Flood Risk Assessment

October 2018

Prepared by CH2M on behalf of the Environment Agency
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<td>One Dimensional</td>
</tr>
<tr>
<td>2D</td>
<td>Two Dimensional</td>
</tr>
<tr>
<td>AEP</td>
<td>Annual Exceedance Probability</td>
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<td>FRA</td>
<td>Flood Risk Assessment</td>
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<td>FRMS</td>
<td>Flood Risk Management Strategy</td>
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<td>Flood Zone</td>
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SECTION 1

Introduction

1.1 The Scheme

The Environment Agency, together with local partners, are proposing a flood alleviation scheme (hereafter referred to as ‘the Scheme’) to reduce flood risk to the city of Oxford over the next 100 years. The Scheme comprises a combination of modifications to existing channels to increase their capacity, together with the construction of a new two-stage channel and new flood defences, to move flood water away from developed areas and reduce flood risk.

The Scheme will comprise of the following key elements:

• Construction of a new two-stage channel running from Botley Road/West Way south-easterly to downstream of the A423 (southern ring road). For the main part, this will be approximately parallel to the A34 to its west and the railway to its east. The new channel, which will carry excess flow from the Seacourt Stream, Bulstake Stream and Hinksey Stream with the aim of reducing the water level in the main River Thames and so reducing the frequency of flooding in built-up areas, will comprise two stages:
  o First stage channel, which will carry water flowing all of the time; and
  o Second (or ‘two-stage’) channel, which will be dry for most of the time, and will fill during flood flows, along with the surrounding existing floodplain.

• New flood embankments and walls will defend properties, which would otherwise continue to flood even with the reduced river levels; and

• New culverts and bridges will maintain access routes.

This FRA has been prepared to accompany a planning application to Oxfordshire County Council.

1.2 Background and Purpose

In 2010, the Environment Agency published the Oxford Flood Risk Management Strategy, which provided a detailed study of the flood risk from rivers in Oxford. The strategy described how flood risk can be managed in Oxford over the next 100 years. Additionally, Oxfordshire County Council, as Lead Local Flood Authority, developed a Local Flood Risk Management Strategy for Oxfordshire in 2016 to set a long-term programme for reducing flood risk in the county.

The Environment Agency is now working with partners, Oxfordshire County Council, Oxford City Council, Vale of White Horse District Council, Thames Water, Thames Regional Flood and Coastal Committee, Oxford Flood Alliance, Oxfordshire Local Enterprise Partnership and University of Oxford, on the Oxford Flood Alleviation Scheme.

The purpose of the scheme is to manage the flood risk to Oxford over the next 100 years, reducing the frequency of flooding by creating more space for water within the existing western floodplain of the city. The scheme addresses flooding from the main channel of the River Thames and from the Hinksey and Bulstake Streams. The scheme will be approximately 5km long, it will run from north of Botley Road down to south of the A423 southern by-pass where it re-joins the River Thames. It will include lowering parts of the floodplain to create a two-stage channel, and working on some of the existing rivers and streams that run through it, to make more space for water and reduce flood risk to the city. In some areas new flood walls and embankments will be built, and existing temporary defence locations will be utilised as a permanent solution.
If nothing was done to manage flood risk, approximately 2,500 properties would be at risk in a flood that has a 1 in 100 (1%) annual risk of occurring. The Environment Agency’s existing flood risk management activities reduces this but around 1,500 properties still remain at risk. This proposal will reduce the likelihood of flooding for all of these properties, with over 1,200 benefiting from a standard of protection greater than a 1 in 100 (1%) annual risk of flooding on opening. If we don’t take action the impacts of climate change means that 3,431 properties will be at flood risk in 50 years’ time in the same event. This threat of climate change will not only increase the extent of flooding, but its frequency and disruption to the city.

The scheme will provide a 1% AEP standard of service upon completion. However, the provision of additional works to maintain this standard of service into the future taking into account climate change predictions were proven unviable during the development of the scheme. Whilst the design life of the scheme is 100 years, the standard of service will gradually reduce over time due to the predicted impacts of climate change. Current climate change predictions increase river flows for the next 50 years. The scheme will still operate and have a benefit into the future and flood risk will be reduced in comparison to not implementing the scheme.

Flooding within Oxford also causes transport disruption, with frequent closure of the railway line and main roads to the west (Botley Road) and the south (Abingdon Road) of the city. These roads are important for access to the city by cars, buses (including Park and Ride) and bicycles. The scheme will also offer greater resilience to important utilities such as the sewer network, electricity sub- stations and broadband communications.

1.3 Maintenance

The general maintenance of the scheme once completed is considered in the Planning Statement. The funding for the scheme includes an allowance for the scheme maintenance for the first 10 years of the 100 year design life. The maintenance will be undertaken by the Environment Agency Field Services team. The Environment Agency will have an ongoing interest, operational budgets and capabilities to contribute towards maintenance of the channel as part of our wider routine maintenance for the whole of the Oxford river systems. There is a commitment to securing maintenance for the scheme for the lifetime of the development (100 years). The future maintenance of the scheme is being discussed with partners, landowners and stakeholders to establish a way of partnership working which will provide a robust plan for sustainable maintenance. The establishment of a partnership approach to maintenance would ensure the efficient and successful management of the multipurpose land associated with the scheme.

It is anticipated that much of the maintenance in the future will be undertaken as part of the stewardship of the land with grazing being used to maintain the second stage channels. The design of the scheme is such that an allowance for longer grass and the environmental features has been made to ensure that maintenance is not onerous and some vegetation growth within the second stage can be accommodated. All the structures associated with the scheme will be maintained by the Environment Agency with the exception of those structures under existing public highways which will be adopted by Oxfordshire County Council.

Following completion of the scheme the Flood Maps for Planning will be updated to reflect the new channels and changes in flood extents. The Environment Agency expect the new channels to be enmained, meaning they become part of the main river network and will be included within the long term maintenance programme for the scheme.
1.4 Available Information

The key information considered in the preparation of this flood risk assessment is listed below.

- National Planning Policy Framework, July 2018 (NPPF)
- Planning Practice Guidance
- Project design drawings
- Topographic survey undertaken for this scheme
- Results of hydraulic modelling undertaken for this FRA
- Independent technical review of modelling

1.5 The Need for a Flood Risk Assessment

1.5.1 Context

This Flood Risk Assessment (FRA) considers the flood risk implications of the proposed scheme in support of the planning application. This report responds to the requirement for planning applications which fall in Flood Zones 2 and 3 and are more than 1 hectare in size in Flood Zone 1 to be accompanied by a Flood Risk Assessment (FRA) explaining the:

- nature of the proposed development
- current land use and flood risk
- current flood risk management planning policy
- flood risk mechanisms that affect the area of the proposed development
- impact of the proposed development on flood risk, both to the development and elsewhere within the affected river reach
- mitigation measures incorporated into the development proposals to reduce and manage flood risk.

1.5.2 Sequential Test

The National Planning Policy Framework (NPPF) aims to ensure inappropriate development is avoided in areas at risk of flooding. Paragraph 158 of the NPPF states ‘The aim of the Sequential Test is to steer new development to areas with the lowest risk of flooding. Development should not be allocated or permitted if there are reasonably available sites appropriate for the proposed development in areas with a lower risk of flooding.’

The Environment Agency produces flood zones shown on the Flood Map for Planning (Rivers and Sea) that are the starting point for the Sequential Test. Flood Zones 2 and 3 indicate the land at medium to high risk of flooding during extreme events, and Flood Zone 1 is the low-risk zone, which is all land outside Zones 2 and 3. These flood zones refer to the probability of sea and river flooding only, excluding any existing defences. Flooding from sources including sewers, surface water, groundwater or impounded water bodies (reservoirs), can occur in any Flood Zone.

Table 1 - summarises the annual probability of fluvial flooding in relation to the Flood Zones and the land uses considered appropriate for each Zone (based upon Table 1 of the PPG Paragraph: 065 Reference ID: 7-065-20140306).
**Table 1: Flood Zone summary table**

<table>
<thead>
<tr>
<th>Flood Zone</th>
<th>Description</th>
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<tbody>
<tr>
<td>Flood Zone 1</td>
<td>Land having a less than 0.1% annual probability of river or sea flooding. (Shown as ‘clear’ on the Flood Map – all land outside Zones 2 and 3)</td>
</tr>
<tr>
<td>Flood Zone 2</td>
<td>Land having between a 1% and 0.1% annual probability of river flooding; or land having between a 0.5% and 0.1% annual probability of sea flooding. (Land shown in light blue on the Flood Map)</td>
</tr>
<tr>
<td>Flood Zone 3a</td>
<td>Land having a 1% or greater annual probability of river flooding; or Land having a 0.5% or greater annual probability of sea flooding. (Land shown in dark blue on the Flood Map)</td>
</tr>
<tr>
<td>Flood Zone 3b</td>
<td>This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)</td>
</tr>
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</table>

The proposed scheme is within Flood Zones 2 and 3 of the Environment Agency flood maps and shown to be within Flood Zones 3a and 3b according to Oxford City Council’s Strategic Flood Risk Assessment. The purpose of the scheme is to reduce flood risk and by necessity, in order to function, it is located in the floodplain.

The Oxford Flood Risk Management Strategy, 2010, considered a list of over 100 options for a flood alleviation scheme for Oxford. A shortlist of 14 options that focused on conveyance improvement was developed through consultation and appraisal and this was narrowed down to one broad route. This led to the proposal for a flood alleviation scheme to the west of Oxford city. The route options at the outline design stage for the Oxford Flood Alleviation Scheme (OFAS) considered alternative channel alignments but all were within Flood Zones 2 and 3.

Two other scenarios were tested in June 2017 using further hydraulic modelling. The scenarios removed the majority of the channel whilst retaining the other elements of the design such as key structures. The results of this modelling demonstrated that these options would not provide the level of flood risk reduction required for the scheme. The report outlining the results of this scenario testing is appended to the Environmental Statement as Appendix Q.

The consideration of options during the strategy and outline design of the scheme show there are no reasonably available sites for this flood alleviation scheme at lower risk of flooding therefore the Sequential Test is passed. This development is an opportunity to reduce the overall level of flood risk in the area through its layout and form.
1.5.3 Exception Test

Paragraph 159 of the NPPF states ‘If it is not possible for development to be located in zones with a lower risk of flooding (taking into account wider sustainable development objectives), the exception test may have to be applied.’

In accordance with Table 2 of the PPG Paragraph: 066 Reference ID: 7-066-20140306, the proposed development will fall into the ‘water compatible’ vulnerability class, under the classification ‘flood control infrastructure’. Table 2 (extracted from Table 3 and accompanying notes of the PPG Paragraph: 067 Reference ID: 7-067-20140306) summarises the flood risk vulnerability and flood zone ‘compatibility’ for the application of the Exception Test.

Table 2: Flood Risk Vulnerability and flood zone ‘compatibility’ (Table 3 PPG)

<table>
<thead>
<tr>
<th>Flood Zones</th>
<th>Essential Infrastructure</th>
<th>Highly Vulnerable</th>
<th>More Vulnerable</th>
<th>Less Vulnerable</th>
<th>Water Compatible</th>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Zone 2</td>
<td>✓</td>
<td>Exception Test required</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Zone 3a †</td>
<td>Exception Test required †</td>
<td>x</td>
<td>x</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Zone 3b ‡</td>
<td>Exception Test required ‡</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
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</table>

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

† In Flood Zone 3a essential infrastructure should be designed and constructed to remain operational and safe in times of flood.

‡ In Flood Zone 3b (functional floodplain) essential infrastructure that has to be there if following the application of the Sequential Test it is not possible to locate it in lower flood risk zones the Exception Test can be applied. It should be designed and constructed to:

- provide wider sustainability benefits to the community;
- be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

As stated above and supported by Table 2, the proposed development is water compatible and as such does not require an Exception Test. Section 6 of this report provides further information on how the scheme will be safe for its lifetime, does not increase flood risk to property elsewhere, and will reduce flood risk to over 1200 properties overall.
SECTION 2

Background

2.1 Development location

Oxford is a historic city with a prestigious university, located on the River Thames in Oxfordshire. The River Thames flows in a north to south direction through predominantly agricultural land to the east of the city.

The study area for the overall Scheme, which is shown on Figure 1, encompasses areas of the River Thames’ floodplain to the west of Oxford’s city centre, that are susceptible to flooding. An overview plan of the scheme is included in Appendix A.

The scheme area extends from north of the A420 Botley Road to south of the A423 ring road, running predominantly between the A34 to the west and the Oxford to Didcot railway line to the east. It comprises all of the permanent Scheme works and temporary working areas required for construction of the scheme.

The footprint of the main scheme lies predominantly within flood meadows and agricultural grazing land but also passes through areas of high conservation value, domestic gardens, allotments and access tracks. Other flood risk management features such as flood gates and raised defences are located throughout the study area to ensure the low-lying residential areas of Botley, North and South Hinksey, Kennington and New Hinksey benefit from a significantly reduced level of flood risk as a result of the scheme.

Within the scheme area, tributaries of the River Thames, namely Seacourt Stream, Bulstake Stream and Hinksey Stream, flow through the city’s residential, industrial and commercial areas, as well as through meadows and farmland. The proposed works will directly connect with and modify these tributaries at various points within the Scheme area.

2.2 Temporary Works

During the construction of the scheme the existing standards of flood risk protection will be maintained at all times. This will ensure that no additional flood risk to residential or commercial property is created at any point during construction process. The contractor undertaking the works will be selected from one of five contractors on the Environment Agency’s Water and Environmental Management (WEM) Framework.

At the time of submission of the planning application the identity of the contractor is not known however all contractors on the framework have been carefully selected and are experienced in undertaking flood risk management construction works in the floodplain and surrounding areas.

The proposed main compound and storage area at South Hinksey have been located on the edge of the existing floodplain upstream of the village to minimize the risk of impacts on flood levels. Temporary stockpiles will be positioned parallel to flood flow paths and breaks included to prevent backing up of flood water. Other measures such removing plant from the floodplain prior to forecast flood events and commissioning the works in a sequence to avoid impacts on flood levels will also be implemented.

The exact methodology and sequencing of the works will be confirmed by the appointed contractor prior to any construction works.

The majority of temporary works methodologies and sequencing will be subject to an Environmental Permit from the Environment Agency.
Figure 1: Scheme Study Area
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Published Flood Risk

3.1 Fluvial Risk

The principal flood risk to the area is the fluvial risk associated with the River Thames. The Environment Agency Flood Map for Planning reproduced in Figure 2 shows large parts of Oxford floodplain is currently within Flood Zones 2 and 3, and thus at a high risk of fluvial flooding. There are no formal flood defences or flood storage areas within the study area.

Updated fluvial modelling (2016) has been carried out to provide a baseline situation as part of the design of the scheme. This modelling has been used to update the Flood Map for Planning.

Figure 2: Environment Agency Flood Map for Planning (Flood Zone 2 and 3)
3.2 Pluvial Risk (surface water)

Pluvial (surface water) flooding is flooding that may occur due to intense rainfall due to exceedance of the local drainage system capacity or localised ponding of runoff. The Environment Agency surface water flood map indicates areas in the vicinity of the scheme that could be vulnerable to surface water flooding during rainstorms. The Environment Agency flood risk from surface water map is shown in Figure 3.


Figure 3: Flood Risk from Surface Water map (pluvial)
3.3 Groundwater flooding

The Environment Agency Susceptibility to Groundwater Flooding map is shown in Figure 4. The Susceptibility to Groundwater Flooding map was developed to provide a strategic indication of areas where there may be potential for groundwater flooding based on geology, ground levels and an estimation of high groundwater levels (and is not intended to provide a definition of local groundwater flood risk). The Susceptibility to Groundwater Flooding map highlights the groundwater flood risk for Oxford.

Figure 4: Environment Agency susceptibility to Groundwater Flooding
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3.4 Flooding from reservoirs and canals

The Environment Agency Risk of Flooding from Reservoirs map indicates Oxford is at risk of flooding from a breach of the Farmoor Reservoir, located to the west of Oxford. Figure 5 shows the simulated reservoir breach flood extent for the reservoir. The Environment Agency website notes that: “If a location is at risk, flooding from reservoirs is extremely unlikely. There has been no loss of life in the UK from reservoir flooding since 1925. An area is considered at risk if peoples’ lives could be threatened by an uncontrolled release of water from a reservoir.”
3.5 Historical flooding

The city of Oxford has a long history of flooding, being located at the confluence of the Rivers Cherwell and Thames. The largest flood event within living memory occurred in March 1947, with other significant events in June 1903, November 1954, January 1959 and December 1979. In recent years, 1998, 2000, 2003, 2007, 2012 and 2014 there have been several notable flood events, resulting in inundation of properties, closure of roads and railway infrastructure. The older city of Oxford is located on higher ground, but as Oxford has grown, developments have expanded generally to the east of the city centre and in to the Thames floodplain. As a result, the following areas are liable to flooding: Wolvercote, Wytham, New Botley, Osney, Kennington, South Hinksey, North Hinksey, New Hinksey and the city centre areas of Jericho and Grandpont.
SECTION 4

Model Development

4.1 River model schematisation

As part of the design of the scheme hydraulic modelling was undertaken to better understand the current flood risk to the Oxford area. This model was developed during the strategy stage, then improved for the outline design stage.

A detailed topographic survey of the whole scheme was undertaken at the commencement of the detailed design stage in late 2016 and early 2017 including a bathymetric survey of key channels. The model was updated with this new survey information and the calibration re-checked. This model was then used to inform the detailed design process. Figure 6 details the model extent and key locations.

Figure 6: Hydraulic Model extent and key locations
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The model area covers approximately 19km of the River Thames from its confluence with the River Evenlode to downstream of Sandford Lock (NGR 445465, 209310 to 453880, 198620) and the River Cherwell from the A40 to its confluence with the River Thames (NGR 451540, 209970 to 452010, 205100).

The model is developed using Flood Modeller (1D) and TUFLOW (2D) which combines two software packages for managing overland flow and rapid inundation modelling. It provides a flexible and comprehensive range of tools for designing cost effective engineering schemes, flood forecasting, flood risk mapping and developing catchment management strategies.

During the outline design stage, the Environment Agency 2014 Oxford Flood Risk Mapping Study\(^1\) model was reviewed, updated with the latest available survey data and re-calibrated. The calibration process covered the more recent events which have resulted in flooding Oxford during 2003, 2007 and 2013/14. At the detailed design stage, new survey undertaken specifically for the study was incorporated into the model. Figure 7 details the baseline flood extents for the 5%, 1% and 1%+ 35% AEP events.

Full details of the model build and results are included in Appendix B. The calibration process and results are included in Appendix C.

---

\(^1\) Mott MacDonald, Oxford Flood Risk Mapping Study, January 2014

**Figure 7: Oxford Baseline model flood extents (detailed design stage)**

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(note: the 1% AEP and 1% AEP +35% outlines show the additional flooding over the 5% AEP event)
4.2 Hydrology

The hydrological assessment includes review of the previous hydrology reports and analysis undertaken to inform the 2009 Oxford Strategy\(^2\) model and the 2014 Oxford Flood Risk Mapping Study\(^3\). It also records the updates and changes made by CH2M, as part of the modelling for appraisal of the Oxford Flood Alleviation Scheme (FAS). Further detail can be found in the the scheme Final Hydrology Report, March 2016 provided in Appendix D.

To support the modelling for appraisal of Oxford FAS, the assessment determined that local design hydrographs for each of the key tributaries (the River Thames, the River Evenlode, the River Ray and the River Cherwell upstream of its confluence with the Ray) should be developed. Flood frequency analysis at Sandford was updated and extended to include other sites, to increase overall confidence in the design estimates of flow.

The peak flows adopted for the study at Sandford Lock are detailed in Table 3, with comparison to the 2009 Oxford Strategy model and the 2014 Oxford Flood Risk Mapping Study.

Full details of the hydrological assessment are included in Appendix D

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>Peak Flow (m(^3)/s)</th>
<th>Oxford FAS</th>
<th>2009 Strategy (^2)</th>
<th>2014 Mapping Study (^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% AEP (1 in 2)</td>
<td>140</td>
<td>142</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>20% AEP (1 in 5)</td>
<td>181</td>
<td>183</td>
<td>184</td>
<td></td>
</tr>
<tr>
<td>10% AEP (1 in 10)</td>
<td>206</td>
<td>206</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>5% AEP (1 in 20)</td>
<td>231</td>
<td>228</td>
<td>228</td>
<td></td>
</tr>
<tr>
<td>3.3% AEP (1 in 30)</td>
<td>246</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2% AEP (1 in 50)</td>
<td>265</td>
<td>257</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>1.3% AEP (1 in 75)</td>
<td>281</td>
<td>268</td>
<td>259</td>
<td></td>
</tr>
<tr>
<td>1 % AEP (1 in 100)</td>
<td>292</td>
<td>278</td>
<td>264</td>
<td></td>
</tr>
<tr>
<td>0.5% AEP (1 in 200)</td>
<td>320</td>
<td>299</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>0.2% AEP (1 in 500)</td>
<td>359</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>0.1 % AEP (1 in 1000)</td>
<td>390</td>
<td>327</td>
<td>299</td>
<td></td>
</tr>
</tbody>
</table>


\(^{3}\) Mott MacDonald, Oxford Flood Risk Mapping Study, January 2014
4.3 Groundwater model

To assess the risk from groundwater and impacts due to the scheme, a groundwater model has been developed. The model was built using MODFLOW, using outputs from the river model (Flood Modeller). The groundwater model extent is detailed in Figure 8, which covers the Oxford Meadow Special Area of Conservation, Iffley Meadows Site of Special Scientific Interest and Hinksey Meadow. The model has been validated to the 2007 event and design scenarios simulated for the 5% AEP flood event and dry period flows (Q 95).

Full details of the groundwater model build and results are included in Appendix E.
Climate Change

5.1 Overview


A number of scenarios for estimating the increase in peak river flows to represent the impacts of climate change are presented in the guidance, for the part of the catchment where Oxford is located the recommended increases to the peak flows are 25%, 35% and 70%. These figures relate to expected increases to peak flows into the 2020s’, 2050s’ and 2080s’ respectively. High++ allowances outlined in the guidance are not considered applicable to the scheme as it does not include any urban extensions or new settlements.

The guidance states that for water compatible developments the central allowance should be used. Therefore, to account for projected climate change, relative to present day (2016) the 1% AEP inflows have been increased by 35%.

The 1% AEP + 35% climate change flows and levels have also been used to inform freeboard allowances for the proposed development (defence levels). However due to the topography some of the defences will be outflanked in the climate change scenario, see Section 6.5.2 for further details of the impacts on flood risk in this scenario.
6.1 Overview

When developing in areas of flood risk, consideration must be given to the potential loss of floodplain storage, as this may increase the level of flood risk locally or downstream. A requirement of NPPF is that ‘a site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall’.

The proposed development option was tested by modifying the baseline model to represent the features of the FAS. Figure 9 details an overview of the scheme, with scheme elements summarised in Table 4. Full details of the model build and results are included in Appendix B.

Figure 9: Overview of Scheme Areas
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## Table 4: Elements of the scheme

<table>
<thead>
<tr>
<th>Area</th>
<th>Key features (note; left bank and right bank refers to the position when looking downstream)</th>
<th>Purpose of key feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A Seacourt Stream and defences to the west</td>
<td>• 2-stage channel on Seacourt Stream.</td>
<td>• To draw water from the flood plain towards the new scheme</td>
</tr>
<tr>
<td></td>
<td>• Full clearance of Botley Road Bridge.</td>
<td>• Improved conveyance through bridge without rebuilding.</td>
</tr>
<tr>
<td></td>
<td>• Embankment and wall upstream of Botley Road on right bank.</td>
<td>• Prevent flows bypassing the bridge and getting onto Botley Road</td>
</tr>
<tr>
<td>1B Raised defences to the east of Seacourt Stream</td>
<td>• Flood wall and embankment adjacent to Park and Ride and properties u/s Botley Road.</td>
<td>• To enhance protection to properties along Botley Road.</td>
</tr>
<tr>
<td></td>
<td>• Floodwall through Botley Allotments</td>
<td>Wall sections minimize footprint and land take, embankment provides habitat and access over defence for wildlife.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Wall to protect properties along Botley Road and minimize land take in allotments</td>
</tr>
<tr>
<td>1C Flood Gate at Helen Road and repairs to existing walls</td>
<td>• Repairs and flap valves to existing wall along right bank of Osney Ditch.</td>
<td>• To prevent flow through existing bridge opening.</td>
</tr>
<tr>
<td></td>
<td>• Low level defence at Allotment entrance.</td>
<td>• Improve scour resistance and defects to wall.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improve standard of protection to Botley Road by delaying onset of flooding from allotments entrance.</td>
</tr>
<tr>
<td>2A Downstream of Botley Bridge to spillway</td>
<td>• Channel widening of left bank, with 1 in 3 slopes.</td>
<td>• Improved channel capacity</td>
</tr>
<tr>
<td></td>
<td>• New Bridge at Minn’s Estate, existing channel through right opening.</td>
<td>• Maintain cycle route across new widened channel.</td>
</tr>
<tr>
<td></td>
<td>• Channel widening of left bank, with 1 in 3 slopes.</td>
<td>• Improved channel capacity.</td>
</tr>
<tr>
<td>2B Spillway to Willow Walk</td>
<td>• Spillway to new channel across access track, crest level 55.50m AOD.</td>
<td>• Control flows into new 2 stage channel and favours existing Seacourt stream for as long as possible.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Improved floodplain capacity.</td>
</tr>
<tr>
<td></td>
<td>• New channel (will be dry under normal flow conditions).</td>
<td>• Maintain bridleway access for the public.</td>
</tr>
<tr>
<td></td>
<td>• New Bridge under Willow Walk.</td>
<td>• Removed to facilitate bridge construction.</td>
</tr>
<tr>
<td></td>
<td>• Existing pipe culverts under Willow Walk removed.</td>
<td></td>
</tr>
<tr>
<td>3A Willow Walk to North Hinksey Causeway</td>
<td>• New channel between Willow Walk and North Hinksey Causeway.</td>
<td>• Enhanced flood plain capacity</td>
</tr>
<tr>
<td></td>
<td>• New access Bridge.</td>
<td>• Maintain historical footpath route along the North Hinksey Causeway public footpath</td>
</tr>
<tr>
<td>3B North Hinksey Causeway to bifurcation from Hinksey Stream</td>
<td>• 4 low flow weirs.</td>
<td>• Maintain low flow groundwater levels in Hinksey Meadow</td>
</tr>
<tr>
<td></td>
<td>• In-line weir on Bulstake Stream to Thames, crest level 54.85mAOD.</td>
<td>• Prevent backflow from River Thames into the new channel at low flows.</td>
</tr>
<tr>
<td></td>
<td>• New Bridge.</td>
<td>• Maintain access on the permissive footpath across the area.</td>
</tr>
<tr>
<td></td>
<td>• New ford crossing.</td>
<td>• Provide access for landowner across the channel.</td>
</tr>
<tr>
<td></td>
<td>• New 2 stage channels with pools/riffles.</td>
<td>• Improved floodplain capacity and environmental improvements.</td>
</tr>
<tr>
<td></td>
<td>• In-line weir to Hinksey Stream, crest level 54.78mAOD).</td>
<td>• Maintain levels in the Hinksey Stream during low flows.</td>
</tr>
</tbody>
</table>
### Area | Key features (note; left bank and right bank refers to the position when looking downstream) | Purpose of key feature
--- | --- | ---
3C | Hinksey Stream bifurcation to Devils Backbone  
- New 2 stage channels with pools/riffles.  
- New ford crossing.  
- New Bridge at Devils Backbone. |  
- Improved floodplain capacity and environmental improvements.  
- Provide access for landowner across the channel.  
- Maintain public access along the Devil’s Backbone footpath and provide vehicle access for landowners, tenants and national Grid across the new channel.
3D | Raised Defences at Ferry Hinksey Road  
- Embankment/wall adjacent to Ferry Hinksey Road. |  
- Enhanced level of protection up to the 1.33% AEP level for Osney Mead Industrial Estate
3E | Eastwyke Ditch  
- New control structure |  
- Normally the structure will be left open but closed during flood or low flow situations. Prevents flood flows flowing east into new Hinksey area but also prevents backflow from River Thames into new scheme during low flows.
4A | Raised Defences at South Hinksey  
- Embankment/wall around east side of South Hinksey. |  
- Provide additional flood risk reduction to residential properties on the east side of the village. Embankments utilised in paddocks and walls in residential gardens where space is limited.
4B | Devils Backbone to Hinksey Stream at Cold Harbour Railway Crossing  
- New 2 stage channels with pools/riffles.  
- New Weir at the end of the existing pond to maintain normal/low flow conditions. Crest level 54.45mAOD |  
- Improved floodplain capacity and environmental improvements.  
- To retain existing ground water and lake levels upstream of the connection to the Hinksey Stream.
4C | Hinksey Stream at Cold Harbour Railway Crossing to new bridge at Old Abingdon Road  
- New channel.  
- New Weir to ensure low flow remain in Hinksey Stream, crest level 54.00mAOD.  
- Low level defence to prevent 1% AEP event flooding via the Network rail access track. |  
- Improved floodplain capacity and environmental improvements.  
- To favour the existing Hinksey Stream during periods of low flows for environmental purposes.  
- Embankment and road hump on track to prevent flood water getting onto Old Abingdon Road and flowing into Kennington village.
4D | New bridge at Old Abingdon Road to A423  
- New channels and widening from Old Abingdon Road to new bypass culvert channel.  
- New Bridges at Old Abingdon Road and Kennington Road. |  
- To create a new flow route and capacity past Old Abingdon Road and avoid existing scheduled monuments in the area.  
- To allow the new channel to pass below Old Abingdon Road and Kennington Road. Two bridges proposed to avoid need for long skewed culvert below road junction.
4E | A423 to Mundays Bridge, including new west side culvert under A423  
- New culvert under A423.  
- Re-profile of existing channel after new culvert to Mundays Bridge  
- Clearance of Mundays Bridge. |  
- Improved flow capacity on the Hinksey Drain below the bypass.  
- Improved flow capacity in the Hinksey Drain to Minday’s Bridge  
- Improved flow capacity under the railway.
4F | Raised Defences at New Hinksey  
- Embankment and flood walls. |  
- To prevent overland flows from the River Thames across the fields to Abingdon Road.
4G | Towles Mill  
- Removal of existing weir |  
- Improved flow capacity and reduction of upstream water levels. Improved fish passage.
### Scheme results

Comparison of the flood extents for the 1% AEP event are detailed in Figure 10 which shows the benefit of the scheme. Peak water levels are detailed in Table 5 for the 5%, 1% and 1%+35% AEP events at the locations detailed in Figure 10. The scheme reduces flood levels in the channel and floodplains in the areas of existing development, the areas which benefit the most from the scheme are downstream of the defences at Botley Road, New Hinksey and South Hinksey. The majority of areas will benefit up to and including the 1% event.

Full details of the model build and results are included in Appendix B.

Key infrastructure, including roads, rail and National Grid assets benefit from the scheme.

- Botley Road and Abingdon Road: under current conditions the roads are predicted to flood between a 50% AEP and 20% AEP event. Under the scheme Botley Road is predicted to flood between the 5% and 2% AEP events and Abingdon Road for events higher than 1% AEP event.
- The Osney Mead National Grid cable end tower: under current conditions this predicted to flood between a 50% AEP and 20% AEP event. Under the scheme the cable end site is predicted to flood between the 5% and 2% AEP events.
- Under current conditions the model predicts flooding of the railway track occurs for flood events greater than a 5% AEP event. The scheme reduces the flood risk to the track, modelling predicts flooding of the track to occur for flood extents greater than a 2% event for the lifetime of the scheme.

Differing standards of protection in some locations are proposed due to topographic and level constraints local to these areas and the need to avoid increasing flood risk to adjacent areas as a result of the scheme.

The Environment Agency have been liaising with landowners and discussing the impacts of the scheme and how it will work with the two-stage channel. Separately land owner agreements which will include ‘rights to flood’ are being negotiated with individual landowners where appropriate.
Figure 10: Comparison of 1% AEP event flood extents
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Table 5: Peak water levels and comparison

<table>
<thead>
<tr>
<th>Ref</th>
<th>Location</th>
<th>5% AEP event (mAOD)</th>
<th>1% AEP event (mAOD)</th>
<th>1%+ 35% AEP event (mAOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
<td>Scheme</td>
<td>Diff</td>
</tr>
<tr>
<td>1</td>
<td>Seacourt/Botley Stream</td>
<td>57.36</td>
<td>57.17</td>
<td>-0.20</td>
</tr>
<tr>
<td>2</td>
<td>Seacourt at Botley Road</td>
<td>57.27</td>
<td>57.02</td>
<td>-0.24</td>
</tr>
<tr>
<td>3</td>
<td>Bulstake at Botley Road</td>
<td>57.14</td>
<td>56.95</td>
<td>-0.19</td>
</tr>
<tr>
<td>4</td>
<td>Osney Ditch</td>
<td>57.34</td>
<td>57.16</td>
<td>-0.18</td>
</tr>
<tr>
<td>5</td>
<td>Thames at Botley Road</td>
<td>57.04</td>
<td>56.90</td>
<td>-0.13</td>
</tr>
<tr>
<td>6</td>
<td>Castle Mill Stream</td>
<td>56.87</td>
<td>56.77</td>
<td>-0.10</td>
</tr>
<tr>
<td>7</td>
<td>Seacourt Willow Walk</td>
<td>56.70</td>
<td>56.42</td>
<td>-0.28</td>
</tr>
<tr>
<td>8</td>
<td>Bulstake Willow Walk</td>
<td>56.71</td>
<td>56.45</td>
<td>-0.26</td>
</tr>
<tr>
<td>9</td>
<td>Thames d/s Osney</td>
<td>56.41</td>
<td>56.28</td>
<td>-0.14</td>
</tr>
<tr>
<td>10</td>
<td>Thames</td>
<td>56.18</td>
<td>56.03</td>
<td>-0.16</td>
</tr>
<tr>
<td>11</td>
<td>Hinksey Stream</td>
<td>56.32</td>
<td>56.15</td>
<td>-0.17</td>
</tr>
<tr>
<td>12</td>
<td>Eastwyke Ditch (west)</td>
<td>56.23</td>
<td>56.12</td>
<td>-0.12</td>
</tr>
<tr>
<td>13</td>
<td>Eastwyke Ditch Abingdon Rd</td>
<td>55.91</td>
<td>55.78</td>
<td>-0.13</td>
</tr>
<tr>
<td>14</td>
<td>Thames (Cherwell Conf)</td>
<td>55.89</td>
<td>55.78</td>
<td>-0.11</td>
</tr>
<tr>
<td>15</td>
<td>Devils Backbone</td>
<td>56.25</td>
<td>56.02</td>
<td>-0.23</td>
</tr>
<tr>
<td>16</td>
<td>Cold Harbour Bridges</td>
<td>56.20</td>
<td>55.88</td>
<td>-0.32</td>
</tr>
<tr>
<td>17</td>
<td>Mayweed Bridge</td>
<td>56.03</td>
<td>55.76</td>
<td>-0.27</td>
</tr>
<tr>
<td>18</td>
<td>Weirs Mill Stream d/s</td>
<td>55.31</td>
<td>55.26</td>
<td>-0.05</td>
</tr>
<tr>
<td>19</td>
<td>Thames Donnington Road</td>
<td>55.68</td>
<td>55.57</td>
<td>-0.11</td>
</tr>
<tr>
<td>20</td>
<td>Thames Iffley Lock u/s</td>
<td>55.53</td>
<td>55.44</td>
<td>-0.09</td>
</tr>
<tr>
<td>21</td>
<td>A423 West (Hinksey Ditch)</td>
<td>55.40</td>
<td>55.46</td>
<td>0.06</td>
</tr>
<tr>
<td>22</td>
<td>A423 East (Hinksey Stream)</td>
<td>55.42</td>
<td>55.21</td>
<td>-0.21</td>
</tr>
<tr>
<td>23</td>
<td>Mundays Bridge</td>
<td>55.18</td>
<td>55.24</td>
<td>0.07</td>
</tr>
<tr>
<td>24</td>
<td>End of Weirs Mill Stream</td>
<td>55.11</td>
<td>55.13</td>
<td>0.02</td>
</tr>
<tr>
<td>25</td>
<td>Thames d/s Hinksey Stream</td>
<td>54.91</td>
<td>54.91</td>
<td>0.00</td>
</tr>
<tr>
<td>26</td>
<td>Thames Binsey/Port</td>
<td>57.72</td>
<td>57.71</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

Table 5 above shows that in the majority of the areas the flood levels are reduced for each event, demonstrated by the negative numbers in the ‘Diff’ column. There is a small increase in levels in the area immediately downstream of Old Abingdon Road, indicated by positive numbers. This is due to the scheme providing more flow capacity under Old Abingdon Road and levels in the Kendal Copse area increasing slightly. The scheme is increasing the capacity of the channel, Stroud’s Bridge and Munday’s Bridge and providing an increased standard of protection through this area by raising and extending flood defences between the A423 and Munday’s Bridge.

It is noted that some of the level changes are relatively small but are sufficient to reduce flood risk in key areas. Whilst there are inherent tolerances to the accuracy of the modelling process in relation to the data used, the same raw data has been used for both the baseline and scheme models. The difference column in Table 5 compares the outputs from the two models which cancels out the potential tolerances in the models as both will be similar, and shows the reduction in levels as a result of the scheme.
6.3 Off-site impacts

6.3.1 Upstream Impacts

There are no negative impacts on flood levels or flow routes upstream of the scheme. The proposed flood alleviation scheme lowers water levels in the residential areas along the Botley Road. This lowering of levels extends upstream of this area, gradually reducing to the north until water levels are unchanged from the current situation to the north of the Binsey Village area. No changes will take place to flood levels, extents and durations in the Oxford Meadow Special Area of Conservation and Iffley Meadows Site of Special Scientific Interest.

6.3.2 Downstream Impacts

Comparison of the outflows from the model (Sandford) for do minimum and the scheme are detailed in Table 6. The modelling predicts that the scheme would result in a small reduction in peak flow for the events 20% AEP to 1% AEP events and a slight increase in peak flow for the 50% AEP event and events greater than the 1% AEP event. This is due to the different timings of the peak flows from other rivers flowing in the River Thames which vary depending on the return period of the event. These timings are based on a statistical analysis of previous flood event records and catchment characteristics. However, as noted in the Table 6 the maximum change to peak flows is only 0.35% of the overall flow figures and no additional properties will be at risk in major flood events and properties will be at slightly less risk in similar events to those experienced in recent years.

The modelling predicts slightly higher flows in the rising limb of the hydrograph due to the increased conveyance provided by the scheme. Whilst this will slightly increase some water levels in the build-up of a flood this small change will not impact on the peak flows in the river or the peak flood levels. A review of the timings of the peak flows from other tributaries to the River Thames which may have earlier maximum flows indicates this effect will not coincide with the peak water levels on these rivers ensuring there are no wider impacts.

The downstream impacts have been further tested using the approved flood mapping model of the Thames (Sandford to Reading) and simulating the do minimum (existing situation) and predicted post scheme flows. Details of the results and predicted flood level comparison tables relating to this modeling are presented in Appendix F. The modelling predicts either the same flood levels or reductions in level (1cm) for the 20% AEP, 5% AEP, 2% AEP and the 1%+35% AEP events tested and similar flood levels or a slight increase (1-2cm) for the 1% AEP event.

A review of the corresponding flood maps comparing before and after scheme levels and extents indicates that the scheme does not create additional flood risk to properties downstream of the scheme area. As noted above, very minor changes to flood levels occur in some isolated locations and these are both positive reductions or slight increases (up to a maximum of 2cm) at the same location depending on the return period of the event under review.

Further details of the downstream impacts are included in Appendix F

<table>
<thead>
<tr>
<th>Table 6: Model outflow comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability of event</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>Do Minimum (m³/s)</td>
</tr>
<tr>
<td>Detailed Design (m³/s)</td>
</tr>
<tr>
<td>Difference (m³/s)</td>
</tr>
<tr>
<td>Difference (%)</td>
</tr>
</tbody>
</table>
### 6.3.3 Displaced floodplain storage

In built developments a like for like storage compensation is required to avoid creating additional flood risk elsewhere. Normally this is usually expected on a level for level basis, however if this is not achievable then a volume for volume check is undertaken. If this is not feasible to achieve then a flood mapping review can be used.

The basis of the scheme is to reduce flood risk to existing developed areas. This will, by definition, reduce the floodplain up the design standard of the scheme if properties are to be protected. The volumes removed from the existing floodplain are the existing flooded areas which are protected by the scheme (Botley Road area, New Hinksey and South Hinksey) and residual areas where the scheme has lowered flood levels e.g. upstream of Botley Road.

Figure 11 details the areas which have flood volumes removed this equates to a volume of 352,575 m$^3$ at 1% AEP event and 138,950 m$^3$ at 1%+35% AEP event lost to the floodplain. The volume change is reduced at the 1%+35% AEP event as this is above the design standard for the scheme and the raised defences will be bypassed and overtopped, resulting in flooding of some of the areas removed from the floodplain at the 1% AEP event.

Applying a level for level comparison to volumes lost to the floodplain and excavation of the scheme is not possible as the majority of the areas removed are above the excavation levels. The excavation route of the new channel from Botley Road to Abingdon Road slopes from 55.4 mAOD to 52.7 mAOD (existing ground levels are 56.4 mAOD to 54.7 mAOD). It is in this level range is where much of the scheme excavation occurs. The elevation of the land removed from flooding at Botley Road and Osney Mead is at a higher than the excavated areas (exceeds 56.6 mAOD). The land adjacent to the New Hinksey defence removed from flooding has typical ground levels of 55 – 56 mAOD, and South Hinksey 55.8 – 56.3 mAOD.

The total excavation of the new 2-stage channel is calculated as 258,000 m$^3$. Based on a volume for volume approach the new channel excavation provides sufficient additional storage compensation when compared to 1%+35% AEP event but less than the floodplain reduction for the 1% AEP event.

However, when reviewing the flood mapping for the before and after scheme scenarios and as demonstrated in Section 6.3.1, the scheme significantly reduces flood risk to existing developed areas through improved flood conveyance through the flood plain with no additional areas flooded within the Oxford area. The scheme has minimal impacts on peak flows in the River Thames and minimal impacts on flooding downstream and no additional flood risk to any properties in any areas at any return period.
In summary, a level for level analysis is generally appropriate for simple developments where new structures are displacing existing floodplain. However, for larger and more complex schemes which are intended to reduce flood risk the detailed modelling outputs are more appropriate than a level for level analysis. As noted elsewhere in the FRA the modelling demonstrates that the scheme has an overall flood risk reduction benefit and therefore full level for level compensation analysis is not required. The scheme has also been designed with excess spoil and material removed from the floodplain to maximise the capacity of the remaining floodplain when the scheme is operational.

Figure 11: Areas used for flood volume calculation (1% AEP event left, 1%+35% AEP event right)
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6.4 Scheme Results (Groundwater)

The scheme design was simulated for the 5% AEP flood event. The scheme is simulated to induce a modest lowering of the groundwater levels across the area (mostly around 10-20 cm and up to 62 cm at Cold Harbour). This may reduce the risk of groundwater flooding, however groundwater flooding in urban areas heavily depends on local sub-surface conditions such as man-made structures and disturbance of natural ground conditions which locally affect groundwater flow. A small increase in groundwater levels of about 10 to 15 cm is simulated south of North Hinksey, on Sand and Gravel outcrop. Although this is not simulated to significantly affect the pattern of potential groundwater flooding in the area. Full details of the model build and results are included in Appendix E. No impacts are shown outside of the scheme area or on the Oxford Meadow SAC or Iffley Meadows and Hinksey Meadow during flood events.
6.5  Residual Risk

6.5.1  Freeboard Allowance

The freeboard allowances in the design for each defence and bridge follow a risk based approach as detailed in Appendix G.

This note demonstrates that trying to achieve a freeboard level of 0.6m above the climate change flood levels for the 1% AEP event is not physically possible at several of the locations and is undesirable at others. Trying to achieve this will create a longer than necessary barrier across the floodplain at each bridge location with approach ramps to bridges which impact on the out of bank flows across the existing system. It is therefore proposed to take a more pragmatic approach and balance the freeboard provided against the risk of blockages, maintaining open floodplain and minimising the visual impact on the landscape.

The freeboard assessment has been undertaken based on the characteristics of the river reach upstream of each of the structures, the risk of debris and vegetation being washed into the structure and the risk of debris becoming snagged on the structure. The bridges have been designed to have open clear spans to reduce the risk of debris collection. Whilst the area is rural in nature the reaches between structures are short with limited sources of materials likely to create a significant blockage. In many of the locations where the second stage is present there is adequate space to allow structures to be bypassed by overland flood flows in the event of a major blockage. We anticipate that typical levels of maintenance will be required for these structures without a need to rely on more intensive or additional enhanced levels of maintenance.

The proposed freeboard values are summarised in Table 7.

Table 7: Summary of proposed freeboard values for key structures

<table>
<thead>
<tr>
<th>Structure</th>
<th>1% AEP design water level (mAOD)</th>
<th>1% AEP+ 35% climate change design water level (mAOD)</th>
<th>Proposed freeboard allowance (m) above the 1% AEP + 35% climate level</th>
<th>Proposed crest / soffit levels (mAOD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botley Road Raised Defences</td>
<td>57.35</td>
<td>57.65+</td>
<td>0.50m for bunds 0.30m for walls</td>
<td>58.15 for bunds 57.95 for walls</td>
</tr>
<tr>
<td>Existing Botley Bridge</td>
<td>57.22</td>
<td>57.53</td>
<td>Existing freeboard: 100yr = 0.25m 100yr +35% CC= -0.06m</td>
<td>N/A</td>
</tr>
<tr>
<td>Westway Cycle Bridge</td>
<td>56.96</td>
<td>57.21</td>
<td>0.30m</td>
<td>57.51</td>
</tr>
<tr>
<td>Willow Walk Bridge</td>
<td>56.66</td>
<td>56.92</td>
<td>0.20m</td>
<td>57.12</td>
</tr>
<tr>
<td>Osney Mead Defences</td>
<td>56.75</td>
<td>N/A</td>
<td>N/A</td>
<td>56.70***</td>
</tr>
<tr>
<td>Monk’s Causeway Bridge</td>
<td>56.48</td>
<td>56.78</td>
<td>0.20m</td>
<td>56.98</td>
</tr>
<tr>
<td>Devil’s Backbone Bridge</td>
<td>56.29</td>
<td>56.62</td>
<td>0.30m</td>
<td>56.92</td>
</tr>
</tbody>
</table>
### 6.5.2 Overtopping/bypassing of defences

The new raised defences have been designed to minimize impacts on flood flow routes. The Botley Road defences only cut off flood flows towards the residential properties. The channel works in the Seacourt area mitigate any impacts of this defence by passing more water below Botley Road and into the new channel.

The other raised defences in South Hinksey and New Hinksey are orientated parallel to the flow of flood water and hence do not significantly change any flood flow routes.

Where new defences are proposed for the scheme, the onset of flooding will occur at the following locations once the scheme is in place:

- The low level defence at the Osney Allotments entrance from Botley Road, is predicted to be overtopped between the 5% AEP and 2% AEP events and will flood the road.
- The Ferry Hinksey Road / Osney Mead defence has a crest level of 56.7 mAOD (set by existing access track levels), the modelling predicts the defence to be overtopped between the 2% AEP and 1.33% AEP events
- Botley Road defence would be bypassed at the Park and Ride entrance road first as it is not possible to achieve freeboard above the 1% AEP event due to the existing road levels, this will initially just inundate the road and not any properties.
- New Hinksey defences would be bypassed on Abingdon Road for events exceeding 1% AEP event.
- South Hinksey Defence would be bypassed at the north-western end of the defence, a low level defence would prevent flooding up to the 1% AEP event.

The scheme is designed to a 1% AEP standard of protection. A flood of a greater magnitude of this will still present a residual flood risk therefore the impacts of the scheme on an exceedance event has been undertaken to identify potential flood hazards in this event. A flood hazard mapping analysis has been undertaken to identify key risk areas based on the flood hazard rating (Table 8). The flood hazard rating is calculated using the following equation (EA Guidance Document FD2321/TR2 – Flood Risks to People, March 2006)
HR = d \times (v + 0.5) + DF

Where, 
- HR = (flood) hazard rating;
- d = depth of flooding (m);
- v = velocity of floodwaters (m/s); and
- DF = debris factor

(DF taken as the conservative land use, DF = 0.5 for depth of 0m to 0.25m and DF = 1.0 for depths greater than 0.25m)

<table>
<thead>
<tr>
<th>Flood Hazard Rating</th>
<th>Code</th>
<th>Degree of Flood Hazard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 0.75</td>
<td></td>
<td>Low</td>
<td>Caution “Flood zone with shallow flowing water or deep standing water”</td>
</tr>
<tr>
<td>0.75 to 1.25</td>
<td></td>
<td>Moderate</td>
<td>Dangerous for some (i.e. children) “Danger: Flood zone with deep or fast flowing water”</td>
</tr>
<tr>
<td>1.25 – 2.5</td>
<td></td>
<td>Significant</td>
<td>Dangerous for most people “Danger: Flood zone with deep fast flowing water”</td>
</tr>
<tr>
<td>More than 2.5</td>
<td></td>
<td>Extreme</td>
<td>Dangerous for all “Extreme danger: Flood zone with deep fast flowing water”</td>
</tr>
</tbody>
</table>

The flood hazard map is presented below in Figure 12, which includes the modelled baseline and scheme hazard rating for the 1%+35% AEP Event. The map shows that the hazard rating does not increase and in several locations shows a reduction for the scheme when the defences are bypassed. This is indicated by the reduction in size of the orange shaded areas on the second image in Figure 12.

This map will be used to inform emergency response plans to ensure that emergency efforts are focused in the most appropriate areas.

The scheme will not remove flood risk altogether and section 6.7 of the flood risk assessment provides the details of our flood information and flood warning services.
Figure 12: Extract from flood hazard map (1%+35% AEP)
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6.5.3  Osney Island

The model predicts the onset of flooding of Osney Island to start between a 20% AEP and 10% AEP event under current conditions (without the scheme or temporary defences). The flooding starts from East Street and flows towards South Street. Flooding of the road at West Street and gardens behind properties at South Street also occurs. The scheme reduces the flood risk in these locations for these return periods by lowering flood levels and increases the standard of protection up to the 5% AEP event level.

Appendix H includes further investigation of the flood risks at Osney Island and the continued use of temporary defences and property protection measures which will provide additional protection to some properties on the island.

The Environment Agency Field Services team have a dedicated set of temporary defence barriers for use on Osney Island which are stored at the Osney Depot adjacent to the island. These are mobilised to the required locations within a few hours of pre-defined trigger levels being reached on the River Thames. The Oxford area flood response guide has full details of the Osney Island deployments and forms part of the current flood response procedures. Field teams are well practiced in deploying the barriers in response to high flows in the Oxford area.

6.6  Emergency Evacuation

Developments in flood risk areas must provide safe dry places of refuge for people to await instructions from emergency services and clear practices for evacuation. As the development is a flood alleviation scheme, it does in itself reduce the risk of flooding and therefore increase protection to roads and improve safe emergency evacuation routes from other areas at risk of flooding. Following the scheme construction, the key locations of the onset of flooding will be known and allow emergency services to focus their efforts in these areas.

It is noted that even with the scheme in place there will still be a residual risk of flooding from exceedance events. Once the scheme is granted planning permission and implementation is underway the Environment Agency will work with our partners to update the multi–agency flood plans and ensure that emergency efforts are focused in the correct locations in times of a flood incident.

6.7  Flood Warnings

The scheme will include telemetry monitoring of water levels, which in turn will provide data for the existing flood warning system in Oxford. New telemetry stations will be installed at Botley Road (Seacourt and Bulstake Stream) and at Abingdon Road (New scheme culvert and Mayweed Bridge).

The Environment Agency operates a Flood Information Service which will provide formal flood warnings of extreme fluvial events from the River Thames. These warnings are available by phone, text or email and are also available on the GOV.UK website, https://flood-warning-information.service.gov.uk/warnings.

Registration for the flood warning service can be made on the GOV.UK website address https://www.gov.uk/sign-up-for-flood-warnings or by calling the Environment Agency on 03459881188.

Following completion of the scheme and once it is operational the Environment Agency will update the Flood Map for Planning to reflect the new channels and changes in flood extents. This will be carried out in line with the programme of flood map updates. The information will also be used to update the flood warning areas and trigger levels used to respond to flooding.
6.8 Other Sources of Flooding

This FRA predominantly deals with fluvial flood risk management. As part of the development of the scheme, however, we are working collaboratively with Thames Water to support use of results from our groundwater and flood model in Thames Water’s Integrated Catchment Model. The reduced water levels from the scheme will provide benefits to Thames Water by relieving drainage networks and sewer flooding. Drainage outfalls will continue to work for longer periods as river levels are lower with the scheme in place and reduce surface water flood risk. The reduction in flood levels should also reduce sewer inundation and flood risk from sewers.

As part of the scheme development we have also consulted with the relevant Lead Local Flood Authority (Oxfordshire County Council) on matters related to surface water, ground water and impacts on ordinary watercourse flood risk. The reduction on flood levels provided by the scheme has a positive benefit on all these sources of flood risk.

Historically a number of flood alleviation schemes which utilise raised defences have effectively reduced the fluvial flood risk but created a problem where any surface water which collects behind the defences during an event cannot escape when flood levels recede. Within the Oxford scheme it is expected that some existing localised residual groundwater and surface water issues will remain during fluvial events however the permeable catchment and general drainage in the area will result in this water being able to drain away once the fluvial flood levels have receded. The one location this may not readily occur is in North Kennington at Munday’s Bridge where the defences run along the edge of the watercourse and will prevent surface water drainage into the channel. The provision of a small pump to overcome this issue is being discussed with the residents at this location.

An updated breach analysis for the Thames Water Farmoor Reservoir with the scheme in place has not been undertaken however the previous breach analysis indicates that flows from the reservoir would enter the River Thames floodplain upstream of the location of the Oxford scheme. The scheme has the benefit of reducing flood levels within the River Thames and will therefore also have a similar effect in reducing the water levels and impacts from any breach in this reservoir.

6.9 Water quality

The scheme will not have any change to sources of flood water or store water for periods and will have no detrimental effects on water quality in the area. There is potential to help reduce contaminants in flood water due to the benefits provided to drainage and sewer networks.
Conclusions

7.1 Scheme Summary

The Scheme will comprise the following key elements:

- Construction of a new two-stage channel running from Botley Road/West Way south-easterly to downstream of the A423 (southern ring road). For the main part, this will be approximately parallel to the A34 to its west and the railway to its east. The new channel, which will carry excess flow from the Seacourt Stream, Bulstake Stream and Hinksey Stream with the aim of reducing the water level in the main River Thames and so reducing the frequency of flooding in built-up areas, will comprise two stages:
  - First stage channel, which will carry water flowing all of the time; and
  - Second (or ‘two-stage’) channel, which will be dry for most of the time, and will fill during flood flows, along with the surrounding existing floodplain.

- New flood embankments and walls will defend properties, which would otherwise continue to flood even with the reduced river levels; and

- New culverts and bridges will maintain access routes.

The proposed sites covered by the scheme are situated within Flood Zones 2 and 3 of the Environment Agency maps, and shown to be within Flood Zones 3a and 3b according to Oxford City Council’s Strategic Flood Risk Assessment.

7.2 Flood Risk Assessment Summary

The consideration of options during the strategy and outline design of the scheme show there are no reasonably available sites for this flood alleviation scheme at lower risk of flooding therefore the Sequential Test is passed. This development is an opportunity to reduce the overall level of flood risk in the area through its layout and form.

The proposed scheme is water compatible and as such does not require an Exception Test. The scheme will be safe for its lifetime and does not create any additional risk to life or property in an event greater than the design standard of the scheme.

The Standard of Protection to over 1200 existing properties is raised significantly from all sources of flooding, in the majority of fluvial cases this is raised to a 1% AEP standard. This study has shown that, in addition to the reduced flood risk to properties, there are further benefits of this scheme. These include lowering depths of flooding and reducing the flood risk to a number of roads and the railway to help keep transport links open longer during flood events and provide economic benefits to the wider business community of Oxford.

Overall, this FRA has demonstrated that the proposed scheme provides a reduced level of flood risk to over 1200 properties within Oxford with no detrimental flood risk impacts to any properties within the city or surrounding areas. Minor variances in predicted flood outlines at isolated locations are identified in the areas downstream of the scheme, up to a maximum of 2cm. However, the results with the scheme in place indicate the same downstream area can show a slight reduction in flood level for one return period and a slight increase in flood level at another return period. This downstream modelling has been verified through an independent review by industry experts.
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