



UNIVERSAL DESTINATIONS & EXPERIENCES UK PROJECT

Former Kempston Hardwick Brickworks
and adjoining land, Bedford

Environmental Statement Volume 3

Appendix 12.1 - Flood Risk Assessment

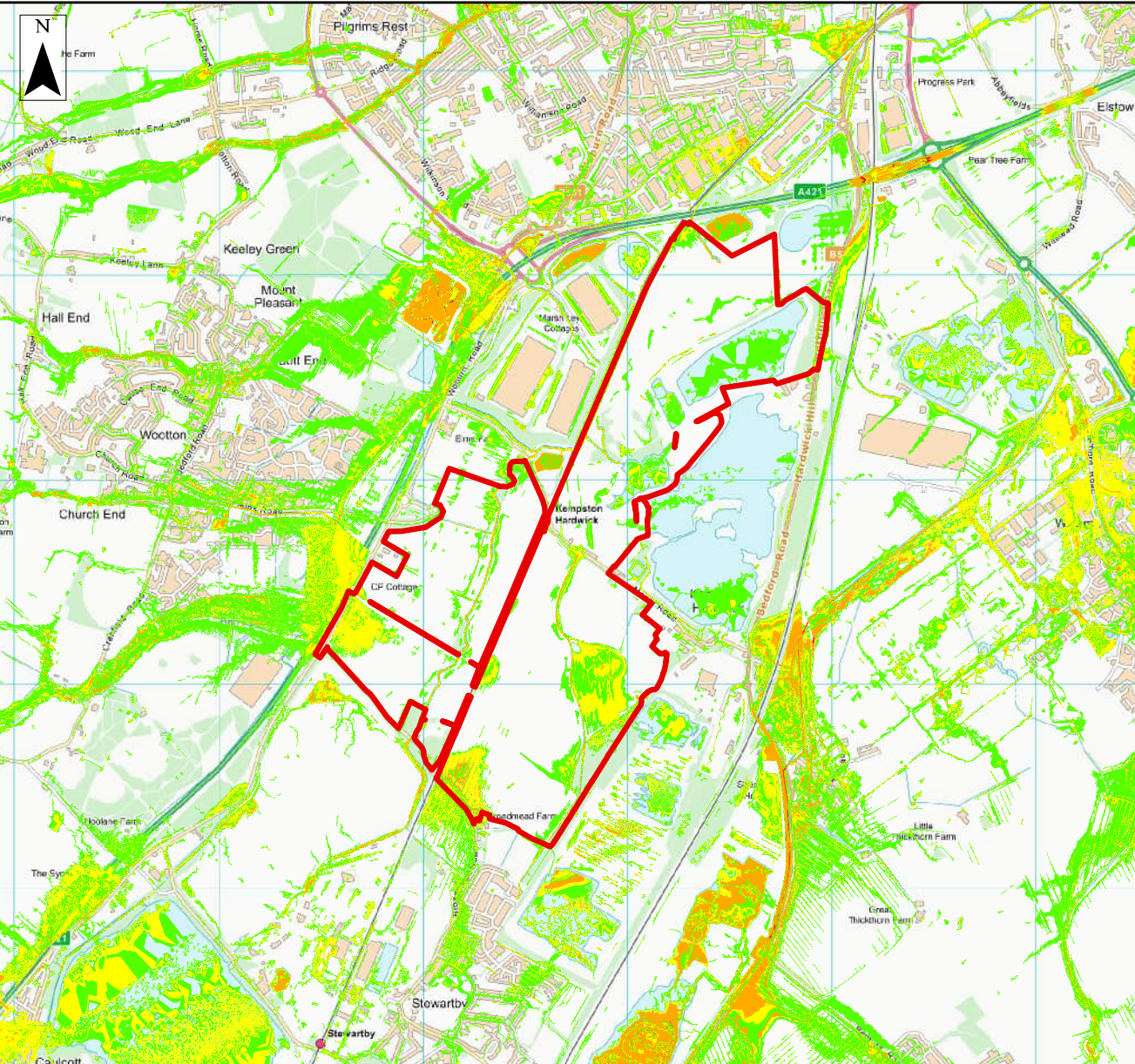
Part 5/6

Report reference: 4.12.1.0

Revision number: 00

Date: June 2025





Bedford Borough Council Level 2 Strategic Flood Risk Assessment

Legend

To use: Click on check box to turn a layer on/off

Fluvial Flood Zones

- ☐ Indicative Flood Zone 3b
- ☐ Flood Zone 3b
- ☐ Flood Zone 3a
- ☐ Flood Zone 2

* Indicative Flood Zone 3b is the Functional Floodplain-land where water can flow or be stored during a flood event.

Fluvial Climate Change Extent (Modelled)

- ☐ 1% AEP plus Central
- ☐ 1% AEP plus Higher Central
- ☐ 1% AEP plus Upper End

Historic

- ☐ Historic Flood Map

Susceptibility to Groundwater Flooding (EA)

- ☐ < 25%
- ☐ >= 25% < 50%
- ☐ >= 50% < 75%
- ☐ >= 75%

Risk of Flooding from Surface Water (EA)

- ☐ 3.3% AEP Extent
- ☐ 1% AEP Extent
- ☐ 0.1% AEP Extent

Flood Defences

- ☐ Bridge Abutment
- ☐ Demountable Defence
- ☐ Embankment
- ☐ Flood Gate
- ☐ High Ground
- ☐ Wall

Risk of Flooding from Rivers and Sea (EA)

- ☐ Very Low
- ☐ Low
- ☐ Medium
- ☐ High

Surface Water Depth (m)

- ☐ 3.3% AEP
- ☐ 1% AEP
- ☐ 0.1% AEP
- ☐ 0.00 - 0.15
- ☐ 0.15 - 0.30
- ☐ 0.30 - 0.60
- ☐ 0.60 - 0.90
- ☐ 0.90 - 1.20
- ☐ > 1.20

Surface Water Depth plus Climate Change Allowances (m)

- ☐ 1% AEP Event (+20%) CC
- ☐ 1% AEP Event (+40%) CC
- ☐ 0.0 - 0.3
- ☐ 0.3 - 0.6
- ☐ 0.6 - 1.1
- ☐ 1.1 - 1.8
- ☐ 1.8 - 4.8

Surface Water Velocity (m/s)

- ☐ 3.3% AEP
- ☐ 1% AEP
- ☐ 0.1% AEP
- ☐ 0.00 - 0.25
- ☐ 0.25 - 0.50
- ☐ 0.50 - 1.00
- ☐ 1.00 - 2.00
- ☐ > 2.00

Surface Water Velocity plus Climate Change Allowances (m/s)

- ☐ 1% AEP Event (+20%) CC
- ☐ 1% AEP Event (+40%) CC

0 - 0.2

0.2 - 0.5

0.5 - 0.8

0.8 - 1.4

1.4 - 6.8

Surface Water Hazard

- ☒ 3.3% AEP
- ☒ 1% AEP
- ☒ 0.1% AEP

Caution

Danger for Some

Danger for Most

Danger for All

Surface Water Hazard plus Climate Change Allowances

1% AEP Event (+20%) CC

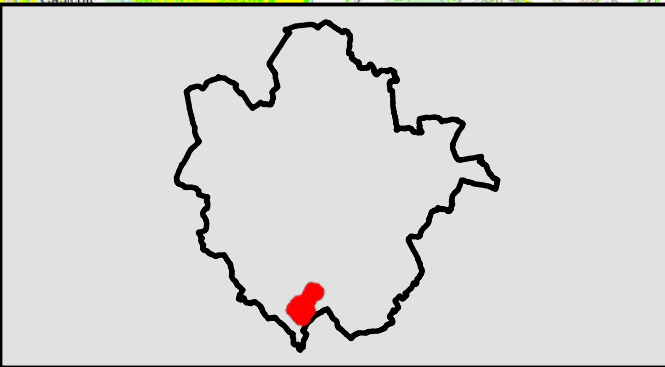
1% AEP Event (+40%) CC

Caution

Danger for Some

Danger for Most

Danger for All



0 0.3 0.6 km

Authority Information

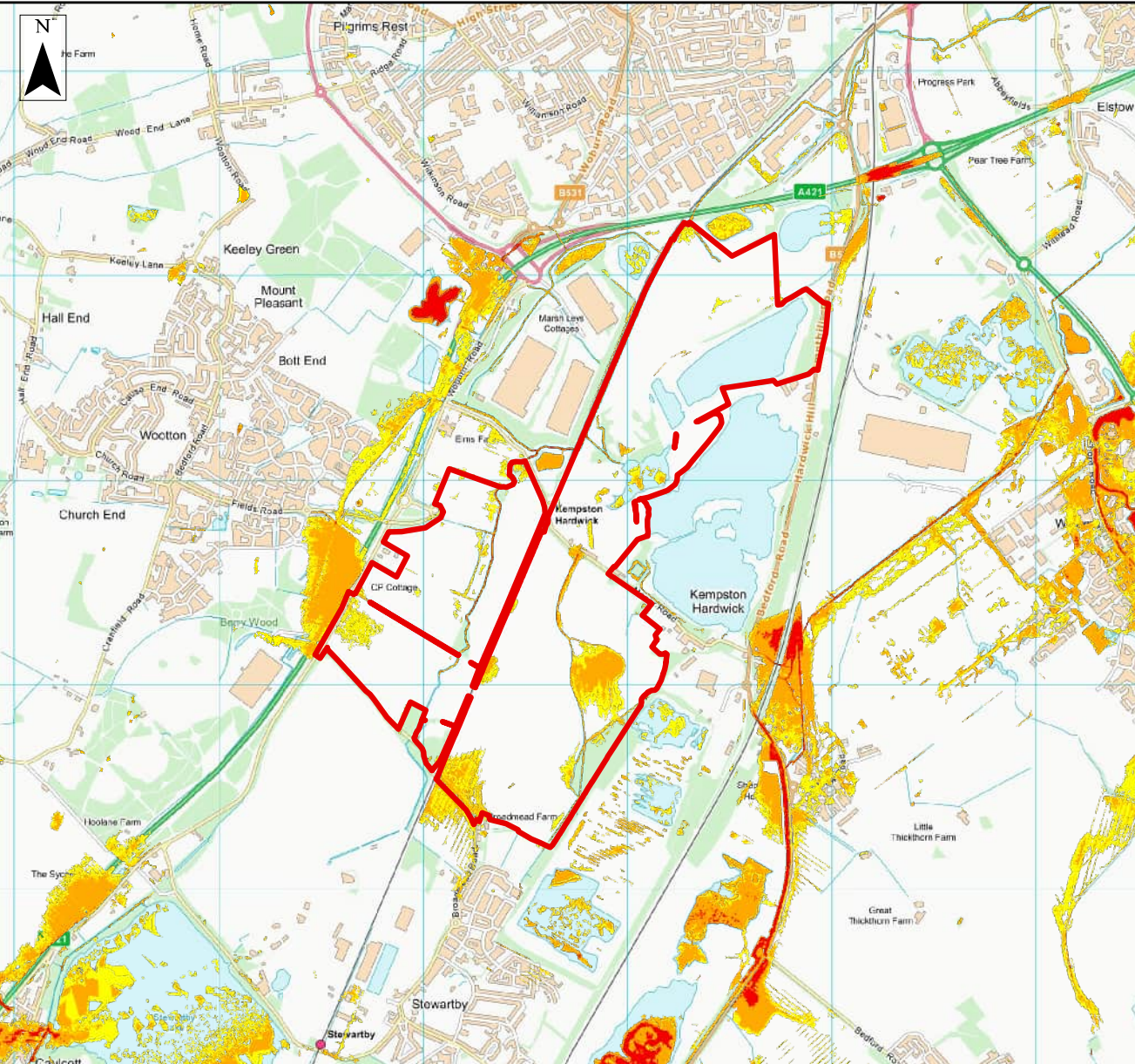
- ☐ Authority Boundary
- ☐ Site Boundary
- ☐ Watercourses

EA Flood Alert and Warning Areas

- ☐ Flood Warning
- ☐ Flood Alert

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Legend

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Fluvial Flood Zones

-   Indicative Flood Zone 3b
  Flood Zone 3b
  Flood Zone 3a
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☐ 1% AEP plus Higher Central
☐ 1% AEP plus Upper End

Historic

-   Historic Flood Map


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- ☐  < 25%
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 >= 50% < 75%
 >= 75%

Risk of Flooding from Surface Water (EA)

- ☐ 3.3% AEP Extent
☐ 1% AEP Extent
☐ 0.1% AEP Extent

Flood Defences

-  Bridge Abutment
-  Demountable Defence
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-  Flood Gate
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-  Wall

Risk of Flooding from Rivers and Sea (EA)

-

Surface Water Depth
(m)

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 0.00 - 0.15
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Surface Water Velocity
plus Climate Change
Allowances (m/s)

- ☐ 1% AEP Event (+20%) CC
- ☐ 1% AEP Event (+40%) CC




Surface Water Hazard

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- ☐ 1% AEP
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☐ 1% AEP Event (+40%) CC
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 0.3 - 0.6
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 1.1 - 1.8
 1.8 - 4.8

Surface Water Hazard
plus Climate Change
Allowances

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- ☒ 1% AEP Event (+40%) CC
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-  Danger for Some
-  Danger for Most
-  Danger for All

Surface Water Velocity
(m/s)

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☐ 1% AEP
☐ 0.1% AEP
- 0.00 - 0.25
 0.25 - 0.50
 0.50 - 1.00
 1.00 - 2.00
 > 2.00

Authority Information

-  Authority Boundary
 Site Boundary
 Watercourses

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- ☐  Flood Warning
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Bedford Borough Council Level 2 Strategic Flood Risk Assessment

Legend

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- ☐ 0.15 - 0.30
- ☐ 0.30 - 0.60
- ☐ 0.60 - 0.90
- ☐ 0.90 - 1.20
- ☐ > 1.20

Surface Water Depth plus Climate Change Allowances (m)

- ☐ 1% AEP Event (+20%) CC
- ☐ 1% AEP Event (+40%) CC
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- ☐ 0.25 - 0.50
- ☐ 0.50 - 1.00
- ☐ 1.00 - 2.00
- ☐ > 2.00

Surface Water Velocity plus Climate Change Allowances (m/s)

- ☐ 1% AEP Event (+20%) CC
- ☐ 1% AEP Event (+40%) CC
- ☐ 0 - 0.2
- ☐ 0.2 - 0.5
- ☐ 0.5 - 0.8
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- ☐ 1.4 - 6.8

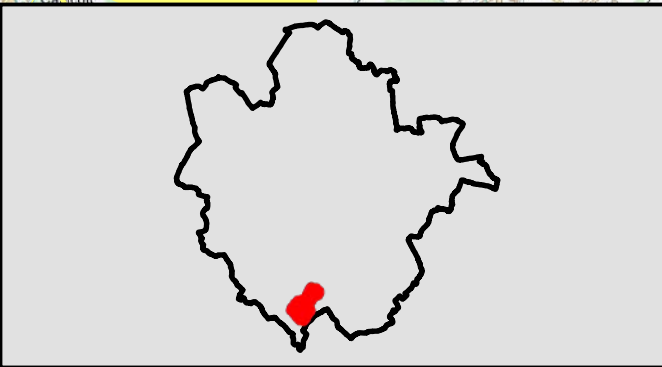
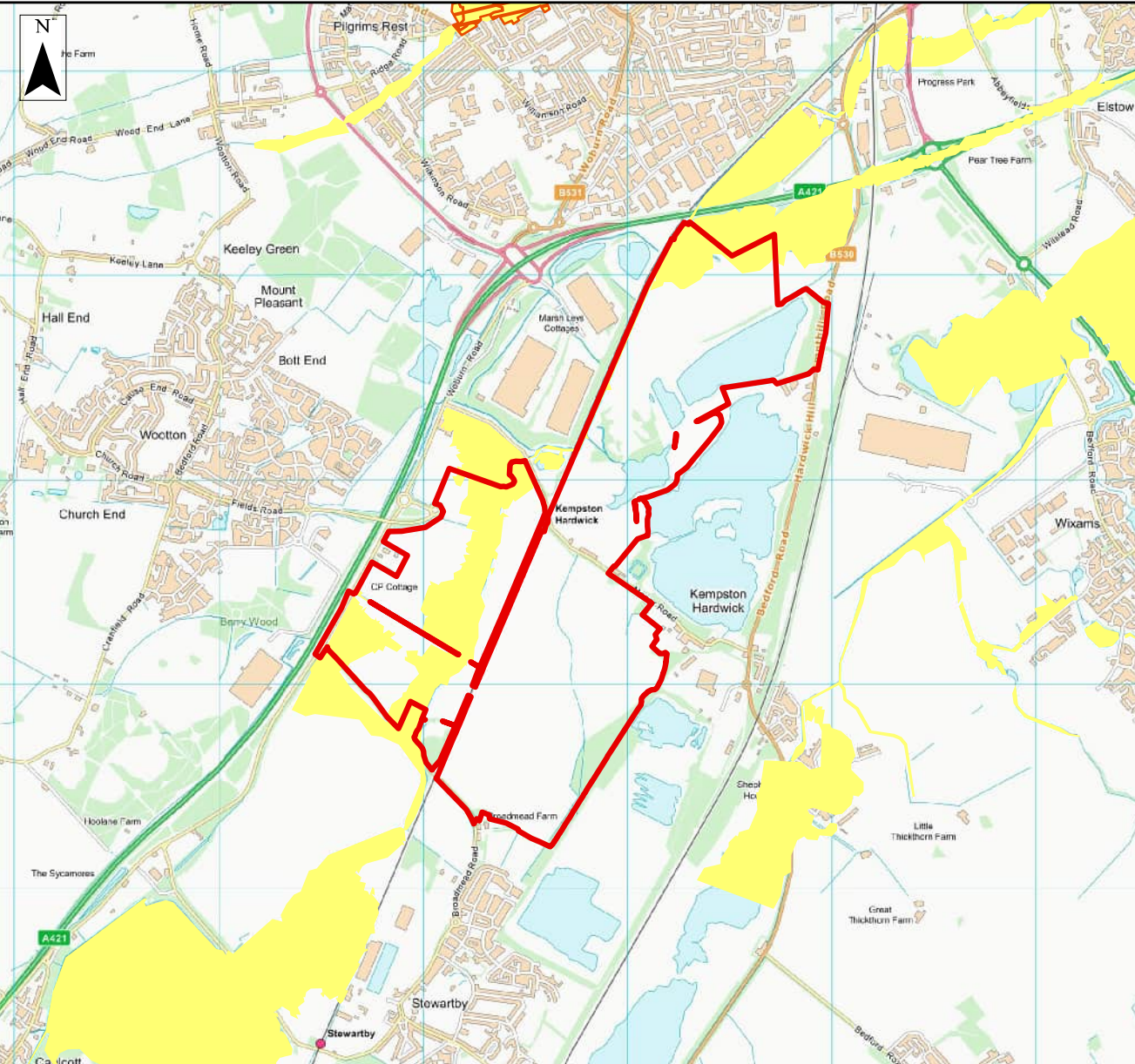
Surface Water Hazard

- ☐ 3.3% AEP
- ☐ 1% AEP
- ☐ 0.1% AEP

- ☐ Caution
- ☐ Danger for Some
- ☐ Danger for Most
- ☐ Danger for All

Surface Water Hazard plus Climate Change Allowances

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- ☐ 1% AEP Event (+40%) CC
- ☐ Caution
- ☐ Danger for Some
- ☐ Danger for Most
- ☐ Danger for All



0 0.3 0.6 km

Authority Information

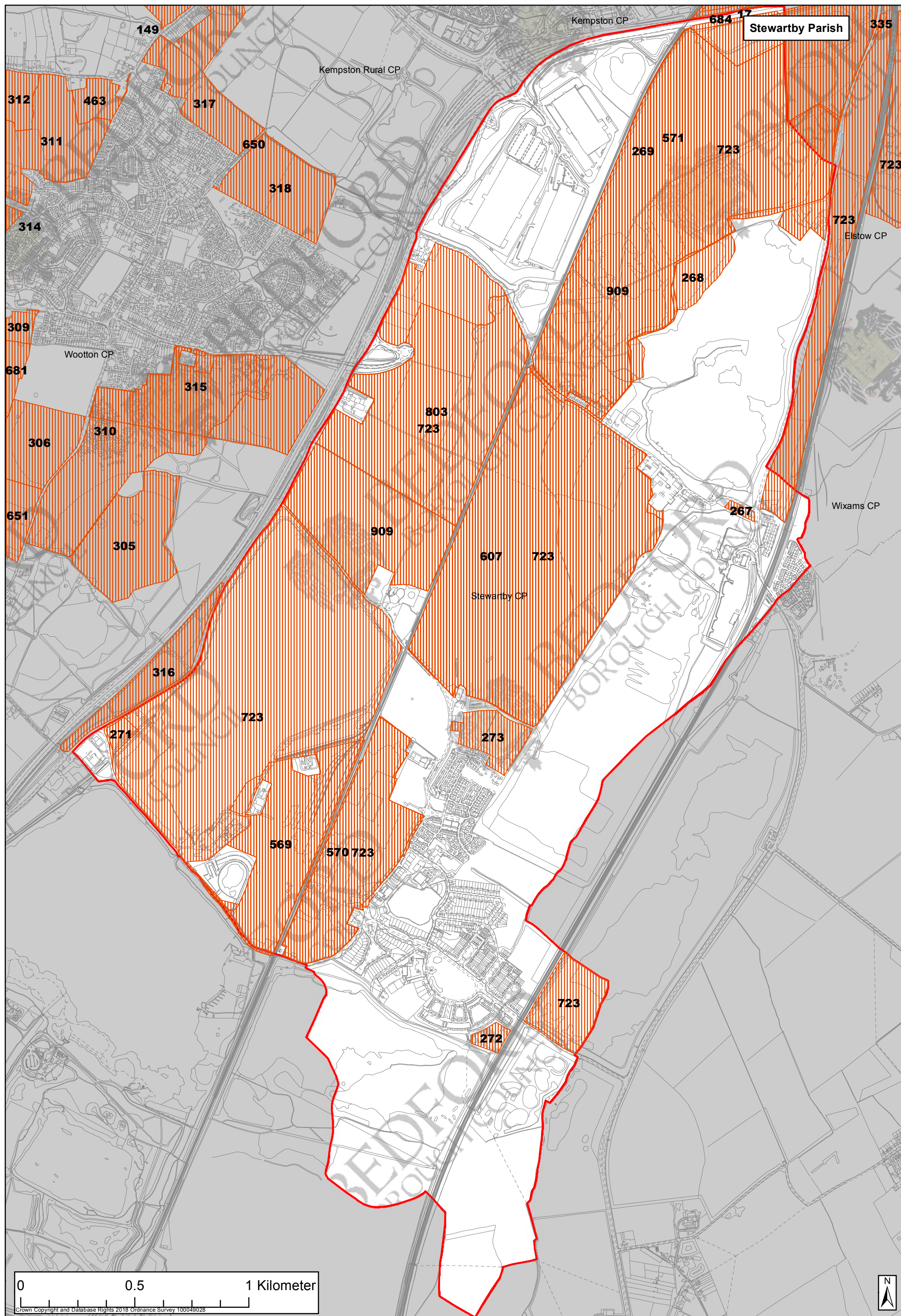
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Bedford Borough Council Level 2 Strategic Flood Risk Assessment Detailed Site Summary Tables

Site details

Site Code

745-809-898-898-1050-905

Address

Land at Kempston Hardwick (502612, 244785)
This site table includes seven areas across the land both sides of the railway line at Kempston Hardwick. Site 745 is situated to the east of the railway line and starts at Broadmead Road in the south, extending north as far as Manor Road. Site 809 includes the area defined as 745 (which will be referred to as 745 throughout this site table) but in addition extends further north as far as the A421 (referred to as 809N) and also extends west in the southern part of the site as far as the A421 (referred to as 809W). The two sites at 898 (referred to as 898N for the northern site and 898S for the southern site) are two small areas attached to the eastern boundary of site 809. Site 905 is located on the western side of the railway line to the south of the sites, bordered by site 809 to the north and east. Site 1050 is also situated on the western side of the railway line and lies to the north of site 809W, extending north as far as Manor Road.

Area

745 – 95.372ha
809N – 98.954ha
809W – 27.236ha
898N – 3.511ha
898S – 1.009ha
1050 – 48.46ha
905 – 2.855ha

Current land use

Predominantly greenfield other than the southern area of 809N which is a brownfield site with Manor Road and several properties along this road with areas of hardstanding and an industrial site to the north of these properties. The site boundaries also include parts of the B530 to the east and Woburn/Bedford Road to the west.

Proposed land use

745 – mixed use
809N – commercial
809W – commercial
898N – residential
898S – residential
905 – residential
1050 – commercial

Sources of flood risk

Location of the site within the catchment

The sites are located in the River Great Ouse Catchment. Elstow Brook flows through the sites from south to north before flowing in a north-easterly direction, joining the River Great Ouse north of Willington. The River Great Ouse then flows in an easterly direction towards its confluence with the River Ivel at Tempsford. It then continues in a north-easterly direction until it reaches the Wash and the North Sea near Kings Lynn.

Existing drainage features

Elstow Brook flows through the sites from south to north. It flows along the western edge of 905, bisecting 809W and 1050 from south to north, flowing along the northern edge of 1050 and under the railway line in a north-easterly direction and then flowing north along the western edge of 809N.
Elstow Brook is an ordinary watercourse and is designated by the Environment Agency as a heavily modified watercourse.
There is an unnamed tributary of Elstow Brook which flows in a north-westerly direction across 745 and then flows in a northerly direction into 809N before flowing west and joining Elstow Brook. There is another tributary which flows north along the western boundary of 809W before flowing east along the boundary between 809W and 1050. There are further small tributaries of Elstow Brook in the north of 809N and in the centre of 1050.

	<p>Local topography shows that the site generally slopes downhill from south to north. The site also slopes downhill to the centre of 745 where a tributary of Elstow Brook flows and to the centre of 809W and 1050 where Elstow Brook flows. 898N is situated at a higher level than the surrounding land.</p> <p>Online imagery shows there are several waterbodies within 809N along the eastern side of the site. There is also a small waterbody in the northwest corner of 905. There are further waterbodies surrounding the site to the north and east.</p>																																								
Fluvial	<p>The proportion of site at risk:</p> <table><tr><th>Site</th><th>FZ3b</th><th>FZ3</th><th>FZ2</th><th>FZ1</th></tr><tr><td>745</td><td>0%</td><td><1%</td><td><1%</td><td>99%</td></tr><tr><td>809N</td><td>1%</td><td>3%</td><td>10%</td><td>90%</td></tr><tr><td>809W</td><td>1%</td><td>2%</td><td>46%</td><td>54%</td></tr><tr><td>898N</td><td>0%</td><td>0%</td><td>0%</td><td>100%</td></tr><tr><td>898S</td><td>0%</td><td>0%</td><td>0%</td><td>100%</td></tr><tr><td>905</td><td>3%</td><td>3%</td><td>10%</td><td>90%</td></tr><tr><td>1050</td><td>2%</td><td>11%</td><td>40%</td><td>60%</td></tr></table> <p><i>The % Flood Zones quoted show the % of the site at flood risk from that particular Flood Zone/event, including the percentage of the site at flood risk at a higher risk zone, e.g. FZ2 includes the FZ3 %. FZ1 is the remaining area outside FZ2 (FZ2 + FZ1 = 100%). As there are no flood defences or risk management measures the Zones also describe the predicted actual fluvial and surface water flood risk at the sites.</i></p> <p>Available data: A 1D-2D hydraulic model for Elstow Brook was available from the Environment Agency. Further modelling was undertaken to apply recent climate change uplifts to the fluvial model of Elstow Brook. However, this model domain only extends south as far as where Elstow Brook meets the northern boundary of 1050. Across the remainder of the sites the Environment Agency’s Flood Map for Planning was used for Flood Zones 2 and 3.</p> <p>Flood characteristics: In the 1%AEP fluvial event there is a flood risk area which follows the path of Elstow Brook through the sites. This flood risk remains mostly confined to the channel however there are small areas of overtopping in 905 and 809W and larger areas of overtopping along the western side of the channel in 1050 and along the boundary between 1050 and 809W where a tributary of Elstow Brook flows. There is also an area of flood risk in the northwest corner of 809N and along the northern boundary of this site, where a small tributary joins Elstow Brook. There is also a small area of flood risk on the eastern boundary of 745 where there is a waterbody.</p> <p>In the 0.1%AEP fluvial event there is no increase in the flood extent on the eastern boundary of 745. However, there are large increases in the flood risk from Elstow Brook with large areas overtopping through the centre of 1050 and the central and western areas of 809W. The flood risk along the boundary between 890W and 1050 extends further west as far as the western boundary of 1050. There is also increased flood risk along the western boundary of 905. In 809N, there is a small area of overtopping in the west of the site, but the flood risk still remains mostly confined to the channel until the north of the site, where the flood risk increases and encroaches further south onto the site.</p> <p>In the 5%AEP fluvial event (FZ3b) the flood risk is mainly confined to the channel of Elstow Brook with a small amount of overtopping along the west of 905 and in the northwest corner of 809N. The flood risk also extends west along a tributary of Elstow Brook along the boundary between 809W and 1050.</p>	Site	FZ3b	FZ3	FZ2	FZ1	745	0%	<1%	<1%	99%	809N	1%	3%	10%	90%	809W	1%	2%	46%	54%	898N	0%	0%	0%	100%	898S	0%	0%	0%	100%	905	3%	3%	10%	90%	1050	2%	11%	40%	60%
Site	FZ3b	FZ3	FZ2	FZ1																																					
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Coastal and Tidal	<p>The site is not at risk from coastal or tidal flooding.</p>																																								
Surface Water	<p>Proportion of site at risk (RoFfSW):</p> <table><tr><th rowspan="2">Site</th><th colspan="3">3.3%AEP</th><th colspan="3">1%AEP</th><th colspan="3">0.1%AEP</th></tr><tr><th>Overa II</th><th>Max depth</th><th>Max velocity</th><th>Overa II</th><th>Max depth</th><th>Max velocity</th><th>Overa II</th><th>Max depth</th><th>Max velocity</th></tr><tr><td>745</td><td>4%</td><td>>1.20 m</td><td>1.00-2.00m/s</td><td>9%</td><td>>1.20 m</td><td>1.00-2.00m/s</td><td>25%</td><td>>1.20 m</td><td>1.00-2.00m/s</td></tr><tr><td>809N</td><td>1%</td><td>>1.20 m</td><td>1.00-2.00m/s</td><td>3%</td><td>>1.20 m</td><td>1.00-2.00m/s</td><td>17%</td><td>>1.20 m</td><td>>2.00m/s</td></tr></table>	Site	3.3%AEP			1%AEP			0.1%AEP			Overa II	Max depth	Max velocity	Overa II	Max depth	Max velocity	Overa II	Max depth	Max velocity	745	4%	>1.20 m	1.00-2.00m/s	9%	>1.20 m	1.00-2.00m/s	25%	>1.20 m	1.00-2.00m/s	809N	1%	>1.20 m	1.00-2.00m/s	3%	>1.20 m	1.00-2.00m/s	17%	>1.20 m	>2.00m/s	
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809 W	1%	0.90-1.20m	1.00-2.00m/s	3%	>1.20m	1.00-2.00m/s	27%	>1.20m	>2.00m/s
898N	0%	-	-	0%	-	-	<1%	0.15-0.30m	0.50-1.00m/s
898S	<1%	0.15-0.30m	0.00-0.25m/s	1%	0.15-0.30m	0.00-0.25m/s	10%	0.30-0.60m	1.00-2.00m/s
905	3%	0.60-0.90m	0.50-1.00m/s	4%	0.60-0.90m	1.00-2.00m/s	9%	>1.20m	1.00-2.00m/s
1050	3%	>1.20m	1.00-2.00m/s	4%	>1.20m	>2.00m/s	12%	>1.20m	>2.00m/s

The % SW extents quoted show the % of the site at surface water risk from that particular event, including the percentage of the site at flood risk at a higher risk zone (e.g. 100-year includes the 30-year %)

Description of surface water flow paths:

The sites are predicted to be at risk of surface water flooding in all events.

During the 3.3%AEP surface water event, there are predicted flow paths which follow the path of Elstow Brook and its tributaries and the unnamed watercourse through 745. Depths along Elstow Brook exceed 1.20m in places with hazard classifications up to 'Danger for most'. Depths along the unnamed watercourse which flows north through 745 exceed 1.20m where it meets Manor Road on the boundary of 745 and 809N. The extent of flooding along this road may be an overestimate as it is likely the watercourse enters a culvert under Manor Road which is not represented in the surface water mapping, however this could not be determine by online imagery so further investigation would be required. There are numerous areas of surface water ponding across the sites. The largest of these is in the northeast of 745, with depths of up to 0.90m and a classification of mainly 'Very Low Hazard' to 'Danger for some', although with areas of 'Danger for most'. There is also considerable surface water flood risk to the north of Broadmead Road, along the southern boundary of 745, with depths of up to 0.60m. There are also a couple of areas of ponding along the eastern side of the railway line in 745.

During the 1%AEP surface water event, the predicted flow paths along the watercourses increase in extent. The areas of ponding also increase in magnitude, particularly the area in the east of 745, which extends further west, around the waterbodies in 890N and along the eastern side of the railway line in 745. There is a large area of predicted flood risk to the west of 809W and 1050 which begins to encroach on the site during the 1%AEP event, with depths of up to 1.20m along the site boundary. The flood risk surrounding the two roads (Broadmead Road and Manor Road) to the south and north of 745 respectively also increase in extent, encroaching further onto the site.

During the 0.1%AEP surface water event, there are predicted to be large increases in the extent of surface water across the sites. The area of surface water flood risk to the west of the sites encroaches further onto the site, covering the western side of 809W with depths of up to 0.60m across the main part of the site and a classification of mainly 'Danger for some' with areas of 'Danger for most'. There is also surface water flood risk through the east of 809W, following the path of Elstow Brook with areas of flood risk either side of the Brook through 809W and 1050. In 905, there are small areas of ponding across the site, and the flood risk from Elstow Brook slightly encroaches on the western side of the site. In 745, there are large areas of flood risk to the south of the site around Broadmead Road and in the east of the site, along the east of the unnamed watercourse. The flood risk areas to the east of the railway line, in the west of 745, also increase in size. In 809N there are large areas of flood risk along the eastern side, where online mapping shows several waterbodies. Surface water ponding from the most southerly of these waterbodies encroaches onto the western boundary of 898N, however depths on 898N are only up to 0.30m and classified as 'Very Low Hazard'. There is also an area of surface water ponding in the south end of 898S. The surface water flood risk along the western side of 890N appears to remain confined to the channel of Elstow Brook until the northwest corner of the site, where it extends southwards onto the site.

Reservoir

The site is shown to be at risk from reservoir flooding from available online maps. When river levels are normal the reservoir flood extent follows the path of Elstow Brook through 905, 809W and 1050 but is not confined to the channel. Large parts of 809N are also shown too be at flood risk. When there is also flooding from rivers, the flooding extent along Elstow Brook extends further from the channel, particularly along the western side through 809W and 1050.

Groundwater	<p>The Environment Agency Areas Susceptible to Groundwater Flooding dataset, provided as 1km grid squares, shows the susceptibility of an area to groundwater flood emergence. The following comments can be made about groundwater flood risk:</p> <ul style="list-style-type: none"> • 745 has a $\geq 50\%$ and $< 75\%$ susceptibility to groundwater flood emergence in the north and a $\geq 25\%$ and $< 50\%$ susceptibility to groundwater flood emergence in the south. • 809N mainly has a $\geq 75\%$ susceptibility to groundwater flood emergence with areas of $\geq 50\%$ and $< 75\%$ susceptibility to groundwater flood emergence in the north and south. • 809W mainly has a $< 25\%$ susceptibility to groundwater flood emergence with an area of $\geq 50\%$ and $< 75\%$ susceptibility to groundwater flood emergence in the northeast and an area of $\geq 25\%$ and $< 50\%$ susceptibility to groundwater flood emergence in the southeast. • 898N has a $\geq 75\%$ susceptibility to groundwater flood emergence. • 898S has a $\geq 50\%$ and $< 75\%$ susceptibility to groundwater flood emergence. • 905 has a $\geq 25\%$ and $< 50\%$ susceptibility to groundwater flood emergence. • 1050 mainly has a $\geq 50\%$ and $< 75\%$ susceptibility to groundwater flood emergence with an area of $< 25\%$ susceptibility to groundwater flood emergence in the west and a small area of $\geq 75\%$ susceptibility to groundwater flood emergence on the northern boundary. <p>This assessment does not negate the requirement that an appropriate assessment of the groundwater regime should be carried out at the site-specific FRA stage.</p>
Sewers	The sites are situated across two postcodes, postcode area MK43 9 has one recorded instance of sewer flooding in the past and postcode area MK45 3 has three recorded instances of sewer flooding in the past.
Flood history	The Environment Agency's historic flooding dataset has no records of flooding on the sites.
Flood risk management infrastructure	
Defences	The sites are not protected by any formal flood defences.
Residual risk	<p>There is no residual risk to the site from flood risk management structures but there are a number of culverts that could be at risk from blockage due to debris which could cause flooding. Consideration should be given to the blockage risk in FRA's prepared.</p> <p>There is also a large waterbody in the northeast of 809N, which could be at risk of overtopping. Consideration should be given to the overtopping risk in FRA's prepared.</p>
Emergency planning	
Flood warning	<p>The site is not located in any of the Environment Agency's flood warning areas.</p> <p>The northern end of 809N, parts of 1050, parts of 809W and the western boundary of 905 are covered by the 'Middle River Great Ouse in Milton Keynes, Bedford Borough and Central Bedfordshire' Flood Alert Area.</p>
Access and egress	<p>The sites to the east of the railway line (809N, 898N, 898S and 745) can be accessed via the B530 which runs to the east of these sites (through the east of 809N) and then along Manor Road, which runs between the south of 809N and the north of 745. Sites 898N and 898S are likely to need to be accessed via the other sites as there is a large waterbody between these sites and the B530.</p> <p>Access to these sites from the north along the B530 should not be affected during the 1% and 0.1%AEP fluvial events as although the modelling of Elstow Brook shows overtopping along the A421 where the B530 crosses to the north of the sites during these events, online imagery shows the B530 passes over a bridge across the A421. Access to these sites from the south along the B530 is shown to be affected during both the 1% and 0.1%AEP fluvial events due to overtopping of Harrowden Brook along the section of road between Manor Road and Stewartby Road. Harrowden Brook flows in a northerly direction adjacent to the west of the B530 before flowing under the road by Waterway Place. However, access could still be gained to the site from the south along the B530 via Stewartby Way and Broadmead Road which bypass the areas of overtopping across the B530.</p> <p>Access to 809N from the north along the B530 is predicted to remain mainly unaffected during the 3.3%, 1% and 0.1% surface water events. In the 1%AEP event, there is a small amount of surface water along the B530 north of where it enters 809N, with depths of up to 0.30m and south of where it exits 809N, with depths of up to 0.60m, however, both these</p>

	<p>flows are classified predominantly as 'Very Low Hazard'. However, there is predicted to be considerable surface water flooding along the B530 around its junction with Manor Road and to the south of this which will affect the access to 745 during all the surface water events, classified in large parts as 'Danger for most'. Furthermore, the surface water flooding along the unnamed watercourse through 745 bisects the site during the 0.1%AEP event which will affect the access between the northeast of 745 and the rest of the site.</p> <p>The remaining sites to the west of the railway line (809W, 905 and 1050) can be accessed along Woburn/Bedford Road which runs along the west of 1050 and through the west of 809W. Manor Road runs from Woburn/Bedford Road in the west, through the north of 1050, crosses the railway line and then runs through the south of 809N before joining the B530 to the east of the sites. Fields Road also runs east towards the site joining with Woburn/Bedford Road at a roundabout on the western boundary of 1050. These sites can also be accessed from the south along Broadmead Road, which runs along east along the south of 745, 905 and 809W before joining Woburn/Bedford Road to the west of the sites. Elstow Brook bisects the sites from south to north which may affect the access between the eastern and western sides of these sites. There is also a tributary of Elstow Brook which runs along the boundary between 1050 and 809W which may affect any access between these two sites to the west of Elstow Brook.</p> <p>Access to the west of the sites along Woburn/Bedford Road remains unaffected during the 1% and 0.1%AEP fluvial events, however, access from the south along Broadmead Road is shown to be affected by overtopping of Elstow Brook during the 0.1%AEP event. Note, the model data for Elstow Brook does not extend this far south. The eastern sides of the sites could be access either along Broadmead Road from the east or along Manor Road from the west.</p> <p>During the 3.3% and 1%AEP surface water events, access to the west of the sites along Woburn/Bedford Road remains unaffected. Access to the east of the sites along Manor Road from the west remains unaffected, however access to the east along Broadmead Road is shown to be affected in both directions. Elstow Brook is shown to overtop to the southwest of 905 with depths of up to 0.90m in the 3.3%AEP event and up to 1.20m in the 1%AEP event, however, this may not be a true representation of reality as there is most likely a culvert under the road which is not included within the surface water mapping. However, online imagery could not confirm this.</p> <p>During the 0.1%AEP surface water event, the western section of 1050 can still be accessed along Woburn/Bedford Road from the west however, there is surface water flood risk along Woburn/Bedford Road near the boundary of 1050 and 809W, extending a considerable distance into 809W, with depths of up to 0.60m along the road. There are further small areas of surface water flood risk along Woburn/Bedford Road to the south of the sites which will affect the access to 809W. The eastern parts of the sites can still be accessed along Manor Road from the west.</p> <p>The depths, velocities, hazards, durations and speeds of onset of fluvial and surface water along access/egress routes should be investigated further where appropriate in a site-specific assessment, to confirm whether access for emergency vehicles could still be obtained.</p> <p>As surface water events are typically flashy and short-lived, it is likely that if access is affected by surface water this would only be for a short period of time. Consideration should be given to the preparation of a Flood Warning and Evacuation Plan for the sites, with a policy of shelter in situ on the site likely to be appropriate if access cannot be provided.</p>
Climate change	
Implications for the site	<ul style="list-style-type: none"> • Some of the sites are sensitive to increased fluvial flows resulting from climate change. • The north of 809N, where there is available modelled data for Elstow Brook, shows increases in flood risk for the 1%AEP event with climate change increases (+19%, +30% and +58%) from Elstow Brook with the flood extent extending further south onto the site. • For the upstream section of Elstow Brook, its tributaries and the unnamed watercourse, no model data was available, so the present day 0.1%AEP fluvial extent (Flood Zone 2) provides an indication of the likely increase in extent of the more frequent fluvial events. There are considerable increases to the risk from fluvial flooding on the sites between the 1% and 0.1%AEP fluvial events, particularly on the western boundary of 905 and across 809W and 1050, suggesting that the site is highly sensitive to the impacts of climate change. • Currently, no model data is available for the unnamed watercourse through 745 or Elstow Brook south of 809N. These should be modelled as part of a site-specific FRA

	<p>with the most up-to-date climate change allowances to investigate the implications of climate change on the site.</p> <ul style="list-style-type: none"> • The present day 0.1%AEP surface water flooding extent provides an indication of the likely increase in extent of the more frequent surface water events. There is a significant increase in the risk from surface water flooding on the site between the 1% and 0.1%AEP surface water events, suggesting that the site is more sensitive to the impacts of climate change. This would require a detailed Flood Risk Assessment to assess the site layout and design. In addition to the Sustainable Drainage Systems features designed to accommodate runoff from new development infrastructure the proposals should also address the potential loss of natural storage of rainfall and runoff provided by the land in its natural condition. • Developers should consider Sustainable Drainage Systems strategies to reduce the impacts of climate change from surface water in a detailed site-specific Flood Risk Assessment.
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Requirements for drainage control and impact mitigation

<p>Broad-scale assessment of possible Sustainable Drainage Systems</p>	<p>Geology & Soils</p> <ul style="list-style-type: none"> • Geology at the site consists of: <ul style="list-style-type: none"> ◦ Bedrock – Peterborough Member (Mudstone). ◦ Superficial – there are no records of superficial deposits across much of the site. Where records exist, they are a combination of Head (Clay, Silt, Sand and Gravel), Head, 1 (Clay, Silt, Sand and Gravel) and Alluvium (Clay and Silt). • Soils at the site consist of: <ul style="list-style-type: none"> ◦ Lime-rich loamy and clayey soils with impeded drainage. <p>Sustainable Drainage Systems (SuDS)</p> <ul style="list-style-type: none"> • 809N and 898N are considered to be highly susceptible to groundwater flooding. Groundwater flooding could occur at the surface which may flow to and pool within topographic low spots during very wet winters. Detention and attenuation features should be designed to prevent groundwater ingress from impacting hydraulic capacity and structural integrity. Additional site investigation work may be required to support the detailed design of the drainage system. This may include groundwater monitoring to demonstrate that a sufficient unsaturated zone has been provided above the highest occurring groundwater level. Below ground development such as basements are not appropriate at this site. • 745, 898S and 1050 are considered to have a moderate susceptibility to groundwater. Detention and attenuation features should be designed to prevent groundwater ingress from impacting hydraulic capacity and structural integrity. Additional site investigation work may be required to support the detailed design of the drainage system. This may include groundwater monitoring to demonstrate that a sufficient unsaturated zone has been provided above the highest occurring groundwater level. Below ground development such as basements are not appropriate at this site. • 809W and 905 are considered to have a low susceptibility to groundwater. Detention and attenuation features should be designed to prevent groundwater ingress from impacting hydraulic capacity and structural integrity. Groundwater monitoring is recommended to determine the seasonal variability of groundwater levels, as this may affect the design of the surface water drainage system. Below ground development such as basements may not be appropriate at this site. • BGS data indicates that the underlying geology is mudstone and is likely to be poorly draining. Any proposed use of infiltration should be supported by infiltration testing. Off-site discharge in accordance with the Sustainable Drainage Systems hierarchy is required to discharge surface water runoff. • For the greenfield areas surface water discharge rates should not exceed the existing greenfield runoff rates for the site. Opportunities to further reduce discharge rates should be considered and agreed with the LLFA. It may be possible to reduce site runoff by maximising the permeable surfaces on site using a combination of permeable surfacing and soft landscaping techniques. • For the brownfield areas surface water discharge rates should not exceed pre-development discharge rates for the site and should be designed to be as close to greenfield runoff rates as reasonably practical in consultation with the LLFA. It may be possible to reduce site runoff by maximising the permeable surfaces on site using a combination of permeable surfacing and soft landscaping techniques.
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	<ul style="list-style-type: none"> Most of the site is within the Bedfordshire and River Ivel Internal Drainage Board district who may have additional requirements regarding discharge rates (directly or indirectly) into their district. The IDB should be consulted during the detailed design of the site to establish the Board's requirements and determine whether there will be a need to apply for surface water discharge or ordinary watercourse consents. The Risk of Flooding from Surface Water (RoFSW) mapping indicates the presence of surface water flow paths during the 3.3%, 1% and 0.1% AEP events. Existing flow paths should be retained and integrated with blue-green infrastructure and public open space. If it is proposed to discharge runoff to a watercourse or sewer system, the condition and capacity of the receiving watercourse or asset should be confirmed through surveys and the discharge rate agreed with the asset owner.
Opportunities for wider sustainability benefits and integrated flood risk management	<ul style="list-style-type: none"> Appropriate development at the sites should not increase flood risk either on or off site. The design of surface water management proposals should take into account the impacts of future climate change over the projected lifetime of the development. Space on the sites should be made for green infrastructure, which presents wider opportunities to improve biodiversity and amenity as well as climate change adaptation. This would most appropriately be coordinated so built development is not placed in locations of functional flood plain or high fluvial risk areas (apply the Sequential Approach to formulate the site layout). In view of the substantive change in risk as a consequence of climate change the sites should be designed so climate change effects can be safely accommodated. If it is proposed to discharge runoff to a watercourse or sewer system, the condition and capacity of the receiving watercourse or asset should be confirmed through surveys and the discharge rate agreed with the asset owner. Implementation of Sustainable Drainage Systems at the site could provide opportunities to deliver multiple benefits including volume control, water quality, amenity and biodiversity. This could provide wider sustainability benefits to the site and surrounding area. Proposals to use Sustainable Drainage Systems techniques should be discussed with relevant stakeholders (LPA, LLFA and EA) at an early stage to understand possible constraints.
NPPF and planning implications	
Exception Test requirements	<p>The Local Authority will need to confirm that the sequential test has been carried out. The Sequential Test will need to be passed before the Exception Test is applied. The NPPF classifies residential development as 'More Vulnerable' and commercial development as 'Less Vulnerable'.</p> <p>As parts of some of the sites are located in Flood Zone 3 and some of the sites are also predicted to be affected by surface water flood risk the Exception Test is required. If it is proposed to place development in areas of high fluvial flood risk then it must be demonstrated that the proposals do not have an adverse effect on third parties or reduce the volume of flood storage available. If development is proposed in areas affected by surface water flood risk, then an FRA is required to demonstrate that there are no adverse effects, and that the natural storage capacity of the undeveloped land is not compromised.</p> <p>An outline summary for each of the sites is as follows:</p> <ul style="list-style-type: none"> 745 will require the Exception Test as there is considerable surface water flooding across the site, particularly along the flow path of the unnamed watercourse and in the southwest corner of the site. 809N will require the Exception Test as the northwest corner of the site and the western boundary are in Flood Zone 3. Furthermore, there are considerable areas of surface water ponding across the site, particularly in the east of the site. 809W will require the Exception Test as large areas of the site are located in the Flood Zones and there is also considerable surface water flooding in the west of the site and along Elstow Brook in the east of the site. 898N will not require the Exception Test as the site is not at fluvial flood risk and there is only a small area of surface water flooding which encroaches on the western boundary of the site. 898S will require the Exception Test as there is an area of surface water ponding which extends across the south of the site. 905 will require the Exception Test as the western boundary of the site is in Flood Zone 3.

	<ul style="list-style-type: none"> 1050 will require the Exception Test as large areas of the site are located in the Flood Zones and there are also several areas of surface water ponding across the site, particularly along Elstow Brook in the east of the site.
Requirements and guidance for site-specific Flood Risk Assessment	<p>Flood Risk Assessment:</p> <ul style="list-style-type: none"> Some of the sites are at risk of fluvial flooding and all of the sites are greater than one hectare, so a site-specific Flood Risk Assessment will be required for all sites to demonstrate that the Exception Test is satisfied. <p>Guidance for site design and making development safe:</p> <ul style="list-style-type: none"> The development should be designed using a sequential approach. Development should be steered away from the areas of fluvial and surface water flood risk, preserving these spaces as green infrastructure where appropriate (functional flood plain must be preserved). Safe access and egress will need to be demonstrated in the 0.1%AEP plus climate change fluvial and rainfall events, using the depth, velocity and hazard outputs. Raising of access routes must not impact on surface water flow routes. Consideration should be given to the siting of access points with respect to areas of surface water flood risk. Resilience measures will be required if buildings are situated in the flood risk areas of the site. Raising Finished Floor Levels above the design event may remove the need for resilience measures. If development is proposed in high risk areas, then it must be demonstrated that there are no significant adverse effects. The risk from surface water flow routes should be quantified as part of a site-specific Flood Risk Assessment, including a drainage strategy, to ensure that runoff from the development is not increased by placing development across any ephemeral surface water flow routes. A drainage strategy should help inform site layout and design to ensure there is no increase in runoff beyond the current greenfield rates. On site attenuation schemes would need to be tested to ensure flows are not exacerbated downstream within the catchment. New or re-development should adopt exemplar source control Sustainable Drainage Systems techniques to reduce the risk of frequent low impact flooding due to post-development runoff. Assessment for runoff should include allowance for climate change effects. Developers should refer to Bedford Borough Council's 'Supplementary Planning Document for Sustainable Drainage Systems' and the Level 1 SFRA for information on Sustainable Drainage Systems for guidance on the information required by the LLFA from applicants to enable it to provide responses to planning applications.
Key messages	
<p>The development is likely to be able to proceed if:</p> <ul style="list-style-type: none"> The most at-risk areas of the sites are left undeveloped. The unnamed watercourse through 745 and Elstow Brook south of 809N are modelled as part of a site-specific FRA with the most up-to-date climate change allowances to investigate the implications of climate change on the site. If flood mitigation measures are implemented then they are tested to ensure that they will not displace water elsewhere (for example, if land is raised to permit development on one area, compensatory flood storage will be required in another). Space for surface water to be stored on the site is provided and rainwater harvesting should be considered. The proposed site should discharge surface water at the original pre-development (greenfield) runoff rate. If this is not possible, a significant reduction in the current rate of discharge should be achieved and agreed with the relevant drainage body (LLFA, IDB or Anglian Water). Safe access and egress routes must not be in the areas of high fluvial and surface water risk and raising of access routes should not impede surface water flows. A Flood Warning and Evacuation Plan should be prepared for the site if safe access and egress cannot be demonstrated during the 0.1% AEP event. 	
Mapping Information	

The key datasets used to make planning recommendations regarding this site were the broadscale 2D modelling outputs from the Environment Agency's Flood Map for Planning, the Elstow Brook hydraulic model and the Risk of Flooding from Surface Water map. More details regarding data used for this assessment can be found below.

Flood Zones	Flood Zones 2 and 3 have been taken from the Environment Agency's Flood Map for Planning mapping. Flood Zone 3b was produced for the Level 1 SFRA.
Climate change	Climate change allowances (for the 2080s) were modelled as part of the Level 2 SFRA for Elstow Brook. This included Central (19%), Higher Central (30%) and Upper End (58%). For the upstream section of Elstow Brook, its tributaries and the unnamed watercourse, no model data was available, so the present day 0.1%AEP fluvial extent (Flood Zone 2) has been used as a proxy for the impacts of climate change on the fluvial flood extent. The 0.1% AEP surface water mapping from the Risk of Flooding from Surface Water map has been used as a proxy for the impacts of climate change on surface water.
Fluvial depth, velocity and hazard mapping	A 1D-2D model was provided by the Environment Agency for Elstow Brook and used to inform the flood risk to this site.
Surface Water	The Risk of Flooding from Surface Water map has been used to define areas at risk from surface water flooding.
Surface water depth, velocity and hazard mapping	The surface water depth, hazard and velocity mapping are taken from the Environment Agency's Risk of Flooding from Surface Water mapping.

3 Catchment-Level Assessment

3.1 Catchment-Level Assessment

In the catchment-level assessment, a higher resolution analysis of the high-risk catchments, as identified in the broadscale assessment, is undertaken. Other factors, such as the catchments' existing urban extent, topography and location within the wider river drainage network, are also considered within this higher resolution assessment to identify policy recommendations that address the specific risks within the catchment.

3.1.1 Elstow Brook (Upstream and downstream of Shortstown)

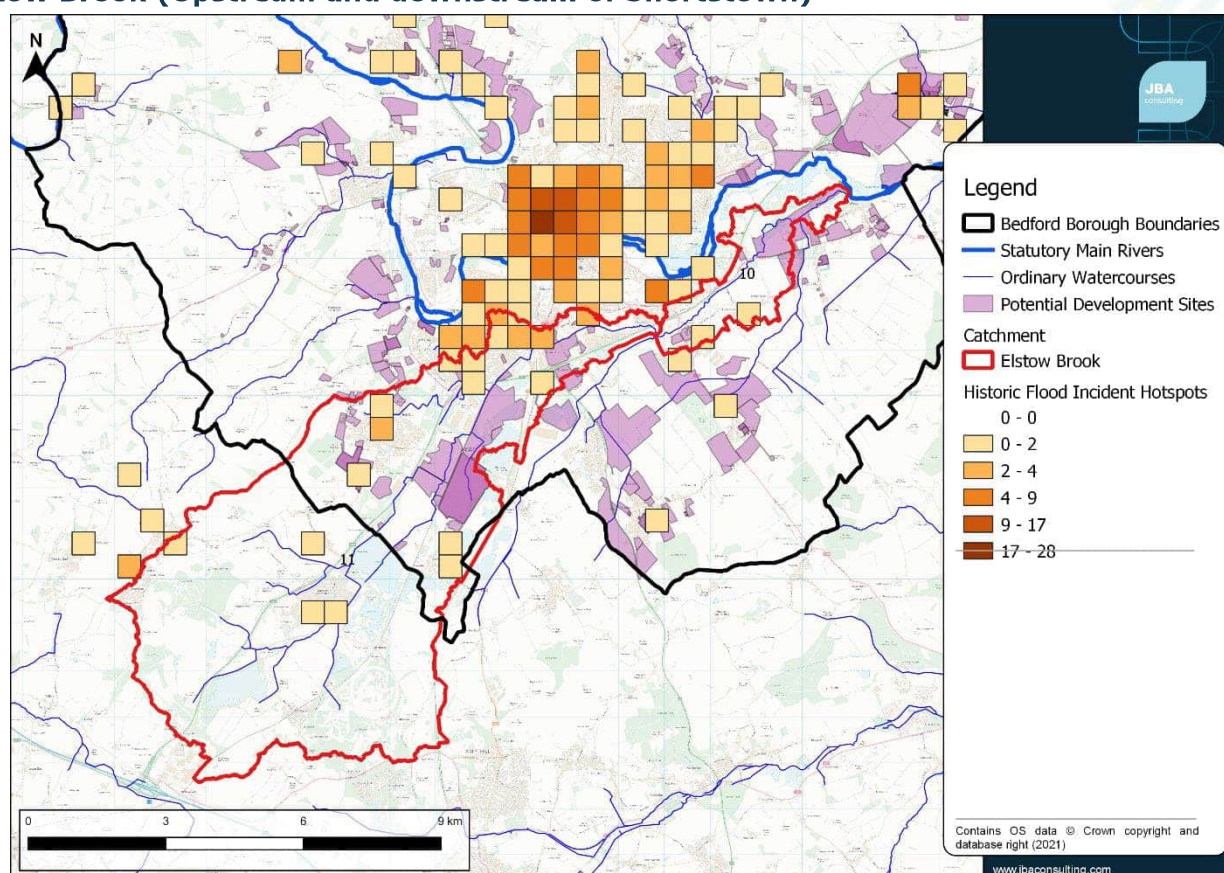


Figure 3-1 Proposed development and historic flooding hotspots within the Elstow Brook Catchment

Elstow Brook is an ordinary watercourse which rises near Lidlington, south of Bedford, and flows northward towards its confluence with the River Great Ouse east (downstream) of Bedford town centre. The catchment is predominantly rural but flows through several urban areas including Marston Mortaine and Wooton, and Bedford at the downstream end of the catchment. The catchment falls within the Bedfordshire and River Ivel IDB area.

In terms of fluvial flood risk, the most significant areas of risk are around Kempston Hardwick and east of Summerhouse Hill, (where several new development proposals are located) and through the built-up area of Elstow in the south of Bedford. Comparing Flood Zones 2 and 3 can give an indication of the areas where risk is most sensitive to increased river flows, and this suggests Elstow and Kempston Hardwick are particularly susceptible to increased flood risk as a result of the cumulative impacts of development upstream.

As an ordinary watercourse, Environment Agency Flood Zones are not available for most of the tributaries in the upper catchment. Risk from these watercourses is unlikely to increase significantly as a result of the cumulative impacts of development (although development in the upper catchment still has the potential for impacts downstream). Due to the size of the River Great Ouse compared to Elstow Brook, increased flows in the Elstow Brook are not likely to significantly increase the risk downstream of the confluence.

In terms of surface water risk, mapping suggests that risk within the catchment is moderately sensitive to increased surface water runoff. Wooton and Marston Moretaine built up areas appear to be most sensitive to increased runoff, with the lower end of the catchment being comparatively less sensitive.

As the main areas of risk are in the lower catchment and the upper catchment is predominantly rural there are likely to be opportunities for upstream measures, such as SuDS implementation and natural flood management measures, to reduce the risk downstream. The upstream half of the catchment lies outside of Bedford Borough, within Central Bedfordshire. There are also numerous lakes and waterbodies within the catchment, some of which already serve a flood storage purpose (maintained by Bedfordshire and River Ivel IDB). The majority of potential future development within the catchment appears to be located on land that is currently greenfield and in the lower end of the catchment, therefore new development should adopt exemplary drainage and source control techniques. It will be important that consideration is given to the potential cumulative loss of surface storage capacity and surface water flow and storage systems as a consequence of the loss of greenfield land. Individual allocations brought forward should include an assessment of the combined effects of all planned development and not just the effects of a single allocation site.

3.1.2 Harrowden Brook

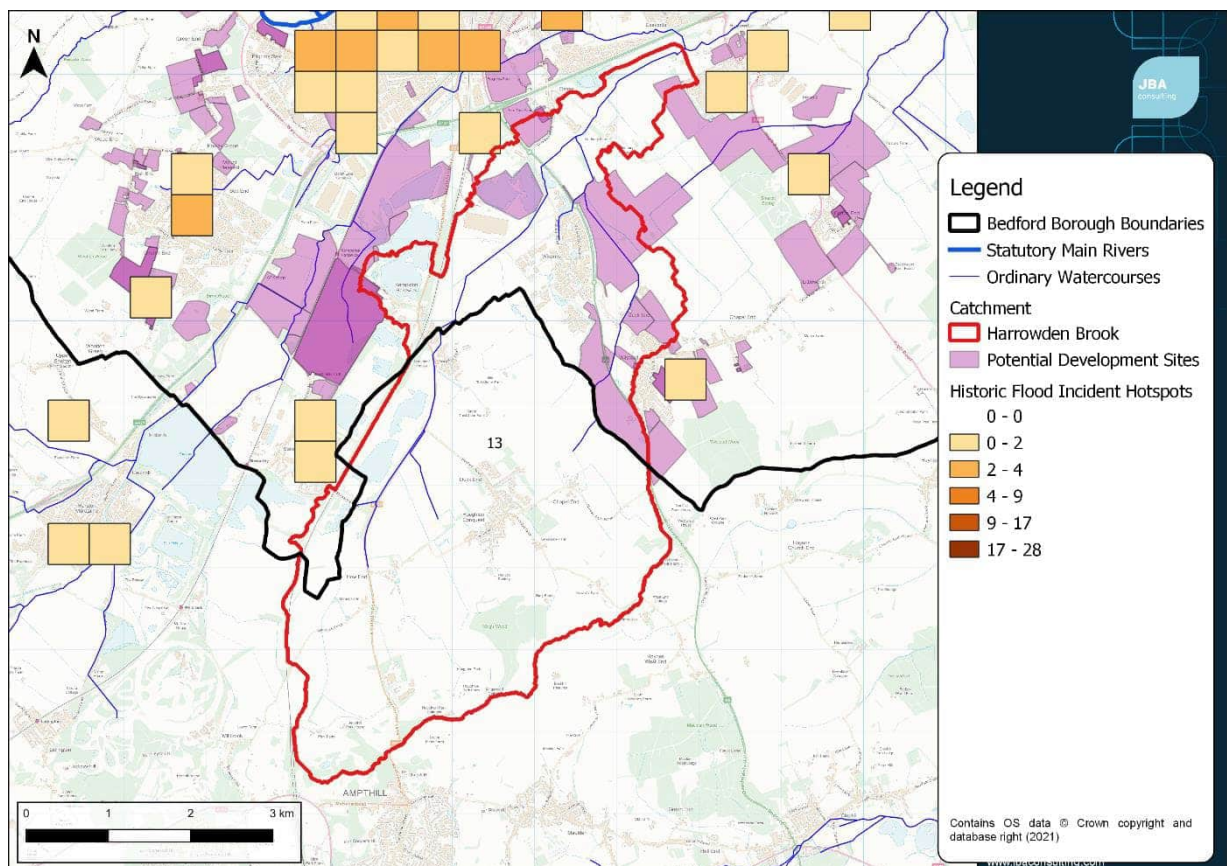


Figure 3-2 Proposed development and historic flooding hotspots within the Harrowden Brook Catchment

Harrowden Brook is an ordinary watercourse which rises just north of Ampthill and flows northwards towards its confluence with Elstow Brook at Shortstown. Similar to the neighbouring Elstow Brook catchment, Harrowden Brook lies within the Bedfordshire and River Ivel IDB area, and the catchment is predominantly rural. The main built-up area within the catchment is Wixams.

In terms of fluvial flood risk, the most significant area of risk is east of Wixams, where a large area of development is proposed. A comparison of Flood Zones 2 and 3 suggests that fluvial risk is not particularly sensitive to increased flows, however flood zones are not available for many of the ordinary watercourses within the catchment, including two watercourses which may pose a risk to Wixams. The risk of surface water mapping can be used to as an indication of the risk from smaller watercourses and this is discussed below. Harrowden Brook flows into the Elstow Brook and increases in river flow as a result of development are likely to have impacts in the Elstow Brook catchment also.

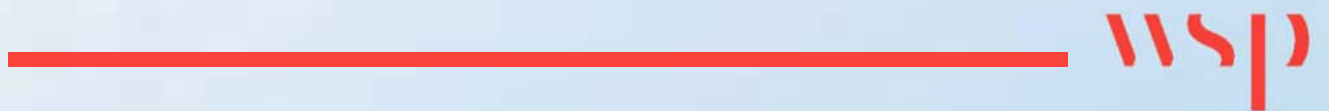
In terms of surface water risk, mapping suggests that the catchment is very sensitive to increases in surface water runoff. A significant surface water flow path flows through the centre of Wixams, associated with the unnamed watercourse. This flow path appears very sensitive to increases in runoff. Flows east of Kempston Hardwick and through Houghton Conquest are also sensitive and flow through urban areas.

There are likely to be opportunities in the upper catchment for upstream measures to reduce the risk downstream. The upstream half of the catchment lies outside of Bedford Borough, within Central Bedfordshire. There are also numerous lakes and waterbodies within the catchment, some of which already serve a flood storage purpose (maintained by Bedfordshire and River Ivel IDB). The majority of potential future development within the catchment appears to be greenfield and in the lower end of the catchment, although significant development is proposed upstream of Wixams and there are likely to be opportunities to address the known downstream risk as part of new development. New development should adopt exemplary drainage and source control techniques. It will be

important that consideration is given to the potential cumulative loss of surface storage capacity and surface water flow and storage systems as a consequence of the loss of greenfield land. Individual allocations brought forward should include an assessment of the combined effects of all planned development and not just the effects of a single allocation site.

Annex 6

LAND DRAINAGE RECORDS





DESIGN	LEGEND
THE LEVELS shown on this plan are metric reduced to a random bench mark.	175mm diameter plastic pipes
AGROCLIMATIC AREA:- 20	125mm diameter plastic pipes
DESIGN DRAINAGE RATE:- 19mm	100mm diameter plastic pipes
DRAINFLOW FACTOR:- 1.9	80mm diameter plastic pipes
RECOMMENDED DRAIN DEPTHS (average to invert)	60mm diameter plastic pipes
175mm pipes 950mm	Direction of Mowing
125mm pipes 850mm	Existing Pipes
100mm pipes 800mm	
80mm pipes 750mm	
60mm pipes 700mm	
PERMEABLE BACKFILL is to be placed over all the drains and brought up to within 380mm of the surface.	
MOLE CHANNELS are to be drawn over the drains in the general direction shown, as soon as soil conditions and cropping will allow. Channel spacing is not to exceed 1800mm at a depth of 550mm.	

LAND AT KEMPSTON HARDWICK, BEDFORD.

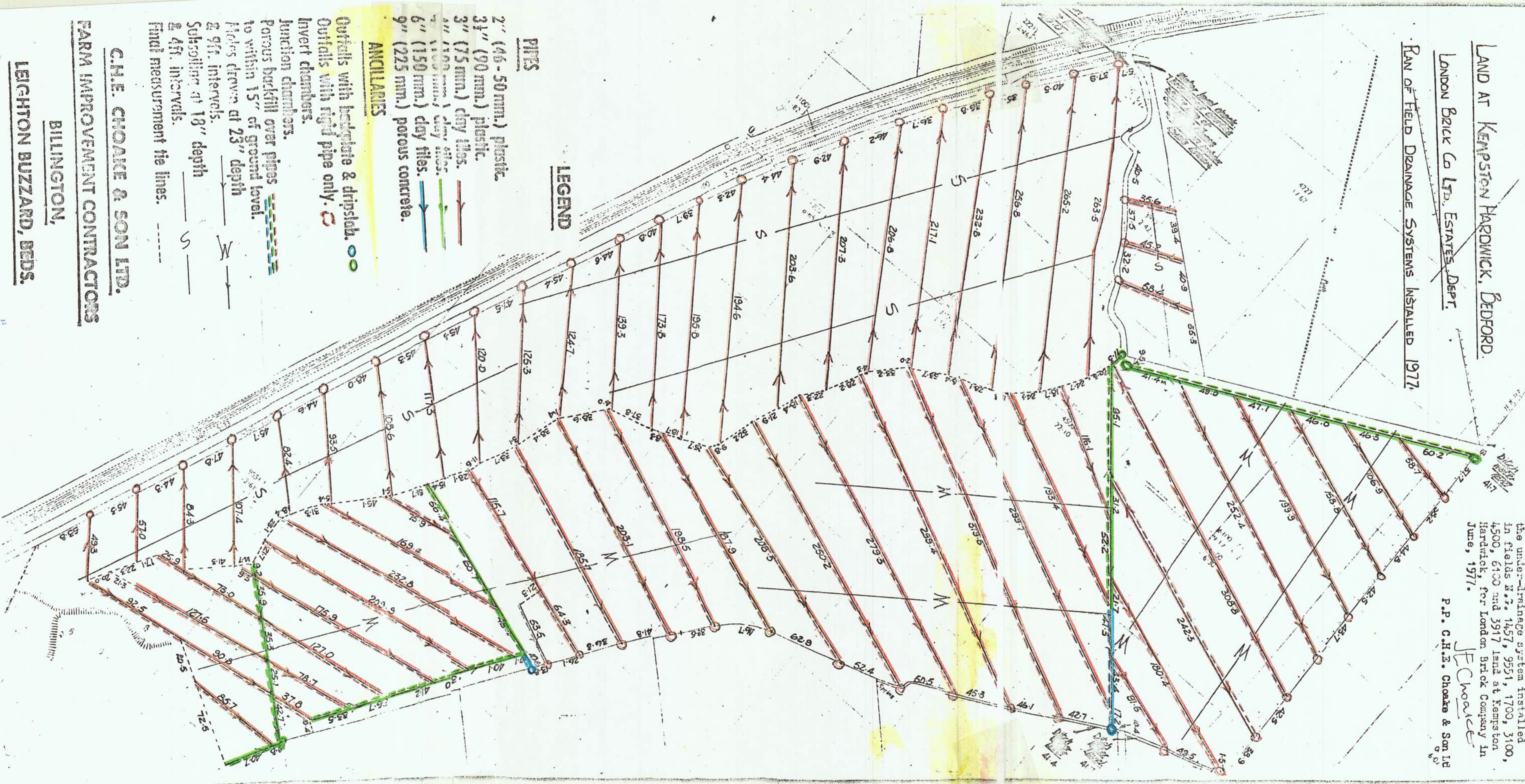
LONDON BRICK CO LTD. ESTATES DEPT.

PLAN OF FIELD DRAINAGE SYSTEMS INSTALLED 1977.

Certified as an accurate record of the under-drainage system installed in fields N.7, 1457, 9551, 1700, 3100, 4500, 6100 and 3917 land at Kempston Hardwick, for London Brick Company in June, 1977.

P.F. C.H.E. Choake & Son Ltd

J.E. Choake



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