

Holbeach Food Centre Development

Flood Risk Assessment

Draft Report

July 2016

University of Lincoln
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Contract

This report describes work commissioned by Dan Clayton of the University of Lincoln, by a purchase order (PO00012664) dated 10 June 2016. The University of Lincoln's representative for the contract was Dan Clayton. Gavin Hodson and Stuart Marshfield of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

The help received from Dan Clayton (the University of Lincoln) and Dom Morris (South Holland IDB) is gratefully acknowledged.

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Executive Summary

JBA was commissioned by the University of Lincoln to carry out an FRA for a proposed professional services development in Holbeach, Lincolnshire. This FRA has been prepared in accordance with the NPPF and associated PPG.

Proposed development

The proposed development is for a Centre of Excellence for Agri-Food, comprising new offices, laboratory space, a conference venue and seminar rooms with associated car parking and green space.

The whole site covers approximately 3.6ha. However only part of the site is to be developed at this time (1.3ha). Therefore, this FRA covers the north eastern third of the site.

Flood risk

The best available data for the site at Holbeach indicates that the proposed development is at risk from flooding to a modelled depth of 0.5m as a result of a breach in the tidal flood defences at the 0.5% and 0.1% AEP under scenarios of predicted future climate change by 2115. The supplied Product 8 data indicates that under the present day scenario, the site is not at risk from the equivalent AEP events. This information is taken in preference to that provided in the SFRA.

Climate change may present additional risk to this area of the UK. The EA propose to manage this under CFMP Policy Option 4. Specifically:

"Policy option 4: Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change."

The site is at low to very low risk of surface water flooding.

Surface water drainage

The South Holland IDB has confirmed that the allowable discharge rate to the watercourses is 1.8l/s for the site (1.4l/s/ha).

To achieve the appropriate amount of storage at the prescribed runoff rate for the 100-year storm over the lifetime of the development (i.e. with allowance for climate change), a total storage volume of 440m³ would be required. The permissible runoff rate is achievable only with a Hydrobrake outfall.

Surface water concept design.

The current masterplan indicates an availability of green space that could be utilised for SuDS. For example, ponds or swales could be sited on open green space. This would act to store surface water prior to discharge at the prescribed rate to the adjacent drainage channel between the site and the A151.

Storage can also be provided through the use of geo-cellular crates beneath car parks.

It is important to note that the adjacent existing drainage channel between the site and the A151 is in the region of 1.0-1.3m deep. This may not provide sufficient fall for surface based SuDS. Therefore, the watercourse may need to be enlarged to accommodate any on site surface water drainage system.

Development design

The NPPF stipulates that finished floor levels should be a minimum of whichever is higher of

- 300mm above the general ground level of the site; or,
- 600mm above the estimated river or sea flood level.

The minimum on-site elevation is approximately 2.6m. The NPPF would thereby stipulate a finished floor level of 3.7m (2.6 + 0.5 + 0.6). Under the current proposal, this may be impractical and costly. However, the flood level is estimated from the breach scenario. Therefore, it may be sufficient to raise finished floor levels 300mm above surrounding ground levels and use flood resilient building techniques.

Flood resilient building design

Under the current proposal, finished floor levels of 3.7m may be impractical and we would therefore suggest exploring methods of flood resilient building design.

For water depth from 0.3m to 0.6m:

- Design your building or development to keep water out (unless there are structural concerns) by:
- using materials with low permeability to at least 0.3m;
- using flood resilient design (e.g. raised electrical sockets);
- making sure there's access to all spaces to enable drying and cleaning.

Access and egress

The breach modelling indicates a maximum flood depth at the site of 0.5m at a sufficient velocity which would pose 'danger to some'. The A151 north and south would be affected by a similar flood depth and velocity. Therefore, during a flood event it is likely that users of the site will experience difficulties with access and/or egress.

Environment Agency flood warning

It is advised that the building occupants sign up to the EA's flood warning system to allow early indication of any defence breach which may hinder either access or egress to the development.

Safe refuge or evacuation

In the event of flooding, safe refuge for any inhabitants should be available through designating appropriate finished floor levels or providing sufficient available space at a second storey level if the ground floor has been designed to flood.

However, within the vicinity of the site, there are areas that are shown in the EA breach modelling (with allowance for climate change) to be at very low risk. These areas include some residential areas of Holbeach to the south of the site (e.g. Wignals Gate) that lies 0.5-1m above the lowest site level and to the east/south east of the site where ground elevations are 1.0-2.0m higher. It may be possible with prompt flood warning and efficient procedures to evacuate occupants to local areas of higher ground that are at very low risk of breach flooding.

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Abbreviations

%	percent
AEP	Annual exceedance probability
BGS	British Geological Survey
CC	Climate Change
EA	Environment Agency
FAS	Flood Alleviation Scheme
FEH	Flood Estimation Handbook
FRA	Flood Risk Assessment
FSR	Flood Studies Report
IDB	Internal Drainage Board
JBA	Jeremy Benn Associates Ltd.
km	kilometres
LLFA	lead local flood authority
m	metres
mAOD	metres Above Ordnance Datum
mm	millimetres
NGR	National Grid Reference
NPPF	National Planning Policy Framework
OS	Ordnance Survey
OS NGR	Ordnance Survey National Grid Reference
PPG	Planning Practice Guidance
RRMfD	Rainfall Runoff Management for Developments
SFRA	Strategic Flood Risk Assessment
SuDS	Sustainable Drainage Systems
WRAP	Winter Acceptance Rainfall Potential
YWS	Yorkshire Water Services

1 Introduction

1.1 Overview

Jeremy Benn Associates (JBA) was commissioned by the University of Lincoln to carry out a Flood Risk Assessment (FRA) for a proposed professional services (Centre of Excellence for Agri-Food) development in Holbeach, Lincolnshire. This FRA has been prepared in accordance with the National Planning Policy Framework (NPPF) and associated Planning Practice Guidance (PPG).

Preliminary enquiries have been made, requesting relevant flood risk information, to:

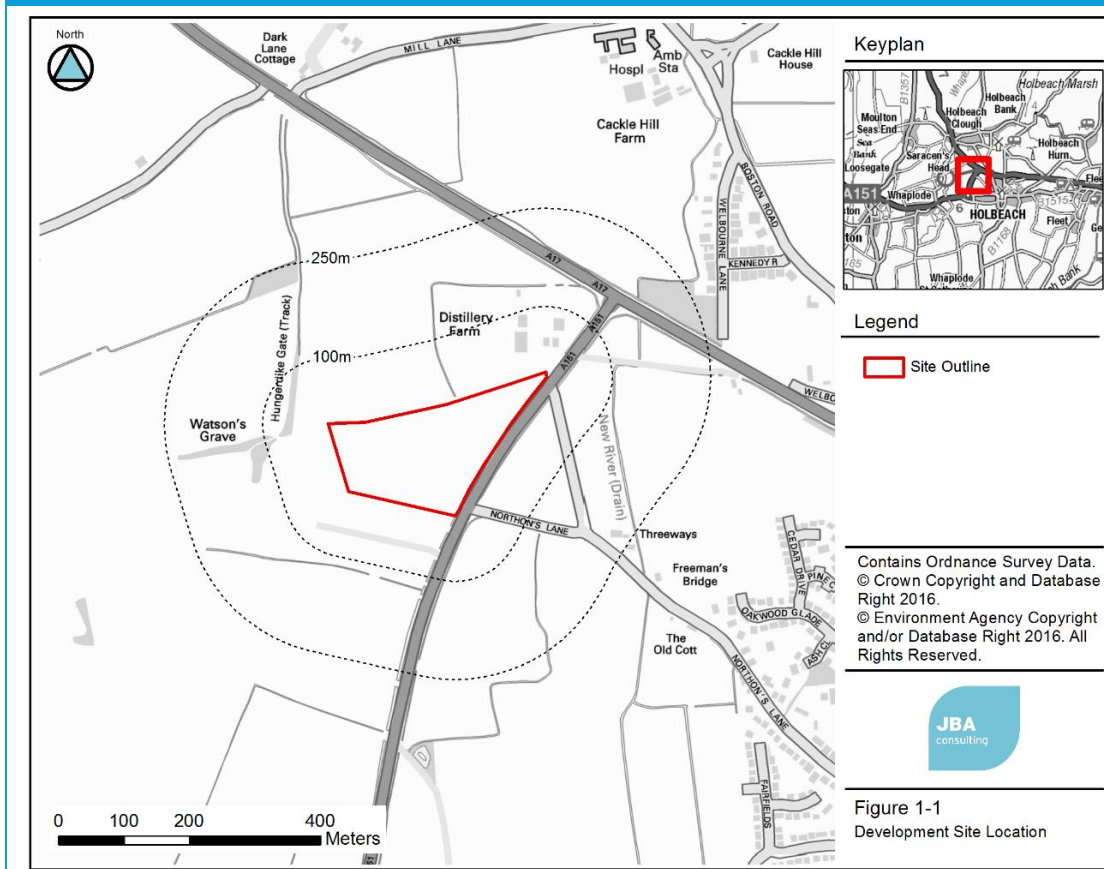
- South Holland District Council - the local planning authority;
- Lincolnshire County Council - the lead local flood authority (LLFA);
- Anglian Water;
- The Environment Agency (EA);
- South Holland Internal Drainage Board (IDB).

1.2 Location

The proposed development site is located approximately 150m south of the junction of the A17 and A151 to the north west of central Holbeach, Lincolnshire (Ordnance Survey National Grid Reference (OS NGR) 533,780m Easting, 325,628m Northing) (Figure 1-1).

The site is approximately 10km east of Spalding and 12km southwest of The Wash.

Figure 1-1: Development site location



The site (Land Parcel 21B) is approximately 3.6 hectares (ha) total area and is currently undeveloped grassland adjacent to the A151. Nearby developments include only small isolated agricultural buildings.

There are no significant watercourses (or EA Main Rivers) in the vicinity of the site. The nearest EA Main River is the River Welland approximately 10km to the west.

However, there are a large number of small drainage channels within the vicinity of the site. Some of these smaller watercourses are the responsibility of South Holland IDB and others are managed privately by the riparian land owner. None of the IDB Ordinary Watercourses in the vicinity of the site are designated 'High Priority' by the South Holland IDB with the exception of New River (100m east of the site).

The supplied site topographic survey is included as Appendix A.

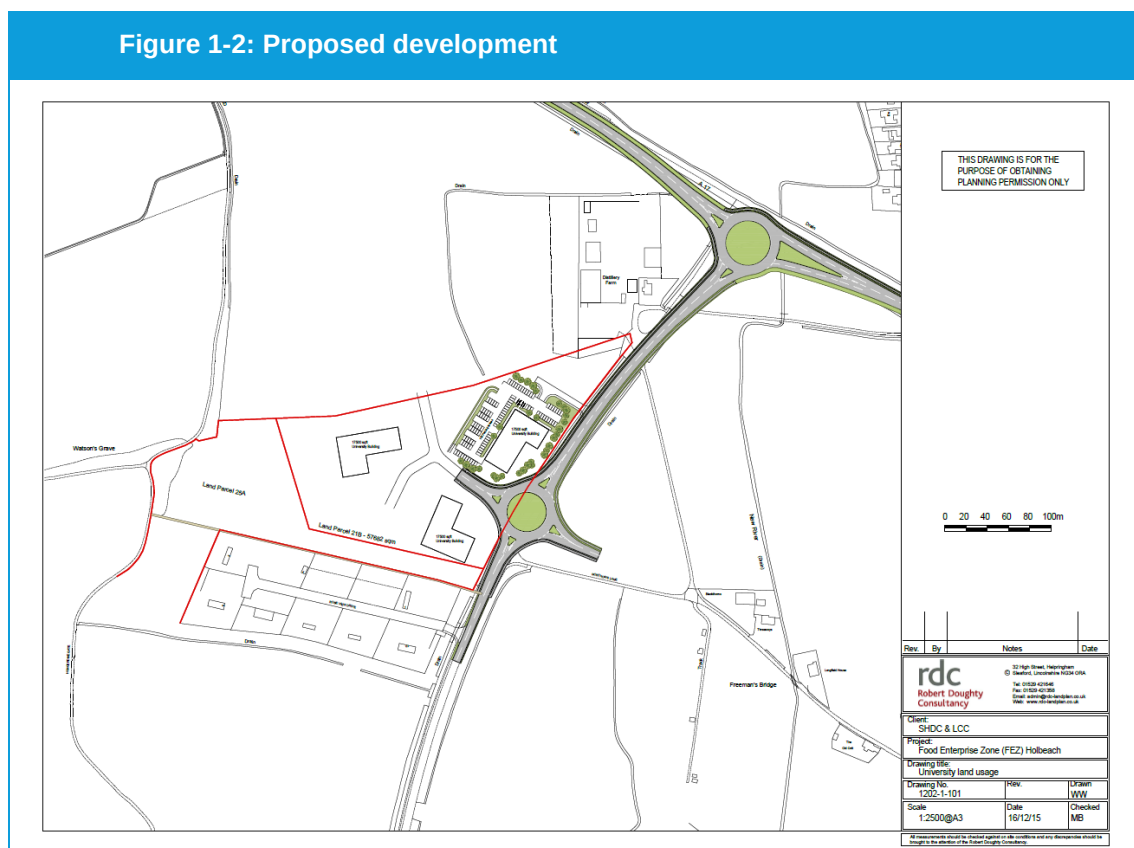
1.3 Proposed development

The proposed development is for a Centre of Excellence for Agri-Food (also referred to as Food Enterprise Zone), comprising new offices, laboratory space, a conference venue and seminar rooms split over three individual university buildings. There is also proposed space allocated for car parking and areas of green space.

The proposed layout is shown in Figure 1-2. A larger version of this drawing is available in Appendix B.

The area covered by this FRA is a third (approximate), or northern corner, of the site (shown in colour in the proposed layout) that has been designed up to this point. This area of the site is approximately 1.3ha of the total 3.6ha site. It is understood that the remainder of the development will be covered by a Local Development Order later in the year.

Figure 1-2: Proposed development



1.4 Requirements for a Flood Risk Assessment

The requirements for an FRA are provided in the NPPF and associated PPG. The NPPF outlines that a site specific FRA should be submitted as part of a planning application for all developments larger than 1ha in Flood Zone 1 or any development of any size within Flood Zones 2 and 3.

FRAs should describe and assess all flood risks (from rivers, the sea, reservoirs, sewers and groundwater) to and from the development and demonstrate how they will be managed, including an assessment of the potential implications of climate change.

1.5 Available data

This FRA has been developed using the following available data:

- EA: Open source Flood Map for Planning, National Flood Risk Assessment (NaFRA) and LIDAR topographic data;
- EA: Product 8 Flood Hazard Mapping including results from breach modelling;
- South Holland District Council: 'Update of Strategic Flood Risk Assessment' (2010);
- EA: 'River Welland Catchment Flood Management Plan (CFMP)' (2009);
- Site topographic survey (Initial Surveys, 1 July 2016);
- Food Enterprise Zone site masterplan (Robert Doughty Consultancy, 16 December 2015).

1.6 Report structure

This FRA has been prepared in the following structure:

1. Introduction
2. National Planning Policy Framework
3. Baseline environmental conditions
4. Flood risk
5. Surface water drainage
6. Development design
7. Summary

2 National Planning Policy Framework

2.1 Overview

We have assessed the proposed development in accordance with the NPPF. Our assessment shows that:

- The proposed development is located wholly in Flood Zone 3. This indicates a 1 in 100 (1%) or greater annual probability of river flooding or a 1 in 200 (0.5%) or greater annual probability of flooding from the sea in any given year. The NPPF stipulates that all development planning proposals in Flood Zone 3 include an FRA.
- Buildings used for non-residential professional or other services are classified as 'Less Vulnerable'¹.
- The NPPF indicates that less vulnerable development is permitted in Flood Zone 3a (land at high risk but not functional floodplain*) without the need for the Exception Test. Additional analysis of the frequency of flooding at the site is required to identify that the site cannot be classified as functional floodplain.

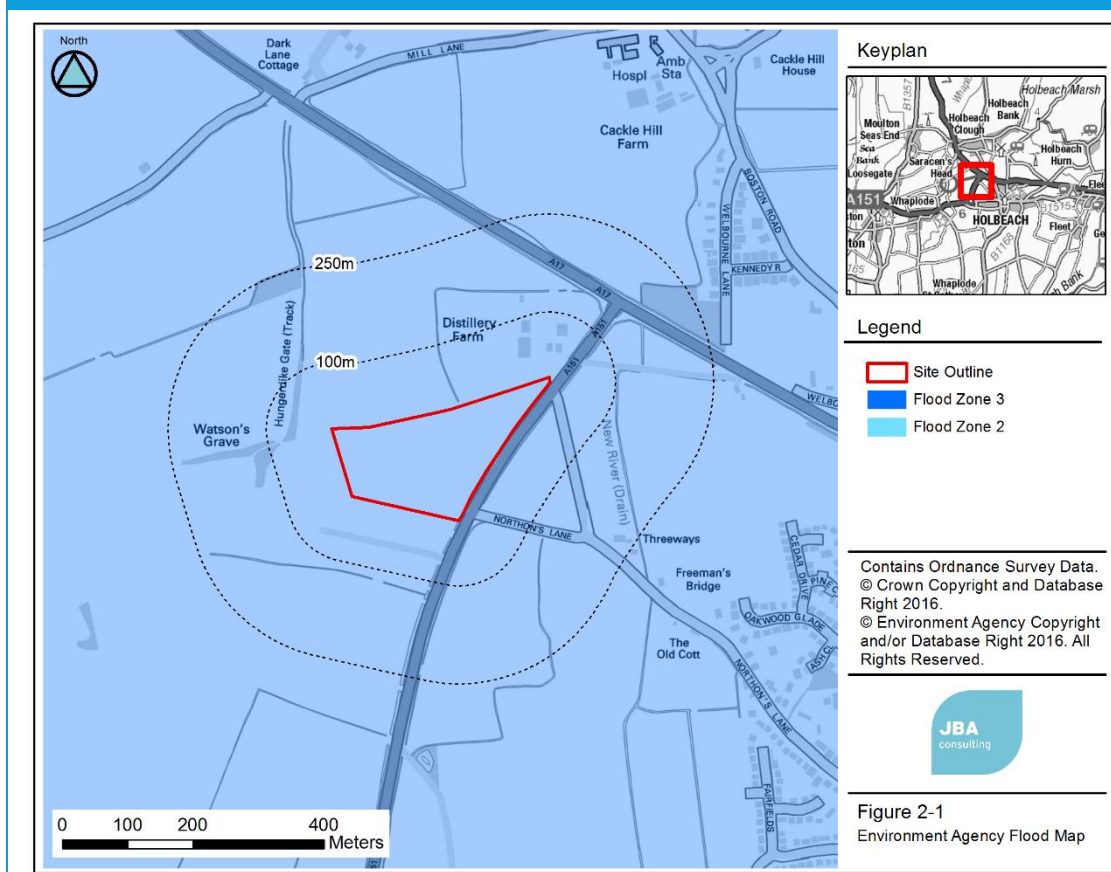
*Functional floodplain is designated land that is required for water storage during a flood event - where the annual probability of flooding is >5%.

2.2 Flood Zone classification

The EA Flood Zone definitions provided in the NPPF are shown in Figure 2-1.

The proposed development is located wholly in Flood Zone 3. The EA Flood Map indicates that the significant majority of the area surrounding the site resides in Flood Zone 3 with the exception of isolated areas of higher ground.

Figure 2-1: Environment Agency Flood Map and Flood Zone definitions



¹ <http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/flood-zone-and-flood-risk-tables/table-2-flood-risk-vulnerability-classification/>

Flood Zone	Definition
Zone 1 Low Probability	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).
Zone 2 Medium Probability	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).
Zone 3a High Probability	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).
Zone 3b The Functional Floodplain	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)

2.3 Land use vulnerability

The proposed land use is to be professional service. This is classed as 'Less Vulnerable'².

2.4 Sequential and Exception tests

The site has been allocated for the proposed development in the emerging South East Lincolnshire Local Plan 2016 and has been subject to an approval in principle by the Local Planning Authority for a Local Development Order, because it is considered by the LPA to be a sustainable and suitable location for the proposed development. This indicates that the site has been assessed as meeting the Sequential Test by the Local Planning Authority.

The development is classed as less vulnerable and therefore appropriate and does not require the Exception Test. This is shown on the flood risk, vulnerability and Flood Zone compatibility matrix in Table 2-1.

The 2016 South East Lincolnshire Local Plan (Housing Paper) describes Holbeach as "the most sustainable location for development outside of Spalding and Boston"³.

Table 2-1: Flood risk, vulnerability and flood zone compatibility					
Flood Zones	Flood Risk Vulnerability Classification				
	Essential infrastructure	Highly vulnerable	More vulnerable	Less vulnerable	Water compatible
Zone 1	✓	✓	✓	✓	✓
Zone 2	✓	Exception Test required	✓	✓	✓
Zone 3a	Exception Test required	X	Exception Test required	✓	✓
Zone 3b	Exception Test required	X	X	X	✓
✓ Development is appropriate X Development should not be permitted					

² <http://planningguidance.communities.gov.uk/blog/guidance/flood-risk-and-coastal-change/flood-zone-and-flood-risk-tables/table-2-flood-risk-vulnerability-classification/>

³ South East Lincolnshire Local Plan: <http://www.southeastlincslocalplan.org/wp-content/uploads/2016/06/Holbeach-Housing-Paper-and-Inset-Map-5-June-2016.pdf>

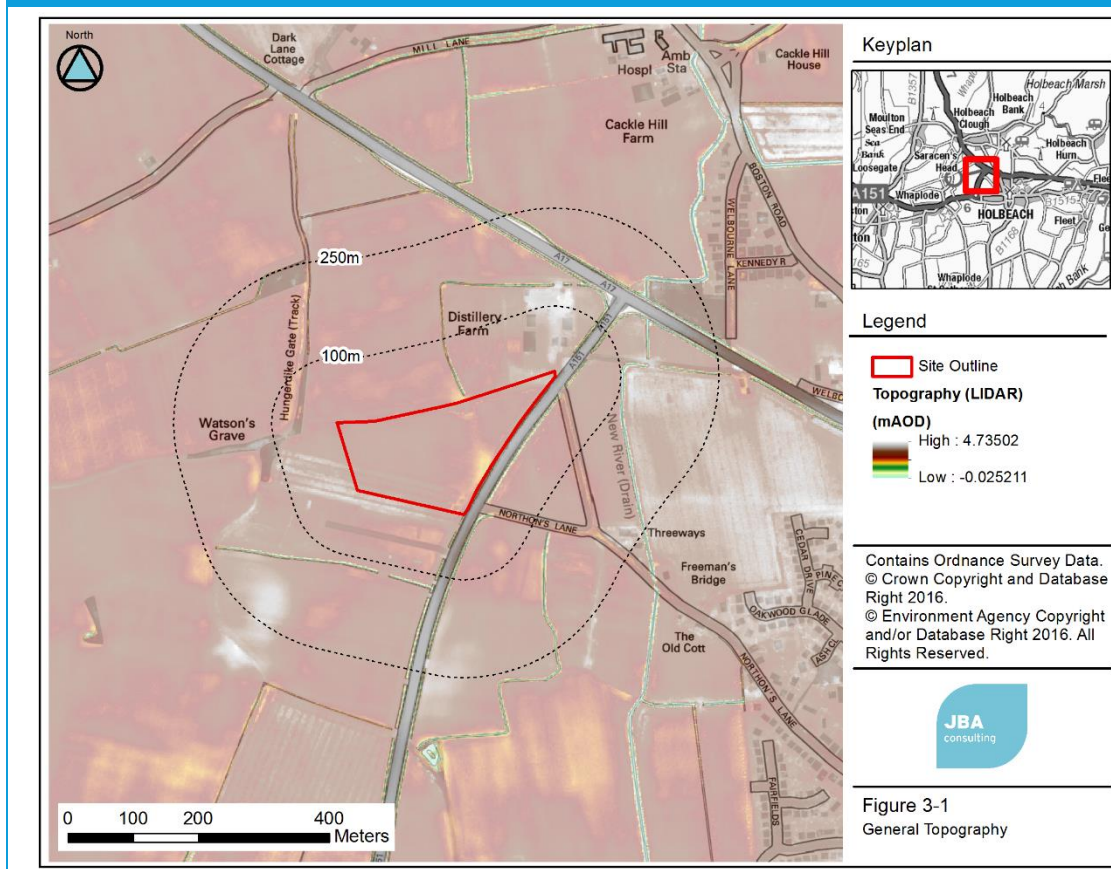
3 Existing environmental conditions

3.1 Topography

The general topography in the area of the proposed development site is shown in Figure 3-1. The site is very flat, with generally slightly higher ground towards the east from the site on the opposite side of the A151.

The surrounding landscape across this area of Lincolnshire and northern East Anglia is very flat with only a small number of intersecting ridges of high ground. The centre of Holbeach itself lies on the crest of one of these areas of higher ground.

Figure 3-1: General topography



3.2 Local watercourses

There are no significant watercourses (or EA Main Rivers) in the immediate vicinity (approximately 10km) of the site. The nearest EA Main River is the River Welland, a high level carrier with linear defences approximately 4m above surrounding ground level. To the south east (13km), there is also the River Nene, a similarly high level carrier with raised linear defences approximately 3m above surrounding ground levels. These surrounding ground levels equate closely to the approximate level of the site.

There are a number of small drainage ditches that drain the surrounding adjacent agricultural land in the vicinity of the site. A number of these are IDB managed Ordinary Watercourses, for example New River to the east of the site. However, some are managed privately. None of the IDB managed drainage channels in the vicinity of the site are identified to be 'High Priority' except New River (100m east of the site).

Regarding the watercourses adjacent to the site, the South Holland IDB have made the following comments (Appendix C):

- The private watercourse surrounding the proposed development will flow into the Board's Gander Ground and/or Distillery Farm watercourses through to Holbeach New River then out through the Holbeach River Outfall Sluice into the River Welland.
- There has been a modelling study carried out for this catchment. At a cost, model results and other information can be requested from the South Holland IDB.
- The Board are not aware of any flooding in this area.

3.3 Geology, soils and hydrogeology

The British Geological Survey (BGS) Geology of Britain viewer shows that the site is underlain by the bedrock geology of Mudstone and Siltstone. Sedimentary Bedrock formed approximately 156 to 161 million years ago in the Jurassic Period. This is typical of a local environment previously dominated by shallow seas.

The bedrock is overlain by tidal flat deposits. These superficial deposits consist of clay and silt up to two million years ago during the Quaternary Period. This indicates a local environment previously dominated by shorelines⁴.

Information from Soilscales⁵ shows soils in the area are loamy and clayey and are designated as rich to moderate fertility with a naturally high water table. This high water table results in generally impeded surface water drainage to groundwater and marginal ditches.

4 http://www.uksuds.com/information/WRAP_map.pdf

5 <http://www.landis.org.uk/soilscales/>

4 Flood risk

4.1 Overview

According to the EA Flood Map for Planning, the proposed development is located exclusively within Flood Zone 3 (Figure 4-1). This indicates a 1 in 100 (1%) or greater annual probability of river flooding or a 1 in 200 (0.5%) or greater annual probability of flooding from the sea in any given year. It is not possible to interpret from the EA Flood Map if this flood risk is a result of undefended tidal or fluvial origin. The likelihood in this area is that there is an undefended flood risk from both tidal and fluvial flooding.

Holbeach is located within a fenland area; a natural low lying, flat wetland protected from regular inundation by fluvial and tidal defences.

The South Holland District Council Strategic Flood Risk Assessment (SFRA) indicates that the Wash and Rivers Welland and Nene are all lined by EA flood defences. The standard of protection (SoP) of the defences is not known. However, the EA Risk of Flooding from Rivers and Sea (RoFRaS) map (part of the National Flood Risk Assessment - NaFRA) takes these defences into account (as well as their likelihood of failing) and identifies the risk posed to the site as medium. This indicates a risk of flooding between 1 in 100 (1%) and 1 in 30 (3.33%). The SFRA indicates that defences on the Rivers Nene and Welland and those along the coast at The Wash are of Good to Fair condition.

The NaFRA mapping is shown in Figure 4-2.

Figure 4-1: Environment Agency Flood Map for Planning

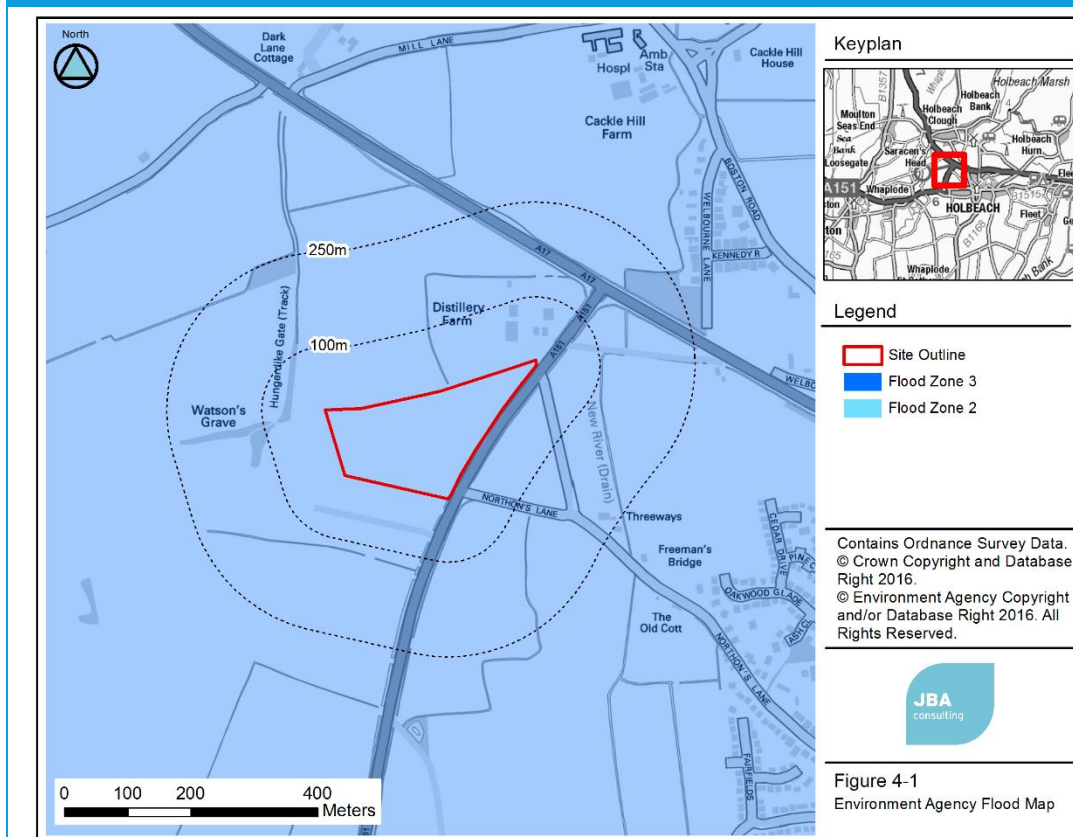


Figure 4-2: Environment Agency Risk of Flooding from Rivers and Sea

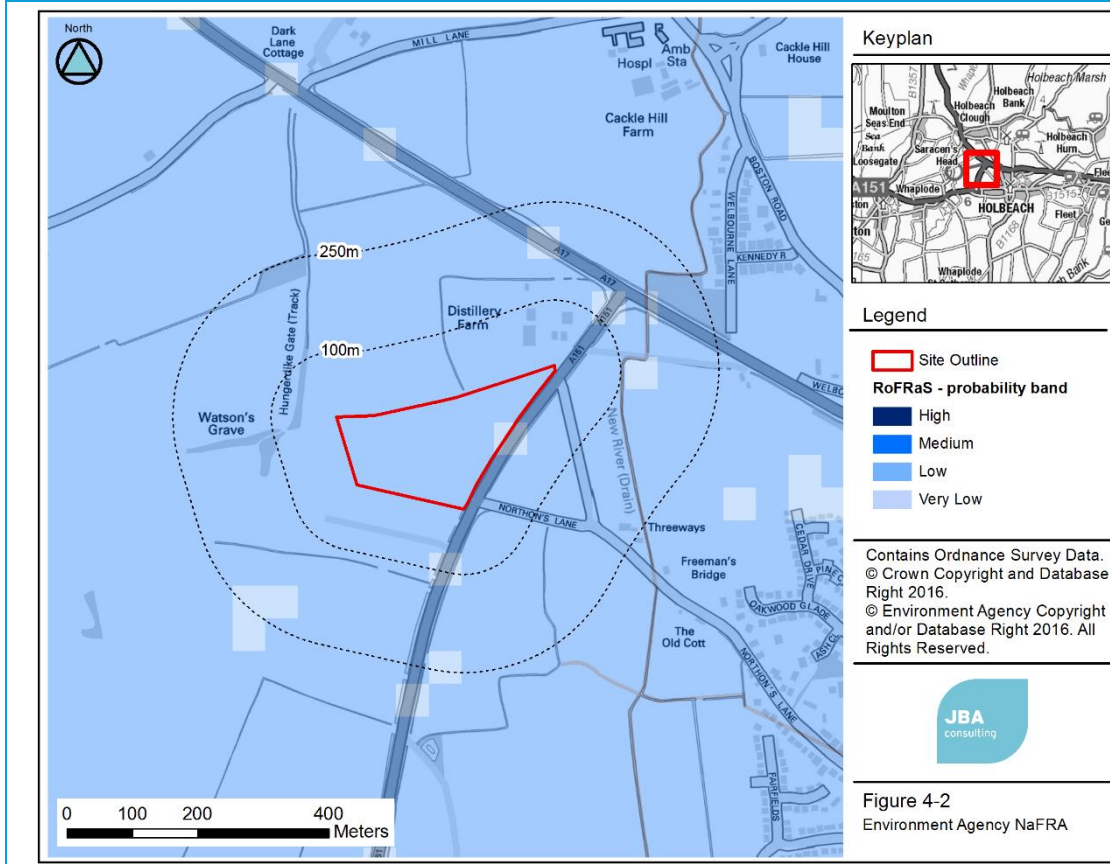


Figure 4-2
Environment Agency NaFRA

4.2 Historic flooding

The South Holland IDB are not aware of any historic flooding in this area.

4.3 Catchment Flood Management Plan

The River Welland and River Nene (catchment) flood management plans (CFMP) give a detailed overview of flood risk in each respective catchment and outline the preferred plan for sustainable flood risk management for the next 50-100 years.

The following is applicable to the site and the area surrounding the site referred to as the Fenlands (or The Fens):

"Policy option 4: Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change."

The preferred strategy therefore is to maintain and improve the existing standard of protection in order to reduce the potential implications of future predicated climate change and sea level rise.

This is further supported by the following text (River Welland CFMP, p.18):

"Historically, the Fens have been heavily managed by a number of organisations to reduce the probability of river and tidal flooding. Flood risk is expected to increase in the future to people, property and the environment. In the short term it will be feasible and effective to maintain the existing flood defences at the current level of flood risk management. However, in the future the protection given by these defences may decline as future flooding is expected to become more intense. It may be difficult to maintain the current level of flood risk management into the future for all low lying areas. Where it is technically, environmentally and economically viable, the policy is to undertake further activities to maintain the current level of flood risk management into the future."

4.4 Strategic Flood Risk Assessment

Royal Haskoning conducted an update to the South Holland District Council SFRA in January 2010.

The SFRA report and supporting mapping summarises the present and future (accounting for predicted climate change) level of flood risk and condition and standard of protection of flood defences across South Holland District.

4.4.1 Summary of strategic flood risk

In the area of Holbeach, the probability of flooding under the present day scenario is 'Low' and any residual risk (where flood defences fail) arises only if the capacity of the local IDB system is exceeded. The SFRA does not class the site as functional floodplain.

Under the 2055 and 2115 climate change scenarios the flood probability increases to 'Medium or Low'.

4.4.2 Flood defences

The SFRA also provides information on the standard of protection (SoP) and present condition of flood defences. Minimum freeboard allowances are detailed in Appendix B1 of the SFRA.

According to the SFRA, all IDBs serving developed areas in South Holland District aim to provide flood protection to the 1% annual exceedance probability (AEP) in urban areas. The South Holland IDB actively maintains only the most critical watercourses (around 25% of the total length of watercourse), in the Drainage District.

For the Wash Frontage, defences are rated as 'Good' to 'Fair'. For the secondary defences inland of the sea defences, on the landward sides of the Wash Cells, the current defence condition is unknown. Two cells in the far east of the South Holland District area (W13 and W13A) are noted to have insufficient freeboard in localised areas of the defence at the 0.5% AEP extreme tide level. This is however unlikely to pose any risk to the site at Holbeach. There are no other noted threats of defence overtopping under the present day scenario.

Under the 2115 climate change scenario, none of the Wash front line defences would have adequate freeboard to be considered secure at the 0.5% AEP event. However, the risk to the site (which is dependent on flood defences including the IDB network) is 'Low to Medium'.

4.5 Environment Agency breach scenarios

For completion of this FRA, JBA requested the EA's Product 8, specifically breach flood hazard mapping for the site at Holbeach. The supplied mapping is included as Appendix D.

According to the best available data (2006), the EA demonstrate that the site is not affected by overtopping for the present day 0.5% (1 in 200) and 0.1% (1 in 1,000) AEP events. The site is however affected by the 0.5% and 0.1% AEP events that account for projections of predicted future climate change by 2115. There are areas of the site where maximum depth could be as high as 1.5m. However, the topographic data used in the breach model at this location is likely identifying the drainage channel that runs along the eastern site boundary. Maximum modelled flood depth for the developed area of the site can therefore be interpreted to be 0.5m.

4.6 Surface water flood risk

The EA's Surface Water Flood Map shows that flooding could occur in the vicinity of and on the site. However, the annual on-site risk is classified by the EA to be from low (0.1-1%) to very low (<0.1%).

Through appropriate design of the site, flood risk from surface water flooding should be managed so that the risk to the site remains low to very low or even reduced further and potential increases surface water runoff does not impact land off site. An increased impermeable area across the site resulting from a change in land use and land cover will present opportunities for surface water flood risk (either to the site or downslope of the site) to increase. See Chapter 5 for our surface water drainage recommendations.

If further information regarding surface water flood risk is required, a copy of the Surface Water Flood Map can be obtained separately from the EA.

4.7 Summary

The best available data for the site at Holbeach indicates that the proposed development is at risk from flooding as a result of a breach in the tidal flood defences at the 0.5% and 0.1% AEP under scenarios of predicted future climate change by 2115 to a modelled depth of 0.5m. The supplied Product 8 data indicates that under the present day scenario, the site is not at risk from the equivalent AEP events. This information is taken in preference to that provided in the SFRA. The tidal defences that protect the site and surrounding area are deemed to be of 'Good' to 'Fair' condition.

The site is at low to very low risk of surface water flooding.

The local CFMPs indicate a proposed approach to sustainable flood risk management that involves maintaining and improving the existing standard of defence protection to keep pace with future climate change.

5 Surface water drainage

5.1 Existing surface water drainage

The site currently consists of agricultural grassland and there are no formal surface water drainage systems on or below the surface of the site. The site is very flat and therefore surface water will likely pond in localised depressions and drain by infiltration into the local highways drain which drains towards the north, through a culvert beneath the A151 and ultimately into the IDB network. Any surface water runoff, when the potential for infiltration is reduced by saturation (made more likely as a result of the high water table and clayey soils), will likely flow directly into the adjacent drainage channel on the eastern site boundary.

5.2 Post-development drainage arrangements

The proposed development will reduce the permeability on the site, which will result in increased runoff. In order to reduce the impact of runoff from the proposed development South Holland IDB have stipulated that discharge from the proposed development should be restricted to 1.4l/s/ha.

5.3 Impermeable surfaces

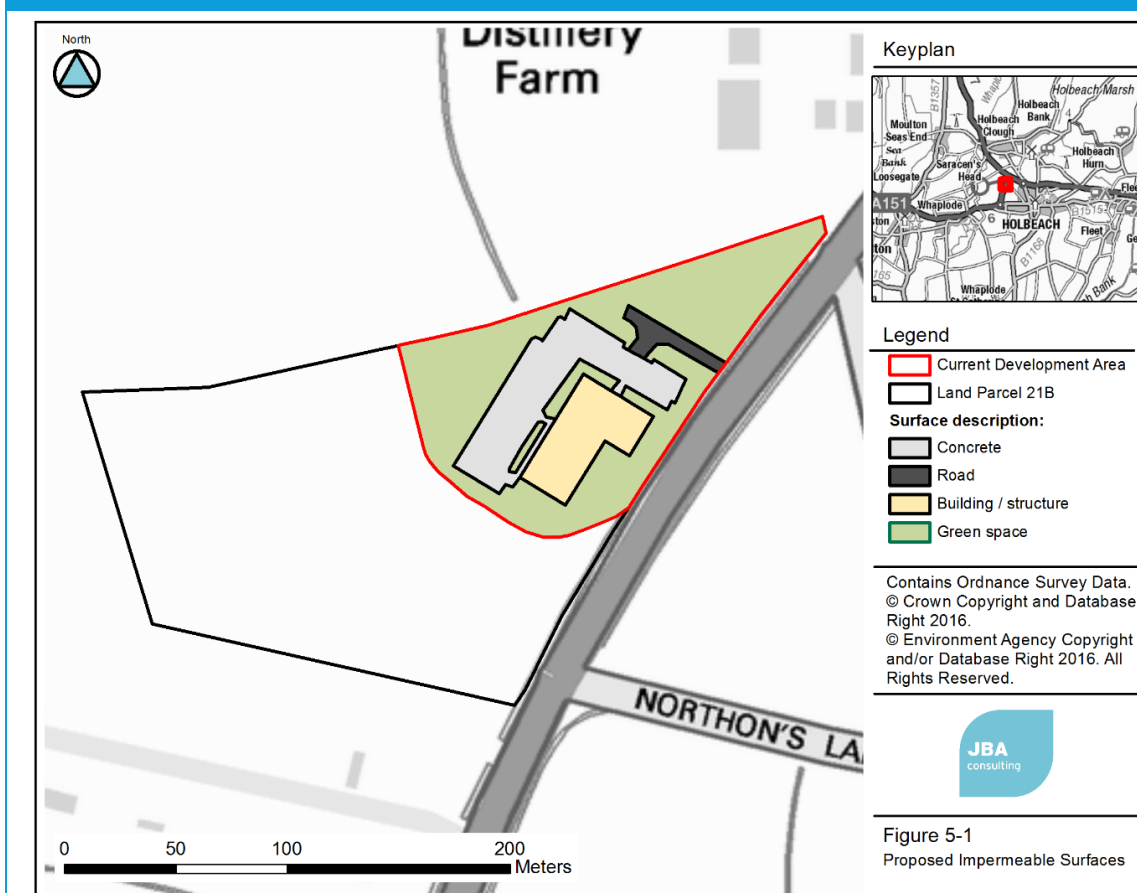
5.3.1 Existing impermeable area

The existing site is agricultural grassland and there are therefore no impermeable surfaces. Although there are a number of access points nearby which may have resulted in areas of compacted soil, it is likely not to have the same impact on surface water runoff as a man-made impermeable surface.

5.3.2 Proposed impermeable area

The impermeable areas of the proposed development have been calculated using the latest masterplan (Appendix B) and are shown in Figure 5-1.

Figure 5-1: Proposed impermeable area



Description	Area (ha)
Buildings	0.158
Impermeable surfaces (100%)	0.313
Permeable surfaces	0.852
Total	1.323

5.4 Storage requirements

5.4.1 Permissible runoff rate

The South Holland IDB have stipulated that discharge from the proposed development should be restricted to 1.4l/s/ha.

Rural Runoff Calculator was used in MicroDrainage to determine the pre-development runoff rate from the site. For a site of this size in this region of the UK:

- 1-year runoff rate 1.6 l/s
- 30-year runoff rate 4.3l/s
- 100-year runoff rate 6.4l/s

The IDB specified runoff rate is therefore in line with 1-year calculated rural runoff rate.

5.4.2 Quick storage estimate

An initial quick storage estimate (QSE) was calculated using MicroDrainage which provides a required storage volume between 279m³ and 536m³.

The calculation is based on:

- A developed area of 0.471km²
- A permissible discharge rate of 1.4l/s/ha (1.9l/s for the site)
- Rainfall depths for the 30-year and 100-year rainfall events (FEH CD-ROM Version 3.0)
- Rainfall depths increased by 40% to allow for climate change (in line with climate change allowances recommended in the NPPF) over the potential lifetime of the development.

The required storage volume is variable due to different outfall configurations that can be used to restrict discharge such as orifices and Hydrobrakes.

5.4.3 Storage volume calculation

In addition to the QSE further analyses has been undertaken using MicroDrainage to determine the runoff from the development site for the 100-year and 30-year plus climate change storm events.

As part of the calculations two outfall configurations were tested:

- Hydrobrake (designed to operate with a maximum head of 1m)
- Orifice (100mm diameter)

The calculations show that the discharge rate can be achieved using a Hydrobrake only. An orifice outfall of 100mm has been used to indicate the difficulty of draining a storage facility at the required rate by gravity alone. An orifice this size or smaller would be impractical and prone to frequent blockage.

Required storage volumes and maximum discharge rates are shown in Table 5-1.

Table 5-1: Required storage volume				
Flow control device	Return period	Storage volume (m ³)	Maximum discharge (l/s)	Critical storm duration
Hydrobrake	100 + CC (40%)	440	1.8	960 min Winter
Hydrobrake	30 + CC (40%)	307	1.8	960 min Winter
Orifice	100 + CC (40%)	274	14.2	240 min Winter
Orifice	30 + CC (40%)	189	11.5	240 min Winter

In summary, to achieve the appropriate amount of storage at the prescribed runoff rate for the 100-year storm over the lifetime of the development (i.e. with allowances for climate change), a total storage volume of 440m³ would be required with a Hydrobrake outfall.

5.5 Conceptual surface water drainage design

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

Generally, the aim should be to discharge surface water runoff based on the following hierarchy:

1. Infiltration
2. To a surface water body (e.g. local watercourse)
3. To a public surface water sewer
4. To a public combined sewer

The surface water drainage assessment has been carried out in accordance with the rainfall runoff management for developments (RRMfD) and the CIRIA SuDS Manual.

5.5.1 Consideration for infiltration drainage

No ground investigation results were available at the time of writing this report. However, soils in the area are loamy clayey with a naturally high water table⁶.

Therefore, we consider the potential for infiltration drainage at the proposed site to be limited. However, a permeability investigation may enable the discussion of infiltration drainage options.

5.5.2 Sustainable drainage systems

JBA has produced a SuDS suitability matrix. This has been supplied in Appendix E. The NPPF recommends that priority is given to the use of SuDS as part of new developments.

The current masterplan indicates an availability of green space that could be utilised for SuDS. For example, ponds or swales could be sited on open green space. This would act to store surface water prior to discharge at the prescribed rate to the adjacent drainage channel between the site and the A151.

Runoff to any SuDS scheme could also be attenuated at the source through rainwater harvesting. This could be achieved through green roof systems to slow the rate at which water drains to the SuDS scheme.

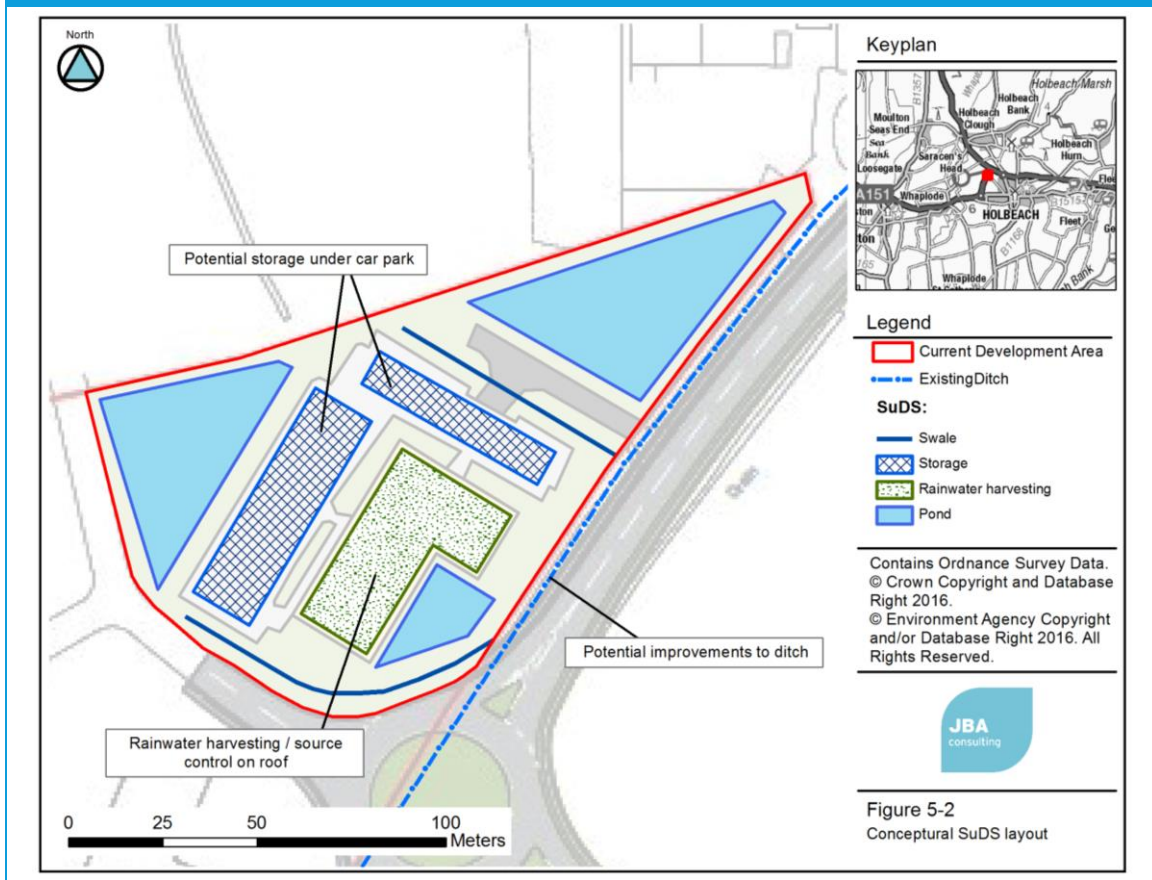
Soakaways, or similar infiltration based SuDS, could be possible at the site in the event that permeability tests indicate favourable conditions. No information was available at the time of writing. However, as indicated above, the general soil classification in this area would indicate that the potential for infiltration drainage is limited.

Therefore, it would be more appropriate to use above ground storage features such as ponds and swales. Figure 5-2 shows possible locations where ponds or swales could be located within the site. Not all, but some combination, of these features will be needed to achieve the required storage volume.

It is important to note that the adjacent existing drainage channel between the site and the A151 is in the region of 1-1.3m deep. This may not provide sufficient fall for surface based SuDS. Therefore, the watercourse may need to be enlarged to accommodate any on site surface water drainage system.

⁶ Soilscales: <http://www.landis.org.uk/soilscales/>

Figure 5-2: Conceptual Sustainable Drainage System layout



5.5.3 Underground water storage

Storage can also be provided through the use of geo-cellular crates beneath car parks.

According to Susdrain:

"Geo-cellular systems can be used to control and manage rainwater surface water runoff either as a soakaway or as a storage tank. The modular/honeycomb nature of geo-cellular systems means that they can be tailored to suit the specific requirements of any site."

However, it is important to note that these underground storage units would require an amount of cover. This is dependent on land use and the likely loading that will occur on the land above. For example, if a storage crate was to be used beneath a car park, a minimum cover of approximately 0.7m would be required. Further cover would be needed (over 1.0m) if the car parking was to be used by heavy goods vehicles. If such an approach was considered, deepening and widening of the adjacent surface water channel would be required.

5.6 Pollution

5.6.1 Environment Agency Pollution Prevention Guidelines

A range of Pollution Prevention Guidelines (PPG) have been prepared by the EA to advise industry and the public on legal responsibilities and good environmental practice. Each PPG gives advice on law and good environmental practice, to help reduce environmental risks from certain activities, the most relevant of these to the Proposed Development are:

- PPG 1 - General guide to water pollution and prevention;
- PPG 5 - Works and maintenance in or near water;
- PPG 6 - Working at construction sites;
- PPG 21 - Pollution incidence response planning; and,
- PPG 22 - Dealing with spills.

5.6.2 Site specific information

Pollution control measures for the proposed development will take into account and comply with the requirements set out in the EA's pollution prevention guidelines and sewers for adoption.

We recommend that runoff generated from the road network enter the surface water system via gullies strategically placed along the roads. Gully pots will reduce the amount of any sediment or potential pollutants entering the surface water drainage system. Alternative pollution controls such as oil filters and sediment traps are available. But if the system is to be adopted by the sewerage undertaker these should not feature on the system. Further work will be required at detailed design stage to take into account the gully spacing along the road network.

6 Development design

6.1 Introduction

This section outlines our recommendations for reducing or managing the risk of flooding to the proposed development.

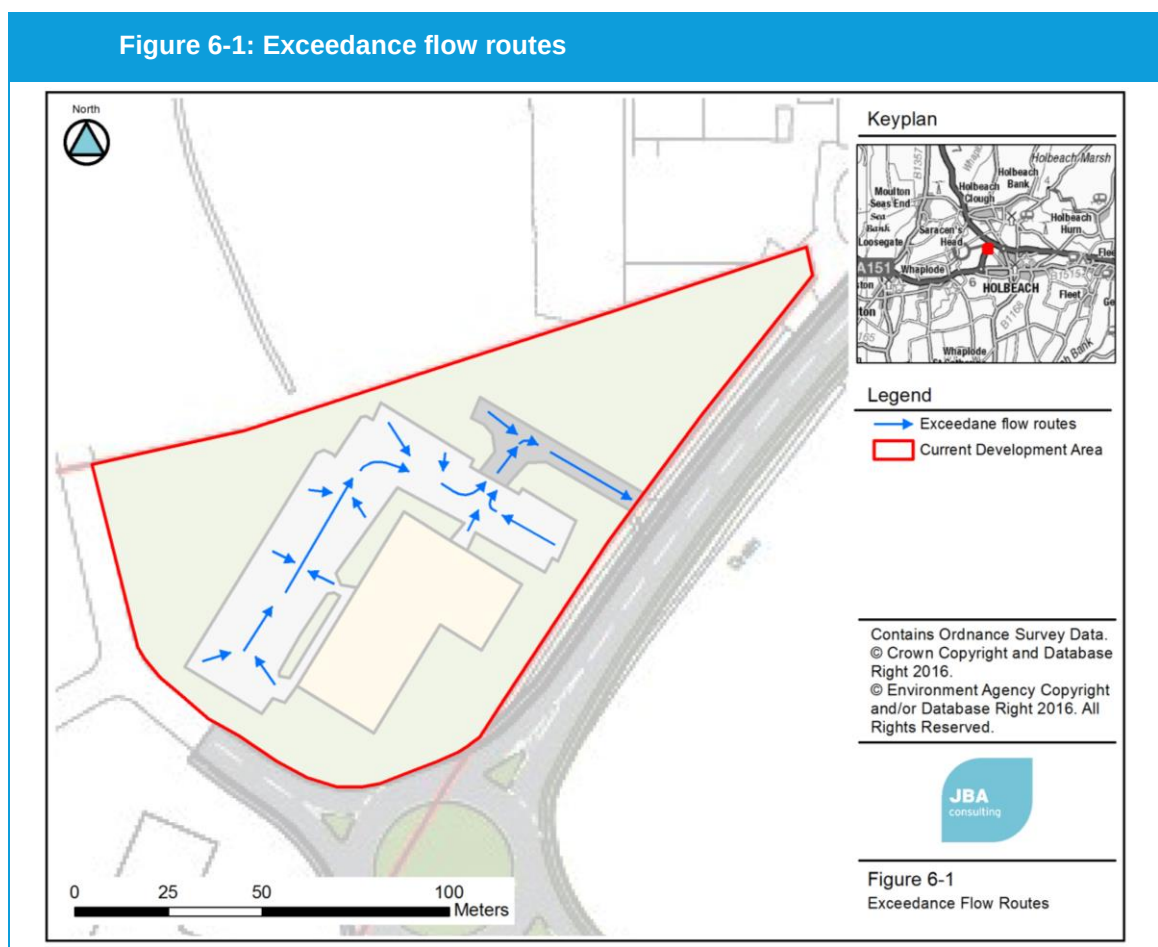
6.2 Advice for developers

The SFRA does not contain any specific advice for developers regarding development design. The NPPF stipulates that finished floor levels should be a minimum of, whichever is higher of, 300mm above the general ground level of the site or 600mm above the estimated river or sea flood level.

6.3 Exceedance of surface water drainage system

The capacity of the conceptual surface water drainage system has been calculated for a critical storm at the 100-year plus climate change return period. In the event that the capacity of the surface water drainage system is exceeded, the development should be designed to divert overland flows to adjacent drainage systems and away from the built structure. The most efficient way for surface water to be diverted is via any surface gullies on roads or carparks.

Conceptual surface water drainage overland pathways, or exceedance flow routes, are indicated in Figure 6-1.



6.4 Finished floor levels

The available flood risk information indicates a potential depth of flooding at the site, following a breach scenario with allowances for climate change, of up to 0.5m.

The minimum on-site elevation is approximately 2.6m. The NPPF would thereby stipulate a finished floor level of 3.7m (2.6 + 0.5 + 0.6). Under the current proposal, this may be impractical

and costly. However, the flood level is estimated from the breach scenario. Therefore, it may be sufficient to raise finished floor levels 300mm above surrounding ground levels and use flood resilient building techniques.

6.5 Flood resilient building design

Where it is accepted that during severe or exceptional flood events water may enter a building, consideration then must turn to flood resilient development design to ensure that the building will return to full operation shortly after the flood waters recede. This can be achieved through selection of materials with efficient drying and cleaning properties, materials that will maintain their structural integrity in the event that they become wet for a prolonged period and placement of potential vulnerable assets (e.g. electrical equipment) above the published flood level.

These flood resilience measures should be established at the detailed design stage.

According to the NPPF, for water depth up to 0.3m:

- Design your building or development to keep water out as much as possible. Do this by using materials that have low permeability (i.e. materials that water can't pass through such as impermeable concrete).

For water depth from 0.3m to 0.6m:

- Design your building or development to keep water out (unless there are structural concerns) by:
 - using materials with low permeability to at least 0.3m;
 - using flood resilient design (e.g. raised electrical sockets);
 - making sure there's access to all spaces to enable drying and cleaning.

6.6 Access and egress

Although the site is at low fluvial or tidal flood risk, the site could be affected by a breach in the tidal defences and therefore consideration must be given to safe access and egress during a flood event.

The breach modelling indicates a maximum flood depth at the site of 0.5m at a sufficient velocity which would pose 'danger to some'. The A151 north and south would be affected by a similar flood depth and velocity. Therefore, during a flood event it is likely that users of the site will experience difficulties with access and/or egress.

It is not possible, due to the nature of the potential flooding and local topography, to build raised access roads to higher ground from the development.

6.7 Environment Agency flood warning

It is advised that the building occupants sign up to the EA's flood warning system to allow early indication of any defence breach which may hinder either access or egress to the development.

6.8 Safe refuge or evacuation

In the event of flooding, safe refuge for any inhabitants should be available through designating appropriate finished floor levels or providing sufficient available space at a second storey level if the ground floor has been designed to flood.

However, within the vicinity of the site, there are areas that are shown in the EA breach modelling (with allowance for climate change) to be at very low risk. These areas include some residential areas of Holbeach to the south of the site (e.g. Wignals Gate) that lies 0.5-1.0m above the lowest site level and to the east/south east of the site where ground elevations are 1.0-2.0m higher. It may be possible with prompt flood warning and efficient procedures to evacuate occupants to local areas of higher ground that are at lower (very low) risk of breach flooding.

7 Summary

7.1 Overview

JBA was commissioned by the University of Lincoln to carry out an FRA for a proposed professional services development in Holbeach, Lincolnshire. This FRA has been prepared in accordance with the NPPF and associated PPG.

7.2 Proposed development

The proposed development is for a Centre of Excellence for Agri-Food, comprising new offices, laboratory space, a conference venue and seminar rooms with associated car parking and green space.

The whole site covers approximately 3.6ha. However only part of the site (1.3ha) is to be developed at this time. Therefore, this FRA covers the north eastern third of the site.

7.3 Flood risk

The best available data for the site at Holbeach indicates that the proposed development is at risk from flooding as a result of a breach in the tidal flood defences at the 0.5% and 0.1% AEP under scenarios of predicted future climate change by 2115 to a modelled depth of 0.5m. The supplied Product 8 data indicates that under the present day scenario, the site is not at risk from the equivalent AEP events. This information is taken in preference to that provided in the SFRA.

Climate change may present additional risk to this area of the UK. The EA propose to manage this under CFMP Policy Option 4. Specifically:

"Policy option 4: Areas of low, moderate or high flood risk where we are already managing the flood risk effectively but where we may need to take further actions to keep pace with climate change."

The site is at low to very low risk of surface water flooding.

7.4 Surface water drainage

7.4.1 Permissible runoff rate

The South Holland IDB has confirmed that the allowable discharge rate to the watercourses is 1.8l/s for the site (1.4l/s/ha).

7.4.2 Required storage volume

To achieve the appropriate amount of storage at the prescribed runoff rate for the 100-year storm over the lifetime of the development (i.e. with allowance for climate change), a total storage volume of 440m³ would be required. The permissible runoff rate is achievable only with a Hydrobrake outfall.

7.4.3 Surface water concept design.

The current masterplan indicates an availability of green space that could be utilised for SuDS. For example, ponds or swales could be sited on open green space. This would act to store surface water prior to discharge at the prescribed rate to the adjacent drainage channel between the site and the A151.

Storage can also be provided through the use of geo-cellular crates beneath car parks.

It is important to note that the adjacent existing drainage channel between the site and the A151 is in the region of 1.0-1.3m deep. This may not provide sufficient fall for surface based SuDS. Therefore, the watercourse may need to be enlarged to accommodate any on site surface water drainage system.

7.5 Development design

7.5.1 Finished floor levels

The NPPF stipulates that finished floor levels should be a minimum of whichever is higher of

- 300mm above the general ground level of the site; or,
- 600mm above the estimated river or sea flood level.

The minimum on-site elevation is approximately 2.6m. The NPPF would thereby stipulate a finished floor level of 3.7m (2.6 + 0.5 + 0.6). Under the current proposal, this may be impractical and costly. However, the flood level is estimated from the breach scenario. Therefore, it may be sufficient to raise finished floor levels 300mm above surrounding ground levels and use flood resilient building techniques.

7.5.2 Flood resilient building design

Under the current proposal, finished floor levels of 3.7m may be impractical and we would therefore suggest exploring methods of flood resilient building design.

For water depth from 0.3m to 0.6m:

- Design your building or development to keep water out (unless there are structural concerns) by:
 - using materials with low permeability to at least 0.3m;
 - using flood resilient design (e.g. raised electrical sockets);
 - making sure there's access to all spaces to enable drying and cleaning.

7.5.3 Access and egress

The breach modelling indicates a maximum flood depth at the site of 0.5m at a sufficient velocity which would pose 'danger to some'. The A151 north and south would be affected by a similar flood depth and velocity. Therefore, during a flood event it is likely that users of the site will experience difficulties with access and/or egress.

7.5.4 Environment Agency flood warning

It is advised that the building occupants sign up to the EA's flood warning system to allow early indication of any defence breach which may hinder either access or egress to the development.

7.5.5 Safe refuge or evacuation

In the event of flooding, safe refuge for any inhabitants should be available through designating appropriate finished floor levels or providing sufficient available space at a second storey level if the ground floor has been designed to flood.

However, within the vicinity of the site, there are areas that are shown in the EA breach modelling (with allowance for climate change) to be at very low risk. These areas include some residential areas of Holbeach to the south of the site (e.g. Wignals Gate) that lies 0.5-1m above the lowest site level and to the east/south east of the site where ground elevations are 1.0-2.0m higher. It may be possible with prompt flood warning and efficient procedures to evacuate occupants to local areas of higher ground that are at lower (very low) risk of breach flooding.

Appendices

A Site topographic survey

B Proposed development masterplan

C Response from South Holland Internal Drainage Board

D Environment Agency breach modelling

E JBA Urban Drainage Suitability Tool

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