Wallaby Creek Wind Farm - Hydrology & Flooding Assessment - Final

Technical Report for Environmental Impact Statement



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1 Introduction

This report presents the flood assessment undertaken on behalf of ERM Pty Ltd (for ACCIONA Energy Australia Global Pty Ltd) to support the State Significant Development Application (SSD-60247211) of the proposed Wallaby Creek Wind Farm Project (the "Project"). The flood assessment was undertaken to address the Secretary's Environmental Assessment Requirements (SEARs) for SSD-60247211, including those recommended by the Biodiversity and Conservation Division (BCD) of DPE. The main objectives are to establish the flood risks and flood impacts of the Project infrastructure including the proposed Wind Turbine Generators (WTGs).

1.1 Site Description

Acciona Energy Global Australia Pty Ltd is proposing to construct and operate the Wallaby Creek Wind Farm, a renewable energy development located north of Tomingley in the Orana region of NSW (refer Figure 1.1). The site is approximately 22 kilometres (km) south of the town of Narromine with a total area of approximately 8,800ha. It is located within the Narromine Shire Local Government Area (LGA) and to the west of the Newell Highway, on land that is used for grazing and cropping.

The site is located within the Wallaby Creek catchment, a tributary of the Macquarie River, with Wallaby Creek and its tributaries such as Jacks Creek, Hawkes Creek, Bundara Creek and Rays Creek flowing in the north-west direction. The catchment area contributing runoff to the site is in the order of 200km^2, with the site located sufficiently upstream to be outside of the Macquarie River mainstream flood extent. Hence, flood risk for the site will primarily be driven by overland flow flooding from the local catchment. As shown in Figure 1.1, Wallaby Creek and its tributaries, such as Jacks Creek, Bundara Creek, and Hawkes Creek, flow within the site.

The existing topography around the Project site is shown in Figure 2.2 and is based on the 5 metres (m) Digital Elevation Model (DEM) generated from LiDAR (Light Detection and Ranging) data collected in 2012, 2013 and 2015 available from the Elevation and Depth - Foundation Spatial Data ("ELVIS") webpage[1] and 1m Digital Elevation Model (DEM) provided by the client in November 2023. The 1m DEM extent is shown in Figure 2.2. Based on the topographic information, the Project site terrain was found to vary between 250 and 525 m Australian Height Datum (AHD), which signifies a significant grade across the site and typically sloping towards the north and west.

1.2 Scope of Assessment

The following tasks have been undertaken as part of the assessment:

- Review of available topographic and flood information for the Project site;
- Review of aerial imagery;
- Simulation and assessment of on-site flood risk for design flood events including the 5% Annual Exceedance Probability (AEP), 1% AEP, the Probable Maximum Flood (PMF), the 0.5% and 0.2% AEP events as proxies for climate change;
- Review of the proposed development works and assessment of flood impacts; and
- Summary of how SEARs have been addressed.

[1] https://elevation.fsdf.org.au/

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The study focuses on the local catchment flooding, which is experienced in upstream rural and vegetated areas during periods of heavy rain.

1.3 Relevant Council Studies

Previous key flood studies in the Narromine Shire Council include:

- Chapter 2 of Narromine Floodplain Risk Management Study and Plan Update, 2021[2]

[2] https://flooddata.ses.nsw.gov.au/flood-projects/narromine-floodplain-risk-management-study-and-plan-update

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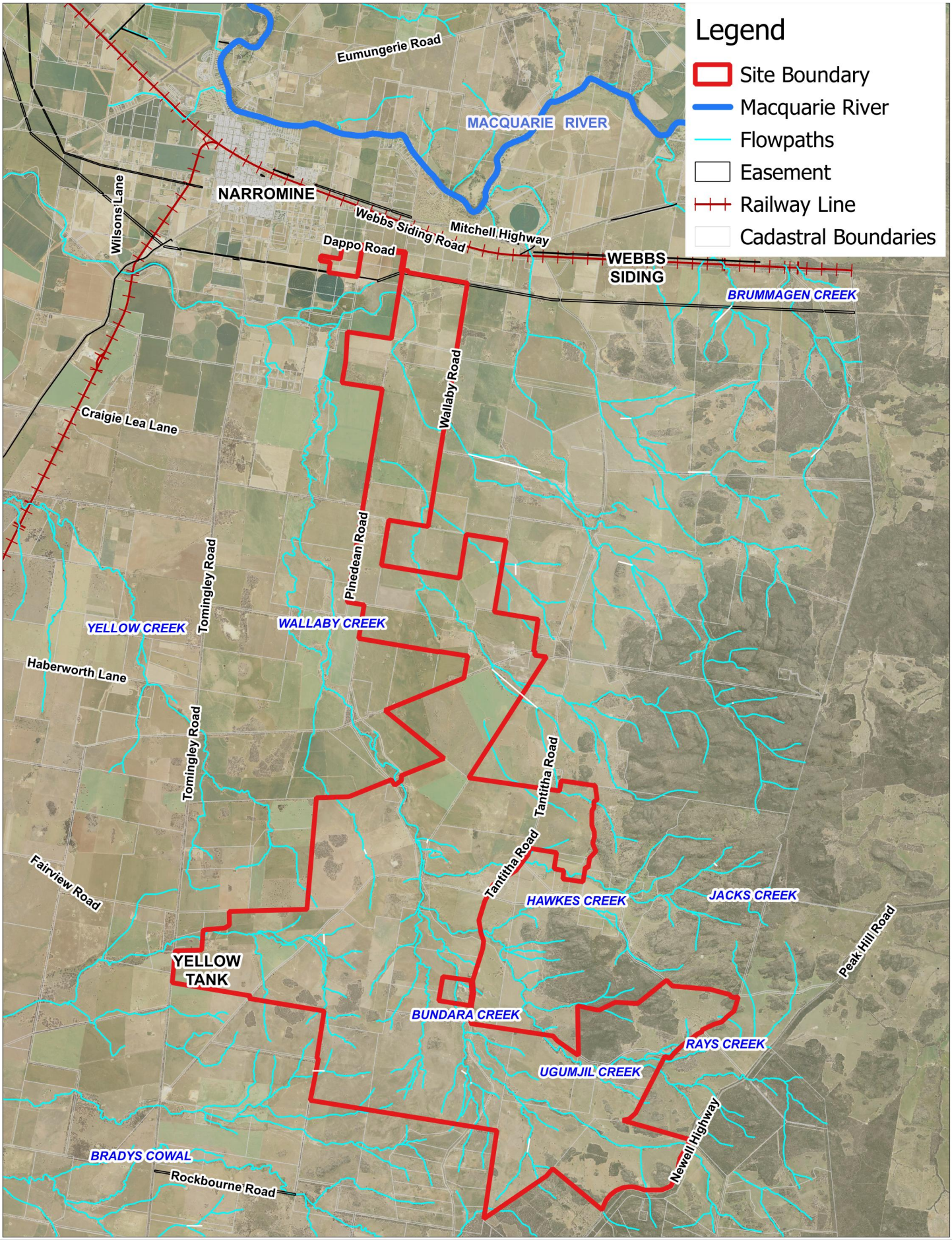

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Locality

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1.4 Project Description

The Project will involve the construction, operation and the decommissioning of a wind farm, Battery Energy Storage System (BESS) and associated infrastructure, as generally illustrated on Figure 1.2.

As noted in the Wallaby Creek Wind Farm document provided by ERM (Feb, 2025) , it is understood that this includes:

- Permanent operational infrastructure:
  - Up to approximately 38 WTGs with a maximum height of 271.5 m;
  - A BESS with a nominal storage of 200 MW / 400 MWh at a centralised location or distributed at turbine hardstands;
  - Operations and maintenance facility (O&M)
  - One substation
  - Three permanent meteorological monitoring masts (maximum height of up to 200 m)
  - One overhead transmission line (132kV)
  - Underground cabling (33kV)
  - Underground communication cabling
  - Internal access tracks
  - Security fencing and landscaping
- Temporary operational infrastructure:
  - One construction compound
  - One carpark
  - One accommodation camp
  - Up to two laydown areas
  - One concrete batching plant
  - One internal borrow pit
  - Up to two security huts
  - Up to nine washdown facilities

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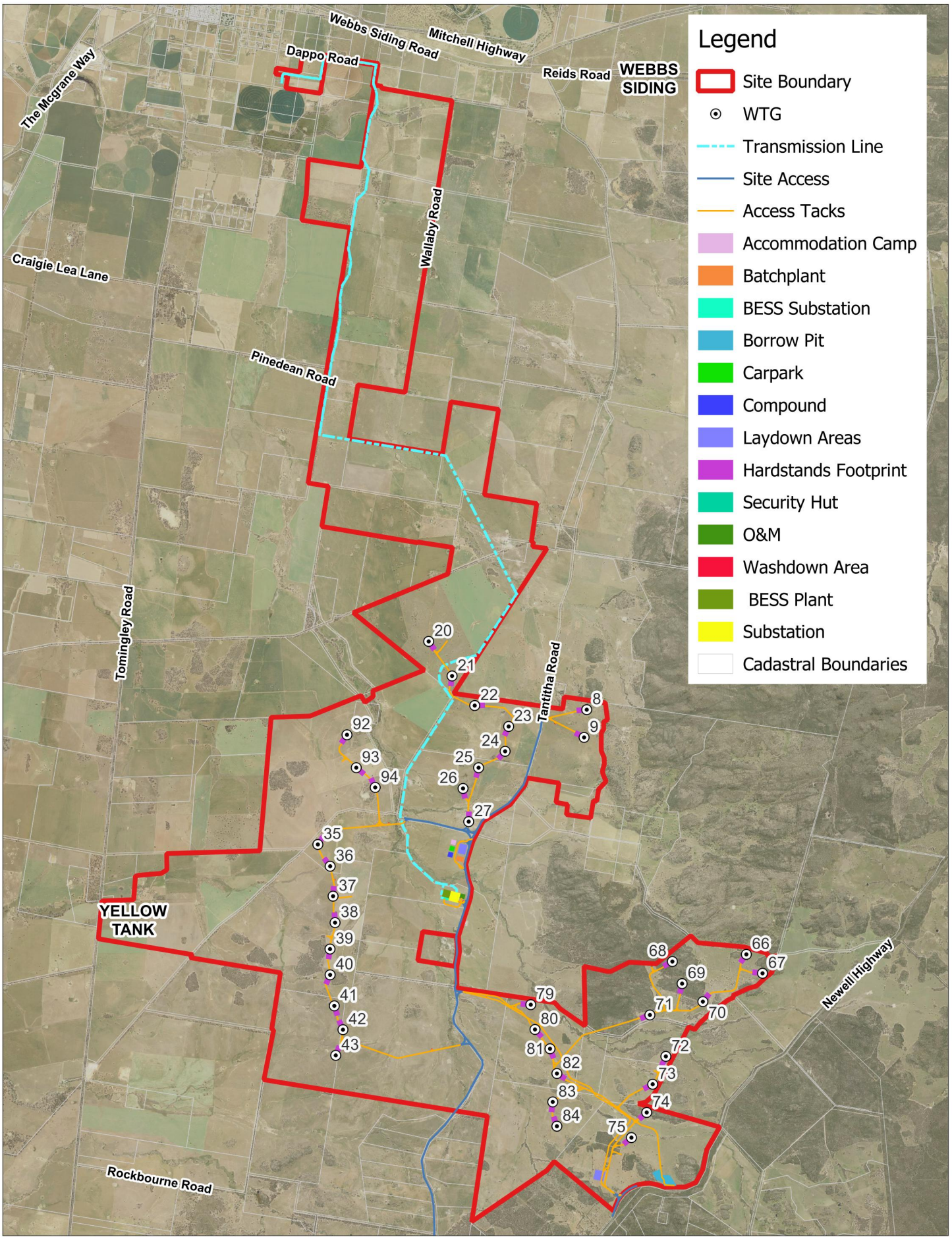

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Site Design Layout

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2 Methodology

The flood assessment has been undertaken in accordance with Australian Rainfall and Runoff 2019[3] (ARR 2019) data and methodology to establish existing (baseline) and post-development flood behaviour for the Project site. The assessment approach is discussed further in the following sections.

2.1 Input Data

To facilitate the assessment, the following datasets were reviewed and used to inform the assessment:

- Aerial imagery of the study area;
- Project description (current as of January 2025, for Submissions Report);
- Project layout as GIS files. Digital Elevation Model (DEM) in 5m resolution tiles based on LiDAR aerial survey obtained from 2012, 2013 and 2015 by the NSW Government[4] and 1m resolution provided by the client in November 2023;
- Cadastral information and hydrolines (watercourses) from SIX Maps[5];
- Bureau of Meteorology (BoM) 2016 design rainfalls[6]; and
- Storm losses and temporal patterns for design rainfalls from ARR Data Hub[7].

2.2 Catchment Modelling

2.2.1 Hydrology

As shown in Figure 2.1, Wallaby Creek and its tributaries such as Jacks Creek, Ugumjil Creek, and Bundara Creek flow through the site. The extent of the catchment model was defined respecting the site boundaries. In total, 215 sub-catchments have been delineated for the hydrologic model. The sub-catchment delineation was based on a 5m resolution DEM, Wind Turbine locations, access road and other important site properties. The catchment model was developed using a standard hydrologic package “WBNM” in this study.

Design rainfall was obtained from the BoM at each subcatchment centroids in the study area, for a range of durations (9 durations – 45min to 9 hours) across the design storm events including 5%, 1%, 0.5%, 0.2% AEP events. This provides the spatial distribution of design rainfall across the study area. As most subcatchments have an area of less than 1 km^2, no Areal Reduction Factors (ARFs) were applied in the determination of the design rainfall estimates.

Rainfall losses (i.e. infiltration) were determined at each sub-catchment centroid using ARR19 methodologies. The Initial Loss (IL) and Continuing Loss (CL) were adopted from spatially varying values recommended in the ARR datahub for each sub-catchment. In the PMF event, no initial and continuing losses were applied to the sub-catchments.

[3] https://arr.ga.gov.au/arr-guideline
[4] https://elevation.fsdf.org.au/
[5] https://maps.six.nsw.gov.au/clipnship.html
[6] http://www.bom.gov.au/water/designRainfalls/revised-ifd/
[7] https://data.arr-software.org/

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An ensemble of ten temporal patterns for four selected durations have been modelled for the 5%, 1%, 0.5% and 0.2% AEP design flood events. The ten temporal patterns vary in terms of their distribution and variability (comprising front, middle and back loaded storms) and can result in a wide range of flood behaviour. The procedures for ARR 2019 provide for the selection of the temporal pattern that gives the peak flow closest to the mean across all ten temporal patterns. This method was followed to confirm the critical temporal pattern for each storm duration.

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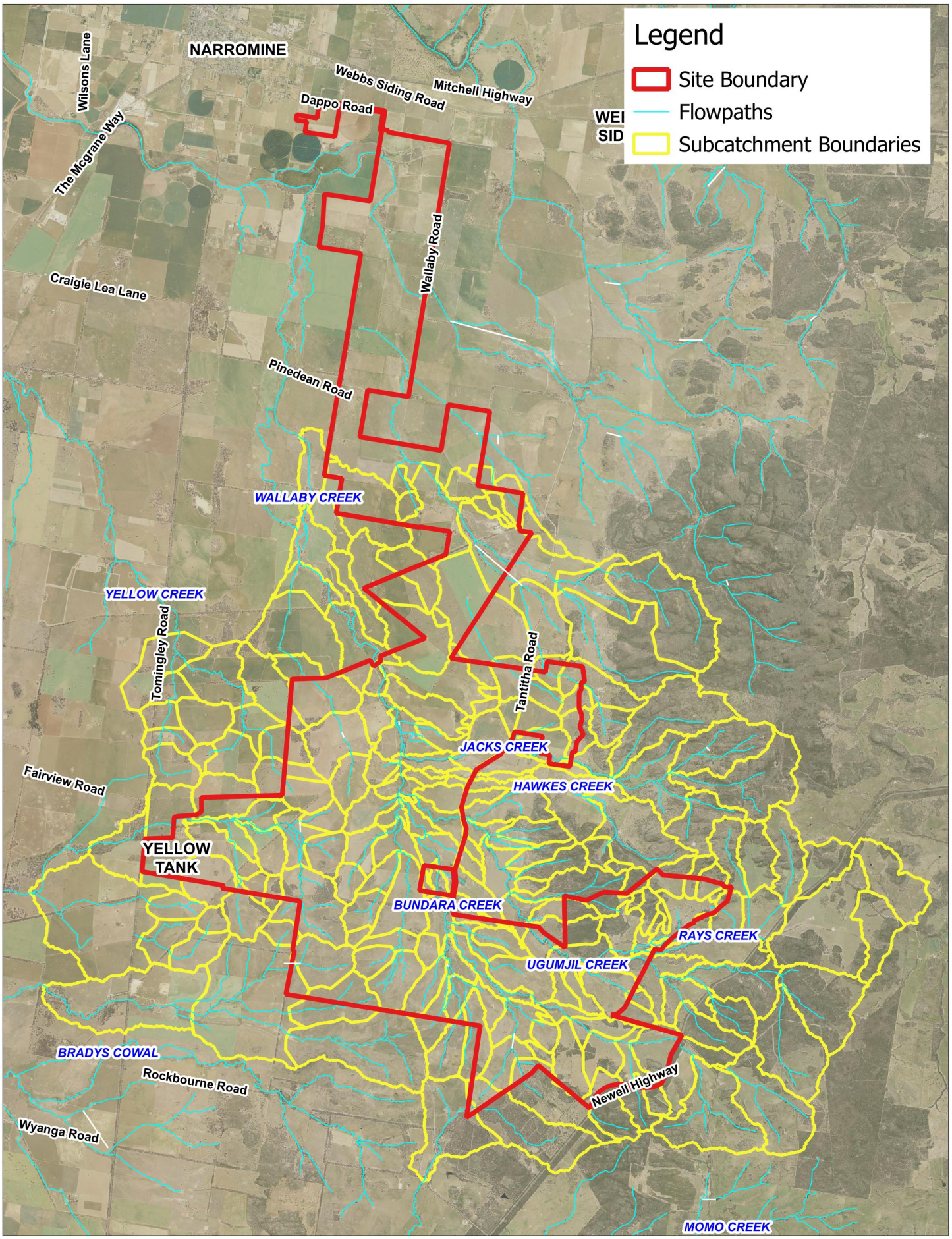

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Hydrology Model Setup

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2.2.2 Hydraulics

The hydraulic model was developed to simulate the dynamic interactions between watercourses and floodplains as well as overland flow paths within the study area, using the TUFLOW modelling software (version 2023-03-AC-iSP-w64) with HPC[8] solver. An overview of the hydraulic model setup is shown in Figure 2.2. Below is information about the TUFLOW model:

- The topography for the model was derived from the high resolution 1 m (provided by client). Also, the 5m DEM (ELVIS GIS website) was used in the model where 1m DEM is not available. The extent of 1m DEM is shown in Figure 2.2. For this study, a 5m grid size was used since it was thought to be suitable given the size of the watershed and the width of the local flow paths.
- The TUFLOW sub grid sampling (SGS) feature was also employed to enhance the precision of the flows through the model. A sampling distance of 1m was used.
- The model extent is contained within the available LiDAR data and covers all the proposed project infrastructure, with a total model area of approximately 233km². In addition, some cut through were included in the model to represent the existing culverts beneath the local roads like Newell Highway, Tomingley Road and Tantitha Road, and to remove potential blockage through the flow paths where they intersect the merged DEM boundary.
- All inflow boundaries to the model have been applied using TUFLOW's source area ('SA') approach. The downstream boundary of the model was applied as a stage-discharge relationship (QT boundary), using the in-built functionality of TUFLOW.
- Detailed land use of the local sub-catchments has been created using the available land use data and through digitised aerial photography and assigned appropriate industry accepted values of Manning's 'n' values (Chow, 1959). The hydraulic model's Manning's roughness (n) is tabulated in in Table 2.1 and shown in Figure 2.3.

Table 2.1 Roughness Parameters

Land use	Manning's 'n'
Sealed roads	0.020
Gravel roads and hardstands	0.023
Waterways (low vegetation)	0.070
Dense vegetation	0.100
Very dense vegetation	0.120
Buildings	1.000
Grassed floodplain	0.035
Waterbodies	0.025

[8] TUFLOW HPC (Heavily Parallelised Compute) is a solver which utilises Graphics Processor Unit (GPU) hardware to undertake simulation runs

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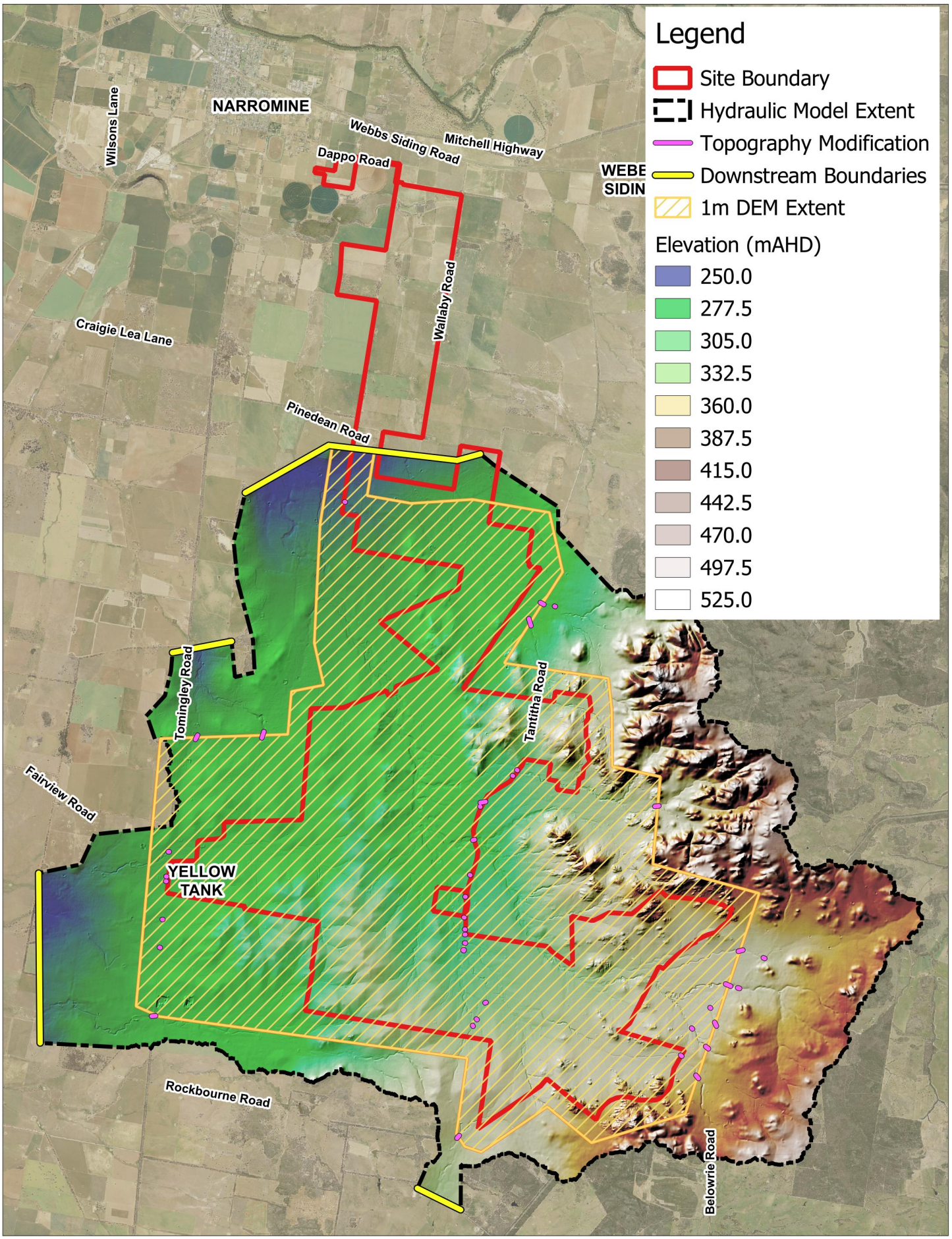

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Hydraulic Model Setup and Topography

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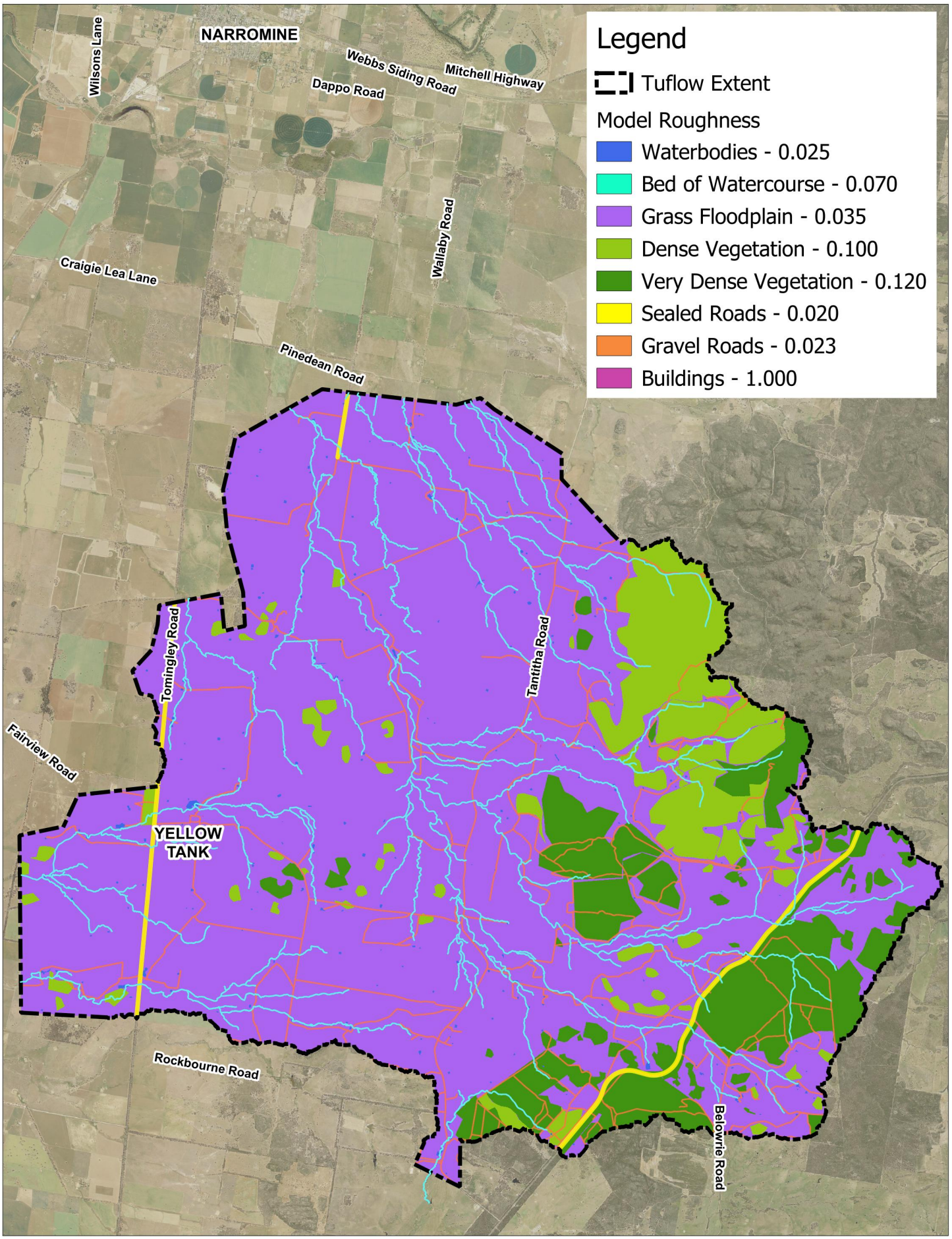

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Hydraulic Model Roughness

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Critical Duration Assessment

A critical duration analysis was undertaken for all model events. As per ARR 2019 recommendations, an ensemble of ten temporal patterns for each duration has been modelled for each flood event. The ten temporal patterns vary in terms of their distribution and variability (comprising front, middle and back loaded storms) and can result in a wide range of flooding behaviour within the catchment. Below is a summary of the method adopted to select critical events in this study:

- The model was simulated for four design events (5%, 1%, 0.5%, and 0.2% AEPs), across nine durations (ranging from 45 to 540 min), and ten temporal patterns, resulting in a total of 360 storm simulations.
- A critical duration assessment was undertaken within the hydraulic model. Through this process, durations that resulted in the maximum water levels within the site area were identified as critical durations. Based on the results, durations of 45, 90, 120, and 180 minutes were found to be critical for the 1%, 0.5% and 0.2% AEP events, while durations of 45, 120, 180, and 270 minutes were identified as critical for the 5% AEP event (Table 2.2).
- A statistical analysis performed to define the adopted temporal pattern leading to peak flood levels for each designed event and critical duration. Over this process, the temporal pattern resulted in maximum water levels within each critical duration zone was selected. The selected temporal patterns are shown in Table 2.2.
- To test the accuracy of the adopted method, the differences between the maximum flood levels generated using all durations and temporal patterns and those from the four selected storms were calculated to assess whether the selected storms accurately represent peak flood levels. The results showed that the differences were very small (ranging from -10 mm to +10 mm) across the model extent. Therefore, 16 design storms, as shown in Table 2.2, were selected for 5%, 1%, 0.5%, and 0.2% AEP events.
- For the PMF, a duration of 120 minutes was found to be critical in areas along the main creeks and developments located at the centre of the site.

Table 2.2 Critical storm durations and adopted temporal patterns

Design Storm (AEP)	Duration (min)	Temporal pattern
5%	45	TP6
	120	TP4
	180	TP7
	270	TP9
1%	45	TP5
	90	TP2
	120	TP8
	180	TP10
0.5%	45	TP5
	90	TP2
	120	TP8

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Design Storm (AEP)	Duration (min)	Temporal pattern
	180	TP6
0.2%	45	TP5
	90	TP2
	120	TP8
	180	TP7
PMF	120	-

Grid filtering

To discern sheet flows from overland flowpaths and obtain a more realistic representation of the overland flowpaths in the site, grid filtering of the model results was applied.

The filtering criteria adopted in the present study featured the application of conditions to flood depths, velocity-depth product and pond sizes in order to obtain well-connected flowpaths and avoid the patchiness often resulting from the application of a simple cutoff depth criteria to the direct rainfall model results.

The final grids of each AEP event were filtered in accordance with the following filtering criteria:

- Step 1: The wet cells were retained for flood depths > 0.01 m AND depth-velocity product > 0.125 m²/s;
- Step 2: The remaining wet cells from step 1 were retained for flood depths > 0.2 m OR depth-velocity product > 0.02 m²/s;
- Step 3: Ponds smaller than 100 m² resulting from step 2 were removed.

2.3 Proposed Development

Following the definition of existing scenario flood conditions for the study area, relevant details of the proposed development layout and configuration were included to represent any potential interactions between the proposed works and the floodplain. This includes only operational infrastructure which are listed in Table 2.3 and shown in Figure 2.4. The temporary operational infrastructures were not included in the development scenario in this study as they only exist during the construction stage. For structures that are expected to be elevated above the floodplain (e.g. WTG towers, buildings), these were raised by nominal amount of 10m in the model, noting that this does not reflect actual structure heights.

BMT were provided with a list of elements for the proposed development in February 2024. Table 2.3 summarises the elements with a description and their respective representation in the hydraulic model.

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Table 2.3 Developed Scenario Representation in the hydraulic model

Proposed Design Item	Representation*
Substation, BESS Substation and BESS Plant	2d_zshp region polygon with elevation* above floodplain. Building model roughness.
Operations and Maintenance facility (O&M)	2d_zshp region polygon with elevation* above floodplain. Building model roughness.
Access Roads	Gravel model roughness.
WTG and associated infrastructure	WTG hardstand footprint, with elevation 0.1m above ground, or 1% AEP(whichever is greater). Gravel model roughness. Top of foundation, 6.5m diameter with elevation 0.3m above ground, or 1% AEP +0.5m freeboard (whichever is greater). Building model roughness. Tower, 5.3m diameter, with elevation* above floodplain. Building model roughness.

*10m elevations were adopted to ensure structures extend out of the floodplain, and do not reflect actual heights.

In order to protect assets, the design of buildings, equipment foundations, footings for electrical componentry and WTGs were designed to consider the 1% AEP flood level. As shown in Table 2.3, the elevation for proposed substation, BESS substation and BESS plant, O&M were set to 10m to ensure they are elevated above the floodplain, noting that this does not reflect actual structure heights, but ensures that structures are adequately reflected in the model. All WTG foundations were raised by 0.3m above ground as requested by the client, although no WTGs were found to be located in the 1% flood extent. For WTG hardstand footprints which are located within the 1% AEP flood extent, these were raised to 1% AEP flood level, while those located outside the 1% AEP flood extent were raised by 0.1m.

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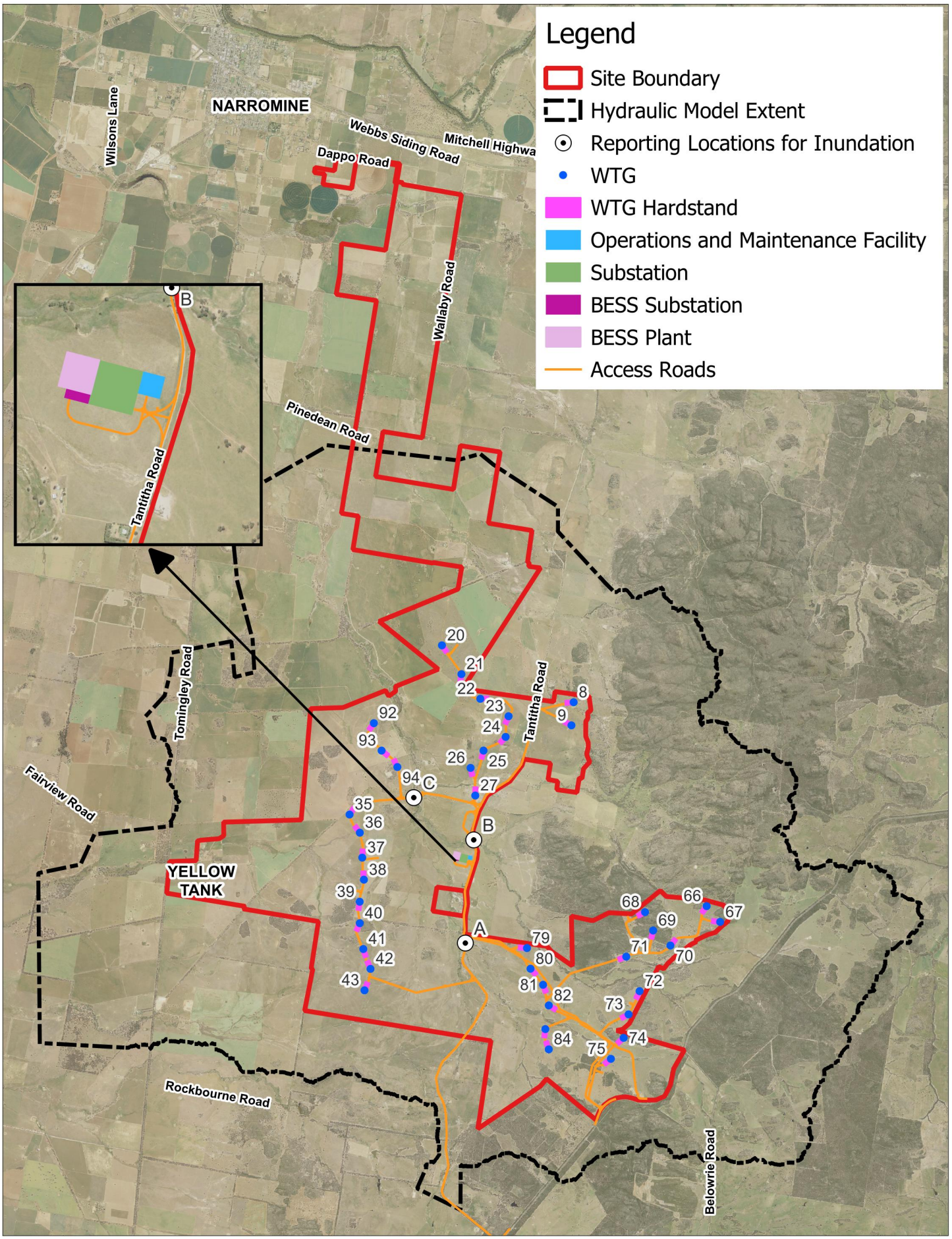

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Proposed Development setup in Hydraulic Model

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3 Results and Discussion

3.1 Comparison to Council Studies

Although there is no Council model which covers the extent of the modelling undertaken as part of this assessment, a summary of how the parameters and approach adopted in this assessment are generally consistent with the closest relevant council flood study (Chapter 2 of Narromine Floodplain Risk Management Study and Plan Update, 2021) is provided as follows:

- Hydrology & FFA
  - Covers a full range of flood events from 5% to 0.2% AEP, consistent with Council study.
  - This study considers the PMF as the representative extreme flood event. In comparison, council's study adopts a flow rate of five times the 1% AEP event as a practical approximation of an extreme flood. The findings of this study indicate that the PMF flow is about six times larger than the 1% AEP flow, suggesting that the two approaches are generally consistent in scale.
  - Follows ARR 2019 guidelines for hydrologic assessments (including losses).
- Hydraulic Modelling
  - Uses TUFLOW modelling.
  - Applies critical storm duration analysis, following ARR 2019 recommendations.
  - Includes 0.5% AEP and 0.2% AEP events as climate change proxies.

Although this assessment and the Council study cover differing extents, it is confirmed that this study is generally consistent with the council study in terms of modelling approach and input data.

3.2 Flood Depths and Levels

Baseline Scenario

The baseline scenario flood levels, depths, velocities and hazards are illustrated in Annex A. Results for the baseline scenario indicate that surface flow hydrodynamics are predominantly influenced by the steep topography, with higher water depths and elevated velocities observed along the main flow paths and defined watercourses. Unlike flatter catchments where storage plays a dominant role, the rapid runoff response in this area is driven by the steep gradients, resulting in more dynamic and concentrated flow behaviour. This is demonstrated by high water depths and velocities observed within flow paths for the 5% AEP up to the PMF (Annex A).

Developed Scenario

Developed scenario results are shown in Annex B. All WTGs are outside of modelled flood extents in the 5%, 1%, 0.5% and 0.2% AEP events. In PMF event, all WTGs except WTG 27, 80 and 81 are also outside of modelled flood extents. The substation and O&M facility are within the modelled flood extents in the 5%, 1%, 0.5%, 0.2% AEP and PMF events. Water reaches a maximum depth of 0.15, 0.17, 0.19, 0.21 and 0.32 m in these events (respectively). The BESS substation and BESS are outside of modelled flood extents in the 5%, 1%, 0.5%, 0.2% AEP and PMF events.

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Flood impacts for all events are provided in Annex C. Within the site boundary, the most significant impacts are observed along the local flowpath in the centre of the site (5%, 1%, 0.5%, 0.2% AEPs and PMF), upstream of proposed Substation and O&M facility and WTG 27. These increases in water level are primarily due to obstructions to flow caused by the proposed substation and O&M facility and hardstand for WTG 27 within the floodplain, and are fully contained within the site.

Flood level increases within the site are summarised as follows (refer Annex C for detailed mapping).

- 5% AEP event: up to +860 mm increase south of proposed O&M facility.
- 1% AEP event: up to +910 mm increase south of proposed O&M facility.
- 0.5% AEP event: up to +980 mm increase south of proposed O&M facility.
- 0.2% AEP event: up to +1000 mm increase south of proposed O&M facility.
- PMF event: up to +1200 mm increase south of proposed O&M facility.

As summarised above, the most notable impacts are observed to be localised around the proposed O&M facility. In all events, no offsite impacts are observed due to the proposed development. It is noted that Austroads (2023) considers impacts of up to 400mm acceptable for open space / forest areas.

Some WTGs are located in areas where flood levels have increased, especially in the centre of the site, during events from the 1% AEP to the PMF. Similarly, proposed Substation and O&M facility in the central part of the site are also within impacted areas. However, these impacts are considered non-detrimental to the proposed WTGs and proposed developments. Furthermore, as the WTGs are located more than 1 km upstream of Tantitha Road, flood levels at this location are unlikely to be affected by the presence or absence of culverts at Tantitha Road.

Flood level decreases within the site are summarised as follows (refer Annex C for detailed mapping):

- 5% AEP event: up to -200 mm reduction west of hardstand for WTG27.
- 1% AEP event: up to -220 mm reduction west of hardstand for WTG27.
- 0.5% AEP event: up to -240 mm reduction west of hardstand for WTG27.
- 0.2% AEP event: up to -460 mm reduction west of hardstand for WTG27.
- PMF event: up to -350 mm reduction west of hardstand for WTG27.

3.3 Flood Velocities

Flood velocities in both baseline and developed scenarios for the events from the 5% AEP up to PMF event show that there is fast moving water in Wallaby Creek and it's upstream tributaries such as Jacks Creek, Hawkes Creek, Bundara Creek, Ugumjil Creek and Rays Creek (between 3 and 5.2 m/s). The reason for fast velocities is understood to be the steep slope in the catchment. As such, it is expected that there may be significant erosion in the river banks, destruction of riparian vegetation or reduction in the stability of river banks or watercourses during major flood events. No significant changes to velocity are expected outside the site as a result of the proposed development, as indicated by pre and post velocity maps presented in this report. Within the site, minimal reductions in velocity (up to 1 m/s) are observed in areas west of the hardstand for WTG 27, located at the centre of the Site.

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3.4 Flood Hazards

Flood hazard for the Project site and surrounding floodplain has been defined based on the composite six-tiered hazard classification in the 'Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia' (AIDR, 2017) and reproduced in Figure 3.1. These hazard classifications are based on adopted thresholds of flood depth, velocity and velocity-depth product that identify when flood conditions are likely to present a risk to people, vehicles and buildings. A description of each hazard threshold is provided in Table 3.1.

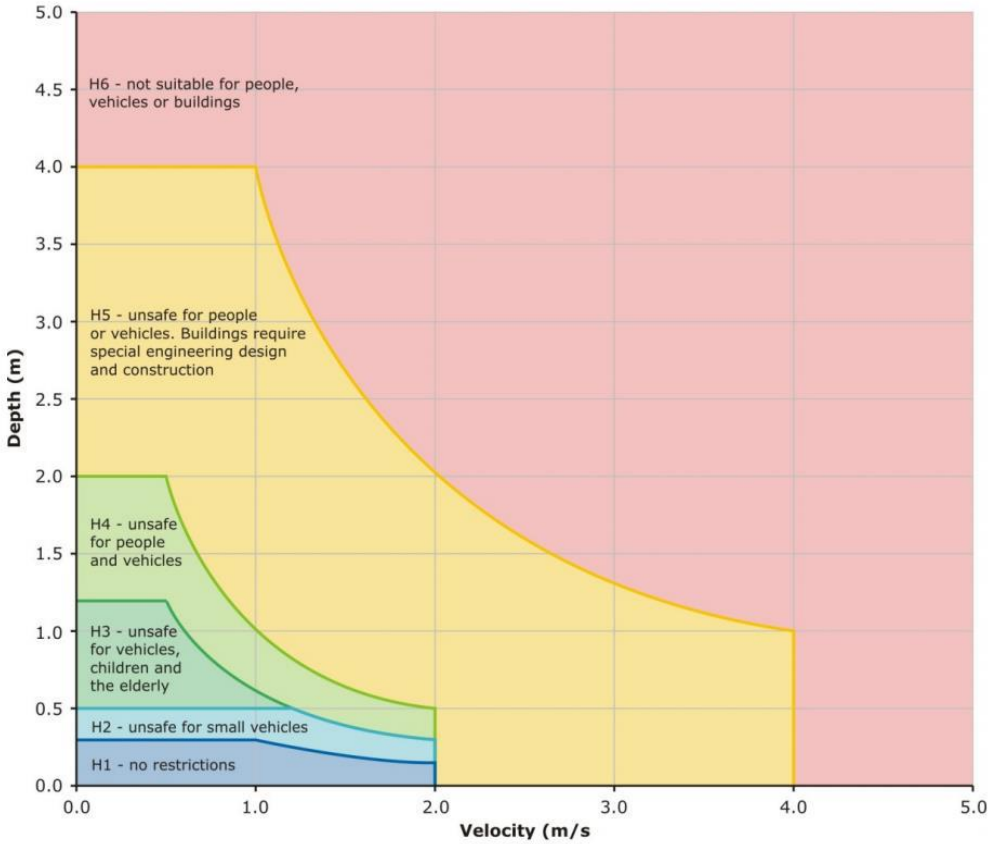

Figure 3.1 Flood Hazard Curves (AIDR, 2017)

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Table 3.1 Flood Hazard Classification Thresholds (AIDR, 2017)

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 types considered vulnerable to failure.

Baseline and developed scenario results (shown in Annex A and Annex B) for events from 5% AEP to PMF show that there are relatively high hazards in most areas along Wallaby Creek and its main tributaries (Hazard Category H4, H5 and H6) within the site. However, lower hazard levels (up to H3) are observed in along the local flowpaths within the site.

The proposed WTGs are in low hazard areas (H1) for events from the 5% AEP to PMF. No significant changes to hazard are expected within or outside of the site as a result of the proposal, as indicated by pre and post hazard maps presented in this report. Some minimal changes to hazard conditions occur due to due to increased water depth (flowpath blockage) upstream of proposed substation and O&M facility and WTG 27, which are shown to cause non-detrimental changes to hazard conditions. Flood hazards and their extents are considered generally compatible with the proposal.

3.5 Flood Planning Area

Flood Planning Levels (FPLs) are typically derived by adding a freeboard to a specific design flood level, with this specific design flood frequently referred to as the “planning” flood. The FPL can be applied directly to topographic data to determine the extent of the Flood Planning Area (FPA), which was determined in this assessment as requested by the SEARs.

The FPA has been derived based on the 1% AEP flood level plus 0.5 m freeboard. The freeboard was applied to the peak 1% AEP flood level results from the TUFLOW modelling and the resultant flood surface was laterally extended until it intersected with the ground surface to develop the FPA for the study area (Annex D).

3.6 Hydraulic Categories

Flood function categories (also referred to as hydraulic categories) defined in ‘Flood Function: Flood Risk Management Guide FB02’ (DPE, 2023) are as follows:

- **Floodway**: Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.

- **Flood Storage**: Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1 m and/or would cause the peak discharge to increase by more than 10%.

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- **Flood Fringe**: Remaining area of flood prone land, after floodway and flood storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

For this assessment, hydraulic categorisation was determined according to the combination of flood depths, velocities and velocity-depth product (VxD), as shown in Table 3.2.

Table 3.2 Flood Categorisation Criteria

Classification	Criteria	Description
Floodway	[VxD > 0.25 m²/s AND Velocity > 0.25 m/s] OR [Velocity > 1.0 m/s]	Areas and flow paths where a significant proportion of floodwaters are conveyed (including all bank-to-bank creek sections).
Flood Storage	Area outside floodway where depth > 0.5 m	Areas where floodwaters accumulate before being conveyed downstream. These areas are important for detention and attenuation of flood peaks.
Flood Fringe	Remaining flood extent	Areas that are low-velocity backwaters within the floodplain. Filling of these areas generally has little consequence to overall flood behaviour.

As requested by the SEARs (and following the above criteria), pre and post flood function maps for the site are shown in Annex D based on the 1% AEP event. Due to the fast moving water in the catchment, it is observed that the areas along the Wallaby Creek and its main tributaries are mostly comprised of Floodway category. Other flood plain areas along the local flowpaths compromised of Flood Fringe category. Some small areas compromised of Flood Storage category within the site. No significant changes to flood function are expected as a result of the proposal, as indicated by pre and post flood function maps presented in Annex D. Flood functions and their extents are considered generally compatible with the proposal.

3.7 Climate Change

As requested by the SEARs, the 0.5% and 0.2% AEP flood events have been modelled as proxies for increased rainfall intensity in a 1% AEP due to climate change. As would be expected, results indicate an increase in flood depths and extents for the proxies modelled. A corresponding increase in flood hazard is also observed, although no significant increase in flood velocity is expected in the climate change scenarios modelled.

3.8 Emergency Management

Based on results outlined, the proposal is not expected to impact the existing emergency management arrangements for flooding, as outlined in the Narromine Floodplain Risk Management Study and Plan. As indicated in the hazard maps derived for this assessment, the site is generally subjected to hazards of up to H3 along the local flowpaths from 5% AEP to PMF, while, in areas along the main defined watercourses, exhibit higher hazards (between H4 and H6). Access throughout the site would be considered limited for events greater than 5% AEP due to these hazards. The risk of isolation during significant flood events requires mitigation through appropriate emergency management, including the preparation and implementation of a site Emergency Response Plan.

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It is proposed that the NSW Hazards Near Me app is monitored for warnings of extreme weather. This includes severe weather warnings and severe thunderstorm warnings issued by the BoM and which may include warnings for possible flooding. These warnings are also disseminated via various media outlets and are available of the BoM website. In the event of a local warning advising of the potential for flooding it is recommended that the site is closed and evacuated.

Given the small catchment area upstream of the site, the time of concentration (i.e. time taken for rainfall to generate runoff at the site) is relatively short. This is reflected in the critical durations determined in this assessment (Table 2.2) which range from less than 1 hour (45 min) to 4.5 hours (270 min). Therefore, there may be limited time for staff to evacuate once a major event is identified. It is recommended that the site remain closed until floodwaters have sufficiently receded and safe access restored. All site staff should be made aware of the potential flood risk during site induction. In the event of site closure, a safety bulletin should be sent to all workers via SMS. A staff member should be nominated to the role of chief flood warden, and ensure that the Site is fully evacuated in the event of a site closure.

In order to provide some indication of how long the site may be inundated during a major flood event, an analysis was conducted for selected sections along the internal access road connecting the Newell Highway to the substation building. Figure 3.2, Figure 3.3, and Figure 3.4 illustrate flood levels during the TUFLOW simulation time (0 to 24 hours) at three locations along the access road. Specifically:

- Location “A” – Located on site access road (Tantitha Road), between site entry on Newell Highway and Substation building, across the Bundara Creek.
- Location “B” – Located on site access road (Tantitha Road), after the Substation building, across the Ugumjil Creek.
- Location “C” – Located on internal access road across the Wallaby Creek.

These results from selected locations (refer Figure 2.4) are considered broadly indicative of the inundation durations across the site. At locations A and B, no culverts were included in the model, which may result in uncertainty in the estimated inundation times. Additionally, at location C, there is no existing road, so the topography reflects the natural ground level (i.e., the bed level of the watercourse). For each location and modelled event, the inundation start time, end time and duration are summarised in Table 3.3, Table 3.4 and Table 3.5 (respectively).

As shown in Figure 3.2 and Figure 3.3, site access road remains flooded for approximately up to 9 hours in all design events. However, the internal access roads (Figure 3.4) remain flooded for a longer duration, approximately 24 to 36 hours. Based on approximate extrapolation of these outputs, it is estimated that internal roads may remain flooded for up to 36 hours (1.5 days) in all events. This is primarily due to the extended time it takes for water to travel from the upstream areas to the site. It is also noted that estimates are indicative only, given limitations associated with model run times and uncertainly associated with extrapolation. Estimates are also subject to assumptions surrounding infiltration rates, while evaporation is not accounted for within the flood model.

A general summary of outcomes with respect to depth and duration of inundation on internal access roads is provided as follows:

- At locations A and B along the site access road (Tantitha Road), overtopping may occur for up to approximately 9 hours during all design events. At location A, water depths may reach up to 0.05 m in the 5% AEP event and up to 0.6 m in events greater than the 5% AEP. At location B, water depths may reach up to 1.29 m in the 5% AEP event and up to 3.7 m in events greater than the 5% AEP.

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- At location C along the internal access road, overtopping may occur for over 24 hours, and up to 36 hours during all design events. Water depths may reach up to 2m in the 5% AEP event and up to 5.3m in events greater than 5% AEP. As noted above, at location C, there is no existing road, so the topography reflects the natural ground level.

Access roads with flood depths of up to 0.3 m and velocities below 2 m/s are assumed safe and trafficable. These conditions correspond to hazard category H1, as per Figure 3.1. A general summary of outcomes with respect to the trafficability of internal access roads is provided as follows:

- The maximum velocity observed across access roads is up to 4 m/s for events from 5% to 0.2% AEP. In PMF, the maximum velocity is up to 5.2 m/s.
- As shown in Figure 3.3 and Figure 3.4, flood depths along the site access road in location B and the internal access road in location C exceed the 0.3 m threshold in all events, while Location A is trafficable in all design events except PMF.
- The site access road at location B, in the centre of the site, is not trafficable up to 10 hours after the start of the event during all design events.
- The internal access road at location C is not trafficable up to 24 hours after the start of the event during all design events.

Table 3.3 Inundation start time (hours) at three selected locations along access roads

Location	5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
“A”	3.5	2.5	2	1.5	0.5
“B”	2	1.5	1	1	0.3
“C”	1	0.6	0.3	0	0.3

Table 3.4 Inundation end time (hours) at three selected locations along access roads

Location	5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
“A”	5.5	5	4.5	4	6
“B”	10	9.5	8	7.5	9.3
“C”	> 24	> 24	> 24	> 24	>24

Table 3.5 Duration of inundation (hours) at three selected locations along access roads

Location	5% AEP	1% AEP	0.5% AEP	0.2% AEP	PMF
“A”	2	2.5	2.5	2.5	5.5
“B”	8	8	7	6.5	9
“C”	<36	<36	<36	<36	<36

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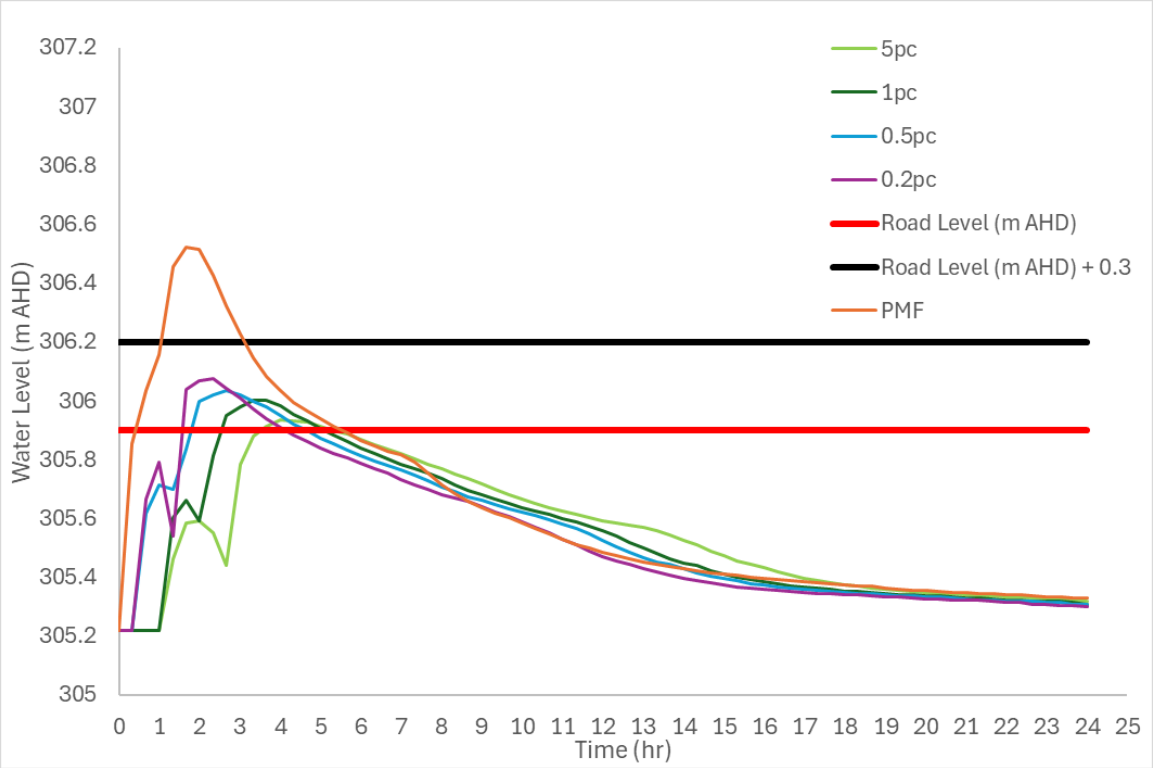

Figure 3.2 Inundation time along the site access road (Tantitha Road) in the centre of the site (Location “A”).

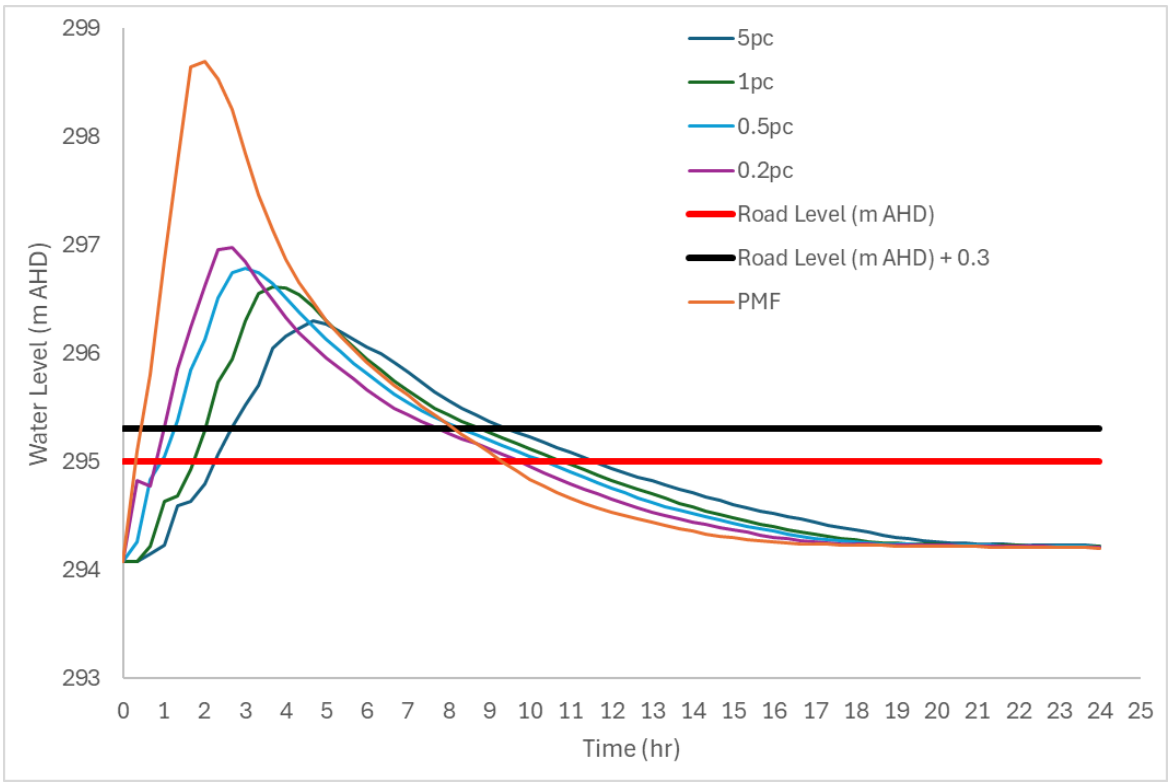

Figure 3.3 Inundation time along the site access road (Tantitha Road) in the centre of the site (Location “B”).

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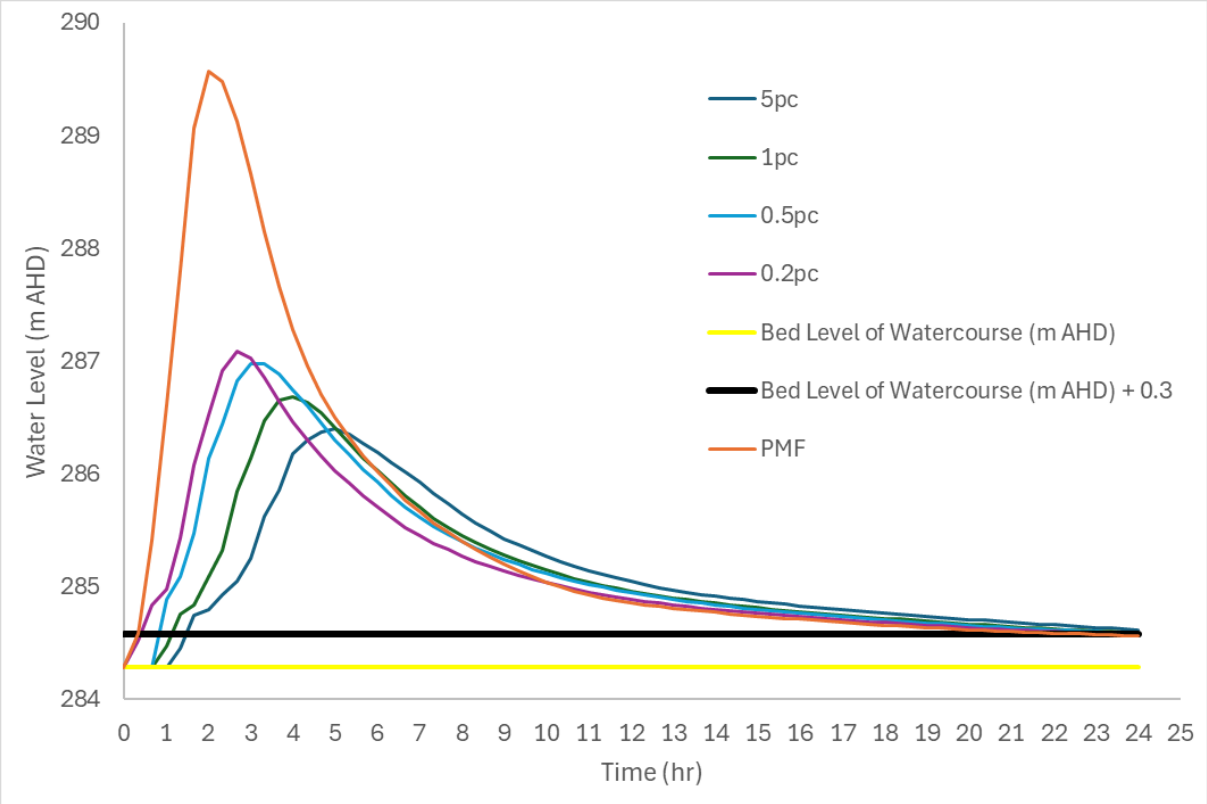

Figure 3.4 Inundation time along the internal access road in the centre of the site (Location “C”).

3.9 SEARs Responses

Project specific requirements were received in a letter from BCS dated 24 July 2023, with those relevant to flood risk management and how they have been addressed summarised in Table 3.6.

Table 3.6 Response to BCS requirements

SEAR	Response
10. The EIS needs to map the following features relevant to flooding as described in the Flood Risk Management Manual 2023 (DPE 2023) including: a Flood Prone Land. b Flood Planning area, the area below the flood planning level. c Hydraulic categorisation (floodways and flood storages). d Flood hazard.	Relevant flood maps are provided in Annexes of this report.
11. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5% Annual Exceedance Probability (AEP), 1% AEP, flood levels and the probable maximum flood, or an equivalent extreme event.	Flood assessment approach is described in Section 2 of this report. In summary, the flood assessment has been undertaken in accordance with Australian Rainfall and Runoff 2019 (ARR 2019) data and methodology to establish existing (baseline) and post-development flood behaviour for the Project

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SEAR	Response
	site. Events assessed include the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF.
12. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios: a. Current flood behaviour for a range of design events as identified in 14 above. This includes the 0.5% and 0.2% AEP year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Flood impacts have been estimated for the 5% AEP, 1% AEP and PMF events , in addition to the 0.5% AEP and 0.2% AEP events as proxies for climate change (refer Section 2).
13. Modelling in the EIS must consider and document: a Existing council flood studies in the area and examine consistency to the flood behaviour documented in these studies; b The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood, or an equivalent extreme flood; c Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazard categories and hydraulic categories; d Relevant provisions of the NSW Floodplain Development Manual 2005.	a This study is consistent with Chapter 2 of Narromine Floodplain Risk Management Study and Plan Update, 2021, in their use of data and modelling approaches. b Flood impacts have been estimated for all requested design storm events, refer to Section 3. Any changes to flood extents, velocities, levels, hazards and hydraulic categories are highlighted in baseline and developed scenario maps, and discussed in Section 3. In summary, no offsite impacts are observed due to inclusion of the proposed developments in all events. c In all events, no offsite impacts are observed due to inclusion of the proposed developments. Additionally, the impacts within the site are considered non-detrimental to the proposed WTGs and developments. d All related provisions in the NSW Floodplain Development Manual 2005 have been considered in this assessment.
14. The EIS must assess the impacts on the proposed development on flood behaviour, including: a Whether there will be detrimental increases in the potential flood affectation of other properties, assets, and infrastructure; b Consistency with Council floodplain risk management plans; c Consistency with any Rural Floodplain Management Plans; d Compatibility with the flood hazard of the land; e Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land; f Whether there will be adverse effect to beneficial inundation of the floodplain	a The proposal does not result in detrimental increases to flood affection of other properties as discussed in Section 3. b There are no Council Floodplain Risk Management Plans in the study area. c There are no Rural Floodplain Management Plans in the study area. d Flood hazards and their extents are considered generally compatible with the proposal as indicated in mapping provided. In summary, the proposed developments and WTGs are located in low hazard areas (H1) for events from the 5% AEP to PMF, refer to Section 3.4. No significant changes to hazard are expected within or outside the site, as shown by the pre- and post-hazard maps.

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SEAR	Response
environment, on, adjacent to or downstream of the site; g Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses; h Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the NSW SES and Council; i Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the NSW SES and Council; j Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the NSW SES; k Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	e Hydraulic functions and their extents are considered generally compatible with the proposal as indicated in mapping provided. In summary, the site consists of Floodway and Flood Fringe categories due to fast-moving water in the catchment. No significant changes to flood function are expected as a result of the proposal, as shown by the pre- and post-flood function maps. f The proposal does not result in detrimental increases to flood affection outside the site as discussed in Section 3.2. g No significant changes to velocity are observed, therefore no increases to erosion, siltation, or bank instability are expected. h Existing community emergency management arrangements are not impacted by the proposal as discussed in Section 3.8. i Recommended emergency management measures are discussed in Section 3.8. Council / SES are to be contacted during the preparation of the site Emergency Response Plan. j As above. k Based on the non-detrimental nature of estimated impacts, no social or economic impacts are expected as a consequence of flooding.

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4 Conclusions & Recommendations

A hydrology and flooding assessment has been undertaken for the proposed Wallaby Creek Wind Farm Project located approximately 22km south of the town of Narromine. The following key observations are noted in terms of flood risk to the site:

- This assessment is generally consistent with the closest relevant council flood study (Chapter 2, Updated Flood Study, Narromine Floodplain Risk Management Study and Plan Update, 2021) in terms of modelling approach and input data.
- Baseline scenario results indicate that surface flow hydrodynamics are predominantly influenced by the steep topography, with higher water depths and elevated velocities observed along the main flow paths and defined watercourses. No significant changes to velocity are expected outside the site as a result of the proposed development. There is minimal reduction in velocity (up to 1 m/s) due to flow obstruction caused by the proposed hardstand for WTG 27 at the centre of the Site.
- Given that no significant changes to velocity are observed, no increases to erosion, siltation, or bank instability are expected.
- The proposed developments including Substation, BESS Substation, BESS Plant, Operations and Maintenance facility and all WTGs achieve 1% AEP flood immunity. However, the internal access roads and hardstand for WTG 27 do not achieve 1% AEP flood immunity.
- All WTGs are outside the modelled flood extents for the 5%, 1%, 0.5% and 0.2% AEP events. In PMF, all WTGs except WTG 27, 80 and 81, are also outside the modelled flood extents.
- In events from 5% AEP to PMF, high hazards (Hazard Category H4 to H6) are observed in areas within the site affected by Wallaby Creek and its main tributaries, except for areas along the local flowpaths within the site which exhibit low hazards (H1 to H3).
- The site mostly consists of floodway (along the main defined watercourses) and flood fringe (along the local flowpaths) categories due to fast-moving water, and the proposal is not expected to cause significant changes to flood function. Flood functions and their extents are considered generally compatible with the proposal.
- Modelling of the 0.5% and 0.2% AEP events as proxies for increased rainfall intensity in a 1% AEP due to climate change shows increased flood depths, extents, velocities and hazard.
- For all modelled events, no flood impacts are observed outside the site. Impacts within the site are considered non-detrimental to the proposed WTGs and developments.
- Emergency management measures may be required to mitigate risks associated with access or isolation during flood events.
- In general, main site access road (Tantitha Road), specifically centre of the site across Ugumjil Creek, is not trafficable during all flood events. It is estimated that main access roads will not be trafficable from approximately 0.5 hour to 10 hours after the start of all events. In addition, the internal access road, specifically centre of the site across Wallaby Creek, will not be trafficable for up to 24 hours after the start of all events.

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- Based on this assessment, the following recommendations are suggested:
  - Consider the outcomes of this hydrology and flooding assessment during subsequent design phases, including the incorporation of any design refinements into updated modelling as necessary, to ensure hydrology and flooding outcomes remain suitable.
  - Prepare and implement a site Emergency Response Plan in consultation with Council and the NSW SES.

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Annex A Baseline Scenario Flood Maps

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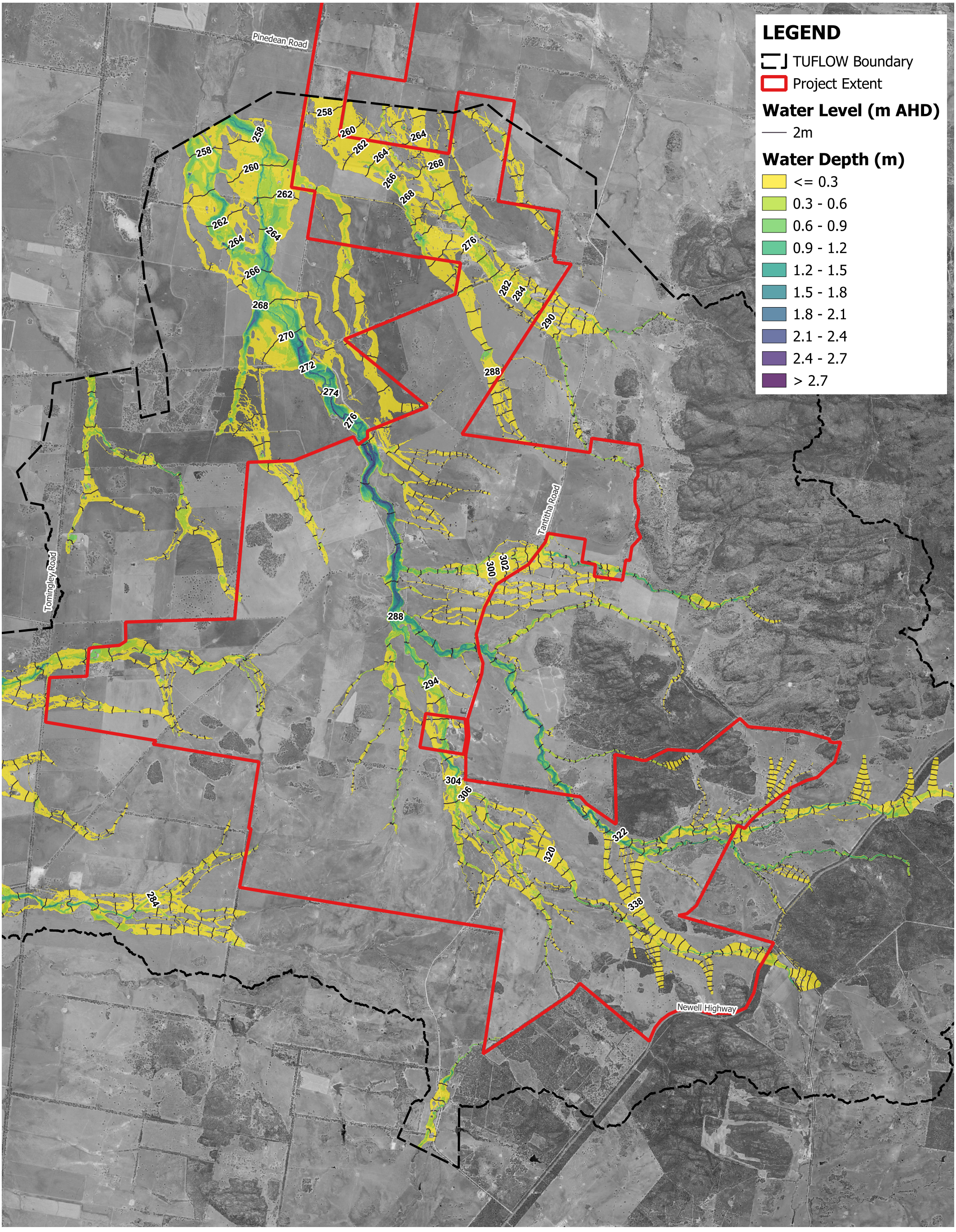

Title:

Baseline Scenario - 5% AEP Peak Flood Levels and Depths

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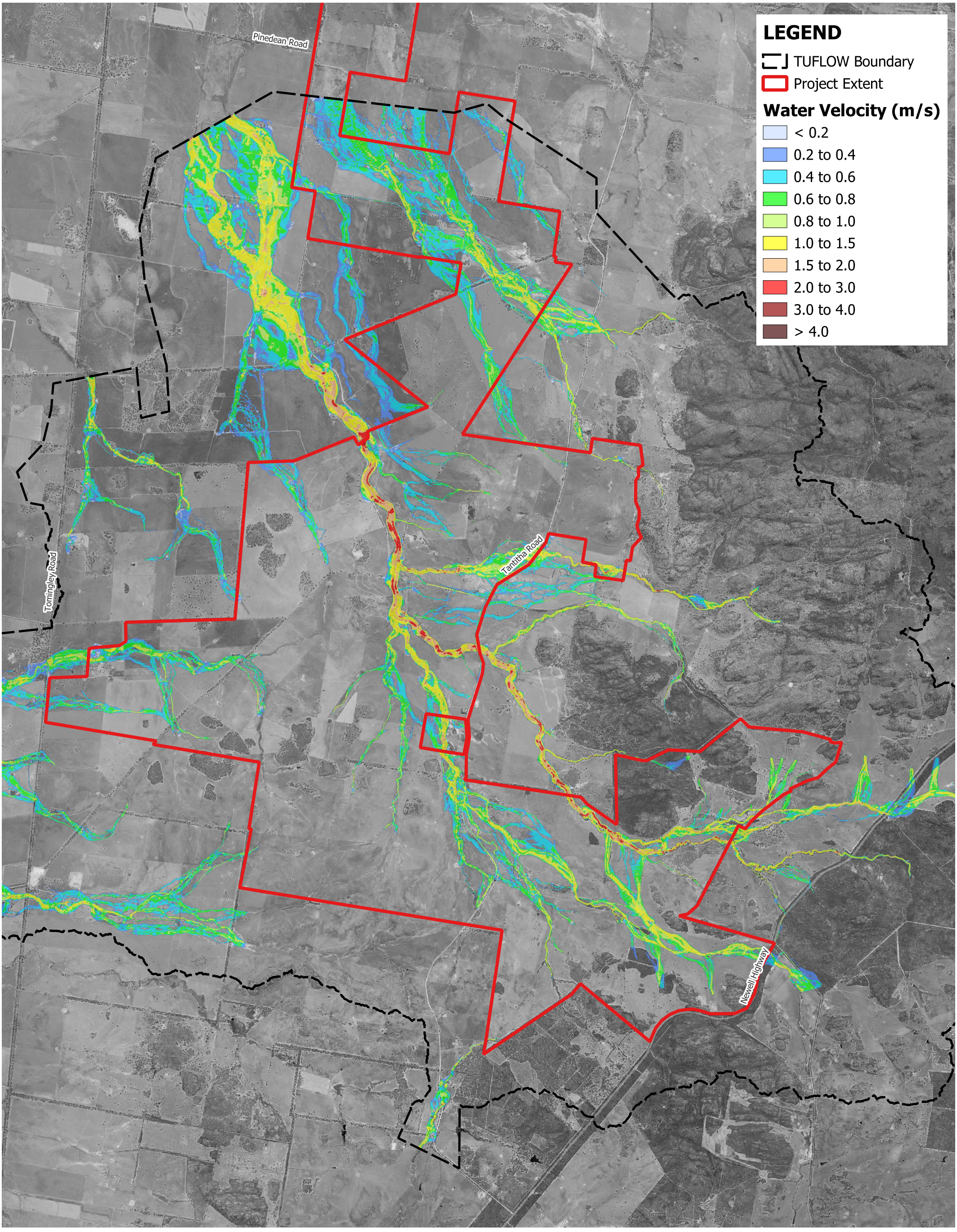

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Baseline Scenario - 5% AEP Peak Velocity

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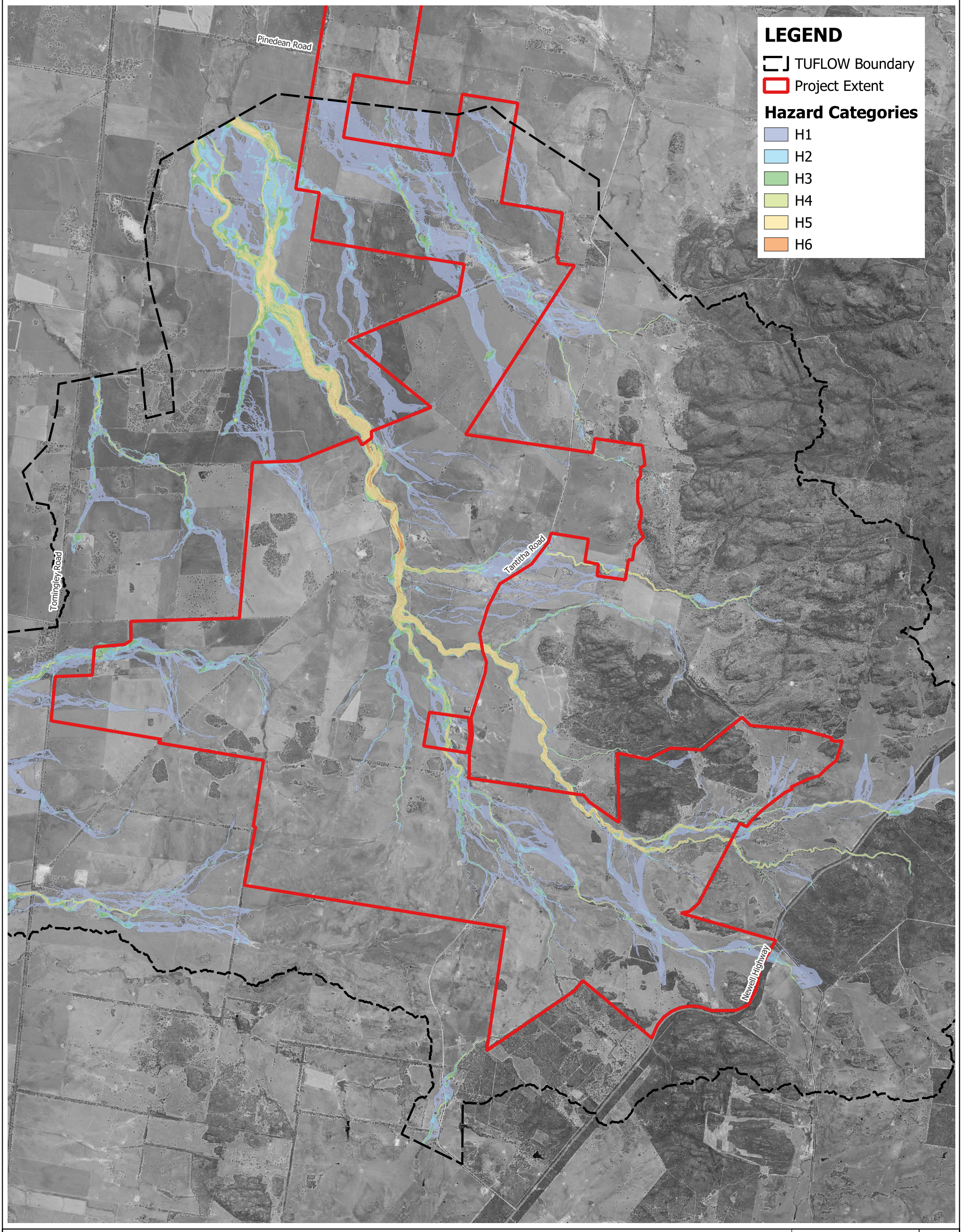

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Baseline Scenario - 5% AEP Peak Hazard Conditions

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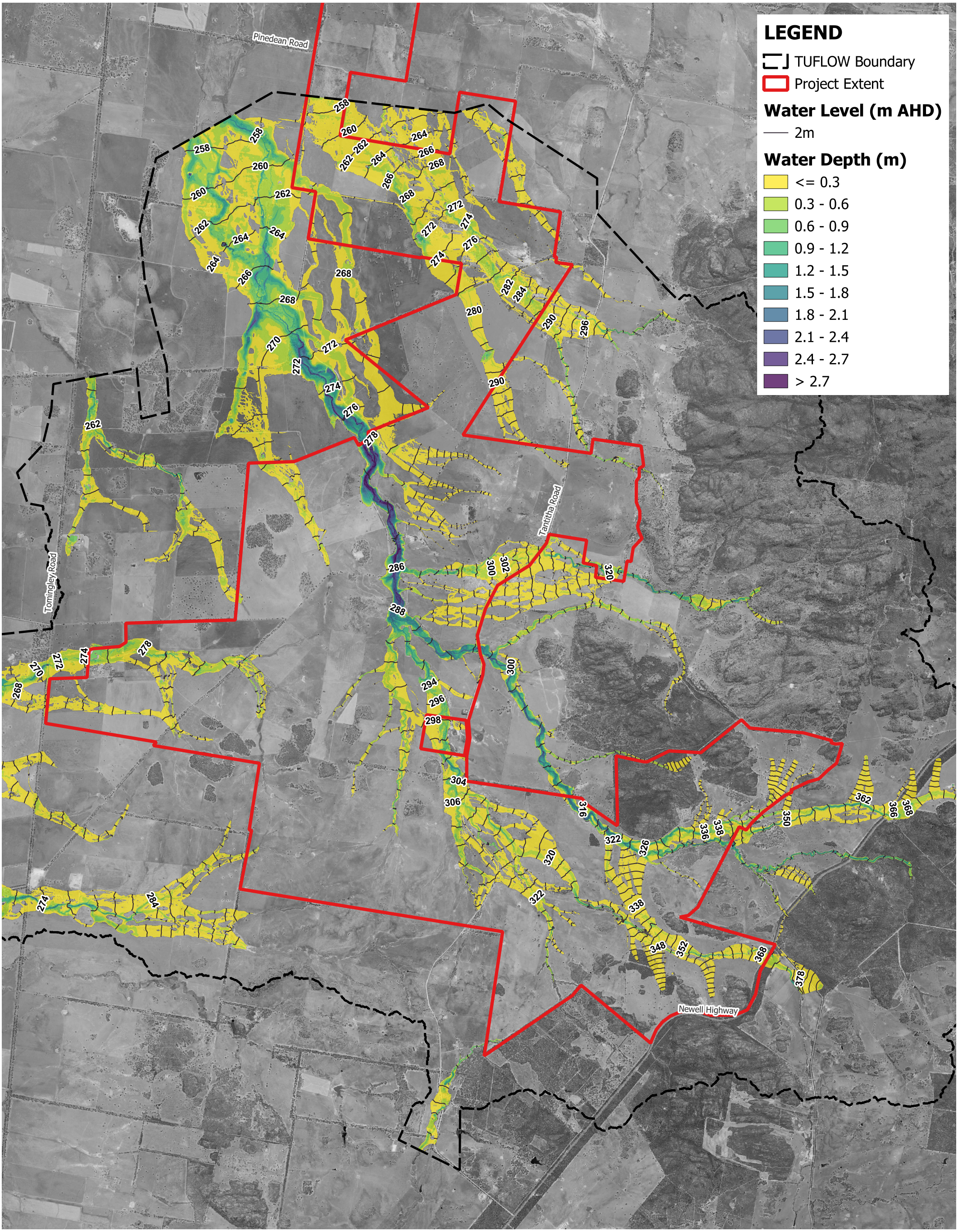

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Baseline Scenario - 1% AEP Peak Flood Levels and Depths

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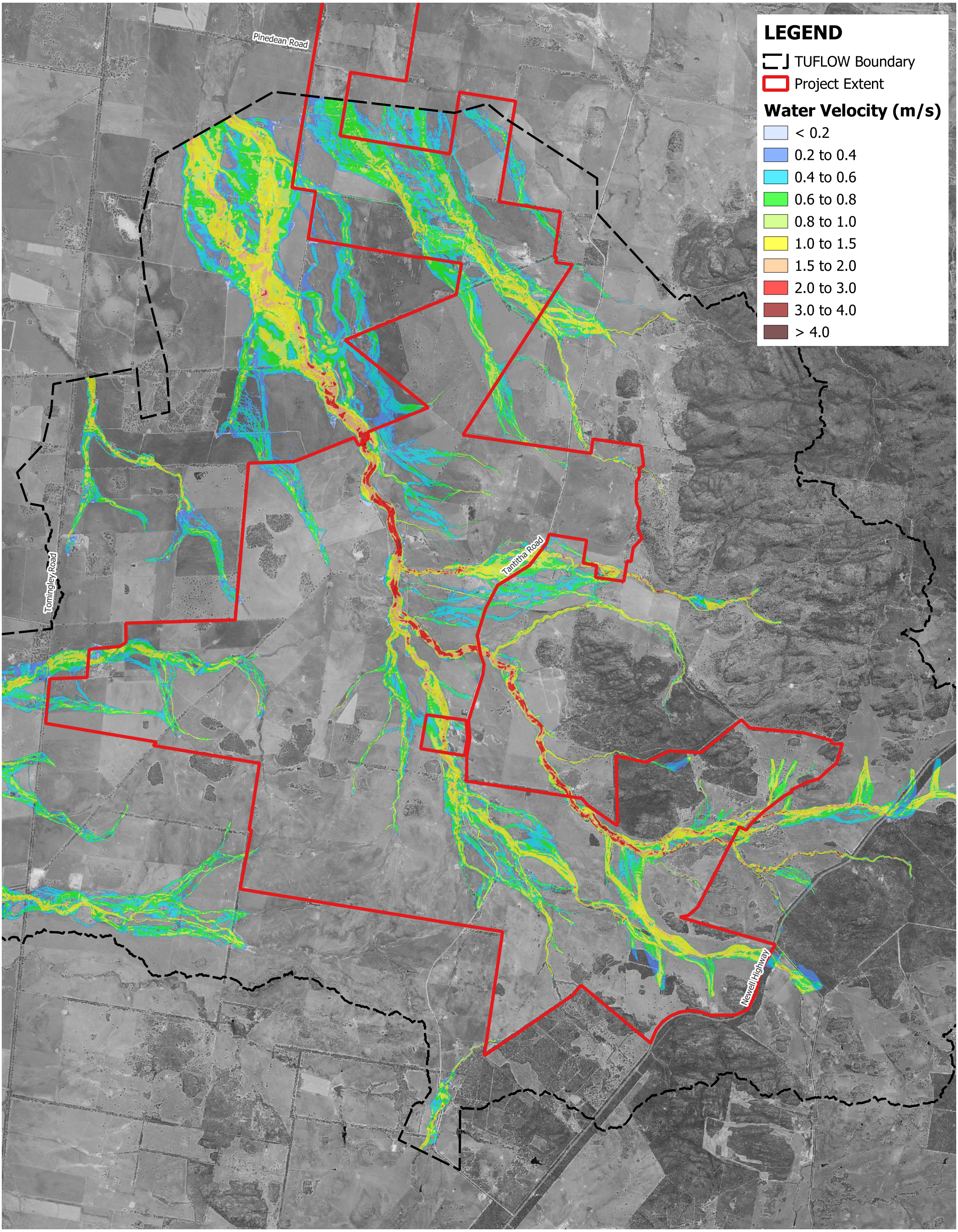

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Baseline Scenario - 1% AEP Peak Velocity

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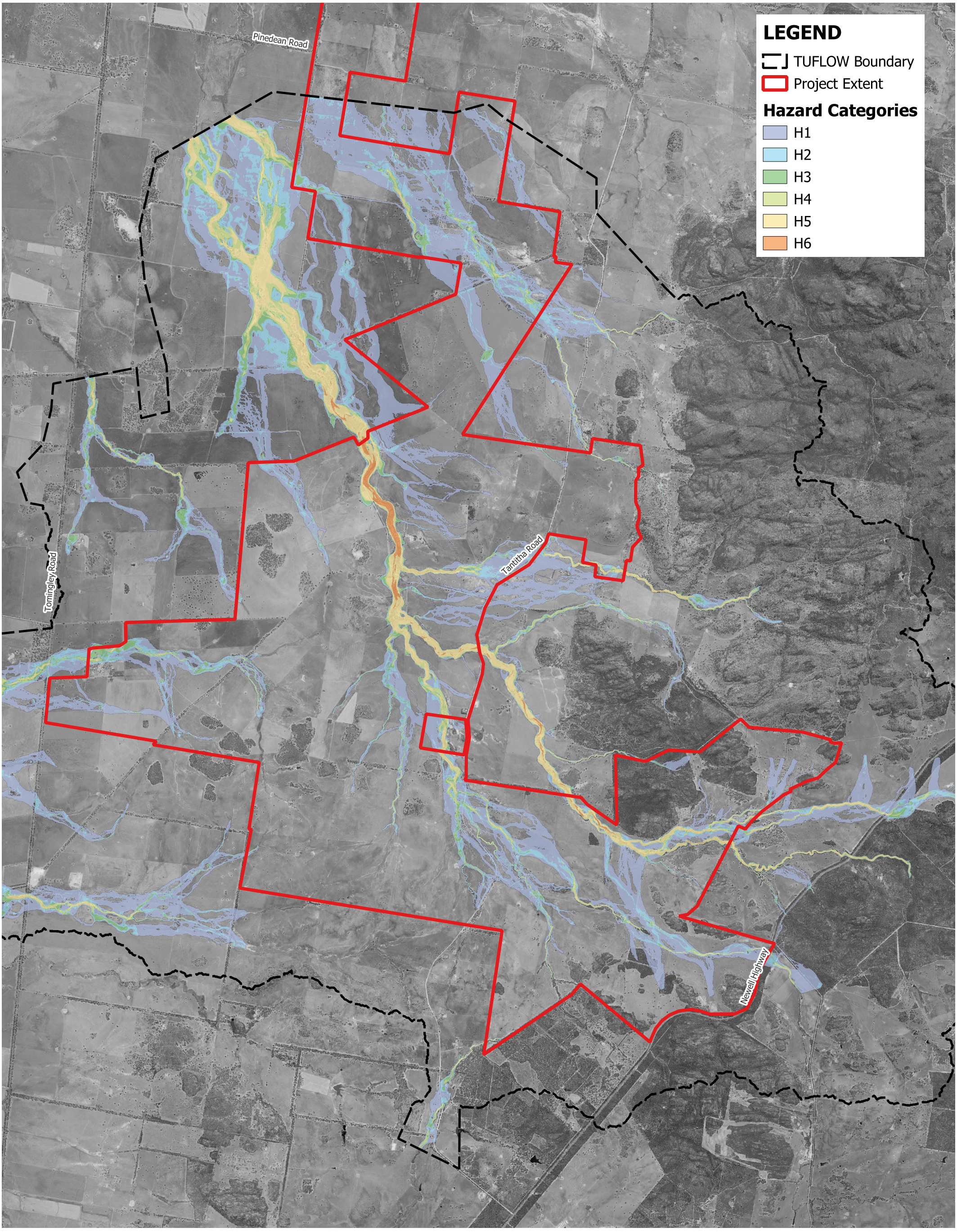

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Baseline Scenario - 1% AEP Peak Hazard Conditions

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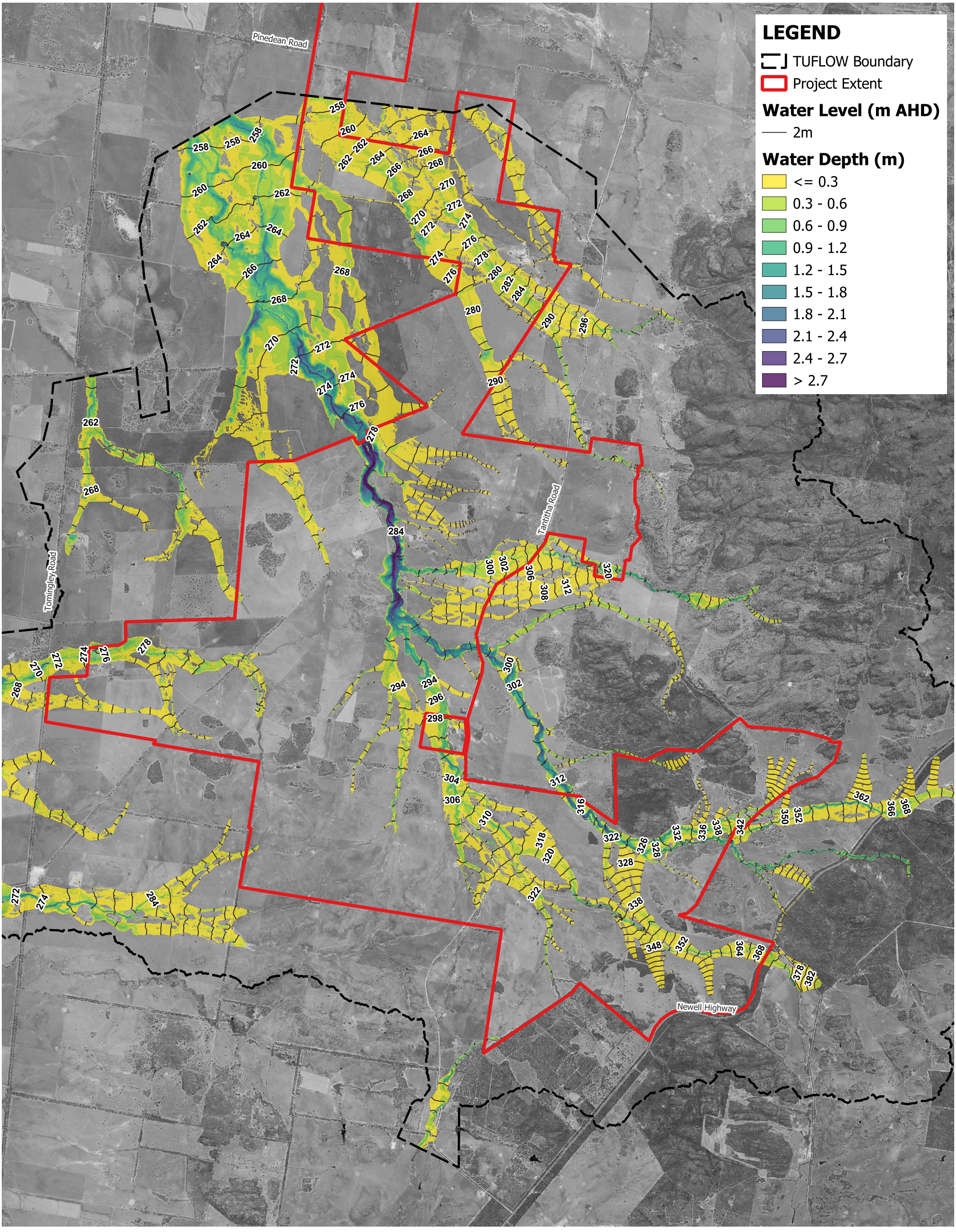

Title:

Baseline Scenario - 0.5% AEP Peak Flood Levels and Depths

Figure: A.7

Rev: A

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N

0 1,400 2,800 m

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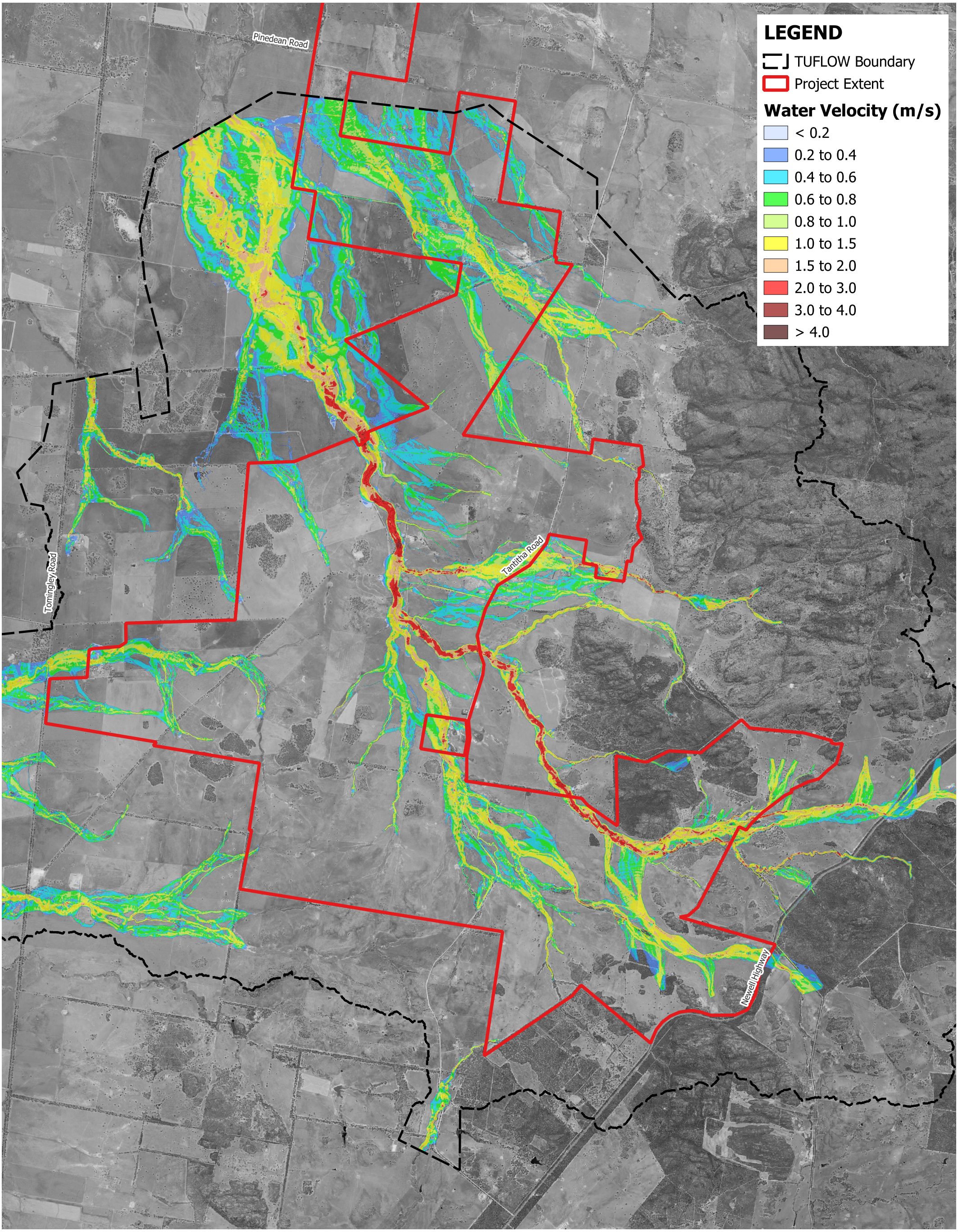

Title:

Baseline Scenario - 0.5% AEP Peak Velocity

Figure: A.8

Rev: A

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N

0 1,400 2,800 m

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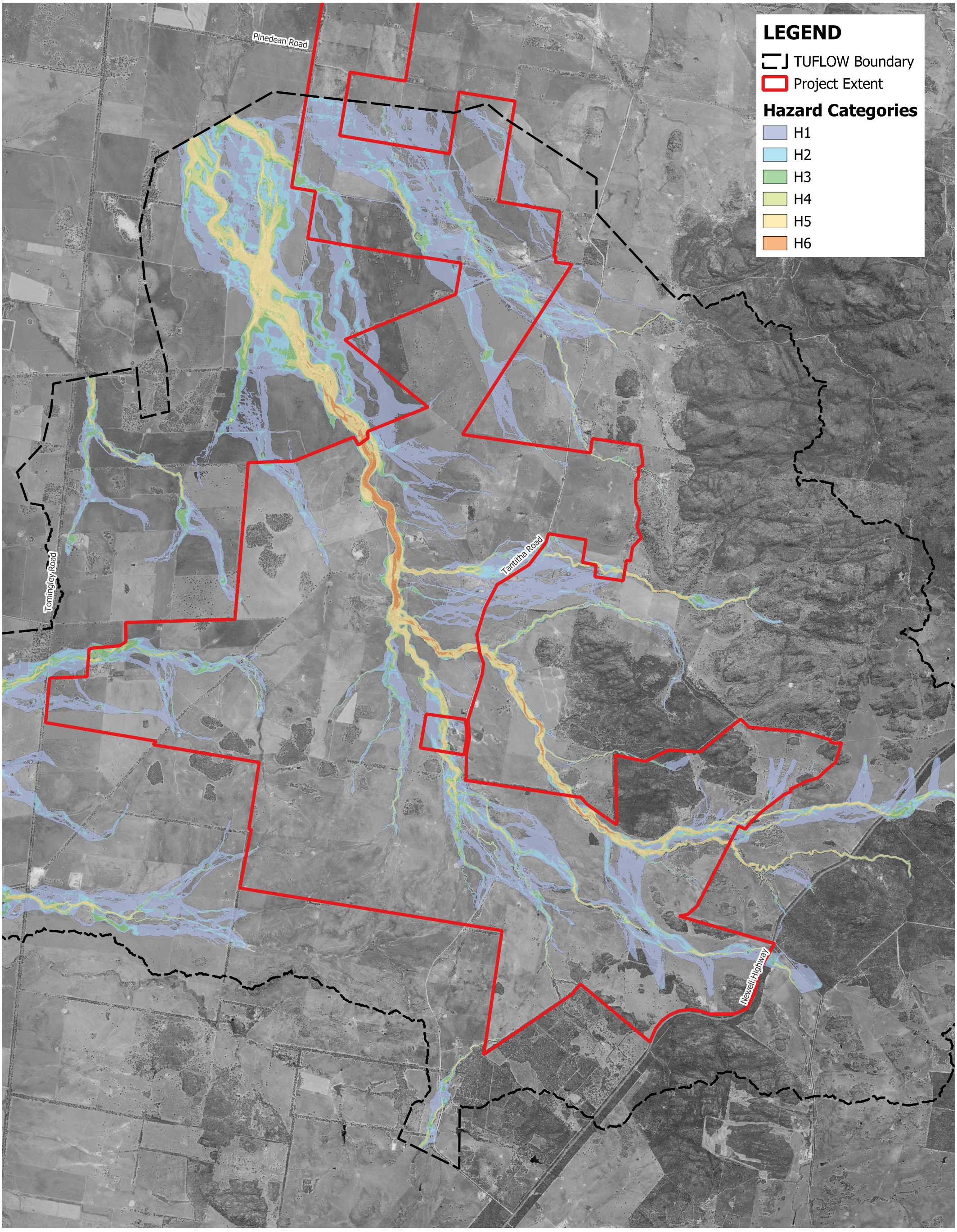

Title:

Baseline Scenario - 0.5% AEP Peak Hazard Conditions

Figure: A.9

Rev: A

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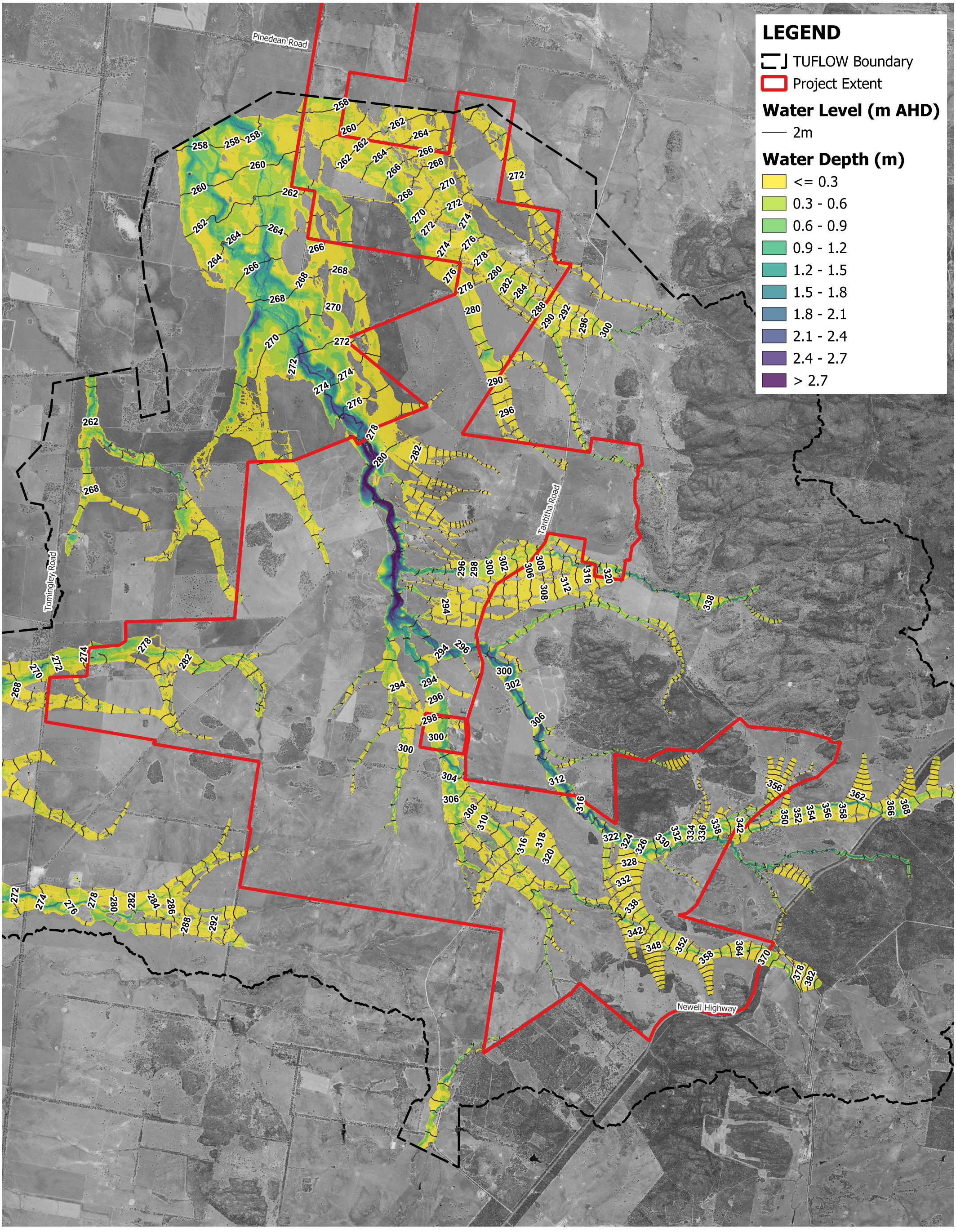

Title:

Baseline Scenario - 0.2% AEP Peak Flood Levels and Depths

Figure: A.10

Rev: A

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N

0 1,400 2,800 m

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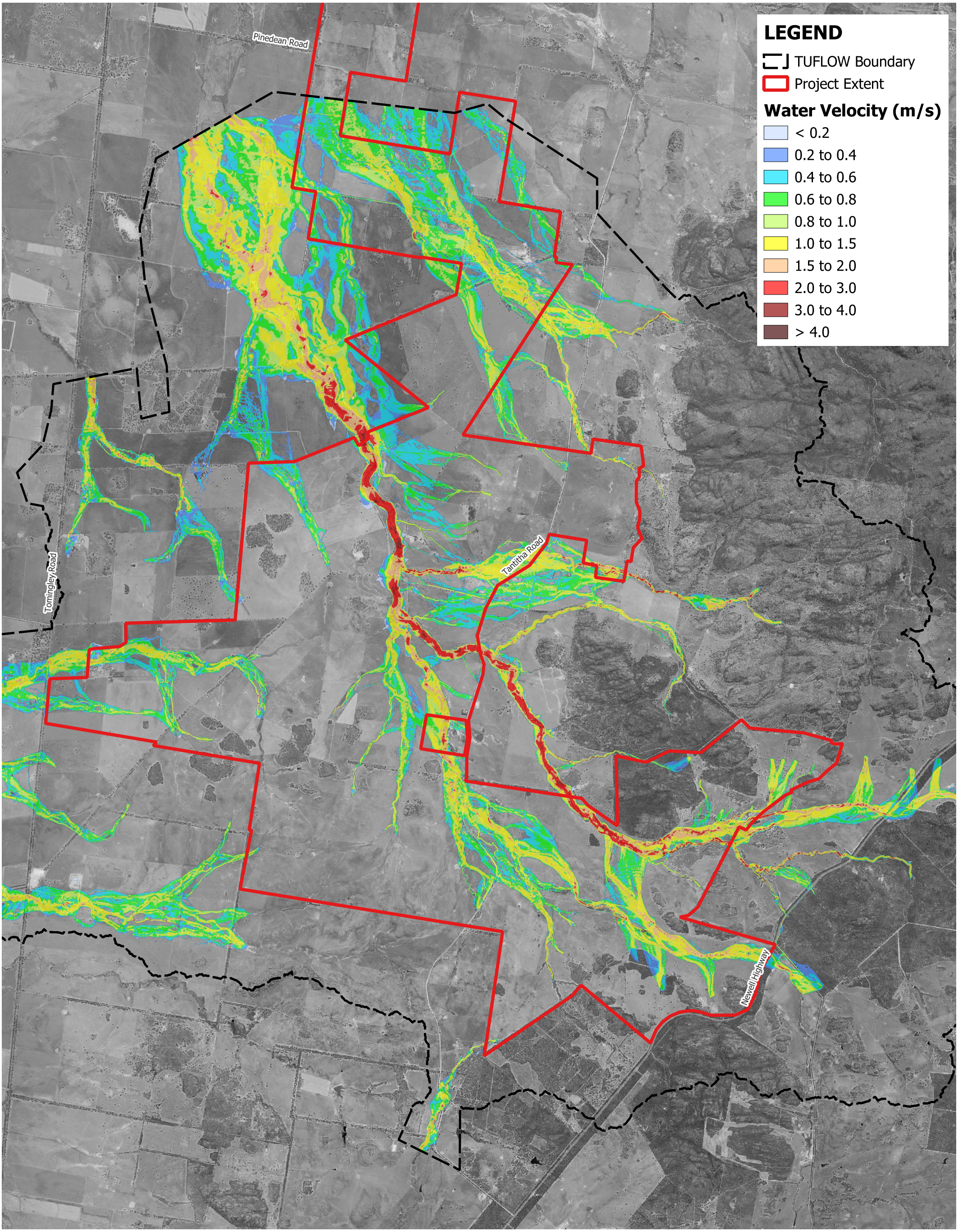

Title:

Baseline Scenario - 0.2% AEP Peak Velocity

Figure: A.11

Rev: A

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N

0 1,400 2,800 m

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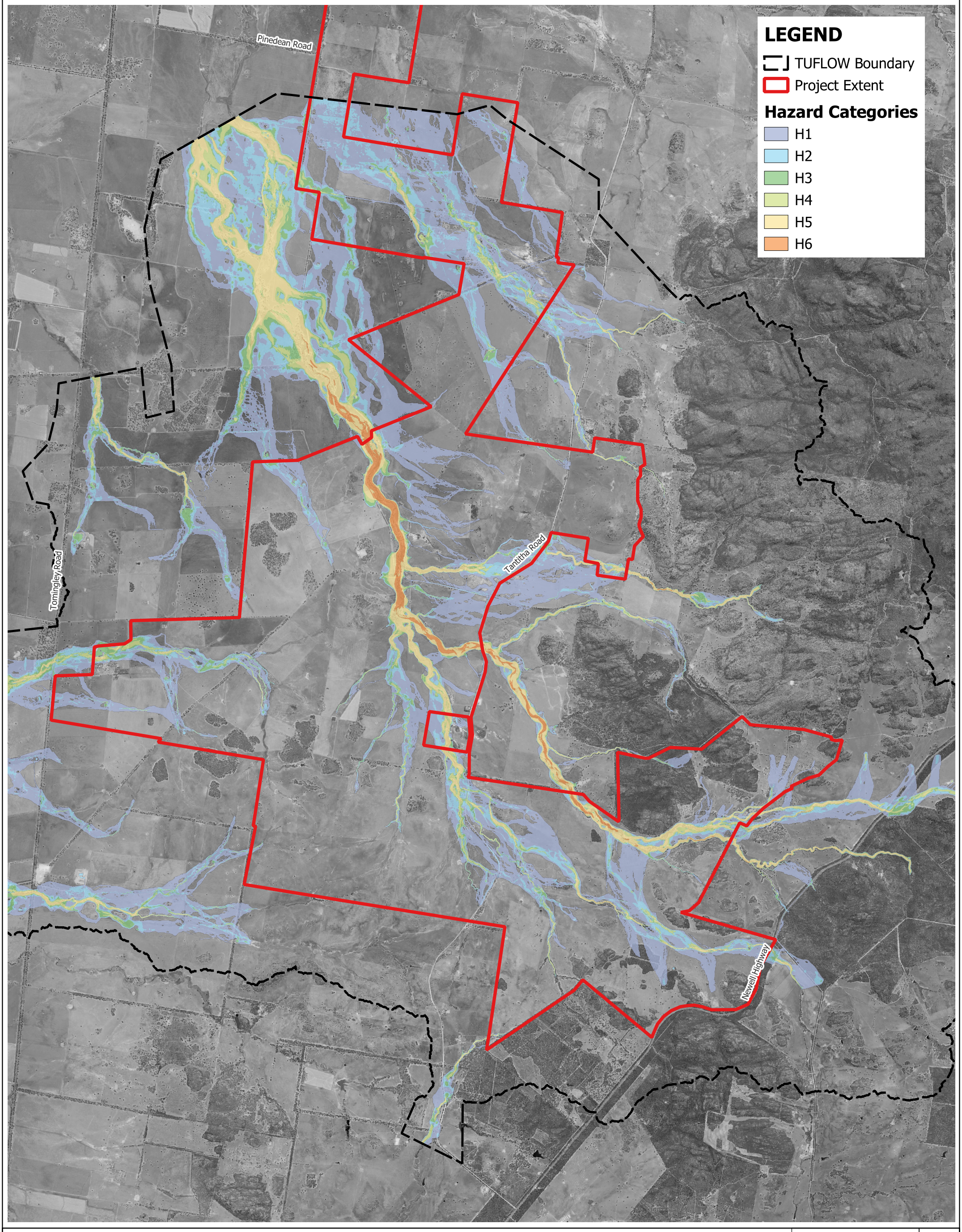

Title:

Baseline Scenario - 0.2% AEP Peak Hazard Conditions

Figure: A.12

Rev: A

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N

0 1,400 2,800 m

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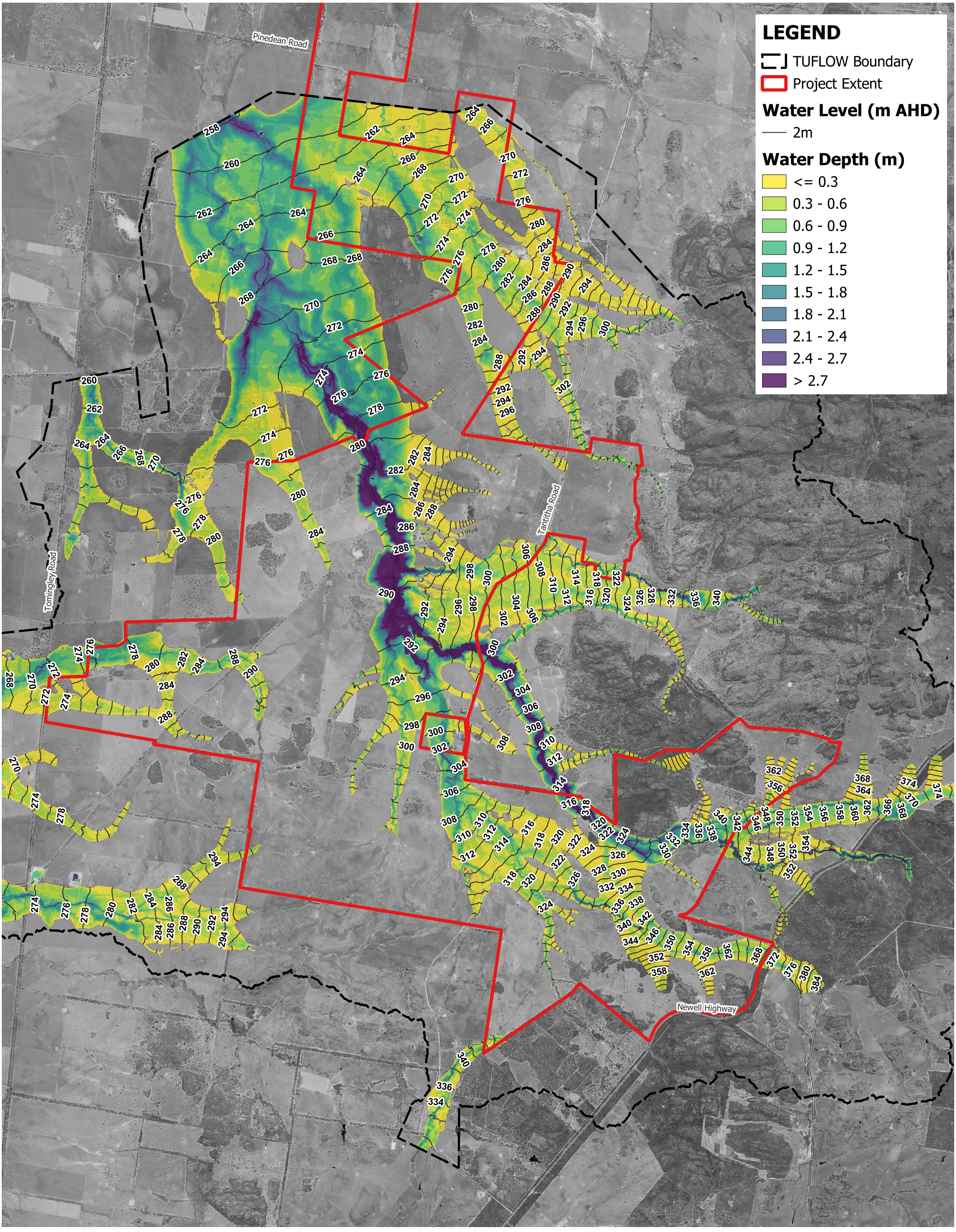

Title:

Baseline Scenario - PMF Peak Flood Levels and Depths

Figure: A.13

Rev: A

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N

0 1,400 2,800 m

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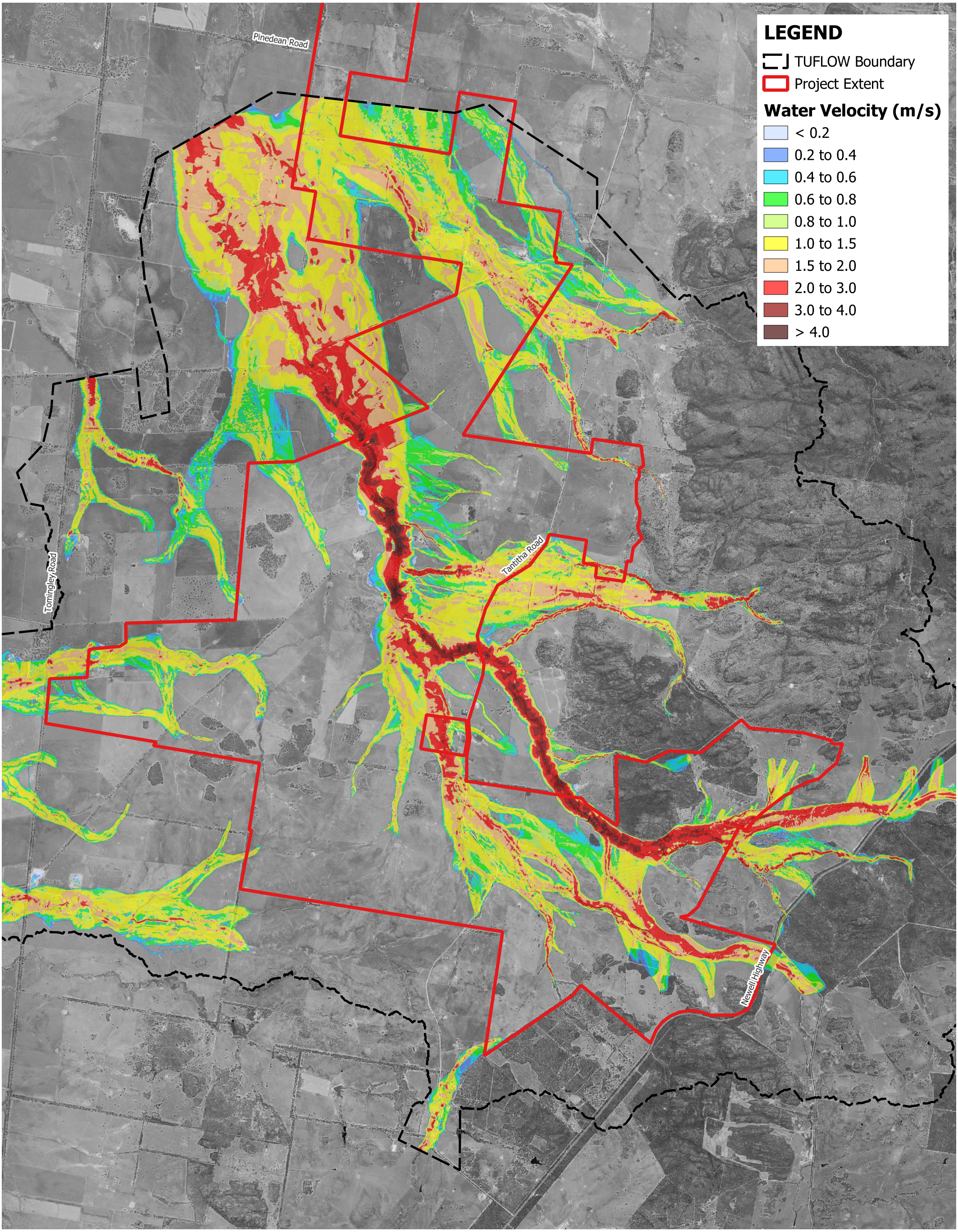

Title:

Baseline Scenario - PMF Peak Velocity

Figure: A.14

Rev: A

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N

0 1,400 2,800 m

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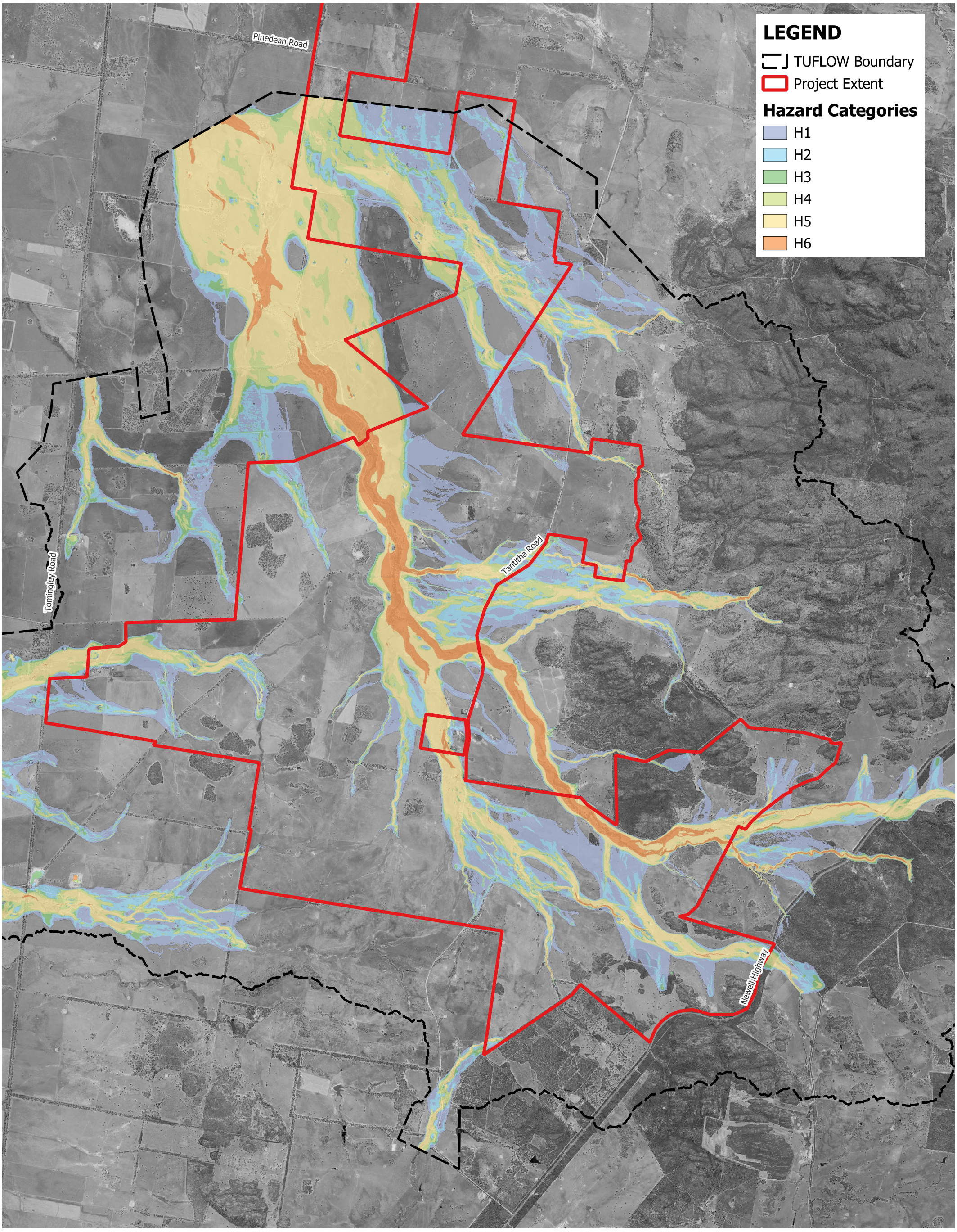

Title:

Baseline Scenario - PMF Peak Hazard Conditions

Figure: A.15

Rev: A

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N

0 1,400 2,800 m

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Annex B Developed Scenario Flood Maps

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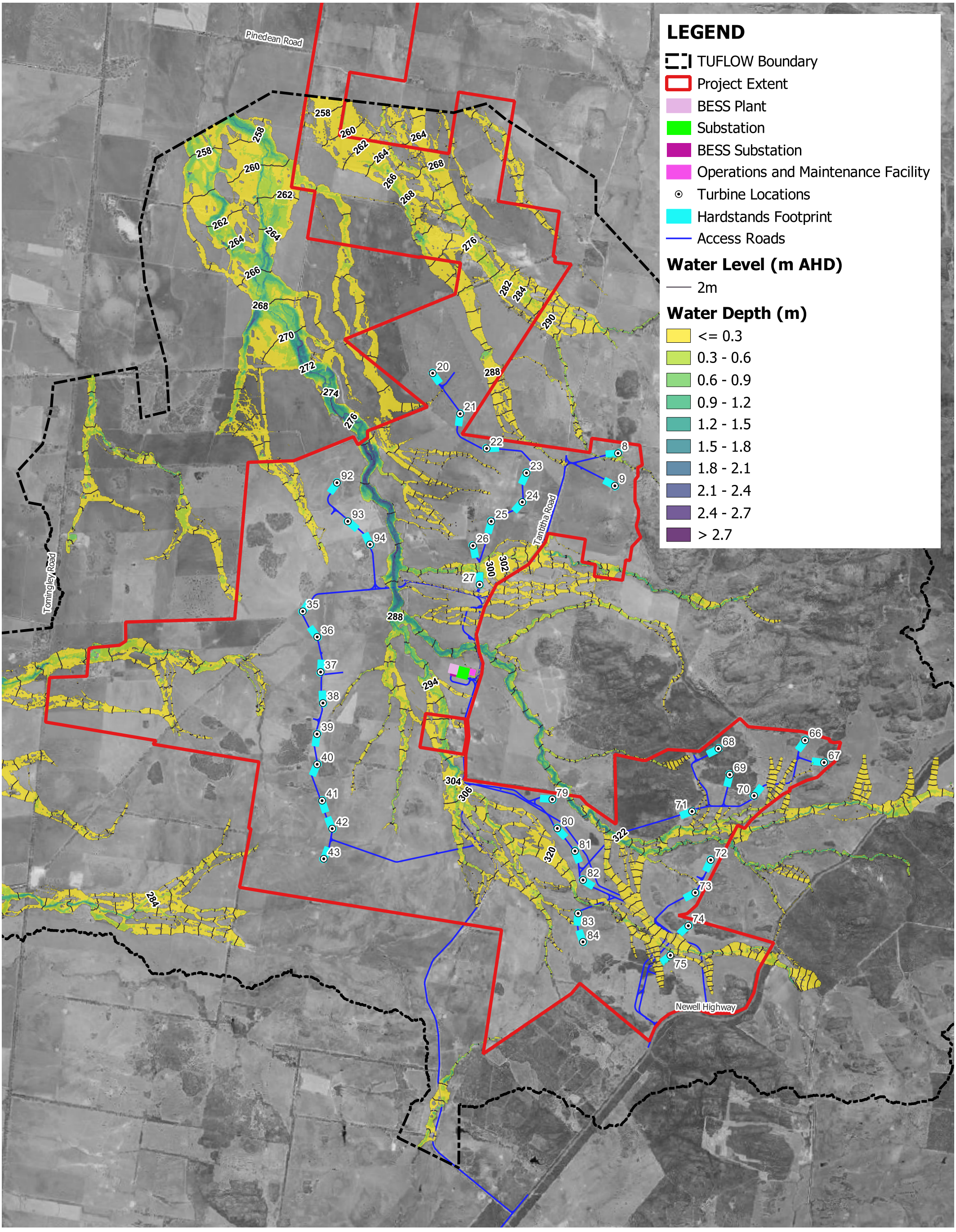

Title:

Developed Scenario - 5% AEP Peak Flood Levels and Depths

Figure: B.1

Rev: A

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N

0 1,400 2,800 m

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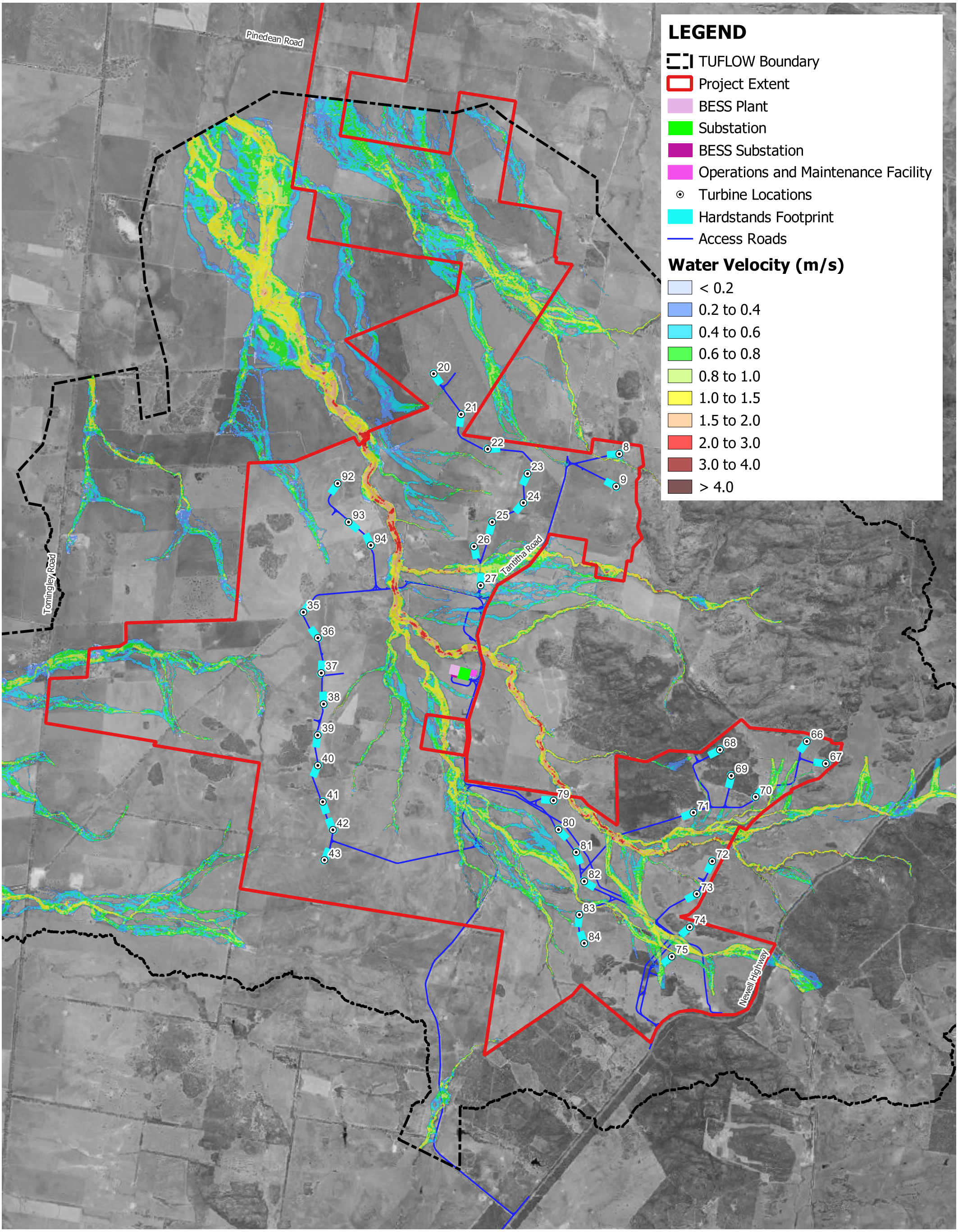

Title:

Developed Scenario - 5% AEP Peak Velocity

Figure: B.2

Rev: A

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N

0 1,400 2,800 m

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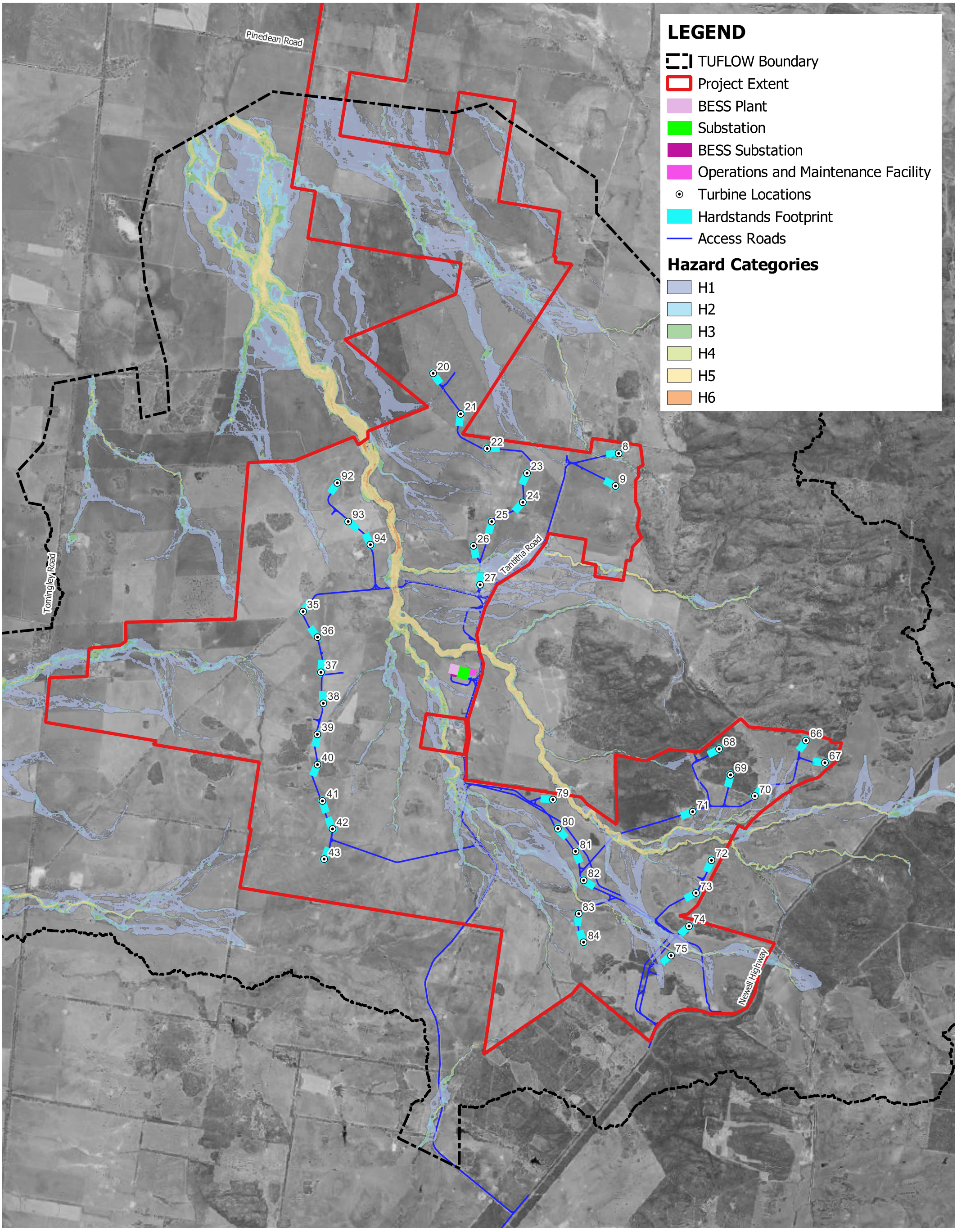

Title:

Developed Scenario - 5% AEP Peak Hazard Conditions

Figure: B.3

Rev: A

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N

0 1,400 2,800 m

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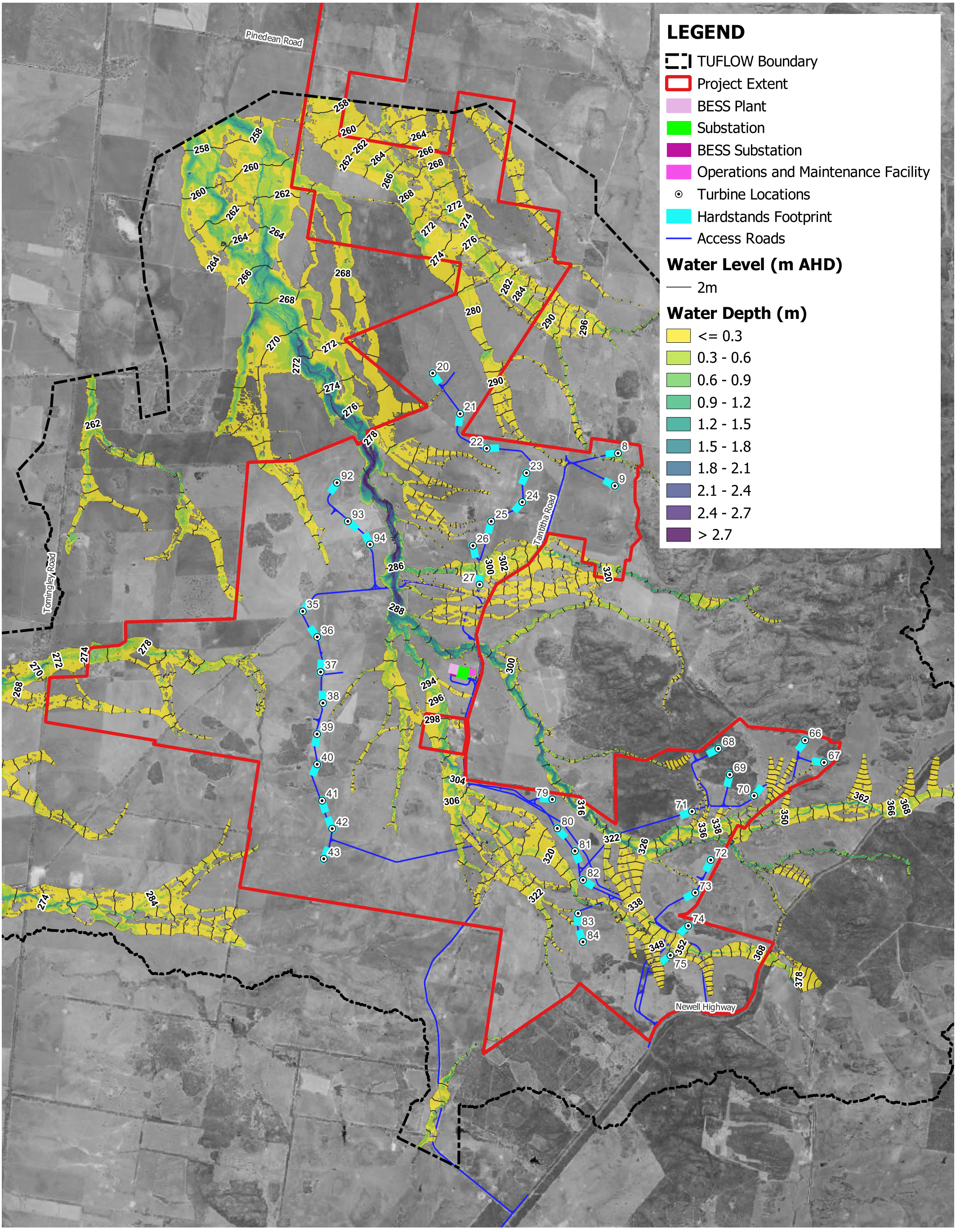

Title:

Developed Scenario - 1% AEP Peak Flood Levels and Depths

Figure: B.4

Rev: A

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N

0 1,400 2,800 m

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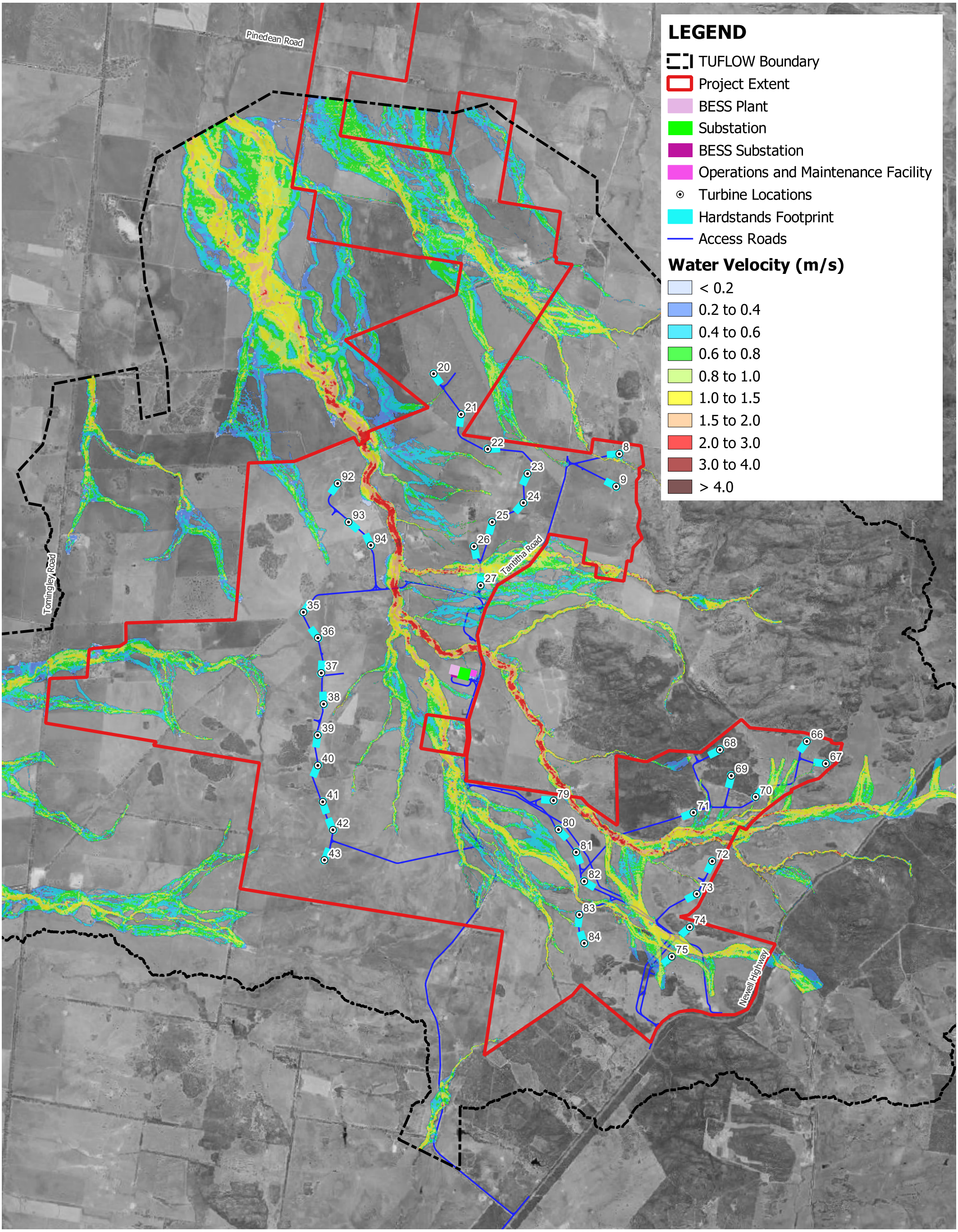

Title:

Developed Scenario - 1% AEP Peak Velocity

Figure: B.5

Rev: A

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N

0 1,400 2,800 m

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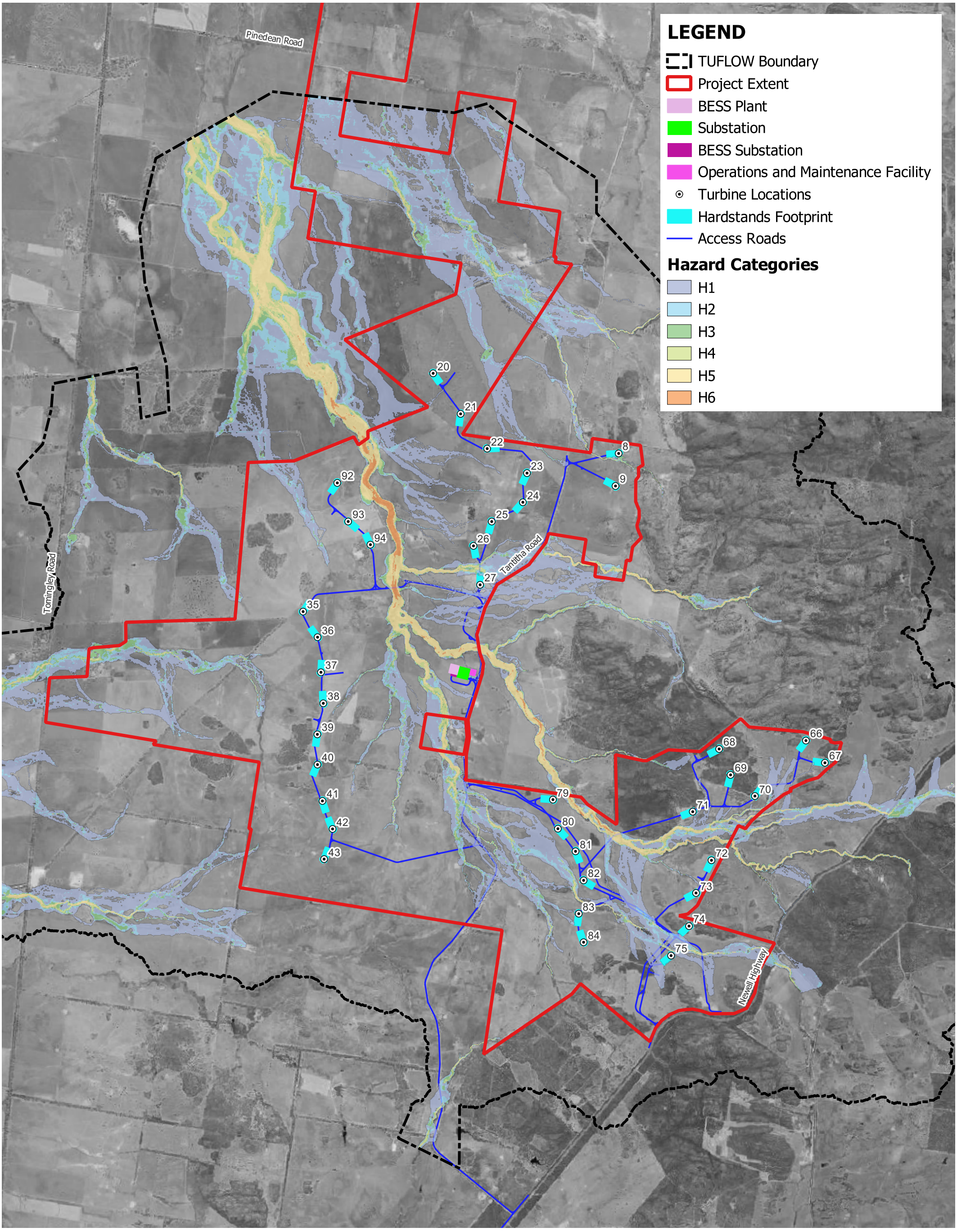

Title:

Developed Scenario - 1% AEP Peak Hazard Conditions

Figure: B.6

Rev: A

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N

0 1,400 2,800 m

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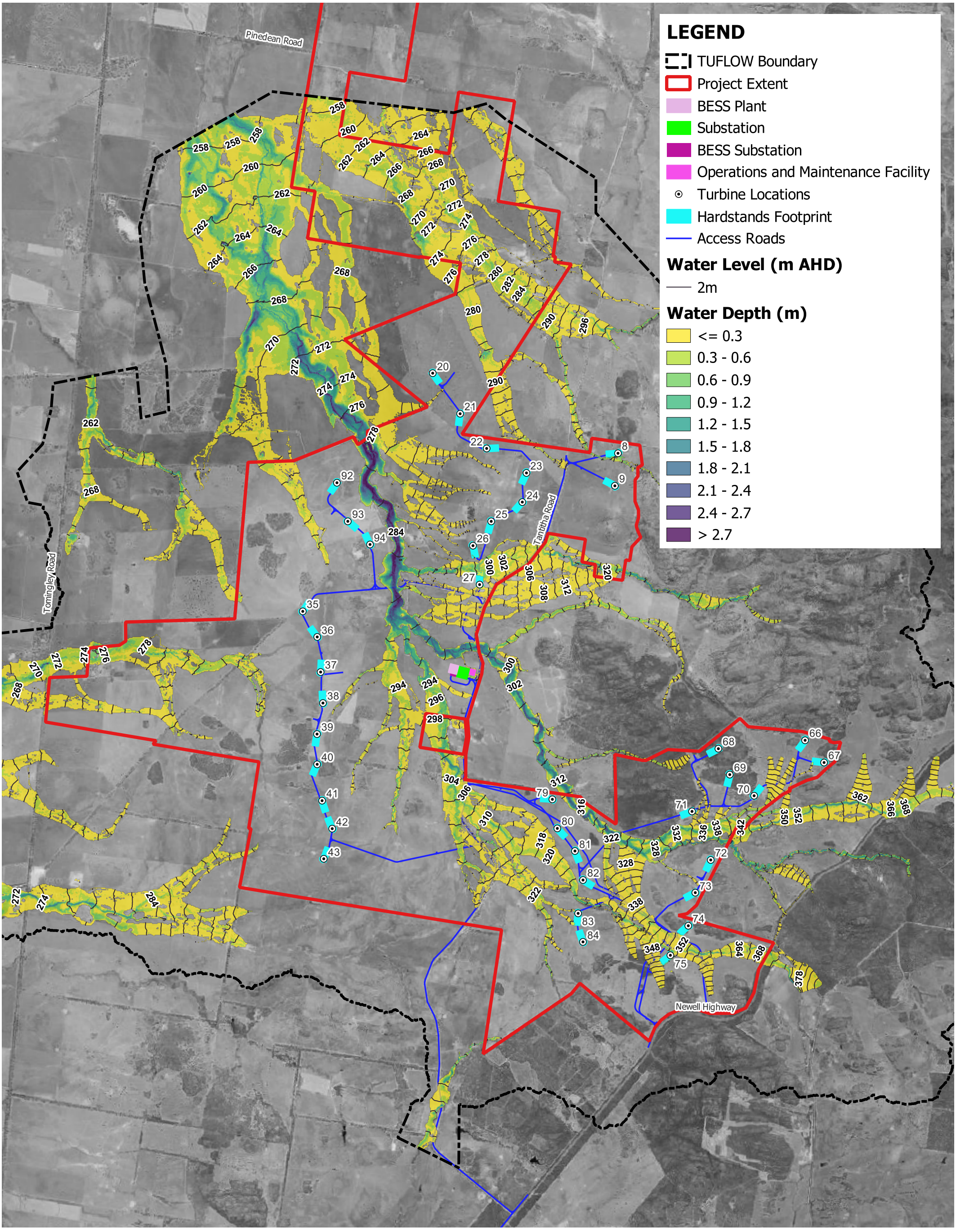

Title:

Developed Scenario - 0.5% AEP Peak Flood Levels and Depths

Figure: B.7

Rev: A

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N

0 1,400 2,800 m

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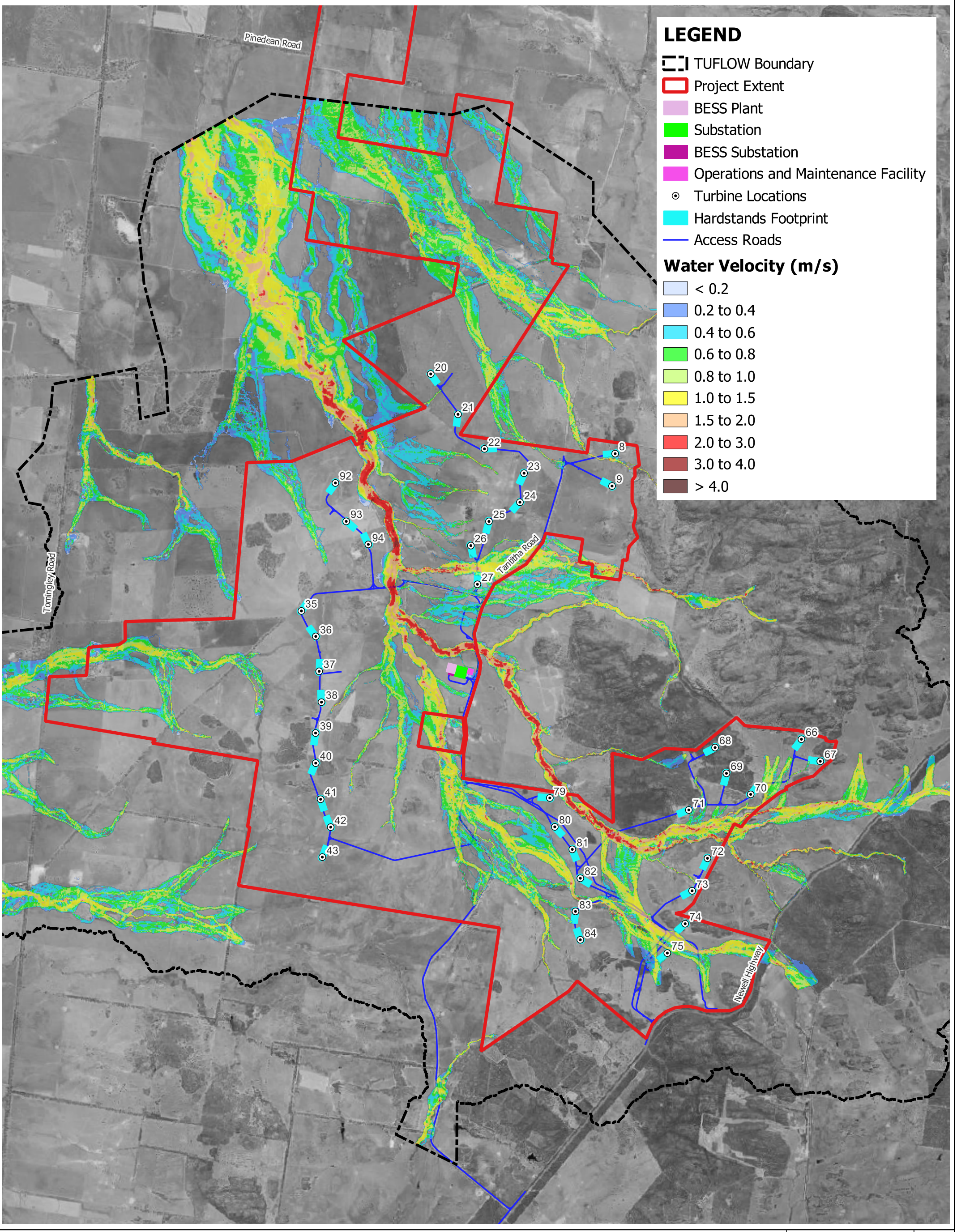
Filepath: I:\000936_WallabyCk_WindFarm_EIS\Fig_Gen\Appendix_B_Dev_Results\AnnexB_WCWF_Dev_Results.qgz



Title:

Developed Scenario - 0.5% AEP Peak Velocity

Figure: **B.8**

Rev: **A**

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N

0 1,400 2,800 m

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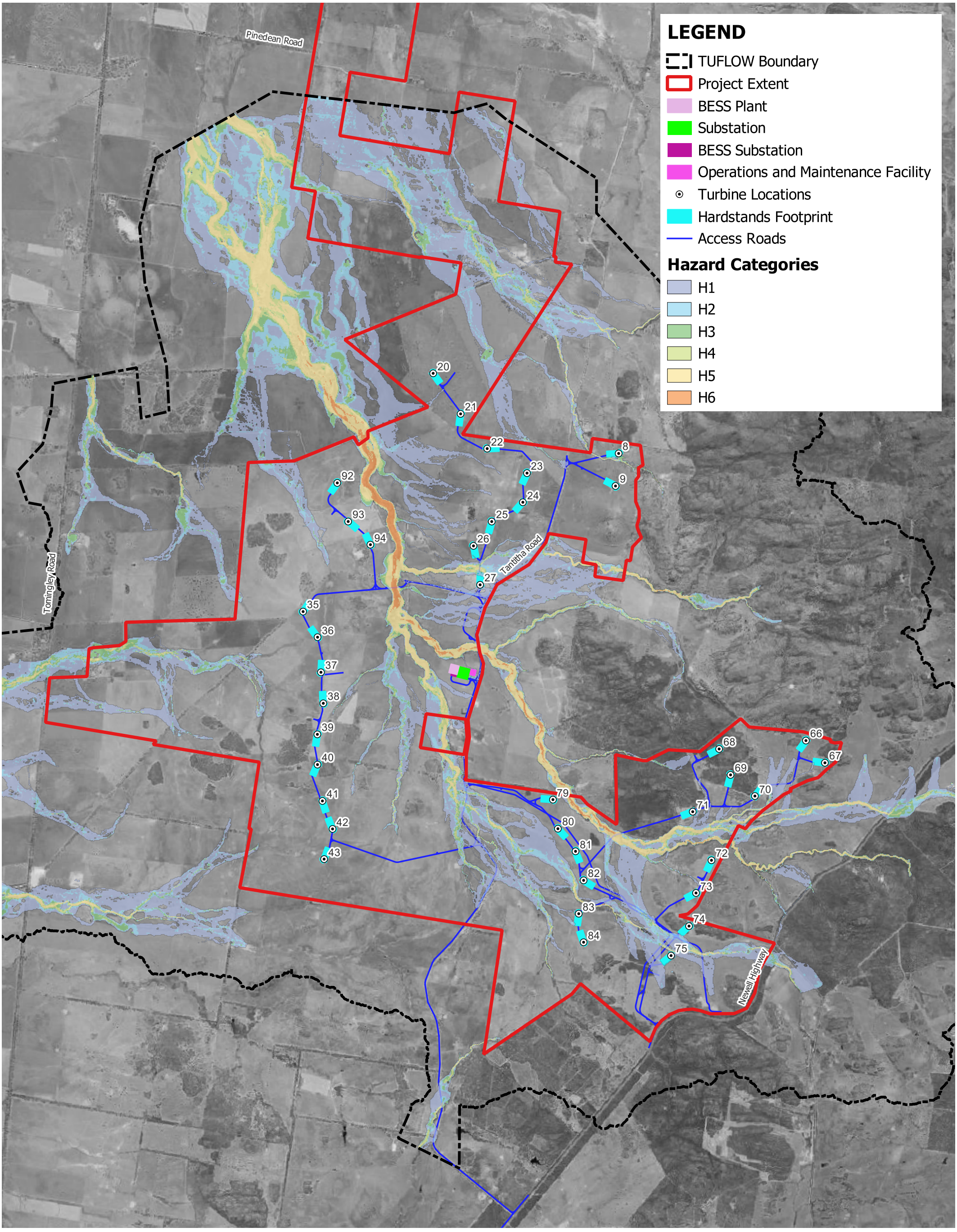

Title:

Developed Scenario - 0.5% AEP Peak Hazard Conditions

Figure: B.9

Rev: A

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N

0 1,400 2,800 m

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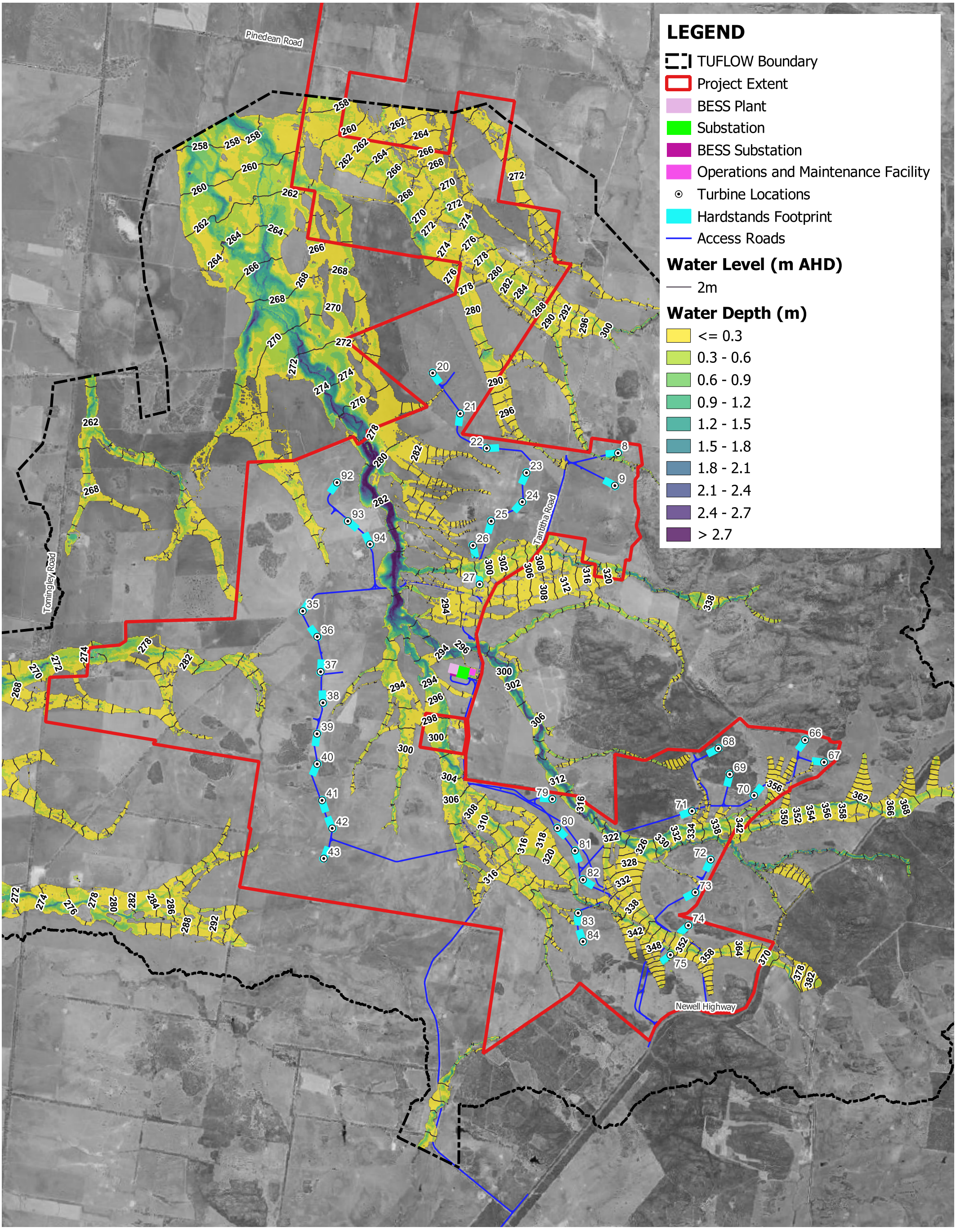

Title:

Developed Scenario - 0.2% AEP Peak Flood Levels and Depths

Figure: B.10

Rev: A

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0 1,400 2,800 m

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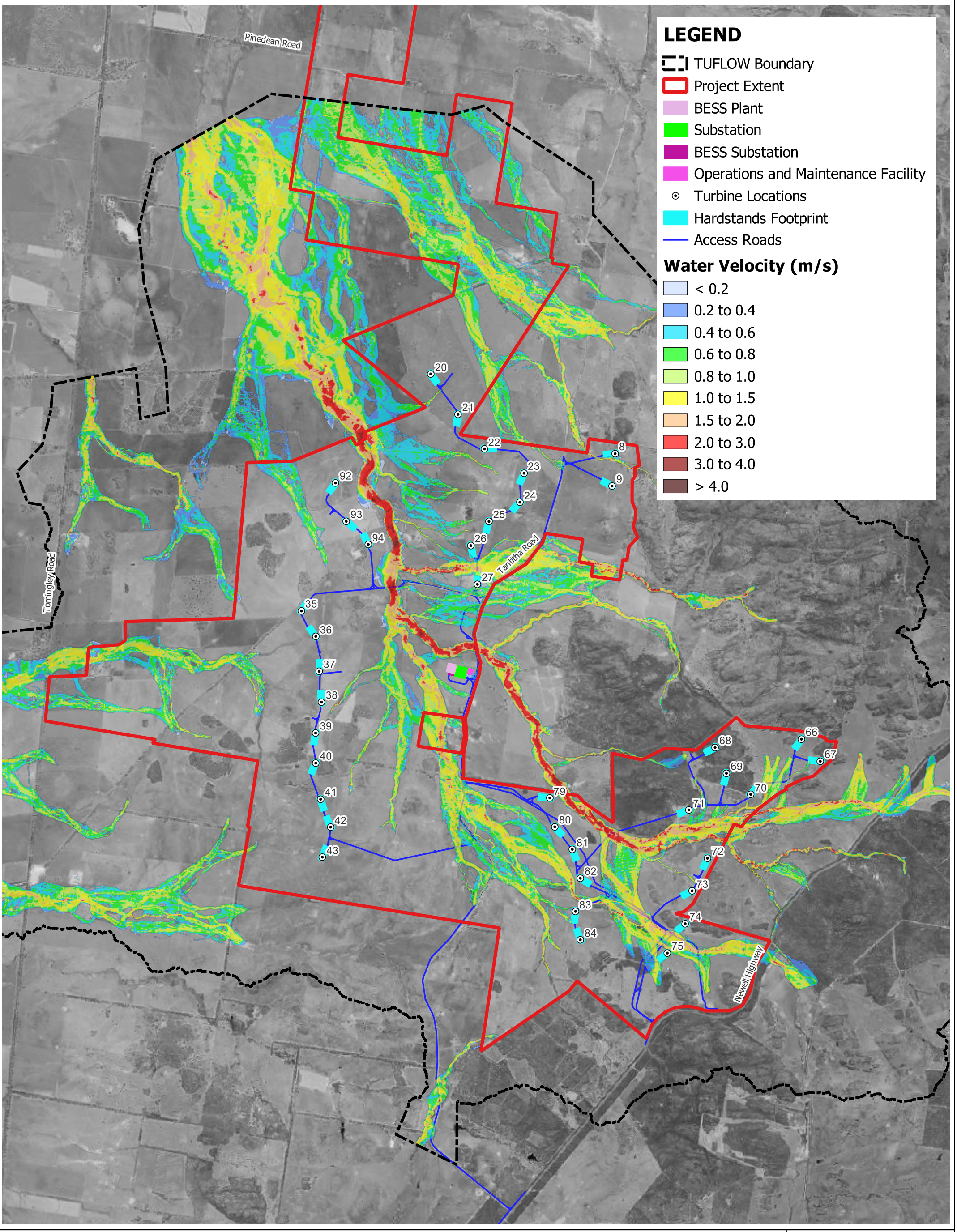

Title:

Developed Scenario - 0.2% AEP Peak Velocity

Figure: B.11

Rev: A

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N

0 1,400 2,800 m

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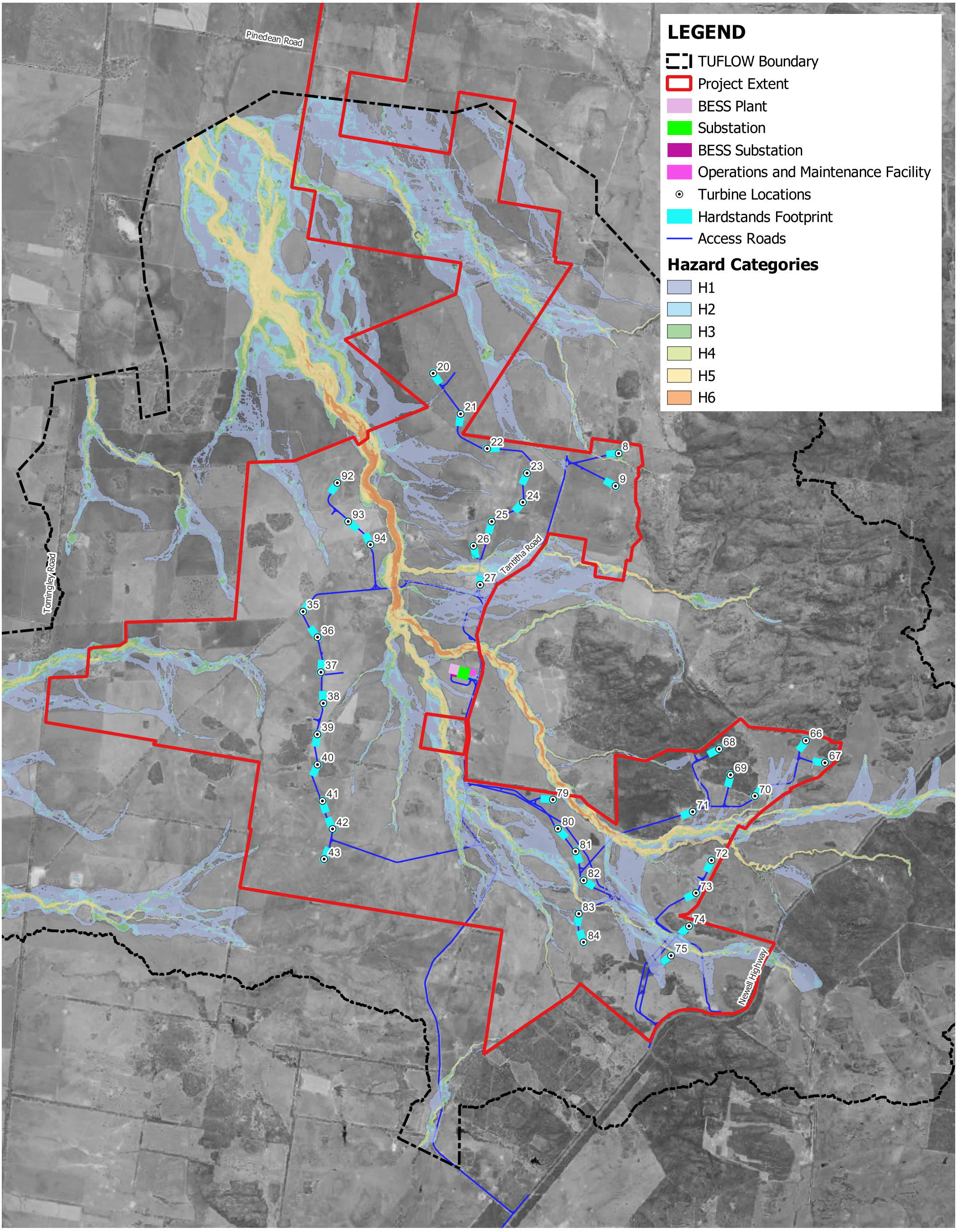

Title:

Developed Scenario - 0.2% AEP Peak Hazard Conditions

Figure: B.12

Rev: A

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N

0 1,400 2,800 m

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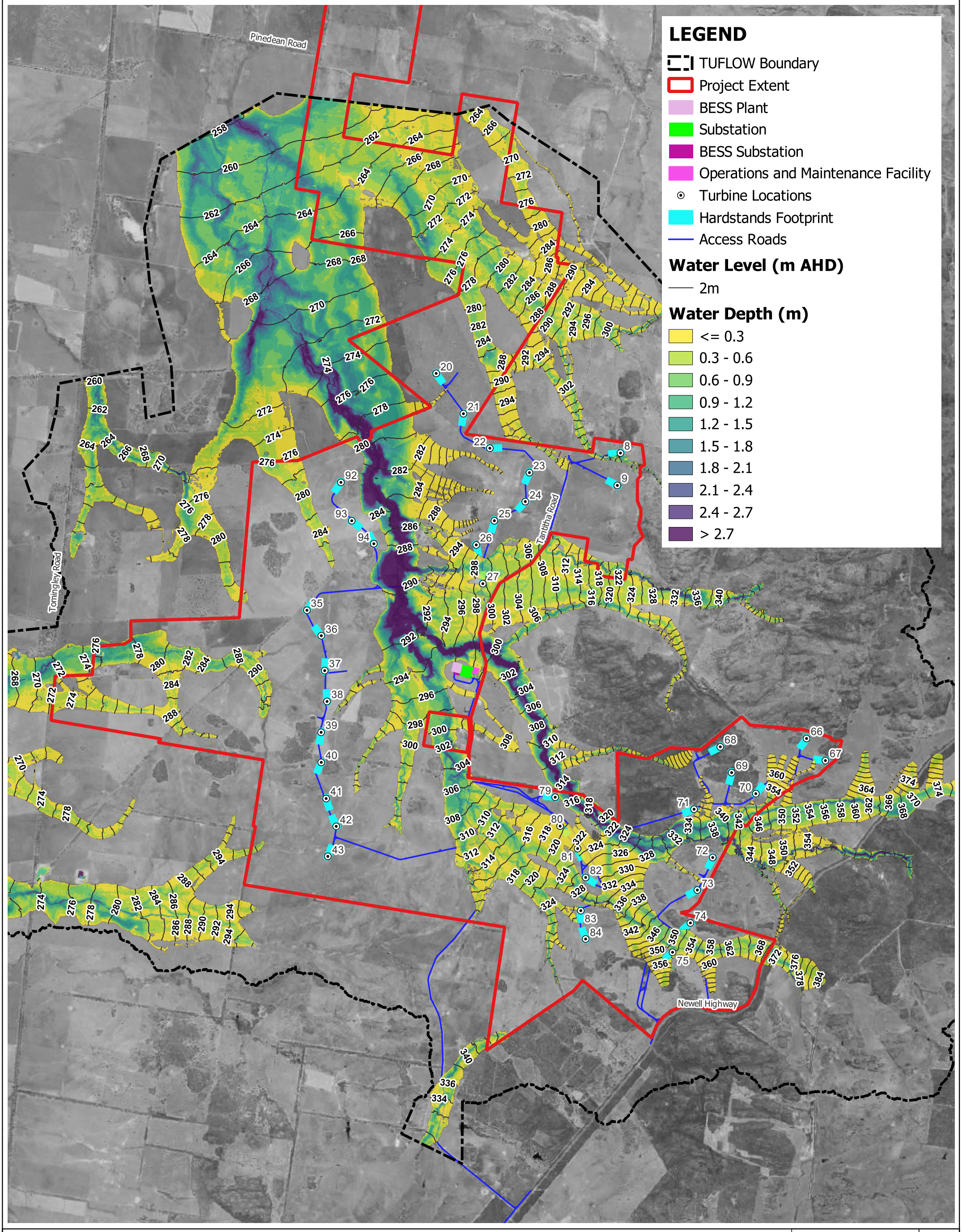

Title:

Developed Scenario - PMF Peak Flood Levels and Depths

Figure: B.13

Rev: A

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N

0 1,400 2,800 m

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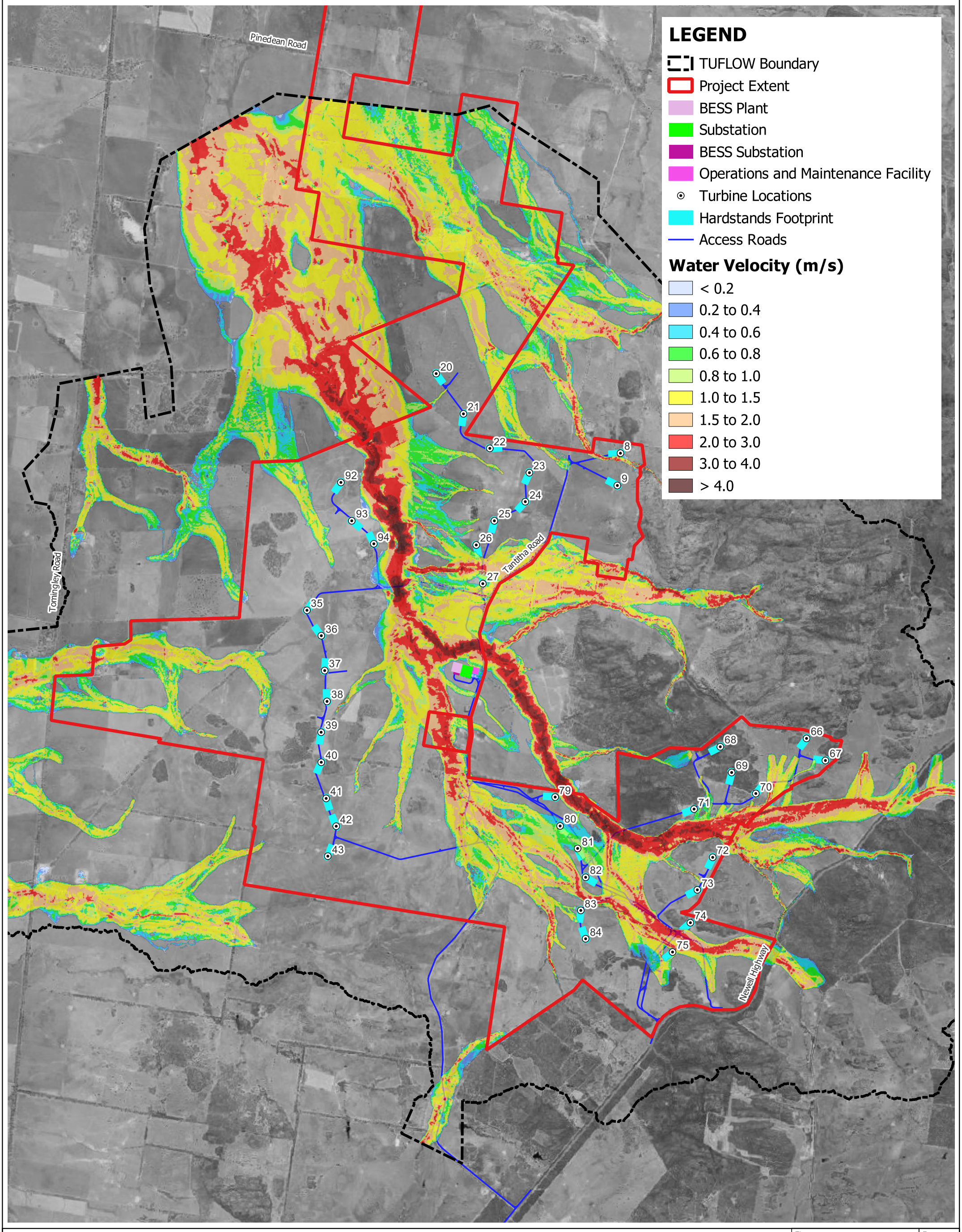

Title:

Developed Scenario - PMF Peak Velocity

Figure: B.14

Rev: A

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N

0 1,400 2,800 m

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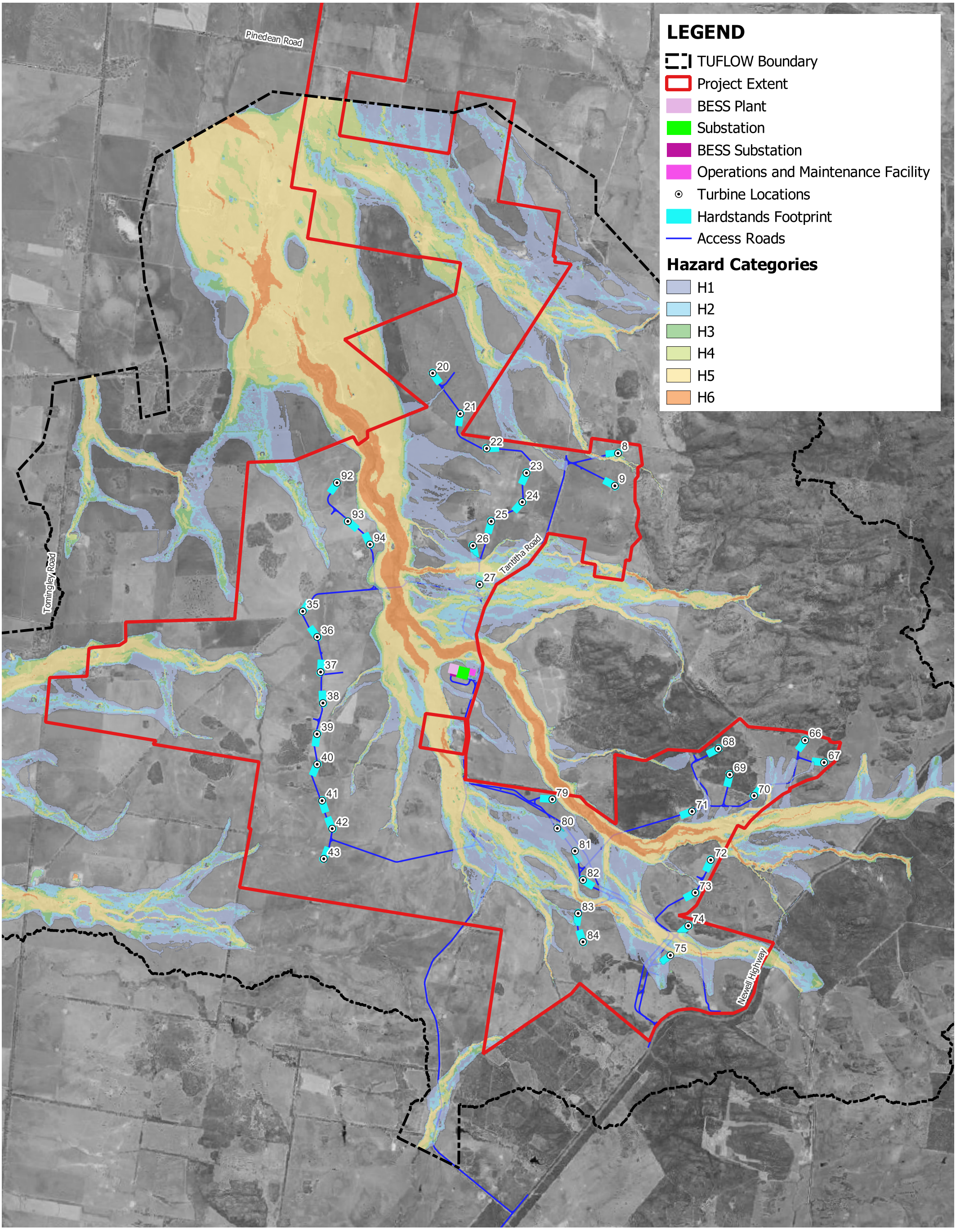

Title:

Developed Scenario - PMF Peak Hazard Conditions

Figure:	Rev:
B.15	A

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0 1,400 2,800 m

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Annex C Flood Impact Maps

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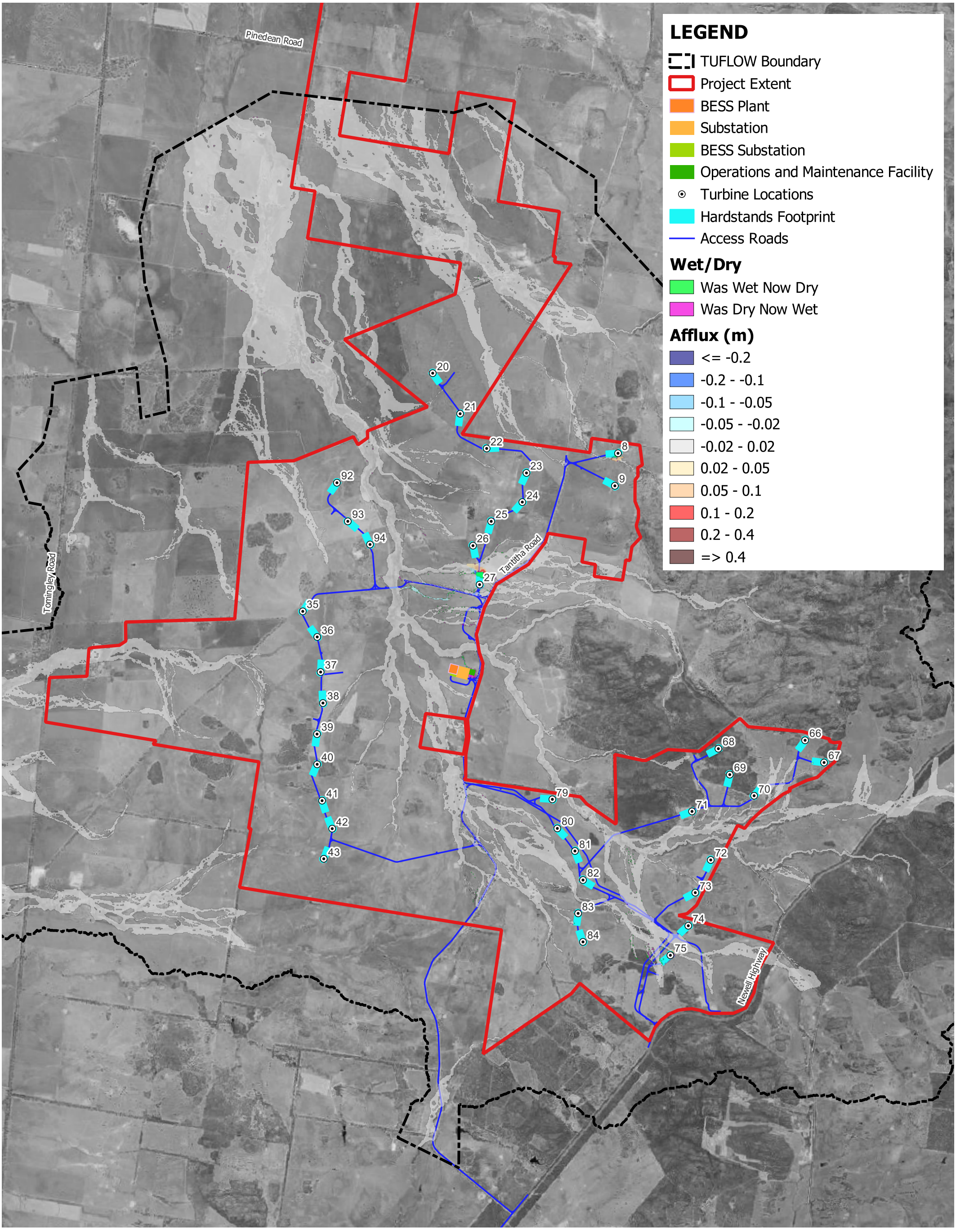

Title:

5% AEP Flood Level Impacts - Developed Scenario

Figure: C.1

Rev: A

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N

0 1,400 2,800 m

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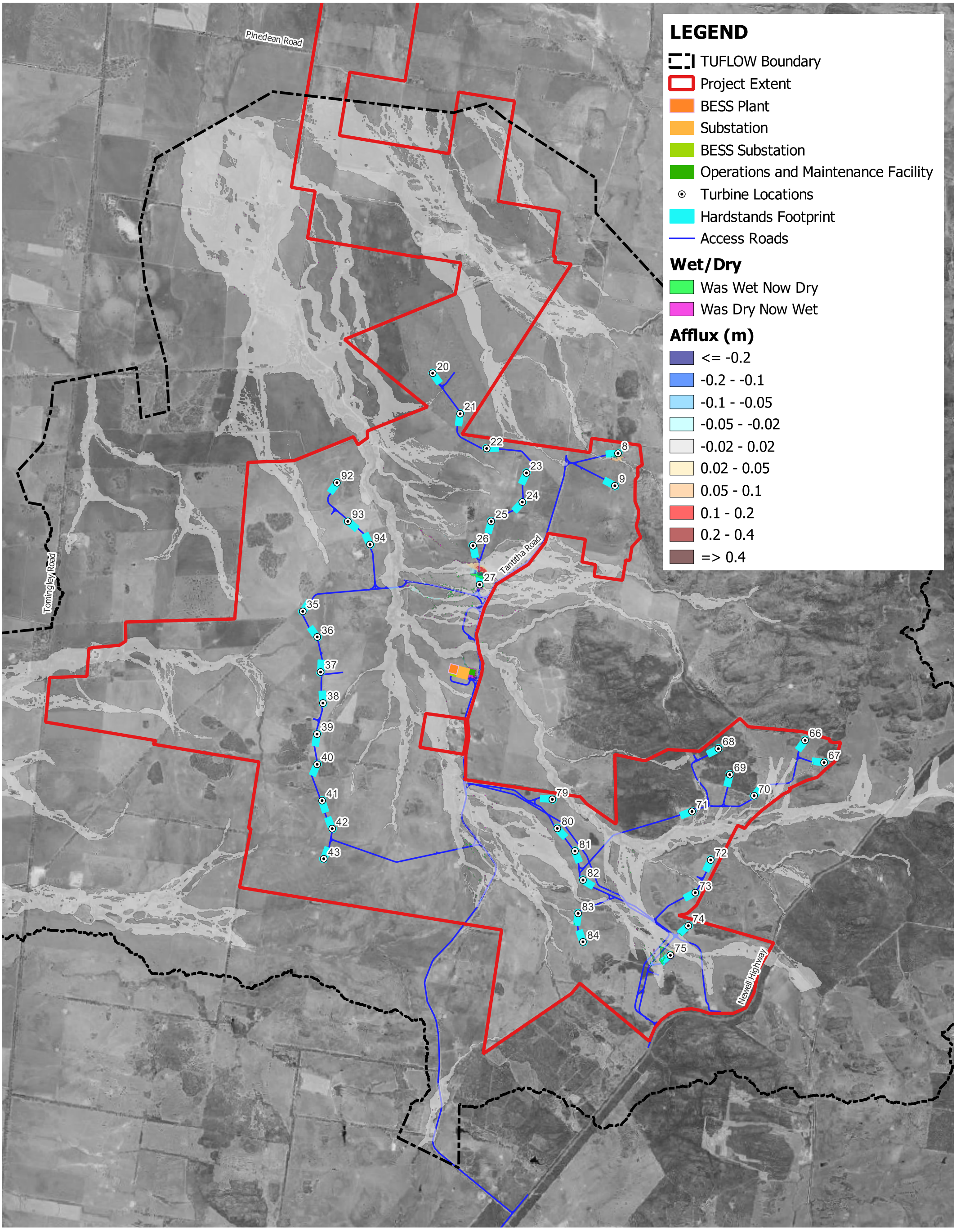

Title:

1% AEP Flood Level Impacts - Developed Scenario

Figure: C.2

Rev: A

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N

0 1,400 2,800 m

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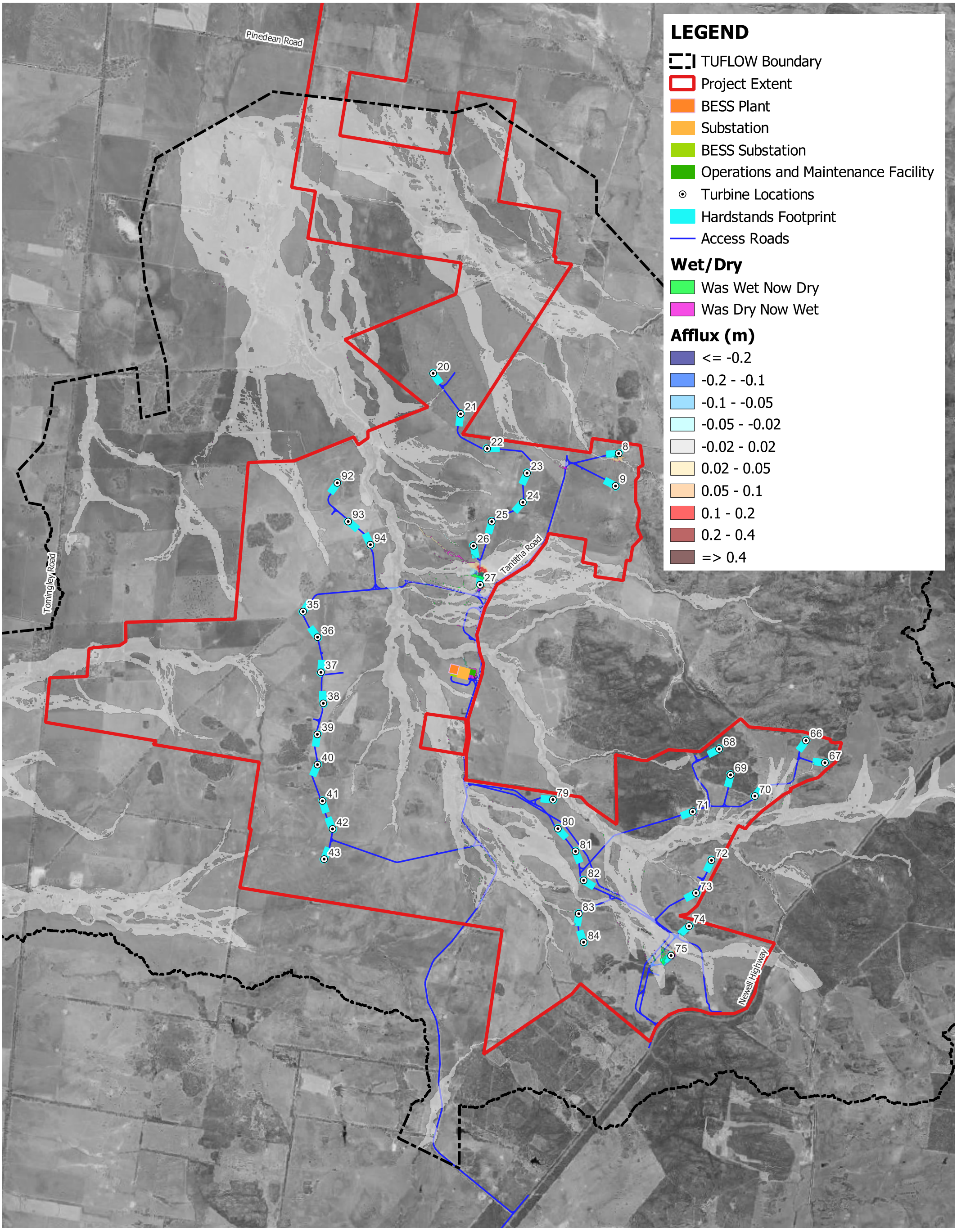

Title:

0.5% AEP Flood Level Impacts - Developed Scenario

Figure: C.3

Rev: A

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N

0 1,400 2,800 m

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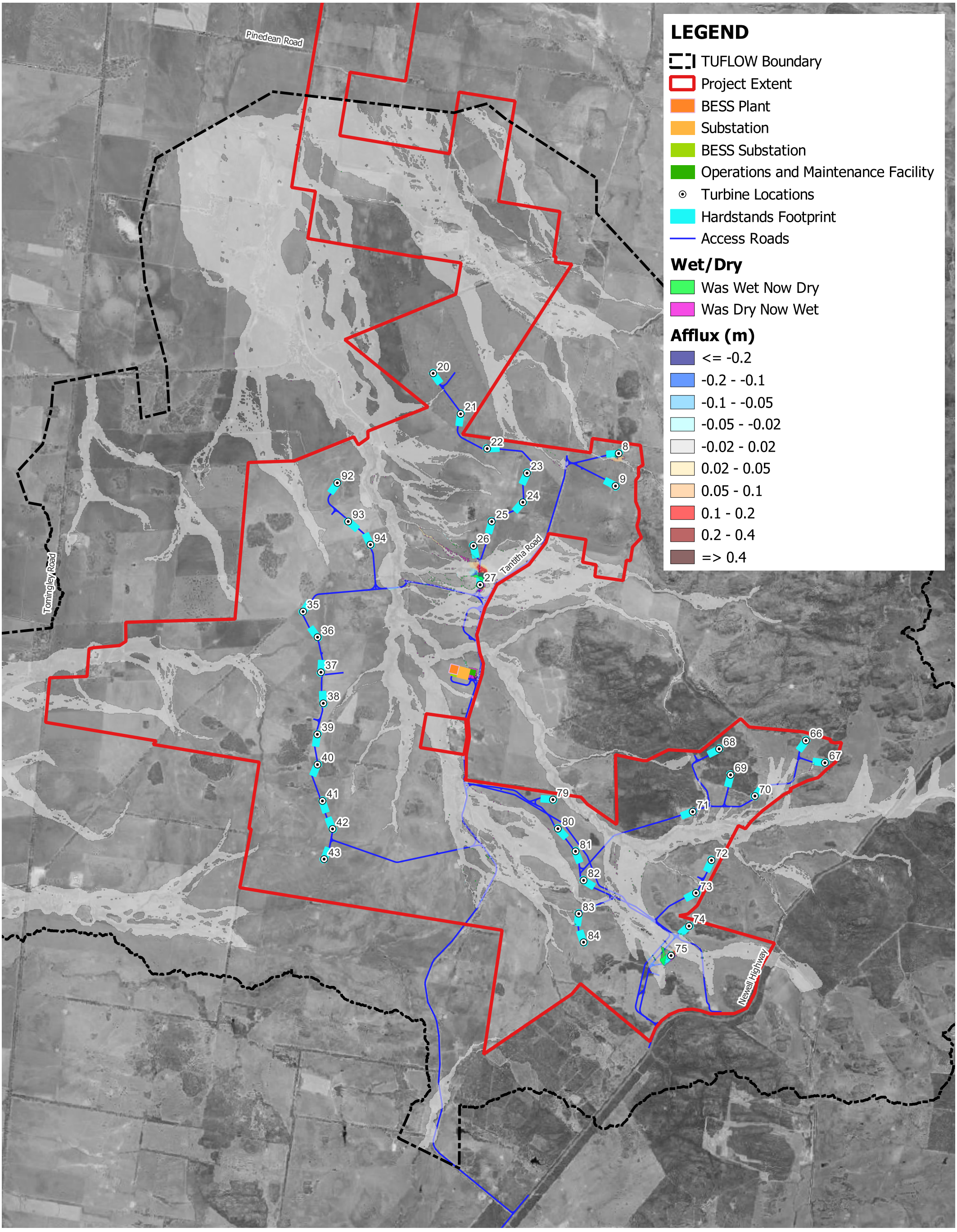

Title:

0.2% AEP Flood Level Impacts - Developed Scenario

Figure: C.4

Rev: A

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N

0 1,400 2,800 m

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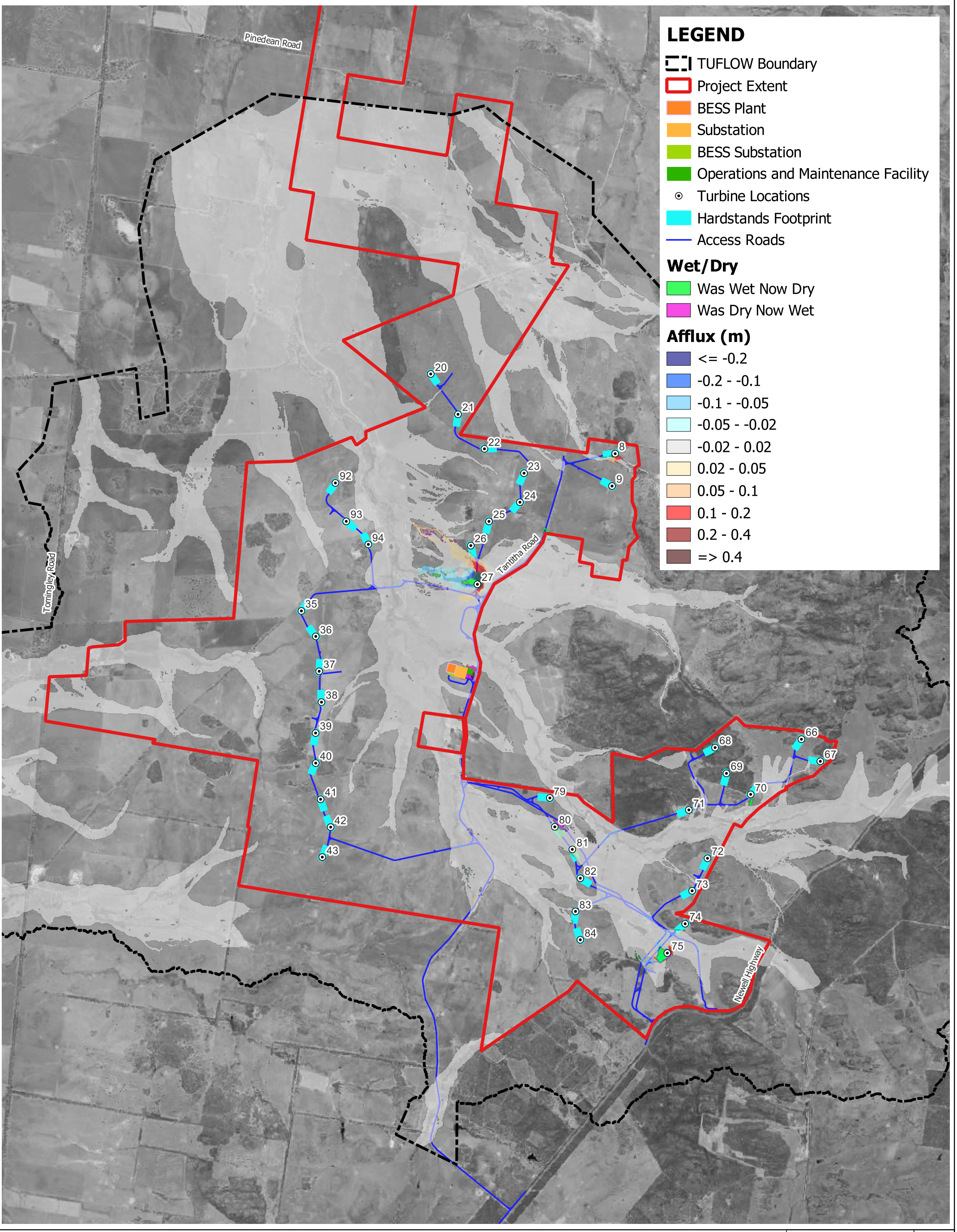

Title:

PMF Flood Level Impacts - Developed Scenario

Figure: C.5

Rev: A

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N

0 1,400 2,800 m

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Annex D Flood Function and Flood Planning Area Maps

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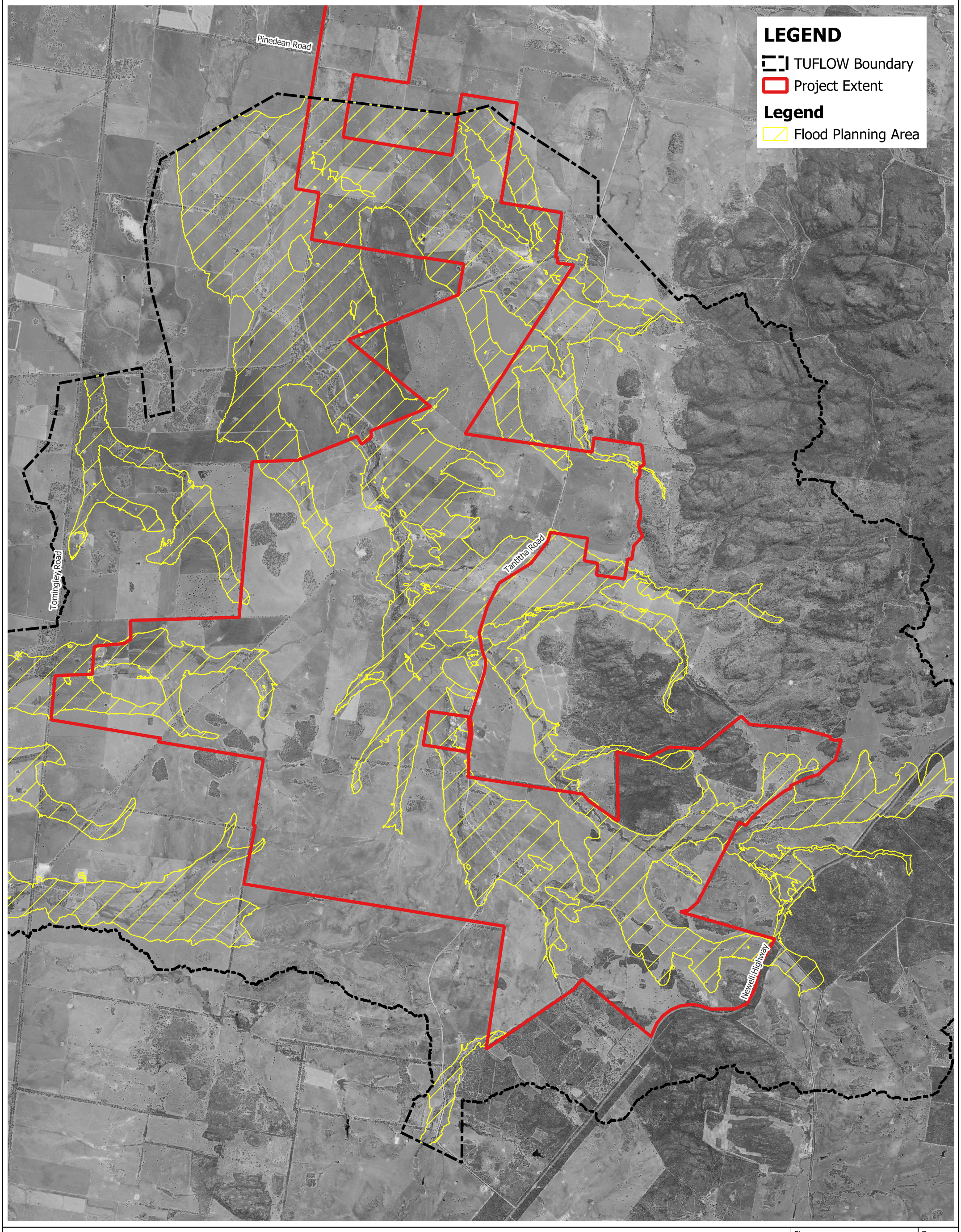

Title:

Flood Planning Area

Figure: D.1

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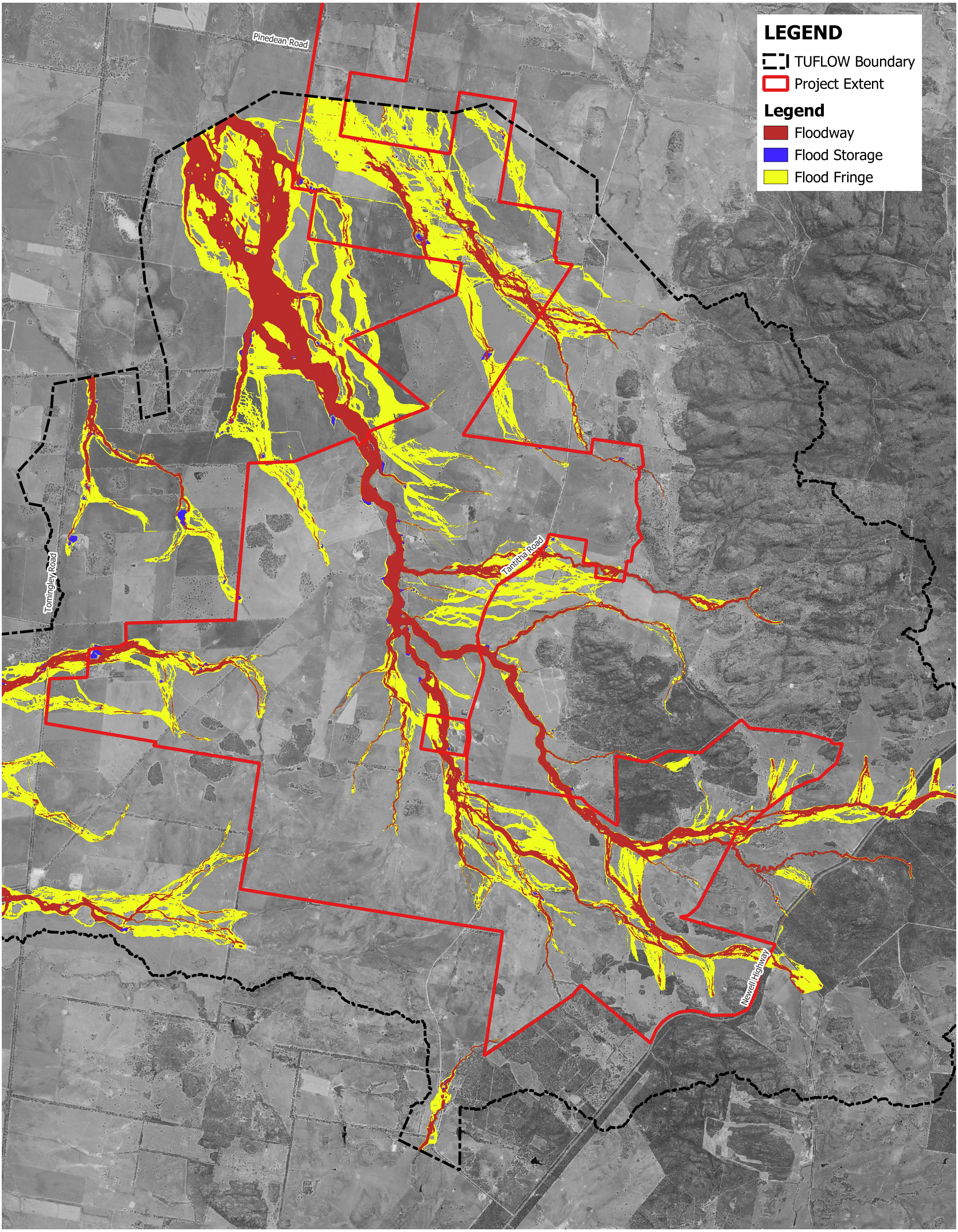

Title:

Flood Function - Base Scenario

Figure: D.2

Rev: A

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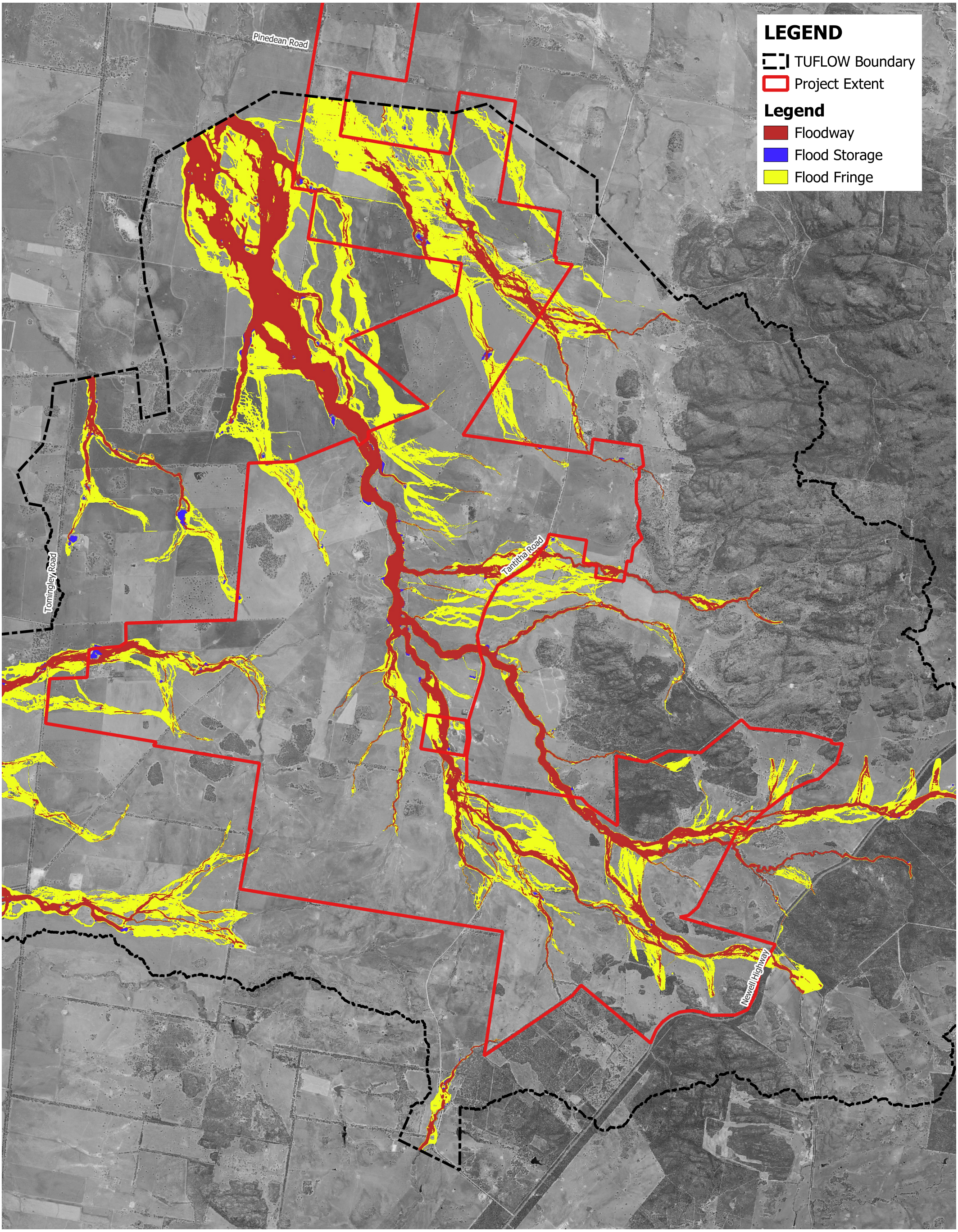

Title:

Flood Function - Developed Scenario

Figure: D.3

Rev: A

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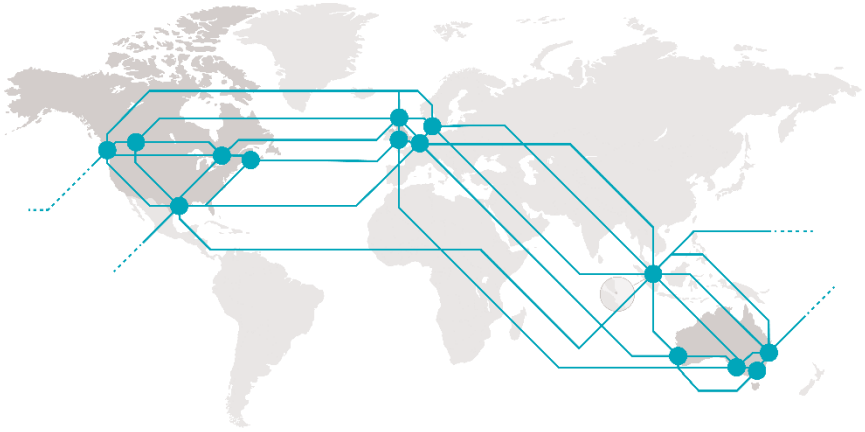

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