Elaine Solar Farm Flooding Impact Assessment

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Template 2.8.1

Contents

List of Figures

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List of Tables

Abbreviations

Abbreviation	Description
2D	Two dimensional
AEP	Annual Exceedance Probability
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DEM	Digital Elevation Model
ELA	Eco Logical Australia Pty Ltd.
HEC-RAS	Hydrologic Engineering Centre River Analysis System
IFD	Intensity-Frequency-Duration
SF	Solar Farm

Executive Summary

Eco Logical Australia Pty Ltd (ELA) were engaged by Urbis to assess potential flood impacts at the Elaine Solar Farm Project Site associated with existing hydrologic conditions under the 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP flood events, as well as proposed conditions under the 1% AEP scenario, to inform civil design recommendations with regard to flood impact mitigation.

Hydrologic and hydraulic modelling of existing conditions at the Project Site were undertaken using the RORB and HEC-RAS software packages to determine flood extents, flood levels and flow velocities associated with each target AEP rainfall design scenario. The modelling methods were calibrated using best initial loss estimates based on previous similar modelling and RFFE analysis for the region.

The existing conditions' flood depths showed that, in general, the flows are concentrated to the waterways and defined overland flow paths in the region with sufficient terrain relief to limit the amount of sheet flow.

Based on the flood modelling results, the primary flood features comprise unnamed tributaries to Williamson Creek located within the Project Site boundary for both portions of the Site (Windy and Peters), which discharge at their junction with Williamson Creek approximately 500 m north-west of the Project Site.

Depths in the inundation areas are generally shallow (< 1 m) under each AEP scenario and will be able to pass under the arrays. Although some proposed access tracks intersect the inundation area, the modelled flood extent and maximum depths indicate likelihood that these will remain passible under flooded conditions. The modelled velocities under existing conditions show that, in general, velocities across the site tend to be low (< 0.5 m/s) and below the threshold (< 2 m/s) where rock armouring to protect waterways and features is required.

Modelling of proposed conditions showed that flood impacts are likely along the north-eastern edge of the proposed south Peters access road. It is recommended to include suitable culverts where flow paths intersect the proposed access road, including on the north-western side of the proposed access road, to allow flows to discharge into the waterway running between the Windy and Peters Project Site boundaries.

Detailed design should re-examine the flood levels and impacts from this assessment to determine specific flood depths and areas of inundation and appropriate measures to allow water to pass through the Project Site and surrounds.

1. Introduction

Eco Logical Australia Pty Ltd (ELA) has been engaged by Urbis on behalf of Elgin Energy to assess hydrological conditions associated with the existing conditions under 10%, 1%, 0.5%, 0.2% and 0.1% Annual Exceedance Probability (AEP) flood events, as well as proposed conditions under the 1% AEP scenario, at the proposed Elaine Solar Farm (SF) located approximately 5 km north-west of Elaine, Victoria (Figure 1-1).

The objective of the flood impact assessment was to provide:

1. Estimated peak flow rates for the specified AEP storm events (see Section 5.1).
2. Estimated peak flood depths and velocities for the specified AEP storm events (see Section 5.2).
3. Recommendations to mitigate flood impacts based on proposed conditions (see Section 5.2.3).

This report details the modelling approach and modelling results that underpin the flood impact assessment.

1.1. Scope of work

The scope of work included:

- review and collation of data sourced and applied as part of the assessment (Section 2)
- hydrologic modelling to determine flow rates and verify the hydraulic modelling (Section 3)
- hydraulic modelling to determine water levels and velocities (Section 4)
- presentation and review of hydrologic and hydraulic modelling results (Section 5)
- assessment of flood impact results in the context of the Project Site (Section 6).

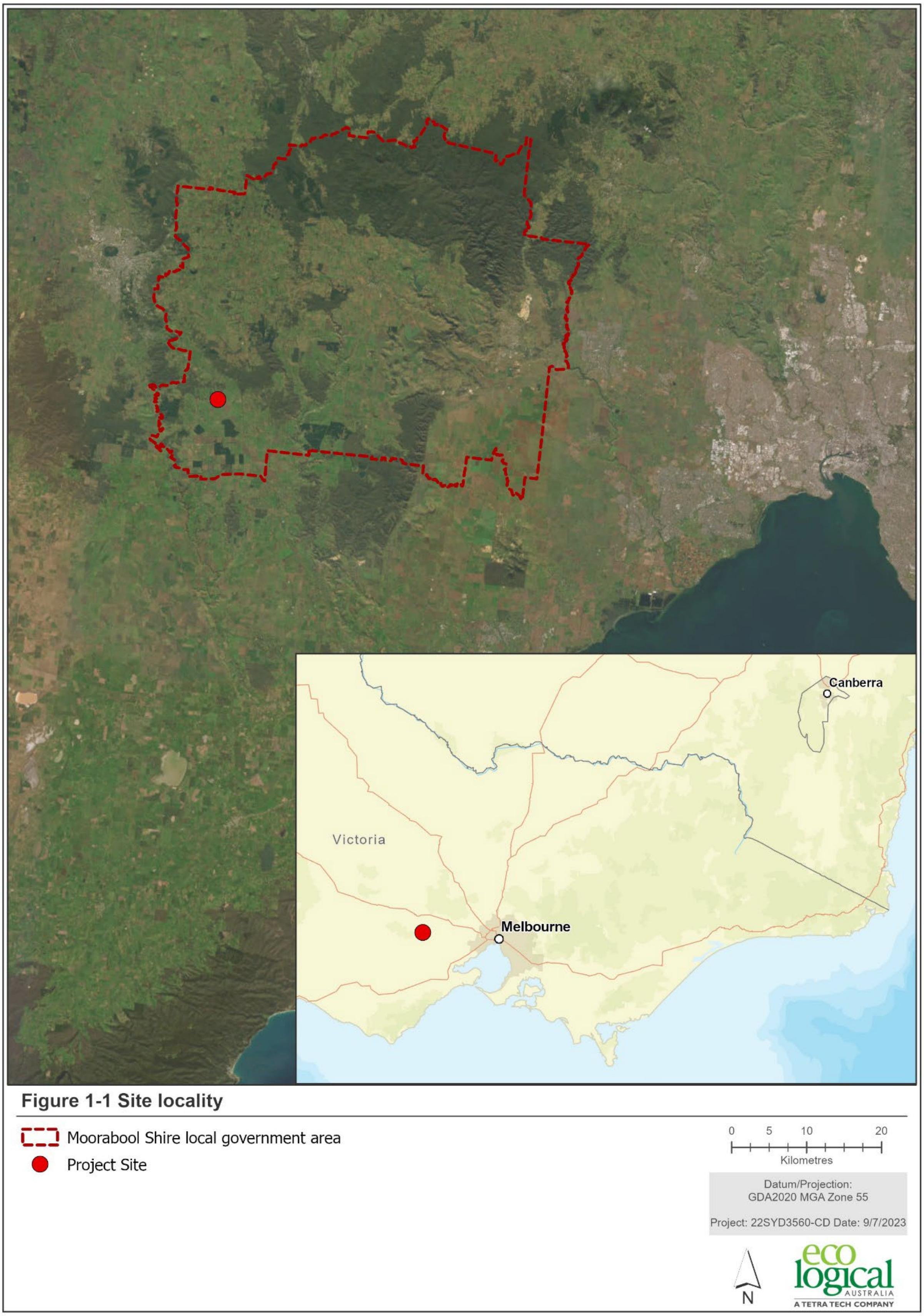

Figure 1-1 Locality map

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2. Data requirements

The following datasets were sourced for use in this assessment:

- Digital Elevation Model (DEM) to represent the watershed (catchment) that drains the site and any adjacent waterways.
- Site survey within the Project Site boundary.
- Development footprint for the Project Site.
- Gauged rainfall data representing the rainfall falling on the catchment at a sub-daily time step for use in calibration.
- Gauged flow data representing flows in the catchment for calibration of flow rates.
- Bureau of Meteorology (BoM) Intensity Frequency Duration (IFD) data representing the rainfall intensities for design rainfall events for the specified catchment.
- Australian Rainfall and Runoff (AR&R) information for rainfall patterns and loss information for use in the flow rate modelling.
- Regional Flood Frequency Estimation (RFFE) modelling to validate the flow rate model results for design storm events.

2.1. Digital Elevation Model (DEM)

A regional DEM was sourced to determine runoff catchments for waterways that drain to or through the Project Site. Regional elevation information was sourced from the Australian Government's Intergovernmental Committee on Surveying and Mapping (ICSM) Elevation and Depth – Foundation Spatial Data (ELVIS) website. The most detailed DEM available that covered the regional catchment area relevant to the Project Site was at a resolution of 0.5 metres (m) by 0.5 m.

The DEM used for hydrologic modelling is illustrated in Figure 2-1.

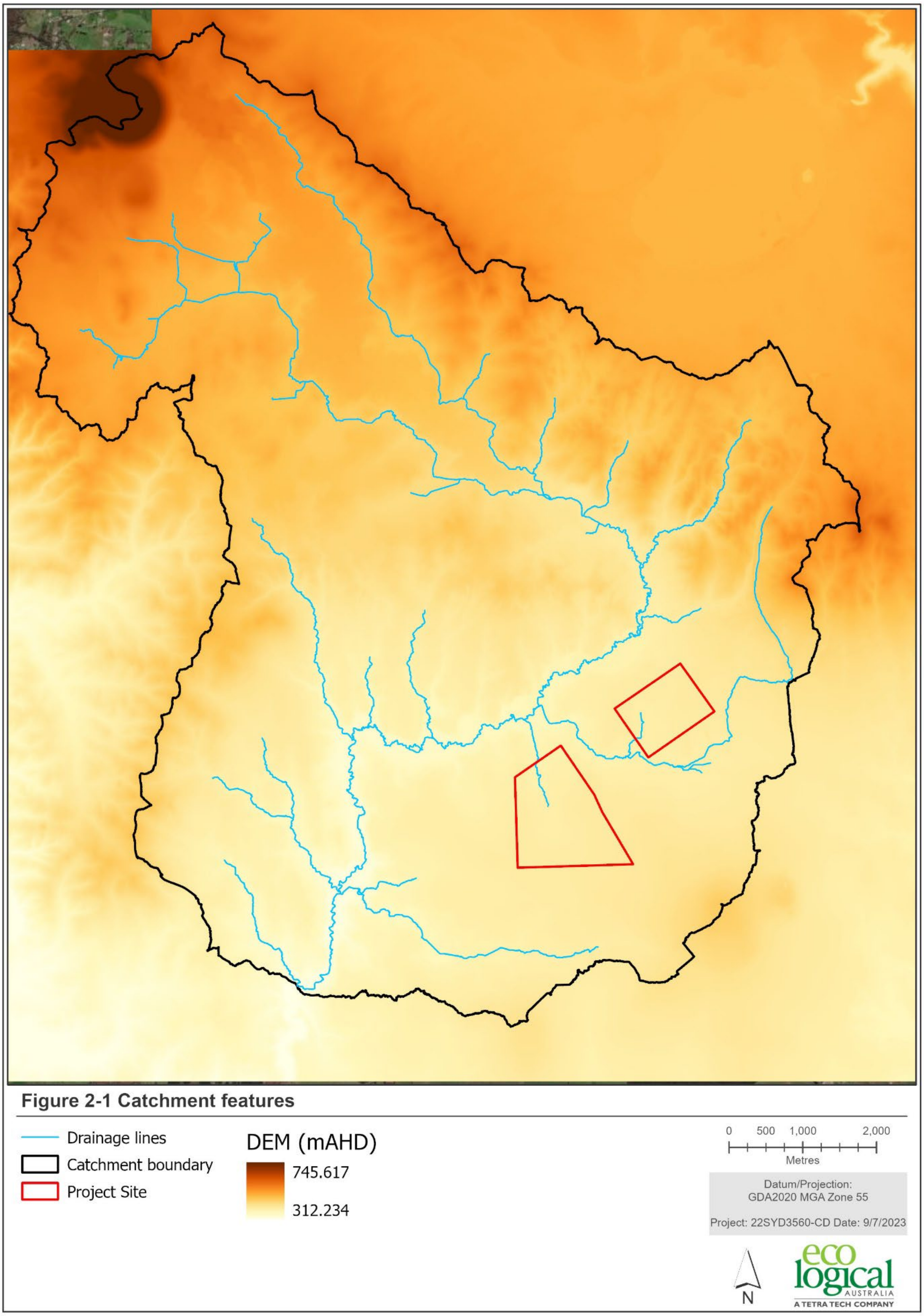

Figure 2-1 Catchment features

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2.2. Observed streamflow

Observed streamflow information was available at the Mount Mercer gauge on the Leigh River (gauge number 232215A), located approximately 18 km south-west of the Project Site (-37.8107˚ S, 43.9184˚ E). Data was sourced from the Bureau of Meteorology (BoM) from 23 May 2006 to 23 May 2016 as shown in Figure 2-2.

Although useful in providing context for expected peak flows at the Project Site, the Williamson Creek catchment relevant to the Project Site is considerably smaller (~91 km^2) than the Leigh River catchment and consists of higher Strahler order streams. Therefore, the observed flows at the nearest available gauge station were not considered suitable for calibration of the RORB model (Section 3.2.3).

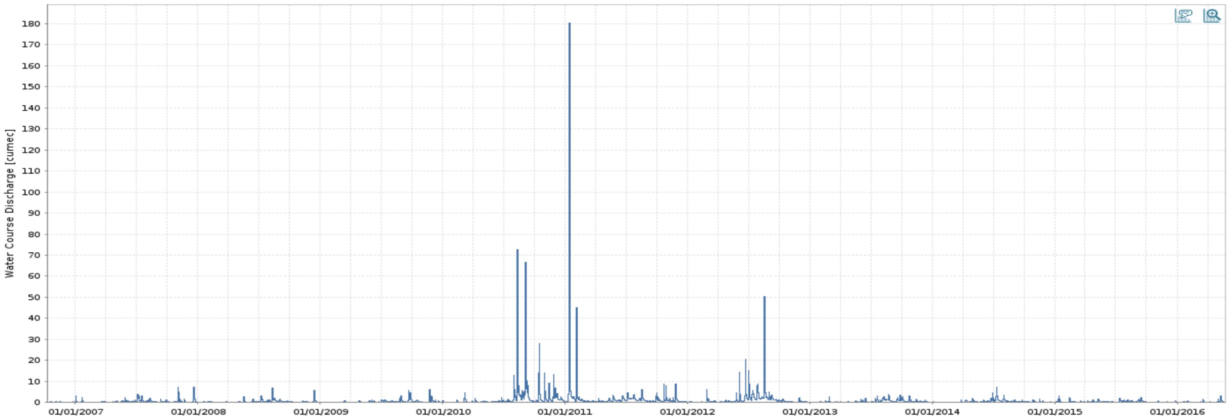

Figure 2-2 Observed streamflow at the Leigh River at Mount Mercer gauge

2.3. Observed rainfall

Observed rainfall information was available at the Mount Mercer gauge on the Leigh River (gauge number 232215A). Data was sourced from the BoM from 23 May 2006 to the retrieved date (5 September 2023) as shown in Figure 2-3.

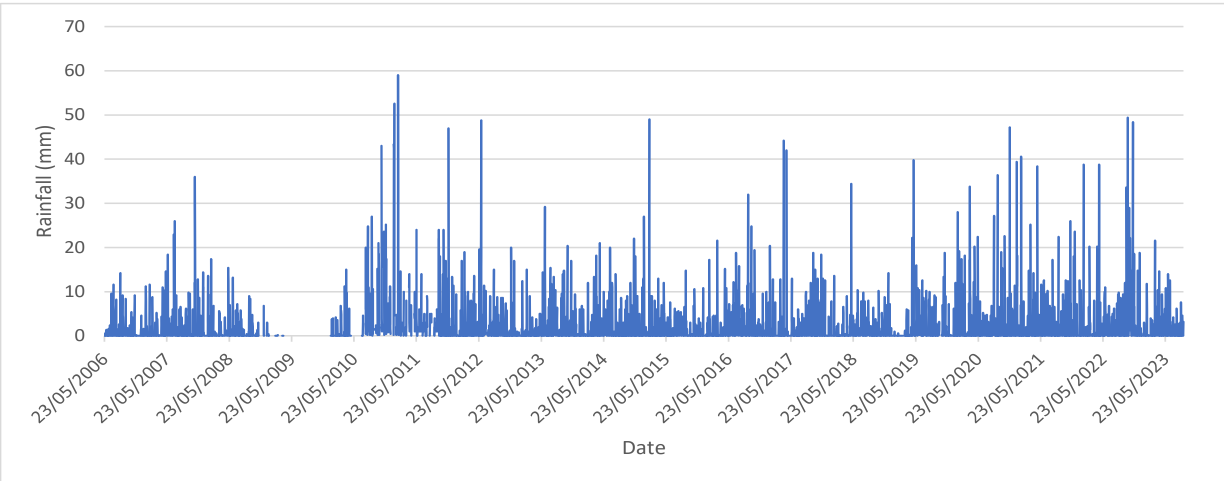

Figure 2-3 Observed daily rainfall at the Leigh River at Mount Mercer gauge

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2.4. Intensity-Frequency-Duration (IFD) information

The IFD information was sourced from the BoM IFD curves (retrieved 5 September 2023) at coordinate 37.7100˚ (S) and 143.9684˚ (E), at the centroid of the contributing catchment area (Figure 2-1). IFD information is required to produce design (e.g. 1% AEP) flow and flood events from the modelling suite. The IFD data is presented in Appendix A1.

2.5. Australian Rainfall and Runoff (AR&R) data hub information

Information required for parameterising the models was sourced from the AR&R data hub[1] (retrieved 5 September 2023) at the coordinate location specified in Section 2.2. Relevant parameters were sourced from the South-East Coast (Victoria) Division, with the sub-region being the Barwon River-Lake Corangamite. Retrieved parameters included:

- Initial loss of 24.0 mm and continuing loss of 4.5 mm/hr.
- Point and areal temporal patterns. Available durations of the point and areal temporal patterns, compared with the IFD durations, are shown in Appendix A2.
- Areal reduction factor (ARF) parameters from the South East Coast (Victoria) Division:
  - a = 0.158
  - b = 0.276
  - c = 0.372
  - d = 0.315
  - e = 0.000141
  - f = 0.41
  - g = 0.15
  - h = 0.01
  - I = -0.0027.

AR&R data hub information imported into the flow modelling software is provided in Appendix A3.

2.6. Regional Flood Frequency Estimation (RFFE) Modelling

The RFFE model[2] was run on 4 September 2023 and used to provide design flow comparison for the RORB model (Section 3.2.3) for the full catchment domain (Figure 2-1). This model uses information from nearby similar catchments to provide an estimation of the peak flow rates. The details required for this are:

- Catchment outlet: 143.9461° (E) and -37.7611° (S).
- Catchment centroid: 143.9684° (E) and -37.7010° (S).
- Catchment area: 91 km^2

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[1] http://data.arr-software.org

[2] http://rffe.arr-software.org

The expected RFFE peak flows and upper and lower confidence limits are presented in Figure 2-4 RFFE analysis is provided in Appendix A4.

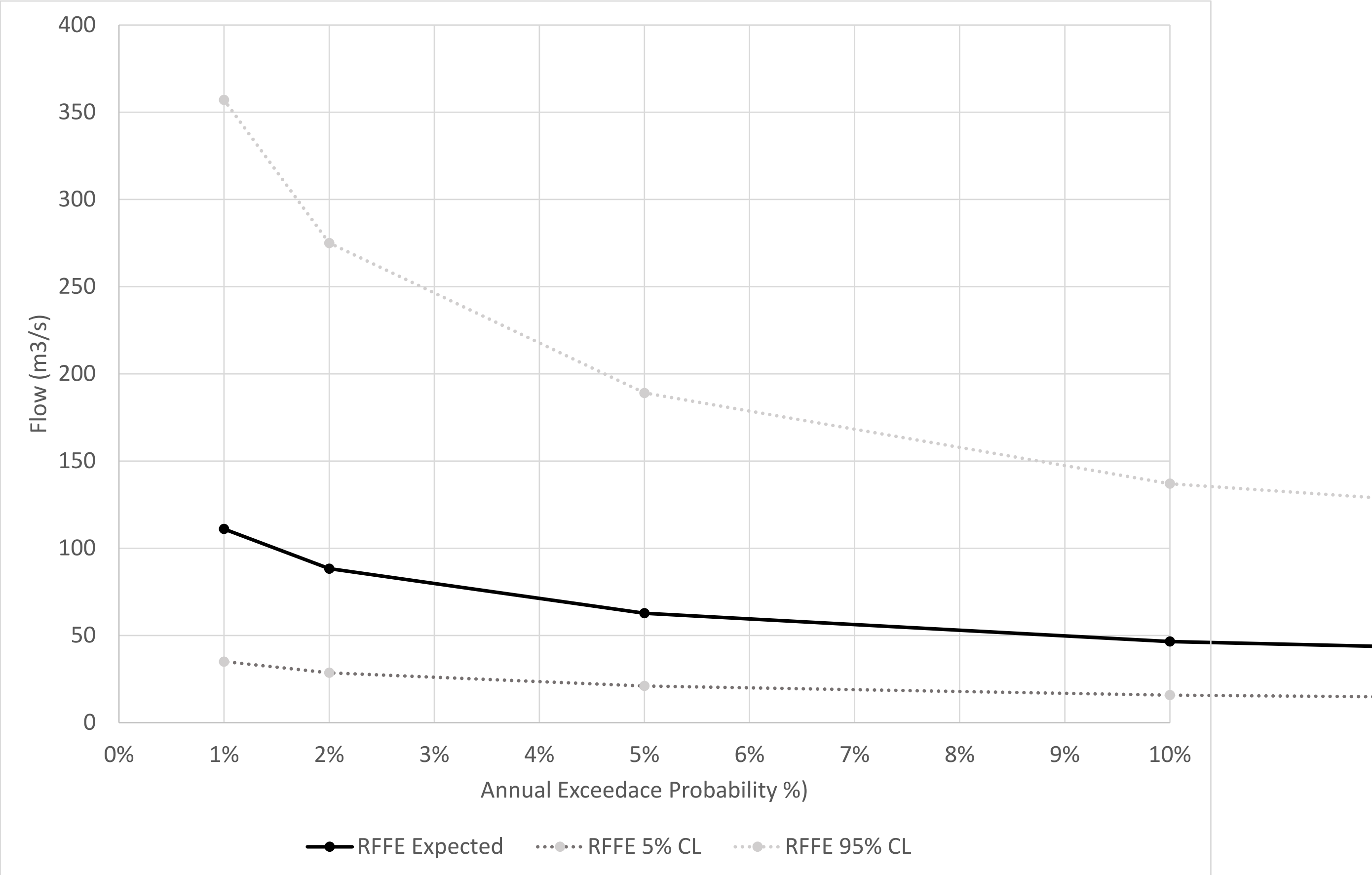

Figure 2-4 RFFE flow estimates including 5% and 95% confidence intervals

3. Hydrologic modelling

This section outlines the hydrologic model approach for determining rainfall-runoff relationships at the Project Site. The flow rate modelling was undertaken using the RORB (version 6.49) software package[3] to determine sub-catchment flows for the region shown in Figure 2-1. The resulting peak flows were used as inputs to the subsequent water level and velocity modelling for each design AEP scenario (10%, 1%, 0.5%, 0.2% and 0.1%) (Section 3.2.3). The RORB runoff routing software was used to calculate flood hydrographs from rainfall for input to the HEC-RAS hydraulic modelling package (see section 3.2.3).

3.1. Catchment and drainage

The DEM presented in Figure 2-1 was used as input to create the overall catchment boundary, sub-catchment boundaries and drainages for use in the RORB modelling process. The ArcHydro add-in to ArcGIS was applied to generate the catchment, sub-catchments and drainage line features.

3.2. Runoff model setup

3.2.1. Catchment input file

The RORB model requires a catchment file to specify how rainfall is applied to the area of interest and how water is routed through the catchment to the outlet. An add-in to ArcGIS, ArcRORB[4], was used to develop shapefiles (Figure 3-1) that were converted into the catchment input file for RORB (Figure 3-2).

The modelled catchment relevant to the Project Site is assumed to be in a natural condition (i.e. no artificially formed waterways/channels/drains) and all reach types within the catchment file were set to ‘Natural’. The ‘fraction impervious’ for the model domain was set to zero. The fraction impervious in this context refers to impervious areas directly connected to waterways. Any impervious regions of the model (e.g. roads) were considered unlikely to be directly connected to the streamlines and any areas that are connected would be such a small proportion (<0.1%) of the overall catchment that they would not affect the modelled outcome.

Reach and sub-catchment details along with the catchment file layout are outlined in Appendix B.

[3] Monash University and Hydrology and Risk Consulting https://www.harc.com.au/software/rorb/, version 6.45
[4] https://www.harc.com.au/software/arcrorb/

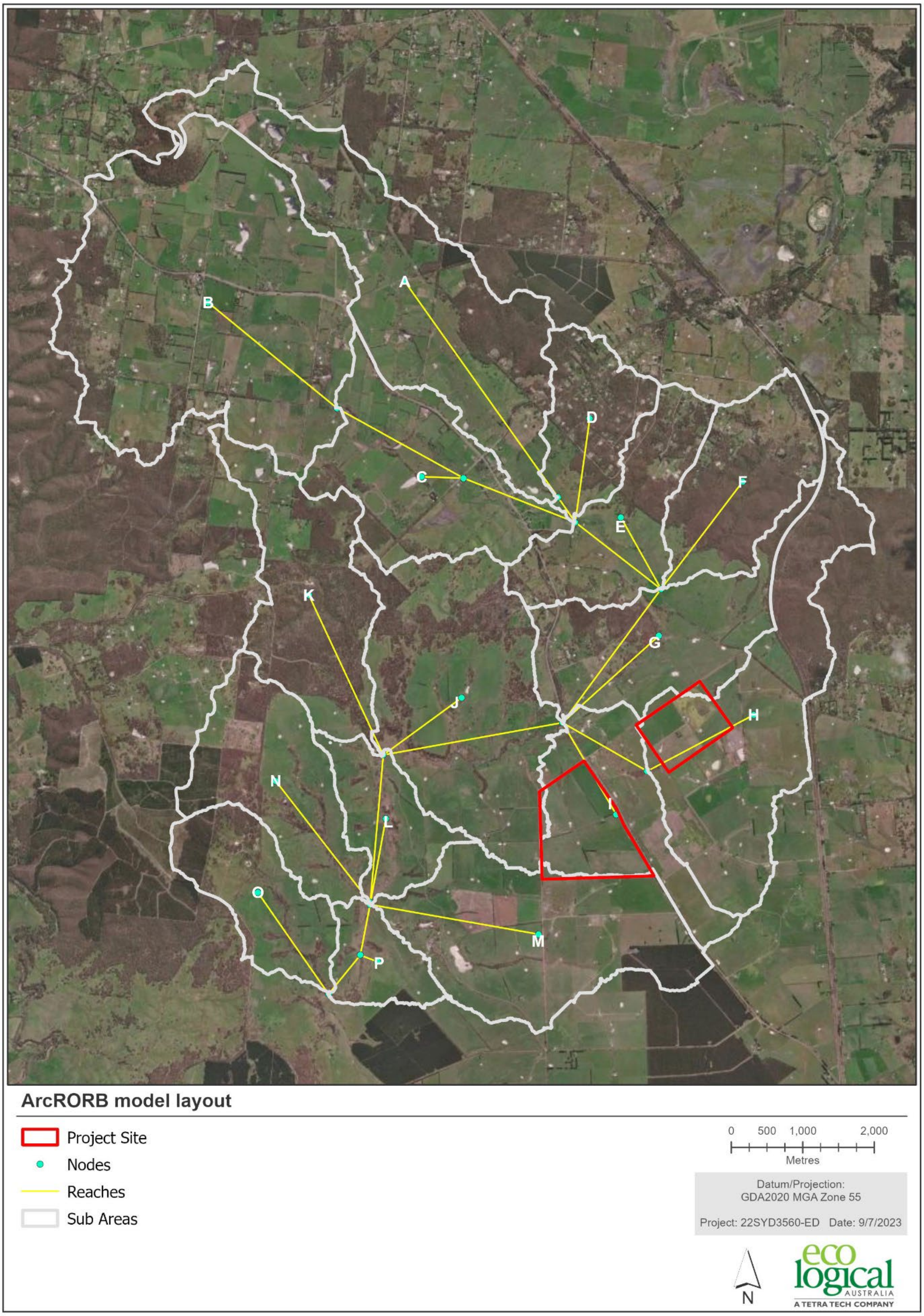

Figure 3-1 ArcRORB model layout

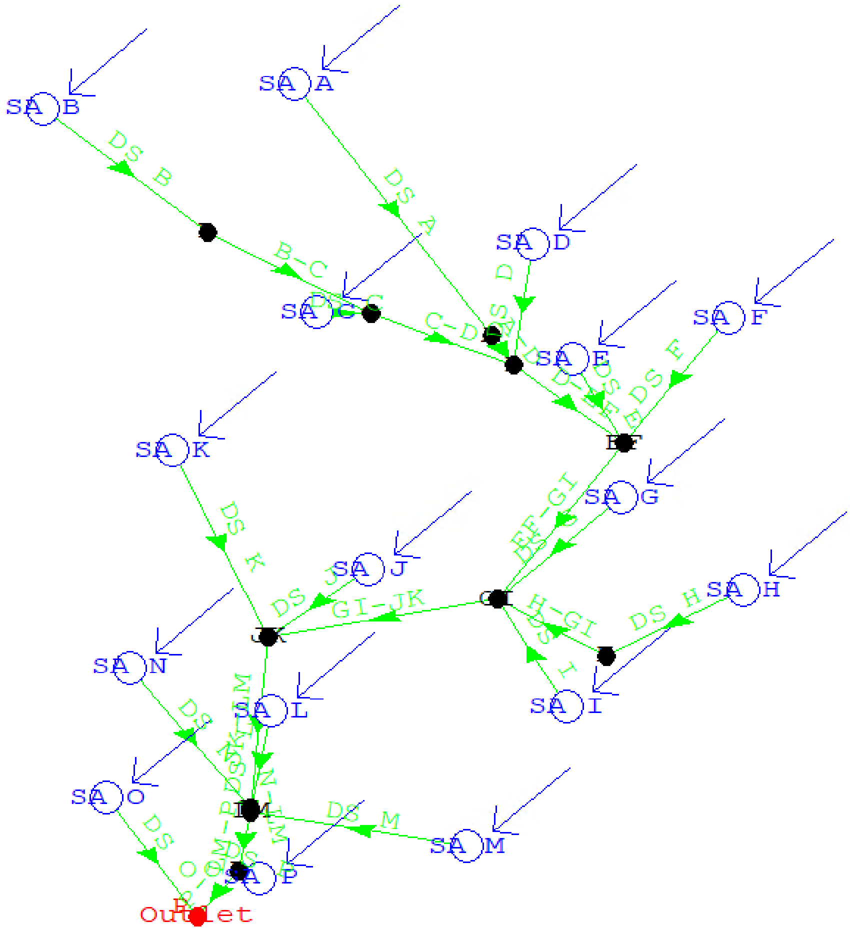

Figure 3-2 RORB catchment structure

3.2.2. Design storm parameter file

Parameter files were created for the RORB model for design storm simulations. The following setup parameterisation was used:

- Separate catchment and generated design storm
- RORB catchment (Figure 3-2) file
- Storm file corresponding to the event being modelled
- Single set of routing parameters
- Initial loss / continuing loss model
- DESIGN run
- Parameters of m, kc, IL and CL calibrated to RFFE (Section 3.2.3):
  - m = 0.8
  - Kc = 16.5
  - IL = 10 mm
  - CL = 2 mm/hr

- Print at nodes GI (approximately 500 m hydraulically downgradient of the Project Site to the north-west) and Outlet (approximately 10 km hydraulically downgradient of the Project Site to the south-west).

The setup for the design storm simulations run in RORB is shown in

Table 3-1. The Monte Carlo framework was used to examine the impact of different temporal patterns upon the design flow rate results.

Table 3-1 RORB parameter file specification for design storms

Parameter file section	Detail
Data Hub Files	• Data hub file as discussed in Section 2.5. • Temporal patterns as discussed in Section 2.5. • Use regional losses is unchecked. • Use ARFs from file is checked.
Design Rainfall Specification	• A user defined IFD as discussed in Section 2.4. • Monte Carlo simulation from 10 minute to 168-hour durations. • Default time increments of 200. • Uniform areal pattern. • No pre burst. • Constant losses.
Parameter Specification	• Adjusted k_c of 16.5. • Default m of 0.8. • Adjusted IL of 10 mm. • Adjusted CL of 2 mm/hr.
Monte Carlo Specification	• Number of rainfall divisions: 50 (default). • Number of samples per division: 20 (default). • Temporal patterns as described above. • Monte-Carlo sample initial loss.

3.2.3. Calibration

As observed flows relevant to the Williamson Creek catchment and Project Site were available for calibration of the RORB model, the hydrologic model was calibrated to the RFFE analysis to fit the expected peak flow curve within the confidence limits specified.

The resulting calibration parameters shown in Table 3-2 with routing parameter and loss sensitivity analysis presented in Figure 3-3 and Figure 3-4, respectively. Comparing the IL and CL values with those from AR&R (24 mm and 4.5 mm/hr, respectively) showed that a reduced IL and CL were required to calibrate the model to expected RFFE results for the catchment.

Table 3-2 Resulting RORB calibration parameters

Event	m	k_c	IL (mm)	CL (mm)
Adopted for design events	0.8	16.5	10	2

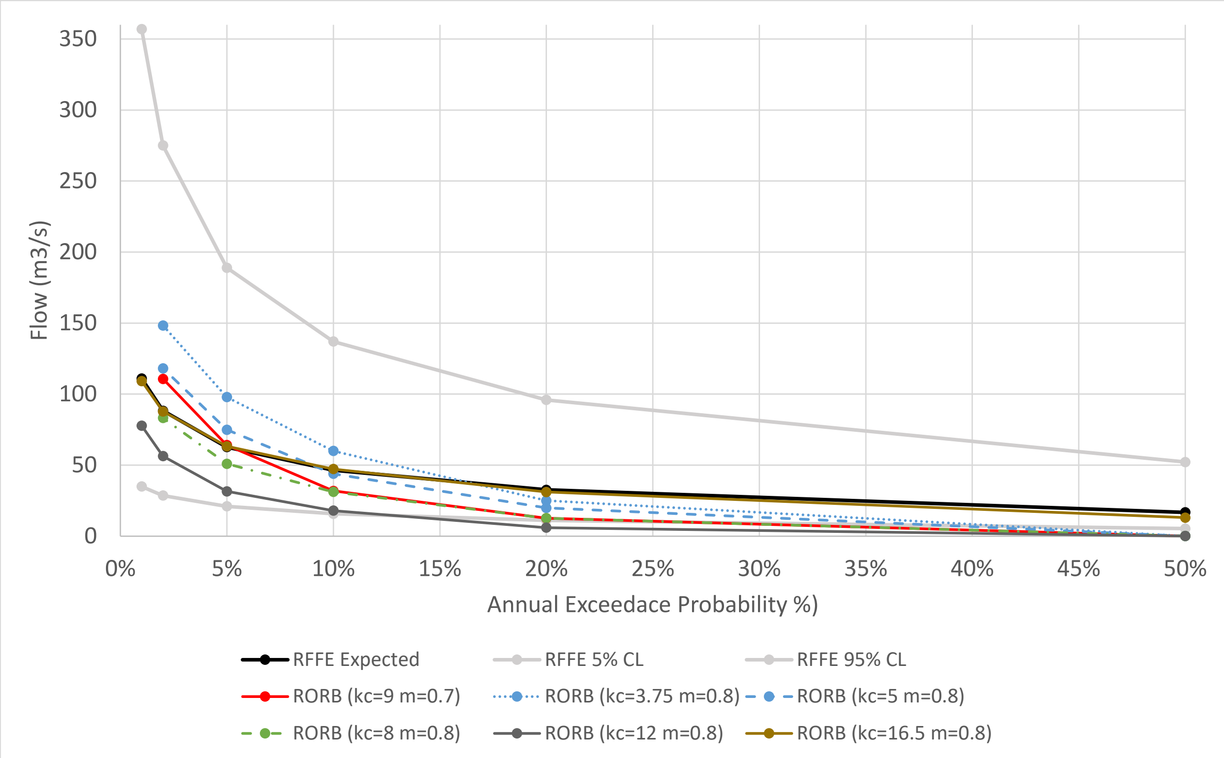

Figure 3-3 RORB routing parameter sensitivity analysis

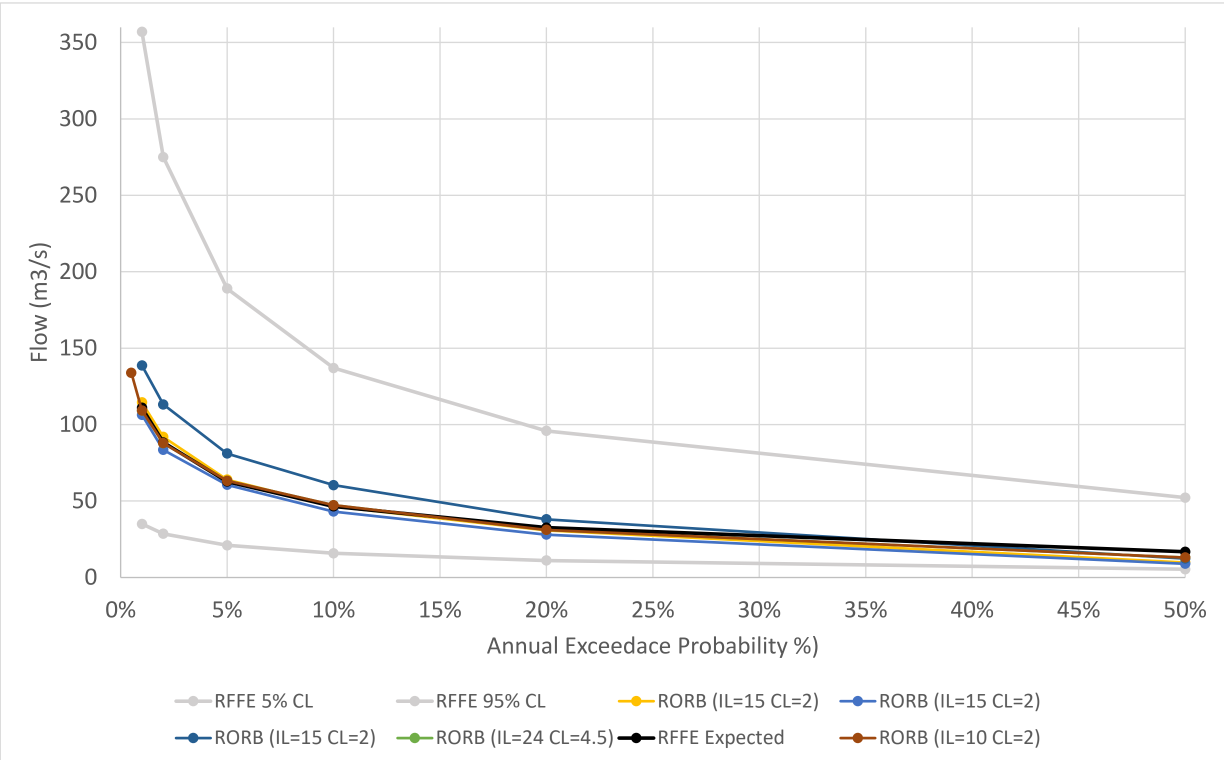

Figure 3-4 RORB loss sensitivity analysis

Figure 3-5 shows the RORB model results calculated relative to the specified catchment size (91 km^2) compared to weighted design event results for nearby gauged catchments. The results show that the RORB model fits within the middle of the nearby gauged catchment results. The storm design events are therefore considered applicable for use in providing target peak flow rates for the hydraulic modelling results in Section 5.1.2.

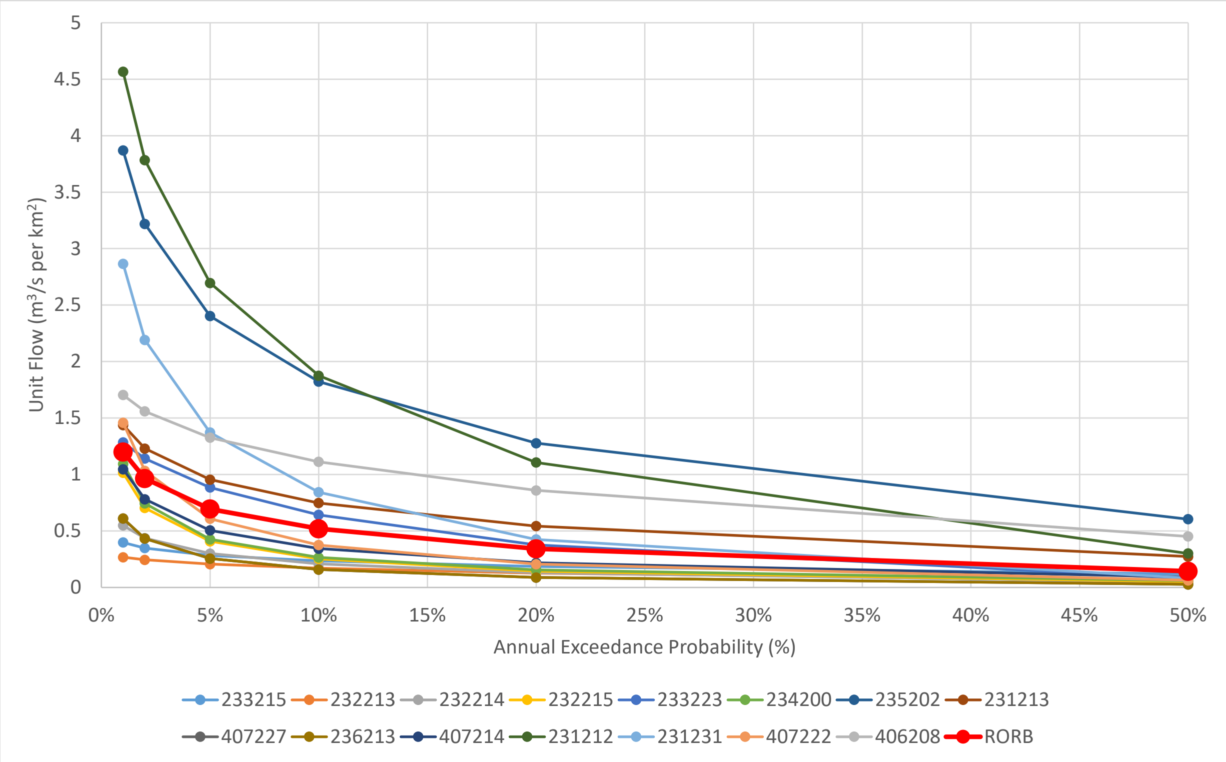

Figure 3-5 RFFE area weighted nearby catchments comparison

4. Hydraulic modelling

This section outlines the hydraulic modelling approach for determining flow characterisation across the Elaine SF Project Site. Hydraulic modelling was conducted using the U.S. Army Corps of Engineers' HEC-RAS[5] (version 6.4.1) software package. HEC-RAS models were developed using a two-dimensional (2D) rain-on-grid analysis for the target AEP scenarios (10%, 1%, 0.5%, 0.2% and 0.1%). The sections below outline the process undertaken to set up the HEC-RAS model.

4.1. Model setup

4.1.1. Precipitation

No inflow hydrographs were required as inputs to this model as the entire catchment is within the model domain and there are no water transfers into the catchment.

The precipitation inputs were derived from the IFD tables sourced from the Bureau of Meteorology (BOM, 2016) on 5 September 2023.

To define the critical rainfall duration, i.e. the duration which yields the highest flow and depth, the time of concentration for the catchment was calculated using two different methods. The first method used the Friend's formula (Australian Rainfall & Runoff, 2014), which considers the land cover, the length of the main drainage path and the average slope in determining the time of concentration:

$$Time\ of\ Concentration = 107\ \times \frac{n\ \times L^{0.333}}{S^{0.2}}$$

Equation 1: Friend's time of concentration formula

Where *n* is the Horton's roughness value for the surface, *L* is the flow path length in metres, *S* is the slope of the surface in percentage, and *Time of Concentration* is in minutes.

The second method used the following formula from Pilgrim (1989), which returns the time of concentration in hours and uses only the drainage area in square kilometres as input:

$$Time\ of\ Concentration = 0.76\ \times A^{0.38}$$

Equation 2: Pilgrim & McDermott's time of concentration formula

The Pilgrim and McDermott method usually results in smaller values than those produced by the Friend method. Therefore, the Friend method was used as a reference for the smallest duration tested whilst the Pilgrim and McDermott was used as a reference for the longest duration, in order to find the critical rainfall duration for the catchment. However, durations higher and lower than the values determined by the Pilgrim and McDermott, and Friends methods, respectively, were also tested to extend confidence in the interpretation of results.

The model results for the rainfall durations (using a 1% AEP) were compared to evaluate which duration would yield the highest flows and depths. For this assessment, the rainfall was distributed across the

[5] U.S. Army Corps of Engineers' HEC-RAS Version 6.3 (USACE 2022)

temporal patterns downloaded from the AR&R Data Hub and the time series produced were used as an unsteady flow boundary condition for the model.

When the critical duration was found for the catchment, the ten temporal patterns for that duration were compared to choose the pattern that yielded the median peak flow value for the 1% AEP event. This pattern was then applied to represent the rainfall patterns for all the design events modelled (10% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and 0.1% AEP).

The patterns applied are shown in Figure 4-1. Note 10% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and 0.1% AEP events are 12 hours in duration, as determined from the RORB results.

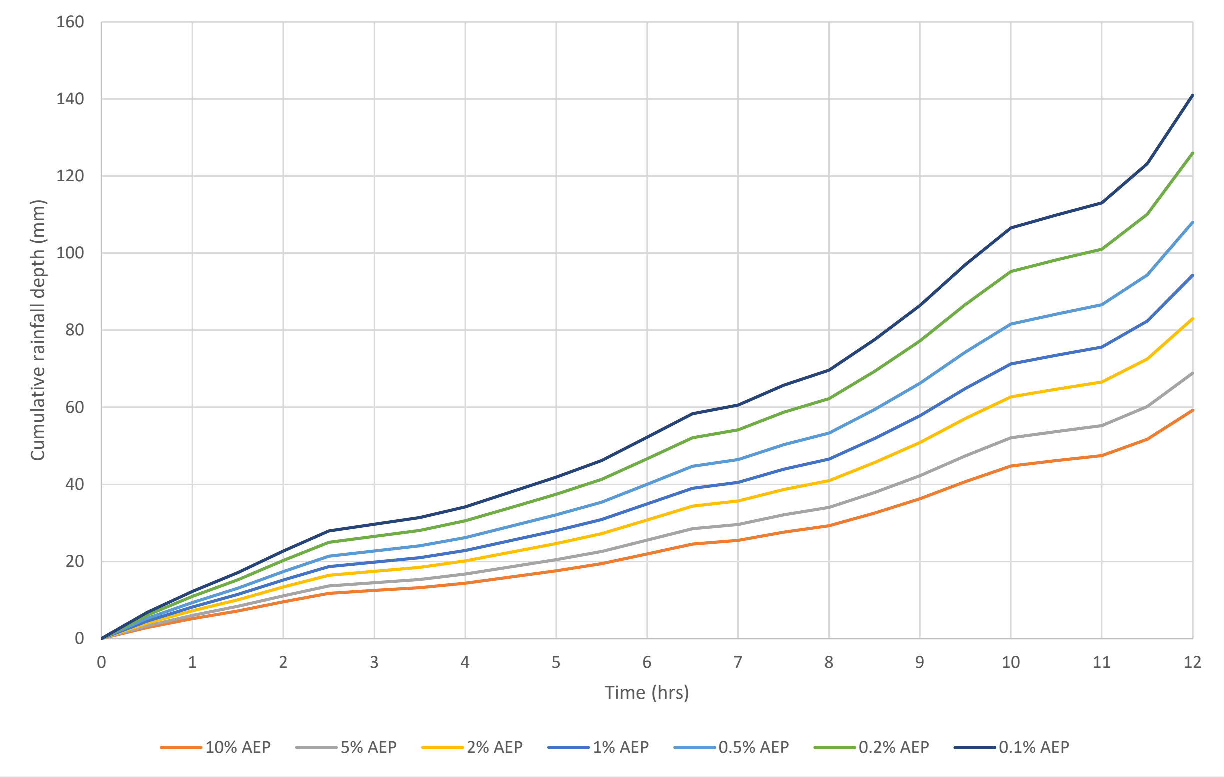

Figure 4-1 Rainfall depths applied to 2D flow area for the 10%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP design events

4.1.2. Losses

A rainfall excess time series (the amount of rain that runs off after the losses) was directly applied to the model through manual removal of initial and continuing losses. An example of this is outlined in Figure 4-2 for the 1% AEP event using the adjusted initial and continuing losses (10 mm and 2 mm, respectively) determined through calibration of the RORB model to RFFE expected peak and nearby observed flows.

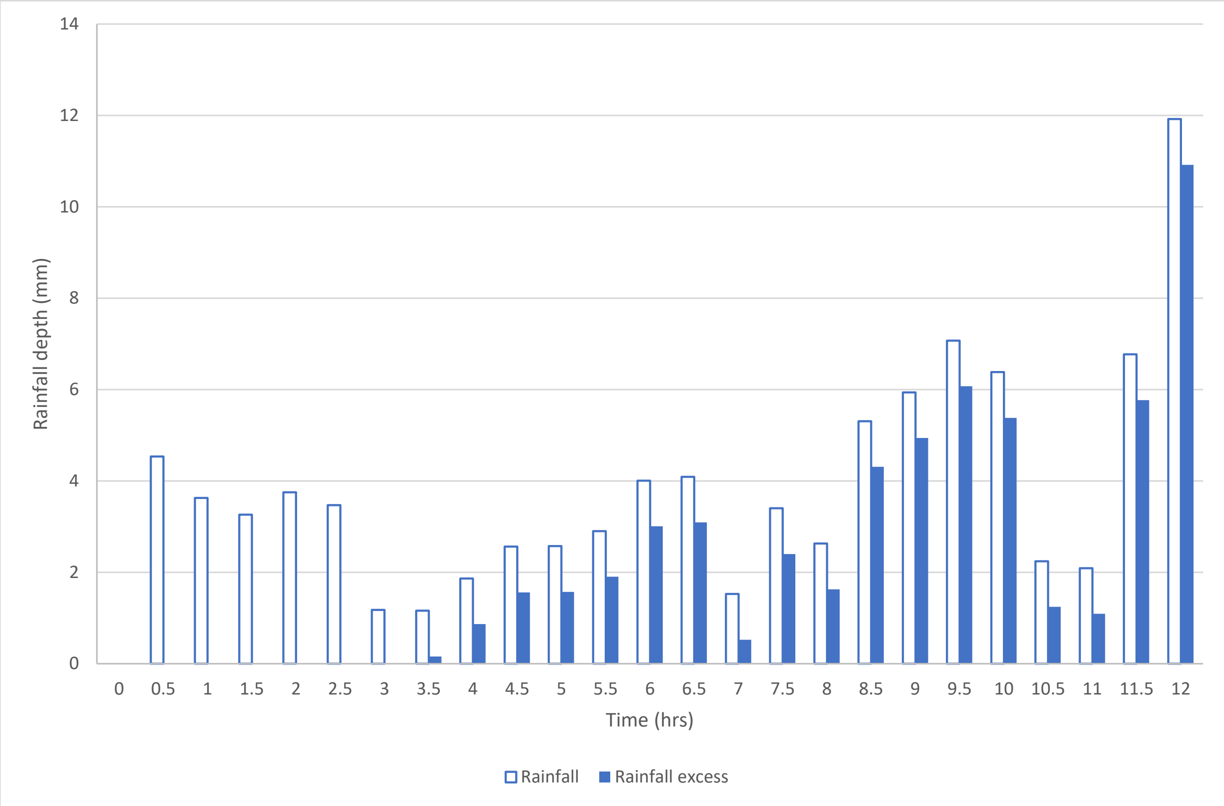

Figure 4-2 1% AEP design event rainfall pattern applied to HEC-RAS after losses are removed

4.1.3. Outflow

Locations where water exits the model domain (outflows) require boundary conditions to be specified. The concentrated flow path that exits the model domain was set to a normal depth boundary condition, using the uniform bed slope of that flow path as the estimated energy slope, as measured from the available terrain data. The normal depth boundary condition applied to the outlet was 0.003.

4.1.4. Computational mesh

A 2D flow area was delineated in HEC-RAS to coincide with the catchment boundary. A computational mesh spacing of 100 m by 100 m was applied across the regional catchment, as shown in Figure 4-3. HEC-RAS recognises the sub-grid terrain resolution within individual computational cells and the flow transfer calculations between individual grid cells account for the geometry of the underlying surface at the terrain resolution. This computational mesh was applied except as noted surrounding breaklines and the refinement regions.

Breaklines were used to alter the direction of grid cells to align with features within the catchment. Breaklines were implemented in the model for drainage lines as per Figure 2-1 as well as Midland Highway which runs between the eastern and western portions of the Project Site.

Refinement regions were used to denote areas where the computation mesh resolution required a finer scale than the overall mesh. The following refinement regions were specified:

- drainage line breaklines with a computational mesh of 50 m by 50 m
- Midland Highway breakline with a computational mesh of 20 m by 20 m

- approximately 150 m beyond the extent of the Project Site and immediately adjacent waterways (tributaries to Williamson Creek) with a computational mesh spacing of 20 m by 20 m.

Figure 4-3 outlines an example region of the computation mesh applied to the existing terrain, showing the mesh spacing, break lines and refinement regions applied.

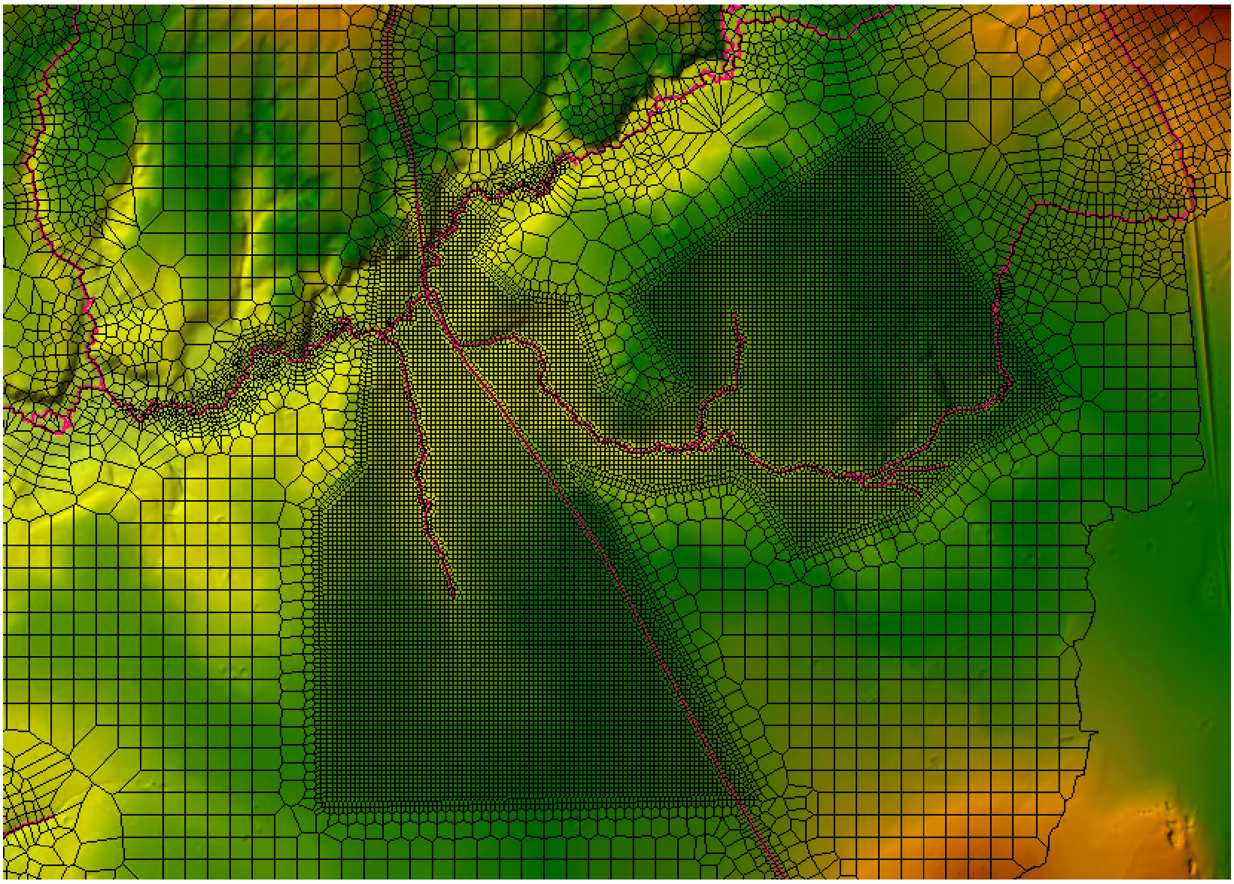

Figure 4-3 Example configuration of HEC-RAS computational mesh (black lines) and breaklines (pink lines) for drainages and Midland Highway

4.1.5. Roughness

Roughness coefficients are used to define how quickly water moves across the terrain and controls the shape of flow hydrographs resulting from the rainfall and upstream flow. Typical roughness values are defined for the range of flow path extents, i.e. from concrete channels to floodplains. Modelling the full 2D catchment area which extends outside of normal channels and their corresponding slopes requires much larger roughness values than are typically applied to models that just model stream flow.

An initial roughness coefficient of 0.1, representing a natural channel condition, was applied to the whole model. This roughness was used in combination with a 10% AEP rainfall event to define waterway channel extents.

HEC-RAS has the ability to apply different roughness coefficients spatially across the model domain. This is achieved through applying a shapefile of “land cover” regions to the model. To improve accuracy of the hydraulics assessment, land cover representing the channel south adjacent to the Project Site (roughness of 0.06) was applied to the model as shown in Figure 4-4.

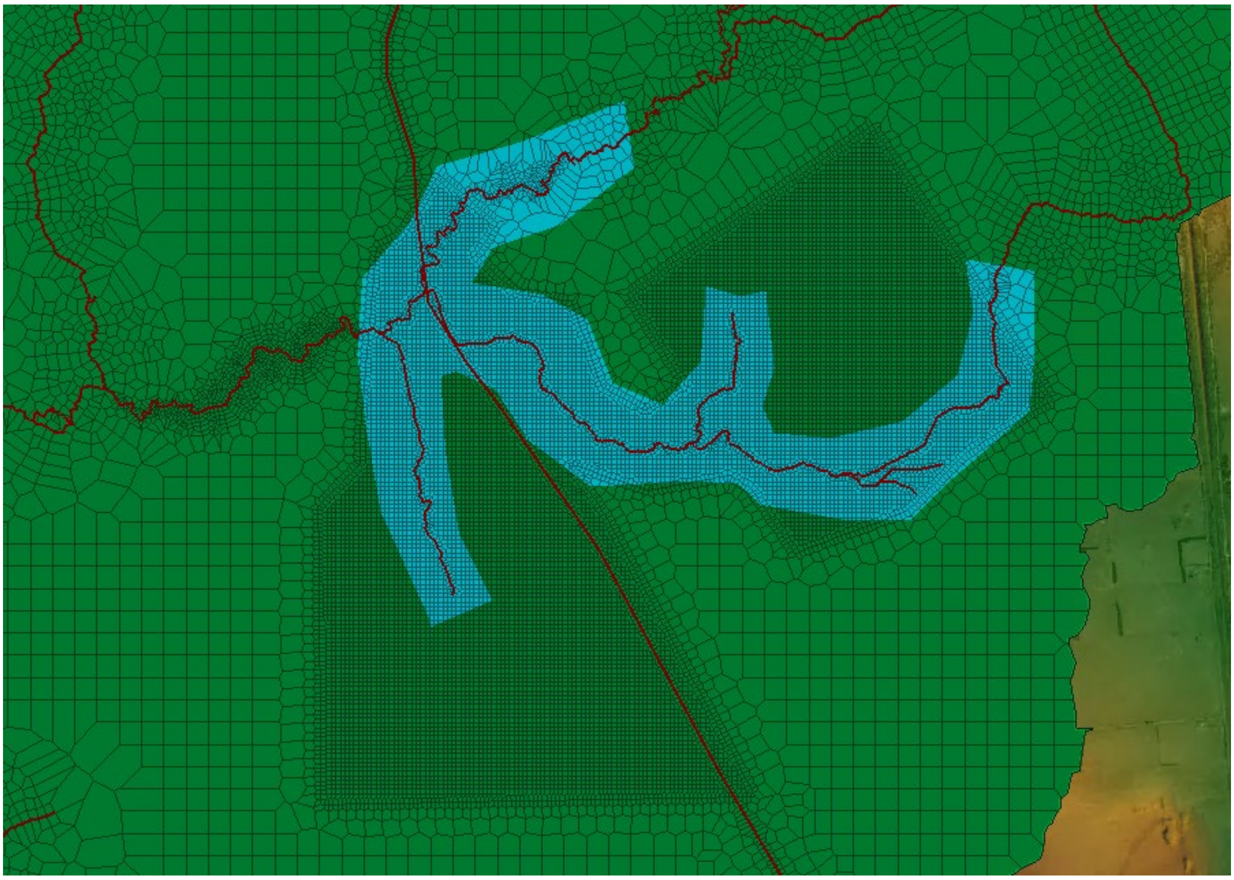

Figure 4-4 Manning's n roughness coefficient specification (green is 0.1, blue is 0.06)

4.1.6. Computational setting

An adaptive computational time-step was applied based on a maximum Courant Number of 2.0. This results in a minimum adopted time-step of approximately 2 seconds. The Full Momentum equation set was adopted in the model to account for the varying flow directions. Mass balance errors and water surface elevation convergence errors were checked for model stability and to confirm that imbalances remained below reasonable thresholds for model stability. A 24-hour simulation window was applied to capture critical-duration peak discharges and allow the flood peaks to propagate through the model.

Default threshold depths were decreased by one order of magnitude to capture the flow transfer effects of direct precipitation sheet flow across the catchment. Except where otherwise noted, other program defaults have been applied to all remaining coefficients, options, tolerances and model settings.

4.1.7. Model set-up summary

Table 4-1 below summarises the model parameters used for the catchment in this project.

Table 4-1: HEC-RAS parameters

Model Parameter	Value
Inflow	10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP frequency storm excess precipitation hyetographs
Losses	IL = 10 mm CL = 2 mm
Outflow	Normal depth slope of 0.3%
Simulation window	24 hours
Computational time step	Controlled by Courant number
Computational mesh grid	100 m by 100 m to 20 m by 20 m
Roughness	0.06 for channel adjacent to Project Site, 0.1 for remaining catchment area including land cover and overland flow
Equation Set	Full Momentum
DEM grid resolution	0.5 m by 0.5 m

5. Results and discussion

5.1. Hydrology results

5.1.1. Existing condition peak flows

The RORB model was run to provide verification flows for the water level modelling. The HEC-RAS model was subsequently calibrated to the RORB results. A summary of the peak flows for each exceedance probability at the catchment outlet from the two modelling methods is provided in Table 5-1 and presented in Figure 5-1. A summary of peak flows for each AEP scenario at the Williamson Creek junction approximately 500 m downgradient of the Project Site is provided in Table 5-2 and presented in Figure 5-2.

Table 5-1 Summary of design event peak flow rates at specified Williamson Creek catchment outlet

AEP (%)	RORB peak flow (m^3/s)	HEC-RAS peak flow (m^3/s)
10%	47.3	49.52
1%	109.2	119.12
0.5%	133.9	153.58
0.2%	169.5	198.3
0.1%	178.7	232

Table 5-2 Summary of design event peak flow rates at tributary junction with Williamson Creek approximately 500 m downgradient of Project Site

AEP (%)	RORB peak flow (m^3/s)	HEC-RAS peak flow (m^3/s)
10%	41.0	36.5
1%	72.8	99.3
0.5%	91.9	129.0
0.2%	107.3	168.9
0.1%	134.5	200.5

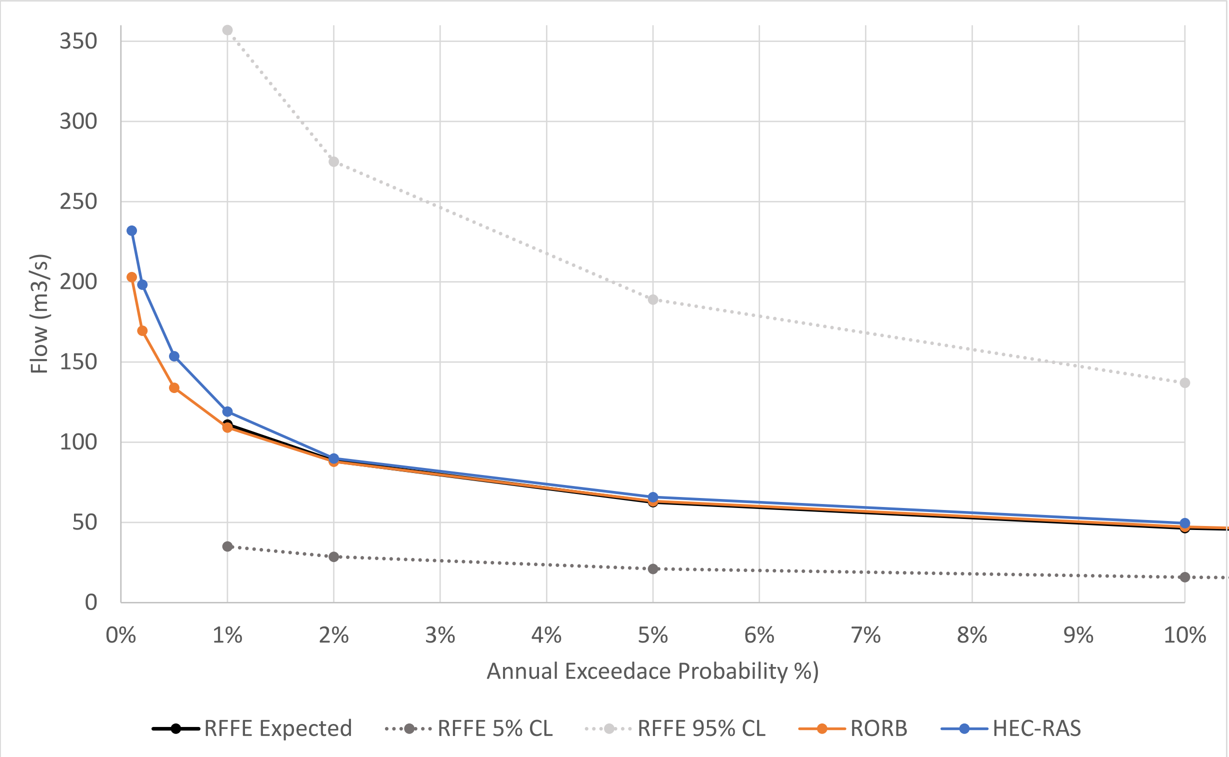

Figure 5-1 RORB and HEC-RAS peak discharge results at specified Williamson Creek catchment outlet (approximately 10 km downgradient of Project Site to the south-west)

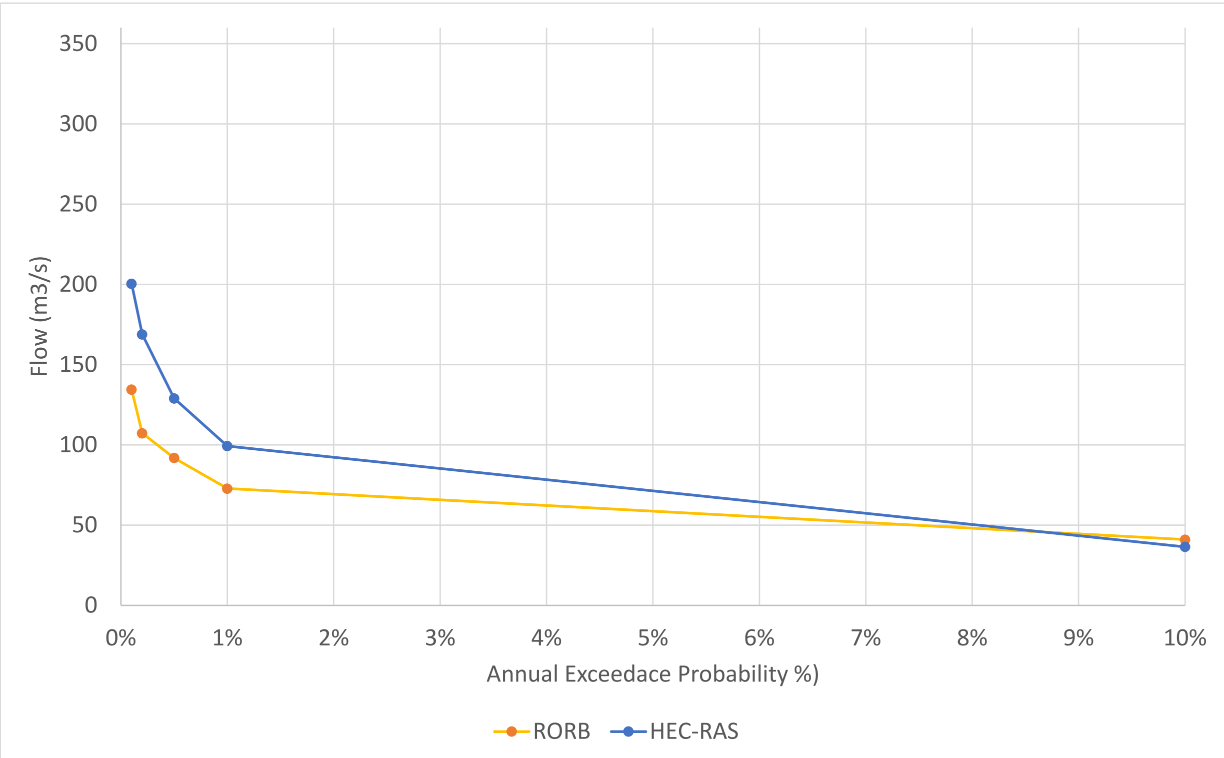

Figure 5-2 RORB and HEC-RAS peak discharge results at tributary junction with Williamson Creek (approximately 500 m downgradient of Project Site to the north-west)

5.1.2. Proposed condition peak flows

Under post development conditions, there will be additional impervious areas within the Project Site associated with infrastructure, such as access tracks, compounds, substations and solar panels. This additional infrastructure may change the runoff characteristics within the Project Site.

The HEC-RAS model was cloned and re-run to account for proposed construction of a sealed access road providing south entry access to the Peters area of the Project Site. The proposed access road was added to the model as a modification feature and additional breakline to assess potential effect on flood impacts under the 1% AEP design rainfall event.

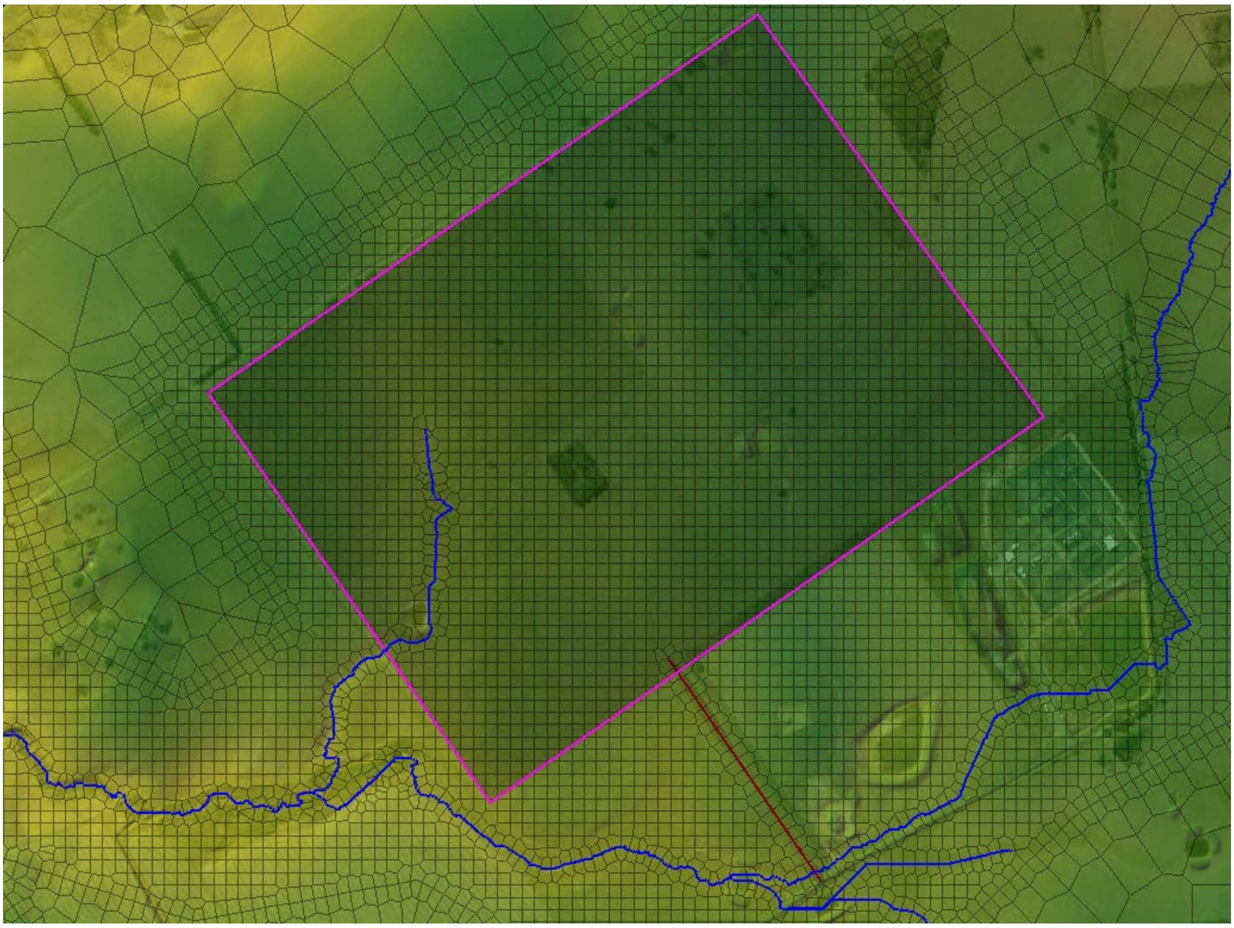

Figure 5-3 Proposed access track terrain modification (red) relative to site boundary (pink) and drainages (blue)

Results indicated minimal changes to peak flows both at the catchment outlet and at the junction of tributaries with Williamson Creek just downgradient of the Project Site. Changes to hydraulics caused by the proposed south entry to Peters access road are discussed in Section 5.2.2. Recommendations for flood impact mitigation relevant to construction of the access road are provided in Section 6.

5.2. Hydraulic results

For each AEP event, site and regional depth and velocity were extracted across the model domain and are discussed below. Maximum flood depths and maximum flood velocities based on existing conditions are presented in Appendix C1 and Appendix C2, respectively.

5.2.1. Existing condition peak flow depths and velocities

The flood depths for existing conditions at the Project Site (Appendix C1) show that, in general, the flows are concentrated to the waterways and defined overland flow paths in the region with sufficient terrain relief to limit the amount of sheet flow.

There is one main overland flow paths / waterway within each portion (Windy and Peters) of the Project Site; both drainages are unnamed tributaries to Williamson Creek and discharge approximately 500 m north-west of the Project Site.

The overland flow path in the western portion of the Project Site (Windy) is located beneath the proposed solar arrays. Depths in the inundation area are generally shallow (< 0.5 m) under each AEP scenario and will be able to pass under the arrays, joining the waterway located within the Windy Project Site boundary. Within the existing waterway, two small pool areas were observed with maximum depths nearing 1.0 m. It is noted that two proposed access tracks cross the inundation area however, the location does not intersect the observed pool areas; maximum depths intersecting the proposed tracks indicate likelihood that any ponding will remain passible under flooded conditions and/or alternate tracks may be utilised to maintain access to inverters throughout the Project Site.

The overland flow path across the eastern portion of the Project Site (Peters) also travels under proposed sections of solar arrays. Again, the maximum depths are generally shallow (< 0.5 m) except in some isolated areas including existing dams, and access tracks are likely to remain passible under flooded conditions.

The maximum depths observed under existing conditions for each modelled AEP scenario are summarised in Table 5-3.

Table 5-3 Potential flood impacts at Project Site

AEP (%)	Maximum flood depth (m) - Windy	Maximum flood depth (m) - Peters
10%	0.70	0.81
1%	0.89	0.85
0.5%	0.95	0.87
0.2%	1.00	0.88
0.1%	1.04	0.90

The modelled velocities under existing conditions (Appendix C2) show that, in general, velocities across the site tend to be low (< 0.5 m/s) and below the threshold (< 2 m/s) where rock armouring to protect waterways and features is required. Some isolated higher velocities (> 1 m/s) occur through the overland flow path / waterway through the middle of the site and at other isolated locations under the current conditions. Should erosion form at these locations then erosion mitigation strategies should be implemented.

The maximum flood depths and velocities relevant to the Project Site under modelled 1% AEP scenario for existing conditions are presented in Figure 5-4 and Figure 5-5, respectively.

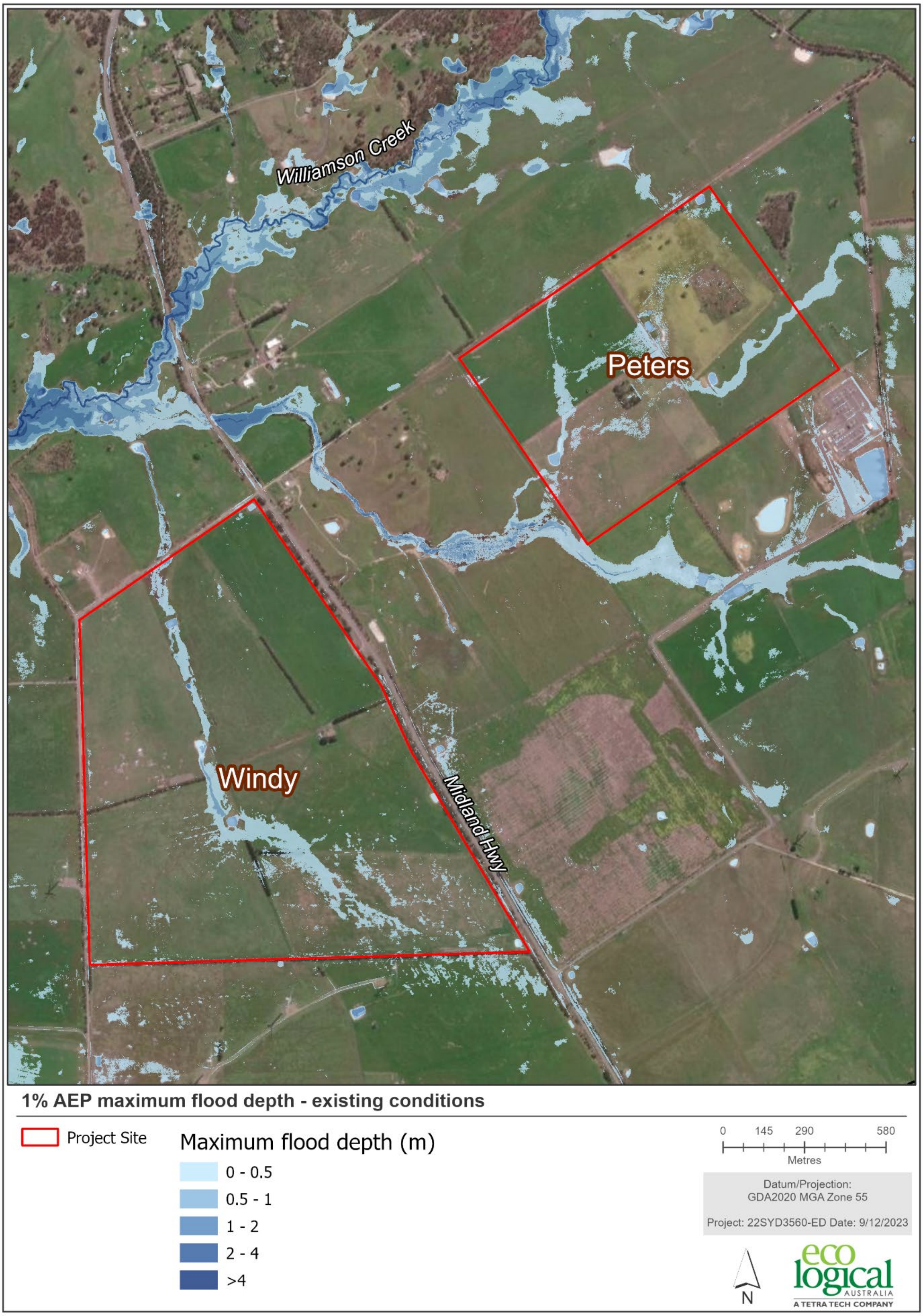

Figure 5-4 1% AEP maximum flood depth – existing conditions

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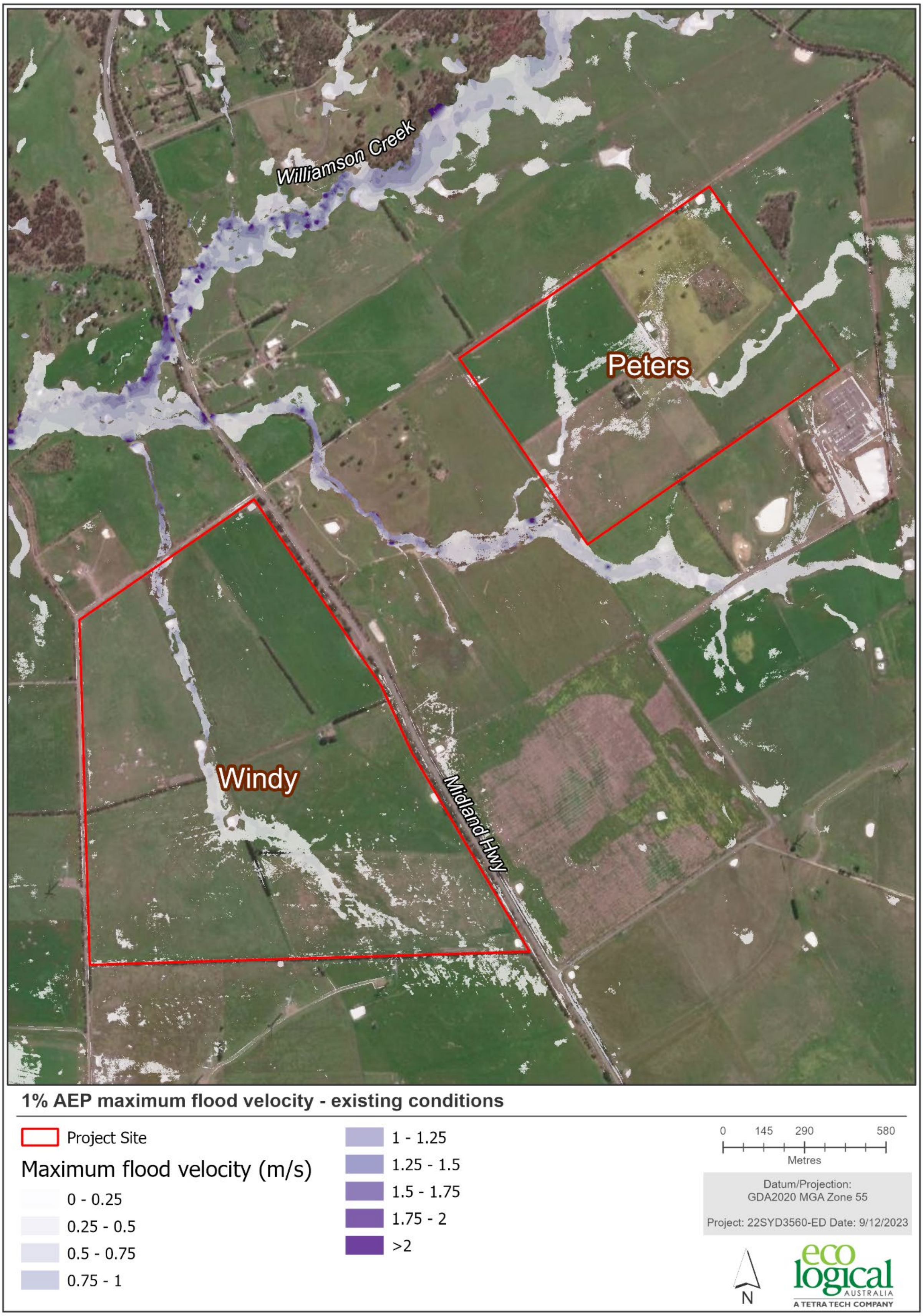

Figure 5-5 1% AEP maximum flood velocities – existing conditions

ADVERTISED PLAN

5.2.2. Proposed condition peak flow depths and velocities

Additional inundation was observed under the 1% AEP scenario in two locations along the up-gradient (north-eastern) edge of the proposed south Peters access road:

- northern extent for up to approximately 200 m adjacent to the access track
- southern extent within at defined drainage line for up to approximately 20 m adjacent to the access track.

The maximum depth was up to 1.4 m under the 1% AEP scenario. Velocity remained below 2 m/s in all areas, but reached up to 1.2 m/s under the 1% AEP scenario in one isolated area.

The maximum flood depths and velocities relevant to the Peters Project Site under modelled 1% AEP scenario for proposed conditions are presented in Figure 5-6 and Figure 5-7, respectively.

5.2.3. Proposed condition impact mitigation measures

Inclusion of the following culverts is recommended to mitigate flood impacts caused by the proposed south Peters access road:

- minimum 1.2 m span culvert on the northern side of the proposed south Peters access road, approximately 320 m from the turnoff and 80 m from the site boundary
- minimum 0.3 m span culvert on the northern side of the proposed south Peters access road, approximately 10 m from the turnoff and 390 m from the sit boundary.

The effects of inclusion of the recommended culverts on the 1% AEP design rainfall scenario are demonstrated in Figure 5-8.

Figure 5-6 1% AEP maximum flood depths – proposed conditions

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Figure 5-7 1% AEP maximum flood velocities – proposed conditions

ADVERTISED PLAN

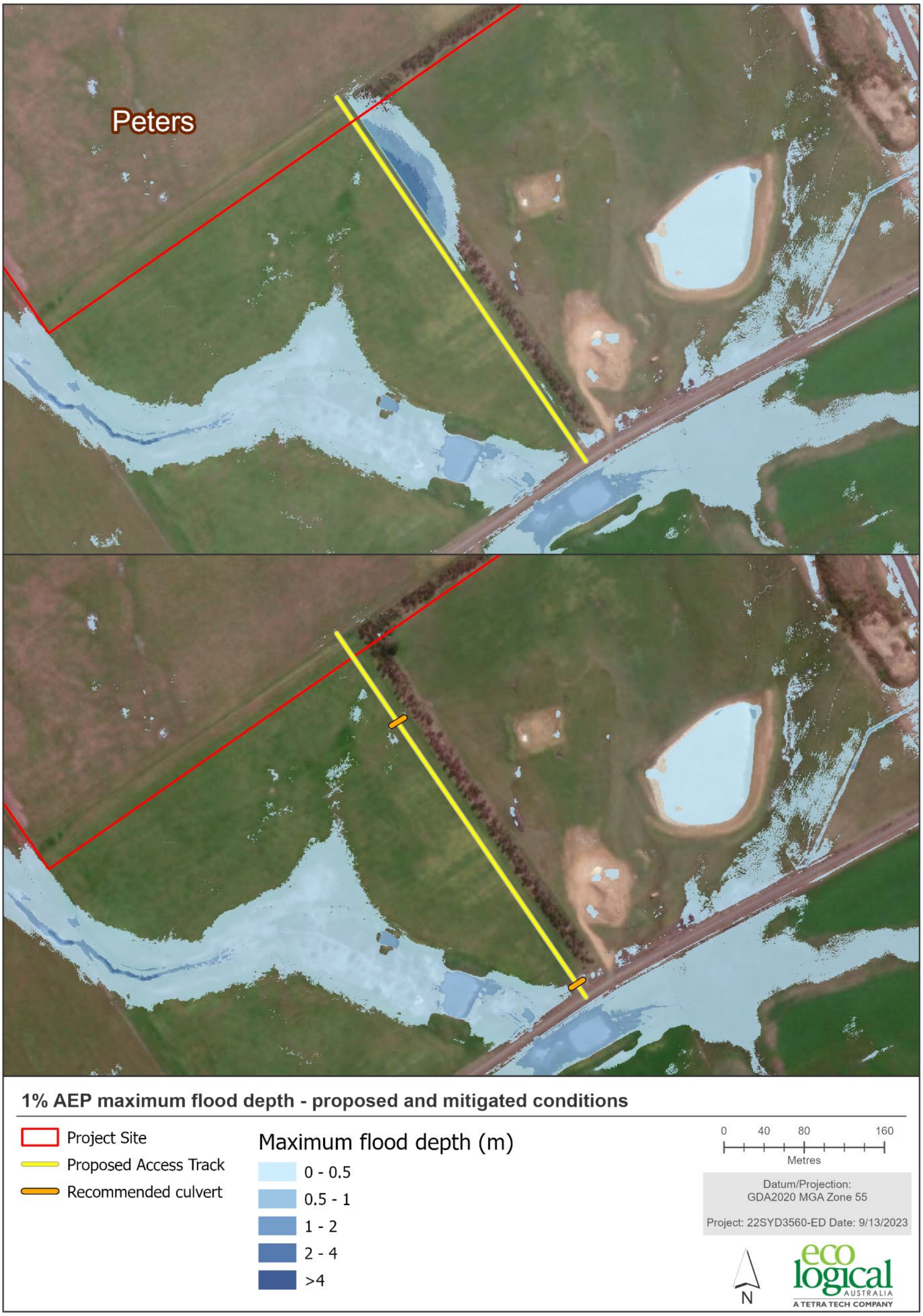

Figure 5-8 1% AEP maximum flood depths – proposed (upper image) and mitigated (lower image) conditions

6. Conclusion and recommendations

ELA has been engaged by Urbis to assess potential flood impacts at the Elaine Solar Farm Project Site associated with existing hydrologic conditions under the 10%, 5%, 2%, 1%, 0.5%, 0.2% and 0.1% AEP flood events, as well as proposed conditions under the 1% AEP scenario, to inform civil design recommendations with regard to flood impact mitigation.

Flow rate modelling was undertaken using the RORB software package to determine sub-catchment flows to verify the flow rate from subsequent water level modelling. Hydraulic modelling was conducted representing existing conditions using the HEC-RAS software package. HEC-RAS models were developed using a 2D rain-on-grid analysis to determine flood extents, flood levels and flow velocities. The modelling methods were calibrated using best initial loss estimates for the region based on previous similar modelling and RFFE analysis for the region.

The existing conditions' flood depths showed that, in general, the flows are concentrated to the waterways and defined overland flow paths in the region with sufficient terrain relief to limit the amount of sheet flow.

Based on the flood modelling results, the primary flood features comprise unnamed tributaries to Williamson Creek located within the Project Site boundary for both portions of the Site (Windy and Peters), which discharge at their junction with Williamson Creek approximately 500 m north-west of the Project Site.

Depths in the inundation areas are generally shallow (< 1 m) under each AEP scenario and will be able to pass under the arrays. Although some proposed access tracks intersect the inundation area, the modelled flood extent and maximum depths indicate likelihood that these will generally remain passible under flooded conditions. The modelled velocities under existing conditions show that, in general, velocities across the site tend to be low (< 0.5 m/s) and below the threshold (< 2 m/s) where rock armouring to protect waterways and features is required.

Modelling of proposed conditions showed that flood impacts are likely along the north-eastern edge of the proposed south Peters access road. It is recommended to include suitable culverts where flow paths intersect the proposed access road, including:

- minimum 1.2 m span culvert on the northern side of the proposed south Peters access road, approximately 320 m from the turnoff and 80 m from the site boundary
- minimum 0.3 m span culvert on the northern side of the proposed south Peters access road, approximately 10 m from the turnoff and 390 m from the sit boundary.

Inclusion of culverts in these locations will allow flows to discharge into the waterway running between the Windy and Peters Project Sites.

Detailed design should re-examine the flood levels and impacts from this assessment to determine specific flood depths and areas of inundation and appropriate measures to allow water to pass through the Project Site.

7. References

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Appendix A AR&R inputs

A1 IFD tables

Table A1-1 Rainfall depths for 12EY to 0.2EY design rainfall events

Duration	Annual Exceedance Probability Rainfall Depths (mm)									
	12EY	6EY	4EY	3EY	2EY	63.20%	50%	0.5EY	20%	0.2EY
1 min	0.514	0.589	0.729	0.835	0.999	1.32	1.53	1.7	2.26	2.31
2 min	0.846	0.974	1.21	1.39	1.66	2.16	2.49	2.77	3.61	3.68
3 min	1.11	1.29	1.61	1.85	2.22	2.94	3.39	3.76	4.92	5.01
4 min	1.34	1.55	1.95	2.25	2.71	3.61	4.18	4.64	6.09	6.21
5 min	1.54	1.78	2.24	2.59	3.13	4.2	4.87	5.4	7.12	7.26
10 min	2.3	2.65	3.31	3.83	4.65	6.31	7.34	8.15	10.9	11.1
15 min	2.84	3.26	4.05	4.67	5.66	7.66	8.92	9.91	13.2	13.5
20 min	3.27	3.74	4.62	5.32	6.41	8.64	10.1	11.2	14.9	15.2
25 min	3.64	4.14	5.09	5.84	7.03	9.42	11	12.2	16.2	16.5
30 min	3.96	4.49	5.5	6.3	7.55	10.1	11.7	13	17.3	17.6
45 min	4.73	5.34	6.49	7.39	8.79	11.6	13.4	14.9	19.6	20
1 hour	5.35	6.01	7.27	8.25	9.76	12.8	14.7	16.4	21.4	21.8
1.5 hour	6.32	7.09	8.52	9.62	11.3	14.6	16.8	18.6	24	24.5
2 hours	7.1	7.95	9.53	10.7	12.6	16.2	18.4	20.5	26.1	26.6
3 hours	8.33	9.33	11.2	12.6	14.7	18.7	21.2	23.6	29.6	30.2
4.5 hour	9.76	10.9	13.1	14.7	17.2	21.8	24.7	27.4	34	34.7
6 hours	10.9	12.2	14.7	16.5	19.3	24.5	27.6	30.6	37.8	38.5
9 hours	12.7	14.3	17.2	19.4	22.7	28.9	32.5	36	44.2	45.1
12 hours	14.2	16	19.3	21.7	25.5	32.5	36.5	40.5	49.7	50.6
18 hours	16.4	18.5	22.4	25.3	29.8	38.1	42.9	47.6	58.6	59.8
24 hours	18.1	20.5	24.8	28.1	33	42.5	47.9	53.2	65.7	67.1
30 hours	19.5	22.1	26.7	30.2	35.6	45.9	51.9	57.6	71.6	73
36 hours	20.7	23.4	28.3	32	37.7	48.7	55.1	61.2	76.5	78
48 hours	22.6	25.5	30.8	34.8	41	53	60.2	66.8	84	85.7
72 hours	25.2	28.3	34.2	38.6	45.4	58.5	66.6	73.9	93.6	95.5
96 hours	26.9	30.2	36.4	41.2	48.3	62	70.4	78.2	98.8	101
120 hours	28	31.6	38.1	43	50.4	64.4	72.9	81	102	104
144 hours	28.8	32.6	39.4	44.5	52.1	66.2	74.7	82.9	103	105
168 hours	29.3	33.3	40.5	45.8	53.6	67.8	76.1	84.4	103	105

Table A1-2 Rainfall depths for 10% to 0.05% design rainfall events

Duration	Annual Exceedance Probability Rainfall Depths (mm)							
	10%	5%	2%	1%	0.5%	0.2%	0.1%	0.05%
1 min	2.8	3.37	4.19	4.87	5.55	6.46	7.2	7.98
2 min	4.41	5.25	6.37	7.29	8.19	9.43	10.4	11.4
3 min	6.02	7.18	8.75	10	11.3	13.1	14.5	16
4 min	7.48	8.94	11	12.6	14.3	16.6	18.4	20.3
5 min	8.78	10.5	13	15	17	19.8	22	24.3
10 min	13.5	16.3	20.3	23.7	27.1	31.6	35.2	39.1
15 min	16.5	19.9	24.9	29.1	33.2	38.8	43.2	48
20 min	18.6	22.4	28	32.7	37.4	43.6	48.6	54
25 min	20.2	24.3	30.4	35.4	40.4	47.1	52.5	58.2
30 min	21.5	25.9	32.2	37.5	42.8	49.8	55.4	61.5
45 min	24.3	29.1	36.1	41.9	47.6	55.3	61.5	68.1
1 hour	26.3	31.5	38.8	44.8	51	59.1	65.7	72.7
1.5 hour	29.3	34.9	42.7	49.1	55.8	64.8	72	79.7
2 hours	31.7	37.6	45.8	52.6	59.8	69.4	77.1	85.4
3 hours	35.8	42.1	51	58.3	66.5	77.3	86	95.4
4.5 hour	40.8	47.8	57.7	65.8	75.2	87.6	97.7	108
6 hours	45.2	52.8	63.6	72.4	82.9	96.7	108	120
9 hours	52.7	61.4	74	84.1	96.5	113	126	140
12 hours	59.2	68.9	83	94.3	108	126	141	157
18 hours	69.9	81.5	98.1	111	127	149	166	185
24 hours	78.6	91.8	110	125	143	166	185	205
30 hours	85.8	100	121	137	158	184	206	229
36 hours	91.8	108	129	146	169	197	219	244
48 hours	101	119	143	162	184	213	236	261
72 hours	113	134	160	181	201	230	252	275
96 hours	120	142	169	191	210	239	261	284
120 hours	123	146	174	196	217	246	270	293
144 hours	125	148	176	199	222	253	278	305
168 hours	125	148	177	200	226	260	288	318

A2 Available temporal patterns

Available durations of point and areal temporal patterns are shown in Table A2- and Table A2-, respectively, compared to available IFD information. The unshaded boxes are those where IFD information is available, but for which no temporal pattern durations are available. Areal temporal patterns are typically used for catchments greater than 75 km² in size. Using the point temporal patterns over the areal patterns generally produces a more conservative (higher) estimation of the peak flows within the catchment.

Table A2-3 Available point temporal pattern durations from AR&R

Durations				
1 minute	15 minutes	1.5 hours	12 hours	72 hours
2 minutes	20 minutes	2 hours	18 hours	96 hours
3 minutes	25 minutes	3 hours	24 hours	120 hours
4 minutes	30 minutes	4.5 hours	30 hours	144 hours
5 minutes	45 minutes	6 hours	36 hours	168 hours
10 minutes	1 hour	9 hours	48 hours	

Table A2-4 Available areal temporal pattern durations from AR&R

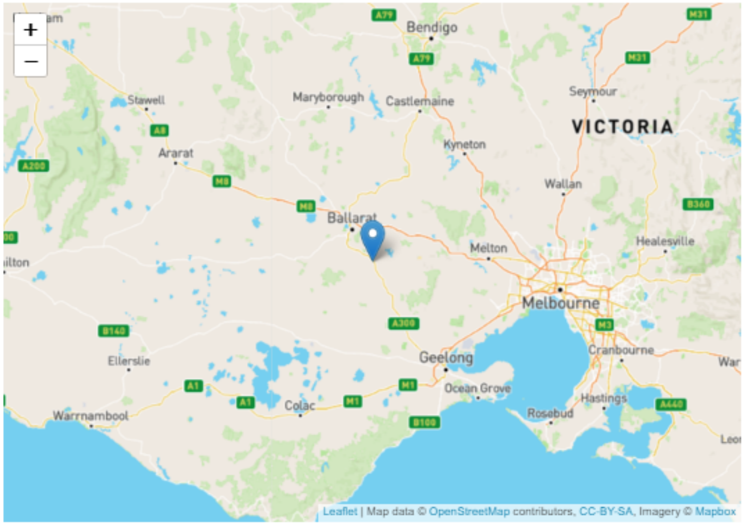
Durations				
1 minute	15 minutes	1.5 hours	12 hours	72 hours
2 minutes	20 minutes	2 hours	18 hours	96 hours
3 minutes	25 minutes	3 hours	24 hours	120 hours
4 minutes	30 minutes	4.5 hours	30 hours	144 hours
5 minutes	45 minutes	6 hours	36 hours	168 hours
10 minutes	1 hour	9 hours	48 hours	

A3 Data hub results

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	143.968
Latitude	-37.701
Selected Regions (clear)	
River Region	show
ARF Parameters	show
Storm Losses	show
Temporal Patterns	show
Areal Temporal Patterns	show
BOM IFDs	show
Median Preburst Depths and Ratios	show
10% Preburst Depths	show
25% Preburst Depths	show
75% Preburst Depths	show
90% Preburst Depths	show
Interim Climate Change Factors	show
Baseflow Factors	show



Data

River Region

Division	South East Coast (Victoria)
River Number	9
River Name	Barwon River-Lake Corangamite

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2016_v1

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ARF Parameters

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

Zone	a	b	c	d	e	f	g	h	i
Southern Temperate	0.158	0.276	0.372	0.315	0.000141	0.41	0.15	0.01	-0.0027

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2016_v1

Short Duration ARF

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

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

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

Note: As this point is in Victoria the advice provided on losses and pre-burst in the VIC specific tab of the ARR Data Hub should be considered.

ID	13324.0
Storm Initial Losses (mm)	24.0
Storm Continuing Losses (mm/h)	4.5

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2016_v1

Temporal Patterns | Download (.zip)

code	SSmainland
Label	Southern Slopes (Vic/NSW)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2016_v2

Areal Temporal Patterns | Download (.zip)

code	SSmainland
arealabel	Southern Slopes (Vic/NSW)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2016_v2

BOM IFDs

Click here to obtain the IFD depths for catchment centroid from the BoM website

Layer Info

Time Accessed	04 September 2023 05:01PM

Median Preburst Depths and Ratios

Note: As this point is in Victoria the advice provided on losses and pre-burst in the VIC specific tab of the ARR Data Hub should be considered.

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	1.6 (0.109)	1.5 (0.072)	1.5 (0.057)	1.5 (0.046)	1.3 (0.033)	1.1 (0.025)
90 (1.5)	3.5 (0.209)	2.5 (0.105)	1.9 (0.064)	1.2 (0.036)	1.4 (0.032)	1.4 (0.029)
120 (2.0)	1.5 (0.080)	1.6 (0.060)	1.6 (0.052)	1.7 (0.045)	2.5 (0.055)	3.2 (0.060)
180 (3.0)	3.2 (0.151)	2.0 (0.069)	1.3 (0.035)	0.5 (0.012)	2.2 (0.043)	3.5 (0.059)
360 (6.0)	1.2 (0.043)	1.2 (0.032)	1.2 (0.028)	1.3 (0.024)	2.5 (0.039)	3.4 (0.047)
720 (12.0)	0.0 (0.000)	0.9 (0.018)	1.5 (0.025)	2.1 (0.030)	4.3 (0.052)	6.0 (0.064)
1080 (18.0)	0.0 (0.000)	0.3 (0.005)	0.5 (0.007)	0.7 (0.009)	1.5 (0.016)	2.2 (0.019)
1440 (24.0)	0.0 (0.000)	0.1 (0.001)	0.1 (0.002)	0.2 (0.002)	0.4 (0.004)	0.5 (0.004)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

10% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

25% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	0.1 (0.008)	0.1 (0.003)	0.0 (0.001)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
90 (1.5)	0.1 (0.009)	0.1 (0.003)	0.0 (0.001)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
120 (2.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
180 (3.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
360 (6.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
720 (12.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1080 (18.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
1440 (24.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2160 (36.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
2880 (48.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

75% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	7.6 (0.515)	9.7 (0.453)	11.1 (0.421)	12.4 (0.394)	11.2 (0.288)	10.2 (0.228)
90 (1.5)	13.1 (0.778)	13.4 (0.557)	13.6 (0.463)	13.8 (0.395)	14.1 (0.330)	14.3 (0.292)
120 (2.0)	8.6 (0.468)	9.7 (0.370)	10.4 (0.326)	11.0 (0.293)	14.9 (0.326)	17.9 (0.340)
180 (3.0)	10.5 (0.496)	10.4 (0.352)	10.4 (0.290)	10.3 (0.245)	14.0 (0.274)	16.8 (0.287)
360 (6.0)	4.8 (0.174)	8.6 (0.227)	11.1 (0.245)	13.5 (0.255)	15.1 (0.237)	16.3 (0.225)
720 (12.0)	3.9 (0.107)	8.6 (0.174)	11.8 (0.199)	14.8 (0.214)	19.3 (0.232)	22.6 (0.240)
1080 (18.0)	1.2 (0.027)	4.8 (0.083)	7.3 (0.104)	9.6 (0.118)	13.9 (0.142)	17.2 (0.154)
1440 (24.0)	1.1 (0.022)	3.2 (0.049)	4.7 (0.059)	6.0 (0.066)	8.9 (0.081)	11.1 (0.089)
2160 (36.0)	0.8 (0.014)	2.3 (0.030)	3.3 (0.036)	4.3 (0.040)	4.8 (0.037)	5.2 (0.035)
2880 (48.0)	0.0 (0.000)	0.3 (0.004)	0.6 (0.006)	0.8 (0.006)	2.5 (0.017)	3.8 (0.023)
4320 (72.0)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.0 (0.000)	0.5 (0.003)	0.9 (0.005)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

90% Preburst Depths

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

min (h)\AEP(%)	50	20	10	5	2	1
60 (1.0)	17.3 (1.173)	23.4 (1.097)	27.5 (1.047)	31.4 (0.999)	25.9 (0.667)	21.7 (0.485)
90 (1.5)	19.5 (1.160)	28.5 (1.186)	34.4 (1.174)	40.1 (1.151)	33.0 (0.773)	27.7 (0.563)
120 (2.0)	21.0 (1.137)	24.2 (0.926)	26.3 (0.829)	28.3 (0.753)	36.3 (0.792)	42.3 (0.804)
180 (3.0)	25.1 (1.182)	24.7 (0.833)	24.4 (0.683)	24.1 (0.573)	30.2 (0.592)	34.7 (0.595)
360 (6.0)	19.6 (0.711)	22.8 (0.604)	24.9 (0.552)	27.0 (0.511)	30.4 (0.478)	33.0 (0.456)
720 (12.0)	20.6 (0.563)	23.4 (0.471)	25.3 (0.427)	27.1 (0.393)	35.5 (0.428)	41.8 (0.443)
1080 (18.0)	17.8 (0.414)	19.0 (0.325)	19.8 (0.284)	20.6 (0.253)	26.9 (0.274)	31.6 (0.284)
1440 (24.0)	10.3 (0.216)	17.2 (0.262)	21.7 (0.277)	26.1 (0.284)	24.6 (0.223)	23.6 (0.188)
2160 (36.0)	12.6 (0.228)	14.9 (0.194)	16.4 (0.179)	17.8 (0.166)	26.1 (0.202)	32.2 (0.220)
2880 (48.0)	1.6 (0.026)	5.4 (0.064)	7.9 (0.078)	10.3 (0.087)	20.4 (0.143)	27.9 (0.173)
4320 (72.0)	0.8 (0.012)	3.6 (0.039)	5.5 (0.048)	7.3 (0.054)	19.5 (0.122)	28.6 (0.158)

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2018_v1
Note	Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

Interim Climate Change Factors

	RCP 4.5	RCP6	RCP 8.5
2030	**0.648 (3.2%)**	0.687 (3.4%)	**0.811 (4.0%)**
2040	**0.878 (4.4%)**	0.827 (4.1%)	**1.084 (5.4%)**
2050	**1.081 (5.4%)**	1.013 (5.1%)	**1.446 (7.3%)**
2060	**1.251 (6.3%)**	1.229 (6.2%)	**1.862 (9.5%)**
2070	**1.381 (7.0%)**	1.460 (7.4%)	**2.298 (11.9%)**
2080	**1.465 (7.4%)**	1.691 (8.6%)	**2.719 (14.2%)**
2090	**1.496 (7.6%)**	1.906 (9.7%)	**3.090 (16.3%)**

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2019_v1
Note	ARR recommends the use of RCP4.5 and RCP 8.5 values. These have been updated to the values that can be found on the climate change in Australia website.

Baseflow Factors

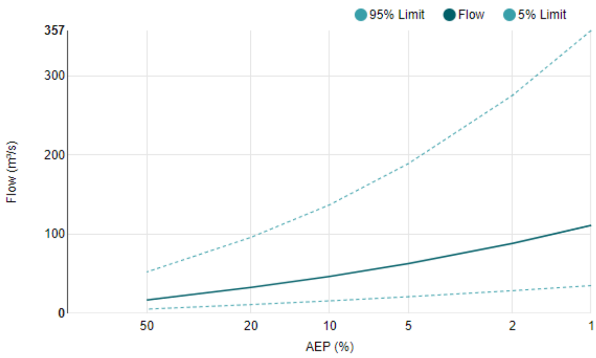
Downstream	11199
Area (km2)	919.145024
Catchment Number	11163
Volume Factor	0.094782
Peak Factor	0.079786

Layer Info

Time Accessed	04 September 2023 05:01PM
Version	2016_v1

A4 RFFE Results

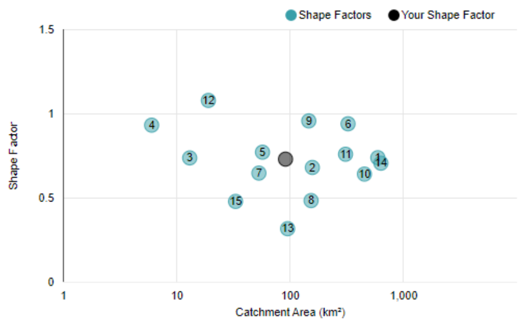
Results | Regional Flood Frequency Estimation Model



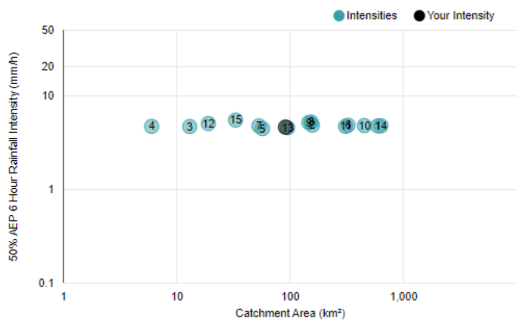
AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	16.8	5.35	52.2
20	32.6	11.1	95.9
10	46.5	15.8	137
5	62.7	21.0	189
2	88.3	28.6	275
1	111	35.0	357

Input Data	
Date/Time	2023-09-04 16:55
Catchment Name	Elaine SF
Latitude (Outlet)	-37.7611
Longitude (Outlet)	143.9461
Latitude (Centroid)	-37.701
Longitude (Centroid)	143.9684
Catchment Area (km^2)	91.0
Distance to Nearest Gauged Catchment (km)	6.7
50% AEP 6 Hour Rainfall Intensity (mm/h)	4.597294
2% AEP 6 Hour Rainfall Intensity (mm/h)	10.565834
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1

Shape Factor vs Catchment Area



Intensity vs Catchment Area



Region Source (User/Auto)	Auto
Shape Factor	0.73
Interpolation Method	Natural Neighbour
Bias Correction Value	0.09

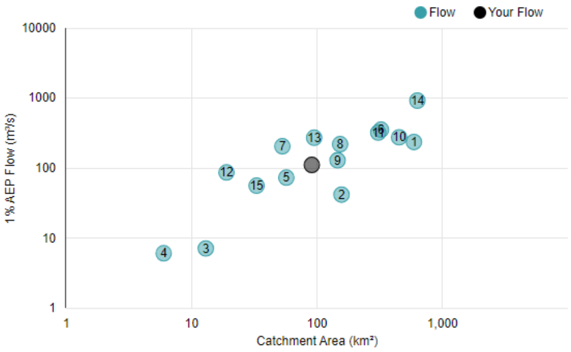
Statistics

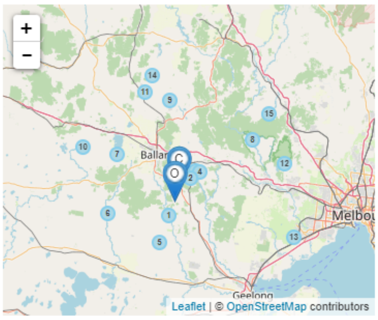
Variable	Value	Standard Dev	Correlation		
Mean	2.868	0.694	1.000		
Standard Dev	0.784	0.197	-0.330	1.000	
Skew	0.135	0.030	0.170	-0.280	1.000

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

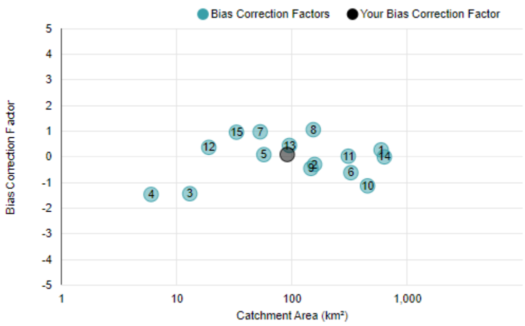
Note: These statistics are common to each region. Details.

1% AEP Flow vs Catchment Area





Bias Correction Factor vs Catchment Area



Appendix B RORB details

Table B-5 RORB reach details

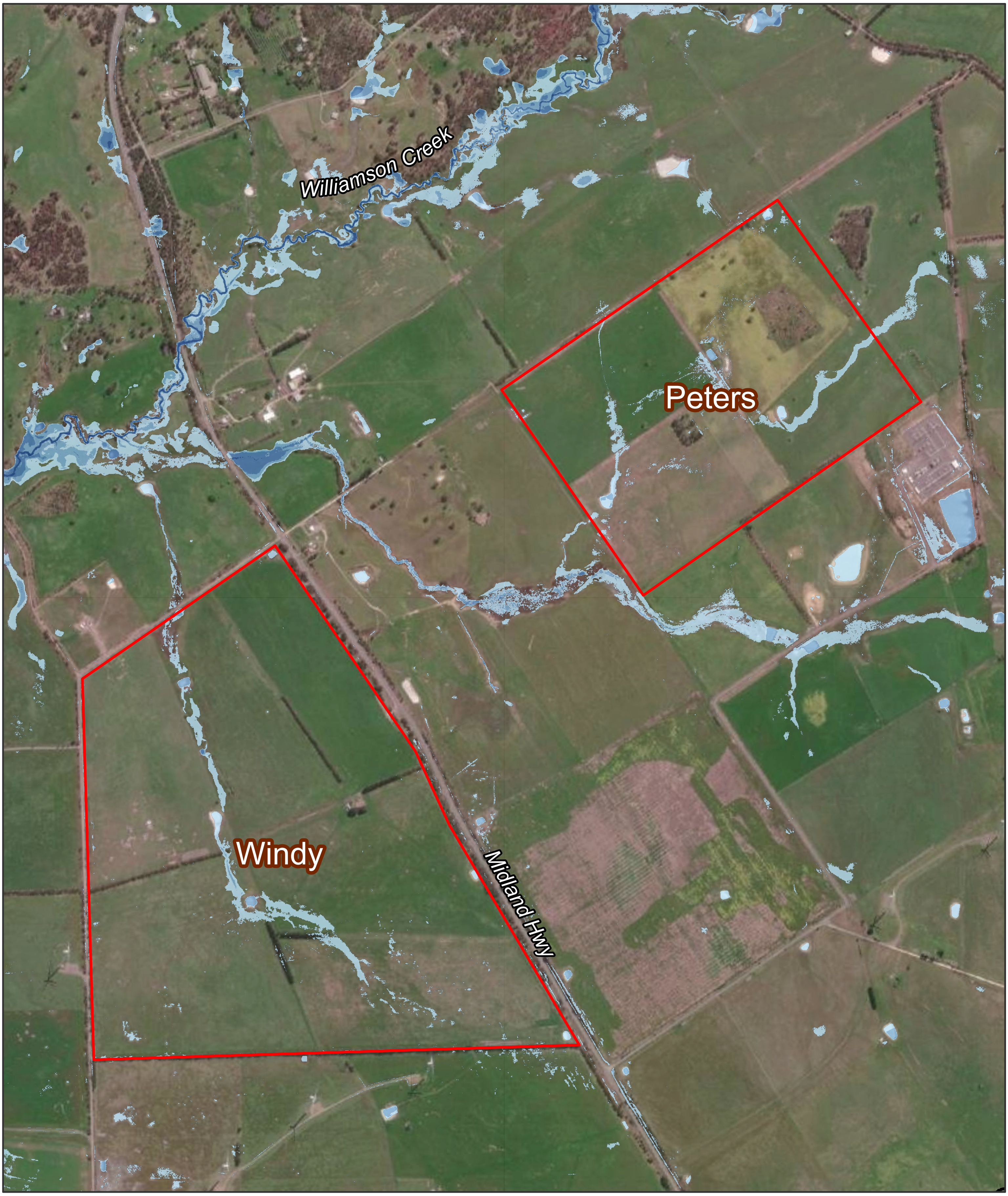
No.	Reach Name	Reach Type	Reach Length (km)
1	DS A	1. Natural	3.701
2	DS B	1. Natural	2.336
3	DS C	1. Natural	0.586
4	DS D	1. Natural	1.468
5	DS E	1. Natural	1.150
6	DS F	1. Natural	1.890
7	DS G	1. Natural	1.815
8	DS H	1. Natural	1.685
9	DS I	1. Natural	1.492
10	DS J	1. Natural	1.360
11	DS K	1. Natural	2.470
12	DS L	1. Natural	1.223
13	DS M	1. Natural	2.392
14	DS N	1. Natural	2.141
15	DS O	1. Natural	1.732
16	DS P	1. Natural	0.256
17	B-C	1. Natural	2.023
18	A-D	1. Natural	0.426
19	C-D	1. Natural	1.679
20	D-EF	1. Natural	1.522
21	EF-GI	1. Natural	2.324
22	H-GI	1. Natural	1.367
23	GI-JK	1. Natural	2.547
24	JK-LM	1. Natural	2.103
25	N-LM	1. Natural	0.038
26	LM-P	1. Natural	0.721
27	P-Outlet	1. Natural	0.704

Table B-6 RORB sub-catchment area details

No.	Node Name	Node Area (km²)
1	SA A	9.431
2	SA B	14.937
3	SA C	5.805
4	SA D	2.803
5	SA E	3.990
6	SA F	4.025
7	SA G	5.154
8	SA H	8.017
9	SA I	4.119
10	SA J	8.665
11	SA K	5.343
12	SA L	2.369
13	SA M	.146
14	SA N	4.529
15	SA O	3.200
16	SA P	1.579

Appendix C HEC-RAS results

C1 Flood depth



10% AEP maximum flood depth - existing conditions

Project Site

Maximum flood depth (m)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4
- >4

ADVERTISED PLAN

0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

1% AEP maximum flood depth - existing conditions

Project Site

Maximum flood depth (m)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4
- >4

0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

ADVERTISED PLAN

1% AEP maximum flood depth - proposed conditions

Project Site

Proposed Access Track

Maximum flood depth (m)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4
- >4

ADVERTISED PLAN

0 65 130 260

Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/13/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

0.5% AEP maximum flood depth - existing conditions

Project Site

Maximum flood depth (m)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4
- >4

0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

ADVERTISED PLAN

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

0.2% AEP maximum flood depth - existing conditions

Project Site

Maximum flood depth (m)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4
- >4

0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

ADVERTISED PLAN

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

0.1% AEP maximum flood depth - existing conditions

Project Site

Maximum flood depth (m)

- 0 - 0.5
- 0.5 - 1
- 1 - 2
- 2 - 4
- >4

0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

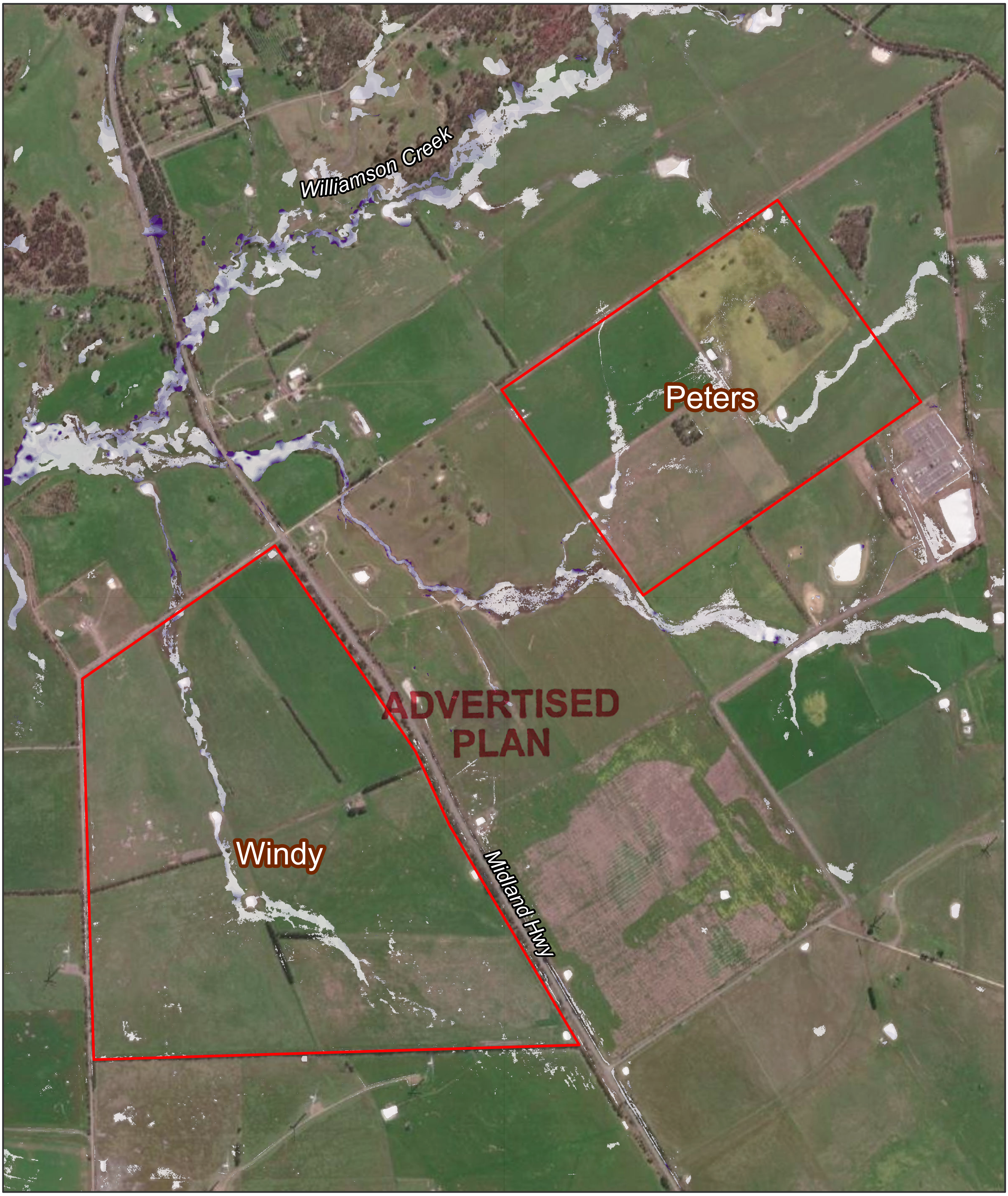
Project: 22SYD3560-ED Date: 9/12/2023

ADVERTISED PLAN

N

eco logical AUSTRALIA
A TETRA TECH COMPANY

C2 Velocities



10% AEP maximum flood velocity - existing conditions

Project Site

Maximum flood velocity (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

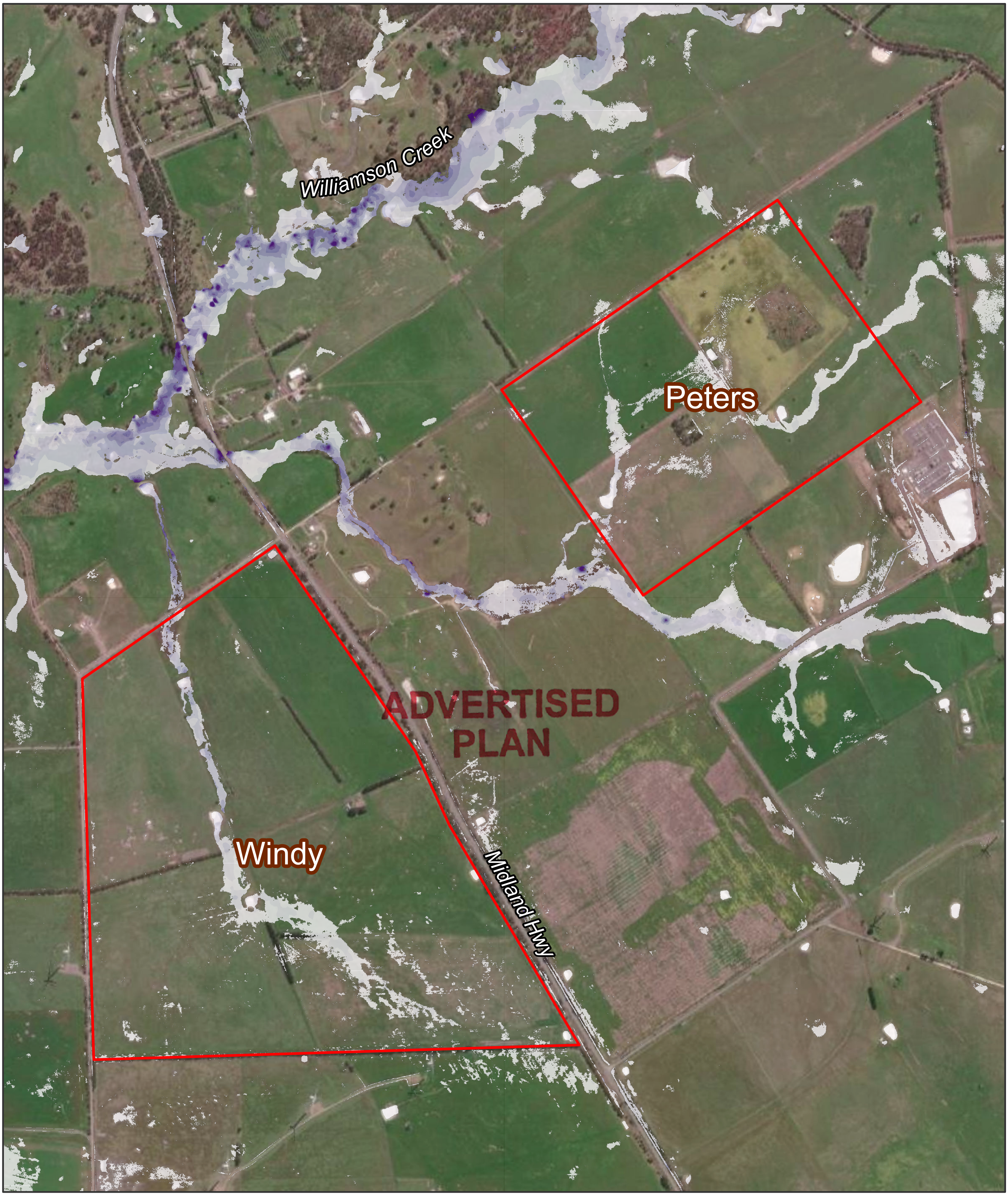
0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY



1% AEP maximum flood velocity - existing conditions

Project Site

Maximum flood velocity (m/s)

0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2

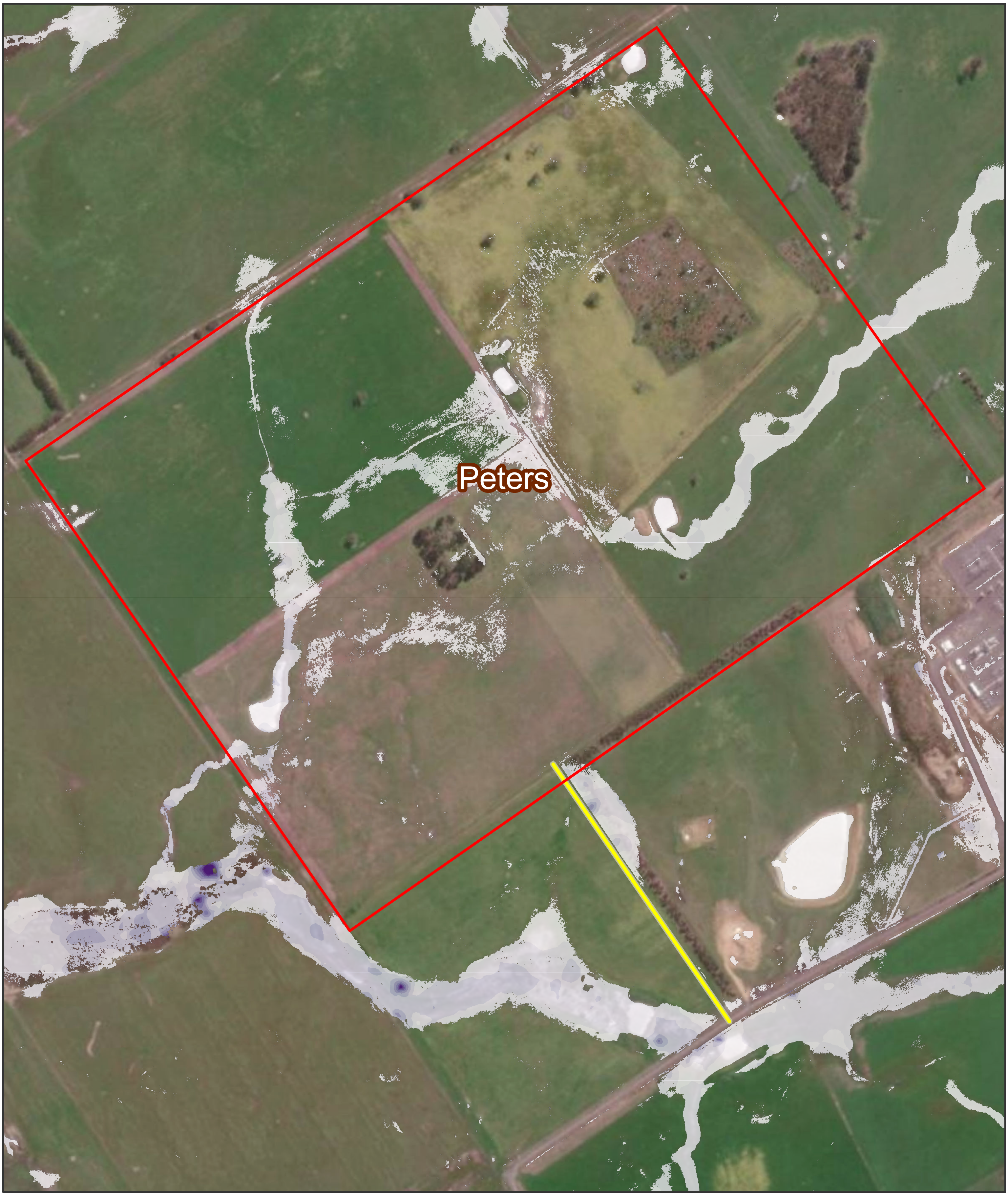
0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY



1% AEP maximum flood velocity - proposed conditions

Project Site

Proposed Access Track

Value

0 - 0.25

0.25 - 0.5

0.5 - 0.75

0.75 - 1

1 - 1.25

1.25 - 1.5

1.5 - 1.75

1.75 - 2

>2

ADVERTISED PLAN

0 65 130 260

Metres

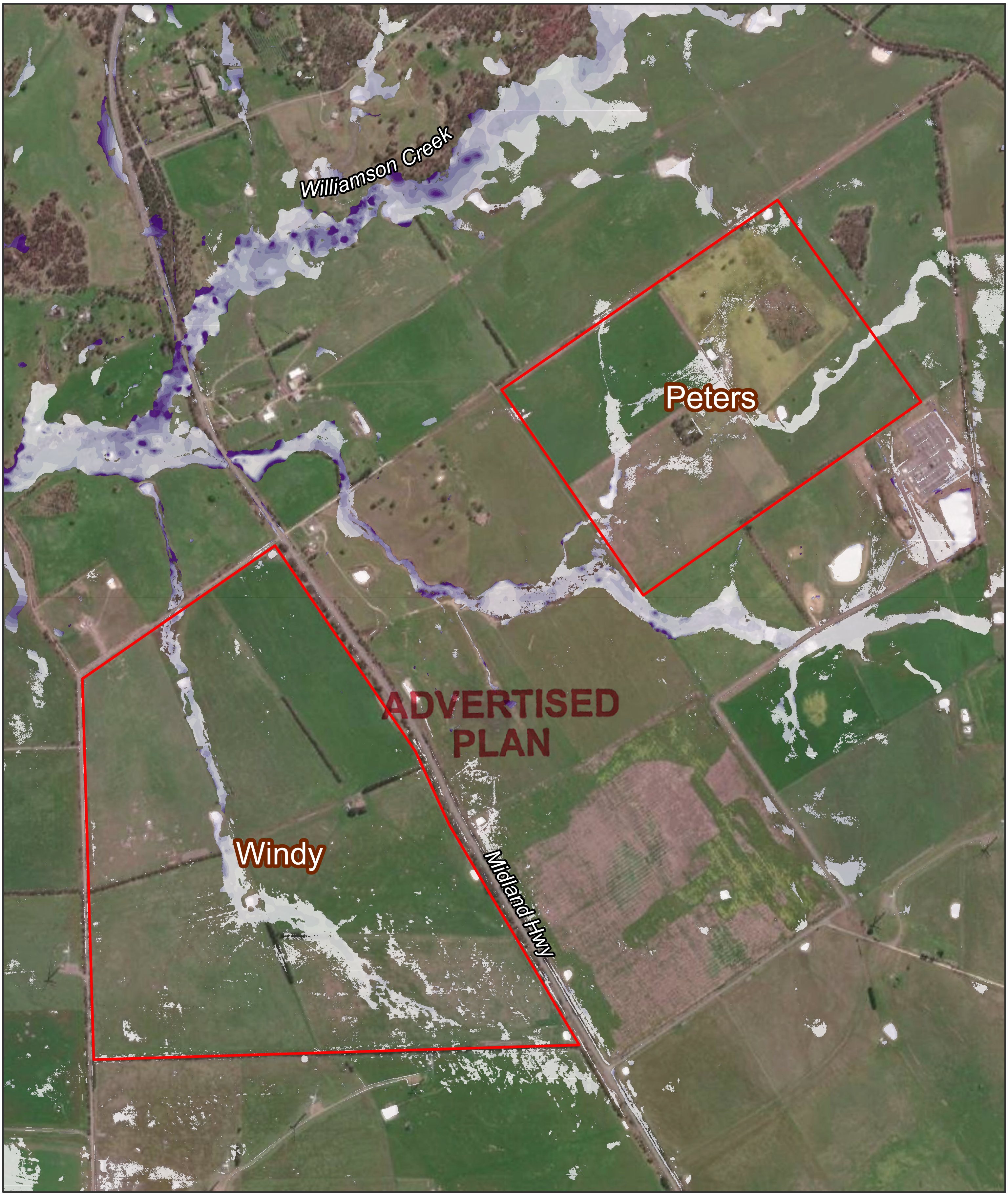
Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/13/2023

N

eco logical AUSTRALIA

A TETRA TECH COMPANY



0.5% AEP maximum flood velocity - existing conditions

Project Site

Maximum flood velocity (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

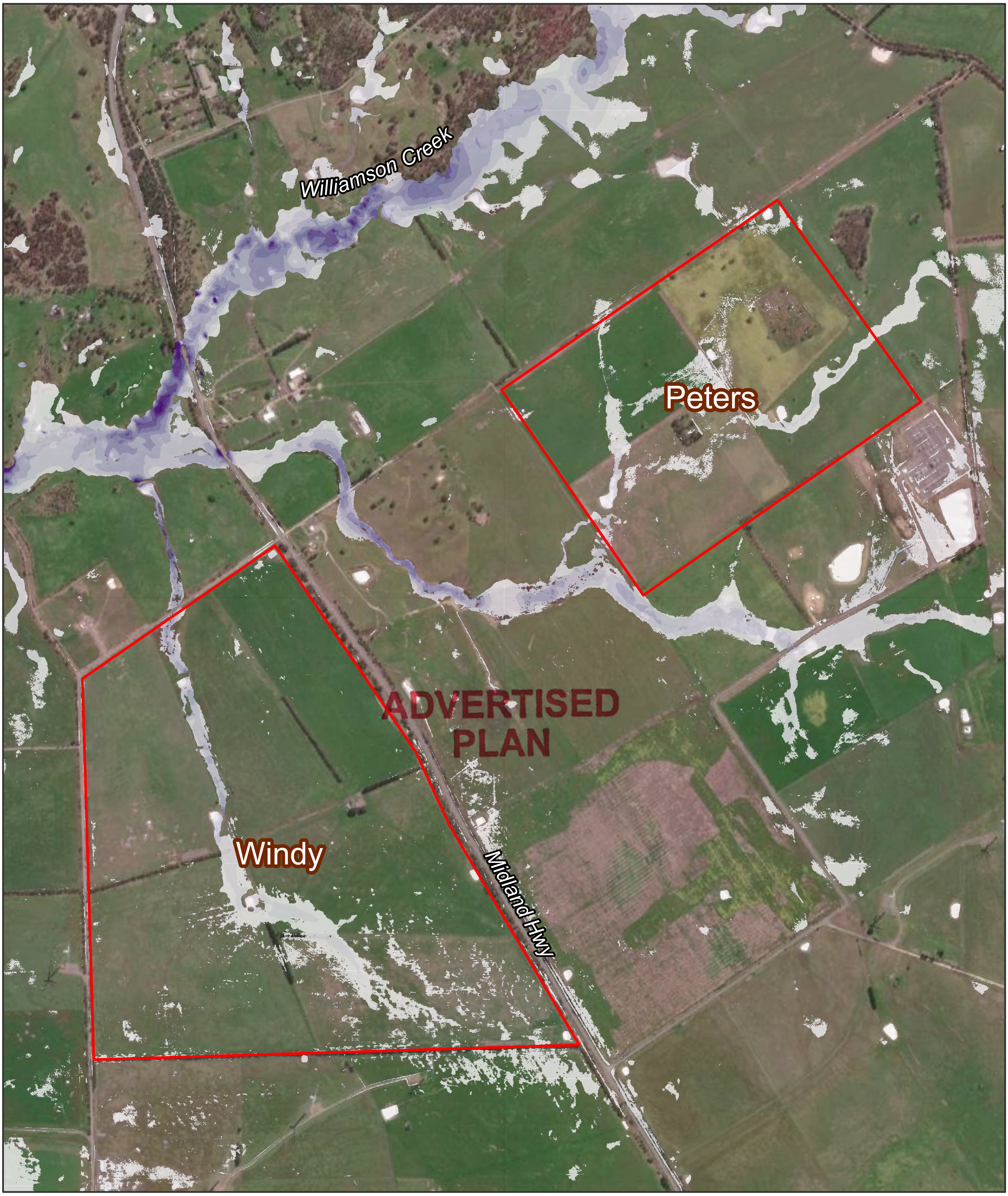
0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY



0.2% AEP maximum flood velocity - existing conditions

Project Site

Maximum flood velocity (m/s)

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- >2

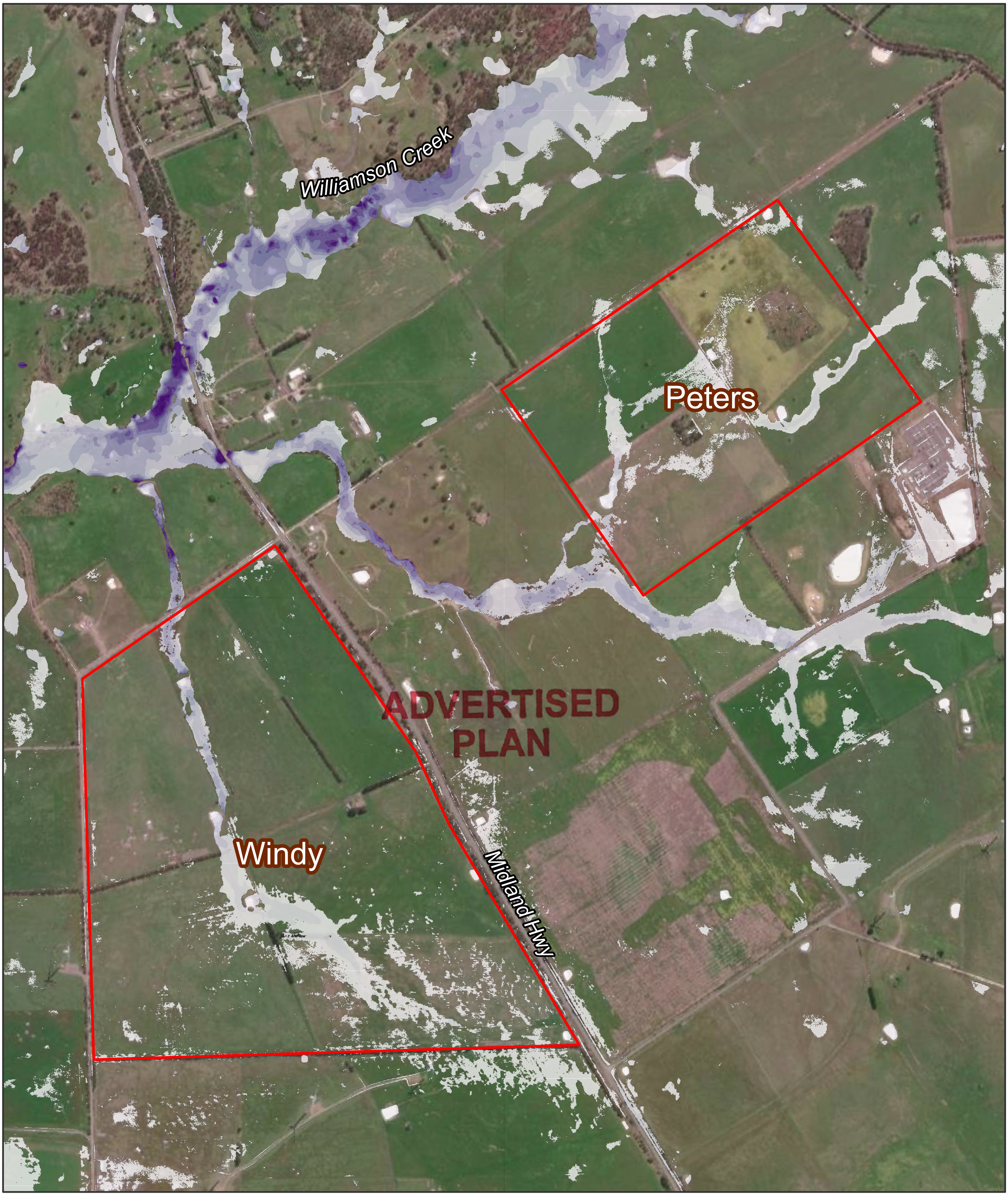
0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY



0.1% AEP maximum flood velocity - existing conditions

Project Site

Maximum flood velocity (m/s)

0 - 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
>2

0 145 290 580
Metres

Datum/Projection:
GDA2020 MGA Zone 55

Project: 22SYD3560-ED Date: 9/12/2023

N

eco logical AUSTRALIA
A TETRA TECH COMPANY