Gilston Area, East Hertfordshire

Flood Risk Assessment & Drainage Strategy

October 2016

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Introduction

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1 Executive Summary

The Gilston Area is the name for an extensive area of land, acquired by Places for People and City and Provincial Properties Ltd, lying north of Harlow and on the north side of the River Stort valley, primarily within the East Herts District Council boundary.

Places for People and City & Provincial Properties are gathering all of the information it needs to prepare a detailed and robust masterplan to promote the site through the East Hertfordshire Local Plan process. This involves producing a series of assessments and reports to assist with the evidence base for the Local Plan.

This site specific Flood Risk Assessment (FRA) has been produced for this purpose in order to inform baseline conditions. A previous ‘Strategic’ Flood Assessment (SFRA) by AECOM in 2006 is superseded by this document in accordance and as requested by the Environment Agency (EA).

This FRA will identify the various flood risk sources to which the development area is potentially vulnerable and evaluate the risk to the area from those sources. It will also assess the impact that proposed development could have on flood risk both on and off site through additional runoff and any displaced water generated by the development and suggest measures to mitigate any such additional flood risk. This FRA will enable a future developer to apply the sequential test (as required within the NPPF) to development proposals and any mitigation measures in order to control any residual flood risks.

The land acquired is approximately 1062 ha in total, largely within the parishes of Hunsdon & Eastwick and Gilston. The masterplan proposals consist of a series of village developments on gently sloping land rising north above the River Stort valley and the adjacent A414. The villages and associated infrastructure occupy an area in the order of 280 ha. The remaining ownership is to be left as open space. Figure 1 gives a location plan and Figure 2 shows the boundaries of the development area (excluding off site highway works).

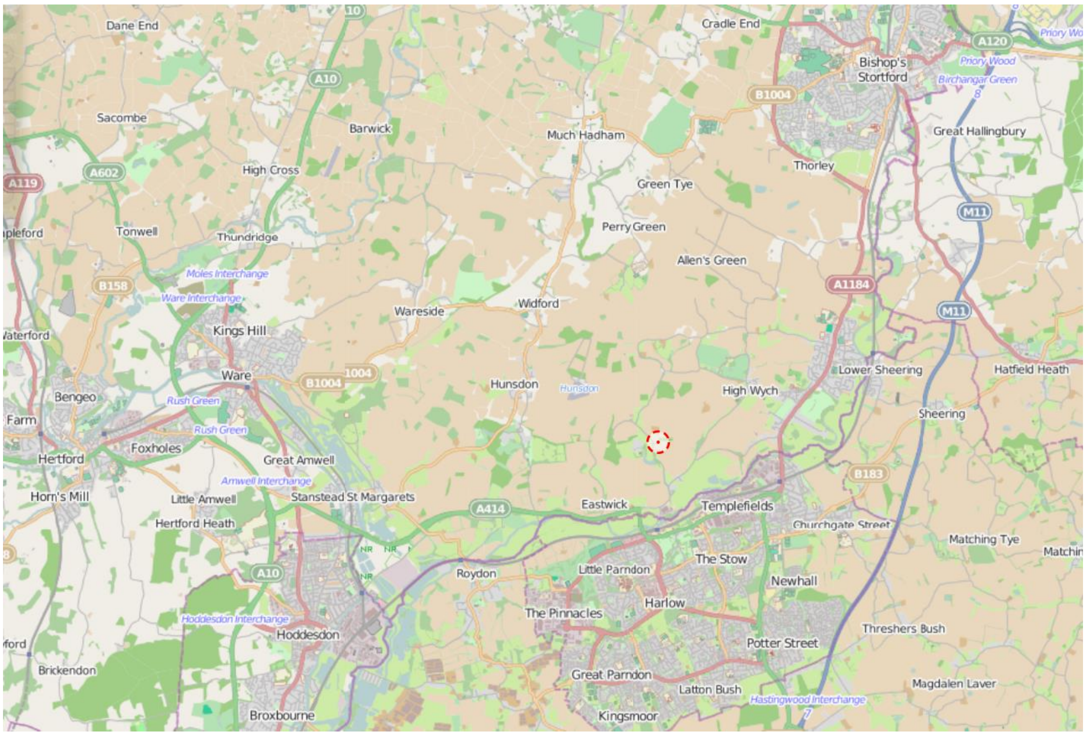

Figure 1 – Location Plan

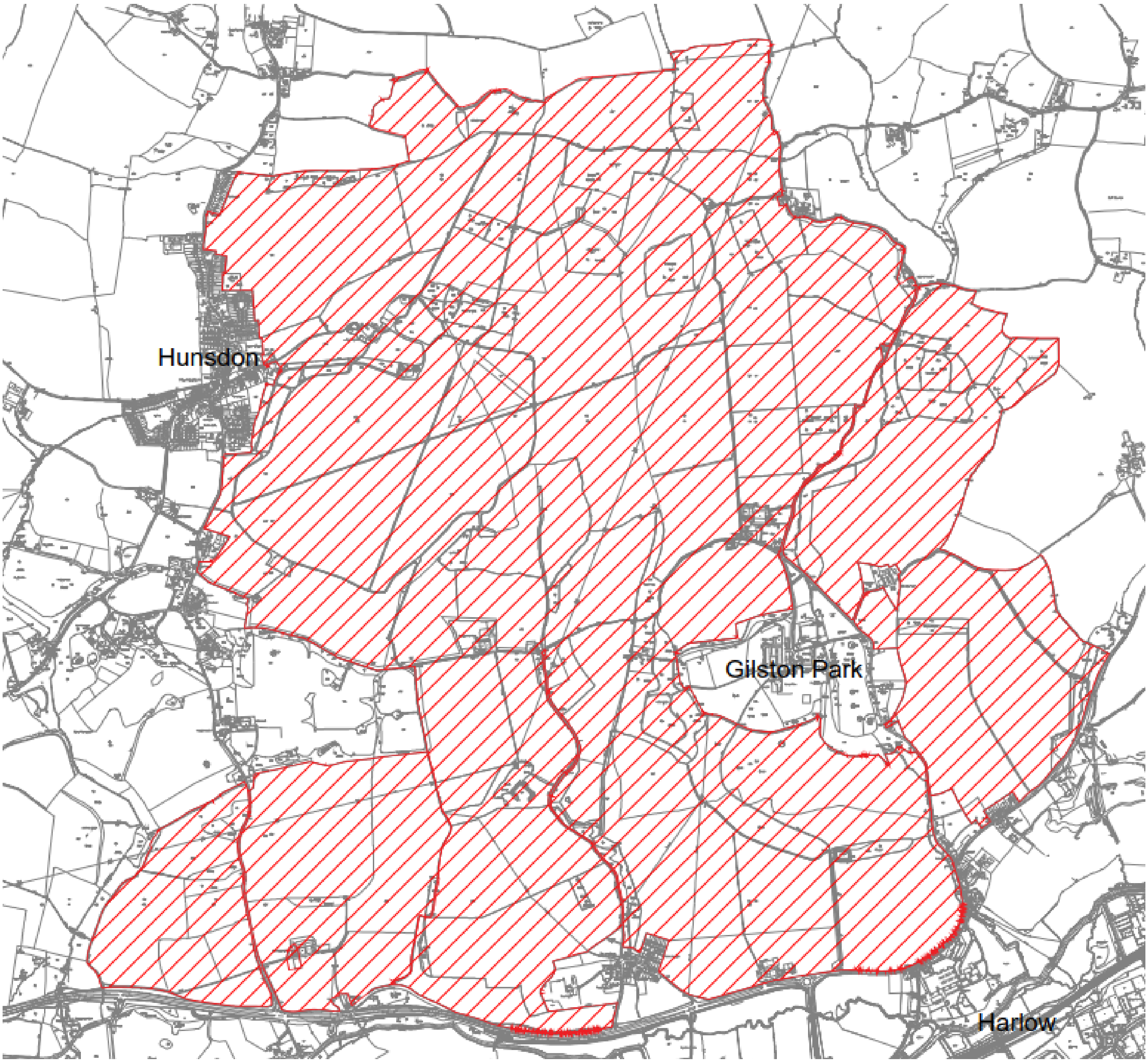

Figure 2 - Development Boundary
(excluding future highway crossings & utility infrastructure connections)

The great majority of proposed development will lie outside the EA designated flood zones 2 and 3 with only some associated infrastructure (road linkages, SuDS features, etc) located within flood zone 2. Proposed bridge crossings over the River Stort between Harlow and the A414 will have piers and abutments and embankments within flood zone 3 and the affect of these will be compensated for.

Proposed development occurs on ‘Greenfield’ land and a considerable volume of additional surface water runoff could be generated by the development if appropriate measures are not taken to attenuate the rate and volume of the additional runoff. This Flood Risk Assessment has therefore been prepared in compliance with the requirements set out for FRA’s in the National Planning Policy Framework 2012 (NPPF), in order to:

- Develop an understanding of possible flooding mechanisms at the site.
- Review the development proposals within the context of the overall catchment.
- Identify and evaluate available data related to flood risk.
- Provide an initial and preliminary quantitative assessment of the potential impact of, and constraints to, the proposed development site.
- Examine the impact of future Climate change.

A Level 1 SFRA report has been assembled by East Herts Council (dated November 2008). The report is available from their websie and it has been reviewed as part of this assessment. This FRA will make use of information contained within the SFRA where appropriate.

Background and Supporting Information

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2 Background and Supporting Information

2.1 Location and Description

The development area is at present an extensive tract of rolling farmland on the northern slopes of the Stort Valley, bisected by three tributary valleys. It is a largely arable landscape, with a number of blocks of deciduous woodland on high land to the north of the development area. The small villages of Eastwick and Gilston are situated within the proximity of the development. Eastwick is situated to the south of the development and Gilston Park, a large house surrounded by its own parkland is situated near the centre. However, both are excluded from the development area.

2.2 Development Type

Principally residential, the Gilston Area will also include some local retail development and land dedicated to educational, recreational and amenity use.

2.3 Local Watercourses

The proposed villages are located around four tributary streams flowing towards the River Stort from the north. Hunsdon Brook and Eastwick Brook are on the western side, centrally Fiddlers Brook and on the east side, Pole Hole Brook. Gilston Park with its surrounding parkland and lake lies in the centre of this area. It does not form part of the proposed development. There are two additional water courses within the development area; a small un-named water course between Pole Hole and Fiddlers Brook that picks up the field drainage below Rectory Plantation. This then discharges via a culvert under Eastwick Road and the landfill area to the south to a field drain. Additionally, Stone Basin spring lies between Brickhouse Farm and Eastwick Manor and picks up local field drainage. This collects in a localised area before discharging under the A414 via a culvert and into the Stort.

The ownership area to the north of the proposed villages will remain undeveloped and retained undisturbed as a valuable natural habitat. It comprises a number of separate blocks of woodland (Eastwick, Black Hut, Lawns, Queens, Battles, Mole and Maplecroft Woods) and the intervening farmland.

2.4 New Stort Valley Crossings

Ownership includes areas south of the A414 within the Stort floodplain. It is not intended to extend any of the development into the floodplain which will be retained as an amenity and landscape area. The existing A414 (Harlow to Hertford) road which crosses the floodplain on an embankment is to be widened to cater for the increased traffic capacities. However, the increase in capacity will be achieved by an adjacent bridge structure over the flood plain. A further bridged crossing of the Stort valley is proposed to connect the A414 with Harlow New Town, to the East of the existing crossing.

2.5 Drainage Overview

The proposed development will incorporate Sustainable Urban Drainage Systems (SuDS) on a large scale as an integral part of the development. These will not only provide a high degree of flood flow attenuation before any storm runoff is discharged to a local watercourse but will also attempt to maximise the infiltration of stored runoff to underlying strata within the constraints of the permeability of the soil and subsoil in the development area and thus reduce the overall volume of storm water discharged. The large scale use of SUDS will also provide an opportunity for significant ecological and landscape enhancement within the development area.

The Foul water drainage will include:

- Collection of sewage using conventional foul drainage system, designed and built to adoptable standards.
- Two connection locations to Thames Water's existing Trunk Sewer running along the Stort Valley.

Outline details of the proposed foul sewerage systems of the Gilston Area development area are given in the Drainage Strategy and Assessment Section.

Assessment of Flood Risk

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3 Assessment of Flood Risk

This Flood Risk Assessment is in accordance with the National Planning Policy Framework 2012 (NPPF). The Environment Agency (EA) need to be satisfied that the proposals for development address the risk of flooding to the development site and will not in turn increase the risk of flooding to neighbouring land and property.

This report will, in accordance with the NPPF (and the accompanying Technical Guidance document), propose preventative measures to mitigate against flooding from any source, if found necessary.

The report will also examine the surface water drainage strategy for the scheme to establish constraints and design requirements and to promote the use of Sustainable Drainage Systems (SuDS), as applicable.

3.1 Summary of Requirements of NPPF

NPPF requires the FRA to consider all potential forms of flooding, including river, sea, estuary, land drainage, groundwater, surface water run-off, flooding from sewer systems, flooding from reservoirs and canals, etc and should consider the impact of flooding on both the development and off site parties and land. Appendix 1 contains further information on its requirements.

3.1.1 Flood Risk and Vulnerability

Flood risk takes account of both the probability and the consequences of flooding (i.e. vulnerability of the development etc.). Flood frequency is usually interpreted in terms of the return period e.g. 1 in 50 and 1 in 100-year event etc. In betting terms, there is a 1/50 (2%) chance of one or more 1 in 50-year floods occurring in a given year. Similarly, there is a 1/100 (1%) chance of one or more 1 in 100-year floods occurring in a given year.

Vulnerability classifications, as defined in the NPPF Technical Guidance document, are Essential Infrastructure, Highly Vulnerable, More Vulnerable, Less Vulnerable and Water Compatible Development. Appendix 1 contains a detailed description of which types of development fall into each vulnerability classification.

3.1.2 Flood Zones

There are four classifications for flood zones, as defined in the NPPF:

- Zone 1
  Low probability (less than 1 in 1000 annual probability of river or sea flooding in any year);
- Zone 2
  Medium probability (between 1 in 100 and 1 in 1000 annual probability of river flooding or between 1 in 200 and 1 in 1000 annual probability of sea flooding in any year);
- Zone 3a
  High probability (1 in 100 or greater annual probability of river flooding in any year or 1 in 200 or greater annual probability of sea flooding in any given year);
- Zone 3b
  High probability (functional flood plain - essentially the 1 in 20 or greater annual probability of flooding in any given year).

3.1.3 The Sequential Test and Exception Test

The Sequential Test is a risk-based test that should be applied at all stages of development and aims to steer new development to areas with the lowest probability of flooding (Zone 1). This is applied by the Local Authority by means of a Strategic Flood Risk Assessment (SFRA).

Furthermore, large sites partially affected by Flood Zones 2 and 3 should be developed sequentially, placing the most vulnerable land uses in the areas with lowest risk of flooding. Further details of the Sequential Test are provided in Appendix 1.

The SFRA may require the Exception Test to be applied to certain forms of new development. The test considers the vulnerability of the new development to flood risk and, to be passed, must demonstrate:

- There are sustainability benefits that outweigh flood risk.
- It is on previously developed land or there are no other reasonably developable sites.
- The new development is safe without increasing flood risk elsewhere.

Further details of the Exception Test are provided in Appendix 1.

3.1.4 Climate Change

The NPPF makes it a planning requirement to account for climate change in the proposed design. The recommended allowances are summarised in Table 1.

Parameter / **Horizon**	**1990 to 2025**	**2025 to 2055**	**2055 to 2085**	**2085 to 2115**
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
Offshore wind speed	+5%		+10%	
Extreme wave height	+5%		+10%	

Table 1: Climate change allowances (Extract from NPPF Technical Guidance, Table 5)

3.1.5 Future Climate Change

It should be noted that on the 19th of February 2016 the Environment Agency published updated guidance on Climate Change allowances. However, the existing River Stort model and Gilston Area SuDS calculations were undertaken using the above Climate Change criteria and were submitted to the EA prior to this date. Environment Agency approval for the River Stort flood model for the above Climate Change criteria was approved on 18th March 2016 (See Appendices). It is anticipated that for any future planning application the latest EA climate change allowance criteria will need to be considered as part of any Flood Risk Assessment.

The future peak river flow allowances show the anticipated changes to peak flow by river basin district. For the Gilston Area this will be the Thames River Basin District.

Making allowance for climate change in future flood risk assessments will help to minimise vulnerability and provide resilience to flooding and coastal change in the future.

The climate change allowances are predictions of anticipated change for:

- peak river flow by river basin district
- peak rainfall intensity
- sea level rise
- offshore wind speed and extreme wave height

These are based on climate change projections and different scenarios of carbon dioxide (CO_2) emissions to the atmosphere. There are different allowances for different epochs or periods of time over the next century.

The updated range of allowances are based on percentiles. A percentile is a measure used in statistics to describe the proportion of possible scenarios that fall below an allowance level. The 50th percentile is the point at which half of the possible scenarios for peak flows fall below it and half fall above it. The:

- central allowance is based on the 50th percentile
- higher central is based on the 70th percentile
- upper end is based on the 90th percentile

So, if the central allowance is 30%, scientific evidence suggests that it is just as likely that the increase in peak river flow will be more than 30% as less than 30%.

At the higher central allowance 70% of the possible scenarios fall below this value. So, if the higher allowance is 40%, then current scientific evidence suggests that there is a 70% chance that peak flows will increase by less than this value, but there remains a 30% chance that peak flows will increase by more.

The EA will use the following data and standards as the benchmarks for the advice it gives as a statutory consultee:

- peak river flow allowances by river basin district for both flood risk assessments and strategic flood risk assessments
- flood risk vulnerability classification for the type of development and flood zone, over the lifetime of the proposed development, in development plan allocations for strategic flood risk assessments
- flood risk vulnerability classification for the type of development and flood zone as a guide to decide which allowances to use based on the vulnerability of the development for flood risk assessments - you should consider the lifetime of the proposed development to decide which future time period to use

Peak River Flow allowances for the Thames Valley area are as follows:

River basin district	Allowance category	Total potential change anticipated for ‘2020s’ (2015 to 39)	Total potential change anticipated for ‘2050s’ (2040 to 2069)	Total potential change anticipated for ‘2080s’ (2070 to 2115)
Thames	Upper end	25%	35%	70%
	Higher central	15%	25%	35%
	Central	10%	15%	25%

Residential development is classed as “more vulnerable” and expected to last 100 years with assessment required to be undertaken on the higher central and upper end to assess the range of allowances.

For peak rainfall intensity allowance the following table will apply:

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper end	10%	20%	40%
Central	*5%*	10%	20%

Therefore SuDS will need to ensure that there is sufficient space in order to accommodate 40% Climate Change allowance within their volumes. Volumes will need to be confirmed for each village as part of the planning application process.

3.1.6 Sustainable Drainage

The key planning objectives in the NPPF are to appraise, manage and where possible, reduce flood risk. The NPPF (and covered by Part H of the Building Regulations (DTLR, 2002 incorporating 2010 amendments)), directs developers toward the use of Sustainable Drainage Systems (SuDS) wherever possible.

3.2 The Sequential Test

Although the development area is located on land that is within various Flood zones the residential proposals all lie within Flood Zone 1. Associated SuDS may occur within Flood Zone 2. There is no highly vulnerable development within Flood Zone 2 hence proposals meet the requirements of the Sequential Test.

3.3 The Exception Test

The proposed scheme is classed as “More vulnerable” and considered appropriate within Flood Zone 1. Application of the Exception Test is therefore not required.

3.4 Impact of Climate Change

Since the proposed development is residential, a minimum 100 year design life is appropriate. For a design life up to 2115 an allowance of 30% increase to peak rainfall intensity has been used at this stage. This allowance is incorporated within the design calculations for surface water run-off. An assessment of climate change on river levels should also be considered. Ground levels at residential properties nearest the River Stort are several metres higher than its 1000 year flood extent. Also, housing development is located away from the steeply sloping valleys of each of the River Stort tributary brooks. The change in river levels due to climate change is unlikely to affect the site.

As previously mentioned, further work will be required at the planning application stage to ensure that the revised Climate Change allowances for River Modelling are considered. Additionally, changes to the Peak Intensity allowances will be also need to be considered for the combined SuDS features throughout the site. However, this report provides some commentary on the implication of the additional climate change requirements.

3.5 Strategic Flood Risk Assessments

East Herts Council produced a Technical Study Level 1 Strategic Flood Risk Assessment issued November 2008 which is available on-line. Scott Wilson has also prepared for Essex County Council, a Level 1 Minerals and Waste Strategic Flood Risk Assessment, dated September 2010. Both these reports have been referred to for information relating to the risk of flooding in the area of the proposed development.

3.6 Floodplain Mapping

Various flood modelling and flood map development, for the site and locality, in consultation with the Environment Agency, has occurred over recent years as modelling software, methods and accuracy has advanced and improved. AECOM has recently modelled flood plain extents of the River Stort and the relevant tributaries near the development, arriving at agreed values for the 20, 100 (with and without climate change) and the 1000 year return events. The 100 year plus climate change and 1000 year event limits have been used to establish the form and assess the development and the associated infrastructure including SuDS proposals. Approval from the Environment Agency for this model is contained within the Appendices.

3.7 Sources of Potential Flooding

Flood risk from the following sources has been considered:

3.7.1 Tidal Flooding

Tidal flooding occurs when an exceptionally high tide, usually accompanied by a storm tide surge, overtops and/ or breaches the tidal defences along a coastline or tidal estuary. The River Stort is situated well above the upstream tidal limit in the River Lea and there are no areas within the Stort Valley that are subject to tidal flooding.

3.7.2 Fluvial Flooding

Fluvial flooding occurs as a result of the overflowing or breaching of river or stream banks when the flow in the water course exceeds the capacity of the river channel to accommodate that flow. The Gilston Area is situated on the western side of the valley of the River Stort. The southern edge of the development area extends close to the bottom of the valley and abuts the raised carriageway of the A414 Hertford to Harlow road. The floodplain of the River Stort generally extends to the south embankment of the A414. The majority of the development lies along the lower flanks of the valley, an area of undulating countryside intersected by a number of minor tributary valleys. The underlying geology of the site is London clay overlain with boulder clay.

When the flow in a river or stream exceeds the capacity of the channel to convey that flow, either because of limited cross-sectional area, limited fall, or a restricted outfall, then the water level in that channel will rise until the point is reached where the banks of the channel are overtopped. Water will then spill over the channel banks and onto the adjoining land. With an upland river the adjoining land is its natural flood plain, which will generally be of limited extent and fairly well defined. This is the case for the three Stort tributaries flowing north south through the development. Although all are classed as main rivers, none of these minor watercourses have any real floodplain and the risk of anything other than very localised flooding from them is minimal.

In the case of a sizeable river, such as the Stort, the floodplain may be a hundred metres or more in width, though it may not be equally distributed on either side of the river channel. However, due to local variations in geomorphology, the width of the floodplain may vary considerably from point to point along the river valley. Floodplains are characterised by flat, riparian land along the valley floor. In pre-industrial England, such land was regarded as liable to flooding and was traditionally reserved for grazing and stock rearing. Human settlements were commonly established beyond the edge of the floodplain. In the industrial age and more recent times with different priorities, pressures for development have resulted in the widespread colonisation of floodplains, often with steps taken to mitigate the associated risks of flooding. The River Stort floodplain in the vicinity of the proposed development consists generally of a series of meads, marshland and recreational areas. Exceptions include Parndon Mill, Burnt Mill with the Lock House and the Moorhen public house. The railway is on embankment, generally raised above the floodplain.

Flooding, especially that caused by overflowing of watercourses, can be exacerbated by operational and maintenance failures. These failures can be due to neglected or inadequate maintenance of watercourses resulting in bottlenecking and a reduction of their hydraulic capacity. Flooding can also be caused or exacerbated by bridge or culvert blockages, although these are not necessarily due to maintenance failures and may be caused by debris, natural or man-made, swept along by flood flows.

3.7.3 Pluvial Flooding

Pluvial flooding results from rainfall generated overland flow before the run-off enters any watercourse, drain or sewer. It is often linked with high intensity rainfall events (typically in excess of 30mm per hour). It can also occur with lower intensity rainfall or melting snow when the ground is saturated, frozen, developed or otherwise where the surface is of low permeability. The consequence is overland flow with pond formation at depressions in the topography. In urbanised areas, pluvial flows are likely to follow the routes of highways and other surface connectivity to low points where flooding can occur. Where water levels overtop containment at low points, flow routes may deviate to sensitive locations.

The site is presently Greenfield in general. Consequently, the potential for significant overland flows to develop is limited. Topography across the site dictates that overland flows generally fall toward the valleys of the three adjacent tributaries and eventually will discharge into the relevant brook.

The proposed development site is to be served by SuDS which will be designed to control run-off at source and mimic the existing drainage regime as close as is practically possible. Final discharges along the relevant watercourse will be controlled via a vortex control units in order that a final Greenfield discharge rate can be confirmed at specific locations.

3.7.4 Groundwater Flooding

Groundwater flooding is caused by the emergence of water from sub-surface permeable strata. Fluctuations in the groundwater table can cause flooding if the water table rises above ground levels. These flooding events tend to have long durations lasting days or weeks.

Given the ground conditions and topography of the site, flooding due to groundwater is considered very unlikely. There are no recorded incidents of groundwater flooding in the vicinity noted in the East Herts SFRA and associated maps.

3.7.5 Flooding from drains and sewers

Sewer network plans obtained from Thames Water show no public surface water sewers in the proposed development area. It is assumed that existing properties within the area have private drainage outfalls to local watercourses or possibly discharge surface water runoff to soakaways where this has been found appropriate. It is possible there may be a few private surface water sewers in the area but these, where they exist, will serve only a single property or handful of properties and have an insignificant impact on flood risk in the brook to which they discharge.

Foul sewage from a wide area is conveyed to Thames Water’s large sewage treatment works at Rye Meads, at the confluence of the Rivers Stort and Lea. The 975mm diameter Harlow Trunk Sewer runs from east to west under the Stort floodplain, receiving inflows from the Harlow urban area from the south at Town Park (450mm sewer) and at the A414 (150mm sewer). At Parndon Meads a 900mm diameter foul sewer from the western end of Harlow joins the Harlow Trunk Sewer which then increases in size to 1275mm.

The only inflow to the Harlow Trunk Sewer from the north is the 225mm foul sewer from Eastwick which joins the Trunk Sewer north of Parndon Mill. It is believed that foul sewage from Gilston and Terlings Park also joins the Trunk Sewer but the Thames Water sewer plan merely shows the local sewer from the village terminating abruptly alongside the A414 at Eastwick Lodge Farm without showing a downstream connection.

Only the Harlow Trunk Sewer is considered to pose any flood risk to the local area. It conveys sewage from urban areas upstream of Harlow. There are few older urban areas in its catchment that might be expected to contribute a combined (mixed foul and surface water) flow. The proportion of surface water runoff to the flow in the Trunk Sewer is therefore likely to be relatively small and the sewer is unlikely to be subject to excessive surcharging during storm conditions with a consequent risk of localised flooding. Also, infiltration leakage to the sewer and illegal surface water connections are considered unlikely to contribute significantly to flows in this sewer. Its potential flood risk is limited to the River Stort floodplain.

3.7.6 Flooding from Water mains

Twin Affinity Water trunk mains (21 and 18 inch diameter) run through the site between Villages 5 and 6. As they enter the proposed development area, they follow the Eastwick Brook valley before diverting east to the north of Eastwick Village. Road crossings and proposed SuDS are the only development close to the water mains and these will maintain a minimum 1.2m deep ground cover over as agreed with Affinity Water. The topography of the site is such, that if a burst should ever occur, flood water will follow the Eastwick brook valley, unlikely to directly affect the proposed development located on higher ground. The risk of flooding from a burst water main is generally low since it is in the interest of the water company to exercise a good monitoring and maintenance regime and ensure measures are in place to quickly isolate leakage or bursts.

3.7.7 Flood Risk from Artificial sources

Non-natural or artificial sources of flooding can include reservoirs, canals and lakes where water is retained above natural ground level. There are no reservoirs within the vicinity. Gilston Park Lake is an ornamental lake formed by artificially enlarging an area adjacent to Fiddlers Brook. It lies central to the proposed Villages and extends approximately 400m along the valley. A breach of the existing embankment at the eastern end of the lake could result in flooding downstream. However, since there is no development, other than SuDS proposed within the valley of Fiddlers Brook there will be no direct risk to the proposed development.

Drainage Strategy and Assessment

04

4 Drainage Strategy and Assessment

4.1 The Proposed development

The Gilston Area development comprises seven closely linked villages, each with an individual architectural character. Each village development is, for the purpose of reference, numbered 1 to 7. Village 1 ('Southern Slopes') would be the earliest development and lies opposite the existing A414 crossing of the River Stort. Each village is progressively numbered in an anti clockwise direction. The masterplan layout with associated major SuDS features is included in appendix 2. This version of the masterplan accommodates approximately 10,000 dwellings with schools, some local retail and employment, play and recreation areas and other associated infrastructure. The villages are located each side of the valleys of three tributaries of the River Stort, namely from west to east, Eastwick Brook, Fiddlers Brook and Pole Hole Brook. The surface water drainage strategy will be split to take into consideration development phasing.

4.2 Proposed Surface Water Arrangements

The development of 'greenfield' land will inevitably result in the generation of additional surface water runoff from the land after development. Surface water run-off from hard, impermeable surfaces can increase the incidence of localised and regional flooding. Almost all of the Gilston Area development is at present agricultural land and is therefore 'greenfield' in nature. It follows that the generation of additional surface water runoff will require attenuation before discharge to the local watercourse in order to limit and elongate flows to the watercourse in order to mimic as far as possible the existing Greenfield drainage regime.

The Gilston Area development will incorporate the principles of sustainable development and the surface water drainage methods adopted will take account of the associated quantity, quality, biodiversity and amenity issues and aspirations. In order to achieve these principles, sustainable drainage systems (SuDS) will be used. Focal points of the drainage strategy will be water features that will be partially sustained by the surface water run-off from the development. A mix of detention basins and retention ponds generally run parallel with the tributary valleys which will provide the final and the anticipated bulk of surface water attenuation prior to release through strategic flow controls to the local watercourse. Surface water will discharge into these features from swales, surface flood pathways, piped networks, etc within the neighbourhoods of the development.

4.3 Existing Surface Hydrology

The site is drained by the River Stort and its tributaries, Hunsdon Brook, Eastwick Brook, Fiddlers Brook and Pole Hole Brook. The River Stort flows from east to west along the southern margin of the site to the confluence with the River Lee approximately 3km south-west of the site.

The River Stort has complex hydrology due to the presence of a series of inter-connecting drainage channels of various levels, irrigating the main valley floor and providing drainage and pollution control functions for the industrial areas on the south of the valley. Most notably the natural river channel has been canalised along part of the valley, except for a length of around 1km immediately to the south of the development. In this area an additional section of dedicated canal has been constructed together with a marina located to the north of Harlow station.

Hunsdon Brook is classed as a main river and is located to the west of the site, originating from the area around Hunsdon and flowing in a north-south direction via a culvert underneath the A414, before discharging into the River Stort. Only the proposed village 7 which lies to the east of the Hunsdon Brook discharges to the brook.

Eastwick Brook is located within the western part of the site and flows generally south to discharge into the River Stort. The proposed Village 6 lies west of Eastwick Brook. This is classified as a 'main river' and rises northwest of the development site. The Brook is fed by several springs and natural land drainage as it winds its way down a shallow valley to Eastwick Village. The Brook runs through the village, passes in culvert beneath the A414 and outfalls to the River Stort.

Fiddlers Brook, also known in part, as Golden Brook, is a 'main river' and flows through the site generally from north to south before outfalling to the River Stort. The Brook is crossed a number of times by road culverts. As the Brook runs through the ground of Gilston Manor, it has been artificially dammed to create a lake with a weir arrangement at the downstream end. It is understood the lake was created to provide power to drive an electric generator for Gilston House, in the early part of the twentieth century. The lake does not perform any balancing function. The weir on the lake and the culvert and road crossings are the only control structures on Fiddlers Brook through the site.

Pole Hole Brook is a 'main river' and bounds the site in the south-east of the development. The Brook follows a shallow valley and passes by Pole Hole Farm before joining the River Stort at the western edge of the gravel workings.

Stone Basin spring lies between Brickhouse Farm and Eastwick Manor and picks up local field drainage. This collects in a localised area before discharging under the A414 via a culvert and into the Stort.

A small un-named water course between Pole Hole and Fiddlers Brook that picks up the field drainage below Rectory Plantation. This then discharges via a culvert under Eastwick Road and the landfill area to the south to a field drain.

It is on record that most of the watercourses on the site, including Eastwick Brook, have low flows during rain-free periods and Fiddlers Brook has been dry along part of its length.

4.4 Ground Investigation and Soakage Tests

From review of existing soils reports, infiltration is not thought to be a viable SuDS technique to use on the site due to the cohesive nature of the underlying soils, subject to further soakage testing at a local level. Therefore, to establish the extent of the strategic SuDS, direct infiltration techniques have not been considered at this stage and a zero infiltration rate has been assumed in the assessment of the strategic SuDS.

4.5 SuDS Strategy – General Principles

The proposed drainage strategy will be designed so as not to exacerbate any existing flood risk associated with properties upstream or downstream of the site.

SuDS will be implemented throughout the development scheme. The conceptual SuDS strategy is in accordance with the principles outlined within Hertfordshire County Council (HCC) Interim SuDS Policy Guidance.

Climate change and its potential impact on development is a factor that influences the drainage strategy. The development is principally residential. Assuming a typical lifespan of 100 years, the contingency allowances for climate change set out by the EA in a recent update on Climate Change allowance states that a range between 20% and 40% should be assessed. Due to the timing of the EA update, the SuDS assessment across the site has considered the previous allowance of 30% increase in peak rainfall intensity. However, for the western village (Village 7) an assessment has been undertaken to ensure that the additional 10% climate change can be accommodated into the development layout (see Appendices). This demonstrates that sufficient volume is available in order to achieve an allowance of 40% climate change.

The on-street SuDS proposals for Villages 1 through to 6 incorporate a greater volume SuDS by comparison to Village 7, with the inclusion of street-side rills, SuDS channels, street-side swales and roadside swales and therefore it can be assumed that there will be will be sufficient volume available in order to achieve an allowance of 40% climate change.

All proposed attenuation basins and ponds are situated outside the agreed fluvial 1 in 100 year flood level, incorporating an allowance for climate change, to avoid loss of attenuation storage during flood conditions. Where possible, this will extend to the agreed fluvial 1 in 1000 year flood level.

Currently, Hertfordshire County Council as the Lead Local Flood Authority does not adopt SuDS features and therefore a third party Management and Maintenance Company will need to be appointed to manage the maintenance of the SuDS throughout the lifetime of the development. An adoption agreement between the Developer and the third party company will be based upon the CIRIA Interim Code of Practice MA2 SuDS Maintenance Framework Agreement.

Strategic SuDS provision within the scheme design has been identified. Due to the level of detail within the scheme layout at this stage, local SuDS within the village neighbourhoods are not determined. However, the intention is for SuDS in the form of source control measures to be used as part of the management train to reduce pollution, flow rates and volumes.

4.6 Neighbourhood Details

As implied above, at this stage, a typical neighbourhood layout does not exist. Therefore, the number of different neighbourhood layouts and building typologies could be significant. In light of this, the SuDS Strategy will follow the main series of Hertfordshire County Council's SuDS principles that would be adopted dependent upon the type and size of actual plot development.

The strategy is to limit and control surface water runoff through hierarchal SuDS conveyance, and may include but not be limited to the following examples:

- Where appropriate - water butts, green roofs, permeable paving within courtyards, local parking, etc, with restricted discharge into the downstream SuDS.
- Street side rills, ditches, bio swales etc. A swale and linkage pipe system that provides attenuation, possible partial infiltration during transfer of surface water through the system to downstream SuDS.
- Linked storage ponds constructed toward the termination of the SuDS before controlled discharge at discreet locations to the local watercourse.

4.7 Strategic SuDS

The site has relatively steep gradients (generally 1:30) and this presents a challenge in terms of creation and utilisation of storage volume. Where possible, swales will be aligned parallel to contour lines to maximize the storage and surface area for infiltration. Where this is not possible, due to a need to be aligned to suit the streetscape or landscape features, they may follow the slope. Weirs will need to be included at intervals and designed to retain the surface water, increase storage volume and also enable easy maintenance.

Currently the SUDS system has been designed to accommodate a 100-year storm with a +30% allowance for climate change. Any future planning application will be required to demonstrate that there is sufficient space within the proposed development to incorporate the additional 10% for future climate change. The strategic SuDS are currently located in areas where there is room for expansion and with the incorporation of on-street SuDS it is unlikely that accommodating the 40% climate change will be a problem.

The drainage scheme will enhance the high quality open green spaces, with the swale and pond network providing 'green fingers' extending from the tributary valleys into the public realm, enhancing the local biodiversity. Health and safety will be a high priority in the planning and design stages.

Account of sustainable drainage at source has not been included specifically for reduction of run-off quantities and storage volumes required i.e. the provision of on street SuDS channels is considered as conveyance only and to contribute 100% run-off to the downstream drainage. Green roof, on plot retention and any infiltration is also not considered for villages 1-7. This is to negate the current unknown details and to arrive at an overall strategic SuDS layout for this large development site. The strategic SuDS extents (basins and ponds discharging to the local watercourse) have been established on the assumption that attenuation basin areas are required to equal 10% of the hard surface areas. With hard (impermeable) surface assumed to be 50% of the developable area. Following this strategy, there is sufficient space to provide the attenuation required as indicated on the plan in appendix 2. However, at this stage, detailed contouring and hence specific attenuation volumes have not been detailed. These will form part of any future planning application and can be combined with proposed SuDS applications required that will form part of any future village masterplan. These will also identify source attenuation volumes prior to discharge to the SuDS basins. SuDS basins will therefore need further consideration at the planning application stage and will also be subject to the availability of detailed topographical and arboricultural information. For village 7, the assessment has considered on street parking and planter areas as SuDS. This has determined that there will be sufficient volume available for attenuation to cope with a 1 in 100 year storm event plus 40% Climate Change, which demonstrates that there will be resilience within the development proposals to cope with the future climate change requirements.

It is important that regular hydraulic reviews of phase by phase drainage planning are carried out with regard to the balance between source control and the run-off to watercourses.

4.8 Surface Water Runoff Rates and Volumes

The existing Site is currently undeveloped farm land, therefore a Greenfield runoff assessment has been carried out for the Site using an Interim Code of Practice run-off assessment which is based upon IoH 124 methodology. Results of Windes ICP calculation as follows:

Return Period (years)	100	30	1	QBAR
GF runoff rate (l/s/ha)	8.37	5.95	2.2	2.62

Refer to Appendix 3 for Windes calculations

SuDS Land Take – Indicative Attenuation Storage Area (All areas in Hectares)

Catchment Area (Village)	1	2	3	4	5	6	7	Total
Assumed impermeable area - 50% Development area (ha)	25.29	32.61	17.34	38.01	11.87	21.32	26.9	173.34
Assumed min basins area – 10% of impermeable area (ha)	2.53	3.26	1.73	3.8	1.19	2.13	2.69	17.33
Volume at 0.5m x basin area (m3)	12650	16300	8650	19000	5950	10650	13450	86650
Windes Quick Storage estimate (m3) for 100 year return period + 30% climate change. Allowable discharge 8l/s/ha	12543 to 16640	16139 to 21456	8600 to 11410	18811 to 25009	5887 to 7809	10573 to 14027	13341 to 17699	84906 to 113841

1.2 Health and Safety Assessment

Subject to local topography, the proposed layout of the SuDS features will be designed in accordance with the emerging National SuDS Standards and supplemented where appropriate with guidance from the Lead Local Flood Authority (Hertfordshire County Council) to ensure that they are effective, not only from hydraulic but also from a safety perspective during construction, operation and maintenance.

A management strategy of improving public awareness and understanding of the risks of surface water within the public realm could be implemented, rather than erecting impenetrable barriers across the site. This could take the form of information boards throughout the site which would be used as an educational tool for the public.

Residual Risks and Mitigation

05

5 Residual Risks & Mitigation

Consideration of residual flood risk is required in accordance with the NPPF. There is a residual risk of flooding occurring from the following circumstances:

- An exceptionally extreme flood event in the River Stort and its north bank tributaries.
- An on-site rainfall event in excess of 1 in 100 years plus climate change allowance that results in flooding from the proposed site surface water systems.
- Breach or failure of the downstream impoundment of the Gilston Park ornamental lake.
- Flooding from blockage of bridge aperture, culvert, etc, particularly by large flood borne debris or fallen trees.
- Poorly maintained SuDS flow control devices.

Mitigation of these residual risks will be managed by:

- Ensuring proposed development is located well above the valley floors and higher than the established 1 in 1000 year flood level.
- Provide new or improved tributary road crossings with a minimum road surface level above the 100 year plus climate change flood level and that the bridge aperture or culvert is sized to pass a flood peak of that minimum magnitude without significant afflux upstream of the crossing.
- Provide safe, dry access/ egress to and from the site.
- Construction of finished floor levels to be 150mm above surrounding ground levels.
- Adoption and long term maintenance of SuDS by Herts County Council or Management Company as applicable.
- Regular inspection and maintenance of main river bridge aperture / culverts by the Environment Agency.

Conclusions

06

6 Conclusions

As a result of this flood risk assessment the following conclusions have been reached:

No part of the proposed development area is in the functional floodplain or high probability zone as defined by the NPPF.

Triggered by development phases, two River Stort crossings will be required. These will be widening of the existing embankment structure for the existing Stort Crossing (5th Avenue) and bridge structures with pier support and foundations within the River Stort floodplain for the future Eastern Crossing. Any landscaping works proposed within the River Stort floodplain is to maintain the existing public open space or improve accessibility without compromise to the existing flood zone.

Detailed hydrological and hydraulic modelling of the River Stort and its tributaries undertaken in connection with previous assessment and recent update has enabled Flood Risk Maps of the development area to be prepared. These maps reinforce the conclusion indicated by the Agency's Flood Map that, apart from the public open spaces etc on riparian land no significant part of the proposed development is at risk of flooding from primary flood risk sources. Environment Agency approval of the flood model is contained within the appendices.

Development associated infrastructure, including strategic SuDS basins will generally be located within the established flood zone 1 area. Exception to this will only be subject to space restricted locations, i.e. due to topography and boundary conditions where basins will be located within Flood Zone 2 but out of Flood Zone 3.

There are very few existing foul or surface water sewerage systems in the development area, none of which pose a flood risk to the development. The only sewer of any significance is the 975mm diameter Harlow Trunk Sewer, a major foul sewer which runs from east to west under the Stort floodplain parallel with the southern edge of the development and within land intended to remain as a public open space.

The development area drains naturally to the River Stort and to four of that river's tributaries which flow through the development area – the Hunsdon, Pole Hole, Fiddlers and Eastwick Brooks. All these watercourses are Main Rivers under the Environment Agency classification.

Flood risk within the development area arising from surcharging of the local surface water drainage systems can be reduced or eliminated by appropriate design of those systems and the layout of the development so that any extreme event flooding is confined to public open spaces, roads or other paved areas with exceedence flood routing to follow natural topography through green corridors to the local Stort tributary valleys.

A range of residual risks of flooding have been identified but none are considered to pose a significant risk to the development area.

The proposed development will result in the generation of significant quantities of additional surface water runoff but discharges of runoff to local watercourses can be restricted to existing Greenfield runoff rates by appropriate design of SuDS incorporating storm runoff storage and flow attenuation devices.

Infiltration rates through ground surfaces in the development area are likely to be restricted by the relatively limited permeability of the majority of the natural soils and subsoils within the area. This does not preclude the incorporation of SuDS assuming partial infiltration may occur. However, subject to any favourable results from local soakage testing, the design of SuDS will assume a zero infiltration rate in the design calculations.

The Environment Agency has agreed variable Greenfield runoff rates related to flood event return period for use in the design of the development's surface water drainage systems as far as practically possible. A sliding scale of Greenfield runoff rates applicable to the local tributary watercourses has been established for this purpose.

There is not considered to be any appreciable residual risk to the development area resulting from extreme hydrological events.

There is low risk to the development should flood waters flow down Fiddlers Brook due to breaching of the embankment at Gilston Park Lake as no development is proposed within the tributary valleys.

This Flood Risk Assessment has considered all potential sources of flooding that may be associated with the site and identified that the site is at low risk from flooding.

The proposed development would be considered as ‘more vulnerable’ according to the NPPF and considered acceptable within Flood Zone 1.

It is proposed to mimic the existing Greenfield runoff regime (as far as is practicable) of discharging surface water flows to the adjacent River Stort tributaries. Surface water discharge from the site will be attenuated to equivalent Greenfield runoff rates. Storage for attenuated volumes up to and including the 1 in 100 year plus 30% climate change event will be provided within ‘strategic’ on-line ponds and attenuation basins discharging via flow control devices.

Mitigation of residual flood risks is to be incorporated in to the development design and maintenance regime.

This Flood Risk Assessment has concluded that the flood risk to the existing site is acceptable in relation to the proposed scheme, and furthermore that the proposed scheme will not increase flood risk to other sites.

Appendices

Appendix 1: Extract from Technical Guidance to the NPPF

Flood risk

As set out in the National Planning Policy Framework, inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. For these purposes:

- “areas at risk of flooding” means land within Flood Zones 2 and 3; or land within Flood Zone 1 which has critical drainage problems and which has been notified to the local planning authority by the Environment Agency;
- “flood risk” means risk from all sources of flooding - including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources.

The Sequential and Exception Tests

As set out in the National Planning Policy Framework, the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. The flood zones (see table 1) are the starting point for this sequential approach. Zones 2 and 3 are shown on the flood map[1] with Flood Zone 1 being all the land falling outside Zones 2 and 3. These flood zones refer to the probability of sea and river flooding only, ignoring the presence of existing defences.

Strategic Flood Risk Assessments (see paragraphs 7-8) refine information on the probability of flooding, taking other sources of flooding and the impacts of climate change (see paragraphs 11-15) into account. They provide the basis for applying the Sequential Test, on the basis of the flood zones in table 1. Where table 1 indicates the need to apply the Exception Test (as set out in the National Planning Policy Framework), the scope of a Strategic Flood Risk Assessment will be widened to consider the impact of the flood risk management infrastructure on the frequency, impact, speed of onset, depth and velocity of flooding within the flood zones considering a range of flood risk management maintenance scenarios. Where a Strategic Flood Risk Assessment is not available, the Sequential Test will be based on the Environment Agency flood zones.

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

1 To access the flood map, see the Environment Agency’s website at:
http://www.environment-agency.gov.uk/homeandleisure/floods/default.aspx3

Table 1: Flood zones

(Note: These flood zones refer to the probability of river and sea flooding, ignoring the presence of defences)

Zone 1 - low probability **Definition** This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%). **Appropriate uses** All uses of land are appropriate in this zone. **Flood risk assessment requirements** For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a flood risk assessment. This need only be brief unless the factors above or other local considerations require particular attention. **Policy aims** In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage systems[2].
Zone 2 - medium probability **Definition** This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year. **Appropriate uses** Essential infrastructure and the water-compatible, less vulnerable and more vulnerable uses, as set out in table 2, are appropriate in this zone. The highly vulnerable uses are *only* appropriate in this zone if the Exception Test is passed. **Flood risk assessment requirements** All development proposals in this zone should be accompanied by a flood risk assessment. **Policy aims** In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of sustainable drainage systems.

[2]Sustainable drainage systems cover the whole range of sustainable approaches to surface drainage management. They are designed to control surface water run off close to where it falls and mimic natural drainage as closely as possible.

Zone 3a - high probability
Definition
This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
Appropriate uses
The water-compatible and less vulnerable uses of land (table 2) are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone.
The more vulnerable uses and essential infrastructure should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood.
Flood risk assessment requirements
All development proposals in this zone should be accompanied by a flood risk assessment.
Policy aims
In this zone, developers and local authorities should seek opportunities to:

- reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems;
- relocate existing development to land in zones with a lower probability of flooding; and
- create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.

Zone 3b - the functional floodplain
Definition
This zone comprises land where water has to flow or be stored in times of flood.
Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.
Appropriate uses
Only the water-compatible uses and the essential infrastructure listed in table 2 that has to be there should be permitted in this zone. It should be designed and constructed to:

- remain operational and safe for users in times of flood;
- result in no net loss of floodplain storage;
- not impede water flows; and
- not increase flood risk elsewhere.

Essential infrastructure in this zone should pass the Exception Test.
Flood risk assessment requirements
All development proposals in this zone should be accompanied by a flood risk assessment.
Policy aims
In this zone, developers and local authorities should seek opportunities to:

- reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems;
- relocate existing development to land with a lower probability of flooding.

Table 2: Flood risk vulnerability classification

Essential infrastructure

- Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk.
- Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood.
- Wind turbines.

Highly vulnerable

- Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding.
- Emergency dispersal points.
- Basement dwellings.
- Caravans, mobile homes and park homes intended for permanent residential use[3].
- Installations requiring hazardous substances consent[4]. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as "essential infrastructure")[5].

More vulnerable

- Hospitals.
- Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
- Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels.
- Non–residential uses for health services, nurseries and educational establishments.
- Landfill and sites used for waste management facilities for hazardous waste[6].
- Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.[7]

[3] For any proposal involving a change of use of land to a caravan, camping or chalet site, or to a mobile home site or park home site, the Sequential and Exception Tests should be applied.
[4] See Circular 04/00: *Planning controls for hazardous substances* (paragraph 18) at: www.communities.gov.uk/publications/planningandbuilding/circularplanningcontrols
[5] In considering any development proposal for such an installation, local planning authorities should have regard to planning policy on pollution in the National Planning Policy Framework.
[6] For definition, see *Planning for Sustainable Waste Management: Companion Guide to Planning Policy Statement 10* at www.communities.gov.uk/publications/planningandbuilding/planningsustainable
[7] See footnote 3.

Less vulnerable
• Police, ambulance and fire stations which are not required to be operational during flooding. • Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in “more vulnerable”, and assembly and leisure. • Land and buildings used for agriculture and forestry. • Waste treatment (except landfill and hazardous waste facilities). • Minerals working and processing (except for sand and gravel working). • Water treatment works which do not need to remain operational during times of flood. • Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).
Water-compatible development
• Flood control infrastructure. • Water transmission infrastructure and pumping stations. • Sewage transmission infrastructure and pumping stations. • Sand and gravel working. • Docks, marinas and wharves. • Navigation facilities. • Ministry of Defence defence installations. • Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location. • Water-based recreation (excluding sleeping accommodation). • Lifeguard and coastguard stations. • Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms. • Essential ancillary sleeping or residential accommodation for staff required by uses in this category, *subject to a specific warning and evacuation plan*.

Notes to table 2:

a. This classification is based partly on Department for Environment, Food and Rural Affairs and Environment Agency research on *Flood Risks to People* (*FD2321/TR2*)[8] and also on the need of some uses to keep functioning during flooding.

b. Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

c. The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

[8] See website for further details. www.defra.gov.uk/science/Project_Data/DocumentLibrary/FD2320_3364_TRP.pdf

Table 3: Flood risk vulnerability and flood zone 'compatibility'

Flood Risk Vulnerability classification (see Table 2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	✗	Exception Test required	✓
	Zone 3b 'Functional Floodplain'	Exception Test required	✓	✗	✗	✗

Key: ✓ Development is appropriate.
✗ Development should not be permitted.

Notes to table 3:
This table does not show:

a. the application of the Sequential Test which guides development to Flood Zone 1 first, then Zone 2, and then Zone 3;
b. flood risk assessment requirements; or
c. the policy aims for each flood zone.

<u>**Flood risk assessment**</u>

Properly prepared assessments of flood risk will inform the decision-making process at all stages of development planning. A Strategic Flood Risk Assessment is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future, taking account of the impacts of climate change, and to assess the impact that changes or development in the area will have on flood risk. It may also identify, particularly at more local levels, how to manage those changes to ensure that flood risk is not increased. A site-specific flood risk assessment is carried out by, or on behalf of, a developer to assess the risk to a development site and demonstrate how flood risk from all sources of flooding to the development itself and flood risk to others will be managed now, and taking climate change into account. There should be iteration between the different levels of flood risk assessment.

Strategic Flood Risk Assessment

As set out in the National Planning Policy Framework, Local Plans should be supported by Strategic Flood Risk Assessment. The Strategic Flood Risk Assessment should be prepared in consultation with the Environment Agency, local planning authorities' own functions of emergency response and drainage authority under the Land Drainage Act 1991, and where appropriate, internal drainage boards. Initially the Strategic Flood Risk Assessment will be used to refine information on the areas that may flood, taking into account other sources of flooding and the impacts of climate change, in addition to the information on the flood map. Local planning authorities should use the Strategic Flood Risk Assessment to inform their knowledge of flooding, refine the information on the flood map and determine the variations in flood risk from all sources of flooding across and from their area. These should form the basis for preparing appropriate policies for flood risk management for these areas. The Strategic Flood Risk Assessment should be used to inform the sustainability appraisal (incorporating the Strategic Environmental Assessment Directive) of local development documents, and will provide the basis from which to apply the Sequential Test and Exception Test in the development allocation and development control process.

Where local planning authorities have been unable to allocate all proposed development and infrastructure in accordance with the Sequential Test, taking account of the flood vulnerability category of the intended use, it will be necessary to increase the scope of the Strategic Flood Risk Assessment to provide the information necessary for application of the Exception Test. This should, additionally, consider the beneficial effects of flood risk management infrastructure in generally reducing the extent and severity of flooding when compared to the flood zones on the flood map. The increased scope of the Strategic Flood Risk Assessment will enable the production of mapping showing flood outlines for different probabilities, impact, speed of onset, depth and velocity variance of flooding taking account of the presence and likely performance of flood risk management infrastructure.

Site-specific flood risk assessment

As set out in the National Planning Policy Framework, local planning authorities should only consider development in flood risk areas appropriate where informed by a site-specific flood risk assessment9. This should identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking climate change into account. Those proposing developments should take advice from the emergency services when producing an evacuation plan for the development as part of the flood risk assessment.

Minor developments[10] are unlikely to raise significant flood risk issues unless they would:

- have an adverse effect on a watercourse, floodplain or its flood defences;
- would impede access to flood defence and management facilities; or
- where the cumulative impact of such developments would have a significant effect on local flood storage capacity or flood flows.

[9] The Environment Agency provides 'standing advice' on flood risk – see the Agency's website at: http://www.environment-agency.gov.uk/research/planning/82584.aspx . Applicants for planning permission will find this advice helpful when preparing a site-specific flood risk assessment for, and before designing, a lower risk development (and for ensuring extensions or alterations are designed and constructed to conform to any flood protection already incorporated in the property and include flood resilience measures in the design). The Agency also provides standing advice to enable local planning authorities to clearly identify the type of planning applications on which they should consult the Agency, and to make decisions on low risk applications where flood risk is an issue, without directly consulting the Agency for an individual response.

[10] Minor development means: - Minor non-residential extensions: industrial/commercial/leisure etc. extensions with a footprint less than 250sqm. - Alterations: development that does not increase the size of buildings e.g. alterations to external appearance. - Householder development: e.g. sheds, garages, games rooms etc. within the curtilage of the existing dwelling in addition to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats.

Taking climate change into account

Global sea level will continue to rise, depending on greenhouse gas emissions and the sensitivity of the climate system. The relative sea level rise in England also depends on the local vertical movement of the land, which is generally falling in the south-east and rising in the north and west. In preparing a Strategic Flood Risk Assessment or a site-specific flood risk assessment, the allowances for the rates of relative sea level rise shown in table 4 should be used as a starting point for considering flooding from the sea, along with the sensitivity ranges for wave height and wind speed in table 5.

Table 4: Recommended contingency allowances for net sea level rises

	Net sea level rise (mm per year) relative to 1990			
	1990 to 2025	**2025 to 2055**	**2055 to 2085**	**2085 to 2115**
East of England, east midlands, London, south-east England (south of Flamborough Head)	4.0	8.5	12.0	15.0
South-west England	3.5	8.0	11.5	14.5
North-west England, north-east England (north of Flamborough Head)	2.5	7.0	10.0	13.0

Notes to table 4:

a. For deriving sea levels up to 2025, the 4mm per year, 3mm per year and 2.5mm per year rates (covering the three geographical groups respectively), should be applied back to the 1990 base sea level year. From 2026 to 2055, the increase in sea level in this period is derived by adding the number of years on from 2025 (to 2055), multiplied by the respective rate shown in the table. Subsequent time periods 2056 to 2085 and 2086 to 2115 are treated similarly.
b. Refer to Department for Environment, Food and Rural Affairs FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006, for details of the derivation of this table. In particular, Annex A1 of this Note shows examples of how to calculate sea level rise.
c. Vertical movement of the land is incorporated in the table and does not need to be calculated separately.

The rise in sea level will change the frequency of occurrence of high water levels relative to today's sea levels, assuming no change in storminess. There may also be secondary impacts such as changes in wave heights due to increased water depths, as well as possible changes in the frequency, duration and severity of storm events. A 10 per cent sensitivity allowance should be added to offshore wind speeds and wave heights by the 2080s.

In making an assessment of the impacts of climate change on flooding from the land, rivers and sea as part of a flood risk assessment, the sensitivity ranges in table 5 may provide an appropriate precautionary response to the uncertainty about climate change impacts on rainfall intensities, river flow, wave height and wind speed.

Table 5: Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights

Parameter	**1990 to 2025**	**2025 to 2055**	**2055 to 2085**	**2085 to 2115**
Peak rainfall intensity	*+5%*	*+10%*	*+20%*	*+30%*
Peak river flow	*+10%*	*+20%*		
Offshore wind speed	*+5%*		*+10%*	
Extreme wave height	*+5%*		*+10%*	

Notes to table 5:

a. Refer to Department for Environment, Food and Rural Affairs FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006, for details of the derivation of this table.
b. For deriving peak rainfall, for example, between 2025 and 2055 multiply the rainfall measurement (in mm per hour) by 10 per cent and between 2055 and 2085 multiply the rainfall measurement by 20 per cent. So, if there is a 10mm per hour event, for the 2025 to 2055 period this would equate to 11mm per hour; and for the 2055 to 2085 period, this would equate to 12mm per hour. Other parameters in table 5 are treated similarly.

Sensitivity testing of the flood map produced by the Environment Agency, using the 20 per cent from 2025 to 2115 allowance for peak flows, suggests that changes in the extent of inundation are negligible in well-defined floodplains, but can be dramatic in very flat areas. However, changes in the depth of flooding under the same allowance will reduce the return period of a given flood. This means that a site currently located within a lower risk zone (e.g. Zone 2 in table 1) could in future be re-classified as lying within a higher risk zone (e.g. Zone 3a in table 1). This in turn could have implications for the type of development that is appropriate according to its vulnerability to flooding (see table 2). It will therefore be important that developers, their advisors and local authorities refer to the current flood map and the Strategic Flood Risk Assessment when preparing and considering proposals.

Flooding in estuaries may result from the combined effects of high river flows and high sea surges. When taking account of impacts of climate change in flood risk assessments covering tidal estuaries, it will be necessary for the allowances for sea level rise in table 4 and the allowances for peak flow, wave height and wind speed in table 5 to be combined.[11]

Managing residual flood risk

Residual risks are those remaining after applying the sequential approach and taking mitigating actions. It is the responsibility of those planning development to fully assess flood risk, propose measures to mitigate it and demonstrate that any residual risks can be safely managed. Flood resistance and resilience measures should not be used to justify development in inappropriate locations.

[11] Refer to Defra *FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts*, October 2006. Annex A2 gives details of joint

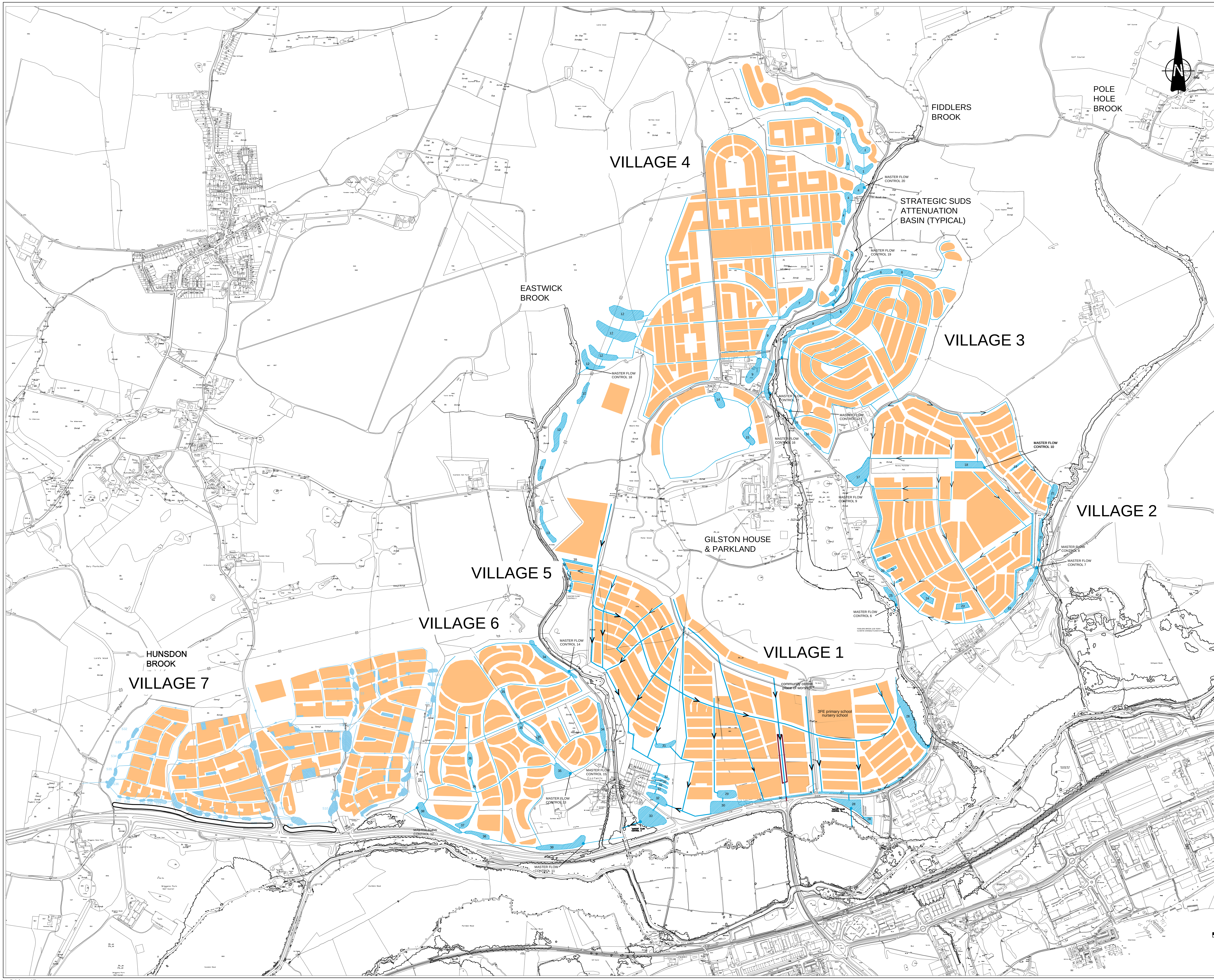
Flood resilience and resistance
The relative benefits of resilient and resistant construction have been assessed both through risk assessment and the real time testing of model forms of construction. Resilient construction is favoured because it can be achieved more consistently and is less likely to encourage occupiers to remain in buildings that could be inundated by rapidly rising water levels.

Flood-resilient buildings are designed to reduce the consequences of flooding and facilitate recovery from the effects of flooding sooner than conventional buildings. This may be achieved through the use of water-resistant materials for floors, walls and fixtures and the siting of electrical controls, cables and appliances at a higher than normal level. The lower floors of buildings in areas at medium and high probability of flooding should be reserved for uses consistent with table 1. If the lowest floor level is raised above the predicted flood level, consideration must be given to providing access for those with restricted mobility. In considering appropriate resilience measures, it will be necessary to plan for specific circumstances and have a clear understanding of the mechanisms that lead to flooding and the nature of the flood risk by undertaking a flood risk assessment.

Flood-resistant construction can prevent entry of water or minimise the amount of water that may enter a building where there is flooding outside. This form of construction should be used with caution and accompanied by resilience measures, as effective flood exclusion may depend on occupiers ensuring some elements, such as barriers to doorways, are put in place and maintained in a good state. Buildings may also be damaged by water pressure or debris being transported by flood water. This may breach flood-excluding elements of the building and permit rapid inundation. Temporary and demountable defences are not normally appropriate for new developments.

.

Appendix 2: Drawings



AECOM

PROJECT

Gilston Area

CLIENT

Places for People and City & Provincial Properties

NOTES

1. STRATEGIC SuDS BASIN REFERENCE NUMBERS FROM ARCHITECT'S PARAMETER PLAN DRAWING PP-09

DRAFT

ISSUE/REVISION

I/R	DATE	DESCRIPTION
P3	Mar 2016	CLA Updates Incorporated
P3	Jan 2016	Village 7 High Level Review
P2	Jan 2014	Update and notation
P1	June 2013	Draft

KEY PLAN

PROJECT NUMBER

60286648

SHEET TITLE

Strategic SuDS Overview

SHEET NUMBER

SK/116

ISO A1 594mm x 841mm

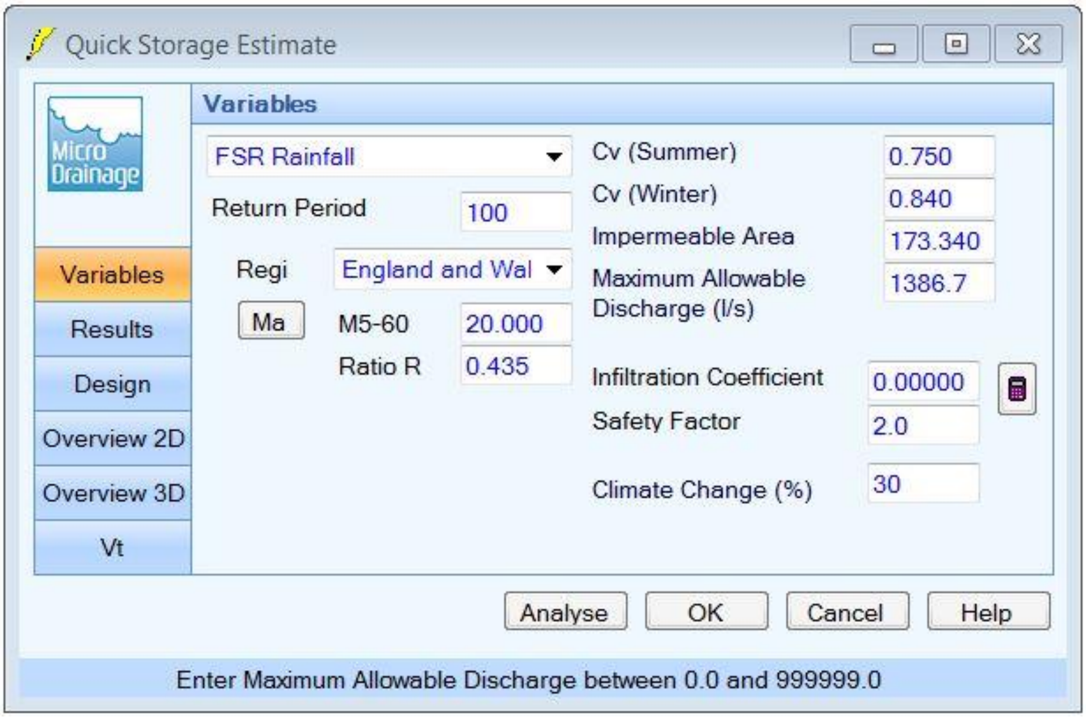
Project Management Initials: Designer: JW Checked: BF Approved: BF

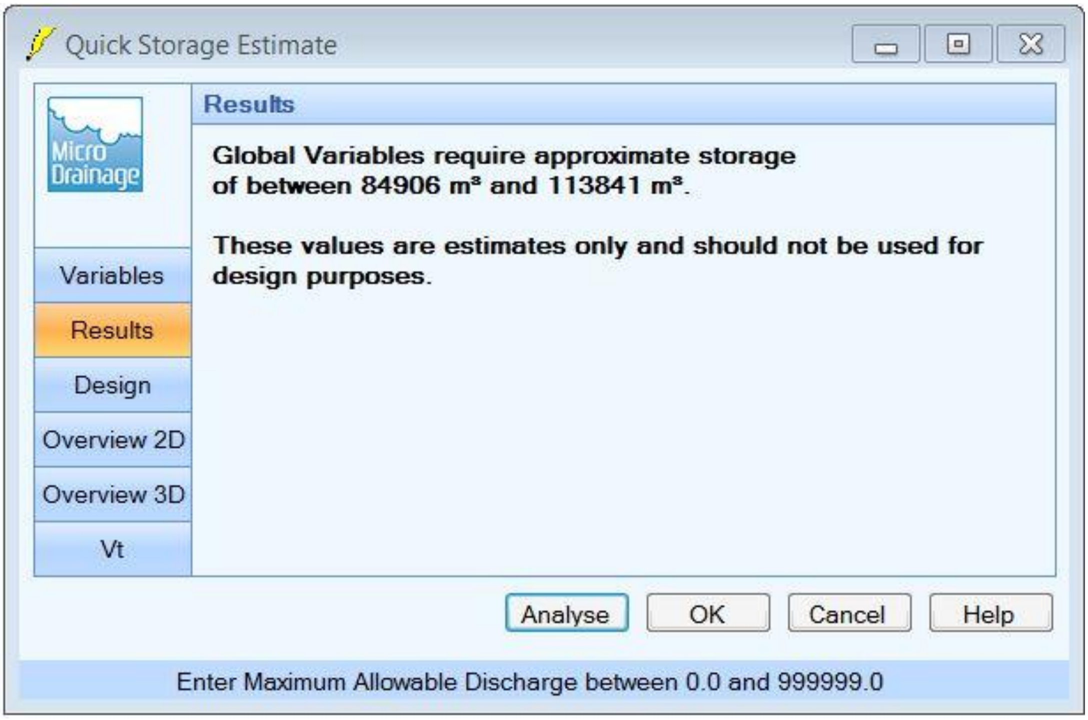
Last saved by: FYFEB(2016-05-04) Last Plotted: 2016-05-04

Filename: P:\PROJECTS\MUNICIPAL INFRASTRUCTURE - A NEW PLACE IN STORT VALLEY\CAD\WORKING\SUDS\STRATEGIC SUDS OVERVIEW_MAR 2016_P4.DWG

Printed on Rainforest Alliance Sustainable Forestry Paper

Appendix 3: WinDes Calculations





Indicative attenuation storage volume based on assumed total development impermeable area

ICP SUDS Mean Annual Flood

Input

Return Period (years)	100	Soil	0.400
Area (ha)	103.000	Urban	0.000
SAAR (mm)	600	Region Number	Region 6

Results 1/s

QBAR Rural 270.2
QBAR Urban 270.2

Q100 years 862.1

Q1 year 229.7 ÷ 103 = 2.2 l/s/ha
Q30 years 612.5 ÷ 103 = 5.9 l/s/ha
Q100 years 862.1 ÷ 103 = 8.4 l/s/ha

Appendix 4: Flood Modelling

Technical Note

Project:	**Gilston Park Estate FRA**	Job No:	**60286648**
Subject:	**Draft Eastern and Central Crossing Design Note**		
Prepared by:	**Chipego Changula**	Date:	**20th May 2014**
Checked by:	**Bruce Fyfe**	Date:	**17th June 2014**
Approved by:	**Bruce Fyfe**	Date:	**17th June 2014**

1 Introduction

The North Harlow Stort Valley Road Crossing and Mixed Development design proposals include new road crossings over the River Stort and its tributaries. Eastern and central crossings are being considered with some portions designed as solid embankments while other portions are open spans. These crossings will invariably take up available flood plain storage, and as such, their effects need to be analysed. This draft note, prepared for discussion, summarises the results of the hydraulic modelling undertaken. A detailed technical note will be provided at a later stage.

2 Design Proposals

This section summarises the two road crossing proposals being considered.

2.1 Proposed Eastern Crossing

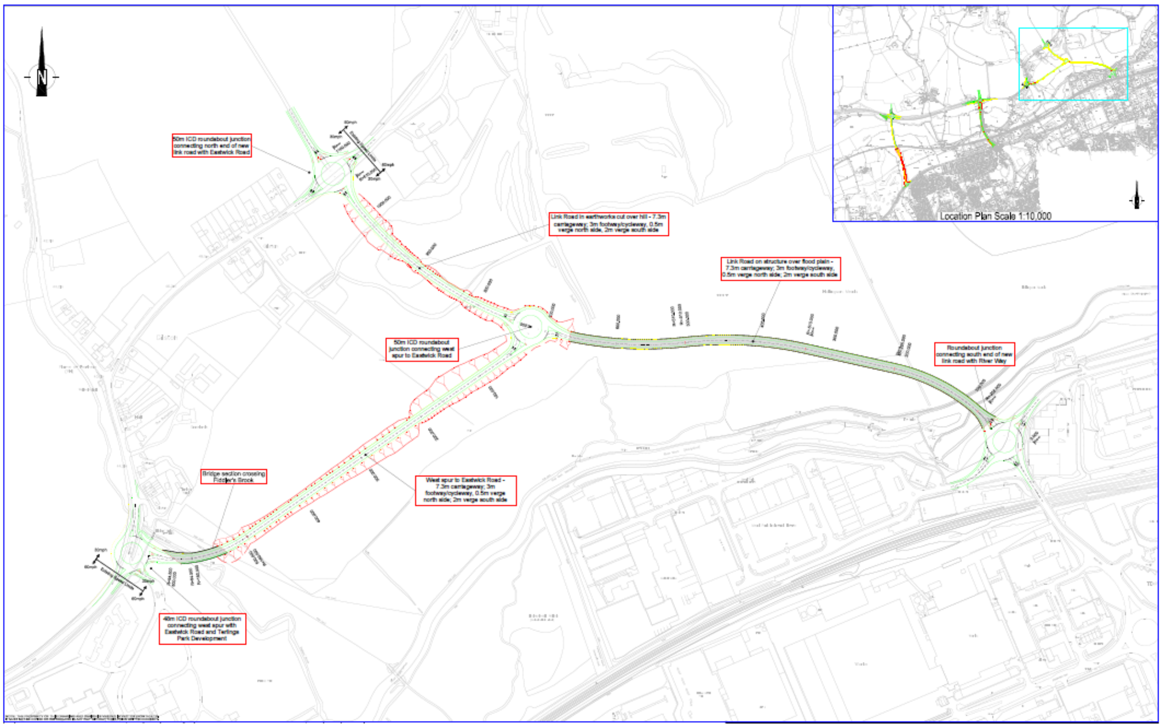


Figure 1: Proposed Eastern Crossing

The proposed eastern crossing is designed to cross the River Stort from River Way between Temple Fields and Hollingson Meads onpiers, in a roughly east to west direction to the north of Latton Lock and Latton Island for approximately 0.7km to a design traffic island, thereby having insignificant hydraulic effects on floodplain flow as shown in Figure 1.

From the design traffic island the proposed road is designed to be on a solid earth embankment running in a south westerly direction towards a proposed crossing over Fiddlers Brook.

2.2 Proposed Central Crossing

The proposed Central crossing (shown in Figure 2) runs parallel to the existing A414 Fifth Avenue and is essentially a carriageway widening scheme between Burnt Mill and Eastwick Lodge Farm across the River Stort and the Stort navigation. As a result the two existing bridges, and culvert through the embankment, will be lengthened to accommodate the carriage widening.

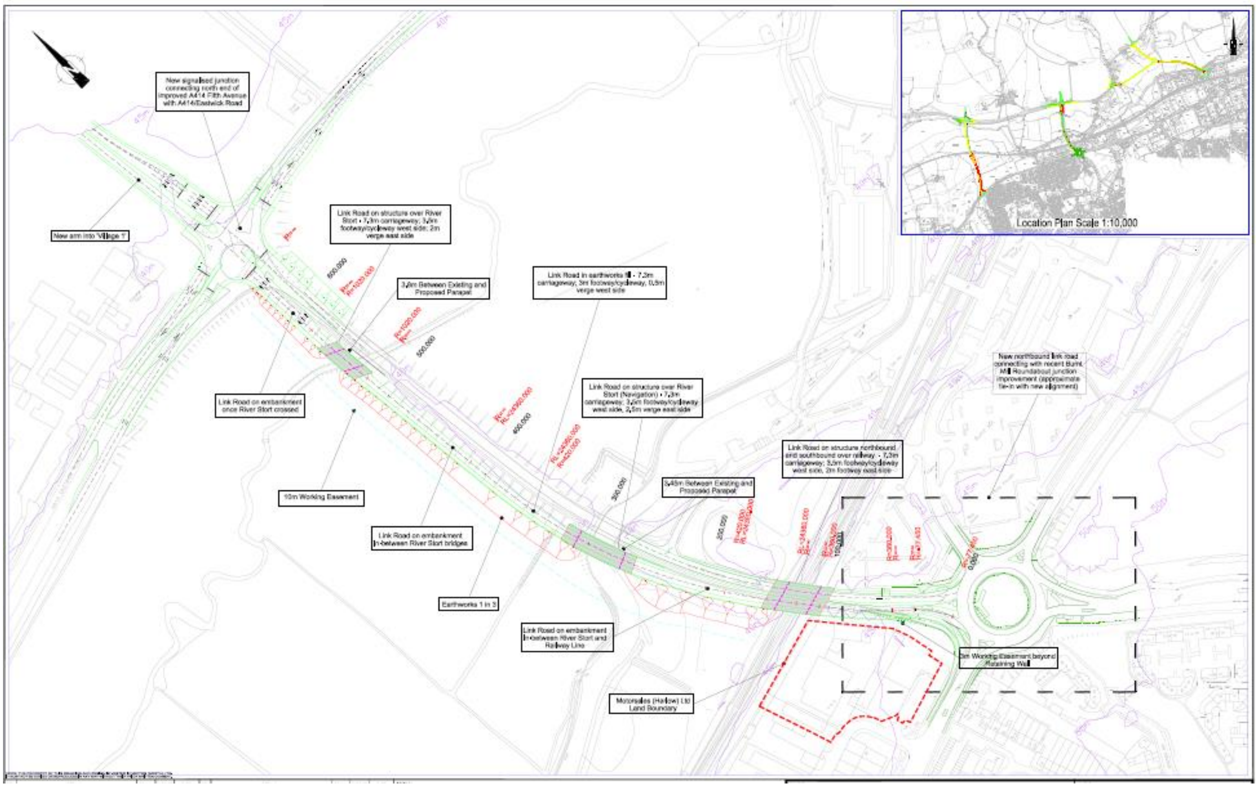


Figure 2: Proposed Central Crossing

The proposed road crossing is designed to be on a raised solid embankment adjacent to the existing Fifth Avenue embankment supported by either batter slopes or a vertical retaining wall structure.

3 Hydraulic Modelling and Results

Both the 1D and 2D portions of the basecase hydraulic model were modified to reflect the design proposals.

3.1 Proposed Eastern Crossing

3.1.1 Modelling amendment summary

The bridge over the Stort and that over Fiddlers Brook were inserted into the original ISIS 1D model. Appropriate amendments were made within the 2D portion of the model to reflect the proposed solid earth embankment in the vicinity of Fiddlers Brook. Following the model update the 1000yr return period flows were run through the model. A more detailed description of the model changes made can be made available upon request.

3.1.2 Results

The results show that apart from the solid earth embankment adjacent to Fiddlers Brook causing a localised increase in flood extents, the design flood extents remain similar to those of the basecase. The increase in maximum flood levels is also shown to be negligible and is in the order of 30mm. The outlines are shown in Figures 3 to 6.

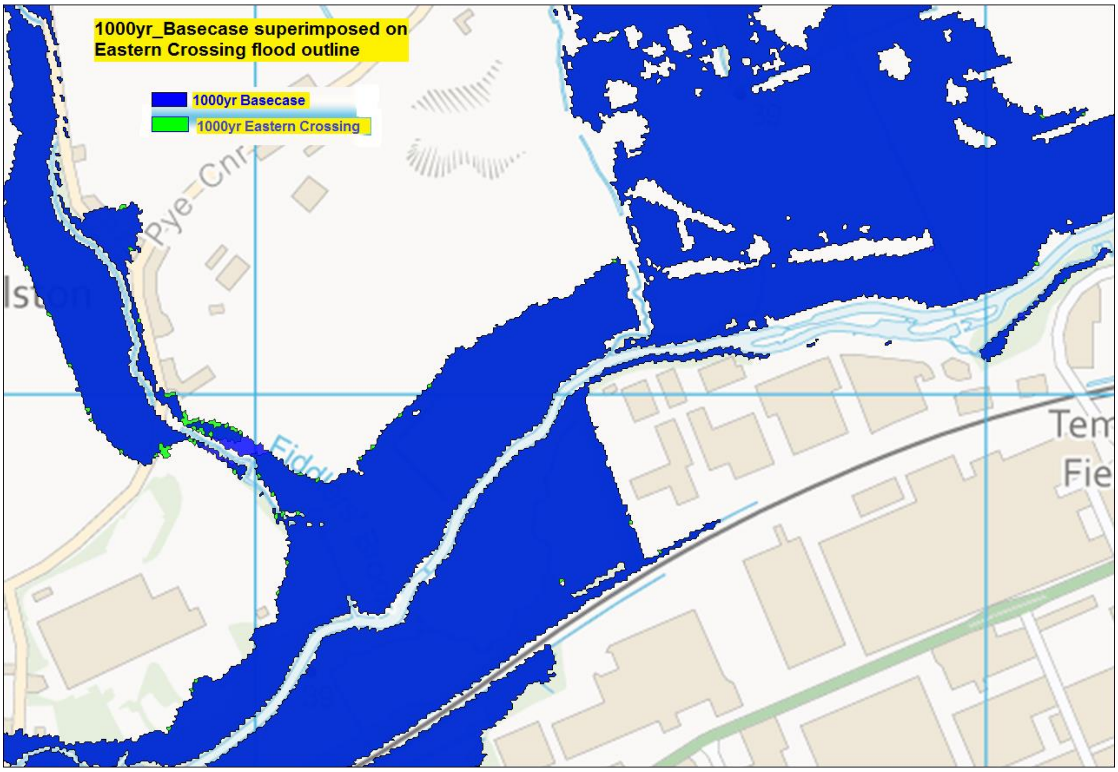


Figure 3: 1000yr Basecase against Eastern Crossing

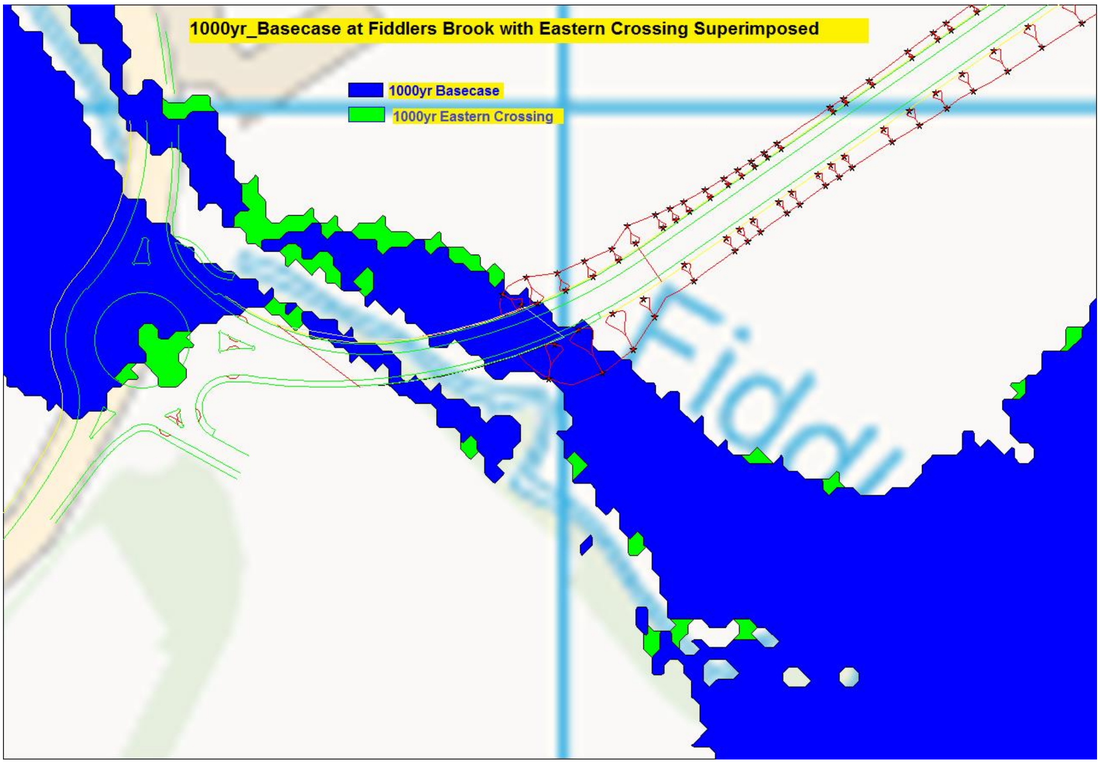


Figure 4: 1000yr Basecase against Eastern Crossing (Zoomed to Fiddlers Brook Crossing)

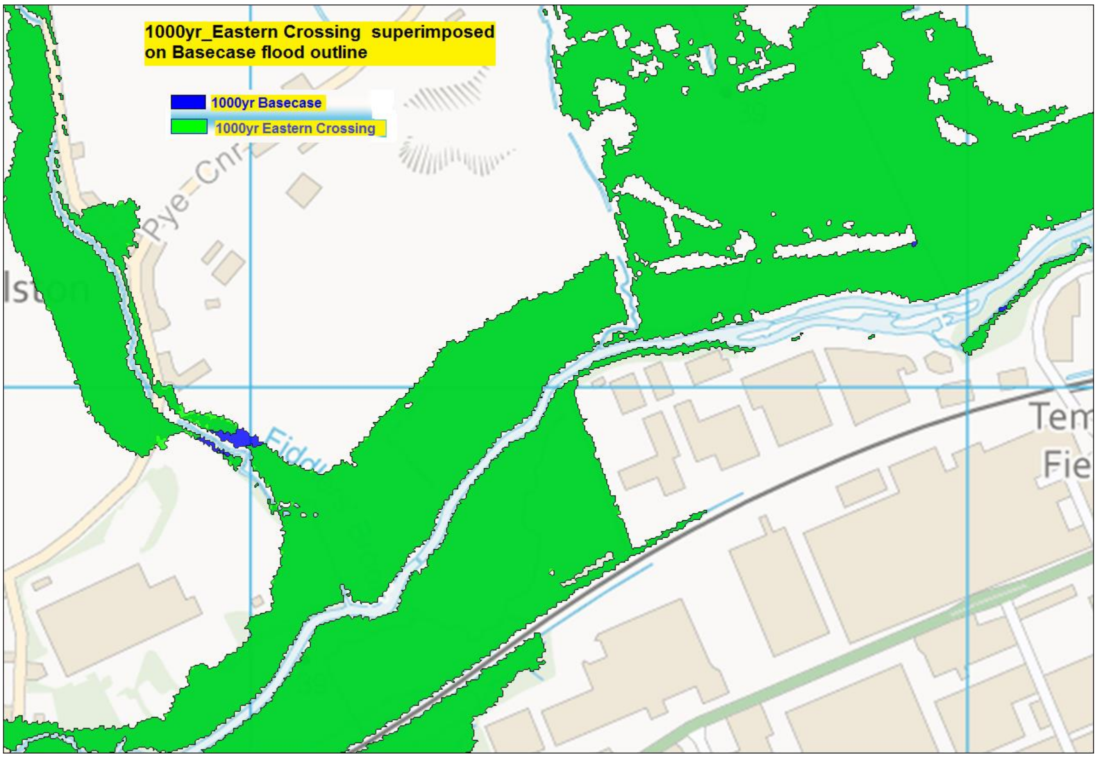


Figure 5: 1000yr Eastern Crossing against Basecase

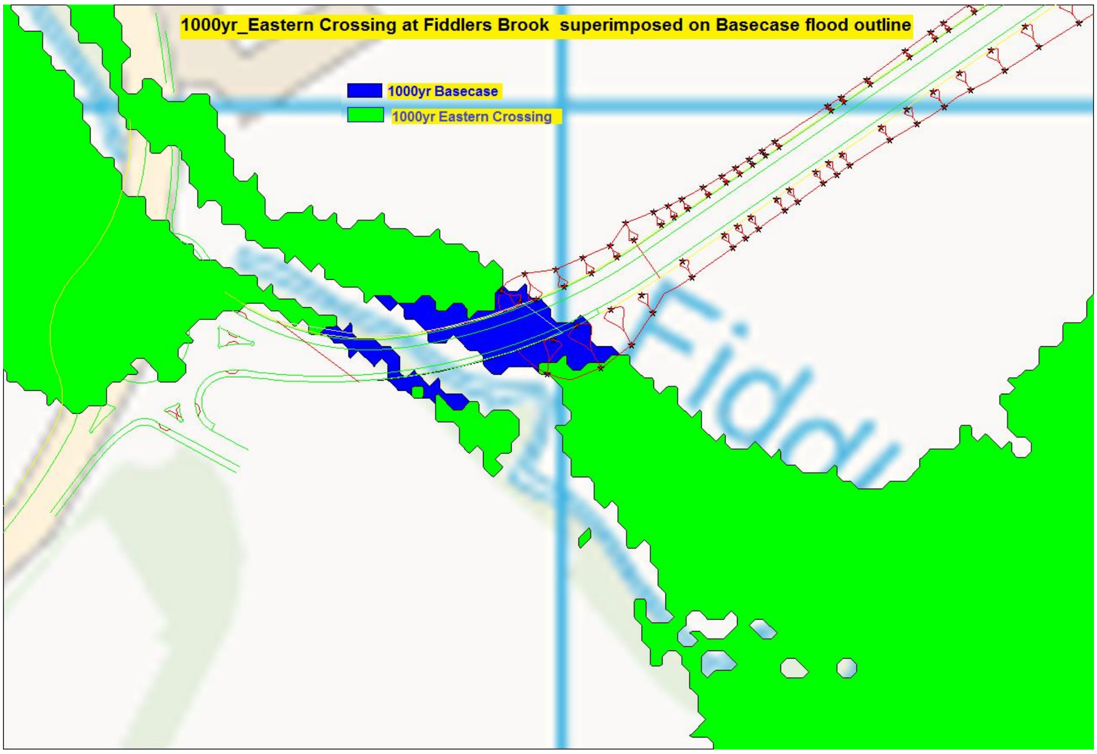


Figure 6: 1000yr Eastern Crossing against Basecase (Zoomed to Fiddlers Brook Crossing)

3.1.3 Eastern Crossing Design Summary and Recommendations

The crossing over the River Stort and Stort Navigation Channels and across their associated floodplains is shown to have a negligible hydraulic effect due to the fact that the proposed bridged crossing will be raised on piers. However, adjacent to and to the north east of Fiddlers Brook, the solid embankment is shown to take up previously available floodplain area. It is therefore recommended that level for level flood volume compensation, in 250mm vertical bands, be sought both upstream and downstream of the proposed new structure / embankment on Fiddlers Brook.

To avoid having to undertake flood volume compensation, it would be advisable to pull back the proposed embankment toe to sit outside the existing 1000 year event flood extents. This would result in the design scenario having similar flood extents and depths in this location as the basecase scenario. Any hydraulic impact caused by the pier positioning can be considered to be negligible.

3.2 Proposed Central Crossing

3.2.1 Modelling amendment summary

The bridges over the River Stort and Stort Navigation were inserted into the ISIS 1D model. Appropriate amendments were made within the 2D portion of the model to reflect the solid embankment adjacent and parallel to Fifth Avenue. These represented 1 in 2 sloped embankment, 1 in 3 sloped embankment and vertical retaining wall scenarios. Following the model update the 1000yr return period flows were run through the model. In addition the 1 in 2 and the in 3 embankment slope models were run with design longitudinal culverts through them to determine whether or not this setup would provide storage to compensate for the loss of floodplain.

A more detailed description of the model changes made can be made available upon request.

3.2.2 Central Crossing (1 in 2 and 1 in 3 slopes options) Results

The Central Crossing Designs (1 in 2 and 1 in 3 slopes) produce relatively similar results. The differences in flood depths and extents for these two scenarios are negligible.

Inclusion of the design embankment longitudinal culverts in the 1in 2 slope and 1 in 3 slope embankment models did not make any significant difference when compared to the embankment only scenario. The longitudinal culverts are perpendicular to the general direction of flow and situated on the downstream face of Fifth Avenue. This therefore reduces the efficiency of flow into and out of the longitudinal culverts. According to the Environment Agency this would not be seen as a legitimate method of providing flood plain volume compensation.

The results show that for the 1000yr return period, there is a localised increase in maximum water levels, in the order of 50mm between Burntmill Lane and Fifth Avenue. This localised increase, caused largely by the increased bridge widths on the two arms of the River Stort, translates to a minimal increase in flood extents. Downstream of Fifth Avenue the design scenario results in a marginal increase in maximum flood extents at the peripheries of the existing flood outline. The 1 in 3 slope embankment with the longitudinal culvert flood outlines are shown in Figures 7 and 8. Note that these outlines are similar to the 1 in 2 slope embankment.

In Figure 7, the basecase (blue shaded polygon) flood extent is superimposed on the design (red shaded polygon) flood extent. This has the effect of producing two different shades of blue. The darker shade of blue is where the basecase and design scenario overlap, with the lighter shade of blue being where there is no flooding in the design scenario. The design scenario is shown to be larger in places, and this is evident immediately north of the railway line west of Fifth Avenue.

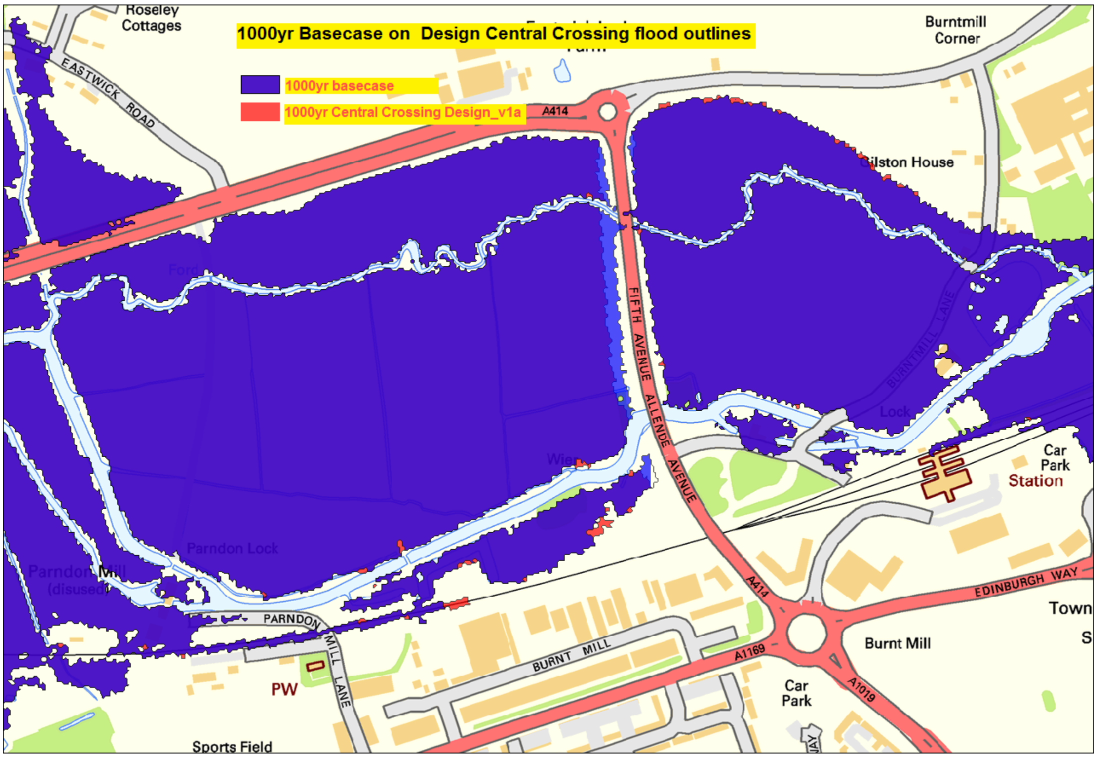


Figure 7: 1000yr Basecase on Design Central Crossing flood outlines(basecase superimposed onto design)

In Figure 8, the design scenario (red shaded polygon) flood extent is superimposed on the basecase (blue shaded polygon) flood extent. This has the effect of producing two different shades of red. The darker shade of red is where the design and basecase scenario overlap, with the lighter shade of red being where there is no flooding in the basecase scenario. The design scenario is shown to be larger in places, and this is evident immediately north of the railway line west of Fifth Avenue. On the western edge of Western Avenue, where the basecase flood extent is larger, the shading is blue.

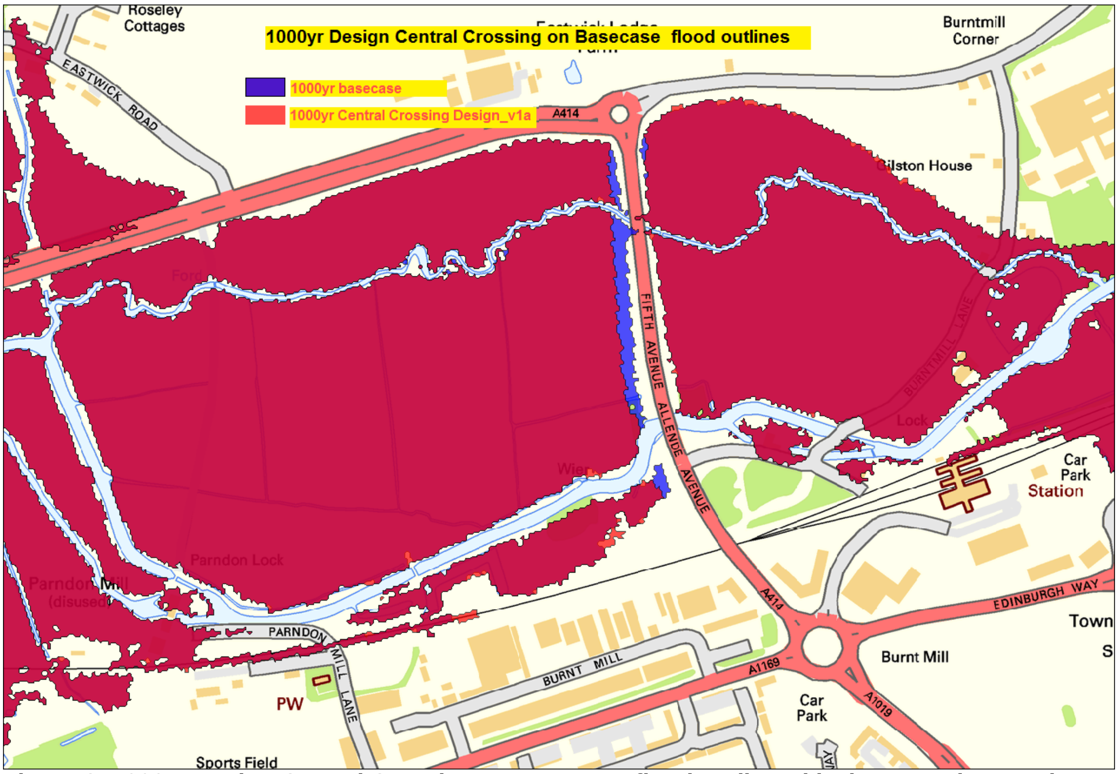


Figure 8: 1000yr Design Central Crossing on Basecase flood outlines (design superimposed onto basecase)

3.2.3 Central Crossing (retaining wall option) Results

The Central Crossing retaining wall option provides a marginal increase in available floodplain compared to the 1 in 2 and 1 in 3 embankment slopes as shown in Figure 7. The retaining wall option also has the longitudinal culvert included. As with the 1 in 2 and 1 in 3 slope embankment scenarios suggest there would be little difference in flood extents without the inclusion of the longitudinal culverts. As with the previous options there is a localised increase in maximum water levels, in the order of 50mm between Burntmill Lane and Fifth Avenue. This localised increase translates to a minimal localised increase in flood extents as observed by the flood outlines.

In Figure 9, a comparison is given of the three different slope options. The colours were selected for ease of visibility. The 1 in 3 slope option flood extent (teal polygon) is superimposed on to the 1 in 2 slope option flood extent (yellow polygon), which is superimposed on the retaining wall option flood extent (orange polygon). Therefore, on the western edge of Western Avenue, the orange flood extent is larger than the yellow flood extent which is itself larger than the teal flood extent.

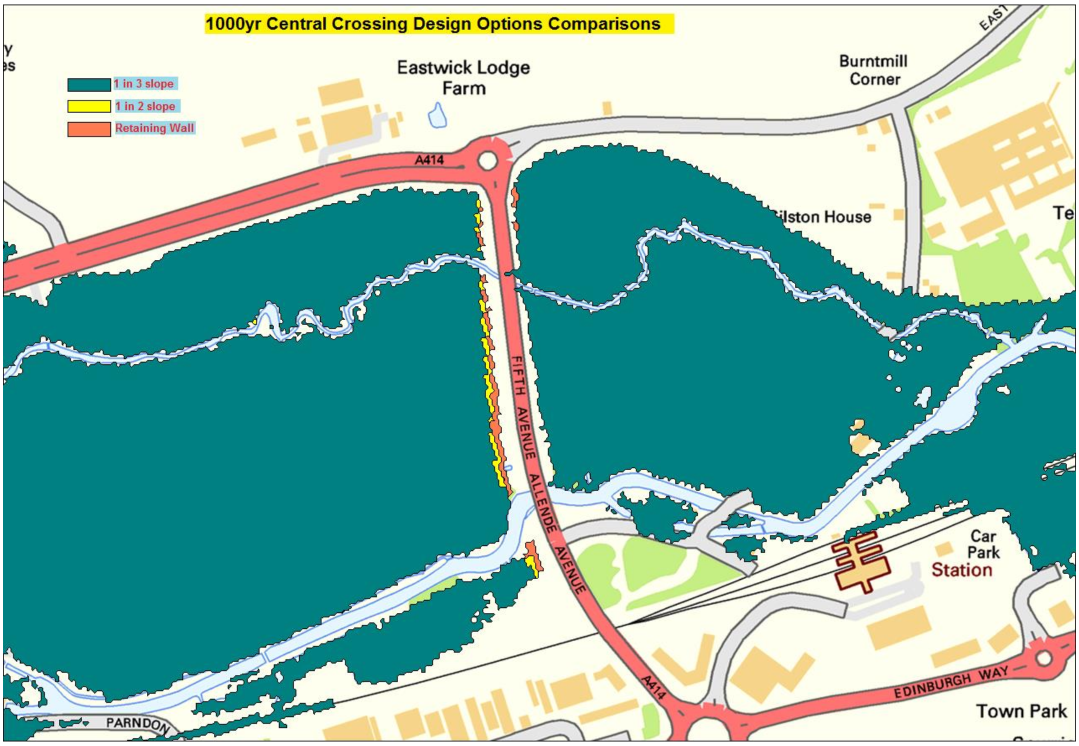


Figure 9: 1000yr Central Crossing Design Options Comparisons (colour scheme chosen for ease of visibility)

3.2.4 Central Crossing Design Discussion Summary

The increase in flood extents and depths, as a consequence of the proposed central crossing embankment design, is shown to be minimal. However, considering the reduction in readily available floodplain it would still be prudent to provide level for level flood volume compensation (FVC) preferably in 250mm vertical bands.

The current FVC option of proposing longitudinal culverts to act as voids within the central portion of the crossing is not a viable option from both operational and consistent compensation aspects. It is therefore recommended that an appropriate area for flood volume compensation be sought. Analysis of the design flood outlines produced would seem to suggest that the most viable location at the moment would be in the vicinity of Gilston House between Eastwick Road and Burntmill lane.

Technical Note

Project:	**Gilston Park FRA**	Job No:	**60286648**
Subject:	**Basecase Hydraulic Model**		
Prepared by:	**Alistair Nisbet**	Date:	**3rd June 2015**
Checked by:	**Cathryn Spence**	Date:	**3rd June 2015**
Approved by:	**Bruce Fyfe**	Date:	

1.0 Introduction

AECOM has been commissioned by Places for People to undertake a site specific Flood Risk Assessment (FRA) for the North Harlow Development of the proposed Stort Valley Road Crossing and mixed development in the tributary reaches of the River Stort. To inform the FRA is was necessary to develop an updated hydraulic model which was capable of simulating and determining the current and future flood risk on the River Stort and its tributaries.

This technical note details the development history of the 'basecase' model and the modelling assumptions undertaken to develop the model for the study. The technical note will not detail the original design decisions made to construct any previous models developed prior to this study. The purpose of the technical note is to allow the Environment Agency to undertake a review of the updates undertaken to the model.

(All Figures are presented at the end of the technical note)

2.0 Model History and Development

2.1 Key previous models

The development of the hydraulic model builds upon two previous studies undertaken in 2006 and 2011.

The 2006 model was developed as part of the SFRA required by the Environment Agency for the proposed Harlow Northern Extension development. The modelling comprised of a hydraulic model of the River Stort and three individual hydraulic models developed for the tributaries: Eastwick Brook, Fiddlers Brook, and Polehole Brook. The models were all developed using Infoworks RS.

In 2011 the River Stort valley model was developed to investigate the impact of a new link road across the Stort valley. This hydraulic model was developed from a previous ISIS model and was linked to TUFLOW to simulate the natural floodplain. The tributaries were represented in the model as point inflows and were not explicitly modelled.

Following an initial review of both these modelling studies the 2011 ISIS/TUFLOW model was adopted for the River Stort and the 3 tributary models, developed in 2006, were linked to the River Stort model.

Table 1: River Stort Model History

Summary of model history			
Date/Client	**Consultant**	**Purpose**	**Description**
Ropemaker Properties Ltd – May 2006	Faber Maunsell / AECOM	Harlow North Extension – Strategic Flood Risk Assessment	• Based on existing ISIS hydraulic model supplied by the Environment Agency. This model only covered the River Stort. Model developed by PBA with subsequent amendments made to the hydrology by Atkins. • ISIS model imported into Infoworks RS – a modelling package similar to ISIS. • Tributaries (Fiddlers Brook, Polehole Brook, and Eastwick Brook) modelled separately in Infoworks RS by AECOM. They were not attached to the River Stort. Tributary models developed based on cross sections derived from filtered LiDAR and later cross checked with topographical survey.
March 2011 / Harlow Renaissance	URS/Scott Wilson	Harlow Town and Surrounding Area Flood Risk Assessment	• This model made use of the 2004 1D ISIS hydraulic model developed by Atkins. • Additional modelling undertaken to develop a linked 1D/2D model using ISIS and TUFLOW. • Further modelling was undertaken to represent the proposed new crossing of the River Stort to the west of the existing A414 crossing.

2.2 Limitations/Caveats of the previous hydraulic models

The previous River Stort and separate tributary models were deemed to be ‘fit for purpose’, by the Environment Agency, and therefore it was anticipated that there would be no need for any significant model adaptations to the existing models, apart from joining the tributaries to the River Stort model. However, a review of the models highlighted several limitations/caveats in the previous models which are described in the following sub-sections.

2.2.1 River Stort - Hydraulic Structures

The bridges and culverts, within the ISIS 1D domain of the main River Stort, are represented by Bernoulli Loss Units which represent the hydraulic losses at these structures. These are listed below:

Culvert inlets and outlets represented as Bernoulli Loss Units

- SHO07CAU– culvert upstream of Latton Lock
- SHO07CBU – culvert upstream of Latton Lock

Bridges represented by Bernoulli Loss Units

- SEL025BU - Footbridge between Moorhen Marina and Terlings Park
- SEL023BU – Burnt Mill Lane Road Bridge

- SEL015BU – Fifth Avenue Bridge
- SEL012BU – Field Bridge
- SEL005BU – Footbridge at Ford 300m North of Parndon Lock
- BMS007 – Burnt Mill Stream Road Bridge
- LNV079BU – Fifth Avenue Bridge / A414 Bridge
- LNV0765BU – Bridge and Pipe Crossing
- PMS010BU – Parndon Mill Stream Vehicle Bridge
- LNV059BU – Footbridge
- LNV031BU – Roydon Road Bridge
- SHR025 – River Stort Hunsdon Reach Vehicle Bridge
- SHR009 – River Stort Hunsdon Reach Vehicle Bridge
- HMS004BU – Hunsdon Mead Stream Farm Field Bridge

(15 culverts were also represented using 1d ESTRY units)

While it may be more appropriate to replace the Bernoulli Loss units with bespoke model culvert of bridge units, it is recognised that the model was built at a time when it was acceptable to use Bernoulli Loss units. Attempts to locate surveys of the structures from outside parties were not forthcoming. Any future studies may consider incorporating survey of the River Stort structures and updating of the model units.

2.2.2 River Stort and Tributaries – Cross Sections

The 2006 "Harlow Northern Extension – Hydrology and Hydraulic Modelling Report" produced for Ropemaker Properties states that the original three separate tributary models were mainly based on filtered LIDAR derived cross sections and used to build three separate InfoWorks models with estimated structure dimensions. The report further states a topographic survey was undertaken to augment, verify and update the LiDAR estimated cross sections and structures. The model channel structure data was updated with the survey. Though the report suggests that generally the LiDAR based cross sections matched well with the surveyed sections, interrogation of the models suggests that the LiDAR derived cross sections were retained. This may have an effect of reducing the available channel capacity in the models.

2.2.3 Model Extents

The upstream model extent is identified as being 800 meters downstream of Harlow Mill Bridge at NGR 546528.16, 212593.30. The downstream model extent was identified as being at Roydon Train Station at NGR 540607.77, 210474.03.

3.0 Baseline Model Update

While, it was beyond the remit and scope of this study to undertake significant model improvements, it was necessary to undertake amendments to ensure that the updated model was stable enough to produce reliable outputs.

3.1 Hydrology

In order to gain a full appreciation of the fluvial risk, the design flows were reviewed and re-estimated for Eastwick Brook, Polehole Brook and Fiddlers Brook. The flows into the main River Stort from the original study were deemed to be suitable and used for this study. The new tributary hydrological boundaries are shown in Figure 1.

3.2 Hydraulic model

Following the initial review of the existing River Stort model data the following elements were updated:

- Extension of the upstream limit of the River Stort by approximately 550 meters, to accommodate the investigation of additional road crossings.

- The conversion of the three tributaries, to the north of the Stort valley, from InfoWorks RS to ISIS and linking them to the 2d domain.

- Extension of the 2d model domain and addition of new boundary conditions.

- Revision of the ground model data for the 2d domain. The existing data was updated with the latest version of the LiDAR data provided by the Environment Agency.

Table 2 provides a summary of the updates made to the two selected hydraulic models (2006 and 2011) for the purposes of building a revised base case model. Figure 1 shows the new model coverage against the previous model coverage.

Table 2: River Stort Baseline Model Updates

This model is an adaptation of the URS/Scott Wilson Harlow 2D modelling Study **<u>ISIS</u>** The ISIS model is a copy of the original **SD100Ycc02_cut_down_v8.DAT** Tributaries Eastwick Brook (EW), Fiddlers Brook (FB), and Polehole Brook (PH) bolted onto the existing River Stort ISIS 1D model. The tributaries were converted from their existing Infoworks format to ISIS 1D format. River Stort ISIS 1D model extended 550m upstream to encompass the area of study <u>Model stabilising amendments:</u> Interpolates added between ISIS model nodes PMS004 and PMS001, in addition to the repositioning of these nodes based on OS tiles and 2d model representation. bc layer conecting the ISIS 1D to the TUFLOW 2D portion amended to reflect the changes made to the ISIS 1D model. **<u>TUFLOW</u>** updated LiDAR acquired and used to generate zpts as supplied model did not have any zpt layer included EW, FB, and PH 1d ISIS nodes added to the 2d model 2d code layer amended to include EW, FB and PH brooks and the upstream extension of River Stort 2d_bc layer amended to include EW, FB and PH brooks and the upstream extension of the River Stort 2d inflows for EW and PH brooks removed from the 2d domain as they have now been included in the 1d elements of these brooks. bc-dbase layer amended to exclude EW and PH brooks **Hydrology** The design flows have been updated and regenerated by AECOM and fed into the hybrid model.

3.3 Run Parameters and Data Files

This section details the run parameters used in the model, together with the main data files used in the 'basecase' model. The run parameters have been inherited from the previous modelling undertaken for the River Stort model and are provided from completeness.

ISIS version:	3.6
TUFLOW version:	2013-12-AC-iDP-w64
Model grid spacing:	5m
Modelled Events:	Q20, Q100, Q100+climate change, Q1000
Model time step:	1s
Simulation Period:	5-30hrs
2d domain roughness:	General grass land - 0.06; Buildings – 0.20

The following data files have been used for undertaking the simulations

IEF files:	Stort_and_Tribs_20yr_Basecase_v1.ief
	Stort_and_Tribs_100yr_Basecase_v1.ief
	Stort_and_Tribs_100yrCC_Basecase_v1.ief
	Stort_and_Tribs_1000yr_Basecase_v1.ief
ISIS file:	Stort_and_Tribs_v1.DAT
IED files:	20yr_v5_Tribs_v6_NewHydrology.IED
	100yr_v5_Tribs_v6_NewHydrology.IED
	100yrCC_v5_Tribs_v6_NewHydrology.IED
	1000yr_v5_Tribs_v6_NewHydrology.IED
TUFLOW files:	Stort_and_Tribs_20yr_Basecase_v1
(.TCF & .ECF):	Stort_and_Tribs_100yr_Basecase_v1
	Stort_and_Tribs_100yrCC_Basecase_v1
	Stort_and_Tribs_1000yr_Basecase_v1
TGC file:	Harlow_Basecase_v1.tgc
TBC file:	Harlow_Basecase_v1.tbc
Outputs:	Elevation, Depth, Velocity, Flow

4.0 Relief Road Options

The existing 'basecase'model has been used to investigate the impact on flooding from two relief road options: Eastern and Central. The Central option has three sub-options.

All the options were run with the same model run parameters listed in Section 3.3.

The following sections detail the adaptations undertaken to the 'basecase' model.

4.1 Eastern Crossing

The eastern crossing, Figure 2, comprises of a new bridges over the River Stort and over Fiddlers Brook. In addition, a new embankment is required in the vicinity of Fiddlers Brook.

Table 3 below list the key files used for the Eastern Crossing model.

Table 3: River Stort Eastern Crossing Model files

<u>ISIS</u>
Stort_and_Tribs_EC_design_1.DAT - The ISIS 1d model has been amended to reflect the two open span bridges on the River Stort and the open span bridge on Fiddlers Brook.
<u>TUFLOW</u>
1d_ISIS_nodes_v6a_EC_design_1 - modification of ISIS 1D nodes on the River Stort Channel
1d_ISIS_nodes_FB_eastern_crossing_v1 - modification of ISIS 1D nodes on the Fiddlers Brook Channel
2d_bc_ISIS_links_v5a_EC_design_1 - modification of 1d-2d links on the River Stort Channel
2d_bc_FB_Eastern_Crossing_v1 - modification of 1d-2d links on the Fiddlers Brook Channel
2d_code_Harlow_2d_1d_inactive_Eastern_Crossing_v1 - modifications of the inactive code layer on the Fiddlers Brook
Harlow_2D_zpts_v1 - new zpts to encompass entire 2d code area.
2d_zsh_Eastern_Crossing_Design_1a - layer representing Fiddlers Brook embankment

4.2 Central Crossing

For the central crossing over the River Stort, Figure3, there have been three options proposed. The difference between the three options relate to the side slopes of the road embankment and the presence of culverts under the embankments.

Table 4 below list the key files used for the Central Crossing model.

Table 4: River Stort Central Crossing Model files

<u>ISIS – Applicable to all options</u>

Stort_and_Tribs_CC_design_1.DAT - The ISIS 1d model has been amended to reflect the two open span bridges on the River Stort channels under Fifth Avenue. This file is applicable to all 3 options.

<u>TUFLOW – Option 1</u>

This model reflects the 1 in 3 embankment slopes with 2 through parallel culverts.

1d_ISIS_nodes_v6a_CC_design_1

2d_bc_ISIS_links_v5a_CC_design_1

2d_zsh_Central_Crossing_Design_Embankment_v1

1d_nwk_culverts_v7_Central_Crossing_Design_v1 - representing flood relief culvert

1d_nwk_Central_Crossing_FRC_v1 - representing longitudinal flood relief culvert

2d_bc_culverts_v7_Central_Crossing_Design_v1

2d_bc_Central_Crossing_FRC_v1

<u>TUFLOW – Option 2</u>

This model reflects the 1 in 2 embankment slopes with 3 through parallel culverts.

1d_ISIS_nodes_v6a_CC_design_1

2d_bc_ISIS_links_v5a_CC_design_1

2d_zsh_Central_Crossing_Design_Embankment_v2

1d_nwk_culverts_v7_Central_Crossing_Design_v1

1d_nwk_Central_Crossing_FRC_v2

2d_bc_culverts_v7_Central_Crossing_Design_v1

2d_bc_Central_Crossing_FRC_v1

<u>TUFLOW – Option 3</u>

This model, an alternative version of option1, reflects the "Retaining Wall" option, with 3 through parallel culverts.

1d_ISIS_nodes_v6a_CC_design_1

2d_bc_ISIS_links_v5a_CC_design_1

2d_zsh_Central_Crossing_Design_Embankment_v3

1d_nwk_culverts_v7_Central_Crossing_Design_v1

1d_nwk_Central_Crossing_FRC_v3

2d_bc_culverts_v7_Central_Crossing_Design_v1

2d_bc_Central_Crossing_FRC_v1

4.3 Option Runs

For each of the design options the model was run for the 1000yr design event.

The following data files have been used for undertaking the simulations

IEF files:	Stort_and_Tribs_1000yr_EC_design_1
	Stort_and_Tribs_1000yr_CC_design_1a.ief
	Stort_and_Tribs_1000yr_CC_design_2a.ief
	Stort_and_Tribs_1000yr_CC_design_3a.ief
ISIS file:	Stort_and_Tribs_EC_design_1.DAT
	Stort_and_Tribs_CC_design_1.DAT
IED files:	20yr_v5_Tribs_v6_NewHydrology.IED
	100yr_v5_Tribs_v6_NewHydrology.IED
	100yrCC_v5_Tribs_v6_NewHydrology.IED
	1000yr_v5_Tribs_v6_NewHydrology.IED
TUFLOW files:	Stort_and_Tribs_1000yr_EC_design_v1
(.TCF & .ECF):	Stort_and_Tribs_1000yr_CC_design_v1a
	Stort_and_Tribs_1000yr_CC_design_v2a
	Stort_and_Tribs_1000yr_CC_design_v3a
TGC file:	Harlow_2D_EC_design_1.tgc
	Harlow_CC_design_v1a.tgc
	Harlow_CC_design_v2a.tgc
	Harlow_CC_design_v3a.tgc
TBC file:	Harlow_Basecase_v1.tbc

5.0 Summary

The existing River Stort 1d/2d model has been updated with the Eastwick Brook, Fiddlers Brook, and Polehole Brook tributary models to allow an assessment of flooding within the Stort Valley. The hydraulic model is now deemed suitable to be used to assess the potential flooding in the Stort valley and for the provision of data to support the FRA.

Model runs have been completed for the Q20, Q100, Q100+climate change, Q1000 for the current day “basecase”.

Model runs have also been completed for the Q1000 event for 4 design options for crossings of the River Stort.

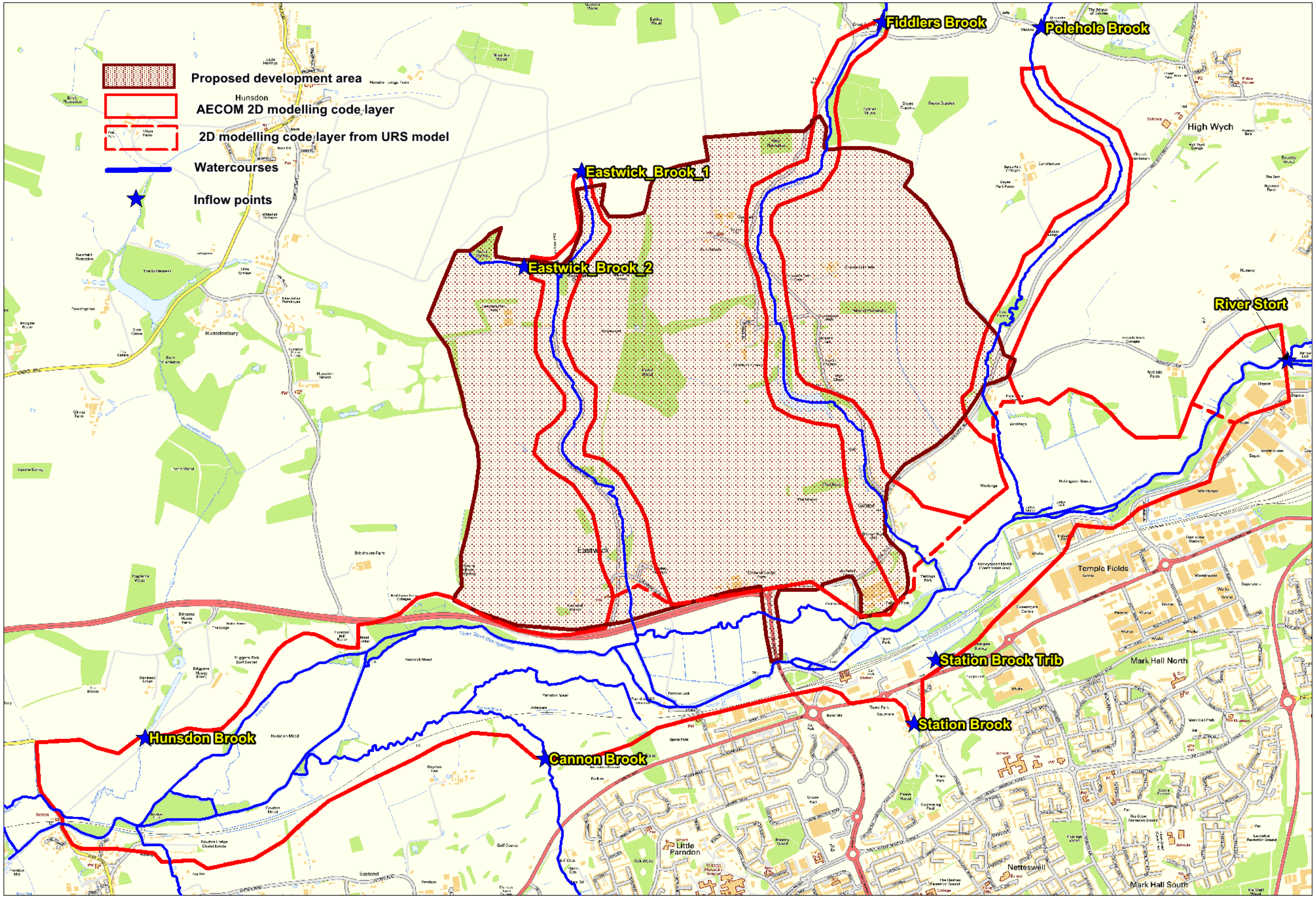


Figure 1: Updated River Stort and Tributaries Model 2013

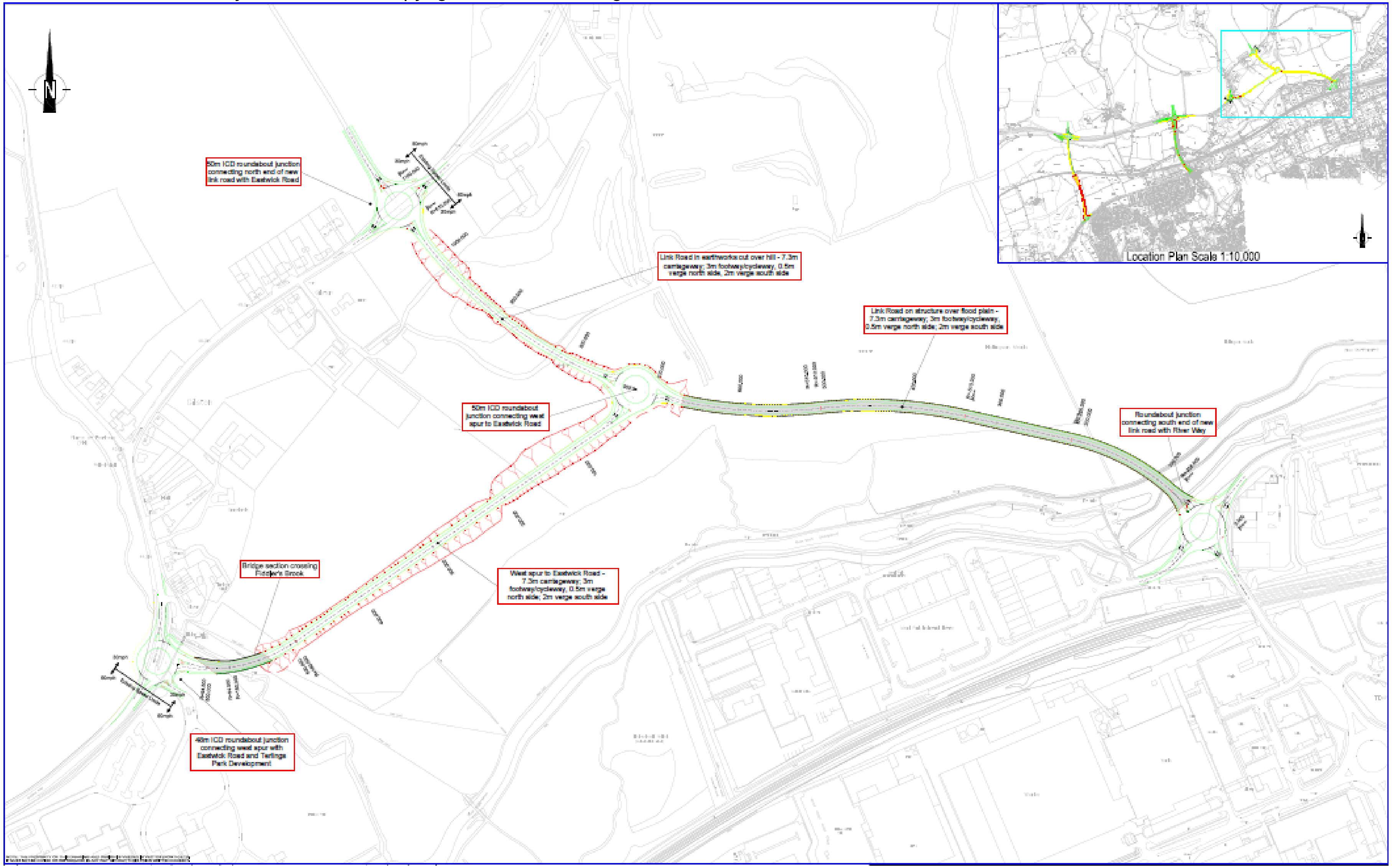


Figure 2: Eastern Crossing

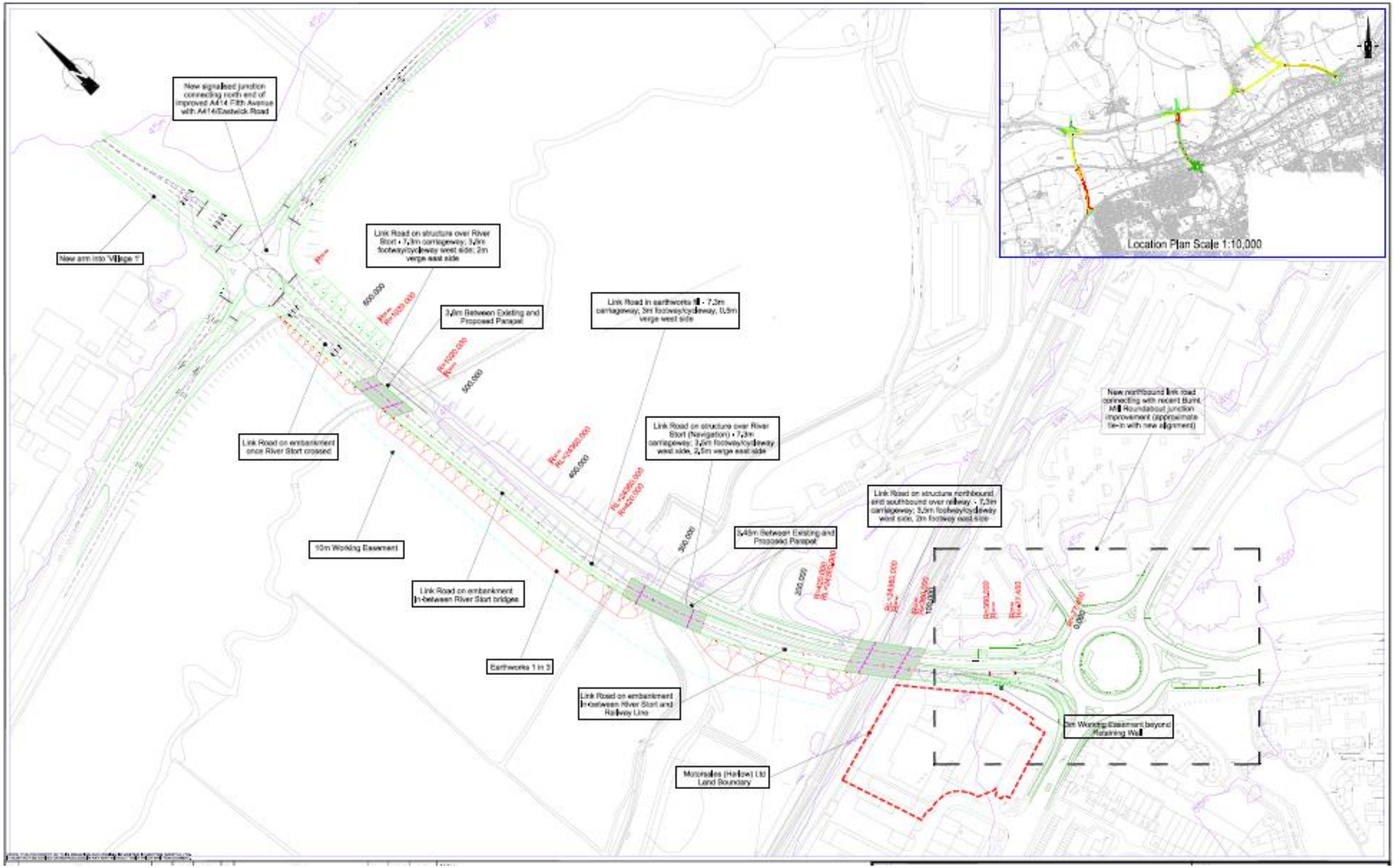


Figure 3: Eastern Crossing

Technical Note

Project:	**Gilston Area FRA**	Job No:	**60286648**
Subject:	**Draft Eastern and Central Crossing Design Note**		
Prepared by:	**Ian Bentley**	Date:	**07/04/2016**
Checked by:	**Ian Small**	Date:	**07/04/2016**
Approved by:	**Bruce Fyfe**	Date:	**07/04/2016**

1.0 Introduction

The Gilston Area Development design proposals include new road crossings over the River Stort and its tributaries. Eastern and Central crossings are being considered with some portions designed as solid embankments while other portions are open spans. These crossings will invariably take up available flood plain storage, and as such, their effects need to be analysed. This technical note summarises the results of the hydraulic modelling undertaken, which has been approved by the EA and shows no effect on flood water levels in the River Stort or within its floodplain. The approximate locations of the two crossings are shown in Figure 1.

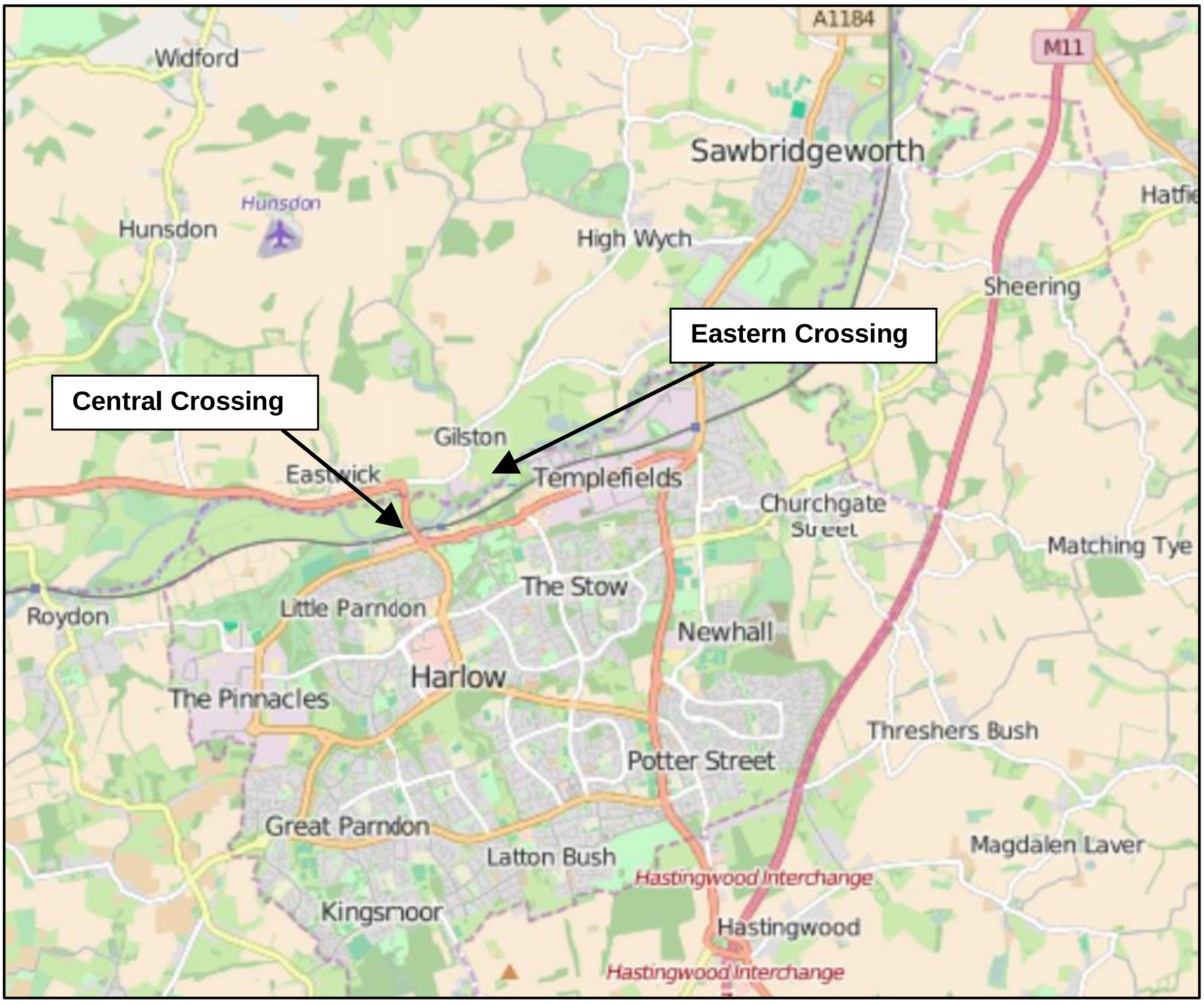


Figure 1: Proposed Crossing Locations

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2.0 Design Proposals

This section summarises the two road crossing proposals being considered.

2.1 Proposed Eastern Crossing

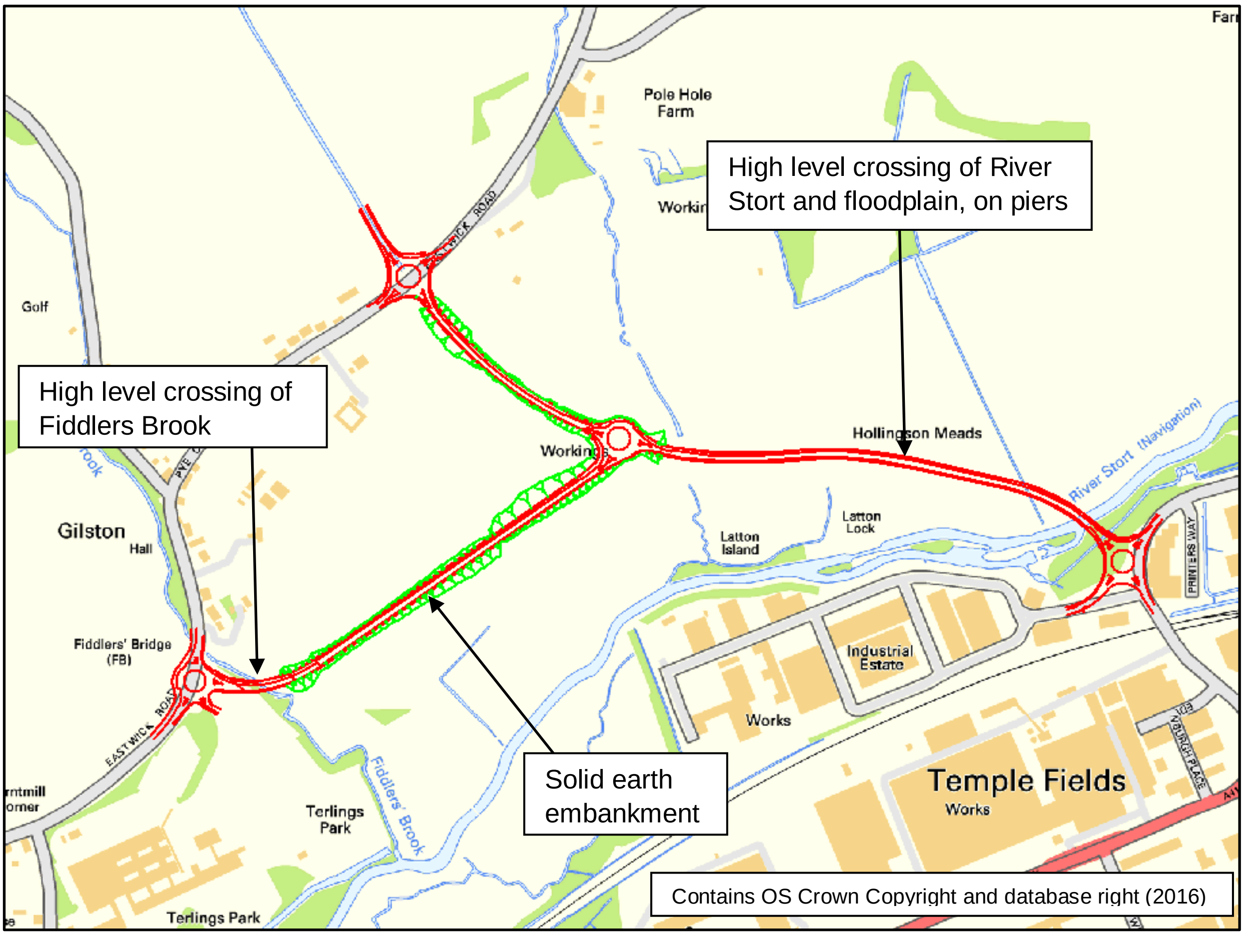

Figure 2: Proposed Eastern Crossing

The proposed eastern crossing is designed to cross the River Stort from River Way between Temple Fields and Hollingson Meads, on piers, in a roughly east to west direction to the north of Latton Lock and Latton Island for approximately 0.7km to a road traffic island, thereby having insignificant hydraulic effects on floodplain flow as shown in Figure 2.

From the road traffic island the proposed road is designed to be on a solid earth embankment running in a south westerly direction towards a proposed crossing over Fiddlers Brook.

2.2 Proposed Central Crossing

The proposed Central crossing (shown in Figure 3) runs parallel to the existing A414 Fifth Avenue and is essentially a carriageway widening scheme between Burnt Mill and Eastwick Lodge Farm across the River Stort and the Stort Navigation. As a result the two existing bridges, and culvert through the embankment, will be lengthened to accommodate the carriage widening.

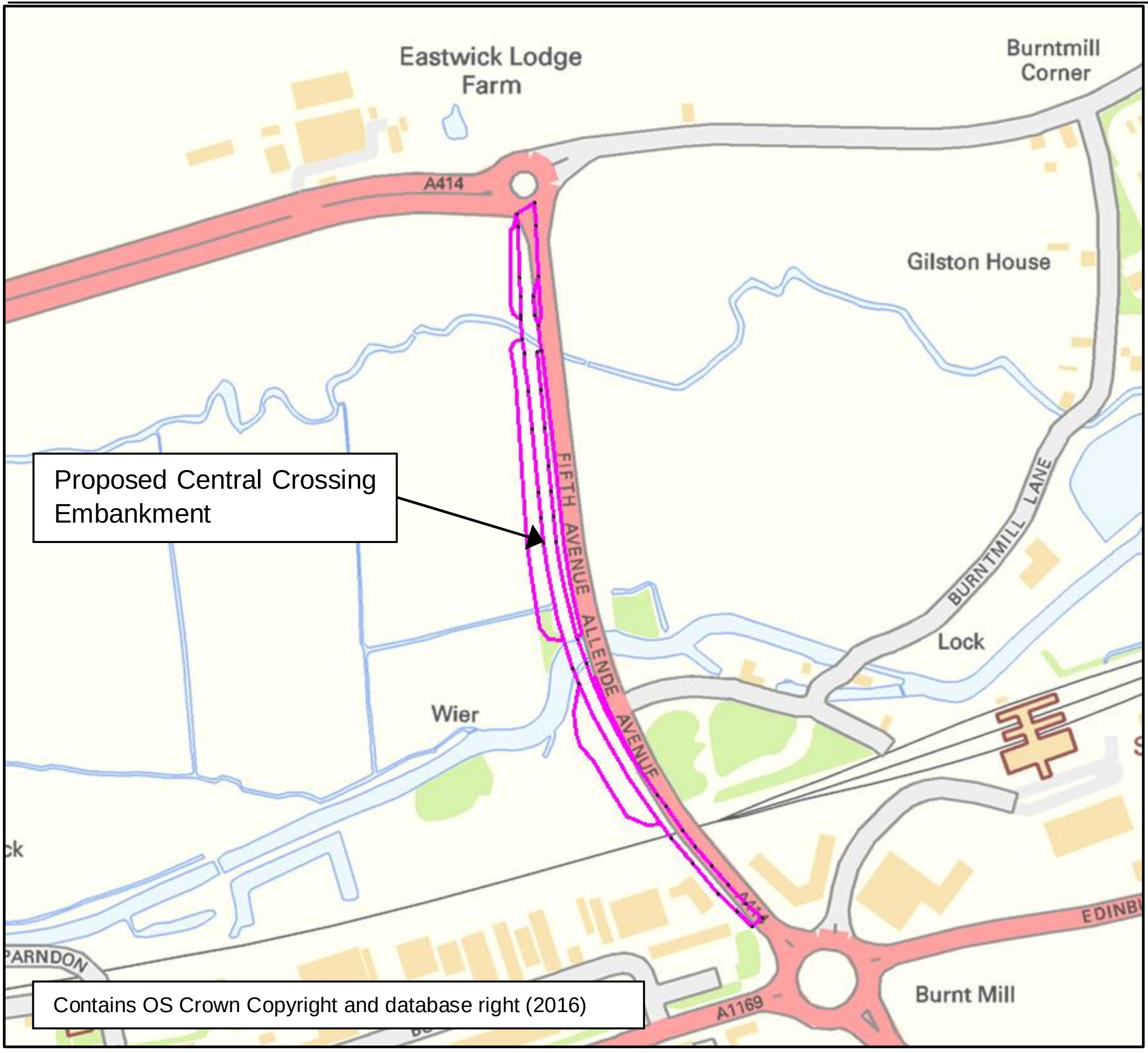

Figure 3: Proposed Central Crossing

The proposed Central Crossing widening is designed to be on a raised solid embankment adjacent to the existing Fifth Avenue embankment, supported by either batter slopes or a vertical retaining wall structure.

3.0 Hydraulic Modelling

The base case hydraulic model, which represents the existing River Stort, Stort Navigation Channel and a number of tributary watercourses, was modified to represent the alternative Eastern and Central Crossing design proposals.

3.1 Proposed Eastern Crossing: Modelling Amendment Summary

The proposed bridges over the River Stort and Fiddlers Brook, which form part of this option, are high level structures with soffit levels well above the maximum water levels in these watercourses. The supporting piers for these bridges are judged to be hydraulically insignificant. Consequently, no changes were made to the 1D component of the hydraulic model (which represents the River Stort and Fiddlers Brook in-channel flow). Amendments were made to the ground levels represented in the 2D component of the model (which represents the River Stort and Fiddlers Brook floodplains), to represent the proposed solid earth embankment in the vicinity of Fiddlers Brook.

3.2 Proposed Central Crossing: Modelling Amendment Summary

The proposed bridges over the River Stort and Stort Navigation Channel, which form part of this option, are adjacent to and of larger size than the existing Fifth Avenue bridges over these channels. Since the existing bridges will continue to form the greatest restriction to flow in these channels, it is judged that the base case 1D model representation of the existing bridges is also an accurate representation for the proposed scenario. Therefore, no changes were made to the 1D component of the model, other than an adjustment to the downstream reach lengths to reflect the increased length of the bridge structures. Amendments were made to the ground levels represented in the 2D component of the model (which represents the River Stort and Stort Navigation floodplain), to represent the proposed solid earth embankment adjacent to the existing Fifth Avenue embankment.

4.0 Conclusions

The hydraulic modelling has shown that both the Eastern and Central Crossing options have no impact on maximum water levels in any of the watercourses or floodplain areas. The hydraulic modelling has been reviewed and approved by the Environment Agency. The Environment Agency approval letter is provided in Appendix A of this Technical Note.

Appendix A

Environment Agency Approval of Hydraulic Modelling

creating a better place

Environment Agency

Ian Bentley
AECOM Ltd
2 City Walk
Leeds
West Yorkshire
LS11 9AR

Our ref: NE/2015/122585/03-L01

Date: 18 March 2016

Dear Ian

Gilston Park Estate, North of Harlow, East Herts.

Thank you for sending us your updated model files.

While there are still a couple of comments which should be addressed (see attached pdf) we are now satisfied with the submitted modelling in regards to the flood risk related to the two crossings.

Disclaimer

Flood risk modelling undertaken by a third party has been used in support of this enquiry and we have applied a risk based approach to the assessment of this model. In this instance a detailed review has been carried out. We have not undertaken a full assessment of the fitness for purpose of the modelling and can accept no liability for any errors or inadequacies in the model.

Please contact me if you have any queries.

Yours sincerely

Natasha Smith
Planning Advisor – Sustainable Places Team

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E-mail SPHatfield@environment-agency.gov.uk