Torrent Consulting Pty Ltd
86 Blanch Street
Shortland NSW 2307

ABN 11 636 418 089

www.torrentconsulting.com.au

Our Ref: DJW: L.T2331.002.docx

10 March 2023
Jeff and Simone Robinson
c/o Le Mottee Group
PO Box 363
Raymond Terrace NSW 2324
Attention: Liam Davis

Dear Liam

RE: FLOOD IMPACT ASSESSMENT FOR PROPOSED MOUND AND SHED CONSTRUCTION AT 1140 RAYMOND TERRACE ROAD, MILLERS FOREST NSW

Background

Torrent Consulting was engaged to undertake a Flood Impact Assessment to assist in the DA process for a proposed mound and shed construction at 1140 Raymond Terrace Road, Millers Forest, NSW (the Site). It is understood that a flood report will be expected by Maitland City Council.

The Site is located within the Hunter River floodplain, between Thornton and Raymond Terrace, as presented in Figure 1. The topography of the local floodplain is flat and low-lying, characterised by raised flood levee embankments and earthen mounds, as presented in Figure 2.

The existing design flood conditions at the Site are detailed in the Williamtown – Salt Ash Floodplain Risk Management Study & Plan (BMT WBM, 2017). Information contained in this study was used to summarise the existing flood conditions and risks in the context of the Site and the proposed development.

The assessment utilises a TUFLOW model of the Lower Hunter River to simulate design flood conditions consistent with those of the existing flood study. This model provides a platform to assess the potential flood impacts associated with the proposed mound. It also enables a more detailed understanding of the local flood velocities and hazards under both existing and the proposed post-construction conditions.

A comprehensive cumulative impact assessment has previously been undertaken for recent mound assessments in the Hunter River floodplain, with several constraints identified for development within the floodplain. The proposed mound was assessed for compatibility with these constraints.

Model Development

For this assessment a TUFLOW hydraulic model was utilised that had been previously developed for similar mound assessments within the Hunter River floodplain. The model covers the entire floodplain of the Lower Hunter River downstream to the river mouth at the Tasman Sea, including upstream to Luskintyre on the Hunter River, Vacy on the Paterson River and Glen Martin on the Williams River, as presented in Figure 3.

The existing TUFLOW model is at a 20 m grid cell resolution, therefore, the recent Quadtree functionality of TUFLOW that enables a variable model grid mesh resolution was utilised allowing a horizontal grid cell resolution of 5 m to be modelled within and surrounding the Site.

The catchment area of the Hunter River covers some 22 000 km^2, with the Paterson and Williams Rivers contributing around 1200 km^2 and 1300 km^2 respectively. The modelled area encompasses some 750 km^2.

The model utilised the NSW Spatial Services LiDAR data product, downloaded via the ELVIS Foundation Spatial Data portal to define the floodplain topography. The model was constructed using a 20 m grid cell resolution, sampling elevations from the LiDAR data. The modelled floodplain contains numerous embankments that function as hydraulic controls and are of too small a scale to be adequately captured by the 20 m grid cell model resolution. Therefore, a network of breaklines was digitised along some 820 km of embankments and the underlying LiDAR data interrogated to populate the breaklines with the elevations of the embankment crests. These were then incorporated into the TUFLOW model using the Z Shape representation, which modifies model cell elevations to match those of the breaklines.

A total of 26 floodplain mound constructions were identified as having been constructed since the LiDAR data was captured in 2012-13, using available aerial imagery in Google Earth. The approximate extent of these mounds was identified from the imagery and incorporated into the TUFLOW model with assumed mound heights being adopted to raise them above the 1% AEP flood level.

The Hunter River Hydrographic Survey (May 2005) was used to provide representative channel cross-section information of the lower Hunter, Paterson and Williams Rivers. An appropriate channel topography was incorporated into the model, with a full 2D representation of both channel and floodplain. Aerial imagery was used to define separate surface materials for areas of cleared floodplain, river channel and remnant vegetation. Modelling of key hydraulic structures within the study area is also included for the Fullerton Cove and Salt Ash floodgates and culverts under Nelson Bay Road.

Many estuarine vegetation communities are not well penetrated, and are subsequently poorly filtered in, the LiDAR data product. These include areas of mangroves, saltmarsh, phragmites, rank grassland, wet heath, and other swampy habitats. The modelled floodplain elevations in these areas have therefore had an elevation correction adjustment applied to the LiDAR data. Vegetation across the Hunter Estuary has been treated in the TUFLOW model, with LiDAR elevations being lowered between 0.2 m and 0.6 m, depending on vegetation cover. The extent of the modified LiDAR elevations is presented in Figure 3.

The upstream model inflow boundaries on the Hunter, Paterson and Williams Rivers were developed using information contained in the Hunter River Branxton to Green Rocks Flood Study (WMA Water, 2010), the Paterson River Flood Study Vacy to Hinton (WMA Water, 2017) and the Williams River Flood Study (BMT WBM, 2009) respectively. Local hydrological inputs for the 750 km^2 of model area were also accounted for, although they are not overly important for the derivation of the design flood conditions. The downstream boundary of the model was configured as a tidal cycle with a peak water level of 1.1 m AHD, which is approximately an annual peak condition.

The model was calibrated to provide consistency with the Hunter River Branxton to Green Rocks Flood Study and the Williamtown – Salt Ash Floodplain Risk Management Study through iterative adjustment of the Manning's 'n' roughness parameters for the digitised land use materials. The adopted Manning's 'n' values are provided in Table 1.

The TUFLOW model produced results at Maitland that closely match those of the Hunter River Branxton to Green Rocks Flood Study. Consistent results at Raymond Terrace were harder to achieve and were found to be significantly influenced by total inflow volumes more-so than peak flow rates alone.

Design flood levels at Oakhampton are driven principally by peak flows (with variations in volume effectively negligible). Flood Frequency Analysis (FFA) undertaken for the Hunter River Branxton to Green Rocks Flood Study and the Singleton Floodplain Risk Management Study (BMT, 2020) provide similar estimates of design flood flows for the Hunter River, which provides a good level of confidence in those estimates.

The derivation of design flood flow estimates through FFA at Raymond Terrace is less certain, due to a shorter period of continuous record and a lack of a site rating curve. Using FLIKE to derive probabilistic estimates of design peak flows, the results for the rarer events were found to vary significantly depending on the assumptions made for data entry of historic flood thresholds. This is because there is less than 40 years of continuous record and the largest flood events all occurred before this period.

Table 1 – Adopted Manning's 'n' Values

Surface Material	Manning's 'n'
Cleared floodplain	0.040
Hunter River channel u/s Morpeth	0.030
Hunter River channel Morpeth to Raymond Terrace	0.025
Hunter River channel d/s Raymond Terrace	0.020
Paterson River channel	0.045
Williams River channel	0.025
Remnant vegetation	0.120
Mangroves	0.150

Rainfall-runoff modelling was undertaken for the entire Hunter River catchment using methods outlined in ARR 2019 to assist in establishing suitable design flow conditions at Raymond Terrace, specifically the relationship between modelled peak flow conditions at Oakhampton and Raymond Terrace. With flows on the Hunter River dominating volumes at Raymond Terrace, establishing a relationship between design flows at Oakhampton and expected design flows at Raymond Terrace provides a useful tool for validating design flood levels at Raymond Terrace. The Hunter River catchment rainfall-runoff modelling found the critical duration at Oakhampton to be 48 hours, whereas it was the 72-hour duration at Raymond Terrace – indicative of the additional reliance on overall flood volume to maintain peak flows and levels. Table 2 presents the design flows at Oakhampton and the estimated equivalent design flow condition at Raymond Terrace.

Table 2 – Hunter River Design Peak Flows (m^3/s)

Design Event	Oakhampton	Raymond Terrace
20% AEP	1700	1400
10% AEP	2600	2300
5% AEP	3800	3200
2% AEP	5800	4700
1% AEP	8000	6300
0.5% AEP	10 300	7900
0.2% AEP	13 500	10 200

Ultimately, design flow estimates were adopted from the FLIKE FFA for the 20% AEP and 10% AEP events and from the rainfall-runoff modelling analysis for the rarer flood events. A comparison of the adopted design flows at Raymond Terrace with the 90% confidence interval determined using FLIKE is presented in Chart 1.

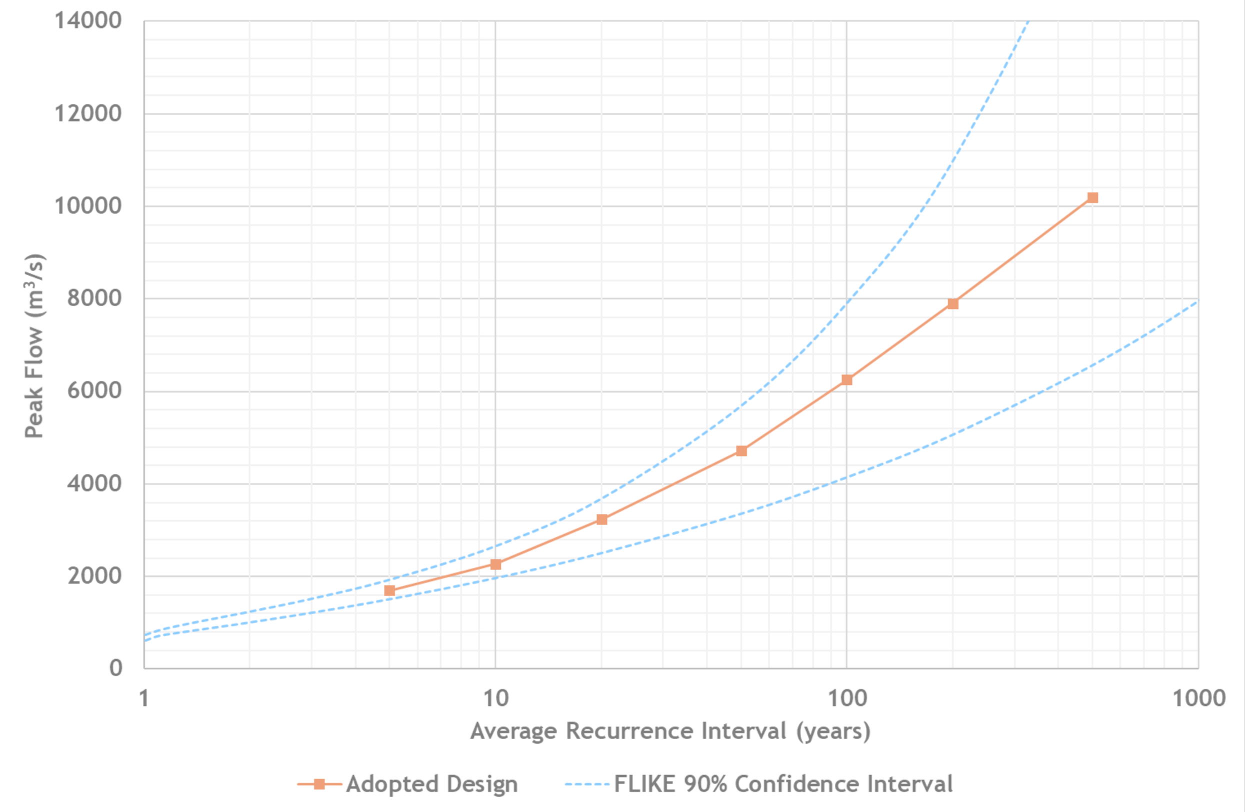


Chart 1 – Adopted Design Flood Flows at Raymond Terrace

Design flood flow hydrographs for the Hunter, Williams and Paterson Rivers were simulated in the TUFLOW model and the volumes of the flood recession were adjusted until the required peak flow conditions at Raymond Terrace were matched. The resultant peak flood levels at the Raymond Terrace gauge are presented in Table 3, together with those established for the Williamtown – Salt Ash Floodplain Risk Management Study. The overall consistency between the two is good and is well within the bounds of uncertainty of the FFA at Raymond Terrace.

Table 3 – Design Flood Levels at Raymond Terrace

Design Event	This Assessment	BMT WBM (2017)
20% AEP	2.6	2.2
10% AEP	2.9	3.0
5% AEP	3.3	3.3
2% AEP	4.0	4.1
1% AEP	4.7	4.8
0.5% AEP	5.3	5.2
0.2% AEP	6.1	N/A

Flood Modelling and Mapping

The TUFLOW model was simulated (using the HPC solver) for the 20% AEP, 10% AEP, 5% AEP, 2% AEP, 1% AEP and 0.5% AEP events to define baseline flood conditions for the purposes of assessing flood risk and as the basis for subsequent flood impact assessment. The Extreme Flood event was also simulated. The modelled peak flood levels at the Site are summarised in Table 4.

The modelled peak flood extents for the 5% AEP, 1% AEP and Extreme events are presented in Figure 4, together with the Site lot boundary and proposed mound. Figure 5, Figure 6, and Figure 7 are presented for additional flooding context and show the modelled peak flood depths and peak flood level contours for the 5% AEP, 1% AEP and Extreme events, respectively.

Table 4 – Modelled Peak Design Flood Levels

Design Event	Flood Level (m AHD)
20% AEP	2.2
10% AEP	2.8
5% AEP	3.3
2% AEP	3.8
1% AEP	4.5
0.5% AEP	5.1
Extreme	8.2

Flood Risk Management

The flood hazard conditions at the Site were assessed to determine the risk to property and risk to life exposure of the proposed development. Appropriate flood risk management measures were identified in accordance with Council's DCP, LEP, and the NSW Floodplain Development Manual.

Figure 8, Figure 9, and Figure 10 present the flood hazard classification at the Site for the 5% AEP, 1% AEP and Extreme Flood events, respectively. The flood hazards have been determined in accordance with Guideline 7-3 of the Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR, 2017). This produces a six-tier hazard classification, based on modelled flood depths, velocities, and velocity-depth product. The hazard classes relate directly to the potential risk posed to people, vehicles, and buildings, as presented in Chart 2.

The flood hazard mapping is useful for providing context to the nature of the modelled flood risk and to identify potential constraints for the future development of the Site with regards to floodplain risk management. The principal consideration of good practice floodplain risk management is to ensure compatibility of the proposed development with the flood hazard of the land, including the risk to life and risk to property.

The objective of the management of risk to property is to minimise the damages that would be incurred in the event of a flood. This includes potential damage to future building structures and their contents. Risk to property is typically managed to the 1% AEP design flood event, with council adopting a Flood Planning Level (FPL) at the 1% AEP flood level plus 0.5 m freeboard.

The flood hazard mapping presented in Figure 9 shows that the Site constitutes almost entirely an H5 hazard, which presents a high risk to life and property. This is principally depth-driven, as modelled velocities across the Site at the 1% AEP event are less than 0.8 m.

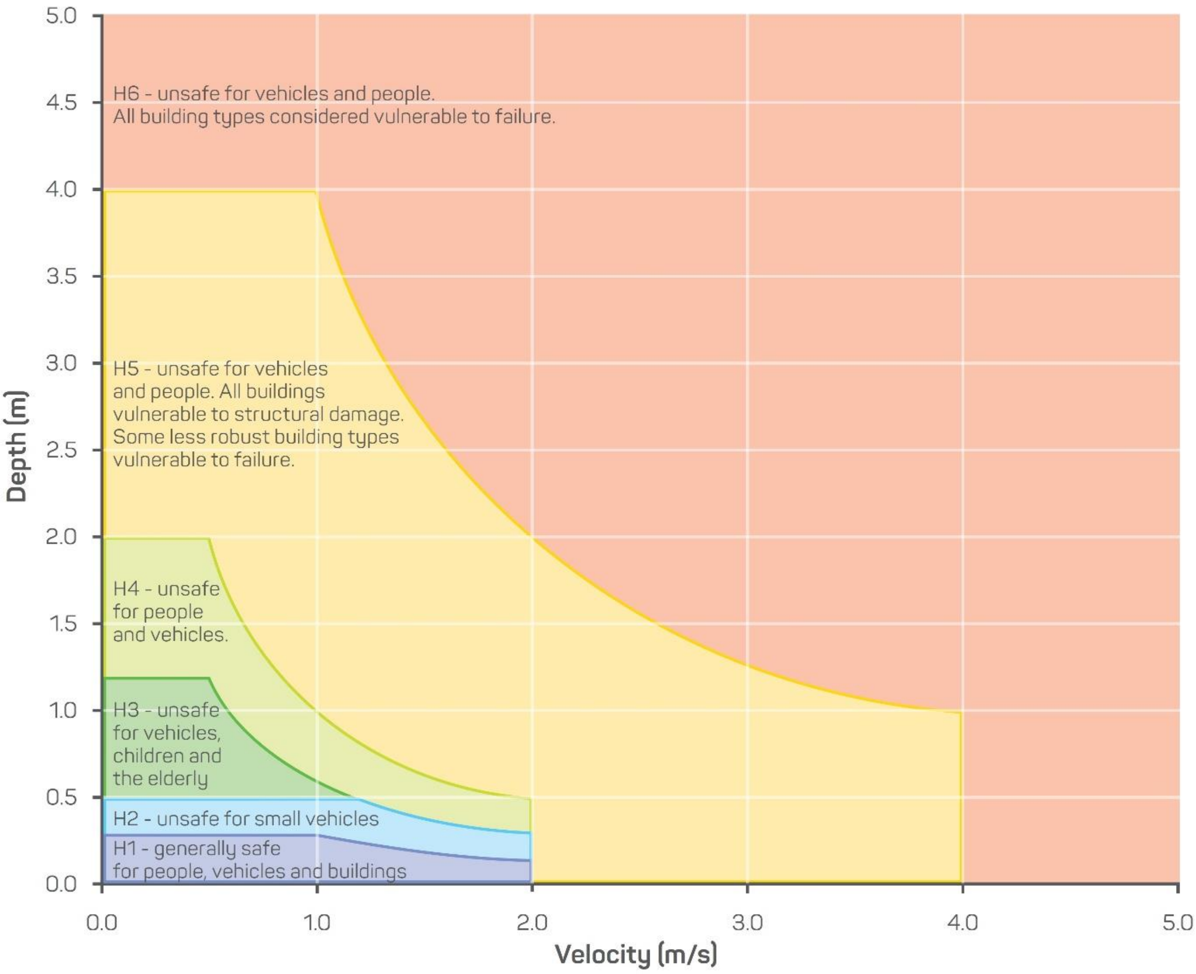


Chart 2 – General Flood Hazard Vulnerability Curves (AIDR, 2017)

The modelled 1% AEP flood level of 4.5 m AHD at the Site corresponds with an FPL of 5.0 m AHD, which is consistent with levels for previous mound assessments within the area. The finished level of the proposed mound will be 5.6 m AHD, therefore, the construction of the mound serves to reduce the peak flood depths and potential structural damage to the proposed shed and can facilitate a reduced risk of damage to valuables stored within the shed.

The objective of the management of risk to life is to minimise the likelihood of deaths in the event of a flood and is typically considered for rarer flood events than the 1% AEP, up to the PMF (or Extreme Flood). Figure 10 shows that the Site constitutes entirely an H6 hazard, which would produce high hazard flood conditions on Site. However, as the proposal does not include any future dwelling the risk to life does not require further consideration in this assessment.

Flood Impact Assessment

The extent of the proposed mound was provided by Le Mottee Group (7950 MOUND-E.pdf) and was incorporated into the TUFLOW model. The design flood events were then re-simulated, and the results compared to the baseline results to identify potential flood impacts. Whilst extensive raising of embankments across the floodplain (e.g. the construction of linear infrastructure) can significantly impact the existing flooding regime, localised filling such as earthen mounds typically does not, unless sited at a sensitive location with high flood velocities.

The results of the flood impact assessment are presented in Figure 11 to Figure 16. Flood impact mapping is presented for the modelled peak flood level and modelled peak flood velocity for the 5% AEP, 1% AEP and 0.5% AEP flood events.

The results show no tangible increase in the modelled peak flood levels and only minor and localised impacts to the flood velocities of up to 0.25 m/s in the vicinity of the mound, with peak velocities not exceeding 0.9 m/s under post-development conditions. This does not present a significant adverse impact that would require any mitigation measures.

Cumulative Development Assessment

Council has previously requested specific assessment of the potential for future cumulative development impacts of mound constructions within the floodplain for other developments. Therefore, it has also been considered as part of this assessment. The assessment of cumulative development across the floodplain of the Hunter River estuary is complex, due to the large area, jurisdiction of multiple LGAs and infinite possibilities of what future development might comprise. It is therefore important to undertake a robust analysis to ensure that development is neither unreasonably constrained nor unsustainable from a flood impact perspective.

A considerable effort has been invested in the cumulative impact assessment undertaken to support this individual development assessment. The scope of the assessment has been limited to the construction of earthen mounds in the Hunter (and Williams) River floodplain. The geographical extent initially comprised some 800 Lots between Hinton, Seaham, and Woodberry. These were then filtered to further focus the assessment based on the following criteria:

- Lots smaller than 1.5 ha were excluded as having insufficient space to accommodate a mound
- Lots with at least 0.5 ha of flood-free land above the 1% AEP extent were excluded as not having the requirement for a mound
- Lots with an insufficient area of land with a 1% AEP velocity-depth product (VxD) below 1.4 were excluded as presenting an unreasonable cumulative development impact

This process reduced the number of Lots assessed for the potential impacts of future cumulative development to a total of 215, as presented in Figure 17. The mapping of areas with a 1% AEP VxD of greater than 1.4 is also provided for context. Through several iterations of initial flood impact modelling, this threshold was identified as being a constraint for development due to unreasonable flood impacts, compared to those resulting from the development of land with a 1% AEP VxD of less than 1.4.

The assessment of the cumulative impacts of potential future mound development was approached using several different methods for developing constraint criteria and for modelling the flood impacts. These methods were tested using a few current in-preparation DAs, being overhauled, and refined through many iterations. Reassuringly, the various methods employed all pointed towards a similar set of constraints for what was considered acceptable as a net cumulative development impact. The main outcome of the methodology iteration process was to not unreasonably constrain potential acceptable developments through ill-considered constraint criteria. It also served to ultimately produce a much simpler list of constraining criteria and associated modelling methodology.

The outcome of refining the cumulative development assessment has resulted in the following criteria limiting development potential within the 215 Lots considered in the assessment:

- each Lot can accommodate a single mound development (or combination of multiple smaller mounds) totalling up to 10% of the Lot area, capped at a maximum of 1.3 ha per Lot, and
- mound footprints should not encroach upon the areas with a modelled VxD of greater than 1.4 at the 1% AEP event.

The area referenced in the first criterium is the effective modelled footprint, which in real terms is approximately halfway between the top area of the mound and the total footprint area at the existing ground surface. The 1.3 ha specified limit correlates with a 1.0 ha limit on mound top area (which is typical of the largest mound proposals). For ease of interpretation, the equivalent mound top area has been calculated and is presented in Chart 3 based on the total Lot area.

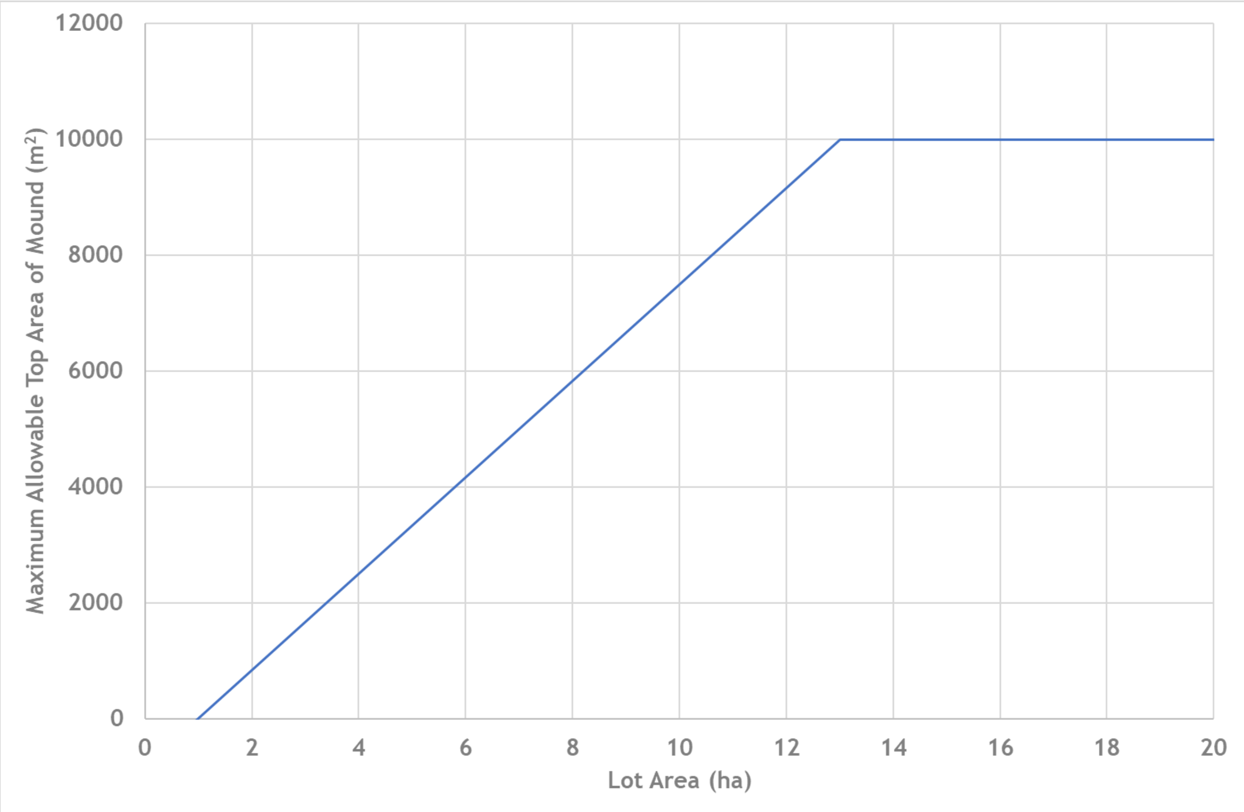


Chart 3 – Developable Mound Area by Lot Area

Perhaps the most significant uncertainty with assessing the cumulative impact of the future mound developments is the actual location at which each mound is sited. To account for this in the modelling, the physical obstruction presented by a hypothetical future mound development on each Lot has been evenly distributed across the entire Lot, using the Layered FC Shape and Storage Reduction Factor representations in TUFLOW. The former accounts for the reduction of available flood flow width (and associated increased velocities and hydraulic losses), whilst the latter accounts for the loss of available floodplain storage.

The percent blockage specified in both the Layered FC Shape and Storage Reduction Factor inputs was calculated using the maximum allowable mound area (i.e. 10% of the Lot area capped at 1.3 ha) divided by the available area for potential mound placement, i.e. the total Lot area minus the areas with a 1% AEP VxD > 1.4. The associated form loss applied in the Layered FC Shape was derived from the overall blockage percentage and was validated through comparison of model simulations using physical mound obstructions undertaken within the individual mound impact assessments, i.e. as Z Shape representations in TUFLOW.

Because the mound blockage in the cumulative development assessment is evenly distributed across the available area of each Lot, the model results are representative of the mound being located within an area where the average 1% AEP VxD product of the mound footprint matches that of the overall average of the available area. Therefore, to ensure that the ultimate impacts of future cumulative development do not exceed those presented in this assessment, future mound proposals should be located where the average 1% AEP VxD within the proposed mound footprint does not exceed that of the overall average of the available area within the Lot, as far as is reasonably possible.

With this additional constraint in mind, it is important to consider that the simulated flood impacts of the cumulative development assessment therefore represent the “worst case” conditions that could eventuate through future mound developments within the Hunter River floodplain, given the recommended constraint criteria. This condition would only be realised if the following were to occur:

- all the 215 Lots considered in the assessment construct earthen mounds – some may not
- all the constructed mounds are of the maximum allowable size – some may be smaller
- all the constructed mounds are sited in locations representative of average conditions throughout the potential available area – some may be sited in locations with a below average VxD.

The cumulative development impact assessment has been simulated for the 1% AEP event, as this is the principal design event for flood planning purposes. It also happens to be around the magnitude at which the localised impacts of individual mounds in the Hunter River estuary floodplain are typically found to be greatest. Figure 18 presents the modelled flood level impact for the cumulative development assessment “worst case” scenario, i.e. that in which all 215 Lots construct mounds to the limit of the recommended criteria. It shows that the impacts of potential future development are relatively minor, with the recommended constraint criteria in place.

The modelled peak flood level impacts are negligible (i.e. < 0.01 m) upstream of Hinton and Seaham and downstream of Woodberry and peak at around 0.05 m at Duckenfield. This is limited to an increase in flood level, with a negligible increase in flood extent. The impacted area also has few receptors aside from the communities that are directly benefitting from the developments. The most significant receptors in terms of flood impact are Seaham, Raymond Terrace and Morpeth where the peak flood levels are increased by around 0.04 m, 0.03 m and 0.02 m, respectively. Further, additional model simulations have found that a reduction in actual development from the maximum developable potential produces a similar reduction in flood level impacts. If only 80% of the maximum developable potential is realised, then the flood level impact at Raymond Terrace is reduced to around 0.02 m. If only 60% of the maximum developable potential is realised, then this is further reduced to around 0.01-0.02 m.

Figure 19 presents the modelled flood velocity impact for the cumulative development assessment. This does not represent a true picture of likely impacts, as the actual velocity impacts will be highly localised to each individual mound location (unlike flood level impacts which are more widespread). However, it does have value in that it shows a negligible impact to the overall average flood velocities within the river channels or across the floodplain.

If future mound developments adhere to the recommended constraints to limit the impact of potential future cumulative development, then it is considered that the likely impacts resulting from such development will only be minor. The impacts are considered reasonable, particularly given the improved flood resilience that the construction of such mounds affords the local communities, most of which are used for the purposes of livestock refuge and/or shed constructions.

It is important to consider that whilst the cumulative development assessment attempts to best represent potential future impacts as far as is reasonable, individual site-specific conditions and impacts can and will vary from those that have been modelled. It is expected that most future mound proposals will be able to adhere to the guidelines recommend in this assessment. However, it should not necessarily exclude all development proposals that cannot satisfy the constraint criteria. In such cases of non-conforming development proposals, it is recommended that the cumulative impact assessment should be re-visited, substituting the assumed cumulative development conditions for the Lot in question with the actual proposed development. The result of such an assessment would need to demonstrate zero change in cumulative impact (except for impacts localised to the mound location itself).

Of the three recommended mound development criteria, the proposed mound conforms to two. The footprint of the modelled equivalent mound is located within an area where the 1% AEP VxD product is less than 1.4. The average 1% AEP VxD product within the modelled equivalent mound footprint is also less than the available area average of 1.05. However, the combined top area of proposed mound is around 6000 m^2, which is more than the maximum area of around 3200 m^2 considered by the cumulative impact assessment, given the Lot area of around 5 ha (refer Chart 3). Therefore, a site-specific cumulative development impact assessment has been undertaken to confirm a zero impact above and beyond the modelled conforming impacts.

Figure 20 presents the site-specific cumulative development peak flood level impact, using an ultrafine impact mapping interval. It shows the local impacts of the actual (compared with the assumed) mound conditions on the cumulative development assessment. These local impacts are a result of the specific mound location being modelled, rather than being evenly distributed across the developable areas of the Lot, as is the case in the overall cumulative development assessment. These impacts reduce to less than 1 mm within 200 m of the proposed mound and do not contribute additional impacts more broadly to the upstream floodplain environment, which is the focus of the cumulative assessment. The non-conforming mound proposal is therefore considered acceptable.

While there is a tangible impact when compared to the baseline cumulative development model, the reasons for the minimal impact of the non-conforming mound can be explained by the fact that although the mound top area is more than the maximum recommended area, the representative mound blockage is not distributed across the Site, with the mound generally aligned lengthwise in the direction of floodplain flows (i.e. the narrow face of the mound presents a smaller blockage to the overall floodplain flow area). Additionally, conformance with the other two criteria limits the likelihood of an adverse impact.

Conclusion

The Site at 1140 Raymond Terrace Road, Millers Forest, NSW requires a Flood Assessment to assist in the approval process for the proposed mound and shed which is located within the Hunter River floodplain.

The flood risk assessment has determined that an FPL of 5.0 m AHD is appropriate for the Site and reduces the likelihood of flood inundation of the proposed shed. However, a mound finished surface of 5.6 m AHD has been proposed.

The flood impact assessment has included use of a TUFLOW hydraulic model to simulate design flood conditions at the Site, whilst maintaining a reasonable consistency with the results of the previous studies. The flood assessment has determined that the proposed mound is compatible with the existing flood hazard and does not result in adverse off-site flood impacts.

Further, a cumulative development assessment has found that if future mound developments adhere to the recommended constraints, then it is considered that the likely impacts resulting from such development will only be minor The impacts are considered reasonable, particularly given the improved flood resilience that the construction of such mounds affords the local communities, most of which are used for the purposes of livestock refuge and/or shed constructions. The recommended criteria for sustainable mound development are:

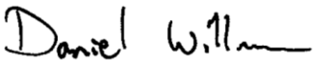
- each Lot can accommodate a single mound development (or combination of multiple smaller mounds) totalling up to 10% of the Lot area, capped at a maximum of 1.3 ha per Lot
- mound footprints should not encroach upon the areas with a modelled VxD of greater than 1.4 at the 1% AEP event and
- mounds should be located where the average 1% AEP VxD within the proposed mound footprint does not exceed that of the overall average of the available area within the Lot.

The proposed mound does not fully conform to the recommended constraining criteria to limit the potential future impacts of cumulative development. Therefore, a site-specific cumulative development impact assessment has been undertaken and confirms a minimal impact above and beyond the modelled conforming impacts across the broader floodplain, being largely contained within 200 m of the mound. The non-conforming mound proposal is therefore considered acceptable from a cumulative development perspective.

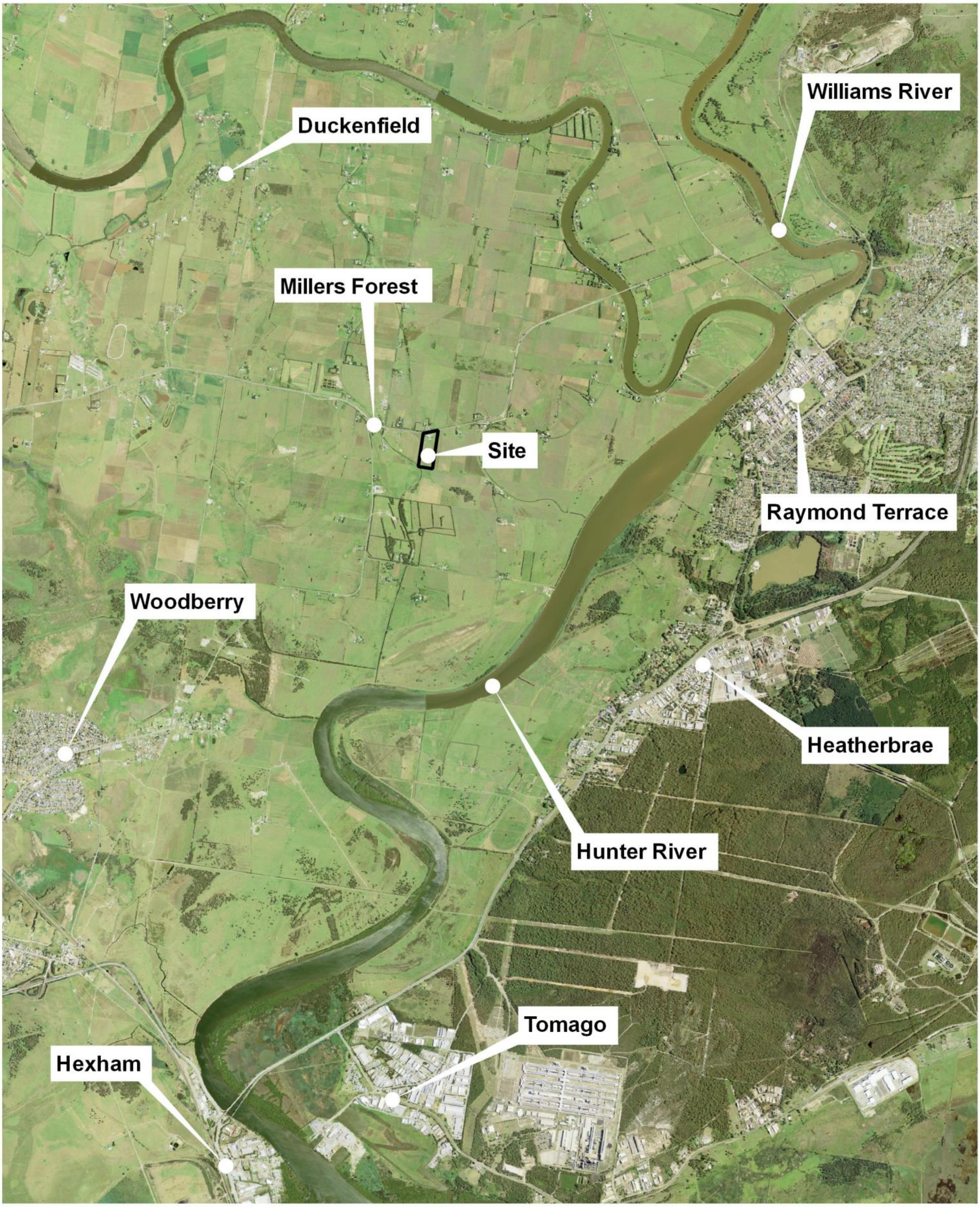
We trust that this report meets your requirements. For further information or clarification please contact the undersigned.

Yours faithfully

Torrent Consulting



Dan Williams
Director



Title:

Study Locality

0 1 2 km

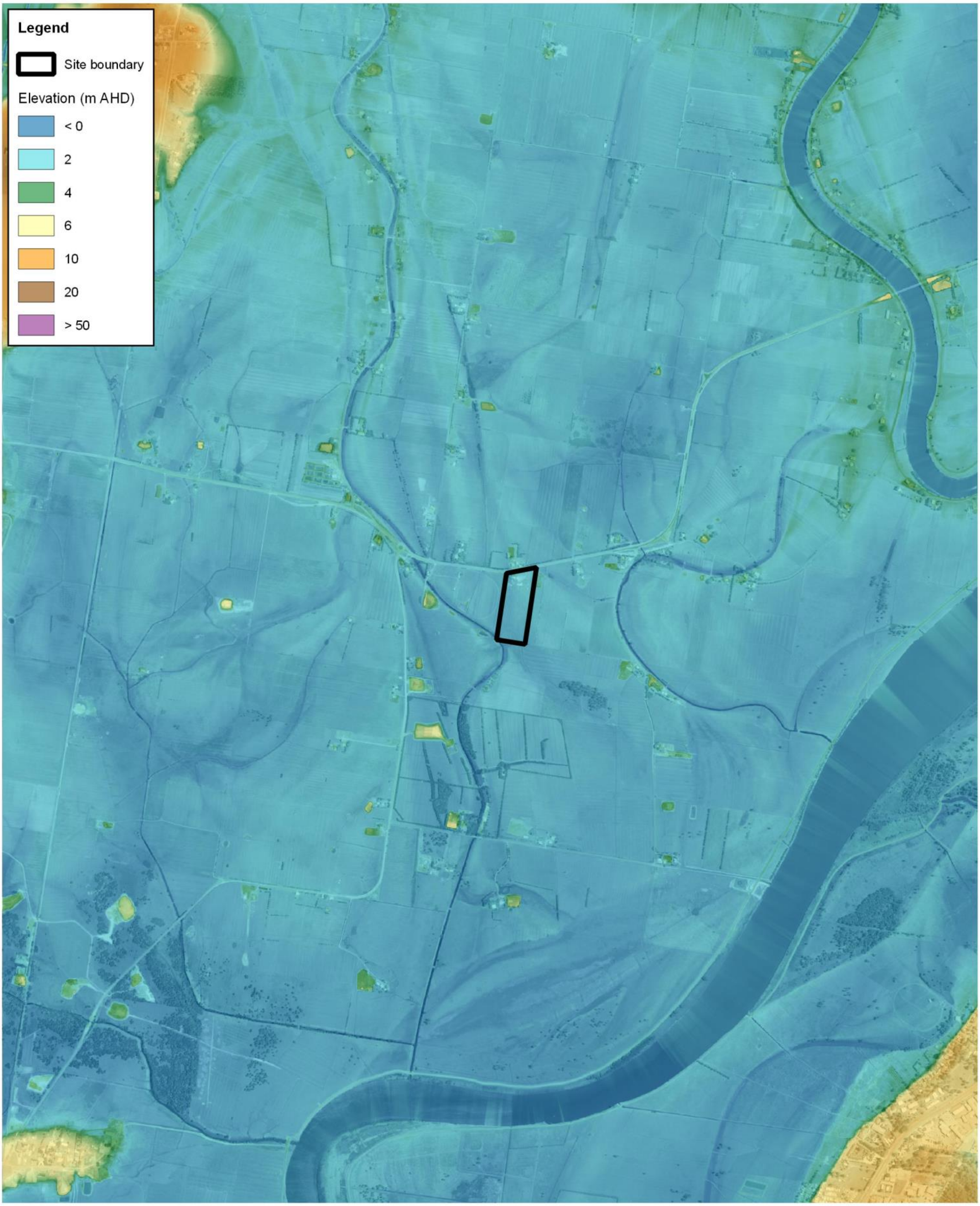
approx. scale

Figure:	1	*Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.*
Revision:	A	

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_001_230310_Locality.qgz

N

Torrent CONSULTING
www.torrentconsulting.com.au



Title:

Local Floodplain Topography

0 0.6 1.2 km

approx. scale

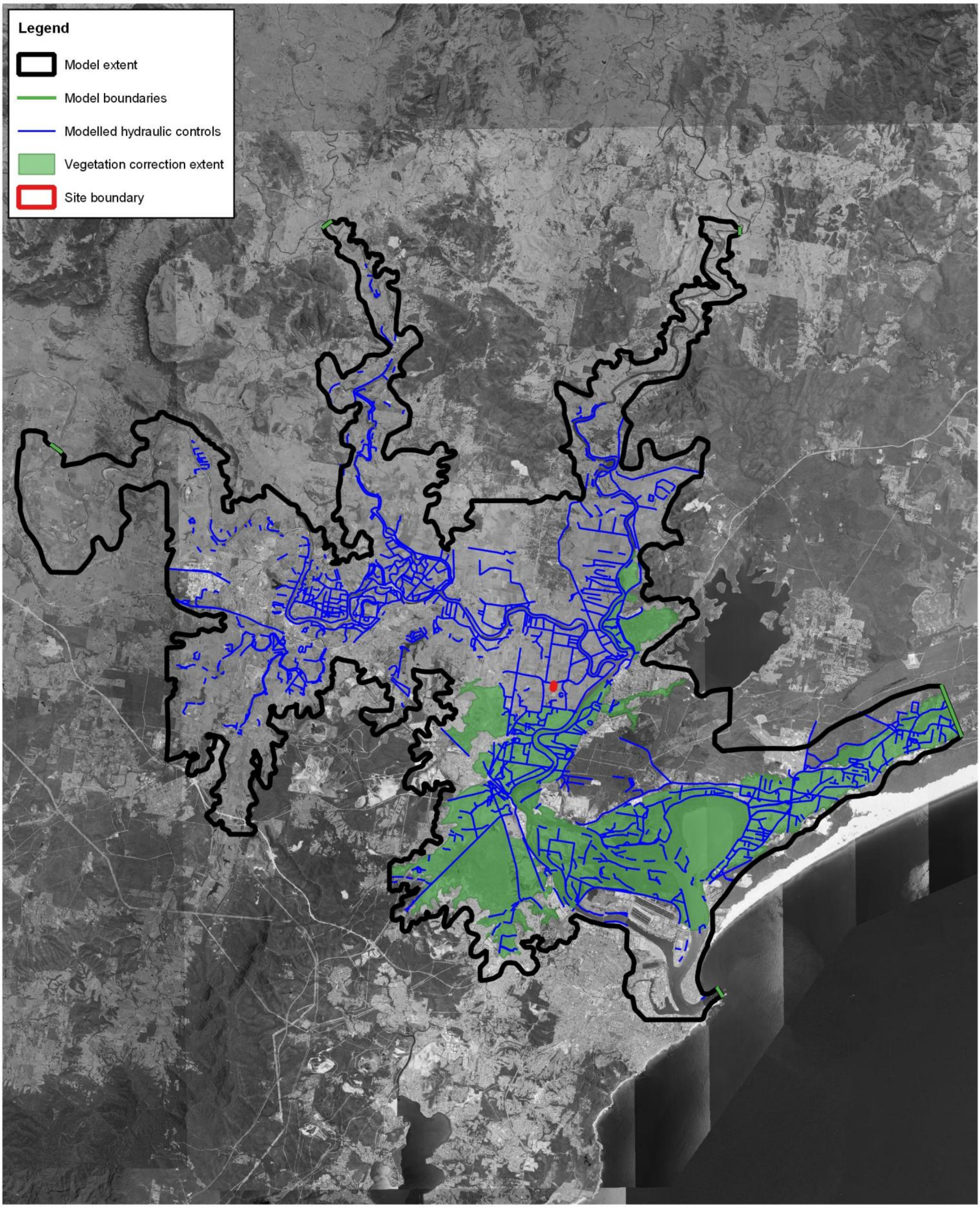
Figure: **2**	*Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.*
Revision: **A**	

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_002_230310_Topography.qgz



Title:

TUFLOW Model Components

0 7 14 km

approx. scale

Figure:	3
Revision:	A

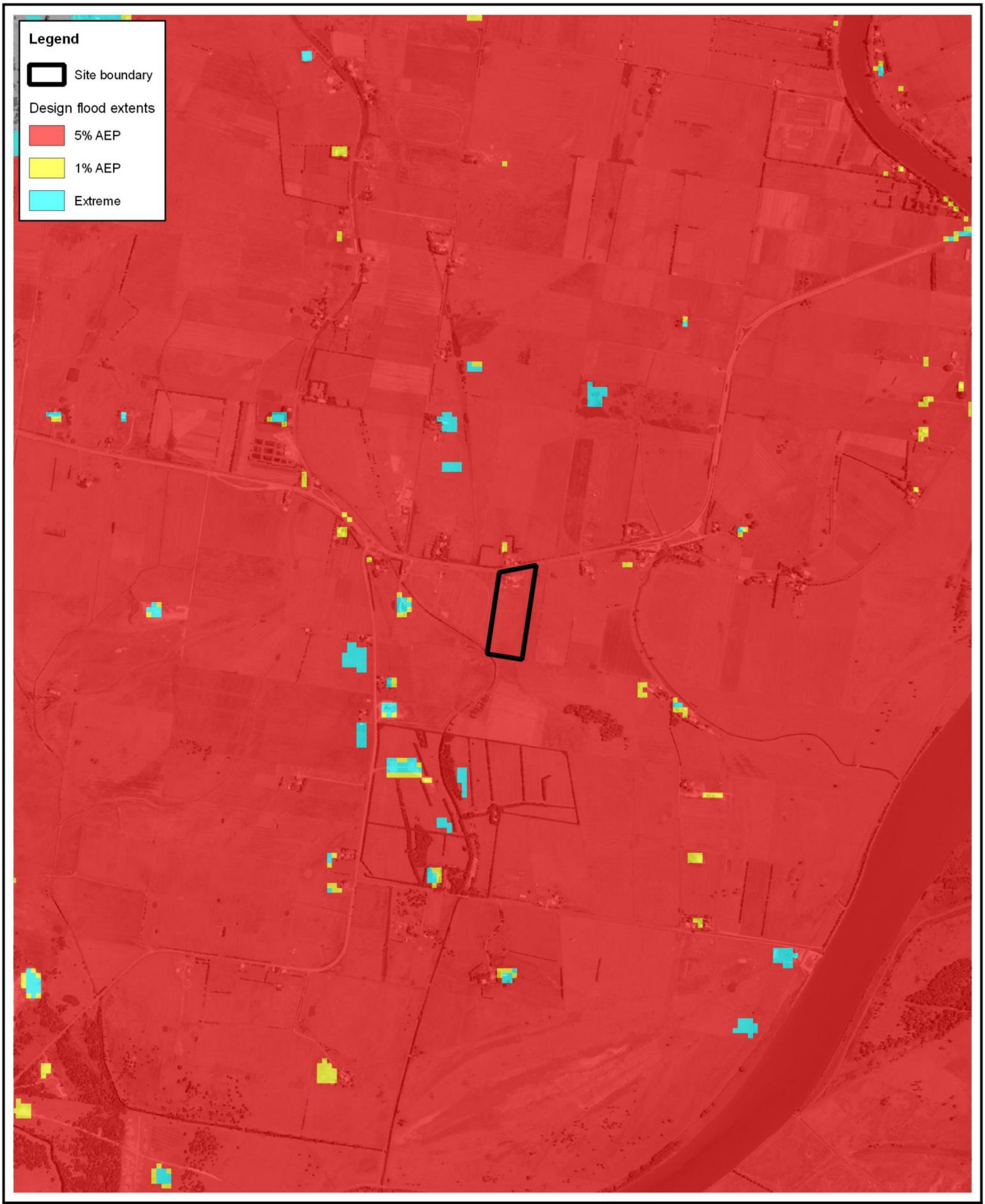
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_003_230310_TUFLOW.qgz



Title:

Modelled Design Flood Extents

Figure: **4**

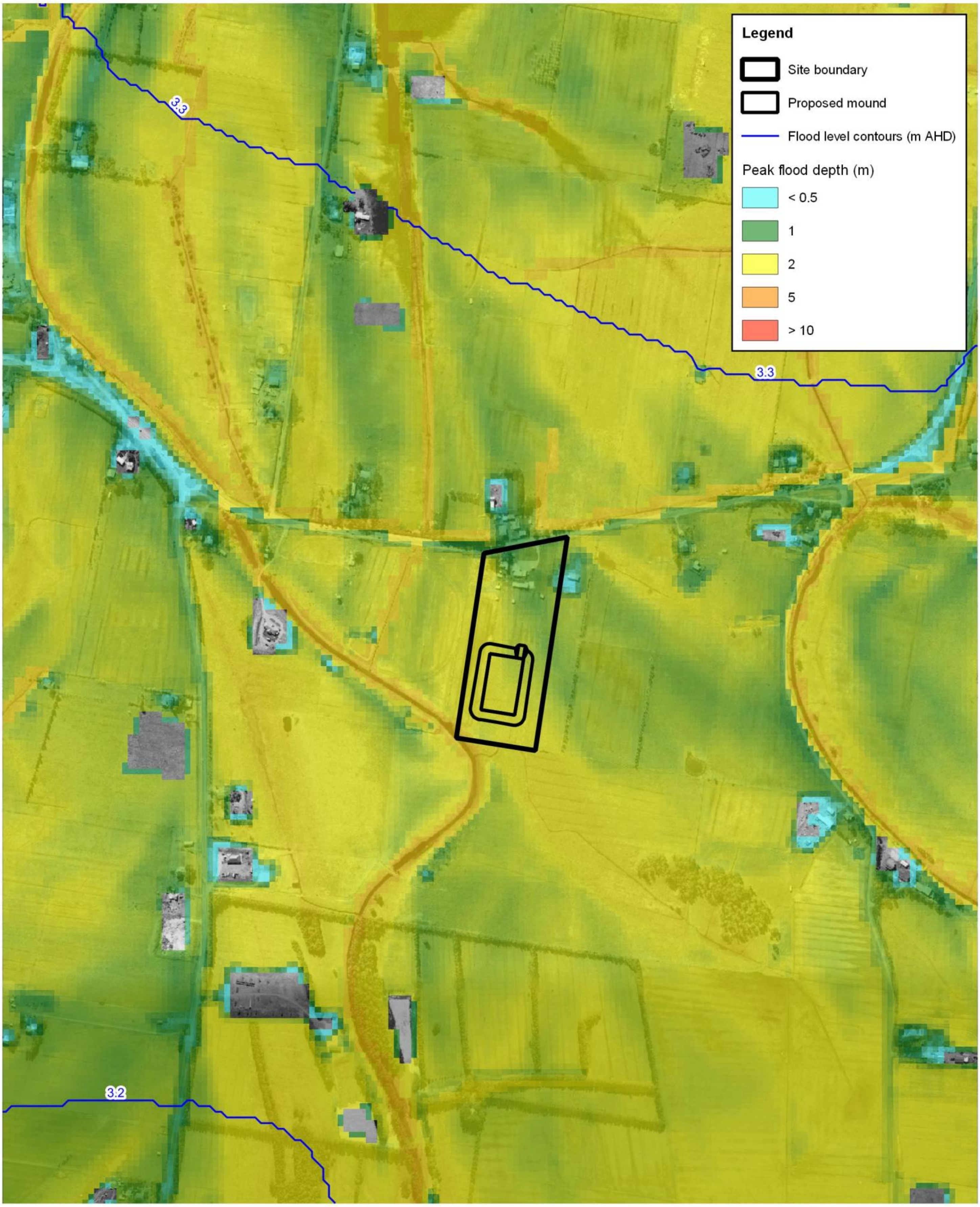
Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_004_230310_Extents.qgz



Title:

Modelled 5% AEP Flood Depths

0 200 400 m

approx. scale

Figure: **5**

Revision: **A**

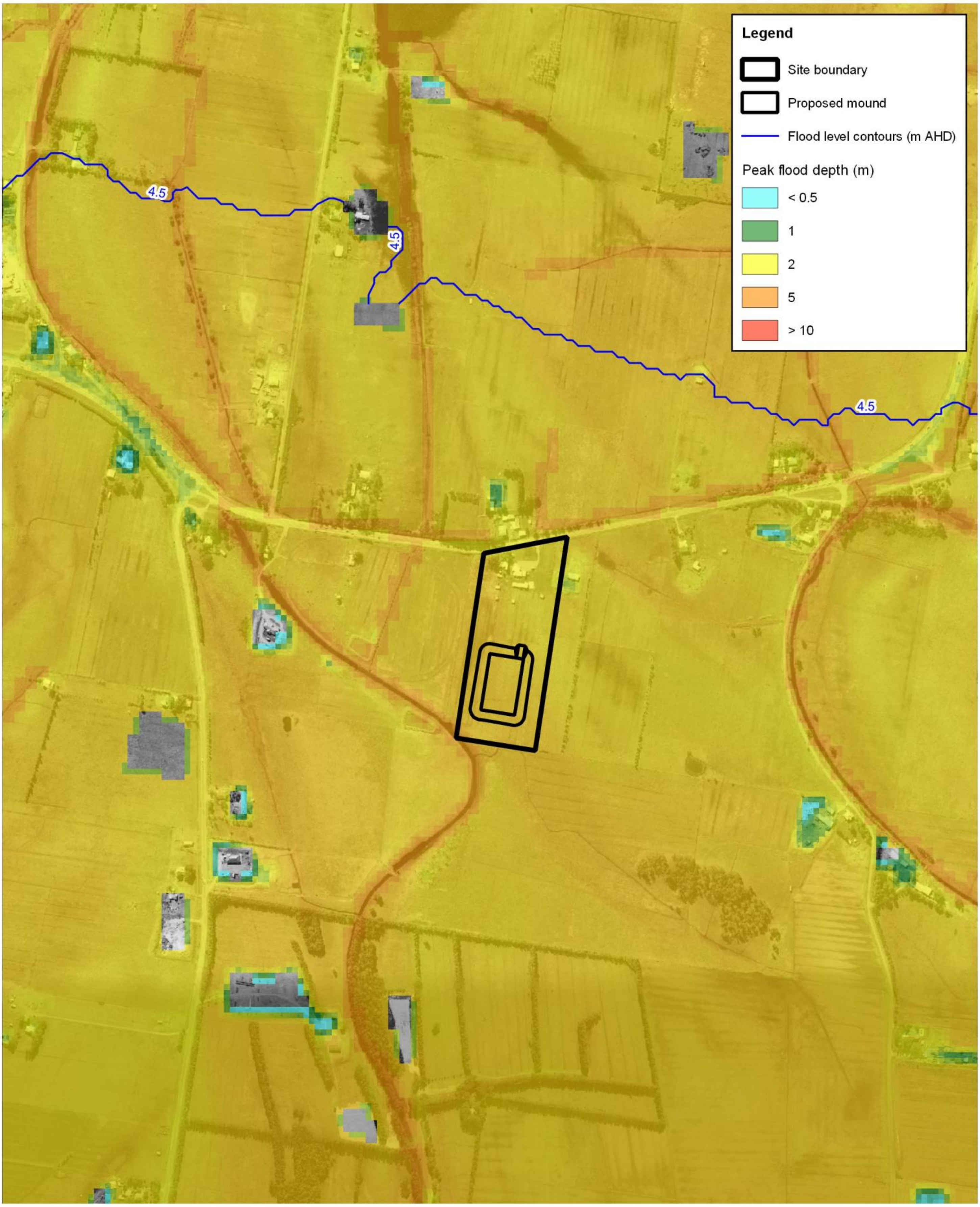
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_005_230310_20y_levels.qgz



Title:

Modelled 1% AEP Flood Depths

0 200 400 m

approx. scale

Figure: 6

Revision: A

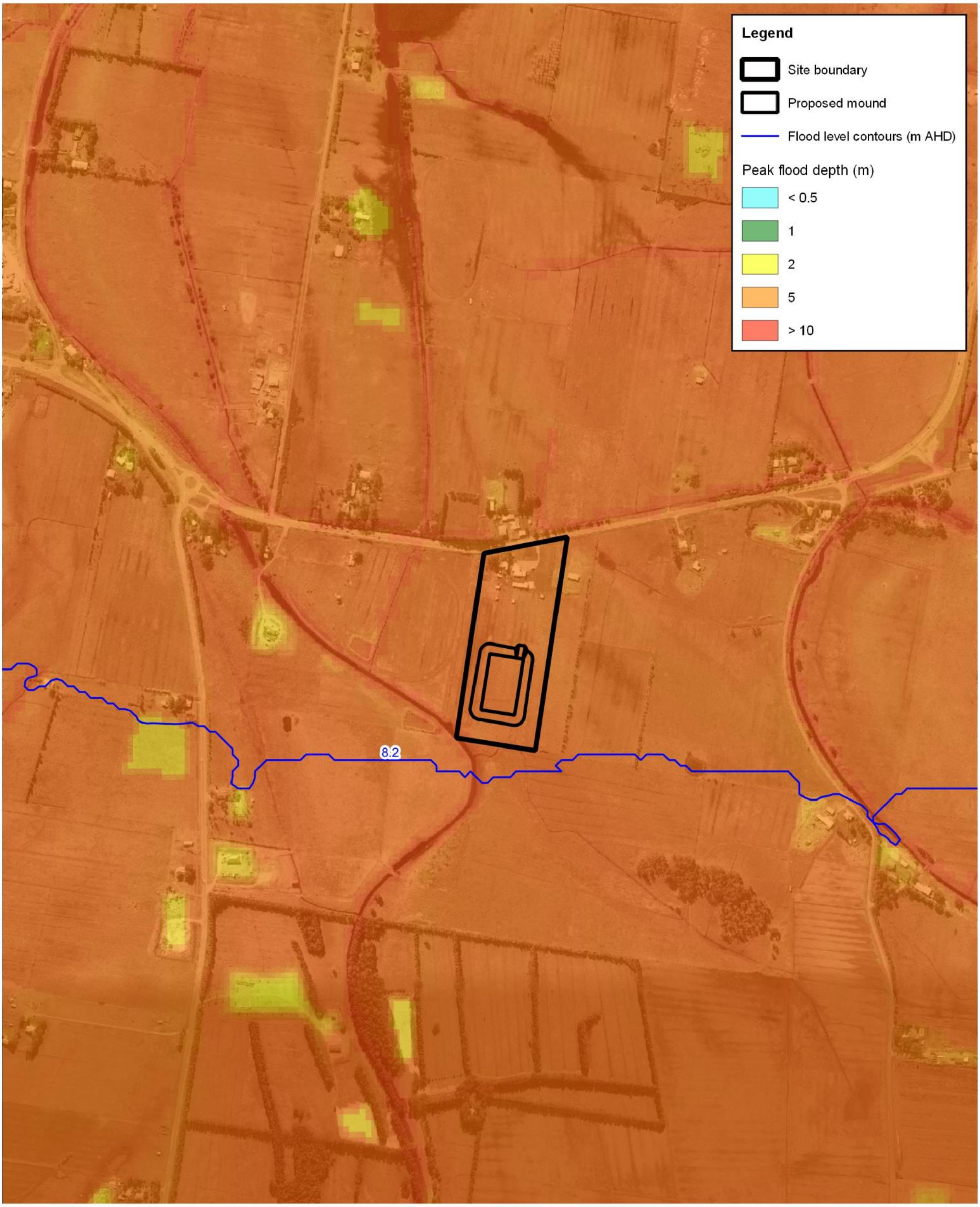
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_006_230310_100y_levels.qgz



Title:

Modelled Extreme Flood Depths

Figure: 7

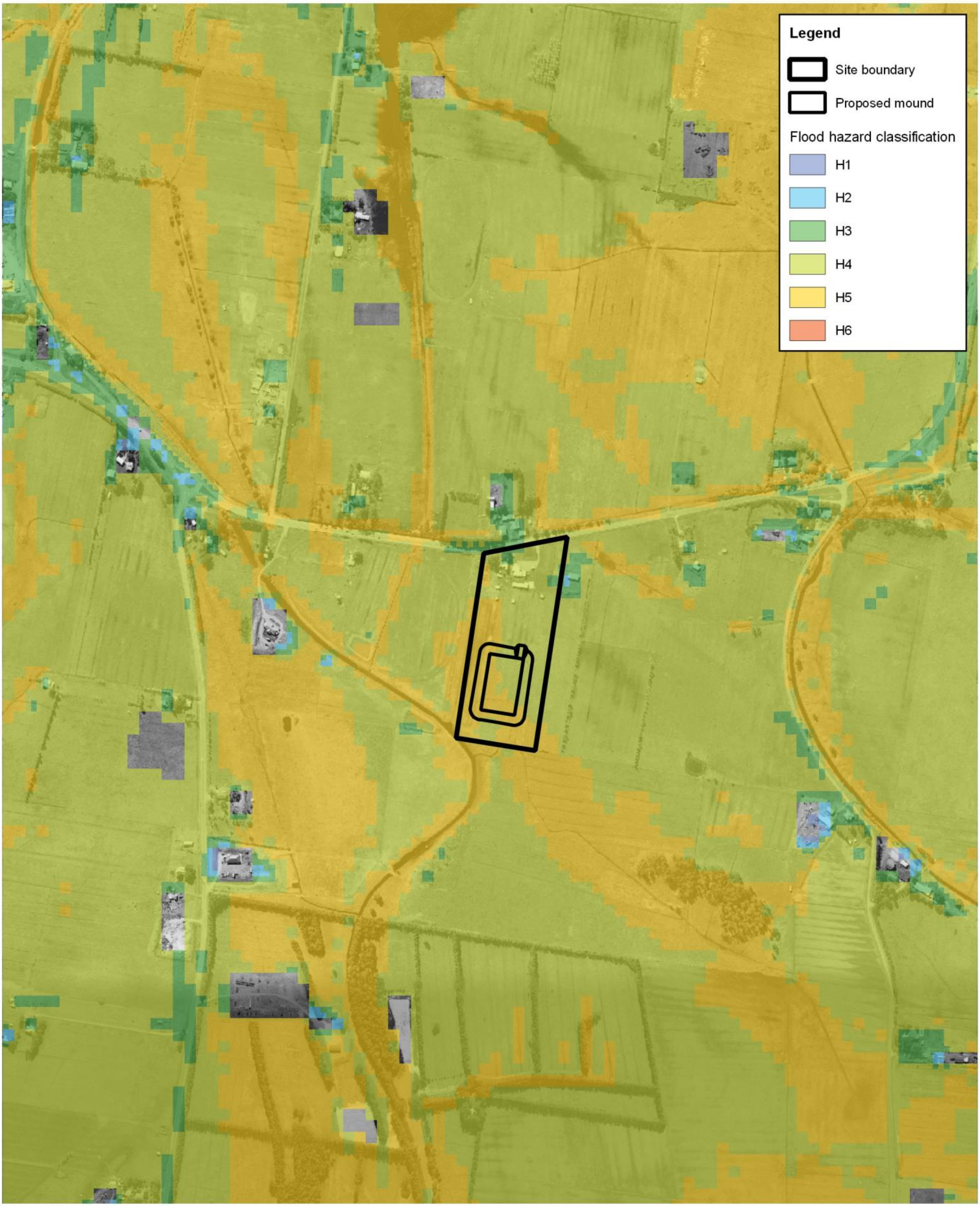
Revision: A

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_007_230310_extreme_levels.qgz



Title:

5% AEP Flood Hazard Classifcation

0 200 400 m

approx. scale

Figure:	8
Revision:	A

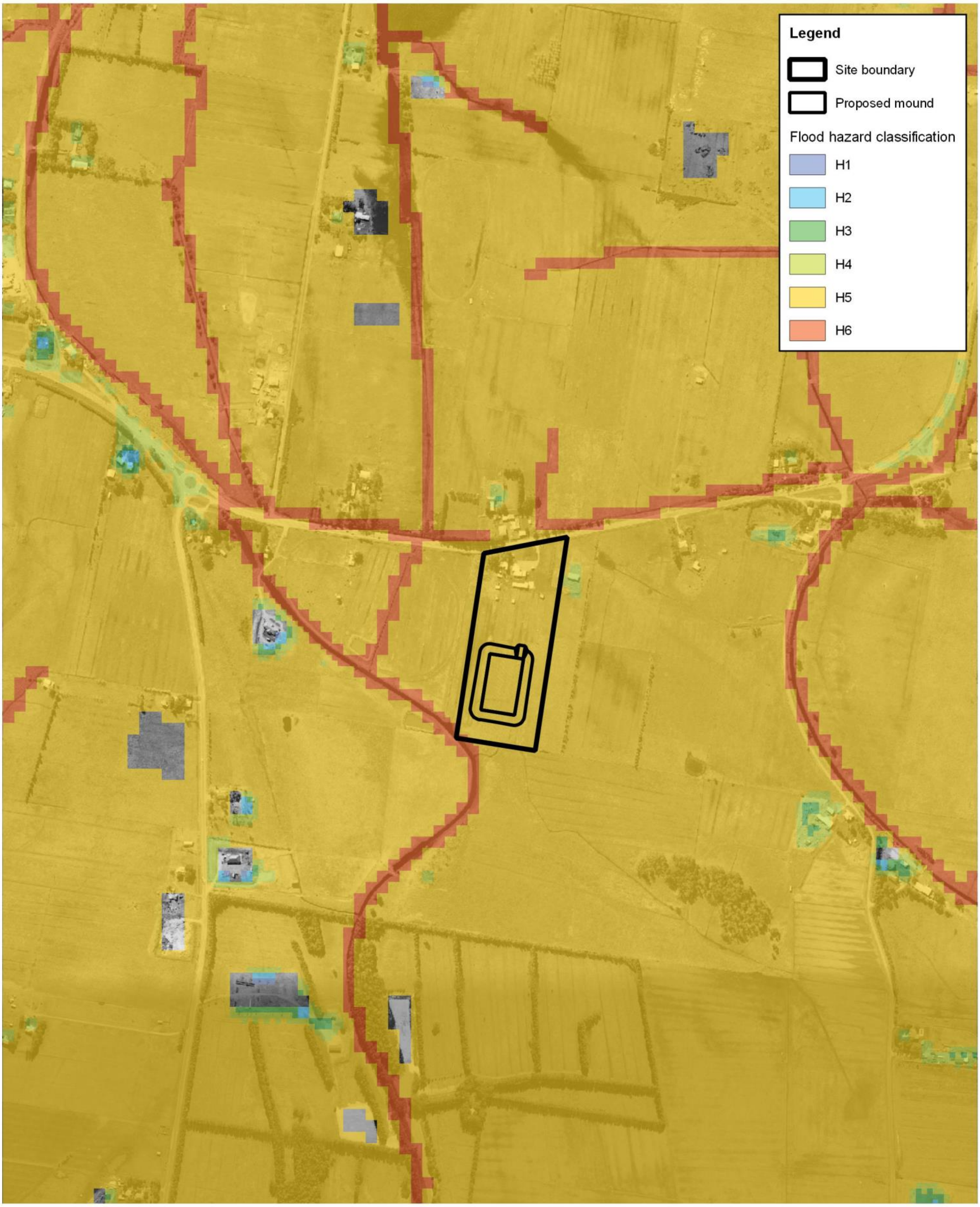
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_008_230310_20y_hazard.qgz



Title:

1% AEP Flood Hazard Classifcation

0 200 400 m

approx. scale

Figure: 9

Revision: A

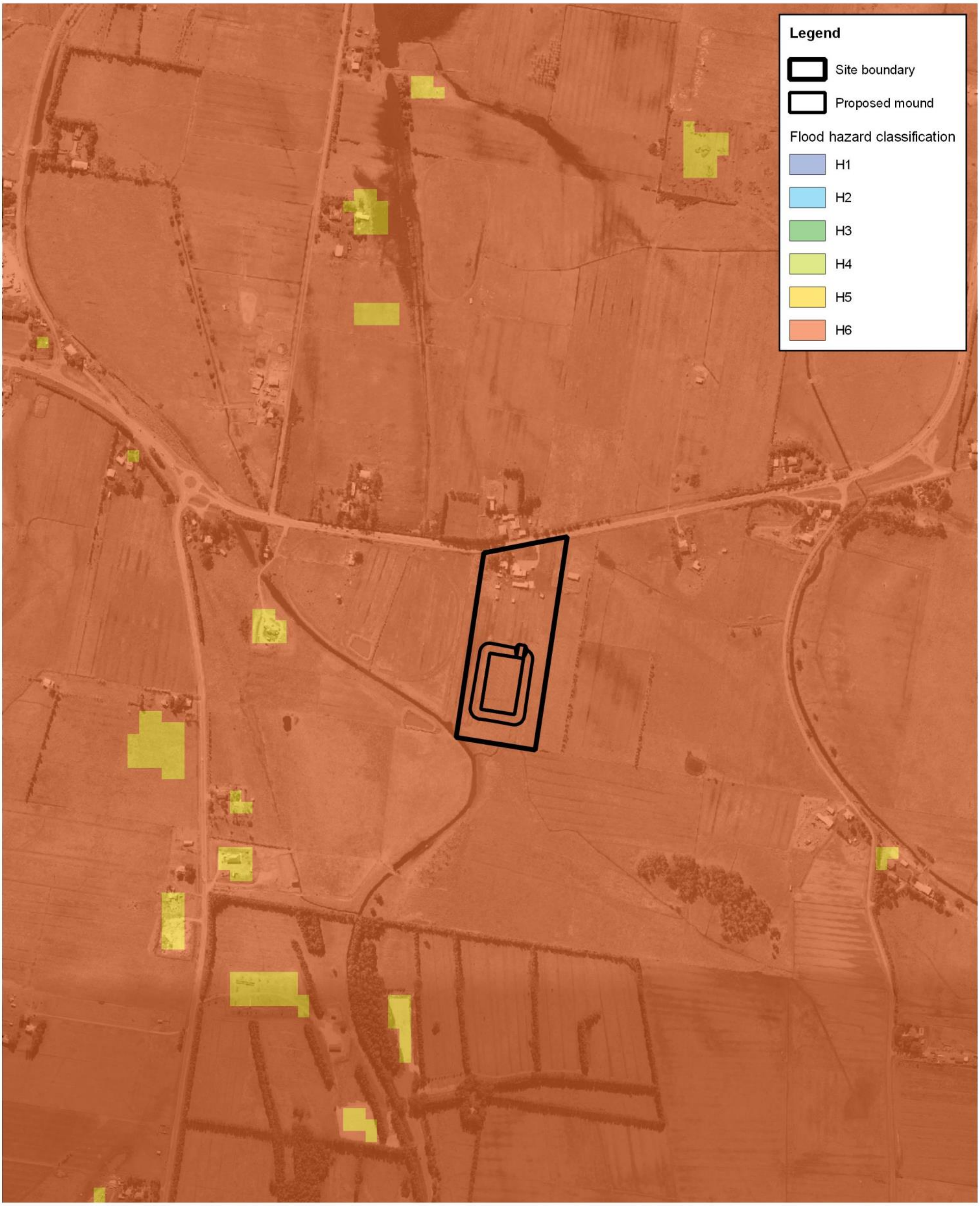
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_009_230310_100y_hazard.qgz



Title:
Extreme Flood Hazard Classifcation

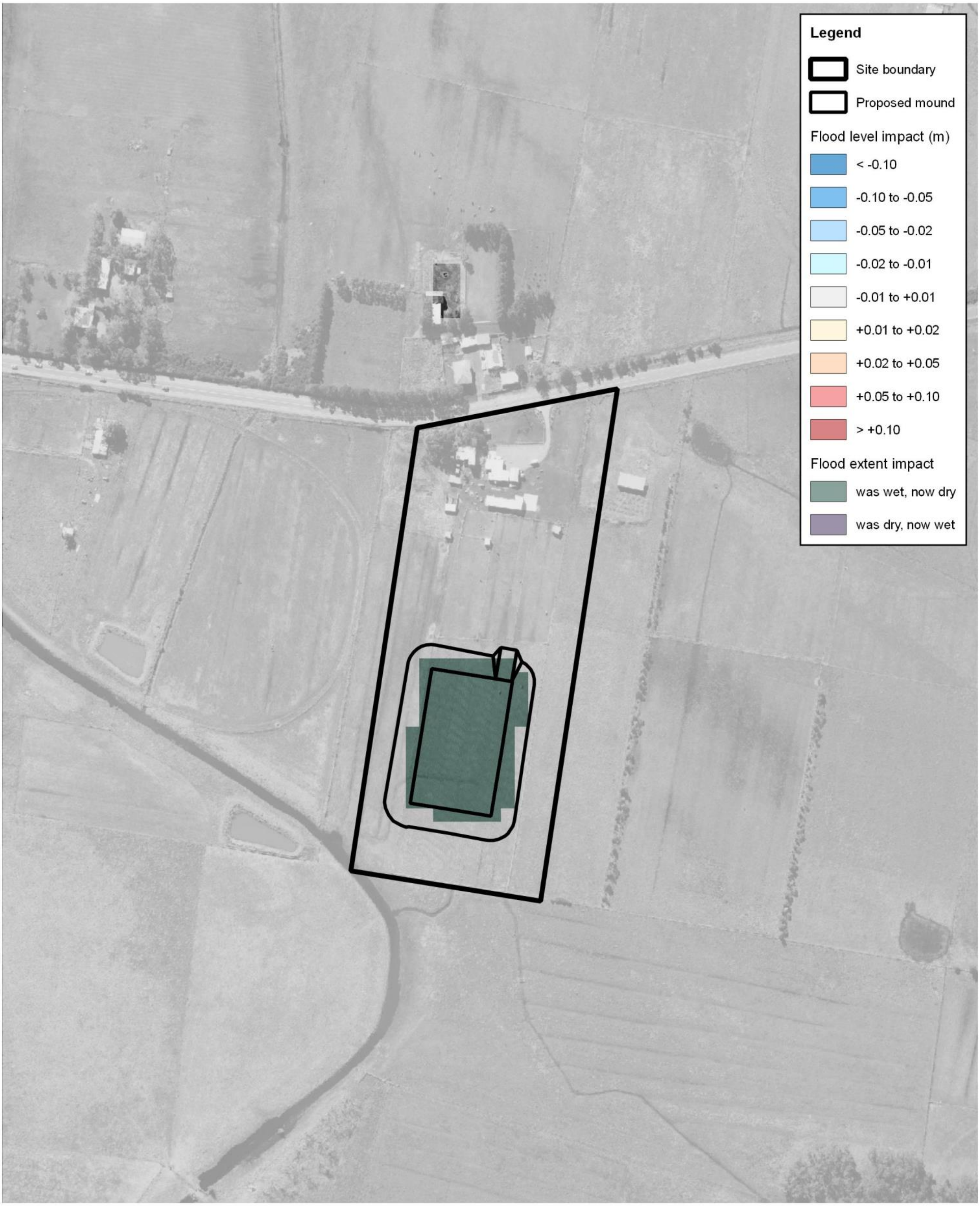
Figure: 10

Revision: A

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

Torrent CONSULTING
www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_010_230310_extreme_hazard.qgz



Title:

Modelled 5% AEP Peak Flood Level Impact

Figure: **11**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

Torrent CONSULTING
www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_011_230310_20y_h_impact.qgz

Title:

Modelled 1% AEP Peak Flood Level Impact

Figure: **12**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_012_230310_100y_h_impact.qgz

Title:

Modelled 0.5% AEP Peak Flood Level Impact

0 100 200 m

approx. scale

Figure: 13

Revision: A

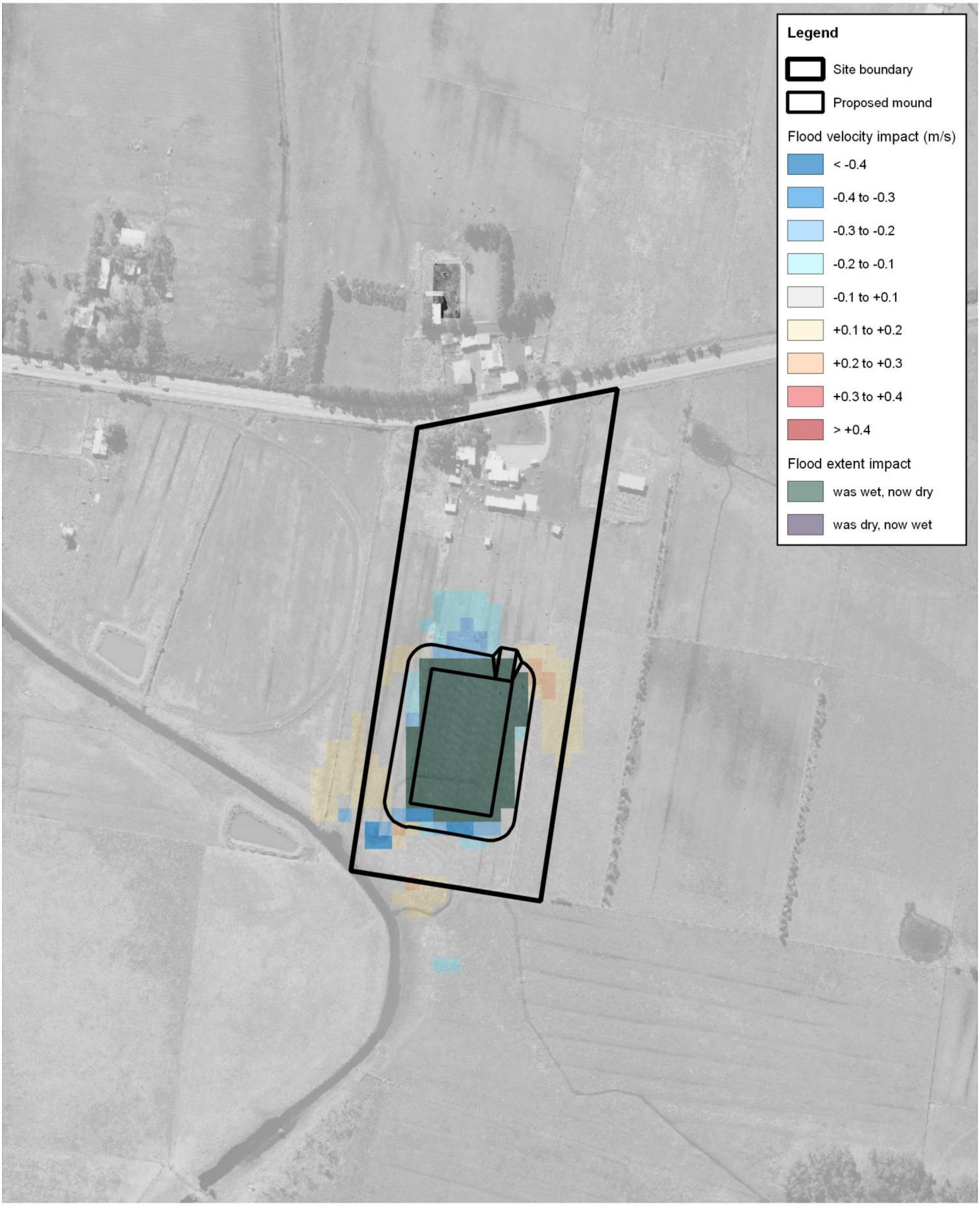
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_013_230310_200y_h_impact.qgz



Title:

Modelled 5% AEP Peak Flood Velocity Impact

0 100 200 m

approx. scale

Figure: **14**

Revision: **A**

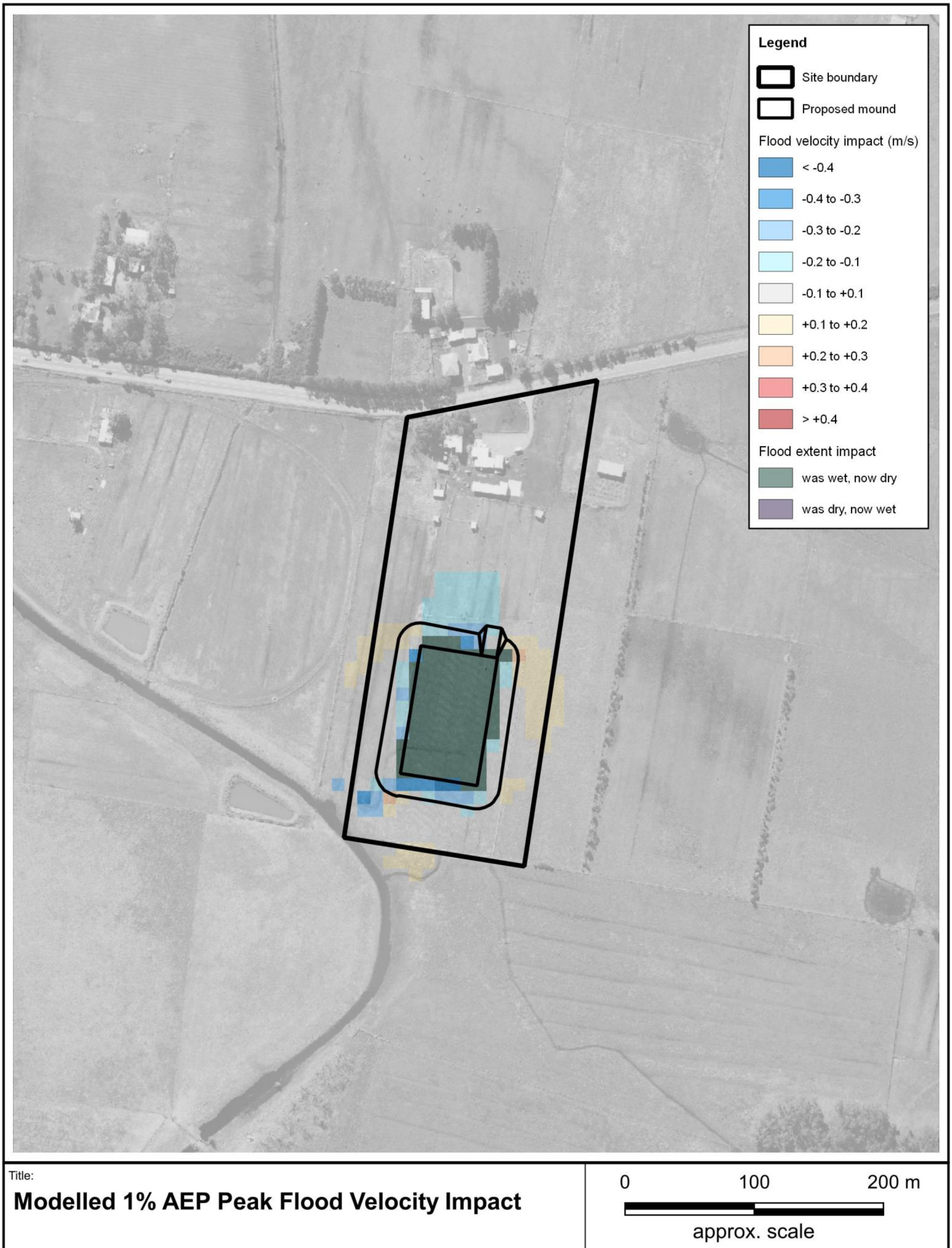
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_014_230310_20y_v_impact.qgz



Title:

Modelled 1% AEP Peak Flood Velocity Impact

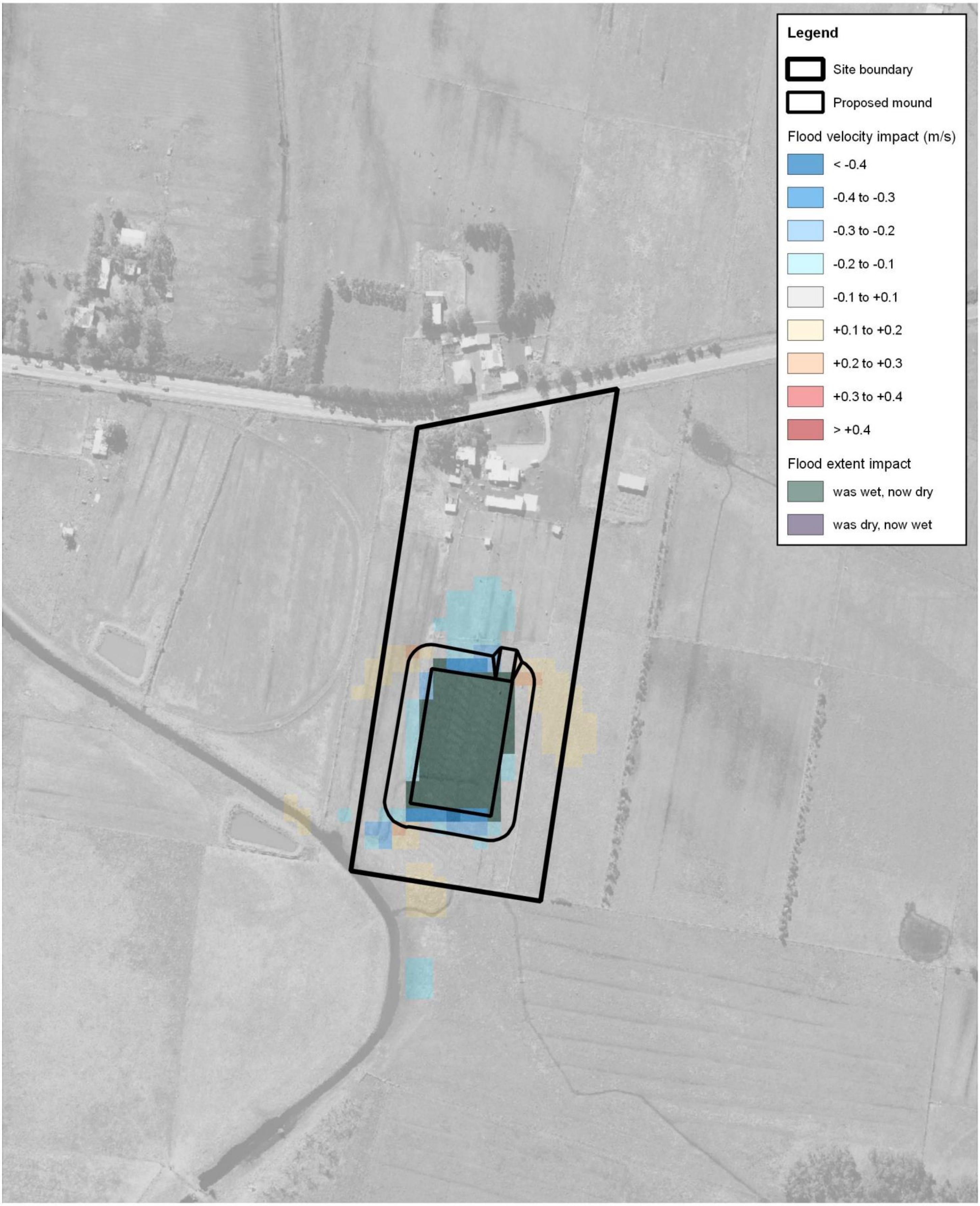
Figure: **15**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

Torrent CONSULTING
www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_015_230310_100y_v_impact.qgz



Title:

Modelled 0.5% AEP Peak Flood Velocity Impact

0 100 200 m

approx. scale

Figure: **16**

Revision: **A**

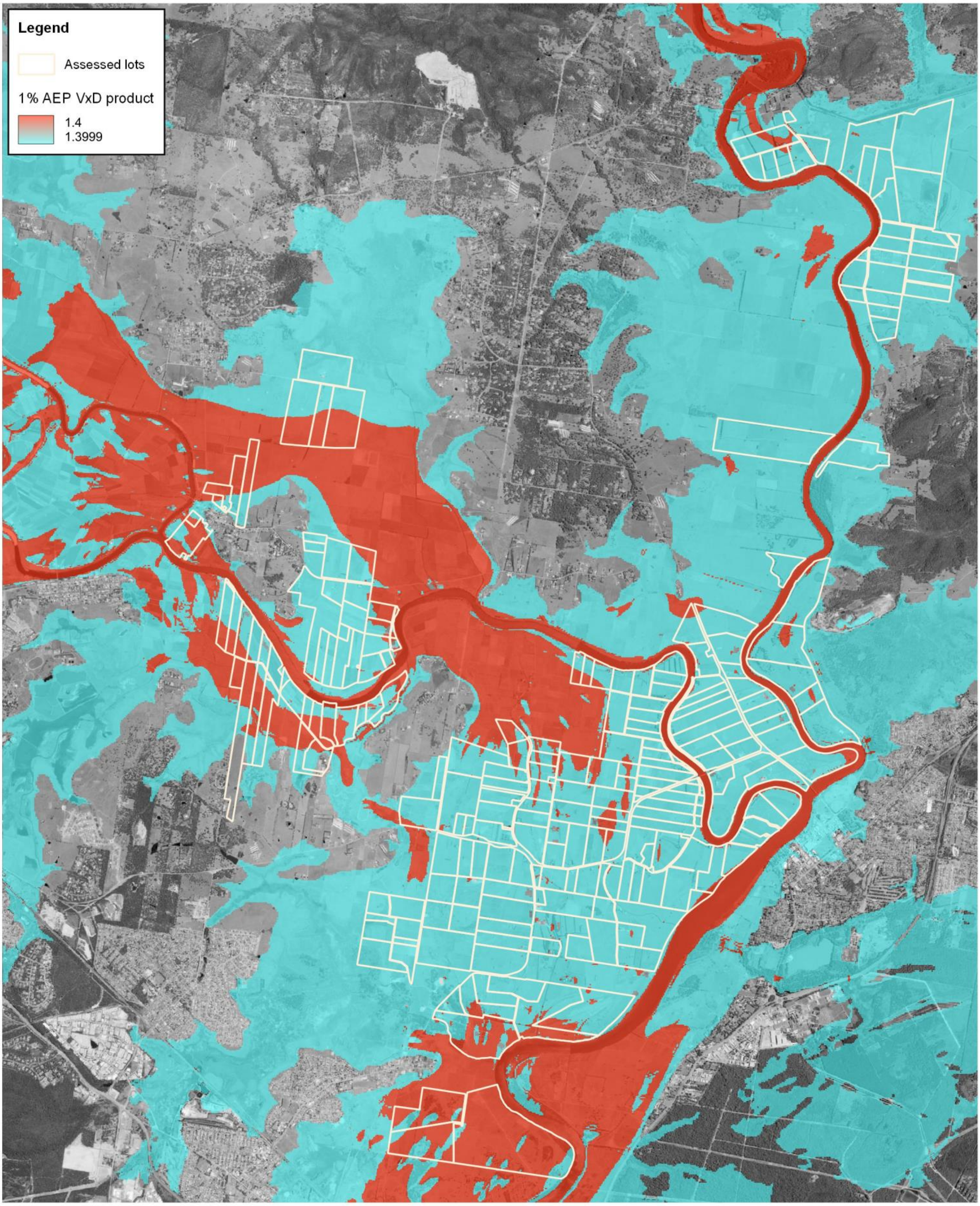
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_016_230310_200y_v_impact.qgz



Title:

Lots Considered for Cumulative Development Impact Assessment

0 2 4 km

approx. scale

Figure: **17**

Revision: **A**

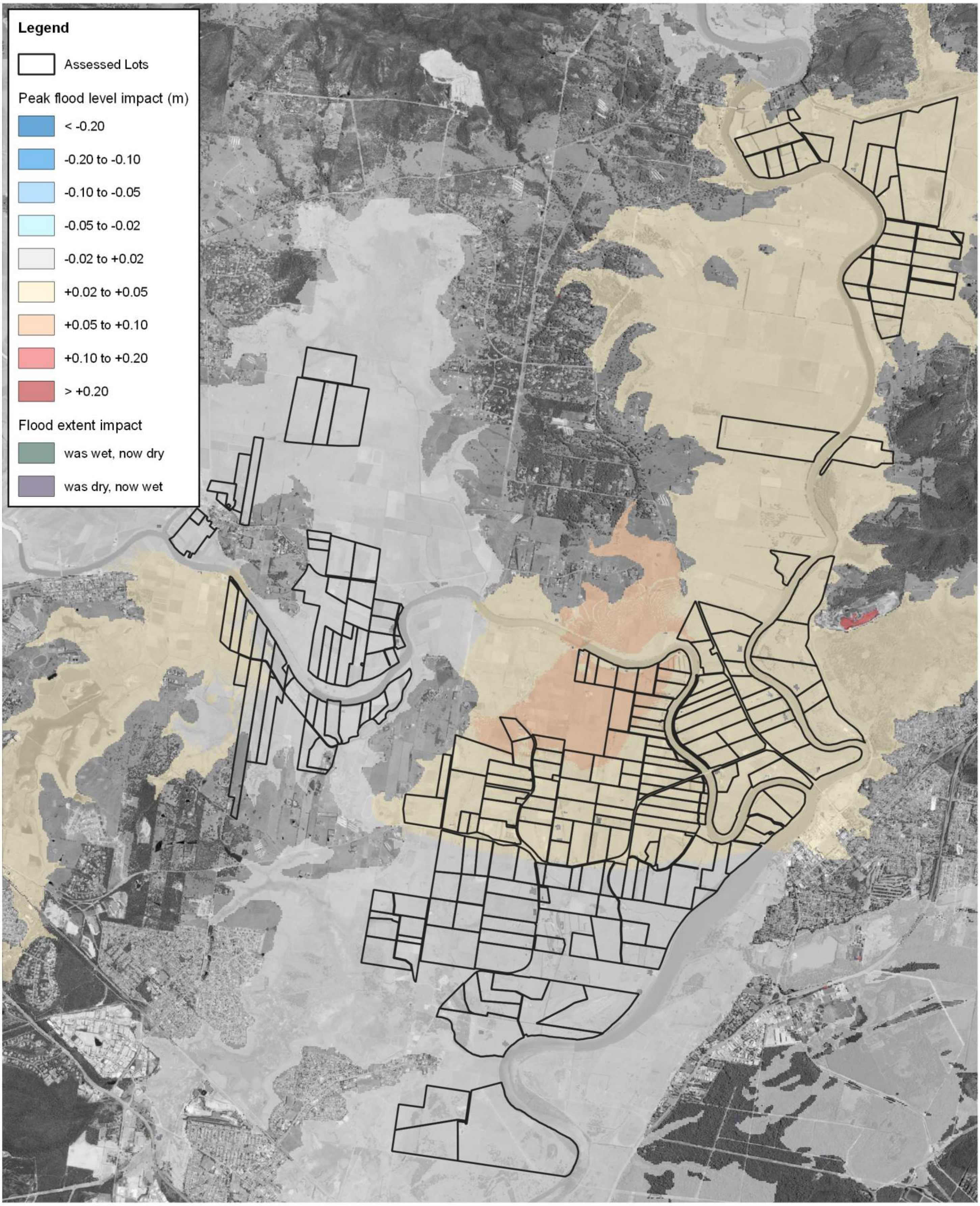
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_017_230310_CumDev_Lots.qgz



Title:

Modelled 1% AEP Peak Flood Level Impact Cumulative Development Assessment

0 2 4 km

approx. scale

Figure: **18**

Revision: **A**

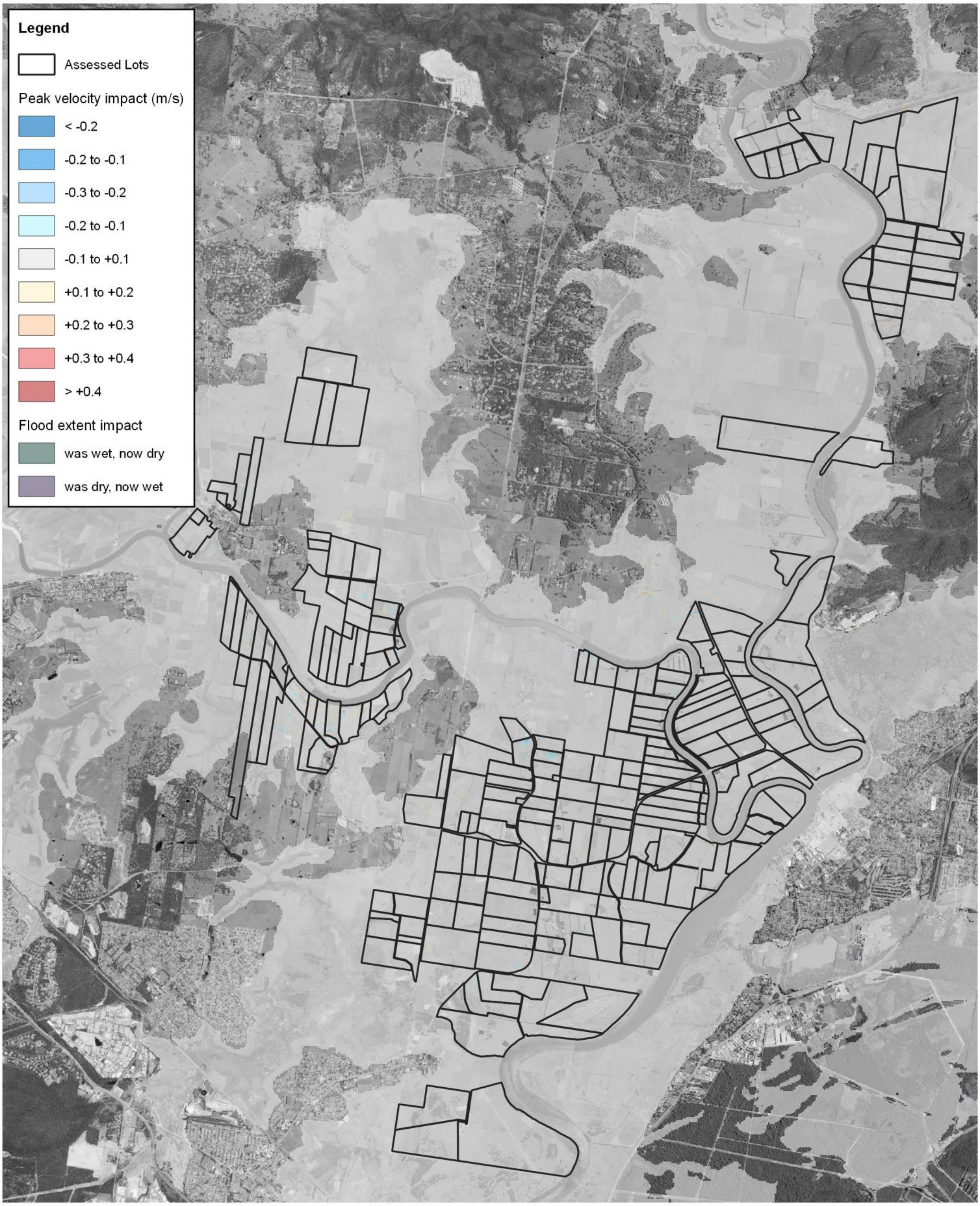
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_018_230310_100y_CumDev_h_impact.qgz



Title:

Modelled 1% AEP Peak Flood Velocity Impact Cumulative Development Assessment

0 2 4 km

approx. scale

Figure: 19

Revision: A

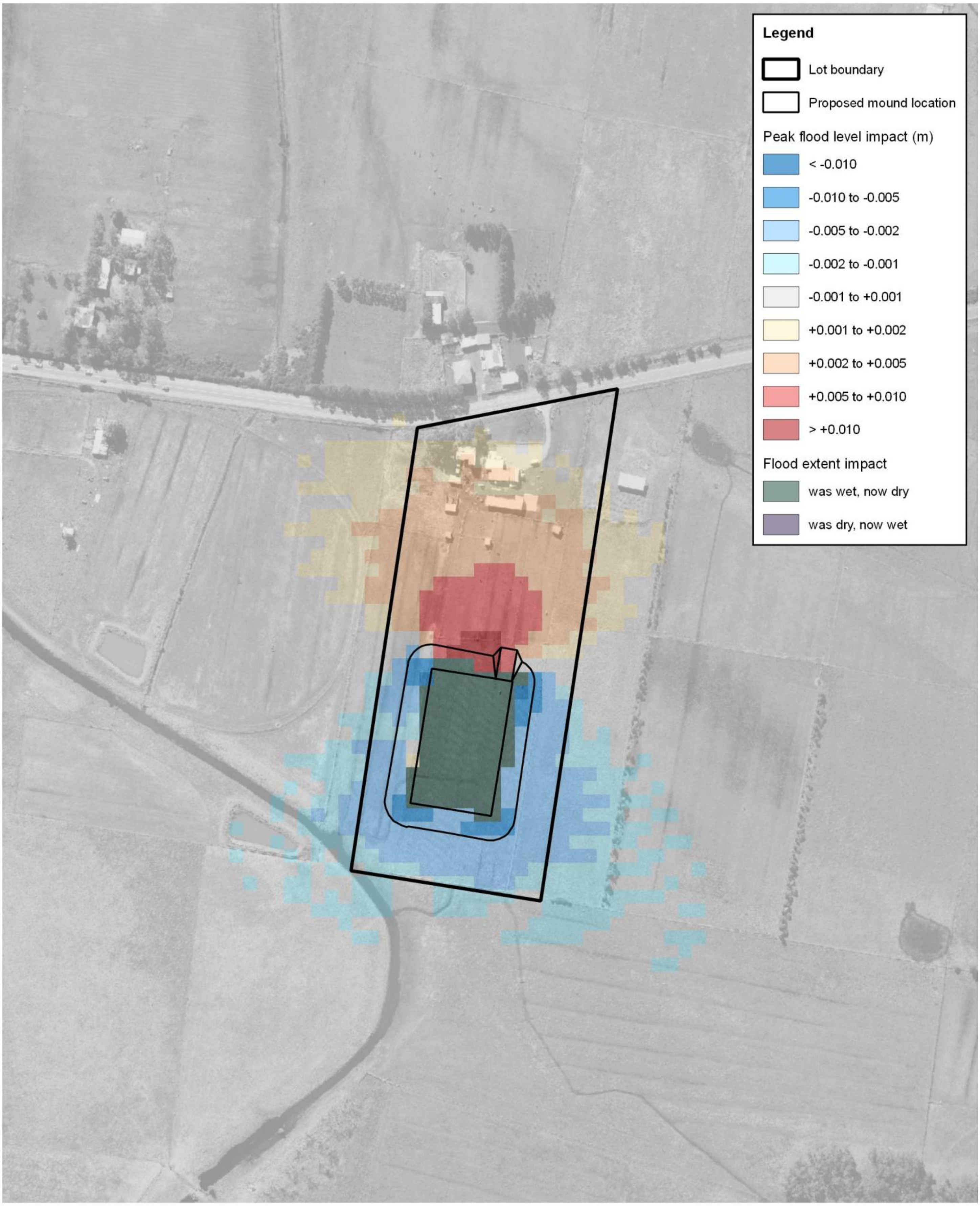
Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath: Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_019_230310_100y_CumDev_v_impact.qgz



Title:

Modelled 1% AEP Peak Flood Level Impact Site Specific Cumulative Development

0 100 200 m

approx. scale

Figure: **20**

Revision: **A**

Information shown on this figure is compiled from numerous sources and may not be complete or accurate. Torrent Consulting cannot be held responsible for the misuse or misinterpretation of any information and offers no warranty guarentees or representations of any kind in connection to its accuracy or completeness. Torrent Consulting accepts no liability for any loss, damage or inconvenience caused as a result of reliance on the information.

N

Torrent CONSULTING

www.torrentconsulting.com.au

Filepath:
Z:\Projects\T2336_Raymond_Terrace_Rd\GIS\T2336_020_230310_100y_SSCumDev_h_impact.qgz