

ARMSTRONG STOKES & CLAYTON LIMITED

Civil & Structural Engineering Consultants



Avon Utilities & Generation

Planning Application for a Battery Storage Facility

**At Land East of
Cellarhead Substation
Rownall Road
Cheddleton
Staffordshire Moorlands**

Flood Risk Assessment & Drainage Strategy Report

December 2021

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REPORT REF:	AVON100 Battery Storage Facility, Rownall Road, Staffordshire Moorlands FRA Rev B
STATUS:	FINAL

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Registered in England No. 04960061

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1.0 INTRODUCTION

- 1.1 This Flood Risk Assessment (FRA) & Drainage Strategy Report has been produced by Armstrong Stokes and Clayton Limited on behalf of Avon Utilities & Generation in support of a proposed Battery storage facility on Land east of Cellarhead Substation, Rownall Road, Cheddleton, Staffordshire Moorlands, ST9 0BT.
- 1.2 This FRA has been prepared in accordance with the National Planning Policy Framework (NPPF) and the accompanying Planning Practice Guidance (PPG), and in consultation with Staffordshire County Council (SCC) Lead Local Flood Authority (LLFA), the Environment Agency, Severn Trent Water and Staffordshire Moorlands District Council.

2.0 PLANNING POLICY

National

- 2.1 The NPPF and PPG provide national planning guidance on the management of flood risk in respect to new development.
- 2.2 Paragraph 155 of the NPPF document states *'Inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk (whether existing or future). Where development is necessary in such areas, the development should be made safe for its lifetime without increasing flood risk elsewhere.'*
- 2.3 For the purposes of applying the NPPF, PPG states *'flood risk is a combination of the probability and the potential consequences of flooding from all sources – including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources'.*
- 2.4 For the purposes of applying the NPPF, PPG states *'areas at risk from all sources of flooding are included. For fluvial (river) and sea flooding, this is principally land within Flood Zones 2 and 3. It can also include an area within Flood Zone 1 which the Environment Agency has notified the local planning authority as having critical drainage problems'.*
- 2.5 PPG states that the key objectives of a site specific FRA is to establish;
- *whether a proposed development is likely to be affected by current or future flooding from any source;*
 - *whether it will increase flood risk elsewhere;*
 - *whether the measures proposed to deal with these effects and risks are appropriate;*
 - *the evidence for the local planning authority to apply (if necessary) the Sequential Test, and;*
 - *whether the development will be safe and pass the Exception Test, if applicable.*

- 2.6 PPG also refers to a FRA being appropriate to the scale, nature and location of the development and be credible and fit for purpose. A site specific FRA should always be proportionate to the degree of flood risk and make optimum use of information already available, including information in a SFRA for the area, and the interactive flood risk maps available on the Environment Agency's web site.

Local

- 2.7 A Level 1 Strategic Flood Risk Assessment (SFRA), covering the Staffordshire Moorlands District Council area, was published in October 2015. This document provides further, more local guidance in respect of flood risk. This FRA has been prepared with reference to the SFRA.

3.0 EXISTING SITE

General

- 3.1 The application site has a total gross area of approx. 5.85 ha and lies 190.0m to the east of the existing National Grid Cellarhead Substation. The site is situated to the northern extents of the hamlet of Rownall, which is 1.0 km to the west of the village of Wetley Rocks, and circa 3 km to the south-west of Cheddleton. The site falls within the Green Belt of Stoke-on-Trent, which to its outer suburbs, is located some 5.0 km to the west. The site falls under the jurisdiction of Staffordshire Moorlands District Council as planning authority and Staffordshire County Council (SCC) as the Lead Local Flood Authority (LLFA). An OS based location plan identifying the application site is included within **Appendix A**.
- 3.2 The site currently comprises of arable agricultural land and is bounded to the north, west and south by further agricultural land, with Rownall Road adjacent to the eastern boundary, where access to the site is gained.
- 3.3 For the purpose of this assessment the site is classified as Greenfield.

Levels

- 3.4 A topographical survey of the site, relative to OSBM, has not been undertaken, but from a visual inspection falls generally from west to east, and is within the general contour range of 240.0m AOD.

Drainage

- 3.5 With the application site being Greenfield, there is no positive foul or surface water drainage currently associated with the site.
- 3.6 There are no public sewers within the vicinity of the site, with the nearest public combined sewer located approx. 1 km to the east as highlighted in *Figure 1* below.

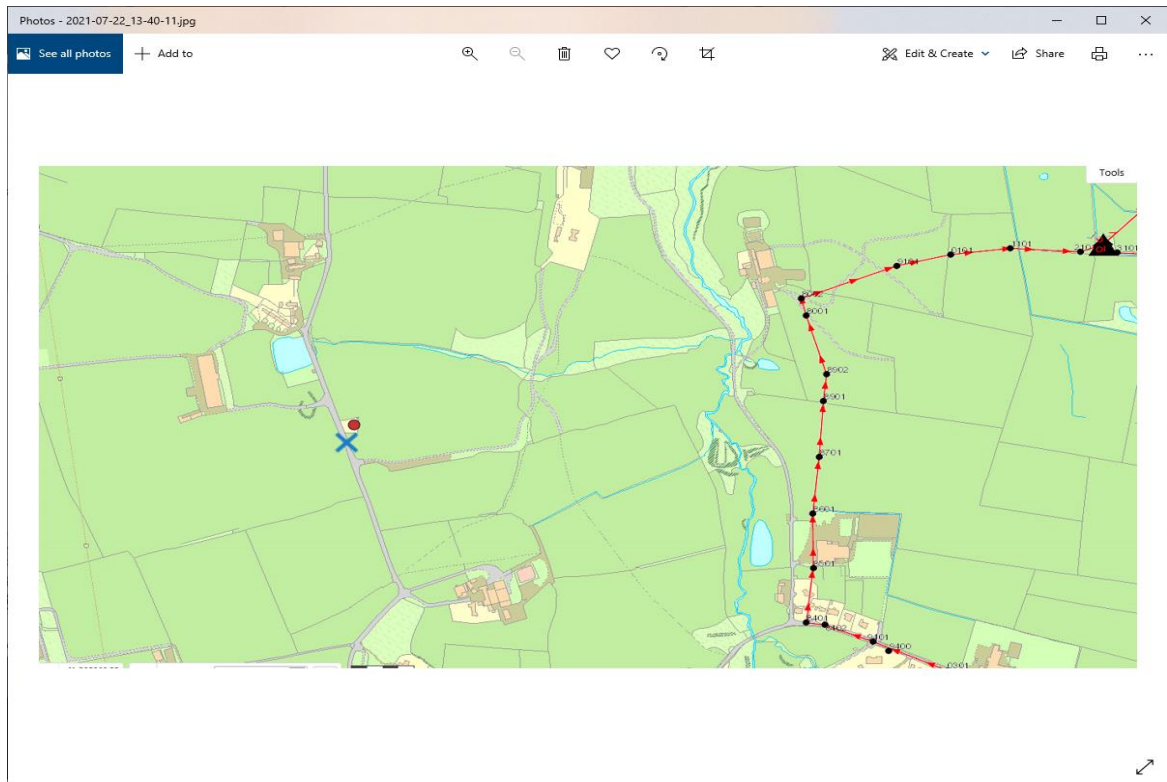


Figure 1 – Public Sewer Record Plan Extract

- 3.7 It is noted that road gullies are present in Rownall Road, situated to the east of the site near the entrance to Rownall Hall Farm, and adjacent to a small open channel watercourse, which they are likely to discharge highway run-off to.

4.0 POTENTIAL SOURCES OF FLOODING

Fluvial / Tidal Flooding

- 4.1 The nearest primary potential source of fluvial / tidal flooding is represented by the River Churnet and its tributaries. The River Churnet is classified as a 'Main River' and located circa 3.5 km to the east, with an 'Ordinary Watercourse' tributary also situated to the east, less than 1.0 km from the site. A further 'Ordinary Watercourse' is situated approx. 0.7 km to the west of the site, with further small issues in the locality feeding in to these respective watercourses.
- 4.2 An extract of the Environment Agency's on-line flood mapping is shown in Figure 1 below. The dark blue areas represent Flood Zone 3, land assessed as having a 1 in 100 or greater annual probability of river flooding ($>1\%$) or a 1 in 200 or greater annual probability of flooding from the sea ($>0.5\%$) in any year. The light blue areas represent Flood Zone 2, land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding ($1\% - 0.1\%$) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding ($0.5\% - 0.1\%$) in any year. All remaining areas are classified as Flood Zone 1, land assessed as having a less than 1 in 1000 annual probability of river or sea flooding ($<0.1\%$) in any year.
- 4.3 The application site is indicated on the flood mapping extract in *Figure 2*, confirming that it lies within Flood Zone 1.

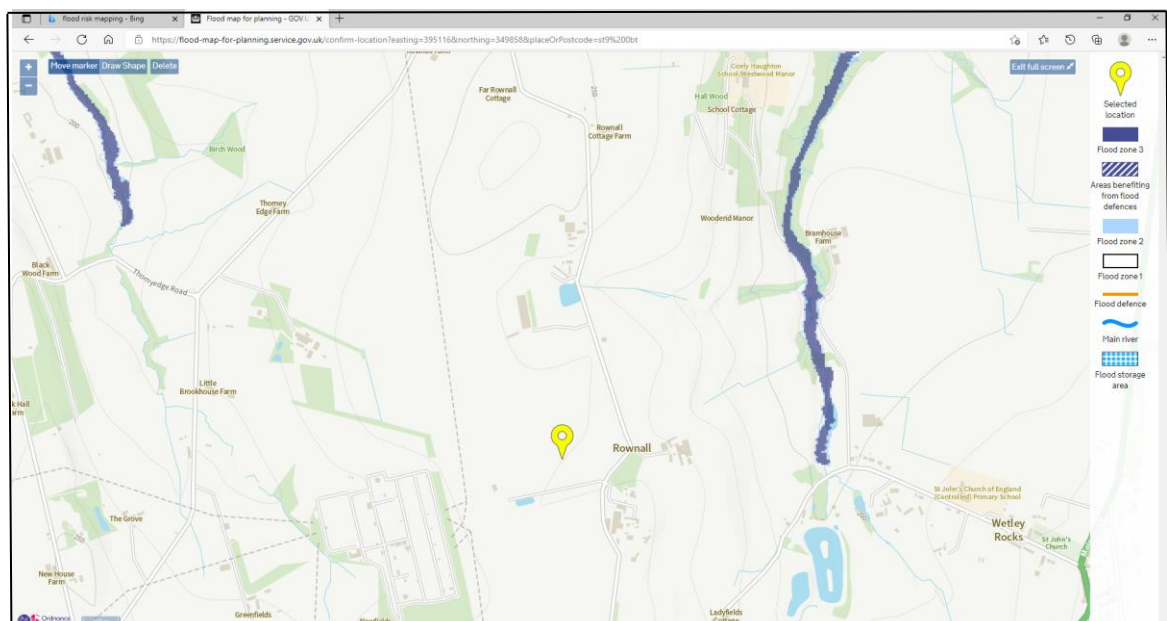


Figure 2 – Environment Agency Floodplain Mapping Extract

- 4.4 As the site is indicated as lying within Flood Zone 1, modelled flood level data has not been sourced from the Environment Agency.

Groundwater

- 4.5 Groundwater flooding is highly variable and dependant on localised ground conditions.
- 4.6 The SFRA does not identify any records of groundwater flooding and states that there is no evidence that groundwater flooding is a major problem within Staffordshire, and anticipates that any issues with flooding from this source would be on a local level. We are not aware of any anecdotal evidence to suggest that the site is susceptible to groundwater flooding.
- 4.7 The site is not located within an Environment Agency Groundwater Source Protection Zone (SPZ).

Overland / Surface Water Flows

- 4.8 We are not aware of any evidence to suggest that the site has ever been subject to flooding via this source.
- 4.9 The Environment Agency on-line surface water flood mapping illustrated within *Figure 3* below, indicates that the site is not susceptible to surface water flooding, whilst there is a low level surface water flow route along the line of an open channel to the south-east of the site.

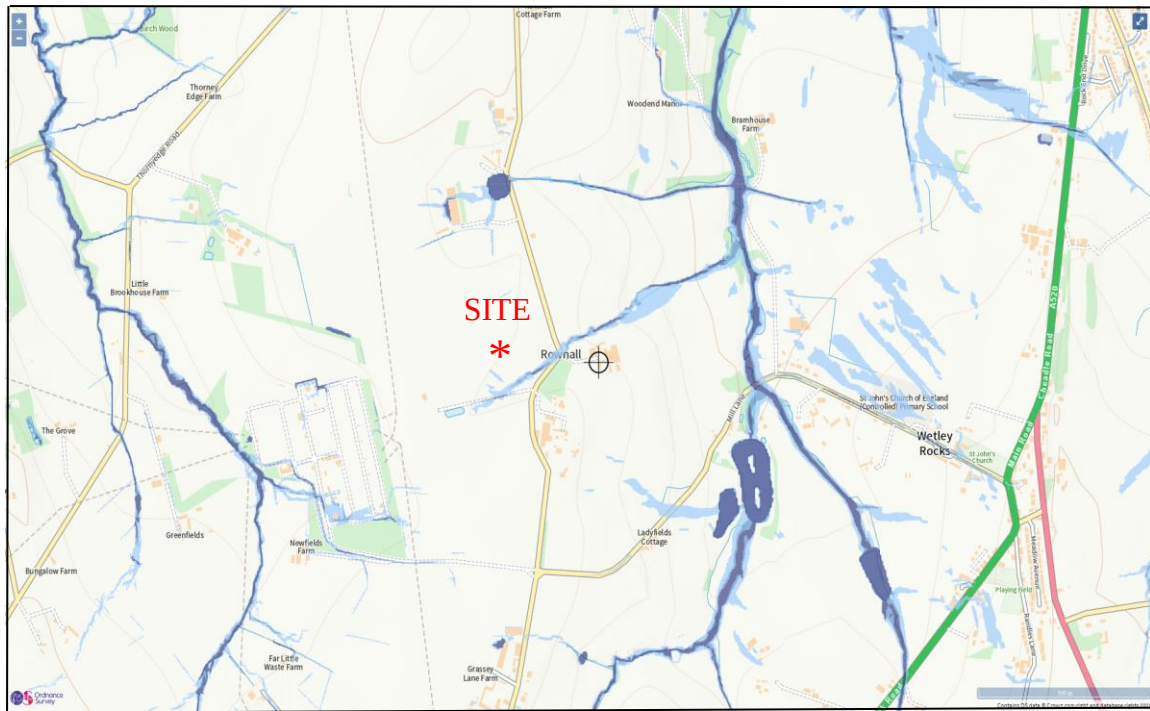


Figure 3 – Environment Agency Surface Water Mapping Extract

Existing Sewers

- 4.10 The SFRA does not identify that the development or surrounding area is at risk from sewer flooding.
- 4.11 We are not aware of any records or evidence to suggest that this site has ever been subject to flooding via this source.

Reservoirs, Canals & Other Artificial Sources

- 4.12 There are water bodies / lakes situated to the east and north-west of the site associated with Millbrook Fisheries and Stanley Pool, respectively. The Caldon Canal is situated further to the east and north. A small reservoir basin is located adjacent to the southern boundary of the site. None of these sources are considered to pose a flood risk to the application site, which in the case of Millbrook Fisheries, Stanley Pool and Caldon Canal are topographically on lower ground.

5.0 PROPOSED DEVELOPMENT

General

- 5.1 The planning application seeks the development of a proposed Battery storage facility, which will consist of 112 No. battery containers, with each container accompanied by an inverter and transformer unit. In addition, 2 No. switch rooms and a substation are located within the site. Access to the site is gained from Rownall Road.
- 5.2 The proposed scheme Planning Layout can be seen at **Appendix B**.

Levels

- 5.3 The proposed finished development levels have yet to be finalised, however, they will generally reflect the prevailing topography, with some localised raising and lowering of levels to facilitate suitable workable plateaus for level access and servicing.
- 5.4 The transformer element of the substation area will be set circa 2.0m below natural ground level for operational purposes. An elevation drawing illustrating the substation dimensions can be seen at **Appendix B**.

Foul Drainage

- 5.5 There is no foul drainage discharge associated with the development proposals.

Surface Water Drainage

- 5.6 A surface water drainage strategy that does not increase discharge levels and therefore does not increase the risk of flooding to other areas, should be provided in accordance with the National Planning Policy Framework (NPPF) document. Furthermore, the surface water drainage strategy should actively seek to reduce positive discharge levels via the use of SuDS wherever possible.

5.7 To establish the surface water strategy for the development, the following assessment of outfall options in line with the CIRIA C753 SuDS Manual has been undertaken, with the conclusions as follows:

- *Into the Ground (Infiltration)* – At the time of preparing this report there is no infiltration or geotechnical information available, however it is understood that the Cheddleton area is underlain by the Sherwood Sandstone group. In addition, in accordance with CIRIA C753 infiltration SuDS is the primary method for surface water disposal from new developments. With a Sherwood Sandstone formation the natural ground conditions should be suitable for the use of infiltration SuDS subject to porosity testing in accordance with BRE365.
- *To a Surface Water Body* – There is a small open channel watercourse to the south-east of the site, associated with the low level of surface water flows identified within *Figure 3* above. The topography of the site generally falls towards this open channel, thus its natural catchment, and therefore may be suitable to accept an equivalent Greenfield run-off from the development.
- *To a Surface Water Sewer, Highway Drain, or another Drainage System* – There is no known available surface water drainage system within the vicinity of the site.
- *To a Combined Sewer* – There is no known available combined sewer system within the vicinity of the site.

5.8 With consideration of the hierarchy above, and that the natural formation is likely to be underlain by Sherwood Sandstone, it is proposed to drain the site via infiltration SuDS, subject to the results of positive porosity testing and suitable infiltration rates in accordance with BRE365.

5.9 As the site is to be surfaced with a permeable gravel finish, infiltration will be through the surface layer, and to a secondary stone storage media situated below, prior to infiltration to the natural formation. The stone media will offer a

30% void content providing attenuation for storms up to and including the 100 year + 40% climate change event.

- 5.10 With the transformer unit being bedded at a level circa 2.0m below natural ground level, a drainage outlet will be required to the base slab. It is proposed to discharge any outlet, whether a gully or channel drain, to a granular pit soakaway, located a minimum of 5.0m from the substation area.
- 5.11 Following the BRE365 testing, if the results deem that infiltration SuDS is not feasible, an attenuation based sustainable surface water system is to be promoted, with a limited Greenfield equivalent discharge to the open channel watercourse to the south-east in accordance with the SuDS hierarchy. The remaining flows generated by the development will be attenuated on site for the 100 year + 40% climate change event, either within a storage media below the gravel surface course or in below ground cellular crates, all to be determined at the detailed design stage.
- 5.12 To assess the Greenfield (QBAR) discharge a calculation utilising ICP SUDS Mean Annual Flood method has been undertaken for a developable site area of 3.5 ha. Within **Appendix C** is the calculation output, which illustrates that the QBAR discharge equates to 20.6 l/s.
- 5.13 To assess the likely attenuation required for a limited QBAR discharge rate to the watercourse, preliminary calculations have been undertaken utilising the Micro Drainage software suite. This will determine the likely maximum size of attenuation structure required. A summary of the design criteria is as follows:
- Contributing Imp. Area – 3.5 ha
 - Design Event – 1 in 100 year (plus a 40% allowance for climate change)
 - Max. Discharge – 20.6 l/s (QBAR)
- 5.14 A copy of the calculation output is included within **Appendix C**. In summary, a total storage volume of approx. 2,270.4m³ will be required, which could be accommodated within a below ground structure with a plan area of 2,000m² at a depth of 1.2m. As an example the storage structure could consist of cellular crates, in total 200.0m long x 10.0m wide x 1.2m high. The final design will be

determined at the detailed design stage and only if infiltration SuDS is not available.

- 5.15 All exceedance flows are to be contained within the site boundary, without flooding third party land.
- 5.16 Whilst the site does not fall within a groundwater SPZ, the proposed surface water drainage system should be designed in accordance with all relevant Environment Agency Pollution Prevention Guidance (PPG). At the detailed design stage further details will be provided illustrating the proposed water quality enhancement measures which are to be incorporated within the final drainage proposals. These proposals should be in accordance with the CIRIA SuDS Manual Simple Index Approach and SuDS treatment design criteria.
- 5.17 The provision of a detailed drainage design could be secured by an appropriately worded planning condition.
- 5.18 A Management and Maintenance Plan is to be prepared to adequately manage the surface water drainage infrastructure, which is to include the future funding mechanism for the entire lifespan of the development. The provision of this plan is to be secured by an appropriately worded planning condition.

6.0 VULNERABILITY & COMPATIBILITY

General

- 6.1 In accordance with Table 2: Flood Risk Vulnerability Classification, contained within the PPG, industrial / energy generation is classified as a 'less vulnerable' development.
- 6.2 In accordance with Table 3: Flood Risk Vulnerability and Flood Zone 'Compatibility', contained within the PPG, 'less vulnerable' development is appropriate for location within Flood Zone 1.

Sequential Test

- 6.3 Paragraph 158 of the NPPF states *'The aim of the Sequential Test is to steer new development to areas with the lowest risk of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower risk of flooding. The SFRA will provide the basis for applying this test. The sequential approach should be used in areas known to be at risk now or in the future from any form of flooding.'*
- 6.4 In this instance, the site is considered to be sequentially acceptable as the proposed development will be located within Flood Zone 1.

Exception Test

- 6.5 In accordance with Table 3: Flood risk vulnerability and flood zone 'compatibility', contained within the PPG, the Exception Test is not required in this instance.
- 6.6 Whilst the Exception Test is not required, it should be noted that this FRA demonstrates that, in accordance with paragraphs 160 and 161 of the NPPF, the proposed development will be safe for its lifetime, taking account the vulnerability of its users. It also demonstrates that there will be no increase in flood risk to other areas.

7.0 ASSESSMENT OF FLOOD IMPACT

Fluvial / Tidal Flooding

- 7.1 The proposed development will be located within Flood Zone 1 and therefore at the lowest risk of fluvial / tidal flooding.
- 7.2 We are not aware of any historical records or anecdotal evidence to suggest that the site has been affected by flooding via this source.

Groundwater

- 7.3 No specific information relating to groundwater levels on the site is available; however, there is no evidence to suggest that the site is susceptible to groundwater flooding.
- 7.4 In the absence of any historical records or anecdotal evidence to suggest otherwise, the risk of groundwater flooding to the proposed development is therefore considered to be low.

Overland / Surface Water Flows

- 7.5 We are not aware of any records or anecdotal evidence to suggest that the development will be subject to flooding from overland / surface water flows.
- 7.6 The overall risk of overland / surface water flooding to the proposed development is therefore considered to be low.

Existing Sewers

- 7.7 We are not aware of any records or anecdotal evidence to suggest that the development will be subject to flooding resulting from deficiencies with any existing drainage networks.

- 7.8 The risk of flooding to the proposed development from this source is therefore considered to be low.

Proposed Drainage

- 7.9 The development proposals do not generate a foul flow discharge, thus there will be no increase in flood risk via this source.
- 7.10 An infiltration SuDS surface water drainage system will ensure no positive discharge of surface water from the development and therefore no increase in the risk of flooding to other areas via this source.
- 7.11 Should an attenuation SuDS based system be promoted in lieu of satisfactory infiltration rates, the restricted Greenfield equivalent discharge will ensure no increase in run-off from the pre-developed site in low order events, with a reduction in run-off in high order events.
- 7.12 Thus, it is considered that the risk of flooding to the development or other areas via this source is low.

Reservoirs, Canals & Other Artificial Sources

- 7.13 The risk of flooding from artificial sources within the vicinity of the site is considered low.

8.0 CONCLUSIONS & RECOMMENDATIONS

General

- 8.1 With consideration of all the information available, including that contained within the SFRA, the risk of flooding to the proposed development from all sources is considered to be low.
- 8.2 The drainage and flood risk strategy conforms to all the relevant national guidance.
- 8.3 Porosity testing to be undertaken in accordance with BRE365 at the detailed design stage.

Mitigation Measures

- 8.4 As the proposed development will be located within Flood Zone 1, it will not displace floodwater in the 1 in 100 year event. No floodwater storage mitigation measures are therefore proposed.
- 8.5 The implementation of a sustainable surface water drainage strategy, as outlined within Section 5 of this report, will ensure that there is no increase in flood risk to surrounding areas resulting from the disposal of surface water run-off in the post development scenario during lower order rainfall events and a reduction in flood risk in more extreme events.
- 8.6 Based on the current Environment Agency indicative flood mapping, it is evident that a safe dry route of access / egress in the 1 in 100 year event will be available from the development.

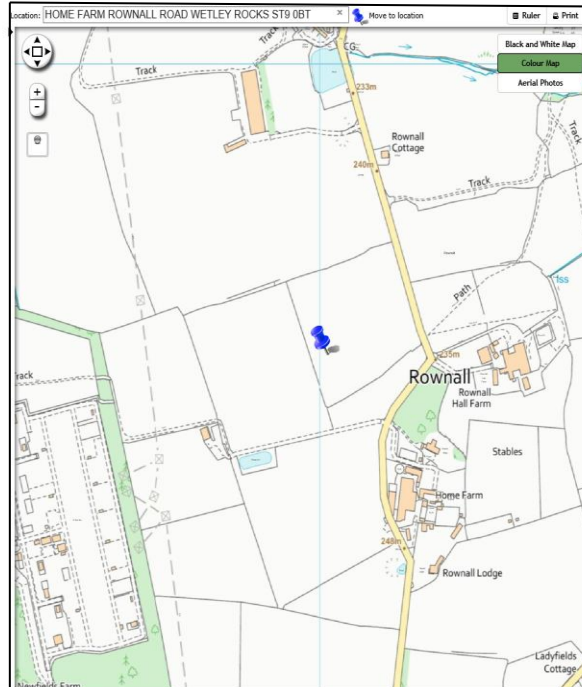
Residual Flood Risk

- 8.7 Whilst flood risk can never be entirely eliminated, it is considered that the residual flood risk to the development from all sources is low.

8.8 There will be no increase in the residual flood risk to other areas as a result of the development proposals.

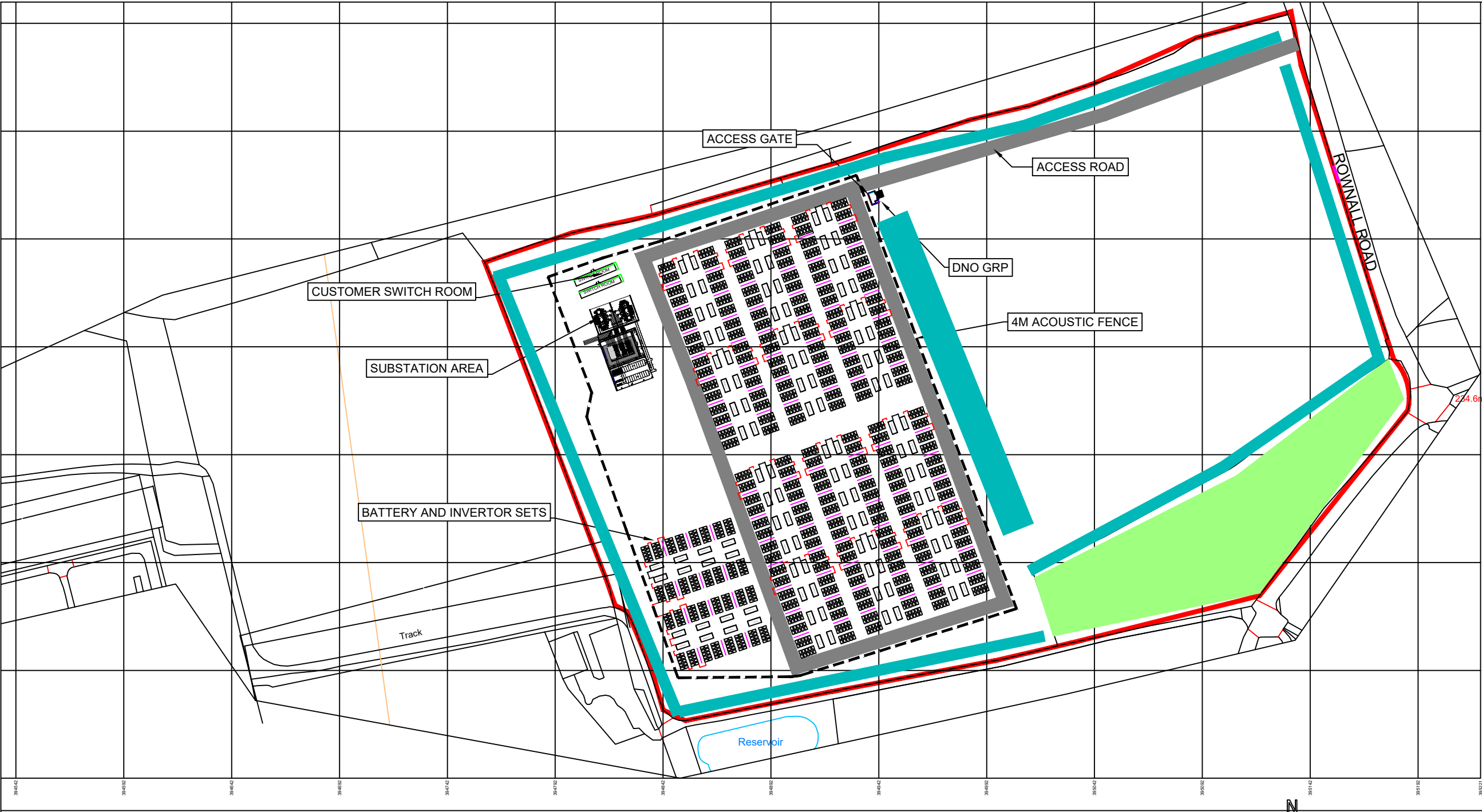
APPENDICES

APPENDIX A



LOCATION PLAN

APPENDIX B



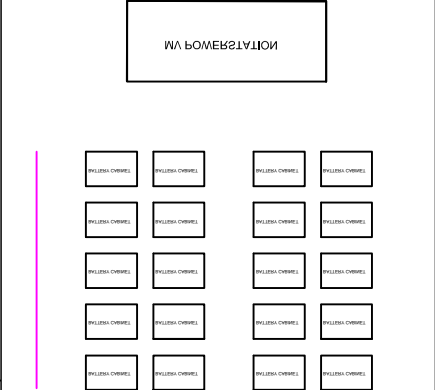
LEGEND

- SITE BOUNDARY
- - - 4M ACOUSTIC FENCE
- ACCESS ROUTE
- FUTURE BATTERY SETS
- NEW TREE PLANTING AREA
- EXISTING TREE LINE

EQUIPMENT DESCRIPTION

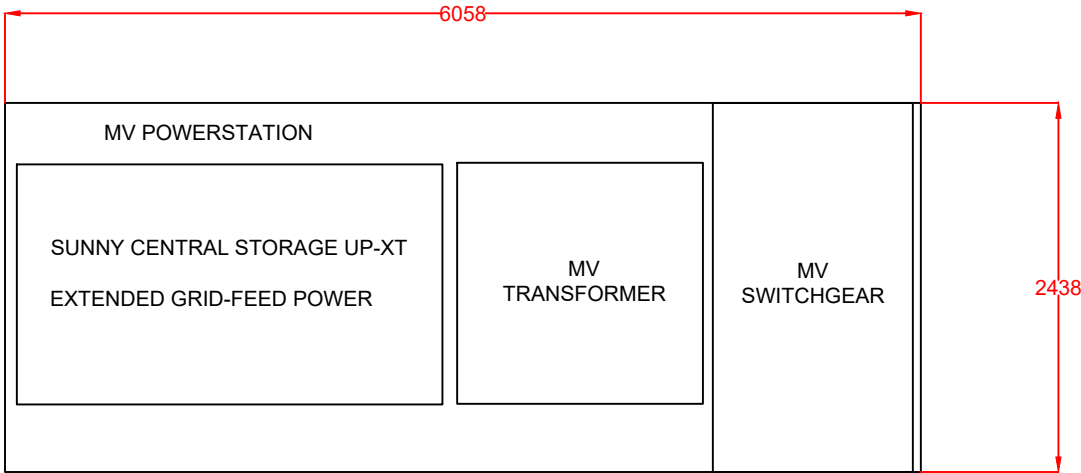
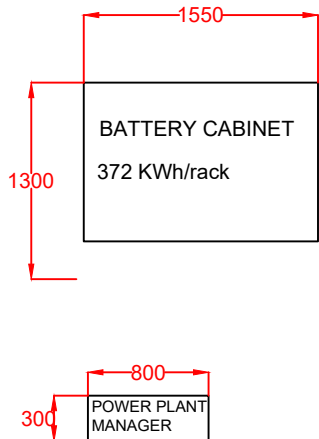
112 X 3.7MW/h 2h (829MWh from day 1)
SETS EACH CONSISTS OF:
2 X 10 BATTERY RACKS
1 MV POWERSTATION

SETS ARE 3M APART WITH
CONCRETE FIRE WALL
BETWEEN THEM.



34493 348542 394392 349498 394405 349413 394616 349461 394653 349407

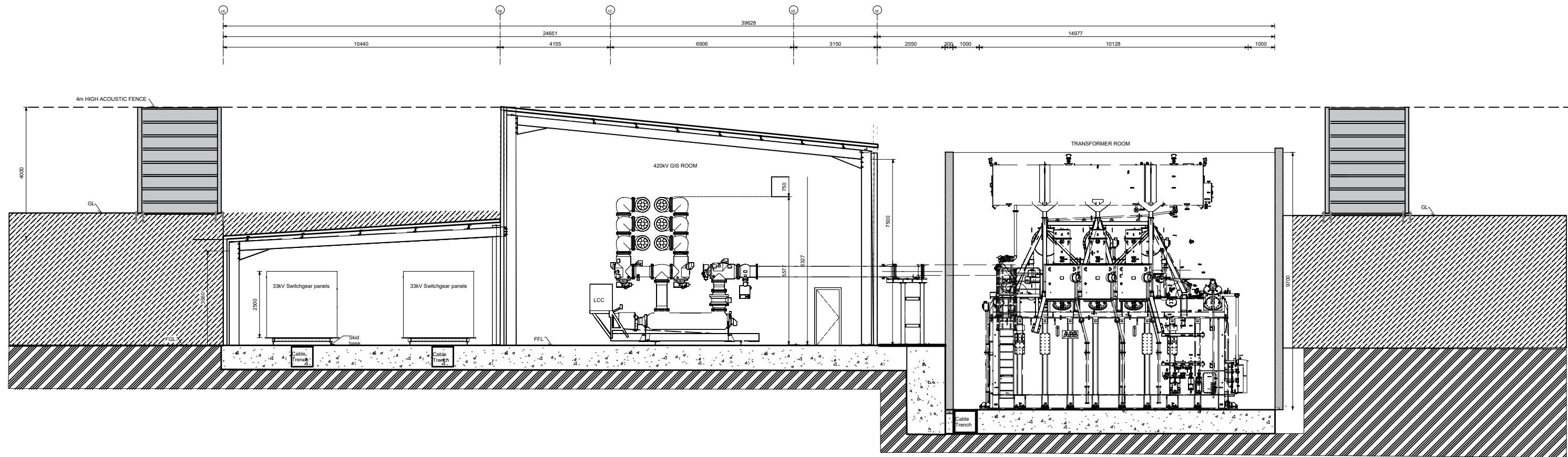
EQUIPMENT
SCALE 1:5- @A3



No	INFORMATION	By	Date	Chkd
J	SUBSTATION AREA ROTATED 180deg	MM	27.09.21	MJ
I	FENCE REDUCED TO 4M	MM	20.09.21	MJ
H	SUBSTATION DATA ADDED	MM	07.09.21	MJ
G	FENCE LOCATION UPDATED	MM	20.08.21	MJ
F	UPDATED	MM	15.08.21	MJ
E	SMA EQUIPMENT USED	MM	12.08.21	MJ
D	SUBSTATION AREA ADDED	MM	29.06.21	MJ
C	TREE BUND REMOVED	MM	23.06.21	MJ
B	TREE PLANTING ADDED AND STAND OFF AREA	MM	09.06.21	MJ
A	FIRST ISSUE	MM	05.06.21	MJ

REVISIONS			
PROJECT NUMBER CELLARHEAD BATTERY SITE			
CLIENT: C&S ENERGY LIMITED			
LOCATION: CELLARHEAD BATTERY SITE ROWNALL ROAD, CHEDDLETON, , STAFFORDSHIRE MOORLANDS, ST90BT			
DRAWING TITLE: SITE LAYOUT			
CAD REFERENCE: 00 CELLARHEAD-104			
SCALE: 1:2000 @ A3			SHEET: 1 OF 1
DRAWN BY: MM		DATE: 08.05.21	
CHECKED BY: MJ		DATE: 08.05.21	
AVON UTILITIES & GENERATION LIMITED UNIT 2 BIRD INDUSTRIAL PARK STATION ROAD STRATFORD-UPON-AVON CV37 8RP			

Avon Utilities and
Generation



SECTION VIEW

B	FENCE REDUCED TO 4m AND FFL LOWERED BY 1m	MM	20.09.21	MJ
A	FIRST ISSUE	MM	07.09.21	MJ
No	INFORMATION	By	Date	Chkd
REVISIONS				
PROJECT NUMBER CELLARHEAD BATTERY SITE				
CLIENT: C&S ENERGY LIMITED				
LOCATION: CELLERHEAD BATTERY SITE ROWNALL ROAD, CHEDDLETON, STAFFORDSHIRE MOORLANDS, ST90BT				
DRAWING TITLE: SUBSTATION- ELEVATION				
CAD REFERENCE: 00 CELLARHEAD-307				
SCALE: 1:150 @ A3			SHEET: 2 OF 2	
DRAWN BY: MM		DATE: 07.09.21		
CHECKED BY: MJ		DATE: 08.09.21		
AVON UTILITIES & GENERATION LIMITED UNIT 2 BIRD INDUSTRIAL PARK STATION ROAD STRATFORD-UPON-AVON CV37 8RP		Avon Utilities and Generation		

APPENDIX C

Armstrong Stokes & Clayton Ltd		Page 1
Regus House, Herald Way Pegasus Business Park Castle Donington, Derbyshir...	Battery Storage Facility Rownall Road Cheddleton	
Date 07/12/2021 File	Designed by JS Checked by	
Micro Drainage Source Control 2017.1.2		
<u>ICP SUDS Mean Annual Flood</u> Input Return Period (years) 2 Soil 0.450 Area (ha) 3.500 Urban 0.000 SAAR (mm) 900 Region Number Region 4 Results 1/s QBAR Rural 20.6 QBAR Urban 20.6 Q2 years 18.5 Q1 year 17.1 Q30 years 40.4 Q100 years 53.0		
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<u>Summary of Results for 100 year Return Period (+40%)</u> Half Drain Time : 941 minutes. <table><tr><th>Storm Event</th><th>Max Level (m)</th><th>Max Depth (m)</th><th>Max Infiltration (l/s)</th><th>Max Control (l/s)</th><th>Max Σ Outflow (l/s)</th><th>Max Volume (m³)</th><th>Status</th></tr><tr><td>15 min Summer</td><td>98.396</td><td>0.396</td><td>0.0</td><td>20.5</td><td>20.5</td><td>751.6</td><td>O K</td></tr><tr><td>30 min Summer</td><td>98.529</td><td>0.529</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1006.0</td><td>O K</td></tr><tr><td>60 min Summer</td><td>98.673</td><td>0.673</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1279.2</td><td>O K</td></tr><tr><td>120 min Summer</td><td>98.820</td><td>0.820</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1558.4</td><td>O K</td></tr><tr><td>180 min Summer</td><td>98.901</td><td>0.901</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1711.5</td><td>O K</td></tr><tr><td>240 min Summer</td><td>98.950</td><td>0.950</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1804.8</td><td>O K</td></tr><tr><td>360 min Summer</td><td>99.002</td><td>1.002</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1904.5</td><td>O K</td></tr><tr><td>480 min Summer</td><td>99.030</td><td>1.030</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1956.9</td><td>O K</td></tr><tr><td>600 min Summer</td><td>99.042</td><td>1.042</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1979.0</td><td>O K</td></tr><tr><td>720 min Summer</td><td>99.043</td><td>1.043</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1981.7</td><td>O K</td></tr><tr><td>960 min Summer</td><td>99.034</td><td>1.034</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1965.3</td><td>O K</td></tr><tr><td>1440 min Summer</td><td>99.006</td><td>1.006</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1911.8</td><td>O K</td></tr><tr><td>2160 min Summer</td><td>98.951</td><td>0.951</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1806.2</td><td>O K</td></tr><tr><td>2880 min Summer</td><td>98.888</td><td>0.888</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1687.4</td><td>O K</td></tr><tr><td>4320 min Summer</td><td>98.746</td><td>0.746</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1418.0</td><td>O K</td></tr><tr><td>5760 min Summer</td><td>98.620</td><td>0.620</td><td>0.0</td><td>20.5</td><td>20.5</td><td>1177.4</td><td>O K</td></tr><tr><td>7200 min Summer</td><td>98.512</td><td>0.512</td><td>0.0</td><td>20.5</td><td>20.5</td><td>973.1</td><td>O K</td></tr><tr><td>8640 min Summer</td><td>98.423</td><td>0.423</td><td>0.0</td><td>20.5</td><td>20.5</td><td>804.4</td><td>O K</td></tr><tr><td>10080 min Summer</td><td>98.354</td><td>0.354</td><td>0.0</td><td>20.5</td><td>20.5</td><td>672.1</td><td>O K</td></tr><tr><td>15 min Winter</td><td>98.444</td><td>0.444</td><td>0.0</td><td>20.5</td><td>20.5</td><td>843.6</td><td>O K</td></tr></table> <table><tr><th>Storm Event</th><th>Rain (mm/hr)</th><th>Flooded Volume (m³)</th><th>Discharge Volume (m³)</th><th>Time-Peak (mins)</th></tr><tr><td>15 min Summer</td><td>117.448</td><td>0.0</td><td>707.8</td><td>26</td></tr><tr><td>30 min Summer</td><td>79.010</td><td>0.0</td><td>959.9</td><td>41</td></tr><tr><td>60 min Summer</td><td>50.812</td><td>0.0</td><td>1298.9</td><td>70</td></tr><tr><td>120 min Summer</td><td>31.621</td><td>0.0</td><td>1619.3</td><td>130</td></tr><tr><td>180 min Summer</td><td>23.637</td><td>0.0</td><td>1815.5</td><td>188</td></tr><tr><td>240 min Summer</td><td>19.105</td><td>0.0</td><td>1955.6</td><td>248</td></tr><tr><td>360 min Summer</td><td>14.037</td><td>0.0</td><td>2152.4</td><td>366</td></tr><tr><td>480 min Summer</td><td>11.286</td><td>0.0</td><td>2303.1</td><td>484</td></tr><tr><td>600 min Summer</td><td>9.522</td><td>0.0</td><td>2423.2</td><td>602</td></tr><tr><td>720 min Summer</td><td>8.282</td><td>0.0</td><td>2522.3</td><td>720</td></tr><tr><td>960 min Summer</td><td>6.640</td><td>0.0</td><td>2676.0</td><td>830</td></tr><tr><td>1440 min Summer</td><td>4.854</td><td>0.0</td><td>2840.4</td><td>1084</td></tr><tr><td>2160 min Summer</td><td>3.541</td><td>0.0</td><td>3318.8</td><td>1492</td></tr><tr><td>2880 min Summer</td><td>2.828</td><td>0.0</td><td>3530.2</td><td>1908</td></tr><tr><td>4320 min Summer</td><td>2.055</td><td>0.0</td><td>3838.2</td><td>2688</td></tr><tr><td>5760 min Summer</td><td>1.637</td><td>0.0</td><td>4113.2</td><td>3456</td></tr><tr><td>7200 min Summer</td><td>1.371</td><td>0.0</td><td>4303.5</td><td>4176</td></tr><tr><td>8640 min Summer</td><td>1.186</td><td>0.0</td><td>4460.3</td><td>4848</td></tr><tr><td>10080 min Summer</td><td>1.049</td><td>0.0</td><td>4591.1</td><td>5544</td></tr><tr><td>15 min Winter</td><td>117.448</td><td>0.0</td><td>796.1</td><td>26</td></tr></table>								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	98.396	0.396	0.0	20.5	20.5	751.6	O K	30 min Summer	98.529	0.529	0.0	20.5	20.5	1006.0	O K	60 min Summer	98.673	0.673	0.0	20.5	20.5	1279.2	O K	120 min Summer	98.820	0.820	0.0	20.5	20.5	1558.4	O K	180 min Summer	98.901	0.901	0.0	20.5	20.5	1711.5	O K	240 min Summer	98.950	0.950	0.0	20.5	20.5	1804.8	O K	360 min Summer	99.002	1.002	0.0	20.5	20.5	1904.5	O K	480 min Summer	99.030	1.030	0.0	20.5	20.5	1956.9	O K	600 min Summer	99.042	1.042	0.0	20.5	20.5	1979.0	O K	720 min Summer	99.043	1.043	0.0	20.5	20.5	1981.7	O K	960 min Summer	99.034	1.034	0.0	20.5	20.5	1965.3	O K	1440 min Summer	99.006	1.006	0.0	20.5	20.5	1911.8	O K	2160 min Summer	98.951	0.951	0.0	20.5	20.5	1806.2	O K	2880 min Summer	98.888	0.888	0.0	20.5	20.5	1687.4	O K	4320 min Summer	98.746	0.746	0.0	20.5	20.5	1418.0	O K	5760 min Summer	98.620	0.620	0.0	20.5	20.5	1177.4	O K	7200 min Summer	98.512	0.512	0.0	20.5	20.5	973.1	O K	8640 min Summer	98.423	0.423	0.0	20.5	20.5	804.4	O K	10080 min Summer	98.354	0.354	0.0	20.5	20.5	672.1	O K	15 min Winter	98.444	0.444	0.0	20.5	20.5	843.6	O K	Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)	15 min Summer	117.448	0.0	707.8	26	30 min Summer	79.010	0.0	959.9	41	60 min Summer	50.812	0.0	1298.9	70	120 min Summer	31.621	0.0	1619.3	130	180 min Summer	23.637	0.0	1815.5	188	240 min Summer	19.105	0.0	1955.6	248	360 min Summer	14.037	0.0	2152.4	366	480 min Summer	11.286	0.0	2303.1	484	600 min Summer	9.522	0.0	2423.2	602	720 min Summer	8.282	0.0	2522.3	720	960 min Summer	6.640	0.0	2676.0	830	1440 min Summer	4.854	0.0	2840.4	1084	2160 min Summer	3.541	0.0	3318.8	1492	2880 min Summer	2.828	0.0	3530.2	1908	4320 min Summer	2.055	0.0	3838.2	2688	5760 min Summer	1.637	0.0	4113.2	3456	7200 min Summer	1.371	0.0	4303.5	4176	8640 min Summer	1.186	0.0	4460.3	4848	10080 min Summer	1.049	0.0	4591.1	5544	15 min Winter	117.448	0.0	796.1	26
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																																																																																																																																																																																																																																																																																	
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Armstrong Stokes & Clayton Ltd						Page 2	
Regus House, Herald Way Pegasus Business Park Castle Donington, Derbyshir...			Battery Storage Facility Rownall Road Cheddleton				
Date 07/12/2021 File POND.SRCX			Designed by JS Checked by				
Micro Drainage				Source Control 2017.1.2			
<u>Summary of Results for 100 year Return Period (+40%)</u>							
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	98.595	0.595	0.0	20.5	20.5	1130.1	O K
60 min Winter	98.757	0.757	0.0	20.5	20.5	1438.6	O K
120 min Winter	98.924	0.924	0.0	20.5	20.5	1756.2	O K
180 min Winter	99.015	1.015	0.0	20.5	20.5	1929.2	O K
240 min Winter	99.072	1.072	0.0	20.5	20.5	2037.1	O K
360 min Winter	99.135	1.135	0.0	20.5	20.5	2156.8	O K
480 min Winter	99.171	1.171	0.0	20.5	20.5	2224.0	O K
600 min Winter	99.188	1.188	0.0	20.5	20.5	2257.8	O K
720 min Winter	99.195	1.195	0.0	20.5	20.5	2270.4	O K
960 min Winter	99.188	1.188	0.0	20.5	20.5	2257.0	O K
1440 min Winter	99.147	1.147	0.0	20.5	20.5	2178.9	O K
2160 min Winter	99.071	1.071	0.0	20.5	20.5	2034.4	O K
2880 min Winter	98.981	0.981	0.0	20.5	20.5	1863.9	O K
4320 min Winter	98.771	0.771	0.0	20.5	20.5	1465.1	O K
5760 min Winter	98.573	0.573	0.0	20.5	20.5	1089.2	O K
7200 min Winter	98.419	0.419	0.0	20.5	20.5	796.5	O K
8640 min Winter	98.309	0.309	0.0	20.4	20.4	587.1	O K
10080 min Winter	98.238	0.238	0.0	19.8	19.8	452.9	O K
Storm Event	Rain (mm/hr)	Flooded Volume (m³)	Discharge Volume (m³)	Time-Peak (mins)			
30 min Winter	79.010	0.0	1075.5	40			
60 min Winter	50.812	0.0	1456.6	70			
120 min Winter	31.621	0.0	1814.0	128			
180 min Winter	23.637	0.0	2032.7	184			
240 min Winter	19.105	0.0	2188.6	242			
360 min Winter	14.037	0.0	2406.4	358			
480 min Winter	11.286	0.0	2571.8	472			
600 min Winter	9.522	0.0	2701.7	586			
720 min Winter	8.282	0.0	2806.3	696			
960 min Winter	6.640	0.0	2956.6	908			
1440 min Winter	4.854	0.0	3000.8	1138			
2160 min Winter	3.541	0.0	3717.6	1604			
2880 min Winter	2.828	0.0	3953.4	2072			
4320 min Winter	2.055	0.0	4296.9	2940			
5760 min Winter	1.637	0.0	4608.3	3640			
7200 min Winter	1.371	0.0	4822.0	4328			
8640 min Winter	1.186	0.0	4998.7	4936			
10080 min Winter	1.049	0.0	5148.4	5544			
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Regus House, Herald Way Pegasus Business Park Castle Donington, Derbyshir...	Battery Storage Facility Rownall Road Cheddleton	
Date 07/12/2021 File POND.SRCX	Designed by JS Checked by	
Micro Drainage Source Control 2017.1.2		

Model Details

Storage is Online Cover Level (m) 100.000

Cellular Storage Structure

Invert Level (m) 98.000 Safety Factor 1.5
Infiltration Coefficient Base (m/hr) 0.00000 Porosity 0.95
Infiltration Coefficient Side (m/hr) 0.00000

Depth (m)	Area (m ²)	Inf. Area (m ²)	Depth (m)	Area (m ²)	Inf. Area (m ²)
0.000	2000.0	2000.0	1.300	0.0	2288.0
1.200	2000.0	2288.0			

Hydro-Brake® Optimum Outflow Control

Unit Reference MD-SHE-0198-2060-1200-2060
Design Head (m) 1.200
Design Flow (l/s) 20.6
Flush-Flo™ Calculated
Objective Minimise upstream storage
Application Surface
Sump Available Yes
Diameter (mm) 198
Invert Level (m) 98.000
Minimum Outlet Pipe Diameter (mm) 225
Suggested Manhole Diameter (mm) 1500

Control Points	Head (m)	Flow (l/s)
Design Point (Calculated)	1.200	20.6
Flush-Flo™	0.379	20.5
Kick-Flo®	0.828	17.3
Mean Flow over Head Range	-	17.5

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	6.9	1.200	20.6	3.000	31.9	7.000	48.0
0.200	18.7	1.400	22.2	3.500	34.4	7.500	49.7
0.300	20.3	1.600	23.6	4.000	36.7	8.000	51.3
0.400	20.5	1.800	25.0	4.500	38.8	8.500	52.8
0.500	20.3	2.000	26.3	5.000	40.8	9.000	54.3
0.600	19.9	2.200	27.5	5.500	42.8	9.500	55.7
0.800	17.9	2.400	28.7	6.000	44.6		
1.000	18.9	2.600	29.8	6.500	46.4		

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