FLOOD CONSEQUENCE AND DRAINAGE IMPACT ASSESSMENT

SWANSEA NORTH ENERGY MANAGEMENT FACILITY

FOR STATKRAFT UK LTD

JUNE 2020

Prepared By:

Arcus Consultancy Services

Suite 1C
Swinegate Court East
York
North Yorkshire
YO1 8AJ

T +44 (0)1904 715 470 l **E** info@arcusconsulting.co.uk
w www.arcusconsulting.co.uk

Registered in England & Wales No. 5644976

TABLE OF CONTENTS

1 INTRODUCTION

Statkraft UK Ltd. (the Applicant) is proposing to develop an energy management facility ('the Development') on agricultural land to the east of the existing Swansea North substation ('the Site').

Arcus Consultancy Services Ltd (Arcus) has been commissioned to undertake a Flood Consequence and Drainage Impact Assessment (this Report) for the Development. This Report is intended to meet the requirements of Natural Resources Wales (NRW) and specifically Planning Policy Wales, Technical Advice Note 15: *Development and Flood Risk* (TAN 15)[1].

This Report has been informed by the following guidance:

- Swansea Council Local Flood Risk Management Strategy[2];
- Swansea Council Preliminary Flood Risk Assessment (PFRA)[3];
- CIRIA C753 - The SuDS Manual[4];
- Welsh Assembly Government 'Technical Advice Note 15: Flooding and Development';
- Welsh Assembly Government 'Statutory Standards for Sustainable Drainage Systems'[5];
- Welsh Assembly Government 'Sustainable Drainage Statutory Guidance'[6];
- Welsh Water – 'Sewers for Adoption 7th Edition' [7]; and
- Flood and Water Management Act (2010) Section 3 – Sustainable Drainage[8].

2 SITE CHARACTERISTICS

The Development is located at national grid reference at NGR E 265322, N 201125 as shown in Plate 1. The site is undeveloped and currently comprises pastoral agricultural land and is currently bounded by agricultural land to the north, east, west and south. However, in the future the Site will be bounded to the north east by the 299MW Abergelli Gas Fired Power Station (Abergelli Power Station) buildings and structures and associated access road to the south. It is intended that the same access be used for the Development as for Abergelli Power Station which means that no additional water crossings are required of the waterbody to the west of the Site.

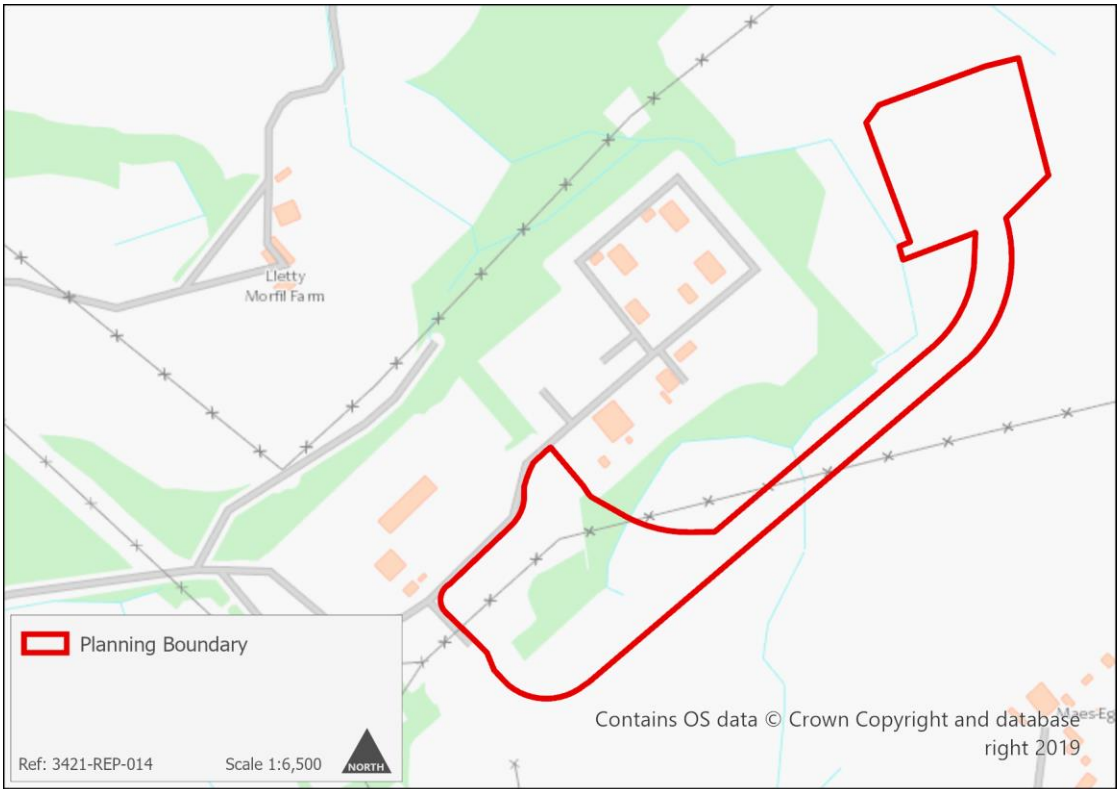
Digital Terrain Model data shows that the Site levels range from approximately 84 to 91 metres (m) above ordnance datum (AOD), with a general fall from the north east to the south west.

The British Geological Survey (BGS) Digital Mapping shows that the Site is underlain by mudstone, sandstone and conglomerate of the Grovesend Formation.

BGS Digital Mapping shows that superficial deposits are classed as till, while the National Soil Resource Institute (NSRI) maps the soils overlying the Development as slowly permeable seasonally wet acid peaty soils[9].

1 Planning Policy Wales, Technical Advice Note 15: Development and Flood Risk (TAN 15) [online] Available at: http://gov.wales/topics/planning/policy/tans/tan15/?lang=en [Accessed 27/04/2020].
2 Swansea City Council, Local Flood Management Strategy [Online] Available at: https://www.swansea.gov.uk/floodstrategy [Accessed 29/04/2020]
3 Swansea City Council, Preliminary Flood Risk Assessment [Online] Available at: https://www.swansea.gov.uk/preliminaryfloodriskassessment [Accessed 29/04/2020]
4 CIRIA, The SuDS Manual C753 [Online] Available at: http://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx
5 https://gov.wales/sites/default/files/publications/2019-06/statutory-national-standards-for-sustainable-drainage-systems.pdf [Accessed 29/04/2020]
6 Welsh Assembly Government, Statutory Guidance for SuDS [Online] Available at: https://gov.wales/sites/default/files/publications/2019-06/statutory-guidance.pdf [Accessed 29/04/2020]
7 Welsh Water, Sewers for Adoption 7th Edition [Online] Available at: https://www.dwrcymru.com/en/Developer-Services/Sewerage-Services/Adoption-of-Proposed-Sewerage.aspx [Accessed 29/04/2020]
8 Welsh Assembly Government, Flood and Water Management Act [Online] Available at: https://www.legislation.gov.uk/ukpga/2010/29/schedule/3 [Accessed 29/04/2020]

Plate 1: Site Location and Adjoining Waterbody



3 ON SITE FLOOD RISK

The TAN 15 Development and Flood Risk Development Advice Map[10] shows that all the proposed new infrastructure at the Site is located in Flood Zone A, which is categorised as being the lowest flood risk and comprises land assessed as having a less than 1:1,000 (0.1 %) annual probability of river or sea flooding in any year[11].

Figure 1 of TAN 15 states that Flood Zone A is "*used to indicate that justification test is not applicable to sites located in this zone and* [there is] *no need to consider flood risk further*".

There is a minor drainage ditch/ water body located immediately to the west of the Site, as shown in Plates 1 and 2, which is unlikely to give rise to flooding issues at the Site.

[9] National Soil Resource Institute Map [online] Available at: https://www.landis.org.uk/soilscapes/ [Accessed 27/04/2015].
10 TAN 15 Development and Flood Risk Development Advice Map [online] Available at: http://data.wales.gov.uk/apps/floodmapping/ [Accessed 27/04/2015].
11 The TAN 15 maps are based on Environment Agency's extreme flood outlines.

Plate 2: Minor Drainage Ditch in proximity to the Site

As such, this report focuses on the principles set out in Section 8: *Surface water run-off from new development* of TAN 15.

4 DEVELOPMENT DESCRIPTION AND THE NEED FOR SUDS

The Development involves the erection of an energy management facility which will comprise approximately 0.29 hectares (ha) of new hardstanding[12] within the Site boundary. Further detail on the Development is included in other documents submitted as part of the planning application, Specifically the Planning, Design and Access Statement and the Site Layout Plan.

TAN 15, Section 8: *Surface water run-off from new development of TAN 15* states:

- "*Runoff from developments…, if not properly controlled, could result in flooding at other locations and significantly alter the frequency and extent of floods further down the catchment*";
- "*Built development, such as roads, tends to increase the surface area of impermeable ground, thus reducing percolation and increasing rapid surface run-off*";
- "*Sustainable Urban Drainage Systems (SuDS) can perform an important role in managing run-off from a site and should be implemented, wherever they will be effective, in all new development proposals, irrespective of the zone in which they are located*"; and
- "*SuDS offer a variety of engineering solutions, both soft and hard, that can be employed to manage surface water run-off*".

The introduction of areas of new hardstanding on a greenfield site has the potential to increase the discharge of water from the developed area relative to the current state.

[12] Non permeable Development aspects

This effect could, in principle, lead to increased probability of down-stream flooding, especially in extreme rainfall events. The Llywodraeth Cymru 'Statutory Standards for SuDS' (2018) document identifies a Hierarchy Standard for addressing excess surface water run-off, which gives criteria for prioritising the choice of run-off destination (Standard S1):

Level 1: Surface water runoff should be collected for use;

Level 2: Surface water runoff should be infiltrated to ground;

Level 3: Surface water runoff should be discharged to a surface water body;

Level 4: Surface water runoff should be discharged to a surface water sewer, highway drain, or another drainage system; and

Level 5: Surface water runoff should be discharged to a combined sewer.

The nature of the Development (*i.e.* an unmanned facility) will not require water usage and, as such, Level 1 shall not be pursued.

The superficial geology underlying the Site comprises slowly permeable soils with considerable existing groundwater[13]. Observations from the site walkover indicated that soils at the Site are easily waterlogged, as shown in Plate 3.

Plate 3: Waterlogged soils at the Site

[13] Cranfield Soil and Food Institute Soil Scapes Map [Online] Available at: http://www.landis.org.uk/soilscapes/

As such Level 2, infiltration to ground is considered unfeasible and shall not be pursued.

The surface water runoff from the Development will be discharged to the drainage ditch running immediately west of the Site, as shown in Plates 1 and 2.

The ICP SuDS method, using Micro Drainage, has been followed to identify approximate rainfall storage volumes required onsite, and is considered appropriate as the document references its applicability in Wales.

Paragraph G2.34 of the Llywodraeth Cymru 'Statutory Standards for SuDS' guidance outlines that critical infrastructure where access is essential should be protected against the 1:100 year return period.

Approximate greenfield run-off flow rates have been calculated using Micro Drainage software and used to estimate appropriate storage volumes required up to the 1:100 year return period in order to satisfy the Statutory Standards for SuDS.

5 GREENFIELD RAINFALL RUN-OFF

Calculations were derived using the ICP SuDS Mean Annual Flood method using Micro Drainage software and are shown in Appendix 1 of this Report.

The Development lies within Hydrological Region 9 of the UK.

A total of 0.29 ha of new hardstanding will be introduced and is assumed to be 100 % impervious in order to represent a 'worst-case' scenario. Hardstanding elements of the Development are displayed in Table 1.

Table 1: Areas of hardstanding to be installed during construction

Hardstanding Infrastructure	**Area of Hardstanding (m^2)**	**Area of Hardstanding (ha)**
Battery Storage Unit x 12	377	0.037
Inverter	89.3	0.008
Temporary Laydown Area	30.25	0.003
Switchgear Container	29.77	0.002
Main Control Room	1200	0.120
Coolers x 4	92.16	0.009
E-House	21.48	0.002
Diesel Generator	10	0.001
Building	799	0.079
Transformer and HV Infrastructure	485.84	0.048
Total Hardstanding:	**2900.25 m^2**	**0.290 (ha)**

The application of this approach leads to mean peak greenfield flow rates from the area to be developed for the 1-year, 30-year and 100-year return periods as well as Q_{BAR}, as shown in Table 2.

Table 2: Estimated Run-off Flow Rates (Q) for 1, 30 and 100-year return periods (taken from Micro Drainage)

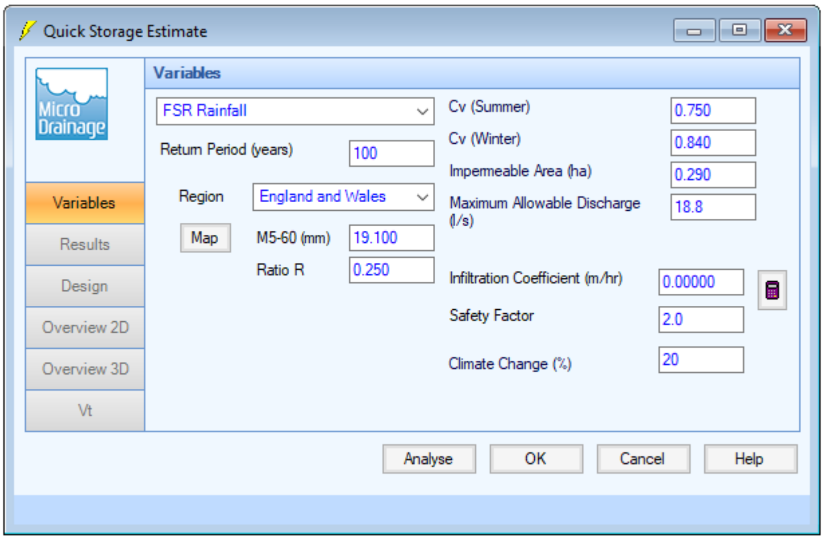
Return Period	**Q (l/s)**
1	16.2
Q_{BAR}	18.8
30	36
100	**47.3**

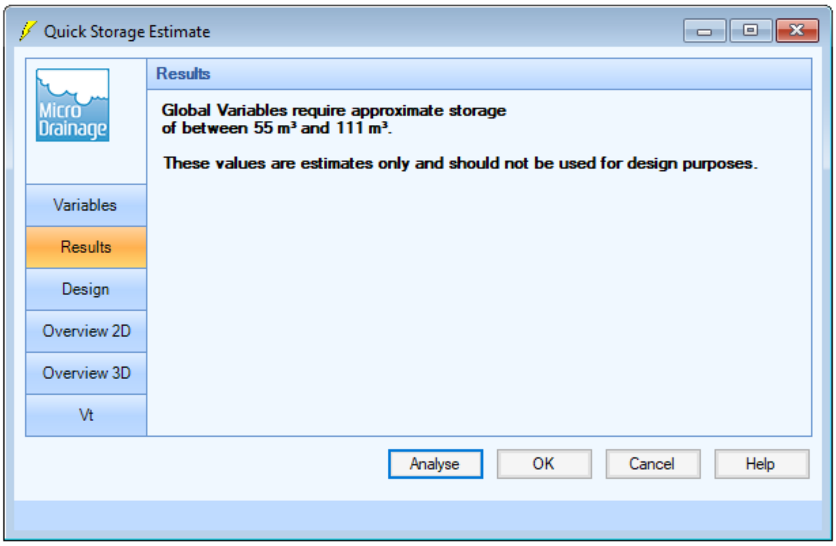
6 REQUIRED STORAGE VOLUMES AND IMPLEMENTATION

The temporary storage required to hold the increase in run-off from the Site is shown below for the 1:100 year return period, as calculated using Micro Drainage software.

Paragraph A2.8 of TAN 15 states that "*increases of peak flow of up to 20 % for a given return period could be experienced within 50 years*". Therefore, a 20 % increase in the rainfall during these events has been included to account for the potential effects of climate change over the operational life of the Development.

The overall storage required is shown in the following Micro Drainage calculations, based on 0.29 ha of new hardstanding.





In accordance with Paragraph A1.14 in Appendix 1 of TAN 15, it is proposed to provide storage for the 1:100 year return period run-off volumes, as the Development is classed as "Industrial and General Infrastructure", which should have a threshold frequency of flooding of 1 %, which equates to the 1:100 year event.

As such, approximately 80 m^3 of storage should be provided to attenuate the 1:100 year event.

7 SUDS MEASURES

7.1 Proposed Surface Water Drainage

The Llywodraeth Cymru 'Statutory Standards for SuDS' (2018) document prioritises the collection of surface water for use onsite (Level 1) unless one or more of the following exception criteria can be demonstrated:

a. There is no demand for non-potable water on the site;
b. The use of rainwater harvesting is not appropriate for the activities that take place on the site;
c. The conservation of water is not a priority for the area; or

d. The use of rainwater harvesting is not a viable/ cost-effective solution for managing surface water runoff on the site.

The Development will be unmanned, apart from ad hoc maintenance visits, and the Development will not have a need for a water source during the operational phase, meaning criteria a and b are fulfilled.

In the circumstance that Level 1 cannot be pursued, infiltration into the ground (Level 2) is to be prioritised unless one of the following criteria can be demonstrated:

a. The use of infiltration is not practicable due to the lack of permeability of the soil for disposing of runoff.
b. The use of infiltration drainage would result in a risk of instability through ground movement or subsidence.
c. The use of infiltration drainage would pose an unacceptable risk of pollution of groundwater or surface water bodies:
    i. As a result of existing contaminants on the site being mobilised; or
    ii. as a result of activities in the area draining to the infiltration device (for example an area where there is the storage or handling of chemicals or fuels); or
    iii. as a result of the sensitivity of the groundwater or surface waterbody;
d. The use of infiltration drainage would result in an unacceptable risk of flooding from groundwater.
e. The use of infiltration may cause ingress of flow into a combined sewer which might result in an increased risk of flooding or pollution on the site or downstream.

The electrically sensitive nature of the Development will require the drainage system not to flood in order to prevent any damage to the on-site infrastructure, which may impact the delivery of a vital resource.

Therefore, due to the existing slowly permeable wet soils and the sensitivity of the development it is proposed that additional run-off will be addressed under Level 3 – *Discharge of surface water into a surface water body.*

The minor drainage ditch which the surface water will discharge into is located immediately west of the Site and drains in a southerly direction, crossing over the proposed site access as shown in Plate 1. The minor drainage ditch discharges into the Afon Llan watercourse approximately 700 m south of the Site. The Afon Llan confluences with the Afon Lliw, which discharges into the River Loughor within Caerfryddin Bay.

7.2 Outline Surface Water Drainage Design

The ICP SuDS method in Micro Drainage gives a Q_{BAR} value of 18.8 l/s for an area of 2.49 ha, as demonstrated in Appendix 1.

The SuDS Manual and Sewers for Adoption states that surface water systems should be designed to accommodate the 1:30 year event (plus climate change) without surcharging and the Site should contain the 1:100 year surcharged event.

Based on the 1:100 year rainfall event, using Micro Drainage software, taking into account a 20 % increase in rainfall, in accordance with *Section 5.4.5* of Swansea City Council Strategic Flood Risk Assessment[14], the introduction of new hardstanding areas will require approximately 80 m^3 of storage, as calculated in the Source Control module of Micro Drainage.

This volume can be achieved by installing 80 m^3 of cellular storage under the access track in the southern section of the Development.

[14] Swansea City Council Strategic Flood Risk Assessment [Online] Available at: https://www.swansea.gov.uk/ldpsfca [Accessed 29/04/2020].

Approximately 300 mm cover will need to be provided between the Development area and the soffit of the crates.

In order to restrict discharge to greenfield rates, a Hydro-Brake (or other flow restricting device) should be placed on the outfall of the pipe.

Outline design parameters have been validated for a number of storm durations for the 1:100 year return period; these can be seen in Appendix 2 of this report.

Outputs from Micro Drainage show that the cellular storage will surcharge with manageable volumes during the 1:100 year event, plus 20 % for climate change.

Crates under the development area attenuate water levels with no flooded volume during the critical storm duration of the 60 min winter event for the 1:100-year return period (plus 20 % uplift for climate change) as displayed in the output table below.

Storm Event	Rain (mm/hr)	Time to Vol Peak (mins)	Max Water Level (m)	Max Depth (m)	Flooded Volume (m³)	Max Control (l/s)	Discharge Volume (m³)	Max Filtration (l/s)	Σ Max Outflow (l/s)	Maximum Volume (m³)	Status
8640 min Summer	1.492	4328	0.071	0.071	0.0	3.6	467.2	0.0	3.6	5.4	O K
10080 min Summer	1.340	5080	0.067	0.067	0.0	3.2	489.7	0.0	3.2	5.1	O K
15 min Winter	95.502	21	0.553	0.553	0.0	18.6	58.1	0.0	18.6	42.0	O K
30 min Winter	67.976	33	0.759	0.759	0.0	18.6	82.7	0.0	18.6	57.7	O K
60 min Winter	46.349	54	0.898	0.898	0.0	18.6	112.9	0.0	18.6	68.2	O K
120 min Winter	30.352	92	0.893	0.893	0.0	18.6	147.8	0.0	18.6	67.9	O K
180 min Winter	23.161	128	0.768	0.768	0.0	18.6	169.2	0.0	18.6	58.3	O K

A schematic drawing of the proposed surface water layout is provided in Appendix 2 of this report.

7.2.1 Responsibilities and Long-Term Management

It will be the responsibility of the Development operator to maintain effective drainage measures and rectify drainage measures that are not functioning adequately. A nominated person will also have responsibility for reporting on the functionality of drainage measures.

Where impermeable areas remain through the lifetime of the Development, the SuDS measures serving these areas will be checked on a regular basis. Should drainage measures require dredging or unblocking, this will be undertaken as soon as practicable by a local contractor engaged by the management company.

A maintenance schedule will be undertaken by the appointed management company, as outlined in Table 3.

Table 3: Long-term Maintenance schedule for the Attenuation Tank[15]

Maintenance schedule	Required action	Typical frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action	Monthly for 3 months, then annually
	Remove debris from the catchment surface (where it may cause risks to performance)	Monthly

[15] **Based on Table 21.3 - Operation and maintenance requirements for attenuation storage tanks of the SuDS Manual**

Maintenance schedule	Required action	Typical frequency
	For systems where rainfall infiltrates into the tank from above, check surface of filter for blockage by sediment, algae or other matter; remove and replace surface infiltration medium as necessary	Annually
	Remove sediment from pre-treatment structures and/ or internal forebays	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlet, overflows and vents	As required
Monitoring	Inspect/check all inlets, outlets, vents and overflows to ensure that they are in good condition and operating as designed	Annually
	Survey inside of tank for sediment build-up and remove if necessary	Every 5 years or as required

7.2.2 Timescales

Drainage measures outlined within this report should be implemented as soon as practical by the Developer's Contractor but in any event before the construction of any impermeable surfaces which are proposed to drain into the approved drainage system. Measures such as drainage pipes should be installed at the same time as the excavations, or as soon as practicable thereafter.

7.3 Foul Water Drainage

During construction of the Development foul water will be disposed of via 'Port-a-loo' type facilities and disposed of via a licenced waste carrier.

During the operational phase the Development is to be primarily unmanned, with ad-hoc maintenance checks being the only time in which the Site will accommodate staff. As such there will be no foul water discharge from the Site and no foul water drainage systems are deemed necessary.

8 CONCLUSION

All new infrastructure at the Development is located in areas classed as Flood Zone A in TAN 15 and therefore the risk of on-site flooding is negligible.

Following the application of MicroDrainage software this report demonstrates that the implementation of cellular storage beneath the Development, with a flow restriction device to restrict discharge rates, will attenuate the 1:100 year event plus a 20% allowance for climate change.

Following implementation of the proposed mitigation measures, the introduction of hard-standing associated with the Development will not lead to an increase in discharge rates from the site above greenfield levels, for the 1:100 year return period. The residual effect of the Development on surface water run-off and consequent off-site flood risk is, therefore, considered to be negligible.

For lower return periods, the implemented mitigation measures will act to reduce any effects of run-off from the site in the wider catchment relative to the greenfield levels and therefore provide a beneficial effect.

This report has been written to meet the requirements of NRW, TAN 15, and Llywodraeth Cymru 'Interim Non-Statutory Standards for SuDS'.

The Developer will apply for SAB approval alongside planning approval.

APPENDIX 1 – MICRO DRAINAGE CALCULATIONS

Summary of Results for 100 year Return Period (+20%)

Half Drain Time : 32 minutes.

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
15 min Summer	0.564	0.564	0.0	18.6	18.6	36.2	O K
30 min Summer	0.774	0.774	0.0	18.6	18.6	49.6	O K
60 min Summer	0.910	0.910	0.0	18.6	18.6	58.4	Flood Risk
120 min Summer	0.929	0.929	0.0	18.6	18.6	59.6	Flood Risk
180 min Summer	0.860	0.860	0.0	18.6	18.6	55.1	O K
240 min Summer	0.756	0.756	0.0	18.6	18.6	48.5	O K
360 min Summer	0.568	0.568	0.0	18.6	18.6	36.4	O K
480 min Summer	0.420	0.420	0.0	18.6	18.6	26.9	O K
600 min Summer	0.317	0.317	0.0	18.5	18.5	20.3	O K
720 min Summer	0.249	0.249	0.0	18.1	18.1	16.0	O K
960 min Summer	0.189	0.189	0.0	16.5	16.5	12.1	O K
1440 min Summer	0.151	0.151	0.0	12.7	12.7	9.7	O K
2160 min Summer	0.125	0.125	0.0	9.6	9.6	8.0	O K
2880 min Summer	0.110	0.110	0.0	7.8	7.8	7.0	O K
4320 min Summer	0.093	0.093	0.0	5.8	5.8	5.9	O K
5760 min Summer	0.083	0.083	0.0	4.7	4.7	5.3	O K
7200 min Summer	0.076	0.076	0.0	4.0	4.0	4.8	O K
8640 min Summer	0.071	0.071	0.0	3.6	3.6	4.5	O K
10080 min Summer	0.067	0.067	0.0	3.2	3.2	4.3	O K
15 min Winter	0.649	0.649	0.0	18.6	18.6	41.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
15 min Summer	95.502	0.0	51.9	21
30 min Summer	67.976	0.0	73.9	32
60 min Summer	46.349	0.0	100.8	50
120 min Summer	30.352	0.0	132.0	86
180 min Summer	23.161	0.0	151.1	120
240 min Summer	19.043	0.0	165.6	152
360 min Summer	14.423	0.0	188.2	214
480 min Summer	11.813	0.0	205.5	270
600 min Summer	10.105	0.0	219.8	326
720 min Summer	8.887	0.0	231.9	382
960 min Summer	7.245	0.0	252.1	494
1440 min Summer	5.415	0.0	282.6	736
2160 min Summer	4.032	0.0	315.7	1096
2880 min Summer	3.273	0.0	341.7	1448
4320 min Summer	2.443	0.0	382.5	2180
5760 min Summer	1.987	0.0	414.9	2904
7200 min Summer	1.696	0.0	442.6	3648
8640 min Summer	1.492	0.0	467.2	4368
10080 min Summer	1.340	0.0	489.7	5024
15 min Winter	95.502	0.0	58.1	22

Summary of Results for 100 year Return Period (+20%)

Storm Event	Max Level (m)	Max Depth (m)	Max Infiltration (l/s)	Max Control (l/s)	Max Σ Outflow (l/s)	Max Volume (m³)	Status
30 min Winter	0.898	0.898	0.0	18.6	18.6	57.6	O K
60 min Winter	1.041	1.041	0.0	18.6	18.6	66.8	Flood Risk
120 min Winter	1.028	1.028	0.0	18.6	18.6	65.9	Flood Risk
180 min Winter	0.903	0.903	0.0	18.6	18.6	57.9	Flood Risk
240 min Winter	0.723	0.723	0.0	18.6	18.6	46.4	O K
360 min Winter	0.433	0.433	0.0	18.6	18.6	27.8	O K
480 min Winter	0.263	0.263	0.0	18.2	18.2	16.8	O K
600 min Winter	0.194	0.194	0.0	17.0	17.0	12.5	O K
720 min Winter	0.173	0.173	0.0	15.0	15.0	11.1	O K
960 min Winter	0.148	0.148	0.0	12.3	12.3	9.5	O K
1440 min Winter	0.122	0.122	0.0	9.3	9.3	7.8	O K
2160 min Winter	0.103	0.103	0.0	6.9	6.9	6.6	O K
2880 min Winter	0.091	0.091	0.0	5.6	5.6	5.8	O K
4320 min Winter	0.077	0.077	0.0	4.2	4.2	4.9	O K
5760 min Winter	0.069	0.069	0.0	3.4	3.4	4.4	O K
7200 min Winter	0.063	0.063	0.0	2.9	2.9	4.1	O K
8640 min Winter	0.059	0.059	0.0	2.6	2.6	3.8	O K
10080 min Winter	0.056	0.056	0.0	2.3	2.3	3.6	O K

Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)
30 min Winter	67.976	0.0	82.7	33
60 min Winter	46.349	0.0	112.9	54
120 min Winter	30.352	0.0	147.9	92
180 min Winter	23.161	0.0	169.2	130
240 min Winter	19.043	0.0	185.5	162
360 min Winter	14.423	0.0	210.8	220
480 min Winter	11.813	0.0	230.2	270
600 min Winter	10.105	0.0	246.1	316
720 min Winter	8.887	0.0	259.8	376
960 min Winter	7.245	0.0	282.4	494
1440 min Winter	5.415	0.0	316.5	736
2160 min Winter	4.032	0.0	353.6	1104
2880 min Winter	3.273	0.0	382.7	1472
4320 min Winter	2.443	0.0	428.4	2180
5760 min Winter	1.987	0.0	464.7	2872
7200 min Winter	1.696	0.0	495.7	3608
8640 min Winter	1.492	0.0	523.3	4288
10080 min Winter	1.340	0.0	548.5	5136

Model Details

Storage is Online Cover Level (m) 1.200

Cellular Storage Structure

Invert Level (m) 0.000 Safety Factor 2.0
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m²)	Inf. Area (m²)	Depth (m)	Area (m²)	Inf. Area (m²)
0.000	67.5	67.5	1.300	0.0	107.1
1.200	67.5	107.1			

Hydro-Brake Optimum® Outflow Control

Unit Reference	MD-SHE-0190-1880-1200-1880
Design Head (m)	1.200
Design Flow (l/s)	18.8
Flush-Flo™	Calculated
Objective	Minimise upstream storage
Diameter (mm)	190
Invert Level (m)	0.000
Minimum Outlet Pipe Diameter (mm)	225
Suggested Manhole Diameter (mm)	1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	18.7
Flush-Flo™	0.376	18.6
Kick-Flo®	0.822	15.6
Mean Flow over Head Range	-	15.9

The hydrological calculations have been based on the Head/Discharge relationship for the Hydro-Brake Optimum® as specified. Should another type of control device other than a Hydro-Brake Optimum® be utilised then these storage routing calculations will be invalidated

Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)	Depth (m)	Flow (l/s)
0.100	6.6	1.200	18.7	3.000	28.9	7.000	43.5
0.200	17.4	1.400	20.1	3.500	31.2	7.500	45.0
0.300	18.4	1.600	21.4	4.000	33.2	8.000	46.4
0.400	18.6	1.800	22.6	4.500	35.2	8.500	47.8
0.500	18.4	2.000	23.8	5.000	37.0	9.000	49.2
0.600	18.0	2.200	24.9	5.500	38.7	9.500	50.5
0.800	16.1	2.400	26.0	6.000	40.4		
1.000	17.1	2.600	27.0	6.500	42.0		

APPENDIX 2 – SURFACE WATER SCHEMATIC LAYOUT

Plot Date : 24 June 2020 09:23:22
File Name : P:\PROJECTS\3421 SWANSEA NORTH\CAD\01-WORKING\01_01-DRAWINGS\3421-DR-P-0016-P1

Project Title: SWANSEA NORTH ENERGY MANAGEMENT FACILITY	Drawing Title: PLANNING DRAWING 015 INDICATIVE DRAINAGE PLAN	Purpose of issue: PLANNING			
		Designed: -	Drawn: KB	Checked: DB	Approved: AM
		Arcus Internal Project No.: 3421		Date: 16/06/20	
Client: Statkraft		Scale @ A3: 1:1000			

Drawing Number	Rev
3421-DR-P-0016	1

Arcus Consultancy Services
7th Floor
144 West George Street
Glasgow, G2 2HG
Tel: +44 (0)141 221 9997
Fax: +44 (0)141 221 5610
www.arcusconsulting.co.uk

ARCUS