NORTHSTOWE
PHASE 2 PLANNING APPLICATION

Flood Risk Assessment and Drainage Strategy

August 2014

Homes & Communities Agency

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Northstowe Phase 2

Flood Risk Assessment & Drainage Strategy

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SUMMARY

This Flood Risk Assessment (FRA) and Drainage Strategy has been prepared on behalf of Homes and Communities Agency (HCA) in support of the planning application for Phase 2 of Northstowe development.

The report assesses the risk of flooding from all sources (rivers, sea, surface water, groundwater, and artificial sources), taking account of the latest climate change predictions. A drainage strategy has been set out that provides a framework for development of both foul and surface water management systems for the Phase 2 of the development at Northstowe and ensures that the requirements of Code for Sustainable Homes are achieved.

A summary of the flood risk findings is presented in Table i below.

Table i. Flood Risk Summary

Source of flooding	Flood risk			Comments	Further investigation required?
	Low	Medium	High		
Rivers		✓		The eastern boundary of the site lies partly within Flood Zone 3 of the Beck Brook. The Cambridge Guided Bus (CGB) route embankment is above the predicted flood levels. The principal flood route from the Beck Brook into the site is likely to be as a result of flood waters backing up and entering via the culverts located along the eastern boundary. To mitigate this:- the existing culverts/pipes passing below the CGB embankment would be closed off or fitted with flap valves to prevent flows from entering the site during times of flood. Development zoning will be implemented to manage flood risk.	No- If mitigation measures are in place.
Sea	✓			-	-
Surface water		✓		To mitigate the potential for increased surface water flooding SuDS will form an integral part of the site design to ensure that post-development runoff does not exceed Greenfield runoff rates.	No- If mitigation measures are in place.
Ground water		✓		The geology of the site creates perched groundwater tables and shallow aquifers. There is the potential for SuDS to introduce new flow paths for groundwater. To mitigate this potential effect the SuDS will be designed to ensure any features do no increase the risk of groundwater flooding.	No- If mitigation measures are in place.
Artificial sources	✓			There are no significant artificial bodies of water located upslope of the site.	-

1 Introduction

1.1 Background

Hyder Consulting (UK) Ltd. (Hyder) has been commisioned by Homes & Community Agency to prepare a Flood Risk Assessment (FRA) and foul and surface water drainage strategy to support a planning application for Phase 2 of the proposed new Northstowe development near Longstanton, Cambridgeshire.

This report establishes the key principles and strategy of flood mitigation and surface water and foul drainage for the site. Any third party flood risk is considered as part of this report and mitigation measures are proposed to ensure that the Main Phase 2 development area and Southern Access Road (West) does not generate any additional risk.

In February 2012, Gallagher Estates submitted an outline planning application to South Cambridgeshire District council (SCDC) for Phase 1 which included drainage details and a flood mitigation strategy, both of which have been approved by the Environment Agency and SCDC. Since flood risk in Longstanton has been addressed by Phase 1, it will not be given further consideration as part of this report (other than to confirm that the proposed drainage strategy for Phase 1 and Phase 2 do not result in flood risk to third parties).

1.1.1 Aims

Under the National Planning Policy Framework (NPPF), all planning applications for development proposals of 1 ha or greater must be supported by an assessment of flood risk.

The aim of this report is to demonstrate that the site can be developed safely, without exposing the new development to an unacceptable degree of flood risk or increasing the flood risk to third parties. The objectives are to:

- Identify potential all sources of flooding and assess the risk they pose to the site;
- Consider the effect of predicted climate change on future flood risk to the site;
- Provide a technical assessment of fluvial flood extents, depths and hazard;
- Establish the spatial variation in fluvial flood risk across the site and identify any areas where development should be avoided;
- Assess the impact of the proposed development on flood risk to third parties;
- Set out a surface water and foul drainage strategy for the Phase 2 development and,
- Recommend appropriate mitigation measures, including indicative finished floor levels.

1.1.2 Previous studies

This report draws and builds upon information contained within the following previous reports:

- Environment Agency (February, 2003) Cottenham Lode Pre-Feasibility Study
- WSP (December 2007). Northstowe Flood Risk Assessment
- WSP (December 2007). Northstowe Water Resources, Flooding and Drainage Environmental Statement (Chapter 14)
- WSP (December 2011). Northstowe Phase 1 Flood Risk Assessment (Technical Appendix H)

- WSP (December 2011).Northstowe Phase 1 Water Conservation Strategy

The Cottenham Lode Pre-Feasibility study (2003) will be superseded by the new Lower Great Ouse Flood Model (exact date unknown but due for release 2014). The Environment Agency has confirmed the updated modelling study includes Longstanton Brook/Swavesey Drain, Beck Brook/ Cottenham Lode. This new assessment covers the Phase 2 site however the results from the assessment are not available for use in this report. Therefore, the information from the Pre-Feasibility study (2003) is the most up to date data and the outputs of the study have been used to inform fluvial flood risk to the Phase 2 site.

1.2 Planning Policy

1.2.1 The National Planning Policy Framework

The NPPF and its accompanying Practice Guidance set out Government planning policy for England. The principal aim of the NPPF is to contribute to the achievement of sustainable development. This includes ensuring that flood risk is taken into account at all stages of the planning process, avoiding inappropriate development in areas at risk of flooding and directing development away from those areas where risks are highest. Where development is necessary in areas at risk of flooding, the NPPF aims to ensure that it is safe, without increasing flood risk elsewhere.

Early adoption of and adherence to the principles set out in the NPPF and its Practice Guidance, with respect to flood risk, can ensure that detailed designs and plans for developments take due account of the importance of flood risk and the need for appropriate mitigation, if required.

1.2.2 Northstowe Area Action Plan (NAAP)

The Integrated Water Strategy for the NAAP was adopted in July 2007 and sets out the requirements for the provision of strategic flood risk management, drainage and water supply infrastructure that should be considered as part of the Northstowe development proposals. The main objectives with regards to flood risk are:

- Ensure that the development will not be at risk of flooding either from itself or surrounding watercourses, for up to the 1 in 100 year event including the forecast effects of climate change.
- Not increase the flood risk to surrounding properties and communities, particularly Oakington and Longstanton, or downstream areas.
- Mitigate current flood risk affecting Oakington and Longstanton village.

The other objectives refer to maintaining the natural catchments, maintaining the Fen-edge character of the surrounding area, ensuring a net increase of biodiversity, appropriate surface and foul systems, use of Sustainable Drainage Systems (SuDS) and water minimisation, conservation and recycling.

Policy NS/21 for land drainage sets out the requirement for the use of SuDS and the release of surface water runoff into the surrounding watercourse at Greenfield rates such that there is no risk of untreated sewage discharge or increased flood risk from treated waste water. All flood mitigation measures should make allowance for the forecast effects of climate change. If practicable, such measures will take the opportunity to mitigate the existing flood risk to Oakington and Longstanton by providing balancing ponds.

1.2.3 South Cambridge and Cambridge City SFRA

The main aim of the Strategic Flood Risk Assessment (SFRA) is to set out the flood risk constraints to help inform the preparation of the Local Development Framework (LDF). The study South Cambridge District Council and Cambridge City Council Level 1 Strategic Flood Risk Assessment (WSP, 2010) provided a detailed assessment of the extent and nature of the risk of flooding in the areas of South Cambridgeshire District which are likely to accommodate significant growth in the next plan period (through to 2016).

The SFRA assessed the flood risk associated with the watercourses in the vicinity of the site and the SFRA confirmed the Northstowe development area lies within a defended Flood Zone 1 (low risk). Although the Northstowe development area itself is not at risk the surrounding villages of Oakington and Longstanton are at risk of flooding. Mitigation will be included within the Northstowe development to ensure that the development does not increase surface water runoff and also will control runoff to benefit the surrounding catchments.

2 Proposed Development

A planning application for development of Phase 2 of Northstowe with details of appearance, landscaping, layout, scale and access reserved (save for the matters submitted in respect of the Southern Access Road (West)) comprising:

1) development of the main Phase 2 development area for up to 3,500 dwellings, two primary schools, the secondary school, the town centre including employment uses, formal and informal recreational space and landscaped areas, the eastern sports hub, the remainder of the western sports hub (to complete the provision delivered at Phase 1), the busway, a primary road to link to the southern access, construction haul route, engineering and infrastructure works; and

2) construction of a highway link (Southern Access Road (West)) between the proposed new town of Northstowe and the B1050, improvements to the B1050, and associated landscaping and drainage.

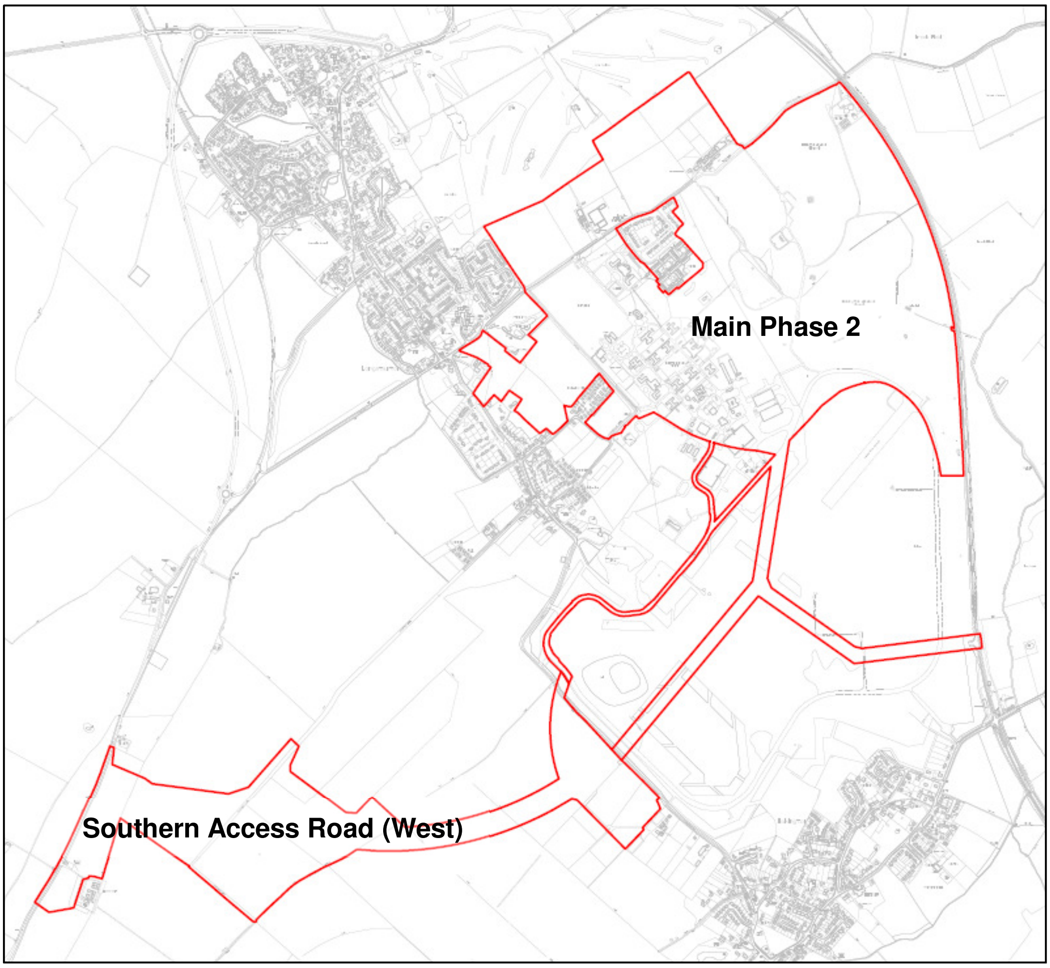

Figure 2.1 Proposed Northstowe Development

2.1 Key Development Principles

The strategies associated with the delivery of Phase 2 are part of the wider strategy for the entire Northstowe site, as defined in the development framework document. The key principals for the entire Phase 2 Scheme are detailed below.

2.1.1 Flood Risk to the Phase 2 Scheme

Section 4.4 confirms that the EA's Flood Map (2014) shows that the Application Site is predominantly located in Flood Zone 1 (low probability of flooding). The eastern fringe of the Main Phase 2 development area lies within Flood Zone 3 (high probability of flooding) of the Beck Brook/ Cottenham Lode. The western fringe of the Southern Access Road (West) lies within Flood Zone 2 (medium probability of flooding) of the Longstanton Drain/ Swavesey Drain

Work undertaken for the original approved application found that this risk to the main Phase 2 Scheme is minimal due to the presence of existing defences. Development across the site will be sequentially steered to place the lower vulnerability land uses, such as the waterparks and green open space, in the area of high risk and placing more vulnerable development, such as residential units in lower risk areas.

In addition it is also proposed to set the level of the buildings within the Phase 2 development above the estimated flood level associated with the 1 in 200 year plus climate change (30%) event as further explained in the subsequent sections. The development is therefore located in Flood Zone 1 having less than 1 in 1000 annual probability of river flooding in any year (< 0.1).

2.1.2 Flood Risk to Third Parties

Although the Northstowe development area itself is not at risk the surrounding villages of Oakington and Longstanton are at risk of flooding and have a long history of flooding. To mitigate flood risk to Longstanton; flood storage is being proposed online of Longstanton Brook, upstream of Longstanton village, which will be implemented as part of Phase 1 Development. Additional flood storage is being proposed upstream of Oakington on the Oakington Brook, which will be implemented as part of future Phase 3 Development.

Flood risk in Longstanton has been addressed by Phase 1 and will not be given further consideration as part of the this report for the Northstowe Phase 2 development (other than to confirm that the proposed drainage strategy does not result flood risk to third parties).

Flood mitigation is proposed to the catchments downstream of the main Phase 2 site by the implementation of the water park and the proposed control mechanisms. Part of the waterpark will be constructed during the Phase 1 Scheme, with the remaining waterpark being part of the Phase 2 Scheme.

3 Site Description

The application site extends to 216 hectares and comprises two parts: the main Phase 2 development area and the Southern Access Road (West), as shown on Plan 3 - Application Areas Plan. Each of the parts is described below.

3.1 Main Phase 2 Development Area

The area of the main Phase 2 development area is approximately 165 hectares. The area is bordered to the east by the route of the Cambridgeshire Guided Busway, and to the west by Longstanton. The area includes the former Oakington Barracks, which currently comprises: three buildings, with no current use; slabs remaining from demolished buildings; remaining facilities associated with the barracks including sports amenities and green space; and a water tower which is the tallest structure on the site and visible feature in the wider landscape. The area surrounds the existing settlement of Rampton Drift, comprised of 92 properties, originally built as part of the barracks complex, although this area is not included in the application. The wider main Phase 2 Development area includes areas of hardstanding and open space associated with the former airfield (much of this currently occupied by agricultural tenants), farmland including Brookfield Farm and Larksfield Farm. The area also includes a section of Rampton Road.

To the south of the main Phase 2 development area, and through which its proposed access routes run is land that is identified for future phases of development of Northstowe.

Intervening vegetation results in the site being largely screened from surrounding villages and farmsteads. There are groups of trees throughout the former Oakington Barracks including avenues of mature trees around the barracks complex and leading to the station headquarter building. There are also groups of mature trees in the western corner of the site and around Rampton Drift. These all contribute to the setting of the site and adjacent Longstanton.

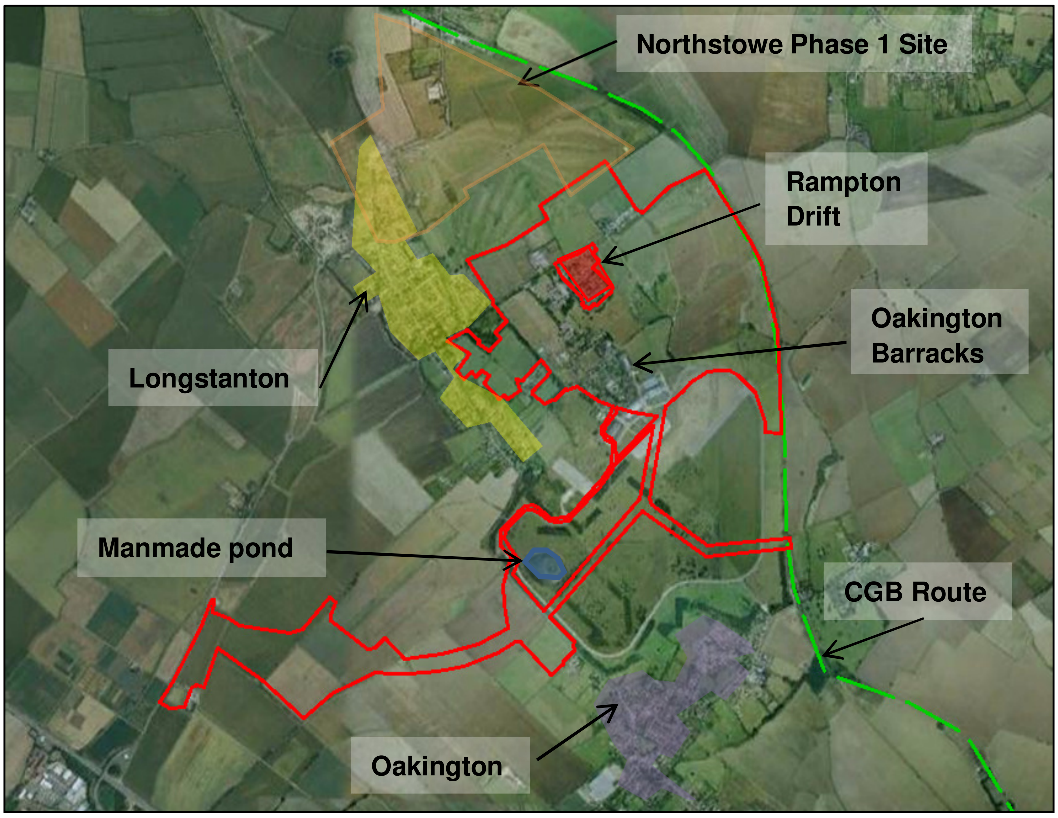

Figure 3.1 Northstowe Location Plan (the Phase 2 site is outlined in red) Aerial photograph © Google (2014); Image © Infoterra Ltd. & Bluesky

The geology underlying the Phase 2 Site consists of River Terrace Deposits, Alluvium and Clay. A large section of the site is classified as 'unproductive strata'. These are rock layers or drift deposits with low permeability that has negligible significance for water supply or river base flow. However, a section of superficial deposit within the Phase 2 site adjacent to Longstanton is classified as a Secondary A Aquifer. A Secondary A Aquifer is defined as permeable layers capable of supporting water supplies at a local rather than strategic scale.

Ground water levels were monitored as part of previous studies between 2002 and 2006. The results of the study showed that the geology of the site creates perched groundwater tables and shallow aquifers. Ground investigation revealed that the site comprises a shallow permeable stratum over an impermeable clay layer that creates a perched groundwater table and shallow aquifer. The level of the groundwater is seasonable variable with a typical range of between 0.2m – 2.0m below ground level. Owing to the topography of the site the aquifer under the site is almost self-contained and drains to the existing drainage outfalls that will be used for the development. This means that if the development has the impact of lowering the groundwater levels within the site the impacts to the surrounding area should not be significant (WSP, 2007).

3.2 Southern Access Road (West)

The area for the Southern Access Road (West) runs from the B1050 to the boundary of Northstowe, as shown on the Plan 3 – Application Areas Plan. This area currently comprises arable fields and extends to approximately 51 hectares. Wilson's Road, a public right of way crosses the area, providing a link from Longstanton towards Bar Hill.

3.3 Local watercourse network

The area surrounding the Phase 2 Site, is drained by two main catchments: Swavesey Drain/Longstanton Brook and the Beck Brook/Cottenham Lode (Figure 3.2). The Longstanton Brook drains directly to the Swavesey Drain and drains south to north to the west of the Phase 2 Site. The Beck Brook drains directly to the Cottenham Lode and drains south to north to the east of the Phase 2 site.

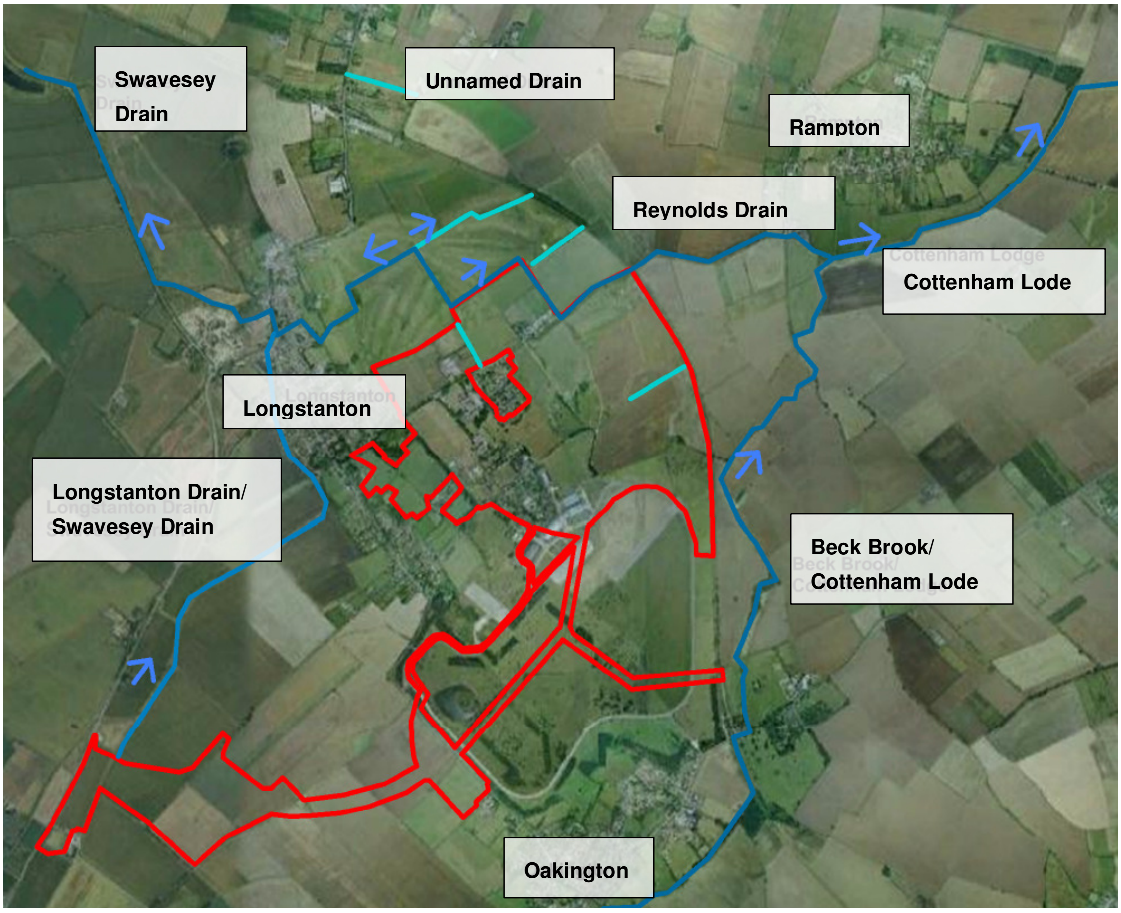

Figure 3.2 Watercourse Network (the Phase 2 site is outlined in red) Aerial photograph © Google (2014); Image © Infoterra Ltd. & Bluesky

The Reynolds Drain is connected to the Cottenham Lode via a 1050mm diameter culvert. The culvert is fitted with a flapped outfall which only opens during low flow conditions in the Cottenham Lode and flow is prevented from outfalling into the Cottenham Lode from the Reynolds drain when the water level is higher in the Cottenham Lode. When this occurs excess flows in the Reynolds Drain overflows into the Burgess Drain, which flows northwards past Rampton.

3.3.1 Main Phase 2 Development Area

The main surface water bodies in the vicinity of the Site generally flow south to north, with drainage generally west to east, linking with the primary surface water bodies. Currently the main Phase 2 Development Site drains to the receiving watercourses through existing culverts under the CGB track (disused railway line) as shown in Figure 3.2.

There are records of a number of SCDC's award drains located within the Site. Award drains are watercourses maintained by a Local Authority and not the Environment Agency or Internal Drainage Board. Award watercourses are any watercourses for which responsibility has been transferred to the Council under Enclosure Acts. However, the current extent and status of these drains are still to be clarified by SCDC and HCA as some of these Award Drains no longer exist.

3.3.2 Southern Access Road (West)

The main surface water bodies in the vicinity of the Site generally flow south to north, with drainage generally west to east, linking with the primary surface water bodies. Currently the eastern portion of the Southern Access Road drains to the Beck Brook/ Cottenham Lode through the existing culverts under the CGB track (disused railway line) as shown in. The western portion of the Site drains to the Longstanton Drain/ Swavesey Drain (Figure 3.2).

3.4 Existing Drainage Mechanism

Rainfall on the main Phase 2 Site discharges predominantly through the following mechanisms:

- Ground Infiltration - water seeps into the ground
- Surface Water Runoff – water discharges along the surface of the ground forming surface water features such as streams, rivers and ponds
- Evaporation and Transpiration – water evaporates from the surface of the ground or is taken up by plants

During large rainfall events, surface water runoff from the site will contribute to flow in the watercourses, both on site and further downstream, directly via surface water runoff and indirectly via ground infiltration.

Assessment of the hydrological conditions provides information regarding the proportion of water discharging by these mechanisms.

3.5 Other local drainage network

Anglian Water is the Sewerage Undertaker for the area. It is responsible for the existing and proposed surface and foul water sewerage systems, as well as the sewerage treatment facilities in the area. It is believed that foul effluent from Longstanton and the surrounding areas is pumped to existing sewage treatment works (STW) at Over and Uttons Drove. The Over STW discharges directly into the Great Ouse, while the Uttons Drove STW discharges into the Swavesey drain system. The Environment Agency previously raised concerns regarding the impact of effluent discharge on flood risks with the Swavesey Drain system, which have been subsequently addressed by Northstowe foul water strategy measures. It was previously reported that Longstanton had severe capacity issues and sewerage overloading and flooding was a frequent event due to failure of the main pumping stations.

There are no known existing public sewers crossing the Phase 2 site. There is one foul rising main from the old married quarters in Rampton Drift, that pump up to the Longstanton foul water pumping station and then discharges to Over STW or Uttons Drove STW.

4 Flood Risk Assessment

4.1 Planning Policy

4.1.1 The Sequential Test

The risk-based Sequential Test should be applied at all stages of planning. Its aim is to steer new development to areas at the lowest probability of flooding (Flood Zone 1).

The EA's Flood Zones are the starting point for the sequential approach. These Flood Zones (Table 4.1) refer to the probability of sea and river flooding only, ignoring the presence of existing defences.

Flood Zone	Annual Probability of Flooding (%)	Corresponding Annual Chance of Flooding (1 in x)
1. Low Probability	Fluvial and Tidal <0.1%	>1,000
2. Medium Probability	Fluvial 0.1-1.0% Tidal 0.1-0.5%	1,000-100 1,000-200
3a. High Probability	Fluvial >1.0% Tidal >0.5%	<100 <200
3b. The Functional Floodplain	Fluvial and Tidal >5.0%* *Starting point for consideration. LPAs should identify Functional Floodplain, which should not be defined solely by rigid probability parameters.	<20

Table 4.1 Summary of NPPF Flood Zones

The overall aim of decision-makers should be to steer new development to Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, decision-makers determining applications for development at any particular location should take into account the flood risk vulnerability of land uses and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required. Only where there are no reasonably available sites in Flood Zones 1 or 2 should decision-makers consider the suitability of sites in Flood Zone 3, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

The NPPF provides guidance on the suitability of each land use classification in relation to each of the Flood Zones as summarised in Table 4.2.

Flood Zone	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	Exception Test required	✓	×	×	×

Key:

✓ Development is appropriate

× Development should not be permitted

Table 4.2 Flood risk vulnerability and flood zone 'compatibility'

4.1.2 The Exception Test

This is applied where is it has not been possible to locate the required type of development in an appropriate Flood Zone.

For the Exception Test to be passed the following conditions must be met:

- It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment (SFRA) where one has been prepared.
- The development should be on previously-developed land or, if it is not on previously developed land, there should be no reasonably alternative sites on developable previously-developed land.
- An FRA must demonstrate that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

The approach is therefore a staged one:

- Categorisation of the site within the Environment Agency Flood Zones.
- Application of the Sequential Test, i.e. consideration of the site by the Local Authority to assess if the development can be relocated to an area of lower flood risk.
- Where a particular type of development cannot be relocated to an appropriate Flood Zone, the Exception Test may be required. This involves an evaluation of the site to ensure that the initial requirements of the test are met and a detailed assessment of flood risk from all sources is undertaken and an FRA is produced.

4.1.3 Flood Zone categorisation of the site

The Environment Agency flood map indicates that the majority of the Phase 2 Site is located within Flood Zone 1- classified as having a low probability of flooding.

The eastern fringe of the Phase 2 Site (within the Main Phase 2 development area) lies within Flood Zone 3 (high probability of flooding) and the western boundary of the Phase 2 Site (Southern Access Road (West)) lies within Flood Zone 2 (medium probability of flooding) (see Figure 4.2 for further details).

4.1.4 Flood risk vulnerability

All forms of development area classified in terms of vulnerability and policy within the NPPF identifies the compatible Flood Zones where types of development can be suitably located. The main Phase 2 Site is a mixed use development and the various components of the Main Phase 2 Development and Southern Access Road (West) developments are classified in Table 4.3 below.

Main Phase 2 development area Development Components	Vulnerability Classification	Flood Zone Compatibility *Exception Test Required
Residential – up to 3,000 dwellings Schools	More Vulnerable	Flood Zone 1 Flood Zone 2 Flood Zone 3a*
Local centre, including shops and community facilities Employment land Sports hubs	Less Vulnerable	Flood Zone 1 Flood Zone 2 Flood Zone 3a
Energy infrastructure	Essential Infrastructure	Flood Zone 1 Flood Zone 2 Flood Zone 3a* Flood Zone 3b*
Main Phase 2 development area Development Components		
Infrastructure	Essential Infrastructure	Flood Zone 1 Flood Zone 2 Flood Zone 3a* Flood Zone 3b*

Table 4.3 NPPF Flood Risk Vulnerability Classification

4.1.5 Sequential and Exception Tests

The Phase 2 Site is predominately located in Flood Zone 1. However, there is residual risk of flooding during the 1 in 100 year event if the local defences were to fail. The location of the site was tested as part of a Core Strategy and the Northstowe Area Action Plan (NAAP) and therefore the Phase 2 Site is deemed to have passed both the Sequential and Exception Tests.

The location of land uses within the Phase 2 site has followed a sequential approach, where new development is steered away from sources of flood risk and less vulnerable development such as the attenuation ponds and green open space areas are located towards the higher risk areas along the northern and eastern boundary of the site, which will not require the application of Exception Test.

Therefore, it is considered that the main Phase 2 site has passed the Sequential Test applied by the Local Authority and also follows the Sequential Approach principles through to the site development level as further demonstrated in the subsequent report sections.

4.2 Flood Risk Overview

In line with best practice, this section of the FRA considers flood risk from the range of possible sources listed in Table 4.4.

Source of Flooding	Description
1. Flooding from rivers (Fluvial)	Floodwater originating from a nearby watercourse when the amount of water exceeds the channel capacity of that watercourse
2. Flooding from the sea (Coastal)	High tides, storm surges and wave action, often acting in combination, flooding low-lying coastal land
3. Flooding from land (Surface Water)	Flooding caused by intense rainfall exceeding the available infiltration and/or drainage capacity of the ground
4. Flooding from groundwater	Flooding caused when groundwater levels rise above ground level following prolonged rainfall
5. Flooding from reservoirs, canals and other artificial sources	Failure of infrastructure that retains or transmits water or controls its flow

Table 4.4 Potential sources of Flooding

4.3 Historical records of flooding

Historical flood records, held by the Environment Agency, indicate that there were two recorded flood events in the vicinity of the Phase 2 site associated with the Beck Brook, one during 1978 and one during 2001 (Figure 4.1). The data below in Table 4.5 indicates the estimated return periods for the two historical events.

Date of flood	Rainfall	Return Period	Reference
05.05.1978	60mm in 24 hours	1 on 30 year (3.33% AEP)	Pearson (1979)
21.10.2001	100mm in 12 hours	1 in 200 year (0.5% AEP)	Halcrow (2003)

Table 4.5. Historical Flood Events

During both flood events the flood water was held back by the CGB route, which acted as a barrier to flows to the west and subsequently the Phase 2 site was not flooded during the events.

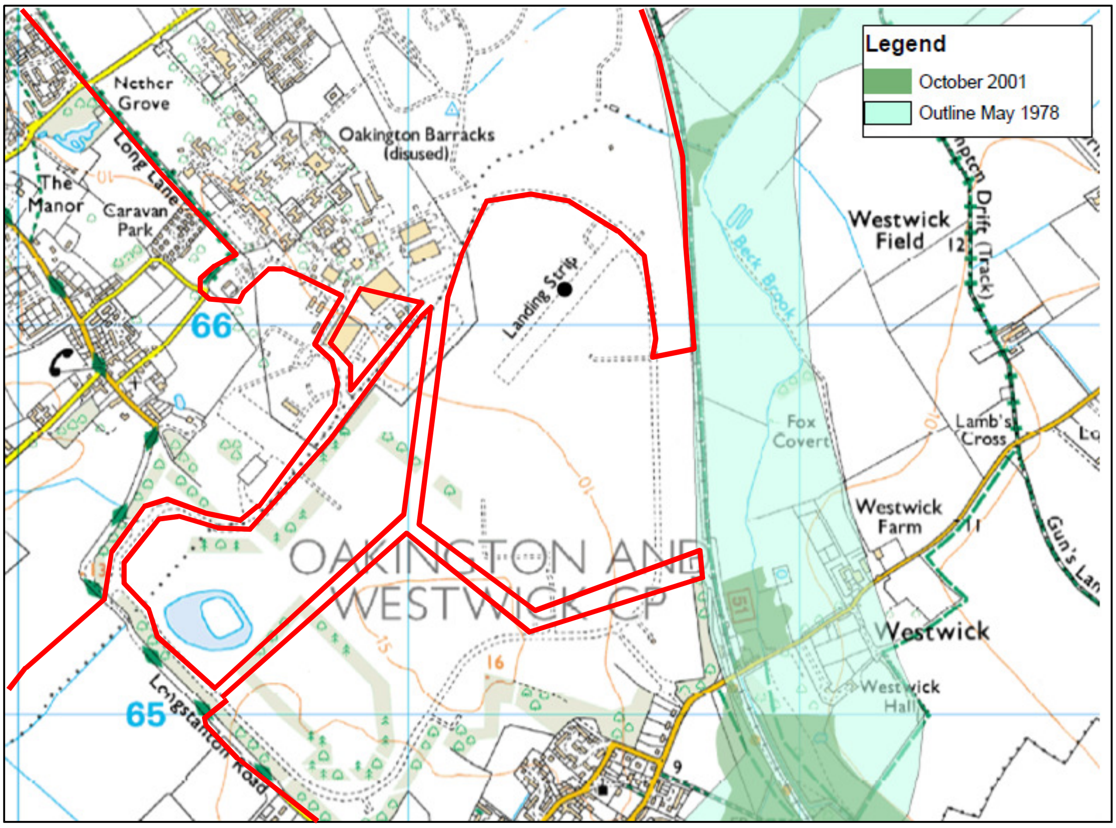

Figure 4.1. The Environment Agency's Historical Flood Map (the site is outlined in red)

4.4 Rivers

The EA's Flood Map (2014) shows that the Phase 2 area is predominantly located in Flood Zone 1 (low probability of flooding). Flood Zone 1 comprises land which has been assessed as having less than 1 in 1,000 annual probability of river (i.e. a return period of 1 in 1000 years or less frequent), ignoring the presence of flood defences.

The site's eastern fringe of Main Phase 2 Development site lies within Flood Zone 3 (high probability of flooding) of the Beck Brook/ Cottenham Lode (Figure 4.2). The areas within Flood Zone 3 are classified as areas benefiting from flood defences. This is classified as land that may benefit from the presence of major defences during a 1% (1 in 100 year) fluvial flood event. These are areas that would flood if the defence were not present, but may not flood because the defence is present.

The western boundary of the Southern Access Road (West) site is located in Flood Zone 2 (medium probability of flooding) of the Longstanton Drain/ Swavesey Drain (Figure 4.2). The areas within Flood Zone 2 are classified as land as having between a 1% – 0.1% (1 in 100 and 1 in 1,000 year) fluvial event.

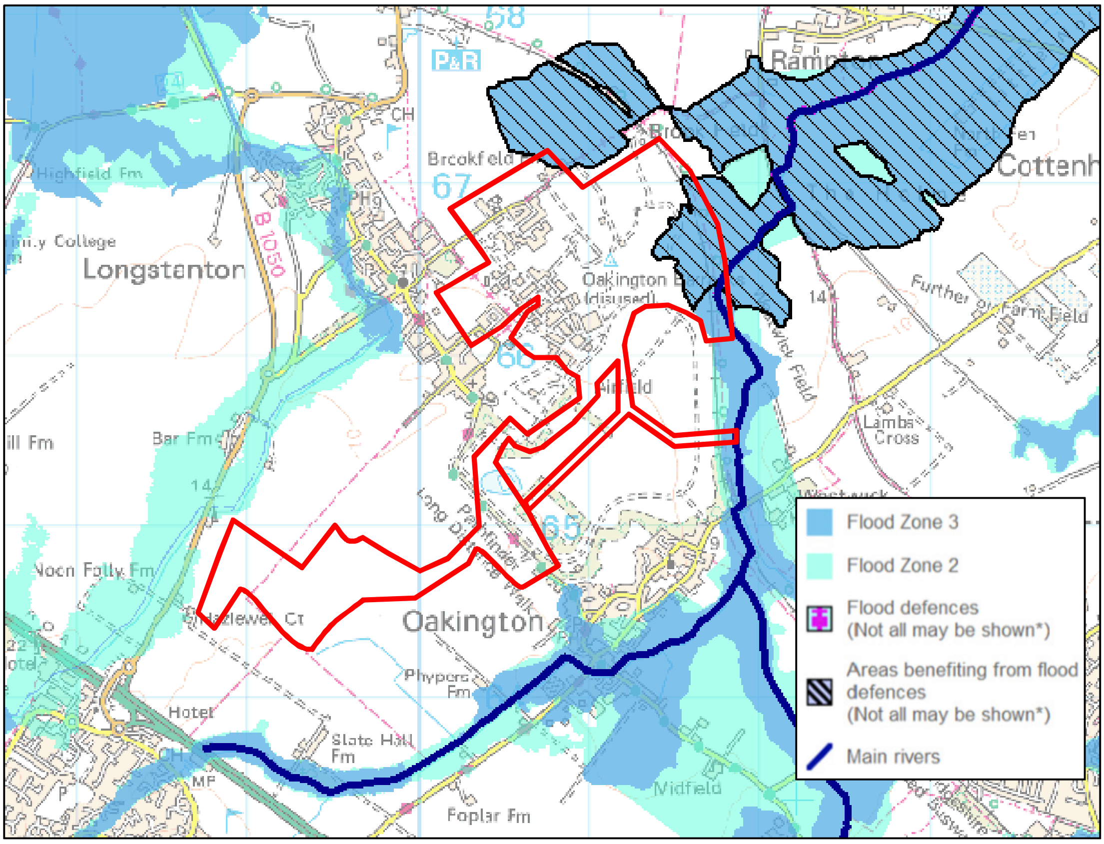

Figure 4.2. The Environment Agency's Flood Map for Planning (the site is outlined in red)

Modelling undertaken as part of the Cottenham Lode Pre-Feasibility study (2003) indicates that the crest level of the CGB route embankment is above the predicted flood levels and the principal flood route from the Beck Brook into the site is likely to be as a result of flood waters backing up and entering the Phase 2 area via the existing culverts located along the eastern boundary, under the CGB route embankment. Anecdotal evidence gathered during previous studies from the October 2001 flood event (estimated to be 1 in 200 year return period) indicates that the predicted 1 in 100 year Flood Zone 3 is conservative and could over predict the flood extents.

The mapped levels and the locations of the nodes from the Cottenham Lode Pre-Feasibility study (2003) are detailed in Table 3.3 and Figure 3.3 below.

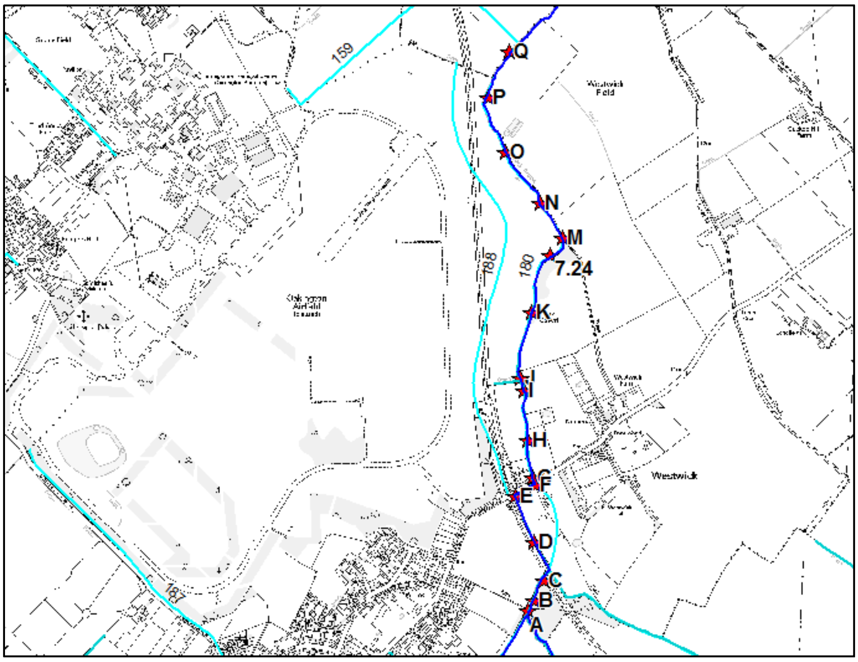

Figure 4.3. The Environment Agency Flood Node Locations

Map ID	1 in 20 year (5% AEP) level (mAOD)	1 in 100 year (1% AEP) level (mAOD)	1 in 200 year (0.5% AEP) level (mAOD)
A	7.90	8.27	8.48
B	7.88	8.20	8.36
C	7.88	8.19	8.35
D	7.87	8.14	8.26
E	7.86	8.14	8.25
F	7.78	8.05	8.05
G	7.49	7.62	7.72
H	7.38	7.52	7.58
I	7.31	7.46	7.52
J	7.15	7.32	7.4
K	7.08	7.26	7.35
L	7.05	7.24	7.33
M	7.04	7.23	7.33
N	7.01	7.22	7.31
O	7.01	7.21	7.3
P	6.98	7.19	7.28
Q	6.67	6.85	6.91

Table 4.6. Modelled Flood Levels (Environment Agency, 2003)

As shown in Figure 3.4 the CGB route forms a barrier to overland as well as fluvial flood flows and the top of the lowest section of CGB route is at a level of approximately 7.0 mAOD at the north west section in Phase 2 site. The CGB embankment crest levels are much higher south of the Phase 2 site.

The modelled flood levels applicable for the southern end of north west section of CGB embankment is approximately 6.85 mAOD (1% AEP event) and 6.91 mAOD (0.5% AEP event). In the 2007 Flood Risk Assessment undertaken by WSP the water levels applicable for the northern end of the north west section of the phase 2 site are thought to be 6.33 mAOD in a 1% AEP event. This again confirms that the CGB route forms a barrier to overland as well as fluvial flood flows reducing flood risk to the Phase 2 site.

Therefore, the topographic survey has confirmed that the level of the CGB route, along the entire eastern boundary of the Phase 2 site, is higher than the 1 in 100 year annual chance (1% AEP) and 1 in 200 year annual chance (0.5% AEP) flood levels for the Oakington Brook/ Beck Brook.

As confirmed in previous studies the main source of fluvial flooding could be as a result of flood waters backing up and entering the Phase 2 study area via the three existing culverts (Figure 4.4) located along the eastern boundary. Section 4 further discusses the proposed measures to mitigate this risk as part of Main Phase 2 Development and 2 development proposals.

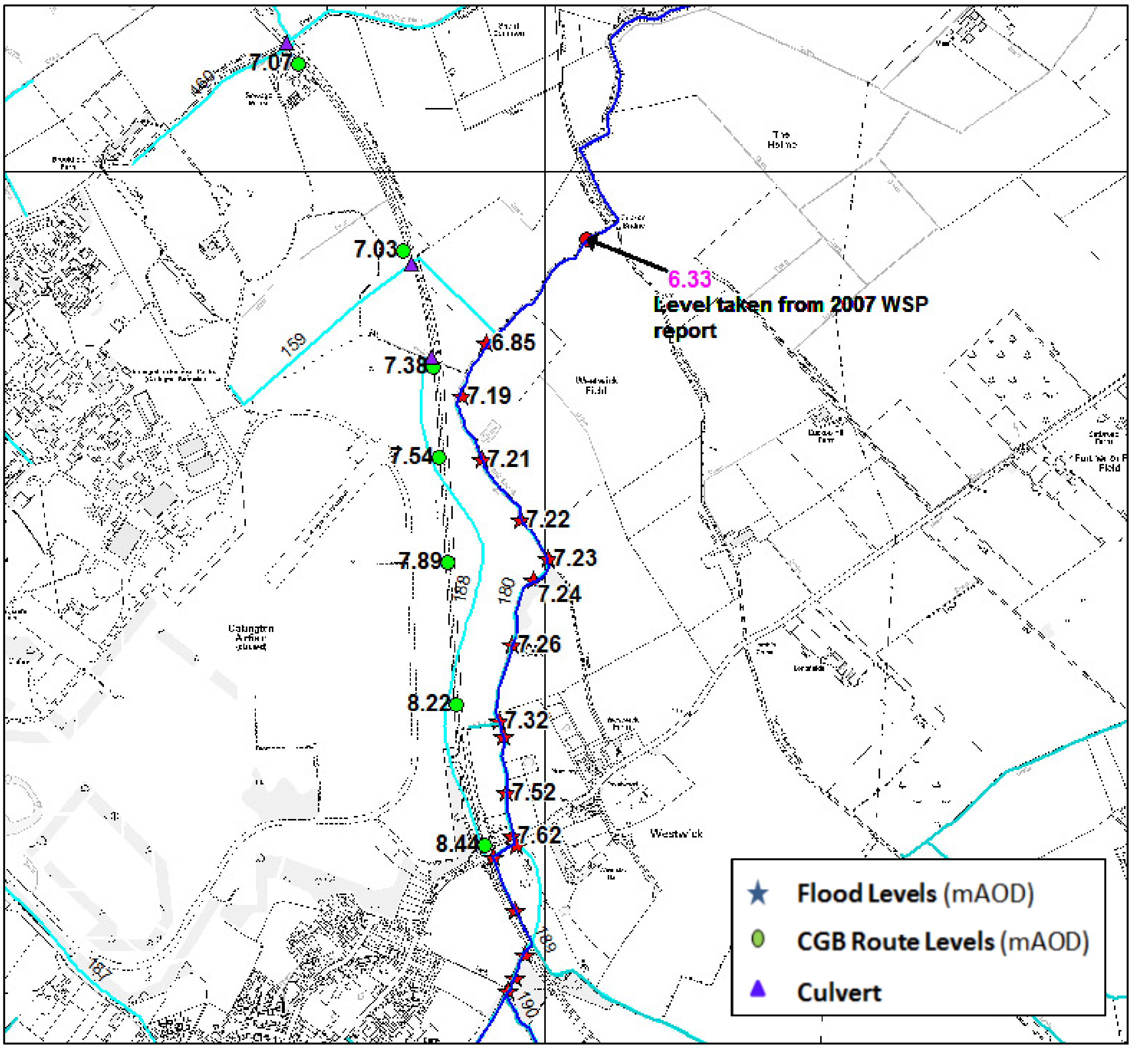

Figure 4.4- 1 in 100 year (1% AEP) Flood Levels and CGB Levels

4.5 Sea

The site is located some 100km from the coast and as such the watercourses in the vicinity of the site are not tidally influenced. Therefore the site is not at risk of flooding from the sea.

4.6 Surface water

The EA's updated Flood Map for surface water (2014) shows that the majority of the Phase 2 area is at low risk of surface water flooding (Figure 4.5). The route of surface water enters the Phase 2 site from west to east and the surface water flood extents mimics the fluvial flood extents.

Within the Main Phase 2 development area there is a surface water flow route through the area of the Oakington Barracks. The EA mapping shows that surface water flows into the site and ponds to the eastern boundary along the CGB route. The areas identified as being at the highest risk are the locations of the proposed attenuation ponds.

Within the Southern Access Road (West) there is a surface water flow path through the route of the Longstanton Drain/ Swavesey Drain. The EA mapping shows that surface water flows out of the site to the north.

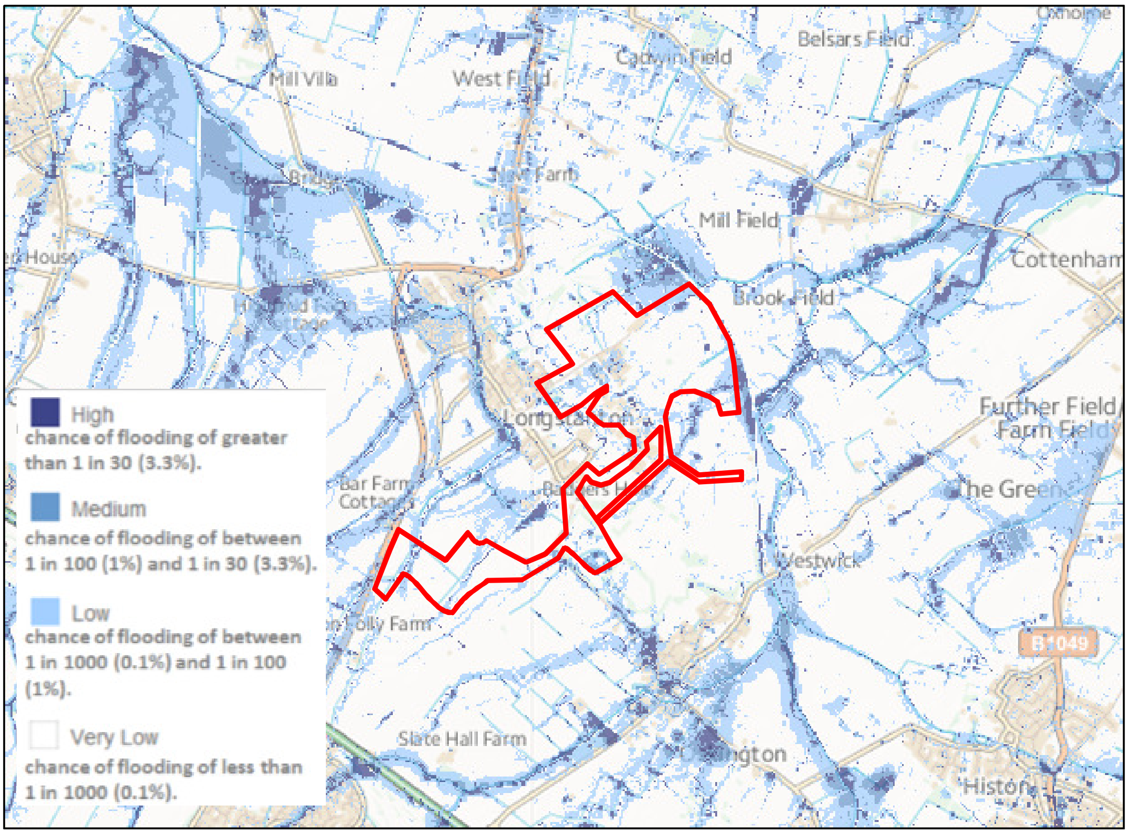

Figure 4.5. The Environment Agency's Flood Map for Planning (the site is outlined in red)

The mitigation measures to manage surface water runoff within the Phase 2 site and to ensure that the development does not increase flood risk to third parties are discussed further in Section 5.

4.7 Groundwater

Based on the Environment Agency online groundwater mapping the risk to the Phase 2 Site from groundwater flooding is considered to be low, as only a small area of the site has been classified as a secondary A aquifer. This type of aquifer has low transmissivity. In other words, it transmits a limited rate of water horizontally. It is, therefore, unlikely to have the capacity to cause significant flooding problems.

However, monitored ground water levels indicated that the level of the groundwater is seasonable variable with a typical range of between 0.2m – 2.0m below ground level. Owing to the topography of the site the aquifer under the site is almost self-contained and drains to the existing drainage outfalls that will be used for the development (WSP, 2007). Due to the potential for shallow groundwater within the site it is considered there could be a risk of groundwater flooding within the Phase 2 site. This could also impact the performance of proposed SuDS features and also have potential risk of introducing new flood flow routes through these during periods of high ground water level.

4.8 Artificial Sources

The Phase 2 Site has a low chance of flooding from artificial sources. Ordnance Survey mapping indicates there are no significant bodies of water (lakes, reservoirs, or canals), retained above natural ground level, upstream of the site. The site is not in an area at risk from reservoir flooding, as indicated on the Environment Agency Risk of Flooding from Reservoirs online map.

5 Flood Risk Mitigation

5.1 General

As highlighted in the previous sections, the eastern boundary of the Main Phase 2 development area and the western boundary of the Southern Access Road (West) are at risk of flooding from the Beck Brook and Longstanton Drain respectively, while the proposed Phase 2 Site has the potential to increase the risk of surface water flooding both on- and off-site. To mitigate these risks, and build resilience to climate change, a range of measures will be employed within the surface water drainage strategy for the scheme.

Existing site levels within the proposed development areas in Phase 2 site are generally above the flood level except in the north-east boundary with the Phase 1 site, where levels are proposed to be raised in a localised area of the Site as previously agreed with the EA, utilising material won from the construction of the strategic attenuation ponds as part of the site wide earthworks strategy (provided it is suitable) thereby retaining material on-site. Similarly all access routes to the site are outside of the EA flood zones 2 and 3. The proposed ground levels for Phase 2 site are shown on the plan contained within Appendix 4. The proposed earth works strategy ensures that the proposed ground levels are higher than the 0.5%AEP modelled fluvial flood levels with a minimum of 0.6m freeboard.

As discussed in Section 4 the CGB embankment already provides flood protection up to 0.5% AEP event and it was assumed that the current crest levels and the integrity of the existing embankment will be maintained through CCC's ongoing maintenance regime for the CGB. The main source of fluvial flooding could be as a result of flood waters backing up and entering the Phase 2 study area via the two existing culverts located along the eastern boundary. To mitigate the risk the existing culverts/pipes passing below the CGB embankment would be fitted with flap valves to prevent flows from entering the site during times of flood whilst allowing for their current land drainage function. The maintenance responsibilities for managing the proposed flap valves will be established as part of the management regime of the site drainage strategy.

The surface water drainage strategy (including residual risk management) is set out in detail in Section 6 and is based on a network incorporating the Regional Control Water Park accepting flows from Site Control SuDS measures coupled with source control drainage features. Discharges from the Water Park regional control would be restricted at the outlet pumping station to not discharge during times of flood in the Beck Brook.

5.2 Managing surface water runoff

Development could increase the volume and rate of surface water runoff, through the addition of the impermeable surfaces of buildings, roads and pavements which limit infiltration. Due to this the effective disposal of surface water from development is a material planning consideration in determining proposals for the development and use of land (CLG, 2012). In particular, storm water should be managed as close to its source as possible, mimicking Greenfield behaviour and minimising the amount of runoff transferred downstream. The following sections address how this can be achieved for the Phase 2 Site.

5.2.1 Estimation of runoff rates

The greenfield runoff rate calculations undertaken as part of Phase 2 work used the FEH statistical method and Revitalised Flood Hydrograph (ReFH) method is summarised below. The technical note included in Appendix 6 further details the hydrological calculations undertaken as part of this FRA and drainage strategy development along with a summary of the previous hydrological calculations as part of Northstowe Sustainable Water Management Strategy (WSP, 2007).

FEH Statistical Methodology

Because the statistical method is based on a much larger dataset of flood events, and has been more directly calibrated to reproduce flood frequency on UK catchments, it is recommended over any rainfall-runoff approach (Environment Agency, 2012).

Table 5.1- Greenfield Runoff Rates*- FEH Statistical Method

Return Period	Peak flow (m3/s)	l/s/ha
1 in 2	0.14	2.7
1 in 30	0.37	7.2
1 in 100	0.54	10.6

* Based on a BFIHOST value of 0.227

FEH Revitalised Flood Hydrograph (ReFH) Methodology

The ReFH method was developed to address several problems in the FEH rainfall-runoff method, which was largely unchanged from the earlier Flood Studies Report method (Environment Agency, 2012).

Table 5.2- Greenfield Runoff Rates*- FEH ReFH Method

Return Period	Peak flow (m3/s)	l/s/ha
1 in 2	0.19	3.7
1 in 30	0.42	8.2
1 in 100	0.57	11.1

* Based on a BFIHOST value of 0.227

Recommended Methodology

The calculations have followed the latest guidance (Environment Agency, 2012) and have been calculated using the statistical method. The methods used to calculate runoff rates in the 2007 study have largely been superseded and in particular the study concluded the ADAS method was not applicable to the Northstowe site. The statistical method has been selected over the ReFH method, as it represents a precautionary approach, with runoff rates that are lower than from the ReFH model, therefore requiring a more conservative drainage design. Additionally, since there is no local hydrometric data available for optimising the ReFH model, preference has been given to the statistical method. This method allows the use of data transfer from geographically, and/or hydrologically, similar gauged catchments to improve the flow frequency estimates at the subject site. Therefore it is recommended that the results of the statistical method shown in Table 4.1 are taken forward for Phase 2 drainage strategy development.

6 Surface Water Drainage Strategy

6.1 Principles

The aim of the drainage strategy is to demonstrate outline drainage proposals for the development that meet the flood risk requirements of the Environment Agency and the requirements to achieve level 4 of the Code for Sustainable Homes (CSH).

The drainage strategy is based on the submitted scheme as set out on the parameter plans, and sets out the principles in line with which design should be carried out and provides initial information regarding key drainage features, based on currently available information. At detailed design stage, further site investigations would be conducted providing additional detail of ground conditions and the findings used in conjunction with the drainage strategy to develop a detailed design.

The strategy includes proposals for a surface water drainage system based on SuDS principles, ensuring that following large rainfall events the developed site presents no greater flood risk to the surrounding area than the predevelopment site.

Residential property would be designed in accordance with the requirements of the CSH, whilst non-residential property such as schools and commercial premises will be designed in accordance with and assessed using BRE Environmental Assessment Method (BREEAM). BREEAM sets targets for flood risk depending on type of property and awards credits against the level achieved for other drainage criteria. For example, for educational establishments, credits can be achieved for the following:

- Rainwater and greywater recycling
- Use of SuDS to minimise flood risk

The non-residential property would be expected to meet very similar criteria to residential property and therefore, for the purposes of the drainage strategy, a common set of criteria based on CSH has been used.

Mandatory requirements are set out within CSH for the management of peak runoff rates and the volume of runoff, which can be met by ensuring that:

- The peak rate of runoff into watercourses is no greater for the developed site than it was for the pre-development site for rainfall events having return periods ranging between 1 and 100 years.
- The additional predicted volume of rainwater discharge caused by the new development, for a 1 in 100 year event of 6 hour duration, including an allowance for climate change, is entirely reduced using infiltration or rainwater harvesting/recycling. Where conditions make these two options infeasible, the peak discharge rate to watercourses from the entire site should be substantially reduced to a defined minimal level.

Two credits are available under CSH for the management of surface water run-off by ensuring that:

- No discharge to the watercourse occurs for rainfall depths up to 5mm.

  OR

- Agreements are established for the ownership, long term operation and maintenance of all sustainable drainage elements used.

CSH supports the drainage hierarchy which is also encouraged within other guidance documents such as the SuDS Manual and the Building Regulations, through which infiltration is to be used as far as is practicably feasible. Where it is not feasible, surface water is to be discharged in a controlled manner to nearby watercourses.

The NPPF states that an allowance for climate change should be incorporated within SuDS proposals, applied by increasing rainfall intensity within calculations. The rate recommended depends on the anticipated lifespan of the proposals in question. A value of 30% is recommended by the NPPF for the period 2085-2115, reflecting a building lifespan of 75 years and over. This would be appropriate for the majority of development being considered as residential property typically has a lifespan of 100years and commercial property of 75 years. Therefore, across the site an allowance for climate change of 30% has been made within calculations.

The drainage strategy has been designed to meet the requirements set out above and to prove that such a scheme is feasible, based on the currently available information.

6.2 Drainage Proposals

The majority of surface water runoff from the existing site discharges either to the ground water through ground infiltration or via overland flow towards the CGB track where the main off-site surface water outfalls are located. Ground infiltration is normally the most suitable method of discharging surface water runoff from a proposed development and should be used wherever feasible to mimic the existing diffuse discharge to ground. However, as discussed in section 3.1, site investigations have identified soils of impermeable nature as well as a high water table. As a result, it is considered that ground conditions are generally unsuitable for infiltration drainage and a controlled connection to a watercourse via swales, ponds and a piped network are the only viable options for this development.

The proposed Main Phase 2 Development development site falls relatively gently from west to east. As such, storage for surface water is most suited to locations in the east of the site bordering the CGB track, allowing swales, pipes and other drainage features to fall with the gradient of the land, minimising the depths of the swales, pipes, storage structures and other relevant drainage features. Suitable surface water storage areas to manage runoff from the Main Phase 2 Development site have been identified within Appendix 7.

A key principle and constraint of the drainage strategy involves a zero discharge from the site when the nearby Beck Brook and Cottenham Lode are in flood (this may be up to 48hrs). This will be achieved by constructing two new large water parks to the east of the site which will act as storage ponds holding large amounts of water in heavy rainfall. This water will gradually be released to Beck Brook at a controlled rate via a sophisticated pumping arrangement using a telemetry system. This system will monitor levels in the receiving watercourse to ensure water is only pumped out of the storage ponds at appropriate times.

In the event that water levels in the receiving watercourse off-site are too high, the telemetry system will halt any discharge from the lifting pumps so as not to release any more water from the storage ponds, until the water levels subside. The Water Park storage ponds and associated drainage have been designed to hold enough water for a 1 in 200 year event plus Climate Change. Exceedance events (i.e. those events above the design events) have also been considered to make sure that any impacts are minimised.

Resilience measures within the waterpark include the extra built-in freeboard capacity and the potential for connecting Phase 1 and Phase 2 ponds are to be connected via pipes and sluices under Rampton Road when needed. The suggested flapped outfalls under the existing culvert crossings under the CGB embankment also provide emergency overflow routes. It is worth noting that the lowest sections of CGB embankment are at least 0.5m lower than the proposed minimum ground levels within the main Phase 2 development area providing a possible exceedance flow route for very extreme events. This effectively means that the proposed buildings or road infrastructure will be unaffected during a very extreme event that may potentially overwhelm proposed pumps and all extra capacity within the waterpark or even pumps are fully taken out of action for a considerable length of time over several days. Therefore, this clearly demonstrates the robustness of the drainage proposals.

6.3 SuDS Strategy

The principles employed in the drainage strategy are to attenuate surface water discharge to within the allowable rates, whilst providing measures to improve the quality of this run off with the use of Sustainable Drainage Systems (SuDS).

SuDS are water sensitive drainage systems which mimic natural catchment processes to manage urban runoff. A “treatment train” of various SuDS is required to capture, detain, convey and discharge water from an urban environment. The treatment train concept is fundamental to designing a successful SuDS strategy.

The treatment train philosophy uses drainage techniques to systematically control the three elements of runoff: pollution, flow rates and volumes. This is achieved in three main steps: Source Control, Conveyance Control and Discharge Control (see Figure 6-1 and Figure 6-2 below). Source control is preferred to those further down the train as they lead to the prevention and control of water before it enters the proposed or existing drainage network/watercourse. All of the methods suggested are recommended controls considered for SuDS and will be utilised where practical.

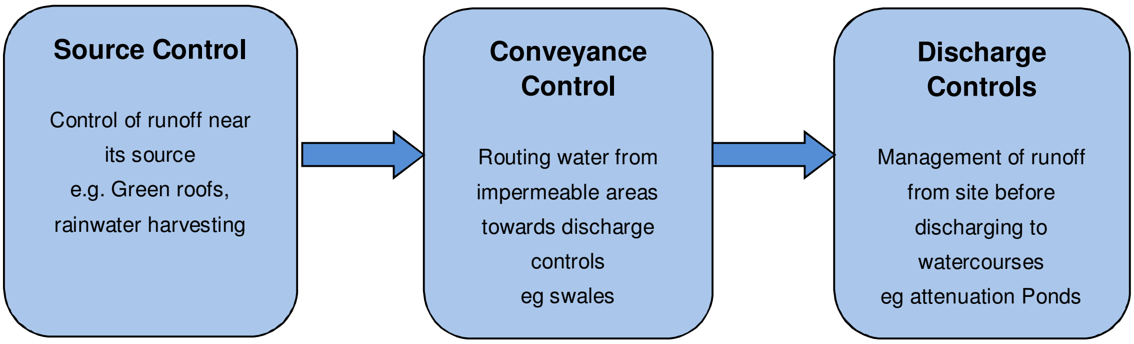

Figure 5-1 – SuDS Treatment Train

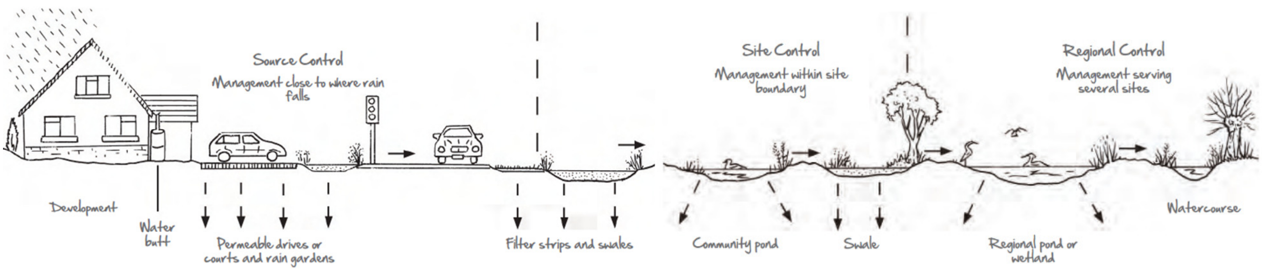

Figure 5-2 –Typical SuDS Management Train (Cambridge Design & Adoption Guide)

The proposed parameter plan layout has been used to generate appropriate treatment trains for the different types of development proposed.

Each proposed development has differing land uses and therefore different sources of runoff. The source of runoff dictates the treatment train i.e. the appropriate source, conveyance and discharge controls. The developments will connect to existing drainage networks prior to discharging from the site so it is also important to understand the location of the proposed development within the drainage catchment. It is also recognised that the soils on the site are generally not conducive to infiltration. Therefore, infiltration is not the primary focus for discharge.

The surface water drainage strategy and key overland flow paths for the Main Phase 2 Development site are illustrated in Appendix 7.

6.3.1 Controlled Discharge to Watercourse

Outfall Location and Discharge Rate

The proposed Water Parks to the east of the development have been designed to accommodate enough water for a 1 in 200 year storm event allowing 30% for climate change and zero discharge for 48 hours. The Phase 2 ponds will include a single pumped outlet to Beck Brook through the CGB embankment as shown within Appendix 7. Surface water will fill the ponds before being discharged at a controlled rate via a pumping arrangement using a telemetry system. In the event that water levels in the receiving watercourses off-site are too high, the telemetry system will halt any discharge from the lifting pumps so as not to release any more water from the storage ponds, until the water levels subside. The maximum pumped discharge rate from the ponds to the Beck Brook has been currently taken as equivalent to the Environment Agency's previously specified target greenfield rate of 3 l/s/ha to the Beck Brook. This value equals to the 1 in 2 year annual chance equivalent greenfield run off rate based on latest hydrology calculations (section 5.2.1) that uses the Environment Agency's recommended FEH Statistical Method. The total storage volume required in the Regional Control for the main Phase 2 Development site is approximately 226,000 m3.

6.3.2 Roads, Paved and Parking Areas

Adopted roads, including those within the spine infrastructure and residential areas, will utilise a number of roadside SuDS features such as swales to discharge runoff to the proposed Water Parks within the landscaped areas. SuDS features proposed are presented on drawings within Appendix 7.

Community streets, parking, driveways and other areas of paving within the individual plots will also utilise these SuDS principles and features as appropriate and practical through effective integration with landscape proposals.

Water Park (Ponds)

Following on from section 6.3.1, a Water Park has been incorporated within the SuDS network as a permanent water feature located to the east of the site bordering the CGB, located within phase 2 of the development as shown within Appendix 7. The Water Park will consist of two inter-linked ponds that will accept runoff from phase 2 and from future development in the form of future developments in the south.

The ponds are located in an area of limited ground permeability due to the impermeable nature of the sub-soils and high water table and will function primarily as a retention feature. Surface water will fill the ponds which will then be discharged at a controlled rate via a pumping arrangement. Only a single permanent pumped outlet to the Beck Brook is proposed. Stand-by pumps may not be absolutely necessary if the Phase 2 ponds are connected to Phase 1 ponds to increase resilience as discussed earlier because Phase 1 pumps can then be utilised if Phase 2 duty pump is out of action for any reason. This needs further consideration as part of detailed design and adoption discussions.

There are positive benefits in having outfall discharges controlled by pumps. These will be linked to "telemetry" systems which monitor levels in the receiving watercourse to ensure water is only pumped out of the storage ponds at appropriate times whilst ensuring zero discharge up to 48hrs when the downstream water levels are high. At present all existing discharges from the site are uncontrolled so this will represent significant flood risk improvements to the current situation. Whilst Phase 2 waterpark ponds can accommodate a maximum pumped discharge rate of 3l/s/ha as per the Environment Agency's current specified requirement (see section 6.3.1) there are considering the merits of higher discharge rates for the purpose of draining down the ponds when the downstream levels are low. Therefore, this will also need further discussion and agreement during the detailed design phase.

As permanent bodies of water, ponds offer amenity, ecological and visual benefit. Ponds encourage sedimentation and some biological treatment through vegetation, and allow development of emergent and submerged aquatic vegetation.

Swales

Following large rainfall events, swales located around the development have been designed to receive and store some of the surface water runoff generated.

Swales are proposed adjacent to roads and residential streets and will receive runoff from adjacent areas and discharges from upstream SuDS features. The swales are incorporated into the landscaping proposals and will convey run-off to the proposed water parks.

Refer to Appendix 7 for typical swales to be used in this development.

6.3.3 Property

Surface water runoff from the roofs and paved areas of residential and commercial property will be discharged via a gravity piped system to localised swales which, in turn, connect to the larger swale network before discharging to the proposed Water Park.

6.3.4 Adoption and Maintenance

Highway drainage, local and regional controls such as swales, basins and ponds, and any associated pipework and structures will be adopted.

SuDS features on site would be adopted and maintained by a variety of parties. All adopted features would be developed in consideration of the requirements of the adopting authority and with due regard to health and safety. For example, ponds would incorporate banks not steeper than 1 in 3 and maintenance strips between the structure and adjacent property and any easement required. Anglian Water have agreed to adopt the Phase 1 Water Park and associated swales network. Therefore, Anglian Water will also be approached for Phase 2 SuDS adoption along with the relevant SuDS Approving Body (SAB).

It is likely that structures within the curtilage of residential, commercial and community properties would become the responsibility of property owners or the private maintenance company proposed to manage other shared facilities on the site, with residents and occupiers paying a maintenance fee.

Where features cannot be provided close to the source of runoff, carrier drains would convey runoff between source and storage. These carrier drains would be offered for adoption by the Water Authority.

SuDS features conveying and discharging runoff from adopted highways would be offered for adoption by the Highway Authority.

6.3.5 Water Quality and Treatment Trains

To expand on section 6.3, the proposed SuDS system would be formed using a broad range of components, each having a variety of attributes and strengths which make them suitable or unsuitable for use in differing situations. The SuDS systems proposed would comprise chains of linked SuDS components which complement one another, combined to form a treatment train.

Where the major SuDS features would be unlikely to provide the required level of water quality treatment, pre-treatment methods would be used to supplement the treatment trains. Pre-treatment are components not subject to water treatment ratings within the SuDS Manual and include systems for water treatment such as bypass separators (petrol interceptors) to remove hydrocarbons, catchpits to remove sediments and vortex separators for sediment and pollutant removal.

It is important to consider the quality of runoff to be discharged when considering the treatment required. For example, relatively clean runoff from a roof would be likely to require less rigorous treatment than runoff from a road. Therefore, where it may be acceptable to treat roof runoff with SuDS features having low to moderate water quality treatment characteristics, it would be more desirable for road runoff to be treated by a SuDS feature having medium or high treatment characteristics for the appropriate contaminants.

Runoff from parking areas and roads would require some form of pollutant removal due to the presence of to remove hydrocarbons and other similar pollutants associated with motor vehicles. Treatment would be by filtration within SuDS features as it runs through vegetation and percolates through the surface stratum and via percolation through layers of filtration material such as sand within permeable paving. Bypass separators (petrol interceptors) or vortex separators could be used for discharges where space is insufficient for a suitable SuDS feature. Catchpits would be used within any piped networks to capture sediments.

The naturally high quality and unpolluted nature of runoff from roofs and paved areas is likely to require minimal treatment. Settlement of solids and pollutants and other passive mechanisms would naturally occur within storage features and could be encouraged through careful design, further improving the water quality.

It is important to also consider the treatment trains in the context of their function. Where structure perform vital SuDS functions but have comparatively low water treatment characteristics, such as detention basins providing storage, such features would be combined with complimentary features to provide suitable water treatment.

6.3.6 Overland Flowpaths

The Code for Sustainable Homes requires that the site should be designed to accommodate all runoff for events up to the 100 year rainfall event with an appropriate allowance for climate change

(30% allowance for climate change has been used). The ponds, swales and other structures discharging directly to the watercourse have been designed to ensure this criterion is met and to ensure that surface water in excess of this event is discharged safely away from property to a watercourse via overland flowpaths. Such flow paths will include the local road network in some locations and direct overflow to watercourses in others.

Individual drainage features would be designed to accommodate a variety of specific maximum rainfall events depending on the requirements of legislation, the adopting party and constraints local to the feature, typically the 10 year, 30 year or 100 year rainfall events. Therefore, where not feasible, practical or permitted to deliberately accommodate 100 year events, surface water in excess of the design event could result in overland flows. These overland flows would be directed to the regional control area along the swales forming the site control / conveyance. The regional control has been tested for 1:1000 year events to determine the possible impact, and this is shown to be outside of the developed Phase 2 site area. Refer to drawings in Appendix 7 which show the overland flow paths within the Main Phase 2 Development site.

6.3.7 Hydraulic Modelling

The required storage volume for the Phase 2 development has been assessed for use within initial spatial planning of the site. This is the volume required to be stored within the regional control.

Modelling of the storage requirement has been undertaken using industry standard software, MicroDrainage WinDES. WinDES uses the Modified Rational Method to analyse pipe networks, soakaways and other drainage features, running a suite of design storms through the system to comprehensively test a network or SuDS feature.

In developing the storage volume, it has been assumed that residential roads and properties will discharge to localised SuDS features such as swales.

Storage Volume

Following on from section 6.3.1, the storage volume has been assessed based on the 200 year rainfall event with an allowance of 30% for climate change. A variety of rainfall profiles have been tested, varying between summer and winter storms and durations between 15 minutes and 7 days. The storage volume has been calculated based on zero discharge for 48 hours.

No allowance has been included for discharge by ground infiltration although it may be possible to introduce this into the source control treatment train dependant on the final remediated ground conditions. The total storage volume would include the upstream source control, site control swales and regional (water park) control.

Analysis using WinDES estimates that a total storage volume of approximately 226,000m^3 would be required in the regional control. Calculations have been provided within Appendix 7.

6.3.8 Off Site Highways

The proposals in relation to the Southern Access Road (West) comprises the construction of a two lane dual carriageway link for a 300 metres section of the B1050 from a point 450 metres north of the A14 Bar Hill junction, joining with a new roundabout junction of the B1050 with the Southern Access Road (West). The dual carriageway will join to and continue the section of dual carriageway proposed north of the Bar Hill junction by the Highways Agency as part of the A14 Cambridge to Huntingdon Scheme.

It is proposed that surface water will be discharged via roadside ditches and 8 localised ponds where it will be stored and discharged at a controlled rate of 1 l/s/ha to the local award drains. A general arrangement drawing indicating the proposed drainage layout for Southern Access Road (West) is included Appendix 7.

Modelling of the storage requirement has been undertaken using industry standard software, MicroDrainage WinDES. WinDES uses the Modified Rational Method to analyse pipe networks.

The storage volume has been assessed based on the 200 year rainfall event with an allowance of 30% for climate change which is in line with requirements for Main Phase 2 Development. Analysis using WinDES estimates that a total storage volume required for the new attenuation ponds constructed as part of Southern Access Road (West) is approximately 6,205m^3. Calculations have been provided within Appendix 7.

7 Foul Water Drainage Strategy

7.1 Principles

This area in Cambridgeshire is served by Uttons drove Sewer Treatment Works (STW) and has been identified as a growth area in the Local Development Framework and has seen new development in recent years such as at Cambourne, with more development expected in the medium to long term such as Northstowe. The Uttons Drove sewage treatment works, which discharges into the Uttons Drove drain, was identified by Anglian Water as the treatment facility best suited for improvement in order to receive the increased effluent associated with any new development in the area. An upgrade to the watercourses between Uttons Drove and Webbs Hole Sluice together with a pumping station at Webbs Hole Sluice will be required to accommodate the increased treated outflow from the STW.

The proposed preferred foul water drainage strategy for Northstowe consists of gravity sewers draining to six lift pumping stations and two terminal pumping stations, which will form the main foul outfalls for the site. The first terminal pumping will be located within phase 1 of the development and serve the first 1500 dwellings. The second terminal pumping station will be located in phase 2 of the development and serve phase 2 as well as future developments. These terminal pumping stations will discharge effluent directly to Uttons Drove STW. The foul water drainage strategy drawing in Appendix 8 indicates the approximate proposed positions of these pumping stations. The main gravity spine sewer is to be located along the alignment of the proposed CGB route through the site from south to north.

Anglian Water have commented that due to the time overlap predicted between the two phases, it would be possible to allow some flows from the early stages of Phase 2 to be served by the Phase 1 Pumping Station. This would be a temporary arrangement and, once the Phase 2 pumping station and rising main is constructed, all Phase 2 flows will be directed through them.

The individual pumping stations will be designed in accordance with Anglian Water's requirements for storage at the detailed design stage and therefore will not pose a significant flood risk. In line with Sewers for Adoption, a typical pumping station occupies a space approximately 8m x 12m.

The layout of the foul sewer system is designed to follow the topography of the site to minimise the depth of sewers whilst minimising the number of pumping stations required. This has an added benefit on the long term operating costs for the water company.

A significant reduction in discharges would be achieved through the implementation of water efficient measures, when compared to regular developments.

The foul water drainage strategy is within Appendix 8.

7.2 Foul Loading

A breakdown of the types of property within the development have been used to assess foul water discharges. Accommodation and non-residential building schedules have been provided within Appendix 8. These figures were used to calculate the preliminary flow estimate based on the number of occupants for each dwelling, the number of end-users/floor plan area for non-residential property and typical usage rates provided by Thames Water (Thames Water Guidelines for Undertaking Sewerage Modelling (November 2005)). The peak foul water loading has been assessed as being 70/s connecting into the terminal pumping station within the Phase

2 area. This peak flow takes into account the rate of outflow for each of the pumping stations and includes an allowance for flows from Phase 3 passing through Phase 2.

The estimated rates are conservative and actual discharges from site will be reduced by use of water efficient appliances, which would offset potential increases due to retro-fitting of property with less efficient devices by home owners.

7.3 Initial Works

Due to the phased nature of the development, key elements of the foul drainage strategy, such as the terminal pumping stations and direct off site connections, would be constructed in the first phase of development as part of the spine infrastructure and phase one/two residential works.

Additionally, foul sewers would be constructed within the spine road to accommodate connections from future phases of the development. Therefore, discharges from the phase two development will be directed to the terminal pumping station within phase two and pumped to directly to Uttons Drove STW, as shown within Appendix 8.

8 Conclusions and Recommendations

This report has assessed the risk of flooding to the Northstowe Phase 2 development. The following conclusions can be drawn from the study:

- A small section of the eastern portion of the Phase 2 site is predicted to be at risk of fluvial flooding from the Beck Brook. Work undertaken for the original approved application and this FRA found that this risk is minimal due to the presence of existing defences proposed additional flood mitigation measures such as ground raising and flapped existing outfalls under CGB embankment. Development across the site will be sequentially steered to place the lower vulnerability land uses, such as the waterparks, in the area of high risk and placing more vulnerable development, such as residential units in lower risk areas.
- The modelling results show that the CGB route embankment is above the predicted flood levels. The main source of fluvial flooding could be as a result of flood waters backing up and entering the Phase 2 study area via the two existing culverts located along the eastern boundary. To mitigate the risk the existing culverts/pipes passing below the CGB embankment would be fitted with flap valves to prevent flows from entering the site during times of flood.
- The main Phase 2 development is located in Flood Zone 1 having less than 1 in 1000 annual probability of river flooding in any year (< 0.1) according to the Environment Agency's flood map. It is also proposed to set the level of the buildings within the development above the flood level associated with the 1 in 100 year plus climate change (20%) event ensuring a minimum freeboard of 0.6m.
- Although the Northstowe development area itself is not at risk the surrounding villages of Oakington and Longstanton are at risk of flooding and have a long history of flooding. Flood mitigation will be proposed to the catchments downstream of the Phase 2 site by the implementation of the water park and the proposed SuDS and flow control mechanisms. In the event that water levels in the receiving watercourse off-site are too high, the telemetry system will halt any discharge from the lifting pumps so as not to release any more water from the storage ponds, until the water levels subside. The Water Park storage ponds and associated drainage have been designed to hold enough water and extra freeboard capacity for a 1 in 200 year annual chance event plus climate change with zero discharge for 48hrs. The proposed design ensures that the buildings within Phase 2 site are not impacted from flooding from water park even for a 1 in 1000 year annual chance event.
- The proposed development has the potential to increase the risk of surface water flooding, both on- and off-site, through the expansion of impermeable surfaces. However, SuDS will form an integral part of the site design to manage and control runoff, and meet the requirements for surface water drainage.
- There is the potential for SuDS to introduce new flow paths for groundwater. To mitigate this potential effect the SuDS will be designed to ensure any features do no increase the risk of groundwater flooding.
- In summary, this report demonstrates that the site can be developed safely, without exposing the new development to an unacceptable degree of flood risk or increasing the flood risk to third parties. In addition the development should reduce flood risk and provide a benefit to the surrounding area due to the onsite storage provided.

A robust drainage strategy is also set out that provides a framework for development of both foul and surface water management systems for Phase 2 of the development at Northstowe and ensures that the requirements of Code for Sustainable Homes are achieved.

In summary:

- Ground conditions indicate an existing rainfall discharge mechanism based on ground infiltration, with relatively low surface runoff rates (see Section 4);
- A SuDS network is proposed comprising a variety of SuDS features such as swales, ponds and permeable paving, mitigating flood risk, protecting the supply to local aquifers and providing valuable habitat and amenity areas (see Section 5);
- Peak discharges to watercourses would not exceed the current greenfield rate;
- The SuDS network proposed utilises source control, site controls based on enhanced swales and a regional control water park (see Sections 5);
- SuDS features and Regional control have been designed to accommodate 200 year events, including a 30% allowance for climate change;
- SuDS treatment trains are proposed which provide appropriate treatment of runoff (see Section 5);
- Overland flow paths for exceedance have been considered as these rainfall events (beyond normal design consideration) are likely to exceed the capacity of the SuDS network. The site will be developed to ensure that such flows are directed away from property onsite to safely discharge to watercourses;
- Foul water is to be discharged offsite through a local piped system which connects to the proposed offsite rising main (see Section 6);

The widespread use of Sustainable Drainage Systems and water efficiency measures will provide sustainable storm water management and create a sustainable resource from rainfall, whilst ensuring that flood risk is reduced for areas downstream and benefitting the local area. Attenuation features will ensure that discharge rates to watercourses are reduced during large rainfall events to far below existing rates, offsetting historical development within the area which would have increased surface water discharge rates to the local watercourses and consequently increased flood risk.

The use of SuDS will contribute to the Green Infrastructure with new wildlife spaces incorporating wetlands, ponds and a variety of vegetation, creating valuable open amenity areas whilst enhancing the local water environment.

The development will promote excellent water quality standards, enhancing the local environmental water quality where possible and improving the flow regime of the watercourses within the site. SuDS would be used to remove any polluted runoff from diffuse sources providing at source treatment prior to discharge into watercourses.

Appendix 1

Site Location Plan

A0

LEGEND

PHASE 2 APPLICATION BOUNDARY

Issue	Date	By	Chkd	Appd
A	22.08.2014	BC	NW	MS

DESIGN TEAM:

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Client
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Job Title
NORTHSTOWE
PHASE 2 PLANNING APPLICATION

Drawing Title
SITE LOCATION PLAN

Scale 1:10,000 @ A0

Discipline URBAN DESIGN

Drawing Status
FOR PLANNING

Job No	Drawing No	Issue
230781-21	**PLAN 1**	**A**