OAKLANDS FARM SOLAR PARK

Applicant: Oaklands Farm Solar Ltd

Environmental Statement

Appendix 8.1 – Flood Risk Assessment and Outline Drainage Strategy

October 2024

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Oaklands Farm Solar Park: Flood Risk Assessment and Drainage Strategy

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Oaklands Farm Solar Park: Flood Risk Assessment and Drainage Strategy

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1. Introduction

1.1. Instruction

Yellow Sub Geo Ltd (Yellow Sub) was instructed by BayWa R.E. UK Ltd (the Client) to provide a Flood Risk Assessment (FRA) and outline drainage strategy for a large parcel of land between Oaklands Farm and Park Farm (the Site).

1.2. Brief

The brief was to provide a suitable Flood Risk Assessment (FRA) and Outline Sustainable Drainage (SuDS) Strategy for the Site to support the application for a Development Consent Order and Environmental Impact Assessment (EIA) for a proposed solar farm.

1.3. Background

The Site is located in Swadlincote to the south of Burton-on-Trent. The proposed development involves the installation of a solar farm comprising ground mounted photovoltaic (PV) panels across 37No. agricultural fields with associated Battery Energy Storage System (BESS) and a connection established to the nearby former Drakelow Power Station.

1.4. Scope

This report presents the findings of an FRA and Outline SuDS Strategy for the Site that demonstrates that the proposed development meets the requirements of the National Planning Policy Framework (NPPF) and Planning Practice Guidance (PPG).

1.5. Limitations

This report is written strictly for the benefit of the Client and bound by the conditions presented in Appendix A.

2. Development description and location

2.1. The Site

The Site (Figure 2-1) lies within the administrative boundaries of South Derbyshire District Council (SDDC) and Derbyshire County Council (DCC), located approximately 0.25km west of the village of Rosliston and 0.7km south east of Walton-on-Trent and stretching from the former Drakelow Power Station, north of Walton Road, to the south of Coton Road. The Site occupies a total area of approximately 191 hectares (ha), although Oaklands Farm covers only 135ha of the Site.

The Site itself includes land within three farms, Park Farm in the north, Fairfields Farm in the centre of the Site and Oaklands Farm in the south. The Drakelow substation land, where the Proposed Development will connect to the grid, is north of Walton Road within the former Drakelow Power Station site.

The southern part of the Site (Oaklands Farm area) comprises a large area of agricultural land to the south of Rosliston Road and west of Catton Lane that wraps around the north and east of the farmstead at Oaklands Farm. A small part of the Site extends south of Coton Road.

A small section of the Cross Britain Way / National Forest Way long distance path (which runs between the villages of Walton Upon Trent and Rosliston), crosses the northern fields of the Oaklands Farm area and is partly enclosed by woodland associated with the Rosliston Forestry Centre to the north-east. The Site is located within the National Forest.

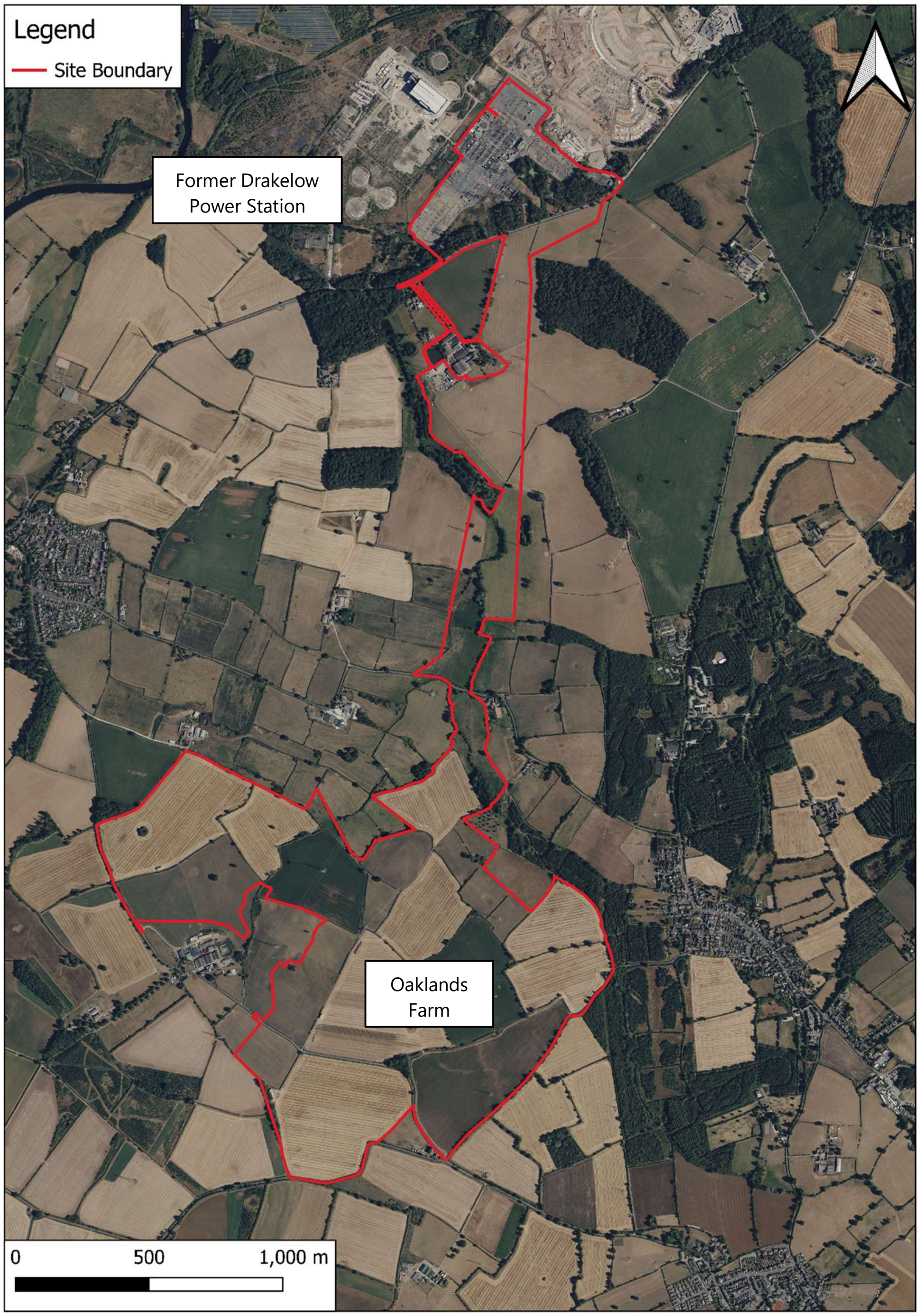
Immediately north of Rosliston Road is the land holding of Fairfields Farm and, further north, the Park Farm area up to Walton Road. Land use here comprises medium-large scale mixed arable and pastoral fields.

Two separate overhead electricity transmission lines run north to south through the Site, connecting into Drakelow substation. One 11kV overhead electricity distribution line also runs north into the Park Farm buildings.

Several adopted roads either border or run through the Site. These include:

- Coton Road, which connects Walton-on-Trent to Coton in the Elms and runs through the southern part of the Site.
- Catton Lane which links Rosliston to Lads Grave and borders the southeastern edge of the Site.
- Rosliston Road, which connects Walton-on-Trent to Rosliston and runs east-west through the Site.
- Walton Road, which connects Walton-on-Trent to the southwest with Stapenhill to the northeast, runs through the north of the Site along the southern boundary of the Drakelow Power Station area.

Figure 2-12-1 Site location



2.2. Topography

The Site is variable in elevation generally sloping down from an elevated high point of 92m above Ordnance Datum (m aOD) in the southern section of Site to around 64m aOD at the northern extent.

2.3. Proposed development

The Oaklands Farm Solar Park comprises a proposed solar farm with an associated battery energy storage facility ('the Proposed Development'). The Proposed Development would have a generating capacity of over 50MW and would be situated on 191 hectares of land at Oaklands Farm to the south-east of Walton-on-Trent and to the west of Rosliston in south Derbyshire.

The solar farm itself, comprising photovoltaic panel arrays, a central electricity substation and Battery Energy Storage System (BESS) together with access, landscaping and other works would be located on 135 hectares at Oaklands Farm currently in use for arable production and grazing. A high voltage underground electricity cable would then run through land at Fairfields Farm and Park Farm to the north to connect the solar farm to the national grid via an electricity substation located at the former Drakelow Power Station which sits south of Burton-upon-Trent.

As the Proposed Development would be an onshore generating station with a generating capacity of over 50MW an application for a Development Consent Order is being made under the Planning Act 2008 to the Planning Inspectorate, for determination by the Secretary of State for Energy Security and Net Zero.

2.4. Geology and hydrogeology

British Geological Survey (BGS) published geology indicates that the Site bedrock comprises the Edwalton Member (siltstone and very fine-grained sandstone). This is partly overlain by superficial deposits, comprising fluvioglacial diamicton in the south and some areas of alluvium in the north typically along watercourses through the Site. The soils close to the watercourse are described as slowly permeable, seasonally wet, with impeded drainage, whilst those away from the watercourse are described as "loamy and clayey soils with slightly impeded drainage".

The alluvium and glaciofluvial deposits beneath some areas of the Site are classified by the Environment Agency (EA) as a high vulnerability Secondary A Aquifers. These are defined by the EA as 'permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers'.

The Edwalton Member bedrock beneath the Site is classified as a Secondary B Aquifer. These are defined by the EA as 'predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering'.

2.5. Hydrology

The vast majority of the Site is within the catchment of the River Trent with a very small area along the far southern edge of the southern-most parcel of the Site lies in the catchment of the River Mease, a tributary of the River Trent.

The majority of the Site drains to the River Trent via an unnamed tributary that flows through the Site. The unnamed tributary (an Ordinary Watercourse[1]) is shown on Ordnance Survey (OS) mapping to originate south of the village of Rosliston, and have its confluence with the Trent approximately 1.4km to the north-west of the Site).

A small tributary to the Ordinary Watercourse crosses the west of the Site from Oaklands Farm buildings to its confluence with the Ordinary Watercourse immediately upstream of Rosliston Road. The Ordinary Watercourse and its tributary are shown in Figure 2-2 along with LiDAR data of the Site.

2.5.1. Flood Defences

There are no formal flood defences throughout the area.

2.5.2. Greenfield Runoff

Greenfield Runoff has been calculated using the online Greenfield runoff rate estimation tool available on uksuds.com and the results are shown in Table 2-1 calculated for 1 ha in the centre of the Oaklands Farm parcel of land as a representative calculation. Further details are provided in Appendix B.

[1] Designation of 'main rivers': guidance to the Environment Agency, 2017. UK Gov. Available at: Designation of 'main rivers': guidance to the Environment Agency - GOV.UK (www.gov.uk)

Figure 2-22-2 Watercourses on Site and Lidar data

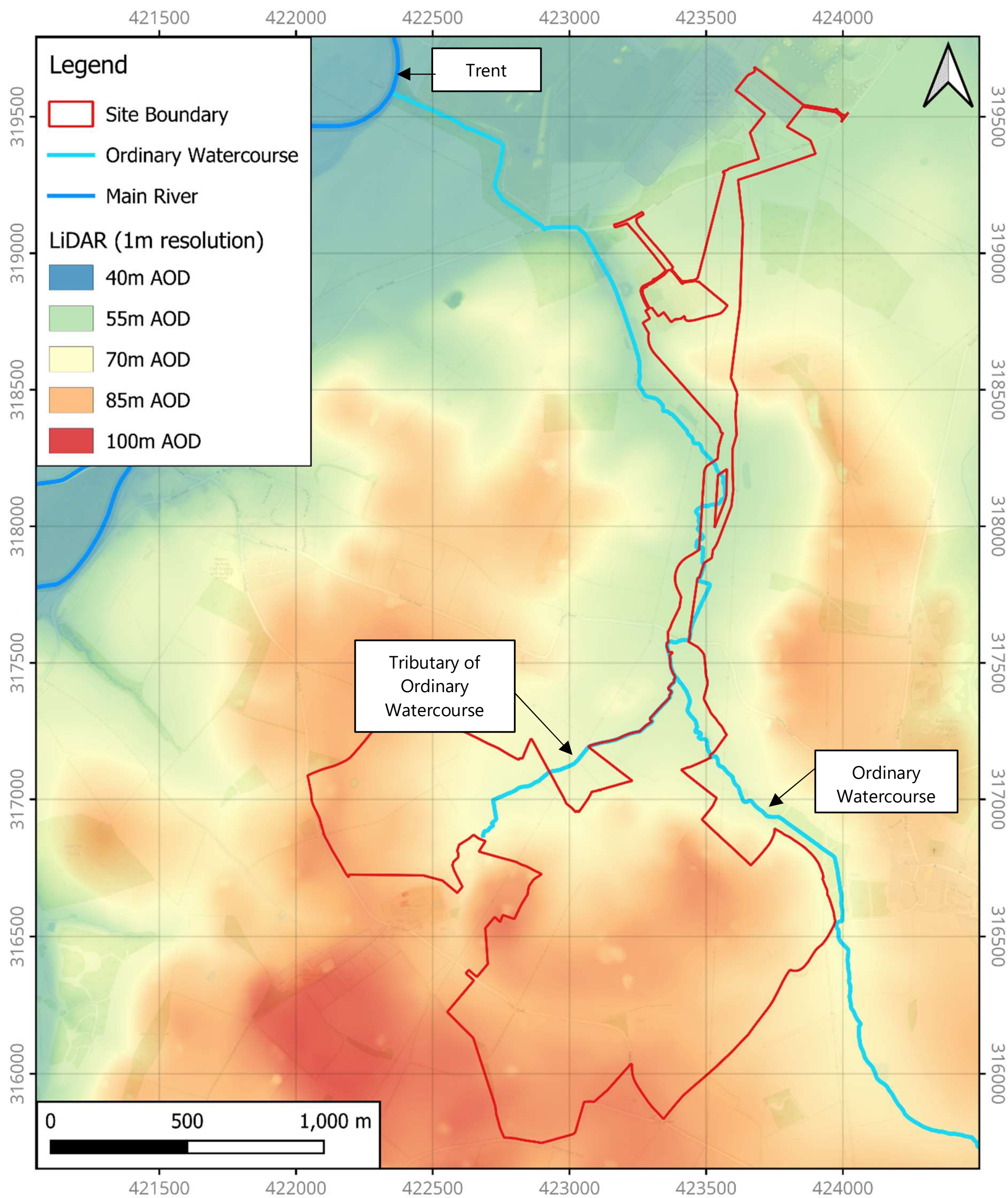


Table 2-1 Greenfield runoff rates per Hectare for the Site

Results using the IH124 method

Estimated site discharges

	My values
Qbar (l/s)	4.34
Greenfield runoff rates	
1 in 1 year (l/s)	3.6
1 in 30 years (l/s)	8.68
1 in 100 years (l/s)	11.15
1 in 200 years (l/s)	13.19

3. Planning Policy

3.1. National Flood Policy

National policy on planning and flood risk is provided by the National Planning Policy Framework (NPPF) and supplementary guidance. The acceptability of different types of development depends on its vulnerability to flooding and the flood zone in which the proposed development is to take place.

Flood risk has been mapped nationally by the EA to show the flood zones used in the NPPF.

3.1.1. Lead Local Flood Authority (LLFA) Flood Zones

Flood Zones 1, 2, 3a and 3b are defined by the LLFA in their Strategic Flood Risk Assessment (SFRA)[2] as:

- Flood Zone 1 refers to all areas that are considered to be at low risk of flooding and fall outside of Zones 2, 2a and 3b.
- Flood Zone 2 outlines an extreme flood of a 1 in 1,000-year flood event.
- Flood Zone 3a outlines a 1 in 100-year event and encompasses everything in Flood Zone 3 outside of Flood Zone 3b. Flood Zone 3a has been determined with an allowance for climate change adding a net increase of 20% over and above peak flows for a 1 in 100-year event. Where climate change modelling has not been undertaken, the Flood Zone 2 outline has been used as a proxy for Flood Zone 3a
- Flood Zone 3b outlines a 1 in 20-year floodplain or land within a Functional Floodplain (FFP) (defined by the 1 in 25-year outline where available, and if absent the 1 in 100-year outline).

It should be noted that national guidance has been updated since the SFRA was published in 2008 and Flood Zone 3b is now typically represented by the 1 in 30-year outline. In addition climate change, assessed per river basin, is not typically accounted for in the Flood Zone data. The EA is planning to publish an update to their 'Flood map for planning' in Spring 2025 which will incorporate future scenarios accounting for climate change.

3.2. Sequential / exceptions test

Solar farm developments are listed as essential infrastructure within Annex 3: Flood Risk vulnerability classification of the NPPF.

[2] South Derbyshire District Council Level 1 Strategic Flood Risk Assessment, 2008. Available at: https://www.southderbyshire.gov.uk/assets/attach/1788/level-1-strategic-flood-risk-assessment.pdf

Essential infrastructure, such as is proposed at the Site, is considered by the NPPF as acceptable in Flood Zones 1, 2 and 3a and 3b, but in 3a and 3b should be subject to an Exception Test as summarised in Figure 3-1.

The layout of the Proposed Development has been sequentially tested to steer infrastructure to areas of lowest flood risk within the Site, with all electrically sensitive infrastructure (solar panels, BESS and substation) within Flood Zone 1 and only buried cables and a short section of internal access track located in Flood Zones 2 and greater[3] (See Figure 4-1). The access track and underground cables within Flood Zone 2 and greater provides the most direct route to the grid connection at Drakelow Substation, minimising environmental impacts associated with construction.

Emergency access to the Site has also been provided along this same route, south off Rosliston Road towards Park Farm and Drakelow Substation as it provides the shortest route from the public highway. As the track will already be in place during construction, retaining this track would result in less impact than constructing a new emergency access route to the west of Site within Flood Zone 1. Therefore, development outside of Flood Zone 1, and most likely within Flood Zone 3a and 3b due to proximity of the watercourses is unavoidable to provide a cable connection and emergency access route for the Proposed Development.

The exception test for infrastructure within Flood Zone 3 (both 3a and 3b) requires that the infrastructure is 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. The buried cables and short section of internal access track within Flood Zone 3 meet these requirements (with alternative access tracks within Flood Zone 1 useable during flood conditions) as no significant changes to land profiles are proposed.

[3] Due to the available Flood Zone data it has not been possible to distinguish between Flood Zone 2, 3a or 3b based on the publicly available data. This is further discussed in Section 4.2.1

Figure 3-13-1 Acceptability of development in Flood Zones

Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a †	Exception Test required †	✗	Exception Test required	✓	✓
Zone 3b *	Exception Test required *	✗	✗	✗	✓ *

Key:

✓ Development is appropriate

✗ Development should not be permitted.

4. Definition of Flood Hazard

4.1. Historical records

There is no mapping of events for the Site in the EA historic flood dataset.

4.2. Sources of flooding

4.2.1. Fluvial and Tidal flooding

The flood risk arising from rivers and the sea is mapped nationally by the EA. The site is not subject to tidal flooding – therefore the risk of flooding from the sea has not been further assessed.

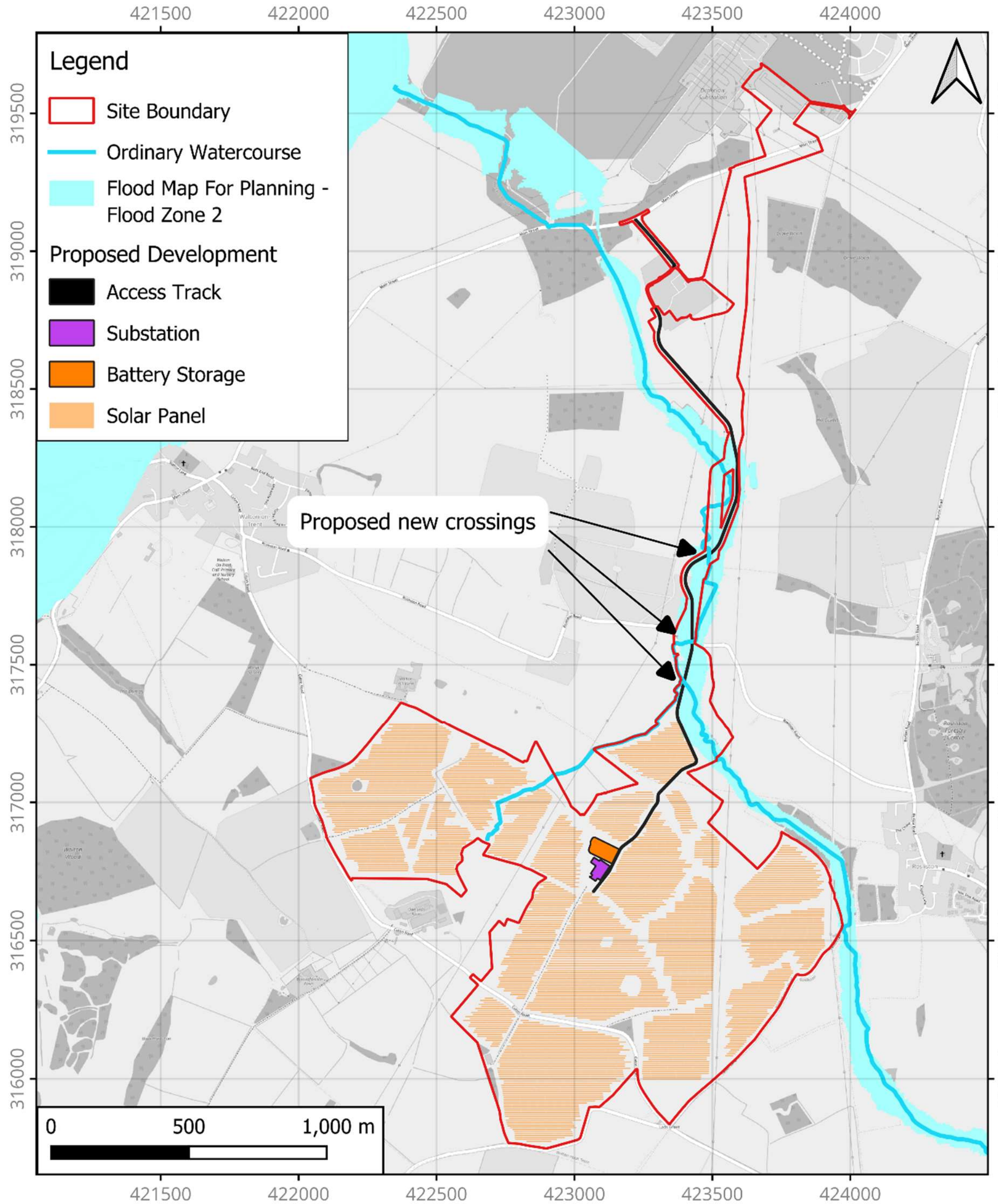
The only available flood modelling available from the Environment Agency are the Flood Zone extents which are based on coarse national modelling. The coarse national modelling has typically been undertaken for the 0.1% Annual Exceedance Probability (1 in 1000 year return period) and 1% AEP (1 in 100 year return period) events, without climate change. Based on the Flood Zone definition provided by the LLFA (Section 3.1.1):

- Flood Zone 2 has been based on the 0.1% AEP flood event (1 in 1000 year return period)
- Flood Zone 3a, in the absence of a modelled 1% AEP event (1 in 100 year return period) with climate change has been based on the 0.1% AEP flood event – hence the same as Flood Zone 2
- Flood Zone 3b, in the absence of a modelled 1 in 20 or 1 in 25 year return period has been based on the 1% AEP event (1 in 100 year return period).

The Flood Zone 3b extent is not published publicly, therefore the only flood extent data available is Flood Zone 2 and Flood Zone 3a, which are both based on the same modelled event – the 0.1% AEP (1 in 1000 year return period). Figure 4-1 details this extent (labelled as Flood Zone 2). The quality of the topography and modelling used to produce this map is low, as can be seen in areas where the flood risk fails to follow the line of the watercourse and provides an indication rather than an accurate description of the true flood risk areas.

The EA were asked to provide flood depths for the flood risk areas but do not have any more detailed information, reflecting the low priority given to modelling flood risk in an Ordinary Watercourse.

Figure 4-14-1 Flood Zone 2 for planning, with proposed development extents



The majority of the Site is in Flood Zone 1 (that is outside of the extent of Flood zone 2) with an annual risk of fluvial flooding less than 1 in 1,000 year return period (0.1% AEP event) and therefore at low risk of flooding, but parts bordering the Ordinary Watercourse are within Flood Zones 2 and greater (at risk of fluvial flooding greater than the 1 in 1000 year return period – 0.1 % AEP event).

The planning flood zones only consider the risk of flooding from main rivers and some of their tributaries, therefore, only the Ordinary Watercourse on-site has been considered within the flood zone mapping, and not the tributary that flows into the Ordinary Watercourse.

As the catchment area is small, parts are excluded from the fluvial flood mapping produced by the EA and it is likely that the surface water flood mapping in the next section provides a more accurate description of flood risk along all the watercourses as this mapping covers the whole country in a greater detail and is more recent. The small tributary that joins the Ordinary Watercourse are considered in subsequent sections of this report.

4.2.2. Surface water flooding

Surface water flooding arises from rainfall intensities exceeding the rate at which the ground can absorb the water and the local drainage system has capacity for. Excess water will flow over the surface, generally following the topography but can also be diverted by walls and buildings and possibly directed preferentially along roadways. Surface water can collect in low areas and pond, causing localised flooding.

For a small watercourse where all the flood runoff is being generated locally the surface water flood maps give a more accurate representation of flood risk than the fluvial flood mapping.

Figure 4-2 shows modelled surface water flood extents for the 3.33% AEP, 1% AEP and 0.1% AEP events. This indicates a network of flow paths channelling excess water across the Site to the watercourse with some limited areas of ponding where surface water may collect before slowly infiltrating into the soil.

The likely depth of flooding in a medium risk event (1%) is shown in Figure 4-3 and indicates that outside of the river channel, these are less than 300mm.

4.2.3. Groundwater flooding

Groundwater flooding is caused when water held within porous strata rises to the land surface due to excess rainfall generally over a long time period.

The majority of the Site is underlain by a secondary B aquifer which is likely to hold very limited volumes of groundwater, and soils which are only slowly permeable. In areas where superficial deposits are present the volumes of groundwater will also be limited due to the limited extent of the deposit and these are also covered by slowly permeable soils.

Groundwater flooding is therefore considered a low risk on the Site.

Figure 4-24-2 Flood risk from surface water

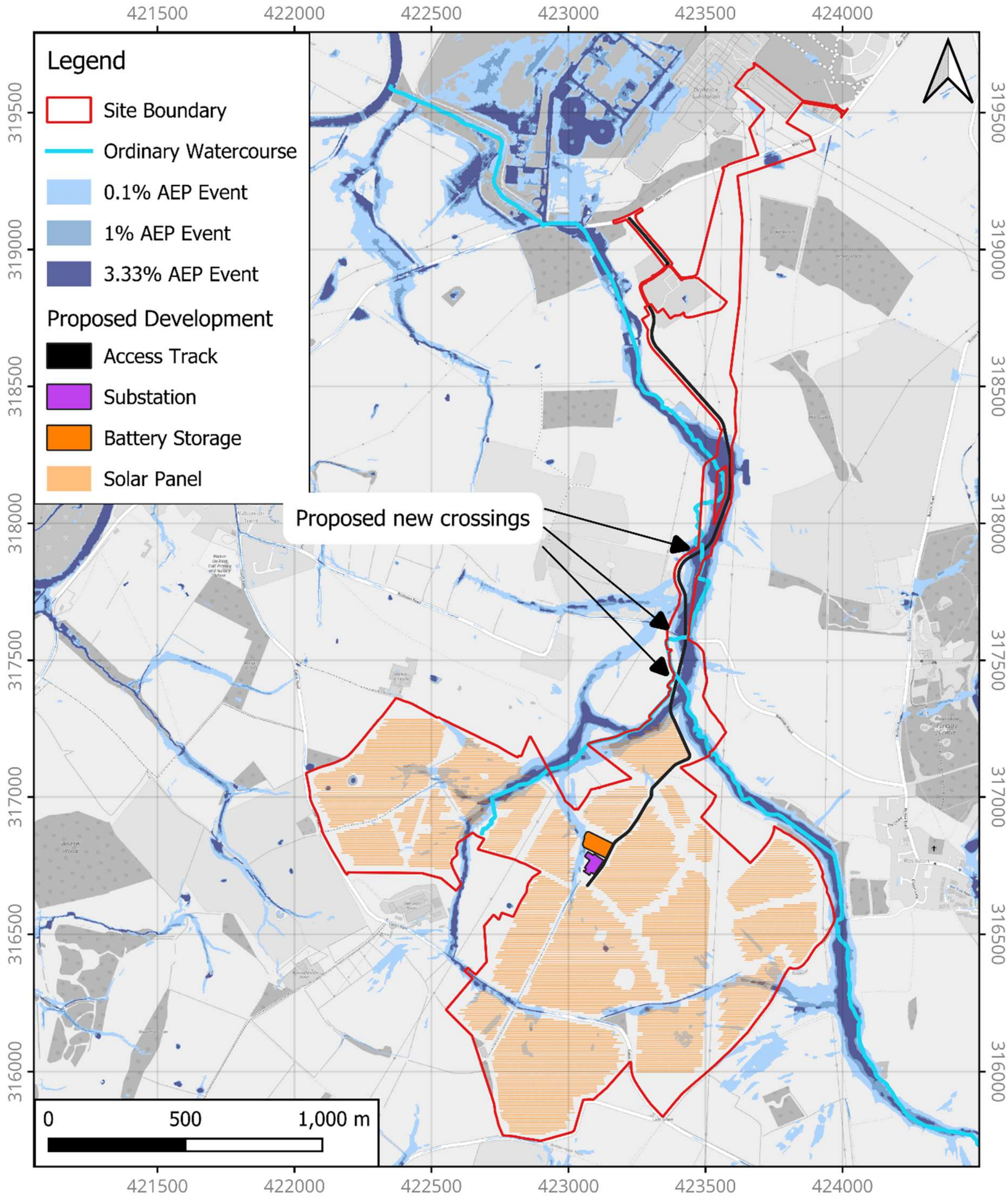
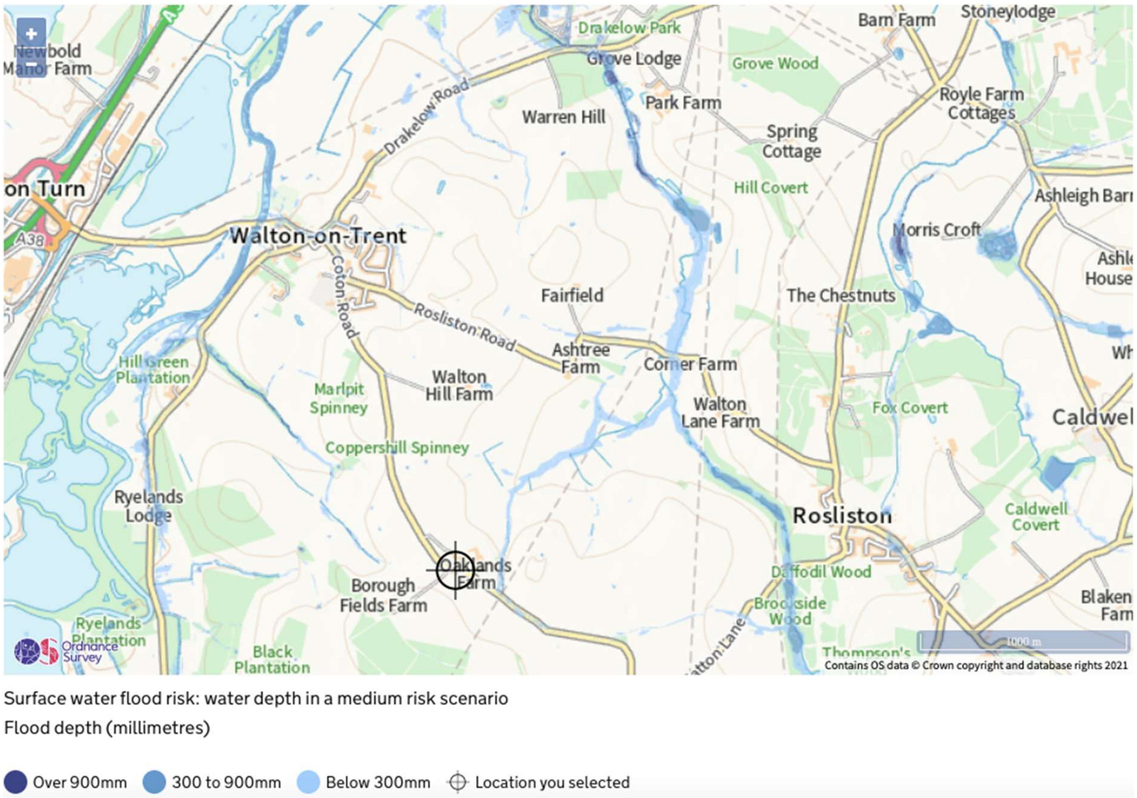


Figure 4-34-3 *Depth of flooding in a 1% AEP surface water flood event*



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. The EA have mapped areas that are at risk of flooding from failure of large reservoirs and the Site is not shown to be potentially at risk from these sources.

There are no other identified large sources of stored water that may affect the Site and the risk of flooding from this source is considered to be negligible.

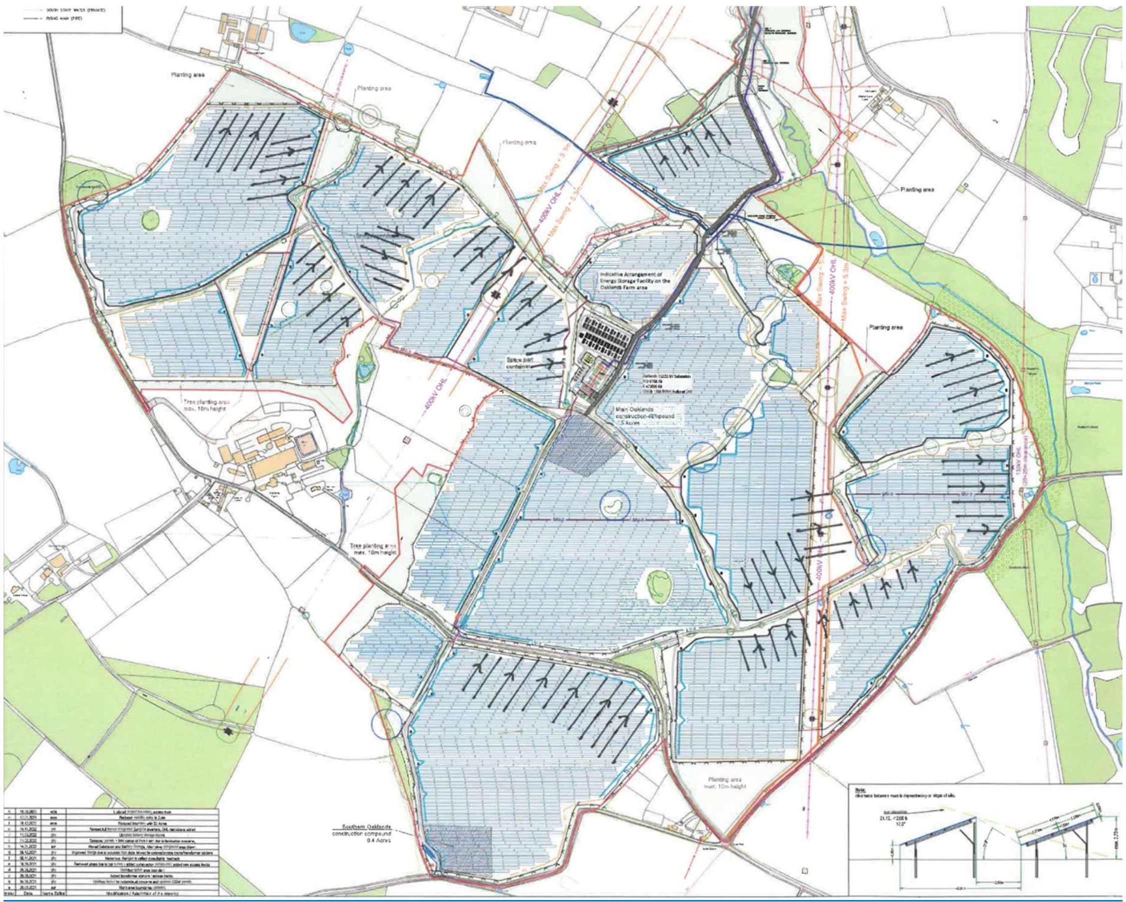
4.2.5. Land drains

Yellow Sub undertook a Site visit in June 2022 which was supplemented by a Site visit by Kernon Countryside Consultants Ltd in November 2022 to discuss and attempt to map field under drainage with the Site owner/ tenant farmer. This resulted in the map presented as Figure 4-4 which shows arrays of field drainage towards the lower margins of several fields. Whilst spacing of these is unknown, based on AHBD guidance[4] they are likely to be at least 40m apart.

[4] https://ahdb.org.uk/drainage

From a flood risk perspective, the presence of these underdrains represents a potential preferential pathway for surface run off and/ or shallow groundwater which may increase potential off-Site flood risk compared to true greenfield conditions.

Figure 4-4 Land drain locations



4.3. Climate Change

Climate will have a limited impact on flood risk over the lifetime of the Proposed Development. A worst case assessment[6] of the potential expansion of the 1% flood extent concluded it is unlikely to exceed the present day 0.1% flood extent.

Use of the 0.1% flood extent will therefore provide a conservative estimate of the future 1% flood, especially as the Site use is expected to be complete well within 100 years.

4.4. Overall Flood risk at the Site

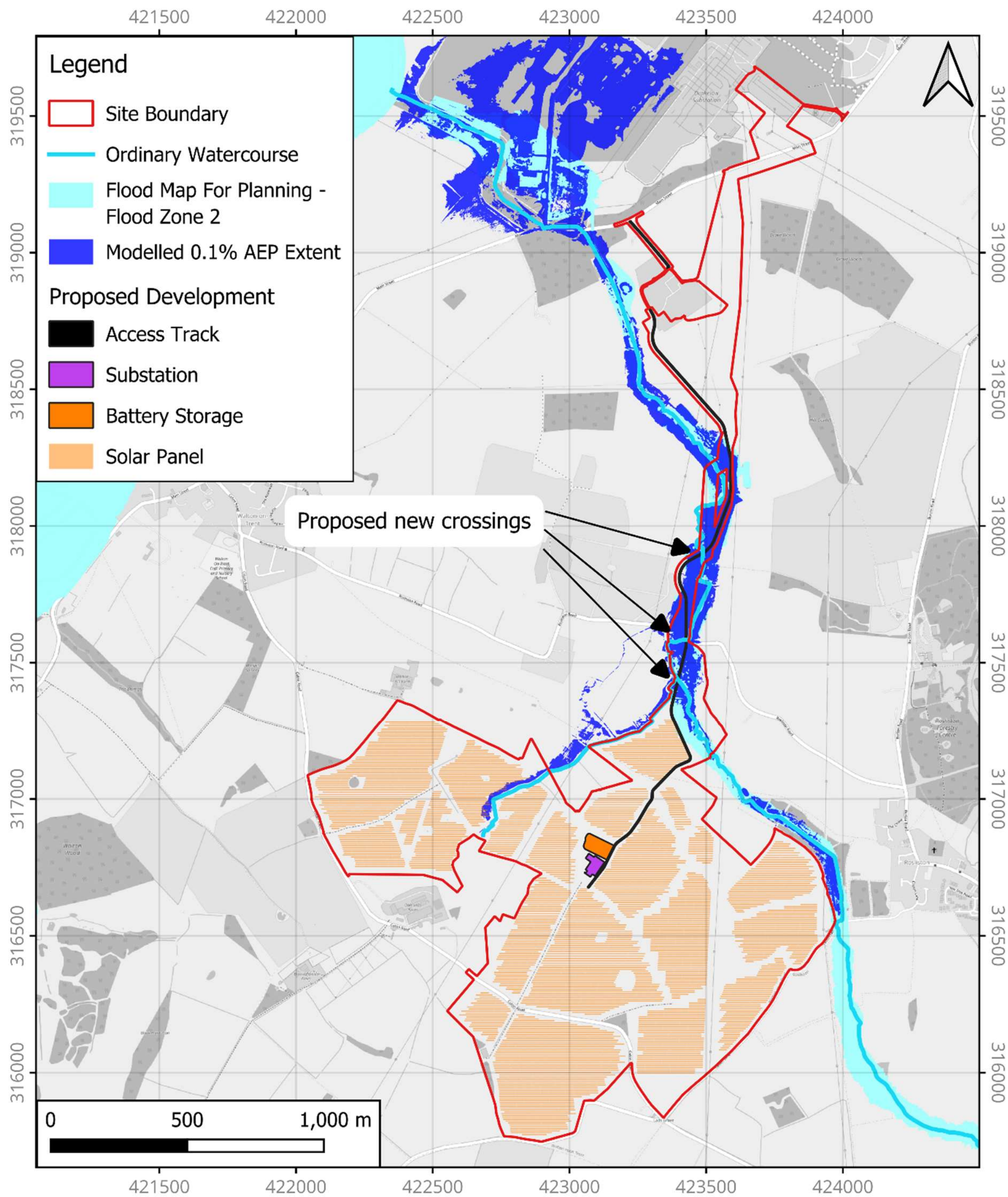
The above review has indicated that flood risk on the Site is restricted to the Ordinary Watercourse and a network of surface water flow paths, some of which are in channels and some overground or in isolated areas of ponding.

Outside of the watercourse channels the likely depth of flooding is less than 300 mm in a 1% AEP event. Flood risk from other sources considered is low or very low.

4.5. Hydraulic modelling

Due to the above indicated flood risk for the Ordinary Watercourse and tributary thereof running through the Site, a hydraulic model has been undertaken in agreement with the EA. The Hydraulic modelling report (ref: P20209_R5) is attached in Appendix G. This 1D-2D model has been analysed for 3.33%, 1%, 0.1% and 1% plus climate change events, baseline, sensitivity and proposed development model runs have been undertaken. Figure 4-5 provides a comparison of the modelled baseline 0.1% AEP flood extent against the existing Flood Zone 2. A more detailed discussion of the changes, and relevance to the Proposed Development is discussed in Section 5.1 and Section 8.1.

Figure 4-54-4 Comparison of modelled 0.1% AEP event against existing Flood Zone 2 extent



5. Detailed Development Proposal

5.1. Development Layout

The proposed development comprises solar panels, inverters, transformers, a substation and battery storage containers. There will be underground cabling connecting these elements and gravel tracks to provide access. Further details on each of these elements is provided below.

The proposed indicative layout is shown in the works plans found within Appendix 1.3 of the Environmental Statement, with the key features shown in Figure 4-1.

The solar panels are located outside of Flood Zone 2, shown in Figure 4-1, but not entirely out of the modelled surface water flood extent, which is more widespread. The detailed flood modelling (Appendix G) shows the modelled flood extents is in close proximity to the proposed infrastructure with flooding over the left (west) bank of the tributary into an area where panels are currently proposed for the 1% AEP event and larger. The maximum flood depth in this area is 0.15 m (0.1% AEP event). The bottom edge of the panels will typically sit 0.8 m above ground level, and therefore will be substantially above the maximum flood depth levels.

There will be a minimum 8 m easement between the top of any watercourse bank and any infrastructure (including panels, the substation and the BESS) to allow for maintenance access to river channels. Cable ducts will be located a minimum of 8 m away from the top of the bank of the watercourse, as far as possible. However, tracks may be constructed within 8 m as these do not prevent access to the watercourse.

Any watercourse crossings, or changes to existing crossings, may need Ordinary Watercourse Consent from the LLFA and should be designed so as not to impede flow or drainage. The LLFA were consulted in relation to the Proposed Development on the 8th June 2023.

5.2. Solar Panels

The solar panels are mounted on a frame supported by steel posts. The arrays are approximately 2.7 m in height, with the lower edge approx. 0.8 m above ground level (+/- 0.1m), which varies with local undulations in the ground surface. The frame foundations will consist of steel piles rammed/pushed into the ground, with a maximum piling depth of 2 m below ground level. 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 exposed during winter and spring.

5.3. Access Tracks

Internal access tracks for construction purposes will be 3.5 – 6.0m wide and made up of 200mm of Type 1 compacted stone/gravel with a geotextile membrane or other surfacing solutions, and, where appropriate, may simply be mown grass corridors. The access tracks will have an edge gradient of 2.5° to facilitate surface runoff. Some of these temporary access tracks will be removed, whilst others remain for operations and maintenance following construction of the Proposed Development. A typical cross section is shown in Appendix C.

5.4. Watercourse Crossings

There are five proposed watercourse crossings of which at least two comprise existing crossings which may need to be reinforced for construction traffic. There are also three additional cable crossing which shall either be trenched across and reinstated or directionally drilled.

There will be three new access track crossings across the Ordinary Watercourse as locations shown in Figure 4-1. The crossings were proposed to be bottomless box culverts with an initial proposed width and height of 0.9 m and 1.0 m respectively. However, based on preliminary modelling results this resulted in an increase in flood levels to surrounding off-Site land. The hydraulic modelling (detailed in Appendix H) has therefore been used to refine these dimensions in order to limit potential off-Site impact. The following dimensions for the culverts are now proposed - a width of 1.5 m, height 0.8 m and a spill level consistent with the bank levels at the location of each crossing. The revised dimensions have reduced the adverse impact off-Site, however some impact still remains. This is further discussed in Appendix G and in Section 8.5.

5.5. Battery Storage

The BESS will comprise a fenced compound containing a series of batteries within containers, power conversion system units (which convert electricity between DC and AC during import or export processes), and an auxiliary transformer to provide necessary power for controls and monitoring systems. Details are provided in Appendix D. Note this drawing provides a general example and details of the base may not be included. Due to the potential risk of fire associated with these units, and the subsequent risk of contaminated firewater, the ground must be impermeable and water should be collected and contained within a storage area, which can be isolated if required.

5.6. Substation

The substation and welfare compound incorporates a number of features, including two substation transformers, Statcom Units, 132KV harmonic filter compound, substation control building, welfare unit, and fire water storage and deluge system. Details are provided in Appendix E. Note this drawing provides a general example and details of the base may not be included. Due to the potential risk of fire associated with these units, and the subsequent risk of contaminated firewater, at least part of the compound area must be impermeable and water should be collected and contained within a storage area, which can be isolated if required.

6. Site Drainage

6.1. Introduction

The following sections describe the outline SuDS Strategy for the proposed development with due regard to DEFRA's Non-Statutory Technical Standards for SuDS (DEFRA, 2015) which recommends the following hierarchy for the disposal of surface water:

- Discharge to ground via infiltration;
- Discharge to a surface water body;
- Discharge to a surface water sewer, local highway drain or another drainage system;
- Discharge to a combined sewer.

6.2. Greenfield runoff and permissible discharge rates

For greenfield sites, the peak runoff rate from the development should not exceed the peak greenfield runoff rate for the same event (DEFRA, 2015). Additionally, where reasonably practical, the runoff volume from the development in the 1% AEP 6-hour rainfall event should not exceed the greenfield runoff volume for the same event.

The existing greenfield runoff rates and volumes for the BESS (8,000m^2) and substation (6,000m^2) areas have been estimated and are summarised in Table 6-1. These were derived using the Revitalised Flood Hydrograph (ReFH2) model and a 6-hour storm duration assumed to calculate the volumes. The catchment descriptors at the Site were obtained from the FEH Webservice.

6.2.1. Climate change

The potential increase in rainfall intensity due to climate change needs to be considered when designing drainage strategies. The recommended allowances for rainfall intensity in the Adur and Ouse Management Catchment are included in Table 6-2.

The Proposed Development has a design life of 40 years, assuming development is completed in the next 5 years the Site will be in use until the 2060s. Therefore, based on the EA guidance for climate change allowances in flood risk assessments (Environment Agency, 2022), the central allowance for the 2070's epoch should be used (see Table 6-2).

Table 6-1 Greenfield runoff rates and volumes for BESS and substation areas

Flood event AEP	Runoff rate (l/s)		Runoff volume (m^3)	
	BESS	Substation	BESS	Substation
50% (1 in 2)	3.92	1.83	64	32
10% (1 in 10)	6.71	3.06	109	53
3.3% (1 in 30)	9.27	4.17	153	73
1% (1 in 100)	13.70	6.03	229	108
1% + 25% climate change	18.34	7.83	307	142

Table 6-2 Climate change allowances for rainfall in the Adur and Ouse Management Catchment

Epoch	Central allowance	Upper end allowance
3.3% AEP (1 in 30)		
2050s	20%	35%
2070s	25%	35%
1% AEP (1 in 100)		
2050s	20%	40%
2070s	25%	40%

6.3. Attenuation storage volumes

In order to achieve the above discharge rates within the BESS and substation areas, attenuation storage will be required. The estimated storage volumes are shown in Table 6-3.

These storage volumes were derived by calculating the flow exceeding the peak greenfield runoff rate for the 1% AEP event.

ReFH2 software has been used to calculate flow hydrographs for a 1% AEP + 25% storm event using a range of storm durations. Catchment descriptors at the site were obtained from the FEH Webservice. An imperviousness factor of 1.0 and 0.2 have been applied for the BESS and substation respectively, no allowance for urban creep has been applied as the hardstanding areas are unlikely to expand.

Volumes were then calculated from the flow exceeding the peak greenfield runoff rate for each storm duration, and the maximum value taken. An additional allowance of 25% has been applied to the volumes as recommended in the SuDS manual (CIRIA, 2015).

Table 6-3 Attenuation volumes for BESS and substation areas

Flood event AEP	BESS (m^3)	Substation (m^3)
1% + 25% climate change	442	66

6.4. Runoff destination and proposed SuDS design

The majority of the Site consists of solar panels mounted on a metal frame, underlain with vegetation. For these areas, no formal surface water collection system is proposed. The BESS and substation pose a theoretical risk of fire, with the potential of contaminant mobilisation due to the chemicals within the electrical units and/or firefighting fluids. Therefore, the surface water system has been designed with an automated pollution control valve (linked to the fire detection system) such that surface water runoff will not be discharged during a fire event in these areas, preventing it from leaving the locality and allowing the potential contaminants to be removed/ treated.

As detailed in the Environmental Statement, a Soil Management Plan will be compiled for the Proposed Development. The purpose of this document will be to demonstrate how damage to soil horizons and ground cover will be mitigated and remediated during and after construction and for future decommissioning. Detailed measures to manage runoff from the various areas in the proposed development are provided below.

6.4.1. Solar Panels

In these areas of the Site rainfall will be allowed to percolate into the underlying soil as occurs at present. This includes rain falling on the solar panels and the supporting infrastructure, which will be drained to ground.

The solar arrays contain frequent gaps up and along the arrays, to allow the individual panels to manage thermal expansion along the array, which are fundamental for thermal movement. These gaps allow rainwater to disperse through the array and avoid concentrated flows landing on the ground.

Runoff from the panels can therefore be intercepted and buffered by the vegetation growing underneath the panels and retained prior to infiltration as with the greenfield situation. 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.

Overall runoff will be reduced as the vegetation will be in place all year round and the underlying soil will not be left bare or compacted by agricultural activities.

A typical example is shown in Figure 6.1. This example site is near Frome in Somerset and sited on mudstone bedrock, with soils described as "slowly permeable seasonally wet slightly loamy and clayey soils with impeded drainage", i.e. the same as at the proposed development. Rainfall is allowed to fall onto the ground beneath: there is no evidence of erosion or runoff from underneath the panels and sufficient vegetation occurs to prevent bare ground developing.

6.4.2. Access tracks

All field access tracks will be constructed of compacted gravel such that they are permeable to negate impacts to drainage. Each track shall be designed with a fall to a gravel filled longitudinal trench into which excess water will flow. These trenches will act as attenuation and treatment prior to infiltration.

Figure 6-16-1 Drainage of solar panels onto grass

6.4.3. BESS and substation

The proposed development will include inverter units and a main substation. Inverter units will be within cabins on concrete pads within the site, which will be connected to cables in backfilled trenches. Each inverter is positioned on legs raised above the base.

The site will also incorporate a BESS to satisfy the modern needs of solar farms. The BESS is made up of batteries in sealed shipping type containers, supported on legs on pads. A typical example is shown in Figure 6-2.

Figure 6-26-2 Typical battery containers used on a solar farm

Due to the potential risk of fire associated with these units, and the subsequent risk of contaminated firewater, infiltration is not considered a suitable SuDS measure in these areas. Instead, water should be collected and contained within a storage area, which can be isolated if required.

It is proposed that underground storage areas are created beneath the BESS and substation areas which are filled with single sized granular material. The BESS and substation will be surrounded by suitable bunds to separate runoff from adjacent areas and the storage provision lined to prevent the potential leaching of contaminants in the event of a fire. Under normal circumstances the storage areas will be drained to the northeast towards the existing drainage channel, approximately 300m north-west of the BESS/substation. However, automated pollution control devices (valves) will be fitted to the tank outfall to prevent the release of water when a fire is detected on Site.

Sizing of storage areas has been undertaken based upon a 100yr + 25% climate change scenario (see

~~Table 6-4~~ Table 6-4). This assumes that water would be released at a rate equivalent to the existing greenfield runoff rate of 13.7l/s and 6l/s at the BESS and substation respectively.

Additionally, storage volumes have been calculated to replicate a fire situation where no water is released from the storage areas. A 24hr storm duration has been used, based upon the assumption that this is the longest time period required for a tanker to arrive at the Site and pump out potentially contaminated water.

Table 6-4 shows the resulting volumes for a range of storm durations, including an additional 300m3 and 100m3 volume for firefighting water at the BESS and substation respectively.

The joint probability of a fire occurring simultaneously with a 1% AEP storm is very remote, therefore a 10% AEP event has been chosen to determine the storage requirements during a fire scenario. The fire scenario attenuation requirements are significantly larger than the normal conditions scenario, despite a smaller storm being considered. At the BESS the storage required to contain a 10% AEP + CC event during a fire scenario is 910m^3, whilst only 442m^3 is required for a 1% AEP + CC under normal conditions. Therefore the storage areas will generally be underutilised during normal conditions.

Table 6-4 Attenuation volumes for BESS and substation areas during a fire event

Flood event AEP plus fire	BESS (m^3)	Substation (m^3)
50% AEP+ 25% CC	753	314
10% AEP+ 25% CC	910	423
3.3% AEP+ 25% CC	1082	514
2% AEP+ 25% CC	1186	570
1% AEP+ 25% CC	1342	652

A preliminary design of the storage areas has been undertaken. It's assumed that the storage areas would be located beneath the BESS and substation areas, which are bunded and lined to prevent infiltration and filled with single sized granular material to provide attenuation. The amount of storage offered would be dependent upon the subgrade depth and Site gradient. The use of permeable surfacing should be considered at the detailed design stage.

An approximate area of 8,000m^2 and 6,000m^2 are available at the BESS and substation areas respectively. By creating storage areas with a depth of 0.4m and 0.3m and a void ratio of 30% within the granular fill material, a storage volume of 960m^3 and 540m^3 would be created at the BESS and substation respectively. Table 6-5 summarises the attenuation area dimensions. A layout of the proposed SuDS scheme is included in Appendix G.

Table 6-5 Preliminary sizing of BESS and substation attenuation areas

	BESS	Substation
Area (m^2)	8,000	6,000
Depth (m)	0.4	0.3
Volume (m^3)	960	540

6.4.4. Land drains~~Event~~

As noted in Section 4.2.5, parts of the Site are underdrained which may present a preferential flow path for surface water run off and/ or shallow groundwater under current, baseline conditions. Consultation with the EA, DCC and SDDC has recognised that land drains, where present, may be damaged by the proposed development including actions such as piling and trenching for cabling. Under the baseline conditions, the presence of underdrains, may, increase potential flood risk to off-Site receptors compared to true greenfield conditions. It is therefore considered that damage caused to land drains will act to 'slow the flow' and return affected areas back to or closer to greenfield conditions, encouraging surface water to infiltrate to the ground and thereby reduce the potential flood risk to off-Site receptors.

As shown in Figure 4-4, the underdrainage is shown to follow the natural topography of each field to an existing boundary ditch. Should a field drain be damaged, whilst surface water run-off will be slowed to greenfield rates, be filtered by the permanent grass sward and encouraged to infiltrate, should excess flows be generated, these will continue to follow the natural Site topography and ultimately discharge into the same existing ditch. Therefore, it can be concluded that, from a hydrological/ drainage perspective, localised damage to land drains may be viewed as a beneficial impact compared to the baseline conditions, slowing down the flow but maintaining the same overall flow path to the local boundary ditch network.

It is acknowledged that damage to land drains may impact the suitability of the soils for agricultural purposes which is covered within the Agricultural Land Assessment, outline CEMP and outline Decommissioning Plan.

6.5. exceedance

Storage at the BESS and substation areas has been provided for the 1% AEP + 25% climate change, as well as for the 10% AEP + 25% climate change under a fire scenario with no release of water. Storm events in excess of these will result in the storage areas being exceeded, the exceedance flows will be designed to follow the existing preferential surface water flow route towards the drain to the northeast. The flow route is detailed in Appendix F. A more detailed analysis of exceedance flows can be undertaken once the Site elevations and storage area design has been finalised and modelled.

6.6. Water quality

SuDS techniques can be used to effectively manage the quality of surface water flowing across a site. Different methods can be used to intercept pollutants and allow them to degrade or be stored in-situ without impacting the quality of water further downstream. Frequent and short duration rainfall events are those that are most loaded with potential contaminants (silts, fines, heavy metals and various organic and inorganic contaminants). Therefore, the first 5mm to 10mm of rainfall (i.e. the 'first flush') should be adequately treated using SuDS.

The proposed development will include low traffic roads, which the CIRIA SuDS manual categorises as presenting a low hazard rating. Table 6-6 shows the pollution hazard indices for each land use.

Table 6-6 Pollution hazard indices

Land use	Pollution hazard level	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Low traffic roads	Low	0.5	0.4	0.4

Where practical, runoff will be directed to permeable surfacing. Within the BESS and substation areas, water will be contained within a storage area prior to discharging to a nearby drainage channel. Table 6-7 below demonstrates that these SuDS methods provide sufficient treatment.

Table 6-7 SuDS mitigation indices

Type of SuDS	Total Suspended Solids (TSS)	Metals	Hydrocarbons
Permeable surfacing	0.7	0.6	0.7
Detention basin	0.5	0.5	0.6

7. Maintenance schedules

7.1. Overview

This section outlines the maintenance and management schedules for the proposed stormwater drainage system. The schedules have been formulated in line with guidelines contained within the CIRIA SuDS Manual (C753) (Woods Ballard, et al., 2015).

There are three categories of maintenance activities (including inspections and monitoring) referred to in this report:

- **Regular maintenance** – tasks which are required to be undertaken on a weekly or monthly basis, or as required.
- **Occasional maintenance** – tasks which are required to be undertaken periodically, typically at intervals of 3 months or more.
- **Remedial maintenance** – tasks which are not required on a regular basis but are done when necessary.

This section is intended to give an overview of the operation and maintenance for the range of drainage features included within the surface water drainage strategy and in relation to typical/ standard details only.

Maintenance schedules for the proposed SuDS components are provided in the following tables. These schedules are not exhaustive and should be reassessed at regular intervals to determine if any additional maintenance requirements are required to preserve the performance and condition of the drainage system.

7.2. Maintenance schedules

7.2.1. Pipes and manholes

A typical schedule of maintenance activities for pipes and manholes is included in Table 7-1.

Table 7-1 Pipes and manholes

Maintenance schedule	Required action	Frequency
Regular maintenance	Remove any accumulation of silt, sediment, leaves and debris etc	Monthly, or as required
	Inspect for evidence of poor operation	Monthly (during the first year), then half yearly
Occasional maintenance	High pressure water jet removal of silt build-up and avoid blockages, particularly at bends or changes in direction	Six monthly, or as required
	Remove or control tree roots where they are encroaching pipe runs, using recommended methods	As required
Remedial actions	Clear pipework and gully grates of blockages	As required
	Replace any damaged or failed pipes, gullies or manholes	As required

7.2.2. Permeable paving

A typical schedule of maintenance activities for permeable paving is included in Table 7-2.

Table 7-2 Permeable paving

Maintenance schedule	Required action	Frequency
Occasional maintenance	Initial inspection	Monthly for three months after installation
	Inspect for evidence of poor operation and/or weed growth – if required, take remedial action	Three-monthly, 48 hours after large storm in first six months
	Inspect silt accumulation rates and establish appropriate jetting frequencies	Annually
	Monitor inspection chambers	Annually
	Stabilise and mow contributing and adjacent areas	As required

Maintenance schedule	Required action	Frequency
	Removal of weeds or management using glyphosate applied directly into the weeds by an applicator rather than spraying	As required – once per year on less frequently used pavements
Remedial actions	Remediate any landscaping which, through vegetation maintenance or soil slip, has been raised to within 50mm of the level of the paving	As required
	Remedial work to any depressions or ruts considered detrimental to the structural performance or a hazard to users.	As required
	Rehabilitation of surface.	As required

7.2.3. Granular Sub-base

A typical schedule of maintenance activities is included in Table 7-3.

Table 7-3 Granular sub-base

Maintenance schedule	Required action	Frequency
Regular maintenance	Inspect/ check all inlets, outlets, inspection/access chamber, vents to ensure that they are in good condition and operating as designed	Monthly for 3 months, then annually
	Inspect silt traps and note rate of sediment accumulation	Monthly in the first year and then annually
	Inspect and identify any areas that are not operating correctly. If required take remedial action	Monthly for 3 months, then annually
Occasional maintenance	Remove sediment from pre-treatment structures	Annually, or as required
Remedial actions	Repair/rehabilitate inlets, outlets, overflows, inspection/access chamber and vents	As required

7.2.4. Flow controls

A typical schedule of maintenance activities for flow control devices is included in Table 7-4.

Table 7-4 Flow control devices

Maintenance schedule	Required action	Frequency
Regular maintenance	Inspect/check pipework to ensure that the flow control is in good condition and operating as designed	Monthly
	Inspect for evidence of poor operation	Monthly, or as required
Occasional maintenance	High pressure water jet removal of silt build-up	Six monthly, or as required
Remedial actions	Replace the flow control if it becomes damaged	As required
	Clear pipework of blockages	As required

7.3. Inspections

In conjunction with the above maintenance schedules and in accordance with both the CEMP (Construction Phase) and management plan (Operational Phase), regular inspections of all stormwater drainage equipment and solar panel arrays will be undertaken to identify potential problems as early as possible. Routine inspections will be undertaken each quarter, with all array foundations, swales, ditches, drains, culverts and track crossing inspected for blockages and/or debris. All blockages are to be cleared immediately.

Swales, ditches, drains, culverts, track crossings and, where relevant, array foundations within Flood Zone 2/ 3 on-Site will also be inspected for blockages and/or debris after a storm event.

8. Flood Risk Management Measures

8.1. Mitigation for on-Site flooding

Outside of the fluvial flood zone 2, the area is not at significant flood risk and climate change will not alter this for the expected lifetime of the Proposed Development.

Due to potential impacts and the uncertainty in published flood risk mapping, at the request of the EA, 1D-2D hydraulic modelling has been undertaken (see Appendix H) for the likely flood extents and depths along the Ordinary Watercourse and tributary thereof running through the Site. The modelling has shown the following:

- The 0.1% AEP event has nearly identical peak flows with the 1% AEP with upper end climate change (51% increase) – therefore the 0.1% AEP event can be considered to be the largest event required to be assessed;
- The modelling has shown flood extents for the area to the east of the proposed panels (on the left/west bank of the Ordinary Watercourse) are substantially reduced in comparison to the existing EA flood zones. Proposed panels adjacent to this location are now outside of the largest modelled event (0.1% AEP); and,
- Baseline modelling has shown flooding for the 1% AEP event and larger over the left / west bank of the tributary in an area where panels are proposed however the maximum flood depth is 0.15 m whereas the panels are proposed to sit approximately 0.8 m above ground level.

The solar panels are raised approximately 0.8 m above ground level and therefore unlikely to be affected by this limited flooding on the left/west bank of the tributary, should it occur. No additional specific mitigation is therefore required to protect them.

Inverters, transformers and substations are not proposed to be sited within areas of fluvial flood risk and should not be sited within the surface water flood risk areas or, if this is unavoidable, vulnerable parts of these structures should be raised at least 0.3 m above the ground level. It is proposed to raise them by 0.6 m above ground level on piers as a precaution and this approach will also avoid any potential blockage or diversion of surface flow paths.

Gravel tracks will not be raised above the ground surface in the surface water flood risk areas to avoid diverting flow paths.

The Site will not be normally 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.

All runoff from the proposed structures will be dealt with locally with source control measures and the Site will not generate extra runoff. Further mitigation for flood risk is not considered to be required but a construction phase surface water management plan should be developed within the CEMP to ensure flood risks and flood runoff are not increased during construction.

8.2. Flood Compensation Volume

Occupation of the flood storage areas by structures will be minimal (as pathways rather than storage areas) and the alternative routes will offer similar storage characteristics. Explicit compensation for lost storage is therefore not required.

Moving vulnerable structures away from surface water flow paths avoids this requirement entirely.

8.3. Safe Access and Exit

Whilst Rosliston Road, and the access tracks off it, are located within the fluvial flood risk area, alternative routes outside of the flood risk area are available such as via Coton Road. The local road network may be affected by flooding where it crosses the unnamed watercourse and by surface water, particularly Coton Road between Oaklands Farm and Lad's Grave. Flood depths along these routes are expected not to exceed 300 mm however, and they should remain passable with care.

8.4. Flood Warning

Flood warning is unlikely to be of use in the area as the catchment is mostly out of the flood risk area and the response of the small watercourses to rainfall could be very rapid. Nevertheless, the site operators should sign up for the flood alert service provided by the EA in order to avoid working on Site when flooding is possible and have measures in place to inform any personnel on Site of the need to close and evacuate. Further information is provided here:

https://flood-warning-information.service.gov.uk/warnings

8.5. Off-site Impacts

The proposed development will not change any land profiles, reduce flood storage volume, increase discharge runoff or impede surface water flows, and therefore with the exception of the three new watercourse crossings of the Ordinary Watercourse it is very unlikely to impact on flood risk elsewhere.

The flood modelling undertaken of the proposed development has shown localised impacts for all events from the proposed crossings with the largest impact indicated for the 3.33% event. Adverse impacts from the two upstream proposed crossings are almost entirely contained within the Site boundary. The third proposed most downstream crossing causes some flow to overtop the right / east bank and increase flood depths off-Site by a maximum of 0.~~08m~~ 11m along pre-existing flow path, up to 0.13m where the floodplain filters into a network of drainage ditches (i.e. within the ditches themselves) and into an existing pond where depths increase by up to 0.18m. There are no changes in flood extents in the vicinity of the pond for any event, indicating that the increase in flood depth does not cause overtopping of this feature.

The proposed development modelling has also shown significant areas where flood depths have been reduced for all events. The area of reduced flood risk off-Site is greater in size than the area at increased flood risk for all events. Over 90% of the impacted off-site land is modelled to have reduced flood depths compared to baseline for the 1% with climate change and 0.1% AEP events – hence the overall impact on flood levels off-site is beneficial.

Impacts for the 3.33% AEP event are shown in Figure 8-1, and a summary of total land adversely and beneficially impacted is provided in Table 8-1. Whilst the 1% AEP with climate change and 0.1% AEP events show~~n~~ the greatest maximum increase in flood depths – these are over a very small area, and therefore it is still considered that the 3.33% AEP event is where the largest adverse impact is shown. A full set of figures comparing the baseline and proposed flood depths are provided in Appendix H with the hydraulic modelling report.

Table 8-1 Summary of off-Site impacts from proposed development

Event	Off site land at increased flood depths (m^2)	Off-site land at decreased flood depths (m^2)	Percentage of impacted land at decreased flood depths	Maximum increase in flood depths off-Site (m)
3.33% AEP	~~13292~~14133	~~18475~~18465	5~~7~~8%	0.18 (Pond / drains)~~3~~ 0.11 (floodplain)
1% AEP	~~8411~~13914	~~28656~~29333	~~77~~68%	0.~~08~~10 (floodplain)
1% AEP + 30% CC	~~3416~~5588	~~54405~~54728	9~~1~~4%	0.12 (within watercourse)~~4~~ 0.06 (floodplain)
0.1% AEP	~~4726~~6092	~~124321~~127172	9~~5~~6%	0.16 (within watercourse)~~5~~ 0.05 (floodplain)

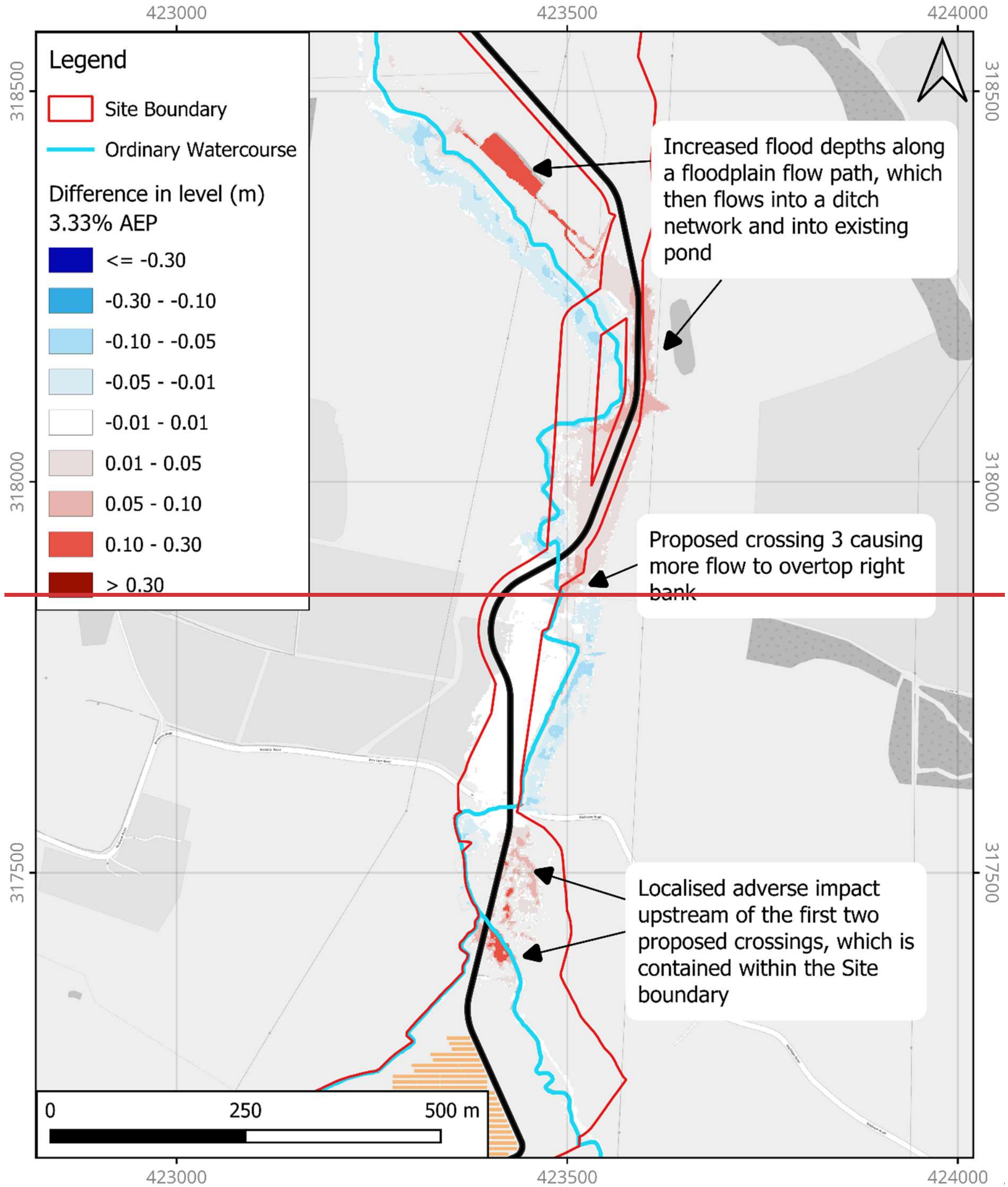
Flood extents are shown to overall decrease off-Site, with more land (approximately double) removed from the flood extent than added for all events modelled. Figure 8-2 shows the extent of the increase and decrease of flood extent for the 3.33% AEP event, and Table 8-2 summarises the areas for each of the events.

As can be seen from Figure 8-2 the areas that are impacted by an increase in flood extent consist entirely of farmland or areas of woodland/ vegetation, with no properties impacted or close to being impacted.

Table 8-2 Summary of change in flood extent outside of Site boundary

	3.33% AEP	1% AEP	1% AEP + 30% CC	0.1% AEP
Decreased flood extent (off-Site) m^2	8,291	4,226	5,748	4,619
Increased flood extent (off-Site) m^2	3,640	3,715	2,301	2,471

Figure 8-18-11 Impact of Proposed Development on flood levels for the 3.33% AEP event


423000
423500
424000
318500
318000
317500
Legend
Site Boundary
Ordinary Watercourse
Difference in level (m)
3.33% AEP
<= -0.30
-0.30 - -0.10
-0.10 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.10
0.10 - 0.30
> 0.30
Increased flood depths along a floodplain flow path, which then flows into a ditch network and into existing pond
Proposed crossing 3 causing more flow to overtop right bank
Localised adverse impact upstream of the first two proposed crossings, which is contained within the Site boundary
0
250
500 m

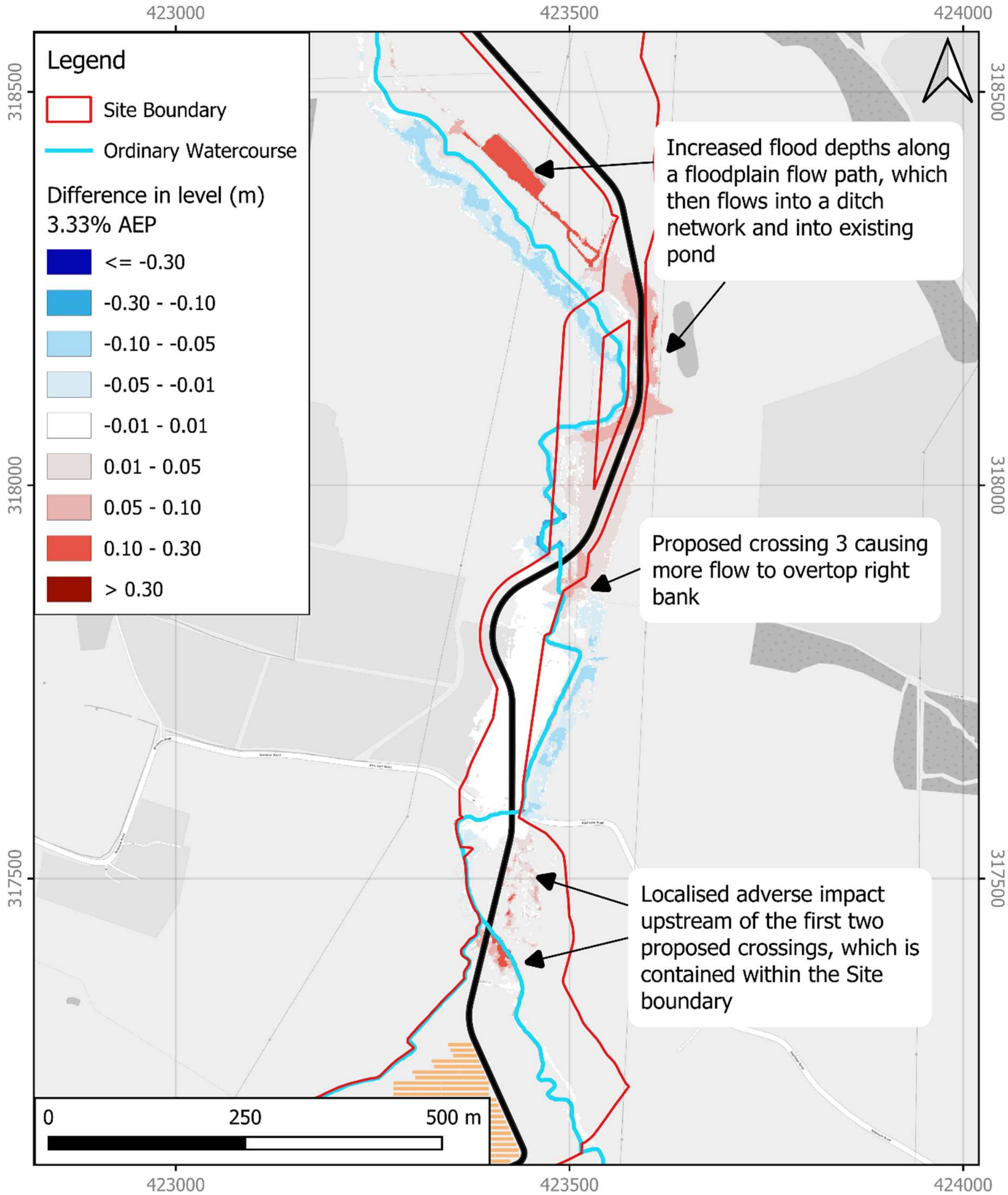
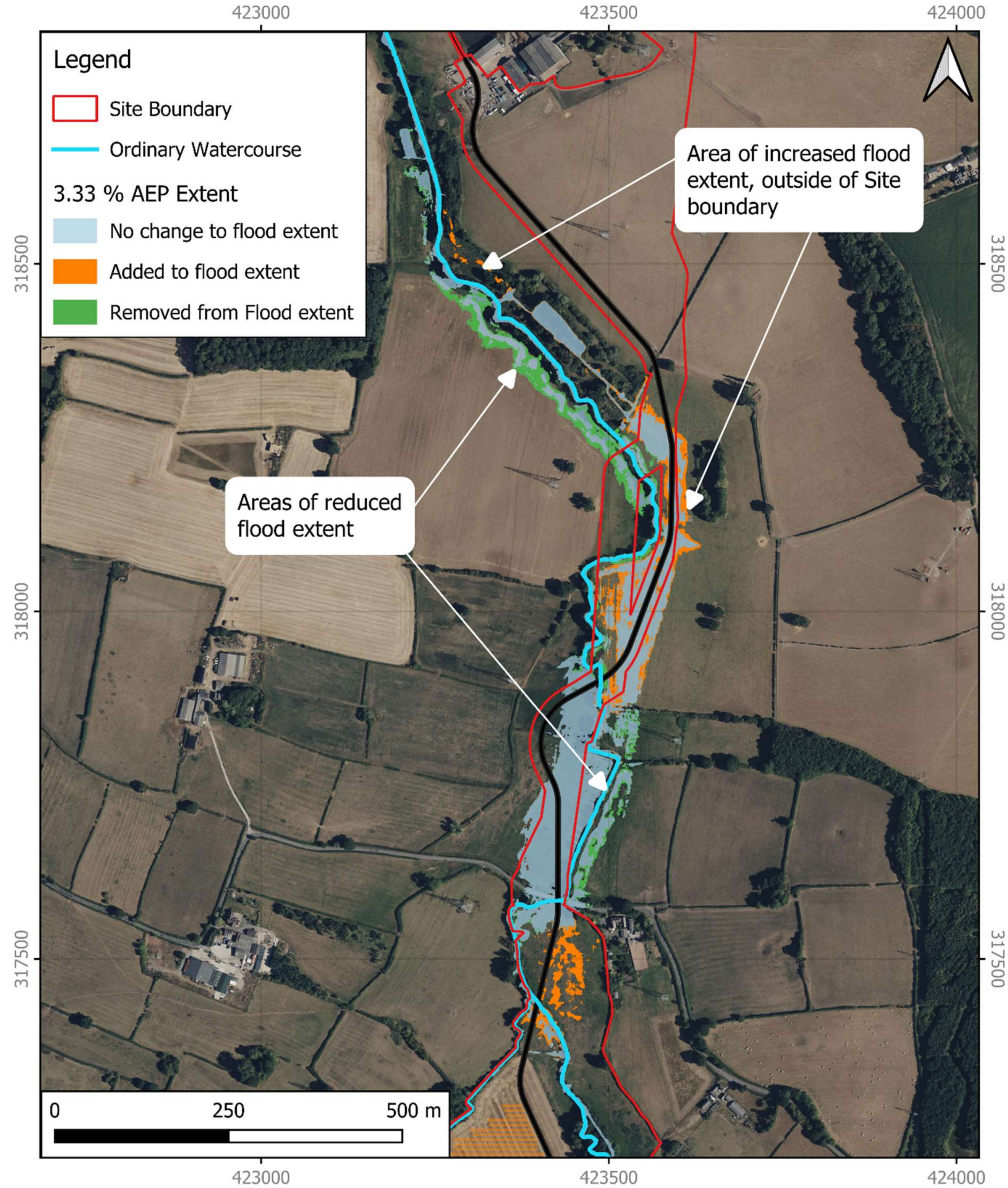

423000
423500
424000
318500
318000
317500
Legend
Site Boundary
Ordinary Watercourse
Difference in level (m)
3.33% AEP
<= -0.30
-0.30 - -0.10
-0.10 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.10
0.10 - 0.30
> 0.30
Increased flood depths along a floodplain flow path, which then flows into a ditch network and into existing pond
Proposed crossing 3 causing more flow to overtop right bank
Localised adverse impact upstream of the first two proposed crossings, which is contained within the Site boundary
0
250
500 m

Figure 8-28-2 Impact of Proposed Development on flood extents for the 3.33% AEP event



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, 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, if 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 Greenfield Runoff Calculations

Appendix C Access Track Cross-Section

Appendix D Battery Storage Details

Appendix E Substation Details

Appendix F SuDS layout

Appendix G Flood Modelling report