Premise

WATER

HYDRAULIC IMPACT ASSESSMENT

FOR WAGGA WAGGA SOLAR FARM SOUTH

Metka ENG

Report No: TER-0001
Document No: 1903277
REV: 01

EXECUTIVE SUMMARY

This Hydraulic Impact Assessment assesses the management of stormwater runoff directly from the proposed Wagga Wagga Solar Farm South (WWSFS) in terms of quantity as well as local flooding of the site and surrounding areas. The assessment undertaken has been in accordance with Australian Rainfall and Runoff 2019 (ARR19).

Hydraulic assessment was undertaken to demonstrate that the proposed solar farm does not cause adverse flood impacts to neighbouring properties. Increased roughness due to the installation of the solar poles over the site and proposed earthworks results in a reduction of peak flow rates from the site for all Average Exceedance Probability (AEP) events. No flood level increase was predicted on the neighbouring properties. Therefore, stormwater quantity/flood mitigation measures are not required.

Table of Contents

1 INTRODUCTION 1
2 SITE CHARACTERISTICS 2
3 PROPOSED DEVELOPMENT 3
4 DATA 4
5 HYDROLOGIC ASSESSMENT 5
5.1 Model Assumptions 6
5.2 Meteorological Data 8
5.3 Rational Method & Regional Flood Frequency Estimation (RFFE) 8
5.4 Hydrologic Assessment Results 8
5.5 Design Storm Event Temporal Pattern Selection 9
6 HYDRAULIC MODELLING 10
6.1 Base Case Model 11
6.1.1 Digital Terrain Model 11
6.1.2 Hydraulic Roughness 11
6.1.3 Hydraulic Boundary Conditions 11
6.2 Post-Development Model 12
6.2.1 Digital Terrain Model 12
6.2.2 Hydraulic Roughness 12
6.2.3 Hydraulic Boundary Conditions 12
6.3 Results 13
7 CONCLUSION 14
8 QUALIFICATIONS 15
9 REFERENCES 16

Figures

Figure 1 – Development Location & Site Extents 1
Figure 2 – Existing Site 1.0m Interval Contours & Drainage Lines 2
Figure 3 – Pre-Development Catchment Plan 5
Figure 4 – Post-Development Catchment Plan 6
Figure 5 – Tuflow Model Layout 10
Figure 6 – Pre-Development Roughness Mapping 11
Figure 7 – Post-Development Roughness Mapping 12

Tables

Table 5.1 – Fraction Impervious for Site Land Uses 6
Table 5.2 – Pre-Development Catchment Parameters 7
Table 5.3 – Post-Development Catchment Parameters 7
Table 5.4 – RFFE & Rational Method Check (Total Catchment) 8
Table 5.5 – WBNM Predicted Peak Flows at Outlet 9
Table 5.6 – Ensemble Temporal Pattern Selection for Hydraulic Modelling 9
Table 6.1 – Predicted Peak Flows Discharging from the Site 13

Appendices

APPENDIX A PROPOSED LAYOUT PLAN
APPENDIX B RATIONAL METHOD & RFFE CALCULATIONS
APPENDIX C PRE-DEVELOPMENT FLOOD MAPPING
APPENDIX D POST-DEVELOPMENT FLOOD MAPPING
APPENDIX E FLOOD IMPACT MAPPING

DOCUMENT AUTHORISATION					
Revision	**Rev. Date**	**Author**	**Reviewer**	**Report Details**	**Authorised By**
					Signature
1	26/11/19	L. Dang	D. Niven	Final For Submission	

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Name	Email Address
Chris Wilson	chris@terrainsolar.com
Jake Steele	Jake@terrainsolar.com
Simon Ingram	simon@terrainsolar.com

1 INTRODUCTION

Premise Australia Pty Ltd (here within referred to as "Premise") has undertaken a Hydraulic Impact Assessment for the Wagga Wagga Solar Farm South (WWSFS) on behalf of Metka ENG. The proposed development consists of construction of solar arrays and associated infrastructure across existing predominately cleared agricultural paddocks.

This Hydraulic Impact Assessment includes an analysis of pre-development site conditions to establish the base runoff characteristics, and quantification of the potential impacts associated with the proposed development. The proposed earthworks and future solar array were included in the models to assess the potential impact from the proposed works on the flooding.

Refer to **Figure 1** for a locality map of the site extents and the proposed extent of the solar farm, with aerial imagery and cadastral overlays included.

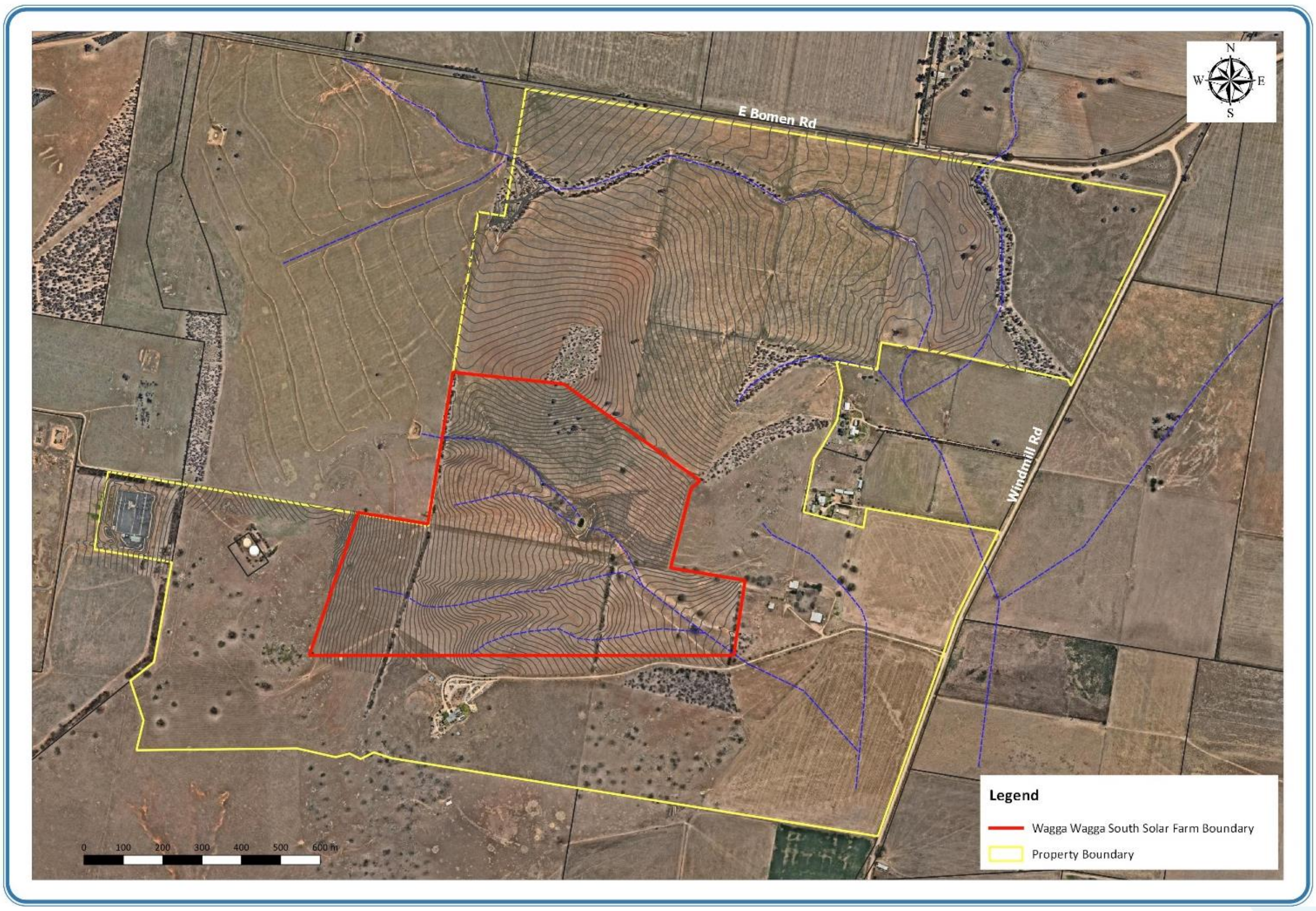


Figure 1 – Development Location & Site Extents

2 SITE CHARACTERISTICS

The subject site is located approximately 7 km north east of the township of Wagga Wagga and encompasses the southern portion of Lot 15 on DP1108978. The total area of the development footprint is approximately 52.5 ha.

A local drainage line traverses the site in a south-easterly direction. The drainage line depicted in **Figure 2** was observed to be dry during a site visit on 7 June 2017. The Wagga Wagga Solar Farm North Preliminary Geotechnical Investigation (August 2017) prepared by Coffey Services Australia Pty Ltd (Coffey), relating to the land immediately to the north of WWSFS, noted landowner observations from the past 10 years that the gully has minimal flow.

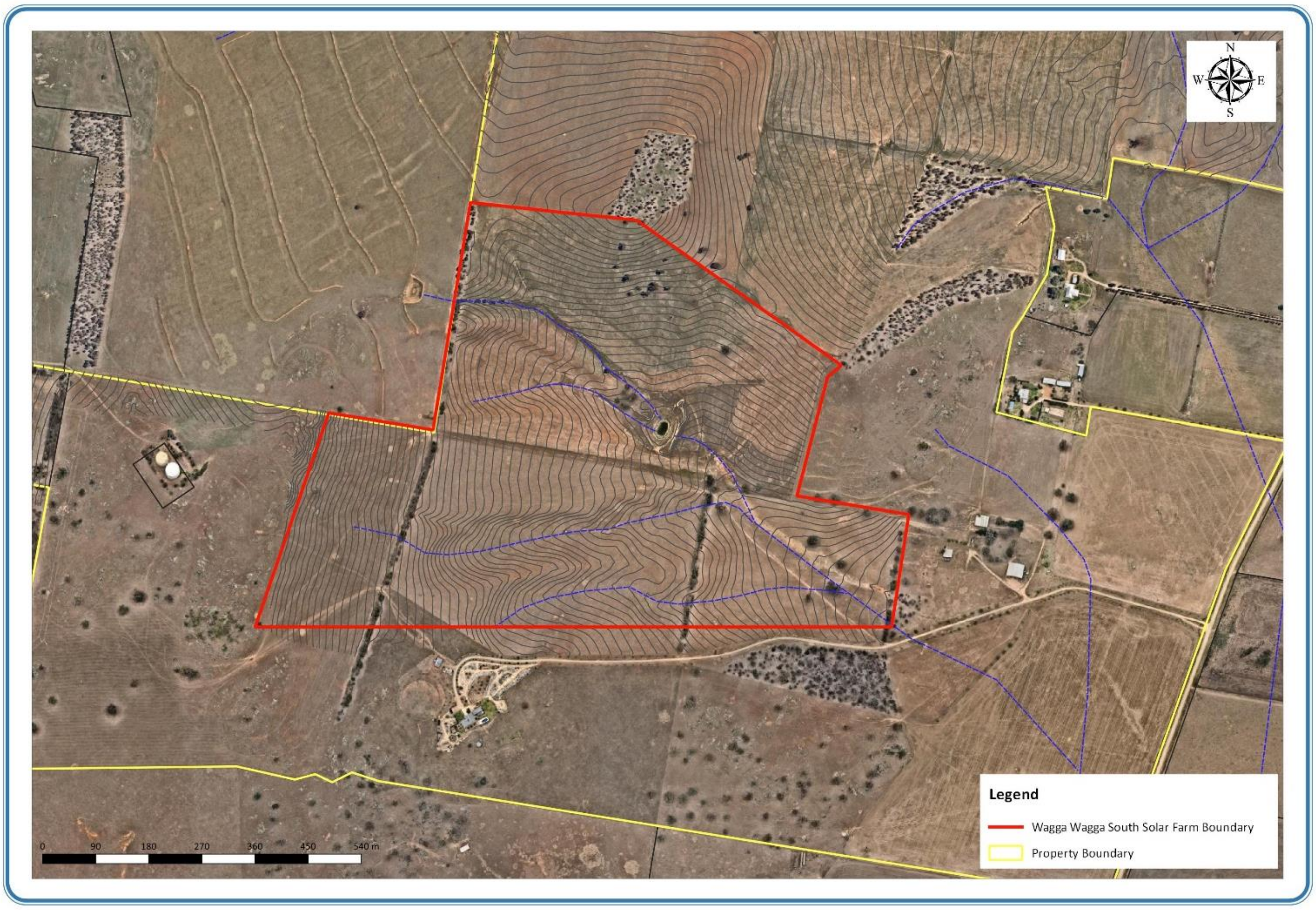


Figure 2 – Existing Site 1.0m Interval Contours & Drainage Lines

Review of the WWCC's *Wagga Wagga Detailed Flood Model Revision - Final Report* (August 2014) and associated mapping confirms that the solar farm footprint is not within the 1% AEP flood inundation area) from Murrumbidgee River. It is noted that the 1% AEP flood inundation does inundate on the eastern portion of the host lot.

3 PROPOSED DEVELOPMENT

It is proposed to install several solar arrays and associated infrastructure across the existing predominately cleared agricultural property. The ground cover beneath the trackers will be vegetated and ground works will be minimised.

The proposed development layout is shown in **Appendix A** of this report.

4 DATA

In the preparation of this report, information about the site was gathered from the following sources:

- Detailed survey provided by Terrain Solar;
- Aerial LiDAR sourced from Geosciences Australia;
- Proposed site layout provided by Metka Eng Pty Ltd;
- Rainfall and meteorological data by the Australian Bureau of Meteorology; and
- Aerial imagery by Nearmap (accessed in March 2019).

5 HYDROLOGIC ASSESSMENT

Hydrologic modelling was undertaken using the WBNM runoff-routing software to provide a preliminary estimate of the peak discharges from the proposed solar farm, and to determine the critical duration and ensemble pattern to be adopted for the more detailed hydraulic model (refer **Section 6**).

The hydrologic assessment was undertaken in accordance with *Australian Rainfall and Runoff 2019* (ARR19). An ensemble of 10 temporal patterns for each ARI/duration combination was considered in accordance with the procedures and methods stated in ARR19.

The hydrologic model was simulated for a full range of Average Reoccurrence Probabilities (AEPs) (39% AEP to 1% AEP) for a range of durations between 10 minutes to 16 hours.

The total catchment and sub-catchment extents were determined from the aerial LiDAR data sourced from Geosciences Australia and the detailed site survey. The sub-catchment boundaries are shown in **Figure 3** and **Figure 4**.

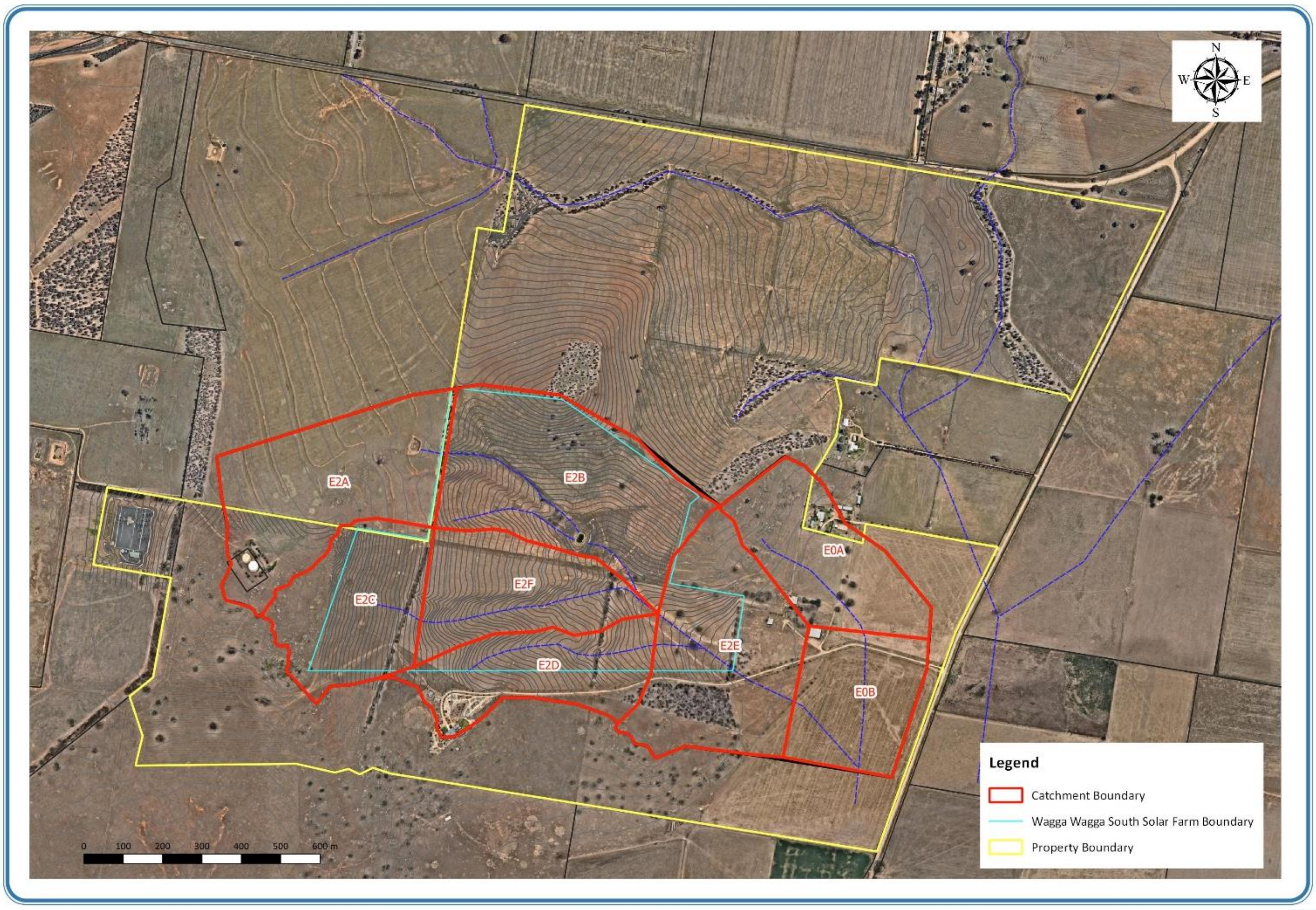


Figure 3 – Pre-Development Catchment Plan

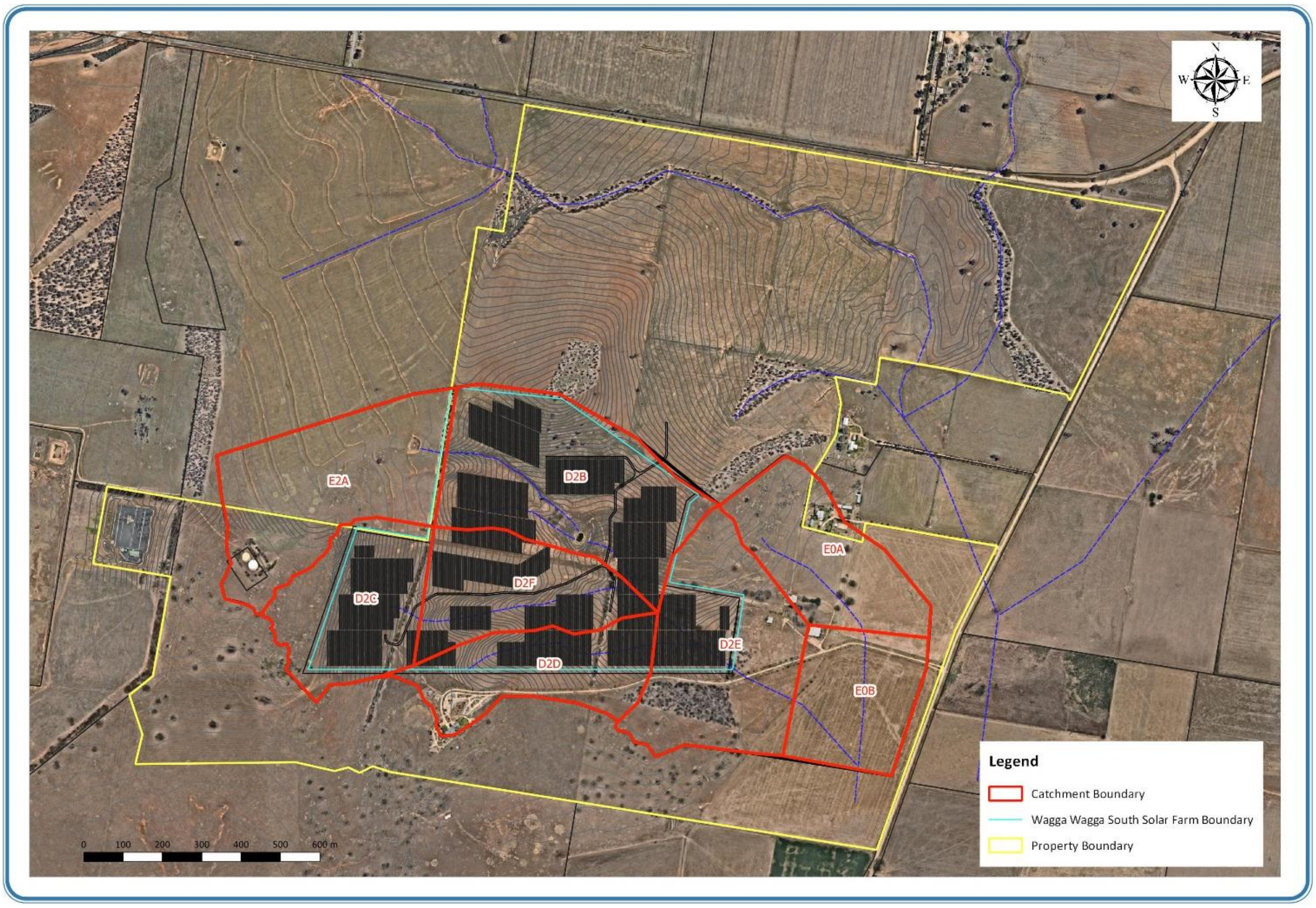


Figure 4 – Post-Development Catchment Plan

5.1 Model Assumptions

Based on the storm initial loss and pre-burst depth obtained from ARR online Data Hub, a constant burst initial loss (IL) value of 22 mm was adopted. The continuing loss (CL) value for the pervious portions of the catchment was obtained from the ARR online Data Hub as 4.6 mm/hr. The adopted stream and catchment lag parameters are 0.1 and 1.6 respectively for all catchments. The adopted fraction imperviousness for each land use are listed in **Table 5.1**.

Table 5.1 – Fraction Impervious for Site Land Uses

Catchment	Fraction Impervious
Road (External)	100%
Internal Access Road (unsealed gravel)	50%
Open Space	0%
Proposed Solar Arrays	0%
Inverter Station	100%

Although solar arrays are proposed for the majority of the site, the area covered by the proposed solar panels is not considered as impermeable as the ground underneath the solar panels will remain as grass.

Solar panels are 100% impermeable and are designed in the way that they can angle towards the sun. This allows stormwater to drain freely off the solar panels onto the underlaying ground which remains permeable.

A study by Cook and McCuen (2013), *Hydrologic Response of Solar Farms*, concluded that providing the underlying ground remains permeable, the solar panels do not have a significant effect on the surface runoff volumes, peak flows, or time to peak. The findings were based on numerical modelling but have not been verified by field measurements.

A summary of the pre- and post-development catchment parameters is contained in **Table 5.2** and **Table 5.3**. Minor increase in fraction imperviousness was predicted for the south solar farm due to the proposed internal access road and inverter stations.

Table 5.2 – Pre-Development Catchment Parameters

Catchment	Area (ha)	Fraction Impervious
E2A	19.35	0.50%
E2B	22.54	0.50%
E2C	13.29	0.50%
E2D	11.58	0.50%
E2E	19.22	0.50%
E2F	12.51	0.50%
E0A	12.58	0.50%
E0B	10.55	0.50%
Total Catchment	121.61	0.50%

Table 5.3 – Post-Development Catchment Parameters

Catchment	Area (ha)	Fraction Impervious
E2A	19.35	0.50%
D2B	22.54	1.00%
D2C	13.29	1.00%
D2D	11.58	1.00%
D2E	19.22	1.00%
D2F	12.51	1.00%
E0A	12.58	0.50%
E0B	10.55	0.50%
Total Catchment	121.61	0.83%

5.2 Meteorological Data

Intensity-Frequency-Duration (IFD) data for the site has been derived in accordance with ARR19 and via Bureau of Meteorology's (BOM's) Rainfall IFD Data System. The rainfall intensities generated for the site have been derived from the co-ordinates: [-35.0767 and 147.4351]. The net rainfall depths (IFD data) have been used in conjunction with the dimensionless Murray Basin temporal patterns, as prescribed by ARR19, in the detailed hydrologic analysis.

5.3 Rational Method & Regional Flood Frequency Estimation (RFFE)

The peak discharges at the downstream end of the hydrologic model for all events have been compared against those obtained from the Rational Method and the RFFE calculations as a comparison that the model is providing reasonable results. The results of this comparison are provided in **Table 5.4** and demonstrate that the hydrologic model is providing results within an acceptable range of the Rational Method and RFFE calculations and is therefore considered appropriate for use in this analysis.

Table 5.4 – RFFE & Rational Method Check (Total Catchment)

AEP	Pre-Development WBNM Peak Flow Rate (m^3/s)	RFFE	Rational Method Peak Flow Rate (m^3/s)
1%	7.60	5.49	4.97
2%	6.02	4.38	4.05
5%	4.53	3.12	2.81
10%	2.98	2.32	2.01
18%	2.12	-	1.24
39%	0.85	-	0.49

Refer to **Appendix B** for the Rational Method and RFFE calculations.

5.4 Hydrologic Assessment Results

As shown in **Table 5.5**, negligible change in peak flow rates was predicted from the hydrologic assessment was predicted due to the associated increase in impervious areas from the development. A detailed hydraulic assessment was undertaken to consider the impacts from these minor changes in the hydrologic flows, that also takes into account for the increased roughness associated with the proposed solar farm. Based on the detailed hydraulic assessment, a reduction of peak flow rates from the site was predicted. Details of the hydraulic assessment are summarised in **Section 6**.

Table 5.5 – WBNM Predicted Peak Flows at Outlet

AEP	WBNM Predicted Peak Flows				
	Pre-Development		Post-Development		Impact (m^3/s)
	Peak Flow Rate (m^3/s)	Critical Duration/ Ensemble No.	Peak Flow Rate (m^3/s)	Critical Duration/ Ensemble No.	
1%	7.60	90min/Storm 3794	7.62	90min/Storm 3794	0.02
2%	6.02	90min/Storm 3907	6.04	90min/Storm 3907	0.02
5%	4.53	120min/Storm 3913	4.54	120min/Storm 3944	0.01
10%	2.98	120min/Storm 3944	3.00	120min/Storm 3944	0.02
18%	2.12	180min/Storm 3983	2.14	180min/Storm 3983	0.02
39%	0.85	180min/Storm 3979	0.86	180min/Storm 3979	0.01

5.5 Design Storm Event Temporal Pattern Selection

ARR19 requires simulation of a large volume of storm to determine the critical duration and the temporal patterns that led to the critical cases. Given the simulation times of numerical modelling, it becomes unpractical to run the complete suite of ensemble design storms for all events through 2D domain. The hydrologic model was used to determine the critical duration and temporal pattern to be adopted for the detailed hydraulic assessment.

The temporal pattern that produced the mean peak flow rates are summarised in **Table 5.6** below.

Table 5.6 – Ensemble Temporal Pattern Selection for Hydraulic Modelling

AEP	Critical Duration/ Ensemble Number
1%	90min/Storm 3794
2%	90min/Storm 3907
5%	120min/Storm 3913 and 120min/Storm 3944
10%	120min/Storm 3944
18%	180min/Storm 3983
39%	180min/Storm 3979

6 HYDRAULIC MODELLING

The hydraulic assessment was undertaken to demonstrate the potential impact from the changes in the hydrology noted in Section 5, the influence of the solar infrastructure on the roughness and the changes in the topography. Hydraulic modelling using inflow source points was applied over the subject site and its surrounding areas. The general model layout is shown in **Figure 5.**

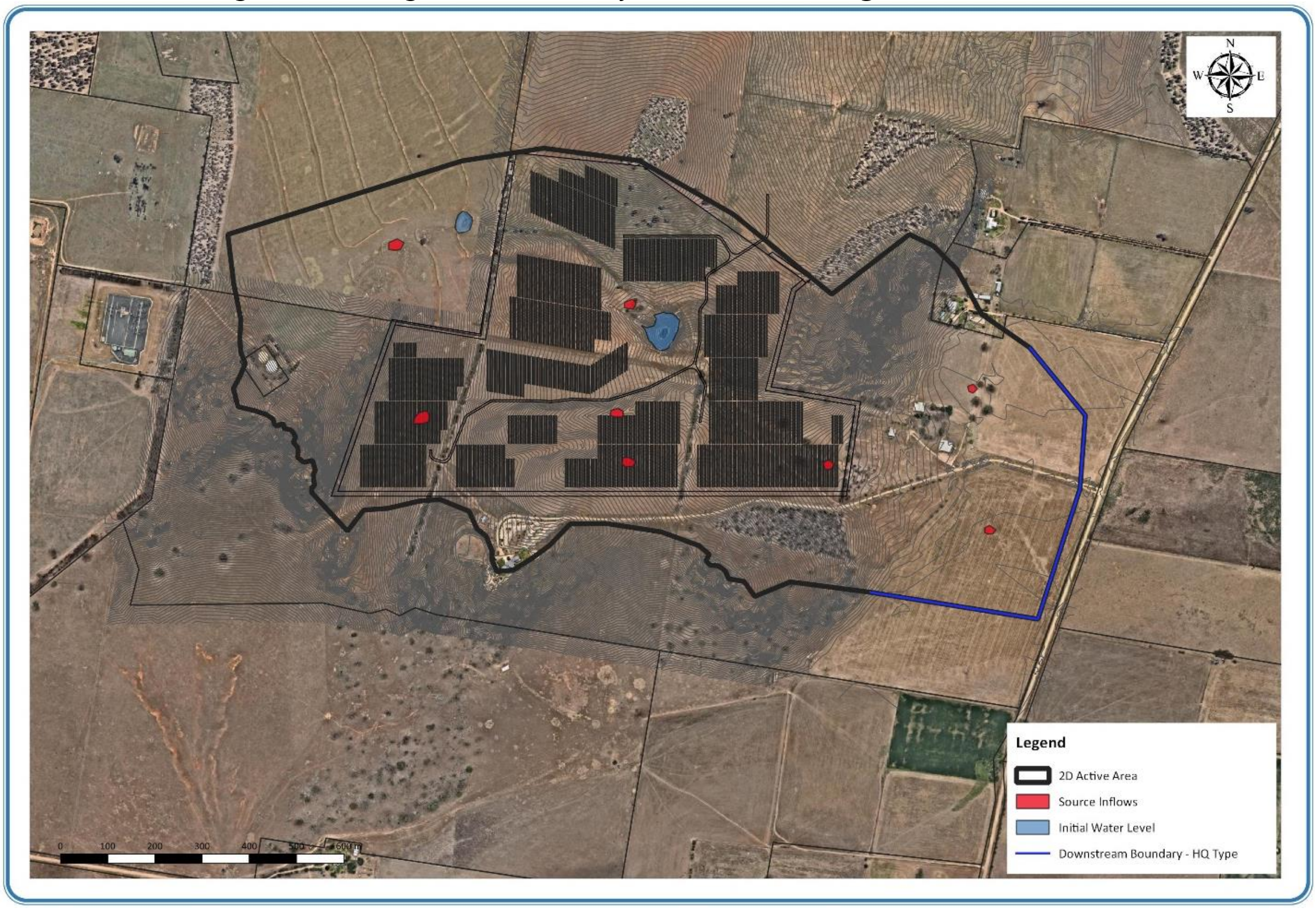


Figure 5 – Tuflow Model Layout

The solar panels are installed on trackers that automatically track the position of the sun in the sky and each tracker post is directly driven into the ground. In general, construction of the solar farm occurs with little disturbance to the earth surface, details of the proposed earthworks for the solar farm has been prepare by Premise and is included in **Appendix A**. This indicates earthworks are generally limited to around 1m of cut or fill.

A study by Cook and McCuen (2013), *Hydrologic Response of Solar Farms*, concluded that providing the underlying groundcover remains permeable, the solar panels do not have a significant effect on the surface runoff volumes, peak flows, or time to peak. The findings were based on numerical modelling but have not been verified by field measurements. The influencing change is therefore the roughness (Manning's n) change from pre-development to post-development with the introduction of approximately 1 tracker post per 30 m^2. To assess the impacts of the proposed solar farm, the proposed solar arrays were represented by an area with higher hydraulic roughness. A Manning's 'n' roughness value of 0.08 was adopted for the proposed solar panel area.

6.1 Base Case Model

6.1.1 Digital Terrain Model

A Digital Terrain Model (DTM) was created for the study area using detailed site survey. A 2D grid resolution of 1m has been adopted.

6.1.2 Hydraulic Roughness

Manning's 'n' roughness values were applied across the 2D grid based on land use. The study area was delineated based on the following land uses:

- Agricultural land n = 0.03
- Buildings
  - Shallow flows (≤0.1 m) n = 0.01
  - Deeper flows (>0.1 m) n = 0.3
- Waterbody n = 0.03

Hydraulic roughness map of the 2D model domain is shown on **Figure 6** for the pre-development scenario.

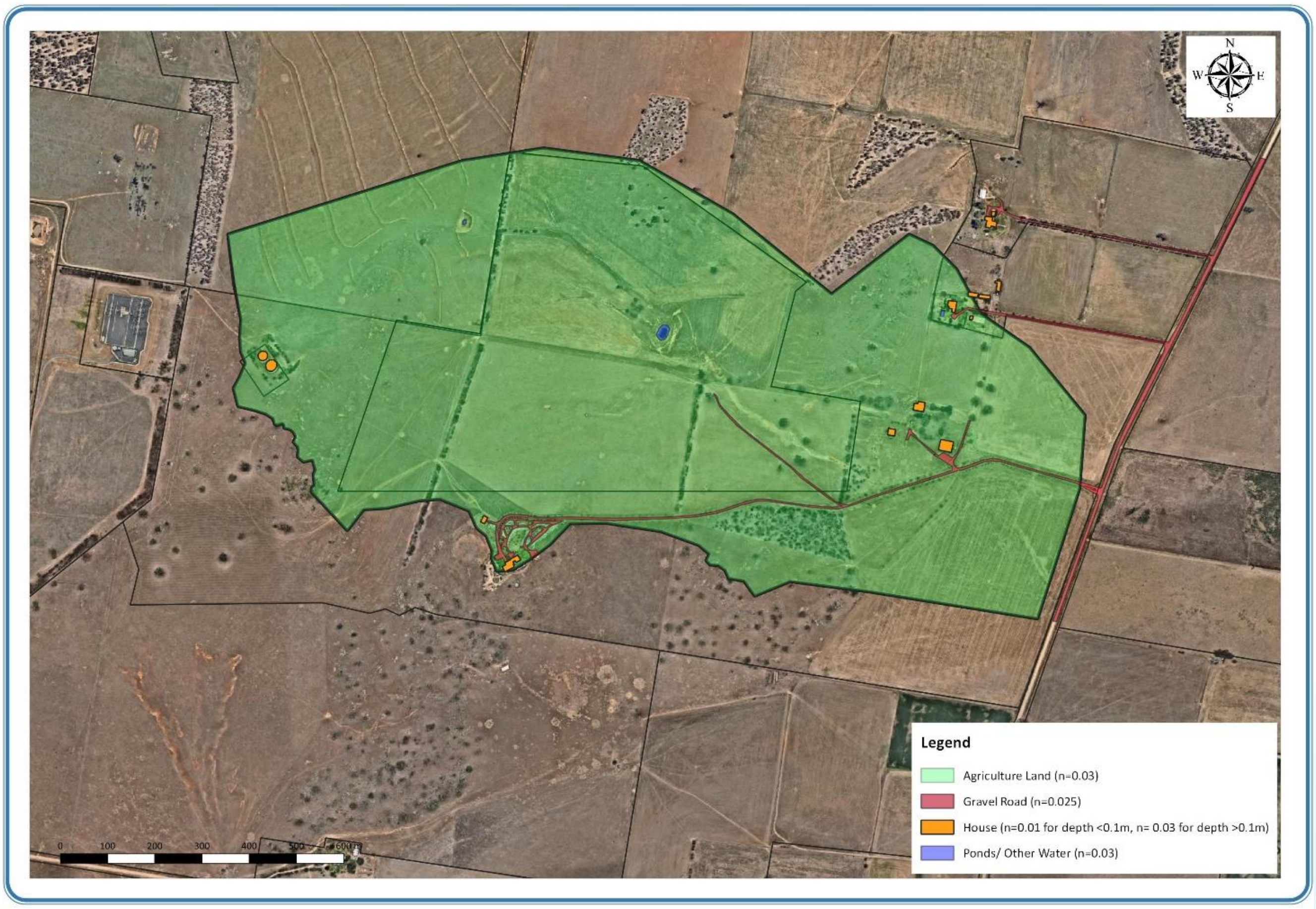


Figure 6 – Pre-Development Roughness Mapping

6.1.3 Hydraulic Boundary Conditions

TUFLOW's automatic HQ boundary condition (i.e. normal flow condition) was applied at the downstream boundary of the hydraulic model. The local catchment inflows from **Section 5** were input into the model within each sub-catchment.

6.2 Post-Development Model

6.2.1 Digital Terrain Model

The DTM created for the base case model was updated for the proposed earthworks for post-development scenario as completed by Premise.

6.2.2 Hydraulic Roughness

Manning's roughness values as detailed in **Section 6.1.2** were adopted for the post-development scenario. Manning's 'n' roughness values for the proposed solar arrays, internal access roads, and vegetation buffer are summarised below:

- Internal road n = 0.025
- Solar panel area n = 0.08
- Vegetation Buffer n = 0.045

Hydraulic roughness map of the 2D model domain is shown on **Figure 7** for the post-development scenario.

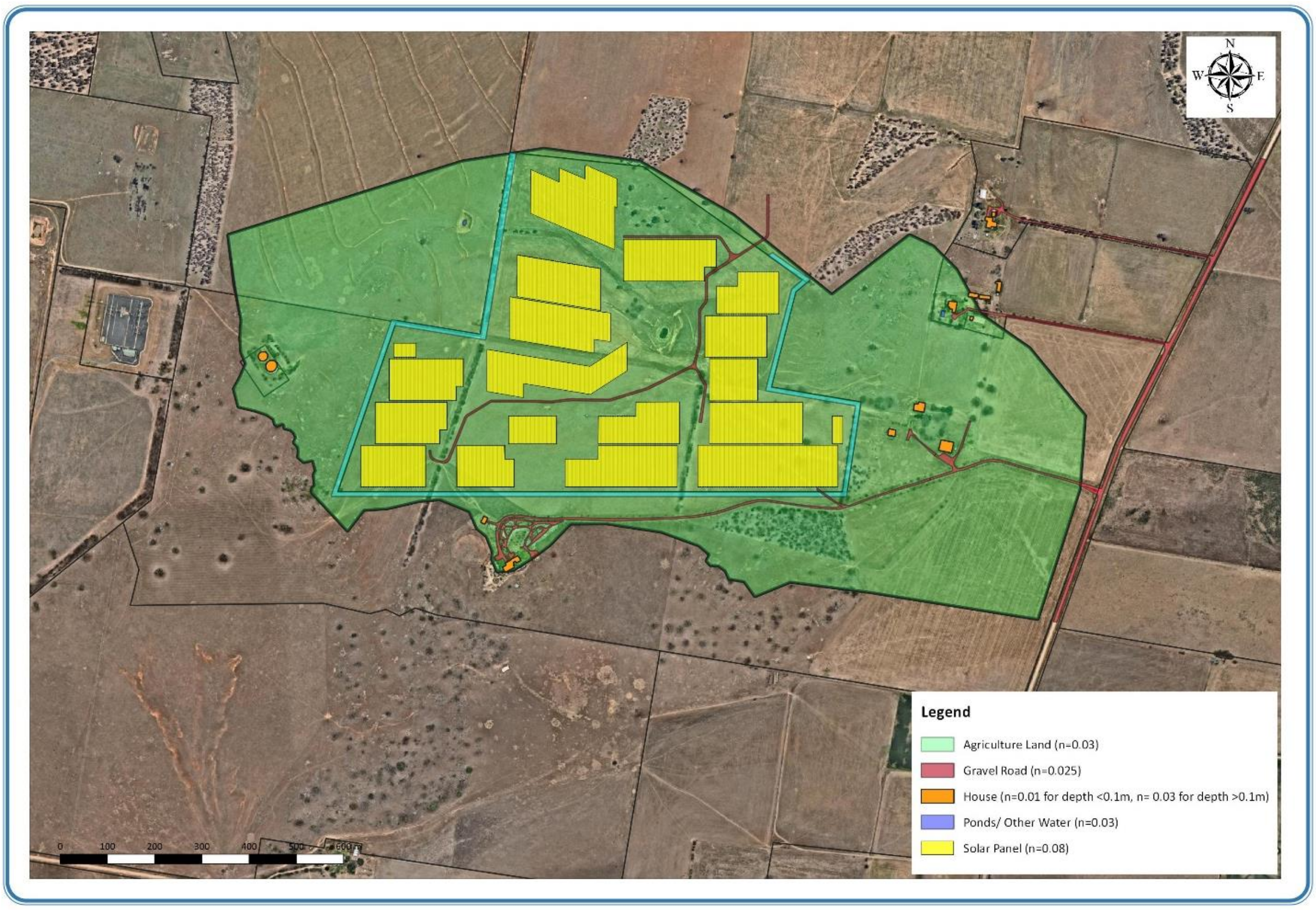


Figure 7 – Post-Development Roughness Mapping

6.2.3 Hydraulic Boundary Conditions

No modifications were made to the hydraulic boundary conditions adopted for the base case model as these are not impacted by the proposed development. The inflows from the post-case hydrologic modelling detailed in **Section 5** were included in the model.

6.3 Results

The predicted peak flows discharging from the site for the pre-development and post-development scenarios are presented in **Table 6.1** below.

Table 6.1 – Predicted Peak Flows Discharging from the Site

AEP	Pre-Development Peak Flow Rate (m^3/s)	Post-Development Peak Flow Rate (m^3/s)	Impact (m^3/s)
1%	7.96	7.89	-0.07
2%	6.24	6.12	-0.12
5%	4.00	3.77	-0.23
10%	2.48	2.18	-0.30
18%	1.96	0.94	-1.02
39%	1.96	0.29	-1.67

Higher Manning's 'n' values caused by the installation of tracker posts over the site and negligible change to impervious areas result in slightly lower post-development flows from the site than pre-development flows. Therefore, stormwater quantity mitigation measures are not required.

2D Flood mapping has been conducted for peak flood level, velocity, depth and flood level impact across the range of ARI events for both the pre and post development scenarios. Refer to:

- **Appendix C** for pre-development flood maps;
- **Appendix D** for post development flood maps; and
- **Appendix E** for flood level impact flood maps.

As shown in the flood level impact maps, the proposed solar farm development is predicted to slightly change the behaviour of the flooding across the site. This has reduced the flooding near the existing farm buildings and caused slight impacts in the paddocks south of the proposed works. These impacts are contained within the property and does not cause actionable nuisance to surrounding premises and infrastructure.

7 CONCLUSION

This Hydraulic Impact Assessment includes an analysis of pre-development site conditions to establish the base flood characteristics, and quantification of the potential impacts associated with the proposed development. Hydraulic assessment was undertaken to demonstrate that the proposed solar farm does not cause adverse flood impacts to neighbouring properties and infrastructure. Increased roughness due to the installation of tracker posts over the site and changes in the topography results in a reduction of peak flow rates from the site for all AEP events. No flood level increase was predicted on the neighbouring properties and infrastructure. Therefore, stormwater quantity/flood mitigation measures are not required.

8 QUALIFICATIONS

Our analysis and overall approach have been specifically catered for the requirements of Metka ENG and may not be applicable beyond this scope. For this reason, any other third parties are not authorised to utilise this report without further input and advice from Premise.

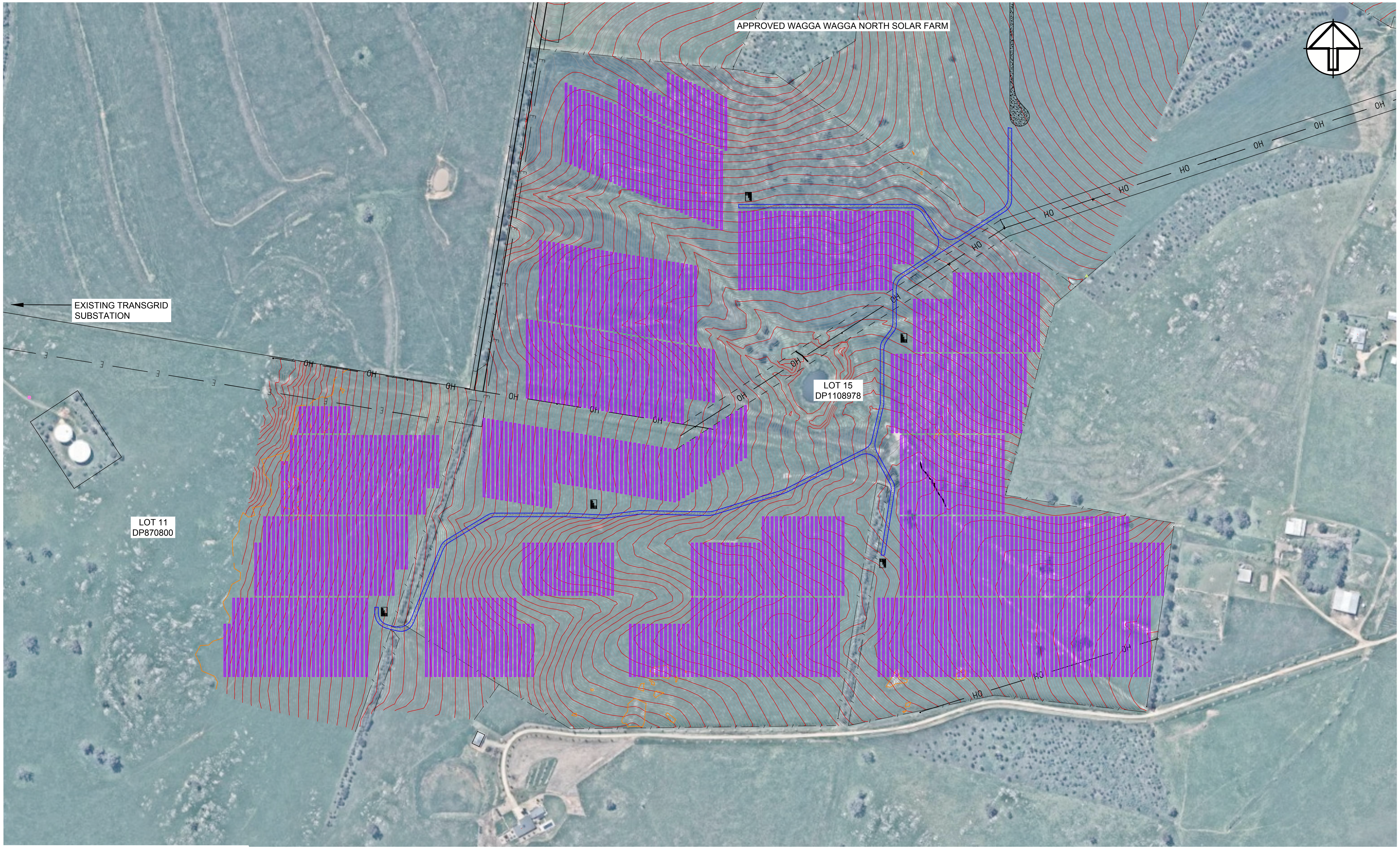
Premise has relied on the following information as outlined in the **Section 4** of this Report**.**

While Premise's report accurately assesses peak flows from design storms in accordance with current industry standards and guidelines, the site is in an ungauged catchment consequently future observed flows may vary from that predicted. For these reasons appropriate freeboards should be adopted.

9 REFERENCES

1. Wagga Wagga City Council, 2014. Wagga Wagga Detailed Flood Model Revision - Final Report.
2. Wagga Wagga City Council, 2010 Development Control Plan
3. Wagga Wagga City Council, 2010 Environmental Plan
4. Geolyse, November 2017, Statement of Environmental Effects Wagga Wagga Solar Farm
5. Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia (Geoscience Australia), 2016, Canberra.
6. Bureau of Meteorology, *2016 IFDs – Rainfall Data.* Available at: http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016
7. Cook, L. M. and R. H. McCuen. 2013. "Hydrologic Response of Solar Farms." *Journal of Hydrologic Engineering* 18:536–41

APPENDIX A PROPOSED LAYOUT PLAN



STRUCTURAL, CIVIL, PLANNING, SURVEYING, ARCHITECTURE & ENVIRONMENTAL

154 PEISLEY STREET
P.O. BOX 1963
ORANGE, NSW 2800
Ph. (02) 6393 5000
Fx. (02) 6393 5050
www.premise.com.au

Premise

REV.	DATE	DFTD.	APPD.	DETAILS
A	30/10/19	GT	DW	ISSUE FOR REVIEW

DRAWING SCALE

0 50 100 150 200

APPROXIMATE SCALE

DO NOT SCALE FROM THESE DRAWINGS. ALL MEASUREMENTS SHALL BE CONFIRMED ON SITE AND WITH GEOLYSE PTY. LTD. PRIOR TO CONSTRUCTION

APPROVAL AUTHORITIES

Wagga Wagga City Council

NSW GOVERNMENT Southern Joint Regional Planning Panel

CLIENT

METKA

PROJECT

WAGGA WAGGA SOLAR FARM

DRAWING

WAGGA WAGGA SOUTH SOLAR FARM
SITE CONCEPT LAYOUT

PROJECT NUMBER 217452 | DRAWING FILE 217452_02A_TP01.dwg | ORIGINAL A3

DATA SOURCE -

IMAGE SOURCE - | SET 02

STATUS FOR APPROVAL | SHEET TP01 OF TP01

NOTES:

1. THIS CONCEPT PLAN IS PREPARED FROM A FIELD SURVEY FOR THE PURPOSE OF DESIGNING NEW CONSTRUCTIONS ON THE LAND. UNDER NO CIRCUMSTANCES SHALL THIS PLAN BE USED FOR CONSTRUCTION.
2. CONTOUR INTERVAL 0.25m.

LEGEND:

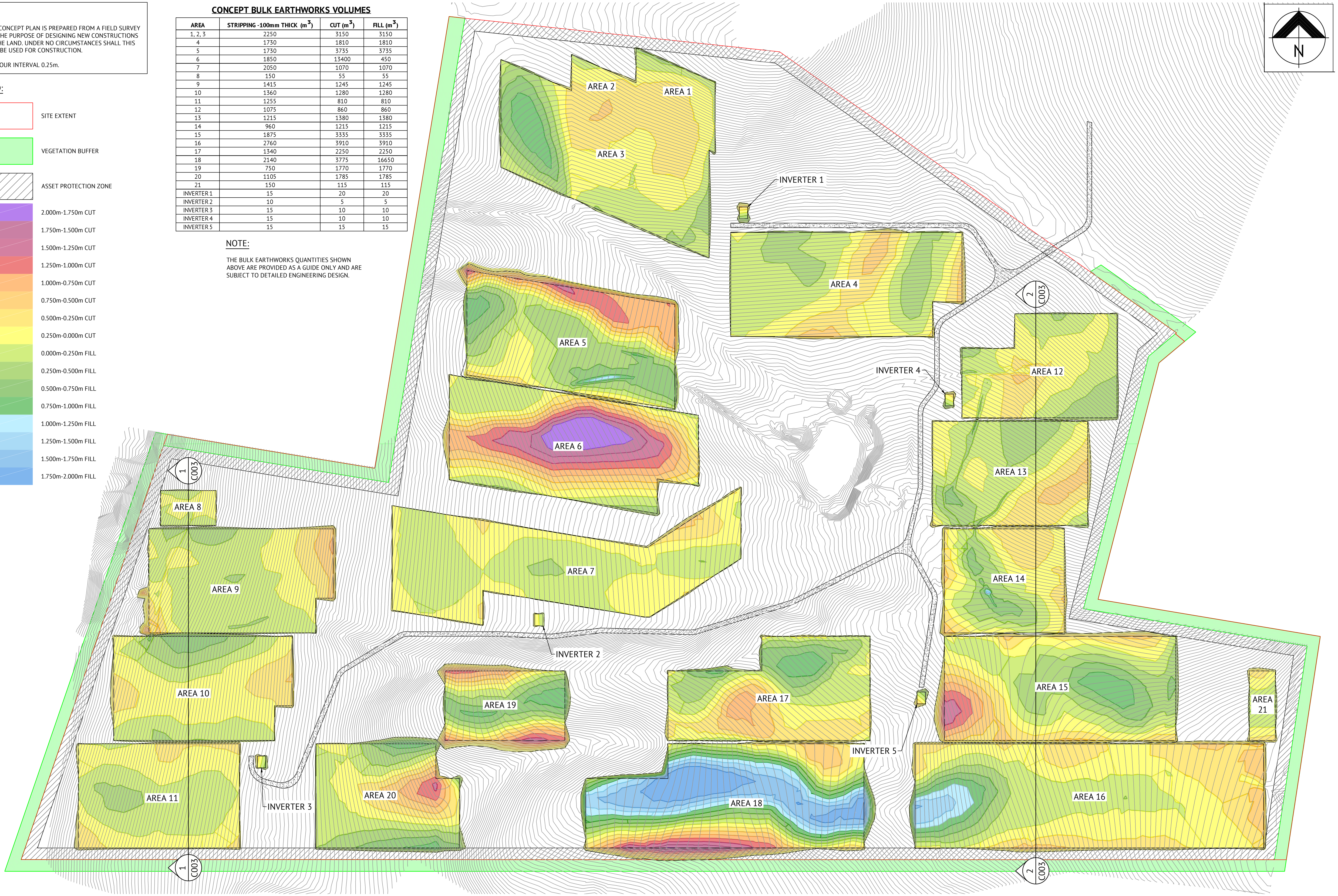
- SITE EXTENT
- VEGETATION BUFFER
- ASSET PROTECTION ZONE
- 2.000m-1.750m CUT
- 1.750m-1.500m CUT
- 1.500m-1.250m CUT
- 1.250m-1.000m CUT
- 1.000m-0.750m CUT
- 0.750m-0.500m CUT
- 0.500m-0.250m CUT
- 0.250m-0.000m CUT
- 0.000m-0.250m FILL
- 0.250m-0.500m FILL
- 0.500m-0.750m FILL
- 0.750m-1.000m FILL
- 1.000m-1.250m FILL
- 1.250m-1.500m FILL
- 1.500m-1.750m FILL
- 1.750m-2.000m FILL

CONCEPT BULK EARTHWORKS VOLUMES

AREA	STRIPPING -100mm THICK (m^3)	CUT (m^3)	FILL (m^3)
1, 2, 3	2250	3150	3150
4	1730	1810	1810
5	1730	3735	3735
6	1850	13400	450
7	2050	1070	1070
8	150	55	55
9	1415	1245	1245
10	1360	1280	1280
11	1255	810	810
12	1075	860	860
13	1215	1380	1380
14	960	1215	1215
15	1875	3335	3335
16	2760	3910	3910
17	1340	2250	2250
18	2140	3775	16650
19	750	1770	1770
20	1105	1785	1785
21	150	115	115
INVERTER 1	15	20	20
INVERTER 2	10	5	5
INVERTER 3	15	10	10
INVERTER 4	15	10	10
INVERTER 5	15	15	15

NOTE:

THE BULK EARTHWORKS QUANTITIES SHOWN ABOVE ARE PROVIDED AS A GUIDE ONLY AND ARE SUBJECT TO DETAILED ENGINEERING DESIGN.



CONCEPT PLAN - ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
06/11/2019	A	CONCEPT PLAN - ISSUED FOR REVIEW	AJD	DW

REVISIONS

Premise

ORANGE OFFICE
154 PEISLEY STREET
ORANGE, NSW 2800
PH: (02) 6393 5000
WEB: www.premise.com.au

DESIGNED: AJD
CHECKED: DW
PROJECT MANAGER: DW
ENGINEERING CERTIFICATION

SCALE: 0 30 60 90m
SCALE 1:1500 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: TERRAIN SOLAR
PROJECT: WAGGA NORTH SOLAR FARM - STAGE 2
LOCATION: WAGGA, NEW SOUTH WALES
SHEET TITLE: CONCEPT BULK EARTHWORKS PLAN

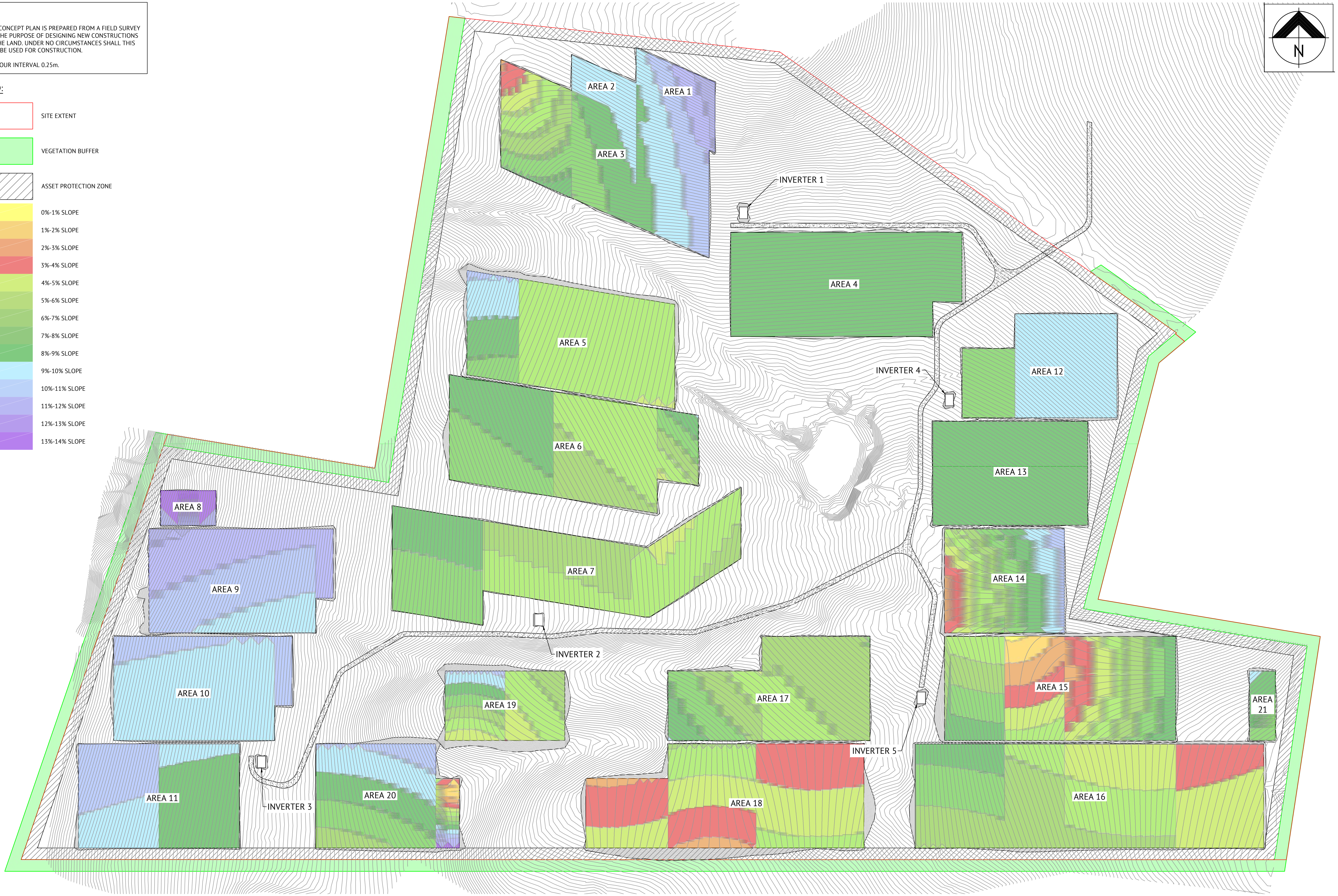
JOB CODE: 217452_03
SHEET NUMBER: C001
REV: A

NOTES:

1. THIS CONCEPT PLAN IS PREPARED FROM A FIELD SURVEY FOR THE PURPOSE OF DESIGNING NEW CONSTRUCTIONS ON THE LAND. UNDER NO CIRCUMSTANCES SHALL THIS PLAN BE USED FOR CONSTRUCTION.
2. CONTOUR INTERVAL 0.25m.

LEGEND:

- SITE EXTENT
- VEGETATION BUFFER
- ASSET PROTECTION ZONE
- 0%-1% SLOPE
- 1%-2% SLOPE
- 2%-3% SLOPE
- 3%-4% SLOPE
- 4%-5% SLOPE
- 5%-6% SLOPE
- 6%-7% SLOPE
- 7%-8% SLOPE
- 8%-9% SLOPE
- 9%-10% SLOPE
- 10%-11% SLOPE
- 11%-12% SLOPE
- 12%-13% SLOPE
- 13%-14% SLOPE



CONCEPT PLAN - ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
06/11/2019	A	CONCEPT PLAN - ISSUED FOR REVIEW	AJD	DW

REVISIONS

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154 PEISLEY STREET
ORANGE, NSW 2800
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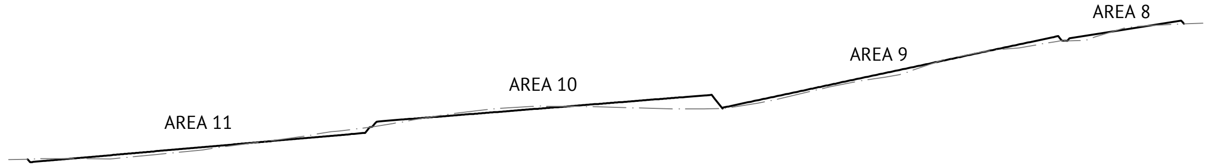
WEB: www.premise.com.au

DESIGNED: AJD
CHECKED: DW
PROJECT MANAGER: DW
ENGINEERING CERTIFICATION

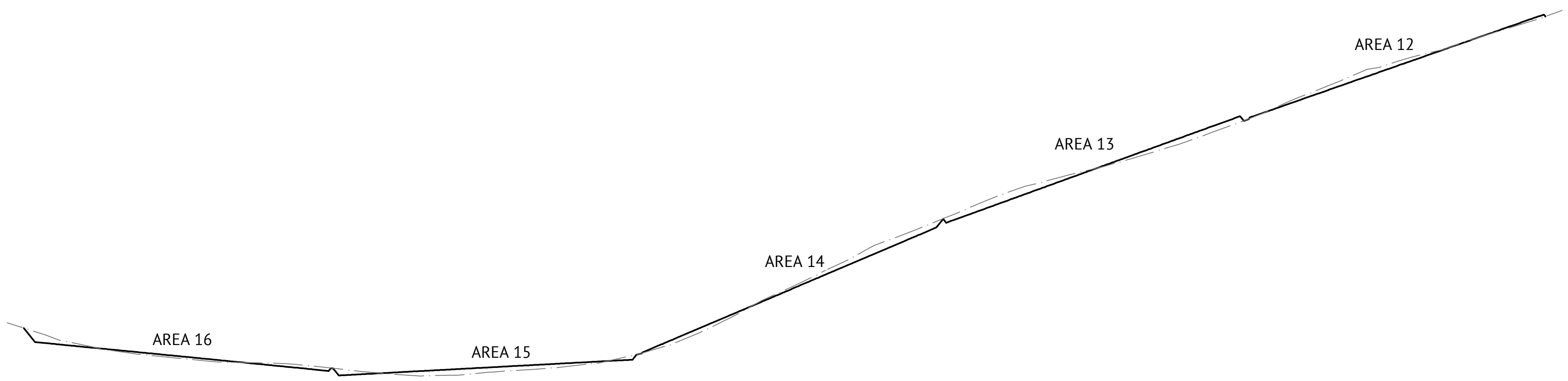
SCALE
0 30 60 90m
SCALE 1:1500 (A1)
ORIGINAL SHEET SIZE A1

CLIENT: TERRAIN SOLAR
PROJECT: WAGGA NORTH SOLAR FARM - STAGE 2
LOCATION: WAGGA, NEW SOUTH WALES
SHEET TITLE: CONCEPT SLOPE ANALYSIS PLAN

JOB CODE: 217452_03
SHEET NUMBER: C002
REV: A



TYPICAL SECTION 1 / C001
HORIZONTAL SCALE 1:1000 (A1)
VERTICAL SCALE 1:200 (A1)



TYPICAL SECTION 2 / C001
HORIZONTAL SCALE 1:1000 (A1)
VERTICAL SCALE 1:200 (A1)

LEGEND:

NATURAL SURFACE

DESIGN SURFACE

CONCEPT PLAN - ISSUED FOR REVIEW

DATE	REV	DESCRIPTION	REC	APP
06/11/2019	A	CONCEPT PLAN - ISSUED FOR REVIEW	AJD	DW

REVISIONS

Premise

ORANGE OFFICE
154 PEISLEY STREET
ORANGE, NSW 2800
PH: (02) 6393 5000
WEB: www.premise.com.au

DESIGNED: AJD
CHECKED: DW
PROJECT MANAGER: DW
ENGINEERING CERTIFICATION

SCALE: AS SHOWN
ORIGINAL SHEET SIZE A1

CLIENT: TERRAIN SOLAR
PROJECT: WAGGA NORTH SOLAR FARM - STAGE 2
LOCATION: WAGGA, NEW SOUTH WALES
SHEET TITLE: TYPICAL SECTIONS

JOB CODE: 217452_03
SHEET NUMBER: C003
REV: A

APPENDIX B RATIONAL METHOD & RFFE CALCULATIONS

Catchment Input Details

Existing Development

Catchment	Total Catchment							
Area (ha)	121.606							
Fraction Imp. (%)	0.500							
$^{1}I_{10}$	34							
Time of Concentration (mins)	49.1							

A (km2), tc (hr) tc=0.76A^0.38

CO-EFFICIENT OF RUNOFF (C_{10})

Premise ENGINEERING

Job No:	TER-0001	Designer	LD
Date:	23.07.2019	Reviewer	DN

10 year, 1 hour rainfall intensity (mm/hr)	34

Note: Input data into green cells, all other cells are calculated automatically

PRE DEVELOPMENT COEFFICIENT OF RUNOFF

Catchment Name	Impervious %	ARI						
		1	2	5	10	20	50	100
Total Catchment	0.50	0.00	0.06	0.11	**0.15**	0.18	0.22	0.24

References

Table of Frequency Factors

ARI	1	2	5	10	20	50	100
Frequency Factor		0.37	0.73	1.00	1.20	1.45	1.58

RATIONAL METHOD SUMMARY

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ENGINEERING

Job Number	TER-0001
Date	23.07.2019
Designer	LD
Reviewer	DN

Pre-Development Scenario

Catchment	Total Catchment								
Area (ha)	121.61								

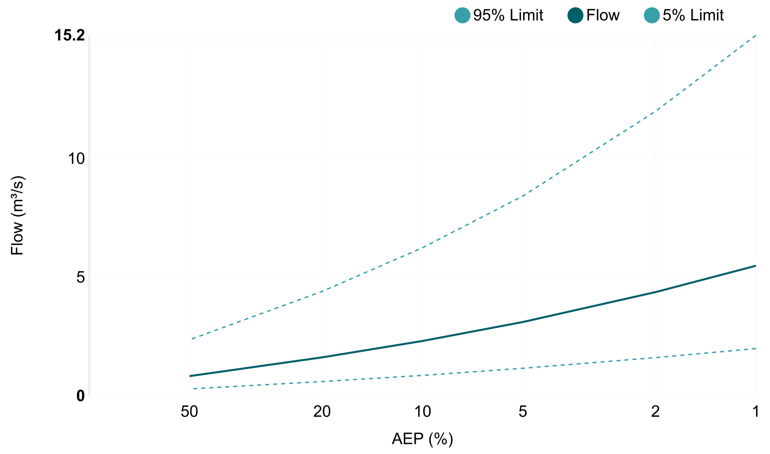
Post-Development Scenario

Catchment								
Area (ha)								

Pre Development Flows

Catchment Name	Area (ha)	t_c (min)	I_{100} (mm/hr)	C_{100}	1% AEP (m^3/s)	I_{50} (mm/hr)	C_{50}	2% AEP (m^3/s)	I_{20} (mm/hr)	C_{20}	5% AEP (m^3/s)	I_{10} (mm/hr)	C_{10}	10% AEP (m^3/s)	I_5 (mm/hr)	C_5	18% AEP (m^3/s)	I_2 (mm/hr)	C_2	39% AEP (m^3/s)	I_1 (mm/hr)	C_1	63% AEP (m^3/s)	Q3month (m^3/s)
Total Catchment	121.61	49	62	0.24	**4.97**	55	0.22	**4.05**	46	0.18	**2.81**	40	0.15	**2.01**	34	0.11	**1.24**	26	0.06	**0.49**	21	0.00	**0.00**	**0.00**

Results | Regional Flood Frequency Estimation Model



AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	0.840	0.300	2.37
20	1.63	0.610	4.41
10	2.32	0.870	6.25
5	3.12	1.17	8.43
2	4.38	1.62	12.0
1	5.49	2.00	15.2

Statistics

Variable	Value	Standard Dev
Mean	-0.210	0.652
Standard Dev	0.784	0.131
Skew	0.087	0.026

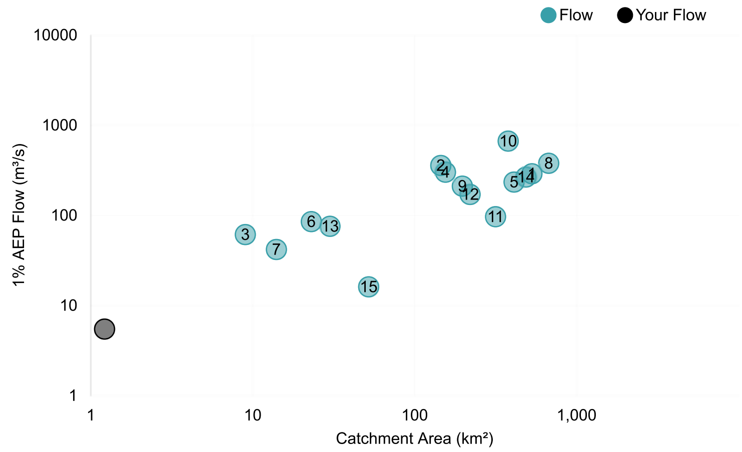
Note: These statistics come from the nearest gauged catchment. Details.

Correlation

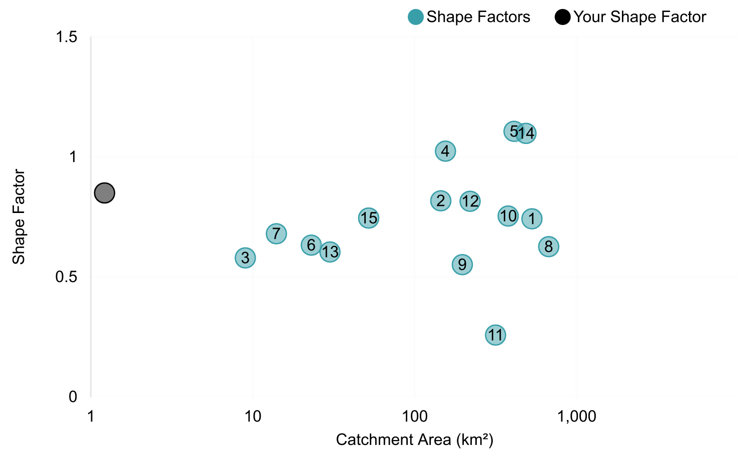
1.000		
-0.330	1.000	
0.170	-0.280	1.000

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

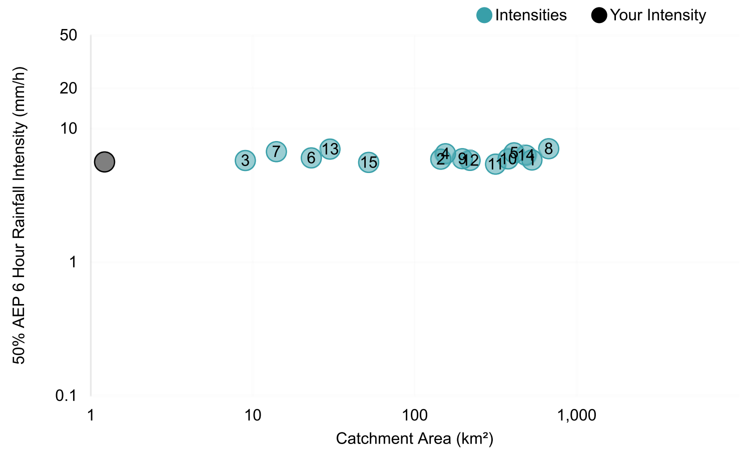
1% AEP Flow vs Catchment Area



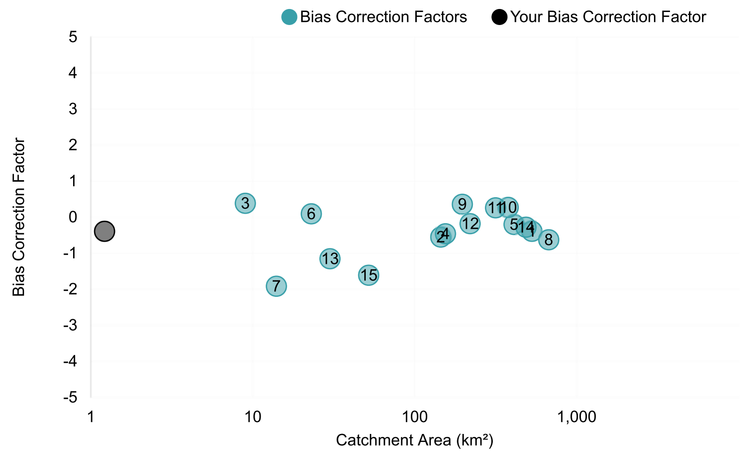
Shape Factor vs Catchment Area



Intensity vs Catchment Area



Bias Correction Factor vs Catchment Area



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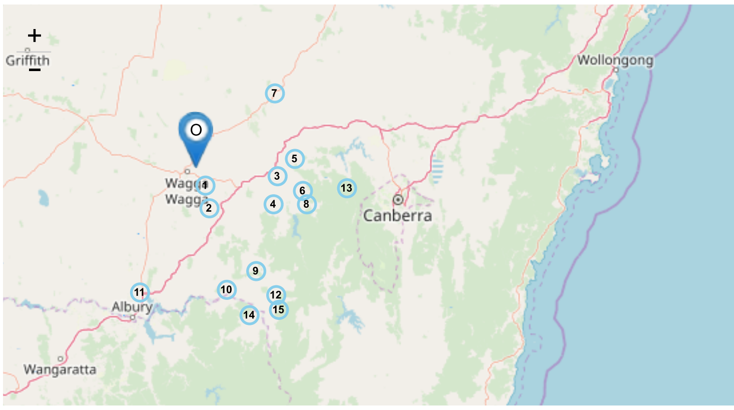
TXT | Nearby | JSON

Input Data

Date/Time	2019-07-23 18:58

Input Data

Catchment Name	Catchment1
Latitude (Outlet)	-35.08138503
Longitude (Outlet)	147.4441379
Latitude (Centroid)	-35.07760276
Longitude (Centroid)	147.434994
Catchment Area (km^2)	1.21606
Distance to Nearest Gauged Catchment (km)	14.49
50% AEP 6 Hour Rainfall Intensity (mm/h)	5.627539
2% AEP 6 Hour Rainfall Intensity (mm/h)	12.608674
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	0.85
Interpolation Method	Natural Neighbour
Bias Correction Value	-0.392



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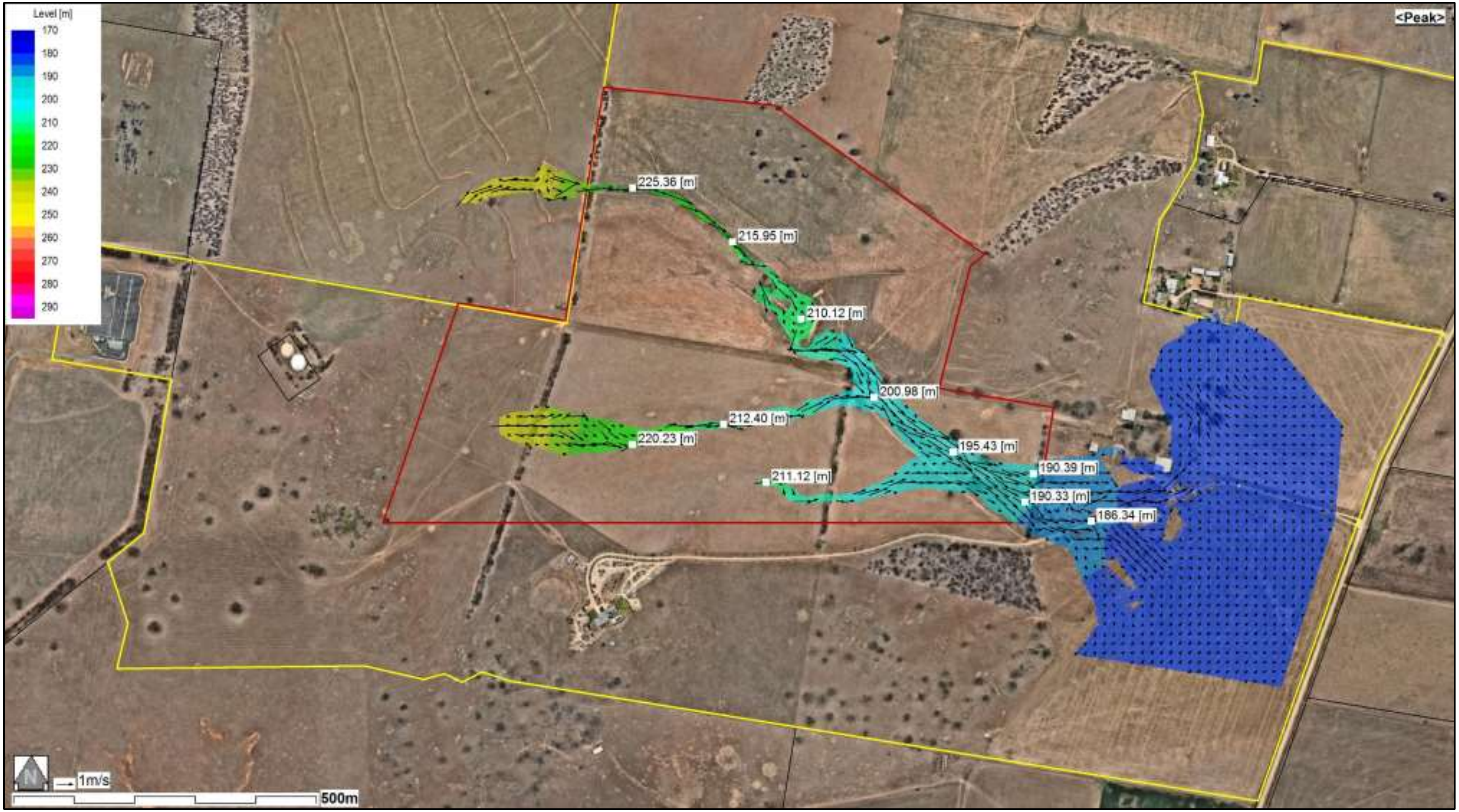
Method by Dr Ataur Rahman and Dr Khaled Haddad from Western Sydney University for the Australian Rainfall and Runoff Project. Full description of the project can be found at the project page (http://arr.ga.gov.au/revision-projects/project-list/projects/project-5) on the ARR website. Send any questions regarding the method or project here (mailto:admin@arr-software.org).

ENGINEERS AUSTRALIA (http://www.engineersaustralia.org.au)

WESTERN SYDNEY UNIVERSITY (http://www.uws.edu.au)

APPENDIX C PRE-DEVELOPMENT FLOOD MAPPING



PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C1 – 1%AEP Event Base Case Peak Water Surface Levels (Case E09)

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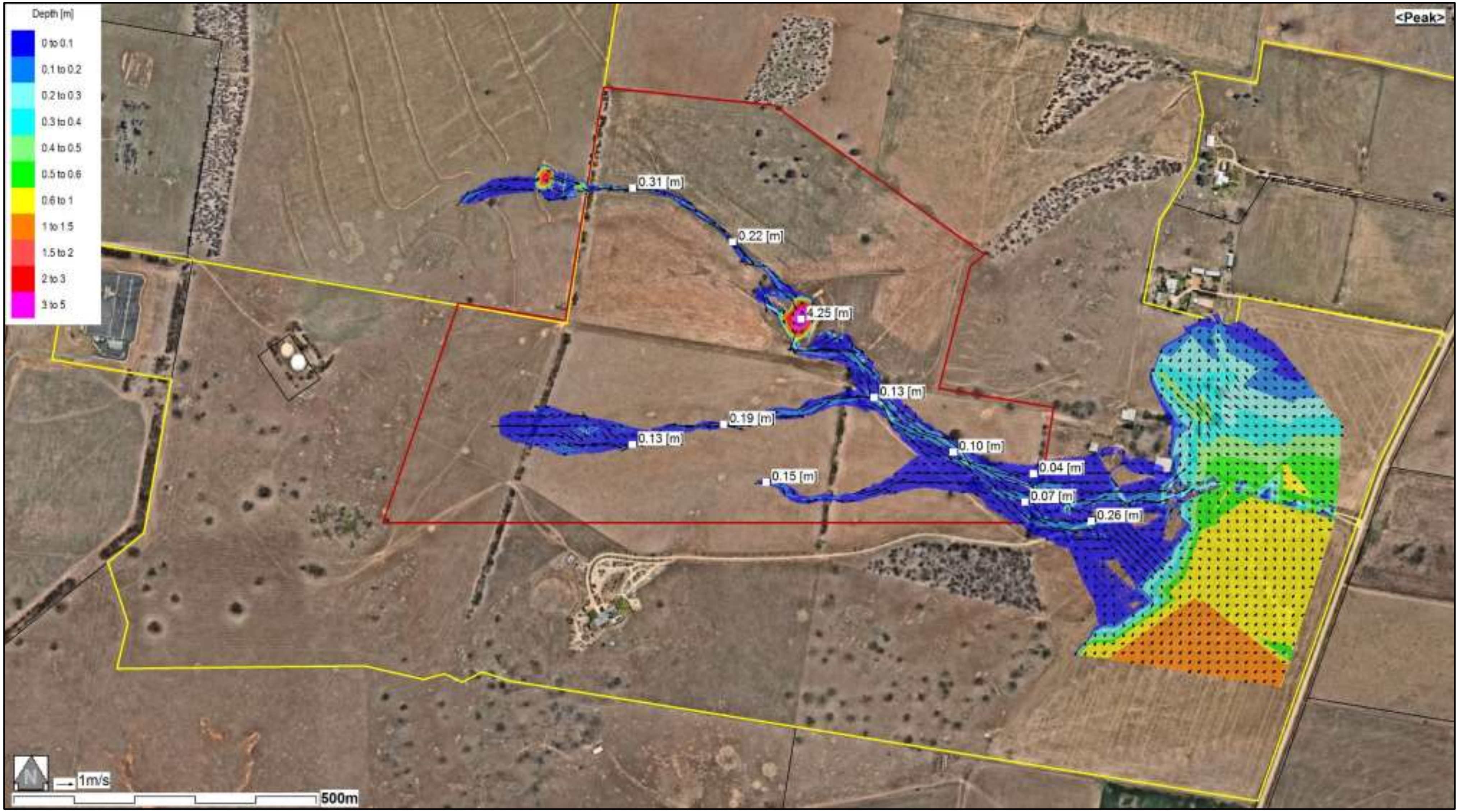

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C2 – 1%AEP Event Base Case Peak Water Surface Depths (Case E09)

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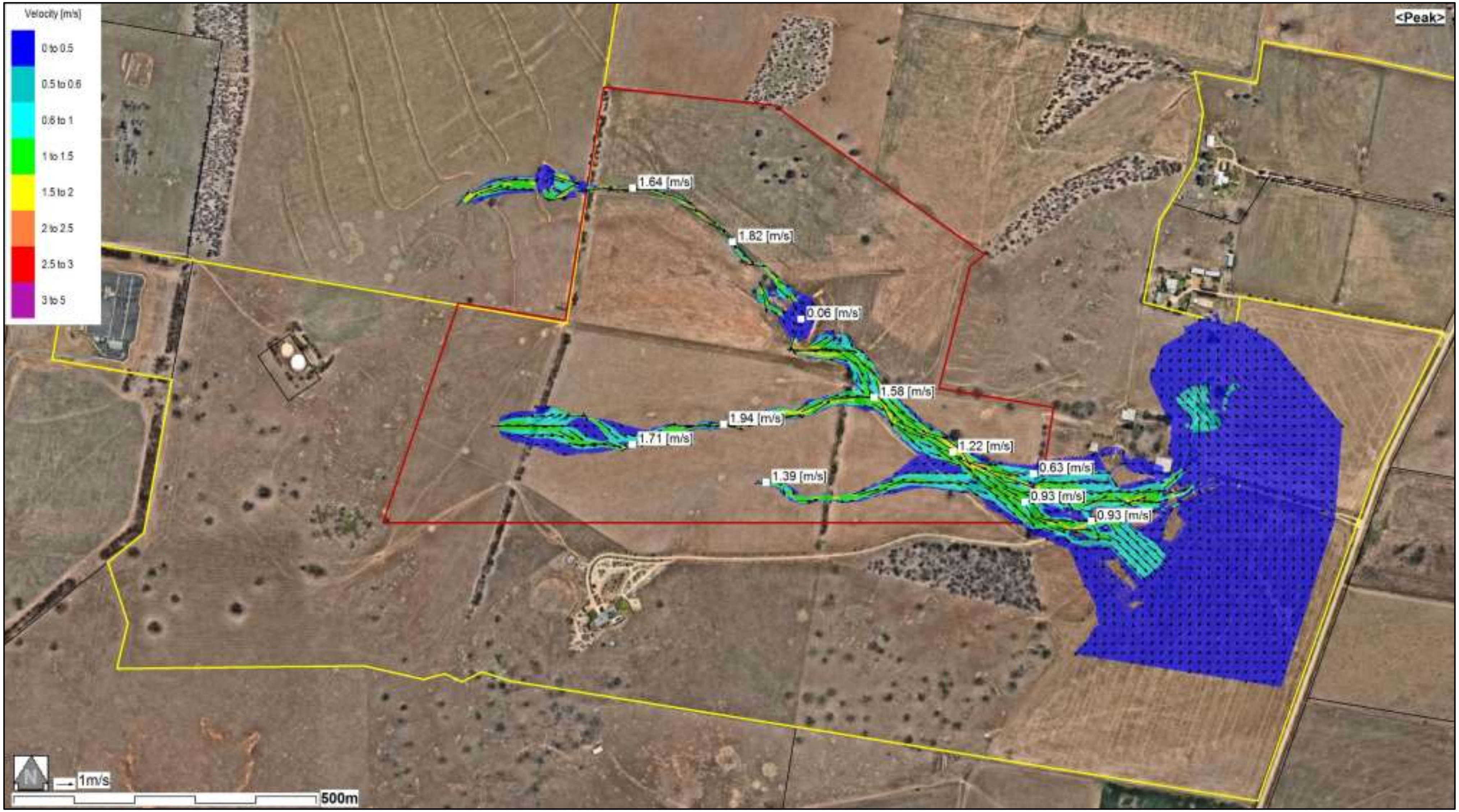

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C3 – 1%AEP Event Base Case Peak Water Surface Velocities (Case E09)

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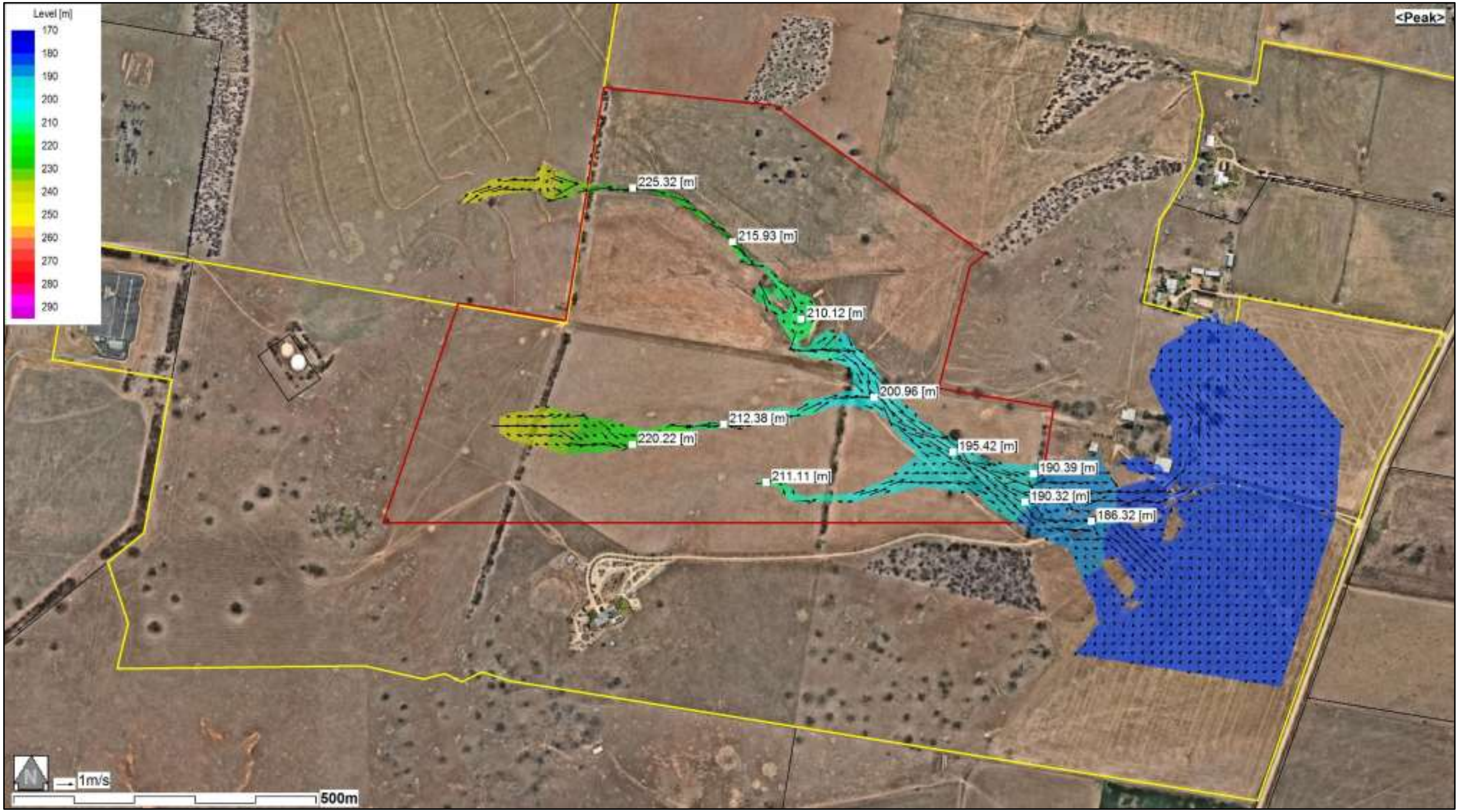

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C4 – 2%AEP Event Base Case Peak Water Surface Levels (Case E09)

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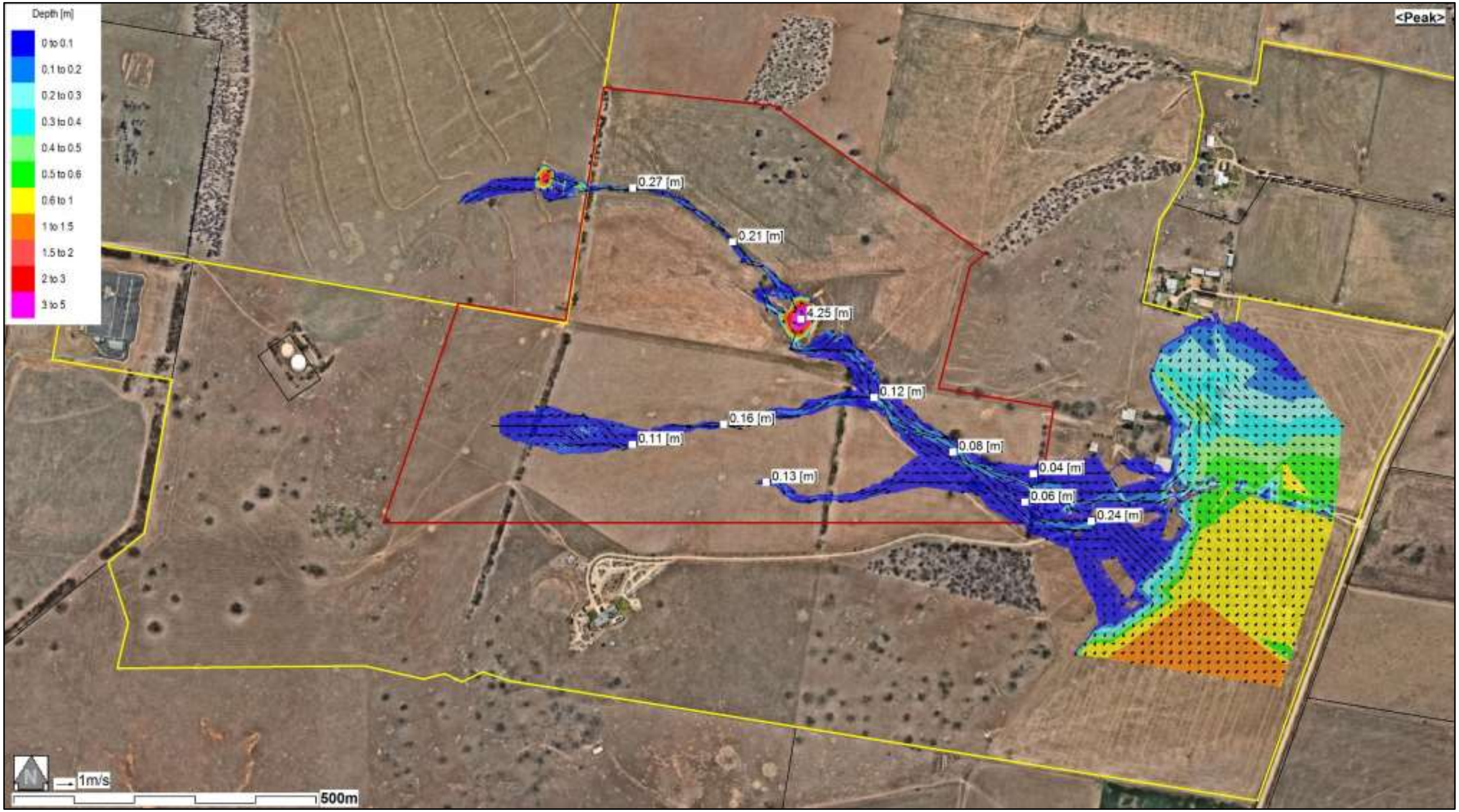

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C5 – 2%AEP Event Base Case Peak Water Surface Depths (Case E09)

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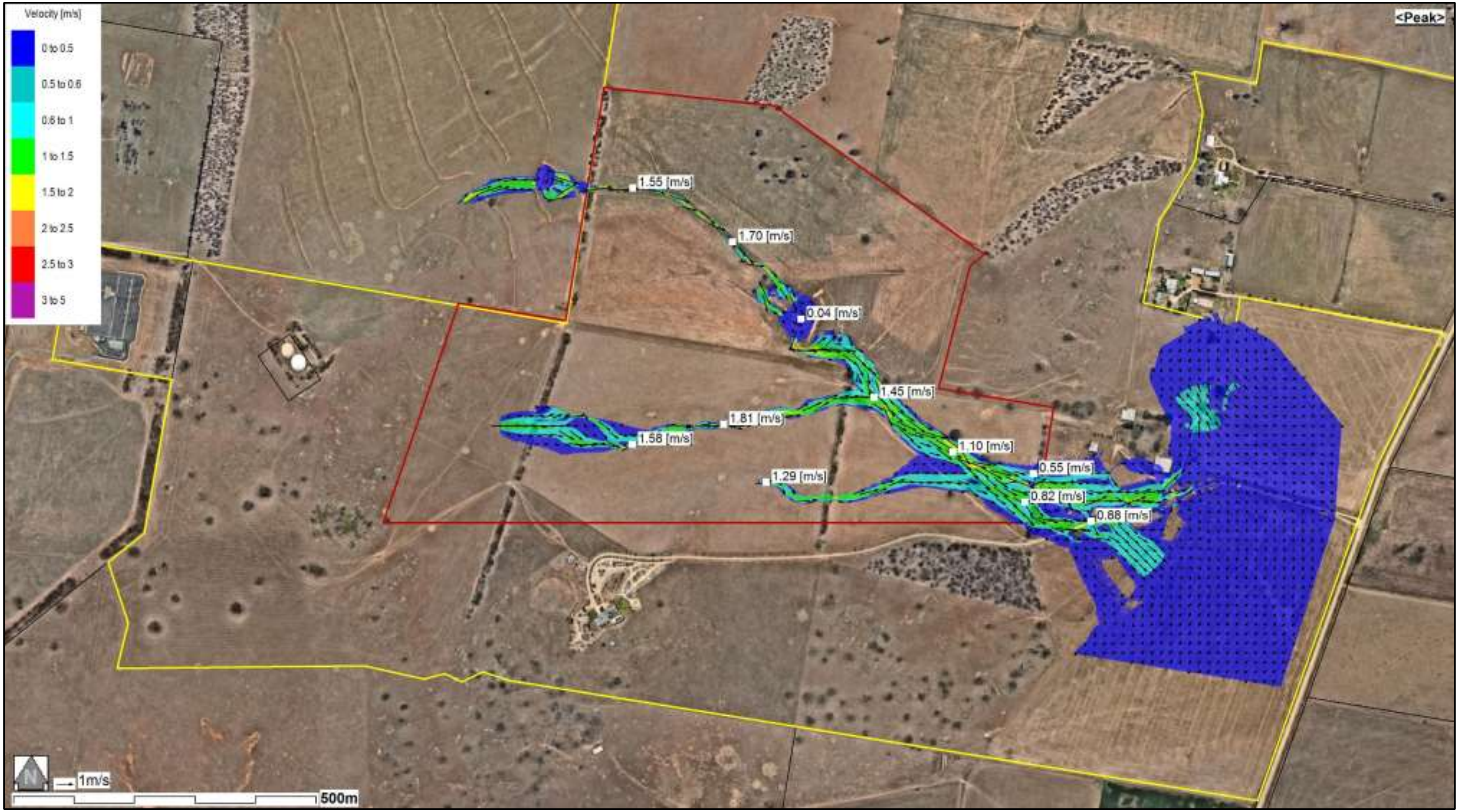

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C6 – 2%AEP Event Base Case Peak Water Surface Velocities (Case E09)

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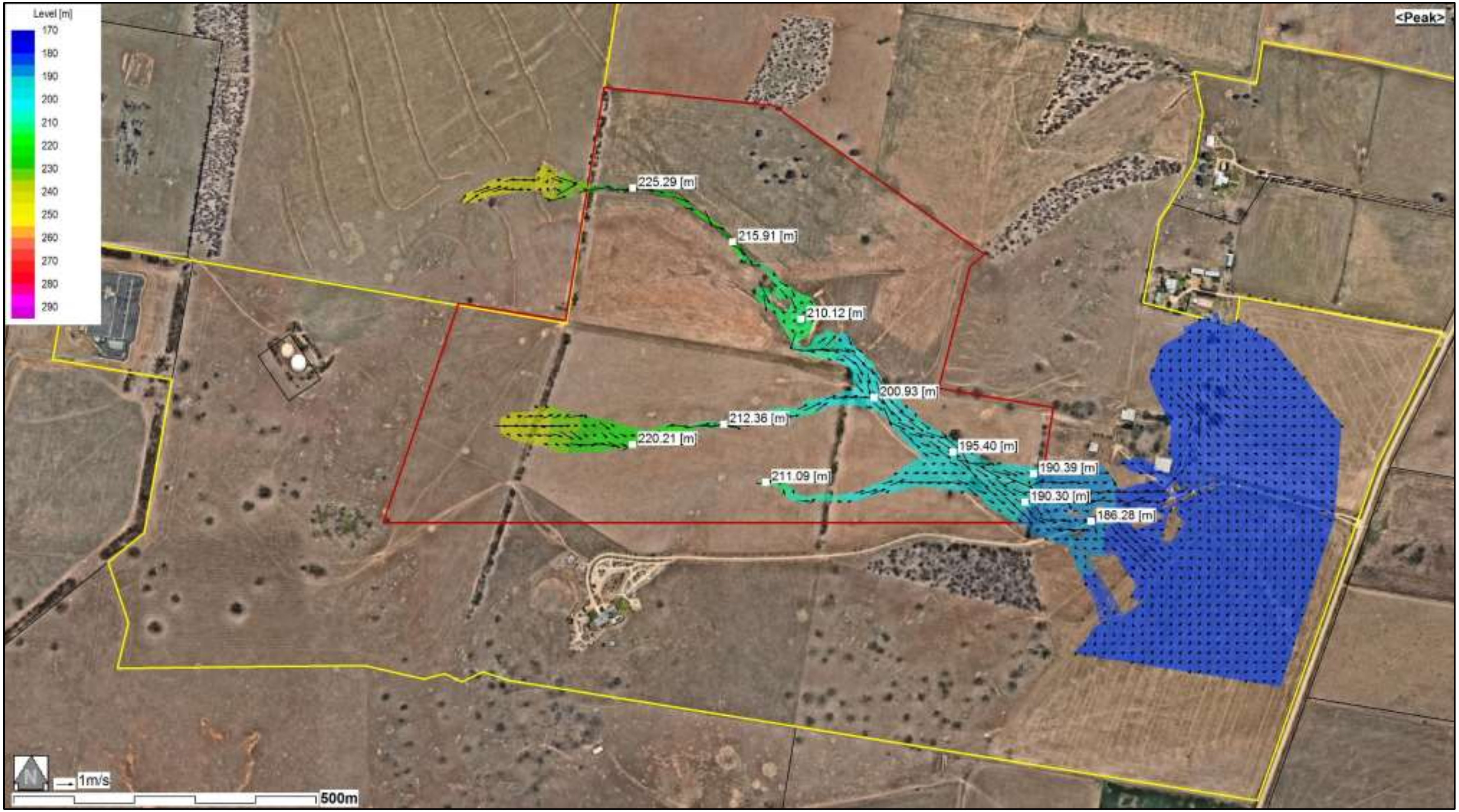

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C7 – 5%AEP Event Base Case Peak Water Surface Levels (Case E09)

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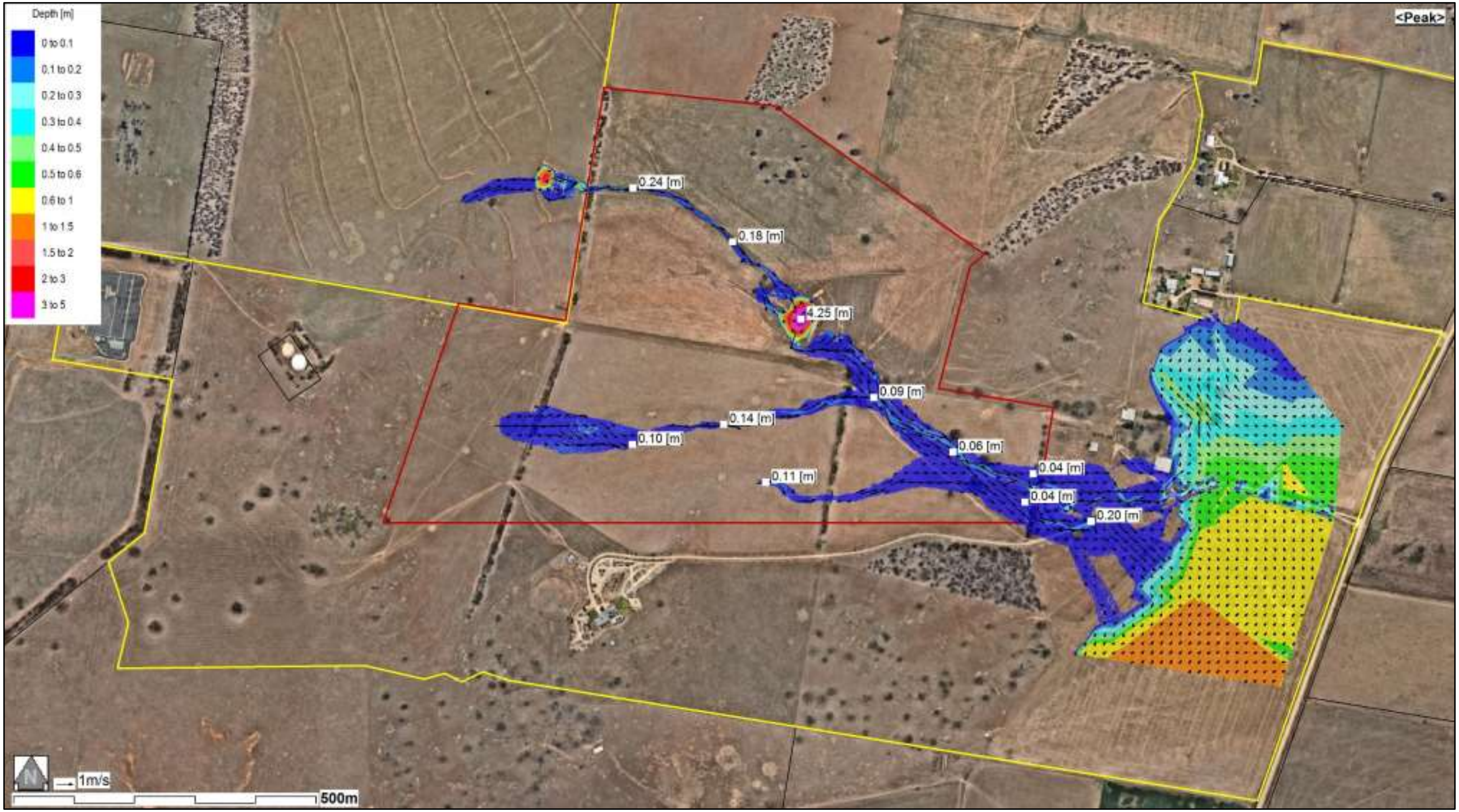

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C8 – 5%AEP Event Base Case Peak Water Surface Depths (Case E09)

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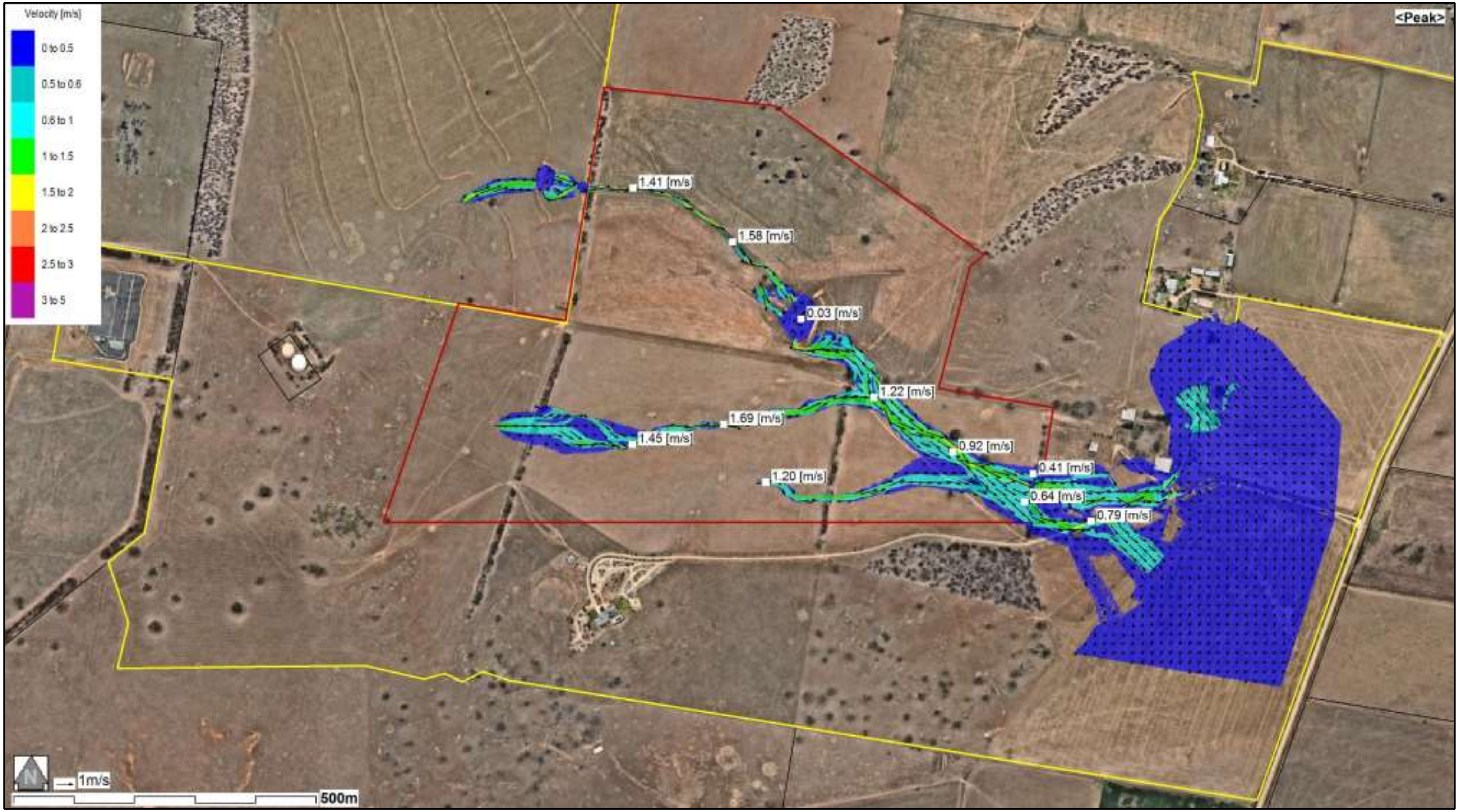

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C9 – 5%AEP Event Base Case Peak Water Surface Velocities (Case E09)

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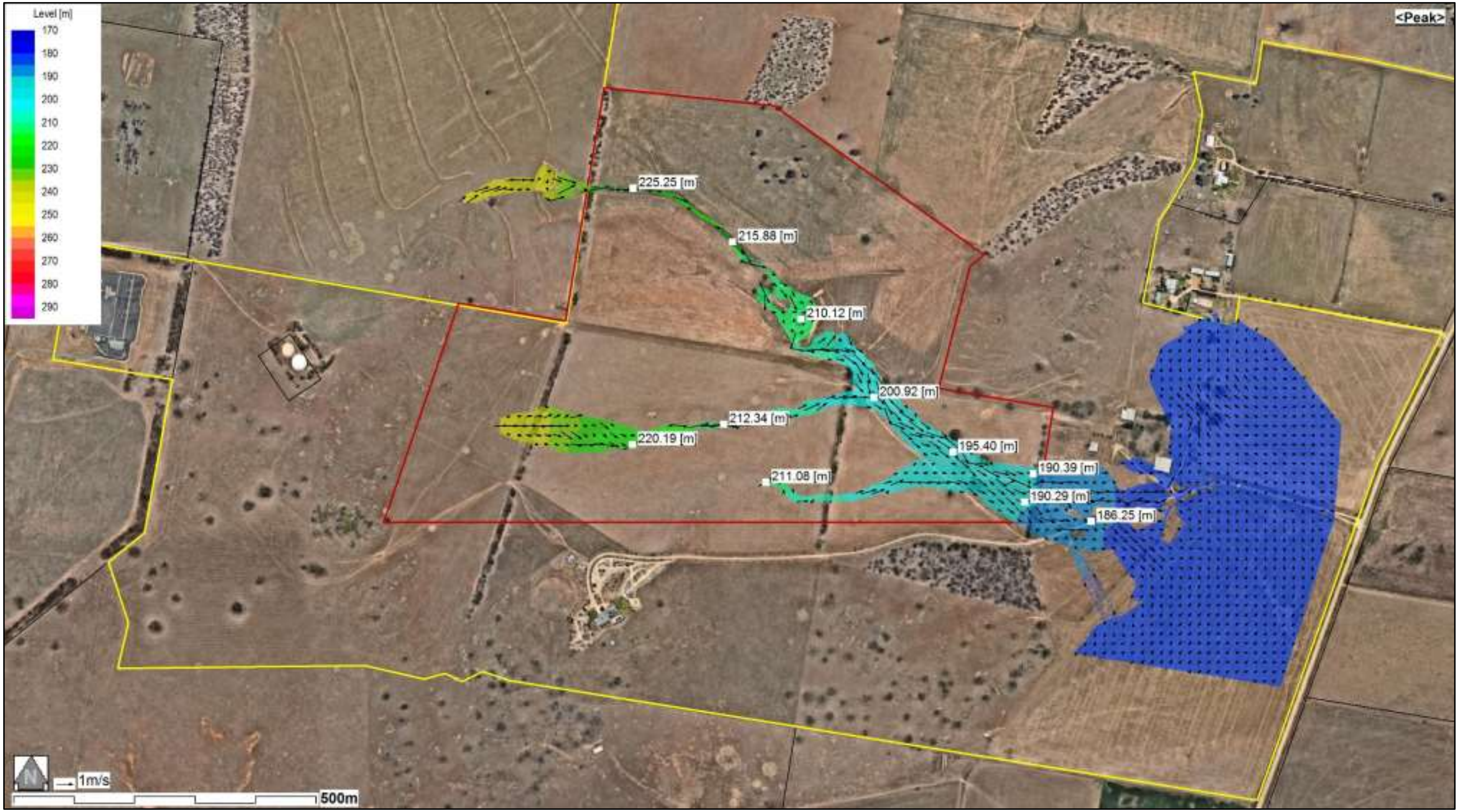

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C10 – 10%AEP Event Base Case Peak Water Surface Levels (Case E09)

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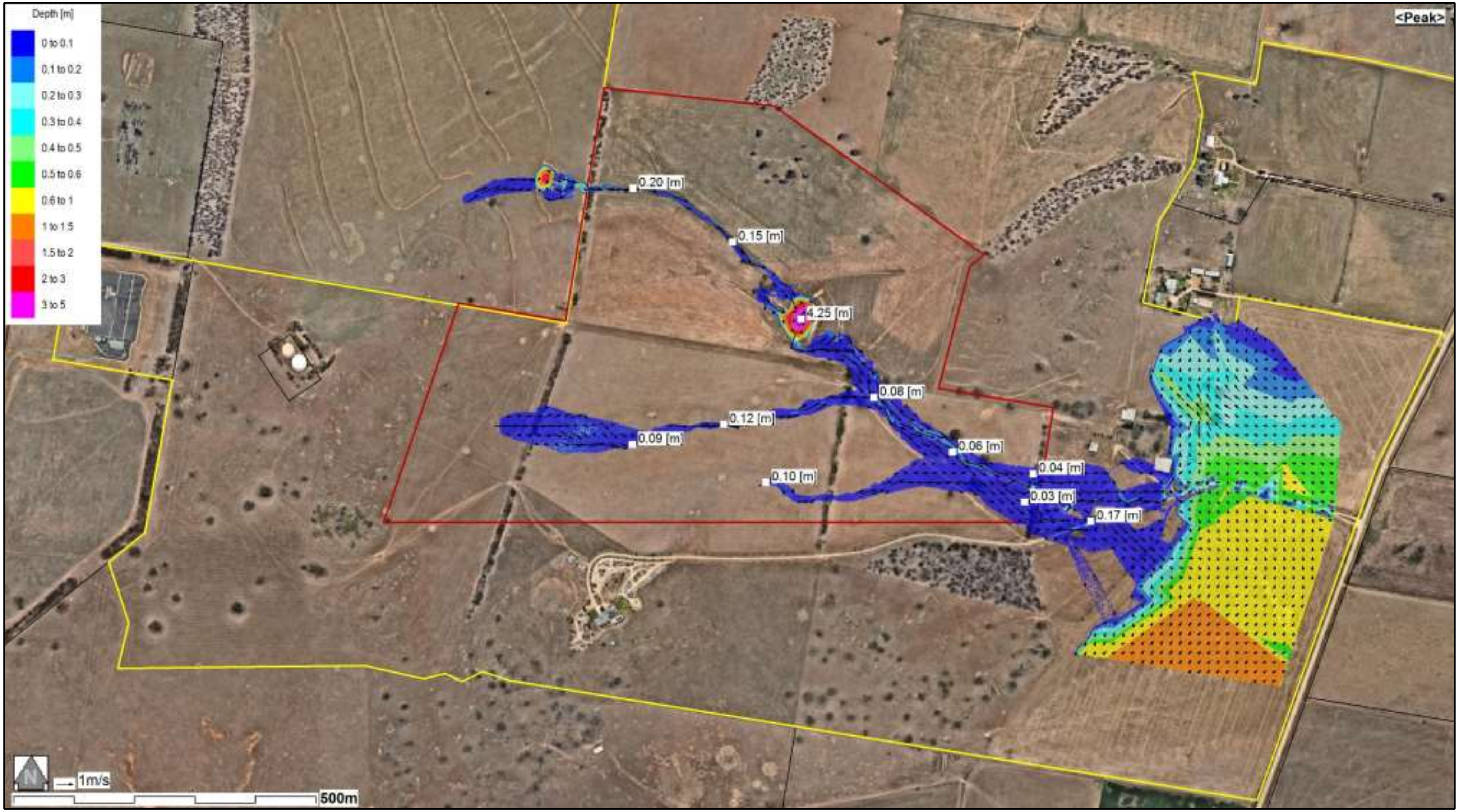

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C11 – 10%AEP Event Base Case Peak Water Surface Depths (Case E09)

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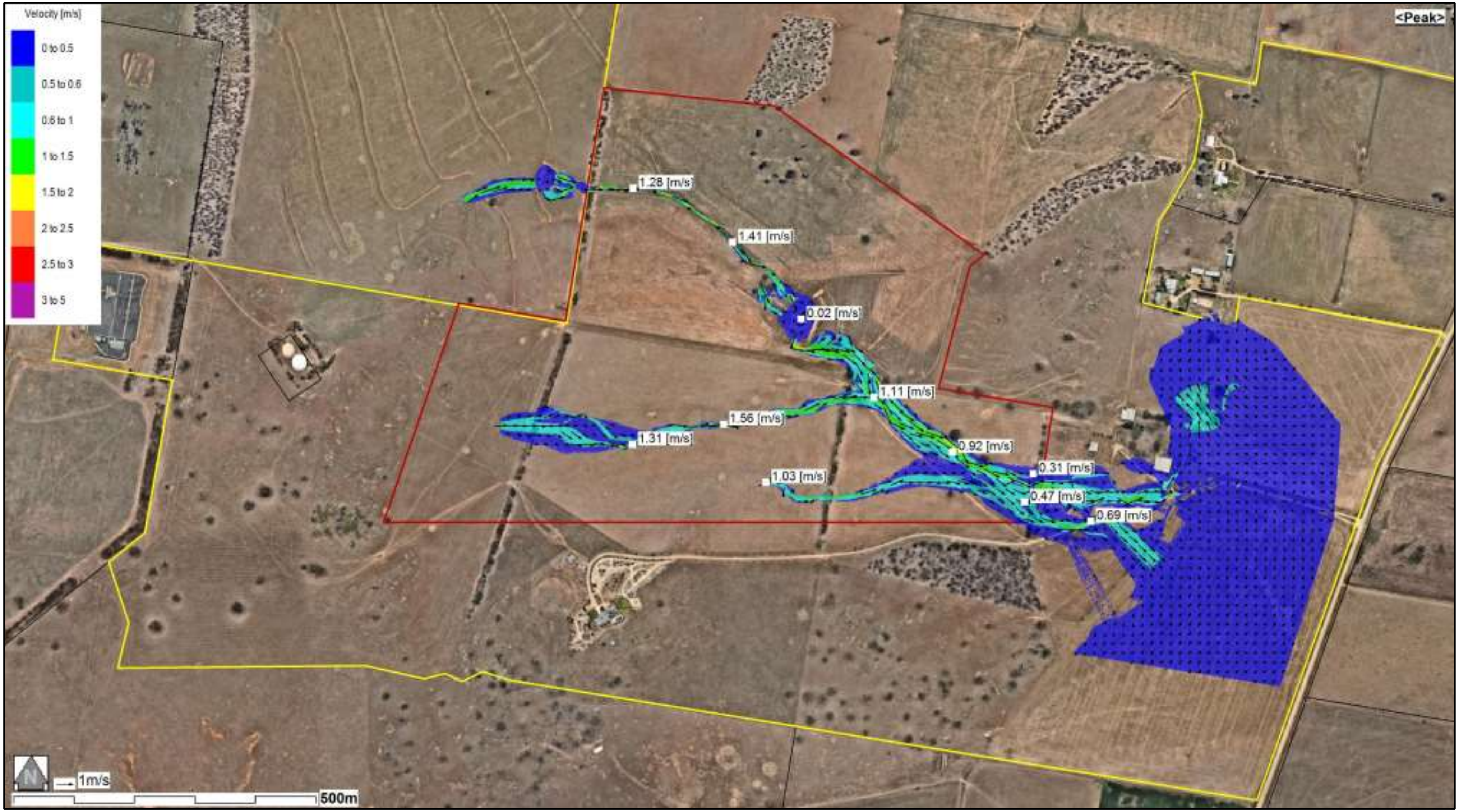

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C12 – 10%AEP Event Base Case Peak Water Surface Velocities (Case E09)

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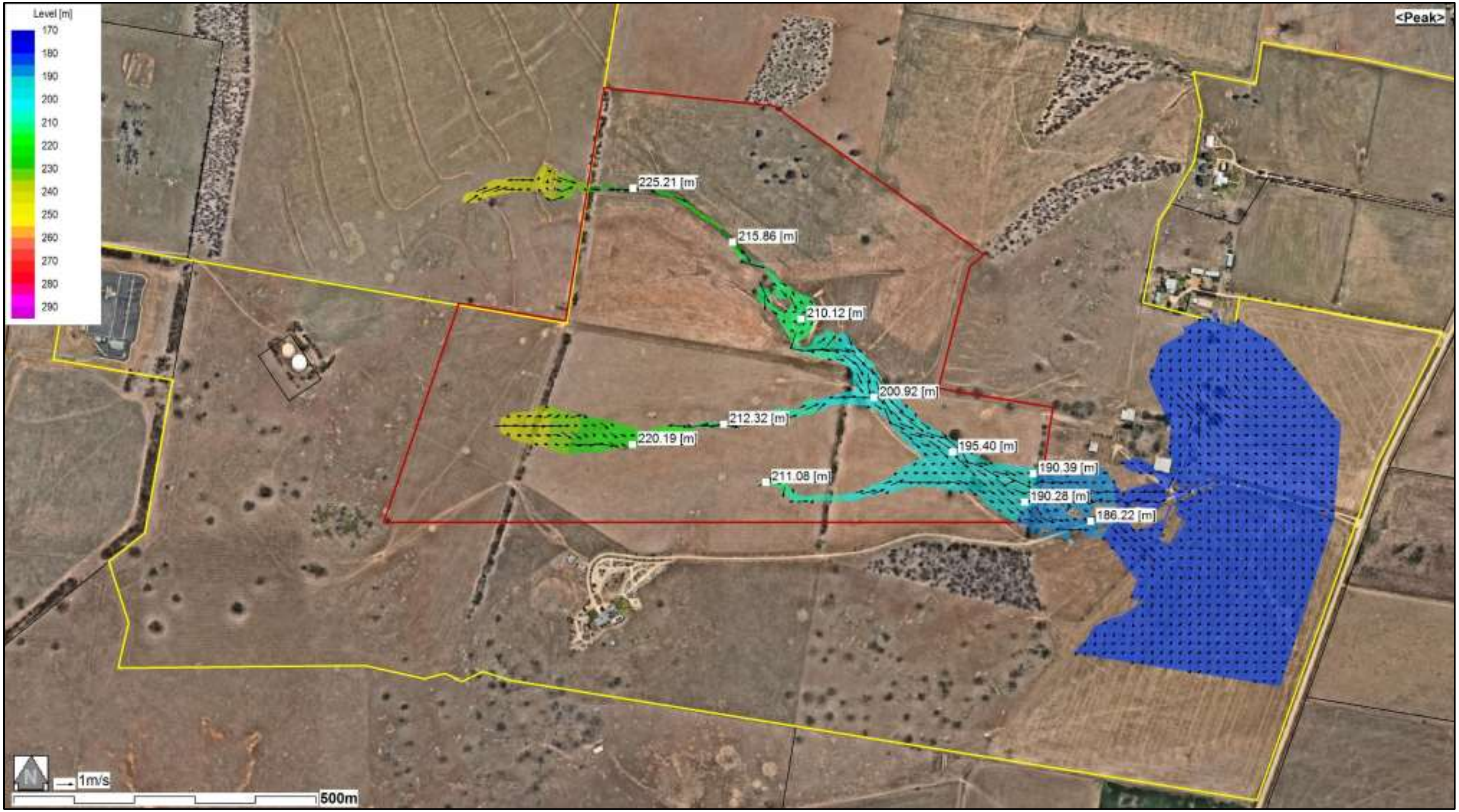

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C13 – 18%AEP Event Base Case Peak Water Surface Levels (Case E09)

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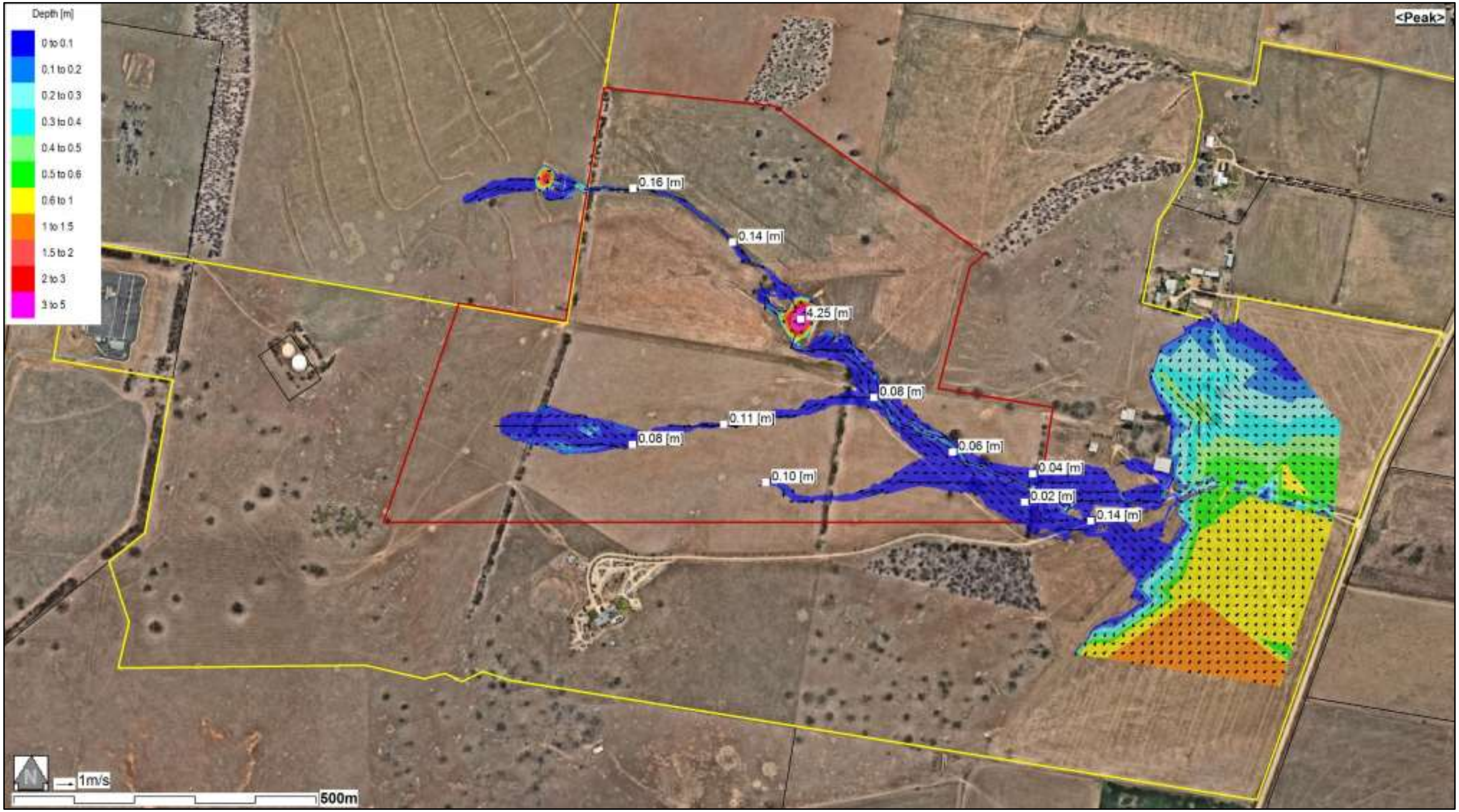

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C14 – 18%AEP Event Base Case Peak Water Surface Depths (Case E09)

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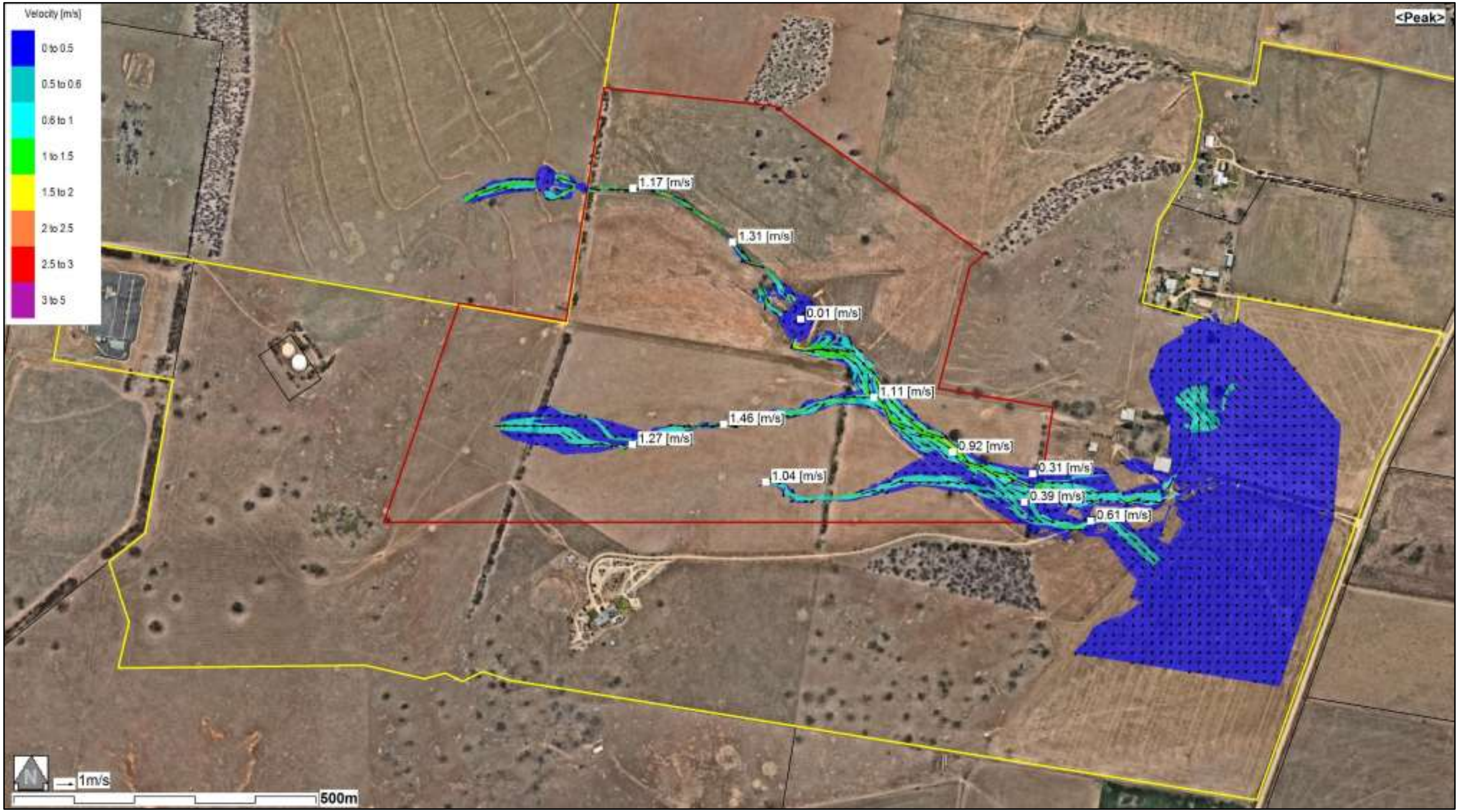

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C15 – 18%AEP Event Base Case Peak Water Surface Velocities (Case E09)

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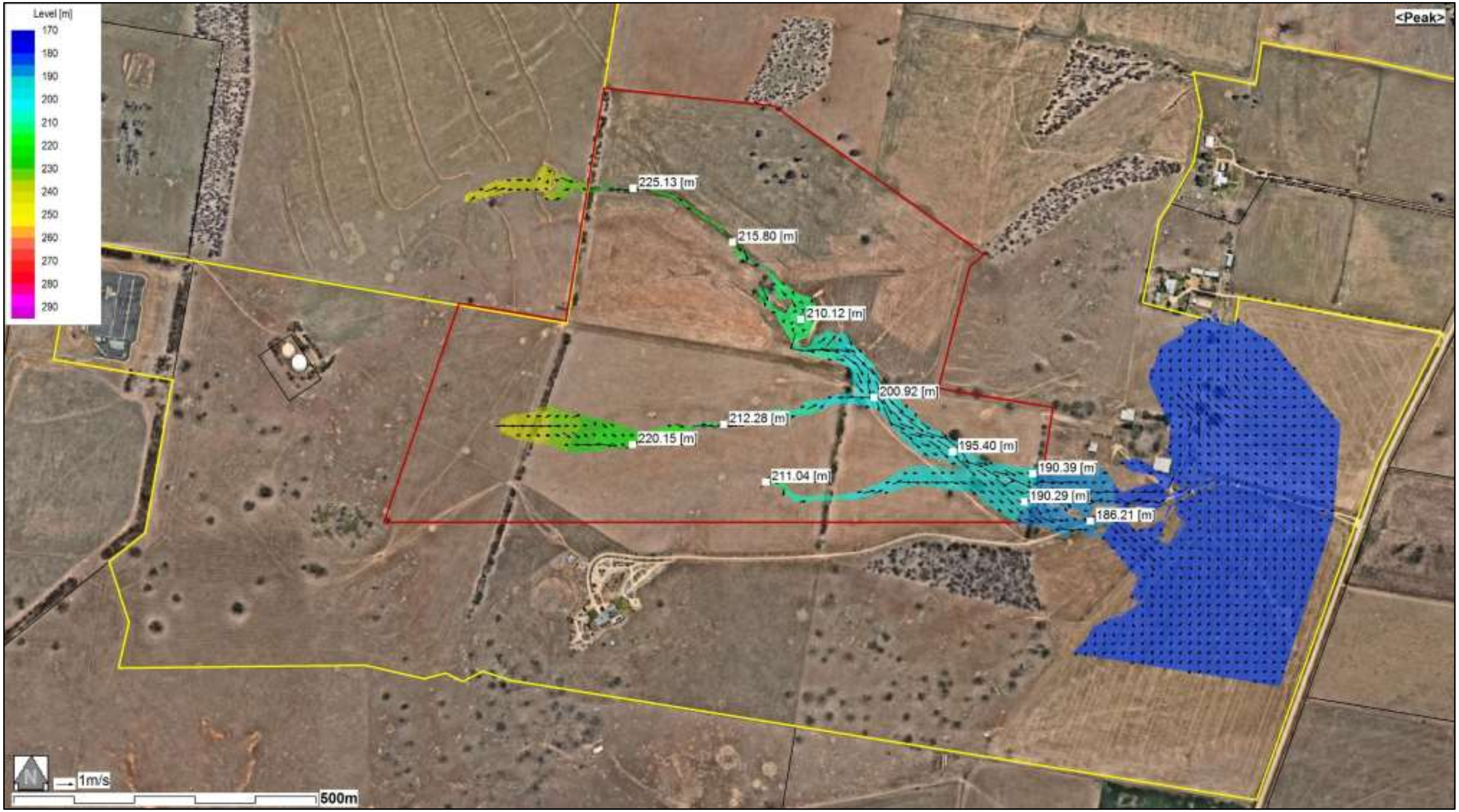

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C16 – 39%AEP Event Base Case Peak Water Surface Levels (Case E09)

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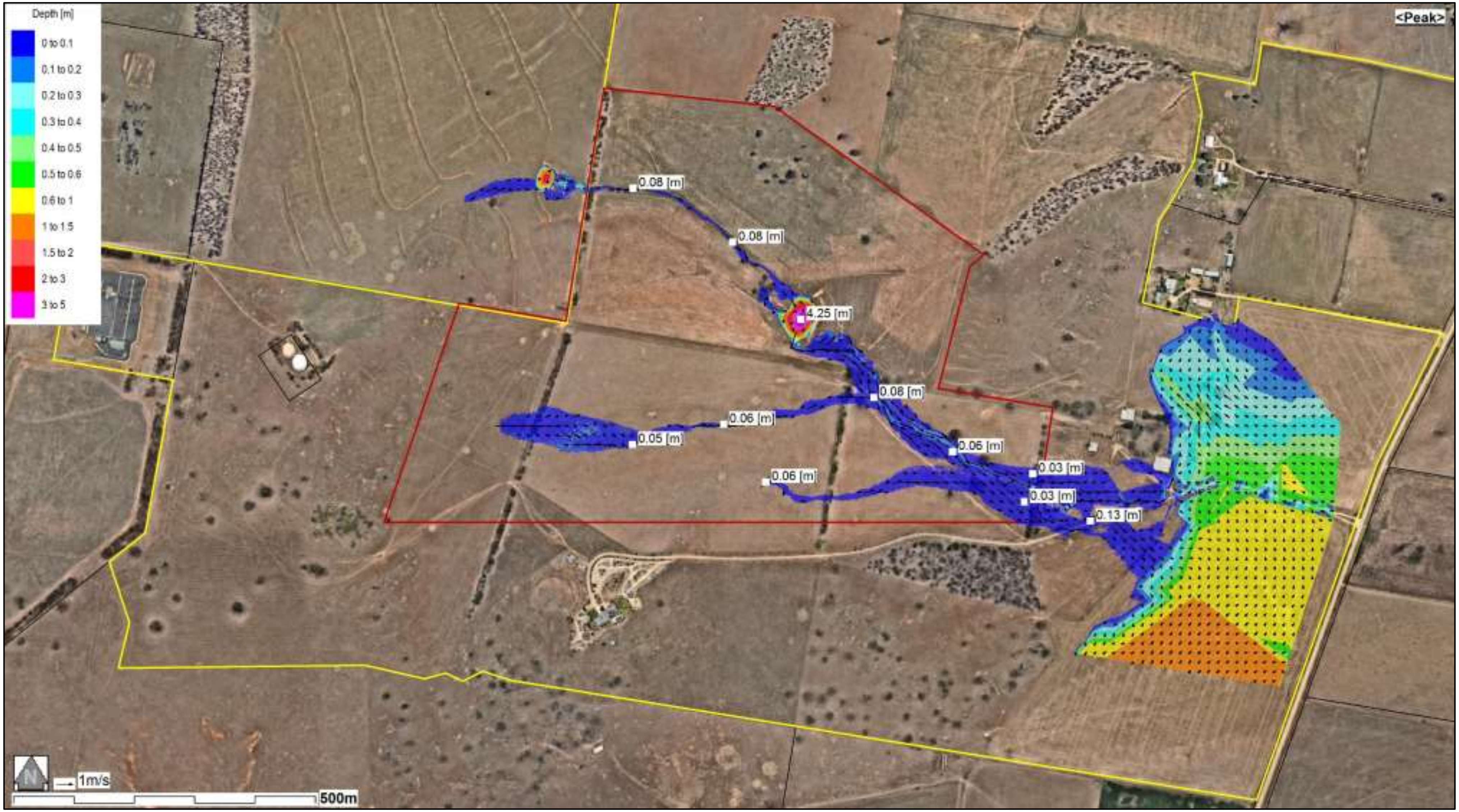

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C17 – 39%AEP Event Base Case Peak Water Surface Depths (Case E09)

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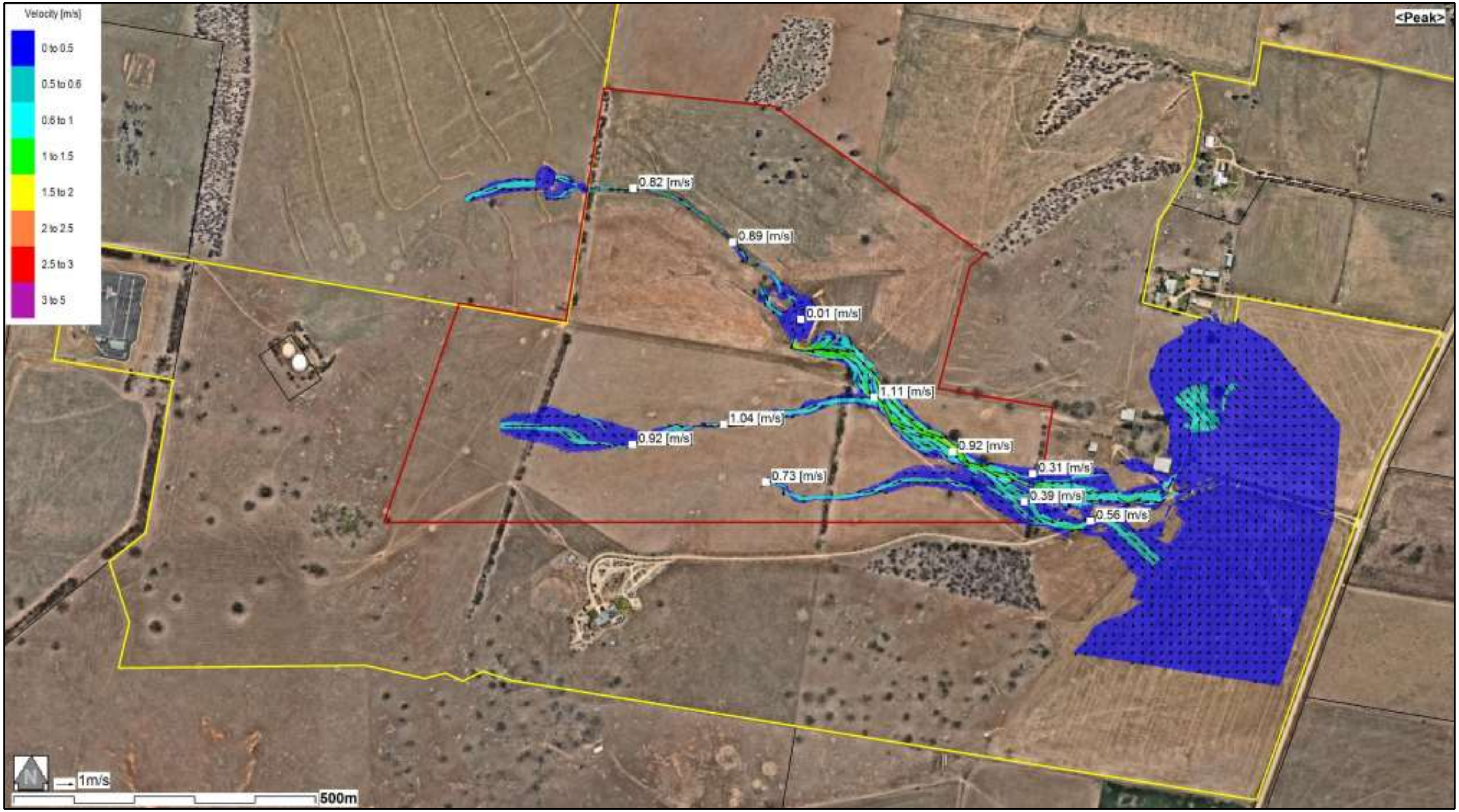

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure C18 – 39%AEP Event Base Case Peak Water Surface Velocities (Case E09)

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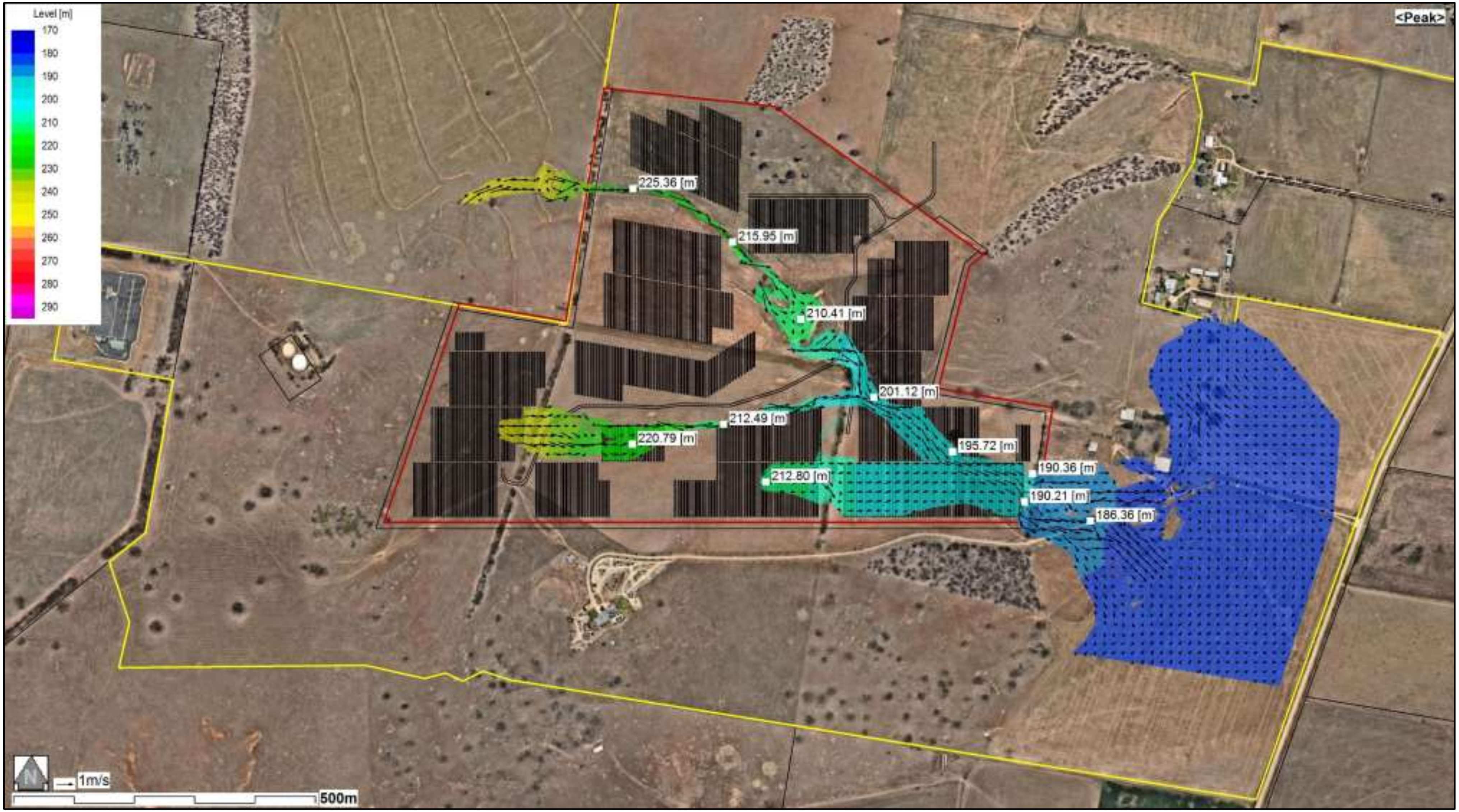
APPENDIX D POST-DEVELOPMENT FLOOD MAPPING



PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D1 – 1%AEP Event Predicted Peak Water Surface Levels (Case D06)

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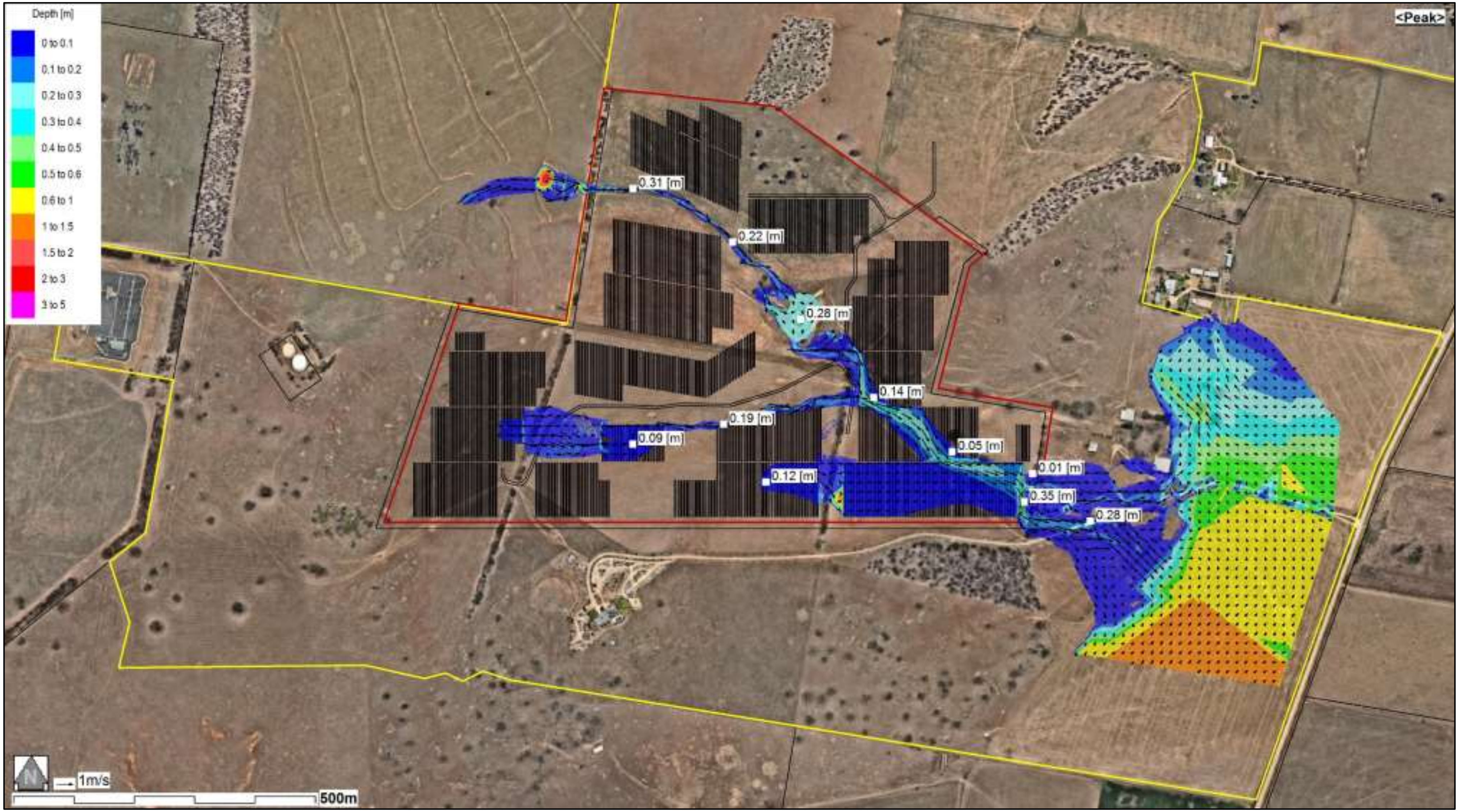

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D2 – 1%AEP Event Predicted Peak Water Surface Depths (Case D06)

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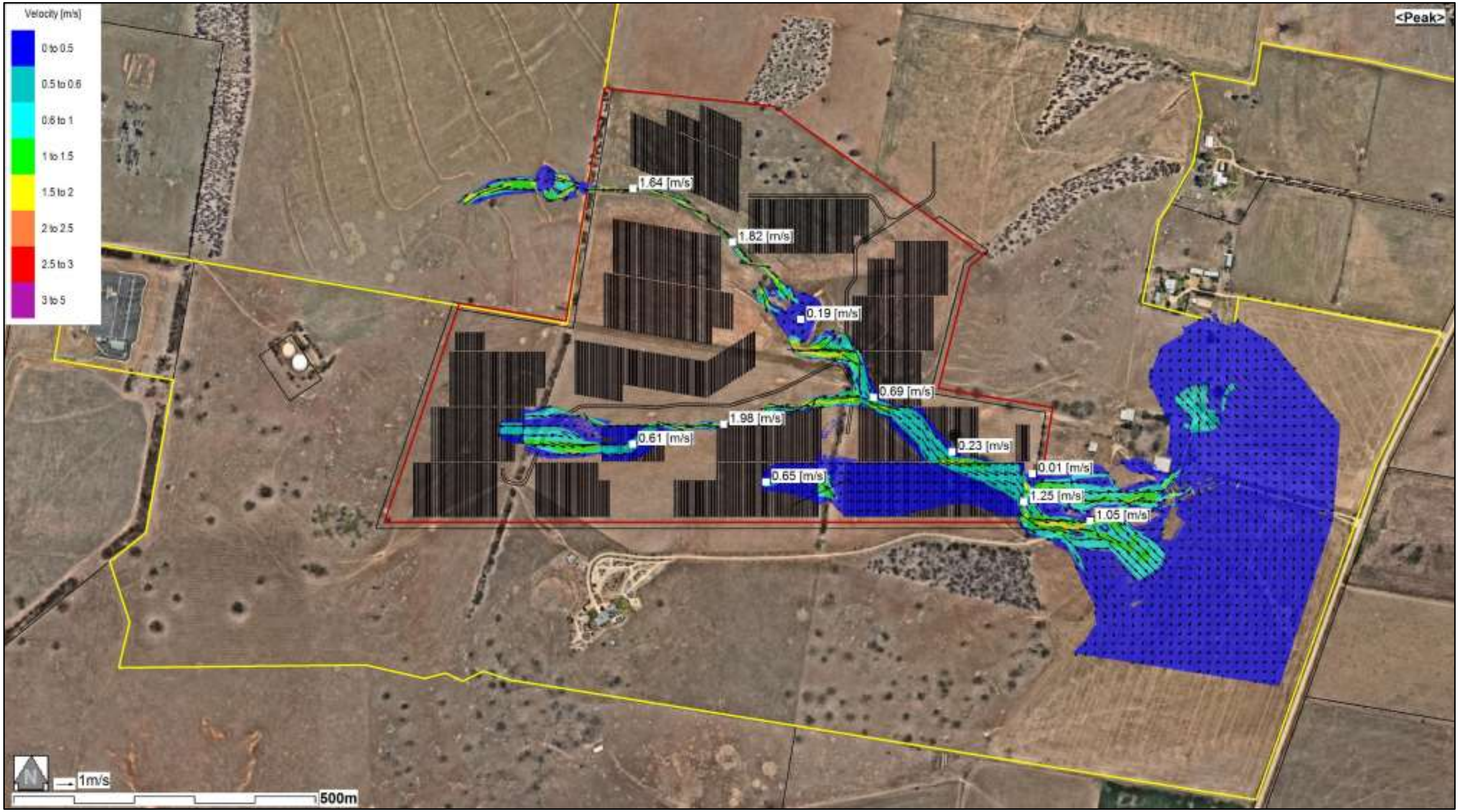

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D3 – 1%AEP Event Predicted Peak Water Surface Velocities (Case D06)

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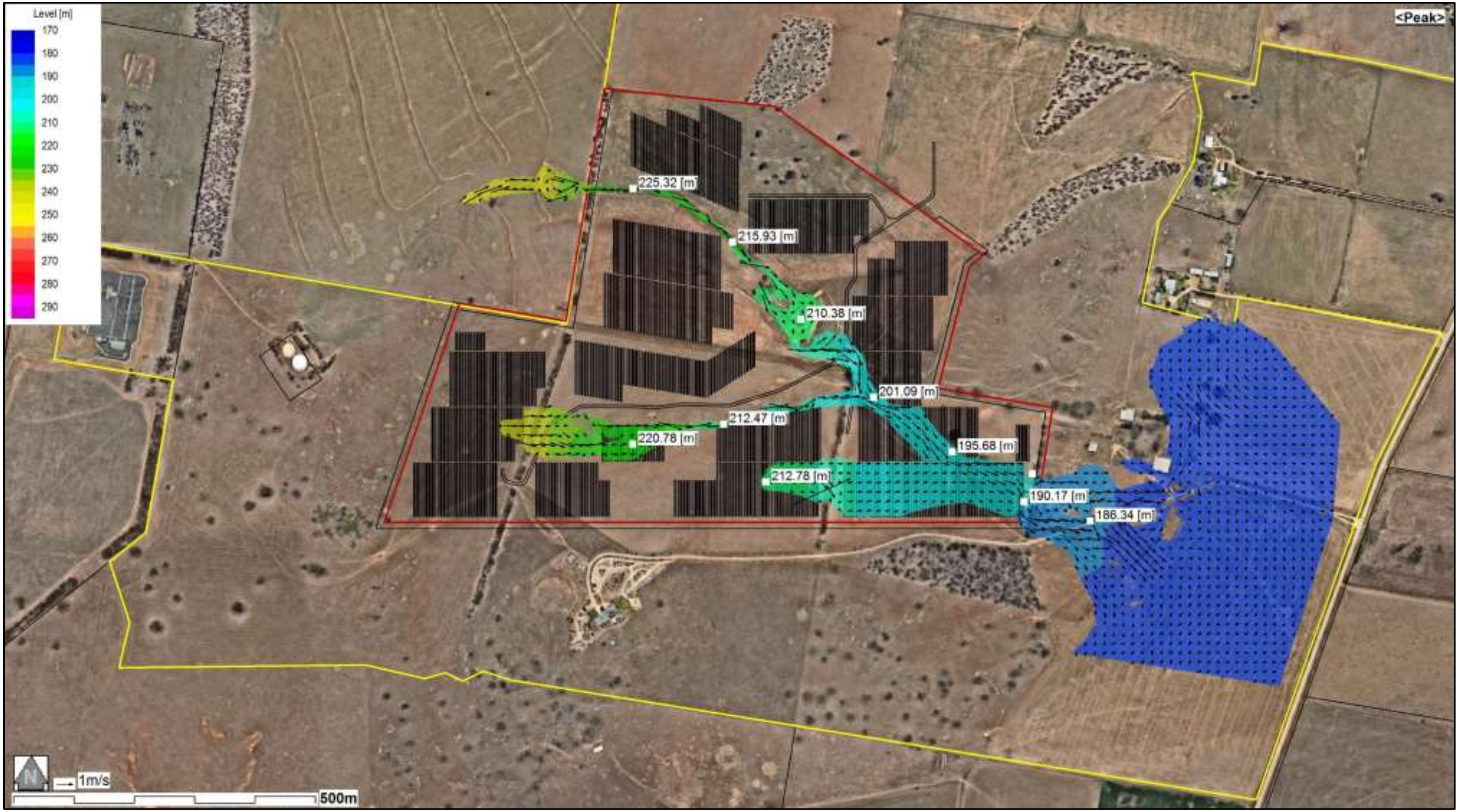

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D4 – 2%AEP Event Predicted Peak Water Surface Levels (Case D06)

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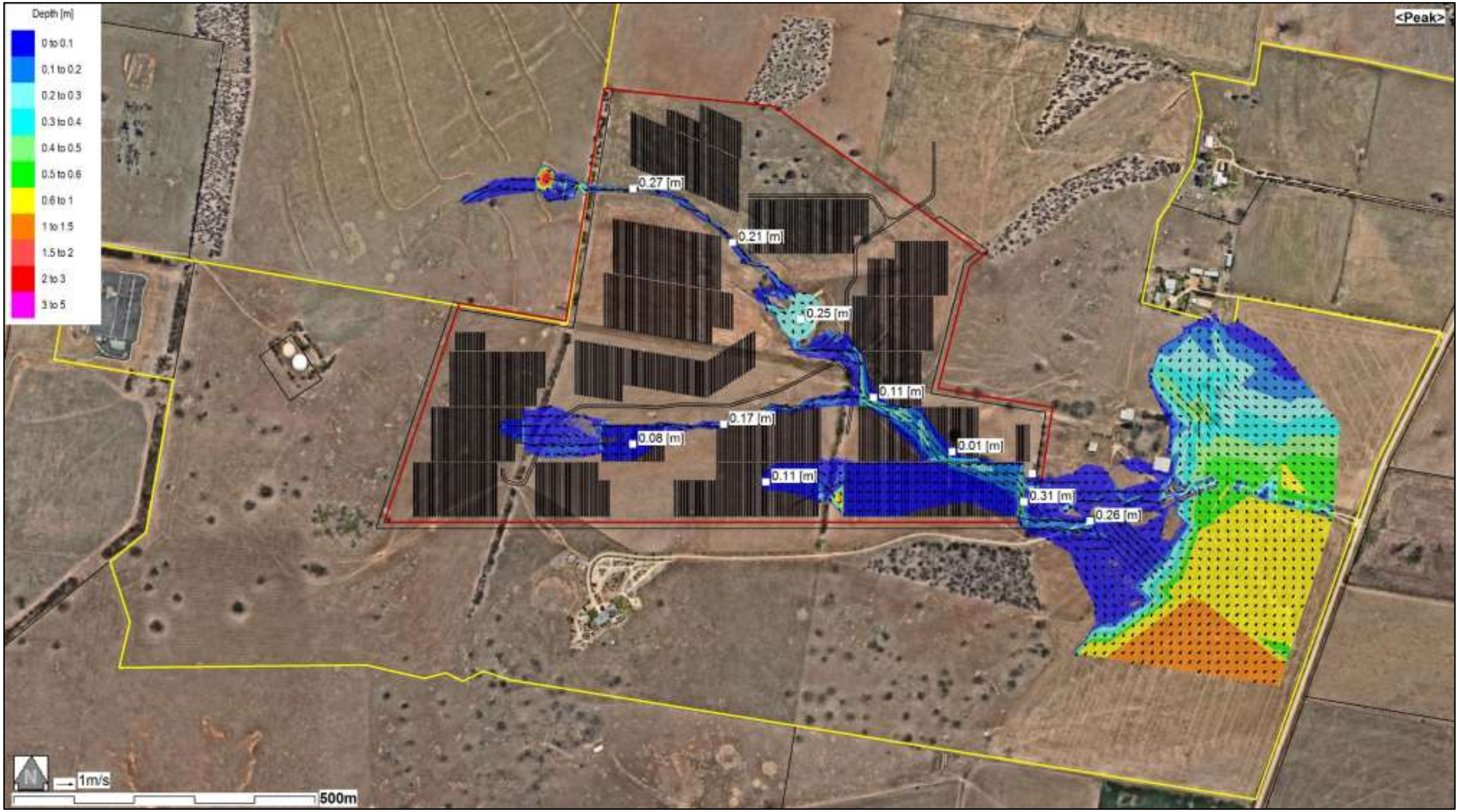

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D5 – 2%AEP Event Predicted Peak Water Surface Depths (Case D06)

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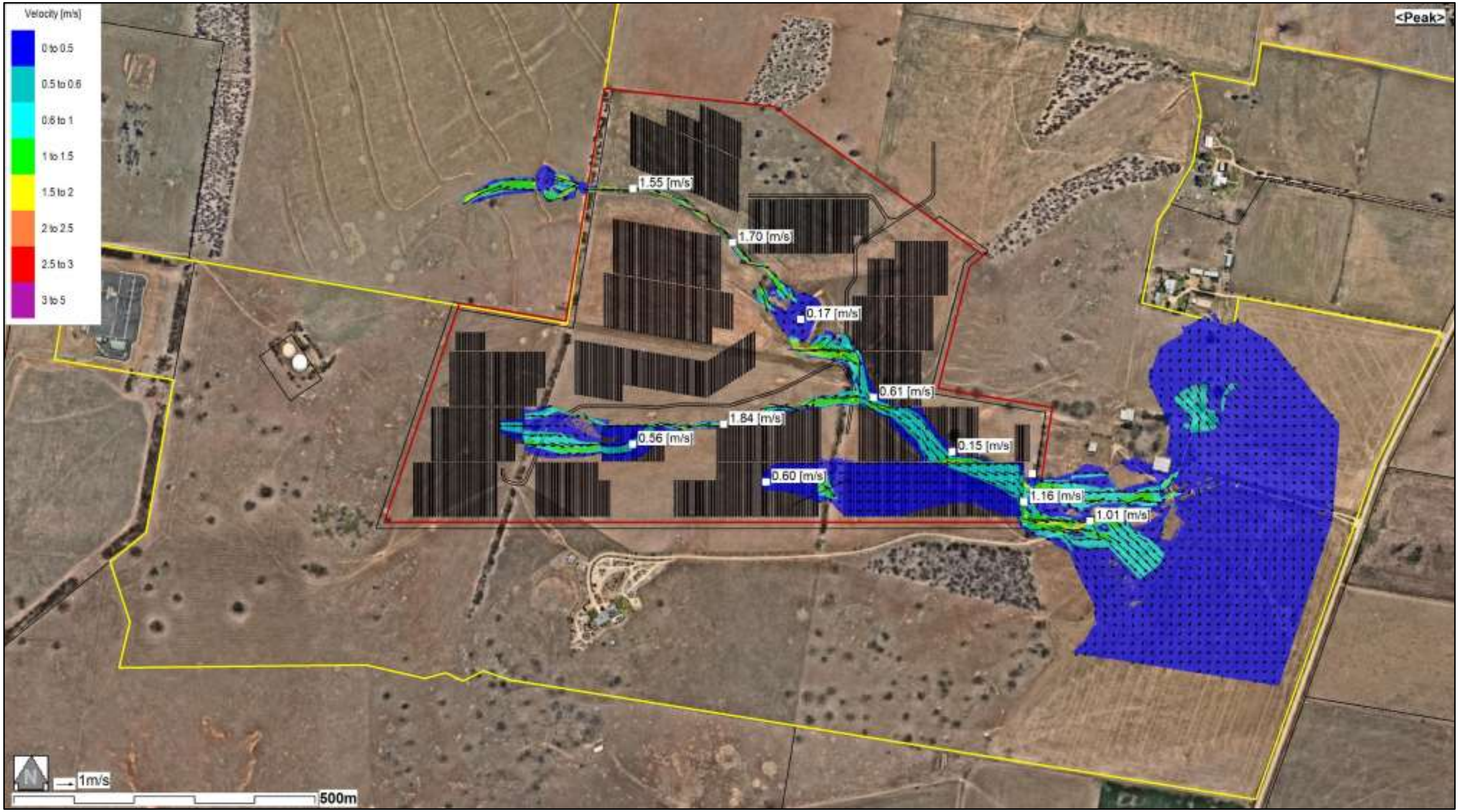

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D6 – 2%AEP Event Predicted Peak Water Surface Velocities (Case D06)

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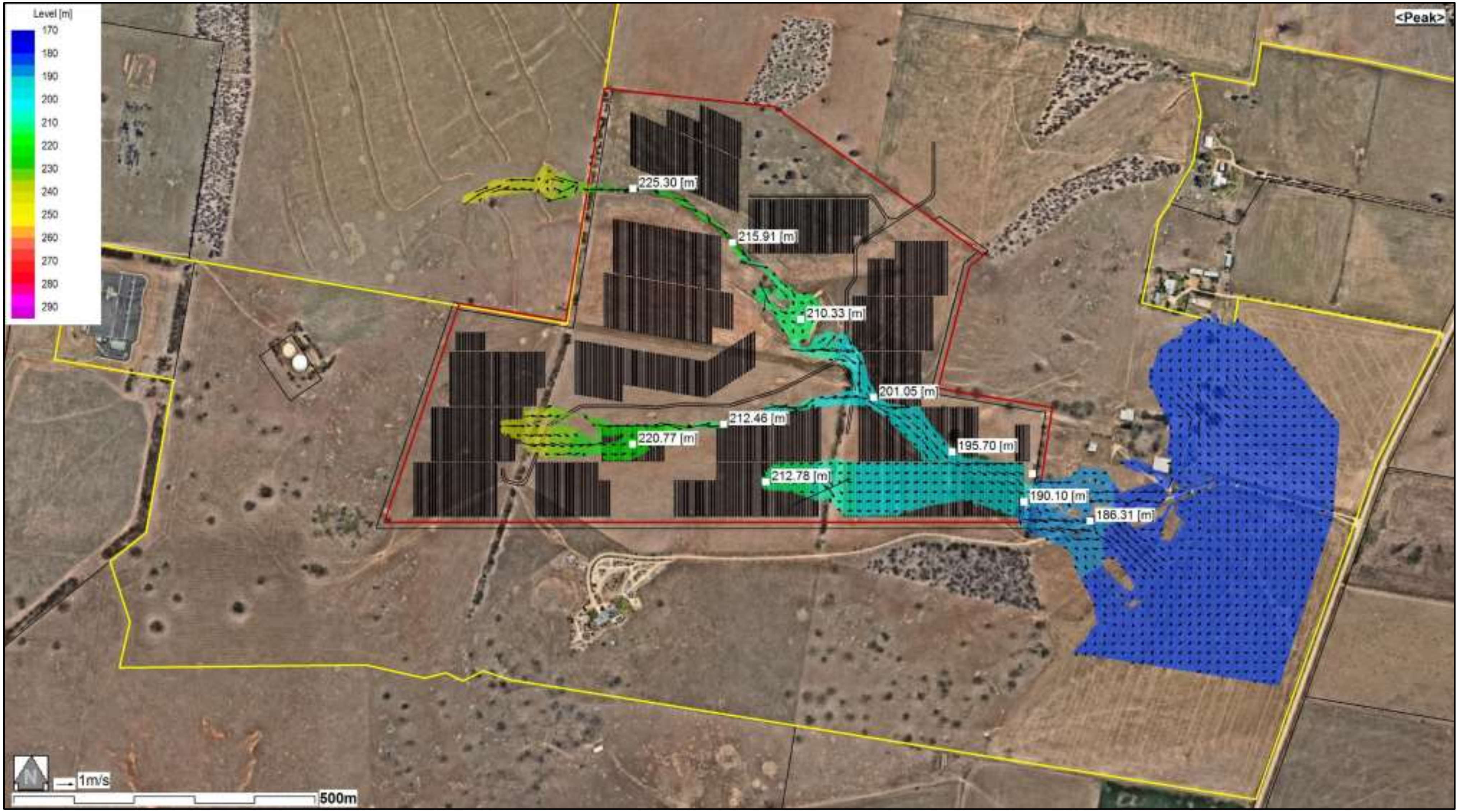

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D7 – 5%AEP Event Predicted Peak Water Surface Levels (Case D06)

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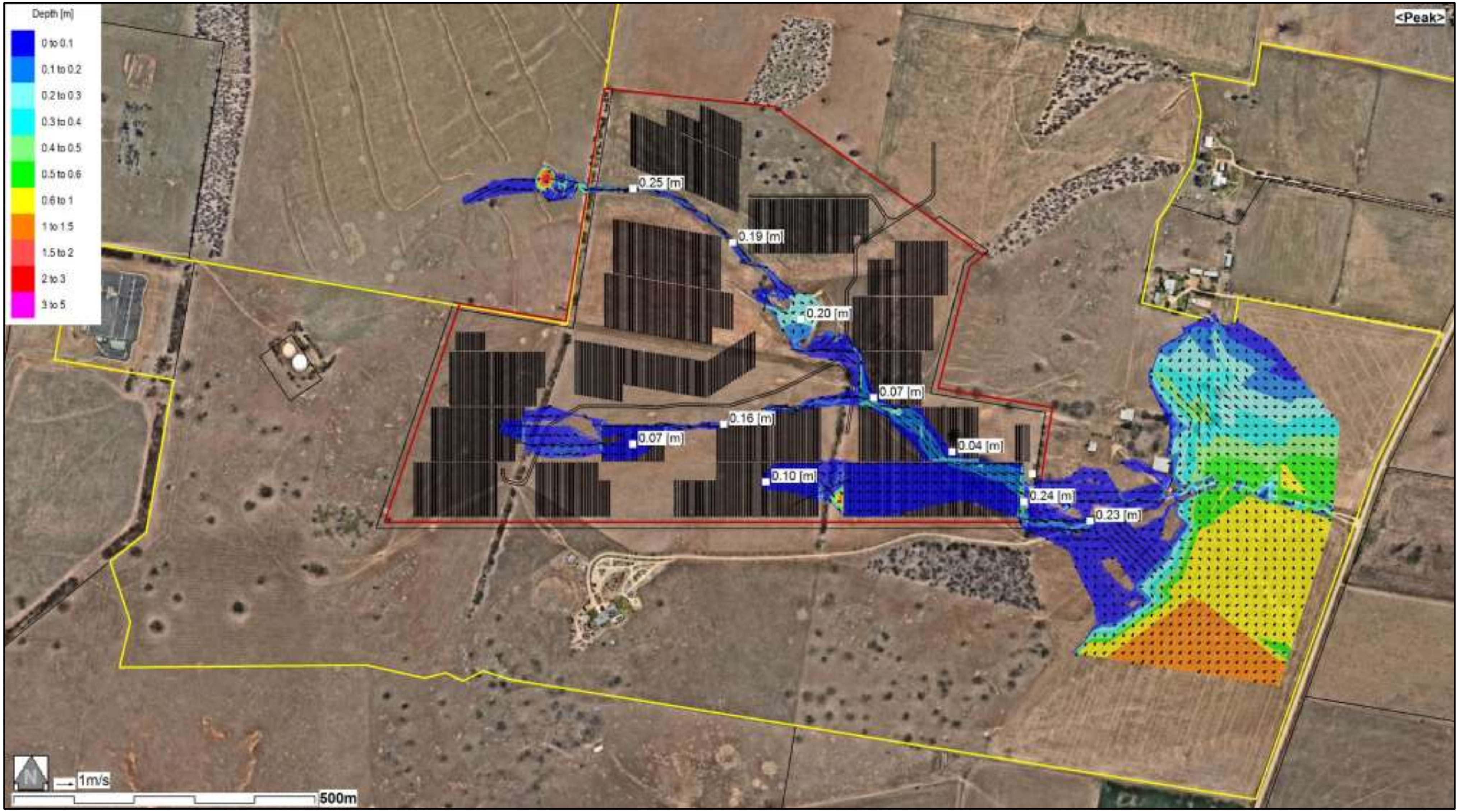

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D8 – 5%AEP Event Predicted Peak Water Surface Depths (Case D06)

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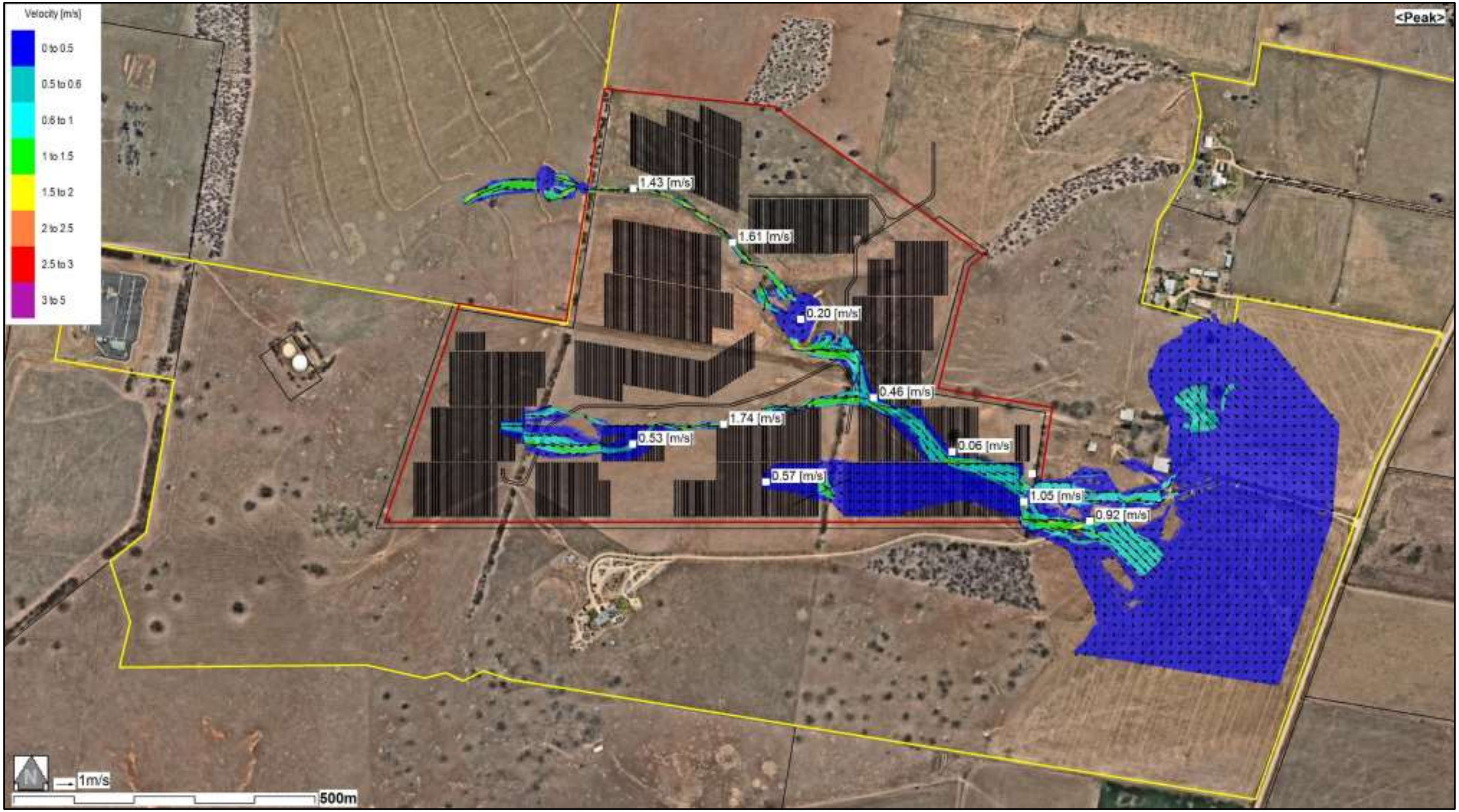

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D9 – 5%AEP Event Predicted Peak Water Surface Velocities (Case D06)

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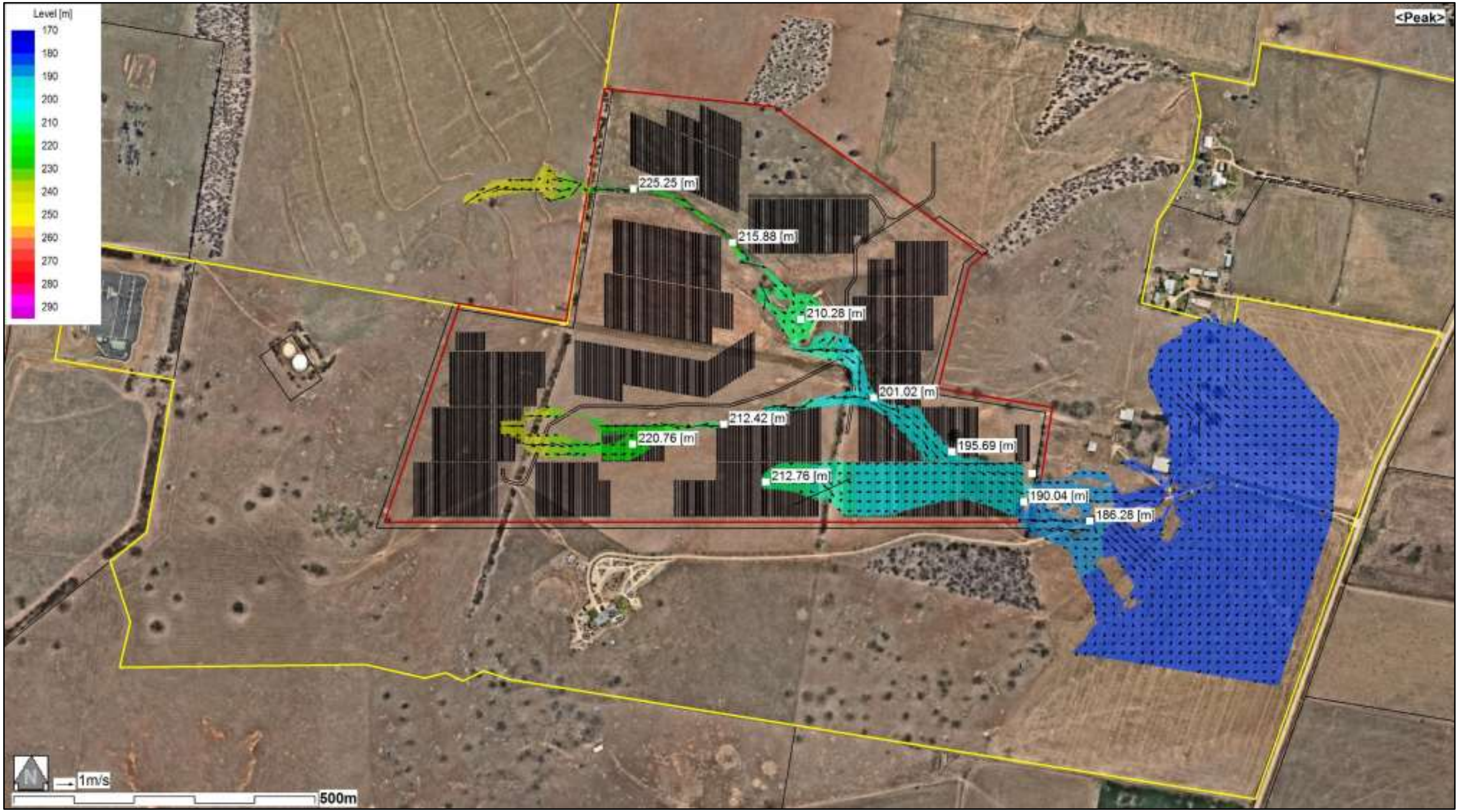

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D10 – 10%AEP Event Predicted Peak Water Surface Levels (Case D06)

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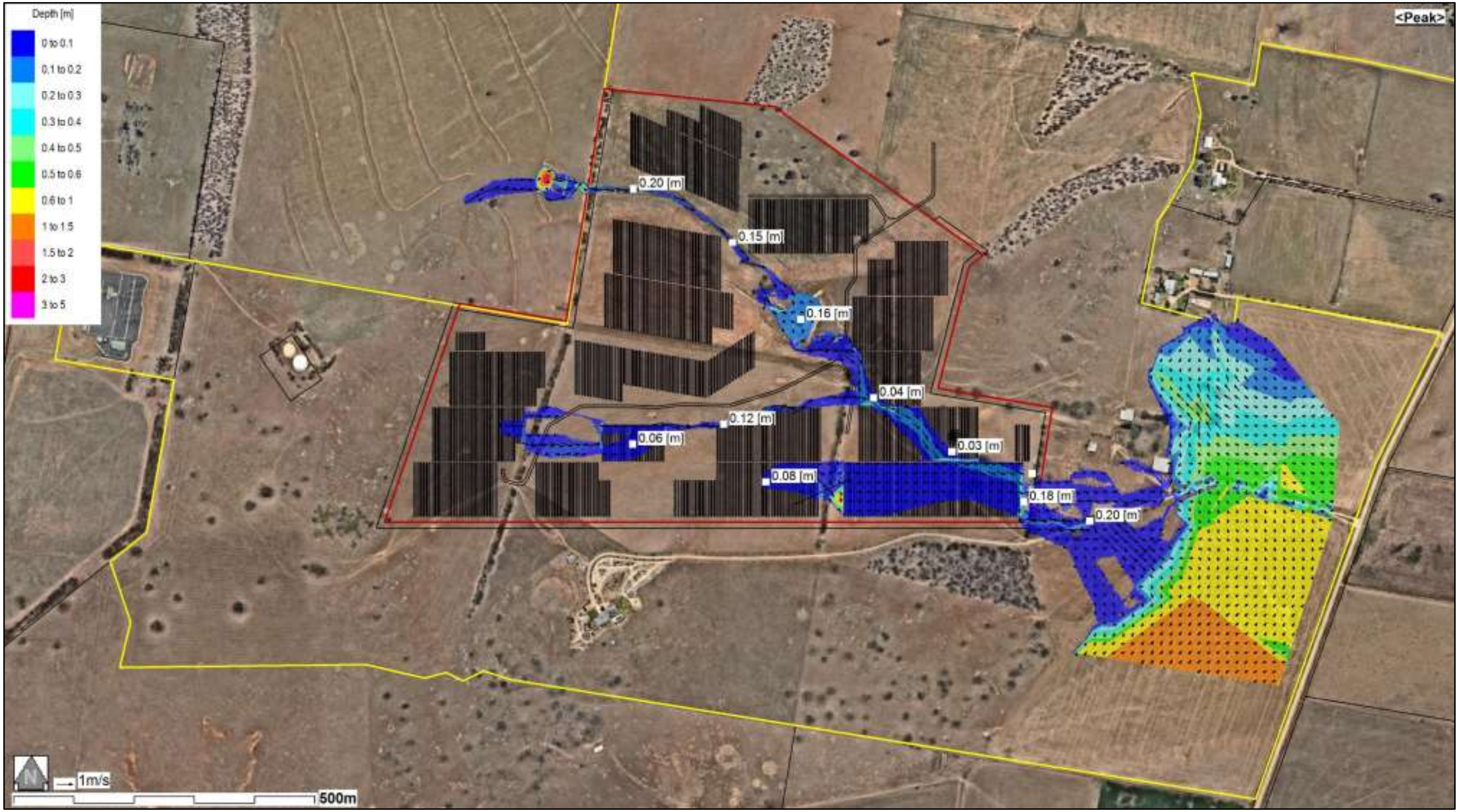

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D11 – 10%AEP Event Predicted Peak Water Surface Depths (Case D06)

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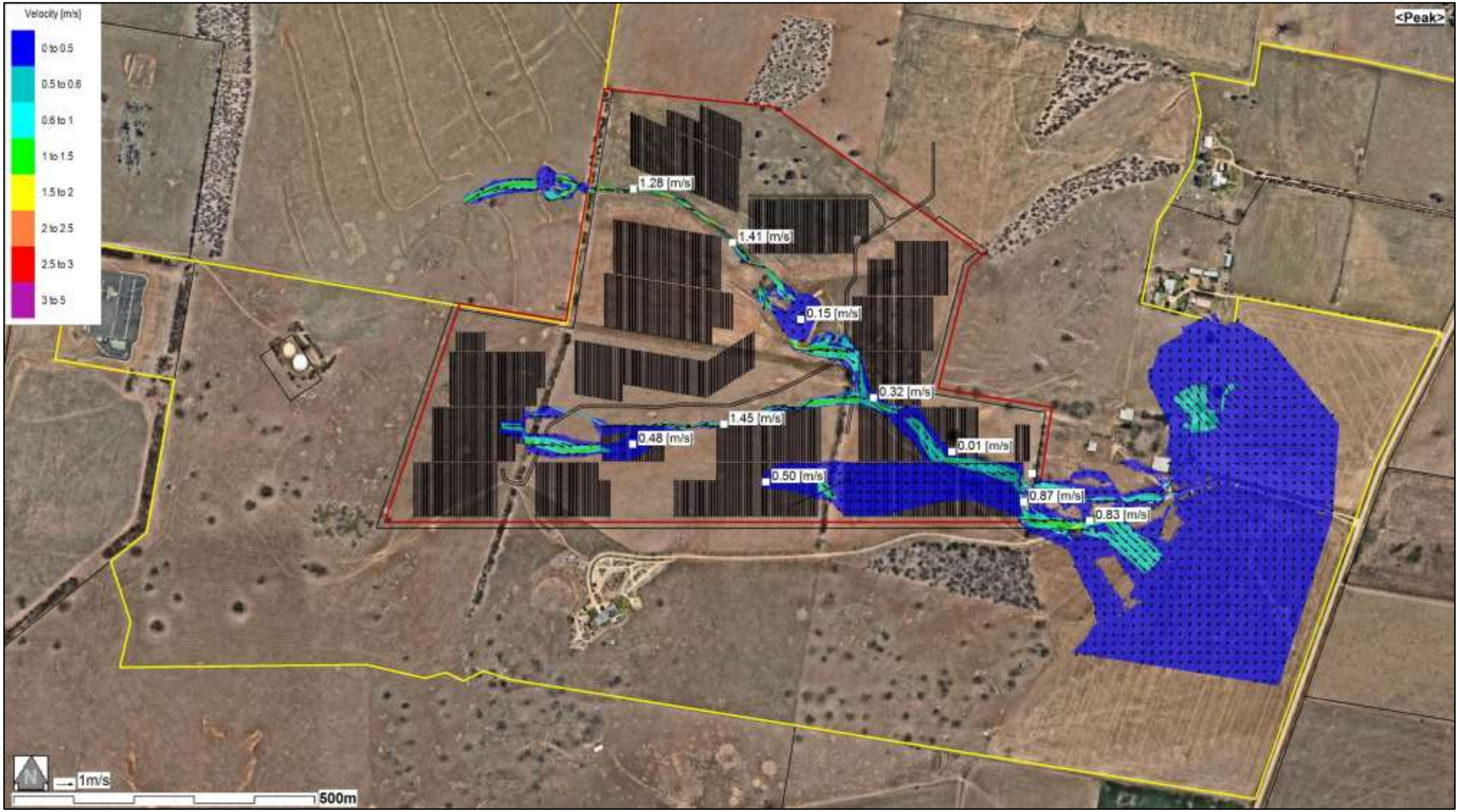

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D12 – 10%AEP Event Predicted Peak Water Surface Velocities (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
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Figure D13 – 18%AEP Event Predicted Peak Water Surface Levels (Case D06)

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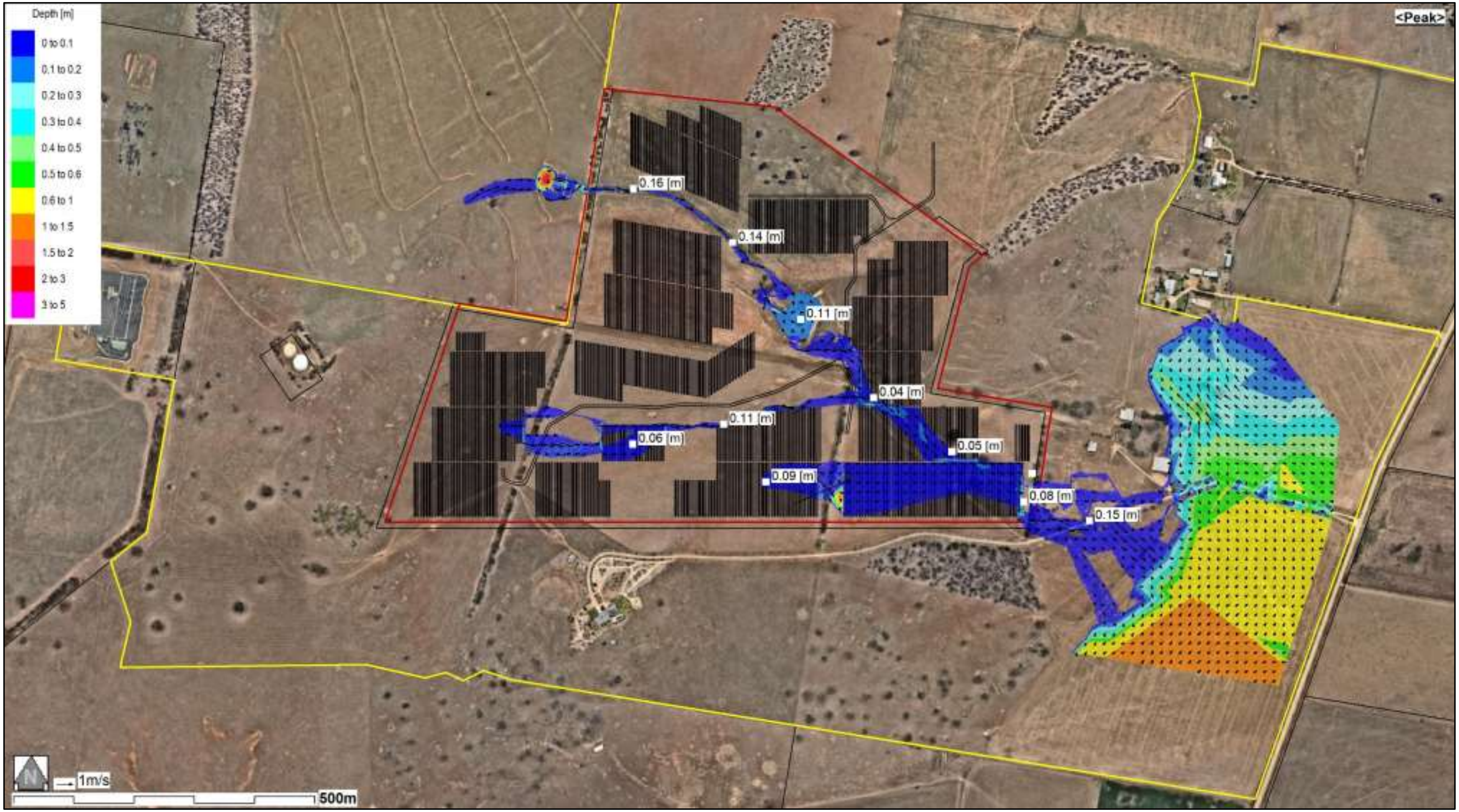

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D14 – 18%AEP Event Predicted Peak Water Surface Depths (Case D06)

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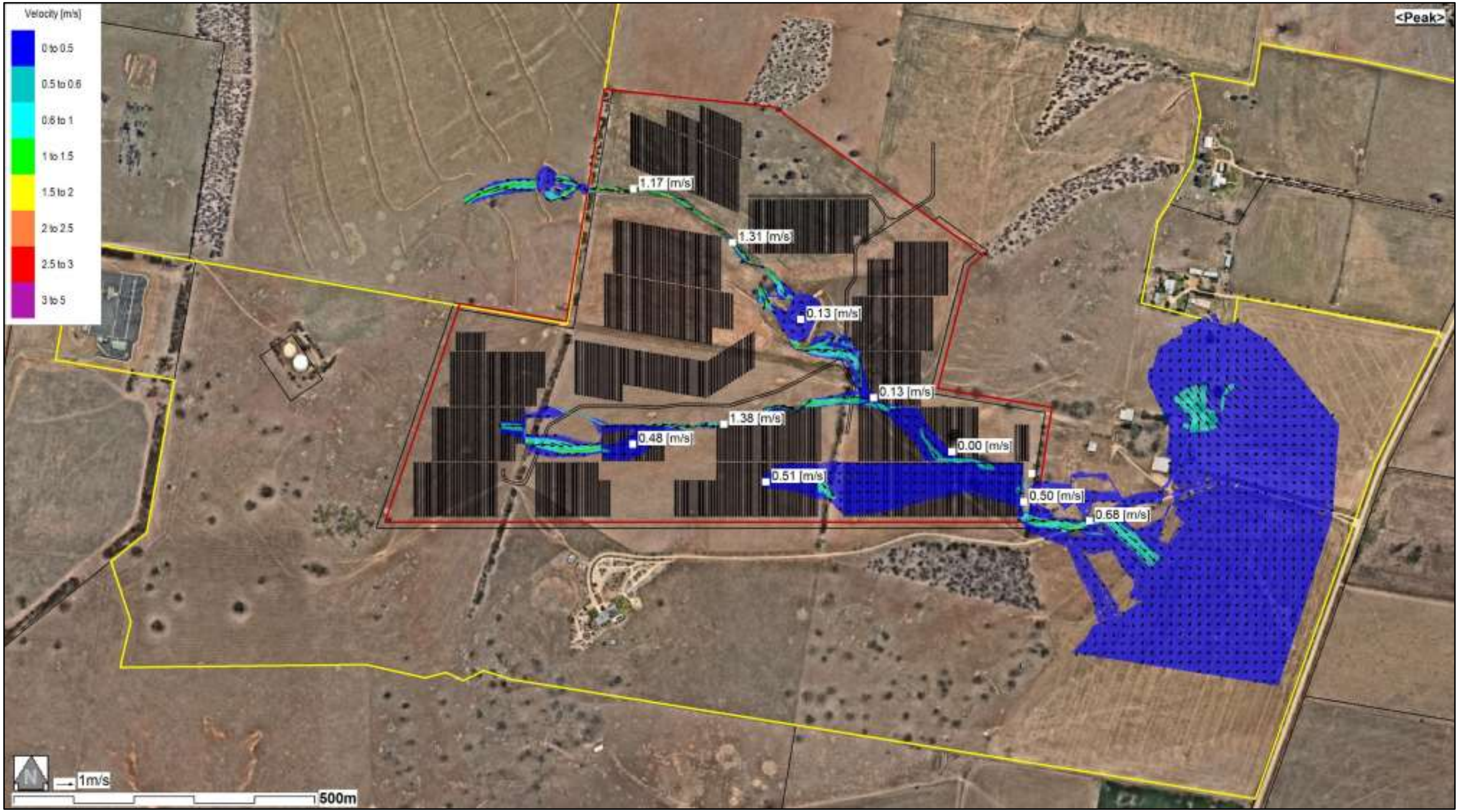

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D15 – 18%AEP Event Predicted Peak Water Surface Velocities (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D16 – 39%AEP Event Predicted Peak Water Surface Levels (Case D06)

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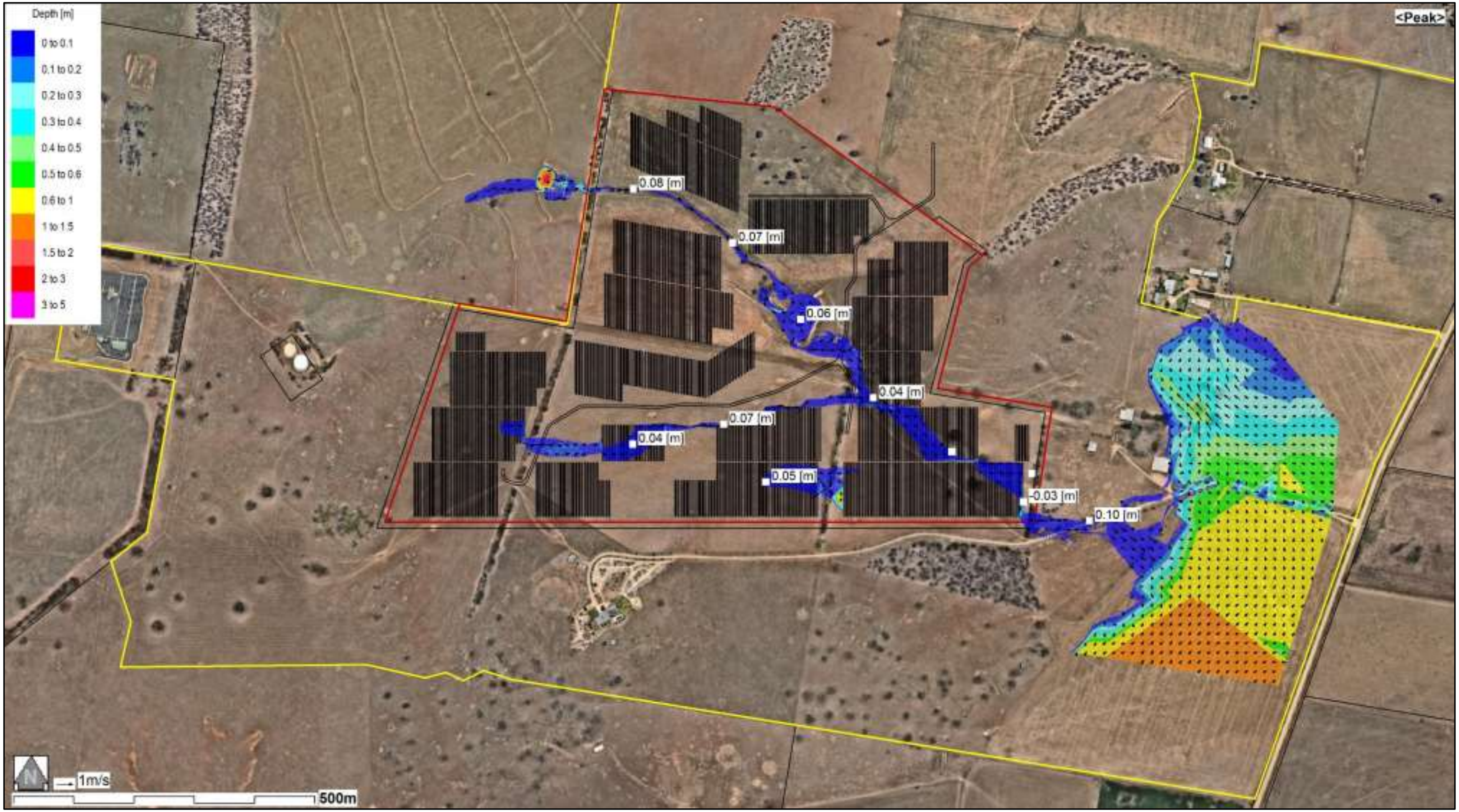

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D17 – 39%AEP Event Predicted Peak Water Surface Depths (Case D06)

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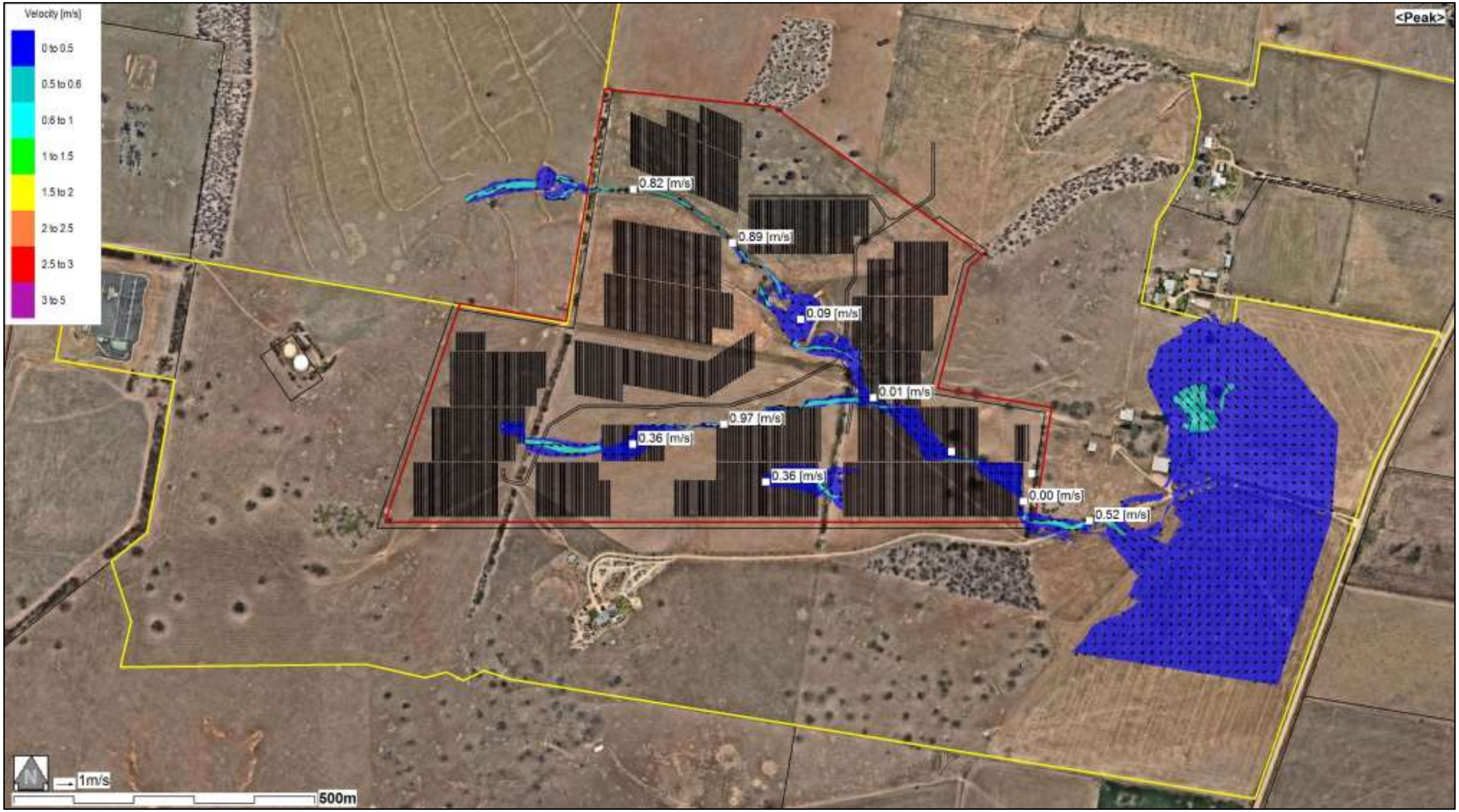

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure D18 – 39%AEP Event Predicted Peak Water Surface Velocities (Case D06)

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APPENDIX E FLOOD IMPACT MAPPING

PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure E1 – 1%AEP Event Peak Water Surface Level Impacts (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure E2 – 2%AEP Event Peak Water Surface Level Impacts (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure E3 – 5%AEP Event Peak Water Surface Level Impacts (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure E4 – 10%AEP Event Peak Water Surface Level Impacts (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure E5 – 18%AEP Event Peak Water Surface Level Impacts (Case D06)

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PROJECT: Wagga Wagga Solar Farm South
CLIENT: Terrain Solar Pty Ltd
DATE: November 2019

Figure E6 – 39%AEP Event Peak Water Surface Level Impacts (Case D06)

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