APPENDIX **H**

HYDROLOGY & FLOOD MODELLING

(SLR Report)

Ref: 610.17428-R03-v3.0
August 2018

YARRABEE SOLAR PROJECT

Environmental Impact Statement - Appendix H
Hydrology & Flood Modelling

Prepared for:

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Reach Solar énergy (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.17428-R03-v3.0	14 August 2018	Samantha Hayes	Steve Crick	Peter Georgiou
610.17428-R02-v2.0	18 July 2018	Peter Cupitt	Paul Delaney, Peter Georgiou	Suzanne Jolly
610.17428-R02-v1.0	29 June 2018	Peter Cupitt	Paul Delaney, Peter Georgiou	Suzanne Jolly

EXECUTIVE SUMMARY

This assessment of hydrology, flooding and water resources for the proposed Yarrabee Solar Project has been developed to address the requirements of the Project SEARs. The study has considered the current site land use, existing environmental conditions, and the flood behaviour in the adjacent Washpen Creek / Yanco Creek floodplain extending from the Yanco Weir in the Murrumbidgee River to Yamma Road, 3 km south of Morundah.

Overall, the nature of the Project will have a very low impact on the environment in relation to the existing behaviour of surface and ground waters, since the Project does not include any broad-scale reshaping of the landform or excavation (other than in relatively small areas associated with site facilities and the Project sub-station), has the same surface area of soils available for infiltration of rainfall, and grass cover will be progressively re-established during construction and maintained during operation of the Project to distribute runoff from the solar panels and provide erosion protection.

The Project will incorporate appropriate water management measures to mitigate potential impacts on several aspects of the environment, as described in **Table 1** in the following areas:

- Riverine flooding in Washpen Creek / Yanco Creek;
- Project site drainage and pattern of runoff to downstream properties;
- Runoff annual yield, and surface infiltration;
- Water quality of surface runoff during construction of the project, and then during operation; and
- Groundwater impacts.

Appropriate management measures and design features will be incorporated into the Project to mitigate potential impacts on the environment, and to provide appropriate management of flooding impacts on the Project. With implementation of mitigation strategies identified in **Table 1**, the environmental impact of the Project on flooding and water resources is considered to be low risk and readily manageable.

Table 1 Summary and Guide to Potential Impacts, Mitigation and Relevant Report Section

Potential Impact	Mitigation Strategy	Refer details in:
Riverine flooding – Washpen / Yanco Creeks		
Impact on Washpen Creek flows, velocities and flood levels	Since no works are proposed within the riparian corridor or below the 1% Annual Exceedance Probability (AEP) flood envelope of these creeks, there will be no change to the flows, flood levels, or velocities within Washpen Creek.	**Section 9**
Riverine flooding of Project site	Flood modelling shows that Washpen Creek would remain within the creek banks with no inundation of the Project site for flood events less than the 5% AEP (1 in 20). During a 1% AEP (1 in 100) event in the Murrumbidgee River, the distribution of flood waters into the Yanco/Washpen Creek floodplain would inundate approximately 30% of the Project site. Flooding results from surcharge of Back Creek to the north with overland floodwaters entering the property from the northeast and travelling in a meandering path to the southwestern corner. Minor surcharge of Washpen Creek occurs in the southern portion of the Project site. The proposed infrastructure does not	**Sections 4.2**

EXECUTIVE SUMMARY

Potential Impact	Mitigation Strategy	Refer details in:
	change the flow behaviour either upstream or downstream of the Project site caused by riverine flooding. The 1% AEP riverine flood would reach depths of 0.8 m, with velocities up to 0.8 m/s on the Project site. The maximum velocity and depth is within the broad overland flow path located in the central southern portion of the Project site. Apart from this small area, the flooding conditions are considered low hazard and should not affect the operation of the proposed infrastructure. A Probable Maximum Flood (PMF) event in the Murrumbidgee River would almost totally inundate the Project site, with depths between 0.1 m and 1.3 m, and velocities from 0.2 m/s to 0.8 m/s. These conditions would be considered high hazard. An area in the centre of the Project site would not be inundated, and would be suitable for refuge in an extreme flood.	
Flooding of Project site from local storms	Flood modelling confirms that the greatest impact for an equivalent AEP is experienced from riverine flooding. The catchment area directly contributing to the site is 96 km^2 and exceptionally flat, with an average slope of 0.05%. Flooding from local rainfall is more widespread and patchy, but with shallower depths and significantly slower velocities than riverine flooding with an equivalent AEP. During a 5% AEP rainfall event the shallow flat depression that meanders through the centre of the site would flow with depths up to 0.5 m, and velocities less than 0.1 m/s. Floodwaters during a 1% AEP rainfall event would reach a depth of 0.75 m with velocities up to 0.3 m/s. The greatest depths are in the central southern area. These flooding conditions are low hazard.	**Sections 4.2**
Flooding of Project site – risk to property and life	Since the site is very flat, runoff moves very slowly and at shallow depths. PV arrays will be pole mounted with the tracking system axis at least 3m above ground. Any equipment susceptible to flood damage will be elevated with freeboard above calculated flood depths. The electrical substation will be designed to be above the predicted 1% AEP flood level, with appropriate freeboard. The greatest impact is experienced from riverine flooding which provides significant warning time. The time required to reach the peak flood level from the Yanco Weir to the Project site varies between 3.5 days and 12 hours for the 5% AEP and PMF respectively. Figure 23 and Figure 25 show the maximum depth and flood envelope of flows across the project site during a 1% AEP event, and the PMF event from riverine sources. Site egress during a 1% AEP would be inadvisable, although the "velocity depth product" indicates low hazard over most of the site. During a PMF event a velocity depth product over the majority of the Project site is considered high hazard and untrafficable. Overall the risk to life is low and manageable, since, a) the flood warning time is significant; b) flood modelling has confirmed a suitable refuge area close to the centre of the Project site; and,	**Sections 4.2 and 9**

EXECUTIVE SUMMARY

Potential Impact	Mitigation Strategy	Refer details in:
	c) the Operational Environmental Management Plan for the Project will include a Flood Management Plan.	
Site drainage discharge and pattern of runoff		
Changes to pattern of runoff and discharges from site	The project design will not change the existing pattern of site overland flows within or discharging from the site. It is not intended to channelize or otherwise alter patterns of overland surface flow. PV arrays will not result in an increase in runoff since the same area of soil is available for infiltration, and vegetative groundcover will be maintained to distribute runoff. Hydrological modelling shows no significant change in runoff flows, volumes, velocities or depths of flow.	**Section 9** **Section 6.1**
Catchment yield, infiltration and harvestable rights		
Environmental flows	Other than maintaining the existing farm dam, no additional harvesting of surface water is proposed. There will be no change to low or environmental flows as a result of the project.	**Section 6.1**
Annual yield of catchment	The annual yield of runoff from the site catchments will be unchanged from the current rural activities.	**Section 6.1**
Water Quality		
Construction phase water quality	Since the existing site is essentially flat there are very low rates of erosion and sediment transport from site. No broad scale earthworks or soil disturbance are proposed, and any localised soil disturbance will be progressively revegetated such that the total area of denuded soil is minimised. If any water quality issues become evident through monitoring, then localised erosion control measures will be intensified – such as hydromulching, contour berms and localised sediment sumps. Preparation of a Construction Environment Management Plan will further detail requirements and procedures for erosion and sediment control, water quality monitoring, bunding of hydrocarbon storages (if relevant), and spill response.	**Section 5.5**
Water quality during operations	An Operational Environmental Management Plan will be prepared to detail requirements and procedures for water management. Although some areas of the site do not drain to the farm dam, the water quality in the farm dam will be representative of the whole site, and will be monitored during initial stages of development. Water quality controls will be adapted if monitoring indicates changes in water quality beyond ANZECC 2000 trigger values. Any changes will be documented in revisions to the Construction and Operational Environmental Management Plans as appropriate.	**Section 5.6**

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

PHOTOS

ATTACHMENTS

ABBREVIATIONS

AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
AR&R	Australian Rainfall & Runoff (2016)
ANZECC 2000	Australia New Zealand Guidelines for Fresh and Marine Water Quality (2000)
BoM	Bureau of Meteorology
DP&E	(NSW) Department of Planning and Environment
DPI-Water	(NSW) Department of Primary Industries - Water
EIS	Environmental Impact Statement
EC	Electrical Conductivity
EPA	(NSW) Environment Protection Authority
EPL	Environmental Protection Licence
GDE	Groundwater dependent ecosystems
IFD	Intensity Frequency Duration
NorBE	Neutral or Beneficial Effect (on water quality)
NTU	Nephelometric Turbity Units
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
SEARs	Secretary's Environmental Assessment Requirements
SRTM	Shuttle Radar Topography Mission (survey data)
SLR	SLR Consulting Australia Pty Ltd
TSS	Total Suspended Solids
VD	Product of flood velocity and depth
WSP	Water Sharing Plan

1 Introduction

This section provides an overview of the Project, describes the study requirements, the study methods, and structure of the report.

1.1 Purpose of this Assessment

This surface water assessment provides an environmental assessment of the surface and groundwater aspects of the Yarrabee Solar Project. The assessment considers mainstream flooding and local site hydrology, as well as issues during the construction, operation and decommissioning phases of the project.

1.2 Project Overview

The proposal is for a 900 MWac solar farm occupying 2,600 ha within an overall 3,000 ha Project site, approximately 23 km southwest of Narrandera in Western NSW. The site is presently used for agriculture and is bounded to the north, south and west by very flat, grassy rural landscapes.

Key features of the project that have been considered within this assessment are:

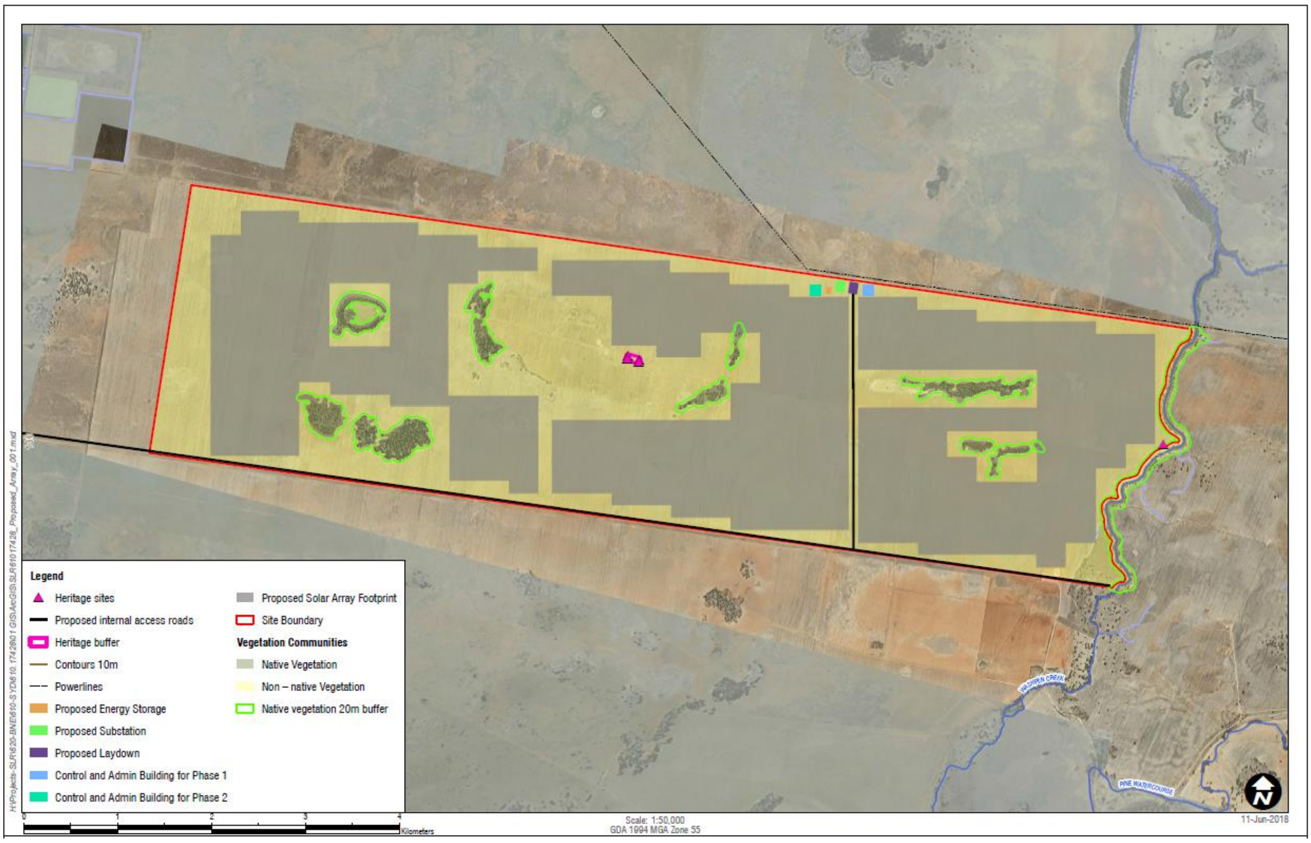
- Solar arrays mounted on poles, with associated underground cabling;
- Electrical substation and connection to transmission line;
- Potential battery storage area;
- Construction of site access tracks;
- Site facilities/office; and
- Temporary laydown area during the construction phase.

The Project will likely be developed in stages, with the number of stages to be constructed dependent on factors including:

  - The contractual obligations for the purchase of electricity by one or more third parties; and
  - The capacity of the high voltage transmission network to which the Project will be connected for the export of generated electricity.

An indicative layout for the 900 MWac Project is presented in **Figure 1**.

Figure 1 Indicative Project Layout



1.3 Report Overview

A summary of information within each section of this assessment is outlined in **Table 2**.

Table 2 Report Overview

Section No.	Content
Section 1	Introduction
Section 2	Describes relevant (existing) site climate information, including rainfall and evaporation, and design assumptions for climate change impacts.
Section 3	Describes the existing site water environment, topography, drainage patterns and site soil characteristics.
Section 4	Describes relevant features of the Project and water management issues.
Section 5	Describes the objectives for water quality and river flows, the potential risks to water quality during the Project construction and operational phases, and mitigation measures that will be implemented to safeguard water quality.
Section 6	Discusses effect of the Project on rainfall infiltration to site soils, the catchment yield, environmental flows, and harvestable rights.
Section 7	Describes the existing groundwater regime, presence of groundwater dependent ecosystems, and how the proposal will impact on groundwater.

Section No.	Content
Section 8	Describes the existing regime of riverine flooding, the impact of the project on flood levels and flows, and how the project may be impacted by flooding.
Section 9	Describes the behaviour of surface water flows across the site during rainfall flooding events.
Section 10	Describes how water will be sourced and used during the Project construction and operational phases.
Section 11	Monitoring, Licensing and Reporting - describes how the project will monitor and report on environmental management during the construction and operational phases.
Section 12	References

Attachments A-D supplement this report and provide details of the flood envelopes over the site and the immediate surrounds from both riverine and local rainfall sources for the range of magnitude storms pertinent to satisfying the SEARs.

1.4 Secretary's Environmental Assessment Requirements (SEARs)

The Secretary of the NSW Department of Environment & Planning (DPE) issued Secretary's Environmental Assessment Requirements (SEARs) for the Project, dated 19 April 2018. The SEARs and where they are addressed within this report are outlined in **Table 3**.

Table 3 SEARs and Relevant Report Section

SEARs Requirement	Where Addressed
A description of the existing environment	**Section 2** describes the climate and Section 3 the topography, soils and drainage patterns within the catchment and local to the site
An assessment of the likely impacts of all stages of development	**Sections 4, 8 and 9** describe the potential impacts of floodwaters on the proposed development during all stages and the change in afflux at the property boundaries as a result of the development during these phases.
A description of the measures that would be implemented to avoid, mitigate and/or offset the impacts of the development (including draft management plans for specific issues as identified below);	**Sections 4** identifies the measures required to offset the impacts of the proposed development to the preserved environment and adjoining properties
An assessment of the likely impacts of the development (including flooding) on surface water and groundwater resources (including Washpen Creek, Yanco Creek, drainage channels, wetlands, riparian land, floodplains, key fish habitat, groundwater dependent ecosystems and acid sulfate soils), related infrastructure, adjacent licensed water users and basic landholder rights, and measures proposed to monitor, reduce and mitigate these impacts.	**Sections 4, 8 and 9** describe the impact of the development on surface water from riverine and local catchment influences.
Details of water requirements and supply arrangements for construction and operation	Construction and operational phase water supply are discussed in **Section 0**

SEARs Requirement	Where Addressed
A description of the erosion and sediment control measures that would be implemented to mitigate any impacts in accordance with Managing Urban Stormwater: Soils & construction (Landcom 2004);	The strategy for erosion and sediment control is described in **Section 5.5** and **Section 5.6**.

1.5 Other Government Authority Requirements

1.5.1 Office of Environment & Heritage (OEH), DPI & EPA

The requirements of other government agencies, and where addressed are shown in **Table 4**.

Table 4 Other Regulatory Body Requirements and Relevant Report Section

Authority / Requirement	Where Addressed
OEH Requirements	
Map the following features relevant to flooding as described in the Floodplain Development Manual (NSW Government 2005) including: a) Flood prone land b) Flood planning area, the area below the flood planning level, c) Hydraulic Categorisation (floodways and flood storage areas), and d) flood hazard. Describe the flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 5%, and 1% AEP flood levels and probable maximum flood, or an equivalent extreme event The EIS must model the impact of the proposed development (including fill) on the flood behaviour under the following scenarios a) Current flood behaviour (5% AEP, 1% AEP and PMF) plus 0.5% and 0.2% AEP events as proxies assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	**Attachments A to J** show the flood prone land, the area below the flood planning area, hydraulic categorisation and flood hazard for the pre and post developed site during the 5% AEP, 1% AEP, 0.5% AEP and the PMP events. Analysis of climate change indicates that the 0.5% AEP event provides an adequate proxy for climate change proxy for the future 1% AEP event, so that modelling of the 0.2% AEP event is unnecessary.
Modelling in the EIS must consider and document: a) Existing council flood studies in the area and examine consistency of flood behaviour documented in these studies b) The impact on existing flood behaviour for a full range of flood events including up to the PMF c) Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affectation of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards, and hydraulic categories	A flood study was performed by Lyall and Associates in 2015 in the Murrumbidgee catchment 15km north. Jacobs completed a flood study for the Morundah catchment 14.3km south. **Section 3** discusses the contribution of these reports in the calibration process. Modelling the full range of events from the 5% AEP to the PMP pre and post development can be seen in **Attachments A to J**.
Relevant provisions of the NSW Floodplain Development Manual 2005.	A Flood Management Plan will be prepared for the site, to address flood awareness, flood warning, limitations on safe egress and flood refuge in extreme events. Further information is contained in **Sections 6, 8 and 9**.
The EIS must assess the impacts on the proposed development on flood behaviour, including:	The project will not alter flood behaviour. A Flood Management Plan will be prepared for

Authority / Requirement	Where Addressed
a) Whether there will be detrimental increases in the potential flood affectation of other properties, assets and infrastructure. b) Consistency with Council Floodplain Risk Management Plans. c) Consistency with any Rural Floodplain Management Plans. d) Compatibility with the flood hazard of the land. e) Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land. f) Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site. g) Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses. h) Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council. i) Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council. j) Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent extreme flood event). These matters are to be discussed with and have the support of Council and the SES. k) Any impacts the development may have on the social and economic costs to the community as a consequence of flooding.	the site. **Sections 6, 8 and 9** describe the flooding regime.
DPI Requirements	
DPI requested that the EIS include, 'An assessment of whether there are likely to be any significant impacts on listed aquatic threatened species, populations or ecological communities scheduled under the Fisheries Management Act 1994. Please note that the current mapping for all threatened species is located on the website: http://www.dpi.nsw.gov.au/fishing/speciesprotection/threatened-species-distributions-in-nsw/freshwater-threatened-speciesdistribution-maps.'	The project site discharges westwards to irrigation channels, and does not discharge to Washpen or Yanco Creeks. Water quality will be monitored against ANZECC 2000 default trigger values. The Project will not have any adverse impact on aquatic species in those natural watercourses.
EPA Requirements	
The EPA advised that 'the proposed activity is not a scheduled activity under the Protection of the Environment Operations Act 1997 and the solar park project does not require an Environment Protection Licence. Under the Protection of the Environment Operations Act 1997 Narrandera Shire Council will be the Appropriate Regulatory Authority for pollution control and environmental management issues for this proposal should it be approved'.	Provisions of the POEA Act relating to water quality during the construction and operational phases are addressed in **Sections 5.5, 5.6 and 11**.

1.6 Relevant Legislation

The following NSW legislation has been considered:

- Protection of Environment Operations Act 1997
- Environmental Planning and Assessment Act 1979
- Fisheries Management Act 1994
- Water Management Act 2000

1.7 Assessment Methodology

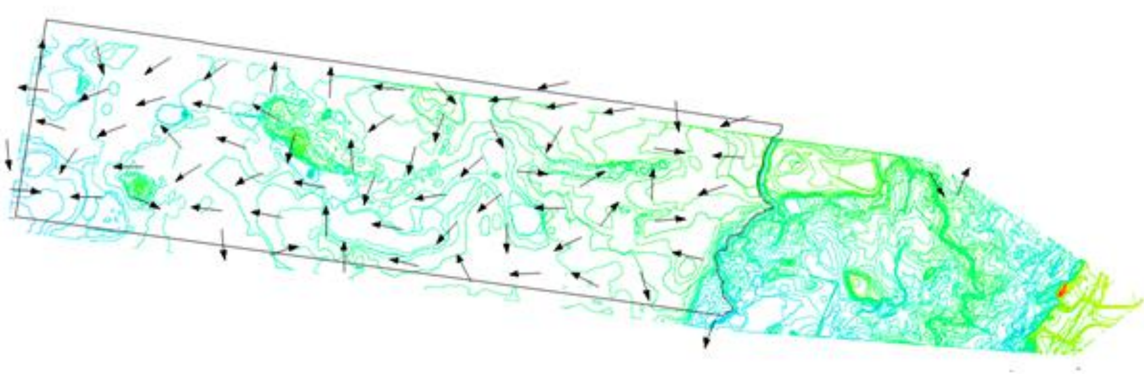
1.7.1 Site Visit

SLR conducted a site visit during April 2018 and obtained information on site soils, catchment wide vegetation, creek water levels and anecdotal information from the current occupier and long standing residents.

1.7.2 Topographical Survey

Topographical survey and imagery of the site using LiDAR methods was carried out by Fyfe in 2017, with supplementary survey of the adjacent floodplain in April 2018. The extent of survey includes the project site, its immediate downstream environment, and the adjacent floodplain of Washpen and Yanco Creeks. The extent of LiDAR survey, the Project site boundary and the localised flow directions are shown in **Figure 2**.

Figure 2 Extent of LiDAR Survey, Site Contours and Localised Flow Direction



Additional topographic data beyond the extents of the Fyfe survey was obtained from the Shuttle Radar Topography Mission (SRTM) data, for the purpose of identifying catchment watersheds beyond the LiDAR data extent.

1.7.3 Assessment of Existing Environment

A desktop assessment of the site was undertaken and relevant publicly available information about the site was reviewed and assessed.

1.7.4 Hydrology and Flooding

Hydrology and flood behaviour of the adjacent watercourses and flow of surface water across the project site have been carried out in accordance with Chapter 6, Book 1 of the online version of the *Australian Rainfall and Runoff 2016* (ARR 2016) guideline, using the XP-SWMM2D software.

Refer: (http://book.arr.org.au.s3-website-ap-southeast-2.amazonaws.com/#b1_ch6_e_fismf)

This study references a previous flood study of the Murrumbidgee River at Narrandera (*Narrandera Flood Study Review and Levee Options Assessment, Lyall & Associates, October 2015)*, and a recent flood frequency analysis performed by Jacobs on the Colombo and Yanco Creeks at Morundah (*Flood Studies for the Towns of Urana, Morundah, Boree Creek, Oaklands and Rand, Jacobs, November 2017).*

1.7.5 Water Quality Assessment

There are no available water quality measurements for the site. Collection of water quality samples is problematic due to the lack of defined watercourses, and disturbance from existing agricultural land-uses. Water quality targets have been established based on the NSW Water Quality Objectives, consideration to published environmental objectives for the Yanco Creek, and the ANZECC 2000 water quality trigger values.

1.7.6 Environmental impacts during construction and operation

Potential impacts on the environment from the project during the construction and operational phases, and the development of appropriate mitigating measures have been assessed on specifics of the development proposal, available site knowledge and consideration of typical potential impacts from projects of a similar nature.

1.7.7 Cumulative Impacts

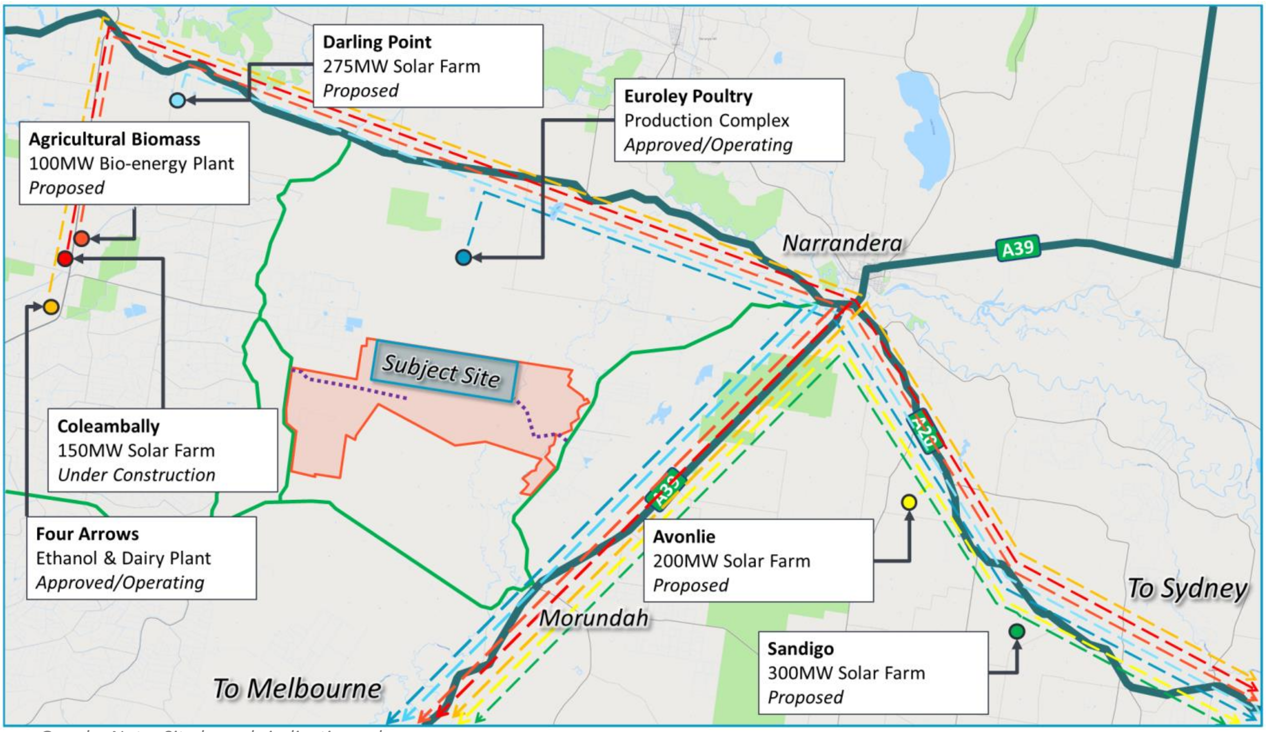
Other major projects in the region need to be considered in terms of cumulative impact on flood flows and flood behaviour. These projects are shown in **Figure 3**, and include:

- Avonlie Solar Farm
- Sandigo Solar Project
- Euroley Poultry Complex

Most of these projects are outside the catchment for the Yanco Creek system, and are not considered to have any potential cumulative impact.

The Euroley Poultry Production Complex is within the catchment but will not have any impact. Hydrological calculations contained within the EIS for the Euroley project indicate that the complex will have zero discharge since dams have been sized at 170% of the estimated runoff volume from a 100-year 72-hour rainfall.

Figure 3 Surrounding Projects and Status



Source: Google, Note: Site bounds indicative only.

2 Climate Information

This section describes the existing site rainfall and evaporation, and design assumptions for climate change impacts.

2.1 Rainfall and Evaporation

The closest Bureau of Meteorology (BoM) station to the project site recording daily rainfall is Narrandera Airport AWS. This station is approximately 23 km to the northeast of the Project site, and has 51 years of rainfall records. Rainfall for the Project site has been based on BoM data at this station.

Narrandera Airport AWS does not maintain evaporation data. The nearest station with evaporation data is at the Wagga Wagga Agricultural Institute, which has been used for estimation of evaporation at the Project site.

Table 1 shows the distances to, and lengths of data record, at each of these stations.

Table 1 - Rainfall Stations within the Surrounding Area

Station	Station Number	Distance from Project	Data available since:
Narrandera Airport AWS	74148	23 km	1967
Wagga Wagga Agricultural Institute	73127	80 km	1898

2.1.1 Seasonal Distribution of Rainfall and Fluctuations between Wet and Dry Years

The average yearly rainfall at Narrandera Airport AWS is 437mm. There is not a substantial seasonal variance in rainfall during average years, with the driest months in February, March April having around 10% less rainfall than the wettest months from June to December. Average monthly and annual average rainfall depths are shown in **Table 2**.

Table 2 - Average Monthly Rainfall Depths at Narrandera Airport AWS

Month	Average Rainfall (mm)	Month	Average Rainfall (mm)
January	34.7	July	37.2
February	35	August	39.9
March	30.5	September	35.9
April	34	October	40.4
May	39.7	November	34.7
June	38.5	December	37.3
Average Yearly Rainfall		**437.3 mm**	

There are considerable fluctuations in the depth of rainfall from year to year. The lowest recorded annual rainfall was 172 mm, and the highest annual rainfall was 776 mm. In particular there are very large differences in summer rainfall between dry and wet years. For example, the 10-percentile rainfall in February is 0.8 mm, while the 90-percentile rainfall is 90 mm.

Rainfall statistics in **Table 5** show the mean and annual monthly rainfalls, as well as information for lowest, median and highest recorded months/years, and the 5th, 10th, 90th and 95th percentile months/years.

Table 5 Detailed Monthly and Annual Rainfall Depths

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Lowest	1.6	0.0	0.0	0.8	5.2	1.0	2.2	1.0	1.0	0.0	0.4	0.0	172.0
5-percentile	3.4	0.0	0.2	2.8	6.4	10.4	7.1	4.8	5.8	7.0	4.7	2.3	260.7
10-percentile	4.6	0.8	2.9	4.8	8.9	11.0	8.4	12.1	10.5	9.3	7.1	4.1	290.8
Median	25.7	25.0	22.3	24.5	31.0	33.8	34.8	37.6	30.6	30.8	30.0	30.2	421.9
90-percentile	66.3	90.4	59.8	70.4	89.8	76.0	64.0	71.8	71.0	85.1	60.9	82.1	628.1
95-percentile	102.3	108.0	93.6	88.3	103.9	84.4	70.7	78.7	88.2	96.8	72.0	99.4	641.9
Highest	156.0	162.2	155.2	170.5	151.8	118.5	82.7	83.4	105.0	136.4	184.1	139.2	775.8
Mean	34.7	35.0	30.5	34.0	39.7	38.5	37.2	39.9	35.9	40.4	34.7	37.3	437.3

2.1.2 Evaporation

The closest BoM station to the Project recording daily evaporation is Wagga Wagga Agricultural Institute where daily Class 'A' Pan Evaporation has been recorded since 1898. Evaporation in site water bodies has been assumed to be 75% of the Class 'A' Pan Evaporation depths, due to corrections for temperature in deeper waterbodies. The average monthly Class 'A' Pan Evaporation at Wagga Wagga Agricultural Institute, site water body evaporation and monthly rainfall depths are compared in **Table 6**.

Table 6 Average 'A' Pan Evaporation at Wagga Wagga Agricultural Institute

Month	Average Class 'A' Pan Evaporation (mm)	Water Body Evaporation (mm)	Average Monthly Rainfall (mm)
January	285.2	213.9	34.7
February	228.8	171.6	35
March	198.4	148.8	30.5
April	117.0	87.75	34
May	58.9	44.2	39.7
June	42.0	31.5	38.5
July	37.2	27.9	37.2
August	55.8	41.9	39.9
September	84.0	63	35.9
October	136.4	102.3	40.4
November	198.0	148.5	34.7
December	272.8	204.6	37.3
Annual Average	**1714.5**	**1285.9**	**437.3**

As can be seen in **Table 6** , evaporation always exceeds rainfall with the exception of July where evaporation is similar to average rainfall.

Data for Existing Rainfall

Intensity Frequency Duration (IFD) information for the site was sourced from the Bureau of Meteorology (BoM) website (2016 IFD data). Rainfall depths (mm) for various AEP's and durations are shown in **Table 7** below.

Table 7 BoM 2016 Rainfall Depths – Frequent to Rare Storms

Duration	Annual Exceedance Probability (AEP)				
	20%	10%	5%	2%	1%
30 min	17.5	21.0	24.5	29.4	33.3
1 hour	22.4	26.8	31.4	37.7	42.7
2 hour	27.9	33.5	39.1	46.8	53.0
3 hour	31.6	37.8	44.1	52.8	59.6
6 hour	38.9	46.3	53.8	64.1	72.3
12 hour	47.5	56.2	65.0	77.2	86.7
24 hour	57.0	67.1	77.3	91.5	103
48 hour	66.3	77.9	89.6	106	119
72 hour	71.2	83.7	96.1	114	127
96 hour	74.3	87.3	100	118	132
120 hour	76.6	90.0	103	122	136
144 hour	78.4	92.0	105	124	138
168 hour	79.9	93.6	107	126	140

2.2 Climate Change and Effect on Rainfall

There is now widespread acceptance that human activities are contributing to observed climate change (global warming) - refer *Climate Change in Australia* website (https://www.climatechangeinaustralia.gov.au).

Climate change has the potential to increase the prevalence and severity of rainfall extremes, and needs to be considered in flood planning for long term projects. *Climate Change in Australia* states that for the Murray Basin region:

- There is very high confidence in continued substantial increases in projected mean, maximum and minimum temperatures, with a corresponding decline in mean annual rainfall depths; and
- There is high confidence that there will be future increase in the intensity of extreme rainfall events.

In a warming climate, rainfall depths in extreme events are expected to increase mainly due to a warmer atmosphere being able to hold more moisture (Sherwood et al., 2010). Since the facility has a long design life, climate change may be significant. For the purpose of this assessment, a 50-year design life was adopted for the facility, rounded to the year 2070.

Australian Rainfall and Runoff (ARR 2016) identifies two alternative methods to estimate the impact of climate change on rainfall depth.

Simplified Method

The first Simplified Method incorporates the effects of climate change in design rainfall and flood estimation by modelling of the 0.5% (1 in 200) AEP and 0.2% (1 in 500) AEP events in lieu of the 1% AEP event. For a 24-hour rainfall event this would represent an increase in rainfall of 12% and 28% respectively. This provides a convenient approach suitable for small sites, but is not considered suitable for the Project site.

Detailed Assessment

The second method involves a more detailed assessment of increased rainfall intensity based on predictive modelling of temperature increases sourced from the *Climate Change in Australia* website and applying a 5% change in design rainfall per degree of global warming (Equation 1.6.1 of ARR 2016). Representative Concentration Pathways (RCPs) are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its Fifth Assessment Report (AR5) in 2014. A conservative high emission RCP 8.5 climate change scenario and intermediate scenario RCP 4.5 have been considered for the year 2070. The climate change predictions are summarised in **Table 8**, and the outcomes summarised below for RCP 8.5 and RCP 4.5:

- For the 48 climate models in RCP 8.5, 67% predicted temperature increases in the Hotter interval (1.5°C to 3°C) while 33% predicted temperature increases in the Much Hotter interval (greater than 3°C).
- For the 46 climate models in RCP 4.5, 32% predicted temperature increases in the Warmer interval (0.5°C to 1.5°C), 65% in the Hotter interval (1.5°C to 3°C), and 15% in the Much Hotter interval (greater than 3°C).

Table 8 Murray Basin Climate Futures – Summary of Data for Year 2070

RCP	No of Input Climate Models	Slightly Warmer > 0.5°C	Warmer 0.5°C to 1.5°C	Hotter 1.5°C to 3.0°C	Much Hotter > 3.0°C
RCP 2.6	29	2	25	2	0
RCP 4.5	46	1	15	30	7
RCP 6.0	22	0	4	18	0
RCP 8.5	8.5	0	0	32	16

Considering the range of outcomes from the climate change models, it is apparent that there is a high level of confidence that temperatures will increase, and for the more conservative higher RCP models (RCP 6.0 and RCP 8.5) it appears likely that the temperature increase will be within 1.5°C to 3.0°C range.

Based on this information, a conservative temperature increase for the project site of 2.5°C is considered suitable for estimating rainfall intensity increases.

A rate of 5% per 1°C (Equation 1.6.1 of ARR 2016) results in a 12.5% increase in rainfall intensity.

Adopted Climate Change Rainfall

The two methods of estimating increase in rainfall associated with climate change are compared in **Table 9**.

Table 9 Comparison of Climate Change Rainfall Increases

Adjustment Method	Event Duration	Rainfall Depth, 24 hour duration	Comment
No adjustment	2016 Rainfall – 1% AEP	99mm	Baseline
Method 1	2016 Rainfall for 1 in 200 (0.5%) AEP	115mm (+12.0%)	Adopted for sensitivity analysis
Method 1	2016 Rainfall for 1 in 500 (0.2%) AEP	132mm (+14.4%)	Not used
Method 2	2016 Rainfall for 1% AEP + 12.5% increase	115.8mm (+12.5%)	Similar to Method 1 for 1 in 200 (0.5% AEP)

Since the estimated increase in rainfall intensity due to climate change from Method 2 is very similar to the 0.5% AEP rainfall event, this event was adopted to examine the effect of climate change on the Project.

2.3 Design Rainfall - Rare and Extreme Events

2.3.1 Influence of the Murrumbidgee River

The size of Murrumbidgee River catchment dwarfs the size of the local catchment of the Yanco Creek system, and therefore the distribution of flow from the Murrumbidgee dominates the flow in Yanco Creek and its anabranches including Back and Washpen Creeks. The lag time between the flood peak at Morundah to the south of the Project site and the flood peak from the Murrumbidgee River for the flood event of March 2012 was more than one week, *Jacobs 2017*.

Rainfall events in the broader Murrumbidgee catchment and localised rainfall coincident with arrival of the flood peak are therefore almost completely independent. For this reason an X% AEP in the Murrumbidgee River and an X% AEP in the Yanco Creek catchment have been modelled separately.

Flooding has been analysed for the following two independent scenarios:

- an X% AEP flood event in the Murrumbidgee River with an overtopping of the Yanco offtake and flooding of the Yanco Creek system; and
- an X% AEP rainfall event centred at the Project site coincident with a 20% AEP event in the Murrumbidgee River.

In the above, X is the 5%, 1%, 1 in 200 (0.5%) AEP and PMP events.

2.3.2 Very Rare Rainfall Events (1:200 and 1:500 AEP)

Estimates of Very Rare storms are derived using extrapolation beyond observed events. They are derived from at-site frequency analysis using rainfall depths corresponding to the specified design probability. The method adopted for deriving the rare design rainfalls is based on the data and method adopted for the more frequent design rainfalls but places more weight on the largest observed rainfall events which are of most relevance to rare design rainfalls.

ARR 2016 recommends the effects of climate change be assessed using design rainfall events that fall into the Very Rare category of 0.5% (1 in 200) and 0.2% (1 in 500) AEP. **Table 10** lists the local rainfall depths for a range of storm durations between 24 and 168 hours.

Table 10 BoM 2016 Rainfall Depths – Very Rare Storms

Duration	AEP	
	0.5% (1 in 200) (mm)	0.2% (1 in 500) (mm)
24 hour	115	132
48 hour	130	147
72 hour	141	159
96 hour	147	167
120 hour	151	172
144 hour	153	174
168 hour	153	174

2.3.3 Extreme Rainfall Events (PMP)

The theoretical definition of the Probable Maximum Precipitation (PMP) is *"the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of year"* (ARR 2016*)*. Estimates of the PMP rainfall have been developed by the Bureau of Meteorology (BoM).

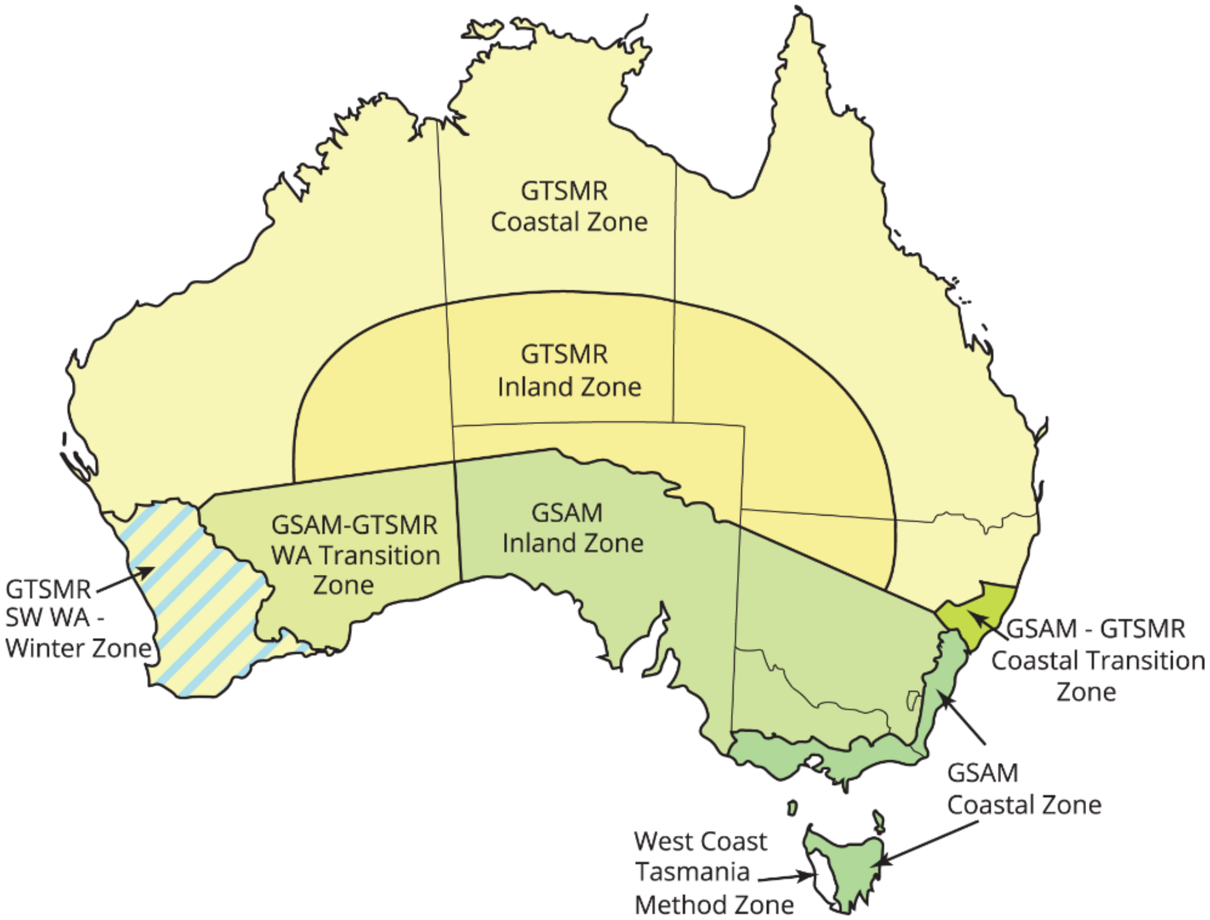
There are two generalised methods which will apply to this site, namely;

(1) The Generalised Short Duration Method (GSDM) method is used for durations up to six hours and areas less than 1000 km^2. The GDSM applies to a localised PMP storm centred over the site. This will not take into consideration flood flows from riverine sources such as the Murrumbidgee River.

(2) The Generalised Southeast Australia Method (GSAM) is used for durations up to 96 hours and areas up to 100,000 km^2 for the region of Australia where the tropical storms are not the source of the greatest rainfall depths. The GSAM will apply to a PMP in the Murrumbidgee catchment upstream of the site resulting in surcharging of the Murrumbidgee River at the Yanco Weir to flood the site.

Figure 4 shows the relevant GSAM zones.

Figure 4 Probable Maximum Precipitation Method Zones



Source: ARR 2016

2.3.4 Case 1 – GDSM (local PMP event)

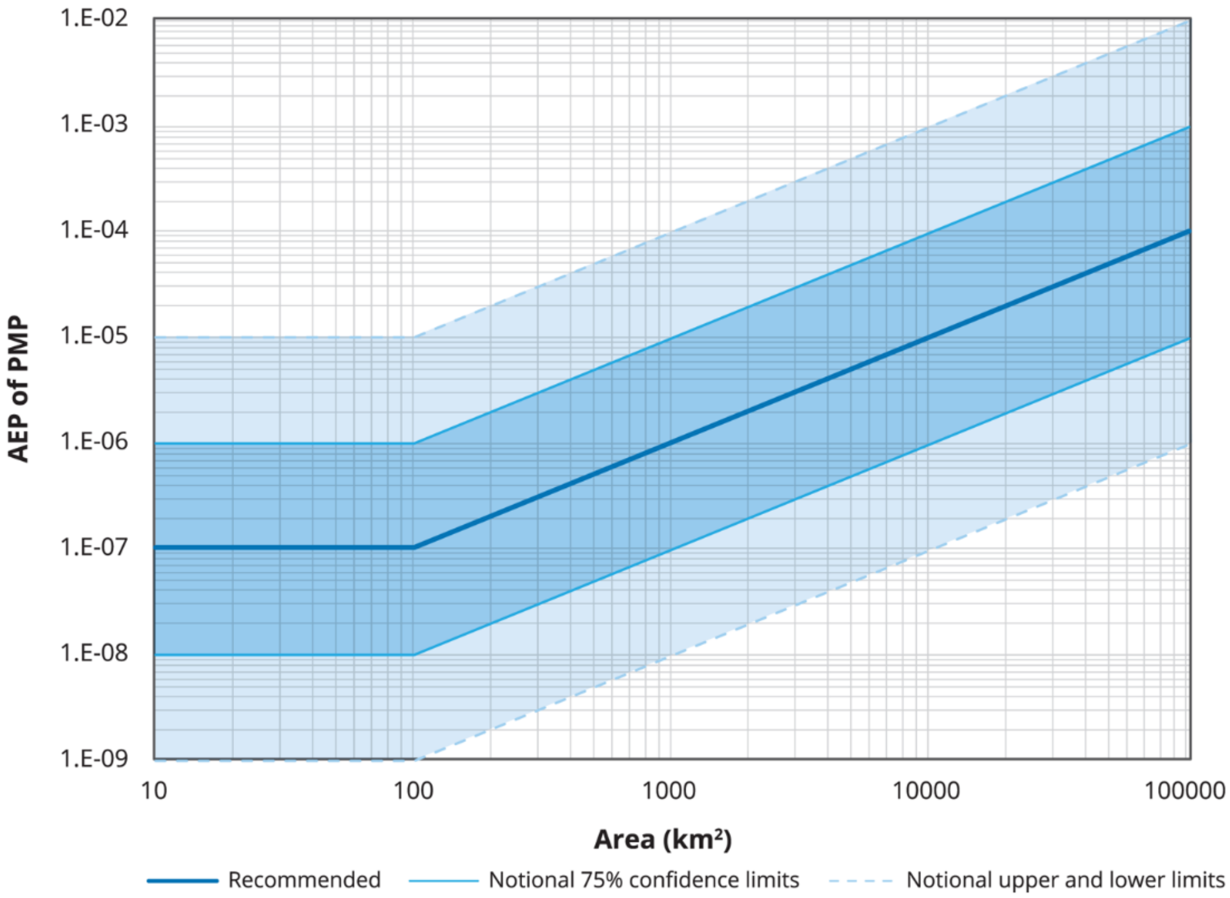
The Bureau of Meteorology in association with the Hydrometeorological Advisory Service prepared a document to provide consistency in the estimation of PMP for catchments less than 1000 km^2 and durations less than 6 hours. It is a culmination of a series of publications over 30 years. The following sections detail the various steps required in the derivation of the PMP rainfall depths.

Assigning an Annual Exceedance Probability (AEP) to the PMP

The annual exceedance probability of the probable maximum precipitate is function of the size of the receiving catchment. The theory is that an intense rainfall cell is more likely to strike a larger catchment purely because of its size so it will have a lower or more frequent AEP.

Figure 5 demonstrates the relationship between catchment area and AEP of the PMP.

Figure 5 Recommended Regional Estimates for the AEP of PMP

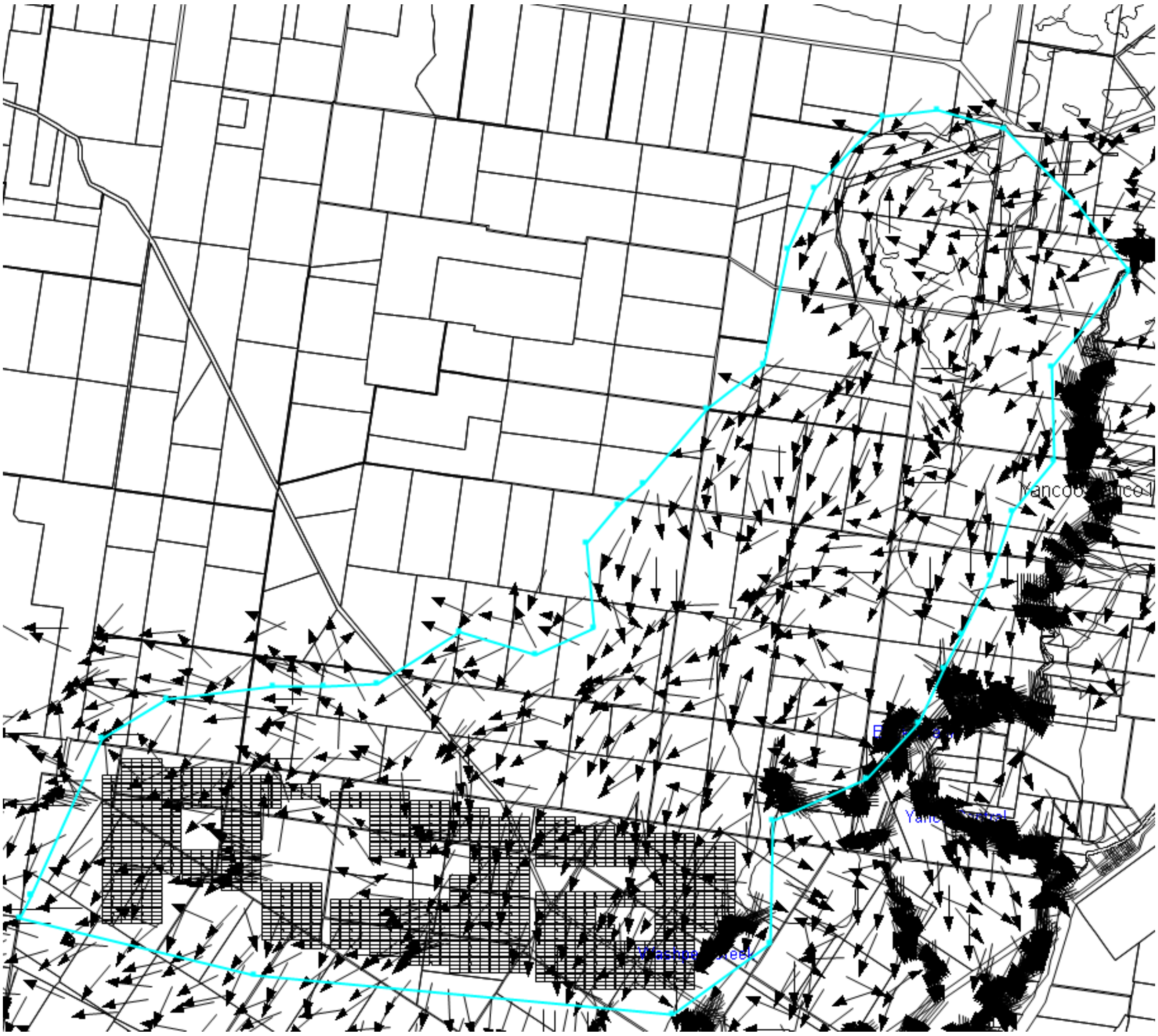


Defining a catchment boundary using tradition methods of contouring is problematic because the catchment is extremely flat. Instead, a 2D flow model passing over a LiDAR scanned 2 m grid was used to determine the direct area which flows onto the site.

Figure 6 shows the direction of water flow enabling a direct run on catchment area of 96 km^2 to be defined.

When referring to **Figure 5**, the AEP of the PMP at the Yarrabee Project site is 10^{-7} i.e. 1 in 10,000,000 AEP. To determine the rainfall estimates for this event it was necessary to perform CRC-FORGE curve fitting between the 2% and 1% AEP events and the Probable Maximum Precipitation (PMP) in addition to assigning site specific factors relative to the location, terrain, elevation and moisture.

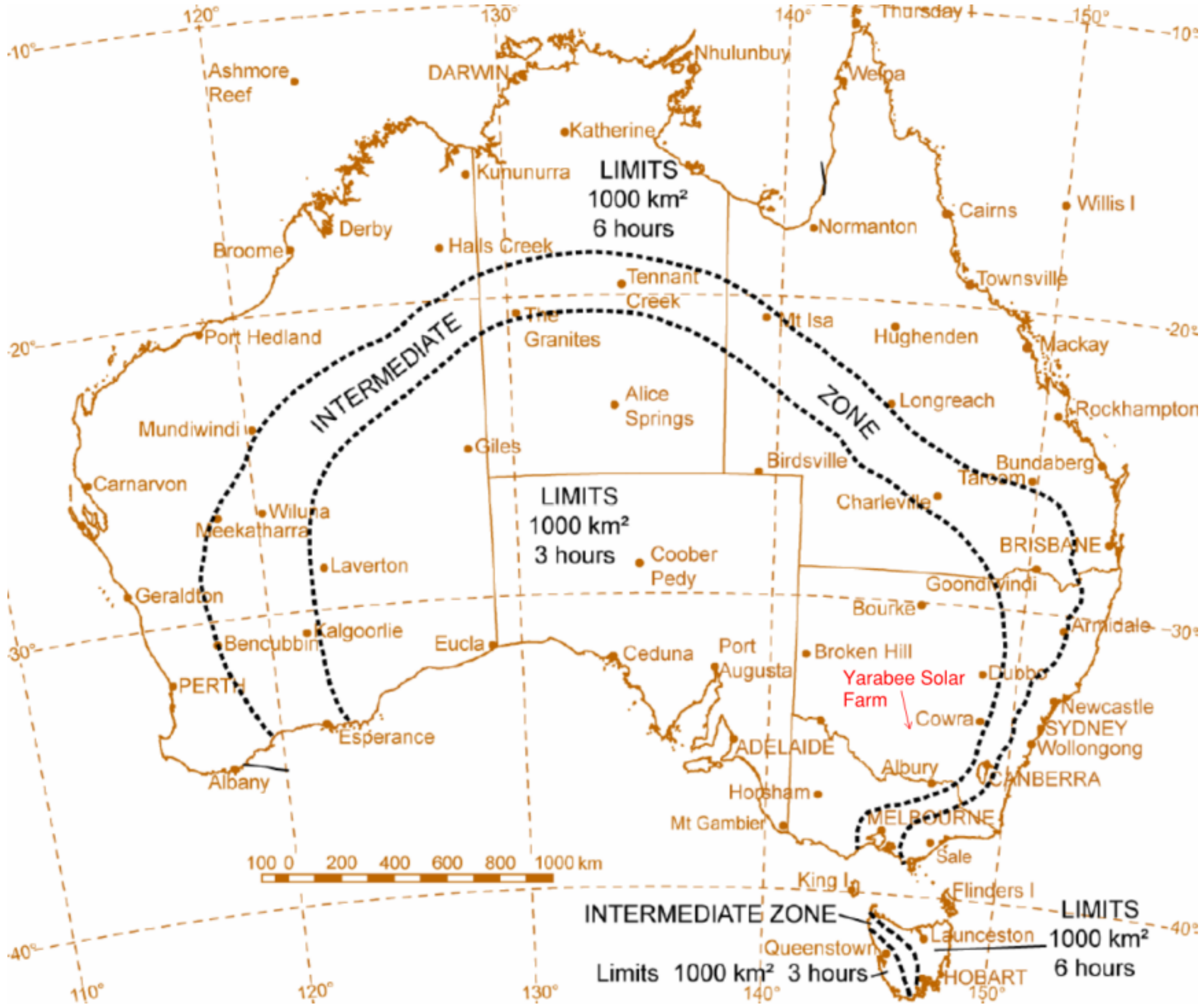
Figure 6 Boundary of Direct Rainfall Contributing to the Project site



Selection of Duration Limits

Figure 7 shows the areas of Australia subject to the duration limits between 3 and 6 hours. The Project site is located within the lower limit zone with a maximum duration of 3 hours.

Figure 7 GDSM duration limit zones (BoM, 2003)



Selection of Terrain Category

The terrain of a catchment has an effect on storm durations greater than 1 hour. A steep terrain induces heavier rainfall. The guideline refers to steep terrain as *'rough'*. It is defined as terrain where elevations change by 50m or more within a horizontal distance of 400 m (slope >12.5%). A site which is located 20 km from a steep terrain is also considered *'rough'*. The average slope of the Yarrabee catchment is 0.05% and is over 120 kms away from the nearest steep terrain in Benambra National Park. The terrain of the Project site would therefore be considered *'smooth'.*

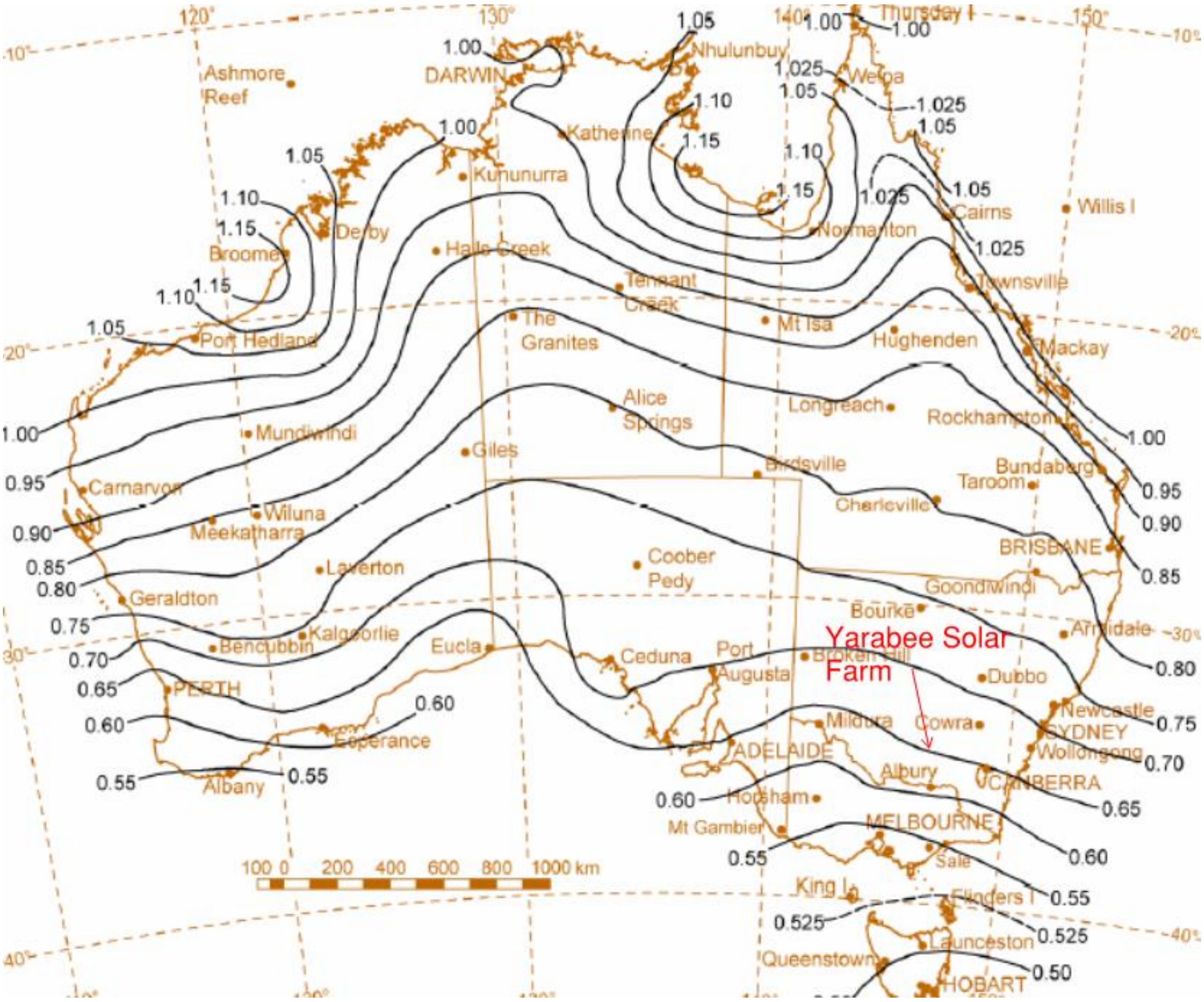
Adjustment for Catchment Elevation

Where the mean elevation of the catchment is less than RL 1,500 (i.e. 1,500 m above mean sea level) then the elevation adjustment factor is equal to one. For elevations exceeding RL 1,500 the elevation adjustment factor should be reduced by 0.05 for every 300 m by which the mean catchment elevation exceeds 1,500m. The Project site has an elevation of approximately RL 130 so the adjustment factor is one.

Adjustment for Moisture

The moisture index is the precipitable water value corresponding to the 24-hour dew point. By assuming a saturated atmosphere with a pseudo-adiabatic lapse rate during storm conditions, the Pacific table water value can be estimated from the surface dewpoint temperature. The rainfall depth duration area curve requires an adjustment as the moisture index has been calculated with a surface dew point temperature of 28°C. From **Figure 8** the moisture adjustment factor is 0.65.

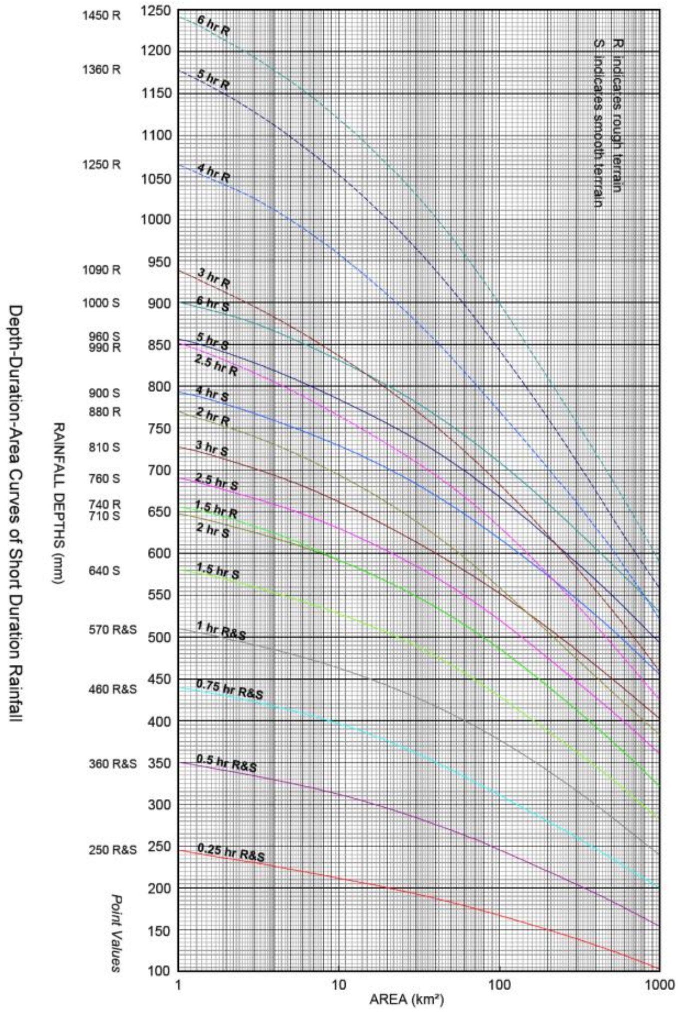
Figure 8 Moisture Adjustment Factor Map (BoM, 2003)



Calculation of PMP Estimates

Figure 9 defines the PMP rainfall depths for a range of durations with respect to the catchment size and topography (either 'rough' or 'smooth'). The area of catchment directly contributing to the Project site is 96 km^2 and the corresponding rainfall depths for the range of durations to three hours are read off the following graph.

Figure 9 PMP Rainfall Depths Duration Curves for GSDM (BoM, 2003)



The PMP estimates (**Table 11**) are then calculated from the following formula:

PMP estimate = moisture adjustment factor x elevation adjustment factor
x (% catchment smooth x depth smooth + % catchment rough x depth rough)

Table 11 PMP Rainfall Depths for the Project

Duration (hours)	Rainfall Depth (mm)	Duration (hours)	Rainfall Depth (mm)
0.25	110	1.5	280
0.5	160	2	320
0.75	200	2.5	330
1	240	3	360

Design Spatial Distribution of the PMP

The design spatial distribution for convective storms is a series of concentric ellipses. It assumes a virtually stationary storm and can be oriented in any direction with respect to the catchment. The PMP has a constant value at all points in the interval between consecutive ellipses. This constant value between ellipses is the mean rainfall depth for that interval.

2.3.5 Case 2 – GSAM (Regional PMP event)

The GSAM model was developed for estimating PMP in those regions of Australia where tropical storms are not the source of the greatest depths of rainfall, and where topographic influences vary markedly. The GSAM region is further divided into two zones, coastal and inland separated by the Great Dividing Range. The GSAM is appropriate for durations of 12 hours to a maximum of 120 hours depending on the location and catchment area. The Murrumbidgee catchment is located with the inland zone and a GSAM PMP was simulated by Lyall and Associates in 2015. The results of this analysis can be seen in **Attachment B**.

2.3.6 The Extreme Flood - Adopting a Worst Case Scenario

The worst case extreme flood between a regional PMF originating from the Murrumbidgee River and flooding derived from a local extreme rainfall event has been adopted as the extreme flood case.

3 Existing Water Environment and Site Soils

This section describes the existing project site topography, drainage patterns and site soil characteristics, the surface water conditions relating to the project site including adjacent watercourses.

3.1 Site Topography and Drainage Pattern

The project site is located immediately west of Washpen Creek, and the topography falls generally westwards away from the western bank of Washpen Creek at very flat grades. Elevations across the project site vary from approximately 133 m to 134 m AHD along the top of the banks of Washpen Creek, to 131 m to 132 m AHD on the western boundary, indicating a fall of around 3 m over a distance of 9 km. Typical site conditions looking east towards Washpen Creek are shown on **Photo 1**.

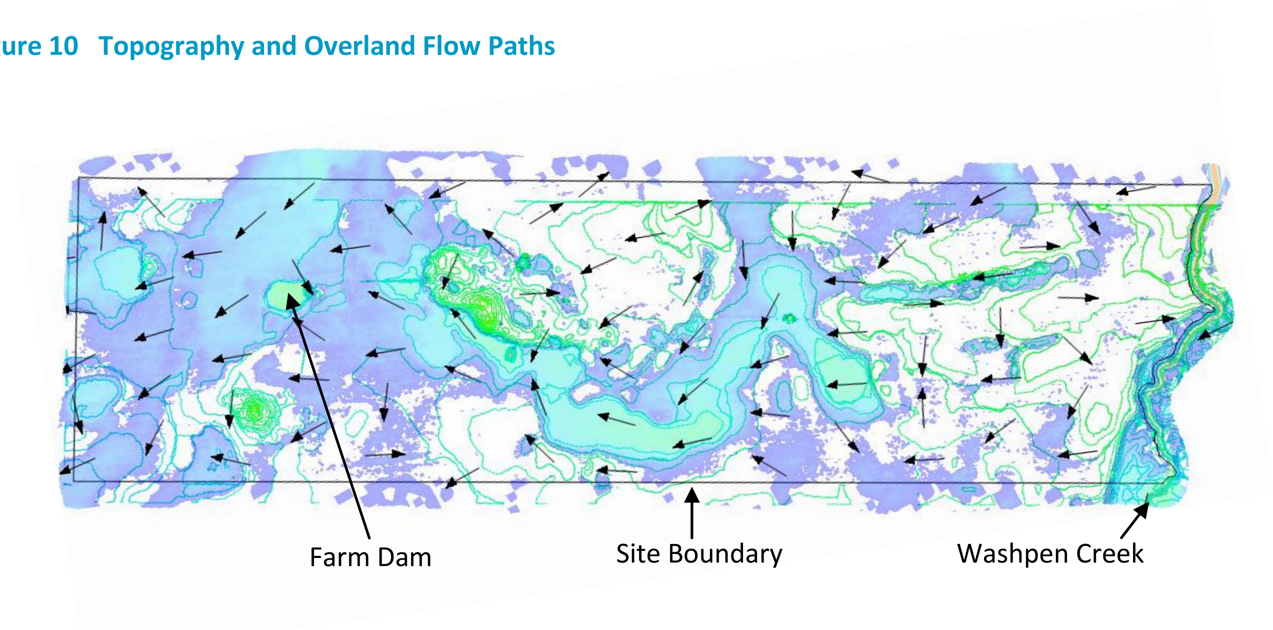
Photo 1 Typical Site Conditions Looking East towards Washpen Creek

A shallow flat depression that meanders through the centre of the site drains surface water to an existing farm dam located within 2,640 m of the western boundary. From the farm dam the topography falls general towards the southwest, although the drainage pathways are very flat and not incised into the landform. Parts of the site adjacent to the southern boundary drain overland towards the south. The surface water drainage paths through the site are not marked on topographic maps as watercourses (no OEH-water 'blue lines').

Downstream from the site the drainage depression continues towards the southwest in shallow braided channels at very flat grades, crosses Morundah Road, and eventually drains into a series of small rural dams upstream of the Coleambally Main Canal approximately 7 km southwest of the project site. Coleambally Main Canal joins Yanco Creek south of Morundah.

The site survey has also identified an existing undrained depression in the eastern part of the site, in which water would collect to a depth of approximately 0.3 m before spilling over into the overland flow path that trend westwards. The topography of the project site, alignment of overland flow paths, and locations of the existing farm dam and depression are shown in **Figure 10**.

Figure 10 Topography and Overland Flow Paths



3.2 Mainstream Flooding in Watercourses

The Murrumbidgee River flows westwards across the riverine plains of the southwest slopes of New South Wales, past Narrandera, and on to its confluence with the River Murray near Balranald.

The Yanco Creek system is a channel and floodplain system that commences from the Murrumbidgee River at the Yanco Weir located about 20 km west of Narrandera. This complex distributary system of paleochannels (Page at al. 2009), consists of a series of creeks including Yanco, Colombo, Billabong and Forest Creeks on the southern side of the Murrumbidgee. Yanco Creek flows for approximately 258 km in length in a southwesterly direction, discharging into the Edward River (part of the Murray River basin) at Moulamein. The broad riverine context is shown in **Figure 11**.

Figure 11 Riverine Context – Yanco Creek System

Flows into Yanco Creek are regulated by the Yanco Weir. Flows are regulated for irrigation and to provide base flows to achieve environmental objectives. During major flood events along the Murrumbidgee, the flow regulating structures at the Yanco Weir cause backwater causing large flood flows to overtop the offtake channel upstream of the weir sending flows southwards into the Yanco Creek floodplain. The Yanco Weir structure has very limited control for flows exceeding 10,000 ML/d *(Jacobs 2017).*

Figure 12 shows the arrangement of the old Yanco Weir which is a fixed concrete weir spanning the southern branch and the new regulated twin gates which act as a sluice during low flows and weir during large flows. The offtake upstream requires a backwater level of 138.55 AHD to enable Murrumbidgee River water to flow into the Yanco system.

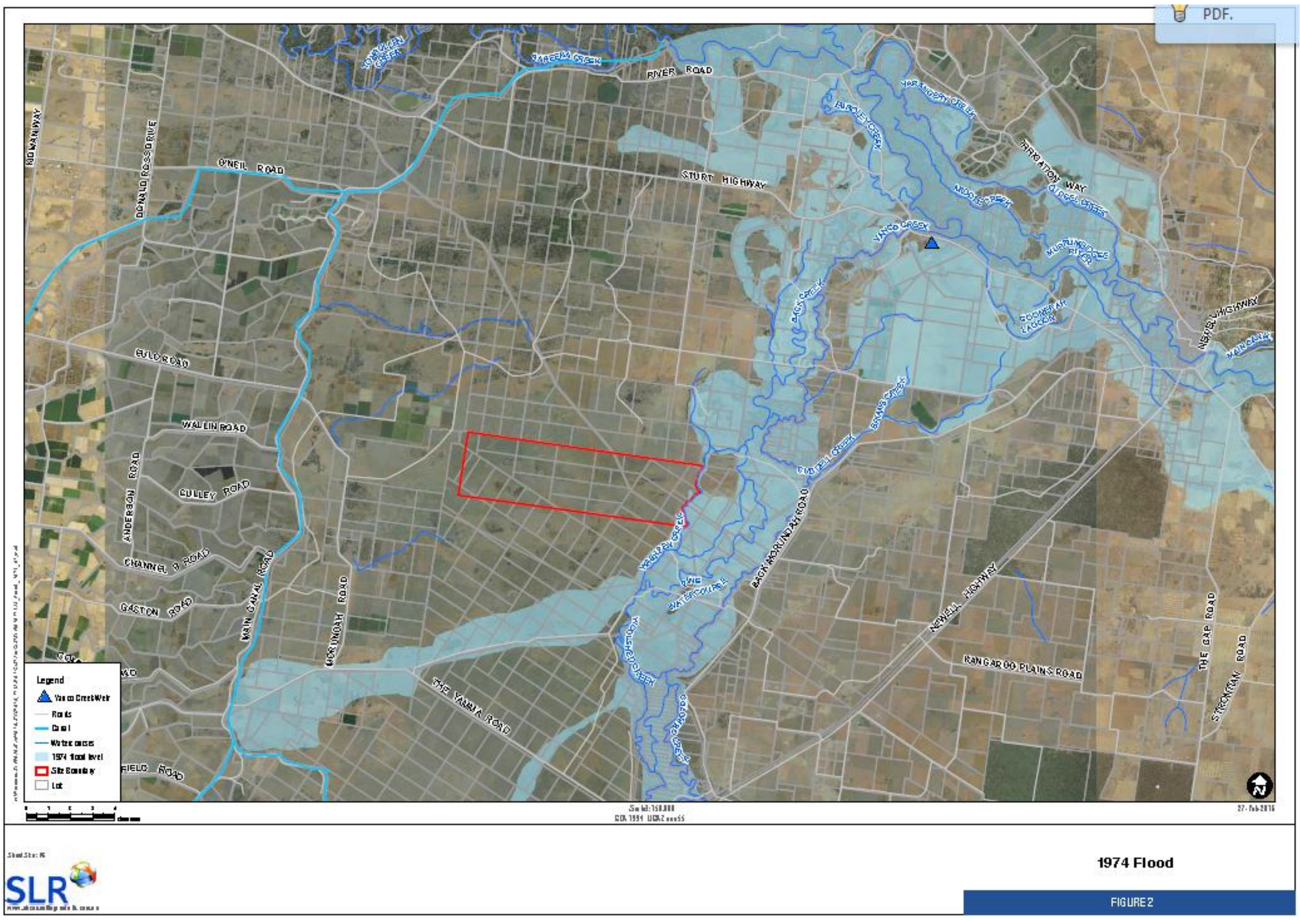
Figure 12 Yanco Control System

Washpen Creek is a minor right bank anabranch located on the upper reaches of Yanco Creek. Back Creek joins Yanco Creek approximately 7.4km south of the offtake from the Murrumbidgee River. Back Creek then splits into Washpen Creek and Pine Watercourse a further 7.5 kms downstream. The divergence occurs approximately 2.9km north of the project site, and then re-joins Yanco Creek further south-west via Woolshed Creek. Washpen Creek and Yanco Creek lie within the same broad floodplain. Adjacent to the Project site, this floodplain width extends approximately 5.3km from Washpen Creek east across to Yanco Creek.

Along Washpen Creek there are a series of wetlands covering around 90 ha, which are connected to the Washpen Creek only during large, natural flood events (Webster 2007). These wetlands provide substantial flood storage.

The extent of the floodplains for the Murrumbidgee River and Yanco Creek System, and complexity of the creek systems can be seen in **Figure 13**, which shows the extent of flooding after the 1974 flood. This may not be a reflection of the flood behaviour today as regulation of flows on the Murrumbidgee has changed since 1974, and the plan was derived from satellite imagery days after the flood peak so there is no indication whether the flooding broke the banks of Back Creek or Washpen Creek and passed over the site or not.

Figure 13 Flood Envelope (1974) and Project Site



The Project site is outside of the Murrumbidgee and Coleambally Irrigation Areas, but within the region for the Murrumbidgee Catchment Management Authority.

The statutory water management plan (under the Water Management Act 2000) encompassing the Yanco Creek system is the Murrumbidgee Regulated River Water Sharing Plan 2003 (Murrumbidgee WSP). The Yanco Creek and Tributaries Advisory Council (YACTAC) comprises over 150 landholders who voluntarily contribute a levy which commenced in 2006 and is used to maintain and improve the health of the Yanco Creek system.

The Project site is located immediately west of Washpen Creek – refer **Photo 2**.

Photo 2 Washpen Creek looking north

3.3 Site Soils

Knowledge of the rate of infiltration and storage capacity of soils is an important factor in understanding the response of a catchment to rainfall.

Detailed soil profile information throughout NSW is published by the Office of Environment and Heritage (OEH). The closest surrounding OEH tests were taken 8.3 km north at Molleys Lagoon off Yanco Creek, 9 km to the east along the Newell Highway and 14 km south along Yamma Road – refer **Figure 14**.

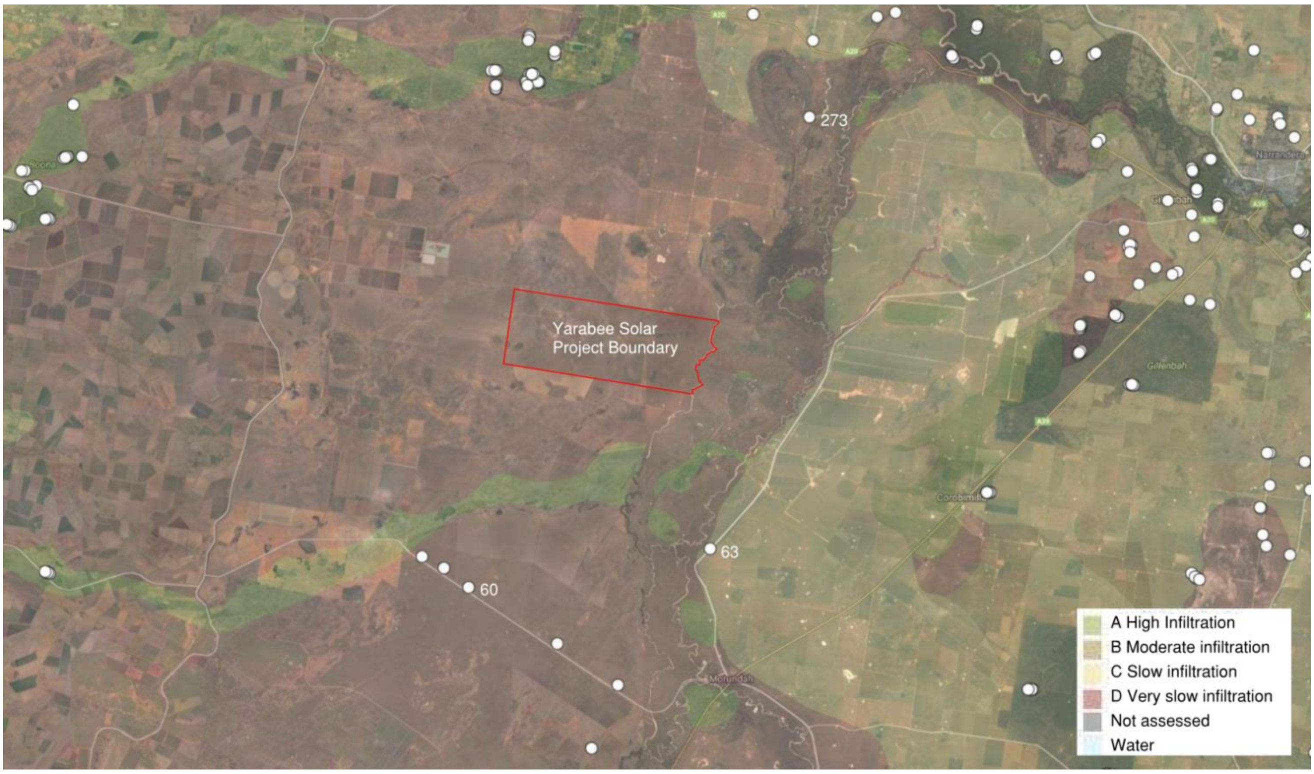
These soil reports identified a very poorly drained alluvial plain on alluvium lithology. The upper 200 mm horizon is described as dark greyish brown silty clay with a very low pH (4.5). Coarse fragments, pans and segregations were not evident. This horizon is underlain with 1.4 m of olive brown light clay with massive structure. Coarse fragments, pans and segregations were not evident in the lower horizon. The Project site is very slowly permeable and very poorly drained. Run-on is high and runoff is low. Initial infiltration rates into a dry soil are approximately 1 mm/hr. After saturation the infiltration rate would drop to an asymptotic 0.6 mm/hr.

Some sampling of Project site soils was completed by SLR in May 2018, as part of the Agricultural Assessment (**EIS Appendix D**). This involved sampling at 18 locations, which identified red and grey Vertosols and Dermosols. Vertosols are clay soils with shrink-swell properties that exhibit strong cracking when dry, and at depth have slickensides and/or lenticular structural aggregates. Most surface soils had slight dispersivity, with two samples exhibiting medium dispersivity. The surface soils were underlain by medium clays. Analysis of the soils within the Project site as sampled by SLR in **EIS Appendix D** indicates that they exhibit some variability but are broadly analogous to those noted to the north and south by OEH.

In summary, the low soil storage capacity, extremely low infiltration rate, extensive clay profile and flat topography implies the site would absorb the first 20 mm of rainfall through depression storage and surface cracking wetting clays which inhibit hydraulic conductivity. The site would be very responsive to subsequent rainfall causing extensive pooling in flat depressions. Site drainage would be very slow moving to the southwest with pools remaining for a considerable length of time after inundation.

The present occupiers of the site have indicated that the site surface is difficult to traffic following rain, and takes several days to dry out. Additional details relating to the soil behaviour can be seen in **Attachment C**

Figure 14 Catchment Wide Soil Profiles and Location of Field Tests (white dots) Relative to the Site



3.4 Acid Sulfate Soils

The risk of encountering acid sulfate soils is very low since there are no known occurrences of acid sulfate soils within the site boundary and the Project will not involve any significant excavation other than shallow trenching for electrical cables. The NSW Government SEED database does not indicate the presence of any known risk of acid sulfate soils on or in the vicinity of the Project site.

Refer: https://datasets.seed.nsw.gov.au/dataset/acid-sulfate-soils-risk0196c

4 Project Description and Water Management Issues

This section outlines the proposed project and provides a summary of the potential impacts and mitigation measures included within the Project. Further detail of specific aspects is provided in subsequent chapters of this report.

4.1 Description of the Project

The Yarrabee Solar Project is located 23 km southwest of Narrandera in Western NSW. It will include 900 MWac of solar arrays and will be connected to the 330 kilovolt (kV) Wagga to Darlington Point Transmission Line. The Project will include solar photovoltaic (PV) modules mounted on single axis tracking systems, inverter stations, a new substation, potential energy storage, grid connection, security perimeter fencing, designated buffer zones for confirmed environmentally and culturally sensitive areas, internal access roads, underground cabling and a Project site office and maintenance building.

As noted in **Section 1**, the Project will likely be developed in stages, with the number of stages dependent on factors including the contractual obligations for the purchase of electricity by one or more third parties and the capacity of the high voltage transmission network to which the Project will be connected for the export of generated electricity.

An indicative layout for the 900 MWac Project was shown in **Figure 1**.

4.2 Potential Impacts of the Project and Available Mitigation Strategies

Without appropriate mitigation measures relating to water management, the Project may have the potential to have impacts on several aspects of the environment, which fall into the categories described below:

- Riverine flooding in Washpen Creek / Yanco Creek;
- Project site drainage and pattern of runoff to downstream properties;
- Runoff annual yield, and surface infiltration;
- Water quality of surface runoff during construction of the project, and then during operation; and
- Groundwater impacts.

The present assessment also considers potential impacts of flooding on the Project's own infrastructure, as well as human safety during extreme flood events.

The environmental assessment presented in subsequent sections of this report assumes that mitigation measures recommended for consideration will form are an integral part of the development application for the Project. It also assumes that these mitigation measures will be included within the Project design as it progresses and incorporated into how the Project is constructed and managed via the Construction and Operational Environmental Management Plans.

4.2.1 Flood Behaviour along Washpen Creek

Washpen Creek is an anabranch of Yanco Creek via Back Creek to the north which divides into both Pine Watercourse and Washpen Creek and then reunites via Woolshed Creek to Yanco Creek. Flow from Yanco Creek to Back Creek is regulated by means of a weir with a control gate at Spiller's Regulator (refer **Figure 15**). Pine Watercourse is ephemeral and only operates when the water level in Washpen Creek exceeds the left overbank.

Figure 15 Spiller's Regulator on Back Creek

The conveyance of Washpen Creek is supplemented by the hydraulic capacity in Pine Watercourse. The hydraulic capacity of Washpen Creek is further enhanced by a 'natural' longitudinal bund running along the top of the western bank. The crest of the bund is higher than the site ground level. With this hydraulic arrangement it is unlikely Washpen Creek would surcharge unless major overbank flooding occurs upstream.

4.2.2 Site Surface Hydrology

The site is essentially very flat with site grades typically less than 0.05%. Even so, there is still a defined drainage path which meanders from the northeastern boundary to the southwestern corner. Along this drainage path there are four surface depressions which have the capacity to hold water, and a constructed dam which is furthest west.

4.2.3 Water Yield and Environmental Flows

The Project's solar PV arrays will not result in an increase in runoff since the same area of soil is available for infiltration, and vegetative groundcover will be maintained to distribute runoff. Other than maintaining the existing farm dam, no additional harvesting of surface water is proposed. The existing farm dam has a capacity of 25 ML, which is less than the site harvestable rights of 134 ML. There will be no change to low flows or environmental flows as a result of the project, and the annual yield of runoff from the site catchments will be unchanged from the current rural activities.

4.2.4 Water Quality during Construction and Operation of the Project

Erosion and sediment controls will be implemented in accordance with Erosion and Sediment Control (ESC) Plans documented in the Construction and Operational Environmental Management Plans. Overall, due to the flatness of the Project site, there is a very low potential for erosion which should be readily managed using standard ESC practices. It is intended to retain the existing farm dam as a sediment basin, and to monitor site water quality.

4.2.5 Groundwater

The Project will not have any impact on groundwater resources since surface infiltration will be unchanged. Furthermore, no excavations are proposed that would intercept the groundwater table(s) found throughout the site.

5 Water Quality and River Flow Objectives

This section describes the existing water quality, objectives for water quality and river flows, and associated water quality trigger values. It then describes the potential risks to water quality during the construction and operational phases of the project, and identifies the mitigation measures that will be implemented to safeguard water quality.

5.1 Existing Water Quality

No existing water quality data is available for the Project site. Despite the highly ephemeral nature of the Project site watercourses, and the expected low impact of the Project, it is intended for the Project to include best practice water quality control measures wherever feasible, with an ongoing water quality monitoring regime to be assessed against ANZECC water quality criteria.

5.2 Water Quality and River Flow Objectives

The NSW Water Quality Objectives are the agreed environmental values and long-term goals for NSW surface waters. Water Quality Objectives for most catchments in NSW are published on the Department of Environment Climate Change and Water website (http://www.environment.nsw.gov.au/ieo/).

The agreed environmental values and river flow objectives for **regulated creeks** within the Murrumbidgee River Catchment, including Washpen Creek are given in **Table 12**.

Table 12 Water Quality and Riverflow Quality Objectives (Regulated Creeks)

Water Quality	Riverflow Quality [1]
Aquatic ecosystems	Protect natural low flows
Visual amenity	Protect important rises in water levels
Secondary contact recreation	Maintain wetland and floodplain inundation
Primary contact recreation	Mimic natural drying in temporary waterways
Livestock water supply	Maintain natural flow variability
Irrigation water supply	Maintain natural rates of change in water levels
Homestead water supply	Manage groundwater for ecosystems
Aquatic foods (cooked)	Minimise effects of weirs and other structures

Note 1 These objectives relate to any works adjacent to Washpen Creek

The majority of the site falls westwards away from Washpen Creek, through shallow overland flow paths through the project site, and towards irrigation channels approximately 5 km downstream from the Project site. There is no primary or secondary recreation, homestead water supply, or production of aquatic foods downstream of the project site, and between the site and Coleambally Main Canal. The environmental values for artificial and irrigation channels are provided in **Table 13**. There are no river flow objectives for artificial channels.

Table 13 Water Quality Objectives for Artificial and Irrigation Channels

Water Quality – Artificial Channels	Riverflow Quality – Irrigation Channels
Aquatic ecosystems	Aquatic ecosystems
Visual amenity	Visual amenity
	Irrigation water supply

River flow objectives suggest that the natural and existing regime of flows from the Project site should be retained as far as practically compatible with other requirements, mimicking natural river flow patterns as closely as possible. Harvesting of surface water on-site (including the addition of new dams) should be minimised, but some minor storages may be necessary to achieve water quality objectives.

5.3 ANZECC 2000 Default Water Quality Trigger Values

The ANZECC 2000 Guidelines advocate a risk based approach to water quality assessment and management. That is, the intensity of assessment of current water quality status or impacts on water quality should reflect the risk of impacts on the achievement/protection of the water quality objective.

For Protection of Aquatic Ecosystems in NSW, and for irrigation water used in primary production, the ANZECC 2000 Guidelines provide default trigger values for major physico-chemical stressors, which are used to assess whether the condition of an ambient water body supports the environmental values.

These values, shown in **Table 14**, provide typical values which if exceeded warrant investigation, and could adversely impact downstream environments and/or water uses.

Table 14 ANZECC Trigger Values – Environment and Irrigation Water

Parameter	Default Trigger Value for NSW lowland rivers for aquatic ecosystems in slightly disturbed ecosystems
Total Phosphorous TP (mg/L)	0.05
Total Nitrogen TN (mg/L)	0.50
Ammonium NH_4^+ (mg/L)	0.02
Total Suspended Solids (mg/L)	50 - Professional judgement
Turbidity (NTU)	6 - 50
Salinity	125 – 2200 µS
pH	6.5 – 8.5

Parameter	Default Trigger Value for NSW lowland rivers for aquatic ecosystems in slightly disturbed ecosystems
Pesticides	Concentrations in discharge water should not exceed the Crop injury threshold values in Table 4.2.12 of the ANZECC 2000 Guidelines
Heavy metals and metalloids	Concentrations in discharge water should not exceed the STV values in Table 4.2.10 of the ANZECC 2000 Guidelines
Thermotolerant coliforms (cfu/100mL)	<1000

5.4 Environmental Values – Yanco Creek System

Environmental objectives for the Yanco Creek System are identified by Alluvium (2013) and were determined from environmental values identified throughout the system by the community, literature review, and assessment by Technical Panels. For 'Upper Yanco Creek', the environmental objectives were as follows:

- Maintain a mosaic of wetlands;
- Support self-sustaining populations of macro-invertebrate taxa from the endangered Lower Murray Aquatic Ecological Community;
- Maintain and/or improve medium-bodied native fish community; and
- Maintain and/or improve small bodied native fish – floodplain specialists.

The Project site actually falls away from Washpen Creek and has been set-back via a dedicated buffer zone from ground areas which fall towards Washpen Creek. Specifically, the Project will maintain a riparian zone of 40 m to the top of bank of Washpen Creek, and will not alter the distribution of flows, or involve any works that would directly impact on mainstream hydrology or flood behaviours along Washpen Creek.

Nevertheless, the management of surface water within the site will be consistent with the recommendations for Environmental Flow in the Alluvium (2013) Study to ensure that the environmental objectives for Upper Yanco Creek are achieved.

5.5 Erosion and Sediment Control – Construction Phase

Construction activities which disturb the land surface typically increase the potential for erosion of soils during rainfall events and increase the risk of sediment-laden stormwater runoff discharging to the receiving environment.

The construction of the Yarrabee Solar Project is expected to result in only minor ground disturbance, and a very low potential for erosion due to the following mitigating factors:

- Construction will proceed in stages, and within each stage the construction activities will be sequenced, such that the construction zone at any one time will only be a small proportion of the overall Project site area;
- The Project will utilise the existing landform and no broad-scale re-contouring of the existing ground levels is proposed. Hence the existing vegetative cover and soil structure will be maintained intact across much of the Project area;

- Solar arrays will be pole mounted, with the poles being supported on a driven or screw pile, so that there is no excavation required other than for electrical cabling;
- Construction areas will be progressively revegetated as installation of solar panels proceeds across the site;
- At locations where earthworks are necessary, such as for sub-station pads, or site facilities, localised erosion and sediment controls will be placed in accordance with the Landcom (2004) guidelines; and
- The flatness of the site is not conducive to erosion or sediment transport, given that surface runoff can only move at very low velocities.

It is also noted that the site presently has a rural land-use, and that the level of soil disturbance for installation of solar arrays will likely be less than that associated with broad-acre agriculture.

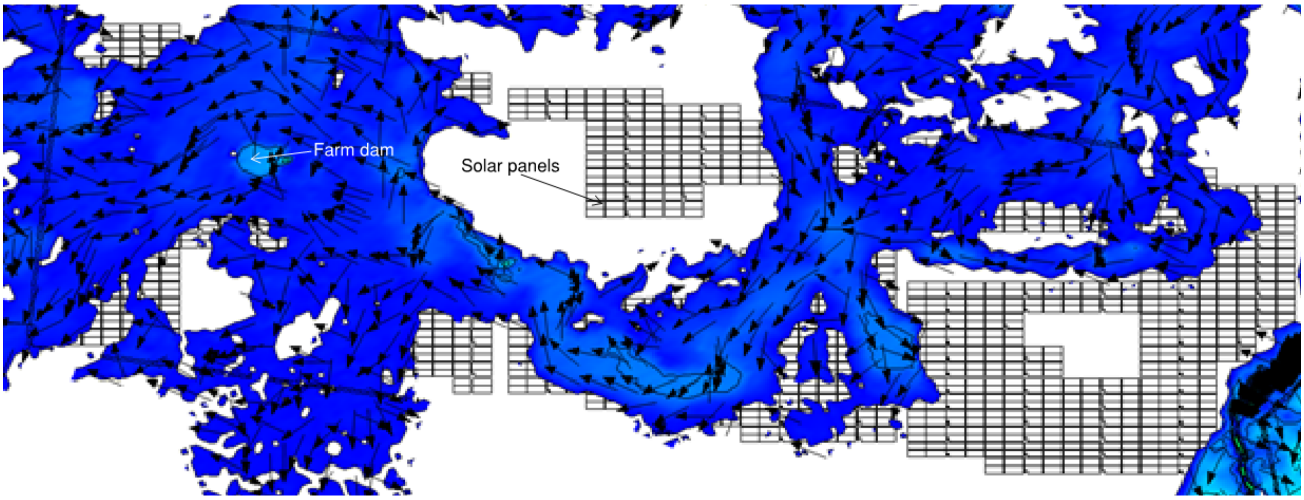
The project incorporates a 40 m riparian buffer zone to the top of bank along Washpen Creek. No ground disturbance will occur within this zone. Since the remainder of the site falls towards the west, there will be no adverse water quality impacts on Washpen Creek. Current rural activities may occur much closer to the top of Washpen Creek.

Hydraulic modelling indicates that a large portion of the Project site drains to an existing farm dam. This dam currently has a capacity of 25 ML – refer **Photo 3**.

Photo 3 Existing Site Dam

The catchment for the existing farm dam, and other areas which discharge off site are shown on **Figure 16** for for a 1% AEP event. The arrows on **Figure 16** illustrate the complicated drainage pattern over the Project site. Flows shown across the northern boundary are flowing south from an overflow of Back Creek.

Figure 16 Site Drainage Paths and Location of the Yarrabee Farm Dam



With the implementation of standard erosion and sediment control measures in accordance with Landcom (2004) the potential environmental impact is considered very low and manageable.

A site-wide Erosion and Sediment Control Plan (ESCP) will be prepared as part of the Construction Environmental Management Plan (CEMP) for the Project. The ESCP will be prepared in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition* (Landcom 2004), known as *"The Blue Book"*, and *Volume 2A Installation of Services* (DECC 2008a). Mitigation measures and site management practices will include:

- Staging of construction works and progressive revegetation to limit the disturbed area
- Early establishment of site access tracks to minimise disturbance of site soils by construction vehicles
- Progressive revegetation of disturbed areas
- Reseeding of soils beneath the lower edge of PV panels, to ensure the early establishment of vegetative ground cover, and limit the potential for soil erosion from panel runoff
- Stabilisation of table drains alongside access tracks using vegetation, and rock check dams
- Installation of sediment fences for any earthworks in proximity to site overland flow paths
- Installation of localised sediment controls such as sediment fencing, straw bales, and sediment sumps at any site areas involving earthworks greater than 1,000m^2 in area
- Install a shaker pad at the site exit to reduce mud or clay on vehicle wheels being tracked onto external roads
- Inspection of ESC measures following heavy rainfall
- Water quality monitoring and reporting requirements
- Providing an appropriate level of resourcing for environmental management and monitoring.
- Appropriate site storage of hydrocarbons within bunded areas, and documented spill response procedures

A separate ESCP will also be prepared prior to the decommissioning phase and for the construction of any future Project upgrades with the potential to disturb soils.

5.6 Erosion and Sediment Controls – Operational Phase

Soil disturbance during operation of the Project would be minimal and limited to maintenance activities, which will involve very small localised disturbance areas on an infrequent basis. Water quality impacts from these minor disturbances are likely to have an insignificant impact on overall site water quality. For sites in proximity (less than 200 m) to site overland flow paths or the site boundary, erosion and sediment control measures will be implemented to minimise the potential for sediment export. These measures would be developed on a case by case basis in accordance with the Landcom (2004) guidelines, and are likely to include measures such as sediment fencing, localised sediment traps, and progressive stabilisation with vegetation.

Concentrated runoff from the surface of solar panels falling onto the ground has some potential to cause localised erosion below the solar array modules. Cook and McCuen's (2013) study of grid-scale solar projects indicates that the potential for localised erosion can be effectively mitigated by the establishment and maintenance of thick groundcover vegetation beneath the panels. The rates of erosion during the period when vegetation is being established will be closely monitored during the initial stages of the development, and if warranted, jute mesh will be used to cover and protect these small areas from erosion during the establishment of grass cover.

During operation the single-tracking system mounted panels would constantly change orientation during the day, with runoff being distributed in the area around each panel, and not drained permanently to a single place on the ground. Measures to manage any bare areas and erosion that develop beneath the solar arrays over time would be included in a groundcover management plan for implementation during ongoing operation of the proposal.

The existing farm dam will be maintained, and will provide a location for collection of samples for monitoring surface water quality from the project.

The main east/west access road and other access tracks across the broader site will be unsealed, and there is some potential for dust creation, mainly when tracks are traversed by site vehicles. Dusts deposited on the ground can be easily washed away during rainfall, increasing the turbidity and sediment loads in downstream waterbodies. The Project will have a strong interest in reducing dust, which can reduce the efficiency of PV arrays. Dust will be reduced by a range of mitigation measures including watering to suppress dust when required on dry windy days, the application of binders to road surfaces to reduce dust, limiting vehicle speeds, and reducing vehicle movements.

5.7 Storage and Use of Hydrocarbons and Chemicals

The limited storage and use of hydrocarbon fuels and other chemicals on-site present a potential risk if spilled substances contaminate site soils or are mobilised and spread to the downstream receiving environment. Chemicals used on-site during both the construction and operational phases may include small amounts of fuels, lubricants and herbicides.

Accidental spill or discharge of hydrocarbons, such as fuels and oils in vehicles and/or earthmoving equipment, has potential to contaminate downstream waterbodies or groundwater.

The risk of hydrocarbon contamination will be mitigated by:

- Storage of chemicals in accordance with Australian Standards;
- Storage of hydrocarbon fuels within bunded storage areas;
- Bunding of substations or other infrastructure that utilises oil;
- Minimise the usage of herbicides, and avoid spraying when rain is predicted; and
- A Spill Response Plan, including emergency response and EPA notification procedures.

Requirements for the storage and use of hydrocarbon fuels and other chemicals on site will be documented in both the Construction and Operational Management Plans.

Herbicides may be used on site to control vegetation growth around the base of PV arrays. Any spills will be managed in accordance with a documented Spill Response Plan. All herbicides used on site will be those with low toxicity, will be used in accordance with best practice, and stored in bunded containers in accordance with Australian Standards.

Overall, with the implementation of suitable controls, these risks are low and considered readily manageable.

6 Rainfall Infiltration, Harvesting and Catchment Yield

This section discusses the impact of the solar farm on rainfall infiltration into site soils, the site harvestable rights, and catchment yield.

6.1 Rainfall Infiltration and Catchment Yield

Mean Annual Runoff (MAR) for the project site is 4,725 ML, based on a contributing catchment area of 9,570 ha, an assumed average annual rainfall of 437 mm and a volumetric runoff coefficient of 0.113.

The Project will not change the existing runoff characteristics of the site. While the Project involves constructing solar arrays with impervious surfaces, runoff volumes will not be increased, because rainwater will drain to the ground underneath the arrays, be dispersed by vegetation maintained below the panels, and infiltrate into the existing soils which will provide the same overall soil surface area available for rainfall infiltration.

This is supported by the study by Cook and McCuen (2013) into the impact of solar projects on hydrology, which found that such facilities using pole-mounted PV arrays do not have a significant impact on the surface water run-off rate, or volume. This study found that underlying groundcover was the primary determinant of runoff rate.

Overland flows will follow the same flow paths as those currently present on the site. No change to the runoff generated by the site is expected, because by retaining good grass cover across the proposal site, runoff water from PV arrays would be absorbed into the ground similar to current conditions.

No additional dams are proposed on site as part of this Project. The existing farm dam will be retained, which has a capacity of 25 ML, or about 0.5% of estimated mean annual runoff.

7 Groundwater Impacts

This section describes the existing groundwater regime, presence of groundwater dependent ecosystems, and the potential Project impact on groundwater.

7.1 Groundwater Dependent Ecosystems (GDEs)

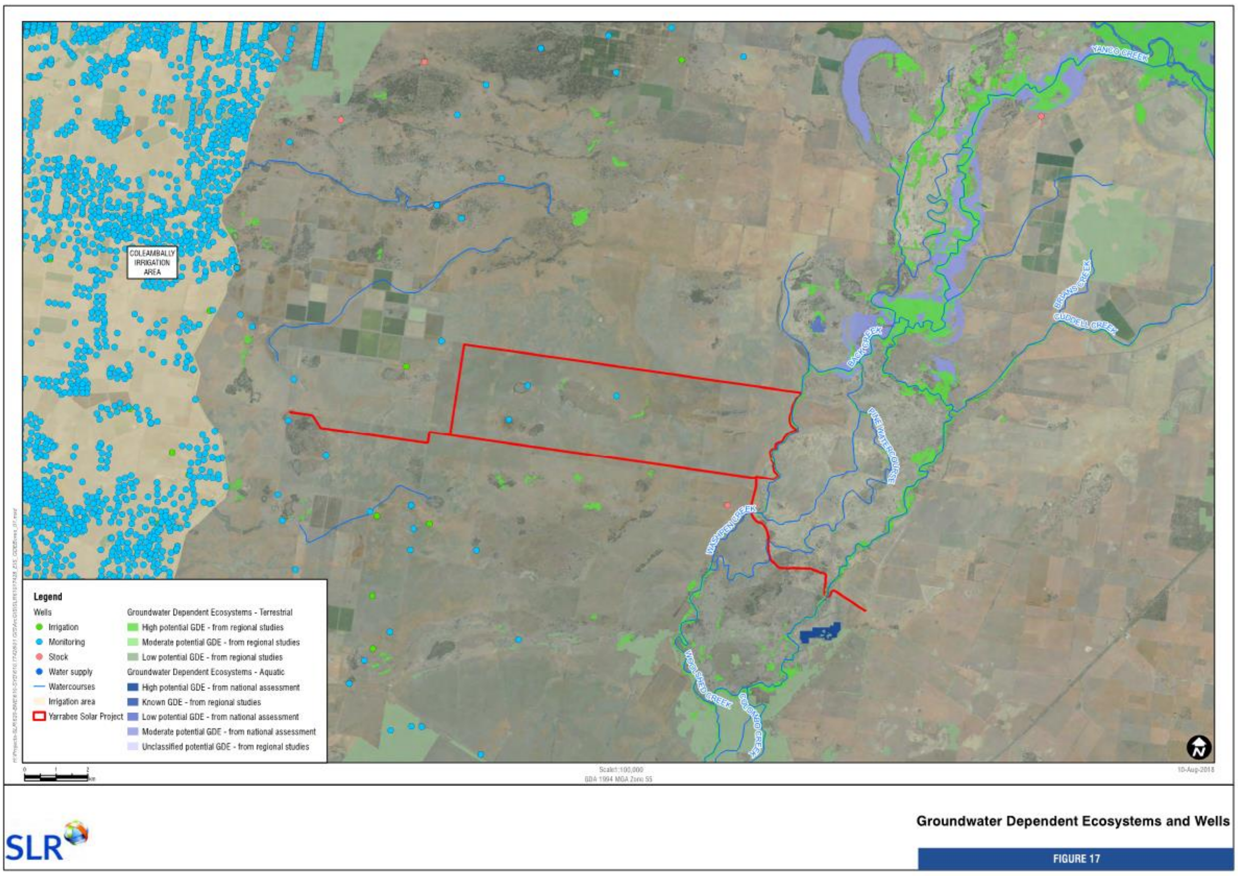
Groundwater is important in sustaining Groundwater Dependent Ecosystems (GDEs), including aquatic and terrestial ecosystems such as springs, wetlands, rivers and forests. GDEs can include aquatic ecosystems which rely on the surface expression of groundwater, and terrestial ecosytsems which rely on the subsurface presence of groundwater.

The *Groundwater Dependent Ecosystems Atlas* (BoM, 2017) indicates that there are two small High Priority Terrestrial GDEs within the proposal area plus the riparian edges along Washpen Creek. The remainder of the site is mapped as having a low potential for GDE's.

Areas to the north-east of the project site, and associated with riverine wetlands within the Yanco Creek System, are also identified as GDE's (terrestrial and aquatic).

The location of these GDE's and existing groundwater wells are shown on Figure 17.

Figure 17 Groundwater Dependent Ecosystems and Wells



7.2 Groundwater Vulnerability

The project site is located within an area mapped as having groundwater vulnerability under the Narrandera LEP, indicating areas in which the hydrological functions of groundwater systems should be maintained to protect vulnerable groundwater resources from depletion and contamination as a result of development. Narrandera LEP Clause 6.5 states that:

> ‘*Before determining a development application for development on land to which this clause applies, the consent authority must consider the following:*
> *(a) the likelihood of groundwater contamination from the development (including from any on-site storage or disposal of solid or liquid waste and chemicals),*
> *(b) any adverse impacts the development may have on groundwater dependent ecosystems,*
> *(c) the cumulative impact the development may have on groundwater (including impacts on nearby groundwater extraction for a potable water supply or stock water supply),*
> *(d) any appropriate measures proposed to avoid, minimise or mitigate the impacts of the development’*

7.3 Existing Water Users

The site has a number of licenced groundwater bores. These bores are not intended to be utilised for water supply to the Project.

7.4 Impact Assessment

The Project is not likely to have any impact on groundwater resources or GDE’s. Impacts to groundwater during construction and operation of the solar farm are unlikely to occur due to the following:

- The pattern of surface drainage and associated groundwater recharge will remain unchanged;
- Soil infiltration across the broader surface of the site will be unchanged, as discussed in Section **6.1** of this report, and therefore the rates of groundwater recharge will be unaffected;
- The project does not include any excavation with potential to interact with groundwater; and,
- No solar arrays or other infrastructure are proposed at or close to the locations of GDE’s within the site

8 Riverine Flooding

This section describes the existing regime of riverine flooding, the potential impact of the Project on flood levels and flows, and how the Project may itself be potentially impacted by flooding.

8.1 Riverine Flooding Behaviour

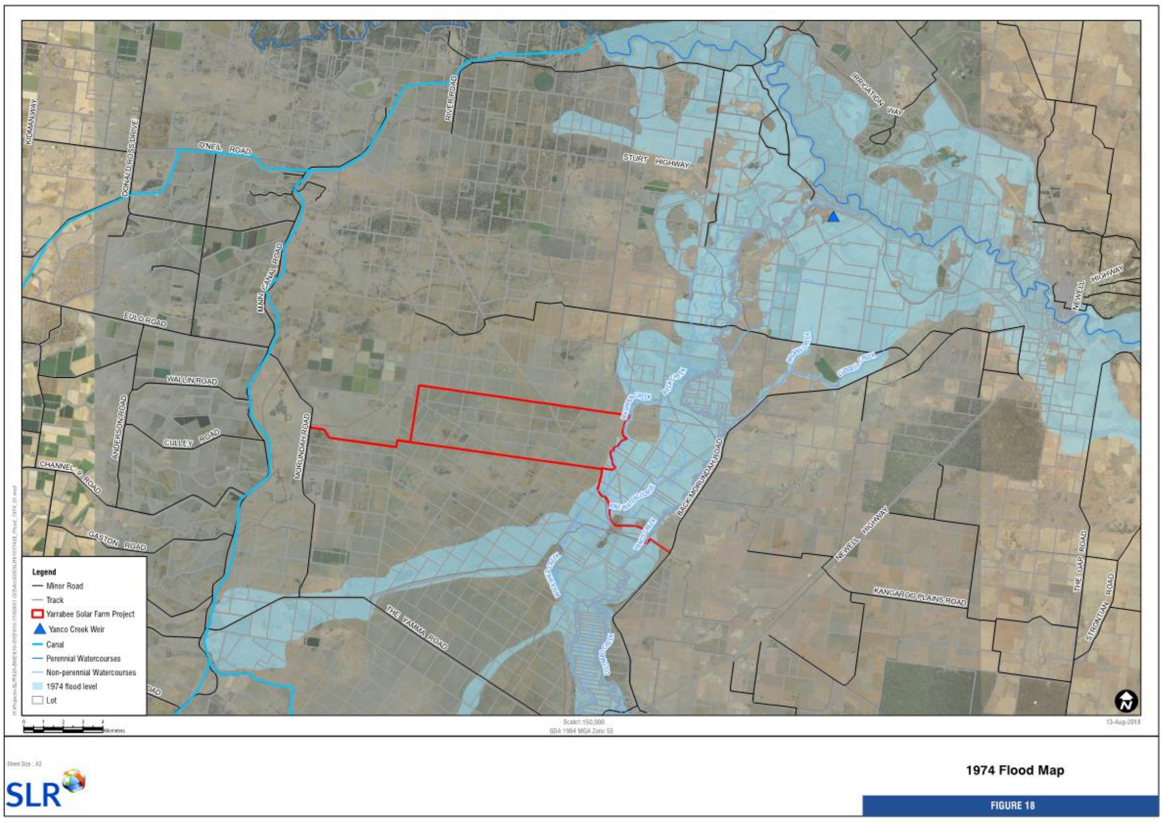
Major flooding along the Yanco Creek floodplain, including Washpen and Back Creeks near the Project site, results from flows distributed from the Murrumbidgee River. The arrival of flood peaks at the Project site may not necessarily be accompanied by local rainfall.

8.2 Flooding – Existing Information

The project site is not within a flood planning area as designated under the Narrandera LEP. There are no flood studies which cover the site location.

Historical information on flood extents at the Project site is provided by mapping of the 1974 flood extent recorded by means of a satellite photograph taken following passage of the peak flood, provided by Narrandera Shire Council as reproduced in **Figure 18**. This event caused major flooding within the Murrumbidgee Catchment. Lyall & Associates (2015) reported that the peak flow recorded at Narrandera during the 1974 flood had an equivalent ARI of 'about 100 years'. The image shows that at the time the aerial photograph was taken that the project site was not inundated beyond the banks of Washpen Creek.

Figure 18 Recorded Extent of 1974 flood



There have been two previous flood studies which provide valuable flooding information upstream and downstream of the project site.

- Lyall & Associates, Oct 2015, *Narrandera Flood Study Review and Levee Options Assessment*
- Jacobs, Nov 2017, *Flood Study Report for Morundah*

Information from these studies relevant to the present study is described below.

***Narrandera Flood Study* (Lyall & Assoc 2015)**

The majority of flood flow along Washpen and Yanco Creeks comprises water that overflows from the Murrumbidgee flood plain south into the Yanco Creek floodplain. The study modelling did not extend south down the Yanco Creek system. Two hydraulic models were developed for a 140 km reach of the Murrumbidgee River between Wagga Wagga and downstream of Narrandera using the TUFLOW hydraulic model, calibrated against the flood events of September 1974, December 2010 and March 2012. The study updated design flood estimates for the Murrumbidgee River at Narrandera gauge (GS 410005) for the full range of flood events between 20% AEP and extreme flood events. The study provides estimates of flood levels in the area where flows overflow into the Yanco Creek system. For a 1 in 100 year Annual Recurrence Interval (ARI) flood event (now referred to as the 1% Annual Exceedance Probability) along the Murrumbidgee River, these levels are approximately RL 140.7 AHD at the Yanco Weir offtake.

***Flood Study Report for Morundah* (Jacobs, Nov 2017)**

This study was focussed on estimating flood behaviour at Morundah, which is approximately 15m south of the project site. As part of the flood study Jacobs prepared a flood frequency analysis using the available annual peak flows for Yanco Creek at Morundah gauge (GS 410015), and the available annual peak flows for the period 1913 to 2012. For Yanco Creek at Morundah (GS 410015), there was 96 years of available data. The largest flood recorded at the station was the 1974 flood, which had an estimated peak flow of 20,250 ML/day. Jacobs fitted a Log-Pearson Type III distribution to the annual maximum flow data using a Bayesian influence methodology, to derive peak flow estimates for a range of AEP’s, as shown in **Table 15.**

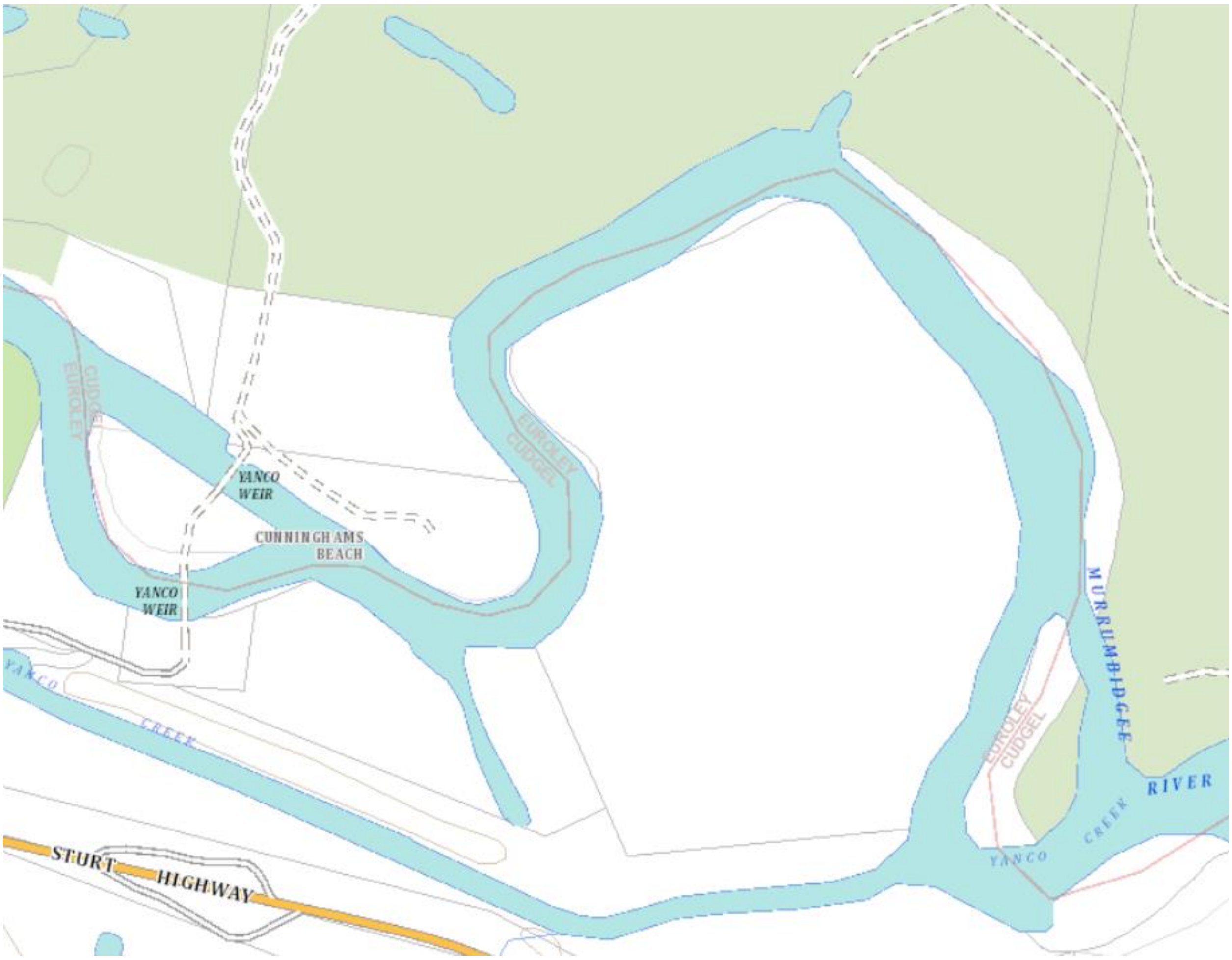
Table 15 Flood Frequency Analysis at Morundah (from Jacobs 2017)

Annual Exceedance Probability	Peak Flow (m^3/s) in Yanco Creek @ Morundah gauge (GS410015) (5% & 95% confidence limits)	Peak Flow (m3/s) Colombo Creek @ Morundah gauge (GS410014) (5% & 95% confidence limits)
20%	30 - 45	18 – 26
10%	50 - 80	27 - 42
5%	70 - 140	37 - 65
2%	100 - 250	50 - 110
1%	130 - 290	65 - 180

SLR’s own flood modelling has been extended down to the Yanco Creek at Morundah gauge (GS 410015) and Colombo Creek at Morundah gauge (GS 410014), to allow calibration of modelling parameters. The 1% AEP peak flood level in the Murrumbidgee River at the Yanco Weir offtake was entered as the northern boundary condition and the peak flow rates simulated at the two flow gauges compared to the flood frequency estimates for verification.

A study by Alluvium (2013) identified that the Yanco Weir take-off point has limited controls for flows exceeding 10,000 ML/day in the Murrumbidgee River recorded at the Narrandera gauge. The Jacobs (2017) study reviewed PINNEENA hourly flood gauge data for the Murrumbidgee River at the Narrandera gauge and the Yanco Creek Offtake gauge for the flood event of March 2012, and were able to establish a relationship between the observed discharges in the Murrumbidgee River at the Narrandera gauge and the Yanco Creek offtake gauge. This flow relationship was not used in the calibration process as the level data was considered more stable and reliable considering the complexity of the relevant flow regulation structures. **Figure 19** shows the location of the Yanco Creek offtake relative to the regulated Yanco Weir on the northern branch and the fixed weir on the southern branch.

Figure 19 Arrangement of the Yanco Weir(s) and the Yanco creek offtake upstream



The regulated Yanco Weir consists of two rectangular sluice gates within concrete channels. Environmental flows pass under the sluice while flood flows overtop the gates - refer **Figure 20**.

The southern anabranch was the original regulated Yanco Weir but has been modified to be a fixed weir – refer **Figure 21**. Water backs up behind these weirs creating a level pool to the Yanco Creek offtake upstream. The offtake is simply a rock lined channel with an invert at 138.55m AHD.

Figure 20 The Gate-Regulated Yanco Weir on the Northern Anabranch of the Murrumbidgee River

Figure 21 The fixed Yanco Weir on the Southern Anabranch of the Murrumbidgee River

8.3 Washpen Creek Flood Behaviour

SLR has carried out a detailed flooding analysis of flood flows along the Washpen Creek/Yanco creek floodplain. This flooding analysis has concluded that:

- The Washpen Creek/Yanco creek floodplain adjacent to the site has capacity to convey the 5% AEP flood without overtopping the banks of Washpen Creek;
- In an extreme flooding event along Washpen Creek, floodwaters from the Washpen Creek/Yanco Creek floodway would overtop the existing banks of Washpen Creek, allowing floodwaters to discharge into the site; and
- The Project does not affect flood flows, flood levels, or velocities along Washpen Creek.

The estimated flood levels and flood envelopes derived from riverine sources along the edge of Washpen Creek are shown on Attachments A to H for the 5%, 1%, 1 in 200 and PMF floods on the Washpen Creek/Yanco Creek floodplain.

The Project does not include any works such as bulk filling that will reduce flood storage and/or redirect flood flows. Accordingly it is not expected that the Project will materially impact on riverine flooding behaviour in Washpen Creek.

8.4 Site Flooding from Riverine Sources

8.4.1 Flooding from a 5%AEP in the Murrumbidgee River

A 5%AEP (1 in 20-year) flood along the Murrumbidgee River would peak at a level of 139 m AHD at the Yanco offtake. Floodwaters from the Murrumbidgee River would partially flood the Yanco floodplain with depths between 0.3 m and 3 m as shown in **Figure 22**. Flood flows are contained within the banks of Back Creek and Washpen Creek.

The Project site would be unaffected by creek surcharge flows from a 5% AEP (1 in 20) in the Murrumbidgee River.

Hydraulic modelling also indicates that a flood peak along the Murrumbidgee River would take 3 to 4 days to reach areas of Washpen Creek adjacent to the site.

A more detailed extent of flooding in the Murrumbidgee River during a 5% (1 in 20) AEP can be seen in in **Attachments B1 and B2**.

Figure 22 Inundation of the Project site from a 5%AEP Event in the Murrumbidgee River

8.4.2 Surcharge Flows from a 1%AEP in the Murrumbidgee River

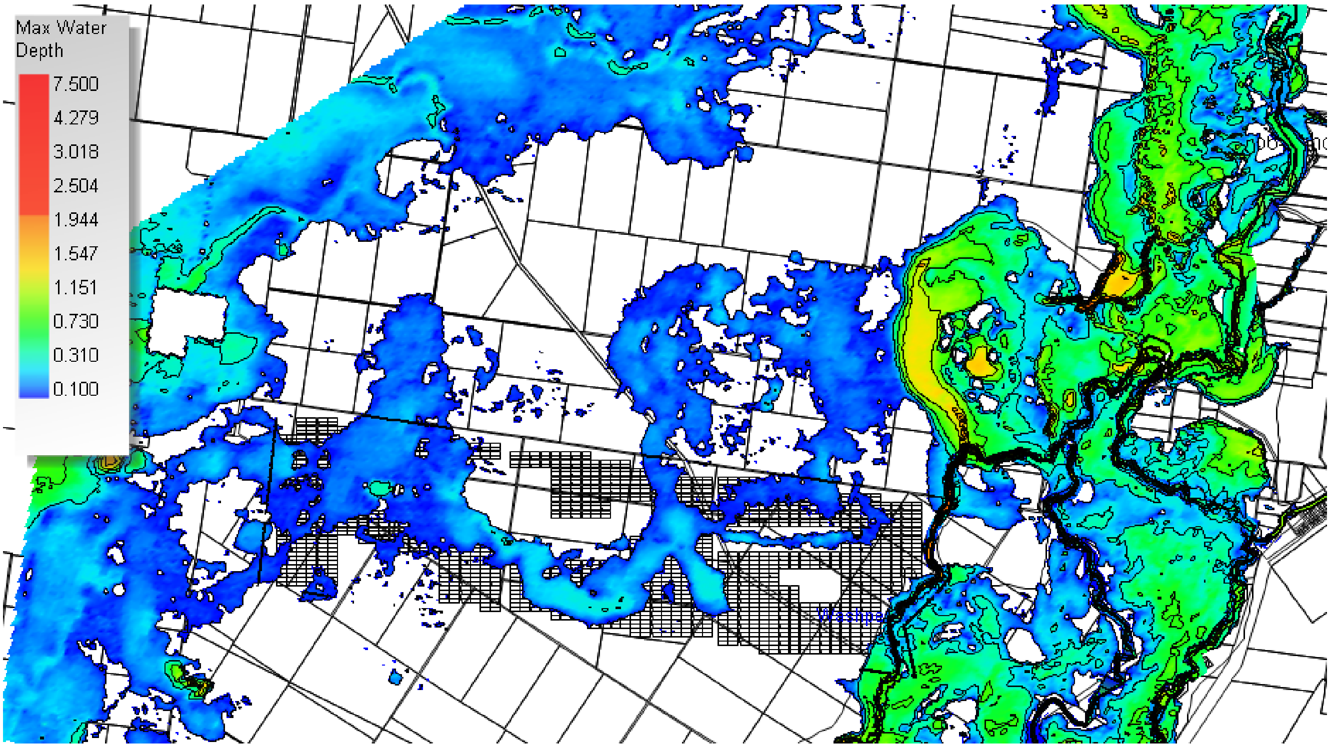
A 1% AEP (1 in 100) in the Murrumbidgee River would peak at a level of approximately 140.75m AHD at the Yanco Creek offtake. This would result in significant surcharging of the Yanco creek system.

Washpen Creek would flood a small section of the southeastern corner of the Project site, to depths of 1m, as indicated in **Figure 23 and Attachment B4**.

An area of Back Creek which is north of the Project site, and upstream of Washpen Creek, breaks it banks during a 1% AEP event. This results in shallow surcharge flows which move west and south from Back Creek, then enter the Project site at the northeastern boundary, subsequently following a meandering path to the southwestern corner.

Approximately 30% of the Project site would be inundated with depths exceeding 100 mm. Depths up to 0.8 m would be experienced in the central southern areas. The velocity of floodwaters would be slow, with peak velocities between 0.3 m/s and 0.8 m/s over the Project site. These conditions would be considered low hazard apart from the small section to the central southern area. However, the site could not be safely accessible by light vehicles during such an event.

Figure 23 Inundation of the Project site from a 1%AEP Event in the Murrumbidgee River



Since the panels are mounted above the ground on posts the potential flood inundation should have no effect on the operation of the facility, provided that equipment sensitive to inundation is designed with adequate elevation. The posts supporting the PV panels will have negligible hydraulic effect on the passage of flood flows, so the flood behaviour across the site, and on the adjoining properties, is unchanged.

An access road along the southern boundary would be largely unaffected by the floodwaters. Any site access roads which are aligned north-south will cross the overland flow path. It is not intended to provide flood free road access, and these roads would be built practically at grade with the existing terrain.

The proposed location for the Project substation is above the 1% AEP flood level and situated between two flow paths. A risk assessment would be performed in the detailed design phase for the substation to confirm the appropriate elevation for this infrastructure, with consideration to factors such as selection of AEP, climate change, accuracy of flood level estimation, and additional freeboard for waves.

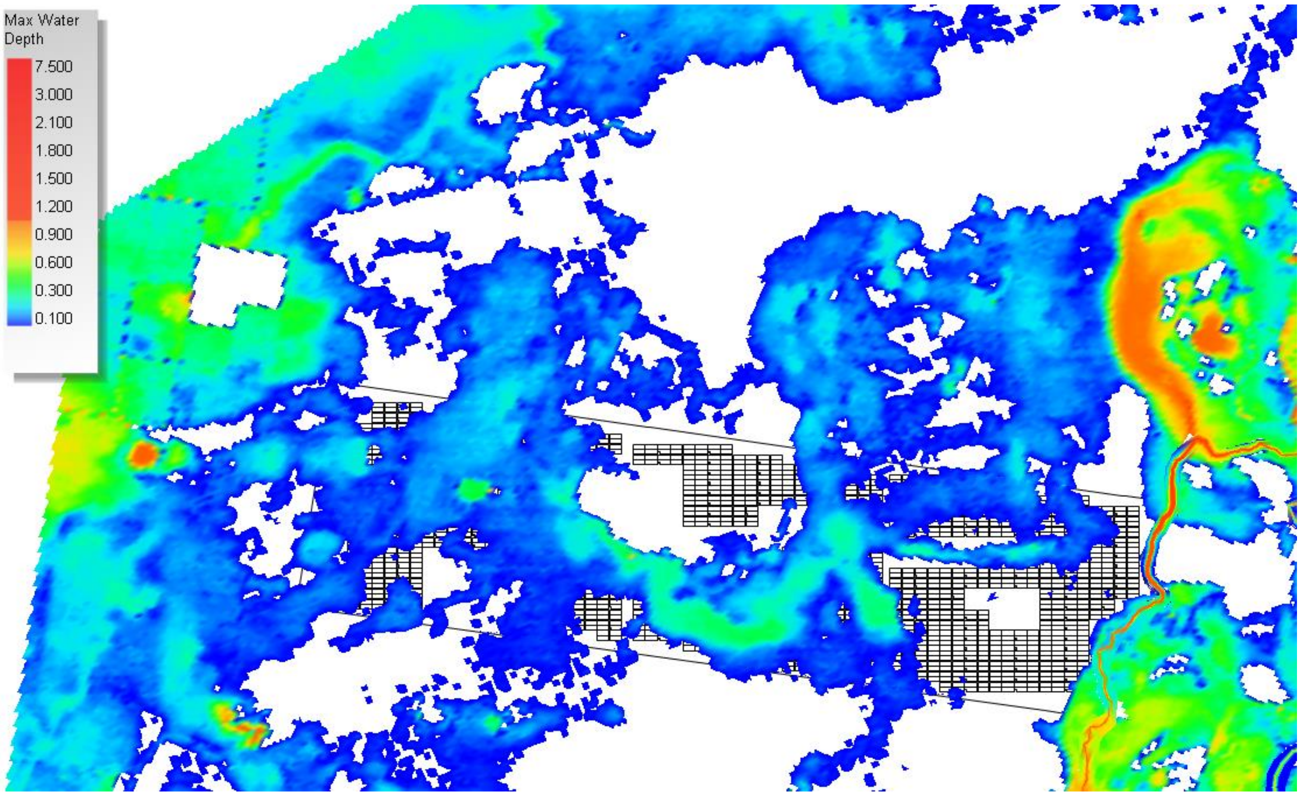
With such low velocities and flood depths the afflux of floodwaters discharging from the Project site to the west during the 1% AEP riverine event would be unaffected by the Project. Properties to the north and south would not experience a change in flood behaviour as the runoff through the Project site travels from a northeasterly to a southwesterly direction.

A more detailed extent of flooding in the Murrumbidgee River during a 1% AEP (1 in 100) can be seen in **Attachment B3** and flooding near the Project site in **Attachment B4**.

8.4.3 Surcharge Flows from a 0.5% AEP Event in the Murrumbidgee River

A 1 in 200 year, or 0.5% AEP flood event in the Murrumbidgee River would peak at a level of approximately 140.9m AHD at the Yanco Creek offtake. This would result in significant surcharging of the Yanco Creek system including Back Creek to the north of the Project site. Approximately 45% of the Project site would be affected by surcharge floodwaters exceeding a depth of 100 mm, with the greatest depth of 1.1m attained in small pockets in the central southern area. The velocity of floodwaters would be slow with peak velocities between 0.3 m/s and 0.8 m/s expected over the Project site. The conditions would be considered low hazard over the majority of the Project site apart from the central southern zone. However, the site may not be safely accessible by light vehicle during such an event. The pattern of flood depths is shown in **Figure 24**.

Figure 24 Inundation of the Project site form a 0.5% AEP event in the Murrumbidgee River



During an event of this magnitude the extent of site inundation from Washpen Creek in the southeastern corner of the site would be increased. PV panels and flood sensitive equipment at this location would need to be elevated to allow for flood depths of up to 1.1 m, plus freeboard.

The proposed infrastructure will not change the flood behaviour either upstream or downstream of the Project site caused by riverine flooding during a 0.5% AEP event. There would be negligible change in flood depths, velocities and flow distribution.

For a flood of this magnitude it takes two days for the flood peak to arrive at the Project site, after the flood peak has arrived at Narrandera. The total flood warning time available would therefore be in excess of two days.

If the project has a lifespan exceeding 50 years then the 0.5% AEP riverine event would be considered the Design Event for elevating infrastructure.

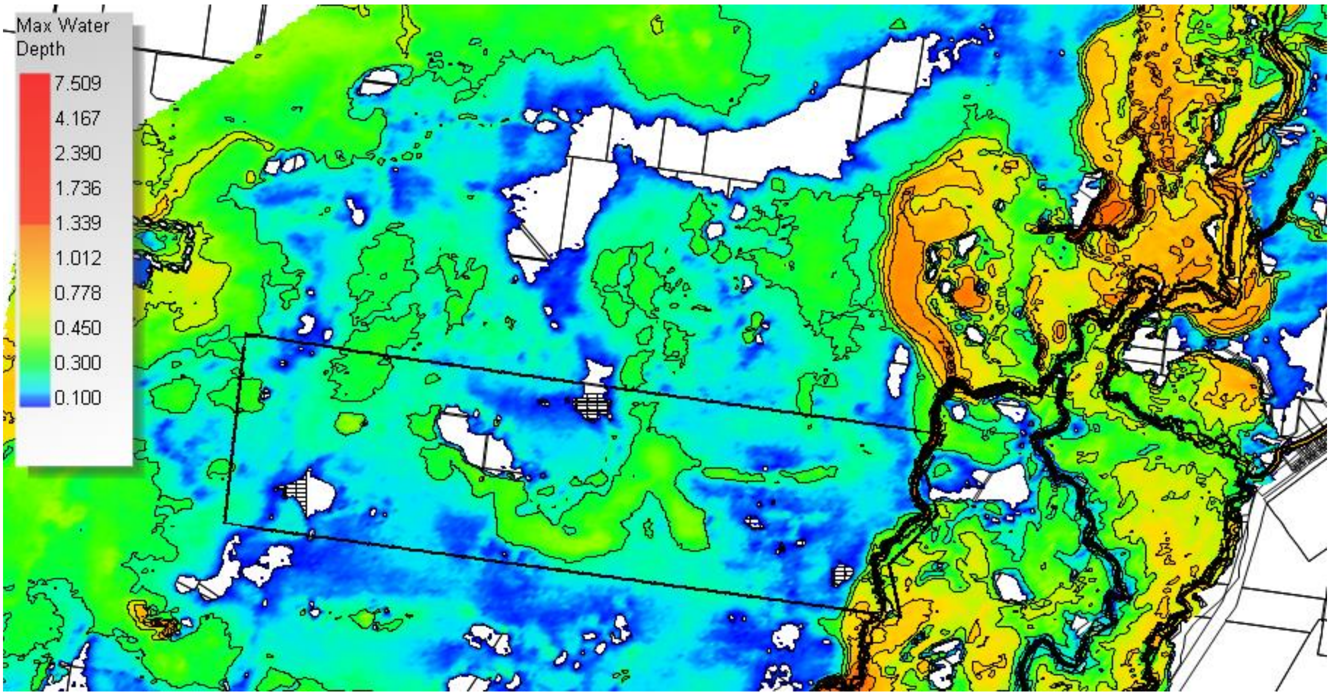
A more detailed extent of flooding in the Murrumbidgee River during a 0.5% AEP can be seen in **Attachment B6** and flooding near the Project site in **Attachment B7**.

8.4.4 Surcharge flows from a PMF in the Murrumbidgee River

A PMF in the Murrumbidgee River would be a catastrophic event resulting in widespread infrastructure damage and inundation at Narrandera and other towns. Catchment wide evacuation warnings would be in place days before the floodwaters reach the Project site. Modelling has indicated that there would be approximately 12 hours warning time between a peak in the Murrumbidgee River and a peak at the Project site.

A PMF in the Murrumbidgee River would result in almost total inundation of the Project site with depths between 0.1 m and 1.3 m and velocities between 0.2 m/s and 0.8 m/s. The combination of these levels and velocities would be considered hazardous at most parts of the site. A detailed Flood Management Plan will be prepared for the operational phase, and will outline procedures for flood awareness, flood warning, evacuation and/or refuge. Since safe egress will not be possible during a PMF event, a flood refuge site will need to be established. The flood modelling indicates that there are several areas not inundated in a PMF event which would be suitable for location of an extreme flood refuge. These are shown in **Figure 25**.

Figure 25 Inundation of the Project site form a PMF in the Murrumbidgee River



A more detailed extent of flooding in the Murrumbidgee River during a PMF can be seen in **Attachment B8** and flooding near the Project site in **Attachment B9**.

9 Site Flooding from Local Rainfall

This section describes the behaviour of surface water flows across the Project site during local rainfall events.

9.1 Existing Conditions

The existing runoff characteristics of the Project site will be maintained throughout the construction and operation of the proposal. As described in **Section 6.1**, while the Project involves constructing solar arrays with impervious surfaces, these would not increase runoff, since the same area of soil is still available for infiltration below the solar panels, and a good vegetation cover will be maintained to spread flows.

9.2 Proposed Drainage Structures

Overland flow pathways will be maintained in their natural state and locations. All PV arrays will be elevated above ground by at least 3 m, and will not impede the flow of runoff across the ground surface.

Where PV arrays are located within overland flow pathways, their height above ground will be increased if warranted by the predicted flow depth and velocity, to reduce the risk of damage to arrays.

Site access tracks will have a table drain on the upslope side that will convey runoff towards the nearest overland flow path. The site access tracks will be graded to follow the existing terrain, which is very flat across most of the site, and the table drains will also be constructed at very flat grades. Some localised ponding is likely to occur in table drains following heavy rainfall.

The existing farm dam will be kept and has been included in the flood modelling.

9.3 Site Flooding from Local Rainfall

Due to flatness of the terrain, hydraulic modelling has been used to reveal the contributing catchment draining to and through the Project site, which is approximately 96km^2. This catchment is shown in **Figure 26**. Rain falling outside this area will enter the Yanco Creek floodplain or pass by the Project site. The catchment is extremely flat so runoff rates will be low.

9.3.1 Site flooding during a local 5%AEP event

Flooding from local rainfall is widespread and patchy. A 5% AEP (1 in 20 year) local rainfall event would inundate approximately 15% of the Project site with depths exceeding 100mm.

The shallow flat depression that meanders through the centre of the Project site would fill to depths between 0.1 m and 0.5m with the greatest depths experienced in the central southern area. Flow velocities are very low, and less than 0.1 m/s – refer **Figure 27**. This indicates that no scour would occur with a rainfall event of this magnitude.

Figure 26 Inundation of the Project site form a local 5%AEP rainfall event

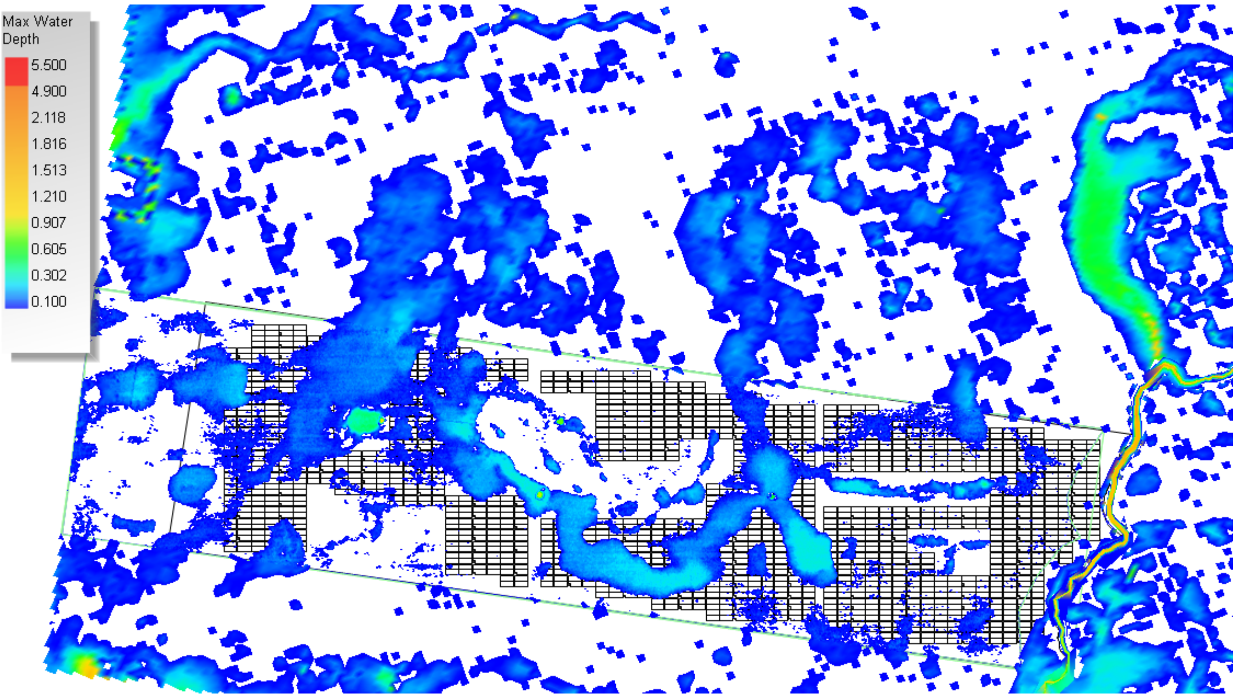
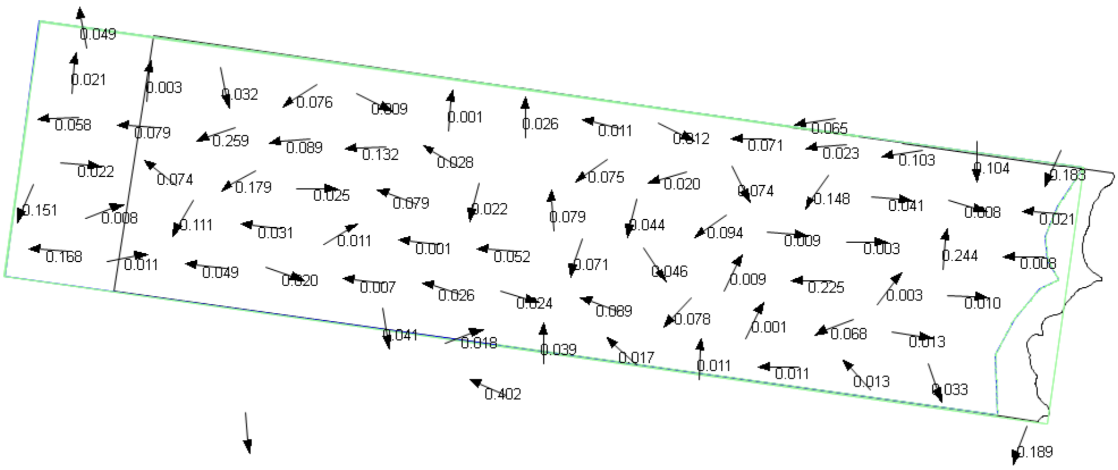


Figure 27 Site velocities during a 5% AEP local rainfall event



A more detailed extent of flooding at the Project site during a 5% (1 in 20) AEP local rainfall event can be seen in **Attachment B10** before development and **Attachment B13** after development.

9.3.2 Site flooding during a local 1% AEP event

A 1% AEP (1 in 100) local rainfall event would inundate approximately 20% of the site with depths exceeding 100mm. The shallow flat depression that meanders through the centre of the site would fill to depths between 0.1 m and 0.75 m with the greatest depths experienced in the central southern area. The water moves very slowly, with velocities of less than 0.3m/s – refer **Figure 29**. This indicates that no scour would occur with a rainfall event of this magnitude.

Figure 28 Inundation of the Project site form a local 1%AEP rainfall event

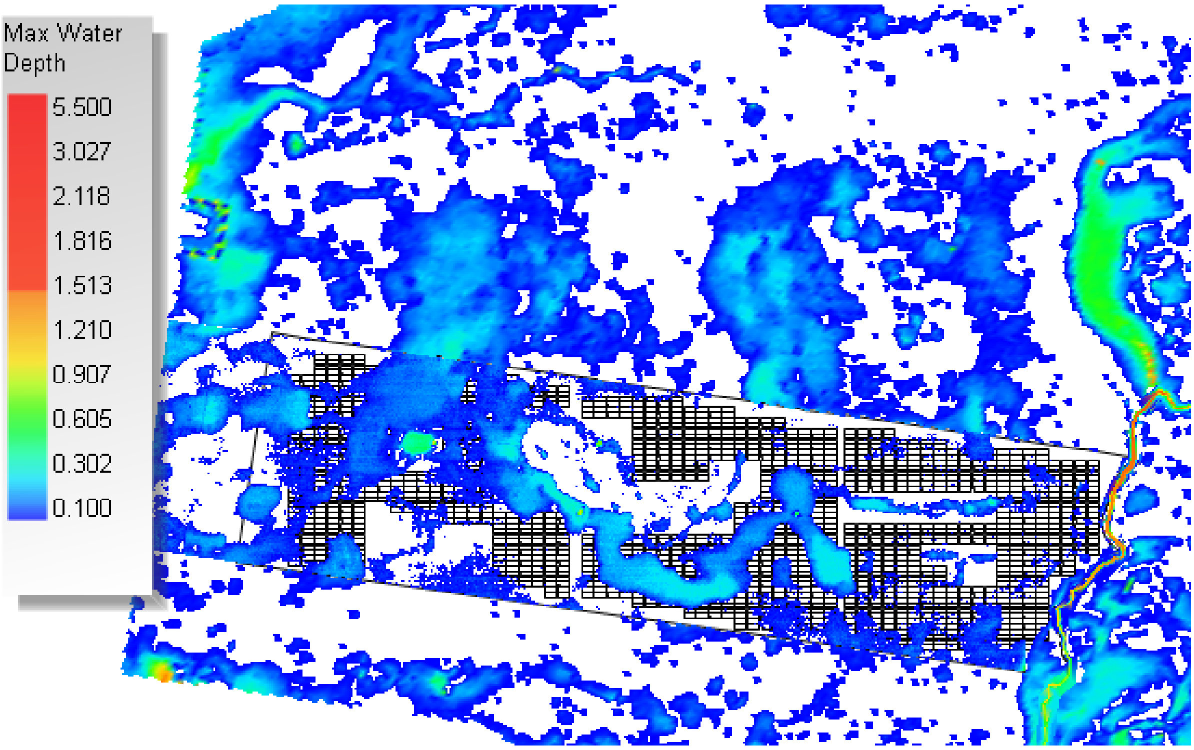
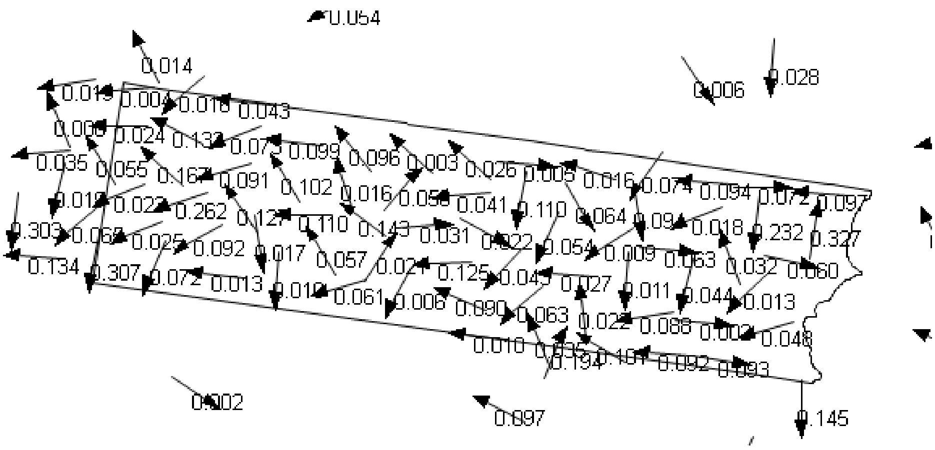


Figure 29 Site velocities during a 1% AEP local rainfall event



A more detailed extent of flooding at the Project site during a 1% (1 in 100) AEP local rainfall event can be seen in **Attachment B11** before development and **Attachment B14** after development.

9.3.3 Site Flooding during a local 0.5% AEP Event

A 0.5% AEP (or termed 1 in 200 in ARR2016) 24 hour local rainfall event would inundate approximately 20% of the site with depths exceeding 100 mm. It should be noted that the critical duration for the site is the 4.5 hours storm however storm of this magnitude commence at 24 hours. The results will therefore not be an incremental increase on the 1% AEP depths.

The shallow flat depression that meanders through the centre of the site would fill to depths between 0.1 m and 0.75 m with the greatest depths experienced in the central southern area. The water is almost stagnant with velocities between 0.05 m/s and 0.3 m/s – refer **Figure 30**. This indicates that no scour would occur with a rainfall event of this magnitude.

Figure 30 Inundation of the Project site form a local 1 in 200 AEP rainfall event

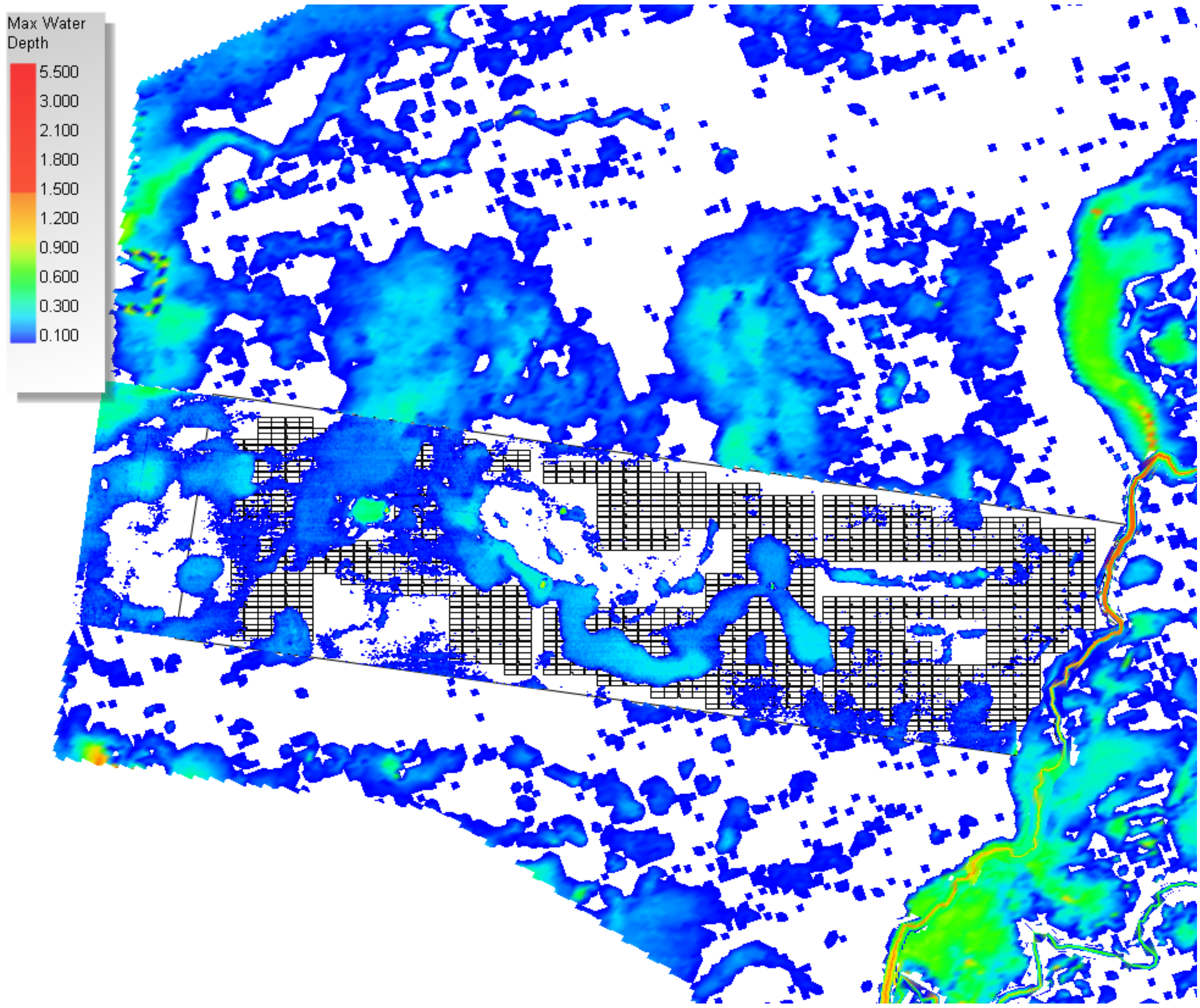
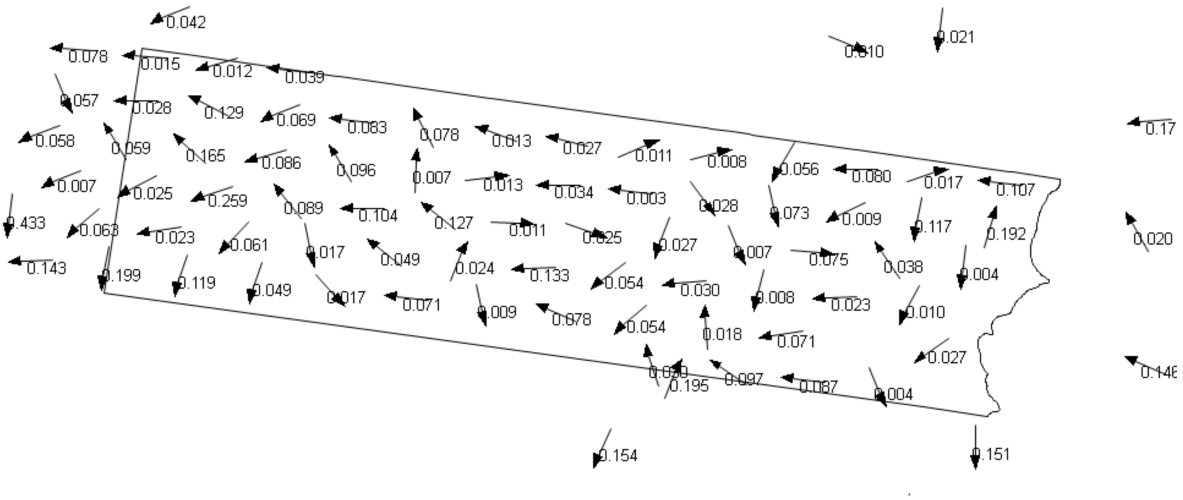


Figure 31 Site velocities during a 1 in 200 AEP local rainfall event



A more detailed extent of flooding at the Project site during a 0.5% (1 in 200) AEP local rainfall event can be seen in **Attachment B12** before development and **Attachment B15** after development.

9.4 Site Discharges

Hydrological and hydraulic modelling of local rainfall events has been carried out using the XP-SWMM software to estimate the peak depths for both the existing Project site, and for the developed Project site, at all boundaries around the site. The results are summarised in Table 16.

Table 16 Project site Perimeter Discharges

AEP	Flood level at boundary (existing)	Flood level at boundary (developed)	Change (%)
Western Boundary			
5%	131.4	131.4	0
1%	131.4	131.4	0
1 in 200*	131.4	131.4	0
Southwestern Boundary			
5%	130.3	130.3	0
1%	130.5	130.6	+0.1
1 in 200*	130.45	130.6	+0.15
Northwestern Boundary			
5%	131.0	131.0	0
1%	131.2	131.1	-0.1
1 in 200*	131.15	131.05	-0.1
Northeastern Boundary			
5%	134.3	134.3	0

AEP	Flood level at boundary (existing)	Flood level at boundary (developed)	Change (%)
1%	134.3	134.3	0
1 in 200*	134.3	134.3	0
Southeastern Boundary			
5%	131.6	131.6	0
1%	131.8	131.7	-0.1
1 in 200*	131.8	131.8	0

Note * the 1 in 200 AEP event was based on a 24 hour duration minimum as required by ARR2016. The 5% and 1% AEP events were based on the critical duration of 4.5hours.

Hydraulic modelling of riverine flooding before and after development has not been tabulated as there is no difference in flood levels for both cases.

9.5 Risk to Loss of Life

The Project will be designed to minimise risk to occupants from flooding events, in accordance with the Floodplain Development Manual (OEH), and any relevant requirements within a Floodplain Management Plan (DPI Water). This would include the risk of extreme events overtopping the banks of Washpen Creek and minimisation of hazardous environments. Hydraulic modelling has indicated that flood magnitudes up to the 1 in 200 AEP would not result in a hazardous environment on the Project site apart from a small area in the central southern portion of the Project site. Velocity depth ratios remain below 0.4 over 98% of the site which is considered low hazard.

A PMF would be considered a high hazard to personnel. A refuge location would be required to be identified. As the critical inundation conditions are experienced during riverine flooding, significant warning times would be made available to ready the site for inundation.

9.6 Risk to Property

PV arrays will be elevated above ground level on steel piles, so that they will not be susceptible to damage from flooding. The axis of arrays will be at least 3m off the ground, and during normal operation the arrays will tilt to follow the sun, and the lowest part of the array will get no closer than 500 mm off the ground. The elevation of the arrays and water sensitive equipment will be designed with regard to estimated flood depths, which vary across the Project site, so that flood damage is very unlikely. Similarly, arrays are not likely to be damaged by debris being carried by floodwater as it is so slow moving. The arrays themselves will not impede the passage of floodwaters. The steel piles which support the arrays are designed to withstand potential damage by water flows, and will not impede the movement of overland flows as the velocity is very low.

Cabling and electrical equipment is generally insulated and hence water resistant and can be either located in areas outside of flood risk, or designed to withstand inundation. Other project infrastructure such as the substation, potential energy storage, etc, will be provided with appropriate levels of flood immunity in accordance with relevant standards. These locations are not within overland flow paths, and any minor earthworks to provide elevated pads will not result in any significant loss of flood storage or flood level afflux.

10 Water Supply

This section describes how water will be sourced and used during the project construction and then during operation.

10.1 Construction Phase

Water demand for the Project will be very minor as the construction of the solar PV project is not water intensive.

During the construction phase potable water may be transported to site in water trucks and stored in temporary water tanks for use by the construction work force. Options for non-potable water supply being considered include:

- Groundwater from the existing site bore, may be utilised subject to landowner agreement;
- Purchase of water from adjoining landholders;
- Trucking water in ;
- Harvesting of site surface water (within harvestable rights); and
- Recycled grey water.

- Non-potable water use during construction would be mainly for dust suppression on unsealed roads and watering to re-establish vegetation on disturbed areas. Based on a staged construction of 100 ha per month, with up to 15% disturbance by area, and a dust suppression/watering application depth of 5mm per day, then the daily demand for construction water may be up to maximum of 750 kL/day during dry weather. Since water usage would be less during and following rainy days, average water usage over the construction period may be less, suggesting an annual water need of between 150 ML and 160 ML.

Wastewater and greywater during construction will be captured and removed from site for off-site treatment.

The provision of potable water, grey water and wastewater infrastructure would be confirmed during the detailed design phase of the project.

10.2 Operational Phase

During operation of the solar facility water will be utilised for the following purposes:

- Potable water for site offices;
- Cleaning of PV arrays;
- Dust suppression on site access roads; and
- Topping up a fire fighting water tank for the Project. Subject to detailed design and consultation with firefighting authorities this will be a single 20,000 L tank or potentially two 10,000 L tanks.

Water demands during this phase of the Project will not be significant, and based on a review of similar projects in NSW are unlikely to exceed 5 ML per year. Potable water will be trucked into site to refill facility water tanks.

Demands for non-potable water may be met by several methods which are under consideration, including:

- Water tanks collecting roof water;
- Collection of surface water within harvestable rights;
- Groundwater from existing water bore on site (subject to landowner agreement); and
- Supplementary water as required via water trucked to site.

Toilet facilities may comprise waterless composting facilities, and will be provided in line with the requirements of Narrandera Council. The provision of potable water, grey water and wastewater infrastructure would be confirmed during the detailed design phase of the project.

Methods for water supply will be finalised during the detailed design phase of the project. Water use approval is not required for State Significant Developments under section 89J (1)(g) of the EP&A Act.

11 Monitoring, Licensing and Reporting

This section describes how the Project will monitor and report on environmental management of water resources during the construction and operational phases.

11.1 Construction Environment Management Plan (CEMP)

A CEMP will be prepared during the detailed design phase of the project, and will outline the environmental measures, monitoring and reporting required to ensure satisfactory environmental performance. Minimum requirements for inclusion within the CEMP include:

- Water quality monitoring during the construction phase, as described below for the OEMP.
- An Erosion and Sediment Control Plan (ESCP) for construction activities that is consistent with the measures outlined in this EIS.

Minimum requirements for inclusion within the CEMP are documented in Section 5.5 (ESCP) and 5.7 (Hydrocarbons and chemicals) of this report.

11.2 Operational Environment Management Plan (OEMP)

An OEMP will be prepared during the detailed design phase of the project, and will outline the environmental measures, monitoring and reporting required to ensure satisfactory environmental performance.

With regard to water quality monitoring, the default water quality triggers from ANZECC 2000 will be used as an initial baseline for water quality trigger values. These trigger values are considered to be conservative, and water management that achieves these outcomes is considered to pose a low risk to the downstream environment and downstream water users.

However, since there is no site specific baseline of water quality data, an adaptive approach is recommended, to enable the management regime to change as appropriate should unforeseen water quality issues become evident. The proposed mechanism for identifying changes is a bi-annual review of water quality.

Minimum requirements for inclusion within the OEMP include:

- Water quality monitoring is to include two background locations in addition to project water quality monitoring.
  - The project water quality monitoring will initially be from the existing farm dam, on the basis that this will be representative of all activities associated with operation of the Project farm.
  - Additional water quality monitoring will be taken from a site immediately downstream from staged construction activities, which may vary in location as construction progresses
- Water quality testing including the suite of analytes as identified in **Table 14**.
- Annual reporting of monitoring results, and comparison to the trigger and background water quality
- A bi-annual review of the adequacy of water quality, and recommendations for any adaptive changes to the water quality trigger values, methods of monitoring water quality on site, and/or any additional frequency and/or analytes to be included within the water quality testing regime.
  - The bi-annual review will be submitted to the ARA.

- ESCP for ground disturbance activities as per **Section 5.6** of this report
- Requirements for storage and use of hydrocarbons and chemicals, and a spill response plan, as per **Section 5.7** of this report

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Floodplain Development Manual (OEH)

Floodplain Management Plan (DPI Water)

Guidelines for Controlled Activities on Waterfront Land (DPI Water)

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ATTACHMENT A

Details of Hydrological and Flood Modelling

FIGURES **Page**

TABLES **Page**

Details of hydrological and flood modelling

This attachment describes technical details of the flood modelling carried out for this assessment.

Rainfall and Temporal Patterns

BoM rainfall data for 2016 has been used to assess existing local flooding conditions.

The potential increased rainfall intensity during storms from climate change (temperature) has been assessed with a sensitivity analysis assuming a 12% increase in 2016 IFD rainfall depths. This equates to the 1 in 200 year rainfall depths and has been modelled as such.

Temporal patterns for use in flood modelling were sourced from Australian Rainfall and Runoff (2016) data hub (http://data.arr-software.org)

Selection of Modelling Software

Hydrology and hydraulic flood behaviour in the creeks and flood plains adjacent to the project site, and surface flows across the site, have been modelled using the XP-SWMM software. The software has the capability to combine 1D and 2D and 2D course mesh with 2D fine mesh. The defined channels with relatively uniform cross sections were modelled using the 1D algorithm to both speed up run times and represent the conveyance relationship of a creek bed more accurately than a stepped 2D section. The overbank sections can rarely be represented well using 1D algorithms and as such are represented using a 2D mesh. The Site was modelled with a mesh five times finer the overall floodplain to ensure all flow paths and storages were well represented.

Soil Information and Rainfall Infiltration

Selection of Rainfall Loss Model

Rainfall loss is defined as the precipitation that does not appear as direct runoff, and the loss is typically attributed to processes such as interception by vegetation, infiltration into the soil, retention on the surface (depression storage) and transmission loss through the stream bed and banks. It is the most important parameter in rainfall/runoff estimations.

Rainfall losses due to infiltration have a significant effect on the rates of runoff generated from rainfall, and vary significantly with soil type. It is therefore important to use the best available soil information to provide an accurate model for estimating runoff.

A commonly used infiltration model is the Initial Loss - Continuing Loss (IL/CL) model. Initial loss simulates the initial catchment wetting process, when no runoff is produced. Continuing loss accounts for ongoing infiltration following initial losses. The programmers of the hydrological model RAFTS-XP used in this study claim the IL/CL model "is at the very best crude and can in many instances cause greater errors in runoff estimates than all other modelling considerations combined" [XP-*RAFTS Reference Manual, WP Software, 2009]*

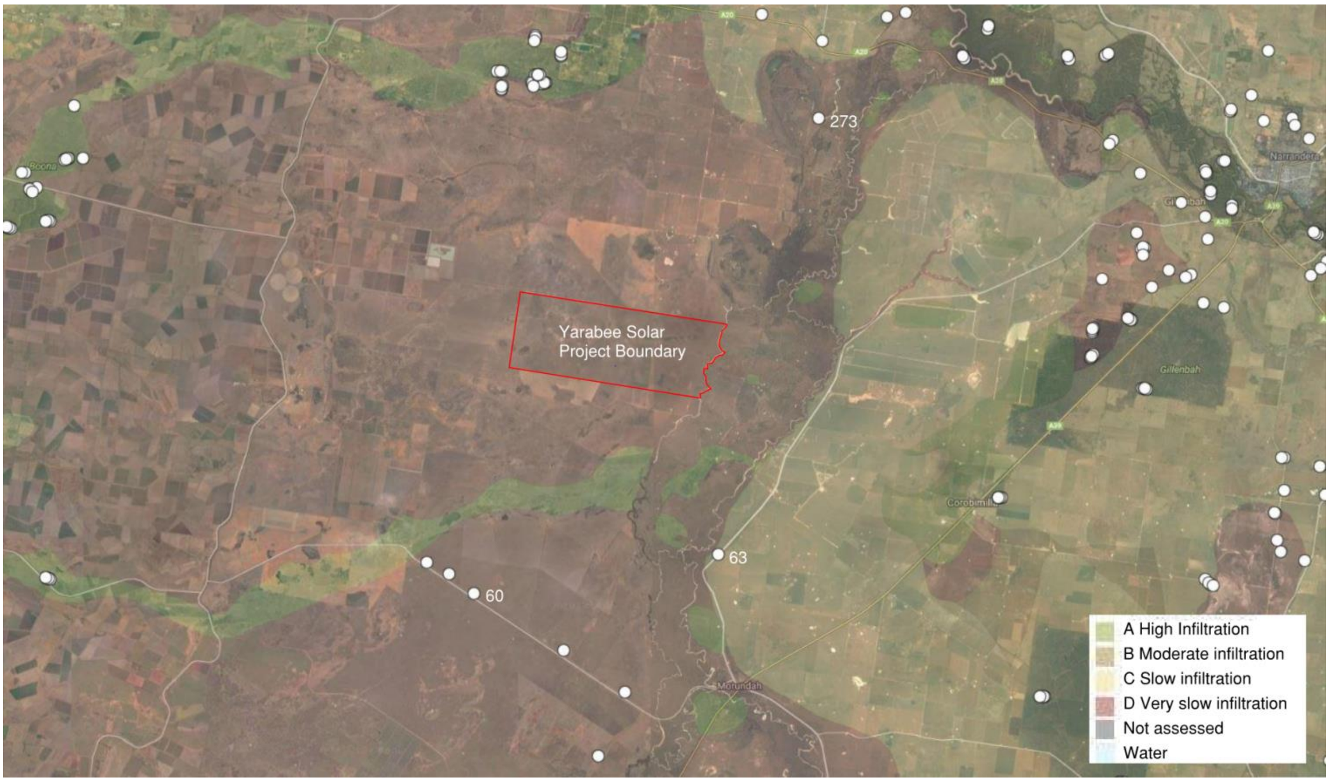
A more refined infiltration model is that suggested by Horton, in which infiltration rapidly declines from an initial rate during the early part of a storm, and then decays until it reaches an approximately constant rate for the remainder of the rainfall event. As reputable information concerning the soil type and depth is available, the Horton's infiltration model was used to describe the infiltration behaviour of the soil.

Available Soil Data

The Office of Environment & Heritage (OEH) has an extensive database of soil information across the state of NSW. Testing of soil in the vicinity of the proposed solar farm was limited with one test 8.2 km to the north, six tests 14km south and one test 9 km to the east. A catchment wide soil profile map prepared by OEH identified three distinct homogeneous soil types.

- Soils west of Yanco Creek including the project site, and the surrounding catchment which have a ‘very slow infiltration rate;
- Soils along the Yanco Creek system, with a high infiltration rate; and,
- East of Yanco Creek with a slow infiltration rate. **Figure A.1** identifies the location of soil testing sites performed by OEH in relation to the position of the Project site.

Figure A.1 Catchment Wide Soil Profile



Riverine Plains – East of Yanco Creek (profile 63)

The riverine plains blanket the floodplain east from Yanco Creek. The OEH assessment of this soil considers it to be moderately permeable and moderately well drained. Three distinct layers were identified namely;

(1) top soil (A1 horizon), which was described as light loamy sand with a depth to 250mm

(2) lower soil (A2 horizon) was identified as light brown sand extending from 250mm to 480mm

(3) subsoil (B horizon) is a band of sandy clay loam 100mm in thickness.

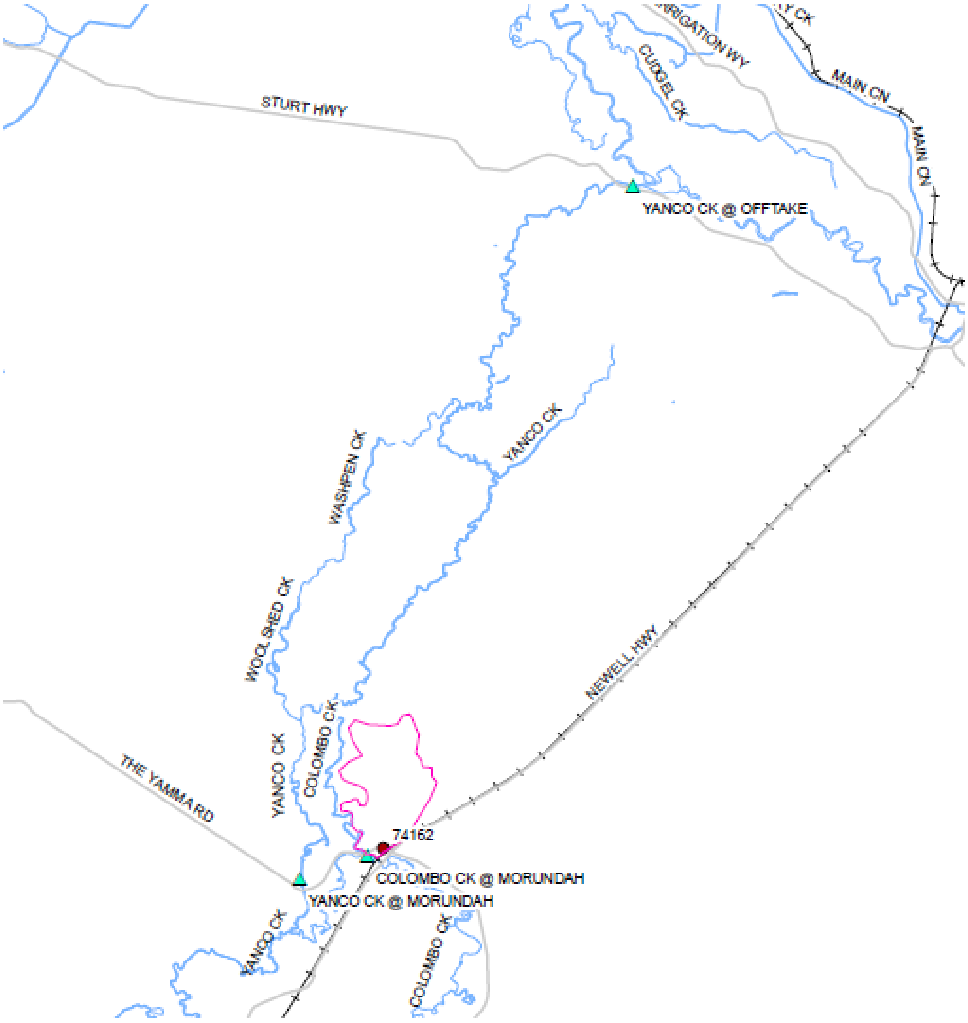
Assumptions:

Available storage capacity loamy sand A1	= (0.125-0.055)/2*250	= 8.8mm
Lower soil light brown sand A2	= (0.091-.033)/2*230	= 6.7mm
Subsoil sandy clay loam	= (0.255-0.148)/2*100	=5.4mm
Available storage capacity	= 21mm	
Initial wetting K of top soil	= 59.8 mm/h	
Asymptotic K	= 3 mm/h	

At the time of soil testing there was no surface water but the soil was moist. The profile was considered moderately permeable and moderately well drained. Refer **Attachment C** for the original soil reports.

The Morundah catchment lies within this soil zone and was calibrated by Jacobs in 2017 using a major event in March 2012. The available Morundah Hotel rainfall gauge was used to obtain a representative rainfall depth across the catchment. The temporal pattern from the Yanco Agricultural Institute pluviograph station was used for the timing and temporal distribution of the rainfall event. Since there was limited flood height information to calibrate the local catchment flows to, reasonable estimates of the model parameters were made. The adopted rainfall loss parameters adopted in this study were an initial loss of 25 mm and continuing loss of 2.0 mm/hr.

Figure A.2 Location of Catchment Calibrated by JACOBS in 2017 in relation to the Project site



Australian Rainfall and Runoff 2016 now provide estimates of infiltration within select areas of Australia based on historic calibration, which can be used in the absence of site specific data. At the location of the project site, infiltration values recommended by ARR are 26 mm initial loss and 0 mm continuing loss. Refer **Attachment D** for an extract from the ARR infiltration website. A continuing loss of 0 mm in a soil comprising a 480 mm depth of light loamy sand is considered to be too low. Research conducted by *Akan 1993* concluded a saturated hydraulic conductivity (continuing loss when saturated) for loamy sand to be between 7.6 mm/hr and 11.4 mm/hr. The variation in values could be a result of the saturated antecedent conditions in combination with the band of sandy clay underlying the light brown sand preventing penetration of water below the sand to continually infiltrate through the surface.

The Jacobs flood study at Morundah, adopted an initial loss of 25mm and continuing loss of 2 mm/hr after calibration. A +/- 20% in the initial loss value was tested without any change in the results. For the final runs Jacobs adopted an initial loss of 15mm for events up to and including the 10% AEP event, and an initial loss of 10mm adopted for events between 10% and 0.2% AEP. An initial loss of 0mm was adopted for the PMP event. A continuing loss of 2.5mm/hr was adopted for all design events up to and including the 0.2% AEP event and a continuing loss of 1mm/hr was adopted for the PMP event. With such variability in these recommendations without any basis for change SLR applied the Horton's infiltration model and assigned values defined by OEH with soil depths and profiles as logged. It was assumed the antecedent moisture condition was mid-way between the wilting point and field capacity at the start of all storms The following soil profiles apply to the contributing catchment.

West of Woolshed & Washpen Creeks (profile 60)

The OEH conducted soil testing in this area in 2003. The report identified the soil in this area to be very slowly permeable and very poorly drained. There was no surface water present at the time of testing and the soil was dry. The pedologist estimated run on of overland flow would be high and runoff low. Three soil layers were identified in the profile namely:

(1) topsoil - (A1 horizon), which was described as dark grey light clay with strong pedality to 20mm

(2) lower soil - (B2 horizon) was identified as light medium clay with strong pedality from 20 to 350mm

(3) subsoil - (B3 horizon) is medium clay with strong pedality from 350 to 650mm.

Refer **Attachment C** for a full report of soil profile 60. With knowledge of the saturated hydraulic conductivity, the wilting point and field capacity of the upper and lower soils, more realistic infiltration behaviour of the soil can be made using Horton's equations. This equation assumes that the infiltration rate decreases with time and the capacity of the of the soil decreases as the time of the storm increases because the pores in the soil become saturated and do not allow water to continuously infiltrate through the surface. The following parameters will be adopted for the soils west of Washpen and Woolshed Creeks:

- Initial infiltration rate in the light to medium clay top soils = 1 mm/hr
- Final infiltration capacity in the lower medium clay when top soils are saturated= 0.6 mm/hr
- Horton's decay coefficient for clay soils k = 0.001 sec-1

As the available water capacity (AWC) = field capacity (FC) – wilting point (WP) then the depth of water required to saturate the soil can be calculated knowing the overall soil depth. ARR recommends adopting an average antecedent condition at the commencement of the storm. This is a condition when the moisture state of the soil is midway between the field capacity and wilting point.

- Soil storage = (FC – WP)/2 x soil profile depth
- Soil storage depth in horizons (A1+ B2) = (0.387-0.250)/2 * 350mm = 24mm
- Soil storage depth in horizon (B3) = (0.396-0.272)/2 * 300mm = 19mm
- Total soil profile storage depth = 43mm

Refer **Attachment C** for soil parameters estimates.

<u>Flood Plain of Yanco Creek System (profile 273)</u>

The soils immediately to the east of the site were described as very slowly permeable and very poorly drained. No free water was evident at the time of testing. Run off was identified as high and runoff low. Five distinct layers were identified namely;

(1) the top soil (A1 horizon), described as dark greyish brown silty clay with strong pedality and 40mm thick

(2) subsoil (A2 horizon), described as dark greyish brown light clay with strong pedality and 170mm thick

(3) subsoil (C11 horizon), described as light olive brown light clay 180mm thick to 360mm depth

(4) subsoil (C12h horizon), described as light olive brown silty clay 310mm thick to 600mm depth

(5) baselayer (C13h horizon), described as light olive brown silty clay 1m thick to a depth of 1600mm

Refer **Attachment C** for a full report of profile 273. The following Horton parameters will be adopted for the soils in the flood zone between Washpen and Yanco Creeks:

- Initial infiltration rate in the silty clay = 1 mm/h
- Final infiltration rate in the light clay = 0.6 mm/h
- Horton's decay coefficient for clay soils k = 0.001 sec^{-1}
- Soil storage depth within the soil horizons:
  - Soil profile A1 = (0.387 - 0.25)/2 * 40mm = 2.7mm
  - Soil profile A2 = (0.396 - 0.272)/2 * 170mm = 10.5mm
  - Soil profile C11 = (0.396 - 0.272)/2 * 180mm = 11.2mm
  - Soil profile C12h = (0.387 - 0.25)/2 * 290mm = 19.9mm
  - Soil profile C13h = (0.387 - 0.25)/2 * 1000mm = 68.5mm
  - Total available depth = 112.8 mm

Refer **Attachment C** for field capacity and wilting point estimates of soils.

Catchment Surface Roughness

<u>Surface Roughness</u>

A critical value in the hydrologic and hydraulic processes is the surface roughness coefficient 'n', termed the Manning's 'n'. It is essentially a frictional resistance coefficient with higher number representing a rougher terrain which slows the passage of water.

The following photographs show typical landforms within the catchment with the adopted Manning's n values. Values were based on the hydraulic engineer's 'bible' *Open Channel Hydraulic, Ven Te Chow, 1959.*

Figure A.3 Natural Channel, Somewhat Irregular Side Slopes, Clean and Regular Bottom n=0.035;

Overbank Regions n=0.04

Figure A.4 Straight, few trees in channel n = 0.048;

Overbank regions heavy timber on overbank, flood stage below branches n = 0.10

Figure A.5 Overbank regions with no trees, short or no grass, eroded furrows n = 0.03

Figure A.6 Grass, weeds, scattered trees and brush n=0.06

Figure A.7 Mature field crops n=0.04

Figure A.8 Long grass, scattered and downed trees patchy areas n = 0.045

Figure A.9 Heavy stand of timber, few downed trees, flood stage reaching branches n=0.12

Figure A.10 Long grass, solar panels above flood level, sparse support posts n=0.05

A summary of the Manning's 'n' values adopted in the SLR model as provided in **Table A.1**.

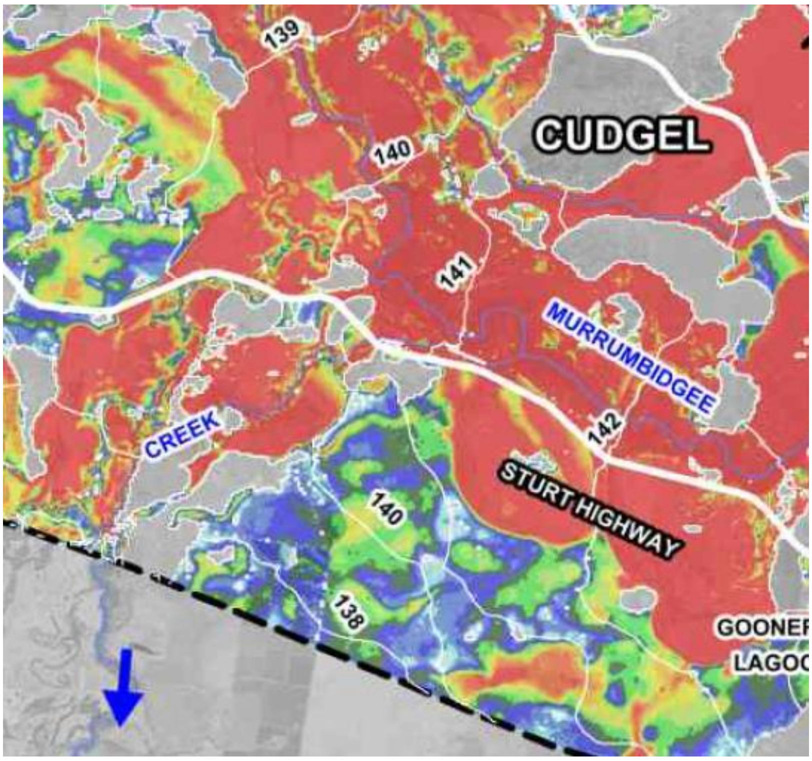
Table A.1 Manning's n Values Adopted for the Catchment

Surface Description	Manning's "n"
Natural channel, somewhat irregular side slopes, clean and regular bottom	0.035
Natural channel, irregular side slopes, scattered trees within the flow path	0.048
Bare earth, some eroded furrows on overbanks	0.03
Very sparse trees on overbank flood level below branches	0.04
Sparse trees on overbank flood level below branches	0.06
Medium timber on overbank flood stage below branches	0.08
Heavy timber flood stage below branches	0.1
Heavy stand of timber, few downed trees, flood stage reaching branches	0.12
Mature field crops	0.04
Long grass, scattered and downed trees patchy areas	0.045
Long grass, solar panels below flood level	0.05

Calibration of Flood Model

Lyall and Associates prepared a flood study of the Murrumbidgee River in 2015 which encompassed the Yanco Weir and offtake **Figure A.11**. The 1% AEP flood level at the weir and offtake corresponded to a water level of 140.7 m AHD. This water level was fixed as a northern boundary condition in the hydraulic model for this magnitude flood.

Figure A.11 Flood Inundation during the 1% AEP Event in the Vicinity of the Yanco Weirs and Offtake

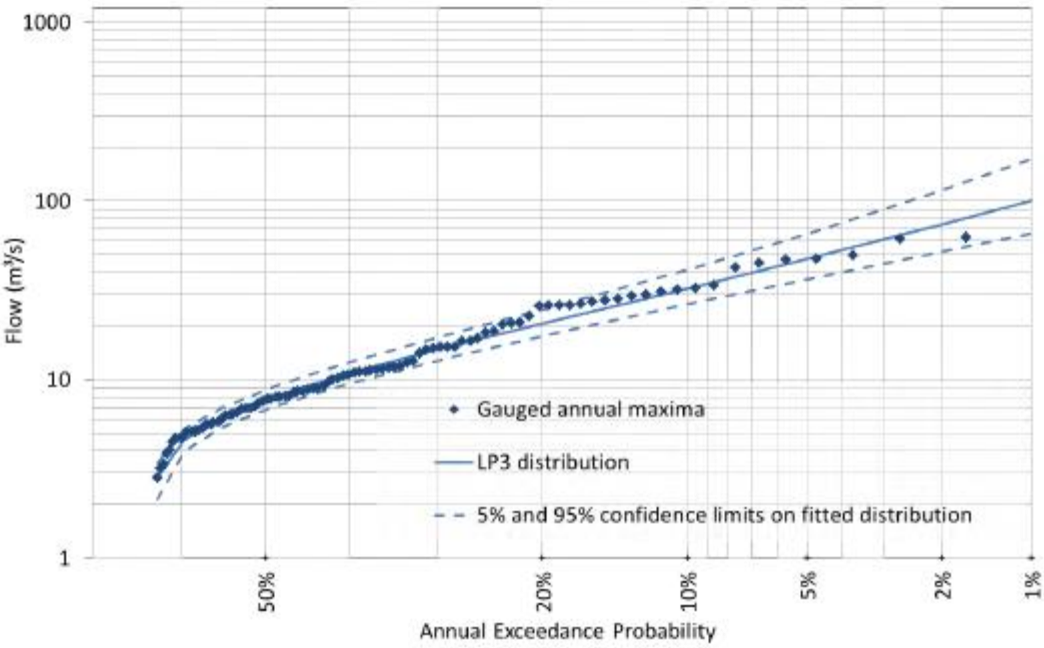


SLR

The hydrologic and hydraulic model prepared for this site extends from the Murrumbidgee River in the north to 3kms south of Morundah, a distance of approximately 34 km.

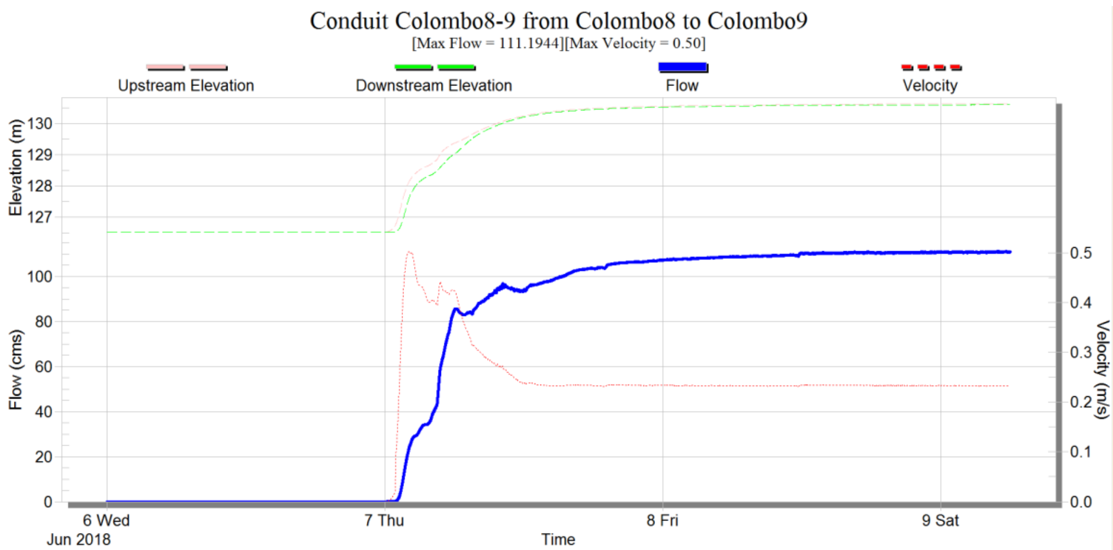
A flood frequency analysis was completed by *Jacobs 2017* at the Colombo Creek - Morundah flow gauge (GS410014) (**Figure A.12**) and the Yanco Creek – Morundah gauge (GS410015) (**Figure A.14**). The curves were derived from flows recorded between 1913 and 2012. The 1% AEP peak flow at the Colombo Creek gauge would be between 65 m^3/sec and 180 m^3/sec and that at the Yanco Creek gauge between 130 m^3/sec and 360 m^3/sec. The flood hydrographs produced at the two gauges to the south of the catchment were compared to these expected flows. A comparison within the confidence limits provides assurance of a satisfactory model build.

Figure A.12 Flood frequency curve for the Colombo Creek - Morundah flow gauge (GS410014)



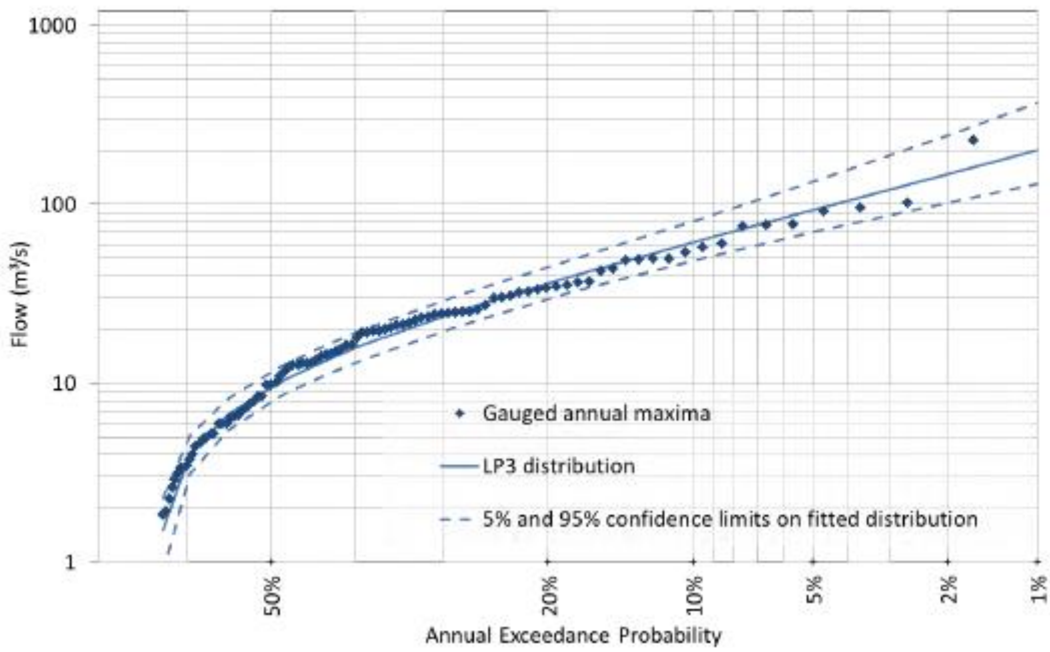
The following hydrograph shows a sound fit within the flood frequency curve for the 1% AEP evet at the Colombo gauge.

Figure A.13 Hydrograph produced at the Colombo gauge during the 1% AEP from riverine sources



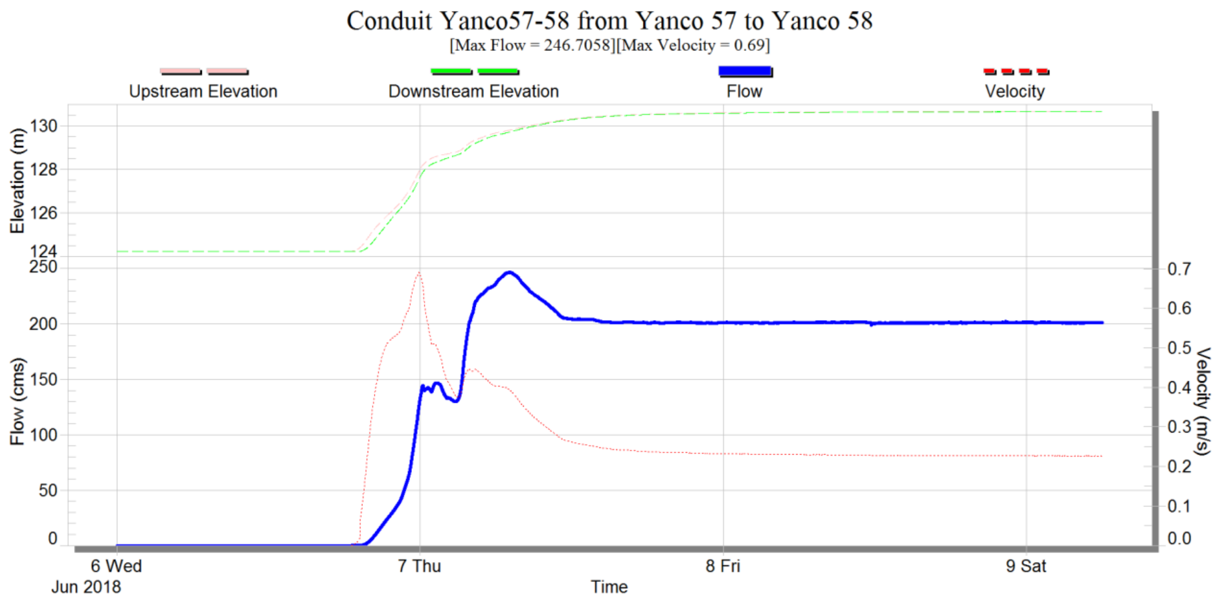
SLR

Figure A.14 Flood frequency curve for the Yanco Creek - Morundah flow gauge (GS410015)



The following hydrograph shows a sound fit within the flood frequency curve for the 1% AEP evet at the Yanco flow gauge.

Figure A.15 Hydrograph produced at the Yanco gauge during the 1% AEP from riverine sources

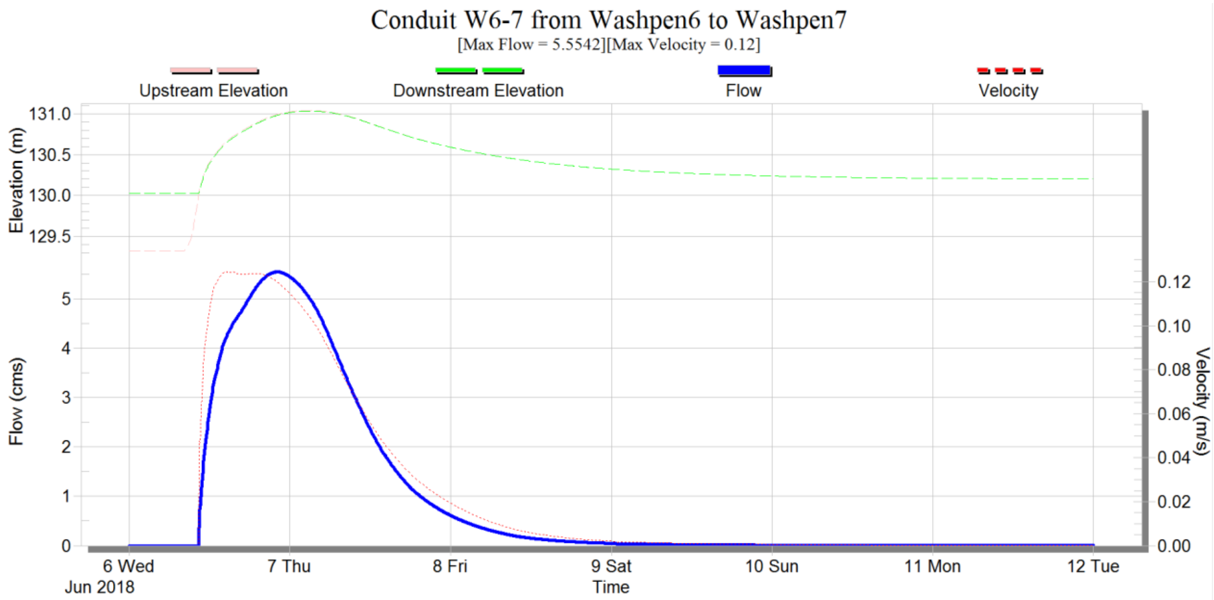


The calibration indicates the Manning's n and infiltration losses adopted for the catchment are sound.

Adoption of nominal Murrumbidgee River flows for local storms

It would be reasonable to assume some flow would be passing down the Murrumbidgee River when a local rainfall event occurs. A 20% AEP event on the Murrumbidgee River has been assumed to coincide with a local 5%, 1% and 1 in 200 AEP events. Figure A.16 identifies the resultant hydrograph in Washpen Creek immediately upstream of the Project site. This flow was applied in addition to the local rainfall. Low flows in Washpen Creek are dependent on the regulation of the Spillers gates on Back Creek immediately upstream. The Surveyor's report in the Jacobs study indicated that these gates are not maintained and are continually open. The control has been modelled to operate in this manner.

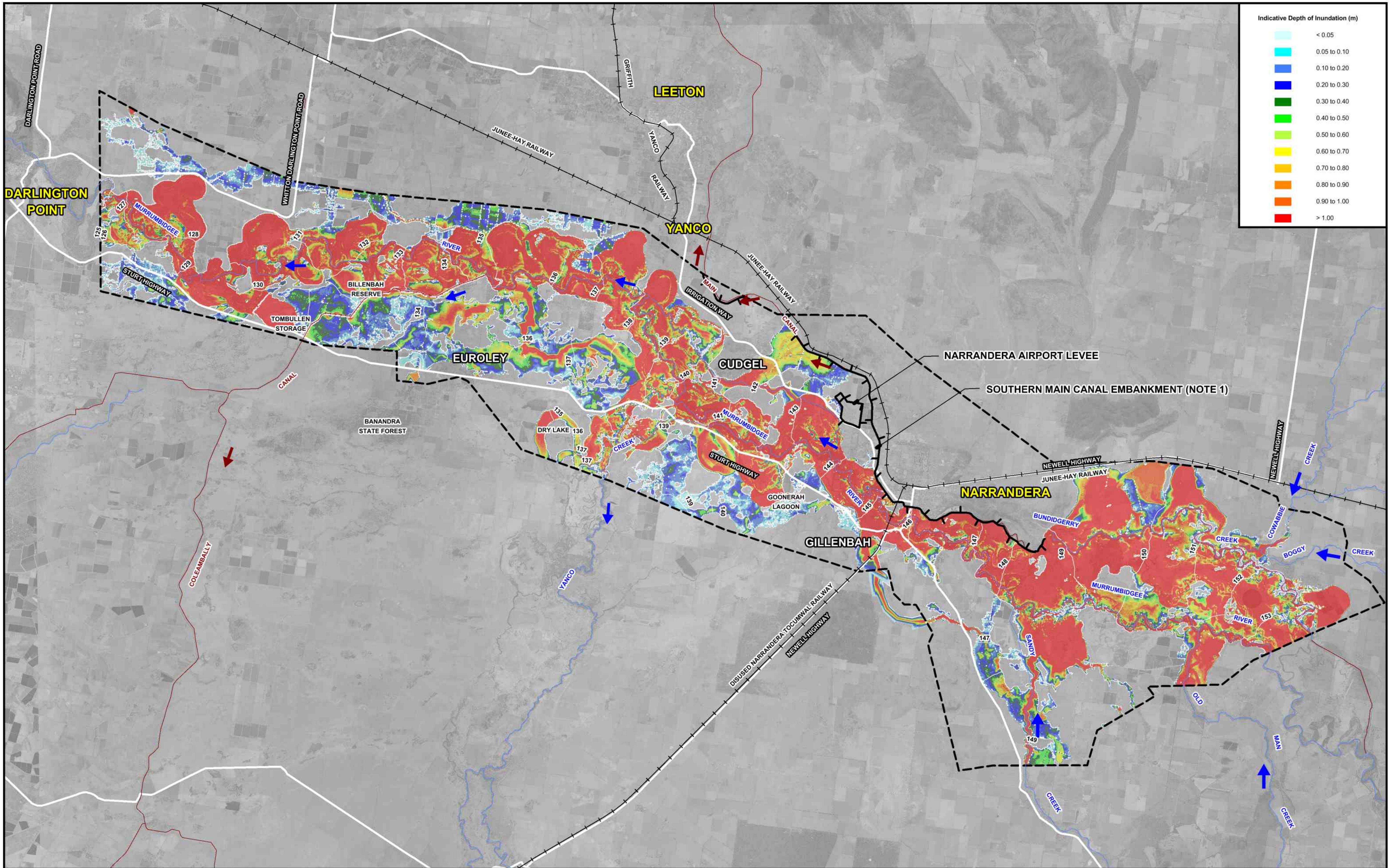
Figure A.16 Hydrograph in Washpen Creek during a 20% AEP in the Murrumbidgee River



ATTACHMENT B

MR Murrumbidgee River

SLR



N

2 0 2 4 6 km

Scale: 1:200,000

Lyall & Associates

NOTE:

The extent of flooding shown was determined from airborne laser scanning survey and are approximate only.

The extent of inundation in individual allotments near the flood fringe should be confirmed by site specific survey.

(1) Alignment of Southern Main Canal Embankment only shown within TUFLOW Model Extent.

(2) March 2012 Roughness Values Adopted for Design (See Figure 4.2)

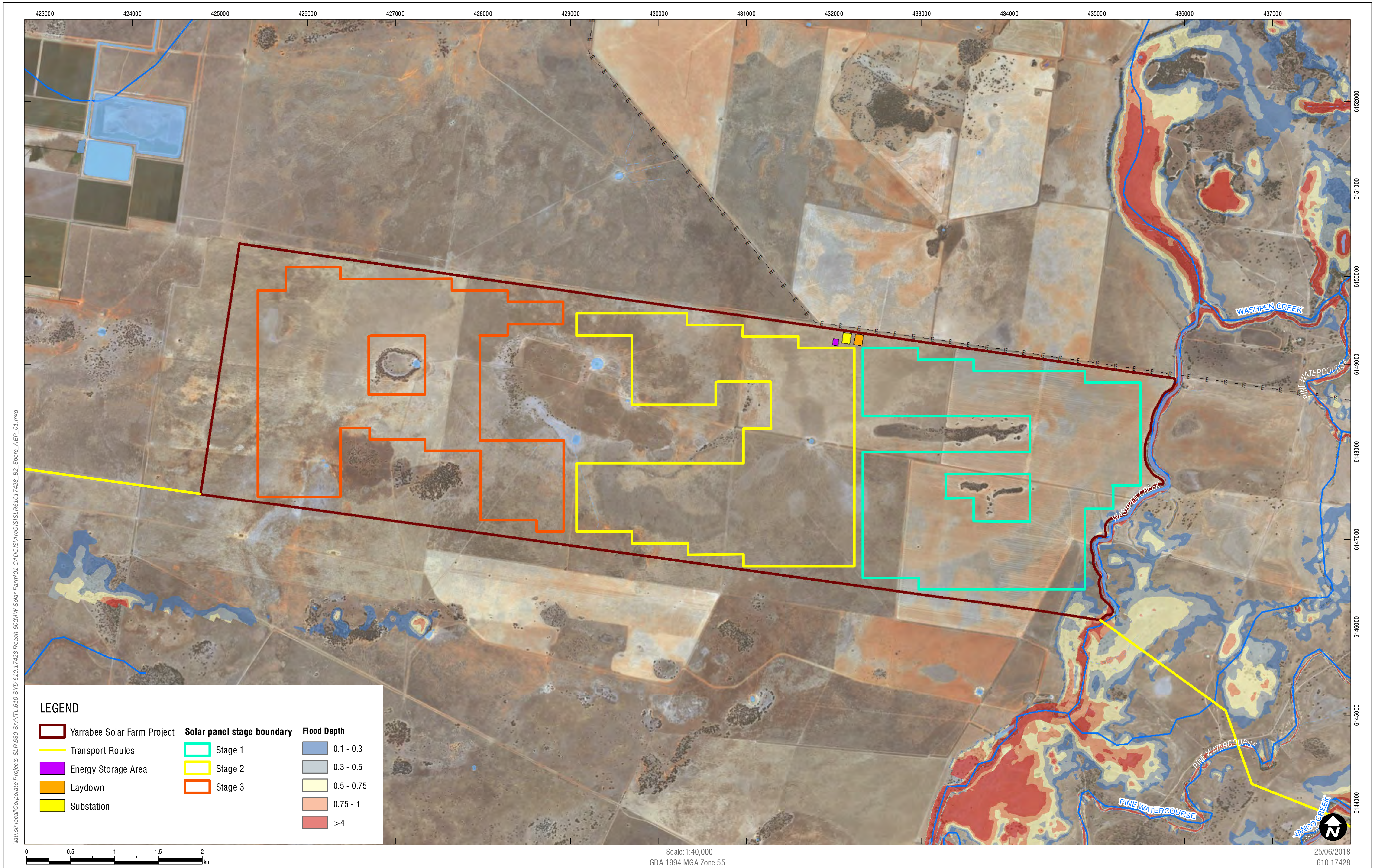
LEGEND

- TUFLOW Model Extent
- Major Road
- Railway
- 140 Water Surface Elevation Contours (m AHD)

NARRANDERA FLOOD STUDY REVIEW AND LEVEE OPTIONS ASSESSMENT

Figure 5.5

NARRANDERA CLASSIC TUFLOW MODEL RESULTS
20 YEAR ARI



Existing site flooding from riverine sources during a 5% AEP event in the Murrumbidgee River (infrequent event)

ATTACHMENT B2

Sheet Size : A3

SLR

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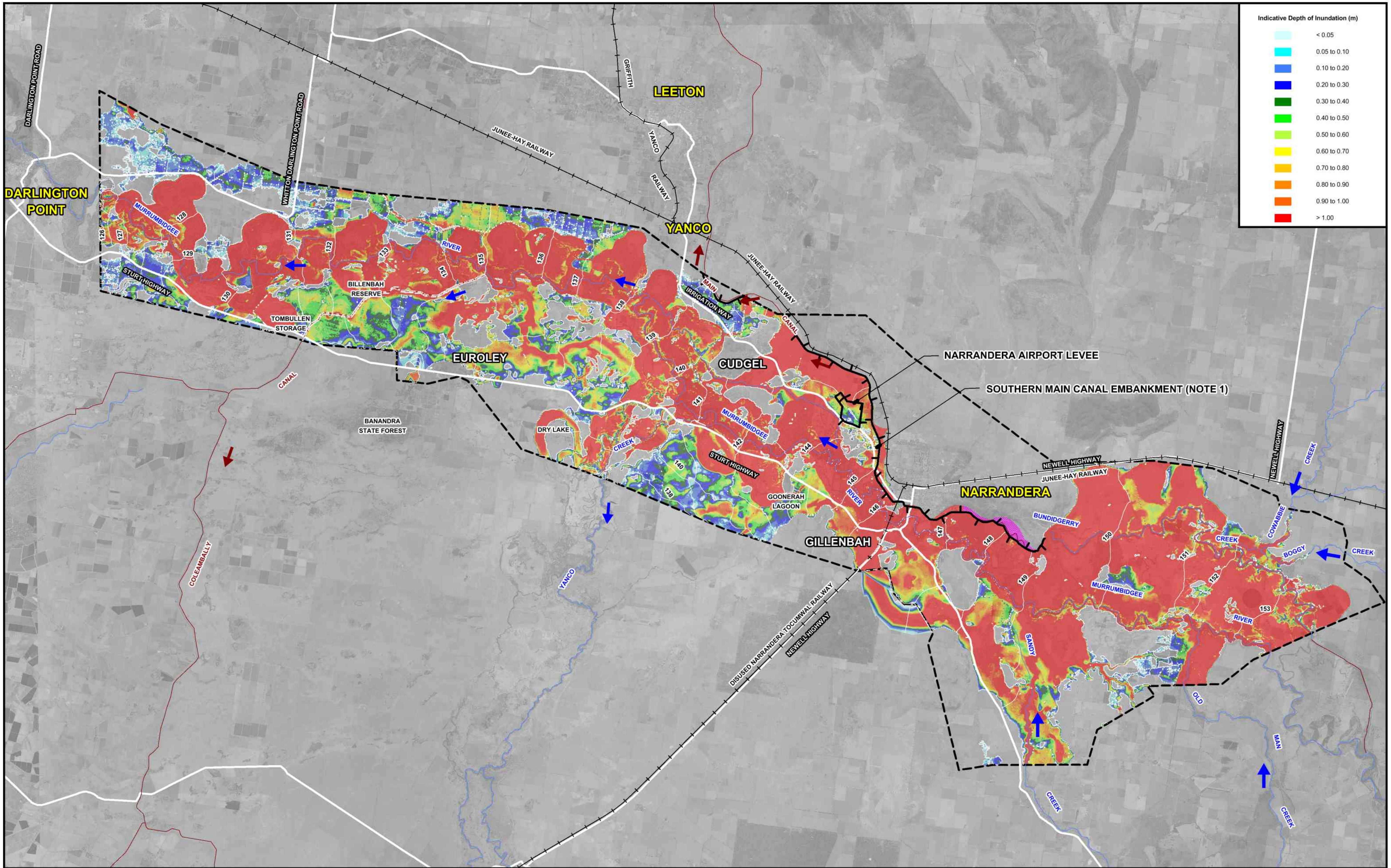


N

2 0 2 4 6 km

Scale: 1:200,000

Lyall & Associates

NOTE:

The extent of flooding shown was determined from airborne laser scanning survey and are approximate only.

The extent of inundation in individual allotments near the flood fringe should be confirmed by site specific survey.

(1) Alignment of Southern Main Canal Embankment only shown within TUFLOW Model Extent.

(2) March 2012 Roughness Values Adopted for Design (See Figure 4.2)

LEGEND

TUFLOW Model Extent

Major Road

Railway

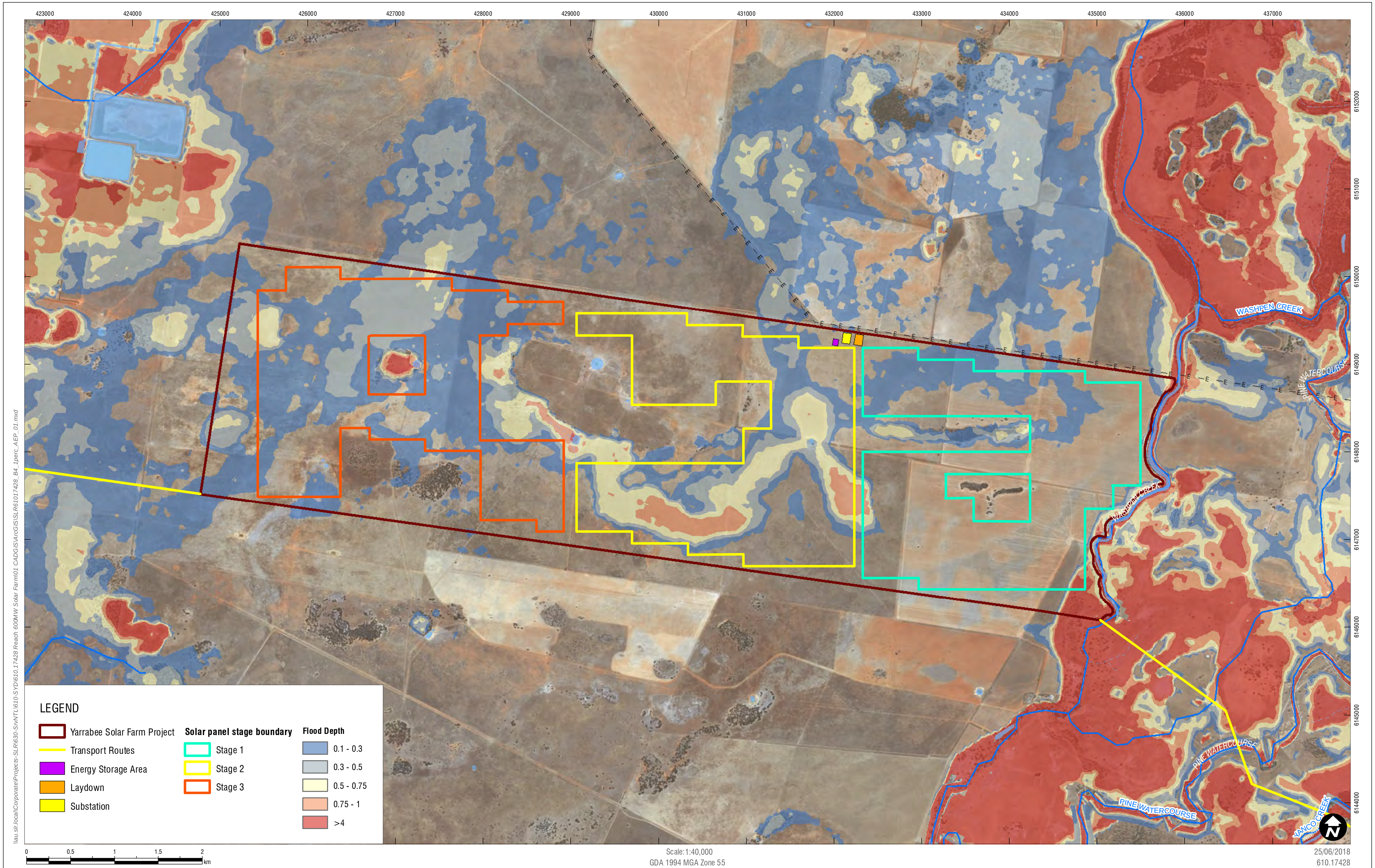
Water Surface Elevation Contours (m AHD)

Flood Behaviour Not Defined Over This Area

NARRANDERA FLOOD STUDY REVIEW AND LEVEE OPTIONS ASSESSMENT

Figure 5.6

NARRANDERA CLASSIC TUFLOW MODEL RESULTS
100 YEAR ARI



Sheet Size : A3

SLR

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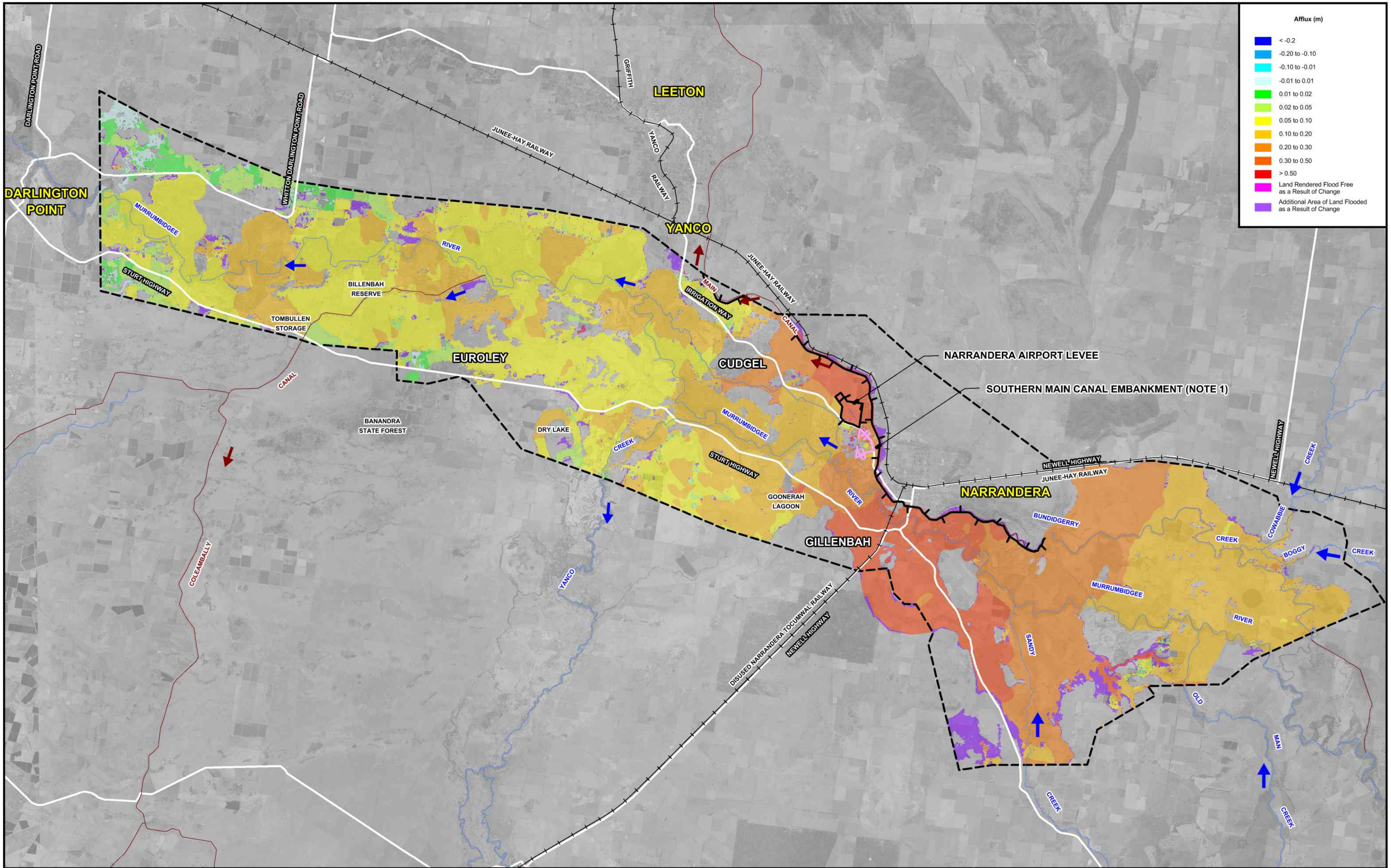
Existing site flooding from riverine sources during a 1% AEP event in the Murrumbidgee River (calibration and design event)

ATTACHMENT B4



N

2 0 2 4 6 km

Scale: 1:200,000

NOTE:

The extent of flooding shown was determined from airborne laser scanning survey and are approximate only.

The extent of inundation in individual allotments near the flood fringe should be confirmed by site specific survey.

(1) Alignment of Southern Main Canal Embankment only shown within TUFLOW Model Extent.

(2) March 2012 Roughness Values Adopted for Design (See Figure 4.2)

LEGEND

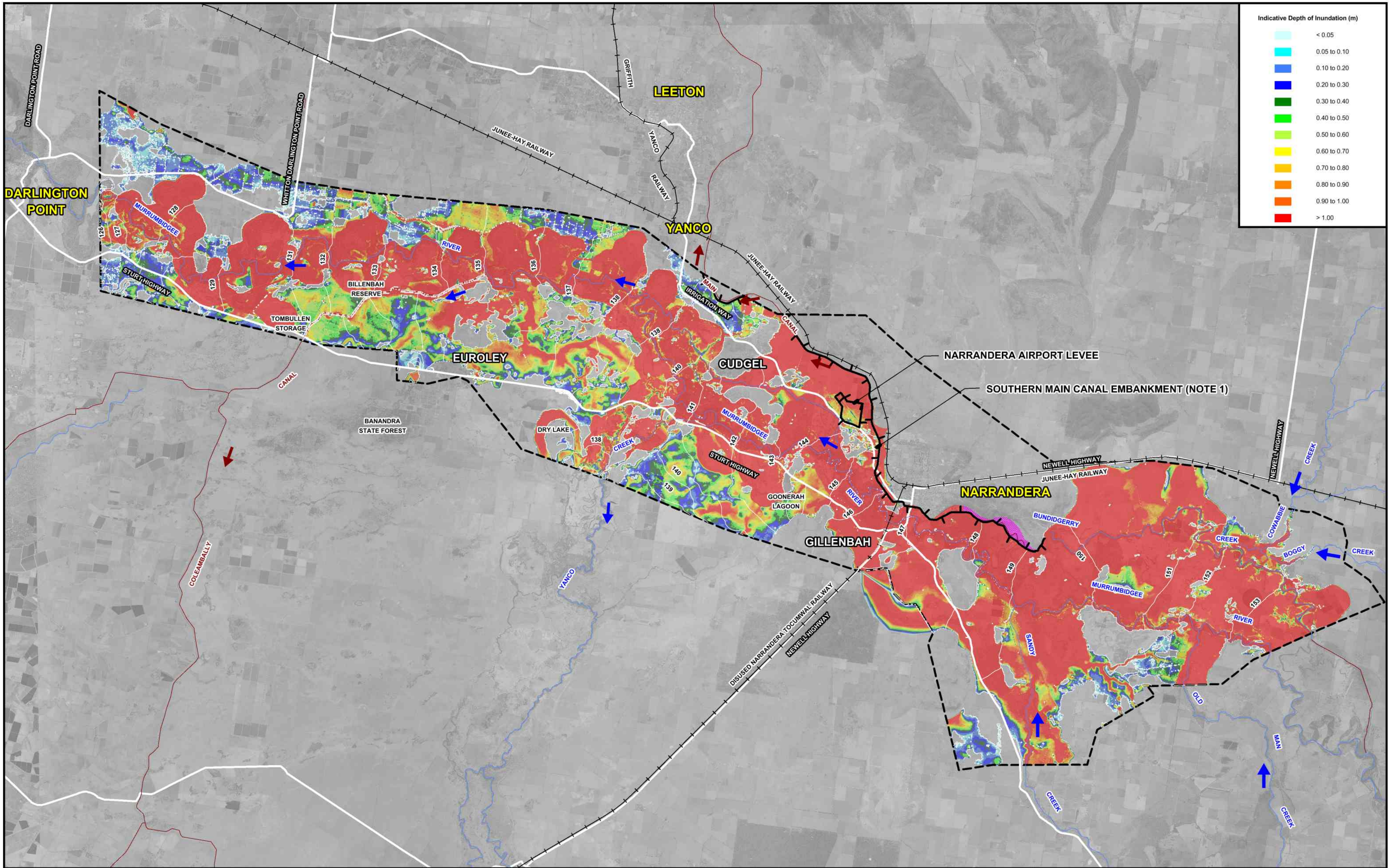
- TUFLOW Model Extent
- Major Road
- Railway
- Nallabooma Estate Boundary

Lyall & Associates

NARRANDERA FLOOD STUDY REVIEW AND LEVEE OPTIONS ASSESSMENT

Figure 5.19

SENSITIVITY OF FLOOD BEHAVIOUR AT NARRANDERA TO CLIMATE CHANGE
100 YEAR ARI



NOTE:

The extent of flooding shown was determined from airborne laser scanning survey and are approximate only.

The extent of inundation in individual allotments near the flood fringe should be confirmed by site specific survey.

(1) Alignment of Southern Main Canal Embankment only shown within TUFLOW Model Extent.

(2) March 2012 Roughness Values Adopted for Design (See Figure 4.2)

N

2 0 2 4 6 km

Scale: 1:200,000

Lyall & Associates

LEGEND

TUFLOW Model Extent

Major Road

Railway

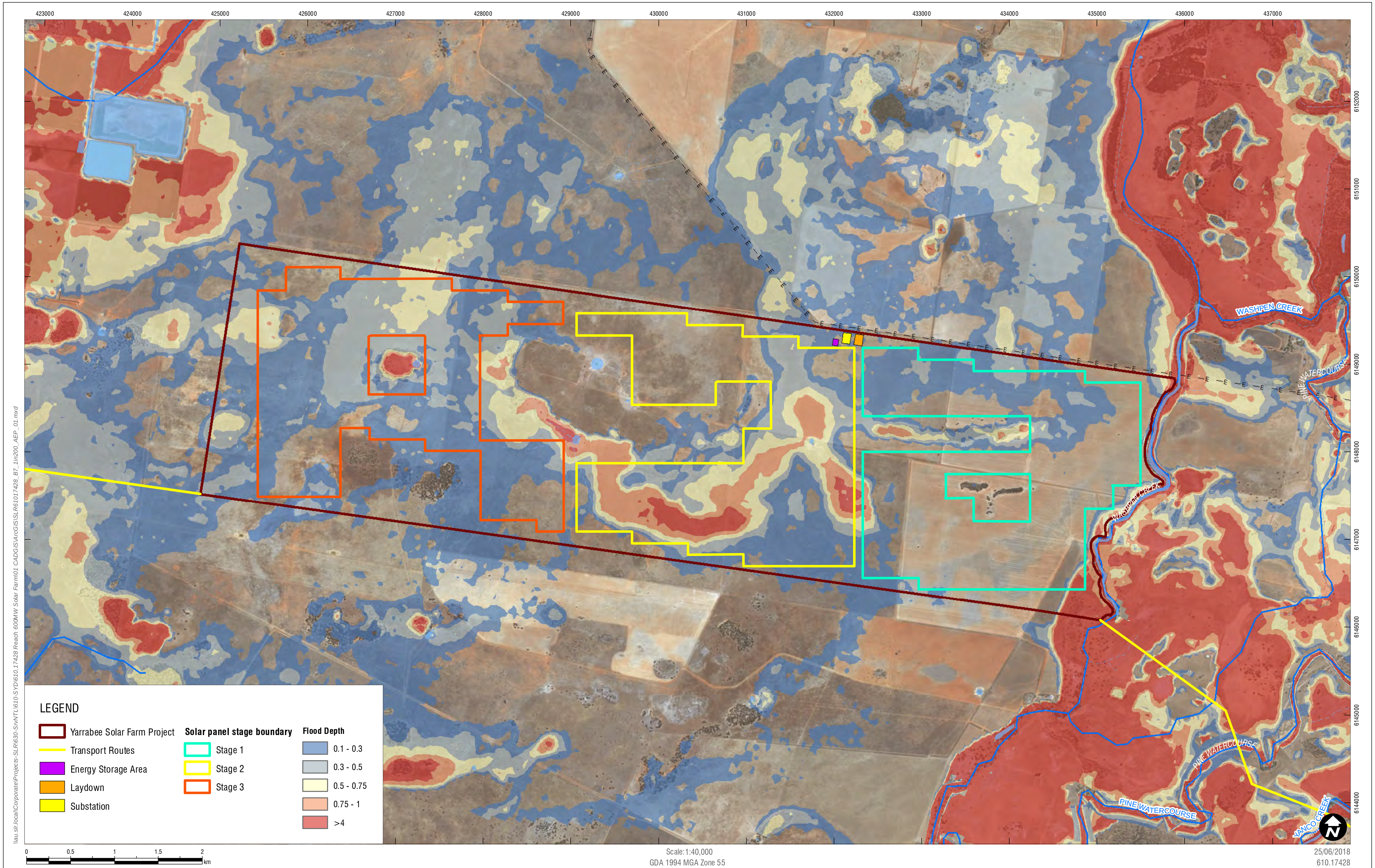
141 Water Surface Elevation Contours (m AHD)

Flood Behaviour Not Defined Over This Area

NARRANDERA FLOOD STUDY REVIEW AND LEVEE OPTIONS ASSESSMENT

Figure 5.7

NARRANDERA CLASSIC TUFLOW MODEL RESULTS
200 YEAR ARI



Sheet Size : A3

SLR

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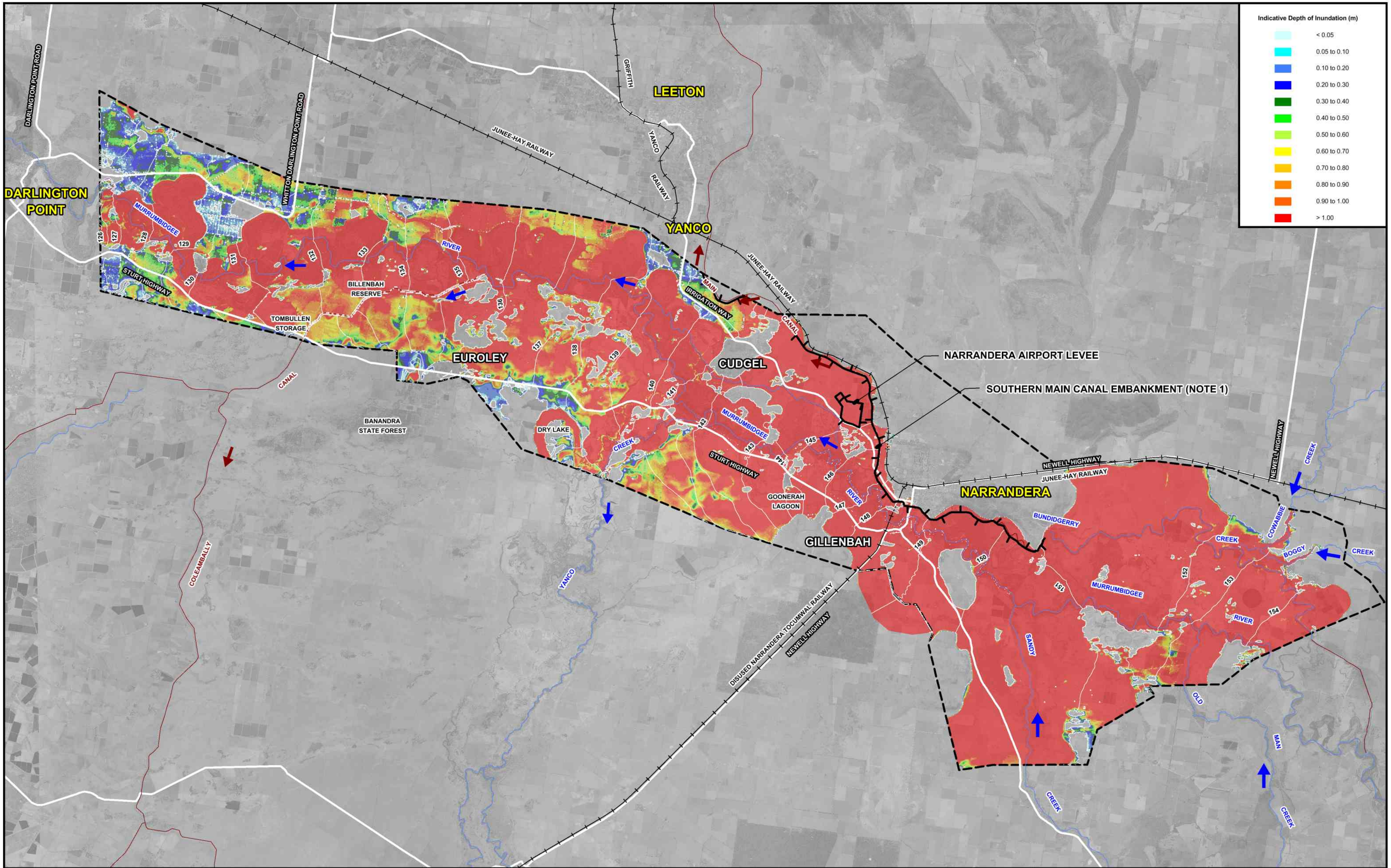
Existing site flooding riverine sources during a 1 in 200 AEP event in the Murrumbidgee River (climate change design event)

ATTACHMENT B7



N

2 0 2 4 6 km

Scale: 1:200,000

NOTE:

The extent of flooding shown was determined from airborne laser scanning survey and are approximate only.

The extent of inundation in individual allotments near the flood fringe should be confirmed by site specific survey.

(1) Alignment of Southern Main Canal Embankment only shown within TUFLOW Model Extent.

(2) March 2012 Roughness Values Adopted for Design (See Figure 4.2)

LEGEND

TUFLOW Model Extent

Major Road

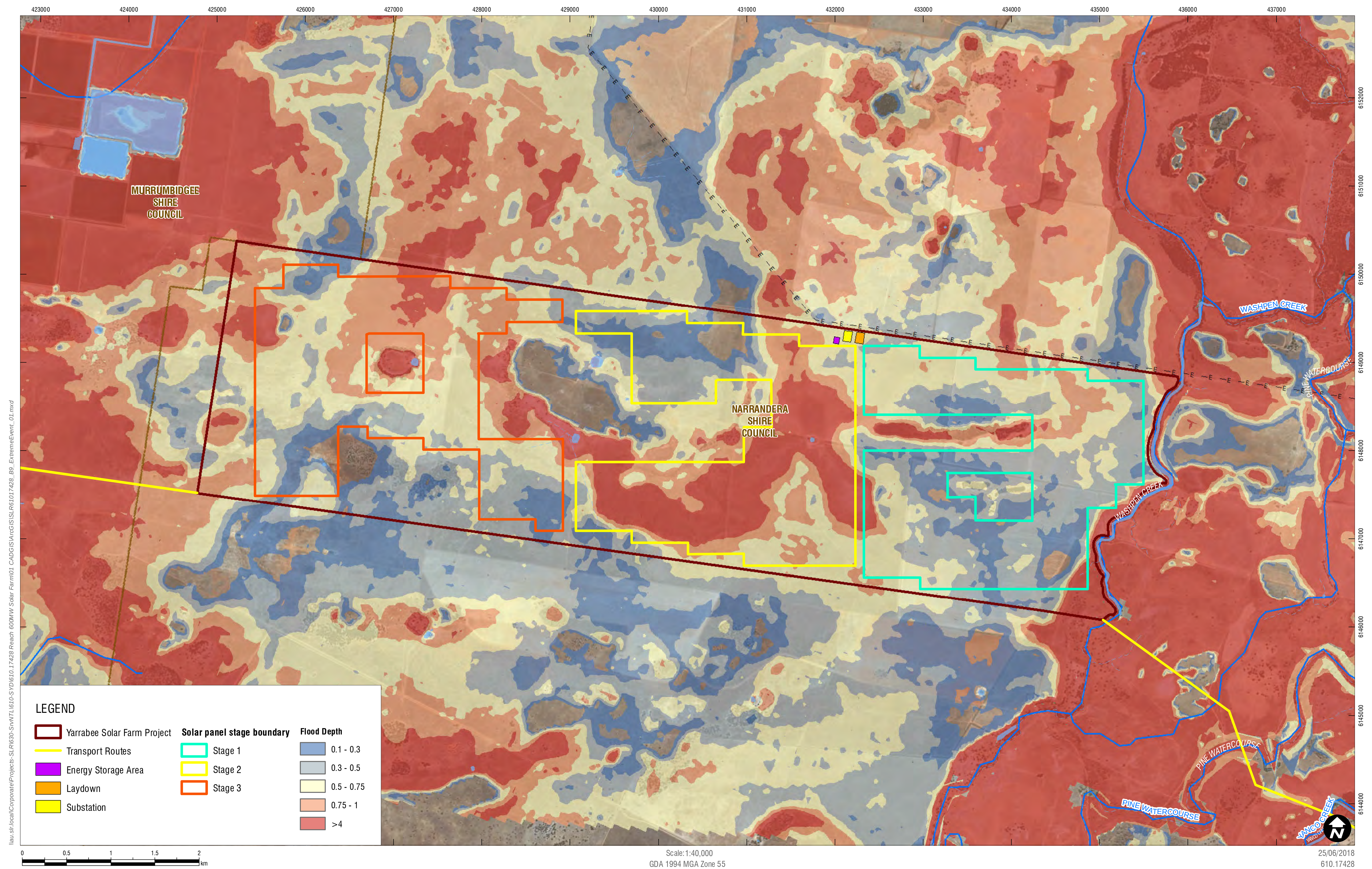
Railway

141 Water Surface Elevation Contours (m AHD)

NARRANDERA FLOOD STUDY REVIEW AND LEVEE OPTIONS ASSESSMENT

Figure 5.9

NARRANDERA CLASSIC TUFLOW MODEL RESULTS
EXTREME FLOOD



Sheet Size : A3

SLR

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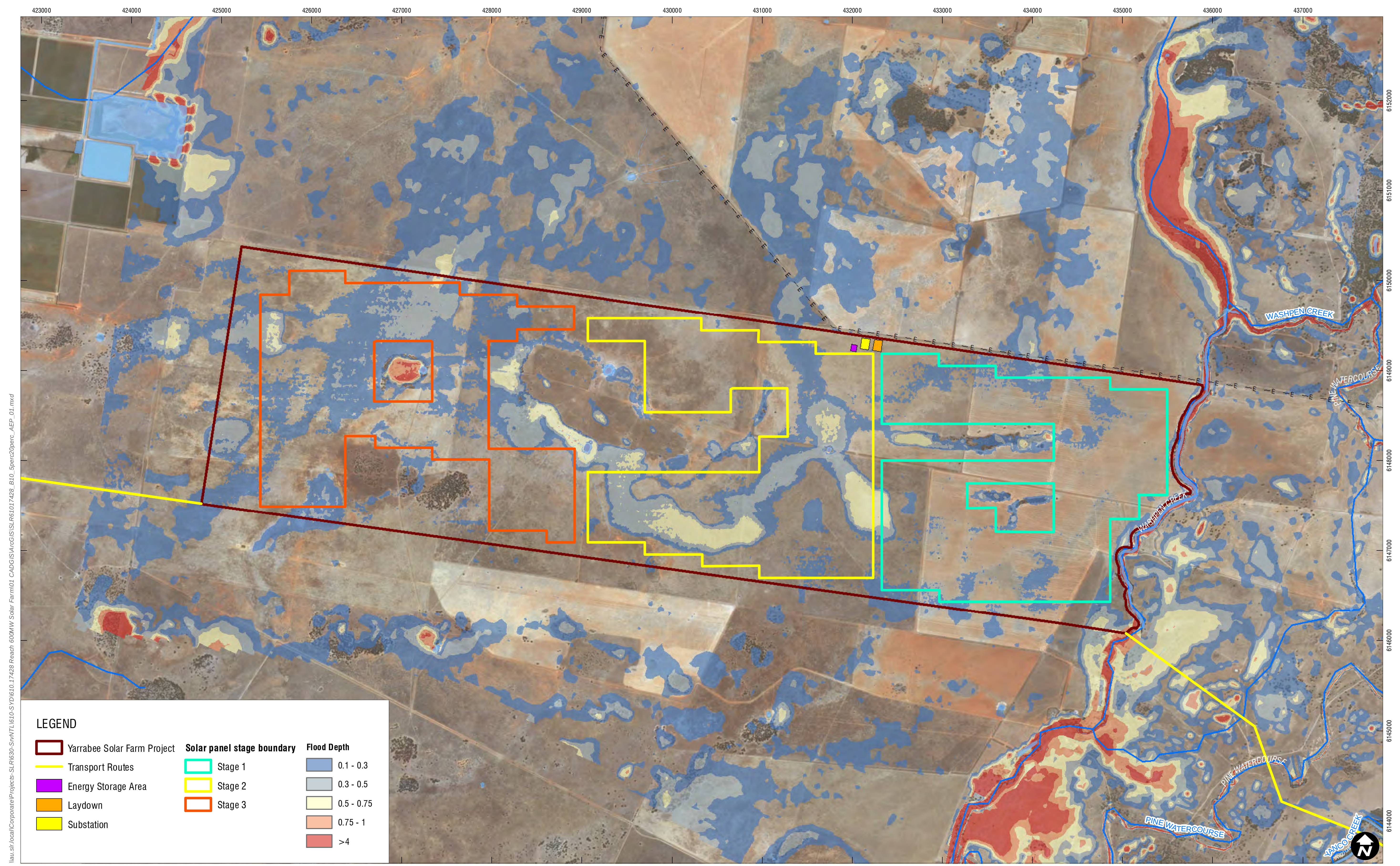
Details of site flooding from an extreme event in the Murrumbidgee River (ultimate case)

ATTACHMENT B9



0 0.5 1 1.5 2 km

Scale: 1:40,000
GDA 1994 MGA Zone 55

25/06/2018
610.17428

Existing site flooding from a local 5% AEP in combination with a 20% AEP event in the Murrumbidgee River

ATTACHMENT B10

Sheet Size : A3

SLR
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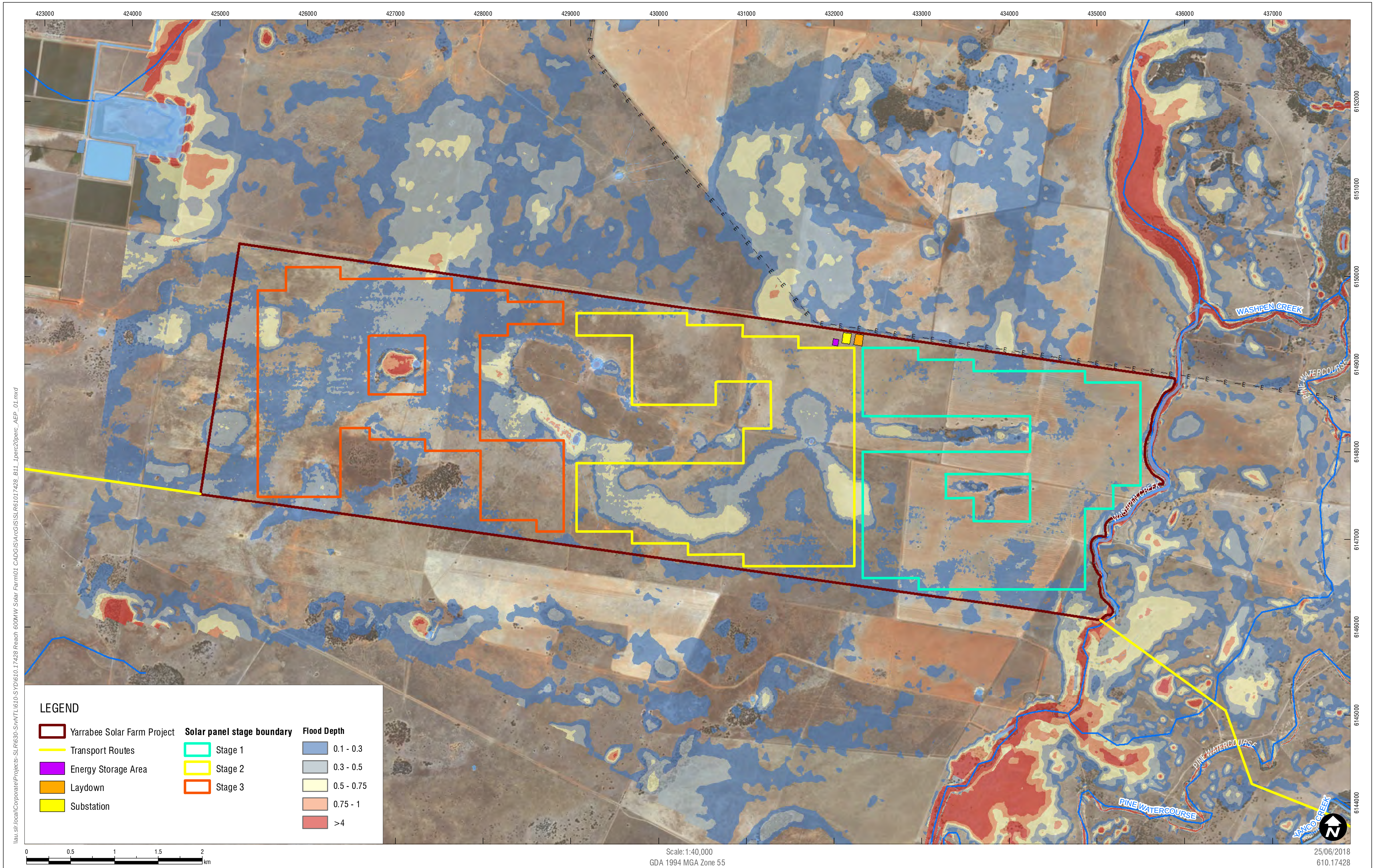

Sheet Size : A3

SLR

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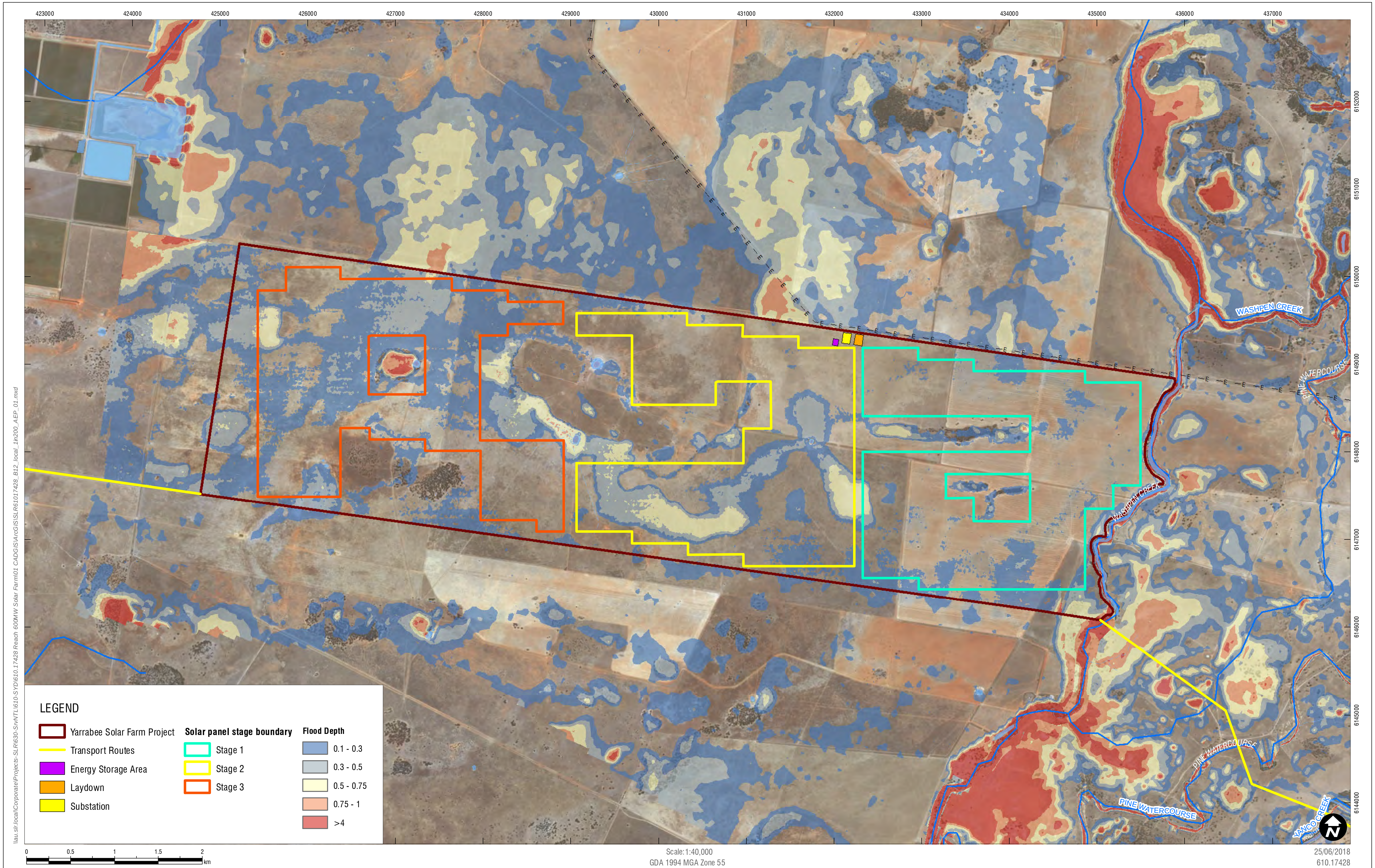
Existing site flooding from a local 1% AEP in combination with a 20% AEP event in the Murrumbidgee River

ATTACHMENT B11



Sheet Size : A3

SLR
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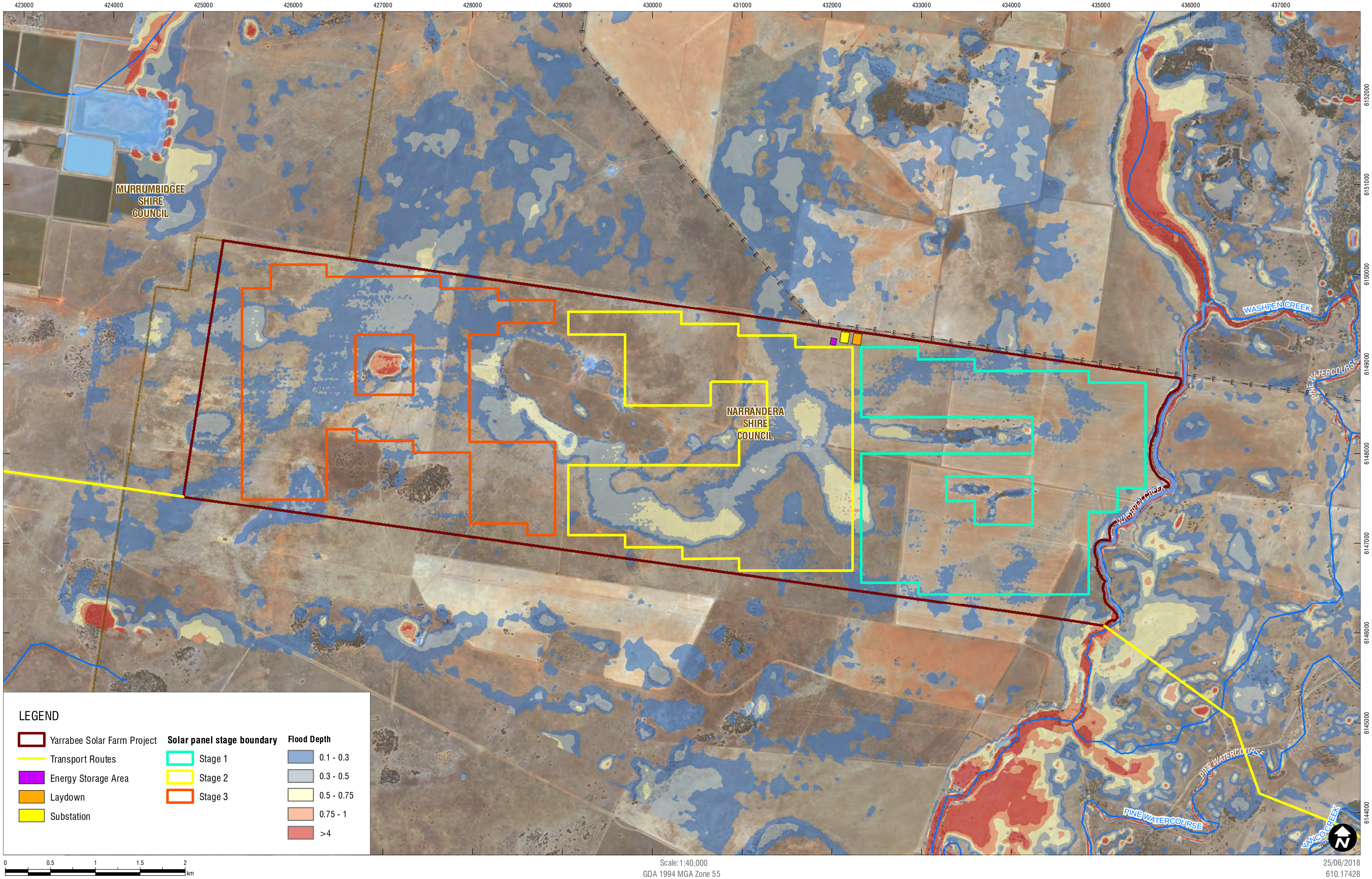
Existing site flooding from a local 1 in 200 AEP event in combination with a 20% AEP event in the Murrumbidgee River

ATTACHMENT B12



Scale: 1:40,000
GDA 1994 MGA Zone 55

25/06/2018
610.17428

Sheet Size : A3

SLR

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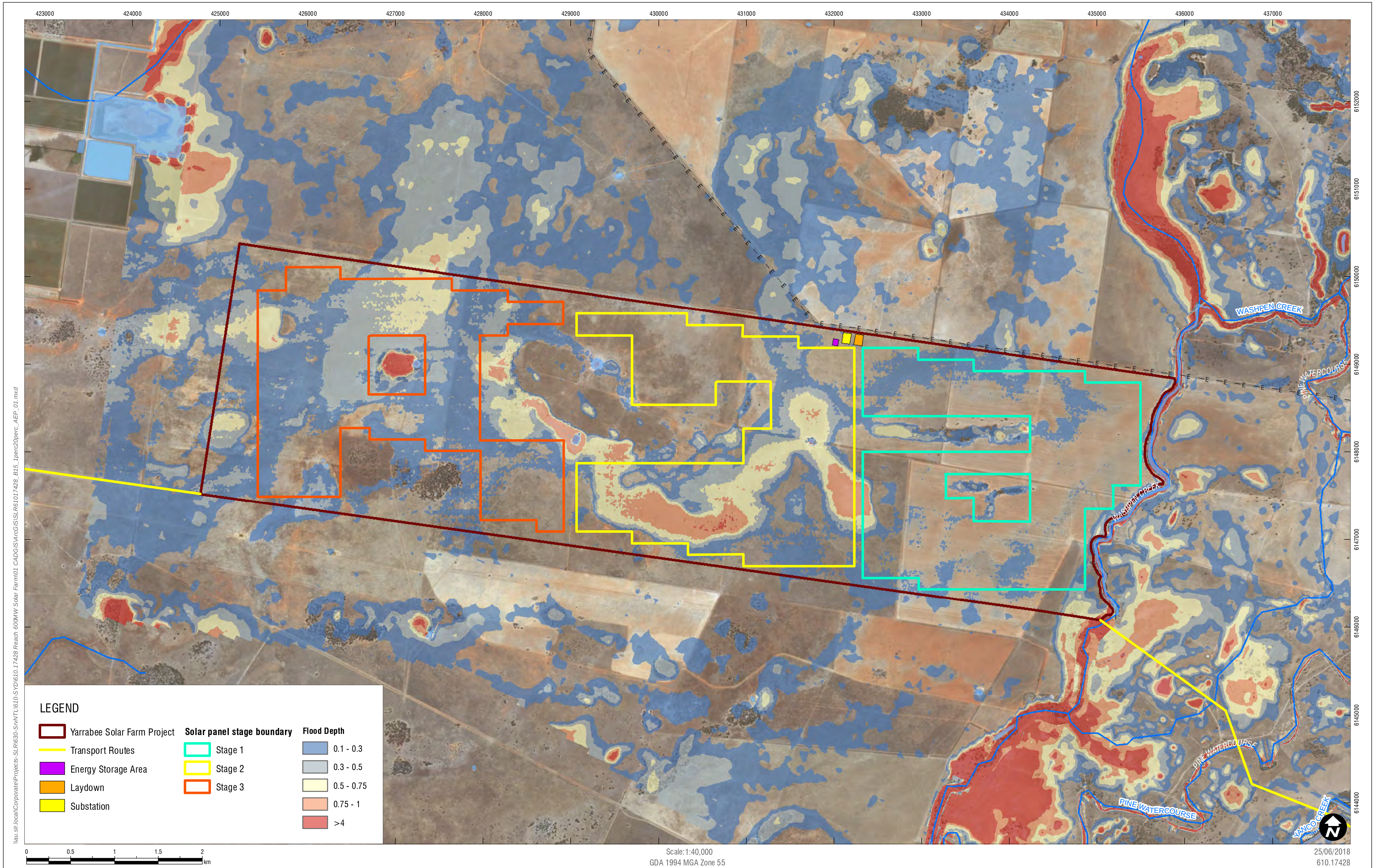
Site flooding post development from a local 5% AEP in combination with a 20% AEP event in the Murrumbidgee River

ATTACHMENT B13



Sheet Size : A3

SLR
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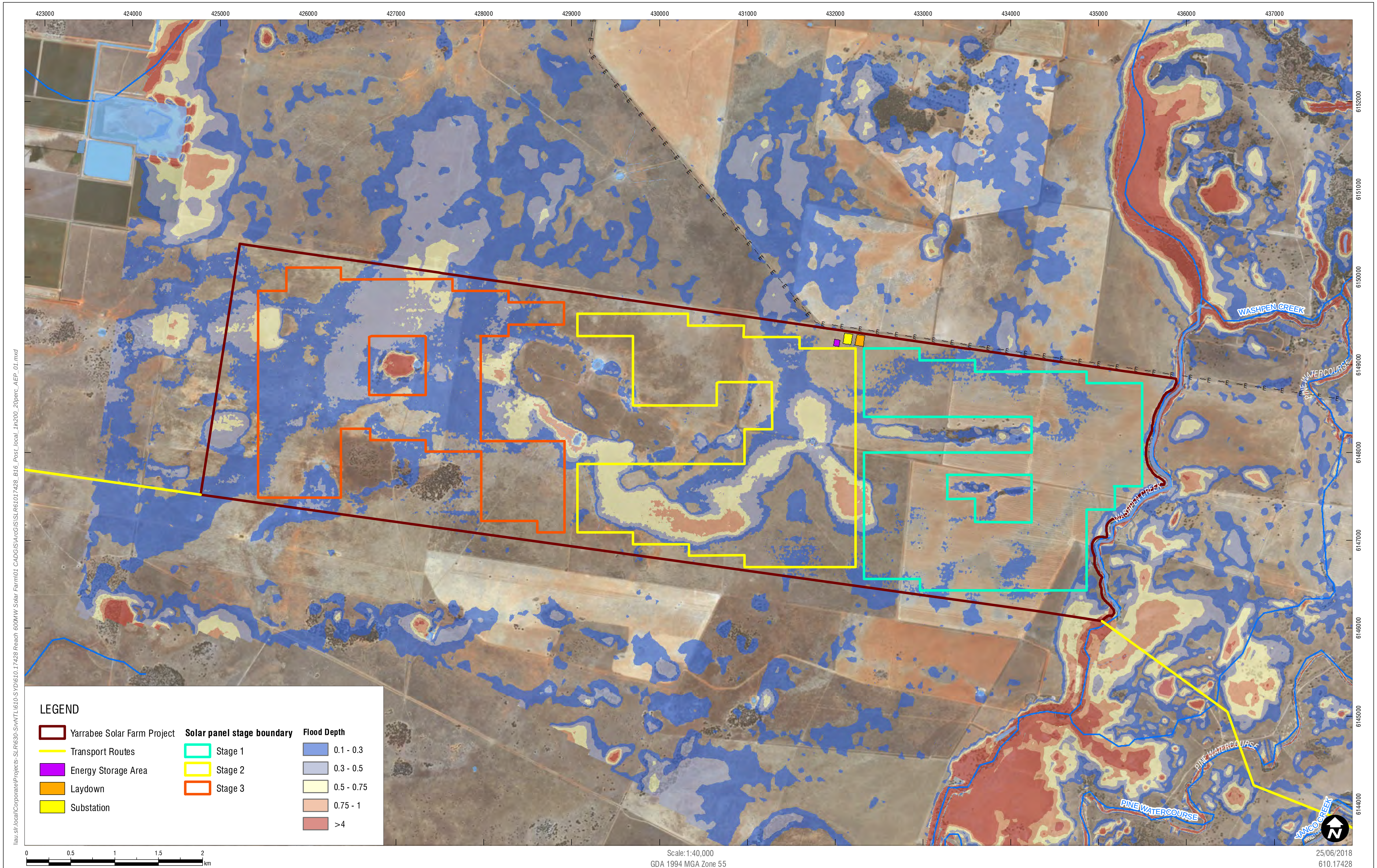
Site flooding post development from a local 1% AEP in combination with a 20% AEP event in the Murrumbidgee River

ATTACHMENT B14



Sheet Size : A3

SLR

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Site flooding post development from a local 1 in 200 AEP event in combination with a 20% AEP event in the Murrumbidgee River

ATTACHMENT B15

ATTACHMENT C

Soil Assessment Reports

NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Yamma Road
Map Reference:	MGA Grid Reference: Zone 55, 425495E, 6137607N. 8128 YANCO (1:100000) map sheet.
Profile Details:	HSHL Riverine Plains Survey (1004554), Profile 60, collected by Mr Michael Davy on 22 March, 2005
Physiography:	plain under grassland/herbland and used for volun./native pasture. Slope 0% (estimated), local relief extremely low (< 9m). Surface condition is self mulched, profile drainage is very poorly drained, erosion hazard is moderate, and no salting evident
Soil Type:	Brown Vertosol (ASC)
Base of observation:	layer continues

Profile Field Notes:

SOIL DESCRIPTION

Layer 1

0.00 - 0.02 m A1 Horizon	dark grey (brownish grey) (7.5YR 4/1) [moist] light clay with strong pedality (crumb, 5 - 10 mm), field pH is 6.5. Coarse fragments are not evident; clear (20-50 mm) boundary to ...

Layer 2

0.02 - 0.35 m B2 Horizon	brown (greyish brown) (7.5YR 4/2) [moist] light medium clay with strong pedality (20 - 50 mm), field pH is 7.0. Coarse fragments are not evident, segregations are very few (< 2%), calcareous; gradual (50-100 mm) boundary to ...

Layer 3

0.35 - 0.65 m B3 Horizon	brown (7.5YR 4/3) [moist] medium clay with strong pedality (20 - 50 mm), field pH is 9.0. Coarse fragments are not evident, segregations are few (2% - 10%), calcareous

Layer 99

LABORATORY TESTS

Sample Code	Upper Bnd.	Lower Bnd.	% Clay 517.99_CL	USCS 550.02	pH 4A1	EC 3A1	OC 6A1	Bray Phos 9E1	Phos Sorb 9I1	Exch Al 15F2_AL	Exch Ca 15F1_CA	Exch K 15F1_K	Exch Mg 15F1_MG	Exch Na 15F1_NA
WEL/05/5/141(1)	0.00	0.02			7.2	0.08								
WEL/05/5/142(1)	0.02	0.35			8.1	0.15								
WEL/05/5/143(1)	0.35	0.65			8.8	0.31								

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

SITE DETAILS

Site Location:	Yamma Road
Profile Details:	HSHL Riverine Plains Survey (1004554), Profile 60, collected from a core sample by Mr Michael Davy on 22 March, 2005
Map Reference:	MGA Grid Reference: Zone 55, 425495E, 6137607N. 8128 YANCO (1:100000) map sheet.
Physiography:	plain under grassland/herbland and used for volun./native pasture. Slope 0.0% (estimated), local relief extremely low (< 9m). Surface condition is self mulched, profile is very poorly drained, erosion hazard is moderate, and no salting evident
Vegetation/Land Use:	cleared, no cultivation at the site, used for volun./native pasture, with improved pasture in the general area
Surface Condition:	self mulched when described, expected to be self mulched when dry, ground cover is 50%
Erosion/Land Degradation:	moderate, erosion at site is none
Soil Hydrology:	profile is slowly permeable and very poorly drained, no free water, run on is low and runoff is low
Soil Type:	Brown Vertosol (ASC)
Base of observation:	layer continues
Profile Field Notes:	

SOIL DESCRIPTION

Layer 0		
0.00 - 0.00 m		
	Coarse Fragments:	not evident,
Layer 1	Horizon: A1	
0.00 - 0.02 m	Texture:	light clay
	Colour:	dark grey (brownish grey) (7.5YR 4/1) [moist] with no recorded mottles
	Structure:	strong pedality (crumb, 5 - 10 mm,)
	Coarse Fragments:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are evident(width <5 mm), evident(width 5-10 mm), evident(width 10-20 mm), macropores are nil
	Moisture/Consistence:	dry, disruptive test result was moderately weak force,

	Field chemical tests:	Field pH is 6.5 (Raupach), HCl test showed no effervescence,
	Sample taken:	unspecified
Layer 2	Horizon: B2	
0.02 - 0.35 m	Texture:	light medium clay
	Colour:	brown (greyish brown) (7.5YR 4/2) [moist] with no recorded mottles
	Structure:	strong pedality (20 - 50 mm,)
	Coarse Fragments:	not evident,
	Segregations:	very few (< 2%), calcareous,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	dry, disruptive test result was very firm force,
	Field chemical tests:	Field pH is 7.0 (Raupach), HCl test showed slightly audible but no visible effervescence,
	Sample taken:	unspecified
Layer 3	Horizon: B3	
0.35 - 0.65 m	Texture:	medium clay
	Colour:	brown (7.5YR 4/3) [moist] with orange mottles
	Structure:	strong pedality (20 - 50 mm,)
	Coarse Fragments:	not evident,
	Segregations:	few (2% - 10%), calcareous,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	dry, disruptive test result was very firm force,
	Field chemical tests:	Field pH is 9.0 (Raupach), HCl test showed strong effervescence,
	Sample taken:	unspecified

LABORATORY TESTS

Sample Code: WEL/05/5/141(1) Upper bound: 0.00 Lower bound: 0.02

Name	Value	Unit of measure
2B1 [As received moisture content]	6.88	%
3A1 [EC of 1:5 soil/water extract]	0.08	dS/m
4A1 [pH of 1:5 soil/water suspension]	7.2	pH
513.98 [Emerson aggregate test SCS method]	3(2)	
517.99_GR [PSA gravel - hydrometer]	0	%

Sample Code: WEL/05/5/142(1) Upper bound: 0.02 Lower bound: 0.35

Name	Value	Unit of measure
2B1 [As received moisture content]	8.69	%
3A1 [EC of 1:5 soil/water extract]	0.15	dS/m
4A1 [pH of 1:5 soil/water suspension]	8.1	pH
513.98 [Emerson aggregate test SCS method]	2(2)	

517.99_GR [PSA gravel - hydrometer]	0	%

Sample Code: WEL/05/5/143(1) Upper bound: 0.35 Lower bound: 0.65

Name	Value	Unit of measure
2B1 [As received moisture content]	8.02	%
3A1 [EC of 1:5 soil/water extract]	0.31	dS/m
4A1 [pH of 1:5 soil/water suspension]	8.8	pH
513.98 [Emerson aggregate test SCS method]	3(3)	
517.99_GR [PSA gravel - hydrometer]	0	%

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Technical Report

SITE DETAILS:

Survey:	HSHL Riverine Plains (1004554)
Profile:	60
Location:	Yamma Road

PROFILE MAP DETAILS:

1:100,000 Mapsheet:	YANCO (8128)	Locational Accuracy:	Other
MGA Easting:	425495	MGA Northing:	6137607
MGA Zone:	55		

PROFILE DETAILS:

Described by:	Mr Michael Davy	Profile Date:	22 March, 2005
Nature of Exposure:	core sample	Photo Taken:	site
Base of observation:	layer continues	No of Layers:	5

SOIL AND MAP CODES:

Geology Map Code:		Soil Map Code:	
Aust. Soil Classification:	Vertosol, Brown		
Great Soil Group:		Northcote PPF:	
Soil Taxonomy:		Atlas(Northcote) Code:	
Atlas (A&M) Code:			

TOPOGRAPHY:

Slope:	0% (estimated)		
Elevation:		Aspect:	

LANDFORM:

Site Morphology:	flat	Site Process:	alluvial
Slope Morphology:		Local Relief:	extremely low (< 9m)
Landform Pattern:		Landform Element:	plain
Plan Curvature:		Position in Landform Element:	
Microrelief:		Microrelief depth:	

Microrelief extent:

LITHOLOGY:

Solum PM:	alluvium	Substrate:	
Rock Outcrop:	Nil	Rock Outcrop (BSAL):	
Outcrop Same As:		Substrate Strength:	
Weathering & Alteration:			
Discontinuities:			
Fragment Amount:			

VEGETATION:

Vegetation Formation:	grassland/herbland
Vegetation Community:	
Growth Form(s):	tussock grass
Crown Separation Ratio:	
Upper Stratum Height:	

SITE CONDITION:

Ground Cover %:	50.00	Site Disturbance:	cleared, no cultivation
Current Condition:	self mulched	Expected Dry Condition:	self mulched
Expected Wet Condition:		Estimated Effective Rooting Depth:	

LAND USE:

Site:	volun./native pasture	General Area:	improved pasture
Land Use Vegetation Species:		Prior Land Use:	

HYDROLOGY:

Presence of Free Water:	none	Free Water Depth:	
Run-on:	low	Runoff:	low
Permeability:	slowly permeable	Profile Drainage:	very poorly drained
Free Water pH:		Free Water EC:	

EROSION:

Wind exposure:	
Erosion Hazard:	moderate

SALINITY:

Salinity:	no salting evident		
Salt Outbreak Mapping:		Salt Outbreak Vegetation Species:	
EM Measurement 1 Type:		EM Measurement 1 horizontal:	
EM Measurement 1 vertical:			
EM Measurement 2 Type:		EM Measurement 2 horizontal:	
EM Measurement 2 vertical:			

FIELD NOTES:

LAYER 0

Depth:	0.00 - 0.00 m		
Layer Notes:			
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

LAYER 1 A1 horizon

Depth:	0.00 - 0.02 m		
Layer Notes:			

TEXTURE: light clay

COLOUR:

Moist: dark grey (brownish grey) (7.5YR 4/1)

FIELD CHEMICAL TESTS:

pH:	6.5 (Raupach)	Field EC:	
HCl:	no effervescence	H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	strong pedality	Fabric:	
Dominant Peds:	5 - 10 mm, crumb	Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

CRACKS AND MACROPORES:

Cracks:

<5 mm width:	evident	5-10 mm width:	evident
10-20 mm width:	evident	20-50 mm width:	
>50 mm width:		Unspecified width:	

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	moderately weak force
Shearing Test:		Toughness:	

SOIL WATER STATUS: dry

SAMPLE TAKEN: unspecified

BOUNDARY:

Distinctiveness: clear (20-50 mm) Shape:

LAYER 2 B2 horizon

Depth: 0.02 - 0.35 m

Layer Notes:

TEXTURE: light medium clay

COLOUR:

Moist: brown (greyish brown) (7.5YR 4/2)

FIELD CHEMICAL TESTS:

pH:	7.0 (Raupach)	Field EC:	
HCl:	slightly audible but no visible effervescence	H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	strong pedality	Fabric:	
Dominant Peds:	20 - 50 mm	Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	

Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

SEGREGATIONS:

Type:	calcareous	Amount:	very few (< 2%)
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	very firm force
Shearing Test:		Toughness:	

SOIL WATER STATUS: dry

SAMPLE TAKEN: unspecified

BOUNDARY:

Distinctiveness:	gradual (50-100 mm)	Shape:	

LAYER 3 B3 horizon

Depth: 0.35 - 0.65 m

Layer Notes:

TEXTURE: medium clay

COLOUR:

Moist: brown (7.5YR 4/3)

FIELD CHEMICAL TESTS:

pH:	9.0 (Raupach)	Field EC:	
HCl:	strong effervescence	H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	strong pedality	Fabric:	
Dominant Peds:	20 - 50 mm	Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

SEGREGATIONS:

Type:	calcareous	Amount:	few (2% - 10%)
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	very firm force
Shearing Test:		Toughness:	

SOIL WATER STATUS: dry

SAMPLE TAKEN: unspecified

LAYER 99

Layer Notes:

Vesicles:		Ped porosity:	

LABORATORY TESTS

Sample Code: WEL/05/5/141(1) Upper bound: 0.00 Lower bound: 0.02

Name	Value	Unit of measure
2B1 [As received moisture content]	6.88	%
3A1 [EC of 1:5 soil/water extract]	0.08	dS/m
4A1 [pH of 1:5 soil/water suspension]	7.2	pH
513.98 [Emerson aggregate test SCS method]	3(2)	
517.99_GR [PSA gravel - hydrometer]	0	%

Sample Code: WEL/05/5/142(1) Upper bound: 0.02 Lower bound: 0.35

Name	Value	Unit of measure
2B1 [As received moisture content]	8.69	%
3A1 [EC of 1:5 soil/water extract]	0.15	dS/m
4A1 [pH of 1:5 soil/water suspension]	8.1	pH
513.98 [Emerson aggregate test SCS method]	2(2)	
517.99_GR [PSA gravel - hydrometer]	0	%

Sample Code: WEL/05/5/143(1) Upper bound: 0.35 Lower bound: 0.65

Name	Value	Unit of measure
2B1 [As received moisture content]	8.02	%
3A1 [EC of 1:5 soil/water extract]	0.31	dS/m
4A1 [pH of 1:5 soil/water suspension]	8.8	pH
513.98 [Emerson aggregate test SCS method]	3(3)	

517.99_GR [PSA gravel - hydrometer]	0	%

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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Soil Essentials Report

SITE DETAILS

Site Location:	Yanco 100K
Map Reference:	MGA Grid Reference: Zone 55, 435654E, 6139286N. 8128 YANCO (1:100000) map sheet.
Profile Details:	HSHL Riverine Plains Survey (1004554), Profile 63, collected by Mr Michael Davy on 22 March, 2005
Physiography:	plain. Surface condition is firm, profile drainage is mod. well drained, erosion hazard is high, and no salting evident
Soil Type:	Red Chromosol (ASC), Red Earth (GSG)
Base of observation:	layer continues

Profile Field Notes:

SOIL DESCRIPTION

Layer 1

0.00 - 0.25 m A1 Horizon	dark brown (7.5YR 3/4) [moist] light loamy sand with single grained (sandy), field pH is 6.0. Coarse fragments are not evident, pans are not evident, segregations are not evident; clear (20-50 mm) boundary to ...

Layer 2

0.25 - 0.48 m A2 Horizon	brown (7.5YR 4/4) [moist] light sand with single grained (sandy), field pH is 6.5. Coarse fragments are not evident, pans are not evident, segregations are not evident; clear (20-50 mm) boundary to ...

Layer 3

0.48 - 0.58 m B Horizon	dark reddish brown (5YR 3/4) [moist] sandy clay loam with massive structure (sandy), field pH is 6.5. Coarse fragments are not evident, pans are not evident, segregations are not evident

Layer 99

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

SITE DETAILS

Site Location:	Yanco 100K
Profile Details:	HSHL Riverine Plains Survey (1004554), Profile 63, collected from a auger by Mr Michael Davy on 22 March, 2005
Map Reference:	MGA Grid Reference: Zone 55, 435654E, 6139286N. 8128 YANCO (1:100000) map sheet.
Physiography:	plain. Surface condition is firm, profile is mod. well drained, erosion hazard is high, and no salting evident
Vegetation/Land Use:	no effective disturbance at the site
Surface Condition:	firm when described, expected to be hard set when dry, ground cover is 80%
Erosion/Land Degradation:	high, erosion at site is none
Soil Hydrology:	profile is moderately permeable and mod. well drained, no free water, run on is low and runoff is low
Soil Type:	Red Chromosol (ASC), Red Earth (GSG)
Base of observation:	layer continues
Profile Field Notes:	

SOIL DESCRIPTION

Layer 0		
0.00 - 0.00 m		
	Coarse Fragments:	not evident,
Layer 1	Horizon: A1	
0.00 - 0.25 m	Texture:	light loamy sand
	Colour:	dark brown (7.5YR 3/4) [moist] with no recorded mottles
	Structure:	single grained (fabric is sandy)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	dry,

	Field chemical tests:	Field pH is 6.0 (Raupach),
Layer 2	Horizon: A2	
0.25 - 0.48 m	Texture:	light sand
	Colour:	brown (7.5YR 4/4) [moist] with no recorded mottles
	Structure:	single grained (fabric is sandy)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	moderately moist,
	Field chemical tests:	Field pH is 6.5 (Raupach),
Layer 3	Horizon: B	
0.48 - 0.58 m	Texture:	sandy clay loam
	Colour:	dark reddish brown (5YR 3/4) [moist] with no recorded mottles
	Structure:	massive (fabric is sandy)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	moderately moist,
	Field chemical tests:	Field pH is 6.5 (Raupach),

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Technical Report

SITE DETAILS:

Survey:	HSHL Riverine Plains (1004554)
Profile:	63
Location:	Yanco 100K

PROFILE MAP DETAILS:

1:100,000 Mapsheet:	YANCO (8128)	Locational Accuracy:	Other
MGA Easting:	435654	MGA Northing:	6139286
MGA Zone:	55		

PROFILE DETAILS:

Described by:	Mr Michael Davy	Profile Date:	22 March, 2005
Nature of Exposure:	auger	Photo Taken:	
Base of observation:	layer continues	No of Layers:	5

SOIL AND MAP CODES:

Geology Map Code:		Soil Map Code:	
Aust. Soil Classification:	Chromosol, Red, medium, non gravelly, sandy, clay loamy		
Great Soil Group:	Red Earth	Northcote PPF:	
Soil Taxonomy:		Atlas(Northcote) Code:	
Atlas (A&M) Code:			

TOPOGRAPHY:

Slope:			
Elevation:		Aspect:	

LANDFORM:

Site Morphology:	flat	Site Process:	alluvial
Slope Morphology:		Local Relief:	
Landform Pattern:		Landform Element:	plain
Plan Curvature:		Position in Landform Element:	
Microrelief:		Microrelief depth:	

Microrelief extent:

LITHOLOGY:

Solum PM:	alluvium	Substrate:	
Rock Outcrop:	Nil	Rock Outcrop (BSAL):	
Outcrop Same As:		Substrate Strength:	
Weathering & Alteration:			
Discontinuities:			
Fragment Amount:			

VEGETATION:

Vegetation Formation:

Vegetation Community:

Growth Form(s):

Crown Separation Ratio:

Upper Stratum Height:

SITE CONDITION:

Ground Cover %:	80.00	Site Disturbance:	no effective disturbance
Current Condition:	firm	Expected Dry Condition:	hard set
Expected Wet Condition:		Estimated Effective Rooting Depth:	

LAND USE:

Site:		General Area:	
Land Use Vegetation Species:		Prior Land Use:	

HYDROLOGY:

Presence of Free Water:	none	Free Water Depth:	
Run-on:	low	Runoff:	low
Permeability:	moderately permeable	Profile Drainage:	mod. well drained
Free Water pH:		Free Water EC:	

EROSION:

Wind exposure:

Erosion Hazard: high

SALINITY:

Salinity: no salting evident

Salt Outbreak Mapping:

Salt Outbreak Vegetation Species:

EM Measurement 1 Type:

EM Measurement 1 horizontal:

EM Measurement 1 vertical:

EM Measurement 2 Type:

EM Measurement 2 horizontal:

EM Measurement 2 vertical:

FIELD NOTES:

LAYER 0

Depth: 0.00 - 0.00 m

Layer Notes:

Vesicles:

Ped porosity:

COARSE FRAGMENTS:

Type: not evident

Amount:

Distribution:

Orientation:

Weathering:

Shape:

Size:

LAYER 1 A1 horizon

Depth: 0.00 - 0.25 m

Layer Notes:

TEXTURE: light loamy sand

COLOUR:

Moist: dark brown (7.5YR 3/4)

FIELD CHEMICAL TESTS:

pH: 6.0 (Raupach)

Field EC:

HCl:

H2O2:

AgNO3:

STRUCTURE:

Grade of Pedality: single grained

Fabric: sandy

Dominant Peds:

Subdominant Peds:

Artificial Aggregates:

SOILpak score:

Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

SOIL WATER STATUS: dry

BOUNDARY:

Distinctiveness:	clear (20-50 mm)	Shape:	

LAYER 2 A2 horizon

Depth: 0.25 - 0.48 m

Layer Notes:

TEXTURE: light sand

COLOUR:

Moist: brown (7.5YR 4/4)

FIELD CHEMICAL TESTS:

pH:	6.5 (Raupach)	Field EC:	
HCl:		H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	single grained	Fabric:	sandy
Dominant Peds:		Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

SOIL WATER STATUS: moderately moist

BOUNDARY:

Distinctiveness:	clear (20-50 mm)	Shape:	

LAYER 3 B horizon

Depth: 0.48 - 0.58 m

Layer Notes:

TEXTURE: sandy clay loam

COLOUR:

Moist: dark reddish brown (5YR 3/4)

FIELD CHEMICAL TESTS:

pH:	6.5 (Raupach)	Field EC:	
HCl:		H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	massive	Fabric:	sandy
Dominant Peds:		Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	

Size:

SOIL WATER STATUS: moderately moist

LAYER 99

Layer Notes:

Vesicles:

Ped porosity:

LABORATORY TESTS

None available

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Essentials Report

SITE DETAILS

Site Location:	Molleys Lagoon off Yanco Creek - puff
Map Reference:	MGA Grid Reference: Zone 55, 439713E, 6157385N. 8128 YANCO (1:100000) map sheet.
Profile Details:	Soil Landscapes of the Tarcutta 1:100 000 Sheet Survey (1000462), Profile 273, collected by Ms Janet Wild on 08 December, 2003
Physiography:	ox-bow in stagnant alluvial plain on alluvium lithology and used for volun./native pasture. Slope 1% (not recorded), local relief extremely low (< 9m), elevation 135.0 m, aspect flat. Surface condition is self mulched, profile drainage is very poorly drained, erosion hazard is slight, and no salting evident
Soil Type:	Mottled Self-mulching Brown Vertosol (ASC), Grey Clay (GSG)
Base of observation:	layer continues
Profile Field Notes:	Sample from puff of gilgai. Sampled by Emma Clifton, for native veg biodiversity project supervised by Pat Murray. Gogelderie Weir sheet.

SOIL DESCRIPTION

Layer 0

Layer 1

0.00 - 0.04 m A1 Horizon	dark greyish brown (dark greyish yellow) (2.5Y 4/2) [moist] silty clay with strong pedality (granular, 10 - 20 mm, smooth-faced peds), field pH is 4.5. Coarse fragments are not evident, pans are not evident, segregations are not evident; abrupt (5-20 mm) boundary to ...

Layer 2

0.04 - 0.21 m A2 Horizon	dark greyish brown (greyish yellow brown) (10YR 4/2) [moist] light clay with strong pedality (polyhedral, 20 - 50 mm, smooth-faced peds), field pH is 5.0. Coarse fragments are not evident, pans are not evident, segregations are not evident. Layer notes are: Not bleached; gradual (50-100 mm) boundary to ...

Layer 3

0.21 - 0.39 m C11 Horizon	light olive brown (yellowish brown) (2.5Y 5/4) [moist] light clay with massive structure (earthy), field pH is 5.5. Coarse fragments are not evident, pans are not evident, segregations are not evident; abrupt (5-20 mm) boundary to ...

Layer 4

0.39 - 0.60 m C12h Horizon	light olive brown (yellowish brown) (2.5Y 5/4) [moist] silty clay with massive structure (earthy), field pH is 5.5. Coarse fragments are not evident, pans are not evident, segregations are not evident. Layer notes are: Blue gley when sampled. Fine micaceous.; gradual (50-100 mm) boundary to ...

Layer 5

0.60 - 1.60 m
C13h Horizon

light olive brown (yellowish brown) (2.5Y 5/4) [moist] silty loam with massive structure (earthy), field pH is 6.0. Coarse fragments are not evident, pans are not evident, segregations are not evident. Layer notes are: Blue gley when sampled. Silt.; gradual (50-100 mm) boundary to ...

Layer 99

LABORATORY TESTS

Sample Code	Upper Bnd.	Lower Bnd.	% Clay 517.99_CL	USCS 550.02	pH 4A1	EC 3A1	OC 6A1	Bray Phos 9E1	Phos Sorb 9I1	Exch Al 15F2_AL	Exch Ca 15F1_CA	Exch K 15F1_K	Exch Mg 15F1_MG	Exch Na 15F1_NA
WEL/03/2/252(1)	0.00	0.04	59		5.1	0.32	2.08	5	667	0	12.9	2.3	7.7	0.5
WEL/03/2/253(1)	0.04	0.21	53		5.2	0.11	0.74	7	571	0	10.6	2.1	6.2	0.5
WEL/03/2/254(1)	0.21	0.39	37		5.9	0.04	0.2	7	499	0	8.8	1.3	5.2	0.3
WEL/03/2/255(1)	0.39	0.60	29		5.9	0.05	0.16	6	406	0.2	6.7	1.3	3.8	0.3
WEL/03/2/256(1)	0.60	1.60	23		5.8	0.04	0.1	6	365	0	5.4	1	2.8	0.2

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

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NSW SOIL AND LAND INFORMATION SYSTEM

Soil Profile Report

SITE DETAILS

Site Location:	Molleys Lagoon off Yanco Creek - puff
Profile Details:	Soil Landscapes of the Tarcutta 1:100 000 Sheet Survey (1000462), Profile 273, collected from a auger by Ms Janet Wild on 08 December, 2003
Map Reference:	MGA Grid Reference: Zone 55, 439713E, 6157385N. 8128 YANCO (1:100000) map sheet.
Physiography:	ox-bow in stagnant alluvial plain on alluvium lithology and used for volun./native pasture. Slope 1.0% (not recorded), local relief extremely low (< 9m), elevation 135.0 m, aspect flat. Surface condition is self mulched, profile is very poorly drained, erosion hazard is slight, and no salting evident
Vegetation/Land Use:	cleared, no cultivation at the site, used for volun./native pasture, with volun./native pasture, cropping in the general area
Surface Condition:	self mulched when described, expected to be self mulched when dry, ground cover is 1%
Erosion/Land Degradation:	slight, erosion at site is none
Soil Hydrology:	profile is very slowly permeable and very poorly drained, no free water, run on is high and runoff is low
Soil Type:	Mottled Self-mulching Brown Vertosol (ASC), Grey Clay (GSG)
Base of observation:	layer continues
Profile Field Notes:	Sample from puff of gilgai. Sampled by Emma Clifton, for native veg biodiversity project supervised by Pat Murray. Gogelderie Weir sheet.

SOIL DESCRIPTION

Layer 0

0.00 - 0.00 m

Layer 1	Horizon: A1	
0.00 - 0.04 m	Texture:	silty clay
	Colour:	dark greyish brown (dark greyish yellow) (2.5Y 4/2) [moist] with not evident mottles
	Structure:	strong pedality (granular, 10 - 20 mm, also granular, 2 - 5 mm, fabric is smooth-faced peds)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil

	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	dry, disruptive test result was moderately strong force, shearing test result was brittle,
	Field chemical tests:	Field pH is 4.5 (Raupach),
	Sample taken:	disturbed
Layer 2	Horizon: A2	
0.04 - 0.21 m	Texture:	light clay
	Colour:	dark greyish brown (greyish yellow brown) (10YR 4/2) [moist] with 2% - 10% distinct weathered orange mottles
	Structure:	strong pedality (polyhedral, 20 - 50 mm, fabric is smooth-faced peds)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	moist, disruptive test result was moderately firm force, shearing test result was labile,
	Field chemical tests:	Field pH is 5.0 (Raupach),
	Sample taken:	disturbed
	Layer Notes:	Not bleached
Layer 3	Horizon: C11	
0.21 - 0.39 m	Texture:	light clay
	Colour:	light olive brown (yellowish brown) (2.5Y 5/4) [moist] with 2% - 10% distinct weathered brown mottles
	Structure:	massive (fabric is earthy)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	moist, disruptive test result was moderately firm force, shearing test result was labile,
	Erodibility Tests:	Crumb (EAT) test showed aggregates slake,
	Field chemical tests:	Field pH is 5.5 (Raupach),
	Sample taken:	disturbed
Layer 4	Horizon: C12h (organic-Al complexes)	
0.39 - 0.60 m	Texture:	silty clay
	Colour:	light olive brown (yellowish brown) (2.5Y 5/4) [moist] with 2% - 10% distinct weathered brown mottles, and 2% - 10% distinct weathered gley subdominant mottles
	Structure:	massive (fabric is earthy)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil

	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	moist, disruptive test result was moderately firm force, shearing test result was labile,
	Erodibility Tests:	Crumb (EAT) test showed aggregates disperse,
	Field chemical tests:	Field pH is 5.5 (Raupach),
	Sample taken:	disturbed
	Layer Notes:	Blue gley when sampled. Fine micaceous.
Layer 5	Horizon: C13h (organic-Al complexes)	
0.60 - 1.60 m	Texture:	silty loam
	Colour:	light olive brown (yellowish brown) (2.5Y 5/4) [moist] with 10% - 20% distinct weathered brown mottles, and 10% - 20% distinct weathered gley subdominant mottles
	Structure:	massive (fabric is earthy)
	Coarse Fragments:	not evident,
	Pans:	not evident
	Segregations:	not evident,
	Soil fauna:	Activity is nil
	Cracks/Macropores:	Cracks are nil, macropores are nil
	Moisture/Consistence:	moist, disruptive test result was moderately firm force, shearing test result was labile,
	Erodibility Tests:	Crumb (EAT) test showed aggregates disperse,
	Field chemical tests:	Field pH is 6.0 (Raupach),
	Sample taken:	disturbed
	Layer Notes:	Blue gley when sampled. Silt.

LABORATORY TESTS

Sample Code: WEL/03/2/252(1) Upper bound: 0.00 Lower bound: 0.04

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	12.9	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	2.3	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	7.7	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.5	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	26.8	cmol/kg
2B1 [As received moisture content]	4.68	%
3A1 [EC of 1:5 soil/water extract]	0.32	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.1	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.5	pH
504.02_FC [Field Capacity, SWC pressure plate]	45.9	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	23.1	
505.99 [Water repellence field method]	0	
513.98 [Emerson aggregate test SCS method]	5	
514.99 [Dispersion percentage]	17	%

515.01 [Dry aggregate distribution]	89	
517.99_CL [PSA clay - hydrometer]	59	%
517.99_CS [PSA coarse sand - hydrometer]	1	%
517.99_FS [PSA fine sand - hydrometer]	7	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	33	%
518.99 [Volume expansion]	14	
550.02 [Unified Soil Classification System (field)]	CH	
6A1 [Organic carbon - Walkley & Black]	2.08	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	5	mg/kg
9I1 [Phosphate sorption index]	667	

Sample Code: WEL/03/2/253(1) Upper bound: 0.04 Lower bound: 0.21

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	10.6	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	2.1	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	6.2	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.5	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	18	cmol/kg
2B1 [As received moisture content]	4.12	%
3A1 [EC of 1:5 soil/water extract]	0.11	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.2	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.5	pH
504.02_FC [Field Capacity, SWC pressure plate]	42.3	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	19.3	
505.99 [Water repellence field method]	0	
513.98 [Emerson aggregate test SCS method]	3(2)	
514.99 [Dispersion percentage]	29	%
515.01 [Dry aggregate distribution]	97	
517.99_CL [PSA clay - hydrometer]	53	%
517.99_CS [PSA coarse sand - hydrometer]	3	%
517.99_FS [PSA fine sand - hydrometer]	16	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	28	%
518.99 [Volume expansion]	21	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.74	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	7	mg/kg
9I1 [Phosphate sorption index]	571	

Sample Code: WEL/03/2/254(1) Upper bound: 0.21 Lower bound: 0.39

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	8.8	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	1.3	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	5.2	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.3	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	16.7	cmol/kg
2B1 [As received moisture content]	3.26	%
3A1 [EC of 1:5 soil/water extract]	0.04	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.9	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.8	pH
504.02_FC [Field Capacity, SWC pressure plate]	39.5	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	15.5	
505.99 [Water repellence field method]	2	
513.98 [Emerson aggregate test SCS method]	2(1)	
514.99 [Dispersion percentage]	28	%
515.01 [Dry aggregate distribution]	97	
517.99_CL [PSA clay - hydrometer]	37	%
517.99_CS [PSA coarse sand - hydrometer]	2	%
517.99_FS [PSA fine sand - hydrometer]	43	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	18	%
518.99 [Volume expansion]	20	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.2	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	7	mg/kg
9I1 [Phosphate sorption index]	499	

Sample Code: WEL/03/2/255(1) Upper bound: 0.39 Lower bound: 0.60

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	6.7	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	1.3	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	3.8	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.3	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0.2	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	9.8	cmol/kg
2B1 [As received moisture content]	2.57	%
3A1 [EC of 1:5 soil/water extract]	0.05	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.9	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.8	pH
504.02_FC [Field Capacity, SWC pressure plate]	35.3	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	12.4	

505.99 [Water repellence field method]	3	
513.98 [Emerson aggregate test SCS method]	2(1)	
514.99 [Dispersion percentage]	29	%
515.01 [Dry aggregate distribution]	90	
517.99_CL [PSA clay - hydrometer]	29	%
517.99_CS [PSA coarse sand - hydrometer]	4	%
517.99_FS [PSA fine sand - hydrometer]	50	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	17	%
518.99 [Volume expansion]	18	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.16	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	6	mg/kg
9I1 [Phosphate sorption index]	406	

Sample Code: WEL/03/2/256(1) Upper bound: 0.60 Lower bound: 1.60

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	5.4	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	1	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	2.8	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.2	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	9.4	cmol/kg
2B1 [As received moisture content]	1.99	%
3A1 [EC of 1:5 soil/water extract]	0.04	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.8	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.8	pH
504.02_FC [Field Capacity, SWC pressure plate]	31.9	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	9.9	
505.99 [Water repellence field method]	1	
513.98 [Emerson aggregate test SCS method]	2(1)	
514.99 [Dispersion percentage]	37	%
515.01 [Dry aggregate distribution]	82	
517.99_CL [PSA clay - hydrometer]	23	%
517.99_CS [PSA coarse sand - hydrometer]	10	%
517.99_FS [PSA fine sand - hydrometer]	54	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	13	%
518.99 [Volume expansion]	15	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.1	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	6	mg/kg

9I1 [Phosphate sorption index]	365

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

Report generated on 23/05/2018 at 02:31 PM

NSW SOIL AND LAND INFORMATION SYSTEM

Soil Technical Report

SITE DETAILS:

Survey:	Soil Landscapes of the Tarcutta 1:100 000 Sheet (1000462)
Profile:	273
Location:	Molleys Lagoon off Yanco Creek - puff

PROFILE MAP DETAILS:

1:100,000 Mapsheet:	YANCO (8128)	Locational Accuracy:	1:25 000
MGA Easting:	439713	MGA Northing:	6157385
MGA Zone:	55		

PROFILE DETAILS:

Described by:	Ms Janet Wild	Profile Date:	08 December, 2003
Nature of Exposure:	auger	Photo Taken:	
Base of observation:	layer continues	No of Layers:	7

SOIL AND MAP CODES:

Geology Map Code:		Soil Map Code:	
Aust. Soil Classification:	Vertosol, Brown, Self-mulching, Mottled, non gravelly, giant, No data available but sufficient knowledge		
Great Soil Group:	Grey Clay	Northcote PPF:	
Soil Taxonomy:		Atlas(Northcote) Code:	
Atlas (A&M) Code:			

TOPOGRAPHY:

Slope:	1% (not recorded)		
Elevation:	135.0 m	Aspect:	flat

LANDFORM:

Site Morphology:	flat	Site Process:	alluvial
Slope Morphology:	minimal	Local Relief:	extremely low (< 9m)
Landform Pattern:	stagnant alluvial plain	Landform Element:	ox-bow
Plan Curvature:		Position in Landform Element:	
Microrelief:	normal gilgai	Microrelief depth:	

Microrelief extent:

LITHOLOGY:

Solum PM:	alluvium	Substrate:	alluvium
Rock Outcrop:	Nil	Rock Outcrop (BSAL):	
Outcrop Same As:		Substrate Strength:	
Weathering & Alteration:			
Discontinuities:			
Fragment Amount:			

VEGETATION:

Vegetation Formation:	
Vegetation Community:	
Growth Form(s):	tree, hummock grass
Crown Separation Ratio:	
Upper Stratum Height:	

SITE CONDITION:

Ground Cover %:	1.00	Site Disturbance:	cleared, no cultivation
Current Condition:	self mulched	Expected Dry Condition:	self mulched
Expected Wet Condition:		Estimated Effective Rooting Depth:	

LAND USE:

Site:	volun./native pasture	General Area:	volun./native pasture, cropping
Land Use Vegetation Species:		Prior Land Use:	

HYDROLOGY:

Presence of Free Water:	none	Free Water Depth:	
Run-on:	high	Runoff:	low
Permeability:	very slowly permeable	Profile Drainage:	very poorly drained
Free Water pH:		Free Water EC:	

EROSION:

Wind exposure:

Erosion Hazard: slight

SALINITY:

Salinity: no salting evident

Salt Outbreak Mapping:

Salt Outbreak Vegetation Species:

EM Measurement 1 Type:

EM Measurement 1 horizontal:

EM Measurement 1 vertical:

EM Measurement 2 Type:

EM Measurement 2 horizontal:

EM Measurement 2 vertical:

FIELD NOTES: Sample from puff of gilgai. Sampled by Emma Clifton, for native veg biodiversity project supervised by Pat Murray. Gogelderie Weir sheet.

LAYER 0

Depth: 0.00 - 0.00 m

Layer Notes:

Vesicles:

Ped porosity:

LAYER 1 A1 horizon

Depth: 0.00 - 0.04 m

Layer Notes:

TEXTURE: silty clay

COLOUR:

Moist: dark greyish brown (dark greyish yellow) (2.5Y 4/2)

MOTTLES:

Dominant Mottles:

Type: not evident

Colour:

Contrast:

Abundance:

FIELD CHEMICAL TESTS:

pH: 4.5 (Raupach)

Field EC:

HCl:

H2O2:

AgNO3:

STRUCTURE:

Grade of Pedality: strong pedality

Fabric: smooth-faced peds

Dominant Peds: 10 - 20 mm, granular

Subdominant Peds: 2 - 5 mm, granular

Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	moderately strong force
Shearing Test:	brittle	Toughness:	

SOIL WATER STATUS: dry

SAMPLE TAKEN: disturbed

BOUNDARY:

Distinctiveness:	abrupt (5-20 mm)	Shape:	

LAYER 2	A2 horizon
Depth:	0.04 - 0.21 m
Layer Notes:	Not bleached

TEXTURE: light clay

COLOUR:

Moist: dark greyish brown (greyish yellow brown) (10YR 4/2)

MOTTLES:

Dominant Mottles:

Type:	weathered	Colour:	orange
Contrast:	distinct	Abundance:	2% - 10%

FIELD CHEMICAL TESTS:

pH:	5.0 (Raupach)	Field EC:	

HCl:		H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	strong pedality	Fabric:	smooth-faced peds
Dominant Peds:	20 - 50 mm, polyhedral	Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	moderately firm force
Shearing Test:	labile	Toughness:	

SOIL WATER STATUS: moist

SAMPLE TAKEN: disturbed

BOUNDARY:

Distinctiveness:	gradual (50-100 mm)	Shape:	

LAYER 3 C11 horizon

Depth: 0.21 - 0.39 m

Layer Notes:

TEXTURE: light clay

COLOUR:

Moist: light olive brown (yellowish brown) (2.5Y 5/4)

MOTTLES:

Dominant Mottles:

Type:	weathered	Colour:	brown

Contrast:	distinct	Abundance:	2% - 10%

FIELD CHEMICAL TESTS:

pH:	5.5 (Raupach)	Field EC:	
HCl:		H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	massive	Fabric:	earthy
Dominant Peds:		Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	moderately firm force
Shearing Test:	labile	Toughness:	

SOIL WATER STATUS: moist

ERODIBILITY TESTS:

Crumb Test:	aggregates slake	Bolus Formation:	
Field Dilatency:			

SAMPLE TAKEN: disturbed

BOUNDARY:

Distinctiveness:	abrupt (5-20 mm)	Shape:	

LAYER 4 C12h horizon (organic-Al complexes)

Depth:	0.39 - 0.60 m
Layer Notes:	Blue gley when sampled. Fine micaceous.

TEXTURE:	silty clay		

COLOUR:

Moist:	light olive brown (yellowish brown) (2.5Y 5/4)		

MOTTLES:

Dominant Mottles:			
Type:	weathered	Colour:	brown
Contrast:	distinct	Abundance:	2% - 10%
Subdominant Mottles:			
Type:	weathered	Colour:	gley
Contrast:	distinct	Abundance:	2% - 10%

FIELD CHEMICAL TESTS:

pH:	5.5 (Raupach)	Field EC:	
HCl:		H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	massive	Fabric:	earthy
Dominant Peds:		Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	moderately firm force
Shearing Test:	labile	Toughness:	

SOIL WATER STATUS:	moist		

ERODIBILITY TESTS:

Crumb Test:	aggregates disperse	Bolus Formation:	
Field Dilatency:			

SAMPLE TAKEN: disturbed

BOUNDARY:

Distinctiveness:	gradual (50-100 mm)	Shape:	

LAYER 5 C13h horizon (organic-Al complexes)

Depth: 0.60 - 1.60 m

Layer Notes: Blue gley when sampled. Silt.

TEXTURE: silty loam

COLOUR:

Moist: light olive brown (yellowish brown) (2.5Y 5/4)

MOTTLES:

Dominant Mottles:

Type:	weathered	Colour:	brown
Contrast:	distinct	Abundance:	10% - 20%

Subdominant Mottles:

Type:	weathered	Colour:	gley
Contrast:	distinct	Abundance:	10% - 20%

FIELD CHEMICAL TESTS:

pH:	6.0 (Raupach)	Field EC:	
HCl:		H2O2:	
AgNO3:			

STRUCTURE:

Grade of Pedality:	massive	Fabric:	earthy
Dominant Peds:		Subdominant Peds:	
Artificial Aggregates:		SOILpak score:	
Vesicles:		Ped porosity:	

COARSE FRAGMENTS:

Type:	not evident	Amount:	
Distribution:		Orientation:	
Weathering:		Shape:	
Size:			

PANS:

Type:	not evident	Cementation:	
Continuity:		Structure:	

SEGREGATIONS:

Type:	not evident	Amount:	
Strength:		Form:	
Size:			

CONSISTENCE:

Degree of Plasticity:		Stickiness:	
Texture Modifier:		Disruptive Test:	moderately firm force
Shearing Test:	labile	Toughness:	

SOIL WATER STATUS: moist

ERODIBILITY TESTS:

Crumb Test:	aggregates disperse	Bolus Formation:	
Field Dilatency:			

SAMPLE TAKEN: disturbed

BOUNDARY:

Distinctiveness:	gradual (50-100 mm)	Shape:	

LAYER 99

Layer Notes:

Vesicles:		Ped porosity:	

LABORATORY TESTS

Sample Code: WEL/03/2/252(1) Upper bound: 0.00 Lower bound: 0.04

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	12.9	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	2.3	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	7.7	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.5	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	26.8	cmol/kg
2B1 [As received moisture content]	4.68	%
3A1 [EC of 1:5 soil/water extract]	0.32	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.1	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.5	pH
504.02_FC [Field Capacity, SWC pressure plate]	45.9	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	23.1	
505.99 [Water repellence field method]	0	
513.98 [Emerson aggregate test SCS method]	5	
514.99 [Dispersion percentage]	17	%

515.01 [Dry aggregate distribution]	89	
517.99_CL [PSA clay - hydrometer]	59	%
517.99_CS [PSA coarse sand - hydrometer]	1	%
517.99_FS [PSA fine sand - hydrometer]	7	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	33	%
518.99 [Volume expansion]	14	
550.02 [Unified Soil Classification System (field)]	CH	
6A1 [Organic carbon - Walkley & Black]	2.08	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	5	mg/kg
9I1 [Phosphate sorption index]	667	

Sample Code: WEL/03/2/253(1) Upper bound: 0.04 Lower bound: 0.21

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	10.6	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	2.1	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	6.2	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.5	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	18	cmol/kg
2B1 [As received moisture content]	4.12	%
3A1 [EC of 1:5 soil/water extract]	0.11	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.2	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.5	pH
504.02_FC [Field Capacity, SWC pressure plate]	42.3	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	19.3	
505.99 [Water repellence field method]	0	
513.98 [Emerson aggregate test SCS method]	3(2)	
514.99 [Dispersion percentage]	29	%
515.01 [Dry aggregate distribution]	97	
517.99_CL [PSA clay - hydrometer]	53	%
517.99_CS [PSA coarse sand - hydrometer]	3	%
517.99_FS [PSA fine sand - hydrometer]	16	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	28	%
518.99 [Volume expansion]	21	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.74	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	7	mg/kg
9I1 [Phosphate sorption index]	571	

Sample Code: WEL/03/2/254(1) Upper bound: 0.21 Lower bound: 0.39

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	8.8	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	1.3	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	5.2	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.3	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	16.7	cmol/kg
2B1 [As received moisture content]	3.26	%
3A1 [EC of 1:5 soil/water extract]	0.04	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.9	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.8	pH
504.02_FC [Field Capacity, SWC pressure plate]	39.5	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	15.5	
505.99 [Water repellence field method]	2	
513.98 [Emerson aggregate test SCS method]	2(1)	
514.99 [Dispersion percentage]	28	%
515.01 [Dry aggregate distribution]	97	
517.99_CL [PSA clay - hydrometer]	37	%
517.99_CS [PSA coarse sand - hydrometer]	2	%
517.99_FS [PSA fine sand - hydrometer]	43	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	18	%
518.99 [Volume expansion]	20	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.2	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	7	mg/kg
9I1 [Phosphate sorption index]	499	

Sample Code: WEL/03/2/255(1) Upper bound: 0.39 Lower bound: 0.60

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	6.7	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	1.3	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	3.8	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.3	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0.2	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	9.8	cmol/kg
2B1 [As received moisture content]	2.57	%
3A1 [EC of 1:5 soil/water extract]	0.05	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.9	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.8	pH
504.02_FC [Field Capacity, SWC pressure plate]	35.3	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	12.4	

505.99 [Water repellence field method]	3	
513.98 [Emerson aggregate test SCS method]	2(1)	
514.99 [Dispersion percentage]	29	%
515.01 [Dry aggregate distribution]	90	
517.99_CL [PSA clay - hydrometer]	29	%
517.99_CS [PSA coarse sand - hydrometer]	4	%
517.99_FS [PSA fine sand - hydrometer]	50	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	17	%
518.99 [Volume expansion]	18	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.16	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	6	mg/kg
9I1 [Phosphate sorption index]	406	

Sample Code: WEL/03/2/256(1) Upper bound: 0.60 Lower bound: 1.60

Name	Value	Unit of measure
15F1_CA [Exchangeable Ca - 0.01M (AgTU)+, no pretreatment]	5.4	cmol/kg
15F1_K [Exchangeable K - 0.01M (AgTU)+, no pretreatment]	1	cmol/kg
15F1_MG [Exchangeable Mg - 0.01M (AgTU)+, no pretreatment]	2.8	cmol/kg
15F1_NA [Exchangeable Na - 0.01M (AgTU)+, no pretreatment]	0.2	cmol/kg
15F2_AL [Exchangeable Al - 0.01 M AgTU+]	0	cmol/kg
15F3_CEC [Cation exchange capacity - 0.01 M AgTU+]	9.4	cmol/kg
2B1 [As received moisture content]	1.99	%
3A1 [EC of 1:5 soil/water extract]	0.04	dS/m
4A1 [pH of 1:5 soil/water suspension]	5.8	pH
4B1 [pH of 1:5 soil/0.01M CaCl2 extract - direct, no stir]	4.8	pH
504.02_FC [Field Capacity, SWC pressure plate]	31.9	
504.02_PWP [Permanent Wilt Point, SWC pressure plate]	9.9	
505.99 [Water repellence field method]	1	
513.98 [Emerson aggregate test SCS method]	2(1)	
514.99 [Dispersion percentage]	37	%
515.01 [Dry aggregate distribution]	82	
517.99_CL [PSA clay - hydrometer]	23	%
517.99_CS [PSA coarse sand - hydrometer]	10	%
517.99_FS [PSA fine sand - hydrometer]	54	%
517.99_GR [PSA gravel - hydrometer]	0	%
517.99_SI [PSA silt - hydrometer]	13	%
518.99 [Volume expansion]	15	
550.02 [Unified Soil Classification System (field)]	CL	
6A1 [Organic carbon - Walkley & Black]	0.1	%
9E1 [Fluoride-extractable P (Bray 1-P) - manual colour]	6	mg/kg

9I1 [Phosphate sorption index]	365

For information on laboratory test data and units of measure, please see: Soil survey standard test methods

Report generated on 23/05/2018 at 02:32 PM

ATTACHMENT D

ARR Datahub – Regional Soil Infiltration Recommendations

Australian Rainfall & Runoff Data Hub - Results

Input Data

Longitude	146.245
Latitude	-34.884
Selected Regions	
Storm Losses	

Region Information

Data Category	**Region**
River Region	Billabong-Yanco Creeks
ARF Parameters	Southern Semi-arid
Temporal Patterns	Murray Basin

Data

Storm Losses

Note: Burst Loss = Storm Loss - Preburst

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

id	30587.0
Storm Initial Losses (mm)	26.0
Storm Continuing Losses (mm/h)	0.0

Layer Info

Time Accessed	27 June 2018 01:15PM
Version	2016_v1

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