DESIGN REPORT

PROJECT LOCATION
Lot 130 DP 105958, Booral Road
Bulahdelah, NSW, 2423, Australia

CLIENT NAME
Paul Sun Energy Pty Ltd

DRB PROJECT NUMBER
243370

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DISCLAIMER

Project Number: 243370

Client: Paul Sun Energy Pty Ltd

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Report Amendments

Revision	Date	Description	Author	Reviewer	Approver
A	06/05/2025	ISSUED FOR DA	FM	JT	JT

CONTENTS

1 INTRODUCTION

1.1 SCOPE OF WORKS

The stormwater strategy outlined in this report has been prepared to support the DA submission for the proposed solar farm at Booral Road, Bulahdelah. This report shows that by adopting grass lined swales and using the existing surface as a grass buffer:

- Neutral or beneficial effect (NorBE) on stormwater quality has been achieved in accordance with MidCoast Councils stormwater policy for lots over 2,500m² with less than 10% existing impervious area, and
- Onsite Stormwater Detention (OSD) can be omitted as post-development peak flow rates are reduced to pre-developed peak flow rates with the provision of stormwater swales. The increase to the overall flow length of the catchments is sufficient to offset the peak in catchment hydrographs reducing the peak flow rate at the discharge point for the site.

1.2 SITE DESCRIPTION

The subject site is located to the northwest of Booral Road and the location can be seen below in Figure 1. The development will be referred to as the subject site throughout this report. The subject site is located within Mid Coast Councils LGA and is zoned as RU2 Rural Landscape.

At the time of preparing the report the subject site was bordered by Booral Road to the southeast, existing rural properties on the remaining boundaries. The site is approximately 40 Ha in area. The existing site general sloped to the east at approximately 0.4%, had good grass and moderate to dense tree coverage at the time of investigation.

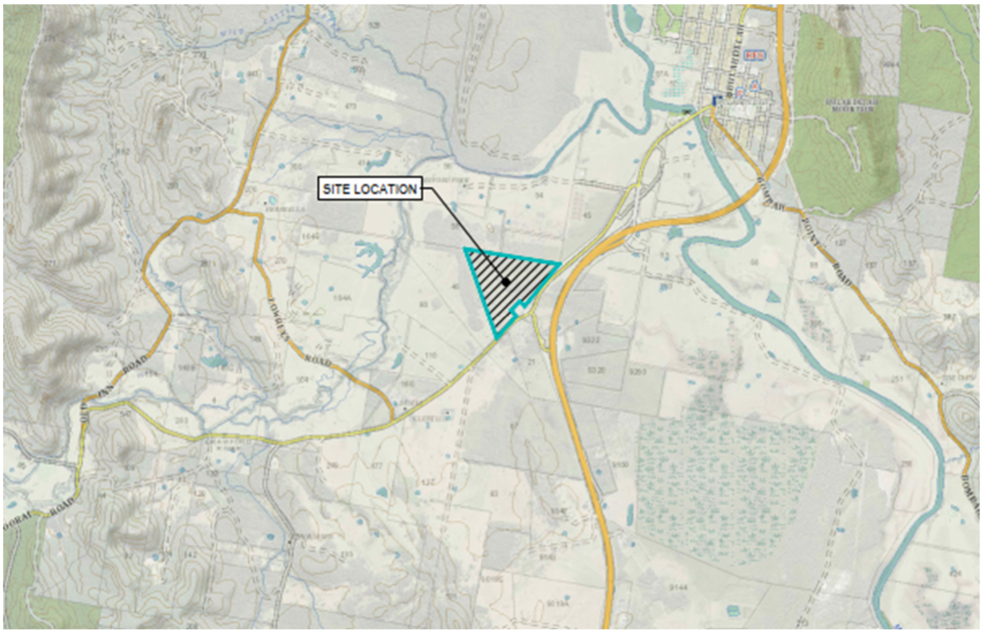


Figure 1 - Subject Site

1.3 PROPOSED DEVELOPMENT

The proposed development involves the construction of 143 solar arrays, a shed, associated solar farm infrastructure and associated gravel access roads. The proposed works will include the following elements:

- A new access road bordering the solar arrays,
- Construction of a single shed, and
- Constructing grass lined swales to convey stormwater runoff from the future development to the respective discharge point.

The proposed grass lined swales, and existing grass areas will polish stormwater runoff to comply with MidCoast Council's stormwater quantity and quality requirements. Drainage for the proposed access road includes the construction of grass lined swales. The location, direction and length of the swales is sufficient to offset the peak flows from hardstand areas and reduce post-development peak flow rates to pre-development levels.

The proposed layout of the site can be seen on the current civil drawings 243370-CIV-005.

2 STORMWATER MANAGEMENT

2.1 DRAINS MODEL

A DRAINS model was developed to determine the pre and post-development peak flow rates for the site. The DRAINs model used the ARR 2019 Initial loss – Continuing Loss (IL-CL) hydrological model and 2016 IFD data. The Hydrological model parameters were determined using the ARR data hub and are shown below. Note the continuing loss has been factored by 0.4 in line with typical ARR guidance when more accurate data is not available. The model parameters can be seen below in Figure 2.

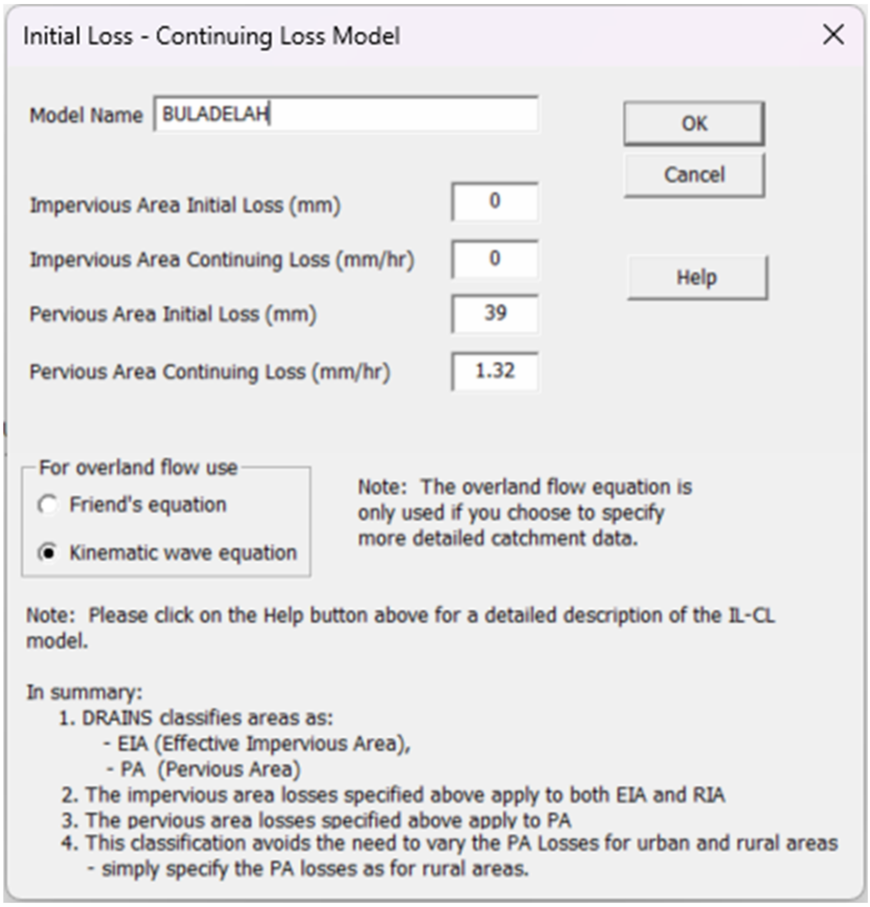


Figure 2 - Hydrological Model Parameters

The model was developed for following storm durations:

5 minutes	30 minutes	3 hours	12 hours
10 minutes	45 minutes	4.5 hours	18 hours
15 minutes	1 hour	6 hours	24 hours
20 minutes	1.5 hours	9 hours	
25 minutes	2 hours	12 hours	

2.2 STORMWATER QUANTITY/OSD

The stormwater quantity assessment was broken down into two separate areas for assessment. One being the photovoltaic array which section 2.2.1 – 2.2.4 outlines, has no net increase in peak flow rates. The other being the remainder of the site understanding that the post developed photo-voltaic array has no net increase in peak flow and thus can be considered as a pervious undeveloped catchment.

2.2.1 PHOTOVOLTAIC ARRAY

The Photovoltaic Array will consist of 143 ground mounted single axis trackers, the array structure will be supported by steel piles and will have an assumed ground clearance of approximately 600mm. The proposed solar farm layout can be seen below in Figure 3.

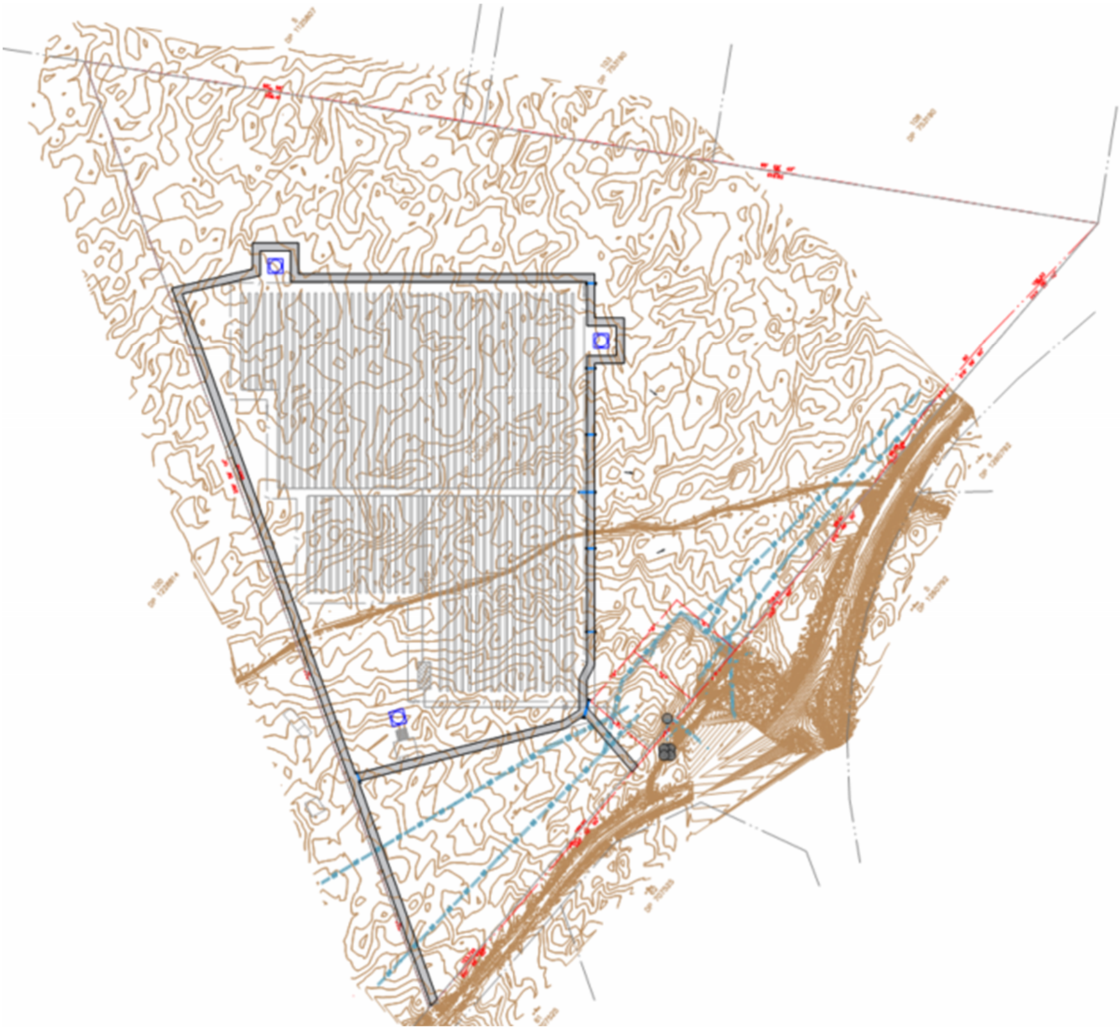


Figure 3 - Solar Farm General Arrangement

2.2.2 PHOTOVOLTAIC ARRAY PRE-DEVELOPMENT PEAK FLOWS

The pre-developed site conditions have been modelled based on the catchment characteristics seen below in Table 1.

Construction Stage	**Parameter**	
Pre-Development	Sub-Catchment Area	92,973 m^2
	Percentage Impervious	0 %
	Flow path Length	100.0 m
	Flow path Slope	0.4 %
	Retardance Coefficient 'n'	0.20

Table 1 – Photovoltaic Array Existing Catchment Parameters

The model was analysed for a range of storm events including the 1 EY (Exceedances per year), 20% AEP (Annual Exceedance Probability), 10% AEP, 5% AEP, and 1% AEP events and the peak flow rates for each storm event can be seen below in Table 2.

Storm Event (Exceedance Probability / Annual Exceedance Probability)	***Peak Flow***
1EY	0.277 m^3/s
20% AEP	0.900 m^3/s
10% AEP	1.400 m^3/s
5% AEP	1.820 m^3/s
1% AEP	3.130 m^3/s

Table 2 - Pre-Development Peak Flow Rates

2.2.3 PHOTOVOLTAIC ARRAY POST-DEVELOPMENT PEAK FLOWS

The post-development site conditions can be summarised below:

- The proposed solar arrays will be at varying angles, however, in a worst-case runoff scenario it can be assumed that the array will be horizontal to the existing ground surface level, which, in theory, maximises the impervious area.
- Runoff from the proposed arrays will fall directly onto the adjacent ground surface. Runoff will then sheet flow toward and over the untouched and unexposed pervious ground area beneath the adjacent solar array. The pervious area beneath the solar arrays will not receive direct rainfall. Therefore, this area beneath the solar array will be available for both initial and continuing losses not accounted for in a standard DRAINS model.

In both the pre-developed and post developed state there will be equal pervious area available for infiltration (initial and continuing losses). i.e flows from the impervious solar array will be directed to a covered pervious area equal in size. Therefore, with no net increase in impervious area it is deemed that solar array would act as a pervious catchment.

Further to this rational an assessment using factored losses DRAINS was undertaken to determine if the above scenario could be modelled. To account for the available losses and areas that would not be modelled in DRAINS it has been deemed appropriate to factor up the initial and continuing losses for the DRAINS model to account for the available losses.

To determine this factor and to account for the losses available in the area not receiving direct rainfall the total area receiving direct rainfall is divided by the pervious area between the arrays that is receiving direct rainfall.

The direct rainfall catchment for the solar arrays can be seen in Figure 4.

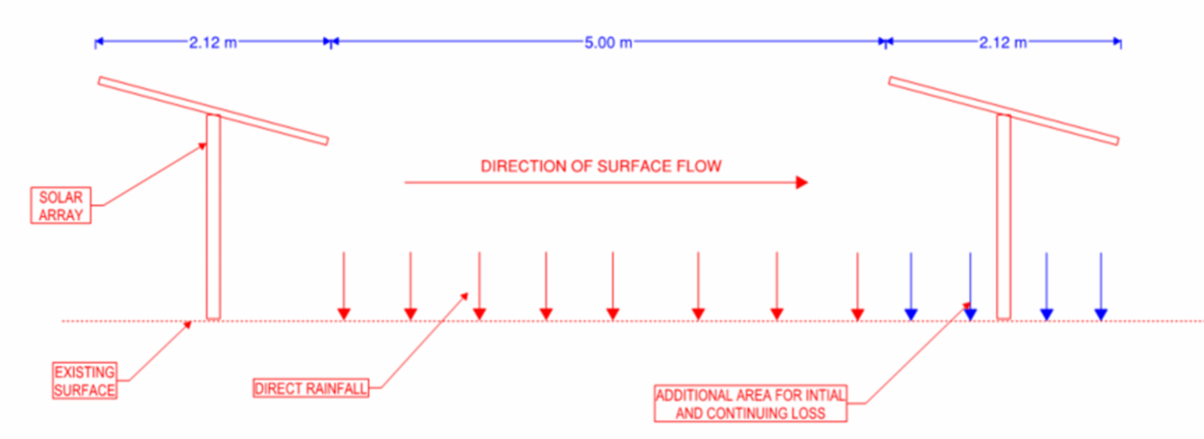


Figure 4 - Solar Array Direct Rainfall Catchment

Therefore the factor is (5.0 + 2.12) / 5 = 1.42 and the new loss values for DRAINS can be seen below in Figure 5.

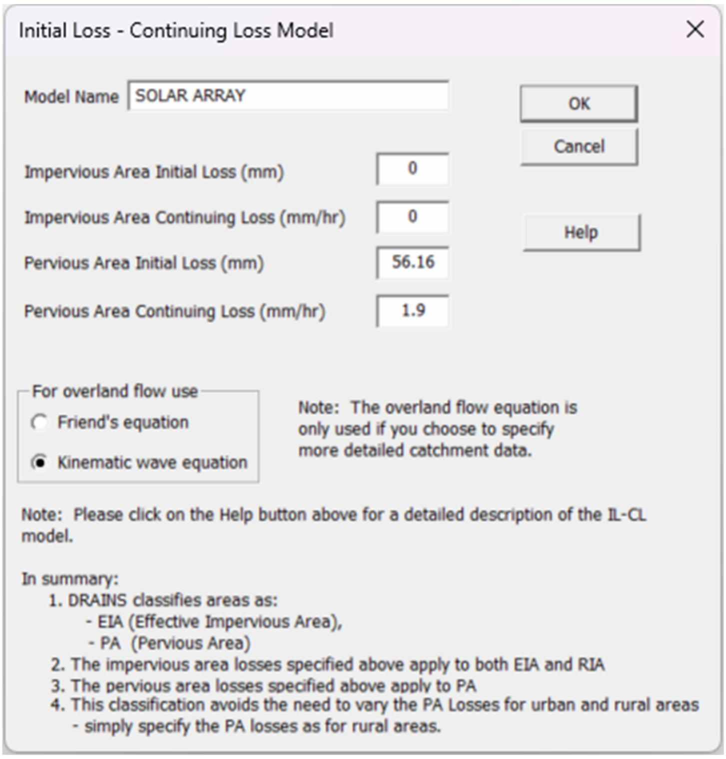


Figure 5 - Post-Development hydraulic Model Parameters

The post-developed site conditions have been modelled based on the catchment characteristics seen below in Table 3.

Construction Stage	***Parameter***	
Post-Development	Sub-Catchment Area	92,973 m^2
	Percentage Impervious	31.00 %
	Flow path Length	100.0 m
	Flow path Slope	0.4 %
	Retardance Coefficient ‘n’ (Impervious)	0.013
	Retardance Coefficient ‘n’ (Pervious)	0.20

Table 3 – Photovoltaic Array Developed Catchment Parameters

The Results of the DRAINs model can be seen below in Table 4.

Storm Event	**Pre-Development Peak Flow**	**Post-Development Peak Flow**	**Difference**
1EY AEP	0.277 m^3/s	0.265 m^3/s	-0.008 m^3/s
20% AEP	0.900 m^3/s	0.778 m^3/s	-0.122 m^3/s
10% AEP	1.400 m^3/s	1.150 m^3/s	-0.250 m^3/s
5% AEP	1.820 m^3/s	1.640 m^3/s	-0.180 m^3/s
1% AEP	3.130 m^3/s	2.950 m^3/s	-0.180 m^3/s

Table 4 – Photovoltaic Array Post Development Drains Results

Table 4 results confirm that the post development site runoff for the photovoltaic array area are less than the pre-development scenario.

2.2.4 TOTAL SITE PRE-DEVELOPMENT PEAK FLOWS

The total lot area of approximately 40ha has been used to assess the pre-developed site conditions which has been modelled based on the catchment characteristics seen below in Table 5.

Construction Stage	***Parameter***	
Pre-Development	Sub-Catchment Area	400,192 m^2
	Percentage Impervious	0 %
	Flow path Length	100.0 m
	Flow path Slope	0.40 %
	Retardance Coefficient ‘n’	0.20

Table 5 - Existing Catchment Parameters

The model was analysed for a range of storm events including the 1 EY (Exceedances per year), 20% AEP (Annual Exceedance Probability), 10% AEP, 5% AEP, and 1% AEP events and the peak flow rates for each storm event can be seen below in Table 6.

Storm Event (Exceedance Probability / Annual Exceedance Probability)	***Peak Flow***
1EY	1.100 m^3/s
20% AEP	3.670 m^3/s
10% AEP	5.520 m^3/s
5% AEP	7.570 m^3/s
1% AEP	13.00 m^3/s

Table 6 - Pre-Development Peak Flow Rates

2.2.5 Total Site Post-Development Peak Flows

The post-developed site conditions have been modelled based on the proposed site layout. The post developed site conditions can be summarised as:

- Runoff from the proposed road will be directed to either an adjacent grass lined swale or directly onto the existing pervious ground.
- The grass lined swales will direct runoff from the road to a piped culvert beneath the road which will be discharged to the existing surface.
- The existing pervious ground surface will act as a grass buffer for stormwater quality requirements and will direct the runoff towards the existing roadside drainage of Booral Road.
- Runoff from the roofwater of the proposed shed will be discharged via downpipes to the existing surface via a level spreader.
- All runoff from the existing surface will sheetflow towards the existing roadside drainage on Booral Road which will act as the legal discharge point for the site.

The catchment characteristics for the post-development catchment areas can be seen below in Table 7 and the catchment plan can be seen below in Figure 6.

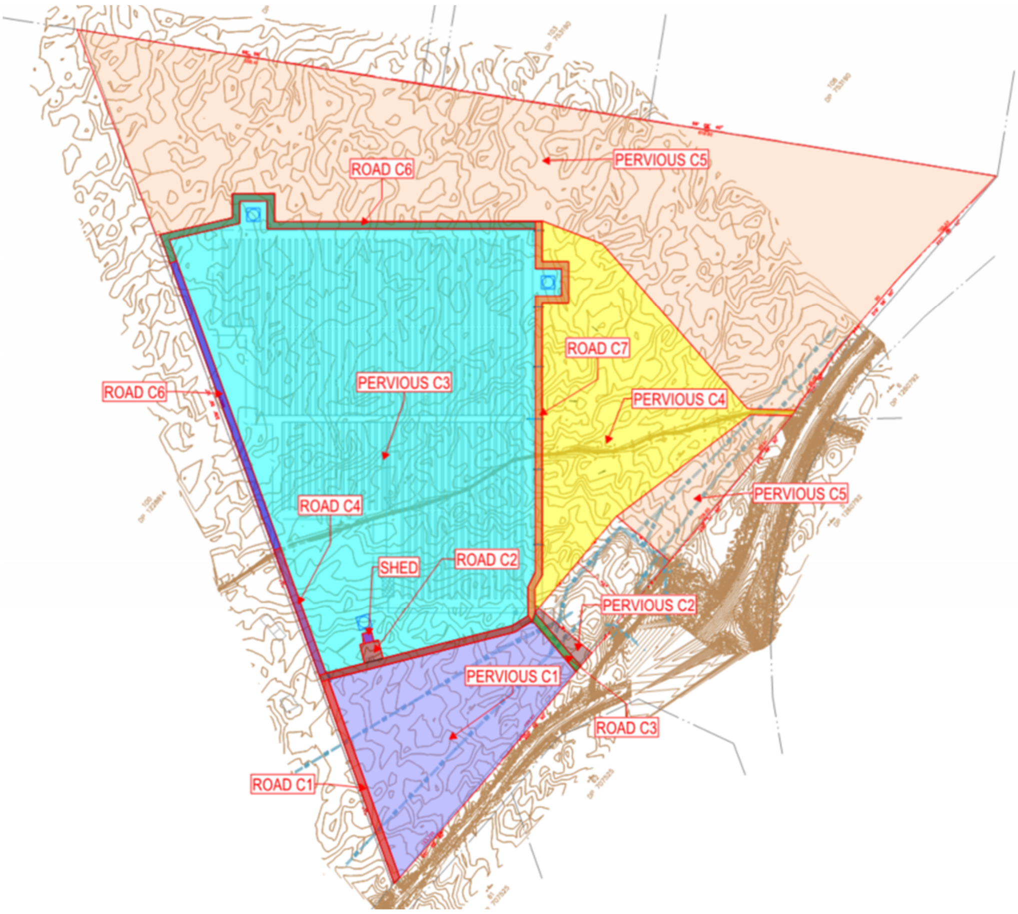


Figure 6 - Post-Development Catchment Plan

Catchment	***Parameter***	
Road C1	Sub-Catchment Area	1674.54 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.02
Road C2	Sub-Catchment Area	2134.46 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.02
Road C3	Sub-Catchment Area	488.04 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.02
Road C4	Sub-Catchment Area	1077.69 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.03
Road C5	Sub-Catchment Area	2332.92 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5.0 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.02
Road C6	Sub-Catchment Area	3618.14 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5.0 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.02
Shed	Sub-Catchment Area	100.00 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	2.0 %
	Retardance Coefficient ‘n’	0.013
Pervious C1	Sub-Catchment Area	34,144.55 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	0.4 %
	Retardance Coefficient ‘n’	0.2
Pervious C2	Sub-Catchment Area	883.44 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	0.4 %
	Retardance Coefficient ‘n’	0.2
Pervious C3	Sub-Catchment Area	137,449.90 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	0.4 %
	Retardance Coefficient ‘n’	0.2

Catchment	***Parameter***	
Pervious C4	Sub-Catchment Area	39849.70 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	0.4 %
	Retardance Coefficient ‘n’	0.2
Pervious C5	Sub-Catchment Area	172,879.50 m^2
	Percentage Impervious	100 %
	Flow path Length	7.5 m
	Flow path Slope	0.4 %
	Retardance Coefficient ‘n’	0.2

Table 7 - Post Development Catchment Parameters

A screenshot of the post-development DRAINS model can be seen below in Figure 7.

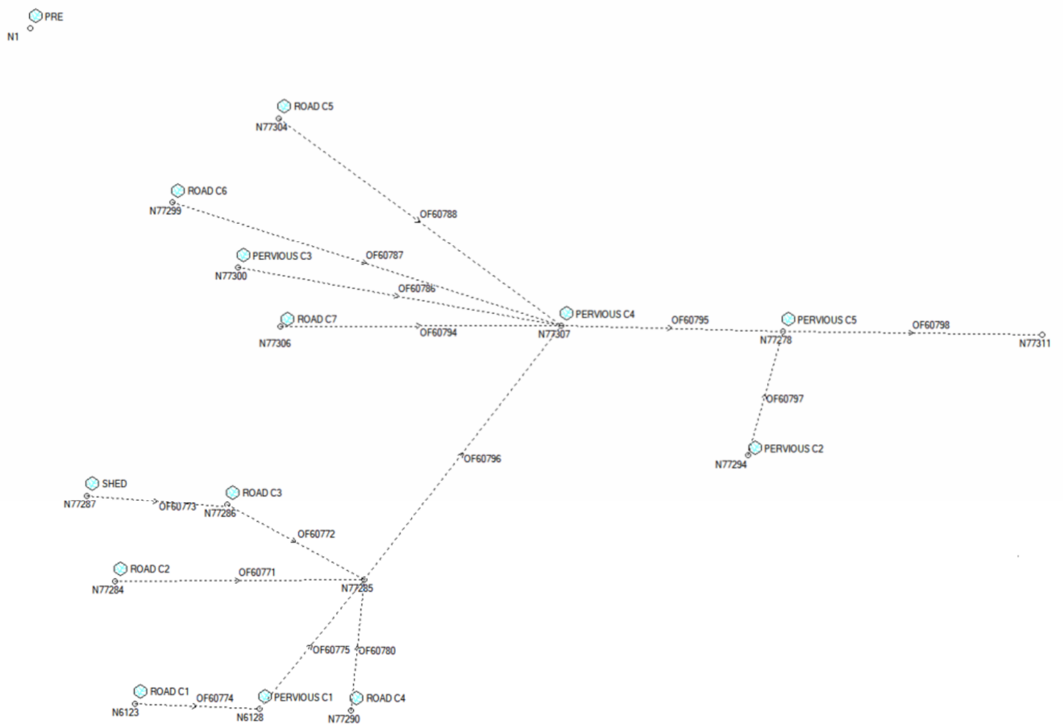


Figure 7 - Drains Model

The Results of the DRAINs model can be seen below in Table 8.

Storm Event	Pre-Development Peak Flow	Post-Development Peak Flow	Difference
1EY AEP	1.100 m^3/s	1.030 m^3/s	-0.070 m^3/s
20% AEP	3.670 m^3/s	3.080 m^3/s	-0.590 m^3/s
10% AEP	5.520 m^3/s	4.560 m^3/s	-0.960 m^3/s
5% AEP	7.570 m^3/s	6.060 m^3/s	-1.510 m^3/s
1% AEP	13.00 m^3/s	9.85 m^3/s	-3.150 m^3/s

Table 8 - Post Development Drains Results

2.2.6 CONCLUSION

With post-development flows conveyed through grass lined swales or via sheet flow across existing surfaces sufficiently longer flow lengths are created to offset the peak flow rates from certain catchments within the site. By staggering the peaks from individual catchments, the post development peak flow rates are reduced to be less than or equal to pre-developed peak flow rates without the addition of a standard OSD structure.

2.3 Water Quality

Stormwater quality treatment analysis was undertaken using the MUSICX software package to show the proposed development could adequately achieve NorBE in accordance with MidCoast Councils stormwater quality requirements. A MUSICX model was created using the rainfall template from MidCoast Council. The MUSICX file has been provided with this submission for review by Council.

2.3.1 MusicX Model & Assumptions

The MUSICX model was prepared based on the proposed layout for the subject site. In the post-developed state, there were the separate catchment areas modelled, being, the shed roof area, the impervious road runoff and the remaining pervious catchment.

The parameters and source nodes associated with each area are outlined below in Table 9. The source node parameters can be seen below in Tables 10 and 11.

Area	Source Node	Total Area	% Impervious	% Pervious
Road C1	Urban – Unsealed Road	0.167 ha	100 %	0 %
Road C2	Urban – Unsealed Road	0.213 ha	100 %	0 %
Road C3	Urban – Unsealed Road	0.049 ha	100 %	0 %
Road C4	Urban – Unsealed Road	0.108 ha	100 %	0 %
Road C5	Urban – Unsealed Road	0.232 ha	100 %	0 %
Road C6	Urban – Unsealed Road	0.362 ha	100 %	0 %
Road C7	Urban – Unsealed Road	0.357 ha	100 %	0 %
Shed	Urban – Roof	0.010 ha	100 %	0 %
Pervious C1	Urban – Rural Residential	3.414 ha	100 %	0 %
Pervious C2	Urban – Rural Residential	0.088 ha	100 %	0 %
Pervious C3	Urban – Rural Residential	13.745 ha	100 %	0 %
Pervious C4	Urban – Rural Residential	3.985 ha	100 %	0 %
Pervious C5	Urban – Rural Residential	17.288 ha	100 %	0 %

Table 9 - MusicX Catchment Source Nodes

SOIL PARAMETER	VALUE
IMPERVIOUS AREA PROPERTIES	
Rainfall threshold (mm/day)	1.00
PERVIOUS AREA PROPERTIES	
Soil Storage Capacity (mm)	100
Initial Storage (% of Capacity)	25
Field Capacity (mm)	70
Infiltration Capacity Coefficient – a	180.0
Infiltration Capacity Exponent – b	3.00
GROUNDWATER PROPERTIES	
INITIAL DEPTH (MM)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	25.00
Daily Deep Seepage Rate (%)	0.00

Table 10 - MusicX Source Node Soil Properties

Catchment	Flow	TSS		TP		TN	
		Mean	**Std Dev.**	**Mean**	**Std Dev.**	**Mean**	**Std Dev.**
Urban - Roof	Base Flow	1.10	0.17	-0.82	0.19	0.32	0.12
	Storm Flow	1.30	0.32	-0.89	0.25	0.30	0.19
Urban – Unsealed Road	Base Flow	1.20	0.17	-0.85	0.19	0.11	0.12
	Storm Flow	3.00	0.32	-0.30	0.25	0.34	0.19
Urban - Rural Residential	Base Flow	1.15	0.17	-1.22	0.19	-0.05	0.12
	Storm Flow	1.95	0.32	-0.66	0.25	0.30	0.19

Table 11 - MusicX Source Node Base Flow & Storm Flow Pollutant Concentration Values

2.3.2 Treatment Train Measures

The stormwater quality treatment train for the subject site consisted of the following:

i) Grass lined swales will be used to capture runoff from the proposed road to the north and west of the solar arrays and direct the runoff towards the existing pervious grassland to the east of the subject area.
ii) Roof water from the shed will be discharged to the adjacent existing surface.
iii) All runoff from the impervious areas will sheet flow over the existing pervious surface towards a new grass line swale before being discharged towards the existing roadside drainage along Booral Road.

2.3.3 MusicX Results

The results of the music model can be seen in Table 12 below. These results show target be achieved for the development.

Pollutants	Sources Pre-Development	Sources Post-Development	Residual Load Post-Development	Reduction %	NorBE Achieved?
TSS (kg/yr)	14090.328	34568.167	9498.487	72.522	YES
TP (kg/yr)	32.487	41.541	29.951	27.901	YES
TN (kg/yr)	303.413	327.473	300.678	8.182	YES
GP (kg/yr)	0.000	390.917	0.000	100.000	YES

Table 12 - MusicX Results

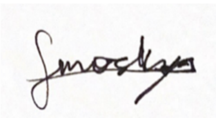
3 CONCLUSION

DRB Consulting Engineers has prepared this stormwater management report to outline the drainage strategy for the site. It found that NorBE could be achieved for the site in accordance with MidCoast Council's water quality requirements through the combination of grass lined swales and grass buffers. The minimal slope of the existing site and the addition of grass lined swales to collect stormwater runoff from the additional impervious areas result in onsite detention not being required to reduce the post-developed peak flow rates to pre-developed peak flow rates.

Should you require any further advice or clarification of any of the above, please do not hesitate to contact us.

Yours faithfully

DRB CONSULTING ENGINEERS PTY LIMITED



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<u>Reference</u>

Civil Drawings 243370-CIV-001-012