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Rush Wall Solar Park: Flood Consequence Assessment

A REPORT FOR BSR
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Document Control

Title

Rush Wall Solar Park: Flood Consequence Assessment

Client

British Solar Renewables
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1 Summary

1.1 PURPOSE

This flood consequences assessment is intended to accompany an application for planning permission to construct a solar park and associated supporting infrastructure at Redwick, Magor.

1.2 OVERVIEW

<table>
<tr><th colspan="6">Site characteristics</th></tr>
<tr><td>Location</td><td colspan="5">Redwick, Magor, NP26 3DX</td></tr>
<tr><td>NGR</td><td>ST 320 877 (approx. site centre)</td><td>Size (Ha)</td><td>105 (approx.)</td><td>Existing land use status</td><td>Agricultural</td></tr>
<tr><td>Development proposal</td><td colspan="5">Solar Park and associated infrastructure</td></tr>
<tr><th rowspan="2">Source of flooding</th><th colspan="3">Flood risk</th><th rowspan="2">Comments</th><th rowspan="2">Further investigation required?</th></tr>
<tr><th>Low</th><th>Medium</th><th>High</th></tr>
<tr><td>Rivers</td><td>✓</td><td></td><td></td><td>The site is not near a watercourse and is drained by reens</td><td>No</td></tr>
<tr><td>Sea</td><td></td><td>✓</td><td></td><td>The site is within flood zone 3 for tidal flooding but protected by substantial flood defences. Flood risk is low at present but will increase with climate change</td><td>No</td></tr>
<tr><td>Surface water</td><td>✓</td><td></td><td></td><td>The site is at very low risk of flooding from this source.</td><td>No</td></tr>
<tr><td>Groundwater</td><td>✓</td><td></td><td></td><td>The site is not on permeable deposits or an aquifer and flood risk from this source is considered to be low</td><td>No</td></tr>
<tr><td>Artificial sources</td><td>✓</td><td></td><td></td><td>The site is not mapped as being affected by reservoir failure. There are no other known significant bodies of water retained above natural ground level, above the site.</td><td>No</td></tr>
</table>

1.3 VULNERABILITY CLASS

A solar park is not classified by TAN15. Planning case law (for example; the 2018 decision to grant planning permission for the Gwent Farmers' Community Solar Scheme[1]) places solar parks into the same vulnerability class as commercial and industrial development – i.e. ***less vulnerable*** to flooding.

[1] The Planning Inspectorate Report 2018. The Developments of National Significance (Wales) Regulations 2016: Application by Gwent Farmers' Community Solar Scheme Ltd. Land on the Caldicot Levels to the south of Llanwern Steelworks Site APP/G6935/A/16/3150137

The site will not be occupied and the consequences of flooding in the extreme flood are minimal and unlikely to present a risk to people.

1.4 PROJECT LIFESPAN

Planning permission is sought for an operational period up to 2055 (30 years from an anticipated construction completion in 2025). This FCA therefore assesses flood risk to 2055. This FCA also considers a timeframe to 2065. This provides allowance for planning and construction delays and/ or an extended project lifetime and hence provides a conservative assessment.

2 Development Description and Location

2.1 PROPOSED DEVELOPMENT

It is proposed to develop a solar park at Redwick, Magor, NP26 3DX. The location of the site is shown in Figure 2.1, and the centre of the site is approximately at NGR ST 413 855. A proposed site plan is provided in Appendix B.

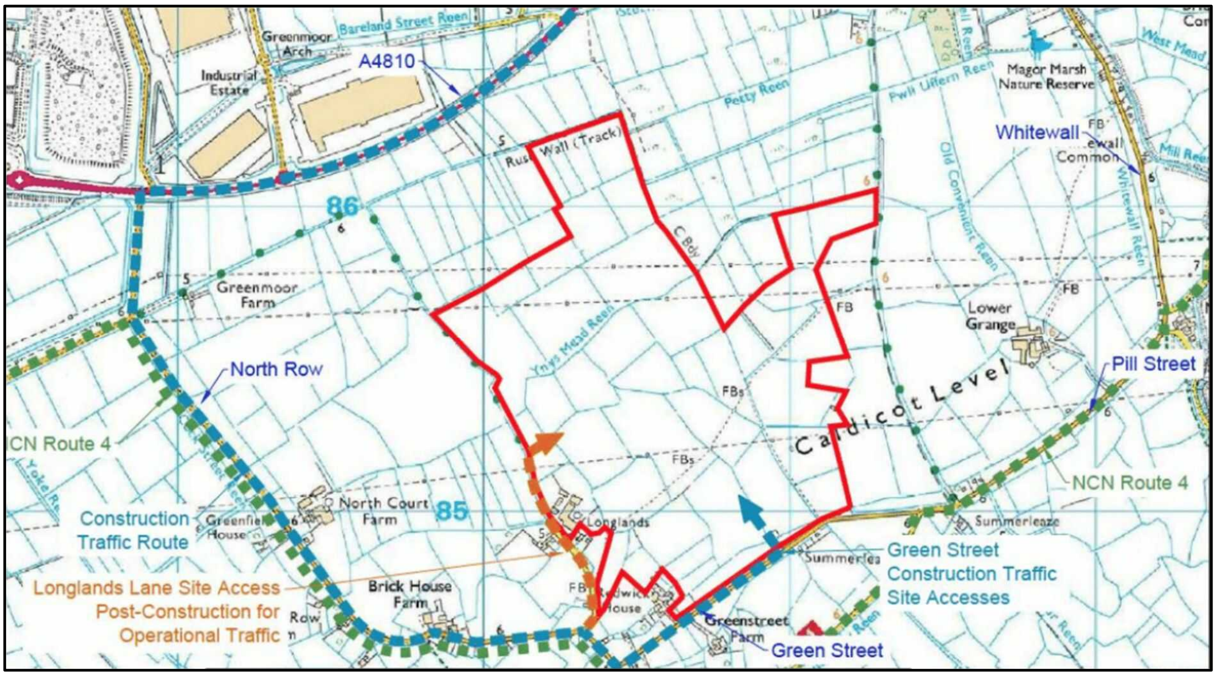

Figure 2.1 Site Location

The solar park would comprise:

- Solar photovoltaic (PV) panels, mounted on a railing sub structure;
- 442 string inverters;
- 43 associated transformers
- Compacted gravel tracks (constructed on a sub layer geogrid membrane) to allow vehicular access between fields;
- A substation access track with a cement based top layer (a statutory requirement of the electricity distribution network operator, Western Power Distribution (WPD));
- Fencing and gates to enclose the panels within each field as illustrated in Figure 2-14 (Drawing no. 1578-0205-01);
- Security and monitoring CCTV mounted on posts within each field, as in Figure 2-15 (Drawing no. 1578-0204-00);
- Welfare and spare parts containers;

- Underground cabling to connect the panels to the substation; and
- A substation within a security-fenced, concrete-based compound measuring approximately 50m x 40m, located at the centre of the site, adjacent to an existing pylon. A T-off connection (i.e. an overhead wire) would provide the point of connection from the substation to the existing 132kV pylon on site. A 10m high single pole communications antenna may be required at the substation.

With the exception of the electricity substation and the main DNO track into the central substation, the site will have no impermeable surfaces, and utilise gravel trackways. No drainage scheme is proposed and so off-site flooding will not be created or exacerbated by the proposal.

2.2 THE SITE

The site, comprising agricultural fields, extends to approximately 105.3 Ha and is currently grazing and cropland, part used for maize-growing, within the Redwick Parish and the Newport City Council local authority area. The Gwent Levels are a distinctive topographic zone comprising of a low-lying, flat and expansive coastal plain extending up to the Severn Estuary. Its elevation is typically between 5 - 6m AOD and generally below 10m AOD. The site is therefore essentially flat.

2.2.1 Existing surface water drainage

The fields on the site are bordered by drainage channels (called reens) or agricultural ditches. The farmland is drained by the reen system, within which water flows slowly towards the Severn Estuary.

The main reens on the site or adjacent to the site are the Ynys Mead Reen, Cockenten Reen, Longlands Reen, Blackwall West Reen and Rush Wall South Reen as shown in Figure 2.2. These are cleared annually by Natural Resources Wales (NRW) who therefore require access to these reens at all times in order to carry out this maintenance. The farm maintains the other reens on the site, mainly to remove vegetation (such as hedge trimmings).

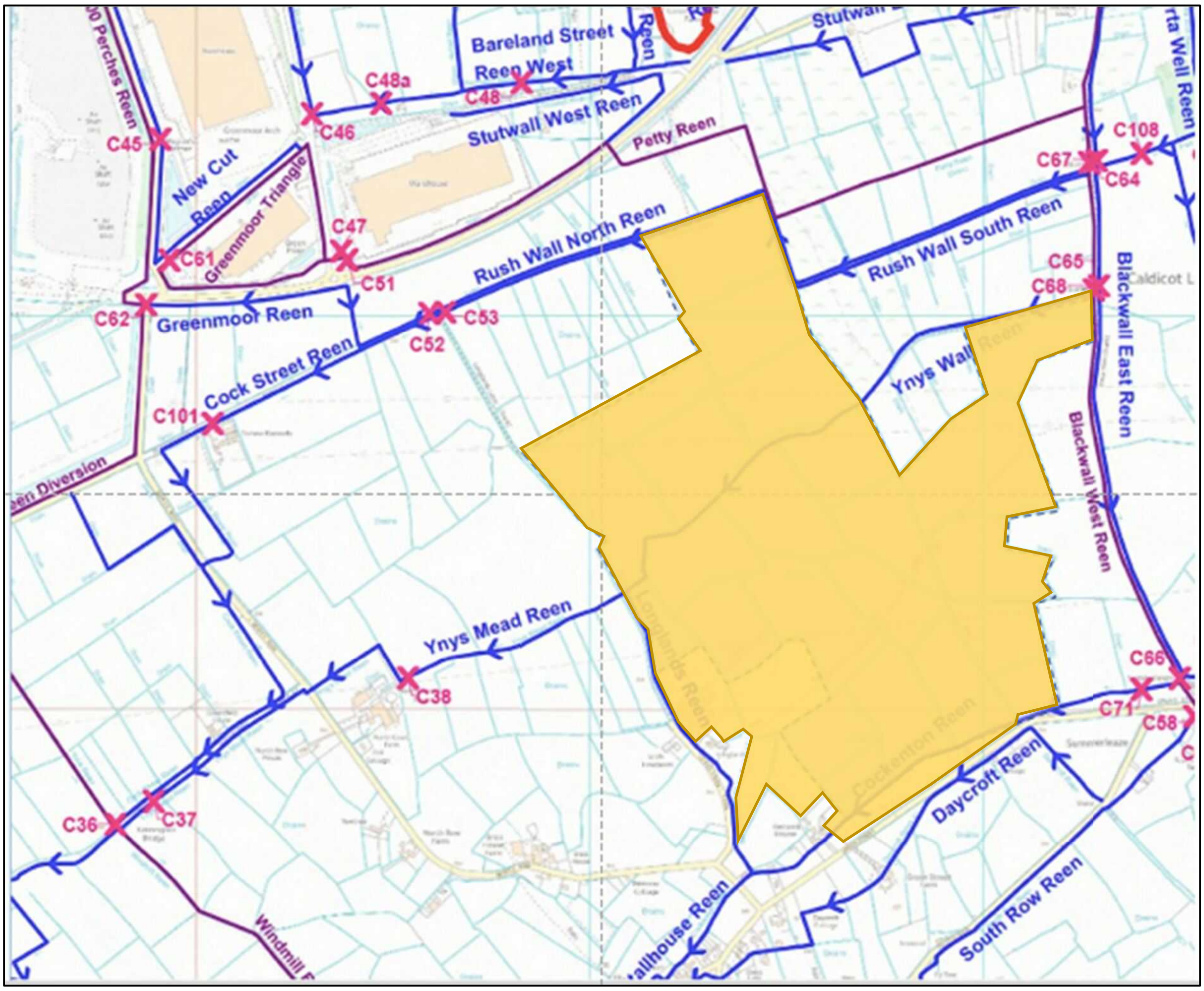

Figure 2.2 Reens managed by NRW in the locality of the Site

2.2.2 Geology

The site is underlain by the Mercia Mudstone Group, with Tidal Flat Deposits recorded at this location[2]. The soils are described as "Loamy and clayey soils of coastal flats with naturally high groundwater"[3].

Boreholes[4] in the locality have found clays and peats to around 11.0 m below ground level, lying on top of pebbles, gravel and sand which in turn are underlain by marls and bedrock.

2 BGS Geology of Britain viewer, http://mapapps.bgs.ac.uk/geologyofbritain/home.html

3 Soilscapes online soils viewer, Cranfield University, http://www.landis.org.uk/soilscapes

4 BGS ID 387060, at 341060,185250

3 Planning Policy

3.1 NATIONAL FLOOD POLICY

National policy on planning and flood risk is provided by Technical Advice Note 15 (TAN15)[5] which defines flood risk zones in Wales. Table 3.1 shows the definition of the flood zones used.

Table 3.1 Flood Zones (TAN15)

Description of Zone		Use within the precautionary framework
Considered to be at little or no risk of fluvial or tidal/coastal flooding.	A	Used to indicate that justification test is not applicable and no need to consider flood risk further.
Areas known to have been flooded in the past evidenced by sedimentary deposits.	B	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.
Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	C	Used to indicate that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences.
Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.	C1	Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.
Areas of the floodplain without significant flood defence infrastructure.	C2	Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.

Flood zones are published by Natural Resource Wales (NRW) in a Development Advice Map (DAM). Figure 3.1 shows an extract from the DAM for the Site and indicates that the site in is entirely in Zone C1. This indicates that the site is within a floodplain, but protected by flood defences.

Being in zone C1 means development may be acceptable, subject to a justification test and acceptability of the consequences of flooding.

[5] Planning Policy Wales Technical Advice Note 15: Development and Flood Risk. July 2004

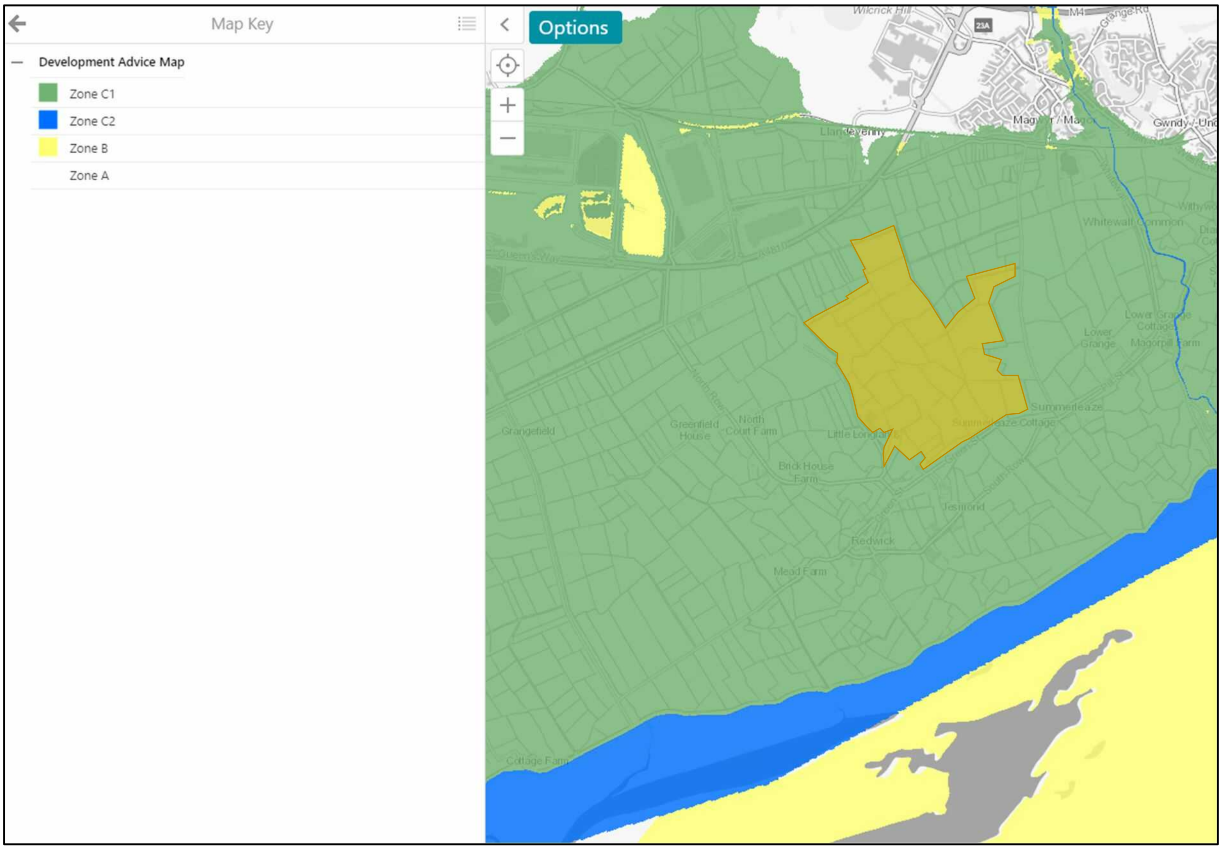

Figure 3.1 Development Advice Map

TAN15 encourages new development away from zone C and towards suitable land in either zone A or zone B (in this order of preference), where river or coastal flooding will be less of an issue. In zone C the new development should only be permitted if determined by the planning authority to be justified in that location.

The DAM does not include the potential effects of climate change and these are considered in subsequent sections of this report.

3.2 VULNERABILITY TO FLOODING

The type of development that may be acceptable in a flood risk area is also defined in TAN15. The guidance dates from 2004 and solar parks are not considered, although power stations are defined as "highly vulnerable" in TAN15. A solar park has a much lower vulnerability to flooding than a traditional power station (no permanent human presence, largely autonomous operation, no below-ground installations other than waterproof cabling, less electrical switchgear etc.) and it has been accepted in other applications, including the Ministerial Decision on a similar solar park on land on the Caldicot Levels nearby (The Planning Inspectorate, 2018[6]), that solar parks should be regarded as similar to other commercial development and utilities infrastructure, which is defined in TAN15 as "less vulnerable".

[6] The Planning Inspectorate Report 2018. The Developments of National Significance (Wales) Regulations 2016: Application by Gwent Farmers' Community Solar Scheme Ltd. Land on the Caldicot Levels to the south of Llanwern Steelworks Site APP/G6935/A/16/3150137

Less vulnerable development is acceptable in flood zone C1, subject to a justification test. Justification for this development in this location is provided in Section 7.4 of this report.

3.3 LOCAL PLAN DOCUMENTS

Newport City Council adopted a local development plan in January 2015[7] and this includes policies to manage and reduce flood risk within the city. Policy SP3: "Flood Risk" states:

> *"Development will only be permitted in flood risk areas in accordance with national guidance. Where appropriate a detailed technical assessment will be required to ensure that the development is designed to cope with the threat and consequences of flooding over its lifetime. Sustainable solutions to manage flood risk should be prioritised."*

Policy GP1 "General Development Principles – Climate Change" states:

> *"Development proposals should:*
>
> > *i) be designed to withstand the predicted changes in the local climate and to reduce the risk of flooding on site and flooding elsewhere by demonstrating where appropriate that the risks and consequences of acceptably managed, including avoiding the use of non-permeable hard surfaces;"*

The *National Strategy for Flood and Erosion Risk Management in Wales*[8] identifies four overarching objectives that must be addressed within Local Strategies. The four overarching objectives are:

1. Reduce the consequences for individuals, communities, businesses and the environment from flooding and coastal erosion;
2. Raise awareness of, and engaging people in the response to, flood and coastal erosion risk;
3. Provide an effective and sustained response to flood and coastal erosion events; and
4. Prioritise investment in the most at risk communities.

Newport City Council also have a Local Flood Risk Management Policy[9]. Within this document, NCC has set objectives for Newport's strategy by translating the four overarching objectives of the National Strategy into objectives specific to Newport. These objectives are aimed at reducing the consequences of flood risk arising from local sources and coastal erosion risk, and address the short term (0-20 years), the medium term (20-50 years) and the long term (50-100 years) outcomes of the strategy.

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[7] Newport City Council. Newport Local Development Plan 2011 – 26. Adopted Plan January 2015.

8 National Strategy for Flood and Coastal Erosion Risk Management in Wales (November 2011), Welsh Government [

9 Newport City Council Local Flood Risk Management Strategy 27th October 2014. Arup.

4 Definition of Flood Hazard

4.1 HISTORICAL RECORDS

NRW has confirmed it holds no records of flooding at the site.

4.2 SOURCES OF FLOODING

4.2.1 River and Sea flooding

The flood risk is tidal, and the site is protected by substantial flood defences that protect the coastal strip along this stretch of coast. The crest of the flood defence is generally at 9.8 m AOD, and the defences are maintained by NRW who regard their condition as very good.

Modelled flood data was requested from NRW (reference ATI-18640a) to assess likely flood depths on the site and the flood maps provided are shown in Appendix C.

The current NRW floodmap is reproduced in Figure 4.1 which shows the site to be in flood zone 3, defined as having an undefended annual risk of flooding more than 1 in 200, or 0.5% Annual Exceedance Probability (AEP), but protected by flood defences.

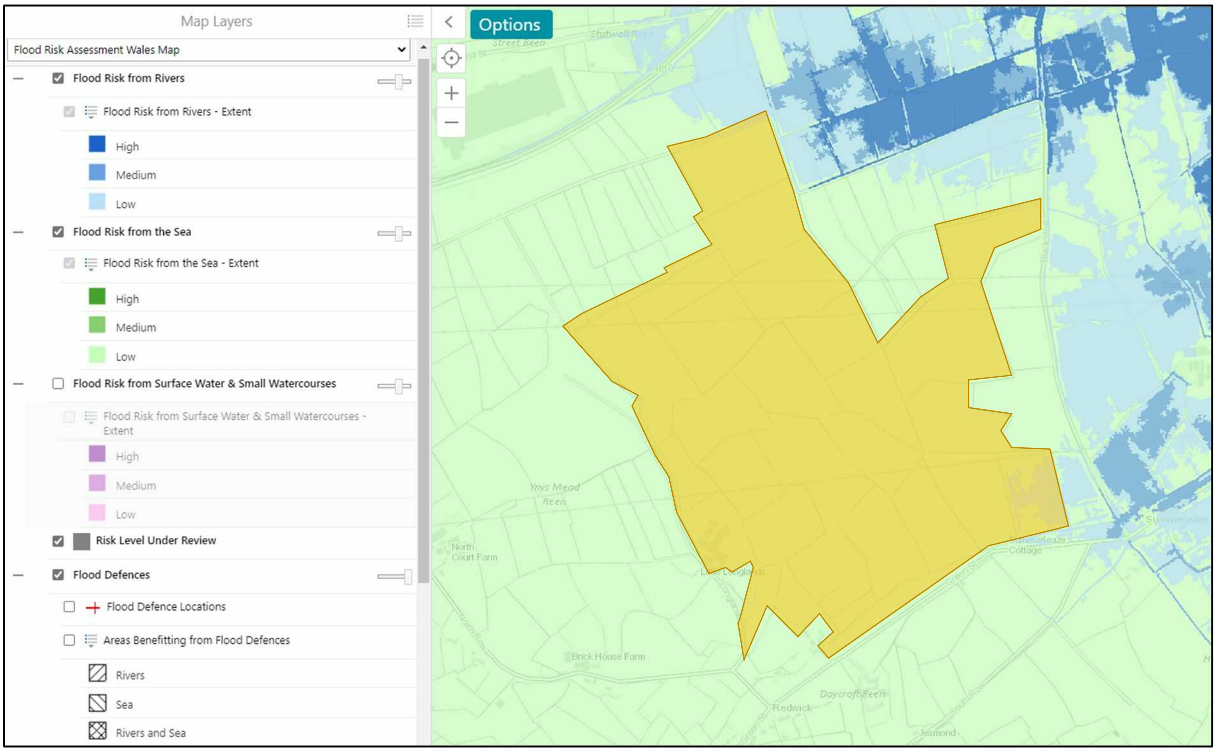


Figure 4.1 Flood Risk from Rivers and the Sea

The mapped modelled flood extents confirm that the site will remain flood-free in the 0.5% AEP defended tidal flood event although adding the modelling upper confidence level indicates a slight inundation could occur with a tidal level of 5.13 m AOD on the site.

The 0.1% AEP (1 in 1000) flood elevation for 2020 is 5.61 m AOD, excluding the upper confidence interval.

The impacts of climate change are assessed in Section 4.3 below.

4.2.2 Surface water flooding

A map of modelled surface water flooding is available online on the NRW website and is reproduced in Figure 4.2 This shows that the site is not at risk from surface water other than that which collects in the reens.

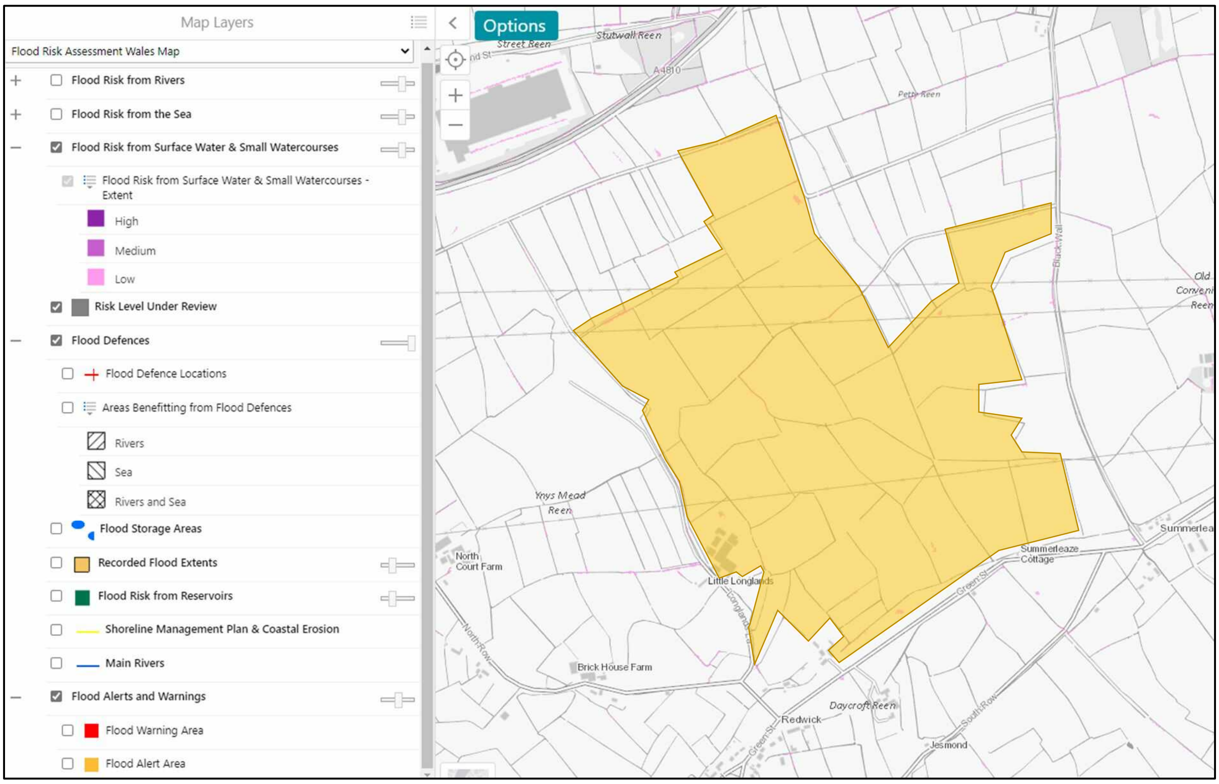


Figure 4.2 Flood Risk from Surface Water

4.2.3 Groundwater flooding

The site is not underlain by permeable deposits or an aquifer and the risk of flooding from groundwater is considered to be very low.

4.2.4 Catastrophic flooding

This source includes release of large volumes of stored water, such as in reservoirs and canals, due to catastrophic failure. NRW maps of areas which might be flooded in the event of a reservoir failure show that the site is not at risk from this source.

There are no other known large sources of stored water that may affect the site.

4.3 CLIMATE CHANGE

TAN15 states that it is necessary to take account of the potential impact of climate change over the operational period of development. Recent guidance[10] issued jointly by NRW and the Welsh Government assumes a lifetime of 75 years for non-residential developments.

Planning permission is sought for this development for an operational period of 35 years. Unlike other non-residential developments which usually involve the construction of

[10] Flood Consequence Assessments: Climate change allowances. Welsh Government Planning Policy Branch, Cardiff

potentially re-usable buildings, this development has a finite timescale driven by the lifetime of the solar generation technology. The effects of climate change have therefore been assessed over the period to 2055 rather than the standard 75-year period. An additional timeframe to 2065 has also been assessed, to provide allowance for planning and construction delays.

Climate change will create an increase in tidal levels and an increase in storminess is also expected. The tidal flood risk will therefore increase, and the rate of increase will accelerate with time as shown in Table 4.1. The annual change (in millimetres per year) is taken from the NRW flood model data, reproduced in Appendix C.

Table 4.1 Sea Level climate change allowance for the Welsh coastline[11]

Period	2009-2025	2026-2055	2056-2085	2086-2115	Cumulative rise to 2115
Annual change (mm/yr)	3.5	8.0	11.5	14.5	-
Total increase (mm)	59.5	240	345	449.5	1,094

NRW supplied tidal level information for 2095 at the site (Appendix C) but this does not provide estimated levels for the 2055 and 2065 epochs of the proposed solar park. In addition, other key issues requiring detailed investigation are flooding from waves overtopping the defences, which will increase as sea level rises, movement of flood water over the land surface behind the defences, and the consequence of potential defence failures.

JBA Consulting were therefore commissioned to undertake modelling of the site and provide a detailed assessment of these issues. JBA completed the 'Caldicot and Wentlooge Coastal Modelling Study' for NRW in 2016 and the model domain included the Rush Wall site. This model has now been updated by JBA to account for the 2018 extreme sea level dataset and current guidance on wind. It was also necessary to investigate flood risk over the lifetime of the proposed development, by simulating climate change for the future years 2055 and 2065.

Details of the tidal flood risk modelling undertaken by JBA Consulting are provided in Appendix G.

The following findings and conclusions were made:

- The main flood risk to the site is from the tidal Severn Estuary, and a consequence of two mechanisms:
    - Wave overtopping volumes passing over the tidal defences; and
    - Still water or over-washing of the tidal defences where extreme water levels exceed the defence crest level. The modelled flood outputs have shown this to occur to the south east of the proposed development site as flood waters travel westwards into Whitewall Common, where they pass over Whitewall Road, and eventually impact the site from the north east.
- Flood modelling shows the proposed development site to be flood free during the 0.5% AEP 2055 and 2065 epochs. Flood waters reach the edge of the site boundary to the north east during the 2065 epoch.

[11] Flood Consequence Assessments: Climate change allowances. Welsh Government Planning Policy Branch, Cardiff

- The proposed development site is potentially vulnerable to flooding during a 0.1% AEP event under climate change conditions projected to the 2055 and 2065 epochs.
- During the 0.1% AEP 2055 event, roughly 70% of the site is inundated. Most flood depths are <0.25m, while towards the north of the site flood depths increase up to roughly 0.5m, and the very northern tip reaches depths of just over 1.1m.
- During the 0.1% AEP 2065 event, roughly 95% of the site is inundated. Flood depths across the site vary. The bulk of flood depths are between 0.25 and 0.50m, while towards the north of the site flood depths increase and range between 0.50 and 1.50m in the very northern most point. This is summarised in Drawing 18053_R2_01.

Further details of the modelling and maps showing model output for various scenarios are provided in Appendix G.

4.4 DEFENCE FAILURE

A breach assessment is not available for the site. The undefended flood levels at the site provide a worst-case scenario and are shown in Table 4.2, with the supplied undefended levels for 2015 increased by the rates shown in Table 4.2.

Table 4.2 Undefended Tidal Levels (m AOD)

0.5% AEP Undefended Model Results (m AOD)	2015	2055	2065
Mean Elevation	8.79	9.06	9.11
Max Elevation	8.82	9.09	9.14

Comparison of these levels with the existing crest level of 9.8 m AOD indicates that there is a good freeboard and breach of the defences is a very low risk. The defences are in good condition and are unlikely to be totally overwhelmed and would be breached in limited stretches if a failure occurred. NRW guidance[12] suggests a breach width of 50 metres is modelled over three tidal cycles for hard defences in an open coastal situation.

Additionally, there is a large area of low-lying land between the site and the defences that could absorb a significant volume of water that might enter through a breach during a breach event. The levels shown in Table 4.2 are therefore a considerable exaggeration of the possible flood levels that might occur in the unlikely event of a defence breach.

[12] Flood Risk Management: Modelling blockage and breach scenarios. NRW document OGN100, February 2015

5 Detailed Development Proposal

5.1 DEVELOPMENT LAYOUT

The proposed layout is shown in Appendix B. Existing field boundaries will be retained and protected. The main elements of the proposal as afar as flood risk is concerned are:

- Solar photovoltaic (PV) panels, mounted to a railing sub structure;
- Compacted gravel tracks (constructed on a sub layer geogrid membrane) to allow vehicular access between fields;
- A substation access track with a cement based top layer (a statutory requirement of the electricity distribution network operator, Western Power Distribution) and;
- A substation compound within a security-fenced concrete-based compound measuring approximately 50m x 40m at the centre of the site adjacent to an existing pylon.

5.2 SOLAR PANELS

The solar panels are to be aligned within existing field boundaries with a buffer or exclusion zones of 7 m from ditches and 12.5 m from reens. The panels will be arranged on rails, as shown in Appendix D which are supported on short piles. Vegetation will be retained or re-sown under the panels which will then maintain a year-round cover of vegetation, unlike the current agricultural cropping regime which can result in bare ground during winter and spring.

The impact of the panels on runoff is therefore likely to be positive, as rainfall compaction of bare ground will be eradicated and soakage into the soil will be feasible throughout the year.

5.3 ACCESS TRACKS

All field access tracks will be constructed of compacted gravel such that they are permeable to negate impacts to drainage, as indicated in Appendix E.

5.4 STRUCTURES

With the exception of the foundations for the substation and the substation access track, use of concrete will be minimal to reduce impacts on drainage. Gravel-filled soakaways are to be created around concrete bases to provide compensatory capacity and allow runoff to infiltrate to ground.

5.4.1 Substation

An area for the base of the substation will be excavated prior to the hard-standing plinth concrete pour, after which the associated substation infrastructure will be installed (as can be seen on Figure 2.7). The ground disturbance associated with the substation is expected to be up to 2m below ground level. Gravel-filled soakaways will be created around concreate bases to provide compensatory capacity and permit infiltration of stored water.

5.5 RUNOFF FROM THE SITE

No surface water collection system is proposed for the site. Rainfall on the site will be allowed to percolate into the underlying soil as occurs at present. This includes rain falling on the supporting structures, which will be drained to ground.

There will therefore be no runoff from the site and no surface water impacts arising on surrounding areas. Flood risk to others will therefore not be adversely affected and may be improved as soil compaction by farm equipment and the creation large areas of bare soil in winter created by the current land use regime will be avoided.

6 Flood Risk Management Measures

6.1 MITIGATION

The area is not at significant flood risk at present because of the extensive flood defences along the coastline to the south. The site will remain flood-free in the 0.5% AEP flood event during the during the operational period of the project to 2055/ 2065.

However, the 0.1 % AEP tidal flood event could cause some inundation of the site during both the 2055 and 2065 epochs, though flood depths will be lowest in the west of the site where the main site access road will be.

Occupation of the flood plain will be minimal and compensation for lost storage is not required due to the tidal nature of the flood risk.

Vulnerable parts of the site infrastructure should be raised above the predicted flood elevations shown in Appendix G.

The site will not normally be occupied. Maintenance will be timetabled and restricted to daylight hours. Maintenance visits should be cancelled and any on-site personnel withdrawn on receipt of a flood warning.

The site will not generate extra runoff and further mitigation for flood risk is not considered to be required.

6.2 FLOOD WARNING

The site is in a NRW flood warning area and it is recommended that Site operators make use of this service to warn of possible flooding in the nearby area. Flood warning should provide a long lead time as the possibility of overtopping or breach is likely to be well forecast and the site is distant from the defences.

Should a flood warning be received any personnel within the site should be instructed to leave and the site should not be revisited until a stand down message has been received.

6.3 EMERGENCY ACCESS AND EGRESS

In the event of an emergency evacuation the site should be left via the Longlands Lane or Green Street exits, along North Row to the A4810 (as defined on Figure 2.1). This will involve exit in the opposite direction from which the flood waters are modelled to inundate the site, with the west of the site being the last area of the site reached by flood water (as the JBA model indicates that inundation occurs westwards across the site from Whitewall Common to the east).

7 Assessment of flood consequences

The proposed development is considered in TAN15 to be "less vulnerable" as it comprises commercial development and should not be regarded as a "Power Station". The development will be unmanned (visited up to approximately 60 times per year) and therefore present a very low risk to people as; it will only be accessed periodically for maintenance during the daytime; will not include sleeping accommodation and; will not be occupied by children and the infirm, who would require particular assistance if a flood should occur.

TAN15 also considers that people generally have more choice about where they work than where they live, and so are more likely to avoid areas that put them at an unacceptable risk.

Development should only be permitted in zone C1 if it can be justified by the LPA. As part of this justification, the development should be proven to:

- **annual risk of flooding** – be flood free in the 1% (plus climate change) flood event (A1.14, TAN15);
- **consequences of flooding in extreme events** – have acceptable consequences of flooding in the extreme 0.1% flood event (A1.15, TAN15);
- and not cause **flooding elsewhere** (A1.12, TAN15).

7.1 ANNUAL RISK OF FLOODING

The site is currently free of flooding for the 0.5% AEP flood event and has been modelled to remain so during the lifetime of the project to 2055 and 2065.

The requirement of A1.14 of TAN15 is therefore passed.

7.2 CONSEQUENCES OF FLOODING IN EXTREME (0.1%) EVENTS

The proposed use is non-residential and there will not normally be people on the site. NRW flood alerts would provide notice of the possibility of flooding and maintenance visits stopped and the site evacuated if occupied at the time of a warning.

The Rush Wall west exit is in the area which is last to flood in a 0.1% event in 2065 and flood depths are expected to be below 0.25m.

Threats to people during an extreme event are therefore minimal and acceptable and the requirement of A1.15 of TAN15 is met.

7.3 FLOODING ELSEWHERE

No drainage system is proposed and the site will remain permeable with the exception of pads beneath the substation. Rain falling on the solar panels will fall to ground. A gravel filled soakaway trench is proposed around each of the substation structures to provide compensatory drainage for the small loss of ground available for infiltration.

The development will therefore not cause flooding elsewhere and will meet the requirement of A1.12, TAN15.

7.4 JUSTIFICATION TEST

The site is in Flood Zone C1, protected by significant infrastructure. TAN 15 confirms that development can take place subject to the application of the justification test including acceptability of consequences.

A Sequential Site Selection Report[13] has been completed as part of the studies undertaken in devising the development location and design. Following a "*robust approach to identify sites that follow the sequential approach …. [using a] search area [that] covers a wide search area and has been refined to take account of brownfield land and constraints, including agricultural land classification and proximity to grid connection"* the report concludes that *"it is evident …. That there are no existing, available, suitable or viable alternatives within the search area which meet the criteria required for a solar PV scheme of this scale"*.

Amongst other factors, this site has been chosen for the development because:

- It is a large site with minimal existing built infrastructure.
- There is adequate grid capacity on nearby power lines.
- The area has very good irradiance, which is superior to most of Wales.
- The site is flat, south-facing and not overshadowed.

In light of the findings of the Sequential Site Selection Report, and given that this FCA shows that that the consequences of flooding are acceptable, the site should therefore pass the justification test.

[13] Sequential Site Selection Report, Land near the Village of Redwirk, south east of Newport, Wales on the Caldicot Levels. Adas UK Ltd. October 2020. Version 3.

8 Conclusions

It is proposed to develop a solar park on a 105 Ha site in the Gwent levels. The project has an operational period to 2055/ 2065 and is considered to be classed as "less vulnerable".

The site is in flood zone C1 and is protected by significant flood defence infrastructure.

Modelling of flood extents by JBA (see Appendix G) shows the site remains free of flooding for the 0.5% AEP (1 in 200 year) defended scenario up to 2065, the expected maximum lifetime of the project.

Flood risk from other sources is negligible or very low.

Permeable surface materials will be used throughout the vast majority of the site. Where concrete pads are required, gravel soakaways shall be constructed to compensate for the very small-scale loss of infiltration. Hence there will be no impact on runoff from the site.

The site will be un-manned most of the time and the consequences of flooding in the extreme 0.1% AEP flood in 2065 are minimal.

Although the site will remain flood-free during the 0.5% event in 2065, it is recommended that any vulnerable equipment is placed above the flood levels shown in Appendix G for the 0.1% AEP 2065 flood event, as summarised in Drawing 18053_R2_01.

The site operators should sign up to receive NRW flood warnings to ensure no maintenance is undertaken and the site evacuated when there is a risk of flooding on the site.

In summary:

- The consequences of flooding on the proposed development can be managed to an acceptable level (i.e. a level that does not adversely affect the operation and commercial viability of the solar park).
- There is considered to be no risk to the public.
- There is no detriment to flood risk elsewhere.

Drawings

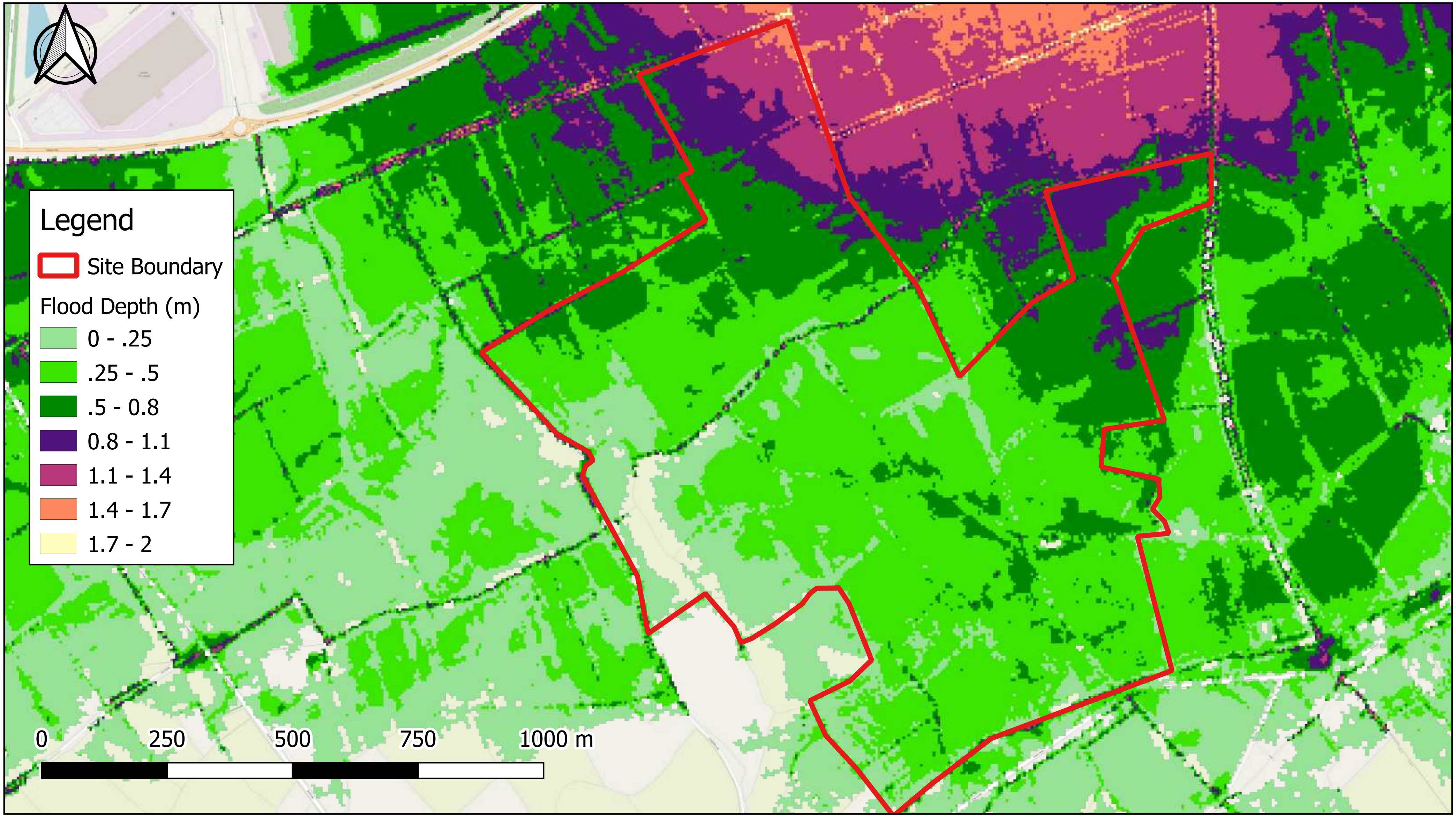


Figure Title: Modelled 0.1% AEP flood depths in 2065, Rush Wall Solar Farm	Client: BSR	Date: 29/04/2020	Drawn: JRB	YELLOW SUB GEO
	Drawing Number: P18053-R2-01	Scale: 1:10500	Checked: GRO	
		Original: A4	1	
	Project Number: 18053	Rush Wall Solar Farm		

Appendices

Appendix A: Report Conditions

Report Conditions

This report has been prepared by Yellow Sub Geo Ltd. (Yellow Sub Geo) in its professional capacity as soil and groundwater specialists, with reasonable skill, care and diligence within the agreed scope and terms of contract and taking account of the manpower and resources devoted to it by agreement with its client, and is provided by Yellow Sub Geo solely for the internal use of its client.

The advice and opinions in this report should be read and relied on only in the context of the report as a whole, taking account of the terms of reference agreed with the client. The findings are based on the information made available to Yellow Sub Geo at the date of the report (and will have been assumed to be correct) and on current UK standards, codes, technology and practices as at that time. They do not purport to include any manner of legal advice or opinion. New information or changes in conditions and regulatory requirements may occur in future, which will change the conclusions presented here.

Where necessary and appropriate, the report represents and relies on published information from third party, publicly and commercially available sources which is used in good faith of its accuracy and efficacy. Yellow Sub Geo cannot accept responsibility for the work of others.

Site investigation results necessarily rely on tests and observations within exploratory holes only. The inherent variation in ground conditions mean that the results may not be representative of ground conditions between exploratory holes. Yellow Sub Geo take no responsibility for variation in ground conditions between exploratory positions.

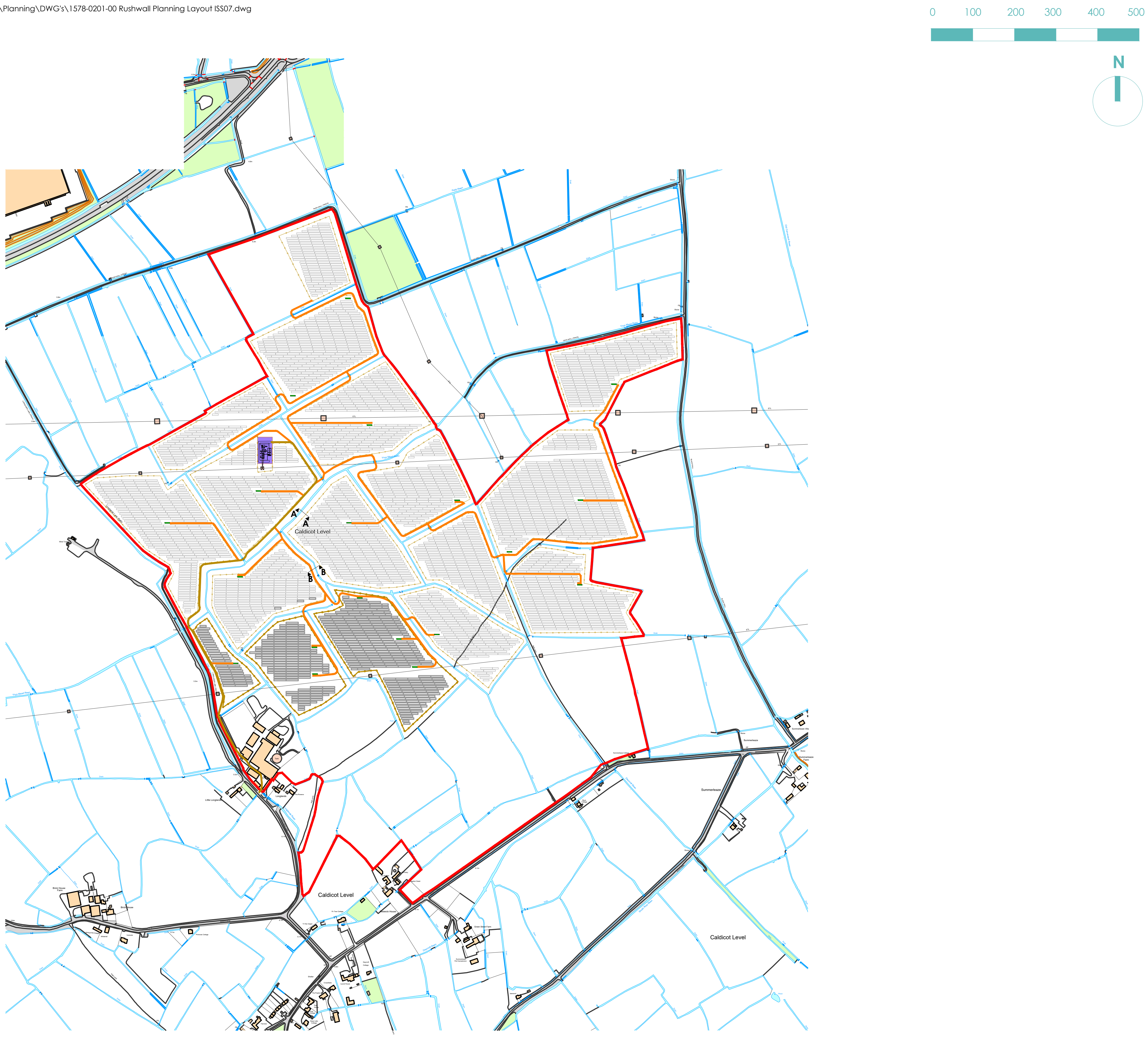
This report is confidential to the client. The client may submit the report to regulatory bodies, where appropriate. Should the client wish to release this report to any other third party for that party's reliance, Yellow Sub Geo may, by prior written agreement, agree to such release, provided that it is acknowledged that Yellow Sub Geo accepts no responsibility of any nature to any third party to whom this report or any part thereof is made known. Yellow Sub Geo accepts no responsibility for any loss or damage incurred as a result, and the third party does not acquire any rights whatsoever, contractual or otherwise, against Yellow Sub Geo except as expressly agreed with Yellow Sub Geo in writing. Yellow Sub Geo reserves the right to withhold and/ or negotiate the transference of reliance on this report, subject to legal and commercial review

Appendix B: Site Plan

Plot Date: 23/04/2020 12:27:32

File Name: S:\New Solar\Design\1578 - Rush Wall Farm\05-Site Plans\Planning\DWG's\1578-0201-00 Rushwall Planning Layout ISS07.dwg

File References:



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OS License No. :- 100022432

Key:

- Planning Boundary
- Security Fence
- Substation Area
- Inverter Stations
- Access to Substation
- Inverter Access
- A — A Buffer Section Views (see drawing 1578-0201-50)

Fenced Area Acres (Approx) : 163.14

Red Line Area Acres (Approx) : 300.9

Red Line Area Hectares (Approx) : 121.7

Rev:	Revision History:	Date:	By:
01	Initial Issue	30/05/19	MB
02	Added access to Substation	21/10/19	AK
03	Added access Inverters Amended Planning Boundary Updated notes	12/12/19	MB
04	Arrays amended due to Reen buffer	24/01/20	MB
05	Updated Fields	24/02/20	AK
06	Updated Route to Inverters	18/03/20	AK
07	Fence line brought away from Reens	23/04/20	MB

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Shepton Mallet,
Somerset,BA4 5QE
United Kingdom

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T:01458 224900
W:www.britishrenewables.com

Project:
Rush Wall Farm Solar Park

Location:
Rush Wall Farm
Redwick, Nr Newport
Gwent
NP26 3DX

Title:
Planning Layout

Scale: 1:5000 @A3

Issue Notes:
Fence line brought away from Reens

BSR Energy

Drawn By: MB	Issue Date: 23/04/20
Checked By: CR	Checked Date: 23/04/20
Approved By: CR	Approved Date: 23/04/20

Drawing Number:
1578-0201-00

Drawing Status: Approved

Issue: 07

Appendix C: Modelled data from NRW

ATI-18640a – Rushwall , Magor

E: 341376 N:185597

1.0 Current Flood Map

Figure 1 shows the current Flood Map (version 201910) at this location. The Flood Map represents a combination of the undefended fluvial and tidal flood extents derived from a combination of detailed local and generalised national model data.

More information on the Flood Map can be obtained from the Natural Resources Wales website http://www.naturalresources.wales/floodriskmap

2.0 Local Flood Risk Mapping Study

Model Summary

This study was commissioned to update the coastal flood model in the area. This study uses extreme combined wave overtopping, wind and tidal level predictions together with new LiDAR data and information on changes to landforms in the area (*ref 5*).

The model was run for undefended and defended tidal flood events for 2015* and defended tidal events with climate change.

Changes in sea level used in the model are shown in **Table 1** (*ref 2)*.

Table 1: Sea Level Rise (mm per year)

Assumed vertical land movement	1990-2025	2025-2055	2055-2085	2085 onwards
-0.5	3.5	8.0	11.5	14.5

Results

The shape for the site has been used to query the elevation, depth, velocity and hazard grids to provide the results in **Tables 3 , 5 and 7**. These results all relate to a base year of 2015.

To get water elevation results for 2020 and future years, model results have been interpolated, the results are shown in **Tables 4 and 6**.

The depth grids for the defended tidal 1 in 200 (2090) excluding confidence intervals and 1 in 200 (2115) including confidence intervals, are shown in **Figures 2 and 3.**

The hazard grid for the defended 1 in 200 year with future climate change including confidence interval is shown in **Figure 4**.

Table 2: Legend for Hazard Grids

Flood Hazard Rating (HR)	Colour Code	Hazard to People Classification (*ref 6*)
Less than 0.75		Very low hazard – Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		Danger for most – includes the general public
More than 2.0		Danger for all – includes the emergency services

*Interpolated results generate tide levels for current day (2020) and future climate change scenarios (2095/2120). These results use the model base year (2015); the sea level rise values from **Table 1** are then added to the elevation values in the model results Tables. For example, to get data for 2095: 14.5mm x 5 (years) = 72.5mm or 0.0725m which can be added to the elevation max value in the results tables.

Model Results - the Site

*Null values show that the site is flood free for that return period.

Table 3: Defended Model Results – Median values

Defended (excluding upper confidence interval)						
	1 in 200			1 in 1000		
	2015	2090	2115	2015	2090	2115
Model Grid Size (m)	5	5	5	5	5	5
Wet Cells	0	51844	51848	17204	51848	51848
Elevation, mean (mAOD)	NULL	6.71	7.18	5.53	7.70	8.06
Elevation, max (mAOD)	NULL	6.80	7.31	5.53	7.83	8.19
Depth, mean (m)	NULL	1.23	1.69	0.34	2.22	2.58
Depth, max (m)	NULL	2.66	3.12	1.44	3.64	4.00
Velocity, mean (m/s)	NULL	0.38	0.59	0.03	0.89	1.01
Velocity, max (m/s)	NULL	2.18	2.49	0.84	2.84	2.93
Hazard, mean	NULL	1.98	2.57	0.94	3.24	3.72
Hazard, max	NULL	3.38	4.28	1.78	5.18	5.75

Table 4: Defended Interpolated Results (2020)*

Defended (excluding upper confidence interval)						
	1 in 200			1 in 1000		
	2020	2095	2120	2020	2095	2120
Elevation, max (mAOD)	NULL	6.88	7.38	5.61	7.91	8.26

Table 5: Defended Model Results – Upper Confidence

Defended (including upper confidence interval)				
	1 in 200			1 in 1000
	2015	2090	2115	2015
Model Grid Size (m)	5	5	5	5
Wet Cells	3112	51848	51848	51844
Elevation, mean (mAOD)	5.05	7.18	7.70	6.71
Elevation, max (mAOD)	5.06	7.31	7.83	6.80
Depth, mean (m)	0.28	1.69	2.22	1.23
Depth, max (m)	0.97	3.12	3.64	2.66
Velocity, mean (m/s)	0.02	0.59	0.89	0.38
Velocity, max (m/s)	0.41	2.49	2.84	2.18
Hazard, mean	0.89	2.57	3.24	1.98
Hazard, max	1.48	4.28	5.18	3.38

*Table 6: Defended Interpolated Results (2020)**

Defended (including upper confidence interval)				
	1 in 200			1 in 1000
	2020	2095	2120	2020
Elevation, max (mAOD)	5.13	7.38	7.91	6.88

Table 7: Undefended Model Results – Median Values

Undefended (2015)		
	1 in 200	1 in 1000
Model Grid Size (m)	5	5
Wet Cells	51848	51848
Elevation, mean (mAOD)	8.79	9.12
Elevation, max (mAOD)	8.82	9.16
Depth, mean (m)	3.30	3.64
Depth, max (m)	4.70	5.03
Velocity, mean (m/s)	1.05	1.12
Velocity, max (m/s)	3.36	3.06
Hazard, mean	3.97	4.50
Hazard, max	6.14	6.73

Model Results – Emergency Access Route

A suitable access route has not been provided

*Null values show that the site is flood free for that return period.

3.0 Additional Information

We hold no historic flooding information in this area.

The local authority may be able to provide information on issues such as localised flooding from sewers, drains and culverts.

4.0 References

1. Tidal Flood Mapping Study (Aberthaw to Undy), Study report Issue 2, NRW June 2013
   Tidal Flood Mapping Study (Penarth to Chepstow), Atkins July 2008
2. Department for Environment, Food and Rural Affairs, 2011. *Technical Report Design sea levels*. R&D Report SC060064. Defra/Environment Agency
3. Flood and Coastal Defence Appraisal Guidance: FCDPAG3 Economic Appraisal. Supplementary Note to Operating Authorities – Climate Change Impacts; October 2006; Department for Environment, Food and Rural Affairs.
4. Using the national coastal flood boundary data for England and Wales, Environment Agency Operational Instruction 490_11, Issued 4/2/2011
5. Caldicot and Wentlooge Coastal Modelling: v1, JBA, June 2016.

6. Supplementary note on flood hazard ratings and thresholds for development planning and control purpose, May 2008

5.0 Notes

Undefended scenarios are provided as being a possible worst case scenario in the event of defence failure. They are used as the basis of the Flood Map.

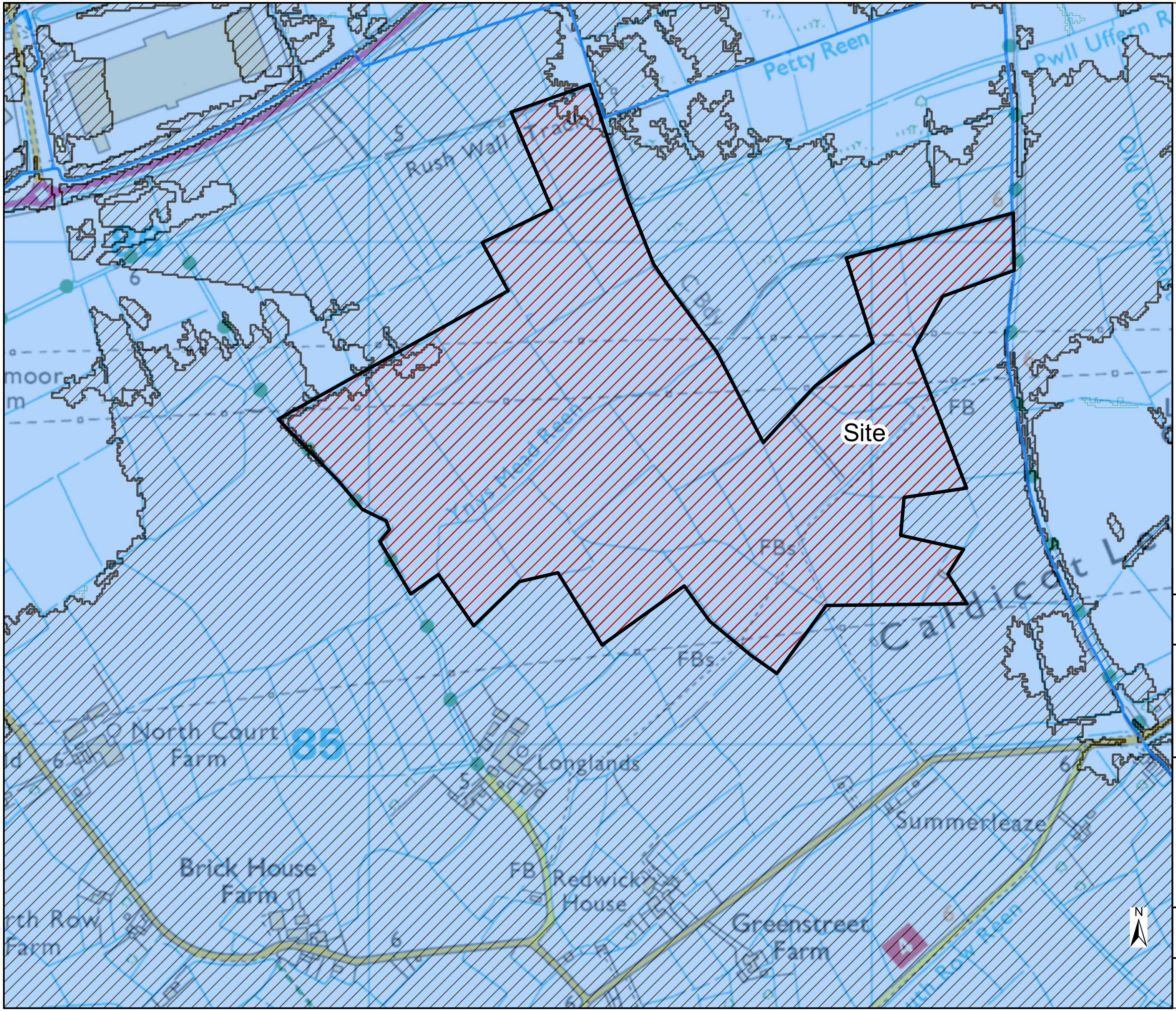
The scope of the model is the mapping of flood risk, it is not intended for detailed design. The model should be considered as the starting point for more detailed modelling, commensurate with the consequences of flooding at the site of interest.

NRW models are available under licence agreement for the purpose of further development. Contact Natural Resources Wales Data Distribution team for details of terms, conditions and pricing.

If the data is used in support of an FCA, please include the reference number.

Please refer to NRW standard terms and conditions.

Flood Risk Analysis
06/02/2020



Legend

- Site
- Defences
- Main Rivers
- Areas Benefiting from Defences
- Flood Storage Areas
- Flood Zone 3
- Flood Zone 2

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

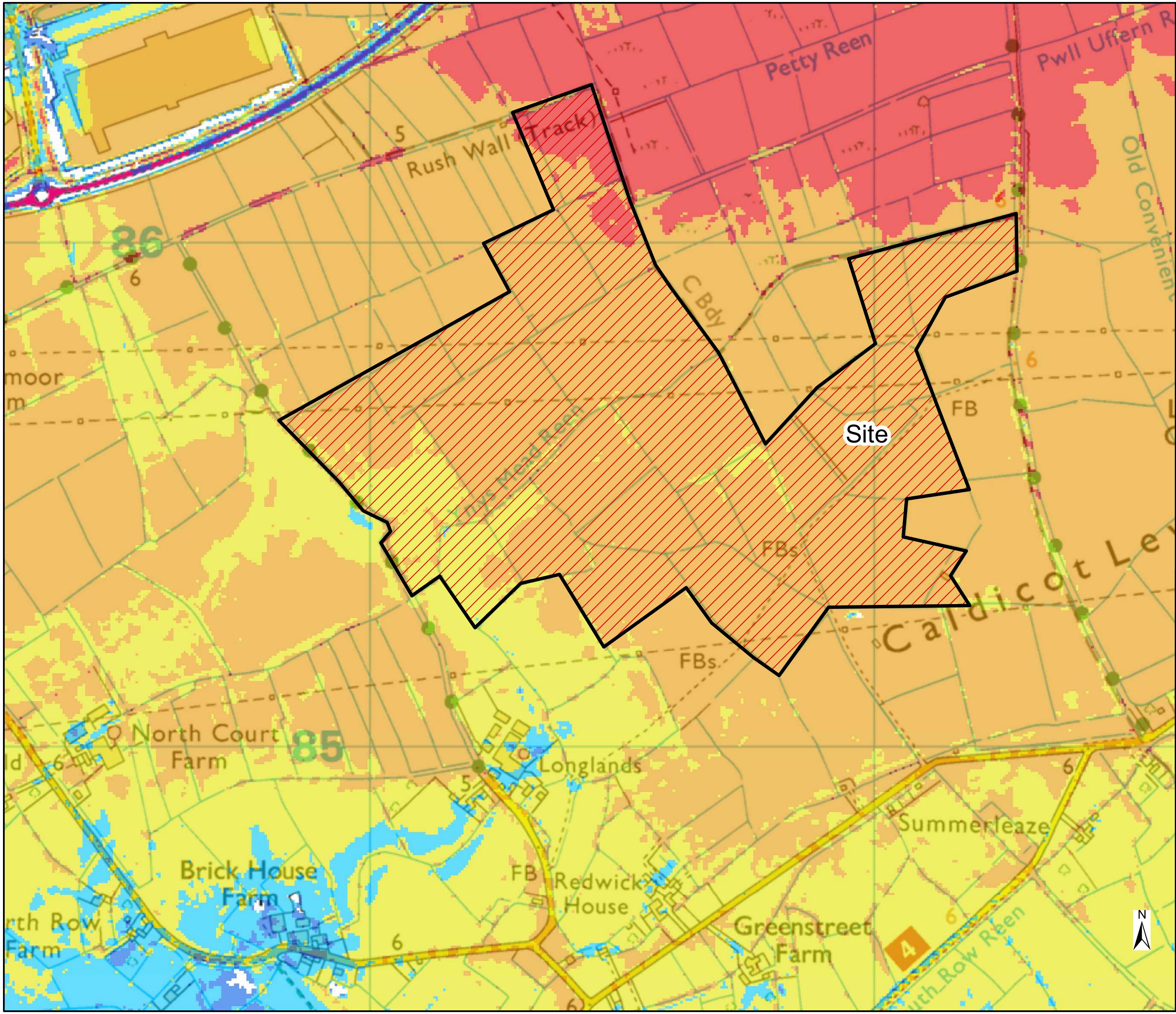
Rushwall , Magor (Ref:ATI18640a)

Drawing

Figure 1:
Current Floodmap
[v201910]

Date 06 Feb 2020

Scale 1:10,000



Legend

Site

T200 2090 (Depth)

- < 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 2.0
- > 2

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

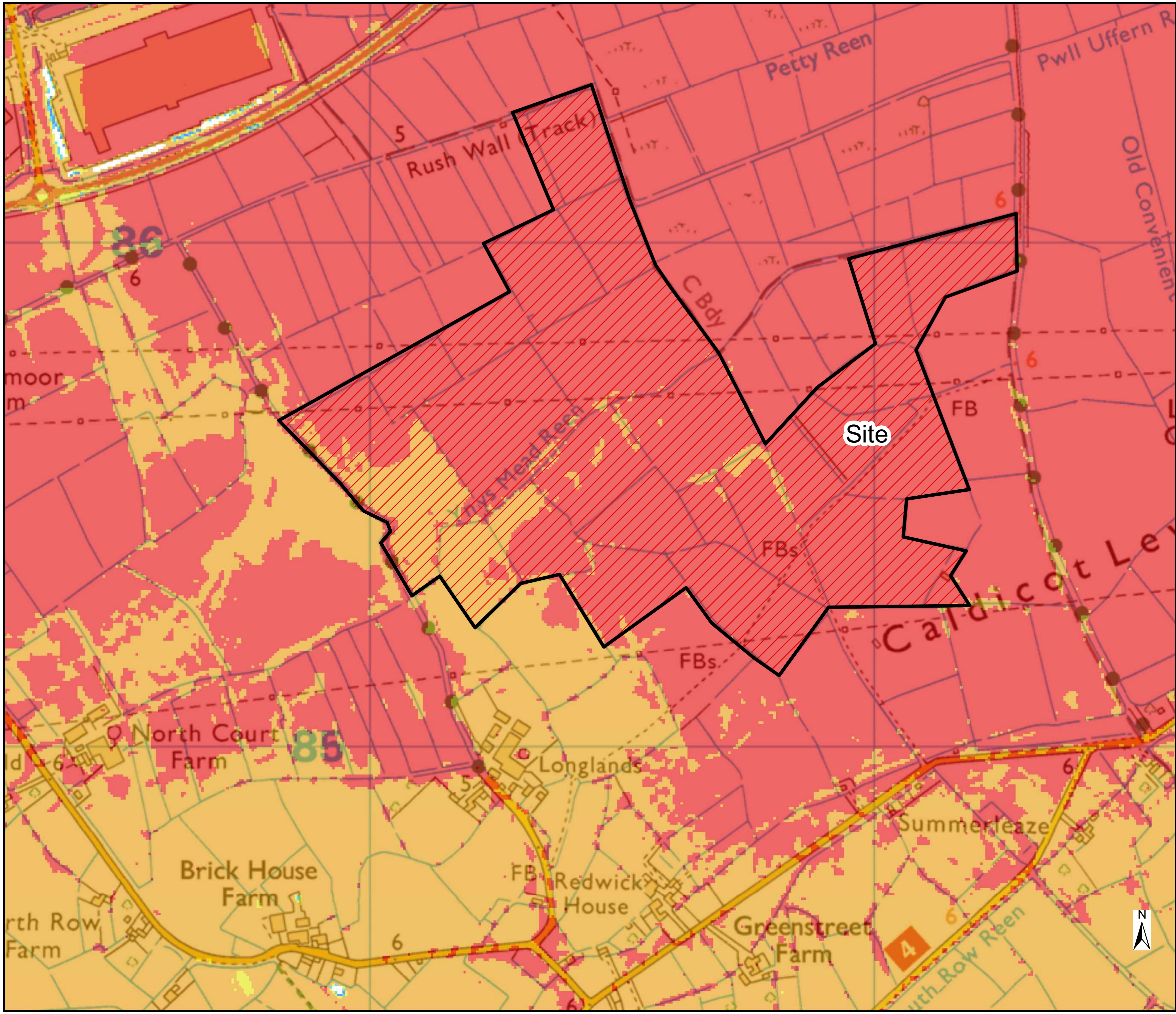
Rushwall , Magor (Ref:ATI18640a)

Drawing

Figure 2:
Depth Grid for 0.5% AEP
(1 in 200) year event - defended
excluding upper confidence
intervals (2090 Commercial)

Date 06 Feb 2020

Scale 1:10,000



Legend

Site

T200 2090 +CI (Depth)

- < 0.3
- 0.3 - 0.6
- 0.6 - 1.0
- 1.0 - 2.0
- > 2

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

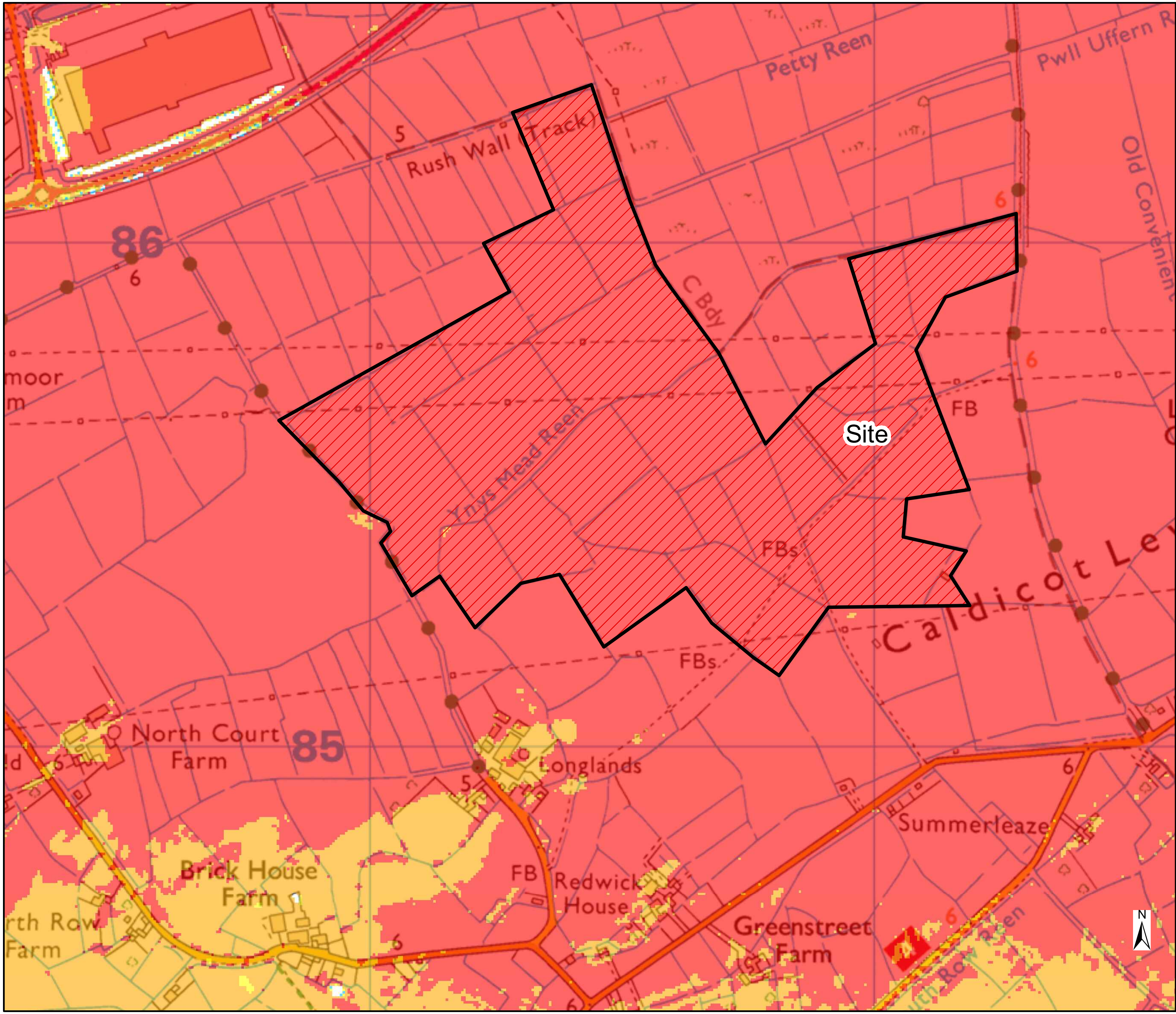
Rushwall , Magor (Ref:ATI18640a)

Drawing

Figure 3:
Depth Grid for 0.5% AEP (1 in 200) year event - defended including upper confidence intervals (2090 Commercial)

Date 06 Feb 2020

Scale 1:10,000



Legend

Site

T200 2090 +CI (Hazard)

< 0.75

0.75 - 1.25

1.25 - 2.00

> 2.00

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

Rushwall , Magor (Ref:ATI18640a)

Drawing

Figure 4:
Hazard Grid for 0.5% AEP (1 in 200) year event - defended including upper confidence intervals (2090 Commercial)

Date 06 Feb 2020

Scale 1:10,000

Appendix D: Solar panel mounting system

Plot Date: 23/10/2019 12:13:39
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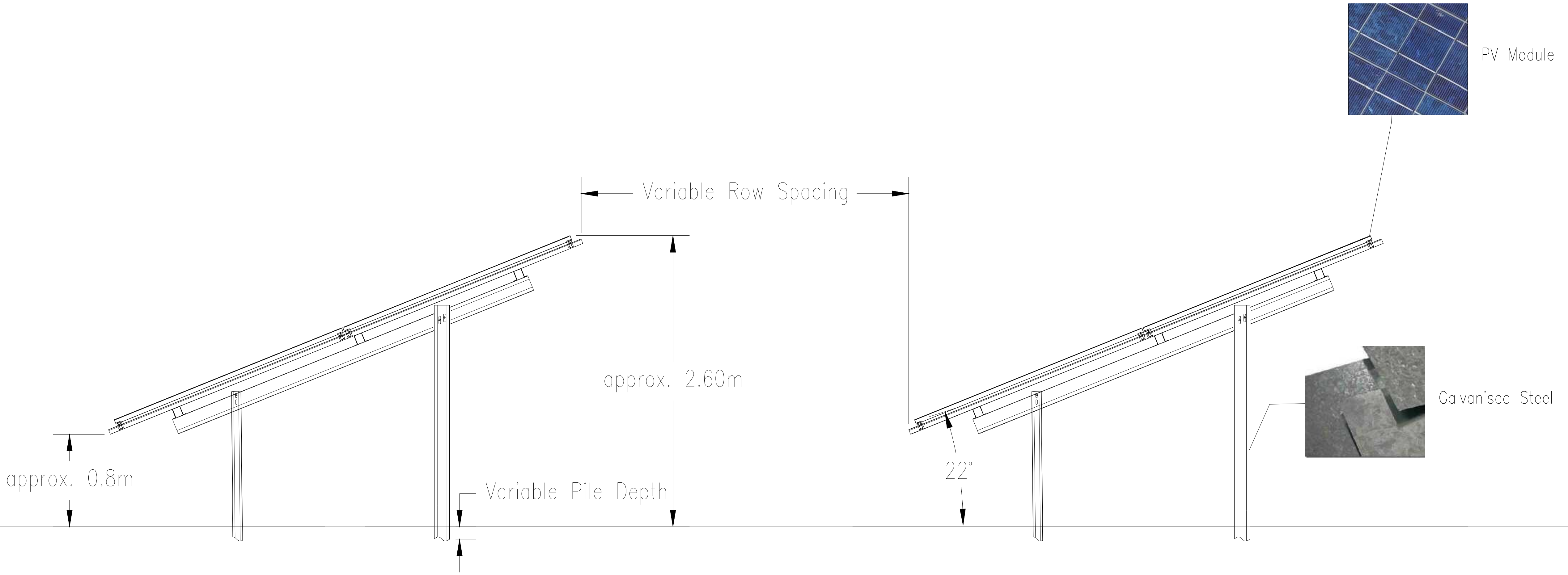
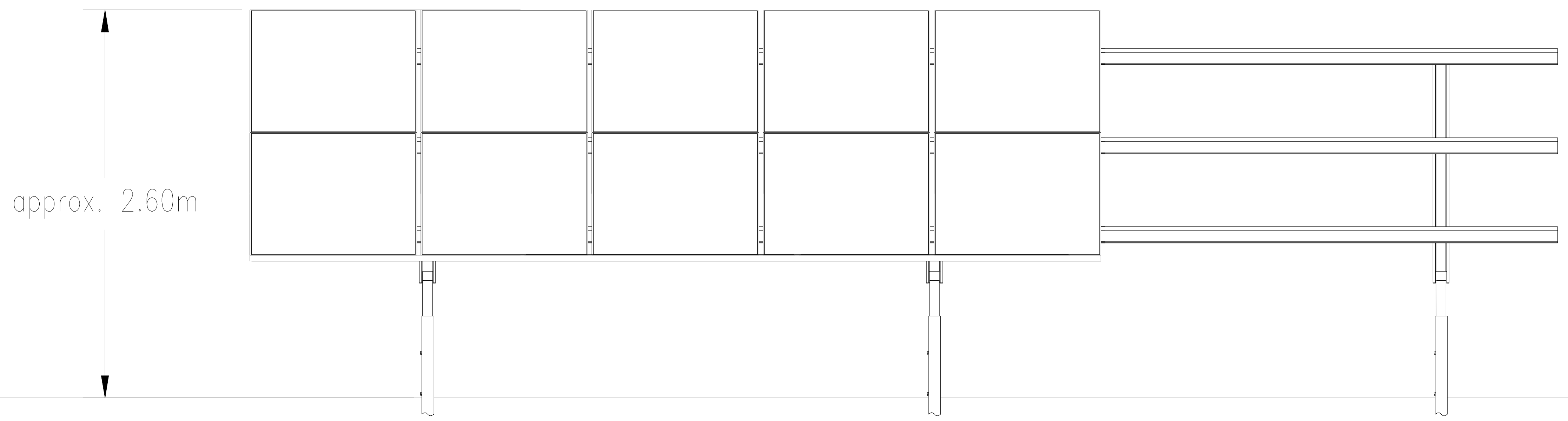
File References:





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Rev:	Revision History:	Date:	By:
01	Initial Issue	23/10/19	AK

35 and 35a The Maltings
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Project:
Rush Wall Farm Solar Park

Location:
Rush Wall Farm
Redwick, Nr Newport
Gwent
NP26 3DX

Title:
Mounting System

Scale: NTS

Issue Notes:
Initial Issue

BSR Energy

Drawn By: AK	Issue Date: 23/10/19
Checked By: MB	Checked Date: 23/10/19
Approved By: AW	Approved Date: 23/10/19

Drawing Number:
1578-0201-28

Drawing Status: Issued for Approval
Issue: 01

Appendix E: Access road design

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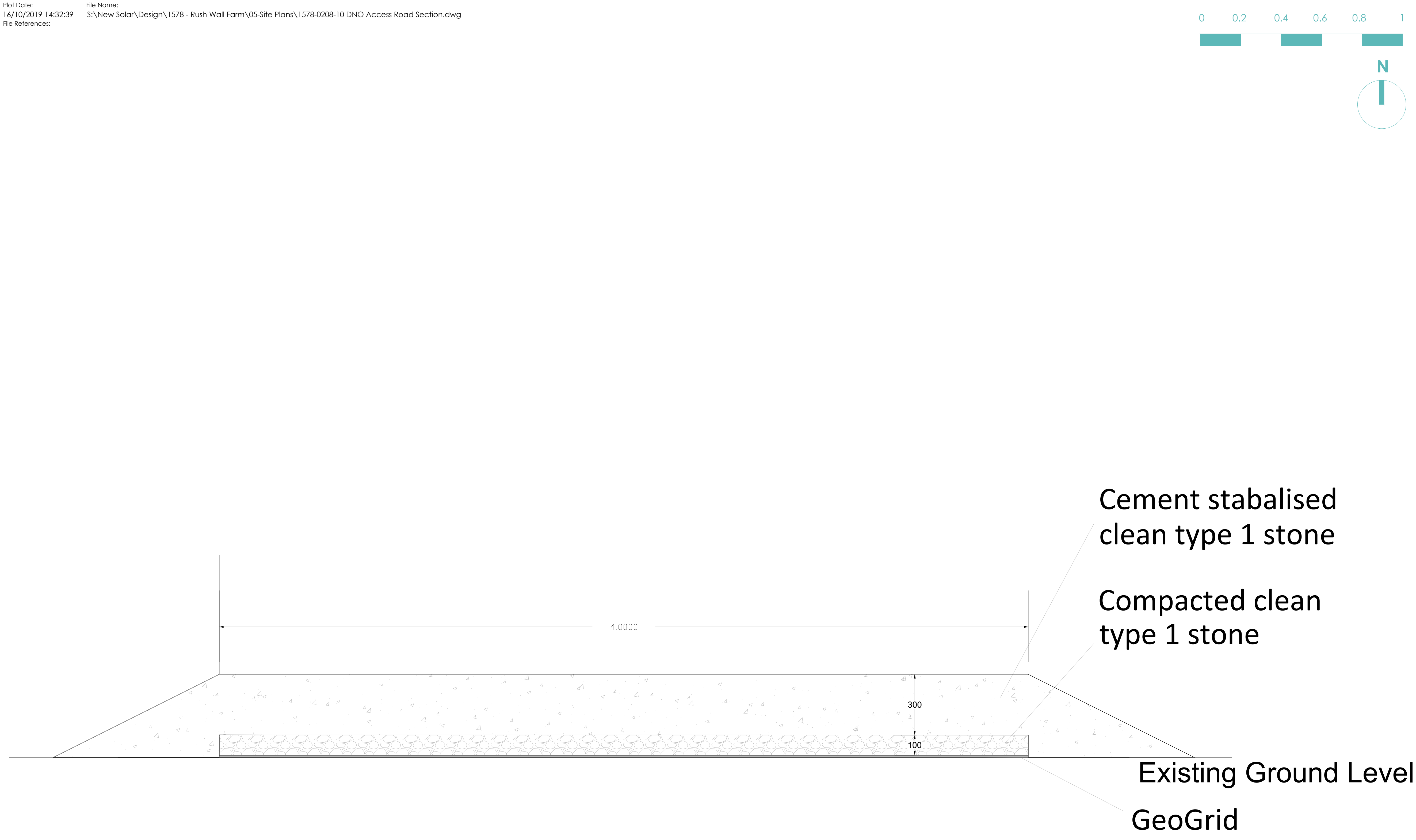
File References:



Rev:	Revision History:	Date:	By:
01	Initial Issue	16/10/19	AK

35 and 35a The Maltings
Lower Charlton Trading Estate,
Shepton Mallet,
Somerset,BA4 5QE
United Kingdom

E:info@britishrenewables.com
T:01458 224900
W:www.britishrenewables.com

Project:
Rush Wall Farm Solar Park

Location:
Rush Wall Farm
Redwick, Nr Newport
Gwent
NP26 3DX

Title:
DNO Access Road Section

Scale: 1:20 @A3

Issue Notes:
Initial Issue

BSR Energy

Drawn By: AK
Issue Date: 16/10/19
Checked By: MB
Checked Date: 16/10/19
Approved By: AW
Approved Date: 16/10/19

Drawing Number:
1409-0208-10

Drawing Status: Issued For Approval
Issue: 01

Appendix F: JBA tidal flood risk analysis report

Rush Wall Solar Farm: Tidal Flood Risk Analysis

Draft Report

April 2020

www.jbaconsulting.com

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Revision history

Revision Ref/Date	Amendments	Issued to
23/04/2020	Draft Report	Gareth Owen

Contract

This report describes work commissioned by Gareth Owen, on behalf of Yellow Sub Geo Ltd, by a contract dated 09 March 2020. Yellow Sub Geo Ltd representative for the contract was Gareth Owen. Callum Rowett and Amy Welch of JBA Consulting carried out this work.

Prepared by .... Callum Rowett BSc (Hons) MSc

Analyst

Prepared by .... Amy Welch BSc (Hons) MSc PhD

Analyst

Reviewed by .... Ian Gaskell BSc MSc CMarSci CSci

Senior Analyst

Purpose

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JBA is aiming to reduce its per capita carbon emissions.

Contents

List of Figures

List of Tables

Abbreviations

AEP	Annual Exceedance Probability
CFBD	Coastal Flood Boundary Dataset
EurOtop	European Overtopping Manual
FCA	Flood Consequence Assessment
JBA	Jeremy Benn Associates
mAOD	Metres above Ordnance Datum
MDA	Maximum Dissimilarity Algorithm
NRW	National Resource Wales

1 Introduction

1.1 Background

JBA were commissioned by Yellow Sub Geo Limited to undertake tidal flood risk analysis for a proposed solar park development at Rush Wall, Magor, NP26 3DX (Figure 1-1). This flood risk analysis is intended to support a Flood Consequence Assessment (FCA) and accompany an application for planning permission for the development.

The site is located in Flood Zone 3 of the current National Resources Wales (NRW) flood map and defined as having an undefended annual risk of flooding more than 1 in 200, or 0.5% Annual Exceedance Probability (AEP), but protected by flood defences.

In late 2016, JBA completed the 'Caldicot and Wentlooge Coastal Modelling Study' for NRW. This study used the very latest methods in wave modelling, wave overtopping, breach analysis and flood inundation modelling. The model domain is shown on Figure 1-1, and covers the proposed development.

In 2018, a new extreme sea level dataset was released as part of the Coastal Flood Boundary Dataset (CFBD). To assess flood risk to the proposed development, it was necessary to update the existing Caldicot tidal model to account for the latest climate change guidance and extreme sea level estimates. It was also necessary to investigate flood risk over the lifetime of the proposed development, by simulating climate change for the future years 2055 and 2065.

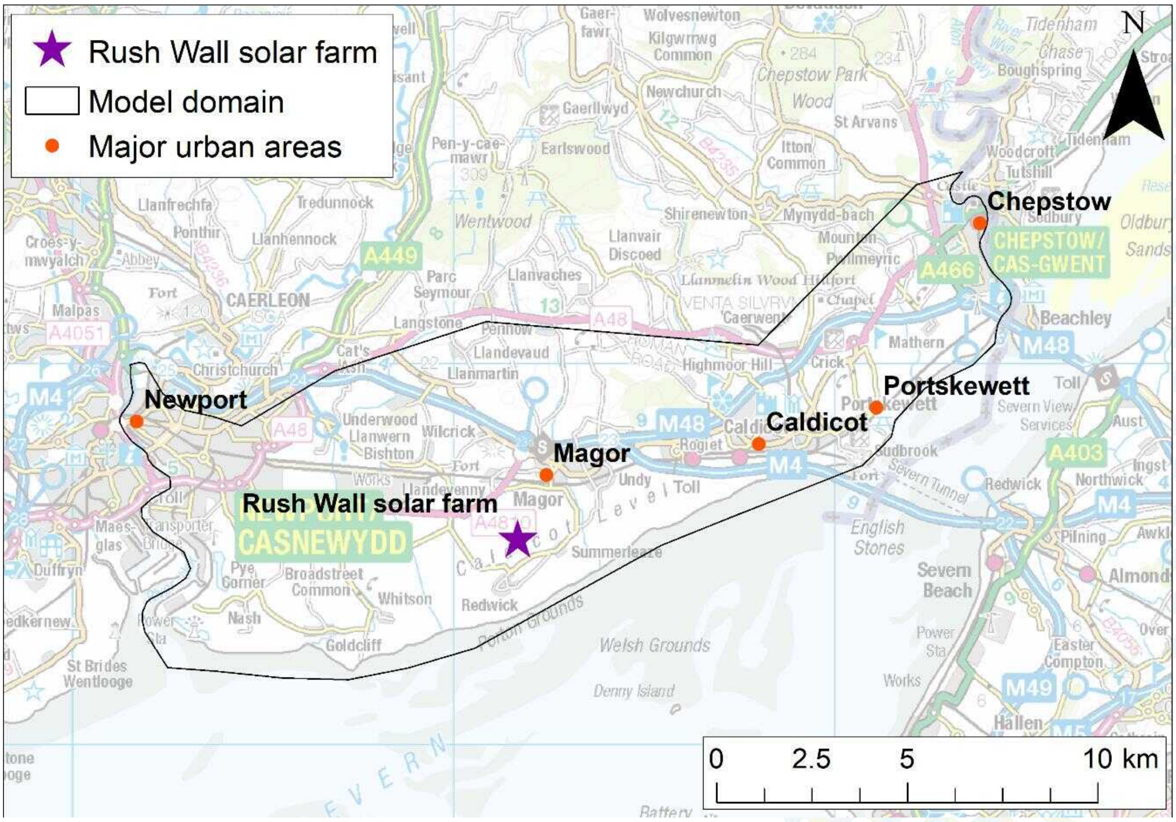

Figure 1-1: Proposed development location

2 Boundary conditions

2.1 Extreme sea levels

In 2018, a new extreme sea level dataset was released as part of the Coastal Flood Boundary Dataset (CFBD)[1]. This dataset provides extreme sea levels for a series of AEPs with a base year of 2017. The existing modelling used extreme sea levels with a 2014 base year. These sea levels were uplifted using sea level rise estimates as described in Chapter 2.2 and used in the modelling process to assess flood risk to the proposed solar development.

2.2 Sea level rise uplifts

Extreme sea levels were uplifted from a 2017 base year to the future epochs of 2055 and 2065. This enabled model simulations to take account of the potential impact of climate change over the lifetime of development as required by TAN15.

Using TAN15 guidance, sea level rise uplift values from a 2017 base year are detailed in Table 2-1.

These levels were used in the wave emulation, overtopping and flood inundation modelling as described in Chapters 3, 4 and 5 respectively.

Table 2-1: Sea level rise climate change uplifts

Epoch	Uplift (m)
2055	+0.27
2065	+0.39

2.2.1 Wind speed uplifts

Wind speeds were increased by 10% for the 2055 and 2065 epochs from that of the present-day base year in-line with UK Climate Projections 2009 (UKCP09) sensitivity guidance.

1 Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (2018). Environment Agency. Scottish Environmental Protection Agency. National Resources Wales.

3 Wave Emulation

3.1 Background

This study used the offshore Monte Carlo sample of waves, winds and water levels from the 2016 JBA study. This dataset was adjusted from base years of 2014 and 2067, to account for climate change to the year 2055 and 2065 using TAN15 guidance. This involved the addition of 0.27m and 0.39m to the water levels and increasing wind speeds by 10% for both event sets. The dataset already included wave height uplifts, so these were not modified.

In the 2016 study, a Maximum Dissimilarity Algorithm (MDA) was used to select 1,000 representative events from the Monte Carlo dataset. The selection of representative events was simulated in the wave model and would characterise the full range of multivariate conditions. From this selection of wave model runs, emulators were trained to reproduce the relationships between the offshore and nearshore waves. The trained emulators were then used to rapidly predict the nearshore conditions using the offshore Monte Carlo sample.

3.2 Updated nearshore wave climate

The emulators that were created as part of the 2016 study were used to transpose the adjusted 2055 and 2065 offshore Monte Carlo event set to the nearshore.

Before doing so, the ability of the existing emulator functions used to predict the nearshore conditions was tested by plotting the emulated results against the original wave model results. The result, and closeness to the modelled epochs and data, showed the emulators performance as suitable for use within this model update.

4 Wave Overtopping

4.1 Background

Once the nearshore wave and water level climate was updated for the 2055 and 2065 epochs, it was necessary to simulate these conditions in a wave overtopping model to determine wave overtopping discharges. The overtopping model required the nearshore wave and water level climate along with a defence schematisation, that would define the defence geometry for specified lengths of defence. The same overtopping model as used in the existing study was used; the European Overtopping Manual (EurOtop) Neural Network 1 tool. This tool uses a database of lab and field tests of different defence geometries and wave and water level combinations to return a mean overtopping discharge. The wave overtopping discharges would then be simulated in a flood inundation model, in parallel with a tidal water level boundary, to map flood risk to the proposed solar development.

4.2 Defence schematisations

The defence schematisations provided by HR Wallingford in the original 2016 study were reused as part of this project, as defences were not updated, just the boundary conditions being applied.

The same defence toe and berm rules were applied, as in the original study, to re-assign the toe position when the water level is high, and the berm becomes out range for the EurOtop Neural Network tool. If the berm was more than 1.5 times the wave height lower than the water level, it became the toe. The locations of the defence schematisations and corresponding wave overtopping profiles can be found in Figure 4-1 and Figure 4-2.

The 23 discrete overtopping profiles modelled along the coastline are detailed in Table 4-1.

4.3 Wave overtopping modelling

The wave overtopping model was simulated for the 23 defence sections using the updated wave and water level combinations for the 2055 and 2065 epochs. Wave overtopping discharges were generated for the 0.5 and 0.1% AEP events that were suitable for inclusion in the existing TUFLOW flood inundation model.

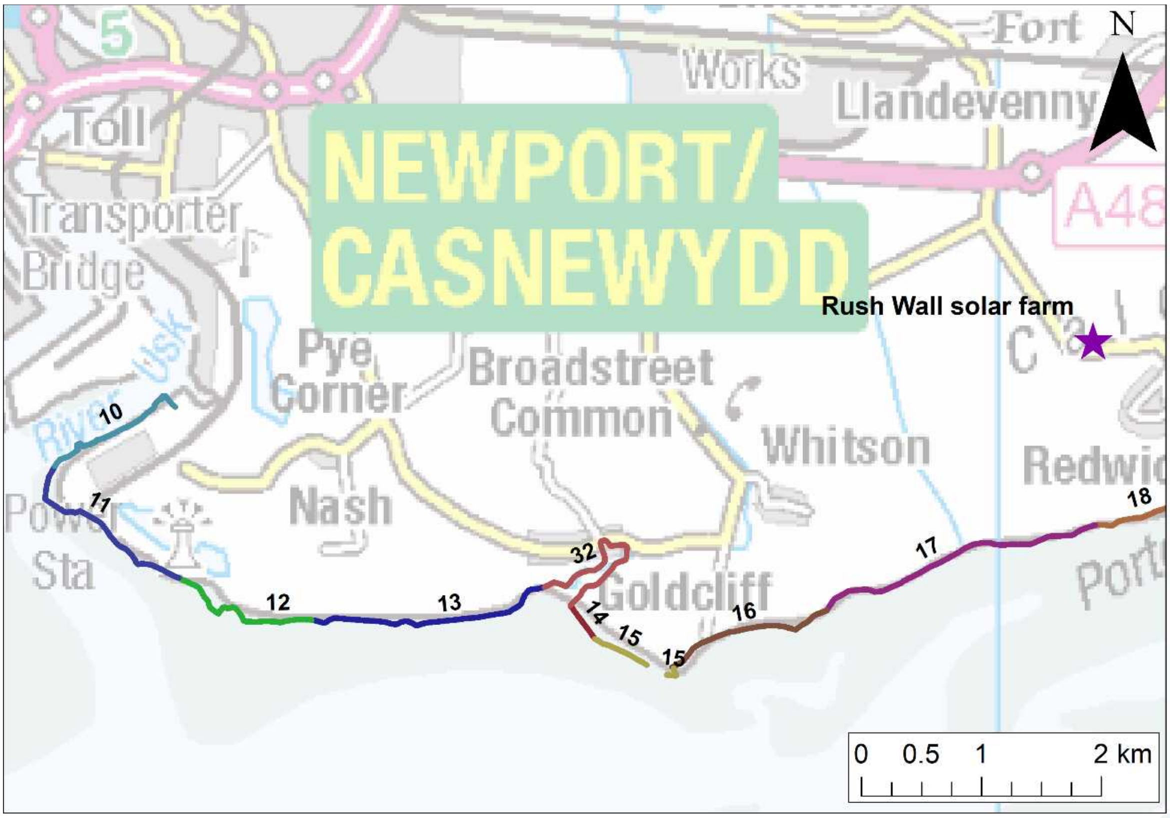

Figure 4-1: Caldicot defence schematisation locations (West)

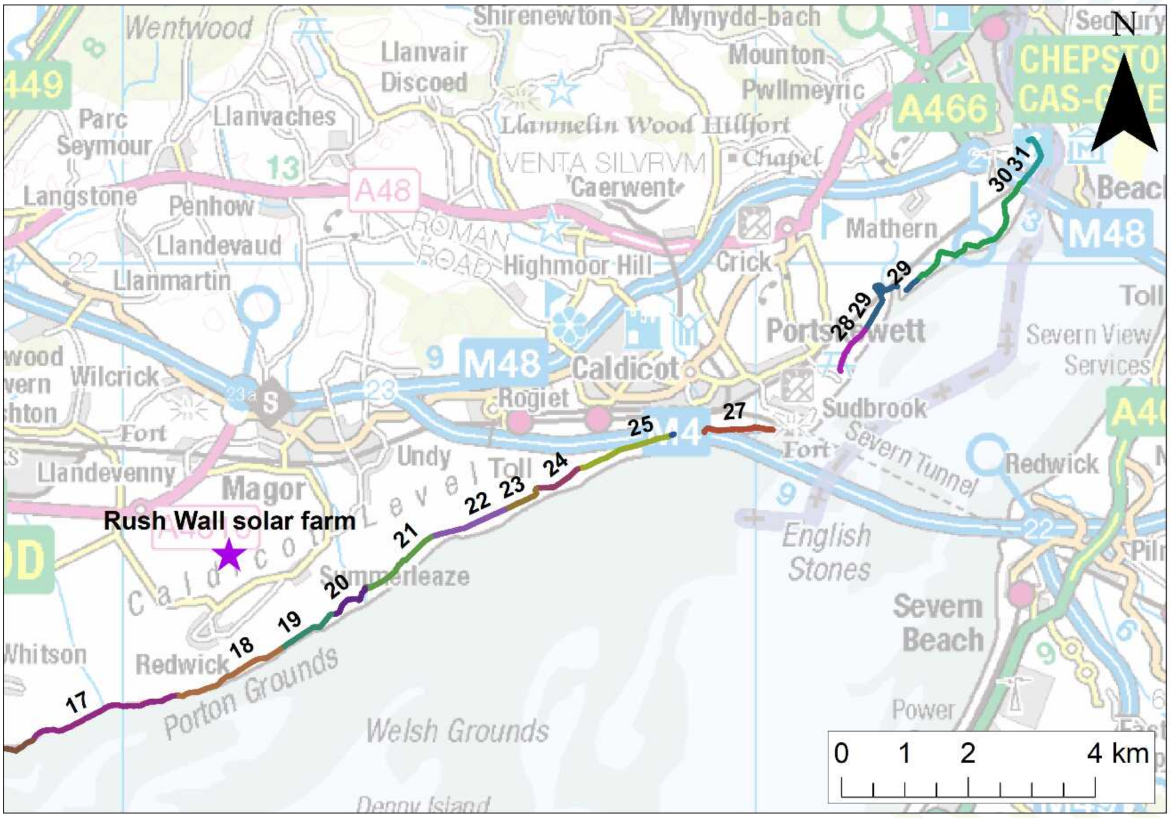

Figure 4-2: Caldicot defence schematisation locations (East)

Table 4-1: Wave overtopping profile information

Section	Toe level (mAOD)	Crest level (mAOD)	Section description
10	-2.79	8.42	Grass embankment
11	6.03	11.34	Grass embankment
12	3.80	11.85	Grass embankment
13	5.90	11.10	Rock armoured revetment fronting a wave return wall
14	6.30	9.47	Blockstone fronting a wave return wall
15	3.12	9.90	Blockstone fronting a wave return wall
16	2.68	9.83	Blockstone fronting a wave return wall
17	3.30	9.72	Blockstone fronting a wave return wall
18	3.74	9.70	Blockstone fronting a wave return wall
19	4.97	9.77	Blockstone fronting a wave return wall
20	6.40	9.78	Blockstone fronting a wave return wall
21	6.71	9.41	Grass embankment
22	6.31	9.06	Grass embankment with berm
23	5.43	9.13	Grass embankment
24	6.91	8.99	Rock armoured revetment fronting a wave return wall with berm
25	6.85	9.13	Grass embankment
26	7.98	9.30	Rock armoured revetment fronting a wave return wall
27	7.71	9.30	Grass embankment
28	7.75	8.96	Grass embankment
29	7.28	8.97	Grass embankment with berm
30	7.38	9.29	Grass embankment
31	6.01	9.05	Grass embankment with berm
32	6.32	9.11	Grass embankment

5 Flood inundation model

5.1 Background

To assess flood risk at the proposed Rush Wall solar development a flood inundation model was required to map the flood extents and depths.

The existing TUFLOW model, used as part of the 2016 'Caldicot and Wentlooge Coastal Modelling Study' for NRW, was updated and used for this study.

5.2 Model updates

The flood inundation model required updated boundary conditions, making use of the 2018 extreme sea level dataset and TAN15 sea level rise, as follows

- Wave overtopping discharges along the open coast
- Water level time-series curves applied offshore and up the up the Usk and Wye rivers
- Updated initial water levels at model start-up

The wave overtopping discharges were taken from the wave overtopping modelling undertaken as described in Chapter 4. The wave overtopping discharges were simulated in-parallel to a tidal time-series water level boundary. Using TAN15 guidance, the CFBD extreme sea level points spanning the coastal frontage between Caldicot and Wentlooge and up the Rivers Usk and Wye were identified and uplifted for use in along the flood inundation model boundary. These uplifted extreme sea level values were used to generate tidal time series curves as per the 2016 tidal modelling. The curves applied in the model are described in Figure 4-1 and located on Figure 5-1. The model boundary interpolates levels between the points to generate a spatially varying water level boundary. Note that the 2016 model used some levels from an existing ISIS model where CFBD levels were not available; this was no longer applicable as the new CFBD levels spanned the entire model domain and were therefore removed.

In addition, an amendment was made to how pump boundaries were applied in the model. From 2017 onwards the SXL option in TUFLOW is no longer supported for nodes, as such the SXL was changed to SX and the US_Invert attribute was left blank. This allows for the model to run on the latest version of TUFLOW.

Table 5-1: Sea level uplifts applied to CFB chainage points

CFBD Chainage	Epoch	Uplift (m)
382	2055	+0.2715
	2065	+0.3865
396	2055	+0.2715
	2065	+0.3865
380_05	2055	+0.2715
	2065	+0.3865
380_9	2055	+0.2715
	2065	+0.3865
380_15	2055	+0.2715
	2065	+0.3865
398_10	2055	+0.2715
	2065	+0.3865

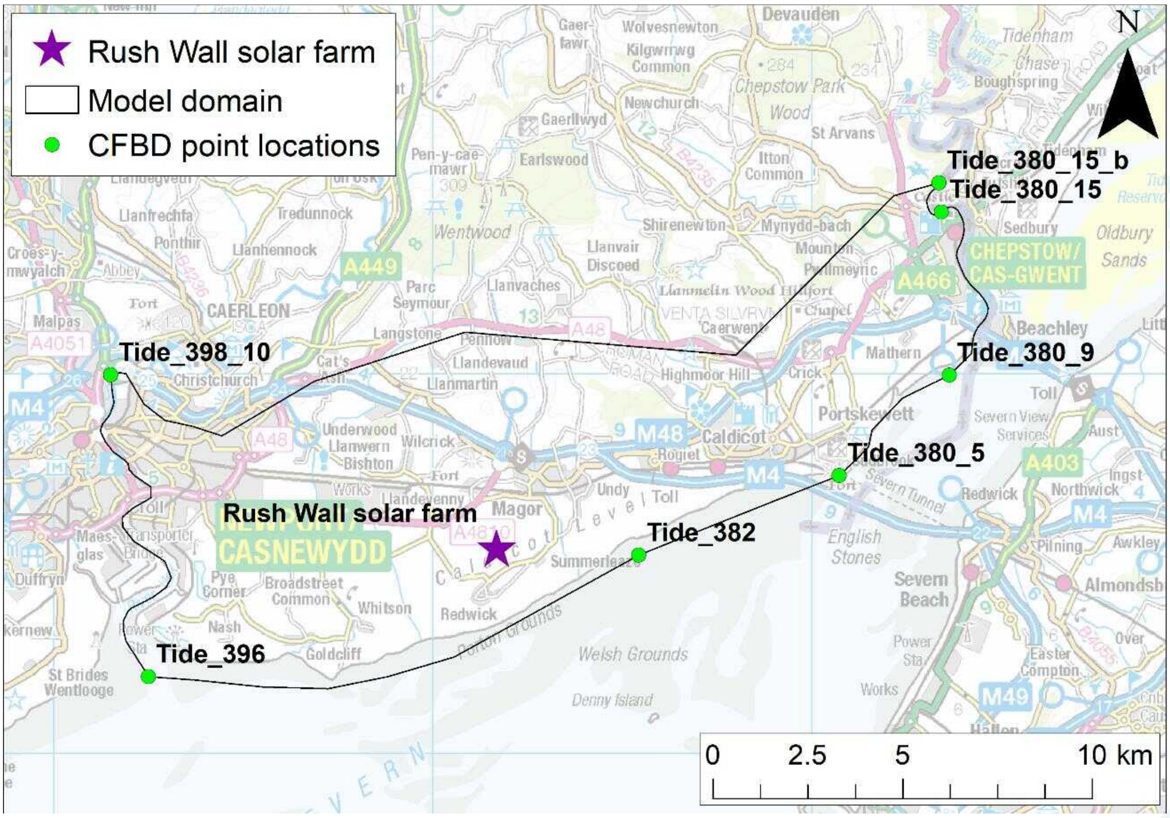

Figure 5-1: CFBD point locations applied in the model

5.3 Flood inundation simulations

The updated model was used to simulate the 0.5% and 0.1% AEP 2055 and 2065 epochs. The flood risk at the proposed development is discussed in Chapter 6.

6 Proposed development flood risk analysis

6.1 Background

This chapter discusses the model results and summarises the risk posed to Rush Wall solar farm. The 0.5% and 0.1% AEP events were simulated for the 2055 and 2065 epochs. All the model runs used the same defence locations and crest levels as per the NRW model, with only the boundary conditions having been updated.

6.2 Model results

The model flood depth grids for the 0.5% and 0.1% AEP 2055 and 2065 future epochs are shown on Figure 6-1 and Figure 6-2 respectively.

During the 0.5% AEP 2055 and 2065 epochs flood waters overtop the tidal embankment running along the banks of the Severn Estuary. During the 2055 epoch, the volume of floodwater is not large enough to generate flood flows that reach as far inland as the proposed development site boundary. During the 2065 epoch, flood water volumes are more significant, propagating from the north east due to overtopping of the tidal defence to the east of the proposed development. Flood waters reach the edge of the site boundary to depths of generally <0.10m but do not inundate the site (Figure 6-3).

During the 0.1% 2055 and 2065 epoch events, the volume of tidal floodwater that overtops the tidal embankment running along the banks of the Severn Estuary, is large enough to lead to flood waters entering the proposed development site boundary. The flood risk to the site is a consequence of wave overtopping discharges from the tidal embankment immediately south of the proposed development, and still water flooding or 'over-washing' of the defence crest levels to the east. The still water flood volumes are likely to be the larger source of flood risk, as flood waters over-wash the defence crest and travel westwards into Whitewall Common, where they pass over Whitewall Road, and eventually impact the site from the north east. As a result, flood depths are largest in the north east of the site boundary.

Figure 6-4 shows flood depths within the proposed development boundary during a 0.1% AEP 2055 event. Roughly 70% of the site is inundated, although mostly to depths of <0.25m. Towards the north of the site flood depths increase, up to roughly 0.5m, and the very northern tip reaches depths of just over 1.1m.

Figure 6-5 shows flood depths within the proposed development boundary during a 0.1% AEP 2065 event, where roughly 95% of the site is inundated. Flood depths across the site vary. The bulk of flood depths are between 0.25 and 0.50m, while towards the north of the site flood depths increase and range between 0.50 and 1.50m in the very northern most point.

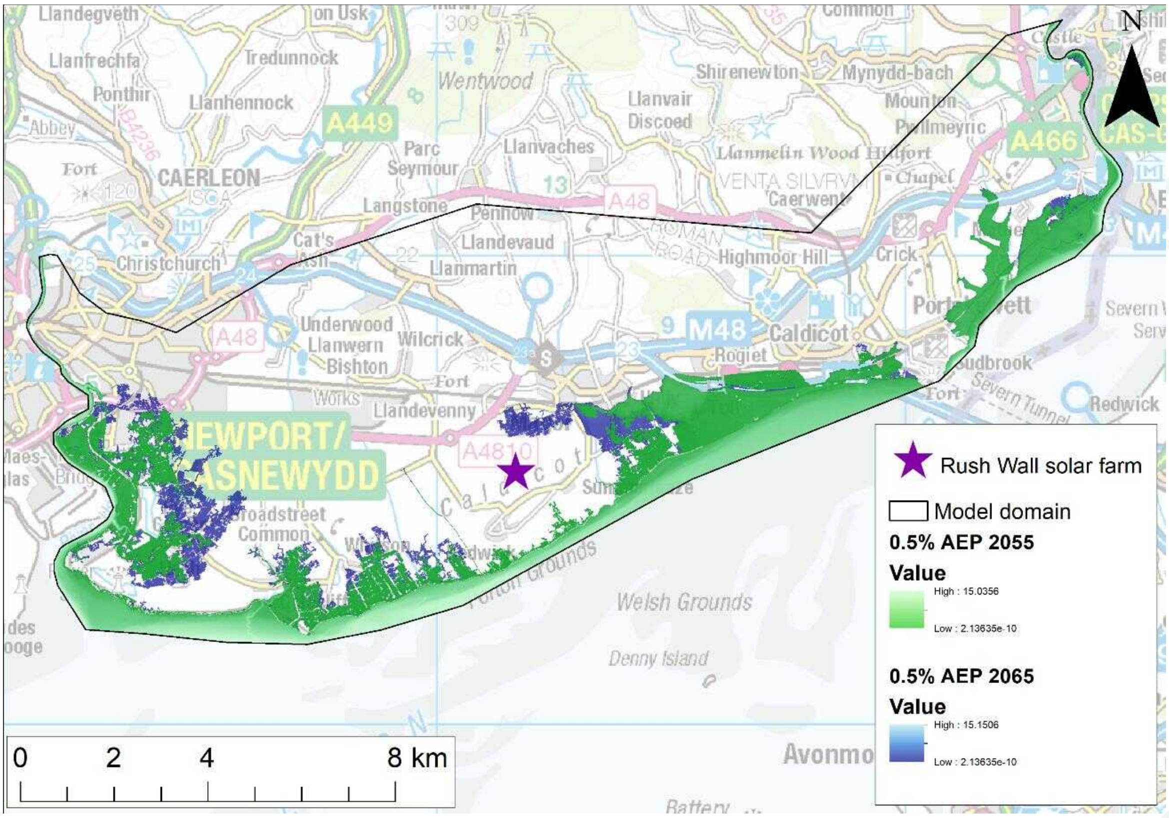

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Figure 6-1: 0.5% AEP 2055 and 2065 model domain flood depth grids

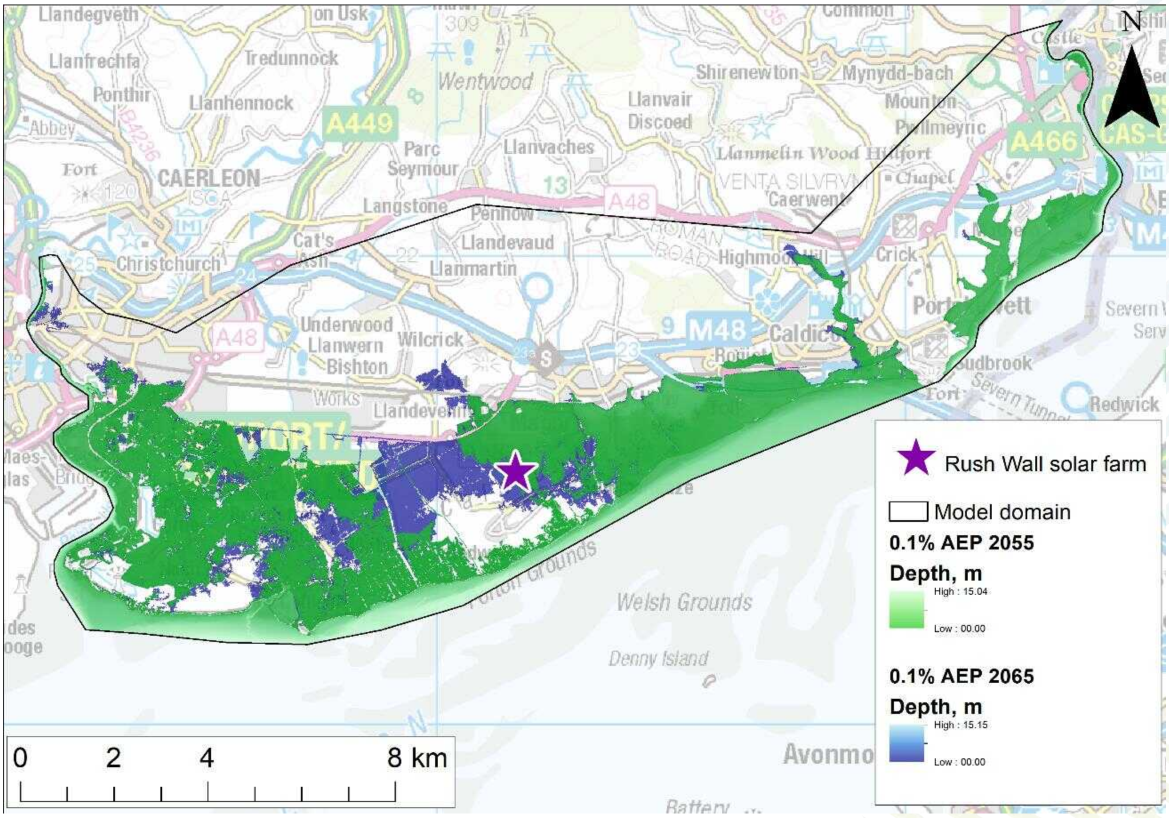

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Figure 6-2: 0.1% AEP 2055 and 2065 model domain flood depth grids

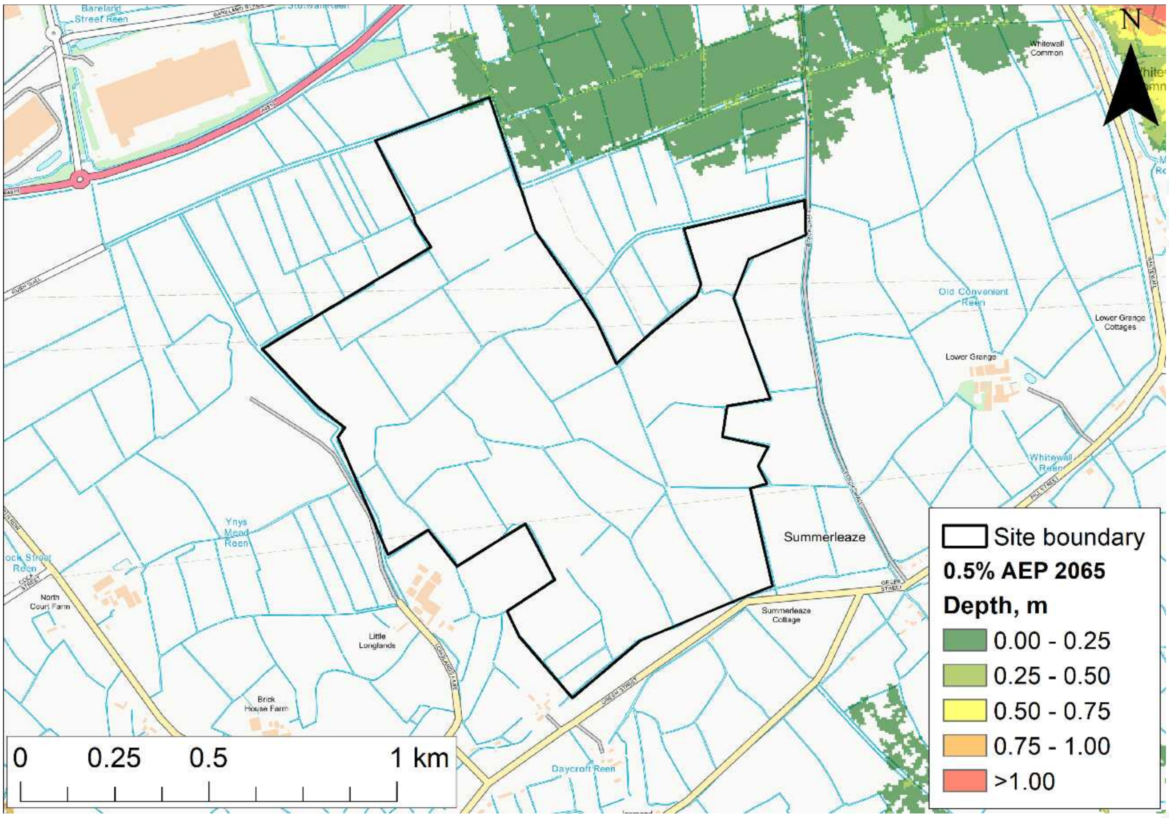

Figure 6-3: 0.5% AEP 2065 site boundary flood depths

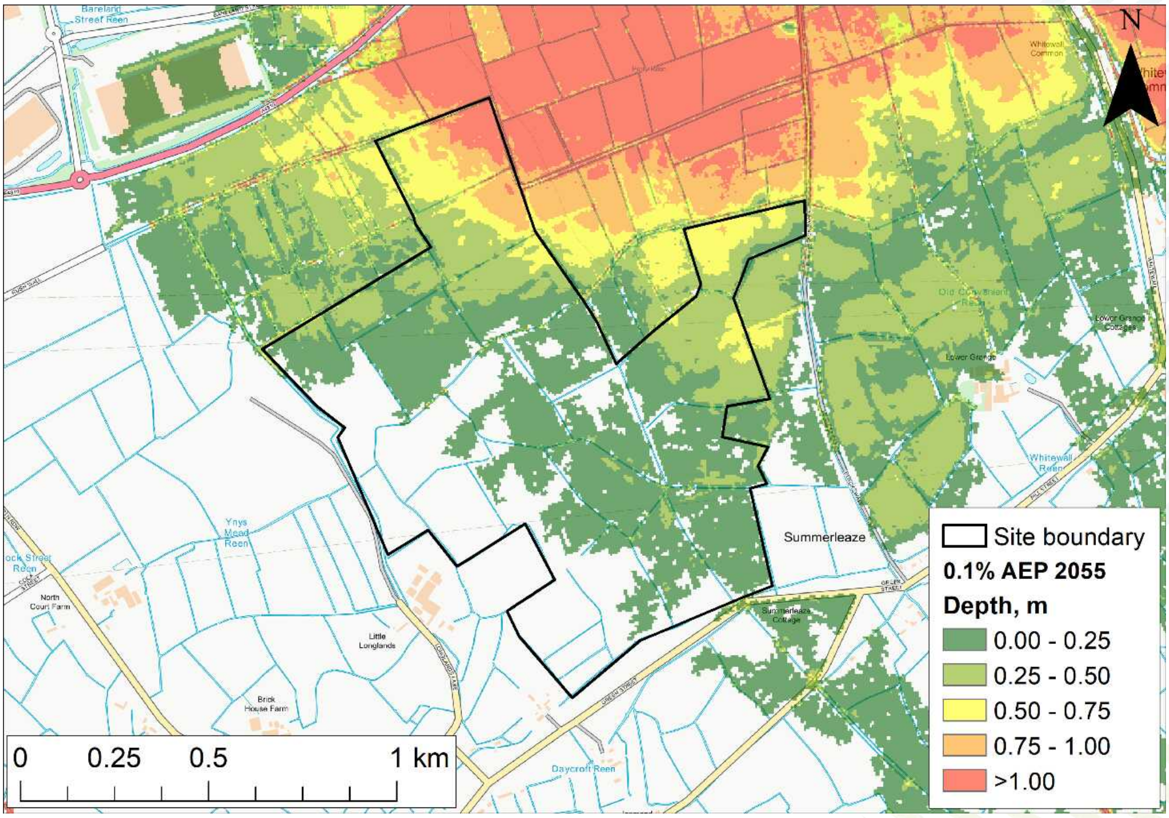

Figure 6-4: 0.1% AEP 2055 site boundary flood depths

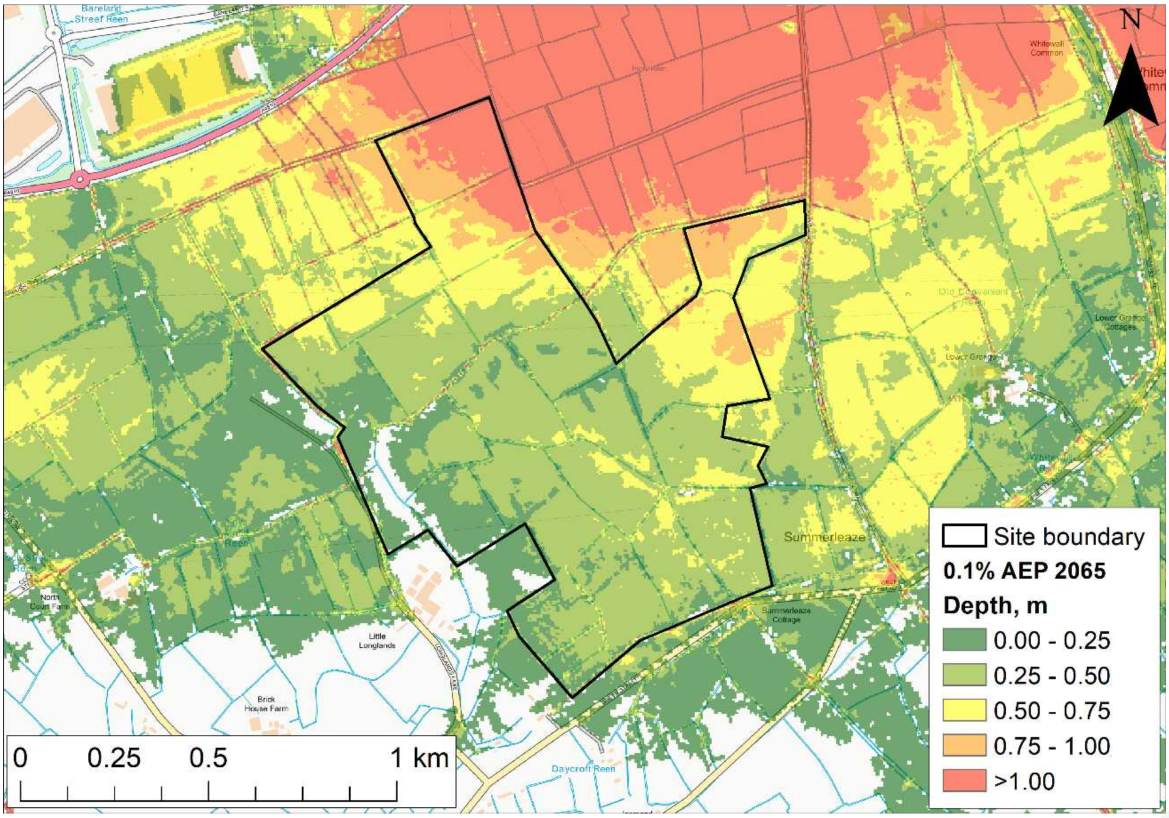

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Figure 6-5: 0.1% AEP 2065 site boundary flood depths

7 Findings and conclusions

The following findings and conclusions were made:

- The main flood risk to the site is from the tidal Severn Estuary, and a consequence of two mechanisms:
    - Wave overtopping volumes passing over the tidal defences; and
    - Still water or over-washing of the tidal defences where extreme water levels exceed the defence crest level. The modelled flood outputs have shown this to occur to the south east of the proposed development site as flood waters travel westwards into Whitewall Common, where they pass over Whitewall Road, and eventually impact the site from the north east.
- Flood modelling shows the proposed development site to be flood free during the 0.5% AEP 2055 and 2065 epochs. Flood waters reach the edge of the site boundary to the north east during the 2065 epoch.
- The proposed development site is potentially vulnerable to flooding during a 0.1% AEP event under climate change conditions projected to the 2055 and 2065 epochs:
    - During the 0.1% AEP 2055 event, roughly 70% of the site is inundated. Most flood depths are <0.25m, while towards the north of the site flood depths increase up to roughly 0.5m, and the very northern tip reaches depths of just over 1.1m.
    - During the 0.1% AEP 2065 event, roughly 95% of the site is inundated. Flood depths across the site vary. The bulk of flood depths are between 0.25 and 0.50m, while towards the north of the site flood depths increase and range between 0.50 and 1.50m in the very northern most point.

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