West Mokoan Solar Farm

892 Benalla-Yarrawonga Development Pty Ltd

10-Jun-2021

Project Amendment Addendum

Hydrology and Hydraulic Modelling Report

Project Amendment Addendum

Hydrology and Hydraulic Modelling Report

Client: 892 Benalla-Yarrawonga Development Pty Ltd

ABN: 628034300

Prepared by

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10-Jun-2021

Job No.: 60597809

AECOM in Australia and New Zealand is certified to ISO9001, ISO14001 AS/NZS4801 and OHSAS18001.

1.0 Introduction

1.1 Planning Permit Application

AECOM Australia Pty Ltd (AECOM) continues to act on behalf of the applicant, 892 Yarrawonga Development C/- South Energy, in relation to Planning Permit Application No. PA2000978 for the West Mokoan Solar Farm.

Planning Permit Application No. PA2000978 was submitted to Department of Environment, Water, Planning and Land (DELWP) on 07 October 2020. The Application is for the use and development of a Renewable Energy Facility and Utility Installation (solar farm and energy storage) and associated buildings and works, removal of native vegetation, display of business identification signage, removal and creation of easements and the creation or alteration of access to a Road Zone Category 1 (the Project).

This letter is an addendum to the Hydrology and Hydraulic Modelling Report (Date 27/08/20).

1.2 Requests for Further Information

Pursuant to Section 54 of the *Planning and Environment Act 1987 (P&E Act),* DELWP issued a Request for Further Information (RFI) dated 5 November 2020. A separate RFI was issued from DELWP – Hume Region, on 26 November 2020. There were no matters raised in either of the RFIs in relation to or concerning surface water.

1.3 Project Amendments

As a result of changes to the Project area and technical requirements, and in response to the RFI's, a formal amendment to the Planning Permit Application is being sought, pursuant to Section 50 of the *P&E Act.* The changes to the project are summarised below:

- ***Change to the substation location***

  Due to AusNet requirements, the substation has been relocated from 892 Benalla-Yarrawonga Road (Lot 1 PS625748), on the northern side of Lake Mokoan Road to the southern side of Lake Mokoan Road on land at Benalla-Yarrawonga Road (Lot 1 TP173518). As a result, the vehicle access gates along Lake Mokoan Road have been altered – with the northern access point to the (former) substation removed and a new access point for the new substation added. Furthermore, the location of solar panels and associated equipment has changed, with solar panels now located on the former substation site.

- ***Change to native vegetation retention and removal***

  In response to the RFI from DELWP – Hume Region (dated 26 November 2020), additional habitat assessments and native vegetation assessments have been undertaken, and the solar farm layout has been revised to optimise native vegetation retention. Previously, a total of 2.868 ha of native vegetation was proposed to be removed, which included 43 scattered trees (39 large trees and 4 small trees). The revised solar layout proposes a total of 1.891 ha of native vegetation to be removed which includes 28 scattered trees (26 large trees and 2 small trees). Refer to the Flora and Fauna Impact Assessment for full details.

- ***Reduction in Project area and capacity***

  Land at 81 Lake Mokoan (Lot 2 PS625748) is now excluded from the project. The dwelling at 81 Lake Mokoan Road (proposed to be used for construction purposes) is now excluded from the Project and maintains its current use as a dwelling on private land and a 'sensitive receptor'.

  As a result of the changes described above, the capacity (energy generation) of the solar farm has been slightly reduced, which is summarised in Table 1.

Table 1 Comparison of Solar Energy Facility Details

Item	Previous Concept Plan	Revised Concept Plan
Total Project Area (ha)	467.2	426.4
Direct Current Capacity (MW)	245.19	233.74
Number of PCUs	60	57
Total Modules	557,256	531,216

2.0 Assessment

A review of the revised Concept Plan (60597809-DWG-EL-0003_Rev11 dated 3/6/2021), presented in Appendix A was undertaken to confirm any surface water impacts as a result of the changes to the project described above.

- ***Change to the substation location***

  The results presented in the Hydrology and Hydraulic Modelling report (dated 27/08/20) (*The Report*) illustrate the revised substation location, on the south side of Lake Mokoan Road (Lot 1 TP173518), is largely outside the 1% AEP maximum flood extent. Furthermore, the proposed substation location is in an area with a maximum flood hazard categorisation of H1 (where H1 is deemed generally safe for people, vehicles and buildings).

- ***Change to native vegetation retention and removal***

  The Report considered eight land use and ground cover categories across the northern site. Each land use category was assigned a hydraulic roughness (Manning's) value to use in the TUFLOW model. The predominant land use category for the majority of the site was classed as *Open Pervious Area.*

  The proposed changes to vegetation retention and removal will not alter the land use and ground cover categorisation used in the modelling assessment. Subsequently, the modelling results presented in *The Report* would remain unchanged.

- ***Reduction in Project area and capacity***

  The project area has been revised following the removal of land at 81 Lake Mokoan (Lot 2 PS625748) resulting in minor changes to the layout of solar energy facilities (Table 1). The revised layout presented in Appendix A and B does not encroach on the designated waterways or their agreed setbacks. The siting of solar energy facilities has also been designed in accordance with the requirements of the Goulburn Broken Catchment Management Authority.

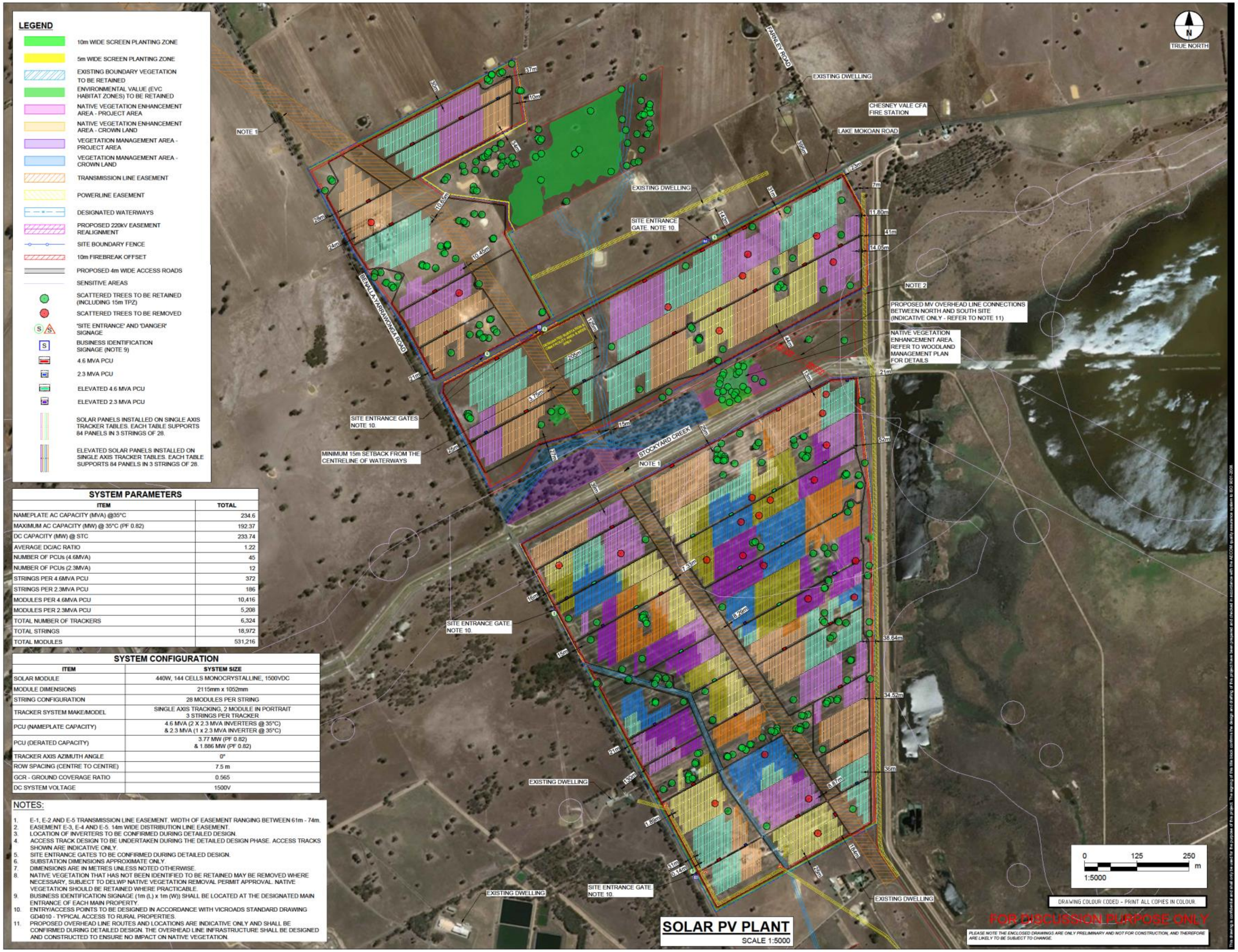
1.0 Conclusion

The proposed amendments to the Project area and technical requirements in response to the RFI's raised by DELWP, dated 5 November 2020, and DELWP – Hume Region, on 26 November 2020, have been reviewed against the Hydrology and Hydraulic Assessment Report (dated 27/08/20).

Based on the planning amendments outlined herein, it is proposed the hydraulic modelling results and conclusions of *The Report* remain unchanged. It should also be noted that the assumptions, exclusions and limitations presented in Section 7 of *The Report* are applicable to the conclusions presented in this addendum.

Appendix A

Revised Concept Plan



SYSTEM PARAMETERS

ITEM	TOTAL
NAMEPLATE AC CAPACITY (MVA) @35°C	234.6
MAXIMUM AC CAPACITY (MW) @ 35°C (PF 0.82)	192.37
DC CAPACITY (MW) @ STC	233.74
AVERAGE DC/AC RATIO	1.22
NUMBER OF PCUs (4.6MVA)	45
NUMBER OF PCUs (2.3MVA)	12
STRINGS PER 4.6MVA PCU	372
STRINGS PER 2.3MVA PCU	186
MODULES PER 4.6MVA PCU	10,416
MODULES PER 2.3MVA PCU	5,208
TOTAL NUMBER OF TRACKERS	6,324
TOTAL STRINGS	18,972
TOTAL MODULES	531,216

SYSTEM CONFIGURATION

ITEM	SYSTEM SIZE
SOLAR MODULE	440W, 144 CELLS MONOCRYSTALLINE, 1500VDC
MODULE DIMENSIONS	2115mm x 1052mm
STRING CONFIGURATION	28 MODULES PER STRING
TRACKER SYSTEM MAKE/MODEL	SINGLE AXIS TRACKING, 2 MODULE IN PORTRAIT 3 STRINGS PER TRACKER
PCU (NAMEPLATE CAPACITY)	4.6 MVA (2 X 2.3 MVA INVERTERS @ 35°C) & 2.3 MVA (1 x 2.3 MVA INVERTER @ 35°C)
PCU (DERATED CAPACITY)	3.77 MW (PF 0.82) & 1.886 MW (PF 0.82)
TRACKER AXIS AZIMUTH ANGLE	0°
ROW SPACING (CENTRE TO CENTRE)	7.5 m
GCR - GROUND COVERAGE RATIO	0.565
DC SYSTEM VOLTAGE	1500V

NOTES:

1. E-1, E-2 AND E-5 TRANSMISSION LINE EASEMENT. WIDTH OF EASEMENT RANGING BETWEEN 61m - 74m.
2. EASEMENT E-3, E-4 AND E-5. 14m WIDE DISTRIBUTION LINE EASEMENT.
3. LOCATION OF INVERTERS TO BE CONFIRMED DURING DETAILED DESIGN.
4. ACCESS TRACK DESIGN TO BE UNDERTAKEN DURING THE DETAILED DESIGN PHASE. ACCESS TRACKS SHOWN ARE INDICATIVE ONLY.
5. SITE ENTRANCE GATES TO BE CONFIRMED DURING DETAILED DESIGN.
6. SUBSTATION DIMENSIONS APPROXIMATE ONLY.
7. DIMENSIONS ARE IN METRES UNLESS NOTED OTHERWISE.
8. NATIVE VEGETATION THAT HAS NOT BEEN IDENTIFIED TO BE RETAINED MAY BE REMOVED WHERE NECESSARY, SUBJECT TO DELWP NATIVE VEGETATION REMOVAL PERMIT APPROVAL. NATIVE VEGETATION SHOULD BE RETAINED WHERE PRACTICABLE.
9. BUSINESS IDENTIFICATION SIGNAGE (1m (L) x 1m (W)) SHALL BE LOCATED AT THE DESIGNATED MAIN ENTRANCE OF EACH MAIN PROPERTY.
10. ENTRY/ACCESS POINTS TO BE DESIGNED IN ACCORDANCE WITH VICROADS STANDARD DRAWING GD4010 - TYPICAL ACCESS TO RURAL PROPERTIES.
11. PROPOSED OVERHEAD LINE ROUTES AND LOCATIONS ARE INDICATIVE ONLY AND SHALL BE CONFIRMED DURING DETAILED DESIGN. THE OVERHEAD LINE INFRASTRUCTURE SHALL BE DESIGNED AND CONSTRUCTED TO ENSURE NO IMPACT ON NATIVE VEGETATION.

AECOM

PROJECT
WEST MOKOAN
SOLAR FARM
CONCEPT DESIGN
BENALLA
Victoria

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DEVELOPMENT Pty Ltd
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South Energy

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ISSUE/REVISION

I/R	DATE	DESCRIPTION
11	03/06/2021	REVISED ISSUE
10	12/05/2020	REVISED ISSUE
9	13/04/2021	REVISED ISSUE
8	29/09/2020	REVISED PER CLIENT REVIEW
7	28/09/2020	REVISED ISSUE
6	18/08/2020	REVISED PER CLIENT REVIEW

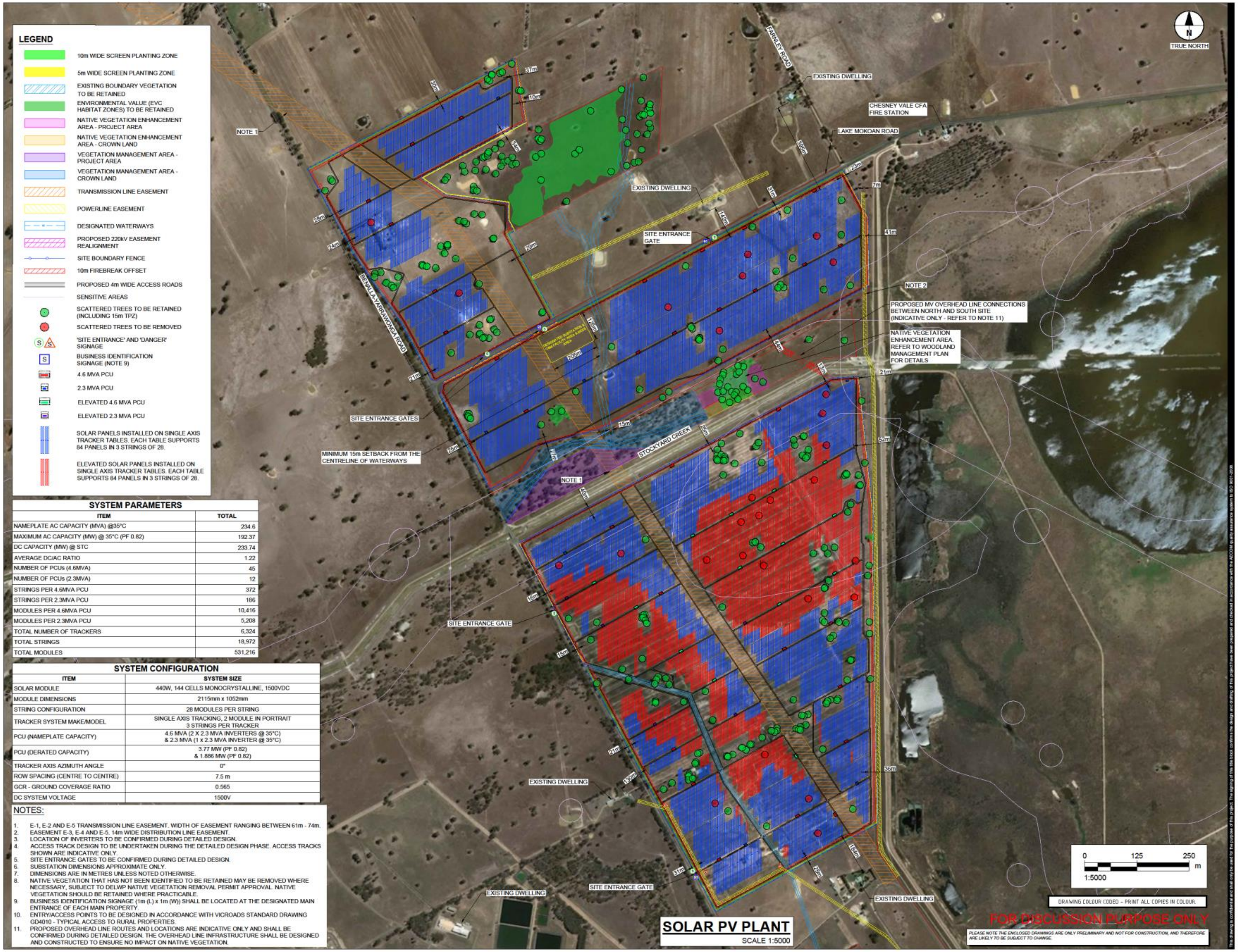
PROJECT NUMBER
60597809

SHEET TITLE
WEST MOKOAN
SOLAR FARM
CONCEPT LAYOUT

SHEET NUMBER
60597809-DWG-EL-0003

Appendix B

Elevated Panels Plan



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SOLAR PV PLANT

SCALE 1:5000

AECOM

PROJECT

WEST MOKOAN SOLAR FARM CONCEPT DESIGN

BENALLA
Victoria

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South Energy

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3	07/06/2021	REVISED ISSUE
2	14/05/2021	REVISED ISSUE
1	13/04/2021	FOR ISSUE

PROJECT NUMBER

60597809

SHEET TITLE

WEST MOKOAN SOLAR FARM ELEVATED VS NON-ELEVATED

SHEET NUMBER

60597809-DWG-EL-0005

892 Yarrawonga Development Pty Ltd
(South Energy)

27-Aug-2020

West Mokoan Solar Farm

Hydrology and Hydraulic Modelling Report

27-Aug-2020
Prepared for – 892 Yarrawonga Development Pty Ltd (South Energy) – ABN: 30 628 034 300

West Mokoan Solar Farm

Hydrology and Hydraulic Modelling Report

Client: 892 Yarrawonga Development Pty Ltd (South Energy)

ABN: 30 628 034 300

Prepared by

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27-Aug-2020

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Executive Summary

AECOM Australia Pty Ltd has been engaged by 892 Yarrawonga Development Pty Ltd (South Energy) to support the planning process associated with the construction of a solar farm facility on land adjacent to Benalla-Yarrawonga Road and Lake Mokoan Road, Benalla, Victoria.

The proposed site is situated in a sub-catchment of Broken River, adjacent to the Winton Wetlands Natural Features Reserve (wetland ID No.67909), formally known as Lake Mokoan. The site is divided into northern and southern land parcels by the Winton Wetlands overflow channel. Designated waterways across the northern land parcel consists of developed and undeveloped drainage lines passing through a catchment of 62 hectares. The only waterway within the southern land parcel is a developed drainage channel crossing a catchment of approximately 72 hectares linking multiple land parcels flowing to the Stockyard Creek.

Hydrology and hydraulic investigations were conducted for the northern land parcel. The work encompasses analysis of the existing data, development of a hydrological model (RORB) and a 2D hydraulic model (TUFLOW) to estimate the 1% Annual Exceedance Probability (AEP) flood depth, extent and hazard across the northern land parcel. Flood mapping was undertaken for the southern land parcel based on GBCMA flood contours and point measurement from a flood in 1993, which is considered to have an AEP of 1%.

The hydrologic and hydraulic investigations showed that most of the northern land parcel has low flood risk except the southern area where flood level increases adjacent to the designated waterway, mostly impacted by the backwater from the Broken River.

Overlaying the site topography with the existing flood data and GBCMA requirements showed that Broken River tailwater and the Kennedys Creek backwater cause flooding within the southern land parcel. Areas adjacent to the designated waterway and the depression on the north east obtained significant flood depth (>1.5 m). Anecdotal evidence from the previous landowner also supports these findings. The topography of the site is less steep compared to the northern land parcel resulting in lower hazard rating for this site because of lower velocity.

A solar farm impact assessment including adjustments to the terrain and roughness was conducted in a sensitivity analysis included within the Raywood Solar Farm Myers Creek – Hydrologic and Hydraulic Modelling Report prepared by AECOM on 23 July 2019 (Planning Permit 5414 – Loddon Shire Council). This assessment showed that solar farm developments including construction of solar panels and associated structures have minimal impacts to the existing flood flow in a catchment because of insignificant changes to the existing flows and flood storage.

The outcomes of the flood investigation have been incorporated into the solar farm layout to avoid adverse impacts to the existing flow regime as well as conveyance impacts to pre-existing flood storage, flood levels, and flood velocities. The proposed infrastructure including single axis trackers, inverter and transformer blocks would be constructed with 300 mm freeboard above the 1% AEP flood level.

1.0 Background

1.1 Background

AECOM Australia Pty Ltd has been engaged by 892 Yarrawonga Development Pty Ltd (South Energy) to support the planning process associated with the construction of a solar farm facility on land adjacent to Benalla-Yarrawonga Road and Lake Mokoan Road, Benalla, Victoria. The proposed site (Figure 1) is located at 892 Benalla-Yarrawonga Road, Goorambat, 81 Lake Mokoan Road, Goorambat, Benalla-Yarrawonga Road, Benalla, and 616 Benalla-Yarrawonga Road, Benalla. The site is located approximately 10 kilometres north-east of Benalla, and 8 kilometres south-east of Goorambat, Victoria. The site address and lots numbers are presented in Table 1.

Table 1 Site addresses included in the development

Site Address	892 Benalla-Yarrawonga Road, Goorambat 81 Lake Mokoan Road, Goorambat Benalla-Yarrawonga Road, Benalla 616 Benalla - Yarrawonga Road, Benalla
Legal Description	Lot 1 & 2 PS625748 Lot 1 & 2 TP173518 Lot 1 TP104377 Lots 1 – 5 LP206524 98B PP2704

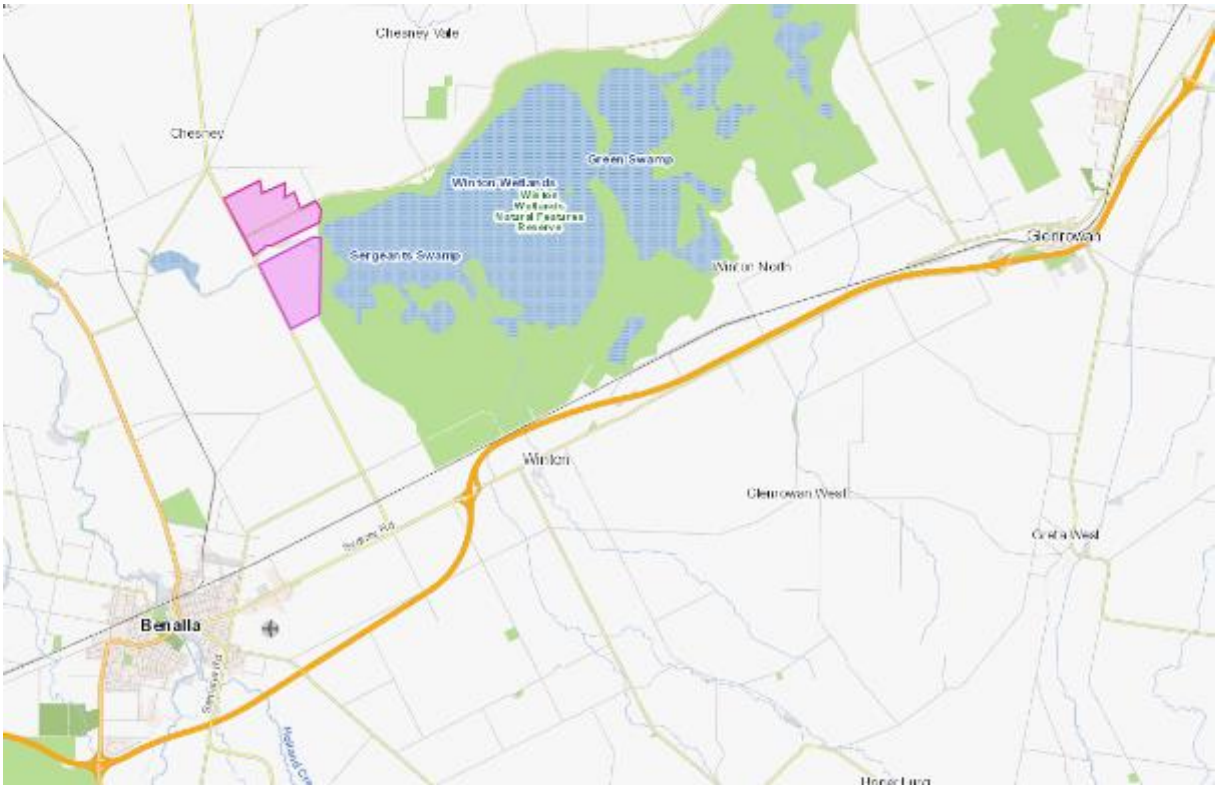


Figure 1 Site context and surrounding features (Source: VicPlan, 2019)

This report forms part of the Planning Permit Application prepared by AECOM, on behalf of 892 Yarrawonga Development Pty Ltd (South Energy). As part of the application, a surface water assessment (AECOM, 2019) was provided following a series of discussions with the Goulburn Broken Catchment Management Authority (GBCMA). An outcome of these discussions with GBCMA was a requirement to undertake a more detailed surface water assessment. This report and associated modelling have been undertaken to address this requirement of a more detailed surface water assessment.

1.2 Scope of Works

The scope of works associated with the hydrology and hydraulic investigations is detailed below:

- Collate and analyse any existing data associated with surface water near the site
- Develop a hydrological model (RORB) of the existing flow paths that intersect with the proposed solar farm site
- Develop a hydraulic model (TUFLOW) that utilises outflows from RORB to provide an estimate of the 1% annual exceedance probability (AEP) flood depth, the extent and hazard across the site

1.3 Catchment Context

The proposed site is situated in a sub-catchment of Broken River, adjacent to the Winton Wetlands Natural Features Reserve (wetland ID No.67909), formally known as Lake Mokoan, which is to the east. Winton Wetlands overflow channel divided the proposed site into the northern and southern land parcels. The channel from the Broken River towards the Lake Mokoan Diverters Pipeline Pumping Station is located immediately west of the dam wall. The waterway across the northern land parcel consists of developed and undeveloped drainage lines passing through a catchment of approximately 62 hectares.

The waterways within the southern land parcel area is a developed drainage channel crossing a catchment of approximately 72 hectares and links multiple land parcels as it flows north towards the Stockyard Creek. Figure 2 represents an overview of the site locality divided by Winton Wetlands channel as well as surrounding waterways and natural flow directions.

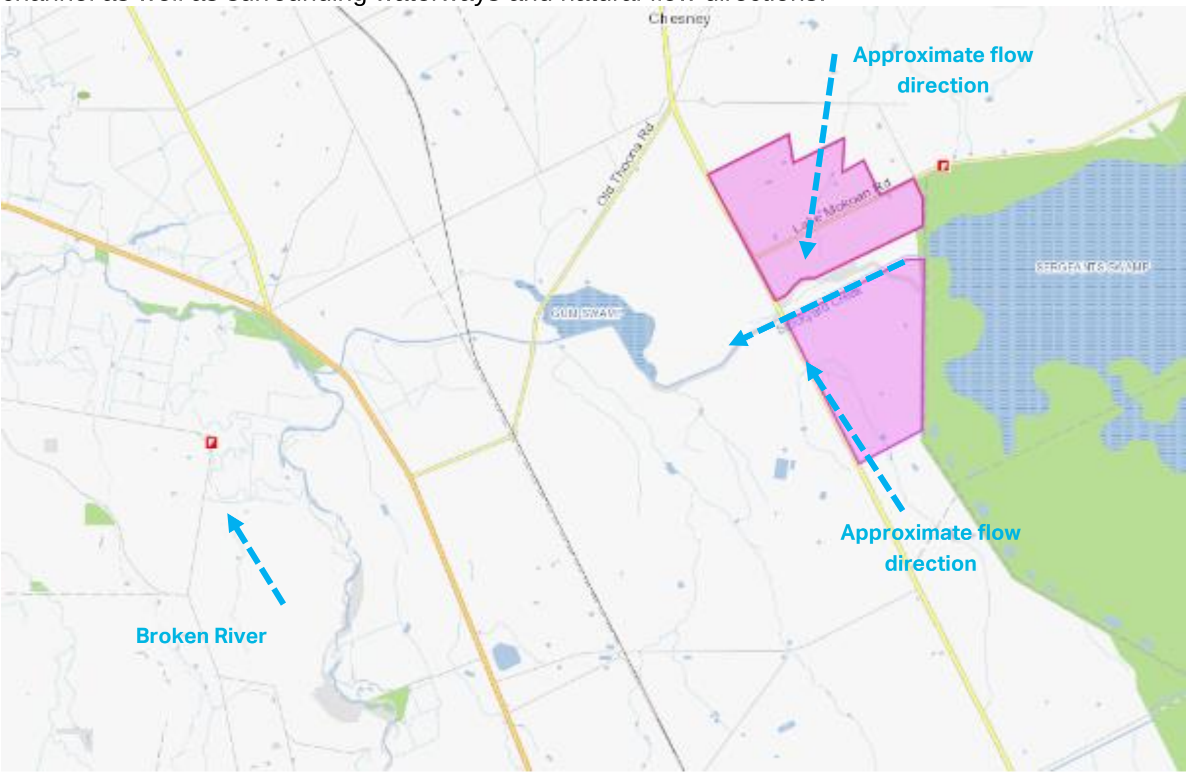


Figure 2 Site context and proximity to Broken River, Stockyard Creek and Winton Wetlands Reserve (Source, MapShareVic - DEWLP 2019)

1.4 Site Survey Data

Spatial survey data conducted for the northern and southern land parcels to capture the site topography and the existing features including drains, low points, roads, farm dams and homesteads. The survey data gives below information within the proposed area:

1.4.1 Northern land parcel

- The highest elevation and the lowest elevation for this parcel is 173 m AHD and 160 m AHD respectively and the general slope is from northern edge of the parcel towards the Stockyard Creek embankment (Figure 3).
- All sub-catchment flows within the northern land parcel drain southward towards the Stockyard Creek.
- The site contains a number of water features including constructed drains, natural channels and nine farm dams. Two dams in the centre of the site, are connected by a channel. The farm dams and channel have been captured on the site survey.
- All other potential flow pathways across are less formal with little evidence of channels or eroded lines.
- The southern boundary of the northern land parcel is more vegetated close to the Benalla-Yarrawonga Rd bridge. This vegetated channel forms the lowest part of the catchment, adjacent to the Stockyard Creek embankment.

1.4.2 Southern Land Parcel

- The land slope changes gently from south (162.8 m AHD) to north (158.5 m AHD) directing surface water flows partly to north westerly direction and partly towards the Stockyard Creek (Figure 3).
- The southern land parcel has a number of features including a drainage easement that runs through the lower south western portion of the study area
- There is a flow path from south to west side of the parcel.

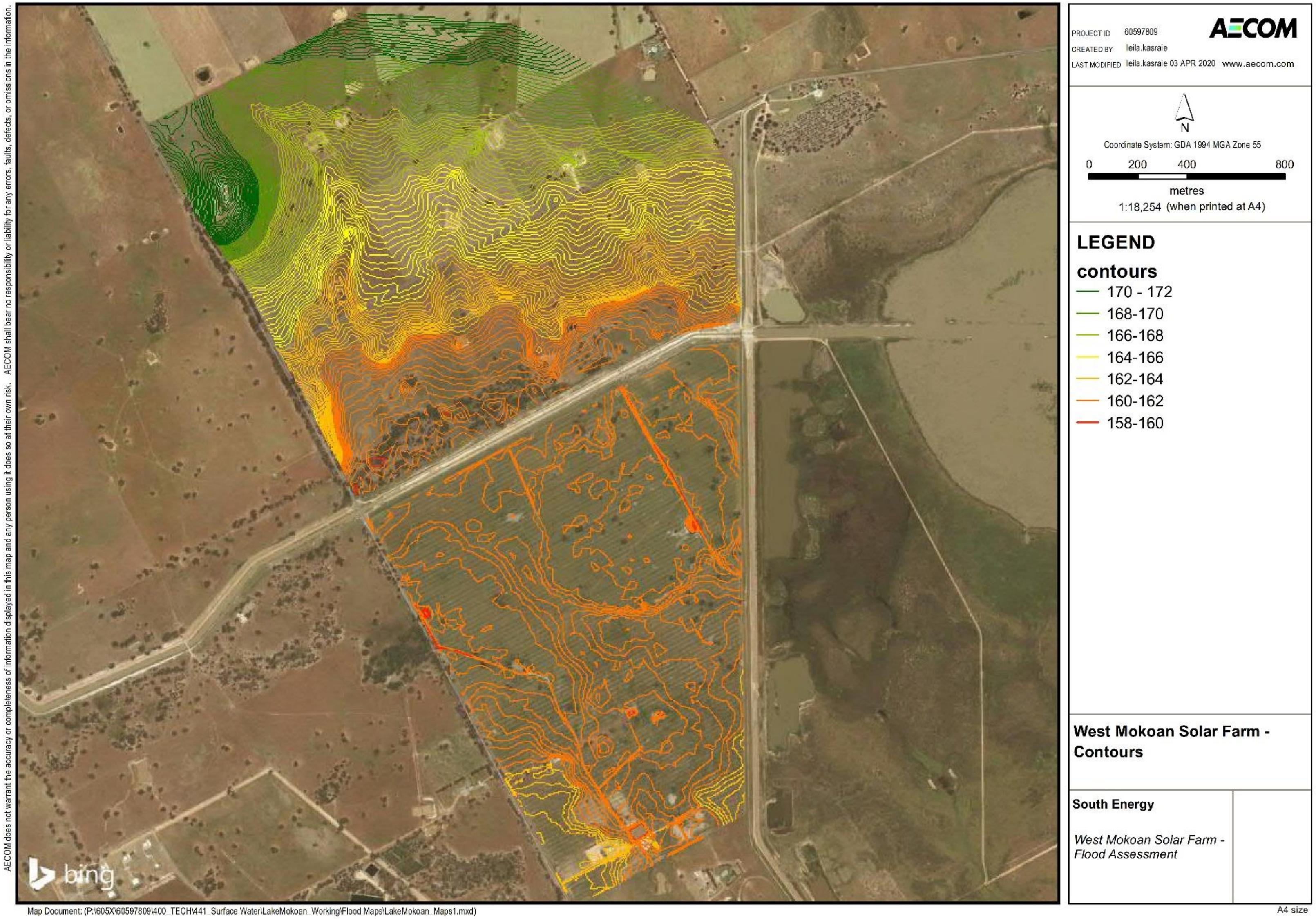


Figure 3 Site topography extracted from survey data in the northern and southern land parcel

2.0 Available data

The publicly available data was obtained from DELWP and updated in the Geographic Information System (GIS) platform. database to determine how surface water interacts with the proposed area. This includes the following data:

- Aerial photography
- State-wide watercourse network (Department of Environment, Land, Water & Planning, 2018)
- 1 in 100-year flood extent (Department of Environment, Land, Water & Planning, 2018)
- Site specific survey data for the northern and southern land parcels
- DTM 20 m grid (Vicmap, 2019)
- STRM Digital Elevation Model Data (20 m) (DEM)
- Converted survey data to 1 m DEM
- ARR Data Hub
- The existing culverts from the land survey

No.	Size (mm)	Upstream Invert	Downstream Invert
1	1x500 RCBC	166.65	166.6
2	1x500 RCBC	165.61	165.5
3	1x500 RCBC	166.3	166.08
4	1x500 RCBC	167.08	166.7
5	4x1200 RCBC	163.81	163.61
6	1x500 RCBC	164.95	164.9
7	1x500 RCBC	163.1	162.7
8	1x1200 RCBC	162.75	162.7
9	1x450 RCBC	164.15	164.01

3.0 Previous Study

- AECOM conducted a preliminary surface water assessment to provide high level commentary on the existing conditions including watercourses and surface waterbodies within and adjacent to the study area. The Goulburn Broken Catchment Management Authority (GBCMA) has been engaged to discuss potential flooding implications and stream stability as a result of the proposed development. The report outlines high level strategies to minimise and manage any likely adverse impacts as a result of the development to the surface water receiving environment.
- A previous hydrologic and hydraulic analysis was undertaken by Water Technology in 2015 (*Kennedys Creek-Flooding Investigation, (2015)).* This study included modelling and the preparation of a hydrologic and hydraulic report to describe the current flooding conditions on the Kennedys Creek floodplain from the Hume Freeway through to upstream reaches of the southern land parcel. Flood maps from this assessment indicated flood depths and velocities within the region required mitigation options to allow for land development. The results presented in this modelling report were slightly different to the actual recorded levels from 1993 in some areas. The report also references a conversation with Guy Tierney from the GBCMA about these differences, concluding that the 1993 levels should be used as the benchmark for flooding in this region.
- 1% AEP Flood Contour Atlas – The GBCMA recommended the utilisation of these flood levels as the minimum expected flood level could occur at the site. Figure 4 shows the 1993 flood levels and backwater from the Broken River.

4.0 Modelling Approach

The Northern Land Parcel

The hydrology and hydraulic methodology adapted to address the scope of works and required outcomes. The hydrologic modelling in RORB was conducted to obtain flow paths and hydrographs for 1% AEP critical durations.

The outputs from RORB were then used as inputs to the hydraulic TUFLOW model, to establish the presented 1% AEP flood depths, extent and hazard across the northern land parcel.

The model was calibrated against GBCMA 1% AEP flood level contours by introducing the backwater flood level from the Broken River to the model.

Southern Land Parcel

GBCMA 1% AEP Flood Level Contour Atlas displays an area of Urban Floodway Zone (UFZ) encroaching the southern land parcel (Appendix E). These flood contours were recorded during a historic event, in 1993 around 30 hours after the peak flow. There are also two measurement points from upstream and downstream of the southern land parcel during this event that have been used to estimate 1% AEP flood level in southern land parcel. GBCMA recommended the utilisation of these flood levels and two measurement points as expected 1% AEP flood level that could occur at the site. Figure 4 shows the 1993 flood levels and backwater from the Broken River. As shown in the figure, Broken river tailwater impact is more of an issue for the site than flow from the Kennedys Creek. Although, culverts at the railway running north-south across the floodplain cause more backwater impact from the Kennedys Creek toward the Broken River.

Considering the above, the conclusion was made that modelling the flood extent for this site would not provide any further benefit for the project while the historical record as the benchmark for the 100-year flood is expected to be used as per discussion with GBCMA.

Therefore, the below mapping exercise was conducted to obtain possible flood levels at the southern land parcel:

- The survey data was used to build STRM Digital Elevation Model Data (1m DEM) (Figure 5).
- As suggested by the GBCMA, the flood measurement points and contours were extrapolated to obtain the expected flood gradient upstream and downstream of the southern land parcel.
- The 1993 flood measurements and contours were overlayed with the survey data to obtain 1% AEP flood depths across the southern land parcel (Figure 6).

Overlaying the site topography with the existing flood data from GBCMA 1993 measurement points showed that the southern land parcel experiences deep flooding in low elevated areas. A small portion of land adjacent to the designated waterway and land on the north east obtained flood depths above 1.5 m. Anecdotal evidence from the previous landowner also supports these findings.

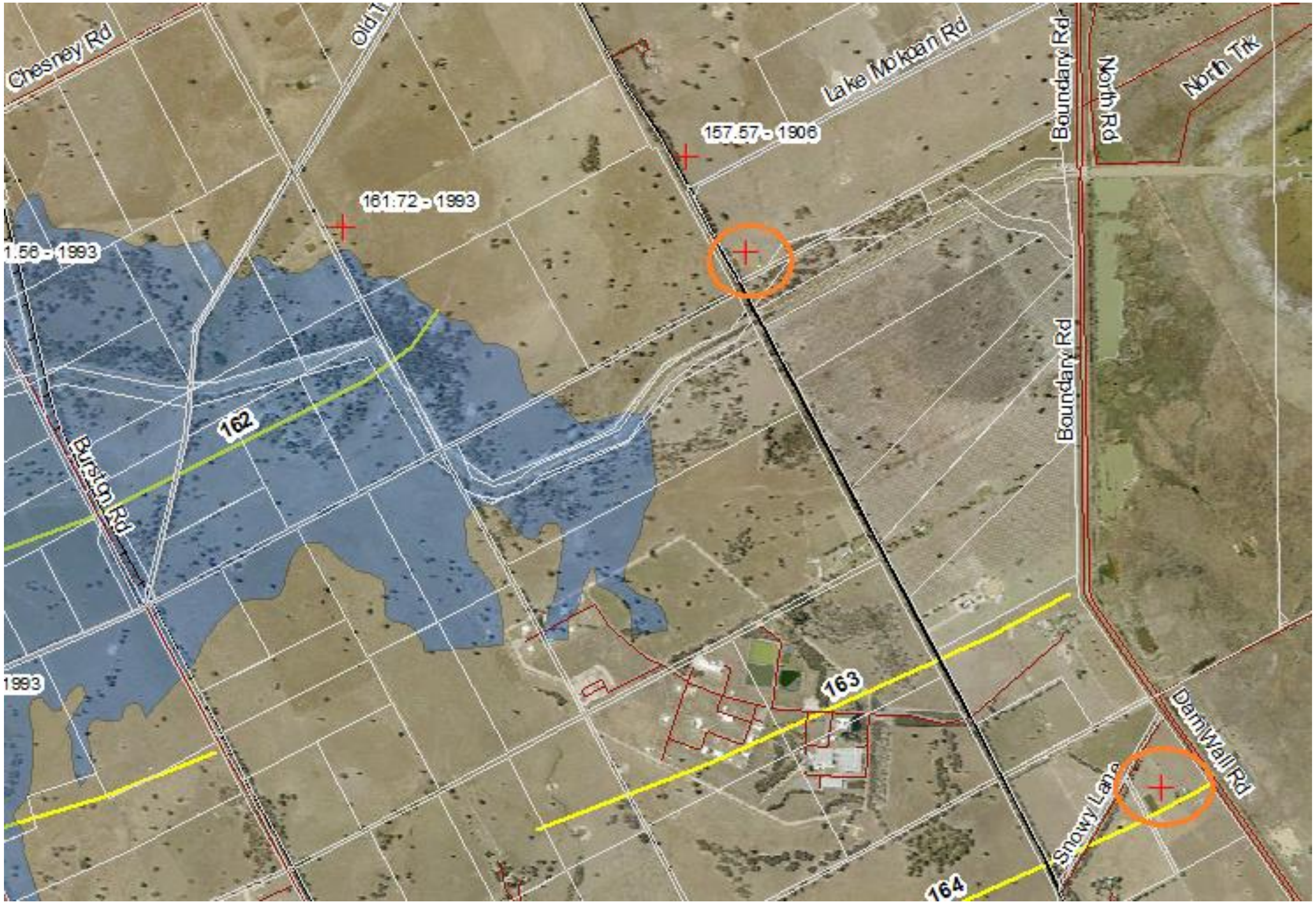


Figure 4. Broken River backwater and the 1993 flood levels recorded around 30 hours after the peak flow

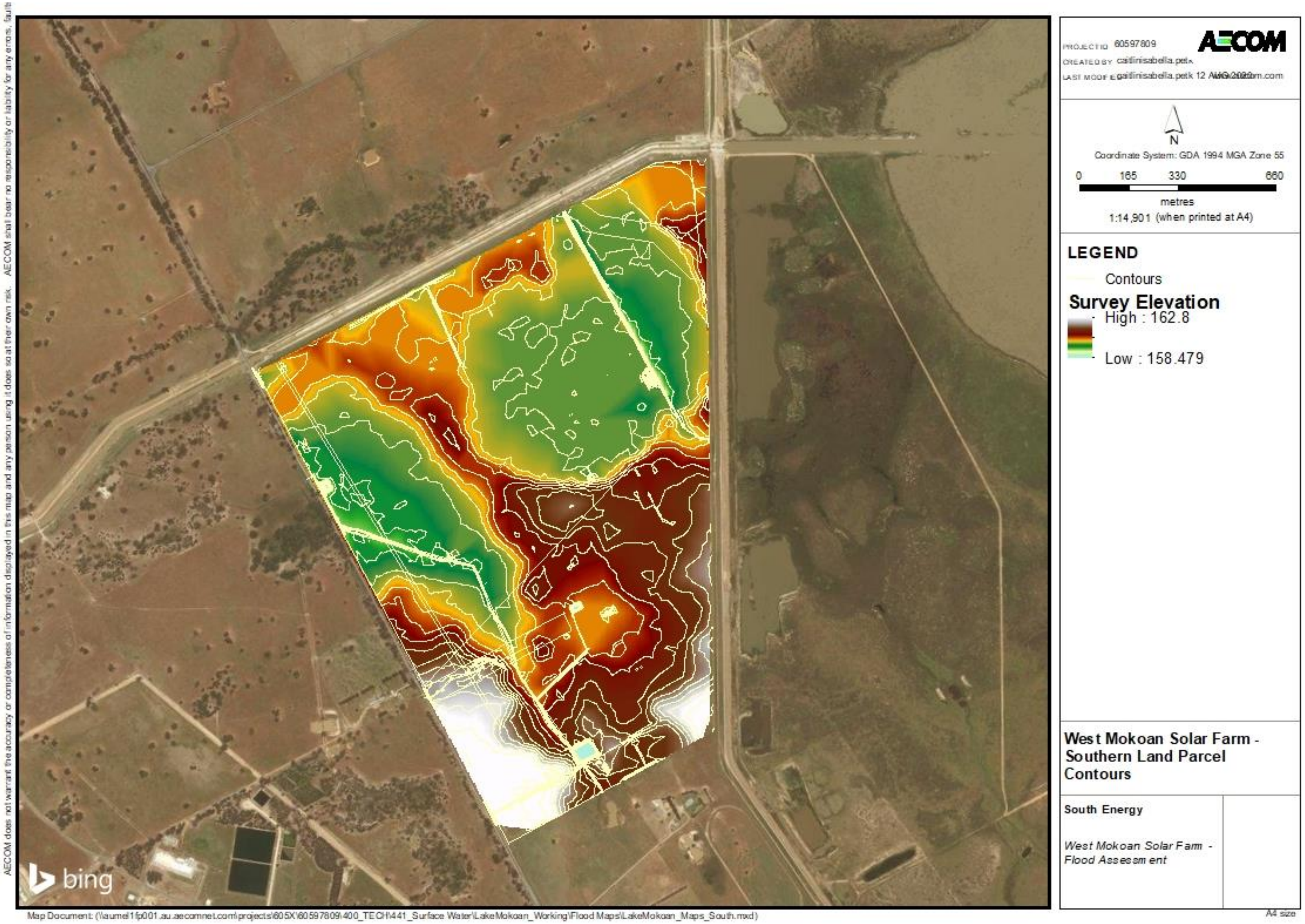


Figure 5 Digital Elevation Model Data (1m DEM) at the southern land parcel

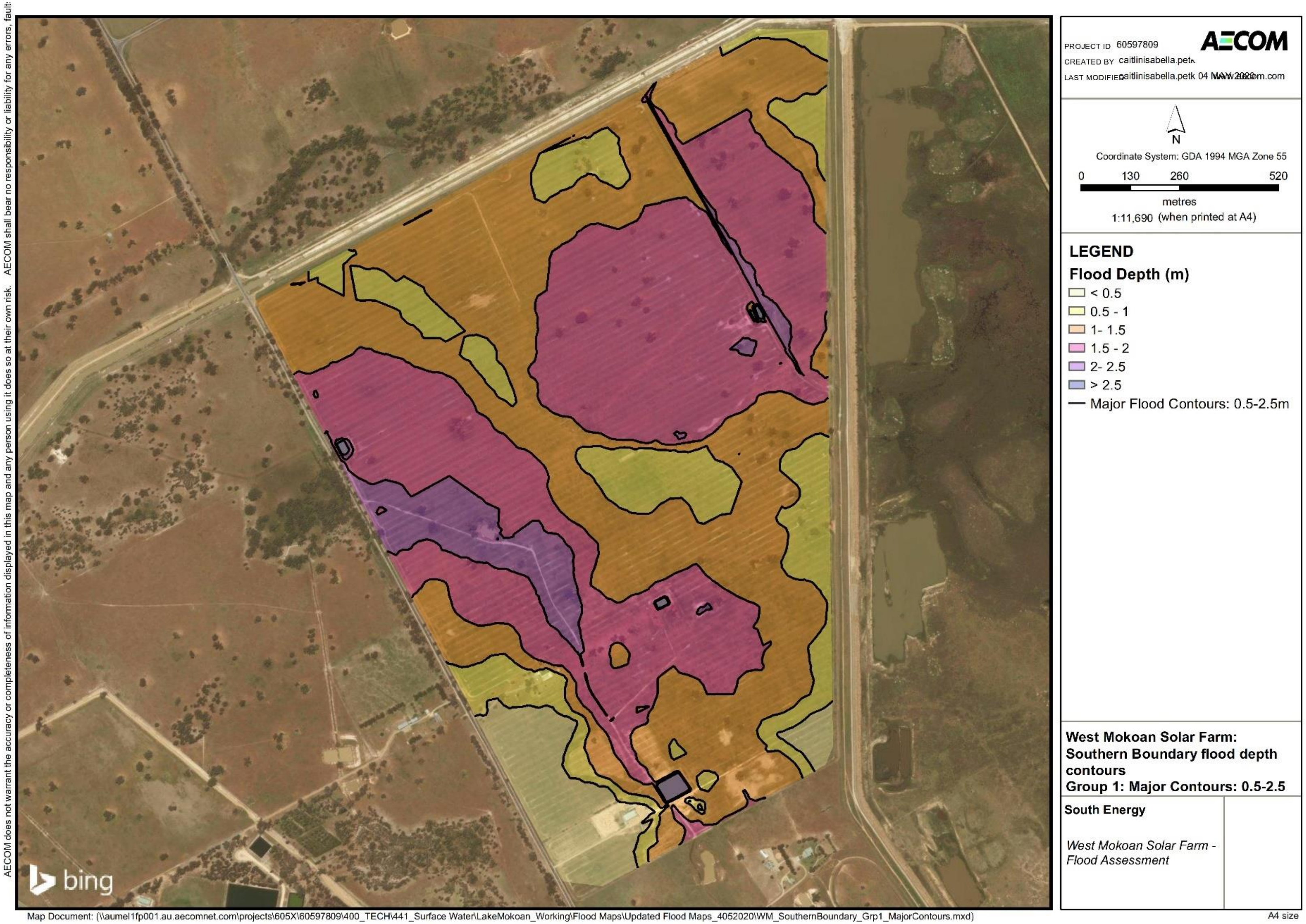


Figure 6 1% AEP flood depth at the southern land parcel

5.0 Hydrologic Modelling

The hydrology model was incorporated with help of RORBWin6.45 to determine 1% AEP critical duration, rainfall excess and associated hydrographs. ARR 2019 design input from ARR Data Hub were applied to the model. Catchment delineation was undertaken by the ArcHydro software package in ARCGIS. 20 m DEM from DELWP website was used to delineate sub-catchments and reaches, which been incorporated into the RORB model (Figure 7).

5.1 RORB Modelling Design Base

RORB model inputs were obtained from the ARR data hub included temporal patterns, areal reduction factors, and initial, preburst and continuing losses. Catchment average design rainfall inputs were obtained from the Bureau of Meteorology (BOM) and imported to the model. These input parameters are presented in Appendix B and C. The following sections describe the RORB model setup and parametrization.

5.1.1 Loss Approach

The initial loss (IL) and continuing loss (CL) were obtained from the ARR 2020 Data Hub incorporated into the RORB Model.

Pre-burst rainfall from ARR 2020 Data Hub obtained by subtracting a median pre-burst from the initial loss to account for the fact that the design rainfall inputs are based on bursts while the losses from the data hub are based on complete storms. Pre-burst losses were deducted from initial storm loss to determine critical durations.

5.1.2 Temporal Pattern

Point temporal patterns were obtained from the ARR 2020 Data Hub and were used given the catchment size is less than 75 km^2. Ensemble runs (single storm event) was conducted for the 1% AEP with the critical durations for the outlet as presented in Table 2.

5.1.3 Fraction Impervious

Fraction impervious was determined based on Victoria Planning Schemes Zones for the existing condition. Overall FI for each subarea is calculated based on the FI for each zone within the subarea. The entire investigation area was considered as Farming Zone (FZ) and FI value of 0.05 was assigned as the relevant FI value for Farming Zone (FZ) code.

5.1.4 Rainfall Temporal Pattern

Rainfall temporal patterns were determined using Ensemble analysis by averaging hydrographs from 10 temporal patterns. This returned critical durations for the catchment outlet are presented in Table 2.

5.1.5 m and K_C Routing Parameters

Parameter m was set to the default RORB value of 0.8.

K_C value estimated based on two Regional relationships provided in ARR 2020 Book 7 Chapter 6.2.1.3 adopted to Victoria (Morris, 1982 & Hansen et al. 1986) as below:

5.1.5.1 Victoria Data (MAR<800mm- Morris, 1982 & Hansen et al. 1986)

Bureau of Meteorology data (BOM, 2020) from nearby weathering stations (Benalla Airport no.82170 & Goorambat no.081017) showed that the average annual rainfall for the catchment is between 500 – 550 mm/year. Therefore, K_C calculated as:

$$A = 0.49.Area^{0.65}$$ Equation 7.6.16 from ARR 2020, book 7

5.1.5.2 Victoria Data (Pears et al., 2002)

Pears et al., 2002 provides K_C estimation as a function of average flow distance from the sub-area inflows to the model outlet (d_{av}).

$$Kc = C_{0.8}.d_{av}$$

Where $C_{0.8}$ is 1.25 for Victorian catchments (Pearse et al., 2002).

A summary of the adopted RORB parameters are presented in Table 2.

Table 2 Parameters for RORB model

<table>
<tr><th>No.</th><th colspan="2">Parameter</th><th>Values</th></tr>
<tr><td>1</td><td colspan="2">RORB Model (Appendix A)</td><td>RORBWin6.45</td></tr>
<tr><td>4</td><td colspan="2">Catchment Area</td><td>6.71 km^2</td></tr>
<tr><td>5</td><td colspan="2">Temporal Pattern</td><td>ARR 2020</td></tr>
<tr><td>6</td><td colspan="2">Parameter m</td><td>0.8</td></tr>
<tr><td>7</td><td colspan="2">Initial Loss (IL) (Appendix B)</td><td>25 mm</td></tr>
<tr><td>8</td><td colspan="2">Continuous Loss (CL) (Appendix B)</td><td>4.4 mm</td></tr>
<tr><td>9</td><td colspan="2">Pre-burst Loss (Appendix B)</td><td>6 mm</td></tr>
<tr><td>2</td><td colspan="2">Intensity Frequency Duration (IFD) (Appendix C)</td><td>ARR 2020</td></tr>
<tr><td>10</td><td colspan="2">Regional Flood Frequency Estimate (RFFE) (Appendix D)</td><td>40 m^3/s</td></tr>
<tr><td>11</td><td colspan="2">$C_{0.8}$ (Pearse et al., 2002)</td><td>1.25 for Victorian catchments</td></tr>
<tr><td rowspan="2">12</td><td rowspan="2">K_C</td><td>Victoria Data (Pears et al., 2002)</td><td>3.06</td></tr>
<tr><td>Australian Rainfall Runoff 2020 ((MAR<800mm- Morris, 1982 & Hansen et al. 1986, Ball et al., 2019)</td><td>1.69</td></tr>
</table>

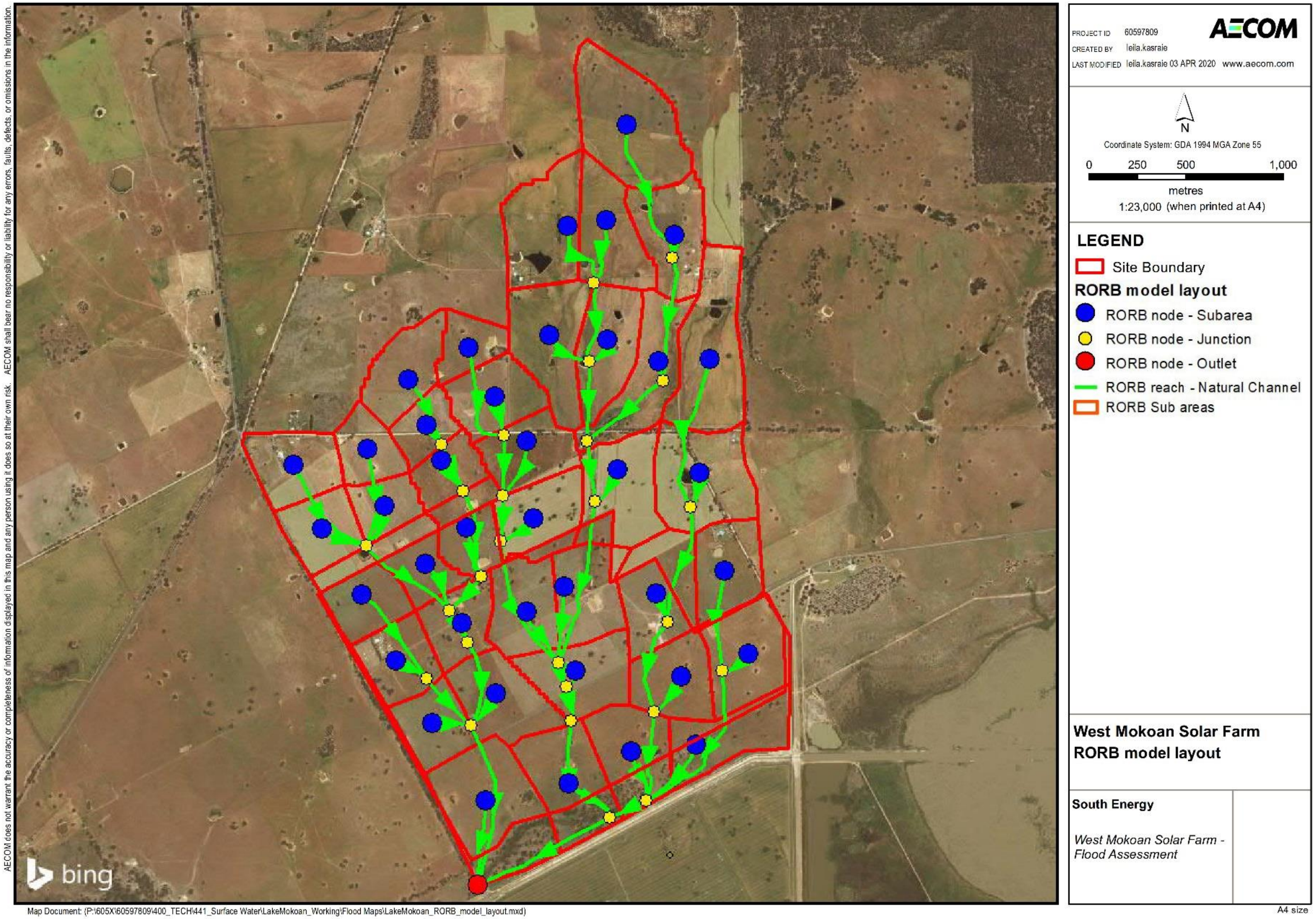


Figure 7 West Mokoan Solar Farm RORB model layout

5.2 Simulations Types

The ensemble simulations were conducted using the parameters presented in Section 4.1. Ten temporal patterns produced for durations from 20 minutes to 18 hours. A temporal pattern with just higher than the median peak flow of the 10 temporal patterns at the catchment outlet was selected for each duration. For the 1% AEP event the median temporal patterns that were selected for each duration are summarised below in Table 4.

5.3 Hydrologic Modelling Validation

No gauge data is available for the waterways within the catchment and it is not possible to verify the results from RORB Model against observed data. Therefore, comparison of flow based upon Approximate methods was undertaken as follows:

- Reginal Flood Frequency Estimate tool (RFFE) developed by (Haddad et al., 2011) and Nikolaou and von't Steen based on data from 853 gauged catchments
- Nikolaou and von't Steen equations from (ARR 2020, Book 7)
    - For rural catchments Q 1%AEP = 4.67 Area $^{0.763}$

Simulated 1% AEP flow at the catchment outlet obtained from RORB models with K_C values from Regional Methods compared with flow from above approximate methods.

Flow obtained from Victoria Data (MAR<800mm- Morris, 1982 & Hansen et al. 1986) happened to be within the range of flows from RFFE and Nikolaou/ von't Steen methods. This was considered reasonable as the catchment area is currently farmland, resembling rural conditions. Therefore, K_C from Victoria data (MAR<800 mm) was considered for the RORB model. The ensemble simulations were conducted using the parameters presented in Section 4.1. Two set of ensemble simulations conducted with and without pre-burst loss. Table 3 shows results from the ensembles compared to Approximate methods.

Table 3 Comparing Discharge from RORB Model to Approximate Methods at the Outlet

Methods	KC VALUE	PRE-BUSRT	CRITICAL DURATION	1% AEP FLOW (ARR 2020)	RFFE[1]	NIKOLOAU/ VON STEEN
		mm	hours		m³/s	
Vic data (MAR<800 mm)	1.69	0	6	28.5	41.2	19.95
		6	3	30.54	17.2 (5%) to 99.5 (95%)	
Pears et al. 2002	3.1	0	6	28.5		
		6	6	17.34		

Note:

1. **The Regional Flood Frequency Estimate (RFFE) is not applicable to catchments urbanized by more than 10%**

5.4 Critical Duration, Peak flow and Temporal Patterns

Ten temporal patterns of 1% AEP events produced for different durations from 20 minutes to 18 hours for the models with the Regional K_C values, initial and continuous losses. A temporal pattern with peak flow just higher than the median value of the 10 temporal patterns was selected for each duration at the catchment outlet. The critical duration with the highest ensemble peak flow was selected for ensemble with KC with Regional methods and compared to approximate methods. Critical duration of 6 hours was obtained for routing parameters (K_C) from both Regional equations. The ensemble runs were repeated with deduction of median pre-burst loss (6 mm) for 6 hours critical duration. Applying pre-burst losses resulted shorter critical duration of 3 hours for the second ensemble. Median temporal patterns of 1% AEP events for the durations are summarised in Table 4. There are 17 farm dams within the catchment that were not been captured by RORB model due to lack of data. High concentration of farm dams could influence catchment storage and time to concentration (ARR-Book 5). Therefore, hydrographs from higher than median temporal patterns of 1% AEP events with K_C from Regional Vic data (MAR<800 mm), and 6 mm pre-burst were selected for 20 minutes to 18 hours durations to be used in TUFLOW.

Table 4 % AEP events with K_C from Regional Vic data (MAR<800 mm), and 6 mm pre-burst for 20 minutes to 18 hours durations

Run	Duration	Temporal Pattern	Rain(mm)	ARF	Peak discharge-outlet, m^3/s
1	20 mins	22	33.9	0.89	9.32
2	25 mins	27	37	0.9	12.42
3	30 mins	26	39.6	0.9	15.08
4	45 mins	27	45.1	0.92	20.83
5	1 hr	22	49.1	0.92	24.65
6	1.5 hr	21	54.8	0.93	28.89
7	2 hrs	28	59.2	0.93	28.54
8	3 hrs	27	66.1	0.93	30.54
9	4.5 hrs	28	74.4	0.95	25.19
10	6 hrs	26	81.2	0.96	28.93
11	9 hrs	29	92.7	0.97	20.35
12	12 hrs	22	102	0.98	19.37
13	18 hrs	24	118	0.98	15.56

6.0 Hydraulic Modelling

The subsequent impact on downstream flow and attenuation requirements were investigated and undertaken using TUFLOW software. Details associated with this model development can be found in the sections below.

6.1 Available Data/Previous Study

The following data and models have been supplied or obtained for use in undertaking this hydraulic modelling.

- Spatial survey data conducted for the northern land parcel, providing the following information:
    - Sub-catchment flow pathways
    - Existing water features within the site and model boundary
    - Elevation features
- Vicmap Elevation Digital Terrain Model 20 m from the Department of Environment, Land, Water & Planning
- Aerial photography

6.2 TUFLOW Modelling Development

6.2.1 Hydraulic Modelling Parameters

An overview of the model and the parameters is provided in Table 5. Figure 8 shows the hydraulic model extent.

Table 5 Hydraulic model overview

Parameter	West Mokoan Hydraulic Model
Completion date	March 2020
AEP's assessed	1% AEP
Durations assessed	20 minutes, 30 minutes, 45 minutes, 1 hour, 1.5 hours, 2 hours, 3 hours, 4.5 hours, 6 hours, 9 hours, 12 hours
Hydrologic modelling	RORB (section 4.1)
IFD input parameters	Refer to section 4.1
Hydraulic model software	TUFLOW Classic version 2018-03-AD-iDP-w64
Grid size	6 metres
DEM	20 m DTM Topographic data from survey converted to 1 m ASCII
Roughness	Spatially varying values outlines in section 5.2.4
Eddy viscosity	Smagorinsky (default)
Model boundaries	Inflow boundary conditions as outlined in section 5.2.5 Downstream boundary conditions as outlined in section 5.2.5
Timesteps	3 seconds in the 2D
Wetting and drying depths	Cell centre 0.0002 m (default)
Outputs	Height, depth, velocity, hazard (ZAEM1)

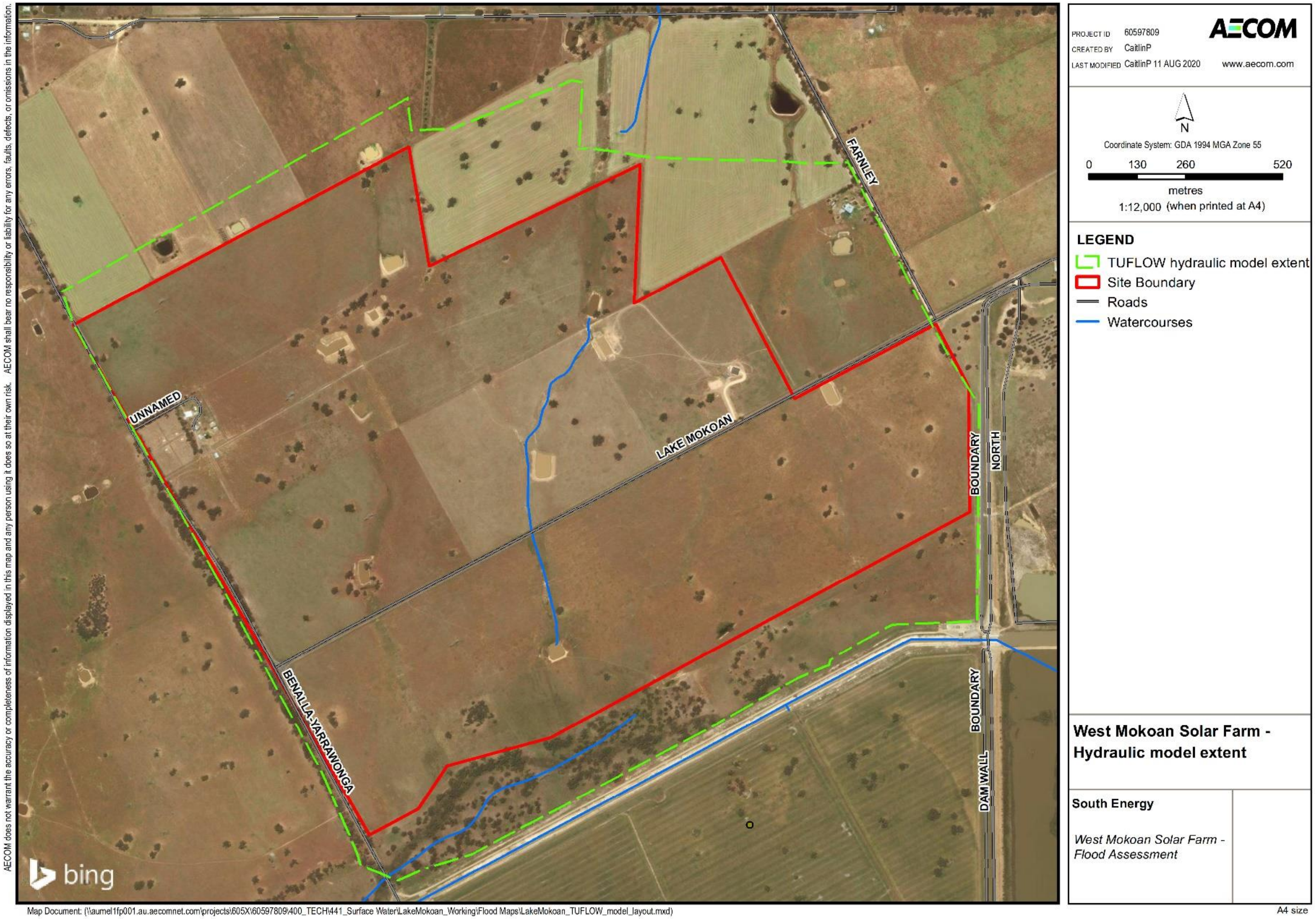


Figure 8: West Mokoan Solar Farm hydraulic model extent

6.2.2 Digital Elevation Model (DEM)

The hydraulic model was developed using two sets of elevation data:

- DTM 20m grid, sourced from Vicmap Elevation data (Vicmap, 2019)
- Site specific survey undertaken and sourced from the client.

Terrain modifications were made to the model to smooth the boundary between the two data sets, using a 2d z shape region to merge the two sets of elevation.

Accordingly, at various locations, specifically waterways and flow pathways, 2d z shape lines and points were used to define these features by interpolation. Likewise, a number of culverts exist along Lake Mokoan Rd, running approximately through the centre of the site. Through a 1D network type, the culverts were represented in the model and connected by 2D model link, depicting more appropriate elevations in these areas along the road. The grid size adopted for this hydraulic model was 6 m. The final topography used is shown in Figure 9.

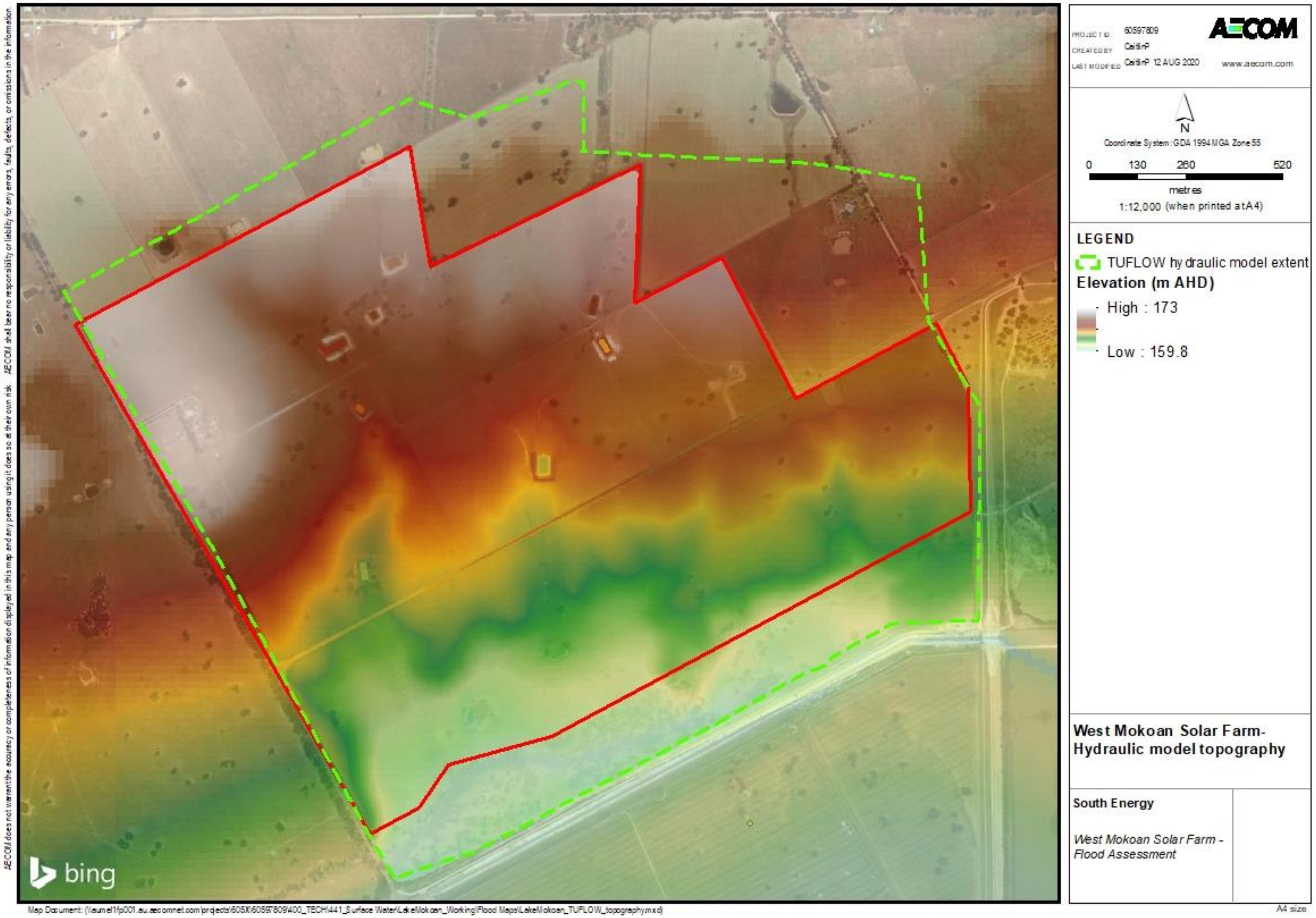


Figure 9 West Mokoan Solar Farm hydraulic model topography

6.2.3 Timestep

A 3 second timestep was used in the 2D domain. The selected timestep was necessary to ensure the courant number remained within the suggested limits and model run times were optimised. Timestep for 1D domain model for culvert crossing was set to be 1 second.

6.2.4 Hydraulic roughness

The hydraulic roughness represents the different type of land use and ground cover that exists within the model extent. Hydraulic roughness has been represented in the model with a Manning's 'n' value.

Table 6 identifies the roughness values for each land use category adopted in the model, which can be seen in Figure 10.

Table 6 West Mokoan TUFLOW adopted roughness values

Material description	Manning's 'n'
Open pervious area – minimal vegetation	0.040
Waterways	0.035
Farm dams	0.020
Unpaved roads (local unsealed)	0.035
Property (Residential – rural (lower density)	0.060
Farm Shed	0.050
Paved Road	0.025
Dense Vegetation	0.060

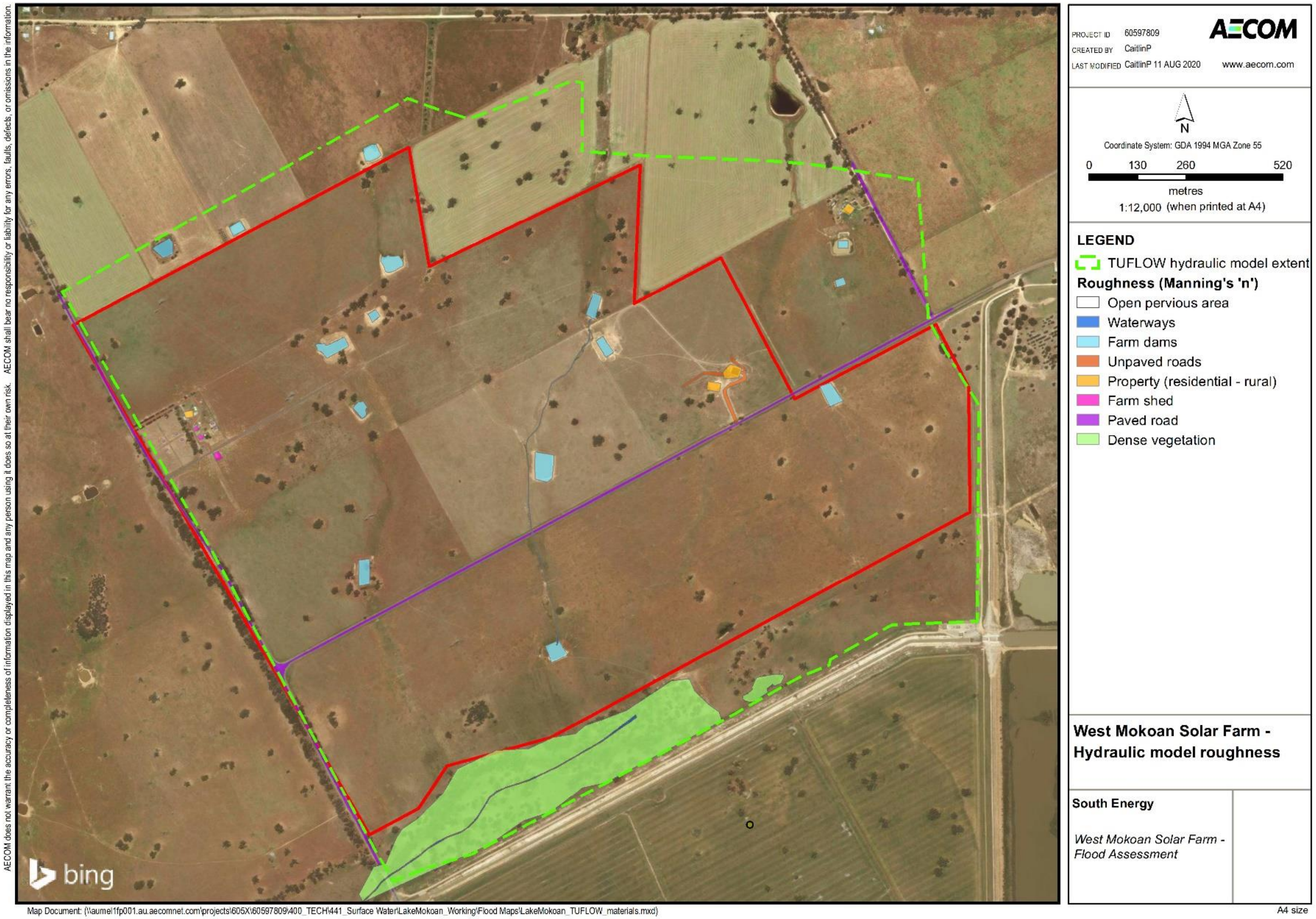


Figure 10 West Mokoan Solar Farm hydraulic model roughness

6.2.5 Boundary conditions

The following section details the boundary conditions adopted for the West Mokoan TUFLOW model.

6.2.5.1 Inflow boundary conditions

Table 7 Inflow boundary condition types

Inflow boundary	GIS input type	Description	Location on Figure 9
Flow versus time (QT) – Inflow hydrographs	Distributes flow across the cells intersected by the 2D GIS boundary condition line	Inflow from regional catchment outside of the hydraulic model boundary.	Green lines on the upstream side of the hydraulic model boundary in Figure 11
Source versus area (SA) – Routed rainfall excess hyetographs	Distribute depth of flow across all wet cells or lowest elevation cells within the polygon	RORB sub-catchments situated within the hydraulic model boundary extent.	Pink polygons that match the RORB sub-catchment boundaries in Figure 11
Flow head versus time – constant value of 161.67 m for water level at the outlet of the model (HT)	Distributes backwater flow level at the outlet by the 2D GIS boundary condition line	Inflow from the GBCMA flood level contour extrapolation outside of the hydraulic model boundary	Yellow line on the outlet of the hydraulic model boundary in Figure 11

6.2.5.2 Downstream boundary conditions

The downstream boundary conditions for the hydraulic model used the water level (head) versus flow (Q) (HQ) and water head versus time (HT) boundary types. By adopting this type of boundary condition, TUFLOW applies a head versus flow relationship at the cross-sectional area at the location of each downstream boundary as well as head versus time boundary (HT) at the outlet. The downstream boundary locations are presented in Figure 11.

6.2.6 Critical duration analysis

An assessment of the critical duration of the model was completed in RORB model to determine the duration at which the peak water surface elevation occurred. Several storm durations with above median temporal pattern (ensemble runs from RORB) were tested in the TUFLOW model, ranging from 20 minutes to 18 hours. The 1% AEP model results show that the duration associated with the peak water level is 6 hours as shown in Figure 12.

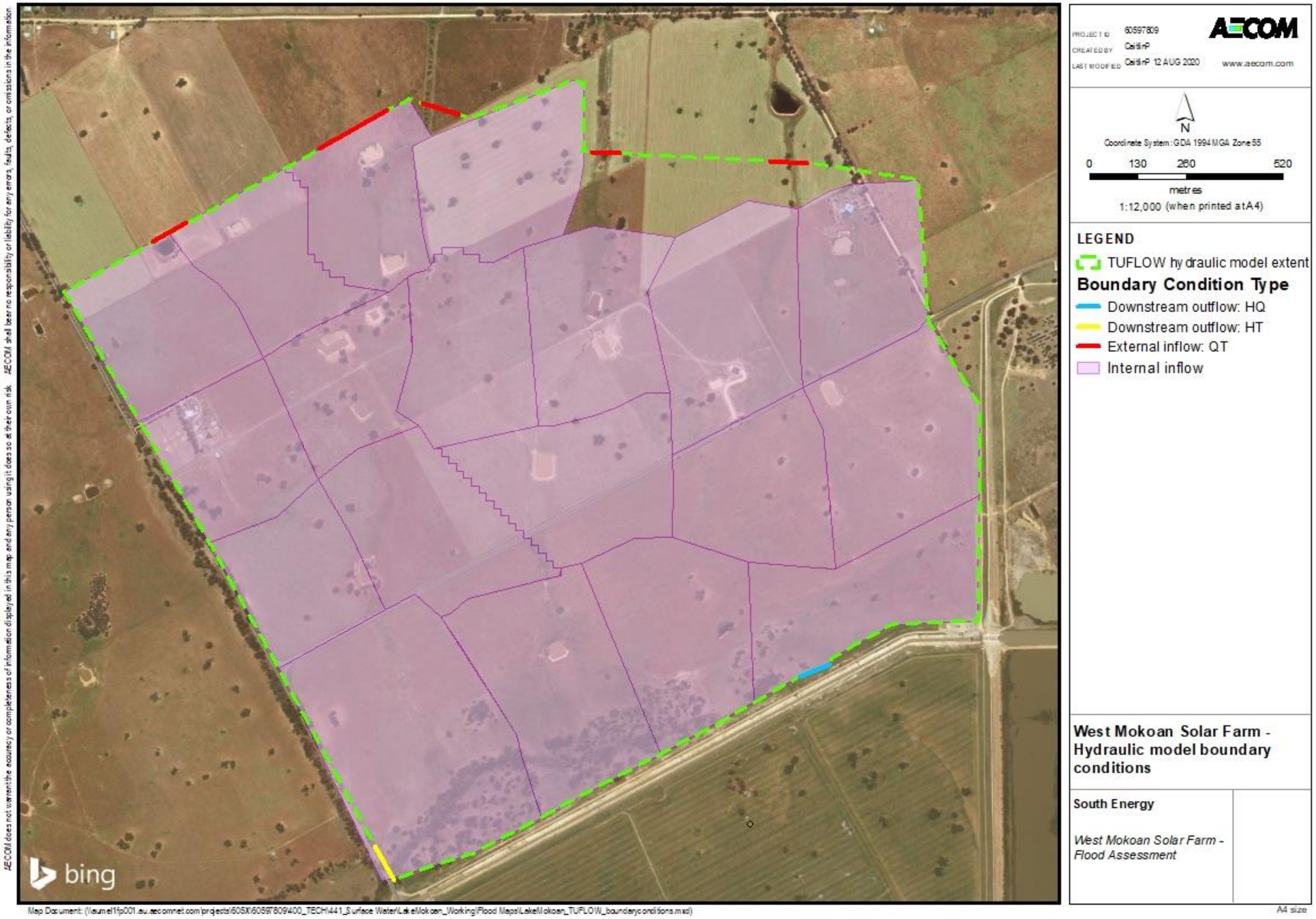


Figure 11 West Mokoan Solar Farm hydraulic model boundary conditions

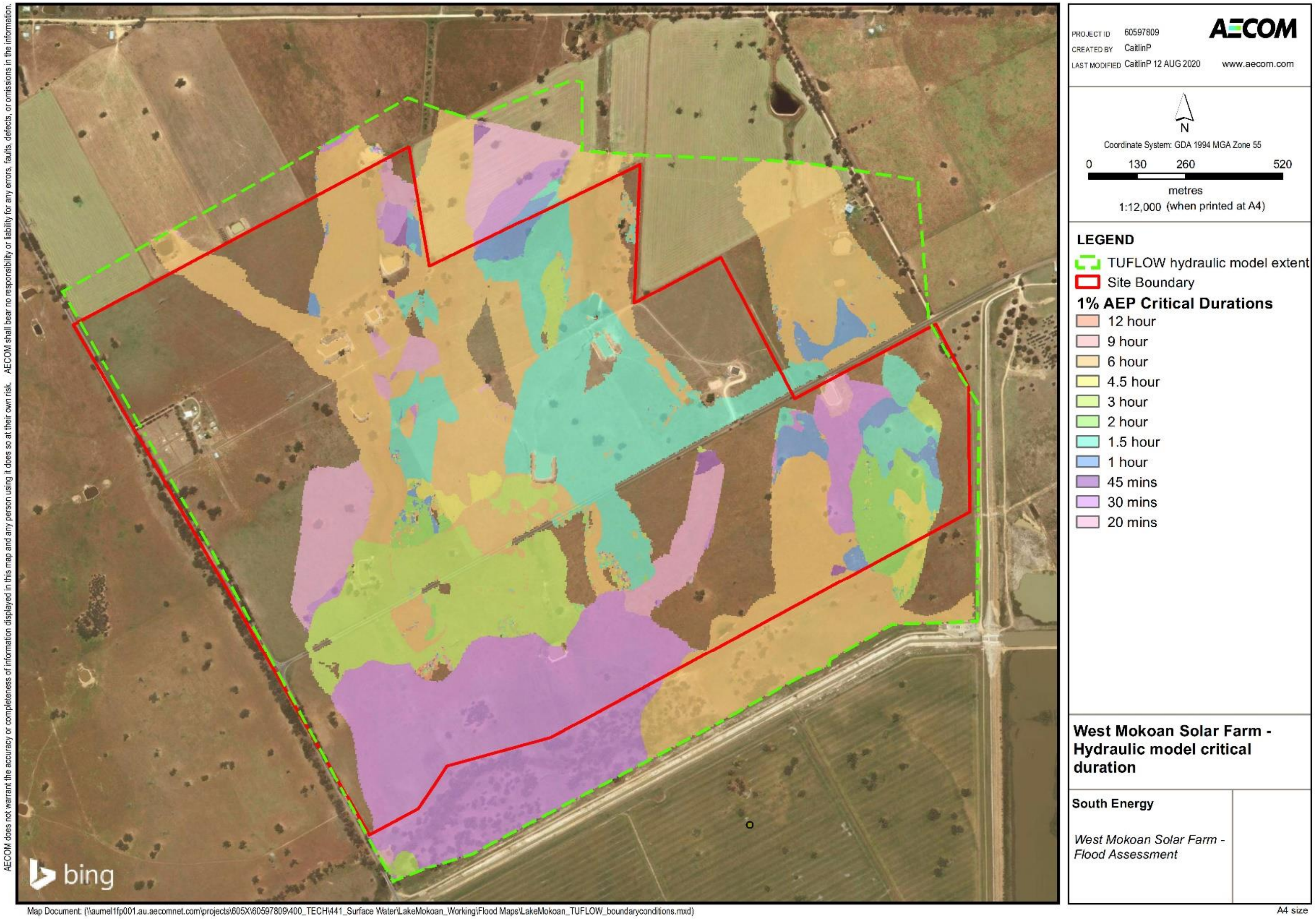


Figure 12 West Mokoan Solar Farm 1% AEP critical duration

6.3 Hydraulic Modelling Results

The maximum flood depth was obtained for the 1% AEP events from 20 minutes to 18 hours at the northern land parcel of the West Mokoan Solar Farm proposed site. The maximum depth results are presented below in Figure 13.

As shown in Figure 13, the northern land parcel is mostly flooded from the southside of the land adjacent to the designated waterway. The extent and depth of the 1% AEP flow are impacted by the backwater from the Broken River. This has been modelled by defining a Head -Time (HT) boundary at the catchment outlet keeping 161.67 m water head at the outlet which is equivalent to the flood contour extrapolation at this location.

The maximum hazard for the site was obtained with a combined set of hazard vulnerability curves, as a general classification of flood hazard on the floodplain. The various categories were used based on the criteria/ methodology outlined in *(Smith, Davey, & Cox, 2014)*. The hazard thresholds were derived from the vulnerability of the community when interacting with floodwaters. A suggested set of curves in (Smith, Davey, & Cox, 2014) are based on the referenced thresholds, divided into hazard classifications relating to specific vulnerability thresholds as described in Figure 14.

Hydrology and hydraulic assessment showed that most of the catchment obtained no flood hazard except the southern area and two spots above the main road crossing the parcel from east to west. The southside of the northern land parcel is partly inundated above 300 mm and the flood level increases at the land adjacent to the designated waterway. The extent and depth of the 1% AEP flow are impacted by the backwater from the Broken River.

Culverts crossing the road have been incorporated into the hydraulic modelling (1D domain in TUFLOW). The modelling results show that flow inundation occurs at the existing culverts conveying 1% AEP flow and hazard within these areas are classified as H2 and H3.

Most of the catchment obtained low risk flood risk except for areas adjacent to the creek where hazard vulnerability was classified H5 as shown in Figure 15 and Figure 16. To avoid any adverse impacts to the existing flood flows and storage, it is recommended not to build inverter and transformer blocks within the high flood risk area. There is no H6 flood hazard zone in the northern land parcel. No solar panel was considered within the areas with H4 and H5 hazard.

The southern land parcel is inundated with 1% AEP flood based on GBCMA flood contours and measurement points extrapolations. The flood level is significant in some areas at the site. Figure 17 shows colour coded solar panels within the southern land parcel based on their locations, above and below a 1.5 m flood depth. The estimated flood depth and required freeboard are to be considered in arrays height in this area.

A solar farm impact assessment including adjustments to the terrain and roughness was conducted in a sensitivity analysis included within the Raywood Solar Farm Myers Creek – Hydrologic and Hydraulic Modelling Report prepared by AECOM on 23 July 2019 (Planning Permit 5414 – Loddon Shire Council). This assessment showed that solar farm developments including construction of solar panels and associated structures have minimal impacts to the existing flood flow in a catchment because of insignificant changes to the existing flows and flood storage.

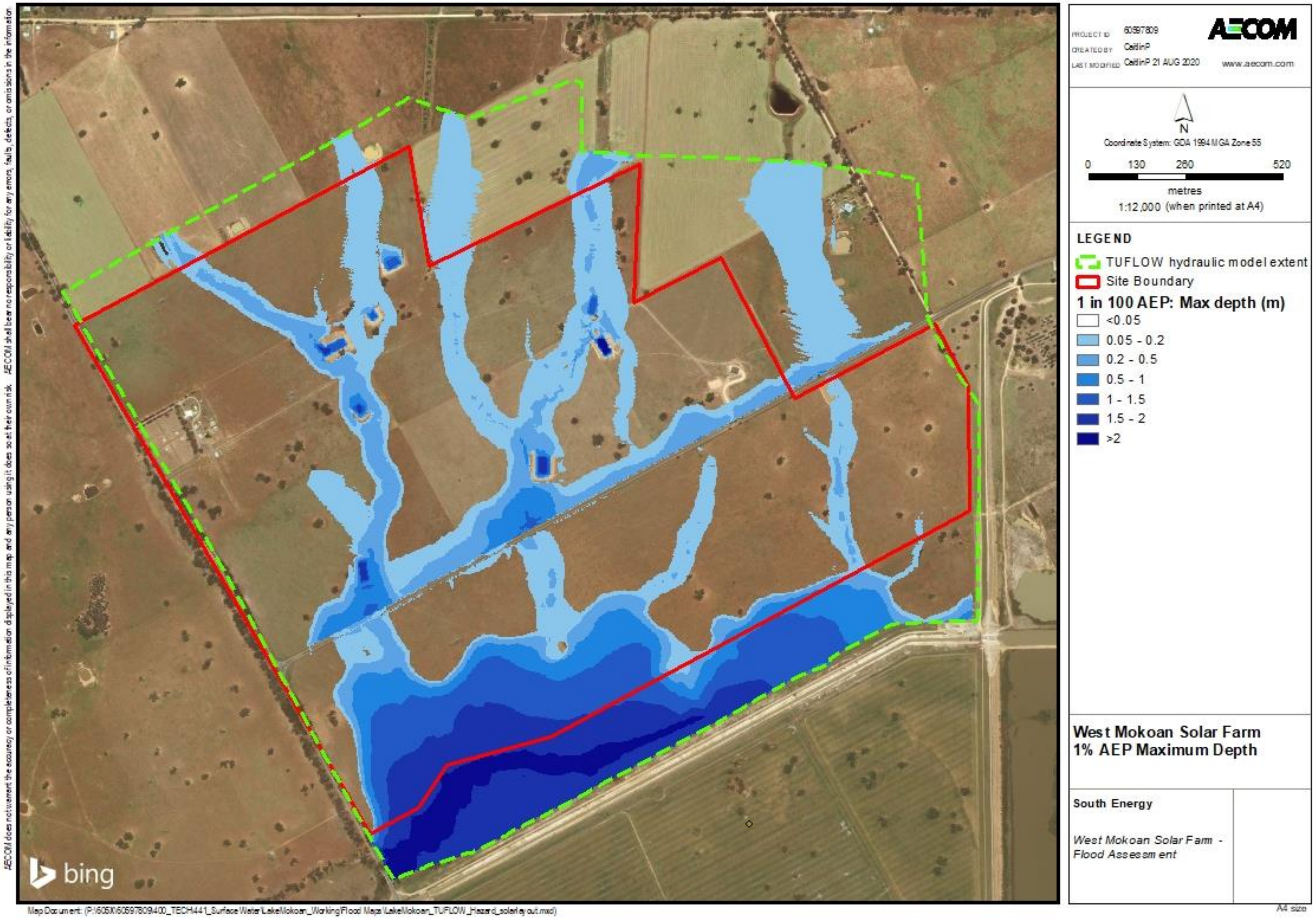
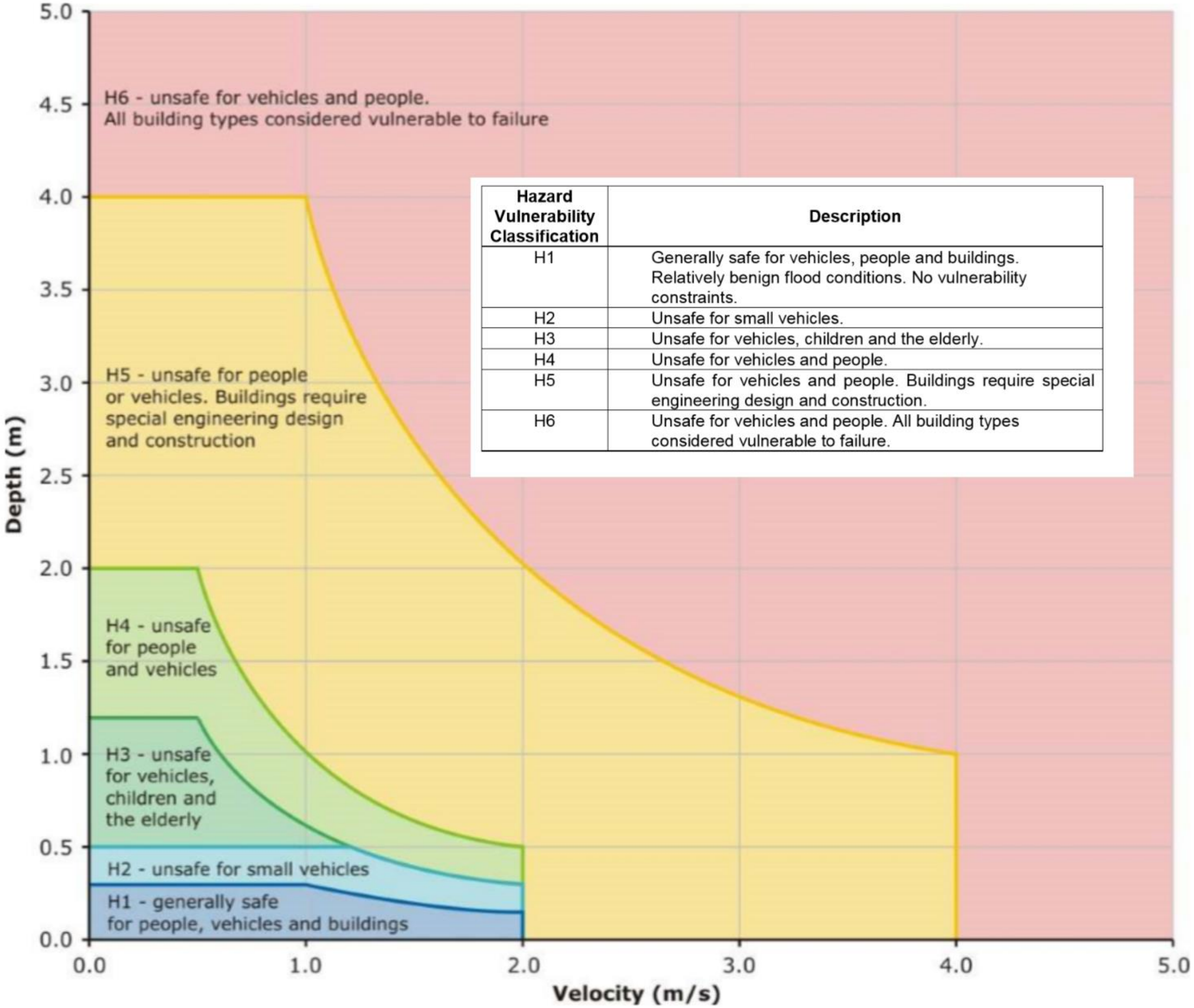


Figure 13 West Mokoan Solar Farm 1% AEP maximum Flood depth



Hazard Vulnerability Classification	Description
H1	Generally safe for vehicles, people and buildings. Relatively benign flood conditions. No vulnerability constraints.
H2	Unsafe for small vehicles.
H3	Unsafe for vehicles, children and the elderly.
H4	Unsafe for vehicles and people.
H5	Unsafe for vehicles and people. Buildings require special engineering design and construction.
H6	Unsafe for vehicles and people. All building types considered vulnerable to failure.

Figure 14 Combined flood hazard curves from (Smith, Davey, & Cox, 2014)

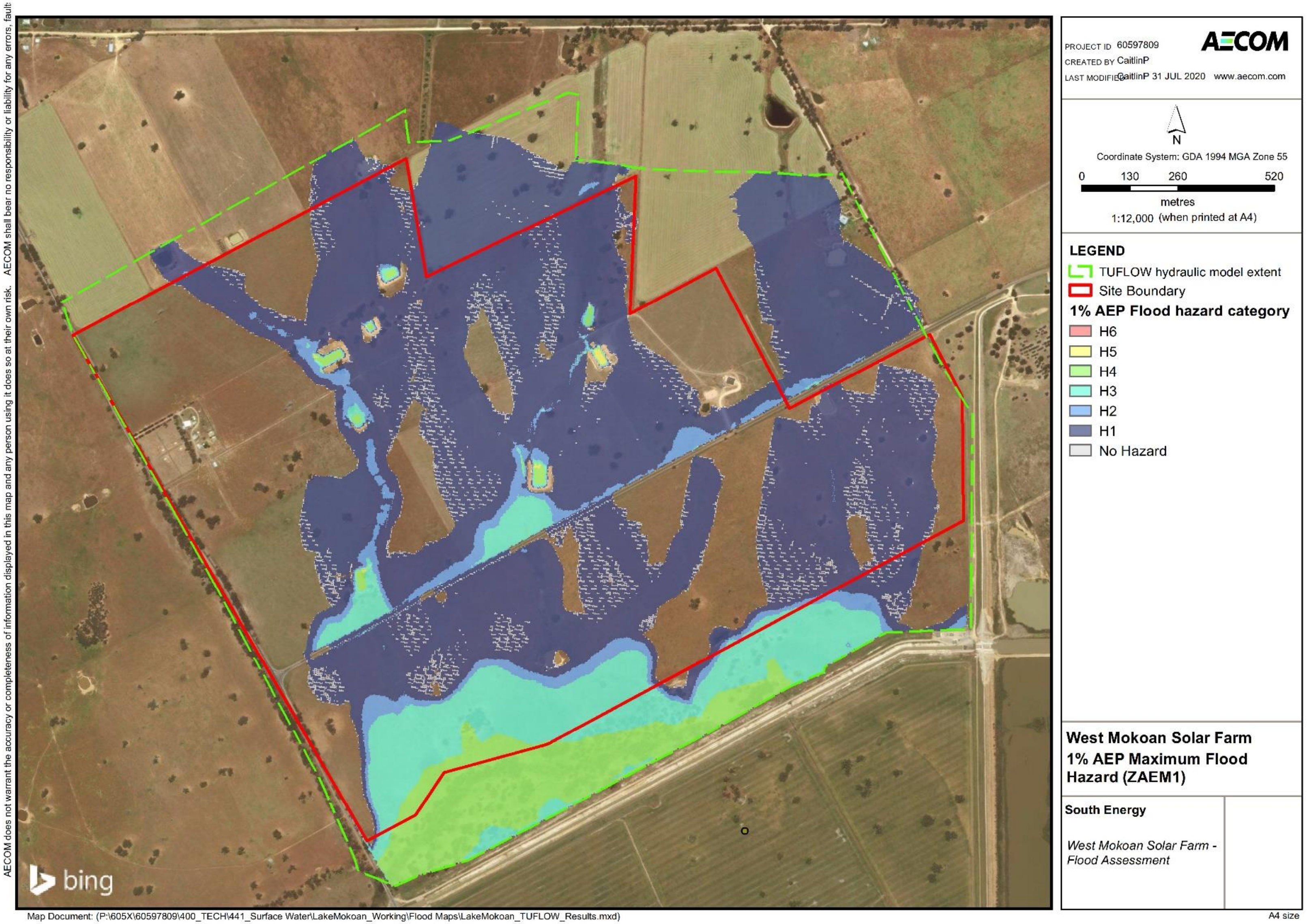


Figure 15 West Mokoan Solar Farm 1% AEP maximum hazard results

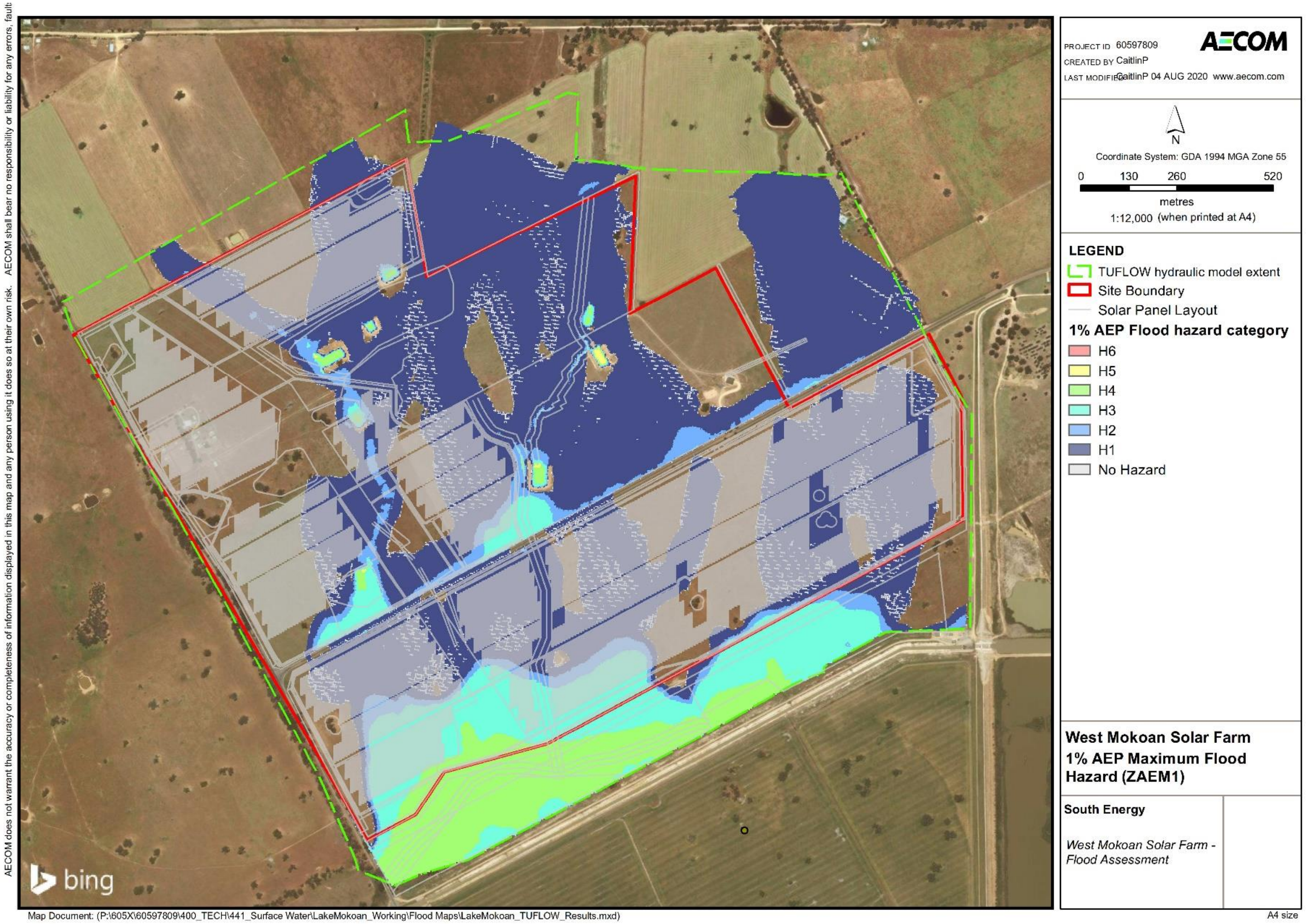


Figure 16 Solar Planes at High Hazard Area, to be Removed from the Planning Scheme – the northern land parcel

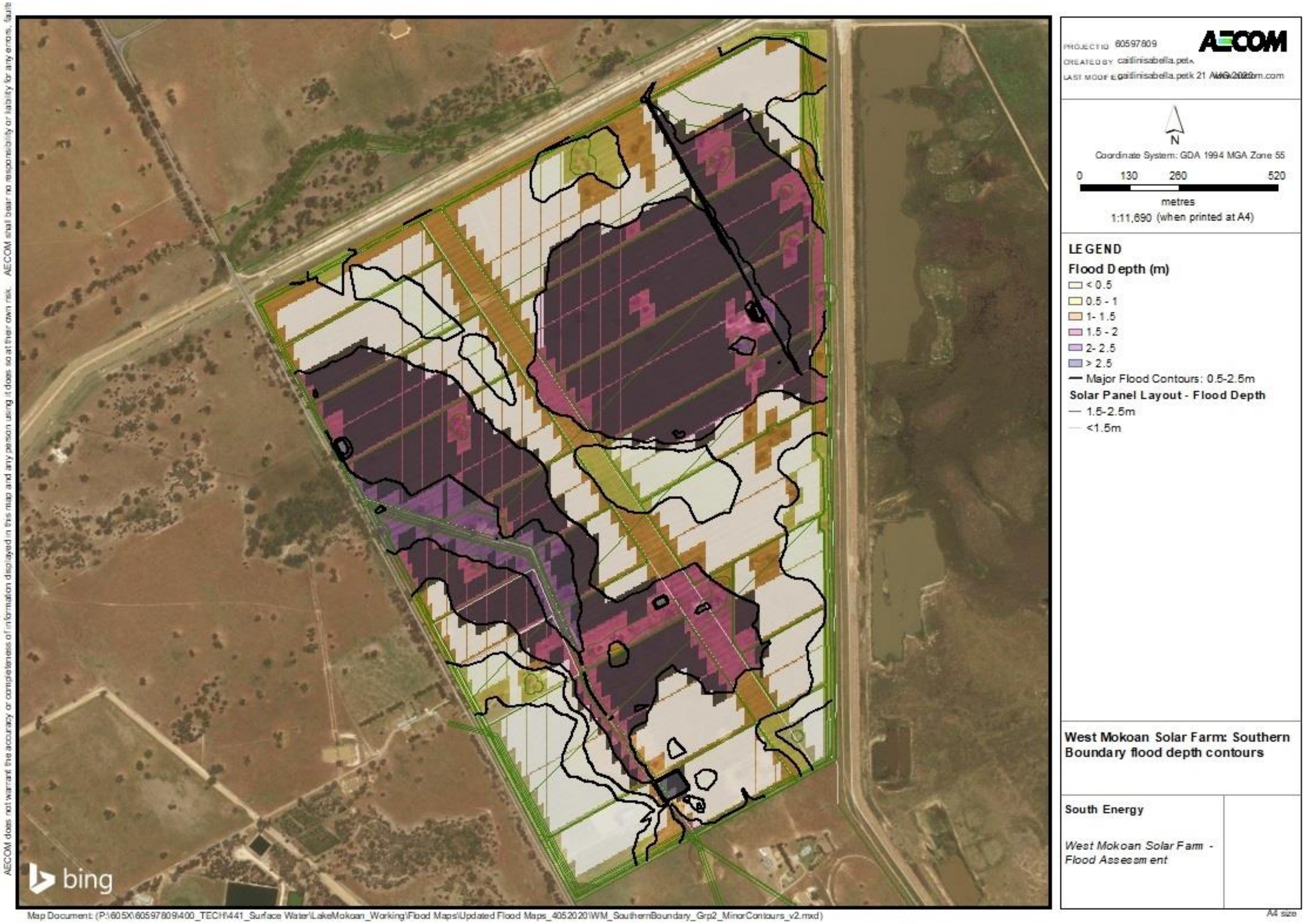


Figure 17 Solar Planes at different Flood depth– the southern land parcel

7.0 Assumptions and Limitations

7.1 Assumptions

The hydrological and hydraulic assessment of the site has been conducted with the following assumptions:

- This hydrology and hydraulics assessment of the West Mokoan Solar Farm modelling is related to the existing flood conditions on the site

6.1.1 Exclusions

The following work has been excluded from the hydrologic and hydraulic modelling of the West Mokoan Solar Farm; however, could be undertaken at detailed design stage when more information about the project becomes available:

- Investigation of erosion potential
- Impact assessment on the floodplain due to the proposed development including a blockage assessment and modelling of proposed structures
- Impact of the changing climate

7.2 Limitations

The following limitations apply to this study:

- Hydrologic modelling of all events is based on methods and data outlined in Australian Rainfall and Runoff (ARR) 2019
- Hydraulic modelling of all events is based on methods and data outlined in Australian Rainfall and Runoff (ARR) 2019
- Any use which a third party makes of this document, or any reliance on or decision to be made based on this document, is the responsibility of such third parties. The project team accepts no responsibility for damages, if any, suffered by any third party because of decisions or actions made based on this document
- Where information has been supplied by the Client or other external sources, the information has been assumed correct and accurate unless stated otherwise. No responsibility is accepted by the project team for incorrect or inaccurate information supplied by other sources

ARR Revision Project 15 outlines several fundamental themes which are relevant to this report:

- All models are coarse simplifications of very complex processes. No model can therefore be perfect, and no model can represent all of the important processes accurately
- Model accuracy and reliability will always be limited by the accuracy of the terrain and other input data
- Model accuracy and reliability will always be limited by the reliability / uncertainty of the inflow data
- A poorly constructed model can usually be calibrated to the observed data but will perform poorly in events both larger and smaller than the calibration data set
- No model is ‘correct’ therefore the results require interpretation
- A model developed for a specific purpose is probably unsuitable for another purpose without modification, adjustment, and recalibration. The responsibility must always remain with the modeller to determine whether the model is suitable for a given problem

8.0 Conclusion

The hydrological and hydraulic assessment indicated that areas within the northern land parcel are mainly inundated under 300 mm for a 1% AEP flood event and are therefore categorised as having a low flood risk, except for land adjacent to the designated waterway impacted by the backwater from the Broken River.

GBCMA requires 300 mm freeboard above the 1% AEP flood level (Nominal Flood Protection Level) for greenfield development within flood affected areas. In compliance with the CMA requirements, appropriate finished floor levels of the proposed infrastructure including inverter, transformer blocks and any buildings would be at 300 mm above the 1% AEP flood level.

The southern land parcel is inundated with 1% AEP flood based on GBCMA flood contours and measurement points extrapolations. Areas adjacent to the designated waterway and low-lying land on the north east are inundated with more than 1.5 m flood depth. The topography of the site is less steep compared to the northern land parcel which decreases the hazard rating for this site as a result of lower velocity. The estimated flood depth and 300mm freeboard are to be considered in the solar arrays height in this area.

The results of this flood investigation have been incorporated into the solar farm layout to avoid adverse impacts to the existing flow regime as well as conveyance impacts to pre-existing flood storage, flood levels, and flood velocities. The proposed infrastructure including single axis trackers; a single line of poles spaced between 6 and 8m apart, inverter and transformer blocks would be constructed with 300 mm freeboard above 1% AEP flood level.

The assessment showed that solar farm developments including solar panels and associated structures cause insignificant changes to the existing flows and flood storage. Subsequently, the project does not increase water levels to any neighbouring buildings outside of the site boundary.

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10.0 Appendices

Appendix A- RORB Catchment file

LM - 1

C RORB_GE 6.45

C WARNING - DO NOT EDIT THIS FILE OUTSIDE RORB TO ENSURE BOTH GRAPHICAL AND CATCHMENT DATA ARE COMPATIBLE WITH EACH OTHER

C THIS FILE CANNOT BE OPENED IN EARLIER VERSIONS OF RORB GE - CURRENT VERSION IS v6.45

C

C LM - 1

C

C #FILE COMMENTS

C 2

C File created using ArcRORB version 1.7.6165.25381

C Original CATG file created on 22/03/2020 at 18:47:20

C

C #SUB-AREA AREA COMMENTS

C 1

C Sub-area areas in km²

C

C #IMPERVIOUS FRACTION COMMENTS

C 0

C

C #BACKGROUND IMAGE

C T F

C

C #NODES

C 63

C 1 44.906 13.966 1.000 1 0 28 A 0.316000 0.050000 0 1 0

C

C 2 58.664 15.737 1.000 1 0 29 B 0.212000 0.050000 0 1 0

C

C 3 13.451 49.690 1.000 1 0 32 AC 0.152000 0.050000 0 1
0

C

C 4 25.554 51.370 1.000 1 0 32 AD 0.105000 0.050000 0 1
0

C

C 5 32.232 58.827 1.000 1 0 42 E 0.190000 0.050000 0 1 0

C
C 6 37.615 50.121 1.000 1 0 42 F 0.139000 0.050000 0 1 0
C
C 7 43.713 60.150 1.000 1 0 51 G 0.184000 0.050000 0 1 0
C
C 8 51.714 52.222 1.000 1 0 48 H 0.202000 0.050000 0 1 0
C
C 9 58.423 75.169 1.000 1 0 63 I 0.218000 0.050000 0 1 0
C
C 10 55.481 63.514 1.000 1 0 30 L 0.214000 0.050000 0 1 0
C
C 11 68.254 85.937 1.000 1 0 47 J 0.294000 0.050000 0 1 0
C
C 12 76.033 74.200 1.000 1 0 47 K 0.181000 0.050000 0 1 0
C
C 13 73.513 60.696 1.000 1 0 46 M 0.200000 0.050000 0 1
0
C
C 14 81.924 60.960 1.000 1 0 35 N 0.272000 0.050000 0 1 0
C
C 15 80.201 48.868 1.000 1 0 35 O 0.242000 0.050000 0 1
0
C
C 16 84.279 38.412 1.000 1 0 62 P 0.153000 0.050000 0 1 0
C
C 17 66.706 49.228 1.000 1 0 44 Q 0.212000 0.050000 0 1
0
C
C 18 73.110 36.054 1.000 1 0 36 R 0.205000 0.050000 0 1 0
C
C 19 36.124 22.166 1.000 1 0 40 AB 0.126000 0.050000 0 1
0
C
C 20 57.988 36.723 1.000 1 0 39 AK 0.166000 0.050000 0 1
0
C
C 21 59.836 27.755 1.000 1 0 45 U 0.181000 0.050000 0 1 0
C
C 22 52.920 43.941 1.000 1 0 31 V 0.162000 0.050000 0 1 0
C

C 23 41.769 43.020 1.000 1 0 41 W 0.130000 0.050000 0 1
0

C

C 24 24.588 35.871 1.000 1 0 33 X 0.149000 0.050000 0 1 0

C

C 25 35.068 39.212 1.000 1 0 34 Y 0.128000 0.050000 0 1 0

C

C 26 77.238 27.173 1.000 1 0 37 Z 0.155000 0.050000 0 1 0

C

C 27 79.669 19.847 1.000 1 0 38 AA 0.171000 0.050000 0 1
0

C

C 28 43.609 5.000 1.000 0 1 0 Outlet 0.000000 0.000000 70 0
0

C

C 29 65.430 12.076 1.000 0 0 28 B1 0.000000 0.000000 70 0
0

C B1

C 30 62.037 60.763 1.000 0 0 43 AH1 0.000000 0.000000 70 0
0

C AH1

C 31 47.354 41.542 1.000 0 0 39 V1 0.000000 0.000000 70 0
0

C V1

C 32 25.285 41.080 1.000 0 0 34 C1 0.000000 0.000000 70 0
0

C C1

C 33 35.275 26.934 1.000 0 0 40 AF1 0.000000 0.000000 70 0
0

C AF1

C 34 38.953 34.240 1.000 0 0 61 AI1 0.000000 0.000000 70 0
0

C AI1

C 35 78.649 45.239 1.000 0 0 36 O1 0.000000 0.000000 70 0
0

C O1

C 36 74.891 32.963 1.000 0 0 37 R1 0.000000 0.000000 70 0
0

C R1

C 37 72.624 23.427 1.000 0 0 38 Z1 0.000000 0.000000 70 0
0

C Z1

C 38 71.319 13.999 1.000 0 0 29 AJ1 0.000000 0.000000 70 0
0

C AJ1

C 39 57.034 28.559 1.000 0 0 45 U1 0.000000 0.000000 70 0
0

C U1

C 40 42.630 21.916 1.000 0 0 28 S1 0.000000 0.000000 70 0
0

C S1

C 41 44.266 37.779 1.000 0 0 34 V2 0.000000 0.000000 70 0
0

C V2

C 42 41.332 46.896 1.000 0 0 41 F1 0.000000 0.000000 70 0
0

C F1

C 43 61.561 52.292 1.000 0 0 44 M1 0.000000 0.000000 70 0
0

C M1

C 44 62.921 45.769 1.000 0 0 39 Q1 0.000000 0.000000 70 0
0

C Q1

C 45 58.229 26.076 1.000 0 0 50 U2 0.000000 0.000000 70 0
0

C U2

C 46 74.209 58.686 1.000 0 0 43 M2 0.000000 0.000000 70 0
0

C M2

C 47 75.649 71.703 1.000 0 0 46 K1 0.000000 0.000000 70 0
0

C K1

C 48 47.855 46.474 1.000 0 0 31 H1 0.000000 0.000000 70 0
0

C H1

C 49 46.768 25.284 1.000 1 0 40 S 0.178000 0.050000 0 1 0

C

C 50 58.998 22.437 1.000 0 0 29 B2 0.000000 0.000000 70 0
0

C B2

C 51 48.073 52.820 1.000 0 0 48 AK1 0.000000 0.000000 70 0
0

C AK1

C 52 28.358 45.375 1.000 1 0 32 D 0.092000 0.050000 0 1 0

C

C 53 18.035 42.855 1.000 1 0 32 C 0.129000 0.050000 0 1 0
C
C 54 30.216 28.820 1.000 1 0 33 AF 0.137000 0.050000 0 1
0
C
C 55 68.985 19.206 1.000 1 0 38 AJ 0.182000 0.050000 0 1
0
C
C 56 88.248 29.528 1.000 1 0 62 AG 0.200000 0.050000 0 1
0
C
C 57 65.032 63.042 1.000 1 0 30 AH 0.176000 0.050000 0 1
0
C
C 58 64.776 75.687 1.000 1 0 63 AE 0.182000 0.050000 0 1
0
C
C 59 40.978 32.832 1.000 1 0 61 AI 0.125000 0.050000 0 1 0
C
C 60 51.662 34.037 1.000 1 0 39 T 0.160000 0.050000 0 1 0
C
C 61 42.032 30.834 1.000 0 0 40 AI2 0.000000 0.000000 70 0
0
C AI2
C 62 83.915 27.802 1.000 0 0 38 AG1 0.000000 0.000000 70 0
0
C AG1
C 63 62.695 69.064 1.000 0 0 30 L1 0.000000 0.000000 70 0
0
C L1
C
C #REACHES
C 62
C 1 K1-M2 47 46 0 1 0 0.637 2.532 2 0
C 76.419 74.649
C 70.028 64.052
C 2 N-O1 14 35 0 1 0 0.807 1.742 4 0
C 79.187 77.369 77.646 76.537
C 55.150 53.190 50.568 48.019
C 3 R-R1 18 36 0 1 0 0.159 0.553 1 0
C 74.000

C 34.508

C 4 AF1-S1 33 40 0 1 0 0.334 0.529 1 0

C 37.594

C 25.082

C 5 C1-AI1 32 34 0 1 0 0.546 0.014 4 0

C 25.949 28.704 31.605 36.982

C 40.558 38.753 37.997 35.585

C 6 V2-AI1 41 34 0 1 0 0.239 -0.138 1 0

C 42.829

C 36.572

C 7 S1-Outlet 40 28 0 1 0 0.852 0.659 2 0

C 46.547 46.070

C 16.114 11.098

C 8 AH1-M1 30 43 0 1 0 0.409 1.381 1 0

C 61.799

C 56.527

C 9 AI1-AI2 34 61 0 1 0 0.190 0.031 1 0

C 40.493

C 32.537

C 10 F1-V2 42 41 0 1 0 0.460 0.820 5 0

C 42.982 43.430 43.355 43.579 43.318

C 44.589 42.898 41.883 40.603 39.033

C 11 AG1-AJ1 62 38 0 1 0 0.877 0.395 9 0

C 84.077 84.279 81.905 81.028 80.974 79.132 77.302 75.268 72.692

C 24.999 21.514 19.627 18.870 17.676 16.736 16.385 15.441 14.388

C 12 Z1-AJ1 37 38 0 1 0 0.469 0.513 3 0

C 71.489 72.129 72.129

C 16.840 16.425 15.596

C 13 AJ1-B1 38 29 0 1 0 0.206 0.002 1 0

C 68.375

C 13.037

C 14 B-B1 2 29 0 1 0 0.282 0.476 5 0

C 59.791 60.935 62.536 63.528 64.748

C 15.063 14.553 14.059 13.598 12.973

C 15 B1-Outlet 29 28 0 1 0 0.764 -0.006 4 0

C 59.071 52.834 51.207 48.021

C 10.011 7.729 7.005 6.303

C 16 A-Outlet 1 28 0 1 0 0.439 0.591 6 0

C 44.501 43.763 44.057 43.808 43.759 43.729

C 10.142 8.700 7.743 7.281 6.411 5.441

C 17 AB-S1 19 40 0 1 0 0.204 0.269 1 0

C 40.173

C 22.201

C 18 AK-U1 20 39 0 1 0 0.396 0.363 3 0

C 57.536 57.314 57.092

C 33.376 32.802 32.191

C 19 M1-Q1 43 44 0 1 0 0.317 1.208 1 0

C 62.241

C 49.031

C 20 Q1-U1 44 39 0 1 0 0.864 0.277 8 0

C 62.340 62.324 61.593 60.008 60.426 59.445 58.828 58.319

C 43.763 43.706 38.549 35.548 34.165 33.171 32.247 30.931

C 21 B2-B1 50 29 0 1 0 0.606 0.572 7 0

C 58.424 58.636 60.204 61.877 63.106 64.780 65.479

C 19.285 16.172 15.075 14.486 14.047 13.197 12.552

C 22 R1-Z1 36 37 0 1 0 0.499 0.612 2 0

C 72.624 71.006

C 31.181 26.937

C 23 O1-R1 35 36 0 1 0 0.616 0.364 5 0

C 78.766 78.872 78.674 76.833 75.174

C 43.436 41.794 40.925 38.805 35.582

C 24 AK1-H1 51 48 0 1 0 0.306 1.593 1 0

C 47.964

C 49.647

C 25 V1-U1 31 39 0 1 0 0.720 0.257 3 0

C 47.965 49.346 52.984

C 39.202 34.623 31.072

C 26 U2-B2 45 50 0 1 0 0.179 0.698 3 0

C 58.466 59.063 59.175

C 25.116 23.787 23.111

C 27 AC-C1 3 32 0 1 1 0.576 1.677 2 0

C 17.776 21.049

C 44.312 42.444

C 28 X-AF1 24 33 0 1 0 0.549 0.086 1 0

C 27.032
C 34.631
C 29 W-V2 23 41 0 1 0 0.270 0.141 3 0
C 42.446 42.751 43.001
C 41.475 39.984 38.871
C 30 E-F1 5 42 0 1 0 0.646 2.730 2 0
C 34.679 37.509
C 56.648 53.631
C 31 V-V1 22 31 0 1 0 0.211 0.077 2 0
C 50.657 48.660
C 42.606 41.959
C 32 AA-AJ1 27 38 0 1 0 0.391 0.232 4 0
C 78.589 77.119 74.872 73.014
C 18.401 17.197 15.671 14.616
C 33 O-O1 15 35 0 1 0 0.185 1.536 2 0
C 79.858 79.470
C 47.481 45.973
C 34 H-H1 8 48 0 1 0 0.314 1.082 1 0
C 51.257
C 49.303
C 35 U1-U2 39 45 0 1 0 0.127 0.650 1 0
C 57.453
C 26.938
C 36 M2-M1 46 43 0 1 0 0.502 1.166 5 0
C 71.960 69.796 67.965 66.357 62.862
C 57.643 56.386 55.453 54.483 52.939
C 37 I-L1 9 63 0 1 0 0.382 4.768 2 0
C 58.812 62.640
C 72.152 71.362
C 38 K-K1 12 47 0 1 0 0.121 4.776 1 0
C 75.843
C 72.960
C 39 AD-C1 4 32 0 1 1 0.511 2.568 2 0
C 27.263 26.375
C 45.120 42.983
C 40 F-F1 6 42 0 1 0 0.194 1.872 1 0
C 39.473
C 48.508

C 41 Q-Q1 17 44 0 1 0 0.212 0.564 3 0
C 65.941 64.498 63.444
C 47.939 46.467 45.856
C 42 S-S1 49 40 0 1 0 0.208 0.155 1 0
C 44.544
C 23.302
C 43 M-M2 13 46 0 1 0 0.100 1.331 1 0
C 73.707
C 59.690
C 44 J-K1 11 47 0 1 0 0.756 6.835 7 0
C 68.076 70.739 71.738 71.849 72.404 74.456 75.399
C 82.980 79.927 78.239 76.336 75.007 73.858 73.068
C 45 Y-AI1 25 34 0 1 0 0.276 -0.033 1 0
C 37.231
C 37.776
C 46 G-AK1 7 51 0 1 0 0.468 2.592 3 0
C 43.667 43.445 44.443
C 56.396 53.918 53.021
C 47 P-AG1 16 62 0 1 0 0.518 0.609 1 0
C 82.782
C 33.225
C 48 U-U2 21 45 0 1 0 0.100 0.269 1 0
C 59.394
C 26.686
C 49 L-AH1 10 30 0 1 0 0.259 1.402 2 0
C 57.019 59.669
C 61.889 61.041
C 50 H1-V1 48 31 0 1 0 0.239 0.952 1 0
C 47.855
C 44.032
C 51 AF-AF1 54 33 0 1 0 0.183 0.222 2 0
C 32.927 34.465
C 27.956 27.327
C 52 AI-AI2 59 61 0 1 0 0.102 0.154 1 0
C 41.505
C 31.833
C 53 AI2-S1 61 40 0 1 0 0.452 0.399 4 0
C 43.285 44.175 44.256 43.609

C 29.374 27.304 25.365 23.532

C 54 C-C1 53 32 0 1 1 0.245 1.350 2 0

C 19.732 22.079

C 42.079 41.555

C 55 D-C1 52 32 0 1 0 0.233 2.134 2 0

C 28.028 27.219

C 44.516 42.708

C 56 AJ-AJ1 55 38 0 1 0 0.269 0.505 4 0

C 69.306 69.873 70.763 71.289

C 18.083 16.982 16.275 15.594

C 57 Z-Z1 26 37 0 1 0 0.235 0.460 2 0

C 75.862 74.243

C 25.523 24.160

C 58 AG-AG1 56 62 0 1 0 0.164 0.282 2 0

C 87.193 85.574

C 28.771 28.038

C 59 T-U1 60 39 0 1 0 0.318 0.451 4 0

C 52.066 53.442 55.061 55.607

C 32.936 32.046 30.631 29.845

C 60 AH-AH1 57 30 0 1 0 0.161 1.801 2 0

C 64.647 62.907

C 61.775 60.832

C 61 AE-L1 58 63 0 1 0 0.340 5.152 6 0

C 64.607 64.890 64.000 63.838 64.121 63.797

C 74.795 73.825 72.594 71.834 71.153 70.158

C 62 L1-AH1 63 30 0 1 0 0.415 2.890 9 0

C 62.897 62.856 62.978 63.059 63.261 63.200 62.512 61.905 61.642

C 68.435 67.505 66.667 65.737 64.467 63.785 62.960 62.200 61.493

C

C #STORAGES

C 0

C

C #INFLOW/OUTFLOW

C 0

C

C END RORB_GE

C

C File created using ArcRORB version 1.7.6165.25381

C Original CATG file created on 22/03/2020 at 18:47:20

1

1, .382, -99 ,Reach 37 node 9 Sub-area I, Reach I-L1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

1, .340, -99 ,Reach 61 node 58 Sub-area AE, Reach AE-L1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

L1

5, .415, -99 ,Reach 62 Reach L1-AH1 - Route running h'graph downstream

3 , Store running hydrograph

1, .259, -99 ,Reach 49 node 10 Sub-area L, Reach L-AH1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .161, -99 ,Reach 60 node 57 Sub-area AH, Reach AH-AH1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

AH1

5, .409, -99 ,Reach 8 Reach AH1-M1 - Route running h'graph downstream

3 , Store running hydrograph

1, .756, -99 ,Reach 44 node 11 Sub-area J, Reach J-K1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

1, .121, -99 ,Reach 38 node 12 Sub-area K, Reach K-K1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

K1

5, .637, -99 ,Reach 1 Reach K1-M2 - Route running h'graph downstream

3 , Store running hydrograph

1, .100, -99 ,Reach 43 node 13 Sub-area M, Reach M-M2 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

M2

5, .502, -99 ,Reach 36 Reach M2-M1 - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

M1

5, .317, -99 ,Reach 19 Reach M1-Q1 - Route running h'graph downstream

3 , Store running hydrograph

1, .212, -99 ,Reach 41 node 17 Sub-area Q, Reach Q-Q1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

Q1

5, .864, -99 ,Reach 20 Reach Q1-U1 - Route running h'graph downstream

3 , Store running hydrograph

1, .468, -99 ,Reach 46 node 7 Sub-area G, Reach G-AK1 - Generate rainfall excess h'graph and route downstream

7 , PRINT

AK1

5, .306, -99 ,Reach 24 Reach AK1-H1 - Route running h'graph downstream

3 , Store running hydrograph

1, .314, -99 ,Reach 34 node 8 Sub-area H, Reach H-H1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

H1

5, .239, -99 ,Reach 50 Reach H1-V1 - Route running h'graph downstream

3 , Store running hydrograph

1, .211, -99 ,Reach 31 node 22 Sub-area V, Reach V-V1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

V1

5, .720, -99 ,Reach 25 Reach V1-U1 - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .396, -99 ,Reach 18 node 20 Sub-area AK, Reach AK-U1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .318, -99 ,Reach 59 node 60 Sub-area T, Reach T-U1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

U1

5, .127, -99 ,Reach 35 Reach U1-U2 - Route running h'graph downstream

3 , Store running hydrograph

1, .100, -99 ,Reach 48 node 21 Sub-area U, Reach U-U2 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

U2

5, .179, -99 ,Reach 26 Reach U2-B2 - Route running h'graph downstream

7 , PRINT

B2

5, .606, -99 ,Reach 21 Reach B2-B1 - Route running h'graph downstream

3 , Store running hydrograph

1, .807, -99 ,Reach 2 node 14 Sub-area N, Reach N-O1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

1, .185, -99 ,Reach 33 node 15 Sub-area O, Reach O-O1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

O1

5, .616, -99 ,Reach 23 Reach O1-R1 - Route running h'graph downstream

3 , Store running hydrograph

1, .159, -99 ,Reach 3 node 18 Sub-area R, Reach R-R1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

R1

5, .499, -99 ,Reach 22 Reach R1-Z1 - Route running h'graph downstream

3 , Store running hydrograph

1, .235, -99 ,Reach 57 node 26 Sub-area Z, Reach Z-Z1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

Z1

5, .469, -99 ,Reach 12 Reach Z1-AJ1 - Route running h'graph downstream

3 , Store running hydrograph

1, .518, -99 ,Reach 47 node 16 Sub-area P, Reach P-AG1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

1, .164, -99 ,Reach 58 node 56 Sub-area AG, Reach AG-AG1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

AG1

5, .877, -99 ,Reach 11 Reach AG1-AJ1 - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .391, -99 ,Reach 32 node 27 Sub-area AA, Reach AA-AJ1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .269, -99 ,Reach 56 node 55 Sub-area AJ, Reach AJ-AJ1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

AJ1

5, .206, -99 ,Reach 13 Reach AJ1-B1 - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .282, -99 ,Reach 14 node 2 Sub-area B, Reach B-B1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

B1

5, .764, -99 ,Reach 15 Reach B1-Outlet - Route running h'graph downstream

3 , Store running hydrograph

1, .646, -99 ,Reach 30 node 5 Sub-area E, Reach E-F1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

1, .194, -99 ,Reach 40 node 6 Sub-area F, Reach F-F1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

F1

5, .460, -99 ,Reach 10 Reach F1-V2 - Route running h'graph downstream

3 , Store running hydrograph

1, .270, -99 ,Reach 29 node 23 Sub-area W, Reach W-V2 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

V2

5, .239, -99 ,Reach 6 Reach V2-AI1 - Route running h'graph downstream

3 , Store running hydrograph

11, .576, -99 ,Reach 27 node 3 Sub-area AC, Reach AC-C1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

11, .511, -99 ,Reach 39 node 4 Sub-area AD, Reach AD-C1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .233, -99 ,Reach 55 node 52 Sub-area D, Reach D-C1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

11, .245, -99 ,Reach 54 node 53 Sub-area C, Reach C-C1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

C1

5, .546, -99 ,Reach 5 Reach C1-AI1 - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .276, -99 ,Reach 45 node 25 Sub-area Y, Reach Y-AI1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

AI1

5, .190, -99 ,Reach 9 Reach AI1-AI2 - Route running h'graph downstream

3 , Store running hydrograph

1, .102, -99 ,Reach 52 node 59 Sub-area AI, Reach AI-AI2 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

AI2

5, .452, -99 ,Reach 53 Reach AI2-S1 - Route running h'graph downstream

3 , Store running hydrograph

1, .549, -99 ,Reach 28 node 24 Sub-area X, Reach X-AF1 - Generate rainfall excess h'graph and route downstream

3 , Store running hydrograph

1, .183, -99 ,Reach 51 node 54 Sub-area AF, Reach AF-AF1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

AF1

5, .334, -99 ,Reach 4 Reach AF1-S1 - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .204, -99 ,Reach 17 node 19 Sub-area AB, Reach AB-S1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .208, -99 ,Reach 42 node 49 Sub-area S, Reach S-S1 - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

S1

5, .852, -99 ,Reach 7 Reach S1-Outlet - Route running h'graph downstream

4 , Add running h'graph to last stored h'graph

3 , Store running hydrograph

1, .439, -99 ,Reach 16 node 1 Sub-area A, Reach A-Outlet - Generate rainfall excess h'graph and route downstream

4 , Add running h'graph to last stored h'graph

7 , PRINT

0

C Sub-area areas in km²

0.21800,	0.18200,	0.21400,	0.17600,	0.29400,
0.18100,	0.20000,	0.21200,	0.18400,	0.20200,
0.16200,	0.16600,	0.16000,	0.18100,	0.27200,
0.24200,	0.20500,	0.15500,	0.15300,	0.20000,
0.17100,	0.18200,	0.21200,	0.19000,	0.13900,
0.13000,	0.15200,	0.10500,	0.09200,	0.12900,
0.12800,	0.12500,	0.14900,	0.13700,	0.12600,
0.17800,	0.31600,			

-99

C Impervious Fraction Data

1 ,

0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,	0.05000,	0.05000,	0.05000,
0.05000,	0.05000,			

-99

Appendix B- Data Hub parameters

Results - ARR Data Hub

[STARTTXT]

Input Data Information

[INPUTDATA]

Latitude,-36.445762

Longitude,146.000289

[END_INPUTDATA]

River Region

[RIVREG]

Division,Murray-Darling Basin

River Number,4

River Name,Broken River

[RIVREG_META]

Time Accessed,12 February 2020 01:37PM

Version,2016_v1

[END_RIVREG]

ARF Parameters

[LONGARF]

Zone,Southern Temperate

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

[LONGARF_META]

Time Accessed,12 February 2020 01:37PM

Version,2016_v1

[END_LONGARF]

Storm Losses
[LOSSES]
ID,19076.0
Storm Initial Losses (mm),25.0
Storm Continuing Losses (mm/h),4.4
[LOSSES_META]
Time Accessed,12 February 2020 01:37PM
Version,2016_v1
[END_LOSSES]

Temporal Patterns
[TP]
code,MB
Label,Murray Basin
[TP_META]
Time Accessed,12 February 2020 01:37PM
Version,2016_v2
[END_TP]

Areal Temporal Patterns
[ATP]
code,MB
arealabel,Murray Basin
[ATP_META]
Time Accessed,12 February 2020 01:37PM
Version,2016_v2
[END_ATP]

Median Preburst Depths and Ratios
[PREBURST]
min (h)\AEP(%),50,20,10,5,2,1
60 (1.0),2.7 (0.141),2.8 (0.103),2.8 (0.088),2.8 (0.076),1.9 (0.043),1.2 (0.024)
90 (1.5),4.2 (0.193),4.0 (0.132),3.9 (0.107),3.7 (0.090),1.8 (0.037),0.4 (0.007)
120 (2.0),5.2 (0.218),5.7 (0.174),6.1 (0.156),6.4 (0.143),2.9 (0.055),0.3 (0.005)
180 (3.0),3.3 (0.125),3.3 (0.089),3.2 (0.074),3.2 (0.063),1.6 (0.027),0.4 (0.006)
360 (6.0),1.4 (0.043),1.5 (0.034),1.6 (0.030),1.6 (0.027),4.2 (0.058),6.1 (0.075)
720 (12.0),0.4 (0.010),1.6 (0.029),2.4 (0.037),3.2 (0.042),5.1 (0.056),6.5 (0.063)
1080 (18.0),0.0 (0.000),0.5 (0.008),0.9 (0.012),1.2 (0.014),2.1 (0.021),2.8 (0.024)

1440 (24.0),0.0 (0.000),0.1 (0.002),0.2 (0.003),0.3 (0.003),0.7 (0.006),0.9 (0.007)

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)

[PREBURST_META]

Time Accessed,12 February 2020 01:37PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST]

10% Preburst Depths

[PREBURST10]

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)

[PREBURST10_META]

Time Accessed,12 February 2020 01:37PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST10]

25% Preburst Depths

[PREBURST25]

min (h)\AEP(%),50,20,10,5,2,1

60 (1.0),0.0 (0.001),0.0 (0.001),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000)

90 (1.5),0.2 (0.011),0.1 (0.004),0.1 (0.002),0.0 (0.000),0.0 (0.000),0.0 (0.000)

120 (2.0),0.0 (0.002),0.0 (0.001),0.0 (0.001),0.0 (0.001),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)

[PREBURST25_META]

Time Accessed,12 February 2020 01:37PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST25]

75% Preburst Depths

[PREBURST75]

min (h)\AEP(%),50,20,10,5,2,1

60 (1.0),17.3 (0.904),17.6 (0.657),17.8 (0.556),18.0 (0.484),15.9 (0.363),14.4 (0.294)

90 (1.5),16.7 (0.769),18.3 (0.607),19.4 (0.539),20.4 (0.490),16.8 (0.343),14.1 (0.258)

120 (2.0),16.6 (0.699),18.3 (0.558),19.4 (0.498),20.5 (0.455),16.7 (0.315),13.8 (0.234)

180 (3.0),13.5 (0.501),14.6 (0.396),15.3 (0.351),16.0 (0.319),16.9 (0.285),17.5 (0.265)

360 (6.0),12.2 (0.367),15.2 (0.338),17.2 (0.324),19.1 (0.312),20.7 (0.286),22.0 (0.270)

720 (12.0),5.6 (0.135),9.6 (0.171),12.2 (0.185),14.7 (0.193),17.8 (0.196),20.1 (0.197)

1080 (18.0),2.4 (0.051),6.7 (0.106),9.5 (0.127),12.3 (0.141),12.3 (0.118),12.3 (0.104)

1440 (24.0),1.2 (0.023),4.0 (0.058),5.9 (0.071),7.7 (0.080),9.3 (0.081),10.5 (0.081)

2160 (36.0),0.0 (0.000),0.8 (0.010),1.3 (0.015),1.9 (0.017),3.7 (0.028),5.0 (0.034)

2880 (48.0),0.0 (0.000),0.3 (0.004),0.6 (0.006),0.8 (0.007),2.2 (0.016),3.3 (0.020)

4320 (72.0),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.0 (0.000),0.3 (0.002),0.6 (0.003)

[PREBURST75_META]

Time Accessed,12 February 2020 01:37PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST75]

90% Preburst Depths

[PREBURST90]

min (h)\AEP(%),50,20,10,5,2,1

60 (1.0),38.6 (2.016),34.8 (1.300),32.3 (1.010),29.9 (0.805),29.3 (0.668),28.9 (0.588)

90 (1.5),31.7 (1.458),36.1 (1.194),39.0 (1.082),41.7 (1.001),34.4 (0.700),28.9 (0.527)

120 (2.0),31.4 (1.324),35.8 (1.092),38.7 (0.993),41.5 (0.921),38.2 (0.720),35.7 (0.603)

180 (3.0),26.4 (0.981),33.0 (0.896),37.3 (0.856),41.5 (0.825),40.8 (0.689),40.3 (0.609)

360 (6.0),23.2 (0.698),29.2 (0.647),33.1 (0.622),36.8 (0.600),40.5 (0.559),43.3 (0.534)

720 (12.0),20.2 (0.488),25.4 (0.456),28.8 (0.438),32.1 (0.423),35.2 (0.388),37.4 (0.366)

1080 (18.0),17.2 (0.365),20.5 (0.324),22.8 (0.304),24.9 (0.287),26.2 (0.252),27.2 (0.231)

1440 (24.0),17.0 (0.330),19.8 (0.286),21.8 (0.265),23.6 (0.248),22.9 (0.200),22.4 (0.172)

2160 (36.0),5.5 (0.095),11.9 (0.153),16.2 (0.174),20.3 (0.188),21.9 (0.168),23.2 (0.155)

2880 (48.0),4.3 (0.068),6.5 (0.077),8.0 (0.080),9.5 (0.081),18.8 (0.132),25.7 (0.158)

4320 (72.0),0.6 (0.009),3.7 (0.039),5.7 (0.051),7.6 (0.058),16.3 (0.103),22.8 (0.126)

[PREBURST90_META]

Time Accessed,12 February 2020 01:37PM

Version,2018_v1

Note,Preburst interpolation methods for catchment wide preburst has been slightly altered. Point values remain unchanged.

[END_PREBURST90]

Interim Climate Change Factors

[CCF]

,RCP 4.5,RCP6,RCP 8.5

2030,0.816 (4.1%),0.726 (3.6%),0.934 (4.7%)

2040,1.046 (5.2%),1.015 (5.1%),1.305 (6.6%)

2050,1.260 (6.3%),1.277 (6.4%),1.737 (8.8%)

2060,1.450 (7.3%),1.520 (7.7%),2.214 (11.4%)

2070,1.609 (8.2%),1.753 (8.9%),2.722 (14.2%)

2080,1.728 (8.8%),1.985 (10.2%),3.246 (17.2%)

2090,1.798 (9.2%),2.226 (11.5%),3.772 (20.2%)

[CCF_META]

Time Accessed,12 February 2020 01:37PM

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.

[END_CCF]

[ENDTXT]

Appendix C- IFD Design Rainfall Depth (mm)

IFD Design Rainfall Depth (mm)

Issued:	12-Feb-20							
Location Label:								
Requested coordinate:	Latitude	-36.446	Longitude	146				
Nearest grid cell:	Latitude	36.4375 (S)	Longitude	146.0125 (E)				

Duration	Duration in min	Annual Exceedance Probability (AEP) 63.20%	50%	20%	10%	5%	2%	1%
1 min	1	1.65	1.89	2.66	3.18	3.69	4.37	4.9
2 min	2	2.79	3.19	4.47	5.34	6.17	7.19	7.95
3 min	3	3.78	4.34	6.07	7.24	8.37	9.78	10.8
4 min	4	4.64	5.32	7.45	8.9	10.3	12.1	13.4
5 min	5	5.4	6.19	8.67	10.4	12	14.1	15.8
10 min	10	8.12	9.32	13.1	15.7	18.2	21.7	24.3
15 min	15	9.91	11.4	16	19.2	22.3	26.6	29.9
20 min	20	11.2	12.9	18.2	21.8	25.4	30.2	33.9
25 min	25	12.3	14.1	19.9	23.8	27.7	33	37
30 min	30	13.2	15.1	21.3	25.5	29.7	35.2	39.6
45 min	45	15.2	17.5	24.5	29.3	34	40.3	45.1
1 hour	60	16.8	19.2	26.8	32	37.1	43.9	49.1
1.5 hour	90	19.1	21.8	30.2	36	41.7	49.1	54.8
2 hour	120	20.9	23.7	32.8	39	45.1	53.1	59.2
3 hour	180	23.7	26.9	36.8	43.6	50.4	59.3	66.1
4.5 hour	270	27	30.4	41.4	48.9	56.4	66.5	74.4
6 hour	360	29.6	33.3	45.1	53.2	61.3	72.5	81.2
9 hour	540	33.8	37.9	51	60.2	69.4	82.4	92.7
12 hour	720	37.1	41.5	55.8	65.9	76.1	90.6	102
18 hour	1080	42.1	47.1	63.4	75	86.8	104	118
24 hour	1440	45.9	51.4	69.3	82.1	95.3	115	130
30 hour	1800	49	54.8	74.1	88	102	123	141
36 hour	2160	51.4	57.7	78.2	93	108	131	149
48 hour	2880	55.4	62.1	84.6	101	118	142	163
72 hour	4320	60.6	68.2	93.1	111	130	157	180
96 hour	5760	64.2	72.1	98.4	117	137	166	190
120 hour	7200	66.8	74.9	102	121	141	170	195
144 hour	8640	68.9	77.1	104	123	142	172	197
168 hour	10080	70.7	78.8	105	123	143	172	198

Appendix D- IFD RESULTS FROM ARR RFFE (https://rffe.arr-software.org/)

RESULTS FROM ARR RFFE 2015 MODEL

Datetime: 2020-02-14 16:27

Region name: East Coast

Region code: 1

Site name: Catchment1

Latitude at catchment outlet (degree) = -36.46999

Longitude at catchment outlet (degree) = 146.00228

Latitude at catchment centroid (degree) = -36.45271

Longitude at catchment centroid (degree) = 146.00726

Distance of the nearest gauged catchment in the database (km) = 16.4

Catchment area (sq km) = 6.7

Design rainfall intensity, 1 in 2 AEP and 6 hr duration (mm/h): 5.443565

Design rainfall intensity, 1 in 50 AEP and 6 hr duration (mm/h): 11.92768

Shape factor of the ungauged catchment: 0.76

ESTIMATED FLOOD QUANTILES:

AEP (%)	Expected quantiles (m^3/s)	5% CL m^3/s	95% CL m^3/s
50	8.12	3.35	19.6
20	14.4	6.20	33.3
10	19.6	8.45	45.3
5	25.2	10.9	58.9
2	33.8	14.3	80.6
1	41.2	17.2	99.5

DATA FOR FITTING MULTI-NORMAL DISTRIBUTION FOR BUILDING CONFIDENCE LIMITS:

1 Mean (loge flow) = 2.145

2 St dev (loge flow) = 0.710

3 Skew (loge flow) = 0.102

Moments and correlations:

No	Most probable	Std dev	Correlation

1	2.145	0.525	1.000		
2	0.710	0.108	-0.330	1.000	
3	0.102	0.028	0.170	-0.280	1.000

This is the end of output file.

Appendix E- GBCMA 1% AEP Flood Level Contour Atlas