Technical Appendix 4: Flood Risk and Drainage Impact Assessment

Longhedge Solar Farm

30/11/2022

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EXECUTIVE SUMMARY

4.1. This Flood Risk and Drainage Impact Assessment (FRA-DIA) has been carried out for the Proposed Development consisting of a 49.9MW solar farm and associated infrastructure on lands between Hawksworth and Thoroton, circa 15.5km east of Nottingham, Nottinghamshire.

4.2. The Proposed Development is for solar power generation that is considered 'essential infrastructure' development under the National Planning Policy Framework (NPPF). Based on NPPF Planning Practice Guidance a sequential test is first required to guide development to Flood Zones 1, then Zone 2, and then Zone 3. In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood whilst also passing the exception test.

4.3. The River Smite runs from southwest to northeast approximately 550m from the east boundary of the Application Site before its confluence with the River Devon approximately 2.2km downstream of the Application Site.

4.4. The River Smite 'Main River' runs approximately 550m east of the Application Site; The Gutter Drain runs northeast through the west of the site; and two unnamed field drains, drain the east of the site.

4.5. Results from EA modelling indicate that the Application Site is located entirely outside Flood Zone 3b, but lower ground levels of the Application Site are within Flood Zone 3a. A sequential approach to development has therefore been undertaken, with vulnerable infrastructure sited outside Flood Zone 3a, where possible.

4.6. The FFL of all electrical infrastructure (e.g. inverters, control buildings, etc) will be raised above the peak climate change allowance water level whilst all panels will also be located above this level. This will result in the Proposed Development being able to remain operational in times of a design event (1 in 100 year). The development will be able to remain operation in time of a 1 in 100 year flood event and therefore passes the main part of the exception test. In addition, all other parts of the exception test have been passed and therefore the Proposed Development should be deemed appropriate in flood risk terms.

4.7. The Application Site is not assessed to be at significant risk of flooding from groundwater or surface water flooding with the design of the Application Site carefully considered to mitigate against any potential risks. Groundwater level measurements taken during site investigations will need to be taken into account in the detailed design of the Application Site. If there are elevated groundwater levels, suitable precautions may need to be considered during detailed design.

4.8. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure (0.83% of the overall

Application Site) proposed for the Application Site. However, drainage in the form of SuDS has been proposed so the post developed site discharges surface water at the greenfield run off rate (QBar). Due to large area of the Grid Substation, and the dispersed nature of the impermeable development of the rest of the Proposed Development, drainage schemes for these have been designed separately.

4.9. It is proposed to construct a network of swales around the Application Site and a detention pond at the grid substation location. The idea is to capture any overland flow in the SuDS device prior to releasing into the natural surface water system. The design volume of the SuDS scheme will not only adequately mitigate the increase in flow rates as a result of the minor increase in impermeable area but also provide significant improvement.

4.10. The SuDS features will be implemented during the construction phase of the Proposed Development and will be planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

4.11. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Swales or similar shall be utilised to collect runoff from access tracks, where required, however these will be designed at the detailed design stage. Where swales are utilised, check dams formed from gravels and other excavated material shall be placed in the swale at frequent intervals; and,
- Inverter Substations, etc: Filter strips will surround the concrete bases of the ancillary buildings to capture any runoff from the roofs. This will be discharged to a percolation area or into the sites drainage network where it is close enough. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water to soak into the underlying subsoils.

4.12. This FRA and DIA demonstrates that the Proposed Development will not increase flood risk away from the Application Site during the construction, operation and decommissioning phases. The Proposed Development is therefore considered to be acceptable in planning policy terms.

INTRODUCTION

Background

4.13. This Flood Risk Assessment ("FRA") has been prepared by Neo Environmental Limited, on behalf of Renewable Energy Systems (RES) Ltd ("the Applicant") in support of a planning application submitted to Rushcliffe Borough Council ("the Council") for a proposed 49.9MW solar farm development (the "Proposed Development") on lands between Hawksworth and Thoroton, circa 15.5km east of Nottingham, Nottinghamshire (the "Application Site"); the approximate centre point of which can be found at Grid Reference E476129, N343467.

4.14. Please see **Figure 4 of Volume 2: Planning Application Drawings** for the layout of the Proposed Development.

Development Description

4.15. The Proposed Development will consist of the construction of a c. 49.9MW solar farm. It will involve the construction of bi-facial ground mounted solar photovoltaic (PV) panels, new access tracks, underground cabling, perimeter fencing with CCTV cameras and access gates, 2x temporary construction compounds, substation and all ancillary grid infrastructure and associated works.

Site Description

4.16. The Application Site is located in a semi-rural setting on lands between the settlements of Hawksworth (0.1km west) and Thoroton (0.2km southeast), circa 15.5km east of Nottingham, Nottinghamshire. (See **Figure 1** of **Volume 2: Planning Application Drawings** for further detail).

4.17. Centred at approximate Grid Reference E476129, N343467, the Proposed Development Site comprises nine fields covering a total area of c. 94.24hectares (ha), although only 37.7ha of this area is required to accommodate the solar arrays themselves, with the remaining area being used for ancillary infrastructure and mitigation and enhancement measures. The Proposed Development Site covers low lying lightly undulating agricultural land with an elevation range of c. 20m to 25m AOD. Internal field boundaries comprise, hedgerows, tree lines and several linear strips of woodland shelter belt. External boundaries largely consist of mature to lower hedgerows with individual trees and some evident gaps. In terms of existing infrastructure; electricity pylons extend north-south through fields 5, 6 & 8, whilst electricity lines pass northwest to southwest through fields 4, 5, 6 & 9.

4.18. The Application Site will be accessed via the creation of a new entrance off the linear public highway Thoroton Road. The vegetation is set back from the road verge by a few metres and therefore visibility will not be an issue. Appropriate visibility splays are included within the CTMP.

4.19. The haul route will be from the A46 to the southwest of the Application Site. The vehicles will exit the A46, signposted A6097 (Mansfield), take the 4th exit at the roundabout onto Bridgford Street followed by the 1st exit at the next roundabout onto Fosse Way. Vehicles will travel along this road for approximately 1.5km to the next roundabout, where they will take the 2nd exit onto Tenman Lane. This road will be travelled on in an eastern direction for approximately 3.2km before taking a left hand turn onto Hawksworth Road and vehicles will travel along here for approximately 2km before taking a right hand turn onto Thoroton Road. Vehicles will travel in a southeast direction for approximately 0.9km before turning left into the Application Site.

4.20. There is one recreational route located within the Proposed Development Site (Bridleway 1 & 6 that pass through the northern fields), and several located close by (**See Figure 3 of Vol 2: Planning Drawings**). National Cycle Network (NCN) route 64 shares the minor road on the east side of the Proposed Development Site.

4.21. The Proposed Development Site is mostly contained within Flood Zone 1 (at little or no risk of fluvial or tidal / coastal flooding), however there are some areas of Flood Zone 2 and 3a which follow the watercourse/drains within the site and have been carefully considered during the design phase.

Scope of Report

4.22. The aim of this assessment is to identify the baseline geological and hydrological conditions of the site and surrounding area; to assess the potential impacts of the Proposed Development during the construction, operation and decommissioning phases; to identify the risk of flooding at the proposed Application Site; and to recommend mitigation measures where appropriate.

4.23. This Flood Risk Assessment has been prepared in accordance with National Planning Policy Guidelines.

4.24. This report is supported by the following figures and appendices:

- Appendix 4A Figures:
  - Figure 4.1: EA Flood Map for Planning
  - Figure 4.2: Flood Zone 3b
  - Figure 4.3: Topographic Survey at the Application Site
  - Figure 4.4: Watercourses at the Application Site
  - Figure 4.5: Flood Zone 3a
  - Figure 4.6: Flood Zone 3a + 20% Climate Change Allowance

  - Figure 4.7: 1 in 100 Year Surface Water Flood Depths
  - Figure 4.8: Site Access with 1 in 50 year and 1 in 100 + 20% Climate Change Allowance
  - Figure 4.9: Hydrology Photo Locations
- Appendix 4B: Hydrology Photos
- Appendix 4C: Flow Report (Substation)
- Appendix 4D: Flow Report (Solar Farm)
- Appendix 4E: BRE Infiltration Report
- Appendix 4F: Outline SuDS Designs
- Appendix 4G: Foul Drainage Assessment Form

Statement of Authority

4.25. This FRA and DIA has been produced by Michael McGhee and Tom Saddington of Neo Environmental and Lee Ruddick of Kaya Consulting. Having completed a civil engineering degree in 2012, Michael has worked on over 1GW of renewable development flood risk and drainage impact assessments across the UK and Ireland whilst working towards becoming a Chartered Engineer. Michael has over 10 years of environmental consultancy experience, mainly producing technical assessments for energy projects. Tom has an undergraduate degree in Bioengineering and graduated with an MSc in Environmental and Energy Engineering in January 2020. He has been working on various technical assessments including flood risk assessment reports for numerous renewable developments in Ireland and the UK. Lee has a Masters degree in Hydrology and Water Management, having graduated in 2019 specialising in flood risk and has since worked on numerous flood risk assessments in both the UK and Europe.

Consultation

4.26. A pre-application request was submitted to Rushcliffe Borough Council and a response was received on the 25th March 2021 from the Principal Development Management Officer. The response stated:

"The application site is within Flood Zones 2 and 3. In this instance, a flood risk assessment would be required. Given that part of the application site is located within zones 2 and 3 the Borough Council will need to have information to allow consideration of the sequential test as well as an exception test."

4.27. The Environment Agency (EA) was also consulted regarding the application and responded with the following;

"We have had overtopping of the River Smite downstream of the River Smite. This has been a result of channel exceedance due to high flows on the River Smite in combination with elevated levels on the River Trent restricting outflows. The points of overflowing and paths of the flood water closely followed the flood outlines available on the floodmaps"

4.28. Nottinghamshire County Council (NCC) were also consulted regarding the application and responded with the following;

"I can confirm we do not hold any specific records relating to surface water flooding at this location, however, it must be noted that only reports of flooding directly made to the team are recorded, we advise that you contact all relevant RMA's to ensure a holistic picture is found of the site."

4.29. All of the points raised above were taken into consideration within this report.

LEGISLATION

The National Planning Policy Framework (NPPF)[1]

4.30. The NPPF was implemented by the Department for Communities and Local Government (DCLG) in 2012 and was most recently updated in 2021. The NPPF sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally-prepared plans for developments can be produced.

Flood Zones and Vulnerability

4.31. Flood risk to a development site is classified using a sequential characterisation of risk. The NPPF considers flood risk as a function of both probability and vulnerability. The vulnerability classifications are used in conjunction with Table 1: Flood Zones of the "*Planning Practice Guidance to the National Planning Policy Framework*" which detail how Flood Zones relate to planning policy. Table 4 -2 summarises flood zone and vulnerability compatibility. These flood zones are found on the EA's 'Flood map for planning' which has been created from large-scale modelling. The EA 'Flood map for planning' does not account for the influence of flood defence schemes or residual risks (those remaining after applying the sequential approach to the location of development and taking mitigating actions). Flood Zones apply to rivers designated as 'Main Rivers' by the EA, these are usually larger rivers and streams and are the responsibility of the EA. Other watercourses are known as 'Ordinary Watercourses' and are represented in the 'Flood Risk from Surface Water Maps'. Ordinary watercourses are the responsibility of the Lead Local Flood Authority (LLFA), typically a County Council.

Sequential and Exception Tests

4.32. The NPPF necessitates that a sequential approach to site selection is undertaken so that development is (where reasonably possible) situated where the risk of flooding is at its lowest. This is ensured by applying the 'Sequential Test' (by Local Planning Authorities) and in some instances, the 'Exception Test'. The Exception Test is applied when there are no reasonably available sites in Flood Zone 1 and in some cases Flood Zone 2 when the proposed development provides wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall. Details of when the exception test is applicable to development can be found in Table 1: Flood Zones of the "*Planning Practice Guidance to the National Planning Policy Framework*".

[1] UK Government, National Planning Policy Framework, 2012 (Updated 2021), Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005759/NPPF_July_2021.pdf

Local Planning Authority (LPA)

4.33. The role of the LPA is to set out the Local Plan and the framework for local development in the council area. The NPPF with its associated Planning Policy Guidance (PPG) states that LPAs are responsible for ensuring that flood risk is managed using a sequential risk approach. To achieve this, LPAs undertake Strategic Flood Risk Assessments (SFRA) which accompany their Local Plans.

4.34. Level 1 SFRAs provide a review of the risk of flooding from all sources across a council area, including flooding from rivers, surface water, groundwater, sewers and other artificial sources, for the use in the development of policy, planning, and importantly, the application of the Sequential Test.

4.35. Where there are no alternative sites in areas of lower flood risk, it may be necessary to develop in areas at flood risk. In these cases, the LPA ensures that development is appropriately flood resilient and resistant, safe for the development lifetime, and that flood risk is not increased as a result of the development. The LPA should seek out flood risk management opportunities that reduce the cause and potential impacts of flooding.

Rushcliffe Borough Council

4.36. Rushcliffe Borough Council is part of The Greater Nottingham Strategic Flood Risk Assessment Partnership, which sees collaboration across Local Authorities to manage flood risk at the strategic level. The Greater Nottingham Strategic Flood Risk Assessment was adopted in 2008 and has since been updated with the inclusion of Greater Nottingham Strategic Flood Risk Assessment Addendum adopted in 2017[2]. The SFRA and associated addendum provide guidance on the approach that should be taken to manage flood risk and the water environment as part of new development proposals.

Strategic Flood Risk Assessment (SFRA)[2]

4.37. The Greater Nottingham SFRA assessment is based upon historic flood records, hydraulic modelling data and the EA's Flood Map for Planning. The assessment shows that parts of the Application Site lie within Flood Zone 2 and Flood Zone 3.

4.38. Pluvial flood maps within the SFRA indicate that parts of the site are predicted to be at pluvial flood risk, however these areas are largely constrained to drainage channels within the site.

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[2] Greater Nottingham Strategic Flood Risk Assessment Addendum (September 2017), Available at https://documents.nottinghamcity.gov.uk/download/5574

Greater Nottingham Strategic Flood Risk Assessment (June 2006) Available at https://www.nottinghamshireinsight.org.uk/d/aAXCKH7

4.39. Groundwater flood maps show that the majority of the Application Site has between a 50-75% chance of groundwater flooding, with the remainder classified as between 25-50%.

The Lead Local Flood Authority (LLFA)

4.40. Nottinghamshire County Council is the Lead Local Flood Authority. Under the Flood and Water Management Act of 2010[3] the LLFA has the duty of leading the coordination of flood risk management from surface water, groundwater and ordinary watercourses in the local area. LLFAs are county councils and unitary authorities. LLFAs are required to prepare and maintain a strategy for local flood risk management in their areas, coordinating views and activity with other local bodies and communities through public consultation and scrutiny, and delivery planning. They must consult Risk Management Authorities and the public about their strategy. LLFAs are also responsible for carrying out work to manage local flood risks in their areas. Under the Land Drainage Act of 1991 they have the power to regulate ordinary watercourses to maintain a proper flow by issuing consents for altering features on ordinary watercourses and enforcing obligations to maintain flows in watercourses. They undertake a statutory consultee role providing technical advice on surface water drainage to local planning authorities regarding major developments (10 or more dwellings) and play a lead role in emergency planning and recovery after a flood event.

Summary of Relevant Legislation

4.41. A Summary of key legislation and requirements relating to the proposed solar farm development is provided below:

- The EA indicative flood map shown below in **Figure 4.1: Appendix 4A** suggests the Application Site is situated within Flood Zones 2 and 3.
- Results extracted from EA Modelling shown below in **Figure 4.2: Appendix 4A** show that the Application Site is outwith Flood Zone 3b entirely and is therefore situated in Flood Zone 2 and Flood Zone 3a.
- The Proposed Development is > 1 Ha in area and is therefore classed as a 'Major Development' by the EA.
- The Proposed Development is for solar power generation that is considered 'essential infrastructure' development under the National Planning Policy Framework.

[3] UK Government (2010). Flood Water a Management Act 2010. Available at https://www.legislation.gov.uk/ukpga/2010/29/contents

4.42. Based on NPPF Planning Practice Guidance a sequential test is first required to guide development to Flood Zones 1, then Zone 2, and then Zone 3. In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

Review of Local Plan Policy

Rushcliffe Borough Council Local Plan Part 2: Land and Planning Policies

4.43. The Rushcliffe Borough Council Local Plan Part 2: Land and Planning Policies (2019)[4] is the adopted plan at present for detailed policies for use in the determination of planning applications.

Table 4 - 1: Local Plan Flood Management Policies/Objectives (key points summarised)

Planning Policy/Objective	Comment
POLICY 17 Managing Flood Risk *"Planning permission will be granted for development in areas where a risk of flooding or problems of surface water disposal exists provided that:* *the sequential test and exception test are applied and satisfied in accordance with the National Planning Policy Framework and National Planning Policy Guidance;* *and development does not increase the risk of flooding on the site or elsewhere, including through increased run-off due to areas of hardstanding, or reduction in ground water storage as a result of basements.* *Development proposals in areas of flood risk will only be considered when accompanied by a site specific flood risk assessment. Proposals will be expected to include mitigation measures which protect the site and manage any residual flood risk, such as flood resistance/resilience measures and the provision of safe access and escape routes."*	The FRA will demonstrate that a Sequential approach has been undertaken when siting infrastructure within the application site. Should the Proposed Development be within Flood Zone 3a then an exception test will be performed.
POLICY 18 SURFACE WATER MANAGEMENT	A Drainage Impact Assessment will include the

4 Rushcliffe Borough Council Local Plan Part 2: Land and Planning Policies 2019. Available at https://www.rushcliffe.gov.uk/media/1rushcliffe/media/documents/pdf/planningandbuilding/planningpolicy/lapp/adoption/Rushcliffe%20LP%20Part%202_Adoption%20version.pdf

"To increase the levels of water attenuation, storage and water quality, and where appropriate, development must, at an early stage in the design process, identify opportunities to incorporate a range of deliverable Sustainable Drainage Systems, appropriate to the size and type of development. The choice of drainage systems should comply with the drainage hierarchy. *Planning permission will granted for development which:* *a) is appropriately located, taking account of the level of flood risk and which promotes the incorporation of appropriate mitigation measures into new development, such as sustainable drainage systems;* *b) reduces the risk to homes and places of work from flooding;* *c) delivers a range of community benefits including enhancing amenity (ensuring a safe environment) and providing greater resistance to the impact of climate change;* *d) contributes positively to the appearance of the area* *e) accommodates and enhances biodiversity by making connections to existing Green Infrastructure assets;* *f) retains or enhances existing open drainage ditches*.	design of SuDS. This will seek to incorporate features which enhance the biodiversity of the site using SuDS.
POLICY 19 DEVELOPMENT AFFECTING WATERCOURSES *In order to protect, conserve and enhance watercourse corridors, the Council will support development proposals that:* *a) reconnects land to the functional floodplain and restores natural flooding processes;* *b) does not have an adverse impact on the functions and setting of any watercourse and its associated corridor;*	Gutter Drain is not a defined watercourse on the EA mapping, however an 8m riparian buffer has been included here.

c) seeks to conserve and enhance the biodiversity, landscape and recreational value of the watercourse and its corridor through good design; *d) pursues opportunities for de-culverting of watercourses. Planning permission will only be granted for proposals which do not involve the culverting of watercourses and which do not prejudice future opportunities for de-culverting (including on sites specifically identified in the Local Plan);* *e) provides a minimum 10 metre buffer where physically feasible between the top of the watercourse and the development site which is free of built development, and includes a long term landscape and ecological management plan for this buffer;* *f) and includes, where appropriate, measures to allow for the natural movement of fish within the watercourse (where barriers to fish movement are present).*	

METHODOLOGY

4.44. Flood planning policy and guidance for England is contained within the National Planning Policy Framework and in relation to flood risk it states:

"A site-specific flood risk assessment should be provided for all development in Flood Zones 2 and 3. In Flood Zone 1, an assessment should accompany all proposals involving:

- *sites of 1 hectare or more;*
- *land which has been identified by the Environment Agency as having critical drainage problems;*
- *land identified in a strategic flood risk assessment as being at increased flood risk in future;*
- *land that may be subject to other sources of flooding, where its development would introduce a more vulnerable use"*

4.45. As this Proposed Development is over 1 hectare in size then a site-specific FRA is necessary. The objectives of a site-specific FRA are 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.

4.46. The Guidelines provide five vulnerability categories, based on the type of proposed development, which are detailed as follows:

- Essential Infrastructure
  - Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk.
  - Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and

primary substations; and water treatment works that need to remain operational in times of flood.

- Wind turbines.
- Solar Farms.

- Highly Vulnerable
  - Police and ambulance stations; fire stations and command centres; telecommunications installations required to be operational during flooding.
  - Emergency dispersal points.
  - Basement dwellings.
  - Caravans, mobile homes and park homes intended for permanent residential use.
  - Installations requiring hazardous substances consent. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as 'Essential Infrastructure').

- More Vulnerable
  - Hospitals
  - Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
  - Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels.
  - Non–residential uses for health services, nurseries and educational establishments.
  - Landfill* and sites used for waste management facilities for hazardous waste.
  - Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.

- Less Vulnerable

- Police, ambulance and fire stations which are not required to be operational during flooding.
- Buildings used for shops; financial, professional and other services; restaurants, cafes and hot food takeaways; offices; general industry, storage and distribution; non-residential institutions not included in the 'more vulnerable' class; and assembly and leisure.
- Land and buildings used for agriculture and forestry.
- Waste treatment (except landfill* and hazardous waste facilities).
- Minerals working and processing (except for sand and gravel working).
- Water treatment works which do not need to remain operational during times of flood.
- Sewage treatment works, if adequate measures to control pollution and manage sewage during flooding events are in place.
- Car Parks.

• Water Compatible Development

- Flood control infrastructure.
- Water transmission infrastructure and pumping stations.
- Sewage transmission infrastructure and pumping stations.
- Sand and gravel working.
- Docks, marinas and wharves.
- Navigation facilities.
- Ministry of Defence installations.
- Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
- Water-based recreation (excluding sleeping accommodation).
- Lifeguard and coastguard stations.

– Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.

– Essential ancillary sleeping or residential accommodation for staff required by uses in this category, subject to a specific warning and evacuation plan.

Table 4 - 2: Flood Risk Vulnerability Classification

Flood Zone	Essential Infrastructure	Highly Vulnerable	More Vulnerable	Less Vulnerable	Water Compatible
Zone 1	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Zone 2	Appropriate	Exception Test Required	Appropriate	Appropriate	Appropriate
Zone 3a	Exception Test Required [x]	Not Appropriate	Exception Test Required	Appropriate	Appropriate
Zone 3b	Exception Test Required *	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate*

[x] *In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.*

[*] *In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there and has passed the Exception Test, and water-compatible uses, should be designed and constructed to:*

- *remain operational and safe for users in times of flood;*
- *result in no net loss of floodplain storage;*
- *not impede water flows and not increase flood risk elsewhere.*

4.47. The sequential test compares the Application Site with other available sites, with the aim to develop on areas of land which are at a lower risk of flooding.

4.48. When applying the sequential test, should the site still be located within Flood Zones 2 and 3 then any flood risk assessment should consider the following:

- What other locations with a lower risk of flooding have you considered for the proposed development?
- If you have not considered any other locations, what are the reasons for this?

- Explain why you consider the development cannot reasonably be located within an area with the lowest probability of flooding (flood zone 1); and, if your chosen site is within flood zone 3, explain why you consider the development cannot reasonably be located in flood zone 2.
- As well as flood risk from rivers or the sea, have you taken account of the risk from any other sources of flooding in selecting the location for the development?

4.49. Where a proposed development requires an Exception Test, this must be undertaken to determine if the development can be justified. The application of the exception test should be informed by a site-specific FRA. For the exception test to be passed it should be demonstrated that:

- the development would provide wider sustainability benefits to the community that outweigh the flood risk; and
- the development will be safe for its lifetime, taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

4.50. Development should only be allowed in areas at risk of flooding where, in the light of the site-specific FRA (and the sequential and exception tests, as applicable) it can be demonstrated that:

- within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
- the development is appropriately flood resistant and resilient;
- it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;
- any residual risk can be safely managed; and
- safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

4.51. Site specific FRA's should also provide surface water management arrangements at the site using sustainable drainage systems wherever appropriate, to ensure there is no increase in flood risk to others off-site. The following questions should be answered in all proposals:

- What are the existing surface water drainage arrangements for the site?

- If known, what (approximately) are the existing rates and volumes of surface water run-off generated by the site?
- What are the proposals for managing and discharging surface water from the site, including any measures for restricting discharge rates? For major developments (eg of 10 or more homes or major commercial developments), and for all developments in areas at risk of flooding, sustainable drainage systems should be used, unless demonstrated to be inappropriate.
- How will you prevent run-off from the completed development causing an impact elsewhere?
- Where applicable, what are the plans for the ongoing operation and/or maintenance of the surface water drainage systems?

BASELINE CONDITIONS

4.52. This section presents the information gathered on the existing topographical, geological, hydrological and hydrogeological conditions of the Application Site and its immediate surroundings.

Topography

4.53. A topographical survey was undertaken at the Application Site (**see Figure 4.3 Appendix 4A**.) The lowest point within the Application Site (15.6m AOD) is found along the channel bed of the Gutter Drain. The high point at 25.8m AOD, is along the northeast boundary.

Geology & Soil

4.54. The geological conditions of the Application Site were identified utilising the British Geological Society ("BGS") Spatial Resources online geological mapping[5] system. This indicated that the Application Site is underlain by Arden Sandstone Formation in Field 1 and 2 and Branscombe Mudstone Formation across all fields. Arden Sandstone Formation formed approximately 228 to 237 million years ago in the Triassic Period. Branscombe Mudstone Formation formed approximately 201 to 228 million years ago in the Triassic Period. This is overlain by River Terrace Deposits in Fields 1 - 3, Whatton Sand and Gravel in Field 5 and Alluvium in Fields 3 - 9. River Terrace Deposits formed up to 3 million years ago in the Quaternary Period. Whatton Sand and Gravel formed up to 3 million years ago in the Quaternary Period. Alluvium formed up to 2 million years ago in the Quaternary Period.

Soil

4.55. Different soil types have different capabilities of soaking up water, the efficiency of which is dependent upon the structure and infiltration capacity. The Soilscapes[6] map has been utilised to obtain soil data. It classes the soil at the Application Site as *'Loamy and clayey floodplain soils with naturally high groundwater* and *'Slightly acid loamy and clayey soils with impeded drainage'*.

[5] BGS Geoindex Onshore., Available at https://mapapps2.bgs.ac.uk/geoindex/home.html?_ga=2.106208195.1172329656.1659960824-1947403049.1659960824

[6] Cranfield Soil and Agrifood Institute, Soilscapes website. Available at http://www.landis.org.uk/soilscapes/

4.56. According to the Wallingford Procedure 'Winter Rain Acceptance Potential' (WRAP) map[7], the soil classification for the site is Class 4. This soil class has a Standard Percentage Runoff (SPR) of 0.47 and will likely not provide good infiltration opportunities.

4.57. The soils encountered beneath the Application Site, found during the infiltration testing, were predominately clay. These were dug within Fields 1, 5, 6 and 8 and the results can be found in the report provided in **Appendix 4E**. There are no borehole records within the Application Site.

4.58. The soakage rates obtained during the investigation were found to be good and permeable. Given the data from the test, it is considered that the use of shallow infiltration is suitable for the Application Site.

Hydrology

4.59. According to the Environment Agency Catchment Data Explorer[8], the Application Site lies within the Humber River Basin District. Within this, the Application Site lies in the Trent Lower and Erewash Management Catchment and within the Nottinghamshire South B Operational Catchment.

Local River Network

4.60. The Application Site is within the catchment of Smite / Devon from Stroom Dyke to Cotham Water Body which has an overall classification of "Moderate" under the Water Framework Directive (WFD). The River Smite and River Devon are located approximately 0.9km east and 3km northeast of the Application Site, respectively. The River Smite joins the River Devon approximately 2.9km northeast of the Application Site before converging with the River Trent approximately 9.7km north of the Application Site. Eventually the River Trent joins the River Ouse to form the Humber Estuary and empties into the North Sea.

4.61. Watercourses around and within the Application Site are shown in **Figure 4.4 Appendix 4A.**

Internal Watercourses

4.62. The Gutter Drain (referred to as Back Dyke downstream of the Application Site) flows northeast through the Application Site. The drain measures approximately 5m wide within the Application Site and drains to the River Devon approximately 3km northeast of the Application Site.

[7] HR Wallingford. Greenfield Runoff Estimation for the Sites. Available at: https://www.uksuds.com/tools/greenfield-runoff-rate-estimation

[8] Environment Agency, Catchment Data Explorer, Available at https://environment.data.gov.uk/catchment-planning/RiverBasinDistrict

4.63. Two unnamed field drains are also present within the Application Site. The unnamed drains converge in the east of the Application Site, flow west and then north through the centre of the Application Site, before draining into the Gutter Drain on the northern boundary. The drains generally have a width of between 2-3m within the Application Site boundary.

4.64. An 8m buffer of no development has been included from the Gutter Drain as this is not an EA designated watercourse, while an 8m buffer has been included from all other drains within the design of the Proposed Development.

4.65. Photographs of the various watercourses and drains can be viewed in **Appendix 4B**, whilst locations of the images can be found in **Figure 4.9: Appendix 4A**.

Flood Defences

4.66. There are no Environment Agency maintained raised defences in this area.

Historic Flooding

4.67. The Environment Agency's historic flood map[9] is a GIS layer showing the maximum extent of individual recorded flood outlines from rivers, the sea and groundwater springs that meet a set criterion. It shows areas of land that have previously been subject to flooding in England. The map shows that an area approximately 600m to the southeast of the Application Site has been included within this historic flood extents.

4.68. The landowner provided photographic evidence of a flood event that occurred in February 2020. The photographs and landowner descriptions correspond to the extent and depth of flooding predicted in the fluvial flood risk maps.

4.69. A review of the Strategic Flood Risk Assessments covering the area has identified that the Application Site is located outside any Flood Warning Areas.

Hydrogeology

4.70. The Application Site is not located within any Groundwater Source Protection Zones.

Groundwater Vulnerability

4.71. Groundwater Vulnerability refers to the intrinsic geological and hydrogeological characteristics that determine the ease at which groundwater may be contaminated by human activities. The more vulnerable the groundwater is, the more easily it can be contaminated by surface water.

[9] Environment Agency, Historic Flood Outlines, Available at https://environment.data.gov.uk/DefraDataDownload/?mapService=EA/HistoricFloodMap&Mode=spatial

4.72. According to the Environment Agency Groundwater Vulnerability Maps, the Application Site has got areas of 'High' and 'Medium-High' groundwater vulnerability.

FLOOD RISK ASSESSMENT

4.73. This section considers the following flood risks:

- Fluvial Flood Risk
- Surface water (pluvial) Flood Fisk
- Groundwater flooding
- Existing and proposed drainage systems
- Access and Egress

Fluvial Flood Risk

River Smite

4.74. Extreme water levels at the Application Site were obtained from the 2012 EA River Smite Flood Modelling Study hydraulic model.

4.75. Flood Zone 3b (the 1 in 20 year floodplain) is shown in Figure 4.2: Appendix 4A. Flood waters spilling from the River Smite are restricted from reaching the Application Site by the raised Shelton Road along the east boundary. Therefore, the Application Site is not inundated and consequently outside Zone 3b.

4.76. Flood Zone 3a (the 1 in 100 year floodplain) is shown in Figure 4.5: Appendix 4A. Flood waters spilling from the River Smite overtop Shelton Road, flowing west initially and then north through the centre of the Application Site.

4.77. Following NPPF, essential infrastructure in Flood Zone 3a should be designed and constructed to remain operational and safe in times of flood. A sequential approach to development has therefore been undertaken, with only the raised solar panels positioned within Flood Zone 3a, where possible, and the more vulnerable infrastructure sited away from Flood Zone 3a.Both essential infrastructure and water compatible development are appropriate in Flood Zone 2.

4.78. The effect of climate change was included as a 20% increase in flows in the EA study, in line with the Humber River Basin Higher Central Allowance Uplift for the period 2040 – 2069 and Upper End Allowance for the Period 2015 – 2039. As expected, this increase in flows results in increased flooding within the Application Site.

4.79. The 100 year plus 20% climate change allowance flood extent with modelled peak water levels is shown in Figure 4.6: Appendix 4A. Vulnerable infrastructure is sited outside the climate change floodplain with the exception of a single Inverter pairing in Field 7, as shown in the flood map inset. The Inverter pairing will be raised above the 100 year plus climate change level (17.60 m AOD) with a freeboard of 600mm to account for modelling uncertainties (i.e. Finished Floor Level (FFL) of 18.20 m AOD). It is noted that this will also set Finished Floor Levels above the 1 in 1000 year level. Vulnerable infrastructure outside the climate change floodplain will also have the FFL raised 300mm above surrounding ground levels. This inverter was required to be located within Flood Zone 2 due to its distance to surrounding panels and reducing cable losses to within a reasonable level of tolerance.

4.80. Due to the small scale of the piles of the solar panels and footprint of the Inverter pairing within the floodplain, the lost flood storage volume is considered negligible given the scale of the Application Site. A volume of 30.0m^3 will be required to compensate for the Inverter pairing as calculated from modelled maximum climate change water levels and the topographic survey.

4.81. Predicted maximum flood depths during the climate change event are less than 1.0m across the Application Site (outside the channels of the drains) and the solar panels will therefore be raised above the maximum modelled flood level, remaining operational. The majority of the potential flooding is below 0.5m depth and therefore the standard panel heights of 0.8m will suffice and also include a freeboard of 0.3m.

4.82. As the catchments of the Gutter Drain and unnamed drains are less than 3km^2, flood risk is not reflected using Flood Zone classifications and is instead considered in the Surface Water Flood Risk section below.

Surface Water Flood Risk

4.83. The EA 1 in 100 year Surface Water Flood Risk Map is shown in Figure 4.7: Appendix 4A. The map indicates that surface water runoff is largely contained within the field drains running through the Application Site. Some low lying parcels of land containing raised panels flood to peak depths of approximately 300-600mm; however, all vulnerable infrastructure is free from surface water flooding and the panels will be raised above the ponding.

4.84. Post-development, overland flow routes will not be altered by the construction of the development as it is not proposed to significantly vary ground levels.

Groundwater Flood Risk

4.85. As mentioned in the Baseline section above, the Environment Agency Groundwater Vulnerability Maps shows the Application Site to be at Medium-High risk of groundwater flooding.

4.86. There is no information on groundwater levels within the Application Site at present. Any groundwater level measurements taken during site investigations will need to be taken into account in the detailed design of the Application Site. If there are elevated groundwater levels, suitable precautions may need to be considered during detailed design.

Existing and proposed drainage systems

4.87. The site is currently drained by The Gutter Drain and two unnamed drains. Surface water flood risk from the drains is considered to be low based on EA Surface Water Risk model results.

4.88. Post-development, the outline drainage has been designed so that flooding will not occur for up to and including the 100 year event (including 40% climate change consideration). Should an exceedance of this 1 in 100 year event occur, surface water will flow the same way as at present, into the surrounding field drains and watercourses, and away from vulnerable infrastructure.

Access and Egress

4.89. The Environment Agency states that:

"Access considerations should include the voluntary and free movement of people during a Design Flood (100 year event), as well as the potential for evacuation before a more extreme flood. Access and egress must be designed to be functional for changing circumstances over the lifetime of the development. Specifically:

- *Access routes should allow occupants to safely access and exit their dwellings in design flood conditions. Vehicular access to allow the emergency services to safely reach the development during design flood conditions will also normally be required.*
- *Wherever possible, safe access routes should be provided that are located above design flood levels and avoiding flow paths. Where this is not possible, limited depths of flooding may be acceptable, provided that the proposed access is designed with appropriate signage etc to make it safe. The acceptable flood depth for safe access will vary depending on flood velocities and the risk of debris within the flood water. Even low levels of flooding can pose a risk to people in situ (because of, for example, the presence of unseen hazards and contaminants in floodwater, or the risk that people remaining may require medical attention)."*

4.90. The proposed access shown in Figure 4.8: Appendix 4A is from Thoroton Road to the south of the Application Site. This wider access area is not predicted to be inundated during the 1 in 100 year plus climate change allowance event.

4.91. The proposed access tracks within the Application Site are predicted to remain free of flooding up to and inclusive of the 1 in 50 year event, providing dry access across the entire site.

4.92. Sections of the proposed access track are inundated during the 100 year plus climate change event. Tracks in the east of the site flood to maximum depths of approximately 0.23m and should therefore still be accessible by vehicle.

4.93. A small section of track in the centre of the site is predicted to flood to depths of up to 0.55m during the climate change event, however a permissive bridleway would provide dry access onto Main Road to the west of the site.

4.94. It should be noted that the proposed development does not introduce overnight accommodation.

4.95. There are a number of watercourse crossings where new culverts will be required. These will be designed post consent to allow the 1 in 100 year event flows to pass freely through with a suitable freeboard. Any consents or permits required for this will be undertaken at this stage and this should be conditioned to any planning consent.

DRAINAGE IMPACT ASSESSMENT

Introduction

4.96. There is a requirement in the NPPG for proposals to incorporate surface water drainage measures that have a neutral or beneficial effect on the risk of flooding both on and off the Application Site.

4.97. Surface water arising from a developed site should, as far as is practicable, be managed to mimic the surface water flows arising from the site prior to the Proposed Development, while reducing the flood risk at the site itself and elsewhere.

Methodology

Catchment Characteristics

4.98. Catchment characteristics were obtained from the Flood Studies Report[10]. Catchment sizes were measured using ArcGIS and catchment boundaries were produced based on the site-specific topographical survey.

Greenfield Runoff and Stormwater Storage

4.99. Greenfield runoff rates and stormwater storage requirements have been obtained using the following tools:

- HR Wallingford UK Sustainable Drainage Greenfield Runoff Estimation Tool (using IH124[11] methodology due to the small-scale nature of the catchment).
- Flow – Causeway Drainage design software (using IH124 methodology due to the small-scale nature of the catchment).
- The areas of permeable and impermeable surfaces have been estimated and are based upon the Proposed Development layout (**Figure 4 of Volume 2: Planning Application Drawings** for the layout of the Proposed Development).

Greenfield Runoff rates

[10] Institute of Hydrology, Flood Studies Report (1975)

[11] Institute of Hydrology (1994). *Flood estimation for small catchments. Report No IH124*, Wallingford.

4.100. The IH24 methodology is used for calculating the Greenfield runoff rates. This is recommended by the Institute of Hydrology for catchments below 200ha.

4.101. The IH124 equation estimates Qbar with the following equation:

$$Qbar - rural = 0.00108\ x\ (0.01\ x\ AREA)0.89\ x\ SAAR1.17\ x\ SPR2.17, m3/s$$

where:

- Qbar-rural is the mean annual flood flow from a rural catchment (approximately 2-3-year return period).
- AREA is the area of the catchment in ha.
- SAAR is the standard average annual rainfall for the period 1961 to 1990, available from the Flood Studies Report
- SPR is Standard Percentage Runoff coefficient for the SOIL category.

Calculating storage estimates

4.102. The storage estimates are calculated using the inputs below:

- Return Period
- Climate Change
- Impermeable Area
- Peak Discharge

4.103. The return period and climate change are combined with the Flood Studies Report (FSR) parameters and storm durations to generate the rainfall used. The result from these calculations is the attenuation storage required for the Application Site as a result of the additional runoff generated by the Proposed Development.

Site and Project Descriptions

4.104. The Proposed Development will have a very limited extent of impermeable ground cover. The area beneath the solar panels will remain as grassland and the post-development site infiltration rate will not change.

4.105. Rainwater falling onto each panel will drain freely onto the ground beneath the panels and infiltrate the ground at the same rate as it does in the site's existing greenfield state. Thus, the total surface area of the photovoltaic array is not considered an impermeable area.

4.106. Similarly, any rainwater falling onto the permeable access tracks will soak into the ground beneath at the same rate that it presently does.

4.107. The extent of impermeable area created as a result of the Proposed Development is summarised in Table 4-3.

Table 4 -3: Extent of less permeable areas created by the Proposed Development

Building	Solar Farm Total Area (m^2)	Grid Substation (m^2)
28 x Inverter Substations (16.0m(L) x 6.0m(W))	2,688.0	NA
2 x Spare Parts Containers (2.4m(L) x 12.2m(W))	58.6	NA
Grid Substation Area	NA	4,651.3
Total Impermeable Area (m^2)	2,746.6	4,651.3
Total Impermeable Area (m^2)	7,397.9	
Site Area (m^2)	895,218.844	

4.108. In its current greenfield state, the Application Site is considered to be 100% undeveloped. As a result of the Proposed Development, the extent of impermeable hardstanding introduced will be approximately 7,397.9m^2 or 0.83% of the total site area.

4.109. Due to the small size of the inverter substations, and the widespread nature of their locations across the Application Site, it is impractical to connect them into a drainage scheme. Water runoff from these buildings will slowly drain into the underlying geology through infiltration and the impact of this will be Negligible. Should surface water accumulate around any of these locations, a simple soakaway can be constructed to allow water soak into the underlying subsoils.

Existing Drainage Arrangements

Existing Runoff Rates

4.110. The existing runoff rates and hydrological characteristics of the Proposed Development are detailed in Table 4-4 below (there are no hardstanding areas on the site at present).

Table 4 - 3: Pre-Development Greenfield runoff rates.

Site Make Up	Solar Farm Green Field	Grid Green Field

Greenfield Method	IH124	IH124
Positively Drained Area (ha)	0.275	0.465
SAAR (mm)	571	571
Soil Index	4	4
Standard Percentage Runoff	0.47	0.47
Region	4	4
	Runoff rate (l/s)	Runoff rate (l/s)
QBar	1.0	1.8
1 year	0.9	1.5
1 in 30 year	2.0	3.5
1 in 100 year	2.6	4.4

4.111. The limiting discharge rate will be the QBar greenfield rate, as detailed in Table 4-4.

Post Development Runoff Rate

4.112. The surface water runoff rate resulting from the Proposed Development has been based on the areas of hardstanding introduced, which will have a lower permeability than the existing greenfield composition.

4.113. Surface water runoff was derived using the Modified Rational Method as outlined within the methodology.

4.114. Using this approach, the runoff rate for the 1-in-100-year, 360-minute storm event, inclusive of the 40% climate change allowance would be a combined 190m^3, if left unmanaged.

Proposed Drainage Arrangements

4.115. The SuDS Manual[12] is the current best practice guidance on the use of SuDS. It promotes the use of a hierarchical approach to managing runoff. This approach is outlined below:

- Prevention - Preventing runoff by reducing impermeable areas.
- Source Control - Effective control of runoff at or very near its source.
- Site Control- Planned management of water in a local area or site.
- Regional Control - Designing a system that can efficiently manage the runoff from a site, or several sites.

4.116. The use of SuDS is generally accepted to have greater benefits than conventional drainage systems and these include[13]:

- Managing runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding;
- Providing opportunities for using runoff where it falls;
- Protecting or enhancing water quality (reducing pollution from runoff);
- Protecting natural flow regimes in watercourses;
- SuDs are sympathetic to the environment and the needs of the local community;
- Providing an attractive habitat for wildlife in urban watercourses;
- Providing opportunities for evapotranspiration from vegetation and surface water; and
- Encouraging natural groundwater/aquifer recharge (where appropriate).

4.117. The surface water drainage strategy for the Proposed Development seeks to provide a sustainable and integrated surface water management scheme for the whole Application Site and aims to ensure no increase in downstream flood risk by managing discharges from the Proposed Development to the local water environment in a controlled manner.

4.118. To comply with current policies, guidance and best practice, the volume and quality of surface water runoff discharged off-site from the Proposed Development at this Application Site will need to be controlled using SuDS.

12 CIRIA (2015). Report C753, The SuDS Manual

13 Susdrain. Sustainable drainage. Accessed http://www.susdrain.org/delivering-suds/using-suds/background/sustainable-drainage.html

4.119. In compliance with the above, the drainage strategy has been developed to meet the following key principles;

- Mimic existing (greenfield) drainage arrangements as far as possible;
- Avoid increases in the greenfield rate, volume and frequency of offsite discharge;
- Avoid significant deterioration in water quality of discharges and no detrimental impact in downstream water quality;
- Achieve the above criteria for all storms up to and including the 100-year event; and,
- Incorporate an allowance for climate change (40%).

Indicative Surface Water Storage Requirements

4.120. Indicative storm water storage volumes have been estimated using Causeway's Drainage Design Flow software. The storage calculations include up to the critical storm 100-year return period event (including a 40% allowance for climate change) and the design limits discharge rates back to greenfield runoff rates. The results are enclosed in **Appendix 4C and 4D.** These are estimated from the new surfaces added to the Proposed Development.

- Attenuation storage limits the rate of surface runoff discharge from the Proposed Development to match the pre-development greenfield runoff rates; and,
- All storage calculations have been given a climate change allowance factor of 40% that has been added to the rain depths.
- Infiltration Co-efficient used can be found in **Appendix 4E**.

Table 4 - 5: Storage Estimates

Storage Estimates		
	Solar Farm	Grid Substation
Return Period (years)	100 years	100 years
Climate Change (%)	40	40
Impermeable Area (ha)	0.275	0.465
Peak Discharge (l/s)	1.0	1.8
Infiltration Co-efficient (m/hr)	0.45455	0.40650

Storage Requirement (m^3)	31 to 128	56 to 223
Compensatory Storage (m^3)	30	0
Total Storage Requirement (m^3)	61 to 158	56 to 223

4.121. The range of storage requirement depends on the flow control device used and how efficient it is. Therefore, a network of swales will likely have to be designed with the higher volume in mind, whether a detention pond with a flow control device such as a hydro brake will likely require close to the lower end of the range.

Proposed Drainage Strategy (Solar Farm)

4.122. It is proposed to construct a network of swales around the Application Site on land which has the highest gradient, see **Appendix 4F**. The idea is to capture any overland flow in the SuDS device, prior to releasing into the natural surface water system.

4.123. The proposed swales will have an overall length of approximately 775m, with a base width of 0.5m, a 0.25m design depth and a 0.15m freeboard and a maximum side slope of 1 in 3. It will provide a total storage volume of approximately 242.2m^3.

4.124. This proposed drainage strategy will provide a storage volume of approximately 242.2m^3. This is significantly greater than the volume of additional runoff generated as a result of the impermeable buildings (158.0m^3). It is therefore considered that this not only adequately mitigates the increase in flow rates as a result of the minor increase in impermeable area but provides **significant improvement**.

Proposed Drainage Strategy (Grid Substation)

4.125. It is proposed that surface run-off will be collected and conveyed by the provision of a swale which leads to a detention pond, see **Appendix 4F**. A notional freeboard level of 150mm shall be incorporated into the detailed design for the 1 in 100-year storm event plus 40% climate change with the final design being submitted to the council prior to the construction period. Calculations are included in **Appendix 4C** and the design volume of the attenuation device will be between 56m^3 and 223m^3. The discharge point will be into the existing site field drainage system to the east of the detention pond.

4.126. The SuDS features will be implemented during the construction phase of the Proposed Development and will be planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

4.127. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Swales or similar shall be utilised to collect runoff from access tracks, where required, however these will be designed at the detailed design stage. Where swales are utilised, check dams formed from gravels and other excavated material shall be placed in the swale at frequent intervals; and,
- Inverter Substations, Spare Parts Containers, etc: Filter strips will surround the concrete bases of the ancillary buildings to capture any runoff from the roofs. This will be discharged to a percolation area or into the sites drainage network where it is close enough. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

Foul Drainage

4.128. A permanent toilet is proposed within the substation compound which will be utilised by maintenance staff of both the solar farm and the substation as well as tour groups and visiting members of the local authority. This will consist of an off grid toilet with water tank which is refilled as and when required. The foul drainage will lead to a package treatment plant which will be emptied when required by an approved contractor. The tanks treated water will lead to an existing drainage ditch or to a soakaway. This will be decided during detailed design; however, a foul drainage assessment form has been completed at this stage, see Appendix 4G.

Designing for Exceedance Events

4.129. Overland flow routes will not be altered by the construction of the Proposed Development as it is not proposed to significantly vary ground levels. The outline drainage has been designed so that flooding will not occur for up to and including the 1-in-100-year storm event (including 40% climate change consideration).

4.130. Should an exceedance of this 1 in 100-year critical storm event occur, surface water will flow the same way as at present, into the surrounding field drains and watercourses. There are no sensitive receptors between the Application Site and the field drains.

Long Term Maintenance of SuDS

4.131. The long-term management and maintenance of the proposed SuDS will be the responsibility of the site owner and/or operators. These responsibilities include:

- Periodic cutting or grazing of vegetation;
- Observation of infiltration performance;
- If poor infiltration is observed then any accumulated silt/litter will be removed and aeration of the soil will be undertaken to improve permeability; and
- Maintain the structural integrity of the swales and attenuation structure.

Potential for Soil Erosion

4.132. The key to avoiding increased runoff and the transport of soil into watercourses is to maintain soil permeability and vegetative cover. Permeable land surfaces underneath and between panels should be able to absorb rainfall as long as they are not compacted and there is some vegetation to bind the soil surface.

4.133. Soil compaction will be limited during construction and operation of the solar farm. During construction, only light machinery will be required to install the solar arrays. Any Heavy Goods Vehicles (HGVs) delivering components will be restricted to site access tracks and the temporary construction compounds.

4.134. The risks of runoff and soil erosion are lowest on land with a gradual gradient with cohesive soils and are highest on dry, sandy and steeply sloping soil surfaces. Furthermore, the slope aspect of the land can also have an effect on runoff rates and soil erosion. The aspect of static solar panels in England will mostly always be south-facing and, therefore, north or south facing slopes will result in runoff flowing in a parallel direction to that of the runoff from the panels; thereby remaining relatively diffuse and unlikely to result in concentrated flows that could cause soil erosion, apart from where very steep slopes occur.

4.135. East or west facing slopes will result in runoff flowing in a perpendicular direction to that of runoff from the panels; this will result in runoff becoming concentrated along the drip-line of each row, which could lead to increased soil erosion.

4.136. With regard to the Proposed Development, most of the fields of the Application Site are relatively flat with very little gradient. The orientation of the solar panels could concentrate surface water flow in some areas of the Application Site and increase the risk of soil erosion. However, due to the low gradient across these fields, the likelihood of increased overland flow or soil erosion occurring is considered to be Low. The addition of the swales in areas of higher gradients will reduce the risk of soil erosion further and reduce any risk of water quality issues on any downstream watercourses or agricultural land.

4.137. Other mitigation techniques which are in place to avoid soil erosion include:

- Maintaining vegetative areas in between the solar arrays to help interrupt and slow the channelised flows, reducing erosion and also enhance and promote the infiltration and interception capacity. Where possible bare ground or gravel should be avoided.
- A robust soil, grass, and/or land management plan will be in place to keep land in good condition. If the ground becomes bare due to lack of maintenance the peak discharge has the potential to increase significantly.
- After construction the soil should be chisel ploughed, harrowed, or similar, to mitigate soil compaction during construction. This will ensure that the site can infiltrate to its potential.

SUMMARY & CONCLUSIONS

4.138. The FRA and DIA requirements are set out by the National Planning Policy Framework and Planning Policy Guidance.

4.139. The Guidance aims to avoid inappropriate development in flood zones and instead direct it to areas of low risk by adopting a sequential approach.

4.140. The Proposed Development is for solar power generation that is considered 'essential infrastructure' development under the National Planning Policy Framework. Based on NPPF Planning Practice Guidance a sequential test is first required to guide development to Flood Zones 1, then Zone 2, and then Zone 3. In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood whilst also passing the exception test.

4.141. The River Smite runs from southwest to northeast approximately 550m from the east boundary of the Application Site before its confluence with the River Devon approximately 2.2km downstream of the Application Site.

4.142. The River Smite 'Main River' runs approximately 550m east of the Application Site; The Gutter Drain runs northeast through the west of the site; and two unnamed field drains, drain the east of the site.

4.143. Results from EA modelling indicate that the Application Site is located entirely outside Flood Zone 3b, but lower ground levels of the Application Site are within Flood Zone 3a. A sequential approach to development has therefore been undertaken, with vulnerable infrastructure sited outside Flood Zone 3a, where possible.

4.144. The FFLof all electrical infrastructure (e.g. inverters, control buildings, etc) will be raised above the peak climate change allowance water level whilst all panels will also be located above this level. This will result in the Proposed Development being able to remain operational in times of a design event (1 in 100 year). The development will be able to remain operation in time of a 1 in 100 year flood event and therefore passes the main part of the exception test. In addition, all other parts of the exception test have been passed and therefore the Proposed Development should be deemed appropriate in flood risk terms.

4.145. The Application Site is not assessed to be at significant risk of flooding from groundwater or surface water flooding with the design of the Application Site carefully considered to mitigate against any potential risks. Groundwater level measurements taken during site investigations will need to be taken into account in the design of the Application Site. If there are elevated groundwater levels, suitable precautions may need to be considered during detailed design.

4.146. It has been demonstrated that the Proposed Developments impact on surface water runoff is minimal due to the small amount of impermeable infrastructure (0.83% of the overall Application Site) proposed for the Application Site. However, drainage in the form of SuDS

has been proposed so the post developed site discharges surface water at the greenfield run off rate (QBar). Due to large area of the Grid Substation, and the dispersed nature of the impermeable development of the rest of the Proposed Development, drainage schemes for these have been designed separately.

4.147. It is proposed to construct a network of swales around the Application Site and a detention pond at the grid substation location. The idea is to capture any overland flow in the SuDS device prior to releasing into the natural surface water system. The design volume of the SuDS scheme will not only adequately mitigate the increase in flow rates as a result of the minor increase in impermeable area but provides a **significant improvement**.

4.148. The SuDS features will be implemented during the construction phase of the Proposed Development and will be planted with vegetation to protect against soil erosion. They will be maintained throughout the lifespan of the Proposed Development, generally in accordance with the recommendations in the appropriate guidance.

4.149. Additional drainage measures to be implemented on-site include the following:

- Solar Panels: current grass cover is to be retained or reinstated adjacent to and under panels in order to maximise bio-retention;
- Access Tracks: access tracks are to be unpaved and constructed from local stone. Swales or similar shall be utilised to collect runoff from access tracks, where required, however these will be designed at the detailed design stage. Where swales are utilised, check dams formed from gravels and other excavated material shall be placed in the swale at frequent intervals; and,
- Inverter Substations, etc: Filter strips will surround the concrete bases of the ancillary buildings to capture any runoff from the roofs. This will be discharged to a percolation area or into the sites drainage network where it is close enough. Should surface water accumulate around any of these locations then a simple soakaway can be constructed to allow water soak into the underlying subsoils.

4.150. This FRA and DIA demonstrates that the Proposed Development will **not increase flood risk** away from the Application Site during the construction, operation and decommissioning phases. The Proposed Development is therefore considered to be acceptable in planning policy terms.

APPENDICES

Appendix 4A Figures:

- Figure 4.1: EA Flood Map for Planning
- Figure 4.2: Flood Zone 3b
- Figure 4.3: Topographic Survey at the Application Site
- Figure 4.4: Watercourses at the Application Site
- Figure 4.5: Flood Zone 3a
- Figure 4.6: Flood Zone 3a + 20% Climate Change Allowance
- Figure 4.7: 1 in 100 Year Surface Water Flood Depths
- Figure 4.8: Site Access with 1 in 50 year and 1 in 100 + 20% Climate Change Allowance
- Figure 4.9: Hydrology Photo Locations

Appendix 4B: Hydrology Photos

Appendix 4C: Flow Report (Substation)

Appendix 4D: Flow Report (Solar Farm)

Appendix 4E: BRE Infiltration Report

Appendix 4F: Outline SuDS Designs

Appendix 4G: Foul Drainage Assessment Form