

Appendix G

Flood Modelling Report





Neoen Australia Pty Ltd

Yathroo Wind Farm

FLOOD MODELLING REPORT

WGA240913

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30 June 2025



Revision History

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1 INTRODUCTION

1.1 Background

The proposed Yathroo Wind Farm (YWF) project comprises of 65 turbines and is located near Yathroo, Western Australia, approximately 120km north of Perth.

Walbridge Gilbert Aztec (WGA) has been engaged by Neoen to undertake a Flood Assessment of the entire footprint and upstream catchments for the YWF Project. Refer to Figure 1 below for the extent of the wind farm footprint and the upstream catchments contributing to the flood extent outlined within this report.

WGA has prepared this flood study report to inform infrastructure location and level requirements throughout the site. This report contains the flood study methodology and results for the proposed site.

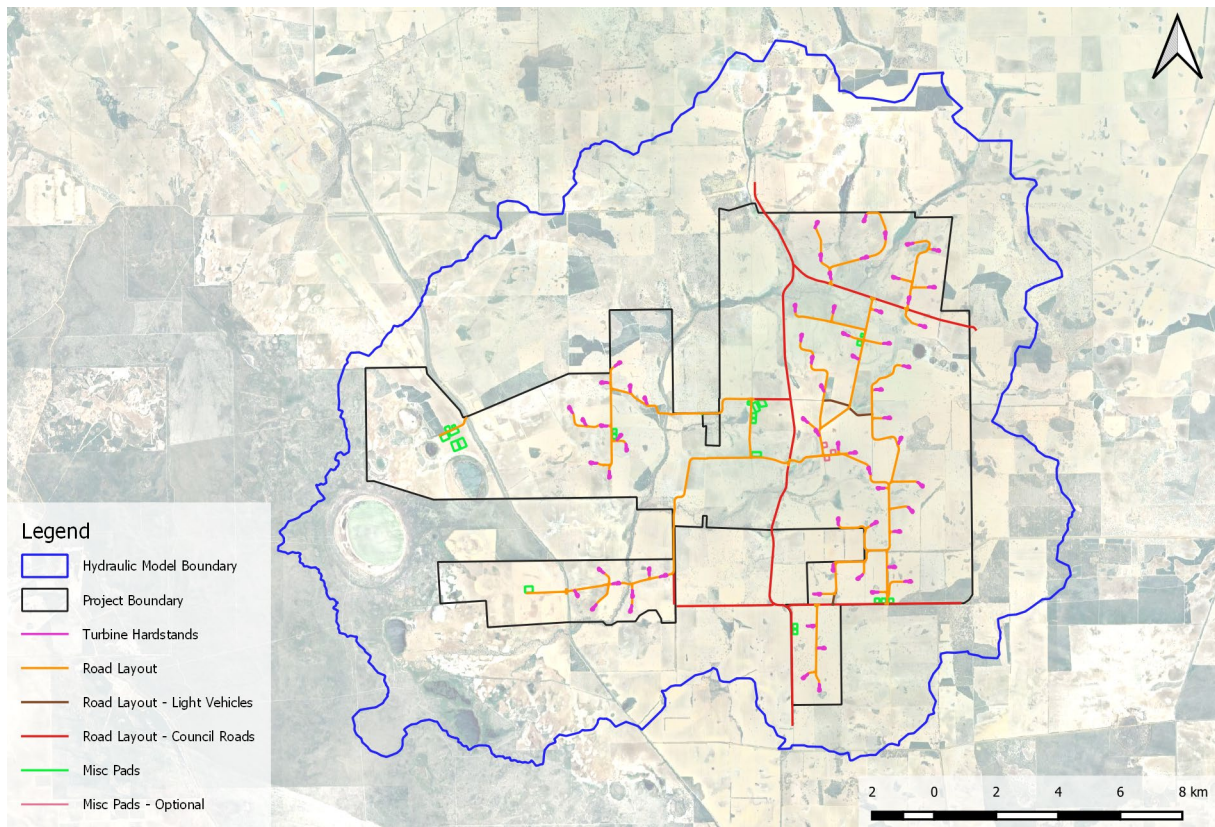


Figure 1: Proposed Site Plan

1.2 Scope of Works

This flood study report details the methodology, assumptions, and findings of the flood modelling assessment for the proposed wind farm. The scope of this flood study is outlined in the procedure below:

- Assess the flooding for the existing condition (no proposed wind farm drainage is incorporated into this flood study)
- Establish and delineate the catchments contributing to the associated civil infrastructure area
- Develop a RORB hydrological model in accordance with the *Australian Rainfall & Runoff 2019 (AR&R 2019) Guidelines* to determine the peak flow rates and the associated critical duration and temporal pattern upstream of the project site
- Develop and run the flood models using a 1D/2D hydraulic model (TUFLOW) based on the available information and inflows from the RORB hydrological models
- Undertake the assessment for the 0.5%, 1% and 10% Annual Exceedance Probability (AEP) design rainfall events
- Prepare a Windfarm Flood Study Report, including flood maps for the modelled AEP events (this report)

The following sections detail the methodology, assumptions, and modelling outcomes for the project.

1.3 Infrastructure Drainage Criteria

The critical wind farm infrastructure including access roads, hardstands and infrastructure pads shall be designed to the AEP requirements outlined in Table 1 below:

Table 1: Infrastructure Design Criteria

INFRASTRUCTURE	AEP REQUIREMENT (%)
Access Roads	10%
Turbine Hardstands	1%
Substations	1%
Misc Pads	1%
Western Power Switching Station	1% + 600mm

2 HYDROLOGY

The subject site is impacted by several upstream catchments with a total combined area of approximately 290km², shown in Figure 2. In this study, RORB hydrological models were utilised to determine the peak flow rates for the upstream catchments at the site hydraulic model boundaries.

Further details on the hydrological modelling process are provided in the subsequent sections.

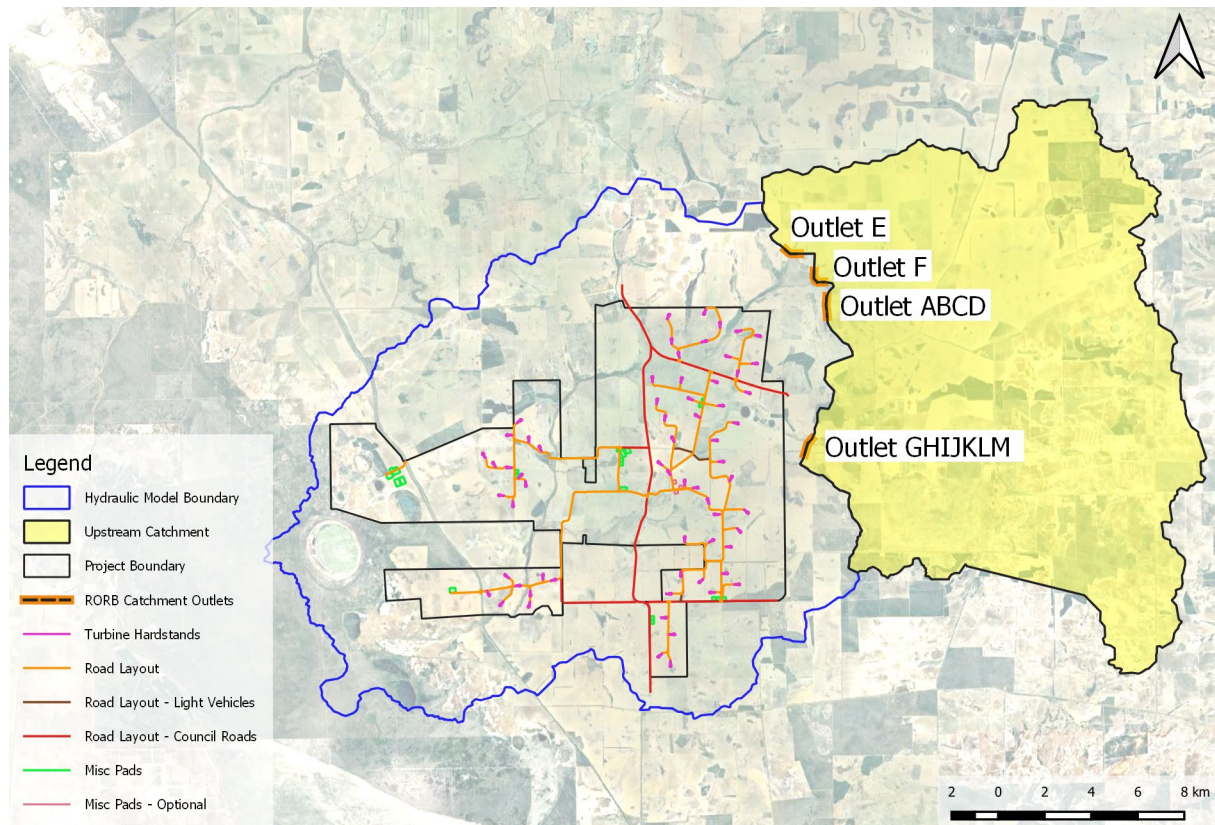


Figure 2: Upstream Catchment Delineation and the Project Area

2.1 RORB Nodes and Reaches

The upstream catchment of the study area shown in Figure 3 has been delineated from terrain elevation data. ELVIS (Geoscience Australia, 2015) 5m grid LiDAR was utilised for catchment delineation and identifying the reach alignments and node locations. Four outlets located along the western side of the RORB model were used to simulate inflow points for the hydraulic model.

RORB reaches were classified as 'natural' across the entire catchment based on Google Satellite imagery. Two hydrological models were developed in RORB for the study:

- **Calibration Model:** The first model encompassed the entire catchment and was used to calibrate the k_c parameter for the 1% AEP event at the catchment outlet
- **RORB peak flow rates at the Hydraulic Model Boundary (Nodes E, F, ABCD and GHIJKLM):** Following calibration, flow rates for all three AEP flood events (0.5%, 1% and 10% AEP) were simulated for the calibrated k_c

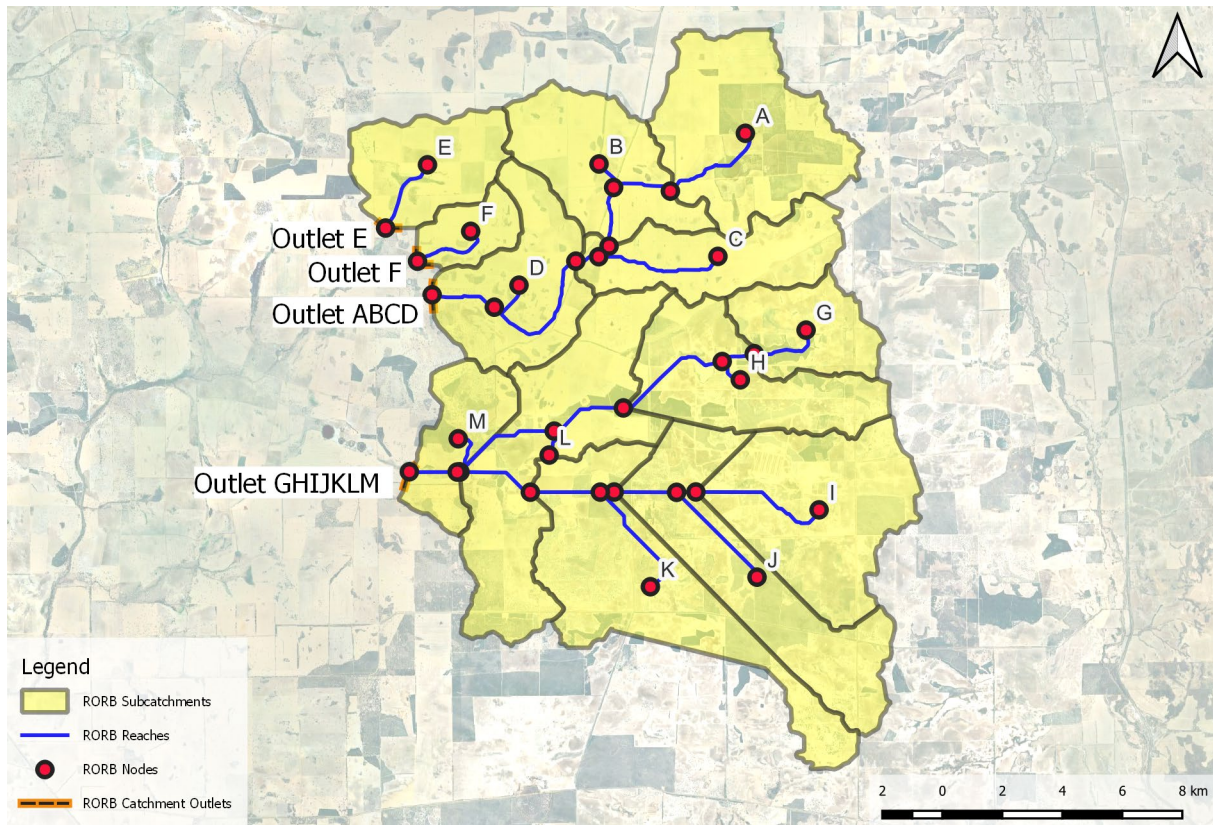


Figure 3: Model Catchment Delineation

2.2 Rainfall data

As the catchment size is greater than 20km², in accordance with *AR&R 2019* an investigation into the spatial distribution of rainfall was conducted throughout the entire catchment. The rainfall depths showed minor variation (+/- 10%) for different durations for a range of AEP events within the catchment area. As the rainfall depth variation was not considered significant, point rainfall with no spatial pattern were adopted for the modelling area. For the catchments with less than 75km², point temporal patterns were used. Areal temporal patterns were used for modelling of the two large sub-catchments with outlets ABCD and GHIJKLM as shown in Figure 3. Since areal temporal pattern durations start from 12 hours, point temporal patterns were also used for modelling of the large sub-catchment to consider durations lower than 12 hours.

The rainfall depths and temporal patterns were sourced from the *AR&R 2019 Data Hub* and the Bureau of Meteorology (BOM) website. The coordinates of the catchment centroid used to obtain the Data Hub data are -30.802, 115.861.

2.3 RORB Parameters

2.3.1 Initial and Continuing Losses

The Initial Loss (IL) and Continuing (CL) method was adopted for the RORB modelling. Loss values were obtained from the AR&R Data Hub at the catchment centroid (Latitude: -30.802, Longitude: 115.861). The IL was determined to be 62mm, while the CL was 3.8mm/h.

To model the pre-burst rainfall impact, Duration Loss Factors were applied to the RORB model by subtracting the 75% pre-burst Depths (sourced from the AR&R Data Hub) from the IL and calculating the proportion of the IL remaining. Initially, the model adopted the median pre-burst Depth when modelling the pre-burst rainfall impact. However, due to the large initial loss found in the project area, the model produced zero runoff particularly during the 10% AEP event.

2.3.2 Routing Parameter – k_c

RORB's routing parameter was calibrated using k_c equations listed in Table 2 below for the 1% AEP event. Among the equations used, the Pilbara W.A data was selected as its result is the closest to the flow rate calculated using the rational method, whilst being slightly less conservative.

Table 2: Rational Method Flow Comparison with Selected k_c Equations

EQUATION NAME	K_c EQUATION	K_c VALUES	PEAK FLOW RATE AT CATCHMENT OUTLET
Regional Flood Frequency Estimation (RFFE)	-	-	34.7 m ³ /s (with lower and upper confidence of 7.34 and 161, respectively)
Rational Method (Austroads Guide to Road Design Part 5 Equation 8)	-	-	408.8 m ³ /s
Rational Method – WA Wheatbelt Loamy Soil Catchments 75% to 100% Cleared	-	-	242.0 m ³ /s
Default (Equation 2.5 RORB Manual)	$2.20 \cdot A^{0.5}$	37.48	67.3 m ³ /s
Aus Wide Dyer (1994) Data (Pearse et al. 2002)	$1.14 \cdot D_{av}$	12.09	219.0 m ³ /s
Aus Wide Yu (1994) Data (Pearse et al. 2002)	$0.96 \cdot D_{av}$	10.18	249.5 m ³ /s
Pilbara W.A Data (Pearcey et al, 2014)	$0.59 \cdot D_{av}$	6.26	377.4 m ³ /s

3 HYDRAULIC MODEL

A 1D/2D hydraulic model was developed for the catchment using TUFLOW. Commercially sourced LiDAR data with 1m resolution was utilised for the terrain analysis and hydraulic modelling for most of the site. For the remaining areas where 1m LiDAR was not captured, ELVIS (Geoscience Australia, 2015) 5m grid LiDAR was used as a substitute. To model the runoff within the hydraulic model boundary, the Rain on Grid (RoG) method was adopted to evenly apply rainfall to all cells within the model boundary.

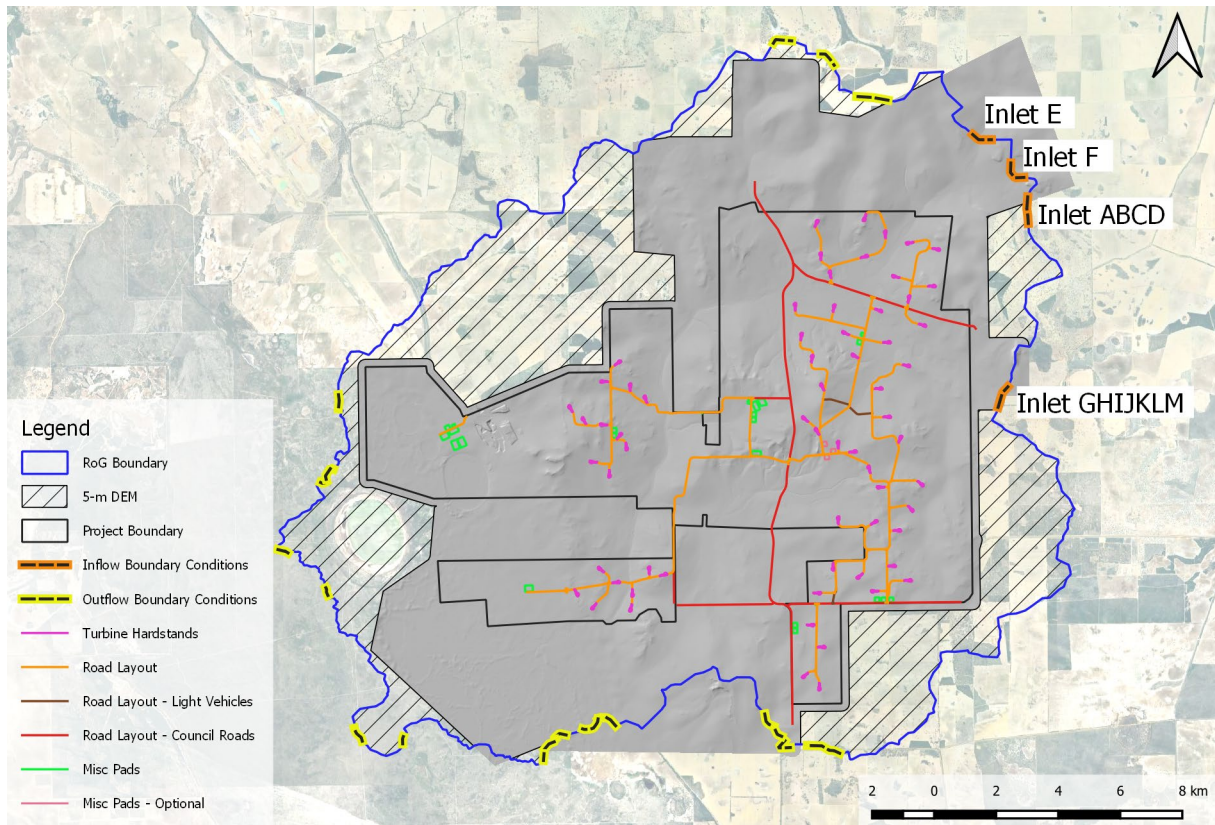


Figure 4: Hydraulic Model Boundary and Key Modelling Items

This section discusses the parameters and information used to develop the hydraulic model. The key model parameters are summarised in Table 3 overleaf.

Table 3: TUFLOW Model Parameters Summary

MODEL PARAMETERS	VALUE	COMMENTS
Model Topography	1m LiDAR survey DEM 5m for the areas where the 1m DEM was not available.	1m DEM provided by the client. 5m DEM sourced from ELVIS.
Model Solver	HPC adaptive timestep using GPU.	
Grid Size and Sub Grid Sampling (SGS)	16m	SGS Sample Frequency = 9
Inflow Boundaries	2d_rf boundary	A 2d_rf rainfall boundary over the entire site.
	2d_bc QT boundary. Four upstream inflows from RORB model results.	Peak flow rates from RORB were applied to include the catchments upstream of the project site.
Outflow Boundaries	2d_bc HQ boundary. 19 outflow boundary conditions were used	The distances are sufficiently far from the areas of interest to avoid boundary impacts.
Initial Water Level	2d_iwl	573 small reservoirs and ponds scattered across the catchment area were modelled using a 2d_iwl approach to provide a more conservative assessment by assuming the storages are all full.
1-d network	1d_nwk for culverts along Brand Highway was utilised.	Available data for existing culverts along the Brand Highway were sourced from the Main Roads WA ArcGIS Platform.
Manning's Roughness Assumption	Thick Vegetation: 0.1 Water Body: 0.03 Creek: 0.07 Paved Roads: 0.018 Buildings: 0.15 Light Vegetation: 0.06 Grassed Open Space: 0.04	Manning values employed align with the standard Melbourne Water values as described in their modelling technical specification. Noting that this project is being completed in Western Australia however, the MW technical specifications are widely accepted. Refer Figure 5.
Durations and Temporal Patterns	Various durations from 3 hours to 48 hours (3, 4.5, 6, 9, 12, 18, 24, 36 and 48 Hours) for the modelled AEP design rainfall events.	The model was run for all standard Point Temporal Patterns for durations up to and including 9 hours, and all Areal Temporal Patterns for durations greater than 9 hours (The area is greater than 75km ²).

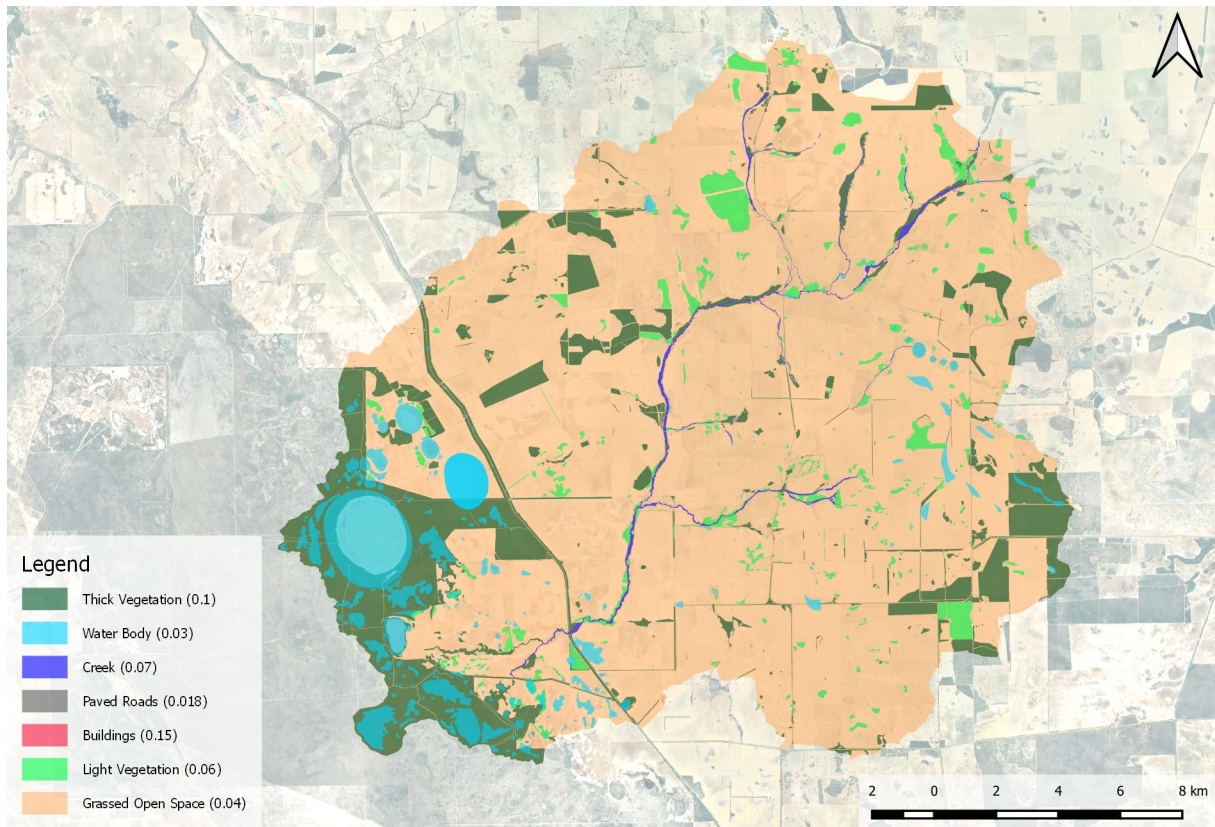


Figure 5: Material Roughness Layers within the Modelling Area (Values in Brackets Correspond to the Manning's n Coefficients)

3.1 Flood Model Results

The results for the 1% AEP flood event are discussed in this section. The flood mapping outputs for the 10%, 1% and 0.5% AEPs are included in Appendix A to Appendix C.

As noted in Table 3, the model was run for a range of durations and temporal patterns. The results were processed to create maximum median flood maps, which display the maximum results from the durations for the median values from the temporal patterns. The results in the flood maps show the critical design flood parameters at all locations across the modelled area.

The peak flood depth for the 1% AEP flood event is shown in Figure 6 below. This figure shows the proposed pads, access roads and hardstands which will be impacted by flood water.

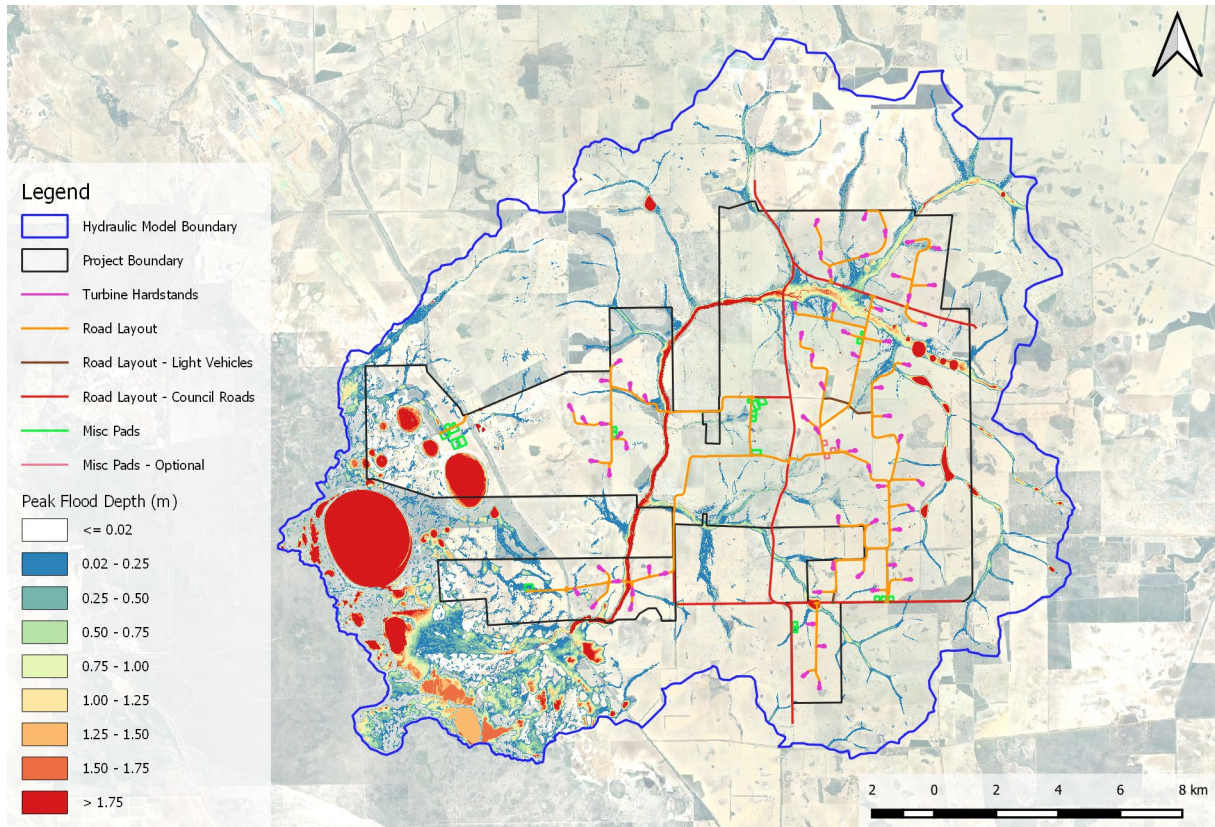


Figure 6: Peak Flood Depth for 1% AEP for the Existing Condition

The Peak flood level, velocity, and hazard category for the 1% AEP are also shown in Figure 7 to Figure 9 below.

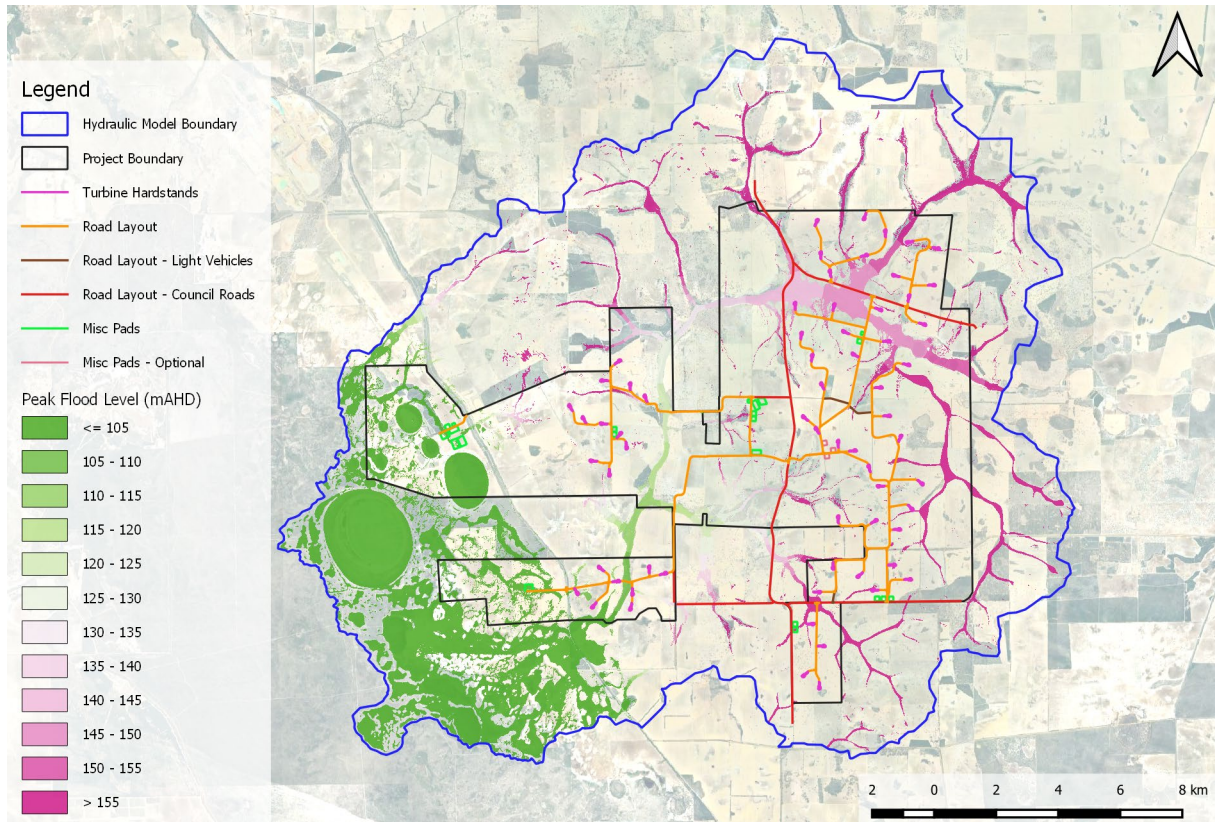


Figure 7: Peak Flood Level for 1% AEP for the Existing Condition

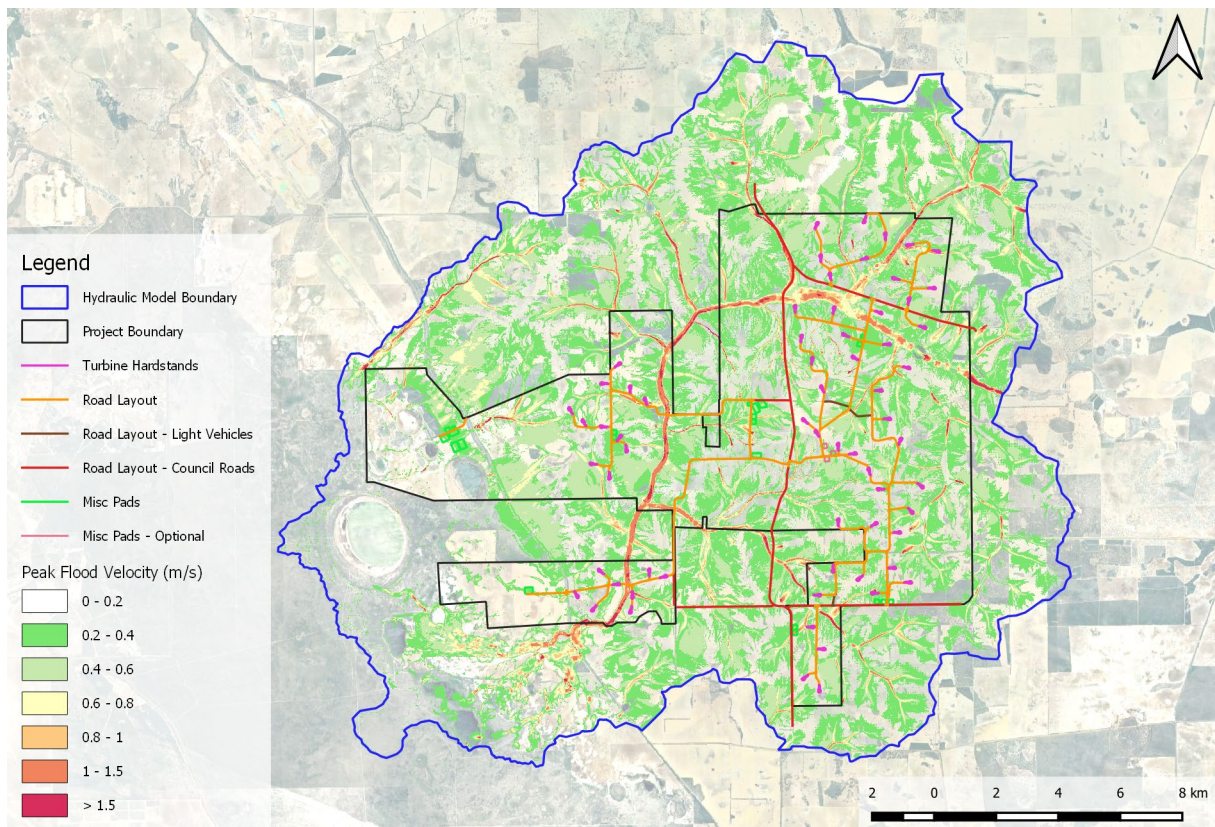


Figure 8: Peak Flood Velocity for 1% AEP for the Existing Condition

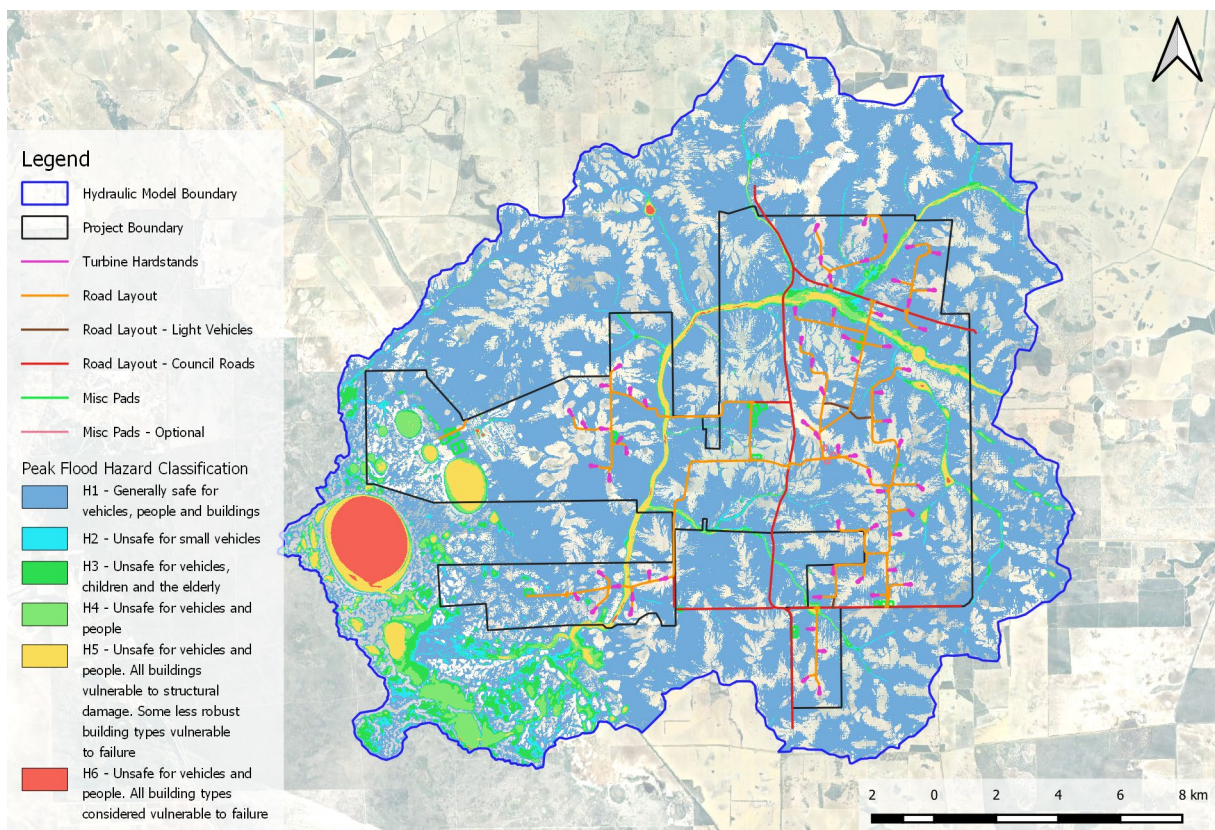


Figure 9: Peak Flood Hazard Category for 1% AEP for the Existing Condition

4 MODELLING ASSUMPTIONS & LIMITATIONS

In this flood study, certain limitations have been identified, and specific assumptions have been made that are integral to the scope and methodology of the analysis. These include factors such as:

- Flood conditions beyond the 1m LiDAR DEM which utilised 5m LiDAR may not be accurately captured by the flood model due to the DEM's low resolution.
- It was assumed that no existing drainage networks are present within the proposed site and within the upstream catchment.
- All storages within the catchment, were assumed to be at full capacity to adopt a conservative approach. This approach was adopted to model in a worst-case scenario where all storages are full and any additional flow is allowed to overtop the storage areas, thus maximising the flood extent.
- Existing culverts modelled are limited to available data on the Main Roads WA ArcGIS Platform, which are only culverts along Brand Highway.
- The model does not assess the impact of any proposed wind farm drainage or road infrastructure.
- The pre-burst depths are not available on the AR&R Data Hub for the 0.5% AEP event. 75% pre-burst depths and resulting duration loss factors for pre-burst for the 1% AEP event were used for the simulation of the 0.5% AEP event.

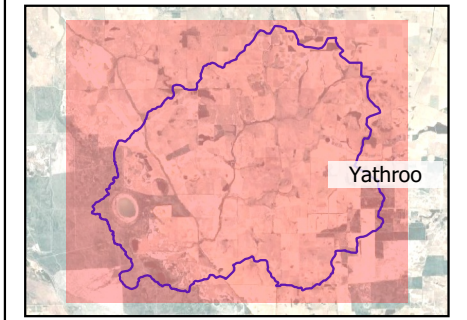
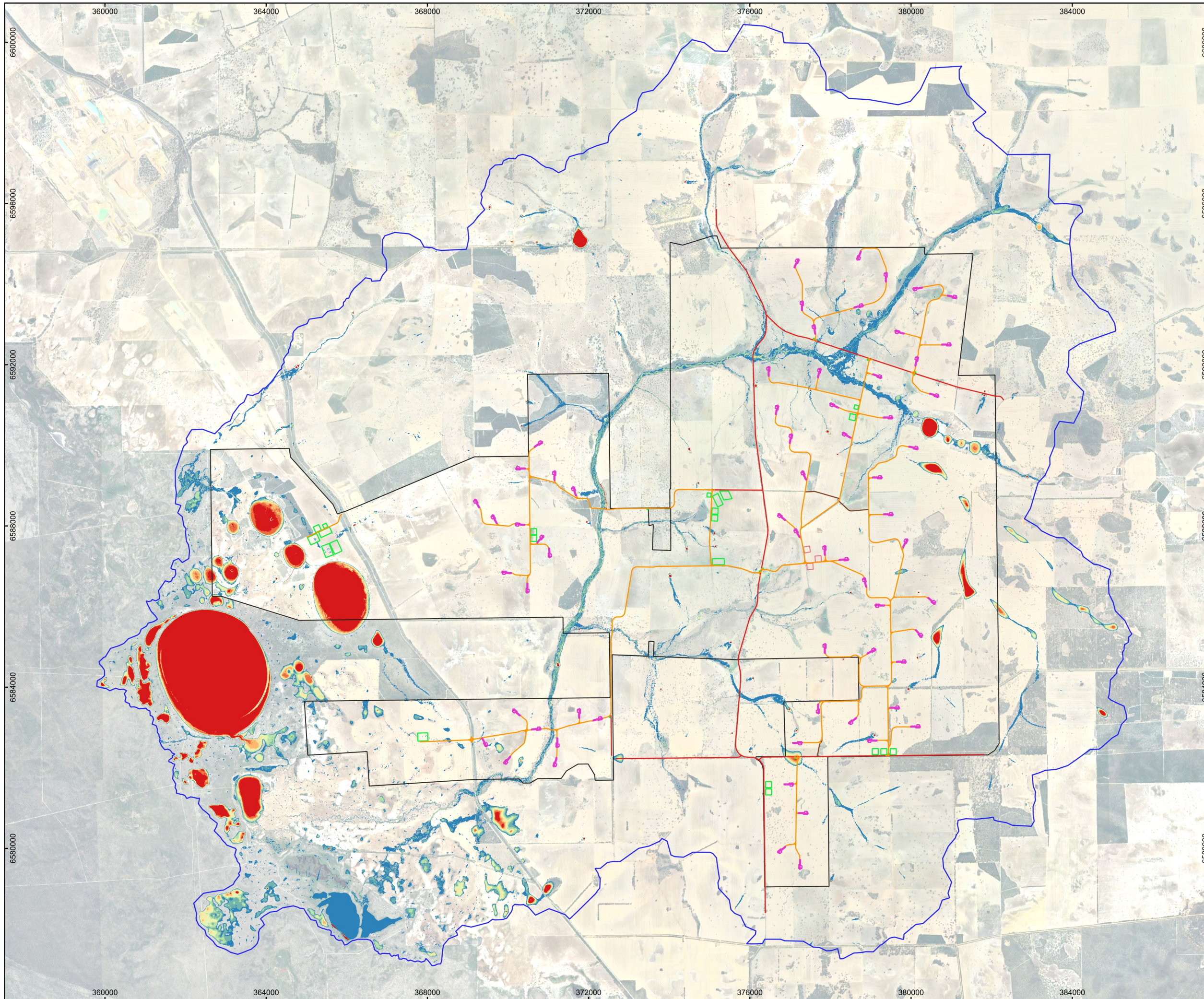
5 CONCLUSION

This flood modelling study has been undertaken for the Yathroo Wind Farm for the 0.5%, 1% and 10% Annual Exceedance Probability (AEP) design rainfall events. A combination of RORB hydrological modelling and 1D/2D TUFLOW modelling has been used for the flood modelling. The models were developed in accordance with the *AR&R 2019 Guidelines*.

The outcomes of the modelling study are presented as flood maps. The results can be used to inform the design of the structures associated with the proposed wind farm project.

APPENDIX A
10% AEP FLOOD MAPS





LEGEND

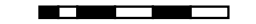
- Hydraulic Model Boundary
- Project Boundary
- Turbine Hardstands
- Road Layout
- Road Layout - Light Vehicles
- Road Layout - Council Roads
- Misc Pads
- Misc Pads - Optional

Peak Flood Depth (m)

- ≤ 0.02
- 0.02 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- 1.50 - 1.75
- > 1.75



450 0 450 900 1,350 1,800 m



Scale 1:90000 on A3

Coordinate System: GDA 2020 MGA Zone 50

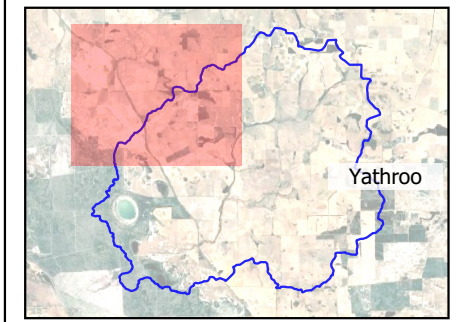
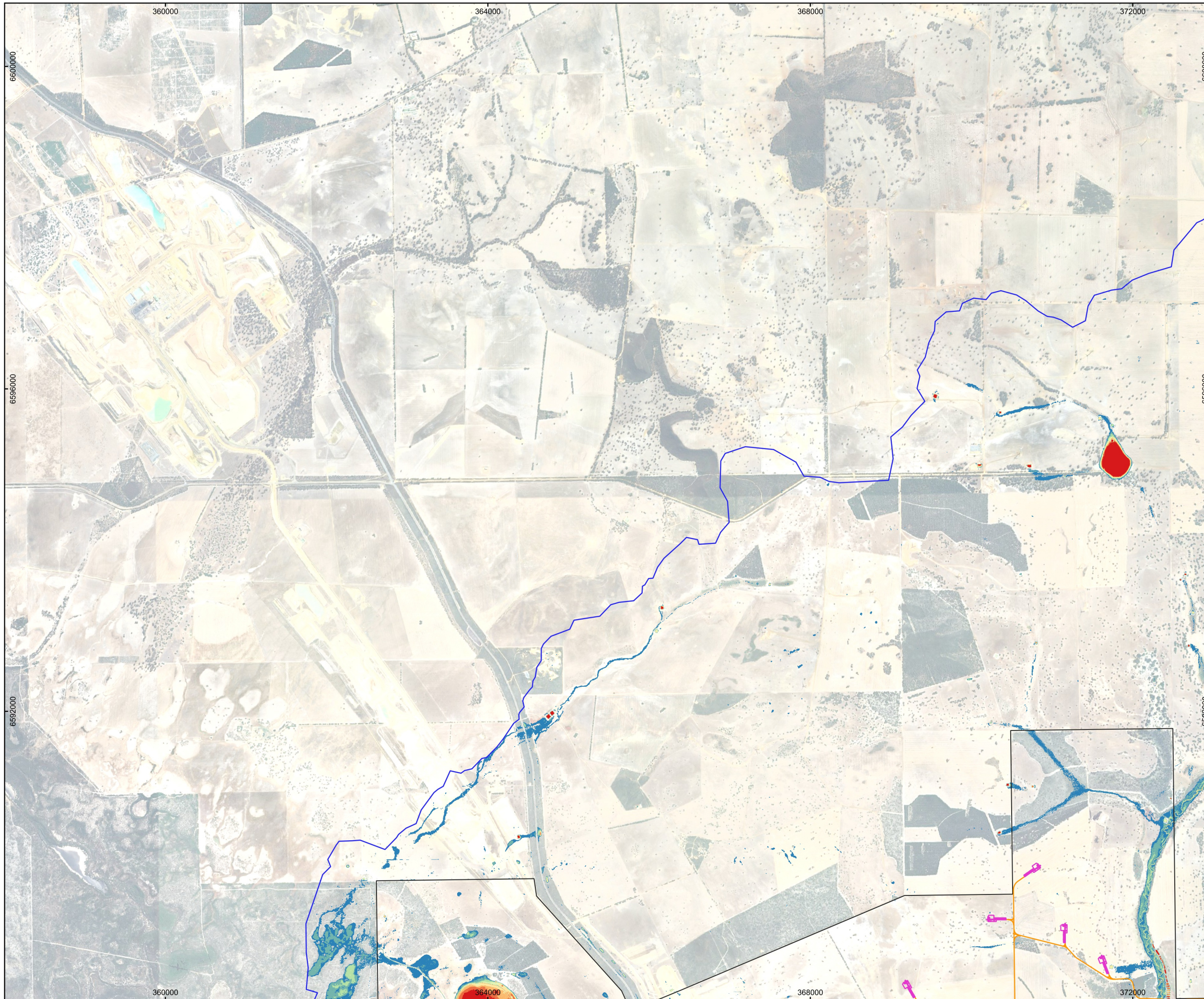
WGA

Map A01 - 1
Yathroo Wind Farm
Project Number: 240913





Peak Flood Depth
10% AEP
Exsiting Conditions

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.










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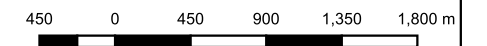


LEGEND

-  Hydraulic Model Boundary
-  Project Boundary
-  Turbine Hardstands
-  Road Layout

Peak Flood Depth (m)

-  <= 0.02
-  0.02 - 0.25
-  0.25 - 0.50
-  0.50 - 0.75
-  0.75 - 1.00
-  1.00 - 1.25
-  1.25 - 1.50
-  1.50 - 1.75
-  > 1.75



Scale 1:45000 on A3

Coordinate System: GDA 2020 MGA Zone 50

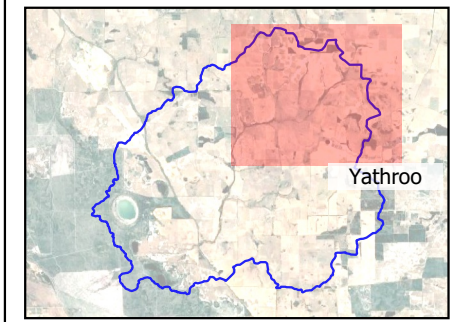
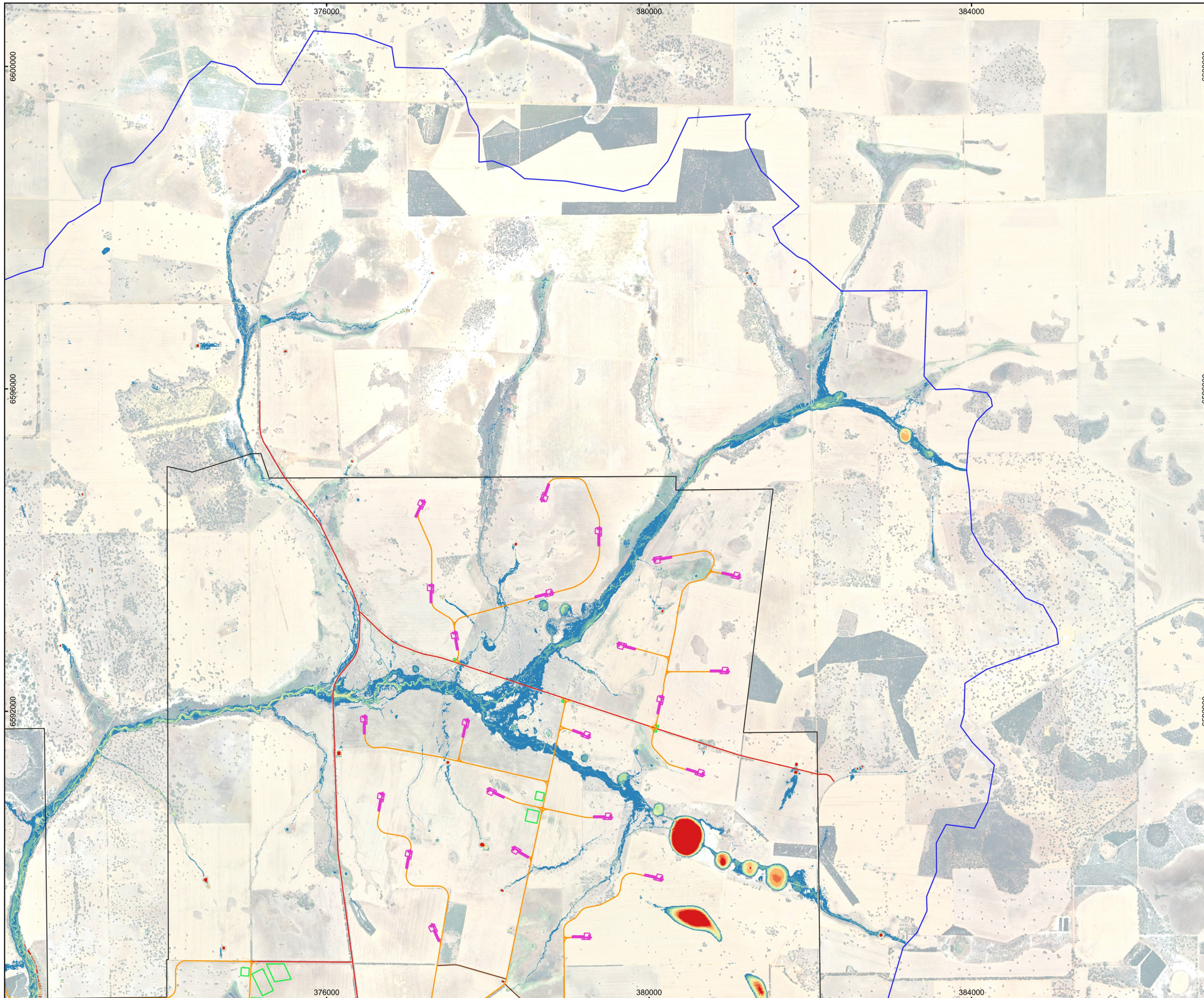
WGA

Map A01 - 2
Yathroo Wind Farm
Project Number: 240913

Peak Flood Depth
10% AEP
Existing Conditions

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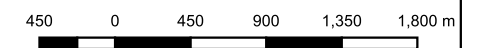


LEGEND

- Hydraulic Model Boundary
- Project Boundary
- Turbine Hardstands
- Road Layout
- Road Layout - Light Vehicles
- Road Layout - Council Roads
- Misc Pads

Peak Flood Depth (m)

- <= 0.02
- 0.02 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- 1.50 - 1.75
- > 1.75



Scale 1:45000 on A3

Coordinate System: GDA 2020 MGA Zone 50

WGA

Map A01 - 3
Yathroo Wind Farm
Project Number: 240913

Peak Flood Depth
10% AEP
Exsiting Conditions

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