocities are noted to have increased by up to 1.0 m/s and, closer to the wall, by more than 1.0 m/s.

McCabes Bridge

In the Proposed Case, the dam upgrade along with the upgrade to McCabes Bridge and changed road alignment resulted in increased peak flood levels and a larger flood extent upstream of the bridge. The upgraded bridge, which has a deck level of 72.0 mAHD, is inundated in all the simulated storm events.

Flood Extents

The flood extents are noted to be wider in the main dam's storage area, with minor increases in flood extent also noted past the confluence of Doon Doon Creek and Commissioners Creek.

6.5.2 Downstream of the Dam

Flood Levels

Peak flood levels for the various design events (AEPs) were extracted at the reporting locations for areas downstream of the dam for the Existing Case and the Proposed Case are presented in Table 6-8 and Table 6-9 respectively. The differences in flood levels are presented in Table 6-10. The differences in flood levels are also presented in Appendix C1 to Appendix C5.

Table 6-8 Flood levels (mAHD) downstream of Clarrie Hall Dam – Existing Case

RP	Description	Flood levels (mAHD)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP07	Doon Doon Ck – Dam DS	29.63	30.93	31.10	31.64	35.17
RP08	Tweed River – Confluence of Doon Doon Ck	27.18	29.08	29.28	29.75	32.99
RP09	Tweed River – Uki	21.24	23.16	23.38	23.94	28.85
RP10	Tweed River – Dum Dum	12.26	14.05	14.27	14.91	21.10
RP11	Tweed River – Byangum Bridge US	9.12	10.13	10.38	10.76	14.13
RP12	Tweed River – Bray Park US	6.56	7.24	7.37	7.70	11.35

Table 6-9 Flood levels (mAHD) downstream of Clarrie Hall Dam – Proposed Case

RP	Description	Flood levels (mAHD)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP07	Doon Doon Ck – Dam DS	29.45	30.67	30.86	31.52	34.86
RP08	Tweed River – Confluence of Doon Doon Ck	26.97	28.93	29.14	29.70	32.87
RP09	Tweed River – Uki	21.06	23.02	23.25	23.82	28.73
RP10	Tweed River – Dum Dum	12.11	13.94	14.16	14.78	21.00
RP11	Tweed River – Byangum Bridge US	9.07	10.09	10.25	10.64	14.10
RP12	Tweed River – Bray Park US	6.52	7.20	7.33	7.66	11.32

Table 6-10 Differences in flood levels (m) downstream of Clarie Hall Dam – Proposed Case minus Existing Case

RP	Description	Differences in flood levels (m)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP07	Doon Doon Ck – Dam DS	-0.18	-0.26	-0.24	-0.12	-0.31
RP08	Tweed River – Confluence of Doon Doon Ck	-0.21	-0.15	-0.14	-0.05	-0.12
RP09	Tweed River – Uki	-0.18	-0.14	-0.13	-0.12	-0.12
RP10	Tweed River – Dum Dum	-0.15	-0.11	-0.11	-0.13	-0.10
RP11	Tweed River – Byangum Bridge US	-0.05	-0.04	-0.13	-0.12	-0.03
RP12	Tweed River – Bray Park US	-0.04	-0.04	-0.04	-0.04	-0.03

The results from the flood modelling show that the proposed raised dam decreases flood levels downstream of the dam. Flood levels downstream of the dam, throughout the Tweed River, are generally decreased by between 10 mm and 250 mm for all design events. At Bray Park, the flood levels are generally lowered by up to 100 mm for all design events.

Flood Velocity

Flood velocities extracted at the reporting locations for areas downstream of the dam for the Existing Case and the Proposed Case are presented in Table 6-11 and Table 6-12, respectively. The differences in flood velocities are presented in Table 6-13. The differences in flood velocities are also presented in Appendix C6 to Appendix C10.

The results from the modelling show that there are minor reductions in flood velocities throughout the reaches downstream of the dam. Flood velocities are generally lower by 0.1 m/s downstream of the dam in the Tweed River for all design events. However, increased velocities of not more than 0.1 m/s are also simulated at the confluence of the Doon Doon Creek with the Tweed River. These increased velocities are mainly confined to the main channel.

Table 6-11 Flood velocities (m/s) downstream of Clarrie Hall Dam – Existing Case

RP	Description	Flood Velocities (m/s)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP07	Doon Doon Ck – Dam DS	2.17	2.24	2.25	2.31	3.17
RP08	Tweed River – Confluence of Doon Doon Ck	2.72	2.94	2.98	3.08	3.90
RP09	Tweed River – Uki	2.74	2.71	2.71	2.69	2.70
RP10	Tweed River – Dum Dum	1.91	2.00	1.98	1.97	1.96
RP11	Tweed River – Byangum Bridge US	1.80	2.00	2.02	2.08	3.05
RP12	Tweed River – Bray Park US	3.60	4.07	4.11	4.16	4.20

Table 6-12 Flood velocities (m/s) downstream of Clarrie Hall Dam – Proposed Case

RP	Description	Flood velocities (m/s)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP07	Doon Doon Ck – Dam DS	2.17	2.21	2.23	2.29	3.02
RP08	Tweed River – Confluence of Doon Doon Ck	2.70	2.92	2.97	3.07	3.88
RP09	Tweed River – Uki	2.72	2.70	2.70	2.70	2.70
RP10	Tweed River – Dum Dum	1.90	1.99	1.99	1.98	1.95
RP11	Tweed River – Byangum Bridge US	1.76	1.97	2.00	2.07	3.03
RP12	Tweed River – Bray Park US	3.56	4.06	4.10	4.16	4.20

Table 6-13 Differences in flood velocities (m/s) downstream of Clarrie Hall Dam – Proposed Case minus Existing Case

RP	Description	Differences in Flood Velocities (m/s)				
		5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
RP07	Doon Doon Ck – Dam DS	0.00	-0.03	-0.02	-0.02	-0.15
RP08	Tweed River – Confluence of Doon Doon Ck	-0.02	-0.02	-0.01	-0.01	-0.02
RP09	Tweed River – Uki	-0.02	-0.01	-0.01	0.01	0.00
RP10	Tweed River – Dum Dum	-0.01	-0.01	0.01	0.01	-0.01
RP11	Tweed River – Byangum Bridge US	-0.04	-0.03	-0.02	-0.01	-0.02
RP12	Tweed River – Bray Park US	-0.04	-0.01	-0.01	0.00	0.00

Peak Flows

The simulated decreases in water levels downstream of the dam are a result of the lower peak flows discharged from the dam's spillway, as the proposed spillway provides more storage and flood attenuation. The peak flows immediately downstream of the dam and at Bray Park Weir are presented in Table 6-14.

Table 6-14 Peak flows immediately downstream of the Clarrie Hall Dam and at Bray Park Weir

Design event (AEP)	Peak flows downstream of the dam (m ³ /s)			Peak flows at Bray Park Weir (m ³ /s)		
	Existing Case	Proposed Case	Difference	Existing Case	Proposed Case	Difference
5%	356	330	-26 (-7.4%)	3,208	3,139	-69 (-2.1%)
1%	532	476	-56 (-10.5%)	4,751	4,677	-74 (-1.6%)
0.5%	560	505	-55 (-9.8%)	5,028	4,950	-77 (-1.5%)
0.2%	661	630	-31 (-4.7%)	5,727	5,648	-79 (-1.4%)
PMF	1,664	1,518	-146 (-8.8%)	15,276	15,167	-109 (-0.7%)

Note: Peak flows presented are the maximum of the peak flows obtained for the critical duration at the location for each design event. Figures in parentheses are percentage differences as compared against existing peak flows.

Table 6-14 highlights the reduction in peak flows downstream of the dam for all design events. Peak flows immediately downstream of the dam are reduced by between 4.7% and 10.5% for all design events. At Bray Park Weir, flows are reduced by between 1.4% and 2.1% for up to the 0.2% AEP design event, while the PMF flows are simulated to be approximately 0.7% lower.

Flood Extents

There are minimal changes in flood extents simulated for all design events in the reaches downstream of the dam. Minor reductions in flood extents were noted at sporadic locations throughout the modelled area downstream of the dam.

6.6

HAZARD CATEGORIES

Flood hazard is typically derived from a combination of peak flood depth and velocity. The visualisation of flood hazard provides for a better understanding of the potential flood risk within the study area. The Australian Institute for Disaster Resilience (2017), in a handbook on best practice in flood management in Australia, provides hazard classifications that add clarity to the hazard categories and what they mean in practice. The classifications are divided into 6 categories, shown in Table 6-15 and, which indicate the restrictions on people, buildings and vehicles.

Table 6-15 Hazard classifications

Hazard classification	Description
H1	Relatively benign flow conditions. No vulnerability constraints
H2	Unsafe for small vehicles
H3	Unsafe for all vehicles, children and the elderly
H4	Unsafe for all people and vehicles
H5	Unsafe for all people and vehicles. Buildings require special engineering design and construction
H6	Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building type considered vulnerable to failure

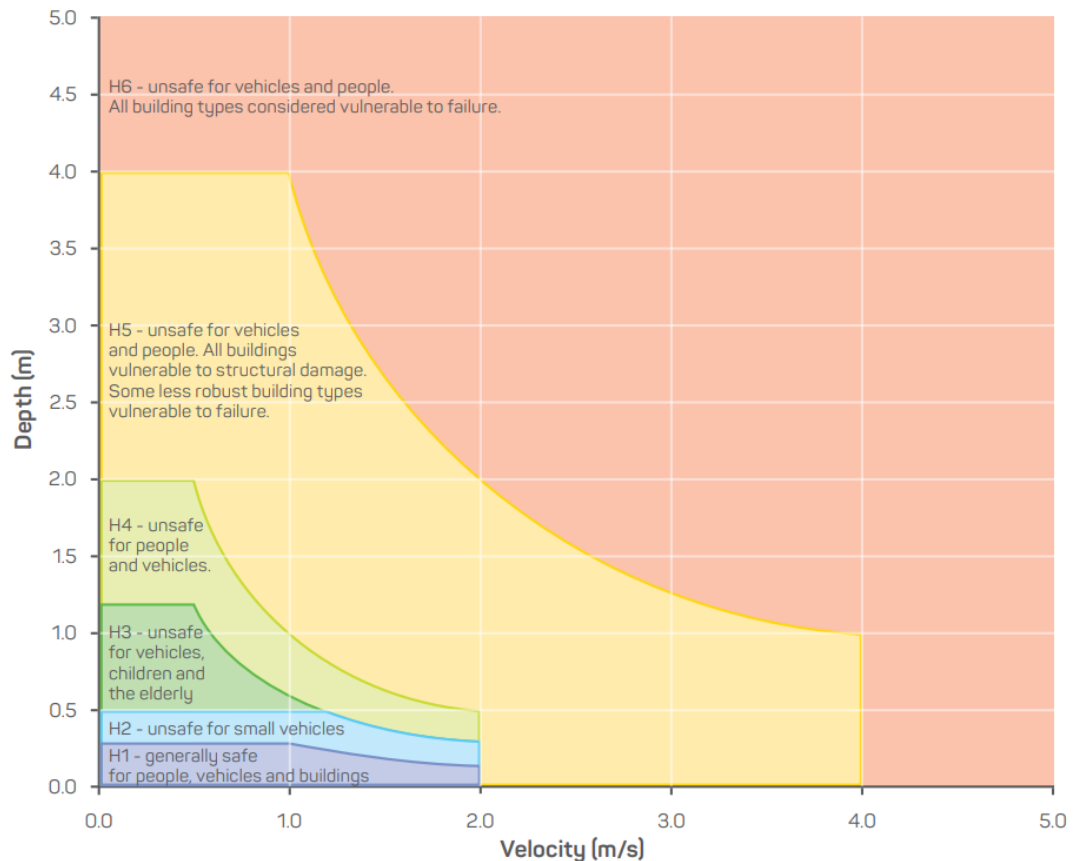


Figure 6-5 AIDR Flood hazard vulnerability curves

Peak flood hazard mapping for all the design events for the Existing Case are presented in Appendix A11 to A15, and in Appendix B11 to B15 for the Proposed Case.

The flood hazard differences, mapped in Appendix C11 to C15, show that the dam upgrade results in increases in flood hazard upstream of the dam and a decrease in flood hazard at sporadic locations downstream of the dam.

Flood hazard classifications increased mainly by one classification upstream of the dam and were mainly restricted to the creek's floodplains.

6.7 CLIMATE CHANGE

The 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF design events with climate change (SSP3-7.0) were simulated within the TUFLOW model to determine the impacts of climate change. The flood level differences maps (Proposed Case minus Existing Case) are presented in Appendix D. The differences in flood levels were similar to the current climate change scenario, i.e., flood levels were reduced downstream of the dam as a result of the dam upgrades.

Water levels for the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP design events with climate change were mainly contained within the dam. The PMF with climate change scenario, simulated a water level of 78.23 mAHD, which resulted in the dam overtopping the proposed wall of 77.0 mAHD by 1.23m.

6.8 DURATION OF INUNDATION

An extended simulation period of 150 hours was undertaken for the Proposed Case for the 24-hour duration storm event to assess the duration of inundation for the area upstream of the dam above the FSL of 70.0 mAHD.

The results of the extended simulation for the Proposed Case indicate that the dam takes approximately 120 hours to drain to the FSL for all design events. It has to be noted that only the 24-hour duration storm was assessed, which was the longest duration run for the 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP events and which was also the critical duration for the PMF. Longer duration storm would take longer to drain. Figure 6-6 presents the water levels in the dam over the longer simulated period for all design events.

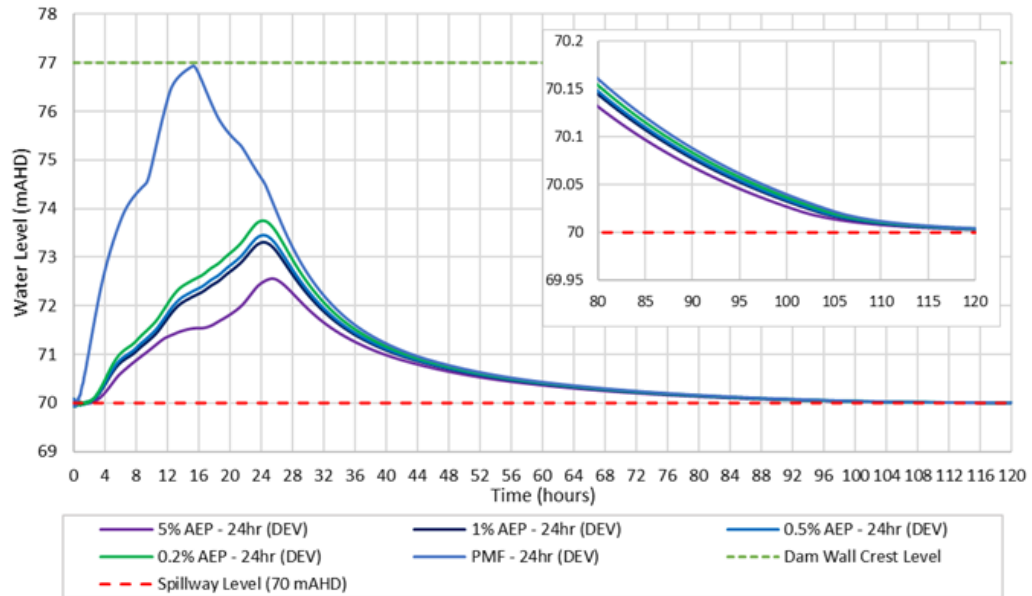


Figure 6-6 Proposed Case stage hydrographs for all design events (48-hour duration) over a longer simulation period (150 hours)

6.9

OUTCOMES OF THE FLOOD ASSESSMENT

While increased flood extents and flood levels are simulated upstream of the dam for all design events, these increased flood impacts are mainly confined to within the main waterway corridors. The increased flood extents encroach onto some properties that are within the vicinity of the additional dam storage. However, there are no buildings that are simulated to be impacted by the increased flood extents and level outside of the intended area for additional storage. Downstream of the dam, the decreased water levels and extents are simulated.

A comparison of flood hazard categorisation shows that flood hazard increases upstream of the dam and decreases at sporadic locations downstream of the dam.

7 Flooding Risk in Construction Phase

During the construction phase, the construction of the proposed upgrades to the dam configuration will be driven by construction management and planning. Hence, it is unclear as to what the temporary spillway width and the dam wall configurations would be during the construction phase. As such, it is not possible to appropriately simulate flood levels during the construction phase with any level of certainty.

It is likely that the existing spillway width will be maintained during the construction phase for a suitable period of time until the new spillway is operational, thus maintaining the flood risk downstream of the dam to existing conditions.

In the event that a temporary spillway is required in the construction phase, the spillway should at the minimum maintain the existing spillway's configurations to ensure that flow through the temporary spillway is maintained at existing conditions. This will ensure that the flood risk downstream is maintained at existing conditions.

The Environmental Impact Statement (EIS) provides a summary on the flooding risk and emergency management in relation to the construction phase.

8 Conclusion

The flood impact assessment investigated the flood impacts of the proposed raising of Clarrie Hall Dam, situated approximately 15 km south-west of Murwillumbah.

A TUFLOW hydraulic model of the dam and its surroundings was created for the purpose of the study. The inflows into the hydraulic model were obtained from a RORB hydrological model created by WRM (2017), which was updated to incorporate AR&R 2019 guidelines, to investigate the impacts of the proposed raising of the dam.

The existing and proposed spillways modelled as 'Q' channels, resulted in modelled rating curves similar to that provided by Council.

Peak flows for all design events are reduced downstream of the dam for all design events in the Proposed Case as a result of the upgraded spillway and raised dam embankment. As a result, peak water levels were simulated to be lower by up to 250 mm for all design events. Changes in flood extents are noted to be minimal downstream of the dam, with sporadic reductions in flood extents. Flood velocities in the downstream reaches are lower by 0.1 m/s.

Upstream of the dam, flood water levels increased in the dam's main storage area by up to 7.6 m. The flood level increase is due to the raising of the dam's spillway by 8.5 m, which results in higher water levels, although the increases in water level are less than the increase in spillway level. The severity of the flood level rise reduces further upstream of the dam. Although higher flood levels are simulated upstream of the dam, the increased flood impacts are confined to the main waterway corridors and are not considered to require any mitigation measures. The increased flood extents encroach onto some properties situated within the vicinity of the additional storage area. However, no buildings are noted to be impacted by the increased flood extents and levels. Flood velocities in the upstream reaches are noted to be lower than in the Existing Case, while closer to the dam wall, flood velocities are noted to have increased by up to 1.0 m/s.

Flood hazard increased by one classification upstream of the dam and decreased at sporadic locations downstream of the dam.

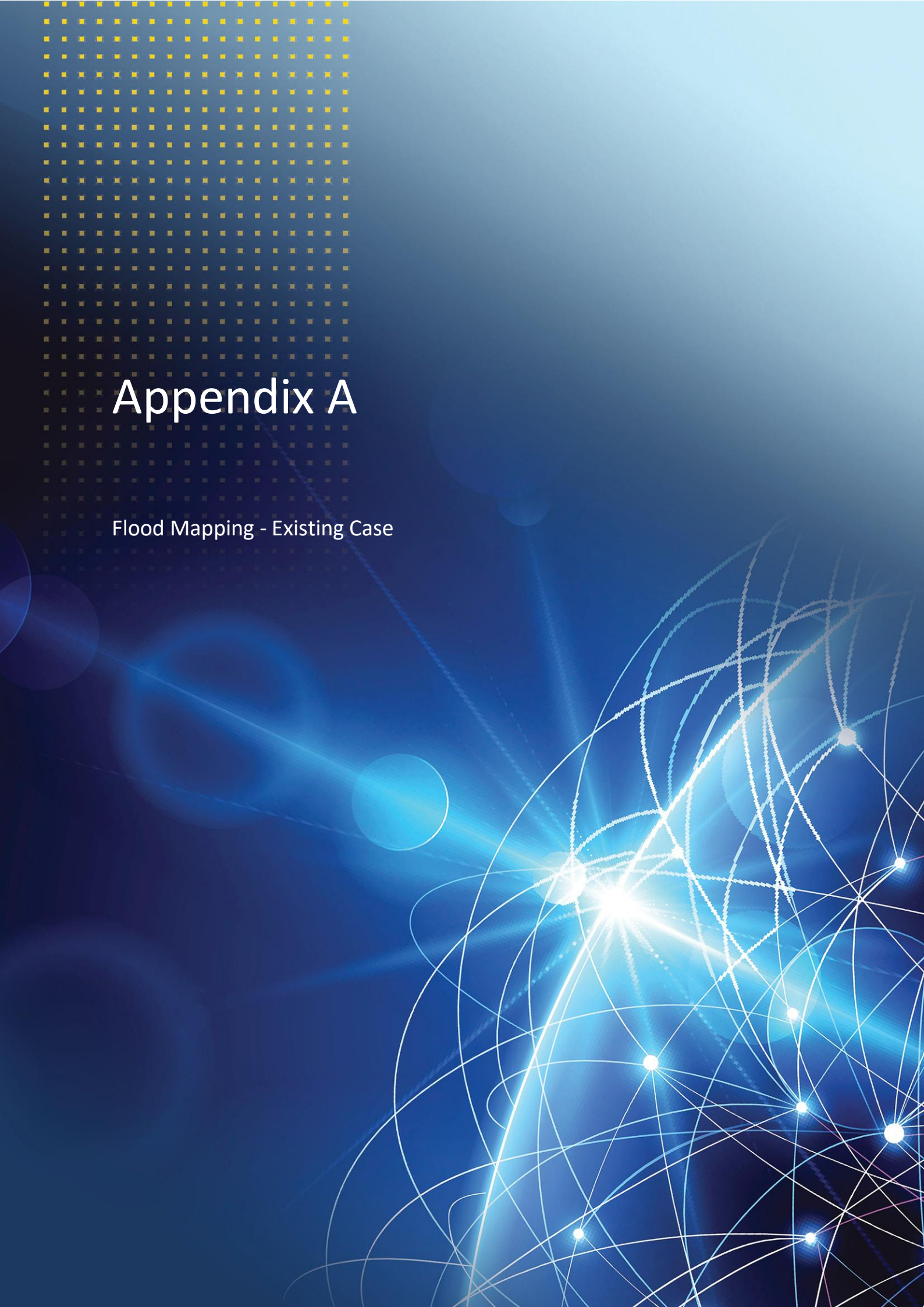
The PMF with climate change (SSP3-7.0) scenario resulted in the dam overtopping while all other design events were contained within the dam.

The dam takes approximately 120 hours to drain to the FSL level for all design events in the Proposed Case.

The outcomes of the flood assessment show that due to the proposed dam upgrade, there is a small increase in flood risk upstream of the dam which is mainly confined with within waterway corridors. The climate change modelling has shown that while water levels are increased, only the PMF with climate change scenario overtops the proposed dam.

9 References

- Advisian (2018), *Clarrie Hall Dam Raising – Computational Fluid Dynamics Modelling*.
- Australian Institute for Disaster Resilience (2017), *Handbook 7 – Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*.
- Babister, M., Trim, A., Testoni, I. & Retallick, M. (2016), *The Australian Rainfall & Runoff Datahub*, 37th Hydrology and Water Resources Symposium Queenstown NZ.
- Ball, J., Babister, M., Nathan, R., Weeks, W., Weinmann, E., Retallick, M., Testoni, I. (eds), *Australian Rainfall and Runoff: A Guide to Flood Estimation*, © Commonwealth of Australia (Geoscience Australia), 2019.
- CAWCR, *Australian Climate Change Science Program Information Paper – Representative Concentration Pathways*, Collaboration for Australian Weather and Climate Research, https://www.cawcr.gov.au/projects/Climatechange/wp-content/uploads/2016/11/ACCSP_RCP.pdf, (Accessed: March 2023).
- Eco Logical Australia (2021), *Clarrie Hall Dam Raising EIS – Flooding Technical Report*. Prepared for Tweed Shire Council.
- ELVIS (2023), *Elvis – Elevation and Depth – Foundation Spatial Data*, <https://elevation.fsdf.org.au/> (Accessed: January 2023).
- GHD (2023), *Clarrie Hall Dam Safety Review – Existing Spillway CFD Study*, Prepared for Tweed Shire Council (23 March 2023).
- Peter Lowndes Consulting Engineer (2021), *Design Report – McCabes Bridge Replacement on Doon Doon Road*.
- Tweed Shire Council (2018), *Clarrie Hall Dam Raising – Concept Design Report*.
- WRM (2017), *Flood Hydrology Study – Clarrie Hall Dam*.
- Department of Climate Change, Energy, the Environment and Water, (2024), *“Draft update to the Climate Change Considerations chapter in Australian Rainfall and Runoff: A Guide to Flood Estimation*



Appendix A

Flood Mapping - Existing Case

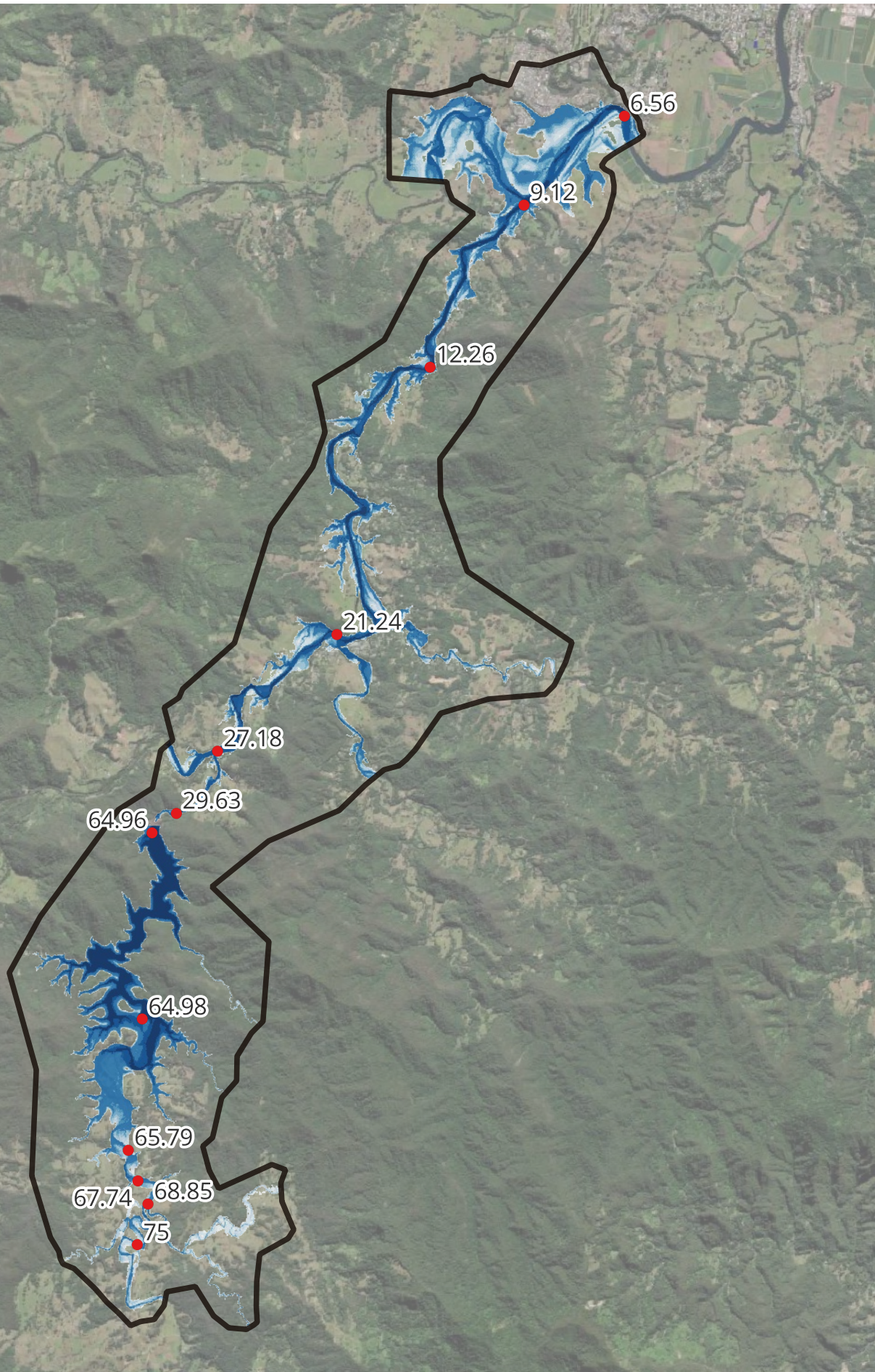
LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

-  <= 0.1
-  0.1 - 0.5
-  0.5 - 1.0
-  1.0 - 1.5
-  1.5 - 2.0
-  2.0 - 2.5
-  2.5 - 5.0
-  5.0 - 10.0
-  > 10.0



Title: Peak Flood Depth and Level - Existing Case 5% AEP Design Event

Figure: **A1**

Rev: **2**

Scale at A4 1:80000.00000000025
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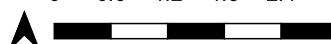
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



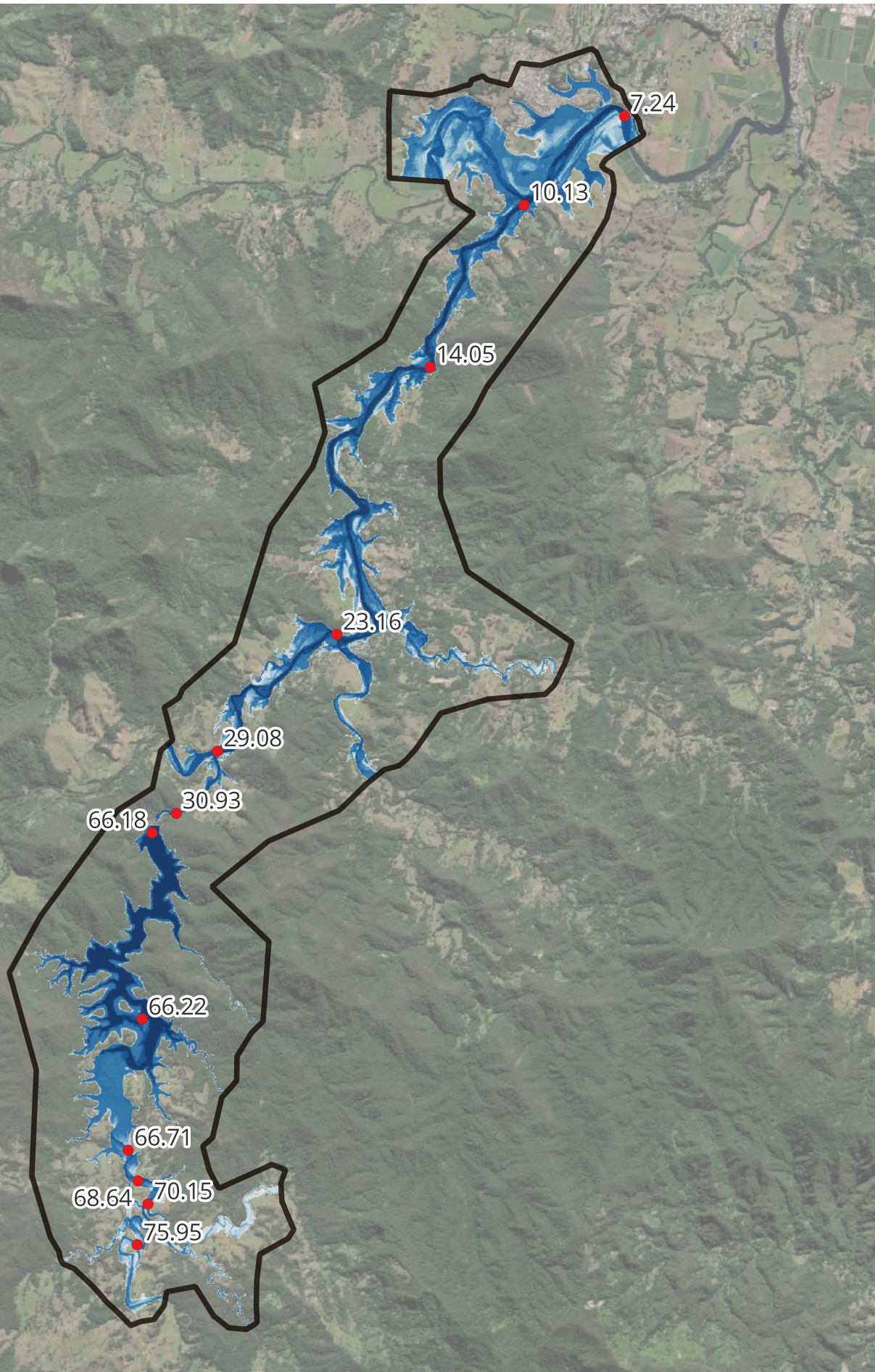
LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

-  <= 0.1
-  0.1 - 0.5
-  0.5 - 1.0
-  1.0 - 1.5
-  1.5 - 2.0
-  2.0 - 2.5
-  2.5 - 5.0
-  5.0 - 10.0
-  > 10.0



Peak Flood Depth and Level - Existing Case 1% AEP Design Event

Figure:

A2

Rev:

2

Scale at A4 1:80000.000000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

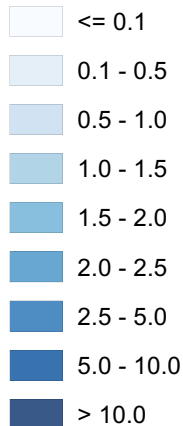


LEGEND

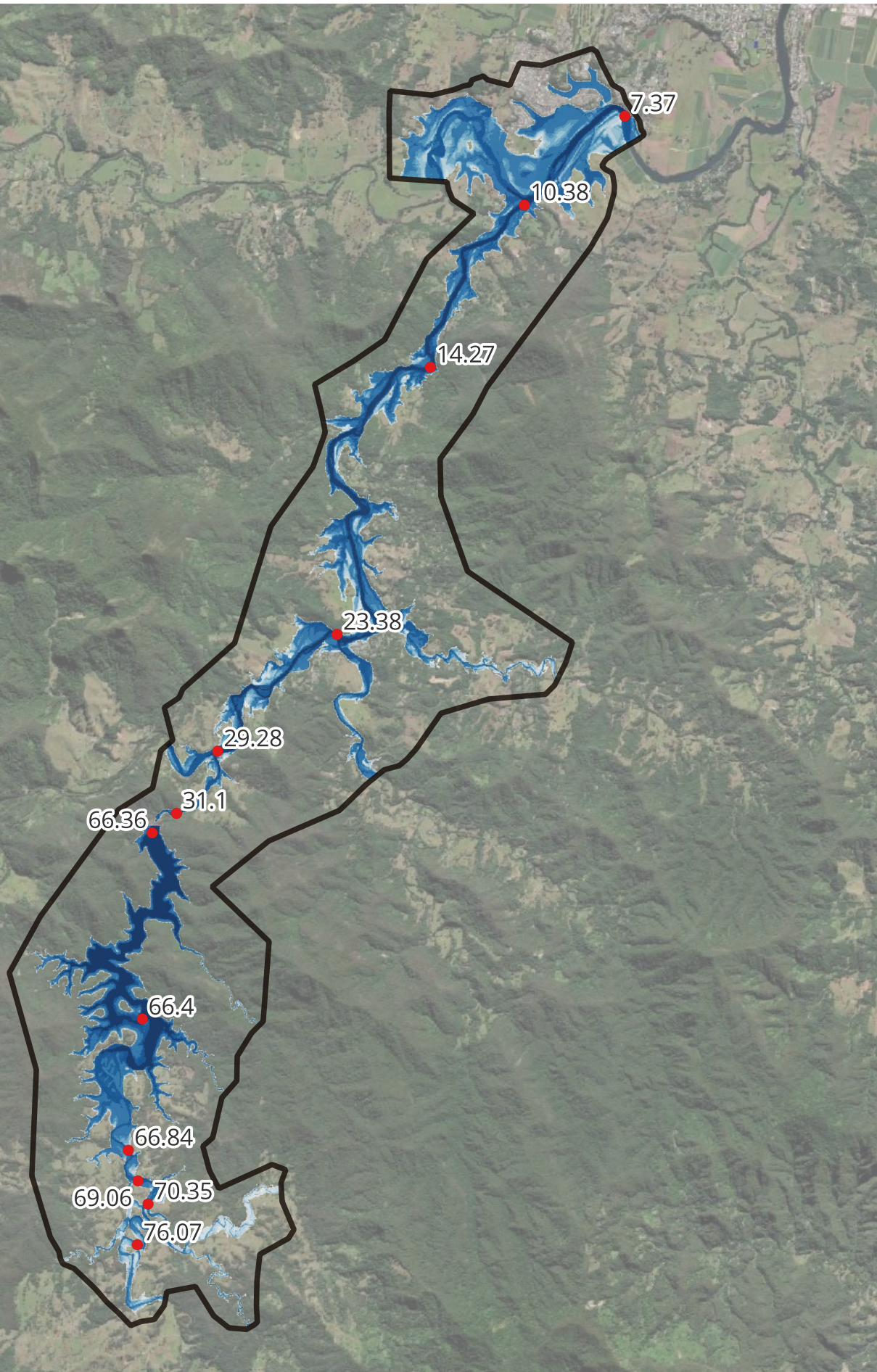
 Model Boundary

 Reporting Points

Flood Depth (m)



- <= 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 5.0
- 5.0 - 10.0
- > 10.0



Peak Flood Depth and Level - Existing Case 0.5% AEP Design Event

Figure:

A3

Rev:

2

Scale at A4 1:80000.00000000025

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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

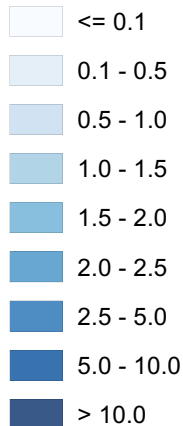


LEGEND

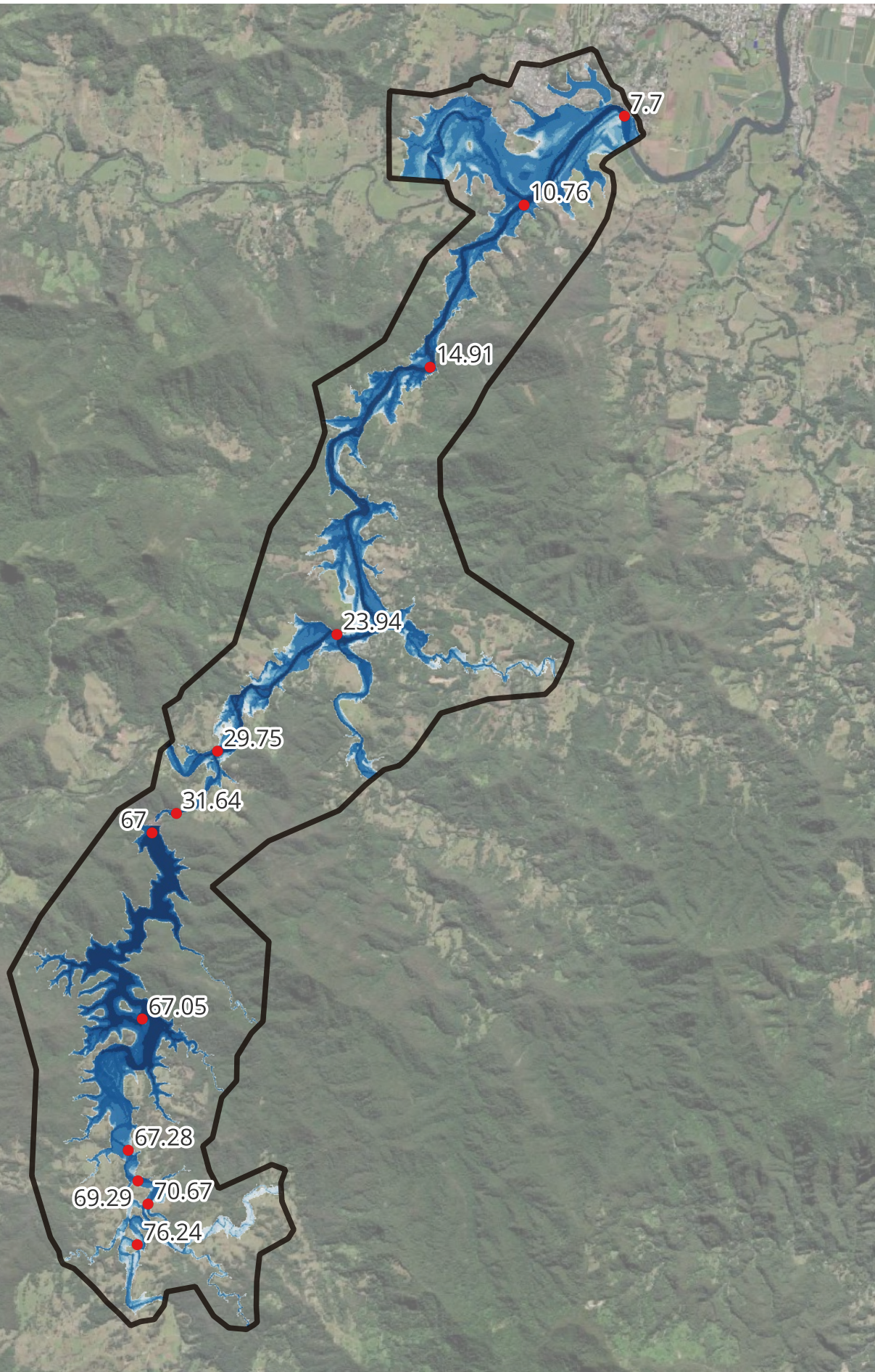
 Model Boundary

 Reporting Points

Flood Depth (m)



- <= 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 5.0
- 5.0 - 10.0
- > 10.0



Peak Flood Depth and Level - Existing Case 0.2% AEP Design Event

Figure: **A4**

Rev: **2**

Scale at A4 1:80000.000000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



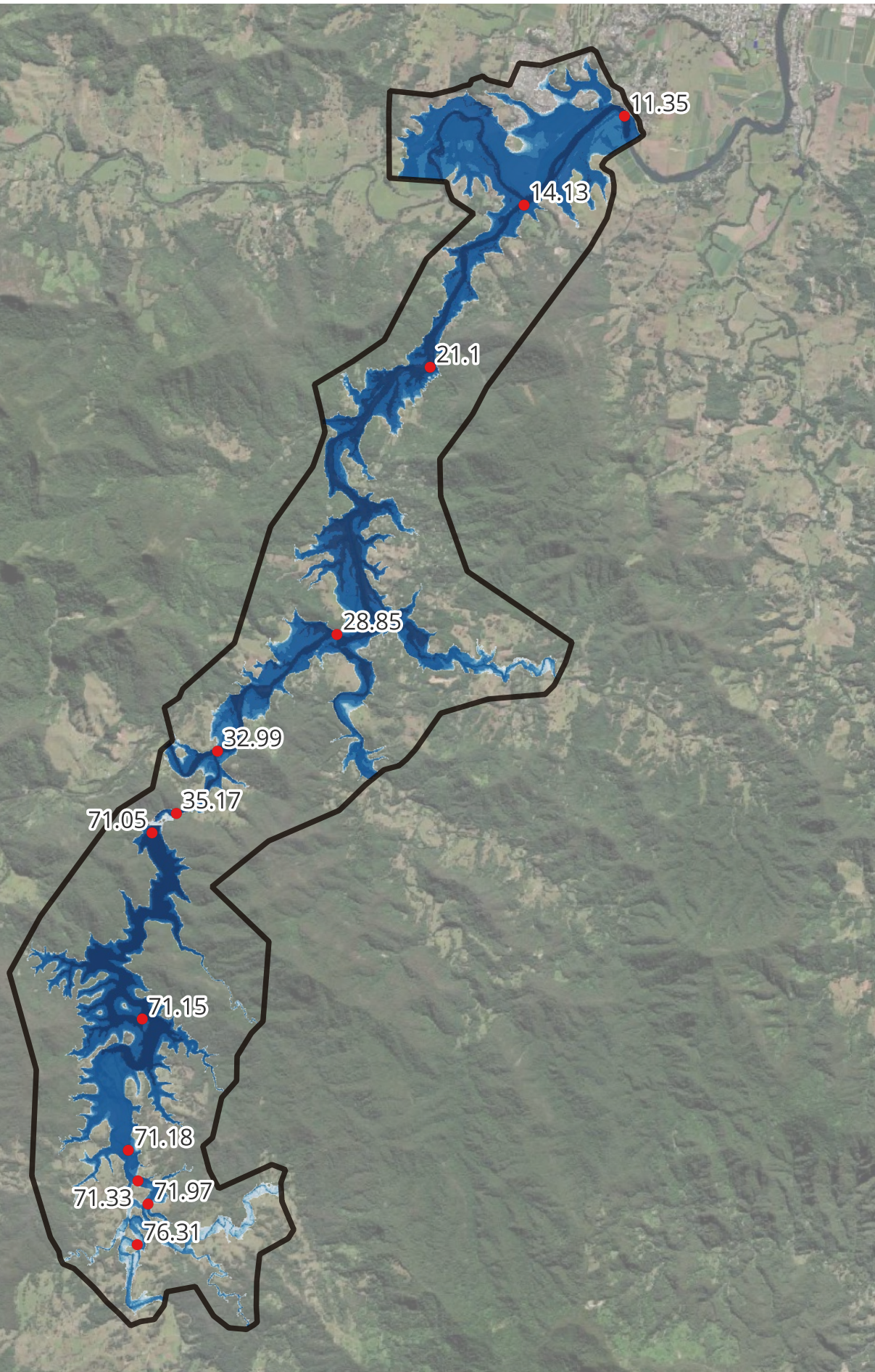
LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

-  <= 0.1
-  0.1 - 0.5
-  0.5 - 1.0
-  1.0 - 1.5
-  1.5 - 2.0
-  2.0 - 2.5
-  2.5 - 5.0
-  5.0 - 10.0
-  > 10.0



Peak Flood Depth and Level - Existing Case PMP Design Event

Figure:

A5

Rev:

2

Scale at A4 1:80000.00000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

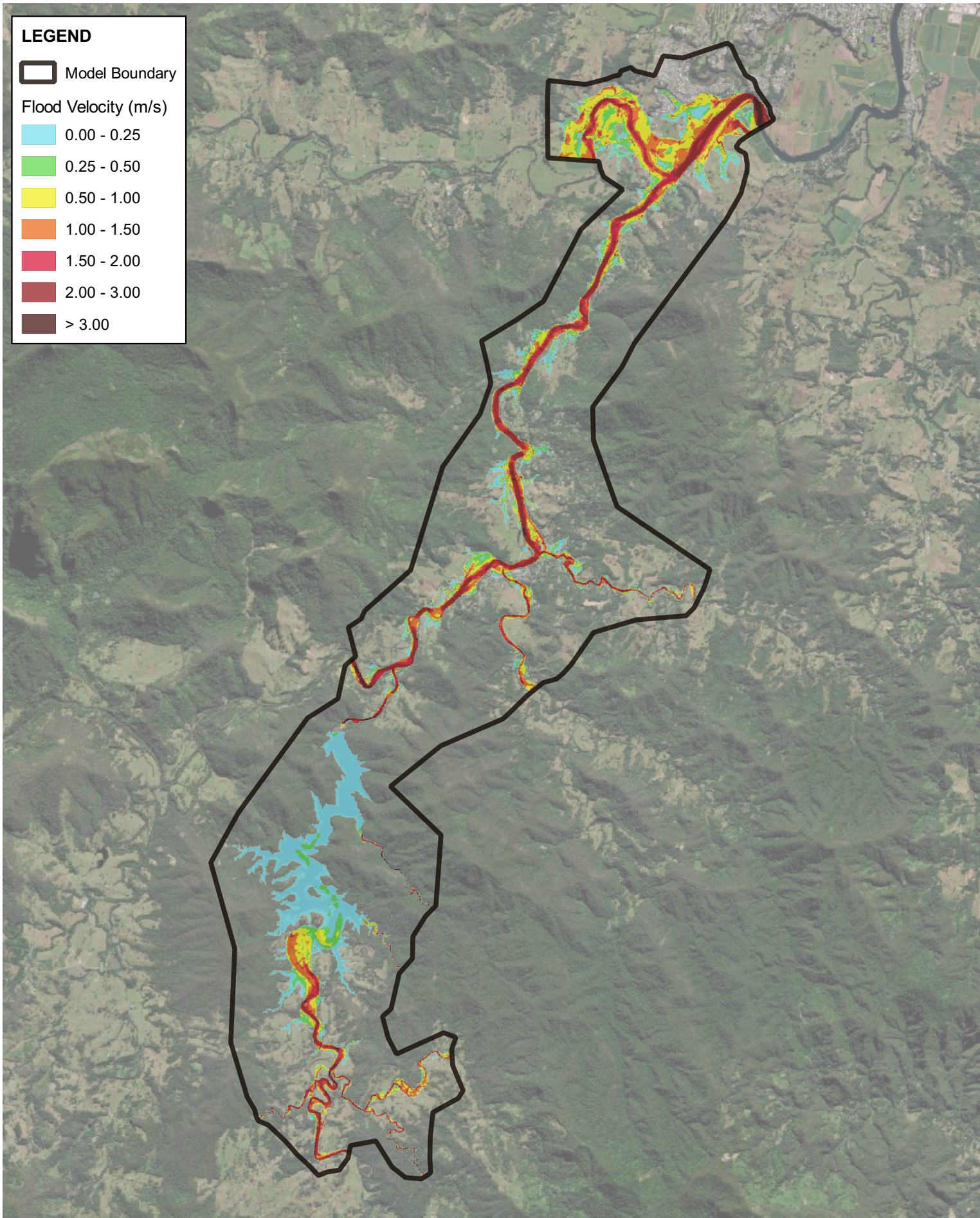
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Peak Velocity - Existing Case 5% AEP Design Event

Scale at A4 1:80000.000000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

Figure:

A6

Rev:

2



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

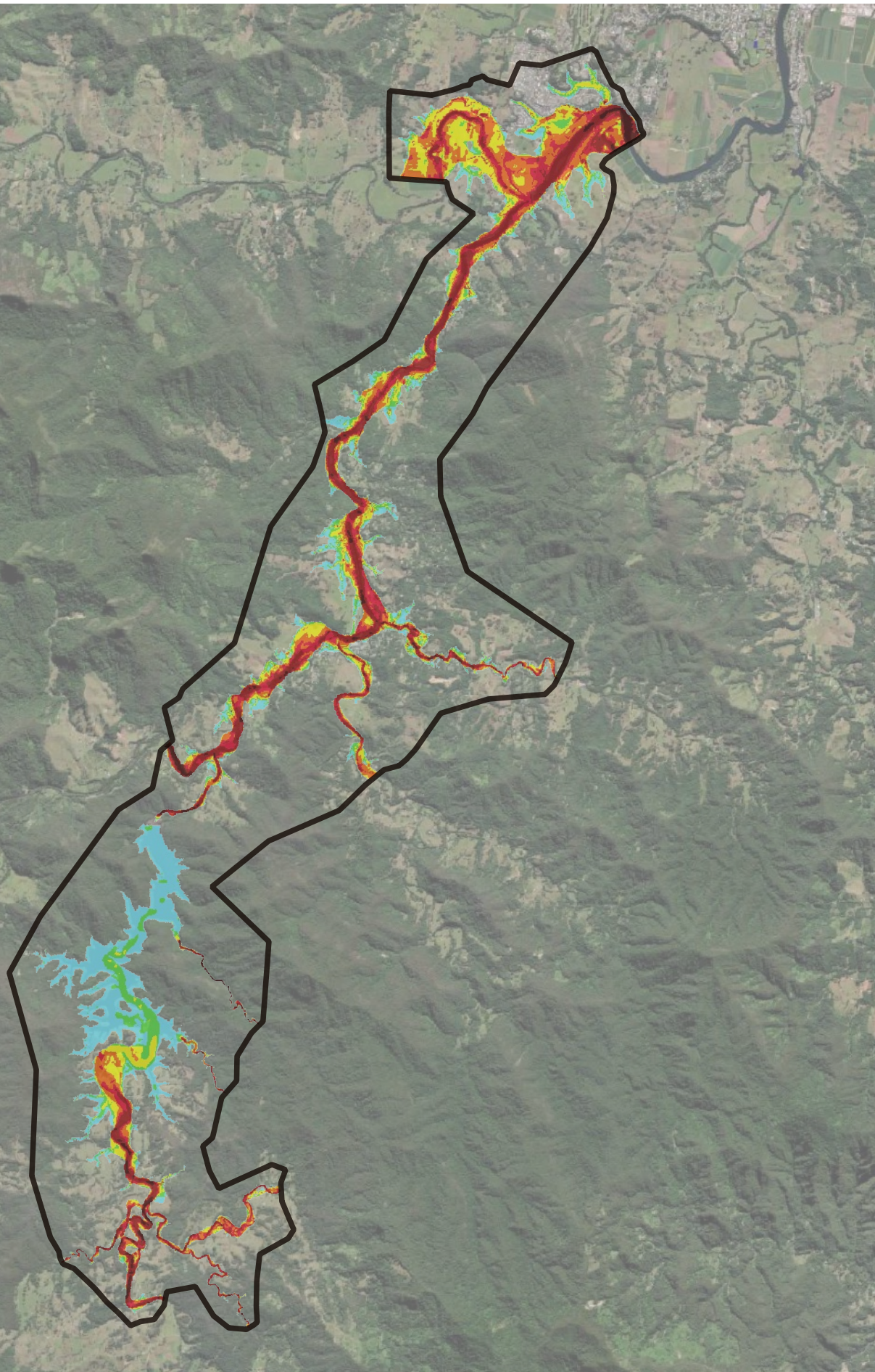
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Peak Velocity - Existing Case 1% AEP Design Event

Scale at A4 1:80000.000000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

Figure:

A7

Rev:

2



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

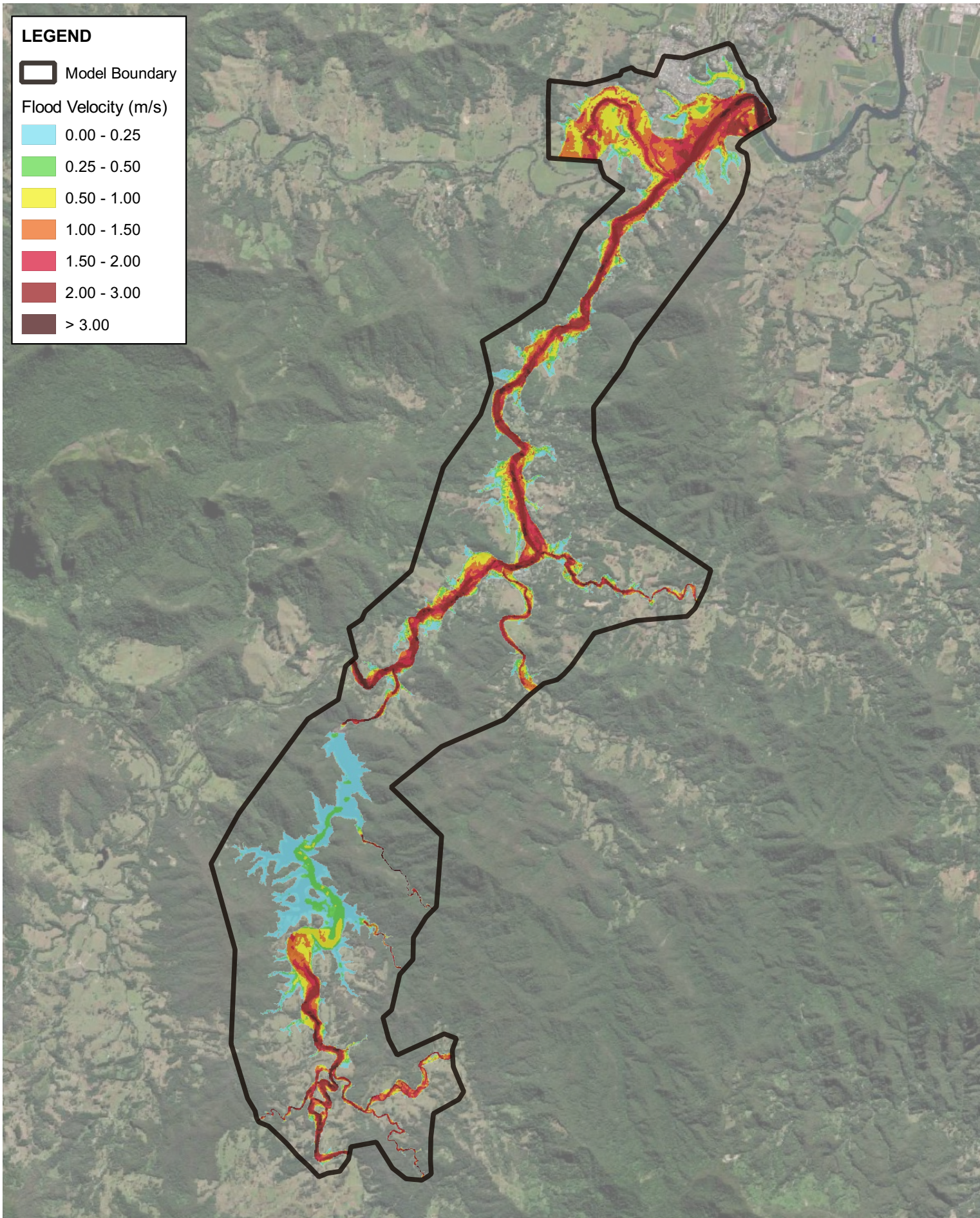
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Existing Case 0.5% AEP Design Event

Figure:
A8

Rev:
2

Scale at A4 1:80000.00000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

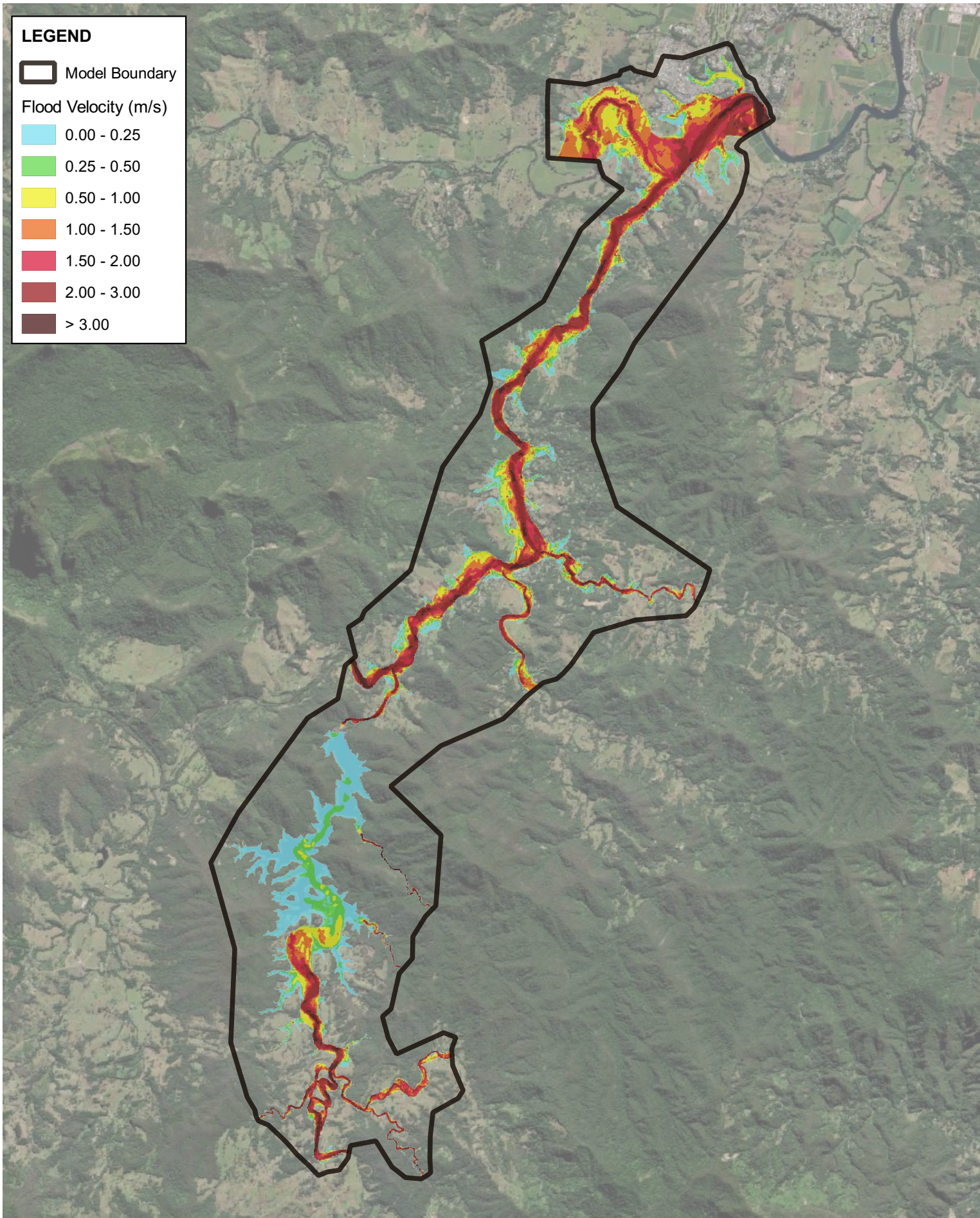
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Peak Velocity - Existing Case 0.2% AEP Design Event

Scale at A4 1:80000.00000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

Figure:

A9

Rev:

2



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

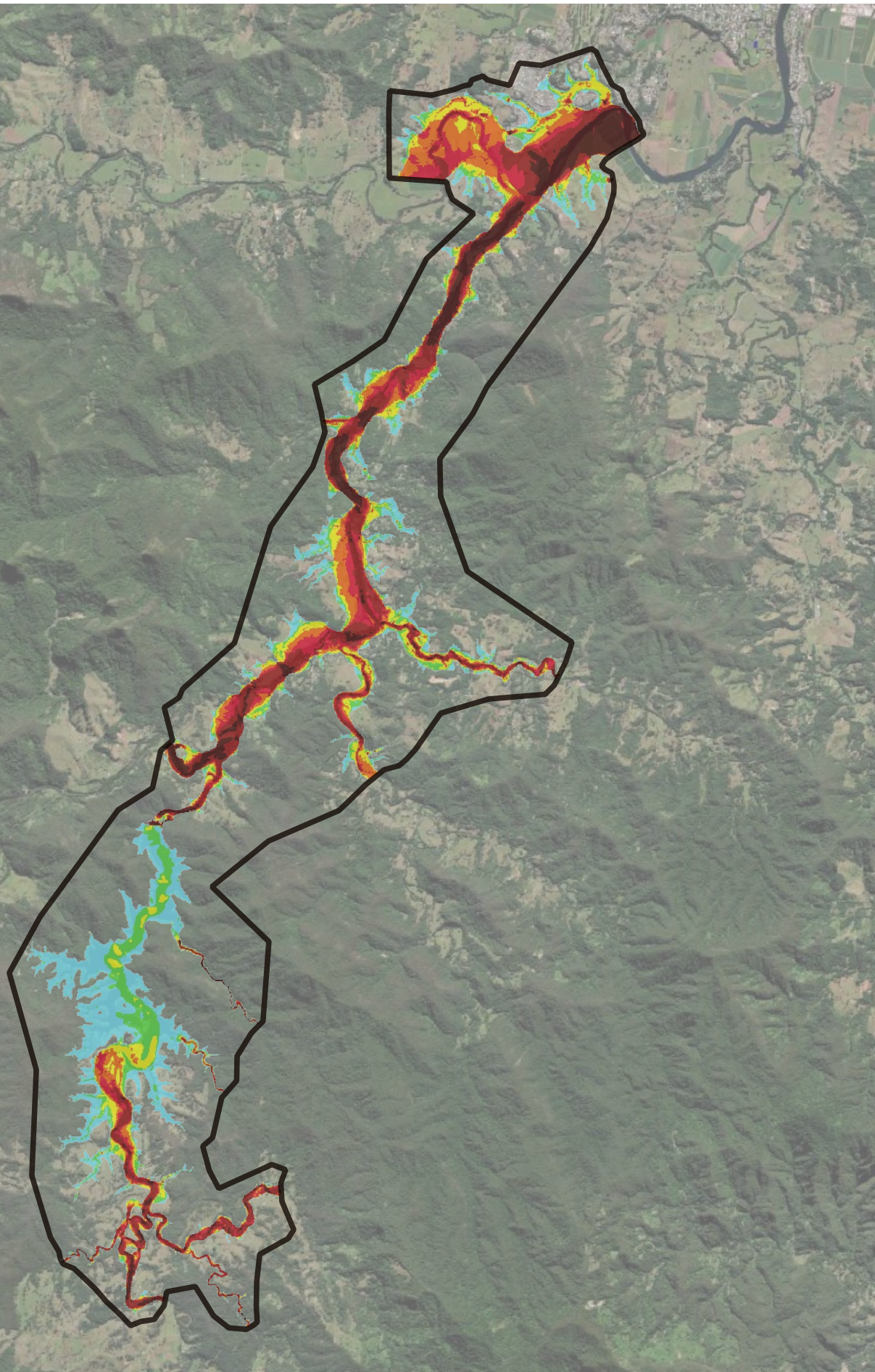
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Existing Case PMP Design Event

Figure:
A10

Rev:
2

Scale at A4 1:80000.00000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

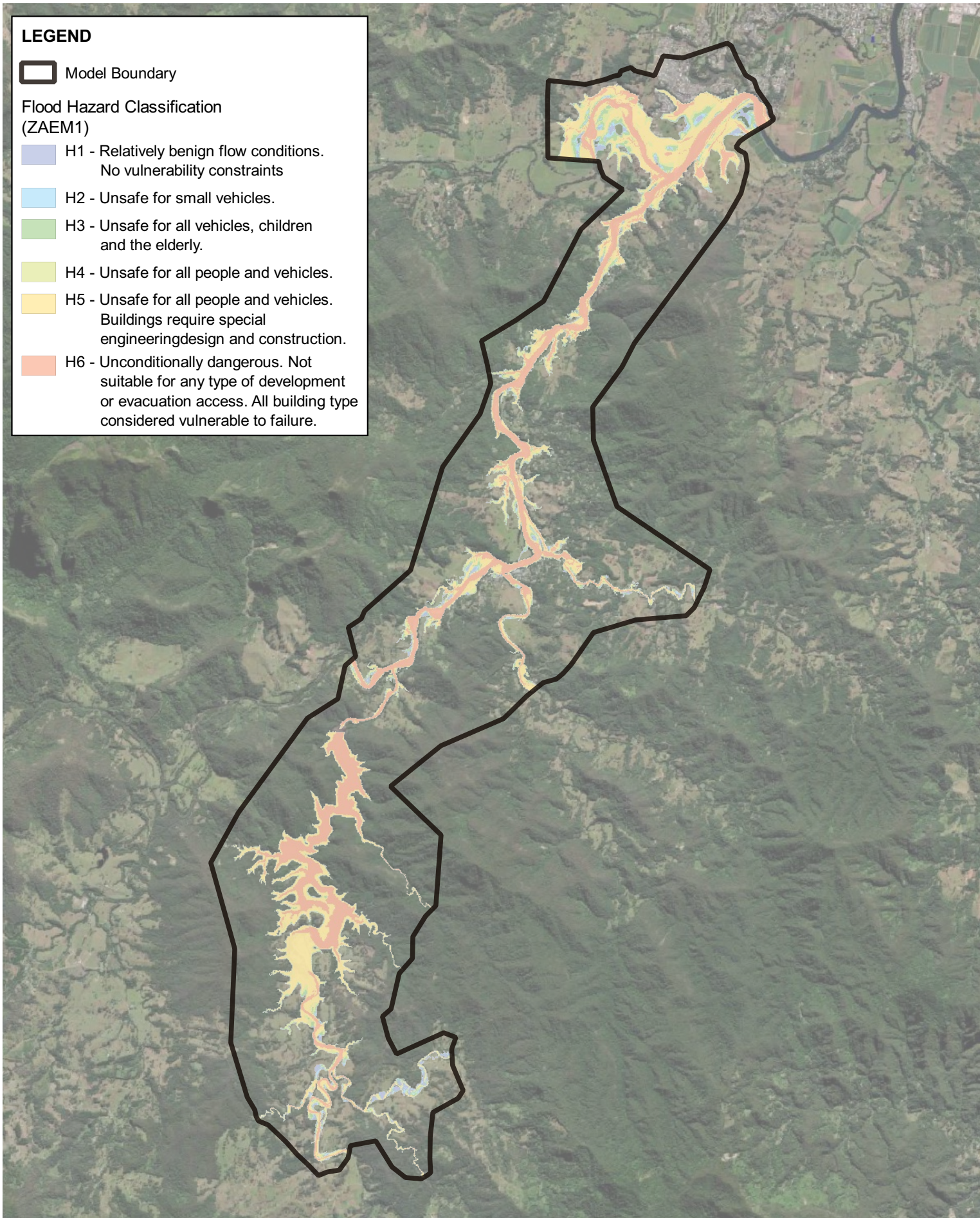


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Flood Hazard - Existing Case 5% AEP Design Event

Figure:
A11

Rev:
2

Scale at A4 1:80000.00000000025
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Scale:

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1:80,000

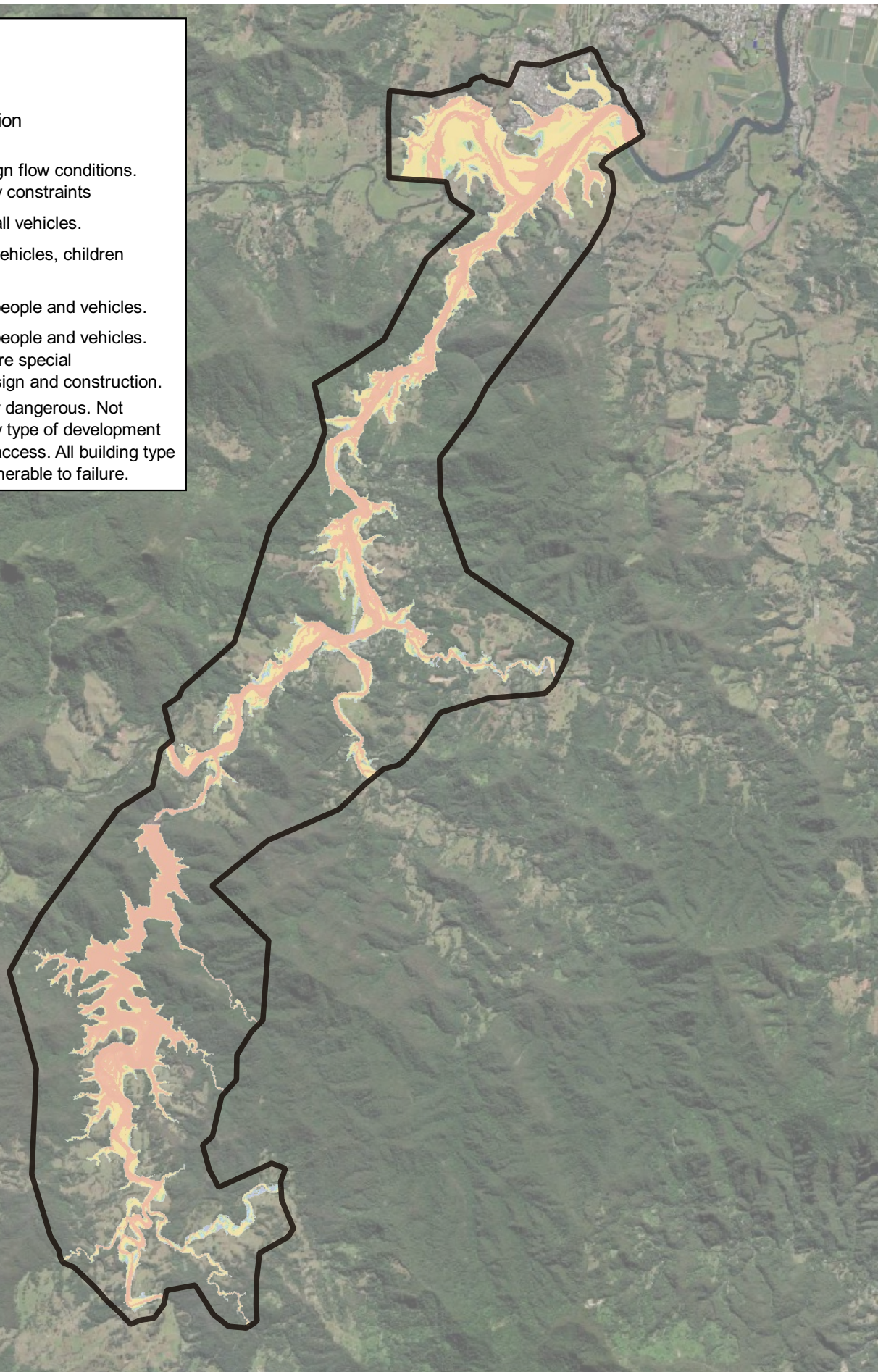


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Flood Hazard - Existing Case 1% AEP Design Event

Figure:
A12

Rev:
2

Scale at A4 1:80000.000000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

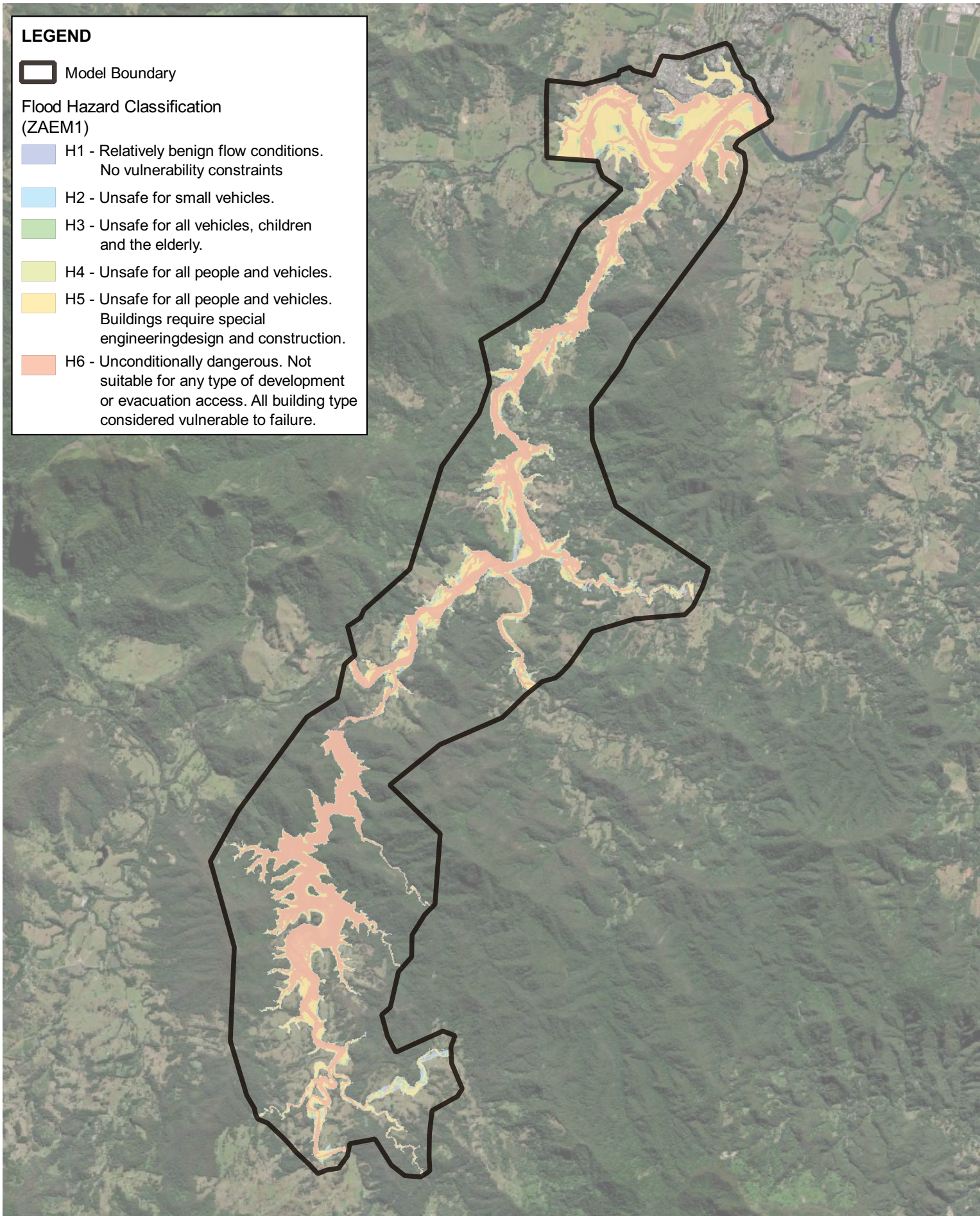


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Title: Flood Hazard - Existing Case 0.5% AEP Design Event

Figure:
A13

Rev:
2

Scale at A4 1:80000.000000000025
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Scale:

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1:80,000

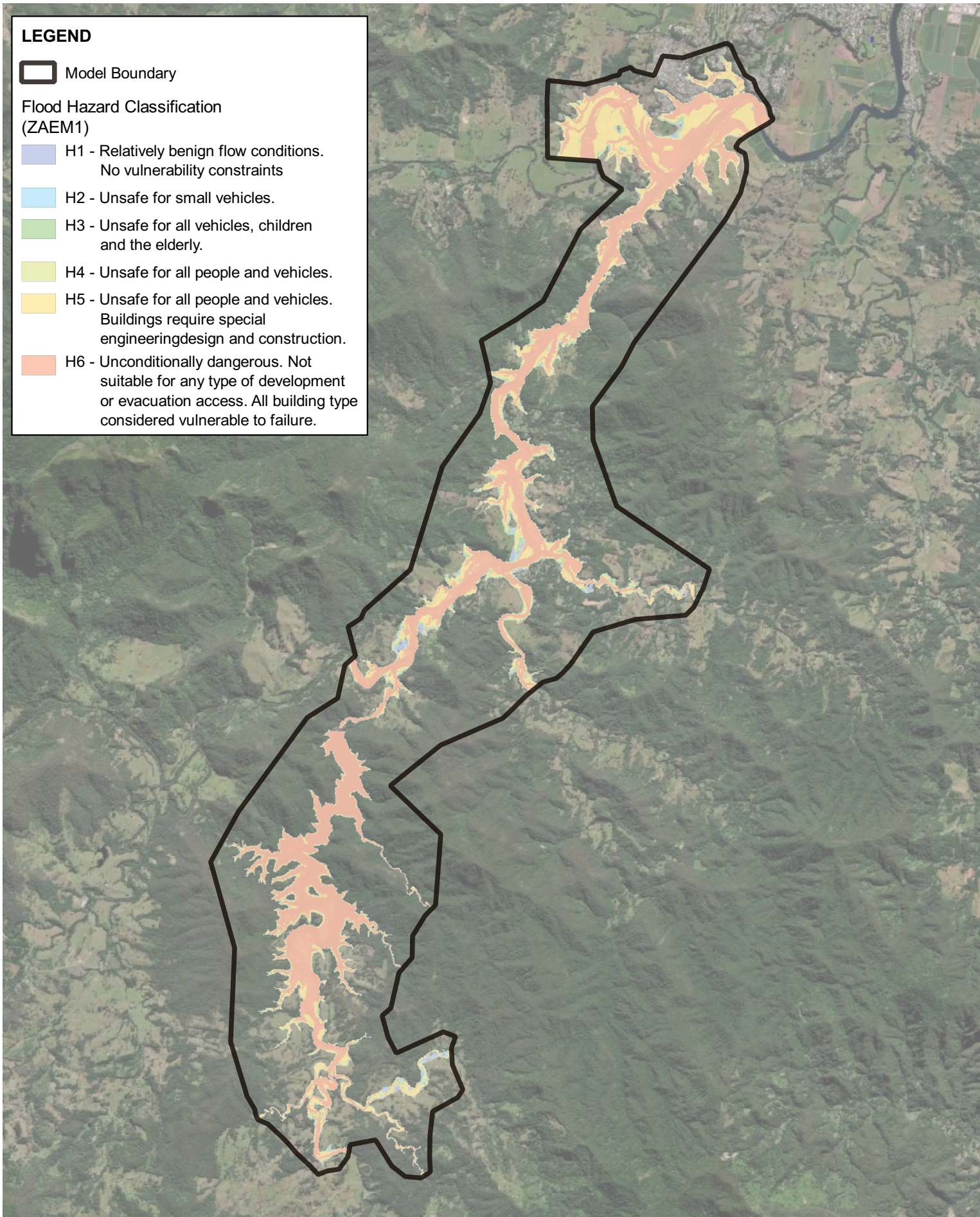


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions. No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles. Buildings require special engineering design and construction.
-  H6 - Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building type considered vulnerable to failure.



Title: Flood Hazard - Existing Case 0.2% AEP Design Event

Figure:
A14

Rev:
2

Scale at A4 1:80000.00000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

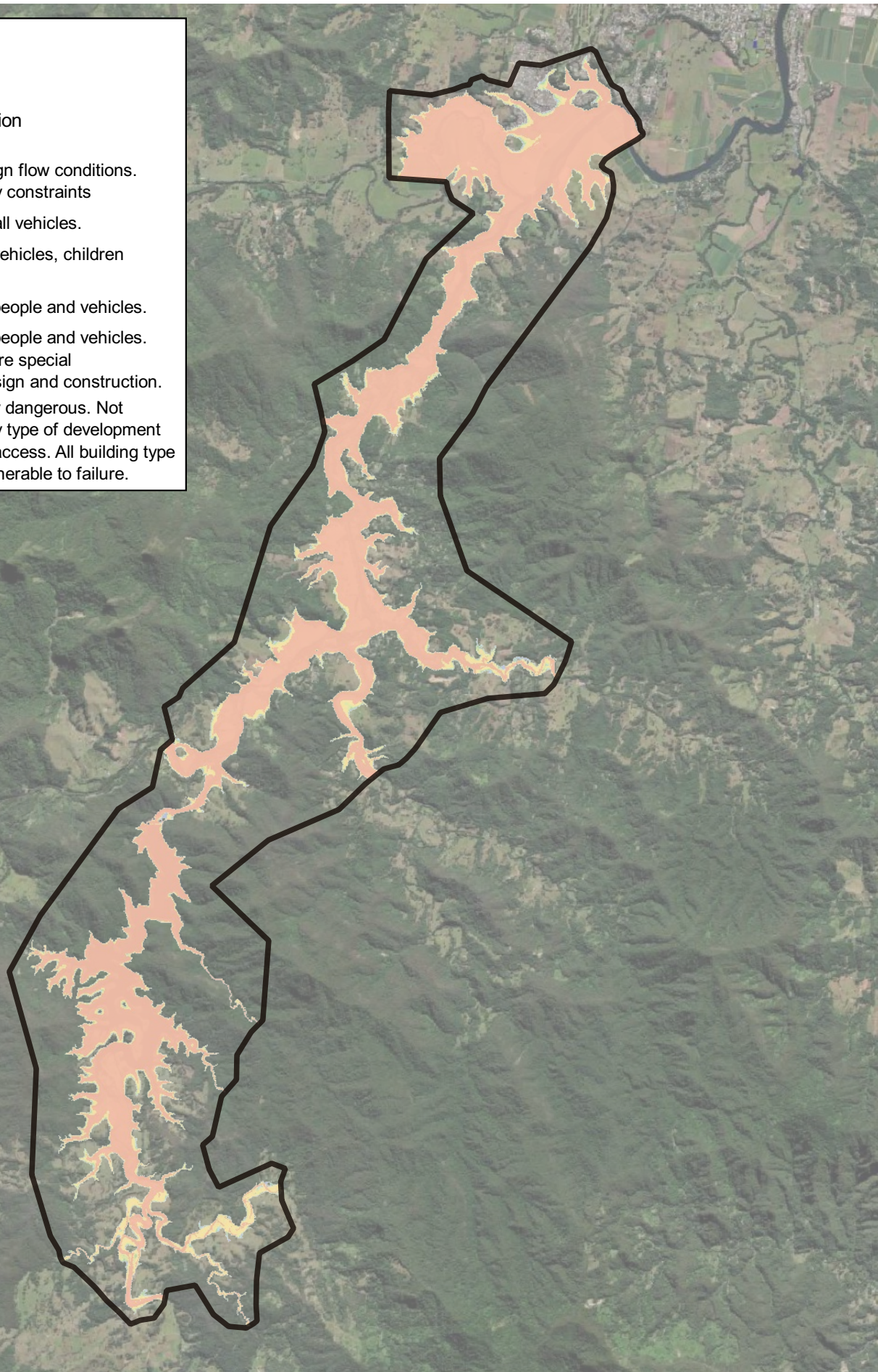


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Title: Flood Hazard - Existing Case PMP Design Event

Figure:
A15

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

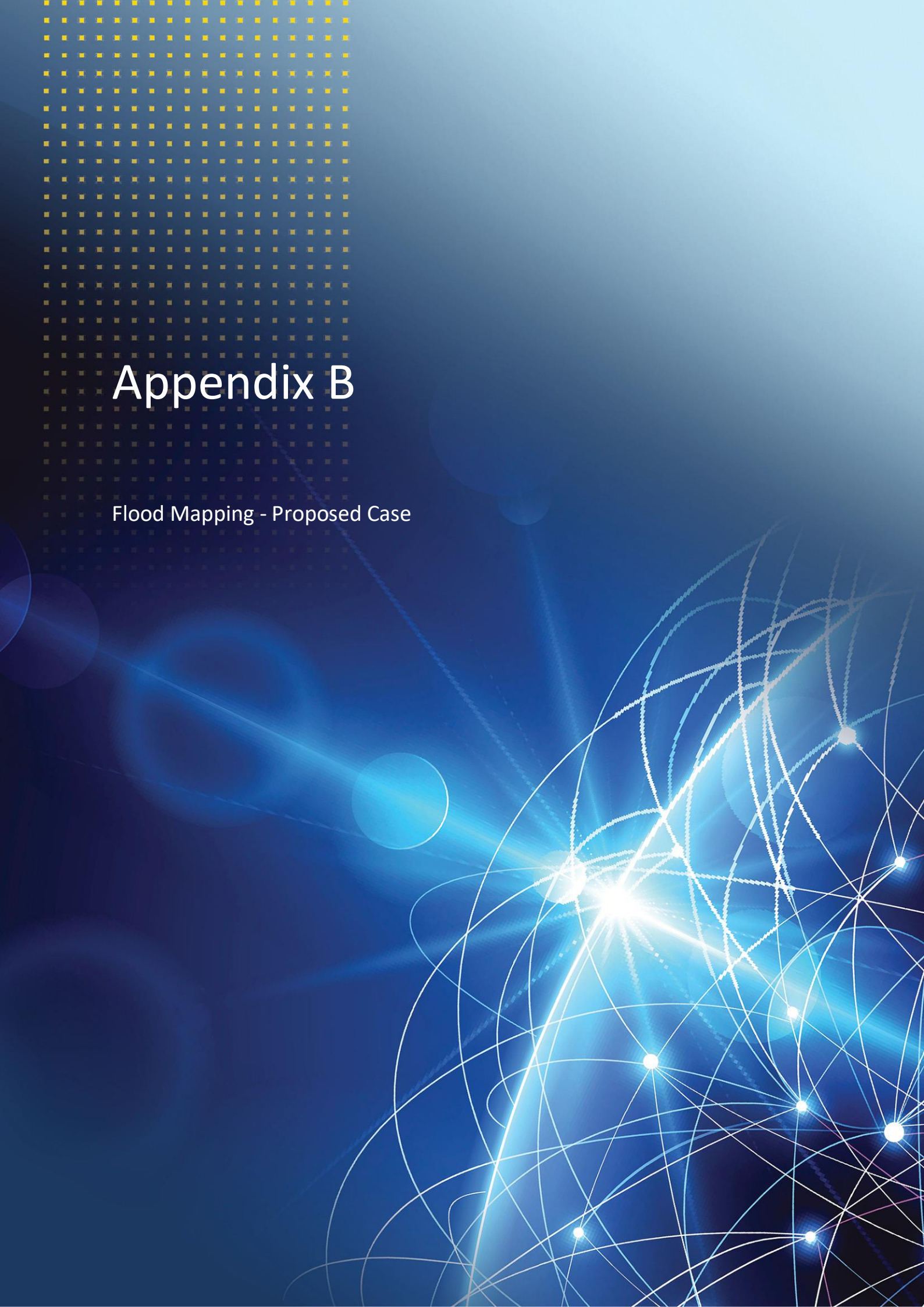
Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000





Appendix B

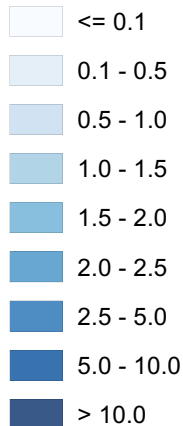
Flood Mapping - Proposed Case

LEGEND

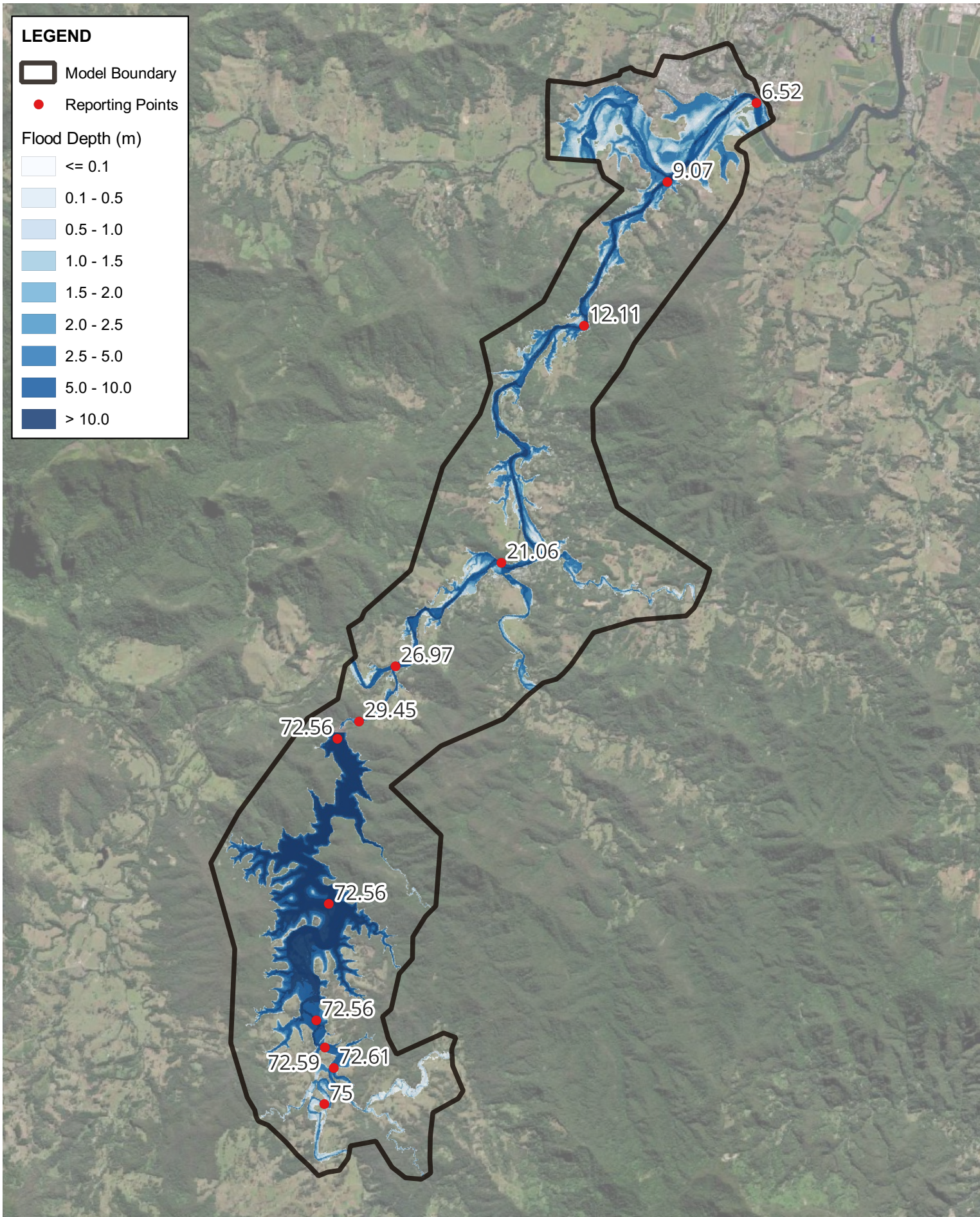
 Model Boundary

 Reporting Points

Flood Depth (m)



- <= 0.1
- 0.1 - 0.5
- 0.5 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5
- 2.5 - 5.0
- 5.0 - 10.0
- > 10.0



Peak Flood Depth and Level - Proposed Case 5% AEP Design Event

Figure:

B1

Rev:

2

Scale at A4 1:80000.00000000025
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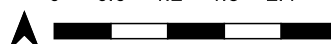
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



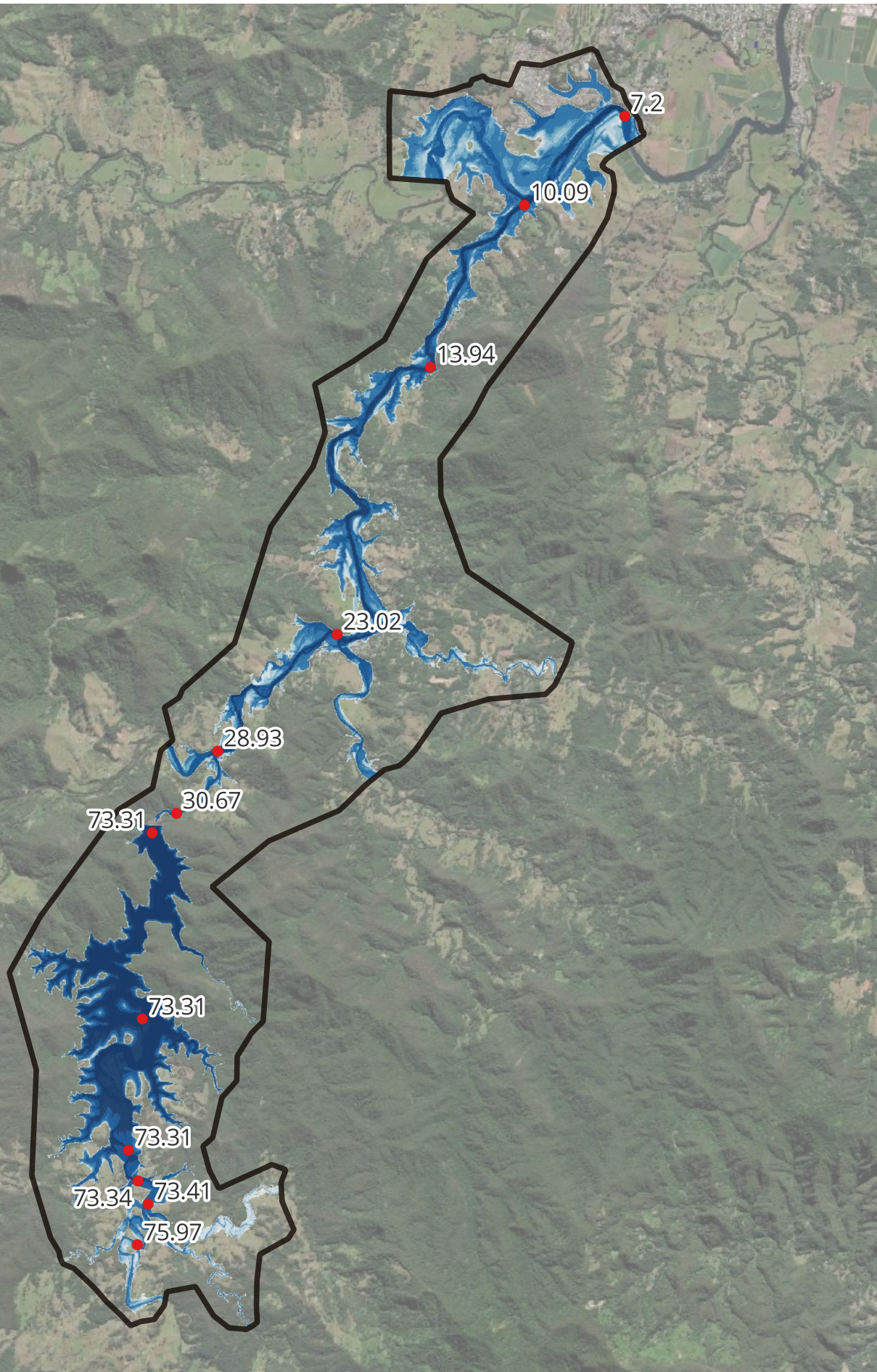
LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

-  <= 0.1
-  0.1 - 0.5
-  0.5 - 1.0
-  1.0 - 1.5
-  1.5 - 2.0
-  2.0 - 2.5
-  2.5 - 5.0
-  5.0 - 10.0
-  > 10.0



Peak Flood Depth and Level - Proposed Case 1% AEP Design Event

Figure:
B2

Rev:
2

Scale at A4 1:80000.00000000025
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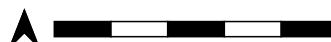
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

 <= 0.1

 0.1 - 0.5

 0.5 - 1.0

 1.0 - 1.5

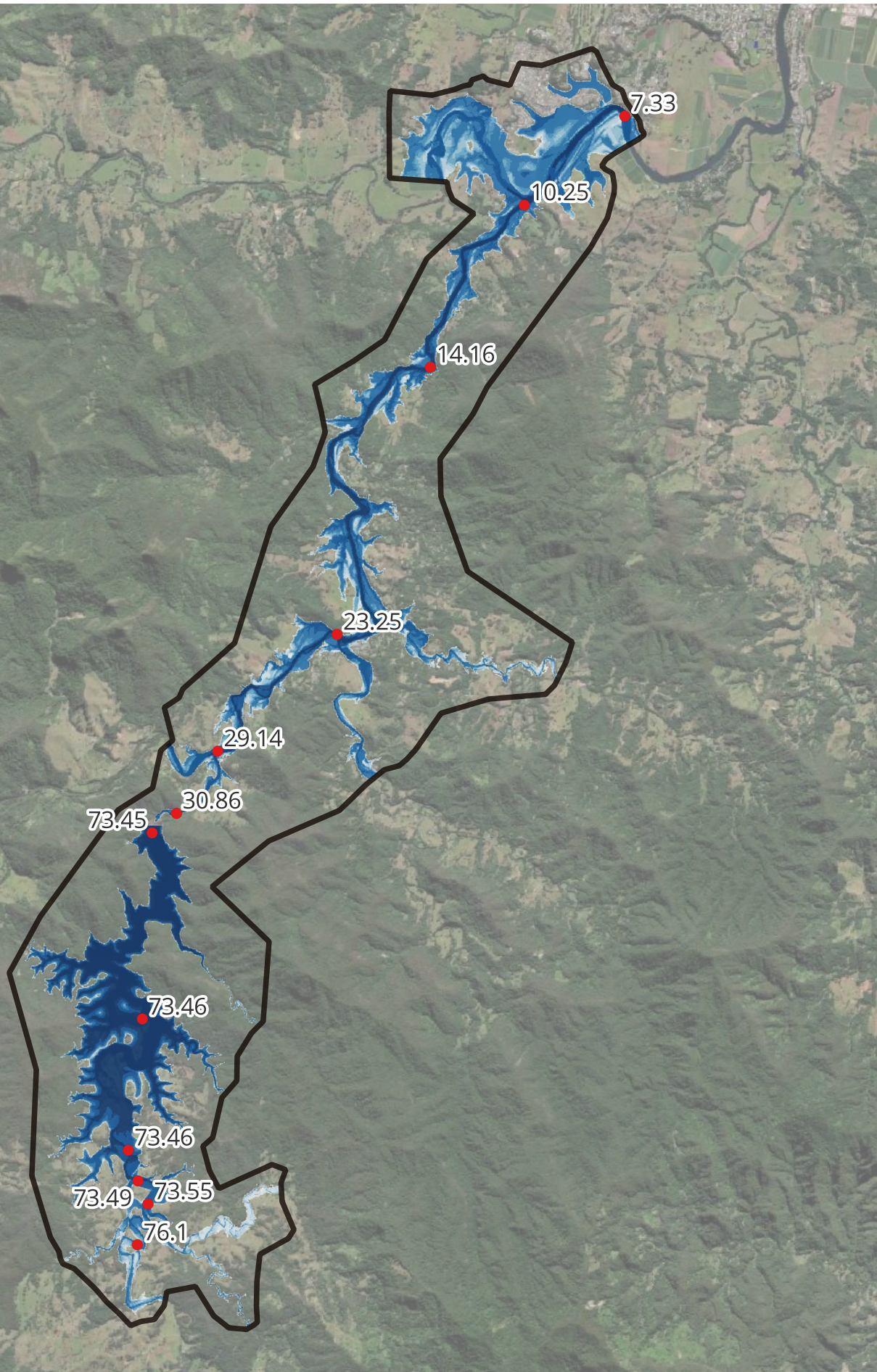
 1.5 - 2.0

 2.0 - 2.5

 2.5 - 5.0

 5.0 - 10.0

 > 10.0



Title: Peak Flood Depth and Level - Proposed Case 0.5% AEP Design Event

Figure:
B3

Rev:
2

Scale at A4 1:80000.00000000025
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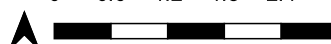
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

 <= 0.1

 0.1 - 0.5

 0.5 - 1.0

 1.0 - 1.5

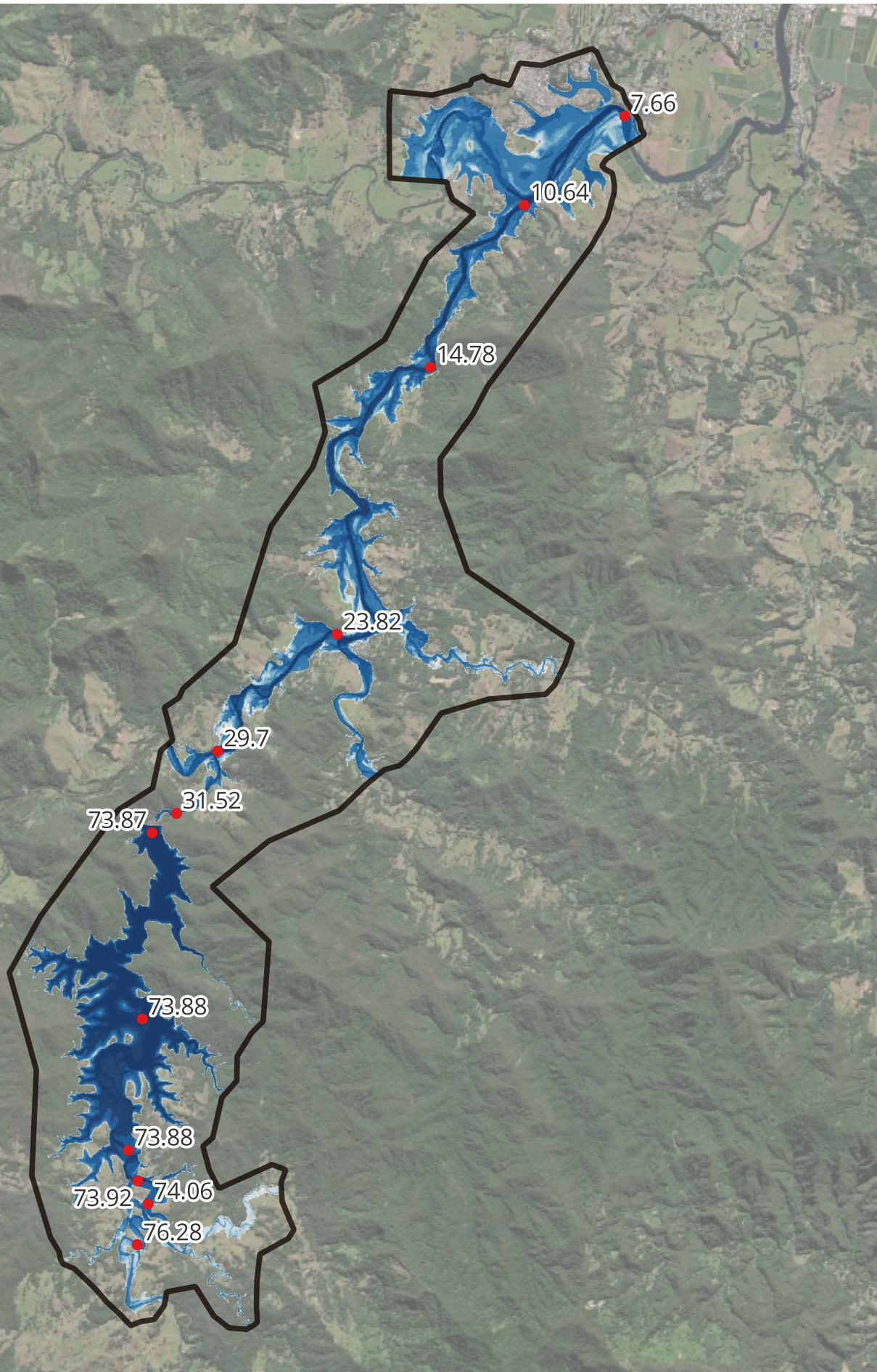
 1.5 - 2.0

 2.0 - 2.5

 2.5 - 5.0

 5.0 - 10.0

 > 10.0



Peak Flood Depth and Level - Proposed Case 0.2% AEP Design Event

Figure:
B4

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



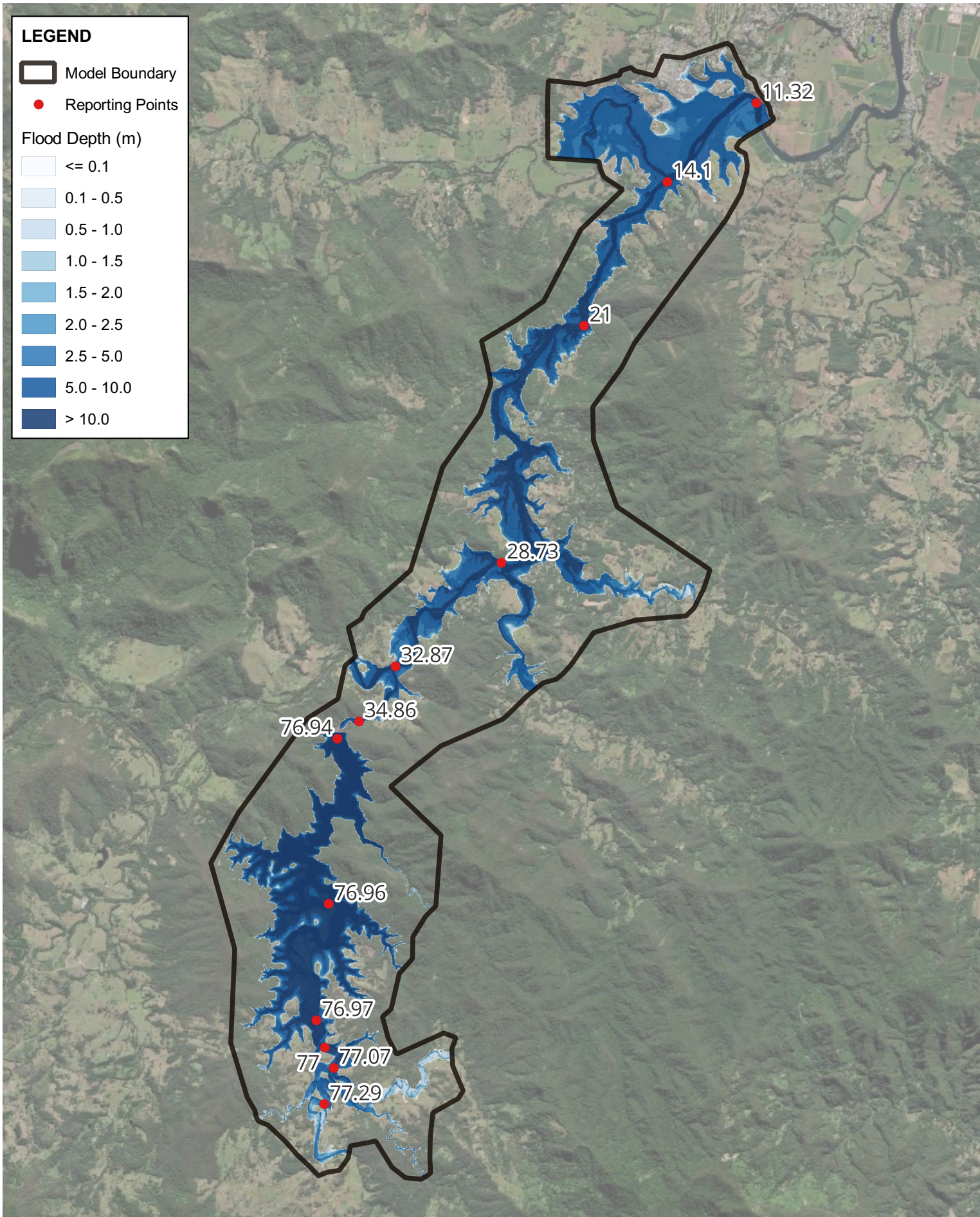
LEGEND

 Model Boundary

 Reporting Points

Flood Depth (m)

-  <= 0.1
-  0.1 - 0.5
-  0.5 - 1.0
-  1.0 - 1.5
-  1.5 - 2.0
-  2.0 - 2.5
-  2.5 - 5.0
-  5.0 - 10.0
-  > 10.0



Peak Flood Depth and Level - Proposed Case PMP Design Event

Figure:
B5

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

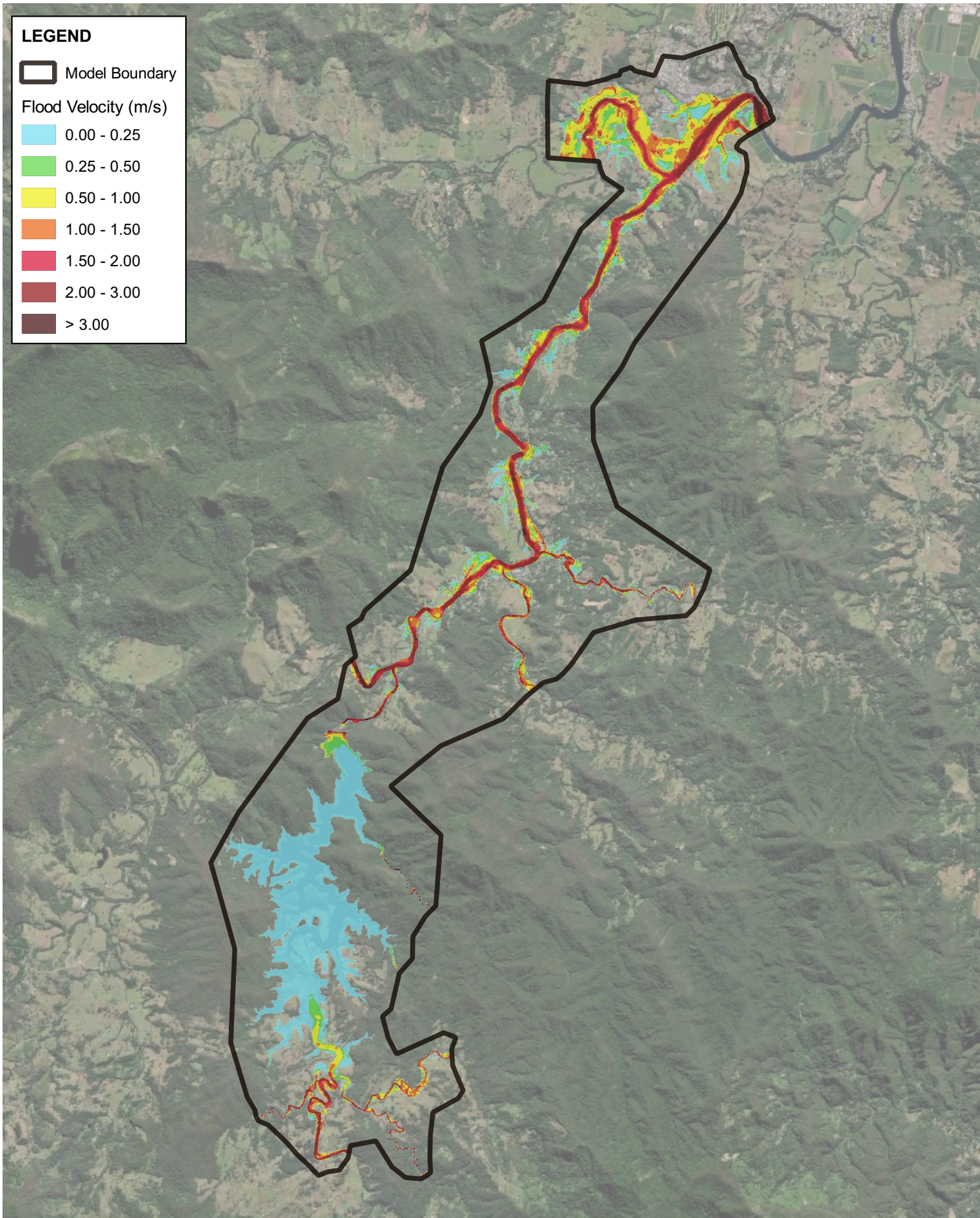
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Proposed Case 5% AEP Design Event

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

Figure:

B6

Rev:

2



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

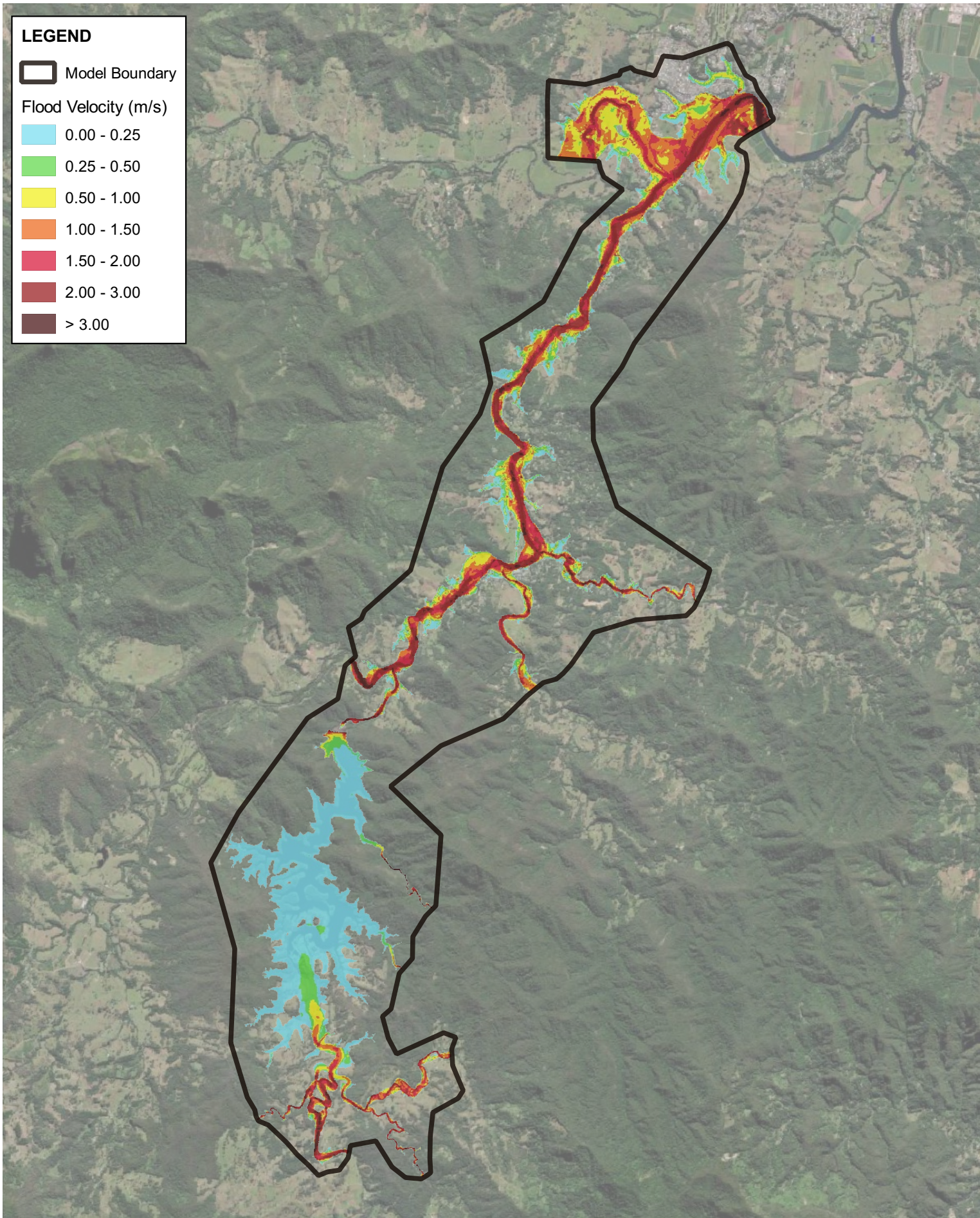
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Proposed Case 1% AEP Design Event

Figure:
B7

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

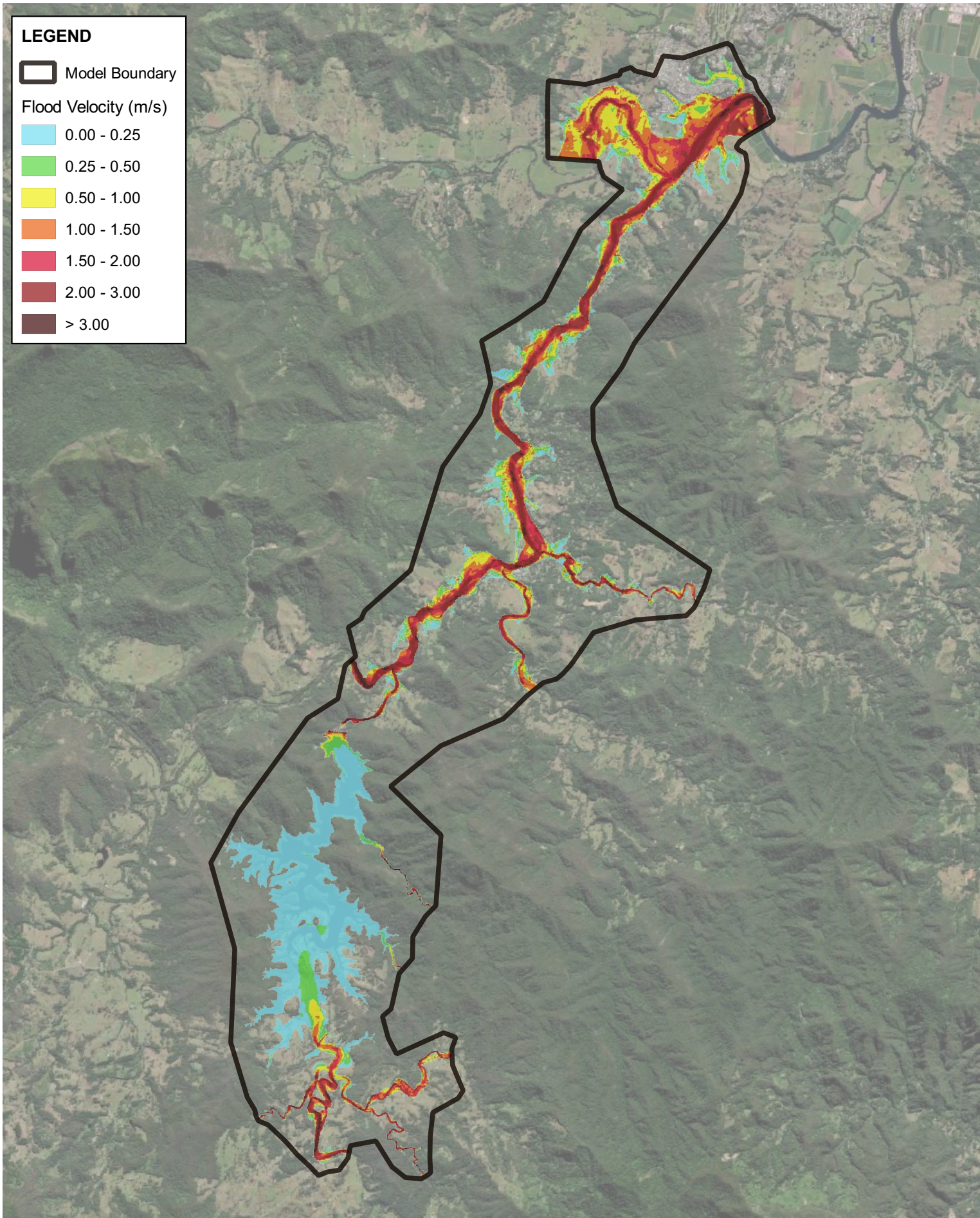
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Proposed Case 0.5% AEP Design Event

Figure:
B8

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

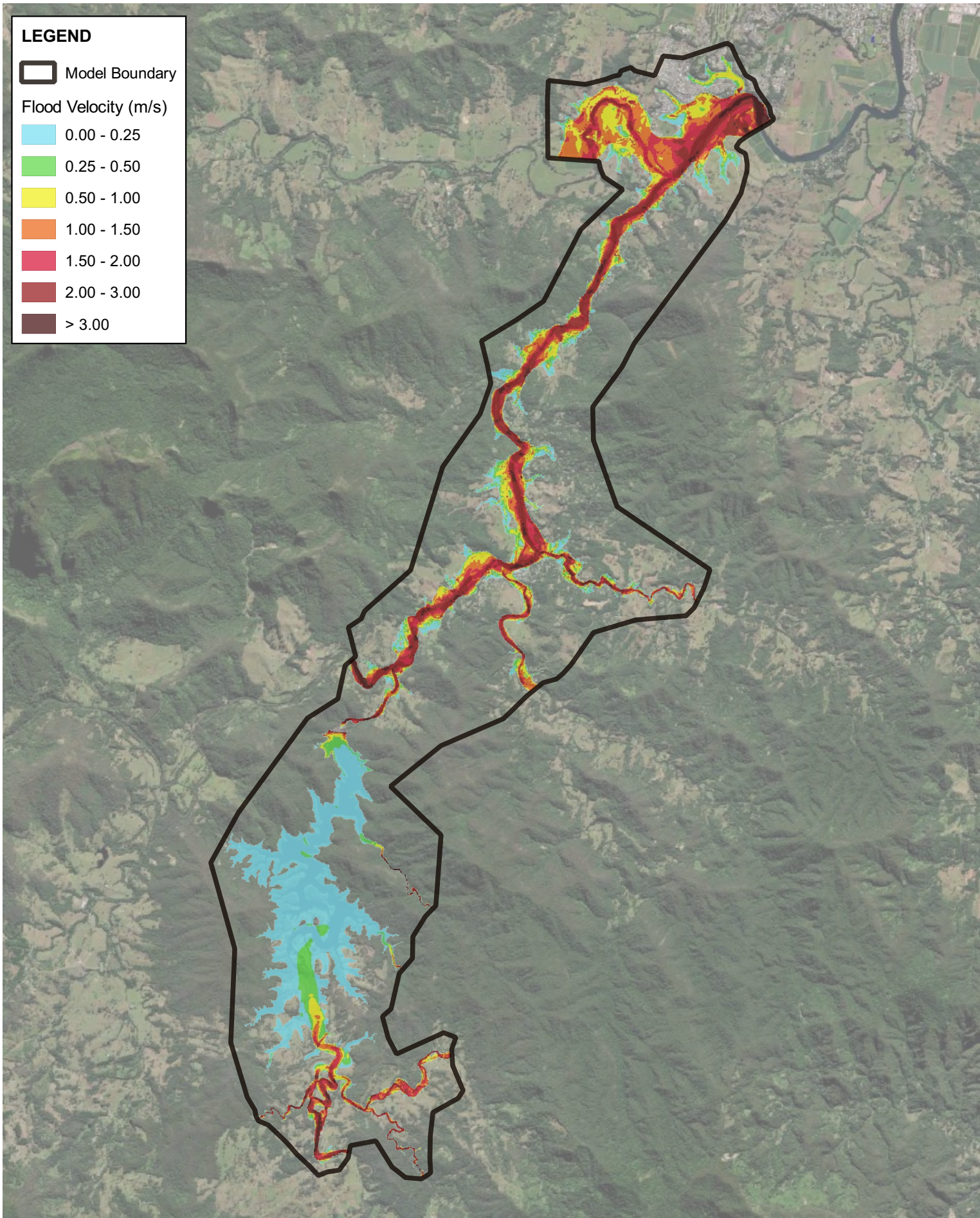
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Proposed Case 0.2% AEP Design Event

Figure:
B9

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Flood Velocity (m/s)

 0.00 - 0.25

 0.25 - 0.50

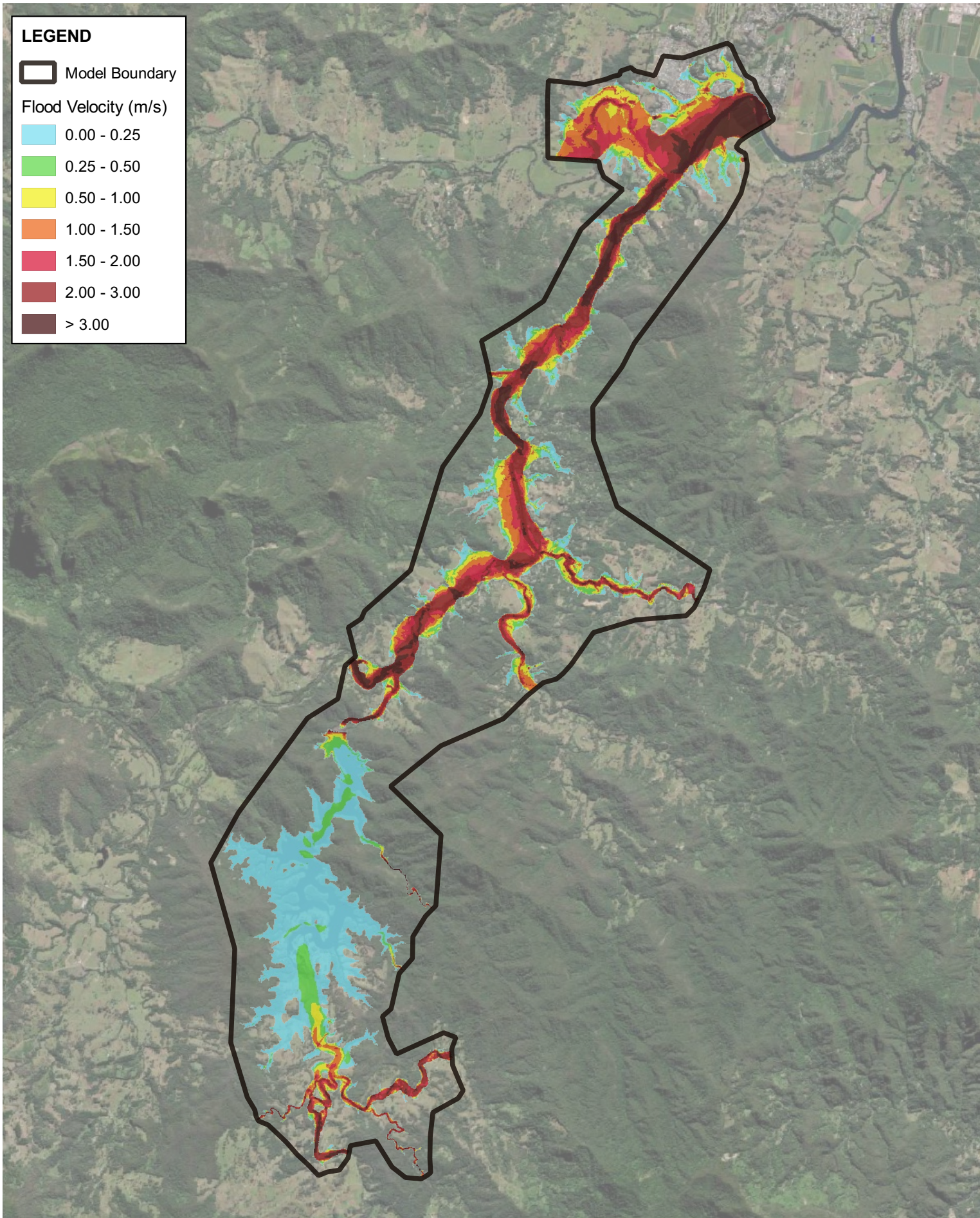
 0.50 - 1.00

 1.00 - 1.50

 1.50 - 2.00

 2.00 - 3.00

 > 3.00



Title: Peak Velocity - Proposed Case PMP Design Event

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

Figure:

B10

Rev:

2

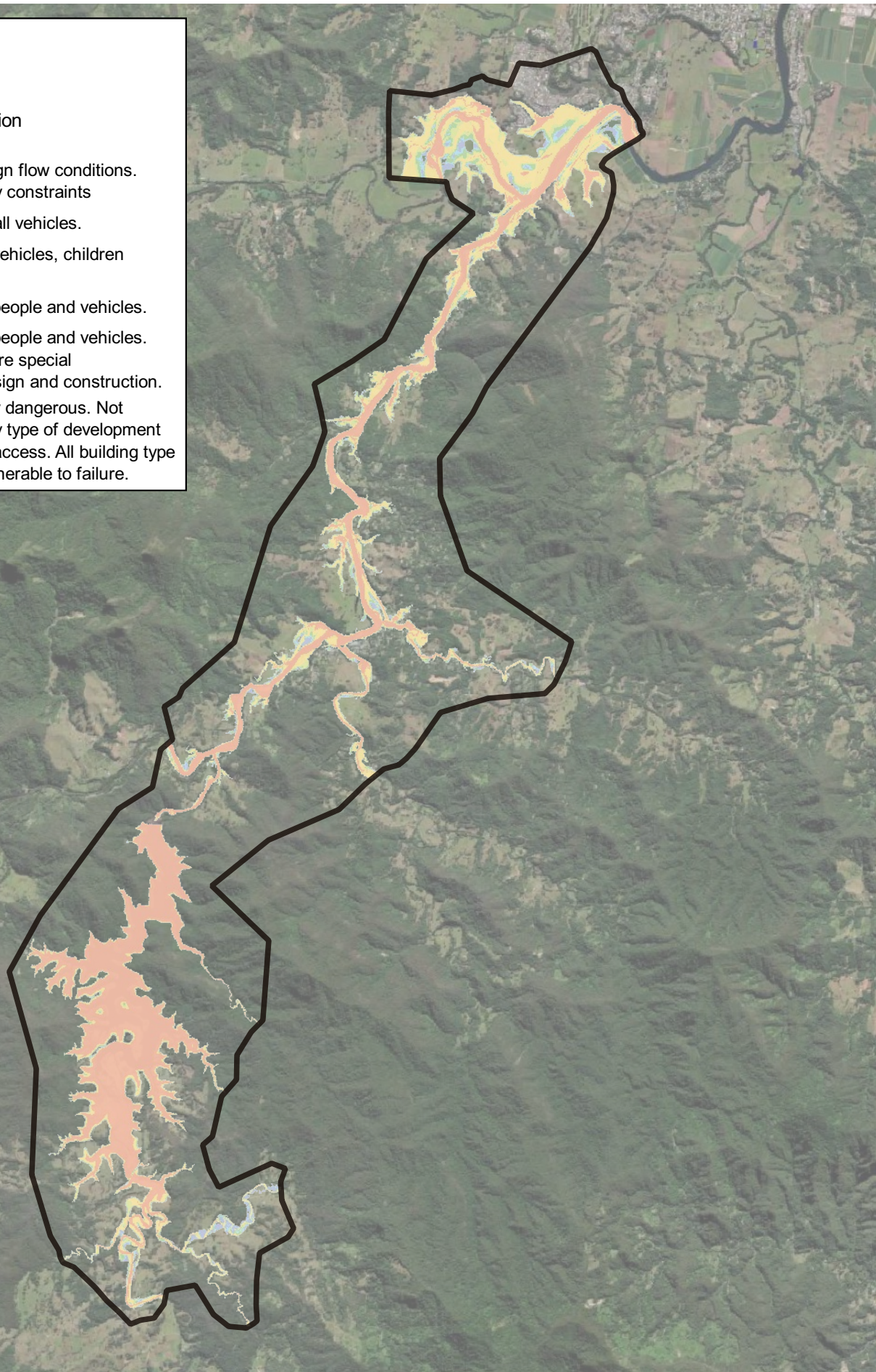


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Flood Hazard - Proposed Case 5% AEP Design Event

Figure: **B11**

Rev: **2**

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

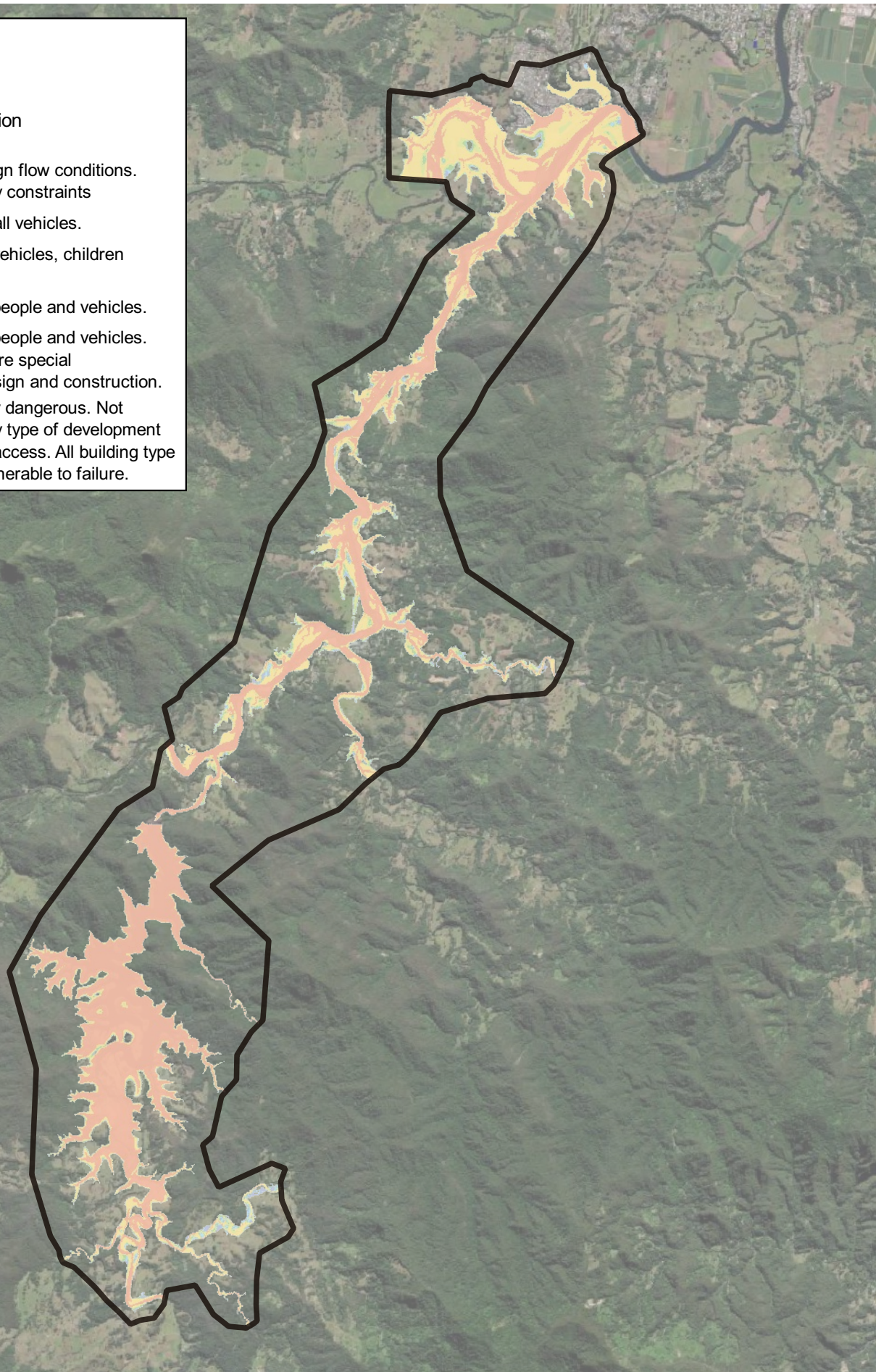


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Flood Hazard - Proposed Case 1% AEP Design Event

Figure: **B12**

Rev: **2**

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

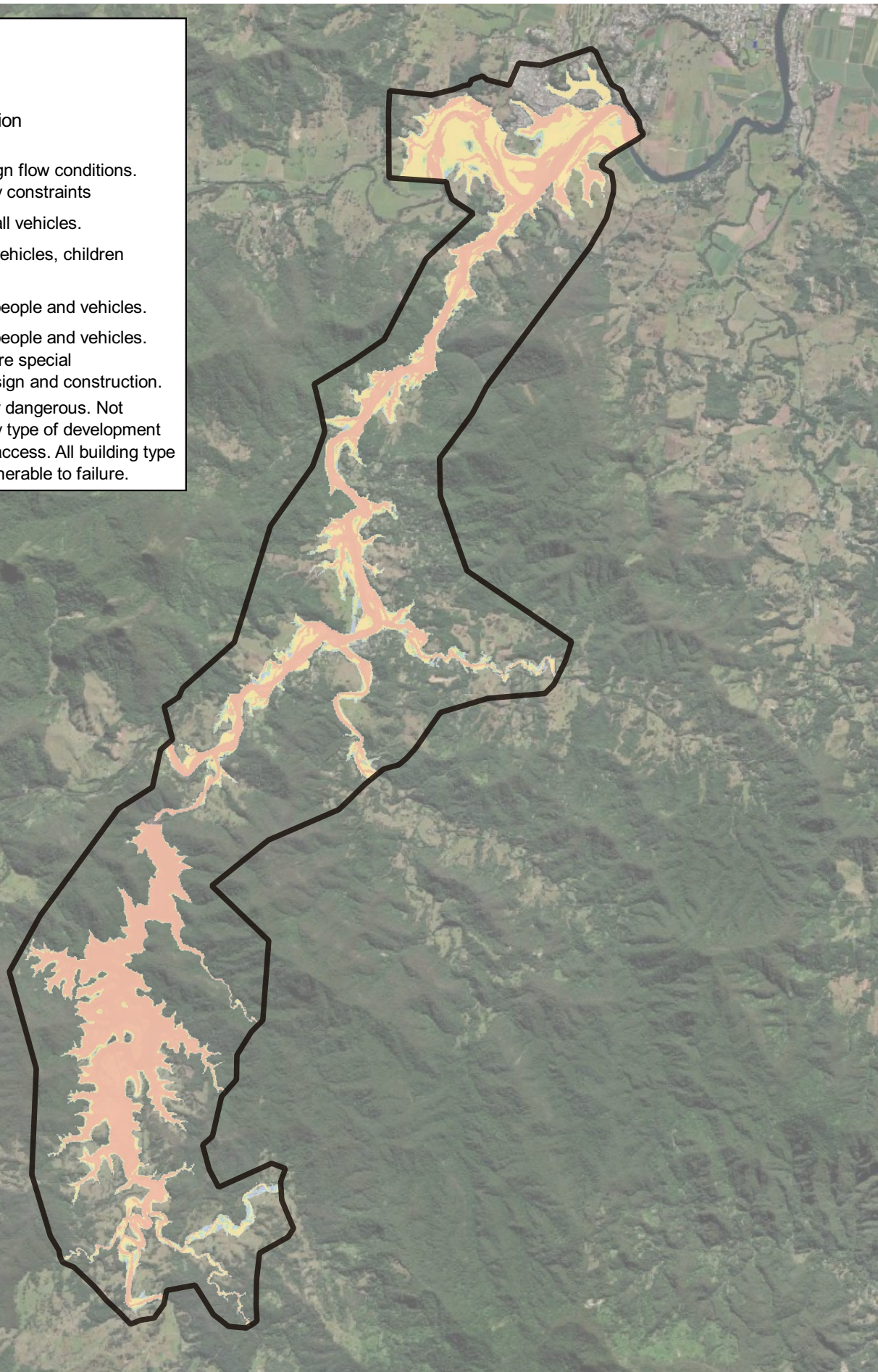


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Title: Flood Hazard - Proposed Case 0.5% AEP Design Event

Figure:
B13

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

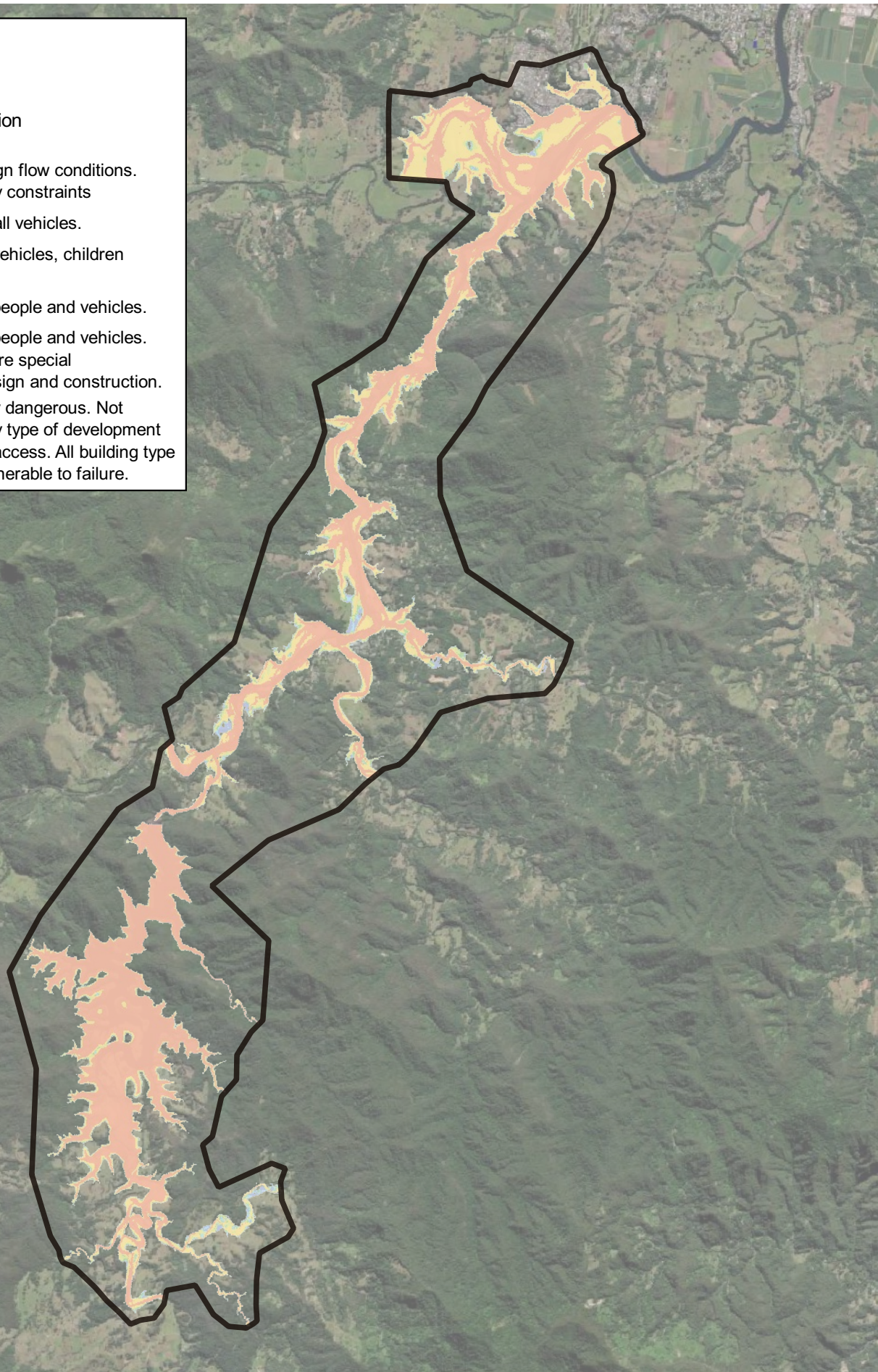


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions. No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles. Buildings require special engineering design and construction.
-  H6 - Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building type considered vulnerable to failure.



Title: Flood Hazard - Proposed Case 0.2% AEP Design Event

Figure:
B14

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

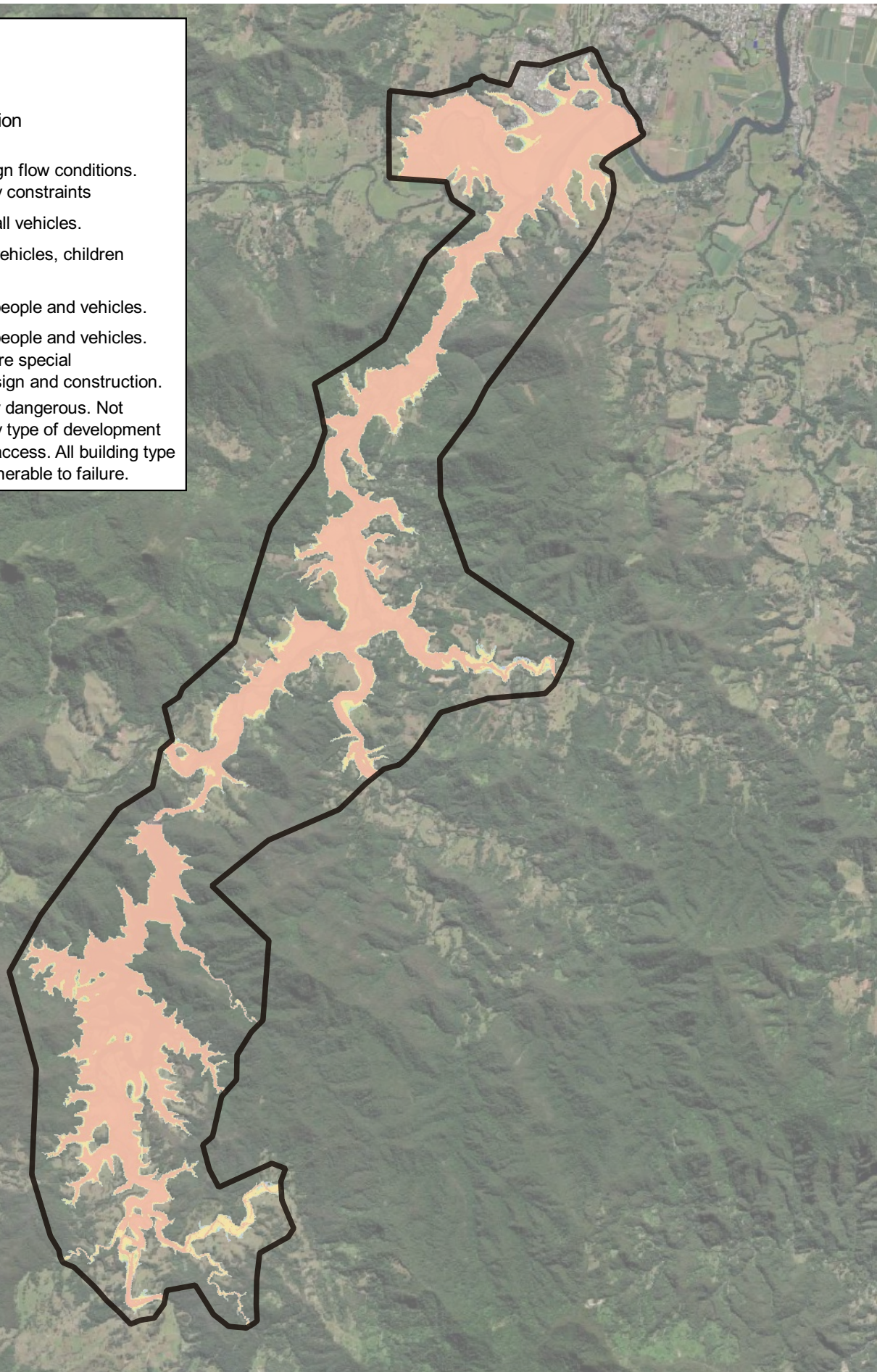


LEGEND

 Model Boundary

Flood Hazard Classification (ZAEM1)

-  H1 - Relatively benign flow conditions.
No vulnerability constraints
-  H2 - Unsafe for small vehicles.
-  H3 - Unsafe for all vehicles, children
and the elderly.
-  H4 - Unsafe for all people and vehicles.
-  H5 - Unsafe for all people and vehicles.
Buildings require special
engineering design and construction.
-  H6 - Unconditionally dangerous. Not
suitable for any type of development
or evacuation access. All building type
considered vulnerable to failure.



Title: Flood Hazard - Proposed Case PMP Design Event

Figure:
B15

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

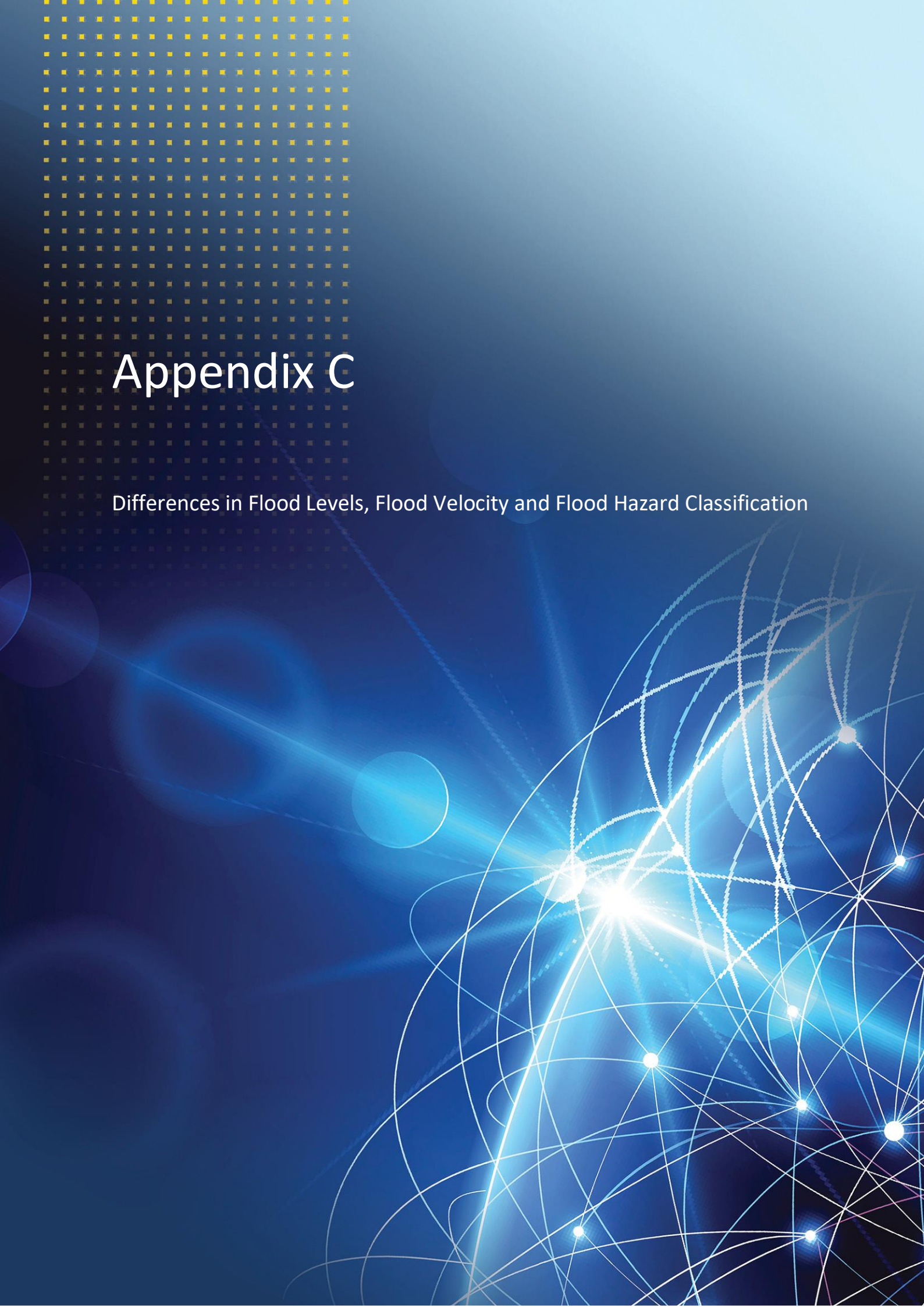
Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000





Appendix C

Differences in Flood Levels, Flood Velocity and Flood Hazard Classification

LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

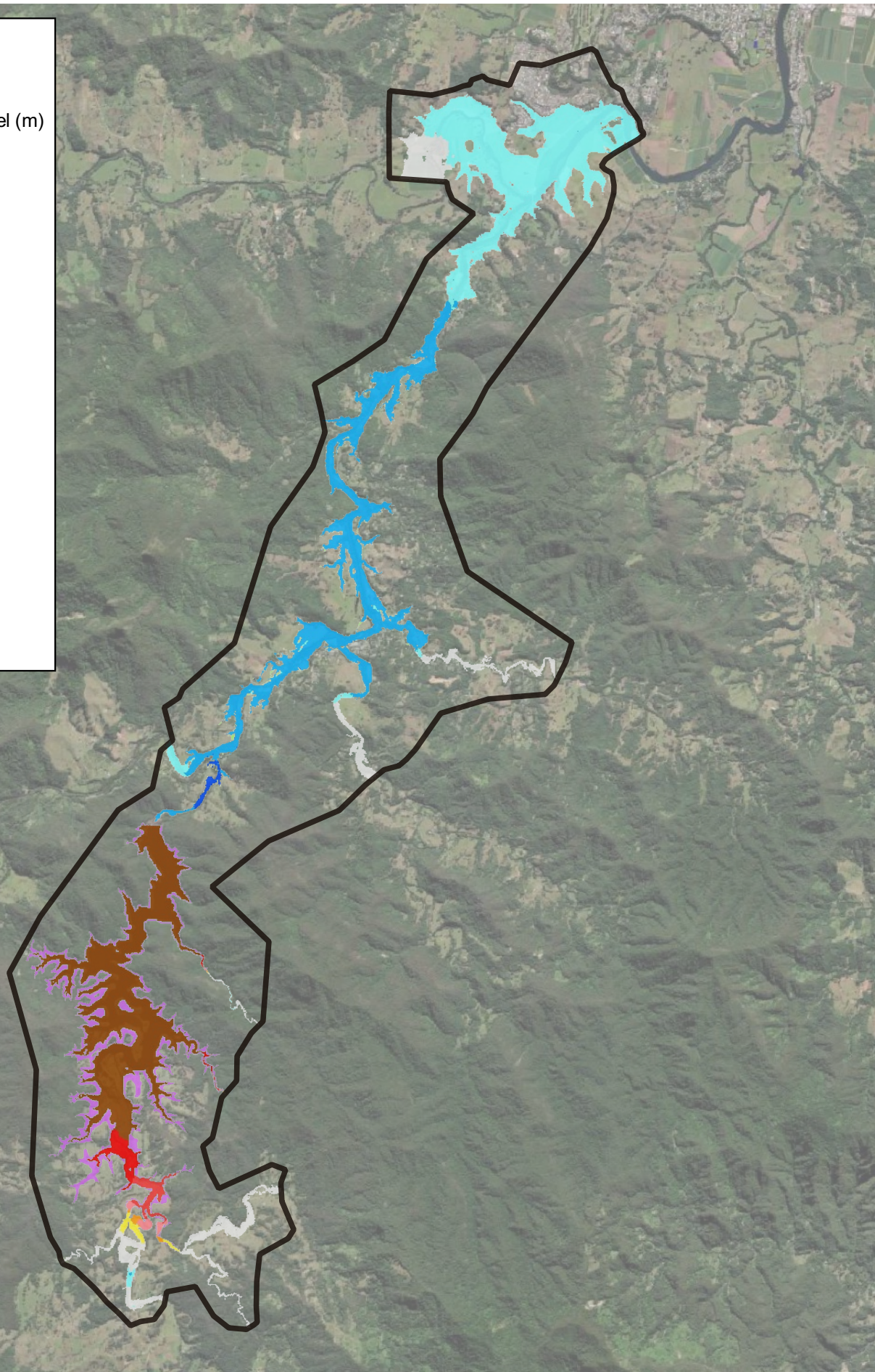
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Level - Proposed Case minus Existing Case
5% AEP Design Event**

Figure:
C1

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

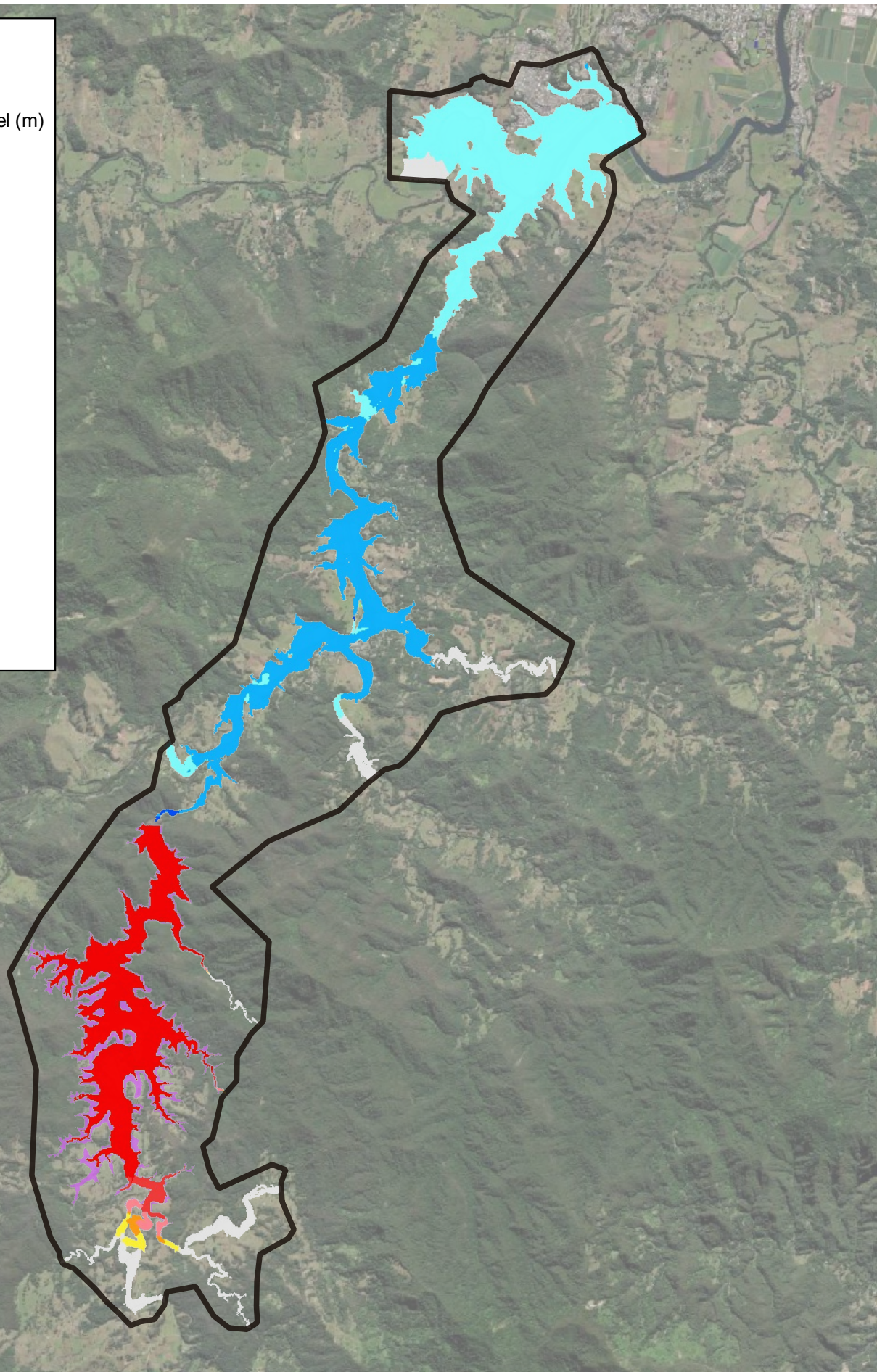
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Level - Proposed Case minus Existing Case
1% AEP Design Event**

Figure:
C2

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

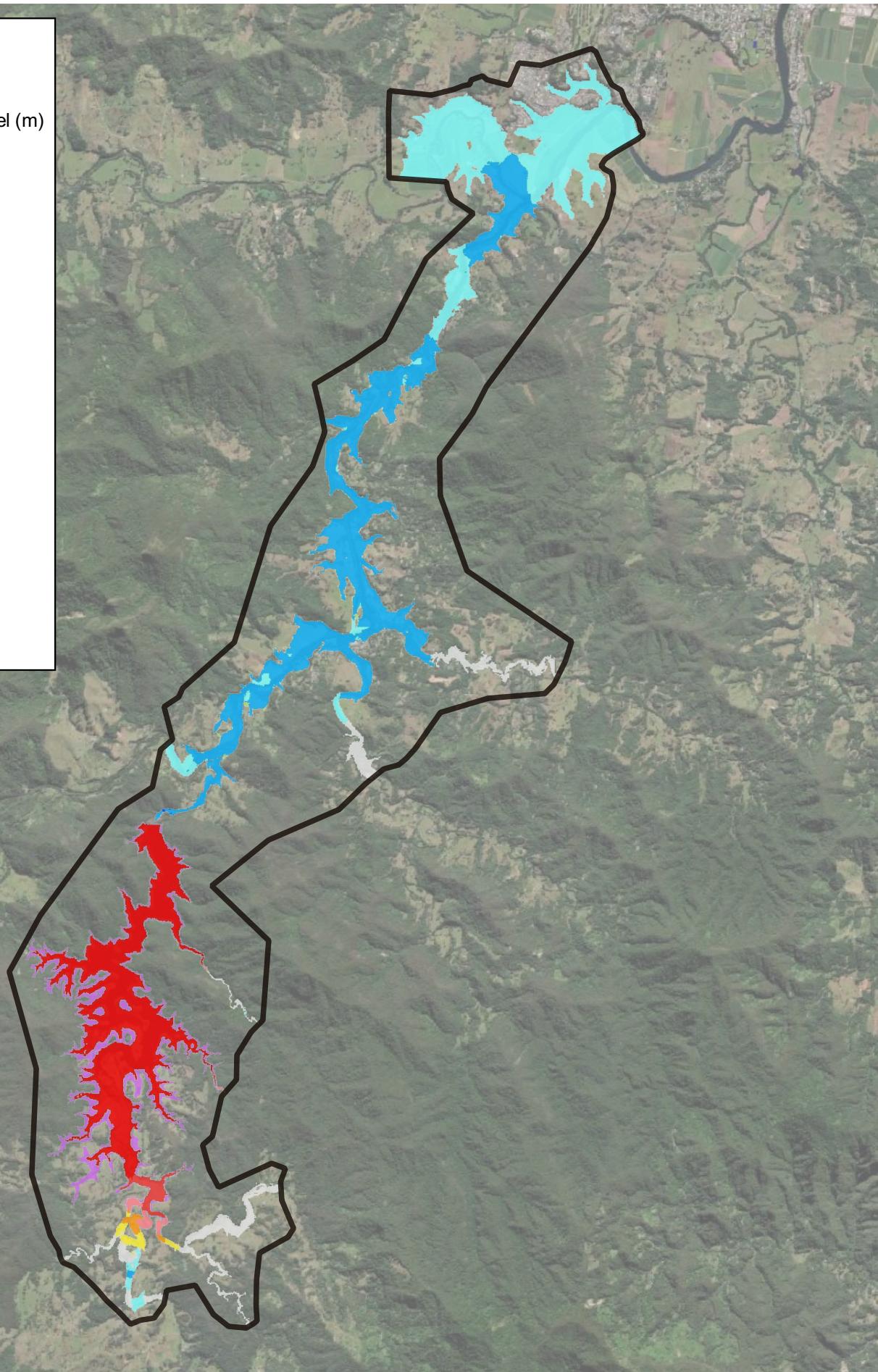
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Level - Proposed Case minus Existing Case
0.5% AEP Design Event**

Figure:
C3

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

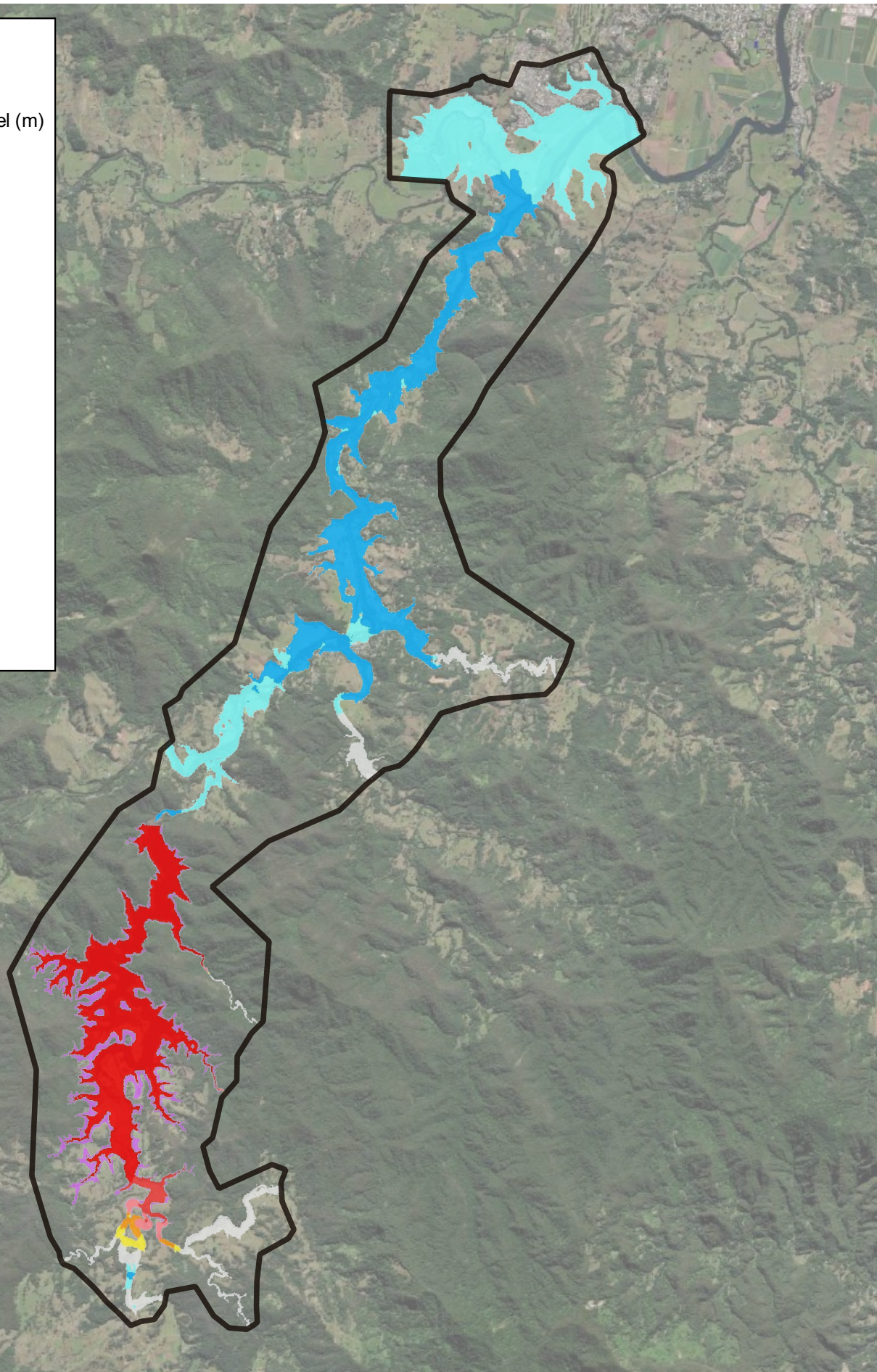
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
Differences in Flood Level - Proposed Case minus Existing Case
0.2% AEP Design Event

Figure:
C4

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

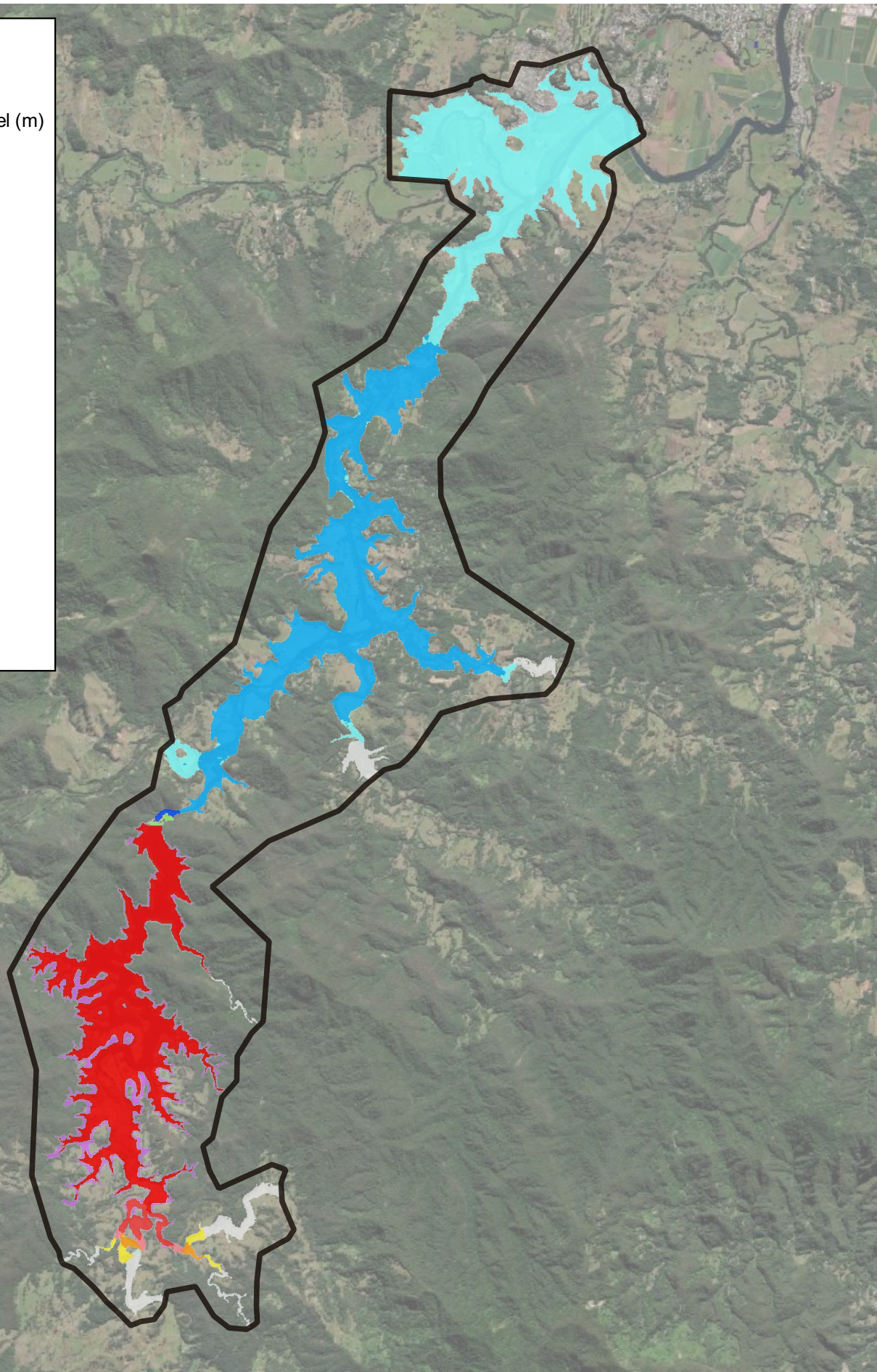
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Level - Proposed Case minus Existing Case
PMP Design Event**

Figure:
C5

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Velocity (m/s)

 <-0.5

 -0.50 to -0.25

 -0.25 to -0.10

 -0.10 to -0.01

 ± 0.01

 0.01 - 0.50

 0.5 to 1.0

 1.0 to 2.5

 2.5 to 5.0

 5.0 to 7.5

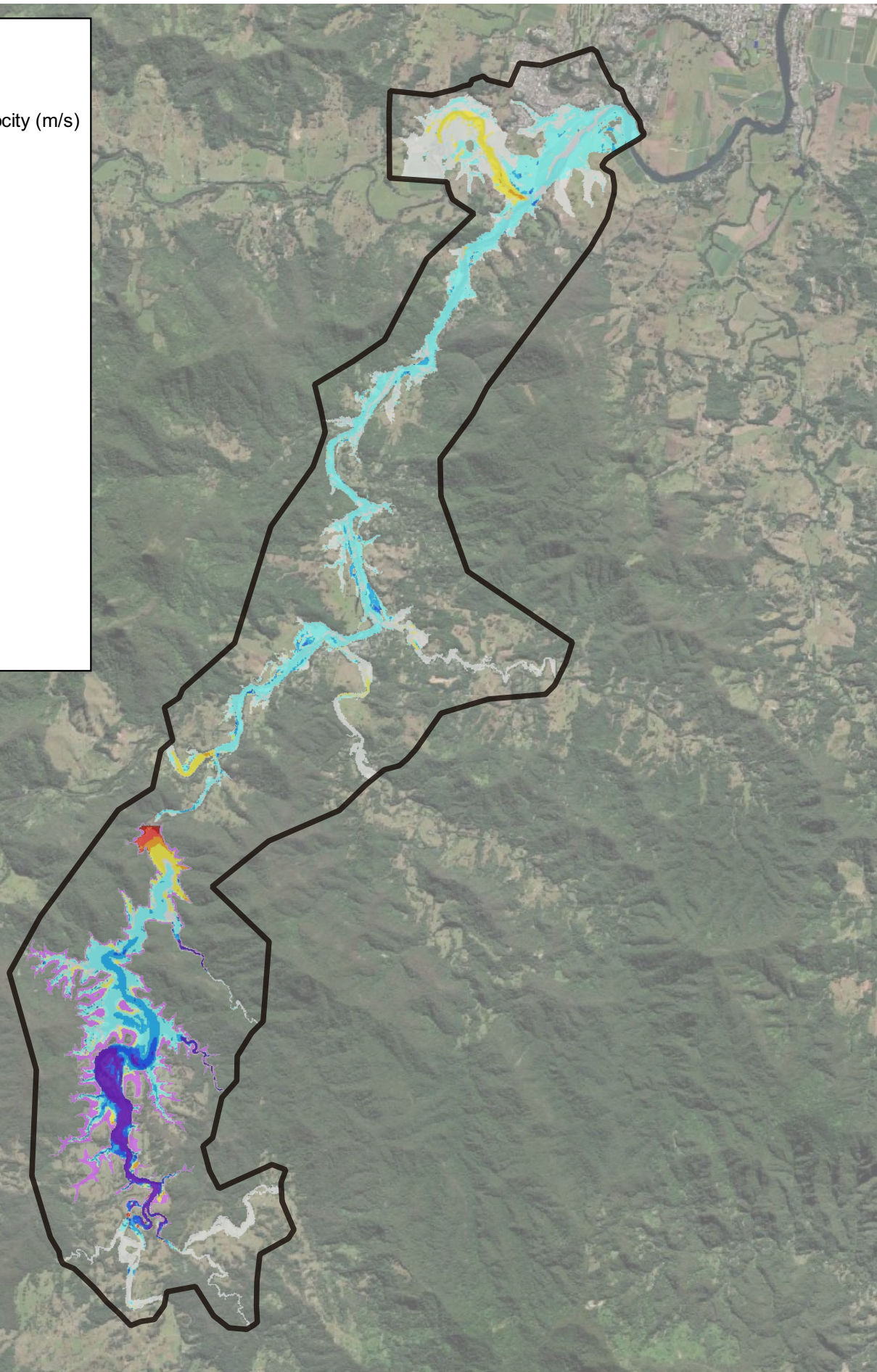
 7.5 to 10.0

 >10

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Velocity - Proposed Case minus Existing Case
5% AEP Design Event

Figure:

C6

Rev:

2

Scale at A4 1:80000.000000000025

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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Velocity (m/s)

 <-0.5

 -0.50 to -0.25

 -0.25 to -0.10

 -0.10 to -0.01

 ± 0.01

 0.01 - 0.50

 0.5 to 1.0

 1.0 to 2.5

 2.5 to 5.0

 5.0 to 7.5

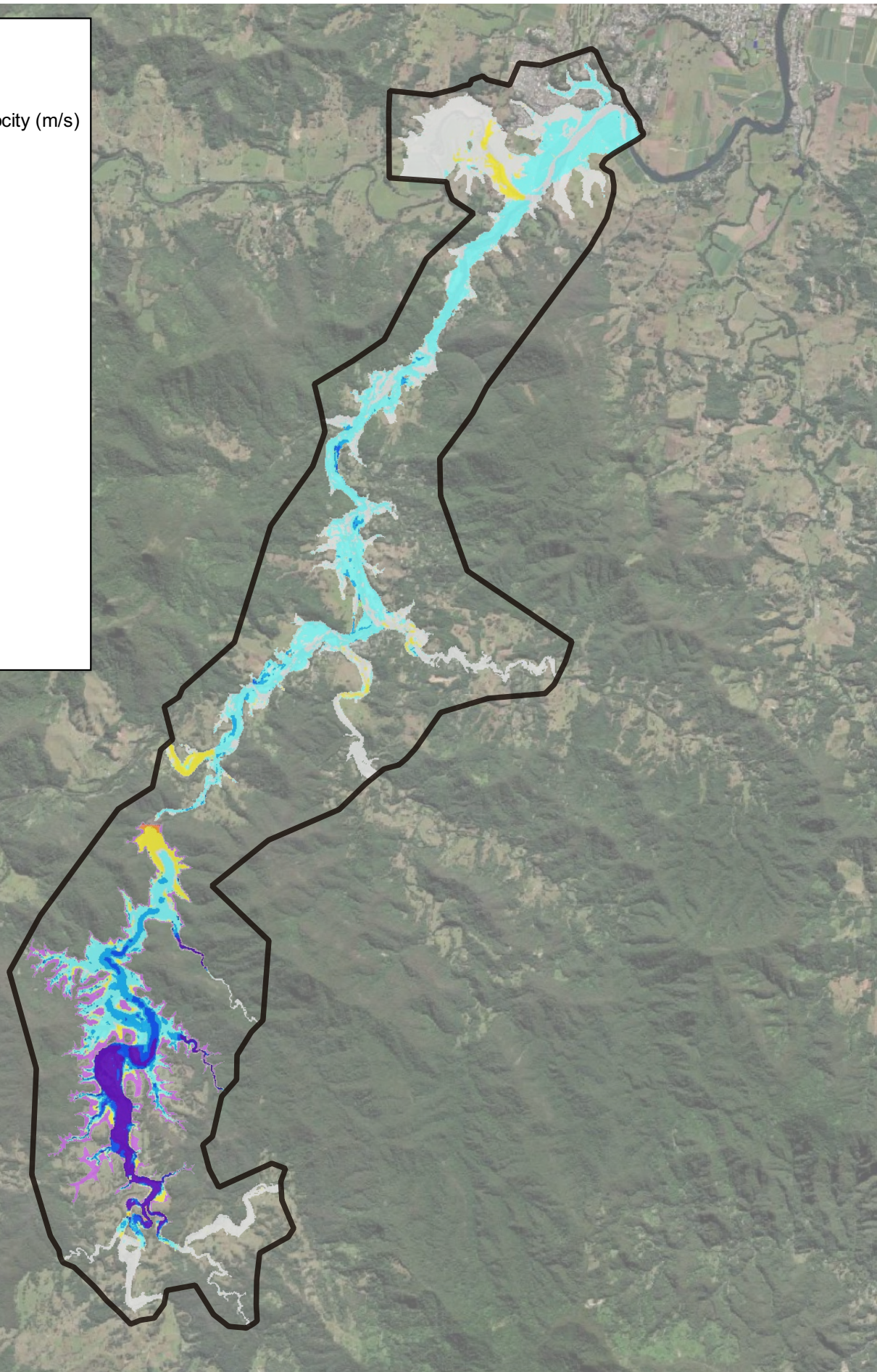
 7.5 to 10.0

 >10

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Velocity - Proposed Case minus Existing Case
1% AEP Design Event**

Figure:
C7

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Velocity (m/s)

 <-0.5

 -0.50 to -0.25

 -0.25 to -0.10

 -0.10 to -0.01

 ± 0.01

 0.01 - 0.50

 0.5 to 1.0

 1.0 to 2.5

 2.5 to 5.0

 5.0 to 7.5

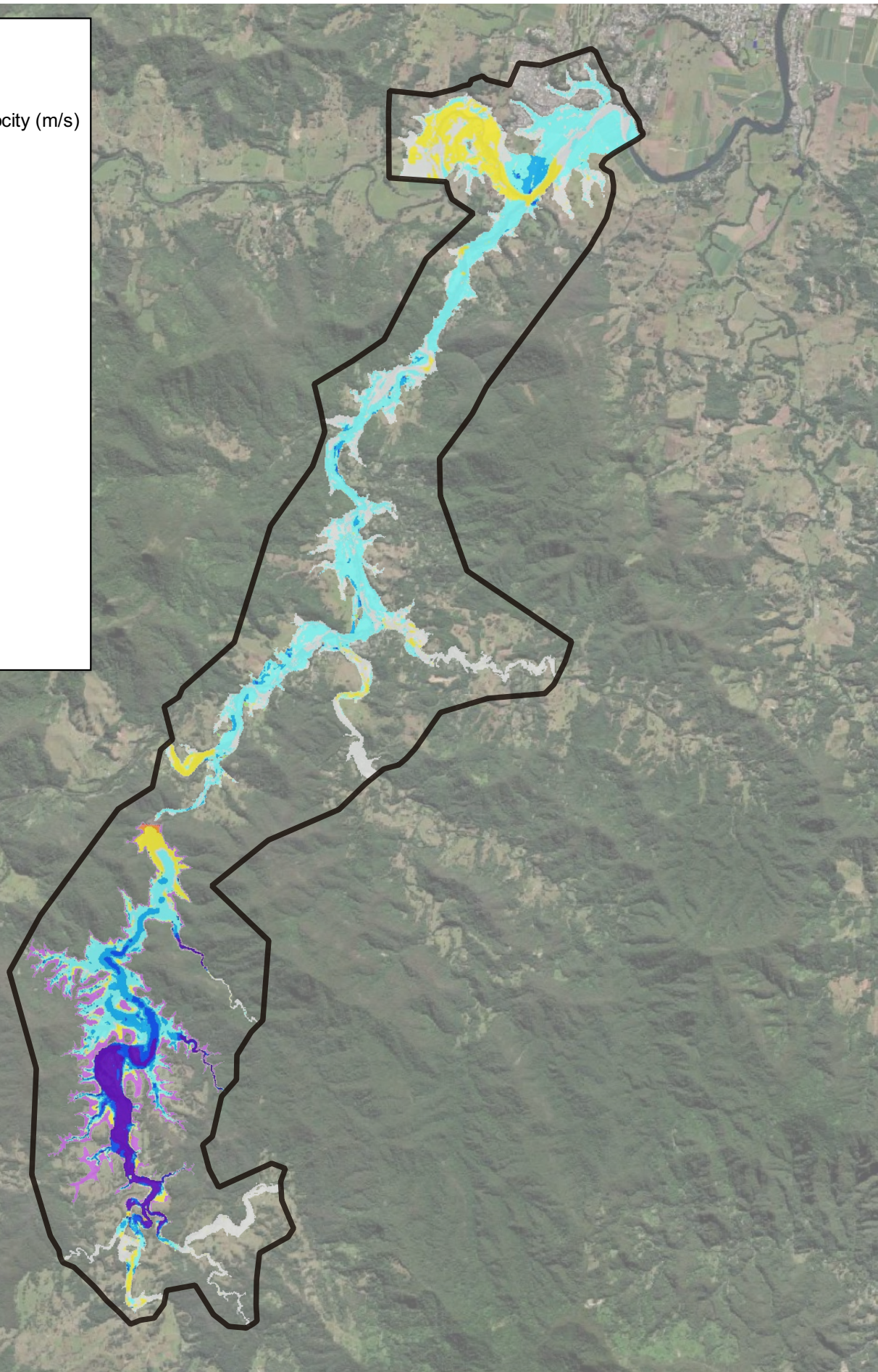
 7.5 to 10.0

 >10

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Velocity - Proposed Case minus Existing Case
0.5% AEP Design Event

Figure:
C8

Rev:
2

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Velocity (m/s)

 <-0.5

 -0.50 to -0.25

 -0.25 to -0.10

 -0.10 to -0.01

 ± 0.01

 0.01 - 0.50

 0.5 to 1.0

 1.0 to 2.5

 2.5 to 5.0

 5.0 to 7.5

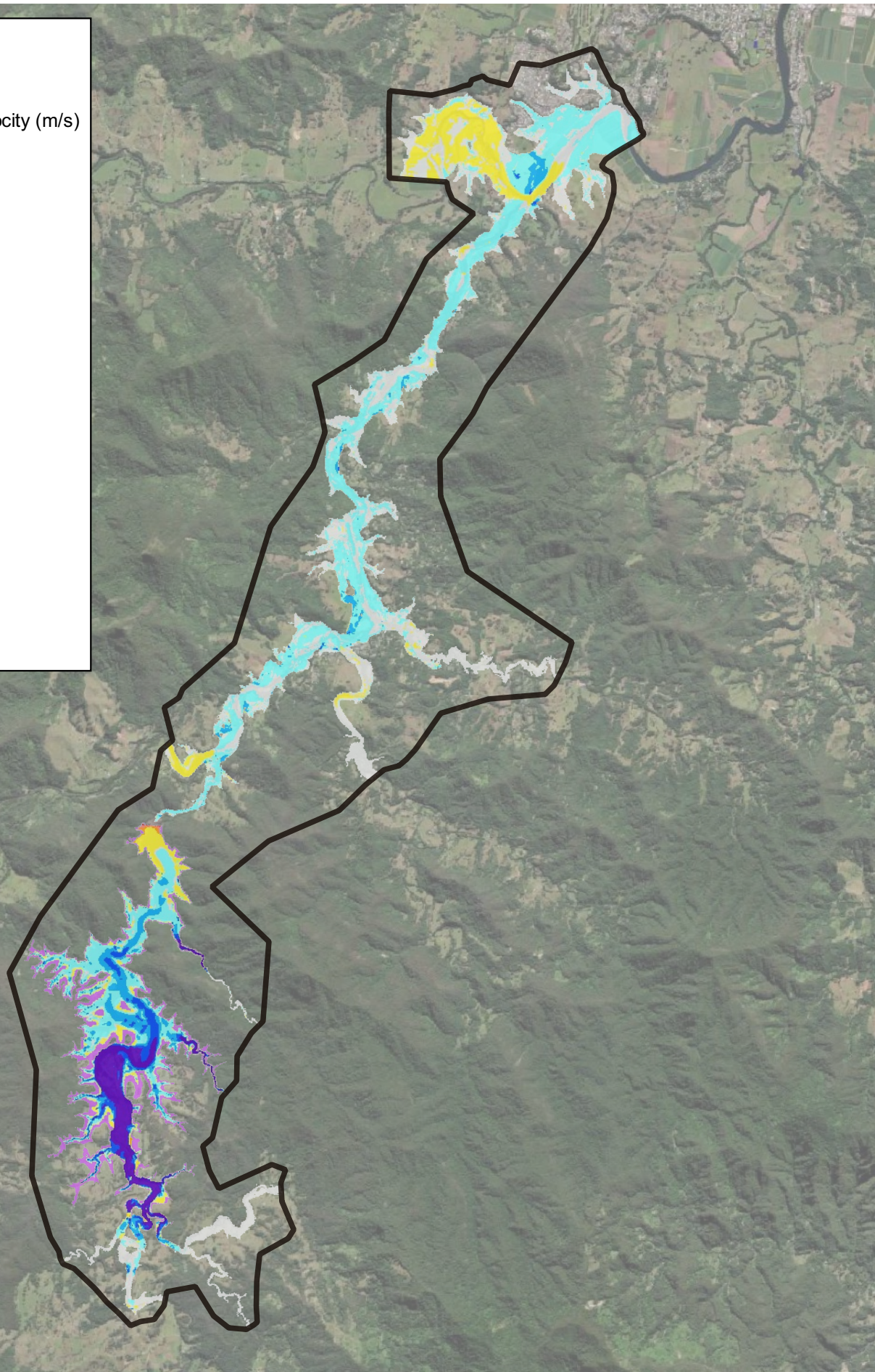
 7.5 to 10.0

 >10

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Velocity - Proposed Case minus Existing Case
0.2% AEP Design Event

Figure:

C9

Rev:

2

Scale at A4 1:80000.00000000025

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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Velocity (m/s)

 <-0.5

 -0.50 to -0.25

 -0.25 to -0.10

 -0.10 to -0.01

 ± 0.01

 0.01 - 0.50

 0.5 to 1.0

 1.0 to 2.5

 2.5 to 5.0

 5.0 to 7.5

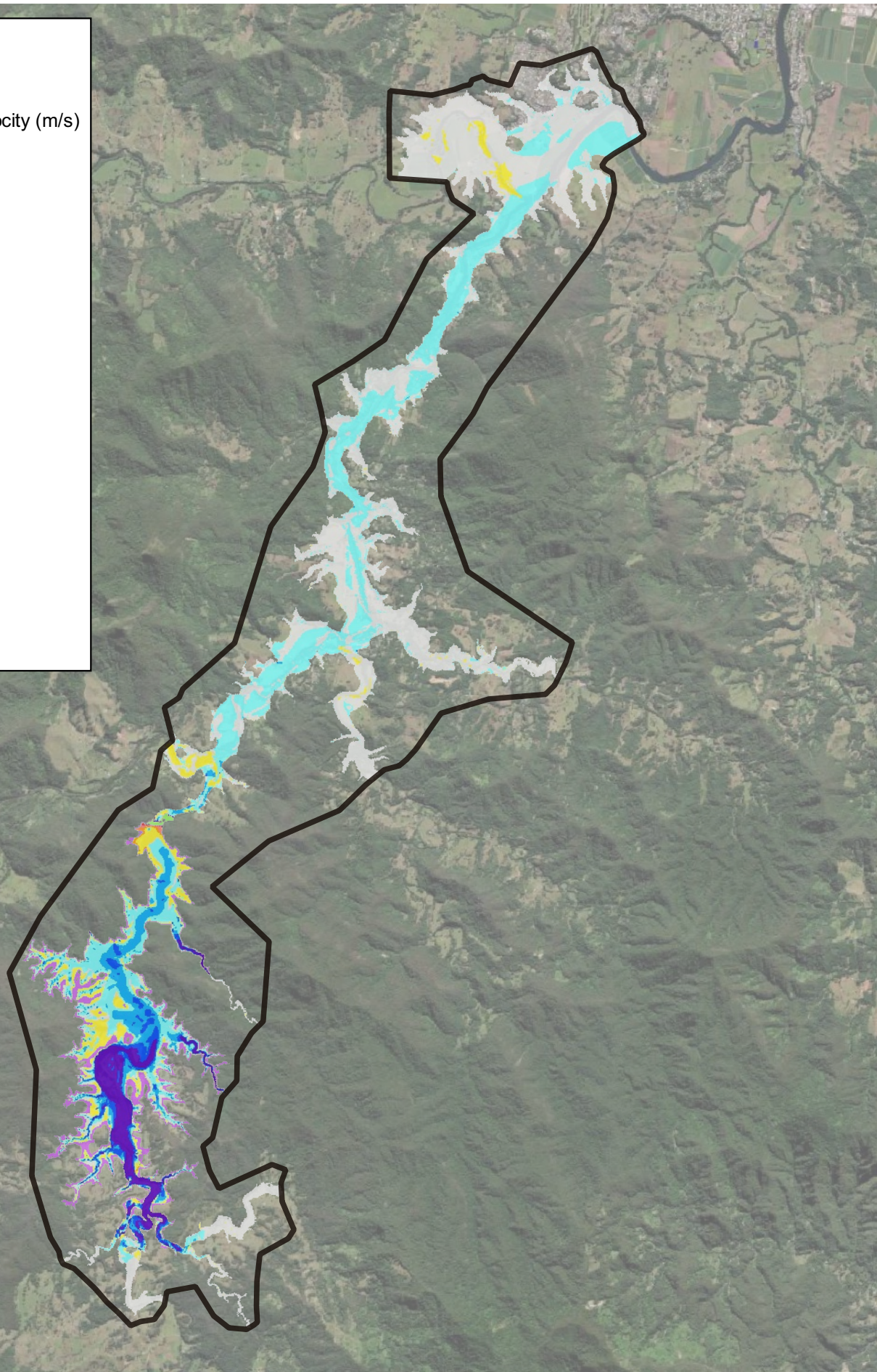
 7.5 to 10.0

 >10

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Velocity - Proposed Case minus Existing Case PMP Design Event

Figure: **C10**

Rev: **2**

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Hazard Classification

 4 Classifications Lower

 3 Classifications Lower

 2 Classifications Lower

 1 Classification Lower

 No Difference

 1 Classification Higher

 2 Classifications Higher

 3 Classifications Higher

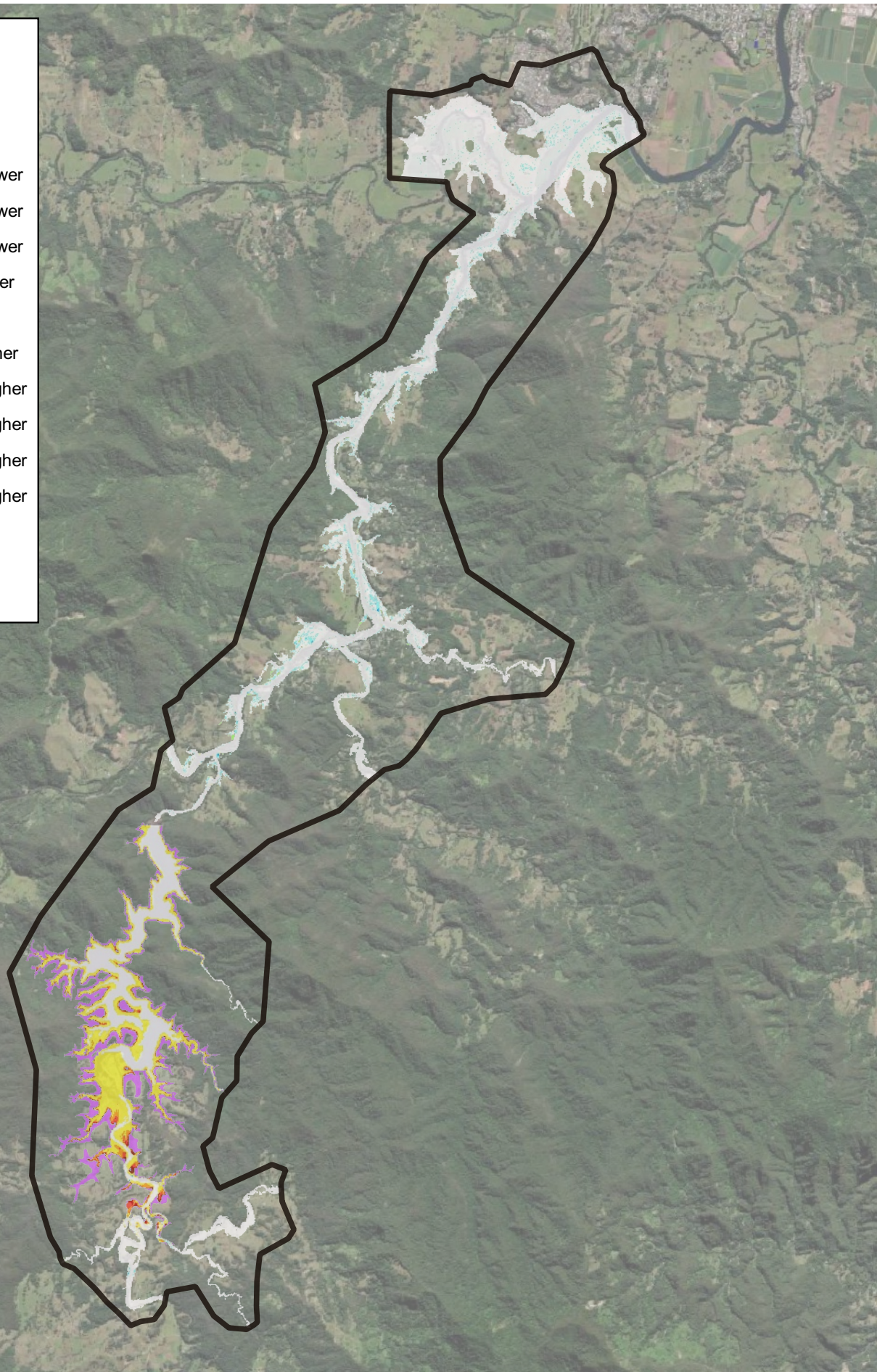
 4 Classifications Higher

 5 Classifications Higher

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Hazard Classification - Proposed Case minus Existing Case
5% AEP Design Event

Figure:
C11

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaising\ES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

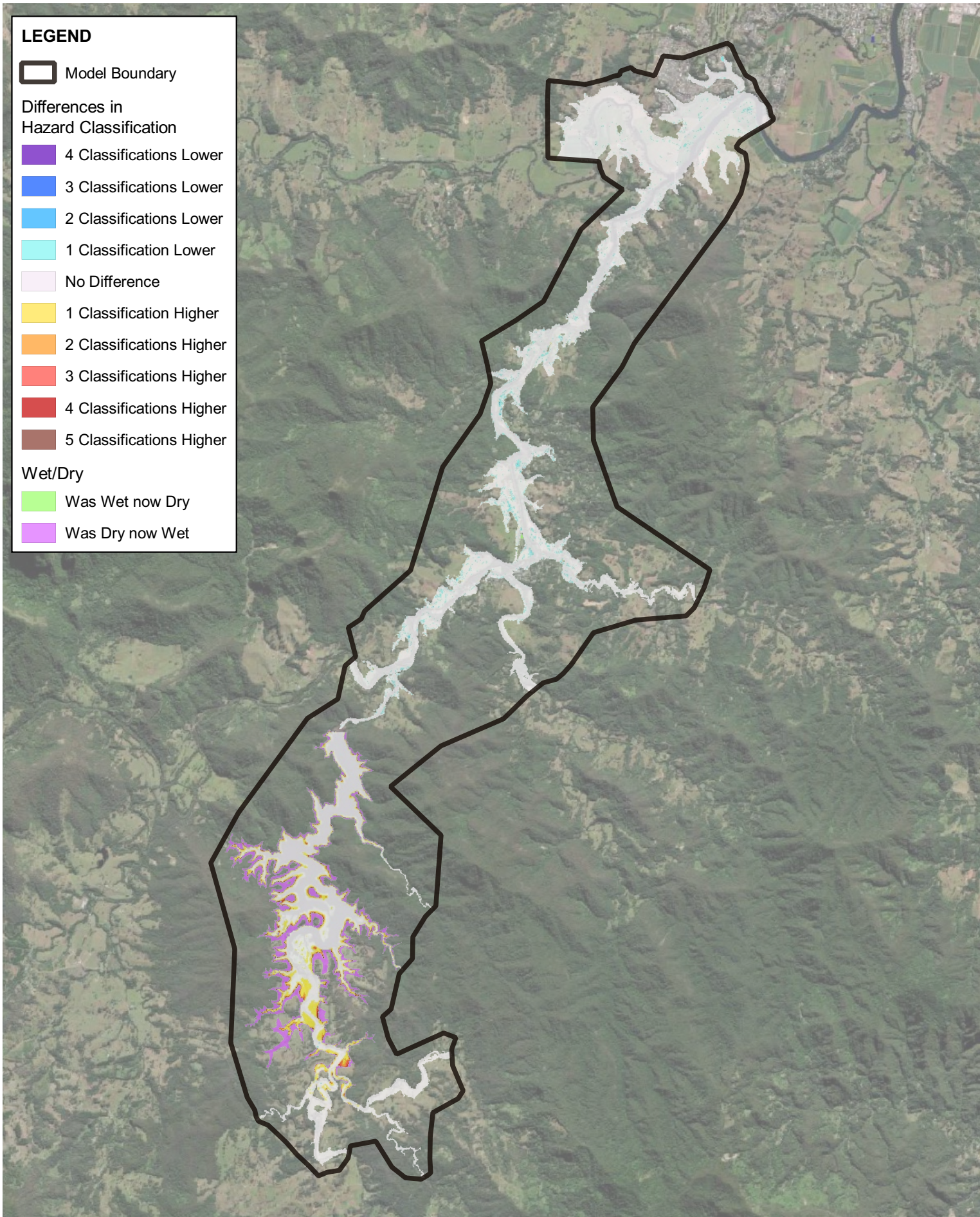
 Model Boundary

Differences in Hazard Classification

-  4 Classifications Lower
-  3 Classifications Lower
-  2 Classifications Lower
-  1 Classification Lower
-  No Difference
-  1 Classification Higher
-  2 Classifications Higher
-  3 Classifications Higher
-  4 Classifications Higher
-  5 Classifications Higher

Wet/Dry

-  Was Wet now Dry
-  Was Dry now Wet



Differences in Flood Hazard Classification - Proposed Case minus Existing Case
1% AEP Design Event

Figure:
C12

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

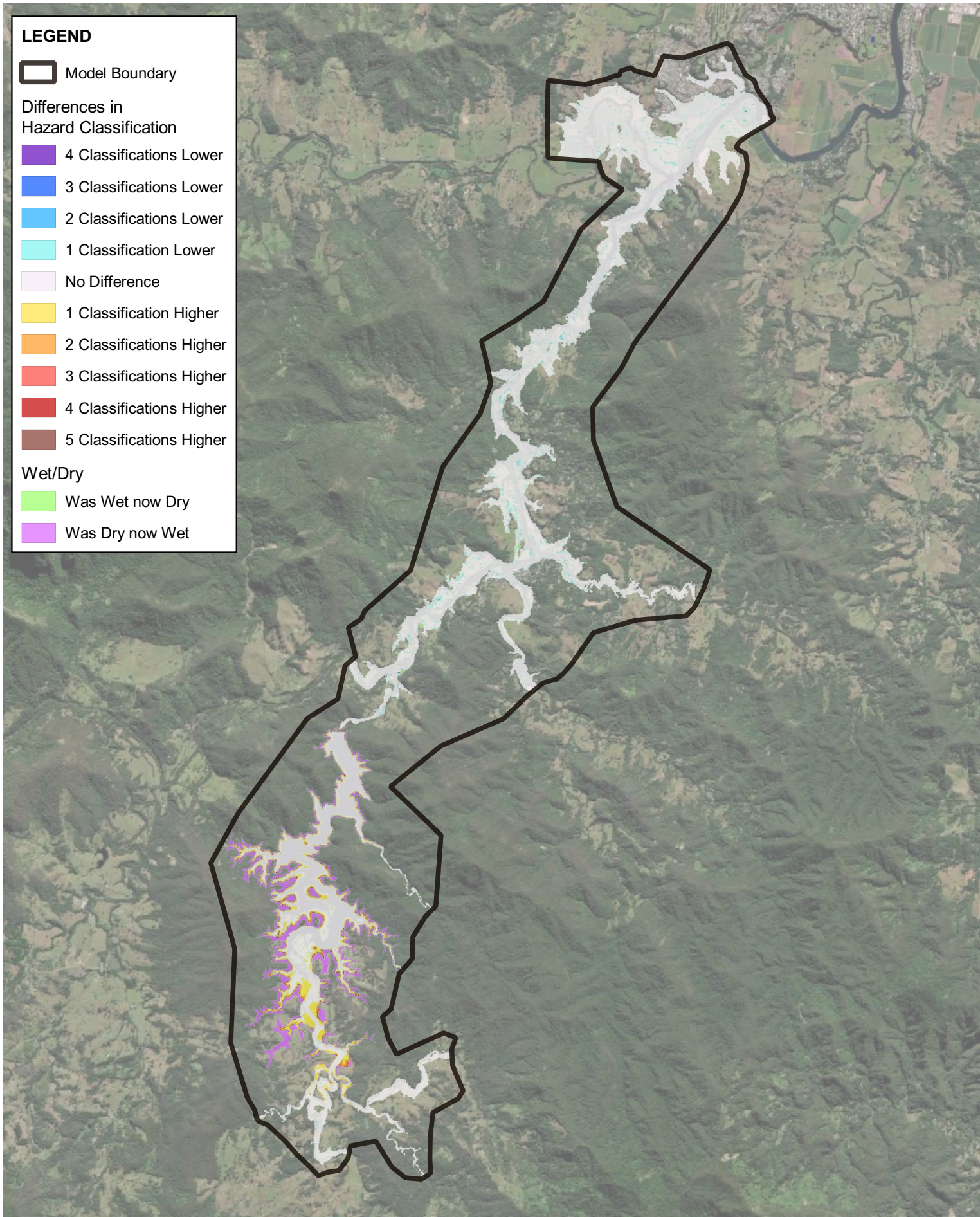
 Model Boundary

Differences in Hazard Classification

-  4 Classifications Lower
-  3 Classifications Lower
-  2 Classifications Lower
-  1 Classification Lower
-  No Difference
-  1 Classification Higher
-  2 Classifications Higher
-  3 Classifications Higher
-  4 Classifications Higher
-  5 Classifications Higher

Wet/Dry

-  Was Wet now Dry
-  Was Dry now Wet



Differences in Flood Hazard Classification - Proposed Case minus Existing Case
0.5% AEP Design Event

Figure: **C13**

Rev: **2**

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Hazard Classification

 4 Classifications Lower

 3 Classifications Lower

 2 Classifications Lower

 1 Classification Lower

 No Difference

 1 Classification Higher

 2 Classifications Higher

 3 Classifications Higher

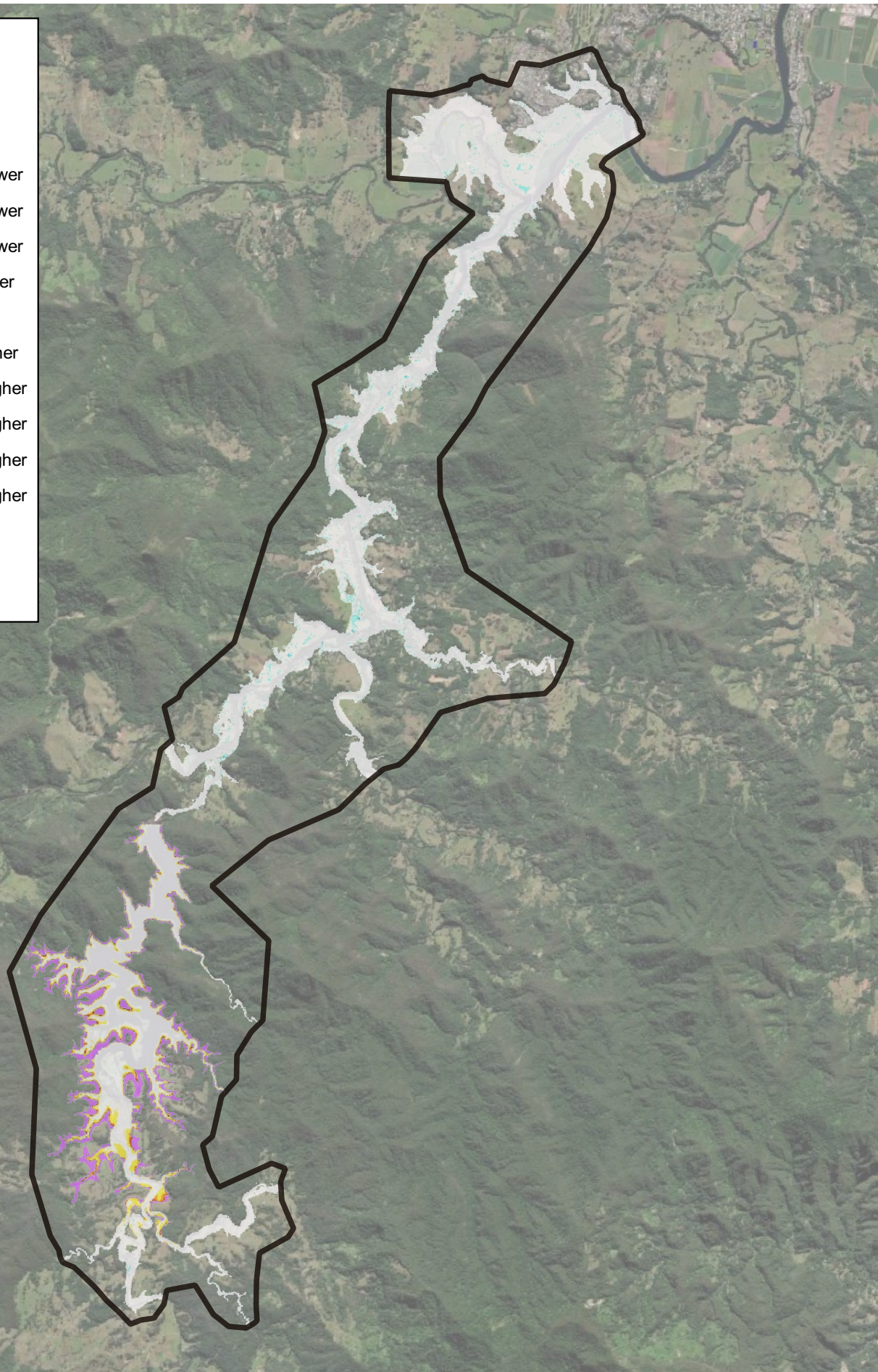
 4 Classifications Higher

 5 Classifications Higher

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Hazard Classification - Proposed Case minus Existing Case
0.2% AEP Design Event

Figure: **C14**

Rev: **2**

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Hazard Classification

 4 Classifications Lower

 3 Classifications Lower

 2 Classifications Lower

 1 Classification Lower

 No Difference

 1 Classification Higher

 2 Classifications Higher

 3 Classifications Higher

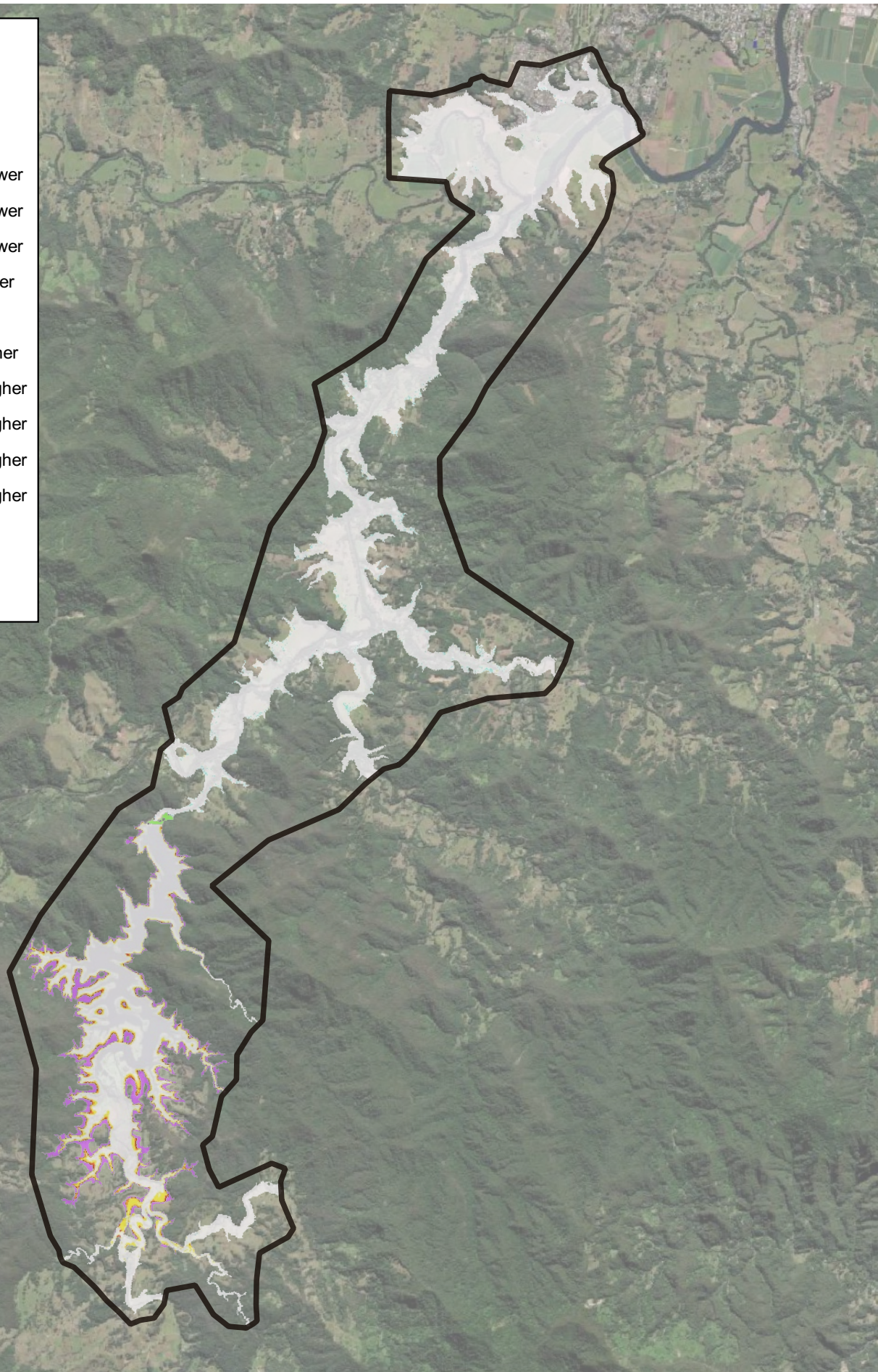
 4 Classifications Higher

 5 Classifications Higher

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



**Differences in Flood Hazard Classification - Proposed Case minus Existing Case
PMP Design Event**

Figure: **C15**

Rev: **2**

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

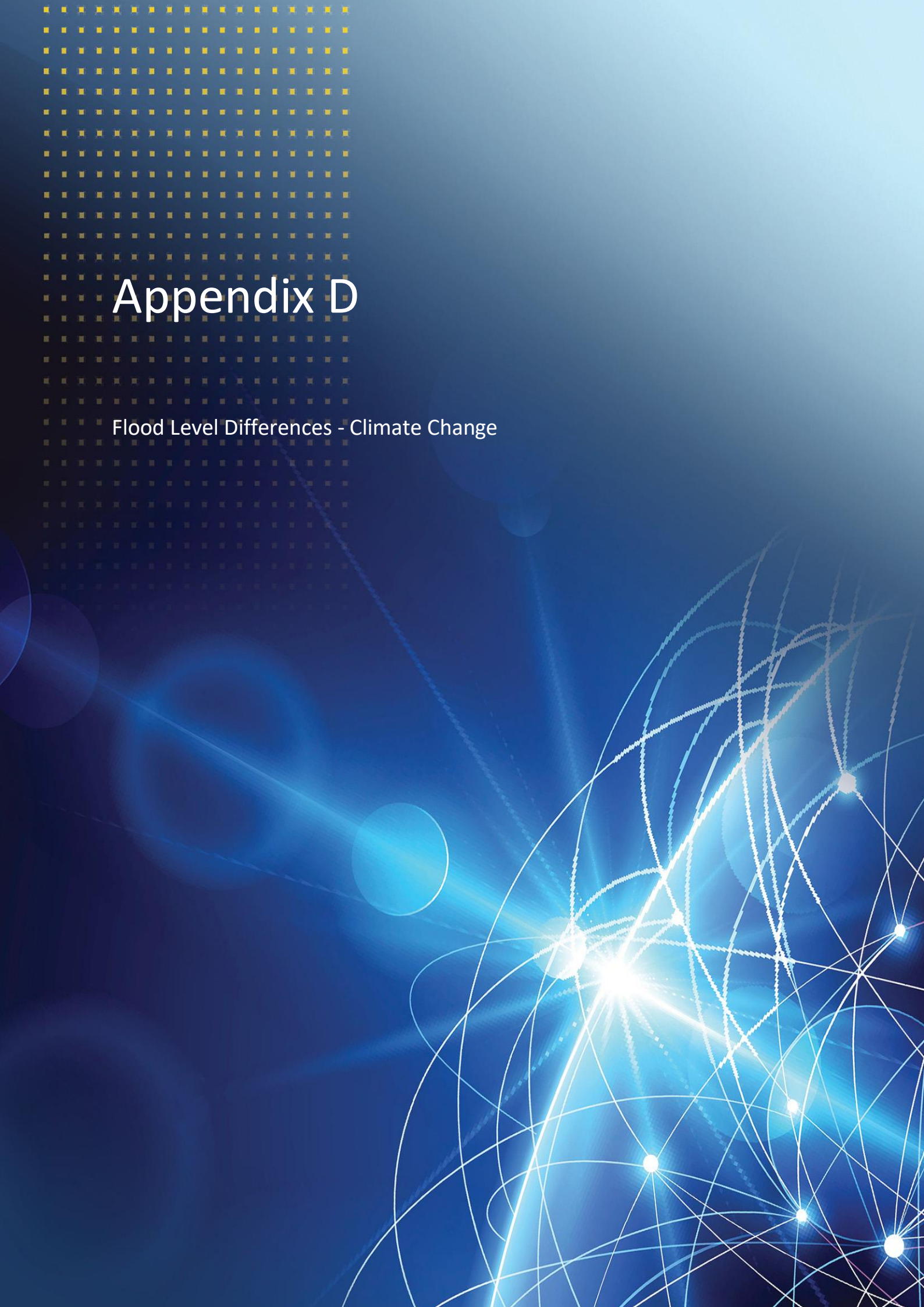
Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000





Appendix D

Flood Level Differences - Climate Change

LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

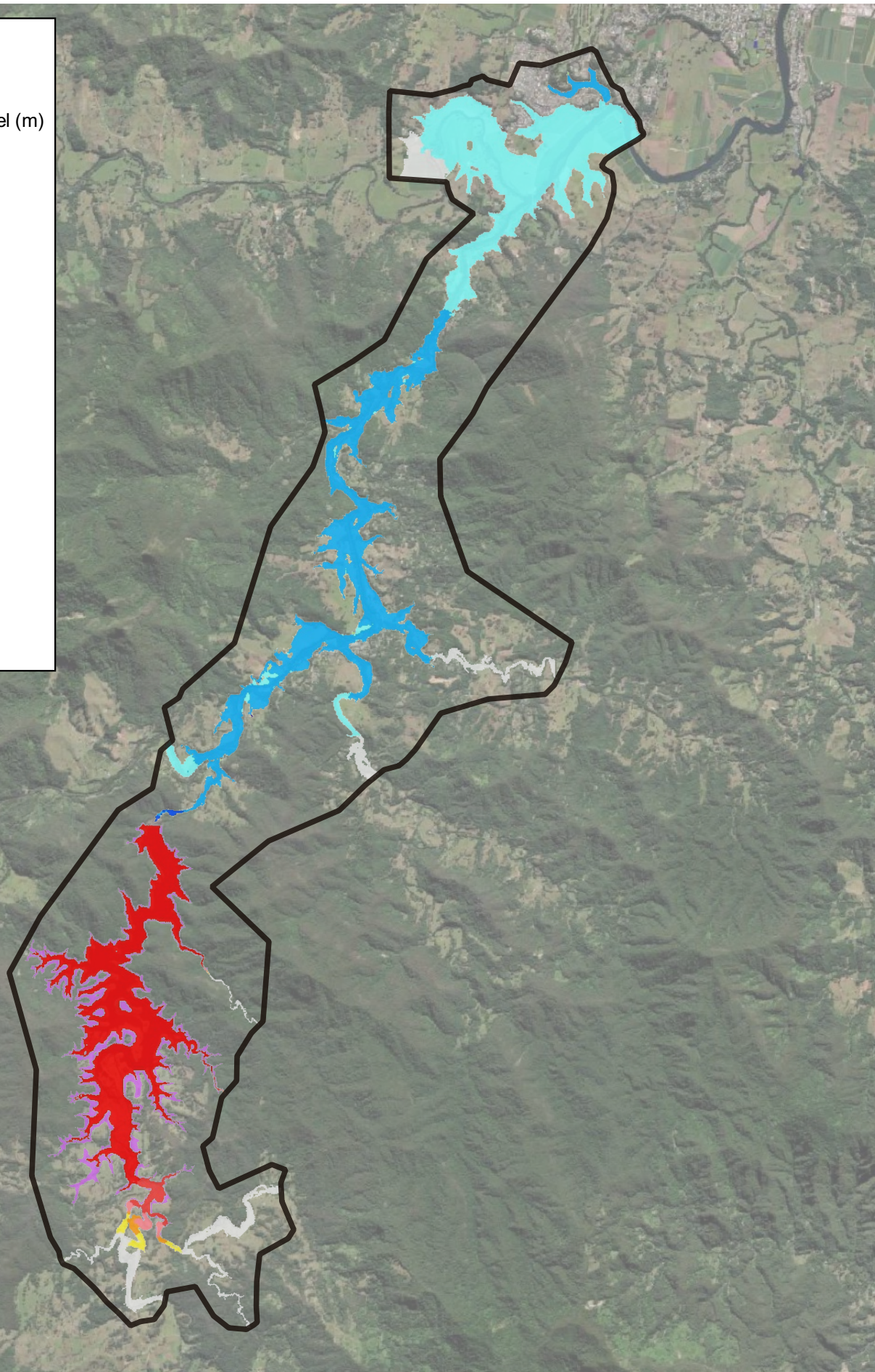
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Level - Proposed Case minus Existing Case
5% AEP Climate Change SSP3-7.0 Design Event**

Figure:
D1

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingEIS\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

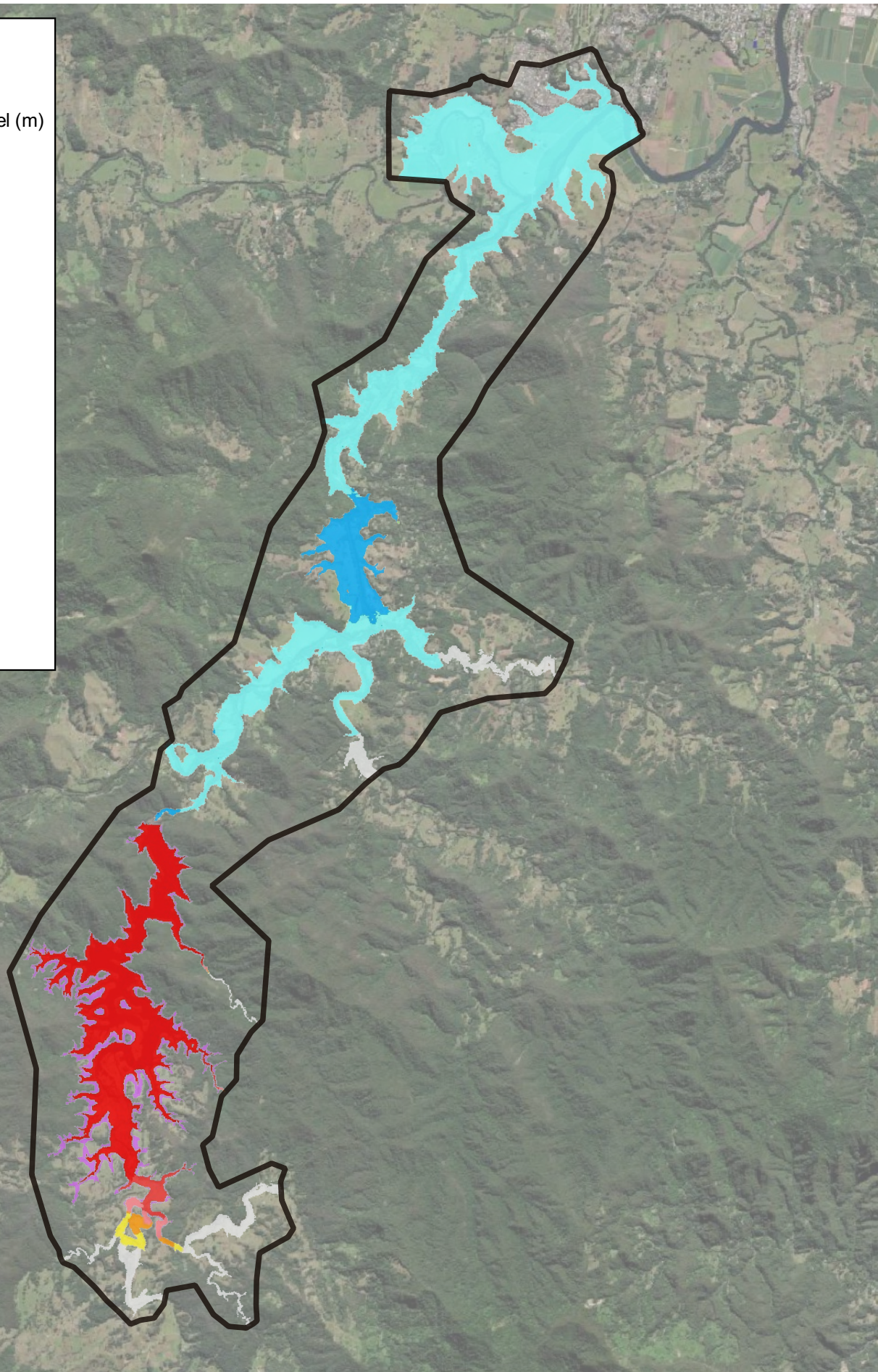
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Level - Proposed Case minus Existing Case
1%AEP Climate Change SSP3-7.0 Design Event

Figure: **D2**

Rev: **2**

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

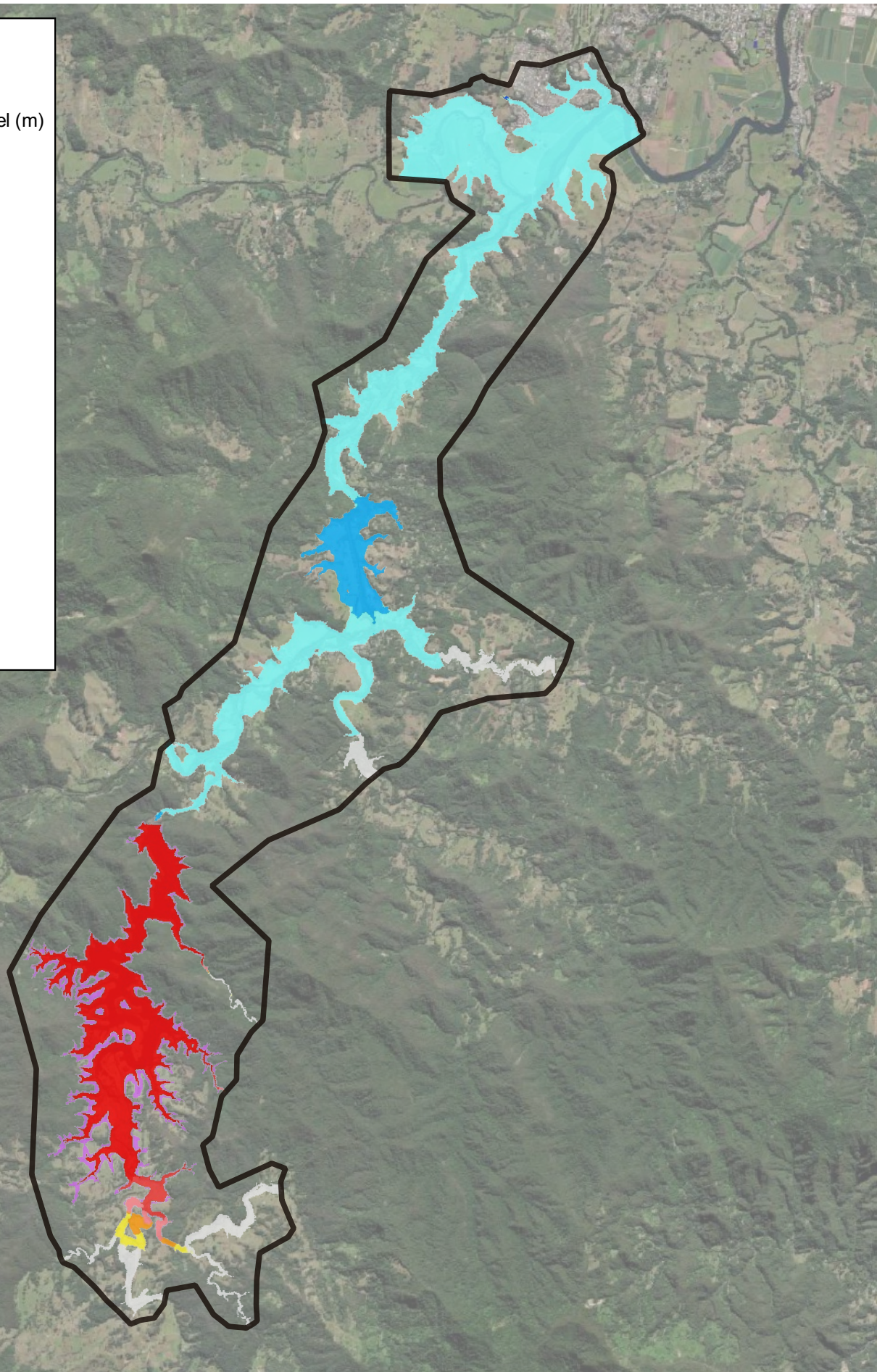
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Differences in Flood Level - Proposed Case minus Existing Case
0.5% AEP Climate Change SSP3-7.0 Design Event

Figure: **D3**

Rev: **2**

Scale at A4 1:80000.00000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

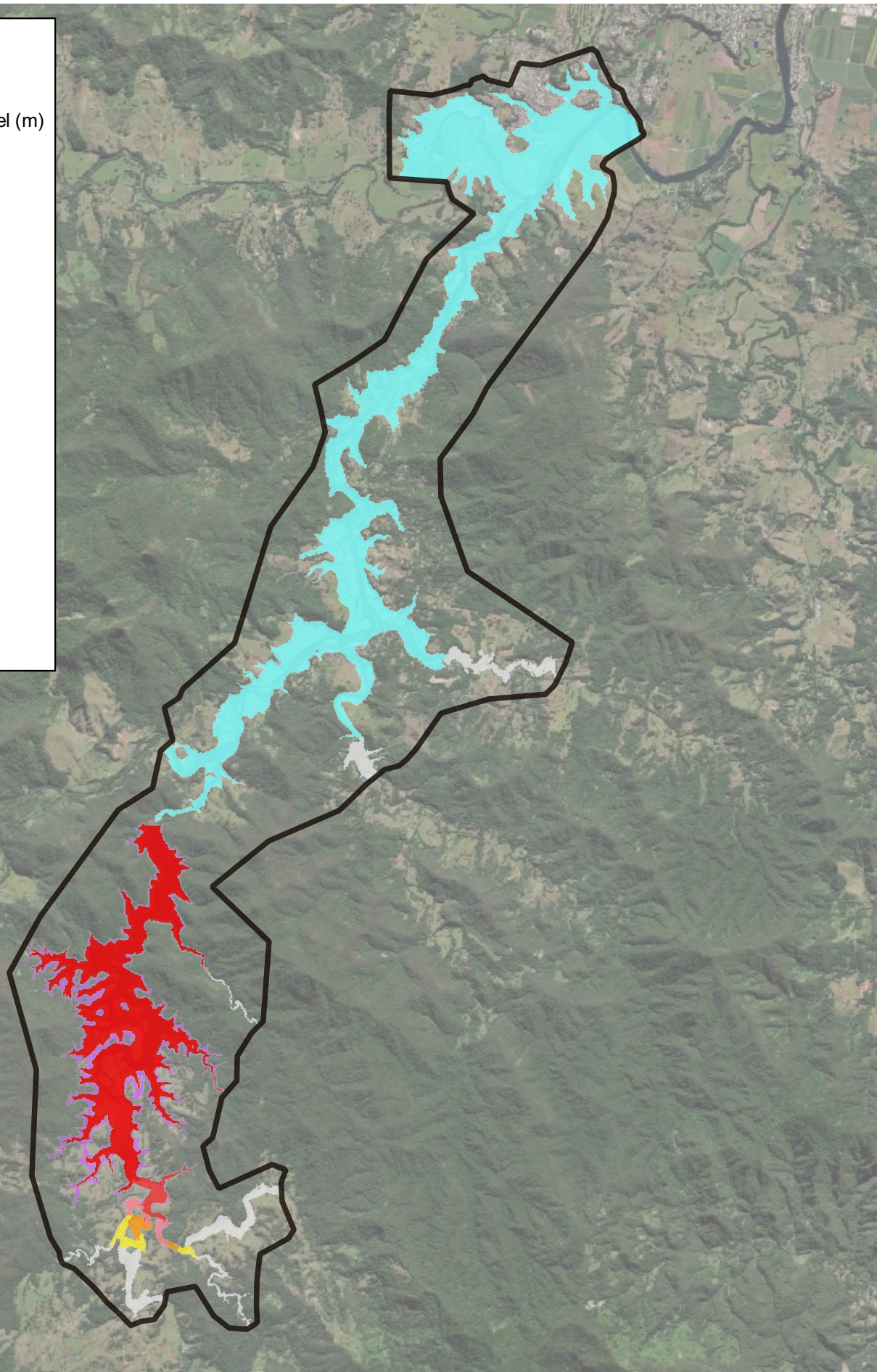
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



Title:
**Differences in Flood Level - Proposed Case minus Existing Case
0.2% AEP Climate Change SSP3-7.0 Design Event**

Figure:
D4

Rev:
2

Scale at A4 1:80000.000000000025
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File: Y:\Water_Resources\Projects\SEN351 - ClarrieHallDamRaisingES\G - GIS\Workspaces\ClarrieHall_Dam_MAPPING_MJ_v21_Rev0.qgz

Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000



LEGEND

 Model Boundary

Differences in Flood Level (m)

 <-0.5m

 -0.50m to -0.25m

 -0.25m to -0.10m

 -0.10m to -0.01m

 ± 0.01 m

 0.01m - 0.50m

 0.5m to 1.0m

 1.0m to 2.5m

 2.5m to 5.0m

 5.0m to 7.5m

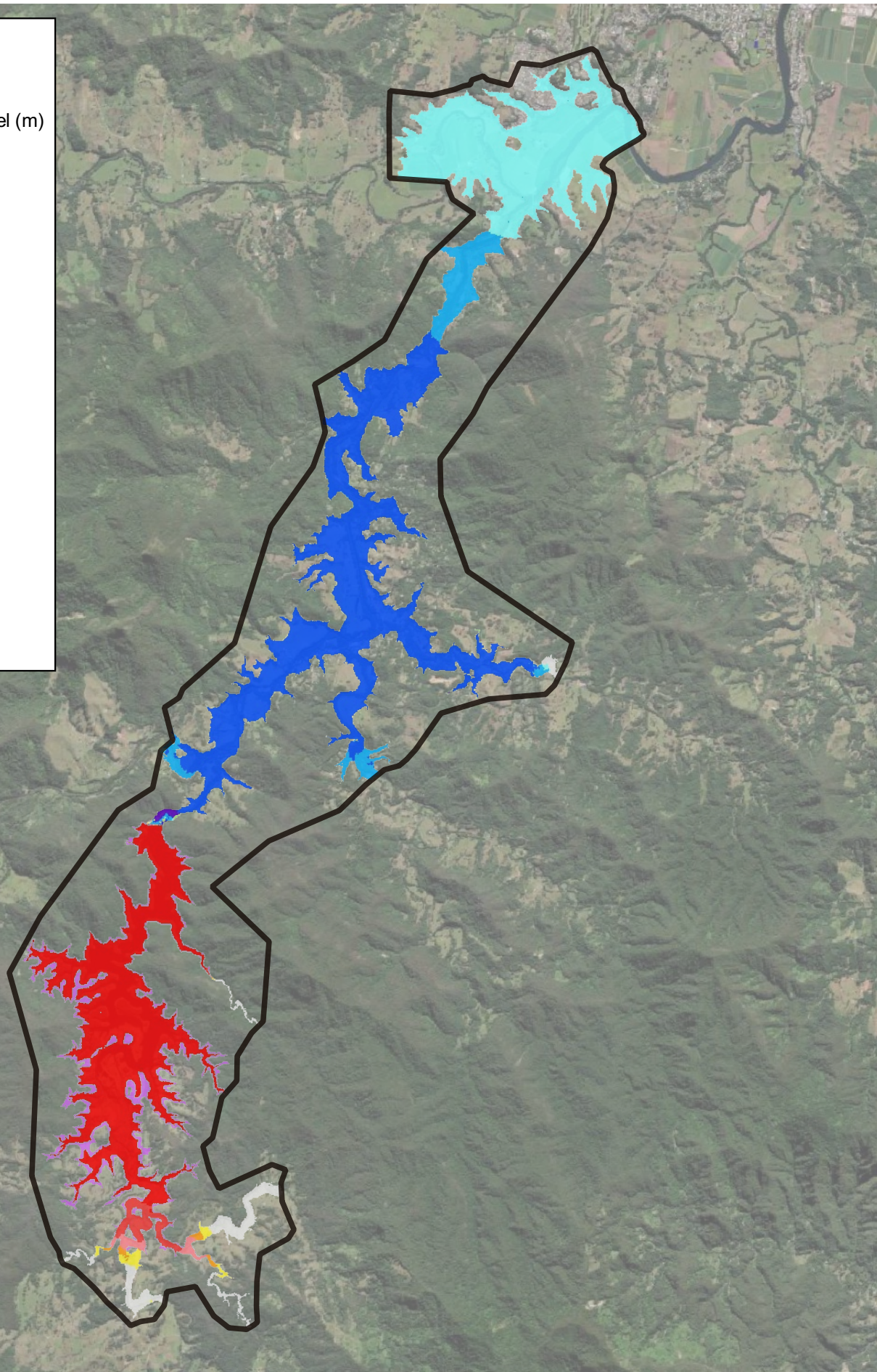
 7.5m to 10.0m

 >10m

Wet/Dry

 Was Wet now Dry

 Was Dry now Wet



**Differences in Flood Level - Proposed Case minus Existing Case
PMP Climate Change SSP3-7.0 Design Event**

Figure: **D5**

Rev: **2**

Scale at A4 1:80000.000000000025
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Scale:

0 0.6 1.2 1.8 2.4 3 km



1:80,000

