NORTH LINCOLNSHIRE GREEN ENERGY PARK

Planning Act 2008

Infrastructure Planning (Applications Prescribed Forms and Procedure) Regulations 2009

APFP Regulation 5(2)(a)

APFP Regulation 5(2)(e)

North Lincolnshire Green Energy Park

Volume 6

Environmental Statement

6.3.3 Annex 3: Flood Risk Assessment

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North Lincolnshire Green Energy Park

Flood Risk Assessment

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Abbreviations

Term	Definition
AEP	Annual Exceedance Probability
AGI	Above Ground Installation
CBMF	Concrete Block Manufacturing Facility
CC	Climate Change
CHP	Combined Heat and Power
CO2	Carbon Dioxide
DCO	Development Consent Order
EA	Environment Agency
ERF	Energy Recovery Facility
EV	Electric Vehicle
FRA	Flood Risk Assessment
FWS	Flood Warning Systems
DFE	Design Flood Event
DEM	Digital Elevation Model
DFE	Design Flood Event
DTM	Digital Terrain Model
H2	Hydrogen
ha	Hectare
HC	Higher Central
H++	H Plus Plus (Climate Change scenario)
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
m AOD	metres Above Ordnance Datum
NGR	National Grid Reference
NLGEP	North Lincolnshire Green Energy Park
NPPF	National Planning Policy Framework
NSIP	National Significant Infrastructure Project

PPG	Planning Practice Guidance
PRF	Plastic Recycling Facility
RHTF	Residue Handling and Treatment Facility
SFRA	Strategic Flood Risk Assessment
SGWMB	Scunthorpe & Gainsborough Water Management Board
SuDS	Sustainable Drainage Systems
SWDS	Surface Water Drainage Strategy
UE	Upper End
UKCP09	United Kingdom Climate Projection 2009
UKCP18	United Kingdom Climate Projection 2018

1 Executive Summary

1.1.1 This report is Annex 3 of the Environmental Statement for the North Lincolnshire Green Energy Park (NLGEP) ('the Project'). The following summarises the flood risk management strategy.

Table 1-1 Summary Findings

Subject	Findings
Site Description	The Application Land is located at land within and to the south of Flixborough Industrial Estate, to the west of Scunthorpe, North Lincolnshire. The Order Limits encompasses an area within and adjacent to Flixborough Port (RMS Trent Ports) on the east bank of the River Trent. The River Trent is tidally influenced in this location.
The Project	The Project is for an Energy Recovery Facility (ERF) that will be an industrial scale facility capable of recovering energy stored within waste products and associated development. The Project will have transport connectivity by road, rail, and river to sea via the River Trent and River Humber, with the latter two used for freight transport only.
Consultation	The Environment Agency, Lead Local Flood Authority and Scunthorpe & Gainsborough Water Management Board have been consulted to develop and agree the flood risk management strategy.
Flood risk management strategy	The following criteria forms the basis of the flood management strategy: • all development uses across the Site protected to the year 2065 • all development uses are required to function and operate during an extreme flood event. Flood risk should be low during either an overtopping or breach of flood defence • safe, dry access and egress to and from buildings; and • the Project should minimise increase in flood risk either by extent, depth, hazard or frequency to third parties in the surrounding area. The design flood event (DFE) has been identified as follows: • flood risk from the River Trent: ○ 1 in 200 year Tidal flood event in 2065 Upper End climate change projection combined with 1 in 2 year Fluvial flood event with 30% allowance for climate change. • flood risk from surface water overland runoff ○ discharge rates into existing ditch network restricted to existing greenfield runoff rates; and

	○ attenuation provided for the 1 in 100 year + 40% allowance for climate change rainfall event.
NPPF	The Project has been assessed as *Essential Infrastructure* according to the NPPF (other than the Visitor Centre as *Less Vulnerable*) and a sequential approach to the layout has been undertaken. A Sequential Test for the site selection has been undertaken (ref. Section 3.2). The Exception Test has been passed through meeting wider sustainability benefits and flood risk mitigation measures (ref. Section 6).
Existing flood risk	Fluvial & Tidal : the Application Land is currently protected during an extreme fluvial or tidal flood event. Due to climate change, in the future the risk increases to *High*.
	Surface Water & Sewers : Flood risk is *Very Low* to *Medium*.
	Groundwater : Flood risk is *Low*. Mitigation measures are required in the bunker hall.
	Artificial Sources : Flood risk is *Low*.
Proposed flood mitigation	To reduce the risk of flooding to the Project and surrounding areas the following has been proposed: • raise plot or building finished floor levels as well as key access routes above DFE level plus freeboard • provide culvert openings in the access road and size according to flow required • modify land levels west of access road and to the east of the site to reduce flows to offsite areas in the south and to the east • either new flood walls with raising of road levels along First Avenue; or new flood walls with a new flood gate installed at the end of the road; or a Flood Warning and Evacuation Management Plan put in place to manage the flood risk during a breach event to the industrial site north of First Avenue • Sitewide Flood Evacuation and Management Plan • tanking in the bunker hall to protect against groundwater seepage; and • Sustainable Drainage Systems (SuDS), including swales and detention basins.
Conclusion	With the proposed mitigation in place, the overall flood risk to the Project is *Low*. The impact of the Project to offsite locations is minimised through the proposed mitigation and is considered negligible.

2 Introduction

2.1 Background

2.1.1 This report has been prepared by Buro Happold on behalf of The North Lincolnshire Green Energy Park Limited (the Applicant) and is Annex 3 of the Environmental Statement (ES). The North Lincolnshire Green Energy Park (NLGEP) (the Project), located at Flixborough, North Lincolnshire, is a Nationally Significant Infrastructure Project (NSIP) with an Energy Recovery Facility (ERF) capable of converting up to 760,000 tonnes of non-recyclable waste into 95 MW of electricity and a carbon capture, utilisation and storage (CCUS) facility which will treat a proportion of the excess gasses released from the ERF to remove and store carbon dioxide (CO_2) prior to emission into the atmosphere.

2.1.2 This Flood Risk Assessment (FRA) has been carried out in accordance with the National Planning Policy Framework (NPPF) (2021) as well as requirements of Regulation 5(2)(e) of The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009. The purpose of this assessment is to assess and describe the impact of the Project in terms of flood risk. In order to comply with the NPPF, this FRA will identify the potential flood risks to the Project and demonstrate appropriate flood mitigation measures to ensure that the risk is acceptable for the level of development proposed and that the Project does not increase the flood risk elsewhere. An indicative surface water drainage strategy has been outlined in this report. Further details can be found in the Indicative Drainage Strategy (**Document Reference 6.3.5**)

2.2 Site Context

2.2.1 The Project is located in North Lincolnshire, north west of Scunthorpe and partly within the Flixborough Industrial Estate. The approximate National Grid Reference is NP 80146 47882. The village of Flixborough is to the east of the site, Scunthorpe to the south east and Amcott to the west across the river.

2.2.2 The Application Land – defined as the land within the Order Limits – consists mostly of drained agricultural land and includes an existing industrial port. It is bound to the west by the River Trent (a designated RAMSAR and SSSI), agriculture fields to the north, agriculture fields and farms to the east, and the B1216 and Phoenix Parkway to the south. The Order Limits wraps around the Flixborough Industrial Estate and includes an existing railway line located to the north. The River Trent flows fluvially from south to north, into the Humber Estuary approximately 7.5 km north of the site and is tidal at this location. The Project location is shown in Figure 2.1.

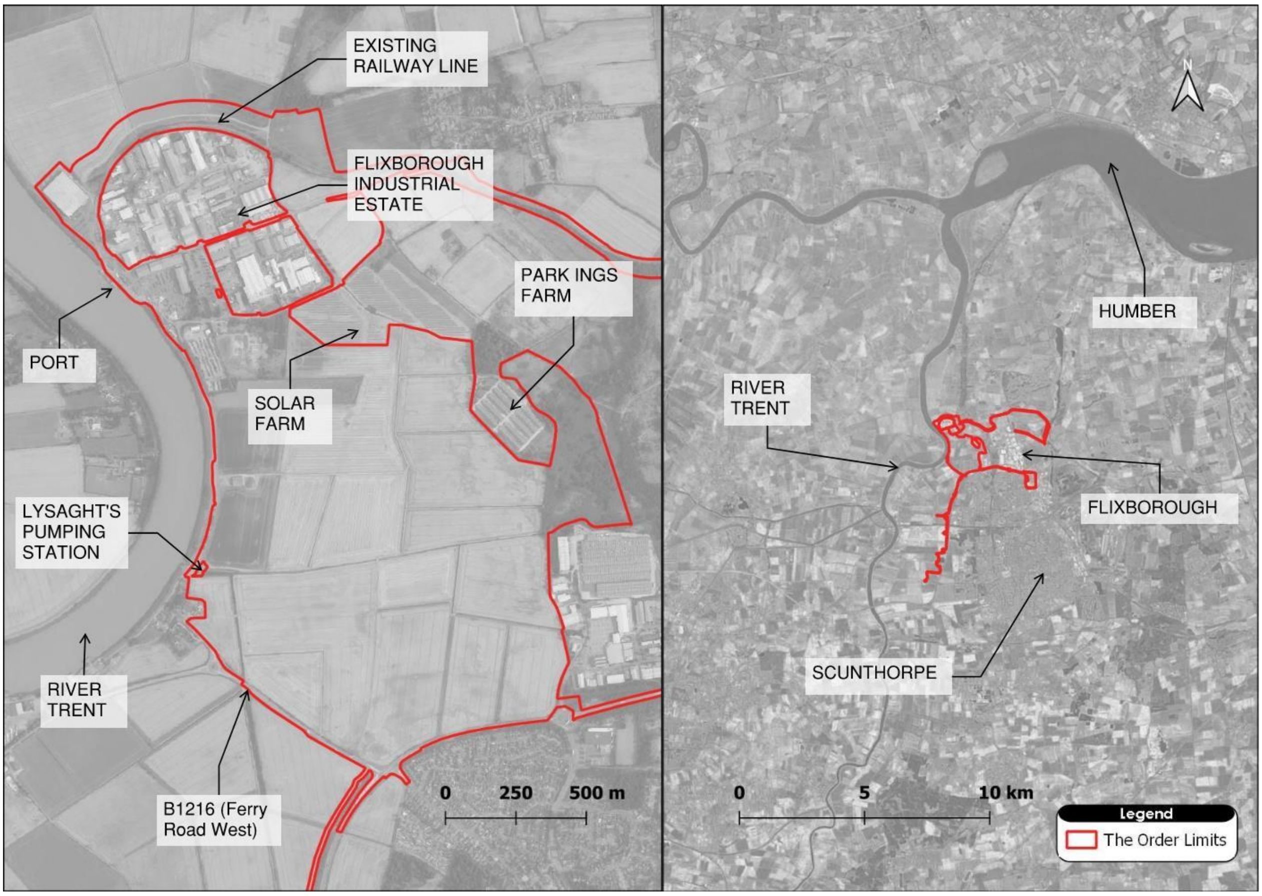


Figure 2.1 The Order Limits shown in red and key locations identified (Image courtesy of Ordnance Survey, © 2021 TomTom).

2.2.3 The topography at the Application Land varies, sloping down from north to south (between 7.8m AOD to 1.2m AOD), an area predominantly underlain by Estuarine Alluvium (clay, silt, sand & gravel). A localised depression within the Order Limits can be seen in the agricultural land dipping to approximately 0.41m AOD. A network of drainage ditches drain the fields to Lysaght's pumping station and discharge into the River Trent. Ground levels then drastically rise to above 30m AOD to the east at Lincoln Edge, a limestone escarpment. Figure 2.2 illustrates the change in topography at the Application Land.

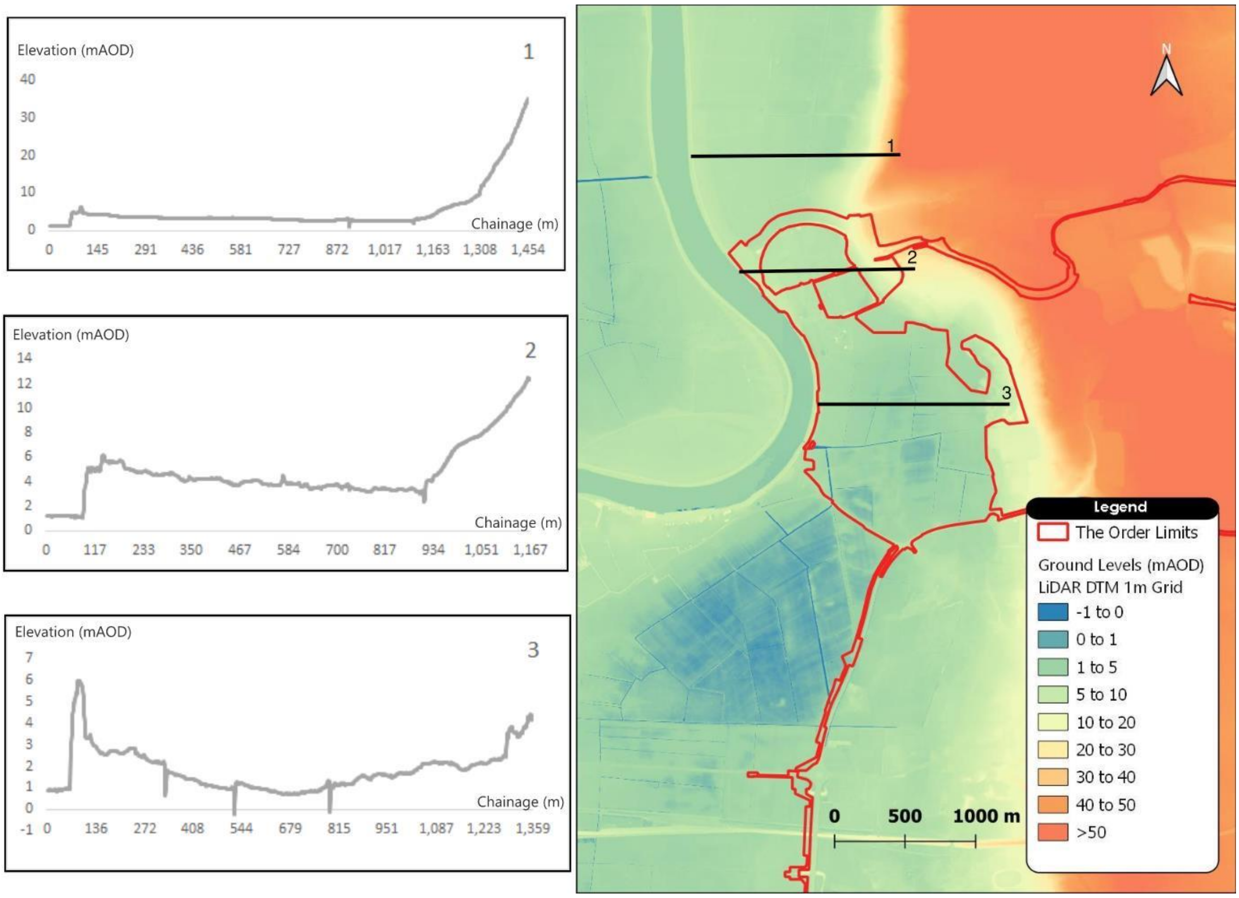


Figure 2.2 Topographic map and cross sections illustrating changes in topography in the vicinity of the Project (Contains public sector information licensed under the Open Government Licence v3.0).

2.3 The Project

2.3.1 The Project is a Nationally Significant Infrastructure Project (NSIP) with an Energy Recovery Facility (ERF) capable of converting up to 760,000 tonnes of non-recyclable waste into 95 MW of electricity and a carbon capture, utilisation and storage (CCUS) facility which will treat a proportion of the excess gasses released from the ERF to remove and store carbon dioxide (CO_2) prior to emission into the atmosphere. The design of the ERF and CCUS will also enable future connection to the Zero Carbon Humber pipeline, when this is consented and operational, to enable the possibility of full carbon capture in the future.

2.3.2 The NSIP incorporates a switchyard, to ensure that the power created can be exported to the National Grid or to local businesses, and a water treatment facility, to take water from the mains supply or recycled process water to remove impurities and make it suitable for use in the boilers, the CCUS facility, concrete block manufacture, hydrogen production and the maintenance of the water levels in the wetland area.

2.3.3 The Project will include the following Associated Development to support the operation of the NSIP:

- a bottom ash and flue gas residue handling and treatment facility (RHTF);
- a concrete block manufacturing facility (CBMF);
- a plastic recycling facility (PRF);
- a hydrogen production and storage facility;
- an electric vehicle (EV) and hydrogen (H_2) refuelling station;
- battery storage;
- a hydrogen and natural gas above ground installations (AGI);
- a new access road and parking;
- a gatehouse and visitor centre with elevated walkway;
- railway reinstatement works including, sidings at Dragonby, reinstatement and safety improvements to the 6km private railway spur, and the construction of a new railhead with sidings south of Flixborough Wharf;
- a northern and southern district heating and private wire network (DHPWN);

- habitat creation, landscaping and ecological mitigation, including green infrastructure and 65 acre wetland area;
- new public rights of way and cycle ways including footbridges;
- Sustainable Drainage Systems (SuDS) and flood defence; and
- utility constructions and diversions.

2.3.4 The Project will also include development in connection with the above works such as security gates, fencing, boundary treatment, lighting, hard and soft landscaping, surface and foul water treatment and drainage systems and CCTV.

2.3.5 The Project also includes temporary facilities required during the course of construction, including site establishment and preparation works, temporary construction laydown areas, contractor facilities, materials and plant storage, generators, concrete batching facilities, vehicle and cycle parking facilities, offices, staff welfare facilities, security fencing and gates, external lighting, roadways and haul routes, wheel wash facilities, and signage.

2.3.6 The overarching aim of the Project is to support the UK's transition to a low carbon economy as outlined in the Sixth Carbon Budget (December 2020), the national Ten Point Plan for a Green Industrial Revolution (November 2020) and the North Lincolnshire prospectus for a Green Future. It will do this by enabling circular resource strategies and low-carbon infrastructure to be deployed as an integral part of the design (for example by reprocessing ash, wastewater and carbon dioxide to manufacture concrete blocks and capturing and utilising waste-heat to supply local homes and businesses with heat via a district heating network).

2.3.7 The core elements of the project, known as the Energy Park, include the ERF; CO_2 capture, ash treatment and concrete block manufacturing, plastic recycling facility, visitor centre, hydrogen production and re-fuelling station).

2.3.8 Figure 2.3 shows the indicative Energy Park layout.

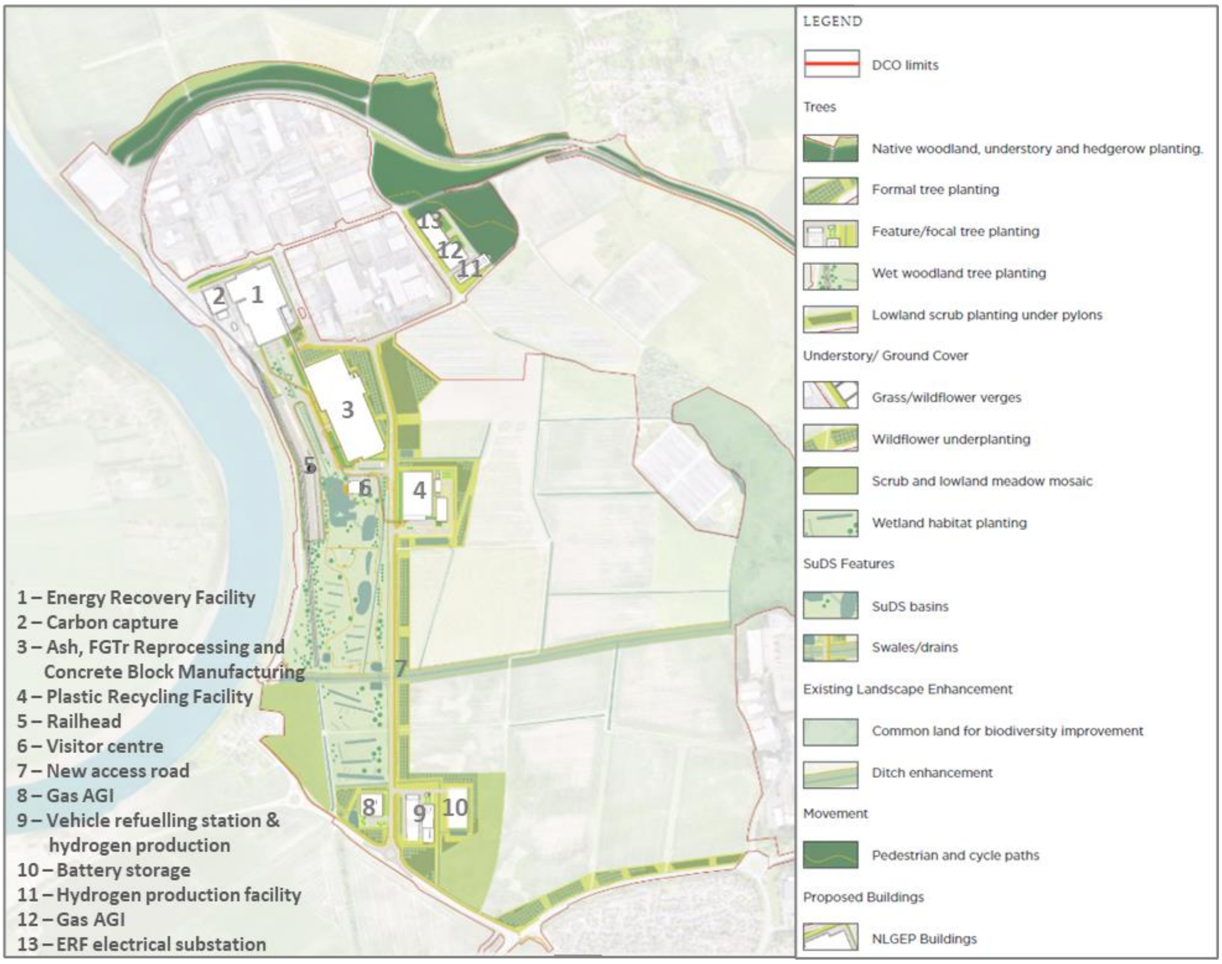


Figure 2.3 Indicative Energy Park (source: adapted from LDA Design, Illustrative Masterplan, December 2021)

2.4 Report Structure

2.4.1 This FRA is structured as follows:

2.4.2 **Section 3 Planning Context**: This section summarises the national, regional and local flood risk management guidelines that apply to the Project, as well as consultation undertaken with key stakeholders. It considers the National Planning Policy Framework (NPPF) (July 2021) and sets out how the framework applies to the Project, and how the Project must satisfy the NPPF Exception Test.

2.4.3 **Section 4 Flood Risk Methodology & Criteria**: This section summarises the approach to flood risk appraisal that is followed in the FRA. It looks at the sources of flood risk that are reviewed, the methodology followed as well as the core principles and design criteria applied.

2.4.4 **Section 5 Flood Risk Appraisal & Management**: This section assesses the risk from tidal, fluvial, surface water, sewer, groundwater, reservoir and artificial sources of flooding to the Project taking into account the approach, core principles and design criteria outlined in Sections 3 and 4. The assessment considers the baseline risk to the site, the impact the Project could have then proceeds to identify the flood mitigation measures required to make the Project safe for users and surrounding areas for the development lifetime. The section then describes the residual flood risk post mitigation.

2.4.5 **Section 6: Exception Test**: This section summarises how the Project satisfies the Exception Test.

2.4.6 **Section 7: Summary and Conclusion**: This section summarises the flood risk to the Project and the proposed flood risk mitigation strategy that has been developed in order to satisfy the NPPF.

3 Planning Context

3.1 Overview

3.1.1 Key policy and guidance used to inform the FRA are listed below:

- Ministry of Housing, Communities & Local Government (MHCLG), National Planning Policy Framework (NPPF) (Updated July 2021);
- MHCLG NPPF Planning Practice Guidance (PPG): Flood risk and coastal change (August 2021);
- Department of Energy and Climate Change, Overarching National Policy Statement for Energy (EN-1) (July 2011);
- Department for Business, Energy & Industrial Strategy, Draft Overarching National Policy Statement for Energy (EN-1) (September 2021);
- Department of Energy and Climate Change, National Policy Statement for Renewable Energy Infrastructure (EN-3) (July 2011);
- Environment Agency (EA), Flood risk assessments: climate change allowances (October 2021);
- EA & Defra, Understanding the risks, empowering communities, building resilience: The national flood and coastal erosion risk management strategy for England (2011);
- EA, National Flood and Coastal Erosion Risk Management (FCERM) strategy for England 2011, (July 2020);
- EA, Revised National Flood and Coastal Erosion Risk Management strategy for England Policy Paper (September 2020);
- EA and FCERM Research & Development Programme, Accounting for residual uncertainty: an update to the fluvial freeboard guide Report – SC120014 (February 2021);
- EA Humber 2100+ A New Strategy Consultation Story Map (2020);
- EA Humber River Basin District River Basin Management Plan (February 2016, updated June 2018);
- EA Humber River Basin District Flood Risk Management Plan (HRBD FRMP) 2015 – 2021 (March 2016);

- EA River Trent Catchment Flood Management Plan (December 2010);
- North Lincolnshire Strategic Flood Risk Assessment (SFRA) (Nov 2011) & Interactive Mapping Tool;
- North Lincolnshire Preliminary Flood Risk Assessment (June 2011, updated December 2017);
- North Lincolnshire Local Development Framework (NLLDF):
  - Core Strategy (June 2011)
  - Sequential Test of the Flood Risk of Potential Development Sites (April 2014)
  - Lincolnshire Lakes Area Action Plan (LLAAP) (May 2016)
  - Housing and Employment Land Allocations Development Plan Document (adopted March 2016)
  - North Lincolnshire Council SuDS and Flood Risk Guidance Document (April 2017)
  - Lincolnshire Lakes Area Action Plan (LLAAP) (May 2016)
- CIRIA C753 'The SuDS Manual' (2015); and
- DEFRA Technical Standards for Sustainable Drainage Systems (TSSuDS) (March 2015).

3.2 National Policy

National Planning Policy Framework

Flood Zone Assessment

3.2.2 The NPPF aims to avoid inappropriate development in areas at highest risk of flooding. The Planning Practice Guidance (PPG) to the NPPF contains a series of tables that help identify the risk of flooding to a development:

- Table 1 defines four Flood Zones based on the annual probability of river or sea flooding;
- Table 2 identifies specific land use types for each of the five flood risk vulnerability classifications (Essential Infrastructure, Highly Vulnerable, More Vulnerable, Less Vulnerable and Water Compatible Uses). For example, office buildings are classified as Less Vulnerable; and

- Table 3 identifies where development is appropriate for each flood risk vulnerability classification and whether the Exception Test is required.

3.2.3 The Flood Zones defined in the NPPF are given in Table 3-1 (Note: The Flood Zones shown on the Environment Agency's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding).

Table 3-1 Flood Zone descriptions (NPPF, 2021).

Flood Zone	Annual Exceedance Probability of Flooding from Rivers or the Sea	Probability
1	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3).	Low
2	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding. (Land shown in light blue on the Flood Map).	Medium
3a	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map).	High
3b	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map).	The Functional Floodplain

Sequential Test

3.2.4 The Sequential Test is used to achieve the aims of NPPF by steering development of particular land use categories towards areas with the most appropriate probability of flooding. There are three possible outcomes of the Sequential Test:

- development is deemed acceptable: the proposed development has passed the Sequential Test;

- Exception Test required: the proposed development may be permitted if the Exception Test can be satisfied, demonstrated through a site-specific flood risk assessment; or
- development is not deemed acceptable: the proposed development has failed the Sequential Test and is not permitted.

3.2.5 The NPPF guidance states that a Sequential Test is required if both:

- the development is in Flood Zone 2 or 3; and
- no sequential testing of the site allocations has been carried out in the development plan, or the proposed use of the site is not in accordance with the development plan.

3.2.6 In determining an application for development consent, Paragraph 5.7.9 of EN-1 states that decision takers should be satisfied that where relevant:

- the application is supported by an appropriate FRA;
- the Sequential Test has been applied as part of site selection;
- a sequential approach has been applied at the site level to minimise risk by directing the most vulnerable uses to areas of lowest flood risk;
- the proposal is in line with any relevant national and local flood risk management strategy;
- priority has been given to the use of sustainable drainage systems (SuDs); and
- in flood risk areas the project is appropriately flood resilient and resistant, including safe access and escape routes where required, and that any residual risk can be safely managed over the lifetime of the development.

3.2.7 Likewise EN-3 Paragraph 2.3.3 states that:

- EfW generating stations may also require significant water resources, but are less likely to be proposed for coastal sites. For these proposals, applicants should consider, in particular, how the plant will be resilient to:
    - increased risk of flooding; and
    - increased risk of drought affecting river flows.

3.2.8 The Applicant has undertaken a sequential approach to site selection in terms of flood risk, as required by the NPPF and paragraph 5.7.13 of NPS EN-1 which states:

"Preference should be given to locating projects in Flood Zone 1 in England or Zone A in Wales. If there is no reasonably available site in Flood Zone 1 or Zone A, then projects can be located in Flood Zone 2 or Zone B. If there is no reasonably available site in Flood Zones 1 or 2 or Zones A & B, then nationally significant energy infrastructure projects can be located in Flood Zone 3 or Zone C subject to the Exception Test."

3.2.9 The Project Site falls predominantly within Flood Zone 3, benefiting from flood defences. There are also two small parts of the Application Land which fall within Flood Zone 1 - Zone J, the Northern District Heat and Private Wire Network and Zone K, Railway Reinstatement Land (please refer to Figure 4.2 and Figure 5.1).

3.2.10 The site for the ERF and Carbon Capture Utilisation and Storage Facility, and a large part of the residue handling and treatment facility and concrete block manufacturing facility, originally fell within a committed industrial site (CIN10) in the North Lincolnshire Local Plan 2003. This allocation was superseded by the Housing and Employment Allocations DPD (March 2016) on the basis that it was "part of an established employment area". The emerging Local Plan (Preferred Options, 2020), includes the same broad area within an "Existing Employment Area" (see Figure 3.1) which are safeguarded for employment uses. It is important therefore from a flood risk perspective that a large proportion of the principal development is located on an area that has been allocated for development. A Strategic Flood Risk Assessment (SFRA) was carried out for the emerging Local Plan, although it notes that applications on the Flixborough Industrial Estate will need to be fully assessed on a site specific basis, given that the Environment Agency had expressed a lack of confidence in the outputs of the hydraulic model at this point, at the time that the SFRA was published (November 2021).

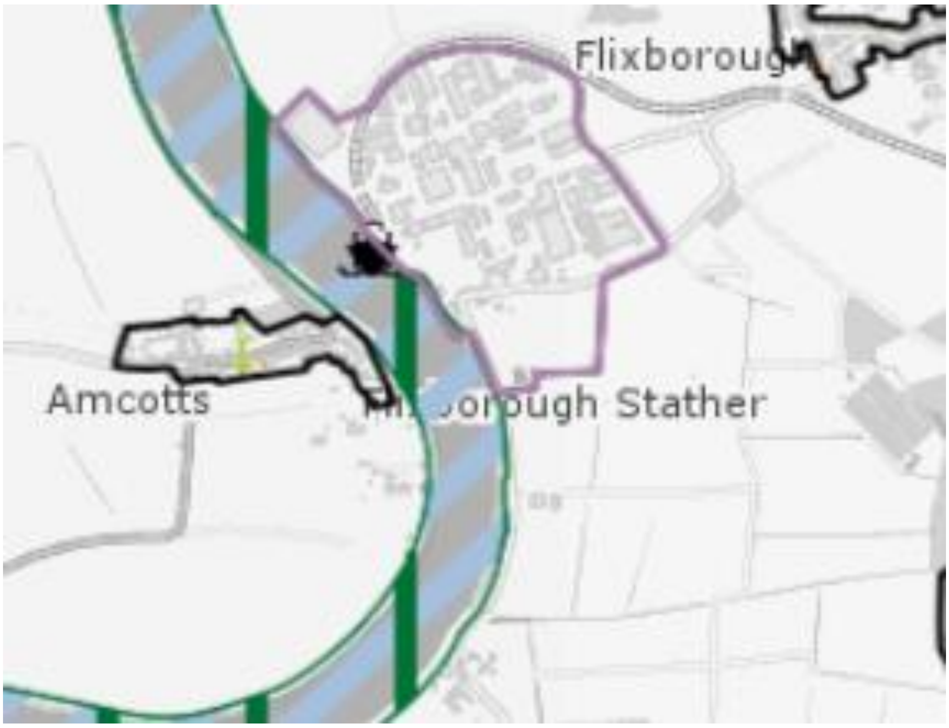


Figure 3.1 Existing Employment Area boundary from Preferred Options Local Plan (2020)

3.2.11 The part of the Site to the south of the Flixborough Industrial Estate falls within the Lincolnshire Lakes Area Action Plan (AAP) (2016) – see boundary on Figure 3.2.

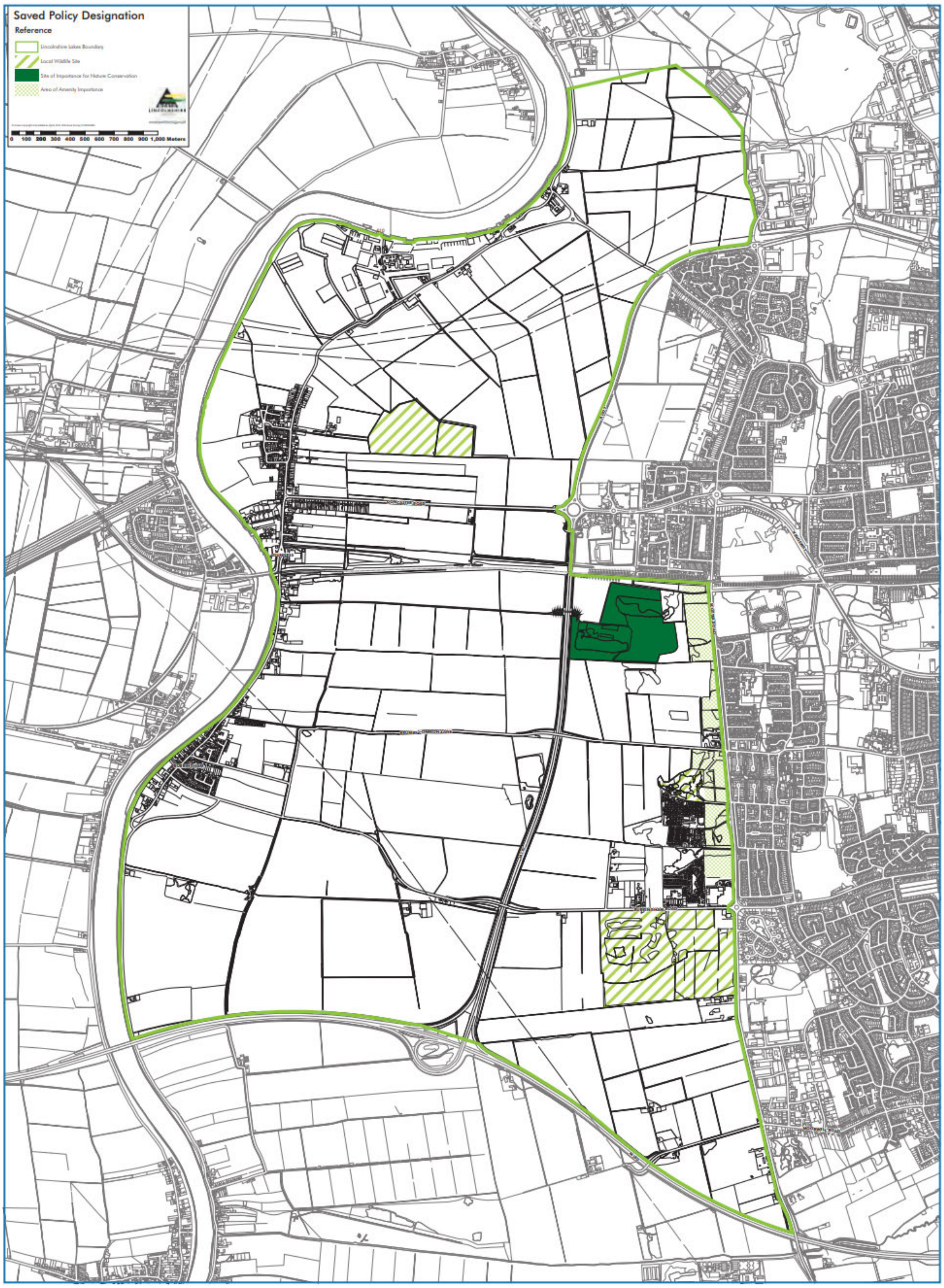


Figure 3.2 Lincolnshire Lakes AAP Boundary

3.2.12 The AAP states with regard to flood risk (paragraph 3.10):

"In line with national policy, development of land at the highest risk of flooding should be avoided as far as possible, with a sequential approach taken to development. A strategic and sustainable solution to managing surface water run-off and drainage must form part of the AAP proposals."

3.2.13 It goes on to state (paragraph 4.75):

"The Council assessed their Core Strategy in line with the then required PPS25 Sequential Testing. The Council's 'Sequential Test of the Flood Risk of Potential Development Sites Final Report' (2014) concludes that only a limited supply of land is available for development in Flood Zone 1 and that in order to meet housing needs, there is a requirement for development in the Lincolnshire Lakes area."

3.2.14 The AAP then proposes a flood risk mitigation strategy (Policy F1) which requires each applicant to provide a fully considered flood mitigation solution within a Flood Risk Assessment (FRA), following the principles established in the AAP.

3.2.15 The area to the south of the Flixborough Industrial Estate has therefore been seen as acceptable for development, through the Local Plan process, subject to detailed flood mitigation measures being applied.

3.2.16 Notwithstanding this, the application of the Sequential Test and Exception Test has been considered on a site-specific basis.

3.2.17 As stated in Chapter 3, section 9.4, of the Environmental Statement (**Document Reference 6.2.3**) the Applicant initially undertook a commercial site finding exercise for a suitable location for an ERF within the UK. Factors influencing commercial viability included the size of the site, the availability of refuse derived fuel sources, availability of a suitable grid connection, potential users of heat and power in the vicinity, proximity to existing ERFs, amount of waste within the region going to landfill, transport links, potential expansion area to include future best available techniques such as carbon capture and the willingness of landowners to enter into commercial negotiations. In this context, it should be noted that there are a limited number of sites that would be suitable for an ERF.

3.2.18 This exercise identified that there was a need for an ERF in the East Midlands and Yorkshire & Humber Region, which has the highest proportion of waste going to export or landfill in the UK.

3.2.19 The shortlisting exercise then identified only two potentially suitable and viable sites within this region, the British Steel Site and Scunthorpe and Flixborough Wharf. There are no other potentially suitable or viable sites within the region having regard to the factors identified above. In particular, accessibility/potential accessibility by sustainable modes was a key factor, with accessibility by river and rail being a key benefit of the Flixborough site.

3.2.20 The British Steel Site in Scunthorpe is located in Flood Zone 1, according to the Environment Agency Flood Zone mapping. It is therefore preferable from the perspective of the sequential test, however, as noted in Chapter 3 of the Environmental Statement, the landowners of the British Steel Site confirmed that the site was not available and therefore the Site is not considered to be reasonably available in the context of the policy test in EN-1.

3.2.21 Although the Project Site is located predominantly in Flood Zone 3, it benefits from flood defences and its riverside location, as explained above, was also a key feature in its selection, in enabling potential access from the river, through the existing Wharf.

3.2.22 Part of the site lies within the Flixborough Industrial Estate which is an existing employment site within North Lincolnshire Council's Local Development Framework – Housing and Employment Land Allocations DPD[1]. Flixborough Industrial Estate remains an existing employment site within the Council's emerging Local Plan (Publication Draft)[2].

Exception Test

3.2.23 The Exception Test requirements as outlined in the NPPF and paragraph 5.7.16 of NPS EN-1 is used to demonstrate that the flood risk to people and property is managed, allowing necessary development to proceed where suitable sites with a lower risk of flooding are not available. The NPS EN-1 exception test criterion includes that 'the project should be on developable, previously developed land or, if it is not on previously developed land, that there are no reasonable alternative sites on developable previously developed land subject to any exceptions set out in the technology-specific NPSs'. Through the Exception Test, development may be permitted if it can be demonstrated that:

[1] https://www.northlincs.gov.uk/planning-and-environment/planning-policy-local-development-framework/#1591179281307-937c5def-58bf

[2] https://localplan.northlincs.gov.uk/stages/4

- the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and
- the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

3.2.24 The Exception Test has been carried out and is presented in Section 6 of this report. A sequential approach to the design layout has been undertaken to minimise the impact of flood risk to and from the site. Further details can be found in Section 6 and Appendix A.

Flood Risk Vulnerability Classification

3.2.25 The PPG of the NPPF outlines the Vulnerability Classifications of land use types and building uses. The proposed Vulnerability Classification for the development is summarised and justified in Table 3-2:

Table 3-2 Proposed Development vulnerability classification

Land Use	Vulnerability Classification	Description from the NPPF
Energy Recovery Facility (inc. CO_2 plant, CBMF, PRF, RHTF)	Essential Infrastructure	• Essential transport infrastructure (including mass evacuation routes) that has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood.

3.2.26 The PPG of the NPPF outlines the Vulnerability Classifications of land use types and building uses. The Project comprises critical infrastructure that is required to remain operational during a flood event in order to continue producing energy and has therefore been classified as Essential Infrastructure for this assessment. Only the Visitor Centre is classified as Less Vulnerable.

3.2.27 The NPPF outlines requirements for the Exception Test according to flood risk vulnerability and flood zone compatibility. Table 3-3 outlines the compatibility, highlighting the applicability to the proposed development in green.

3.2.28 Table 3-3 illustrates that the Exception Test is required to support the proposed development.

Table 3-3 NPPF flood risk vulnerability and Flood Zone compatibility (the Project classification shown in green).

Flood Zone	Flood Risk Vulnerability Classification				
	Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	✓	Exception Test Required	✓	✓
Zone 3a	Exception Test Required	✓	×	Exception Test Required	✓
Zone 3b (Functional Floodplain)	Exception Test Required	✓	×	×	×

✓ = *Development is appropriate*

× = *Development should not be permitted*

Climate Change

3.2.29 In February 2016, the EA updated their guidance[3] with regard to the application of climate change (CC) allowances for peak rainfall intensities, peak river flows, sea level rise, offshore wind speeds and extreme wave heights, based on UKCP09 climate change projections. In December 2019 and July 2020, the EA provided updated guidance to sea level rise and the H++scenario, based on the UKCP18 climate change projections and in July 2021 updated the peak river flow allowances based on management catchments instead of river basin districts based on the UKCP18 climate change projections and the guidance on how to apply peak river flow allowances.

3.2.30 Allowances for the predicted effects of climate change should be taken into account when preparing site-specific FRAs. The guidance published by the EA to support the NPPF contains sensitivity ranges that are recommended to be applied. The guidance further notes that the following considerations be made in order to decide which allowances are used to inform the flood risk management strategy for a development:

- likely depth, speed and extent of flooding for each allowance of climate change over time considering the allowances for the relevant epoch (2020s, 2050s and 2080s);

[3] Environment Agency, (2016). *Flood risk assessments: climate change allowances*. [online] Available at: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances [Accessed 10/10/21].

- vulnerability of the proposed development types or land use allocations to flooding;
- 'built in' resilience measures used, for example, raised floor levels; and
- capacity or space in the development to include additional resilience measures in the future, using a 'manage adaptive' approach.

3.2.31 The CC values recommended to be adopted for peak rainfall, peak river flow, and sea level rise are summarised in Table 3-4, Table 3-5, and Table 3-7 respectively. The Higher Central projections are those that are surpassed by only 30% of the projection scenarios. The Upper End projections are those that are surpassed by only 5% of projection scenarios. The H++ scenarios are climate change projections designed to explore the high-end plausible future sea level rise should sea level rise exceed model predictions.

3.2.32 The estimated Project life is between 25 – 35 years. Based on an operation start date around 2028 plus a 2-year construction/operation programme contingency, the climate change projected for up to 2065 has been used for this assessment.

3.2.33 For peak rainfall, it is recommended by the EA that the Upper End allowances are assessed in order to understand the impact on Essential Infrastructure. The Indicative Drainage Strategy (**Document Reference 6.3.5**) has made an allowance for a 40% increase in peak rainfall intensity as this Upper End allowance represents the more conservative scenario.

Table 3-4 EA guidance on peak rainfall intensity allowance in small and urban catchments

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total Potential change anticipated for the '2050s' (2040 to 2069)	Total Potential change anticipated for the '2080s' (2070 to 2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

3.2.34 Guidance on future changes in peak flow was updated by the EA in July 2021. Table 3-5 and Table 3-6 show the changes in guidance. For Essential Infrastructure the Upper End category (30%) was recommended prior to the change, with a sensitivity check against the H++ category (35%). The latest guidance indicates the Higher Central category (23%) should be used and sensitivity check against the Upper End category (38%). This FRA is based on the recommended EA guidance pre-July 2021 (Table 3-5). The differences in peak flows between the different guidance are considered negligible for the purpose of this study.

Table 3-5 EA guidance on peak river flow allowances by river basin district, shown for Humber basin, pre July 2021.

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total Potential change anticipated for the '2050s' (2040 to 2069)	Total Potential change anticipated for the '2080s' (2070 to 2115)
H++	20%	35%	65%
Upper End	20%	30%	50%
Higher Central	15%	20%	30%
Central	10%	15%	20%

Table 3-6 EA guidance on peak river flow allowances shown for Lower Trent and Erewash Management Catchment, July 2021.

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total Potential change anticipated for the '2050s' (2040 to 2069)	Total Potential change anticipated for the '2080s' (2070 to 2115)
Upper End	29%	38%	62%
Higher Central	18%	23%	39%
Central	13%	17%	29%

3.2.35 As the River Trent is tidal at the location of the Application Land, climate change will also increase the risk of flooding from extreme tidal events. The government provides a regional allowance for each epoch or time frame for sea level rise, as given in Table 3-7. The EA has indicated that the Upper End allowances should be assessed, and the H++ allowances should be sensitivity tested to understand the residual risk to the Project.

Table 3-7 EA guidance on sea level rise (mm/year)

Area of England	Climate Change Scenario	EA Guidance (UKCP18) – Sea Level Rise (mm/yr)			
		2000 - 2035	2036 - 2065	2066 - 2095	2096 - 2125
Humber	Higher Central	5.5	8.4	11.1	12.4
	Upper End	6.7	11.0	15.3	17.6
	H++	6.0	12.5	24.0	33.0

3.3 Regional Policy

Humber River Basin District (HRBD) Flood Risk Management Plan (FRMP)

3.3.2 The HRBD FRMP outlines the characteristics of the Humber River Basin District and summarises the key considerations regarding flood risk within the wider catchment. It notes the responsibilities of the national and local stakeholders regarding flood risk and outlines existing measures in place to manage flood risk.

3.4 Local Policy

North and North East Lincolnshire Strategic Flood Risk Assessment (SFRA)

3.4.2 Local authorities are required to carry out a SFRA that can be used by developers as guidance on the authority's approach to avoiding, reducing and managing flood risk.

3.4.3 The North and North East Lincolnshire SFRA considered the risk of flooding from the following sources:

- tidal flooding from the sea;
- fluvial flooding from rivers;
- surface water;
- sewers;
- groundwater; and
- artificial sources.

North Lincolnshire Local Development Framework (NLLDF)

3.4.4 The NLLDF represents a collection of Development Plan Documents (DPDs) that set out planning policy for the local area, the key documents of which are listed in Section 3.1. Some of the key considerations extracted from the documents, and used to inform this assessment, are as follows:

Core Strategy (2011)

- Sequential Test should be undertaken in accordance with the NPPF to ensure that no alternative, suitable sites are available;
- All development should meet the highest possible flood risk management standards including the implementation of sustainable drainage systems, where practicable;
- The North and North East Lincolnshire SFRA Review and any subsequent reviews should be used as a basis for all FRAs;
- FRAs should demonstrate that development should positively manage flood risk, and it is important not to sterilise high flood risk areas by prohibiting necessary sustainable development; and
- No development should be proposed in the functional floodplain.

Lincolnshire Lakes Area Action Plan (2016)

3.4.5 The flood risk mitigation measures identified to support the Lincolnshire Lakes development are:

- localised raising of the River Trent right bank flood defences;
- raising and maintaining the River Trent right bank defences to climate change standards;
- improving flood conveyance for improved dynamic storage across the site;
- major ground raising across the site;
- adoption of flood resilient measures across the site; and
- a secondary flood bund between the River Trent defences and the site.

3.4.6 The level of the Project should be set at a minimum of the 0.5% storm event + CC allowances, plus a 300mm freeboard. It notes that the proposed levels should be checked against the 0.1% event.

SuDS and Flood Risk Guidance Document (2017)

- this outlines a Sustainable Drainage Systems (SuDS) selection guide according to the scale of development
- proposed maintenance plan with frequencies related to maintenance operations activities
- additional local requirements with regard to consultation, infiltration, storage, and betterment requirements, as follows:
  - strong recommendation to seek pre-application advice from the NLC flood risk and drainage team;
  - SuDS are required for all developments;
  - no water should be stored above ground up to and including the 1 in 100 year event unless stored in a SuDS component;
  - surface water runoff should be limited to greenfield runoff rate;
  - storage components should not be constructed in private land;
  - infiltration should only be viable for areas where the infiltration rate of the soils are above 1 x 10-6 m/s, however filter strips etc. can be used to treat runoff and convey surface water in conjunction with other SuDS components;
  - infiltration testing should be undertaken over a period of time, preferably over various seasons to obtain a range of infiltration rates;
  - it is not acceptable to use the roads as flood conduits, formal overland routes should be formed from SuDS techniques if required;
  - the level of betterment will be considered on a site by site basis for all brownfield sites; and
  - design calculations should be undertaken with industry accepted programs e.g. MicroDrainage. The critical storm period should always be submitted.

3.5 Consultation

Environment Agency

3.5.2 The EA has been consulted on an ongoing basis throughout the design development of the Project, in order that the proposals align with EA requirements. Five meetings have been undertaken with the EA, and the flood management strategy agreed with updated modelling results and proposals shared for comment. The meeting minutes and comments are summarised in Table 3-8.

3.5.3 During the meetings, the flood risk management strategy and design criteria presented in this FRA was developed and agreed with the EA, who also advised on the most suitable data and hydraulic flood models on which to base the assessment on (detailed in Section 4.3). The EA confirmed that there are no known schemes happening or proposed in the surrounding area that may impact on the Project or that would need to be considered as part of this assessment.

Table 3-8 Summary of key points raised during consultation with the Environment Agency

Date	EA Key Comments	Buro Happold Action
Meeting 5th August 2020	• An introduction to the Order Limits and Project made. • The EA has a hydraulic flood model for the Application Land area which is the 2015 Tidal Trent model. This model is planned to be updated in the next couple of years to include the latest climate change guidance. • The EA is aware that North Lincolnshire Council have a model that was created more recently (NLC 2017) that included the 2016 updated climate change guidance. It also includes updates to flood defences that were constructed as part of the Lincolnshire Lakes scheme (immediately south of the Application Land). • It is anticipated that the updated EA Humber Tidal model will be complete in October/November 2020. • The EA advised that modelling undertaken for assessing the Project should include the tidal boundary as extracted from the Humber Tidal model when it is made available. • Design levels should be based on the vulnerability of the land use being proposed. Safe access and egress should be based on the same event as used for the site.	• Buro Happold requested the NLC Tidal Trent Lincolnshire Lakes 2017 model from NLC to use as a basis of the assessment. A review of the model was undertaken updated to be site-specific. Sea level rise for the development lifetime was applied to the tidal boundary. • Different development layout options were tested to find the layout that had the least impact on flood risk to other areas.
Meeting 27th November 2020	• EA specified that the following flood events should be modelled: o Design Flood Event will be the extreme tidal event including climate change for the lifetime of the development. o Residual risk should also be assessed including breach in the existing embankment where key flood mechanisms identified and breach in any proposed embankments. o H++ tidal event should be used as a sensitivity test. o EA Humber model should be used to update the tidal boundary in the NLC model when made available.	• Buro Happold modelled the events agreed to inform the flood risk management strategy. Described further in Section 4.3. • Buro Happold tested different flood mitigation measures to reduce impact to others.

Date	EA Key Comments	Buro Happold Action
	• The EA asked that the FRA should make clear those areas that see an increase in flood risk (by extent, depth, frequency or hazard) due to the proposals and identify the receptors (land uses). • The EA agreed with the proposed flood vulnerability classifications in principle, although it is the Local Authority who agree the vulnerability classifications for a development. • The EA confirmed that the NLC 2017 model has been approved by the EA and is suitable for the purpose of the Project assessment. • The EA noted that there are plans to review the condition of the existing defences over the next few months.	
Meeting 2nd March 2021	• The EA noted that standard freeboard suggested by the EA is 600mm but that reduced freeboard can be acceptable if justification provided, such as through the proposed application of the EA Uncertainty Allowance guidance. • The EA advised that ownership and maintenance responsibilities for any proposed flood mitigation measures are outlined in the FRA, and that indicative details of measures is acceptable for the planning application stage. • Flood gates were agreed as a potential form of flood mitigation where re-grading land levels was not feasible. However, the impact of the flood gates being left open should be assessed. • Post meeting, the EA Humber hydraulic flood model was completed and made available to Buro Happold. • EA confirmed that the extreme fluvial event did not need to be hydraulically modelled and used for the assessment of the Project, because the extreme tidal event is considered more relevant for the Project.	• The Project flood model was updated to incorporate the tidal data extracted from the EA Humber model that includes the most recent guidance on sea level rise. • All scenarios re-tested to check whether proposed flood mitigation strategy remained effective or whether new measures were required.

Date	EA Key Comments	Buro Happold Action
Meeting 22nd April 2021	• The EA agreed in principle the updates made to the hydraulic modelling and the flood risk management strategy presented. • The EA indicated that a review of the hydraulic model will be required and that this should ideally be completed before the DCO submission.	• The updated strategy was used to inform the Draft FRA.
Meeting 26th August 2021	• Discussion regarding updates to the flood modelling since the PEIR submission, including updates to the baseline model, such as amending attributes to the B1216 culvert based on survey data and incorporation of new flood mitigation measure to include reprofiling of landscape rather than changes to existing culvert structure. • EA confirmed that the latest updates in climate change guidance for peak river flow (July 2021) did not need to be included in the assessment due to tidal flooding being the main risk to the site. • Different flood mitigation options around the port during the breach scenario at the port, including flood warning and evacuation were discussed and EA confirmed that the different options can be included in the FRA. • Post meeting (03-12-21), EA completed review of the NLGEP 2021 hydraulic flood model and confirmed it fit-for-purpose, approving its use to support the FRA.	• Updates to the modelling used to inform this FRA as described in Section 5.
Email 3rd December 2021	• Letter from EA confirming completed review of the hydraulic flood model and considered fit for purpose.	• No action required.

Lead Local Flood Authority

3.5.4 The LLFA, North Lincolnshire Council, was met with in May 2021 and confirmed the following:

- rainfall intensity of 40% should be used for assessing climate change;
- stormwater attenuation should be provided for the 1 in 100 year + CC storm event; and
- no further restriction for the reinstated railway catchment will be required and it will maintain the existing strategy repairing or replacing the drainage that is not in acceptable condition.

Water Management Board

3.5.5 The Scunthorpe & Gainsborough Water Management Board (SGWMB) was consulted on 21 October 2020 and met with on 10th May 2021 and advised the following with regard to surface water drainage:

- discharge to any watercourse must be restricted to the greenfield runoff rate 1.4 l/s/ha; and
- any changes to watercourses, ditches, or drainage channels, requires approval from the SGWMB.

3.5.6 In a following meeting held 24th May, SGWMB provided further information relating to the Neap House Drain and the existing B1216 culvert (surveyed drawings provided to Buro Happold post meeting). They also advised that, when developing the flood mitigation strategy, changes to existing drainage ditches and hydraulic structures should be avoided.

3.6 Permits & Licenses

3.6.1 Under the Environmental Permitting (England and Wales) Regulations 2016, any permanent or temporary works in, over or under a designated main river will require an Environmental Permit for Flood Risk Activities from the Environment Agency.

3.6.2 Any permanent or temporary works within 16 metres of the top of bank of a designated tidal main river, or landward toe of a flood defence may require an Environmental Permit for Flood Risk Activities from the Environment Agency. In addition, any permanent or temporary works within the floodplain of a designated main river may also require an Environmental Permit for Flood Risk Activities.

4 Flood Risk Methodology & Criteria

4.1 Overview

4.1.1 Section 5 assesses the sources of flood risk to the Project, and outlines the proposed flood mitigation measures, where appropriate, to ensure the site is safe for users and does not increase the flood risk elsewhere. For the purpose of this assessment, the following sources of flood risk are assessed:

- flooding from rivers (fluvial) & the sea (tidal) – from overtopping of defences or in the event of a breach / failure in the flood defences;
- flooding from surface water runoff (pluvial) and sewer surcharge;
- flooding from groundwater; and
- flooding from artificial sources.

4.1.2 The appraisal for each of these sources of flood risk is described in further detail in the following section.

4.2 Historical Flooding

4.2.1 The EA has records for fluvial flooding at the Site in 1947 as shown in Figure 4.1. The EA do not hold records with further detail as that shown in the image. There are no more known recent records of flooding from the River Trent in this area.

4.2.2 The largest tidal surge recorded on the Humber estuary was on 5th December 2013[4]. The tidal surge combined with high spring tides and a deep low pressure system, resulting in the highest recorded water levels at several locations around the estuary, including Hull. There are no known records of flooding at the Application Land during this event.

4.2.3 The LLFA confirmed that there are no records of surface water flooding at the Application Land.

4 [redacted]

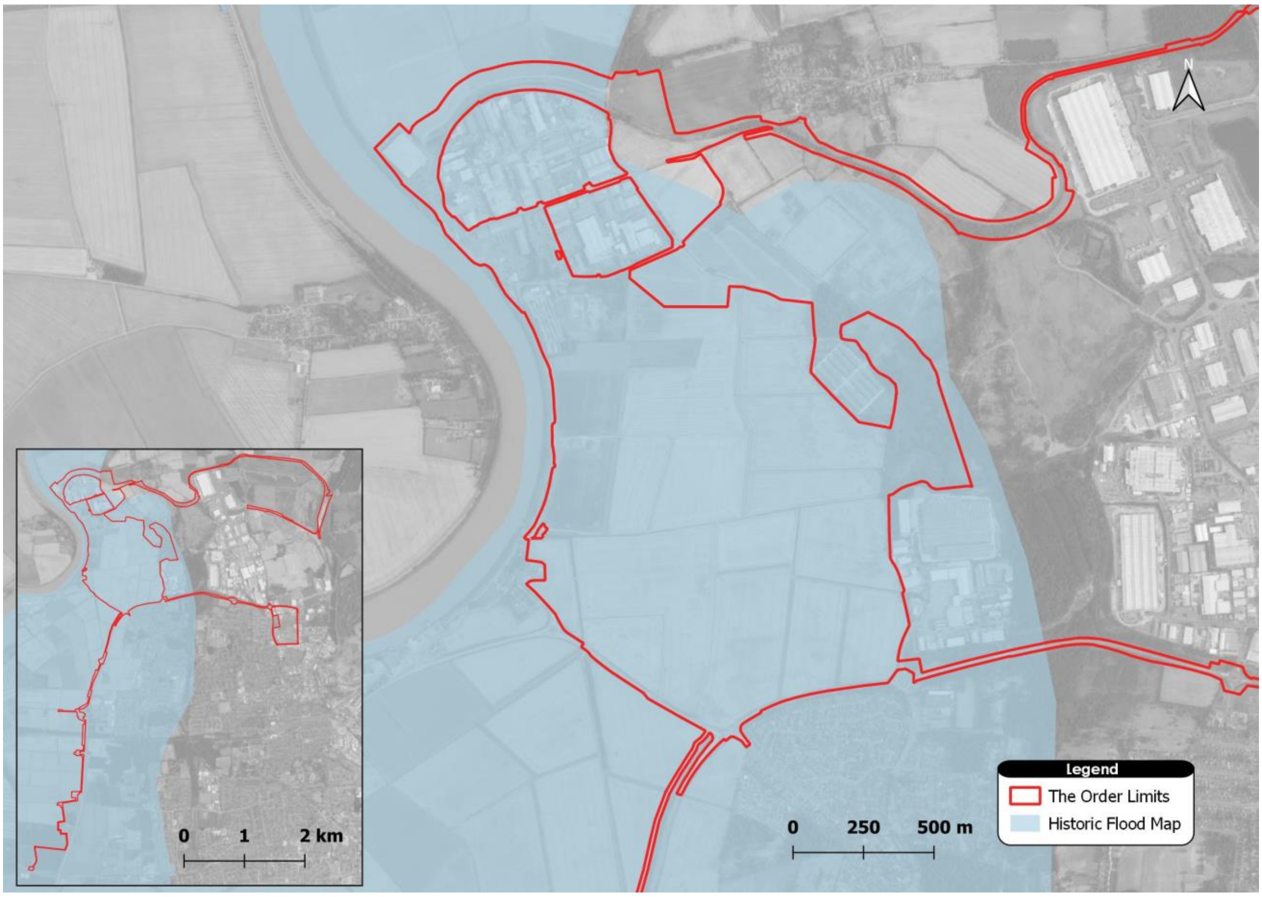


Figure 4.1 Historic flood event shown for flood event recorded in 1947 (Contains public sector information licensed under the Open Government Licence v3.0. Image courtesy of Ordnance Survey, © 2021 TomTom).

4.3 Principles of the Flood Risk Management Strategy

4.3.1 The key principles for the flood risk management strategy that will be addressed in the following sections are as follows:

- ensure the Project is safe for all users throughout the life of the development;
- ensure that the Project does not increase the flood risk to surrounding areas;
- ensure that design of the Project is resilient to future uncertainties;
- maintain discharge from offsite areas within the Project to avoid increasing flood risk offsite;
- manage existing overland rainfall runoff within the Order Limits to reduce impact offsite;

- utilise passive flood mitigation measures rather than active ones that are subject to human mismanagement or mechanical failure where possible; and
- develop mitigation measures that can provide multiple benefits and enhance the economic, social and environmental value of the Application Land.

4.3.2 The overall approach to flood risk management has been to ensure that the Application land is defended in accordance with the requirements of the regional and local policy documents, and that the Project will not cause an adverse effect on flood levels or extent to other sites.

4.4 Design Criteria

4.4.1 The Standard of Protection (SoP) for the Project will be developed for the vulnerability classification Essential Infrastructure. The following criteria forms the basis of the flood management strategy:

- all development uses across the Project protected to the year 2065;
- all development uses are required to function and operate during an extreme flood event. Flood risk should be low during either an overtopping or breach of flood defence;
- safe, dry access and egress to and from buildings; and
- the Project should minimise increase in flood risk either by extent, depth, hazard or frequency to third parties in the surrounding area.

4.4.2 The design flood event (DFE) has been identified as follows:

- flood risk from the River Trent:
    - 1 in 200 year Tidal flood event in 2065 Upper End climate change projection combined with 1 in 2 year Fluvial flood event with 30% allowance for climate change.
- flood risk from surface water overland runoff:
    - discharge rates into existing ditch network restricted to existing greenfield runoff rates and not more than 1.4l/s/ha.
    - attenuation provided for the 1 in 100 year + 40% allowance for climate change rainfall event.

4.4.3 When setting development levels or flood mitigation crest levels, an allowance for freeboard will be included. This will be derived using the EA guidance on accounting for residual uncertainty[5]. Further details have been provided in the hydraulic modelling report (Appendix B) as the category bandings are based on the suitability and accuracy of the modelling and data used in the assessment.

4.4.4 The H++ model results will be used as a sensitivity check to understand the impact of flooding on the Project using the most conservative climate change projection.

4.5 Assessment Methodology

4.5.1 To identify the flood risk to the Project and inform the flood mitigation measures required, the various sources below have been used:

- national, regional and local planning policy and guidance as listed in Section 3.2 to understand flood risk from all sources
- EA pre-application data providing information on existing flood defences and flood levels
- NLC Tidal Trent Lincolnshire Lakes hydraulic flood model 2017 to estimate future flood levels at the Application Land due to tidal overtopping or breach (baseline and with Proposed Development); and
- EA Humber Extreme Water Level hydraulic flood model 2020 to estimate future tidal boundary condition.

4.5.2 Details of the hydraulic flood modelling undertaken can be found in Appendix B. However, the following points summarise the key models and steps undertaken to inform the assessment:

- NLGEP Baseline 2021 Model –
  - NLC 2017 model + site-specific amendments + tidal boundary extracted from EA Humber model incorporating UKCP18 climate change projections.
- NLGEP Proposed 2021 Model –
  - NLGEP Baseline 2021 Model + Proposed Development as raised development platforms.

[5] https://www.gov.uk/flood-and-coastal-erosion-risk-management-research-reports/accounting-for-residual-uncertainty-an-update-to-the-fluvial-freeboard-guide

- NLGEP Proposed With Additional Mitigation 2021 Model –
    - NLGEP Proposed 2021 Model + flood mitigation measures incorporated into the design of the Proposed Development.

4.5.3 As discussed with the EA, the main source of flood risk to the site is from an extreme tidal event for the development's lifetime. To meet the objectives of the flood management strategy the following scenarios have been assessed:

i) Baseline:
  - Flood risk in 2065 during the DFE assuming existing flood defences remain at current elevations and land uses do not significantly change in the area.

ii) Proposed development:
  - Proposed development plots and access road removed from the floodplain. This could either be through levels raised above the flood level or through secondary flood defences or resistant measures (preventing the ingress of floodwater into the buildings).

iii) Proposed development during a breach event:
  - Assessment of a 50m wide failure in the existing earth embankment 1hr before the peak tide level reached (2 locations tested).

iv) Proposed development with additional flood mitigation measures:
  - Additional flood mitigation measures incorporated in proposals to ensure impact of flood risk is minimised to the sites and surrounding areas during Scenarios (ii) and (iii).
  - Remaining flood risk identified at the Site and to surrounding areas.
  - Sensitivity test during H++ scenario.

4.5.4 This assessment considers the flood risk identified in key zones across the Order Limits.

4.5.5 Figure 4.2 indicates the main zones that will be referred to in this assessment. The flood risk impacts described in the following chapter will refer to the greatest impact observed within a particular zone (such as the greatest depth or changed observed).

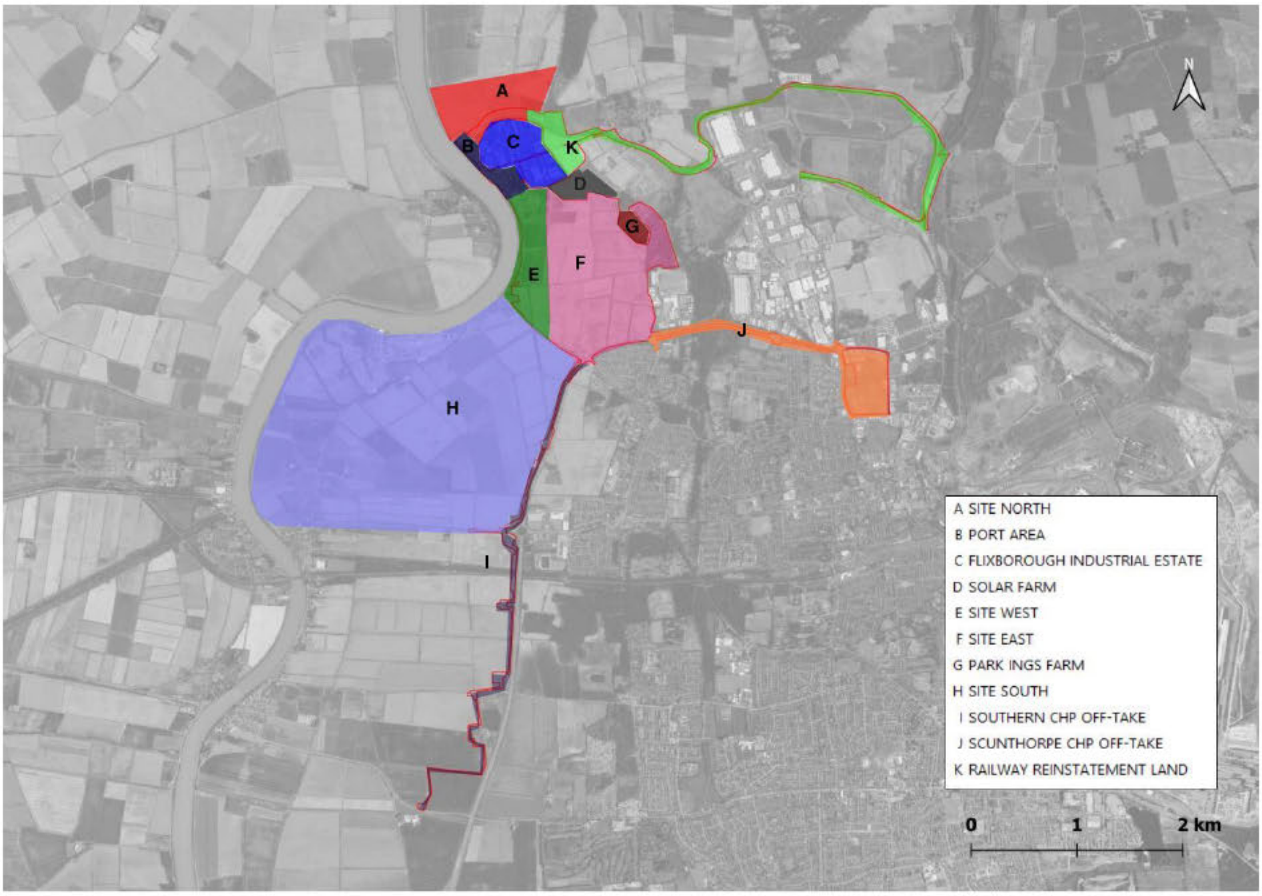


Figure 4.2 Zones identified to describe impacts of flood risk in this FRA (Image courtesy of Ordnance Survey, © 2021 TomTom).

4.5.6 The table below provides a description of the existing land uses with the different zones.

Table 4-1 Description of existing land uses within the Order Limits.

Zone	Existing land use description
A – Site North	Agricultural fields, wind turbines and part of the existing rail track.
B – Port area	Wharf, Steel works warehouse, and outdoor storage areas.
C – Flixborough Industrial Estate	Commercial industrial units.
D – Solar Farm	PV solar panels and generator.
E – Site West	Agricultural fields, Lysaght's Pumping station.
F – Site East	Agricultural fields.
G – Park Ings Farm	Indoor poultry farming.
H – Site South	Agricultural fields, industrial units and Gunness residential area.

Zone	Existing land use description
I - Southern CHP off-take	Agricultural fields.
J - Scunthorpe CHP off-take	A1077 road and verge landscaping.
K - Railway reinstatement land	Railway line and landscaping.

5 Flood Risk Appraisal & Management

5.1 Fluvial & Tidal Flooding

Overview

5.1.1 Fluvial flooding arises following sustained or intense rainfall events that increase the flow in rivers causing water levels to rise above the banks and flow into the surrounding areas. Tidal flooding occurs when particularly high tides coincide with storm surges driven by low atmospheric pressure events causing localised raising of sea levels.

Baseline – Present Day

Flood Zone

5.1.2 The EA Flood Map for Planning identifies the Order Limits being primarily in Flood Zone 3, in an area benefitting from flood defences, with Zone J, Scunthorpe CHP off-take and Zone K, railway reinstatement land in Flood Zone 1 as shown in Figure 5.1.

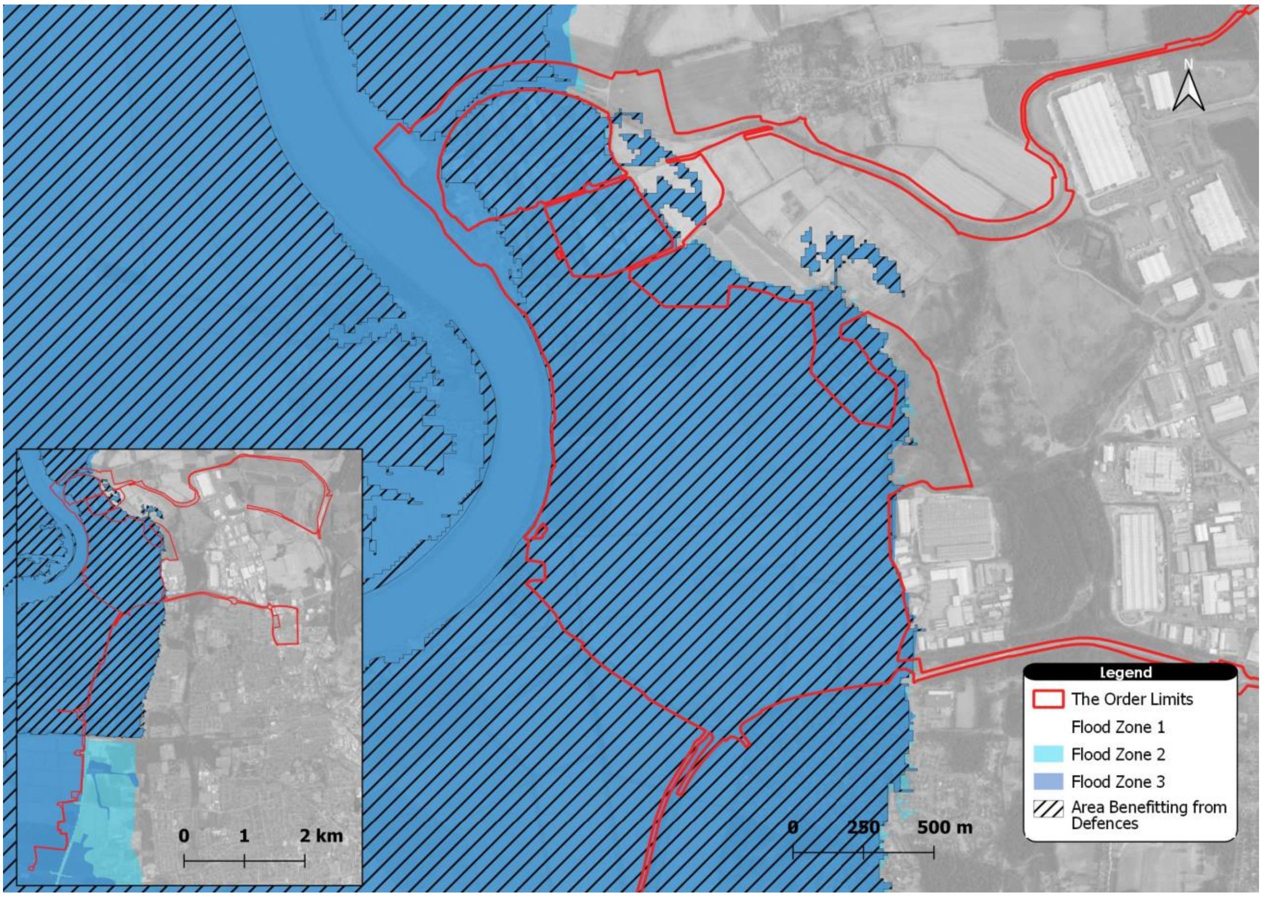


Figure 5.1 Environment Agency Flood Zone map with Order Limits shown in red (Contains public sector information licensed under the Open Government Licence v3.0. Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.3 Flood Zone 3 is defined as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any given year. The Flood Zone extents are derived assuming that defences are not in place. The hatched area shown as benefitting from defences continues further south to the M181 on the east bank. These defences were constructed as part of the Lincolnshire Lakes flood defence scheme (in 2018 / 2019).

5.1.4 Therefore, the full extent of the Order Limits is currently protected to a present day tidal 1 in 200 year flood event.

5.1.5 The SFRA confirms that the Application Land is located in Flood Zone 3a, not Flood Zone 3b, and therefore is not located within the functional floodplain.

5.1.6 The SFRA defines the functional floodplain (Flood Zone 3b) as the 'land where water has to flow or be stored in times of flood'. The SFRA notes that the identification of the functional floodplain takes account of local circumstances but is guided by the general principle of land which would flood with an annual probability of 1 in 20 years.

5.1.7 According to the SFRA 2011, the area identified between Burton Stather and the railway embankment north of Flixborough Industrial Estate currently used for agriculture has been identified by the EA as potentially suitable area for managed realignment with the aim of creating flood storage and therefore has been classified as Flood Zone 3b (shown in Figure 5.2).

5.1.8 As such, the locating of the Project has deliberately avoided the area north of Flixborough Industrial Estate.

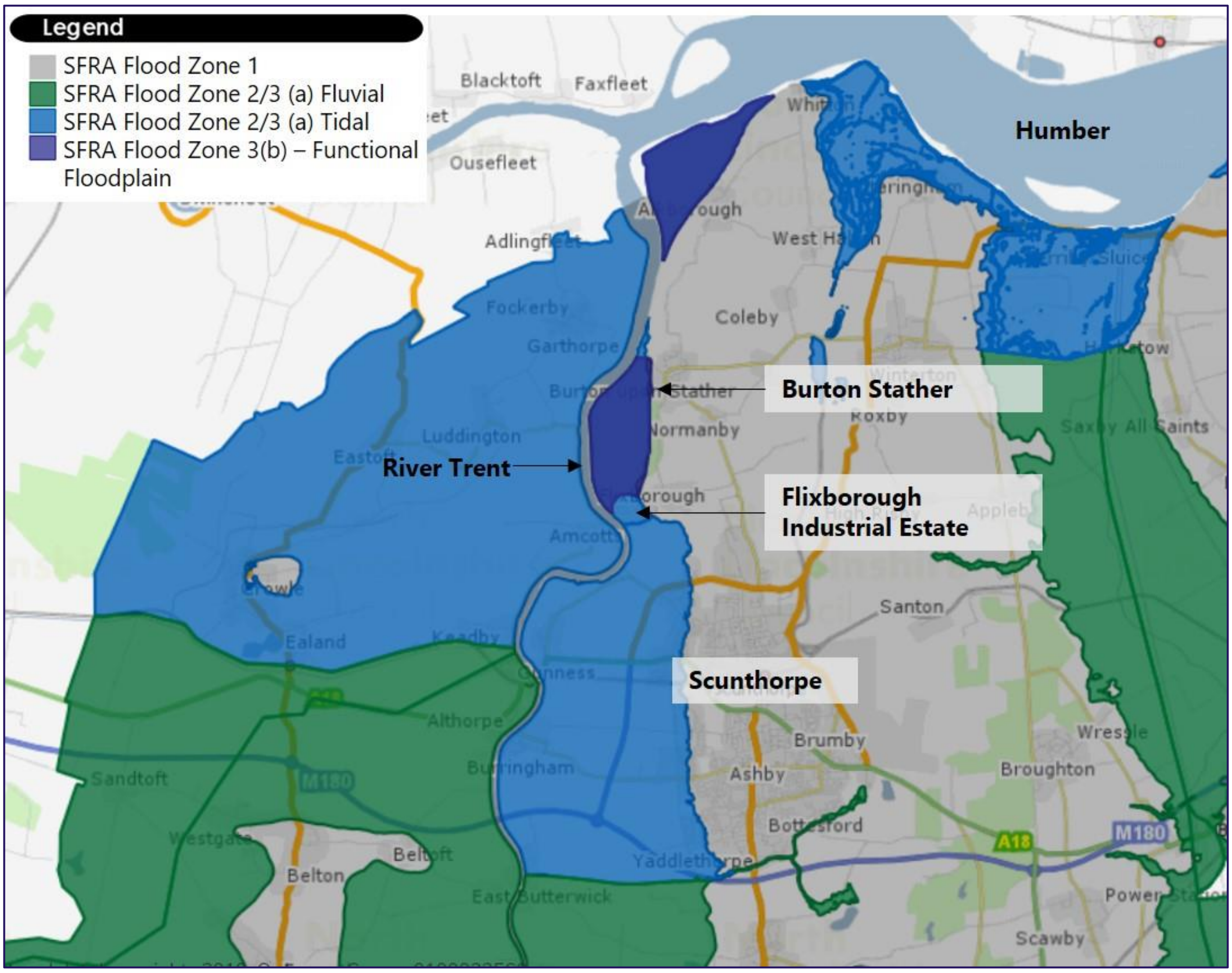
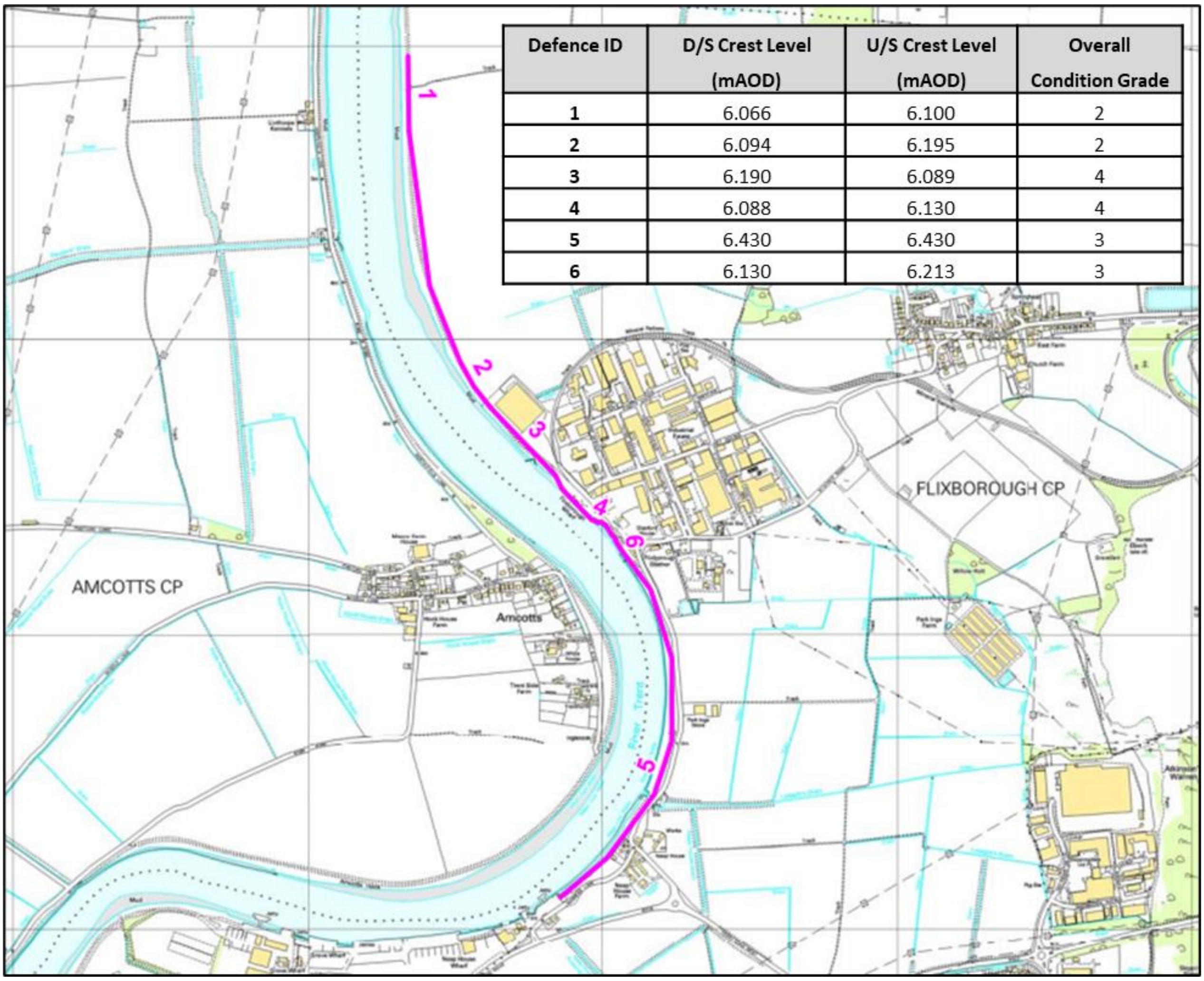


Figure 5.2 Flood Zone delineation in the SFRA 2011

Existing EA Flood Defences

5.1.9 The Project benefits from existing flood defences along the east bank of the River Trent, managed and maintained by the EA. The defences consist of a raised embankment, in addition to raised levels at the port. The crest levels along the defence line vary. The levels are summarised in Figure 5.3 according to the EA data provided.



Defence ID	D/S Crest Level (mAOD)	U/S Crest Level (mAOD)	Overall Condition Grade
1	6.066	6.100	2
2	6.094	6.195	2
3	6.190	6.089	4
4	6.088	6.130	4
5	6.430	6.430	3
6	6.130	6.213	3

Figure 5.3 Existing alignment and data for EA flood defences by the Application Land. Condition scale from Grade 1 = Very Good to 5 = Very Poor (source: EA data provided July 2020)

5.1.10 It is understood based on discussions with the EA that the existing defences are due to be inspected and an improvement programme to be identified later in 2021.

5.1.11 The image below shows the existing earth embankment flood defences along the east bank of the River Trent that currently provide protection to the site.

Figure 5.4 Photograph showing River Trent on the left, raised earth embankment in centre and Stather Road and agricultural land on the right (photograph taken by Buro Happold April 2021 looking north).

5.1.12 The flood defences protect the Application Land for the present day extreme fluvial flood event (1 in 100-year event, or event with 1% chance of happening in any given year) and the present day extreme tidal flood event (1 in 200-year event, or event with 0.5% chance of happening in any given year) as shown in Table 5-1.

Table 5-1 River Trent peak flood level data provided by EA for fluvial (F) and tidal (T) dominated events for different storm events. See Figure 5.5 for location reference points (EA data provided 22-07-20).

Node ID	EA River Levels									
	1 in 5 year		1 in 20 year		1 in 100 year		1 in 200 year		1 in 1000 year	
	F	T	F	T	F	T	F	T	F	T
TRENT08930	-	5.64	-	5.78	5.73	5.94	-	5.98	5.71	6.06
TRENT09550	-	5.64	-	5.78	5.75	5.93	-	5.97	5.73	6.05
TRENT10230	-	5.65	-	5.77	5.77	5.92	-	5.96	5.75	6.04
TRENT10640	-	5.65	-	5.77	5.79	5.92	-	5.96	5.76	6.04
TRENT11170	-	5.67	-	5.78	5.80	5.93	-	5.98	5.79	6.05

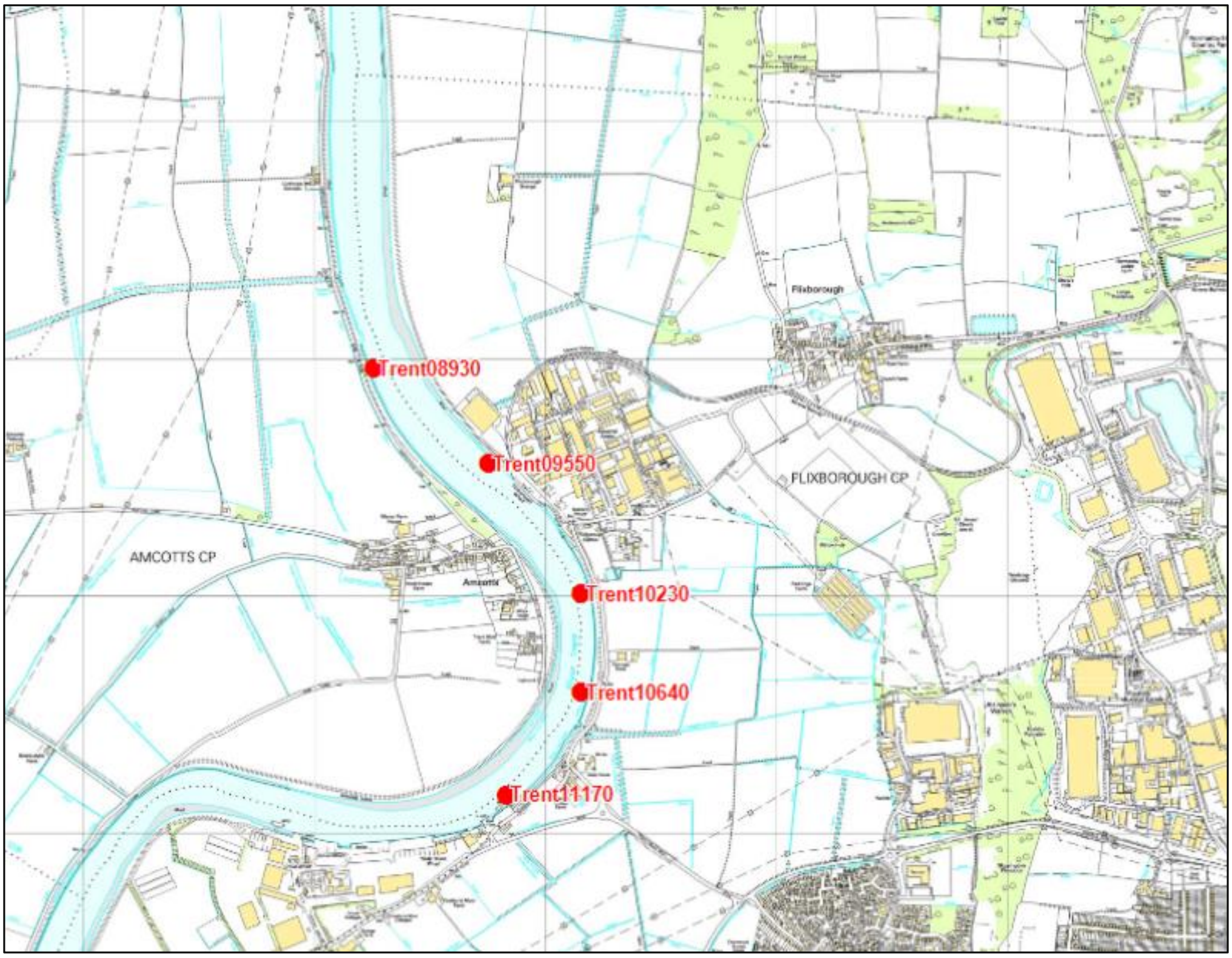


Figure 5.5 Node ID locations for EA flood levels provided in Table 5-1.

Future Flood Risk

5.1.13 As indicated in the table above, the higher water levels observed in the Trent are tidally driven rather than from fluvial sources. Therefore, the assessment of impact at the Project in the future has been undertaken for a future extreme tidal event, rather than an extreme fluvial flood event as agreed with the EA.

5.1.14 As described previously, sea level and peak river flows are estimated to increase in the future due to climate change. The results from the NLGEP Baseline 2021 Model simulated for the DFE in 2065 indicates that the existing defences will overtop. Resulting flood depths vary across the Site from 100mm to 1.2m (see Figure 5.6).

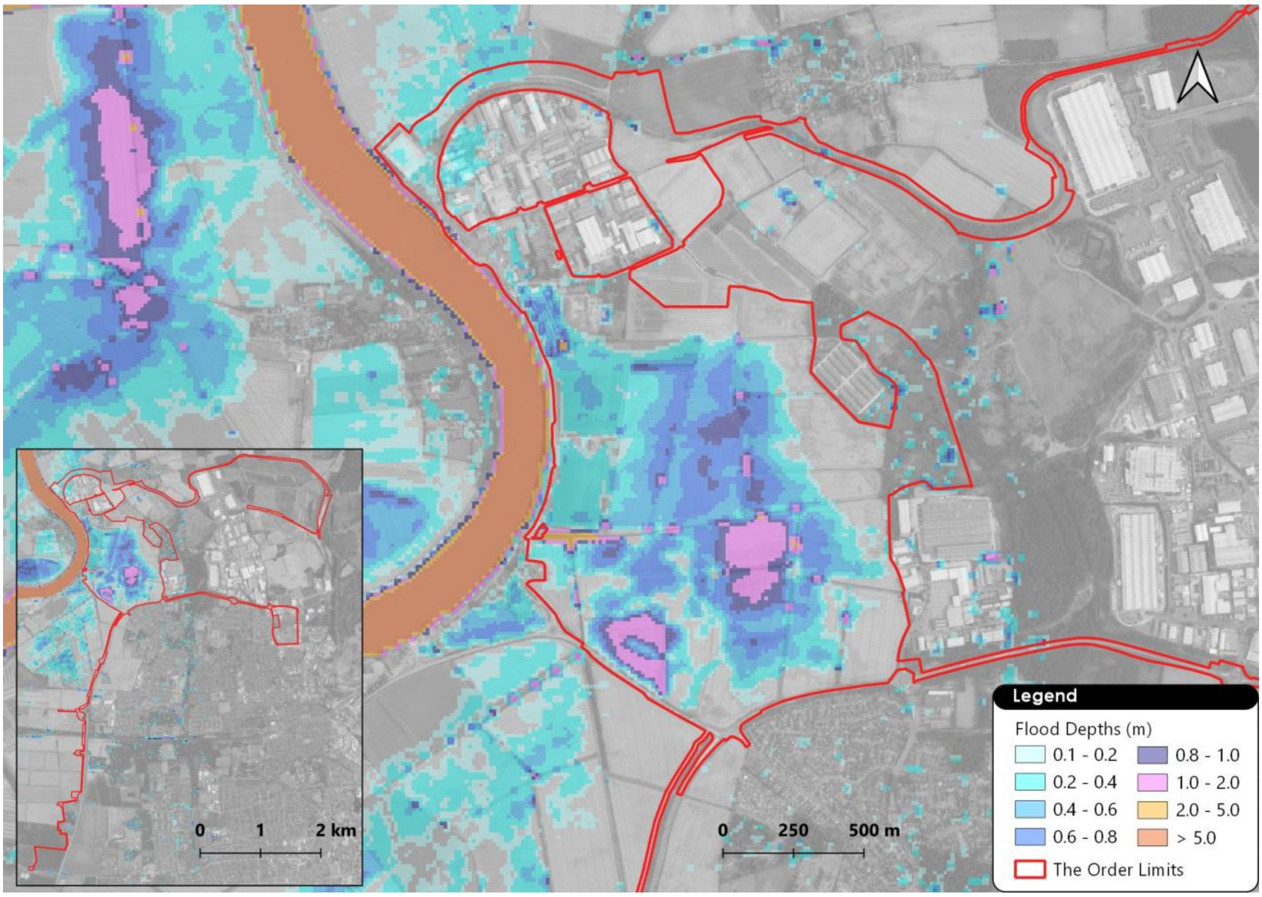


Figure 5.6 Baseline flood depth for the DFE in 2065 (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.15 Figure 5.7 illustrates the estimated hazard ratings across the Application Land based on the Defra guidance, that classifies hazards as follows:

- Very Low Hazard (Caution)
- Danger for Some (inc. children, the elderly, and the infirm)
- Danger for Most (inc. the general public)
- Danger for all (inc. the emergency services).

5.1.16 Hazard is identified as the combination between estimated flood depths and velocities. The hazard observed across the Application Land is predominantly classed as Danger to Most, with some localised areas classed as Danger to All and Danger to Some, where depths are higher.

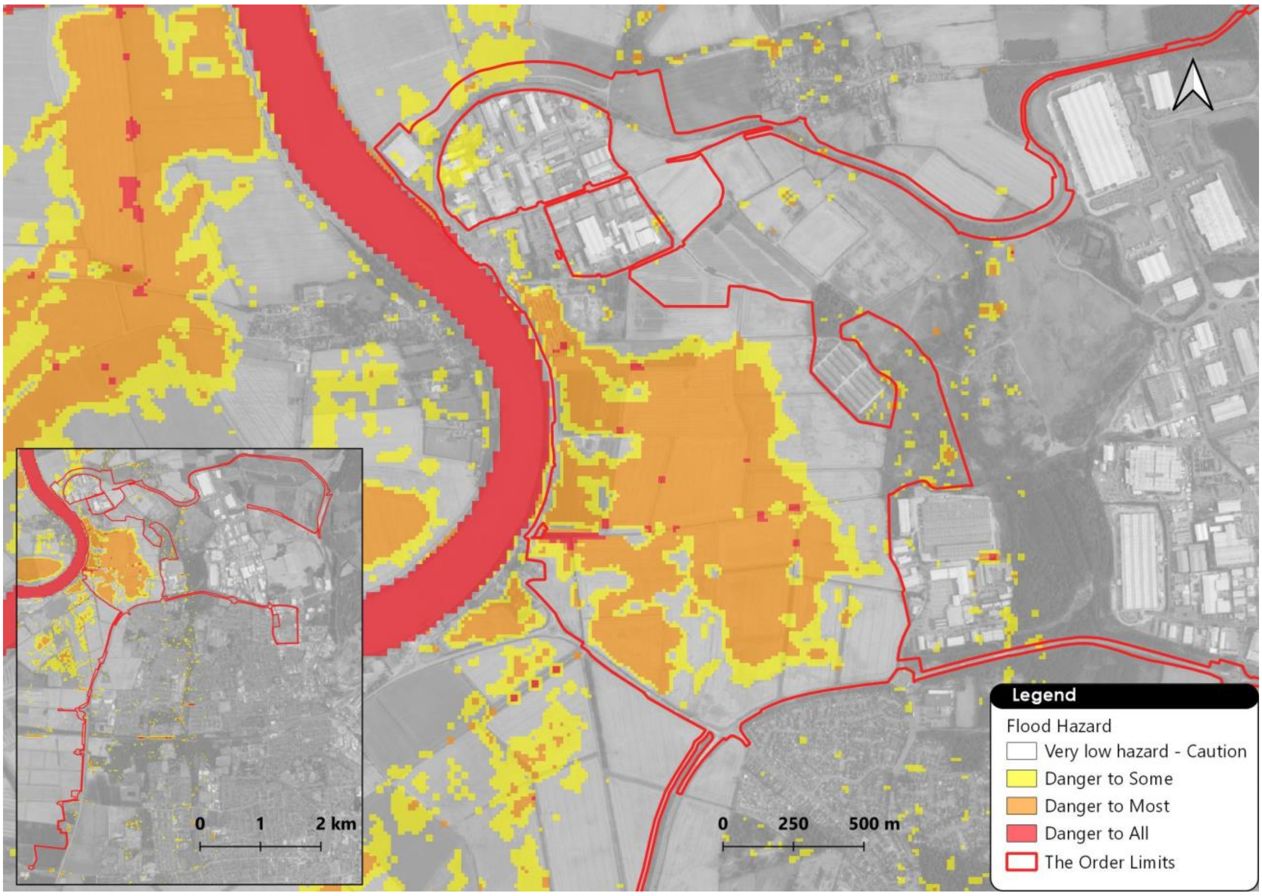


Figure 5.7 Baseline flood hazard for the DFE in 2065 (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.17 By inspecting the results at different time increments during the model simulation, enabled a better understanding of the flood mechanism to the Application Land. As shown in Figure 5.8 the existing defences overtop along the east bank directly flooding the Application Land, as well as overtop the embankment ~3km north of the Application Land and flow south across the low point on the railway line, through Flixborough Industrial Estate into the agricultural fields where it ponds and continues to drain south of the B1216 via a culvert connecting the Neap House Drain.

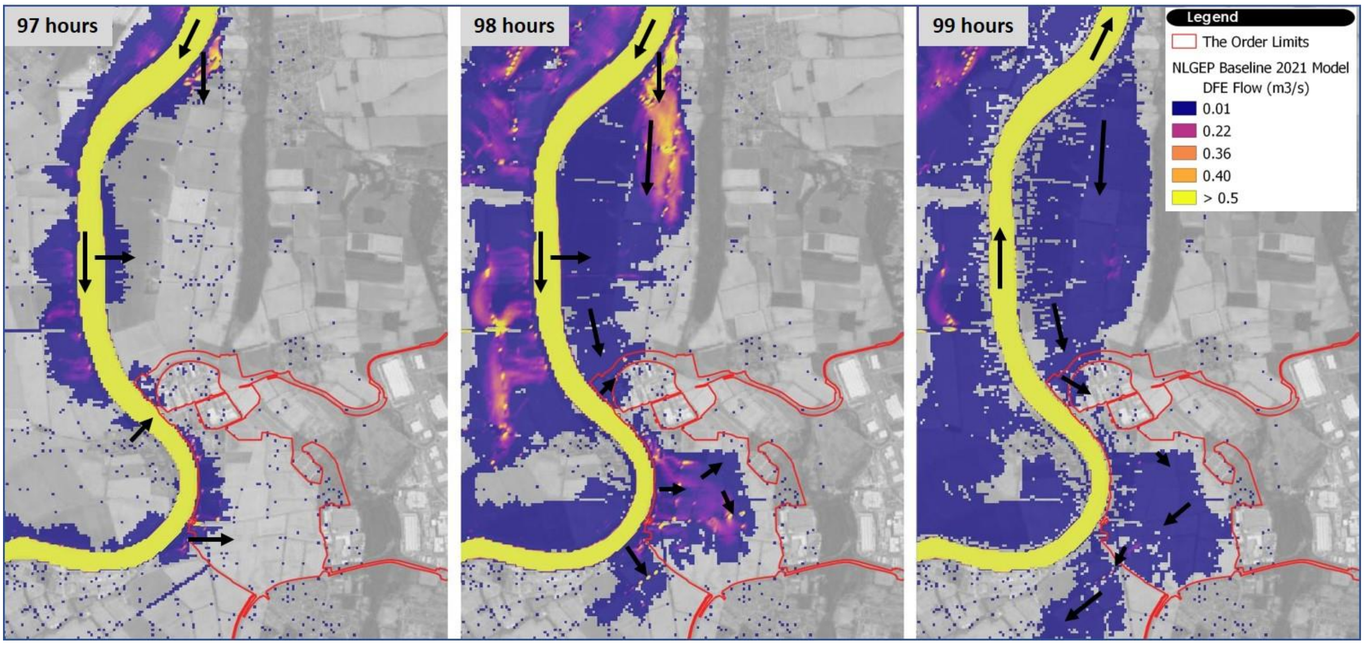


Figure 5.8 Timestep series output for the Baseline DFE in 2065 indicating primary flood mechanism to the Application Land. (Note, the arrows are indicative of direction of flow only, not proportional to flow value) (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.18 As a sensitivity test, the H++ scenario was also simulated. This scenario was tested to assess whether the flood mechanism changed during a more extreme event than the DFE. The results indicate a similar flood mechanism is observed, although greater flow passes from the north through Flixborough Industrial Estate through the Application Land and south of the B1216.

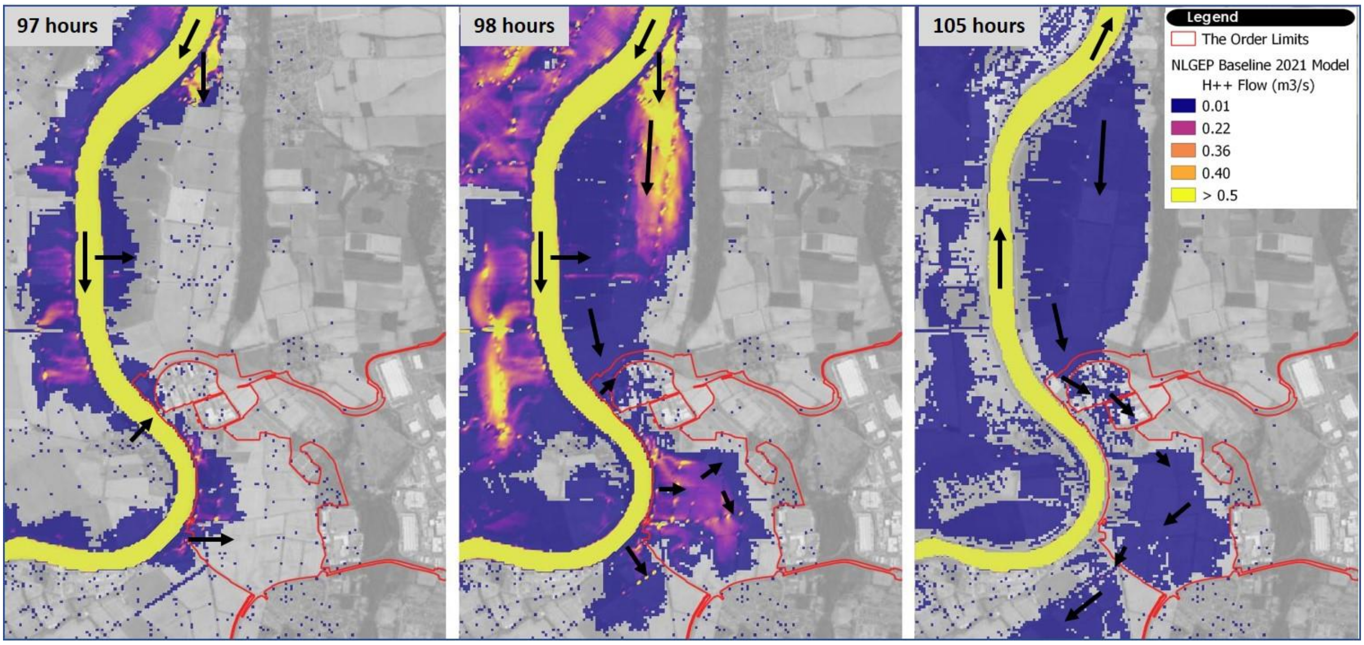
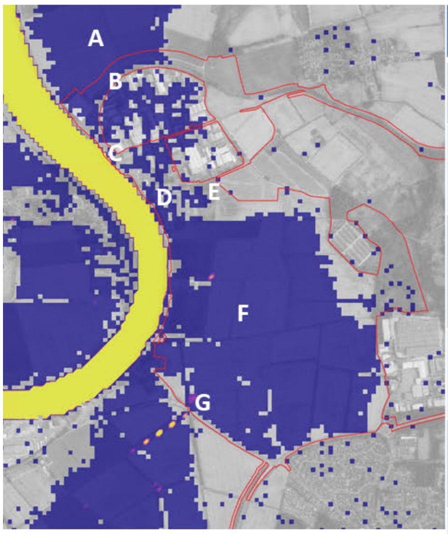


Figure 5.9 Timestep series output for the Baseline H++ event indicating primary flood mechanism to the Application Land. (Note, the arrows are indicative of direction of flow only, not proportional to flow value) (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.19 The observations made of the flood mechanism enabled further design criteria to be defined that ensured the proposals were developed in the most sensitive way to its location in the floodplain, minimising impact both to the Application Land and to surrounding areas. Flood modelling was undertaken to support the assumptions and test their impact. Further details of the criteria are provided in Figure 5.10 and Appendix A.



Label	Design Criteria	Reason
A	Minimise obstructions in area north of Industrial Estate.	To maintain north-south flow route and retain area as flood storage space (FZ3b SFRA).
B	Keep railway line and landscaping at existing levels to maintain north-south flow route.	This will prevent backing up of floodwater in the agricultural fields to the north.
C	Minimise alterations in the river channel such as at the wharf and to the existing defences.	By not altering the river channel and existing defences will ensure the frequency of overtopping in the future will not increase and impact to offsite areas minimised.
D	Set development away from bank edge to maintain a flow route when defences are overtopped.	This will prevent displacing floodwater downstream or to the west bank.
E	Avoid locating development for the full west-east width on the south side of the Industrial Estate.	This is to retain the north-south flow route and prevent raising levels in the Industrial Estate.
F	Avoid raising development fully in a north-south direction in the agricultural fields.	This is to maintain flow routes east and west and maintain the existing flood storage capacity in the fields. Sizing of openings in access road should minimise increase in flood extent.
G	Do not block Neap House Drain.	This is to allow water to drain from the Site and continue to flow south, reducing backing up of floodwater in the Site.

Figure 5.10 Design criteria developed based on future flood mechanism (Image courtesy of Ordnance Survey, © 2021 TomTom).

Proposed Development - Future Flood Risk

5.1.20 The Project has been assessed as follows:

- development plots, storage containers and access road raised above flood level. The final design may be a mix of raising levels, providing flood resistant measures, or structures raised on columns;
- land levels between access road and plots also raised to allow landscaping levels to tie in between them;
- raised access road has openings to allow floodwater to pass through. During detailed design the openings will be developed further and sized either as bridge structures or culverts. (Note, the opening locations shown on the following images are indicative and not necessarily representative of the location of the final structures);
- no changes in ground levels to the re-instatement of railway track, the location of the new railhead or new public rights of way; and
- New landscaping enhancements or SuDS are not included in the assessment.

5.1.21 The impact of the Project has been assessed for the DFE for both overtopping and during two breach scenarios. The probability of slip failure or collapse of a 50m section of the existing earth embankments is low. However, if such an event did happen, the sudden release of floodwater could have devastating impacts due to high velocities and flood depths. Therefore, the Project has been assessed during breach scenarios to ensure measures are put in place to reduce impact to the development as well as ensuring impacts are not increased to third parties as a result of the development being in place.

5.1.22 The figure below illustrates the Project as represented in the NLGEP Proposed 2021 Model and the locations chosen for the breach scenarios. Breach 01 was applied directly next to the Project in the existing earth embankment where the impact would be greatest to the new development. Breach 02 was applied ~3km north of the Application Land in the earth embankment where the north-south flow route through the development has been observed. It should be noted that the 'blocky' appearance of the Project is due to the 25m x 25m grid resolution of the hydraulic model.

Figure 5.11 The Project and breach locations (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.23 The results of the assessment are shown below in Table 5-2, Table 5-3 and Figure 5.12 to Figure 5.17.

Table 5-2 Summary of results for the Project, Breach 01 and Breach 02 scenarios compared to baseline during the DFE.

Zone	Summary of Results
A - Site North D – Solar Farm G – Park Ings Farm I, J, K – Land off-takes	No changes in extent, depth or hazard observed during the DFE or breach scenarios due to the Project.
B – Port area	Localised increase in flood depth (up to 120mm) in the Steel Works warehouse, however, no change in hazard category or frequency. Localised increase in flood depth immediately to the west of the Project at the CBMF from 70mm to over 500mm with hazard category increasing from 'Danger to Most' to 'Danger to All' during the breach scenarios.
C – Flixborough Industrial Estate	A general decrease in flood level and hazard in Breach 01 scenario. A localised area showing an increase in flood level at junction between Fourth Avenue and Stather Road between 55mm and 150mm in the with scheme and Breach 01 scenarios. A localised area up to 60 - 140mm increase in flood level observed during the Breach 01 scenario, in the junction between First Avenue and Second Avenue as well as localised increase in extent to the warehouse in this location.
E – Site West	Localised increase directly to the west of the Project during all scenarios with depths increasing to ~1m from 0.5m. Hazard category also increasing during all scenarios from 'Danger to Most' to 'Danger to All'. The land use in this area will be Stather Rd which will no longer be the main access route but used primarily for maintenance of the embankment and facilitate the development.
F – Site East	Flood depths increase ~35mm with scheme in the agricultural fields. No change in hazard category observed during all scenarios.
H – Site South	During with scheme and Breach 02 scenarios an increase in flood level is observed in the agricultural fields south of the Order Limits. Existing flood depths of ~20mm increase by up to 50mm. No change in hazard category observed.

Table 5-3 Estimated flood level and depth during the DFE baseline (B'line) and change in flood level due to the proposals (with no flood mitigation), for the DFE, Breach 01 and Breach 02 scenarios (results provided for the maximum change in level observed within the Result Zone shown in Figure 4.2). Hazard Classifications: 1 = Very Low, 2 = Danger to Some, 3 = Danger to Most, 4 = Danger to All

Result Zone	DFE				DFE + Breach 01				DFE + Breach 02			
	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating
A – Site North	3.40	0.07	0	N/A	3.40	0.07	+1	N/A	4.47	1.14	0	N/A
B – Port area (Steel Works)	5.57	0.18	0	N/A	5.44	0.07	+117	N/A	5.43	0.06	0	N/A
B – Port area (ERF)	4.78	0.02	+348	N/A	5.30	0.45	+614	3 - 4	4.77	0.02	+347	N/A
C – Flixborough Industrial Estate	3.84	0.13	+55	N/A	4.13	0.42	+149	3 - 2	3.84	0.13	0	N/A
D – Solar Farm	2.66	0.09	0	N/A	2.75	0.06	-45	3 - 2	2.68	0.01	0	N/A
E – Site West	3.19	0.47	+558	3 - 4	3.27	0.55	+856	3 - 4	3.17	0.45	+546	3 - 4
F – Site East	1.67	1.23	+20	N/A	1.94	1.50	+34	N/A	1.64	1.20	+20	N/A
H – Site South	0.34	0.24	+30	N/A	0.68	0.58	0	N/A	0.31	0.21	+47	N/A

Notes: changes for Zones G, I to K not reported due to negligible changes observed.

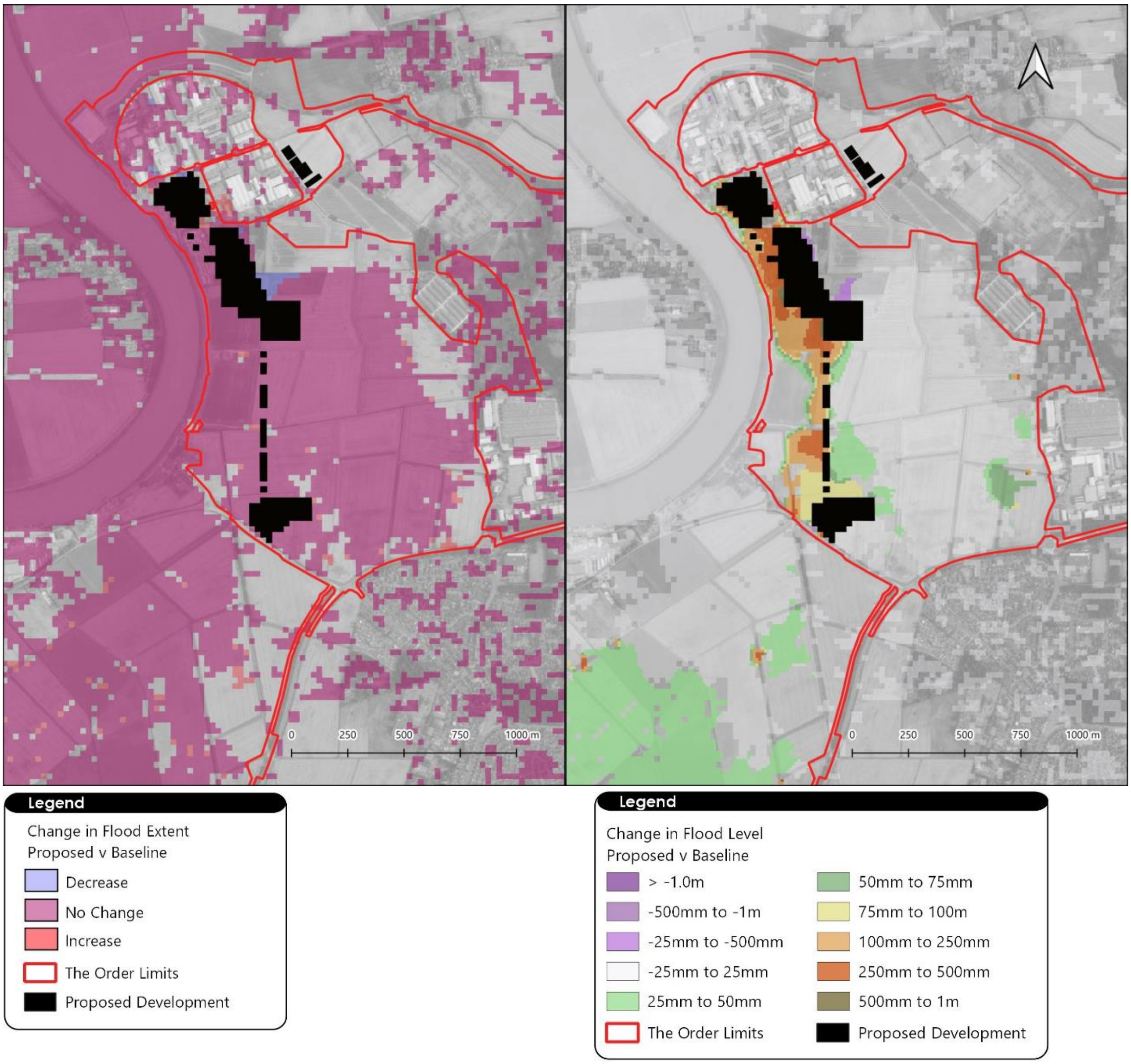


Figure 5.12 Change in flood extent and flood depth during the DFE due to the Project (Image courtesy of Ordnance Survey, © 2021 TomTom).

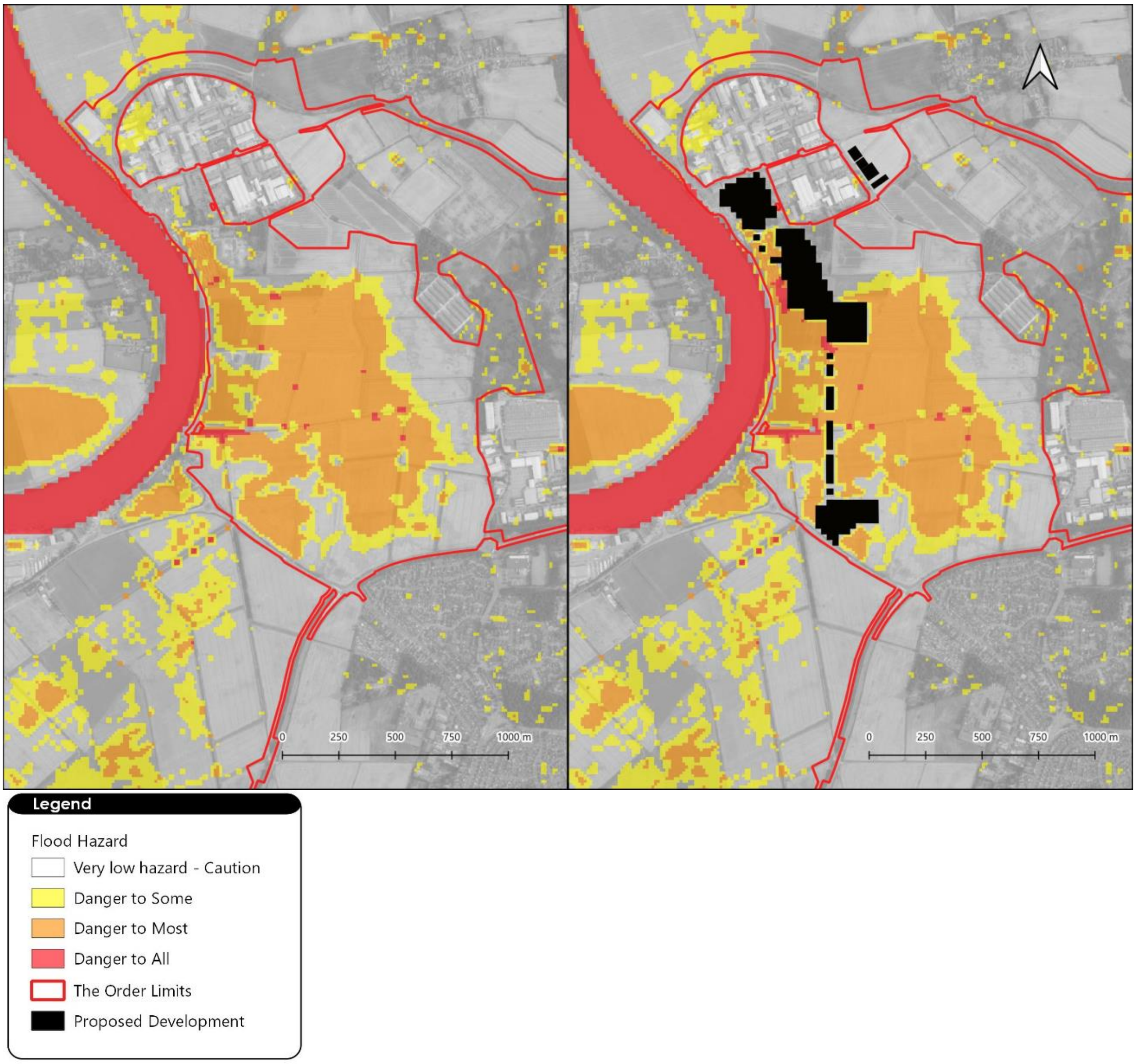


Figure 5.13 Hazard in the future baseline scenario (left image) and future scenario with the Project (right image) (Image courtesy of Ordnance Survey, © 2021 TomTom).

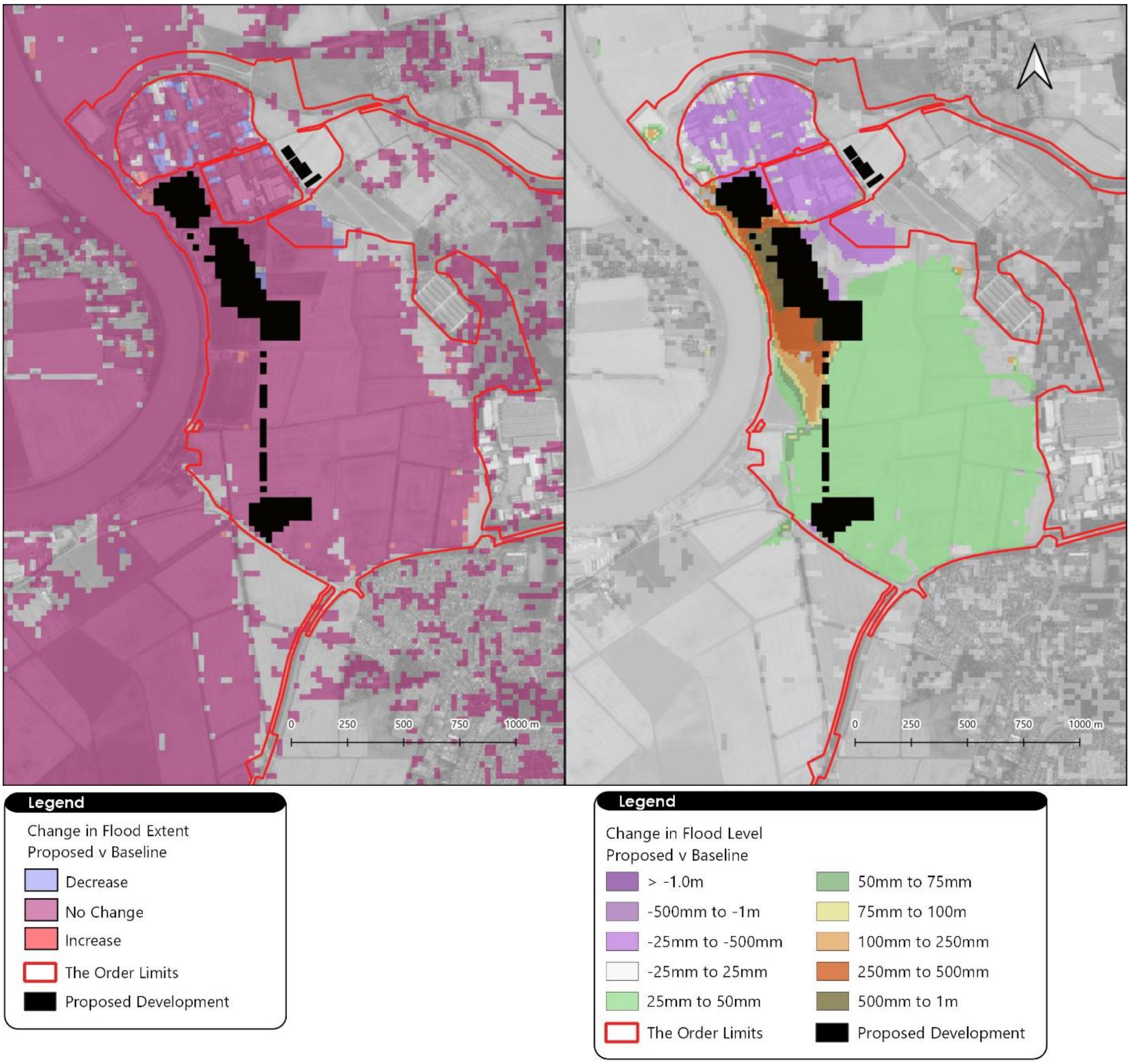


Figure 5.14 Change in flood extent and flood depth during the DFE with Breach 01 due to the Project (Image courtesy of Ordnance Survey, © 2021 TomTom).

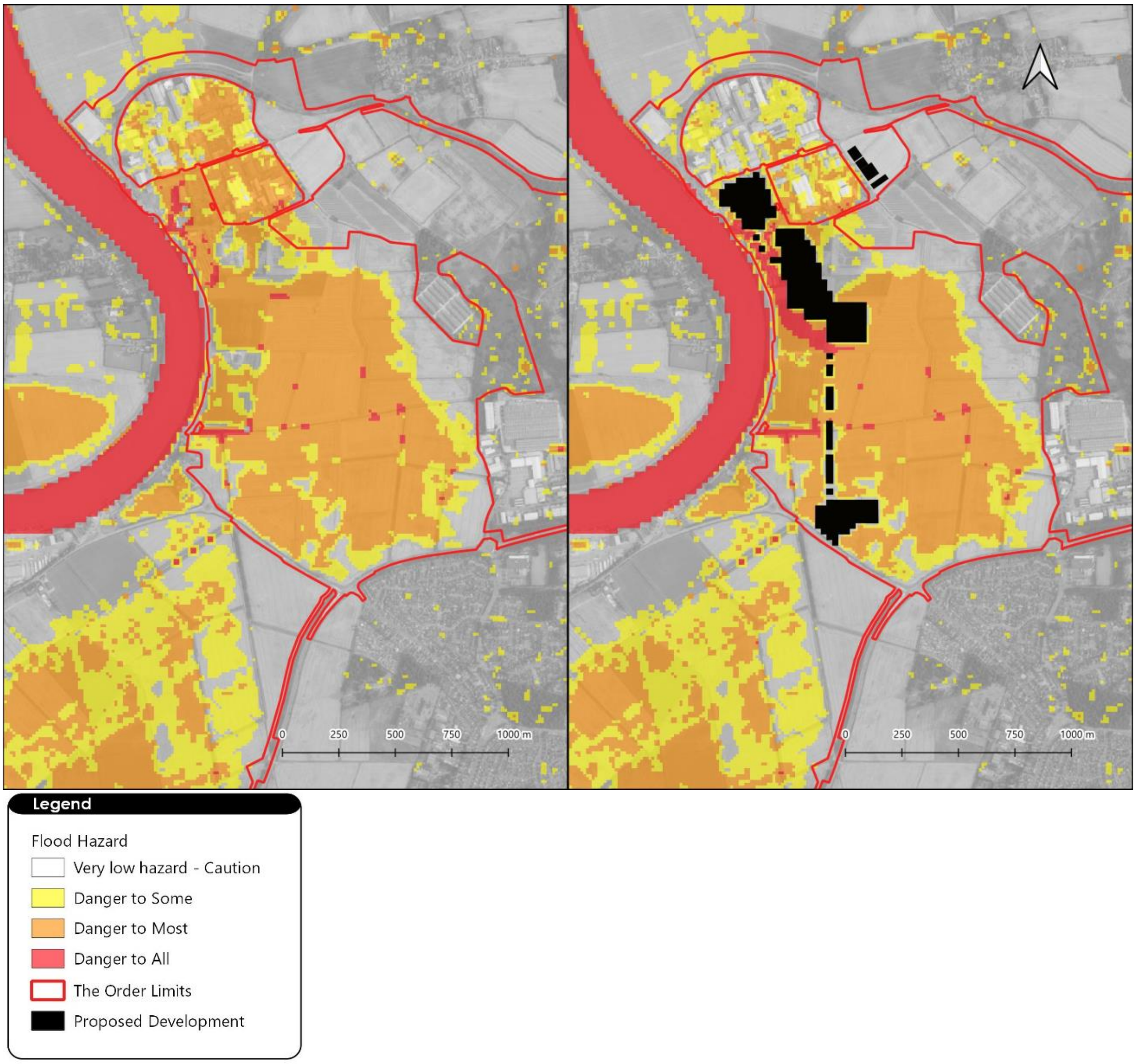


Figure 5.15 Hazard in the future baseline scenario with Breach 01 and future scenario with Breach 01 and the Project (Image courtesy of Ordnance Survey, © 2021 TomTom).

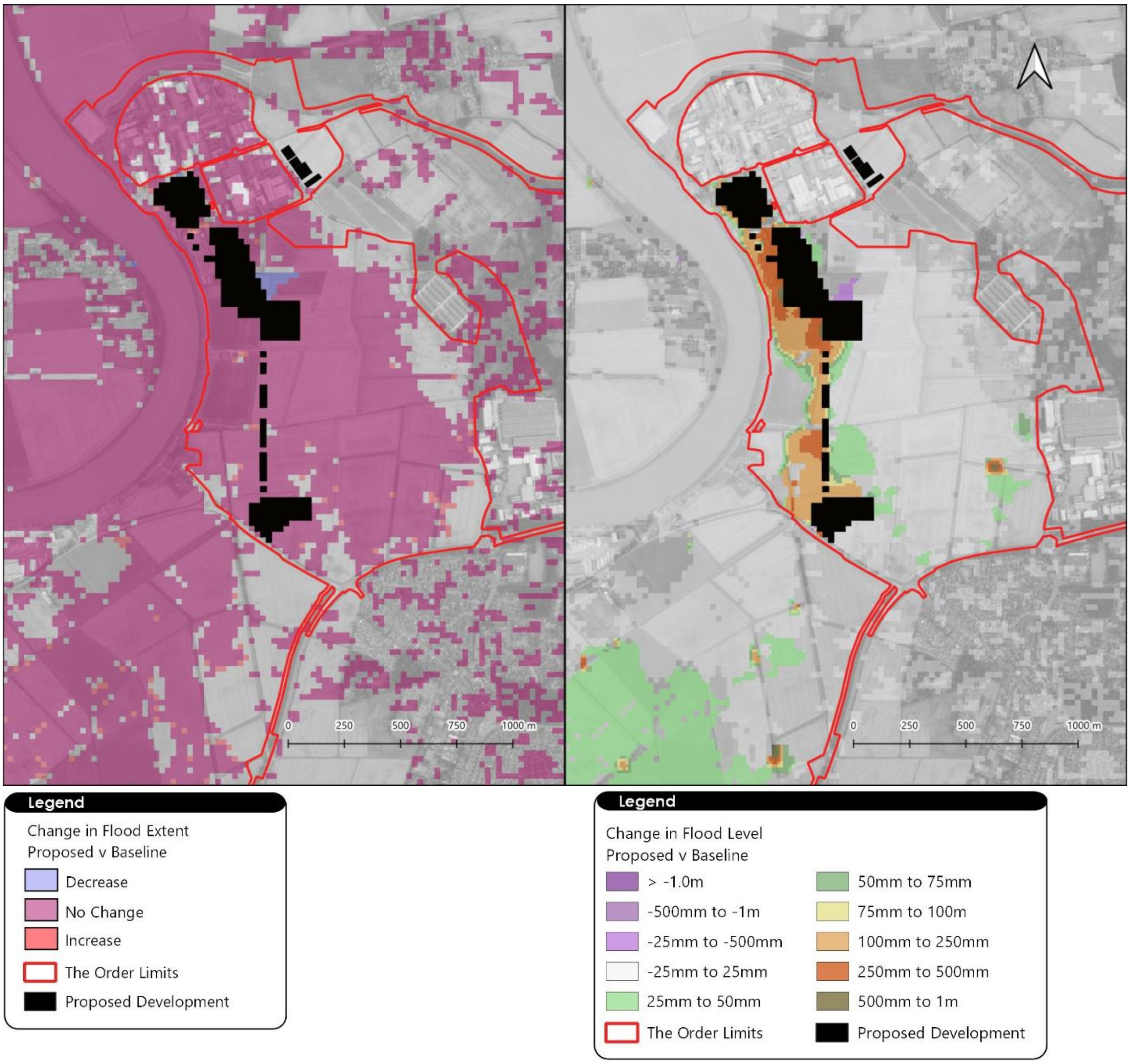


Figure 5.16 Change in flood extent and flood depth during the DFE with Breach 02 due to the Project (Image courtesy of Ordnance Survey, © 2021 TomTom).

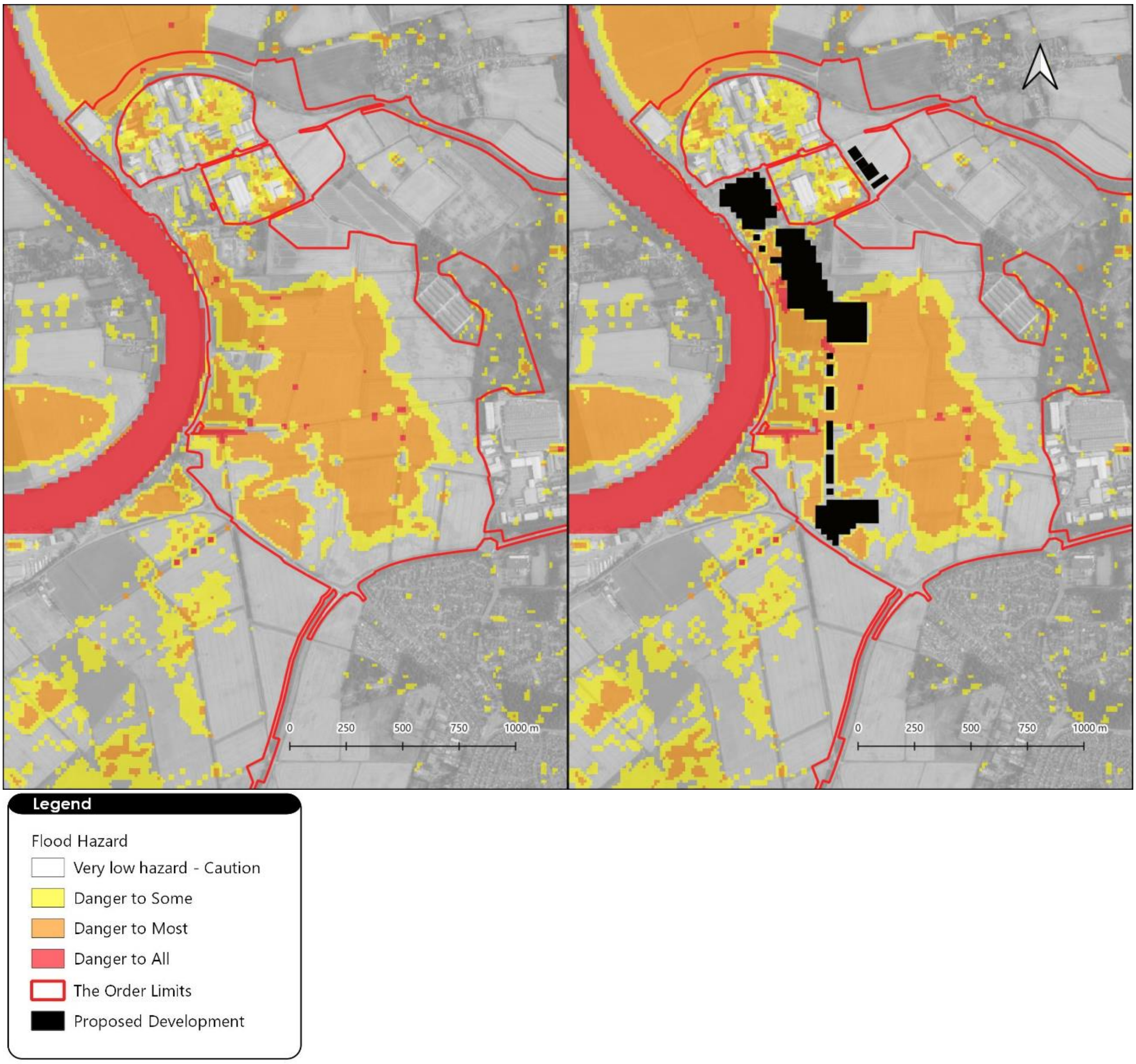


Figure 5.17 Hazard in the future baseline scenario with Breach 02 and future scenario with Breach 02 and the Project (Image courtesy of Ordnance Survey, © 2021 TomTom).

Proposed Mitigation Strategy

5.1.24 In order to mitigate the flood risk impacts of the Project, a series of measures have been tested. It is not proposed to raise the existing EA formal flood defences due to the displacement of floodwater that would result in other areas. Therefore, the following secondary flood defences are proposed as part of the flood risk management strategy which would be managed and maintained by the Applicant. These include the following:

1) The raised access road connecting the ERF and CBMF will have minimal culvert openings or will be completely blocked to ensure that overtopping to flow east into the industrial estate is prevented (details to be determined during detailed design stage). This will provide mitigation during the overtopping and Breach 01 with scheme scenario during the DFE and reduce potential impact in the industrial estate to the east.

2) Land levels west of the new access road will be modified to ensure that flood flows are not immediately directed through the existing culvert and south of the Application Land as illustrated in Figure 5.18. Land levels will be raised and integrated with the new landscaping area, tying into higher land levels. This measure replaces modification of the existing B1216 culvert previously outlined in the Draft FRA appended to the PEIR submission where the culvert opening was reduced in size to ensure flows did not increase compared to baseline.

   Typical grading of the modified landform may be 1 in 12 slopes to allow vegetation to be integrated (creating a raised embankment in the order of approx. 1.7m in height, 3m top width and 40m bottom width). Slope stability assessment will be undertaken during the next stage to inform the gradients and vegetation to ensure new vegetation does not compromise the stability of the embankments. The toe of the embankments will be set at least 9m from the watercourse top of bank and existing ditch crossing to allow access and maintenance for SGWMB. [redacted]

   Figure 5.19 illustrates the approximate location and alignment.

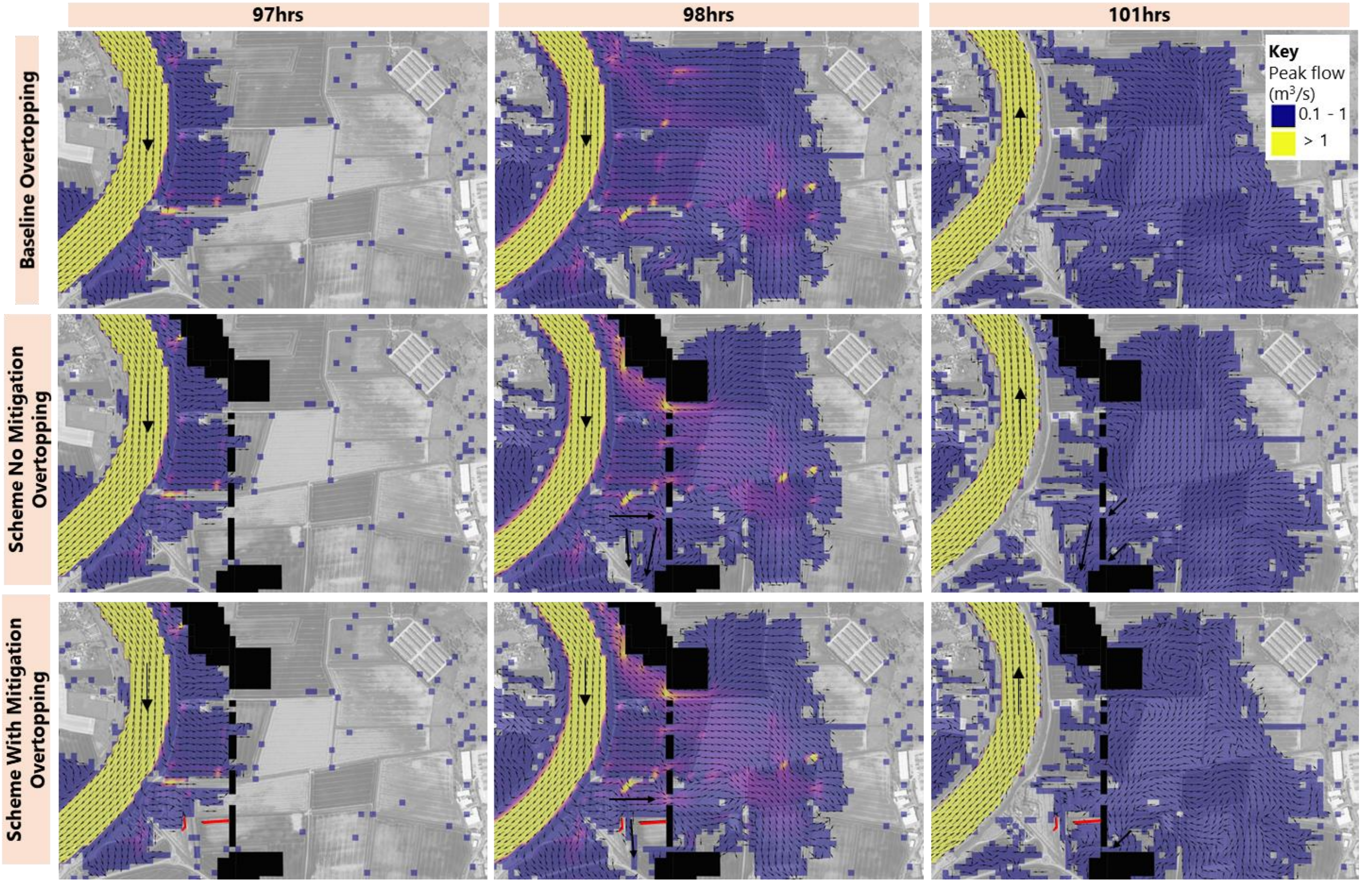


Figure 5.18 Flood mechanism during overtopping baseline and with scheme scenario (with and without mitigation). Time snapshots taken at peak tidal event at 97hours, immediately after the peak at 98 hours and at 101 hours as the tide recedes. Alignment of proposed land reprofiling shown by red lines in images on last row. Arrows indicate direction of flow (Image courtesy of Ordnance Survey, © 2021 TomTom).

Figure 5.19 Plan view of location and footprint for proposed modifications to existing land levels (dashed lines indicate top and bottom of embankment).

By reducing the flow of floodwater towards the south, a slight increase in floodwater level is observed to the east side of the access road. During the detailed design stage optimisation of the modified land levels and culvert sizing along the access road will be undertaken to minimise this increase whilst not increasing flood levels to offsite areas.

3) During indicative testing of the above mitigation measures an increase in flood extent was observed in Park Ings Farm on the east side of the Application Land. To ensure that an increase in flood extent is not observed during the next stage of design, it is proposed to also include a secondary flood defence along the perimeter of the Application Land; a raised bund with a culvert to allow existing drainage to continue to flow through the existing open ditch (see Figure 5.20). The proposed bund could be in the order of approx. 0.9m in height, 3m top width and 25m bottom width for 1 in 12 bank gradients with an access track along the west side.

Figure 5.20 Indicative alignment location plan of proposed defences at east of Application Land (Image courtesy of Ordnance Survey, © 2021 TomTom).

4) New flood walls along the east side of the port and partly along First Avenue are proposed on the west side of Flixborough Industrial Estate to divert flood flows away from industrial estate. Different options have been considered and will be developed further during the detailed design stage. As shown in Figure 5.21, and Figure 5.22 the site north of First Avenue is primarily affected by the proposed development during the Breach 01 scenario at time of the tidal peak. Following the breach, floodwater flows north towards the port, along First Avenue, continuing north into the industrial estate. The hydraulic flood model does not contain information on existing FFLs of buildings or the location of door openings. These would have an effect on the flood levels observed during a flood event. Further details will be incorporated into the flood model at the next stage where applicable.

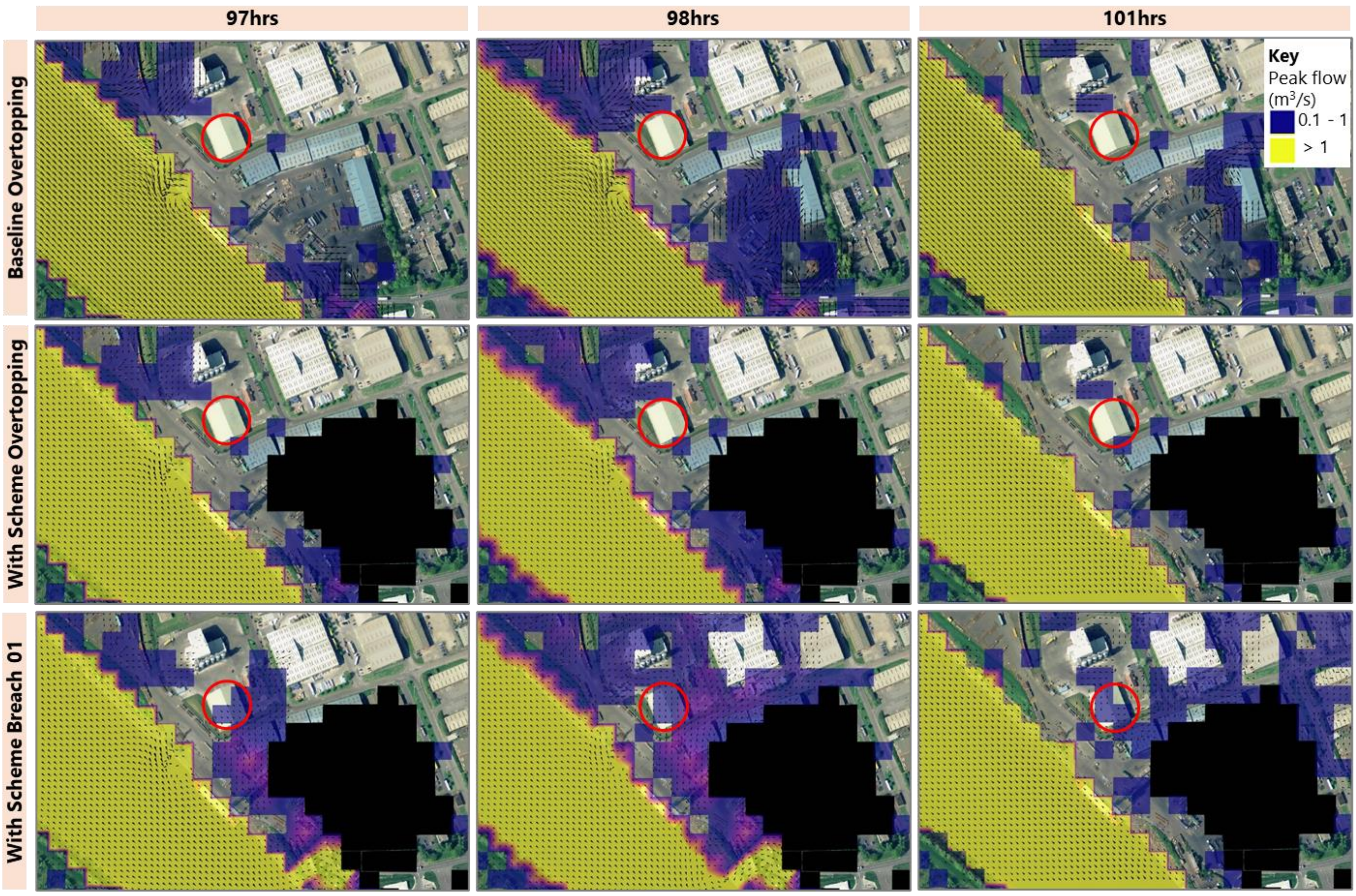


Figure 5.21 Flood mechanism during overtopping baseline and with scheme scenarios, and with scheme during Breach 01 scenario. Time snapshots taken at peak tidal event at 97hours, immediately after the peak at 98 hours and at 101 hours as the tide recedes. Warehouse circled in red is of the affected industrial unit (Image courtesy of Ordnance Survey, © 2021 TomTom).

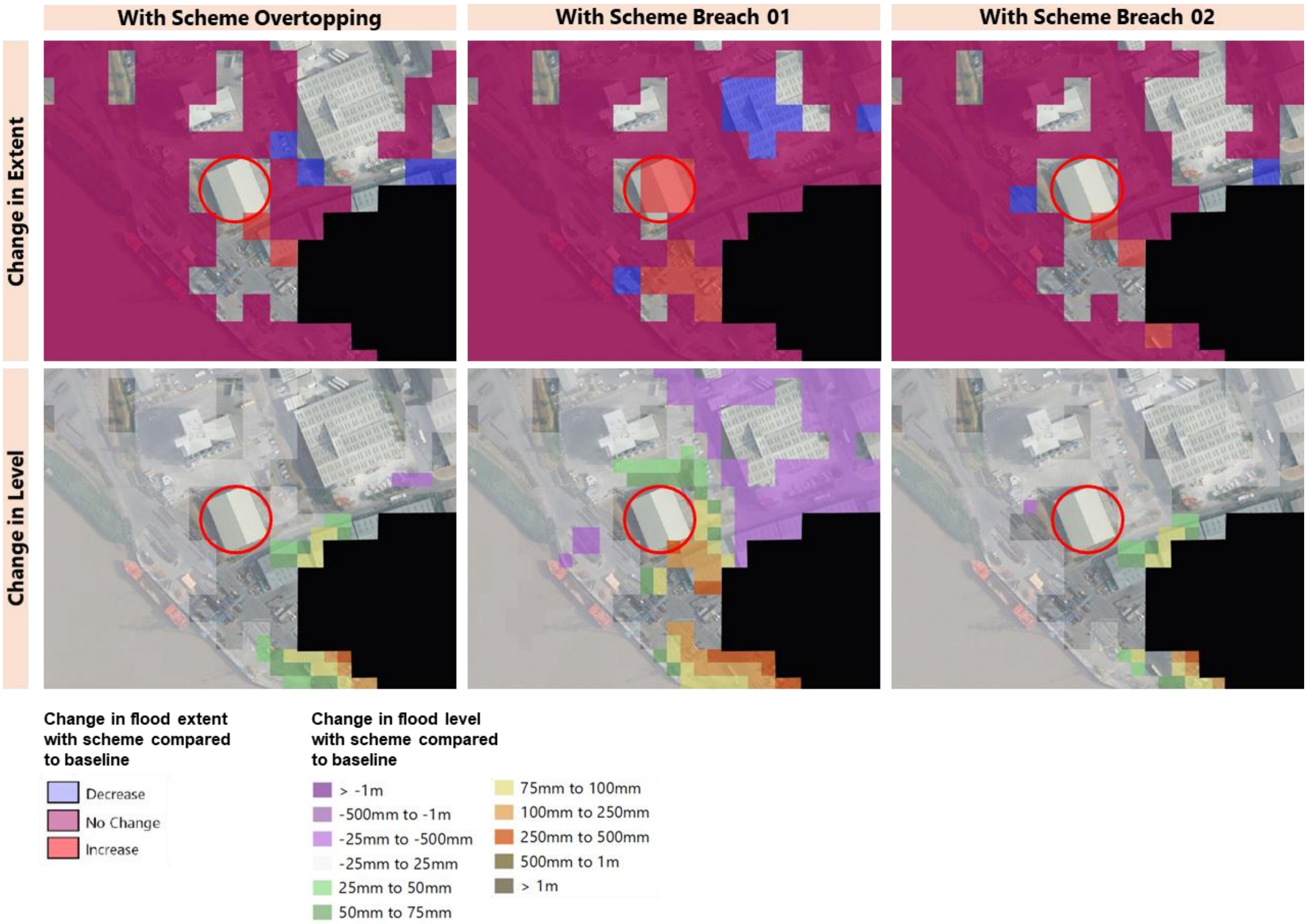


Figure 5.22 Change in flood extent and level during with scheme compared to baseline for overtopping, Breach 01 and Breach 002 scenarios. Warehouse circled in red is of the affected industrial unit (Image courtesy of Ordnance Survey, © 2021 TomTom).

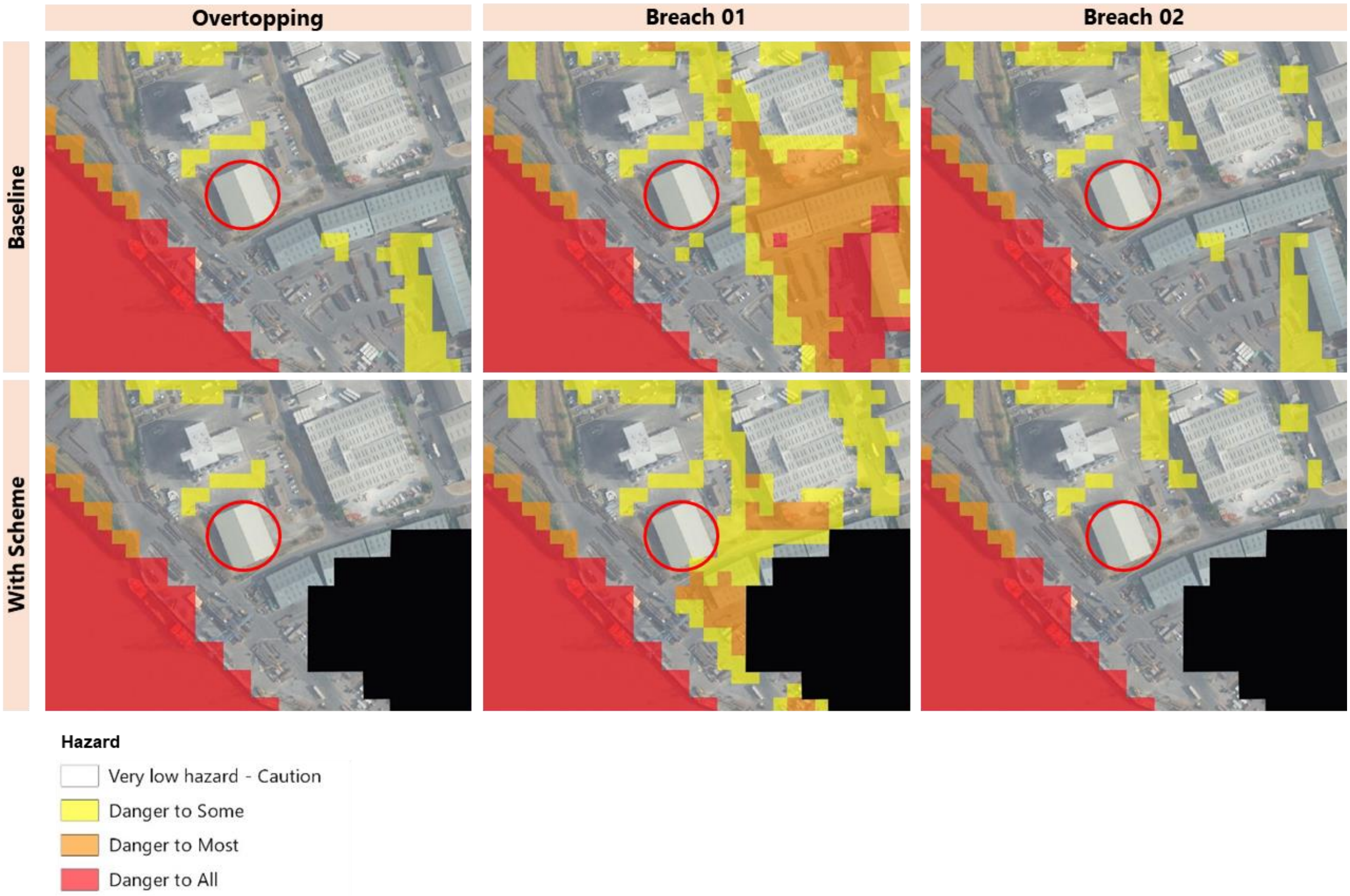


Figure 5.23 Hazard category for baseline and with scheme during the overtopping, Breach 01 and Breach 02 scenarios (Image courtesy of Ordnance Survey, © 2021 TomTom).

Proposed Mitigation

5.1.25 Option 1 - the first option would be to manage the safety of users in the warehouse by including the site in the Flood Evacuation and Management Plan. This would ensure people are evacuated ahead of a potential storm event which could lead to a breach in the defences. There may be residual risk to content of the warehouse building if a breach event did occur depending on FFL (not during an overtopping event).

5.1.26 Option 2 – raise the road level along First Avenue and incorporate flood defences around the perimeter of the site north of First Avenue wrapped around to the port. Due to space constraints, flood bunds would not be a viable option and instead flood walls would be constructed to maintain the flood defence crest level. The flood wall along the port side would only need to extend up to the existing access point into the industrial estate, as floodwater during a breach scenario is only observed to partially flow northwards along the port and instead flows primarily along First Avenue where land levels drop. This option would be a passive flood defence solution, providing flood protection during a breach scenario that may happen without prior warning. However, the solution is fairly disruptive during the construction process, restricting and diverting vehicle movements to the port for an extended period as well as the coordination for raising the road approximately 2m and any associated existing services.

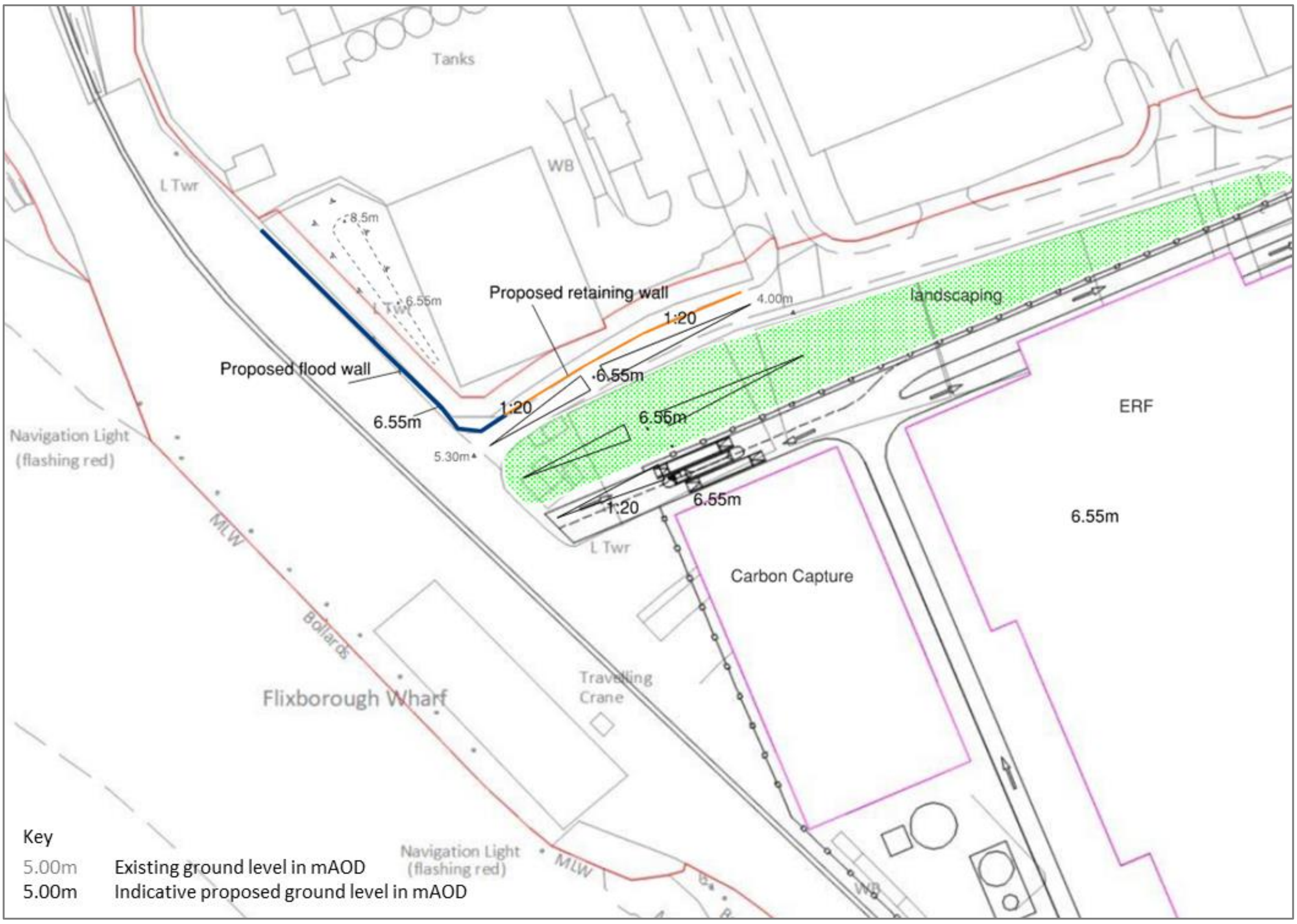


Figure 5.24 Plan view of change in land levels and alignment of new flood walls for Option 2.

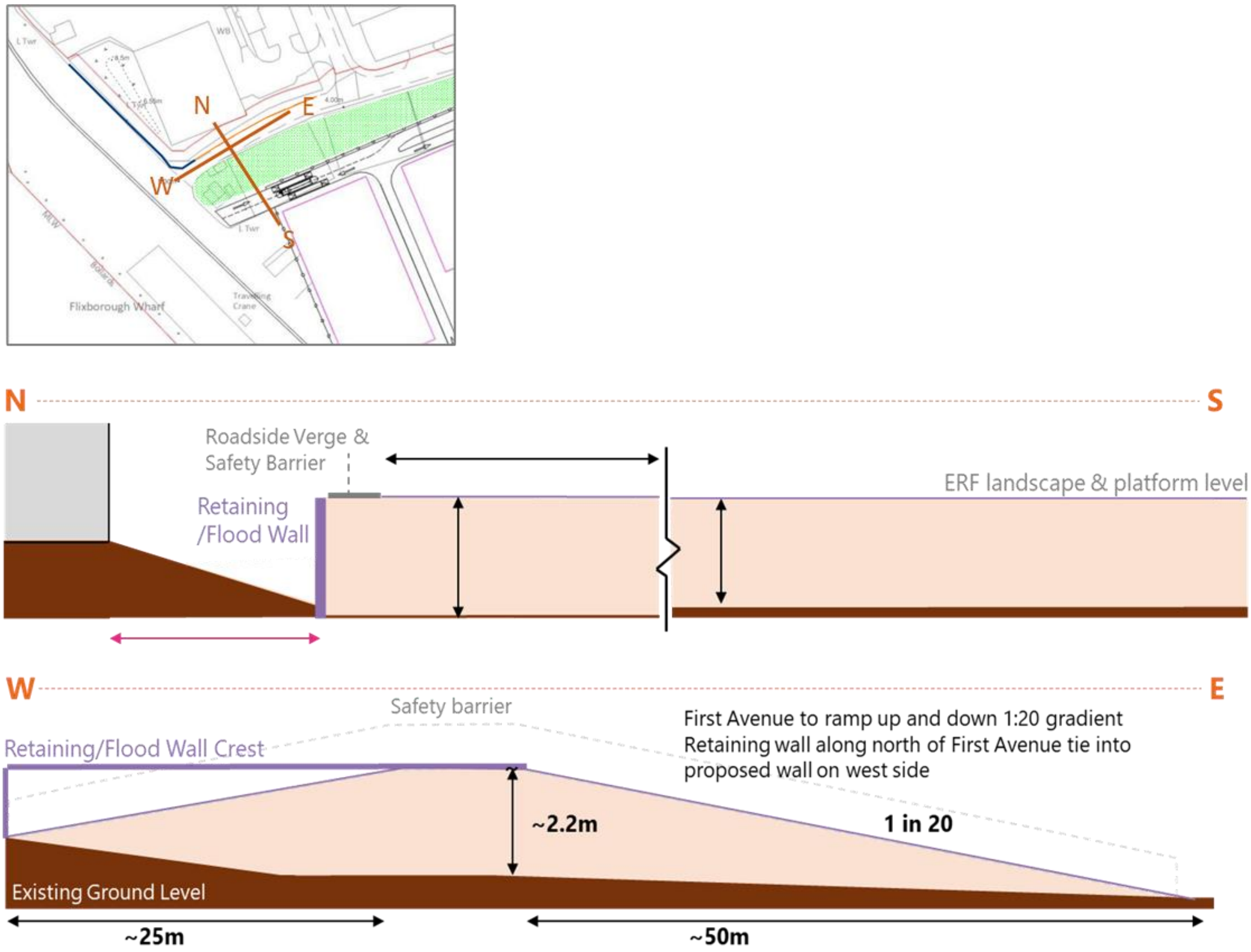


Figure 5.25 Indicative cross sections along First Avenue illustrating raising of the road for Option 2.

5.1.27 Option 3 – incorporate flood defences around the perimeter of the site north of First Avenue wrapped around the port and maintain flood defence crest level with a flood gate across the road. This would reduce the requirement for extensive changes to the existing road. The flood gate would be managed and operated by the site management staff who will be onsite 24hours a day and therefore able to operate closure of the gate. Ahead of an anticipated storm event, the Flood Evacuation Management Plan will include management of vehicles to and from the port.

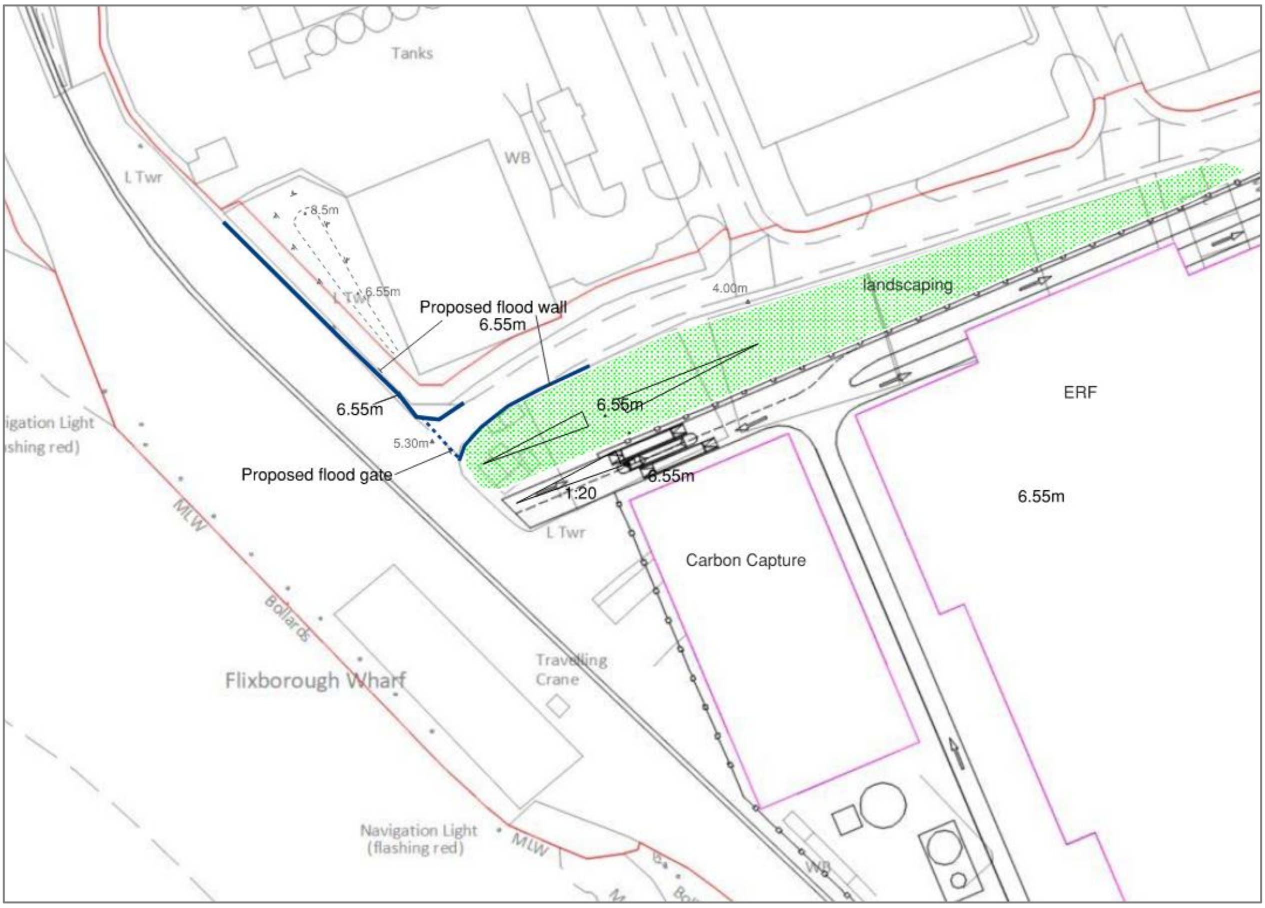


Figure 5.26 Plan view of change in land levels and alignment of new flood walls and flood gate for Option 3.

5.1.28 The three options will be developed further during the next stage of design, when further details of existing conditions in the area can be obtained and through further discussions with the EA.

5.1.29 The results of the assessment with all mitigation measures in place are shown below in Table 5-5 and Figure 5.27 to Figure 5.32. A summary of the key impacts observed are as follows.

Table 5-4 Summary of results for the Project with mitigation measures, Breach 01 and Breach 02 scenarios compared to baseline during the DFE.

Zone	Summary of Results
A - Site North D – Solar Farm G – Park Ings Farm I, J, K – Land off-takes	No changes in extent, depth or hazard observed during the DFE or breach scenarios due to the Project. Some reductions in flood levels observed.
B – Port area	The increase in flood level observed in the Steel Works warehouse during the Breach 01 scenario remains in place. No change in hazard category. Frequency of flooding not increased as no changes to the river channel proposed that would affect the timings that overtopping would occur.
C – Flixborough Industrial Estate	Flood levels in the Industrial Estate reduce during all scenarios, in some locations by up to 170mm, providing betterment compared to the existing condition. The increase in level observed at the junction of Stather Road and Fourth Avenue and First and Second Avenue have now been removed.
E – Site West	Increase in flood levels and hazard category observed locally to the west of the Project remain.
F – Site East	Increase in flood levels observed in the agricultural fields to the east of the Project remain. Slight increase in extent observed within the fields at risk during the baseline for each scenario. Negligible change in hazard category. Frequency of flooding not increased as no changes to the river channel proposed that would affect the timings that overtopping would occur.
H – Site South	Increase in flood level south of the Application Land now removed.

Table 5-5 Estimated flood level and depth during the DFE baseline (B'line) and change in flood level due to the proposals with flood mitigation measures, for the DFE, Breach 01 and Breach 02 scenarios (results provided for the maximum change in level observed within the Result Zone shown in Figure 4.2) Hazard Classifications: 1 = Very Low, 2 = Danger to Some, 3 = Danger to Most, 4 = Danger to All

Result Zone	DFE				DFE + Breach 01				DFE + Breach 02			
	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating
A – Site North	3.40	0.07	0	N/A	3.40	0.07	+2	N/A	4.47	1.14	+1	N/A
B – Port area (Steel Works)	5.57	0.18	0	N/A	5.44	0.07	+117	N/A	5.43	0.06	0	N/A
B – Port area (ERF)	4.78	0.02	+348	N/A	5.30	0.45	+680	2 - 3	4.77	0.02	+347	N/A
C – Flixborough Industrial Estate	4.16	0.37	-2	2 - 1	4.29	0.50	-173	3 - 1	4.38	0.59	+2	N/A
D – Solar Farm	2.66	0.09	0	N/A	2.75	0.06	-115	3 - 1	2.68	0.01	0	N/A
E – Site West	3.19	0.47	+585	3 - 4	3.27	0.55	+958	3 - 4	3.17	0.45	+553	3 - 4
F – Site East	1.67	1.23	+53	N/A	1.94	1.50	+82	N/A	1.64	1.23	+53	N/A
H – Site South	0.34	0.24	-43	N/A	0.68	0.58	-12	2 - 1	0.31	0.21	-68	N/A

Notes: changes for Zones G, I to K not reported due to negligible changes observed.

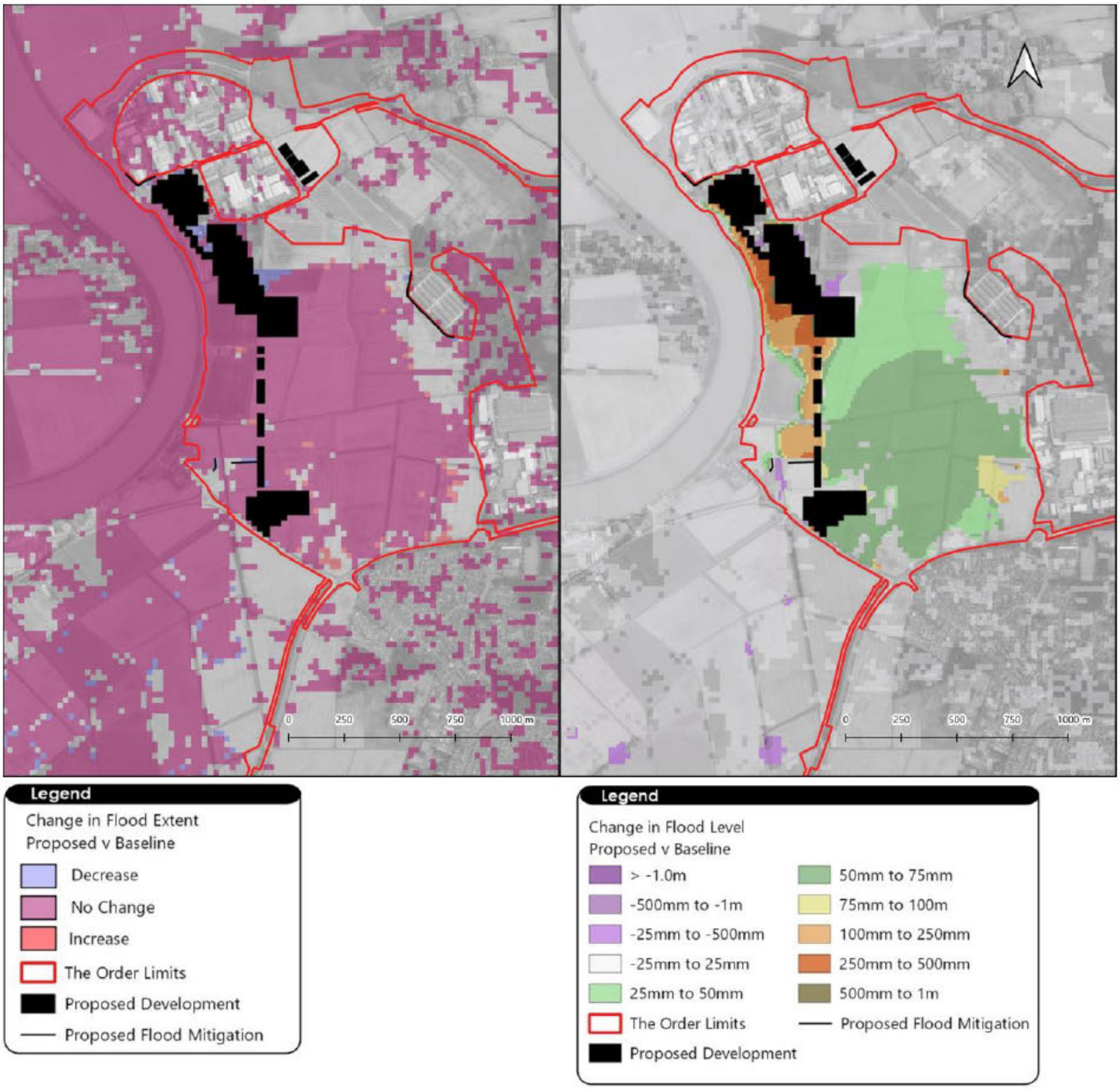


Figure 5.27 Change in flood extent and flood depth during the DFE due to the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

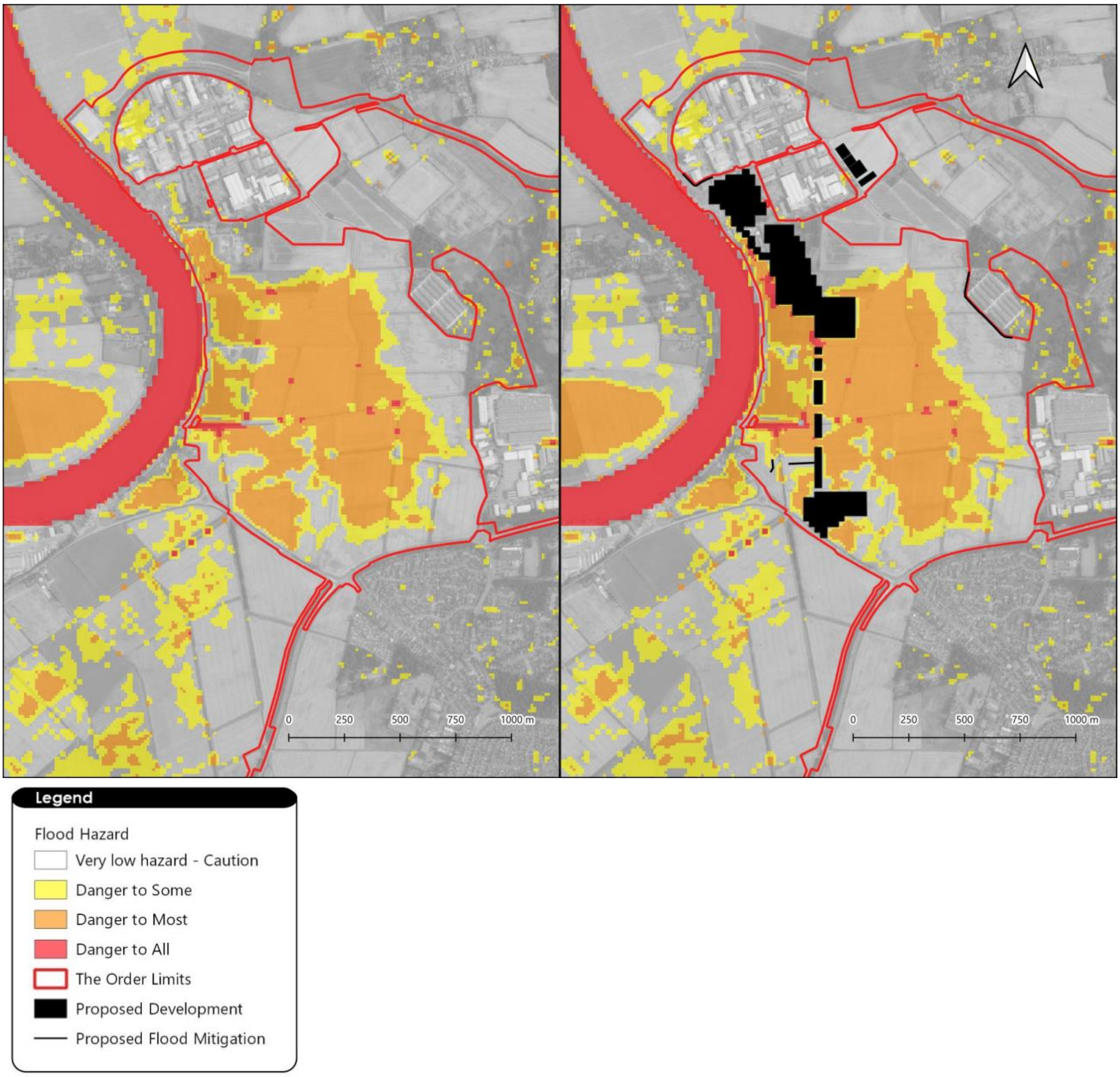


Figure 5.28 Hazard in the future baseline scenario and future scenario with the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

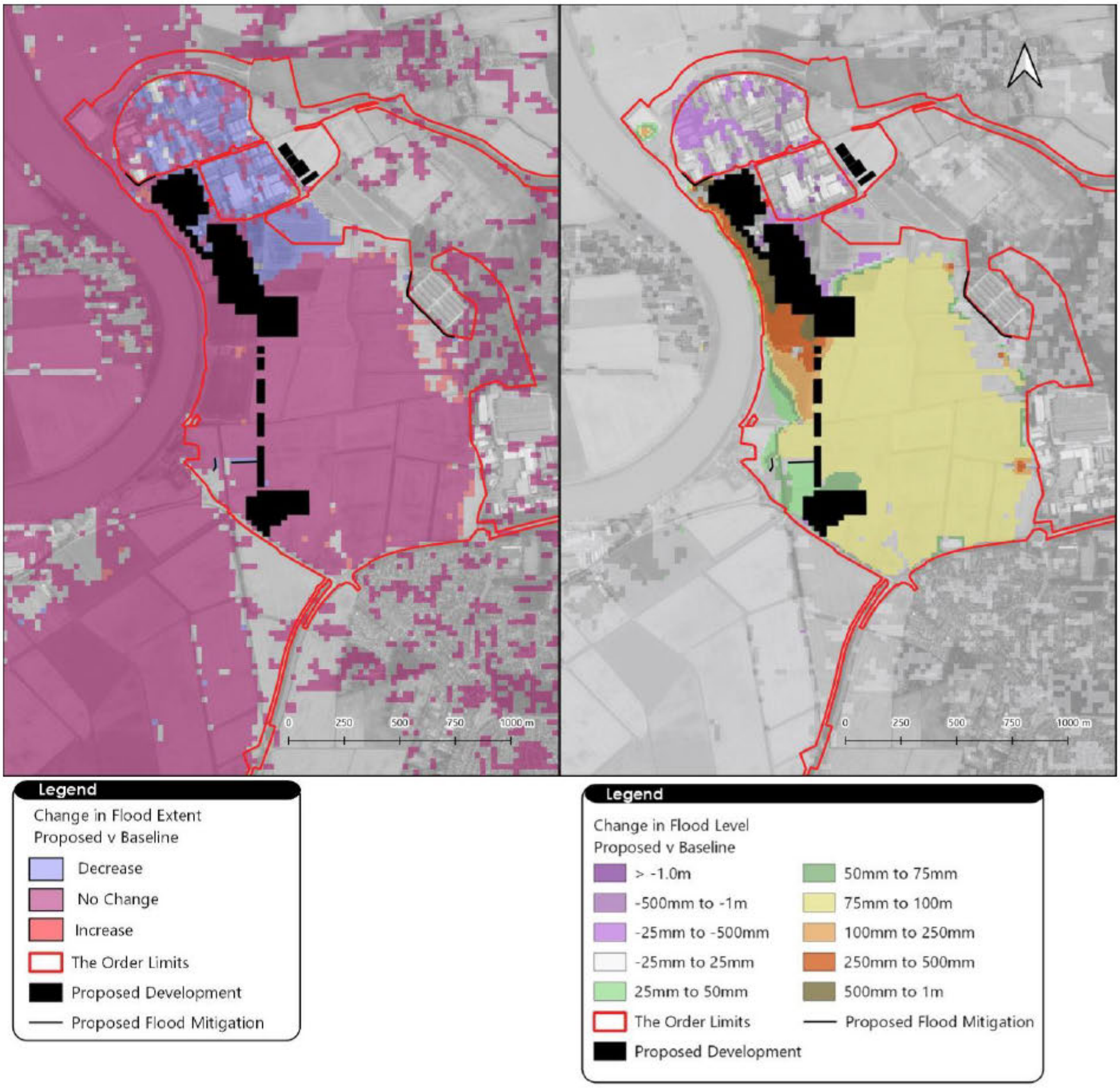


Figure 5.29 Change in flood extent and flood depth during the DFE with Breach 01 due to the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

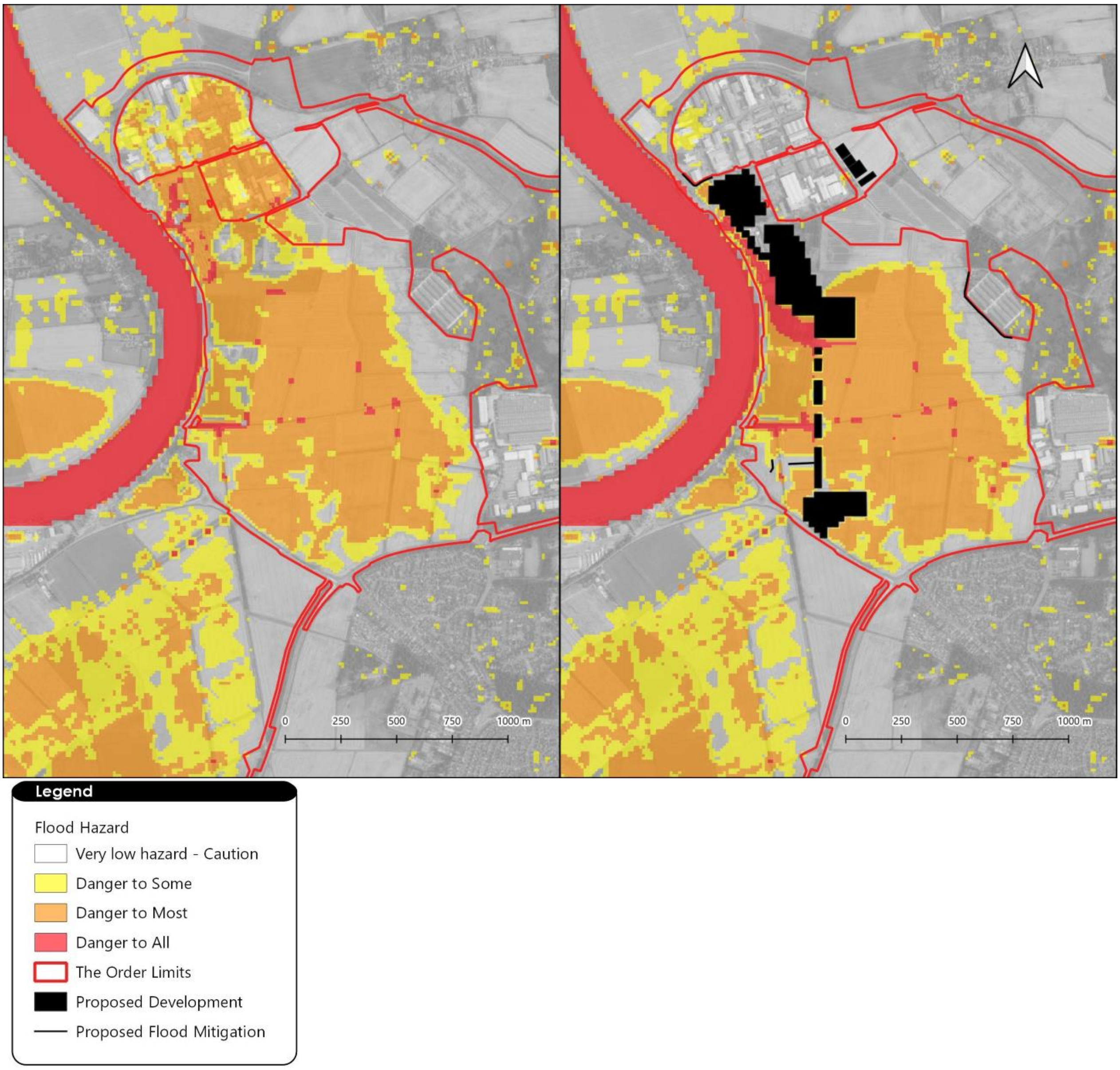


Figure 5.30 Hazard in the future baseline scenario with Breach 01 and future scenario with Breach 01 and the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

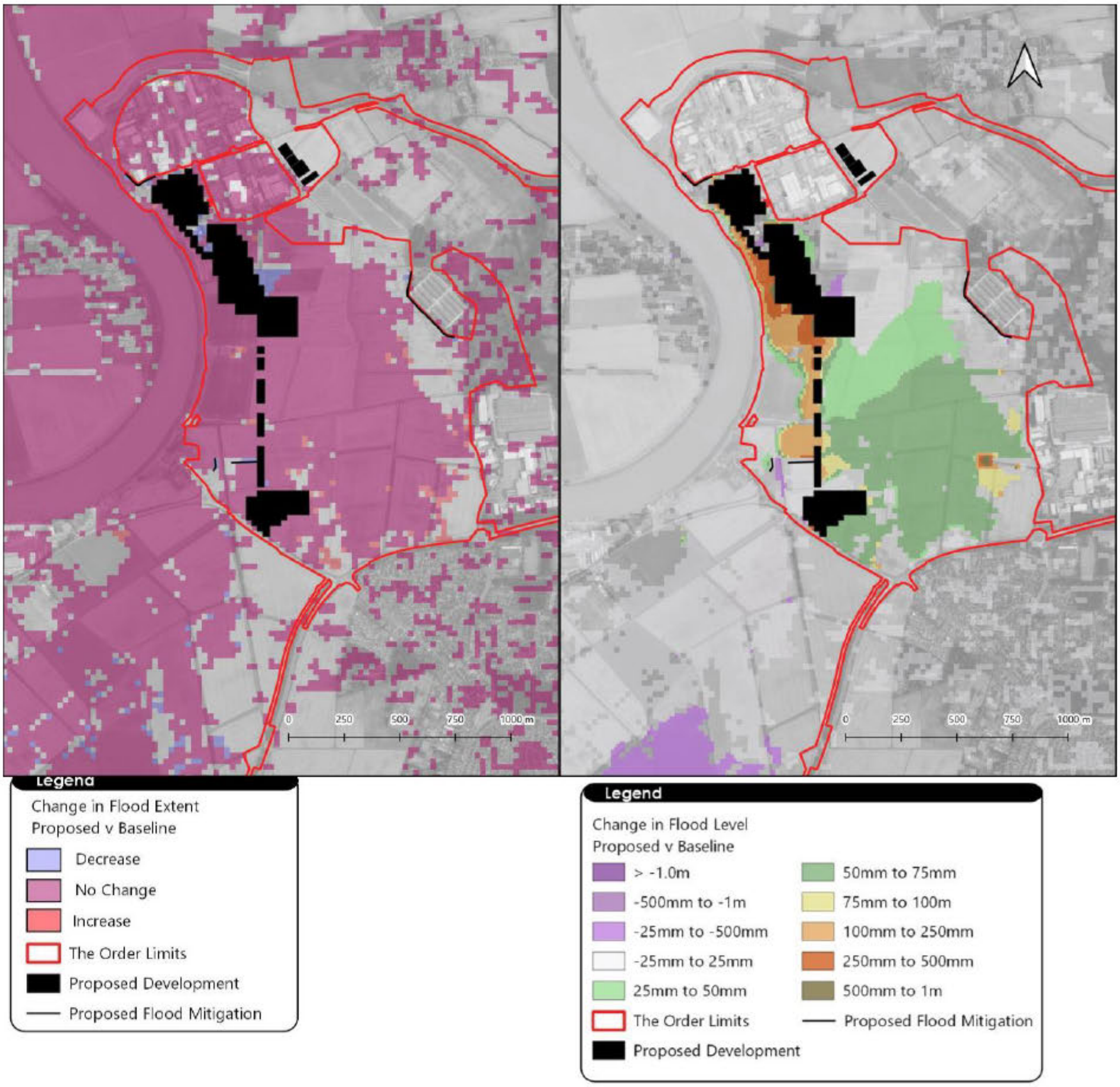


Figure 5.31 Change in flood extent and flood depth during the DFE with Breach 02 due to the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

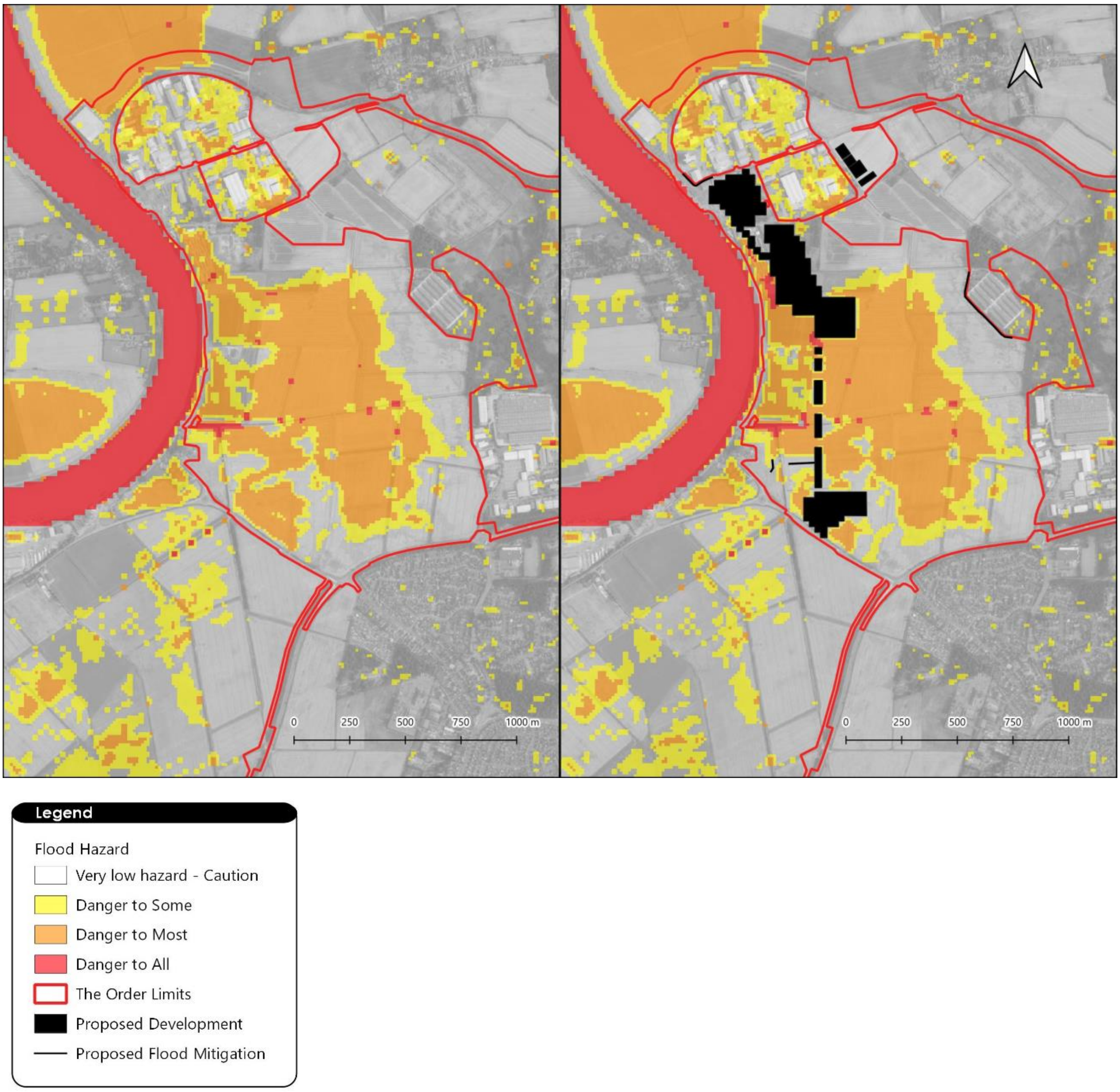


Figure 5.32 Hazard in the future baseline scenario with Breach 02 and future scenario with Breach 01 and the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.1.30 To ensure that the Project is at a low risk from flooding during the DFE, FFLs and the access road will be set above the DFE flood level with an allowance for freeboard. To ensure that the Project remains fully operational during the DFE and any potential breach event, it is recommended that either FFLs are set above the breach level or that appropriate resistant features are included within the design to prevent water ingress to key equipment during such an event. The table below provides flood levels and minimum recommended FFLs for different areas across the Application Land.

Table 5-6 Estimated flood levels and recommended setting of finished floor levels or equipment levels. Recommended levels include 450mm freeboard. Minimum FFL based on DFE flood level + freeboard; equipment level/protection through resistant measures based on either Breach 01 or Breach 02 flood level + freeboard. See Figure 5.33 for location map of Site IDs.

Site ID	Flood Level (mAOD)			Minimum recommended FFL		Minimum recommended level/protection for equipment	
	DFE	Breach 01	Breach 02	mAOD	m above existing	mAOD	m above existing
1	5.61	6.04	5.53	6.06	0.8 – 3.2	6.49	1.2 – 3.6
2	3.60	3.60	3.85	4.05	0 - 0.7	4.30	0.2 – 0.9
3	3.96	4.47	3.91	4.41	0.8 – 2.0	4.92	1.3 – 2.5
4	3.85	4.34	3.80	4.30	1.6 – 2.6	4.79	2.1 – 3.1
5	2.84	3.08	2.80	3.29	1.7 – 2.2	3.53	1.9 – 2.4
6	2.02	2.14	2.0	2.47	1.0 – 1.1	2.59	1.1 - 1.2
7	1.93	2.02	1.90	2.38	0.7 – 1.6	2.47	0.8 – 1.7
8	1.65	1.98	1.56	2.10	0.5 – 1.6	2.43	0.8 – 1.9
9	4.08	4.08	4.11	4.53	0	4.56	0

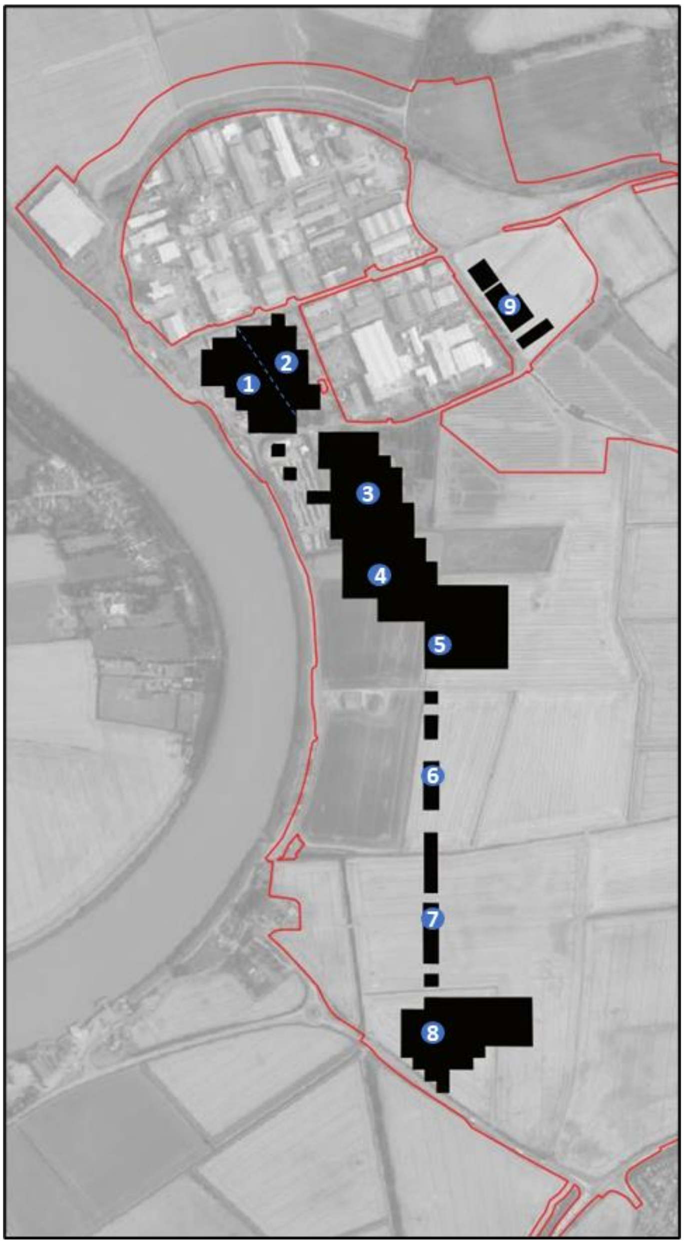
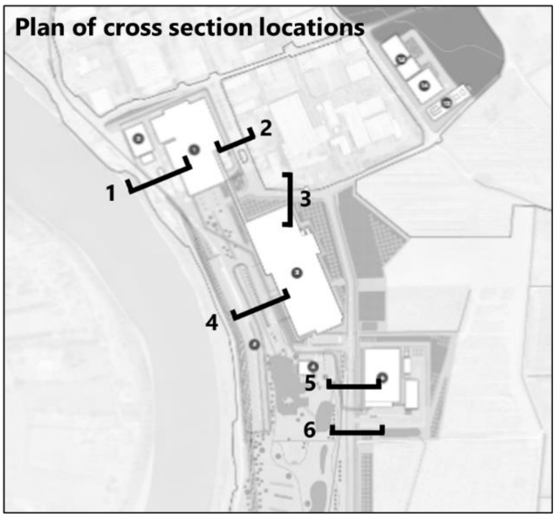


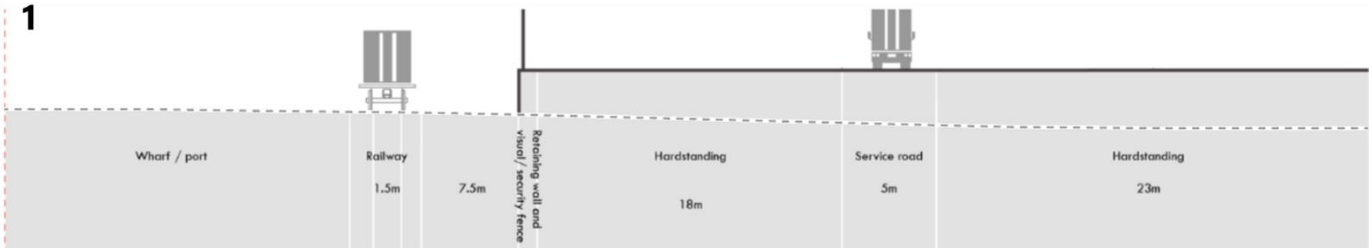
Figure 5.33 Location map with ID reference locations that correspond to ID in Table 5-6 (Image courtesy of Ordnance Survey, © 2021 TomTom).

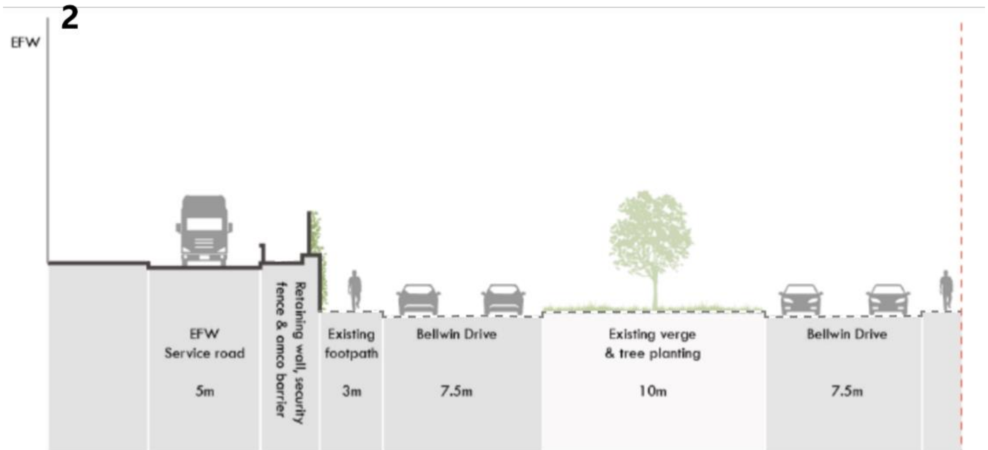
5.1.31 Indicative proposed finished floor levels in relation to surrounding levels can be found in the Indicative elevations and sections (**Document Reference 4.12**) and Indicative Highways drawings (**Document Reference 4.14**). It should be noted that the levels shown are subject to final design but will not be lower than the minimum recommended levels set out in Table 5-6.

5.1.32 All proposed development platforms can be accessed via the new access road from the south, the wharf and Stather Road where the roads ramp up from existing road levels. The only building that has been designed across a split level is the Visitor Centre. This is to allow an immersive experience for visitors to transition between the proposed landscaped wetland area and the ERF. To ensure the safety of visitors, the Lower Ground Floor (3.1mAOD, similar to existing ground levels) will only have less vulnerable uses such as car parking, outdoor terrace furniture, storeroom for chairs/tables for use on the wetland terrace. The main Visitor Centre will be located on the raised Ground Floor currently proposed at 5.1mAOD.

5.1.33 Illustrations of the proposed vehicle and pedestrian access routes around the ERF in relation to surrounding ground levels can be found in the Design and Access Statement (**Document Reference 5.3**) and in Figure 5.34.

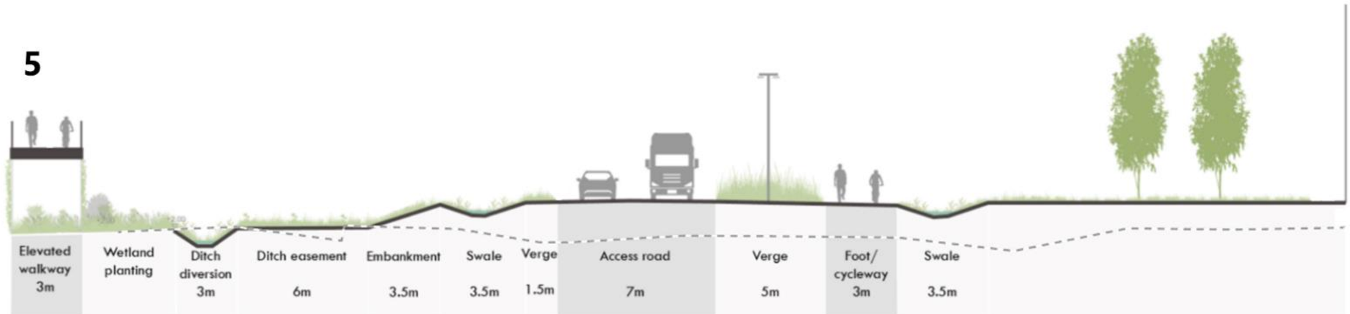





2
EFW
EFW Service road 5m
Retaining wall, security fence & amco barrier
Existing footpath 3m
Bellwin Drive 7.5m
Existing verge & tree planting 10m
Bellwin Drive 7.5m


3
Access & Maintenance 3m
Wildflower planting 11m
Foot/ cycleway 3m
Verge 5m
Stather Road 10m
Existing vegetation


4
Stopped up Stather Road
Security fence
Railhead 10m
Container handling & storage area 22m
Hardstanding 5.5m
Retaining wall & security fence
Service road 10m
Retaining wall & security fence
Wetland planting 13m
Swale 3m
Wetland planting 13m
Retaining wall & security fence
Service road 10m
Verge 10m
Elevated walkway 3m
Wildflower planting 20m
Footpath 2m


5
Elevated walkway 3m
Wetland planting
Ditch diversion 3m
Ditch easement 6m
Embankment 3.5m
Swale 3.5m
Verge 1.5m
Access road 7m
Verge 5m
Foot/ cycleway 3m
Swale 3.5m

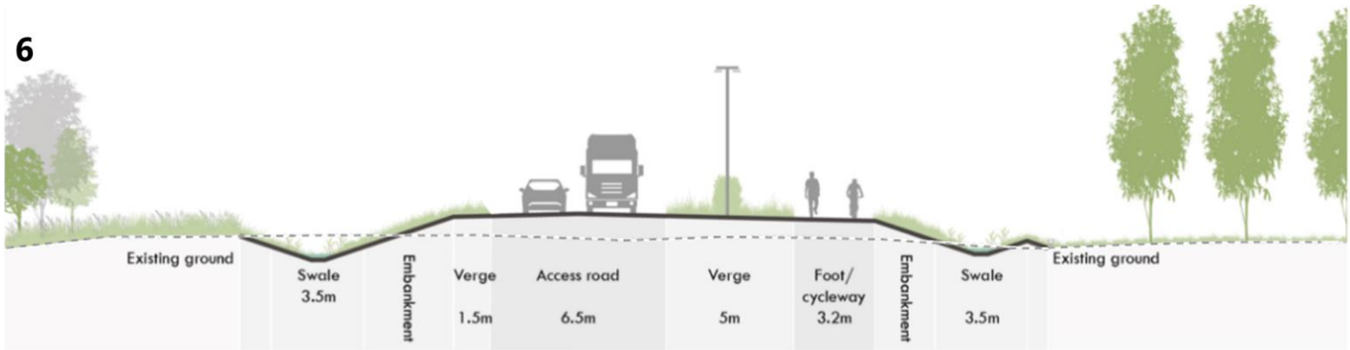


Figure 5.34 Indicative cross sections at six locations. Proposed levels shown by solid dark grey line. Existing ground levels shown by dashed light grey line. Cross sections extract from Document Reference 5.3.

5.1.34 Discussions were undertaken with the EA regarding sensitivity tests of a breach in proposed new secondary flood defences. This is because failure can occur if not constructed properly or, in the case of a manual flood gate, is left open. This has not been tested in the proposed flood wall around the port and First Avenue because behind the wall is an existing earth embankment and warehouse. The embankment and building will prevent any onset of fast flowing water to users on the site. If the gate remained open flood water would continue along First Avenue and the anticipated risk would be as shown in the flood results above. At this location velocities are approximately 0.5m/s and depths 0.3m with a hazard category of 'danger to some'. As part of the proposals a Flood Warning and Evacuation Plan will be in place to manage users around the site.

5.1.35 A breach in the proposed bund in the east of the Application Land has also not been undertaken. This is due to flood depths and velocities being low at the periphery of the floodplain extent.

5.1.36 As a sensitivity test, the H++ scenario was assessed. This is considered a very low probability of occurrence but has been assessed to understand the potential future impact to the Project, rather than to guide design criteria.

5.1.37 The results shown in Table 5-7, Figure 5.35 and Figure 5.36 indicate that during the H++ sensitivity test, significant changes in results are not observed. The resulting flood levels are lower than the minimum recommended FFL set out in Table 5-6.

Table 5-7 Estimated flood level and depth during the DFE baseline (B'line) and change in flood level due to the proposals with flood mitigation measures, for the H++ sensitivity test (results provided for the maximum change in level observed within the Result Zone shown in Figure 4.2). Hazard Classifications: 1 = Very Low, 2 = Danger to Some, 3 = Danger to Most, 4 = Danger to All

Notes: changes for Zones G, I to K not reported due to negligible changes observed

Result Zone	Sensitivity Test: H++			
	B'line Flood level (mAOD)	B'line Flood Depth (m)	Change in Flood Level (mm)	Change in Hazard rating
A – Site North	3.74	0.19	-1	N/A
B – Port area (Steel Works)	5.66	0.26	0	N/A
B – Port area (ERF)	4.88	0.09	+249	N/A
C – Flixborough Industrial Estate	4.33	0.54	0	N/A
D – Solar Farm	2.66	0.09	0	N/A
E – Site West	3.23	0.51	+666	3 - 4
F – Site East	1.89	1.48	+79	N/A
H – Site South	0.59	0.48	-9	N/A

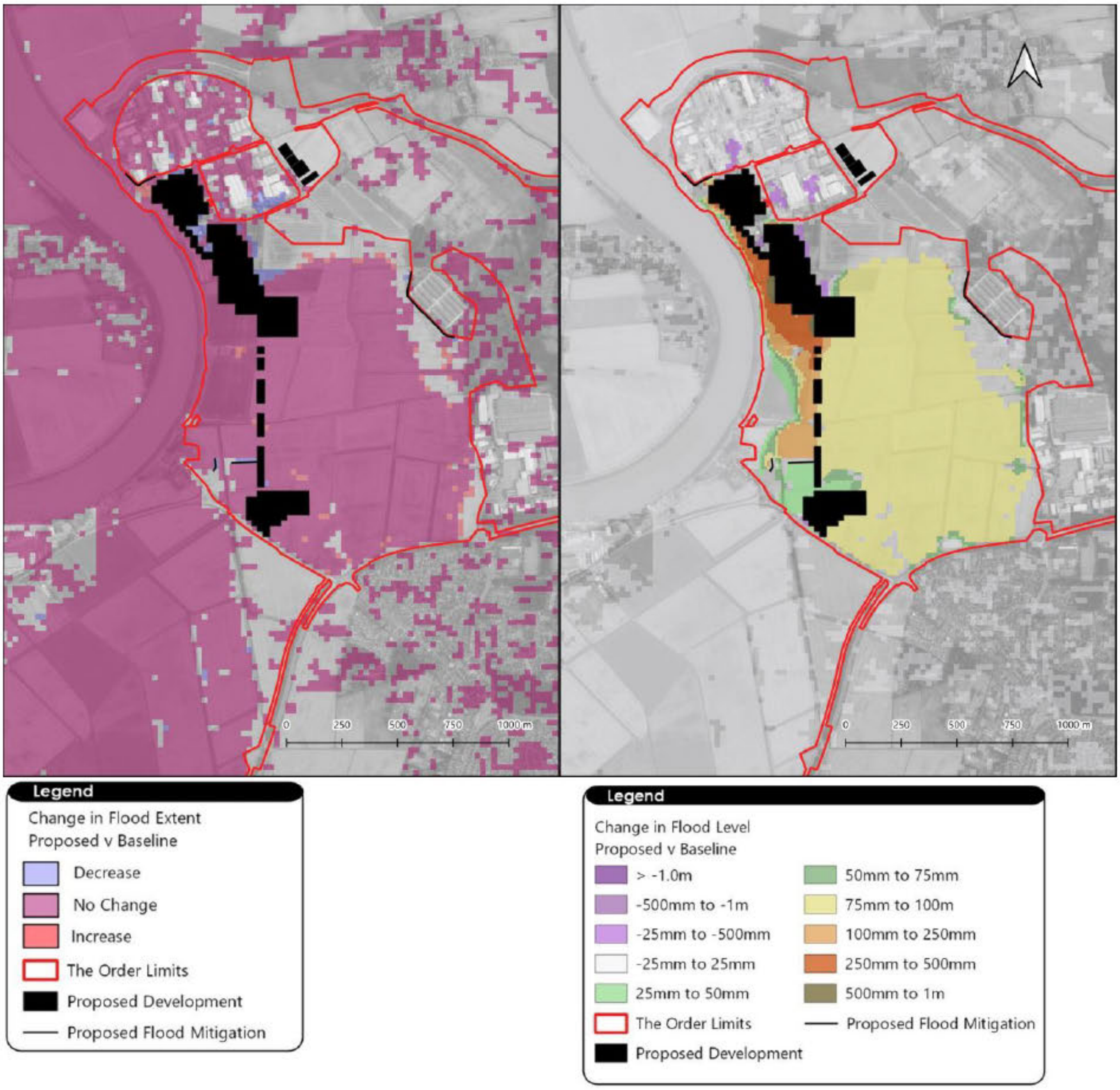


Figure 5.35 Change in flood extent and flood depth during the sensitivity test H++ scenario due to the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

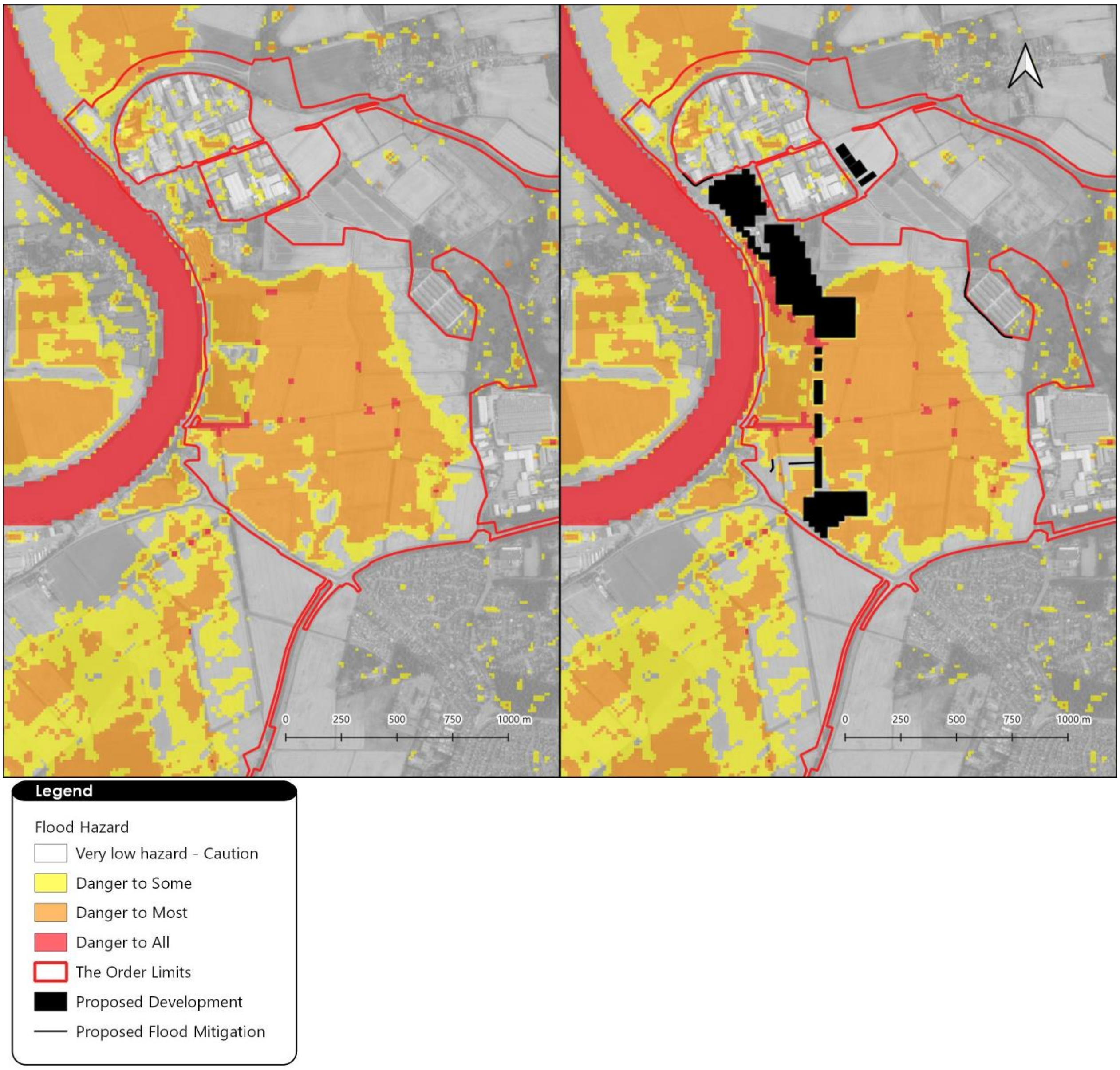


Figure 5.36 Hazard in the future baseline scenario and future scenario during sensitivity test H++ scenario due to the Project with mitigation measures (Image courtesy of Ordnance Survey, © 2021 TomTom).

Flood Evacuation and Management Plan

5.1.38 To manage the areas where the increase in flood risk has not been mitigated, it is recommended that a Flood Evacuation and Management Plan is developed.

5.1.39 The plan would be used to primarily manage the increased depth and hazard identified in Zone B, port area, to alert users of a potential flood event. This would be required for new users of the Project and rail line as well as existing users of the port.

5.1.40 Recommended measures include signing up to the EA flood warning alert system and Met Office weather forecasts and disseminating information from the visitor centre across the site using information boards, phone messaging and text messaging services. The proposed measures will be further developed as part of the wider Flood Evacuation and Management Plan in consultation with the local authority's emergency planners.

5.2 Surface Water & Sewer Flooding

Overview

5.2.1 Surface water flooding occurs when intense rainfall is unable to naturally soak into the ground due to impermeable ground coverings such as concrete or is prevented from flowing overland to natural watercourses due to topography or engineered features.

5.2.2 Flooding from sewers occurs when capacities of existing sewers are exceeded, and flooding of the surface is observed. This can be due to excess rainfall entering the sewer network or due to blockage.

Baseline Flood Risk

5.2.3 Surface water flood risk Very Low to Medium, with areas of ponding across the site, generally corresponding with existing drainage channel locations and depressions in the topography.

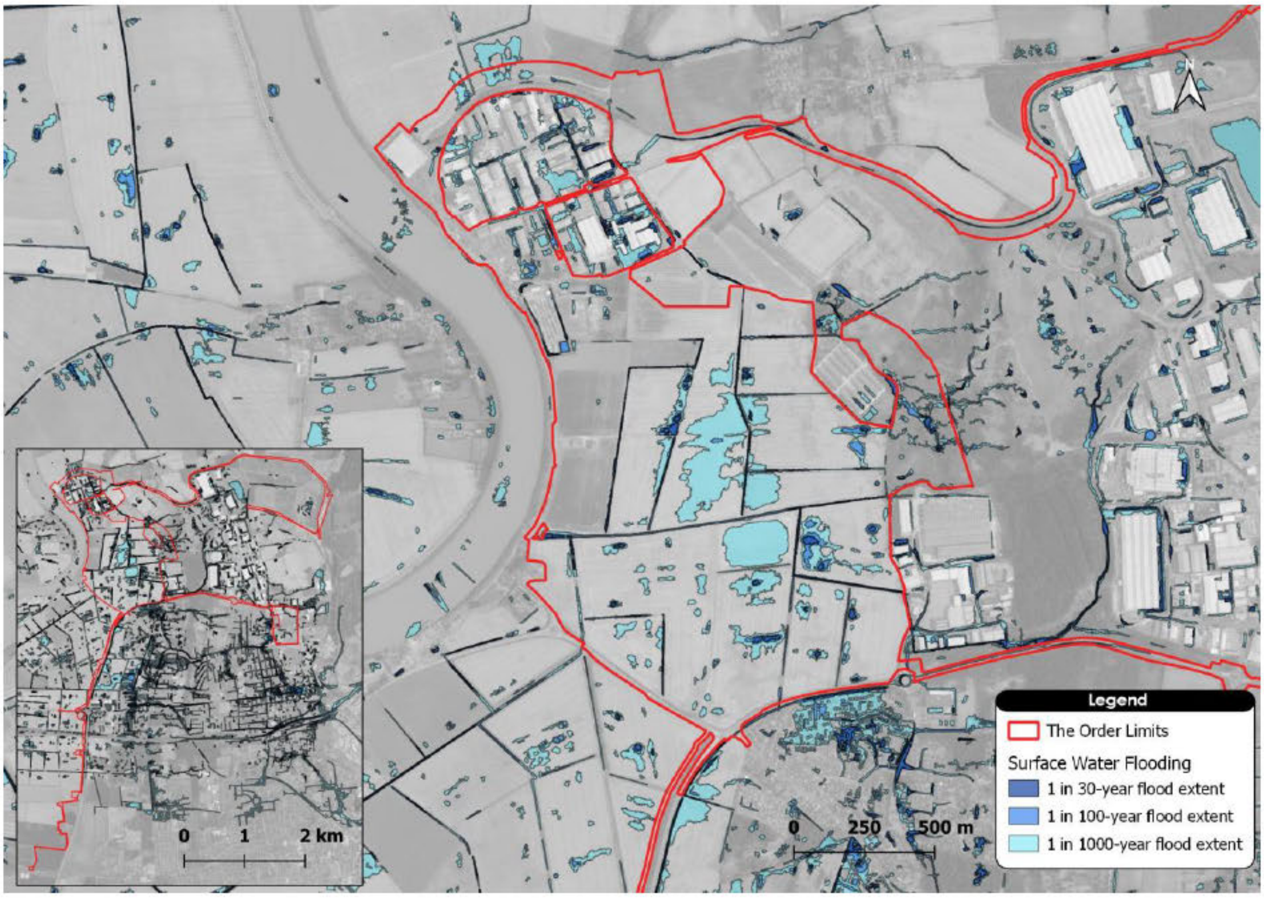


Figure 5.37 EA surface water flood map (Image courtesy of Ordnance Survey, © 2021 TomTom).

Figure 5.38 Location of surface water pumping stations. Lysaghts pumping station draining the majority of the Site in the left image and Flixborough Industrial Estate drained via the pumping station in the right image (source, SGWMB October 2020).

5.2.4 Existing drainage across the agricultural areas of the site predominantly consists of land drains. Stather Road drains to either the existing agricultural fields or to adjacent ditches along its length. A piped drainage system exists within the Flixborough Industrial Estate and pumped to the River Trent.

5.2.5 The agricultural ditches drain to Lysaght's Drain, which runs east-west through the centre of the Site and in turn discharges to the River Trent, via a pumping Station, Lysaght's pumping station. Existing land is drained by a series of water courses that discharge to the River Trent. There are two pumping stations and outfalls. One is located to the north of the Industrial Estate and the other is located to the north of Neap House and south of the proposed site (see Figure 5.38).

Proposed Development

5.2.6 The Project considers the use of sustainable drainage techniques in accordance with local policy. The CIRIA SuDS Manual contains a hierarchy of sustainable methods of capturing and storing rainwater in a descending order: from drainage into the ground to recharging water resources. Since infiltration is not possible, surface water will be stored on site in open water features and then released at a controlled rate.

5.2.7 As all the catchments are discharging to a water course, the existing greenfield runoff rate has been calculated to comply with requirements set by Scunthorpe & Gainsborough Water Management Board (SGWMB). This flow rate of 1.4 l/s/ha will be used for the Project.

5.2.8 As agreed with the LLFA the proposed surface water drainage system should have capacity to store the 1 in 100-year (plus 40% climate change) storm event on site prior to discharge into the existing ditches.

Flood Risk Mitigation

5.2.9 The Application Land has been divided into 10 catchments. These were divided due to the large site area and several existing ditches crossing the site. There are 10 detention basins and 1 storage tank used to promote biodiversity, treat water quality and attenuate stormwater before being discharged into the existing ditches. Where possible, swales will be used to convey runoff instead of pipes and basins will be used for storage instead of tanks. An orifice is used to control discharge rates from the basins.

5.2.10 The proposed buildings will be constructed on platforms raised above the existing levels, to raise the buildings out of the River Trent flood areas. Overland flow paths around these platforms will be maintained such that any exceedance events will follow the existing flow paths to the existing points of discharge (see Figure 5.39).

5.2.11 Details of the proposed surface water drainage strategy can be found in the Indicative Drainage Strategy (**Document Reference 6.3.5**).

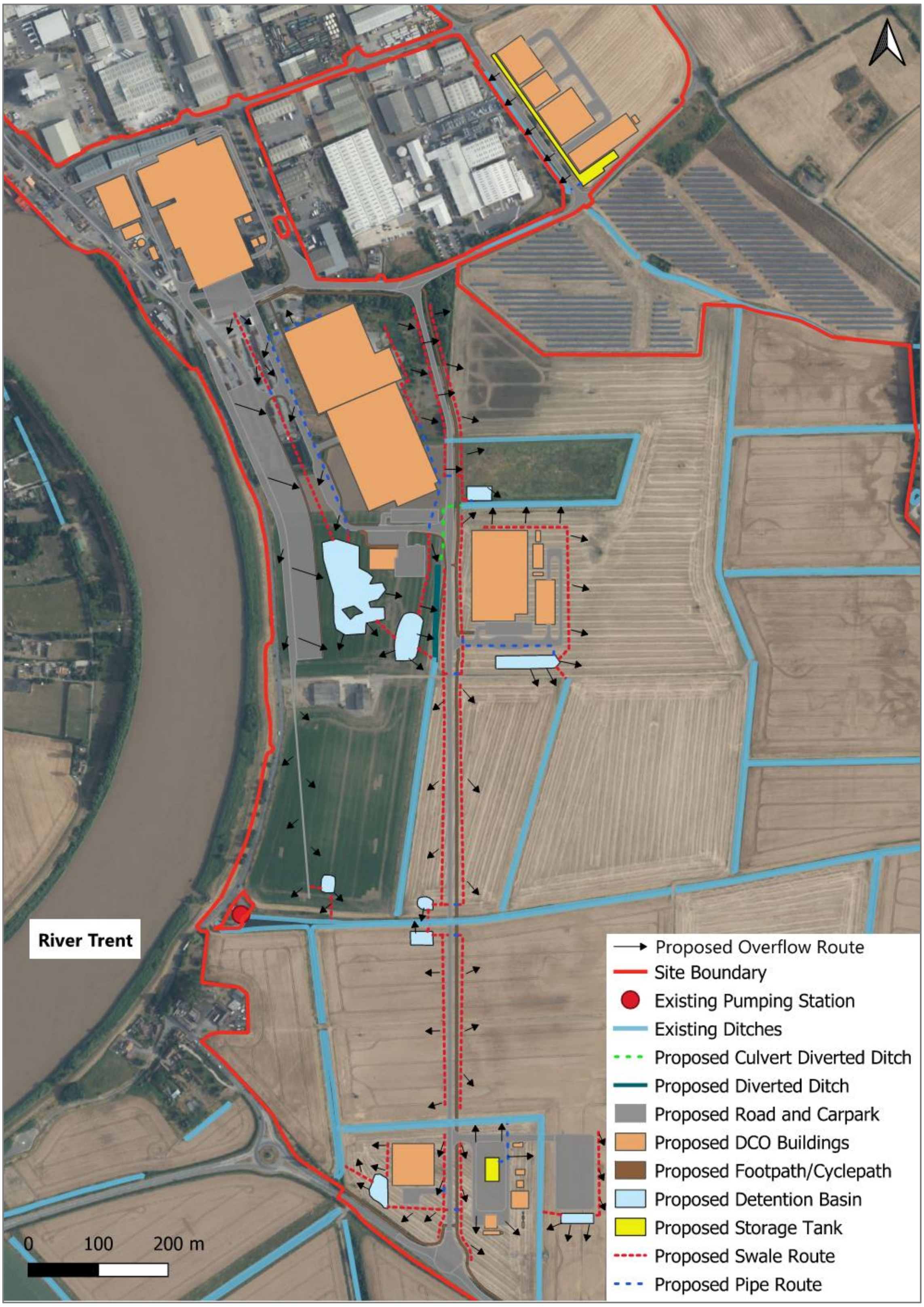


Figure 5.39 Proposed surface water drainage strategy, including SuDS measures and exceedance flow routes (Image courtesy of Ordnance Survey, © 2021 TomTom).

5.3 Groundwater Flooding

Overview

5.3.1 Groundwater flooding generally occurs in low-lying areas above permeable rock aquifers where the water table meets and rises above the ground surface.

Baseline Flood Risk

5.3.2 Historical borehole log records, in addition to a Ground Investigation report by Ian Farmer Associates (2018), have been reviewed to develop a deeper understanding of the ground conditions and groundwater flood risk at the site.

5.3.3 23no. borehole logs greater than 10m below ground level (bgl) and within the vicinity of the Application Land have been reviewed to identify and understand the general ground conditions. 5no. water well records are available for the surrounding site area within approx. 3 km. The borehole records are to be taken as generally representative of the geology across the site. The stratigraphic succession, indicative depths and thicknesses encountered by the boreholes are summarised in Table 5-8:

Table 5-8 Summary of Soil Strata from ground investigation carried out

Depth to Top of Strata (m BGL)	Typical Thickness (m)	Generalised Description	Aquifer Status
0.00-0.20	3.10	Soft dark grey silty slightly sandy clay with gravel, concrete, bricks. [MADE GROUND]	-
0.00-3.10	1.27-32.0	Soft grey clayey SILT with fine sand partings. AND Grey silty fine to medium SAND with occasional fine gravel. [ESTUARINE ALLUVIUM]	Secondary A
5.18-17.20	1.80-8.69	Silver grey sand AND Red sand [BLOWN SAND]	Secondary A
4.27-49.70	0.10-378.75	Light grey weathered MUDSTONE with inclusions of gypsum AND Weak red brown, locally green grey, MUDSTONE with very closely and closely spaced laminations and very thin beds of gypsum. [MERCIA MUDSTONE]	Secondary B

Depth to Top of Strata (m BGL)	Typical Thickness (m)	Generalised Description	Aquifer Status
273.41-385.26	153.00-390.00	Red SANDSTONE AND Bunter SANDSTONE [CHESTER FORMATION]	Principal

5.3.4 A number of groundwater strikes were encountered in the historical BGS & GI boreholes. The 2018 Ground Investigation Report indicates that groundwater strikes ranged between 12.3 and 6.3 m bgl. Wet ground was encountered at much shallower depths and this is considered likely to be ground saturated by surface water or perched groundwater.

5.3.5 The EA Groundwater Vulnerability Map records the Application Land to be in an area of 'Medium - High' risk of groundwater vulnerability. The EA website records that the site is not indicated to be in a Groundwater Source Protection Zone (GSPZ). Furthermore, there are no GSPZ recorded within 1 km of the site.

Proposed Development

5.3.6 A bunker hall is proposed within the ERF that could extend 10 m bgl. It is proposed that this will be constructed as a watertight facility that can withstand hydraulic loadings and uplift from groundwater.

5.3.7 The overall groundwater flood risk is considered Low with the proposed mitigation in place to protect the bunker hall from the effects of rising groundwater.

5.4 Flood Risk from Artificial Sources

5.4.1 Flooding from artificial sources refers to flooding from lakes, canals, and reservoirs. Residual flood risk associated with artificial sources is typically Low owing to the controlled operation of engineered water bodies.

5.4.2 The Reservoir Act of 1975 requires that reservoirs are inspected and maintained on a regular basis. The EA reservoir flood risk map shows that the site is not located within an area at risk of flooding from reservoirs, as shown in Figure 5.40:

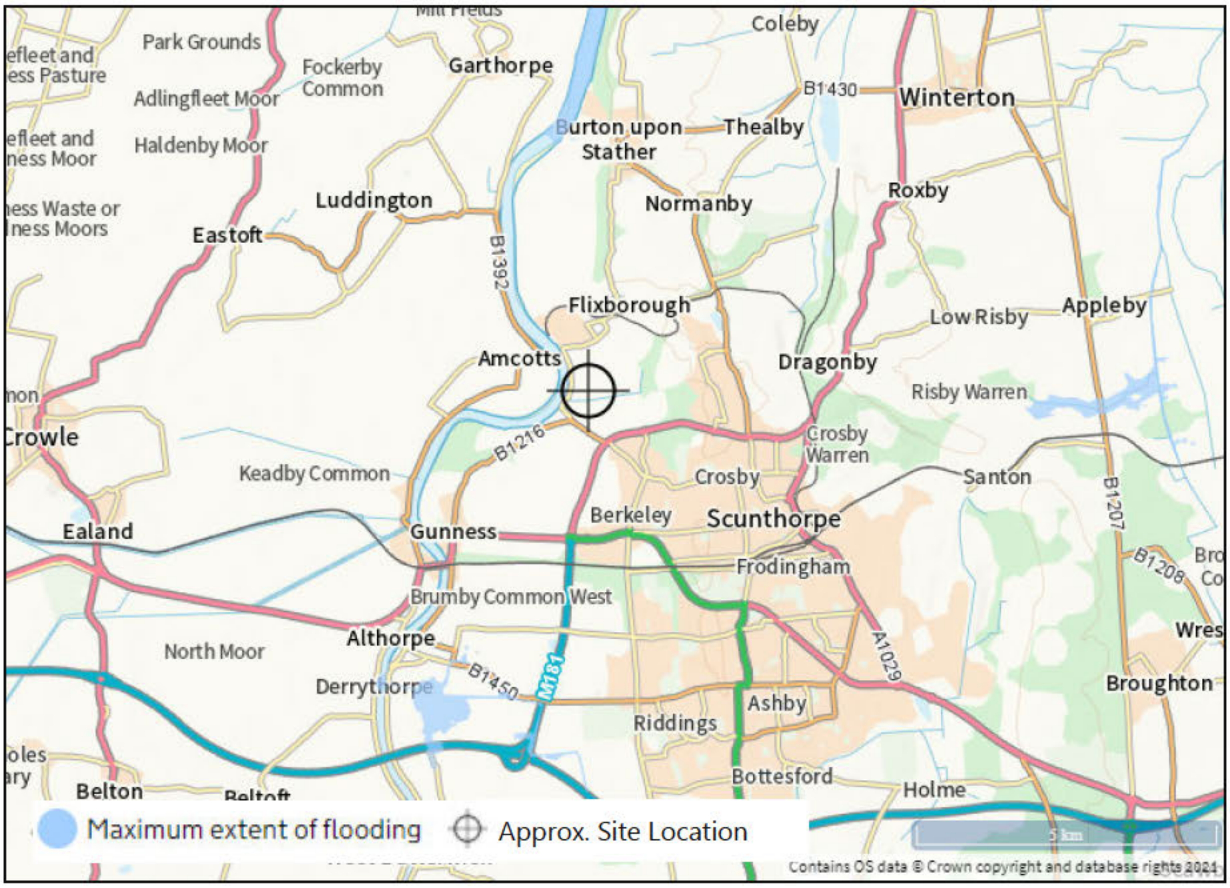


Figure 5.40 EA flood map showing maximum flood extent for flood risk from artificial sources

5.4.3 The overall flood risk from artificial sources is Low and no further mitigation is required.

6 Exception Test

6.1.1 According to the NPPF guidance, and as outlined in Section 3.2 of this report, the Exception Test is required. The Exception Test requires that the following is demonstrated:

- it can be demonstrated that the sustainability benefits of the development for the community outweigh the flood risk; and
- the proposed development will be safe for the lifetime of the development.

6.1.2 The primary purpose of the Project is to act as an Energy Recovery Facility, meaning that it produces energy from waste. The implementation of Energy Recovery Facilities offers the following primary sustainability benefits:

- provides a more efficient means of managing waste;
- reduces dependency on landfill and disposal of waste that cannot yet be recycled;
- enables the production of valuable, low carbon energy, in accordance with national emission targets and standards; and
- the energy source produced is non-intermittent and therefore can complement wind, solar and wave energy sources.

6.1.3 In addition to the wider sustainability benefits, the Project has been designed such that sensory impact to the community is managed through building placement and tree planting.

6.1.4 A large proportion of the built elements of the Project is located on previously developed land and the part that is not benefits from a previously issued planning permission for development (Glanford Park) granted in May 1991 for an industrial business park, sewage treatment plant and fire and ambulance station (determined under call-in procedure - reference YH5264/219/19 and LPA reference 7/1021/89). Whilst this permission had lapsed, there was some history of a very large-scale development proposal being viewed as acceptable on this part of the site.

6.1.5 The Project is also Essential Infrastructure, having regard to the definition in the NPPF, in that it has be to be located in a flood risk area for operational reasons, i.e. that it is providing power through the sustainable recovery of waste, reducing waste to landfill and is located in close proximity to an operational Wharf, offering the potential for more sustainable transport during construction and operation. As part of the Project, the Applicant is also proposing to reinstate the existing 6km Dragonby to Flixborough railway line serving the Wharf and construct a new railhead and sidings. The railway is essential infrastructure that can only be reinstated where it occurs and will facilitate the movement of materials at scale to and from the Project, reducing the need for movements by road.

6.1.6 Those elements of the Project that are not on previously developed land have been reduced as far as possible through an iterative approach to design, with flood risk being the predominant factor influencing the siting of key elements on the Site.

6.1.7 The ERF has been located in defended Flood Zone 3 as it is necessary that the development is located near to the port for ease of materials delivery. However, the layout has been sequentially adapted to ensure that it is located entirely within Flood Zone 1, 2 and 3a and not Flood Zone 3b, and to minimise flood risk to the development and third-party land.

6.1.8 The sequential approach included the following considerations:

- Where development did not need to link directly to the ERF, development plots were located in Flood Zone 1 (such as the ERF electrical substation).
- Modifications to existing flood defence levels and the wharf were avoided to ensure flood risk was not increased to other areas along the River Trent.
- In order to maintain existing hydrological regime where possible, modifications to existing land levels were minimised (such as the railway line) and development was located outside of key River Trent overtopping flow routes.
- Development plots were assessed with different alignments to establish the alignment with minimal impact and obstruction to flow routes.
- Where development needed to be raised above the flood level in order to be made safe, the impact of obstructing flow has been reduced through introducing culverts and openings to allow water to flow as it currently would.

- To ensure raised development does not displace water to new areas or existing development, flood mitigation measures such as earth embankments and flood walls have been incorporated to direct flow safely to non-developed areas.

6.1.9 Further details of the sequential approach to the development design can be found in Appendix A.

6.1.10 In addition to the sequential development of the layout, the mitigation measures outlined in this report have been adopted such that the site is safe for the lifetime of the development. Key considerations and measures include:

- use of latest EA climate change guidance in the hydraulic model;
- use of latest EA uncertainty allowance to determine the proposed freeboard for Finished Floor Levels;
- setting Finished Floor Levels at DFE flood level + freeboard;
- implementation of secondary flood defences to protect offsite areas from increase in flood risk;
- provision of an access and egress route set at DFE flood levels + freeboard; and
- implementation of a Flood Evacuation and Management Plan.

6.1.11 It is concluded that the Project passes the Exception Test due to the sustainability benefits provided and the flood risk mitigation measures proposed in this report.

7 Summary & Conclusion

7.1.1 This report has been prepared by Buro Happold on behalf of The North Lincolnshire Green Energy Park Limited (the Applicant). The North Lincolnshire Green Energy Park (the Project) is identified as a Nationally Significant Infrastructure Project, and as such the Project is being brought forward for planning under a Development Consent Order. This Flood Risk Assessment has been undertaken in accordance with the NPPF.

7.1.2 The Project is located north west of Scunthorpe and partially within the Flixborough Industrial Estate. The River Trent flows from south to north, into the Humber Estuary approximately 7.5 km north of the site. However, the river is tidally influenced at the Application Land.

7.1.3 The proposals consist of an Energy Recovery Facility (ERF) and a carbon capture, utilisation and storage (CCUS) facility; a switchyard, and a water treatment facility. The Project will include the following Associated Development to support the operation of the NSIP:

- a bottom ash and flue gas residue handling and treatment facility (RHTF);
- a concrete block manufacturing facility (CBMF);
- a plastic recycling facility (PRF);
- a hydrogen production and storage facility;
- an electric vehicle (EV) and hydrogen (H_2) refuelling station;
- battery storage;
- a hydrogen and natural gas above ground installations (AGI);
- a new access road and parking;
- a gatehouse and visitor centre with elevated walkway;
- railway reinstatement works including, sidings at Dragonby, reinstatement and safety improvements to the 6km private railway spur, and the construction of a new railhead with sidings south of Flixborough Wharf;
- a northern and southern district heating and private wire network (DHPWN);
- habitat creation, landscaping and ecological mitigation, including green infrastructure and 65 acre wetland area;

- new public rights of way and cycle ways including footbridges;
- Sustainable Drainage Systems (SuDS) and flood defence; and
- utility constructions and diversions.

7.1.4 The Project comprises critical infrastructure that is required to remain operational during a flood event in order to continue producing energy and therefore has been classified as Essential Infrastructure. Only the Visitor Centre is classified as Less Vulnerable. The Project is located within Flood Zone 3a benefitting from defences and partially in Flood Zone 1 and 2 in accordance with the EA flood maps for planning and the Strategic Flood Risk Assessment.

7.1.5 Existing EA flood defences run along the east bank of the River Trent in the form of a raised embankment. The primary source of flood risk is tidal. The risk of fluvial and tidal flooding is Low in the present day but will increase in the future due to climate change. The latest EA climate change allowances have been applied in the assessment of future flood risk to the Proposed Development, and the proposed DFE applied is the **1 in 200 year Tidal Upper End CC + 1 in 2 year Fluvial + 30% CC event in 2065**. During this event, the existing EA flood defences overtop at two locations: adjacent to the site near to the existing port, and approximately 3km north of the site.

7.1.6 The NLGEP 2021 Model used to inform the assessment consists of the North Lincolnshire Council 2017 model + site-specific amendments + tidal boundary extracted from EA Humber model incorporating UKCP18 climate change projections.

7.1.7 The DFE has been assessed to inform FFLs and access and egress routes. The following scenarios were assessed to determine the overall impact of the Project on flood risk:

- impact of the Project during the Design Flood Event;
- impact of the Project during the Design Flood Event + a breach located at the point of over topping near to the existing port (Breach 01); and
- impact of the Project during the Design Flood Event + a breach located at the point of over topping 3km north of the site (Breach 02).

7.1.8 Localised increases in flood levels and flood hazards were observed during the above scenarios and as such associated mitigation was identified as follows:

- the raised access road between the ERF and CBMF will have minimal culvert openings to restrict flow towards the east, minimising the impact of the proposed development on flood risk to the Industrial Estate;
- land levels west of the access road will be modified to reduce displaced floodwater increasing flood levels south of the site. Inclusion of a bund along the perimeter of the east side of the Application Land will reduce risk to increase in flood levels to the east if required; and
- either new flood walls with either raising of road levels along First Avenue or a new flood gate installed at the end of the road or a Flood Warning and Evacuation Management Plan put in place to manage the flood risk during a breach event increasing flood extents to the industrial site north of First Avenue.

7.1.9 The details of the flood mitigation measures are to be confirmed at a later design stage and developed through discussions with the EA.

7.1.10 Safe access and egress has been provided connecting the Project to the B1216. This is to be set at the DFE flood level + freeboard. Local flood walls or other resistant measures at plot level may be required.

7.1.11 There remains a residual risk of flooding at the Steel Works and at the port area west of the Project. To manage the increased depth and hazard identified in this area, a Flood Evacuation and Management Plan is proposed to alert users of a potential flood event. This would be required for new users of the Project and rail line as well as existing users of the port.

7.1.12 The H++ scenario was assessed in addition to a breach scenario in the proposed bund at the Industrial Estate, and the scenario whereby the flood gates in this bund are left open. These are considered a low probability of occurring but have been sensitivity tested to understand the potential future impact to the Project, rather than to guide design criteria. The off-site impact of the Project during each of these scenarios is negligible.

7.1.13 With the proposed mitigation in place, the residual flood risk to the Project, and impact of the Project on flood risk, is considered Low. The Exception Test has been undertaken in accordance with the NPPF. It is proposed that given the climate related benefits to the Project and the flood risk mitigation measures identified through this Flood Risk Assessment, the Project passes the Exception Test.

7.1.14 Surface water flood risk is Very Low to Medium. Existing land is drained by a series of water courses that discharge to the River Trent. Different SuDS are proposed as part of the surface water drainage strategy for the Project. These include ten new detention basins to promote biodiversity, treat water quality and attenuate stormwater before being discharge into the existing ditches. Where possible, swales will be used to convey runoff instead of pipes and basins used for storage instead of tanks. Further details of the proposed surface water drainage strategy can be found in the Indicative Drainage Strategy (**Document Reference 6.3.5**)

7.1.15 Ground Investigation data indicates that groundwater ranges between 12.3 and 6.3 m bgl. A bunker hall is proposed within the ERF that could extend 10 m bgl. It is proposed that this will be constructed as a watertight facility that can withstand hydraulic loadings and uplift from groundwater. The overall groundwater flood risk is considered Low with the proposed mitigation in place.

7.1.16 The EA reservoir flood risk map shows that the Application Land is not located within an area at risk of flooding from reservoirs. The overall flood risk from artificial sources is Low and no further mitigation is required.

7.1.17 With the proposed mitigation in place, the overall flood risk to the Project is Low. The impact of the Project to offsite locations is minimised through the proposed mitigation and is considered negligible.

7.1.18 The NLGEP 2021 hydraulic modelling report and hydraulic modelling files have been reviewed by the EA and been given approval as fit-for-purpose to support this FRA.

Appendix A Flood Modelling Iterations

To maximise the development layout with minimal impact on flood risk to surrounding users, different development options and layouts were investigated. The table below summarises the main scenarios assessed and commentary on the results observed. These scenarios informed the design criteria outlined in the FRA Section 5 and were tested to support the final development layout of the scheme. Additional flood mitigation measures were explored to ensure the flood risk to third parties was reduced during both overtopping and breach scenarios as described in the FRA Section 5.1.24.

Table A Flood modelling scenarios tested to inform the development layout

ID	Scenario	Commentary	Options
A	Raise flood defences between Burton upon Stather and Stather Road – Gunness Lane junction.	This option resulted with an extensive increase in flood levels observed on the west bank of the R. Trent.	Included and described as a strategic intervention
B	Raise the railway line around the north of Flixborough Industrial Estate.	Similarly, this option resulted with an extensive increase in flood levels observed on the west bank and to the north of the site.	Included and described as a strategic intervention
C	Raise flood defences from approx. 1km north of Flixborough Industrial Estate to Gunness Lane junction.	This option resulted in a significant increase in flood levels in the agricultural fields to the north of the site.	Included and described as a strategic intervention
D	Raise platform level for the ERF footprint located to SW of Flixborough Industrial Estate up to bank edge.	Similarly, this option resulted with an increase in flood levels observed to the north of the site.	Southern
E	Raise platform level for the ERF footprint located to north of Flixborough Industrial Estate	Although located on the other side of the industrial estate, this option resulted in an increase in flood levels observed in the industrial estate, likely to be due to the overtopping ~3km north flowing south beyond the site.	Northern

F	Raise platform level for the ERF footprint located by the port.	This option resulted with an increase in flood levels within the southeast area of the Flixborough Industrial Estate.	Central
G	Scenario F with raised levels at the port and jetty.	This option resulted with an increase in flood levels on the west bank of the R. Trent to the SW of the site.	Northern, Central and Southern
H	Raise platform level for the ERF footprint located to SW of Flixborough Industrial Estate.	This option resulted in an increase in flood level to the solar farm located to the east of the site.	Southern
I	Scenario H with raised platform level for the ash maturation and concrete block footprint located to SW of Flixborough Industrial Estate (aligned north to south).	This option resulted with an increase in flood level in the Industrial Estate, with greater levels when located immediately south of the industrial estate.	Southern
J	Raise platform level for the ERF by the port and the ash maturation and concrete block footprint located to SW of Flixborough Industrial Estate.	This option resulted with an increase in flood levels in the Industrial Estate but to a reduced depth and extent compared to the previous scenario.	Central
K	Scenario J with raised access road between the two.	This option resulted in an increase in flood levels increased in the southeast part of the industrial estate.	Central
L	Scenario K but aligned north-south rather than footprint extending west-east, with raised access road between the two.	This option removed the increase in flood levels in the southeast of the Industrial Estate.	Plan 2
M	Scenario L with polymer recycling facility directly east of the ash maturation plant.	This option resulted in an increase in flood levels in the solar farm to the east of the site.	Plan 2
N	Scenario M with the polymer recycling facility shifted to south (southeast	This option removed the increase in flood levels in the solar farm. This option was	Plan 3

	of the ash maturation plant).	taken forward and used as the basis for the FRA.	
-	Flood storage areas were tested in different locations to the north of the Industrial Estate, to the west of the proposed access road, including lowering the bank level and setting back the flood defence line.	These options did not provide additional storage for the displaced flood volumes due to the raised development platforms.	Included and described as a strategic intervention

Appendix B Hydraulic Flood Modelling Report

North Lincolnshire Green Energy Park

Hydraulic Flood Modelling Report

0046658-FMR-REP-01

0046658

27 May 2022

Revision P0

Revision	Description	Issued by	Date	Checked
P0	Issued for DCO submission	DN	27/05/22	NV

[redacted]

This report has been prepared for the sole benefit, use and information of North Lincolnshire Green Energy Park Limited for the purposes set out in the report or instructions commissioning it. The liability of Buro Happold Limited in respect of the information contained in the report will not extend to any third party.

author	**Dominic Nugent**
date	**27 May 2022**
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signature	[redacted]
date	**27 May 2022**

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Abbreviations

Term	Definition
AEP	Annual Exceedance Probability
CBMP	Concrete Block Manufacturing Plant
CC	Climate Change
CHP	Combined Heat and Power
CO2	Carbon Dioxide
DCO	Development Consent Order
EA	Environment Agency
ERF	Energy Recovery Facility
FRA	Flood Risk Assessment
FWS	Flood Warning Systems
DFE	Design Flood Event
DEM	Digital Elevation Model
DFE	Design Flood Event
DSM	Digital Surface Model
DTM	Digital Terrain Model
ha	Hectare
HC	Higher Central
H++	H Plus Plus (Climate Change scenario)
LiDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
m AOD	metres Above Ordnance Datum
NGR	National Grid Reference
NLGEP	North Lincolnshire Green Energy Park
NPPF	National Planning Policy Framework
NSIP	National Significant Infrastructure Project
PPF	Polymer Production Facility
PPG	Planning Practice Guidance

Term	Definition
SFRA	Strategic Flood Risk Assessment
SGWMB	Scunthorpe & Gainsborough Water Management Board
SuDS	Sustainable Drainage Systems
SWDS	Surface Water Drainage Strategy
SWMP	Surface Water Management Plan
UE	Upper End
UKCP09	United Kingdom Climate Projection 2009
UKCP18	United Kingdom Climate Projection 2018

1 Background Information

1.1 Introduction

1.1.1 This Hydraulic Flood Modelling Report describes the hydraulic modelling undertaken to support the Development Consent Order (DCO) application for the North Lincolnshire Green Energy Park (NLGEP) (the Project) in Flixborough, North Lincolnshire, UK (National Grid Reference NP 80146 47882).

1.1.2 This report should be read in conjunction with the NLGEP Flood Risk Assessment (FRA) (0046658-FRA-REP-01).

1.1.3 The Project is a Nationally Significant Infrastructure Project (NSIP) comprising an Energy Recovery Facility (ERF) capable of converting up to 760,000 tonnes of non-recyclable waste into 95 MW of electricity and a carbon capture, utilisation and storage (CCUS) facility which will treat a proportion of the excess gasses released from the ERF to remove and store carbon dioxide (CO_2) prior to emission into the atmosphere. The design of the ERF and CCUS will also enable future connection to the Zero Carbon Humber pipeline, when this is consented and operational, to enable the possibility of full carbon capture in the future.

1.1.4 The Application Land – defined as the land within the Order Limits – is currently protected by existing flood defences along the east bank of the River Trent up to a 1 in 200 year tidal event. However, the risk of overtopping increases in the future due to climate change and during potential breach scenarios.

1.1.5 This report describes the flood modelling data used and the updates made to represent the Project demonstrating any impacts to the site and surrounding third parties and the mitigation measures proposed.

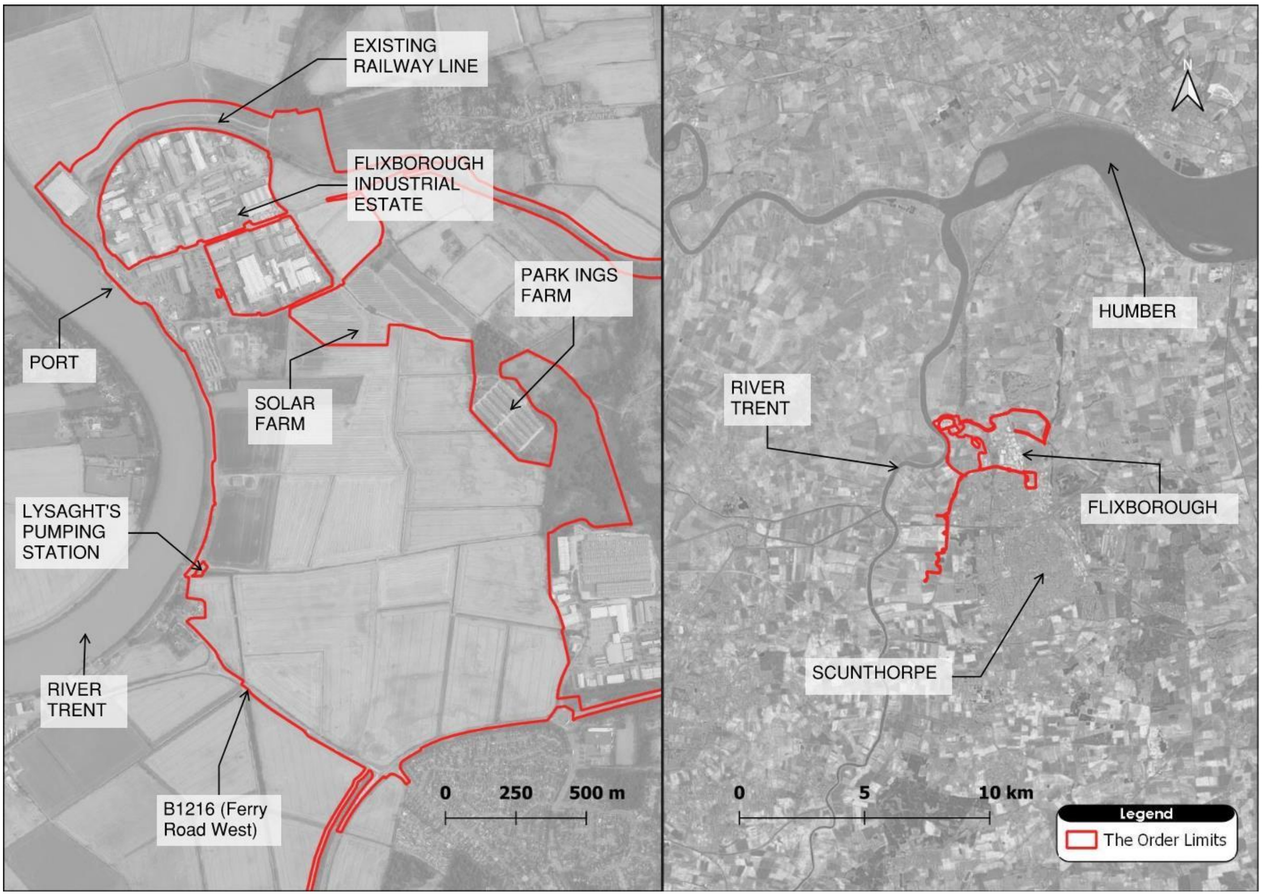


Figure 1.1 Project location plan (Image courtesy of Ordnance Survey, © 2021 TomTom).

1.2 Stakeholder Consultation

1.2.1 The Environment Agency (EA) has been consulted early in the project to ascertain the best source of information on which to base the FRA. The EA have a flood model for the River Trent that was last updated in 2015. It is understood that this model is currently being updated based on the latest climate change projections.

1.2.2 The EA indicated that North Lincolnshire Council (NLC) updated the EA River Trent model to include flood defence works to support the Lincolnshire Lakes Area Action Plan (LL AAP). Construction of the flood defences were completed in 2019. Therefore, the NLC flood model contains the latest available data for the local area. The EA confirmed that this model has been reviewed and approved by the EA. NLC were consulted and the flood model was obtained for use in the Project.

1.2.3 The EA also advised that the EA Humber team were updating the Humber Estuary flood model taking into account the latest UK climate change projections (UKCP 18). These projections were used to inform the EA's climate change guidance updated in July 2020, and therefore provides the most up-to-date information on the tidal water levels that should be considered in the Project. As the Application Land is located in the tidal extent of the River Trent, the EA Humber model was obtained once available in March 2021, and used to inform the downstream tidal boundary of the River Trent model for the Project.

1.3 Source of Model Data

1.3.1 A summary of the different sources of model information available and their use for this project can be found in Table 1.1.

Table 1.1 Summary of different models available for the Site, and the data used for the NLGEP project.

Model/Study	Date	Purpose	Commentary
EA River Humber North Bank Tidal Modelling study	2011	Detailed analysis of water levels along the Humber Estuary.	The tidal curve data was used to inform the downstream boundary of the EA Tidal Trent 2013 model.

Model/Study	Date	Purpose	Commentary
EA Tidal Trent	Dec 2013	Model used to improve understanding of flood risk in the area based on latest survey data; inform sustainable floodplain planning; identify asset maintenance options; improve existing Flood Warning Service.	1D – 2D model of the River Trent from tidal limit at North Muskham to confluence with River Humber at Trent Falls. Includes tributaries River Eau, Bottesford Beck and the Three River discharging to the River Trent via a pumping station at Keadby.
EA Interim Tidal Trent Model	June 2014	Updated design water levels.	EA Tidal Trent 2013 flood model updated tidal boundary following a tidal surge on 5th December 2013.
EA Tidal Trent Modelling and Mapping Addendum	Jan 2015	Addendum to the EA Tidal Trent Modelling and Mapping Report, Dec 2013.	Includes EA Interim Tidal Trent model Jun 2014 water levels. Defence crest levels updated based on survey undertaken post Dec 2013 (identifying low spots in areas of settlement and some scouring following overtopping) in vicinity of Burringham and Keadby and other localised erroneous changes in level in the flood model.
NLC Lincolnshire Lakes Flood Defence Scheme	July 2017	Model used to design improvements to existing flood embankments along 3.5km length of the River Trent from the M180 motorway bridge to the A18 Keadby Bridge north of Burringham.	Based on the EA Tidal Trent 2015 flood model. Schematisation of the 1D-2D changed from the entirety of the River Trent in 1D to truncating the 1D at Owston Ferry with the remaining downstream reach represented in 2D. Bathymetric survey data undertaken by EA in July 2013 was used to represent the channel bed levels. Defence crest level survey data undertaken in Sep 2015 and August 2016 included where appropriate.

Model/Study	Date	Purpose	Commentary
EA Humber 2100+ Extreme Water Levels	Nov 2020	Used to inform new strategic approach to tidal flood risk management around the estuary over the next 100 years for the EA and partner organisations.	A 1D model developed from existing EA flood models as follows: Humber Extreme Water Levels, 2017; Upper Humber Flood Risk Mapping Study, 2016; and Tidal Trent Modelling and Mapping Study, 2013 updated 2015. The 2D floodplain was represented in the model using reservoir units.

1.3.2 For the Project, the following models have been used to form the Baseline Model for the study:

- NLC Lincolnshire Lakes Flood Defence Scheme, 2017 (NLC 2017 Model)
- EA Humber Estuary Extreme Water Level model, 2020 (EA Humber 2020 model)

1.3.3 Details of the updates made to these models to make them project specific is presented in the following sections.

1.3.4 A summary of the key model parameters for both models are provided in Table 1.2.

Table 1.2 Summary of key model parameters for the NLC 2017 Model and the EA Humber 2020 Model

Parameter	NLC 2017 Model	EA Humber 2020 Model
Type	1D – 2D	1D
Software	Flood Modeller Pro v 4.2 single precision TuFLOW v 2013-12-AD-iSP-w64	Flood Modeller Pro v 4.4 double precision
2D grid resolution	25m x 25m	N/A
Storm Events	Fluvial Design Events 5, 10, 20, 50, 75, 100, 200, 1000 and 100+20%. Tidal Events 200, 1000, 200+CC (change factor +0.396m) and 200_CC (upper end +0.82m).	Joint probability events derived to give the 2, 5, 10, 20, 50, 75, 100, 200, 500 and 1000 year events. SLR applied to the years 2021, 2040, 2056, 2071 and 2121.
Simulated storm duration	140hours	200hours

Parameter	NLC 2017 Model	EA Humber 2020 Model
Timestep	1D 5s; 2D 2.5s	30s
Calibration events	Nov 2000, Jan 2005, Jun 2007, Nov 2011, Jul 2012, Nov 2012, and Dec 2013	Dec 2013, Nov 2000, Jan 2005, Nov 2011, Nov 2012, Jan 2014, Dec 2015 and Nov 2020. Calibration target of +/- 150mm

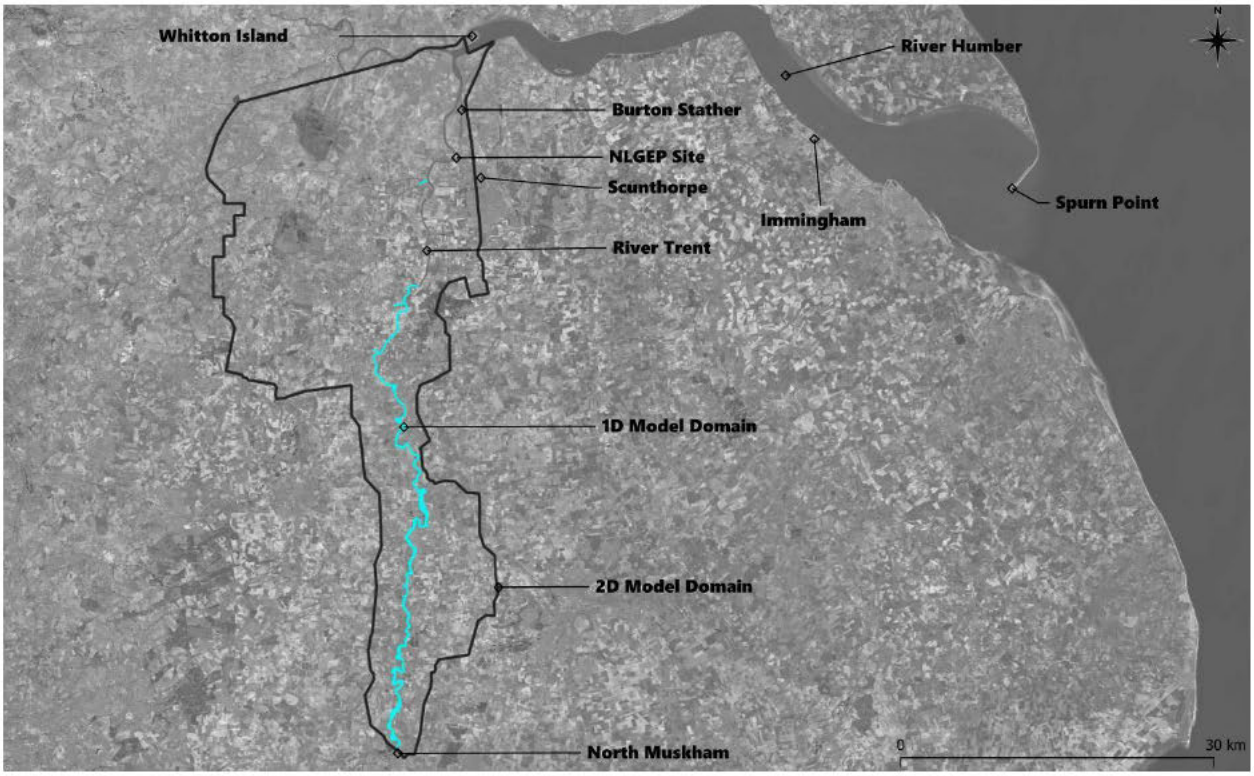


Figure 1.2 NLC Lincolnshire Lakes 2017 Model extent (Image courtesy of Ordnance Survey, © 2021 TomTom).

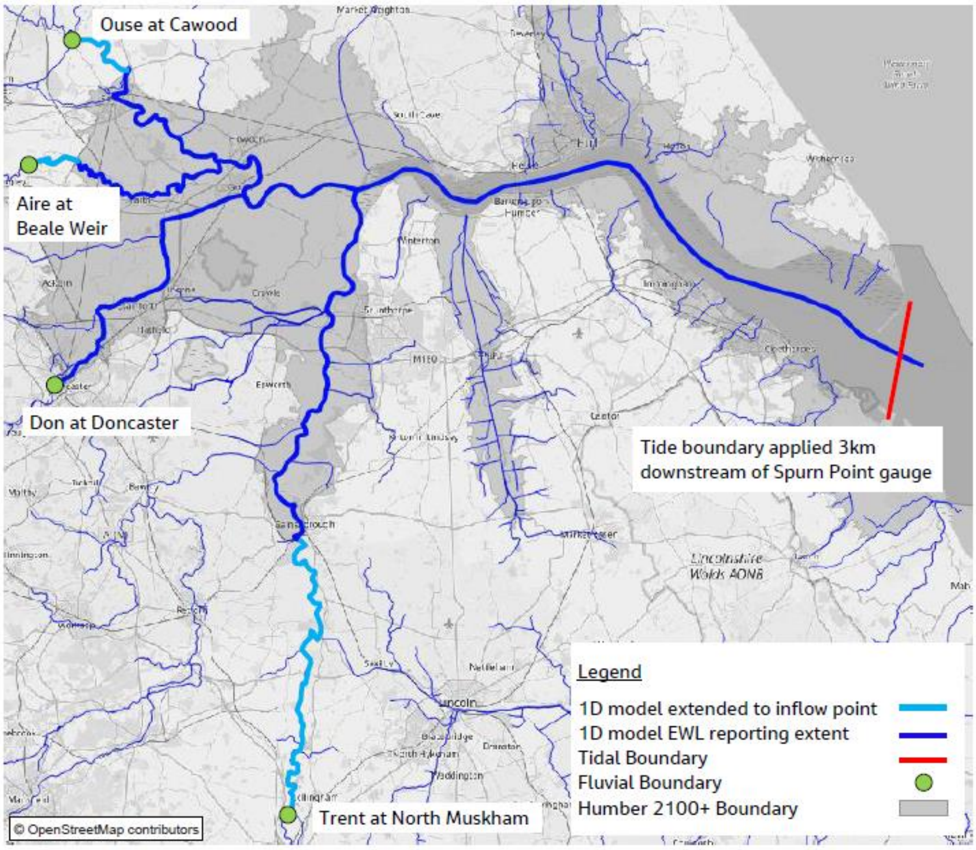


Figure 1.3 EA Humber Model EWL 2020 Model extent (image extracted from EA Humber 2100+ report, Nov 2020)

1.4 Report Structure

1.4.1 The following sections include the information as outlined below:

1.4.2 **Section 2 – Baseline Model**: This section summarises the updates to the flood model used to form the basis for the Project FRA and the results.

1.4.3 **Section 3 – Proposed Model**: This section summarises the changes made to the Baseline Model to represent the Project and the results.

1.4.4 **Section 4 – Flood Mitigation Measures**: This section summarises the additional measures included in the model to minimise flood risk impact to third parties.

1.4.5 **Section 5 – Model Nomenclature**: This section summarises the names of the key model files used for the assessment.

2 Baseline Model

2.1 Modelled Events

2.1.1 The ERF has an estimated development life between 25 to 40 years. Based on a construction date of 2025, the assessment considers the impact of climate change up to the year 2065.

2.1.2 The design flood event (DFE) has been identified as follows:

- flood risk from the River Trent:
  - 1 in 200 year Tidal flood event in 2065 Upper End climate change projection combined with 1 in 2 year Fluvial flood event with 30% allowance for climate change.

2.1.3 The H++ scenario was used as a sensitivity test.

2.1.4 Extreme fluvial events were not simulated as agreed with the EA. The risk from tidal flooding is anticipated to have a greater impact at the Project.

2.2 Ground representation

Topography

2.2.2 The NLC 2017 model includes the following topographic data at the Project:

Table 2.1 Files used in the NLC 2017 Model to represent topography at the Project.

Name of file read into NLC 2017 Model	Description
Lidar_2m.asc	Light Detecting and Ranging (LiDAR) data flown in July 2011 with typical vertical accuracy of +/- 0.15m.
2d_zsh_Bed_Levels_04.MIF	Bathymetric data used to represent the River Trent in 2D domain.
2d_zln_BankSurvey_Aug16_09.MIF	EA survey of defence crest level undertaken in August 2016.
2d_zsh_TTRENT_BUILDINGS_02.MIF	Reads in building footprints and applied with threshold survey data for specific elevations.
2d_zsh_TTRENT_BUILDINGS_ADD_01.MIF	Reads in building footprints and a nominal value of 0.3m applied where survey data not available.

2.2.3 For the Project, a drone survey was flown to collect topographic data for the study site. This data has a resolution of 1m.

2.2.4 A comparison was made between the LiDAR in the model (2011_LiDAR), drone survey (2020_Drone) and more recent available LiDAR (2020_LiDAR) data to understand whether the topography in the model was still relevant for the site. Using the profile tool in QGIS, the comparisons can be seen in Figure 2.2 to Figure 2.3. The main differences noted were the drone data picking up top of buildings in some locations and an overall increase in level in the agricultural fields. This is considered that fully grown vegetation anticipated at the time of the survey (July) had not been appropriately filtered out of the dataset. Data obtained for the west edge of the drone survey was also considered not to be accurately representative of the flood defences due to anomalies along the interpolation along the edge of the dataset. Minor differences were observed between the 2011 and 2020 LiDAR datasets, likely due to land uses not significantly changing across the site area over the past 9 years.

2.2.5 It was concluded that the topography has not changed at the site and in the vicinity of the site that required any further amendments to the model topography. Therefore, no changes were made to the topography in the Baseline model.

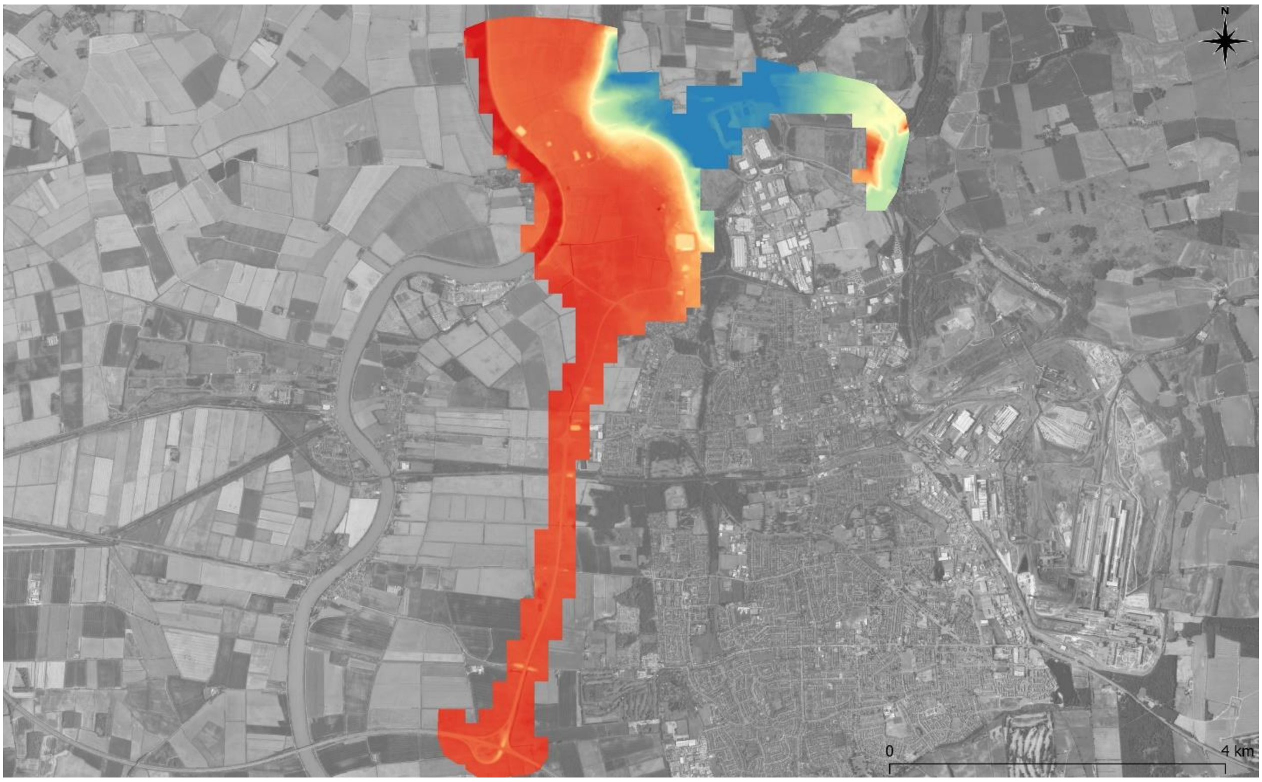
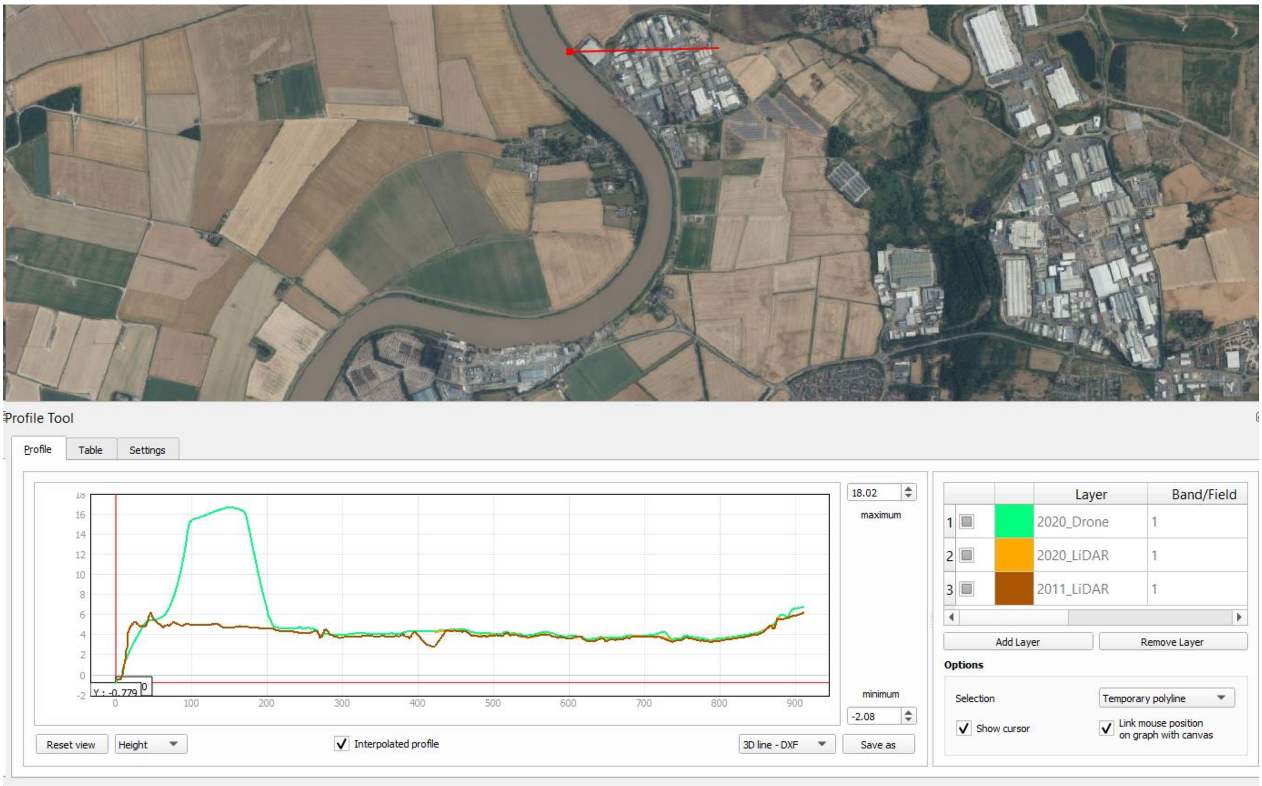
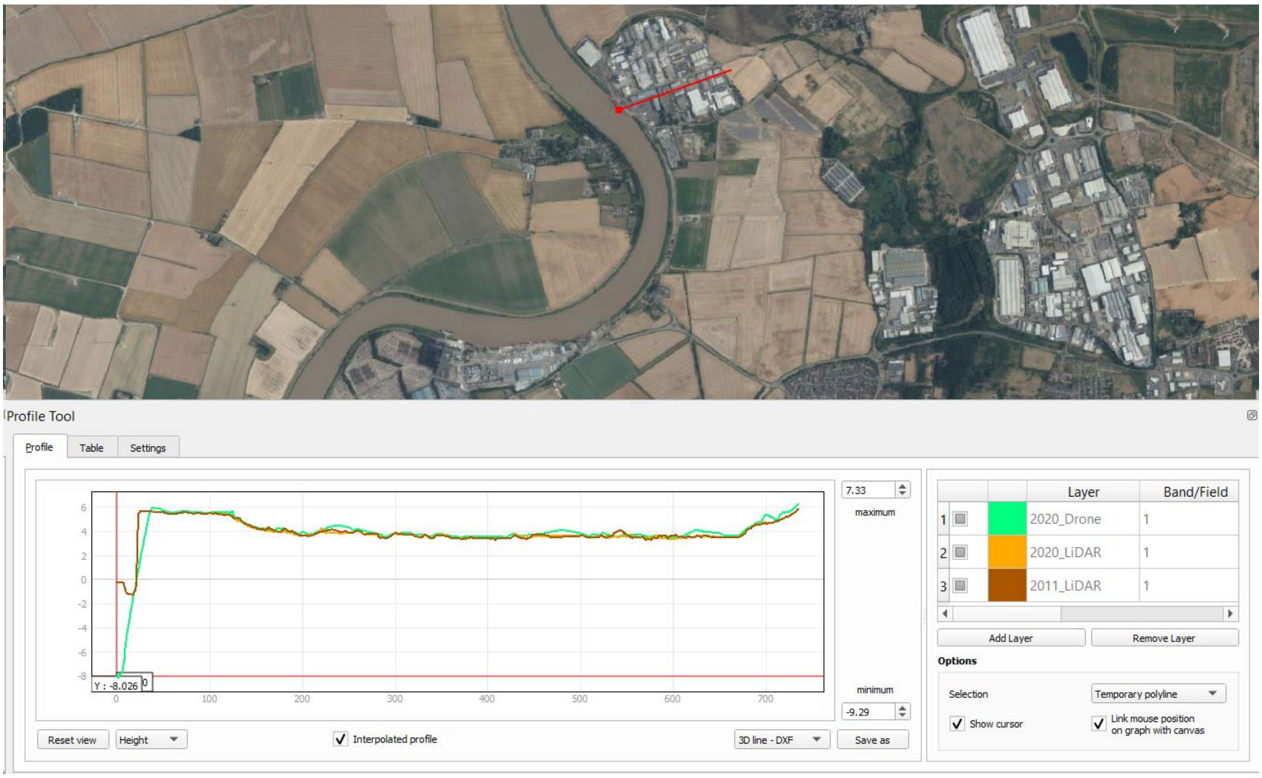


Figure 2.1 Coverage of the drone data flown July 2020 (Image courtesy of Ordnance Survey, © 2021 TomTom).

Figure 2.2 Long section profile through the Site comparing the drone survey flown 2020. LiDAR flown in 2020 and the Lidar flown in 2011 used in the NLC 2017 model (Image courtesy of Ordnance Survey, © 2021 TomTom).

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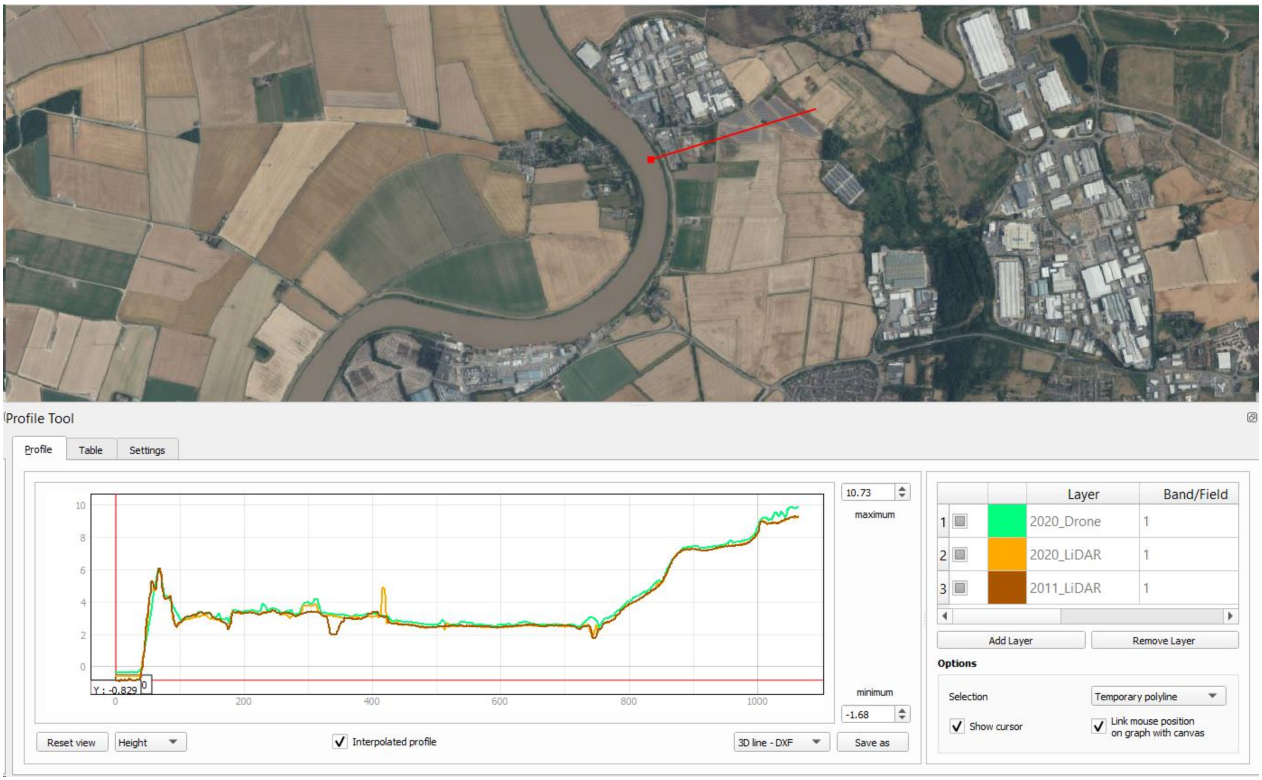
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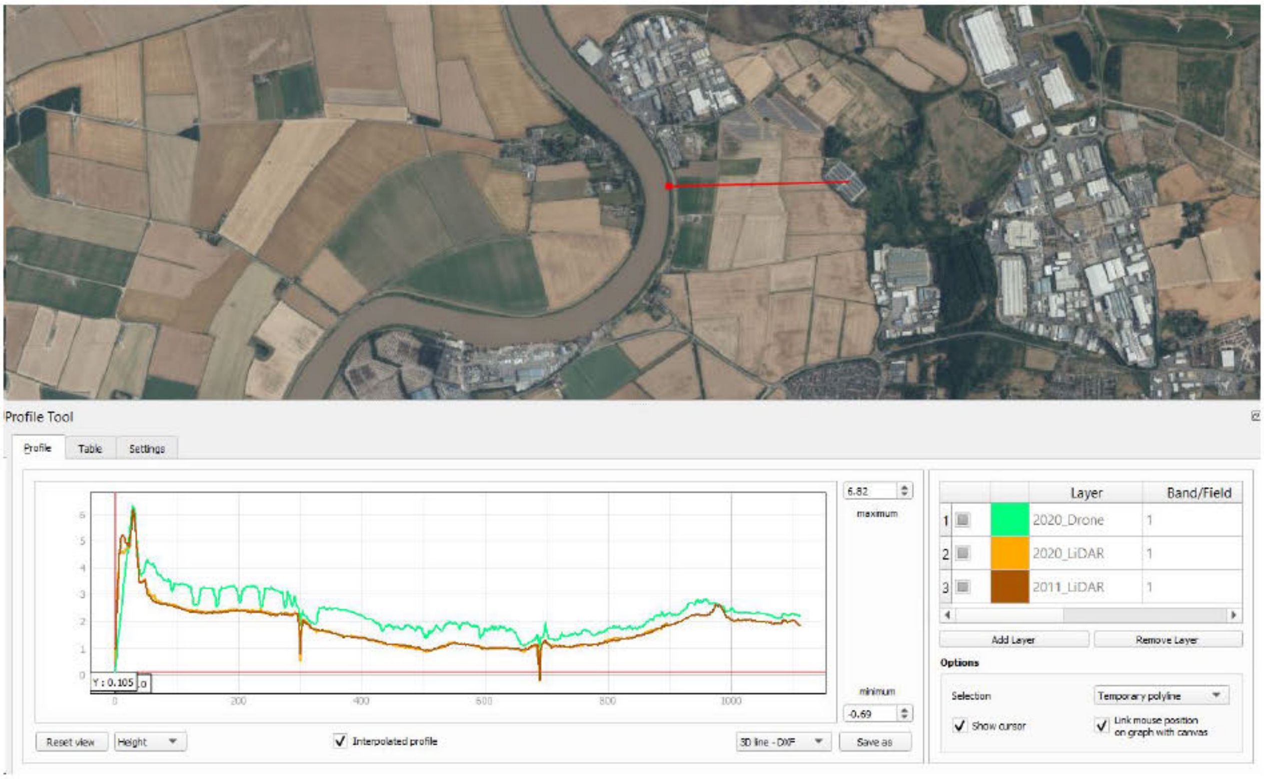


Figure 2.3 Four cross section profiles through the Application Land comparing the drone survey flown 2020 (green), LiDAR flown in 2020 (orange) and the Lidar flown in 2011 (brown) used in the NLC 2017 model (Image courtesy of Ordnance Survey, © 2021 TomTom).

2.2.6 Two amendments were made to the 1D-2D representation at the culvert through Ferry Road West (B1216). The culvert is represented in 1D transferring flow from the 2D domain across the road. However, the road crest/spill had been omitted from the model and 2D elevations were picking up the ditch level, allowing floodwater to pass across the road both in the 1D and 2D. This was updated in the Baseline model. Figure 2.4 illustrates the location of amendment and Table 2.2 provides the name of the new file.

Table 2.2 Name of file added to the Baseline model.

Model filename	Description
2d_ZLN_BH_SouthRoad_001.shp	- Elevation of road set to 3.1mAOD based on interpolation of road level in neighbouring cells along the road.

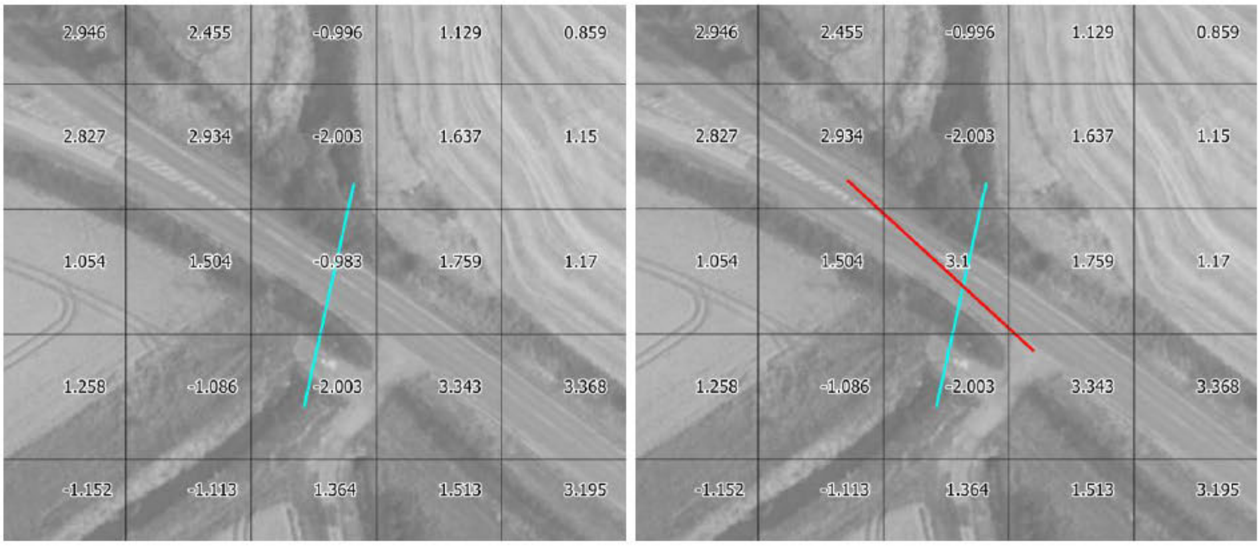


Figure 2.4 Location of amendment to road spill representation in the model. Culvert network line shown in blue. Added Z line to represent road spill level shown in red. Image on the left shows grid check file and ZC values for NLC 2017 model and image on the right shows grid check file and ZC values for Project baseline model (Image courtesy of Ordnance Survey, © 2021 TomTom).

2.2.7 In May 2021 a meeting was held with Scunthorpe and Gainsborough Water Management Board (SGWMB). Following the meeting SGWMB provided Buro Happold with survey information held for the culvert (Figure 2.5). This data indicated that the culvert size was larger than previously represented. The alignment of the culvert also contains a 45° bend. The culvert size and an additional form loss to represent the bend was included in the updated baseline model. A sensitivity test with a higher form loss (0.4 vs 0.2) was undertaken and had negligible change in results. Other attributes were left unchanged. The table below summarises the changes made to the culvert attribute for the updated baseline model.

Table 2.3 Name of files removed and added from Baseline model representing culvert at B1216.

Model file name	Description
1d_nwke_TTRENT_03_flapped.MIF (removed)	1d network layer used in NLC 2017 Model. ID: 81.63.30 Width: 1m Height: 1m Length: 45m Form Loss: 0
1d_nwke_TTRENT_03_NO_MIT_flapped.SHP (added)	1d network layer used in NLGEP 2021 updated Baseline Model. ID: 81.63.30

Model file name	Description
	Width: 2m Height: 2m Length: 54m Form Loss: 0.2

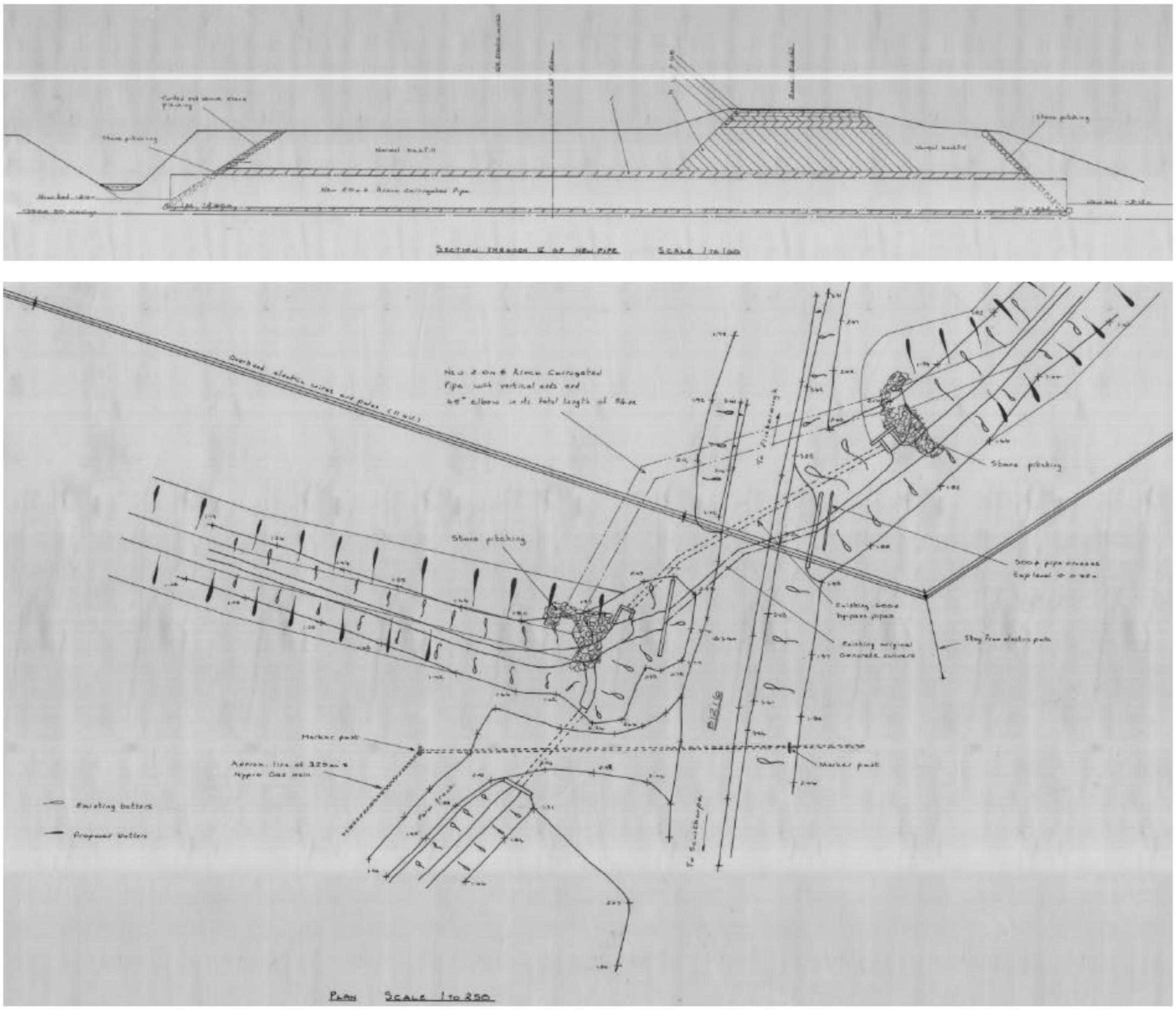


Figure 2.5 Drawing Lysaghts pumping station scheme B1216 Road Crossing, S.173/27, Scunthorpe Internal Drainage Board, March 1982.

Flood Defences

2.2.8 The existing flood defences along the east bank of the River Trent are included in the NLC 2017 model as described in Table 1.1. Figure 2.6 shows that the LiDAR in the NLC 2017 model in the vicinity of the flood defences appears to be more representative of the flood defences compared to the other datasets. A thick Z line is used in the model to represent the surveyed defence crest undertaken by the EA in 2016. This is considered the most representative data for the Site and therefore was retained in the baseline model.

2.2.9 No changes have been made to the representation of the flood defences in the model.

Figure 2.6 Profile sections along the east bank of the River Trent (top) and across the east bank (bottom) comparing the different datasets (Image courtesy of Ordnance Survey, © 2021 TomTom).

Manning's roughness

2.2.10 The Manning's 'n' values used in the model can be found in Table 2.4. No changes have been made to the NLC 2017 tmf file or to the model.

Table 2.4 Manning's n value as included in the tmf file, MM_LL_TTRENT_01.tmf.

Material layer file ID	Manning's 'n' value used in model	Description
1	0.050	Default global
2	0.10	Trees
3	0.060	Scrub, Orchard, Marsh, Rough Ground
4	0.05	Rail
5	0.038	Roads
6	0.05	Manmade
7	0.05	Multi surface
8	0.035	Water
9	0.500	Buildings
10	0.010	Downstream of Keadby
11	0.018	Upstream of Keadby
12	0.02	Transaction area

2.3 Boundary Conditions

Fluvial inflows

2.3.1 No changes have been made to the fluvial inflows to the model. Further details of the fluvial inflows can be found in the studies used to develop initial stages of the model as described in Table 1.1.

2.3.2 Flow-Time (QT) hydrograph boundaries in Flood Modeller are used to input key inflows and lateral inflow points into the model. Figure 2.7 shows the main tributaries and sub-catchments draining to the River Trent and the location of the Site.

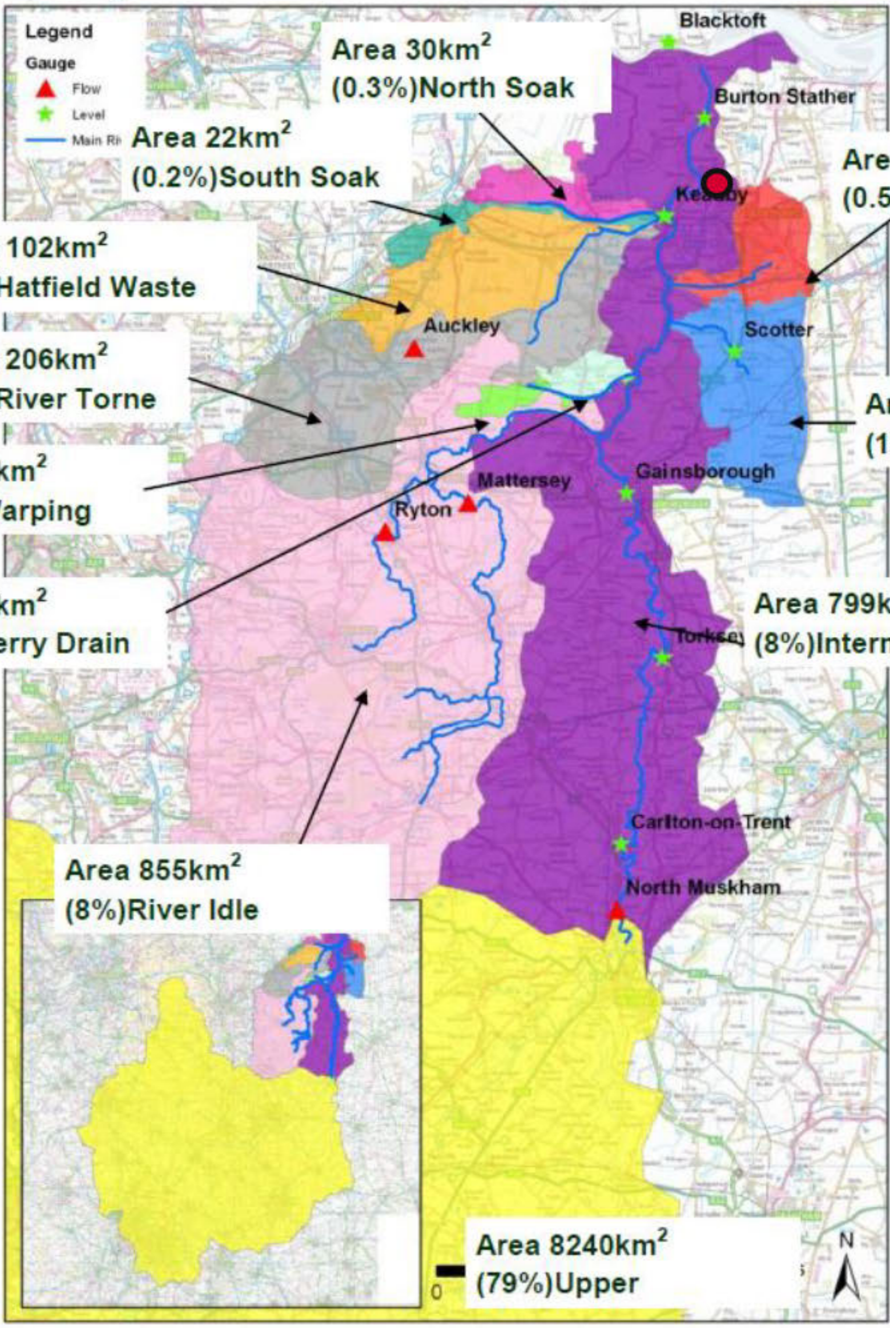


Figure 2.7 Tributaries and sub-catchments draining to the River Trent. The Project is shown in red circle. Image extracted from EA Tidal Trent Modelling & Mapping Study, December 2013.

2.3.3 The DFE for the assessment is the tidal dominated event in 2065. This includes a 1 in 2 year fluvial event. Table 2.5 illustrates the allowance for increase in peak flow that should be made based on the EA guidance on climate change at the start of the Project assessment and the most recent EA guidance in July 2021.

2.3.4 For essential infrastructure the Upper End category (30%) was recommended prior to the change, with a sensitivity check against the H++ category (35%). The latest guidance indicates the Higher Central category (23%) should be used and sensitivity check against the Upper End category (38%). For the lifetime of the development up to 2065, an allowance of 30% has been used for the assessment. This is the same allowance used for the 2050 scenarios run as part of the NLC 2017 model, and therefore, have been used in this assessment too. Although this value is greater than the recommendation in the latest EA guidance (23%), it is considered that the changes in peak flow have minor impact on the DFE water level which is primarily determined by the tidal levels.

Table 2.5 Extract from EA climate change guidance for the Humber river basin district, pre July 2021.

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total Potential change anticipated for the '2050s' (2040 to 2069)	Total Potential change anticipated for the '2080s' (2070 to 2115)
H++	20%	35%	65%
Upper End	20%	30%	50%
Higher Central	15%	20%	30%
Central	10%	15%	20%

Table 2.6 EA guidance on peak river flow allowances shown for Lower Trent and Erewash Management Catchment, July 2021.

Allowance Category	Total potential change anticipated for the '2020s' (2015 to 2039)	Total Potential change anticipated for the '2050s' (2040 to 2069)	Total Potential change anticipated for the '2080s' (2070 to 2115)
Upper End	29%	38%	62%
Higher Central	18%	23%	39%
Central	13%	17%	29%

2.3.5 As documented in the EA Tidal Trent Modelling and Mapping report, 2013, the design hydrograph shape applied at North Muskham was based on an observed event in 1986 and scaled according to the estimated peak for different storm events. The flow hydrographs from the tributaries and the Trent were phased so the peak flow on the Trent coincided with the peak flow from the River Idle at the confluence of the River Idle with the Trent. Similarly, the remaining tributaries were phased to peak at the same time to achieve a conservative estimate.

2.3.6 A review of the 1D inflows in the EA Tidal Trent 2015 model was made as part of the EA Humber 2020 study. It was noted in the document Humber Strategy Hydrology Review, version 1, Oct 2020, that the QMED and growth curve for higher return periods applied at North Muskham (Inflow Node NMUSKHAM) in the Tidal Trent model is likely to be overestimated.

2.3.7 No changes were made to the fluvial inflows for the NLC 2017 model. Likewise, as the current fluvial inflows are considered a conservative estimate, they have not been changed as part of this study.

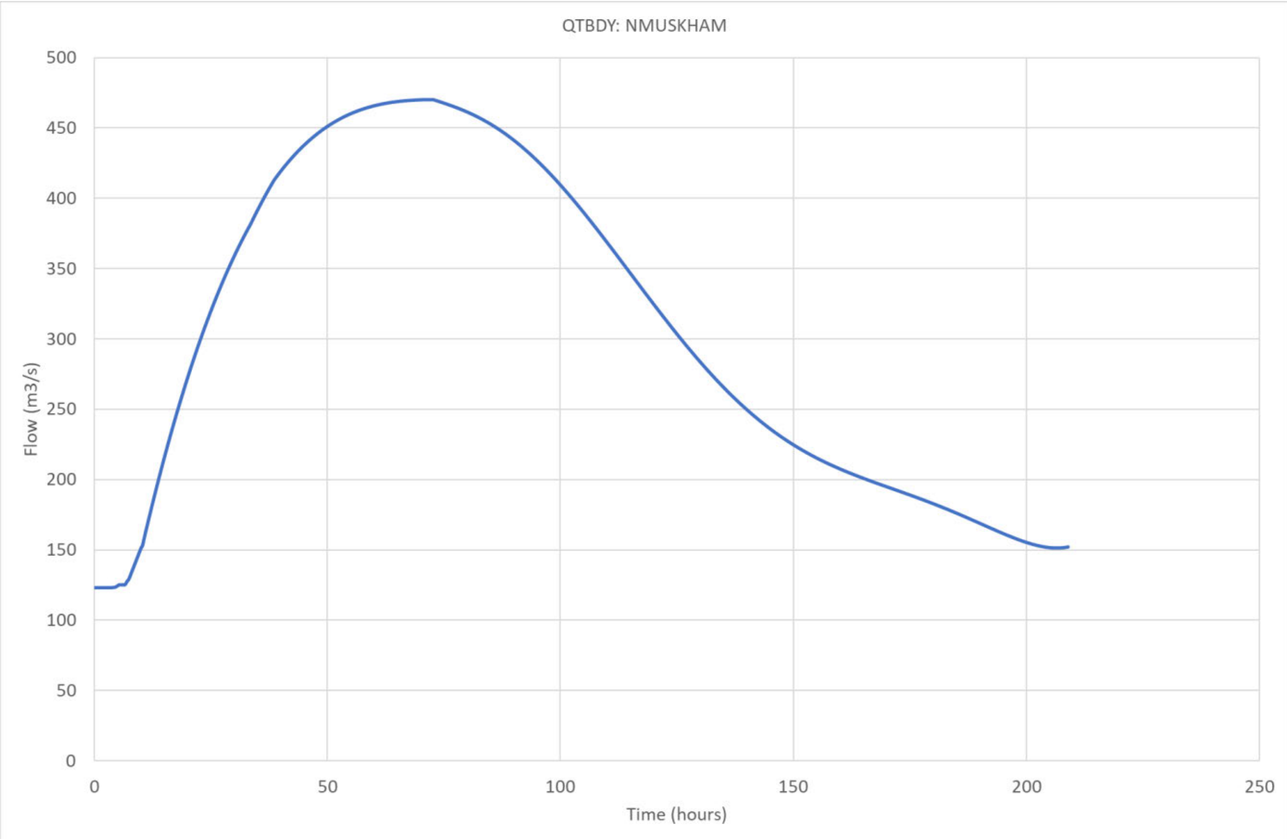


Figure 2.8 Inflow hydrograph at 1D Node NMUSKHAM at upstream location to the NLC 2017 model and NLGEP models.

2.3.8 Tidal boundary

2.3.9 In July 2020 the EA guidance on climate change was updated to take into account the estimated rise in sea level based on UKCP18 (previously the guidance was based on UKCP09). The NLC 2017 model was based on UKCP09 estimates in sea level rise. The EA Humber 2020 model was updated based on UKCP18.

2.3.10 Therefore, to ensure the NLGEP models were based on the latest estimates in sea level rise, the following steps were undertaken:

i) Calculate sea level rise using EA 2020 guidance up to the DFE year 2065.
ii) Scale the EA Humber 2020 Model tidal boundary curve to peak at the estimated SLR calculated for Step (i).
iii) Run the EA Humber 2020 model with updated tidal boundary curve from Step (ii).
iv) Extract the resultant water level profile from the EA Humber 2020 model at Burton Stather to input into the NLGEP model.
v) Shift tidal peak of the Burton Stather profile to occur at time 97.75 hours.
vi) Run the NLGEP model with updated tidal boundary curve.

2.3.11 For Step (i) a SLR of 451mm was calculated. This was calculated from a baseline year of 2017 that the EA Humber study was based on (peak tidal level of 4.75mAOD) and calculated to the year 2065 using the Upper End category. Table 2.7 and Table 2.8 show the EA guidance on climate change used in the assessment.

Table 2.7 EA climate change guidance on sea level rise (values shown in green used for the assessment).

Area of England	Climate Change Scenario	EA Guidance (UKCP18) – Sea Level Rise (mm/yr)			
		2000 - 2035	2036 - 2065	2066 - 2095	2096 - 2125
Humber	Higher Central	5.5	8.4	11.1	12.4
	Upper End	6.7	11	15.3	17.6

2.3.12 For the H++ scenario, the EA Humber study used the previously published EA guidance for H++ as show in Table 2.8. An additional 2mm was also applied for each year to allow for increase in tidal surge. The same approach has been used for this study.

Table 2.8 EA climate change guidance on sea level rise (values shown in green used for the assessment).

Climate Change Scenario	EA Guidance (UKCP09) – Sea Level Rise (mm/yr)			
	Up to 2025	2026 – 2050	2051 - 2080	2081 - 2115
Upper End	4	8.5	12	15
H++	6	12.5	24	33

2.3.13 For Step (ii) the EA Humber 2020 model tidal curve at the downstream node (1D Node HU_0_069) was scaled to the tidal peaks as shown in Table 2.9. The names of the files used in the model runs for Step (iii) can be found in Table 5.1.

Table 2.9 Peak tidal water levels derived in the Humber 2020 Model and re-run for year 2065 for use in this study.

EA Humber 2020 Model run for 2065	Peak water level (mAOD)	
	Spurn Point 1D Node HU_0_069	Burton Stather 1D Node Trent04930
1 in 200 year Peak tidal level	5.199	6.166
H++ peak tidal level	5.569	6.276

2.3.14 For Step (iv) the tidal curve derived at Burton Stather (1D Node Trent04930**)** was extracted from the simulated model to input into the NLGEP model. Although the 2D boundary is located near West Walker Dykes at the western end of Whitton Island, the tidal curve in the NLC 2017 study was derived for Burton Stather and therefore, the same was used for this study.

2.3.15 A check was made between the peak water level observed in the EA Humber 2020 Model DFE at Whitton Island compared with the peak water level observed at Burton Stather from which the tidal curve was extracted. The table below indicates that water levels vary by only 5mm, and therefore the same approach used for the NLC 2017 Model was adopted for this study.

Table 2.10 Peak tidal water levels derived in the Humber 2020 Model at Burton Stather and Whitton Island

EA Humber 2020 Model run for 1 in 200 year 2065	Peak water level (mAOD)
Whitton Island (1D Node HU_0_005)	6.161
Burton Stather (1D Node Trent04930)	6.166

2.3.16 The time at which the peak tidal water level occurs in the EA Humber 2020 model at Burton Stather differs to the time at which the peak occurs in the NLC 2017 model. The difference is due to the different base data used to form the design tidal hydrographs for the different studies as outlined below:

- NLC 2017 Model design tidal hydrograph derived by:
    - combining a base astronomical tidal curve at Blacktoft with surge profile obtained from Immingham recorded between 28th January to 3rd February 1958; and
    - developing a water level relationship between Blacktoft and Burton Stather based on observed data and applying to the design tidal hydrograph as input to the model.
- EA Humber 2020 Model design tidal hydrograph derived by:
    - combining a base astronomical tide curve at Spurn Head from 2nd December to 10th December 2013 with a composite surge profile obtained from Coastal Flood Boundary Conditions[1] data for Immingham published in 2018.

2.3.17 As previously noted, the fluvial peaks in the NLC 2017 Model were aligned to derive a conservative estimate of peak water levels. To ensure that this approach was maintained, the tidal curve extracted from the EA Humber 2020 Model was shifted to coincide with the time of tidal peak used in the downstream boundary in the NLC 2017 Model. For Step (v) the peak was amended from 70 hours to 97.5 hours. The initial 30 hours was replaced with a repeat of the first phase of the tidal cycle. Figure 2.9 illustrates the updates made to the tidal curve.

[1] https://www.gov.uk/government/publications/coastal-flood-boundary-conditions-for-uk-mainland-and-islands-design-sea-levels

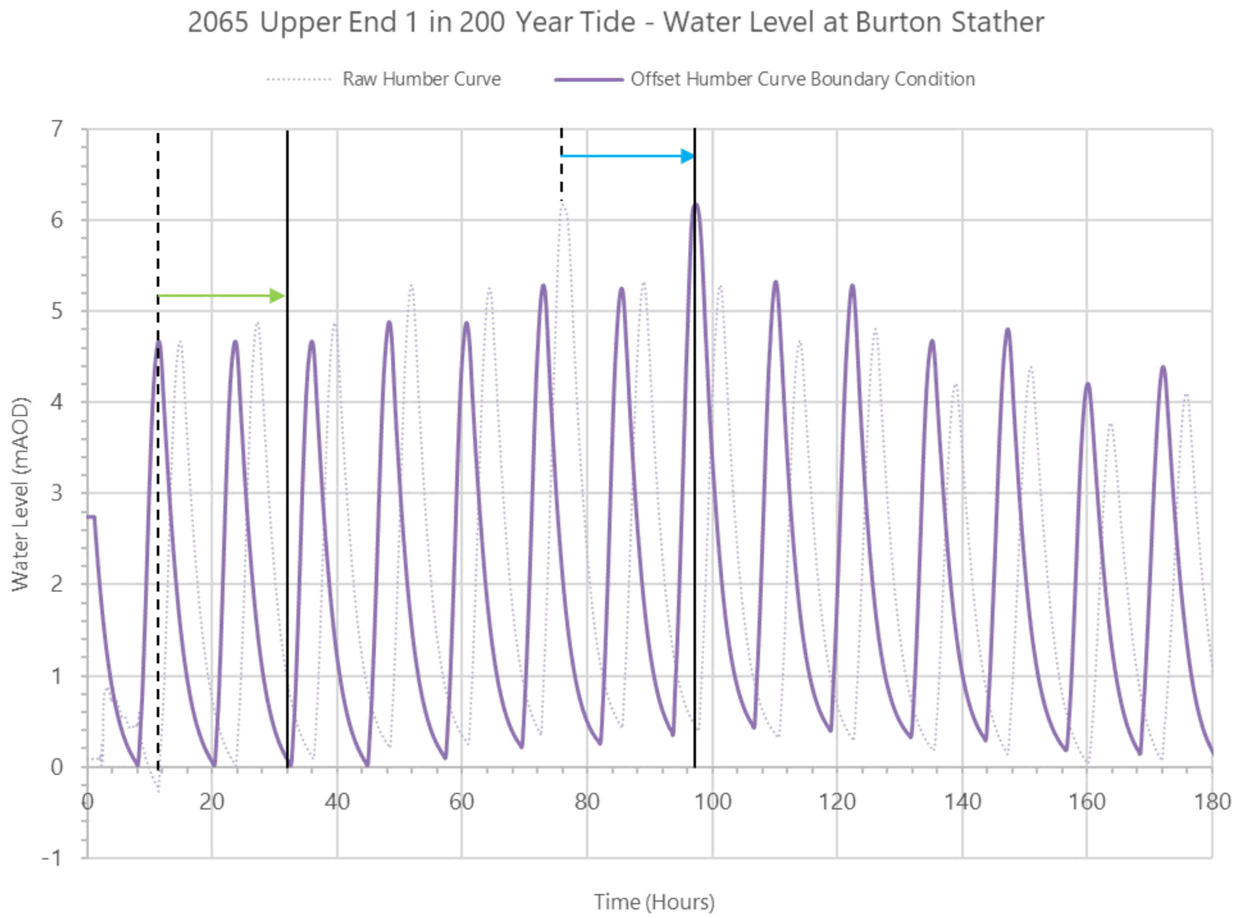


Figure 2.9 Adjustments made to the EA Humber 2020 tidal curve for input to the NLGEP model. The blue arrow shows the adjustment to the time of peak and the green arrow shows the repeated cycle of the first peak to account for the peak adjustment.

2.3.18 No other adjustments have been made to the tidal curve.

2.3.19 The Humber Extreme Water Levels (2020) User Guidance Version 2, 18th February 2021 states the following:

'Currently, the tidal River Trent water level profile is based on modelling that used the 2014 Interim Water levels to define the downstream boundary conditions. Rerunning the Tidal Trent model with an updated downstream boundary based on the Humber extreme water levels is therefore considered to provide an improved and more robust water level profile. This is because the Humber extreme water level modelling has used the latest tidal information, allowed for bank overtopping and taken account of fluvial conditions, which the Interim Water Levels did not.'

2.3.20 As the EA Humber 2020 Model also included fluvial inputs, a sensitivity test was undertaken whereby the tidal curve extracted from the Humber model was directly entered into the NLGEP bc_dbase without adjustments to the time of peak. The peak water level observed in the River Trent at the port of the Project is shown in the following table.

Table 2.11 Peak water level for the NLGEP Baseline DFE event compared to Sensitivity Test.

Modelled scenario	Peak water level at the Site
NLGEP baseline model DFE (including shift in time to peak)	6.23mAOD
NLGEP baseline model DFE Sensitivity Test (no change made to EA Humber 2020 Model extracted tidal curve)	6.22mAOD

2.3.21 The results indicated that there was an increase of 8mm when the time to peak was shifted. Therefore, as a conservative approach, this shift was adopted for all the model scenarios.

3 Proposed Model

3.1 Modelled Events

3.1.1 The Proposed Model has been simulated for the DFE.

3.2 Ground Representation

Topography

3.2.2 The Project has been represented in the model as outlined in the table below.

Table 3.1 Model set-up of the Project.

Model filename	Description
2D_ZSHP_BH_LANDRAISE_Op513_001.shp	- A nominal level of 50m was applied to the elevation of the Project. This is not a proposed FFL, but a level to remove the development platform from the floodplain by raising above a possible flood level. - The high level is to raise the development platform above the flood level to assess the impact of displacing flood volume. - The development footprint includes landscape area required to tie development platform to access road or surrounding areas. - The proposed access road was also raised. Opening in the access road were made to allow flood water to pass across the road. This would either be designed as a culvert or bridge structure.

Flood Defences

3.2.3 No changes made to existing flood defences as part of the Project.

3.2.4 Two breach scenarios of the existing flood embankments were carried out. The locations were selected based on the following:

- a location close to the Project footprint that is likely to have the greatest impact at the development (to inform setting of design platform levels). Location also chosen where existing ground levels behind the embankment appear relatively low; and

- secondary location selected ~3km north of the Project where a main flow route that would have an influence on the impact of the Project. Location also chosen where existing ground levels behind the embankment appear relatively low.

3.2.5 The breaches were based on a 50m breach in the existing earth embankment (equivalent of two grid cells). Similarly to the breach scenarios in the NLC 2017 study, the timing of the breaches were set to one hour before the highest tidal peak. The table below provides the name and description of the files used in the modelling.

Table 3.2 Model set-up of breach scenarios.

Model filename	Description
2d_vzsh_Breach_01_002_R.shp	Breach 01 scenario (south of the port) 50m wide lowering of embankment levels set to ZC ground level behind (landward) of the embankment alignment at 4.652mAOD. Breach triggered at 96.75hours.
2d_vzsh_Breach_02_002_R.shp	Breach 02 scenario (~3km north of the Site) 50m wide lowering of embankment levels set to ZC ground level behind (landward) of the embankment alignment at 3.649mAOD. Breach triggered at 96.75hours.

3.2.6 The breach scenarios were also simulated for the baseline condition using the same model files as outlined above.

Manning's Roughness

3.2.7 No changes in manning's values were made as part of the Project compared to baseline model.

3.3 Boundary Conditions

3.3.1 No changes in the boundary conditions were made as part of the Project compared to baseline model.

3.4 Result Outputs

3.4.1 To undertake the FRA, the following datasets were output from the flood model:

- max. flood level
- max. depth; and

- hazard.

Extents and Levels

3.4.2 In the NLC 2017 report, changes in modelled water levels between with scheme and baseline models have been identified where changes are greater than 25mm. It is understood that changes less than this are within the modelling tolerances of the model based on its resolution. The same approach has been adopted in this study, where changes less than 25mm in water level due to the proposals compared to baseline condition have not been shown in the FRA.

Hazard

3.4.3 The model output ZUK0 has been used to output flood hazard. This output is based on Defra's flood hazard classification. The formula is:

$$H = D(V + 0.5) + DF$$

3.4.4 Where: 'H' is the calculated hazard; 'D' is the flood depth; 'V' is the flood velocity and 'DF' is a factor to account for debris. The DF factor is assumed to be 1 based on the conservative value. The hazard categories are shown in Table 3.3.

Table 3.3 – Flood Risk Hazard Categories (DEFRA R&D Outputs: Flood Risks to People Phase Two Draft FD2321/TR2)

Hazard (H)	Degree	Description
< 0.75	Low	Caution
0.75 – 1.25	Moderate	Dangerous for some
1.25 – 2.5	Significant	Dangerous for most people
> 2.5	Extreme	Dangerous for all

4 Proposed Model + Flood Mitigation

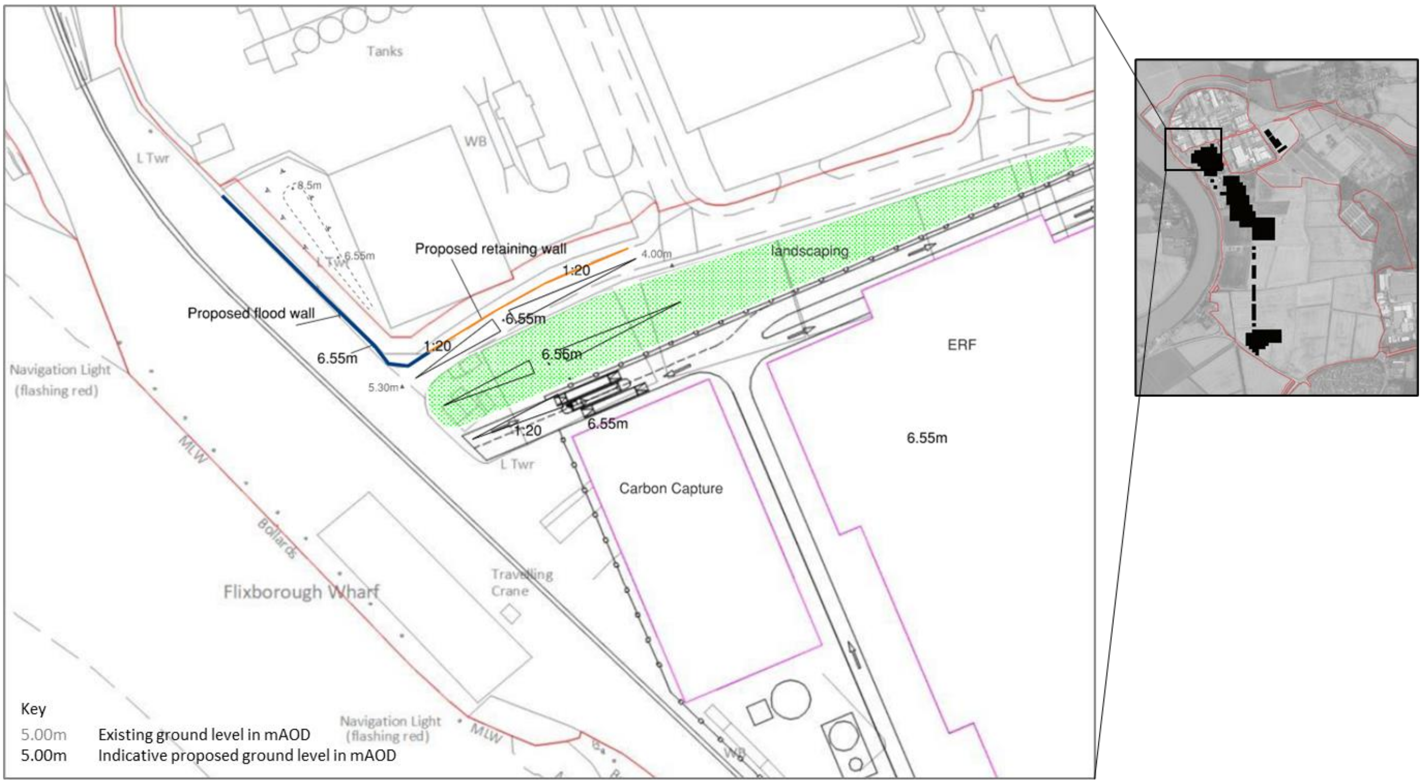
4.1 Changes to Model

4.1.1 Four flood mitigation measures are proposed to reduce the impact to third parties as follows:

- reduce culvert openings in access road between ERF and CBMF. This may include the following:
    - removing any culverts in the new access road to prevent floodwater flowing east into the Industrial Estate, or keeping the size of the culvert small to restrict flows to ensure levels in the Industrial Estate do not increase compared to baseline.
- new secondary flood defence around First Avenue. This may include the following:
    - create new flood walls along north edge of First Avenue and partially along west side of Industrial Estate
    - create new flood walls, raise landscaping levels on south side of First Avenue that ties into new development platform; and
    - grade the road so that it ramps up and down to required crest, or alternatively tie in a new flood gate to the new flood walls.
- new secondary flood defence around perimeter of east fields. This may include the following:
    - create new earth embankment within fields to the west of Park Ings Farm; and
    - include a pipe culvert where bund crosses existing ditch.
- new secondary flood defence within fields west of new access road. This may include the following:
    - create new earth embankments within fields immediately to the west of proposed access road.
    - new embankments will allow water to continue to flow along existing Neap House Drain.
    - new embankment crest level will tie into new access road crest level; and

- purpose of embankments is to hold back floodwater within the Site by reducing conveyance of overtopping floodwater flowing directly south through the existing B1216 (Ferry Road West) culvert.

4.1.2 The figures below illustrate their proposed locations and approximate alignment.



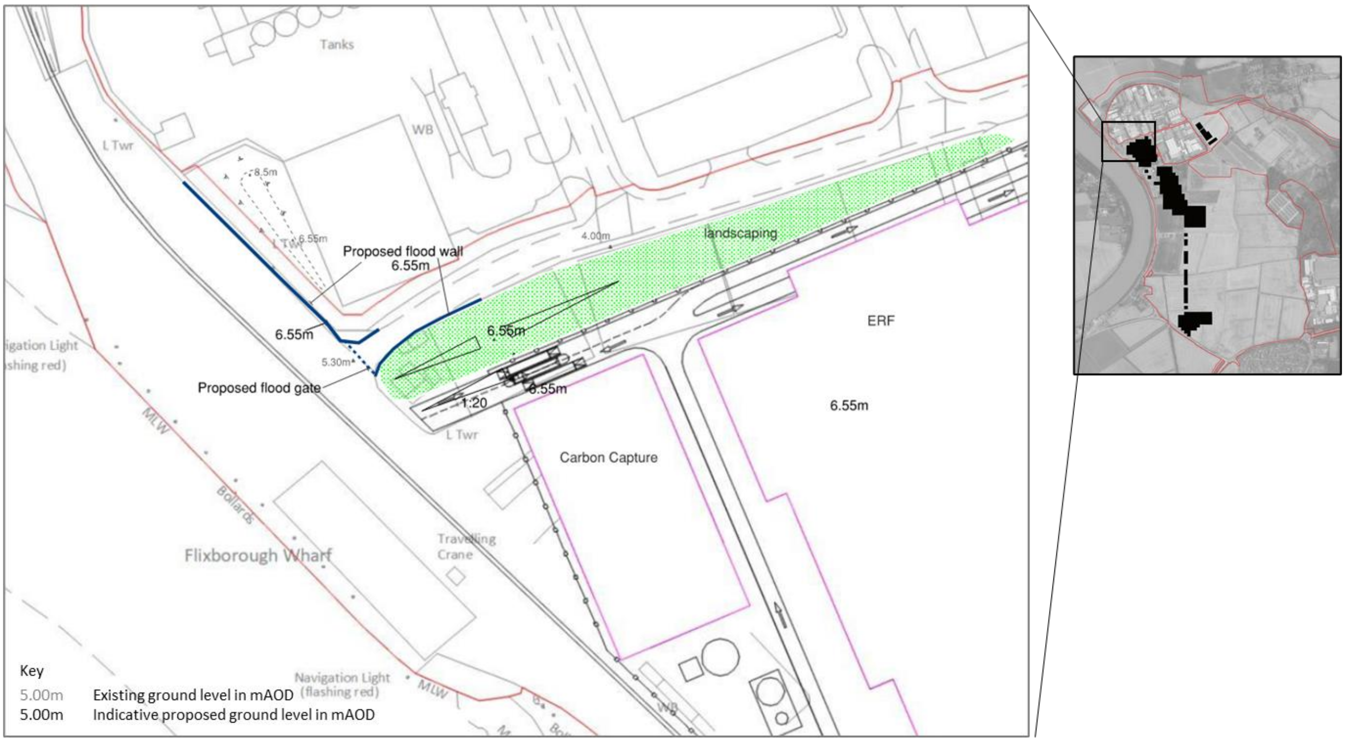


Figure 4.1 Indicative alignment location plan of proposed defences at First Avenue (top image with raised road, bottom image with flood gate) (Image courtesy of Ordnance Survey, © 2021 TomTom).

Figure 4.2 Indicative alignment location plan of proposed defences at east of the Project (Image courtesy of Ordnance Survey, © 2021 TomTom).

Figure 4.3 Indicative alignment location plan of proposed defences west of proposed Access Road, north of the B1216. The dashed lines indicate the footprint of the crest and toe of the embankments.

4.1.3 The table below provides the name and description of the files used in the modelling:

Table 4.1 Proposed flood mitigation files represented in model.

Model filename	Description
2D_ZSHP_BH_LANDRAISE_Op612_002.shp	Based on the Project whereby development platform raised to a nominal level of 50m applied to the elevation level, including the full length of access road between ERF and CBMF (i.e. No gaps in access road to replicate worst case). This file also includes blocked out cells for the raised secondary defences in the fields west of the proposed access road.
2D_ZLN_BH_LANDRAISE_Op59_002.shp	Thin Z line read in to prevent floodwater to move east or north across the line to represent raised defence works at First Avenue wrapping around along the port. Nominal elevation value of 50m used. This is to reduce flood levels into the Industrial Estate during the Breach 01 scenario. Flood water anticipated to still flow west to east into the Industrial Estate to the north of the flood defence during all scenarios.
2D_ZLN_BH_LANDRAISE_Op56_002.shp	Thin Z line read in to prevent floodwater to move east across the line to represent raised defence works at Park Ings Farm. Nominal elevation value of 50m used.

4.1.4 Discussions were undertaken with the EA regarding sensitivity tests of a breach in proposed new secondary flood defences. This is because failure can occur if not constructed properly or, in the case of a manual flood gate, is left open. This has not been tested in the proposed flood wall around the port and First Avenue because behind the wall is an existing earth embankment and warehouse. The embankment and building will prevent any onset of fast flowing water to users on the site. If the gate remained open flood water would continue along First Avenue and the anticipated risk would be as shown in the flood results above. At this location velocities are approximately 0.5m/s and depths 0.3m with a hazard category of 'danger to some'. As part of the proposals a Flood Warning and Evacuation Plan will be in place to manage users around the site.

4.1.5 A breach in the proposed bund in the east of the Project has also not been undertaken. This is due to flood depths and velocities being low at the periphery of the floodplain extent.

4.2 Result Outputs

4.2.1 For the Breach 02 model, an increase greater than 25mm was observed ~28km southwest of the Project. An increase in flood level of 30mm to 100mm is observed (see Figure 4.4). This location is in the River Idle, a tributary to the River Trent and is not hydrologically connected to the flood mechanism observed at the Project. Overland flooding in the floodplain does not connect the two areas. Changes in the River Trent at the Project location are less than 1mm and therefore not considered to be the cause of the increase in flood level observed in the agricultural fields. Mass balance errors in localised cells at the inflow QT boundary and along the River Idle from approximately 53 hours into the model simulation and onwards are observed.

4.2.2 Therefore, this change in flood level has been attributed to model instabilities in this localised area and no further flood mitigation measures have been identified to reduce this increase.

Figure 4.4 Image showing change in peak flood level due to proposals with mitigation Breach 02 versus baseline Breach 02 model. Change greater than 30mm to 100mm outside of the Project circled in blue (Image courtesy of Ordnance Survey, © 2021 TomTom).

4.3 Accounting for Residual Uncertainty

4.3.1 As part of the FRA a freeboard allowance has been applied to the DFE flood level when setting finished floor levels (FFLs). In February 2017, updated in 2021 the EA published guidance on accounting for residual uncertainty to incorporate into flood risk management strategies (Accounting for residual uncertainty: updating the freeboard guide Report SC120014, February 2017). Appendix A summarises the primary sources and scale of the residual uncertainty. Following the methodology set out in the guidance, a freeboard allowance of 450mm has been applied to FFLs and mitigation measures to ensure the Project is at a low risk from flooding for the lifetime of the development.

5 Model Nomenclature

5.1 Model Files

5.1.1 Table 5.1 to Table 5.3 provides a list of the key models files and changes between them and from the NLC 2017 model and EA Humber 2020 model that were used as the basis of the modelling.

Table 5.1 Files and changes made to EA 2020 Humber model.

Event scenario	Description	IEF files	IED files
Design Flood Event	1 in 200 yr tidal Upper End climate change projection in 2065 with 1 in 2 or 5 yr fluvial + 30% CC	V5_HEWL_2065_H_RP200_T.ief Based on V5_HEWL_2046_H_RP200_T.ief	REMOVED Tide_RP200_P023CM.ied ADDED Tide_RP200_P045CM.ied
H++	H++ tidal Upper End climate change projection in 2065 with 1 in 2 or 5 yr fluvial + 35% CC	V5_HEWL_2065_HPP_RP200_T.ief Based on V5_HEWL_2065_H_RP200_T.ief	REMOVED: Aire_RP2_P30Q.ied Don_RP2_P30Q.ied Ouse_RP5_P30Q.ied Trent_RP2_P30Q.ied Tide_RP200_P023CM.ied ADDED: Aire_RP2_P35Q.ied Don_RP2_P35Q.ied Ouse_RP5_P35Q.ied Trent_RP2_P35Q.ied Tide_RP200_P082CM.ied

Note:

All runs based on v9_Humber_2021.dat. No changes made.

Original model used from EA Humber model package is V5_HEWL_2046_H_RP200_T.ief.

Table 5.2 Summary of events and corresponding files used in NLGEP model simulations

Event scenario	Description	IED files	bc_dbase & event files
Design Flood Event	1 in 200 yr tidal Upper End climate change projection in 2065 with 1 in 2 yr fluvial + 30% CC	TTRENT_F0002_2050_UE.IED	bc_dbase_BH_NLGEP_TTRENT_07.csv TTRENT_F0002_30CC_UE_T0200_2065_UE_v4.csv
H++	H++ tidal Upper End climate change projection in 2065 with 1 in 2 yr fluvial + 35% CC	TTRENT_F0002_2050_Hpp.IED	bc_dbase_BH_NLGEP_TTRENT_07.csv TTRENT_F0002_35CC_UE_T0200_2065_HPP_v4.csv

Table 5.3 Files and changes made to NLC 2017 model and NLGEP models.

ID Ref	Model	Run name (ief & tcf) & new files	Tgc and new/removed files
M1	NLGEP Baseline Model	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V601_Baseline_V004 BH_NLGEP_TTRENT_F0002_35CC_HPP_T0200_2065_HPP_V601_Baseline_V004 REMOVED 1d_nwke_TTRENT_03_flapped.MIF ADDED 1d_nwke_TTRENT_03_NO_MIT_flapped.shp	MM_LL_TTRENT_27_WITH_ST_MITIGATION_V25_BH003_V002.tgc Based on NLC 2017 model*. ADDED 2d_ZLN_BH_SouthRoad_001.shp
M2	NLGEP Baseline Model + Breach 01	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V601_Baseline+Breach01_V004	MM_LL_TTRENT_27_WITH_ST_MITIGATION_V25_V501_BASELINE+BREACH01_V002.tgc Based on M1 ADDED 2d_vzsh_Breach_01_002_R.shp

ID Ref	Model	Run name (ief & tcf) & new files	Tgc and new/removed files
M3	NLGEP Baseline Model + Breach 02	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V601_Baseline+Breach02_V004	BH_NLGEP_TTRENT_V501_BREACH02_V001.tgc Based on M1 ADDED 2d_vzsh_Breach_02_002_R.shp
M4	NLGEP Proposed Model	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V602_NO_MITIGATION-B_V004	BH_NLGEP_TTRENT_V513-NO_MITIGATION_V001.tgc Based on M1 ADDED 2D_ZSHP_BH_LANDRAISE_Op513_001.shp
M5	NLGEP Proposed Model + Breach 01	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V602_NO_MITIGATION-B_BREACH01_V004	BH_NLGEP_TTRENT_V513-NO_MITIGATION_V001_BREACH01.tgc Based on M4 ADDED 2d_vzsh_Breach_01_002_R.shp
M6	NLGEP Proposed Model + Breach 02	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V602_NO_MITIGATION-B_BREACH02_V004	BH_NLGEP_TTRENT_V513-NO_MITIGATION_V001_BREACH02.tgc Based on M4 ADDED 2d_vzsh_Breach_02_002_R.shp
M7	NLGEP Proposed + Mitigation Model	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V617_DCO_V004 BH_NLGEP_TTRENT_F0002_35CC_HPP_T0200_2065_HPP_V617_WITH_MITIGATION-C_V004	BH_NLGEP_TTRENT_V617-DCO_V001.tgc Based on M4 REMOVED 2D_ZSHP_BH_LANDRAISE_Op513_001.shp

ID Ref	Model	Run name (ief & tcf) & new files	Tgc and new/removed files
			ADDED 2D_ZSHP_BH_LANDRAISE_Op612_002.shp ADDED 2D_ZLN_BH_LANDRAISE_Op59_002.shp ADDED 2D_ZLN_BH_LANDRAISE_Op56_002.shp
M8	NLGEP Proposed + Mitigation Model + Breach 01	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V617_WITH_MITIGATION-A_BREACH01-C_V004	BH_NLGEP_TTRENT_V513-WITH_MITIGATION_V001_BREACH01_V003.tgc Based on M7 ADDED 2d_vzsh_Breach_01_002_R.shp
M9	NLGEP Proposed + Mitigation Model + Breach 02	BH_NLGEP_TTRENT_F0002_30CC_UE_T0200_2065_UE_V617_WITH_MITIGATION-A_BREACH02-C_V004	BH_NLGEP_TTRENT_V513-WITH_MITIGATION_V001_BREACH02_V003.tgc Based on M7 ADDED 2d_vzsh_Breach_02_002_R.shp

Note:

*NLGEP Baseline Model based on MM_LL_TTRENT_F0002_2050_UE_T0200_2050_UE_V27_WITH_ST_MITIGATION_V25.tcf from NLC 2017 modelling package.

DAT file used for all modelled scenarios: MM_LL_TTRENT_08a.DAT

TBC file used for all modelled scenarios: MM_LL_TTRENT_11.tbc

TMF file used for all modelled scenarios: MM_LL_TTRENT_01.tmf

TRD file used for all modelled scenarios: MM_TTRENT_27_Mit_V25_BH001.trd

Topographic data not used in model run but for data comparison can be found in the following folders:

TUFLOW\grid\Drone2020

TUFLOW\grid\LiDAR2020

For models that are to be re-run, the commands that do not have relative file name paths are as follows:

- TRD file:
    - Log folder
    - Output folder
    - Write Check Files

Appendix A Accounting for Residual Uncertainty

Stage 1 & 2 – Identify primary sources of uncertainty and estimate scale of the residual uncertainty

Criteria	Applicable (Y/N)	Score (1 High to 10 Low)	Reasoning
How apt is the flood risk analysis - e.g. up-to-date / inc. culverts etc. / land use change	Y	1	The model has been updated to represent local features more accurately, such as the culvert upstream of the site, along the B1216. The model includes the upgrades to the defences for the Lincolnshire Lakes development.
How well is floodplain modelled - e.g. topography / drainage channels / embankments / resolution	Y	2	Topography has been sensitivity checked against a Bank Survey (2016) and a drone survey (2020), in addition to LiDAR data. Drainage channels are not included, although as LiDAR data has been used, the top of water level is represented which assumes channels do not have additional capacity during normal conditions. Bank elevations include EA surveyed data from 2016 (included in NLC model received). Floodplain uses a 25m x 25m grid resolution. Majority of floodplain in the Site is within agricultural fields which grid resolution is appropriate. More subtle changes around roads in the Industrial Estate are not picked up.
How well has potential for breach been modelled - e.g. no. and type	Y	2	Two breach locations have been assessed locally, in addition to the 32 within the model, and these have been agreed with the EA. The scenarios include the breach of the EA defences in the South and approx. 3km north of the Site.
Hydrology confidence - e.g. source of data / length of records	Y	2	The hydrological analysis was undertaken for the previous versions of the River Trent model developed by the EA and NLC and the Humber Estuary model which takes into account the different tributaries into the Humber. Both models have been calibrated against the December

Criteria	Applicable (Y/N)	Score (1 High to 10 Low)	Reasoning
			2013 tidal surge, which is the largest recorded surge in recent years. Therefore, the hydrology in the model is considered appropriate.
Coastal/Estuarine/Tidal Boundaries - considered approach to boundary conditions re. waves/sea level?	Y	1	Coastal threats and tidal risk is included in the assessment. The Design Flood Event is the 1 in 200 year + UE CC Tidal event. The tidal boundary has been based on the EA's latest model for the Humber based on UKCP18 projections.
How apt. is modelling technique	Y	2	Purpose of the model is to assess the flood risk to the scheme and impact to other users and develop mitigation measures to reduce the impact. The purpose is not to develop final culvert or channel sizings which would be undertaken using a different modelling technique. Therefore, for the purpose of the model, the underlying data and representation is considered suitable.
Representation of coastal threats - overtopping/tidal inundation	Y	1	Coastal threats and tidal risk is included in the assessment. The Design Flood Event is the 1 in 200 year + UE CC Tidal event based on the latest EA climate change guidance, UKCP18. Wave overtopping not considered applicable at the Site.
How has surface water runoff been represented - modelling vs complexity of site	N	-	Surface water run-off is not represented in the hydraulic model and has been assessed in a different model. This is because the main flood risk to the Site is considered to be tidal. Surface water runoff is being calculated using FEH rainfall data, catchment analysis, and MicroDrainage modelling such that a full and comprehensive surface water drainage strategy is provided.
How have groundwater hazards been represented -	N	-	Groundwater data has been obtained via BGS boreholes local to the site. The Boreholes provide groundwater levels and data on soil/bedrock strata. These factors are not included in the hydraulic

Criteria	Applicable (Y/N)	Score (1 High to 10 Low)	Reasoning
model detail vs complexity of site			model but are being assessed by a combination of flood risk engineers and ground engineering specialists. Appropriate mitigation will be provided.
Has it been calibrated against observed events	Y	1	The NLC hydraulic model and Humber Estuary model provided by NLC and the EA have been previously calibrated against observed events. The NLGEP model does not significantly change the baseline models received and therefore no further calibration was necessary for the model.

Stage 3 – Determine appropriate response*

Based on the two lowest scores (2 and 2) the following table gives the study 4 star scoring.

		Worst topic 1 score				
		10	5	3	2	1
Worst topic 2 score	10	1 star			2 star	3 star
	5	1 star		2 star	3 star	4 star
	3	1 star	2 star	3 star	4 star	
	2	2 star	3 star	4 star		5 star
	1	3 star	4 star		5 star	

A confidence rating of 4 star indicates that a residual allowance of 450mm should be applied in development planning.

Confidence rating	Confidence description	Proportion of design flood depth [1]	Minimum depth (mm)
1 star	Very unlikely to be locally reliable	40%	900
2 star	Unlikely to be locally reliable	30%	750
3 star	Likely to be locally reliable	20%	600
4 star	Very likely to be locally reliable	10%	450
5 star	Highly likely to be locally reliable	5%	300

*Tables above extract from Accounting for residual uncertainty: updating the freeboard guide Report SC120014, February 2017, EA.

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