RWE

Peartree Hill Solar Farm

Environmental Statement

Volume 4

Appendix 5.6: Flood Risk Assessment

Revision 2

Planning Act 2008

Infrastructure Planning

(Applications: Prescribed Forms

and Procedure) Regulations 2009 –

Regulation 5(2)(a)

Application Document Ref: EN010157/APP/6.4

July 2025

Prepared by calibro on behalf of RWE Renewables UK Solar and Storage LTD

calibro

PEARTREE HILL SOLAR

Beverley, East Yorkshire, HU17 9SS

FLOOD RISK ASSESSMENT

Project No	20-206
Revision No	06
Issue date	08/07/25

Transport Planning | Flood Risk & Hydrology | Infrastructure & Drainage

Control Sheet

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1 EXECUTIVE SUMMARY

1.1.1 *RWE Renewables UK Solar and Storage Ltd* is applying for permission for a Solar Farm. The Proposed Development is a solar photovoltaic (PV) electricity generating and storage facility proposed by the Applicant with an export capacity of 320 megawatts (MW) and associated infrastructure. The Proposed Development encompasses an area of approximately 891 hectares (ha) ('the Site') and is located within the administrative area of East Riding of Yorkshire Council. Approximately 500ha will contain solar power generating infrastructure. This report focusses on these areas as the remainder is for below-ground cable routes, access and environmental improvements which will have no material bearing on flood risk or drainage.

1.1.2 This document considers the flood risk to the Site, sets out appropriate mitigation and presents a drainage strategy to mitigate against the potential downstream impacts of the Proposed Development.

1.1.3 The Site falls partly within Flood Zone 2 and 3. The proposals constitute 'Essential Infrastructure' and are appropriate in all Flood Zones subject to passing the Sequential Test and, for development within Flood Zone 3, the Exception Test. These are considered elsewhere in the Planning Statement. This document demonstrates compliance with the second part of the Exception Test, that the development will be safe for the lifetime of the Proposed Development and has been supported by site-specific modelling that demonstrates no increase to flood risk elsewhere. The assessment is based on decommissioning commencing before 2070.

1.1.4 A review of model output data and defence information concludes that the Site is not at significant actual or residual risk of tidal flooding and that no further hydraulic modelling is required. This has been agreed with the Environment Agency.

1.1.5 Site-specific hydraulic modelling has been carried out to assess the actual risk of fluvial flooding to the development during the design event as well as the residual risk should there be a breach of defences or should key sections of defences be removed entirely. The modelling work also includes a simulation of the Credible Maximum Scenario (refer to Section Fluvial Flood Risk5.11) to ensure the proposals for the safety critical elements (exporting substations) are sufficiently resilient to extreme climate change. The modelling work has been submitted to the Environment Agency who has confirmed that the modelling is fit-for-purpose.

1.1.6 The Proposed Development layout has been derived so that supporting water sensitive infrastructure (substations, hybrid packs, switch gear etc.) is placed outside the design event flood extents in accordance with the sequential approach, wherever possible, and that they would be flood resilient. The principle of placing solar arrays in areas at risk of flooding is well established.

1.1.7 The two exporting substations have been located on high ground outside the flood extents for the Credible Maximum Scenario (to 2100) and the maximum breach extents. All water-sensitive infrastructure in these substations will be at least 0.3m above the Credible Maximum Scenario Flood Level which satisfies the relevant policy set out in Overarching National Policy Statement for energy (NPS EN-1).

1.1.8 Batteries and other containerised infrastructure have been located outside the maximum breach extents wherever practicable.

1.1.9 Solar arrays and containerised infrastructure will be set at least 0.3m above the design event flood level which will be sufficient to mitigate to account for uncertainty and floating debris. Additionally, they will be set above the maximum breach flood level.

1.1.10 The January 2025 iteration of the Risk of Flooding from Surface Water (RoFSW) dataset[1] shows that the majority of the Site is at 'Very Low' risk, with areas at risk generally associated with watercourses and isolated low points across the Site. The predicted flooding would not affect any of the proposed substations or containerised infrastructure. Panels and associated inverter/combining boxes and tilting/rotating mechanisms would be set above the predicted 1 in 1,000 year surface water flood level. Surface water flooding would therefore not present a risk to the proposals and the proposals would not impact the movement of surface water.

[1]https://www.data.gov.uk/dataset/d1f31121-0ddc-41e9-9d28-80a4b3e40b7d/risk-of-flooding-from-surface-water-complex-bundle

1.1.11 The Proposed Development is not considered to be at significant risk of flooding from sewers, reservoirs, or other artificial sources.

1.1.12 The solar arrays and containers housing batteries, inverters and storage dispersed across the Site will be raised above ground and have an insignificant impact on the response of the land to rainfall.

1.1.13 Discharging runoff from the proposed hardstanding across the Site is constrained in terms of infiltration, potential for saturation and potentially high water levels in the watercourses. Furthermore, as the Site has a flat topography, rainfall currently falling on the Site would slowly percolate to the ground and slowly flow to the watercourses.

1.1.14 It is therefore proposed to mimic this arrangement by utilising the gravel bases beneath infrastructure to accommodate runoff and allow it to percolate as per the existing Site. The gravel bases have been sized to accommodate a 1 in 100 year +25% 12-hour rainfall event.

1.1.15 The cessation of intensive agriculture across the Site will allow establishment of natural grassland and a commensurate improvement in soil structure. This will reduce runoff rates and volumes, soil erosion and pollution.

1.1.16 There is a network of watercourses on the Site. In accordance with guidance from the relevant authorities, a development buffer is proposed for these watercourses. They would be 9m from 'top of bank' of the IDB 'viewed' watercourses, 8m from 'top of bank' of Main Rivers and formal flood defences, 5m from 'top of bank' of Ordinary Watercourses and 16m from the top of tidal water bodies (which are limited).

1.1.17 This document demonstrates that the Proposed Development demonstrates compliance with the relevant flood risk and drainage policies in NPS EN-1 and NPS EN-3 and meets the aims of the National Planning Policy Framework, being safe from all sources of flooding over the lifetime of the development and not increasing flood risk elsewhere.

2 INTRODUCTION

2.1 Report Updates

2.1.1 This version (V06) of the document includes updates to reflect the updated RoFSW mapping published on 8 January 2025 and the updated Flood Map for Planning Flood Zones published on 25 March 2025.

2.2 Study Scope

2.2.1 Calibro has been appointed by *RWE Renewables UK Solar and Storage Ltd* (the Applicant) to undertake a Flood Risk Assessment (FRA) for a proposed Nationally Significant Infrastructure Project (NSIP) comprising a solar farm and associated infrastructure hereafter referred to as Proposed Development. The Proposed Development location and hydrology characteristics are discussed in Section 3.

2.2.2 Pre-application engagement has been carried out with the Environment Agency's National Infrastructure Team to agree the approach to hydraulic modelling and flood risk mitigation and with the Lead Local Flood Authority (LLFA) and Beverely and North Holderness Internal Drainage Board (IDB) to agree the approach to drainage. Relevant meeting minutes, emails and letters are reproduced in Appendix D.

2.2.3 Hydraulic modelling has been carried out to assess the risk of fluvial flooding. The outputs of the modelling work were used to guide the layout of the Proposed Development as well as to determine requirements for raising solar arrays and enabling infrastructure

2.2.4 The hydraulic modelling report includes discussion of Land Area A (refer to Figure 3-2) located on the eastern side of the River Hull to the north of Beverley Airfield. The River Hull embankments in this location are approximately 4m high and simulated breaches resulted in extensive, deep flooding. This was one of the key considerations which resulted in Land Area A being removed from the development proposals.

2.2.5 Further details can be found in the Pear Tree Hill Hydraulic Modelling Report which is contained within Appendix C.

2.2.6 This FRA assesses the flood risk from all sources in order to avoid inappropriate development in areas at risk of flooding, taking a sequential approach to the layout, sets out mitigation so that the Proposed Development will be safe over its lifetime without increasing flood risk elsewhere, demonstrates that it will remain operational during times of flood and sets out the general approach to flood warning and evacuation plans in accordance with relevant parts of NPS EN-1 and EN-3 as discussed in Section 2.3 below.

2.2.7 This FRA considers all sources of flooding including:

- Tidal Flooding - from the sea.
- Fluvial Flooding - from rivers and streams.
- Surface Water Flooding - from intense rainfall events.
- Groundwater flooding - from elevated groundwater levels or springs.
- Flooding from sewers - from existing sewer systems.
- Artificial sources - from reservoirs, canals etc.

2.2.8 Section 5 of this document considers actual risk, residual risk, floodplain storage and emergency planning including accounting for the impacts of climate change. In accordance with National Policy Statement (NPS) EN-1, 'Overarching National Policy Statement for energy', it also considers the Credible Maximum Scenario for 'safety critical elements', namely the exporting substations.

2.2.9 Mitigation measures to minimise flood risk to the site are presented in Section 6.

2.2.10 Section 7 discusses the Proposed Development's impact on drainage and summaries the strategy to manage surface water for the lifetime of the development.

2.2.11 This FRA demonstrates compliance with relevant policy and guidance particularly relevant NPSs (EN-1, EN-3 and EN-5) and the NPPF and supporting guidance as discussed below.

2.3 National Policy Statements for Energy infrastructure

2.3.1 The NPSs sets out how NSIP applications for energy infrastructure will be assessed and the way in which impacts and mitigations will be judged. The 2023 revised NPSs (EN-1 to EN-5) came into force on 17 January 2024.

Overarching National Policy Statement for energy (EN-1)

2.3.2 Relevant parts of NPS EN-1[2] are reproduced below.

2.3.3 Paragraph 4.10.11

"Applicants should demonstrate that proposals have a high level of climate resilience built-in from the outset and should also demonstrate how proposals can be adapted over their predicted lifetimes to remain resilient to a credible maximum climate change scenario. These results should be considered alongside relevant research which is based on the climate change projections."

2.3.4 Paragraph 4.10.12

"Where energy infrastructure has safety critical elements, the applicant should apply a credible maximum climate change scenario. It is appropriate to take a risk-averse approach with elements of infrastructure which are critical to the safety of its operation."

2.3.5 Paragraph 5.8.6

"The aims of planning policy on development and flood risk are to ensure that flood risk from all sources of flooding is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to steer new development to areas with the lowest risk of flooding."

2.3.6 Paragraph 5.8.7

"Where new energy infrastructure is, exceptionally, necessary in flood risk areas (for example where there are no reasonably available sites in areas at lower risk), policy aims to make it safe for its lifetime without increasing flood risk elsewhere and, where possible, by reducing flood

[2] https://assets.publishing.service.gov.uk/media/65bbfbdc709fe1000f637052/overarching-nps-for-energy-en1.pdf

risk overall. It should also be designed and constructed to remain operational in times of flood."

2.3.7 Paragraph 5.8.27

"The surface water drainage arrangements for any project should, accounting for the predicted impacts of climate change throughout the development's lifetime, be such that the volumes and peak flow rates of surface water leaving the site are no greater than the rates prior to the proposed project, unless specific off-site arrangements are made and result in the same net effect."

2.3.8 Paragraph 5.8.29

"The sequential approach should be applied to the layout and design of the project. Vulnerable aspects of the development should be located on parts of the site at lower risk and residual risk of flooding. Applicants should seek opportunities to use open space for multiple purposes such as amenity, wildlife habitat and flood storage uses. Opportunities should be taken to lower flood risk by reducing the built footprint of previously developed sites and using SuDS."

2.3.9 Paragraph 5.8.30

"Where a development may result in an increase in flood risk elsewhere through the loss of flood storage, on-site level-for-level compensatory storage, accounting for the predicted impacts of climate change over the lifetime of the development, should be provided."

2.3.10 Paragraph 5.8.33

"The receipt of and response to warnings of floods is an essential element in the management of the residual risk of flooding. Flood Warning and evacuation plans should be in place for those areas at an identified risk of flooding."

National Policy Statement for renewable energy infrastructure (EN-3)

2.3.11 Relevant parts of NPS EN-3[3] are reproduced below.

2.3.12 Paragraph 2.4.11:

"Solar photovoltaic (PV) sites may also be proposed in low lying exposed sites. For these proposals, applicants should consider, in particular, how plant will be resilient to:

- *increased risk of flooding; and*
- *impact of higher temperatures."*

2.3.13 Paragraph 2.10.84

"Where a Flood Risk Assessment has been carried out this must be submitted alongside the applicant's ES. This will need to consider the impact of drainage. As solar PV panels will drain to the existing ground, the impact will not, in general, be significant.

2.3.14 Paragraph 2.10.85

"Where access tracks need to be provided, permeable tracks should be used, and localised Sustainable Drainage Systems (SuDS), such as swales and infiltration trenches, should be used to control any run-off where recommended."

2.3.15 Paragraph 2.10.86

"Given the temporary nature of solar PV farms, sites should be configured or selected to avoid the need to impact on existing drainage systems and watercourses."

2.3.16 Paragraph 2.10.87

"Culverting existing watercourses/drainage ditches should be avoided."

2.3.17 Paragraph 2.10.154

[3]https://assets.publishing.service.gov.uk/media/65a7889996a5ec000d731aba/nps-renewable-energy-infrastructure-en3.pdf

"Water management is a critical component of site design for ground mount solar plants. Where previous management of the site has involved intensive agricultural practice, solar sites can deliver significant ecosystem services value in the form of drainage, flood attenuation, natural wetland habitat, and water quality management."

2.4 Guidance

2.4.1 The following guidance documents have been used during the preparation of this preliminary assessment:

- Flood Risk and Coastal Change Planning Practice Guidance (Department for Levelling Up, Housing and Communities, 2022);
- Flood Risk Assessments: climate change allowances (Environment Agency, 2022); and
- Non-Statutory Technical Standards for Sustainable Drainage Systems (Department for Environment, Food and Rural Affairs, 2015).
- 'Breach of Defences Guidance - Modelling and Forecasting Technical Guidance Note'

2.4.2 For further details refer to Section 15.2 of the Environmental Statement and associated Appendices.

2.5 National Planning Policy Framework

2.5.1 The NPPF requires that the planning system takes full account of flood risk. Although the framework does not contain specific policies for nationally significant infrastructure, in accordance with Paragraph 5 of the NPPF, it is considered to be relevant and therefore a material consideration for the Proposed Development.

2.5.2 *"The Framework does not contain specific policies for nationally significant infrastructure projects. These are determined in accordance with the decision making framework in the Planning Act 2008 (as amended) and relevant national policy statements for major infrastructure, as well as any other matters that are relevant (which may include the National Planning Policy Framework). National policy* *statements form part of the overall framework of national planning policy, and may be a material consideration in preparing plans and making decisions on planning applications*". The NPPF requires that:

- A 'site specific' FRA will be undertaken for any site that has a flood risk potential.
- Flood risk potential is minimised by applying a 'sequential approach' to locating 'vulnerable' land uses.
- Sustainable drainage systems are used for surface water management where practicable.
- Flood risk is managed through the use of flood resilient and resistant techniques.
- Residual risk is identified and safely managed.
- Safe access and egress to and from the development can be achieved.

2.5.3 NPPF states that a site-specific FRA will be required for proposals:

- that are greater than 1 hectare in area within Flood Zone 1.
- that are located in Flood Zones 2 and 3.
- in an area within Flood Zone 1 which has critical drainage problems.
- in an area within Flood Zone 1 identified in a Strategic Flood Risk Assessment as being at increased flood risk in the future.
- in an area in Flood Zone 1 that may be subject to other sources of flooding, where its development would introduce a more vulnerable use.

2.6 Engagement

2.6.1 The completion of this FRA has been informed by engagement with the Environment Agency, Lead Local Flood Authority and Internal Drainage Board. A summary of the engagement is provided in Table 2-1 with additional details in Appendix D.

Table 2-1 Stakeholder Engagement

Consultee	Date and format	Summary of matters raised	How this matter has been addressed
Environment Agency National Infrastructure Team	Meeting via Microsoft Teams on 27 March 2024	Confirmation that modelling of tidal flooding is not required. The Environment Agency agreed the modelling approach is reasonable, subject to consideration of the Humber 2100+ study (the report of which was provided by the Environment Agency). Agreement that the breach modelling parameters used are appropriate but that additional simulations for the Monk Dike were prudent. Agreed the approach to sensitivity testing as well as Site mitigation.	Agreed approach embedded within the modelling methodology.
East Riding of Yorkshire Council Lead Local Flood Authority **Beverley and North Holderness Internal Drainage Board**	Meeting via Microsoft Teams on 06 June 2024	Agreed the approach to surface water drainage and that damage to existing land drainage is acceptable. Site and drainage designs to be cognisant of saturated conditions often experienced.	Reflected in this FRA.

Consultee	Date and format	Summary of matters raised	How this matter has been addressed
Environment Agency National Infrastructure Team	Letter dated 29 August 2024	Positive review of Hydraulic Modelling Report Addendum agreeing the Site hydraulic model is fit for purpose.	Reflected in the hydraulic modelling report (Appendix C to this FRA)
Environment Agency National Infrastructure Team	Meeting via Microsoft Teams on 20 January 2025	Request for clarification regarding the Proposed Development lifetime and therefore climate epoch to apply. Request for clarification that construction material storage would be outside Flood Zone 3b	Reflected in this FRA – clarification on decommissioning commencement and that storage would be outside Flood Zone 3b.
Planning Inspectorate	Letter dated 21 March 2025	Request to update the assessments in line with newly released flood and coastal erosion risk data	Revision to the FRA to assess the revised RoFSW and Flood Map for Planning mapping
Environment Agency National Infrastructure Team	Email dated 30 June 2025	Confirmation that Flood Zones associated with Bowlams Dike are based on the New National Model and recommendations for assessment in	Analysis included in Section Fluvial Flood Risk5.11

Consultee	Date and format	Summary of matters raised	How this matter has been addressed
		absence of output data	
Environment Agency National Infrastructure Team	Regular, ongoing monthly meetings held on the 4th Thursday of each month, commencing on 24 April 2025	Agreement to update the FRA in line with PINS request, tracking progress of the FRA updates and discussing relevant issues	Reflect discussions held in the revised FRA

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3 EXISTING SITE AND HYDROLOGY CHARACTERISTICS

3.1 Site Description

3.1.1 The Proposed Development encompasses an area of approximately 891 hectares (ha) (‘the Site’) and is located within the administrative area of East Riding of Yorkshire Council. It comprises several areas of land connected by a series of underground cables: Land Area B, Land Area C, Land Area D, Land Area E and Land Area F (together ‘the Land Areas). Land Area A does not form part of the Proposed Development.

3.1.2 The Proposed Development will be located within ‘the Order Limits’ which sets out the maximum extent within which the Proposed Development can be carried out. The description of the Proposed Development is set out in Section 4. The extent of land contained within the Order Limits is hereafter referred to as ‘the Site’.

3.1.3 The Site is located near the town of Beverley, East Riding of Yorkshire. The approximate co-ordinates at the centre of the Site are TA 090 419. The nearest postcode to the centre of the Site is HU17 9SS.

3.1.4 The Site is located to the north of the city of Kingston Upon Hull (hereafter referred to as Hull) and the Humber estuary, to the east of Beverley and the River Hull and to the south of Driffield. The Order Limits are shown in Figure 3-1.

3.1.5 The Site covers approximately 891ha. Approximately 500ha is solar generation and supporting infrastructure, with the remainder of the land holding primarily for cable routes and environmental enhancements. As the cable routes will be buried and not vulnerable to flooding the focus of this report is the areas where above ground infrastructure is proposed. The Proposed Development Land Areas are shown labelled B-F in Figure 3-2. Land Area A is discussed in the modelling report contained in Appendix C but does not form part of the Proposed Development and is only included for completeness in Figure 3-2.

Figure 3-1 Order Limits

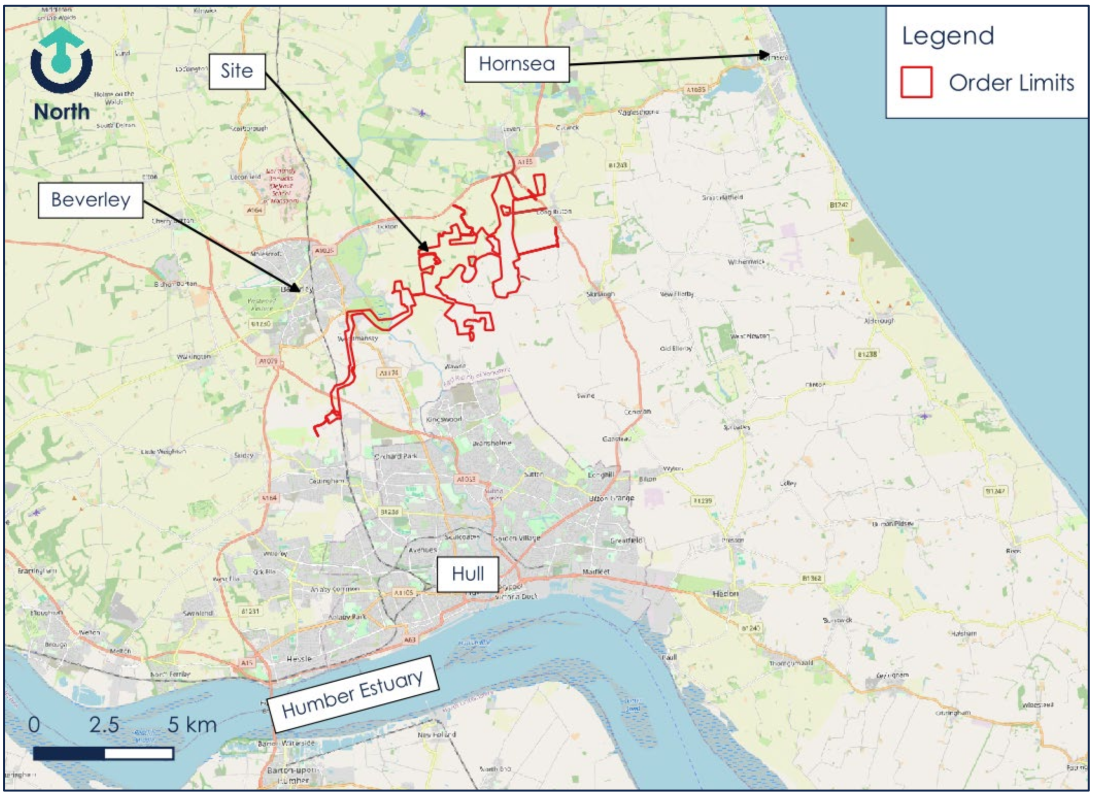
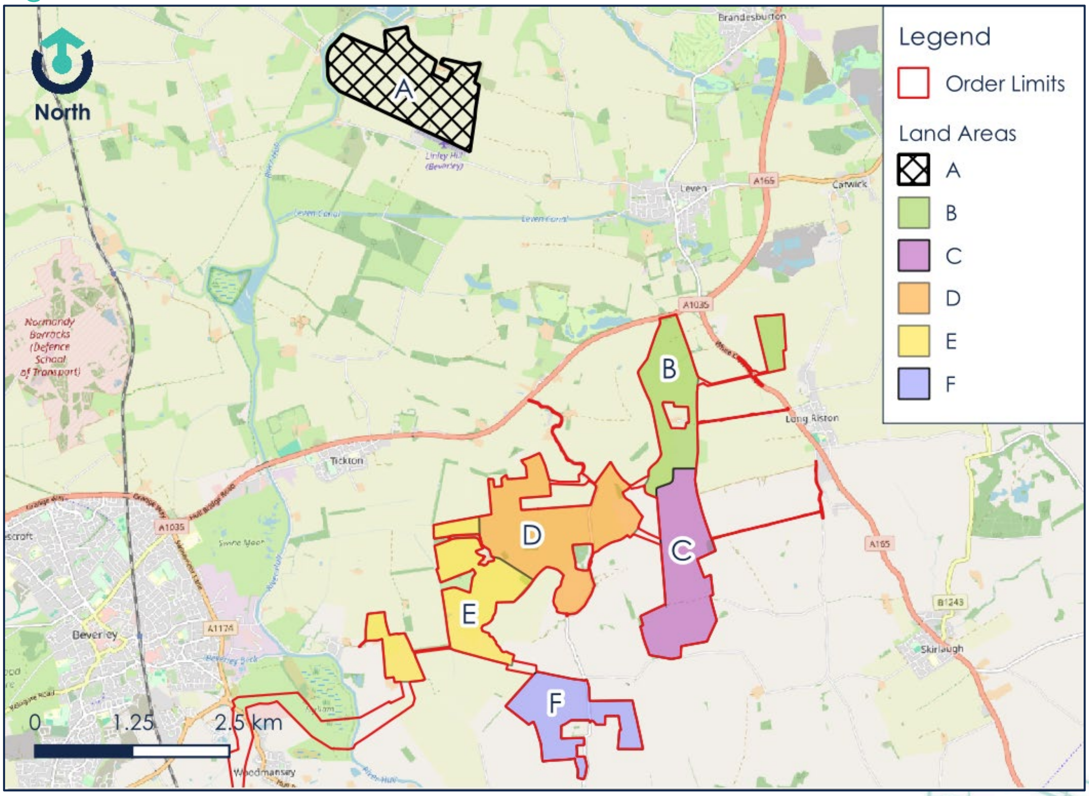


Figure 3-2 Land Areas



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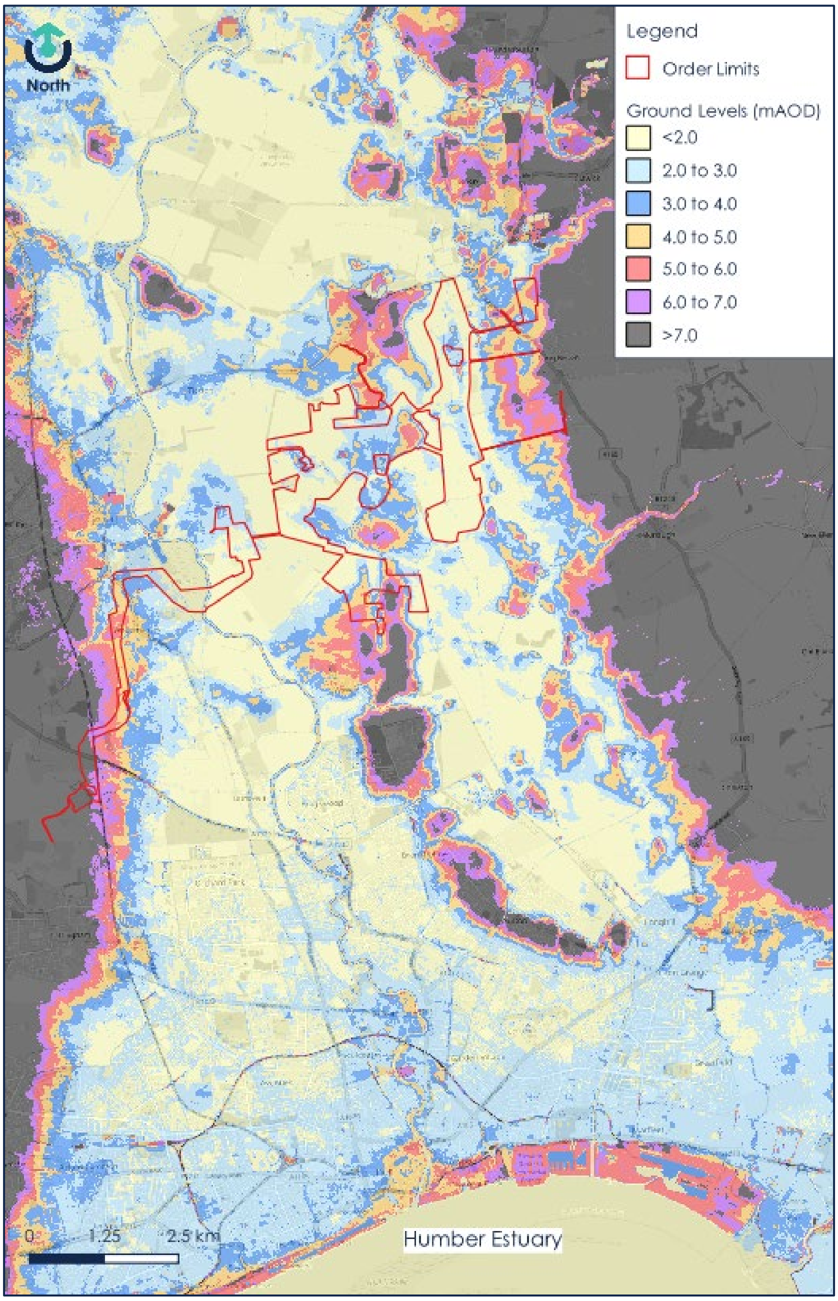
3.2 Topography and Hydrology

3.2.1 The proposed areas of solar generation are predominantly on low-lying land as shown in Figure 3-3. Drawing 20-206-60-300 presents the same information in A3 format and is contained in Appendix B. Site levels generally vary between 0 and 8 metres Above Ordnance Datum (mAOD) and the ground tends to be very flat. The cable routes extend into higher ground to the southwest of the Site.

Figure 3-3 Site Topography



3.2.2 There are a large number of watercourses that flow through or are adjacent to the Site. The principal watercourses and IDB administrative area are shown in Figure 3-4.

3.2.3 The IDB administrative area covers a large area that is generally below 7mAOD. The extensive network of watercourses are managed by the IDB using control structures including sluices and pumping stations for the purpose of drainage, flood risk management, and environmental benefit. An excerpt of the IDB map, which shows their network of assets, is presented in Figure 3-5. An A3 copy with the Order Limits overlaid is reproduced in Appendix B.

3.2.4 The drainage network ultimately discharges to the River Humber either via the River Hull or the Holderness Drain and its tributary the Monk Dike. These watercourses are flanked by substantial earthen embankments. Water is pumped into these watercourses at various locations within the IDB administrative area. Discharge from the Holderness Drain is controlled by the Heddon Road Outfall which prevents tidal ingress. The East Hull Holderness Drain Pumping Station pumps this drain into the River Humber. The Holderness Drain and Monk Dike are classified by the Environment Agency as fluvial watercourses

3.2.5 Tidal ingress from the Humber Estuary into the River Hull is controlled by the Hull Tidal Surge Barrier which closes when particularly high tides are predicted. The River Hull is classified by the Environment Agency as a fluvial/tidal watercourse.

3.2.6 The site itself is understood to have numerous below ground land drains which have been installed to reduce the occurrence of soil saturation and improve agricultural productivity. They typically comprise clay tile drains or perforated corrugated pipes which drain to the network of small field perimeter drains.

Figure 3-4 Principal Watercourses and IDB Area

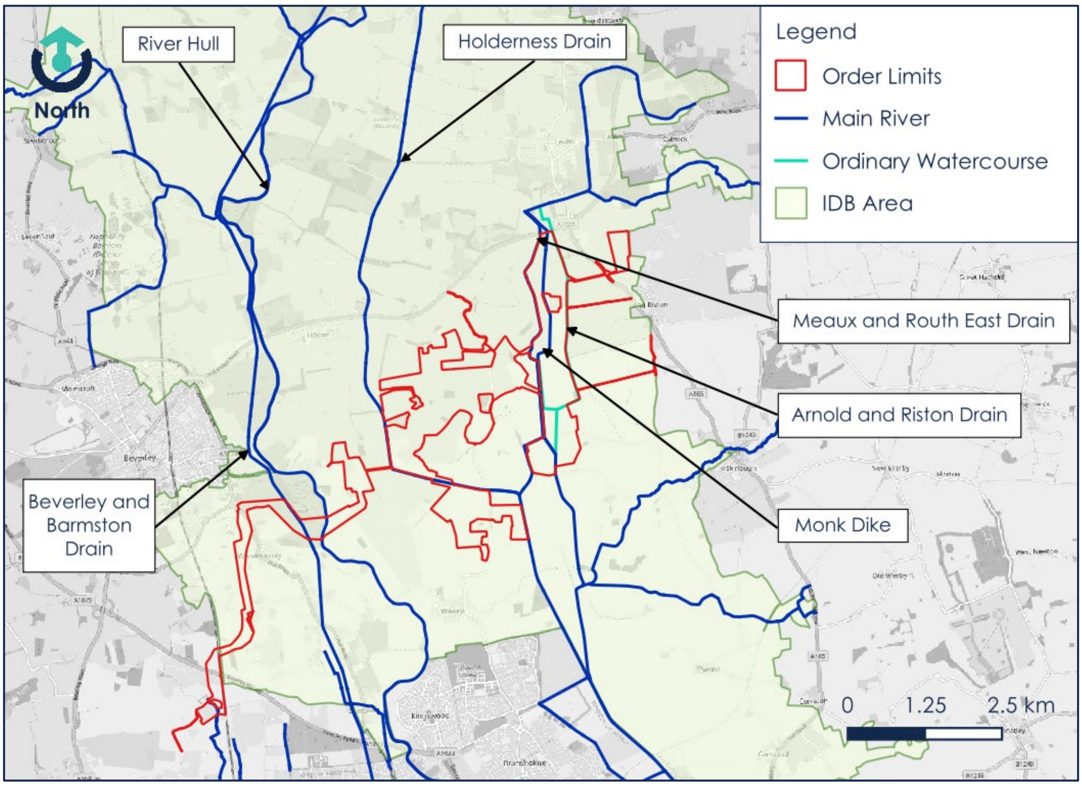
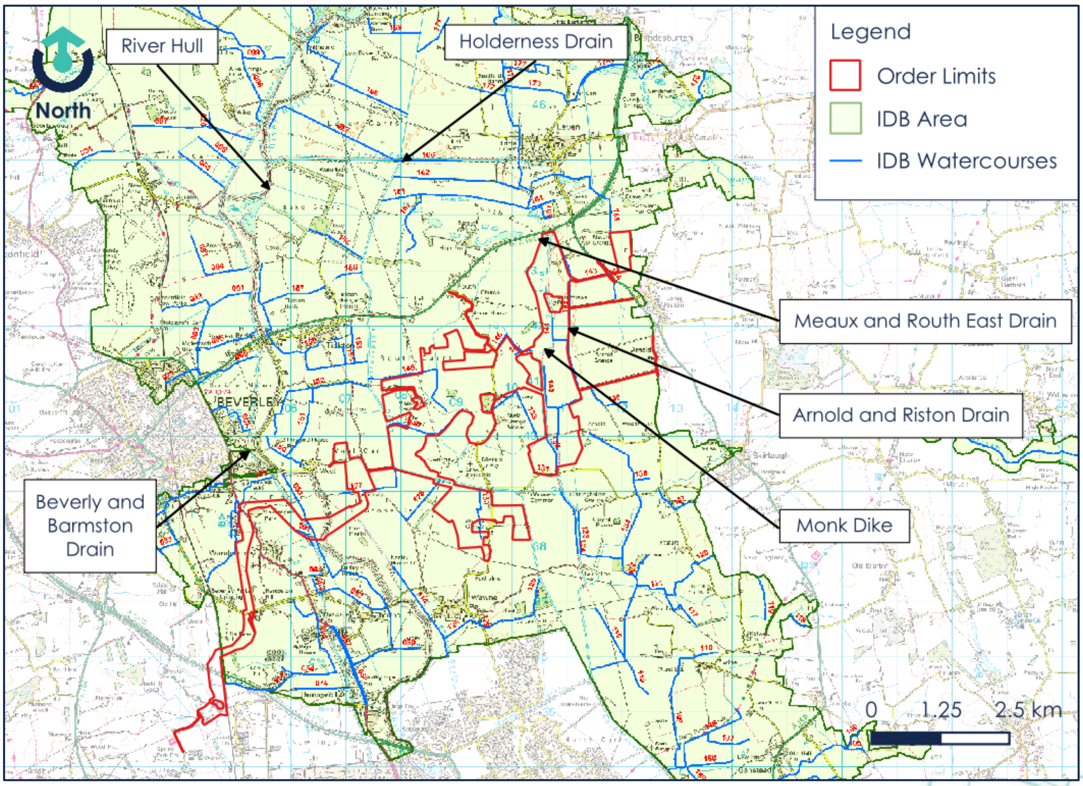


Figure 3-5 IDB Area and Watercourses



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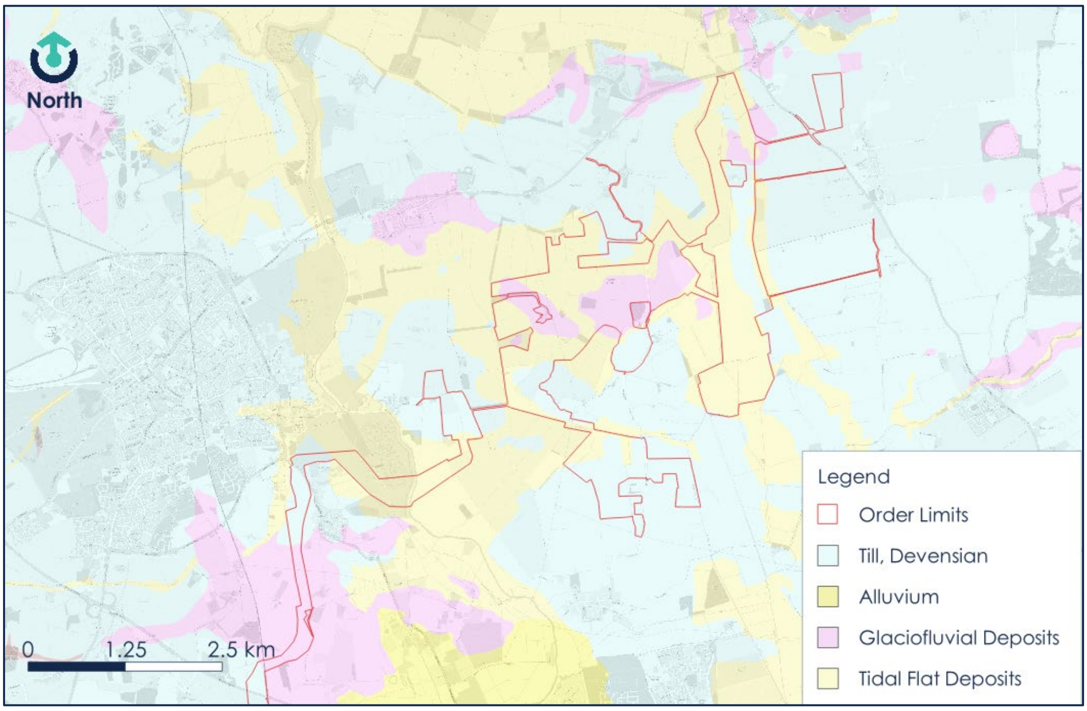
3.3 Geology and Soils

3.3.1 Geological data held by the British Geological Survey (BGS)[4] shows that the Site is entirely underlain by '*Flamborough Chalk Formation – Chalk*'.

3.3.2 The mapping records the presence of four different superficial deposits at the Site: '*Alluvium – Clay, Silt, Sand and Gravel*', '*Till, Devensian – Diamicton*', *Tidal Flat Deposits – Clay and Silt*' - and '*Glaciofluvial Deposits, Devensian – Sand and Gravel*'. Figure 3-6shows the BGS Superficial Deposits Map for the Site.

3.3.3 The BGS Hydrogeology aquifer classification (625k)[5] records the geology under the entire Site as a '*Highly Productive Aquifer*' – '*Flow is virtually all through fractures and discontinuities*'.

Figure 3-6 BGS Superficial Deposits Map



Contains British Geological Survey materials © UKRI [2024]

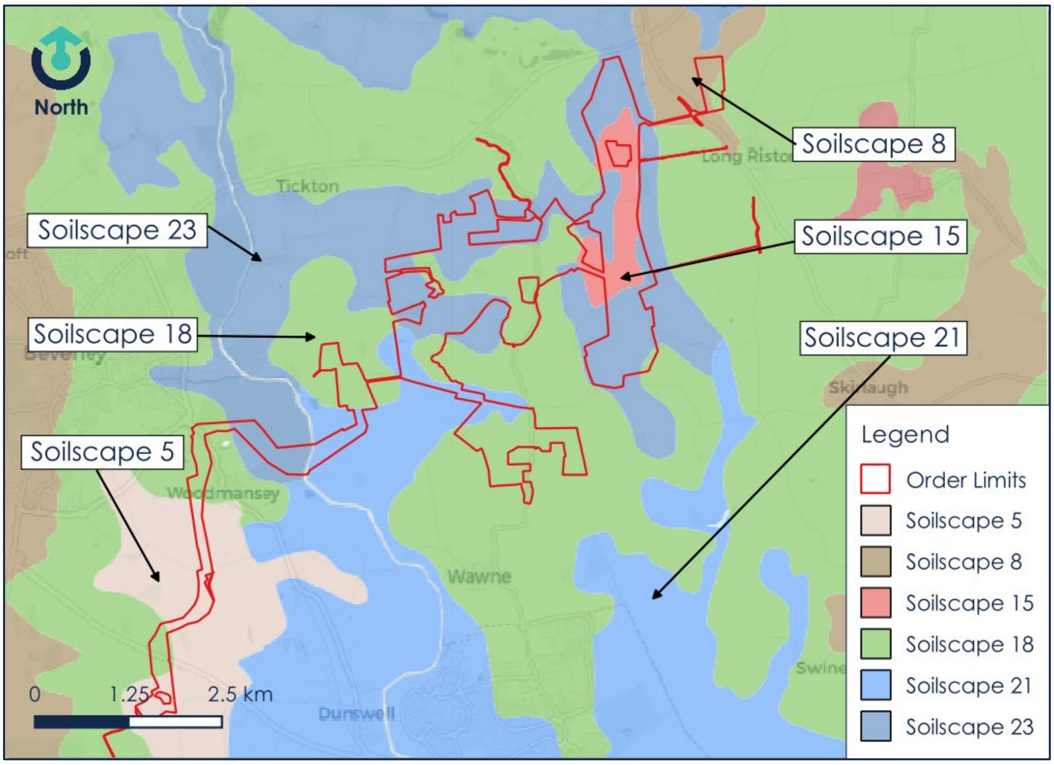
3.3.4 SoilScapes mapping[6] records seven soil types at the Site as shown in Figure 3-7 Soilscapes and summarised below:

[4] https://geologyviewer.bgs.ac.uk/
[5] https://www.bgs.ac.uk/datasets/hydrogeology-625k/
[6] https://www.landis.org.uk/soilscapes/

- Soilscape 5 – Freely draining lime-rich loamy soils
- Soilscape 8 - Slightly acid loamy and clayey soils with impeded drainage
- Soilscape 15 - Naturally wet very acid sandy and loamy soils
- Soilscape 18 - Slowly permeable seasonally wet slightly acid but base-rich loamy and clayey soils
- Soilscape 21 – Loamy and clayey soils of coastal flats with naturally high groundwater
- Soilscape 23 - Loamy and sandy soils with naturally high groundwater and a peaty surface

3.3.5 The majority of the areas where above-ground infrastructure is proposed are classified as Soilscape type 23, with 18 and small area of 21 in the southwest and 15 in some the Land Areas adjacent to the Monk Dike. These soils are generally poorly draining or have elevated groundwater levels.

Figure 3-7 Soilscapes



'Soils Data © Cranfield University (NSRI) and for the Controller of HMSO [2024]'

4 DEVELOPMENT PROPOSALS AND POLICY REQUIREMENTS

4.1 Site Proposals

4.1.1 The Proposed Development is a solar photovoltaic (PV) electricity generating and storage facility proposed by the Applicant with an export capacity of 320 megawatts (MW) and associated infrastructure. The Proposed Development encompasses an area of approximately 891 hectares (ha) ('the Site') and is located within the administrative area of East Riding of Yorkshire Council.

4.1.2 The main elements of the Proposed Development include:

- Solar photovoltaic (PV) modules and associated mounting structures (groupings of solar PV modules are referred to as 'arrays');
- On-site supporting equipment including inverters, transformers, direct current (DC)-DC converters and switchgear;
- A battery energy storage system (BESS) including batteries and associated enclosures, monitoring systems, air conditioning, electrical cables and fire safety infrastructure;
- Two on-site 132 kV substations, including transformers, switchgear, circuit breakers, control equipment buildings, control functions, material storage, parking, as well as wider monitoring and maintenance equipment;
- Low voltage and 33 kV interconnecting cabling within the Land Areas to connect the solar PV modules together and to transmit electricity from the solar PV modules and BESS to one of the two on-site 132 kV substations;
- 132 kV underground cables (two 132 kV export cables) connecting the on-site substations to the National Grid Creyke Beck Substation;
- Works at the National Grid Creyke Beck Substation to facilitate the connection of the 132 kV underground cabling into the substation;

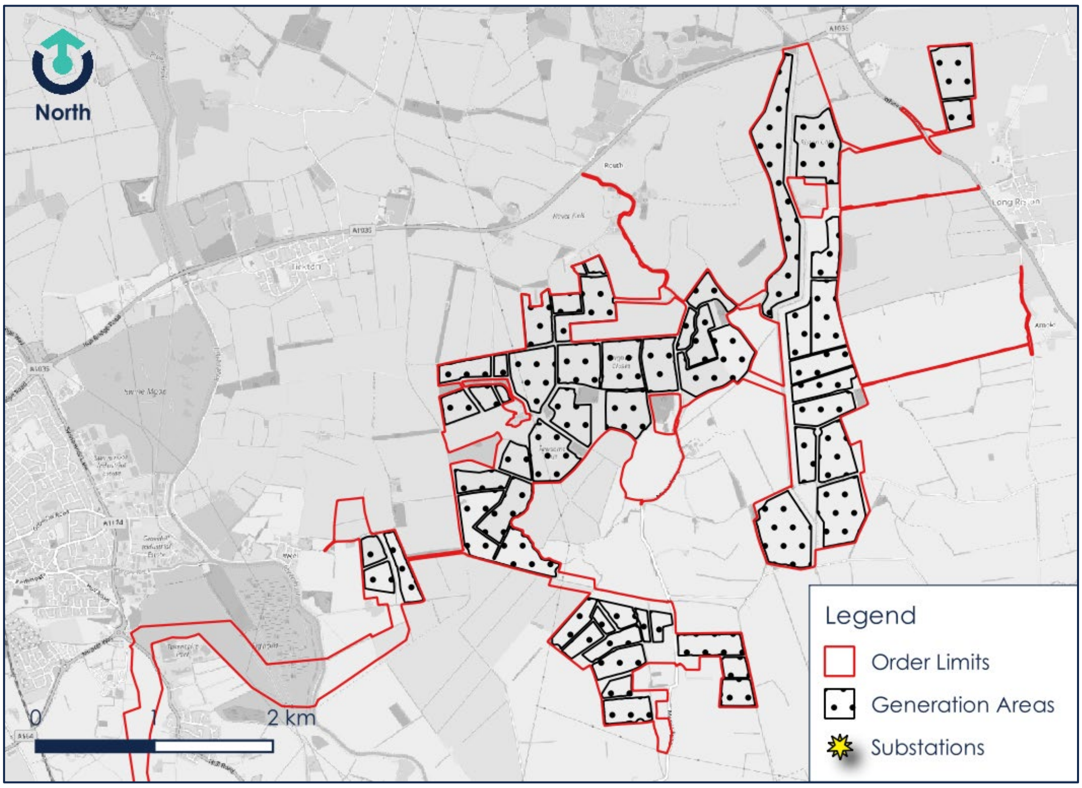
- Associated infrastructure including access tracks, parking, security measures, gates and fencing, lighting, drainage infrastructure, storage containers, earthworks, surface water management, maintenance and welfare facilities, security cabins and any other works identified as necessary to enable the developments;
- Highways works to facilitate access for construction vehicles, comprising passing places where necessary to ensure that heavy goods vehicles (HGVs) can be safely accommodated amongst existing traffic, new or improved site accesses and visibility splays;
- A series of new permissive paths connecting to the existing public right of way network;
- Environmental mitigation and enhancement measures, including landscaping, habitat management, biodiversity enhancement and amenity improvements; and,
- Temporary development during the construction phase of the Proposed Development including construction compounds, parking and laydown areas.

4.1.3 This report reviews the proposals as shown on the 'Typical Fixed Design' Layout drawings included in Appendix A. This layout has been provided for the purposes of providing an assessment based on the 'worst-case scenario'. The locations in the Indicative Operational Layout are at this stage indicative so we need to state that the locations of infrastructure as assessed are done. Appendix A also includes an ancillary drawings pack showing plans and elevations of key infrastructure (solar arrays, substations, hybrid inverter packs etc).

4.2 Key Development Proposals

4.2.1 This report focusses on the elements of the Proposed Development which are relevant in terms of flood risk and drainage. The primary focus of this report is on the water-sensitive infrastructure which is entirely located within the generation areas shown in Figure 4-1.

Figure 4-1 Generation Areas



4.2.2 The key design parameters which reflect the worst-case scenario adopted in the Environmental Impact Assessment are detailed in the Design Parameters document. As the detailed design of the Proposed Development will be upheld in accordance with these assessed parameters, the conclusions of this FRA will be upheld.

4.2.3 For the purpose of this report the Water Sensitive Infrastructure comprises the following elements:

- 'Solar arrays' – the solar panels and attached inverter /combiner boxes and tilting/rotating mechanisms
- 'Substations' – the two 132kV exporting substations described below
- 'Containerised infrastructure' - Hybrid packs, switchgear containers and spares containers -

4.2.4 The spares containers are not necessarily water sensitive but have been included for completeness.

Solar Arrays

4.2.5 the solar arrays will either be fixed or tracker panels. In either case they will be mounted on piles driven into the ground. The water sensitive parts of the installation (trailing edge of the panels inverter/combiner boxes and tilting/rotating mechanisms for the tracker panels) will be a minimum of 0.8m above ground and specified to ensure compliance with the proposed flood mitigation (see Figure 4-2 & Figure 4-3).

Figure 4-2 Typical Fixed Table (side view)

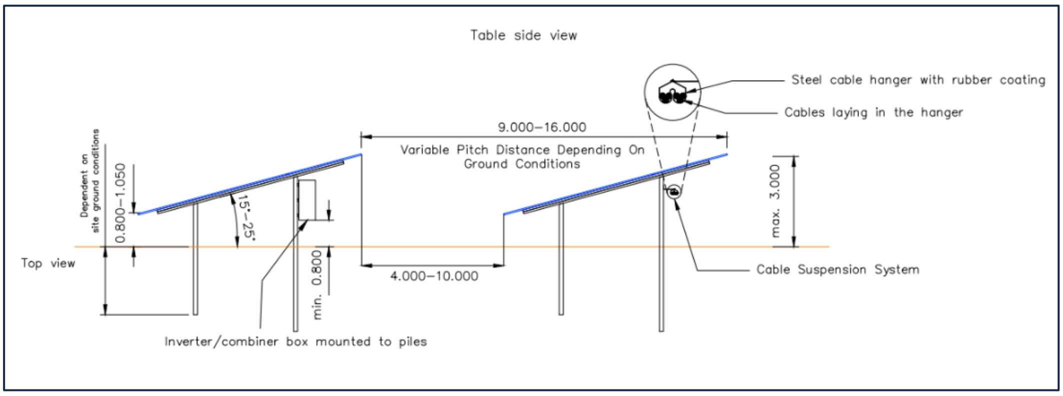
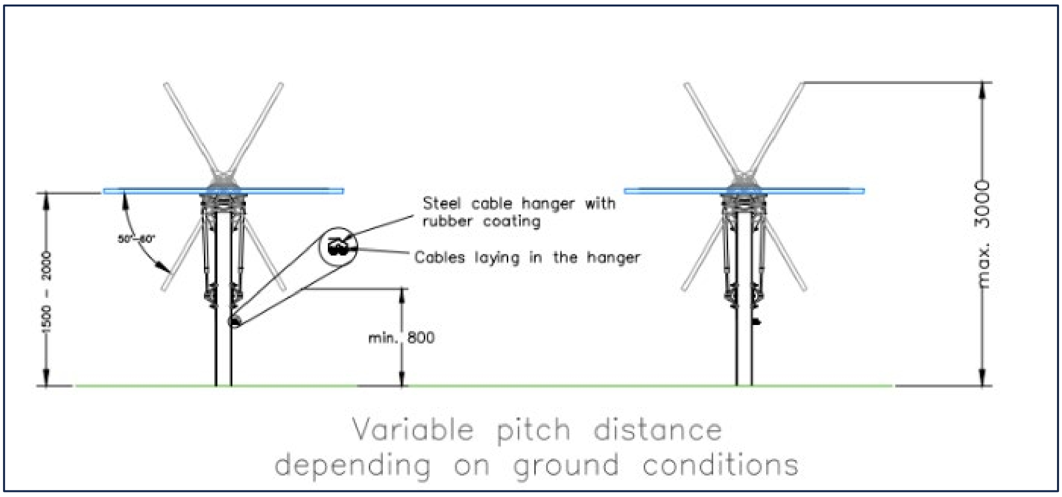


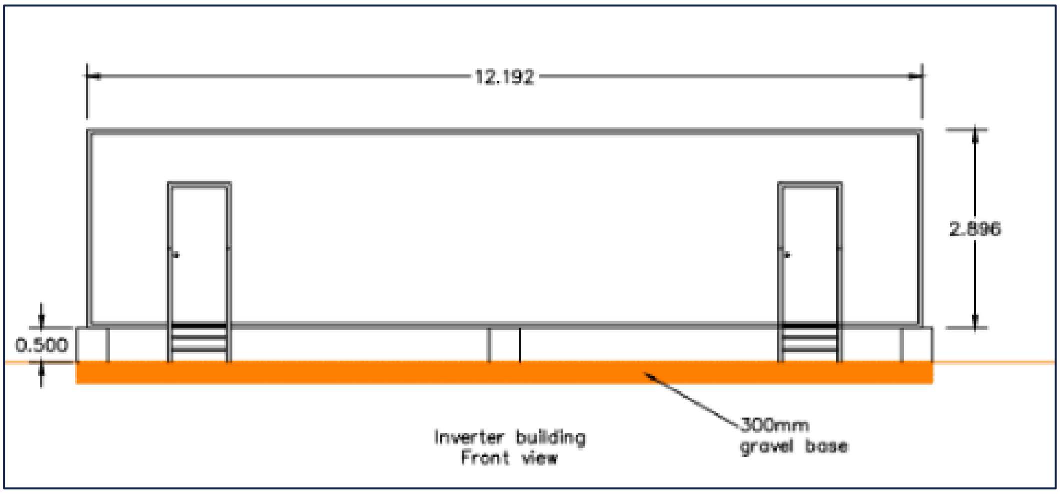
Figure 4-3 Typical Tracker Table (side view)



Containerised Infrastructure

4.2.6 Hybrid packs and customer switch gear containers will be distributed across the Site. There will also be spares containers distributed across the site. The customer switch gear and spares containers approximately 12.5m long by 2.7m wide raised at least 0.5m above the ground on pad foundations overlying a 0.3m gravel base Figure 4-4).

Figure 4-4   Typical Container (side view)



4.2.7 Each hybrid pack would comprise four Battery Energy Storage Systems (BESS), one inverter (including transformer) and four DC-DC converters (Figure 4-5). The footprint of the hybrid packs will be a maximum of 13 m by 22 m and have a maximum height of 3.5 m. They will sit on a 0.3m gravel base. These units will be raised at least 0.5m above ground level (Figure 4-6).

4.2.8 The BESS will be 3.5m in height, 6.5m in length and 2.5m in width. The inverters will be up to 3.5 m in height, 12.5 m in length and 2.5 m in width. They will sit on a gravel base with a maximum footprint of 13m by 22m and anticipated depth of 0.3m. DC-DC Converters will be up to 2.3 m in height, 1.8 m in length and 0.9 m in width.

Figure 4-5 Hybrid Pack Layout

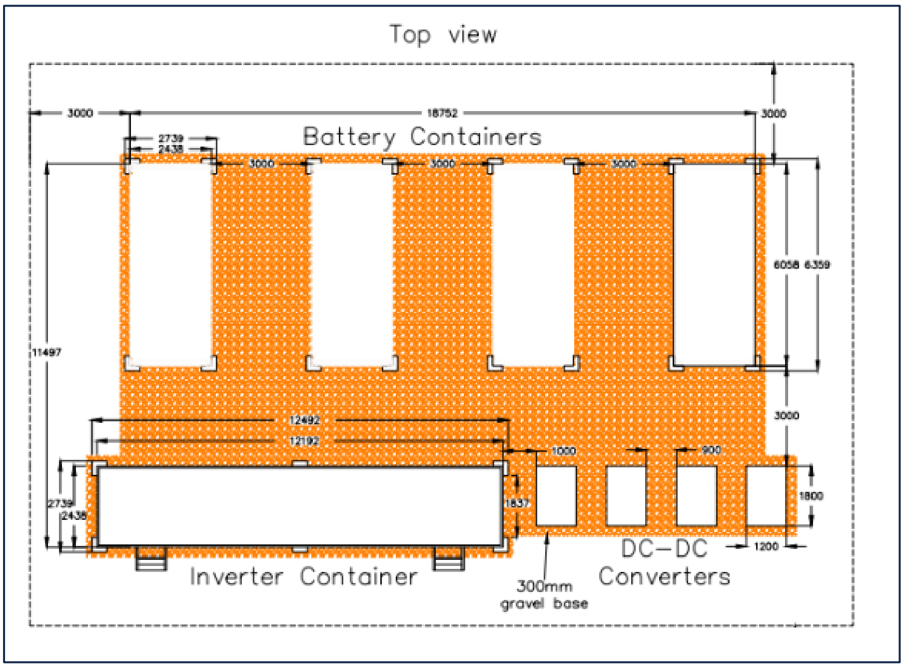
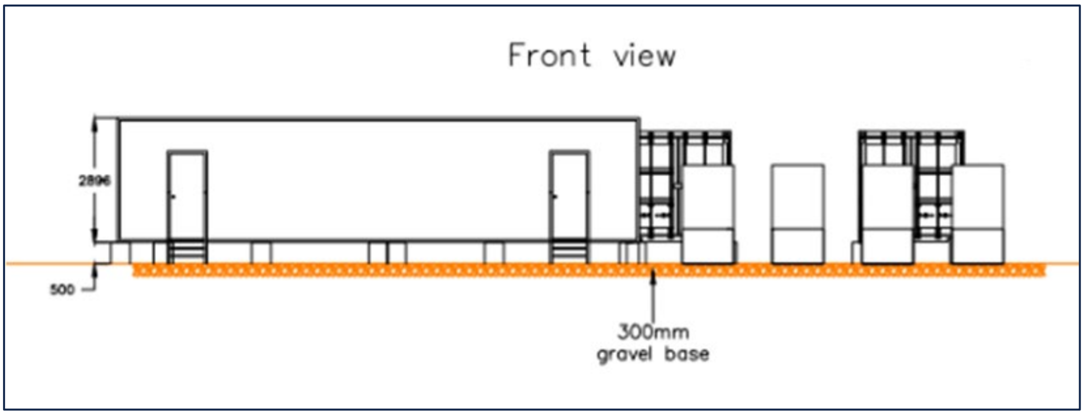


Figure 4-6 Hybrid Pack Side Elevation



Substations

4.2.9 The 132kV exporting substation compounds include a variety of ground-mounted infrastructure, two enclosed switchrooms and an access road. These are considered to be safety-critical elements of the development and in accordance with NPS EN-1s need to have a high level of climate resilience.

Other Infrastructure

4.2.10 Elements of the Proposed Development other than those discussed above are not material considerations in terms of flood risk and drainage and therefore are not discussed at length in this report.

4.2.11 The cable routes will be contained to buried cables and not impact upon flood risk nor drainage and are therefore not considered to be a material consideration.

4.2.12 Access tracks within the Site will be formed of compacted granular material and at grade and therefore will not affect the sites response to runoff or impact flood flows.

4.3 Easements

4.3.1 In accordance with guidance from the relevant authorities, easements are proposed. They would be 9m from 'top of bank' of the IDB 'viewed' watercourses, 8m from 'top of bank' of Main Rivers and formal flood defences, 5m from 'top of bank' of Ordinary Watercourses and 16m from the top of tidal water bodies (which are limited).

4.3.2 These easements would, wherever possible, be free from development including fencelines to retain maintenance access. The only notable exception would be the inclusion of new, or improvement of existing, watercourse crossings. Any encroachment into the easements would be subject to relevant consent.

4.4 Development Vulnerability

4.4.1 Table 2 of the Planning Practice Guidance (PPG) defines which types of development are acceptable in each Flood Zone and is reproduced in Table 4-1. The Proposed Development is for a solar farm which falls within the 'Essential Infrastructure' category and is appropriate in all Flood Zones.

Table 4-1 PPG Development Vulnerability Classification

Flood Zone	Flood Risk Vulnerability				
	Essential Infrastructure	**Highly Vulnerable**	**More Vulnerable**	**Less Vulnerable**	**Water Compatible**
1	✓	✓	✓	✓	✓
2	✓	Exception Test Required	✓	✓	✓
3a	**Exception Test Required**	×	Exception Test Required	✓	✓
3b	**Exception Test Required**	×	×	×	✓

4.5 Sequential Test

4.5.1 The Sequential Test is required for development in Flood Zones 2 and 3 as set out in NPS EN-1 Section 5.8. This is addressed in the Planning Statement.

4.6 Exception Test

4.6.1 The Proposed Development is classified in Annex 3 of the NPPF[7] as 'Essential Infrastructure' and located partially within Flood Zones 3a and 3b and therefore the Exception Test is required as set out in NPS EN-1 Section 5.8.

4.6.2 Essentially, the Exception Test requires the proposed development to:

- provide wider sustainability benefits to the community that outweigh flood risk.

[7] https://www.gov.uk/guidance/national-planning-policy-framework/annex-3-flood-risk-vulnerability-classification

- be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall.

4.6.3 The Exception Test is addressed in the Planning Statement.

4.6.4 This document sets out the approach to mitigation to ensure that the development will be safe for its lifetime (refer to Section 6). The hydraulic modelling work demonstrates that the impact of the panel supports on storage and flow in the floodplain will be insignificant and model tests show that there would be no increase of flood risk to third parties. The surface water drainage strategy (refer to Section 7) will effectively manage any minor change in runoff to mimic existing conditions and ensure no detriment.

4.6.5 As a consequence of the nature of the local hydrology it is not practicable to secure a significant reduction in flood risk elsewhere as part of the development. However, the change in land management should result in a reduction in runoff from the Site (see Section 7.1) reducing the burden on the local drainage network and principal drains the Monk Dike and Holderness Drain.

5 FLOOD RISK

5.1 Recorded Flooding

5.1.1 The Recorded Flood Outlines dataset[8] retrieved from the Defra Data Services Platform Data includes outlines of five flooding episodes that have affected the Site. These outlines are shown in Drawing 20-206-60-301 contained in Appendix B and are discussed below. There are limited areas of flooding on the Site for four of the events, which are attributed to 'drainage', but the 2007 extents were widespread.

June 2007 Event

5.1.2 The June 2007 event is recorded as having occurred from the 15th to the 25th of June and the recorded in the Recorded Flood Outlines dataset cause is 'surface water'. The flood outlines cover an extensive area of the Site. According to an independent review of the floods in Hull, the extent of the flooding was not known with certainty as there are no suitable aerial photos and this appears to apply to the flooding on Site.

5.1.3 The affected land on the Site is mainly below 1.5mAOD but doesn't entirely accord with the topography. For example, there are areas at 7mAOD shown to be flooded with adjacent low-lying land not included in the outlines. It is concluded that the majority of the flooded areas would be shallow flooding caused by elevated levels in the local drainage, and a shortfall in pumping capacity to lift water to the perched watercourses.

5.1.4 The 2007 floods wrought significant damage to the City of Hull which is 90% below high tide level and relies on a pumped drainage system to discharge surface water to the Humber Estuary making it acutely vulnerable to surface water flooding.

5.1.5 June 2007 was the wettest month in Yorkshire since 1882. The geography Department at the University of Hull recorded 250mm of rainfall in June, with over 70mm falling on the 15th of June and 110mm on the June 25th. The return period of the event has been reported as

[8] https://environment.data.gov.uk/dataset/8c75e700-d465-11e4-8b5b-f0def148f590

being 1 in 150 years (Yorkshire Water) and in excess of 1 in 200 years in media sources.

5.1.6 Over 8,600 households were affected by the June 25th 2007 flood but many homes were only flooded by a few centimetres.

5.1.7 Hull City Council commissioned an Independent Review Body to examine the key factors and make recommendation to improve flood protection in the future. The resulting report, 'The June 2007 floods in Hull', was completed in November 2007. It concluded that the urban drainage network had limited capacity and identified a "series of serious shortcomings related to the design, maintenance and operation of Yorkshire Waters pumped drainage system in Hull".

5.2 IDB and LLFA Flooding Records

5.2.1 Both the LLFA and the IDB have, during engagement with them, identified that parts of the Site can experience saturated conditions during winter months. In particularly areas around the Holderness Drain, East Drain and Beswick village experienced standing water in the winter of 2023/24, which was well reported to be a particularly wet winter and preceded prolonged wet weather in the summer months. It was reported that the flooding was not of a significant depth, being less than 300mm, but did persists for some months.

5.3 Flood Zones

5.3.1 The Flood Zones are based on the assessed probability of the Site flooding from rivers and the sea, ignoring the presence of flood defences. The flood zone classifications from the Flood Risk and Coastal Change Planning Practice Guidance (PPG) are presented in Table 5-1 below.

Table 5-1 Flood Zone Classification

Flood Zone	Risk	Fluvial Flooding Annual Exceedance Probability	Tidal Flooding Annual Exceedance Probability
1	Low	< 0.1%	
2	Medium	0.1% - 1%	0.1% - 0.5%
3	High	> 1%	> 0.5%
3b	Functional Floodplain	Land where water has to flow or be stored in times of flood. This is defined in the relevant SFRA.	

5.3.2 The Flood Map for Planning defines substantial areas of the Site as Flood Zone 2 and 3, at risk of flooding from the Main Rivers flowing through the Site and in its vicinity (Figure 5-1).

5.3.3 The Flood Zones which represent both fluvial and tidal flooding, do not match undefended model outputs provided by the Environment Agency and are presumed to be derived from a combination of sources. It should be noted that Flood Zone 2 includes land at over 6m AOD and consequently is not accurate.

5.3.4 As the Site is located in land defined as Flood Zone 2 and 3 the Proposed Development is subject to the Sequential Test and the Exception Test. These tests are considered in the Planning Statement. This FRA demonstrates that the proposals meet the second criteria of the Exception Test, that the development will be safe from flooding over its proposed lifetime. The site-specific modelling demonstrates the proposals would not increase flood risk elsewhere.

5.4 Flood Zone 3b

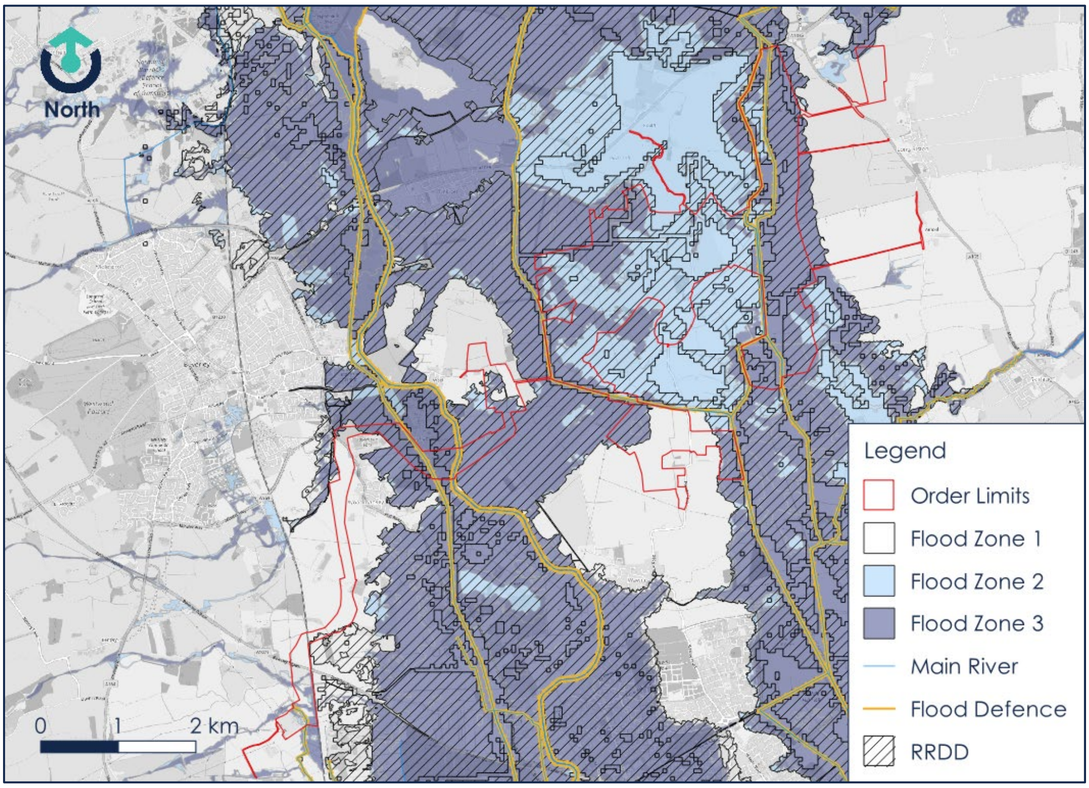
5.4.1 The functional floodplain is defined by the PPG as being land that would be flooded in a 1 in 30 year event. In absence of the appropriate hydrological flow estimates for this event being available, the 1 in 50 year event was used as a proxy, which is more conservative.

5.4.2 The outputs of the baseline 1 in 50 year event are shown along with the 1 in 20 year event in Drawings 20-206-60-315-00 & 20-206-60-316-00 in Appendix B. The extent of the 1 in 50 year event is only marginally larger than the 1 in 20 year event and does not flood areas where containerised infrastructure or substations are proposed.

5.5 Impact of Defences

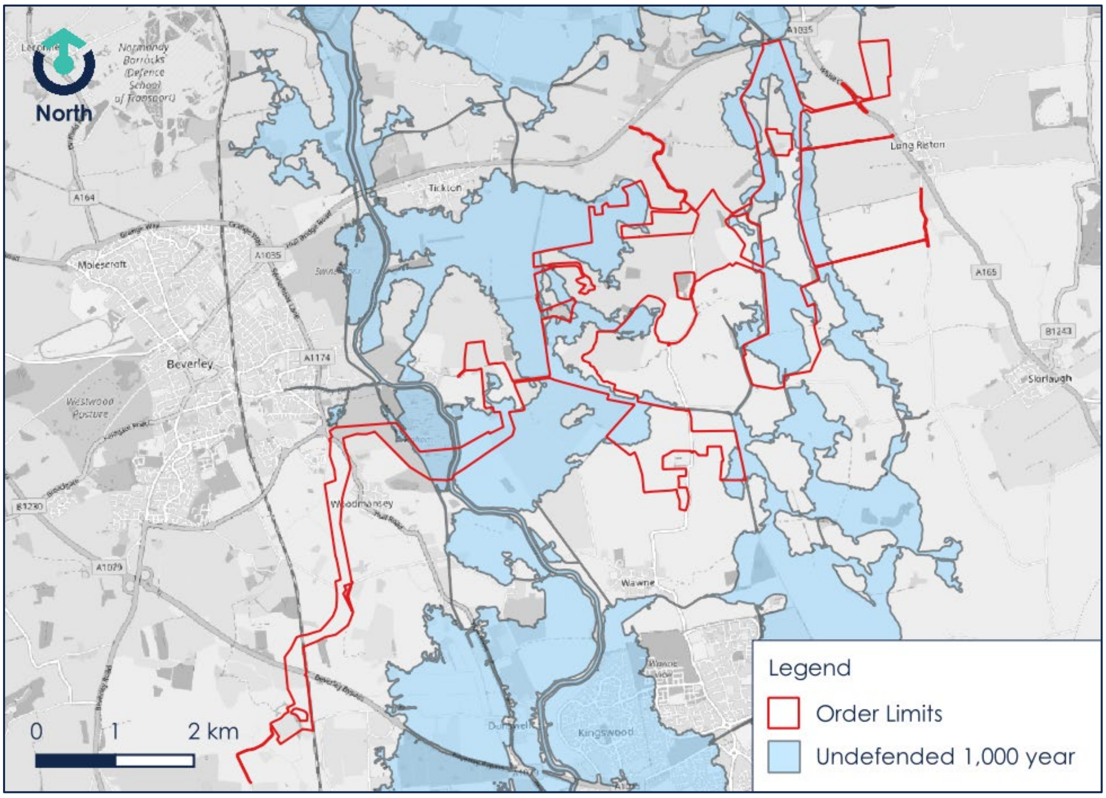
5.5.1 The Environment Agency maintained 'Spatial Flood Defences including Standardised Attributes' dataset records extensive flood defences located along the Main Rivers through and around the Site (Figure 5-1). The defences vary in type and include high ground – natural bank and embankments. As a result of the flood defences discussed above, much of the Site falls within the 'Reduction in Risk of Flooding from Rivers and Sea due to Defences' (RRDD) area

Figure 5-1 Flood Zones, Defences and RRDD



5.5.2 The vast majority of the Site defined as Flood Zone 2 or 3 is within the RRDD area. Areas of Flood Zone 2 and 3 in the study area which are not within the RRDD area are generally associated with watercourses or otherwise are land between 3 and 7.0mAOD. These areas of higher ground are not at risk from undefended fluvial flooding as shown in the River Hull and Holderness Drain outputs provided by the Environment Agency (Figure 5-2). They are also not at risk of defended tidal flooding as shown in Figure 5-5. It is presumed that the discrepancy is because undefended outlines from which the RRDD outlines are derived are a more accurate reflection of undefended flooding than the Flood Zones and those used for the Flood Zones have undergone post-processing to fill in 'dry-islands' (areas that are surrounded by simulated flooding).

Figure 5-2 River Hull and Holderness Drain Model 1 in 1,000 year undefended flood outlines



5.5.3 It should be noted that the RRDD dataset has been temporarily discontinued following the publication of the updated Flood Zones on 25 March 2025. However, as the Flood Zones have not changed significantly (with the exception of at Land Area B5) the conclusions drawn in Paragraph 5.5.2 are considered to remain valid.

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5.6 Defences

5.6.1 The principal defences that reduce flood risk to the Site are associated with the River Hull to the west of the Site and the Monk Dike which flows through the eastern part of the Land Areas B & C.

5.6.2 The River Hull is flanked by substantial embankments which are typically 3-4m high and 30-40m wide. The River Hull is tidally influenced, so these defences protect land from both tidal and fluvial flooding. The River Hull Tidal Surge Barrier closes when high tide levels are forecast to prevent tidal ingress.

5.6.3 The Monk Dike is flanked by embankments which are typically 1-2m high and 10m wide. The Monk Dike discharges into the Holderness Drain. Tidal ingress is prevented into the Holderness by the Heddon Road Outfall. Water from the Holderness Drain is pumped into the Humber Estuary at the East Hull Holderness Drain Pumping Station.

5.6.4 There are numerous other defences in the area including low banks, pumping stations, sluices etc.

5.6.5 There are also substantial coastal defences along the Humber Estuary. There have recently been several schemes in the area to upgrade defence standards (embankments and walls) and these schemes have been designed so as to allow a managed adaptive approach. This allows the height of these defences to be raised so that they can keep pace with sea-level rise.

5.7 Relevant Flood Risk Management Policy

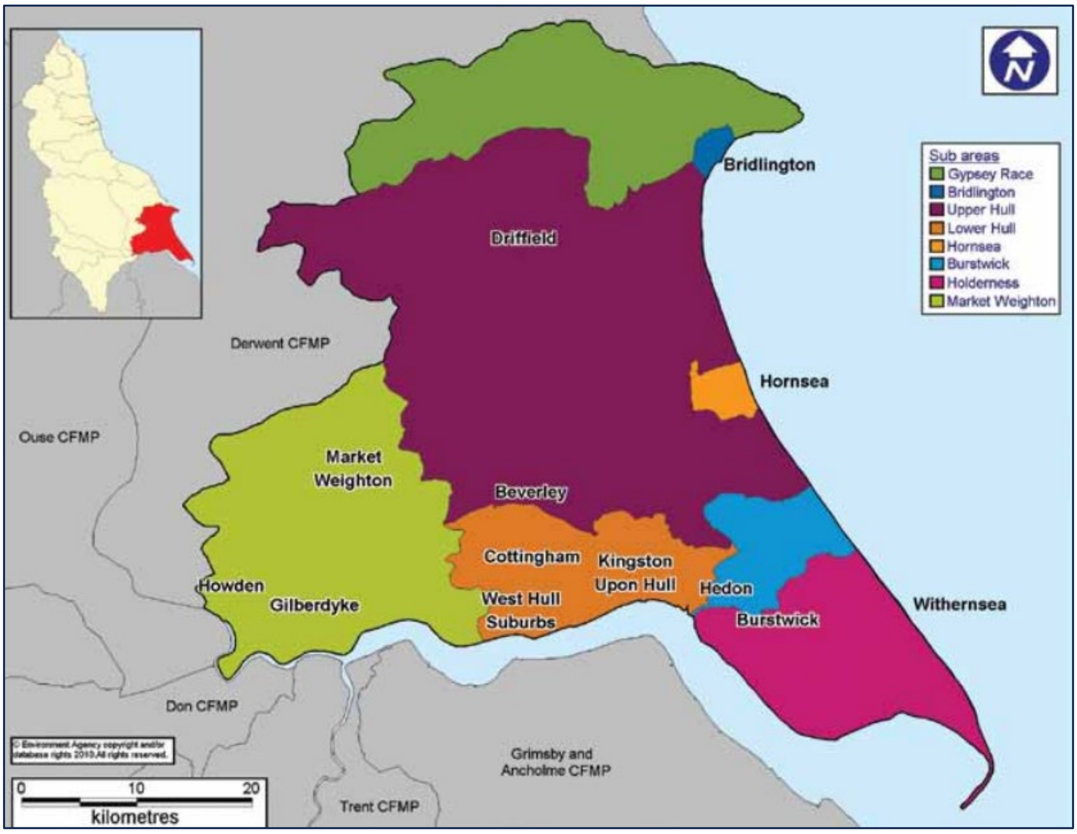
Hull and Coastal Streams Catchment Flood Management Plan (CFMP)

5.7.1 The Hull and Coastal Streams Catchment Flood Management Plan (CFMP) sets out the policies for managing flood risk within the study area.

5.7.2 The defences alongside the Humber Estuary fall within the Lower Hull catchment sub-area (as shown in Figure 5-3). The policy for this area is to "*take action to further reduce flood risk*". The inland defences fall within the Upper Hull area where the policy is "*Continue with existing or alternative actions to manage flood risk at the current level*".

5.7.3 The Site and surroundings fall within the Upper Hull sub-catchment. The policy for this area is to *"Continue with existing or alternative actions to manage flood risk at the current level"*.

Figure 5-3 CFMP catchment sub-areas



Humber Flood Risk Management Strategy

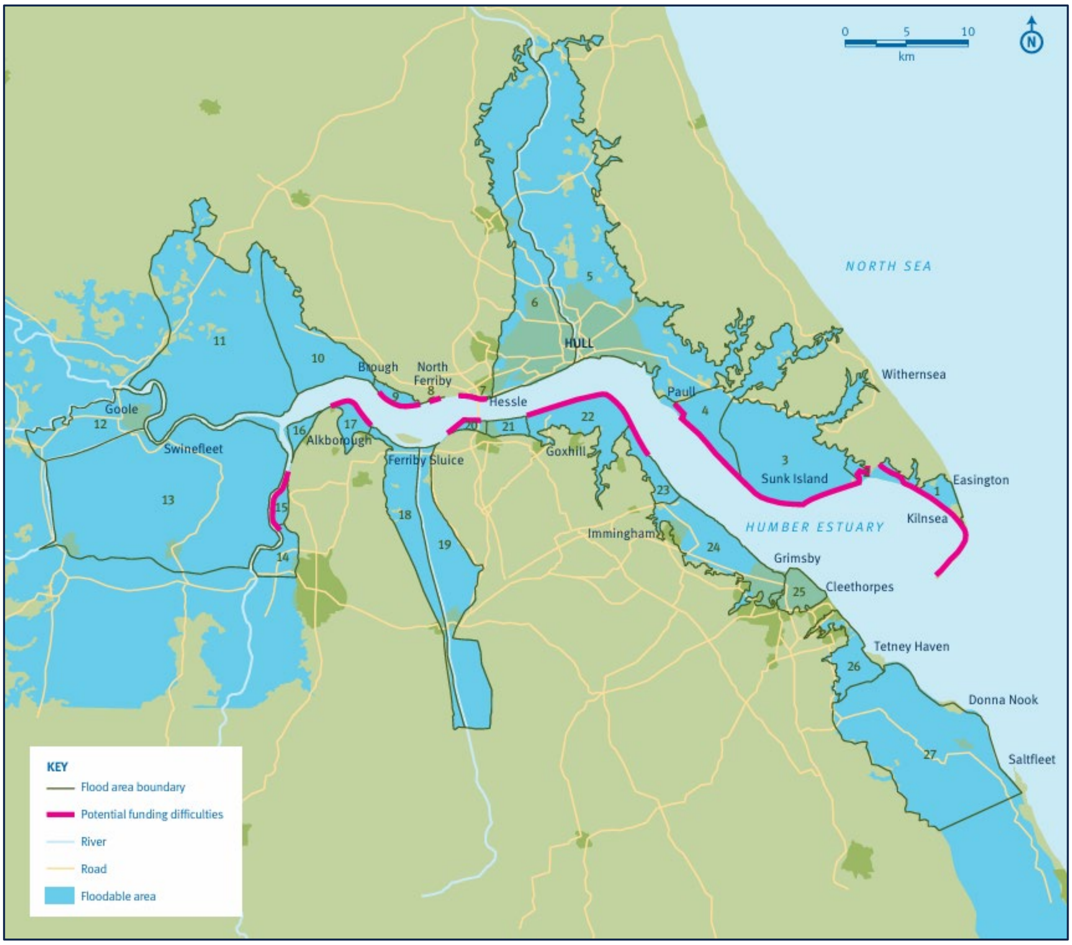
5.7.4 The long term plan for managing flood risk from the Humber Estuary is summarised in the Humber Flood Risk Management Strategy (HFRMS). The proposed development Site falls within 'Floodable Areas' 5 (Hull East) & 6 (Hull West) as shown in Figure 5-4.

5.7.5 The proposed management approach for both of these areas is:

> *"We will continue to protect this area and will work with the local and regional authorities, property owners and developers to make sure flood risk is taken into account at all stages of the planning process. The defences will need to be improved as sea levels rise. This will be expensive so we will seek to supplement public funds with contributions from major beneficiaries and from developers,*

who will be expected to pay the full cost of any new works needed to protect their development."

Figure 5-4 Floodable Areas (taken from HFRMS)



Local Flood Risk Management Strategy 2022-2028

5.7.6 Hull City Council's strategy for managing flood risk is set out in the Local Flood Risk Management Strategy 2022 – 2028 document

"Over the last 6 years, more than £220 million has been spent on flood infrastructure to reduce the risk of flooding to homes and businesses in Hull, through partnership working with other risk management authorities."

5.8 Significant Recent Flood Defence Schemes

The Hull Tidal Surge Barrier refurbishment project

5.8.1 'The Hull Tidal Surge Barrier refurbishment project' paper[9] presented at the British Dams 2012 conference states that:

> *"The Hull Tidal Surge Barrier underwent a £10M refurbishment in 2009 and 2010. It is the most important flood risk management asset in the Environment Agency's Yorkshire & North East Region. To put the importance of the barrier into context, without it a high surge tide would result in damages to Hull in excess of £230M with the flooding of 17,000 homes."*

5.8.2 According to the Hull City Council's Local Flood Risk Management Strategy the tidal barrier is designed to reduce the risk of tidal flooding for a 1 in 200-year event / 0.5% Annual Exceedance Probability (AEP).

5.9 Humber Hull Frontage Improvements Scheme

5.9.1 The Humber Hull Frontage Scheme (HHFI) is a £42 million flood defence scheme which was officially opened in March 2022. It includes the 7km of higher flood wall and improved flood gates and connects with other flood defence improvements which have been built along the Humber by East Riding of Yorkshire Council; east of Hull at Paull and to the west of the city at Hessle.

5.9.2 The works are presented in the Humber Hull Frontage Improvements Scheme Flood Risk Assessment (2018) which supported the planning application and set out the overarching objective as:

[9]https://britishdams.org/2012conf/papers/6%20Construction%20-%20new%20dams%20and%20upgrades/Papers/6.1%20Griffiths%20-%20The%20Hull%20Tidal%20Surge%20Barrier%20refurbishment%20project.pdf

"Defences will be raised at or near the frontage to limit overtopping to 1 l/s/m during a 1:200 (0.5% [AEP]) event in 2040, to meet the strategy objectives of limiting flooding to properties. This standard of protection will be sustained as sea levels rise in future through interventions around 2040."

5.10 Tidal Flooding

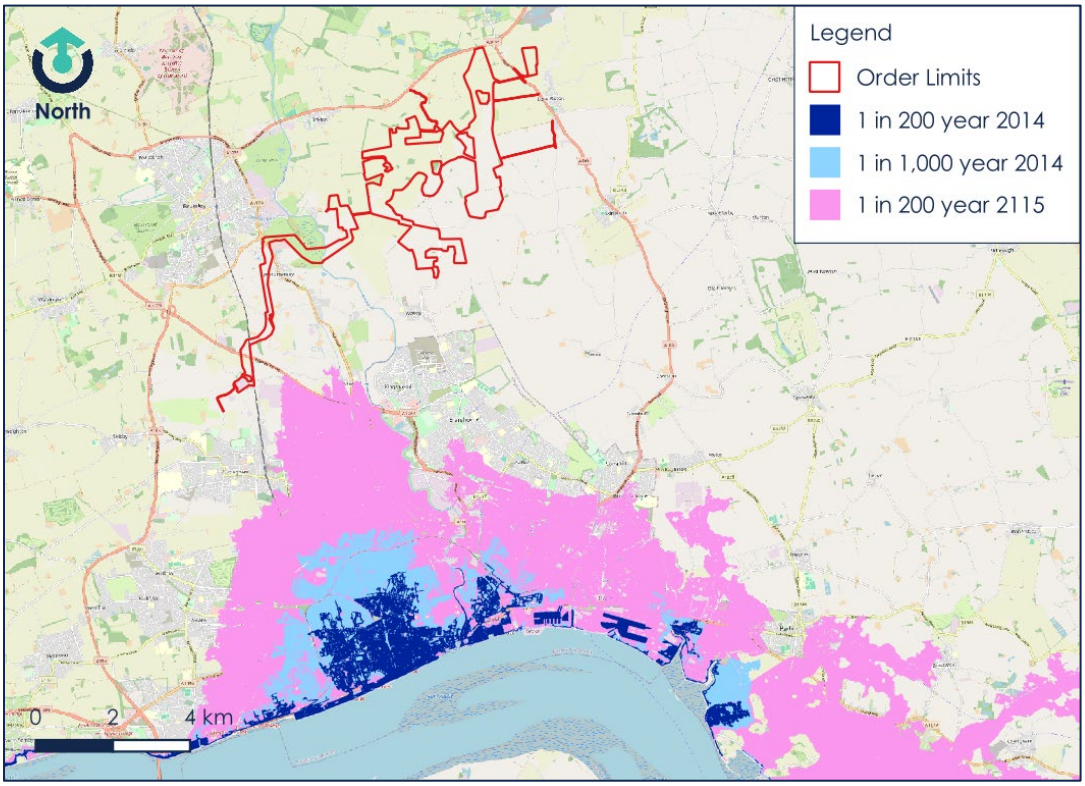
5.10.1 As a significant proportion of the Site is below predicted extreme tidal flood levels some of it would be at risk of tidal flooding when ignoring the presence of existing defences. The tides also have a significant effect on the drainage of fluvial and surface water flows as the area becomes tide-locked which is considered separately in Section 5.10.8.

Actual Risk

5.10.2 Outputs from the Humber North Bank Tidal Model (2013) were provided by the Environment Agency representing the best-available data for the study area. The extent of tidal flooding predicted whilst the defences are operating for several events is shown in Figure 5-5.

5.10.3 No flooding to the Site is predicted even during a 1 in 200 year event in 2115 when sea levels would be approximately 0.5m higher than at the end of the development's 40-year lifetime. It is also likely that the substantial defence improvements carried out since the modelling study would significantly reduce the volume of water overtopping the tidal defences and hence the extent of flooding.

Figure 5-5 Modelled Defended Tidal Flood Extents



5.10.4 Accounting for the commitment to defences in this area and the fact that they protect thousands of properties in Hull the risk of tidal flooding is assessed as being **Very Low**.

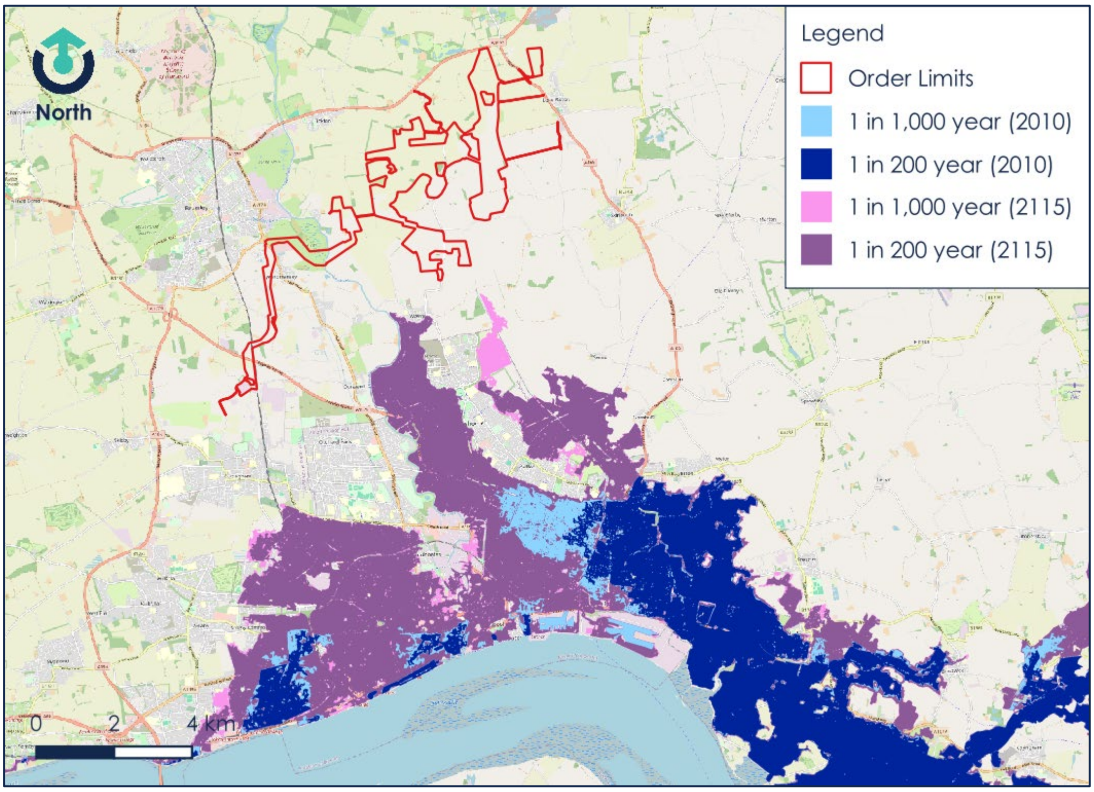
Residual Risk

5.10.5 The residual risk of tidal flooding during a more extreme event than the design event from overtopping is represented by the 1 in 200 year event in 2115 presented in Figure 5-5. There is also a residual risk associated with potential breach of tidal defences.

5.10.6 The Environment Agency provided model outputs from the River Humber North Bank Breach Modelling Study (2012). This study simulated 43 individual breaches each with a 72 hour breach opening. The combined flood outlines from these simulations are presented in Figure 5-6.

5.10.7 Even during the 1 in 1,000 year event in 2115 breach the Site remains unaffected. Consequently, the Site as assessed a being at **Very Low** residual risk to flooding due to a breach of tidal defences.

Figure 5-6 Modelled Tidal Breach Flood Extents



Summary

5.10.8 Given the fact that the Site remains unaffected during extreme future flooding way beyond the proposed development's lifetime, no further assessment of tidal flooding is considered necessary. It was agreed during a meeting with the Environment Agency on 27th March 2024, that no site-specific tidal modelling was required (Meeting minutes are provided in Appendix D).

5.11 Fluvial Flood Risk

5.11.1 Fluvial flood risk is the principal source of flooding to the Site. Three meetings were held with the Environment Agency to agree the requirements for assessing this risk and mitigating it (Meeting minutes are provided in Appendix D).

5.11.2 The Environment Agency advised that fluvial flooding at the site should be assessed using the River Hull and Holderness Drain Model. The model was last updated in 2013 as part of the River Hull and Holderness Drain Food Mapping Study. The model and associated report was provided to Calibro under licence in November 2023.

5.11.3 The River Hull and Holderness Drain Model was updated and numerous simulations were carried out using this model to assess the actual and residual risk to the development over its lifetime. The updated version of the model was submitted to and reviewed by the Environment Agency. The Environment Agency review included requirements for clarification and some additional simulations which have been carried out and were summarised in a modelling addendum submitted to the Environment Agency on 14th August 2024. The Environment Agency confirmed that the hydraulic modelling work is 'fit for purpose' in a letter dated 29th August 2024.

5.11.4 The modelling work is detailed in the Peartree Hill Hydraulic Modelling Report (20-206-60-050-02), which incorporates the addendum and is contained in Appendix C of this document and summarised below.

5.11.5 Flood risk modelling has not been carried out to assess the risk of flooding to Land Area B5. The March 2025 Flood Zone update resulted in an increase in flood extent in this area associated with the Bowlams Dike.

Land Area B5

5.11.6 The Environment Agency confirmed by email on 30 June 2025 that the Flood Zones have been produced using a combination of the Hull and Holderness Drain 2013 model and the New National Model (NNM) outputs. In the vicinity of Land Area B5 the NNM are more extensive and have been adopted.

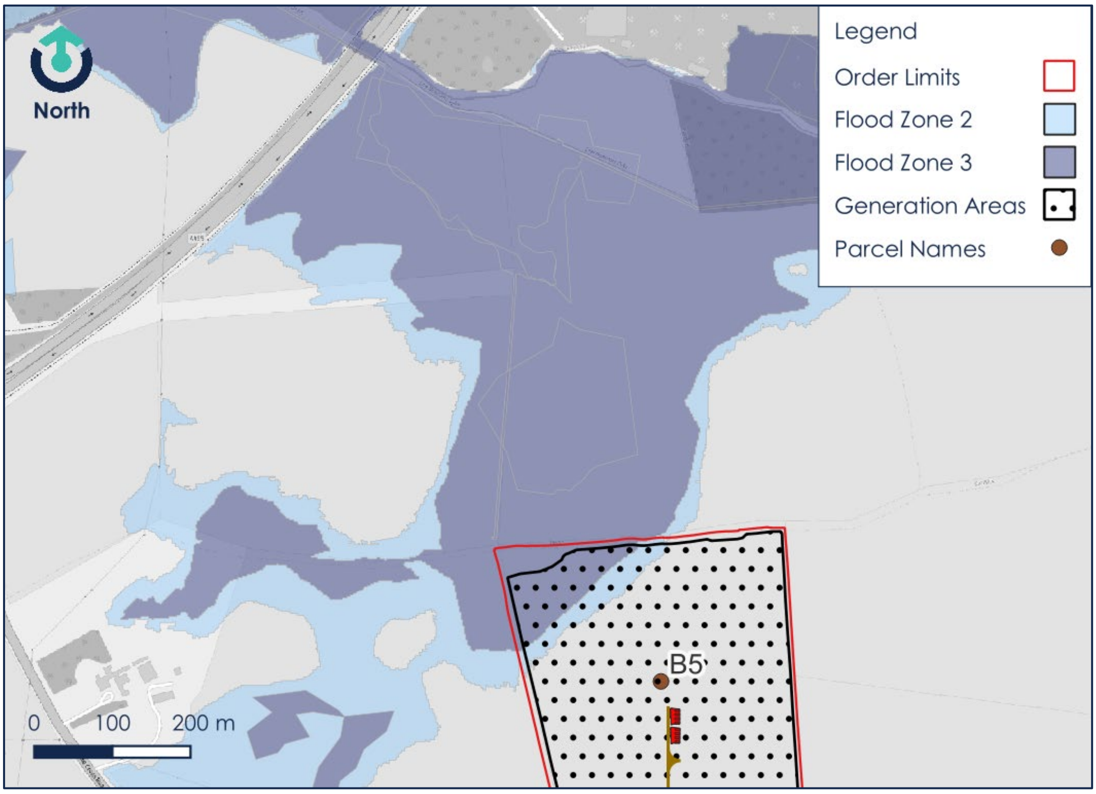
5.11.7 As the outputs of the NNM are not yet available to be issued externally, the Environment Agency recommended cross-referencing the flood outlines against LiDAR data.

5.11.8 The updated Flood Zones show flood waters from the Bowlams Dike affecting the site as shown in Figure 5-7. Flood Zone 2 extends up to 150m into the site from the northern boundary during an undefended 1 in 1,000 year event and affect approximately 1.4ha of proposed generation area.

5.11.9 Although there are defences recorded along the Bowlams Dike these are not significant in nature and have a recorded Standard of

Protection of between 1 in 20 years and 1 in 50 years so are unlikely to afford significant protection in a design event.

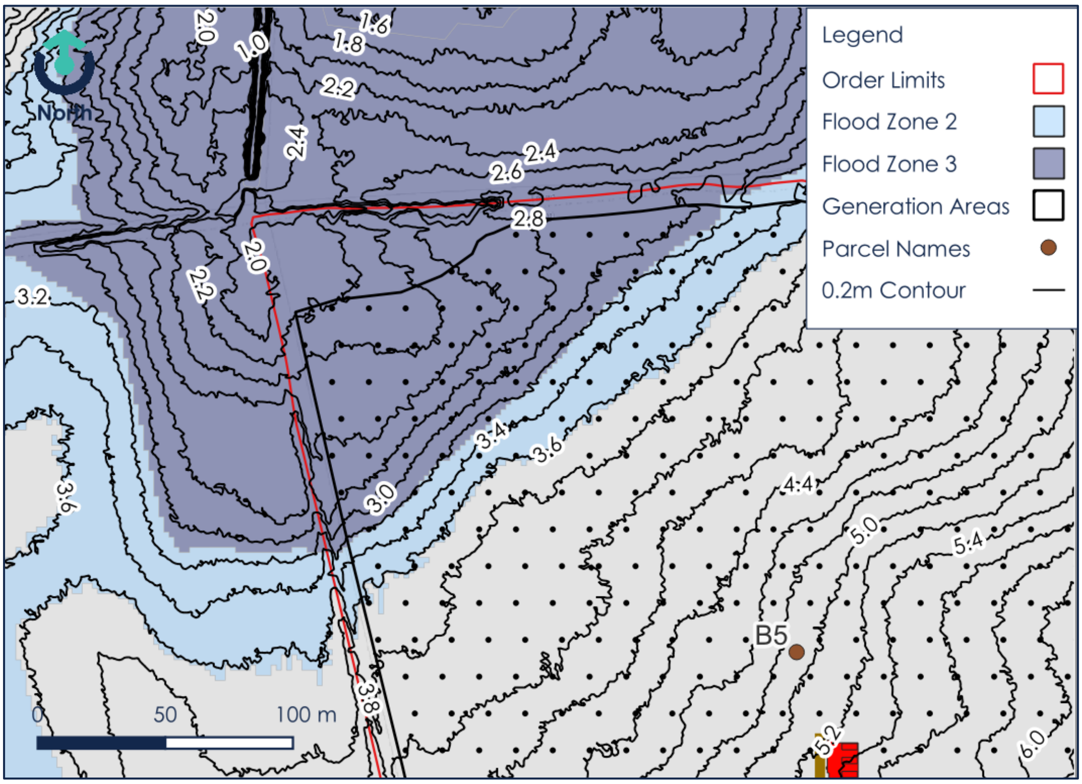
Figure 5-7 Flood Zones Land Area B5



5.11.10 The 1 in 1,000 year event is typically 1.4 – 2.0 times larger than a 1 in 100 year flow. It is therefore reasonable to adopt the 1 in 1,000 year outline as a proxy for a design (1 in 100 +17%) event flood.

5.11.11 With reference to LIDAR data the maximum depths in the generation areas during the 1 in 1,000 year event is approximately 1.6m. the flood level at the edge of Flood Zone 2 is approximately 3.6mAOD and the minimum ground levels are approximately 2.0mAOD as shown in Figure 5-8. In the absence of the modelling output data, a precautionary design event flood level of 3.6mAOD will be assumed. It should be noted that the adapted Hull and Holderness Drain model predicts a flood level adjacent to the site of 3.0mAOD in the 1 in 100 year +17% event.

Figure 5-8 Flood Zones Land Area B5 with ground level contours



Hydraulic Modelling

5.11.12 The River Hull and Holderness Drain (2013) Model was provided by the Environment Agency and adapted for the purpose of assessing the actual and residual risk to the Site. As part of this work, some of the model was developed from a 1D only to a 1D-2D linked model, principally to assess flooding to Land Area A which has since been removed from the scheme.

5.11.13 There were also updates to the model topography to represent the latest available data and to the schematisation of the confluence of the Beverley and Barmston Drain and River Hull to stabilise the model.

5.11.14 The hydraulic modelling work considered the following scenarios:

- The Design Event.
- Numerous breach scenarios.
- The Credible Maximum Scenario.
- Scenarios in which sections of defence were removed.
- Numerous Sensitivity Tests.

The Design Event

5.11.15 The model inflows were modified to represent a 1 in 100 year fluvial event in 2066. The fluvial inflows were adjusted to reflect the higher central estimate of predicted climate change for the 2050s epoch (which covers the period 2040-2069, on the assumption that decommissioning would commence before 2070) for the Hull and East Riding Management Catchment. This equates to a 17% increase in peak fluvial flows.

5.11.16 The tidal curve boundaries were adjusted to represent predicted peak tidal levels. For the design event, the highest astronomical tide level of 4.09m was taken from the Coastal Flood Boundary Dataset (CFB 'UK Mainland Chainage 3886') in accordance with the PPG[10].

5.11.17 This level was adjusted to reflect the higher central estimate of sea-level rise to 2066 (calculated from a base date of 2018) of 356.6mm. This comprises: a rise of 93.5mm between 2018 and 2035 (5.5mm/yr); a rise of 252mm between 2035 and 2065 (8.4mm/yr), and a rise of 11.1mm between 2065 and 2066 (11.1m/yr). This resulted in a revised peak tidal flood level of 4.45mAOD.

5.11.18 The design event simulations predicts that the vast majority of the Site will remain flood free, but some areas are predicted to flood as discussed below. For more detailed flood model outputs reference should be made to Drawings 20-206-60-004 & 20-206-60-005 in Appendix B which includes the indicative layout of water-sensitive infrastructure (solar arrays, substations, hybrid packs, switch gear containers and spares containers).

5.11.19 The most significant flooding is in the vicinity of the Monk Dike in the northern part of Land Area B as shown in Figure 5-9 Depths are generally less than 1.1m with the exception of parts of Land Area B4. Of the water-sensitive infrastructure, only solar arrays are proposed in the flooded areas.

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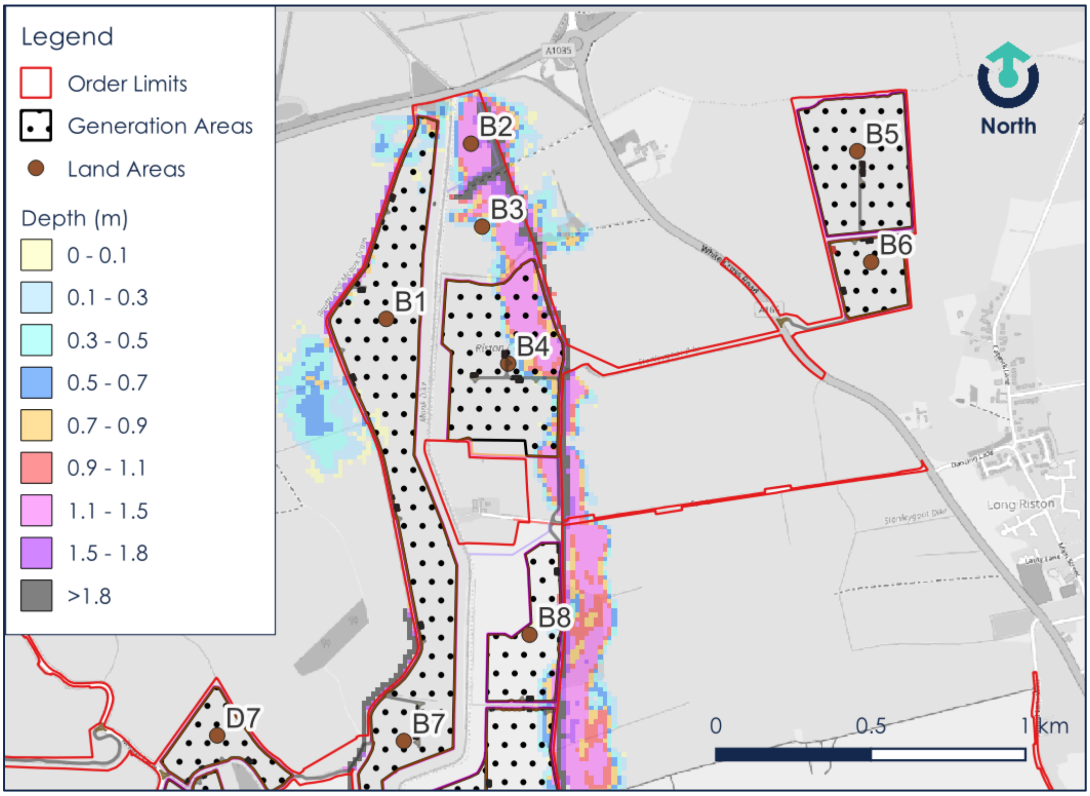
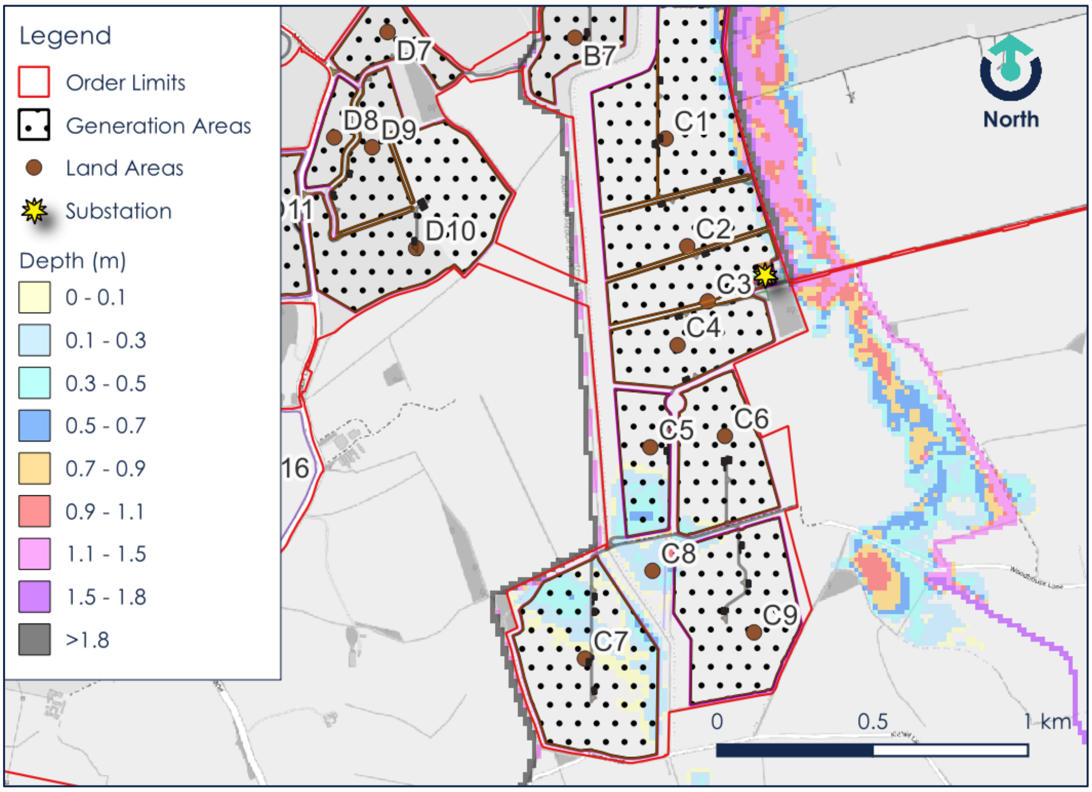
[10] https://www.data.gov.uk/dataset/73834283-7dc4-488a-9583-a920072d9a9d/coastal-design-sea-levels-coastal-flood-boundary-extreme-sea-levels-2018

Figure 5-9 Design Event Flooding Land Area B North



5.11.20 Some minor flooding is predicted along the western edge of Land Area C and a more significant area is predicted to flood to up to 0.5m in Land Areas C5, C7 and C8 (see Figure 5-10).

Figure 5-10 Design Event Flooding Land Area C



5.11.21 There is a hybrid pack in Land Area C7 within the predicted flood extents. Depths are below 0.1m and would therefore not impact the infrastructure which is a standard raised 0.5m above ground.

5.11.22 Minor flooding is also predicted to the northern part of Land Area D but only to depths of less than 0.3m and only solar arrays are proposed in this area (Figure 5-11).

5.11.23 No flooding is predicted in Land Areas E and F (Figure 5-12

5.11.24 In summary, there is limited flooding to areas where water-sensitive infrastructure is proposed and no raising of infrastructure beyond the standard design is necessary. On this basis the actual risk of flooding to the Proposed Development over its lifetime is considered to be **Low**.

Figure 5-11 Design Event Flooding Land Areas D

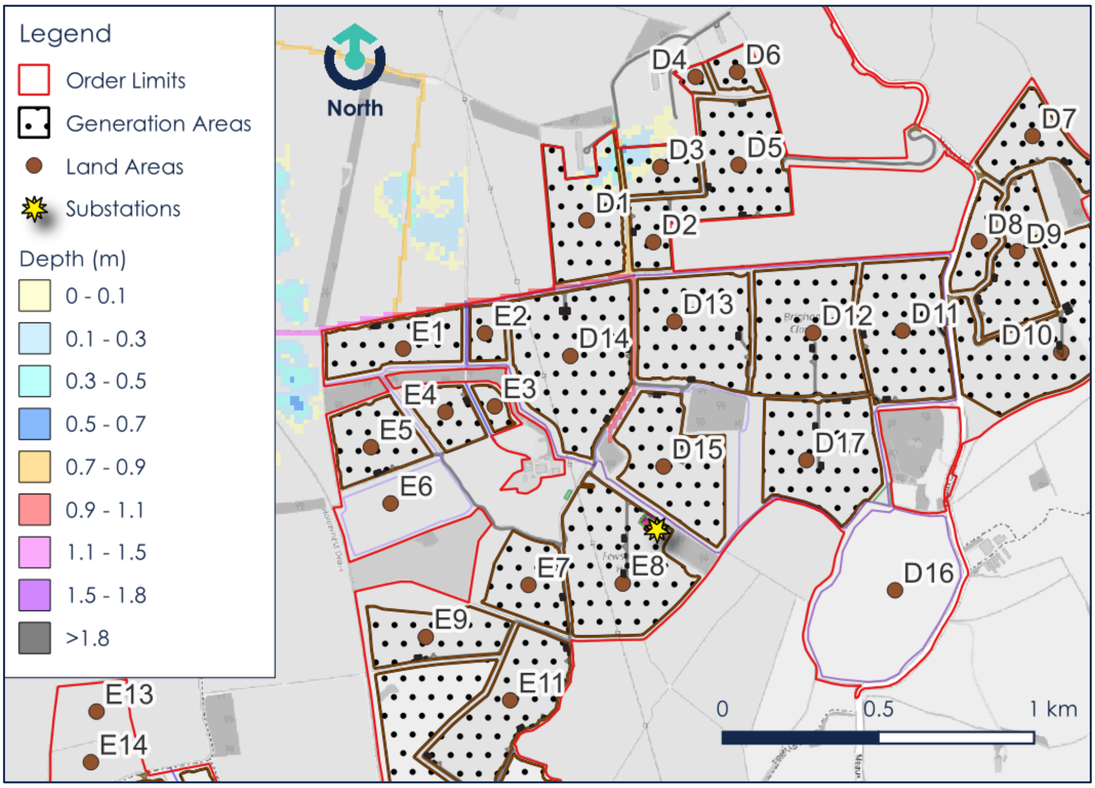
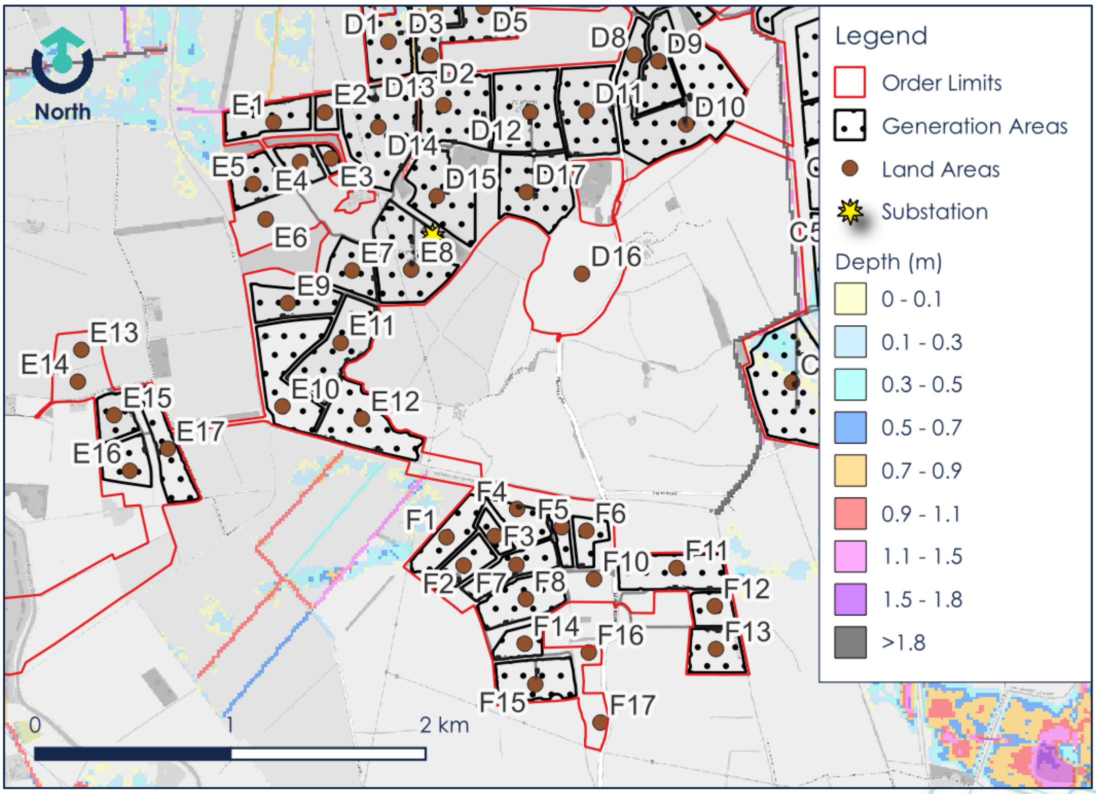


Figure 5-12 Design Event Flooding Land Areas E&F



Residual Risk

5.11.25 To assess the residual risk of flooding 18 breach simulations were carried out. Three of these breaches (A, B and C) were to assess the residual risk to Land Area A which has since been removed from the Proposed Development and are not discussed further (refer to the Appendix C for further details).

5.11.26 The breaches were simulated in accordance with guidance set out in the 'Breach of Defences Guidance - Modelling and Forecasting Technical Guidance Note'. All of the breaches assume an instantaneous failure of a 50m breach of flood defence during the peak of a future 1 in 100 year plus climate change event. The outputs therefore represent a worst-case scenario.

5.11.27 The locations of the breaches were selected to result in maximum impact on the Site with reference to the local topography (where landward ground levels were particularly low) and the proposed layout (proximity to sensitive infrastructure). The breach locations were agreed with the Environment Agency(email dated 12th April 2024 contained in Appendix D).

5.11.28 The location of simulated breaches is shown in Figure 5-13 and Figure 5-14. Drawing 20-206-60-302 contained in Appendix B shows the breach locations, Land Areas and areas of sensitive infrastructure.

Figure 5-13 Monk Dike Breach Locations

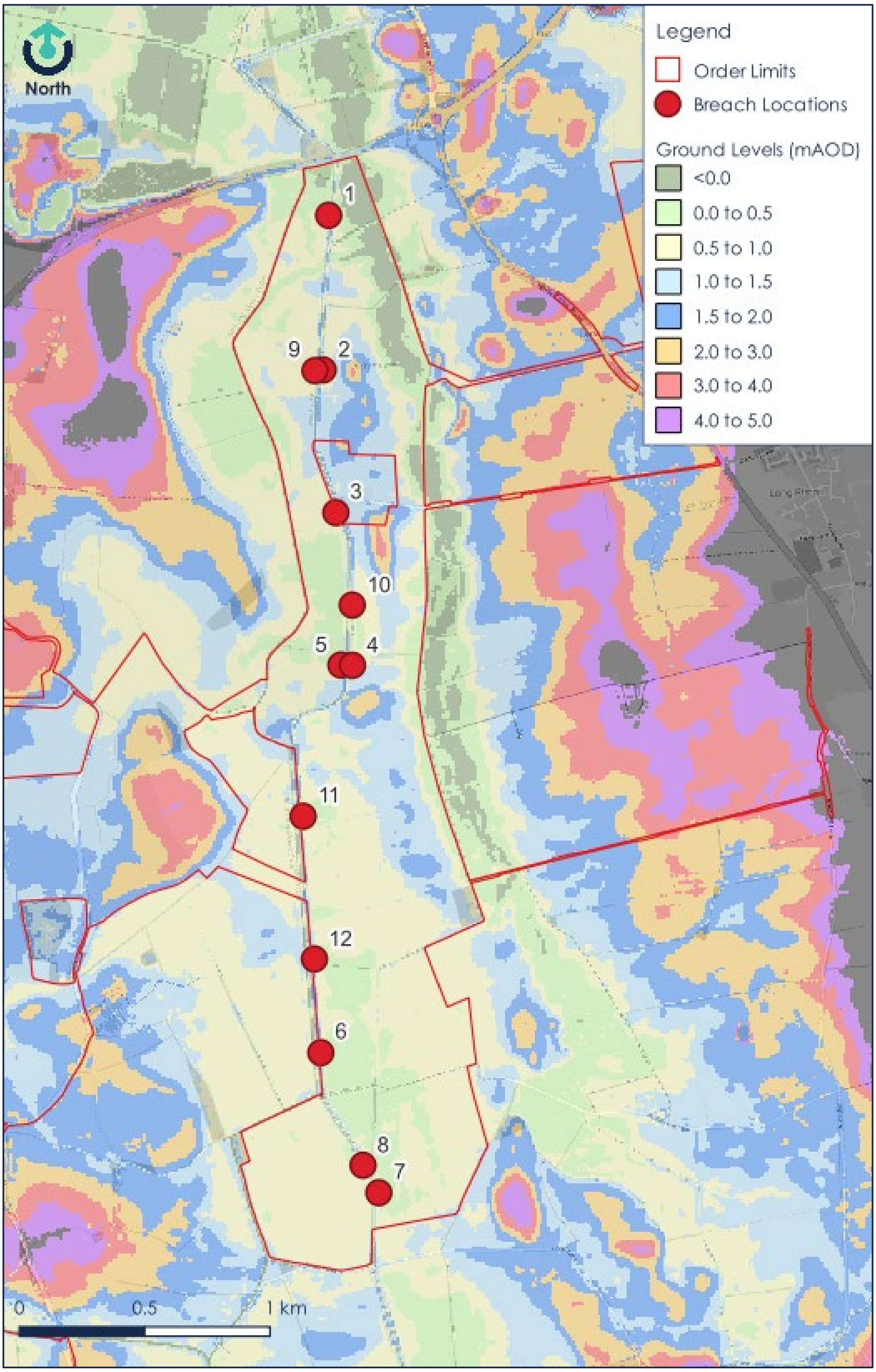
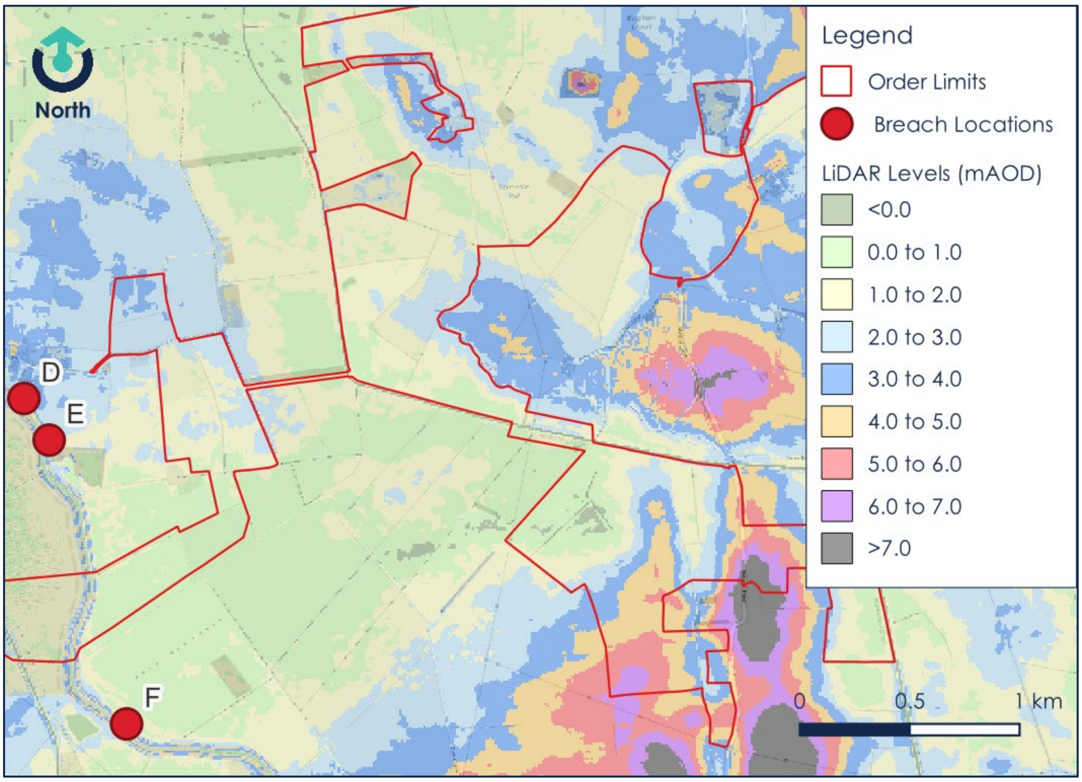


Figure 5-14   River Hull Breach Locations



5.11.29 The outputs from the breach modelling were combined to produce a maximum breach flood depths dataset. The resultant peak flood depths are presented in Drawings 20-206-60-250 & 20-206-60-251 contained in Appendix B.

5.11.30 The breaches result in extensive flooding to parts of the Site and the surrounding areas. However large parts of the Site including the location of the substations in Land Areas C and E remain unaffected.

5.11.31 It was agreed with the Environment Agency that placing solar arrays, hybrid packs and containerised infrastructure in these areas was acceptable so long as they were raised above the maximum breach flood level.

5.11.32 The vast majority of switch gear, hybrid packs and spares containers are located outside the breach flood extents, but there are Land Areas where this was not practicable due to the requirement for proximity to the solar arrays. In these cases, the infrastructure has been located in areas where predicted depths are the shallowest. For the majority of them, the predicted depths are less than 0.3m. These units will be as standard raised 0.5m above ground.

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5.11.33 For the majority of the flooded area, depths are below 0.8m There are notable exceptions, but the predicted depths will not preclude the placement of solar panels because they will be raised above the maximum simulated flood level. Panels will be set above the maximum flood level from the breach scenarios.

5.11.34 In summary, although a worst-case defence failure could cause significant flooding of land adjacent to a breach, the layout has been designed so that such flooding would not impact upon the water-sensitive elements of the scheme.

Credible Maximum Scenario

5.11.35 The Credible Maximum Scenario, which accounts for the plausible worst-case impacts of climate change, has been applied in accordance with the requirements set out in NPS EN-1. The document states at paragraph 4.10.12 that:

> *"Where energy infrastructure has safety critical elements, the applicant should apply a credible maximum climate change scenario. It is appropriate to take a risk-averse approach with elements of infrastructure which are critical to the safety of its operation."*

5.11.36 The Credible Maximum Scenario was applied in accordance with 'Flood risk assessments: climate change allowances guidance'[11], which states:

[11] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances#credible-maximum-scenarios

"If you develop NSIPs you may need to assess the flood risk from a credible maximum climate change scenario. Check the relevant national policy statement."

"In these circumstances you should use:

- *the H++ climate change allowances for sea level rise*
- *the upper end allowance for peak river flow*
- *the sensitivity test allowances for offshore wind speed and extreme wave height*
- *an additional 2mm for each year on top of sea level rise allowances from 2017 for storm surge*

You should treat this as a 'sensitivity test'. It will help you assess how sensitive your proposal is to changes in the climate for different future scenarios. This will help to ensure your development can be adapted to large-scale climate change over its lifetime."

5.11.37 In the absence of specific guidance on how this should be applied for shorter time scales, the H++ climate change allowance for sea level rise to 2100 of 1.9m was applied along with the upper end peak river flow uplift to 2125 of 66%. The storm surge, offshore wind speed and extreme wave height allowances are for tidal modelling and therefore not relevant.

5.11.38 The flooded areas do not change significantly when compared to the design event. and levels generally increase by less than 0.2m. The notable exceptions being land in Land Areas C5, C6, C8 and C9 where levels increase by approximately 0.3m. Flooding during the Credible Maximum Scenario is significantly less extensive than the combined breach outputs.

5.11.39 The difference between flood levels in the design event and the Credible Maximum Scenario are presented along with the combined breach extents in Drawing 20-266-60-260 & 20-266-60-261 in Appendix B.

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5.11.40 The substations are located in areas unaffected by the Credible Maximum Scenario to ensure their long-term viability, despite the development lifetime being just 40 years.

Defence Reaches Removed

5.11.41 Environment Agency letter dated 25th June 2024 (ref:XA/2024/100093/01-L01) states:

> *"Although breach modelling is being undertaken by the applicant, any assessment of residual flood risk, both now and in the future, will be insufficient without further consideration of the condition of the flood defences. Through understanding the condition of existing defences and how defence conditions may change over the lifetime of the development, you must give appropriate consideration to how residual flood risk can be managed and mitigated."*

5.11.42 As discussed in Section 5.6 the Site is protected by earth embankments flanking the Monk Dike which fall within the Upper Hull subcatchment where the policy is to *"Continue with existing or alternative actions to manage flood risk at the current level"*.

5.11.43 Even if maintenance was with withdrawn, it would take a significant period of time for the defence to provide no protection to the Site. In fact, it is likely that overtopping of the lowest part of the defences which is on the western bank at the northern end of the reach (just south of the A1035) would erode the bank and progressively reduce its height and that further loss of bank would be limited beyond this point.

5.11.44 A review of the defence conditions as recorded in the 'Spatial Flood Defences including Standardised Attributes' was carried out which revealed a 4km reach of the western Monk Dike embankment is in poor condition. To assess the potential impact of this defence deteriorating over time a simulation ('Bank Removal West – NB1') was carried out with the entire reach removed from the model.

5.11.45 The results of this simulation for the future 1 in 100 year flood shows that the extent of flooding on the Site only marginally exceeds the maximum breach extent. A review of the model reveals that flooding would not increase significantly when compared to the combined worst-case from the breach scenarios for the vast majority of the Site. The resultant flood depths are presented in Drawing 20-206-60-253 in Appendix B.

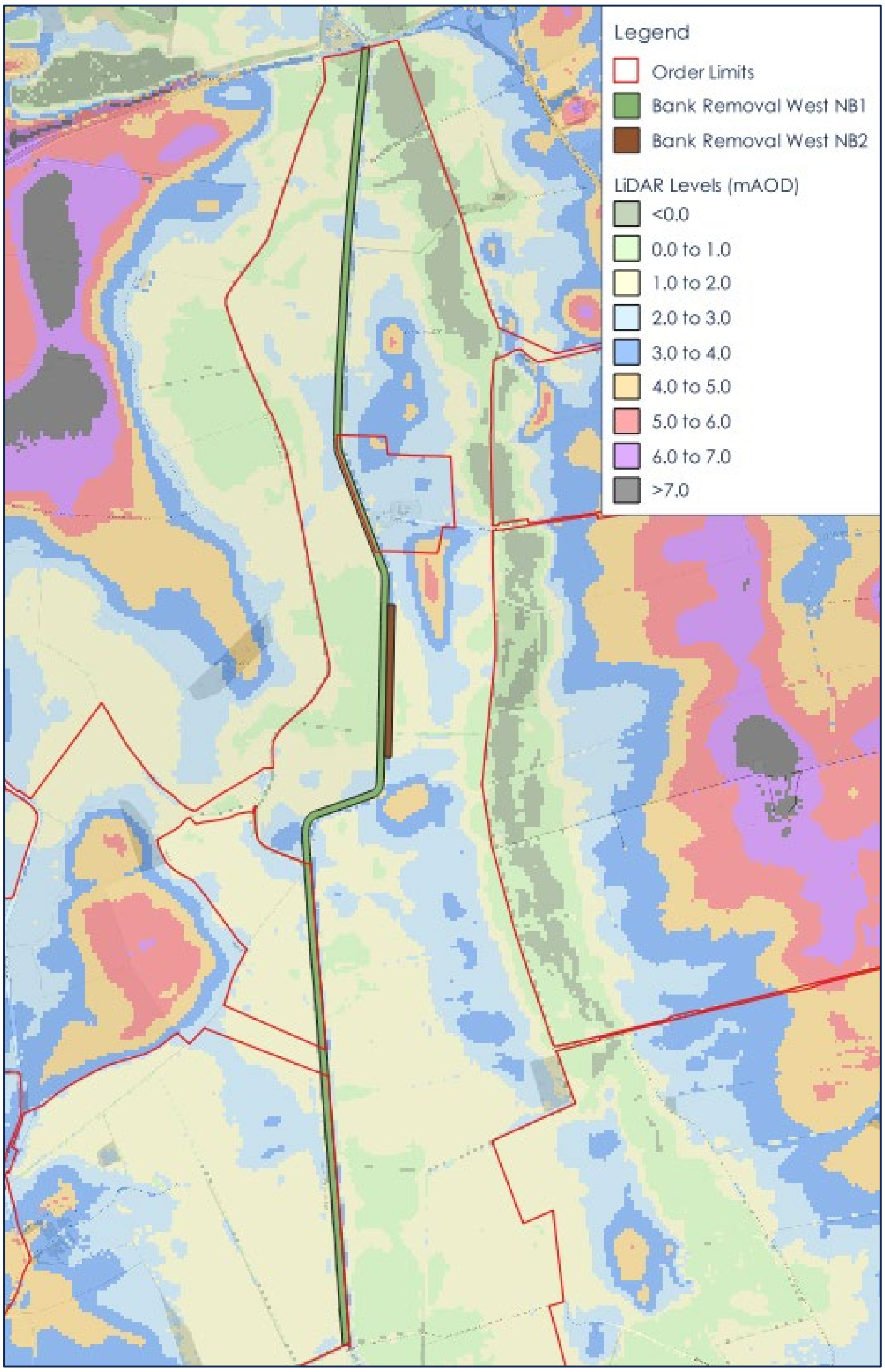
5.11.46 An additional simulation ('Bank Removal East – NB2')) was run where a section of the eastern Monk Dike embankment was removed, despite it being in good condition. This was carried out due to it defending 'safety critical' elements, namely the substation in Land Area C3.

5.11.47 As the Monk Dike preferentially overtops the low spot in the right (western) bank at the upstream end of the site, the more likely mechanism for failure of the left bank would be seepage, piping and then collapse of a section of the bank. For this reason, an approximately 400m long section of the bank was removed where ground levels at the toe are the lowest. This will produce a similar result as removing the entire reach as ground levels elsewhere are higher and therefore overtopping is unlikely to occur. The extent of flooding adjacent to the section of defence removed is almost identical to the worst-case breach scenario and flood levels are just 5mm higher. The resultant flood depths are presented in Drawing 20-206-60-254 in Appendix B.

5.11.48 As both of these scenarios are extreme cases (and not normally required as an assessment of flood risk) and the outcomes are almost entirely mitigated by the approach to mitigating breach scenarios the development proposals are considered suitable in this respect.

5.11.49 The sections of bank which were removed are shown in Figure 5-15. Further details are contained in the Peartree Hydraulic Modelling Report in Appendix C.

Figure 5-15 Monk Dike Defence Reaches Removed



Sensitivity Tests

5.11.50 The sensitivity of the hydraulic model was tested for the following:

- Tidal Boundary – adjusted to reflect the finds of the Humber Extreme Water Levels Study (HEWL)

- Model inflows – a combined 20% increase in standard percentage runoff and 30% increase in baseflows for both the baseline and the breach events

- Mannings roughness – increased by 20% across the model

5.11.51 The change in flood extents resulting from these sensitivity tests was minor and significantly below the 0.3m freeboard applied to the design event water level to set levels for the solar arrays and water-sensitive infrastructure.

Development Flood Level Change

5.11.52 As agreed with the Environment Agency, a simulation was carried out where Manning's roughness was increased to 0.1 in developed areas to represent the solar panel array supports.

5.11.53 This value is typically used for dense brush which would provide more resistance to flow than the narrow supports for the panel arrays. The change in flood levels is generally +/- 0.005m demonstrating that there would be a non-material change to flood risk for third parties. Refer to the Peartree Hydraulic Modelling Report in Appendix C for further details.

Summary

5.11.54 The hydraulic modelling work demonstrates that the majority of the Site is not at risk of fluvial flooding. The extensive defences, particularly the embankments alongside the principal watercourses (River Hull and Monk Dike) serve to contain the majority of flood waters.

5.11.55 Where flooding does occur during the defended scenario, flood depths tend to be low. The development proposals have been derived taking account of these outputs taking the sequential approach by locating containerised infrastructure outside the design event flood extents. All water-sensitive infrastructure will be raised at least 0.3m above the design event flood level.

5.11.56 The modelling work also considers the Credible Maximum Scenario using the H++ allowances in accordance with Planning Practice

Guidance (PPG)[12] and NPS EN-1[13]. The two exporting substations would be located outside the predicted flooding and comfortably above the predicted flood level.

5.11.57 The hydraulic modelling work also includes fifteen breach simulations of earthen embankments in the vicinity of the Site to determine the residual risk. These simulations provide sufficient information to determine a suitable approach to mitigating residual risk which is discussed in Section 6.

5.11.58 Sensitivity testing of the tidal boundary, fluvial inflows and Manning's roughness demonstrate that the model is not particularly sensitive to these conditions. Generally, increases in flood level are below 0.1m and entirely below 0.2m. Accordingly it is concluded that 0.3m freeboard above the design event flood level should be sufficient to account for uncertainty and any floating debris which would be limited due to the local land use and the low velocities predicted within the floodplain.

5.11.59 Modelling of the H++ Credible Maximum Scenario flood for 2100 resulted in an increase of up to 0.3m above design event flood levels . Consequently, a freeboard of 0.3m of the design event flood level will effectively mitigate the impact of extreme climate change to 2100.

5.11.60 Mitigation measures are set out in Section 6.

5.12 Surface Water Flooding

5.12.1 This Section of the report refers to The Risk of Flooding from Surface Water (RoFSW) dataset as updated on 8 January 2025 and retrieved from the Defra Data Services Platform. On this website it states:

"Risk of Flooding from Surface Water (RoFSW) map is an assessment of where surface water flooding may occur when rainwater does not

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[12] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

[13] Overarching National Policy Statement for energy (EN-1) - GOV.UK (www.gov.uk)

drain away through the normal drainage systems or soak into the ground, but lies on or flows over the ground instead"[14]

5.12.2 The RoFSW mapping indicates areas where water would tend to flow and accumulate during extreme rainfall events. The mapping is derived by simulating 1 in 30, 1 in 100 and 1 in 1,000 year rainfall events to define areas at high, medium and low risk of surface water flooding. The mapping is derived by combining the outputs of the simulated 1 hour, 6 hour and 18 hour rainfall storms for each of the probability events.

5.12.3 On natural ground the routing model outputs from the Revitalised Flood Hydrograph Method (ReFH2) are used as inputs to the RoFSW model. This model was designed for estimating flows in rivers and comprises a routing model and a baseflow model the outputs of which are combined to derive river flows. The Environment Agency's NaFRA2 New National Modelling Methodology Statement (February 2025) provided by the Environment Agency notes in Section 4 entitled 'Surface water-specific model setup and component':

"Key assumption for applying ReFH losses model is that the quick flow component of a fluvial flood hydrograph is composed of water that has flowed overland all the way from where the rain falls to where it enters the river"

5.12.4 However, the 'quick flow' (routing model) accounts for all non-groundwater flow which comprises both overland flow and interflow within the soil above the water table. In reality the interflow is unlikely to affect surface water flooding, particularly given land drainage works to reduce soil saturation and improve agricultural productivity.

5.12.5 As standard, the simulations extend for 6 hours beyond the end of the simulated storm. Within the methodology statement this is noted under the heading 'Assumptions and Limitations':

"The hydraulic model does not account for any infiltration or evaporation, so water will continue to accumulate in localised

14 https://environment.data.gov.uk/dataset/b5aaa28d-6eb9-460e-8d6f-43caa71fbe0e

topographic lows beyond the end of the storm even if such water would, in all likelihood, have been lost from the surface."

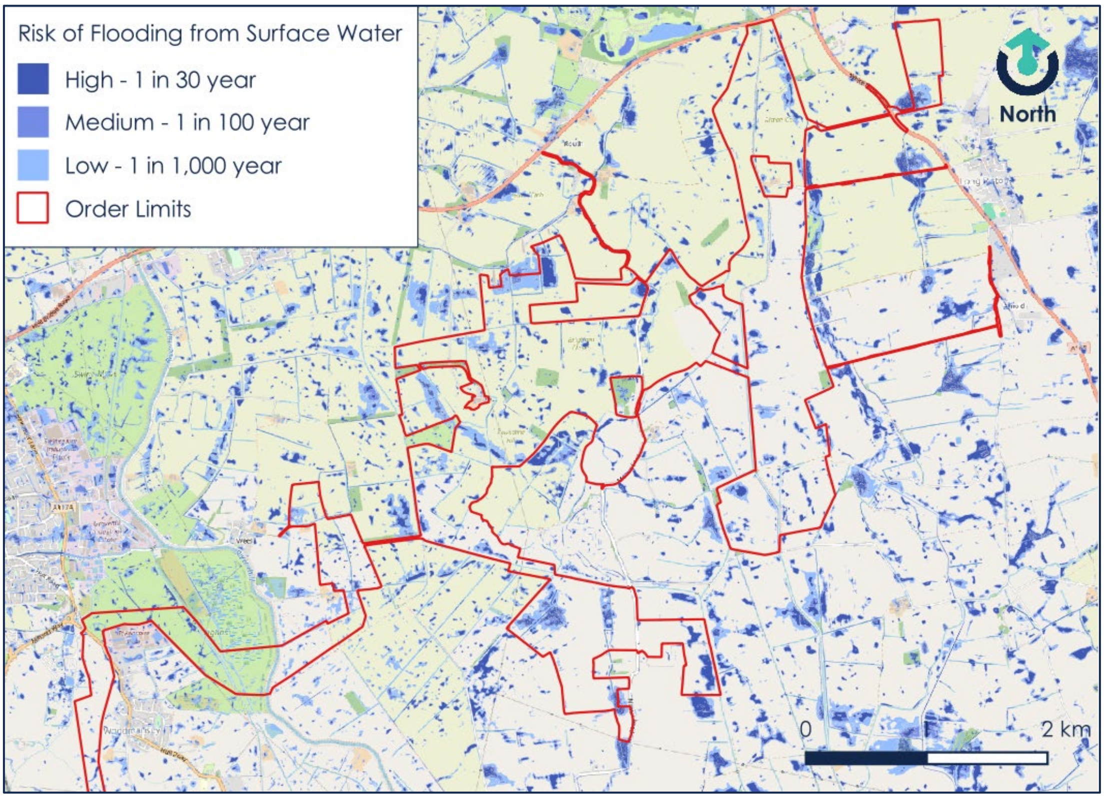
5.12.6 This limitation will tend to overestimate flooding in depressions which receive runoff from the surrounding area.

5.12.7 The RoFSW dataset is based on a 2m horizontal grid and consequently does not adequately represent small watercourses.

5.12.8 As per the previous methodology, the new modelling does not explicitly model below ground drainage or pumping stations. The Site is currently agricultural land which benefits from below ground land drains. These land drains discharge to a complex network of field drains which themselves generally rely on pumping to raise water into large carrier drains such as the Monk Dike. This infrastructure is not reflected by the RoFSW method and consequently the outputs will tend to overestimate surface water flood risk. Despite its shortcomings, the dataset does show areas where water would pond should the local drainage cease to function and identifies area where water would accumulate should the drainage system become overwhelmed.

5.12.9 The RoFSW dataset shows the majority of the Site to be at Very Low risk of flooding from surface water and hence not at risk from a 1 in 1,000 year rainfall event (Figure 5-16). However, there are large areas predicted to be at risk.

Figure 5-16   RoFSW Extents



5.12.11 The 1 in 1,000 year surface water depths over 0.3m and the extent of flooding from the combined breach simulations are presented in drawings 20-206-60-309 & 20-206-60-310 in Appendix B.

5.12.12 Flooding over 0.3m is generally confined to watercourses and localised depressions in the topography. The predicted surface water flooding does not impact the proposed substation locations. There is no containerised infrastructure in areas where predicted surface water flood depths exceed 0.3m. These units will be raised at least 0.5m above the ground which will effectively mitigate the risk of surface water flooding.

5.12.13 The solar arrays will be raised at least 0.8m above the ground which will effectively mitigate the risk of surface water where depths are predicted to be less than 0.6m.

5.12.14 Flooding over 0.6m is generally confined to watercourses and localised depressions. However, flooding over 0.6m is predicted in generation areas within Land Areas B6, C1, C7, E5, F1, F2, F3 and F5.

5.12.15 Within Land Areas C1, C7, F1, F2 and F3 the predicted surface water depths do not exceed the maximum breach flood depth. The panels will be above the maximum breach level which will mitigate the predicted risk of surface water flooding. This is not the case for Land Areas B6, E5 and F5 which are discussed in the following subsections

The only areas where panels are proposed and predicted surface water flooding exceeds 0.6m are:

- Land Areas F1, F2 and F3 – predicted surface water flooding is approximately 0.5m shallower than maximum breach flood depths.
- Land Area F5 and F6 – some areas are predicted to flood to depths of 0.6-0.9m and a very limited area is predicted to flood to depths of 0.9-1.2m. A drainage channel exists between these Land Areas which connect to the Holderness Drain.
- Land Area E5 – a small area of land is predicted to flood to depths of 0.6-0.9m. A review of the RoFSW direction data shows this water flows through Land Areas E8, E7 and E6 passing over four drains which would inhibit this flood mechanism.

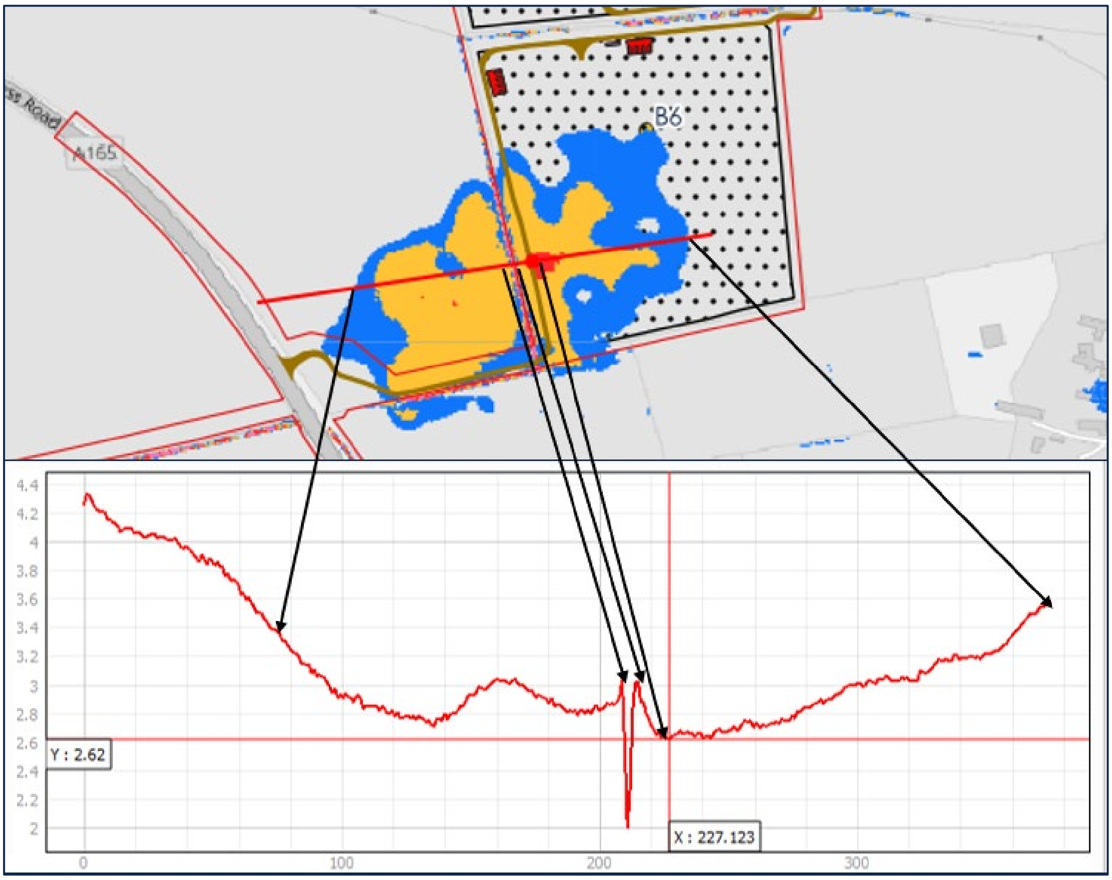
5.12.16 Within Land Areas C1, C7, F1, F2 and F3 the predicted surface water depths do not exceed the maximum breach flood depth. The panels will be above the maximum breach level which will mitigate the predicted risk of surface water flooding. This not the case for Land Areas B6, E5 and F5 which are discussed in the following subsections.

Land Area B6

5.12.17 Flooding is predicted in the southwestern corner of Land Area B6. The depths in this location predominantly fall within the 0.6-0.9m band but the very southern tip falls within an area predicted to flood to 0.9-1.2m. The predicted flooding. 1 in 1,000 year depths from RoFSW dataset are presented in Figure 5-17 along with a section showing key ground levels.

5.12.18 LiDAR elevation data records ground levels in the area of deepest flooding are approximately 2.6mAOD and the highest ground levels in the 0.3-0.6m band are approximately 3.3m. Therefore the maximum predicted flood level is approximately 3.6mAOD resulting in peak depths of approximately 1.0m.

Figure 5-17 Land Area B6 – RoFSW 1 in 1,000 Depths and Ground Levels



5.12.19 However, there is a substantial ditch on the western edge of the site with bank levels of approximately 3.0mAOD. Consequently at a maximum depth of 0.4m water would flow overland into the western ditch. Furthermore, the presence of below ground land drainage in the fields would allow drainage even at lower levels.

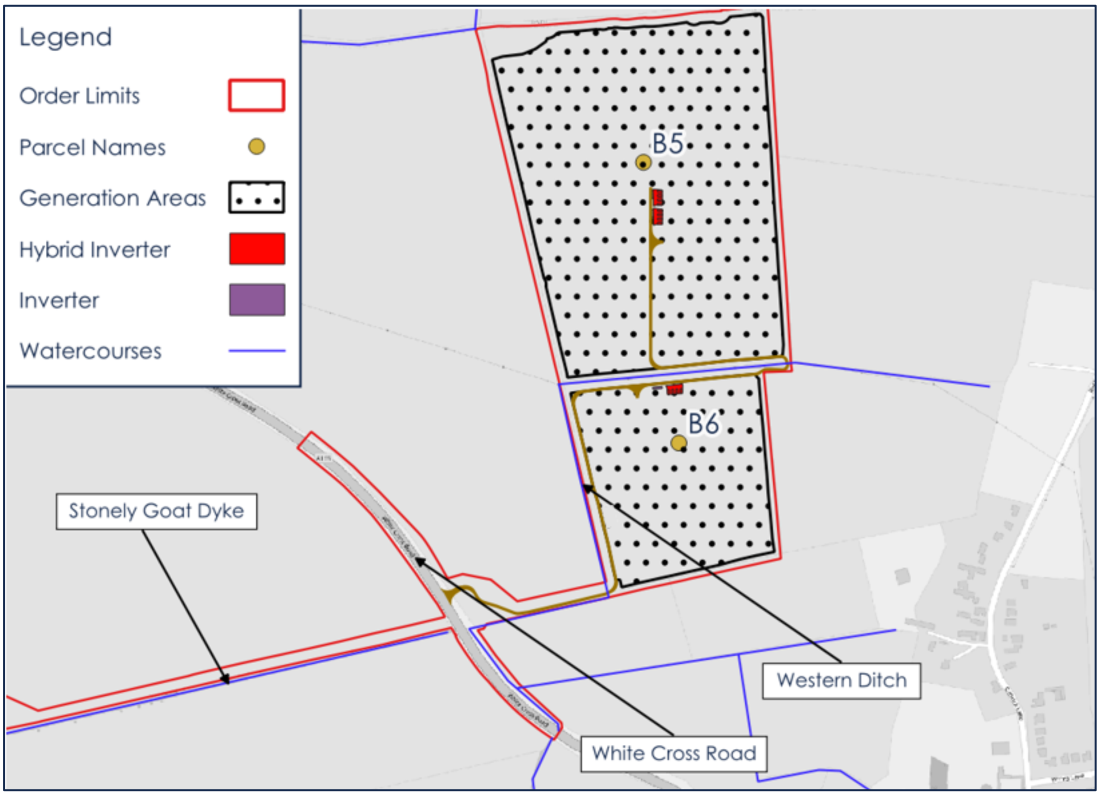
5.12.20 LiDAR data records the ditch to be approximately 1.0m deep. During a site visit, the western ditch was recorded as approximately 1.5m deep as was the continuation of this ditch to the west . A photo of the western ditch is reproduced in Figure 5-18.

Figure 5-18 Western Ditch Land Area B6

5.12.21 The western ditch is part of a larger network of drains which connect to the IDB maintained Stonely Goat Dyke which itself drains to the Arnold and Riston Drain. Parts of these watercourses are shown as being flooded in the RoFSW dataset but they are not continuous. There is a break in the flooded areas at White Cross Road as the culvert under the road is not represented. It is therefore concluded that water gets trapped in this area and flooding in this location is overestimated. The onward drainage network is shown in Figure 5-19.

5.12.22 Despite the noted shortcomings of the modelling, a precautionary approach will be taken to the Proposed Development on the basis of a predicted maximum depth of 1.0m in this location. Panels would be raised above this level and no further mitigation will be required.

Figure 5-19 Onward Drainage Network



Land Area E5

5.12.23 LiDAR records ground levels at the edge of the 0.3-0.6m depth band in Land Area E5 to be approximately 0.7mAOD and lowest ground levels to be 0.3m suggesting a maximum flood level of 1.0mAOD and peak depths of 0.7m.

5.12.24 At a level of 0.7mAOD, and a maximum depth of 0.4m, water would flow into the ditch to the south which is not adequately represented in the RoFSW dataset and so depths are likely to be significantly overestimated.

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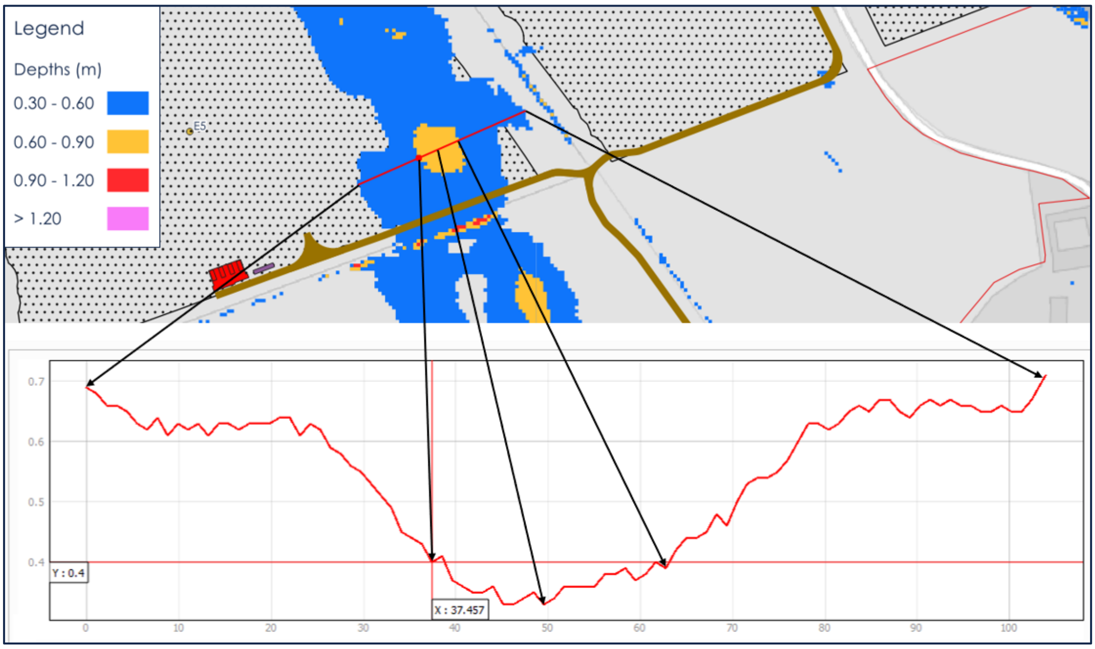
Figure 5-20Land Areal E5 – RoFSW 1 in 1,000 Depths and ground levels



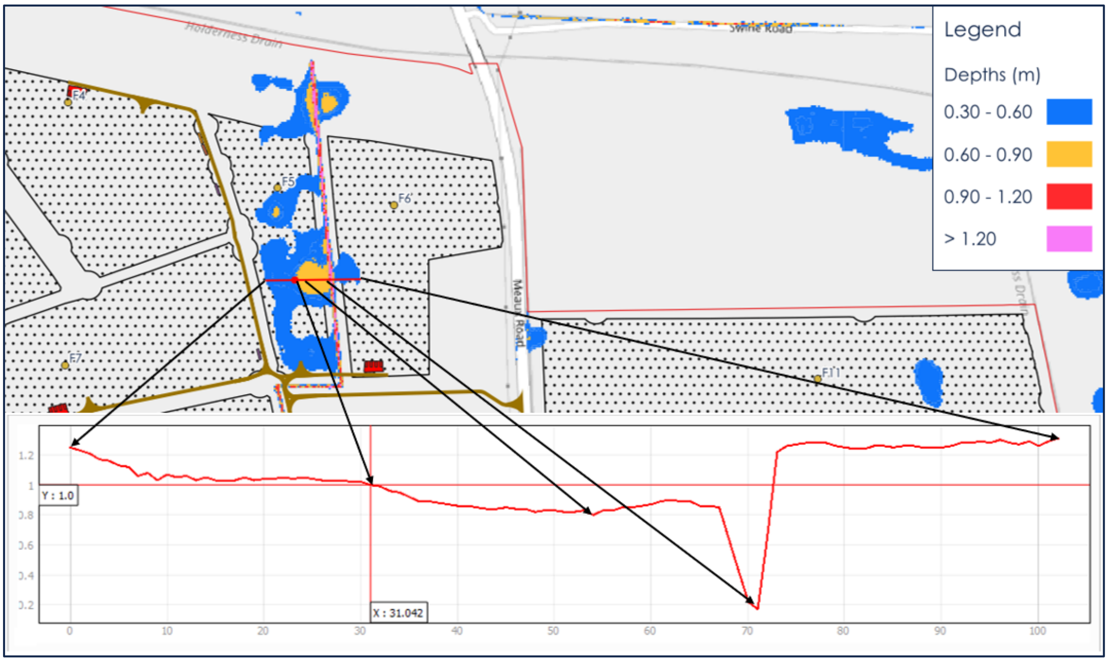
Land Area F5

LiDAR records ground levels at the edge of the 0.3-0.6m depth band for the 1 in 1,000 year event in Land Area F5 to be approximately 1.2mAOD and lowest ground levels in the generation area to be approximately 0.8mAOD. This indicates a maximum flood level of 1.5mAOD and peak depths of 0.7m.

At a level of 0.9mAOD and maximum depth of 0.1m, water would flow into the ditch to the east. This ditch connects to the Holderness Drain to the north. This connection is not represented in the RoFSW dataset due to the raised embankments and consequently water cannot drain from this area. The result is that depths are likely to be significantly overestimated.

5.12.25 The predicted 1 in 1,000 year depths from the RoFSW dataset are presented in Figure 5-21 along with a section showing key ground levels.

Figure 5-21 Land Area E5 – RoFSW 1 in 1,000 Depths and ground levels



Summary

5.12.26 The RoFSW dataset does not accurately reflect the nature of the catchment and significant drainage infrastructure which serves it, particularly the network of smaller field drains.

5.12.27 The RoFSW dataset does not predict flooding of the proposed on-site substations and the predicted 1 in 1,000 year depths are generally below the maximum breach depths, which have been mitigated through layout design and setting panel heights.

5.12.28 The RoFSW data does not predict flooding to depths greater than 0.3m during the 1 in 1,000 year event where containerised infrastructure is proposed These units will be 0.5m above ground levels which will effectively mitigate surface water flood risk. No change is required in this regard.

5.12.29 The only location within the generation areas where surface water depths are predicted to be above 0.8m is in Land B6, where maximum depths are approximately 1.0m. However, the dataset does not reflect the local drainage network. A substantial ditch would receive overland flows when maximum depths reach 0.4m. Nonetheless a precautionary approach will be taken by setting panels above the inferred maximum flood level 3.6mAOD which will effectively mitigate against the residual risk of failure of local drainage infrastructure.

5.12.30 Standing water may be present for weeks or months during prolonged rainfall and saturated conditions. This is expected to remain shallow and as such the raising of infrastructure should provide sufficient mitigation. Demarking access track edges would facilitate safe access for maintenance through standing water.

5.12.31 Consequently, the risk of surface water flooding to sensitive infrastructure is assessed as being **Low**.

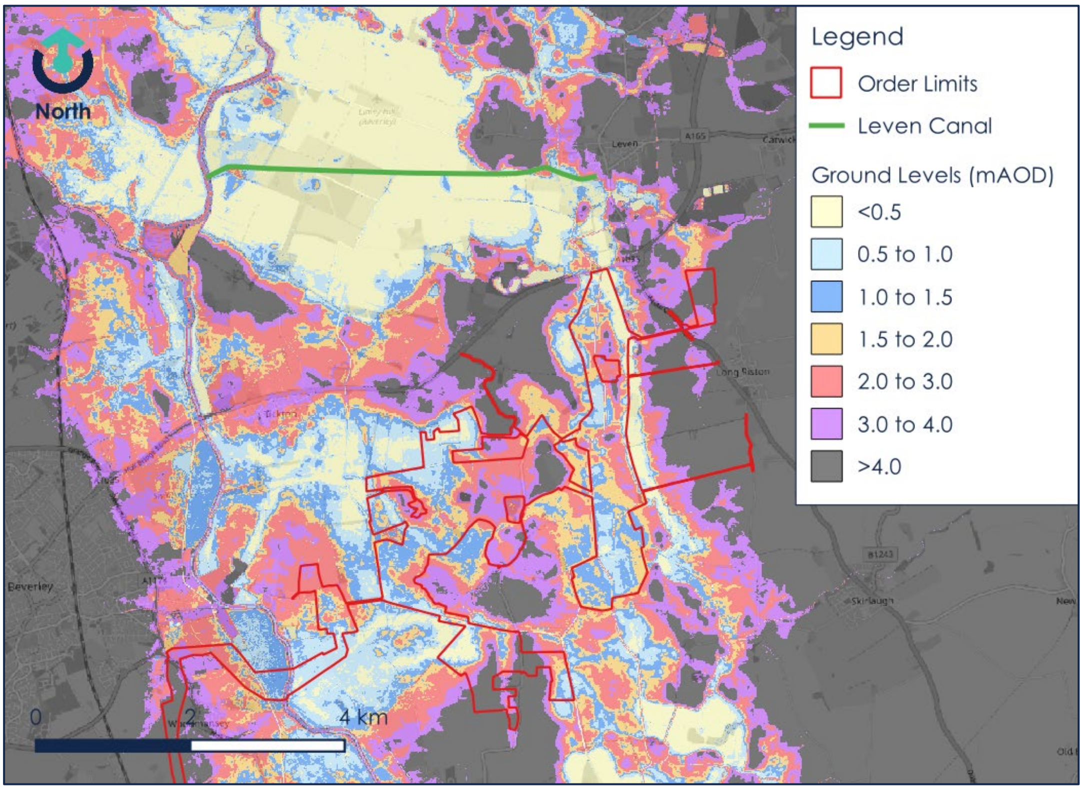
5.13 Flooding from Artificial Sources

5.13.1 Mapping data from the Environment Agency show that the Site is located outside the flood extents presented by potential breach of large reservoirs which includes an assessment of breach of Tophill Low No. 1 and Top Hill Low No.2 approximately 5km to the north of the Site on the western side of the River Hull.

5.13.2 The Leven Canal is located approximately 1.5km to the north of the Site and has banks at approximately 1.5-2mAOD. The normal water level is not known but is unlikely to significantly exceed 1mAOD. Should breach of the canal occur and water was not able to be drained down to the River Hull it would be expected to flood low-lying land below 0.5mAOD adjacent to it. Some water may affect the northern part of Land Area B to adjacent to the Monk Dike but it is unlikely that such flooding would exceed the worst-case breach scenario which is mitigated by the Site proposals.

5.13.3 Ground levels and the location of the Leven Canal are shown in Figure 5-22.

Figure 5-22 Ground Levels and Leven Canal



5.13.4 The development is considered to be at **Very Low** risk of flooding from reservoirs, canals and artificial sources.

5.1 Groundwater Flooding

5.1.1 The hydrogeology aquifer classification shows that the entire Site classified as '*Highly Productive Aquifer*'.

5.1.2 The BGS maps indicate that the Site is underlain by permeable chalk geology, with various superficial deposits also recorded, including Glaciofluvial deposits, Alluvium and Till.

5.1.3 Given the large areas of lower lying land in the vicinity of the Site (see Figure 5-22) and the extensive drainage network in the area it is considered unlikely that groundwater levels would rise to depths such that they would affect the panels, water-sensitive infrastructure or substations which are located on elevated land.

5.1.4 The risk of flooding from groundwater is assessed as being **Low**.

5.2 Flooding from Sewers

5.2.1 A premium utility report for the Order Limits was produced by emapsite. The sewerage assets recorded in the plans from Yorkshire Water are as follows

- There is a sewage treatment works approximately 80m to the south of Land Area E14 (approximate NGR 506730, 439450). It receives sewage from a 225mm diameter sewer which appears to serve the village of Weel to the west and discharges to a drain.
- There is a 3 inch cast iron combined sewer originating at Manor Farm (NGR 509186, 442190)approximately 300m north east of Land Area D6) and flowing to the north along Meaux Lane.
- A 4 inch cast iron combined sewer alongside Carr Lane serving Triple B Farm and neighbouring properties.

5.2.2 Given the flat nature of the land and the extensive network of land drainage in the area it is considered extremely unlikely that flooding from these sewers would cause worse flooding than surface water or fluvial flooding which has been effectively mitigated through the site design. The risk of sewer flooding to the Site is considered to be **Very Low**.

5.3 Safe Access and Egress

5.3.1 The solar farm will be controlled remotely and only visited occasionally for maintenance operations. Consequently, there will be no requirement for access or egress to the Site during times of flood.

5.3.2 However, before operation a site Flood Emergency Management Plan should be drawn. It is recommended that this is done in consultation with the East Riding of Yorkshire Council's Civil Contingencies Team. The site falls with the Holderness Drain area including Leven and Bransholme' flood alert area. The site operator should register for this service to inform flood management plan actions.

5.3.3 As shown by the hydraulic modelling work and the Risk of Flooding from Surface Water dataset flooding during most events will only affect areas where panel arrays are proposed but not supporting water-sensitive infrastructure so access should not be required.

5.3.4 It is acknowledged that shallow flooding within the Land Areas could persist for weeks or even months. It is possible that some access tracks would be located in the areas of standing water. The predicted depths should not impact maintenance access presuming a 4x4 vehicle would be used. Nonetheless, consideration should be made during Site setting out to use waymarkers or similar to visually denote the track edges and facilitate safe access should there be shallow standing water on the site.

6 FLOOD RISK MITIGATION MEASURES

6.1.1 Mitigation has been derived for the water sensitive elements of the proposals, namely the two substations and containerised infrastructure (hybrid packs, inverter containers and spares containers).

6.1.2 The principle of placing solar arrays in areas at risk of flooding, including within Flood Zone 3b, is well-established. The solar arrays will either be fixed or tracker units. Panels on tracker units will have a minimum height from the ground of 0.8m at full declination. Fixed panels will also have a minimum height from the ground of 0.8m. Regardless of the type, the inverter/combiner boxes mounted on the array supports will be a minimum of 0.8m above ground.

6.1.3 The containerised infrastructure will, as standard, be raised 0.5m above the ground.

6.1.4 The hydraulic modelling work demonstrates that 0.3m is sufficient freeboard above the design event level to account for uncertainty in the fluvial modelling. 0.3m is also the maximum difference between the design event level and the Credible Maximum Scenario level. Consequently 0.3m of freeboard would also safeguard against extreme climate change to 2100.

6.1.5 Solar panel edges and containerised infrastructure will therefore be raised to the design event flood level plus 0.3m freeboard as a minimum. This has been agreed with the Environment Agency. For development within Parcel B5 a design event flood level of 3.6mAOD, which is significantly higher than the Hull and Holderness Drain modelled flood level will be adopted. It has also been agreed that all water sensitive infrastructure will be raised above the simulated worst-case breach scenario.

6.1.6 The model also reflected the siting of panels within flood extents by raising the Manning's roughness to 0.1 in the areas where panels and supporting infrastructure are proposed. The results demonstrate that there would be an insignificant change in water levels and consequently a non-material change to flood risk for third parties. This is described in greater detail by the model reporting in Appendix C.

6.1.7 The two substations they have been located outside the combined breach flood extents and the Credible Maximum Scenario. To further safeguard against extreme climate change all associated water-sensitive infrastructure will be raised at least 0.3m above the worst-case flood level of the combined breach outputs and the H++ scenario.

6.1.8 All containerised infrastructure and substations will be located outside of the modelled 1 in 50 year event and be outside Flood Zone 3b, as shown in drawings 20-206-60-315 & 20-206-60-316 in Appendix B.

6.1.9 The risk of surface water will be mitigated by raising the water-sensitive elements of the Proposed Developments above the predicted flood level in the 1 in 1,000 year event. The 1 in 1,000 year event is more severe than the 1 in 100 year plus climate change providing some freeboard. As discussed in Section 5.12, the RoFSW methodology does has several limitations which are likely to result in an overestimation of the flooding, particularly where the local drainage network is not represented and in localised depressions where water continues to accumulate beyond the modelled storm with no account of ongoing drainage to ground.

7 SURFACE WATER MANAGEMENT

7.1 Hydrological Impact of the Proposals

7.1.1 The proposed development is for a solar farm and consequently, the majority of the Land Areas will be taken up by solar arrays. Rows of solar panels will be separated by gaps of approximately 4-12m for fixed arrays and 4-6m for tracking arrays. The solar arrays themselves have thermal expansion gaps (Figure 7-1).

Figure 7-1 Typical Solar Panel Arrangement (showing expansion gaps)

7.1.2 The concentration of runoff from the solar panels will be spatially localised, with water draining from the panel between the expansion gaps. The velocity of water falling from the panels will be significantly less than the velocity of unimpeded rainfall. The velocity of a raindrop depends on the size and wind speed but can exceed 10m/s.

7.1.3 Once rainfall has exceeded the interception capacity of vegetation it will initially take up any available depression storage and soil moisture deficit before moving laterally through the soil and percolating downwards. If the incident rainfall exceeds the rate of soakage into the ground it will move laterally above the soil and soak into areas which are within the 'rain shadow' of the panels. Consequently, the impact of the panels on runoff is considered to be negligible.

7.1.4 This is reflected in *Paragraph 2.10.84 of EN3:*

"Where a Flood Risk Assessment has been carried out this must be submitted alongside the applicant's ES. This will need to consider the impact of drainage. As solar PV panels will drain to the existing ground, the impact will not, in general, be significant."

7.1.5 The proposed access tracks occupy a limited area within the Site and will be formed of compacted granular material and will not have a significant impact on runoff rates or volumes.

7.1.6 Across the Site the cessation of intensive agricultural activities, particularly arable farming, will have beneficial effects. The ability of soil to accept rainfall is dependent on good aggregate stability and pore structure. Soil structure depends on a healthy soil ecosystem. Key components of a healthy soil ecosystem which improve soil structure are discussed in the 'Soil Structure and Infiltration Fact Sheet', by the Agriculture and Horticulture Development Board (AHDB). These include:

- Tunnels created by earthworms and roots of plants.
- Fungal hyphae (root-like structures).
- Polysaccharides produced by bacteria and fungi which act as biological glues.

7.1.7 Farming the land can negatively impact soil structure through the application of pesticides and only allowing the growth of a limited number of plants with poor diversity of root structure. In addition to impairing the ability of the soil to maintain a good structure, farming causes compaction by the movement of machinery and grazing animals, particularly when the soil is wet, which can significantly damage the soil structure.

"Farming has a profound influence on the natural ability of soil to accept rainfall. Working, travelling across and keeping livestock on the land in wet conditions can seriously degrade soils by reducing soil porosity."

Source: Soils and Natural Flood Management (East Devon Catchment Partnership)

7.1.8 This compaction causes a corresponding decrease in depression storage, absorption, infiltration and an increase in runoff rates, soil erosion, pollution and flooding downstream:

> *"When soils become compacted, they are more likely to become waterlogged and experience surface ponding that leads to run-off and flooding. This increases nutrient losses to watercourses causing pollution and reducing nutrient levels in soil."*

Source: The state of the environment: soil (Environment Agency, 2019)

7.1.9 According to 'Lowland Natural Flood Management Measures – a practical guide for farmers (Dales to Vales River Network':

> *"Runoff from compacted soils is 50-60% higher than on aerated healthy soils".*

7.1.10 Clearly, the magnitude of impact will depend on the mineral content of the native soil, the degree of compaction and the intensity and duration of rainfall. Nonetheless, it is indicative of the magnitude of impact compaction can have on runoff rates.

7.1.11 Work carried out on soils in Devon and Cornwall by the National Soil Resources Institute of Cranfield University states:

> *"At Boscastle, the study found that grassland with a strongly developed stable soil structure with fine granular soil aggregates only generated 2% runoff under 36mm/hr rainfall. Grassland with weakly developed soil structure with coarse, dense aggregates and low porosity had 60% runoff. This soil became saturated at the surface generating overland flow after 20 minutes of rainfall. Similar results were found in experiments at Ottery St Mary where compacted grassland generated 88% runoff under 50mm/hr rainfall."*

Source: Soils and Natural Flood Management (East Devon Catchment Partnership)

7.1.12 In the case of Boscastle, the rate of runoff from grassland was 30 fold higher where the soil structure was poor. An intensity of 36mm/hr for 15 minutes is approximately equivalent to a 1 in 2 year storm.

7.1.13 In addition to compaction, surface crusts, known as capping, can form on unprotected soils preventing the downward movement of water and promoting runoff.

"Capping can be a particular problem where soils have a large amount of fine sand and silt, and a low content of clay and organic matter. When these soils are exposed to the battering action of rainfall an impermeable surface cap can form which can generate overland flow of rainwater.

Source: Soils and Natural Flood Management (East Devon Catchment Partnership)

7.1.14 The change of use to a solar farm will allow the establishment of a healthy soil ecosystem, an increase in organic matter content, and associated improvements in soil structure, especially in areas which were formally ploughed and left to bare earth following harvest, and those areas where overgrazing and trafficking has caused compaction and erosion. The solar arrays will also protect the ground from intense rainfall whilst vegetation is becoming established and should reduce the formation surface crusts in certain soil types.

7.1.15 These changes will result in a reduction in runoff rates and volumes. The reduction in the application of herbicides and fertilisers will also result in a reduction in soil erosion and improvement in runoff quality.

7.1.16 This is recognised in the NPS EN-3, paragraph 2.10.154 reproduced below:

"*Where previous management of the site has involved intensive agricultural practice, solar sites can deliver significant ecosystem services value in the form of drainage, flood attenuation, natural wetland habitat, and water quality management*"

7.1.17 Figure 7-2 illustrates the difference between good soil structure and compacted soil structure.

Figure 7-2 Illustrative Comparison of Poor and Good Soil Structure

Figure 2.3. Good soil structure (left) and compacted soil structure (right): Very little surface runoff is able to infiltrate into the subsoil layers due to the surface crust and compacted soil layers while vegetation is deprived of oxygen due to the compression of pores that normally transport air and water.

Source: Natural Flood Management Handbook, Scottish Environmental Protection Agency.

7.1.18 Figures 7-3 to 7-5 show the contrast between arable land and solar farm land adjacent to one another in Gloucestershire taken on May 22nd 2020 after relatively dry weather for the preceding two months. The arable land was noticeably harder under foot and exhibited significant cracks from shrinkage. Where the panels are located the ground was not as severely cracked and vegetation was lush, indicating better soil structure and moisture retention.

Figure 7-3 Arable Land Adjacent to a Solar Farm, Gloucestershire (May 2020)

Figure 7-4 Close Up of Arable Ground, Gloucestershire (May 2020)

Figure 7-5 Close Up of Solar Farm Ground, Gloucestershire (May 2020)

7.2 SuDS Hierarchy

7.2.1 The SuDS hierarchy requires that surface water runoff should be managed as high up the following list as practically possible:

- Into the ground (infiltration), or then;
- To a surface water body, or then;
- To a surface water sewer, highway drain or another drainage system, or then;
- To a combined sewer.

7.2.2 In order to determine the most suitable method of surface water management, the options have been assessed below, with the highest option in the SuDS hierarchy selected.

7.2.3 Furthermore, paragraph 5.8.38 of the NPS EN-1 requires that a DCO will need to make provision for appropriate operation and maintenance of any SuDS through the project lifetime.

Infiltration

7.2.4 The BGS geology maps[4] indicate that the entire Site is underlain by permeable chalk geology. The BGS Hydrogeology aquifer classification (625k)[5] records the geology under the entire Site as 'Highly Productive Aquifer'. However, the main parts if the Site are underlain by soils with either low permeability and/or are naturally wet.

7.2.5 Such soils would impede the function of an infiltration basin and consequently, infiltration is not considered to be a viable method for managing surface water from the Proposed Development.

Surface Water Body

7.2.6 The next option in the SuDS hierarchy is to discharge surface water to a nearby surface water body at greenfield runoff rates.

7.2.7 During a meeting with the IDB and the LLFA, it was agreed that the often-saturated conditions at the Site are generally accompanied by high water levels in the watercourses. Given the low-lying and flat nature of the Site, achieving a connection to the watercourses by gravity would lead to prolonged 'tidelocked' conditions. This would mean the discharge to the watercourses would be restricted to negligible rates for prolonged periods. Therefore, a conventional store-and-release attenuation approach is not viable.

Sewer

7.2.8 As described in Sections 3.2 and 5.13., there is no known public surface water system within the vicinity of the proposed infrastructure.

Mimicking Existing Conditions

7.2.9 As a result of the above, it was agreed with the LLFA and IDB, at a meeting them on 6th June 2024, that the conventional methods of discharge are not practicable. Therefore, accounting for the Site's flat topography, it was agreed to use the gravel bases beneath the BESS, substation and isolated infrastructure to store and spread runoff.

7.2.10 Given the flat nature of the Site, it was agreed that rain falling on the infrastructure area would not have a clearly defined flow path and therefore rain falling on the existing Site would slowly percolate into the ground. The proposals would therefore mimic the existing situation and negate impacts on third parties.

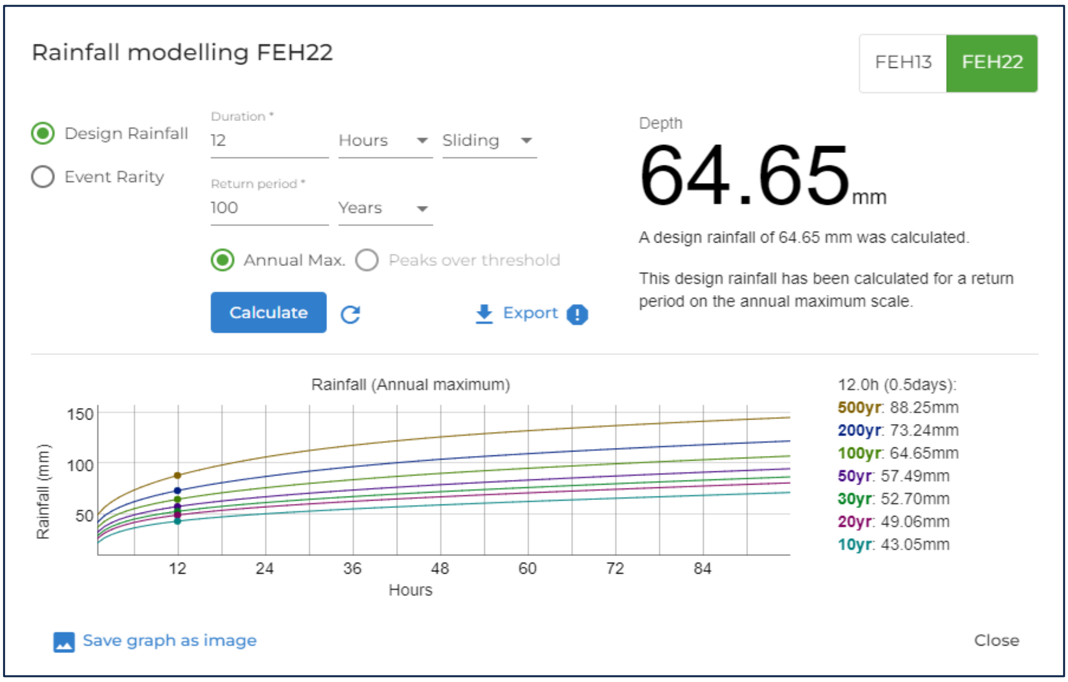
7.2.11 The mimicking of existing, and therefore greenfield, conditions ensure compliance with relevant drainage standards such as the Sustainable Drainage Systems: Non-Statutory Technical Standards.

7.3 Infrastructure Drainage Strategy

Storage Requirements

7.3.1 To calculate the volume of runoff generated from the BESS, substation and isolated containers the Depth-Duration-Frequency model in the Flood Estimation Handbook (FEH) was used. The FEH predicted rainfall depth for the present day 1 in 100 year, 12 hour storm is 64.7mm (0.07m) as shown in Figure 7-6.

Figure 7-6 Depth-Duration Curve Model Results



7.3.2 In accordance with the NPPF and the PPG, an allowance for climate change must be applied to the design rainfall. The proposed development will have a lifetime of 40 years. The Site lies within the Hull and East Riding Management Catchment. For a development with a 40-year lifetime, the central allowance for the 2070s epoch, which covers the period from 2061 to 2125 is applied. This equates to a 25%

uplift in rainfall rates. Therefore, the 1 in 100 year, 12 hour +25% (the design event) rainfall depth is 80.8mm (0.08m).

7.3.3 A 12-hour duration storm has been selected as a precautionary approach as this is double the length of the 6-hour duration storm recommended by the Non-Statutory Technical Standards for SuDS.

7.3.4 The gravel bases beneath the infrastructure would extend at least 300mm from each container edge and be wrapped in a permeable geotextile membrane to restrict sediment and fines entering but encourage percolation. The resultant dimensions, runoff and storage provision of the gravel bases is shown in Table 7-1. The footprints include the gravel base surrounds. This ensures that rain falling on the gravel bases as well as the containerised infrastructure is accounted for.

7.3.5 Furthermore, it is understood some of the cabins or infrastrucutre in the substation would be constructed on concrete foundations. These could be sufficiently deep to replace the gravel base beneath their footprint, which would reduce the available storage capacity of the gravel base. Notably, the switchrooms (total footprint of 100m^2) and the base for the transformer (footprint of 90m^2). These areas have been accounted for (removed) from the gravel base storage in Table 7-1.

Table 7-1 Isolated infrastructure Surface Water Management

Infrastructure	Footprint (m^2)	Runoff (m^3)	Gravel Base Depth (m)	Gravel Base Storage (m^3)
Substation Compound	2,026	163.7	0.3	165
Isolated BESS Units	231	18.7	0.3	21
Isolated Inverters	38.4	3.1	0.3	3.5

7.3.6 Care will need to be taken during the detailed designs of the foundations and loading of the infrastructure to ensure it would remain stable despite the potential for saturated ground. This may result in the need for deeper gravel bases than calculated above, providing additional storage capacity.

Design for Exceedance

7.3.7 As demonstrated above, the storage capacity of the gravel beds would exceed the volume of runoff in a design event, providing some additional capacity for an exceedance event or repeat storms.

7.3.8 In the unlikely event the capacity of the beds was exceeded, water would slowly dissipate overland onto surrounding grassed areas, where it would absorb into the ground as per the existing condition.

7.3.9 As described above, the proposed containerised infrastructure (BESS, inverters, switchgear etc.) would sit on pad foundations and would be raised above the surrounding ground which would prevent flood damage to them in an exceedance event.

Water Quality

7.3.10 The SuDS manual (CIRIA C753) states that the design of surface water drainage should consider minimising contaminants in surface water discharged from the Site. the level of treatment required depends on the proposed land use, according to the pollution hazard indices. To provide adequate treatment, the SuDS mitigation indices for the development must be equal to or exceed the pollution hazard indices.

7.3.11 Surface water runoff from the containers is likely to have an extremely low sediment and pollution content. The closest equivalent considered by Table 26.2 of the SuDS Manual is residential roofs, which present a Very Low hazard to water quality.

7.3.12 The closest SuDS type to gravel beds considered by Table 26.4 is n infiltration trench with depth of at least 300mm. As demonstrated in Table 7-2, the proposed gravel beds (filter drain) are more than sufficient to mitigate the likely low levels of pollutants expected.

Table 7-2 Water Quality Indices (as per C753 The SuDS Manual)

		Pollution Hazard Level	Total suspended solids	Metals	Hydrocarbons
Land Use	Residential roofs	Very Low	0.2	0.2	0.05
Infiltration trench	Mitigation Indices	-	0.4	0.4	0.4

7.4 Operation and Management

7.4.1 Maintenance of the proposed drainage infrastructure is essential for their operation. The maintenance responsibility will lie with the operator. The proposed maintenance activities outlined in Table 7-3 below have been sourced from the CIRIA SuDS Manual.

Table 7-3 Gravel Beds Maintenance

Maintenance Schedule	Action	Frequency
Regular maintenance	Inspect and identify any areas that are not operating correctly. If required, take remedial action.	Monthly for 3 months, then annually
	Remove debris from the surface where it may affect performance	Monthly
Remedial actions	Replacement of clogged geotextile (reconstruct filter bed where required)	As required

7.5 Construction and Operation Management

7.5.1 Flood risk during the construction, operation (including maintenance) and decommissioning phases would be managed through the **Outline Construction Environmental Management Plan (CEMP) [EN010157/APP/7.2]**, **Outline Operational Environmental Management Plan (OEMP) [EN010157/APP/7.3]**, **Outline Decommissioning Environmental Management Plan (DEMP) [EN010157/APP/7.4]** and

Outline Soil Management Plan (SMP) [EN010157/APP/7.8] which are secured pursuant to requirements in the **Draft Development Consent Order [EN010157/APP/3.1]**.

7.5.2 The application for development consent is accompanied by **Environmental Statement (ES) Volume 2, Chapter 10: Land, Soil and Groundwater [EN010157/APP/6.2]** and **ES Volume 4, Appendix 5.5: Water Framework Directive Screening and Scoping Report [EN010157/APP/6.4]**, whereby the potential impacts on the water environment are further assessed. However, a summary of the embedded mitigation is provided in this section for clarity.

7.5.3 During the construction of the Proposed Development there is potential for soil compaction and erosion through vehicular movements. These effects will be addressed via measures that will be implemented through the CEMP, which will be agreed with East Riding of Yorkshire Council and will be substantially in accordance with the **Outline CEMP [EN010157/APP/7.2]**.

7.5.4 The following measures should be implemented as appropriate/required:

- Use of low tyre pressure machinery to reduce compaction.
- A delivery and construction schedule that minimises repeat journeys.
- Temporary measures such as sediment traps using geotextiles, straw and temporary bunding to minimise the risk of pollution.

7.5.5 Where the soil has been disturbed as part of the construction, the **Outline SMP [EN010157/APP/7.8]** secures the following measures. Soil is adequately prepared for seeding. Tillage (mechanical loosening) may be advisable where the soil is compacted. A native seed mix should be used which allows for rapid establishment of ground cover. The seed mix should, where possible, include plants with a diversity of root structures. It is also recommended that consideration is given to including species that are particularly effective at breaking up compacted soil and increasing soil organic matter content.

7.5.6 Existing vehicular watercourse crossings will be utilised wherever possible. Where new crossings are unavoidable, they would be via temporary span truss bridges with the soffit of the deck at bankfull level wherever possible to minimise impacts on the flow of water. They would be subject to consent (most likely from the IDB but depending on the watercourse) post-planning consent.

7.5.7 In some cases, on the smaller watercourses, span bridges are not viable. In such circumstances, box culverts would be preferred. However, the soffit would be at or above bankfull, the width would be at least the width of the channel and bed substrate would be equal to that upstream and downstream. Therefore, in effect they would act as a span bridge and have limited impact on the channel morphology or flows. It should also be noted that the hydraulic modelling demonstrated crossings have limited impact on flooding in or around the Site.

7.5.8 Vehicular crossings may be required over minor in-field ephemeral ditches. These would be facilitated by small piped culverts set in compacted granular backfill. Therefore, in essence these would act as check dams and help to slow the flow of water and augment the benefits of the scheme. Check dams are considered best SuDS practice.

7.5.9 Cables crossing watercourses would be limited. Where they are unavoidable, they would be facilitated by trellising (attaching the cables to crossings) or horizontal directional drilling beneath the beds of the watercourses to avoid impacts upon them.

7.5.10 The construction processes are understood to be sufficiently flexible to ensure that temporary stockpiling of excavated materials can be located outside the 1 in 20 year event extents.

8 CONCLUSIONS

8.1.1 The Site falls partly within Flood Zone 2 and 3. The proposals constitute 'Essential Infrastructure' and are appropriate in all Flood Zones. Both the Sequential Test and Exception Test are required for the Proposed Development. These are considered in the Planning Statement.

8.1.2 A review of model output data and defence information provided by the Environment Agency concludes that the Site is not at significant actual or residual risk of tidal flooding and that no further modelling is required. This has been agreed with the Environment Agency.

8.1.3 Site-specific hydraulic modelling has been carried out to assess the actual risk of fluvial flooding to the development during the design event as well as the residual risk should there be a breach of defences. Simulation of loss of entire sections of embankments alongside the Monk Dike have also been carried out as requested by the Environment Agency. This modelling work has been reviewed by the Environment Agency and confirmed to be fit for purpose.

8.1.4 During the design event, the vast majority of the Site is not predicted to flood. There is flooding associated with the Holderness Drain in the east and the Monk Dike and Arnold Riston Drain.

8.1.5 Sensitivity testing of the tidal boundary, fluvial inflows and Manning's roughness demonstrate that the model is not particularly sensitive to these parameters. Resulting increases in flood level are generally below 0.1m and entirely below 0.2m. Modelling of the H++ Credible Maximum Scenario flood for 2100 resulted in an increase in flood levels of up to 0.15m.

8.1.6 Accordingly, it is concluded that 0.3m freeboard will be sufficient to account for uncertainty and any limited floating debris. In order to mitigate the risk of flooding all sensitive infrastructure (solar arrays and containerised infrastructure) will be raised at least 0.3m above the design event flood level. The containerised infrastructure is entirely outside the design event flood extent.

8.1.7 As is to be expected, the breach simulations predict much more widespread flooding which is deep in places. Solar arrays wills be set above the maximum breach flood level. The layout has been developed so that containerised infrastructure are outside the breach extents wherever practicable. Where this is not the case, they will be set above the maximum breach flood level.

8.1.8 The two substations will be located outside of the Credible Maximum Scenario and maximum breach flood extents and any water-sensitive infrastructure in the substation compounds will be at least 0.3m above the Credible Maximum Scenario water level. With these measures in place the proposals satisfy the requirement of NPS EN-1 with regard to the Credible Maximum Scenario.

8.1.9 Furthermore, a comparison of the Credible Maximum Scenario and the design event reveals that modelled flood levels do not increase significantly by 2100. Therefore, the mitigation recommended in this document is a robust approach to safeguarding against the potential of extreme climate change given the development has a proposed 40 year lifetime.

8.1.10 The substations and containerised infrastructure would not be located within the modelled 1 in 50 year event extent, which has been used as a proxy for the Functional Floodplain (defined by the 1 in 30 year event). Furthermore, stockpiles or similar would be located outside this extent during the construction phase.

8.1.11 The RoFSW dataset predicts flooding to parts of the site. Generally the predicted depths are less than the simulated breaches which the sensitive elements will be raised above. A site-specific analysis of areas where this is not the case concluded that the predicted depths are likely to be overestimated due to poor representation of the extensive ditch network. Nonetheless, as a precautionary measure it is proposed to raise all water-sensitive elements above the predicted 1 in 1,000 year surface water flooding. During site setting out, it may be prudent to include waymarkers to delineate access roads and assist safe access where these may be affected by surface water flooding.

8.1.12 The Site proposals are not considered to be at significant risk of flooding from sewers, reservoirs, or other artificial sources.

8.1.13 As part of the development, access crossings will be formed over Ordinary Watercourses on Site. The crossings will be clear-span on larger watercourses or box culverts on smaller watercourses to preserve the existing channel capacity.

8.1.14 The tracks themselves should return to existing ground levels as soon as is reasonably practicable so not to impair the conveyance of the land alongside the watercourses during extreme rainfall events.

8.1.15 The solar arrays and the hybrid packs and containerised infrastructure dispersed across the Site will be raised above ground and have an insignificant impact on the response of the land to rainfall.

8.1.16 Hybrid packs and containerised infrastructure which are spread across the Site will be sited on a gravel beds 0.3m deep allowing for distribution of runoff and infiltration into the ground below, mimicking existing site conditions.

8.1.17 Discharging runoff from the proposed hardstanding across the Site is constrained in terms of infiltration, potential for saturation and potentially high water levels in the watercourses. Furthermore, as the Site has a flat topography, rainfall currently falling on the Site would slowly percolate into the ground and slowly flow to the watercourses.

8.1.18 It is therefore proposed to mimic this arrangement by utilising the gravel bases beneath infrastructure to accommodate runoff and allow it to percolate as per the existing situation. The gravel bases have been sized to accommodate a design 1 in 100 year +25% 12-hour rainfall event. The bases have also accounted for concrete foundations within the substation compound.

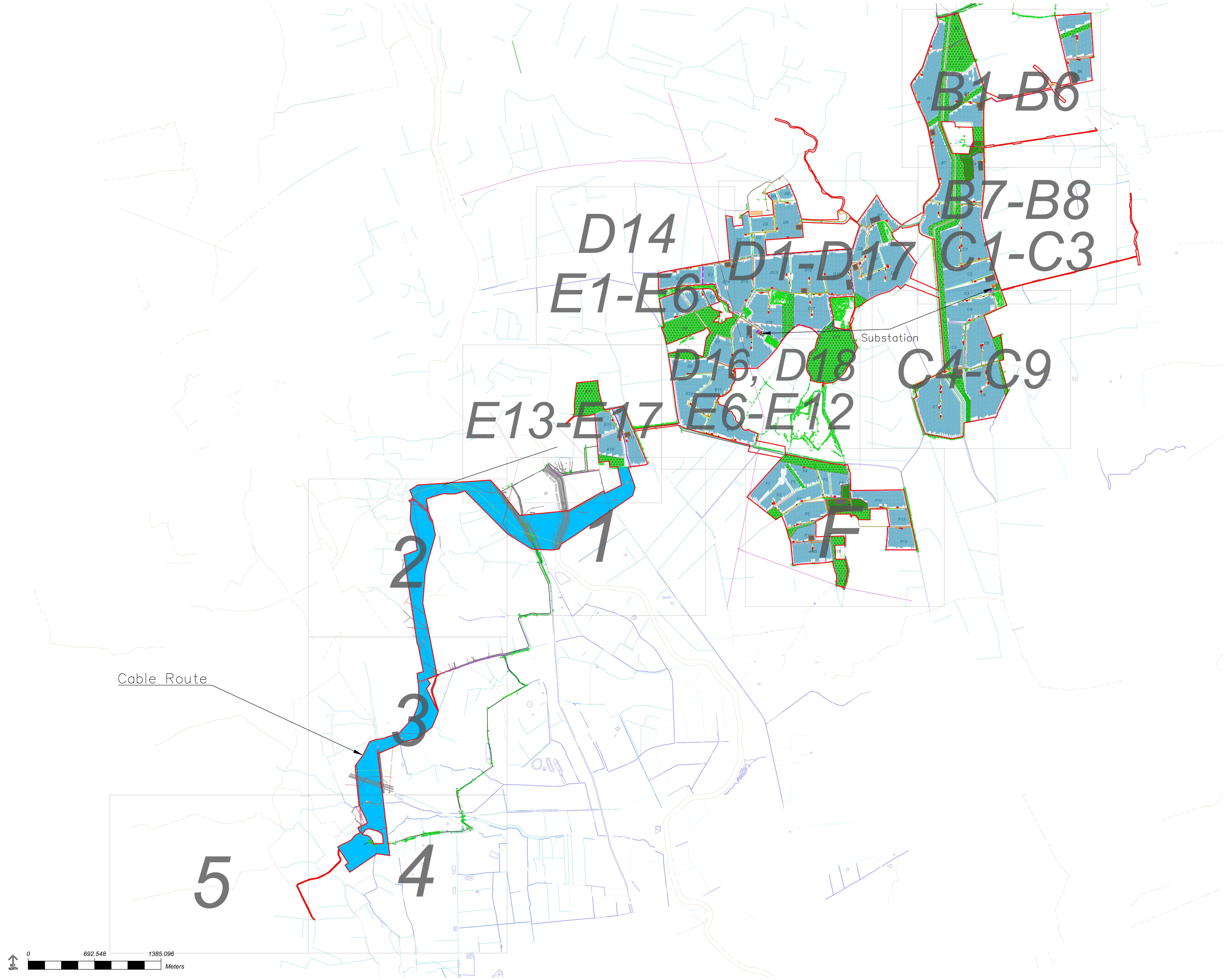
8.1.19 The cessation of intensive agriculture across the Site will allow establishment of natural grassland and a commensurate improvement in soil structure. This will reduce runoff rates and volumes, soil erosion and pollution.

8.1.20 In conclusion, the proposals will be safe from all forms of flooding and will provide a betterment in terms of downstream flood risk and pollution. The simulation of the Maximum Credible Scenario flood using H++ allowances demonstrates that the proposed development will have a high level of climate resilience. The modelling work and calculations demonstrate the proposals would not increase flood risk elsewhere. The proposals therefore meet the aims of NPPF, NPS EN1 and NPS EN3 with regards to flood risk and drainage.

APPENDICES

APPENDIX A

Site Proposals



NOTES

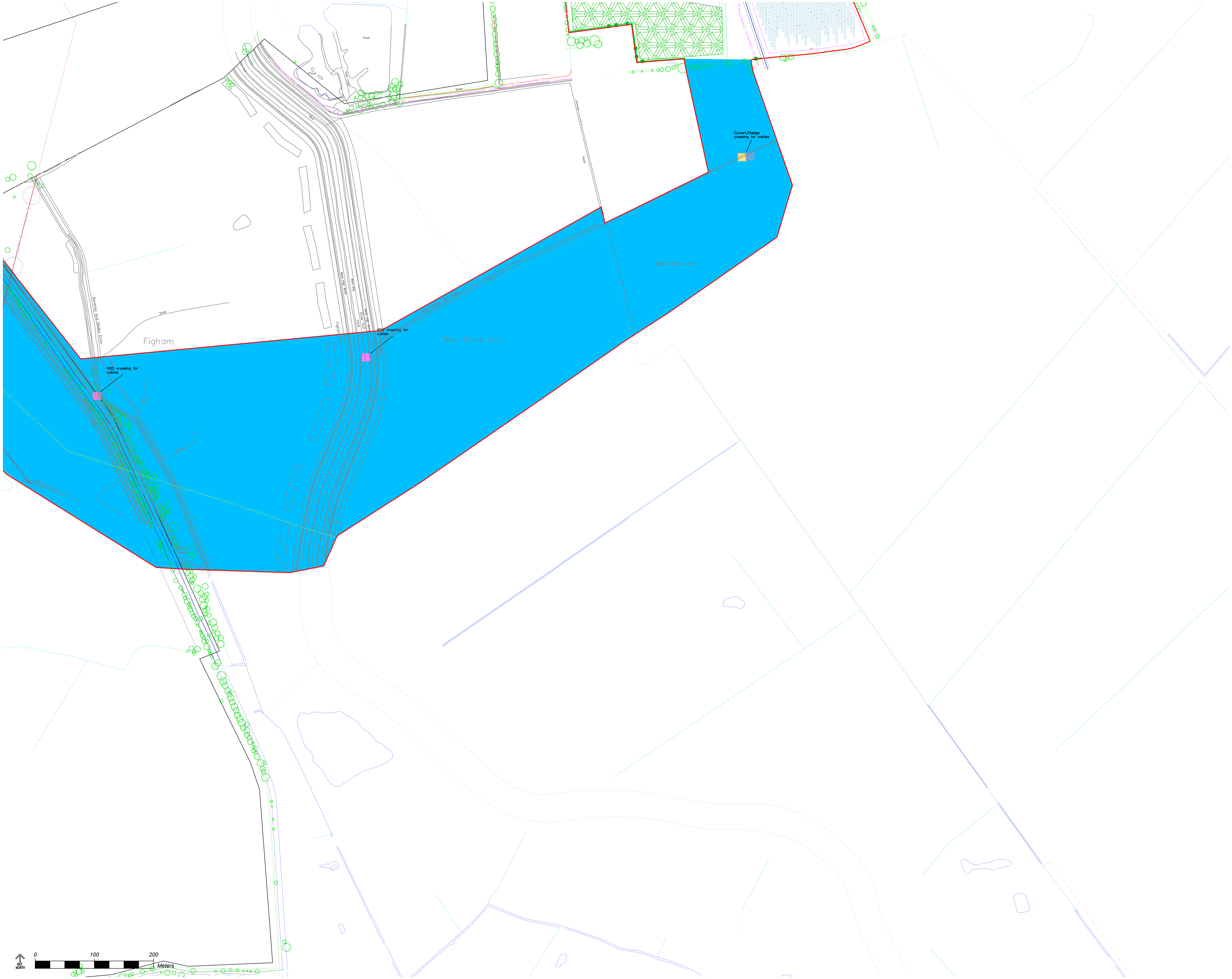
1. All details are indicative only.
2. Dimensions are in metres unless stated otherwise.
3. Refer to HSE document "Avoiding danger from overhead power lines – Guidance Note GS6" to ensure safe operation of machinery in proximity to overhead power lines.
4. Contains OS Data © Crown copyright and database rights 2023 Ordnance Survey 0100031673
5. CCTV Icons are indicative positions at 1.5m from the fence line

LEGEND

- Planning Red Line
- Landowners Line
- Road
- Landowner Road
- Solar panels
- Fence
- Hedges
- Trees
- Hybrid BESS Station
- Spares Container Container
- Customer Switch Gear Container
- CCTV
- Access Gate
- Construction compound
- Substation Construction Compound
- Drains
- River
- Bank
- Public Rights Of Way
- Proposed Permissive Path
- Proposed Permissive path (allowing travel on horses)
- Gas Pipe
- Water Pipe
- Fuel Pipe
- High Voltage Cable
- Low Voltage Cable
- Telecom Cable
- Wind Turbine
- Acoustic Fencing
- DNO Operational Land
- Wildlife Enhancement
- Archaeological Buffers
- Crossing Hedge/Water course/Direction Drill
- Bridge Works
- Weather Mast

DETAILS

TITLE	Peartree Hill Solar
LOCATION	Near Drove Lane, Wawne, East Riding of Yorkshire, England, HU7 5XZ, United Kingdom.
DATE	July 25
CONFIGURATION	Typical Tracker Design
REVISION	8.1



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LEGEND

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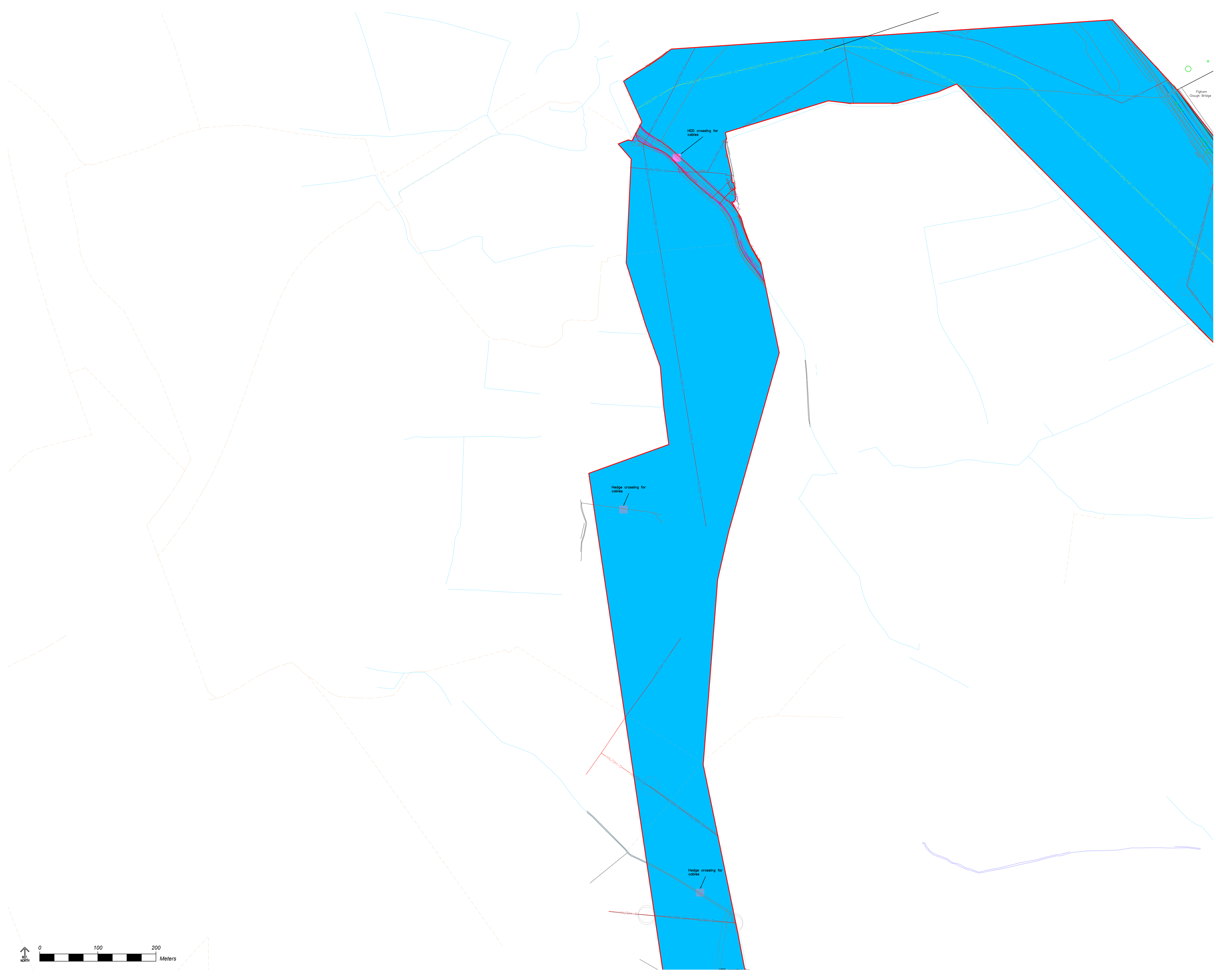
DATE	July 25
CONFIGURATION	Typical Tracker Design
REVISION	8.1



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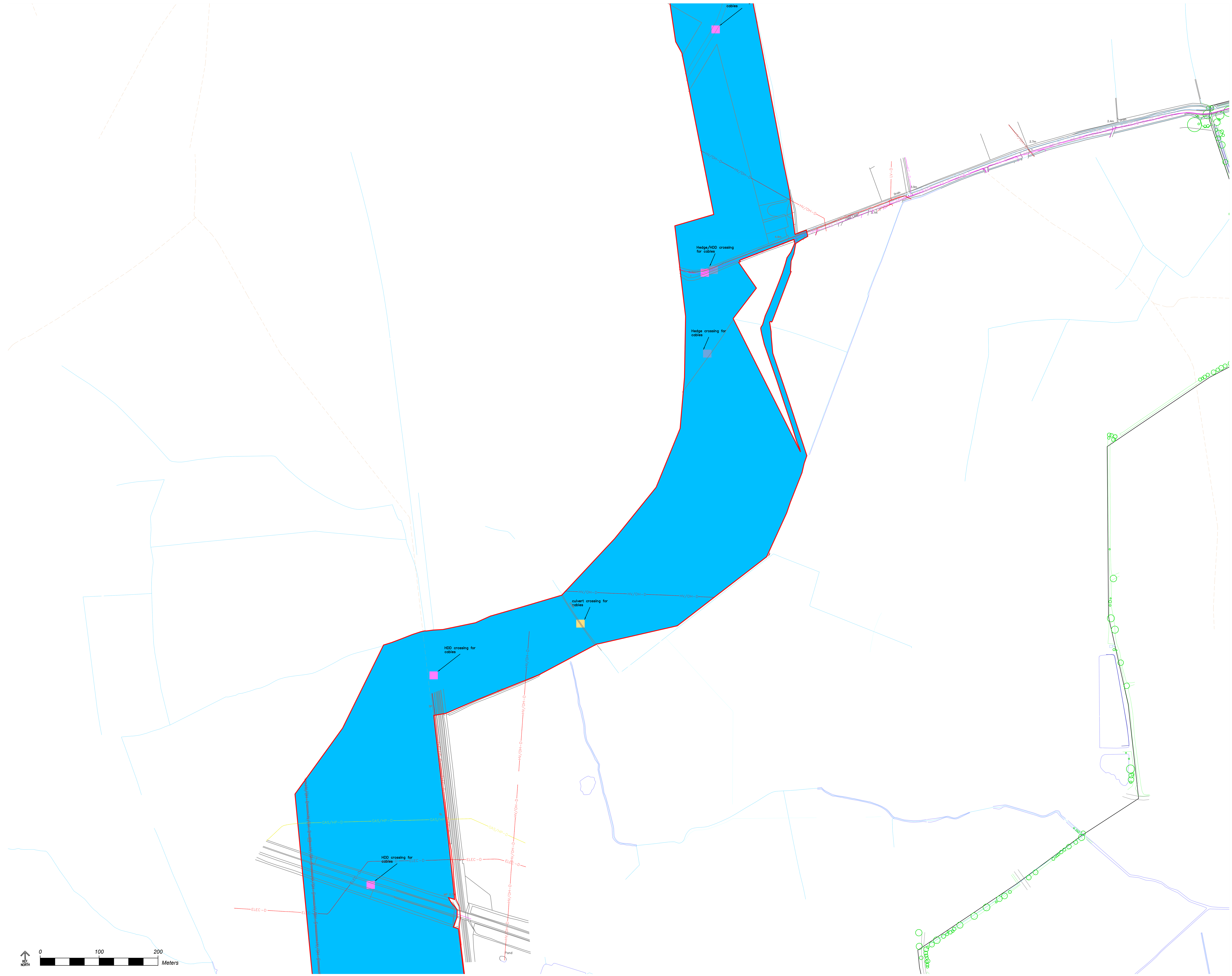

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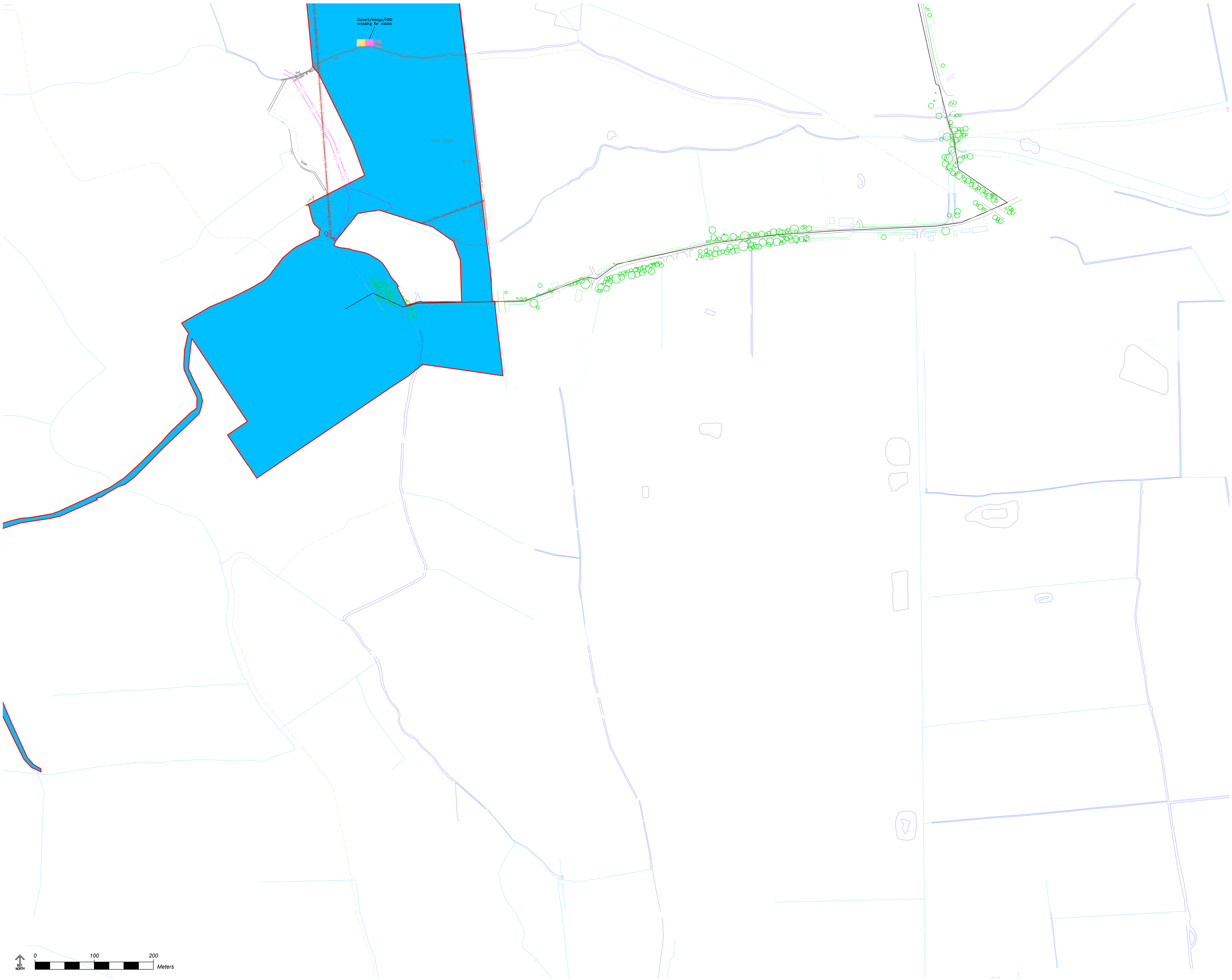

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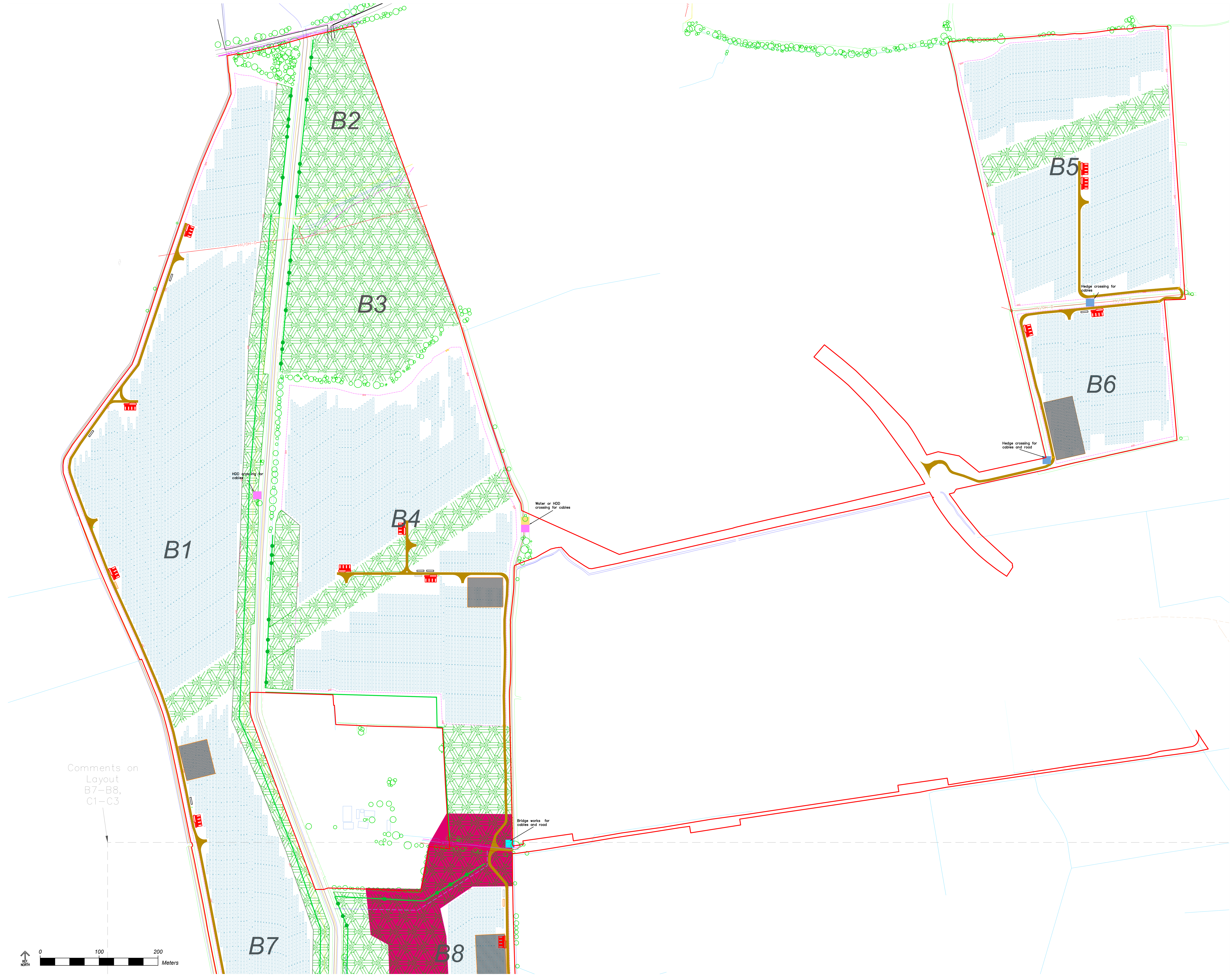

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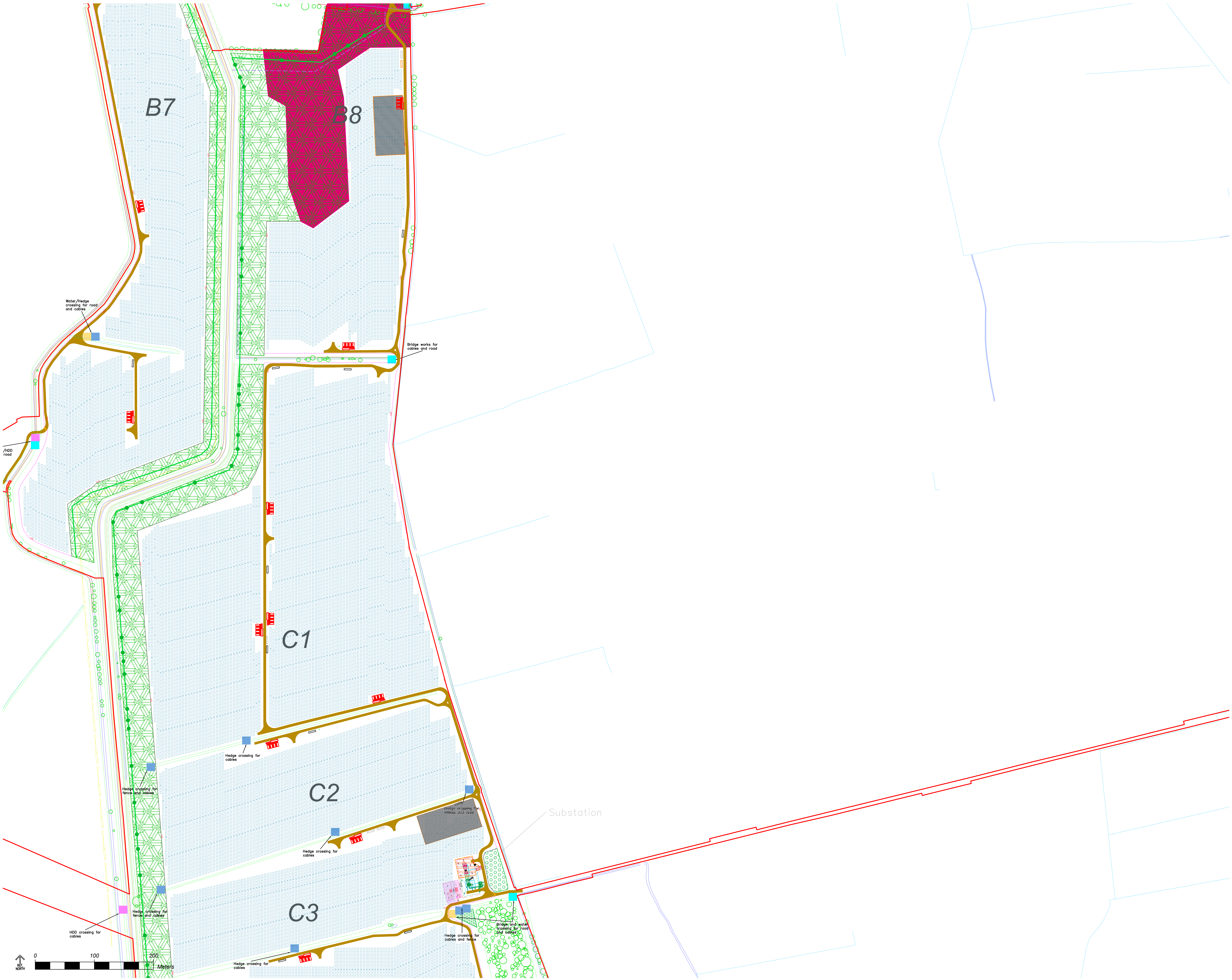

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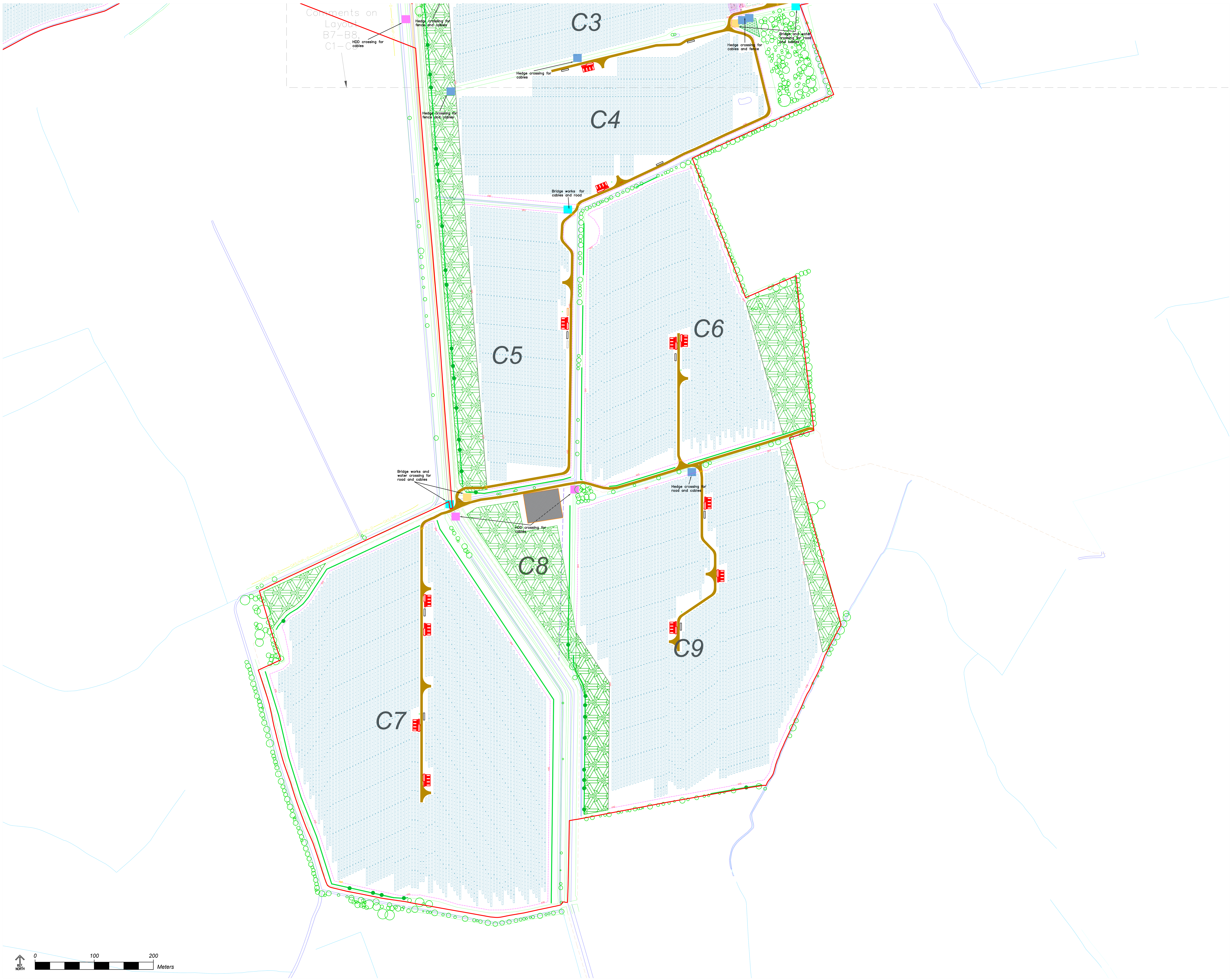

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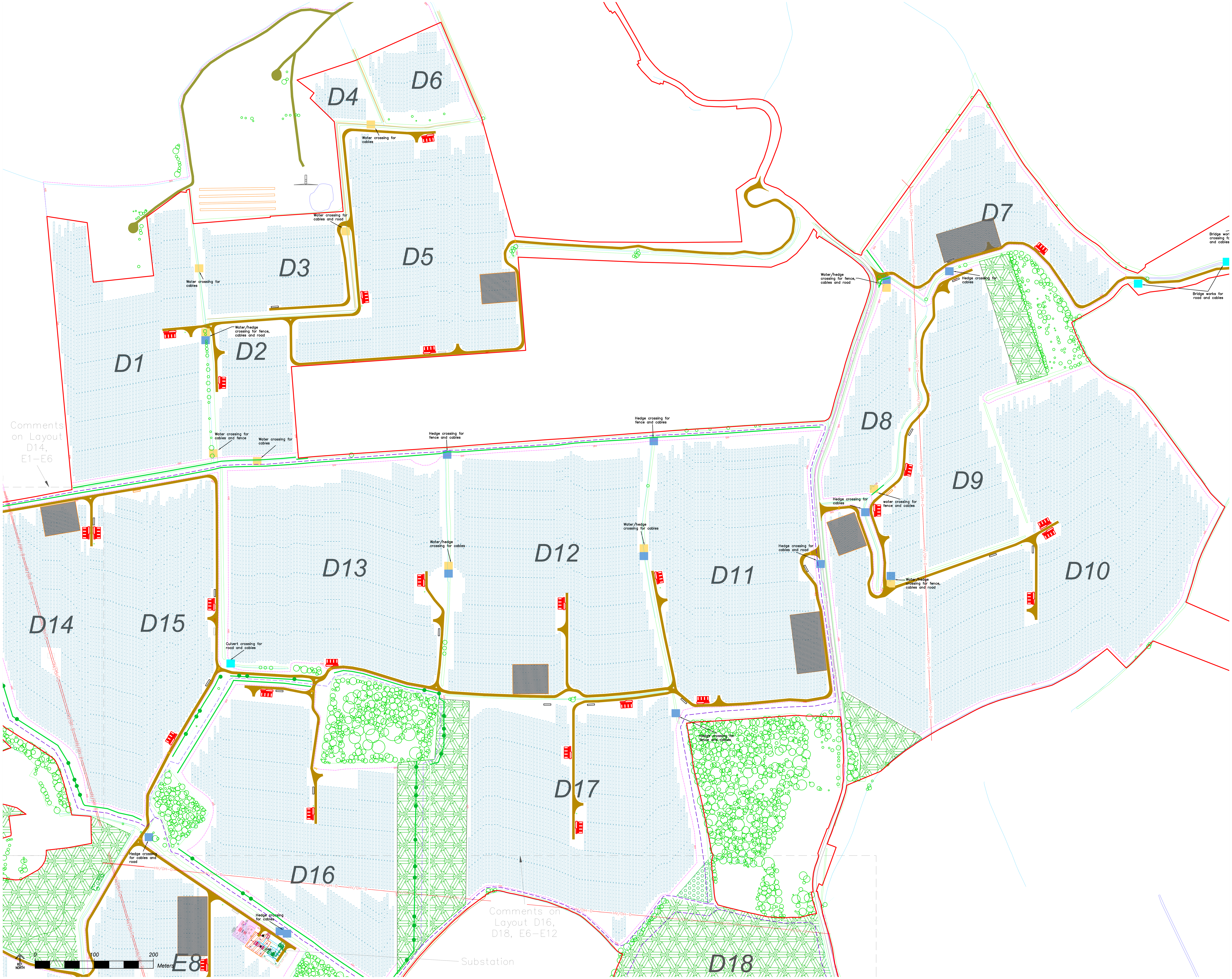

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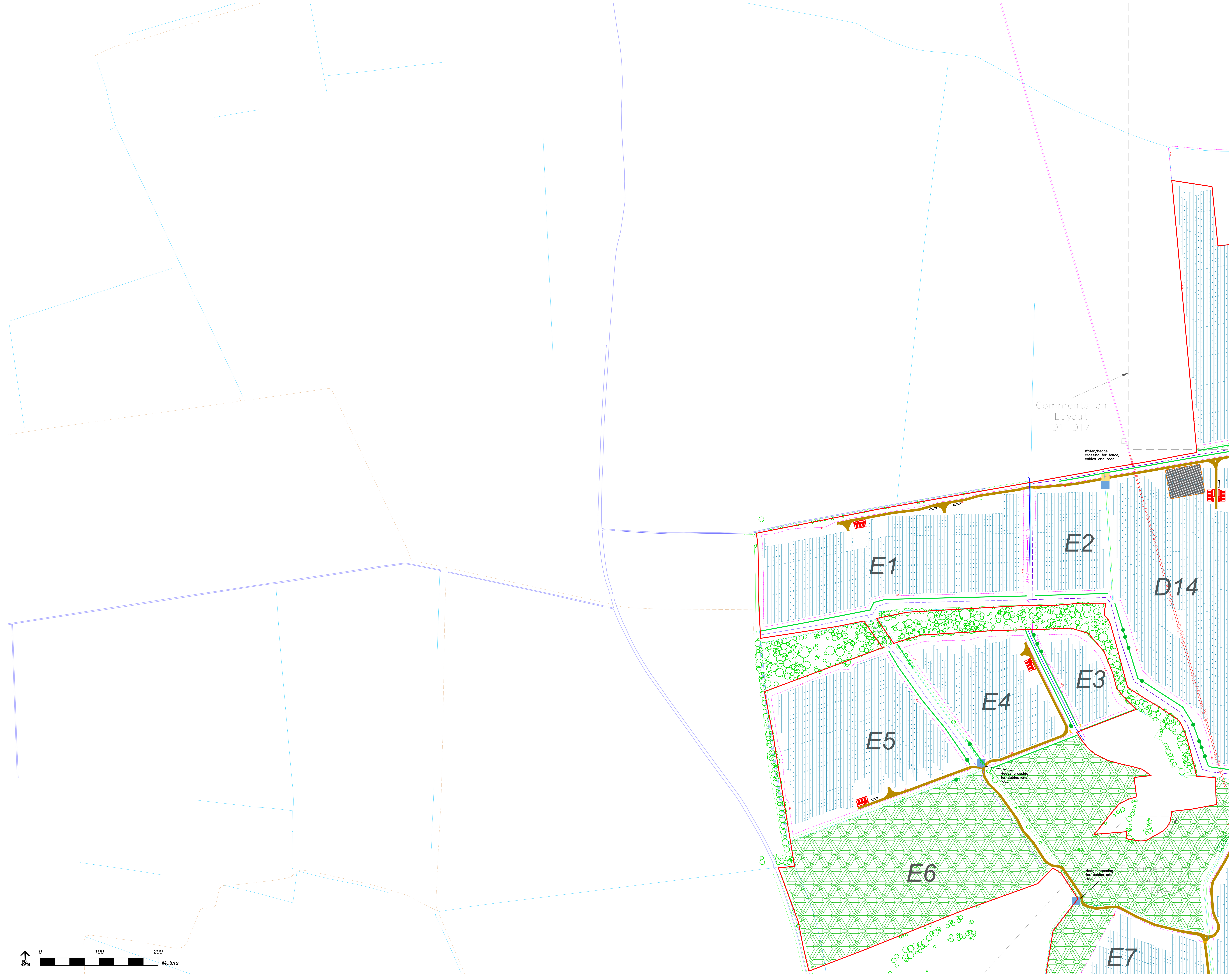

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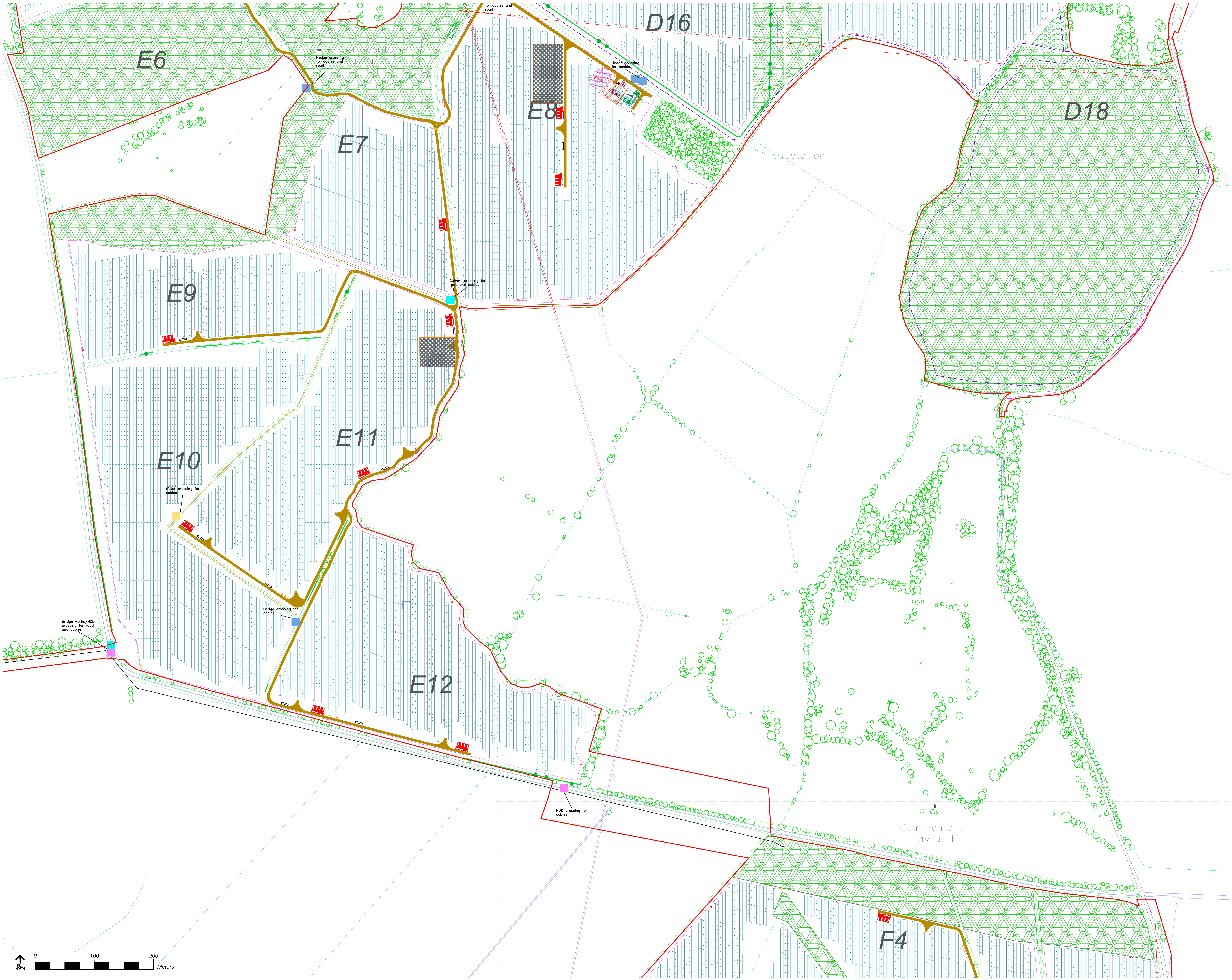

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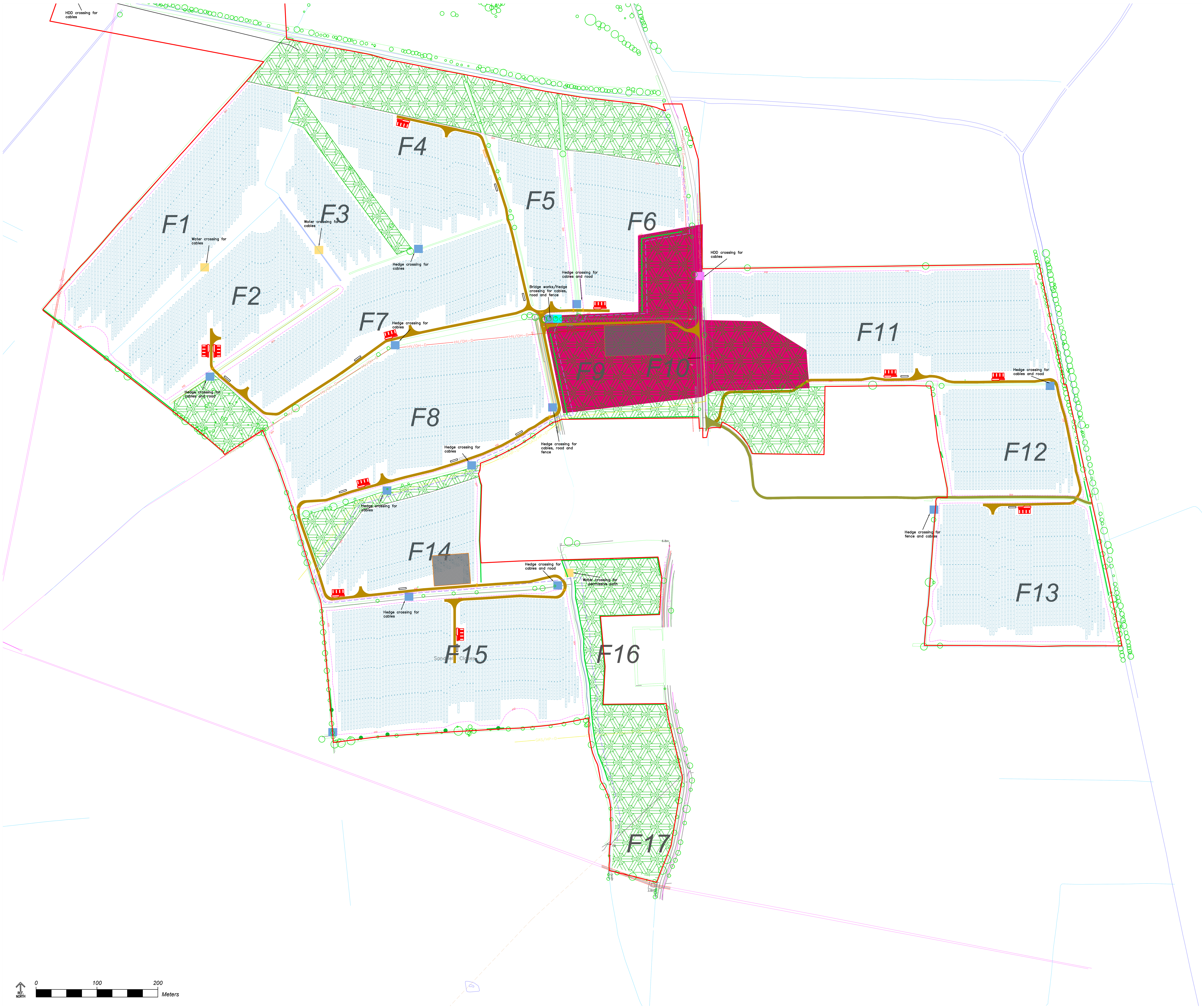

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APPENDIX B

Drawings

Internal Drainage Board Plan
20-206-60-300-03 - Site Topography
20-206-60-301-02 Recorded Flood Outlines
20-206-60-004-05 Design Event Flood Depths Sheet 1 of 2
20-206-60-005-05 Design Event Flood Depths Sheet 2 of 2
20-206-60-302-03 – Breach Locations and Land Area Names
20-206-60-250-03 Combined Breach Maximum Depths Sheet 1 of 2
20-206-60-251-03 Combined Breach Maximum Depths Sheet 2 of 2
20-206-60-260-02Maximum Credible Scenario Level Change 1 of 2
20-206-60-261-02 Maximum Credible Scenario Level Change 2 of 2
20-206-60-253-03 Monk Dike Bank Removal West (NB1) 100yr + 17% Maximum Depth
20-206-60-254-03 Monk Dike Bank Removal East (NB2) 100yr + 17% Maximum Depth
20-206-60-309-01 RoFSW 1 in 1,000 yr Depths (1 of 2)
20-206-60-310-01 RoFSW 1 in 1,000 yr Depths (2 of 2)
20-206-60-315-01 1 in 20 year and 1 in 50 year Flood Outlines (Sheet 1 of 2)
20-206-60-316-01 1 in 20 year and 1 in 50 year Flood Outlines (Sheet 2 of 2)

calibro

York Consortium of Drainage Boards

Beverley and North Holderness IDB

Map produced by
York Consortium of Drainage Boards
Derwent House
Crockey Hill
York
YO19 4SR

www.yorkconsort.gov.uk

Legend

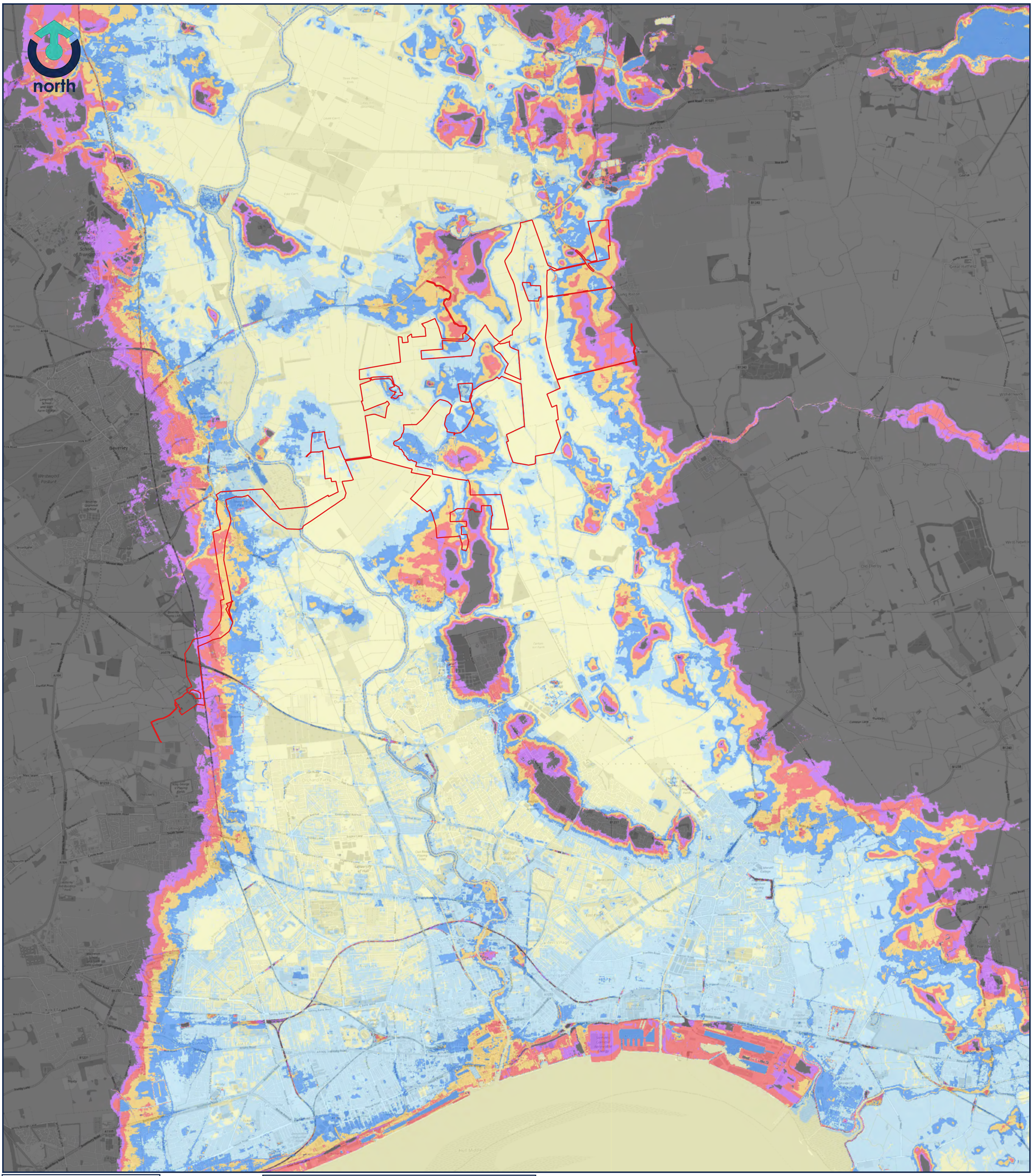
IDB Maintained Watercourse

IDB Boundary

0 1 2 4 Kilometers

Watercourses

BH 1 South Bullock
BH 2 South Bullock North Branch
BH 3 South Bullock South Branch
BH 4 North Bullock
BH 5 White Dike
BH 6 Whitewater Drain
BH 7 Scorborough Boundary
BH 8 Coal Dike
BH 9 Black Dike
BH 10 Beswick New cut
BH 11 Kilnwick Arm
BH 12 Kirby Drain
BH 13 Potter Drain
BH 14 Decoy Drain
BH 15 South Old Rivers
BH 16 North Old Rivers
BH 17 Rotsea Drain
BH 18 Nafferton Lowlands Drain
BH 19 Brigham Drain
BH 20 Foston Side Dike
BH 21 Frodingham Side
BH 22 Constable Drain
BH 23 Frodingham Church Drain
BH 24 Andrew Hall Drain
BH 25 Frodingham Mill Drain
BH 26 New Cross Drain
BH 27 Harrisons
BH 28 Holts Drain
BH 29 Halls Drain
BH 30 Roam Drain
BH 31 Kilnwick New cut
BH 32 Mill Dam Drain
BH 33 Moor Drain
BH 34 Ellis Dike
BH 35 Bryan Mill Beck
BH 36 Watton Beck
BH 37 Decoy House Drain
BH 38 Scurf Dike
BH 39 Holmes Dike
BH 40 Gosberdale Dike
BH 41 Northfield Beck
BH 42 Kroika Dike
BH 43 Wanlass Drain
BH 44 Creyke Dike
BH 45 Towns Drain
BH 46 Dunnington Sewer
BH 47 Inholmes
BH 48 Waterloo
BH 49 White Dike Branch
BH 50 White Dike
BH 51 Warren Hill Drain
BH 52 Lingholms Drain
BH 53 Beverley Parks Sewer
BH 54 Fox Drain
BH 55 Fox Drain Tributary
BH 56 Western Drain
BH 57 Hull Road East Side Drain
BH 58 Hull Road West Side Drain
BH 59 Beverley and Skidby
BH 60 Sicey Lane
BH 61 Figham
BH 62 North Carr
BH 63 Oxgang Drain
BH 64 Church Drain
BH 65 Storkhill Drain
BH 66 Swinemoor North Boundary
BH 67 Swinemoor
BH 69 Fisholmes Drain
BH 70 Watson Drain
BH 71 Model Farm
BH 72 Willow Lane Drain
BH 73 Beverley Park Sewer
BH 74 Riley Drain
BH 75 Throstlenest Drain
BH 76 Kelk Beck Soak Dike
BH 77 Skipsea Branch
BH 78 Skipsea
BH 79 Barmston Sea End
BH 80 Dringhoe
BH 81 Yew Dyke
BH 82 Gransmoor Drain
BH 83 Hards Covert
BH 84 Burton Agnes
BH 85 Nutholmes Dyke
BH 86 Burton Drain
BH 87 Stonehills Drain
BH 88 Earles Dyke
BH 89 Demming Drain
BH 90 Haisthorpe Beck
BH 91 Thornholme Drain
BH 92 Burton Carr Drain
BH 101 Holderness Drain
BH 103 Ganstead Drain
BH 104 Turmer Hall Drain
BH 105 Continuation of Ganstead Drain
BH 106 Ganstead Branch Drain
BH 107 Branch of Swine South Side Drain
BH 108 Swine South Side Drain
BH 109 Swine church Drain
BH 110 Swine Church Continuation
BH 114 Engine Drain
BH 115 Swine and Castle Hill
BH 116 Newlands
BH 117 Stackholmes
BH 118 Branch of Kelwell Drain (South)
BH 119 Branch of Kelwell Drain (North)
BH 120 Kelwell Lowlands Continuation
BH 121 Kelwell Lowlands Drain
BH 122 Branch of SB and Arnold Ings
BH 123 Cowdyke Drain
BH 124 Benningholme West Side
BH 125 Old Main Drain
BH 126 Wawne Croft
BH 127 Weel Stone Carr Drain
BH 128 Stone Carr
BH 129 wawne Garage Drain
BH 130 North Wray
BH 131 Bulldike Drain
BH 132 Drewerey's Soak Dike
BH 133 Wise and Habbershaws Drain
BH 134 Swine Benningholme & Arnold Ings
BH 135 Benningholme Ings
BH 137 Lambwath Branch
BH 138 Jackson Low Side
BH 139 Arnold Green Lane
BH 140 Arnold West Carr
BH 141 Riston Drain
BH 142 Arnold and Riston
BH 143 Stoneley Goat Dike
BH 144 Tributary of Stoneley Goat Dike
BH 146 Routh Road Side
BH 147 Routh Road Side Branch
BH 148 Meaux and Routh
BH 149 Meaux West
BH 150 Weel Towns Drain
BH 151 Causway Dale
BH 152 New Holland
BH 153 Turf Gutter and Esk River Side
BH 154 Tickton Carr
BH 155 Tickton Sewer
BH 156 Turf Gutter
BH 157 Parting Dike
BH 158 Esk Plantation
BH 159 Tickton Carr Lane Drain
BH 161 Leven Cross Drain
BH 162 Leven Town Drain
BH 163 Firth Drain
BH 164 Jackson & Sampson Low Ground
BH 165 Bowlams Dyke
BH 166 Leven Canal Side Drain
BH 167 Leven South Carr Drain
BH 168 Leven North Carr Drain
BH 169 Baswick Steer Drain
BH 170 Inn Carr Drain
BH 171 Heigholme Drian
BH 172 Burshill and Barff Branch Drain
BH 173 Starr Carr Dike
BH 174 Starr Carr South Branch
BH 175 Mill Dam Beck
BH 176 Stream Dike
BH 177 Starr Carr New Road Drain
BH 178 Starr Carr & Barff Hill Drain
BH 179 Burshill and Barff
BH 180 Halleytree Holme Farm Drain
BH 181 Burshill Park Drain
BH 182 Ushaws Drain
BH 184 Continuation of Lambwath Stream
BH 185 'L' Dike
BH 186 Bilton Drain
BH 187 Hall Farm Drain
BH 188 Nicholson Dyke
BH 189 Ganstead New Drain



Legend

Site Boundary

- Order Limits

Ground Levels (mAOD)

- <2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- 5.0 to 6.0
- 6.0 to 7.0
- >7.0

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: PEARTREE HILL SOLAR

REV:	DESCRIPTION:	AMENDMENTS:	BY:	DATE:
03	FOR INFO	RORDER LIMITS UPDATED	CF	07.07.24

TITLE: TOPOGRAPHY

SCALE AT A3:	DRAWN:	CHECKED:	REVISION:
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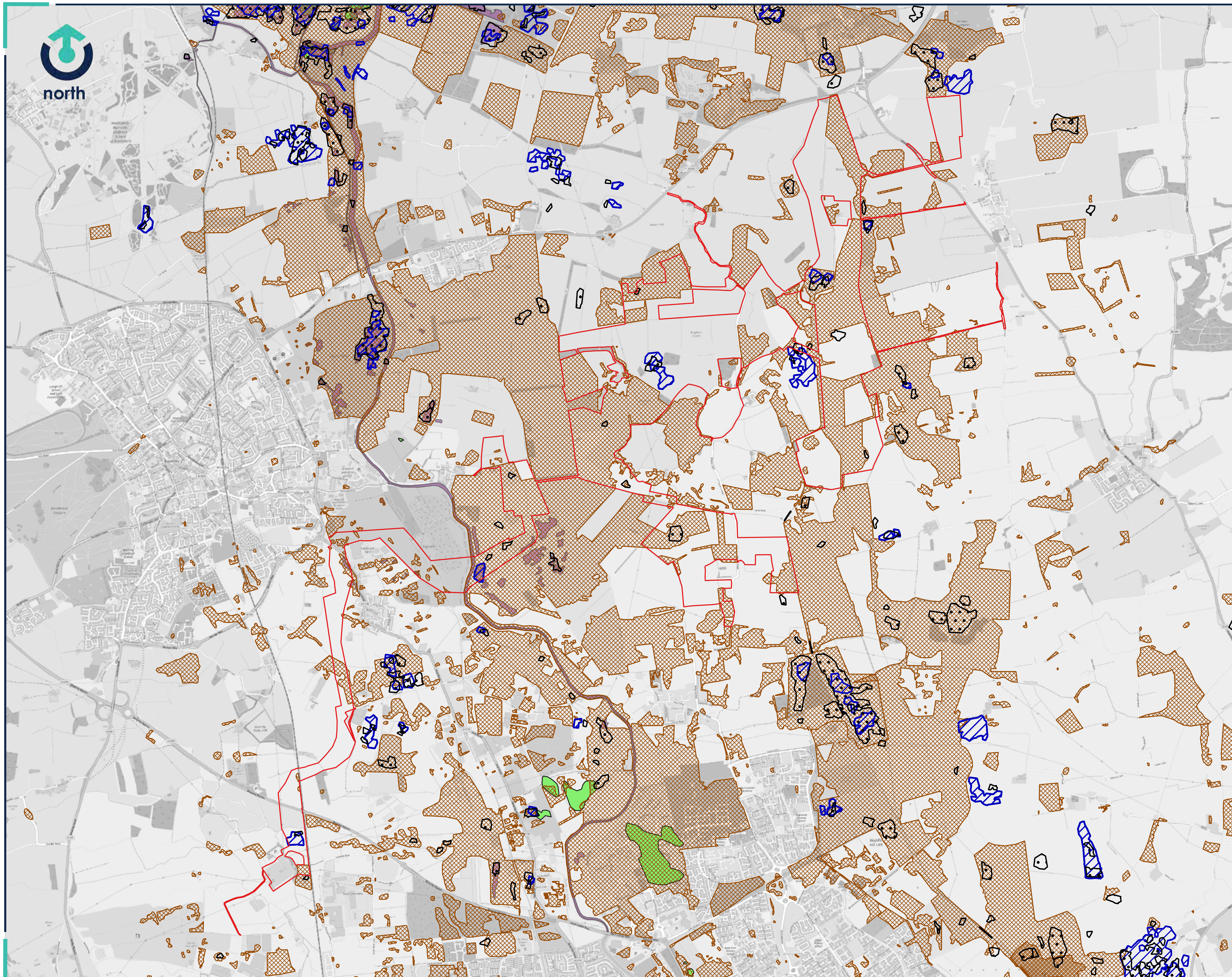

Legend

- Order Limits
- June 25th 2007
- 15th February 2020
- 31st March 2018
- 7th November 2019
- 8th February 2020
- January 1969

REV:	DESCRIPTION:	BY:	DATE:
02	FOR INFORMATION	AB	07.07.25

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Recorded Flood Outlines

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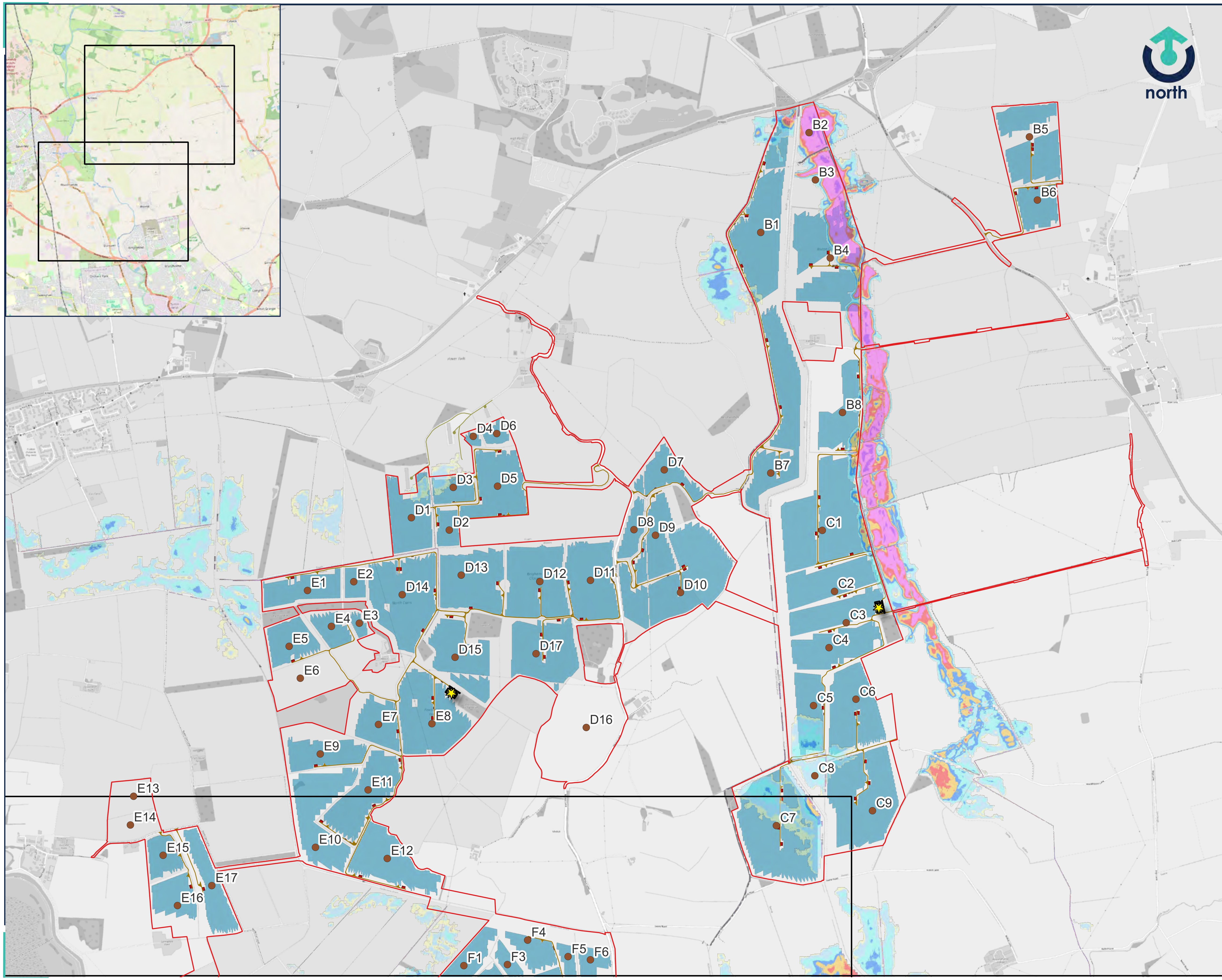

Legend

Order Limits	
Parcel Names	
Substations	
Hybrid Inverters	
Switchgear	
Spares Container	

Depths (m)

0 - 0.1	
0.1 - 0.3	
0.3 - 0.5	
0.5 - 0.7	
0.7 - 0.9	
0.9 - 1.1	
1.1 - 1.5	
1.5 - 1.8	
>1.8	

REV:	DESCRIPTION:	BY:	DATE:
05	UPDATED LAYOUT	CF	07.07.25

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Design Event (2066) Flood Depths Sheet 1 of 2

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PROJECT NO:		DRAWING NO:	REVISION:
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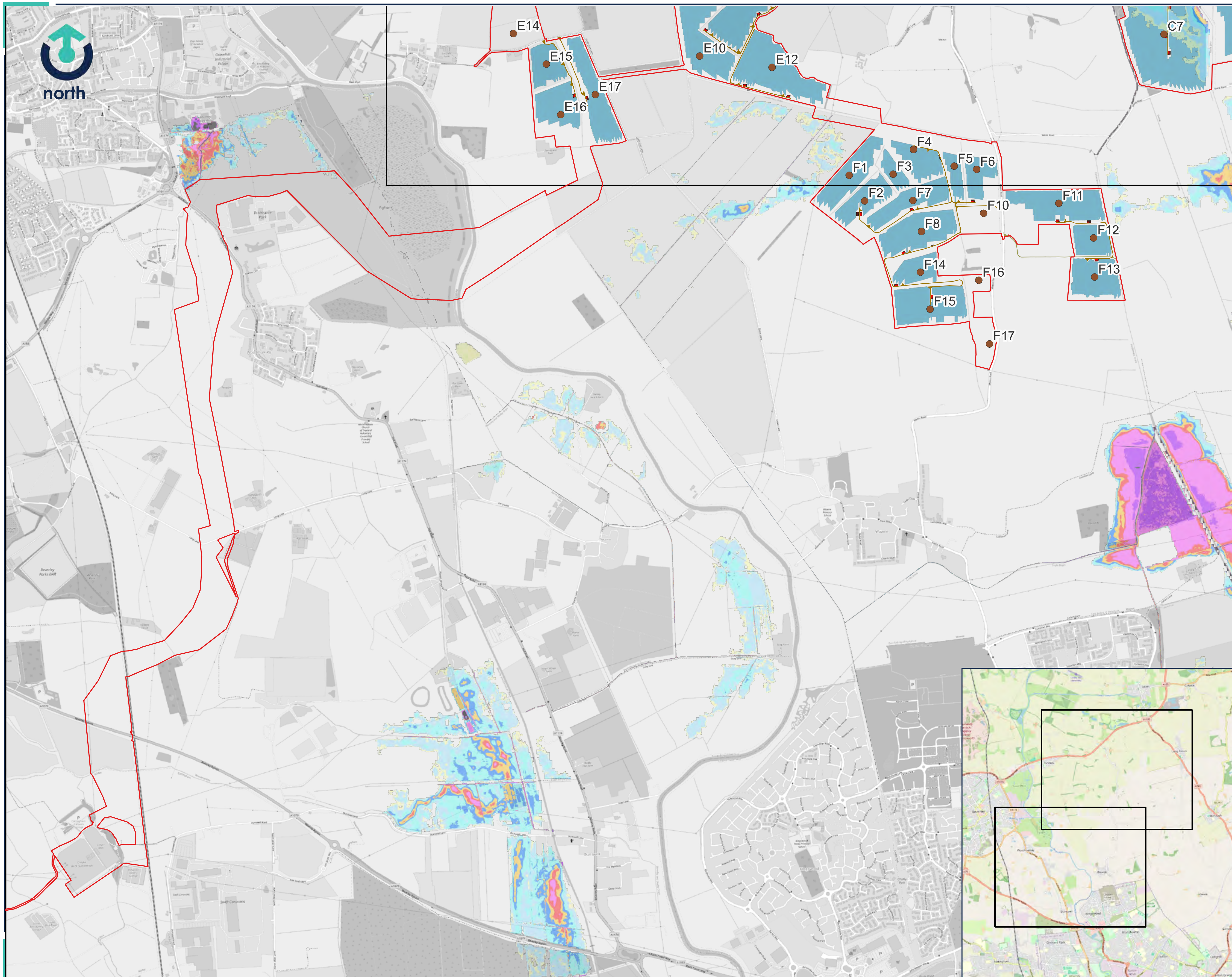

Legend

Order Limits	
Parcel Names	
Substations	
Hybrid Inverters	
Switchgear	
Spares Container	

Depths (m)

0 - 0.1	
0.1 - 0.3	
0.3 - 0.5	
0.5 - 0.7	
0.7 - 0.9	
0.9 - 1.1	
1.1 - 1.5	
1.5 - 1.8	
>1.8	

REV:	DESCRIPTION:	BY:	DATE:
05	FIFTH ISSUE	CF	07.07.25

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Design Event (2066) Flood Depths Sheet 2 of 2

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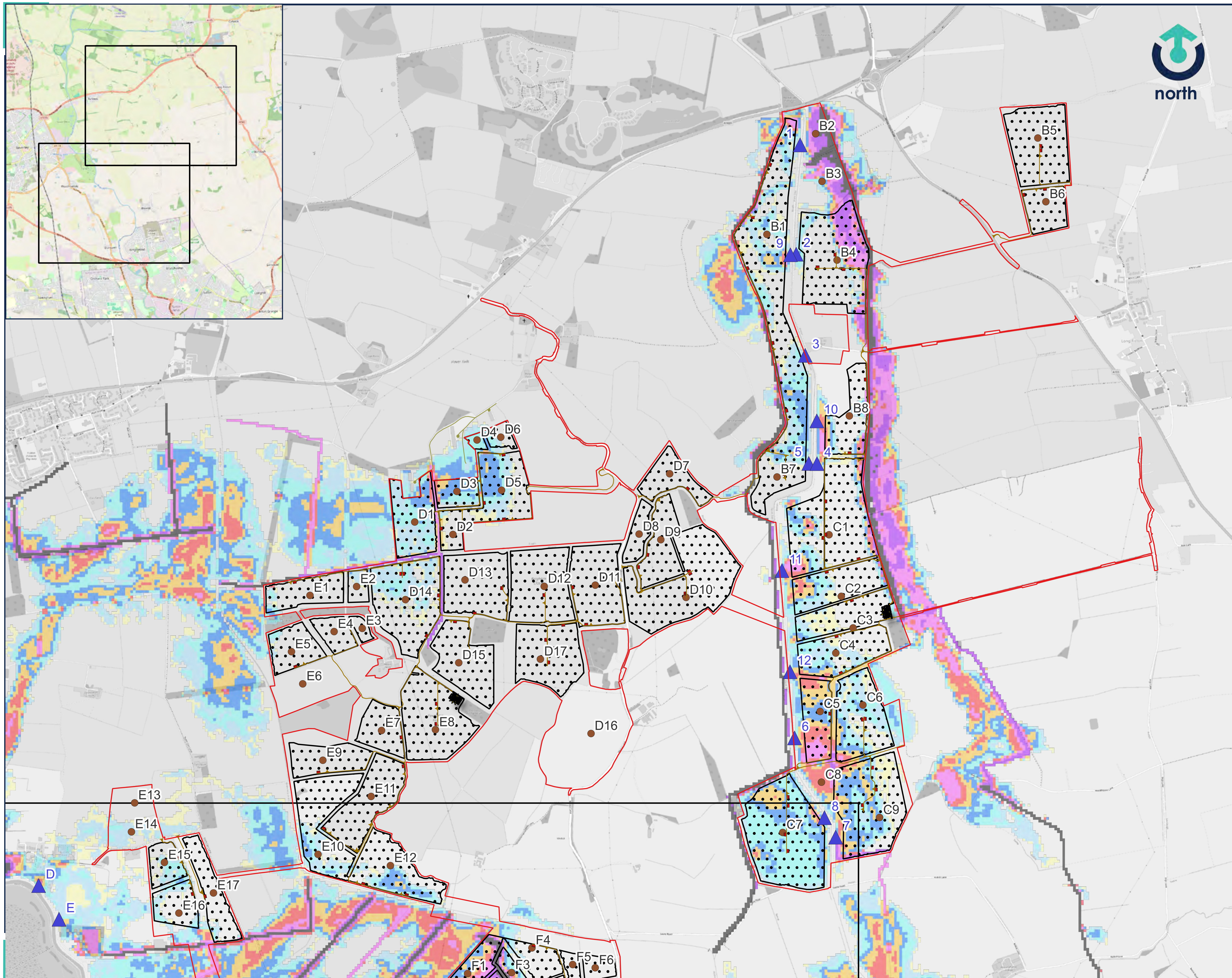

Legend

Order Limits	
Sensitive Infrastructure	
Parcel Names	
Breach Locations	
Substations	
Hybrid Inverters	
Spares Container	
Switchgear	

Depths (m)

- 0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 1.1
- 1.1 - 1.5
- 1.5 - 1.8
- >1.8

Notes

Sensitive infrastructure areas encompass the coverage of solar panels, substations, inverters, battery storage etc. but do not include access or cable routes.

REV:	DESCRIPTION:	BY:	DATE:
03	FOURTH ISSUE	CF	07.07.2025

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Combined Breach Flood Depths Sheet 1 of 2

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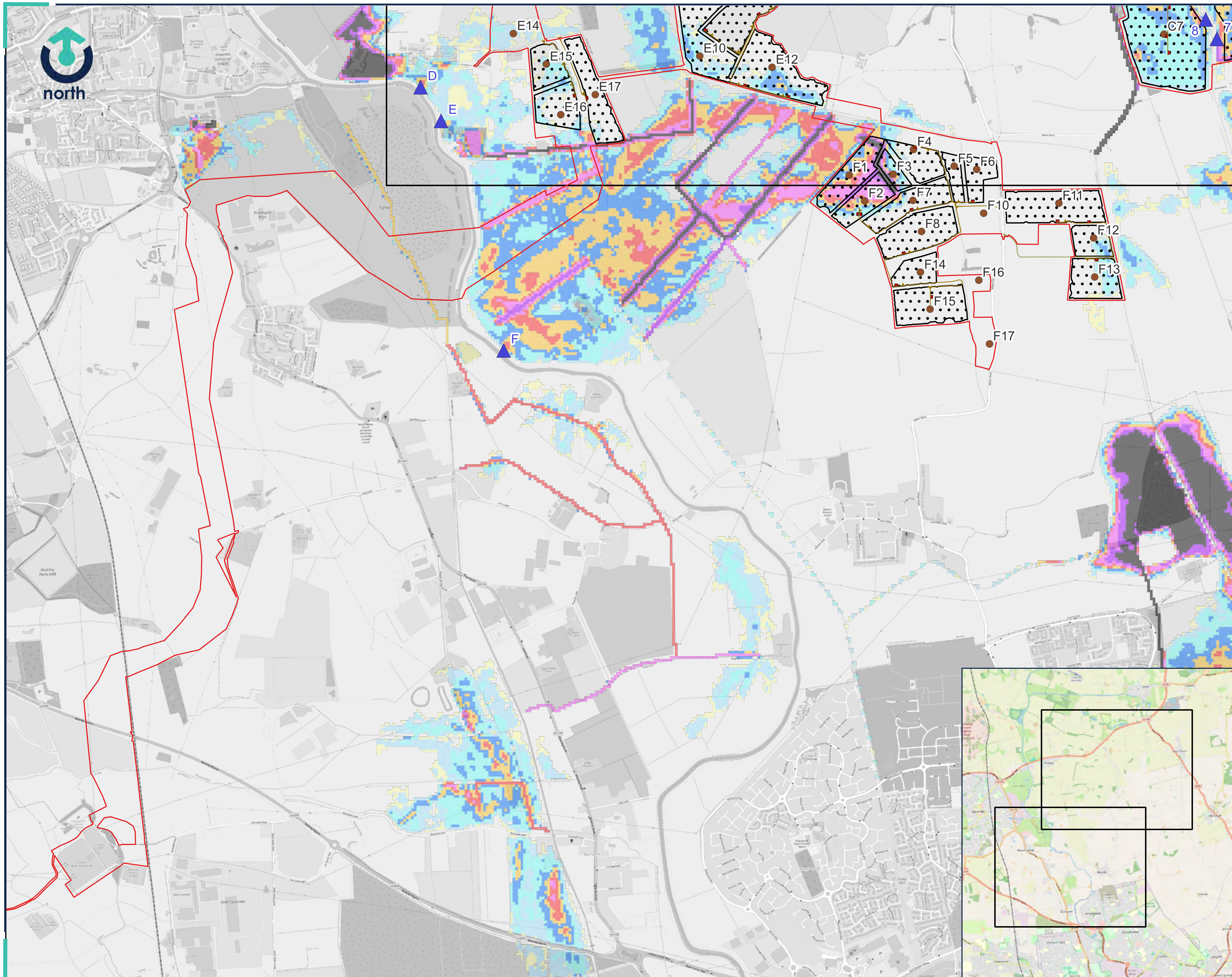

Legend

Order Limits	
Sensitive Infrastructure	
Parcel Names	
Breach Locations	
Substations	
Hybrid Inverters	
Spares Container	
Switchgear	

Depths (m)

- 0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 1.1
- 1.1 - 1.5
- 1.5 - 1.8
- >1.8

Notes

Sensitive infrastructure areas encompass the coverage of solar panels, substations, inverters, battery storage etc. but do not include access or cable routes.

REV:	DESCRIPTION:	BY:	DATE:
03	FOURTH ISSUE	CF	07.07.2025

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Combined Breach Flood Depths Sheet 2 of 2

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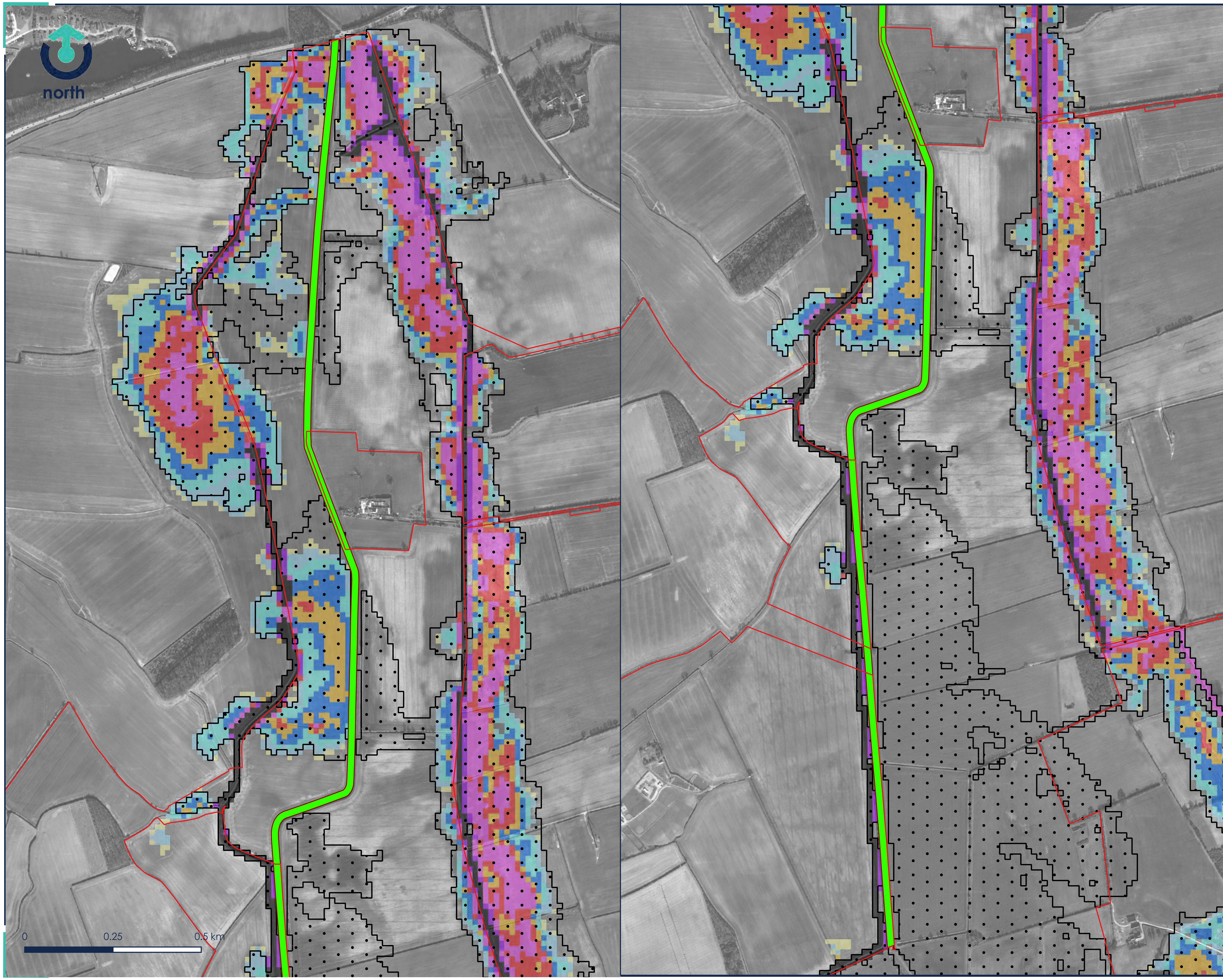

Legend

- Order Limits
- Combined Breach Extents
- Defence Section Removed

Depth (m)

- 0 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- 0.5 - 0.7
- 0.7 - 0.9
- 0.9 - 1.1
- 1.2 - 1.5
- 1.5 - 1.8
- >1.8

REV:	DESCRIPTION:	BY:	DATE:
03	UPDATED LAYOUT	AB	07.07.25

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Monk Dike Bank Removal West (NB1)
100yr + 17% Maximum Depth

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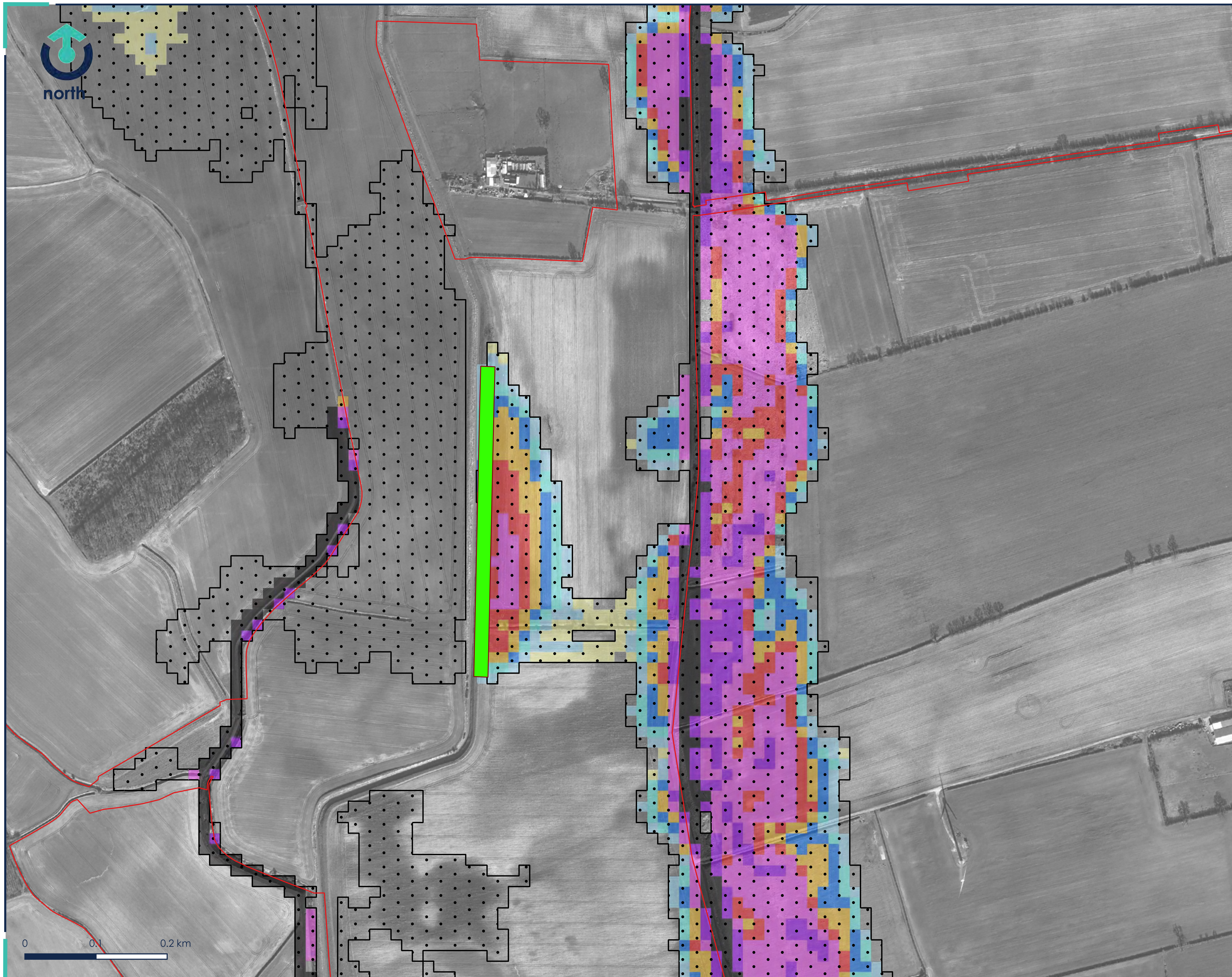

Legend

Order Limits	
Combined Breach Extents	
Defence Section Removed	
Depth (m)	
0 - 0.1	
0.1 - 0.3	
0.3 - 0.5	
0.5 - 0.7	
0.7 - 0.9	
0.9 - 1.1	
1.2 - 1.5	
1.5 - 1.8	
>1.8	

REV:	DESCRIPTION:	BY:	DATE:
03	UPDATED LAYOUT	AB	07.07.25

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Monk Dike Bank Removal East (NB2)
100yr + 17% Maximum Depth

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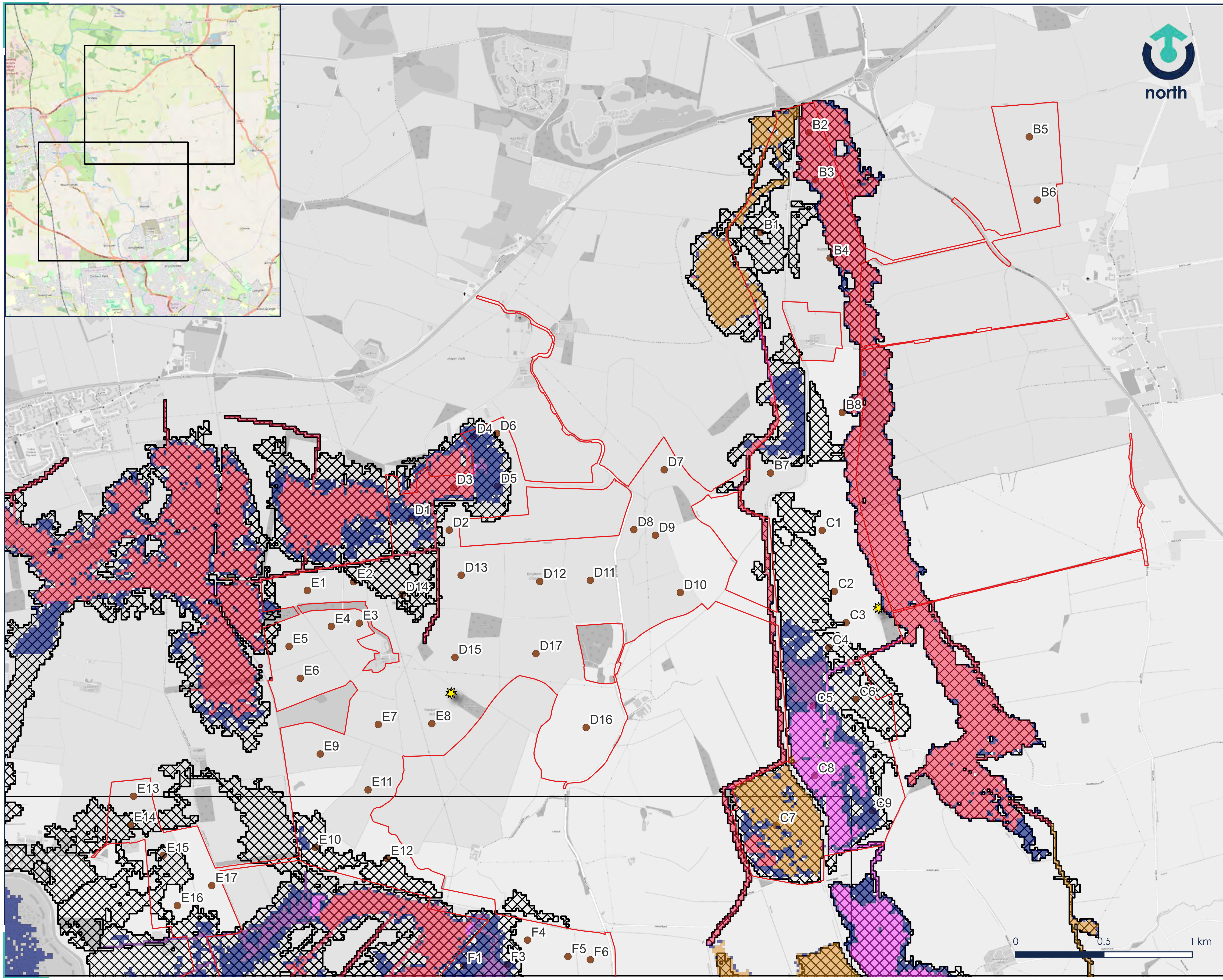

Legend

Order Limits	
Land Areas	
Substations	
Combined Breach Extent	
Increase (m)	
< -0.3	
-0.3 to -0.2	
-0.2 to -0.1	
-0.1 to -0.005	
-0.005 to 0.005	
0.005 to 0.1	
0.1 to 0.2	
0.2 to 0.3	
> 0.3	
Was wet now dry	
Was dry now wet	

REV:	DESCRIPTION:	BY:	DATE:
02	UPDATED LAYOUT	CF	07.07.25

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Maximum Credible Scenario level increase from Design Event (Sheet 1 of 2)

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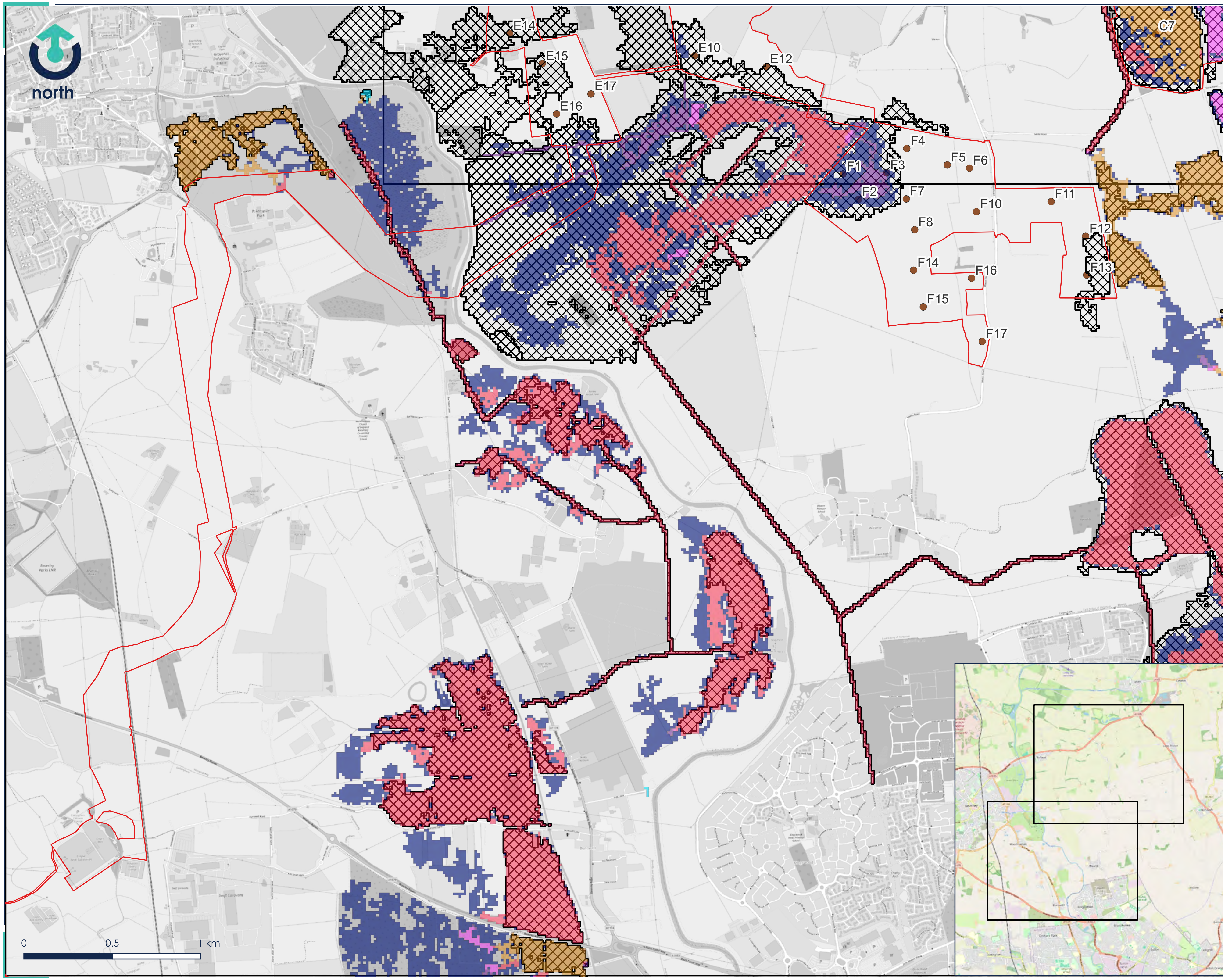

Legend

Order Limits	
Land Areas	
Substations	
Combined Breach Extent	
Increase (m)	
< -0.3	
-0.3 to -0.2	
-0.2 to -0.1	
-0.1 to -0.005	
-0.005 to 0.005	
0.005 to 0.1	
0.1 to 0.2	
0.2 to 0.3	
> 0.3	
Was wet now dry	
Was dry now wet	

REV:	DESCRIPTION:	BY:	DATE:
02	UPDATED LAYOUT	CF	07.07.25

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Maximum Credible Scenario level increase from Design Event (Sheet 2 of 2)

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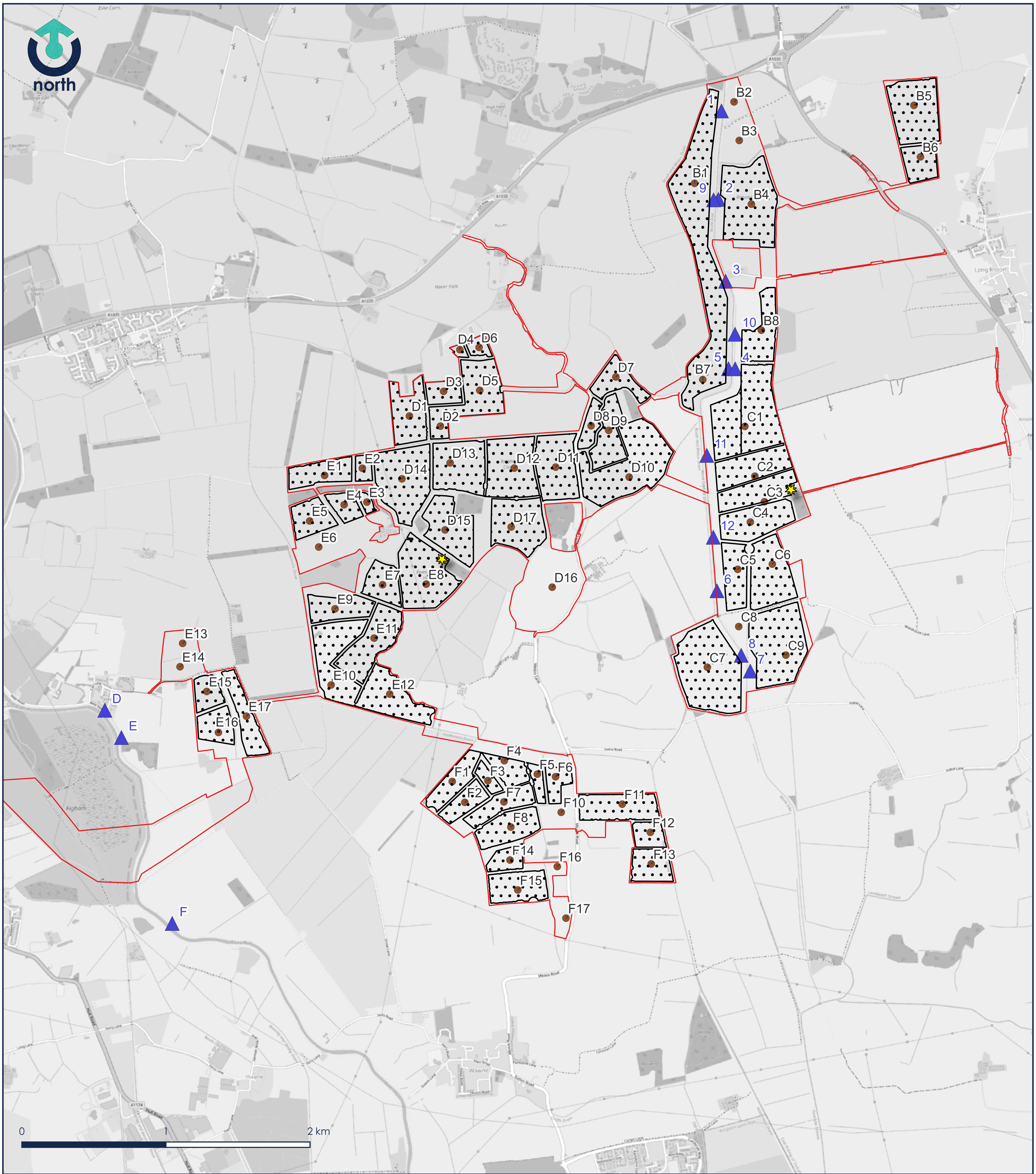

Legend
- Order Limits
- Breach Locations
- Generation Areas
- Land Areas
- Substations

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: PEARTREE HILL SOLAR

03	THIRD ISSUE	UPDATED ORDER LIMITS	CF	07.07.25
REV:	DESCRIPTION:	AMENDMENTS:	BY:	DATE:

TITLE: BREACH LOCATIONS AND PARCEL NAMES

SCALE AT A3:	DRAWN:	CHECKED:	REVISION:
1:25,000	CF	AB	03

PROJECT NO:	DRAWING NO:	DATE:
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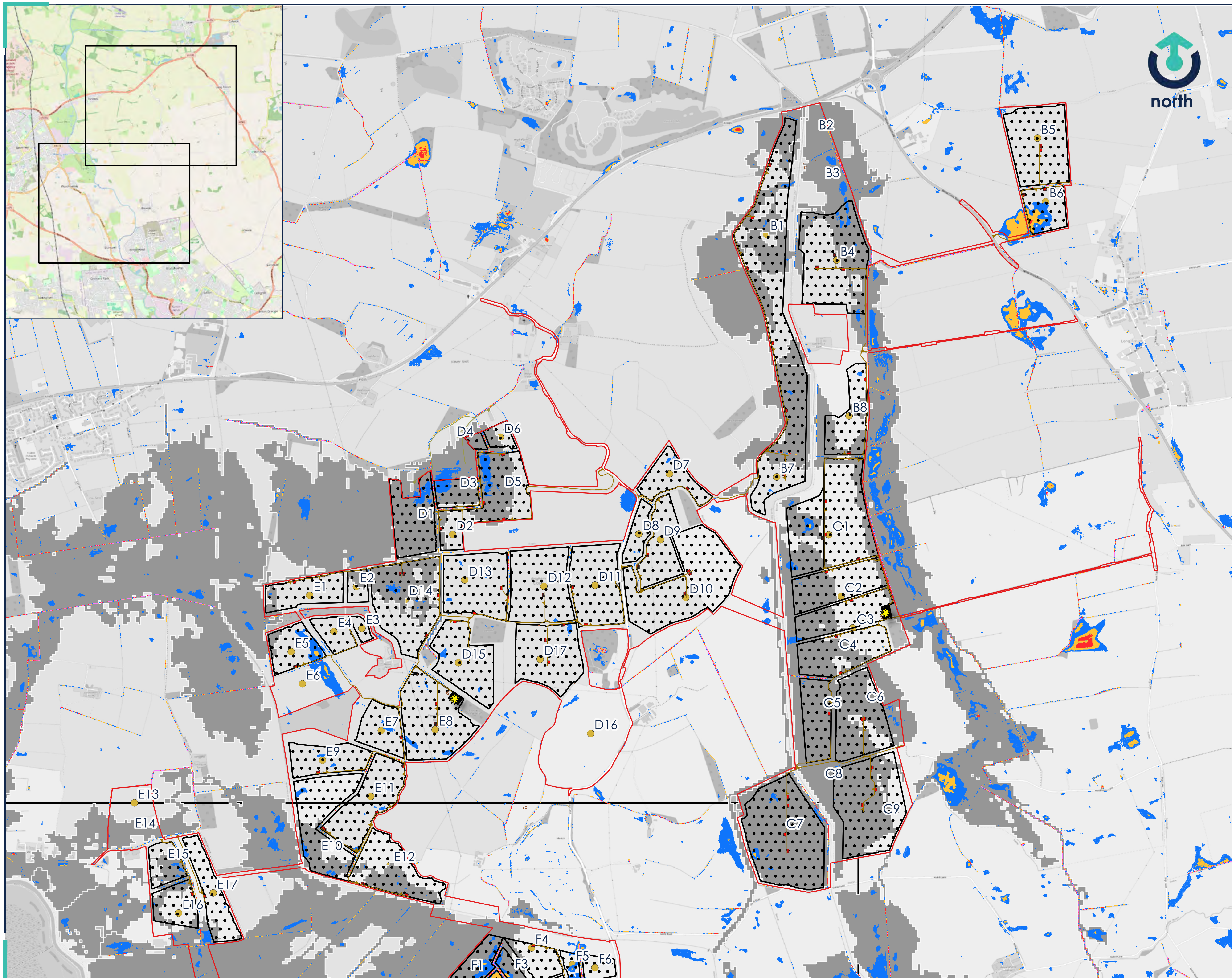

Legend

Order Limits	
Surface Water Depth (m)	
0.30 - 0.60	
0.60 - 0.90	
0.90 - 1.20	
> 1.20	
Parcel Names	
Generation Areas	
Substations	
Max Breach Extents	
Spares Container	
Hybrid Inverter	
Switchgear	

Notes

The RoFSW data was downloaded from the Defra Data Services Platform on April 1st 2025

REV:	DESCRIPTION:	BY:	DATE:
01	SECOND ISSUE	CF	07.07.25

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: RoFSW 1 in 1,000yr Depths
Sheet 1 of 2

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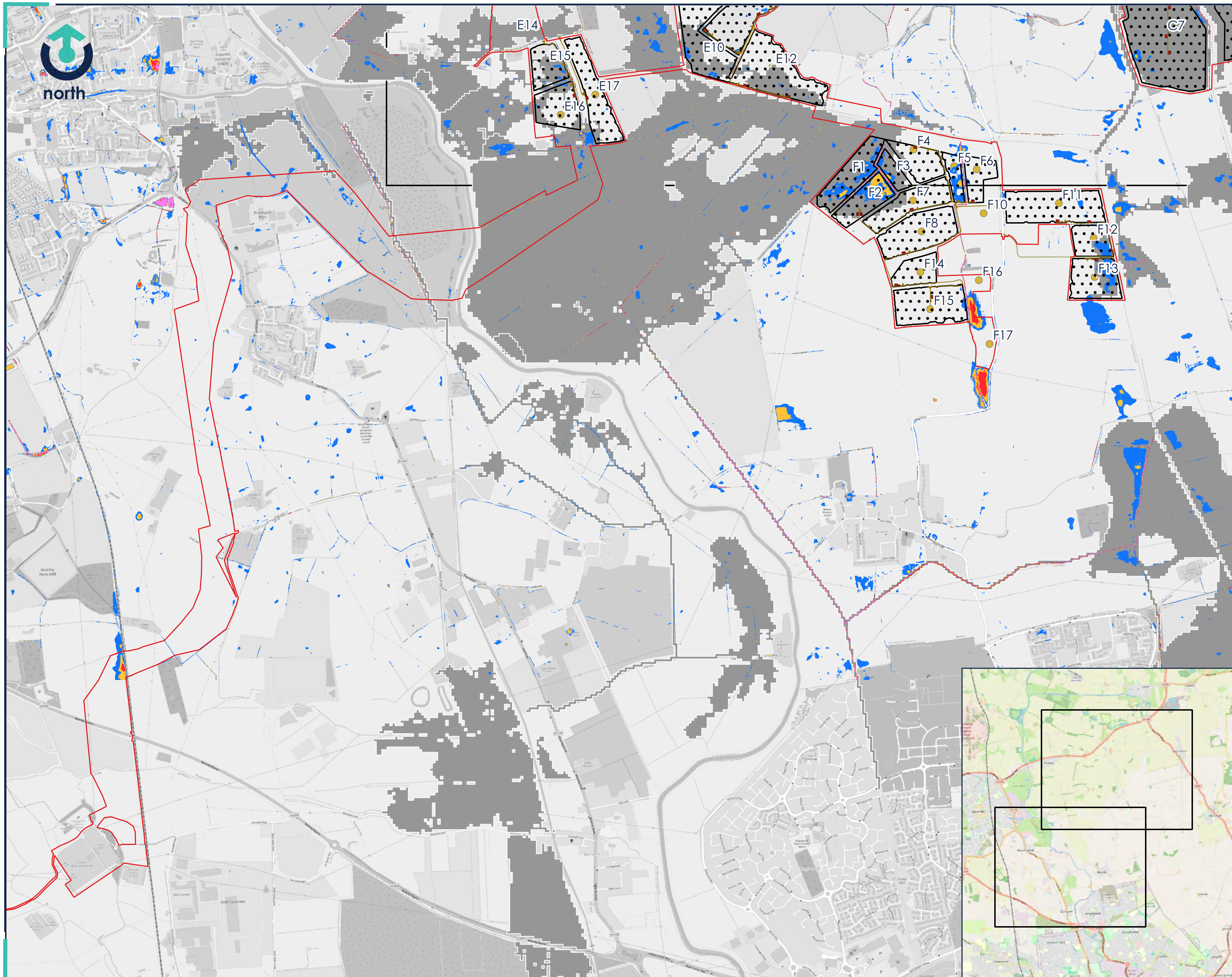

Legend

Order Limits	
Surface Water Depth (m)	
0.30 - 0.60	
0.60 - 0.90	
0.90 - 1.20	
> 1.20	
Parcel Names	
Generation Areas	
Substations	
Max Breach Extents	
Spares Container	
Hybrid Inverter	
Switchgear	

Notes

The RoFSW data was downloaded from the Defra Data Services Platform on April 1st 2025

01	SECOND ISSUE	CF	22.05.25
REV:	DESCRIPTION:	BY:	DATE:

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: RoFSW 1 in 1,000 yr Depths
Sheet 2 of 2

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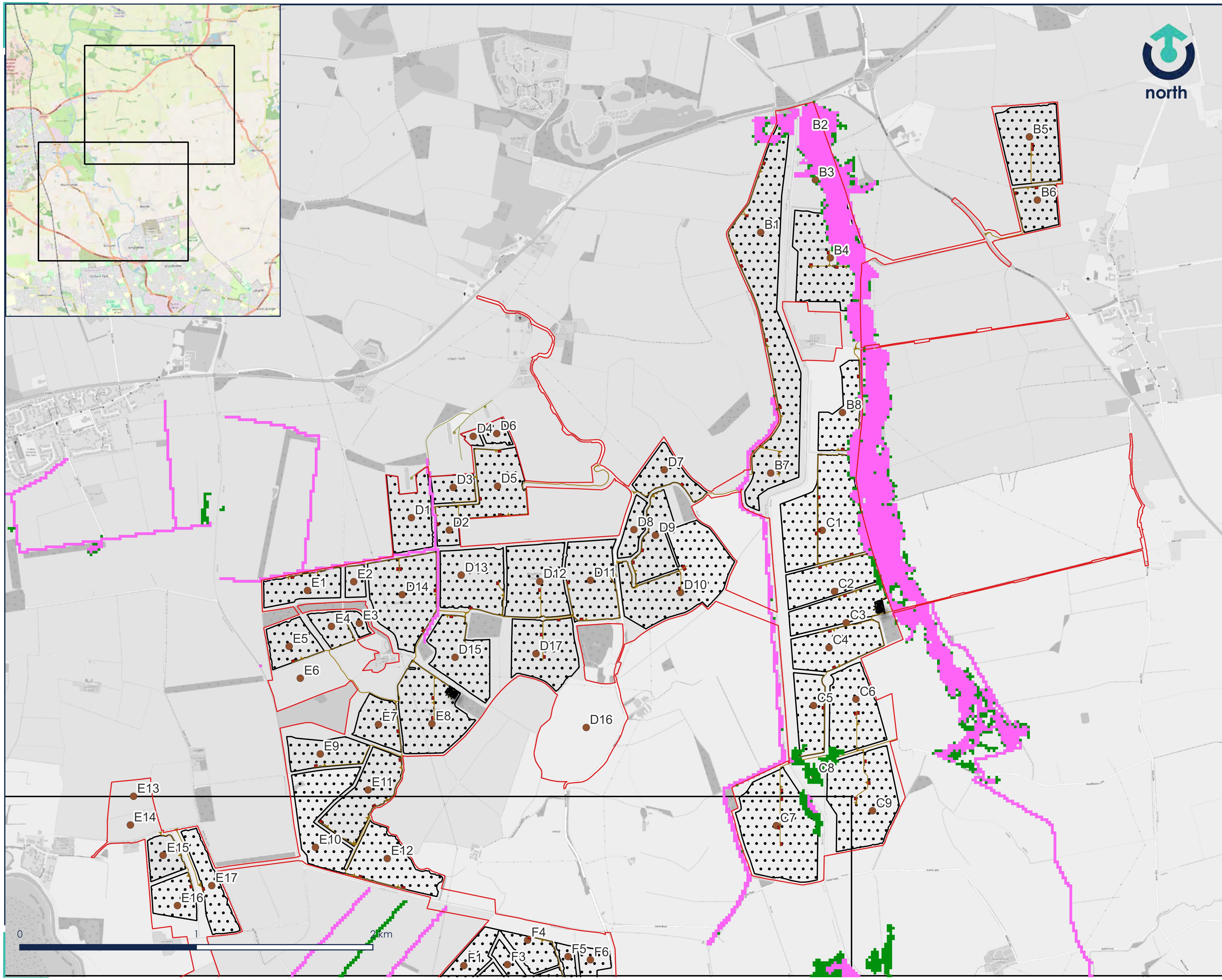

Legend

Order Limits

Generation Areas

Land Areas

Substations

Hybrid Inverters

Switch Gear

Spares Container

Flood Outlines

1 in 50 year

1 in 20 year

REV:	DESCRIPTION:	BY:	DATE:
01	FOR INFORMATION	AB	07.07.25

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: 1 in 20 year and 1 in 50 year Flood Outlines (Sheet 1 of 2)

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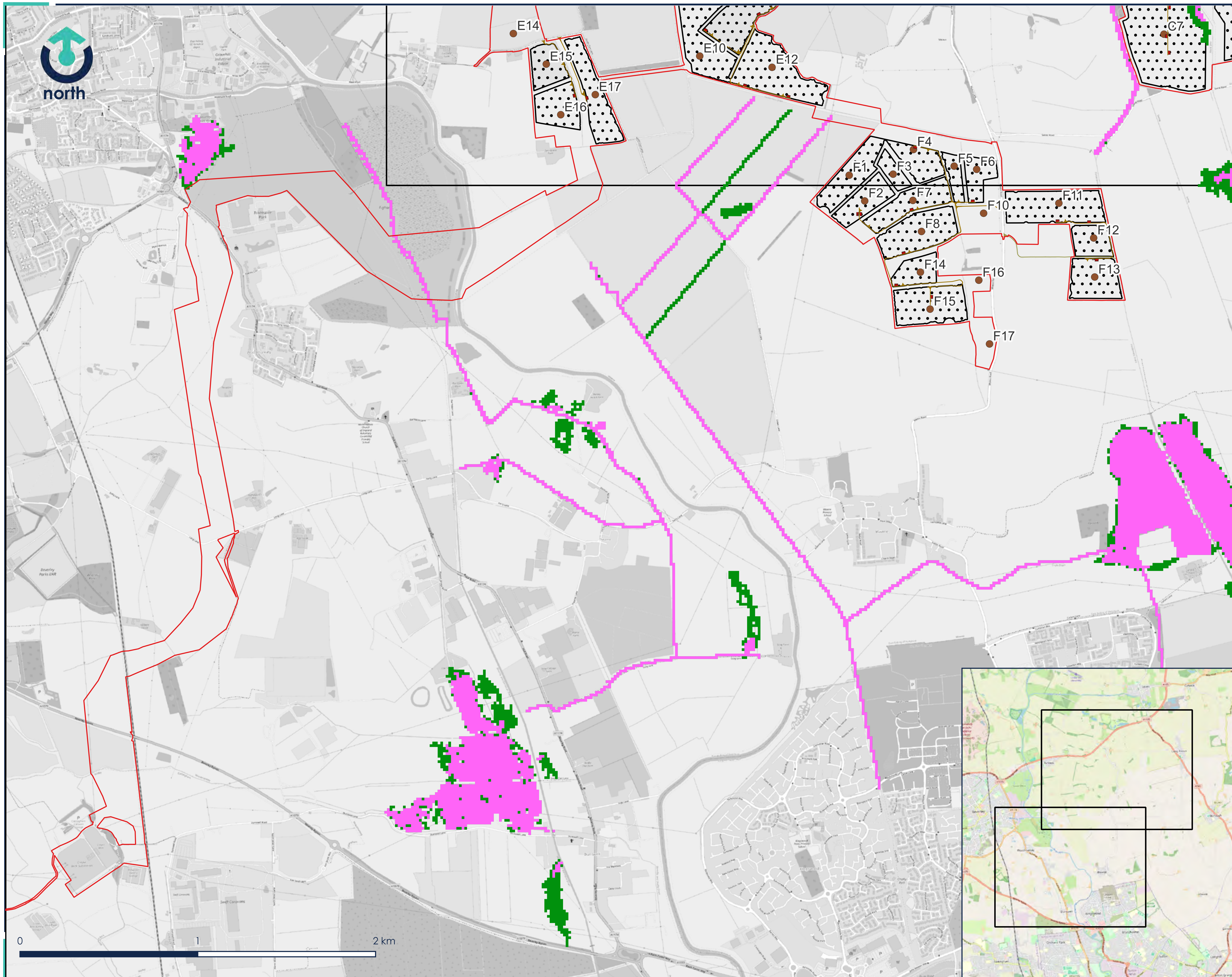

Legend

Order Limits	
Generation Areas	
Land Areas	
Substations	
Hybrid Inverters	
Switch Gear	
Spares Container	
Flood Outlines	
1 in 50 year	
1 in 20 year	

REV:	DESCRIPTION:	BY:	DATE:
01	FOR INFORMATION	AB	07.07.25

STATUS: INTERNAL USE ONLY

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: 1 in 20 year and 1 in 50 year Flood Outlines (Sheet 2 of 2)

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PROJECT NO:		DRAWING NO:	REVISION:
20-206		60-316	01

APPENDIX C

Peartree Hill Hydraulic Modelling Report (20-206-60-050-01)

PEARTREE HILL SOLAR

Beverley, East Yorkshire, HU17 9SS

HYDRAULIC MODELLING REPORT

Project No	20-206-60
Revision No	01
Issue date	11/11/24

Control Sheet

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Prepared by	Signature	Date
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Reviewed by	Signature	Date
Patrick Goodey BSc MSc Head of Flood Risk and Hydrology	[redacted]	11/11/2024

Approved for issue by	Signature	Date
Patrick Goodey BSc MSc Head of Flood Risk and Hydrology	[redacted]	11/11/2024

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Appendices

1 EXECUTIVE SUMMARY

1.1.1 Calibro has been appointed by RWE to carry out hydraulic modelling to support a planning application for a proposed solar development at Peartree Hill, East Riding of Yorkshire. This work was informed by pre-application engagement with the Environment Agency (EA).

1.1.2 The Hull and Holderness Drain model was adapted for the purpose of assessing the actual and residual risk to the site (through multiple breach and defence removal scenarios). As part of this work, some of the model was developed from a 1D only to a 1D-2D linked model.

1.1.3 The modelling work demonstrates that the majority of the site is not at risk of fluvial flooding. The extensive tidal defences along with the embankments alongside the principal watercourses (River Hull and Monk Dike) serve to contain the majority of flood waters during the design (1 in 100 year plus climate change) event.

1.1.4 Where flooding does occur during the defended scenario, flood depths and velocities tend to be low. The development proposals have been derived taking account of these outputs by locating supporting water sensitive infrastructure outside these areas where practicable. Where this is not practicable supporting infrastructure (e.g. inverters, switch gears, batteries) would be raised at least 0.3m above the predicted flood level.

1.1.5 The modelling work also considers the Credible Maximum Scenario using the H++ allowances in accordance with Planning Practice Guidance (PPG)[1] and the Overarching National Policy Statement for Energy EN-1[2]. The two exporting substations would be located outside the predicted flooding and comfortably above the predicted flood level.

1.1.6 The modelling work also includes 18 breach simulations of earthen embankments to determine the residual risk to the site. 3 of these breaches were selected to assess the residual risk to Parcel A. No development is proposed in this parcel but the breach simulations are still presented in this document for completeness. The breach simulations provide sufficient information to determine a suitable approach to mitigating residual risk. The majority of supporting water sensitive infrastructure would be located outside areas at residual risk of flooding, but where this is not possible they would be raised above the predicted flood level.

1.1.7 Removal of large sections of the Monk Dike embankments resulted in flooding in adjacent parcels which are similar to the worst-case breach extents and therefore the mitigation measures for the breach scenarios are considered to be sufficient to safeguard against the defences being completely removed during the development's lifetime.

[1] https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[2] Overarching National Policy Statement for energy (EN-1) - GOV.UK (www.gov.uk)

1.1.8 Sensitivity testing concludes that the model is not particularly sensitive to the definition of the tidal boundaries, flow estimates or roughness. Furthermore, a comparison of the Credible Maximum Scenario and the design event reveals that flood levels would not increase significantly by 2100. Therefore the mitigation recommended in this document is a robust approach to safeguard against the potential of extreme climate change to 2115 despite the development's proposed operational lifetime of 40 years.

1.1.9 Subsequent simulations including structures that are not defined in the model provided by the Environment Agency determined that these structures would have an insignificant impact on design event flood levels.

1.1.10 The impact of the proposals has been tested by raising Manning's roughness to 0.1 in the areas where panels and supporting infrastructure are proposed. This value is typically used for dense brush which would provide more resistance to flow than the narrow supports for the panel arrays. The results demonstrate that there would be an insignificant change in water levels and consequently a non-material change to flood risk for third parties.

1.1.11 The modelling work and the first version of this report was submitted to the EA's National Infrastructure Team for review. The EA requested additional work including a review of missing structures and simulations considering the impact of loss of entire sections of defence. These points are addressed in a Hydraulic Modelling Addendum (contained in Appendix F) submitted to the EA on 13th August 2024. The EA responded by letter on 29th August 2024 confirming the modelling is fit for purpose.

1.1.12 Since this work was carried out the development proposals and the site boundary has changed, the most significant change being the removal of Parcel A. This is partly as a result of the findings of the modelling work which predicted deep extensive flooding in Parcel A in the event of breach of the River Hull embankments. As a consequence, the figures in this report and drawings in the Appendices do not reflect the latest site layout. The revised information is presented in the Peartree Hill Solar Farm Flood Risk Assessment (20-206-60-030-01).

2 CONTEXT

2.1 Introduction

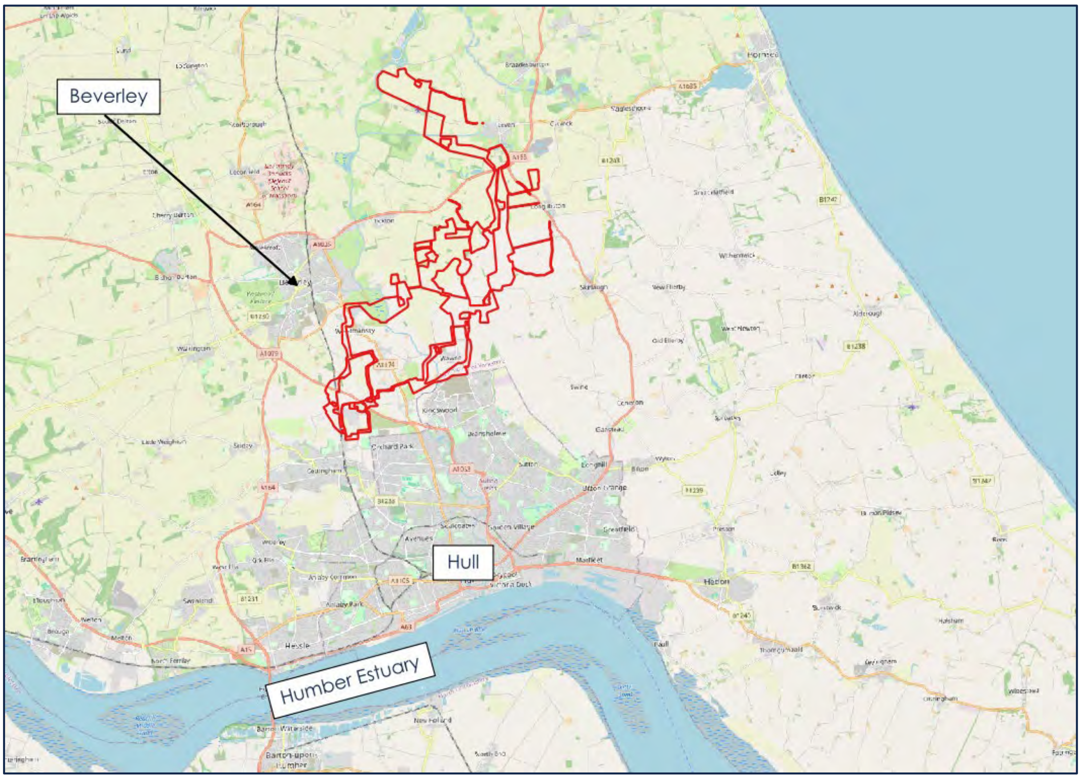
2.1.1 This report reflects the site proposals and site boundary as they were at the time that the modelling work was carried out (reproduced in Appendix A). The revised site proposals are presented Peartree Hill Solar Farm Flood Risk Assessment (20-206-60-030-01).

2.2 Site Location

2.2.1 The site is located near the town of Beverley, East Yorkshire. The approximate co-ordinates at the centre of the site are National Grid Reference (NGR) 508750, 440450. The nearest postcode to the centre of the site is HU17 9SS.

2.2.2 The site is located to the north of the city of Kingston Upon Hull (hereafter referred to as Hull) and the Humber estuary, to the east of Beverley and the River Hull and to the south of Driffield. The Draft Order Limits, hereafter referred to as the site boundary, is shown in Figure 2-1.

Figure 2-1 Site Location



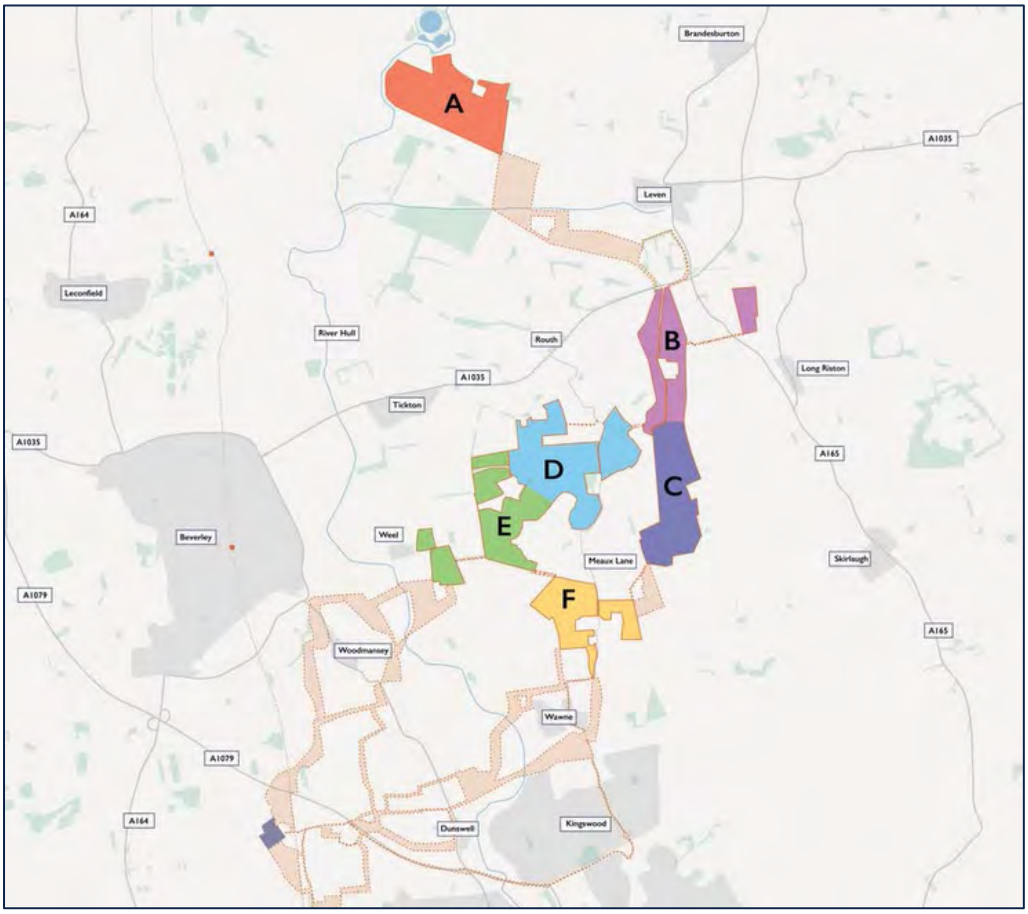
2.2.3 The site covers approximately 1,400ha. Approximately 700ha is expected to be solar generation and supporting infrastructure, with the remainder of the land holding set aside for cabling routes. The solar generation infrastructure is located in the Land

Areas labelled A-F in Figure 2-2. A copy of the Proposed Operation Phase Layout Plan is included in Appendix A. The cable routes will be buried and not water sensitive so are not discussed in this report.

2.2.4 The Proposed Development comprises the following main elements:

- Solar PV modules and associated mounting structures;
- On-site supporting equipment including inverters, transformers, and switchgear;
- A Battery Energy Storage System (BESS);
- Two on-site substations to connect the solar PV modules to distribution and transmission networks;
- Low voltage and 33 kilovolts (kV) interconnecting cabling within the Land Areas to connect the solar PV modules together and to connect the solar PV modules to the two on-site substations;
- 132 kV underground cabling connecting the Land Areas to the National Grid Creyke Beck Substation;
- Associated infrastructure including access tracks, parking, security measures, gates and fencing, lighting, drainage infrastructure and storage containers;
- Works at National Grid Creyke Beck Substation to facilitate the connection of the 132 kV underground cabling in to the Substation;
- Highways works to facilitate access for construction vehicles;
- Environmental mitigation and enhancement measures; and
- Temporary development during the construction phase of the Proposed Development including construction compounds, parking and temporary access roadways.

Figure 2-2 Land Areas



2.2.5 The focus of this study was to determine the actual and residual risk to the proposed above ground solar infrastructure in order to determine flood extents and levels to inform the development layout.

2.3 Site Topography and Hydrology

2.3.1 The proposed solar generation is predominantly on low-lying land as shown in Figure 2-3. Drawing 20-206-60-300 presents the same information in A3 format and is contained in Appendix B. Site levels generally vary between 0 and 8mAOD and the ground tends to be very flat. The cable route options extend into higher ground to the southwest.

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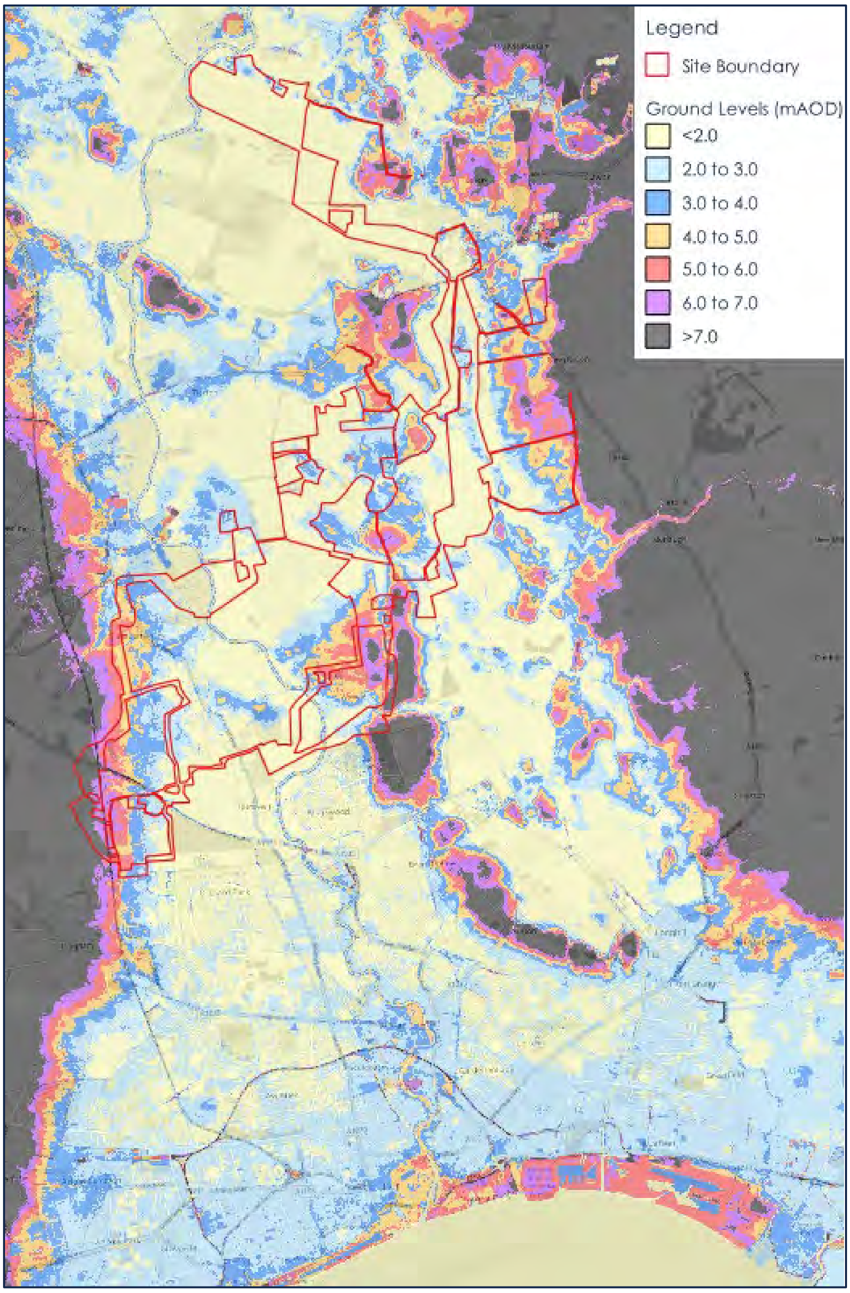
Figure 2-3 Site Topography

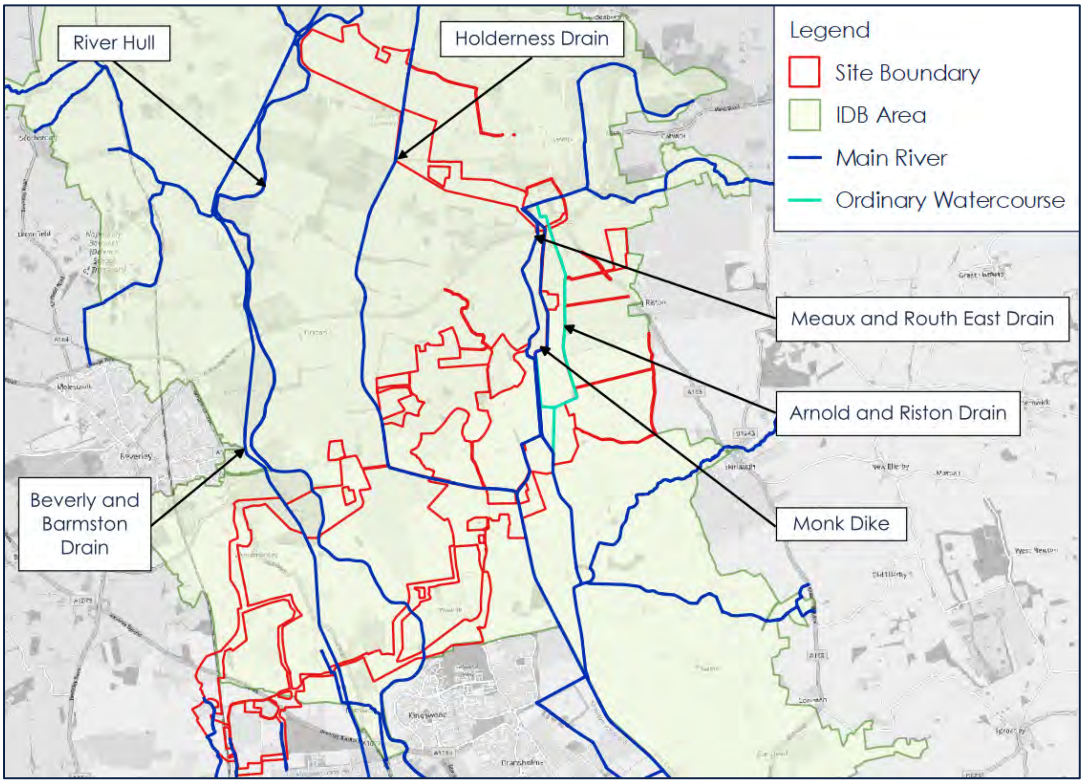


2.3.2 The Beverely and North Holderness Internal Drainage Board (IDB) administrative area covers a large area that is generally below 7mAOD. The extensive network of watercourses are managed by the IDB using control structures such as sluices and pumping stations for the purpose of drainage, flood risk management, and environmental benefit.

2.3.3 The drainage network ultimately discharges to the River Humber either via the River Hull or the Holderness Drain. Discharge from the Holderness Drain is controlled by a flapped outfall which prevents tidal ingress. Discharge from the River Hull is controlled by the Hull Tidal Surge Barrier which closes when particularly high tides are predicted.

2.3.4 There are a large number of watercourses within the study area. The principal watercourses which drain the area the Main Rivers shown in Figure 2-4. The River Hull and Monk Dike are flanked by earthen embankments and consequently they present a residual risk of flooding to the site should a breach occur.

Figure 2-4 Principal Watercourses and IDB Area



2.4 Modelling Scope

2.4.1 It was agreed during a meeting with the EA area team on 12th October 2022 and subsequently with the National Infrastructure Team on April 10th 2024 that the focus of the study should be on fluvial flood risk. The site is protected from tidal flooding by extensive defences along the River Humber Estuary. There have been several schemes recently constructed by Hull City Council and East Riding of Yorkshire Council which protect the City of Hull against a future (2040) 1 in 200 year flood and allow for a managed adaptive approach (raising the defences in the future to mitigate sea-level rise beyond 2040).

2.4.2 Should these defences be breached or overtopped, flooding of the site is unlikely as the panels and associated infrastructure are 10km or more inland and there is significant intervening low-lying land which would absorb flood waters. Furthermore, land adjacent to the River Humber is generally significantly higher than the low-lying land further inland which would reduce the flow through defences should a breach occur.

2.4.3 An assessment of tidal flood risk is contained in the Flood Risk Assessment.

3 Modelling Approach

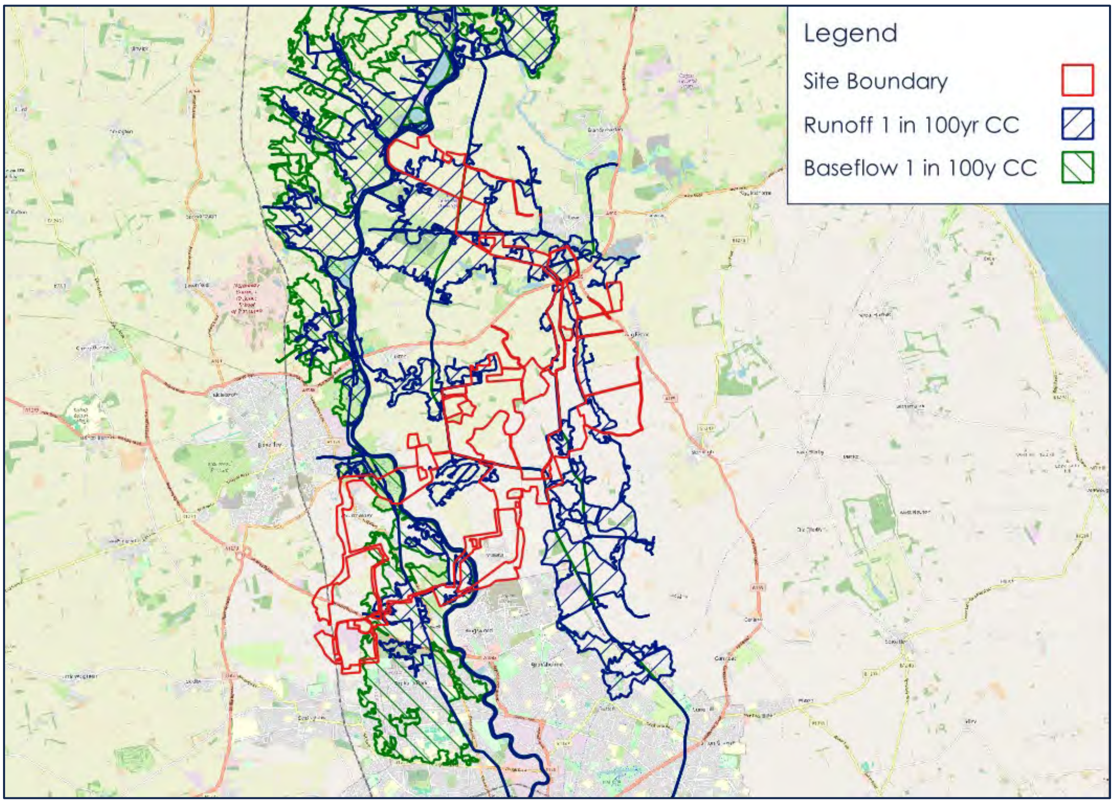
3.1 Existing Model and Run Parameters

3.1.1 As the purpose of the modelling is to establish flood levels and depths during the simulated design event and breaches, the modelling work has been based on the supplied 'defences operating' model.

3.1.2 As some of the catchments in the study area (generally to the west of the River Hull) exhibit a baseflow-dominated response. The original model simulated 'fluvial baseflow' events (derived using inflows created to produce the worst-case on baseflow-dominated catchments) and 'fluvial runoff' events (derived using inflows created to produce the worst-case on rainfall-runoff dominated catchments).

3.1.3 A review of these outputs revealed that the fluvial runoff scenario produces significantly worse flooding than the baseflow scenario for the solar generation areas[3]. The 1 in 100 year plus climate change event outputs for each of the scenarios is shown in Figure 3-1. This approach was discussed and agreed during a meeting with the EA's National Infrastructure team on April 10th 2024.

Figure 3-1 Existing 1 in 100 year plus climate change flood outlines



[3] The baseflow events are worse for land to the west of the River Hull but the cable routes are not discussed in this report being buried services.

3.1.4 The 1 in 100 year plus climate change model has been adopted for the purpose of the study. The existing model has a 15m grid and uses a 7.5s timestep for both the 1D and 2D elements. Running the existing model with a 3.75s 1D timestep, in accordance with good practice, had no discernible impact on the model outputs but did result in worse 1D mass balance and a higher number of unconverged timesteps. Consequently, the existing parameters have been retained. This was discussed and agreed during the meeting on April 10th.

3.1.5 The models were run for 200 hours (approximately 16 tidal cycles), well beyond the peak predicted flood levels which are 100 to 150 hours into the simulations.

3.2 Boundary Data

Fluvial Boundaries

3.2.1 For the design event and breach runs, the fluvial inflows were adjusted to reflect the higher central estimate of predicted climate change for the 2050s epoch (which covers the period 2040-2069) for the Hull and East Riding Management Catchment. This was completed by changing the existing scaling factors in the .IED from 20% to 17%. The H++ scenario was assessed using the 2080s Upper End estimate of 66%.

Tidal Boundaries

3.2.2 The existing 1 in 100 year plus climate change tidal curve boundaries were adjusted to represent predicted peak tidal levels. For the design event the highest astronomical tide level of 4.09m was taken from the Coastal Flood Boundary Dataset (CFB 'UK Mainland Chainage 3886') in accordance with the policy set out in the Planning Practice Guidance (PPG).

3.2.3 This level was adjusted to reflect the higher central estimate of sea-level rise to 2066 (calculated from a base date of 2018) of 356.6mm. This comprises: a rise of 93.5mm between 2018 and 2035 (5.5mm/yr); a rise of 252mm between 2035 and 2065 (8.4mm/yr), and; a rise of 11.1mm between 2065 and 2066 (11.1m/yr).

3.2.4 This resulted in a revised peak tidal flood level of 4.45mAOD. The tidal boundaries were created by adjusting the existing 1 in 100 year plus climate change boundaries (contained within Q100CC_75pt25hr.IED) which had a predicted peak level of 4.96mAOD and was presumably derived for the year 2100 or 2115.

3.2.5 The values were shifted downwards to preserve the tidal shape on the basis that the principal difference between the tides would be sea level rise which would affect all states of the tide equally.

3.2.6 For the H++ scenario the full 1.9m increase was applied, resulting in a peak tidal level of 5.99mAOD. This represents the worst-case scenario of sea level rise to 2100.

3.2.7 Although the EA agreed with this approach in the meeting April 10th, they requested that consideration be given to the outputs of the Humber Extreme Water Level (HEWL) study.

3.2.8 An alternative tidal boundary was derived with reference to the HEWL dataset to be used as a sensitivity test. The tidal level estimation points are shown in Figure 3-2. Relevant HEWL outputs are presented along with corresponding CFB values in Table 3-1.

3.2.9 A comparison of the nearest available level from the CFB with selected nodes from the HEWL dataset revealed that:

- The HEWL levels for node HU_0_069, at the mouth of the Humber Estuary, match those from the CFB Mainland Chainage _3912.
- The HEWL levels predict an increase in flood levels moving up the estuary due to a funnelling effect.
- The HEWL dataset (2071 HC) predicts levels at the confluence with the Hull to be 0.64m higher than at the mouth of the estuary, whereas the CFB data predicts an increase of 0.31m

1.2 To reflect the increase in peak tidal levels up the Humber Estuary predicted by HEWL, the CFB derived tidal boundary for the design event was increased by 0.33m (to reflect the difference between to two datasets) to 4.79mAOD to derive the alternate boundary (referred to as HEWL) used as a sensitivity test.

Figure 3-2 Selected HEWL and CFB nodes

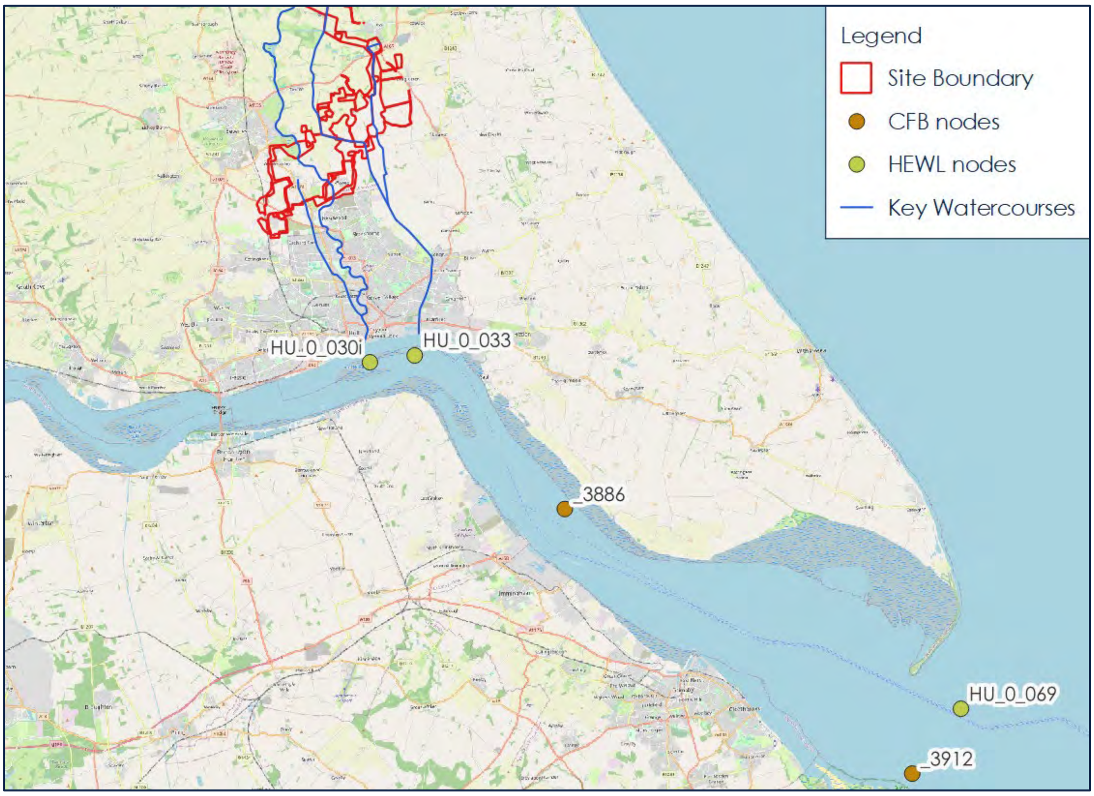


Table 3-1 Key Peak Tidal Levels

Event	2018	2046 Higher Central	2071 Higher Central
		CFB	
3912	3.96	4.15	4.37
3886	**4.27**	**4.46**	**4.68**
		HEWL	
HU_0_069	n/a	4.15	4.38
HU_0_033	n/a	4.72	4.96
HU_0_030i	**n/a**	**4.78**	**5.02**

3.3 Model Amendments

3.3.1 The following modifications were made to the model:

- The 2D element of the River Hull and Holderness drain was extended to the north near Tophill Low Nature Reserve to allow breach modelling adjacent to proposed solar generation in the northwest of the site. The 1D and 2D elements of the model are shown in Figure 3-3. Drawings showing the model extent are included in Appendix B (20-206-60-001, 20-206-60-002 & 20-206-60-003).

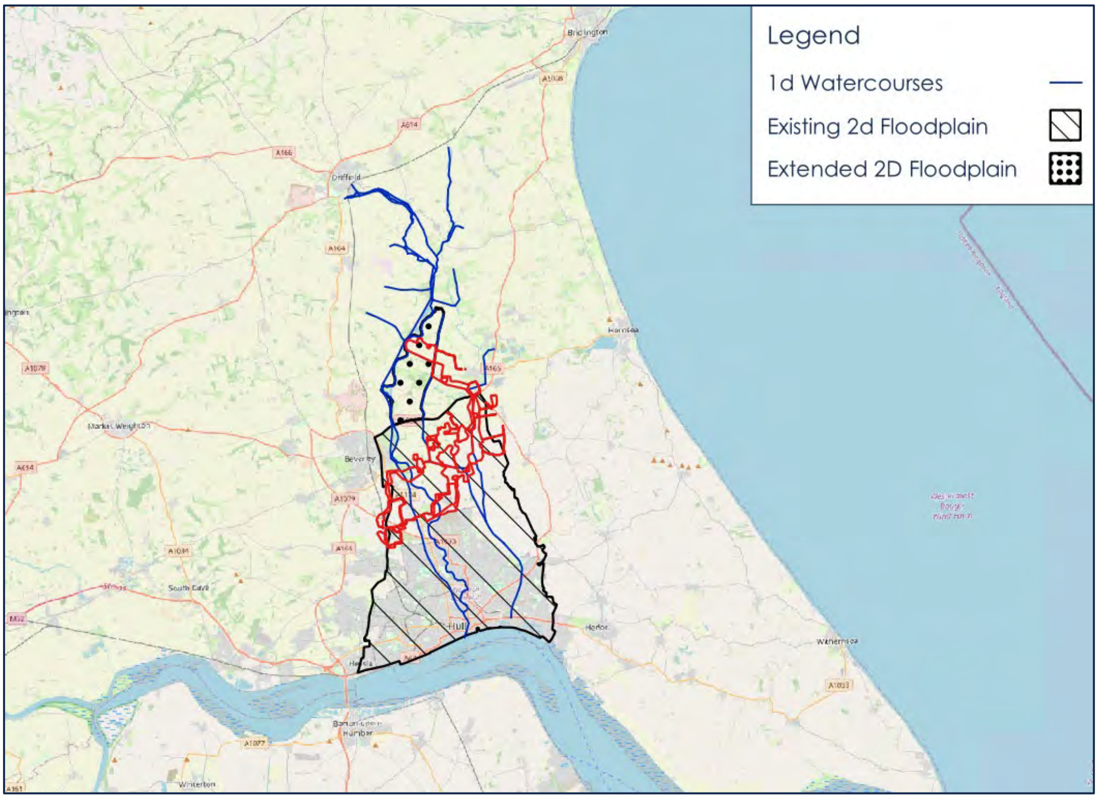
- The latest 1m filtered LiDAR data was downloaded from the gov.uk website to define the 2D model topography.

- Levels on the right bank of the Monk Dike just south of the A1035 were lowered to match LiDAR levels. Flooding has been observed in this location and it is presumed that some erosion has resulted in lowering of the crest level. Following the modification, overtopping commences earlier in the design event and results in increased flood levels to the west of the Monk Dike (approximately 100-200mm). There is also an insignificant reduction in flood levels to the east of the Monk Dike (approximately 10mm).

- The schematisation of the 1D element at the confluence of the Beverley and Barmston Drain and the River Hull was modified to stabilise the model. A spill was added where the Beverley and Barmston Drain drops into the River Hull and additional interpolates were added to stabilise the model.

3.3.2 In order to run the model with the latest versions of Flood Modeller Pro and Tuflow it was necessary to include the command ‘SX FMP Unit Type Error == OFF’ in the Tuflow control file (.trd) so that the existing model schematisation would function. Other run parameters were preserved.

Figure 3-3 Model Extents



3.4 Breach Scenarios

3.4.1 Breaches were simulated in accordance with guidance set out in the 'Breach of Defences Guidance - Modelling and Forecasting Technical Guidance Note'.

3.4.2 Breaches of the Monk Dike were carried out using the recommended parameters for earth banks on fluvial rivers: breach width 40m; time to close (rural) 56 hours. Breaches on the River Hull were carried out using the recommended parameters for Tidal Rivers: breach width 50m; time to close (rural) 56 hours. The level of the breach was defined on the basis of landward ground levels.

3.4.3 The breaches are modelled as occurring instantaneously to their full width. The timing of each breach was selected to be centred around the peak in-channel water level in order to produce the worst-case result. The in-channel water levels were taken from the design event (defended 1 in 100 year +17%) model. 30 hour breaches on the River Hull commenced 15 hours before the peak in-channel water level. 56 hour breaches on the Monk Dike commenced 28 hours before the peak in-channel water level.

3.4.4 The locations of the breaches were selected to result in maximum impact on the site with reference to the local topography (where landward ground levels were particularly low) and an indicative layout (proximity to sensitive infrastructure). The location of simulated breaches is shown in Figure 3-4, Figure 3-5 & Figure 3-6 and in Drawing 20-206-60-302 contained in Appendix B.

Figure 3-4 River Hull Breach Locations (North))

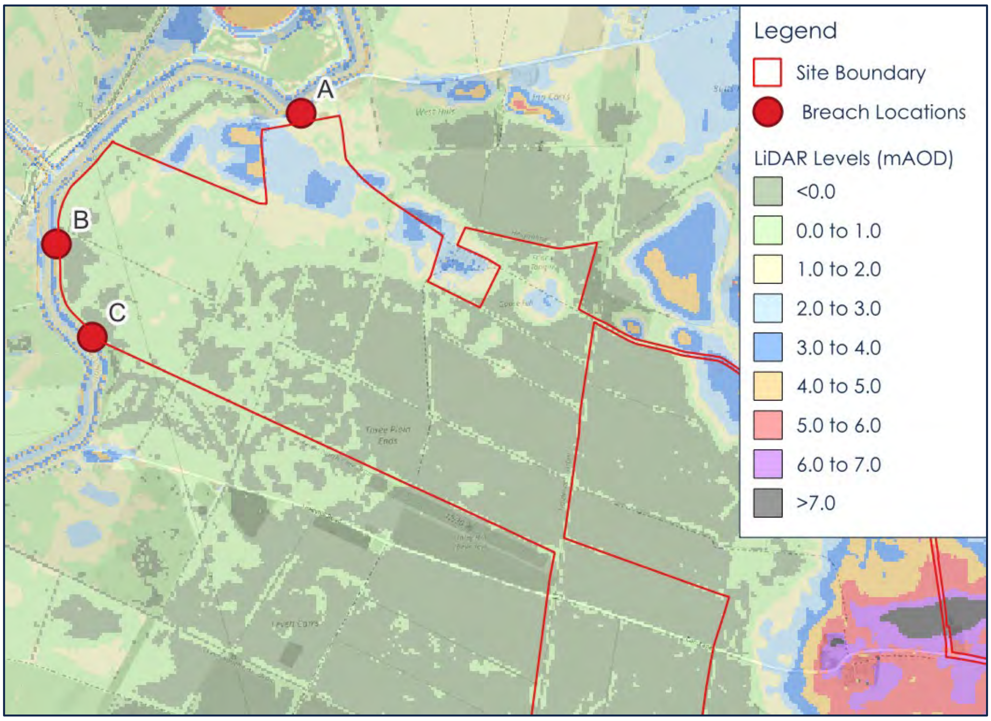


Figure 3-5 River Hull Breach Locations (South))

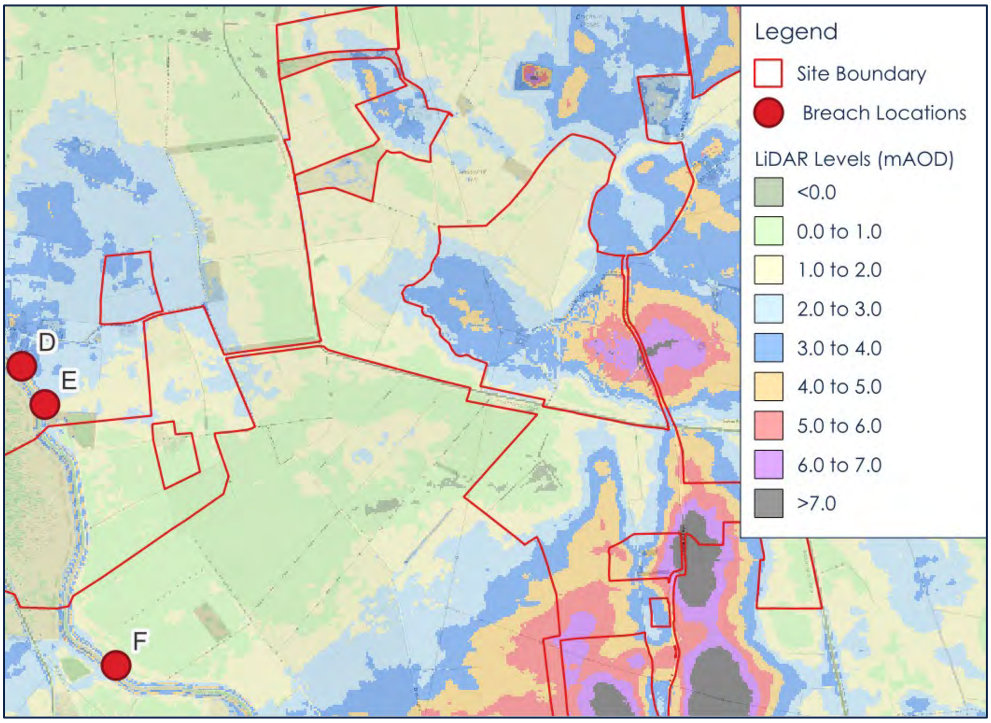


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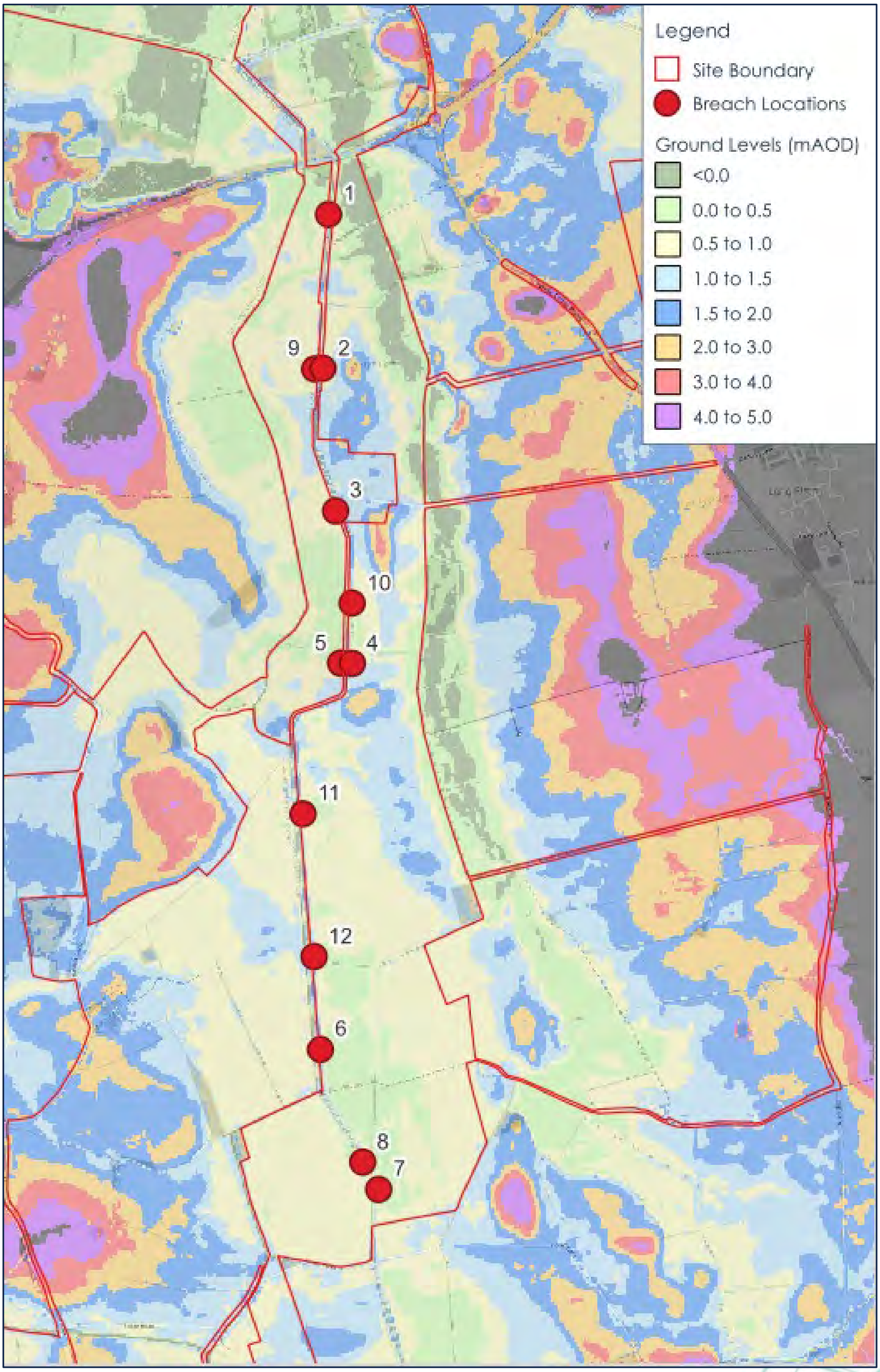
Figure 3-6 Monk Dike Breach Locations



3.4.5 The breach locations were provided to and agreed with the EA. It was queried whether the River Hull should be considered a fluvial defence. The trigger for the barrier closing is a tide of 4.2mAOD. The peak tidal level in the design event is 4.45mAOD so the barrier only closes on the two highest tides for a combined duration of 6 hours. Consequently, there is significant tidal influx into the River Hull (peaking at over 70m^3/s on each tide) and therefore it is considered to be a tidal river.

3.5 Simulations

3.5.1 The design event simulations and breach runs are summarised in Table 3-2.

Table 3-2 Design Event and Breach Simulations

Event	IEF
Design Event – Defended 1 in 100yr +17%	MD_UHL_039_100_17R_T0.ief
Monk Dike Breach 1 - 1 in 100 yr +17%	MD_UHL_MDB1_039_100_17R_T0.ief
Monk Dike Breach 2 - 1 in 100 yr +17%	MD_UHL_MDB2_039_100_17R_T0.ief
Monk Dike Breach 3 - 1 in 100 yr +17%	MD_UHL_MDB3_039_100_17R_T0.ief
Monk Dike Breach 4 - 1 in 100 yr +17%	MD_UHL_MDB4_039_100_17R_T0.ief
Monk Dike Breach 5 - 1 in 100 yr +17%	MD_UHL_MDB5_039_100_17R_T0.ief
Monk Dike Breach 6 - 1 in 100 yr +17%	MD_UHL_MDB6_039_100_17R_T0.ief
Monk Dike Breach 7 - 1 in 100 yr +17%	MD_UHL_MDB7_039_100_17R_T0.ief
Monk Dike Breach 8 - 1 in 100 yr +17%	MD_UHL_MDB8_039_100_17R_T0.ief
Monk Dike Breach 9 - 1 in 100 yr +17%	MD_UHL_MDB9_039_100_17R_T0.ief
Monk Dike Breach 10 - 1 in 100 yr +17%	MD_UHL_MDB10_039_100_17R_T0.ief
Monk Dike Breach 11 - 1 in 100 yr +17%	MD_UHL_MDB11_039_100_17R_T0.ief
Monk Dike Breach 12 - 1 in 100 yr +17%	MD_UHL_MDB12_039_100_17R_T0.ief
River Hull Breach A - 1 in 100 yr +17%	MD_UHL_HLBR1a_039_100_17R_T0.ief
River Hull Breach B - 1 in 100 yr +17%	MD_UHL_HLBR1b_039_100_17R_T0.ief
River Hull Breach C - 1 in 100 yr +17%	MD_UHL_HLBR1c_039_100_17R_T0.ief
River Hull Breach D - 1 in 100 yr +17%	MD_UHL_HLBR1d_039_100_17R_T0.ief
River Hull Breach E - 1 in 100 yr +17%	MD_UHL_HLBR1e_039_100_17R_T0.ief
River Hull Breach F - 1 in 100 yr +17%	MD_UHL_HLBR1f_039_100_17R_T0.ief

3.6 Sensitivity Tests

3.6.1 A number of runs were carried out to determine the sensitivity of the model to key assumptions. The tidal boundary was tested with reference to the HEWL outputs as discussed in Section 3.2.

3.6.2 Floodplain roughness was tested by increasing Manning's n values by 20%. An additional run was carried out where floodplain roughness in areas where panels are proposed were increased to 0.10 which is generally considered to be representative of heavy forestry or coppice. This was carried out in accordance with the EA's request in order to test the potential impact of the development on third parties.

3.6.3 The inflows were tested using an approach which reflected that undertaken in the original study. In the original study, the sensitivity of the model to baseflow was tested by increasing baseflows by 30%. The sensitivity of the model to surface runoff was tested by increasing standard percentage runoff (SPR) values for each of the inflows by 20%. The sensitivity test undertaken in this study comprises a 30% increase in baseflows along with a 20% increase in SPR. The increased flows were run not only for the design event simulation but also for Monk Dike Breaches 4 and 6 and Hull Breaches B and D.

3.6.4 A Maximum Credible Scenario for 2100 was also run in accordance with the H++ scenario guidance which in this case comprises an increase in flows of 66% and an increase in peak tidal level of 1.9m.

3.6.5 The additional simulations carried out are summarised in Table 3-3.

Table 3-3 Sensitivity Tests

Event	IEF
Maximum Credible Scenario (1 in 100+66% +1.9m sea level rise)	MD_UHL_039_100_66R_Tcms.ief
Tidal Boundary Sensitivity (HEWL)	MD_UHL_039_100_17R_T0_HEWL.ief
Manning's Roughness Sensitivity	MD_UHL_039_100_17R_T0_MNI.ief
Manning's roughness for developed areas increased to 0.1	MD_UHL_039_100_17R_T0_PRP3.ief
Design Event Flow Sensitivity	MD_UHL_039_100_17R_T0_BFSPR.ief
Monk Dike Breach 4 Flow Sensitivity	MD_UHL_MDB4_039_100_17R_T0_BFSPR.ief
Monk Dike Breach 6 Flow Sensitivity	MD_UHL_MDB6_039_100_17R_T0_BFSPR.ief
River Hull Breach B Flow Sensitivity	MD_UHL_HLBR1b_039_100_17R_T0_BFSPR.ief
River Hull Breach D Flow Sensitivity	MD_UHL_HLBR1d_039_100_17R_T0_BFSPR.ief

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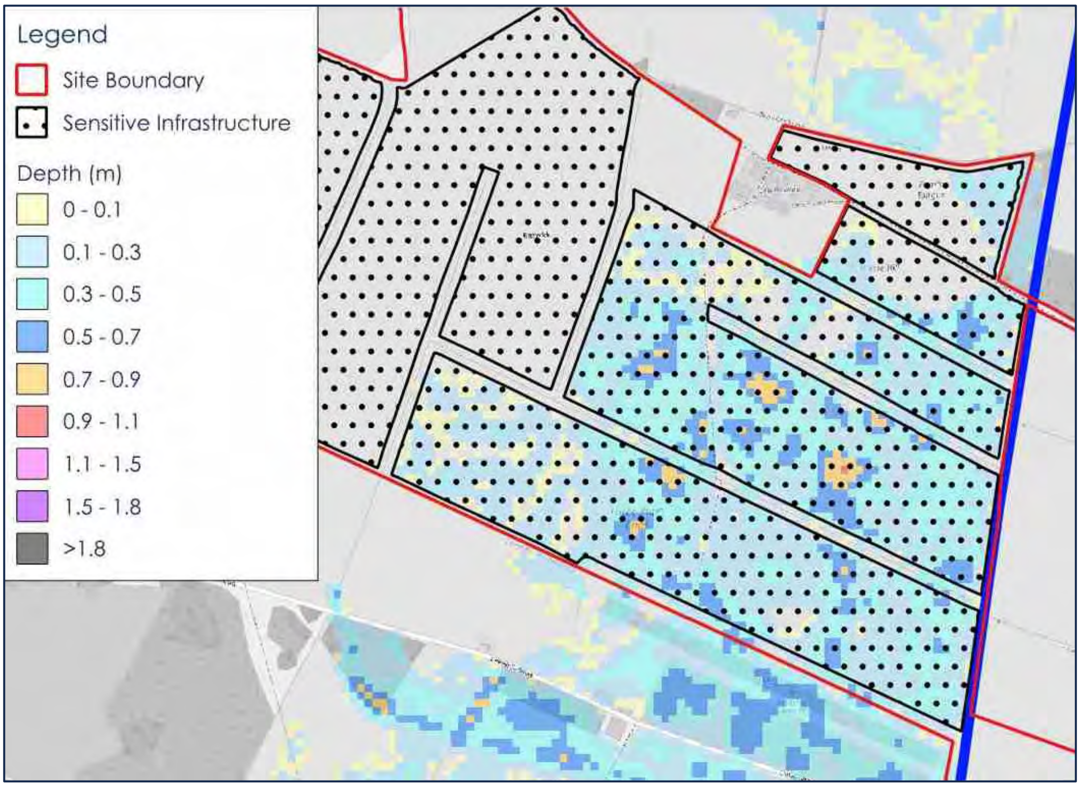
4 Model Results

4.1 Design Event

4.1.1 The vast majority of the site is not predicted to flood. Simulated flooding on the site is associated with the Hull and Holderness Drain in the west and the Monk Dike, Meaux and Routh East Drain and Arnold and Riston Drain in the east as discussed below. The design event flood depths are presented in Drawings 20-206-60-04 through to 20-206-60-06 (Appendix C).

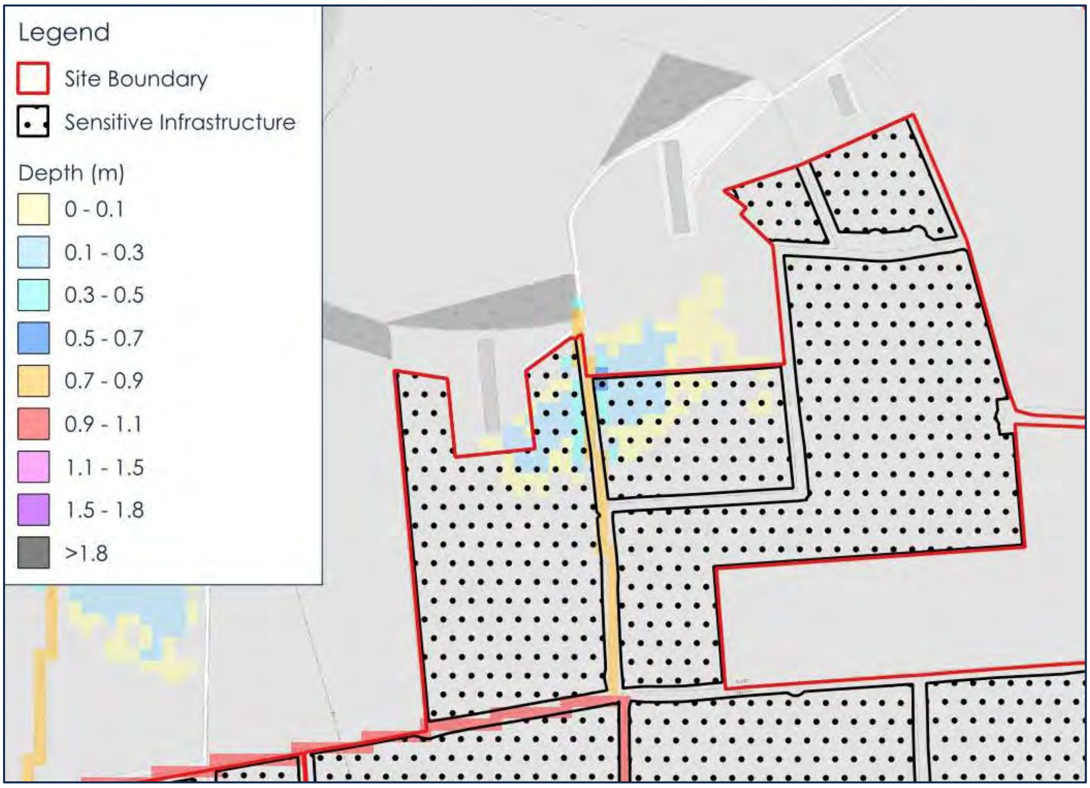
4.1.2 Drainage through the Holderness Drain is heavily restricted by high tide levels which results in flooding in the eastern part of Land Area A. Flooding is generally less than 0.5m but in some places is up to 1m deep (Figure 4-1).

Figure 4-1 Design Event Flooding Land Area A



4.1.3 Overtopping of the Holderness Drain also causes minor flooding to the northern part of Land Area D. Flooding in these locations is almost entirely below 0.3m and does not exceed 0.5m (Figure 4-2).

Figure 4-2 Design Event Flooding Land Area D



4.1.4 In the eastern part of the site, water overtops the western bank of the Monk Dike and causes flooding to a small area of land in the northwestern part of Land Area B before flowing into the Meaux and Routh Drain to the west (Figure 4-3). Flooding is also predicted in the eastern part of Land Area B caused by water from the Arnold and Riston Drain which relies on pumping to lift it into the Monk Dike. In the northeast an area of land is flooded to depths in the range 1.1-1.5m. Further south in Land Area B the flooding is constrained to the site perimeter and rarely exceeds 0.9m.

4.1.5 In the southern part of Land Area C water is predicted to overtop the Monk Dike and cause flooding. The flooding is generally shallow (<0.3m) and only a small area (~2,000m^2) is predicted to flood to depths 0.3-0.5m.

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Figure 4-3 Design Event Flooding Land Area B

Figure 4-4 Design Event Flooding Land Area C

4.1.6 During the design event, flood velocities within the proposed development area are consistently below 0.25m/s. Design event flood velocities are presented in Drawings 20-206-60-07 through to 20-206-60-09 (Appendix C).

Credible Maximum Scenario

4.1.7 The Credible Maximum Scenario which accounts for the plausible worst-case impacts of climate change have been applied in accordance with the requirements set out in National Policy Statement for Energy (EN-1). The document states that:

> *"Where energy infrastructure has safety critical elements, the applicant should apply a credible maximum climate change scenario. It is appropriate to take a risk-averse approach with elements of infrastructure which are critical to the safety of its operation."*

4.1.8 In the absence of guidance on how this should be applied for shorter time scales, the H++ climate change allowance for sea level rise of 1.9m was applied along with the upper end peak river flow allowance to 2125.

4.1.9 The predicted depths during this event are presented in Drawings 20-206-60-227 through to 20-206-60-229 (Appendix C). The flooded areas do not change significantly when compared to the design event and levels generally increase by less than 0.15m. The notable exception being some land in the south of Land Area C where levels increase by approximately 0.3m (refer to Drawings 20-206-60-247 through to 20-206-60-249 in Appendix E).

4.1.10 The substations would be located in areas unaffected by the Credible Maximum Scenario to ensure their long-term viability, despite the development lifetime being just 40 years.

4.2 Breach Simulations

4.2.1 The maximum depth and velocity outputs for each of the 18 breach scenarios are presented in Appendix D, along with combined maximum breach depth outputs.

River Hull

4.2.2 The breaches in the River Hull embankment cause widespread flooding. This is a result of both the scale of the embankments and the considerable tidal influence on the River Hull.

4.2.3 Of the northern breaches, Breach B has the most significant impact on the site, causing widespread flooding to approximately 7.5km^2 of land between the River Hull and the Holderness Drain including the majority of Land Area A. The level to which the embankment is lowered to simulate the breach is approximately 3m lower than peak in-channel flood level during the design event.

4.2.4 Peak flood depths within Land Area A are generally below 1.5m (Drawing 20-206-60-206). Peak flood levels are relatively static at approximately 500m from the breach locations.

4.2.5 Approximately 500m from the breaches, the flood levels resulting from Breaches A and C are within 50mm of Breach B demonstrating that the results are not particularly sensitive to the precise location of the breach.

4.2.6 Flood velocities at the location of breach are in excess of 4m/s but generally diminish to below 1m/s within approximately 200m. The areas of proposed development have been drawn back approximately 200m from the defence line. (Drawings 20-206-60-201, 20-206-60-204 & 20-206-60-213).

4.2.7 Of the southern breaches, Breach F causes the most significant flooding on the site with the exception of the southwestern part of Land Area E which is worst-affected by Breach D (Drawings 20-206-60-215 & 20-206-60-221). Flood depths in Land Areas D and E are generally below 0.7m. Flood depths in the western part of Land Area are up to 1.5m deep.

4.2.8 With the exception of drainage channels, flood velocities on the site are below 0.5m/s.

Monk Dike

4.2.9 Breaches on the Monk Dike have a less significant impact on the site than breaches on the River Hull due to a combination of less flow in the channel and lower embankments.

4.2.10 The maximum breach depths are principally determined by the topography behind the defence in the location of the breach. Where the ground is flat flooding disperses and results in relatively shallow depths. Deeper flooding is predicted in areas which are effectively depressions in an otherwise flat landscape.

4.2.11 As the results of the breach are influenced significantly by the location, 12 breaches have been carried out. With the exception of Breaches 4 and 10 and Breaches 6 and 7, which have almost identical results, each of the breaches result in a different area of proposed development experiencing flooding.

4.2.12 Flood depths for the breach events are generally below 1.2m. Where the ground is relatively even and there are no distinct depressions, flooding spreads out fairly quickly and depths and velocities diminish fairly rapidly generally reducing to below 0.5m and 0.5m/s within 50m of the simulated breaches.

4.2.13 Where there are localised depressions water accumulates in these areas and flood depths are predicted to be as high as 1.5m. However these locations are well-defined - e.g. adjacent to the defence for Breaches 4 and 10 but outside the generation area; adjacent to Breach 11; and adjacent to Breach 6 not particularly sensitive to the breach location.

4.2.14 All breaches of the eastern bank of the Monk Dike result in increased levels in the Arnold and Riston Drain. The combined worst-case simulation predicts an increase in flood levels of 0.2 to 0.3m when compared with the design event levels.

4.2.15 The breach that results in the most widespread flooding is Breach 7 which causes deep flooding in the southeastern part of the site. Flood depths predicted by Breach 6, approximately 600m upstream, are approximately 5mm lower than those predicted by Breach 7 and those predicted by Breach 12 approximately 1km upstream are approximately 10mm lower. It can therefore be concluded that flood depths in the worst-affected area are not sensitive to breach location.

4.2.16 With the exception of land within 50m of the breaches, velocities are generally less 0.5m/s.

4.3 Defence Reach Removal

4.3.1 Simulations with sections of the Monk Dike embankments removed are discussed in the addendum contained in Appendix F

4.4 Sensitivity Tests

4.4.1 The impact of the various sensitivity tests has been assessed by subtracting the peak water levels from those of the design event which provides not only a change in level but also delineates the change in flood outline (areas which were dry but become wet and vice versa). These outputs are presented in drawings contained in Appendix E.

4.4.2 It should be noted that outliers in flood level difference were observed in the same location for numerous runs. These outliers centre around the cell at NGR 51078076, 440026 and generally propagate up to two cells in each direction. This cell has a Zc elevation of -1.14m and is surrounded by cells with Zc elevations of -0.58 to 0.97mAOD. Consequently, it is concluded that the 'increases' predicted in these locations are an artefact of the modelling computation rather than any actual effect that would be expected to occur. This area is hereafter referred to the low cell in Land Area C.

Tidal Boundary Increase

4.4.3 Testing an increase of 0.338m in tidal levels to account for the increase in tidal levels predicted by HEWL, results in a minor increase in flood levels in locations flooded by watercourses which discharge via the Holderness Drain (Land Areas B and C). Levels associated predominantly with flooding from the Hull (Land Areas A, D, E & F) are reduced. This is because the increase in tidal levels results in more frequent closing of the Hull Tidal Surge Barrier and marginally reduces the significant influx of tidal waters into the River Hull and associated tributaries.

4.4.4 The increase in flood levels is less than 10mm within the developed areas. The only exception is three cells centred on the low cell in Land Area C which increase by

0.025m-0.047m. Four additional cells are wetted in this area. The maximum increase outside of the site is 0.081m in Swine Moor and the maximum decrease is 0.236m in Sutton in the northern part of Hull.

4.4.5 It is concluded that the model is not particularly sensitive to the definition of the tidal boundary.

4.4.6 The level difference resulting from increasing the tidal boundary is shown in Drawings 20-206-60-231 to 20-206-60-233.

Flow Increase - Design Event

4.4.7 Increasing SPR by 20% and baseflows by 30% results in an increase in fluvial inflows of approximately 20% and a minor increase in flood levels within developed areas as shown in Drawings 20-206-60-234 to 20-206-60-236.

4.4.8 Within Land Area A flood levels increase by approximately 0.08m. Within Land Area D flood levels are predicted to increase by approximately 0.18m.

4.4.9 In the land area affected by flooding from the Monk Dike, levels increase by less than 0.15m with the exception of cells associated with the low spot in Land Area C where increases of 0.245, 0.395, 0.295 and 0.158m are predicted.

4.4.10 It is concluded that flooding during the design event is not overly sensitive to the model inflows.

Flow Increase - Breach Events

4.4.11 The impact of increasing SPR by 20% and baseflows by 30% for four breach scenarios was also tested. For the majority of the model extent the results were equivalent to the baseline sensitivity test.

4.4.12 For Hull Breach B, levels in the vicinity of the breach and within Land Area A generally, increase by approximately 0.035m, approximately half the increase predicted during the baseline event (see Drawing 20-206-60-237).

4.4.13 For Hull Breach D levels in the vicinity of the breach are predicted to increase by less than 0.01m. Flood levels in Land Area D and E increase by 0.04m and 0.02m respectively (see Drawing 20-206-60-238).

4.4.14 The Hull Breaches are not sensitive to flow estimates due to the significant influx of tidal waters into the River Hull.

4.4.15 For Monk Dike Breach 1 the increase in the vicinity of the breach is up to 0.10m and levels further south in Land Area B increase by approximately 0.15m (see Drawing 20-206-60-239).

4.4.16 For Monk Dike Breach 6 the impact in the vicinity of the breach is approximately 0.06m and levels associated with the Arnold and Riston Drain to the east increase by approximately 0.16m (see Drawing 20-206-60-240).

4.4.17 The Monk Dike Breaches are not particularly sensitive to inflows.

Roughness Sensitivity Increase

4.4.18 Increasing Manning's roughness by 20% generally results in levels changing by +/- 0.05m (see Drawings 20-206-60-241 to 20-206-60-243). Some limited areas report a change in the +/- 0.1m range. Within the developed areas the changes are consistently within +/- 0.01m. The exception is the southern part of Land Area C which generally have a predicted increase of approximately 0.025m. There are four cells associated with the low spot in Land Area C which have predicted increases of 0.141m, 0.276m, 0.177m and 0.041m.

Development Roughness Increase

4.4.19 Increasing Manning's roughness in the developed areas to 0.1 results in a change in flood levels of +/- 0.005m (see Drawings 20-206-60-244 to 20-206-60-246). The only exception to this is in the southern part of Land Area C where an increase in flood levels of approximately 0.015m is predicted. This does not propagate outside the site boundary. This is not surprising given that the flooding is slow moving, slow rising and volume rather than conveyance driven.

4.4.20 It is concluded that the development proposals would not result in a material change in flood risk and would not negatively impact third parties.

Missing Structures

4.4.21 A suite of additional runs testing the impact of structures which were not included in the original model are discussed in the addendum in Appendix F.

5 DEVELOPMENT RECOMMENDATIONS

5.1 Managing Actual Risk

5.1.1 The majority of the site is not at risk of flooding during the design event. However, there are parts of the site where flooding is predicted.

5.1.2 In accordance with the sequential approach, these areas should be used for the least vulnerable uses which in this case is solar panels. The minimum height of the panels would be 0.8m.

5.1.3 The sensitivity tests demonstrate that the flood levels are not particularly sensitive to model assumptions. The increases are generally less than 0.1m and less than 0.2m in Land Area D. Furthermore, simulation of the Credible Maximum Scenario for 2100 generally only results in increases of 0.15m.

5.1.4 On that basis, a freeboard allowance of 0.3m should be sufficient to account for uncertainty and any floating debris. The catchment is almost entirely agricultural with limited tree cover, the major watercourses are embanked and the flood velocities in the floodplain are very low and for the most part originate from low-level ditches that drain pasture or arable land. Therefore raising panels 0.3m above the design event flood should be sufficient.

5.1.5 The supporting water sensitive infrastructure (inverters, DNO substations etc.) would be inside containers and as a minimum raised 0.5m above surrounding ground levels. These should be located outside the areas predicted to be flooded in the design event. If this is not possible they would set at least 0.3m above the design event flood level. Sensitive infrastructure in the predicted flood extents would be raised using plinths or pads to negate the impact on floodplain displacement. Based on the model sensitivity test results, such plinths or pads would have negligible impact on the propagation of floodwater.

5.1.6 The proposals include two exporting substations. These substations would be located outside the Credible Maximum Scenario flood extents. Water-sensitive infrastructure within the substation compounds should be raised at least 0.3m above the predicted maximum water levels during the Credible Maximum Scenario.

5.2 Managing Breach Risk

5.2.1 The breach simulations represent flooding in an incredibly unlikely scenario. It assumes that a 1 in 100 year flood (with 17% uplift for climate change) coincides with the peak of a highest astronomical tide. It is also assumed that a breach of 40m-50m occurs at the peak of the resultant flood.

5.2.2 In the case of the Hull Breach 1, this assumes an instantaneous loss of 50m of bank approximately 3.5m high and 35m deep which is clearly physically implausible.

5.2.3 Nonetheless, where possible, it is recommended that the panels are designed so that the lowest panel edges are above the breach flood level. This should mitigate against the risk of flooding should there be a breach of the River Hull defences.

5.2.4 Breaches on the Monk Dike result in less predictable flooding. However, the 12 breach simulations have identified the areas where deep flooding could occur and also demonstrated that flooding in these locations is not particularly sensitive to the precise location of the breach. Elsewhere, it is unlikely that breach depths would exceed the minimum panel height of 0.8m in proposed areas of development which are offset approximately 30m from the banks.

5.2.5 Supporting containerised infrastructure should be located outside of the breach extents where possible. However, this infrastructure does need to be distributed throughout the site. In the case of Land Areas B and C which are potentially at risk of a breach of the Monk Dike this infrastructure should be sited on the highest available land and be raised above the predicted breach levels where necessary.

6 SUMMARY AND CONCLUSIONS

6.1.1 Detailed 1D-2D hydraulic modelling has been carried out as requested by the EA to inform the layout for a proposed solar development at Peartree Hill Farm, north of Hull.

6.1.2 The modelling work is based on the Hull and Holderness model provided under licence by the EA. Minor changes were made to the model to stabilise it with the latest Flood Modeller and Tuflow executables.

6.1.3 The fluvial inflows and tidal boundary were updated to produce outputs for the design event at the end of the proposed development's lifetime; a 1 in 100 year flood in 2066.

6.1.4 During the design event, the vast majority of the site is not predicted to flood. There is flooding associated with the Holderness Drain in the east and the Monk Dike and Arnold Riston Drain. The layout available at the time of this report excluded all water-sensitive supporting infrastructure from the areas shown to be at risk. Panels should be raised above the flood level to ensure that they remain operation during a flood.

6.1.5 18 breach simulations have been carried out. These breaches assume a catastrophic, instantaneous failure of substantial earth embankments which protect vast areas of land. They also assume that this failure occurs at the peak of a future 1 in 100 year flood coinciding with a future highest astronomical tide. This is incredibly unlikely, but where possible the development should be designed so no water sensitive infrastructure is affected, and the site remains operational.

6.1.6 The 6 breaches for the River Hull are considered to adequately cover the range of potential impacts of breach on the western land areas. It is recommended that panels and all water sensitive infrastructure should be raised above the maximum breach level. The northern River Hull breaches resulted in extensive deep flooding and were a key consideration of the removal of Parcel A from the development proposals.

6.1.7 The 12 breaches for the Monk Dike are considered to adequately represent the worst-case scenario for various land areas in terms of breach flooding. However, given the topography some areas adjacent to the flood defences is not shown to be flooded in the combined breach depth outputs. To safeguard against the potential for breaches in other locations it is recommended that the containerised water-sensitive infrastructure is located at least 100m from the Monk Dike banks and least 0.5m above existing ground levels. Panels are proposed to commence approximately 30m from the banks and would have a minimum height of 0.8m when tilted and 1.5m when flat which should be sufficient to mitigate breaches in locations that have not been modelled.

6.1.8 Sensitivity testing of the tidal boundary, fluvial inflows and Manning's roughness demonstrate that the model is not particularly sensitive to these conditions. Generally, increases in flood level are below 0.1m and entirely below 0.2m.

Modelling of the H++ Credible Maximum Scenario flood for 2100 resulted in an increase in flood levels of up to 0.15m. Accordingly it is concluded that 0.3m freeboard should be sufficient to account for uncertainty and any limited floating debris.

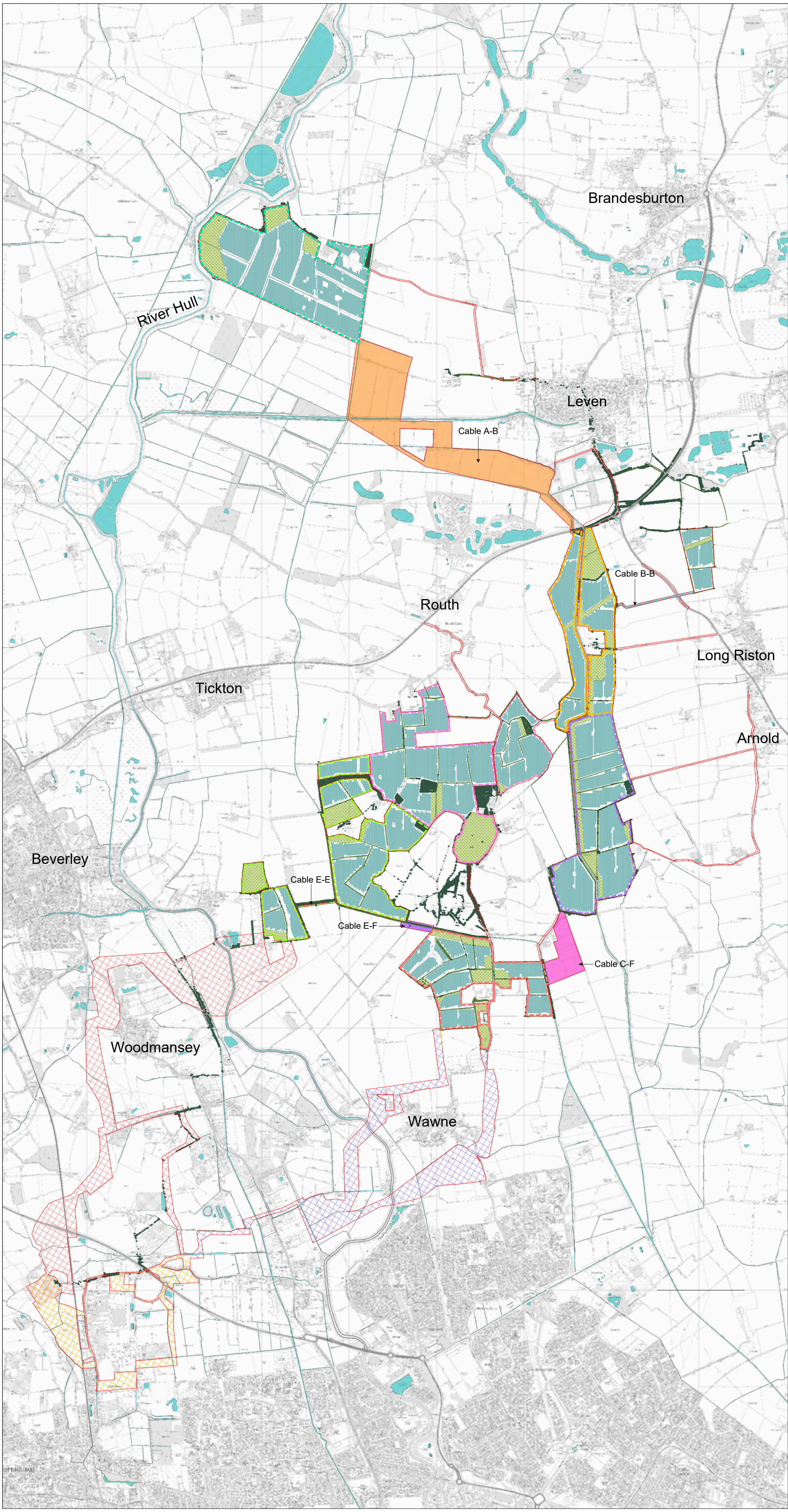
6.1.9 Given the importance of the two exporting substations, they should be located outside the flood extents for the Credible Maximum Scenario. To further safeguard again the potential for catastrophic climate change it is recommended that any water-sensitive infrastructure in the substations is at least 0.3m above the Credible Maximum Scenario water level.

6.1.10 The modelling work presented in this document was submitted to and reviewed by the EA. The EA review included requests for clarification and some additional simulations which have been addressed and are discussed in the modelling addendum submitted to the EA on August 14th 2024 (Appendix F). The EA confirmed that the hydraulic modelling work is ‘fit for purpose’ in a letter dated 29th August 2024.

APPENDICES

APPENDIX A

Proposed Operational Phase Layout Plan



Key

Draft Order Limits

Existing Features

- Woodlands within and around the Site
- Hedgerow/Trees within and around the Site
- Waterbodies and Watercourses

Proposed Development Construction Elements

- Solar PV Modules
- Indicative Areas for Mitigation, Enhancement and/or Retained Agricultural Land

Interconnecting Cabling Corridors between Land Areas:

- Cable A-B
- Cable B-B
- Cable C-F
- Cable E-E
- Cable E-F

Cable Route Corridor Options to Creyke Beck Substation:

- Cable Route Option 1
- Cable Route Option 2
- Cable Route Mixed Option

Land Areas:

- Land Area A
- Land Area B
- Land Area C
- Land Area D
- Land Area E
- Land Area F

Coordinate System: WCS

Rev	Date	Description	Drn	Chk	App

Peartree Hill Solar

RWE

TITLE: Proposed Operational Phase Layout Plan

ID: Stage 2 Peartree NTS

0 0.5 1 1.5

Kilometers

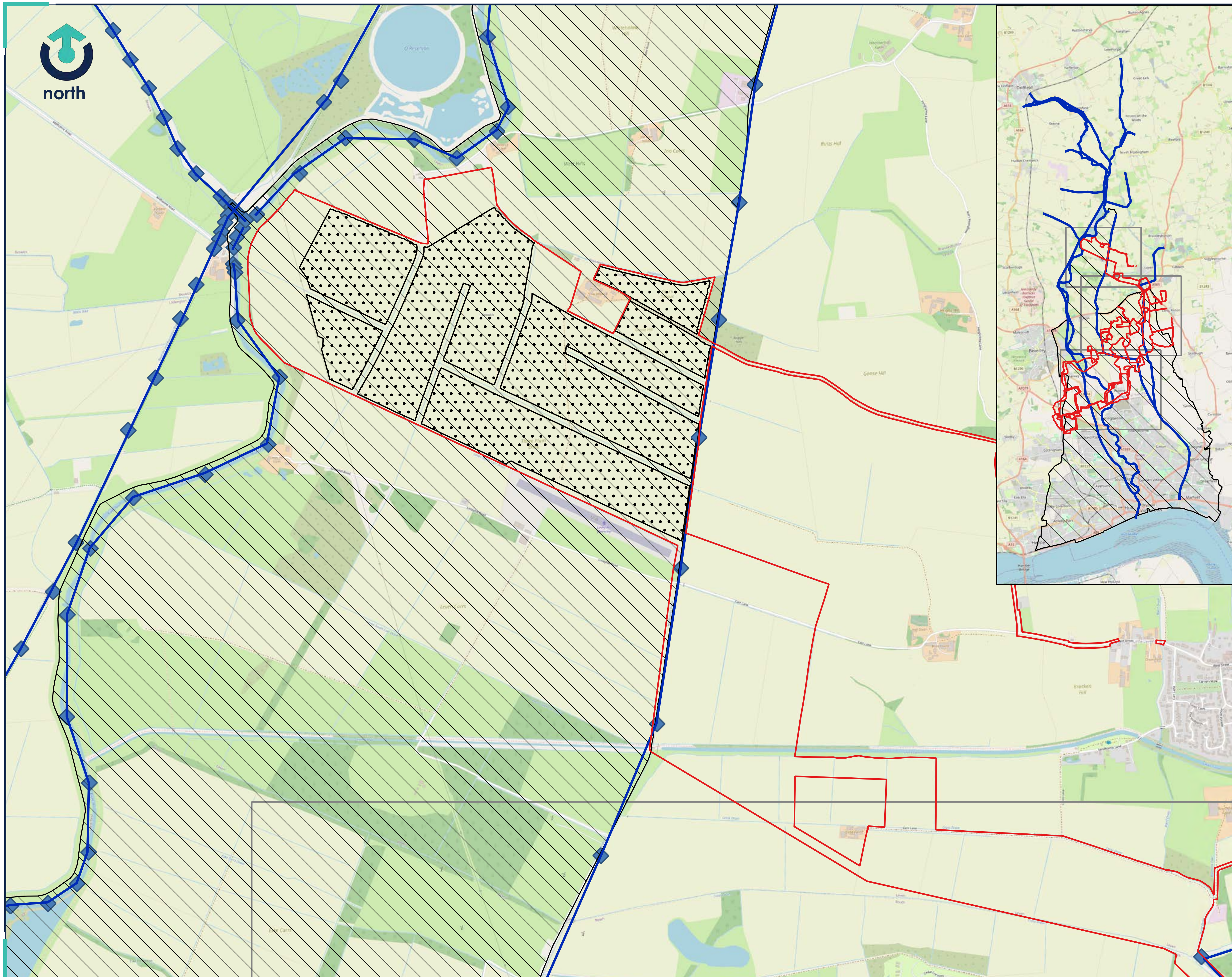
Scale:1:60,000 @ A4

N W E S

REV 00

APPENDIX B

Model Overview and Topography Drawings



Legend

Site Boundary	
Sensitive Infrastructure	
1D Nodes	
1d Watercourses	
2d Model Extent	

Notes

Beyond the 2D model extent the floodplain is modelled in 1D using reservoir units. Mapping outputs have not been generated for these areas as no development other than cabling are proposed within them.

Sensitive infrastructure areas encompass the coverage of solar panels, substations, inverters, battery storage etc. but do not include access or cable routes.

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-	SECOND ISSUE	AB	17.04.2024

STATUS: FOR INFORMATION

CLIENT: RWE

SITE: Peartree Hill Solar Farm

TITLE: Hydraulic Model Extent
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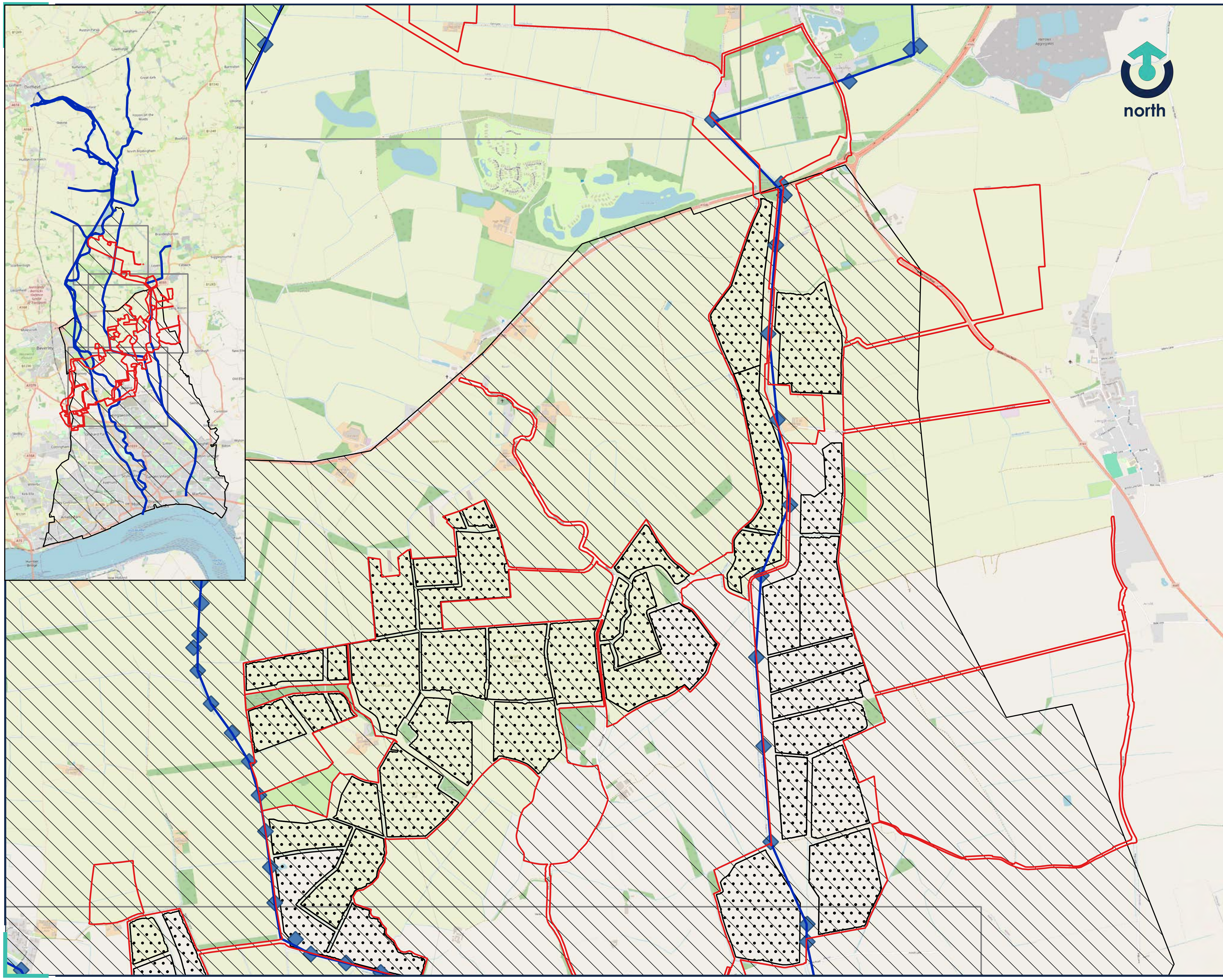

Legend

- Site Boundary
- Sensitive Infrastructure
- 1D Nodes
- 1d Watercourses
- 2d Model Extent

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