Summary Report

Dubbo Solar Farm Flood, Drainage and Groundwater Assessment

ACEnergy

15 March 2021

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15 March 2021

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Dear Jane

Dubbo Solar Farm Flood, Drainage and Groundwater Assessment

This report documents a flood risk assessment of the proposed Dubbo Solar Farm site at 47R Wellington Road, Dubbo NSW 2830. The report identifies the level of flood risk for the site and provides recommendations to aid the approval process.

If you have any queries regarding this report, please do not hesitate to contact me directly.

Yours sincerely

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WATER TECHNOLOGY PTY LTD

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Overview

The proposed Dubbo Solar Farm requires the following assessments to satisfy Council requirements as part of its Development Application (DA):

- Flood assessment – identifying flood risk for the development
- Hydraulic assessment – advising on surface water / stormwater management
- Groundwater assessment – noting any potential impact of the development to groundwater

Water Technology was commissioned by ACEnergy to undertake these assessments and provide advice on potential impacts.

This report discusses the work conducted by Water Technology, including the hydrological and hydraulic modelling used to assess the level of flood risk for the development under existing and estimated climate change conditions. The existing scenario was assessed for the 1% Annual Exceedance Probability (AEP) flood event.

1.2 Background

The site is located on the outskirts of Dubbo, in NSW, as shown in Figure 1-1. Also shown is the upstream catchment boundary of Eulomogo Creek, which flows to the south of the proposed site.

The address of the site is 47R Wellington Road, Dubbo – Lot 190, DP 754308. It has a total area of 18 hectares and is currently agricultural land (pasture).

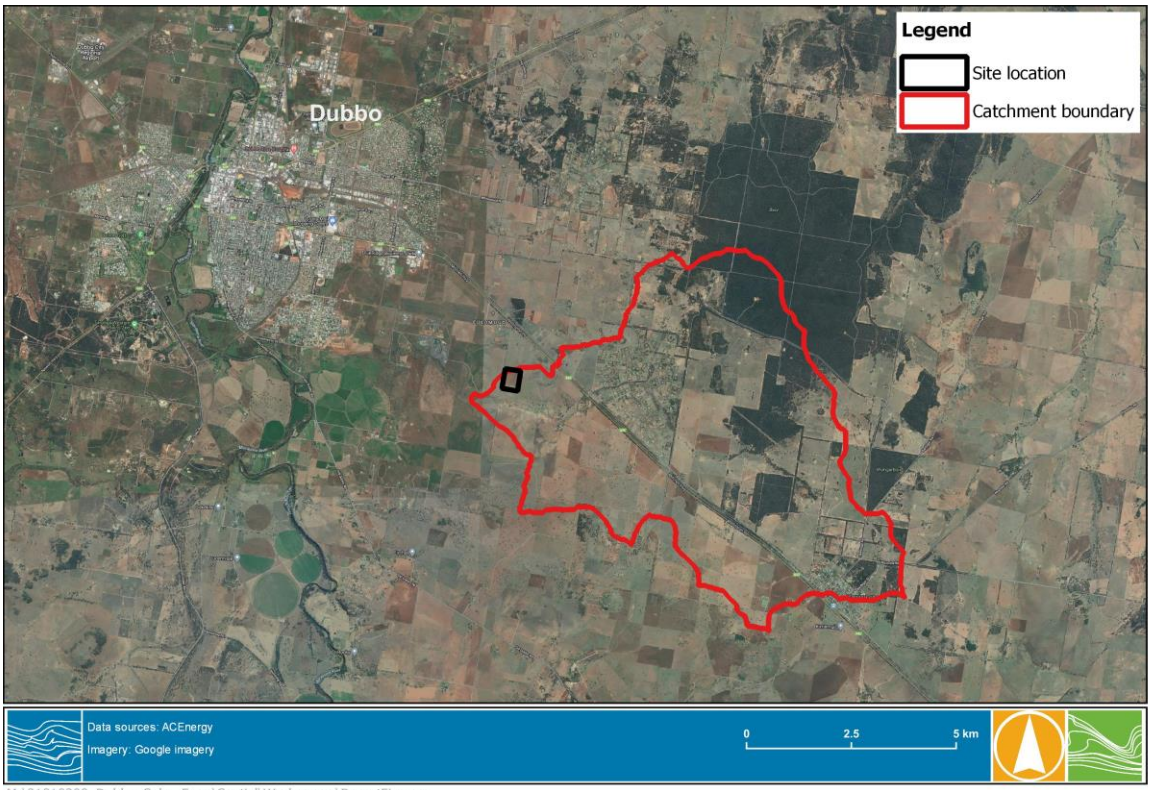

FIGURE 1-1 SITE LOCATION SHOWING UPSTREAM CATCHMENT BOUNDARY

1.2.1 General landscape features

The site is located approximately 300 metres north of Eulomogo Creek, which flows westward to join the Macquarie River south of Dubbo. As a result, drainage across the site is predominately in a south-westerly direction.

The surrounding area mostly comprises agriculture (grazing and cropping), with an urban area east of Wellington Road (Firgrove Estate), and the south-eastern urban extent of Dubbo commencing approximately 4.5 km to the west.

Figure 1-2 shows the location of the proposed site in relation to these features.

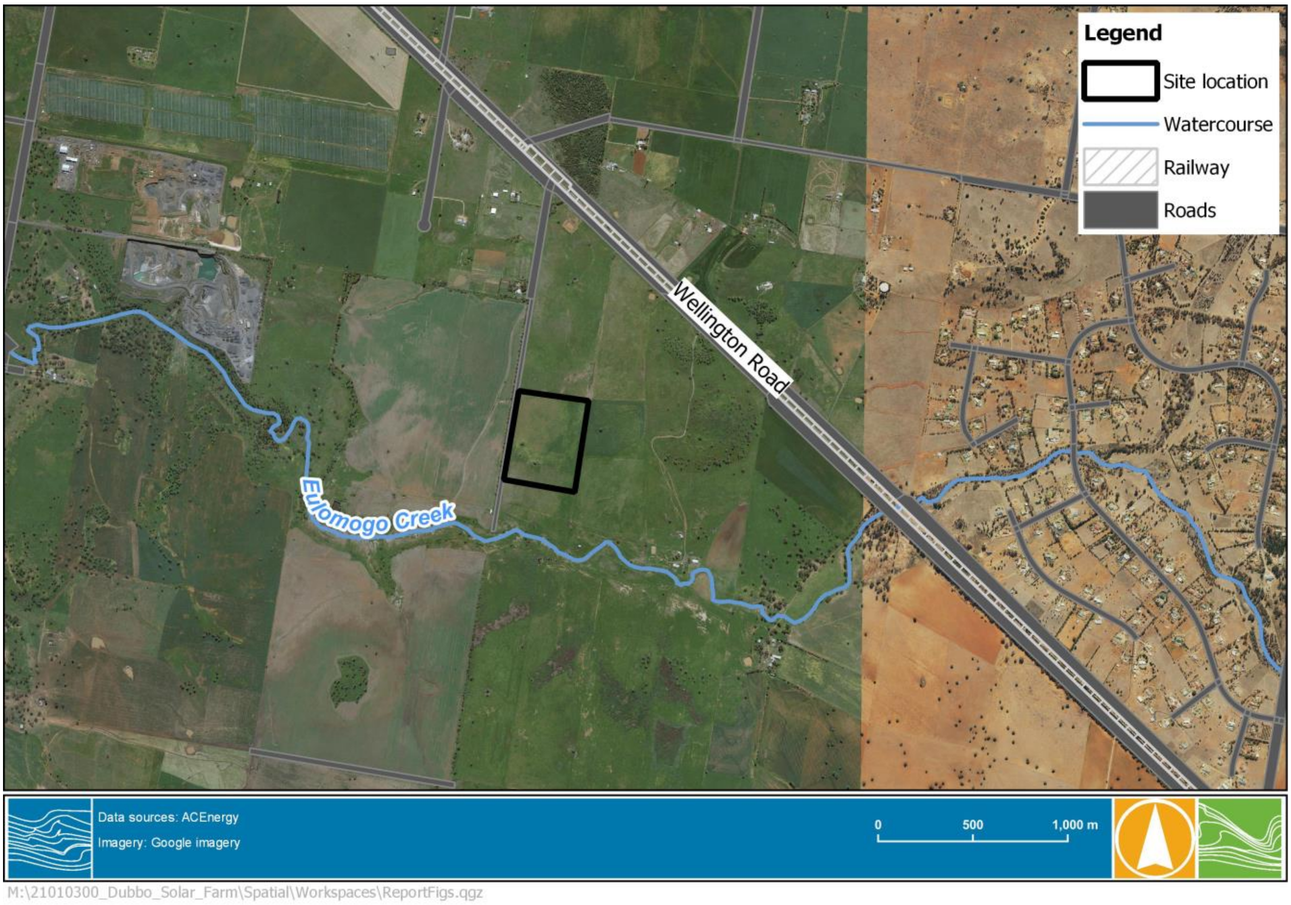

FIGURE 1-2 SITE LOCALITY PLAN

1.2.2 Rainfall

The monthly rainfall data from the Dubbo Airport AWS station is presented in Figure 1-3. Mean rainfalls are highest from November to March.

1.2.3 Evaporation

The average annual evaporation at the site is estimated from Figure 1-4 to be around 1,800 mm/year.

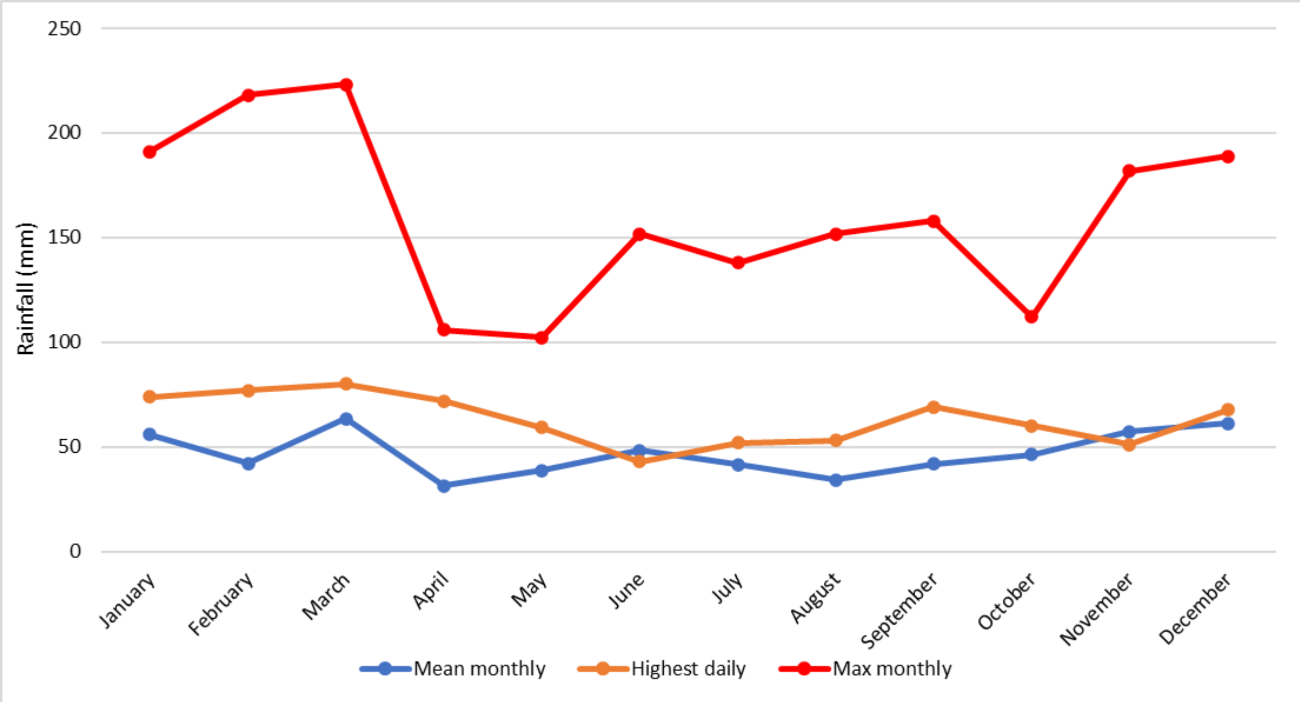

FIGURE 1-3 MONTHLY RAINFALL AT DUBBO AIRPORT AWS (065070)

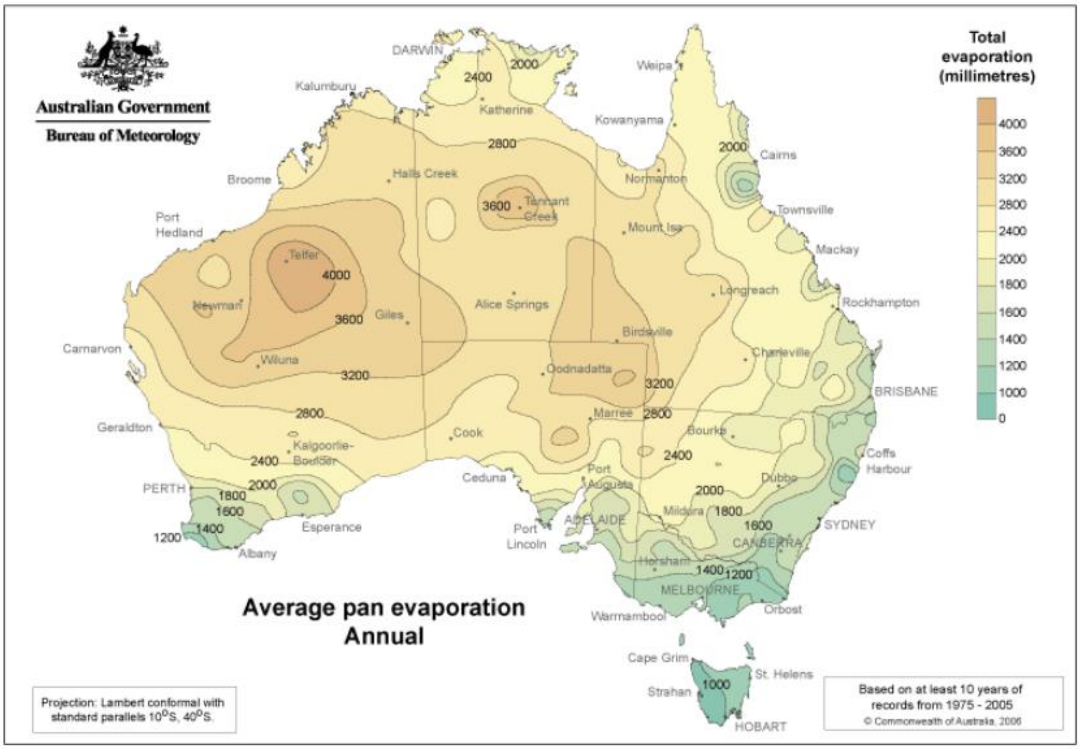

FIGURE 1-4 AVERAGE ANNUAL EVAPORATION

2 FLOODING ASSESSMENT

2.1 Overview

A flood investigation was carried out for several Annual Exceedance Probability (AEP) events. AEP is a measure of the likelihood that a flood level or flow will be equalled or exceeded in any given year. The flood investigation consisted of hydrologic (development of flows from converting rainfall to runoff) and hydraulic modelling (determining water levels, velocities and depths). The hydrologic model generated flows from the upstream catchment and determined the critical storm durations used in the hydraulic model, which in turn determined flood behaviour. Details of the hydrologic and hydraulic modelling are presented in the following sections.

The key purpose of the modelling was to determine:

- The extent to which natural flooding (e.g. along Eulomogo Creek) could impact the site; and
- The impact that development at the site could have on existing overland flow and drainage patterns.

2.2 Hydrological Model

Hydrologic modelling was conducted using RORB, a widely used Australian runoff routing model. RORB was used to calculate flood hydrographs upstream and throughout the subject site. Hydrographs for the following events were estimated: 5%, 1%, 0.5%, 0.2% AEP using the recommended methodology and parameters outlined in Australian Rainfall and Runoff 2019 (ARR2019)[1].

The methodology for determining the design flows is summarised below:

- Catchment delineation.
- Determination of Kc and m (RORB routing parameters).
- Design inputs (e.g. rainfall, losses).
- Verification of model results.
- Selection of temporal patterns.
- Determination of design hydrographs.

Details on each step are given in the following sections.

2.2.1 Catchment Delineation

Sub-catchments were delineated using the Dubbo 1m LiDAR and are shown as part of the RORB model layout in Figure 2-1. Also shown is the reporting location at the railway crossing as a green star. This is used as the upstream input to the Hydraulic Model. All modelled sub-catchments contribute to Eulomogo Creek, the main watercourse nearest the site.

The total catchment area upstream of the site was calculated as 49.4 km². The overall catchment has a general slope varying between 1% to 2%.

A series of nodes and reaches were defined in the RORB model to represent the routing characteristics of the catchment. All reaches were defined as ‘natural’. These definitions were derived from expected flow characteristics based on the aerial photography.

[1] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2019, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia

Impervious areas of the catchment were represented in the RORB model using appropriate Fraction Impervious (FI) values for each RORB subarea.

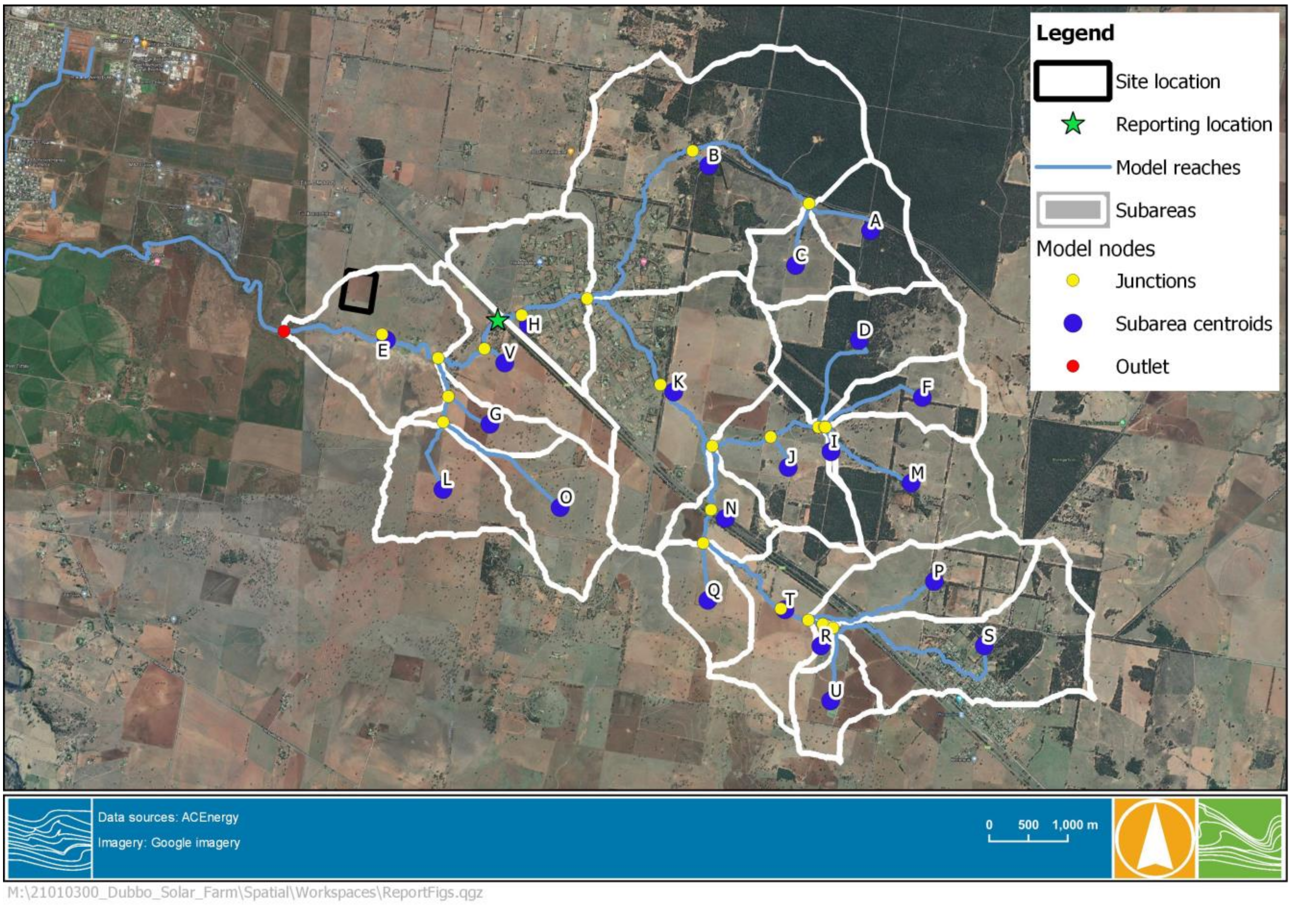

FIGURE 2-1 RORB MODEL LAYOUT

2.2.2 Routing parameters – kc and m

There are no streamflow gauges within the study area catchment to directly calibrate the RORB model to. Prediction equations for ungauged catchments were used to inform the selection of a ‘reasonable’ routing parameter, k_C.

McMahon and Muller (1983) showed that *kc* is directly proportional to the average flow distance (d_{av}). The recommended equation for catchments east and west of the Great Dividing Range for New South Wales is expressed as:

$k_C = 1.18A^{0.46}$

where *A* is the catchment area.

The resultant k_c of 7.09 was adopted.

Sensitivity testing of k_C values was carried out using the RORB Monte Carlo analysis and verified against the ARR Regional Flood Frequency Estimation Model (RFFE), this process is discussed in more detail in Section 2.2.4.

The RORB model *m* was set at 0.8. This is the recommended value for ungauged catchments[2].

2.2.3 Design inputs

2.2.3.1 Event Duration

Design rainfall was derived for burst durations between 30 min and 48 hours. Each duration was run through the RORB model to determine the critical duration at the upstream and downstream boundary of the site.

2.2.3.2 Intensity-Frequency-Duration (IFD)

Rainfall burst depths for the modelled AEP events were estimated for the centroid of the catchment using the 2016 ARR IFD analysis available from the Bureau of Meteorology[3].

TABLE 2-1 DESIGN RAINFALL DEPTHS (MM) FOR VARIOUS EVENT DURATIONS AND AEP

AEP (1:Y)	30 min	1.5 hr	2.0 hr	3.0 hr	6.0 hr	12.0 hr
5	25.5	36.5	39.7	44.6	54.3	66.3
10	30.3	43.3	47.1	52.7	64.1	78.0
20	35.1	50.1	54.4	60.8	73.7	89.7
50	41.7	59.1	64.1	71.6	86.9	106
100	46.9	66.1	71.6	79.9	97.2	120
200	54.7	77.0	83.4	93.3	114	141
500	64.9	91.3	98.9	111	135	167

Areal Reduction Factors

The point rainfall estimates were converted to catchment average values using the areal reduction factors developed for Australia during the recent revision of ARR2019[4], Book 2 Chapter 4. These factors vary with catchment area and storm duration, and account for the fact that larger catchments are less likely to experience high intensity rainfall over the whole of the catchment.

Temporal Patterns

Temporal patterns downloaded from ARR 2019 Data Hub[5] were used to simulate the distribution of burst rainfall depth during each storm duration modelled. Point temporal patterns were adopted given the relatively small size of the catchment.

Design Losses

An initial/continuing loss model was applied for the RORB modelling. Losses were initially taken from the ARR online datahub[5], with the suggested losses being 33 mm initial loss and 2.0 mm/hr continuing loss. As the site is in NSW, the continuing loss was multiplied by a factor of 0.4, to a continuing loss value of 0.8, as per industry advice[5]. These values were adopted as the starting values for the analysis and changed through verification as described below.

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[2] E.M. Laurenson, R.G. Mein, and R.J. Nathan (2010), RORB User Manual
[3] http://www.bom.gov.au/water/designRainfalls/ifd/
[4] http://book.arr.org.au.s3-website-ap-southeast-2.amazonaws.com/
[5] http://data.arr-software.org/

2.2.4 Model Verification

2.2.4.1 Approach

Sensitivity of k_C and rainfall losses were estimated by comparing modelled peak flows with peak flows produced by the ARR Regional Flood Frequency Estimation (RFEE) method[6]. The RFFE method is a replacement for the Probabilistic Rational Method described in the previous version of ARR. It is a software implementation of the ARR Revision Project 5. A full description of the method is provided in ARR project (http://arr.ga.gov.au/).

The RORB model was run in a Monte-Carlo framework, and the 20% to 1% AEP flood quantiles were compared with results from the RFFE method. The discharges for different AEPs from RFFE method and RORB are presented in Table 2-2. Peak flows from the direct / ensemble RORB modelling are also shown, further discussed in the next section.

TABLE 2-2 ARR REGIONAL FLOOD FREQUENCY MODEL RESULTS

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%)	Upper Confidence Limit (95%)	RORB (m^3/s)	
				Monte-Carlo	Direct
50	20.2	8.38	48.2	-	-
20	47.1	20.4	108	90.8	62.1
10	73.9	32.3	169	116	105
5	108	47.1	246	139	124
2	165	71.3	381	169	161
1	219	94.1	512	194	216

The RORB model produced a peak flow of 194 m^3/s compared to 219 m^3/s produced by the RFFE model at the outlet position for the 1% AEP. The peak flow of the 2% AEP is notably closer, with the model producing 169 m^3/s compared to RFFE's estimate of 165 m^3/s.

The k_c and loss values summarised in Table 2-3 were adopted in the RORB design modelling for the purpose of flood impact assessment.

TABLE 2-3 ADOPTED RORB PARAMETER VALUES

Parameters	Adopted Values
M	0.8
k_C	7.09
Median Initial Loss (mm)	13.2
Continuing Loss (mm/hr)	0.80

[6] https://rffe.arr-software.org/

2.2.5 Critical Storms and Temporal Patterns

The Monte-Carlo analysis undertaken in RORB identifies the critical storm duration for each AEP at selected locations. These durations are reported for the railway crossing upstream of the solar farm site, and at the catchment outlet downstream of the site.

Ensemble RORB runs for these durations were used to determine the temporal pattern for each critical storm, based on the peak flow which most closely matched the Monte-Carlo results. The results are presented in Table 2-4. These scenarios were modelled in the hydraulic model, discussed further in Section 2.3.

TABLE 2-4 CRITICAL STORM WITH SELECTED TEMPORAL PATTERNS

AEP	Critical Storm (hour)	Temporal Pattern	Location
20%	6	4	Railway
	6	4	Outlet
10%	6	4	Railway
	6	4	Outlet
5%	6	4	Railway
	6	4	Outlet
2%	6	10	Railway
	6	4	Outlet
1%	6	8	Railway
	6	4	Outlet

2.3 Hydraulic Model

2.3.1 Overview

Hydraulic modelling of the floodplain, including the local catchment areas draining through the subject site were completed using a two-dimensional (2D) TUFLOW flood model. TUFLOW software is one of the most widely used hydraulic modelling software packages in Australia. The software is considered an appropriate modelling tool for modelling riverine and local overland flooding. TUFLOW allows the simulation of runoff generated from local rainfall on a grid that is representative of the site topography, known as “Rain on Grid” modelling, which was adopted during this project. The model DEM was developed from the Dubbo 1m LiDAR available for the site, as shown in Figure 2-2.

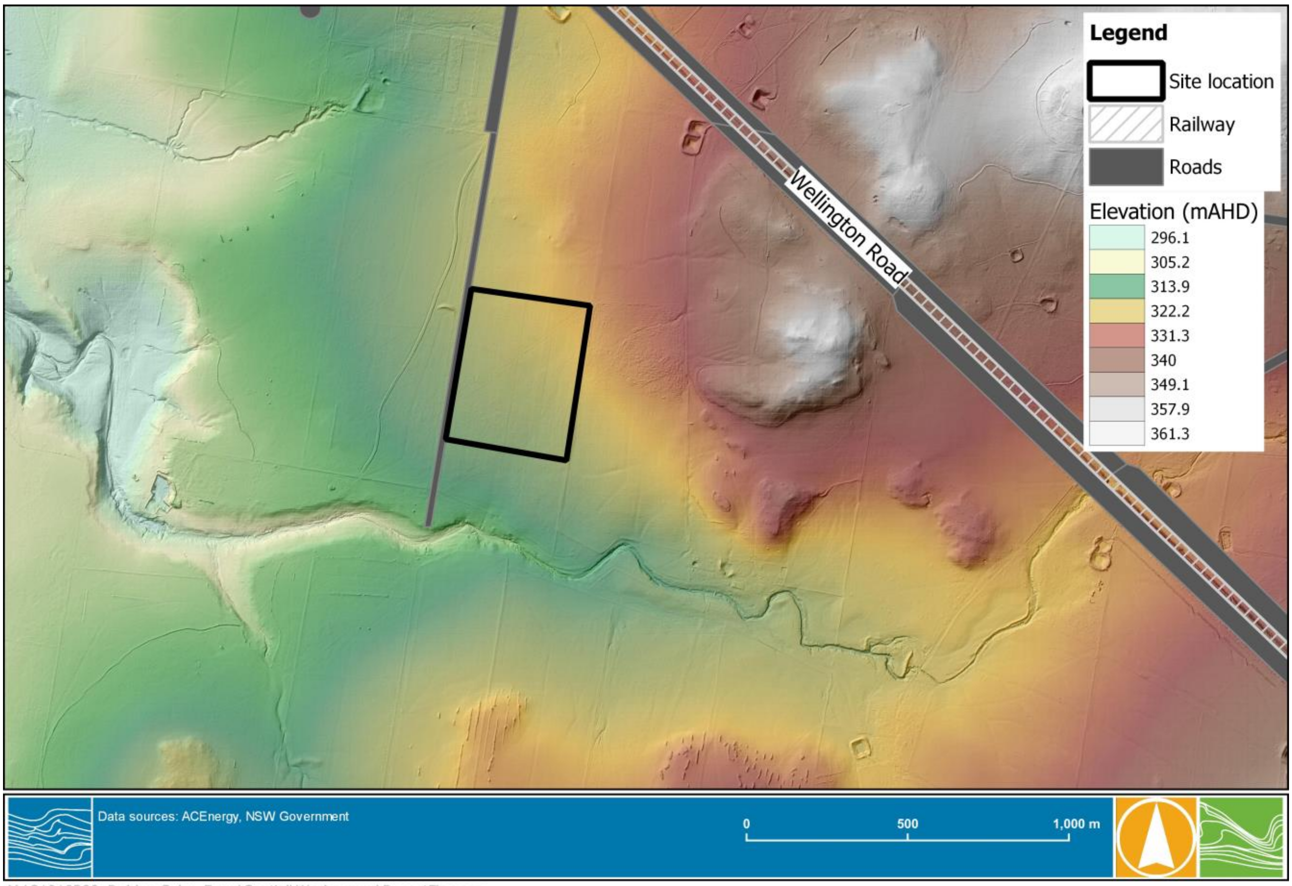

FIGURE 2-2 SURROUNDING SITE TOPOGRAPHY

The Rain-on-Grid approach adopted the critical storm durations and selected temporal patterns determined by RORB and discussed in Section 2.2.5. To represent flow from the upper catchment, an inflow boundary at the creek railway was applied.

Manning's 'n' roughness zones were assigned across the model based on recommendations in ARR2019[7], as shown in Table 2-5. Most of the area was modelled with a roughness of 0.03, representing open space with minimal vegetation. The Initial Loss (IL) and Continuing Loss (CL) applied to the rainfall are also shown in the table.

TABLE 2-5 MANNING'S ROUGHNESS AND LOSSES USED IN THE HYDRAULIC MODEL

Manning's 'n'	IL (mm)	CL (mm/hr)	Land Use
0.150	10.0	2.0	Residential - Rural (lower density)
0.030	15.0	1.0	Open Space or Waterway - minimal vegetation
0.060	15.0	1.0	Open Space or Waterway - moderate vegetation
0.020	2.5	0.5	Roads
0.125	5.0	1.0	Railway

[7] http://book.arr.org.au.s3-website-ap-southeast-2.amazonaws.com/

2.3.2 2D TUFLOW Model

The domain (Figure 2-3) of the 2D TUFLOW model extends beyond the site boundary to cover the full local catchment area draining to the site. The figure also shows the Mannings 'n' roughness value assigned to each area based on land use. Inflow and outflow boundaries are shown along the perimeter of the model.

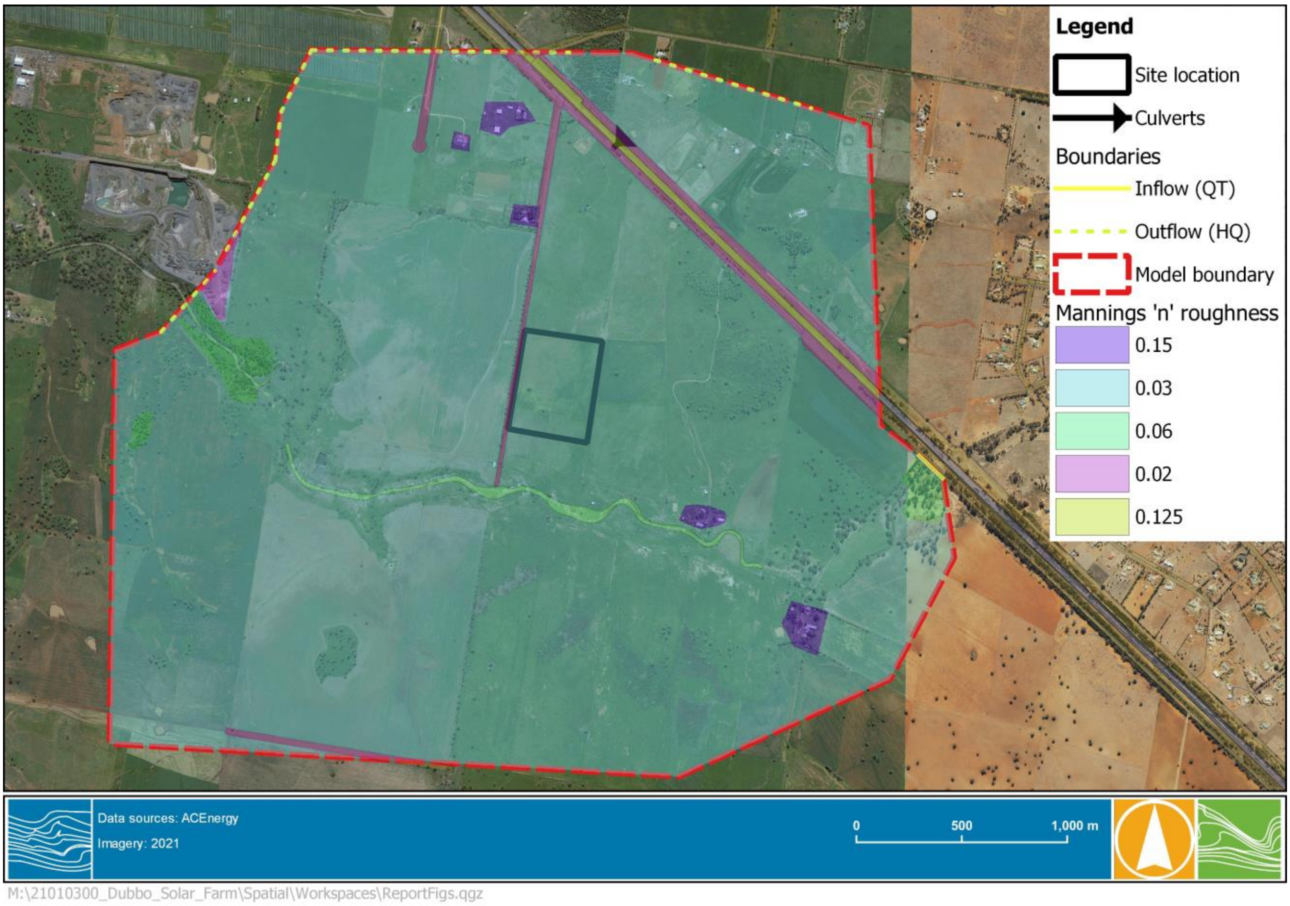

FIGURE 2-3 TUFLOW MODEL LAYOUT

2.3.3 Model scenarios

Hydraulic modelling was undertaken for the 1% AEP for the 6 hour duration (identified as critical) as well as neighbouring durations. For each, selected temporal patterns were run as identified in the RORB modelling.

3 RESULT AND DISCUSSION

3.1 Overview

The results of the flood modelling are presented in this section. The maximum flood level, depth, velocity and hazard for each modelled AEP was determined across the modelled event durations. Note that flood depths less than 5 cm have been filtered from the results.

In this report only the 1% AEP event is discussed under existing site conditions.

Floods can be hazardous, producing harm to people, damage to infrastructure and potentially loss of life. In examining the potential hazard of flooding at the site, there are several factors to be considered, as outlined in ARR 2019 (Book 6 Chapter 7)[8]. An assessment of flood hazard should consider:

- velocity of floodwaters;
- depth of floodwaters;
- combination of velocity and depth of floodwaters;
- isolation during a flood;
- effective warning time; and
- rate of rise of floodwater.

The flood hazard of the site was assessed in accordance with ARR2019, which defines six hazard categories. The combined flood hazard curves are presented in Figure 3-1 and vulnerability thresholds classifications are tabulated in Table 3-1.

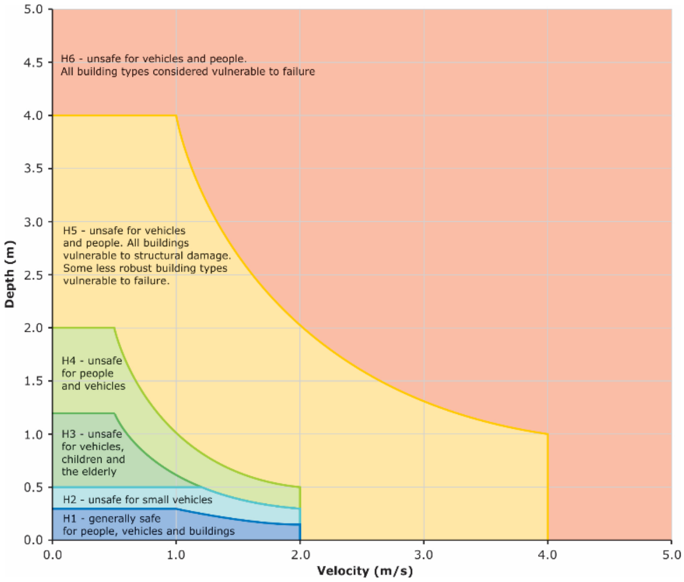

FIGURE 3-1 COMBINED FLOOD HAZARD CURVES

TABLE 3-1 HAZARD CLASSIFICATION (ARR, 2016)

Hazard Vulnerability Classification	Classification Limit (D and V in combination)	Limiting Still Water Depth (D)	Limiting Velocity (V)	Description
H1	D*V ≤ 0.3	0.3	2.0	Generally safe for vehicles, people and buildings.
H2	D*V ≤ 0.6	0.5	2.0	Unsafe for small vehicles.
H3	D*V ≤ 0.6	1.2	2.0	Unsafe for vehicles. children and the elderly.
H4	D*V ≤ 1.0	2.0	2.0	Unsafe for vehicles and people.
H5	D*V ≤ 4.0	4.0	4.0	Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
H6	D*V > 4.0	-	-	Unsafe for vehicles and people. All building types considered vulnerable to failure.

[8] http://book.arr.org.au.s3-website-ap-southeast-2.amazonaws.com/

3.2 1% AEP Flood Depth Existing Condition

For the 1% AEP, the flood depth at the site is generally less than 0.1 m (Figure 3-2). In small patches across the site within overland flow paths, depths reach 0.15 m.

Depths within Eulomogo Creek south of the site peak between 2-3 m, with floodwaters remaining within the banks. Modelled flood extents along the creek are approx. 240 m from the site's southern fence.

Within the proposed development footprint, the solar panels have been proposed in area where the flood depth is less than 0.1 m. For solar panels proposed in inundated areas, it is recommended that these are located above the 1% AEP flood level. For any critical infrastructure, it is recommended that it be sited 300 mm above the 1% AEP level. Impacts are further discussed in Section 3.7.

3.3 1% AEP Flood Velocity Existing Condition

Velocities within the proposed development area are very low and generally beneath 0.3 m/s (Figure 3-3). Along the overland drainage paths through the site, these peak at 0.6 m/s and 0.8 m/s. North and east of the site, surrounding flow paths reach 1.0 m/s.

3.4 1% AEP Flood Hazard Existing Condition

The flood hazard map created from the model results is presented in Figure 3-4. This is a product of both flood depth and velocity. For the 1% AEP flood event, the site and surrounds are entirely characterised as H1: 'Generally safe for vehicles, people and buildings'. Based on the hazard levels identified for the site, the site is considered a low flood risk.

3.5 1% AEP Flood Elevation Existing Condition

Peak flood levels are shown in Figure 3-5. Across the proposed site, these levels vary from 325.6 mAHD in the north-east corner, to 316.4 mAHD in the south-west corner. Given the low depths, typically below 0.1 m, these flood levels are generally little higher than the ground level.

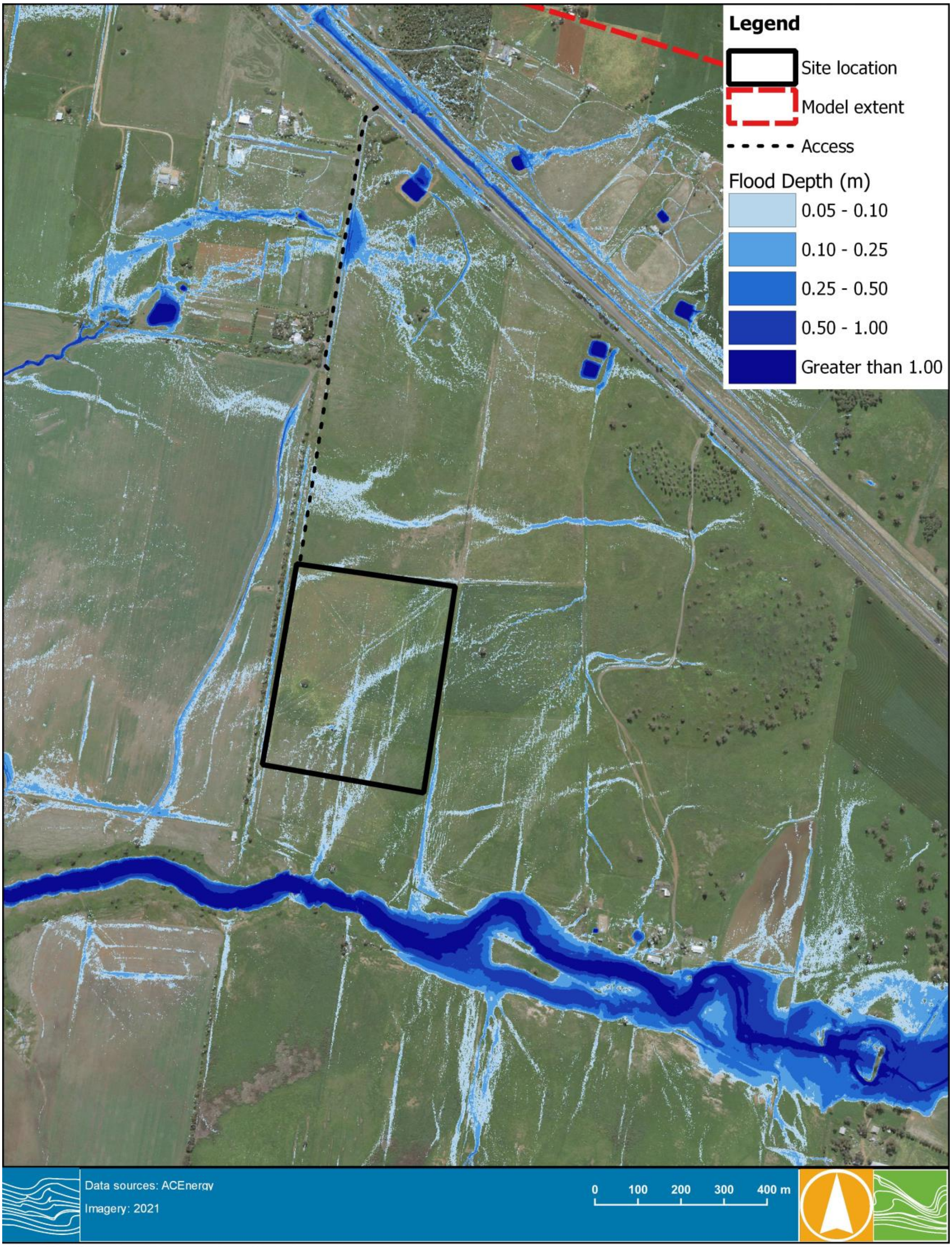

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FIGURE 3-2 1% AEP FLOOD DEPTH FOR EXISTING CONDITION

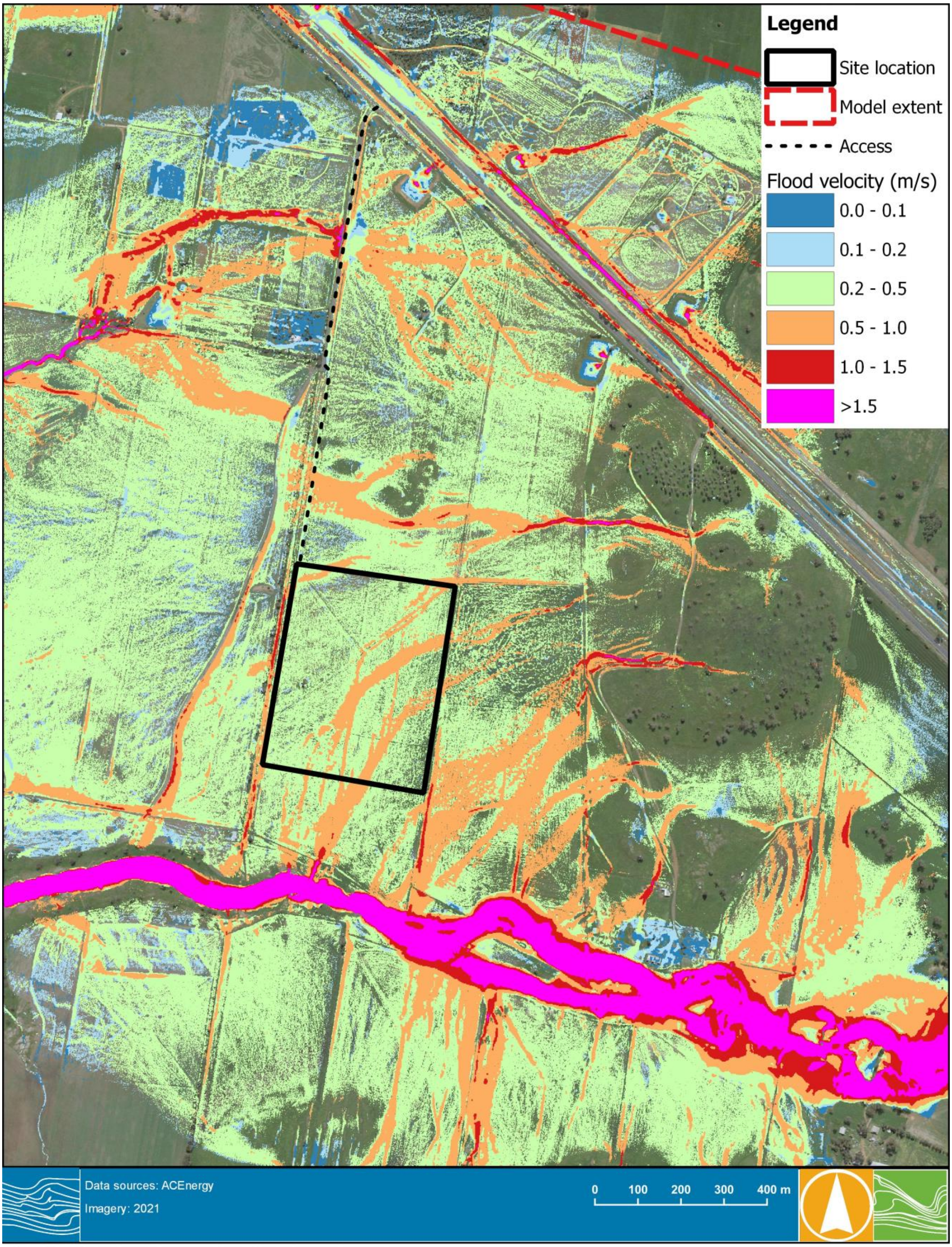

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FIGURE 3-3 1% AEP FLOOD VELOCITY FOR EXISTING CONDITION

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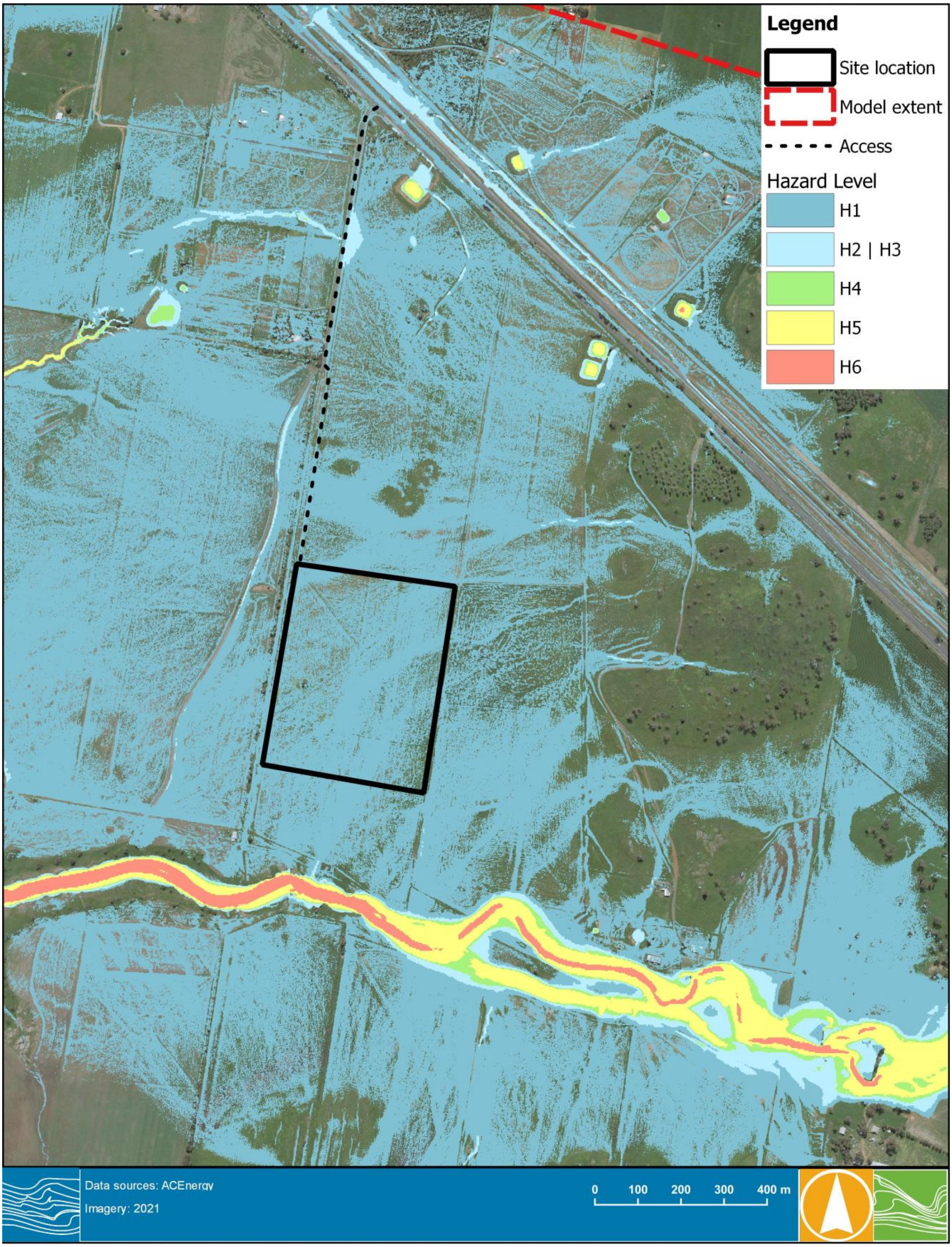

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FIGURE 3-4 1% AEP FLOOD HAZARD FOR EXISTING CONDITION

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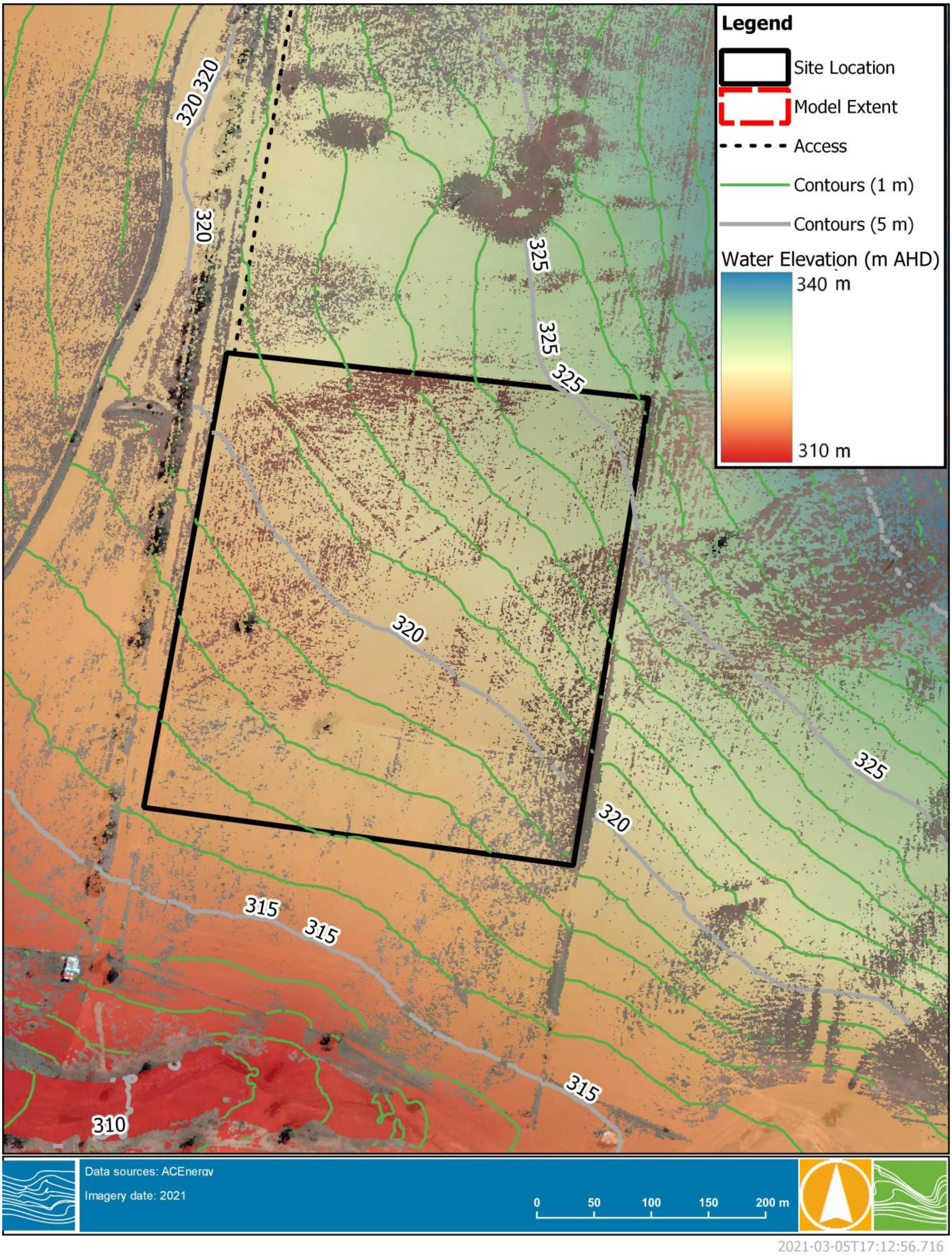

FIGURE 3-5 1% AEP FLOOD ELEVATION FOR EXISTING CONDITION

3.6 Comparison of the Hydrologic and Hydraulic Model Results

The peak flows from both the hydrologic and hydraulic models were compared at the Eulomogo Creek outlet location shown in Figure 2-1. For the 1% AEP, 6 hrs storm duration, the peak flow at the hydrologic model (RORB) was 216 m^3/s. The peak flow from the hydraulic model (TUFLOW) was 198 m^3/s (with the flow entering and exiting the proposed solar farm site peaking at only 2 m^3/s). The closeness in the two peaks flows suggests that the hydraulic model is producing an accurate estimation of the flood behaviour.

3.7 Effects of Proposed Development

The impact of the proposed development on the flood behaviour is likely to be very low as no major changes to the land topography are expected. No change in impervious area is expected within the majority of the site, given a solar panel will spill its surface runoff to the ground and travel under the neighbouring solar panel at the downstream side. This allows water to travel on the existing ground surface and no artificial surfaces are required. Minor changes to impervious area would be expected in the north-west corner of the site as a result of roadways and proposed car park. Given the location of these changes relative to the drainage paths, as well as the low depths seen, impacts as a result of these changes are likely to be insignificant.

3.8 Site Access

The site is to be accessed from Basalt Road, which runs south from the main road (Wellington Road / Mitchell Highway). The existing road is to be extended further south to reach the site as shown in Figure 3-6. The flood modelling shows two shallow overland flow paths crossing the access track. The northernmost of these is currently conveyed beneath the road by a set of culverts. These culverts were not included in the modelling to simulate a blockage scenario, showing water backing up to the east of the road. Eventually the road overtops with 1% AEP depths below 0.15 m. Depths at the track crossing further south remain below 0.1 m, pooling on either side of the road due to local drainage. As the proposed track levels are unknown, natural surface has been used in this location.

The track design should consider drainage in light of these modelled 1% AEP flood levels and the suitability of additional culverts given the implication on access. In the event of a 1% AEP event, it is unlikely that flood depths would limit access to the site for extended periods.

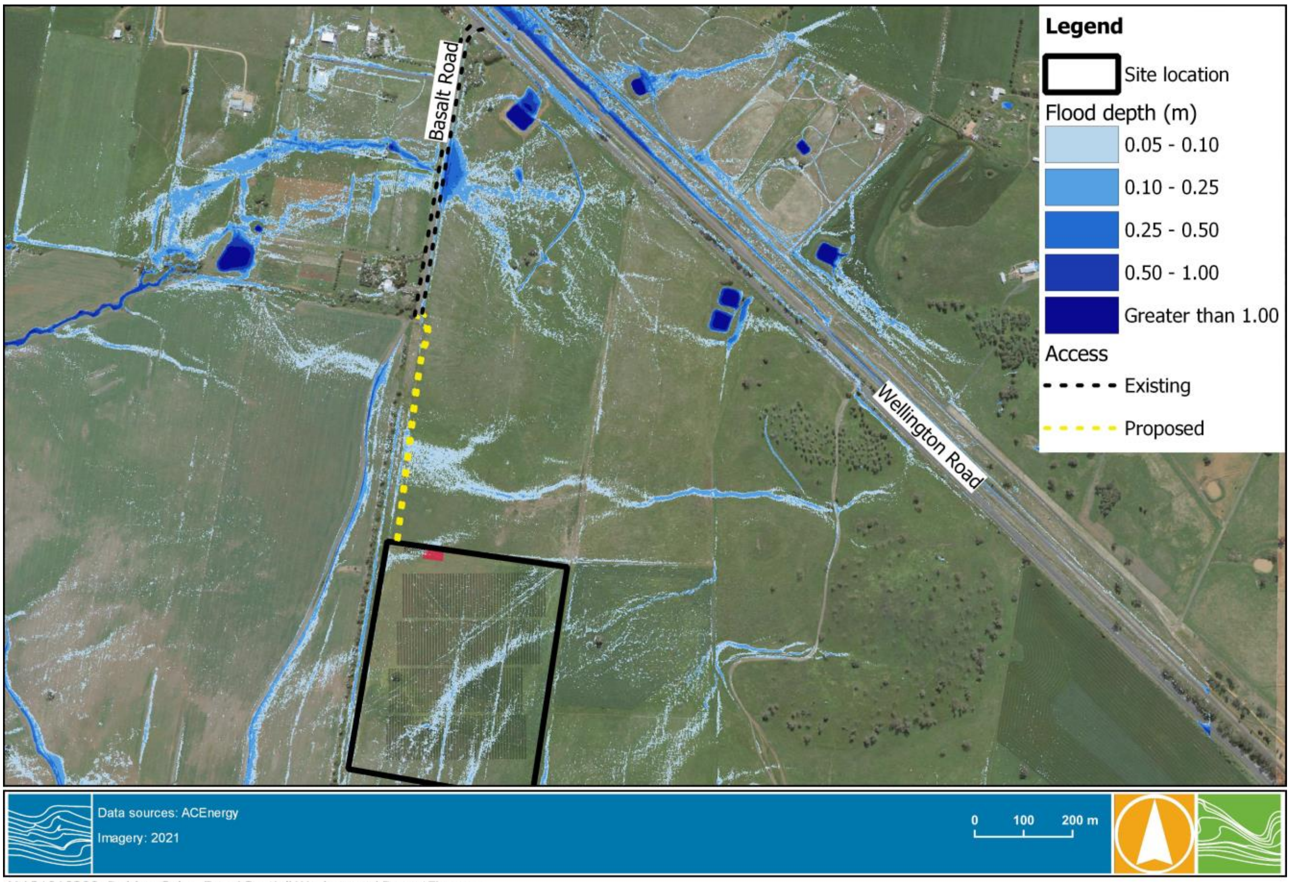

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FIGURE 3-6 SITE ACCESS WITH 1% AEP FLOOD DEPTHS

4 SITE STORMWATER MANAGEMENT

4.1 Stormwater Volumes

It appears the site is currently used for pasture cropping/grazing. It is considered the site currently has a low fraction imperviousness with minimal hard surfaces which generate runoff quickly. The site is however likely to generate a higher percentage of runoff due to the cut drains when compared with a completely natural or unchanged site.

When assessing the impact of stormwater runoff as a result of the development, consideration to the design layout and plans has been undertaken. Due to the nature of the solar panels which are raised well above the natural surface placed on a stand. there will be a shadow under each of the panels. The shadow is where rainfall will not fall directly on the ground, runoff from the uphill panel will be able to flow across the ground and under the downhill panel, as such solar panels do not effectively increase the fraction impervious in the same way road pavement or the roof of a building do.

The site is to be accessed via a track from the north. It is assumed the track will be an unsealed gravel road along with several car parking spots located at the north of the site. The overall impact of the gravel road will be extremely negligible in regards to runoff volumes and peak flow rates generated on the site.

The roadway is expected to account for around 2% of the site. The site itself is around 0.5% of the local upstream catchment. As a result, it is not expected that any stormwater infrastructure (other than drainage associated with the roadway, solar panel array-see below, and infrastructure buildings) will be required to be considered by the designer.

4.2 Water Quality Measures

Stormwater management is an important consideration on solar farm sites as the addition of panels across large areas has the potential to increase erosion and runoff if not treated properly. If solar panels are not fixed and change direction to track the sun, the drip line of runoff from the panels will vary depending on the time of the day. It is understood, the panels proposed in this site will utilise a sun tracking device, therefore the risk of a drip line within this development is reduced.

There has been a lot of discussion and some research into the impact of solar farms on stormwater runoff in the USA and the UK. Some of the research has included theoretical modelling, and some research has been focused on applied field-based work. The general consensus with this research is that solar panels will not have a significant impact on the hydrology of the site under the following conditions:

- Ensure that the soil profile has not been overly compacted due to heavy machinery during construction, if it has, mitigate the soil to increase infiltration rates.
- Encourage vegetation cover to establish and be maintained. Native grasses would be the preference, but when dealing with cleared farmland, improved pasture is likely to exist in the soils seed bank already.
- Concentrated flows along narrow flow paths should be avoided to minimise erosion potential. There are no major flow paths within the site, therefore there is low risk of erosion as a result of concentrated flow paths.
- The gap between each row of solar panels is greater than or equal to the width of the solar panel rows to allow the runoff from the upslope panel a buffer strip to spread across the surface and allow vegetation growth.
- If the slope of the land is greater than 5% provide an energy dissipator or contour that will hold the runoff up and allow it to spread across the downslope evenly. This break in slope should be provided downhill of each dripline from the upslope panel. The site is relatively flat (about 1 ~ 2 %), so this measure will not be required at this site.

- Existing vegetation, for example grasses and grass cover, provide a filter for sediment control. These should be maintained where possible.

If the site layout can meet the general stormwater management principles proposed above, then there should be no adverse impacts of the solar farm on the hydrology of the catchment or the sediment loading of the runoff from the catchment.

5 PRELIMINARY GROUNDWATER ASSESSMENT

5.1 Introduction

5.1.1 Objectives and scope

Water Technology was requested to conduct a preliminary desktop groundwater assessment of the proposed solar farm from publicly available information. Although specific requirements were not provided, this assessment considers the Water Management Act 2000 and the Environmental Planning and Assessment Act 1979. At a community presentation in Dubbo, it was noted that solar farms may be State Significant Developments if they are >$30 million (DPE, 2019). This would attract specific scoping requirements for a detailed groundwater assessment.

The scope of this preliminary groundwater assessment excludes the following:

- Modification of any groundwater recharge or discharge structures e.g. dams or salinised land.
- Any groundwater extraction.
- Any intersection of groundwater with excavations.
- Consideration of direct removal of groundwater dependent ecosystems (GDEs)
- Consideration of hazardous materials (e.g. sewage or chemicals from battery storage).
- Any cumulative impacts.

The scope and objective of this preliminary assessment is to consider the proximity of nearby receptors (bore users and ecosystems) to provide a high level assessment of the impacts of the planned actions considering the property has a moderately high and high groundwater vulnerability.

5.1.2 Legislative framework

The NSW Murray Darling Basin Fractured Rock Groundwater Sources are the aquifers of interest in the relevant Water Sharing Plan (2020) governed by the Department of Primary Industries Water (DPI Water) under the Water Management Act 2000 for the proposed site. This plan discusses contamination and lists high priority GDEs.

5.1.3 Actions and impacts

From shapefiles provided, the proposed development will include the actions shown in Table 5-1. This table can be a useful tool to guide further investigations that may be required.

TABLE 5-1 PRELIMINARY IMPACT ASSESSMENT

Action	Possible Impact	In Scope?
Power transmission poles	Foundations intersect groundwater, requiring dewatering that impacts groundwater users/receptors	No
Fencing	Foundations intersect groundwater, requiring dewatering that impacts receptors	No
35 m x 35 m concrete slab in the south	Altered recharge, impacting receptors	Yes

Action	Possible Impact	In Scope?
Removal of trees	Altered groundwater discharge, impacting receptors	No
A surface water drainage point	Altered recharge, impacting receptors	No
Low permeability tracks	Altered recharge, impacting receptors	Yes
Installation of hazardous chemicals	Leakage impacts groundwater users/receptors	No

Considering Table 5-1, altered recharge is the focus of this assessment. This may impact the beneficial uses/receptors accessing the shallow aquifer.

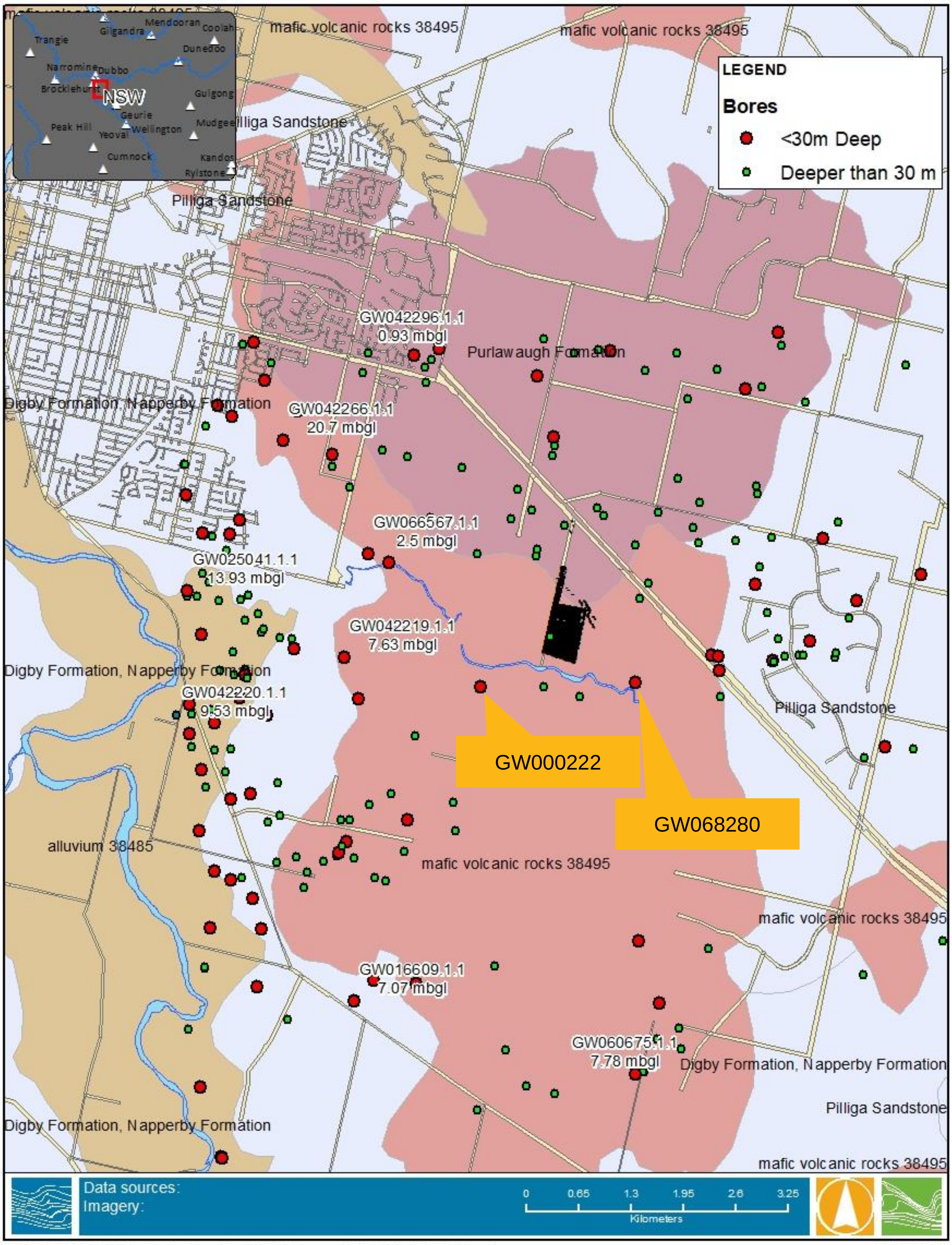
5.2 Local hydrogeology

Information on geology and bores within 5 km of the site are shown in Figure 5-1. Table 5-2 provides the drillers log on site.

TABLE 5-2 SITE GEOLOGY – BORELOG FROM GW008368.1.1 (GROUND ELEVATION 317.46 FROM LIDAR)

Depth From (m)	Depth To (m)	Description
0	2.44	Clay red
2.44	5.79	Basalt
5.79	7.01	Basalt hard
7.01	14.94	Basalt
14.94	15.24	Basalt decomposed
15.24	16.76	Basalt water supply
16.76	18.9	Shale light grey
18.9	36.58	Clay red

The closest shallow bores include bore GW000222.1.1 (17.5 m deep bore located 860 m south west of the development drilled in 1918 for no listed purpose) and GW068280.1.1 (a 26 m deep household water supply well drilled in 1989). Local bores show a clay layer of 1.5-2.5 m overlying variably weathered basalt. This basalt is the water source for GW068280.1.1. The clay layer is likely to provide a *barrier zone* to vertical recharge (and any *threat* from contamination) where present. More detail on the distribution of the clay layer is important, as it will influence any altered to natural rainfall recharge by impermeable infrastructure such as the concrete slab.



M:\21010300 Dubbo Solar Farm\Spatial\Workspaces\Site Data10 7GW.mxd 23/02/2021

FIGURE 5-1 SURFACE GEOLOGY (GEOSCIENCE AUSTRALIA) AND REGISTERED BORE MAP

5.2.1 Groundwater Level

Static/standing water level (SWL) data is sparse in the area, with the majority of data from the 1970s. At the site, SWL must be inferred from neighbouring wells in the shallow aquifer. There are two data points within two kilometres: GW042219.1.1 at 290.35 mAHD (SWL of 7.63 metres below ground level - mbgl) and GW066567.1.1 at 281.72 mAHD with a SWL of 2.5 mbgl. Site elevation is 319.2 mAHD, which infers a site SWL of 38 m bgl if the water table was flat, however, if the water table follows the ground surface the SWL is likely to be ~ 5 mbgl which is lower than the root systems of most terrestrial GDEs.

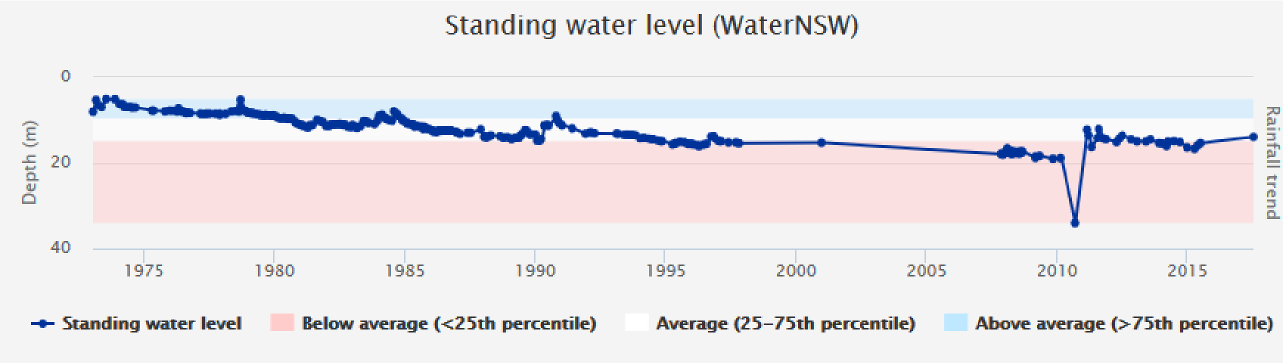


FIGURE 5-2 GROUNDWATER HYDROGRAPH FOR WATER NSW MONITORING WELL GW025041.1.1

5.3 Assessment of adverse effects to vulnerable groundwater resources

5.3.1 GDEs

Approximately one kilometre north of the planned development, there is low potential for groundwater interaction by significant Eucalyptus crebra, and 1.5 km west of the planned development, there is moderate potential for groundwater interaction with eucalyptus and Callitris as shown in Figure 5-3 (GDE Atlas, 2016). No high priority GDEs are present in the area (NSW Office of Water, 2018).

5.3.2 Bore users

The closest registered shallow groundwater well is approximately a kilometre away.

Considering the scope of work provided in this section, although the shallow groundwater is likely potable quality available at reasonable yield, the altered recharge from tracks and impermeable foundations are likely to have a negligible impact to receptors. As such, these works are compliant with the Water Management Act 2000 and the Environmental Planning and Assessment Act (1979) if detailed designs do not change the existing groundwater recharge or discharge.

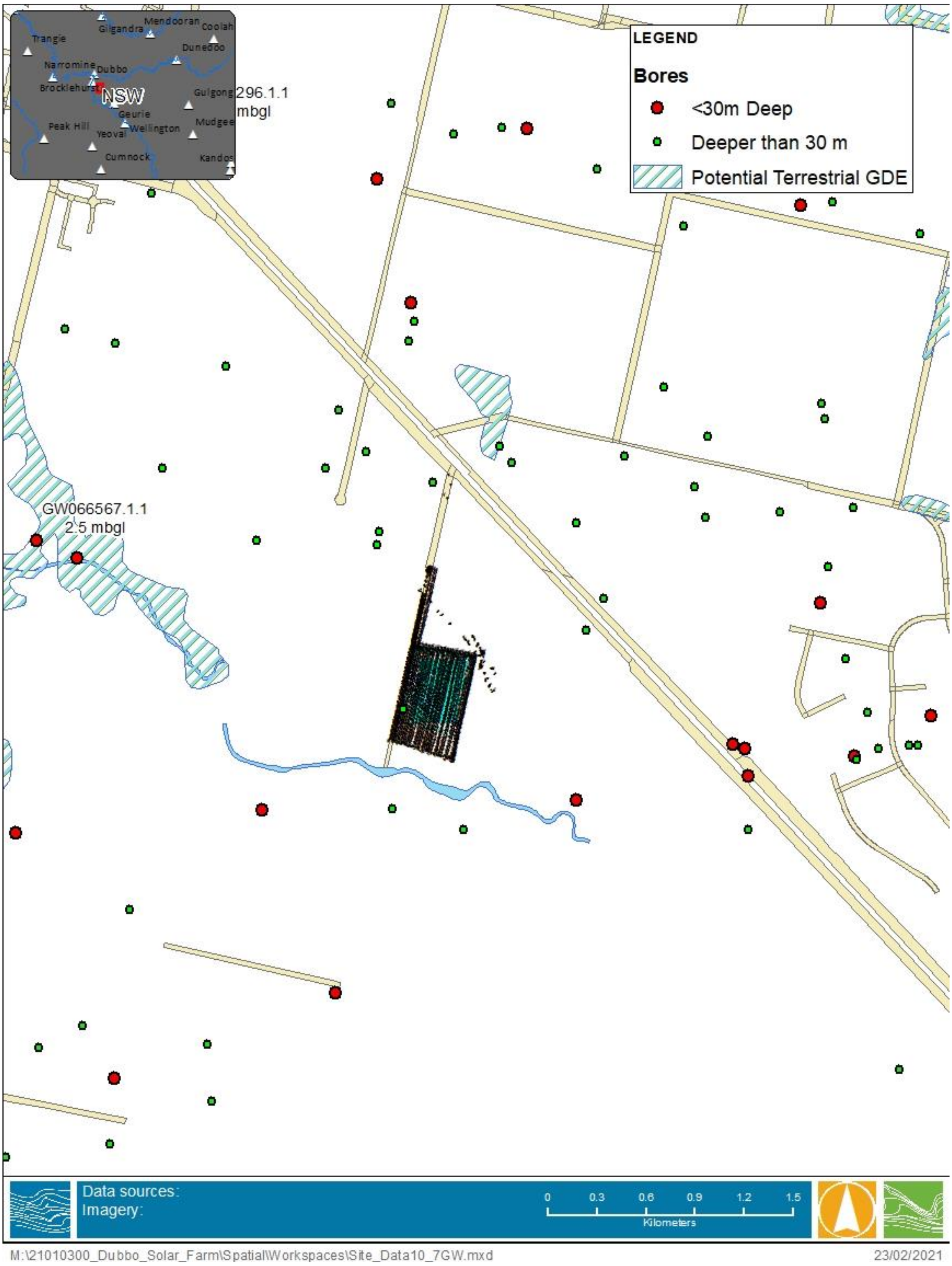


FIGURE 5-3 LOCATIONS WITH POTENTIAL FOR GDE HABITAT (GDE ATLAS, 2016)

6 RECOMMENDATIONS

Based on the flood depth, velocity and hazard levels estimated in the flood modelling of the site, the site is generally categorised as low flood risk. The following recommendations have been proposed to be adopted at the site:

- Any sensitive infrastructure such as inverters and battery storage etc, is recommended to be located above the maximum of the 1% AEP flood level with 300 mm freeboard. It is common for this type of infrastructure to be housed within shipping containers or small sheds with relatively small footprints. Given the shallow depths across the site, raising this infrastructure, either through increased footings or raised fill pads is unlikely to result in any adverse flooding impacts offsite.
- Solar panel arrays should be designed so that they can be positioned to have the lowest edge of the solar panel above the 1% AEP flood level. This need not be a permanent setting, but it is suggested that the panels could be operated to tilt so the lowest edge can lift in times of flood.
- The panel post and footings should be designed to withstand the flood velocities described in this report, which are mostly low in the areas proposed for solar panels.
- The layout provided shows that no works are proposed within the immediate vicinity of Eulomogo Creek, so setbacks are not a concern.
- It is recommended that the best practice principles to stormwater and sediment control be incorporated into the design, construction and operation phases of the solar farm site. Sediment control is important at all stages of design, construction, and operation.
- The site can be safely accessed from the north in a 1% AEP flood event. Design considerations should be made for the access track to ensure that overland flow paths identified in this report are catered for.
- From a groundwater perspective, considering the scope of work provided, there is no need for further action beyond preparation of an appropriate environmental management plan during detailed design. A response to the NSW State Environmental Planning Policy 33 may be required if there is potential for hazardous material. It is assumed this will be addressed as part of the development's Environmental Management Plan. Water Technology recommends that Table 5-1 and the findings in this section can inform future requirements.

7 SUMMARY

An assessment of the proposed solar farm was conducted in this study to consider the surface water and groundwater at the site. This included an assessment of:

- Flood behaviour for both the existing and proposed conditions. The 1% Annual Exceedance Probability Flood was assessed using flood depth, velocity, and hazard levels. Both the broader catchment of Eulomogo Creek (located to the south of the site) and the local upstream catchment were considered in the flood risk assessment. Flooding from Eulomogo Creek is not likely to impact the site. The local catchment has several minor and shallow overland flow paths which enter the site from the north east. Flood model results overlaid with the development plan show only minor flood depths in a 1% AEP flood event, as shown in Figure 7-1.

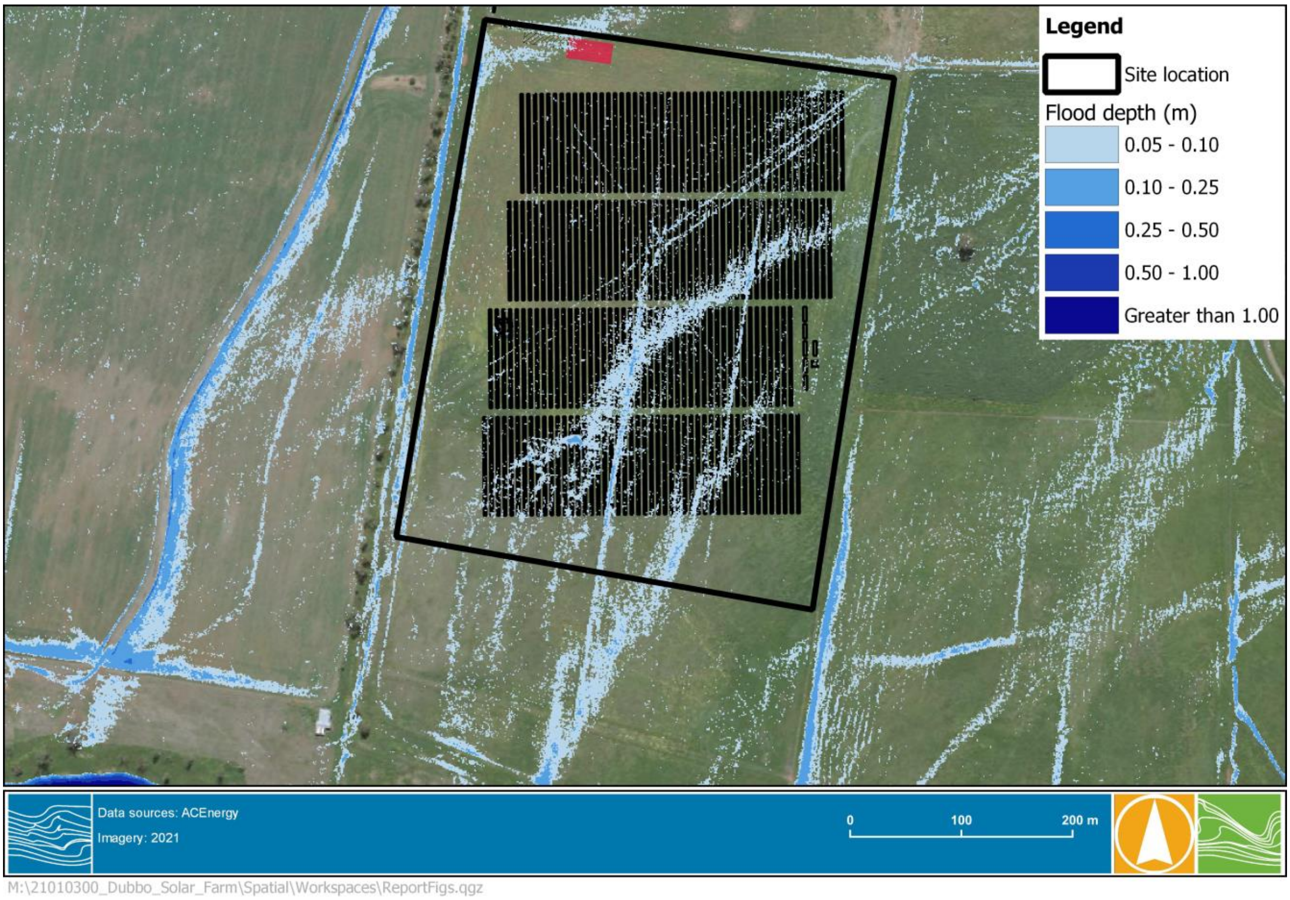


FIGURE 7-1 1% AEP FLOOD DEPTHS AT THE PROPOSED SITE

- Stormwater impacts were considered by assessing the design layout and plans provided to identify potential increases in 'hard' or impervious surfaces.
- Groundwater impacts have also been considered to provide a high level assessment of the impacts of the planned actions considering the property has a moderately high and high groundwater vulnerability.

The site is found to be a low risk of flooding for both the existing and proposed conditions. The site is not subject to inundation from the waterway to the south, with the current layout having infrastructure set back significantly from the flood extent. Minimum changes to the land topography are anticipated due to the nature of solar farm project. This results in low likelihood of changes to the hydraulic flood behaviour of a local catchment or intense storm event. Minimal changes to fraction imperviousness of the site are also expected and it is not anticipated that a storage basin or water quality treatment is expected.

The proposed infrastructure design is not likely to result in changes or impacts to the groundwater environment with construction methods not likely to interact with the groundwater.

8 REFERENCES

ARR. (2016). A Guide to Flood Estimation. In A. R. Runoff. Australia.

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