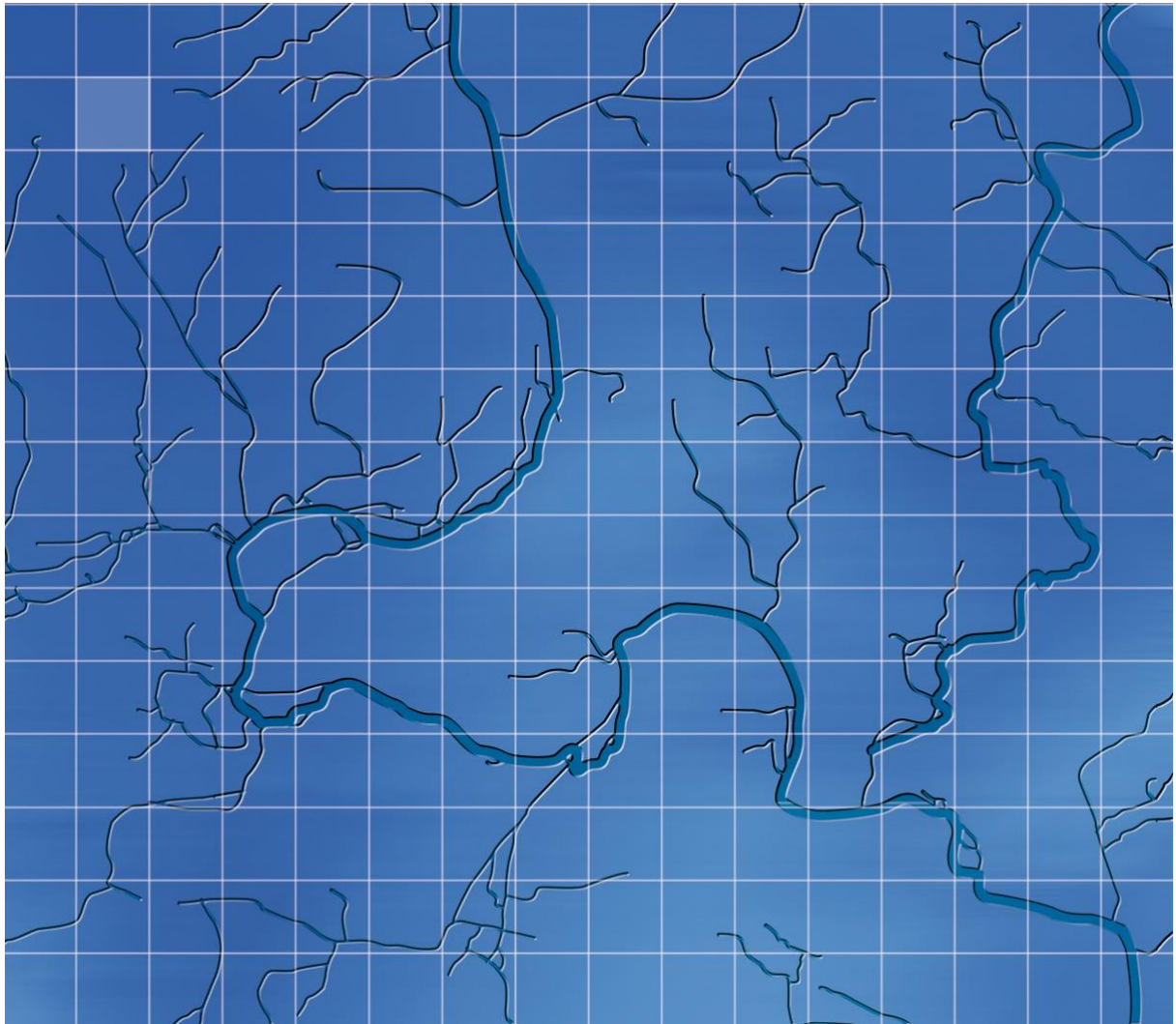


Dulas

October 2018

Mynydd Y Gwrhyd Solar Farm Drainage Strategy



WHS

Dulas

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Document issue details

WHS1626

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1	12/10/2018	Draft	Jessica Pearce (Consultant)	Jude Jeans (Technical Director)
2	19/10/2018	Final	Jessica Pearce (Consultant)	Jude Jeans (Technical Director)

For and on behalf of Wallingford HydroSolutions Ltd.

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WHS

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1 Introduction

1.1 Scope

Wallingford HydroSolutions Ltd has been commissioned by Dulas to complete an outline drainage strategy for an Awel Aman Tawe proposed solar farm located near to an existing wind farm site at Mynydd y Gwrhyd NGR: SN 7268 1057. This document forms an appendix to the hydrology and hydrogeology chapter of the Environmental Report for the proposed development.

The hydrology and hydrogeology chapter of the Environmental Report requires an assessment of the surface water runoff emanating from the proposed development to ensure that this can be sustainably managed, demonstrating minimal off-site impacts. In summary, this report will:

- Provide the site details.
- Summarise flood risk to the development site.
- Provide an outline drainage strategy suitable for sustainably managing surface water at the site.

1.2 Sources of Data

- Natural Resources Wales online flood pluvial and fluvial flood maps¹.
- The CIRIA SuDS manual².
- Site plans provided by Dulas and proposed layout CAD drawing provided by Dulas³.

¹ NRW Online flood maps, Accessed via: <https://naturalresources.wales/evidence-and-data/maps/long-term-flood-risk/?lang=en>

² The SuDS Manual vC753, CIRIA, 2015

³ Awel Aman Tawe Phase 2, E05419- Preliminary Site Layout Plan, Dulas, 2018

2 Site details

2.1 Location

The site is located adjacent to the existing Awel Aman Tawe wind farm in Mynydd y Gwrhyd, 7 miles north of Pontardawe in South Wales and approximately 1 mile south of the Celtic Energy east pit near the town of Taigwaith at NGR: SN 7268 1057. Access to the site will be via the existing road to the north of the proposed development which currently services the wind farm.

The site is surrounded by a series of small ditches which join to form the River Egel approximately 150m to the south of the site boundary. The drainage ditches run to the east and west of the site boundary. The site location is shown in Figure 1.

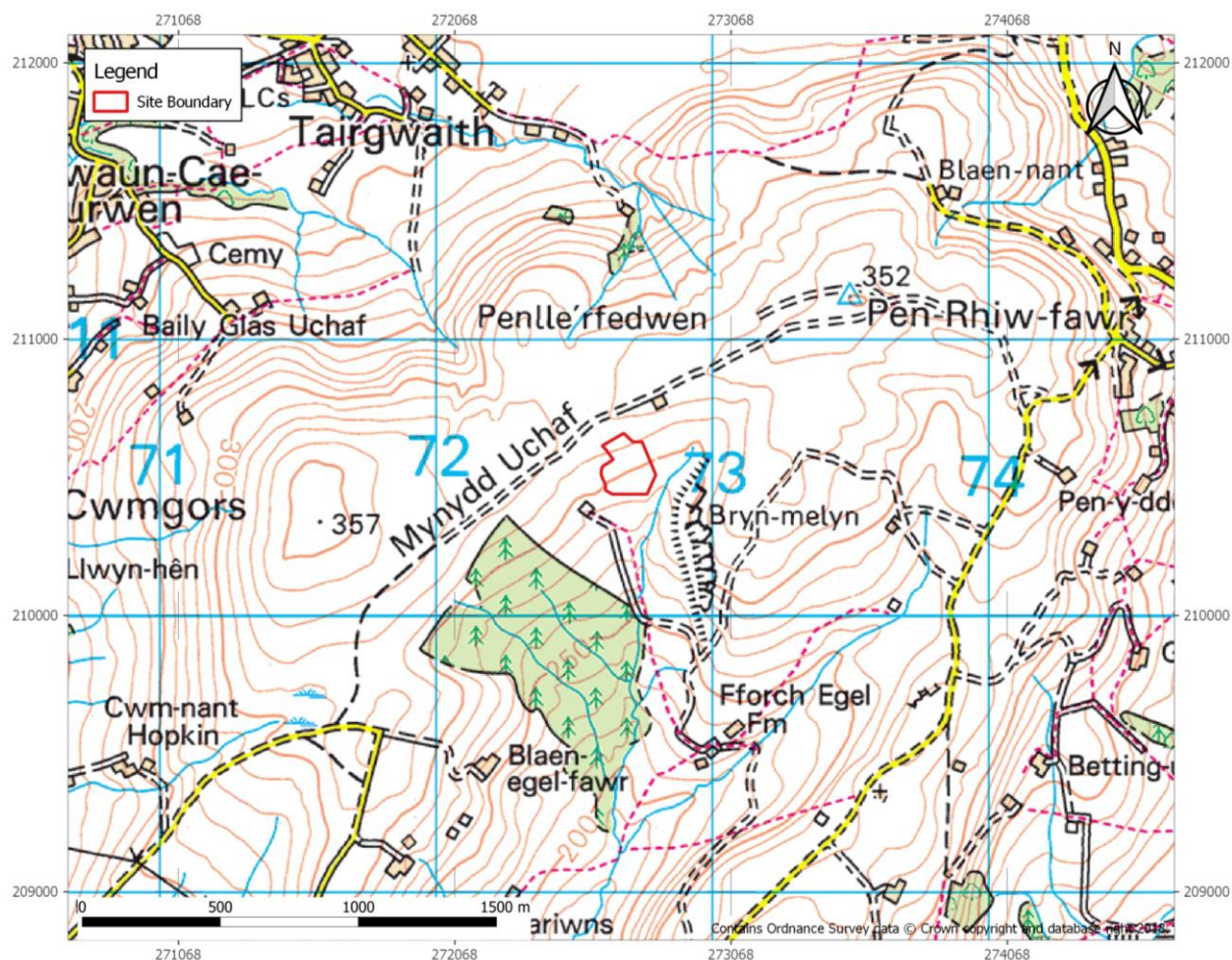


Figure 1 - Site location

2.2 Topography and Existing Drainage

Ground levels at the site range from 315m AOD along the north of the site boundary to 291m AOD at the south of the site. The site slopes in a southerly direction towards the River Egel which begins approximately 150m to the south of the site boundary, therefore the site is expected to drain in a southerly direction as per the topographic fall. There is an existing drainage ditch which runs approximately 50m to the east of the site in a southerly direction, another runs approximately 45m to the west and a third originates around 25m south of the southern part of the site boundary. The existing ditches drain into, and form the source of, the River Egel. The site topography and flow direction arrows are shown in Figure 2.

No other hydrological features have been identified within the site boundary. However, there is a small pond seen to the south west of the site approximately 20m from the site boundary.

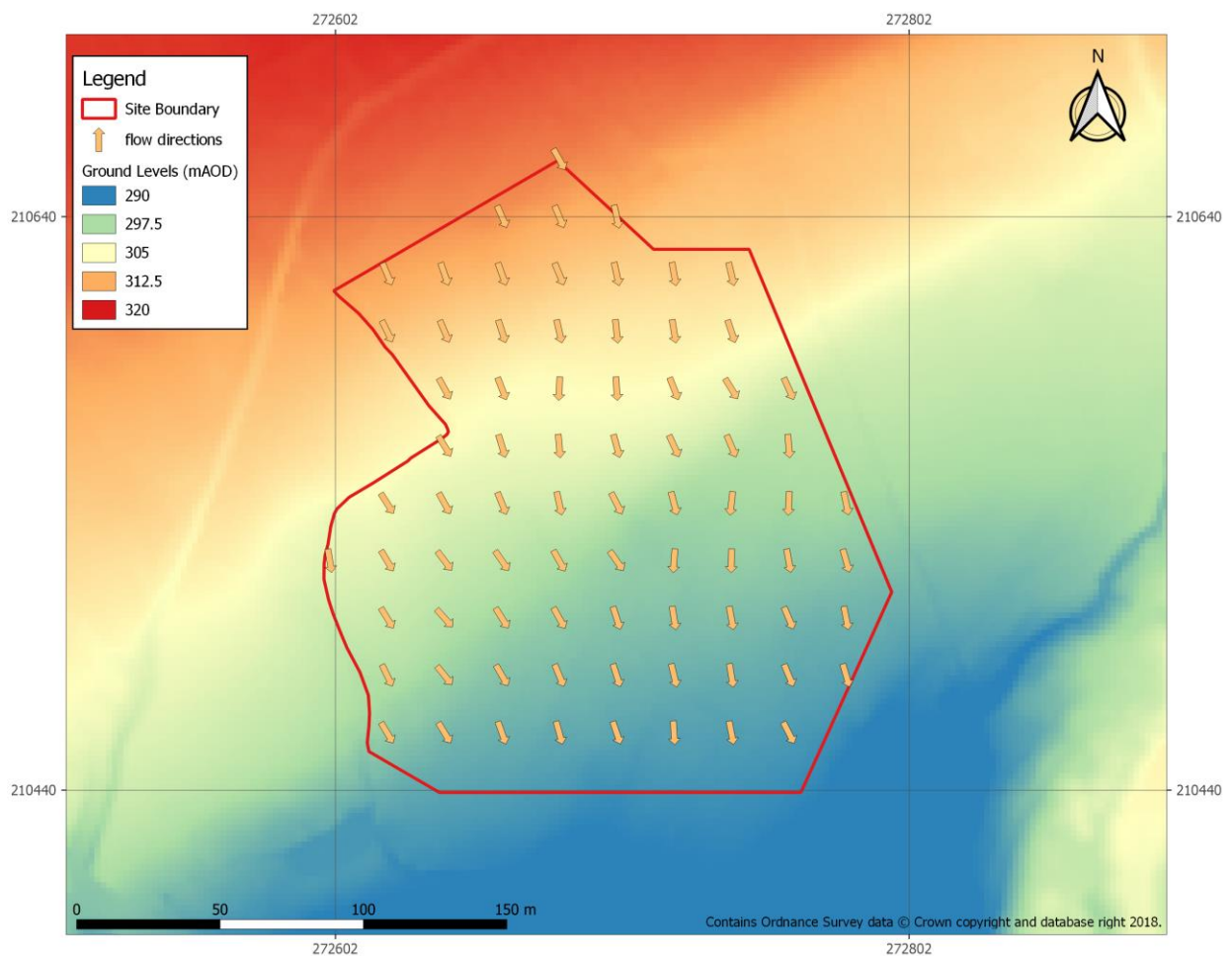


Figure 2 - Site topography

2.3 Proposed Development

The intended use of the development is for a solar farm. Within the site boundary, there will also be allocation for a battery storage plant and substation. There will also be a temporary compound during construction. A detailed site plan is available as Figure 1-2 in the planning maps. The total area of the site has been measured as 3.16 ha, with a total area of the panels measured as 1.16 ha as per the site layout drawing³ presented in Figure 1-2.

3 Flood Risk

3.1 Fluvial Flood Risk

A review of the Natural Resources Wales (NRW) online fluvial mapping has identified that the site lies completely within Flood Zone 1 and is therefore not a risk of fluvial flooding for all events up to and including the 0.1% AEP event.

3.2 Surface Water Flood Risk

The NRW surface water flood map indicates that the site is not at risk of surface water flooding for all events up to and including the 0.1% AEP event. There are areas of surface water flood risk to the east, south and west of the site all confined within the existing drainage network. There is a small area of low surface water flood risk (at risk between the 0.1% and 1% AEP events) to the south west of the site boundary, this is confined to an existing pond. The surface water flood risk is shown in Figure 3.

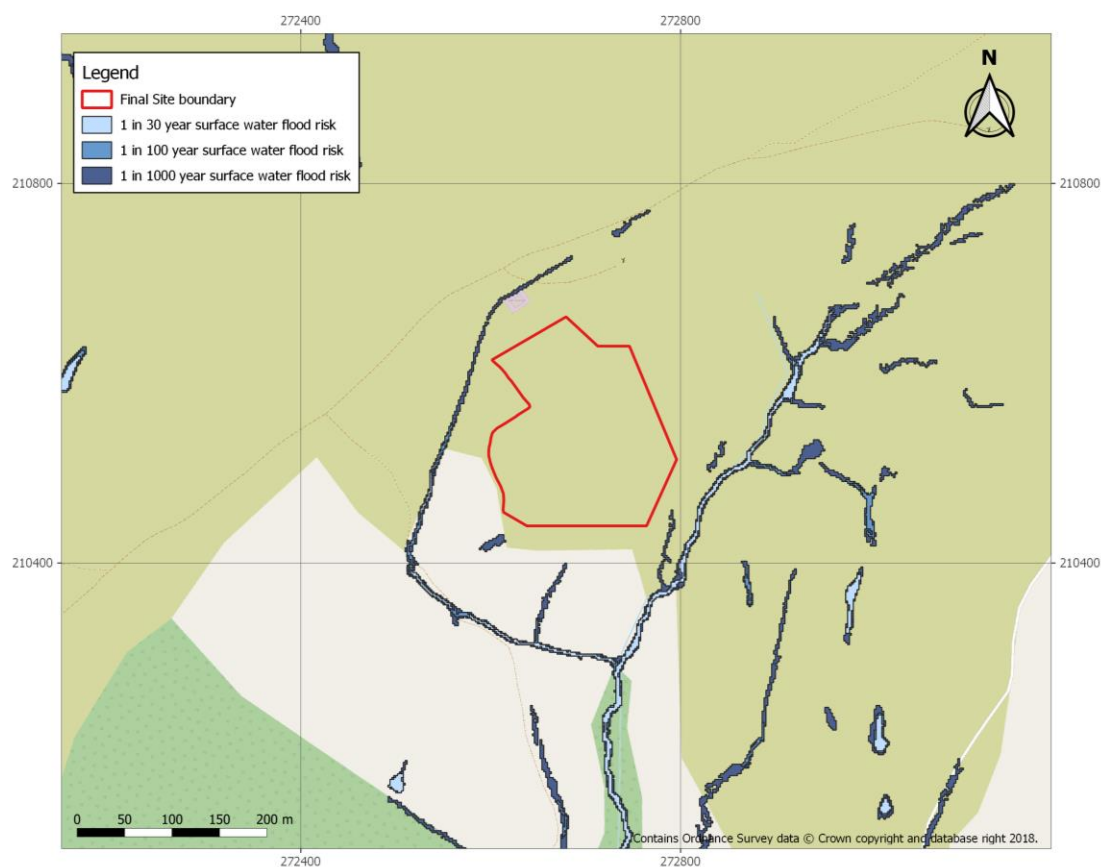


Figure 3- Surface water flood risk

4 Hydrology Assessment

4.1 Greenfield Runoff Calculations

The greenfield runoff calculations were completed using ReFH2, which is the current recommended method outlined within the CIRIS SuDS manual. Existing runoff rates have been estimated using an area of 50ha before being linearly scaled based on the estimated area of the site.

Table 1 presents the greenfield runoff rates as the unit per hectare, in addition to the total rate over the 3.16ha site. The calculations are available in Appendix A.

Table 1 - Greenfield runoff rates

Return Period	Greenfield runoff rate (l/s/ha)	Greenfield runoff rate (l/s)
1 in 1	14.73	46.56
1 in 30	32.98	104.23
1 in 100	41.28	130.43

The greenfield run off rates presented in Table 1 are based on a total area of 3.16ha, a Standard Average Annual Rainfall (SAAR) of 1771mm, a base flow index (BFIHOST) of 0.35 and a proportion of time soils are wet (PROPWET) of 0.62.

4.2 Long Term Storage Volume Calculations

The long term storage equation was applied to identify the extra volume emanating from the site due to the impermeable area of the solar panels. Due to the minor footprint of the panels themselves, i.e. rainwater is still able to drip onto the existing fields, this method was deemed appropriate as it accounts for the increase in volume of runoff rather than the increase in runoff rate.

This was calculated for the 100yr rainfall event, including a 30% allowance for climate change⁴. The 100 year 6hr rainfall depth was used in the calculation, this was taken as 75.31mm (excluding an allowance for climate change), and 98mm incorporating an addition of 30% for climate change. The rainfall depth was obtained from the FEH13⁵ rainfall model via the FEH Web Service. The site area and impermeable areas have been calculated from the proposed site layout.

Due to the footprint of the panels, 25% of their total area was used for the contributing impermeable area. This is a conservative assumption based upon current research on the hydrological impacts of solar arrays⁶. It provides an allowance for the arrays to contribute to increased runoff volume during the construction and operational phases of the project.

⁴ Adapting to Climate Change, Welsh Government. December 2017. Available: <https://gov.wales/topics/environmentcountryside/epg/flooding/nationalstrategy/guidance/climateguide/?lang=en>

⁵ FEH13 rainfall FEH Web Service <https://fehweb.ceh.ac.uk/GB/map>

⁶ Cook L.M. and McCuen R.H (2013) Hydrologic response of Solar Farms. Journal of Hydrologic Engineering 18: pp 536-541

The access track has not been included in the impermeable area calculations, as it is advised that the access track would be laid with permeable gravels.

A summary of the permeable and impermeable area for the site is presented in Table 2 and the long-term storage equation is presented as Equation 1.

Table 2- Area summary

Infrastructure	Area (ha)
Site area	3.16
Panels	1.16

$$Vol = 98 \times 3.2 \times 10 \left[\frac{9.2}{100} (1 \times 0.8) + \left(1 - \frac{9.2}{100} \right) (1 \times 0.53) - 0.53 \right]$$

Equation 1 - Example of long term storage equation

5 Drainage Strategy

An existing drain has been identified running through the centre of the site boundary in a south easterly direction, it is assumed that the solar panels will not impact upon the functioning of this drain.

A total additional runoff volume of 77m³ has been calculated due to the impermeable area of 0.29ha calculated for the proposed solar farm. To address this increase in volume, it is proposed to implement a vegetated swale as a means of sustainably managing the additional volume of runoff as a result of the proposed development. The swale is suggested to be located to span the length of the southern edge of the site boundary. This can be viewed in the drainage strategy drawing in Appendix C.

A swale length of 80m is considered appropriate to capture runoff originating from the site. The width of the swale has been calculated as 0.50m, with a side slope of 1 in 3 and depth of 0.50m. This provides a total cross section area of 1.00m². A typical cross section of the swale is shown below, followed by a figure showing the proposed swale geometry (also available as Appendix B). It is proposed that filter drains are installed along the south eastern and south western boundaries to route additional runoff into the swale. Due to the steep gradient along these boundaries, around 10%, it is proposed to utilize a stepped filter drain connected by stone weirs in order to route water into the swale along the southern boundary. The weirs will act as small control devices, and the steps will ensure that storage is maintained, rather than encouraging increasing flow rates in a southerly direction. Weir steps should be located where required to ensure a minimal gradient of 1 in 200 is achieved as recommended by the CIRIA SuDS Manual².

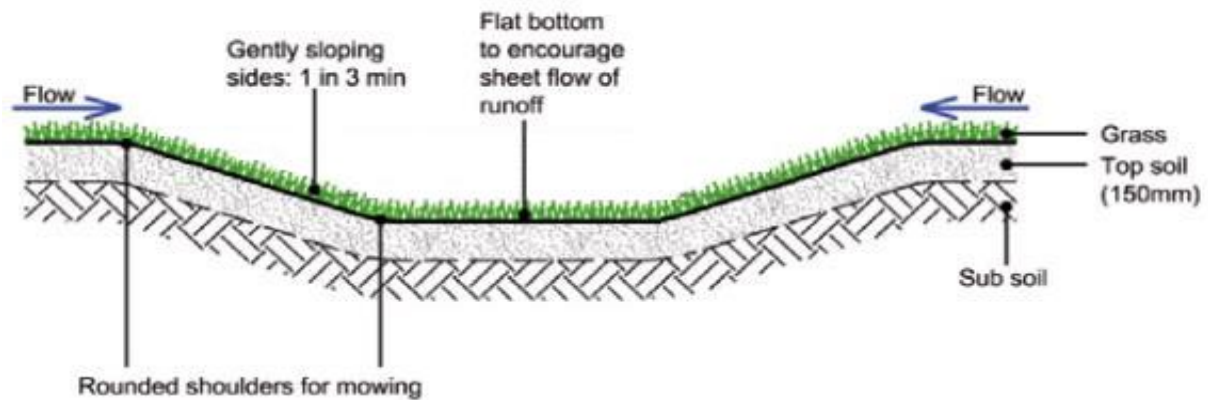


Figure 4 - Typical swale cross section

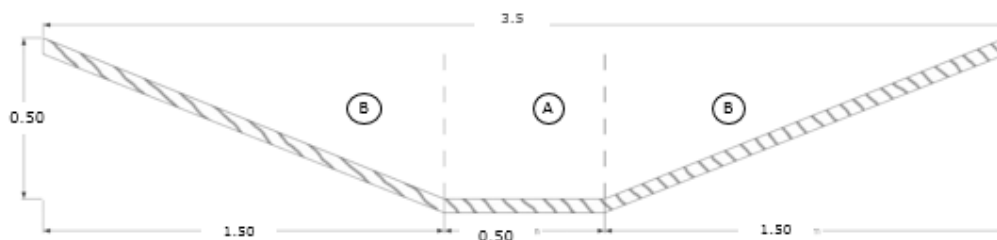


Figure 5 - Outline swale geometry

The swale will provide a safeguard to manage the expected increase in runoff volume during both the construction and operational phases of the project. The swale has been designed in accordance with the CIRIA SuDS manual² using the long term storage equation, which specifically addresses the additional runoff caused by a development. It is recommended however that detailed ground investigation is carried out during the detailed design stage to establish infiltration rates at the site. These can be used to update the equation and may reduce the volume of storage required.

At detailed design stage, it is recommended that 3m easements are provided surrounding the swale and filter drain in line with the SuDS manual².

6 Conclusions and Recommendations

This drainage strategy has provided an appropriate method of managing additional runoff volume caused by the proposed solar farm. The outline swale and filter drains have been designed in accordance with the SuDS manual² and are a widely used method of managing runoff volume across the solar industry. There is also scope to refine the runoff volume at detailed design stage via detailed ground investigation to determine potential infiltration rates at the site.

Although the risk of runoff volumes increasing to this extent is low, it is advised that a conservative approach to flood risk is adopted to minimise the impacts on the hydrological regime downstream of the site. Therefore, it is recommended that any vegetation removal during the construction phase is replaced on site as soon as possible to promote natural infiltration, in line with the literature surrounding solar farm hydrology⁶.

The site has been treated as a single drainage zone in terms of runoff volume and sustainable drainage due to the simple drainage route of water through the site to the south. It is proposed to utilize a stepped filter drain along the south eastern and south western boundaries of the site and a swale along the southern site boundary to capture surface water volumes. It has therefore been demonstrated that surface water at the site can be managed by adopting a sustainable and conservative approach.

Appendix A- Greenfield Runoff Estimation



Greenfield Runoff Estimate Calculation Sheet

Site Name	Mynydd Y Gwrhyd Solar Farm
Site Location	Mynydd Y Gwrhyd
X (Eastings)	272680
Y (Nothings)	210570
Engineer	Jess Pearce
Checked by	Brett Park
Reference	WHS1626
Revision	1
Date	19-Sep-18

		Manual User Value	From ReFH Report
Summary of site	Total Area (km2)	0.0316	0.03
	Total Area (ha)	3.16	3.16
	Existing developed area (ha)	0	0
	Development area (ha)		
	Is the catchment greenfield (no present development)	no	

Relevant Catchment descriptors	SAAR (mm)		1771
	BFIHOST		0.35
	PROPWET		0.62
	FARL		1

ReFH Parameters:

Estimated Parameters	Rainfall Used		0
	Tp		1
	CMAX		240.6
	BL		24.24 [19.66]
	BR		1.01
	Duration		02:42:00

			QMED Value (m3/s)
Growth Curves and Discharge rates	Comparison of QMED value (m3/s)	ReFH	0.052228389
		Statistical method (catchment descriptors)	0.104572502
		IH124 (if applicable)	0.007608748

$$QMED = 8.3062 AREA^{0.8510} 0.1536 \left(\frac{1000}{SAAR} \right) FARL^{3.4451} 0.0460 BFIHOST^2$$

	Event	Q/Qmed	Q (m ³ /s)	Q (l/s)	Q (l/s/ha)	IH124 Ql/s)
	Q1		0.04656	46.557	14.73	0.00
Q	Q2	1.00	0.05223	52.228	16.53	0.00
Y	Q5	1.35	0.07036	70.356	22.26	
AG	Q10	1.59	0.08327	83.267	26.35	
AO	Q30	2.00	0.10423	104.225	32.98	16.55
AW	Q50	2.20	0.11471	114.710	36.30	
BE	Q75	2.37	0.12364	123.643	39.13	
BM	Q100	2.50	0.13043	130.432	41.28	0.00
BU	Q200	2.85	0.14892	148.915	47.13	
CC	Q1000	4.18	0.21850	218.501	69.15	

Appendix B- Long Term Storage/ Swale Calculation

Site Name	Mynydd Y Gwrhyd
Site Location	Mynydd Y Gwrhyd
X (Eastings)	272706
Y (Nothings)	210546
Engineer	Jess Pearce
Checked by	Brett Park
Reference	WHS1626
Revision	1
Date	19-Sep-18

Extra Run-off Volume Calculation Sheet - Zone A

Extra Run-off Equation

"The long term storage equation specifically addresses the additional volume run-off caused by a development." The SuDS Manual (CIRIA C753, 2015)

EQ. 24.10 Estimating the extra runoff volume from a development site compared to the greenfield equivalent

$$Vol_{xs} = RD \times A \times 10 \left[\frac{PIMP}{100} (\alpha \ 0.8) + \left(1 - \frac{PIMP}{100} \right) (\beta \ SPR) - SPR \right]$$

where:

- Vol_{xs} = extra runoff volume of development runoff over greenfield runoff (m^3)
- RD = rainfall depth for the 1:100 year, 6 hour event (mm)
- $PIMP$ = impermeable area as a percentage of the total area
- A = area of the site, in hectares (ha)
- SPR = SPR index for the SOIL or HOST class (specified as a decimal proportion; this specifies the proportion of runoff from pervious surfaces (if SPRHOST values are used, then the minimum value should be set to 0.1)
- α = proportion of paved area draining to the network (values 0–1) with 80% assumed runoff
- β = proportion of the pervious area draining to the network or directly to the river (values from 0 to 1)

If the paved area is assumed to drain to the network, and all the permeable areas are landscaped so that they do not enter the drainage system or river, Equation 1 simplifies to:

$$Vol_{xs} = RD \times A \times 10 \left(0.8 \frac{PIMP}{100} - SPR \right)$$

However, where all the permeable areas are assumed to continue to drain to the river or network as well as all paved areas, Equation 2 becomes:

$$Vol_{xs} = RD \times A \times 10 (0.8 - SPR) \frac{PIMP}{100}$$

Design Variables

Rainfall Depth (100yr, 6hr Event)	75.31 mm
Rainfall Depth (100yr, 6hr Event +30% for Climate Change)	98 mm
Total Area (A)	3.2 ha
Impermeable Area	0.3 ha
PIMP	9.2 %
Alpha	1
Beta	1
SPR	0.53

Extra Run-off Volume

$$Vol = 98 \times 3.2 \times 10 \left[\frac{9.2}{100} (1 \times 0.8) + \left(1 - \frac{9.2}{100} \right) (1 \times 0.53) - 0.53 \right]$$

$$Vol = 77m^3$$

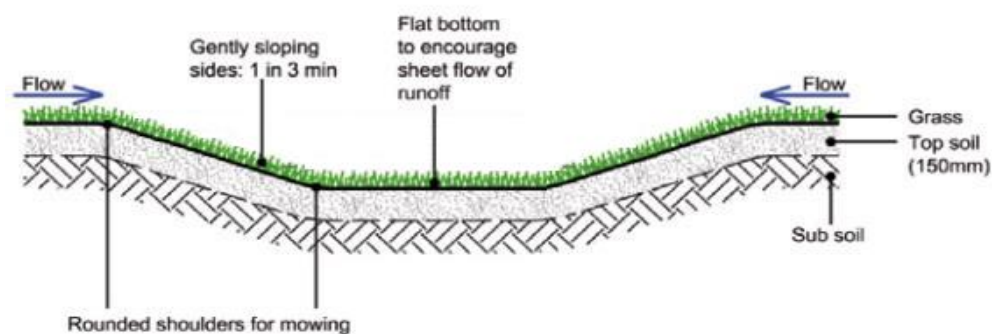
$$Vol_{xs} = 77 \ m^3$$

Site Name	Mynydd Y Gwrhyd
Site Location	Mynydd Y Gwrhyd
X (Eastings)	272706
Y (Nothings)	210546

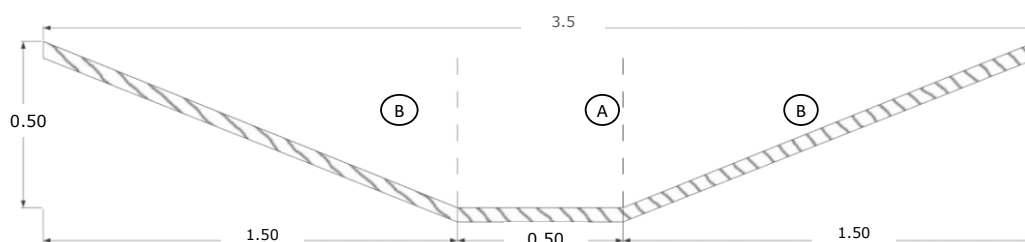
Outline Swale Design Calculation Sheet - Zone A

Engineer	Jess Pearce
Checked by	Brett Park
Reference	WHS1626
Revision	1
Date	19-Sep-18

General Cross Section



Proposed Dimensions



Slope	S =	1 : 3
Area A	b =	0.50 m
	h =	0.50 m
	A = b x h =	0.25 m ²
Area B	b =	1.50 m
	h =	0.50 m
	A = 0.5 x b x h =	0.38 m ²
Total Area	A + 2b	1.00 m ²

Appendix C- Drainage Strategy Drawing



Project : Mynydd Y Gwrhyd Solar Farm	
Client :  dulas Inspiring renewable energy	
Legend : - Site Boundary - Flow Direction - Swale - Filter Drain	
Contains Ordnance Survey data © Crown copyright and database right 2018	
Scale : 0 25 50 m 	
Title : Mynydd Y Gwrhyd Solar Farm Outline Drainage Strategy	
Drawing : WHS1626_T001_001	Rev : 1
	

Stepped Filter Drain due to steep topography to direct runoff into the swale

Stepped Filter Drain due to steep topography to direct runoff into the swale

Swale along southern boundary to capture surface water runoff.
Swale length: 80m.
Base width: 0.5m
Depth: 0.5m
Top of swale width: 3.5m

